Communal Roosts of the American Swallow-tailed Kite in Florida: Habitat Associations, Critical Sites, and a Technique for Monitoring Population Status

FINAL REPORT

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ABSTRACT: Previous research on swallow-tailed kite *(Elanoides forficatus forficatus)* nesting ecology and observations of communal roosts suggested that roosts should be studied to identify management needs and to develop methods for monitoring population trends. Such a study was conducted in Florida during 1992 and 1993 with funding from the Florida Game and Fresh Water Fish Commission. The objectives were to locate and describe large and small (neighborhood) roosts; to identify critical sites, threats, and management needs; and to develop techniques for locating roosts, determining their size, and estimating population productivity. Supporting information on habitat selection, nesting success, and productivity for a large sample of nests and from observations of radio-tagged kites came from field studies conducted with other funding from 1990 to 1993. Neighborhood roosts of 10 to 40 kites were found within 5 km of nests and were occupied from the start of nesting through fledging. They were located in isolated stands of swamp forest with high densities of snags and were in standing water most of the season. Three large, pre-migration roosts located during previous work were monitored during July and August. The largest, Fisheating Creek (FC), was monitored most intensively. In the 1992 and 1993, 5 of 16 kites radio-tagged in Big Cypress National Preserve joined the roost, a distance of 80 to 109 km from their nests (4 of the 16 died prior to dispersal), and attendance ranged from 12 to 59 days. Aerial survey methods were tested and the percentage of juveniles in the roost was estimated from photographs. The observed value (16.8%) at the peak closely matched that predicted from nesting effort, productivity, and juvenile mortality (13–17%). Adults left the roost before juveniles; 1 month after the peak, 79% were juveniles. The FC roost peaked at 1,550 on 27 July 1992 and contained 2,200 in early August 1993. Rough estimates of total occupancy, based on average attendance and the daily numbers of kites present, were 1,812 to 2,537 in 1992 and 3,100 in 1993. These estimates are within the range of expected values given current U.S. population estimates of 800 to 1,200 pairs, or 3,200 to 4,800 individuals at the end of the breeding season. Annual variations were strongly associated with differences in surface water levels, which apparently influenced the timing of dispersal from nest areas. Detailed protocols were produced for locating, surveying, and estimating population productivity from large roosts. A GIS analysis of nest and neighborhood roost sites and radio-tracking of breeding adults indicated the importance of forested wetlands and diverse habitat mosaics to swallow-tailed kites. Large roosts in Florida probably are a response to feeding demands prior to migration and may not draw birds from wide areas beyond the state. Even though the roosts are active for relatively short periods, they serve a vital function in preparing the birds for migration. In light of the inadequacies of presently protected lands to support long-term viability of a breeding population and the threats to existing nest and roost habitat on private land, it is essential that known roost sites be protected, new sites be sought, and conservation efforts in southern Florida, primarily the southwest, be expanded to halt further degradation of essential habitat.

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INTRODUCTION

Florida is the breeding-season stronghold of the northern subspecies of the American swallow-tailed kite *(Elanoides forficatus forficatus)* (Howell 1932, Bent 1937, Cely 1979, Robertson 1988). This strikingly beautiful bird of prey, which once nested in as many as 21 states (Cely 1979, Robertson 1988), suffered an abrupt decline at the turn of the century chiefly as a result of shooting and habitat loss (Robertson 1988). The breeding distribution has changed little, if any, since the 1940s, when the population reached its low point. At present in the United States, swallow-tailed kites nest only in Florida and small portions of 5 other southeastern states. Current estimates place the U.S. breeding population at 800 to 1,200 pairs (Robertson 1988, Meyer and Collopy 1990). The Florida Game and Fresh Water Fish Commission (FGFWFC), in setting priorities for conservation efforts in the state, ranked the swallow-tailed kite as one of Florida's most vulnerable and poorly understood species (Millsap et al. 1990).

Previous research in Florida examined the swallow-tailed kite's breeding biology, including distribution, nesting success and productivity, the correlates of success, habitat associations, and range sizes (Meyer 1990; Meyer and Collopy 1990; Meyer and Collopy, in press). This work illuminated the factors that jeopardize the swallow-tailed kite's future in the United States. Low reproductive potential results from delayed breeding, low success and productivity, and the inability to renest following failure. First-year mortality, typically at least 50% in resident raptors, undoubtedly is increased by the swallow-tail's long-distance migration to South America. Strong fidelity to nest and roost sites promotes social behavior and efficient foraging, thus enhancing productivity and survival. Site fidelity, however, concentrates nesting activity and discourages colonization of other sites, increasing the species' sensitivity to disturbance. Essential habitat consists of mature, uneven-aged stands of pine and cypress within diverse mosaics of freshwater wetlands. The rate of loss and degradation of critical habitat in south-central and southwestern Florida, where most of the remaining swallow-tailed kites nest and roost on privately owned land, is accelerating. Swallow-tailed kites have been recommended for listing as Endangered at state and federal levels (Meyer and Collopy, in press).

Three areas have been identified as having the highest priorities for further research in order to establish policies and management practices that will protect critical habitat and assure long-term viability of the population: demography, migration, and post-breeding dispersal and staging (Meyer and Collopy 1990, Meyer and Collopy, in press). Demographic models will help explain the population's response to historic declines and future management efforts. Long-term protection also will require an understanding of migration routes and destinations, which we know virtually nothing about at present. The most pressing need, however, has been for further research on pre-migration dispersal and staging behavior. This report describes a study that examined dispersal and communal roosting behavior of swallow-tailed kites, identified critical sites, and developed survey and monitoring methods based on observations at large roosts.

Swallow-tailed kites are known to be social in most aspects of their behavioral ecology. The distribution of nesting territories has been described as loosely colonial (Robertson 1988), with 2 to 5 pairs occupying an area up to 700 to 800 m in diameter (Meyer and Collopy 1990). Nonbreeding adults, averaging 1 or more per pair, also occupy these nesting "neighborhoods" and join with breeders in responding to intruders or potential predators near nests. Foraging aggregations, common near nesting neighborhoods and frequently observed outside the breeding season, typically include 3 to 30 birds but may number in the hundreds (Wayne 1906, Howell 1932, Skutch 1965, Haverschmitt 1977, Meyer and Collopy 1990).

Communal night roosts are a particularly distinctive feature of swallow-tailed kite biology. In the previous study (Meyer and Collopy 1990), neighborhood roosts composed of several to 30 birds were commonly observed within several hundred meters of active nests, although some radio-tagged breeding adults regularly roosted up to 5 km from their nests. Neighborhood roosts were observed over the entire nesting cycle, from the courtship/nest-building stage until dispersal from nest territories (March through September, depending on local conditions).

Large roosts that have been observed during July and August, between post-breeding dispersal and migration to South America, represent one of the most dramatic examples of swallow-tailed kite social behavior. Large communal roosts have been noted for other birds of prey, vultures, and corvids and are usually explained as either adaptations for social facilitation of feeding or as staging aggregations prior to seasonal movements (Dixon et al. 1957; Brown and Amadon 1968; Bildstein 1979; Newton 1979; Sykes 1985; Rabenold 1986, 1987; Johnson et al. 1987; Clark and Wheeler 1989; Crenshaw and McClelland 1989; Curnutt 1992; Engel et al. 1992).

The largest of the swallow-tailed kite roosts, near the western shore of Lake Okeechobee, was found in 1987 (Millsap 1987) and has been observed near that location in each subsequent year to date (Millsap and Runde 1988; Joiner 1990, 1991; this report). Millsap's (1987) observations indicated that a roost formed at or near the same site in 1986, and it is likely that large numbers of swallow-tailed kites have roosted in the area for many years. At its peak, this roost has contained from one-third to one-half of the total estimated U.S. population of swallow-tailed kites (Millsap 1987, Robertson 1988, Meyer and Collopy 1990). It is larger than any similarly stable and predictable roost site reported for raptors. Other large, pre-migratory roosts of swallow-tailed kites have recently been observed in Corkscrew Swamp, Collier County (280 birds in 1988 [Meyer and Collopy 1990] and 340 in 1989 [Bensen 1992]), and in the St. Johns Marsh, Brevard County (153 birds in 1990 [Joiner 1990]).

Apart from interest in communal roosts as a fundamental feature of avian ecology, there are 2 important reasons for studying this phenomenon in swallow-tailed kites. First, previous observations indicate that neighborhood and large roosts probably serve important functions during both the nesting cycle and the conditioning stage prior to migration. Successful management of this vulnerable population will have to include consideration for adequate roost sites in conjunction with nesting habitat as well as identification and protection of large roost sites. Second, large roosts probably offer the best opportunity for population monitoring (Millsap and Runde 1988) due to the small population size, impediments to locating large numbers of nests, and the lack of conspicuous concentrations during migration. Given the swallow-tailed kite's vulnerable status and the central role that Florida must play in its conservation, implementation of an effective monitoring program should have the highest priority for management of the species within the state.

The study described in this report was conducted mainly during 1992 as Project Number NG90-036 of the Florida Game and Fresh Water Fish Commission. Additional field work during 1990, 1991, and 1993, supported by other sources, contributed data on neighborhood roost sites and movements of radio-tagged kites. The objectives of the study were: 1) to locate and describe neighborhood and large, pre-migration roosts, including habitat, proximity to nests, patterns of use, and associations of adults and young; 2) to develop methods for surveying large roosts, including estimating total numbers; 3) to develop methods for estimating numbers of adults versus juveniles and breeding versus nonbreeding adults in large roosts, and to compare these results with estimates derived from nest observations; 4) to produce feasible and cost-effective protocols for finding large roosts and for using roost surveys to monitor population status and predict long-term trends; 5) to identify critical roost sites and potential threats to those sites; and 6) to recommend a management strategy that accommodates the swallow-tailed kite's range of spatial and habitat requirements for nesting, roosting, and staging in Florida.

METHODS

Study Area

Field work was conducted in south-central and southern Florida in many of the same areas used for the previously reported study on nesting ecology (Meyer and Collopy 1990). Searches for nests and neighborhood roost sites centered on Big Cypress National Preserve and the adjacent public lands of Everglades National Park, Florida Panther National Wildlife Refuge, and Fakahatchee Strand State Preserve (Fig. 1). Most of the nests on private land were concentrated in Golden Gate Estates, west of Fakahatchee Strand State Preserve. Other privately owned nest sites were on ranchland or suburban woodlots. In all, observations of nests, neighborhood and large roost sites, and dispersing birds involved work in Collier, Monroe, Dade, Broward, Palm Beach, Lee, Hendry, Glades, Highlands, Brevard, and Osceola counties.

Most observations of large roosts were made from the air. The exception was the largest of the known roosts, a mixed swamp forest and marsh site on private land near Fisheating Creek in Glades County, which I was permitted to enter during August and early September 1992. Access was along a levee road maintained by the Army Corps of Engineers.

Study Period and Relationship to Previous Research

Although most of these data were collected during 1992, much of the supporting information on neighborhood roosts, dispersal times, foraging habitat, and reproduction was gathered during 1990, 1991, and 1993 as part of a long-term study of Florida's population of swallow-tailed kites.

Nest Location and Radio-tagging Techniques

Nest-finding techniques and methods for trapping adults for radio-tagging are described in Meyer and Collopy (1990).

Juveniles were captured in the nest by a climber, with techniques modified from those described in Meyer and Collopy (1990). The fastest and most successful climbs were made with the use of mechanical ascenders on a 13-mm climbing rope. The climbing rope was pulled into place over a major limb of the nest tree in roughly the middle third of the crown by a lighter rope that had been pulled up by a monofilament nylon line. The weighted end of the monofilament was shot over the limb with a slingshot as the line spooled off a spinning reel. A light (<70 kg) climber working in little or no wind can gain access to most nests using this technique, which avoids the risks (to tree and climber) of spurs and is logistically far simpler than tree-climbing ladders. The best age for radio-tagging is around 35 days in normally developed young, or about 4 to 6 days before fledging. At this age, they are large enough to be properly fitted with the transmitter but too young to be likely to jump from the nest.

Radio transmitters were attached with a back-pack harness, but the material and methods differed from those described in Meyer and Collopy

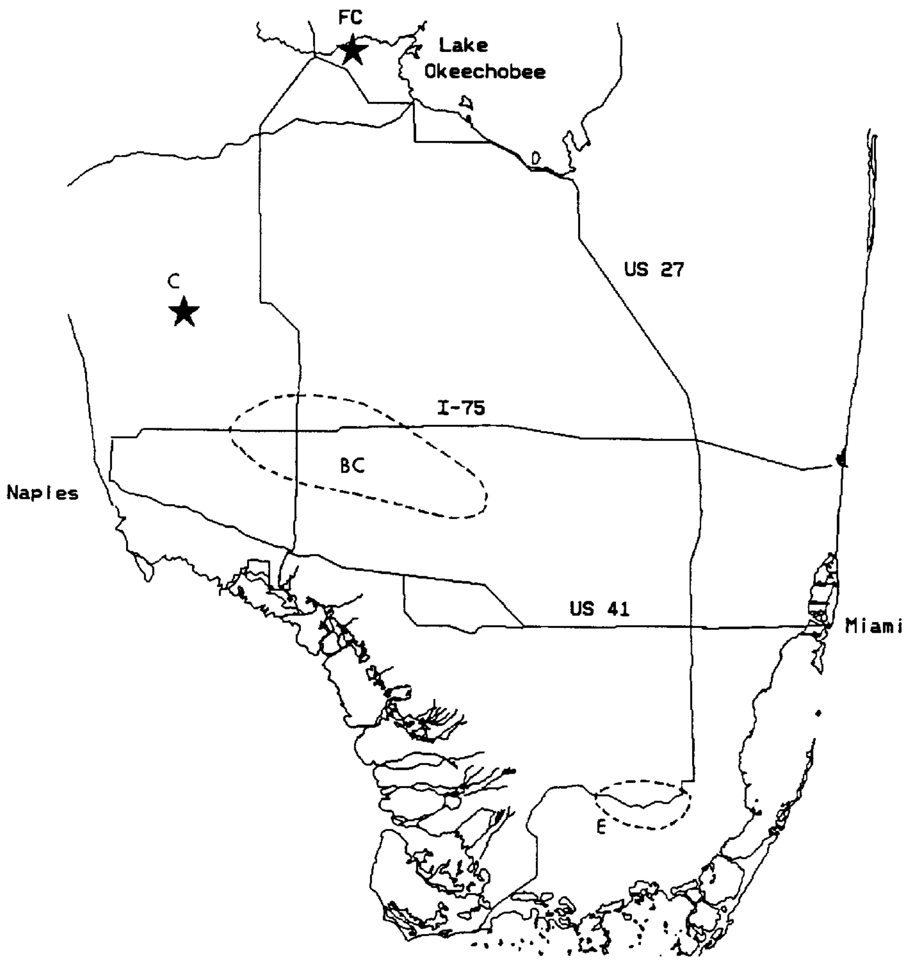

Fig. 1. Study area in southern Florida. Dashed ellipses indicate general locations of nests and associated small roosts (BC = Big Cypress, E = Everglades). Stars indicate locations of large roosts (FC = Fisheating Creek, C = Corkscrew Swamp).

(1990). Harnesses were made of 6-mm-wide teflon ribbon (Bali Ribbon Co., Bali, Pennsylvania). The ends of 4 separate strands were stitched together with cotton thread at a single point and a 12-mm square of soft material was threaded onto the teflon to form a cushion at the junction, which was placed on the bird's sternum. In the field, the free ends of the harness were brought up onto the bird's back (2 anterior to the wings, 2 posterior to the wings and anterior to the legs) and laced bottom to top through holes at the anterior and posterior ends of the transmitter (2 strands at each end). The teflon harness ends were then held in place just above the transmitter with small nylon cable-wraps, which were cut to a point so that they could be passed through the teflon. The cable-wraps were ratcheted tight when the desired fit was achieved, thus preventing the teflon from slipping down through the holes in the transmitter. Excess nylon and teflon were trimmed away and a small amount of cyano-acrylic cement was placed on the ends of the teflon and the clasp of the cable-wrap.

This attachment method has a number of advantages. The teflon, which is strong, nonabrasive, and nonphotosensitive, has been widely used for transmitter harnesses with excellent results. The cotton thread at the single closure will eventually rot away, opening both front and back loops simultaneously and allowing the package to safely fall free. The attachment process is quickly performed in the field and, most importantly, can be accurately adjusted or refitted with little difficulty or loss of time and materials. The single disadvantage is that the teflon does not stretch to accommodate growth or movement. Inhibited movement is far more of a problem with birds that have vigorous, rapid wing motion, such as falcons and accipiters, than with birds such as kites. A tight harness on a growing bird, however, is a cause for concern. The best approach is to err on the side of fitting the harness too loosely, but not so loose that the bird will be able to get its head, a wrist, or a leg lodged under one of the loops.

Twenty swallow-tailed kites (4 adults and 16 juveniles) were radio-tagged from 1990 to 1993, 15 of which were tagged during 1992 or 1993. The kites were tracked from the ground to the extent possible and from the air when long-range movements or mortality precluded detection from the ground. Eleven of the 15 were fitted with transmitters that operated until October or November 1994, providing an opportunity to begin estimating survival, age of first breeding, and extent of philopatry.

Location and Monitoring of Roosts

In addition to data on habitat use during the nesting and dispersal stages, the radio-tagged kites lead to the detection of neighborhood roosts that were not readily located by following unmarked birds. Five kites radio-tagged at nests and tracked to the Fisheating Creek roost provided an estimate of the relative numbers of individuals that joined large roosts, the distances they traveled from their nests to do so, and the conditions that were correlated with early dispersal from the nesting areas. Although no new large roosts were located as a result of radio-tracking, daily activity patterns, foraging ranges, and estimates of total attendance were determined for birds occupying the Fisheating Creek roost.

Surveys to Determine Roost Size and Timing

The total number of kites present in the Fisheating Creek and Corkscrew Swamp roosts was estimated from direct visual counts and photographs during morning flights in July and August 1992. The aircraft was a single-engine Cessna 172 and the primary observer/photographer was seated in the front with access to a window that could be opened for photography. An intercom was essential for effective communication with the pilot.

Because the roost was linear, occupying a narrow stand of trees for a length of 2 to 3 km, the flight path that was least disturbing to the birds, yet sufficiently effective, was an elongated oval surrounding the stand and laterally displaced from the birds by about 250 m. Altitudes varied from 100 to 200 m above ground level (AGL) and airspeed averaged 70 to 75 knots. These conditions allowed for safe operation, little apparent disturbance, and adequate data collection as long as the pattern could be repeated as required, usually for a total time overhead of 15 to 20 minutes. The birds did not take flight as long as the aircraft remained at least 100 to 150 m away and 100 m high. If the aircraft passed over the birds, particularly at an altitude of 100 to 150 m AGL but even above 200 m, large numbers flew up and either drifted off or returned to perches after several minutes, probably depending on thermal or wind conditions.

Survey flights at the Fisheating Creek roost by FGFWFC biologists have been conducted in the early evening by helicopter (Millsap and Runde 1988; Joiner 1990, 1991). While this method allows for exceptional maneuverability and may not be any more disruptive than a fixed-wing survey if sufficient altitude and lateral distance are maintained, it has the disadvantage of much greater cost. Morning flights also face a lower probability of encountering rain and thunderstorms (none of the morning flights in this study were delayed or canceled due to weather, including fog), and it was convenient and cost-effective to track departing kites visually or by radio to determine foraging locations after the roost count was complete.

The kites' behavior also was more stable and predictable in the morning. Swallow-tailed kites arriving at the roost may not remain perched for the night until well after dark, often taking flight and realighting in smaller groups. Bensen's (1992) descriptions of evening arrivals at the Corkscrew Swamp roost suggest that such movements occur more often than not at that site, and I observed similar behavior at Fisheating Creek on my single evening visit on the ground. It also was apparent that the birds were much more easily disturbed in the evening than in the morning, when it was possible to walk quietly within 20 m of the roost trees without causing any of the birds to fly.

Direct visual estimates were made with the commonly used method of counting a portion of the total number (e.g., 50 or 100) and estimating the number of times that unit was repeated. Considerable practice was required and variability was quite high among observers on the same flight. By referring to the aerial photographs taken during the same flights, I was able to check and improve the accuracy of my visual estimates.

The best aerial photographs for counting roosting kites were taken with a 35-mm camera with automatic film advance and a zoom lens set at a focal length of about 70 to 100 mm. Focusing and exposure were best set manually. Color film was essential for distinguishing the kites' white heads against the vegetation; speeds of 100 (e.g., Ektachrome 100) to 200 (e.g., Kodachrome 200) offered the best compromise of short exposure and low grain. High-quality ASA 200 film in conjunction with shutter speeds of 1/250 of a second or faster reduced the effects of engine and wind vibration and produced the best results.

The most accurate counts were possible when the successive slides shot during a given pass overlapped enough to make omissions or duplications of individual birds apparent. Three or more sets of slides, each including the entire roost, were the best assurance that a flight would produce an accurate count for that morning.

Total numbers were estimated from the 35-mm slides by projecting them on a white surface that could be marked with an erasable pen. Portions of the total scene that could be conveniently counted at one time were enclosed with the marker and tallied. Care was necessary to avoid mistaking the white scapulars, which can appear as 2 large blotches on the bird's back, for 2 heads. This was particularly challenging on slides blurred by camera movement or poor focusing.

The 9 flights at Fisheating Creek coincided with the peak and declining phase of the roost. An earlier visual count by FGFWFC biologist N. Joiner, adjusted for the average percentage by which I underestimated my own visual counts (determined by comparison with photographs), was included with these 9 points to produce a curve estimating total numbers in the roost over the season (Program TABLECURVE).

The mean estimated length of attendance at the roost by the 5 radio-tagged kites was divided into the total kite occupancy days (the sum of all daily estimates of numbers present, based on the curve derived from aerial counts) to estimate the total number of individuals using the roost over the season. This estimate of total numbers, while very approximate because of crude and highly variable estimates of attendance by radio-tagged birds, was evaluated for consistency in relation to the size of other recently observed large roosts and the estimate of total population size (Meyer and Collopy, in press).

Estimating Productivity from Counts at Large Roosts

Field observations.—Even though vibration was much less of a problem than in aerial photography, high-speed, low-grain film (e.g., Kodachrome 200) still produced the best results and made it possible to score a greater number of birds per slide than slower, lower-quality film. Automatic film advance with manual focus and manual exposure were the best settings for the ground photographs. Plumage details were more apparent in distant birds if the film was underexposed by 0.5 to 1.0 f-stop relative to the light meter reading.

Juveniles were distinguished from adults in slides taken from the ground by their shorter tails and slightly narrower, shorter wings. Some young birds still appeared to have the pointy wings characteristic of recent fledglings, a condition that gradually disappears in most juveniles as the 2 longest primaries grow to be more equal in length. Adults in particular stages of molt also appear to have short tails, but these birds also were simultaneously undergoing wing molt that was readily apparent (Meyer and Collopy 1990).

The relative numbers of adults and juveniles were counted using methods similar to those described for the aerial photographs of total numbers. Usually 40 to 60% of the birds in a slide could be confidently assigned to an age class. Because many individuals appeared in more than 1 slide, they undoubtedly were counted more than once. The birds, however, were constantly changing position in relation to each other, thereby continually altering the composition of the slides from one shot to the next. Thus, each slide was treated as an independent sample without any inherent biases regarding relative numbers of adults and juveniles. The ratio of adults to juveniles for each morning that departing kites were photographed was derived from the sum of all adults and the sum of all juveniles counted in that day's slides.

Some biases could have resulted from the apparent tendency of juveniles to group together in the roost. This could have created a sampling problem on mornings late in the season when relatively few birds were present, particularly if photographs were taken immediately after the birds rose and before the young became re-sorted among the adults. This situation was relatively obvious, however, and was easily avoided during the photography.

Comparison with reproductive data.—Six years of nesting success and productivity data from 141 nests were used to predict the percentage of juveniles in the Fisheating Creek roost at its peak in 1992. This assumed that relatively few kites left on migration prior to when the roost reached its peak.

Nesting success was defined as the percentage of nests with eggs that fledged at least 1 young. The Mayfield method (Mayfield 1961, 1975) was used to correct the nesting success estimate for the effects of disparities in the timing of nest locations and, thus, the differences in amount of time the nests were exposed to possible failure. The 6-year estimate for nesting success was used solely to determine whether 1992 was a fairly typical year and, thus, an appropriate time to test the accuracy of the productivity estimate derived from roost observations.

Productivity for the 6-year period was estimated as both number of fledged young per nest with eggs and number per successful nest; the former was used to derive the prediction, which was then adjusted to take into account the estimated 1 to 2 nonbreeding adults per nesting pair (Meyer and Collopy 1990) and post-fledging mortality. Six of 20 juveniles (30%) radio-tagged from 1988 through 1993 died prior to migration, with most mortality occurring within 5 weeks of fledging or at least 6 weeks before migration.

Stage of Molt as an Indication of Nesting Success

It was apparent from observations at swallow-tailed kite nests that not all adults molted on the same schedule (Meyer and Collopy 1990). Although few individuals were uniquely marked, and even radio-tagged birds were closely observed over only a portion of the nesting cycle, it became clear that large numbers of unidentified birds were molting during April and May, a time when none of the breeding birds at nests under observation had begun to molt. There are no previous descriptions of molt or molt schedules in swallow-tailed kites, and the study by Meyer and Collopy (1990) did not provide a clear understanding of the relationship between molt and breeding status, the length of time required to complete molt, the variance among individuals in timing and duration, or the progression of molt in failed breeders.

One goal of the present study was to try to clarify any distinctions in schedule between breeding and nonbreeding birds by following the progress of radio-tagged individuals and to attempt to relate the proportions of roosting adults in different stages or molt (i.e., early, late, and complete replacement of plumage) to estimates of the number of adults that bred that year. It was hypothesized that over several seasons an index of breeding effort might at least be developed by correlating known productivity within a year with the percentage of adults in a distinctive stage of molt (e.g., the early stage when the tail appears short and wing secondaries are being replaced) at a standard time, such as during the roost's peak in numbers. The utility of such a measure would depend on the extent of the difference in timing between breeders and nonbreeders and the variance among individuals in each class.

The same ground-based photographs used to estimate percentages of adults and juveniles were used to estimate the percentages of adults in 3 stages of molt: early, late, and complete.

Testing Search Methods for Locating Large Roosts

Four flights were conducted, each with 2 naive observers in the back seat, to determine the altitude, airspeed, and lateral search distance that were most conducive to detecting roosts of 30 to 100 swallow-tailed kites. None of the observers had ever viewed a swallow-tailed kite roost prior to their first flight, and a different site was used for each observer's second flight. The observers were paired with a different person for his or her second flight.

Habitat Descriptions

Because neighborhood roost-site selection was directly related to nest-site selection on all but the finest scale, and because neighborhood roosts were at most 5 km from nests (typically within several hundred meters), a GIS analysis of the relative areas of 20 vegetation cover types within 5 km of 48 nests located in the Big Cypress Swamp region was used to assess neighborhood roost site selection (see Cox et al. [1994] for sources of GIS data and analytical methods). Habitat selection (use versus availability) was determined by comparing the 48 nest sites with 48 randomly selected sites by means of a discriminant function analysis. The 48 sites were chosen by randomly selecting pairs of UTM coordinates from within the boundary of a 95% harmonic mean home range area derived from the distribution of the 48 nests (Program HOMERANGE). Once the accuracy of the discriminant functions for nest and random sites were compared, a stepwise analysis was used to determine the specific cover types selected for and against by the kites.

On a finer scale, the main variables evaluated in the immediate vicinity of neighborhood roost sites were distance from the nests, species and physical structure of the overstory, extent of surface water, and isolation from possible disturbance.

Morning observations of departing kites at the Fisheating Creek roost, mainly in the immediate vicinity during 1992, but also from the periphery during 1993, indicated directions for foraging flights and the consistency of movements within and between seasons. Activity patterns, approximate range sizes, and general foraging habitat were estimated from ground tracking of the 5 radio-tagged kites that joined the Fisheating Creek roost. Habitat use and apparent foraging preferences during the roosting phase were compared with those of radio-tagged kites observed on their nesting ranges.

Annual Variation in Timing and Size of Large Roosts

The extent and possible sources of annual variation in the timing and size of large roosts were evaluated to determine their effects on collecting and interpreting annual survey data.

Monitoring data for large roosts at Fisheating Creek, Jane Green Swamp (Millsap 1987; Millsap and Runde 1988; Joiner 1990, 1991), and Corkscrew Swamp (Meyer and Collopy 1990, Bensen 1992, this report), while not the result of uniform sampling regimes or effort, offered the opportunity to assess annual variation in the timing and maximum number of birds at the large Fisheating Creek roost.

The timing of dispersal from nesting ranges for radio-tagged kites from 1988 to 1993 in relation to surface water levels was used to evaluate the potential influence of environmental conditions, and thus possibly prey populations, on the development and use of large pre-migration roosts. Egg-laying dates for the Big Cypress Swamp and Everglades regions for 1988 through 1993 were used to determine the confounding influence of annual variations in nest initiations on the phenology of large roosts.

Survey and Monitoring Protocols

Protocols were developed for searching for unknown large roosts, surveying large roosts for numbers and timing, and estimating within-year productivity as a means of monitoring long-term population trends. The protocols were based on review of trial aerial searches and surveys and a comparison of productivity estimates from roost observations and reproductive data. The goal was to produce methods that were effective, feasible, and affordable so that they will have a high likelihood of being repeated at regular, frequent intervals. Descriptions of nest-finding, trapping, and radio-tagging techniques are intended to encourage more intensive searches and study in cases where these more costly approaches are justified.

Critical Sites and Management Recommendations

Recommendations for protecting appropriate and sufficient habitat for neighborhood roosts, at both gross and fine scales, fell within those made for nesting habitat and they are reiterated in this report. The chief consideration regarding these small, nesting-cycle roosts is that the characteristic features required for these sites be included in any evaluation and management of known or potential nesting habitat.

Three categories were used to evaluate the importance of sites for large, pre-migration roosts: relatively large (used by ≥100 kites), well-documented roosts known to be recently and consistently used; roost sites or general locations used during July and August within the last 5 years by at least 20 kites; and areas that have high potential for containing large roosts based on suitability of habitat and landscape features, proximity and extent of appropriate nesting habitat, and any records of concentrations of nesting or foraging kites. Recommendations for management action were based on the relative importance and vulnerability of the sites.

Conservation needs imposed by the habitat requirements of roosting swallow-tailed kites were evaluated in relation to the known inadequacies of presently protected lands as nesting habitat (Meyer and Collopy 1990, in press; Cox et al. 1994). The resulting recommendations, made with reference to a statewide evaluation of habitat conservation needs (Cox et al. 1994), a study of habitat conversion in the study area (Mazzotti et al. 1992), and the combined results of studies of nesting ecology and roosts of swallow-tailed kites (Meyer and Collopy 1990, this report) are aimed at increasing the long-term viability of the population in its current center of abundance.

RESULTS

Roost Locations and Phenology

Neighborhood roosts began forming in late February and early March, as soon as the swallow-tailed kites arrived after migration. Early-season roosts often were small (2 to 10 birds), transitory, and conspicuous within 100 to 200 m of active nest sites. Most of the small neighborhood roosts that we observed were in areas where we had located the greatest numbers of nests and, subsequently, spent the most time: Bear Island, located in the northwestern corner of Big Cypress National Preserve adjacent to what remains of the Okaloacoochee Slough; eastern Long Pine Key in Everglades National Park; and Golden Gate Estates, a platted, but mostly undeveloped, privately owned area between Fakahatchee Strand State Preserve and Naples.

Ten swallow-tailed kites radio-tagged during 1989, 1992, and 1993 were tracked and observed in a total of 11 neighborhood and large roosts (Table 1). Seven of the radio-tagged kites revealed a total of 8 neighborhood (small) roosts that were farther from nests (an average of 2.8 km), larger (10 to 40 birds), and more consistently used over the nesting season than the smaller neighborhood roosts that formed near nests early in the season (Table 1, all small roost sites except Fisheating Creek South and Corkscrew South). These sites also were more isolated from disturbance, more likely to have snags, and wetter, with the roost trees in standing water for most or all of the season. The Fisheating Creek South and Corkscrew South roosts were used for short

Table 1. Distances from nests to large and small roosts for 10 radio-tagged swallow-tailed kites in 1989, 1992, and 1993.

Bird #	Year	Large Roost	Small Roost	Distance (km)
717	1989		Fakahatchee	3.9
210	1989		Slough	2.7
807	1989		Cowpen	0.7
476	1989		Raccoon Point	2.2
478	1989		Taylor Slough	4.9
566	1992		Twin Palms	3.4
566	1992		Fisheating Creek South	74.4
566	1992		Fisheating Creek	71.5
259	1992		Cowpen	0.9
259	1992		Twin Palms	3.5
259	1992		Corkscrew South	33.7
259	1992	Fisheating Creek		80.9
196	1993	Fisheating Creek		80.7
236	1993	Fisheating Creek		79.4
870	1993	Fisheating Creek		109.5

periods of time late in the season. The Fisheating Creek South site, located about 8 km southwest of the large Fisheating Creek roost, was used by a juvenile from Bear Island for at least 5 nights in July 1992 before joining the large roost. The Corkscrew South site was used by an adult from Bear Island and 12 to 31 other kites for 4 nights in August 1992 after the radio-tagged bird left the large Fisheating Creek roost. Both of these sites fit the physical description given above for the larger neighborhood roost sites.

In addition to the neighborhood roosts located by radio-tracking (Table 1), some of which contained 20 to 40 birds and were quite stable over time, 5 other roosts of similar size were identified as a result of regular nest observations in the Big Cypress National Preserve and Everglades National Park. These probably were neighborhood roosts as well, since they were observed prior to the time when young would have fledged.

Two large roosts, Fisheating Creek and Corkscrew Swamp (Fig. 1), were regularly monitored, and the Jane Green Swamp site was checked once in 1992. The Fisheating Creek and Corkscrew Swamp roosts, both of which have been monitored to some extent since 1988 (Millsap and Runde 1988; Joiner 1990, 1991; Meyer and Collopy 1990; Bensen 1992; T. Below, pers. commun.; this report), generally have formed in late June, peaked from late July to early August, and emptied by mid-September.

Fisheating Creek was used by 2 of 5 radio-tagged kites in 1992 and 3 of 11 in 1993 (Table 1). No radio-tagged kites were detected in either of the other 2 large roosts. All 5 kites that joined the Fisheating Creek roost were radio-tagged at nests in Big Cypress National Preserve, and 4 of the 5 were juveniles (#259 was the adult). Three of the juveniles and the single adult came from Bear Island (#s 196, 236, 566, and 259), an average distance of 80.6 km south-southwest of the roost; the fourth juvenile (#870) came from the eastern edge of Big Cypress, 109.5 km south-southeast of the roost (Table 1). During the 2 years, a total of 6 other radio-tagged kites, trapped at distances ranging from 1.1 to 31.6 km (mean = 16.3 km ± 5.7 S.E.) to the east, west, and north of the 5 birds that used the roost, were not detected in or near the Fisheating Creek roost. One, a juvenile in Bear Island, remained near its nest until late August and the other 5 were last detected within about 15 km of their nesting territories from late July to early August, or at least until the Fisheating Creek roost reached its peak.

Large Roost Surveys: Timing and Numbers

Of 9 survey flights at Fisheating Creek during July and August 1992, 7 included both direct and photographic counts, while the last 2 had only direct counts (Fig. 2). Both direct and photographic methods were used during the 3 flights at the Corkscrew roost during the same period (Fig. 3). The aerial photographs were reviewed as soon as possible after each flight and compared with the direct visual estimate. On the first 3 flights at Fisheating Creek, visual counts were 20 to 35% lower than photographic counts, but by flights 5 through 8, the difference averaged less than 10% (Fig. 2).

All the photo interpretation and direct visual counts reported here were made by the researcher. Visual counts by the pilot and other observers differed from the researcher's visual counts by about ±25 to 40%, and this difference showed no tendency to decrease over the course of the observations.

The greatest number of kites at Fisheating Creek as estimated from the photographic counts was 1,550 on 1 August. The maximum number observed at Corkscrew was 135 on 29 July.

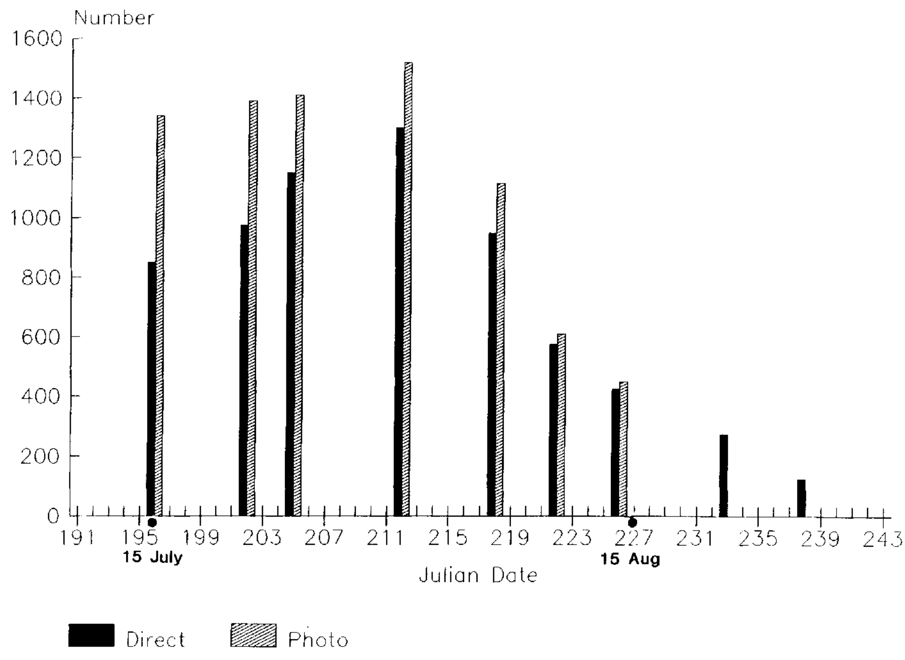

Fig. 2. Comparison of direct and photographic aerial counts of roosting swallow-tailed kites at Fisheating Creek, July and August 1992.

A curve estimating the overall number and temporal distribution of swallow-tailed kites at the Fisheating Creek roost in 1992 was derived from 10 daily estimates (Fig. 4). Seven estimates were based on the photographic counts, 2 were late-season visual counts corrected by a factor of +8%, and 1 was a visual count made by a FGFWFC biologist on 30 June (N. Joiner, pers. commun.), which was corrected by the average discrepancy for the 7 counts made both visually and photographically. The curve was constructed using Program TABLECURVE and had the following equation:

$$y = ([a + cx] / [1 + bx + \{dx.dx\}]),$$
where: $a = 2.8996$,
$b = 0.0092$,
$c = 0.0110$, and
$d = 2.1430$;
$r^2 = 0.9728$.

Based on the curve, the Fisheating Creek roost peaked on 27 July at 1,550 kites.

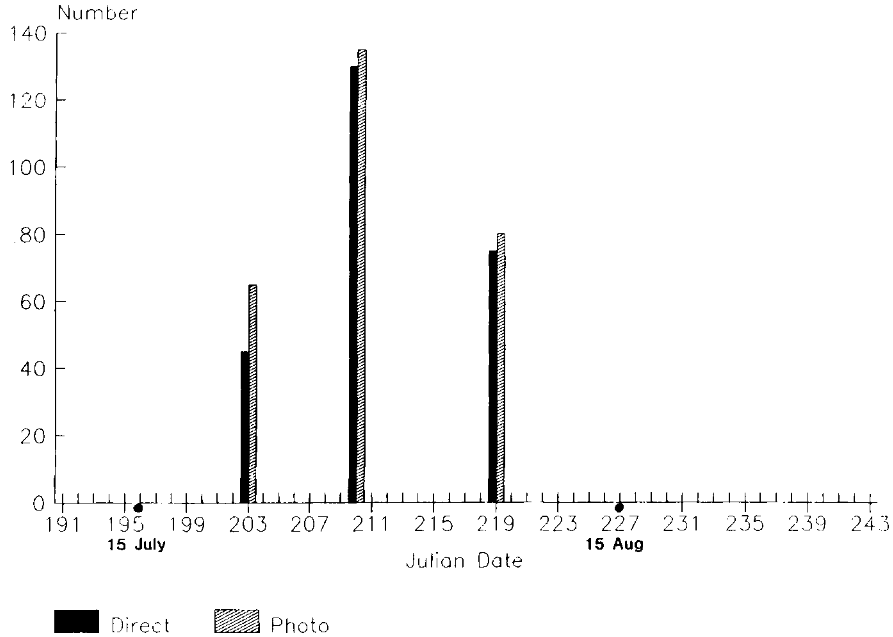

Fig. 3. Comparison of direct and photographic aerial counts of roosting swallow-tailed kites in Corkscrew Swamp, July and August 1992.

Estimates for the total length of attendance at the Fisheating Creek roost by the 5 radio-tagged birds were imprecise due to occasional long intervals between detections. These estimates ranged from a possible minimum of 12 days for 1 bird to a possible maximum of 59 days for another. It was possible, however, to estimate total kite-occupancy days with a reasonable degree of accuracy by summing the daily occupancy estimates taken from the curve in Fig. 4. Using a range for mean length of attendance of 25 to 35 days and total kite-occupancy days of 63,415, the total number of swallow-tailed kites that occupied the Fisheating Creek roost over the season was estimated at 1,812 to 2,537 (63,415/35 and 63,415/20).

Estimating Productivity from Counts at Large Roosts

Three estimates were made in the field for morning departure times in relation to sunrise during the 6 ground visits to the Fisheating Creek roost: first departures, approximate peak, and when fewer than 10% of the birds remained

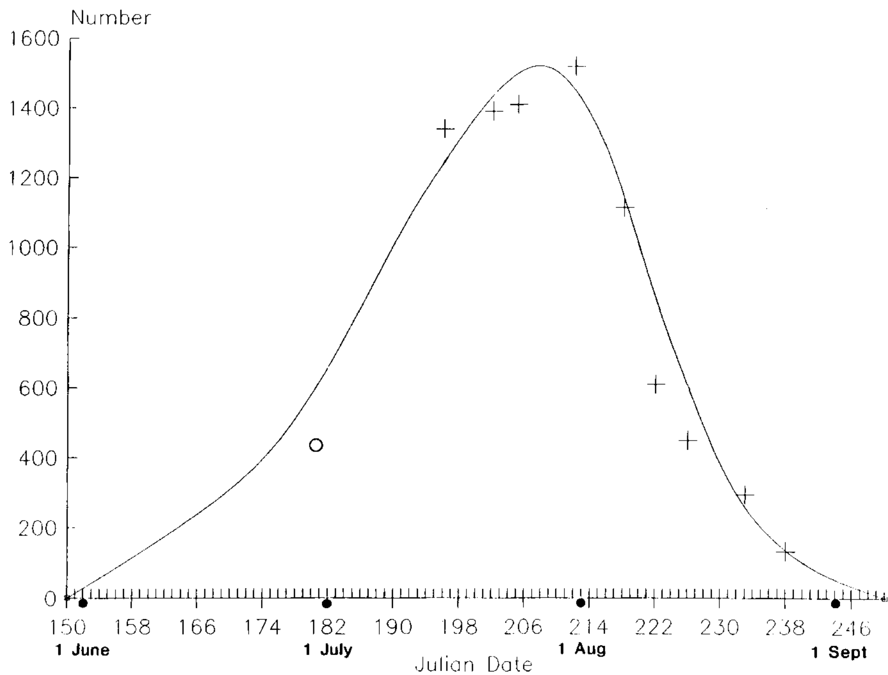

Fig. 4. Overall estimate of numbers of swallow-tailed kites (adults and juveniles combined) during June, July, August, and early September 1992 at Fisheating Creek roost, derived from curve-fitting program TABLECURVE and based on 9 aerial counts (+ signs, see Fig. 2). Open circle indicates corrected direct aerial estimate by FGFWFC personnel on 29 June ($r^2 = 0.973$; see Results for equation).

Table 2. Time of morning departures (in minutes after sunrise) of swallow-tailed kites at the Fisheating Creek roost in August and early September 1992. Observations were made from the ground (n = 6) and from the air (n = 2).

	First departure	Approximate peak	<10%
Mean	98	111	128
SE	3	6	8
Range	86–109	92–128	102–151

perched (Table 2). The variance was very low, indicating that morning departures are quite predictable. This enhances the efficiency of morning visits for photographing departing flights. Departures also were relatively late (nearly 2 hours after sunrise for the peak), making light conditions favorable for photography.

The percentage of juveniles present in the roost shortly after the peak on 4 August 1992, as determined from photographs of departing flocks, was about 17% (Fig. 5). There was little change over the next 10 days, but the

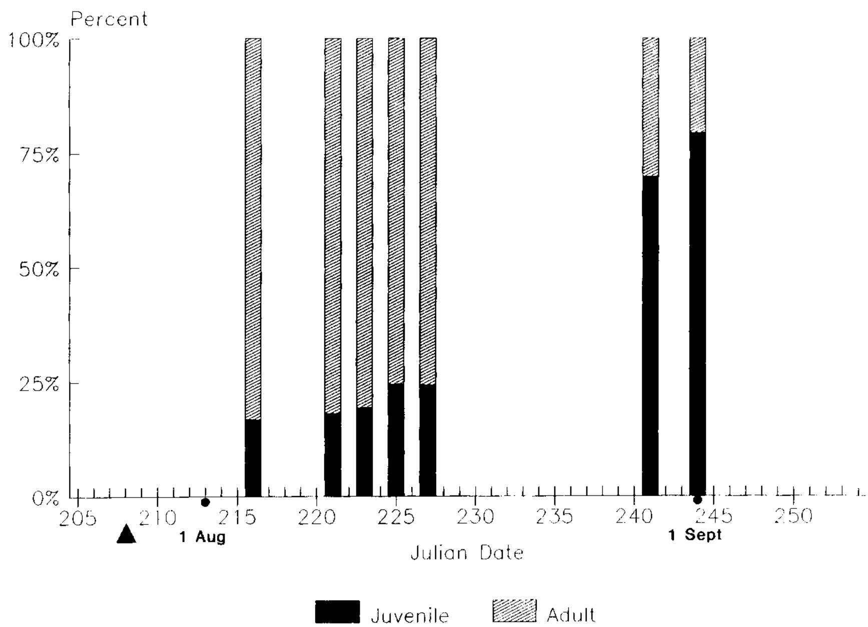

Fig. 5. Changes in relative proportions of adult and juvenile swallow-tailed kites during the declining phase of the Fisheating Creek roost, August and early September 1992. Triangle indicates date when roost had maximum number of kites.

Table 3. Relative proportions of adults and juveniles in Fisheating Creek roost during August and September 1992.

Date	Number present[a]	Number photographed	Number scored	Adult:juvenile	Percent juvenile
08-04	1,250	689	322	4.96:1	16.8
08-09	735	569	330	4.50:1	18.2
08-11	570	353	124	4.17:1	19.4
08-13	490	399	209	3.08:1	24.5
08-15	425	361	173	3.10:1	24.4
08-29	105	162	101	0.43:1	69.8
09-01	45	324	260	0.26:1	79.4

[a]Estimated from photographic counts on nearest dates.

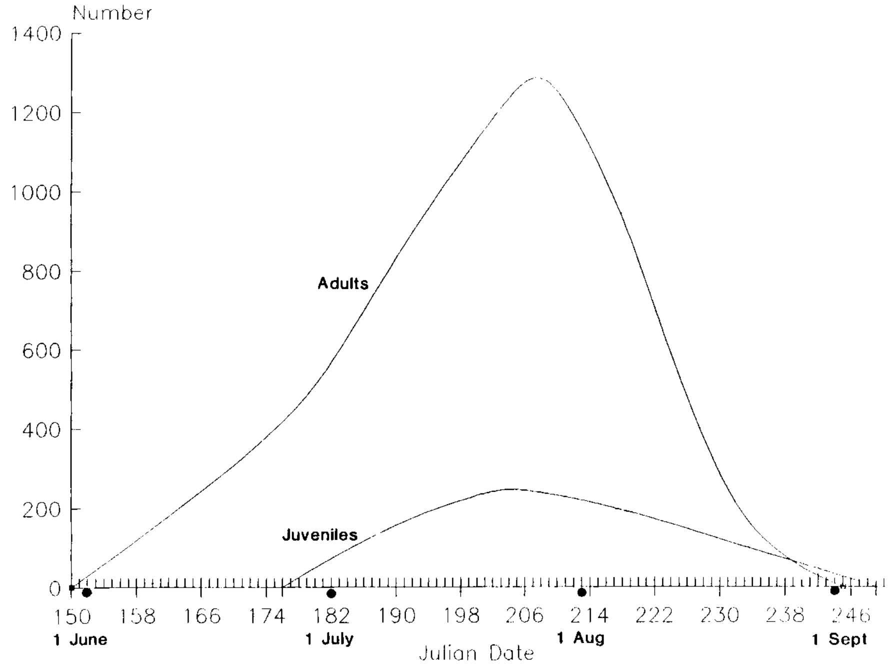

Fig. 6. Estimate of relative numbers of adult and juvenile swallow-tailed kites during June, July, August, and early September 1992 at Fisheating Creek Roost. Curves are based on the overall estimate of kite numbers (Fig. 4) and the relative proportions of adults and juveniles as estimated from photographs of morning departures.

relative number of adults fell sharply after mid-August. By 1 September 1992, 79% of the kites in the roost were juveniles (Fig. 5 and Table 3).

One flock of 30 kites and a second of 30 to 40 were observed flying south in early evening in Big Cypress National Preserve, 120 km to the south, on 9 August and on 11 August 1992. These flights were particularly noteworthy because almost no swallow-tailed kites had been observed in the preserve for nearly 5 weeks, and winds were northeasterly during one observation and had been northerly the day before the other (Big Cypress National Preserve Remote Access Weather Station data). Northerly winds are relatively rare, or at least short-lived, in southern Florida during the summer. Two similar observations of possible migrant kites on 10 August 1993 (12 birds) and 15 August 1993 (20 birds) also were made after a shift to northerly winds.

The curve in Fig. 4 was redrawn to show the separate adult and juvenile components of the Fisheating Creek roost (Fig. 6), as suggested by the estimated ratios of adults to juveniles during August (Table 3).

In order to evaluate the potential value of large swallow-tailed kite roosts for estimating within-year productivity and, thus, monitoring longer-term population trends, it was first necessary to review the annual estimates for nesting success and productivity collected over the last 6 years. Mean nesting success for 141 nests was 60% (±7% S.E.), and mean productivity was 0.90 (±0.13 S.E.) young fledged per nest with eggs (Table 4). In 1992, nesting success was 56% for 31 nests and productivity was 0.89 young per nest with eggs (Table 4), indicating that the year was sufficiently close to average for reproduction to justify a test of estimating population productivity from roost observations.

Table 5 summarizes the derivation of a prediction for the percentage of juveniles in the swallow-tailed kite population prior to migration, after annual

Table 4. Estimates of swallow-tailed kite nesting success (Mayfield method) and productivity for 6 years.

Year	Percent (n) successful	Young per attempt	Young per successful attempt
1988	41 (23)	0.48	1.20
1989	80 (26)	1.27	1.57
1990	45 (15)	0.75	1.62
1991	81 (23)	1.26	1.55
1992	56 (31)	0.89	1.42
1993	57 (23)	0.72	1.23
X ± SE	60 ± 7.0 (141)	0.90 ± 0.13	1.43 ± 0.07

Table 5. Predicted percentage of juvenile swallow-tailed kites in the population prior to migration (based on estimates for nesting productivity, fledgling mortality, and the relative number of nonbreeding adults) compared with the percentage observed at Fisheating Creek in 1992.

Mean productivity (fledged young per nesting attempt, n = 141 nests over 6 years)	0.90
Productivity in 1992 (n = 31 nests)	0.89
Adjusted productivity in 1992 (productivity minus 30% estimated for post-fledging mortality, based on 20 radio-tagged fledglings)	0.62
Estimated nonbreeding adults per nesting attempt	1–2
Predicted percentage of juveniles in population prior to migration	13–17
Observed percentage of juveniles in 1992 communal roost	16.8

productivity, post-fledging mortality, and the average number of nonbreeding adults per breeding pair are taken into account. If the average number of nonbreeders per pair is 2, 13% of the roost occupants should be juveniles in a year with average productivity and mortality. If the average number of nonbreeders per pair is 1, the prediction is for 17% juveniles. The observed percentage of juveniles in the Fisheating Creek roost on 4 August, 8 days after the estimated peak in roost occupancy (Fig. 4), was 16.8% (Table 3).

The estimates for percentage of juveniles present in the Fisheating Creek roost were based on the assignment of 1,519 bird images out of a total of 2,857 images photographed to either the adult or juvenile age class (Table 3). The mean number of bird images assigned an age class per morning for the 7 mornings on which departing flights were photographed was 217 (±34 S.E.).

On 24, 27, and 30 August 1993, I counted juveniles and adults departing the Fisheating Creek roost area during 3 observations from a point 15 km southeast of the roost. Of a total of 70 birds seen crossing my position, 37 were juveniles, 11 were adults, and 22 could not be assigned an age. Of the known-age birds, 77% were juveniles. The average percentage of juveniles counted from photographs taken at the roost on 29 August and 1 September 1992 was 75%.

Estimating Nesting Effort and Success by Evaluating Molt in Large Roosts

Observations at many nests have indicated that distinct stages of adult molt could be recognized and adults could be distinguished from juveniles during any stage (Fig. 7) (Meyer and Collopy 1990). There also was a distinction in the timing of molt between breeders and nonbreeders and probably between successful breeders and adults that failed relatively early in

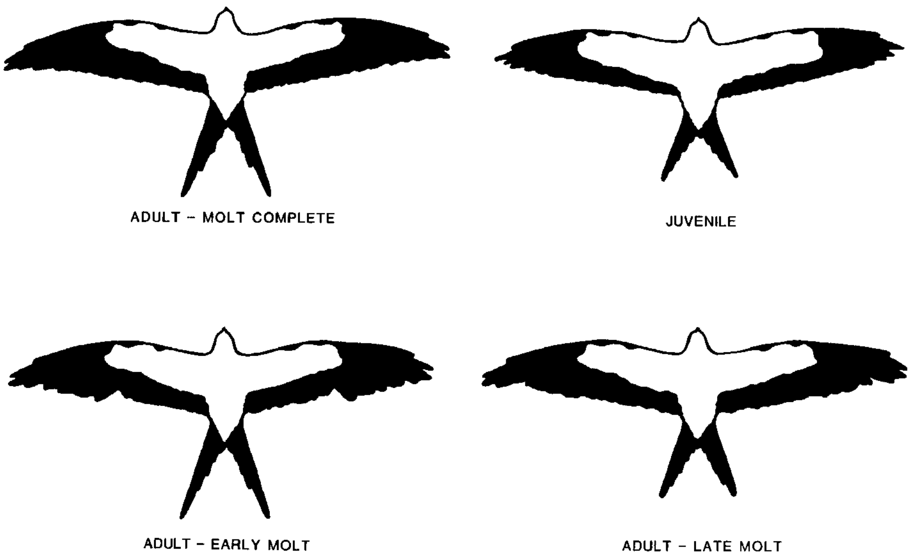

Fig. 7. General plumage and molt patterns of adult and juvenile swallow-tailed kites observed during 5 nesting seasons, 1988–1992.

nesting. Adults photographed during morning departures at the Fisheating Creek roost showed wide disparity in the extent to which molt had progressed (Fig. 8). As in the previous study, however, it was not possible to observe enough marked adults closely or frequently enough to accurately describe molt schedules. It remains unclear whether the difference between and the variance within the 2 groups will permit observations of adult plumages at roosts to be used for estimating within-year nesting success.

Testing Search Methods for Large Roosts

None of the observers discovered the roost on their first flight until they were within 200 to 300 m and had deduced from our repeated coverage of a transect that a roost was nearby. The 2 observers who made second flights showed a dramatic improvement in their ability to detect the roost during the first pass within 500 m. The observers, including 1 with several years of experience conducting aerial surveys for large birds (as both pilot and observer), were unanimous in concluding that the 2 most important considerations were the lateral distance they were expected to search and, especially, the prior experience of observing at least 1 moderately small swallow-tailed kite roost from the air.

The performance and comments of the observers indicated that the most effective and efficient flight regime, within the limits of safe operation, was an airspeed of 75 to 80 knots at an altitude of about 225 m. All observers had a strong tendency to gradually concentrate their searching closer to the aircraft and had to make a continuous, conscious effort to look outward. At 225 m AGL, the maximum lateral distance that observers can be expected to consistently search was about 750 m.

Migration

Adult kite #259 was radio-tracked for nearly 3 months after being tagged near its nest on 21 May 1992. Its movements are traced in Figure 9, beginning at the nest in Bear Island, Big Cypress National Preserve. Two local neighborhood roosts were used until 6 July (Cowpen and Twin Palms, Table 1). The kite was next detected in the Fisheating Creek roost on 31 July, a distance of 80.9 km from its nest, and was present on all 10 successive ground and air checks of the roost through 11 August. It was not in or near the roost

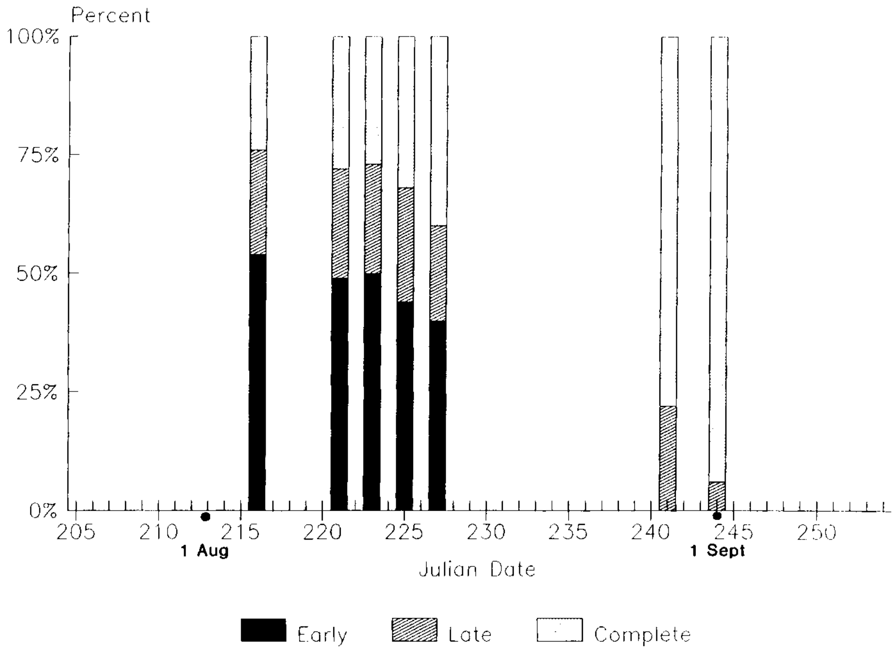

Fig. 8. Relative portions of adults in 3 stages of mole, based on ground photographs of aggregations of swallow-tailed kites during morning departures at Fisheating Creek roost, August and September 1992.

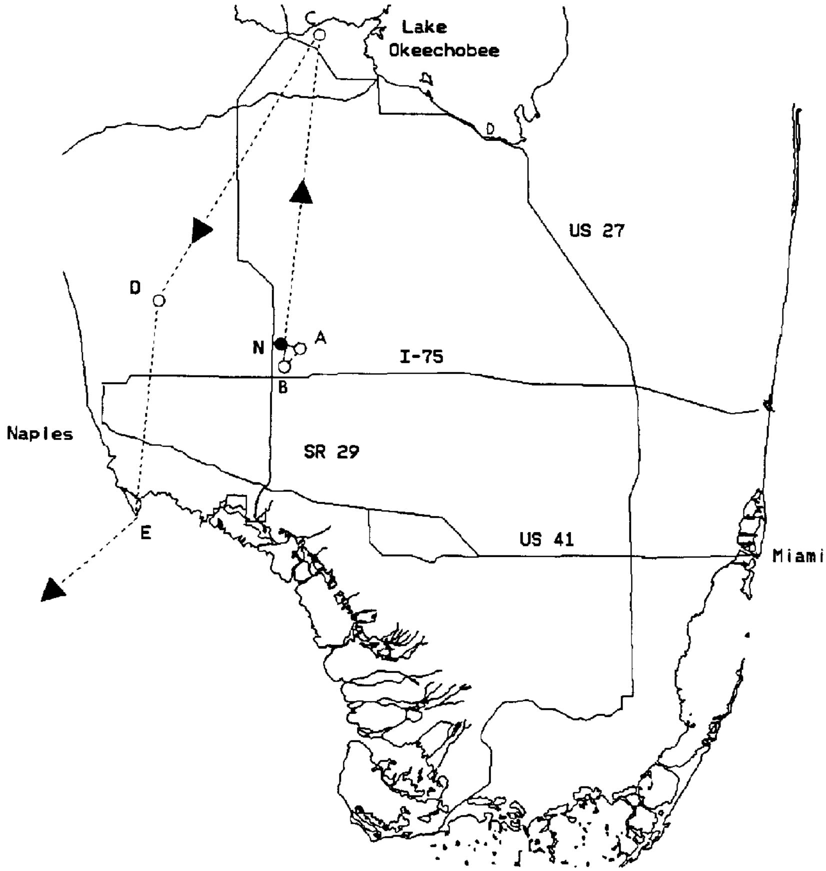

Fig. 9. Study area in southern Florida with nest and roost locations for radio-tagged kite #259 in 1992 (N = nest, A and B = small roosts, C = large roost at Fisheating Creek, D = small roost south of the large Corkscrew Swamp roost, E = the last land location [Cape Romano] at the start of migration).

on 12 or 13 August, but was located (from the air) in late afternoon on 14 August roosting 8 km south-southwest of the visitor center at Corkscrew Swamp Sanctuary, Collier County (Corkscrew South, Table 1), a distance of 33.7 km from its nest and 80.1 km from the Fisheating Creek roost. The kite remained in that area, foraging and going to roost in early to mid-afternoon, until 1510 hours on 17 August, when it was located (from the air) moving southwestward over Cape Romano, 30 km south of Naples in Collier County.

The flight of #259 and the accompanying 12 kites consisted of small circles, at times rising and at other times drifting more downwind with a loss of altitude. The birds mostly remained between 150 and 300 m above sea level. It took the 13 kites 3.3 hours to travel 21 km offshore. Their average heading during that time was 225°, and the winds in the Naples area were light to moderate from the north-northeast, a heading of about 200°.

Habitat Selection

The neighborhood roosts that contained the largest numbers of birds and were most consistently occupied over the season were within 5 km of the nests of the radio-tagged kites used to locate the roost. In general, these roosts were in cypress or swamp hardwoods, except in Everglades, where pines were used; usually in stands with above average densities of snags, although the kites appeared as likely to use live trees; almost invariably in standing water, at least after early summer; usually isolated from human disturbance to a greater degree than nests.

A GIS analysis of the 78.5-km^2 area (5-km radius) surrounding 48 nest sites in the Big Cypress region characterized the habitat selected by nesting and roosting swallow-tailed kites. The relative percentages of 20 cover types within a 5-km radius of the 48 nests are shown in Table 6. The discriminant functions produced for the 48 nest areas and 48 randomly selected areas successfully distinguished between nest and random areas when the 96 areas were evaluated by the model, with 90% of the nest areas and 77% of the random areas correctly assigned to category (Table 7). The subsequent stepwise analyses determined that hardwood swamp and cypress swamp were

Table 6. Percentages of 20 vegetation cover types within a 5-km radius of 48 swallow-tailed kite nests in the Big Cypress Swamp region.

Cypress swamp	25.34
Freshwater marsh	20.50
Hardwood hammock	10.10
Pine forest	9.65
Grassland/agricultural	8.53
Hardwood swamp	7.66
Barren land	4.97
Shrub and brush	4.00
Shrub swamp	2.41
Dry prairie	1.17
Wet prairie	1.11
Hardwood with pine	1.51
Sandhill	0.95
Open water	0.68
Salt marsh	0.46
Oak scrub	0.28
Bay swamp	0.24
Mangrove swamp	0.10
Tropical hammock	0.05
Bottomland hardwood	0.02

Table 7. Discriminant function analysis of 48 swallow-tailed kite nest sites in the Big Cypress Swamp region, based on a GIS analysis of 20 vegetation cover types within 5-km radii of the nests and 5-km radii of 48 randomly selected points within a 95% harmonic mean area derived from the distribution of nest locations (Program HOMERANGE). Cell values are the percentages of nest and random sites classified into each category by the discriminant function.

	Nest (n = 48)	Random (n = 48)
Nest	90%	10%
Random	23%	77%

Table 8. Stepwise discriminant analysis, indicating the vegetation cover types that were most strongly selected for (+) and against (-) by nesting swallow-tailed kites. Probability values are the results of F tests.

Cover type	r-squared (partial)	Probability	Selection
Hardwood swamp	0.237	0.0001	+
Cypress swamp	0.165	0.0001	+
Grassland-agricultural	0.017	0.2176	-

most strongly selected for ($p < 0.0001$), while grassland/agricultural cover types were most strongly selected against ($p = 0.2176$) (Table 8).

A use-versus-availability analysis of radio-tracking data for 8 nesting swallow-tailed kites indicated preferences among foraging habitats (Table 9). The most strongly selected vegetation associations were mosaics dominated by cypress, with pine, hardwood hammocks, and small, interspersed prairies. Second were similar mosaics with pine rather than cypress dominant. Additional selection for hardwood hammocks and hardwood scrub reinforced the conclusion drawn in the previous study that nesting swallow-tailed kites, which fed their developing young large numbers of small arboreal vertebrates, foraged in long-hydroperiod, structurally diverse vegetation mosaics that

Table 9. Habitat selection based on radio tracking of 8 nesting swallow-tailed kite adults in the Big Cypress Swamp region, 1988 to 1992. Use versus availability was analyzed using Chi-square and Bonferroni Z statistics, with $p < 0.05$ for all vegetation associations listed. Within each association, cover types are listed in order of decreasing dominance.

Rank	Used more than expected	Used less than expected
1	Cypress, pine, hammock, and small prairie mosaic	Prairie with scattered pine and cypress
2	Pine, cypress, hammock, and small prairie mosaic	
3	Hardwood hammock	
4	Hardwood scrub	

offered hardwood foliage, shrubs, and emergent grasses as a substrate (Meyer and Collopy 1990).

Observations from the ground and air at the Fisheating Creek roost from 15 July to 1 September 1992 indicated that most departing kites headed northeast to southeast (Fig. 10). Two radio-tagged kites (#259 and #566 from Big Cypress National Preserve), tracked from the roost during 6 all-day sessions during the first 2 weeks of August 1992, appeared to have established foraging ranges based at the roost. During the first 5 sessions, 1 bird (#566) went northeast each morning to the Brighton Indian Reservation and the other (#259) went southeast over the freshwater marshes west of Lake Okeechobee. The maximum distance traveled by both birds on each day was 19 to 21 km, which is very similar to the maximum foraging distances for radio-tagged kites in Everglades National Park (Meyer and Collopy 1990) and coastal South Carolina (Cely and Sorrow 1990). During the sixth session, which was the last time the birds were detected near the Fisheating Creek roost, the birds reversed their departure directions (#259 went northeast and #566 went southeast) but used forested wetlands and freshwater marshes in essentially the same areas used by each other during the 5 previous sessions. Both birds were nearly always observed with 1 to 14 other swallow-tailed kites. Observations from the roost and from various points within 16 km indicated that the ascending

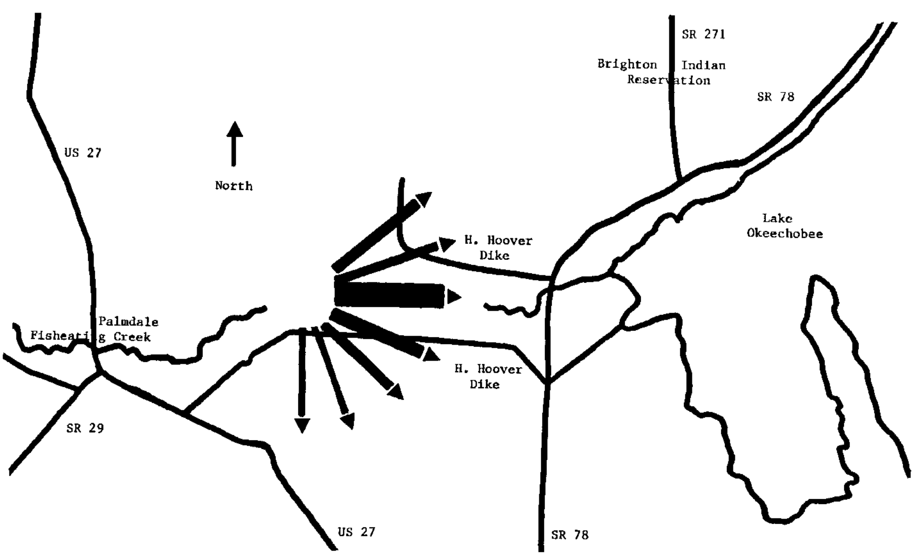

Fig. 10. Fisheating Creek roost site and direction of morning departures during 11 observations, 15 July to 1 September 1992. Departure bearings were averaged to create seven general directions. Arrow width indicates relative numbers of kites.

flocks of hundreds of kites drifting eastward from the roost each morning broke up into such smaller groups within 3 to 10 km of the roost.

Annual Variations in Timing and Numbers at Large Roosts

The existing data for Fisheating Creek (Millsap 1987; Millsap and Runde 1988; Joiner 1990, 1991) and Corkscrew Swamp (Meyer and Collopy 1990, Bensen 1992, this report) suggest that the peak at both sites has occurred anywhere from 17 July to 6 August. Of the 3 large pre-migration roosts (Fisheating Creek, Corkscrew, Jane Green Swamp), only Fisheating Creek and Corkscrew have been observed frequently enough within a year to determine with fair accuracy the date and occupancy at the roost's peak. Fisheating Creek peaked with at least 1,295 kites between 20 July and 2 August 1988 (7 observations, Millsap and Runde 1988) and at about 1,550 on 27 July 1992 (10 observations, Fig. 4); Corkscrew peaked at 344 on 25 July 1989 (17 observations, Bensen 1992).

Annual variations in timing can be detected and adjusted for with sufficient and appropriately timed survey flights (Fig. 4). Annual variations in the maximum number that are not due to changes in the population are more problematic if roosts are to be used for long-term monitoring. Estimates for the maximum numbers at Fisheating Creek from 1987 to 1993 (excluding 1989, for which observations were too few and too late) ranged from about 800 to 2,200 (mean = 1,406 ± 188 S.E.).

Kites using the Fisheating Creek roost have occupied at least 4 different sites within about an 8-km^2 area from 1987 to 1993. When first found, the roost was in an insular, open stand of small cypress trees (Millsap 1987). In 1988, a nearby stand of slash pine *(Pinus elliottii)* was used for about 3 weeks at the start of the roosting period, after which the kites returned to the cypress stand (B. Millsap, pers. commun.). In 1990, the roost moved about 2.5 km south to a linear stand of Australian pines *(Casuarina* sp.), where large numbers of birds were observed through 1993. In 1992, about 100 kites were also seen about 1.0 to 1.5 km north of the *Casuarina* site about 500 m from the edge of a fairly continuous stand of small cypress (pers. obs.). In 1993, while 700 to 800 were using the *Casuarina* site, about 1,500 more were observed about 1.5 km to the north roosting in small trees at the fragmented edge of a cypress stand (N. Joiner, pers. commun.).

As already described for radio-tagged swallow-tailed kites in Big Cypress Swamp (see Roost Locations and Phenology), it is difficult to predict and explain the number and departure times of birds that join the Fisheating Creek roost. Variations in laying dates and dispersal times of radio-tagged kites were analyzed between the Big Cypress and Everglades regions and within Big Cypress between years to examine the possible influence of these factors on the development of the large roost. Swallow-tailed kites in the Everglades dispersed from their nesting areas later than kites in Big Cypress (Fig. 11) ($p < 0.05$, Mann-Whitney U test). Similarly, egg laying dates were significantly later in Everglades than in Big Cypress (Table 10) ($p < 0.00003$, Mann-Whitney U test). No radio-tagged kites from Everglades joined the Fisheating Creek roost, however, and roosts numbering 30 to 40 birds were observed in Everglades National Park until late August in several years.

Laying dates in the Big Cypress region did not differ significantly over 5 years, ranging from 29 to 31 March (Table 11) ($p = 0.92$, Chi-square approximation of the Kruskal-Wallis test).

Table 10. Comparison of mean laying dates and estimated fledging dates of swallow-tailed kites in the Big Cypress Swamp and Everglades regions from 1988 to 1992 (years combined).

Region	Mean laying date[a]	Estimated fledging date[b]
Big Cypress (n = 74)	30 March	6 June
Everglades (n = 21)	11 April	18 June

[a]$p < 0.00003$, Mann-Whitney U test
[b]Based on mean laying date plus average incubation (28 days) and nestling (40 days) periods

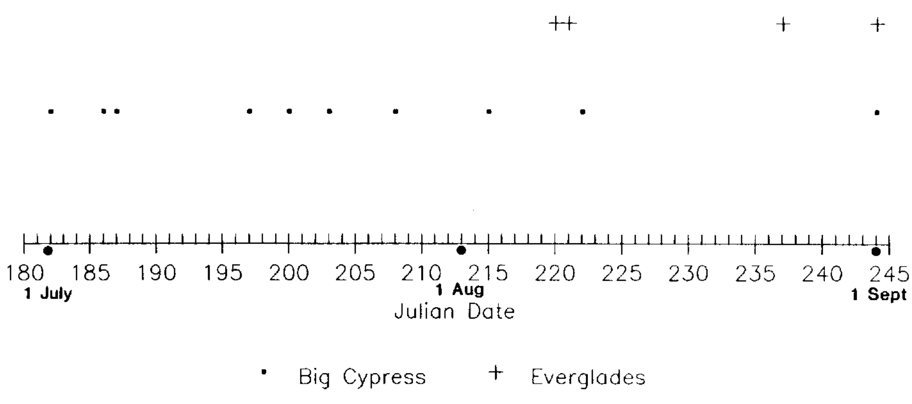

Fig. 11. Comparison of Big Cypress Swamp and Everglades regions in the timing of dispersal from nesting home ranges for radio-tagged swallow-tailed kites in 1989, 1990, and 1992 (years combined).

Table 11. Annual mean laying dates and estimated fledging dates for swallow-tailed kites in the Big Cypress Swamp region from 1988 to 1992.

Year (nests)	Mean laying date[a]	Estimated fledging date[b]
1988 (9)	30 March	6 June
1989 (15)	29 March	5 June
1990 (11)	29 March	5 June
1991 (20)	31 March	7 June
1992 (19)	31 March	7 June

[a]$p = 0.92$, Kruskal-Wallis test (Chi-square approximation)
[b]Based on mean laying date plus average incubation (28 days) and nestling (40 days) periods

The timing of dispersal from nesting ranges for radio-tagged kites in 4 years was correlated with surface water levels, with dispersal occurring earliest in years with the highest water levels (Fig. 12).

Critical Sites

Large, well-documented pre-migration roosts.—These 3 sites have contained ≥100 swallow-tailed kites in at least 3 years: Fisheating Creek, Corkscrew Swamp (on North Marsh, within Corkscrew Swamp Sanctuary), and the upper St. Johns River drainage near Lake Helen Blazes and Jane Green Swamp.

Small to moderate sized pre-migration roosts active in the last 5 years.—The group of roosts and possible roost sites listed in this category differed from the neighborhood roost listed in Table 1 (those located by tracking radio-tagged kites) and in Roost Locations and Phenology (located by other methods) in that they consisted of relatively larger numbers (40 to 200) and occurred during late July or August, when large pre-migration roosts were active. None of these sites were consistently monitored, so it was not known if they were regularly used roosts. In all cases, however, the timing and quality of the observations indicate that these areas have a high probability of containing large, pre-migratory roosts and should be thoroughly searched at the appropriate time: Long Pine Key in Everglades National Park, north of the Visitor Center; northern Bear Island, Big Cypress National Preserve; Taylor Slough south of Hole-in-the-Donut; Itchetucknee River, near the main spring head; Suwannee River, just north of Manatee Springs run; upper St. Johns River, near Lake Winder; near Blountstown, Liberty County; and near Mayo, Lafayette County.

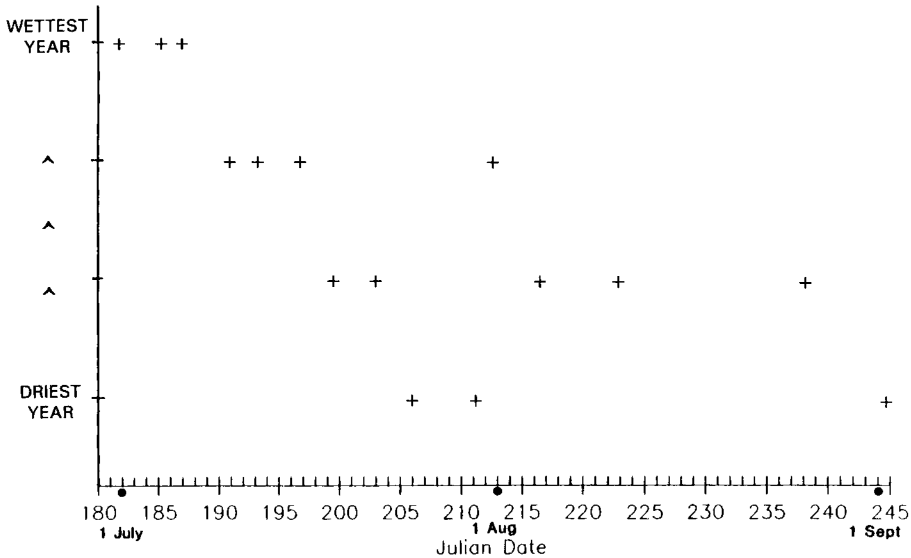

Fig. 12. Relationship between timing of dispersal of swallow-tailed kites and surface water levels. Each cross represents the last date on which a radio-tagged kite was located on its nesting home range ($p < 0.05$ Chi-square approximation of Kruskal-Wallis test).

Potential areas for pre-migration roosts.—The following areas are likely to contain at least small to moderate sized pre-migration roosts based on the availability of appropriate habitat, landscape and habitat features that suggest relatively high nesting densities, and observations of swallow-tailed kites: Green Swamp; St. Johns River valley, especially in Osceola, Putnam, Flagler, and St. Johns counties; river floodplains in the Big Bend region, from the Apalachicola to the Suwannee rivers; creek floodplains and mixed-forest swamps adjacent to the Lake Wales Ridge, especially in Polk County (e.g., near Lake Arbuckle and Lake Kissimmee); north of Big Cypress National Preserve in southern Hendry County, including the Seminole Indian Reservation; central Hendry County, from the Devils Garden area westward; and the Corkscrew Swamp northeast of the present Corkscrew Swamp Sanctuary boundary.

DISCUSSION

Functions of Communal Roosts

Communal roosts, particularly of predatory birds and scavengers, are most readily explained as a means of improving foraging efficiency (Newton 1979). Many communal roosts, particularly of vultures and corvids, persist year-round (Bildstein 1979, Rabenold 1987, Curnutt 1992, Engel et al. 1992), while others are seasonal, either during migration (Johnson et al. 1987) or periods of unusual food abundance (Crenshaw and McClelland 1989). The most popular hypothesis offered to explain this apparent paradox (i.e., why should an individual share its knowledge of a food source?) is that of the information center (Ward and Zahavi 1973; Rabenold 1986, 1986), in which successful foragers share information about food, but because of familial associations in roosts, their behavior is more likely to benefit related rather than unrelated individuals.

Explanations for communal roosts that do not invoke kin selection, while more difficult to justify in terms of selective forces, can be more broadly applied and generally focus on the advantages of social facilitation of feeding (Erwin 1978, Waltz 1982). These explanations are particularly applicable when the food is unpredictable in space and time, such as with the insect prey of swallow-tailed kites.

Communal roosts of ≥100 individuals have been reported for at least 4 new world species of kites other than swallow-tails (Wayne 1906, Dixon et al. 1957, Eisenmann 1963, Sykes 1985, Clark and Wheeler 1989). Aggregations and roosts of swallow-tailed kites numbering over 200 also have been reported (Wayne 1906, Howell 1932, Haverschmitt 1977, Meyer and Collopy 1990), including numerous sightings since 1929 (summarized by Millsap [1987]) near the western and southern shores of Lake Okeechobee. The large communal roost near the western shore, located in 1987 (Millsap 1987), has been explained as both a staging area along a major migration route for the U.S. population (Millsap 1987, Robertson 1988) and, more recently, as a more local phenomenon (Millsap and Runde 1988).

It appears likely that the Fisheating Creek roost and other large pre-migration roosts such as in Corkscrew Swamp and Jane Green Swamp serve as staging areas in which adults and juveniles acquire the necessary fat stores for migration to South America. *Staging* in this case is not meant to imply that the kites depart on migration en masse, but rather that they gather to take advantage of abundant food and/or the opportunities provided by foraging collectively. There is no indication that the Fisheating Creek roost serves as a stopover for migrants from throughout the Southeast, although it is possible or even likely that this occurs to some extent.

Results of this study suggest that groups of kites depart as their condition warrants and winds permit, perhaps restaging in smaller groups closer to the coast to await favorable weather conditions. Distinct differences in the timing of migration for adults and juveniles indicate that the roost does not serve to synchronize departures of families or mixed-age groups.

Large Roost Surveys

The timing of roost formation and migration for swallow-tailed kites is early relative to other migratory bird species in Florida (Millsap 1987). Regular, properly scheduled survey flights are necessary to assure that the maximum number of swallow-tailed kites will be counted and the peak date identified. The latter will be necessary for standardizing the timing of productivity estimates.

Direct visual counts can be sufficiently accurate if observers have the opportunity to check themselves frequently against photographic counts and improve their accuracy. Considering the relatively small expense, however, photographic counts are cost-effective and certainly the most accurate method of estimating total numbers. Counts could not be effectively made from ground-based photographs, and ground-based direct visual counts had very high margins of error when compared with aerial photographic counts made on or near the same date.

The 1992 count for Fisheating Creek was the highest to that date, but this may be attributable to differences in counting methods over the 6-year period. The 1993 count of 2,200 kites undoubtedly represented the largest number yet detected at that site. It is interesting that the roost that year was divided into 2 groups, separated by about 1.5 km. This may indicate that the kites have begun moving north from the *Casuarina* stand to the cypress site used from 1987 to 1989. Some disturbance during the summer of 1993, including a wildfire (lightning strike) and mechanical clearing along the edge of the stand, may have encouraged the move.

The Corkscrew and Jane Green Swamp roosts have been far more variable in numbers and, for the latter, in location than the Fisheating Creek roost. Smaller roosts may be less stable over time. It also may be more difficult to relocate these smaller pre-migration roosts when they shift even relatively small distances unless rigorous searches are conducted. During a morning survey flight at Fisheating Creek in August 1993, the researcher, pilot, and 2 observers failed to detect the larger, northern group of kites, even though the aircraft passed within less than 1.5 km of the birds at least 4 times. Obviously it is necessary to deliberately and systematically cover all possible roost habitat before concluding that an area is not occupied.

The decreasing percentage of adults in the Fisheating Creek roost over time clearly indicated that adults were migrating sooner than juveniles and, for the most part, without their young of the year (Table 3). The much flatter curve for juveniles (Fig. 6), estimated from the proportions of juveniles observed on 7 mornings after the peak, suggests that juveniles remained in the roost longer than adults, perhaps because they required more time to gain sufficient fat for migration. Apparently most juveniles are not being led by their parents or by any other adults on their first southward migration.

During morning observations at Fisheating Creek, juveniles appeared to be clustered in the roost more than expected based on chance, and regularly were first to make short flights out and back to the roost trees. Vocalizations, including juvenile begging calls, were frequently heard during these brief flights.

Radio-tagged adult and juvenile kites in Everglades National Park continued to associate until late August or early September, including obvious feedings of perched young by adults (Meyer and Collopy 1990). As a rule, the Everglades kites were conspicuous in their nesting areas at least until early August in the 6 years they were observed and the roosts of 20 to 40 kites found in the park may have served the pre-migration function of the larger, more northerly roosts. In this situation, it may have been possible, or even unavoidable, for juveniles to continue to associate with their parents until the time of migration, but in a very large roost like Fisheating Creek it seems unlikely that most juveniles could maintain contact with their parents. The Everglades adults probably left the area sooner than their young, just as at Fisheating Creek, if they acquired the necessary fat stores more quickly than the juveniles.

Estimating Productivity

If observers can gain access on the ground to large roosts, photographs of departing flights can be used to estimate within-year productivity for large portions of the total swallow-tailed kite population. The estimate derived from observations at Fisheating Creek in 1992 was very close to the predicted value (16.8% versus 13 to 17%, Table 5), which was based on the productivity for 31 nests monitored that year (Table 4), mortality of juveniles, and the ratio of nonbreeding to breeding adults.

The estimate for juvenile mortality was tentative, based only on 20 radio-tagged birds, but within the range of what should be expected. The estimate for the number of nonbreeding adults per breeding pair was more difficult to estimate and may be quite variable between years. On average, nests had at least 1 extra, nonbreeding bird per nest (Meyer and Collopy 1990). It was not clear if these birds were subadults, perhaps neighborhood young from previous years, or previously reproductive birds that were not breeding that year. Only 1 copulation, involving a mated female and an extra male, was observed, and it occurred after the female's young had fledged.

Despite annual variations, the effects of these potential sources of error on the value of the roost-based productivity estimate are minimal. The primary advantages of estimating productivity from roost observations is that it is an actual measure of the number of young surviving at that point relative to the number of adults in the population. The breeding ratio, fledging rate, and juvenile mortality that result in the observed percentage of juveniles are all conveniently taken into account. The resulting estimate should have high value as an annual index that can be used in combination with values from successive years as an indicator of population changes. In the case of swallow-tailed kites, the value of this estimate is greatly increased by the opportunity to sample such a large portion of the total population.

One disadvantage of the method is that it will not detect overall declines in number, since it only provides a measure relative to the number of birds present in the roost. This is one reason why, to whatever extent possible, such estimates as productivity should be made in conjunction with estimates of absolute numbers.

Roost-based productivity estimates should be relatively easy and inexpensive to obtain, assuming that access to the site is granted. Morning departure times are highly predictable in relation to sunrise (Table 2), and the kites can be approached carefully to within very close range.

Because the percentage of juveniles increased rapidly as the roost numbers declined (Fig. 5, Table 3), it is important to standardize the time at which the productivity estimate is made. The most consistently identifiable point will be when the roost reaches its largest size. The peak was short-lived, however, so it is essential that a sufficient number of survey flights be conducted at the appropriate time (see Large Roost Surveys).

Estimating Nesting Effort and Success

Observations at nests support the suggestion (Meyer and Collopy 1990) that the timing of molt differs between breeders and nonbreeders (nonbreeders start earlier), breeding males and females (females start earlier), and successful and unsuccessful breeders (unsuccessful breeders start earlier). It may be possible after several years of roost observations and concurrent nest-based estimates of success to correlate relative percentages of the 3 recognizable stages of adult molt (Fig. 7) with annual nesting success. A disproportionately high number of birds displaying late or completed molt, for instance, might indicate that a large portion of the adult population did not successfully breed. Used as an index of within-year nesting success, the plumage observations would provide collaborative data for roost-based productivity estimates.

Unfortunately, the information currently available for differences in the molt schedules of breeders and nonbreeders does not permit a test of the accuracy of roost-based estimates of within-year nesting success. The problem has been in relocating and closely observing radio-tagged kites frequently enough to accurately describe the timing of molt. More data from marked birds of known breeding status, indicating the difference between and the variance within the 2 groups, will be necessary to assess the correlation between proportions of molt classes observed in the roost and actual breeding effort and success.

Annual Variations in Large Roosts

The significantly later egg-laying date for Everglades National Park compared with the Big Cypress region probably has little direct influence on the timing of the development of the Corkscrew and Fisheating Creek roosts because kites nesting in that portion of the Everglades apparently do not leave the area to join the large roosts. Mean annual laying dates within the Big Cypress region had remarkably low variance from 1988 to 1992. If such low variance is representative of the broader area from which the Fisheating Creek roost draws its birds, even if mean laying dates vary from one portion of the area to the next, then annual differences in nest initiations are not likely explanations for the annual differences observed in the timing of large roost development.

The significantly earlier dispersal of radio-tagged kites from nesting areas in years with high surface-water levels (Fig. 12) was consistent with striking differences in the numbers of unmarked kites observed in Big Cypress during July and August in wet versus dry years. The range of nearly 1 month for the mean annual dispersal dates of the radio-tagged birds is sufficient to explain the annual differences in the timing of the development of the Fisheating Creek roost. It also suggests that, in the driest years, fewer kites may join large roosts in southern and south-central Florida. The 2 wettest years in Fig. 12 were 1992 and 1993, which also had the highest counts at the Fisheating Creek roost (1,550 and 2,200), while in 1990, the driest year in Fig. 12, only 800 kites, the smallest number, were counted at the roost (sufficient count data are lacking for 1989, the other dry year in Fig. 12).

The relationship between dispersal and surface-water levels is difficult to explain with information presently available, but it is likely due to the effects of water levels on insect populations. High water levels may shift the timing of emergence and decrease the concentration of insects, such as dragonflies, with aquatic life stages, thus influencing swallow-tailed kite foraging efficiency.

Population Monitoring

The high numbers observed at the Fisheating Creek roost in the last 2 years might be taken to suggest that the swallow-tailed kite population is increasing, or that previous population estimates cannot be reconciled with the numbers observed in the roost (Millsap and Runde 1988). As explained in the preceding section, annual variations in occupancy of large roosts may well have been due to annual differences in foraging conditions over the nesting range, and conditions during 1992 and 1993 were consistent with high dispersal rates from nesting areas during July, when the large roosts reached their peak. It also bears noting that in 1993, when the Fisheating Creek roost reached its highest numbers in 6 years, only small numbers of kites were found at the Corkscrew and Jane Green Swamp sites, suggesting that kites that had previously used the 2 smaller roosts may have traveled to Fisheating Creek instead.

If the mean length of attendance in the Fisheating Creek roost was 25 days in 1992, the total occupancy for the season was 2,537, or 64% more than the number present during the peak. If the same increment is added to the maximum number observed at Fisheating Creek in 1993 (2,200), then the total occupancy in 1993 was 3,600. These high estimates for total occupancy at Fisheating Creek are not inconsistent with current estimates for the total population of 800 to 1,200 pairs if young of the year and nonbreeding adults are taken into account, although the actual number probably is near the upper limit of the estimate.

It is reasonable to assume that the Fisheating Creek roost would include the majority of the population, since it is central to the highest concentration of nesting swallow-tailed kites in the country. Individuals from nests to the south traveled up to 109 km to join the roost (Table 1), and it is likely that birds are being drawn from at least that far to the north, since the roost lies close to the most likely route for southbound migrants. It is unlikely that South

Carolina's population of swallow-tailed kites regularly joins the Fisheating Creek roost, since monitored nesting areas remained occupied until late August (J. Cely, pers. commun.). Populations outside of Florida, however, probably do not exceed 300 to 350 pairs, or a maximum of about 1,400 individuals at the end of the breeding season.

There is no doubt that large communal roosts offer the best opportunity for monitoring swallow-tailed kite populations. Even though annual counts may vary independently of real changes in the population, and despite annual irregularities in use of some of the sites (particularly those of small to moderate size), simple counts of absolute numbers, if collected at as many sites as possible over a number of years, probably will be sufficiently accurate to indicate significant changes in population size. Aerial searches in areas likely to contain roosts will have a high probability of locating at least small to moderate sized pre-migration roosts. With additional effort and expense, radio-tracking of kites tagged in selected areas also should reveal new roost sites.

Counts of absolute numbers will be most useful if combined with other estimates of population health. The productivity estimate based on roost observations (see Estimating Productivity) can serve as 1 such measure.

Habitat Associations

The landscape-scale features that characterized nesting habitat selection also describe the habitat preferred for roosts by nesting kites. Forested wetlands, both cypress and hardwoods, were the dominant features around nests, including the areas used as roosts, and forest-hammock-prairie mosaics were selected for foraging.

On a smaller scale, roost sites differed from nest sites in that the overstory trees were frequently denser and snags were more abundant. Snags were often used and appeared to be selected when present (particularly in burned-out stands of cypress or pine), but large numbers of kites also roosted in live trees with relatively dense crowns (e.g., cypress, bays, *Casuarina*). Surface water was higher and present for longer periods in roost stands than in nest stands, although this may have been due to the fact that most nests were in pines. In any case, locating roosts in standing water may decrease the probability of predation or minimize undetected intrusions by mammals, although the possible effects seem minimal.

The most consistently used roosts clearly were isolated from human disturbance, even more than nest sites. It was apparent when any of these occupied sites were approached during late afternoon or early evening that the kites were easily disturbed and likely to fly, usually with agitated circling and vocalizing. These same sites could be carefully approached in the morning, however, with little or no disturbance.

It is not advisable, or even feasible, to consider managing habitat for small, neighborhood roosts that form during the nesting season. It is essential, however, that the roost features selected on both fine and coarse scales by nesting swallow-tailed kites be taken into account in any assessment of potential nesting habitat or in the management of known nesting habitat.

The dominant landscape features surrounding large roost sites were freshwater marshes and forested wetlands. The most likely explanation is the ability of these habitats to produce and support large numbers of prey. Although flying insects are the typical food reported for large foraging aggregations of swallow-tails and other kites (Wayne 1906, Skutch 1965, Johnson et al. 1987, Robertson 1988, Cely and Sorrow 1990, Meyer and Collopy 1990), and aerial foraging was the rule for kites departing the Fisheating Creek and Corkscrew roosts as well as for radio-tagged kites tracked from the roost on foraging flights, the prey species most important to foraging kites are not known.

The directions of morning departure flights at Fisheating Creek in 1992 (Fig. 10) mirror the arrival routes mapped by Millsap (1987) for 1987. Millsap (pers. commun.), however, saw large numbers departing to the west the following year, suggesting that foraging activity, at least for some birds, may shift to some extent between years.

As Millsap (1987) pointed out, large expanses of freshwater marshes are abundant along Lake Okeechobee near the Fisheating Creek roost, but swallow-tailed kites are not seen in large numbers over the more expansive marshes of the Everglades to the south (Robertson 1988, pers. obs.). Millsap (1987) suggested that the combination of marshes for foraging and wetland forests for roosting may make Fisheating Creek an attractive site. On a smaller scale, the same can be said for the Corkscrew and Jane Green Swamp roost areas.

Swallow-tailed kites regularly reuse areas for nesting and have long records of use for particular areas (Meyer and Collopy 1990, in press). In many cases, it is difficult to recognize any particularly attractive features that distinguish a well-used area from the rest of the landscape. It is tempting to regard such repeated use as traditional, a suggestion supported by the swallow-tailed kite's distinctive social behavior. By returning to a regularly used nesting neighborhood, even if the area is not superior to adjacent, unused areas, nesting swallow-tailed kites can accrue the benefits of sociality (e.g., group detection and defense against predators, social facilitation of feeding).

The same reasoning can apply to explaining the locations of large roosts. Foraging opportunities must be sufficient, but perhaps they need not be superior to other potential roosting sites. The benefits of group foraging for ephemeral swarms of prey at a time when rapid fat deposition is essential may be the strongest attractant. Once a roost develops at a particular site, for whatever reasons, the expectation that large numbers will be encountered in subsequent years may be sufficient to keep large numbers of birds returning. This could also help explain why roost locations seem to become more stable over time as occupancy increases; a "critical mass" is more likely to develop each year which, in turn, will catalyze further growth.

The Fisheating Creek site also is centrally located within a very large network of formerly expansive forested wetlands. This region, including the Kissimmee and St. Johns drainages, the swamp forests that drain the slopes of the Lake Wales Ridge, and the mixed wetland/upland systems north of the Big Cypress Swamp and west of the Everglades, probably offered excellent foraging habitat interspersed with pine-forested uplands, the swallow-tailed kite's preferred nesting habitat (Meyer and Collopy 1990). It is fair to suspect that this roost site, or some nearby location, has a long history of use by communally roosting swallow-tailed kites.

MANAGEMENT RECOMMENDATIONS AND IMPLICATIONS FOR CONSERVATION

Summary of Key Findings

1. Roosts of 10 to 40 swallow-tailed kites formed soon after nesting was initiated and persisted at least for several weeks after fledging. Some of these roosts, particularly in Everglades National Park, were active until late August or early September. In general, these small to moderate size roosts near nesting neighborhoods, or loosely colonial clusters of nests, were in forested swamps with longer hydroperiods, above average densities of snags, and greater isolation than nest sites. Most were used quite regularly within and even between seasons. Neighborhood roosts appear to be a regular and important feature of swallow-tailed kite nesting ecology.

2. Three previously discovered large roosts were monitored, particularly the largest at Fisheating Creek. Methods were refined for determining the time and the number of kites present when the roost reached its peak.

3. Five of 16 kites radio-tagged in the Big Cypress Swamp region during 1992 and 1993 joined the roost at Fisheating Creek, traveling straight-line distances of 80 to 109 km (4 died prior to dispersal and 1 radio failed). Roost occupancy ranged from at least 12 to 59 days for the radio-tagged kites. These birds provided information on foraging habitat, activity patterns, and migration.

4. Systematic monitoring of the Fisheating Creek roost in 1992 documented use by 1,550 swallow-tailed kites at the roost's peak on 27 July. Formation and decline of the roost was relatively rapid, with large numbers of adults leaving as early as the second week of August.

5. At the roost's peak, the percentage of juveniles very closely matched a prediction based on productivity at 31 nests monitored in 1992, post-fledging mortality estimated from 20 radio-tagged juveniles, and breeding effort (or the relative numbers of breeders and nonbreeders) among adults.

6. The relative number of juveniles increased from 17% at the roost's peak to 79% a month later, when the roost had declined to less than 5% of its maximum size. Apparently most juveniles remain in pre-migration roosts longer than adults and do not migrate with their parents.

7. By combining results of the survey that determines the date and

number of kites present when a large, pre-migration roost reaches its peak with periodic observations of the percentage of juveniles present in the roost, within-year productivity for the population can be estimated. This estimate takes into account the year's nesting productivity, post-fledging mortality, and breeding effort. Annual estimates of population productivity and the total number of kites derived from observations at large roosts provide an unusually good opportunity to monitor the Florida population of swallow-tailed kites.

8. A rough estimate of the total number of swallow-tailed kites that used the Fisheating Creek roost during 1992 was calculated using the estimated average attendance for radio-tagged birds (25 to 35 days) and the total number of kite-occupancy days, derived from the aerial survey data. The total occupancy of the roost over the season was estimated at 1,812 to 2,537 kites, or 17 to 64% more than the number counted in the roost at its peak. If the average of this increment, 41%, is added to the 1993 peak estimate of 2,200 kites, the total occupancy in 1993 would have been 3,100. If annual production and nonbreeding adults are taken into account, the most recent estimate for the U.S. population of 800 to 1,200 pairs (Meyer and Collopy, in press) predicts that there are about 3,200 to 4,800 individuals at the end of the breeding season, and that about 2,000 to 3,600 of these birds are in Florida. Estimates for the number of kites that occupied the Fisheating Creek roost during 1992 and 1993 and speculation that the roost is not drawing many kites from outside Florida are consistent with the current estimate for the total U.S. population and its distribution within the Southeast. This suggests that the Fisheating Creek roost site was used by at least 45% of the U.S. population in 1992 and 65% in 1993.

9. A GIS analysis of habitat selected for nests, foraging, and roosting during the nesting season determined that cypress and hardwood swamp forests were selected for and agricultural/grassland habitats were selected against by nesting kites. Radio-tracking indicated that habitat mosaics dominated by forested wetlands were preferred by foraging swallow-tailed kites.

10. Foraging habitat used by kites occupying the large pre-migration roost at Fisheating Creek differed from nesting and neighborhood roost habitat in that it consisted of large expanses of freshwater marshes. The difference in habitat used during these 2 phases may reflect a basic seasonal difference in diet. Nesting swallow-tailed kites in Florida feed their young large numbers of small, arboreal vertebrates, while the main prey of adults and independent juveniles the rest of the year is insects. Kites from the Fisheating Creek roost that were observed foraging were mostly pursuing and capturing flying insects. These prey may be particularly abundant over freshwater marshes in

late summer. As Millsap (1987) pointed out, the combination of wetland forests for roosting and large expanses of adjacent freshwater marshes for foraging may be the main attractant at the Fisheating Creek roost site. The same habitat description applies to the Corkscrew and Jane Green Swamp sites. This characterization should be useful for selecting and prioritizing areas to be searched for roosts.

11. Annual variations in the number of kites and the timing of the development of large pre-migration roosts cannot be explained by annual variations in the timing of nest initiations. The timing of dispersal from southern Florida nesting areas was correlated with surface water levels, with the kites leaving the area much earlier, and in greater numbers, in wet years. Over the last 5 years, Fisheating Creek reached its highest numbers during the 2 wettest years, and the lowest number of kites was observed during the driest year. It seems reasonable to speculate that high surface water levels adversely affect the availability of swallow-tailed kite prey and, thus, can result in dispersal to areas that are more likely to supply adequate food to prepare for migration. As with the pre-migration roosting phase, however, diet and foraging strategies during post-breeding dispersal are very poorly understood.

12. Limited observations and informed speculation suggest that swallow-tailed kites that have acquired sufficient fat for migration leave the large roosts in relatively small groups when winds are favorable for southward movement. These smaller groups may move mainly toward the southwest coast of Florida over a period of days and may stage again if winds are unfavorable. In the single observed case, movement offshore was slow but continuous and followed a heading toward the Yucatan Peninsula.

13. The results of this study support the suggestion by Millsap (1987) that large, post-breeding communal roosts serve mainly as staging areas in which the kites prepare for their migration to South America. Whether their route takes them directly south over the Caribbean (no substantial flights are observed in the Antilles) or southwestward and then south via Mexico, single flights of 800 to 1,500 km are likely. The magnitude and apparent regularity of the largest roost at Fisheating Creek indicate that such gatherings are vital to swallow-tailed kites no matter how brief a period they occupy in this species' annual cycle.

14. Protocols are provided for searching for roosts, surveying large roosts, and estimating annual population productivity at large roosts. These techniques are designed to be effective and relatively inexpensive ways to monitor Florida's population of swallow-tailed kites and detect population trends.

Three Protocols for Population Monitoring

The following 3 protocols are recommended as ways of searching for, surveying, and estimating annual productivity at pre-migration communal roosts of swallow-tailed kites.

Searching for roosts.—1. Once a likely area has been identified (see Potential areas for pre-migration roosts), use satellite imagery, recent aerial photographs, or site visits to assess the vegetation and select the most likely locations for roosts.

2. Using aerial photographs or topographic maps, establish a sufficient number of parallel east-west transects 1.5 km apart to include the entire area. A map or overlay with the numbered transects is a useful reference for navigating and noting observations. Select prominent landmarks on the maps wherever possible to aid in navigation, but assume that this method alone will rarely be sufficient for maintaining an accurate course if the area includes more than 2 or 3 transects. This is especially true if visibility is poor, winds are high, or the air is turbulent. If the landscape lacks distinctive, map-referenced features, or if for any reason the pilot cannot maintain an accurate east-west ground track, an on-board LORAN or GPS receiver (preferably the latter) with externally mounted antenna will be required. Plot the endpoints of the transects beforehand in degrees latitude/longitude or UTM coordinates and have the pilot fly the desired track, which should correct for wind drift. These procedures can require a good deal of preparation time, and some pilots may mistakenly assume that they can provide good coverage with visual references alone. There is no doubt, however, that electronic navigation over a well-mapped course will minimize poor coverage and wasted flight time.

3. Fixed-wing aircraft are entirely adequate for roost searches and are much less expensive (20 to 30% of the cost) to operate than helicopters. High-wing models capable of safe flight at 75 knots, such as the Cessna 170, 172, 180, or 182, are best. All of these aircraft seat 3 people in addition to the pilot, although the pilot may not want to carry more than 2 observers if the fuel load is high and/or rough conditions are expected.

4. Searches should be conducted during July and August, with the largest numbers of birds expected in the middle of that period. A roost that peaks at 100 birds at the end of July could still be detectable at the end of August.

5. Flights should be scheduled so that the highest priority areas can be covered from about 30 to 90 minutes after sunrise. Light conditions are not

favorable earlier, and kites will begin leaving the roost after that time. Some (about 10%) may still be perched 2 hours or more after sunrise, and birds that have already flown may still be noticeable in the area at this time.

6. The factor that will most influence success of the search will be the prior experience of the observers, who should have had at least 1 opportunity to observe a roost of swallow-tailed kites under flight conditions similar to the search protocol (10 to 50 birds would be good practice).

7. Fly the transects at an airspeed of 75 to 80 knots 225 to 250 m AGL.

8. If 2 observers are present, have 1 in front to direct the pilot and the other in back on the opposite side. Use an intercom with headsets. Pilots should not act as observers, although once they have learned what to look for, many pilots will frequently detect perched or flying birds before the observers. If several flights are planned, work with the same pilot whenever possible; reschedule a flight rather than train a new pilot.

9. Search the area out from and slightly behind the aircraft. Make a conscious effort to search from as close as possible to the transect to a point halfway to the next transect, or 750 m. This is not intuitive and is best achieved after practice over a course where ground features mark the 750-m distance. There is a strong tendency to neglect the area beyond 300 to 400 m. Try to keep your eyes moving toward and away from the aircraft. If for any reason there is doubt that coverage was adequate on a given pass, repeat the transect from the opposite direction. This is also advisable if visibility is poor.

10. If perched kites are observed, fly directly to the site but do not pass over the birds. Counts can be made from circling flight at 150 to 200 m AGL and 200 to 250 m from the perched birds. Climb, if necessary, to locate the site on maps or photographs and to take a fix with a LORAN or GPS receiver. If possible, photograph the roost and surrounding area from 500 m or higher to document the exact location for future reference. If the transects are mapped and end-point coordinates are known, you can then resume the search without losing or duplicating coverage.

11. If observers become airsick, straight and level flight at a higher altitude (where the air may be smoother and cooler) should help. The person should be advised to watch the horizon straight ahead and avoid rapid head movements. Even people with strong tendencies to become ill will remain more comfortable for longer periods if they fly frequently. Half doses of motion sickness medication may reduce discomfort without causing disabling drowsiness. This is another case in which mapped transects with known

coordinates are an advantage, since searching can be resumed without any loss of coverage after a diversion.

Surveys of large roosts.—1. Fixed-wing aircraft are sufficient and more cost-effective than helicopters for surveys of known roosts. See #3 under Searching for large roosts.

2. Surveys should be scheduled at no more than 5-day intervals during a 30-day period centered on the expected date of the roost's peak (27 July at Fisheating Creek in 1992). If large roosts prove to be too variable for this schedule, the 5-day interval should begin earlier in the season. Before and after that period, starting on 1 July and ending around 1 September, 10-day intervals should be sufficient. This schedule will produce about 10 to 15 daily estimates, from which the roost's timing and the maximum number of kites can be accurately estimated.

3. Plan on arriving at the roost within about 1 hour after sunrise, which leaves enough time for photography before the birds begin leaving, but is late enough to insure good light conditions. A sufficient number of photographs can be taken within 20 minutes at a very large roost.

4. Fly around the roosting birds at 100 to 200 m AGL at an airspeed of 70 to 75 knots and a distance of 200 to 250 m (the greater distance at the lower altitude). If birds fly up, and it is no later than 90 minutes after sunrise, it is possible that the aircraft is disturbing them. Increase lateral distance and altitude if this seems to be the case.

5. Take photographs from the front right seat with the window open. A 35-mm camera with manual focus, exposure, and shutter speed settings; automatic film advance; and a zoom lens that includes a range of 70 to 100 mm focal length works well. Use relatively fast, low-grain film (such as Kodachrome 200 or even Ektachrome 100) at 1/250 of a second (or at least 1/125). Shoot continuously as the plane passes the birds, and overlap each frame enough to facilitate counting.

6. Following flights (e.g., to document foraging habitat and behavior) is more difficult with swallow-tailed kites than with wading birds, but morning survey flights provide the best opportunity, particularly if the kites are picked up as they leave the trees and are most conspicuous.

7. In order to estimate the number of kites present from the slides, it is best to view them a few times in groups that represent a single pass or circuit around the roost, learning to recognize landmarks that provide continuity

between slides. By projecting the slides on an erasable surface, sections of each slide can be blocked out to make counting easier. It is very difficult to distinguish white heads from white shoulder plumage in blurred slides, so do not hesitate to reject poor shots.

8. Visibility of birds within the foliage on the tops of the trees, and in recesses within the crowns, will depend on the angle at which the roost is viewed. This, in turn, depends on the combination of altitude and lateral distance from the trees. If the trees are especially tall, it may be necessary to either increase the altitude or decrease the distance to improve the viewing angle. The most difficult distinction to make when counting from the slides is whether birds seen in one view are the same as birds seen in views from the opposite side of the roost.

Estimating productivity at large roosts.—In order for ground-based photographs of roost departures to be used to estimate the relative numbers of adults and juveniles, the period over which the roost is photographed must include the time when the roost contains the maximum number of kites. This will have to be determined by concurrent aerial surveys, as described above. To guarantee that the ratio of adults to juveniles will be estimated at or near the roost's peak, ground visits should be made at intervals of 5 days or less over the 20-day period centered on the peak.

1. Arrive at the roost no more than 90 minutes after sunrise and slowly approach a point below the expected departure route for most of the kites. Several morning visits may be required to determine departure routes and ways to approach without disturbing the birds.

2. Unless winds are unusually strong, the kites will begin forming kettles soon after leaving the roost. Many of these kettles may drift out of camera range too quickly to provide good photographs, but others will linger, or even drift back overhead, before moving out of range. The best photographs for distinguishing between adults and juveniles are those taken against the sky from as close as possible to a point directly below the birds.

3. Use the same camera equipment, settings, and film as described for the roost surveys. Underexpose slightly (0.5 to 1.0 f-stop) when shooting against a bright sky. It does not take long for the birds to move out of range, so move quickly to stay below as many kettles as possible. The composition of the kettles shifts rapidly, so shoot in quick succession (but focus sharply).

4. Be careful when counting from the projected slides not to confuse short-tailed molting adults with juveniles. The wings of every short-tailed kite

should be examined carefully to determine the correct age class. If the trailing edge of the wing is irregular, if there are any gaps in the primaries or secondaries, or if the tail length is asymmetrical, the bird should be considered an adult (refer to Fig. 7). Do not attempt to assign an age to bird images that are blurred or too distant to reveal plumage irregularities.

Conservation Concerns

Critical sites.—Of the 3 known large roost sites, only Corkscrew is on protected land (Corkscrew Swamp Sanctuary, National Audubon Society). The roost was not in its usual location in 1993, however, and it is not known if it formed elsewhere within the sanctuary. Large portions of the adjacent land, including much of the presently unprotected parts of Corkscrew Swamp to the northeast, are either being purchased or under consideration for purchase as part of a multi-agency effort that includes the Southwest Florida Water Management District.

The Jane Green Swamp roost, which is actually a set of relatively variable, moderate size roosts that have occurred at various locations within roughly a 20-km^2 area over the last 4 years (Joiner 1990, 1991), is more sensitive. The freshwater marshes adjacent to the roosts, presumably one of the main reasons for the kites' use of the area, have some measure of protection, but under present plans they are vulnerable to alteration as wastewater management areas. The roost stands are not on protected land and some of a nearby cypress forest has recently been logged.

The Fisheating Creek roost is the largest and, over the last 7 years, most consistently used of the pre-migration roosts. It also is the most sensitive and vulnerable of the known roosts. Despite some changes in location within the area, the roost has remained well within the boundaries of a very large expanse of privately owned land that is managed for timber, citrus, and cattle production.

The roost's shift after 3 years from a remote stand of cypress within a large marsh system to a more accessible, but perhaps less disturbed, stand of Australian pines (Millsap and Runde 1988, Joiner 1990) coincided with a sudden increase in access by recreational airboaters to the cypress/marsh site. Access to the latter site again became restricted just prior to the 1993 roosting season, and large numbers of swallow-tailed kites were subsequently found roosting again in the cypress forest. It is possible that the cypress site is preferred by roosting kites and the shifts in roost location were influenced by changes in disturbance.

While the type of disturbance that may have precipitated the roost's move at Fisheating Creek is currently being controlled to a large extent by private ownership, the longer-term security of the site is threatened by potential changes in land use and more intensive management for timber. Cypress is being cut on a large scale in the same cypress/marsh system that has been used by the roosting kites. The Australian pine roost site is potentially more secure, since it is within an easement managed by the Army Corps of Engineers. Given the apparent preference of the kites for the cypress site, however, it is inadvisable to allow changes in land use to dictate the use of what may be a suboptimal, and ultimately more vulnerable, alternate site.

State or federal agencies should move as quickly as possible to secure the future of the Fisheating Creek roost area. Options that should be considered include designation as a critical wildlife area, restricted airspace, cooperative agreements with the landowner, conservation easements, or acquisition. The roosting kites' requirements for foraging habitat should be considered in the development of the plan. The recommendation for federal and state listing as Endangered (Meyer and Collopy, in press) should be pursued in order to increase the effectiveness of management and conservation efforts.

Of the small to moderate size roosts listed as Critical Areas, about half are on public lands presently managed for conservation. The rest are in poorly defined locations on or adjacent to privately owned lands. Their locations and use should be more accurately determined as soon as feasibly possible to assess their importance and sensitivity to disturbance.

It is imperative that additional potential large roost sites be searched as soon as possible, particularly those areas that best fit the profile of forested wetlands adjacent to large freshwater wetlands. A review of current GIS data should help in prioritizing areas for searching. The classification system and maps generated by the FGFWFC's recent initiative to identify areas in need of conservation protection (Cox et al. 1994) might be especially useful for this effort.

Use of the Jane Green area by small aircraft, perhaps for training, seems high (K. Meyer, pers. obs.), and in 1993 an ultralight aircraft was observed making repeated low passes at a small group of roosting swallow-tailed kites (N. Joiner, pers. commun.), causing them to disperse. This incident highlights a concern about the security of large roosts. As the locations of these sites become more widely known, there is increasing potential for disturbance by well-intentioned but uninformed observers. Although ground access to the known sites is largely restricted, overflights for recreation or commercial photography will become increasingly likely. Disruptive flights will be difficult to detect and control; it may become advisable to request that the Federal Aviation Administration restrict the use of airspace over the largest roosts, at least seasonally. Rarer but potentially more destructive acts of vandalism also will become an increasing threat.

Landscape-scale habitat requirements.—A previous study (Meyer and Collopy 1990, in press) concluded that privately owned lands in south-central and southwestern Florida are the center of abundance for swallow-tailed kites, and that protection of this region's ecological integrity is fundamental to the long-term viability of Florida's swallow-tailed kite population. The region's importance to kites probably results from the prevalence of heterogeneous habitat mosaics that provide the diverse array of vegetation structure and prey on which nesting and roosting swallow-tailed kites depend.

The importance of forested wetlands to nesting and roosting swallow-tailed kites is clear. To complete the view of nesting habitat requirements, however, it is necessary to consider nest site selection. Over the last 6 years, 34% of the swallow-tailed kite nests monitored for success and productivity were in cypress trees. Most of the remaining nests in the sample of 141 nests were in pines (nearly all slash pine). Nests in pines, however, were significantly more successful than nests in cypress (Table 12). Even though the swallow-tailed kite's nesting landscape is dominated by wetlands, pine trees, and particularly old stands of pine (Meyer and Collopy 1990), are an essential part of that landscape.

The extent of pine forest decreased by 85% since between 1900 and 1989 on the privately owned lands in Hendry, Glades, and Collier counties, in the area between Big Cypress National Preserve and Lake Okeechobee (Mazzotti et al. 1992). Most of this loss occurred after the mid-1970s. Furthermore, fragmentation of the remaining pine forest has increased dramatically. The area devoted to citrus and sugar cane production in this region increased by 350% from 1973 to 1989, with the acreage devoted to citrus in Collier County tripling between 1986 and 1989 (Mazzotti et al. 1992). Clearly, the pressure to convert wildlife habitat to incompatible uses is enormous in the portion of the state most important to swallow-tailed kites.

Table 12. Numbers of successful and failed swallow-tailed kite nesting attempts (n = 132) in pine and cypress trees from 1988 to 1993 ($p < 0.05$, Chi-square test).

	Pine	Cypress
Successful	57	27
Failed	23	25

The FGFWFC's analysis of wildlife habitat requirements in order to identify and prioritize areas in need of conservation protection included swallow-tailed kites as 1 of 34 indicator species (Cox et al. 1994). The analysis used data from a previous study (Meyer and Collopy 1990) and the Florida Breeding Bird Atlas (Kale et al. 1992) to determine the population's habitat needs and the extent to which sufficient habitat is protected under present ownership or conservation plans. The authors concluded that insufficient habitat is currently protected to ensure long-term viability for the population.

A map indicating areas with the highest priority for acquisition or protection (i.e., Strategic Habitat Conservation Areas) (Cox et al. 1994) included substantial parcels of land in all the areas of the state deemed critical to swallow-tailed kites (Meyer and Collopy, in press). The largest of the presently unprotected areas designated for protection were in southwest Florida, between southern Florida's public lands and Lake Okeechobee. These areas apparently are critically important not only to swallow-tailed kites but also to a broad range of other indicator species as well.

The combination of results from studies of swallow-tailed kite nesting ecology and communal roosts (Millsap 1987; Cely and Sorrow 1990; Meyer and Collopy 1990, in press; this report), clarifies the need and appropriate course for action. Nesting habitat presently under some form of protection is insufficient to insure long-term viability of the population. Communal roost sites and associated foraging habitat, while used for a relatively small portion of the year, are vital to the population's success and are highly vulnerable. Prompt and effective habitat protection at the landscape level, whether by acquisition or more creative means of management, is imperative if swallow-tailed kites are to be a part of Florida's future. This action, furthermore, will help accomplish many of the broader goals for protecting the range of diversity in Florida's ecosystems.

Recommendations for further research.—Recent studies, which illuminate the causes and extent of the swallow-tailed kite's vulnerable status in Florida, suggest several areas of research for immediate consideration:

1. demographics, to accurately model and predict population trends;
2. migration, to determine conservation needs on travel routes, wintering locations, and possible staging areas for spring migration; and
3. dispersal and staging behavior, to address critical habitat needs. Two specific issues related to staging that require prompt attention are accurate measures of attendance in pre-migration roost, which will require more extensive radio-tracking than previously undertaken; and an investigation of food and feeding behavior by staging swallow-tailed kites.

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