

Habitat Associations, Reproduction, and Foraging Ecology of Audubon's Crested Caracara in South-central Florida

**Stephen R. Humphrey
Joan L. Morrison**

Department of Wildlife Ecology and Conservation
P.O. Box 110430
University of Florida
Gainesville, Florida 32611

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HABITAT ASSOCIATIONS, REPRODUCTION, AND FORAGING ECOLOGY OF
AUDUBON'S CRESTED CARACARA IN SOUTH-CENTRAL FLORIDA

DR. STEPHEN R. HUMPHREY
JOAN L. MORRISON

Department of Wildlife Ecology and Conservation
P.O. Box 110430, University of Florida
Gainesville, Florida 32611

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ABSTRACT:

The crested caracara (*Caracara plancus*) is a unique raptor/scavenger with a limited North American distribution. An isolated population occurs in south-central peninsular Florida, where the species inhabits open grassland habitats. The status of this population has long been a subject of concern. In recent decades, grassland and prairie habitats in this region have undergone extensive conversion to urban and agricultural development. Concomitant with this habitat loss has been the apparent contraction of the caracara's historic range and the population is believed to be in a long-term decline.

We studied the reproductive ecology, habitat associations and foraging ecology of crested caracara in south central Florida from August 1993 through June 1996. The purpose of this research was to provide basic ecological information for Florida's caracara population, particularly information that is relevant to management. Our research focused on documenting the dispersion and reproductive success of breeding pairs across the population's range and on assessing relationships between the species' distribution and cattle ranches, where most caracaras now apparently persist.

We monitored nesting activity in 65 territories during the 3 years of the study. Florida's caracaras exhibited high territorial occupancy and breeding rates, nesting success, and productivity. Although caracaras may breed from September through June, the breeding cycle is strongly tied to the annual precipitation cycle and the peak of egg-laying occurs in January. Pairs can make several nesting attempts per year. Renesting occurred predictably following an early season failure. Pairs that successfully raised two broods in a season may incur higher inclusive fitness. Estimated probability of survival to recruitment was highest for young from first of two broods.

Estimates of home range size and local nesting density determined using telemetry were considerably smaller and higher, respectively, than previously published estimates based on observations of unmarked individuals. Home range size for 25 breeding adult crested caracaras ranged from 551 to 2778 ha, and maximum local density found in Highlands County was 1 pair per 555 ha. Caracaras are highly territorial around the nest but apparently tolerate conspecifics in foraging areas, as home ranges overlapped as much as 35%.

Caracaras apparently prefer open, structurally simple habitats for nesting and foraging. Differences in management regimes between private and publicly owned lands result in differences in vegetation structure. These differences translate further into differences in occupancy rate and nesting success within caracara territories. Habitat analyses indicated a positive association of caracara home ranges with improved pastures. The size of individual caracara home ranges was strongly inversely related to the proportion of improved pasture.

Caracaras are generalist predators that tolerate some human activity as long as the nest site is left intact. They are diet generalists, feeding on live prey as well as carrion and use wetlands for foraging more than originally believed. A conservation strategy for this population should be based on protecting known nest sites and areas where juveniles congregate, and should focus at a regional scale. Management plans must address effects of habitat loss and degradation, particularly conversion of pastures to citrus and sugar cane. Because most suitable habitat is in private ownership, habitat protection must involve cooperative efforts between land management agencies and private landowners.

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HABITAT ASSOCIATIONS, REPRODUCTION, AND FORAGING ECOLOGY OF AUDUBON'S CRESTED CARACARA IN SOUTH-CENTRAL FLORIDA

INTRODUCTION

One of the most profound and widespread impacts of humans on the landscape is alteration of natural habitats. Fragmentation and loss of natural habitats have been implicated in the decline or extinction of many species (Askins et al 1990, Wilcox and Murphy 1985). Consequences of these habitat changes may include reduced reproductive success or survivorship due to loss of suitable breeding and foraging habitats, altered dispersal and other behavioral patterns, and increased predation pressure within remaining habitat patches (Whitcomb et al. 1981, Wilcove et al. 1984, Hagan and Johnston 1992, LaHaye et al. 1992, McKelvey et al. 1993, Herkert 1994, Lens and Dhondt 1994, Dunning et al. 1995, Redpath 1995, Robinson et al. 1995, Matthysen and Currie 1996). Formerly contiguous populations are fragmented into disjunct subgroups if individuals are unable to disperse among isolated patches that are embedded in an inhospitable matrix (Opdam et al. 1985, Sjögren 1991, Fahrig and Merriam 1994).

The effects of fragmentation or loss of natural habitats on small, isolated, or peripheral populations are of particular concern. These populations have high conservation value due to some degree of genetic, behavioral, and/or morphological divergence from central populations (Levin 1970, Lawton 1993, Lesica and Allendorf 1995). Geographically isolated populations are subject to higher risk of extinction due to demographic, environmental, and genetic stochasticity (Shaffer 1981). It is reasonable to expect that effects of habitat loss and fragmentation acting in concert with isolation and small size pose serious threats to peripheral populations.

Fragmentation and loss of natural habitats are occurring at a rapid rate throughout peninsular Florida. Due to its geographic position and recent glacial history, Florida has a rich biodiversity (Neill 1957, Myers and Ewel 1990). The peninsula is a mosaic of habitat islands and small, often disjunct populations of species, many of which have differentiated at least at the subspecies level from their closest relatives in the western U.S. Continued

fragmentation and conversion of natural habitats combined with geographic isolation may jeopardize chances for the long-term persistence of many species in Florida.

Study species - History and Background

The crested caracara (*Caracara plancus*) is a medium-sized tropical raptor that occupies open habitats, typically grassland, prairie, rangeland, savanna, and desert. Its current geographic distribution covers most of South and Central America, through parts of northern Mexico, and into the southern US (del Hoyo et al. 1994). Its current North American distribution is limited to disjunct populations in Texas, Arizona, Cuba, and Florida (Fig. 1).

Fossil records and the distribution of these populations suggest that the caracara may have been more widespread throughout southern North America during the Pleistocene (Howard and Miller 1933, Brodkorb 1964, Chandler and Martin 1991, Vuilleumier 1985). This epoch was characterized by extensive periods of reduced rainfall. During these times, grassland and savanna habitats presumably reached their maximum extent across the continent. Especially during the glacial cycles when sea levels were lowest, an extensive subtropical savanna corridor may have extended around the Gulf of Mexico, facilitating the exchange and movement of western biota eastward into Florida (Neill 1957, Webb 1977, Webb and Wilkins 1984). It is possible that ancestors of the extant caracara expanded northward through Central America during the biotic interchange, followed by continued expansion throughout the Gulf region and into peninsular Florida.

As a consequence of numerous glacial cycles, repeated fluctuations in sea level and associated climate and habitat changes, the geographic ranges of many North and Central American species eventually became divided and reduced in size. Populations of many species having western affinities, including the caracara, were ultimately restricted to Florida (Jackson 1973, Woolfenden and Fitzpatrick 1984). Today, conservation efforts throughout Florida are increasingly focusing on these populations because of their isolation, small size, and disjunct distributions.

The extant Florida population of the crested caracara (*C.p. audubonii*) occurs in the south-central peninsula. Described by early ornithologists as inhabiting much of the central peninsula (Howell 1932, Bent 1937, Nicholson 1929, 1930), its historic distribution probably

conformed closely to the original location of the major prairie ecosystems (Davis 1967). Representatives of this ecosystem included the Kissimmee prairie, which extended north and westward from Lake Okeechobee in association with the extensive Kissimmee River floodplain, and the DeSoto prairie, which extended westward from the southernmost portion of the central ridge. These prairies constituted vast expanses of low, open, nearly treeless grasslands, with sparse cabbage palm hammocks and scattered patches of shrubs and saw palmettos (Harshberger 1914).

The current breeding range of the caracara in Florida encompasses parts of about 10 counties within this presumed historic range (Kale et al. 1992, Stevenson and Anderson 1994) (Fig. 2). Because this population is isolated and occurs at the northern edge of the species' geographic range, it has a high value for conservation. Additionally, the grassland and prairie ecosystems in this region are now only limited in extent (Abrahamson and Hartnett 1990). Extensive areas of the original prairies have been converted to improved pastures, which are dominated by non-native grasses and are intensely managed for forage production for cattle. What remains as natural and semi-natural habitat in this region is rapidly being converted for agricultural and urban development.

The status of Florida's crested caracara population has long been a subject of concern. Apparent steep declines in numbers during the late 1960s and early 1970s (Funderberg and Heinzman 1967, Heinzmann 1970) first focused attention on the population. Results of surveys of historic territories in the late 1980s suggested that the population may be undergoing a long-term decline concomitant with accelerated habitat loss (Millsap 1989). Layne (1995), however, stated that during the period 1972 to 1991, the adult population appears to have been stable. Current published estimates for this population are approximately 400-500 individuals statewide (Layne 1995, 1996).

Due to its restricted range, apparent small population size and history of decline, Florida's crested caracara population was listed as federally threatened in 1987 (US Fish and Wildlife Service 1987), followed by a similar state listing (Wood 1990). The current paucity of demographic and ecological information precludes accurate assessment of this population's status or trends, however. Habitat fragmentation and loss is assumed to pose a threat to population persistence, but little ecological information exists with which to test this

hypothesis. In 1989, a federal recovery plan was accepted for this population (US Fish and Wildlife Service 1989), but there was little biological basis from which to develop appropriate recovery goals.

Management of wildlife populations and development of appropriate conservation strategies require in-depth knowledge of a species' life history and population dynamics. The caracara apparently now occurs primarily on cattle ranches in this region, most of which are privately owned. This undoubtedly is one major reason why this population has been little studied to date. Confrontations between land management agencies and private landowners have escalated in recent years, particularly over issues relating to threatened and endangered species (Lewis 1995, Bean and Wilcove 1997). Landowners are hesitant to permit access to their lands, particularly when a threatened or endangered species is involved. This poses a major dilemma for conservation of a species that occurs regularly on private lands.

Research Objectives

The purpose of this research was to provide basic ecological information for Florida's caracara population, particularly information that is relevant for management. Although caracaras apparently persist on the cattle ranches, their distribution throughout the region remains poorly known and nothing is known about habitats actually used or productivity in these habitats. Our research focused on improving knowledge of the dispersion and reproductive success of breeding pairs across the population's range and on assessing relationships between the species' distribution and cattle ranches. Basic biological data are critical for determining the status of this population. A better understanding of relationships between the species and various land uses is important for developing guidelines for long-term population monitoring and management.

Major objectives were:

- 1) To determine the distribution and abundance of caracaras within the study area;
- 2) To locate nests and characterize nesting territories;
- 3) To evaluate breeding chronology, reproductive success and productivity;
- 4) To document habitat use and movement patterns of breeding adults;
- 5) To document nesting and foraging habitat associations;

- 6) To assess availability of important habitats within the study area;
- 7) To evaluate spatial relationships among caracara territories in relation to land use patterns;
- 8) To determine diet during the breeding season.

Study Area

The study area in south-central Florida encompassed much of the crested caracara's current breeding range. Included were all or parts of Highlands, Glades, Okeechobee, Osceola, DeSoto, Polk, Hendry, and Indian River counties (Fig. 2), an area totaling approximately 21,000 km². The landscape in this region is a mosaic of habitats, primarily grasslands and pastures interspersed with cropland, citrus groves, dairies, pine flatwoods, freshwater marshes and lakes, oak scrub, hardwood hammocks, and urban developments. Over half of this area is in private ownership. Primary land uses are cattle ranching, citrus production, and other agricultural crops. The land in public ownership is managed for a variety of uses including recreation, military training, hunting, natural areas, and river floodplain management.

Study organization

This research examined the reproductive ecology, habitat associations, and foraging ecology of Florida's crested caracaras. Results and conclusions are organized into 7 chapters.

Chapter 2 details the breeding biology and discusses reproductive strategies of Florida's crested caracaras. We examine territorial occupancy, breeding rates, and various reproductive parameters for the sample population. Specifically, we test the hypothesis that caracaras, like other large raptors, have low reproductive rates and low productivity. We also examine relationships between breeding chronology and environmental parameters. Finally, we examine factors that may influence overall productivity in this population.

In Chapter 3, we examine the incidence, determinants, and potential costs of double brooding in this population, a strategy previously unknown for this species. We also discuss potential implications of double-brooding for individual and population productivity.

Results of habitat analysis at caracara nest sites are presented in Chapter 4. These analyses focused on characterizing the vegetation within the general nest stand area. We

evaluated the nest location and orientation and characterized the types and structure of vegetation within the vicinity of the nest tree. We also examined relationships between particular habitat and land use features at the nest site and nest success or failure.

Spatial requirements and dispersion of breeding pairs are examined in Chapter 5. We estimate home ranges using several methods and compare ranging behaviors of males and females and of individuals between breeding and non-breeding seasons. We also examine spatial relationships among breeding pairs, focusing on inter-nest distances and use of overlap areas by neighboring individuals in adjacent territories.

In Chapter 6, we examine landscape level habitat selection by breeding pairs and spatial relationships among territories in relation to land use patterns. Using known home ranges developed in Chapter 5 and resource selection techniques, we develop a model that describes habitat and landscape features important to breeding pairs in selection of a home range.

Information on diet and foraging of crested caracaras during the breeding season is presented in Chapter 7. We evaluate diet by conducting observations of food deliveries at nests and analyzing composition of prey remains collected at nests. We conducted regular roadkill surveys throughout the study area to assess availability of roadkill.

Chapter 8 contains conclusions from this research. We present an evaluation of the current status of this population within the context of its historical background and research results. We also provide recommendations for conservation efforts, management, and monitoring of this population.

This research included an extensive educational component. An outline of our educational efforts and examples of media coverages are presented in the appendices, along with banding information for all captured crested caracaras.



Fig. 1. Distribution of the crested caracara (*Caracara plancus audubonii*) in North and Central America.

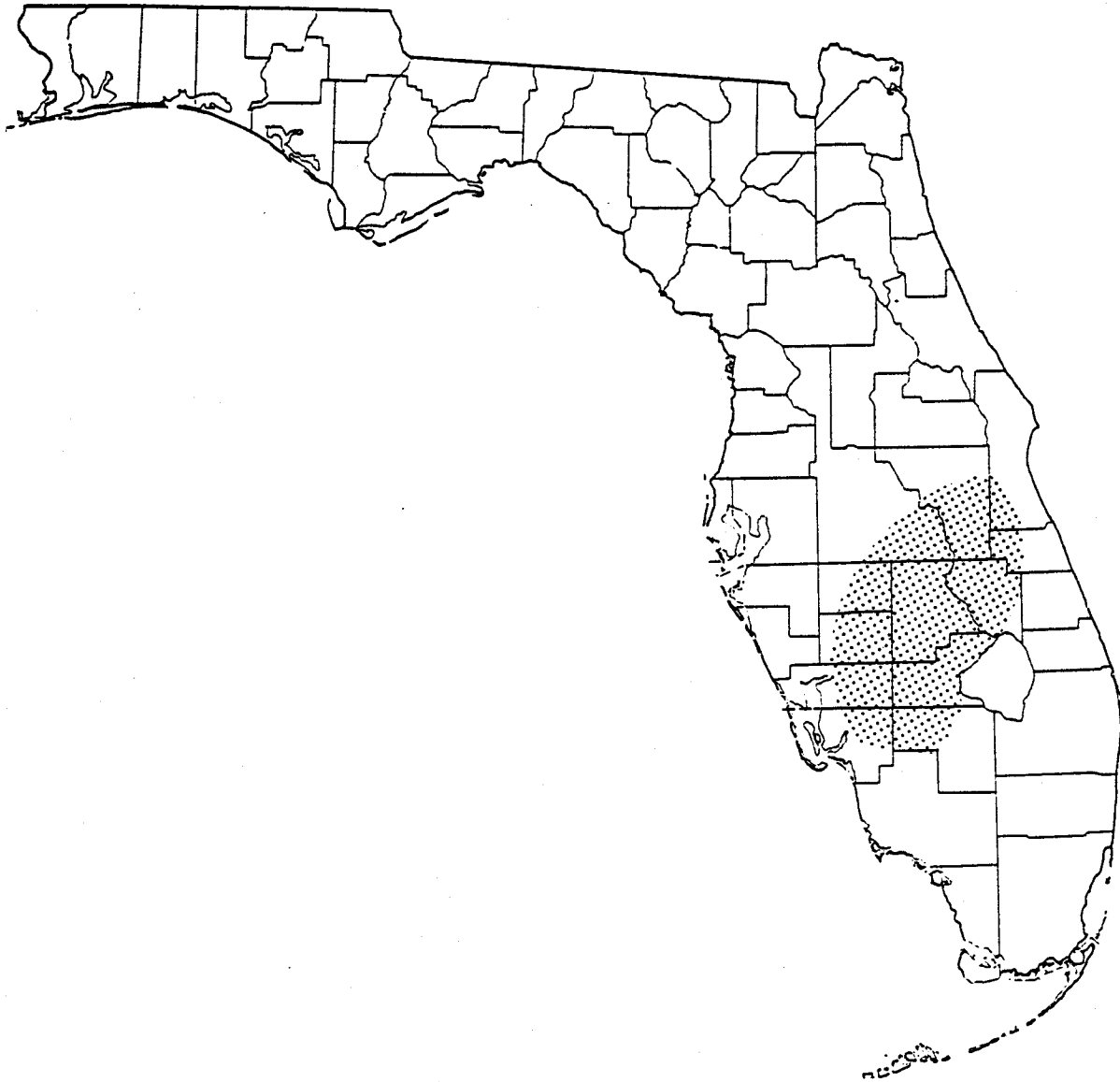


Fig. 2 Current known breeding range of the crested caracara in Florida.
The study area encompassed much of this range.

BREEDING ECOLOGY AND PRODUCTIVITY OF FLORIDA'S CRESTED CARACARAS

INTRODUCTION

The crested caracara (*Caracara plancus*) is one of 9 species in the subgroup Caracarinae (caracaras), family Falconidae. Although some species are widely distributed throughout Central and South America, caracaras as a group have been little studied. The crested caracara is the only species that reaches North America. Breeding populations occur in Texas (Oberholser 1974), southern Arizona (Levy 1988, Ellis et al. 1988), and Florida (Howell 1932, Stevenson and Anderson 1994). The breeding ecology of this species is poorly known throughout its range, although populations in Texas (Dickinson and Arnold 1996) and Baja California Sur, Mexico (Rivera-Rodríguez and Rodríguez-Estrella, unpubl. data) have received recent attention.

Florida's crested caracara population is of conservation concern because it is isolated from other populations, has a restricted range, and apparently is of small size (Funderberg and Heinzmann 1967, Heinzman 1970, Millsap et al. 1990). Nesting habitat throughout its historic range has been greatly reduced by conversion of grassland and pasture habitats for urban and agricultural development, and this habitat loss is expected to continue. This population is currently listed as Threatened by the USFWS and the state of Florida. Despite this listing, published information is limited to descriptions of its natural history and distribution (Nicholson 1929, Howell 1932, Bent 1937, Sprunt 1954, Stevenson and Anderson 1994, Layne 1996).

The intent of this research was to study the breeding ecology of Florida's crested caracaras, particularly to provide data useful for conservation and management of this population. Specific objectives were to 1) describe the breeding ecology, 2) assess relationships between breeding and environmental variables, 3) relate breeding ecology to annual population productivity, and 4) assess variation in reproductive parameters.

STUDY AREA AND METHODS

I studied the breeding ecology of crested caracaras during 3 years in south-central Florida (Fig. 1). The landscape is a mosaic of habitats, primarily grasslands and pastures interspersed with cropland, citrus groves, dairies, pine flatwoods, freshwater marshes and lakes, oak scrub, hardwood hammocks, and urban developments. Primary land uses are cattle ranching, citrus production, and other agricultural crops. Breeding pairs of crested caracaras occupy open

grasslands and pastures. These habitats are characterized by large expanses of low-growing (<0.5 m in height) ground cover of grasses and forbs and are dotted with numerous shallow ponds, wetlands, and marshes, and single or small clumps of live oaks (*Quercus virginiana*), cabbage palms (*Sabal palmetto*), and cypress (*Taxodium sp.*).

Southern Florida has a humid, subtropical climate with a distinct annual pattern of temperature and precipitation (Chen and Gerber 1990). During the rainy season, June through September or October, temperatures are warm and relatively uniform, averaging about 28°C, and monthly rainfall is high. Daily convective rains and thunderstorms are common. The dry season, usually from November through May, is characterized by low monthly rainfall. Temperatures are cooler but rarely drop below freezing. Daily averages are around 20° C, but in May, temperatures as high as 38°C have been recorded.

During the 3 years of this study, I monitored 33, 62, and 62 nesting attempts in 30, 48, and 55, (65 different) territories, respectively. I captured 49 adult caracaras, representing 41 territories. Each received a standard U.S. Fish and Wildlife Service (USFWS) band and an aluminum band with a unique combination of color and alphanumeric character. I banded and radiotagged nestlings between 7 and 8 weeks of age while still in the nest or just after fledging when they could be captured easily on the ground.

Nest Location and Visitation

I located occupied territories by visiting known historic sites (Layne unpubl data, Millsap 1989) and by conducting observations at sites where I had seen adult caracaras. Nests were found by observing the behavior of adults and searching trees in areas where pairs were regularly seen. I conducted monthly observations throughout the year in known territories to assess site fidelity of adults and to look for nesting activity. Although most nests in 1994 were found after hatching, I followed nest progress before laying began in most territories in 1995 and 1996.

Once found, nests were checked weekly to determine their fate. Clutch size, hatching date, brood size, and chick age were determined using a mirror attached to an extendible pole. Each nest was assigned a week of initiation based either on the known time of egg-laying or on back-dating from known hatching or fledging dates (assuming an incubation period of approximately 32 days and a nestling period of approximately 8 weeks). Week of initiation was

then calculated from the first week of September, which I assigned as the first week of the breeding season each year, based on the earliest known egg-laying during all 3 years. I defined breeding season length each year as the number of weeks during which I found nests with eggs. Early nests were defined as those in which egg-laying was initiated before the median laying week each year, late nests were those in which egg-laying was initiated after the mean laying week.

Following nest failures, I continued to check these territories at least monthly for signs of re-nesting. I also regularly searched all territories that had successfully fledged one brood in a breeding season, for second nests (Morrison unpubl. data). After fledging, chicks were monitored weekly by telemetry to determine survival.

Reproductive Success

I estimated probabilities of nest success using Mayfield's method (Mayfield 1961, Johnson 1979) for all nest attempts during all years ($n = 157$ attempts). I estimated weekly rather than daily probabilities of nest success (Mayfield 1961), because of the length of the caracara's breeding cycle. I defined a successful nest as one in which at least one fledgling survived to independence, because conclusions based on reproductive output measured at fledgling independence can differ strongly from those measured at fledging (e.g. Haukioja 1970). From telemetry, I defined independence as the end of the post-fledging dependency period (PFDP), the first 8 weeks post fledging. During this time, young remained near the nest and were dependent on their parents for food. I calculated nest success for the incubation, nestling, and post-fledgling periods, using lengths of 4, 8, and 8 weeks, respectively. I compared Mayfield nest success probabilities between periods and years using a Z-test (Hensler and Nichols 1981). Measures of reproductive success also included clutch size, nestling survival to fledging, fledgling survival to independence, and egg success (the proportion of eggs laid that produced independent young). For these analyses, I used a subset of the total nests with known clutch size ($n = 98$ nests representing 50 territories). I compared these measures using Mann-Whitney and Kruskal-Wallis nonparametric tests (Sokal and Rohlf 1995).

Along with nesting success, territorial occupancy and breeding rates are often used as indicators of the stability and productivity of a population (Steenhof 1987, Newton 1979). Relatively unbiased estimates of these parameters may be derived by determining these rates

over several years for a set of preselected territories (Steenhof and Kochert 1982). I identified 37 territories for which occupancy and breeding status were known in 1994 and tracked their status through the subsequent 2 years. I defined an occupied territory as one in which adult caracaras were seen on 3 or more visits to the territory. I considered a breeding attempt to be actual egg laying, not just nest construction. To assess changes in these rates between years, I used Cochran's *Q*-test (Sokal and Rohlf 1995).

Productivity and Components of Variation

I defined two measures of annual productivity: the number of independent young per nesting attempt and the number of independent young per successful pair. Productivity per successful pair included young from renesting attempts. To evaluate factors that influenced overall annual productivity, I calculated an Index of Productivity for each year using information from known clutch-size nests:

$$\text{Index of Productivity} = \frac{(C) (B) (S)}{N}$$

where *C* = mean clutch size, *B* = length of the breeding season, *S* = egg success, and *N* = length of the breeding cycle (Ricklefs and Bloom 1977, van Riper 1987). Length of the breeding season was the average number of weeks each year when nests with eggs were found, and length of the breeding cycle was:

$$N = b + e + y + n + f$$

where *b* = nest building time (4 weeks), *e* = egg laying (0.5 weeks), *y* = length of incubation period (4.5 weeks), *n* = nestling period (8 weeks), and *f* = fledgling dependency period (8 weeks). All time estimates are average for the sample. Total length of the breeding cycle is approximately 25 weeks.

To evaluate seasonal trends in reproductive performance, I compared clutch size, number of independent young per nesting attempt, and Mayfield nest success estimates for early (initiated egg laying before the median week of egg laying) and late (initiated egg laying after the median week of egg laying) nests for all 3 years. I assessed monthly trends in clutch size and

number of independent young per nesting attempt using weighted regression for unequal sample sizes among categories (Sokal and Rohlf 1995).

To examine variation among reproductive parameters, I calculated the coefficient of variation (standard deviation/mean, Ricklefs 1973) in percent, for clutch size, number of independent young per nesting attempt, number of independent young per successful pair, and Mayfield nest success.

Environmental Data

Data collected from 35 stations throughout the study area by the National Weather Service and the South Florida Water Management District were used for monthly rainfall analysis. I averaged daily precipitation values for each month to obtain monthly average precipitation, for all 35 stations. Values for all stations were then averaged to obtain monthly precipitation averages for the overall study area.

Statistical Analyses

Because each year's sample of territories contained a subset of the previous year's territories, data were not pooled across years, unless indicated. I conducted statistical analyses using SigmaStat ver. 2.0 (Jandel Scientific 1995). All statistics were evaluated at the $\alpha = 0.05$ level.

RESULTS

Territorial Occupancy and Breeding Rates

Territorial occupancy rates for the subsample of 37 territories were 97% and 100% in 1994 and 1995, respectively, but were lower in 1996 (89%, $Q = 6.5 > X^2_{(0.05, 2 \text{ df})} = 5.991$, $P < 0.05$). One territory was only occupied during 1995, and I could not confirm occupancy in 2 additional territories during 1996. Adult caracaras were seen in these areas, but no individuals were banded in these territories and no breeding activity was observed near the traditional nesting site, so these territories were classed as unoccupied. Among known occupied territories, breeding rates remained high during all 3 years, at 100%, 97%, and 97%, respectively ($Q = 2.0 < X^2_{(0.05, 2 \text{ df})} = 5.991$, $P > 0.25$).

Breeding Behavior and Site Fidelity

Pairs of breeding caracaras are apparently monogamous and remain together on the territory throughout the year, although they are not easily observed outside the breeding season. The beginning of the breeding season was signaled by several changes in the adults' behavior. Pairs were often observed around the traditional nesting site perching together, preening and allopreening, and sharing food. Adults were generally faithful to both mate and site. Thirty-nine of 49 banded adults, including both banded members of 5 pairs were present in the same territory and reproduced there for at least 2 years. This represents an annual turnover rate of approximately 18%. Re-pairing within a breeding season was observed only once, after disappearance of a banded female shortly after her single chick fledged. During the 1995 breeding season, an entire family abandoned its breeding territory about one month after the 2 chicks fledged, and moved to an area approximately 4 km from the nest. This new area was within the territory of another pair that had successfully fledged two young that year. Radiotelemetry data for the female and 2 chicks that had relocated indicated that they did not return to their original nesting territory. This female nested successfully in the new territory during 1996.

Nest Building and Incubation

Both males and females build the nest. All pairs that built nests eventually produced a clutch. Building time ranged from 2 to 4 weeks ($n = 34$ pairs) and often, up to 2 months elapsed between nest completion and egg laying. Both parents developed a brood patch and incubated the clutch. Neither mate delivered food to other during incubation, but one would remain on the nest while the other left the area to forage.

Length of the Breeding Season and Timing of Broods

Florida's caracaras' exhibit a prolonged breeding season (Fig. 2). Chicks fledged from successful nests as early as December, indicating that eggs had been laid during late September. The latest eggs were reported in July, in 1995, although these nests failed ($n = 2$, both were second nest attempts). Most young fledged during March and April. Chicks from late and second nests fledged as late as July.

Although there was yearly variation in onset and duration of the breeding season, the median week of egg-laying for all nesting attempts ($n = 157$) was late January each year (Fig. 2) and did not differ among years ($H = 4.14$, $P = 0.13$, Table 1). Secondary peaks of egg-laying in March and April (Fig. 2) represent territories where pairs made a second nesting attempt following a successful first brood ($n = 16$, Morrison unpubl. data). The breeding season was longest in 1995, when nests with eggs were found during 40 weeks. Breeding season length in 1994 and 1996 was approximately 28 weeks (Table 1).

Although within-year variation existed in timing of nest initiation among pairs, between-year nesting intervals for individual pairs were remarkably consistent. The median year-to-year interval between egg laying for single brood pairs was 50 weeks ($n = 41$ pairs, Table 1), thus individual pairs tended to initiate nests at about the same time each year.

Number of Broods Per Year

Multiple nesting within a breeding season occurred during all 3 years. Early nesting pairs regularly renested, either by attempting a second brood or if the first attempt failed (Fig. 3). During 1995 and 1996, an average of 17.5% of early nests failed in the incubation or early nestling stages. Eighty percent of those pairs renested and half of those were successful (Table 2). Time between failure of the first nest and egg-laying in the second nest ranged from 3 to 14 weeks ($n = 8$ pairs, Table 2).

Successful double brooding was recorded during all 3 years (Table 2) (Morrison unpubl. data). Although second nests failed more often and had smaller clutch sizes, pairs that successfully raised two broods during a season had higher annual productivity than pairs that raised only one brood (Morrison unpubl. data). More pairs renested after early failure and attempted a second brood in 1995 than in other years (Table 2).

Clutch Size

For known-size clutches ($n = 98$), the overall mean was 2.23 eggs (Table 3). Modal clutch size was 2 eggs for all 3 years. Mean clutch size was higher in 1994 ($H = 7.61$, $P = 0.02$, $n = 16$) due to more clutches of 3 (Fig. 4) but did not differ between 1995 and 1996 ($U = 1698$, $P = 0.98$). For the same females, clutch size decreased between first nests (2.18 ± 0.20) and replacement or double brood nests (1.91 ± 0.09 , paired t -test, $t = 2.19$, $P = 0.03$, $n = 11$ pairs).

Broods

Hatching was asynchronous, eggs hatched one to two days apart. Both parents fed and cared for the young. Brood size at approximately 4 weeks after hatching averaged 82% of mean clutch size for all 3 years ($n = 81$ broods, Table 3). Brood reduction occurred when chicks fell out of nests (pers. obs.), some chicks simply disappeared, some may have died from starvation (unpubl. data). Over all years, only 38% of nests with 3-egg clutches fledged all 3 chicks. Nestlings were in the nest for 7 to 8 weeks, although the earliest recorded fledging occurred at age 42 days. By fledging, size differences among siblings were lessened (unpubl. data). After fledging, the young remained in the general nest area and were dependent on the adults for food for at least 2 months. Even after independence, some remained in the territory until the adults begin breeding the following year (unpubl. data).

Reproductive Success, Productivity, and Components of Variation

The overall Mayfield probability of nest success for all nest attempts ($n = 157$) was 0.74 (SD = 0.03, Table 4). Nest success in 1995 was lower than in 1996 ($Z = -4.83$, $P < 0.0001$) and in 1994, but not significantly ($Z = 0.73$, $P > 0.46$, Table 4). Lower nest success in 1995 was due to higher rates of failure of early nesting pairs and second brood attempts. Probabilities of nest success during all phases of the nesting cycle were similar within years (Table 4) except for the incubation period in 1994. Most nests that year were found after hatching, so the number of exposure weeks for the incubation period was less in 1994 than in other years.

Measures of productivity were lowest in 1995 (Table 5), due to reduced egg success (Table 3) and nest success (Table 4) during that year. In all years, productivity per successful pair was enhanced because pairs successfully renested following early failure or double brooded. Clutch sizes of 3 produced the most fledglings and independent young during all years (Fig. 5). Two- and 3-egg clutches produced approximately equal proportions of independent young. Most clutches of 1 failed.

Measures of productivity showed the highest variability among reproductive parameters (Table 6). Clutch size varied little and nesting success showed the least variability among parameters (Table 6).

Performance and Laying Date

All measures of breeding performance declined with advance in laying date (Table 7). Mean clutch size was negatively correlated with laying date ($r = -0.85$, $P < 0.01$, Fig. 6) and the regression was significant ($F_{(\alpha=0.05, 1,9)} = 29.07$, $P =$, $n = 98$). Approximately 76% of the variation in clutch size was due to month of nest initiation. The probability of a nest succeeding varied throughout the breeding season (Fig. 7), but during all years, early nesting pairs had a higher probability of nest success ($Z = -3.06$, $P < 0.001$, $n = 76$) than late nesting pairs ($n = 81$, Table 7). Timing of nest initiation also clearly affected productivity. The number of independent young per nesting attempt declined as the breeding season progressed ($r = 0.95$, $P < 0.01$, Fig. 8) and again, the regression was significant ($F_{(\alpha=0.05, 1,9)} = 18.44$, $P < 0.005$, $n = 157$). Approximately 67% of the variation in productivity could be explained by month of nest initiation.

Nest Failure, Egg and Chick Mortality

Overall, 61.2% of all eggs from known-size clutches that hatched survived to fledging and 48.4% survived to independence (Table 3). The fate of most eggs that did not result in an independent young was unknown (Table 8). Total nest failure rates occurred most often during late incubation and right around hatching (Table 9). Overall, an average of 25% of nests failed each year (Table 9), but most early nesting pairs that failed renested, and approximately 50% of renesters were successful (Table 2). On average, 18% of pairs each year failed to produce any young despite a nesting attempt (Table 9).

DISCUSSION

The reproductive rate of birds presumably represents the maximum number of young individuals in a population can raise given the prevailing environmental conditions during a breeding period (Amadon 1964, Lack 1968, Ricklefs 1973). Raptors typically have lower reproductive rates than most birds (Newton 1979). Territorial occupancy rates vary widely, and a percentage of pairs annually may not attempt to breed or may abandon an attempt, often due to weather, food availability, or density dependent effects (Newton and Marquiss 1976, Newton and Marquiss 1986, Village 1990, Kostrzewa 1996).

My results indicate territorial occupancy and breeding rates for Florida's crested caracaras that are not typical of most raptors. In a resident population where pairs are monogamous and remain on the territory year-round, individuals' familiarity with both territory and mate may facilitate successful annual breeding.

Although annual breeding rates were high, productivity varied considerably among pairs and years. In all years, factors that influenced productivity included weather, timing and length of the breeding season, clutch size, timing and number of broods, and mortality.

Weather and Timing and Length of the Breeding Season.

Cues that function to initiate the crested caracara's breeding season in Florida are unknown. Many avian species respond to day length as a cue for reproduction (Immelmann 1971), but I found in all years that caracaras started breeding when day length was still decreasing. Particularly for tropical and subtropical species, many factors may interact to modify the timing of reproduction (Skutch 1950, Immelmann 1971, Ricklefs and Bloom 1977). Food supply is a proximate factor regulating both reproductive timing and effort (Perrins 1970, Newton and Marquiss 1981, Dijkstra et al. 1982, Daan et al. 1989). In tropical and subtropical regions, the abundance of food resources and thus many birds' reproductive cycles are closely tied to rainfall cycles (Skutch 1950). Similarly, Florida's climatic cycle may provide predictable cues to resource availability for crested caracaras. The length and timing of the caracara's breeding season was strongly tied to the rainfall cycle. Reproduction occurred during the winter dry season, with the peak in egg-laying following periods of decreasing precipitation in the fall. During the fall, as conditions become drier, fish and other prey become concentrated in ephemeral wetlands, ponds, and ditches (Kushlan 1990, Babbitt 1996). Caracaras often forage in these habitats and regularly kleptoparasitize other species feeding there (Rivera-Rodríguez and Rodríguez-Estrella 1992, pers. obs.). Seasonal and predictable abundance of prey may enhance individual females' ability to attain body condition necessary for breeding.

Alternatively, because they have a generalist diet, the caracara's breeding cycle may not necessarily be tied to pulses of particular food resources. In Florida, caracaras typically inhabit areas associated with human activities such as cattle ranches, agricultural lands, and urban dumps. These habitats may provide a diversity of predictable food resources, in some part due to

regular schedules of management activities. The abundance of food resources that becomes available during the fall calving season on cattle ranches may influence the timing of reproduction of individuals occupying these habitats.

Rainfall cycles also apparently affect the length of the breeding season. Greater amounts of precipitation during the winter of 1994-1995 (Fig. 2) resulted in a higher water table at the beginning of the rainy season in summer 1995. I found nests containing eggs during a longer period in 1995 and more breeding attempts were recorded. Overall productivity for 1995 was lower, however, despite the longer breeding season and similar mean clutch size. This was due to reduced egg and nest success during that year (Tables 3 and 4).

Temperature cycles may also affect timing of reproduction. Climate during the winter months in Florida is typically mild, whereas higher temperatures in the spring at the end of dry season may impose additional physiological stress, particularly on late nesters. In 1995, many second and late season (June-July) nests failed, and 3 clutches were found abandoned during incubation in May, when ambient temperatures reached $>40^{\circ}\text{C}$ for several consecutive days.

Clutch Size

Variation in clutch size is important if it has an adaptive value to the species. Lack's hypothesis predicts that the modal clutch size is the most productive (Lack 1954, 1966). The most productive clutch size for Florida's crested caracaras was larger than the modal clutch size during all years. Females frequently laid smaller clutches than the most productive clutch size. This is contrary to Lack's hypothesis but instead supports von Haartman's (1971) hypothesis that females capable of laying a variable number of eggs lay clutches as large as they can produce. Klomp (1970) and Högstädt (1980) contend that females generally lay a clutch that corresponds to the number of young that can be raised in each one's particular situation. For Florida's caracaras, the fact that the largest clutches consistently produced the most independent young suggests differences in territorial and individual quality that translate into the ability of each female to lay her optimal clutch size.

Timing and Number of Broods.

A decline in all aspects of breeding performance with advance in laying date has been well documented for birds (Lack 1968, Perrins 1970, Newton and Marquiss 1984, Daan et al

1989, Verhulst and Tinbergen 1991). Timing of nest initiation clearly affects the reproductive performance of Florida's crested caracaras. Clutch size, probability of nest success, productivity, and probability of renesting all declined as the breeding season progressed. Differences in territory or individual quality can affect the timing of egg-laying as well as clutch sizes of individual females (Klomp 1970, Murphy 1978, Verhulst et al 1995). Reduced nesting success late in the breeding season may be indicative of seasonal environmental changes, particularly declining food availability (Perrins 1970, Korpimäki and Lagerström 1988).

Although the ability to renest is clearly advantageous for many avian species (Smith and Roff 1980, Westmoreland et al. 1986, Guepel and DeSante 1990, den Boer-Hazewinkel 1987) most raptors do not normally hatch more than one clutch per season (Newton 1979). The ability to renest enhances the annual productivity and thus, inclusive fitness, of individual caracaras. About half of the pairs that renested following early failure ultimately did produce independent young during the same year. During all 3 years, pairs that successfully fledged two broods in a breeding season incurred higher productivity than pairs that fledged only one brood (Morrison unpubl. data).

Mortality

Loss of eggs and chicks during the breeding cycle affected annual productivity. Less than half of all eggs from known-size clutches resulted in independent young. The loss of most eggs occurred before fledging and the cause of most losses was unknown. Most eggs lost during incubation disappeared right around hatching. With weekly nest checks, it was difficult to determine whether eggs disappeared or whether newly hatched nestlings were lost during the first week. Predation, possibly by crows and raccoons (Layne 1996, pers. obs.) and weather were suspected causes of egg and chick disappearance. Most nest failures that occurred after fledging were caused by vehicle collisions. The loss of a relatively large number of fledglings due to vehicle collisions in 1995 contributed heavily to reduced productivity during that year.

Breeding Strategy and Variation in Reproductive Parameters

Florida is characterized by both spatial and temporal environmental heterogeneity. Individual caracaras time their reproductive efforts to coincide with favorable conditions. Florida's crested caracaras exhibit much spatial and temporal variation in the timing of

reproduction and reproductive performance by individual pairs, as indicated by high coefficients of variation for most parameters. Clutch size and nesting success showed the least variation. Since clutch size is related to the number of young parents can raise (Lack 1954), there would be little advantage to varying clutch size unless future conditions were predictable (Cody 1971). Brood reduction generally occurs to bring brood size in line with local resource conditions (O'Connor 1984). The low coefficient of variation for nest success suggests that most pairs have a good chance at producing at least one independent young during any year. Total nest failures most often occurred late in the season, during all years. High variation in productivity may be attributable to variable food supply and a myriad of potential causes for loss of eggs and chicks. High variation in productivity is also partly due to the fact that productivity was measured after the young had become independent and mortality factors had acted for a longer period.

Variable weather and resource conditions have probably been major factors in the evolution of observed life history patterns for Florida's crested caracaras. Patterns of reproduction may have evolved because they are effective in a variable environment. Despite indications that caracaras may breed in any month of the year, most nests are initiated during a limited period in winter. This timing may have evolved because this was the optimal period in terms of factors such as climate, food resources, or predation. Winter weather is unpredictable in south-central Florida, however. Early nesting pairs in particular, face a tradeoff because unpredictable storms and cold fronts may impose high risk of failure on these nests.

Multiple nesting per year is a beneficial strategy. Pairs that successfully renest after failure or successfully double brood ultimately may have more young recruited into the breeding population. Despite the risk of failure due to weather, nesting as early as possible is advantageous because early nesting pairs generally fledge more chicks per nest and have the opportunity to make a second nesting attempt.

Population Persistence

Successful reproduction by individuals is critical in maintaining viability of populations, particularly those not benefiting from the influx of individuals from other populations. My results suggest that breeding season length, clutch size, probability of nest success, and mortality are important factors influencing productivity of Florida's crested caracaras. Future research

efforts should focus on identifying habitat or other resource characteristics correlated with large clutch sizes and high nesting success in this population. This knowledge would improve the ability of land managers to identify and manage caracara habitat to maximize productivity on known territories

Comparison with Other Crested Caracaras

Information on the breeding biology and nesting success of other crested caracara populations is limited. Dickinson and Arnold (1996) and Rivera-Rodríguez and Rodríguez-Estrella (unpubl. data) have reported extended breeding seasons for crested caracaras in Texas and Baja California Sur, Mexico, respectively. Crested caracaras in Texas had a mean clutch size of 2.14 ± 0.14 SD eggs, ($n = 7$ clutches, Dickinson and Arnold 1996). Productivity was 1.14 ± 0.46 SD independent young per breeding pair ($n = 7$ attempts) and declined as the breeding season progressed (Dickinson and Arnold 1996). Rivera-Rodríguez and Rodríguez-Estrella (unpubl. data) reported productivity of 1.91 ± 0.08 SE fledglings per nesting attempt ($n = 22$) in Mexico. Double brooding was also suspected at both sites. Second clutches were observed in June in Texas (Dickinson and Arnold 1996), and in August in Mexico (Rivera-Rodríguez and Rodríguez-Estrella, unpubl. data).

Table 1. Breeding chronology and intervals, in weeks, between broods for Florida's crested caracara population, 1994 - 1996.

Year	Length of breeding season (weeks)	Median week of initiation for all attempts	<i>n</i>	Median year to year interval for single brooded pairs	<i>n</i>
1994	28	21 (3rd wk Jan)	33	ND	
1995	40	22 (4th wk Jan)	62	52	18
1996	28	22 (4th wk Jan)	62	48	23

Table 2. Multiple nesting in Florida's crested caracara population, 1994 - 1996. Early nests are those that initiated egg-laying before the median week of egg-laying for the entire sample, each year.

Year	Number of territories	Early nests	Early nests that failed	Attempted renesting after failure	Successful	Interval between failed first nest and replacement nest in same year	<i>n</i>	Attempted second brood	Successful
1994	30	ND	ND	ND	ND	ND		3 (10.0%)	3 (100%)
1995	48	26	7 (26.9%)	6 (85.7%)	3 (50%)	4 - 6 weeks	6	8 (16.7%)	4 (50%)
1996	55	31	3 (9.7%)	2 (66.7%)	1 (50%)	3 - 14 weeks	2	5 (9.1%)	3 (60%)

Table 3. Reproductive success parameters for Florida's crested caracaras, 1994 - 1996. Nestling survival to fledging (number of fledglings/number of eggs laid), fledgling survival to independence (number of young alive at end of PFDP/number fledged), and egg success (proportion of eggs laid that produced independent young) for eggs from known size clutches.

Year	No. clutches	Clutch size	Eggs Laid	Brood size	No. broods	Percent of clutch size	No. fledged	Nestling Survival	No. survived to end of PFDP	Fledgling Survival	Egg Success
1994	16	2.56 (0.16)	41	2.23 + 0.20	13	87%	27	65.9%	22	81.5%	0.54
1995	41	2.17 (0.08)	89	1.75 + 0.12	32	81%	51	57.3%	34	66.7%	0.38
1996	41	2.17 (0.08)	89	1.75 + 0.12	36	81%	56	62.9%	50	89.3%	0.56
Overall	98	2.23 (0.05)	219	1.83 + 0.07	81	82%	134	61.2%	106	79.1%	0.48

Table 4. Estimates of Mayfield nest success probabilities for breeding pairs of crested caracara in south-central Florida, 1994 - 1996.

Year	Territories Followed	Nesting Attempts	Incubation period (SD)	Nestling period (SD)	Fledgling period (SD)	Total probability of nest success (SD)
1994	30	33	0.75 (0.06)	0.95 (0.02)	0.93 (0.02)	0.66 (0.09)
1995	48	62	0.87 (0.02)	0.82 (0.02)	0.83 (0.02)	0.59 (0.04)
1996	55	62	0.94 (0.02)	0.92 (0.01)	0.98 (0.01)	0.85 (0.03)
Overall	65	157	0.89 (0.02)	0.88 (0.01)	0.93 (0.01)	0.74 (0.03)

Table 5. Measures of annual productivity (mean $\pm$ SE) and Index of Productivity for crested caracaras in south-central Florida, 1994 - 1996. See text for calculation of Index of Productivity. Productivity per successful pair includes young from renesting attempts.

Year	Number of independent young per attempt	<i>n</i>	Number of independent young per successful pair	<i>n</i>	Index of Productivity
1994	1.33 $\pm$ 0.16	33	1.87 $\pm$ 0.16	23	1.55
1995	0.98 $\pm$ 0.11	62	1.69 $\pm$ 0.10	36	1.32
1996	1.34 $\pm$ 0.10	62	1.69 $\pm$ 0.09	49	1.36
Overall	1.20 $\pm$ 0.07	157	1.73 $\pm$ 0.06	108	

Table 6. Variability in reproductive parameters for crested caracaras during 3 years in south-central Florida. CV = coefficient of variation (standard deviation/mean). Productivity/successful pair include young from renesting efforts. N = 98 clutches, 88 pairs.

Parameter	1994			1995			1996			Total		
	Mean (SD)	CV (%)	n	Mean (SD)	CV (%)	n	Mean (SD)	CV (%)	n	Mean (SD)	CV (%)	n
Clutch size	2.56 (0.63)	24.6	16	2.17 (0.54)	24.9	41	2.17 (0.50)	23.0	41	2.23 (0.55)	24.4	98
Productivity per nesting attempt	1.33 (0.89)	66.9	33	0.98 (0.90)	91.8	62	1.34 (0.79)	59.0	62	1.20 (0.87)	72.5	157
Productivity per successful pair	1.87 (0.78)	41.7	23	1.69 (0.62)	36.7	36	1.69 (0.62)	36.7	49	1.73 (0.65)	37.6	108
Nesting success (Mayfield)	0.66 (0.09)	13.6	33	0.59 (0.04)	6.8	62	0.85 (0.03)	3.5	62	0.74 (0.03)	4.0	157

Table 7. Seasonal decline in breeding performance (mean $\pm$ SE) for known size clutches and for all nest attempts of crested caracara in south-central Florida, 1994 - 1996. Early nests initiated egg laying before the median week of egg laying each year, late nests initiated egg laying after the median week.

	Year							
	1994	<i>n</i>	1995	<i>n</i>	1996	<i>n</i>	Total	<i>n</i>
Clutch size (<i>n</i> = 98)								
Early	2.75 + 0.16	8	2.29 + 0.11	24	2.24 + 0.09	29	2.33 + 0.07	61 ^a
Late	2.38 + 0.26	8	2.00 + 0.12	17	2.00 + 0.12	12	2.08 + 0.09	37 ^a
Number independent young per attempt (<i>n</i> = 157)								
Early	1.53 + 0.19	19	1.27 + 0.18	26	1.39 + 0.16	31	1.38 + 0.10	76 ^b
Late	1.07 + 0.25	14	0.76 + 0.14	36	1.29 + 0.12	31	1.02 + 0.09	81 ^b
Nest success (<i>n</i> = 157)								
Mayfield estimate (SD)								
Early	0.95	(0.03)19	0.72	(0.06) 26	0.82	(0.05) 31	0.79(0.03)	76 ^c
Late	0.55	(0.11)14	0.50	(0.06) 36	0.88	(0.04) 31	0.64(0.04)	81 ^c

^a *t* = -2.18, *P* = 0.03

^b *U* = 6687.5, *P* = 0.02

^c *Z* = -3.05, *P* < 0.001

Table 8. Fates of eggs from known-size clutches for crested caracara nests in south-central Florida, 1994 - 1996.

Fate	1994	1995	1996
Chick survived to independence	22 (53.7%)	34 (38.2%)	50 (56.2%)
<u>Incubation stage</u>			
Unknown egg/chick ^a	5 (12.2%)	20 (22.5%)	23 (25.8%)
Eggs did not hatch	3 (7.3%)	1 (1.1%)	0
Died during pipping	0	1 (1.1%)	0
Eggs abandoned	0	8 (9.01%)	0
Known predation	3 (7.3%)	2 (2.2%)	0
<u>Nestling stage</u>			
Chick died in nest ^b	0	0	2 (2.2%)
Chick defect/disease ^c	0	2 (2.2%)	0
Chick disappeared, fate unknown	2 (4.9%)	4 (4.4%)	7 (7.9%)
Chick fell out of nest	1 (2.4%)	1 (1.1%)	1 (1.1%)
<u>Fledgling stage</u>			
Killed by vehicle	1 (2.4%)	7 (7.9%)	6 (6.7%)
Fledgling found dead, cause unknown	2 (7.3%)	8 (9.0%)	0
Fledgling disappeared, fate unknown	2 (2.4%)	1 (1.1%)	0
Total eggs	41	89	89

^a Not known whether eggs were lost during incubation or whether they hatched and chicks were lost during early nestling stage.

^b Chick found dead in nest, during first two weeks, from unknown causes.

^c Chick died of injury or defect before it fledged.

Table 9. Failure of crested caracara nests in south-central Florida, 1994-1996.

	1994	1995	1996
Total nest attempts	32	62	62
Total territories	30	48	55
Failures (% of all nest attempts)	7 (21.9%)	24 (38.7%)	11 (17.7%)
During incubation/hatching	2	9	5
During nestling period	2	7	3
After fledging	3	8	3
Territories that did not produce any young despite nesting attempt	6 (20.0%)	11 (22.9%)	5 (9.1%)

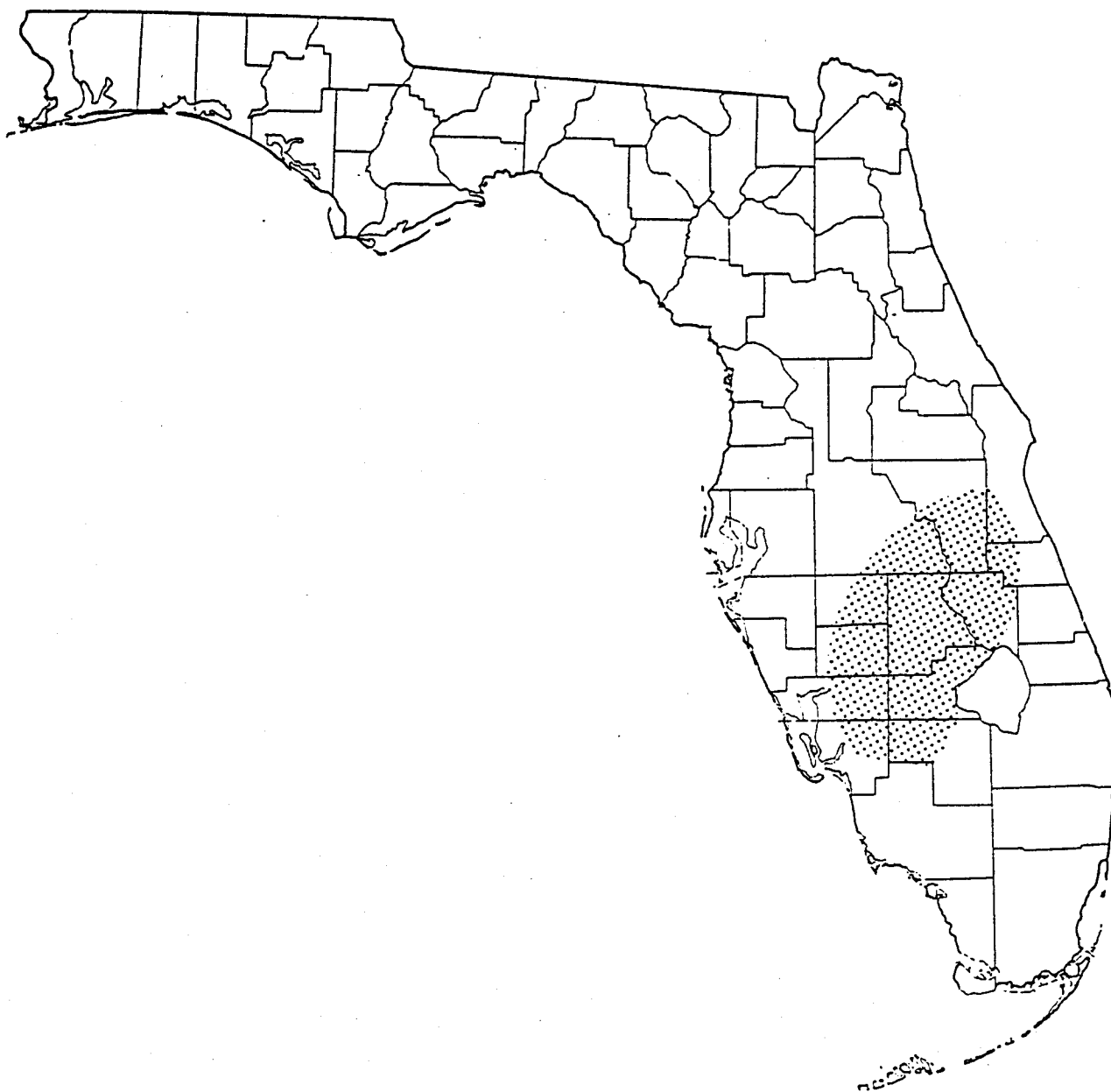


Fig.1 Location of study area for crested caracaras in south-central Florida. Study area encompassed much of the species' current known breeding range in Florida.

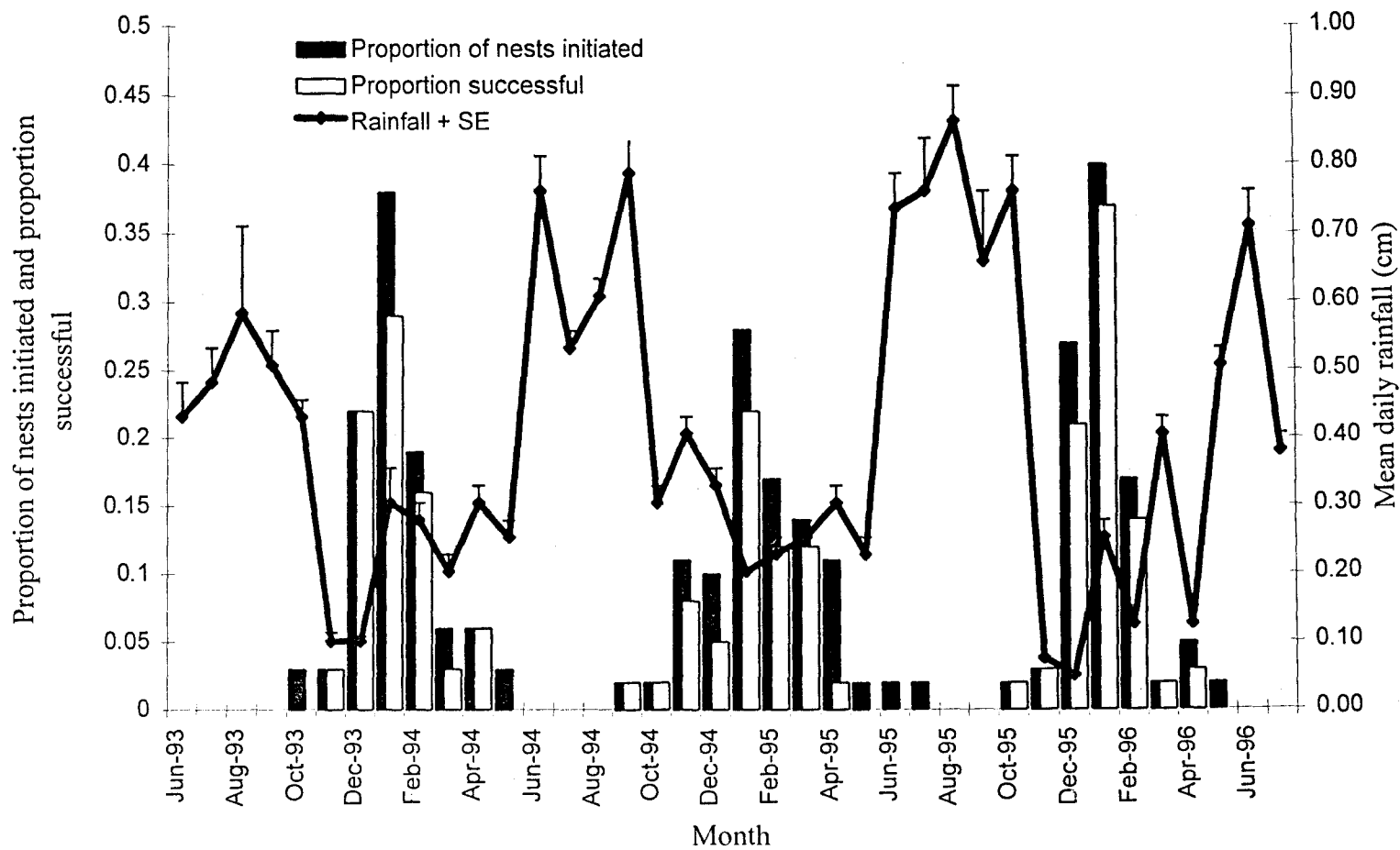


Fig. 2. Relationship between mean daily rainfall and proportion of nests initiated and of those, the proportion successful, for crested caracaras in south-central Florida, 1994 ($n = 33$ nest attempts), 1995 ($n = 62$ attempts), 1996 ($n = 62$ attempts).

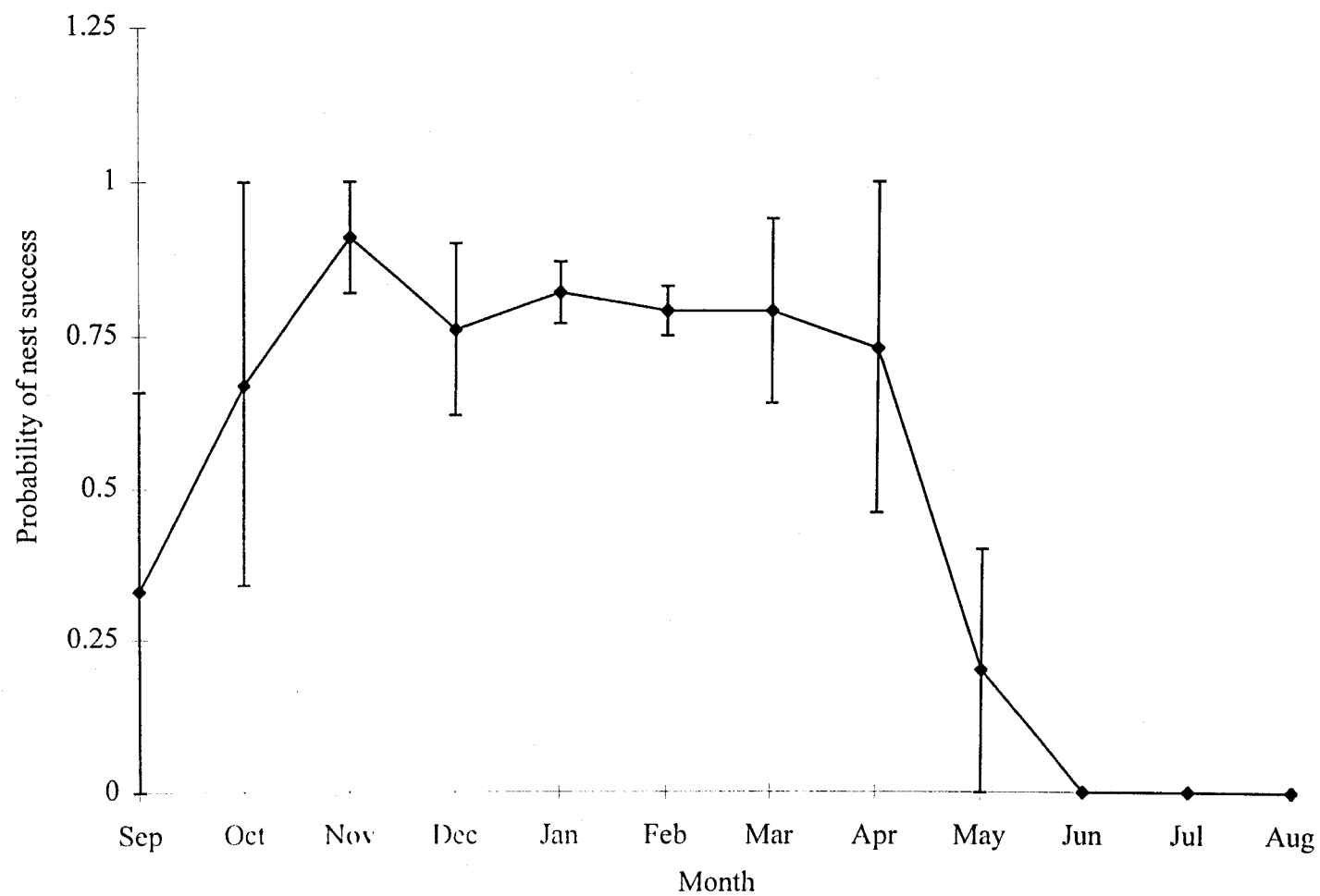


Fig. 7. Mayfield probability of nest success (+ SD) by month for Crested Caracaras in south-central Florida, 1994 - 1996 (n = 157 nest attempts).

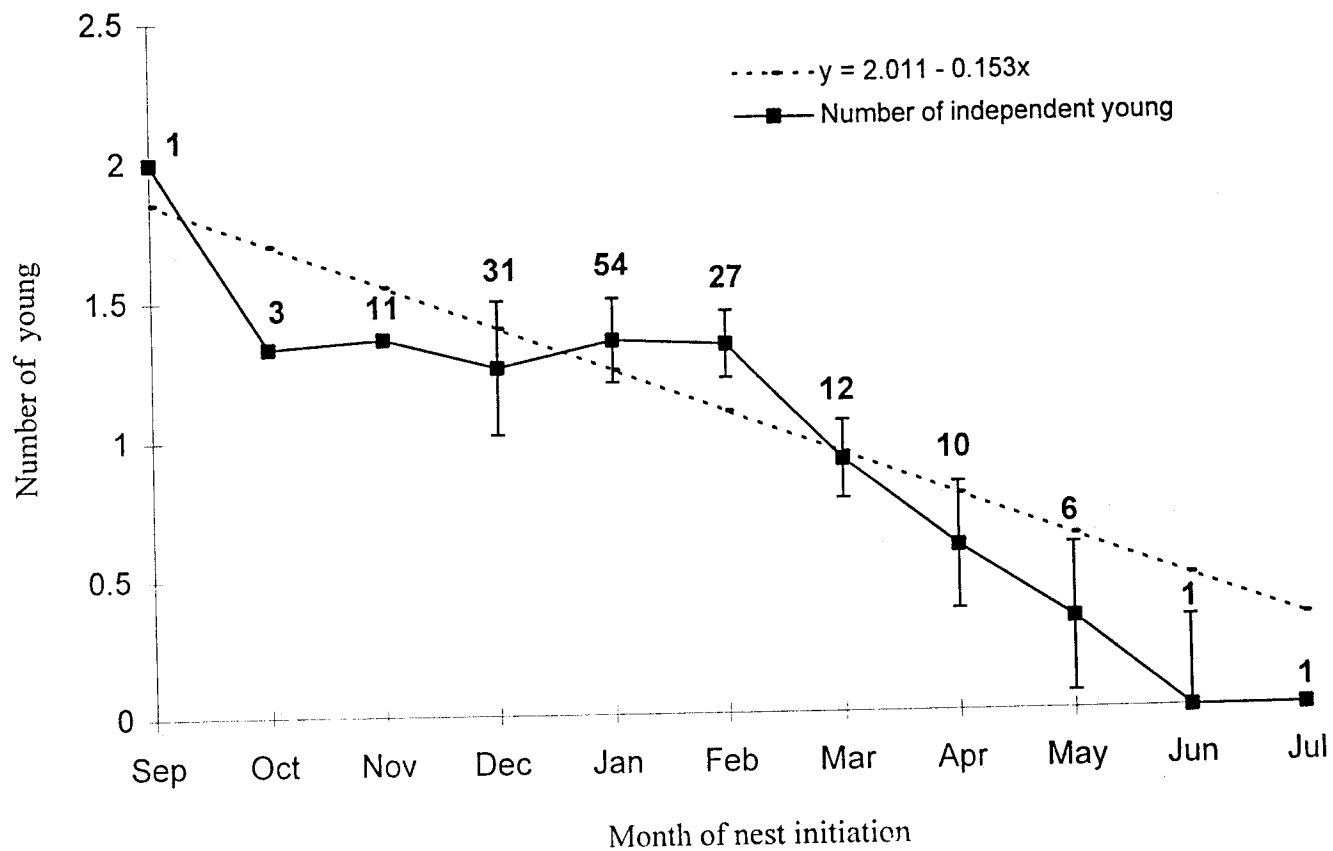


Fig. 8. Relationship between productivity per nest attempt ($n = 157$ attempts) and month of nest initiation for Crested Caracaras in Florida, 1994 - 1996. Number of nest attempts are shown above each month.

year. For 1995 and 1996, I compared timing of first nest initiation between pairs that had double brooded the previous year and pairs that produced only one brood.

I used logistic regression to evaluate the effects of several factors on the occurrence of double brooding in this population. I examined whether initiation date of the first clutch (INITWK) and numbers of fledglings in the first brood (NUMFRST) influenced the occurrence of double brooding during the same year. For pairs whose reproductive history was known for at least 2 years, I examined whether the occurrence of double brooding during any year was influenced by whether or not the pair had double brooded during the previous year (DBPREV), the number of fledglings from the previous year (NUMPREV), and the fledging date from the previous year (WKPREV).

I used SigmaStat (Jandel Scientific 1995) for statistical tests. Significance for all tests was assumed at the $\alpha = 0.05$ level. Comparisons of fecundity, timing of nest initiation, and productivity were made using Wilcoxon rank sum and Kruskal-Wallis nonparametric tests (Sokal and Rohlf 1995). Post-hoc power estimates for two-sided Wilcoxon tests were obtained using the program Resampling Stats (Resampling Stats Inc. 1995). I first simulated 10,000 values of the rank sum statistic under the null hypothesis of no differences between nest types. The 95th percentile of these values was used as the critical value for determining significance of the difference between nest types, given the two corresponding sample sizes. Real data values were resampled to approximate the alternate distribution of the rank sum statistic as suggested by the data. The power of the Wilcoxon test at the 0.05 level was then estimated as the proportion of times out of 10,000 iterations that the resampled test statistic was at least as large as the critical value.

RESULTS

Extent of Occurrence of Double Brooding

I monitored breeding activity on 60 different territories throughout the study, although only a subset of those each year (Table 1). A second nesting attempt was made during at least one year on 13 territories (21.7%, Table 1). On three other territories, the pair initiated a second nesting attempt during two consecutive years, although none of these pairs successfully fledged two broods in more than one year. Both adults were color banded in one

territory where double brooding occurred. In all other territories where double brooding occurred, one adult was banded and participated in both nesting efforts.

Timing of broods

Pairs that attempted a second brood initiated their first nests significantly earlier ($U = 1504.5$, $P = 0.00$, $n = 16$) than single-brooded pairs ($n = 103$) (Table 1). Second nests of double-brooded pairs were initiated 9 - 13 weeks later ($U = 26.5$, $P = 0.00$, $n = 16$) than nests of single brooded pairs. Median week of nest initiation did not differ among years for each nest type (single brood, $H = 0.79$, $P = 0.67$, $n = 103$; first of two, $H = 1.88$, $P = 0.39$, $n = 16$; second of two, $H = 0.65$, $P = 0.72$, $n = 16$, Table 1).

Because I monitored territories year round, I determined that only early breeders attempted to double brood. The proportion of successful first-brood pairs that attempted second broods decreased with increasing laying date (Fig. 1). Of pairs that attempted a second brood ($n = 16$), 72% fledged young from their first brood before 1 March, 94% before 1 April. Of all pairs that fledged a brood before 1 March ($n = 16$), 69% made a second nesting attempt. The mean interbrood interval was 7.6 weeks (range 2 - 13 weeks, $n = 16$), and interval length was positively correlated with the number of young fledged from the first nest ($r = 0.50$, $P < 0.05$, Fig. 2).

Productivity and nesting success

Mean clutch size declined between the first and second nests of double-brooded pairs (Table 2). Laying times of second clutches and the first clutches of late breeders overlapped during March and early April (Fig. 1). Mayfield success estimates for second nests were significantly lower than those for first nests or nests of single-brooded pairs (Table 2). Despite higher failure rates of second nests, pairs that successfully double-brooded fledged significantly more young ($U = 984.0$, $P < 0.001$, power > 0.99 , $n = 10$) than pairs that only fledged a single brood each year ($n = 93$, Fig. 3).

Parental care and post fledging survival

First brood young incurred shorter periods of post-fledging parental care. Mean time to departure from the natal territory of first brood fledglings ($11 \text{ wk} \pm 2.56 \text{ SE}$, $n = 18$) was significantly shorter ($U = 290.5$, $P = 0.00$) than that of fledglings from single brood pairs (33

wk $\pm$ 1.61 SE, $n = 34$) or of second brood fledglings (29.7 wk $\pm$ 1.73 SE, $n = 9$, $U = 33.0$, $P = 0.01$). Post-fledging care of first brood young overlapped incubation of the second clutch in all cases. Young from first broods typically left the natal territory during the early nestling stage of the second brood. The period of post-fledging parental care for fledglings from single brood pairs and second brood fledglings did not differ ($U = 54.4$, $P = 0.40$). In many cases, these fledglings remained in the natal territory until the parents began breeding the following year.

Estimates of survival probability to recruitment differed between young from first and second broods (Kaplan-Meier survival function, $X^2 = 8.51$, $P = 0.004$, Fig. 4). Survival estimates for young from first broods were also higher than estimates for young from single broods ($X^2 = 75.95$, $P = 0.00$, Fig. 4).

Potential costs to adults

Survival estimates to subsequent breeding seasons did not differ ($X^2 = 0.01$, $P = 0.92$) between known double brooded ($n = 16$) and single-brooded ($n = 38$) adults. Clutch sizes did not differ between known adults that had successfully double brooded in the previous year ($U = 95.0$, $P = 1.0$, $n = 10$) and known adults that produced only one brood ($n = 19$), but power of this test was low (0.05) because of small sample sizes each year. I did not detect a delay in nesting by double brooded adults in the year following a double brood event. The median week of egg-laying did not differ between pairs that had successfully double-brooded the previous year and pairs that fledged only one brood in either 1995 ($U = 80.0$, $P = 0.13$, $n = 3$ double brooded pairs, 35 single brooded pairs) or 1996 ($U = 105.0$, $P = 0.46$, $n = 4$ double brooded pairs, 43 single brooded pairs). Power of these tests was low, however, at 0.23 and 0.12, respectively.

Influence of factors

Timing of initiation of the first brood (INITWK) was the only factor important in predicting the occurrence of double brooding that same year by caracara pairs (Table 3). For pairs whose reproductive status was known for the previous year ($n = 45$), the occurrence of double brooding in any year was not influenced by double brooding the previous year, the number fledged during the previous year, or the date of fledging the previous year (Table 4).

DISCUSSION

Life history theory predicts that a breeding attempt will occur when the likely benefits to lifetime reproductive success exceed expected costs (Williams 1966, Stearns 1992). In Florida's crested caracara population only a small percentage of pairs apparently attempt a second brood in any year. This strategy is likely maintained, however, because double brooded individuals may incur higher inclusive fitness (Perrins 1970, Boer-Hazewinkel 1987). Although offspring quality declines between the first and second broods and the probability of recruitment is lower for second brood young, successful double brooded individuals are more productive, so potentially have more young recruited into the breeding population. In addition, costs of double brooding to adults and young seem minimal.

Second clutches may reduce the reproductive value of the first brood because of reduced post-fledging care of first brood fledglings (Verhulst and Hut 1996). I found no evidence that first-brood young incurred reduced post-fledging survival despite reduced post-fledging parental care. First brood fledglings had the highest probability of survival to recruitment. This suggests that juvenile caracaras can become independent foragers in a period as short as 7-8 weeks.

I found little evidence of costs to double brooded adults, though these conclusions remain preliminary because of the short time frame of the study, small sample sizes, and low power of statistical tests. Caracaras are long-lived (Klimkiewicz and Fletcher 1989, Morrison 1996), so evidence of costs may not be evident in the short term. First brood young have the highest survival probabilities, thus, the timing of breeding is apparently the most important factor influencing individual productivity and reproductive success (Morrison unpubl. data). Individuals that nest early enough to attempt a second brood may be the most fit. Additional years of tracking the survival and reproductive efforts of known adults are needed to properly evaluate these potential costs.

The occurrence of double brooding in Florida's crested caracara population may be related to length of the breeding season and food availability. These two factors largely determine the number and the timing of broods produced by a breeding pair (Perrins 1970, Newton 1979, Tinbergen and van Balen 1988). The subtropical climate of south Florida (Chen and Gerber 1990), allows crested caracaras to extend the breeding season, generally

beginning in September and continuing throughout the winter and into June or early July (Morrison 1996). Early nesting pairs, at least, may have sufficient time to raise two broods.

Food supply is an important factor influencing the occurrence and timing of breeding in raptors (Cavé 1968, Dijkstra et al. 1982, Newton and Marquiss 1984). Food supply apparently influences the number of young fledged annually by a breeding pair primarily by influencing the occurrence of multiple brooding (Malherbe 1963, Bednarz 1987). The crested caracara has a varied diet and feeds on live vertebrate and invertebrate prey as well as carrion (Richmond 1976, Ellis et al. 1988, Morrison 1996), therefore breeding need not be synchronized with availability of particular foods. It typically inhabits areas associated with human activity such as cattle ranches, agricultural lands, and urban dumps (Rodríguez-Estrella 1996, pers. obs.). These habitats may provide a diversity of predictable food resources, in some part due to regular schedules of management activities. The combination of a relatively mild climate and the availability of a variety of food resources apparently allows early initiation of breeding and occasionally, double brooding by some pairs. Whether individuals actually attempt a second brood or even attempt to nest early in the season may depend on the age and quality of individuals, experience of pairs, and territory quality. The occurrence of double-brooding in any year was not influenced by the previous year's reproductive effort, again suggesting that double brooded individuals may be the most fit.

Year-round residency and persistence of the pair bond between nesting seasons may facilitate double brooding in crested caracaras because of individuals' familiarity with habitats and resources. Males and females have similar parental roles, so pairs may have little difficulty feeding first-brood fledglings and incubating a second clutch. Caracaras also frequently reuse old nests for first and second breeding attempts. Reuse of old nests reduces the time required for nest-building (Mader 1975, Toland 1985, Westmoreland et al. 1986).

Double brooding is likely a regular but uncommon occurrence in Florida's population of crested caracaras and may occur in other populations (Dickinson and Arnold 1996, Rodríguez-Estrella and Rivera-Rodríguez, unpubl. data). An extended breeding season and post-fledging dependency period may have contributed to a previous lack of its confirmation. Some juveniles remain on their natal territory for several months after fledging (Morrison

1996). Therefore, determining whether juveniles seen with adults during any month of the year are from a single or second brood is not possible.

Since only a small percentage of pairs attempt second nests and contributions by these pairs to overall annual population productivity seem only marginal, why does this strategy persist? The ultimate value of double brooding must be that these individuals produce more young with some probability of establishing themselves in the breeding population. Combined with an extended breeding season, environmental and food conditions during some years may be favorable for some pairs to attempt a second nest. In addition, costs may be small, at worst. Of greater interest is why more individuals do not adopt this strategy. For many avian species, the occurrence and timing of a breeding effort is influenced by age and experience of the parents or energetic constraints related to territory or individual quality (e.g., Smith and Roff 1980, Evans Ogden and Stutchbury 1996). The absence of double brooding in some early nesting pairs of crested caracaras and the lack of earlier nesting by many single-brooded pairs may be related to these factors. Further studies of conditions that influence the occurrence and timing of breeding by individuals and a more accurate assessment of recruitment rates of first and second brood young are needed to better understand the contribution of double brooding to individuals' lifetime reproductive success and to the overall dynamics of Florida's crested caracara population.

Table 1. Occurrence and timing of nesting attempts between years for crested caracaras in south-central Florida. NA = not applicable for that year.

Year	Total territories followed/new territories added	No. of 2nd nest attempts found (%) /Different from previous year	Median week of initiation of single brood nests	<i>n</i>	Median week of initiation of first of two nest attempts	<i>n</i>	Median week of initiation of second of two nest attempts	<i>n</i>
1994	28/28	3 (10.7)/NA	21 (3rd wk Jan)	25	14 (5th wk Nov)	3	32 (2nd wk Apr)	3
1995	43/17	8 (18.6)/7	22 (4th wk Jan)	35	12 (4th wk Nov)	8	32 (2nd wk Apr)	8
1996	48/15	5 (10.4)/3	22 (4th wk Jan)	43	16 (3rd wk Dec)	5	35 (4th wk Apr)	5
Overall	60 territories	16 attempts/13 territories		103		16		16

Table 2. Clutch size (mean $\pm$ SE) and nesting success (SD in parentheses) between nest types for crested caracaras in south-central Florida, 1994-1996. The same letter indicates significant differences between nest types. ND = no data on clutch sizes of first or second nests in 1994 because these nests were found after hatching.

Nest type	Year	Clutch size	<i>n</i>	Mayfield nest success	<i>n</i>
Single broods	1994	2.60 $\pm$ 0.16	15	0.67 (0.09)	25
	1995	2.28 $\pm$ 0.11	25	0.72 (0.05)	35
	1996	2.22 $\pm$ 0.09	32	0.92 (0.03)	43
Total		2.32 $\pm$ 0.07	72	0.81 (0.03) ^a	103
First of two	1994	ND		1.00 (0.00)	3
	1995	2.66 $\pm$ 0.32	3	1.00 (0.00)	8
	1996	2.33 $\pm$ 0.33	3	1.00 (0.00)	5
Total		2.50 $\pm$ 0.22 ^b	6	1.00 (0.00) ^c	16
Second of two	1994	ND		1.00 (0.00)	3
	1995	1.80 $\pm$ 0.02	5	0.35 (0.15)	8
	1996	2.00 $\pm$ 0.00	2	0.25 (0.20)	5
Total		1.86 $\pm$ 0.14 ^b	7	0.35 (0.12) ^{a,c}	16

^a $Z = 3.72, P < 0.0002$

^b $U = 33.0, P = 0.03$

^c $Z = 4.19, P < 0.0001$

Table 3. Statistics for logistic regression analysis of the influence of timing of initiation of the first brood (INITWK) and the number fledged in the first brood (NUMFRST) on the occurrence of double brooding in crested caracaras in south-central Florida, 1994 - 1996. $n = 16$ double-brooded pairs, 103 single-brooded pairs.

Variable	Coefficient	SE	<i>P</i>
Constant	7.50	2.22	0.001
INITWK	-0.52	0.12	<0.001
NUMFRST	0.01	0.43	0.97

Table 4. Statistics for logistic regression analysis of the influence of double brooding the previous year, fledging date and number fledged the previous year on the occurrence of double brooding in crested caracaras in south-central Florida, 1994 - 1996. $n = 11$ double-brooded pairs, 34 single-brooded pairs.

Variable	Coefficient	SE	<i>P</i>
Constant	2.40	0.28	0.39
DBPREV	0.72	0.92	0.44
WKPREV	-0.12	0.86	0.15
NUMPREV	0.27	0.55	0.63

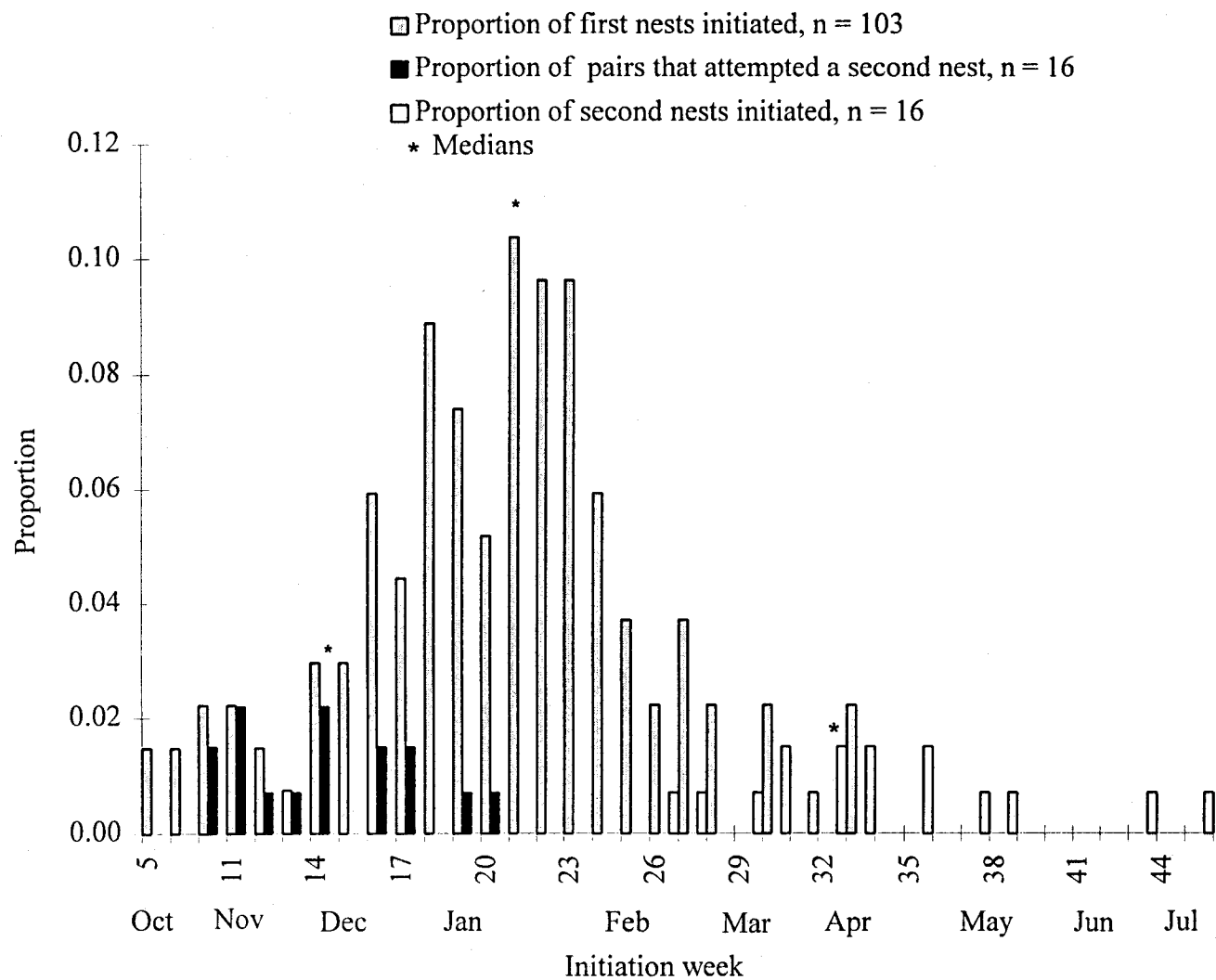


Fig. 1. Timing of nest initiation throughout the breeding season for crested caracaras in south-central Florida, 1994 - 1996.

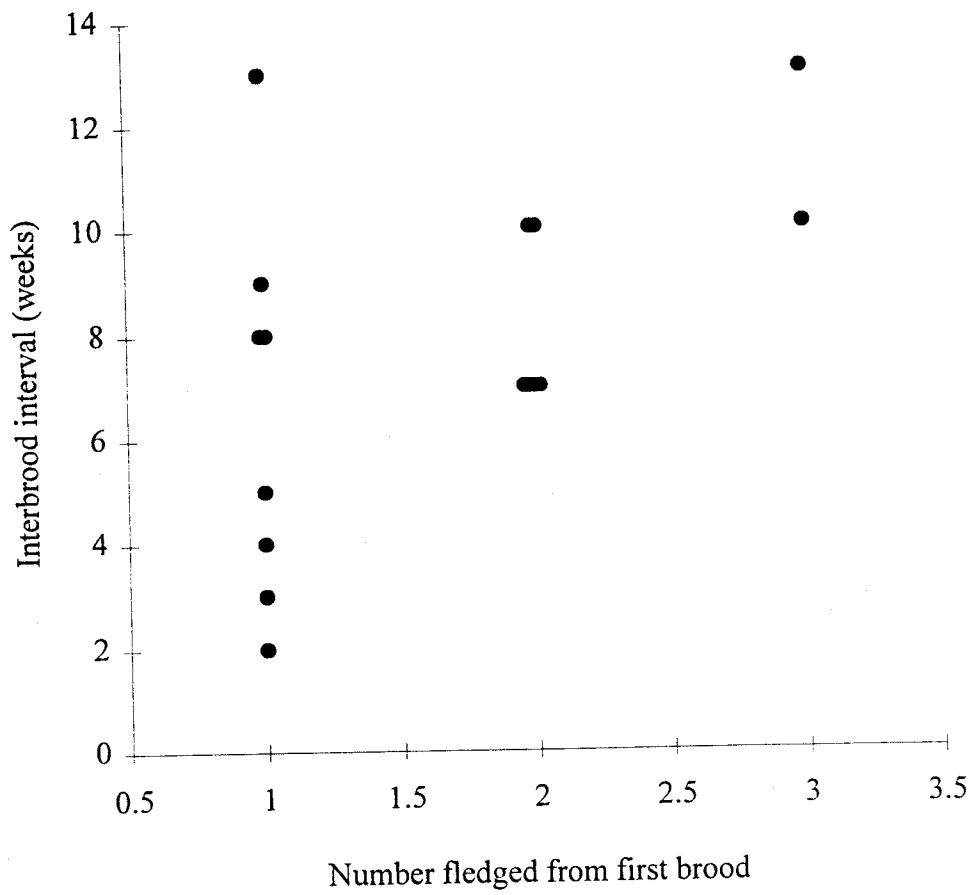


Fig. 2. Length of the interbrood interval in relation to number fledged from the first nesting attempt for double brooded crested caracaras in south-central Florida, 1994 - 1996. n = 16 pairs.

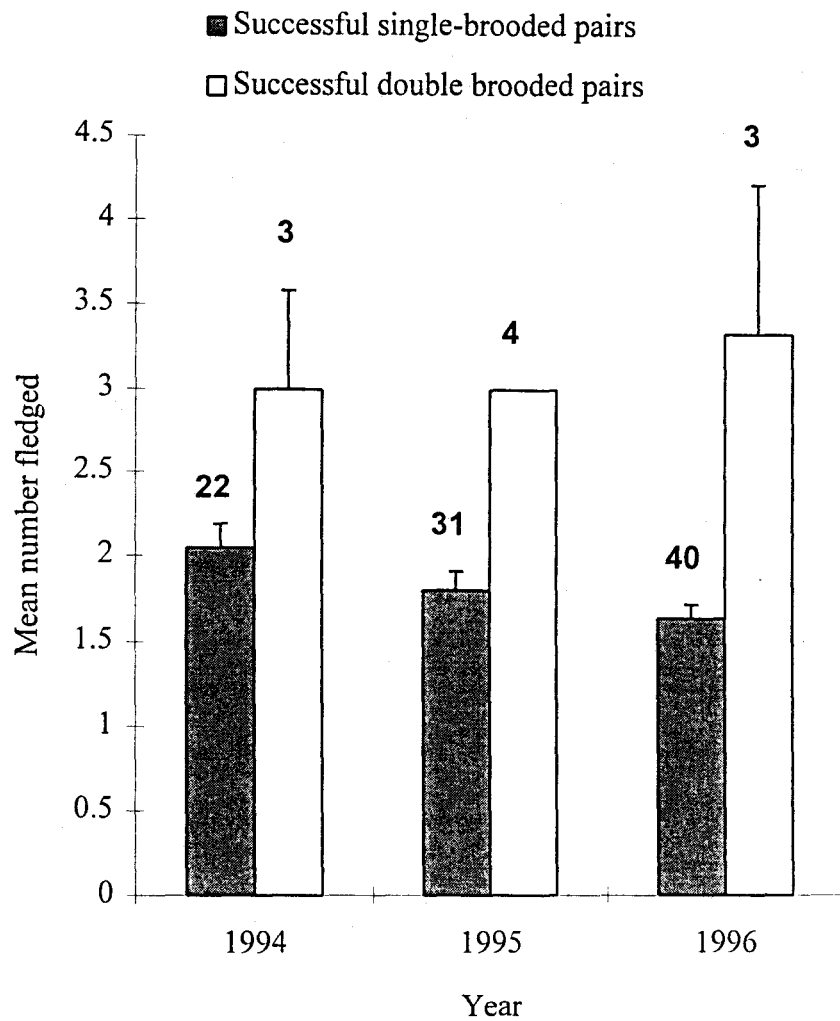


Fig. 3. Annual productivity (number of young fledged per pair) for single brooded and successful double brooded pairs of crested caracaras nesting in south-central Florida. Number of pairs shown above each column.

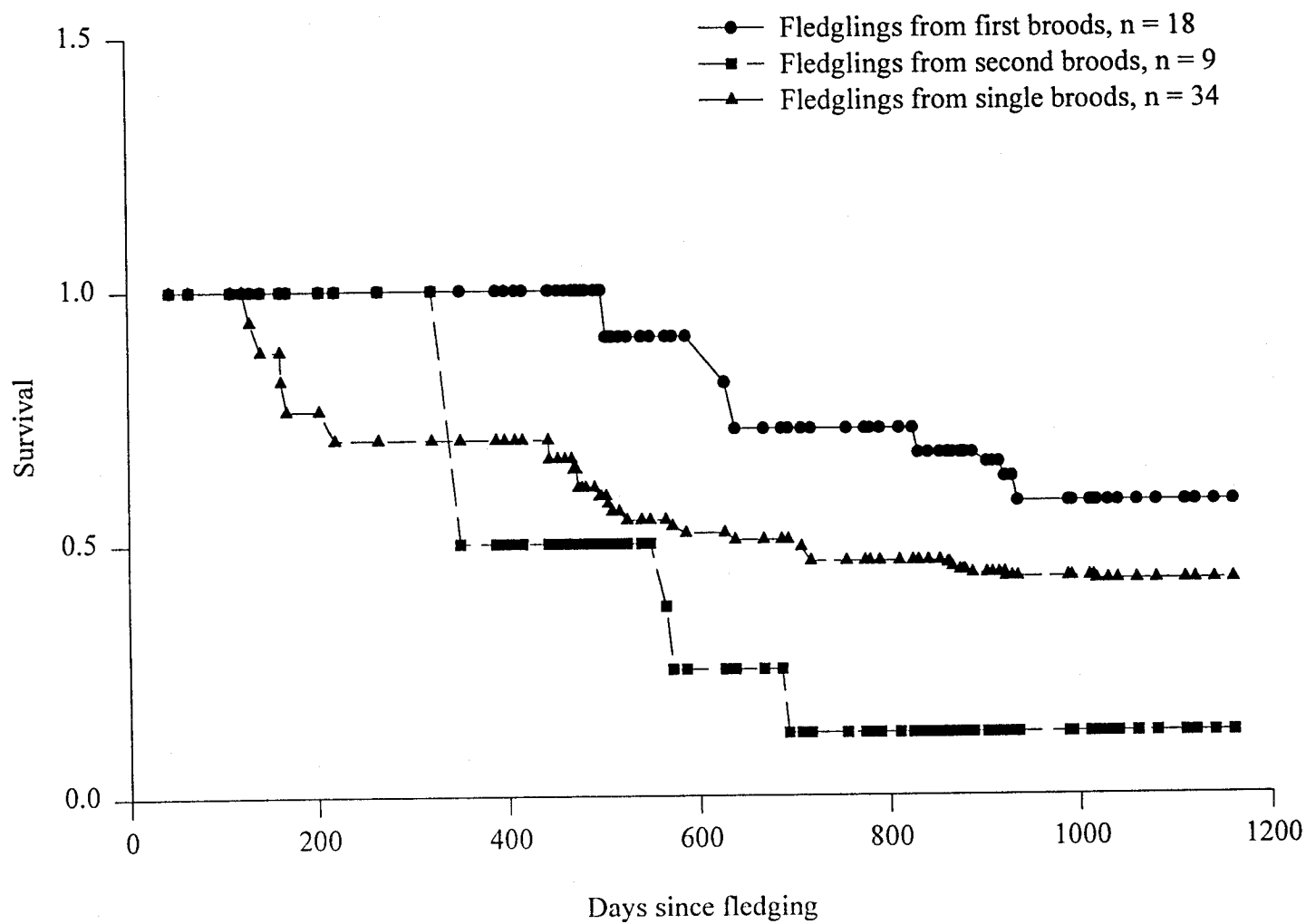


Fig. 4. Kaplan-Meier survival functions estimated for juvenile crested caracaras from first, second, and single broods in south-central Florida, 1994 - 1996.

CRESTED CARACARA NESTING HABITAT

INTRODUCTION

Identification and protection of nest sites is vital for conservation, particularly of species that exhibit strong fidelity to a territory and nest site. The crested caracara, a unique raptor/scavenger, is resident in Florida. Breeding adults remain on territories year-round and typically use the same nest tree in successive years. Alternate trees are occasionally used but generally are within 0.5 km of each other. Caracaras occupy open habitats and historically were recorded in native prairies. Although caracaras now are found regularly on cattle ranches in the region, a major concern is the ongoing loss and degradation of suitable nesting habitat due to increasing conversion of grasslands to urban and agricultural development.

Recommendations for protection of nesting habitat for other site-faithful species such as the bald eagle (*Haliaeetus leucocephalus*) include 3 categories of nesting habitat: recently occupied sites, historic sites where suitable habitat still exists, and habitat similar to currently used sites that would be important in habitat improvement or reintroduction efforts (Bohall Wood et al. 1989). Protection of current or potential nest sites requires knowledge of characteristics about nest trees and the area immediately surrounding them. For caracaras, this information will provide a baseline for identifying suitable nesting habitat and for determining if nesting habitat has been altered in a particular area.

The objectives of this study were to characterize specific habitat features at active caracara nest sites, to identify landuse patterns and ownership associated with these nest sites, and to examine relationships between particular habitat features of the nest site and nest success or failure. With this information, managers of public lands having occupied, historic, or potential caracara nest sites can take steps to conserve nesting habitat. In addition, private landowners can use this information to manage their lands in an effort to protect and/or enhance existing or potential caracara nest sites.

STUDY AREA AND METHODS

We collected data on an array of habitat variables (Table 1) at 85 active crested caracara nest sites representing 58 different territories located throughout the study area. These included all sites from 1994, new sites added in 1995 and 1996, and alternate nest sites

within 27 territories. Territories were located in Highlands, Glades, Okeechobee, Osceola, and DeSoto counties (Fig. 1).

Most of our sample of nests were within 2 km of a road and human activity; this lends some bias to our evaluations of nesting habitat. On some ranches we had permission to access areas farther than 2 km from a main road. In areas on these ranches where management practices were the same as along roads, we also found caracaras nesting, in similar densities and with similar nesting success, as caracaras nesting within 2 km of main roads and human activity.

Characterization of Habitat at the Nest Site

Objectives of this habitat analysis were twofold: 1) to evaluate the nest location itself - i.e., orientation and relationship of the nest tree to other trees in the stand, and 2) to characterize the types and structure of vegetation within the immediate vicinity of the nest tree. During the first 2 months after fledging, juvenile caracaras spend much time on the ground near the nest, hiding under vegetation, presumably from predators. Therefore, habitat analysis at the nest site focused on characterizing the vegetation within the general nest stand area. We wished to evaluate the amount of cover where the fledglings can hide and open pasture where they can feed on insects and watch for adult birds returning with food. Plant species composition was not recorded because we assumed that vegetation structure is probably more important in caracara nest site selection than types or distributions of individual plant species.

At each nest site, we established a 3.14 ha (100 m-radius) plot centered on the nest tree, then established 2 transects, one aligned N-S and the other E-W that bisected the plot into 4 quadrants. To characterize the nest tree with respect to other trees in the plot, we measured diameter at breast height (dbh) and height of the nest tree, distance to and height of the nearest 3 trees within each quadrant. We also ranked the 4 quadrants from the most to the least number of trees within 30 m of the nest tree. We evaluated whether the distribution of ranks among the four quadrants in the plot differed from an equal distribution of ranks, with respect to the number of trees within 30m of the nest tree, using a chi-square analysis. Nest orientation in the nest tree was estimated using a compass. Rayleigh's test (Batschelet 1981,

Fisher and Lewis 1983) was used to test whether nest orientation differed from a random circular distribution.

We evaluated the structure of vegetation in the plot by recording the height and type of vegetation (grass/forb, shrub, or tree) at a point 2 m from the nest tree, then at each point every 10 m along the 100 m transect in each cardinal direction. We measured vegetation height with a meter stick. We defined cover in each quadrant as vegetation taller than the average height of the ground cover that appeared to be sufficient to conceal a caracara fledgling from a predator. We evaluated dispersion of cover throughout the plot by measuring the distance to the nearest such vegetation in each quadrant. When possible, we directly measured distances to major roads and human activity. Otherwise, we measured these distances from maps or aerial photos.

Nest Success, Habitat Associations, and Patterns of Land use and Land Ownership

To evaluate whether patterns of land use and land ownership were related to territorial occupancy, breeding rates, or nest success, we used the preselected set of 37 territories as described in Chapter 2, Breeding Ecology of Florida's crested caracaras. These were territories for which we had occupancy and reproductive information for all 3 years of the study. We classified each territory as to primary landownership (LANDOWN) and major land use (LANDUSE).

We examined habitat features at 42 nest sites to determine differences associated with failed and successful nests. Successful nests are defined as those that produce at least one independent young (see Chapter 2). For this analysis, we used only one nest per territory, to avoid pseudoreplication. Caracaras are very site faithful and use of alternate nests would result in lack of independence among sites within a given territory between years. We also only used first nests in each territory, not double brood nests. Success or failure of these second nests is likely influenced by the timing and fate of the first nest. Nesting success was similar for all 3 years, so we pooled data for all years. Of the sample of 42 nests, twelve nests failed and 30 were successful.

Habitat characteristics measured at nest sites as described above were used in this analysis. Features included nest tree height (NTRHGT); number of trees in nest tree group

(NUMTRGRP); height of vegetation at the nest tree (HTVEGNTR); a combined variable comprised of several variables that measured the amount and height of shrub vegetation along transects (SHRUBVEG); nearest primary road (NRROAD); and nearest human activity (NRHUMAN). We logistic regression analysis to identify whether any of these independent variables were good predictors of nest success and discriminated between successful and failed nests. The bivariate dependent variable was nest success or failure. We chose logistic regression over discriminate function analysis because the former does not assume multivariate normality (Press and Wilson 1979). We used Rayleigh's test and the Watson-Williams test (Zar 1974) to examine relationships among nest orientation (NANGLE) and nest success.

RESULTS

Characterization of Habitat at the Nest Site

Most caracara nests were in cabbage palms (*Sabal palmetto*), although in 1996, a pair successfully fledged 2 chicks from a nest in a cypress (*Taxodium distichum*) along the edge of Lake Istokpoga (Morrison et al. 1997). Most nests were in single trees or in clumps with > 10 trees (Fig. 2). For nests in cabbage palms, mean nest tree height (7.25 m + 0.23 SE, $n = 85$) did not differ ($t = 1.98$, $P = 0.07$) from mean height of a random sample of palm trees in nest stands (6.79 m + 0.22 SE, $n = 88$). The distribution of caracara nests tree heights did not differ from the distribution of heights of the random sample of palm trees ($\chi^2 = 0.49$, $P > 0.99$, $df = 4$, Fig. 3).

For nest trees in a group of 10 or more trees, mean nest tree height was slightly taller (1.13 times) (ANOVA, $F_{0.05, (1,21)} = 26.90$, $P = 0.00$, $n = 26$) than the average height of trees in the nest stand, perhaps allowing ease of aerial access (Fig. 4). Analysis of the circular distribution of nest orientation in the nest tree indicated strong selection for a S-SE direction (mean angle 164.43° , Rayleigh's $R = 55.37$, $P < 0.001$, $n = 85$). If the nest tree was located within a stand of 3 or more trees, it was generally located on the southern or eastern edge of the stand. For all sites ($n = 85$), the northwest quadrant ranked first most often (had the most trees within 30m) ($\chi^2 = 60.46$, $P < 0.001$, $df = 3$).

Habitat at the nest site is generally quite open. Analysis of transect data within the 100 m-radius plots indicated that ground cover (grasses and forbs) in all directions out to 100m was generally less than 0.5 m in height (Fig. 5). Tall trees close to the nest occurred mostly on the north and west transects, again as might be expected if a southern and eastern nest orientation offers the most protection from prevailing northwesterly winds. Twenty-one percent of nests had no cover within 100m of the nest tree. When present, cover was mostly within 15 m of the nest tree (Fig. 6).

Habitat Features Associated with Successful and Failed Nests

For the set of 37 preselected territories for which we had reproductive history for all 3 years, 30 (81%) territories were on privately-owned lands and 7 (19%) were on public lands. For all 3 years, occupancy rates, breeding rates, and nesting success were higher for the territories on privately-owned lands (Fig. 7).

In the sample of 42 nests used for the analysis of habitat features associated with successful and failed nests, 7 (11%) were on public lands and 35 (89%) were on private lands. Where territories were identified on private lands, the land use was primarily cattle ranching. Lands under public ownership where we found caracara territories were primarily managed as natural areas, with moderate grazing and farming in some areas of the territory (Fig. 8).

Results of stepwise logistic regression indicated that the variable SHRUBVEG, which describes the amount and height of shrub vegetation in the nest stand area, was the variable that best discriminated between successful and failed nests (Table 2). In other words, nests were more likely to succeed if there was little or no shrub vegetation within the nest stand area. Results of these analyses also indicated that successful nests were positively associated with taller nest trees and more than one tree in the nest tree group, and were negatively associated with roads and human activity. None of these other relationships were significant at the $\alpha = 0.05$ level, however. There were few nest failures overall; the sample for these analyses included only 12 failed nests. Watson-Williams' test (Zar 1974) did not indicate any effect of nest orientation on nest success ($F = 3.21$, $P > 0.05$).

DISCUSSION

Crested caracaras in Florida apparently prefer open habitats for nesting. Habitats on cattle ranches, where we found caracaras most regularly, are characterized by open expanses of short grasslands with scattered groups of cabbage palms (*Sabal palmetto*), live oak (*Quercus virginiana*), and cypress (*Taxodium distichum*), and little diversity of other vegetation such as shrubs. Most nest trees in this habitat had little vegetation around them. In contrast, sites on public lands where we found caracaras were characterized by greater variability in types and heights of vegetation in the nest stand. Nest sites on public lands generally had taller grasses, more and taller shrubs interspersed throughout the trees, and taller vegetation near the nest tree. Predation by terrestrial predators such as raccoons and bobcats may be lower in improved pastures. Fewer terrestrial predators may be willing to traverse these open areas so are less likely to find a caracara nest tree. Given their terrestrial foraging habitats, caracaras may have an easier time walking about and finding food in pastures containing little structural diversity.

Relationships between tree height and basal area within a stand of trees are often reported as important factors characterizing suitable nesting habitat for many raptors (Mosher et al. 1987). For caracara nesting habitat the dispersion and orientation of trees may be more important. Cabbage palms within the prairie ecosystem generally grow in clusters separated by large expanses of open grassland. Consequently, we believe that reporting basal area or density of cabbage palms is not appropriate when describing these habitats. Furthermore, a strong negative correlation exists between height and dbh of cabbage palms ($r = -0.44$, $P < 0.0001$, $n = 88$, Fig. 9). This and the fact that caracara nests were not particularly associated with any particular size or height of cabbage palm suggests that caracaras are not necessarily selecting for size or height of the nest tree. Caracaras may instead select for structure that would provide adequate nest support and orientation that would provide adequate microclimate. The orientation of a caracara's nest and nest tree may provide optimum microclimate conditions within the nest by facing toward the early morning sun and away from the prevailing northwesterly winter winds (Chen and Gerber 1990).

Management activities such as grazing, burning, mowing, and plowing influence vegetation structure. This structure probably affects the presence/absence of caracaras and their nesting success more closely than does the actual composition of vegetation species. Variables that characterized vegetation structure in the nest stand area indicated that nest sites on public and private lands differed primarily with respect to the amount and variability in height of vegetation. These differences are most likely related to the types of management activities conducted on these lands. Grass/forb vegetation on private lands was generally shorter and less variable in height whereas nest sites on public lands generally had more and taller shrubs and more trees along the transects, in all directions. Results suggest that these differences may be translated into differences in territorial occupancy and reproductive success. In general, it was more difficult to find nests and to relocate pairs on public lands than it was to relocate historic pairs on private lands. We conclude that regular occupancy and nesting on public lands is not as consistent or predictable as on privately-owned ranches.

Results from this study indicate that crested caracaras in Florida are faced with potentially significant disturbance from human land use patterns. Habitat analyses suggest that caracaras may utilize human influenced habitats such as ranches, but may also incur more disturbance due to human activities. Road mortality is also a problem for nests within 1 km of a major road. Management plans for caracara nesting habitat may have to be site specific, depending on land ownership and management activities at known nest sites. Because so many nests and potential nest sites are on private lands, cooperation of private landowners to protect habitats should be encouraged. This may be difficult given economic pressures to convert, particularly to citrus and sugar cane. Lands owned by larger landowners may contain more nest sites, but development on these lands, when it occurs usually encompasses huge acreages, thus may include more than one nest site.

Caracara nest sites on lands owned by private individuals with small holdings are probably secure, at least for the near future, although many of these sites experience frequent disturbance. Certain pairs moved their nest site some distance subsequent to large scale alteration of the surrounding land. For example, a pair that nested in an urban pasture at the edge of the town of Moore Haven in Glades County moved their nest over 2 km following construction of a state prison in the field across from their historic nest site. We found that

caracaras were not longer observed regularly in areas following the removal of cattle or fire suppression, both of which result in thick growth of tall weedy and shrub vegetation.

Because caracaras seem to be doing well on cattle ranches, efforts being made in some areas to restore native prairie habitats may instead target species that require these native habitats. Currently planned restoration of floodplain habitat along the Kissimmee River may increase foraging opportunities for caracara. Existing nest sites in upland improved pastures adjacent to the river may be lost as these areas become flooded, cattle are removed, and the vegetation changes. Such areas should be carefully monitored to determine the outcome of altered management activities on these historic nest sites.

Table 1. Habitat variables measured at crested caracara nests in south-central Florida, 1994 - 1996.

Variable	Symbol
Primary landownership (private, public)	LANDOWN
Primary land use (ranching, farming, natural area)	LANDUSE
Nest tree height	NTRHGT
Diameter at breast height of nest tree	DBH
Number of trees in nest tree group	NUMTRGRP
Orientation of nest in nest tree	NANGLE
Height of vegetation at the nest tree	HTVEGNTR
Amount and height of shrub vegetation	SHRUBVEG
Distance to nearest cover	NRCOVER
Nearest human activity	NRHUMAN
Nearest major road	NRROAD

Table 2. Statistics for logistic regression analysis of the influence of various nest site characteristics on nest success of crested caracaras in south-central Florida, 1994 - 1996.
n = 42 nests.

Variable	Coefficient	SE	<i>P</i>
Constant	-1.06	2.96	0.72
NTRHGT	0.94	0.82	0.26
NUMTRGRP	0.65	0.43	0.14
HTVEGNTR	1.93	1.67	0.25
SHRUBVEG	-4.46	1.89	0.02
NRHUMAN	-1.07	1.19	0.37
NRROAD	-1.03	1.38	0.46

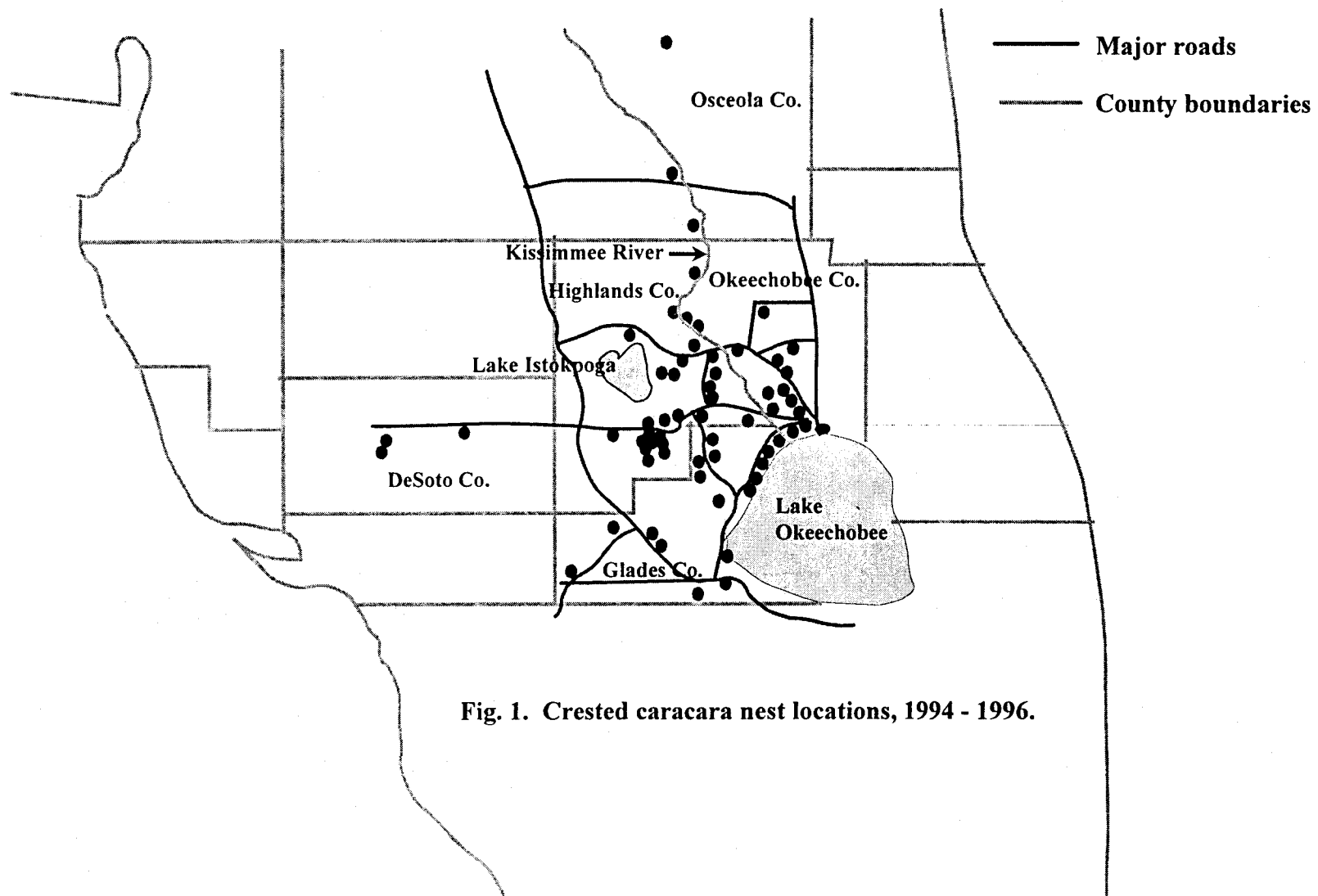


Fig. 1. Crested caracara nest locations, 1994 - 1996.

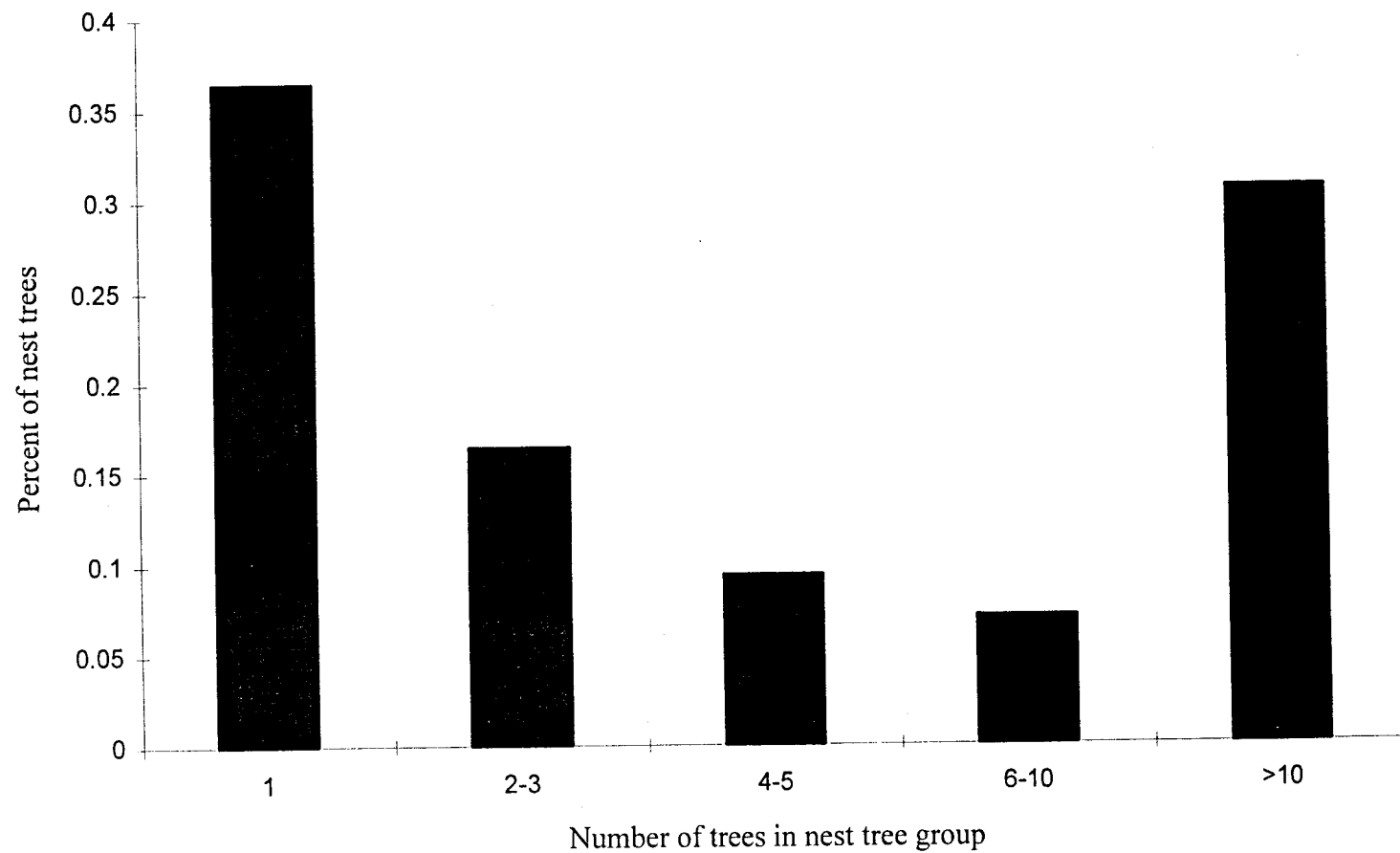


Fig. 2. Frequency distribution of the number of trees in the nest tree group for crested caracara nests in south-central Florida, 1994 - 1996. $n = 85$ nests.

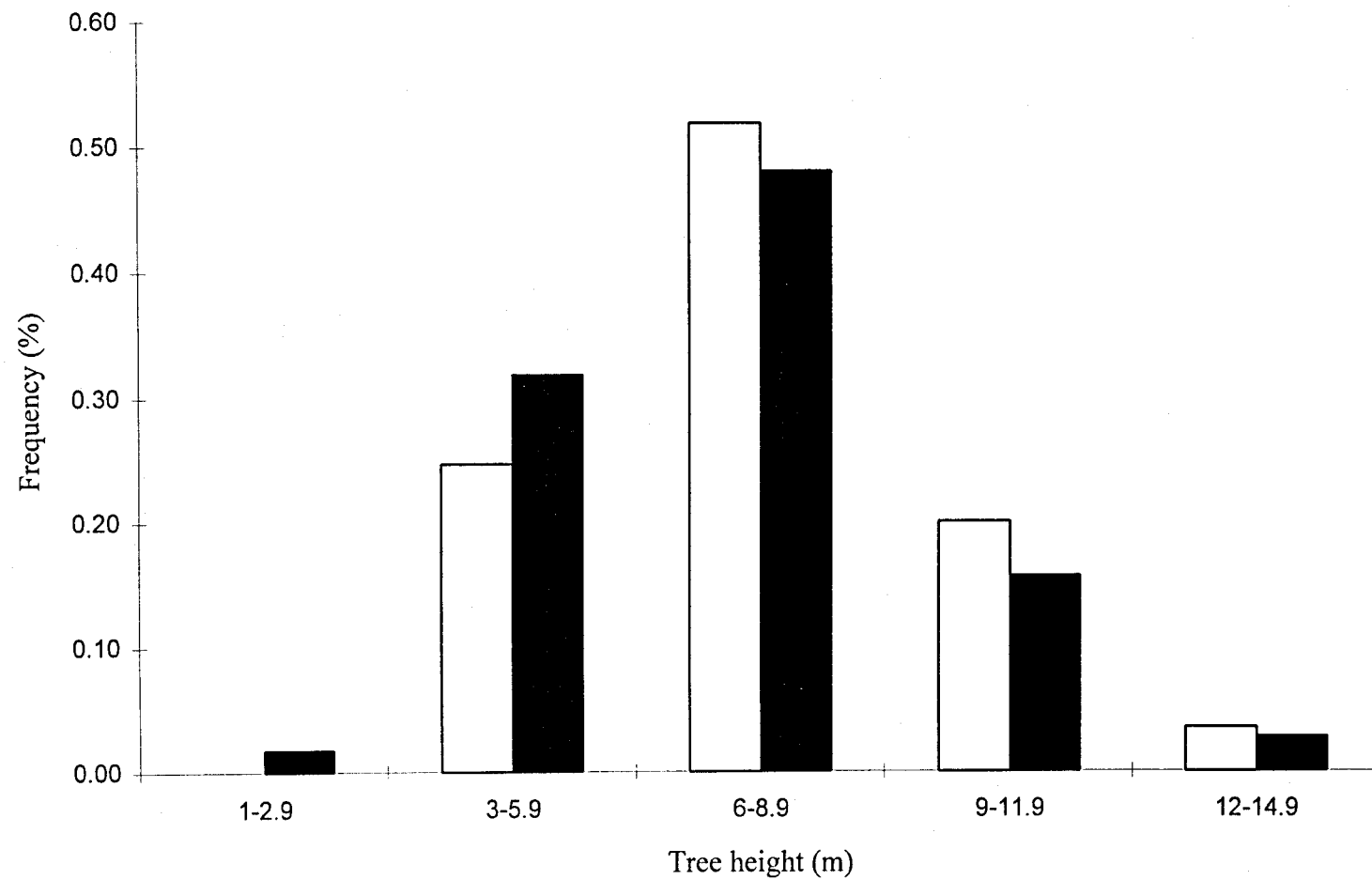


Fig. 3. Frequency distribution of crested caracara nest tree heights in relation to heights of a random sample of cabbage palm trees in south central Florida, 1994 - 1996. n = 85 nest trees, 88 random trees.

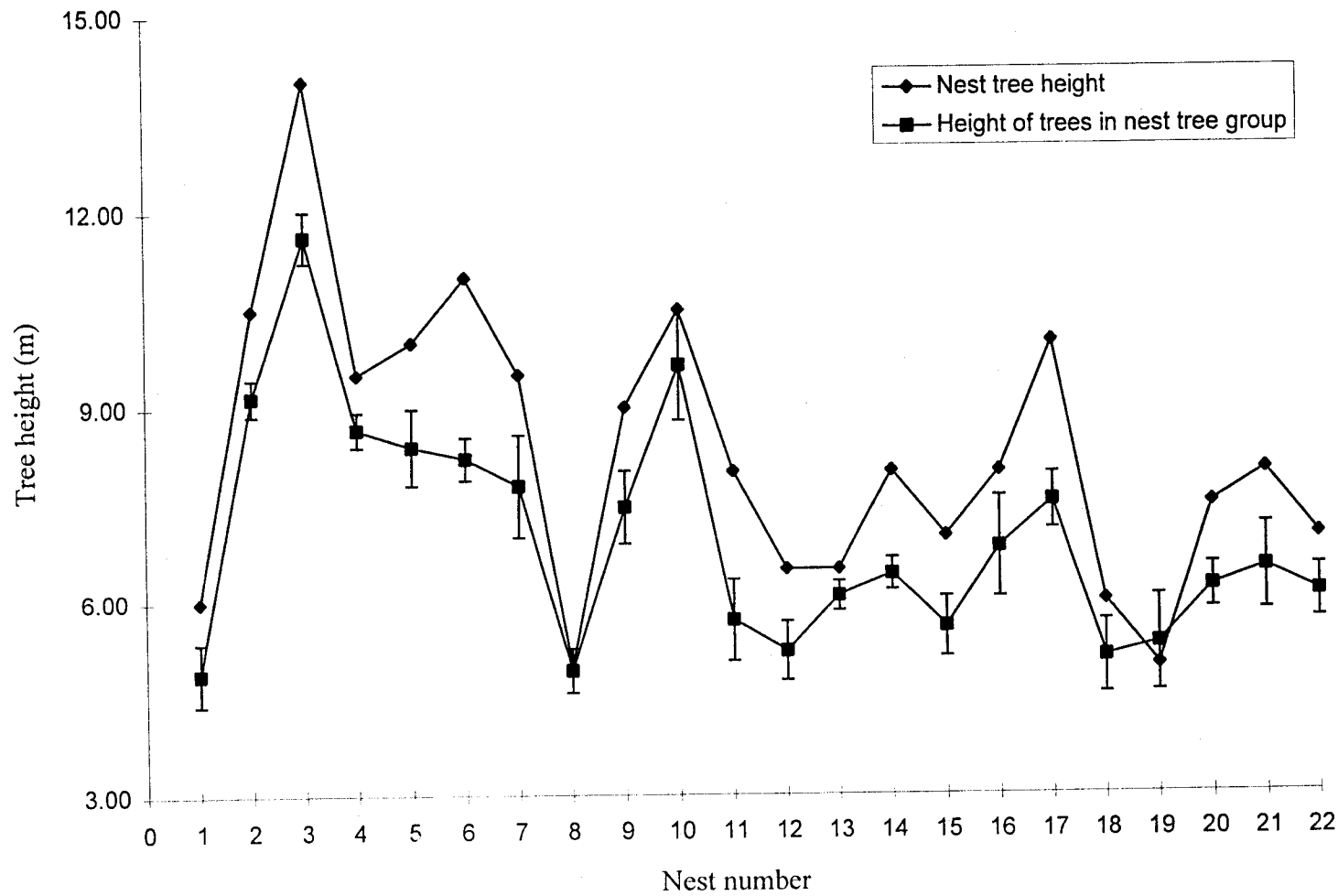


Fig. 4. Relationship between nest tree height and height of trees within nest stand for crested caracara nest trees in a group of 10 or more trees, south-central Florida, 1994 - 1996.
 $n = 26$ nests.

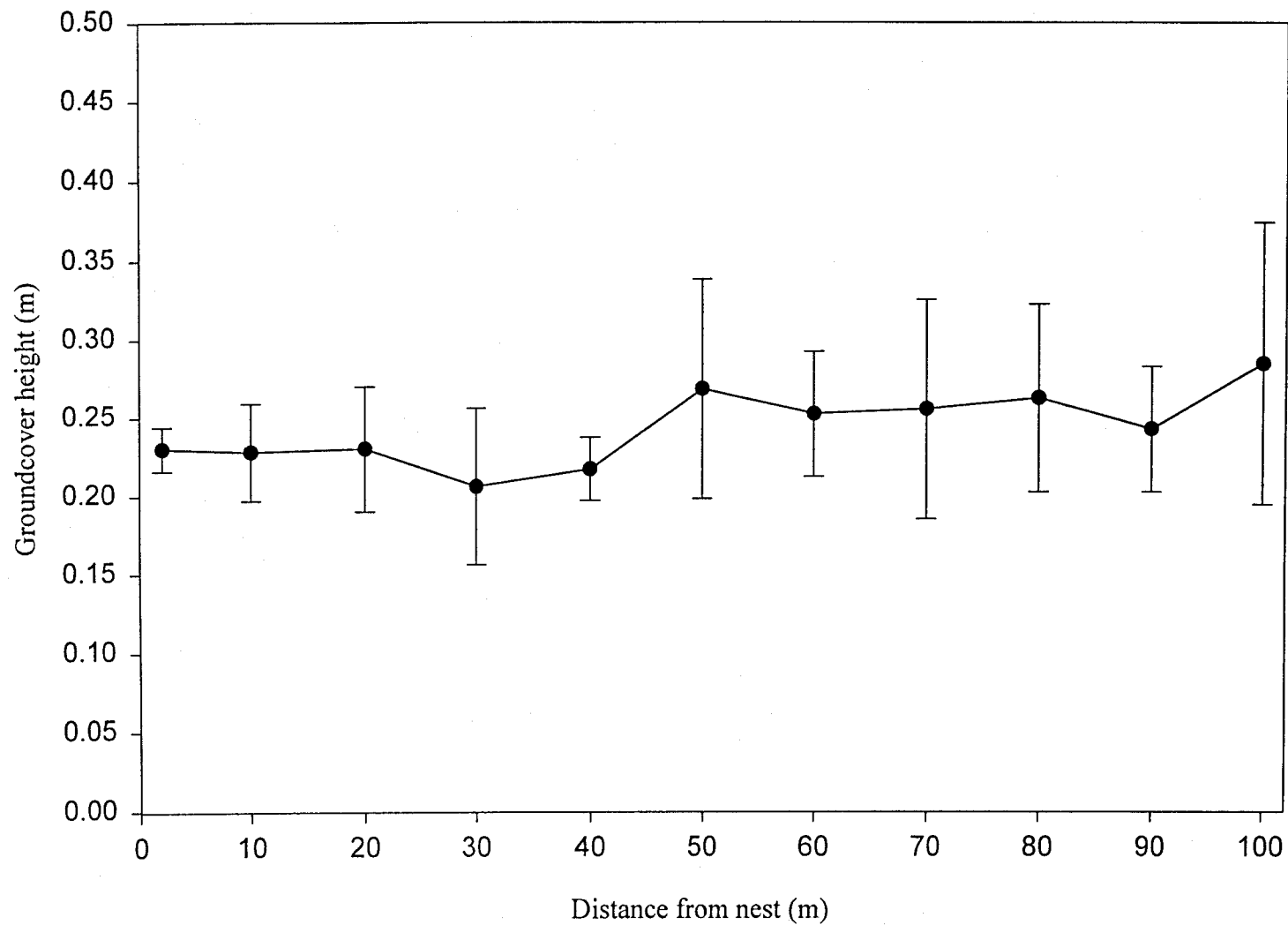


Fig. 5. Average groundcover height within 100 m of crested caracara nests in south-central Florida, 1994 - 1996. Values averaged for all 4 transects. $n = 85$ nests.

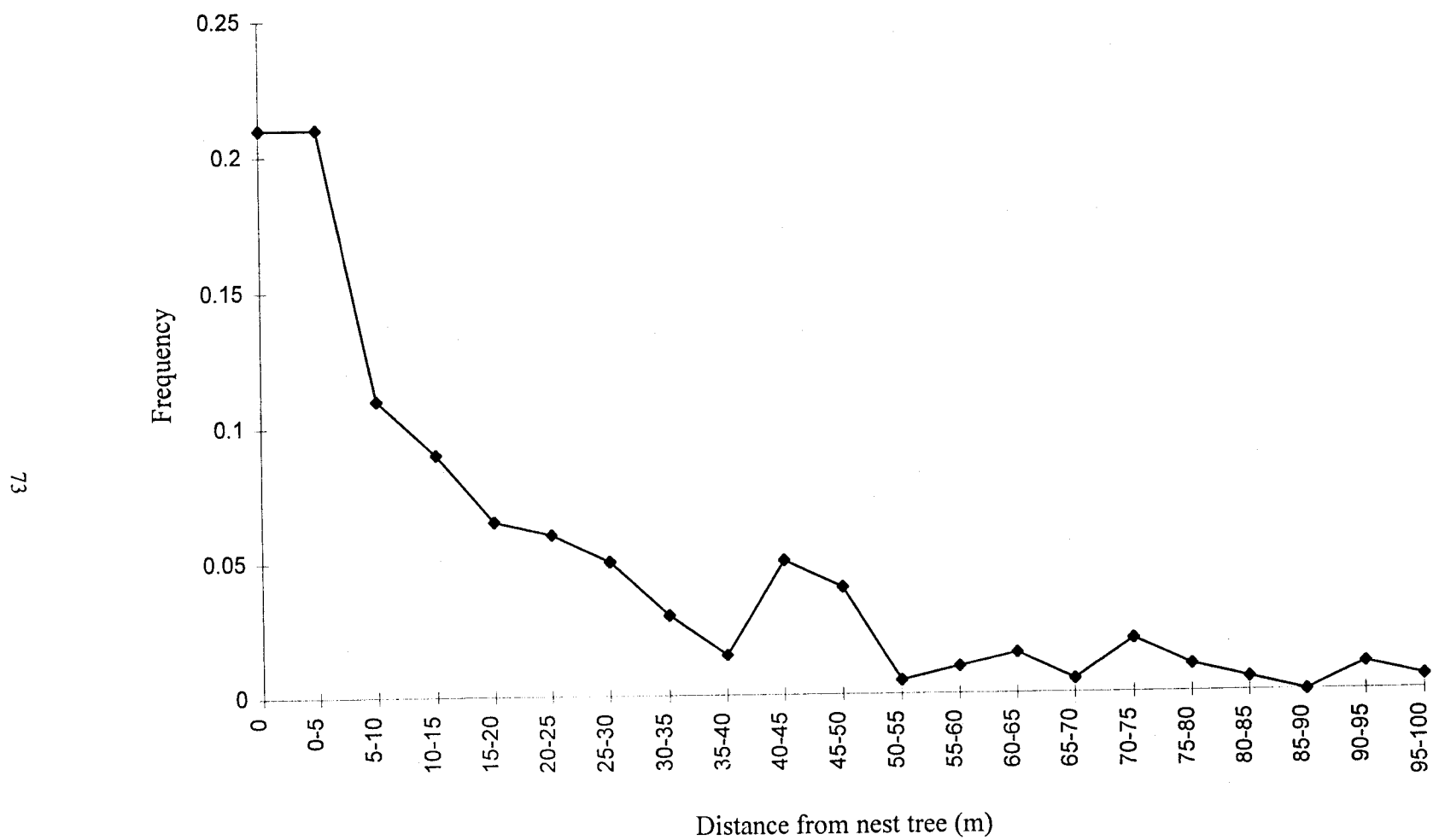


Fig. 6. Frequency distribution of distances to cover from the nest tree, averaged for all quadrants, for 85 crested caracara nests in south-central Florida, 1994-1996.

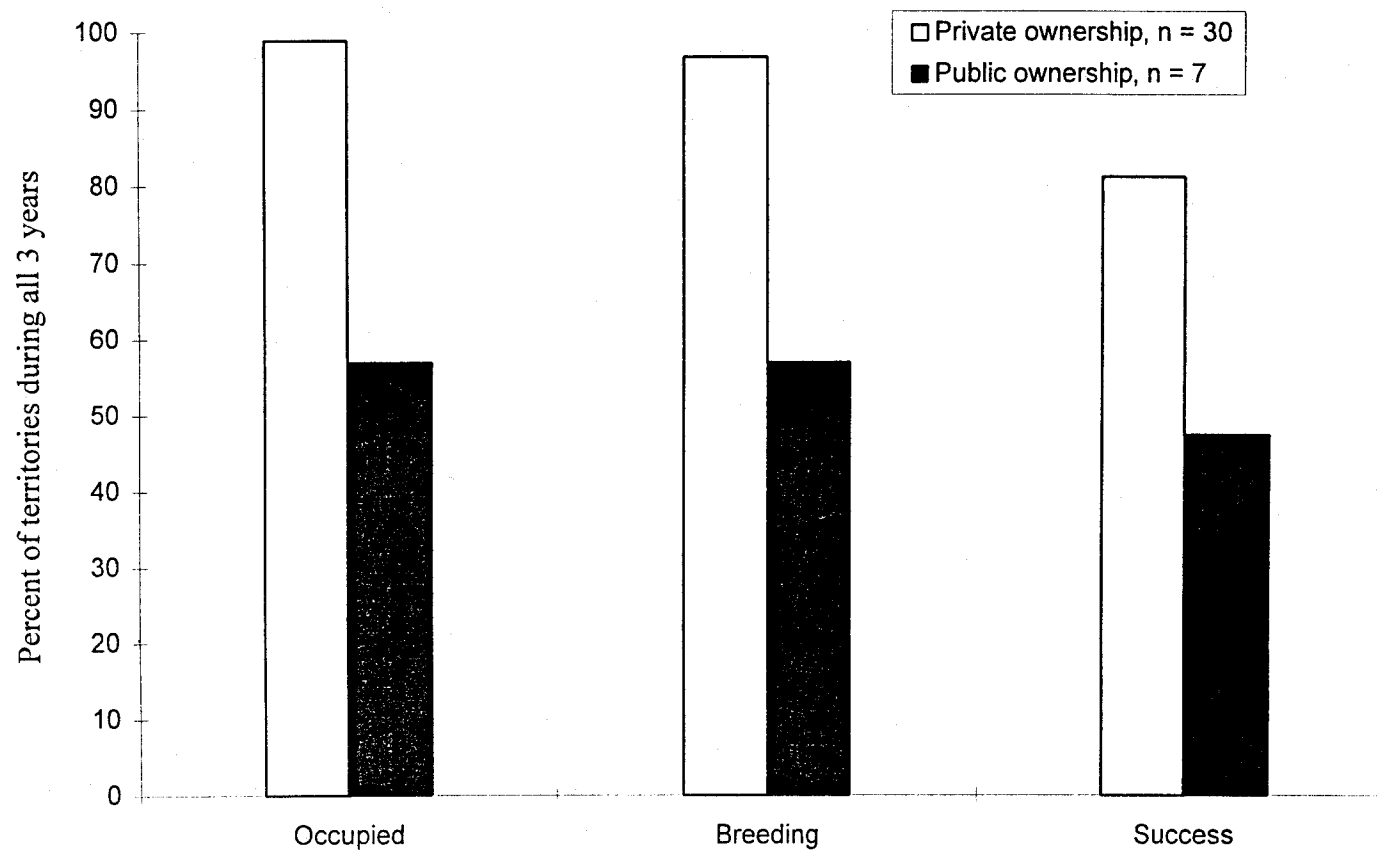


Fig. 7. Relationship between occupancy, breeding attempt, and successful nesting and landownership for 37 crested caracara territories, 1994 - 1996.

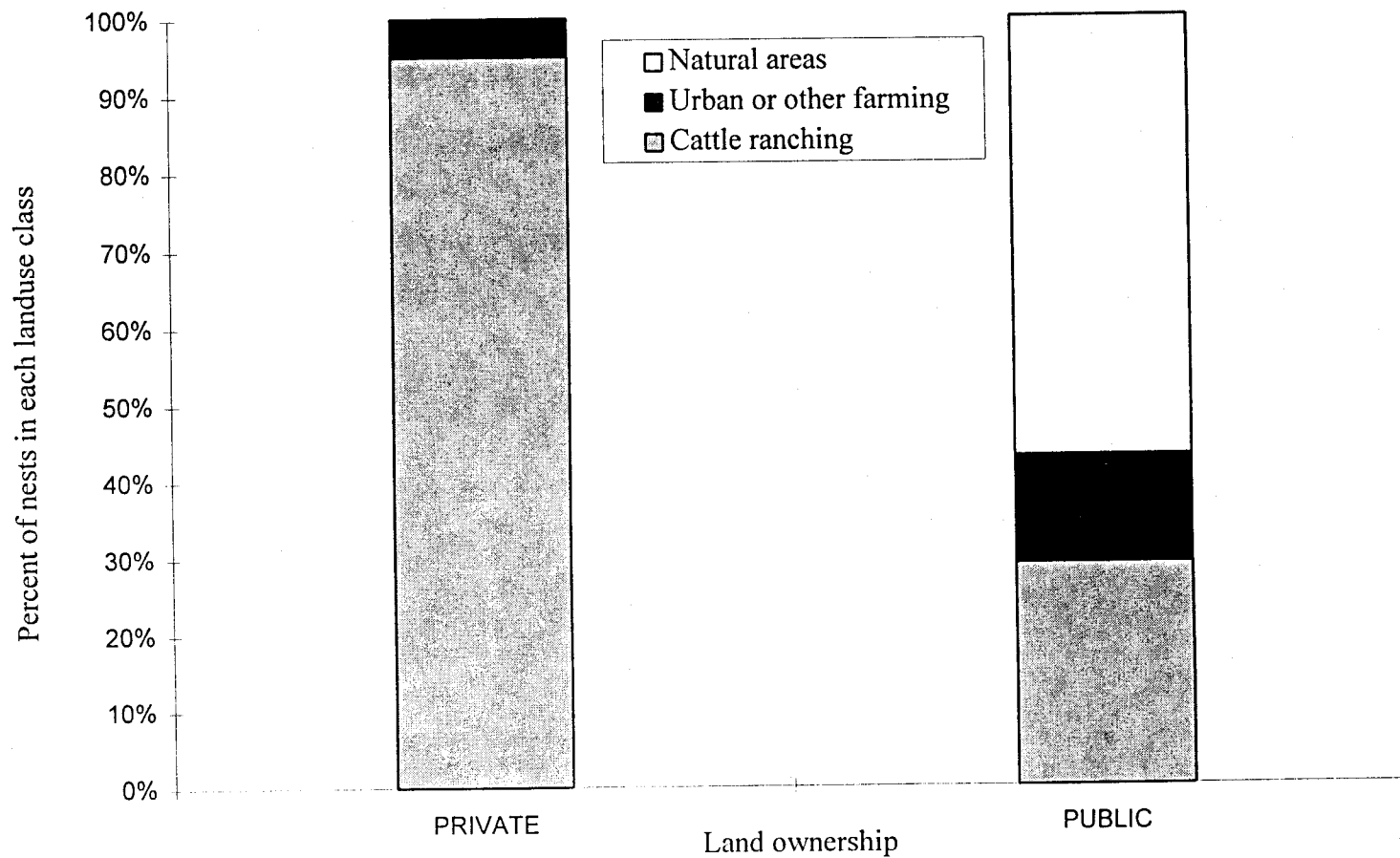


Fig. 8. Relationship between landownership and major land use for crested caracara territories in south-central Florida, 1994 - 1996. Private ownership, $n = 30$ territories. Public ownership, $n = 7$ territories.

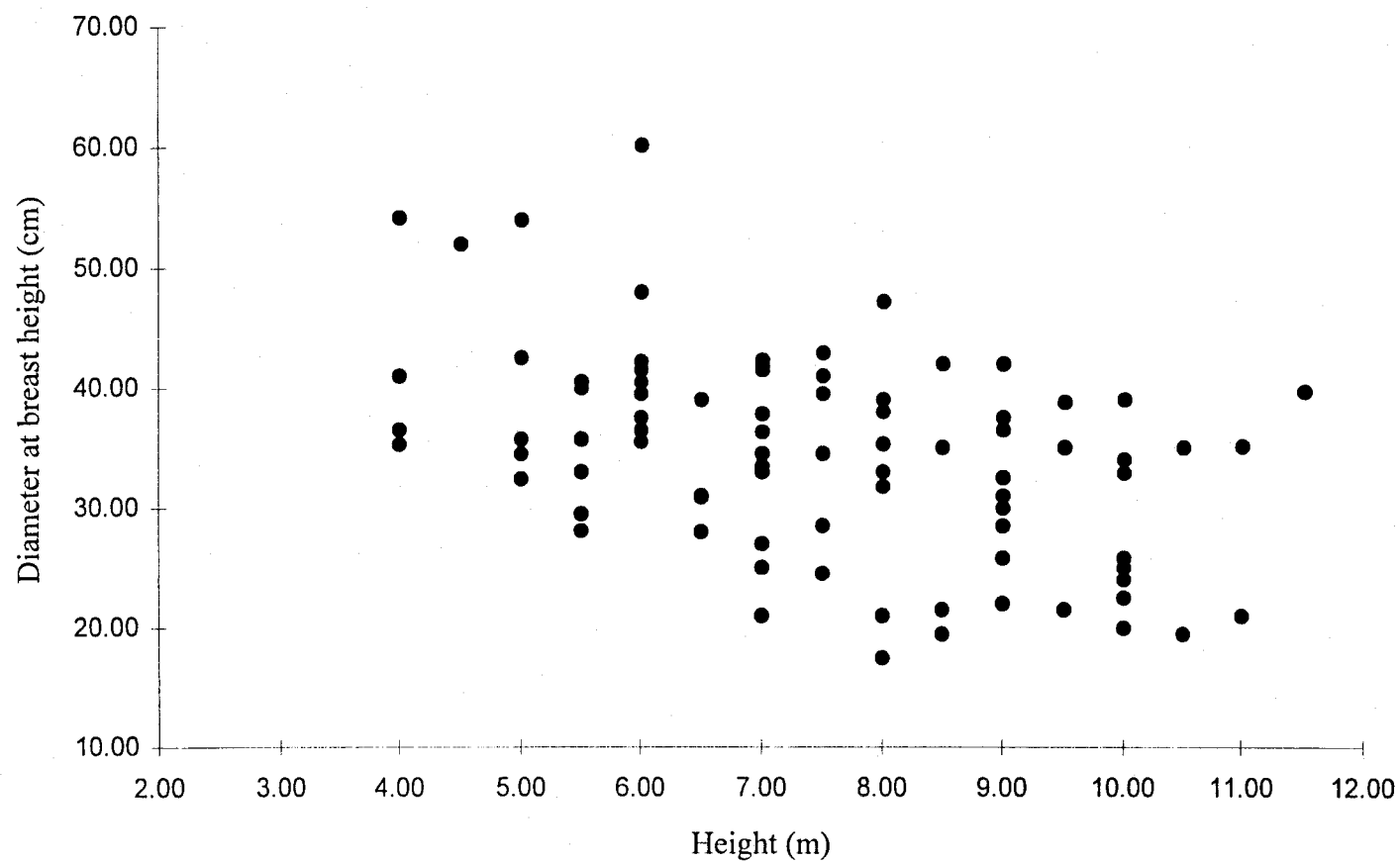


Fig. 9. Relationship between DBH and height of cabbage palms (*Sabal palmetto*) at crested caracara nest sites, south-central Florida, 1994 - 1996. $n = 88$ trees.

HABITAT ASSOCIATIONS AND PRODUCTIVITY OF CARACARAS ON CATTLE RANCHES

INTRODUCTION

Wildlife managers face the increasingly difficult task of providing suitable areas and habitats for wildlife in landscapes that are continually changing due to a complex array of human-induced processes. Management of wide-ranging species can be particularly challenging because individuals' activity areas may cross socio-political or landownership boundaries.

The crested caracara is a gregarious raptor with a limited distribution in North America. In Florida, a small population occurs in the south-central peninsula, a region historically dominated by native prairie. Much of this ecosystem, in which the caracara historically occurred (Phelps 1912, Nicholson 1929, 1930, Howell 1932), has been replaced by large acreages of privately-owned cattle ranches. Although these ranches consist of open grasslands with scattered trees, vegetation cover types and land management practices differ considerably from those occurring on native prairies. Most ranches include large areas of improved pasture, grasslands dominated by non-native vegetation species that are intensively managed to produce forage for cattle. The natural hydrologic regime in improved pastures has also been altered by extensive ditching and draining of wetlands.

The current landscape in south-central Florida reflects complex patterns of land ownership and land uses. Within recent decades, urban and agricultural development has escalated in this region. On private lands, remnant prairie and, increasingly, pasture habitats are being converted to citrus and sugar cane. The crested caracara is likely to be affected by these land use changes. This raptor is now often found on the cattle ranches (Layne 1978, Millsap 1989), but this relationship is not well understood. The spatial and habitat requirements of the crested caracara and land management practices compatible with its survival are poorly known. Thus, consequences of these land use changes on this population are difficult to predict.

Understanding relationships between caracaras and land uses is critical to conservation planning for Florida's population. The objective of this study was to examine these

relationships by considering habitat and spatial use of breeding adults and productivity of pairs breeding on the cattle ranches. Specifically, I identify patterns of land ownership and land use associated with active nest sites, examine home ranges of breeding adults and spatial relationships among neighboring pairs, evaluate landscape-level habitat selection by breeding pairs, and examine productivity by pairs nesting on cattle ranches.

STUDY AREA

The study area encompassed approximately 21,000 km² and included all or parts of Highlands, Glades, Okeechobee, DeSoto, Osceola, Polk, Hendry, and Indian River Counties (Fig. 1). The landscape is a mosaic of habitats, primarily grasslands and pastures interspersed with cropland, citrus groves, dairies, pine flatwoods, freshwater marshes and lakes, oak scrub, hardwood hammocks, and urban developments. Over half of this area is in private ownership. Principal land uses are cattle ranching, citrus production, and other agricultural crops. The land in public ownership is managed for a variety of uses including recreation, military training, hunting, natural areas, and river floodplain management.

METHODS

Land ownership/land use

I located active caracara nests by visiting known historic territories (B. Millsap pers. comm., J. Layne pers. comm.) and areas where caracaras had been observed within the past 5 years, and by searching other areas of potentially suitable habitat on both public and private lands. The searching methodology involved conducting observations near potential nest sites. I also covered entire areas on foot to look into individual cabbage palm (*Sabal palmetto*) and live oak (*Quercus virginiana*) trees. When caracaras were observed on private land, the landowner was contacted for access permission. For each territory located, I classified landownership as private or public and primary land use in the vicinity of the nest tree as ranching, other (included urban or other agriculture), or natural.

To evaluate whether occupancy and breeding rates in caracara territories were related to patterns of land use and land ownership, I used a set of 37 territories that were monitored during all 3 years. I recorded whether or not each territory was occupied and if so, whether or not the pair made a breeding attempt, for each year. Using a z-test with Yates' correction

(Sokal and Rohlf 1995), I tested the null hypothesis of no differences in the proportions of territories that were occupied or where the pair made a breeding attempt during all 3 years, between territories on privately owned ($n = 30$) and publicly-owned lands ($n = 7$).

Home range estimation and spatial dispersion of territories

I trapped and radiotagged 39 (16 females, 23 males) breeding adult caracaras during the nesting seasons in 1994 through 1996 (Morrison and McGehee 1996). Each captured adult was banded with a standard USFWS aluminum leg band and a colored aluminum band with a unique alphanumeric character that permitted identification of individuals. Radiotransmitters (Holohil, Ltd.) were attached using a standard backpack harness constructed of Teflon ribbon and secured at the bird's chest. Because caracaras are monomorphic, gender of captured adults was determined using DNA from blood samples collected in the field (Morrison and Maltbie *in review*).

I monitored radiotagged adult caracaras throughout the year. I located all radiotagged adults (Mech 1983) and obtained GPS coordinates of their locations during weekly aerial surveys from a fixed-wing Cessna 172 aircraft. I ascertained additional locations for adult caracaras by triangulation (White and Garrott 1990). Determining ground locations was facilitated by access to ranch interiors granted by local ranchers. Most locations were taken from a distance of $< 500\text{m}$. I also recorded visual observations of radiotagged adults during scheduled visits to territories. Triangulation and visual locations used for home range estimation comprised approximately 18% and 15%, respectively, of all locations for adults.

The 95% confidence circle around aerial location estimates (Marzluff et al. 1994) was approximately 42 ha. Error polygons around triangulated locations (White and Garrott 1990, Kennedy et al. 1994) were all < 50 ha; most were < 20 ha. Because all locations used for home range estimation were taken at least 24 hours apart, I did not conduct tests for independence of observations (Swihart and Slade 1985).

I delineated home ranges using kernel methods (Worton 1989, 1995, Seamen and Powell 1996) and the software RANGESV (Kenward and Hodder 1995). The boundary of each caracara's home range was defined as the 99% contour estimated with the fixed kernel method and a 0.85 smoothing factor (Kenward and Hodder 1995, Seamen and Powell 1996).

Core areas (Wray et al. 1992) were identified as the 60% kernel contour using cluster analysis in RANGESV.

I compared home range estimates between males and females and between breeding and non-breeding seasons using a two-tailed Mann-Whitney test (Sokal and Rolf 1995). The breeding season was defined as the period from the beginning of incubation to the end of the post-fledging dependency period, 8 weeks after the young fledged from the nest. After this time, young were considered independent, and parents and young were together less often as a family unit.

To evaluate nesting density and spatial relationships among territories, I calculated distances between nests of neighboring caracara pairs. Using RANGESV, I evaluated overlap of 99% contours and core areas among 9 neighboring, successfully breeding pairs of caracaras inhabiting the MacArthur Agro-Ecology Research Center (MAERC) and an adjoining ranch, and among 4 neighboring, successfully breeding pairs at a site along the Kissimmee River.

Landscape-level habitat selection by breeding pairs

Habitat data -- Data on vegetation cover types throughout the study area were obtained from the Florida GAP Analysis project at the University of Florida. Analyses were performed in ArcINFO GRID (ESRI 1996), version 7.0.4. The study area map, initially classified from LANDSAT satellite imagery, was imported into the GIS in grid-cell (raster) format. The map was 1909 X 1571 cells at a grid cell resolution of 90m. I recognized 13 natural and semi-natural vegetation cover types (Table 1). Other cover types reflected land use conversion by humans such as citrus, croplands, sod fields, quarries, and urban areas.

Model Development. -- I used resource selection techniques (Thomas and Taylor 1990, Manly et al. 1993) to identify habitats and landscape features that distinguished between known caracara home ranges and potentially "available" home ranges throughout the study area. These "available" units were 1296 ha in size, comparable to the average caracara's home range, and were sampled across the entire study area using a sliding window technique and the GIS. Because of the finite 90m grid cell size, square units 40 cells (3600m) on a side were used.

Resource categories used for model development consisted of variables describing proportions of the 13 natural and semi-natural vegetation cover types (Table 1). Cover types that reflected human use were not included, although some caracara home ranges contained them. I assumed that these land use changes occurred after a caracara pair had selected their territory so these cover types were associated by default with cover types actually selected by caracaras. Other variables included 1) total proportion vegetated, 2) total proportion of open habitat, 3) total proportion of shrubs, 4) total amount of improved pasture habitat, and 5) largest contiguous patch of improved pasture habitat (Table 1).

Using the GIS, I determined that caracara home ranges were at least 53% vegetated with natural or semi-natural vegetation. For model development, I only used available units that contained more than 53% natural or semi-natural vegetation ($n = 925$) and the 25 known caracara home ranges. I used the GIS to calculate values for all variables for all home ranges and available units.

I used logistic regression procedures in SAS (SAS Institute 1995) to calculate coefficients and standard errors for all variables (Manly et al. 1993). These procedures fit linear logistic regression models for binary data by the method of maximum likelihood (Menard 1995). The response probability produced by the models was the probability of a sample unit being a territory, or "used." I assumed that variables that distinguished between the home ranges and the available units indicated selection by caracaras.

Because use of multiple variables results in many alternative models, selection of the "best" or "correct" model is an important step in data analysis (Burnham and Anderson 1992). To choose among the models produced in SAS, I used AIC (Akaike 1985, Burnham and Anderson 1992) and Goodman's criterion (Goodman 1984), both of which consider the principle of parsimony in model selection. To evaluate model fit, I conducted Hosmer and Lemeshow's goodness of fit test (Hosmer and Lemeshow 1989).

Model Validation. -- A model used to make inferences about important habitats for a species is only as good as its ability to make correct predictions about new observations. I tested the ability of the "best" logistic regression model to predict use of 29 other known caracara home ranges. Because I did not have telemetry data for these test ranges, they were delineated using the GIS. For each test range, I created an area 1296 ha in size (square units

3600m on a side) centered on the nest. I then applied the model to each test range to calculate probability of use.

Caracaras and cattle ranches

To evaluate caracara's use of cattle ranches, I investigated relationships between home range size, productivity, and the proportion of improved pasture in each home range. I defined productivity as the total number of young produced during all 3 years of the study by each pair. For this analysis, I only used home ranges for which I had these data ($n = 18$). I also examined relationships between land use and mean annual numbers of young fledged for all territories found ($n = 65$). For this analysis, territories were combined by land ownership but separated by land use, which was classified as either ranching or other (urban, agriculture, and natural). Additionally, I only included territories for which I had at least 2 years of reproductive information ($n = 49$). Statistical tests were conducted using SigmaStat (Jandel Scientific 1995).

RESULTS

Land ownership/Land use

Land ownership and land use patterns were determined for 65 active caracara territories. Most territories found were on privately-owned land (Table 2). The major land use in the vicinity of caracara nests at all sites was cattle ranching (Table 2). Lands under public ownership where I found caracara territories were primarily managed as natural areas, with moderate grazing and farming in some areas. The proportions of the 37 preselected territories that were occupied and where adults attempted breeding during all 3 years were higher ($z = 2.64$, $P = 0.008$, $1-\beta = 0.71$ and $z = 2.02$, $P = 0.04$, $1-\beta = 0.52$, respectively) for territories on privately-owned lands (Fig. 2).

Home ranges and spatial dispersion of territories

Breeding adult caracaras remained on territory throughout the year. I obtained usable data for home range estimation from 25 individuals (16 males and 9 females). Home range sizes ranged from approximately 551 to 2778 ha (Table 3). Most home ranges were more than 80% vegetated with natural or semi-natural vegetation. All ranges contained improved pasture, ranging from approximately 11% to 94% of the naturally vegetated area (Table 3).

Approximately 90% of locations for all adults were within 2.5 km of the nest (Fig. 2). Home range sizes did not differ between males and females ($t = 1.13$, $P = 0.27$, $df = 23$), although power of this test was low ($1-\beta = 0.10$). Adult caracaras ranged farther from the nest, on average, during the non-breeding season ($X^2 = 56.17$, $P < 0.001$, $df = 7$, Fig. 3). For 11 adult caracaras (7M, 4F) having approximately equal numbers of radiolocations for each season, breeding season home ranges were smaller than non-breeding season home ranges (paired t -tests, $t = -3.45$, $P = 0.006$, $df = 10$, $1-\beta = 0.86$).

Inter-nest distances for adjacent successfully breeding pairs averaged $3.08 \text{ km} + 0.18 \text{ SE}$ (range 1.01 - 5.08 km, $n = 30$ pairs, Fig. 4). Core areas rarely overlapped (Table 4), although 99% contours overlapped on average $14.7\% + 2.82 \text{ SE}$ at MAERC and $10.08\% + 5.39 \text{ SE}$ at the Kissimmee River site (Table 5). At MAERC, 6 caracara home ranges overlapped home ranges of at least 2 other pairs of caracaras.

Landscape-level habitat selection by breeding pairs

The model that best distinguished between known caracara home ranges and available units throughout the study area indicated a negative association of caracara home ranges with the variables PINEFOR, MIXFOR, and WOODL, and a positive association with the variables IMPPAST, and CONTIGP. All variables were significant at the 0.10 level (Table 6). Hosmer and Lemeshow's test indicated good fit of this model ($G = 10.16$, $P = 0.25$, Table 6).

Since caracaras are known to be associated with open rather than forested habitats, I reran logistic regression analysis with the forest and woodland variables omitted. Results of this analysis indicated a strong, positive association between caracara home ranges and improved pasture, native grassland/prairie, and wax myrtle, a shrub commonly associated with grassland habitats. Again, all variables were significant at the 0.10 level (Table 7). Hosmer and Lemeshow's goodness of fit test indicated a poorer fit of this model, however ($G = 22.86$, $P = 0.003$, Table 7).

Although these 2 models were biologically meaningful and statistically fit the data, their predictive capability was poor. For the model that included the forest and woodland variables, the mean predicted probability of use for the 29 test ranges was 0.10 (range = 0.00

to 0.31, Table 8). The model that did not contain the forest variables was only slightly better at predicting probability of use for the test ranges (mean = 0.13, range 0.00 to 0.42, Table 8).

Caracaras and cattle ranches

I found a strong inverse relationship between the proportion of improved pasture and home range size ($r = -0.57$, $P = 0.003$, $df = 23$, $n = 25$, Fig. 5). For pairs for which I had telemetry data and reproductive information for all 3 years ($n = 18$), the total number of young fledged during all 3 years was positively but not significantly correlated with the proportion of improved pasture in the home range ($r = 0.20$, $P = 0.42$, $df = 16$, Fig. 6). For territories in which the major land use at the nest was cattle ranching ($n = 42$), the mean number of young fledged annually was higher (1.73 ± 0.08 SE) but did not differ significantly ($t = 1.52$, $P = 0.14$) from mean number of young fledged annually for territories in which the major land use at the nest was urban, agriculture, or natural (1.36 ± 0.31 SE, $n = 7$). Power of this test was low, however ($1-\beta = 0.19$).

DISCUSSION

In south-central Florida, breeding pairs of crested caracaras are distributed across the landscape in regularly spaced, well-defined, year-round territories. Caracara home ranges are strongly associated with improved pasture habitats on cattle ranches. Little overlap of core areas among neighboring pairs suggests that breeding pairs are highly territorial near the nest. Food resources may be shared in areas distant from the nest, however, as indicated by overlapping 99% contours among neighboring pairs. This territorial dispersion pattern is typical of raptors. Many species are highly territorial around the nest site. In habitats containing adequate food resources, nests may occur close together and feeding areas may overlap (Schoener 1968, Newton 1979, Village 1982).

Estimates of home range size varied considerably among breeding individuals. Despite this variation, results indicate substantial differences in overall estimates of home range size and nesting density from those reported by Layne (1996). Layne (1996) estimated home ranges of 1800-7400 ha based on maximum observed distances of 4.8 km to 9.7 km between sightings of unmarked individuals presumed to be members of the same pair. He also recorded maximum local density of 1 pair/1400 ha, but suggested that average density

was much less. In this study, home ranges varied from approximately 500 to 2800 ha. Local density was 9 successfully breeding pairs within about 5000 ha, or approximately 1 pair/555 ha on MAERC and an adjacent ranch in Highlands County. This density is more than twice the maximum local density estimated by Layne (1996). The availability of food and nest sites generally limits breeding density (Village 1982, 1983). Typically, large raptors breed at lower densities than small raptors, which utilize a wider variety of numerous prey species (Newton 1979).. High local density of crested caracaras on MAERC may reflect habitat quality (availability of both food and nest sites) in that area. Although the density of caracaras at MAERC may not occur throughout the population's entire Florida range, results of this study suggest that at least in some areas, nesting densities may be higher than previously thought for this population.

A strong association between caracaras and improved pastures suggests that caracaras may benefit from land management activities routinely conducted on cattle ranches such as grazing, burning, mowing, and disking. Overall, occupancy, reproductive activity, and nesting success were more consistent at territories on ranches. Pairs nesting on cattle ranches apparently produce more fledglings than pairs nesting on lands managed as natural areas. In general, however, comparisons between territories associated with different land uses were difficult because I had trouble locating caracaras on lands other than cattle ranches. Despite regular searching on public lands or other lands managed as natural areas, few territories were found.

Ranging behavior by crested caracaras reflects breeding commitments and temporal and spatial variation in food availability, particularly the amount and configuration of suitable foraging habitat within each home range. The availability of nest sites also influences the size and shape of the home range. In this study, few caracara ranges were circular or centered on the nest. On most cattle ranches, suitable nest trees are few in number and widely spaced. Home range size and shape primarily reflected the relationship between the nest site and improved pasture habitat (see map).

Caracaras exhibit strong fidelity to a nest site and year-round home range. Management recommendations for raptors typically focus on protecting the nest site and a circular buffer around the nest in which development or management activities are limited

(US Fish and Wildlife Service 1987b). Suitable caracara nest trees are often clumped and associated with hammocks that do not constitute suitable foraging habitat. A circular buffer around a nest may not encompass areas required for all activities associated with reproduction and year-round survival of a breeding pair of caracaras. Management plans for this species must consider the arrangement as well as the amount of both nest sites and suitable foraging habitat.

A landscape approach to identifying important habitats and assessing a species' distribution is particularly appropriate for raptors (Austin et al. 1996, Johansson et al 1994, Carey et al. 1992). Many species require large areas of land to support viable populations and are particularly sensitive to changes in land use (Marquiss et al. 1985, Carey et al. 1992). Conservation of these species require consideration of land uses and management practices throughout entire regions. Landscape-level models that evaluate resource selection by animals can provide information about important habitats and about land uses compatible with species' survival. These models ultimately can be used to evaluate a species' distribution, delineate key protection areas, predict effects of future land use changes, and identify potential areas for habitat improvement or restoration.

The models developed here represent an important first step in identifying habitat and landscape features important to crested caracaras in Florida. These models corroborate the observed association between breeding Crested Caracaras and improved pasture on cattle ranches. These models must be used with caution, however. While they showed a good fit statistically, their biological usefulness for management is currently limited, as indicated by the poor ability of the statistically "best" models to predict use of the 29 test known caracara home ranges.

Future model development would benefit from consideration of two current constraints. First, agricultural and grassland habitats were poorly classified on the study area map obtained from the Florida GAP Analysis Project. The resolution of the available GIS data did not permit detailed differentiation among these cover types or delineation of habitats within them such as patches of hammocks, wetlands, and ditches, which might be important to caracaras in selection of a territory. Second, these models did not consider context of habitats either within or around caracara home ranges. Habitat quality is determined not only

by content but by the context of suitable habitats (Kushlan 1981, Janzen 1986, Fahrig and Merriam 1994, Harris et al 1996). Reproduction and productivity of caracara pairs may be influenced not only by the types of habitats present in the home range, but by context of those habitats. Further research directed towards understanding relationships between caracaras and habitats should focus on refining cover types that represent open habitats and on considering habitat context both within the home range and at a larger scale.

Table 1. Variables included in development of the logistic regression model describing caracara home ranges. Unless noted, all variables are expressed as proportions of the total area of the home range that was vegetated with natural or semi-natural vegetation.

Variable	Symbol
oak forest	OAKFOR
pine forest	PINEFOR
cypress	CYPRESS
mixed forest	MIXFOR
saw palmetto	SAWP
oak shrub	OAKSHRB
hypericum shrub	HYPSHRB
woodland	WOODL
willow	WILL
wax myrtle	WAXMYRT
seasonally flooded native grassland or prairie	GRASSL
marsh	MARSH
improved pasture	IMPPAST
proportion vegetated with natural or semi-natural vegetation	PROPVEG
proportion of open habitat (pasture + grassland)	OPEN
proportion of vegetated area in shrubs	ALLSHRB
total area of improved pasture	AMTP
area of largest patch of contiguous improved pasture	CONTIGP

Table 2. Landownership and major land use for crested caracara territories in south-central Florida, 1994 - 1996. $n = 65$ territories.

Landownership	Major land use			Total
	Ranching	Other	Natural	
Private	56 (98.0%)	1 (2%)	0	57 (87.7%)
Public	3 (37.5%)	2 (2.5)	3 (37.5%)	8 (12.3%)
Total	59 (90.8%)	3 (4.6%)	3 (4.6%)	65

Table 3. Size and vegetation composition of crested caracara home ranges. Home ranges are defined as the 99% kernel contour estimated using a 0.85 smoothing factor. N = number of radiolocations used to estimate home range size.

Bird ID	Sex	N	Home range size (ha)	% of total home range in natural or semi-natural vegetation	proportion of vegetated area in improved pasture	largest area of contiguous pasture (ha)
120	F	48	1265.273	0.858	0.597	492.342
121	M	26	2190.443	0.933	0.493	373.879
200	M	28	1251.969	0.973	0.406	350.991
280	M	68	551.039	0.531	0.831	227.695
360	F	68	1363.798	0.979	0.732	653.605
458	M	96	1879.477	0.836	0.663	722.800
479	M	43	2777.219	0.976	0.109	53.460
498	M	91	848.295	0.905	0.535	188.930
518	F	27	571.288	0.899	0.849	410.240
538	F	27	1014.189	0.917	0.287	125.636
609	F	67	994.957	0.843	0.741	596.455
689	F	37	736.403	0.986	0.759	526.300
969	M	72	1609.962	0.960	0.690	919.980
1110	M	81	1176.541	0.958	0.581	498.884
1379	F	25	1301.698	0.900	0.571	323.155
1469	M	71	1454.535	0.990	0.642	578.182
1490	M	42	659.221	0.989	0.765	400.091
1558	M	39	1129.249	0.937	0.632	522.410
1568	M	30	1083.789	0.942	0.522	213.750
1589	M	97	1604.085	0.924	0.577	323.356
1600	F	25	1685.152	0.865	0.717	803.179
1608	M	45	681.562	0.790	0.707	325.852
1711	M	38	859.928	0.720	0.691	279.356
1969	F	77	1072.958	0.946	0.937	788.290
1989	M	33	1537.786	0.821	0.709	817.595

Table 4a. Overlap matrix for 60% contours (core areas) for 9 adjacent pairs of breeding crested caracaras on MacArthur Agro-Ecology Research Center, Highlands County, south-central Florida. Birds in rows are overlapped (%) by birds in columns.

Bird ID	360	689	969	1469	1490	1558	1600	1608	1711
360	-	0	2.6	0	0	0	0	0	0
689	0	-	0	0	0	4.4	0	0	0
969	2.9	0	-	18.8	0	0	0	0	0
1469	0	0	21.9	-	0	0	0	0	0
1490	0	0	0	0	-	2.8	0	0	0
1558	0	3.7	0	0	1.5	-	0	0	0
1600	0	0	0	0	0	0	-	0	0
1608	0	0	0	0	0	0	0	-	0
1711	0	0	0	0	0	0	0	0	-

Table 4b. Overlap matrix for 60% contours (core areas) for 4 adjacent pairs of breeding crested caracaras along the Kissimmee River, Highlands and Okeechobee counties, south-central Florida. Birds in rows are overlapped (%) by birds in columns.

Bird	498	120	1379	1568
498	-	0	0	0
120	0	-	0	0
1379	0	0	-	8.5
1568	0	0	7.5	-

Table 5a. Overlap matrix for 99% contours for 9 adjacent pairs of breeding crested caracaras on MacArthur Agro-Ecology Research Center, Highlands County, south-central Florida. Birds in rows are overlapped (%) by birds in columns.

Bird	360	689	969	1469	1490	1558	1600	1608	1711
360	-	0	33.1	12.4	6.2	0	9.7	0	0
689	0	-	0	0	25.9	21.4	3.1	1.9	14.6
969	27.2	0	-	38.8	7.6	4.1	0	0	0
1469	11.0	0	41.7	-	0	0	0	0	0
1490	13.6	31.5	19.8	0	-	24.8	23.0	0	0
1558	0	14.1	5.9	0	13.4	-	0	0	0
1600	7.7	1.4	0	0	8.3	0	-	0	1.5
1608	0	2.4	0	0	0	0	0	-	32.9
1711	0	12.6	0	0	0	0	2.9	22.7	-

Table 5b. Overlap matrix for 99% contours for 4 adjacent pairs of breeding crested caracaras along the Kissimmee River, Highlands and Okeechobee counties, south-central Florida. Birds in rows are overlapped (%) by birds in columns.

Bird	498	120	1379	1568
498	-	3.9	11.2	5.7
120	2.7	-	0	0
1379	7.3	0	-	22.4
1568	4.3	0	26.0	-

Table 6. Parameter estimates for model produced using logistic regression analysis that best distinguished between known caracara home ranges and available units throughout the study area. Variables include pine forest (PINEFOR), mixed forest (MIXFOR), wax myrtle (WAXMYRT), woodland (WOODL), and contiguous pasture (CONTIGP).

Parameter	DF	Coefficient	Std. Err.	<i>P</i>
Constant	1	-3.04	0.69	0.000
PINEFOR	1	-0.06	0.04	0.087
MIXFOR	1	-0.22	0.12	0.062
WAXMYRT	1	0.10	0.05	0.053
WOODL	1	-0.17	0.07	0.012
CONTIGP	1	0.003	0.001	0.003

Table 7. Parameter estimates for model that best distinguished between known caracara home ranges and available units throughout the study area and that did not include forest variables. Variables include native grassland/prairie (GRASSL), waxmyrtle (WAXMYRT), improved pasture (IMPPAST), and contiguous pasture (CONTIGP).

Parameter	DF	Coefficient	Std. Err.	P
Constant	1	-9.18	1.31	0.000
GRASSL	1	0.04	0.02	0.069
WAXMYRT	1	0.19	0.06	0.000
IMPPAST	1	0.08	0.02	0.000
CONTIGP	1	0.002	0.001	0.090

Table 8. Predicted probabilities of use for test caracara home ranges calculated using logistic regression models that best distinguished between caracara home ranges and available units throughout the study area.

Nest No.	Model that included forest and woodland variables	Model with forest and woodland variables omitted
1	0.000	0.019
2	0.021	0.010
3	0.047	0.052
4	0.256	0.349
5	0.211	0.391
6	0.189	0.172
7	0.096	0.061
8	0.270	0.356
9	0.132	0.351
10	0.015	0.019
11	0.049	0.067
12	0.006	0.001
13	0.151	0.116
14	0.161	0.142
15	0.017	0.013
16	0.042	0.015
17	0.194	0.292
18	0.314	0.418
19	0.056	0.128
20	0.113	0.125
21	0.009	0.033
22	0.000	0.001
23	0.011	0.001
24	0.175	0.154
25	0.122	0.130
26	0.068	0.123
27	0.021	0.021
28	0.045	0.087
29	0.036	0.243
Mean	0.098	0.134

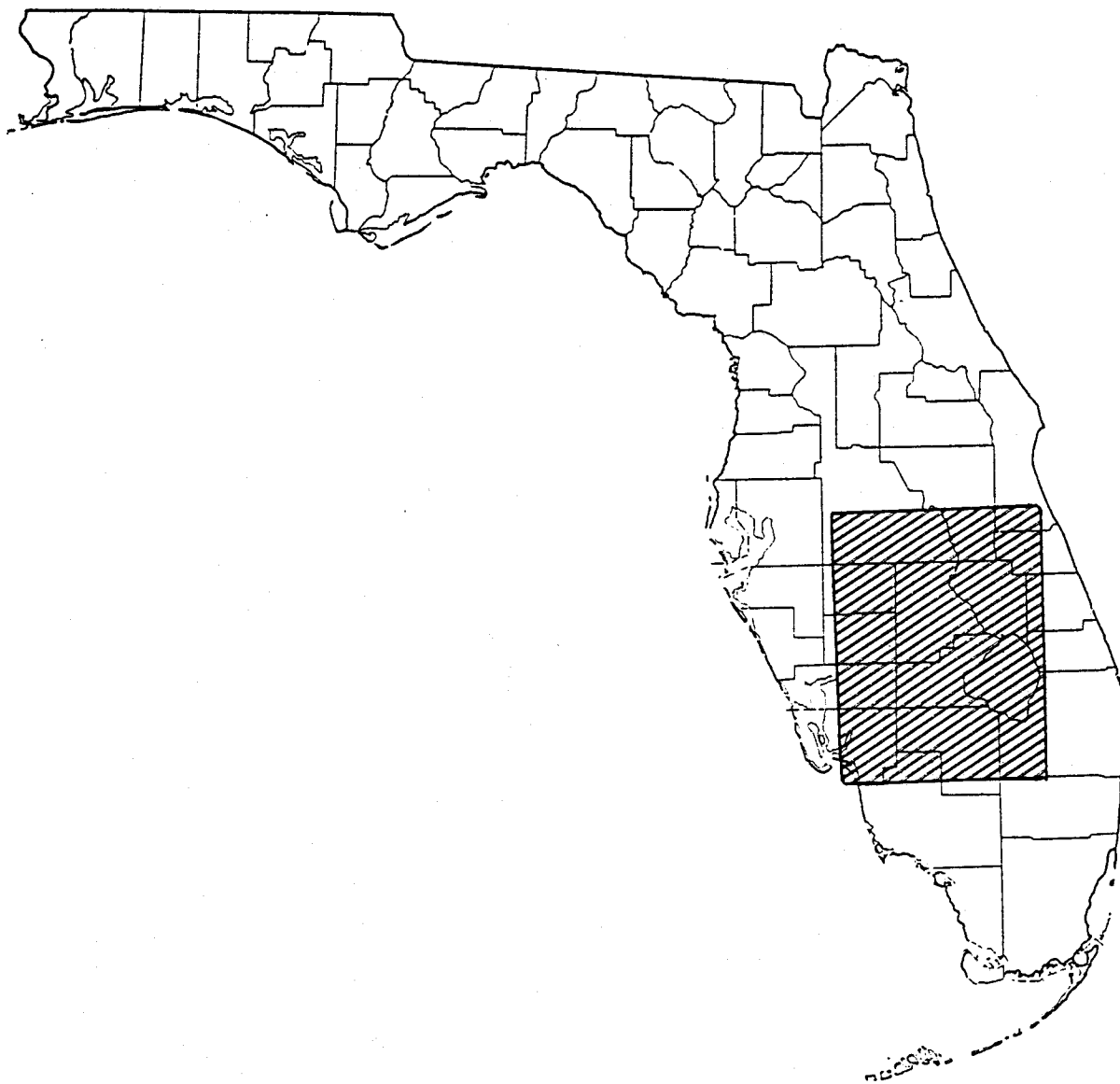


Fig. 1 Study Area for evaluating landscape-level habitat associations of crested caracaras in Florida, 1994-1996.

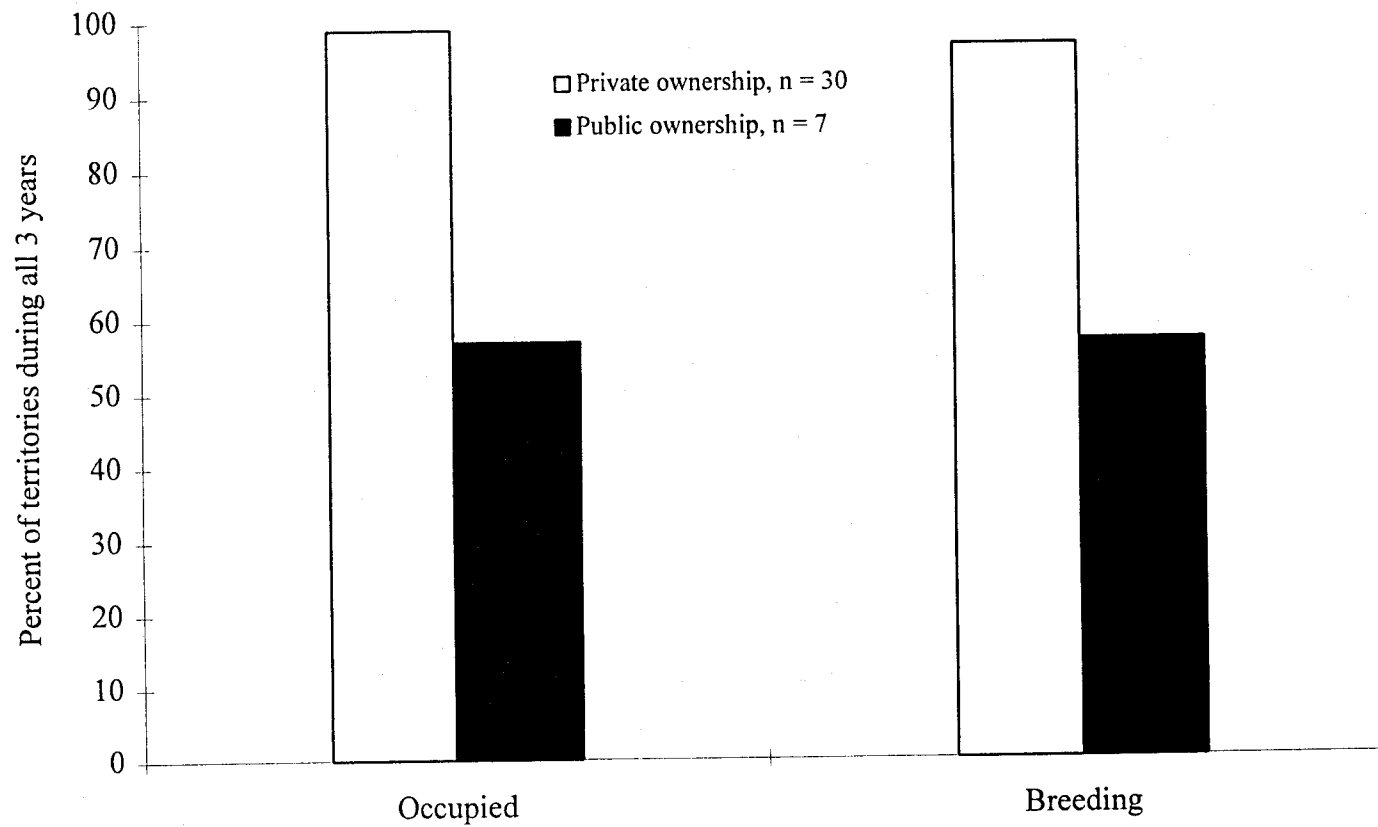


Fig. 2. Relationship between occupancy, breeding attempt, and successful nesting and landownership for 37 crested caracara territories, 1994 - 1996.

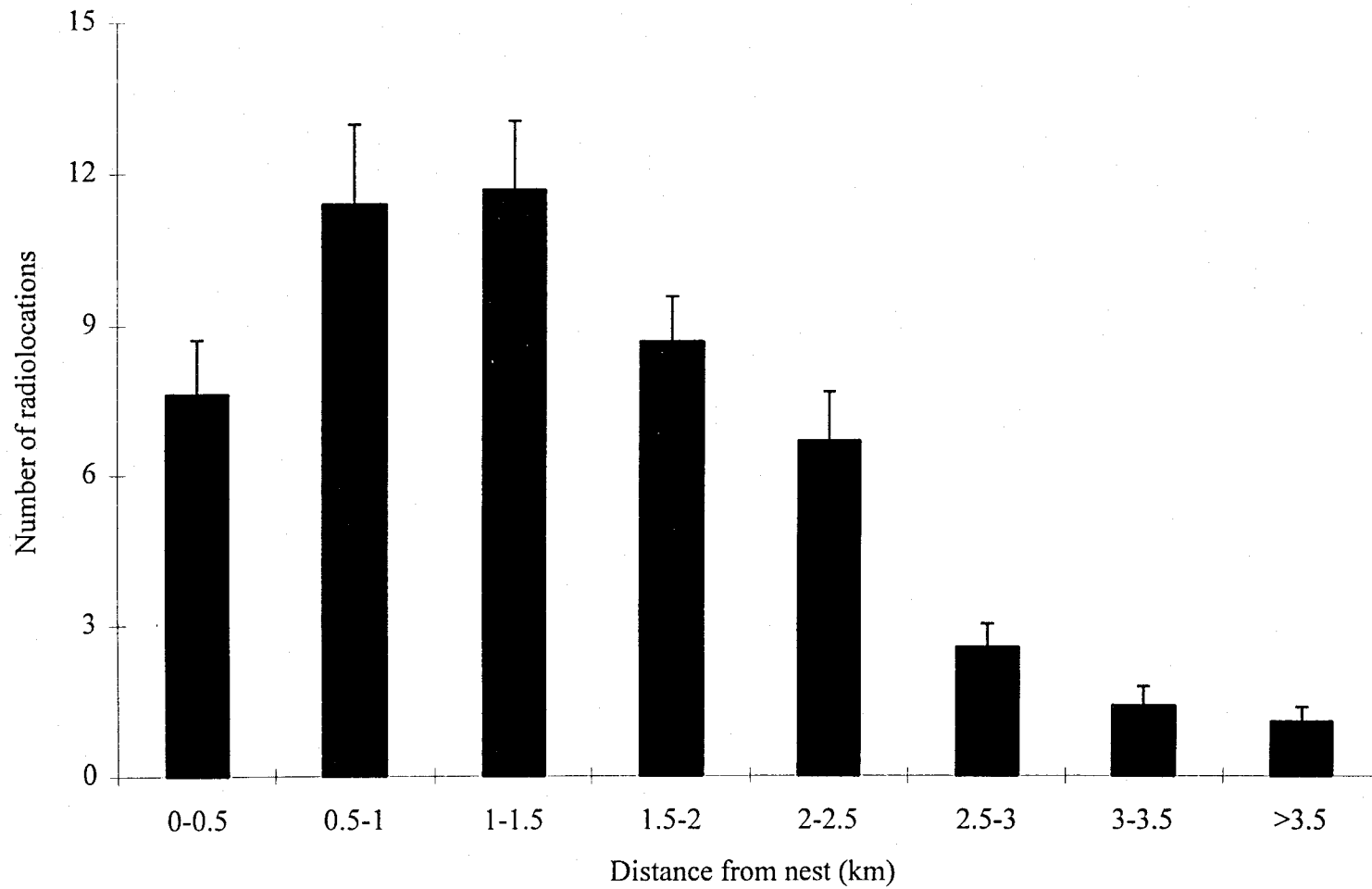


Fig. 3. Distribution of the number of radiolocations for 25 breeding adult crested caracaras in relation to distance from the nest. $n = 1283$ total radiolocations.

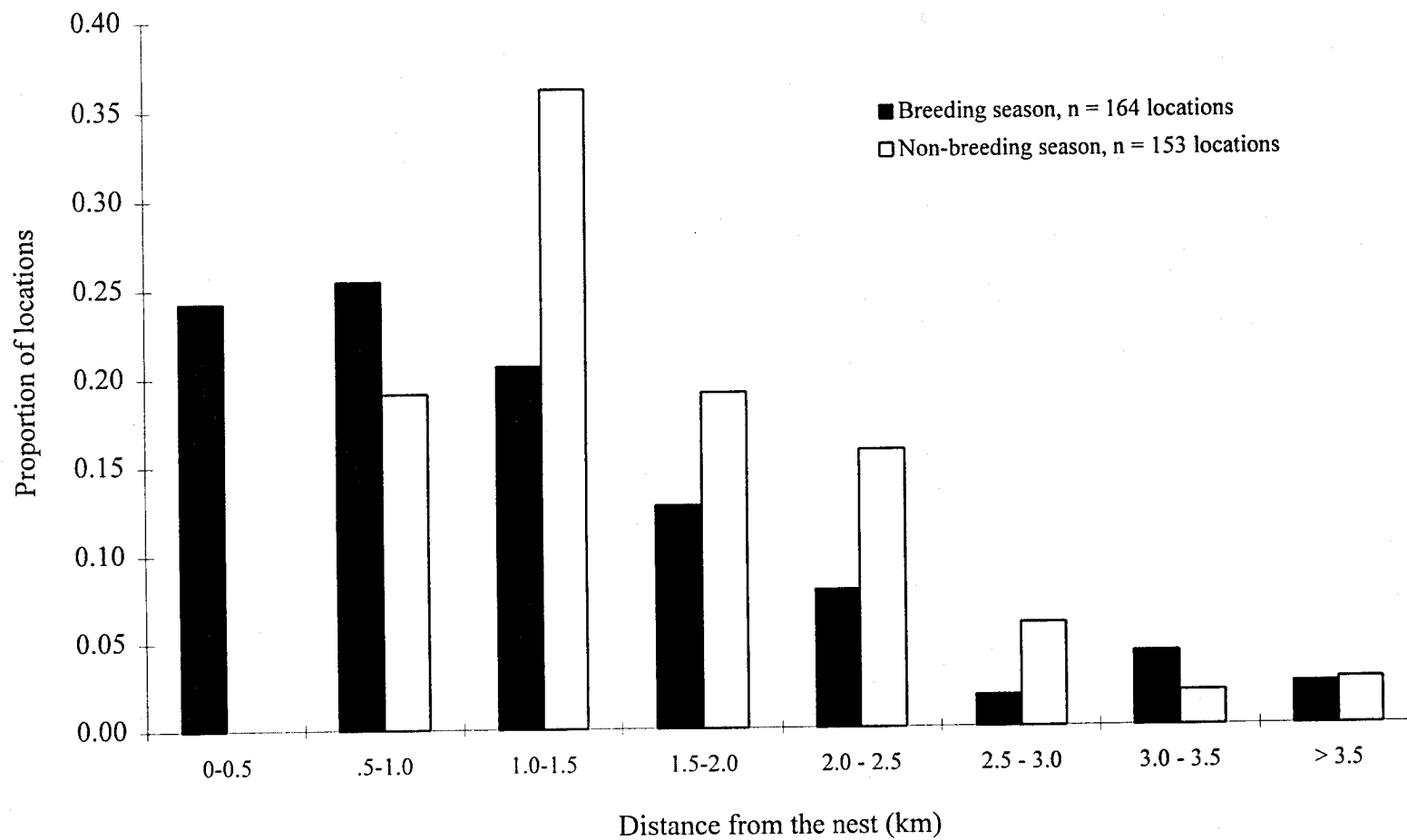


Fig. 4. Distributions of radiolocations of 25 breeding adult crested caracaras in relation to distance from the nest during breeding and non-breeding seasons in south-central Florida, 1994 - 1996.

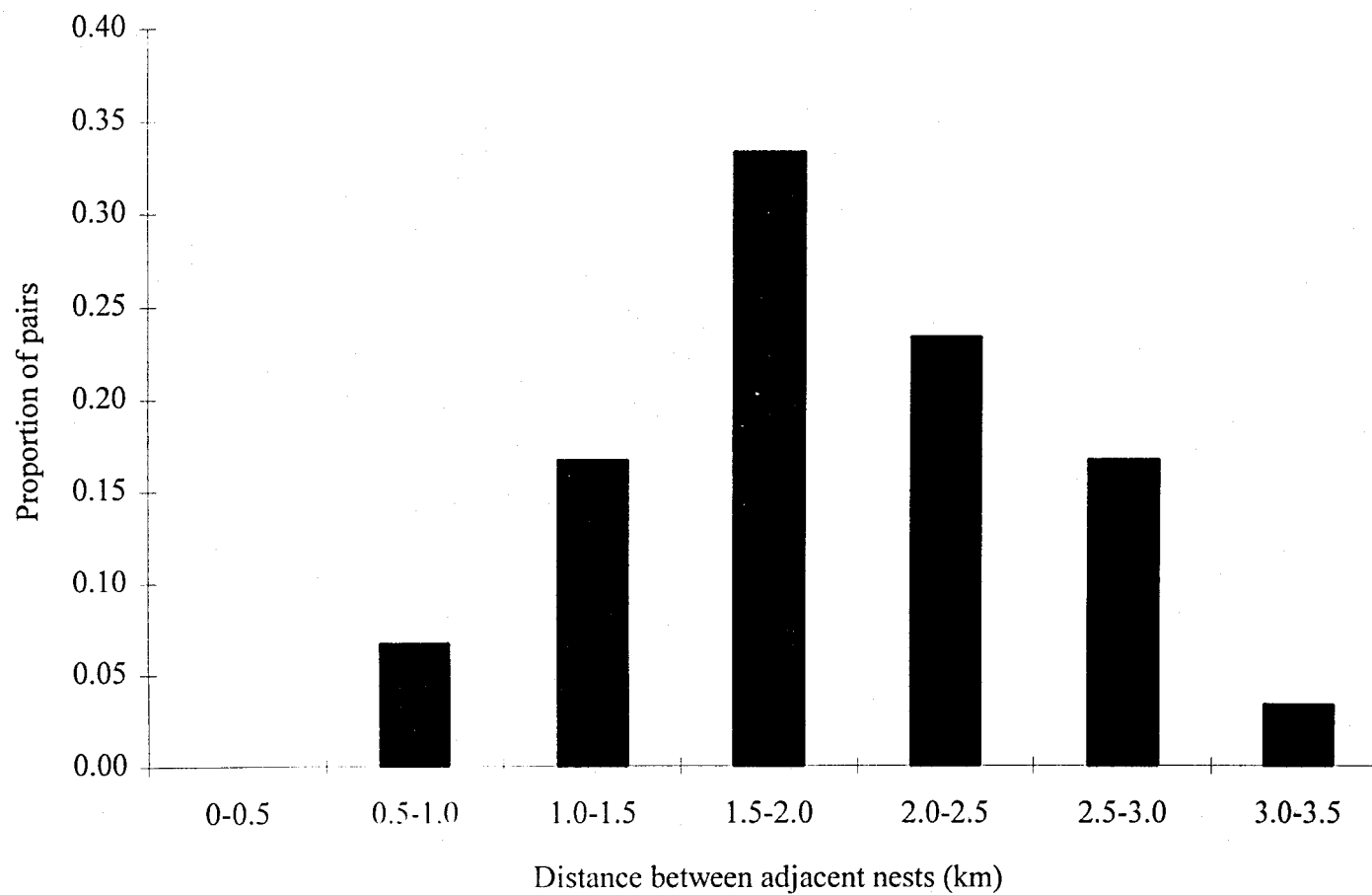


Fig. 5. Distribution of distances between adjacent crested caracara nests in south-central Florida, 1994-1996. $n = 30$ adjacent pairs.

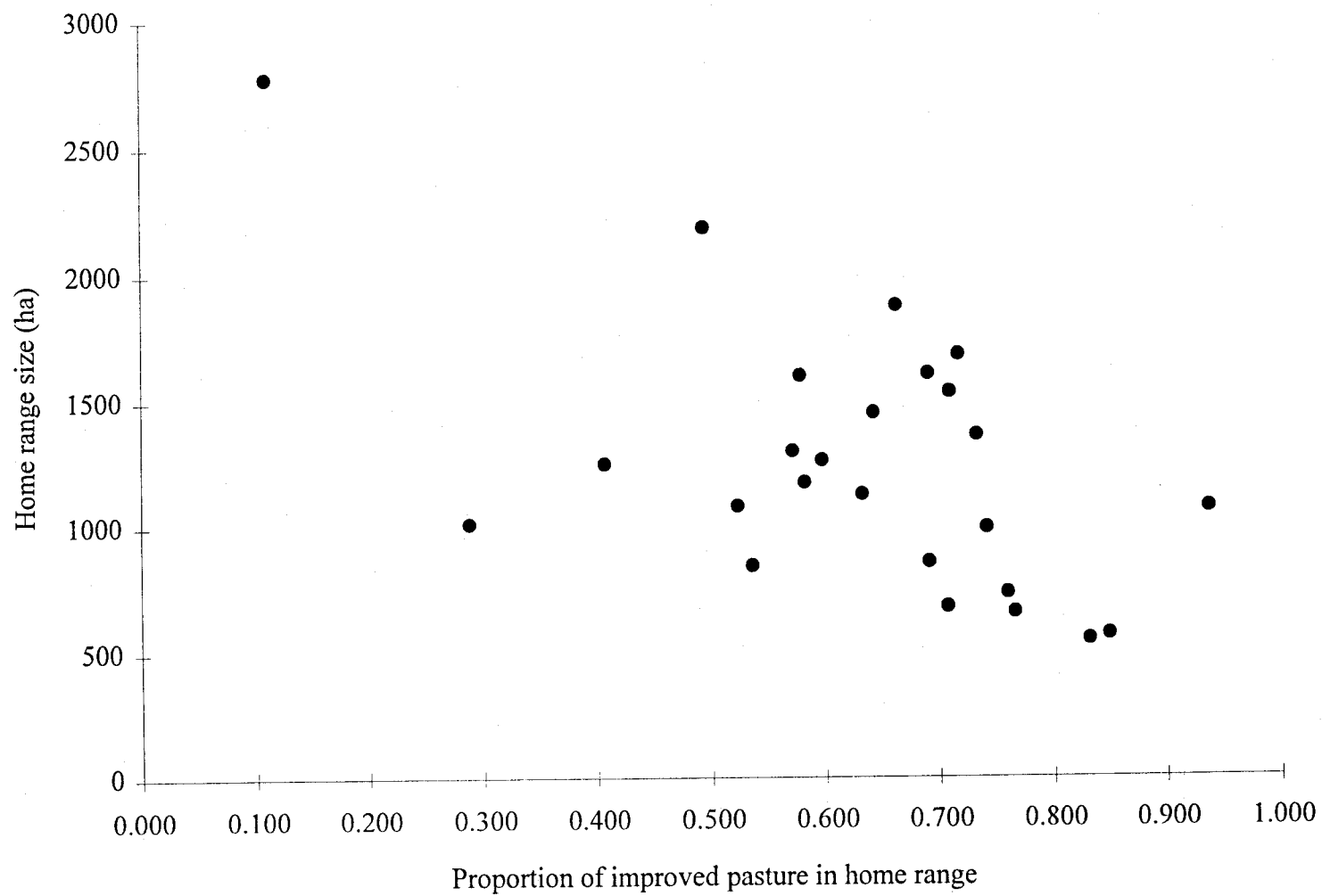


Fig. 6. Relationship between proportion of improved pasture in home range and home range size for 25 crested caracara home ranges in south-central Florida, 1994-1996.

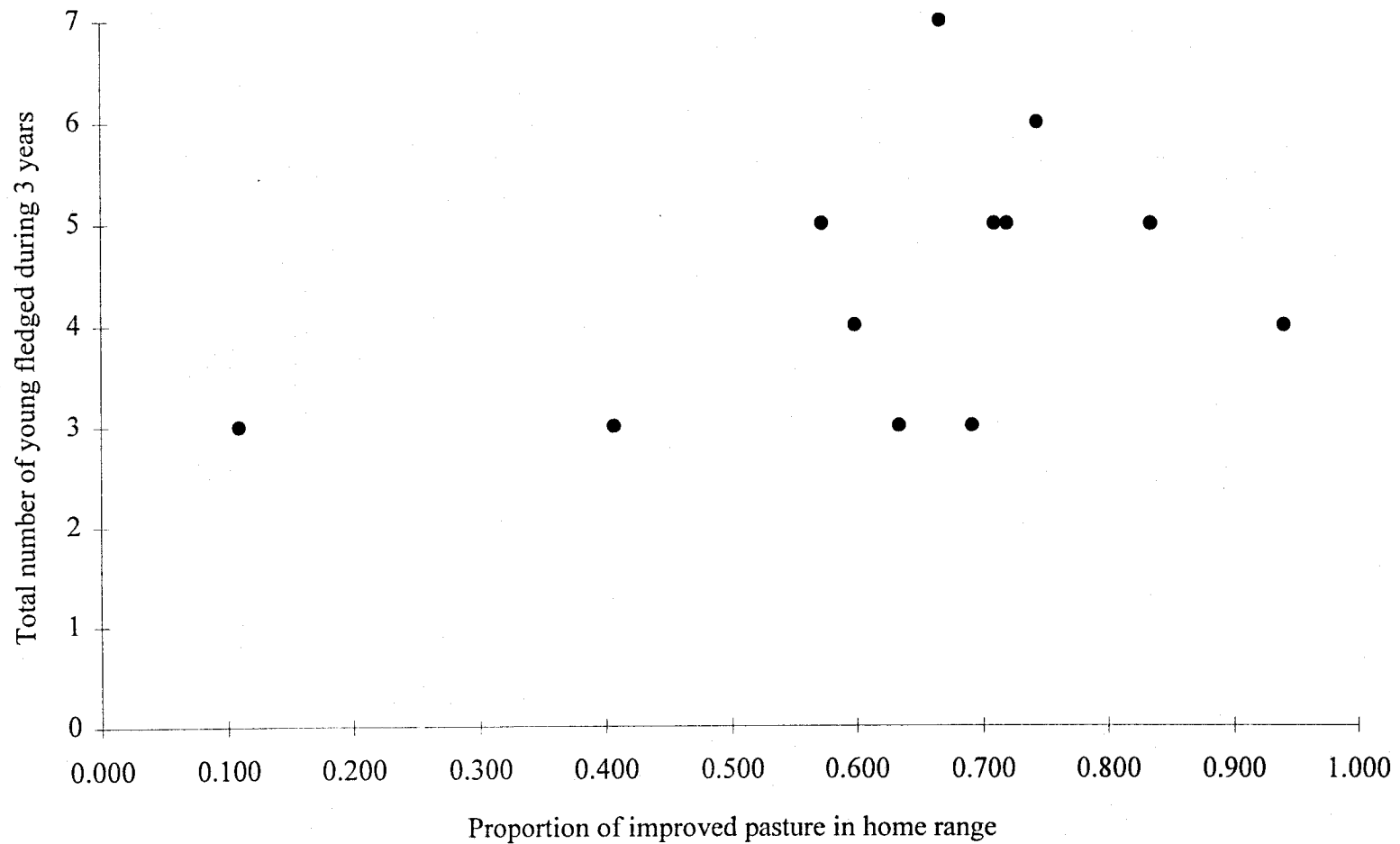


Fig. 7. Relationship between amount of improved pasture in the home range and total number of young fledged during 1994-1996, for crested caracaras in south-central Florida.

DIET AND FORAGING ECOLOGY

INTRODUCTION

The crested caracara is a unique raptor/scavenger frequently associated with human activities. Commonly seen feeding on roadkill, it is generally considered a scavenger (Knowlton 1909, Bent 1938). Numerous descriptions and anecdotal observations of the caracara feeding on a wide variety of prey, both live and dead (reviewed in Morrison 1996), however, suggest that this raptor is actually a diet generalist. Little quantitative data exist on the caracara's diet although limited information is available from populations in Texas (Dickinson 1990), Costa Rica (Richmond 1976), Mexico (Rivera-Rodríguez and Rodríguez-Estrella 1993), and Arizona (Levy 1988).

In Florida, the landscape is increasingly influenced by human activities. Many of these activities potentially affect the food resource base utilized by top predators. The extent and hydroperiod of natural wetlands have been altered by extensive ditching and draining (Babbitt 1996), the use of agricultural chemicals has increased, and poisons are regularly used against nuisance wildlife (pers. obs.). High levels of mercury have been found in several animal taxa throughout Florida (Fleming et al. 1982, Royals and Lange 1990, Spalding and Forrester 1991). The most probable source of mercury contamination in top predators is via the food chain. We hypothesized that caracaras may be exposed to high mercury levels because they feed on a variety of species that inhabit both aquatic and terrestrial ecosystems such as fish and amphibians, and scavenge on carrion such as raccoons and wading birds.

No quantitative information exists on the diet of crested caracaras in Florida. Land use patterns continue to change throughout areas in Florida where the caracara persists. Foraging habits and diet are aspects of this species' ecology important for consideration in management of this threatened population. The main objective of this part of the study was to obtain information on the diet of crested caracaras in Florida during the breeding season and on habitats used for foraging. Specific objectives were:

- 1) to quantify the amount of carrion brought to the nest;
- 2) to evaluate diet by analyzing composition of prey remains collected at nests;
- 3) to assess the availability of roadkill throughout the study area.

STUDY AREA AND METHODS

We conducted observations of food deliveries at caracara nests. We were limited as to the number of nests we could use because caracaras are very wary of disturbance near the nest. We determined early in the study that the adults would not go to the nest when an observer was sitting in a blind, even if the young were begging loudly for food. Apparently the adults were aware of the observer or perhaps the presence of the blind itself was a deterrent. We subsequently attempted to collect these observations from along roads using a vehicle as a blind. The observer arrived at the nest before dawn and for periods of 3 to 5 hours recorded all activity at the nest as observed through a spotting scope from the vehicle. Vehicles were parked at least 200m from the nest. The observer recorded and identified, when possible, the number and types of food items delivered to nestlings. Delivery times were also recorded.

During visits to nests, we collected all pellets and prey remains. These were subsequently dried for later analysis. Prey remains were verified by comparing bones with specimens in reference collections at the Florida Museum of Natural History in Gainesville.

To assess the abundance and availability of roadkill, we conducted bi-monthly surveys from August 1993 through March 1996 along a 200-mile route of two- and four-lane highways throughout the study area (Fig. 1). During these surveys, the observer drove at approximately 88 kph along the road, counted all road-killed animals, and recorded them according to species and locations. We also recorded age, number, and location of all crested caracaras seen along these surveys.

To test our hypothesis about mercury exposure, we collected 22 feather and 29 blood samples from caracaras during 1994. These samples were sent to a laboratory in Wisconsin for analysis, which was arranged by Dr. Charles Facemire, US Fish and Wildlife Service, Atlanta.

RESULTS AND DISCUSSION

Observations of food deliveries and foraging at nests

We conducted approximately 100 hours of observations at 10 different crested caracara nests. All data were collected from a vehicle so data may be somewhat biased

towards foods eaten by caracaras nesting along major roads. Although we were able to identify some of the food items brought to the nest, we determined that this method is not particularly effective for obtaining unbiased quantitative data on diet. At most nests, after a couple of hours, the adult caracaras exhibited behaviors indicating that they were uncomfortable with the observer's presence, even though we had visited these same nests many times, parked the vehicle, and conducted other activities. Apparently, parking for extended periods of time upset the adults, so we cannot be confident that the rates of food delivery that we observed are representative of normal behavior. In some instances, the adults would not come to the nest at all. If it became obvious that our presence was affecting the adults' behavior and that the chicks were not being fed, we left the nest. Nests where adults seemed to react to our presence were not used in data analysis.

At nests where we were able to collect data, most items (66%) brought in could not be readily identified (Table 1). Many appeared to be pieces of flesh, perhaps obtained from roadkilled animals. Few whole items were brought in, although we could identify some frogs, fish, sirens, and mammals. Those listed as carrion were identified as such because the observer observed the adults pick up the food from a roadkilled animal. To obtain a complete picture of the diet of caracaras, it is necessary to assess the amount of carrion brought in. However, because of difficulties incurred with these data collections, we are not confident that our observations are true reflections of this diet component. It is clear, however, that caracaras are not obligate scavengers as has been previously noted in the literature (Knowlton 1909, Bailey 1925, Bent 1938).

Caracaras forage mostly in early morning and late afternoon. Delivery rates averaged 1.21/hr at nests where we conducted observations, similar to the slightly > 1 /hr reported by Richmond (1976). Adults regularly forage on the ground within 100m of the nest even during the nestling stage, occasionally scratching the ground and turning over cowpats, rocks, and debris. All age groups were observed wading in shallow water along the edges of ditches and wetlands taking fish, frogs, and insects. Caracaras nesting within 1 km of a major road were regularly seen patrolling roads at sunrise, presumably searching for carrion.

Identification of prey remains and pellet contents

Analysis of a subsample of 126 prey remains collected at 21 nests supports classification of crested caracaras as diet generalists. They use carrion as well as feed regularly on a variety of prey including armadillo (*Dasypus novemcinctus*), opossum (*Didelphis virginiana*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), spotted skunk (*Spilogale putorius*), rat (*Rattus rattus*), water rat (*Neofiber alleni*), rabbit (*Sylvilagus floridanus*), cotton rat (*Sigmodon hispidus*), pig (*Sus scrofa*), and siren (*Siren lacertina*) (Table 2). Fish, birds, snakes, and turtles are also common food items. Preliminary analysis indicated that insect parts were present in 100% of the pellets sampled ($n = 100$, Table 2). Due to time and funding limitations, we did not undertake detailed quantitative analysis of the entire pellet sample.

Roadkill surveys

In all years, we noted more roadkill per mile during winter months as compared to summer months (Fig. 2). This apparent increase in roadkill in winter may reflect increased movements of animals or increased traffic levels during this season. Because clocks are on standard time during winter months, daily traffic levels peak during those dawn and dusk hours when animals are most active, leading to more vehicle-related deaths.

The fairly consistent numbers of caracaras seen per mile during these surveys suggests that caracaras are not particularly responding to increased roadkill abundance in the winter. Caracaras seen along roadways may be surveying territories or positioned along territorial boundaries. The relatively consistent number of caracaras seen per mile may simply reflect a constant number of territories that are present along the survey route. We saw young caracaras most often with their parents during the breeding season. Lone immature caracaras were seen infrequently along roadways. This observation further supports our hypothesis that these age classes tend to be cryptic in their behavior and not often visible in exposed places when within another caracara's territory.

Mercury Analysis

Blood samples taken for this analysis represented 6 adults and 23 juveniles. Mercury levels in all samples were low (feathers, mean $1.45 \text{ ppm} \pm 0.22 \text{ SE dry wt.}$, range 0.44 - 3.42

ppm; blood, mean $0.12 \text{ ppm} \pm 0.01 \text{ SE dry wt.}$, range 0.04 - 0.32 ppm). These concentrations are comparable to those found in feather and blood samples obtained from nestling bald eagles inhabiting central Florida (Bohall Wood et al. 1996) and are well below concentrations found in tissues of wading birds in Florida (Spalding and Forrester 1991) and of birds that died of mercury poisoning (Finley and Stendell 1978).

Management Implications and Needs for Further Research

Unlike the snail kite (*Rostrhamus sociabilis*), which is a diet specialist (Sykes et al. 1995), the crested caracara in Florida may be more adaptable to certain changes in land use and to moderate levels of human activities because it can utilize a variety of foods from a variety of habitats. These habits may enhance exposure of individuals to a wide realm of mortality agents, however. Collisions with vehicles along major roads are a primary cause of mortality of juvenile caracaras, particularly just after they become independent and leave the natal territory (Morrison unpubl. data). Caracaras on ranches may risk exposure to poisons, which are increasingly being used against coyotes in the region. Caracaras have also been observed foraging in citrus groves during certain times of the year. Consequences of exposure to chemicals used in these agricultural habitats remain unknown.

Detailed quantification of the caracara's diet will require extensive effort. Due to time and funding limitations, we did not undertake such an analysis during this study. For similar reasons, determining food availability will also be difficult. Sampling insects and small vertebrates is time consuming and labor intensive. For the overall study, we elected to pursue breeding biology and habitat-related questions rather than spend the intensive time required to obtain detailed information on food availability. Consequently, relationships among reproduction and productivity, habitat use, and food resources remain important areas for future research on this population.

We have presented some general observations of the caracara's breeding season diet in Florida. During the nestling stage, a significant portion of food brought to the nest is live prey. Caracaras also forage in and around wetlands more than previously believed, as is indicated by the prevalence of fish bones in the prey remains sample. This species may actually be strongly dependent on wetlands, particularly during the breeding season. As

drainage of pastures and conversion to citrus or sugar cane continues in certain areas, loss of wetlands may alter the food abundance or availability for individual pairs.

Future research should also consider differences in abundance and availability of food resources on cattle ranches as compared to more "native" or less intensively managed habitats. Hypotheses that involve differences in reproductive effort and productivity as related to food resources in these habitats should be tested.

Table 1. Food items delivered at active crested caracara nests in south-central Florida, 1995 - 1996. $n = 100$ observation hours, 10 nests.

Food Item	% Occurrence in sample
Carrion	14
Unknown	66
Fish	6
Frog	2
Bird	<1
Snake	<1
Siren	3
Rabbit	2
Squirrel	<1
Small rodent	<1
Insects	4

Table 2. Summary of crested caracara diet from preliminary analysis of a subsample of prey remains collected at nests and roost sites in active territories, 1994 - 1996. *n* = 21 nests, 126 samples of prey remains.

Order	Relative Abundance (%)
Mammals	49.2
Fish	21.4
Reptiles	17.5
Birds	7.1
Amphibians	4.8

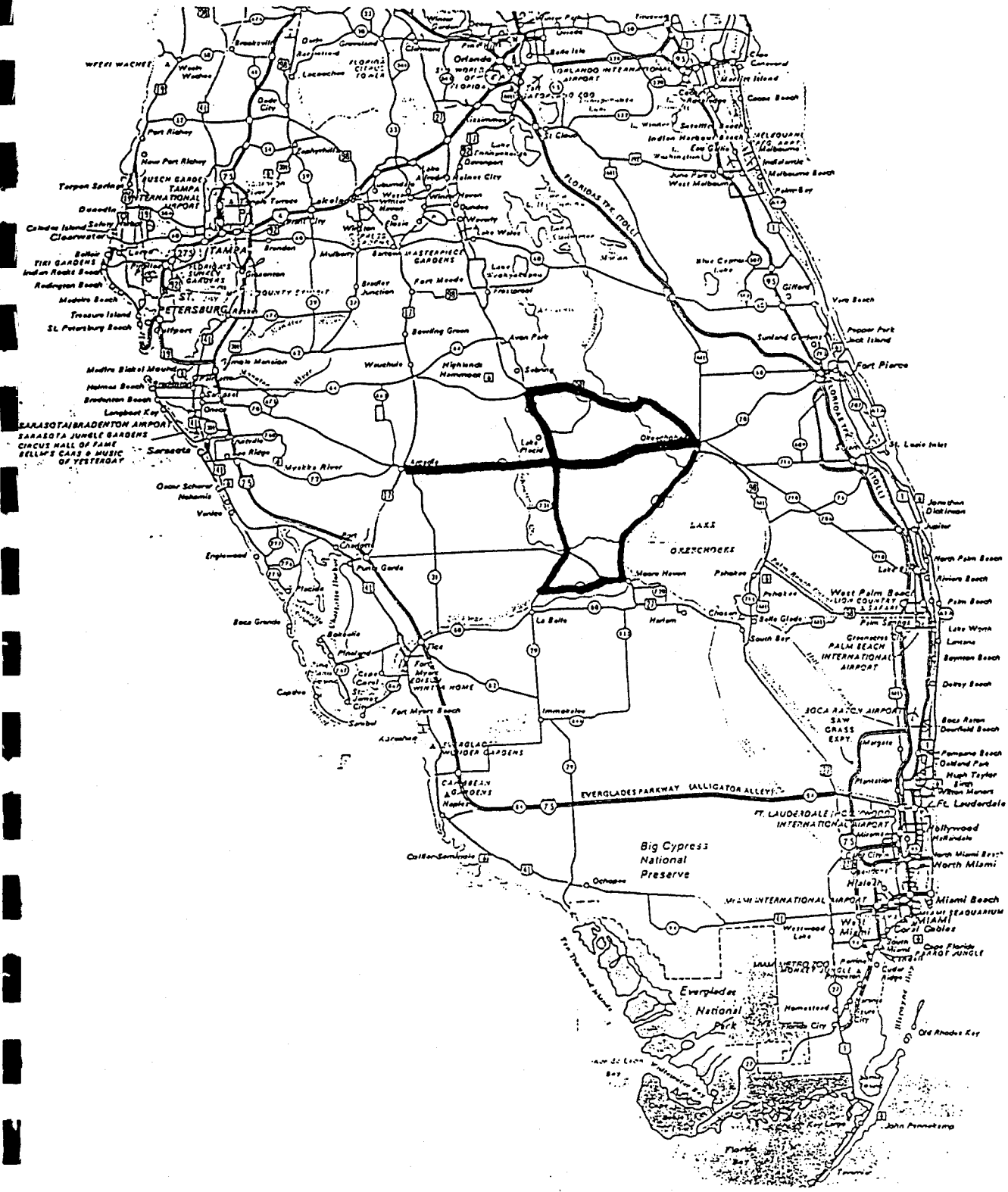


Fig. 1. 200 mile route for roadkill surveys throughout the study area in south-central Florida, 1994 - 1996.

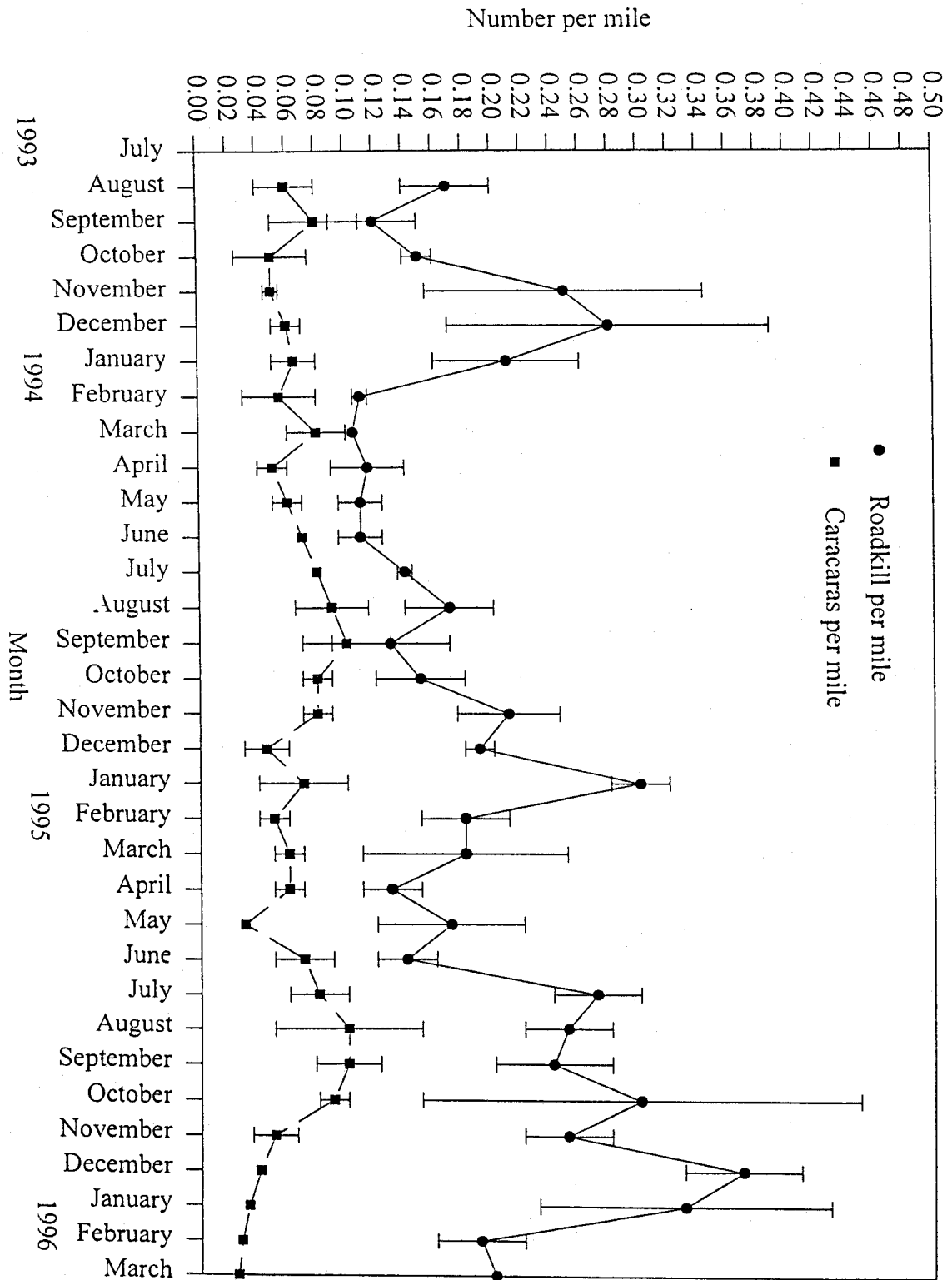


Fig 2. Abundance of roadkill and caracaras seen along regular route within study area, 1993 - 1996.

SUMMARY AND CONCLUSIONS

This study constitutes the first in-depth examination of the ecology of the crested caracara in Florida, or anywhere throughout its geographic range. The Florida population is isolated and remote from other caracara populations, so is of conservation concern. Conversion of grassland and pasture habitats is occurring rapidly throughout the south-central region of Florida, which constitutes most of the current breeding range of the caracara. This population is listed as Threatened by the US Fish and Wildlife Service and the state of Florida.

From August 1993 through June 1996, we monitored reproductive activity and habitat associations of crested caracaras in 65 territories throughout south-central peninsular Florida. Territories were located in Highlands, Glades, Okeechobee, DeSoto, Osceola, Hendry, Polk, and Indian River Counties. We monitored nesting activity during three breeding seasons and tracked activities and movements of adult and juvenile caracaras throughout the rest of the year using radiotelemetry. During the course of the study, we banded 49 breeding adult caracaras and 189 nestlings.

Following are some of the major findings and conclusions from this research.

Conclusions drawn here are assumed to apply to the Florida population but may have only limited relevance to caracara populations elsewhere throughout the species' geographic range.

- 1) Crested caracaras in Florida have relatively high nest success and productivity compared to most raptors and in contrast to what has been previously reported for this population. High nesting success and productivity are indicated by high territorial occupancy and breeding rates coupled with comparatively low nest failure rates and the ability of pairs to make multi-nesting attempts.
- 2) The caracara in Florida exhibits a reproductive strategy typical of other sedentary tropical and semi-tropical bird populations. This raptor's breeding cycle is closely tied to the annual precipitation cycle. Abundance and variety of food, a fairly constant climate, and absence of migration facilitate a long breeding season. Most reproductive activity occurs during the winter dry season, although nesting attempts can be made in almost all months of the year.

- 3) As with many other avian species, all reproductive parameters of Florida's caracaras declined as the breeding season progressed. Clutch sizes of 3 produced the most independent young during all 3 years, perhaps indicating differences in territory or individual quality for pairs that produced 3-egg clutches.
- 4) The ability to make multi-nesting attempts has important ramifications for lifetime reproductive success of individuals and also for growth rate of the population. Most pairs that renest after an early season failure successfully raise young during that same year. Pairs that successfully raise two broods during a season fledge significantly more young than single-brooded pairs, thus potentially increasing the inclusive fitness of double-brooded adults.
- 5) Juvenile crested caracaras remain with their parents for at least 2 months after fledging from the nest. If the parents attempt a second brood, first brood young may become independent and leave the natal territory in as little as 8 weeks post-fledging. Estimates of survivorship to recruitment were highest for young from first (of two) and early season broods.
- 6) Estimates of home range size and local nesting density determined in this study using telemetry were considerably smaller and higher, respectively, than previously published estimates, which were based only on observations of unbanded individuals. Home range size for 25 breeding adult crested caracaras ranged from approximately 1150 to 1400 ha, using the fixed kernel estimation method and a 0.85 smoothing factor. Adult caracaras regularly ranged within 2.5 km of the nest although excursions of up to 9 km from the nest were noted. Breeding season home ranges were smaller than non-breeding season home ranges, perhaps reflecting nest commitments or seasonal differences in food availability.
- 7) Some caracara pairs nested as close together as 0.5 km although distances between nests of most adjacent pairs were 1.0 - 3.0 km. Caracaras are highly territorial near the nest site but may tolerate conspecifics in feeding areas away from the nest. Ninety-nine percent kernel contours overlapped as much as 35% among adjacent pairs but core areas (60% kernel contour) overlapped less than 10%. Movements to or from the overlap area by individuals of adjacent pairs did not seem to be coordinated relative to one another.

- 8) Crested caracaras in Florida apparently prefer open, structurally simple habitats. The immediate area around a nest is generally open with low ground cover and low density of tall or shrubby vegetation. Structural characteristics of vegetation at nest sites differed between public and privately owned lands, probably due to differences in management regimes. These differences may translate into differences in regular territorial occupancy and reproductive success between territories on private and public lands.
- 9) Logistic regression analysis comparing known caracara home ranges and potentially available units throughout the study area indicated a positive association of caracara home ranges with improved pastures. Most caracara home ranges contained at least 70% natural or semi-natural vegetation, up to 94% of which was improved pasture.
- 10) The size of individual caracara home ranges was strongly inversely correlated with the proportion of improved pasture. Weak positive correlations between mean annual productivity and the amount of improved pasture in the home range suggest that many other factors besides habitat composition influence annual productivity of a caracara pair.
- 11) Caracaras are diet generalists, feeding on live prey as well as carrion. They use wetlands for foraging more than originally believed, particularly extensive networks of drainage ditches and small wetlands found in pastures.
- 12) The crested caracara is a generalist predator that frequently occupies areas in close association with human activities such as cattle ranches and other agricultural lands. Caracaras are generally tolerant of some human activity and moderate habitat changes, as long as they are not harassed and the nest site is left intact. Certain pairs are quite tolerant of small-scale burning, clearing, removal of sod, building construction, and general human activity even during the nesting season. Normal levels of ranching activities are well tolerated. These activities probably have aided in maintaining suitable caracara habitat on private lands. Pasture management programs include controlled fires set during winter and spring. These often sweep through active nest stand with little effect. Caracaras seem most sensitive to disturbance near nests during nestbuilding, incubation, and early nestling stages when prevention of regular food deliveries can result in nest failure.

MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

Florida's population of crested caracaras is listed as federally and state Threatened. A recovery plan was prepared by the US Fish and Wildlife Service in 1989. Currently, as part of the South Florida Ecosystem Recovery Effort, attempts are being made to update the knowledge base and to refine recovery goals and plans for the crested caracara (J. Tutton, US Fish and Wildlife Service, pers. commun.). A comprehensive management plan for this population is clearly needed.

Until this study, little was known about this species in Florida or elsewhere throughout its geographic range. Few data were available to substantiate the Threatened listing or to critically evaluate population status or trends. The size of this populations is still in question. Published estimates of population size based on observations of adult caracaras and adult/immature age ratios are 400-500 individuals (Layne 1995). Difficulties with access to many areas of suitable habitat, particularly away from major roads, preclude a completely systematic search of the species' Florida range. In our study, we found high territorial occupancy and breeding rates, good reproductive success, and pairs nesting as close together as 0.5 km. These findings suggest that 1) it is unlikely that the Florida population was reduced to < 100 birds between 1967 and 1970 (Heinzmann 1970); 2) breeding densities of Florida's crested caracaras may be higher than expected in some areas of their current breeding range; and 3) total population numbers may be higher than published estimates.

Florida's population of crested caracaras may be stable at present, particularly in light of our recent findings. Little change has occurred in the core area of distribution from that shown by Howell (1932), but overall, contraction and fragmentation of the range has occurred. Caution is warranted in evaluating population trends. Counts are hampered by limited access to all areas of suitable habitat and by the effects of the birds' terrestrial behavior on their detectability.

If the population is in a long-term decline, factors other than reproduction are likely involved. The greatest threat continues to be loss and degradation of nesting habitat. Our observations suggest that most suitable habitat may be occupied. We found caracara pairs in most areas where we looked for them, particularly on private ranches. A decline seems

inevitable if habitat conversion continues at the present rate throughout the caracara's limited range. During the last decade, the amount of ranchland acreage converted to citrus production, particularly in Highlands, Glades, and Hendry counties has increased sharply. Urban development has proceeded rapidly in Osceola, Brevard, and Indian River counties; ranches are lost to urban sprawl. On some ranches, removal of palms has precluded the use of these areas as nesting sites.

A conservation strategy for this population should be based on protecting known nest sites and areas where juveniles congregate. Such a strategy should focus at a regional scale, and include nesting sites on both public and private lands in the context of the entire regional population. Overall, management and conservation plans must address effects of habitat loss and degradation, particularly rapid conversion of pastures to citrus. That most suitable habitat is in private ownership will complicate conservation efforts. Because caracaras seem to be doing well on cattle ranches, efforts being made in some areas to restore native prairies may instead target species that require these native habitats. While beneficial for prairie-dependent species, these choices may preclude management for caracaras on public lands. Habitat protection must incorporate cooperative efforts among land management agencies and private landowners and should focus at an ecosystem and regional scale. Critical to conservation of Florida's crested caracaras is to develop means to preserve the large cattle ranches that now support the bulk of this population. These efforts of necessity will include creative alternatives to direct land purchase such as conservation easements and Habitat Conservation Planning (US Fish and Wildlife Service and National Marine Fisheries Service 1996).

Caracaras exhibit strong fidelity to a nest site and year-round home range. For species that exhibit similar traits such as the bald eagle, management recommendations typically focus on protecting the nest site. Occasionally a buffer area around the nest is included, in which development or management activities are limited. Because of the dispersion of nest trees within open grassland habitats, a circular home range for Florida's crested caracaras cannot be assumed. Nest trees are often associated with large hammocks that do not constitute suitable foraging habitat, therefore a circular buffer around a nest may not encompass areas required for all activities associated with reproduction and year-round survival of a breeding pair. Of additional concern is that the caracara's sociality and site

fidelity of pairs may limit the tendency for new pairs to colonize new or restored habitat, particularly far from the core of the species' distribution.

Collisions with vehicles seems to be a serious current problem affecting survival of Florida's caracaras, particularly for juveniles. This may affect local productivity in some areas. Management efforts should also incorporate a strong education component, to reduce negative impressions of scavengers and encourage awareness about roadkill mortality as a threat to many species. Shooting and trapping of caracaras are still a problem in some areas. We found that many ranchers still believe that caracaras kill livestock. Well-known nests are especially vulnerable to harassment and destruction and should be protected by confidential treatment of locations. Education efforts should stress the value of the crested caracara as an example of the potential for coexistence of sustainable economic activities and native wildlife.

Habitat preservation is the key to conservation of this raptor. Management plans for this species must consider the amount and context of both nest sites and suitable foraging habitat. Future research on this population should be directed towards identifying important habitats within home ranges of breeding pairs, and evaluating habitat context as well as content within and around known caracara home ranges.

Guidelines for caracaras should be developed that are similar to those used for bald eagles, wood storks, and other habitat-specific species in Florida. These guidelines should outline caracara nesting habitat and perhaps, as a point of beginning, recognize different zones of protection around known nest sites, taking into account suitable foraging habitat and neighboring caracara pairs. Because of the variation in context and levels of human disturbance among caracara nest sites, each site may have to be treated separately in management planning.

This study represents an important beginning towards understanding the population dynamics, demographics, and habitat ecology of Florida's crested caracara population. As with any species that is long-lived and ranges widely across habitats, however, more years of study are required to fully understand the role of the caracara in the Florida landscape.

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APPENDIX A.

EDUCATION, CONSERVATION, AND PUBLICATIONS

EDUCATION AND PUBLIC RELATIONS

Throughout this study, we made numerous efforts to increase awareness and to stimulate interest in the caracara in Florida, and in conservation issues throughout this region. We gave talks to numerous groups including the Archbold Biological Station summer ecology camp ; the Highlands County, Kissimmee/St. Cloud, and Alachua County Audubon groups; 4H groups; the Florida Cattleman's Association annual meeting in June 1995; the Florida Falconry Association; 4th grade at Lake Country Elementary School, Lake Placid; Wrede's Wildlife Rehabilitation Center; a college group from Audubon Expeditions Institute; 4th grade at Buena Vista Academy, Windermere, FL; and a wildlife rehabilitator's workshop in Orlando.

We also conducted a successful media campaign highlighting this research that consisted of numerous articles that appeared in newspapers across the state, a short film clip prepared by IFAS that appeared on several local television stations, a feature on National Public Radio, articles in the February 1996 issue of the Florida Cattleman's magazine, the December 1996 issue of Birder's World, and the Summer issue of the Florida Naturalist. See Appendix C for examples of these articles.

IFAS TV also produced a one-half hour television show entitled "Protecting Birds of Prey" for Public Television's IMPACT. Copies of this film were distributed to all landowners who worked with us on this research. We also conducted a showing of the film at the 1997 Florida Cattleman's Association meeting at Marco Island, Florida, June 23, 1997.

PAPERS PRESENTED AT PROFESSIONAL MEETINGS

- 1996: Managed landscapes and Threatened species: nest success of Crested Caracaras on cattle ranches in Florida. Annual Meeting, American Ornithologists' Union and Raptor Research Foundation, Boise, ID. Aug. 13-17.
- 1996: Characteristics and habitat composition of Crested Caracara home ranges in south-central Florida. (poster, with L.D. Todd). Annual Meeting, American Ornithologists' Union and Raptor Research Foundation, Boise, ID. Aug. 13-17.
- 1995: Post-fledging exploratory movements of juvenile crested caracaras in Florida. Annual Meeting, Raptor Research Foundation, Duluth, MN, Nov. 1-4.

- 1995: Reproductive ecology of the crested caracara on agricultural lands. Bi-annual meeting, Florida Ornithological Society, Cocoa Beach, FL, Oct. 21.
- 1995: Environmental correlates of breeding in the crested caracara. Bi-annual meeting, Florida Ornithological Society, Gainesville, FL, April 29.
- 1995: Breeding biology of the crested caracara in south-central Florida. Annual meeting, Florida Ecological and Evolutionary Society, Archbold Biological Station, Lake Placid, FL, Mar. 31 - Apr. 2.
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APPENDIX B.

BANDING RECORDS FOR CRESTED CARACARAS CAPTURED IN SOUTH-CENTRAL FLORIDA, 1994 - 1996

USFWS #	Leg	Color	Leg	Age	Frequency	Date Banded	County
98799361	R	Blue D	L	HY	151.519	8/31/93	Highlands
98799362	L	Black	R	HY	-	1/9/94	Highlands
98799363	R	Green	L	HY	-	1/9/94	Highlands
98799364	R	Black	L	HY	151.280	2/14/94	Okeechobee
98799365	L	Green	R	HY	-	2/15/94	Okeechobee
98799366	R	Blue	L	HY	-	2/15/94	Okeechobee
98799367	R	Blue/silver	L	HY	151.501	2/15/94	Okeechobee
98799368	R	Blue	L	A/F	151.260	2/20/94	Glades
98799369	R	Black	L	A/M	-	2/20/94	Glades
98799370	L	Silver	R	A/F	151.379	3/5/94	Okeechobee
98799371	R	Green	L	A/M	-	3/5/94	Okeechobee
98799372	L	Blue	R	A/M	151.440	3/7/94	Okeechobee
98799373	L	Black	R	HY	151.300	3/7/94	Okeechobee
98799374	L	Blue/silver	R	HY	151.799	3/9/94	Glades
98799375	L	Black/green	R	HY	-	3/9/94	Glades
98799376	L	Blue/black	R	HY	-	3/10/94	Okeechobee
98799377	R	Blue/green	L	HY	-	3/10/94	Okeechobee
98799378	L	Silver/black	R	HY	151.321	3/10/94	Okeechobee
98799379	L	Blue/green	R	HY	151.977	3/10/94	Highlands
98799380	R	Black/silver	L	HY	151.938	3/10/94	Highlands
98731217	L	Black/silver	R	HY	151.358	3/14/94	Okeechobee
98731218	R	Blue/black	L	A/F	151.780	3/12/94	Okeechobee
98731219	L	Black/blue	R	HY	151.839	3/17/94	Highlands
98731220	R	Black/blue	L	HY	-	3/23/94	Okeechobee
98731221	L	Silver/green	R	HY	151.338	3/23/94	Okeechobee
98731222	R	Black/green	L	HY	-	3/23/94	Highlands
98731223	L	Silver/blue	R	HY	151.859	3/23/94	Highlands
98731224	R	silver/blue	L	HY	-	4/7/94	Highlands
98731225	L	green/black	R	HY	151.639	4/7/94	Highlands
98731226	L	green/blue	R	HY	151.620	4/7/94	Glades
98731227, blue	L	blue	R	HY	151.896	4/8/94	DeSoto
98731228	R	silver/black	L	HY	-	4/8/94	Highlands
98731229	L	green/silver	R	HY	151.957	4/8/94	Highlands
98731230 black	L	blue	R	HY	-	4/8/94	Highlands
98731231	R	silver/green	L	HY	-	4/10/94	Okeechobee
98731232 blue	L	black	R	HY	151.670	4/10/94	Okeechobee
98731233	R	green/blue	L	HY	-	4/10/94	Glades
98731234	L	orange	R	HY	151.877	4/10/94	Glades
98731235	R	green/black	L	HY	-	4/10/94	Glades

APPENDIX B (continued)

USFWS #	Leg	Color	Leg	Age	Frequency	Date Banded	County
98731236 blue	L	green	R	HY	-	4/10/94	Glades
98731237	R	orange	L	HY	-	4/10/94	Glades
98731238	L	Blue 9	R	A/M	151.558	4/12/94	Highlands
98731239	R	Blue E	L	A/F	151.600	4/17/94	Highlands
98721240 green	R	green	L	HY	151.540	4/20/94	Highlands
98731241	L	Blue 8	R	HY	-	4/27/94	Okeechobee
98731242	R	Black 4	L	HY	151.687	4/27/94	Okeechobee
98731243	L	Green 2	R	HY	-	4/27/94	Okeechobee
98731244	R	Blue 2	L	HY	-	4/27/94	Okeechobee
98731245	L	Black H	R	HY	-	4/30/94	Highlands
98731246	R	Green C	L	HY	151.738	4/30/94	Highlands
98731247	L	Black E	R	HY	151.321	5/2/94	Glades
98731248	R	Green W	L	HY	-	5/2/94	Glades
98731249	R	Black U	L	A/M	151.759	5/3/94	Highlands
98731250	R	Green O	L	A/F	151.718	5/3/94	Glades
180736805	L	Black T	R	HY(2)	-	6/16/94	Okeechobee
180736806	R	Green M	L	HY(2)	-	6/16/94	Okeechobee
180736807	L	Green 8	R	HY(2)	151.670	6/16/94	Okeechobee
180736808	R	Green A	L	HY(2)	-	6/16/94	Okeechobee
180736809	L	Brown 2	R	HY	151.817	1/23/95	Okeechobee
180736810	R	Purple 8	L	HY	151.260	1/29/95	DeSoto
180736811	L	Green 7	R	HY	151.799	1/29/95	DeSoto
180736812	L	Brown E	R	HY	151.440	2/1/95	Highlands
180736813	L	Black R	R	HY	151.877	2/2/95	Highlands
180736814	R	Blue R	L	A/M	150.010	2/7/95	Okeechobee
180736815	L	Black V	R	A/M	150.810	2/8/95	DeSoto
180736816	L	Brown N	R	HY	150.050	2/12/95	Glades
180736817	R	Purple K	L	HY	150.140	2/12/95	Glades
180736818	L	Brown A	R	A/F	150.120	2/13/95	Highlands
180736819	L	Blue H	R	HY	150.160	2/20/95	Highlands
180736820	R	Purple E	L	HY	150.300	2/20/95	Highlands
180736821	L	Black O	R	HY	151.759	2/20/95	Highlands
180736822	L	Blue 5	R	A/F	150.260	2/24/95	Glades
180736823	R	Purple 3	L	HY	150.030	2/25/95	Osceola
180736824	L	Green 3	R	A/F	-	2/26/95	Glades
180736825	R	Blue P	L	A/M	150.280	2/26/95	Glades
180756701	L	Brown T	R	HY	150.439	2/26/95	Glades
180756702	L	Black I	R	A/F	-	2/28/95	Highlands
180756703	R	Purple V	L	A/M	150.200	2/28/95	Highlands
180756704	L	Black G	R	HY	-	3/5/95	Highlands
180756705	R	Green V	L	HY	-	3/5/95	Highlands
180756706	L	Brown M	R	A/M	150.458	3/7/95	Okeechobee

APPENDIX B (continued)

USFWS #	Leg	Color	Leg	Age	Frequency	Date Banded	County
180756707	R	Purple 2	L	A/M	150.418	3/17/95	Highlands
180756708	L	Brown O	R	HY	150.320	3/19/95	Glades
180756709	R	Green 1	L	HY	150.360	3/19/95	Glades
180756710	L	Black S	R	HY	150.498	3/20/95	Okeechobee
180756711	R	Purple H	L	HY	150.398	3/20/95	Okeechobee
180756712	L	Orange	R	HY	150.560	3/20/95	Glades
180756713	L	Blue V	R	HY	150.770	3/20/95	Glades
180756714	R	Purple W	L	HY	-	3/21/95	Okeechobee
180756715	R	Black 7	L	HY	150.343	3/21/95	Okeechobee
180756716	L	Blue W	R	5 wk	150.659	3/22/95	Highlands
180756717	R	Purple S	L	5 wk	150.848	3/22/95	Highlands
180756718	L	Green P	R	A/M	150.479	3/24/95	Highlands
180756719	R	Black 9	L	HY	150.380	3/24/95	Highlands
180756720	L	Brown B	R	HY	-	3/26/95	Highlands
180756721	R	Brown 9	L	HY	150.889	3/29/95	Okeechobee
180756722	R	Blue K	L	HY	-	3/29/95	Okeechobee
180756723	L	Brown V	R	6 wk	150.689	3/29/95	Okeechobee
180756724	R	Purple 4	L	6 wk	-	3/29/95	Okeechobee
180756725	L	Green U	R	5 wk	-	3/29/95	Okeechobee
180756726	R	Black M	L	5 wk	150.709	3/29/95	Okeechobee
180756727	L	Brown 1	R	HY	150.518	4/2/95	Glades
180756728	R	Green 5	L	HY	150.729	4/2/95	Okeechobee
180756729	L	Green Z	R	A/F	-	4/3/95	Glades
180756730	R	Purple Y	L	A/M	150.627	4/3/95	Glades
180756731	R	Purple A	L	HY	150.828	4/6/95	Glades
180756732	L	Brown X	R	A/M	151.110	4/10/95	Glades
180756733	R	Blue M	L	HY	150.588	4/11/95	Okeechobee
180756734	R	Purple X	L	HY	151.007	4/11/95	Highlands
180756735	L	Green 9	R	HY	151.209	4/11/95	Highlands
180756736	R	Green N	L	A/M	-	4/17/95	Okeechobee
180756737	L	Black P	R	A/F	150.609	4/17/95	Okeechobee
180756738	L	Blue N	R	HY	150.748	4/17/95	Highlands
180756739	R	Purple R	L	HY	150.788	4/17/95	Highlands
180756740	L	Brown K	R	HY	150.948	4/18/95	Glades
180756741	R	Black A	L	HY	151.088	4/18/95	Glades
180756742	L	Green B	R	HY	-	4/18/95	Glades
180756743	R	Purple M	L	6 wk	150.988	4/18/95	Glades
180756744	R	Blue U	L	5 wk	-	4/18/95	Highlands
180756745	L	Brown H	R	5 wk	-	4/18/95	Highlands
180756746	L	Brown C	R	A/F	-	4/19/95	Highlands
180756747	R	Black M	L	A/M	151.159	4/19/95	Highlands
180756748	R	Green T	L	A/F	151.919	4/23/95	Glades

APPENDIX B (continued)

USFWS #	Leg	Color	Leg	Age	Frequency	Date Banded	County
180756749	L	Brown 5	R	7 wk	151.192	4/25/95	Highlands
180756750	L	Blue X	R	7 wk	150.588	4/28/95	Glades
180756751	L	Grn/blk	R	7 wk	-	4/28/95	Glades
180756752	L	Black C	R	A/M	150.969	5/3/95	Highlands
180756753	R	Purple 9	L	6 wk	-	5/3/95	Glades
180756754	R	Purple 1	L	A/F	151.969	5/5/95	Glades
180756755	L	Brown 8	R	7 wk	151.398	5/7/95	Highlands
180756756	R	Green X	L	7 wk	--	5/7/95	Highlands
180756757	R	Green K	L	A/M	151.469	5/12/95	Highlands
180756758	L	Green 4	R	7 wk	151.540	5/13/95	Highlands
180756759	L	Brown Y	R	7 wk	151.489	5/13/95	Highlands
180756760	R	Purple T	L	6 wk	151.710	5/14/95	Glades
180756761	R	Purple D	L	5 wk		5/15/95	Highlands
180756762	R	Purple 2	L	7 wk	-	5/16/95	Highlands
180756763	L	Blue T	R	7 wk	-	5/16/95	Highlands
180756764	R	Purple 6	L	A/M	150.498	5/23/95	Highlands
180756765	R	Black 8	L	7 wk	151.509	5/25/95	Okeechobee
180756766	L	Green D	R	HY	150.908	5/26/95	Okeechobee
180756767	L	Green R	R	4 wk	150.518	5/27/95	Highlands
180756768	R	Purple 6	L	A/F	150.360	5/27/95	Highlands
180756769	L	Blue Z	R	A/F	151.728	5/28/95	Highlands
180756770	R	Green G	L	A/M	151.589	5/30/95	Highlands
180756771	L	Brown Z	R	6 wk	151.989	5/31/95	DeSoto
180756772	L	Brown U	R	HY	-	6/7/95	Okeechobee
180756773	R	Black X	L	HY	-	6/7/95	Okeechobee
180756774	L	Green Y	R	HY	150.928	6/9/95	Okeechobee
180756775	L	Black N	R	HY	151.568	6/12/95	Highlands
180756776	L	Blue Y	R	A/M	151.989	1/17/96	DeSoto
180756777	R	Yellow N	L	HY	151.053	1/29/96	DeSoto
180756778	L	Brown D	R	HY	151.272	1/29/96	DeSoto
180756779	R	Green S	L	7 wk	151.234	1/30/96	Glades
180756780	L	Brown 6	R	A/F	150.538	2/7/96	Glades
180756781	R	Purple C	L	4 wk	151.163	2/10/96	Glades
180756782	L	Black K	R	4 wk	151.523	2/10/96	Glades
180756783	L	Blue G	R	A/M	-	2/13/96	Okeechobee
180756784	R	Purple 5	L	7 wk	151.693	2/14/96	Okeechobee
180756785	L	Yellow G	R	7 wk	151.552	2/14/96	Okeechobee
180756786	R	Green E	L	7 wk	151.503	2/14/96	Okeechobee
180756787	L	Black D	R	7 wk	151.420	2/20/96	Highlands
180756788	L	Brown S	R	31 d	151.243	2/20/96	Highlands
180756789	R	Purple B	L	A/M	151.608	2/22/96	Highlands

APPENDIX B (continued)

USFWS #	Leg	Color	Leg	Age	Frequency	Date Banded	County
180756790	L	Yellow A	R	A/F	151.710	2/28/96	Highlands
180756791	R	Green G	L	HY	151.073	3/1/96	Okeechobee
180756792	L	Yellow V	R	HY	151.314	3/1/96	Okeechobee
180756793	L	Yellow O	R	HY	150.832	3/6/96	Okeechobee
180756794	R	Green H	L	HY	151.183	3/12/96	Highlands
180756795	L	Yellow D	R	HY	151.344	3/12/96	Okeechobee
180756796	L	Yellow 2	R	HY	-	3/13/96	Highlands
180756797	L	Yellow C	R	6 wk	-	3/13/96	Glades
180756798	R	Purple 7	L	6 wk	150.673	3/13/96	Glades
180756799	L	Yellow 8	R	HY	151.143	3/13/96	Highlands
180756800	R	Black Y	L	HY	151.603	3/13/96	Highlands
180761501	R	Blue 2/2	L	HY	-	3/13/96	Highlands
180761502	L	Brown 7	R	HY	151.642	3/19/96	Highlands
180761503	L	Blue 0/5	R	HY	151.614	3/19/96	Highlands
180761504	R	Yellow P	L	HY	151.453	3/19/96	Highlands
180761505	R	Purple U	L	A/F	150.518	3/20/96	Highlands
180761506	R	Blue 0/6	L	HY	151.382	3/21/96	Osceola
180761507	L	Brown P	R	HY	151.544	3/21/96	Okeechobee
180761508	R	Blue 2/7	L	HY	-	3/23/96	Okeechobee
180761509	R	Purple N	L	HY	150.814	3/23/96	Highlands
180761510	L	Yellow 1	R	HY	-	3/23/96	Highlands
180761511	R	Purple O	L	A/M	150.120	3/26/96	Highlands
180761512	R	Blue 1/9	L	HY	151.432	3/27/96	Indian River
180761513	L	Yellow 3	R	HY	-	3/27/96	Indian River
180761514	L	Yellow T	R	HY	151.582	3/28/96	Highlands
180761515	L	Brown G	R	HY	151.334	3/28/96	Highlands
180761516	L	Brown 3	R	7 wk	-	3/29/96	Highlands
180761517	R	Blue 2/4	L	7 wk	151.412	3/29/96	Highlands
987-49289	L	Black B	R	A/F	150.689	4/1/96	Highlands
180761518	R	Yellow K	L	HY	151.263	4/1/96	Highlands
180761519	L	Black Z	R	HY	-	4/1/96	Highlands
180761520	R	Blue 2/2	L	A/M	-	4/2/96	Hendry
180761521	R	Yellow M	L	HY	150.398	4/2/96	Hendry
180761522	L	Black 3	R	HY	151.633	4/2/96	Hendry
180761523	L	Blue 0/9	R	6 wk	-	4/4/96	Highlands
180761524	L	Blue 3/4	R	HY	151.033	4/8/96	Glades
180761525	L	Yellow 5	R	A/M	151.568	4/9/96	Highlands
180761526	R	Blue 1/1	L	HY	-	4/10/96	Highlands
180761527	L	Yellow U	R	HY	150.870	4/10/96	Highlands
180761528	L	Brown R	R	5 wk	151.373	4/10/96	Highlands
180761529	L	Yellow Y	R	6 wk	-	4/15/96	Highlands
180761530	L	Blue 0/7	R	6 wk	151.922	4/15/96	Highlands

APPENDIX B (continued)

USFWS #	Leg	Color	Leg	Age	Frequency	Date Banded	County
180761531	R	Purple P	L	7 wk	151.122	4/17/96	Polk
180761532	L	Blue 2/6	R	HY	150.543	4/19/96	Glades
180761533	L	Blue 1/4	R	7 wk	-	4/19/96	Highlands
180761534	L	Brown 4	R	7 wk	150.574	4/19/96	Highlands
180761535	R	Blue 3/0	L	HY	-	4/23/96	Glades
180761536	L	Yellow B	R	HY	-	4/23/96	Glades
180761537	L	Brown W	R	HY	-	4/23/96	Glades
180761538	R	Blue 1/3	L	HY	-	4/23/96	Glades
180761539	R	Blue 3/7	L	HY	-	4/24/96	DeSoto
180761540	L	Black 2	R	HY	151.663	4/24/96	DeSoto
180761541	R	Blue 2/3	L	7.5 wk	-	4/25/96	Highlands
180761542	R	Yellow 5	L	7 wk	150.643	4/26/96	Glades
180761543	R	Yellow 7	L	HY	150.560	4/27/96	Hendry
180761544	R	Black 5	L	HY	-	4/30/96	Highlands
180761545	L	Blue 3/9	R	HY	-	4/30/96	Highlands
180761546	R	Yellow Z	L	A/M	151.489	5/2/96	Highlands
180761547	R	Blue 0/4	L	6 wk	-	5/2/96	Glades
180761548	L	Yellow R	R	6 wk	-	5/2/96	Glades
180761549	R	Black 9	L	HY	150.993	5/2/96	Highlands
180761550	R	Yellow H	L	HY	-	5/5/96	Okeechobee
180761551	L	Blue 1/5	R	HY	151.672	5/5/96	Okeechobee
180761552	R	Yellow E	L	A/F	151.088	5/6/96	Highlands
180761553	L	Blue 4/5	R	A/M	-	5/6/96	Highlands
180761554	R	Yellow X	L	7 wk	-	5/8/96	Highlands
180761555	L	Blue 3/3	R	7 wk	1.613	5/8/96	Highlands
180761556	R	Blue 4/1	L	7 wk	-	5/8/96	Highlands
180761557	R	Blue 4/0	L	HY	0.623	6/24/96	Okeechobee
180761558	L	Blue 4/3	R	HY	0.398	7/10/96	Okeechobee
180761559	R	Yellow 6	L	HY	1.923	7/10/96	Okeechobee
180761560	L	Yellow W	R	7 wk	1.552	7/17/96	Highlands
180761561	R	Blue 3/6	L	7 wk	1.540	7/17/96	Highlands

APPENDIX C.

EXAMPLES OF MEDIA COVERAGE FOR CRESTED CARACARA RESEARCH IN
SOUTH-CENTRAL FLORIDA, 1994 - 1996

Research Ranch:

Buck Island builds a bridge between agriculture and ecology

By Sylvia K. Beauchamp

A caracara cries out in the distance, and cows appear as dark silhouettes against a vibrant pink sunset. As dusk settles over Buck Island Ranch, another day of work is ending, a day devoted to research that will benefit both wildlife ecology and cattle ranching in Florida.

This setting reflects the relationships between Florida's ecological and agricultural interests, called "agro-ecology," or the mixture of commercial agriculture and the natural resources of an operation, including its soils, plants and wildlife, said George Tanner, an associate professor of wildlife and range sciences at the University of Florida.

In 1991, UF's Institute of Food and Agricultural Sciences established a long-term, multidisciplinary program in agro-ecology to address complex issues surrounding natural resource management in Florida's agricultural areas. UF/IFAS joined with MacArthur Agro-ecology Research Center (MAERC) and the South Florida Water Management District (SFWMD) to initiate a cooperative research program at the Buck Island Ranch in Highlands County, said Thomas Bancroft, MAERC director and coordinator of on-site research at the ranch. In 1996, the Florida Cattlemen's Association and U.S. Natural Resources Conservation Service joined the effort.

A team of more than 30 researchers, policy-makers and ranchers are working together to develop strategies for enhancing Florida's sensitive natural resources while maintaining economically viable and compatible agricultural industries in the state. With an integrated team approach, the research program at Buck Island Ranch provides UF/IFAS' scientists with a unique opportunity to study Florida's environmental and agricul-

tural issues and to develop databases needed for management and regulatory decisions, Bancroft said.

The ranch is home to 12 ongoing projects in sustainable agriculture, wildlife, system-wide conservation and educational outreach. UF/IFAS faculty lend a wide range of project expertise in wildlife and range sciences, soil and water science, agricultural and biological engineering, animal science, and entomology and nematology, Tanner said.

Within these efforts, faculty in the agricultural and biological engineering department are designing water monitoring stations and equipment, soil and water scientists are studying the chemistry of water from pastures, and wildlife faculty are looking at the vegetation, species composition, quality and quantity of forages, and wildlife populations on the ranch, Tanner said. The Department of Entomology and Nematology is studying grasshoppers, spiders and the nematode complex in citrus and pastures, and UF/IFAS' Department of Statistics is organizing data collection procedures to ensure their statistical validity.

Getting the results of the studies to agricultural producers, natural resource managers, regulatory agencies and the general public is an important part of the effort. Faculty from UF/IFAS' Cooperative Extension Service distribute the information through in-service training workshops, demonstration areas and educational events.

"Extension professionals use our findings on how cattle operations affect resident wildlife to recommend management options that can protect natural resources and benefit wildlife on ranches," Tanner said. "Through their efforts, the public can learn to appreciate the value cattle ranches have in maintaining various species of wildlife.



Above, a threatened species, the crested caracara is an endearing example of how cattle ranches provide habitat for native species. Photo by Joan Morrison



UF/IFAS has established a long-term, interdisciplinary research program at Buck Island Ranch to study the complex issues of natural resources management in agricultural environments. The ranch is located near Lake Placid in Highlands County. Photo by Milt Putnam

One of the great values of Florida's ranches is that they have the lands and the ability to provide excellent wildlife habitat."

Faculty of UF/IFAS' agricultural and biological engineering department have also created a homepage for the research center's documents. The homepage (<http://arc.imok.ufl.edu/buck/index.html>) is maintained at UF/IFAS' Southwest Florida Research and Education Center in Immokalee, providing updates on ranch research

programs and study results. It allows research data, documents, maps, schedules and other information to be shared by cooperating researchers.

The 10,300-acre Buck Island Ranch was leased from the John D. and Catherine T. MacArthur Foundation by UF/IFAS and Archbold Biological Station, which established the MAERC for long-term research on the relationships between cattle ranching, citrus production and native ecological systems of Central Florida. Gene Lollis,

a 1993 UF graduate in animal science, manages the ranch's 3,000 head of cattle and 160 acres of citrus at full production for research studies, allowing UF/IFAS and MAERC scientists an opportunity to evaluate alternative agricultural practices in real-world conditions.

This fall, Lollis will use different cattle stocking rates on experimental summer and winter pastures for research on the influence that cattle numbers have on water quality, plants



and wildlife habitat. This information will help ranchers find an effective blend between the optimal number of cows for an area and the protection of its ecology.

"Agriculture doesn't have the negative impact on the environment like people tend to think," Lollis said. "Ranchers need the hard data to show people we're not the bad guys."

UF/IFAS researchers in the departments of soil and water science and agricultural and biological engineering are studying the landscape, land use practices and water quality on the ranch, scientifically measuring both rainfall and the chemical makeup of water runoff that eventually reaches Lake Okeechobee and South Florida. The program will help ranchers and officials alike develop a better understanding of the factors in beef cattle operations that affect surface water quality in the Lake Okeechobee Watershed.

MAERC research associate Lisa Collins, a 1994 UF master's graduate in agricultural engineering, takes water samples and data from automatic water systems on the ranch and sends them to

UF/IFAS Professors Donald Graetz and Kenneth Campbell for analysis. The results show the nutrient loading in an area, reflecting the effectiveness of alternative management practices in lowering levels of nitrates and phosphates in water runoff.

A recent state mandate for lower phosphate levels and cleaner water running into the Lake Okeechobee Watershed will affect Central Florida ranchers, Collins said, and it's better to develop more effective management practices now than to receive additional regulations later.

"We need basic, long-term information on ranch management practices that influence nutrient loading in an area, which is important for learning what they do to surface water quality," Collins said. "As a large-scale, working cattle ranch, Buck Island is a prime starting place for studying the effects of real management practices in Central Florida. Here we can get more realistic results and examine the variables of alternative ways of managing the land."

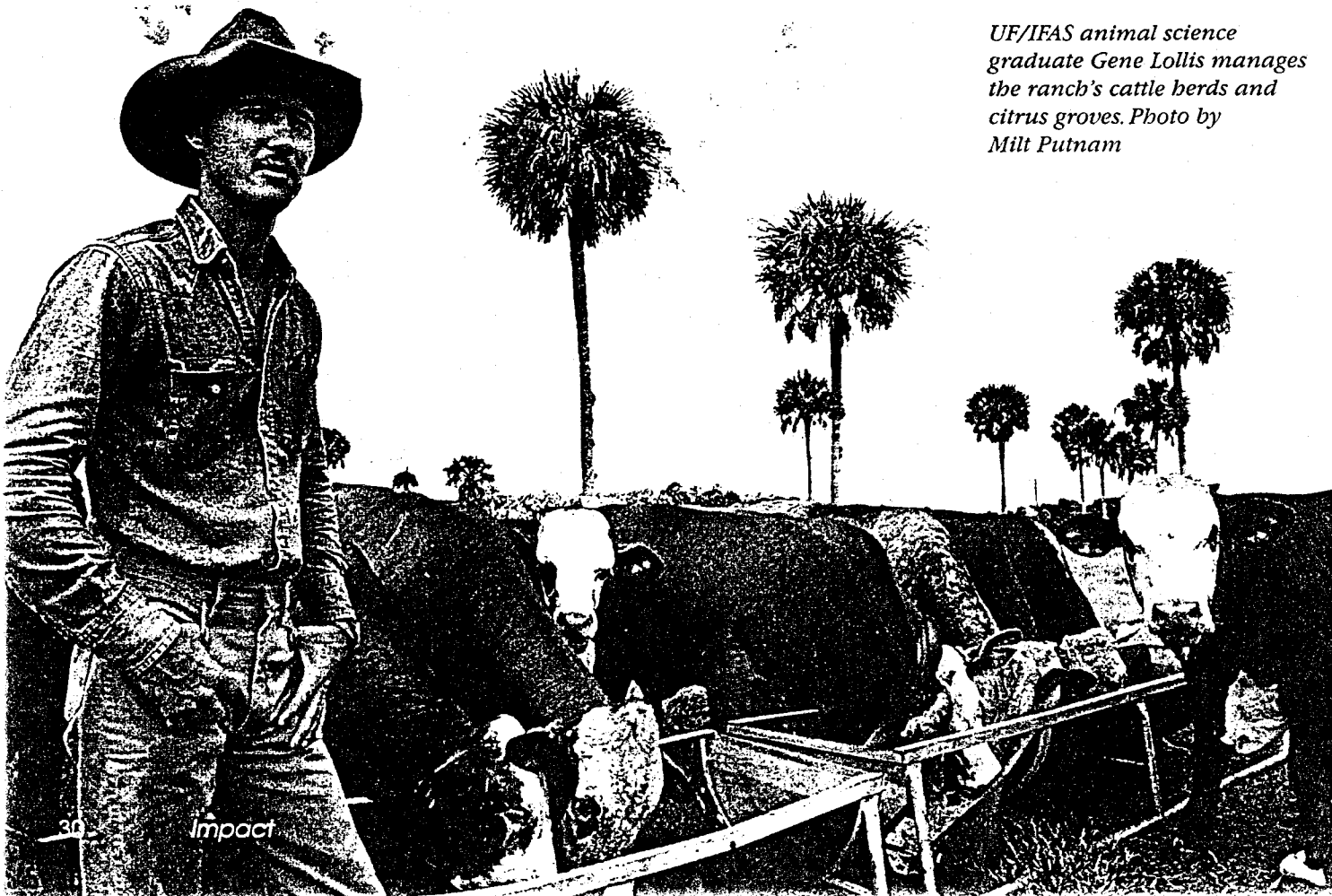
Finding economically sustainable management practices that reduce

nutrients in surface water and protect the natural biodiversity found on Florida's cattle ranches is one conservation goal. Florida's semi-native cattle ranches also support a diverse community of wildlife and plants, and a ranch's mixture of habitats supports such distinctive species as sandhill crane, burrowing owl and crested caracara, as well as white-tailed deer and wild turkey, Tanner said.

"Maintaining Florida's ranches is vital for the protection of Florida's unique biodiversity, and wildlife is an important and valuable component of Central Florida's cattle ranches," Tanner said. "UF/IFAS researchers have developed a list of species on Buck Island Ranch, and learning about their ecology will help promote the ecological value of these ranches and help develop management practices for preserving species while keeping cattle ranches viable."

A threatened species, the crested caracara is found in Florida almost exclusively on cattle ranches, which contain much of the remaining native and semi-natural grassland habitats. Joan Morrison, a UF/IFAS doctoral

UF/IFAS animal science graduate Gene Lollis manages the ranch's cattle herds and citrus groves. Photo by Milt Putnam





Left, Joan Morrison, a UF/IFAS doctoral student in wildlife ecology and conservation, is studying the crested caracara, a threatened species found in Florida almost exclusively on cattle ranches. Photo by Milt Putnam

Below, Lisa Collins, a UF/IFAS graduate in agricultural and biological engineering, records data from automatic water sampling sites on Buck Island Ranch and sends the information to UF researchers in various departments on campus. Photo by Milt Putnam



student in wildlife ecology and conservation, is conducting a three-year study of the caracara's habitat use and population biology. She has been following the reproductive success of caracaras on over 40 ranches in six Central Florida counties, including seven nests on Buck Island Ranch.

Many local ranchers are supporting the research by allowing access to their lands, and Morrison's studies have shown caracaras are doing particularly well on Florida's ranches, providing just one example of how humans, agriculture and native wildlife can co-exist in harmony.

"These data couldn't have been collected without the help of local ranchers, so these efforts have already helped relations between conservation and agriculture," Morrison said. "We are learning how ranch practices help these birds, which benefits Florida's agricultural community by letting ranchers learn management activities that are good for wildlife. We can also teach the public that ranchers aren't the bad guy, and that cattle ranching is a good activity in Florida."

The research can help ranchers and policy-makers develop management guidelines to monitor the caracara's population and long-term survival. Morrison said one major accomplishment of the project has been increased attention on the importance of cattle ranches for native wildlife and on the need for habitat conservation plans that include private landowners.

Kim Babbitt, a recent UF/IFAS doctoral graduate, agrees that agricultural interests and wildlife are not mutually exclusive. For three years, Babbitt has studied frog populations on Buck Island Ranch, and recently finished her dissertation research for UF/IFAS on the interactions between wetland type and the ecology of fishes, frogs and invertebrates. Isolated wetlands are an important wildlife habitat on Florida's cattle ranches, and understanding the factors affecting the distribution and abundance of frogs, fishes and insects in wetlands is important to understanding how ranch ecosystems function and how different management practices may affect species.

"South Florida's cattle ranches can play an important role in conservation efforts for many frog and toad species," Babbitt said. "This role will become increasingly more valuable in the future since current land-use practices on cattle ranches are compatible with the conservation of many species. With the concern over worldwide declines in amphibian populations, as well as

the important role frogs have as a food resource for so many species, cattle ranches provide a good example of how conservation and agriculture can be compatible."

Babbitt and Tanner have created an extension fact sheet for teaching ranchers the habitat requirements of frogs and toads and how they can provide them with suitable conditions. The information will also help educate the public about the positive role that cattle ranches play in amphibian conservation.

In the end, UF's cooperative research efforts on Buck Island Ranch will help ranchers and others make the right decisions for meeting ecology conservation and economic sustainability goals of Florida's cattle ranches. Babbitt added: "What we have on Buck Island Ranch is a marriage where conservationists can work with agricultural interests to help ranchers maintain their livelihood and still provide property with a higher wildlife value. The ultimate objective is for conservationists to work hand-in-hand with ranchers." ☐

Jessie A. Micales

Land Uses, Habitat Protection and Native Wildlife

Joan Morrison, University of Florida

One of conservation biology's major challenges is to determine how natural habitats and biodiversity can best be protected given complicated and sometimes conflicting land-use issues. In rapidly developing states such as Florida, a growing interest in ecosystem management is fostering increased cooperation between scientists, land managers, regulatory agencies, and private landowners. These efforts demand new, creative approaches to protecting natural areas. Understanding the needs of species that inhabit these areas is of prime importance.

Because of their role as top predators, birds of prey are indicators of ecosystem health and an important component of biodiversity. We are studying the Crested Caracara, a unique bird of prey that inhabits open prairies and grasslands in south-central Florida. This population is listed as "threatened" because it is isolated from all other caracara populations. Also, much of its native grassland habitat has been lost or fragmented due to widespread urban and agricultural development. Today, much of the remaining natural habitat in this region occurs on large, privately owned cattle ranches, where most of the remaining caracaras are found.

Our research focuses on understanding the caracara's population biology and use of the complex matrix of habitats in this region. During the nesting season, we locate nests and monitor them regularly. Data such as fecundity, number of nesting efforts per year, and individual survival are being used to develop a demographic model for this population. We are also comparing the timing of nest initiation, nest success, and productivity among caracaras nesting on the highly managed cattle ranches and on less intensively managed, more natural grassland habitats. Adult and young caracaras are captured and banded with uniquely colored aluminum leg bands which permit identification of individuals. Selected birds are fitted with radiotransmitters which allow long-term monitoring. To keep track of these individuals, we survey our entire study area weekly from a Cessna single-engine airplane.

Because most nests are on private land, studying the caracaras requires cooperation with the land owners. Many local ranchers are supporting our research by permitting access to their lands, and our results suggest that caracaras are doing particularly well on the ranches. Routine land management activities that occur there, such as grassland burning, seem to keep the habitat in a condition preferred by caracaras. Thus, a major accomplishment of our research has been to focus attention on the importance of cattle ranches to native

Research

In

Progress

Focus on:

Wildlife

Below: Researchers Morrison and
McGehee (left) and Morrison



wildlife using the caracara as an example of how humans, agriculture, and native wildlife can coexist.

Other important findings include the previously unknown fact that caracaras feed regularly in wetlands. Although this raptor will eat carrion, during the nesting season it feeds its young live prey including fish, snakes, rodents, amphibians, reptiles, and insects. Through radiotelemetry, we have also learned that caracaras are quite social. Family groups remain together for several months. After the young leave their home territory, they form aggregations, sort of like teenage "gangs." These young birds are nomadic, wandering long distances throughout south-central Florida, but occasionally returning to the familiar area near their home territory.

Future research plans include long-term monitoring of known nests to continue data collection on population biology and continued tracking of radio-tagged juvenile caracaras to assess their long-term survival. Development of management guidelines for this population is also planned. These guidelines will assist private landowners and public land management agencies alike in future land-use planning so that known caracara nest sites and important feeding areas can be protected.

Joan Morrison received her B.S. in Biology from the College of Wooster in Ohio (1975) and a M.S. in Resource Ecology and Managment from the University of Michigan (1979). After working for several years for the U.S. Forest Service and U.S. Fish and Wildlife Service, she returned to the University of Florida, where she will soon complete a Ph.D. in Wildlife Ecology.

Crossroads for the Caracara

An exquisite raptor struggles for survival in the U.S.

BY JEFF RIPPLE

Two caracaras rose from a carcass to perch on nearby fence posts. The sun's low angle bathed the birds in a warm wash of light that glowed golden through their spread wings as they landed on the narrow posts. I slowed my truck, turned it around, and rolled to a stop about 200 feet away so I could take a longer look. The birds fidgeted nervously and then flew from the posts, landing about halfway across a large pasture. I was without binoculars, so the birds remained small silhouettes standing in the short grass. They would not return to their meal until I left. Disappointed and mentally kicking myself for leaving my binoculars at home, I continued on my way, reflecting on my fleeting encounter with these remarkable members of the falcon family.



Steve Benisen

The Crested Caracara is found in only three areas of the United States: south-central Florida, southeastern Texas, and southwestern Arizona. The entire range of the Crested Caracara encompasses the Americas, stretching from the southern United States into Mexico and Baja California, through Central America, and into South America, where they are reported to be common. Crested Caracaras are also found in Cuba, where they are locally common.

An adult Crested Caracara is about twenty-three inches long, slightly larger than what field guides describe as

The large, eagle-like bill and flat top give the Crested Caracara (above) a distinctive appearance.

crow-sized. The head is large, flattened on top, with an orange, bare-skinned face and a black crown sporting a bushy crest that is erected only when the bird is agitated or threatened. The beak is formidable, shaped much like an eagle's. A distinctive white throat and neck provide a striking contrast to the blackish-brown body. The breast and upper back are lightly barred, as is the tail. The caracara's long, sturdy yellow legs and conspicuous white wing

patches, visible near the wing tips when the bird is in flight, make it unmistakable, even when viewed from a distance. Caracaras seldom soar, and when seen in flight, they usually flap with steady, shallow wingbeats with their heads pointing down. Young caracaras are similar to adults, but are a duller brown overall, with streaked throats and white tips on the shoulder feathers. Caracaras are known for their distinctive, harsh, rattling cry, thought by some to be the origin of their name. When producing the call, the bird's head is thrown so far backwards that it touches the upper back.

In Florida, where I live, the Crested Caracara is listed as a threatened species by state and federal agencies, meaning that it is in danger of serious decline. As with many other listed species,

the principle threat to the caracara is loss of habitat. Crested Caracaras keep year-round territories and do not migrate. The traditional habitat of Crested Caracaras in Florida is native dry prairie—open grasslands with scattered palms and oak hammocks. Today, much of the native prairie is gone, replaced by cattle ranches, which, fortunately for the caracaras, are dominated by open grassy pasture with scattered trees. Cattle keep the grass cropped short, a modification to the caracara's native habitat that the birds don't seem to mind because they can walk around easily, searching for food

in the short grass. Caracaras nest almost exclusively in cabbage palms. Ranchers generally do not remove these trees because they provide shade for cattle.

The problem for the caracaras, however, is that the open pastures of cattle ranches, like the native dry prairies they replaced, are disappearing all too quickly. Ranch land is being converted to citrus groves or is being paved over to make way for trailer parks, shopping centers, and other urban development. Unless measures are taken to curtail this trend, there is little hope the birds can sustain their numbers over time.

Joan Morrison, a biologist with the Department of Wildlife Ecology and Conservation at the University of Florida, should know. Morrison and her team have been in the field almost continuously over the last two years studying these threatened birds. The purpose of her work has been to study the ecology of Crested Caracaras, evaluate the status of the Florida population, and provide data that can be used to develop management plans for helping the birds survive. To do this, the team has been capturing adults and fledglings and fitting them with radio transmitters. Once fitted, the caracaras are released, and Morrison follows their movements over several months by tracking signals from the transmitters by plane. Data gathered from the movements of adult caracaras are used to estimate the size of territories, which include areas used for feeding and nesting. Data obtained by following the movements of immature caracaras may provide important information regarding their use of habitat, ability to survive their nomadic first few years, and a better understanding of dispersal patterns as they establish territories.

The Crested Caracara's white wing patches are clearly evident when in flight (above). Another characteristic feature of the caracara is its harsh, cackling call, which is given while throwing the head backward in dramatic fashion (right).



Brian K. Wheeler



Steve Bentsen

Morrison's findings, although preliminary and focused on Florida's population of Crested Caracaras, offer considerable insight into little known

aspects of the ecology of the species in general. According to Morrison, Crested Caracaras are very social and form strong pair-bonds. They set up

permanent territories that frequently overlap those of neighboring pairs, at least in feeding areas. Caracaras may range as far as two miles from their nests to find food, yet the nests may be surprisingly

close together—as near as a half-mile on some large ranches with lots of good habitat. Furthermore, Crested Caracaras spend more time foraging on wetlands than people realize. “We are finding a lot of wetland-dependent creatures in the food they are bringing in, particularly around nesting time,” says Morrison. “These animals include cotton rats, marsh rabbits, fish, amphibians, and snakes.” Information such as this is crucial not only because it indicates the importance of wetlands to caracaras, but it underlines the continued need to preserve wetland areas, particularly around ranches.

Morrison's observations also add more weight to the growing body of evidence that the Crested Caracara is less of a scavenger than an opportunistic generalist, willing and able to eat almost anything it can find. Live prey, such as invertebrates, fish, amphibians, turtles, birds, and small mammals, as well as carrion, find their way down the nondiscriminating gullets of caracaras. The ability to take advantage of a diverse array of food is a useful trait that may help the birds survive vagaries in prey populations or environmental conditions.

Caracaras in Florida breed between September and June with the peak period being January through early February. The nest is a loosely constructed mass of vines and small twigs placed high in a cabbage palm. Two to three eggs are laid, although incidents in which parents actually raise three chicks are infrequent (about 15 percent). The survival rate of chicks in the nest is generally very good, and any loss to predators typically occurs during the first week after hatching. If chicks survive their first week, they usually make it through the entire nesting period. One problem, however, is that chicks occasionally fall out of trees. Because caracara nests are not particularly well made and they sometimes lean, the eggs or chicks roll out and fall to the ground. Sometimes the chicks survive the fall and the adults feed them on the

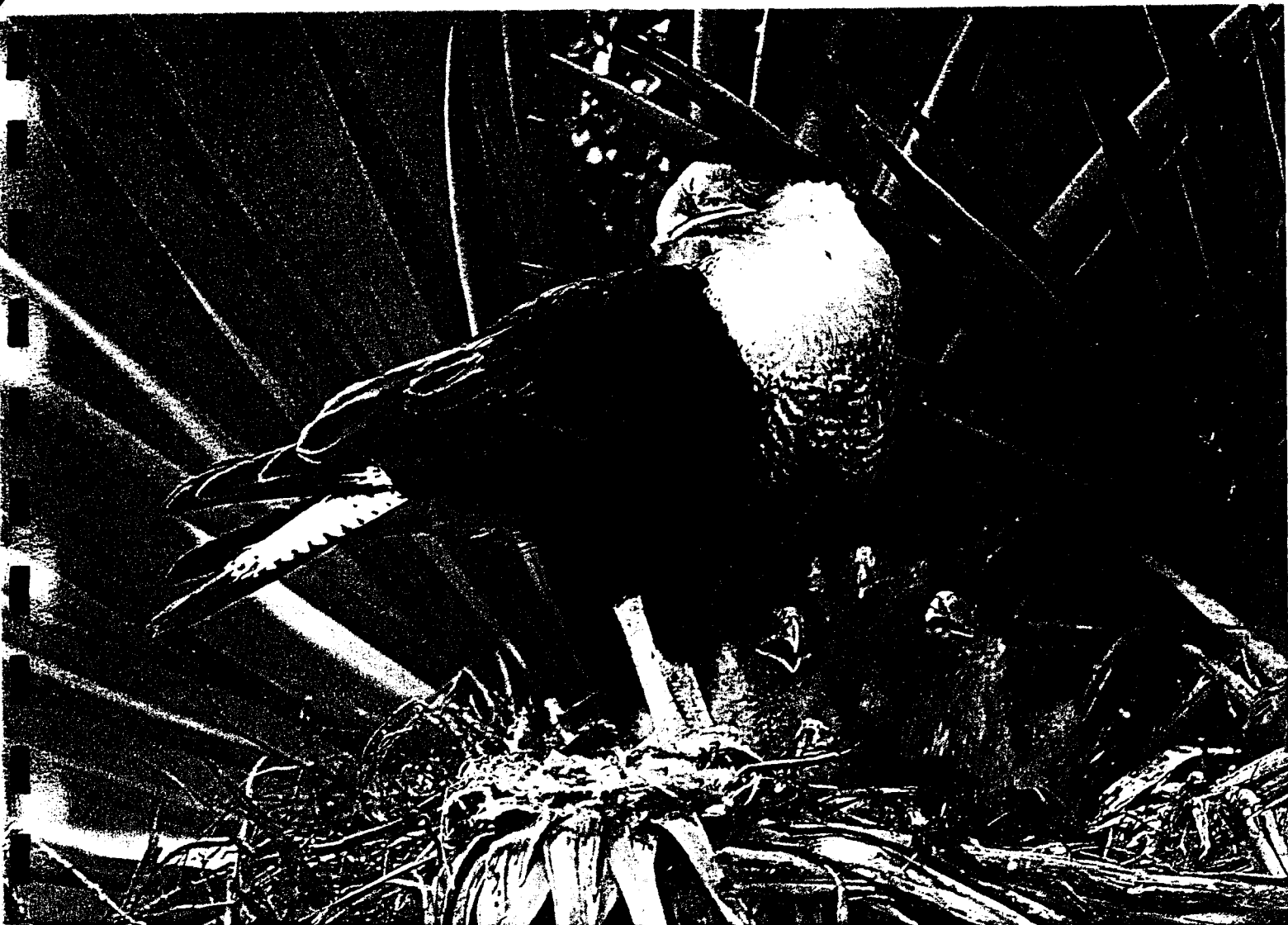


John Canalsosi

Crested Caracaras are not fussy about what they eat or how they obtain it. A caracara (left) walks along the edge of a grass fire in search of fleeing insects and rodents. A carcass produces a feeding frenzy of opportunistic caracaras (below).



Kevin Karlson



Anthony Mercieca

A Crested Caracara (above) feeds its young at the nest, a loose assemblage of twigs and vines high in a palm tree. The young fledged in about seven weeks.

ground. Other chicks are not so fortunate and die on impact.

The nestling period of the Crested Caracara is about seven weeks. Fledgling caracaras are highly dependent on their parents for at least two months after leaving the nest and may stay in the home territory for six to nine months. Often, the chicks do not leave the home territory to explore on their own until the parents' next breeding season. After that time, they may wander as far as thirty to forty miles from their nest site during their search for their own territory. The young birds sometimes join groups of other caracaras that travel the landscape looking for food and potential mates,

but no one knows how long these groups stay together. To date, Morrison's research has not yielded any conclusive evidence regarding the age Crested Caracaras first breed or what their life span is in the wild. Because individuals have survived up to twenty-five years in captivity, they are probably long-lived.

Crested Caracaras have few, if any, predators once they fledge and become adults. Accidents attributed to human activities are their primary concern. Caracaras are sometimes shot, they may fly into barbed wire fences, or they are hit by cars when feeding on carrion. Car collisions are the most significant cause of mortality. In Morrison's study, 60 percent of all known mortality was due to collisions with vehicles. Most of the fatalities involve young birds that haven't quite mastered the art of dodging traffic. "If

it wasn't for cars, the survival rate of immature caracaras would be excellent," says Morrison. "There isn't much else that gets them."

In spite of the tenuous situation of the Crested Caracara populations in North America, very little research has been conducted on their behalf. No one is sure how many caracaras are left in the wild. Morrison's research in Florida suggests that mosaics of open, grassy prairies, wetlands, and hammocks must be preserved in order for the birds to survive. But how much habitat do they need? How do young birds find new territories? How old must caracaras be before they can breed? How long do they live? Until we devote the time and resources to answer these questions and many more that have yet to be asked, the future of these exquisite raptors in the U.S. is uncertain. 🦅

sted Caracara

Jim Sanderson, Ph.D.

One of Florida's most striking birds is the Crested Caracara (*Caracara plan-cius*). Known also as Audubon's Caracara (for its discoverer), Mexican Buzzard, and Mexican Eagle, this distinctive bird of prey can be easily recognized by its regal cap of black feathers, distinctive yellow-orange face and long legs, and bluish-white bill. While most of the body is black, the neck, breast, and upper back feathers are white, tipped with horizontal black bars. When the caracara is in flight, patches of white can be seen on the otherwise black wings and tail. Adult males and females do not differ in color or size, weigh about 2 pounds, and have a wingspan of about 4 feet.

While the Crested Caracara is one of Florida's specialties, it is also the national bird of Mexico and is displayed on the Mexican flag. Its name may be derived from one of its unique vocalizations. Often when agitated or excited, the Crested Caracara throws its head backward until the top almost touches its back and utters a loud unforgettable rattle that sounds somewhat like its name, "caracara."

Native to Florida, the Crested Caracara has been here since the last ice age. During this time, its range was probably more extensive in North America, as revealed by fossils found as far north as Nebraska. Today, Florida's population of Crested Caracaras is found only in the south-central region, with strongholds in Highlands, Glades, Okeechobee, DeSoto, and Hendry counties. The nearest neighboring populations are found on the island of Cuba and in south-central Texas, although it is believed that no mixing between these populations occurs and that Florida's caracaras are isolated. South of the border, the range of the species extends throughout Mexico and open habitats in Central and South America to Tierra del Fuego. Three subspecies are recognized and the bird is only locally common throughout its range, persisting in areas of suitable habitat.

Although the Crested Caracara is often seen scavenging road-killed animals, it is not a vulture, but is more closely related to falcons. The caracara is a generalist and also takes live prey, including snakes, rodents, fish, amphibians, reptiles, and insects. Unlike most other raptors, caracaras generally do not swoop down upon their prey from above. Instead, being well-adapted to a terrestrial life, they usually land on the ground nearby and walk toward their prey. Also unlike other

PHOTO: Jean Morrison

Continued on Page 18

raptors, caracaras carry food items in the beak rather than in the talons. They are quite opportunistic. In the company of black and turkey vultures at feeding sites, adult caracaras can hold their own, often working as a team to steal food from the competition. They also have been observed capturing Cattle Egrets by reaching out with powerful claws and seizing the neck of the unwary prey.

Currently, the Crested Caracara is listed as threatened in Florida by the U.S. Fish and Wildlife Service and by the Florida Game and Fresh Water Fish Commission, and there is some concern that the population is declining. One estimate suggests that only 150 breeding pairs remain. Since 1992, University of Florida researcher Joan Morrison has been studying Florida's Crested Caracaras. Supported by grants from the Avon Park Air Force Range and the Non-Game Research Program of the Florida Game and Fresh Water Fish Commission, and the South Florida Water Management District, her research focuses on gaining a better understanding of the caracara's breeding biology and habitat use and of the population's status.

Caracaras favor open habitats such as prairies and cattle pastures that have adequate nesting trees and wetlands where they can find food. They seem to be doing particularly well on the cattle ranches, which often contain a mixture of grassland, woodland, and wetland habitats that support a variety of wildlife. Many local ranchers are supporting Morrison's research by permitting access to their lands to monitor the caracaras. "Without their help this project would not be nearly as successful, and we believe that our results lend support to many of Florida's ranches as stewards of native habitats and wildlife," says Morrison. "The caracara represents an excellent example of how humans, agriculture, and native Florida wildlife can coexist."

Caracaras are monogamous and both members of a pair together defend a territory. With the onset of the breeding season in November, nestbuilding takes place, generally in a palm tree. One to three eggs are laid in the large, somewhat unkempt nest that is generally constructed of thin twigs and vines. Caracaras are quite selective about their nest site. The nest is almost always located on the south side of the tree, facing toward the warm morning sun and away from the cold northwesterly winter winds. Both adults share nestbuilding, incubation, and raising of the young. Incubation takes about 30 days and the chicks fledge after 7 to 8 weeks in the nest. Juvenile caracaras are patterned as the adults, but are overall brown in color, with buffy neck and breast, vertical brown streaks instead of horizontal bars on the breast feathers, and pale pinkish-gray face and legs. After their

first flight, the young remain close to the nest. Although they are constantly testing their wings, they spend much of their time running about on the ground, learning to find food. During the first 2-3 months, the parents continue to feed the young caracaras and defend the territory. A family of caracaras can often be seen roosting together on a tall tree as the sun sets.



The wingspan of the Crested Caracara is approximately four feet.

Caracaras are wary and opportunities to capture them are limited outside the breeding season. Hence, December through April are busy months for the research team. Veteran research assistant Steve McGehee has become an expert at finding nests. After locating areas where birds have been reported by birdwatchers and interested ranchers, Steve begins his stakeout before sunrise. With binoculars in hand he watches for evidence of nest building by the adult caracaras. Usually he can identify the nest tree within a few hours. Sometimes the birds construct a nest and then abandon it, only to build another nest in a different tree. Once a nest is verified and incubation of the eggs has begun, the researchers begin regular monitoring to determine nest success.

To keep track of her study of caracaras, Morrison uses a variety of methods. All captured individuals are banded with colored leg bands, and to learn about survival and dispersal, some adults and young are fitted with radio-transmitters. Because the birds range throughout such a large area, the researchers relocate them by flying weekly surveys in a fixed-wing aircraft. During these flights, individual caracaras are found by tracking the signal of their transmitter. After four years of fieldwork Morrison stands at the threshold of many new discoveries about this interesting raptor, piecing together mysteries and, as is always the case with scientific research, raising many more questions.

So far the research team has banded 160 caracaras and attached radio transmitters to over 75. One important objective of the study is to learn more about the dispersal of young caracaras after they leave their natal territory. After collecting two years of data from radiotagged young caracaras, the story of their movement patterns and habitat selection is beginning to unfold. Although they frequently wander long distances throughout south central Florida, young caracaras periodically

return to spend time in the general area of their natal territory. These roaming juveniles also seem to favor large areas of open habitat, particularly cattle ranches.

Another interesting finding has been that some caracara pairs are highly productive. Normally, a pair lays from one to three eggs and fledges an average of two young each year. However, some pairs are able to raise a second brood in the same year. This raises many questions involving the age of the individuals that reproduce twice and differences in habitat quality among territories. Such questions can be answered only by continued long-term study of these unique birds.

So if Florida's caracaras seem to be reproducing well and many young survive their first year why are they in trouble? It is probably because these birds suffer the fate of much of Florida's native wildlife - habitat loss. Rapid habitat conversion, particularly to agricultural and urban development is reducing the amount of land available for nesting. The number of breeding pairs is directly related to the number of possible territories. Rarely is a suitable habitat unoccupied. Also of concern are vehicle collisions, which account for over 50% of the mortality of young caracaras. Inexperienced juveniles are often killed while feeding on other traffic victims. They simply do not recognize a vehicle as a threat until it is too late. In a few instances caracaras with radio-transmitters have been deliberately shot. Since the radio continues to function these victims are easily located. One transmitter was found in a culvert beneath the roadbed. The transmitter's harness had been cleanly cut and the transmitter tossed underwater. Another transmitter was tracked to the refrigerator in the kitchen of a private home! Why would someone shoot such a magnificent bird? According to Morrison, some people carry the mistaken belief that caracaras kill livestock, but due to their size and stature, that would be an impossible feat.

As with many of Florida's plants and animals, the story of conservation of the Crested Caracara is a complex one, involving people and land use issues. But as with many conservation issues, education is of prime importance. Also, there are some things each of us can do to help the caracara's chances. It seems generally tolerant of humans - with some careful land use planning and cooperation there is little reason why the caracara cannot continue to exist. Indeed, the caracaras seem to do well on ranchlands so their future there seems secure at least for a while. Most Floridians are proud that the Crested Caracara finds a home in their state. We are all responsible, from our driving behavior to the food we eat, for its continued existence.



Jim Sanderson, Ph.D., Department of Wildlife Ecology and Conservation, University of Florida

Caracara

Lake Placid Journal
Feb. 15, 1996

UF/IFAS Researchers Work With Ranches To Save Majestic Birds

The adult caracara circles above, keeping an eye on the clump of palm trees standing alone, far into the cow pasture in southern Highlands County.

A yellow pole nudges an upper branch. A human voice cries out. University of Florida researcher Joan Morrison, one of several scientists ringing the thicket, snatches up an aluminum net and bolts into the dark island of shade. A few moments of ruckus in the underbrush and Morrison emerges with a brown-and-white fledgling caracara who's obviously having a bad day.

"Where were you going, huh?" Morrison affectionately chides the baby raptor, its beak open, head leaning to one side and most probably a wee bit confused.

Wings flap briefly as the infant, a little more than a foot tall, shifts its weight on its perch. Morrison's straightened arm. "No, no, no," Morrison tells her seven-week-old bird as she gives a bit of order to some willful feathers.

Over the next several hours, Morrison and her team will catch his young caracara's sibling and band, draw blood, measure and fit them with radio transmitters—while the pair's parents circle above or perch on a nearby tree. The radio transmitter helps Morrison track the birds as they grow up.

The caracara is also known as the Mexican eagle, but it is native to

Florida, presently concentrated in south central Florida. It is recognized by a crown of black feathers, yellow-orange face, long legs and a bluish-white bill. Unfortunately, this beautiful bird is also threatened as its habitat falls victim to Florida's rapid development of wild areas and farm land.

The "threatened" label applied to the caracara is midway between the "special concern" and "endangered" categories used to classify species at risk. The worst label, before extinction, is "endangered."

Hoping to save the bird, Morrison runs the Caracara Project for UF's Department of Wildlife Ecology and Conservation and the Institute of Food and Agricultural Sciences. The effort is based out of the MacArthur Agro-Ecology Research Center at the Buck Island Ranch south of Lake Placid.

The recent trip to briefly capture the fledgling caracaras couldn't have been timed any better.

"Another day and it probably would have been too late," Morrison said as she softly felt the bird's chest area. The young birds were hardly enough to handle Morrison's exam, but not quite strong enough to fly. Just a day or so more, Morrison said, and the birds would have built up their pectoral muscles to fly away from the researchers.

The Caracara Project is funded

through the Avon Park U.S. Air Force Range, the Florida Game and Fresh Water Fish Commission and the South Florida Water Management District. Morrison's work, however, is also succeeding in no small part due to the cooperation of ranchers and landowners.

In an era when landowners and environmentalists are portrayed as frequently at odds with each other, Morrison and the ranchers have formed a unique bond of trust. At last count, almost 40 local ranchers were assisting the caracara project. Many of these long-time Floridians have given Morrison free range of their land, even giving her keys to their gates to allow her to come and go at will.

Jim Fowler ranches 175 acres northwest of Okeechobee. Standing amid two dozen cows, Fowler sees his partnership with Morrison as natural. "Like everybody else, we farmers are concerned about nature and the environment," Fowler said. "We're the good guys. We care about the environment."

"Farmers are willing to do whatever it takes. If it's true and honest science, we want to be a part of that. I'm getting a better understanding of endangered species, and I'm learning that everybody who works with wildlife is not a radical environmentalist."

Adds Morrison, "It's a very good, cooperative relationship."



University of Florida researcher Joan Morrison examines a caracara on Buck Island Ranch near Lake Placid. Morrison has forged a unique partnership with more than three dozen ranchers and other landowners who allow her access to their land to study the birds.