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SEMI-ANNUAL PROGRESS REPORT: 1990

CA: Cooperative Agreement No. CA-5000-8007,
Subagreement No. 3

TITLE: Population Dynamics of White-tailed Deer
in the Big Cypress National Preserve

PERIOD: 1 January-30 June 1990

SPONSOR: USDI--National Park Service (Southeast
Region), Big Cypress National Preserve

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EXECUTIVE SUMMARY

A large-scale, 3-year research investigation of white-tailed deer (*Odocoileus virginianus*) populations in the prairie/tree island habitat of the Big Cypress National Preserve (hunted site--Stairsteps) and the Everglades National Park (protected site--upper Shark River Slough) was initiated in March 1989 to elucidate the biological potential of the herds as (1) a food resource (prey base) for the endangered Florida panther (*Felis concolor coryi*), and (2) a recreational resource for sport hunting. As of 30 June 1990, 126 (84%) of 150 deer "pursued" were captured by helicopter netgunning; helicopter time per capture averaged 0.63 h. Collectively, as of 30 June 1990, 111 radio-instrumented deer had been entered into the sample herd,

including 54 adults (23 males, 31 females), 9 yearlings (4 males, 5 females), and 48 fawns (29 males, 19 females). These 111 radio-instrumented deer were subsequently radio-located, by fixed-wing aircraft, a total of 3,881 times from the time of capture through 30 June 1990; visual sightings of the radio-instrumented deer were recorded for 1,015 (26%) of the radio-locations. Sixty-three (57%) of the 111 radio instrumented deer were "alive and transmitting" as of 30 June 1990.

Survival rates, using Kaplan-Meier "staggered entry" procedures, were calculated by study site--hunted (BCNP) and nonhunted (ENP) and by age/sex cohort for the annual cycle, 01 April 1989-31 March 1990. Age and sex ignored, the annual survival rate of deer was higher in the hunted BCNP herd (0.6234, n=33) than in the nonhunted ENP herd (0.5236, n=35). Importantly, (1) the annual survival rate of fawns was substantively higher in the hunted BCNP herd than in the nonhunted ENP herd (0.2188, n=8 vs. 0.0695, n=8); (2) the annual survival rate of adult females was substantively higher in the hunted herd than in the nonhunted herd (0.8081, n=15 vs. 0.4533, n=14); and (3) the annual survival rate of adult males was substantively lower in the hunted herd than in the nonhunted herd (0.3334, n=6 vs. 0.7778, n=9). The annual survival rate of the two herds combined, age and sex ignored, was 0.5833.

Annual survival rates by age/sex cohort within the combined BCNP/ENP herd for the 12-months, 01 April 1989-31 March 1990, were: fawns (n=17), 0.1403; yearling females (n=4), 1.000; yearling males (n=4), 1.000; adult females (n=29), 0.6447; and adult males (n=16), 0.6188. Preliminarily, the low survival rates of fawns in the BCNP/ENP deer herd suggest that fawn mortality may be a depressant to recruitment.

Forty (36%) deaths occurred among the 111 radio-instrumented deer between 12 April 1989, the first date of radio-instrumented deer "at risk", and 30 June 1990. Of the 40 deaths, 16 (40%) were attributable to bobcat (*Felis rufus*) predation, 15 (38%) to undetermined causes, 4 (10%) to legal hunting (males only), 3 (8%) to illegal hunting, 1 (2%) to panther predation, and 1 (2%) to severe malnutrition. Of the 16 deer preyed upon by bobcats, 10 (63%) were male fawns, 4 (25%) were adult females, 1 (6%) was a yearling female, and 1 (6%) was an adult male. No female fawns have been preyed upon by bobcats to date. High bobcat density, low alternative prey availability, nutritional stress on deer, and coincident parturition cycles for both predator and prey are probable factors contributing to the high level of bobcat predation on deer in BCNP/ENP.

Six replicated aerial censuses, conducted on the BCNP and the ENP study sites in late June/early July 1990, yielded an observed density of 1.17 deer/km² and 0.83 deer/km² in the BCNP and ENP, respectively. However, when adjusted for visibility coefficients of 0.260 and 0.413 that were derived from concurrent locations of radio-instrumented deer in the BCNP and ENP, respectively, estimated deer densities were 4.50 deer/km² for the BCNP herd and 2.01 deer/km² for the ENP herd. The observed and estimated densities for the combined BCNP/ENP herd were 0.98 deer/km² and 3.12 deer/km², respectively. These census statistics, although obviously restrictive, suggest that the population density of deer is greater on the hunted BCNP site than on the nonhunted ENP site.

Preliminarily, productivity of the BCNP/ENP deer herd appears to be equivalent to that documented in other Florida herds. However, recruitment to the herd appeared to be depressed by the relatively low annual survival (0.1403) of fawns. The most significant finding to date has been the low annual survival (0.5833) of deer in the BCNP/ENP herd. And, notably, the annual survival of deer in the nonhunted ENP herd is substantively less (0.5236) than in the hunted BCNP herd (0.6234). In fact, the annual survival rate for the BCNP/ENP deer herd, and particularly for the ENP herd, is indicative of a population that is declining in abundance. Further, the high level of predation by bobcats on deer (40% of all recorded deaths), adults as well as fawns, suggests that the bobcat is the predator that plays a key role in the natural regulation of population abundance in the BCNP/ENP deer herd. Accordingly, it is recommended that a radio-telemetry study of bobcats be initiated, and conducted concurrently with the deer study, for the purpose of evaluating this critically important predator-prey relationship in the Everglades system.

RESEARCH GOALS

This research study is designed to elucidate selected population characteristics of white-tailed deer in the Big Cypress National Preserve (BCNP)/Everglades National Park (ENP) for the purpose of determining the biological potential of the herd as (1) a food resource (prey base) for the endangered Florida panther, and (2) a recreational resource for sport hunting.

THE STUDY AREA

BCNP consists of approximately 240,000 ha of primarily cypress (*Taxodium distichum*), pine (*Pinus elliotti* var. *densa*), and marsh communities in southwest Florida. The climate of the region is driven by both tropical and temperate influences. Mean annual temperature is 23 C (74 F); mean monthly temperatures range from 14 C (57 F) in January to 28 C (83 F) in August (Duever et al. 1986). Mean annual rainfall for the region is 1,360 mm (53.54 inches) (Duever et al. 1986). The region has a distinct dry winter season (Nov-Apr) and a wet summer season (May-Oct). Generally, precipitation that falls during the wet season is insufficient to compensate for the annual water loss; hence, mild to severe drought conditions are not uncommon in BCNP/ENP. In this respect, 1989 was characterized by a modest drought.

Topographically, the Big Cypress region is nearly flat, with a slight sloping (< 1 foot per mile [Duever et al. 1986]) toward the south and west. Within the 640,000-ha watershed of the Big Cypress Swamp, the sheet flow of water is southwest--toward the Ten Thousand Islands and Gulf of Mexico. In the wet season, the sheet flow inundates the low topographic plain; in the dry season, only sloughs are characterized by standing water.

The project study area is located within the contiguous wet prairie/mixed hardwood island habitat type (termed prairie/tree island in this report) that extends from Stairsteps Unit of BCNP southward into ENP. Encompassing about 200km², the area (excluding the "west Steps" site, which initially was included in the study site) is bounded on the north by Dr. Tiger Hammock, on the west by Lostmans Slough, on the east by the BCNP/ENP boundary, and on the south by Shark River Slough (Fig. 1).

The study area is comprised of 2 principal habitat types: wet prairie (prairie) and mixed hardwood islands (tree island). Duever et al. (1986) define wet prairie as that vegetation community characterized by 50-150 days of

water inundation per year. Common plants of the wet prairie include maidencane (*Panicum hemitomon*), sand cordgrass (*Spartina bakeri*), sawgrass (*Cladium jamaicense*), muhly grass (*Muhlenbergia* spp.), beak rush (*Rhynchospora* spp.), spike rush (*Eleocharis* spp.), white water-lily (*Nymphaea odorata*), flag (*Sagittaria lancifolia*), and pickerel weed (*Pontederia lanceolata*) (Loveless 1959, Duever et al. 1986). The mixed hardwood islands, found on slightly elevated bedrock sites in the wet prairie, are characterized by a usually elongated shape, northeast-southwest orientation (axis), variable size (0.01-100.0 ha), closed dome canopy (<20 m in height), and shallow and short-term inundation, if any, by water. These hardwood islands contain a mixture of tropical and temperate plants (Long 1974). Common tree species include wax myrtle (*Myrica cerifera*), dahoon holly (*Ilex cassine*), willow (*Salix caroliniana*), redbay (*Persea borbonia*), elderberry (*Sambucus simpsonii*), cabbage palm (*Sabal palmetto*), strangler fig (*Ficus aurea*), and coco plum (*Chrysobalanus icaco*)--the latter being very susceptible to foliar damage by freezing temperatures e.g., December 1989 (Loveless 1959, Duever et al. 1986). The ground cover in the hardwood islands often is dominated by royal fern (*Osmunda regalis*), but also includes swamp fern (*Blechnum serrulatum*), blood-berry (*Rivina humilis*), greenbriar (*Smilax* spp.), and aster (*Aster caroliniensis*) (Loveless 1959, Wade et al. 1980).

SPECIFIC OBJECTIVES

This research investigation is designed to elucidate survival rates of age/sex cohorts, productivity/recruitment, spatial distributions, and habitat availability/use of white-tailed deer herds in the contiguous prairie/tree island habitat of BCNP (hunted population) and ENP (nonhunted population) for 3 annual cycles: April 89-March 90; April 90-March 91; and April 91-March 92.

RESEARCH DESIGN

The study design for the conduct of research on the population ecology of the BCNP/ENP deer herd centered on the use of radio-telemetry procedures as the most feasible means for evaluating mortality, recruitment, spatial distribution, and habitat use. The study design was predicated on two basic assumptions: (1) deer could be captured in sufficient numbers; and (2) radio-instrumented animals could be monitored accurately from fixed-wing aircraft (the latter dictated by the lack or near lack of access to the study site for the conduct of ground monitoring). Both assumptions were validated in 1989. Accordingly, to meet

project objectives for 1990, the study plan was expanded to include the capture and radio-instrumentation of 30 fawns, and the maintenance of a radio-instrumented herd of approximately 50 adults, divided equally between sexes.

METHODS

Capture Procedures

White-tailed deer were captured exclusively by helicopter-netgunning (Barrett et al. 1982), a technique recently used successfully to capture deer in "open" habitats in south Florida (Smith et al. 1988, 1989; Land 1987, 1989; Labisky et al. 1990). The netgun (CODA Enterprises, Inc., Mesa, AZ), powered by a .308 caliber blank, deploys a 12 x 12-ft² mesh net from 4 barrels via 4 cylindrical stainless-steel cylinder projectiles; the net, prior to deployment, is contained within a canister that is cradled within the spread of the 4 projectile barrels. The net is fired (forward and down) from the helicopter on deer (running) under pursuit; the net is normally deployed from an above-ground height of 3-4 m. The helicopter pursuit of any individual deer was restricted to a maximum of 3 minutes; if the deer was not captured within 3 minutes, the pursuit was terminated. (Note: Most deer were captured within 2 minutes after the initiation of pursuit.)

All captured deer were immediately blindfolded, physically restrained in the net, and then immobilized by securing the front and hind legs together with cord. Biological data recorded from each deer included: sex; age (Severinghaus 1949); neck and chest circumference (cm); hind foot and total body length (cm); body weight (kg); antler measurements for males--points (right and left), beam circumferences (mm), inside antler spread (cm), and beam lengths (cm); pregnancy/lactation status for females; tail-fat condition index (Stockle et al. 1978); and ectoparasite index. Blood smears (thick and thin) were also collected from a sample of fawns for subsequent blood parasite analyses. Each deer was marked with numbered No. 49 monel eartags in both right and left ears, and a radio-transmitter/collar (150-152 MHz frequency range), equipped with motion-sensitive activity (2X signal pulse) and mortality (4X signal pulse) modes (Wildlife Materials, Inc., Carbondale, IL). Processing time averaged about 20 minutes per animal (for a 2-person team), after which time the deer was released at the capture site.

Radio-telemetry Monitoring

The relatively remote location of the study area (a portion being in the Everglades, where ground access by vehicle is prohibited), the seasonally fluctuating hydroperiod, and the areal expanse of the study area essentially limit the obtainment of radio-locations of instrumented deer to aerial telemetric monitoring (by fixed-wing aircraft), which, in turn, restricts the location-monitoring to daylight hours. Given these logistical restrictions, a biological-clock regime was designed to obtain unbiased daylight monitoring data. To this end, the daylight hours were subdivided into 4 distinct periods: sunrise to 2 hours post-sunrise; 2 hours post-sunrise to mid-day; mid-day to 2 hours pre-sunset; and 2 hour pre-sunset to sunset. Accordingly, each radio-instrumented deer is located once each 5-day period, which yields 72 radio-locations per surviving animal per year; all radio-locations for any given animal are equally divided among the 4 discrete daytime monitoring periods. Additionally, all radio-instrumented deer are monitored with respect to mortality on every radio-location flight, which equates to a minimum of 4 times every 5 days.

Each radio(deer)-location is sketched on a notepad, using topographic features, during the flight, and supplemented by the following information: date/time; habitat, including distance to, type and size of nearest hardwood island and sawgrass patch; behavioral activity; associations with other deer when applicable; and transmitter-signal characteristics (1X, 2X, or 4X pulse). Immediately after the completion of each flight, the sketched locations are verified by satellite photographs (scale = 1:26,000) of the study area, and then plotted on Universal Transverse Mercator (UTM) maps (scale = 1:24,000) to obtain empirical x and y coordinates. The coordinates for each radio-location are then both recorded on a data sheet and logged into a computer file.

(Note: Although most radio-instrumented deer occupied areal space within either the BCNP or ENP exclusively, some radio-instrumented deer, especially those that were captured near the boundary separating the 2 units, used space in both the BCNP and ENP. The latter deer were included in whichever unit $\geq 75\%$ of their radio-locations were obtained. Based on this criterion, all deer except 2--1 adult male (BC8927) and 1 fawn male (BC9075)--could be assigned to either the BCNP or ENP herds. The 2 "boundary" deer that could not be assigned to a specific herd were included in analyses in which location was not considered, but excluded from analyses in which location was considered.)

Mortality

Detection of death.--All radio-instrumented deer for which death was indicated by the emittance of the transmitter-mortality signal (4X pulse) were investigated upon occurrence (fixed-wing flight). This airborne investigation generally isolated one of 3 outcomes: (1) a false-mortality signal, which was usually detected by "buzzing" the site of radio-location, thereby disturbing the deer and reactivating the normal activity switch (1X pulse); (2) sighting the carcass of the dead radio-instrumented animal; or (3) failure to either sight the dead radio-instrumented animal or to verify a false-mortality signal. In the latter 2 instances, efforts were made to reach the site as soon as possible by helicopter (ENP) or by either helicopter, airboat, or 4-wheel ATVs (BCNP) to verify death, and if verified, to determine cause and time of death as well as to recover the carcass, pending the usefulness of its condition, for subsequent necropsy.

Survival analyses.--Annual survival rates of radio-instrumented deer were derived by the product-limit estimator procedure (Kaplan and Meier 1958), modified to allow for the staggered entry of new radio-instrumented animals that were added to the sample population as the study progressed in calendar time (Pollock et al. 1989). The biological year for deer in the BCNP/ENP was designated to begin 01 April, at which time the peak of fawning season has been reached; thus, annual survival rates represent the 12-month period, 01 April-31 March.

(Note: No radio-instrumented animal was added to the sample herd prior to 14 days post-capture, the interval during which death from capture myopathy (Chalmers and Barrett 1982) was most probable.)

Evaluating Causes of Death.--Field observations for each mortality were recorded on a mortality data sheet (Appendix A). Each carcass, as well as the area (habitat) surrounding the carcass, was photographed to establish a permanent photo file. Each carcass was examined for signs of predation (Wade and Bowns 1984), and evaluated with respect to condition parameters, disease, and ecto- and endoparasites (Stockle et al. 1978, Nettles 1981, Davidson and Nettles 1988). If available, the rumen contents, rumen, abomasum, heart, lungs, and trachea were collected and frozen for later analysis.

Predation was considered a possible cause of death when the carcass exhibited evidence of trauma. When evidence of trauma was present, the head, throat, and neck region of each dead deer was skinned and examined for puncture wounds

(in trachea, cranium, and hide), subcutaneous hemorrhaging, and tissue damage (Cook et al. 1971, Garner et al. 1976, Epstein et al. 1983). Hemorrhaging, based on the presence of blood in the mouth, nares, or trachea, or on the neck, and/or froth in the trachea, indicated that the deer was alive at time of attack and was not scavenged (Cook et al. 1971, Hawthorne 1980). The relative amount of consumption and decomposition of the carcass also was used to differentiate predation from scavenging (Bartush and Lewis 1981). Feeding pattern was also examined; feeding on the hindquarters with no marks on the rest of the carcass indicated probable scavenging, whereas feeding on the shoulders, neck, thoracic cavity, and hindquarters indicated possible predation.

The species responsible for predation was determined by sign on and surrounding the carcass. When tracks were present, the predatory species was identified by track size and shape (Wade and Bowns 1984); scat was collected also. Tracks and scat alone were not considered proof of predation, but were supporting evidence of other sign. Feline predators were considered if the carcass had been dragged, gutted, or covered (grass/leaves), or the hair plucked, and if sign such as mounds, scrapes, tracks, and scat were present (Hawthorne 1980; Robinette et al. 1959; Wade and Bowns 1984). Size, location, and distance between tooth marks, type of bone damage, and size of tracks and scrape were used to differentiate predation by bobcat and panther (Hawthorne 1980; Wade and Bowns 1984). A distance of 3.8-5.7 cm between upper canines and 2.8-4.7 cm between lower canines, and a canine puncture diameter >0.5 cm indicated panther predation, whereas a distance of 1.9-2.5 cm between canines, and a canine puncture diameter <0.3 cm indicated bobcat predation. The distance of reach for scraping litter to build mounds and cover the carcass was measured also; panthers have a longer reach, up to 90 cm, whereas bobcats reach 30-35cm. Extensive feeding in one night and extreme damage, including broken neck and broken bones (legs, ribs), were indicative of panther predation (Robinette et al. 1959). Multiple bite marks were indicative of a predator smaller than its prey, thereby being unable to fell its prey with one bite, i.e., bobcat (Wade and Bowns 1984). When possible, kill sites and feeding sites were determined by the presence of mounds and draglines and the position of the carcass. Predation by alligators (*Alligator mississippiensis*), although not verified in this study to date, was considered when a deer carcass that had exhibited traumatic injury was retrieved near gator holes or freshwater ponds (Epstein et al. 1983).

Census

Aerial censuses were conducted during 2, 3-day periods, 25-27 June and 7-9 July 1990, to provide an estimation of deer density in the contiguous prairie/tree island habitat of BCNP and ENP. Two census areas (Fig. 1), one in each BCNP and ENP, were flown by fixed-wing aircraft (Cessna 172), starting 0.5 hr after sunrise each census day; the censuses were completed prior to 2 hr post-sunrise. Each census area contained 8 parallel transects, located at 1 km intervals; the transects were oriented on a east/west axis. The transects were flown, alternately, east-to-west and west-to-east. Starting points were alternated among transects within each census area, between flight directions, and between census areas for each of the 6 census-flights. Visual delineation of transect boundaries was modeled after Caughley (1977); width-calibration followed the procedures of Norton-Griffiths (1978). Transect width was established as 300 m (150 m on either side of the aircraft) at an altitude of 31 m. Flight speed was 80 km/hr. All census flights were conducted by the same pilot and 2 rear-seat observers; the latter maintained either left or right observer positions throughout the 6 census flights. All observations of deer (numbers, sex, age) were reported to a recorder, who, from his position in the right front seat, also monitored starting/stopping locations, flight altitude, and flight speed for each transect.

The objective was to census 30% of each area. Due to a more scattered distribution of radio-instrumented deer in the ENP site, the census area for ENP was slightly larger than for BCNP--43.8 km² vs. 36.5 km², respectively. Accordingly, transect lengths varied between the 2 census areas, being 5 km in BCNP and 6 km in ENP.

The census was designed to provide 2 estimates of deer density: the transect sample estimator; and a mark-reobservation (Petersen) estimator. The latter was predicated on the ability to detect radio-collars (marks) on deer observed within the designated transects at a census altitude and transect width of 31 m and 150 m, respectively. Initial concerns that the low flight altitude might alter deer activity/behavior, thereby negatively biasing the census data, were unfounded as few animals appeared to alter their behavior; thus, the 31-m flight altitude was maintained throughout the census. However, the ability of observers to verify the presence/absence of a radio-collar on a deer toward the outer fringe of the 150-m transect zone did confound the validity of the mark-reobservation estimator.

Radio-location Visibility Analysis

Visual observations of radio-instrumented deer were obtained for 1,015 (26%) of the 3,881 radio-locations recorded between 01 April 1989 and 30 June 1990 (see Results). To determine trends of diurnal animal activity, the visual sightings were analyzed on the basis of age (adult [including yearlings] or fawn), sex, time of day, and season for both the BCNP (536 sightings) and ENP (459 sightings) study areas.

Visual sightings were grouped into the 4 "bioclock" radio-location periods: "early" (sunrise-midmorning), "AM" (midmorning-noon), "PM" (noon-midafternoon), and "late" (midafternoon-sunset). Seasonal designations followed those delineated by Land (1989), with minor modifications (refer to Table 18). Inasmuch as only 49 visual observations were obtained during the months of April, May, and June in 1989, these sightings were incorporated with the data for the corresponding months in 1990 for this analysis.

RESULTS/DISCUSSION

Capture Success/Study Sample

Sixty-five individual deer were captured by helicopter netgunning during 36.0 h of helicopter time expended during March, April, May, June, and August 1989, and 61 deer (including 5 recaptures) were captured similarly during 43.2 h of helicopter time during January, March, April and June 1990 (Tables 1 and 2). Collectively, 126 (84%) of 150 deer pursued were captured; the number of helicopter hours required to capture each animal averaged 0.63 h (Table 2).

Of the 126 deer (including the 5 recaptures) captured from the initiation of the study through 30 June 1990, 2 (2%) died as a result of the capture process, and 6 (5%) died within 14 days post-capture from probable capture myopathy (Chalmers and Barrett 1982). Additionally, 1 deer escaped prior to the attachment of the radio-transmitter, and 1 was released without a radio because of symptoms of stress at capture. Thus, as of 30 June 1990, a total of 111 individual radio-instrumented deer had been entered into the study herd (Table 3). This radio-instrumented sample of 111 was comprised of 54 adults (23 males, 31 females), 9 yearlings (4 males, 5 females), and 48 fawns (29 males, 19 females); 53 deer (48%) were located in BCNP, and 58 (52%) in ENP (Table 3). The status of the 111 deer as of 30 June 1990 was: 8 (7%) censored (transmitter loss/failure); 40 (36%) dead; and 63 (57%) alive/transmitting.

Age and Sex Structure

The sex/age structure of the 121 individual deer captured during 1989 and 1990 was 59 males (25 adults, 5 yearlings, and 29 fawns) and 62 females (35 adults, 5 yearlings, and 22 fawns). The selective capture of deer employed in the study precludes an unbiased analysis of the sex and age structure of the sample. However, the age structure of the adult female component of the herd should not reflect capture bias, and, thus, merits evaluation. The unverified age profile among 34 adult (≥ 2 years in age) females was: 2 years = 21%; 3 years = 44%; and ≥ 4 years = 35%. Comparatively, the age profile among 143 adult females from 5 disjunct herds in Florida was: 2½ years = 30%; 3½ years = 25%; and ≥ 4 ½ years = 45% (Richter and Labisky 1985). These data preliminarily suggest that the BCNP/ENP deer herd, specifically adult females, exhibits an old (≥ 3 years) age structure. Interestingly, the sex ratio among captured fawns, notably distorted toward males in 1989, approached equity in 1990 (Table 3).

Survival/Mortality

Survival rates were derived from the radio-instrumented herd using the product-limit estimator procedure (Kaplan and Meier 1958), modified to allow for the "staggered entry" of radio-instrumented individuals added to the sample during the course of the investigation (Pollock et al. 1989) (Tables 4-13). The annual survival rate of radio-instrumented deer, sex and age ignored, in the combined BCNP/ENP herd (n=70) was 0.5833 for the 12 months, 01 April 1989-31 March 1990 (Table 4). In contrast, annual survival rates for radio-instrumented herds averaged 78% (n=110) in the nonhunted East Everglades herd during the 3 years, 1987-89 (Smith et al. 1990) and 74% in the hunted Bear Island (BCNP) herd during the 2 years, 1987-88 and 1988-89 (Land 1989). Thus, survival of deer in the BCNP/ENP study area appears to be notably less than in other herds, hunted or nonhunted, within the Everglades system.

Annual survival rates by age/sex cohort within the radio-instrumented BCNP/ENP herd during the 12-months, 01 April 1989-31 March 1990, were: fawns (n=17), 0.1403; yearlings (n=8), 1.000; adult males (n=16), 0.6188; and adult females (n=29), 0.6447 (Tables 5-8). Again, these annual survival rates for the designated age/sex components of the BCNP/ENP herd were notably less, except for yearlings, than those reported for radio-instrumented deer in the nonhunted East Everglades herd during the 3 years, 1987-89: fawns (n=34), 56%; yearlings (n=27), 56%; adult males (n=20), 80%; adult females (n=29), 85% (Smith et al. 1990).

adult male. No female fawns have been preyed upon by bobcats to date.

The bobcat has been documented to prey upon fawns in the South (Cook et al. 1971; Garner et al. 1976; Bartush and Lewis 1981) and on adult deer in Maine, particularly when snow depths limit deer mobility (Marston 1942). In the BCNP/ENP, pinnacle rock and dense stands of sawgrass may limit deer mobility and may provide cover for predators. Surprisingly, Maehr and Brady (1984) did not report the presence of deer in the stomachs of bobcats from south Florida. However, Land (1989) attributed the deaths of 2 adult female deer to bobcat predation on Bear Island in 1988. Of the 6 yearling and adult deer killed by bobcats in this study, 4 were ambushed in either dense cover or pinnacle rock. The other 2 deer taken by bobcats, both adult females, were particularly vulnerable; 1 (BC8931) was emaciated and 1 (BC9019) was in the process of giving birth. High bobcat density, low alternative prey availability, nutritional stress on deer, and coincident parturition cycles for both predator and prey are probable factors contributing to the high level of bobcat predation on deer in BCNP/ENP. Regardless of the ecological circumstances contributing to the high rate of predation on deer by bobcats, the loss of deer to bobcats appears to be a major factor regulating the population abundance of deer in the BCNP/ENP.

Familial Units/Associations

Five new family units were created through selective capture during the period 01 January-30 June 1990 (Table 15), including two doe-fawn pairs (doe BC8906/1989 male fawn BC9075, and doe BC8981/1990 female fawn BC9080), one set of 1990 twins (male fawn BC9098/female fawn BC90101), and one three-generation unit (doe BC8908/doe BC9066/1990 male fawn BC90102). Two 8-month-old 1989 fawns (female BC9072/male BC9073) were added to an existing family unit (doe BC8945/male fawn BC8928). Death or transmitter malfunction had altered composition of 5 of these 6 family units by 30 June 1990. To date, 13 family units have been created, of which 11 have been altered by death or transmitter malfunction (Table 15).

Estimation of Population Density

One hundred-fifty deer were observed during the mid-summer aerial census in 1990--76 during the 3 transect flights in June, and 74 during the 3 transect flights in July (Table 16). Efforts to supplement density estimates derived from the strip-transect census with estimates derived from mark-reobservation procedures (Peterson

estimator) were unsuccessful because of the inability of the census observers to detect radio-collars on deer at the outer fringes of the transects; thus, all estimates of density are restricted to the direct strip-transect counts.

The number of deer observed per total transect area censused was adjusted by a calculated visibility coefficient (proportion of radio-located deer observed) to derive density estimates for the two areas, BCNP and ENP. For example, 81 deer were observed within the 69.52 km² transect area censused in BCNP (Table 16). These transect observations translated, without adjustment, into a population density of 1.17 deer/km². However, concurrent telemetry data revealed that only 26.0% of the radio-locations of deer were confirmed visually in the BCNP during the sunrise to mid-morning bioclock period, which coincided with the diel census period. Thus, given this visibility coefficient, the density estimate was increased by 285%, which yielded an adjusted density of 4.50 deer/km² for BCNP. Similar procedures, using a visibility coefficient of 41.3%, yielded a density of 2.01 deer/km² for ENP (Table 16).

These density estimates are comparable to those previously reported within the general BCNP/ENP region. Schortemeyer and McCown (1988) derived an estimate of 2.5-5.0 deer/km² for the same prairie/tree island region of BCNP. In the Everglades, Loveless (1959) and Smith (1989) obtained density estimates of 2.2 and 0.25-0.40 deer per km², respectively. Collectively, these studies suggest that the population density of deer is substantively greater in the BCNP (hunted) than in ENP (nonhunted).

Diurnal Deer Activity

Radio-instrumented deer, sex and age considered, in the BCNP were consistently more visible ($p < 0.05$) than their counterparts in ENP (Table 17). Sexes combined, the sighting of fawns was less frequent ($p < 0.05$) than that of adults in both BCNP and ENP. However, the sighting of fawns was proportionately greater ($p < 0.01$) in BCNP than in ENP. Previous analyses has demonstrated the greater availability of small tree islands and large tracts of cover in ENP, in contrast to BCNP (Boulay and Sargent 1989); thus, the proportionately higher frequency of sightings among fawns in BCNP may be a reflection of a lesser amount of cover available for concealment. Also, the sighting of female fawns in BCNP was proportionately greater ($p < 0.01$) than that of male fawns, and greater ($p < 0.01$) than that for both males and female fawns in ENP (Table 17); this relationship persisted among the seasons (spring, summer, and hunt) as well (Table 18).

Although adult females were equally visible (30%) in BCNP and ENP, adult males were significantly ($p < 0.05$) more visible in BCNP (29%) than in ENP (22%) (Table 17). Again, variation in cover availability may be a factor contributing to this difference. Another contributing factor may be the documented larger home range sizes of adult males in BCNP than in ENP (Labisky et al. 1990). In fact, BCNP males were less visible than ENP males only during the hunting season (Table 18), which can be attributed to hunting-related disturbance (Marchinton 1964, Swenson 1982).

In general, there was a distinctive trend towards increased deer visibility as the year progressed (Table 18). This trend among fawns is undoubtedly tied to age-related behavioral differences (Jackson et al. 1972), whereas the trend among adults is probably related to rutting activities and to increased nutritional demands associated with the wet season. The low visibility of deer in spring is probably a result of reduced activity related to parturition among females and antler-shedding (i.e., reclusiveness) among males (Smith 1989).

"Bioclock" analyses revealed that visual observations of radio-instrumented deer were recorded most frequently during the early and late periods of the daylight period; in fact, the proportion of visual observations did not differ ($p < 0.05$) between early morning and early evening (Table 19). This activity pattern is consistent with that reported for white-tailed deer by Marchinton (1964). Although visibility was lowest during the mid-day (AM and PM periods), deer were obviously quite active during "the heat of the day". The latter hints that standing water, which occurs over the study area for much of the year, provides a cool microclimate that allows deer the option of traveling and foraging throughout the day--even during the summer when ambient temperatures usually exceed 32 C.

ASSESSMENT

Preliminarily, productivity of the BCNP/ENP deer herd appears to be equivalent to that documented in other Florida herds (Labisky et al. 1990). However, recruitment to the herd appeared to be depressed by the relatively low annual survival (0.1403) of fawns. The most significant finding to date has been the low annual survival (0.5833) of deer in the BCNP/ENP herd. And, notably, the annual survival of deer in the nonhunted ENP herd is substantively less (0.5236) than in the hunted BCNP herd (0.6234). In fact, the annual survival rate for the BCNP/ENP deer herd, and particularly for the ENP herd, is indicative of a population that is declining in abundance (Fuller 1990). Further, the

high level of predation by bobcats on deer (40% of all recorded deaths), adults as well as fawns, suggests that the bobcat is the predator that plays a key role in the natural regulation of population abundance in the BCNP/ENP deer herd. Accordingly, it is recommended that a radio-telemetry study of bobcats be initiated, and conducted concurrently with the deer study, for the purpose of evaluating this important predator-prey relationship in the Everglades system.

ACKNOWLEDGMENTS

Appreciation is extended to personnel of the Big Cypress National Preserve, notably F. Fagergren, R. W. "Buck" Thackery, K. C. Kacer, D. K. Jansen, D. D. Teague, M. E. Spier, C. "Chip" Davis, and G. Greco, for encouragement, technical support, and logistical assistance. Special thanks are due J. R. Snyder, who as NPS Liaison, keeps the project "on track" administratively. T. R. Smith is acknowledged for his field instruction on helicopter netgunning. P. C. Carlson was instrumental in establishing field protocol in 1989. A. W. Todd and W. R. Labisky provided quality assistance in the "big push" to capture deer in 1989. Karen Dunne skillfully piloted the Cessna 172 for obtaining aerial locations of radio-instrumented deer. And finally, we are indebted to our helicopter pilots, especially Tommy Bowling and Tom Monterastelli, who, with great patience, timely humor, and unmatched skill, served as "the" pilots for the netgun capture of deer for radio-instrumentation.

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DATE OF REPORT: 27 November 1990

Table 1. Continued, 2 of 6.

Deer ID	Capture date	Capture location ^a	Sex	Age at capture (yrs)	Body weight (kg)	Radio frequency (collar-type) ^b	Exposure days/ 30 Jun 90 ^c	Radio-locations/ 30 Jun 90	Status: 30 Jun 90
BC8920	10 May 89	G(ENP)	F	3 ^e	30.8	151.965(F)	08	00(00)	Dead: capture myopathy 17 May 89
BC8921	10 May 89	G(ENP)	F	>3	41.7	151.985(F)	416	72(16)	Alive/transmitting
BC8922	10 May 89	B(ENP)	F	<3	40.8	151.998(F)	416	74(27)	Alive/transmitting
BC8923	10 May 89	B(END)	M	1	24.9	151.920(E)	416	70(30)	Alive/transmitting
BC8924	10 May 89	B(ENP)	M	Fawn (89)	13.6	151.813(B)	80	07(00)	Censored: 29 Jul 89
BC8925	10 May 89	G(ENP)	M	4/5	54.5	151.730(E)	416	71(20)	Alive/transmitting
BC8926	10 May 89	G(ENP)	F	>4	37.6	150.976(F)	416	81(21)	Alive/transmitting
BC8927	10 May 89	G(BOTH)	M	4	51.7	151.761(F)	416	72(12)	Alive/transmitting
BC8928	11 May 89	G(ENP)	M	Fawn (89)	9.5	151.830(B)	179	28(07)	Dead: bobcat predation 05 Nov 89
BC8929	11 May 89	G(ENP)	M	Fawn (89)	7.8	151.857(B)	122	14(02)	Dead: bobcat predation 10 Sep 89
BC8930	11 May 89	G(ENP)	F	4 ^e	27.2	151.065(F)	133	13(07)	Dead: undetermined cause 20 Sep 89
BC8931	11 May 89	G(ENP)	F	3 ^e	27.2	151.651(F)	145	22(05)	Dead: bobcat predation 03 Oct 89
BC8932	11 May 89	G(ENP)	M	Fawn (89)	11.3	151.867(B)	82	10(05)	Dead: undetermined cause 01 Aug 89
BC8933	11 May 89	G(ENP)	M	3/4	63.5	151.775(E)	415	74(15)	Alive/transmitting
BC8934	11 May 89	G(ENP)	M	>5	65.8	151.890(E)	415	74(12)	Alive/transmitting
BC8935	11 May 89	S(BCNP)	F	Fawn (89)	11.8	151.896(B)	228	39(25)	Dead: undetermined cause 25 Dec 89
BC8936	11 May 89	S(BCNP)	M	1	31.3	151.710(E)	415	72(27)	Alive/transmitting
BC8937	11 May 89	S(ENP)	F	2	35.8	151.736(F)	211	31(02)	Censored: 09 Dec 89
BC8938	11 May 89	S(BCNP)	F	5 ^e	33.1	151.757(F)	90	14(04)	Dead: undetermined cause 09 Aug 89
BC8939	11 May 89	S(ENP)	F	1	29.0	151.781(F)	415	58(08)	Alive/transmitting

Table 1. Continued, 3 of 6.

Deer ID	Capture date	Capture location ^a	Sex	Age at capture (yrs)	Body weight (kg)	Radio frequency (collar-type) ^b	Exposure days/30 Jun 90 ^c	Radio-locations/30 Jun 90	Status: 30 Jun 90
BC8940	28 Jun 89	C(BCNP)	M	3	52.6	151.596(E)	148	28(09)	Dead: legal kill 22 Nov 89
BC8941	28 Jun 89	C(BCNP)	F	>5	38.1	151.692(F)	367	74(20)	Alive/transmitting
BC8942	28 Jun 89	C(BCNP)	F	Fawn (89)	20.0	151.699(B)	281	12(03)	Censored: 14 Aug 89; dead: bobcat predation 04 Apr 90
BC8943	28 Jun 89	G(ENP)	F	4 ^e	37.2	151.679(F)	90	17(12)	Dead: poached 25 Sep 89
BC8944	28 Jun 89	G(ENP)	M	Fawn (89)	21.8	151.542(E)	263	46(16)	Dead: panther predation 17 Mar 90
BC8945	28 Jun 89	G(ENP)	F	>3	30.8	151.671(F)	367	70(34)	Alive/transmitting
BC8946	28 Jun 89	G(ENP)	M	>3	49.9	151.531(E)	367	70(15)	Alive/transmitting
BC8947	28 Jun 89	S(BCNP)	F	2/3	30.4	151.960(F)	367	66(14)	Alive/transmitting
BC8948	28 Jun 89	C(BCNP)	M	Fawn (89)	12.7	151.500(B)	126	28(01)	Censored: 02 Nov 89
BC8949	28 Jun 89	C(BCNP)	M	2/3	41.7	151.522(E)	123	23(11)	Dead: legal kill 29 Oct 89
BC8950	29 Jun 89	C(BCNP)	F	Fawn (89)	19.5	151.554(B)	209	43(08)	Dead: undetermined cause 23 Jan 90
BC8951	29 Jun 89	B(ENP)	F	Fawn (89)	12.2	151.452(B)	14	03(01)	Dead: undetermined cause 12 Jul 89
BC8952	29 Jun 89	G(ENP)	M	3	42.2	151.512(E)	366	68(14)	Alive/transmitting
BC8953	29 Jun 89	G(ENP)	F	>3	34.9	151.663(F)	258	44(07)	Dead: undetermined cause 14 Mar 90
BC8954	29 Jun 89	B(BCNP)	F	5 ^e	38.1	151.664(F)	121	24(16)	Dead: poached 28 Oct 89
BC8955	14 Aug 89	C(BCNP)	F	2.5	38.6	151.635(F)	320	64(12)	Alive/transmitting
BC8956	14 Aug 89	C(BCNP)	M	2.5	34.9	151.490(E)	320	63(08)	Alive/transmitting
BC8957	14 Aug 89	C(BCNP)	M	5.5	68.0	151.482(E)	78	13(02)	Dead: legal kill 30 Oct 89
BC8958	14 Aug 89	B(BCNP)	F	3.5	37.6	151.623(F)	320	61(15)	Alive/transmitting
BC8959	14 Aug 89	B(BCNP)	F	2.5	34.0	151.590(F)	320	63(44)	Alive/transmitting

Table 1. Continued, 4 of 6.

Deer ID	Capture date	Capture location ^a	Sex	Age at capture (yrs)	Body weight (kg)	Radio frequency (collar-type) ^b	Exposure days/30 Jun 90 ^c	Radio-locations/30 Jun 90	Status: 30 Jun 90
BC8960	14 Aug 89	B(BCNP)	M	3.5	44.4	151.471(F)	320	61(19)	Alive/transmitting
BC8961	14 Aug 89	G(ENP)	M	3.5	65.8	151.387(E)	320	65(05)	Alive/transmitting
BC8962	14 Aug 89	G(ENP)	F	1.5	25.9	151.965(E)	320	65(25)	Alive/transmitting
BC8963	14 Aug 89	G(ENP)	F	2.5	34.9	151.579(F)	320	68(14)	Alive/transmitting
BC8964	14 Aug 89	G(ENP)	F	5.5 ^e	39.9	151.569(F)	88	19(06)	Dead: undetermined cause 10 Nov 89
BC9065	06 Jan 90	C(BCNP)	F	>3	38.6	None	00	00(00)	Unknown
BC9066	06 Jan 90	C(BCNP)	F	1.5	40.4	151.065(F)	151	33(11)	Censored: 06 Jun 90
BC9067	06 Jan 90	C(BCNP)	F	>3	39.5	151.306(F)	175	38(11)	Alive/transmitting
BC9068	06 Jan 90	C(BCNP)	F	>2	34.5	151.980(F)	07	00(00)	Dead: capture myopathy 13 Jan 90
BC9069	06 Jan 90	B(BCNP)	F	3	41.2	151.909(F)	175	34(21)	Alive/transmitting
BC9070	06 Jan 90	C(BCNP)	F	>3	42.2	151.992(F)	87	19(06)	Dead: bobcat predation 03 Apr 90
BC9071	07 Jan 90	C(BCNP)	M	1.5	36.7	151.522(E)	05	00(00)	Dead: capture myopathy 11 Jan 90
BC9072	07 Jan 90	G(ENP)	F	Fawn (89)	20.4	151.560(F)	175	33(12)	Alive/transmitting
BC9073	07 Jan 90	G(ENP)	M	Fawn (89)	17.2	151.971(E)	28	05(01)	Dead: undetermined cause 03 Feb 90
BC9074	07 Jan 90	G(ENP)	M	>3	39.0	151.748(E)	12	00(00)	Dead: capture myopathy 19 Jan 90
BC9075	07 Jan 90	B(BOTH)	M	Fawn (89)	24.5	151.372(E)	153	29(08)	Dead: malnutrition 09 Jun 90
BC9076	09 Mar 90	C(BCNP)	M	Fawn (90)	8.5	151.452(B)	113	22(00)	Alive/transmitting
BC9077	09 Mar 90	C(BCNP)	M	3	35.4	151.748(E)	113	23(01)	Alive/transmitting
BC9078	09 Mar 90	C(BCNP)	M	1.5	35.4	151.522(E)	113	26(09)	Alive/transmitting
BC9079	09 Mar 90	C(BCNP)	F	Fawn (90)	7.3	151.427(B)	113	22(01)	Alive/transmitting
BC9080	09 Mar 90	B(BCNP)	F	Fawn (90)	8.2	151.437(B)	88	20(12)	Dead: undetermined cause 06 Jun 90
BC9081	09 Mar 90	B(BCNP)	F	3	34.0	151.757(F)	113	26(20)	Alive/transmitting

Table 1. Continued, 6 of 6.

Deer ID	Capture date	Capture location ^a	Sex	Age at capture (yrs)	Body weight (kg)	Radio frequency (collar-type) ^b	Exposure days/ 30 Jun 90 ^c	Radio-locations/ 30 Jun 90	Status: 30 Jun 90
BC90102	08 Apr 90	C(BCNP)	M	Fawn (90)	8.6	151.039(B)	84	15(04)	Alive/transmitting
BC90103	08 Apr 90	G(ENP)	F	Fawn (90)	10.9	151.169(B)	84	17(02)	Alive/transmitting
BC90104	08 Apr 90	G(ENP)	F	Fawn (90)	9.1	150.312(B)	33	06(01)	Censored: 11 May 90
BC90105	08 Apr 90	G(ENP)	F	Fawn (90)	9.5	151.091(B)	84	17(00)	Alive/transmitting
BC90106	08 Apr 90	G(ENP)	F	Fawn (90)	5.9	151.150(B)	84	17(03)	Alive/transmitting
BC90107	12 Apr 90	C(BCNP)	F	Fawn (90)	7.8	151.190(B)	80	16(03)	Alive/transmitting
BC90108	12 Apr 90	C(BCNP)	M	Fawn (90)	6.5	151.825(B)	61	14(03)	Dead: bobcat predation 10 Jun 90
BC90109	13 Apr 90	G(ENP)	M	4	56.2	151.460(E)	79	17(01)	Alive/transmitting
BC90110	21 Apr 90	G(ENP)	M	Fawn (90)	8.7	150.430(B)	71	13(01)	Alive/transmitting
BC90111	21 Apr 90	G(ENP)	F	Fawn (90)	11.8	150.491(B)	71	14(02)	Alive/transmitting
BC90112	21 Apr 90	G(ENP)	M	Fawn (90)	14.5	150.371(B)	71	14(01)	Alive/transmitting
BC90113	21 Apr 90	G(ENP)	M	Fawn (90)	8.6	150.391(B)	09	02(00)	Dead: bobcat predation 29 Apr 90
BC90114	21 Apr 90	G(ENP)	F	Fawn (90)	17.2	150.452(B)	71	14(02)	Alive/transmitting
BC90115	29 Apr 90	G(ENP)	M	Fawn (90)	14.5	150.411(B)	57	11(01)	Dead: undetermined cause 24 Jun 90
BC90116	29 Apr 90	G(ENP)	M	Fawn (90)	13.6	150.470(B)	35	08(01)	Dead: bobcat predation 02 Jun 90
BC90117	29 Apr 90	C(BCNP)	M	Fawn (90)	8.9	150.350(B)	41	09(00)	Dead: bobcat predation 08 Jun 90
BC90118	22 Jun 90	B(ENP)	M	3	47.2	151.332(E)	63	02(00)	Alive/transmitting
BC90119	28 Jun 90	C(BCNP)	M	3	42.2	151.542(E)	09	00(00)	Alive/transmitting
BC90120	28 Jun 90	S(ENP)	M	4	60.8	151.971(E)	03	00(00)	Alive/transmitting

^a Specific capture sites (C=Camp 107; S=Steps; B=Boundary; and G=Glades) within BCNP and ENP.

^b Collar-type: B = breakaway fawn; F = fixed, permanent; E = expandable, permanent.

^c Number of transmitter days from capture through 30 June 1990.

^d Numerals within parentheses denote number of radio-locations for which animal was sighted.

^e Aged by examination of wear and replacement of teeth at time of death; age back-calculated to time of capture.

Table 2. Efficiency of capturing white-tailed deer by helicopter netgunning, Big Cypress National Preserve/Everglades National Park, 1989 and 1990 (through 30 June).

Dates	Capture efficiency			Capture-time efficiency	
	Number of deer for which capture was attempted	Number of deer captured	Percentage captured	Hours of helicopter time	Helicopter hours/captured deer
Mar 89	5	2	40	1.5	0.75 ^a
Apr	27	15	56	11.0	0.73 ^a
May	22	22	100	9.0	0.41 ^a
Jun	16	16	100	10.2	0.64 ^b
Aug	10	10	100	4.3	0.43 ^b
Subtotal/mean	80	65	81	36.0	0.55
Jan 90	13	13	100	7.1	0.55 ^b
Mar	29	23	79	20.0	0.87 ^b
Apr	25	22	88	12.9	0.59 ^b
Jun	3	3	100	3.2	1.07 ^b
Subtotal/mean	70	61	87	43.2	0.71
Total	150	126	84	79.2	0.63

^aNon-selective capture of individuals.

^bSelective capture of individuals.

Table 3. Age and sex of white-tailed deer captured by helicopter netgunning, Big Cypress National Preserve/Everglades National Park, March-December 1989 and January-June 1990.

Location	Number of deer captured						Total
	<u>Adults</u>		<u>Yearlings</u>		<u>Fawns</u>		
	M	F	M	F	M	F	
1989							
BCNP	6	13 ^a	2	1	5	3	30
ENP	9	16 ^b	1	3	5	1	35
Subtotal	15	29	3	4	10	4	65 ^c
1990							
BCNP	2	6 ^d	2 ^e	1	10	8 ^f	29
ENP	8 ^g	0	0	0	9 ^h	10 ⁱ	27
Subtotal	10	6	2	1	19	18	56 ^j
Total	25	35	5	5	29	22	121

^aIncludes 1 adult doe injured (dispatched) during capture operations.

^bIncludes 1 adult doe captured and radio-instrumented that subsequently died from probable capture myopathy.

^cThirty-one (31) individuals captured and radio-instrumented in 1989 were alive/transmitting as of 30 June 1990.

^dIncludes 1 adult doe that was not radio-instrumented due to severe stress, and 1 adult doe that subsequently died from capture myopathy.

^eIncludes 1 yearling male captured that subsequently died from capture myopathy.

^fIncludes 2 female fawns captured that subsequently died from capture myopathy.

^gIncludes 1 adult male that died during capture operations and 1 adult male that subsequently died from capture myopathy.

^hIncludes 2 male fawns born in 1989; these fawns, captured in January 1990, were approximately 10 months of age.

ⁱIncludes 1 female fawn born in 1989; this fawn, captured in January 1990, was approximately 10 months of age. Also included is 1 female fawn, born in 1990, that escaped prior to the attachment of a radio-transmitter.

^jThirty-two (32) individuals captured and radio-instrumented in 1990 were alive/transmitting as of 30 June 1990.

Table 4. Annual survival rate of radio-instrumented white-tailed deer (n=70), sex and age ignored, in the Big Cypress National Preserve/Everglades National Park, 01 April 1989-31 March 1990. Survival rate derived from the product-limit estimator procedure (Kaplan and Meier 1958), modified to allow for the "staggered" entry of radio-instrumented animals captured during the course of the study (Pollock et al. 1989).

Month	Number at risk (r_j)	Number of deaths (d_j)	Number censored ^a	Number added	Survival (S_t)
Apr 89	2	0	0	15	1.0000
May	17	0	0	21	1.0000
Jun	38	0	0	15	1.0000
Jul	53	3	1	0	0.9434
Aug	49	2	1	10	0.9049
Sep	56	3	0	0	0.8564
Oct	53	4	0	0	0.7917
Nov	49	5	2	0	0.7109
Dec	42	3	1	0	0.6601
Jan 90	38	1	0	7	0.6427
Feb	44	1	1	0	0.6281
Mar	42	3	0	6	0.5833

^aNumber of deer for which radio-transmitter malfunctioned.

Table 5. Annual survival rate of radio-instrumented fawn (born in 1989) white-tailed deer (n=17), sex ignored, in the Big Cypress National Preserve/Everglades National Park, 01 April 1989-31 March 1990. Survival rate derived from the product-limit estimator procedure (Kaplan and Meier 1958), modified to allow for the "staggered" entry of radio-instrumented animals captured during the course of the study (Pollock et al. 1989).

Month	Number at risk (r_j)	Number of deaths (d_j)	Number censored ^a	Number added	Survival (S_t)
Apr 89	1	0	0	3	1.0000
May	4	0	0	5	1.0000
Jun	9	0	0	5	1.0000
Jul	14	2	1	0	0.8571
Aug	11	1	2	0	0.7792
Sep	8	1	0	0	0.6818
Oct	7	0	0	0	0.6818
Nov	7	1	1	0	0.5843
Dec	5	2	0	0	0.3506
Jan 90	3	1	0	3	0.2337
Feb	5	1	0	0	0.1870
Mar	4	1	0	0	0.1403

^aNumber of deer for which radio-transmitter malfunctioned.

Table 6. Annual survival rate of radio-instrumented yearling (born in 1988) white-tailed deer (n=8), sex ignored, in the Big Cypress National Preserve/Everglades National Park, 01 April 1989-31 March 1990. Survival rate derived from the product-limit estimator procedure (Kaplan and Meier 1958), modified to allow for the "staggered" entry of radio-instrumented animals captured during the course of the study (Pollock et al. 1989).

Month	Number at risk (r_j)	Number of deaths (d_j)	Number censored ^a	Number added	Survival (S_t)
Apr 89	0	0	0	3	N/A
May	3	0	0	3	1.0000
Jun	6	0	0	0	1.0000
Jul	6	0	0	0	1.0000
Aug	6	0	0	1	1.0000
Sep	7	0	0	0	1.0000
Oct	7	0	0	0	1.0000
Nov	7	0	0	0	1.0000
Dec	7	0	0	0	1.0000
Jan 90	7	0	0	1	1.0000
Feb	8	0	0	0	1.0000
Mar	8	0	0	1	1.0000

^aNumber of deer for which radio-transmitter malfunctioned.

Table 7. Annual survival rate of radio-instrumented adult female (> 2 years) white-tailed deer (n=29) in the Big Cypress National Preserve/Everglades National Park, 01 April 1989-31 March 1990. Survival rate derived from the product-limit estimator procedure (Kaplan and Meier 1958), modified to allow for the "staggered" entry of radio-instrumented animals captured during the course of the study (Pollock et al. 1989).

Month	Number at risk (r_j)	Number of deaths (d_j)	Number censored ^a	Number added	Survival (S_t)
Apr 89	1	0	0	5	1.0000
May	6	0	0	9	1.0000
Jun	15	0	0	6	1.0000
Jul	21	1	0	0	0.9524
Aug	20	1	0	5	0.9048
Sep	24	2	0	0	0.8294
Oct	22	2	0	0	0.7540
Nov	20	1	0	0	0.7163
Dec	19	0	1	0	0.7163
Jan 90	18	0	0	3	0.7163
Feb	21	0	1	0	0.7163
Mar	20	2	0	1	0.6447

^aNumber of deer for which radio-transmitter malfunctioned.

Table 8. Annual survival rate of radio-instrumented adult male (>2 years) white-tailed deer (n=16) in the Big Cypress National Preserve/Everglades National Park, 01 April 1989-31 March 1990. Survival rate derived from the product-limit estimator procedure (Kaplan and Meier 1958), modified to allow for the "staggered" entry of radio-instrumented animals captured during the course of the study (Pollock et al. 1989).

Month	Number at risk (r_j)	Number of deaths (d_j)	Number censored ^a	Number added	Survival (S_t)
Apr 89	0	0	0	4	N/A
May	4	0	0	4	1.0000
Jun	8	0	0	4	1.0000
Jul	12	0	0	0	1.0000
Aug	12	0	0	4	1.0000
Sep	16	0	0	0	1.0000
Oct	16	2(2) ^b	0	0	0.8750
Nov	14	3(3)	1	0	0.6875
Dec	10	1	0	0	0.6188
Jan 90	9	0	0	0	0.6188
Feb	9	0	0	0	0.6188
Mar	9	0	0	4	0.6188

^aNumber of deer for which radio-transmitter malfunctioned.

^bNumerals within parentheses denote number of deer killed legally or illegally by hunters

Table 9. Annual survival rate of radio-instrumented fawn (born in 1990) white-tailed deer (n=31), sex ignored, in the Big Cypress National Preserve/Everglades National Park, 01 March-30 June 1990. Survival rate derived from the product-limit estimator procedure (Kaplan and Meier 1958), modified to allow for the "staggered" entry of radio-instrumented animals captured during the course of the study (Pollock et al. 1989).

Month	Number at risk (r_j)	Number of deaths (d_j)	Number censored ^a	Number added	Survival (S_t)
Mar 90	0	0	0	13	N/A
Apr	13	2	0	18	0.8462
May	29	1	1	0	0.8170
Jun	27	7	0	0	0.6052

^aNumber of deer for which radio-transmitter malfunctioned.

Table 10. Annual survival rate of radio-instrumented deer (n=33), sex and age ignored, in the Big Cypress National Preserve, 01 April 1989-31 March 1990. Survival rate derived from the product-limit estimator procedure (Kaplan and Meier 1958), modified to allow for the "staggered" entry of radio-instrumented animals captured during the course of the study (Pollock et al. 1989).

Month	Number at risk (r_i)	Number of deaths (d_i)	Number censored ^a	Number added	Survival (S_i)
Apr 89	2	0	0	11	1.0000
May	13	0	0	3	1.0000
Jun	16	0	0	8	1.0000
Jul	24	1	0	0	0.9583
Aug	23	1	1	5	0.9166
Sep	26	0	0	0	0.9166
Oct	26	3	0	0	0.8108
Nov	23	2	2	0	0.7403
Dec	19	2	0	0	0.6623
Jan 90	17	1	0	4	0.6234
Feb	20	0	0	0	0.6234
Mar	20	0	0	3	0.6234

^aNumber of deer for which radio-transmitter malfunctioned.

Table 11. Annual survival rate of radio-instrumented deer (n=35), sex and age ignored, in the Everglades National Park, 01 April 1989-31 March 1990. Survival rate derived from the product-limit estimator procedure (Kaplan and Meier 1958), modified to allow for the "staggered" entry of radio-instrumented animals captured during the course of the study (Pollock et al. 1989).

Month	Number at risk (r_j)	Number of deaths (d_j)	Number censored ^a	Number added	Survival (S_t)
Apr 89	0	0	0	4	N/A
May	4	0	0	17	1.0000
Jun	21	0	0	7	1.0000
Jul	28	2	1	0	0.9286
Aug	25	1	0	5	0.8915
Sep	29	3	0	0	0.7992
Oct	26	1	0	0	0.7684
Nov	25	3	0	0	0.6762
Dec	22	1	1	0	0.6454
Jan 90	20	0	0	2	0.6454
Feb	22	1	1	0	0.6160
Mar	20	3	0	3	0.5236

^aNumber of deer for which radio-transmitter malfunctioned.

Table 12. Annual survival rate of radio-instrumented adult female (> 2 years) white-tailed deer in the Big Cypress National Preserve (BCNP) and the Everglades National Park (ENP), 01 April 1989-31 March 1990. Survival rate derived from the product-limit estimator procedure (Kaplan and Meier 1958), modified to allow for the "staggered" entry of radio-instrumented animals captured during the course of the study (Pollock et al. 1989).

Month	Number at risk (r_j)	Number of deaths (d_j)	Number censored ^a	Number added	Survival (S_t)
BCNP (n=15)					
Apr 89	1	0	0	4	1.0000
May	5	0	0	1	1.0000
Jun	6	0	0	3	1.0000
Jul	9	0	0	0	1.0000
Aug	9	1	0	3	0.8889
Sep	11	0	0	0	0.8889
Oct	11	1	0	0	0.8081
Nov	10	0	0	0	0.8081
Dec	10	0	0	0	0.8081
Jan 90	10	0	0	3	0.8081
Feb	13	0	0	0	0.8081
Mar	13	0	0	1	0.8081

Table 12. Continued, 2 of 2.

Month	Number at risk (r_j)	Number of deaths (d_j)	Number censored ^a	Number added	Survival (S_t)
ENP (n=14)					
Apr 89	0	0	0	1	N/A
May	1	0	0	8	1.0000
Jun	9	0	0	3	1.0000
Jul	12	1	0	0	0.9167
Aug	11	0	0	2	0.9167
Sep	13	2	0	0	0.7756
Oct	11	1	0	0	0.7051
Nov	10	1	0	0	0.6346
Dec	9	0	1	0	0.6346
Jan 90	8	0	0	0	0.6346
Feb	8	0	1	0	0.6346
Mar	7	2	0	0	0.4533

^aNumber of deer for which radio-transmitter malfunctioned.

Table 13. Annual survival rate of radio-instrumented adult male (>2 years) white-tailed deer in the Big Cypress National Preserve (BCNP) and Everglades National Park (ENP), 01 April 1989-31 March 1990. Survival rate derived from the product-limit estimator procedure (Kaplan and Meier 1958), modified to allow for the "staggered" entry of radio-instrumented animals captured during the course of the study (Pollock et al. 1989).

Month	Number at risk (r_j)	Number of deaths (d_j)	Number censored ^a	Number added	Survival (S_t)
BCNP (n=6)					
Apr 89	0	0	0	2	N/A
May	2	0	0	0	1.0000
Jun	2	0	0	2	1.0000
Jul	4	0	0	0	1.0000
Aug	4	0	0	2	1.0000
Sep	6	0	0	0	1.0000
Oct	6	2(2) ^b	0	0	0.6667
Nov	4	2(2)	1	0	0.3334
Dec	1	0	0	0	0.3334
Jan 90	1	0	0	0	0.3334
Feb	1	0	0	0	0.3334
Mar	1	0	0	1	0.3334

Table 13. Continued, 2 of 2.

Month	Number at risk (r_j)	Number of deaths (d_j)	Number censored ^a	Number added	Survival (S_t)
ENP (n=9)					
Apr 89	0	0	0	2	N/A
May	2	0	0	3	1.0000
Jun	5	0	0	2	1.0000
Jul	7	0	0	0	1.0000
Aug	7	0	0	2	1.0000
Sep	9	0	0	0	1.0000
Oct	9	0	0	0	1.0000
Nov	9	1(1)	0	0	0.8889
Dec	8	1	0	0	0.7778
Jan 90	7	0	0	0	0.7778
Feb	7	0	0	0	0.7778
Mar	7	0	0	3	0.7778

^aNumber of deer for which radio-transmitter malfunctioned.

^bNumerals within parentheses denote number of deer killed legally or illegally by hunters.

Table 14. Causes of death of radio-instrumented white-tailed deer, Big Cypress National Preserve (BCNP)/Everglades National Park (ENP), 17 May 1989-30 June 1990.

ID ^a	Sex	Age ^b (years)	Location	Date of death	Habitat	Probable cause of death
BC8920	F	3	ENP	17 May 89	PR	Capture myopathy
BC8951	F	Fawn	ENP	12 Jul 89	PR	Undetermined
BC8918	F	5	ENP	13 Jul 89	HI	Undetermined
BC8911	M	Fawn	BCNP	25 Jul 89	PI	Undetermined
BC8932	M	Fawn	ENP	01 Aug 89	PR	Undetermined
BC8938	F	5	BCNP	09 Aug 89	CY	Undetermined
BC8929	M	Fawn	ENP	10 Sep 89	HI	Bobcat predation
BC8930	F	4	ENP	20 Sep 89	PR	Undetermined
BC8943	F	4	ENP	25 Sep 89	HI	Poaching ^d
BC8931	F	3	ENP	03 Oct 89	HI	Bobcat predation ^d
BC8954	F	5	BCNP	28 Oct 89	PR	Poaching
BC8949	M	2.5	BCNP	29 Oct 89	HI	Legal kill
BC8957	M	5.5	BCNP	30 Oct 89	HI	Legal kill
BC8912	M	3.5	BCNP	05 Nov 89	PI	Legal kill
BC8928	M	Fawn	ENP	05 Nov 89	PR	Bobcat predation
BC8964	F	5.5	ENP	10 Nov 89	PR	Undetermined
BC8940	M	3.5	BCNP	22 Nov 89	PR	Legal kill
BC8915	M	2.5	ENP	25 Nov 89	PR	Poaching
BC8901	M	Fawn	BCNP	21 Dec 89	PR	Bobcat predation
BC8907	M	2.5	ENP	21 Dec 89	HI	Undetermined
BC8935	F	Fawn	BCNP	25 Dec 89	PR	Undetermined
BC9071	M	2	BCNP	11 Jan 90	SG	Capture myopathy

Table 14. Page 2 of 3.

ID ^a	Sex	Age ^b (years)	Location	Date of death	Habitat	Probable cause of death
BC9068	F	≥2	BCNP	13 Jan 90	SG	Capture myopathy
BC9074	M	≥3	ENP	19 Jan 90	SG	Capture myopathy
BC8950	F	Fawn	BCNP	23 Jan 90	PR	Undetermined
BC9073	M	Fawn	ENP	03 Feb 90	PR	Undetermined
BC8953	F	>3	ENP	14 Mar 90	SG	Undetermined
BC8919	F	>4	ENP	16 Mar 90	PR	Bobcat predation
BC8944	M	Fawn	ENP	17 Mar 90	SG	Panther predation
BC9094	F	Fawn	BCNP	30 Mar 90	PR	Capture myopathy
BC9088	M	Fawn	ENP	02 Apr 90	SG	Bobcat predation
BC9070	F	≥3	BCNP	03 Apr 90	SG	Bobcat predation
BC8942	F	1	BCNP	04 Apr 90	SG	Bobcat predation
BC90100	F	Fawn	BCNP	18 Apr 90	SG	Capture myopathy
BC90113	M	Fawn	ENP	29 Apr 90	HI	Bobcat predation
BC9097	M	3	ENP	13 May 90	SG	Bobcat predation
BC8916	F	2	ENP	20 May 90	HI	Bobcat predation
BC9095	M	Fawn	BCNP	30 May 90	HI	Bobcat predation
BC90116	M	Fawn	ENP	02 Jun 90	WH	Bobcat predation

Table 14. Page 3 of 3.

ID ^a	Sex	Age ^b (years)	Location	Date of death	Habitat	Probable cause of death
BC9080	F	Fawn	BCNP	06 Jun 90	WL	Undetermined
BC90117	M	Fawn	BCNP	08 Jun 90	PR	Bobcat
BC9075	M	1	ENP	09 Jun 90	HI	predation
BC90108	M	Fawn	BCNP	10 Jun 90	HI	Malnutrition ^d
BC9086	F	Fawn	BCNP	12 Jun 90	HI	Bobcat
BC9090	M	Fawn	ENP	17 Jun 90	HI	predation
BC90115	M	Fawn	ENP	24 Jun 90	PR	Undetermined

^aCapture number.^bAge (years) at death.^cHabitat: prairie (PR); hardwood island (HI); pine island (PI); cypress (CY); sawgrass (SG); willow (WL).^dNecropsy indicated emaciated condition.

Table 15. Family-units consisting of two or more radio-instrumented deer as of 30 June 1990, Big Cypress National Preserve/Everglades National Park.

Site	Age/sex composition (Deer ID)	Relationships	Status, 30 June 1990
BCNP	Adult female (10) Adult female (47) Yrlg ('89) male (36) Fawn ('89) male (11)	Female 10 is matriarch. Yearling 36 and fawn 11 are progeny of 10. Female 47 also observed with a fawn ('89). Female 10 observed with fawn ('90).	Fawn 11 died 25 Jul 1989.
BCNP	Adult female (41) Adult female (55) Fawn ('89) male (09)	Female 41 mother of fawn 09 and possible mother of female 55. Additional family members possibly include a doe and fawn ('89).	Fawn 09 censored 22 Aug 1989.
BCNP	Adult female (04) Yrlg ('89) female (05) Fawn ('89) male (48)	Mother/yearling/fawn. Fawn 48 observed with twin; females 04 and 05 each observed with a doe. Female 05 observed with fawn ('90).	Fawn 48 censored 2 Nov 1989.
BCNP	Adult female (08) Adult female (66) Fawn ('90) male (102)	Female 08 probable mother of female 66. Female 66 mother of fawn 102. Female 08 observed with fawn ('90).	Female 66 censored 5 Jun 1990.
BCNP	Fawn ('90) male (98) Fawn ('90) female (101)	Twin siblings of uncollared doe.	Unchanged.
ENP	Adult female (22) Fawn ('89) female (51)	Mother/fawn. Female 22 observed with a doe and fawn ('90).	Fawn 51 died 12 Jul 1989.
BCNP	Adult female (14) Adult female (58)	Unknown. Observed with two does and two fawns ('89). Doe 14 observed with fawn ('90).	Unchanged.
BCNP	Adult female (54) Adult female (59)	Unknown. Female 59 observed with two does and fawn ('90).	Female 54 died 28 Oct 1989.

Table 15. Page 2 of 2.

Site	Age/sex composition (Deer ID)	Relationships	Status, 30 June 1990
ENP	Adult female (06) Yrlg ('90) male (75)	Possible mother/fawn.	Female 06 censored 8 Feb 1990. Male 75 died 9 Jun 1990.
BCNP	Adult female (81) Fawn ('90) female (80)	Mother/fawn. Female 59 also has been located with this unit.	Fawn 80 died 6 Jun 1990.
ENP	Adult female (30) Fawn ('89) male (29)	Mother/fawn.	Female 30 died 20 Sep 1989. Fawn 29 died 10 Sep 1989.
ENP	Adult female (45) Fawn ('89) male (28) Fawn ('89) female (72) Fawn ('89) male (73)	Female 45 probable mother of fawn 28. Fawns 72 and 73 may be fawns of an associated doe. Female 45 observed with fawn ('90).	Fawn 28 died 5 Nov 1989. Fawn 73 died 3 Feb 1990.
ENP	Adult male (74) Yrlg ('89) female (62)	Unknown. Male 74 located with female 62.	Male 74 died 19 Jan 1990.

Table 16. Aerial census of white-tailed deer in the Big Cypress National Preserve and Everglades National Park, summer (25-27 June and 07-09 July) 1990.

	BCNP ^a	ENP ^b	Total
Deer observed			
25 Jun	25	10	35
26 Jun	14	10	24
27 Jun	11	6	17
07 Jul	8	13	21
08 Jul	16	18	34
09 Jul	7	12	19
Total	81	69	150
Mean/transect	13.50	11.50	N/A
SD	6.60	3.99	N/A

Deer density (deer/km ²)			
Observed	1.17	0.83	0.98
Adjusted ^c	4.50	2.01	3.12

^aEach daily census conducted on 8, 5-km x 300-m transects.

^bEach daily census conducted on 8, 6-km x 300-m transects.

^cObserved density adjusted for visibility coefficient (see text).

Table 17. Percentage of total radio-locations of radio-instrumented deer, by age/sex cohort, that were confirmed visually, Big Cypress National Preserve and Everglades National Park, 01 April 1989-30 June 1990.

Sex/age cohort	Percentage of visual confirmations		
	BCNP	ENP	Total ^a
Adults			
Males ^b	29.0 (115/397) ^c	22.3 (157/703)	24.3 (288/1187)
Females ^b	30.7 (298/971)	29.9 (246/823)	30.3 (544/1794)
Subtotal	30.2 (413/1368)	26.4 (403/1526)	27.9 (832/2981)
Fawns			
Males	16.6 (57/343)	20.2 (37/183)	17.9 (94/526)
Females	30.8 (66/214)	13.0 (19/146)	23.6 (85/360)
Subtotal	22.1 (123/557)	17.0 (56/329)	20.2 (179/886)
Total	27.8 (536/1925)	24.7 (459/1855)	26.2 (1015/3881)

^aIncludes 2 boundary deer (BC8927 and BC9075) not included in either the BCNP or ENP herds.

^bYearlings grouped with adults due to small sample size.

^cNumbers in parentheses represent actual sightings/total number of radio-locations.

Table 18. Percentage of locations of radio-instrumented white-tailed deer, by age/sex cohort, that were confirmed visually within designated seasons in the Big Cypress National Preserve and Everglades National Park, 01 April 1989-30 June 1990.

	Percentage of visual confirmations		
	Spring (1 Jan-31 May)	Summer (1 Jun-30 Sep)	Hunt (1 Oct-31 Dec)
BCNP			
Adults^a			
Males	24.3 (33/136) ^b	33.3 (57/171)	27.8 (25/90)
Females	29.8 (140/470)	29.6 (89/301)	34.5 (69/200)
Fawns			
Males	11.8 (19/161)	20.9 (28/134)	20.8 (10/48)
Females	25.0 (24/96)	35.4 (28/79)	35.9 (14/39)
Total	25.0 (216/863)	29.5 (202/685)	31.3 (118/377)
ENP			
Adults^a			
Males	18.6 (55/295)	21.5 (51/237)	29.8 (51/171)
Females	23.0 (67/291)	34.9 (96/315)	38.3 (83/217)
Fawns			
Males	15.3 (11/72)	22.4 (19/85)	26.9 (7/26)
Females	13.6 (14/103)	11.6 (5/43)	----
Total	19.3 (147/761)	25.2 (171/680)	34.1 (141/414)

^aYearlings grouped with adults due to small sample size.

^bNumbers in parentheses represent actual sightings/total number of radio-locations.

Table 19. Percentage of locations of radio-instrumented white-tailed deer that were confirmed visually within designated bioclock intervals, Big Cypress National Preserve/Everglades National Park, 01 April 1989-30 June 1990.

	Percentage of visual confirmations			
	Early (Sunrise-0930)	AM (0931-1200)	PM (1201-1530)	Late (1531-Sunset)
BCNP	31.2 (159/509) ^a	23.5 (115/490)	23.3 (112/480)	33.6 (150/446)
ENP	30.2 (146/484)	17.6 (81/459)	20.8 (100/480)	30.6 (132/432)
Total ^b	30.6 (312/1019)	20.4 (198/973)	21.9 (215/983)	32.0 (290/906)

^aNumbers in parentheses represent actual sightings/total number of radio-locations.

^bIncludes 2 boundary deer (BC8927 and BC9075) not included in either the BCNP or ENP herds.

APPENDIX A: Mortality Data Sheet

DEER INFORMATION:

ID# _____ Freq. 15 _____ DATES: _____ captured _____ death (est.) _____
 Measures: TL _____ TLT _____ HF _____ days since capture _____
 Sex _____ Age _____ recovered _____ carcass age _____
 pregnant? _____ # fetuses _____ meas./CRL _____ HF _____ lactating? _____
 antlers? _____ # pts./R _____ L _____ bd/R _____ L _____ is _____ oc _____

SITE DESCRIPTION:

Habitat _____ nearest cover: type _____ size _____ distance _____
 Position of carcass _____
 Drag marks? _____ distance carcass moved _____
 Animal trails? _____ type _____
 Tracks? _____ species _____ measures: W _____ L _____
 Animal scat? _____ type _____ collected? _____
 Animal fur? _____ type _____ collected? _____
 Carcass in water? _____ depth _____ water nearby? _____
 Airboat/buggy trails near? _____ how far _____ how recent _____
 Signs of poaching (parts removed)? _____

CARCASS CONDITION:

Ectoparasites? _____/location _____
 Endoparasites? _____/location _____
 Tongue: color _____ ulcers? _____ erosion of dental pad? _____
 Facial swelling? _____
 Lesions: what _____/location _____
 Hoofs: sloughing? _____/extent _____
 Entrails exposed? _____
 Color of lungs _____/heart _____/liver _____
 Hemorrhages, lesions, or discharges? _____
 Condition Indexes (Stockle et al. 1978):

Tail Fat Index	1	2	3	
Kidney Fat Index	1	2	3	4
Pericardial Fat Index	1	2	3	4
Heart Fat Index	1	2	3	4
Condition	1	2	3	4

PARTS COLLECTED: blood: whole (#) _____ smears/thin (#) _____ thick (#) _____
 rumen contents _____ rumen _____ abomasum _____ heart _____ lungs _____ trachea _____

PREDATION/SCAVENGING:

Parts fed on _____/missing _____
 Skeleton only? _____ bones scattered? _____ pred. or scavenged? _____
 Predation signs:
 carcass covered? _____ material _____
 buried? (parts, location) _____
 tooth marks? _____/location _____ measure between marks _____ cm
 claw marks? _____/location _____ (especially note neck)
 subcutaneous or internal hemorrhage _____
 signs of struggle or chase? _____/blood on grass? _____
 condition of skull _____
 condition/location of collar (marks, blood?) _____
 probability of predation: high _____ low _____ uncertain _____

FAWNS: confirmed acceptance by doe? _____ stomach full? _____ wt loss? _____
 wounds from collision or fall? _____

ESTIMATED CAUSE OF DEATH _____

OTHER COMMENTS (include notes on signal and recent weather): _____