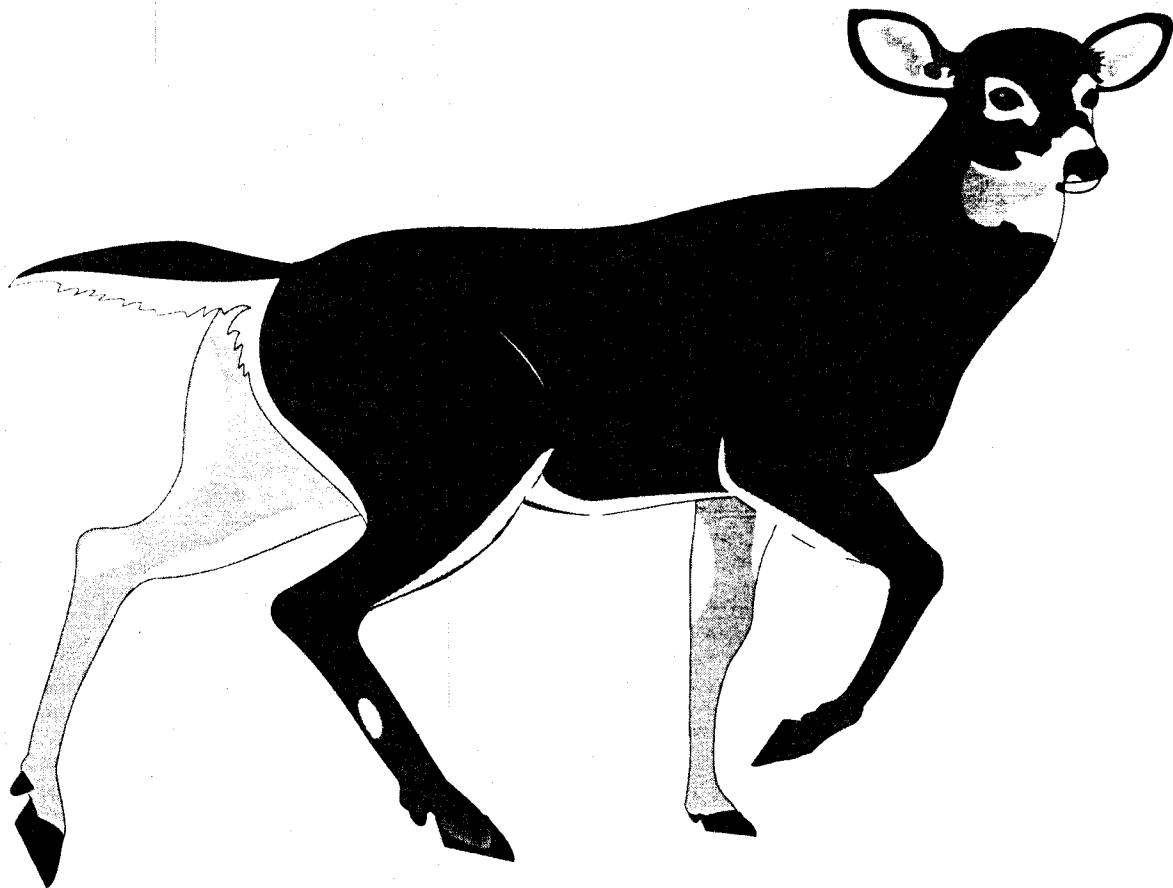


POPULATION ECOLOGY OF WHITE-TAILED DEER IN BIG CYPRESS NATIONAL PRESERVE AND EVERGLADES NATIONAL PARK

RONALD F. LABISKY
MARGARET C. BOULAY
KARL E. MILLER
ROBERT A. SARGENT, JR.
JODIE M. ZULTOWSKY



Draft

FINAL REPORT TO USDI – NATIONAL PARK SERVICE

DEPARTMENT OF WILDLIFE ECOLOGY AND CONSERVATION
UNIVERSITY OF FLORIDA
GAINESVILLE, FL 32611-0430

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FINAL REPORT

Population Ecology of White-tailed Deer
in Big Cypress National Preserve and Everglades National Park

Ronald F. Labisky, Margaret C. Boulay, Karl E. Miller
Robert A. Sargent, Jr., and Jodie M. Zultowsky

Department of Wildlife Ecology and Conservation
University of Florida
Gainesville, Florida 32611-0430

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RESEARCH SYNOPSIS

A 3-year research investigation of white-tailed deer (*Odocoileus virginianus*) populations in the prairie/tree island habitat of Big Cypress National Preserve (hunted site--Stairsteps Unit) and Everglades National Park (nonhunted site--upper Shark River Slough) was initiated in 1989 to elucidate the biological potential of the populations as: (1) a food resource (prey base) for the endangered Florida panther (*Felis concolor coryi*); and, (2) a recreational resource for sport hunting.

A total of 222 deer (204 individuals and 18 recaptures) was captured by helicopter netgunning during 1989, 1990, and 1991. Capture efficiency averaged 80% (222 captures per 276 pursuits); capture time averaged 0.65 h per captured deer (222 captures per 143.4 hours of helicopter time, including ferry). The death rate associated with capture, including capture-related injuries and subsequent capture myopathy, was 6.3% (14 deaths per 222 captures).

A total of 188 radio-instrumented deer constituted the initial sample population of deer "at risk" during the 3-year study. This sample was comprised of 85 adults (40 males, 45 females), 15 yearlings (10 males, 5 females), and 88 fawns (48 males, 40 females); 96 deer (51%) were located in BCNP, and 92 in ENP (Table 3). The status of these 188 deer, as of 31 March 1992 was: **censored** (transmitter loss/failure), 51 (27%); **dead**, 95 (51%); and **alive/transmitting**, 42 (22%). These 188 radio-instrumented deer "at risk" were radio-located 11,493 times between the date of capture and either the date of death/censor or 31 March 1992; 4,172 (36.3%) of the 11,493 radio-locations were confirmed by visual sightings.

The density of deer, derived from aerial-transect surveys, approximated 3.5-4.0 deer/km² in the hunted BCNP population and 4.5-5.0 deer/km² in the nonhunted ENP population during 1990, 1991, and 1992. The difference in the estimated density between the 2 sites was principally a product of the disparity in the sex ratio of adults due to hunting; males comprised 21.5% and 45.6% of the adult population in the hunted BCNP and the nonhunted ENP, respectively. The carrying capacity of this wet prairie/tree island habitat appears to approximate 5 deer/km².

The median fawning date in the BCNP/ENP population was 22 February. Ninety-six percent of yearling and adult females (n=25) captured in 1989 gave birth to ≥1 fawn. Breeding by fawn females was not observed. Multiple litters, principally twins, occurred at a frequency of about 25%. Thus, productivity per breeding female at parturition approached 1.2 fawns (litter size 0=5%, 1=70%, and 2=25%), which compares favorably with deer populations throughout Florida.

Annual survival rates of fawns, gender ignored, did not differ ($P>0.05$) among years, being 0.1169, 0.3466, and 0.02981 in 1989-90, 1990-91, and 1991-92, respectively. The mean survival rate of fawns for the 3 biological years, data pooled, was 0.2333. Annual survival rates for fawns, gender and years pooled, differed ($P<0.05$) between BCNP (0.4260) and ENP (0.0000). **Notably, no radio-instrumented fawn "at risk" in ENP survived their first year of life during the 3-year study.** Predation by bobcats was the primary cause of death among fawns in both BCNP and ENP, accounting for 31 (60%) of the 52 fawn deaths.

Survivorship of yearlings, years and locations pooled, averaged 0.6563 for males and 1.0000 for females. Thus, survival among yearlings appears adequate for population maintenance; however, the low survival of fawns, particularly in ENP, precludes adequate recruitment into the yearling cohort.

Survival rates among adults, within gender, did not differ ($P>0.05$) among years; mean survival rates, locations pooled, were 0.6705 and 0.8115 for adult males and adult females, respectively. Survival rates of adult males differed ($P<0.05$) between the hunted BCNP population and the nonhunted ENP population during all 3 years, 1989-90, 1990-91, and 1991-92; consequently, the mean survival rate of males differed ($P<0.05$) between BCNP (0.4308) and ENP (0.8351). Survival rates of adult females did not differ ($P>0.05$) between BCNP and ENP among years; thus, the mean survival rate of adult females did not differ ($P>0.05$) between BCNP (0.8743) and ENP (0.7369). Hunting was the principal cause of death of males in BCNP; 57%, 33%, and 50% of available yearling/adult males were harvested during the hunting seasons of 1989, 1990, and 1991, respectively. Annual harvest rates in BCNP, years pooled, averaged 33% for yearling males and 48% for adult males.

Survival rates of yearling and adult deer, gender ignored, in both the hunted BCNP population and the nonhunted ENP population were generally within the demographic limits for low density, stationary populations. Further, annual survival rates of fawns in the hunted BCNP population approached levels (albeit with annual variation) for maintaining stationary population growth. However, the minimal survival among both male and female radio-instrumented fawns in the nonhunted ENP during the 3-year study indicated the ENP population is in a demographic collapse. Only 5 (9%) of 55 radio-instrumented fawns survived to 18 months of age, the age of recruitment to the breeding population. This level of recruitment was markedly less than that required to replace annual losses of either adult males (33%) or adult females (19%). The high losses of fawns to bobcats ($\geq 60\%$) is a depressant to the recruitment of animals into the breeding population. Bobcat predation appears to be the principal factor in regulating the growth and abundance of the deer population in this wet prairie ecosystem.

Model outputs of data-based population growth for the hunted BCNP population revealed a stationary population in 1989-90 (deterministic r [dr], 0.054; stochastic r [sr], 0.030), a slightly increasing population in 1990-91 (dr , 0.1000; sr , 0.077), and a markedly declining population in 1991-92 (dr , -0.004, sr , -0.050). In contrast, model outputs of data-based population growth for the nonhunted ENP population revealed sharply declining populations for all 3 years, 1989-90 (dr , -0.0758; sr , -0.772), 1990-91 (dr , -0.115; sr , -0.158), and 1991-92 (dr , -0.241; sr , -0.241); all populations exhibited an extinction probability of 1.000. The driving demographic force behind the modeled collapse of the ENP deer population was the almost negligible recruitment of fawns into the yearling cohort.

The most applicable maintenance model for the hunted BCNP population was derived from the following mortality rates: females--55%, 5%, and 15% for fawns, yearlings, and adults, respectively, and males--55%, 35%, and 50% for fawns, yearlings, and adults, respectively. This maintenance model yielded a positive growth rate (dr , 0.057; sr , 0.036); a population sex ratio of 23% males; and a low probability of extinction (0.040). The increasing of harvest rates for males in this model, to levels of 50% for yearlings and 70% for adults, did not compromise population growth. The most suitable maintenance model for the nonhunted ENP population was derived from the following mortality rates: females--40%, 5%, and 15% for fawns, yearlings, and adults, respectively, and males--50%, 5%, and 20%, respectively. This model yielded a positive growth rate (dr , 0.122; sr , 0.102); a population sex ratio of 42% males, and no probability of extinction. Further demographic manipulations of these models suggested that the mortality of fawns, especially females, and adult females are the 2 elements most influencing population growth.

The maintenance models were used as the base models for measuring the impacts of hurricanes and floods, singly and combined, in both the hunted BCNP and nonhunted ENP deer populations. The catastrophic inputs were: hurricanes--5% frequency, 5 % reduction in survival, and 50% reduction in productivity; and floods--10% frequency, 50% reduction in survival, and 50% reduction in productivity. These catastrophic models revealed that hurricanes did not constitute a major depressant to sustained growth of deer populations. Floods, however, were a serious depressant to population growth, and resulted in precipitous declines in the abundance of deer. Notably, both hurricanes and floods exerted greater negative impacts on the hunted population than on the nonhunted population. The greater vulnerability to natural catastrophes of the hunted BCNP population, in contrast to the nonhunted ENP population, may be related to the lower standing crop of deer as a consequence of removal by harvest.

Annual home ranges sizes of both adult males and adult females were greater ($P < 0.05$) in the hunted BCNP population

(males, 7.0 km²; females, 5.4 km²) than in the nonhunted ENP population (males, 2.9 km²; females, 3.0 km²). Home range sizes of adult males were greater ($P < 0.05$) during the wet season than the dry season, which probably reflects the fact that the rutting period occurs during the wet season. However, home range sizes of adult females were greater ($P < 0.05$) during the dry season than during the wet season; the smaller home range size of females during the wet season may be a reflection of greater food availability.

Hunting activities constituted a spatial disturbance for deer in the hunted BCNP population. Speculatively, the increased bioenergetic costs associated with expanded movements of breeding females (pregnant) as a result of hunting activities could reduce female productivity.

Home range sizes differed ($P < 0.05$) among the 3 defined habitat types for both females (cypress edge, 9.3 km²; prairie, 5.6 km²; ridge, 2.5 km²) and males (cypress edge, 9.9 km²; prairie, 7.1 km²; ridge, 5.4 km²). Core area sizes differed ($P < 0.05$) among habitat types for females, but not ($P > 0.05$) for males. Thus, home ranges of both genders were largest in cypress edge, intermediate in prairie, and smallest in ridge; core area sizes followed a similar pattern.

Home range and core area sizes of females were inversely correlated with the availability of hardwood tree islands and the proportion of edge; however, home range and core area sizes of males was inversely correlated only with the proportion of edge. Thus, core areas were larger in the areas where habitat interspersions were low (minimal edge), e.g., prairie, and smaller in areas where habitat interspersions were high (abundant edge), e.g., ridge. Thus, the availability and interspersions of habitats strongly influence the use of areal space by deer.

Use of specific habitats within home ranges differed ($P < 0.001$) for both males and females. The relative use of wet prairie was 39% for females and 14% for males, whereas the relative use of hardwood tree islands was 30% for females and 47% for males. This differential use of habitats by males and females is in concert with maximizing reproductive fitness.

Principal habitats on the BCNP/ENP study site were not used in proportion to their availability in either prairie or ridge habitat-types. Hardwood tree island and willow/sawgrass habitats were used more ($P < 0.001$) than expected, based on their availability, by males and females in both prairie and ridge sites. Conversely, with exception of the proportionate use of herbaceous prairie by females in the ridge site, wet prairie and herbaceous prairie habitats were used less ($P < 0.001$) than expected by both males and females in both sites. Thus, deer in BCNP/ENP exhibit strong habitat preferences, a behavior that may be intensified by the sparsity of habitats available in this wet prairie ecosystem.

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RESEARCH OBJECTIVES

This 3-year research investigation of white-tailed deer (*Odocoileus virginianus*) populations in the prairie/tree island habitat of Big Cypress National Preserve (hunted site--Stairsteps Unit) and Everglades National Park (nonhunted site--upper Shark River Slough) was initiated in 1989 to elucidate the biological potential of the populations as: (1) a food resource (prey base) for the endangered Florida panther (*Felis concolor coryi*); and, (2) a recreational resource for sport hunting. Specific objectives were to elucidate survival rates, recruitment, spatial distributions, habitat availability/use, and population growth of the 2 populations during 3 annual cycles: April 89-March 90; April 90-March 91; and April 91-March 92.

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 136 cm (53.54 inches) (Duever et al. 1986). The region has a 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, the BCNP/ENP system was characterized by moderate droughts in 1989 (rainfall = 112 cm) and 1990 (rainfall = >78 cm; data for July unavailable). However, study area was moderately wet during 1991 due to the combination of near-average rainfall (134 cm) and increased releases of water into Upper Shark River Slough from the upstream water conservation areas. Located on the southern tip of the Florida peninsula, the area also experiences frequent tropical cyclones (Gentry 1974).

Topographically, the Big Cypress region is nearly flat. Within the 640,000-ha watershed of the Big Cypress Swamp, the sheet flow of water is southwestward, along a declining elevation of 9 cm/km (Duever et al. 1986), 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 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 main study area 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).

Vegetation on the study area is comprised principally of wet prairie (93%), which is characterized by a hydroperiod of 50-150 days of water inundation per year, and mixed hardwood tree islands (7%) (Duever et al. 1986; Miller 1993). The wet prairie community is dominated principally by grasses and sedges; common plants include maidencane (*Panicum hemitomon*), sand cordgrass (*Spartina bakeri*), sawgrass (*Cladium jamaicense*), muhly grass (*Muhlenbergia filipes*), love grass (*Eragrostis maicensis*), 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 an 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. 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). 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).

Although prohibited in ENP, recreational hunting is allowed in BCNP. Hunting regulations in BCNP are established, with National Park Service oversight, by the Florida Game and Fresh Water Fish Commission. The general hunting regulations for deer in the Stairsteps Unit, which includes the BCNP study site, during 1989, 1990 and 1991 were as follows: males-only harvest; minimum antler length >12.5 cm (5 inches); season length of 92 days, including a 4-week archery season beginning in September, an immediately continuing 2-week primitive weapons season in October, and a 45-day modern gun season (60 days in 1989) beginning in mid-November; and daily and seasonal hunter bag limits of 1 and 2 males, respectively. Notable modifications to hunting regulations for deer were effected in 1990. These modifications prohibited the hunting of deer with dogs, restricted swamp buggy vehicles to designated trails in upland areas; and, as noted above, reduced the general gun season from 60 to 45 days; the latter shifted the opening of the modern gun season about 2 weeks later in the year.

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, 1990; Land 1991; Labisky et al. 1992). The netgun (CODA Enterprises, Inc., Mesa, AZ), powered by a .308 caliber blank, deploys a 12 x 12-ft² or 14 x 14-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 altitude 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.

All captured deer were immediately blindfolded, physically restrained in the net, and then immobilized by securing the front and hind limbs 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. 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.

Population Surveys

Six aerial transect-surveys to determine deer density were conducted in both BCNP and ENP during each of 3 predetermined seasons in each of 2 years: summer/wet (June/July), 1990 and 1991; fall/hunting (October), 1990 and 1991; and spring/dry (March), 1991 and 1992. Each survey consisted of 6 flights (replicates). The 2 survey areas (Fig. 1), one in each BCNP and ENP, were flown by fixed-wing aircraft (Cessna 172), starting 0.5 hr after sunrise each survey day; the surveys were completed prior to 2 hr post-sunrise. Each survey 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 survey area, between flight directions, and between survey areas for each of the 6 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 survey flights were conducted by the same pilot and 2 rear-seat observers; the latter maintained either left or right observer positions throughout the 6 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 survey approximately 30% of each of the BCNP and ENP study areas. Due to a more scattered distribution of radio-instrumented deer in the ENP site, the survey area for ENP was slightly larger than for BCNP--43.8 km² vs. 36.5 km², respectively. Accordingly, transect lengths varied between the 2 survey areas, being 5 km in BCNP and 6 km in ENP. Thus, the survey coverage areas approximated 12 km² in BCNP (8 transects x 5 km x 300 m) and 14.4 km² in ENP (8 transects x 6 km x 300 m); these coverage areas (i.e., transect width) were adjusted for variations in flight altitude for each survey.

The surveys were designed initially 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 flight 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 survey data, were unfounded as few animals appeared to alter their behavior; thus, the 31-m flight altitude was maintained for all surveys. 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 rendered the mark-reobservation estimator unusable.

Aerial surveys consistently provide an underestimation of ungulate population densities. Accordingly, the observability bias that contributes to this underestimation should be measured, and the population estimates derived from transect counts adjusted appropriately (Caughley 1974). Observability bias in aerial-transect counts can be estimated by measuring the proportion of radio-instrumented animals that are sighted during radio-telemetry flights within the same study area (Floyd et al. 1979). Accordingly, observability coefficients, restricted to the early morning census period (sunrise to 2 hr post-sunrise) were calculated for radio-instrumented deer of all age/sex cohorts for each of the 3 survey periods in both BCNP and ENP (Labisky et al. 1992). The derived observability coefficients

were: summer/wet season--BCNP, 0.229 and ENP, 0.359; fall/hunting season--BCNP, 0.714 and ENP, 0.591; and spring/dry season--BCNP, 0.575 and ENP, 0.466. Estimated population density was calculated by multiplying the estimates derived from deer observed by the reciprocals of the observability coefficients (Floyd et al. 1979).

Statistical differences in the mean number of deer observed per seasonal survey (6 replicates) in BCNP and ENP were determined by t-test analyses as the data, with a single exception, were distributed normally.

Population Structure: Sex and Age

Sex ratios.--Unbiased measures of secondary sex ratios of fawns were available from capture statistics, i.e., the sex of a fawn captured by helicopter netgunning could not be determined a priori. However, the selective capture of adult males and females precluded valid measures of secondary sex ratios from captured animals.

Sex ratios of adult deer were derived from observations obtained from the aerial-transect surveys conducted in BCNP and ENP during the summer/wet seasons (coincident with the rutting period) in 1990 and 1991. Because intersexual differences in observability of males and females would bias the observed sex ratios, the counts were adjusted by application of appropriately derived observability coefficients (see Population Surveys).

Chi-square analyses were used to test for differences in sex ratios among fawns captured in BCNP and ENP (tests based on equity), and among adults observed on the aerial-transect surveys in BCNP and ENP.

Age ratios.--This study was not designed to evaluate the age structure of the populations. Crude estimates of the age profile of adults were available from animals captured by helicopter netgunning; however, these age ratios are limited in validity due to small sample sizes.

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 limited the obtainment of radio-locations of instrumented deer to aerial-telemetric monitoring (by fixed-wing aircraft), which, in turn, restricted location-monitoring to daylight hours. Given these logistical restrictions, a biological-clock regime was designed to obtain unbiased daylight monitoring data, thus, avoiding the problem of

autocorrelation of data (Swihart and Slade 1985). To this end, the daylight hours were subdivided into 4 distinct periods: sunrise to 2 hr post-sunrise; 2 hr post-sunrise to mid-day; mid-day to 2 hr pre-sunset; and 2 hr pre-sunset to sunset. Thus, all radio-locations for any given animal were equally divided among the 4 discrete daytime monitoring periods.

Individual deer were radio-located once every 5 days, or approximately 6 times per month; this rate equated to 72 locations per deer surviving a 12-month period. Additionally, all radio-instrumented deer were monitored with respect to mortality, if possible, on every radio-location flight.

Each radio(deer)-location was sketched on a notepad, using topographic features, or a topographic map 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 recorded locations were verified by satellite photographs (scale = 1:26,000) of the study area, digitized on Universal Transverse Mercator (UTM) maps (scale = 1:24,000) to obtain empirical x and y coordinates, and entered into a computer file.

The location error associated with aerial-based telemetry in this wet prairie/tree island habitat, estimated from the blind placement of "dummy" radio-collars, was ≤ 30 m (Miller 1993). However, that accuracy of locations was enhanced substantially by the visual verification of the radio-instrumented animal for 33% of all radio-locations, and by the small areal size of the hardwood tree islands in the wet-prairie matrix.

Survival/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 (1 or 2X 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.

Evaluating Causes of Death.--Field observations for each mortality were recorded on a mortality data sheet. If feasible, each carcass, as well as the area (habitat) surrounding the carcass, was photographed to establish a permanent photo record. 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, and long bones 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, if present, was collected. 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 (*Felis rufus*) 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. Distance of reach for scraping litter to build mounds and cover carcasses was measured; panthers will reach up to 90 cm, whereas bobcats will reach only 30-35 cm. 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*) was considered when a deer carcass that had exhibited traumatic injury was retrieved near "gator holes" or freshwater ponds (Epstein et al. 1983), or confirmed when predation was observed.

Assignment of causes of death attributable to the combination of starvation, malnutrition, and stress was based on multiple criteria. Starvation/malnutrition was considered if the carcass revealed the lack of endogenous body fat, evidence of emaciation (i.e., extreme protrusion of femurs and spine), and/or pinkish or jellylike marrow in the long bones. Marrow in the long bones of deer in adequate physical condition will appear whitish in color and solid in substance (Davidson and Nettles 1988). Stress, resulting from the exhaustion of the adrenocortico endocrine system (General Adaptation Syndrome: Selye 1955), was considered both an indirect (predisposing) and direct death agent.

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). Importantly, the product-limit estimator procedure is sensitive to small sample sizes (<40) (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; the median date of fawning in this deer population was 22 February (Boulay 1992). Thus, annual survival rates for fawns, yearlings, and adults represent the 12-month period, 01 April-31 March. Annual survivorship was calculated by monthly time periods, i.e., deer were added (new captures), removed (death), or censored (transmitter failure) by consecutive monthly increments, beginning in April and ending in March.

(Note: No radio-instrumented animal was added to the sample population prior to 7 days post-capture, the interval during which the probability of occurrence of death from capture myopathy [Chalmers and Barrett 1982] was most probable. This 7-day interval was determined a valid period by assessing the timing and circumstances of death for all deer that died within 21 days of capture.)

Annual survival patterns, by age/sex cohort and study site (BCNP vs. ENP), were compared among and between biological years, 1989-90, 1990-91, and 1991-92, by application of the log-rank test, using the variance described by $r_{0j}r_{1j}d_j/r_j^2$; this test is moderately conservative (Pollock et al. 1989). The formula for this log-rank test is:

$$\text{Chi-square} = \frac{[\sum d_{1j} - \sum (d_j r_{1j}/r_j)]^2}{r_{0j}r_{1j}d_j/r_j^2}$$

where r_{0j} = number at risk by month, year 1;
 d_{0j} = number of deaths by month, year 1;
 r_{1j} = number at risk by month, year 2;
 d_{1j} = number of deaths by month, year 2;
 r_j = number at risk by month, years 1 and 2;
 d_j = number of deaths by month, years 1 and 2.

Population Modelling

The deer populations in BCNP and ENP were modelled by a modified (August 1994 version) VORTEX software program (Lacy 1993). VORTEX is a model that incorporates stochastic processes that impact population growth and viability: demographic stochasticity, environmental variation, catastrophic events, and genetic drift. Constant parameters on all model scenarios included: (1) age of first reproduction as 2 years for females and males; (2) polygynous mating; (3) age of senescence (death) as 10 years; (4) 5% of females nonbreeding, 70% producing a litter of 1, and 25% producing a litter of 2, which equates to a rate of fawn production of 1.2/breeding female (Richter and Labisky 1985, Land 1991); (5) equity in sex ratio at birth (Boulay 1992); (6) reproduction as density-independent, which is supported by the evidence from low density populations (Shea et al. 1992, this study); (7) all adult males in breeding pool each year; (8) initial population densities of 3.5 deer/km² or 350 deer/100 km² in BCNP and 4.5 deer/km² or 450 deer/100 km² in ENP (see Population Surveys); (9) carrying capacity constant (5 deer/km² or 500 deer/100 km²) for BCNP and ENP; (10) standard deviations for environmental variation of 10% for reproduction and 15% for mortality rates and carrying capacity; (11) stable age distributions; (12) no harvest (harvest in BCNP incorporated in mortality estimates); (13) no supplementation; and (14) 100 years of simulations (100 iterations).

The deer populations in BCNP and ENP were first modeled annually, using population statistics derived from the study, for the 3 biological years, 1989-90, 1990-91, and 1991-92. The only modification of data occurred with respect to annual mortality rates, i.e., if a given age/sex cohort was characterized by 100% mortality, it was assigned 95% mortality, and, if characterized by 0% mortality, it was assigned 5% mortality.

The populations also were modeled, by manipulating the mortality of age/sex cohorts, to yield a demography that permitted maintenance of a population size of 3.5 deer/km² in BCNP and 4.5 deer/km² in ENP. The maintenance-level populations were manipulated further to reveal the impacts of increasing or decreasing the mortality of critical age/sex cohorts. And finally, the maintenance-levels populations were subjected to 2 types of environmental catastrophes: hurricanes and floods.

Tropical cyclones, including hurricanes and tropical storms, are commonplace in south Florida, occurring at a frequency of about 1 per 3 years (Gentry 1974). Fifty-six percent of these storms occur during July, August and September (Gentry 1974), which coincides with the breeding season of deer in the Everglades system (Sargent 1992). The rainfall associated with these storms may be nominal or excessive; the accumulation of excessive storm-derived rainfall may be exacerbated by the release of water from water-control impoundments (Light and Dineen 1994). Hurricanes were incorporated into the population models at a conservative frequency of 5% (1 per 20 years), which was intended to approximate the probability of a specific deer population being impacted by a major hurricane; the modeled impact on the deer population was a 5% reduction in survival and a 50% reduction in productivity (R. F. Labisky, unpubl. data). Floods were incorporated into the models at the realistic level of 10% (1 per 10 years), i.e., major flooding occurred in the Everglades system in 1982 (Brantly 1982) and 1994 (Labisky and MacDonald 1995); the modeled impact on the deer population was a 50% reduction in survival and a 90% reduction in productivity (Labisky and MacDonald 1995).

Home Range Analyses

Home range size was calculated by minimum convex polygon (MCP) (Mohr 1947) and harmonic-mean (HM) (Dixon and Chapman 1980) estimators, using the HOMERANGE software program (Ackerman et al. 1989). Centers of activity, and core-area size (65%), were computed by harmonic-mean analysis. In analyses relating to use of space, home range size was expressed as 100% MCP for females (Zultowsky 1992) and 95% MCP for males (Sargent 1992), whereas in analyses relating to use of habitats, home range size was expressed as 95% HM (Miller 1993).

Home range size of males and females was analyzed among years (n=3), study sites (n=2), hydrological seasons (n=2), and biological seasons (n=4). Calendar definitions of the hydrological seasons were: **wet**, 01 May-31 October; and **dry**, 01 November-30 April. Calendar definitions of the biological seasons were: **lactation (LACT)**, 01 April-30 June; **rut (RUT)**, 01 July-30 September; **gestation/hunting (GEST/HUNT)**, 01 October-31 December; and **parturition (PART)**, 01 January-30 April).

The observation-area curve technique (Odum and Kuenzler 1955, Harris et al. 1990) was used to determine the number of radio-locations (sample size) required for a valid measure of annual and hydrological home range sizes of adult males and females. For males, radio-locations from the June-November, June-October and November-April intervals were used to estimate annual, wet-season, and dry-season home range sizes, respectively (Sargent 1992); this equates to a minimum sample size of approximately 36, 30, 30 radio-locations for calculating annual, wet-season, and dry-season home range sizes for adult males. For females, annual and hydrological home range sizes were estimated from ≥ 10 months and ≥ 5 months of radio-locations, respectively (Zultowsky 1992); this equates to a minimum sample size of approximately 60 and 30 radio-locations for calculating annual and hydrological season home range sizes for adult females. Home ranges sizes for the biological seasons were limited to adults of both sexes that were radio-monitored for the entire 3-month period of the specific season, with a minimum restriction of 15 radio-locations per deer (Sargent 1992, Zultowsky 1992).

Habitat Analysis

A vegetation map of the study area was developed (due to the unavailability of same) from SPOT multi-spectral satellite imagery, using an unsupervised sequential clustering technique; the SPOT scene was geo-rectified using GRASS 3.0 (Miller 1993). The final Geographic Information Systems (GIS) vegetation map included 7 primary habitat types (20-m spatial resolution), and was characterized by a user/producer accuracy of 80.4%. This GIS map allowed the division of the study area into 3 habitat categories: **FRINGE** (5,350 ha)--wet prairie (36%), herbaceous prairie (21%), hardwood tree islands/scrub (6%), willow/sawgrass (2%), and cypress (35%); **PRAIRIE** (12,550 ha)--wet prairie (90%), herbaceous prairie (4%), hardwood tree islands/scrub (3%), and willow/sawgrass (3%); and **RIDGE** (9,360 ha)--wet prairie (52%), herbaceous prairie (29%), hardwood tree islands/scrub (11%), and willow/sawgrass (8%) (Fig. 2).

Habitat use by deer was analyzed via multiway contingency tables, using log-linear models. Populations were constructed for each sex x season x year sample to control for variation attributable to temporal differences in sampling intensities, i.e., the number of radio-instrumented animals was not constant.

Habitat use was measured for individual radio-instrumented deer and then compared with habitat availability in the entire study area (2nd order analysis) and with habitat availability within each deer's home range (3rd order analysis) (Thomas and Taylor 1990). The Chi-square goodness-of-fit test and simultaneous Bonferroni confidence intervals (Neu et al. 1974, White and Garrott 1990) were used to determine if habitats were used in proportion to their availability in each of the 3 habitats ($P \geq 0.05$). Tests of total habitat selection were performed both on individuals and on individuals pooled by sex, whereas tests of annual habitat selection were performed on individuals pooled by sex.

Statistical Significance

Statistical significance was established *a priori* at $P \leq 0.05$.

RESULTS AND DISCUSSION

The Sample Population

Capture success.--A total of 222 deer (204 individuals and 18 recaptures) was captured by helicopter netgunning during 1989, 1990, and 1991 (Tables 1-3). Capture efficiency averaged 80% (222 captures per 276 pursuits); capture time averaged 0.65 h per captured deer (222 captures per 143.4 hours of helicopter flight time, including ferry) (Table 2). The death rate associated with the capture effort, including capture-related injuries and subsequent capture myopathy, was 6.3% (14 deaths per 222 captures).

Radio-instrumented sample.--Of the 204 individual deer captured during 1989, 1990, and 1992, 6 (3%) died from capture-related injuries, 8 (4%) died within 7 days post-capture from probable capture myopathy, 1 escaped prior to the attachment of a radio-transmitter, and 1 was released due to a emergency situation (Tables 1 and 3). Thus, a total of 188 radio-instrumented deer constituted the initial sample population of deer "at risk" during the 3-year study. This sample was comprised of 85 adults (40 males, 45 females), 15 yearlings (10 males, 5 females), and 88 fawns (48 males, 40 females); 96 deer (51%) were located in BCNP, and 92 in ENP (Table 3). The status of these 188 deer, as of 31 March 1992 was: **censored** (transmitter loss/failure), 51 (27%); **dead**, 95 (51%); and **alive/transmitting**, 42 (22%). (Note: Five of the 42 alive/transmitting as of 31 March 1992 were still alive/transmitting as of 31 March 1995 [Table 1].)

Radio-locations.--Collectively, the 188 radio-instrumented deer "at risk" were radio-located 11,493 times between the date of capture and either the date of death/censor or 31 March 1992, which equates to a mean location rate of 61 radio-locations per deer; 4,172 (36.3%) of the 11,493 radio-locations were confirmed visually. (Note: Additionally, the 41 deer alive/transmitting as of 31 March 1992 were radio-located 1449 times between 01 April 1992 and either the date of death/censor or 31 March 1995; 395 (27.3%) of these location were confirmed visually.)

Estimates of Population Density

The density of deer observed was greater in ENP than in BCNP in 5 of 6 transect surveys: summer 1990, 0.83 vs. 1.16 deer/km² ($P>0.05$); fall 1990, 1.71 vs. 0.65 deer/km² ($P<0.05$); spring 1991, 3.89 vs. 2.23 deer/km² ($P<0.05$); summer 1991, 2.54 vs. 2.30 deer/km² ($P<0.05$); fall 1991, 2.20 vs. 0.55 deer/km² ($P<0.05$); and spring 1992, 1.73 vs. 0.71 deer/km² ($P<0.05$) (Table 4; Fig 3). However, the mean density of deer observed on the 6 transect surveys in ENP (2.15 deer/km²) and BCNP (1.27 deer/km²) did not differ ($P>0.05$) (Table 4).

The density of deer observed on transect surveys represents a minimum density. Thus, actual deer density was estimated by multiplying the observed density by the reciprocal of the observability coefficient derived (in 1990) for each survey season. Again, the estimated density of deer was greater in ENP than in BCNP in 4 of the 6 surveys--fall 1990 and 1991, and spring 1991 and 1992. The mean estimated density of deer in ENP (4.68 deer/km²) was greater than in BCNP (3.65 km²); the means, however, did not differ statistically ($P>0.05$).

The higher observed (1990) and estimated (1990 and 1991) densities of deer in BCNP in summer, in contrast to ENP, may be partially attributable to differences in the fawn component of the populations. Fawns comprised a greater proportion of total deer observed in BCNP than in ENP during each summer survey period, e.g., 12% vs. 7% in 1991. Inasmuch as fawn visibility is not inherently greater in BCNP than in ENP (Labisky et al. 1992), the higher proportion of fawns observed in BCNP is likely a product of greater fawn survival in BCNP in contrast to ENP (see Table 7).

The principal factor underpinning the higher observed and estimated density of deer in ENP, in contrast to BCNP, is related to the disparity in sex ratio among adults. Males comprised 45.6% of the adult population in the nonhunted ENP, but only 21.5% of the adult population in the hunted BCNP (see Table 6). Thus, the density of males in ENP was double (112%) that in BCNP. If the male component of the population in BCNP was augmented to the level of that recorded in ENP, the differences in population

density between the 2 areas would be reduced by 80%. This observation indicates that the density of deer in BCNP and ENP would be similar in the absence of hunting in BCNP, and, in turn, that the carrying capacity of the 2 sites is reasonably similar. *untrue*

The density of deer approximated 3.5-4.0 deer/km² in the hunted BCNP and 4.5-5.0 in the nonhunted ENP population during 1990, 1991, and 1992. In light of the absence of catastrophic environmental events in the years during and preceding the study, the ENP population probably is functioning at, or near, carrying capacity. Thus, the carrying capacity of this wet prairie/tree island environment appears to approximate 5 deer/km².

Bozzo and Schortemeyer (1993) reported estimated densities for 3 habitat types (units) in BCNP for the years 1989-91: wet prairie/tree island (Stairsteps), 1.5 deer/km²; hammock/marsh (Bear Island), 1.8 deer/km²; and pine/cypress (Corn Dance), 1.1 deer/km². Loveless (1959) reported an estimated density of 2.2 deer/km² for Everglades Water Conservation Areas 2 and 3. And, Smith et al. (1990) reported an estimated density of 0.5 deer/km² for a dry prairie site in the eastern portion of ENP. Thus, the density estimates derived from this study equal or exceed those reported for other habitats in the Everglades system, which, in turn, suggests that the wet prairie/tree island complex represents an important habitat for maintaining deer populations in south Florida.

Population Structure

Sex structure.--The sex ratio among the 94 fawns captured was 54% males, and did not differ from equity ($P>0.05$). Neither did sex ratios among fawns differ ($P>0.05$) from equity among years or between BCNP and ENP (Table 5).

The finding that the sex ratio of fawns did not differ between the hunted BCNP population and the nonhunted ENP population contrasts with both experimental and field evidence, and thus, merits comment. Disparity in fetal sex ratios, favoring males, has been correlated with inadequate nutrition of breeding females (Verme 1965, 1969) and with delayed breeding of females after the onset of the estrus (Verme and Ozoga 1981). The latter finding suggests that if the population is skewed toward females as a result of the intensive harvest of males, there may be insufficient males to service females within the first 24-36 h of estrus. This compensating mechanism would facilitate a balance in the population sex ratio. Richter and Labisky (1985) provided evidence in support of this mechanism in Florida by demonstrating a skewness toward males in fetal sex ratios from hunted populations (56% males) in contrast to nonhunted populations (39% males). The failure to detect a skewness toward males among fawns in the intensively hunted BCNP

(mean male harvest rate=48%) likely reflects supplementation of the male breeding component in BCNP by the influx of males from the adjacent nonhunted ENP during the rutting season (Sargent 1992).

Among adults, females dominated the hunted BCNP population; the sex ratio being 4.7 females/male (17.5% males) in 1990 and 3.1 females/male (24.6% males) in 1991 (Table 6). The apparent increase in males between 1990 and 1991 was probably attributable to the low rate of harvest (33%) of males in BCNP in 1990 (see Table 11). In contrast to BCNP, the adult sex ratio in the nonhunted ENP population approached parity, being 1.1 females/male (48.6% males) in 1990 and 1.3 females/male (43.7% males) in 1991. Supportively, males in ENP exhibited high survival rates (mean=0.8351) relative to those in BCNP (mean=0.4308) during 1989, 1990, and 1991 (see Table 9).

Among adult deer, a preponderance of females is typical among populations in which annual harvests are restricted to males (McCullough 1984). Adult sex ratios reported for the hunted BCNP in this study are consistent with those reported from other hunted populations in south Florida environments, i.e., 3.6-4.6 females/male (Crossett and Johnson 1990, McCown 1990). Similarly, adult sex ratios reported from the nonhunted ENP are relatively similar to those recorded from other nonhunted populations in south Florida, i.e., 1.2-2.0 females/male (Smith et al. 1989, McCown 1990).

Age structure.--The mean age of yearling/adult females captured during 1989, 1990, and 1991 did not differ ($P>0.05$) between BCNP (3.29 years, $n=24$) and ENP (3.33 years, $n=29$). Collectively, the age profile of adult females from BCNP and ENP ($n=47$) was: 2 yrs, 30%; 3 yrs, 45%; and ≥ 4 yrs, 26%. Comparatively, the age profile among adult females ($n=143$) from 5 disjunct populations in Florida was: 2 yrs, 30%; 3 yrs, 25%; and ≥ 4 yrs, 45% (Richter and Labisky 1985). Thus, the age profile in BCNP/ENP appears to be equivalent to, or perhaps slightly younger, than that in other Florida populations.

The mean age of yearling/adult males captured during 1989, 1990, and 1991 years differed ($P<0.05$) between the hunted BCNP population (2.68 ± 0.23 (SE) years, $n=28$) and the nonhunted ENP population (3.88 ± 0.18 (SE) years, $n=26$). The younger age profile among males in BCNP was an expected result of the removal of males by hunting.

Reproduction/Productivity

The mean conception date in the BCNP/ENP deer population was 6 August (Sargent 1992); this date coincides with the mean breeding date of 10 August reported from the northern portion of

the Everglades system (Rotenberger Wildlife Management Area [WMA]) by Richter and Labisky (1985). The median fawning date for the population was 22 February (Boulay 1992).

In Florida, rates of pregnancy among deer populations are low among fawns (14%) and relatively high among yearlings (93%) and adults ((92%) (Richter and Labisky 1985). In the northern portion of the Everglades system (Rotenberger WMA), the pregnancy rate among yearling and adult females averaged 96% (n=46) during the 4 years, 1978-81 (Richter and Labisky 1985). In the southwestern Everglades, the collective pregnancy rate for yearling and adult females from 5 sites (Bear Island, Raccoon Point, Fakahatchee Strand State Preserve, Florida Panther National Wildlife Refuge, and Collier Enterprises averaged 87% (n=114) for the 6 years, 1984-90 (Forrester 1991). Interestingly, rates of pregnancy for deer inhabiting the dry prairie of the eastern Everglades are lower; Smith et al. (1989, 1990) reported a mean pregnancy rate of 79% for the 3 years, 1987-89, and Forrester (1990), a mean rate of 75% for the 2 years, 1988-89. In the BCNP/ENP study site, 96% (n= 25) of adult females captured in 1989 gave birth to at least a singleton fawns (Labisky et al. 1990). No evidence of breeding by females fawns was observed in this study, which corroborates the observations of Smith (1992) in the eastern Everglades. Thus, the pregnancy rate among reproductively mature females in the BCNP/ENP study area compares favorably with that from other sites in the Everglades system, and appears to be notably higher than that in the drier habitat of the eastern Everglades.

The number of fetuses per pregnant doe, derived by necropsy, for deer populations throughout Florida has been reported within the narrow range of 1.28 (Richter and Labisky 1985) and 1.30 (Harlow and Jones 1965). Comparatively, the number of fetuses per pregnant female averaged 1.25 (n=48, 25% with twins) in the northern portion of the Everglades system (Richter and Labisky 1985) and 1.21 (n=112, 21% with twins) in the southwestern portion (Forrester 1991). In the BCNP/ENP study area, the frequency of litter sizes (albeit minimum) ascertained at capture or by subsequent radio-locations for 14 females in 1989 was: singletons, 12 (86%) and twins, 2 (14%); these litters equated to a minimum productivity of 1.14 fawns per fecund female. And, in the Stairsteps Unit of BCNP, the number of fetuses per pregnant female averaged 1.44 (n=12, 44% with twins) in 1988 and 1990; however, in the eastern Everglades during the same years, the number of fetuses per pregnant female averaged (n=12, 0% with twins) (Forrester and Wright 1989; Forrester 1990). The latter finding is in concert with the findings of Smith et al. (1992), who reported the occurrence of only singleton births in the eastern Everglades. Thus, although singleton births appear characteristic of the dry prairie habitat of the Everglades, multiple litters appear to comprise about 25% of the births in the wet prairie habitat. (Note: Three litters of neonatal

triplets were observed during capture flights in the BCNP/ENP study area in 1989; however, no triplets were observed in 1990 or 1991).

No difference in fawn productivity, as determined by the radio-monitoring of adult females, was observed between the BCNP and ENP study sites. Pooled data for the 3 years, 1989-91, revealed that 79% of the radio-instrumented adults in BCNP (n=42) and 79% of those in ENP (n=39) were observed with ≥ 1 fawn (Boulay 1992). (Note: These rates must be considered minimal because of the occurrence of neonatal mortality and the failure to observe neonates from the aerial surveys.)

In conclusion, the productivity of females in the BCNP/ENP population equals or exceeds that of other populations in the Everglades system. Nonetheless, the productivity of deer in Florida, including the Everglades system, is still substantially less than that reported for populations not only in the South, but also throughout eastern North America (Richter and Labisky 1985).

Survival/Mortality

Fawns.--Annual survival rates of fawns, gender ignored, did not differ ($P>0.05$) among years in BCNP/ENP, being 0.1169, 0.3466, and 0.02981 in 1989-90, 1990-91, and 1991-92, respectively; the mean survival rate of fawns for the 3 biological years, data pooled, was 0.2333 (Table 7). These annual survival rates were less than the estimated survival rates of 33%, 62%, and 45% reported for fawns in the eastern Everglades for the 3 years, 1987-89, respectively (Smith et al. 1990), and notably less than the $>80\%$ survivorship of fawns in an central Illinois population during the 5-year period, 1981-86 (Nixon et al. 1991). These low survival rates of fawns in BCNP/ENP evince that fawn mortality is a depressant to recruitment, and, thus, population growth.

Annual survival rates within gender, among years, differed ($P<0.05$) only for male fawns in BCNP between 1990-91 and 1991-92 (0.5002 vs. 0.7111, respectively) and for female fawns, data pooled, between 1990-91 and 1991-92 (0.3875 vs. 0.1543, respectively) (Table 7).

Annual survival rates between sexes, among years, differed ($P<0.05$) only in ENP in 1990-91 (male fawns, 0.0000 vs. female fawns, 0.2679) (Table 7).

With respect to study site, annual survival rates within gender, among years, differed ($P<0.05$) between BCNP and ENP only for male fawns in 1991-92 (0.7111 vs. 0.0000, respectively) and for male fawns, data pooled (0.5492 vs. 0.0000, respectively) (Table 7). Annual survival rates for fawns, gender ignored,

differed ($P < 0.05$) between BCNP and ENP in 1991-92 (0.5093 vs. 0.0000, respectively), and for years pooled (0.4260 vs. 0.0000).

Predation by bobcats was the primary cause of death among fawns in both BCNP and ENP (Table 10). Of the 52 fawn deaths, 31 (60%) were attributable to bobcat predation, 19 (37%) to undetermined causes, and 2 (4%) to malnutrition. Thus, the mortality due to bobcat predation exceeded all other causes of death combined. (Note: If the death rate among known causes of death were applied to deaths attributable to "undetermined causes", the mortality of fawns due to bobcat predation would approximate 94%. Thus, in all likelihood, bobcat predation of fawns exceeded the measured 60%, and probably approached the 80-90% level.) Mortality rates of fawns due to bobcat predation tended to be greater for males (68%) than for females (32%), and greater in ENP (66%) than in BCNP (52%) (Table 10); these rates, however, did not differ statistically ($P > 0.05$).

Although predation on fawns by bobcats is well documented (Cook et al. 1971, Garner et al. 1976, Bartusch and Lewis 1981), the magnitude of predation in the southeastern U.S. is notably high (60-85%) (Epstein et al. 1985; this study). Interestingly, studies of bobcat food habits reveal that deer constitute only a minor portion (<5%) of the bobcat's diet in Florida (Maehr and Brady 1986, Wassmer et al. 1988, Land 1991). Tentatively, this seeming disparity may be explained by the fact that the predation on fawns by bobcats occurs during a narrow temporal window, e.g., 60% of the losses to bobcats in BCNP/ENP occurred in June and July (Boulay 1992); thus, losses of fawns to bobcats may be underestimated due to sampling biases or simply "averaged-out" in food habits studies spanning the annual cycle.

In summary, the survival rate for fawns in BCNP (0.4260) was within the range of those reported for other white-tailed deer populations in which predation was a principal cause of death (see review by Boulay 1992). **However, the fact that no radio-instrumented male or female fawn "at risk" in ENP survived their first year of life during the 3-year study is unprecedented, and undoubtedly reflects the high incidence of predation by bobcats.**

Yearlings.--Small sample sizes of yearlings preclude a definitive assessment of the survival mechanics of this age cohort. The probability of survival of yearlings in BCNP/ENP, data pooled for the 3 biological years, 1989-90, 1990-91, and 1991-92, was 0.6563 and 1.0000 for males and females, respectively (Table 8). In northern Florida, Labisky et al. (1991) reported an annual survivorship of 100% for yearling females in 1989-90. However, Smith (1992) reported an annual survivorship of 63%, gender ignored, for yearlings in a nonhunted population in the dry prairie of the eastern Everglades for the 3 years, 1987-89. Tentatively, it appears that the probability of survival among yearlings, particularly females, is adequate for

population maintenance in BCNP/ENP; the bottleneck, however, is the lack of adequate recruitment of fawns into the yearling cohort. The harvest of males was the principal cause of death among yearlings in BCNP/ENP (Tables 10 and 11).

Adults.--Survival rates, within gender, did not differ ($P>0.05$) among years; mean annual survival rates, locations pooled, were 0.6705 and 0.8115 for adult males and adult females, respectively (Table 9). Annual survivorship between sexes differed ($P<0.05$) only for adult males (0.4546) and adult females (0.9333) within BCNP in 1991-92, and for adult males (0.6667) and adult females (0.9630), locations pooled, in 1991-92.

Annual survival rates of adult males differed ($P<0.05$) between the hunted BCNP population and the nonhunted ENP population for all 3 biological years, 1989-90, 1990-91, and 1991-92; consequently, the mean annual survival rate of adult males differed ($P<0.05$) between BCNP (0.4308) and ENP (0.8351) (Table 9). However, annual survival rates of adult females did not differ ($P>0.05$) between BCNP and ENP among years; thus, the mean annual survival rate of adult females did not differ ($P>0.05$) between BCNP (0.8734) and ENP (0.7369) (Table 9).

Comparatively, Smith et al. (1990) reported survival rates of 85% ($n=29$) and 80% ($n=20$) for adult females and males, respectively, in the nonhunted population in the eastern Everglades. Land (1991) reported a mean survival rate of 81% for adult females in the hunted Bear Island Unit of BCNP for the 4 years, 1987-91. And, in a hunted population in northern Florida, mean annual survival rates for adult females and males (including yearlings) were 90% and 56%, respectively (Labisky et al. 1991). Thus, the annual survival rates of adult females and males in BCNP and ENP compare favorably with those from other hunted and nonhunted populations, respectively, in Florida.

Of the 36 recorded deaths of radio-instrumented adults, 18 (50%) were attributable to legal/illegal harvest, 10 (28%) to undetermined causes, 6 (17%) to bobcat predation, 1 (3%) to Florida panther predation, and 1 (3%) to alligator predation (Table 10).

The surprisingly high incidence of bobcat predation on adult deer in BCNP/ENP does not reflect an isolated event in Florida. Land (1991) reported that bobcats were responsible for 10 (38%) of 26 deaths of adult females in the Bear Island Unit of BCNP during the 4 years, 1987-91. And in a northern Florida study, bobcat predation accounted for 2 (17%) of 12 deaths of yearling and adult deer during the 3 years, 1988-89, 1989-90, and 1990-91 (Labisky et al. 1991).

The bobcat is an ambush predator (Kleiman and Eisenberg 1973), and is opportunistic. In the wet prairie habitat of

BCNP/ENP, the occurrence of pinnacle rock, dense stands of sawgrass, and seasonally high water levels may restrict both the mobility of deer and provide "stalking" cover for the bobcat. To illustrate, of the 7 yearling and adult deer killed by bobcats in this study, 4 were ambushed from either dense sawgrass or pinnacle rock, and 3, all adult females, were uniquely vulnerable (1 emaciated, 1 in process of giving birth, and 1 approaching parturition).

As expected, the survival rate of adult males was less in the hunted BCNP population than in the nonhunted ENP population. Harvest, legal and illegal, accounted for 17 (94%) of the 18 deaths of radio-instrumented yearling (3 of 3) and adult (14 of 15) males recorded in BCNP during the 3 years, 1989-91. Further, 57%, 33%, and 50% of available yearling and adult males were harvested in BCNP during the fall hunting seasons of 1989, 1990, and 1991, respectively (Table 11). Annual harvest rates in BCNP, years pooled, averaged 33% for yearling males and 48% for adult males.

Population.--Survival rates of yearling and adult deer, gender ignored, in both the hunted BCNP population and the nonhunted ENP population were generally within the demographic limits for low density, stationary populations. Furthermore, annual survival rates of fawns in the hunted BCNP population, with the exception of female fawns in 1991-92, were adequate for maintaining stationary population growth. However, the total lack of survival among both male and female radio-instrumented fawns in the nonhunted ENP during this 3-year study indicates the ENP population is in demographic collapse. The single greatest cause of death among fawns in this wet prairie system was predation by bobcats. Speculatively, high bobcat density, low alternative prey availability, and coincident parturition cycles for both predator and prey are probable factors contributing to the high level of bobcat predation on deer, especially fawns. Regardless of the ecological circumstances, the high losses of fawns to bobcats is a depressant to the recruitment of animals into the breeding population. Thus, bobcat predation appears to be the principal mortality agent in regulating deer abundance in this wet prairie ecosystem.

Recruitment

Only 5 (9%) of 55 radio-instrumented fawns (censored fawns excluded) in BCNP/ENP survived to 18 months of age, the age of recruitment to the breeding population. Annual recruitment of fawns born in 1989, 1990, and 1991 was 25% (n=12), 10% (n=21), and 0% (n=22). With respect to location, 4 (15%: 3 males, 1 female) of 27 fawns (15 males, 12 females) were recruited in BCNP, and 1 (4%: 1 female) of 28 (18 males, 10 females) were recruited in ENP. With respect to gender, 3 (9%: 3 in BCNP, 0 in ENP) of 33 male fawns and 2 (9%: 1 in BCNP, 1 in ENP) of 22

female fawns were recruited to the breeding population. Notably, no female fawns were recruited to the ENP population in either 1990 or 1991, and no male fawns were recruited to either the BCNP or ENP populations in 1991. These levels of recruitment were markedly less than required to replace annual losses of either adult males (33%) or adult females (19%) in the BCNP/ENP population (Table 9).

Population Models

Data-based population models.--Model outputs of data-based population growth for the hunted BCNP population revealed a stationary population in 1989-90 (deterministic r [dr], 0.054; stochastic r [sr], 0.030), a slightly increasing population in 1990-91 (dr , 0.1000; sr , 0.077), and a markedly declining population in 1991-92 (dr , -0.004, sr , -0.050) (Table 12, Fig. 4). The decline in population growth in 1991-92 was a reflection of a reduction the survival of female fawns (0.5000 in 1989-90 and 1990-91 vs. 0.2500 in 1991-91).

Model outputs of data-based population growth for the nonhunted ENP population revealed sharply declining populations for all 3 years, 1989-90 (dr , -.0758; sr , -0.772), 1990-91 (dr , -0.115; sr , -0.158), and 1991-92 (dr , -0.241; sr , -0.241) (Table 13, Fig. 5). These populations exhibited an extinction probability of 1.000. The driving demographic force behind the modeled collapse of the ENP deer population was the almost negligible recruitment of fawns into the yearling cohort.

Maintenance models.--Models that projected the maintenance of stationary population levels were derived by manipulating the data-based mortality rates of the age/sex cohorts of the populations, holding all other parameters constant. The most applicable model for the hunted BCNP population was derived using the following mortality rates: females--55%, 5%, and 15% for fawns, yearlings, and adults, respectively, and males--55%, 35%, and 50% for fawns, yearlings, and adults, respectively. This maintenance model yielded a positive growth rate (dr , 0.057; sr , 0.036); a population sex ratio of 23% males, which was consistent with that reflected by aerial-transect surveys (see Table 6), and a low probability of extinction (0.040) (Table 14, Fig. 6).

This maintenance model for the BCNP population was then manipulated to reflect an increased harvest (mortality) of males, specifically from 35% to 50% for yearlings and from 50% to 70% for adults (Table 14, Fig. 6). This increased level of harvest of males basically had little effect on either short-term or long-term population growth. Thus, the harvest of males in BCNP, up to rates of 50% for yearlings and 70% for adults, would appear not to compromise population abundance, provided that other demographic constants in the model were not violated.

A further modification of the maintenance model for hunted BCNP population superimposed an incremental 5% increase (15% to 20%) in the mortality rate of adult females to the increased harvest of males (described above). This model scenario yielded a declining population, which reflects the sensitivity of adult female mortality in the model (Table 14, Fig. 6). Thus, the illegal harvest of females, yearling or adult, from the BCNP population would constitute a depressant to population growth.

The most applicable maintenance model for the nonhunted ENP population was derived using the following mortality rates: females--40%, 5%, and 15% for fawns, yearlings, and adults, respectively, and males--50%, 5%, and 20%, respectively. This model yielded a positive growth rate (dr , 0.122; sr , 0.102); a population sex ratio of 42% males, which was consistent with that reflected by aerial-transect surveys (see Table 6), and no probability of extinction (Table 15, Fig. 7). However, to achieve this stationary level of population growth in ENP, the rates of fawn mortality had to be relaxed by increments of 15% (55% to 40%) for females and 5% (55% to 50%) for males in relation to those rates incorporated in the maintenance model for BCNP.

This maintenance model for ENP was manipulated to reflect an incremental 5% increase in female fawn mortality (40% to 45%), and superimposed on that, an incremental 5% increase in adult female mortality. The incremental 5% increase in female fawn mortality yielded only a slight decline in population growth, whereas the incremental 5% increase in both fawn and adult female mortality effect, as expected, produced a stronger decline (Table 15, Fig. 7). Thus, manipulation of the maintenance models for both BCNP and ENP indicated that the most sensitive elements in these population models are the mortality of fawns, especially females, and adult females.

Catastrophe models.--The maintenance models were used as the base models for measuring the impacts of hurricanes and floods, singly and combined, in both the hunted BCNP and nonhunted ENP deer populations. The impact of both environmental catastrophes were held constant for both populations. The catastrophic inputs were: hurricanes--5% frequency, 5 % reduction in survival, and 50% reduction in productivity; and floods--10% frequency, 50% reduction in survival, and 50% reduction in productivity.

The impact of hurricanes on population growth in BCNP was detectable in BCNP (dr , 0.049; sr , 0.020; extinction probability, 0.040), but not in ENP (dr , 0.113; sr , 0.095; extinction probability, 0.000) (Tables 16 and 17; Figs. 8 and 9). The impacts of floods generated precipitous declines in both deer populations; the decline, however, was more severe in the hunted BCNP population (dr , -0.014; sr , -0.074; extinction probability, 0.910) than in the nonhunted ENP population (dr , 0.049; sr ,

0.006; extinction probability, 0.220) (Tables 16 and 17, Figs. 8 and 9). Similarly, the combined impacts of both hurricanes and floods were a greater depressant to population growth in BCNP (dr , -0.022; sr , -0.090; extinction probability, 0.960) than in ENP (dr , 0.040; sr , 0.004; extinction probability, 0.290) (Tables 16 and 17, Figs. 8 and 9).

These findings relating to catastrophic events revealed that hurricanes in the subtropical system of the Everglades do not constitute a major depressant to the sustained population growth of deer. Floods, however, are a serious depressant to population growth, and result in precipitous declines in the abundance of deer. Notably, both hurricanes and floods exerted greater negative impacts on the hunted population than on the nonhunted population. To illustrate, the relative long-term (100 years) decline in population size due to floods was approximately 70% in BCNP, but only about 55% in ENP. Speculatively, the greater vulnerability to natural catastrophes of the hunted BCNP population, in contrast to the nonhunted ENP population, may be related to the lower standing crop of deer that results from removal by harvest, i.e., lower density populations exhibit less demographic resiliency.

Spatial Distributions

Adult males.--Mean annual home ranges of adult males were larger ($P<0.05$) in BCNP (7.0 km²) than in ENP (2.9 km²) (Table 18). Similarly, mean annual core areas of adult males were larger ($P<0.05$) in size in BCNP (3.3 km²) than in ENP (1.0 km²) (Sargent 1992).

Mean home range size of adult males in BCNP did not differ ($P>0.05$) between the wet season (5.5 km²) and dry season (3.7 km²); however, mean home range size of adult males in ENP was larger ($P<0.05$) during the wet season (3.2 km²) than the dry season (2.9 km²) (Table 18). Notably, both wet- and dry-season home ranges of adult males in BCNP exceeded ($P<0.05$) those of their counterparts in ENP.

Mean home ranges of adult males in BCNP did not differ ($P>0.05$) among biological seasons (Table 18). Home range size among adult males in ENP did not differ ($P>0.05$) between GEST/HUNT and PART seasons; however, mean RUT-season home ranges of adult males in ENP (2.4 km²) were larger ($P<0.05$) than LACT- (1.5 km²), GEST/HUNT- (1.2 km²), and PART- (0.6 km²) season home ranges (Table 18). Further, home range size of adult males during the LACT season in ENP was greater ($P<0.05$) than during the GEST/HUNT and PART seasons.

Home range sizes of adult males in BCNP exceeded ($P<0.05$) those in ENP for all biological seasons (Table 18). Notably, the mean home range size of adult males in BCNP during the GEST/HUNT

season was larger ($P < 0.05$) than that of adult males during the RUT season in ENP.

Annual home range sizes of adult males from nonmigratory populations of white-tailed deer beyond Florida have been reported within the range of 1.0-4.9 km² (Progulske and Baskett 1958, Thomas et al. 1964, Michael 1965, Gavin et al. 1984). In northern Florida, annual home ranges of adult males have been reported within the range of 2.0-6.2 km² (Smith 1970, Labisky et al. 1991). Thus, comparatively, the home range sizes of adult males in the subtropical Everglades system, particularly those in the hunted BCNP population, were larger than those of their non-migratory counterparts in south and north temperate environments.

Adult and yearling male deer in the hunted BCNP population did not move regularly into the sanctuary of ENP (refuge) to avoid hunting activity (Sargent 1992); this finding supports the conclusions of previous studies (Hawkins et al. 1971, Kammermeyer and Marchinton 1976, Pilcher and Wampler 1982, Root et al. 1988, Nixon et al. 1991). However, a few adult males from ENP entered BCNP to participate in rut, and then returned to ENP before, or coincident with, the onset of hunting in the BCNP (Sargent 1992); these ENP males likely entered the BCNP breeding population due to the reduced competition for females as a result of the annual removal of males by hunting in BCNP.

Adult females.--The mean annual home range size of adult females in BCNP (5.4 km²) exceeded ($P < 0.05$) that of their counterparts in ENP (3.0 km²) (Table 18). Similarly, mean core area size of adult females in BCNP (1.2 km²) exceeded ($P < 0.05$) that of adult females in ENP (0.6 km²) (Zultowsky 1992). The mean proportion of the annual home range area included in the core areas was similar ($P > 0.05$) in BCNP (25%) and ENP (25%) (Zultowsky 1992).

Mean home range sizes of adult females did not differ ($P > 0.05$) between wet and dry seasons in either BCNP (wet, 3.2 km²; dry, 4.0 km²) or ENP (wet, 2.2 km²; dry, 2.5 km²) (Table 18). Mean home range size during the dry season in BCNP exceeded ($P < 0.05$) that in ENP; however, mean home range size during the wet season did not differ ($P > 0.05$) between BCNP and ENP (Table 18).

In BCNP, the mean home range size of adult females during GEST/HUNT (3.1 km²) exceeded ($P < 0.05$) that during RUT (1.7 km²), PART (1.8 km²), and LACT (1.3 km²) (Table 18). Also, the mean home range size of adult females in BCNP during PART exceeded ($P < 0.05$) that during LACT; however, mean home range size did not differ ($P > 0.05$) between PART and LACT. Mean home range sizes of adult females in ENP did not differ ($P > 0.05$) among biological seasons (LACT, 0.9 km²; RUT, 1.5 km²; GEST/HUNT, 1.2 km²; PART, 1.3 km²) (Table 18).

Mean home range sizes of adult females in BCNP exceeded ($P < 0.05$) those of adult females in ENP during the biological seasons of GEST/HUNT, PART, and LACT; however, home range sizes during RUT did not differ ($P > 0.05$) between BCNP and ENP.

Home range sizes of adult female deer in the Everglades system were similar or larger than those reported from other nonmigratory populations in Florida (2.7 km², Bridges 1968; 2.4 km², Land 1991; 4.3 km², Labisky et al. 1991; 2.0 km², Easton 1993). The large home ranges of adult females in the wet prairie ecosystem of BCNP/ENP probably resulted from a combination of factors: open terrain; low population density; high predation; fluctuating hydroperiods; and quite probably, low nutritional quality of forages (Zultowsky 1993).

Population.--Annual home ranges sizes of both adult males and adult females were greater in the hunted BCNP population than in the nonhunted ENP population, as were wet- and dry-season home ranges. And, with the exception of the RUT-season for females, the seasonal home ranges of both adult males and adult females were greater in BCNP than in ENP. Home ranges of adult males were greater during the wet season than the dry season, which probably reflects the fact that the rutting period occurs during the wet season. However, home ranges of adult females were greater during the dry season than during the wet season; the smaller home range size of females during the wet season may be a reflection of greater food availability.

Loveless (1959) reported that water depths ≥ 0.6 m restricted the movements of deer in the Everglades system. In this study, water depths in the BCNP/ENP study area rarely exceeded 0.3 m; thus, as expected, restricted movements of males or females, attributable to high-water levels were not observed.

The fact that the rutting season in this subtropical ecosystem is completed prior to the onset of annual hunting offered an unprecedented opportunity to compare simultaneously the movements of deer in a hunted (BCNP) and a nonhunted population (ENP). Normally, both adult males and females increase their movements, and home range size, during the breeding season, after which both movements and home range size diminish. The expected increase in home range size during the rutting season occurred in both BCNP and ENP (Table 18). However, the decline in home range size following the rutting season occurred only in the nonhunted ENP population. In the hunted BCNP population, home range sizes of both male and females increased between the rutting season and the subsequent hunting season, and did not decline until after the hunting season. This observation suggests that hunting activities constituted a spatial disturbance for deer in the hunted BCNP population. Speculatively, the increased bioenergetic costs associated with expanded movements of breeding females (pregnant) as a result of

hunting activities could reduce female productivity (Zultowsky 1993).

Habitat Use/Selection

Home range size and habitat.--Home range size of deer did not differ ($P>0.05$) between BCNP and ENP within the 3 habitat-types (cypress edge, prairie, and ridge); thus, data from the 2 areas were pooled by habitat-type. Home range sizes differed ($P<0.05$) among the 3 habitat-types for both females (cypress edge, 9.3 km²; prairie, 5.6 km²; ridge, 2.5 km²) and males (cypress edge, 9.9 km²; prairie, 7.1 km²; ridge, 5.4 km²) (Table 19). Core area sizes differed ($P<0.05$) among habitat-types for females, but not ($P>0.05$) for males. Thus, home ranges of both genders were largest in cypress edge, intermediate in prairie, and smallest in ridge; core area sizes followed a similar pattern. Home ranges were characteristically elliptical in shape in the prairie habitat-type and circular in shape in the ridge habitat-type (Miller 1993).

Home range and core area sizes of females were inversely correlated with the availability of hardwood tree islands and the proportion of edge; however, home range and core area sizes of males was inversely correlated only with the proportion of edge (Miller 1993). Thus, core areas were larger in the areas where habitat interspersion was low (minimal edge), e.g., prairie, and smaller in areas where habitat interspersion was high (abundant edge), e.g., ridge.

Habitat use.--The use of specific vegetation-types within their home ranges differed ($P<0.001$) for both males and females (Fig. 10). To illustrate, the relative use of wet prairie (WPR) was 39% for females and 14% for males, whereas the relative use of hardwood tree islands (HWD) was 30% for females and 47% for males. The comparatively greater use of the wet prairie by females and greater use of tree islands by males is supported by the food intake (derived from the microscopic analyses of rumen content [Johnson 1982]) of adult females and adult males on the study site. Aquatic herbs (principally swamp lily [*Crinum americanum*]) comprised 69% of the diet of females, but only 41% of the diet of males; conversely, woody plants comprised 35% of the diet of males, but only 21% of the diet of females (Hurd et al. 1995). This differential habitat use, which supports current sex segregation theory among ungulates (see review by Main and Coblentz 1990), can be attributed to behaviors that end to maximize reproductive fitness by each sex. The maximization of reproductive fitness among males involves the enhancement of physical mass and strength, whereas among females, it involves strategies to ensure the survival of offspring (Main 1994). Males, due to their proportionately larger rumen volume, apparently can ingest greater quantities of food than females and, thus, can subsist on abundant, lower quality forages

(McCullough 1979, Bowyer 1984, Bier 1987). Thus, to maximize reproductive fitness, males optimize their foraging opportunities on hardwood tree islands, which likely support a higher biomass of forage per unit area than other habitats, whereas females optimize their foraging in the open prairie to decrease the risk of predation on their offspring by bobcats.

Habitat selection.--The principal habitats on the BCNP/ENP study site were not used in proportion to their availability in either prairie or ridge habitat-types (Table 20). Hardwood tree islands (HWD) and willow/sawgrass (WS) were used more ($P < 0.001$) than expected, based on availability, by males and females in both prairie and ridge sites. Conversely, with exception of the proportionate use of herbaceous prairie (HPR) by females in the ridge site, wet prairies (WPR) and HPR were used less ($P < 0.001$) than expected by both males and females in both sites (Table 20).

Space use and resource availability.--Home range size is correlated inversely with both population density (Marchinton and Hirth 1984) and resource availability (Ford 1983). However, both the ENP and BCNP deer populations exist at low densities (4.5 deer/km² and 3.5 deer/km², respectively), which minimizes the effect of population density on the use of space. Furthermore, because home ranges of deer were larger in the prairie habitat-type than in the ridge habitat-type, even within the nonhunted ENP site, suggests that the use of space by deer in BCNP/ENP is influenced principally by resource availability. Larger, linear home ranges were characteristic of the open prairie, which was typified by a low interspersions of habitats and, thus, a low frequency of edge; smaller, circular home ranges were characteristic of the ridge, which was typified by a moderate interspersions of habitats, and, thus, a moderate frequency of edge. Consequently, deer in the ridge habitat-type appeared to be able to meet their needs in a smaller unit of space than those in the prairie habitat-type because of the increased availability and interspersions of resources. Thus, landscape diversity is an important factor governing the distribution of deer in space.

ASSESSMENT OF POPULATIONS

The populations of deer in the wet prairie of the Everglades system, as evidenced by the demographics obtained during this 3-year study, 1989-90, 1990-91, and 1991-92, must be evaluated on the basis of the operative management regime--hunted or protected. Population growth, as derived from data-based models, was precipitously negative in the nonhunted ENP population, and only marginally stationary in the hunted BCNP population. Furthermore, it must be identified that neither of these populations experienced the impacts of natural catastrophes during the study, or in decade preceding the study. Notably, in the absence of natural catastrophes, the removal of males through

harvest, under the current hunting regime, did not appear to be a factor in restricting population growth (size) in BCNP.

The major depressant to population growth, and to potential population recovery, focuses on the low rate of fawn survival, especially in the nonhunted ENP population. To illustrate, no radio-instrumented female fawn "at risk" in ENP survived to be recruited into the yearling cohort during the 3-year study. In short, the rates of recruitment of fawns were grossly inadequate to replace annual losses of adults in ENP, and only marginally adequate in BCNP. Predation by bobcats was responsible for 60% (possibly 90% [extrapolated]) of all fawn deaths, and 17% of all adult deaths. Thus, predation by bobcats appeared to be the single most important factor involved in regulating the growth and abundance of deer in this wet prairie ecosystem.

The potential impacts of natural catastrophes on these populations must also be considered. Since the completion of this study in March of 1992, the deer population in the BCNP/ENP was impacted by Hurricane Andrew in the late summer of 1992 and by a severe flood in the late summer/fall of 1994. The superimposing of these catastrophes on models of stationary population growth revealed that whereas the impacts of hurricanes on population growth were relatively minor, the impacts of flood were devastating. Furthermore, these catastrophic events, especially floods, had greater negative impacts on the hunted BCNP population than on the nonhunted ENP population. Speculatively, the latter finding suggests that populations at artificially lower densities, due to the removal of animals through harvest, exhibit a reduced demographic resiliency to respond to adverse environmental events.

MANAGEMENT CONSIDERATIONS

Positive growth in the BCNP and ENP deer populations, especially the latter, is currently precluded by the high level of predation on fawns. Although this problem is imminently critical if immediate recovery of the population is to be achieved, it is less critical with respect to recovery "down-the-road". The bobcat and deer represent the classic, vertebrate predator-prey relationship (Lotka-Volterra concept), i.e., a high prey population stimulates the growth and survival of the predator population, which, in turn, reduces the prey population to a level that can no longer sustain the predator population, at which time the predator population declines. Thus, the bobcat population in BCNP/ENP, without the surge of an alternative prey species, can be expected to decline in abundance as the deer population declines. This reduction in the predator pressure, in turn, would allow the deer population to exhibit positive growth, and, thus, recover to the abundance levels dictated by the environment. This "do-nothing" approach not only is supported by

the body of evidence that demonstrates animal populations are self-regulating, but also is in concert with holistic ecosystem management. However, this approach would be subject to compromise if other management considerations, such as the provision of deer as prey for Florida panthers (or surrogates) or the maintenance of deer populations at an abundance level to support successful recreational hunting (in BCNP), emerged as priority issues.

In the lack of catastrophic natural events, the effects of annual males-only hunting in the BCNP appeared not to be deleterious to population maintenance. However, 2 additional factors must be entered into this hunting equation. First, population models revealed that flood conditions, which severely depress both survival and reproduction (Labisky and MacDonald 1995), exerted major negative impacts on the deer populations in this wet prairie system. These negative impacts were especially severe in the hunted BCNP population, and were likely associated with the lower standing crop of animals resulting from harvest. Thus, it would seem prudent to either curtail or restrict annual hunting activities in BCNP in years in which the population had been depressed by flood conditions. This action would eliminate a further reduction in population abundance through harvest, and reduce the stress on the population, especially females, resulting from hunter-disturbance, thereby, expediting population recovery. Second, if the Stairsteps Unit of BCNP is to become a prime site for recovery of the Florida panther, consideration must be given to the availability of deer, which are the primary prey of panthers (Maehr et al. 1990). Belden and Hagedorn (1993) projected an estimated annual kill rate of 42 deer per cougar/panther, and D. K. Jansen (pers. comm.) observed that >80% of the deer killed by panthers in BCNP were males ≥ 1 year in age. Thus, given the low density of deer (3.5 deer/km²), the female-dominated sex ratio (21.5% males), and the male-harvest of 48% in BCNP, the capacity of the deer population to support both a viable population of panthers and recreational hunting would appear strained, particularly in light of the current low-level of growth exhibited by the BCNP deer population.

Habitat/landscape analyses demonstrated that the availability and interspersions of habitats play an important role in the use of space by deer in the wet prairie of BCNP/ENP. Thus, habitat management should focus on increasing landscape diversity and habitat interspersions. And, despite the sparsity of information on the quantity and nutritional quality of forages available to deer seasonally in the BCNP/ENP, prescribed burning during both the winter-dormant and summer-growing seasons, must be viewed as a principal tool for enhancing the biomass, quality, and palatability of deer forages.

PRIORITY RESEARCH NEEDS

1. A study of the quantity and nutritional quality of forages available to deer seasonally in major habitat types in both BCNP and ENP. **Justification:** Information of the quantity and nutritional quality of deer forages in this wet prairie/tree island is not available. Such information is needed for 3 specific reasons: to verify if the observed differences in deer population density between BCNP and ENP are attributable to recreational hunting or to differences in the availability and nutritional quality of forages; to provide information for the development of data-based prescriptions for managing wildlife habitat; and to supply data on forage quantity and quality for the Across-Trophic-Level Systems Simulation (ATLSS) model that is being developed to predict the effects of different hydrological management regimes on the Everglades ecosystem.

2. A study of the population ecology of bobcats that is designed to elucidate population density, reproductive phenology, population demography, and prey availability. **Justification:** Predation on deer, notably fawns, by bobcats appears to be the single most important factor in regulating the population growth of deer in this wet prairie system. This information is not only essential to the management of deer populations, but also critical to the evaluation of potential competitive interactions between bobcats and panthers.

3. An annual aerial-transect survey for estimating the population density of deer in both BCNP and ENP. (Note: It is recommended that the surveys be replicated on 8 days, and be conducted in June, the calendar time at which fawns are mobile, and yearling/adult males are in "velvet" and, thereby, distinguishable from females.) **Justification:** Knowledge of trends in population abundance are prerequisite to the implementation of management regimes. Information on population size is especially critical in this ecosystem because of catastrophic natural intrusions, i.e., hurricanes, tropical storms, and floods.

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Table 1. Statistics on deer captured by helicopter netgunning and radio-instrumented on Big Cypress National Preserve (BCNP) and Everglades National Park (ENP), Florida, 28 March 1989-18 July 1991. Number of available transmitter-days and number of radio-locations are presented for each deer from date of capture through 31 March 1995.

Deer ID	Capture date	Capture location ^a	Sex	Age at capture (yrs)	Body weight (kg)	Radio freq. in MHz (Collar type) ^b	Exposure days/ 31 Mar 95 ^c	Radio locations/ 31 Mar 95 ^d	Status: 31 Mar 95
BC8901	28 Mar 89	C (BCNP)	M	Fawn: 89	04.5	151.806 (B)	269	45 (12)	Dead: bobcat predation, 21 Dec 89
BC8902	28 Mar 89	C (BCNP)	F	4.0	40.0	151.902 (F)	1123	203 (84)	Censored, 25 Apr 92
BC8903	05 Apr 89	C (BCNP)	M	Fawn: 89	11.3	151.845 (B)/151.836 (E)	1096	201 (47)	Recaptured: 06 Jan 90; censored: 25 Apr 92; dead: legal kill, 16 Dec 92
BC8904	05 Apr 89	C (BCNP)	F	4.0	35.8	151.853 (F)	881	163 (44)	Dead: alligator predation, 02 Sep 91
BC8905	05 Apr 89	C (BCNP)	F	1.0	31.3	151.863 (F)/151.010 (F)	1022	178 (23)	Censored: 07 Jun 91; recaptured: 26 Jun 91; censored: 8 Feb 92
BC8906	05 Apr 89	B (ENP)	F	3.0	39.9	151.873 (F)	309	42 (04)	Censored: 08 Feb 90
BC8907	05 Apr 89	B (ENP)	M	2.0	34.5	151.748 (E)	262	42 (06)	Dead: undetermined cause, 21 Dec 89
BC8908	05 Apr 89	C (BCNP)	F	2.0	34.0	151.931 (F)	1927	201 (91)	Censored: 15 Aug 94
BC8909	05 Apr 89	C (BCNP)	M	Fawn: 89	15.4	151.825 (B)	138	18 (06)	Censored: 22 Aug 89; dead: legal kill, 01 Dec 90
BC8910	05 Apr 89	S (BCNP)	F	3.0	36.3	151.950 (F)	934	165 (36)	Censored 26 Oct 91
BC8911	05 Apr 89	S (BCNP)	M	Fawn: 89	11.8	151.885 (B)	111	08 (02)	Dead: undetermined cause, 25 Jul 89
BC8912	06 Apr 89	S (BCNP)	M	3.0	43.5	151.836 (E)	214	24 (06)	Dead: legal kill, 05 Nov 89
BC8913	06 Apr 89	C (BCNP)	M	3.0	43.5	151.794 (E)/151.644 (E)	727	130 (05)	Censored: 07 Nov 89; recaptured: 16 Jul 90; dead: legal kill, 09 Dec 91
BC8914	06 Apr 89	B (BCNP)	F	3.0	35.8	151.916 (F)/151.322 (F)	905	326 (87)	Censored: 27 Sep 91; recaptured: 09 Aug 93; alive/transmitting
BC8915	06 Apr 89	B (ENP)	M	2.0	43.1	151.971 (E)	234	32 (11)	Dead: illegal kill, 25 Nov 89
BC8916	06 Apr 89	B (ENP)	F	(1.0) ^e	28.1	151.940 (F)	409	68 (17)	Dead: bobcat predation, 20 May 90
BC8917	06 Apr 89	C (BCNP)	M	(1.0)	28.1	151.880 (E)	599	108 (54)	Dead: legal kill, 26 Nov 90
BC8918	10 May 89	G (ENP)	F	(3.0)	42.2	151.909 (F)	65	09 (02)	Dead: undetermined cause, 13 Jul 89
BC8919	10 May 89	G (ENP)	F	4.0	35.4	151.955 (F)	311	52 (35)	Dead: bobcat predation, 16 Mar 90
BC8920	10 May 89	G (ENP)	F	(3.0)	30.8	151.965 (F)	07	00 (00)	Dead: capture myopathy, 17 May 89
BC8921	10 May 89	G (ENP)	F	3.0	41.7	151.985 (F)	868	161 (38)	Censored: 24 Sep 91
BC8922	10 May 89	B (ENP)	F	3.0	40.8	151.998 (F)	937	178 (62)	Censored: 04 Dec 91
BC8923	10 May 89	B (ENP)	M	1.0	24.9	151.920 (E)	451	77 (33)	Censored: 04 Aug 90
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	4.0	54.5	151.730 (E)	748	139 (41)	Censored: 28 May 91
BC8926	10 May 89	G (ENP)	F	(2.0)	37.6	150.976 (F)	661	134 (39)	Dead: undetermined cause, 02 Mar 91
BC8927	10 May 89	G (ENP)	M	(3.0)	51.7	151.761 (E)	493	89 (13)	Dead: illegal kill, 15 Sep 90
BC8928	11 May 89	G (ENP)	M	Fawn: 89	09.5	151.830 (B)	179	27 (07)	Dead: bobcat predation, 15 Nov 89
BC8929	11 May 89	G (ENP)	M	Fawn: 89	07.8	151.857 (B)	122	14 (02)	Dead: bobcat predation, 10 Sep 89
BC8930	11 May 89	G (ENP)	F	(3.0)	27.2	151.065 (F)	133	13 (07)	Dead: undetermined cause, 20 Sep 89
BC8931	11 May 89	G (ENP)	F	(4.0)	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	4.5	63.5	151.775 (E)	1557	209 (40)	Censored: 16 Aug 93
BC8934	11 May 89	G (ENP)	M	5.0	65.8	151.890 (E)	1079	198 (43)	Censored: 25 Apr 92

Table 1. Continued, 2 of 6.

Deer ID	Capture date	Capture location ^a	Sex	Age at capture (yrs)	Body weight (kg)	Radio freq. in MHz (Collar type) ^b	Exposure days/ 31 Mar 95 ^c	Radio locations/ 31 Mar 95 ^d	Status: 31 Mar 95
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	(1.0)	31.3	151.710 (E)	959	183 (64)	Dead: legal kill, 26 Dec 91
BC8937	11 May 89	S (ENP)	F	2.0	35.8	151.736 (F)	211	31 (02)	Censored: 09 Dec 89
BC8938	11 May 89	S (BCNP)	F	(4.0)	33.1	151.757 (F)	90	14 (04)	Dead: undetermined cause, 09 Aug 89
BC8939	11 May 89	S (ENP)	F	1.0	29.0	151.781 (F)	780	94 (19)	Censored: 01 Jul 91
BC8940	28 Jun 89	C (BCNP)	M	(3.0)	52.6	151.596 (E)	147	27 (09)	Dead: legal kill, 22 Nov 89
BC8941	28 Jun 89	C (BCNP)	F	5.5	38.1	151.692 (F)	1448	214 (72)	Censored: 16 Jun 93
BC8942	28 Jun 89	C (BCNP)	F	Fawn: 89	20.0	151.699 (B)	47	12 (02)	Censored: 14 Aug 89; dead: bobcat predation, 04 Apr 90
BC8943	28 Jun 89	G (ENP)	F	(3.0)	37.2	151.679 (F)	90	16 (12)	Dead: illegal kill, 25 Sep 89
BC8944	28 Jun 89	G (ENP)	M	Fawn: 89	21.8	151.542 (E)	262	46 (16)	Dead: panther predation, 17 Mar 90
BC8945	28 Jun 89	G (ENP)	F	3.5	30.8	151.671 (F)	1662	206 (110)	Censored: 16 Jan 94
BC8946	28 Jun 89	G (ENP)	M	3.5	49.9	151.531 (E)	1482	210 (62)	Censored: 20 Jul 93
BC8947	28 Jun 89	S (BCNP)	F	2.5	30.4	151.960 (F)	1417	199 (57)	Censored: 16 May 93
BC8948	28 Jun 89	C (BCNP)	M	Fawn: 89	12.7	151.500 (B)	126	27 (01)	Censored: 02 Nov 89
BC8949	28 Jun 89	C (BCNP)	M	(2.0)	41.7	151.522 (E)	123	22 (10)	Dead: legal kill, 29 Oct 89
BC8950	29 Jun 89	C (BCNP)	F	Fawn: 89	19.5	151.554 (B)/151.679 (F)	209	43 (09)	Recaptured: 06 Jan 90; dead: undetermined cause, 23 Jan 90
BC8951	29 Jun 89	B (ENP)	F	Fawn: 89	12.2	151.452 (B)	14	01 (01)	Dead: undetermined cause, 12 Jul 89
BC8952	29 Jun 89	G (ENP)	M	(2.5)	42.2	151.512 (E)	1508	239 (55)	Dead: undetermined cause, 16 Aug 93
BC8953	29 Jun 89	G (ENP)	F	3.0	34.9	151.663 (F)	258	44 (07)	Dead: undetermined cause, 14 Mar 90
BC8954	29 Jun 89	B (BCNP)	F	(4.0)	38.1	151.664 (F)	121	22 (15)	Dead: illegal kill, 28 Oct 89
BC8955	14 Aug 89	C (BCNP)	F	2.5	38.6	151.635 (F)	2054	205 (44)	Alive/transmitting
BC8956	14 Aug 89	C (BCNP)	M	(1.5)	34.9	151.490 (E)	390	76 (12)	Dead: legal kill, 08 Sep 90
BC8957	14 Aug 89	C (BCNP)	M	5.5	68.0	151.482 (E)	78	12 (01)	Dead: legal kill, 30 Oct 89
BC8958	14 Aug 89	B (BCNP)	F	3.5	37.6	151.623 (F)	1523	203 (70)	Censored: 16 Oct 93
BC8959	14 Aug 89	B (BCNP)	F	(2.5)	34.0	151.590 (F)	517	103 (76)	Dead: bobcat predation, 12 Jan 91
BC8960	14 Aug 89	B (BCNP)	M	3.5	44.4	151.471 (E)/151.874 (E)	2020	344 (97)	Recaptured: 14 Aug 93; dead: undetermined cause, 27 Feb 95
BC8961	14 Aug 89	G (ENP)	M	(3.5)	65.8	151.387 (E)	836	166 (31)	Dead: undetermined cause, 28 Nov 91
BC8962	14 Aug 89	G (ENP)	F	1.5	25.9	151.965 (F)	858	170 (89)	Censored: 21 Dec 91
BC8963	14 Aug 89	G (ENP)	F	2.5	34.9	151.579 (F)	1401	211 (64)	Censored: 16 Jun 93
BC8964	14 Aug 89	G (ENP)	F	(4.0)	39.9	151.569 (F)	88	17 (06)	Dead: undetermined cause, 10 Nov 89
BC9065	06 Jan 90	C (BCNP)	F	4.0	38.6	151.757 (F)	02	00 (00)	Dead: capture-related, 08 Jan 90
BC9066	06 Jan 90	C (BCNP)	F	1.5	40.4	151.065 (F)	151	31 (10)	Censored: 06 Jun 90
BC9067	06 Jan 90	C (BCNP)	F	3.0	39.5	151.306 (F)	1348	179 (95)	Censored: 16 Sep 93
BC9068	06 Jan 90	C (BCNP)	F	(2.0)	34.5	151.980 (F)	07	01 (00)	Dead: capture myopathy, 13 Jan 90
BC9069	06 Jan 90	B (BCNP)	F	(3.0)	41.2	151.909 (F)/150.031 (F)	1002	232 (161)	Censored: 20 May 91; recaptured: 10 Aug 93; dead: undetermined cause, 27 Dec 94
BC9070	06 Jan 90	C (BCNP)	F	(5.0)	42.2	151.992 (F)	87	17 (06)	Dead: bobcat predation, 03 Apr 90
BC9071	07 Jan 90	C (BCNP)	M	1.0	36.7	151.522 (E)	04	00 (00)	Dead: capture myopathy, 11 Jan 90
BC9072	07 Jan 90	G (ENP)	F	Fawn: 89	20.4	151.560 (F)	354	68 (37)	Censored: 27 Dec 90

Table 1. Continued, 3 of 6.

Deer ID	Capture date	Capture location ^a	Sex	Age at capture (yrs)	Body weight (kg)	Radio freq. in MHz (Collar type) ^b	Exposure days/ 31 Mar 95 ^c	Radio locations/ 31 Mar 95 ^d	Status: 31 Mar 95
BC9073	07 Jan 90	G (ENP)	M	Fawn: 89	17.2	151.971 (E)	27	04 (01)	Dead: undetermined cause, 03 Feb 90
BC9074	07 Jan 90	G (ENP)	M	(3.0)	39.0	151.748 (E)	12	03 (01)	Dead: undetermined cause, 19 Jan 90
BC9075	07 Jan 90	B (ENP)	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	08.5	151.452 (B)	200	39 (10)	Censored: 25 Sep 90
BC9077	09 Mar 90	C (BCNP)	M	(3.0)	35.4	151.748 (E)	267	53 (10)	Dead: legal kill, 01 Dec 90
BC9078	09 Mar 90	C (BCNP)	M	(1.0)	35.4	151.522 (E)	617	128 (59)	Dead: legal kill, 16 Nov 91
BC9079	09 Mar 90	C (BCNP)	F	Fawn: 90	07.3	151.427 (B)	233	47 (07)	Censored: 27 Oct 90
BC9080	09 Mar 90	B (BCNP)	F	Fawn: 90	08.2	151.437 (B)	88	19 (12)	Dead: undetermined cause, 05 Jun 90
BC9081	09 Mar 90	B (BCNP)	F	3.0	34.0	151.757 (F)	686	140 (109)	Censored: 25 Jan 92
BC9082	09 Mar 90	G (ENP)	F	Fawn: 90	06.5	151.396 (B)	130	25 (05)	Dead: bobcat predation, 17 Jul 90
BC9083	10 Mar 90	C (BCNP)	F	Fawn: 90	04.5	151.608 (B)	147	31 (09)	Dead: undetermined cause, 04 Aug 90
BC9084	10 Mar 90	C (BCNP)	M	Fawn: 90	09.2	151.415 (B)	165	33 (11)	Censored: 22 Aug 90; dead: legal kill, 22 Nov 92
BC9085	10 Mar 90	C (BCNP)	M	Fawn: 90	08.2	151.806 (B)/151.851 (E)	898	143 (53)	Recaptured: 07 Feb 91; censored: 25 Aug 92; dead: illegal kill, 09 Sep 92
BC9086	10 Mar 90	B (BCNP)	F	Fawn: 90	07.1	151.699 (B)	94	19 (03)	Dead: undetermined cause, 12 Jun 90
BC9087	10 Mar 90	C (BCNP)	M	Fawn: 90	04.3	151.554 (B)/150.771 (E)	513	101 (17)	Recaptured: 07 Feb 91; censored: 15 Aug 91
BC9088	10 Mar 90	G (ENP)	M	Fawn: 90	03.9	151.857 (B)	23	05 (00)	Dead: bobcat predation, 02 Apr 90
BC9089	10 Mar 90	G (ENP)	M	4.0	62.1	151.325 (E)	165	32 (07)	Censored: 23 Aug 90
BC9090	21 Mar 90	G (ENP)	M	Fawn: 90	10.4	151.830 (B)	89	17 (01)	Dead: bobcat predation, 17 Jun 90
BC9091	21 Mar 90	G (ENP)	M	4.0	54.4	151.349 (E)	989	150 (31)	Dead: undetermined cause, 04 Dec 92
BC9092	29 Mar 90	G (ENP)	F	Fawn: 90	12.7	None	00	00 (00)	Deer escaped; not radio instrumented
BC9093	29 Mar 90	G (ENP)	F	Fawn: 90	13.6	151.845 (B)	204	41 (08)	Dead: bobcat predation, 18 Oct 90
BC9094	29 Mar 90	C (BCNP)	F	Fawn: 90	06.9	151.825 (B)	01	00 (00)	Dead: capture myopathy, 30 Mar 90
BC9095	29 Mar 90	C (BCNP)	F	Fawn: 90	07.8	151.111 (B)	62	12 (02)	Dead: bobcat predation, 30 May 90
BC9096	29 Mar 90	G (ENP)	M	4.0	53.5	None	00	00 (00)	Dead: capture-related stress, 30 Mar 90
BC9097	30 Mar 90	G (ENP)	M	(3.0)	48.1	151.644 (E)	45	09 (01)	Dead: bobcat predation, 13 May 90
BC9098	06 Apr 90	C (BCNP)	M	Fawn: 90	10.0	151.500 (B)	88	19 (04)	Dead: bobcat predation, 03 Jul 90
BC9099	06 Apr 90	C (BCNP)	M	Fawn: 90	10.0	151.212 (B)	297	62 (15)	Censored: 28 Jan 91
BC90100	06 Apr 90	C (BCNP)	F	Fawn: 90	10.0	151.130 (B)	12	02 (00)	Dead: undetermined cause, 18 Apr 90
BC90101	08 Apr 90	C (BCNP)	F	Fawn: 90	08.2	151.231 (B)	395	76 (31)	Censored: 08 May 91
BC90102	08 Apr 90	C (BCNP)	M	Fawn: 90	08.6	151.039 (B)	104	22 (05)	Dead: bobcat predation, 21 Jul 90
BC90103	08 Apr 90	G (ENP)	F	Fawn: 90	10.9	151.169 (B)	88	17 (02)	Dead: undetermined cause, 05 Jul 90
BC90104	08 Apr 90	G (ENP)	F	Fawn: 90	09.1	150.312 (B)	28	06 (01)	Censored: 11 May 90
BC90105	08 Apr 90	G (ENP)	F	Fawn: 90	09.5	151.091 (B)	316	63 (21)	Dead: bobcat predation, 17 Feb 91
BC90106	08 Apr 90	G (ENP)	F	Fawn: 90	05.9	151.150 (B)	104	22 (06)	Censored: 21 Jul 90
BC90107	12 Apr 90	C (BCNP)	F	Fawn: 90	07.8	151.190 (B)/151.980 (F)	994	142 (53)	Recaptured: 07 Feb 91; dead: undetermined cause, 01 Jan 93
BC90108	12 Apr 90	C (BCNP)	M	Fawn: 90	06.5	151.825 (B)	59	12 (03)	Dead: bobcat predation, 10 Jun 90
BC90109	13 Apr 90	G (ENP)	M	4.0	56.2	151.460 (E)	584	118 (43)	Dead: illegal kill, 18 Nov 91
BC90110	21 Apr 90	G (ENP)	M	Fawn: 90	08.7	150.430 (B)	77	14 (01)	Dead: bobcat predation, 07 Jul 90
BC90111	21 Apr 90	G (ENP)	F	Fawn: 90	11.8	150.491 (B)	184	37 (10)	Censored: 22 Oct 90

Table 1. Continued, 4 of 6.

Deer ID	Capture date	Capture location ^a	Sex	Age at capture (yrs)	Body weight (kg)	Radio freq. in MHz (Collar type) ^b	Exposure days/ 31 Mar 95 ^c	Radio locations/ 31 Mar 95 ^d	Status: 31 Mar 95
BC90112	21 Apr 90	G (ENP)	M	Fawn: 90	14.5	150.371 (B)	72	14 (02)	Dead: bobcat predation, 02 Jul 90
BC90113	21 Apr 90	G (ENP)	M	Fawn: 90	08.6	150.391 (B)	08	01 (00)	Dead: bobcat predation, 29 Apr 90
BC90114	21 Apr 90	G (ENP)	F	Fawn: 90	17.2	150.452 (B)	303	62 (19)	Censored: 18 Feb 91
BC90115	29 Apr 90	G (ENP)	M	Fawn: 90	14.5	150.411 (B)	56	10 (01)	Dead: undetermined cause, 24 Jun 90
BC90116	29 Apr 90	G (ENP)	M	Fawn: 90	13.6	150.470 (B)	34	07 (01)	Dead: bobcat predation, 02 Jun 90
BC90117	29 Apr 90	C (BCNP)	M	Fawn: 90	08.9	150.350 (B)	40	08 (00)	Dead: bobcat predation, 08 Jun 90
BC90118	22 Jun 90	B (ENP)	M	(3.0)	47.2	151.332 (E)	150	28 (07)	Dead: legal kill, 19 Nov 90
BC90119	28 Jun 90	C (BCNP)	M	3.0	42.2	151.542 (E)	911	123 (32)	Dead: legal kill, 26 Dec 92
BC90120	28 Jun 90	S (ENP)	M	4.0	60.8	151.971 (E)	621	118 (35)	Censored: 10 Mar 92
BC90121	11 Jul 90	C (BCNP)	M	(4.0)	53.5	151.372 (E)	442	88 (10)	Dead: panther predation, 26 Sep 91
BC90122	16 Jul 90	C (BCNP)	M	(3.0)	47.6	151.481 (E)	489	94 (23)	Dead: legal kill, 17 Nov 91
BC90123	03 Aug 90	G (ENP)	F	2.0	32.7	150.250 (F)	1718	126 (75)	Alive/transmitting
BC90124	03 Aug 90	G (ENP)	F	2.5	37.2	151.679 (F)	1261	130 (62)	Censored: 16 Jan 94
BC90125	03 Aug 90	G (ENP)	F	2.5	33.6	151.663 (F)	1139	130 (60)	Censored: 16 Sep 93
BC90126	14 Aug 90	S (BCNP)	M	(4.0)	59.9	None	00	00 (00)	Dead: capture-related stress, 14 Aug 90
BC90127	15 Aug 90	G (ENP)	F	3.5	30.4	150.191 (F)	92	16 (05)	Censored: 15 Nov 90
BC90128	15 Aug 90	G (ENP)	M	3.5	46.3	150.870 (E)	1552	128 (61)	Censored: 15 Nov 94
BC90129	15 Aug 90	G (ENP)	F	3.5	28.1	150.072 (F)	1552	127 (102)	Censored: 15 Nov 94
BC90130	15 Aug 90	G (ENP)	M	3.5	50.4	151.595 (E)	820	109 (37)	Dead: undetermined cause, 08 Nov 92
BC90131	15 Aug 90	B (BCNP)	F	(2.5)	37.2	150.210 (F)/151.805 (F)	1535	238 (144)	Recaptured: 11 Aug 93; dead: undetermined cause, 29 Oct 94
BC90132	16 Aug 90	C (BCNP)	M	2.5	46.3	150.750 (E)	167	33 (04)	Censored: 30 Jan 91
BC90133	16 Aug 90	C (BCNP)	M	3.5	39.9	151.569 (E)	241	54 (08)	Censored: 14 Apr 91
BC90134	16 Aug 90	B (ENP)	M	4.5	51.7	150.730 (E)	285	48 (11)	Censored: 28 May 91
BC90135	16 Aug 90	B (BCNP)	F	2.5	29.0	150.290 (F)/151.612 (F)	1705	283 (168)	Recaptured: 09 Aug 93; alive/transmitting
BC90136	16 Aug 90	G (ENP)	M	5.5	49.9	150.830 (E)	120	22 (08)	Censored: 14 Dec 90
BC90137	16 Aug 90	G (ENP)	F	(3.5)	30.8	150.270 (F)	53	10 (04)	Dead: undetermined cause, 08 Oct 90
BC90138	16 Aug 90	G (ENP)	F	3.5	32.7	151.631 (F)	973	130 (86)	Censored: 16 Apr 93
BC90139	17 Aug 90	G (ENP)	F	5.5	46.3	150.131 (F)	83	15 (08)	Censored: 09 Nov 90
BC90140	17 Aug 90	G (ENP)	M	4.5	42.6	150.888 (E)	340	66 (25)	Censored: 23 Jul 91
BC90141	17 Aug 90	G (ENP)	F	5.5	28.6	150.148 (F)/150.270 (F)	1086	123 (97))	Censored: 05 Jun 91; recaptured; 13 Jun 91; censored: 16 Aug 93
BC91142	05 Mar 91	C (BCNP)	M	Fawn: 91	08.8	150.551 (B)	118	23 (13)	Dead: bobcat predation, 01 Jul 91
BC91143	05 Mar 91	C (BCNP)	F	Fawn: 91	05.2	150.651 (B)	94	18 (03)	Dead: undetermined cause, 07 Jun 91
BC91144	06 Mar 91	C (BCNP)	F	Fawn: 91	06.0	150.590 (B)	21	04 (01)	Dead: bobcat predation, 27 Mar 91
BC91145	06 Mar 91	C (BCNP)	F	Fawn: 91	03.6	151.885 (B)	133	27 (08)	Dead: bobcat predation, 17 Jul 91
BC91146	06 Mar 91	C (BCNP)	M	Fawn: 91	06.1	151.001 (B)	134	26 (06)	Censored: 18 Jul 91
BC91147	06 Mar 91	C (BCNP)	M	Fawn: 91	09.1	150.631 (B)	02	01 (00)	Dead: capture myopathy, 08 Mar 91
BC91148	06 Mar 91	B (BCNP)	M	Fawn: 91	03.3	150.531 (B)	04	00 (00)	Dead: capture myopathy, 10 Mar 91
BC91149	06 Mar 91	C (BCNP)	M	Fawn: 91	07.1	150.669 (B)	230	45 (22)	Censored: 22 Oct 91; recaptured: 09 Aug 93; dead: capture-related, 11 Aug 93

Table 1. Continued, 5 of 6.

Deer ID	Capture date	Capture location ^a	Sex	Age at capture (yrs)	Body weight (kg)	Radio freq. in MHz (Collar type) ^b	Exposure days/ 31 Mar 95 ^c	Radio locations/ 31 Mar 95 ^d	Status: 31 Mar 95
BC91150	07 Mar 91	C (BCNP)	F	Fawn: 91	06.4	151.250 (B)	415	67 (29)	Censored: 25 Apr 92
BC91151	07 Mar 91	C (BCNP)	M	Fawn: 91	07.9	151.857 (B)	415	74 (13)	Censored: 25 Apr 92
BC91152	07 Mar 91	G (ENP)	F	Fawn: 91	02.5	151.896 (B)	92	19 (08)	Dead: bobcat predation, 07 Jun 91
BC91153	08 Mar 91	G (ENP)	M	Fawn: 91	14.1	150.690 (B)	133	26 (08)	Dead: undetermined cause, 19 Jul 91
BC91154	08 Mar 91	G (ENP)	F	Fawn: 91	05.2	150.569 (B)	61	19 (03)	Censored: 16 Jun 91
BC91155	09 Mar 91	C (BCNP)	F	Fawn: 91	05.0	150.932 (B)	81	15 (05)	Dead: undetermined cause, 29 May 91
BC91156	09 Mar 91	C (BCNP)	F	Fawn: 91	08.7	151.699 (B)	07	01 (00)	Dead: bobcat predation, 16 Mar 91
BC91157	09 Mar 91	C (BCNP)	M	Fawn: 91	03.6	150.910 (B)	146	28 (15)	Censored: 03 Aug 91
BC91158	09 Mar 91	C (BCNP)	M	Fawn: 91	05.1	151.437 (B)	73	14 (04)	Dead: undetermined cause, 21 May 91
BC91159	19 Mar 91	G (ENP)	F	Fawn: 91	07.0	150.951 (B)	12	03 (00)	Dead: undetermined cause, 31 Mar 91
BC91160	19 Mar 91	G (ENP)	F	Fawn: 91	03.1	150.611 (B)	26	04 (00)	Censored: 14 Apr 91
BC91161	19 Mar 91	C (BCNP)	F	Fawn: 91	04.9	151.130 (B)	69	13 (01)	Dead: undetermined cause, 27 May 91
BC91162	20 Mar 91	G (ENP)	M	Fawn: 91	08.6	150.511 (B)	49	11 (02)	Dead: undetermined cause, 08 May 91
BC91163	20 Mar 91	G (ENP)	F	Fawn: 91	10.0	151.111 (B)/150.631 (B)	124	24 (08)	Recaptured: 16 Jul 91; dead: bobcat predation, 22 Jul 91
BC91164	20 Mar 91	G (ENP)	M	Fawn: 91	05.0	151.415 (B)/150.331 (B)	145	32 (15)	Recaptured: 23 Jul 91; dead, bobcat predation, 12 Aug 91
BC91165	21 Mar 91	G (ENP)	M	Fawn: 91	12.3	151.500 (B)	83	16 (02)	Dead: bobcat predation, 12 Jun 91
BC91166	21 Mar 91	G (ENP)	M	Fawn: 91	07.3	151.607 (B)	02	00 (00)	Dead: capture myopathy, 23 Mar 91
BC91167	21 Mar 91	G (ENP)	M	Fawn: 91	04.9	151.426 (B)	129	26 (10)	Dead: bobcat predation, 28 Jul 91
BC91168	21 Mar 91	G (ENP)	F	Fawn: 91	09.0	150.631 (B)	34	06 (00)	Dead: bobcat predation, 24 Apr 91
BC91169	22 Mar 91	C (BCNP)	M	Fawn: 91	11.8	151.169 (B)/150.371 (B)	343	67 (39)	Recaptured: 09 Sep 91; censored: 28 Feb 92
BC91170	22 Mar 91	C (BCNP)	M	Fawn: 91	09.5	151.020 (B)	63	12 (03)	Dead: undetermined cause, 24 May 91
BC91171	22 Mar 91	B (BCNP)	M	Fawn: 91	06.4	151.699 (B)	18	01 (00)	Censored: 09 Apr 91
BC91172	22 Mar 91	G (ENP)	M	Fawn: 91	05.6	150.531 (B)	67	13 (01)	Dead: bobcat predation, 28 May 91
BC91173	23 Mar 91	C (BCNP)	M	Fawn: 91	10.9	151.825 (B)/150.312 (B)	398	62 (20)	Censored: 17 Jul 91; recaptured: 18 Jul 91; censored: 25 Apr 92; dead: legal kill, 16 Nov 92
BC91174	23 Mar 91	C (BCNP)	M	Fawn: 91	07.4	150.391 (B)	174	34 (19)	Censored: 12 Sep 91
BC91175	12 Apr 91	G (ENP)	F	Fawn: 91	06.1	151.607 (B)	121	22 (11)	Dead: malnutrition, 11 Aug 91
BC91176	12 Apr 91	G (ENP)	M	Fawn: 91	13.2	150.590 (B)	53	10 (04)	Dead: bobcat predation, 04 Jun 91
BC91177	12 Apr 91	G (ENP)	F	Fawn: 91	09.1	151.150 (B)	52	10 (04)	Dead: bobcat predation, 03 Jun 91
BC91178	12 Apr 91	G (ENP)	F	Fawn: 91	11.3	151.830 (B)/150.470 (B)	77	15 (05)	Recaptured: 26 Jun 91; dead: malnutrition, 27 Jun 91
BC91179	12 Apr 91	G (ENP)	M	Fawn: 91	09.1	150.331 (B)	04	00 (00)	Dead: capture myopathy, 16 Apr 91
BC91180	13 Apr 91	C (BCNP)	F	Fawn: 91	09.1	150.312 (B)	41	08 (02)	Dead: bobcat predation, 24 May 91
BC91181	13 Apr 91	B (BCNP)	F	Fawn: 91	05.5	150.411 (B)	49	09 (04)	Dead: bobcat predation, 01 Jun 91
BC91182	14 Apr 91	G (ENP)	F	Fawn: 91	08.2	150.951 (B)	10	02 (00)	Censored: 24 Apr 91
BC91183	14 Apr 91	B (BCNP)	F	Fawn: 91	03.2	151.039 (B)	377	60 (47)	Censored: 25 Apr 92
BC91184	07 Jun 91	C (BCNP)	M	1.5	34.0	None	00	00 (00)	Dead: capture-related stress, 07 Jun 91
BC91185	07 Jun 91	C (BCNP)	M	(1.0)	35.4	151.615 (E)	190	34 (12)	Dead: legal kill, 13 Dec 91
BC91186	07 Jun 91	C (BCNP)	M	(1.0)	35.4	151.759 (E)	162	29 (16)	Dead: legal kill, 16 Nov 91
BC91187	07 Jun 91	C (BCNP)	M	(2.0)	53.5	151.652 (E)	171	36 (06)	Dead: legal kill, 25 Nov 91
BC91188	11 Jun 91	C (BCNP)	M	(1.0)	34.5	151.953 (E)	201	37 (16)	Dead: legal kill, 29 Dec 91
BC91189	11 Jun 91	C (BCNP)	M	(1.0)	38.1	151.746 (E)/151.746 (E)	1246	181 (20)	Recaptured: 10 Aug 93; dead: alligator predation, 09 Nov 94

Table 1. Continued, 6 of 6.

Deer ID	Capture date	Capture location ^a	Sex	Age at capture (yrs)	Body weight (kg)	Radio freq. in MHz (Collar type) ^b	Exposure days/ 31 Mar 95 ^c	Radio locations/ 31 Mar 95 ^d	Status: 31 Mar 95
BC91190	11 Jun 91	C (BCNP)	M	1.0	36.3	151.444 (E)	1388	220 (60)	Alive/transmitting
BC91191	13 Jun 91	B (BCNP)	M	(2.0)	44.5	151.879 (E)	317	48 (22)	Censored: 25 Apr 92; dead: legal kill, 21 Nov 92
BC91192	13 Jun 91	G (ENP)	M	3.0	62.6	151.939 (E)	1401	63 (06)	Censored: 15 Apr 95
BC91193	13 Jun 91	B (ENP)	M	4.0	49.0	151.489 (E)	540	48 (25)	Dead: legal harvest, 05 Dec 92
BC91194	18 Jun 91	B (BCNP)	M	1.0	30.8	150.711 (E)	68	13 (08)	Censored: 25 Aug 91
BC91195	18 Jun 91	G (ENP)	F	3.0	34.5	150.111 (F)	188	33 (17)	Censored: 23 Dec 91
BC91196	20 Jun 91	C (BCNP)	F	1.0	28.1	151.992 (F)	633	61 (25)	Censored: 16 Mar 93; dead: undetermined cause, 15 Sep 93
BC91197	20 Jun 91	B (BCNP)	M	Fawn: 91	12.7	150.350 (B)	44	08 (01)	Censored: 03 Aug 91; recaptured: 08 Aug 93; dead: capture-related cause, 10 Aug 93
BC91198	20 Jun 91	B (BCNP)	F	(2.0)	29.0	151.590 (F)	760	63 (37)	Dead: undetermined cause, 20 Jul 93
BC91199	20 Jun 91	G (ENP)	M	4.5	56.4	150.810 (E)	321	46 (14)	Censored: 06 Jun 92
BC91200	26 Jun 91	G (ENP)	F	3.5	33.6	151.868 (F)	34	05 (05)	Censored: 31 Jul 91
BC91201	18 Jul 91	C (BCNP)	M	4.5	47.2	150.791 (E)	1013	99 (15)	Censored: 27 Apr 94

^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 censor, death, or 31 March 1995.

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

^e Age of adults verified by examination of wear 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, 1990, and 1991. Recaptured deer (n=18) are included.

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 89	27	15	56	11.0	0.73 ^a
May 89	22	22	100	9.0	0.41 ^a
Jun 89	16	16	100	10.2	0.64 ^b
Aug 89	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 90	29	23	79	20.0	0.87 ^b
Apr 90	25	22	88	12.9	0.59 ^b
Jun 90	3	3	100	3.2	1.07 ^b
Jul 90	4	3	75	3.8	1.27 ^b
Aug 90	28	22	79	11.7	0.53 ^b
Subtotal/mean	102	86	84	58.7	0.68
Feb 91	6	3	50	2.8	0.94 ^b
Mar 91	46	33	72	27.3	0.83 ^b
Apr 91	14	9	64	5.9	0.66 ^b
Jun 91	21	20	95	7.5	0.38 ^b
Jul 91	6	5	83	3.9	0.78 ^c
Sep 91	1	1	100	1.1	1.10 ^c
Subtotal/mean	94	71	76	48.7	0.69
Total	276	222	80	143.4	0.65

^a Non-selective capture of individuals.

^b Selective capture of individuals.

^c Recapture of specific fawns to replace non-functioning radio-collar.

Table 3. Age and sex of white deer captured by helicopter netgunning, Big Cypress National Preserve/Everglades National Park, 28 March 1989-27 September 1991. Recaptured deer are excluded.

Location/Year	Number of deer captured						Total
	Adults		Yearlings		Fawns		
	M	F	M	F	M	F	
1989							
BCNP	7	13 ^a	2	1	5	3	31
ENP	9	15 ^b	1	3	5	1	34
Subtotal	16	28	3	4	10	4	65
1990							
BCNP	8	8 ^c	2 ^d	1	9	9 ^e	37
ENP	14 ^f	9	0	0	9 ^g	10 ^h	42
Subtotal	22	17	2	1	18	19	79
1991							
BCNP	3	2	7 ⁱ	0	14 ^j	10	35
ENP	3	2	0	0	9 ^k	10	24
Subtotal	6	4	7	0	23	20	59
Total	44	49	12	5	51	43	204

^a Includes 1 adult female injured (dispatched) during capture operations.

^b Includes 1 adult female (BC8920) that subsequently died from capture myopathy.

^c Includes 1 adult female (BC9065) that died of capture-related stress, and 1 (BC9068) that subsequently died from capture myopathy.

^d Includes 1 yearling male (BC9071) that subsequently died from capture myopathy.

^e Includes 1 female fawn (BC9094) that subsequently died from capture myopathy.

^f Includes 2 adult males that died from capture-related stress (BC9096, BC90126), 1 injured (dispatched) during capture operations, and 1 released uncollared due to an emergency situation.

^g Includes 2 male fawns (BC9073, BC9075) born in 1989; these fawns, captured in January 1990, were approximately 10 months of age.

^h Includes 1 female fawn (BC9072) born in 1989; this fawn, captured in January 1990, was approximately 10 months of age. Also included is 1 female fawn (BC9092), born in 1990, that escaped prior to the attachment of a radio-transmitter.

ⁱ Includes 1 yearling male (BC91184) that died from capture-related stress.

^j Includes 2 male fawns (BC91147, BC91148) that subsequently died from capture myopathy.

^k Includes 2 male fawns (BC91166, BC91179) that subsequently died from capture myopathy.

Table 4. Observed and estimated densities of white-tailed deer, derived from aerial transect surveys, in Big Cypress National Preserve (BCNP) and Everglades National Park (ENP) during the summer/wet season in 1990 and 1991, fall/hunting season in 1990 and 1991, and spring/dry season in 1991 and 1992.

Location/season	Daily surveys ^a	Number of deer observed				Mean density (deer/km ²)	
		Minimum	Maximum	Total	Mean (SE)	Observed (SE)	Estimated ^b
BCNP							
Summer 1990	6	7	25	81	13.50 (2.69)	1.16 (0.21)	5.07
1991	6	11	39	160	26.67 (5.18)	2.30 (0.45)	10.04
Fall 1990	6	5	13	45	7.50 (1.18)	0.65 (0.09)	0.91
1991	6	3	16	44	7.33 (2.22)	0.55 (0.17)	0.77
Spring 1991	6	21	46	190	31.67 (4.15)	2.23 (0.30)	3.88
1992	6	0	14	53	8.83 (2.07)	0.71 (0.10)	1.23
Mean (SE)						1.27 (0.32)	3.65 (0.41)
ENP							
Summer 1990	6	6	18	70	11.67 (1.61)	0.83 (0.11)	2.31
1991	6	21	45	208	34.67 (5.52)	2.54 (0.39)	7.08
Fall 1990	6	9	31	141	23.50 (3.58)	1.71 (0.26)	2.89
1991	6	25	46	210	35.00 (3.27)	2.20 (0.22)	3.72
Spring 1991	6	49	78	389	64.83 (3.89)	3.89 (0.20)	8.35
1992	6	14	37	158	26.33 (3.06)	1.73 (0.22)	3.71
Mean (SE)						2.15 (1.47)	4.68 (1.00)

^a Each daily survey was conducted on 8, 5 km x 300 m transects in BCNP and 8, 6 km x 300 m transects in ENP; the coverage area of each transect was adjusted for variation in altitude on every flight.

^b Estimated density is the product of the observed density multiplied by the reciprocal of the observability coefficient. The observability coefficients, derived in 1990 were: summer/wet season--BCNP, 0.229 and ENP, 0.359; fall/hunting season--BCNP, 0.714 and ENP, 0.591; and spring/dry season--BCNP, 0.575 and ENP, 0.466.

Table 5. Sex ratios among fawn white-tailed deer captured by helicopter netgunning, Big Cypress National Preserve (BCNP) and Everglades National Park (ENP) during the fawning years of 1989, 1990, and 1991.

Year	BCNP		ENP		Pooled		Percentage males ^a
	Male	Female	Male	Female	Male	Female	
1989	5	3	7	2	12	5	71
1990	9	9	7	9	16	18	47
1991	14	10	9	10	23	20	53
Pooled	28	22	23	21	51	43	54
Percentage males ^a	58		52		54		

^a None of the sex ratios differed ($P > 0.05$) from equity.

Table 6. Sex ratios of adult white-tailed deer derived from aerial surveys during the summer/wet season (coincident with rut) in Big Cypress National Preserve (BCNP) and Everglades National Park (ENP), 1990 and 1991.

Location/Year	Males			Females			Sex ratios ^c	
	Observed	OC ^a	Estimated ^b	Observed	OC	Estimated	Females/male	Percentage males
BCNP								
1990	15	0.155	97	181	0.396	457	4.7/1	17.5
1991	42	0.246	171	178	0.341	522	3.1/1	24.6
Pooled	57	0.213	268	359	0.367	979	3.7/1	21.5 ^d
ENP								
1990	91	0.300	303	151	0.470	321	1.1/1	48.6
1991	149	0.356	419	347	0.644	539	1.3/1	43.7
Pooled	240	0.332	722	498	0.579	860	1.2/1	45.6 ^d

^a Observability coefficient.

^b Estimated number is the product of the observed number multiplied by the reciprocal of the observability coefficient.

^c Sex ratios expressed on basis of estimated numbers.

^d Sex ratio between BCNP and ENP populations differed ($P < 0.05$).

Table 7. Annual survival rates of radio-instrumented **fawn** white-tailed deer in Big Cypress National Preserve (BCNP) and Everglades National Park (ENP) for the 3 biological years (01 April-31 March), 1989-90, 1990-91, 1991-92. Survival rates derived from the product-limit estimator procedures (Kaplan and Meier 1958), modified to allow for the staggered entry of animals captured during the biological year (Pollock et al. 1989). Rates connected by horizontal or vertical lines differed statistically ($P < 0.05$)

Sex/Year	BCNP (Hunted)	ENP (Nonhunted)	Pooled
Males			
1989-90	0.4000 (n=05)	0.0000 (n=06)	0.1750 (n=12 ^a)
1990-91	0.5002 (n=10)	0.0000 (n=05)	0.4124 (n=15)
1991-92	0.7111 (n=12)	0.0000 (n=07)	0.4160 (n=19)
Pooled	0.5492 (n=27)	0.0000 (n=18)	0.2453 (n=46 ^a)
Females			
1989-90	0.5000 (n=03) ^b	0.0000 (n=01)	0.0000 (n=04)
1990-91	0.5000 (n=06)	0.2679 (n=08) ^b	0.3875 (n=14)
1991-92	0.2500 (n=08)	0.0000 (n=08)	0.1543 (n=16)
Pooled	0.2794 (n=17)	0.1186 (n=17) ^b	0.2202 (n=34)
Sexes Combined			
1989-90	0.2188 (n=08)	0.0000 (n=07)	0.1169 (n=16 ^a)
1990-91	0.5000 (n=16)	0.1563 (n=13) ^b	0.3466 (n=29)
1991-92	0.5093 (n=20)	0.0000 (n=15)	0.2981 (n=35)
Pooled	0.4260 (n=44)	0.0000 (n=35)	0.2333 (n=80 ^a)

^a Includes male fawn (BC9075) that used both BCNP and ENP space.

^b No fawns survived biological year. Thus, the survival rate listed represents the annual rate for the month, February in all cases, in which the last fawn in the cohort was censored.

Table 8. Annual survival rates of radio-instrumented **yearling** white-tailed deer in Big Cypress National Preserve (BCNP) and Everglades National Park (ENP) for the 3 biological years (01 April-31 March), 1989-90, 1990-91, 1991-92. Survival rates derived from the product-limit estimator procedures (Kaplan and Meier 1958), modified to allow for the staggered entry of animals captured during the biological year (Pollock et al. 1989). No paired rates within matrix differed statistically ($P>0.05$).

Sex/Year	BCNP (Hunted)	ENP (Nonhunted)	Pooled
Males			
1989-90	1.0000 (n=03)	1.0000 (n=01)	1.0000 (n=04)
1990-91	1.0000 (n=02)	0.0000 (n=01)	0.6667 (n=03)
1991-92	0.5000 (n=08)	----- (n=00)	0.5000 (n=08)
Pooled	0.7272 (n=13)	0.5000 (n=02)	0.6563 (n=15)
Females			
1989-90	1.0000 (n=02)	1.0000 (n=03)	1.0000 (n=05)
1990-91	----- (n=00)	1.0000 (n=01)	1.0000 (n=01)
1991-92	1.0000 (n=03)	----- (n=00)	1.0000 (n=03)
Pooled	1.0000 (n=05)	1.0000 (n=04)	1.0000 (n=09)
Sexes Combined			
1989-90	1.0000 (n=05)	1.0000 (n=04)	1.0000 (n=09)
1990-91	1.0000 (n=02)	0.5000 (n=02)	0.7500 (n=04)
1991-92	0.6250 (n=11)	----- (n=00)	0.6250 (n=11)
Pooled	0.7850 (n=18)	0.8000 (n=06)	0.7773 (n=24)

Table 9. Annual survival rates of radio-instrumented **adult** white-tailed deer in Big Cypress National Preserve (BCNP) and Everglades National Park (ENP) for the 3 biological years (01 April-31 March), 1989-90, 1990-91, 1991-92. Survival rates derived from the product-limit estimator procedures (Kaplan and Meier 1958), modified to allow for the staggered entry of animals captured during the biological year (Pollock et al. 1989). Rates connected by horizontal or vertical lines differed statistically $P < 0.05$.

Sex/Year	BCNP (Hunted)	ENP (Nonhunted)	Pooled
Males			
1989-90	0.2222 (n=06)	0.7500 (n=08)	0.5778 (n=15 ^a)
1990-91	0.6155 (n=13)	0.9091 (n=17)	0.7669 (n=30)
1991-92	0.4546 (n=12)	0.8462 (n=16)	0.6667 (n=28)
Mean ^b	0.4308	0.8351	0.6705
SE	0.1142	0.0463	0.0547
Females			
1989-90	0.8081 (n=15)	0.4534 (n=14)	0.6447 (n=29)
1990-91	0.8789 (n=18)	0.7572 (n=17)	0.8268 (n=35)
1991-92	0.9333 (n=16)	1.0000 (n=14)	0.9630 (n=30)
Mean ^b	0.8734	0.7369	0.8115
SE	0.0363	0.1583	0.0923

^a Includes 1 adult male (BC8927) that used both BCNP and ENP space.

^b Data for adults cannot be pooled because of statistical dependence, i.e., the same adult may be present in all years.

Table 10. Causes of death of radio-instrumented deer "at risk," Big Cypress National Preserve (BCNP) and Everglades National Park (ENP) during the 3 biological years (01 April - 31 March), 1989-90, 1990-91, and 1991-92.

Location/causes of death	Fawns		Yearlings		Adults		Total	
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
BCNP								
Bobcat predation	12(7/5)	52	0	0	1(0/1)	5	13(7/6)	28
Undetermined cause	11(3/8)	48	1(0/1)	25	1(0/1)	5	13(7/6)	28
Legal/illegal harvest	0	0	3(3/0)	75	15(14/1)	79	18(17/1)	39
Malnutrition	0	0	0	0	0	0	0	0
Panther predation	0	0	0	0	1(1/0)	5	1(1/0)	2
Alligator predation	0	0	0	0	1(0/1)	5	1(0/1)	2
Total	23(10/13)	100	4(3/1)	100	19(15/4)	99	46(28/18)	99
ENP								
Bobcat predation	19(14/5)	66	1(0/1)	33	5(1/4)	29	25(15/10)	51
Undetermined causes	8(5/3)	28	0	0	9(3/6)	53	17(8/9)	35
Legal/illegal	0	0	0	0	3(2/1)	18	3(2/1)	6
Malnutrition	2(0/2)	7	1(1/0)	33	0	0	3(1/2)	6
Panther predation	0	0	1(1/0)	33	0	0	1(1/0)	2
Alligator predation	0	0	0	0	0	0	0	0
Total	29(19/10)	101	3(2/1)	99	17(6/11)	100	49(27/22)	100
Combined								
Bobcat predation	31(21/10)	60	1(0/1)	14	6(1/5)	17	38(22/16)	40
Undetermined cause	19(8/11)	37	1(0/1)	14	10(3/7)	28	30(11/19)	32
Legal/illegal harvest	0	0	3(3/0)	43	18(16/2)	50	21(19/2)	22
Malnutrition	2(0/2)	4	1(1/0)	14	0	0	3(1/2)	3
Panther predation	0	0	1(1/0)	14	1(1/0)	3	2(2/0)	2
Alligator predation	0	0	0	0	1(0/1)	3	1(0/1)	1
Total	52(29/23)	101	7(5/2)	99	36(21/15)	101	95(55/40)	100

Table 11. Percentage harvest of radio-instrumented male deer that were available for harvest during the fall hunting seasons (September-December) in Big Cypress National Preserve, 1989, 1990, and 1991.

Year	Number available: September 1	Harvested: ^a September-December		Harvest as percentage of total deaths annually
		Number	Percentage	
1989				
Yearlings	1	0	0	0
Adults	6	4	67	100
Total	7	4	57	100
1990				
Yearlings	2	0	0	0
Adults	13	5	38	100
Total	15	5	33	100
1991				
Yearlings	6	3	50	100
Adults	10	5	50	83
Total	16	8	50	88
Years Pooled				
Yearling	9	3	33	100
Adults	29	14	48	93
Total	38	17	45	94

^a Includes males harvested legally and illegally.

Table 12. Model outputs of data-based population growth of white-tailed deer in Big Cypress National Preserve (hunted population) for the 3 biological years (01 April-31 March), 1989-90, 1990-91, 1991-92. Initial population size: 350.

Parameter	Population growth models		
	1989-90	1990-91	1991-92
Population growth			
Deterministic r^a	0.054	0.100	-0.004
Stochastic r^b	0.030 (0.261) ^c	0.077 (0.239)	-0.050 (0.301)
R_0	1.275	1.623	0.976
Population size			
Year 10	372 (122)	428 (101)	272 (145)
20	342 (136)	390 (126)	208 (150)
30	350 (150)	414 (118)	165 (139)
40	321 (151)	403 (133)	155 (156)
50	333 (156)	397 (122)	145 (156)
100	315 (153)	409 (123)	72 (98)
Extinction			
Probability	0.150 (0.138)	0.000	0.680 (0.384)
T_e (years) ^d	65.2 (25.5)	N/A	60.7 (21.6)

^a Instantaneous rate based on female population, with assumptions of no limitations on males, no density dependence, and no inbreeding depression.

^b Mean population growth rate prior to carrying-capacity truncation.

^c Standard deviations within parentheses.

^d Mean years to first extinction.

Model Inputs: BCNP

- Reproduction (all years): minimum breeding age (males and females) = 2 years; litter size = 0 (5%), 1 (70%), 2 (25%); all males in breeding population.
- Mortality rates (see Tables 7-9):
 - 1989-90--females = 50% (F), 5% (Y), 19% (A); males = 60% (F), 5% (Y), 78% (A).
 - 1990-91--females = 50% (F), 5% (Y), 12% (A); males = 50% (F), 5% (Y), 38% (A).
 - 1991-92--females = 75% (F), 5% (Y), 7% (A); males = 29% (F), 50% (Y), 55% (A).
- Population size (all years): initial = 350; carrying capacity = 500.
- Environmental variation: reproduction = 10% SD; mortality/carrying capacity, 15% SD.
- No catastrophes.
- Populations simulated for 100 years, 100 iterations/year.

Table 13. Model outputs of data-based population growth of white-tailed deer in Everglades National Park (nonhunted population) for the 3 biological years (01 April-31 March), 1989-90, 1990-91 and 1991-92. **Initial population size: 450.**

Parameter	Population growth models		
	1989-90	1990-91	1991-92
Population growth			
Deterministic r^a	-0.758	-0.115	-0.241
Stochastic r^b	-0.772 (0.332) ^c	-0.158(0.296)	-0.298 (0.362)
R_0	0.052	0.587	0.211
Population size			
Year 10	3 (01)	178 (138)	64 (63)
20	0	112 (123)	9 (10)
30	0	50 (54)	0
40	0	35 (52)	0
50	0	65 (00)	0
100	0	0	0
Extinction			
Probability	1.000	1.000	1.000
T_e (years) ^d	5.1 (2)	17.4 (9.6)	14.4 (5.7)

^a Instantaneous rate based on female population, with assumptions of no limitations on males, no density dependence, and no inbreeding depression.

^b Mean population growth rate prior to carrying-capacity truncation.

^c Standard deviations within parentheses.

^d Mean years to first extinction.

Model Inputs: ENP

- Reproduction (all years): minimum breeding age (males and females) = 2 years; litter size = 0 (5%), 1 (70%), 2 (25%); all males in breeding population.
- Mortality rates (see Tables 7-9):
 - 1989-90--females = 95% (F), 5% (Y), 55% (A); males = 95% (F), 5% (Y), 25% (A).
 - 1990-91--females = 73% (F), 5% (Y), 24% (A); males = 95% (F), 5% (Y), 9% (A).
 - 1991-92--females = 95% (F), 5% (Y), 5% (A); males = 95% (F), 5% (Y), 15% (A).
- Population size (all years): initial = 450; carrying capacity = 500.
- Environmental variation: reproduction = 10% SD; mortality/carrying capacity, 15% SD.
- No catastrophes.
- Populations simulated for 100 years, 100 iterations/year.

Table 14. Model of population growth of white-tailed deer at maintenance level, plus subsequent manipulations of mortality rates, in Big Cypress National Preserve (hunted population). **Initial population size: 350.**

Parameter	Population growth models (BCNP): harvest		
	Maintenance: normal harvest	Increased harvest: males	Increased harvest males/adult females (5%)
Population growth			
Deterministic r^a	0.057	0.057	0.023
Stochastic r^b	0.036 (0.260) ^c	0.033 (0.274)	-0.008 (0.284)
R_0	1.314	1.314	1.110
Population size			
Year 10	364 (139)	403 (119)	313 (139)
20	350 (131)	354 (136)	277 (148)
30	341 (142)	338 (148)	247 (147)
40	341 (155)	327 (141)	221 (156)
50	328 (151)	344 (139)	251 (170)
100	354 (148)	323 (152)	230 (165)
Extinction			
Probability	0.040 (0.039)	0.130 (0.121)	0.370 (0.294)
T_e (years) ^d	65.0 (13.1)	61.5 (28.5)	54.6 (22.1)

^a Instantaneous rate based on female population, with assumptions of no limitations on males, no density dependence, and no inbreeding depression.

^b Mean population growth rate prior to carrying-capacity truncation.

^c Standard deviations within parentheses.

^d Mean years to first extinction.

Model Inputs: BCNP

- Reproduction (all years): minimum breeding age (males and females) = 2 years; litter size = 0 (5%), 1 (70%), 2 (25%); all males in breeding population.
- Mortality rates:
 - Maintenance, normal harvest (males)--females = 55% (F), 5% (Y), 15% (A); males = 55% (F), 35% (Y), 50% (A).
 - Maintenance, increased harvest (males)--females = 55% (F), 5% (Y), 15% (A); males = 55% (F), 50% (Y), 70% (A).
 - Maintenance, increased harvest (males) and increased mortality (adult females)--females = 55% (F), 5% (Y), 20% (A); males = 55% (F), 50% (Y), 70% (A).
- Population size (all years): initial = 450; carrying capacity = 500.
- Environmental variation: reproduction = 10% SD; mortality/carrying capacity, 15% SD.
- No catastrophes.
- Populations simulated for 100 years, 100 iterations/year.

Table 15. Model of population growth of white-tailed deer at maintenance level, plus subsequent manipulations of mortality rates, in Everglades National Park (nonhunted population). **Initial population size: 450.**

Parameter	Population growth models (ENP): no harvest		
	Maintenance	Increased female mortality: fawns (5%)	Increased female mortality: fawns (5%)/adults (5%)
Population growth			
Deterministic r^a	0.122	0.102	0.069
Stochastic r^b	0.102 (0.218) ^c	0.083 (0.224)	0.047 (0.228)
R_0	1.752	1.606	1.357
Population size			
Year 10	436 (88)	439 (86)	401 (112)
20	443 (79)	432 (91)	391 (126)
30	455 (75)	425 (104)	389 (130)
40	438 (101)	408 (117)	385 (135)
50	442 (101)	415 (111)	394 (130)
100	429 (110)	436 (116)	335 (160)
Extinction			
Probability	0.000	0.000	0.010 (0.010)
T_e (years) ^d	N/A	N/A	60.0 (0.0)

^a Instantaneous rate based on female population, with assumptions of no limitations on males, no density dependence, and no inbreeding depression.

^b Mean population growth rate prior to carrying-capacity truncation.

^c Standard deviations within parentheses.

^d Mean years to first extinction.

Model Inputs: ENP

- Reproduction (all years): minimum breeding age (males and females) = 2 years; litter size = 0 (5%), 1 (70%), 2 (25%); all males in breeding population.
- Mortality rates:
 - Maintenance--females = 40% (F), 5% (Y), 15% (A); males = 50% (F), 5% (Y), 20% (A).
 - Maintenance, with increased fawn female mortality--females = 45% (F), 5% (Y), 15% (A); males = 50% (F), 5% (Y), 20% (A).
 - Maintenance, with increased fawn female/adult female mortality--females = 45% (F), 5% (Y), 20% (A); males = 50% (F), 5% (Y), 20% (A).
- Population size (all years): initial = 450; carrying capacity = 500.
- Environmental variation: reproduction = 10% SD; mortality/carrying capacity, 15% SD.
- No catastrophes.
- Populations simulated for 100 years, 100 iterations/year.

Table 16. Model of population growth of white-tailed deer at maintenance level subjected to environmental catastrophes (hurricanes, 5% frequency; floods, 10% frequency) in Big Cypress National Preserve (hunted population). **Initial population size: 350.**

Parameter	Population growth models (BCNP): maintenance & catastrophes		
	Hurricane	Flood	Hurricane & flood
Population growth			
Deterministic r^a	0.049	- 0.014	- 0.022
Stochastic r^b	0.020 (0.311) ^c	- 0.074 (0.421)	- 0.090 (0.440)
R_0	1.265	0.935	0.901
Population size			
Year 10	333 (139)	237 (164)	209 (157)
20	356 (143)	178 (148)	133 (128)
30	332 (139)	126 (136)	130 (144)
40	312 (152)	126 (147)	103 (133)
50	292 (151)	101 (118)	85 (99)
100	289 (165)	103 (74)	40 (39)
Extinction			
Probability	0.400 (0.310)	0.910 (0.273)	0.960 (0.192)
T_e (years) ^d	58.2 (25.7)	45.9 (23.6)	44.1 (22.2)

^a Instantaneous rate based on female population, with assumptions of no limitations on males, no density dependence, and no inbreeding depression.

^b Mean population growth rate prior to carrying-capacity truncation.

^c Standard deviations within parentheses.

^d Mean years to first extinction.

Model Inputs: BCNP

- Base model = maintenance, normal harvest (males). (See Table 14.)
- Catastrophes:
 - Hurricane = 5% frequency; 5% reduction in survival; 50% reduction in reproduction.
 - Flood = 10% frequency; 50% reduction in survival; 90% reduction in reproduction.

Table 17. Model of population growth of white-tailed deer at maintenance level subjected to environmental catastrophes (hurricanes, 5% frequency; floods, 10% frequency) in Everglades National Park (nonhunted population). **Initial population size: 450.**

Parameter	Population growth models (ENP): maintenance & catastrophes		
	Hurricane	Flood	Hurricane & flood
Population growth			
Deterministic r^a	0.113	0.049	0.040
Stochastic r^b	0.095 (0.218) ^c	0.006 (0.364)	0.004 (0.366)
R_0	1.265	1.246	1.201
Population size			
Year 10	433 (97)	312 (147)	284 (154)
20	436 (96)	286 (154)	270 (164)
30	432 (106)	232 (172)	249 (175)
40	448 (94)	242 (177)	223 (175)
50	430 (108)	228 (168)	219 (185)
100	448 (83)	194 (183)	225 (174)
Extinction			
Probability	0.000	0.220 (0.194)	0.290 (0.244)
T_e (years) ^d	N/A	57.7 (21.0)	67.5 (23.3)

^a Instantaneous rate based on female population, with assumptions of no limitations on males, no density dependence, and no inbreeding depression.

^b Mean population growth rate prior to carrying-capacity truncation.

^c Standard deviations within parentheses.

^d Mean years to first extinction.

Model Inputs: ENP

- Base model = maintenance, no harvest. (See Table 15.)
- Catastrophes:
 - Hurricane = 5% frequency; 5% reduction in survival; 50% reduction in reproduction.
 - Flood = 10% frequency; 50% reduction in survival; 90% reduction in reproduction.

Table 18. Mean biological season^a, hydrological season^b, and annual home range sizes of adult male and female white-tailed deer in Big Cypress National Preserve (BCNP) and Everglades National Park (ENP) for the 3 biological years (01 April-31 March), 1989-90, 1990-91, and 1991-92 (pooled).

Sex/season	Mean home range size (km ² ± SE)	
	BCNP	ENP
Adult males (95% MCP ^c)		
LACT	3.5 ± 0.9 (12) ^d	1.5 ± 0.2 (21)
RUT	3.9 ± 0.7 (15)	2.4 ± 0.3 (29)
GEST/HUNT	4.2 ± 1.2 (09)	1.2 ± 0.2 (34)
PART	2.6 ± 1.0 (05)	0.6 ± 0.1 (21)
WET	5.5 ± 0.9 (12)	3.2 ± 0.5 (23)
DRY	3.7 ± 0.9 (07)	2.9 ± 0.4 (23)
ANNUAL	7.0 ± 1.4 (10)	2.9 ± 0.4 (23)
Adult females (100% MCP ^c)		
LACT	1.3 ± 0.6 (24)	0.9 ± 0.6 (14)
RUT	1.7 ± 1.3 (29)	1.5 ± 1.6 (18)
GEST/HUNT	3.1 ± 3.7 (29)	1.2 ± 1.0 (18)
PART	1.8 ± 1.0 (26)	1.3 ± 1.0 (14)
WET	3.2 ± 2.2 (32)	2.2 ± 2.2 (24)
DRY	4.0 ± 2.8 (25)	2.5 ± 2.3 (17)
ANNUAL	5.4 ± 4.2 (29)	3.0 ± 2.2 (18)

^a Biological seasons: LACT, 01 Apr-30 Jun; RUT, 01 Jul-30 Sep; GEST/HUNT, 01 Oct-31 Dec; PART, 01 Jan-31 Mar.

^b Hydrological seasons: WET, 01 May-31 Oct; DRY, 01 Nov-30 Apr.

^c 95% minimum convex polygon.

^d Sample sizes (number of deer) within parentheses.

^e 100% minimum convex polygon.

Table 19. Total home range and core area size (km²) of radio-instrumented white-tailed deer (n=53), adults and yearlings combined by habitat sites, Big Cypress National Preserve/Everglades National Park, 1989-92.

	n	Home range size (95% HM ^a)		Core area size (65% HM)	
		Mean	SE	Mean	SE
Females					
Cypress edge	4	9.3	3.4	3.5	1.0
Prairie	19	5.6	0.8	2.2	0.3
Ridge	5	2.5	0.4	0.9	0.2
Total	28	5.6	0.8	2.2	0.3
Males					
Cypress edge	6	9.9	1.7	3.5	1.0
Prairie	9	7.1	1.1	2.8	0.3
Ridge	10	5.4	0.6	2.1	0.3
Total	25	7.1	0.7	2.7	0.3

^a HM = harmonic mean.

Table 20. Habitat selection by radio-instrumented white-tailed deer, adults and yearlings combined, in the **Prairie** and **Ridge** sites, Big Cypress National Preserve/Everglades National Park, 1989-92.

	Habitat types ^a			
	WPR	HPR	HWD	WS
Prairie				
Availability (%)	89.5	4.3	2.7	3.5
Use by adult females (%)	61.4 (--) ^b	7.6 (--)	18.0 (+)	13.0 (+)
Use by adult males (%)	33.8 (--)	9.8 (--)	37.8 (+)	18.5 (+)
Ridge				
Availability (%)	51.7	29.1	10.8	8.4
Use by adult females (%)	24.2 (--)	28.8	31.2 (+)	15.8 (+)
Use by adult males (%)	13.4 (--)	18.8 (--)	46.1 (+)	21.7 (+)

^a Habitat types: WPR = wet prairie; HPR = herbaceous prairie; HWD = hardwood tree island/hardwood scrub; WS = willow/dense sawgrass.

^b (+) = habitat used more than expected based on its availability ($P < 0.001$); (--) = habitat used less than expected based on its availability ($P < 0.001$).

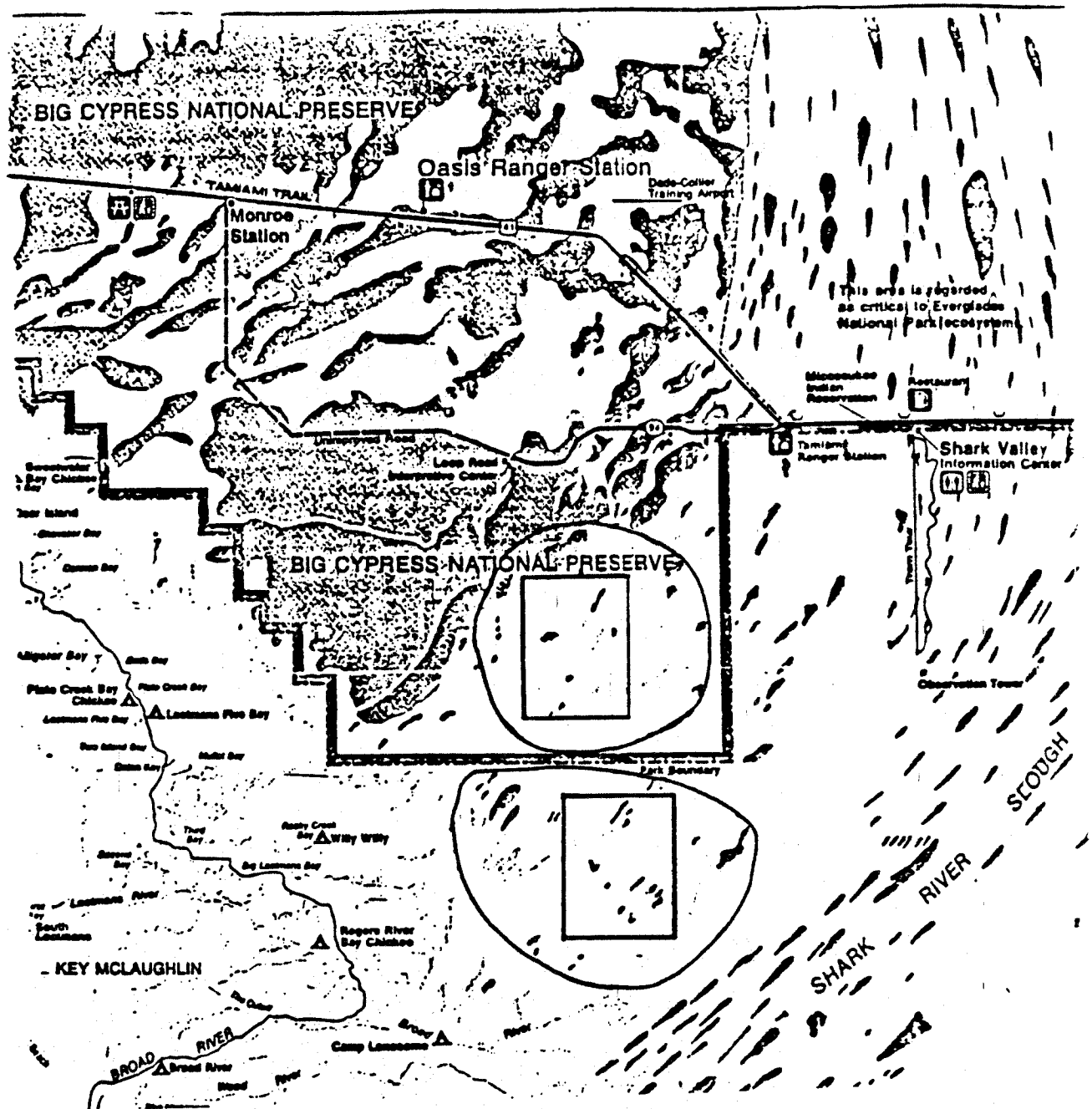


Figure 1. Location of the study sites within Big Cypress National Preserve (upper) and Everglades National Park (lower). Ovals denote the areas in which white-tailed deer were captured, radio-instrumented, and monitored between 28 March 1989-31 March 1992. Rectangles depict the tracts in which aerial transect-surveys were conducted to provide estimates of population density.

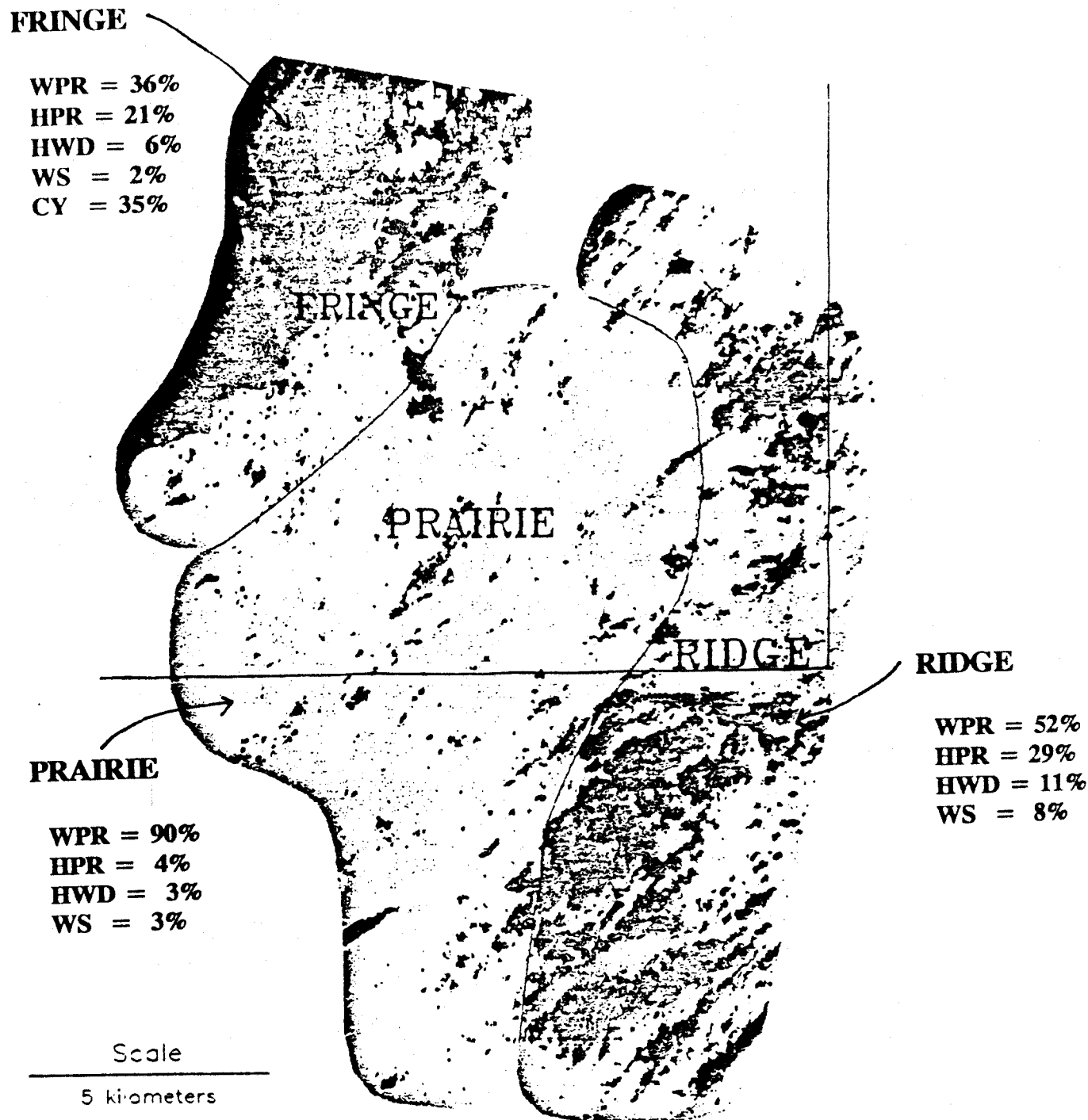


Figure 2. GIS-derived vegetation map of the study area in Big Cypress National Preserve and Everglades National Park (adapted from Miller 1993). Habitats: WPR, wet prairie; HPR, herbaceous prairie; HWD, hardwood tree islands/hardwood scrub; WS, willow/dense sawgrass; and CY, cypress.

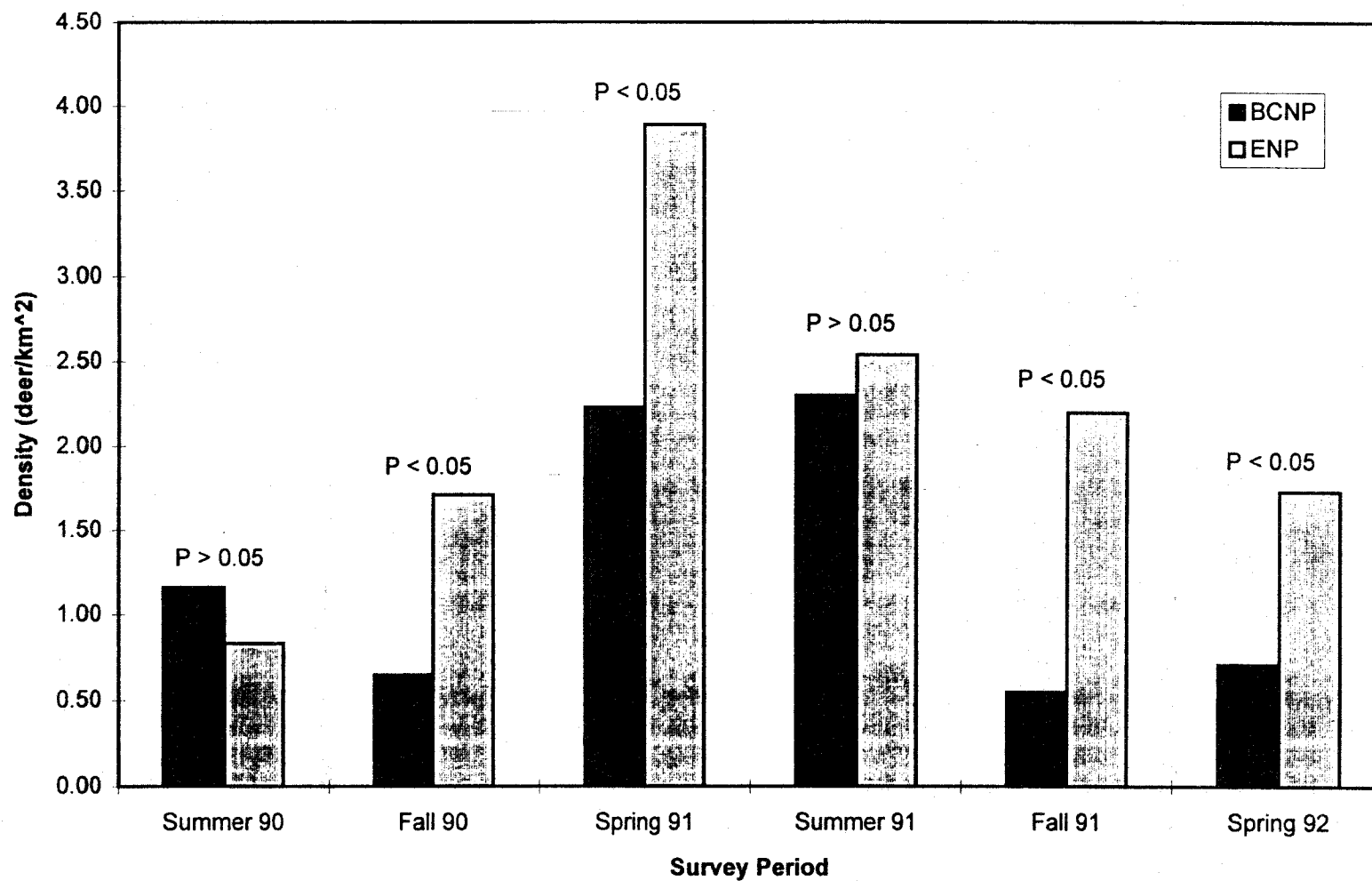


Figure 3. Differences in observed deer densities between Big Cypress National Preserve (BCNP) and Everglades National Park (ENP) as derived from 6 seasonal, aerial-transect surveys (6 replicates per survey), 1990-92. Statistical significance ($P < 0.05$) is denoted above paired bars.

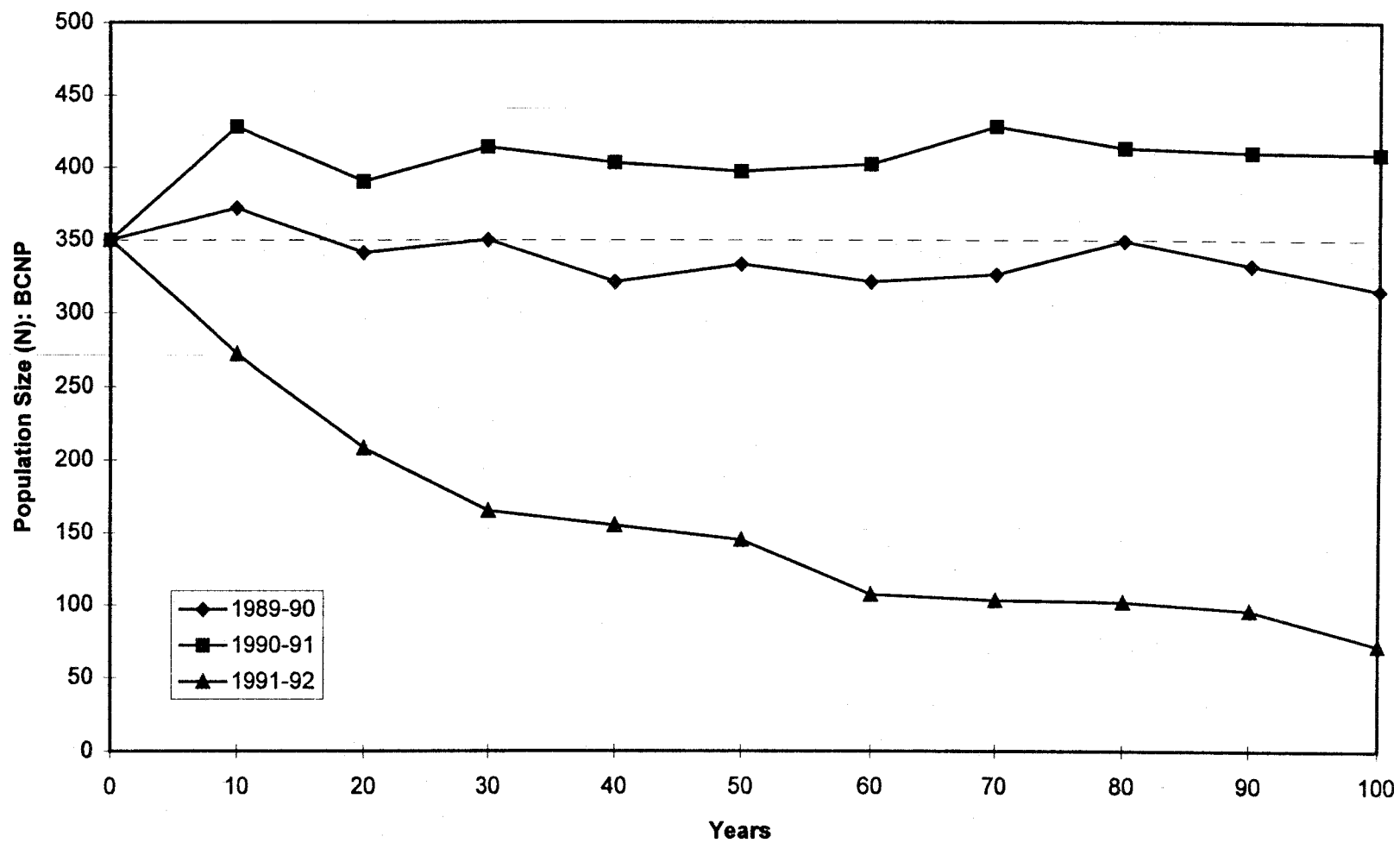


Figure 4. Models of data-based population growth of white-tailed deer in Big Cypress National Preserve (hunted population) for the 3 biological years, 1989-90, 1990-91, and 1991-92 (see Table 12 for model inputs).

Initial population size, 350; carrying capacity, 500.

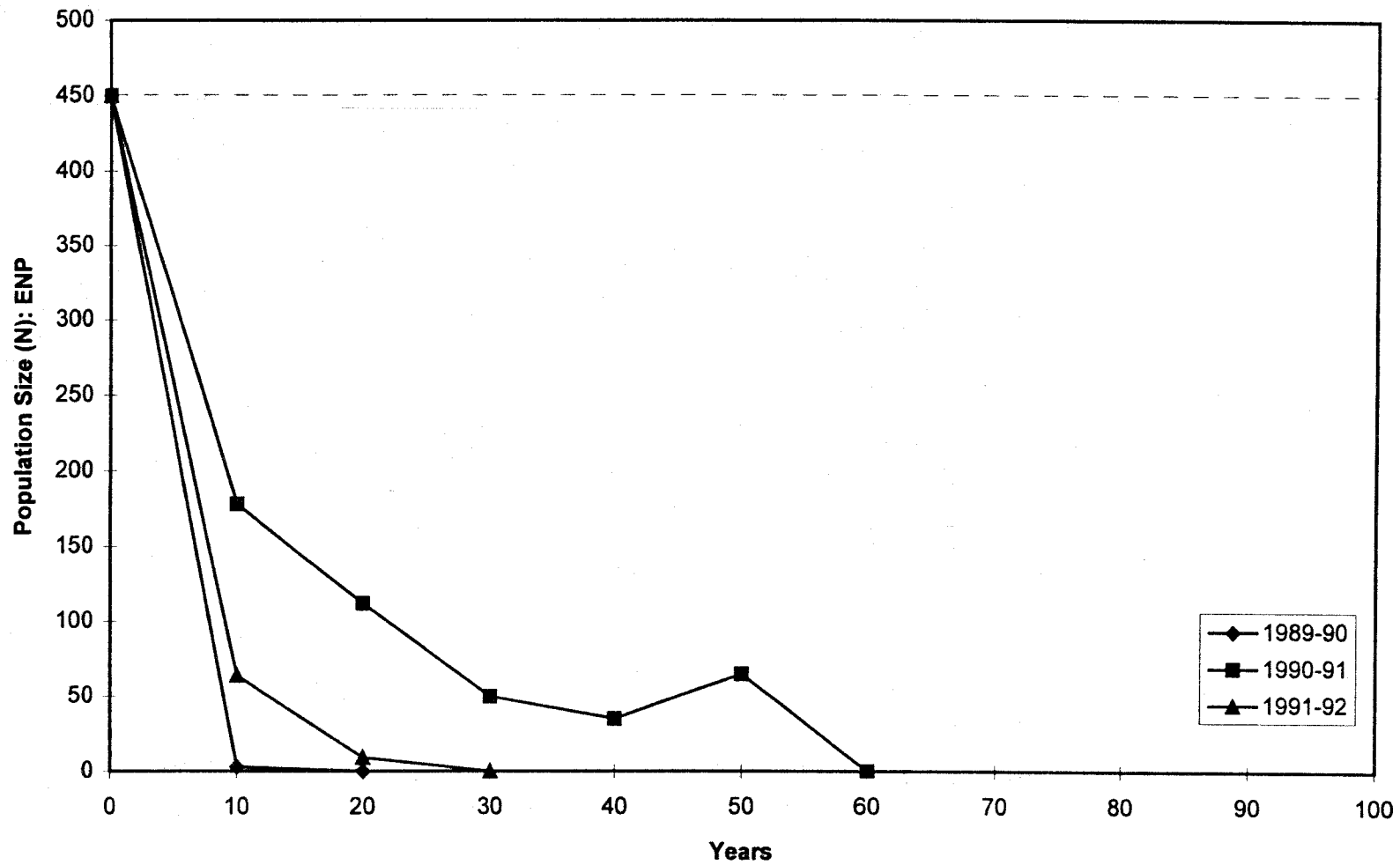


Figure 5. Models of data-based population growth of white-tailed deer in Everglades National Park (nonhunted population) for the 3 biological years, 1989-90, 1990-91, and 1991-92 (see Table 13 for model inputs).

Initial population size, 450; carrying capacity, 500.

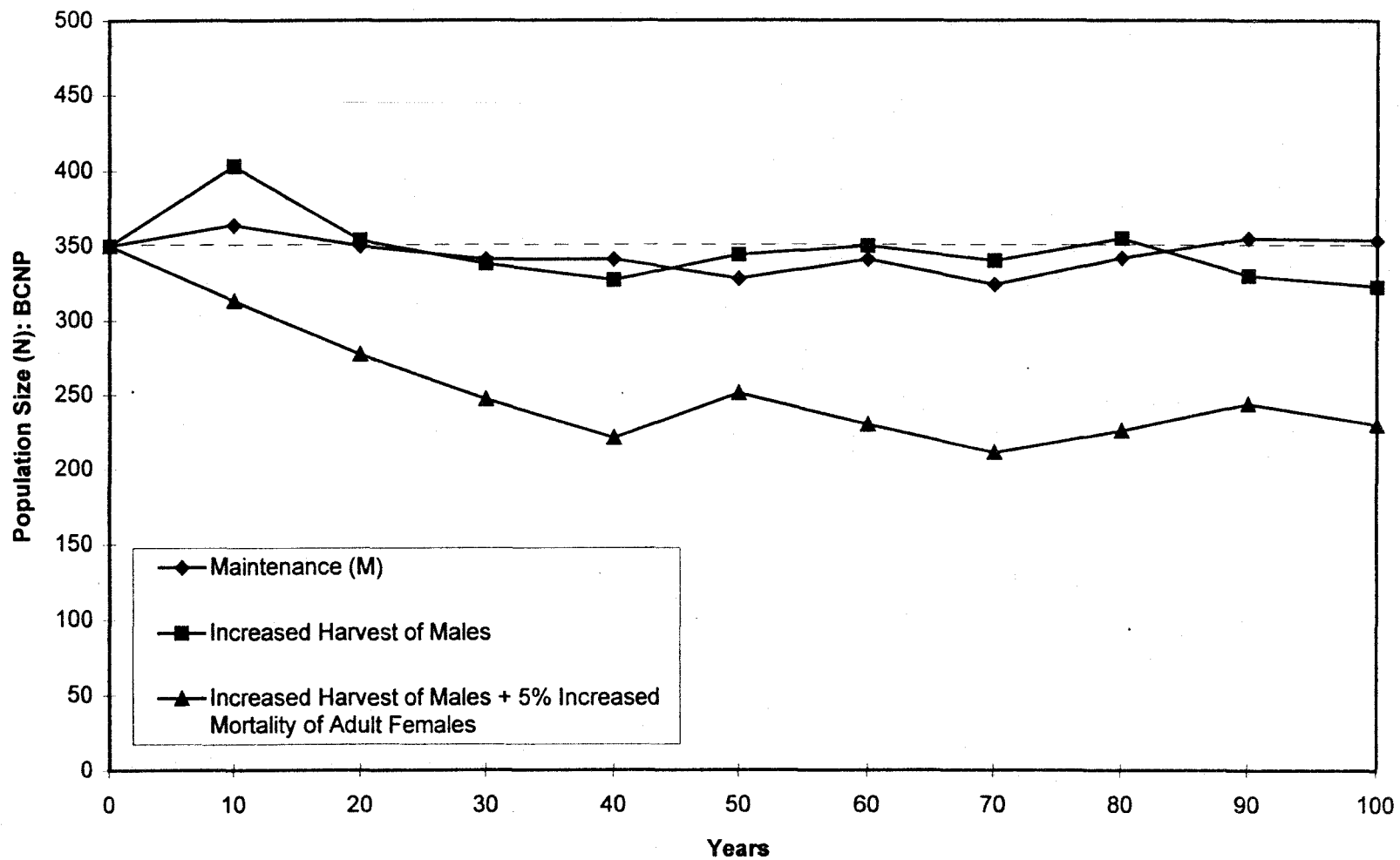


Figure 6. Models of population growth of white-tailed deer at maintenance level, plus subsequent manipulations of mortality, in Big Cypress National Preserve (hunted population) (see Table 14 for model inputs).

Initial population size, 350; carrying capacity, 500.

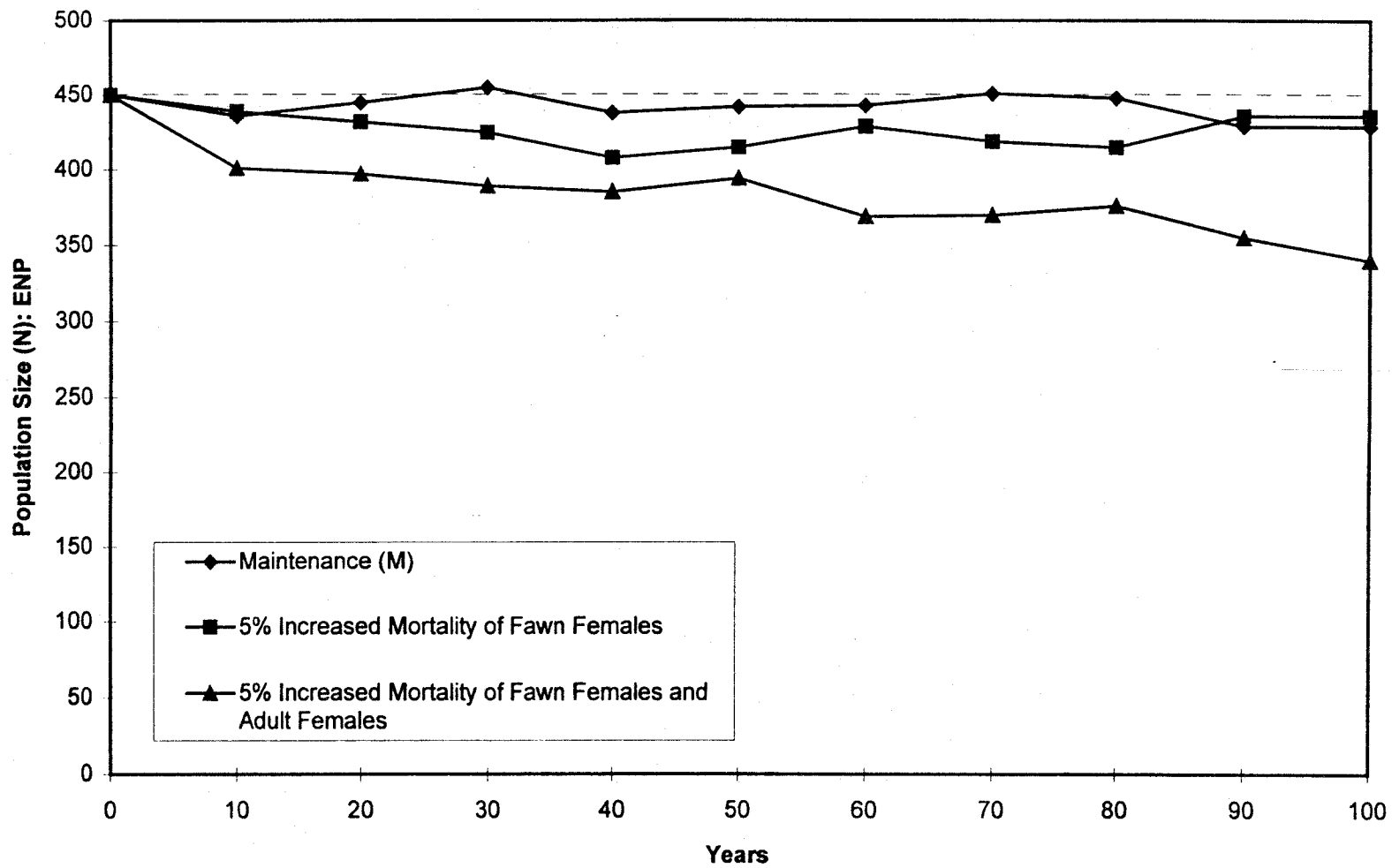


Figure 7. Models of population growth of white-tailed deer at maintenance level, plus subsequent manipulations of mortality, in Everglades National Park (nonhunted population) (see Table 15 for model inputs).

Initial population size, 450; carrying capacity, 500.

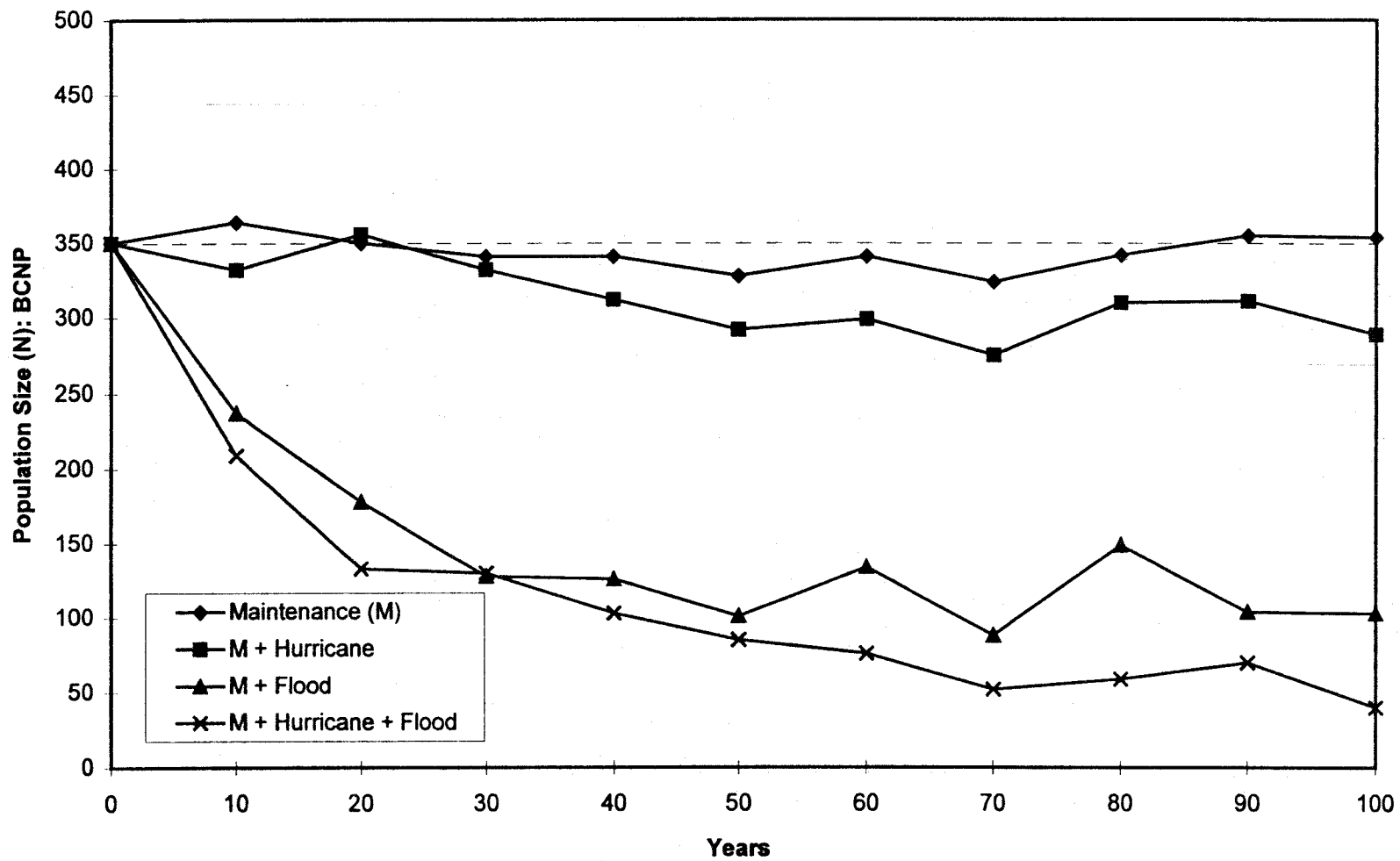


Figure 8. Models of population growth of white-tailed deer at maintenance level subjected to environmental catastrophes (hurricanes, 5% frequency; floods, 10% frequency) in Big Cypress National Preserve (hunted population) (see Table 16 for model inputs).

Initial population size, 350; carrying capacity, 500.

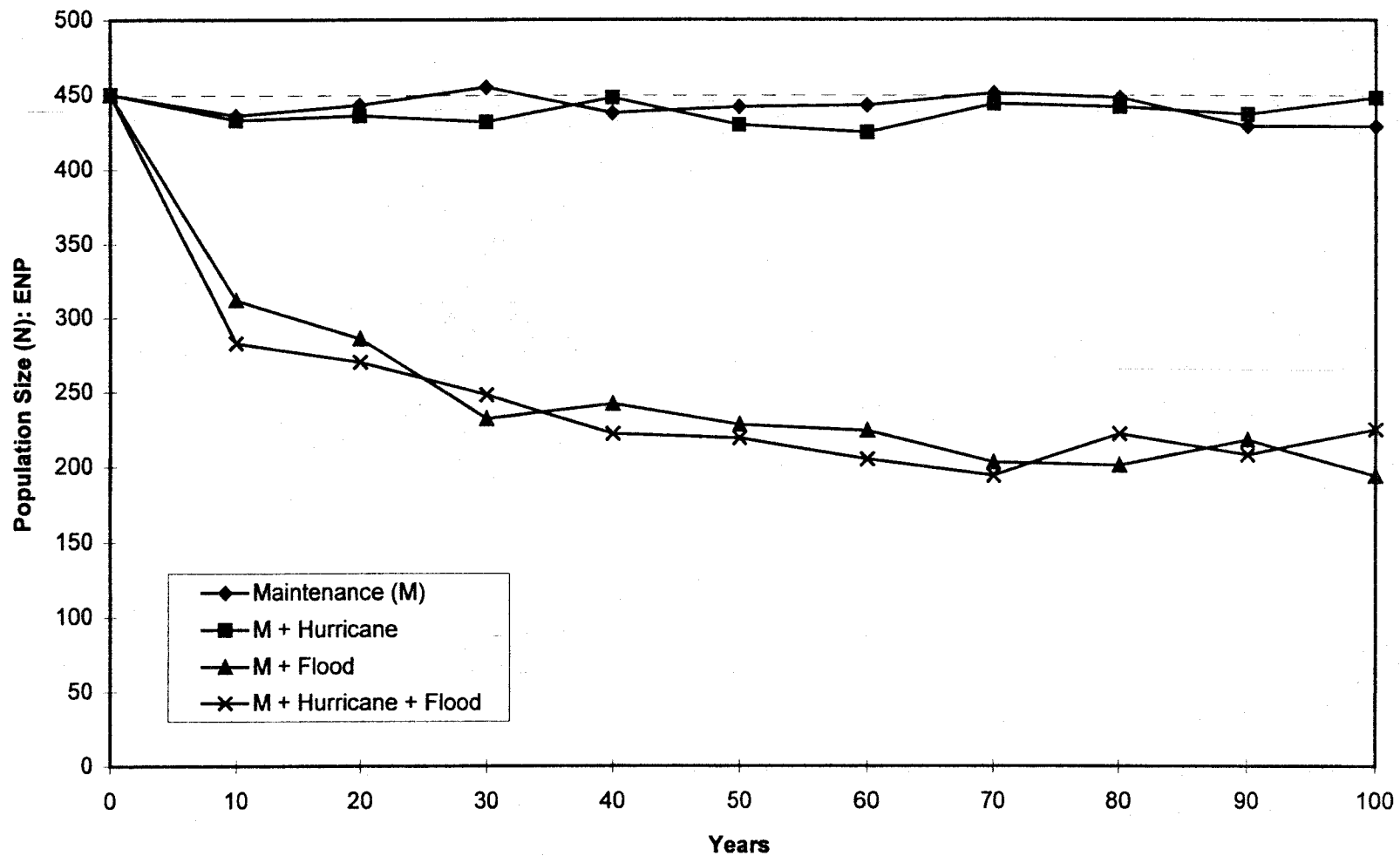


Figure 9. Models of population growth of white-tailed deer at maintenance level subjected to environmental catastrophes (hurricanes, 5% frequency; floods, 10% frequency) in Everglades National Park (nonhunted population) (see Table 17 for model inputs).

Initial population size, 450; carrying capacity, 500.

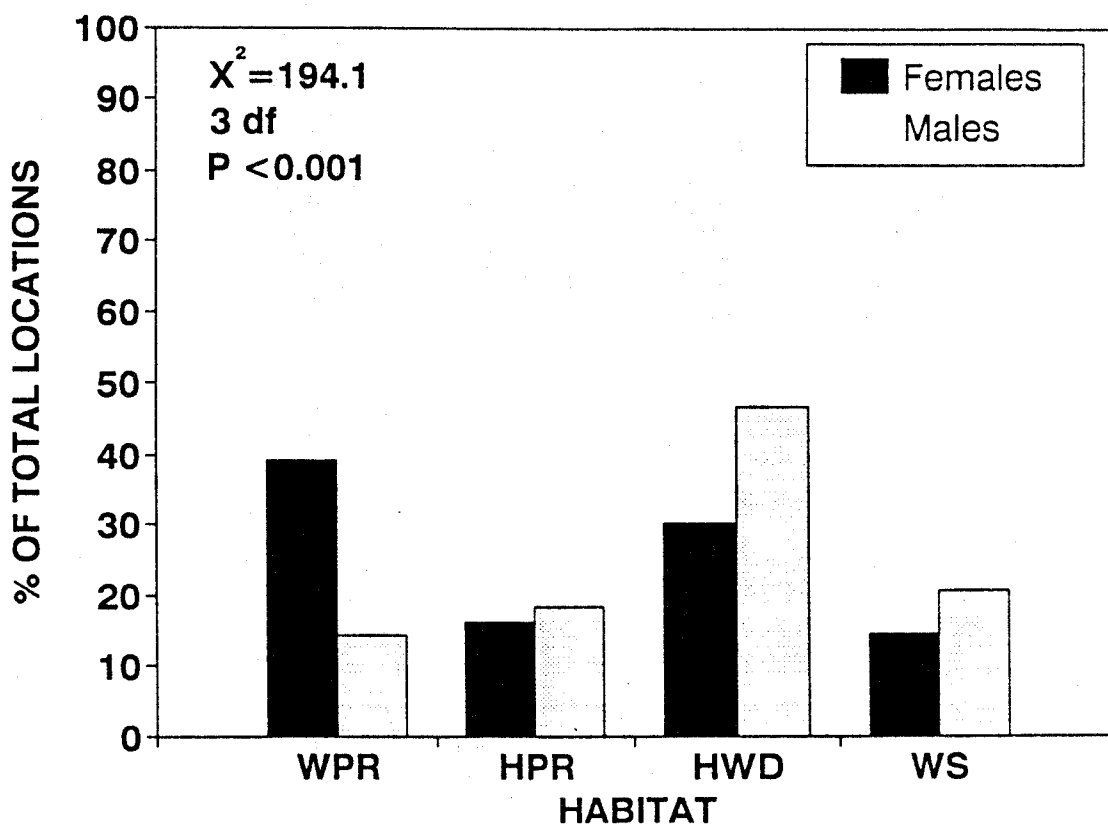


Figure 10. Differences in habitat use by adult female (n=7) and male (n=6) white-tailed deer in Big Cypress National Preserve and Everglades National Park during the 3 years, 1989-90, 1990-91, and 1991-92 (adapted from Miller 1993). Habitat types: WPR, wet prairie; HPR, herbaceous prairie; HWD, hardwood tree islands/hardwood scrub; and WS, willow/dense sawgrass.

APPENDIX A, Table 1. Death log of radio-instrumented deer: BCNP/ENP Study

Sample: Deer captured (Nos. 001-201), 1989-92

Death Log: 01 April 1989-31 March 1995

(Note: Deaths of deer that occurred after censoring are not included; however, deaths that occurred during capture are included.)

ID	Deer	Sex	Age at death	Area	Date of death	Cause of death
01	BC8920	F	(3.0 yr) ^a	ENP	16 May 89	capture myopathy
02	BC8951	F	(3.0 mo)	ENP	12 Jul 89	undetermined cause
03	BC8918	F	(3.0 yr)	ENP	13 Jul 89	undetermined cause
04	BC8911	M	(6.0 mo)	BCNP	25 Jul 89	undetermined cause
05	BC8932	M	(4.0 mo)	ENP	01 Aug 89	undetermined cause
06	BC8938	F	(4.5 yr)	BCNP	09 Aug 89	undetermined cause
07	BC8929	M	(5.0 mo)	ENP	10 Sep 89	bobcat predation
08	BC8930	F	(3.5 yr)	ENP	20 Sep 89	undetermined cause
09	BC8943	F	(3.5 yr)	ENP	25 Sep 89	illegal kill (poached)
10	BC8931	F	(4.5 yr)	ENP	03 Oct 89	bobcat predation
11	BC8954	F	(4.5 yr)	BCNP	28 Oct 89	illegal kill (poached)
12	BC8949	M	(2.5 yr)	BCNP	29 Oct 89	legal kill
13	BC8957	M	5.5 yr	BCNP	30 Oct 89	legal kill
14	BC8928	M	(7.0 mo)	ENP	05 Nov 89	bobcat predation
15	BC8912	M	3.5 yr	BCNP	05 Nov 89	legal kill
16	BC8964	F	(4.5 yr)	ENP	10 Nov 89	undetermined cause
17	BC8940	M	(3.5 yr)	BCNP	22 Nov 89	legal kill
18	BC8915	M	2.5 yr	ENP	25 Nov 89	illegal kill (poached)
19	BC8901	M	(9.0 mo)	BCNP	21 Dec 89	bobcat predation
20	BC8907	M	2.5 yr	ENP	21 Dec 89	undetermined cause
21	BC8935	F	(9.0 mo)	BCNP	25 Dec 89	undetermined cause
22	BC9071	M	(1.0 yr)	BCNP	11 Jan 90	capture myopathy
23	BC9068	F	(2.0 yr)	BCNP	13 Jan 90	capture myopathy
24	BC9074	M	(3.0 yr)	ENP	19 Jan 90	undetermined cause
25	BC8950	F	(1.0 yr)	BCNP	23 Jan 90	undetermined cause
26	BC9073	M	(9.0 mo)	ENP	03 Feb 90	undetermined cause
27	BC8953	F	4.0 yr	ENP	14 Mar 90	undetermined cause
28	BC8919	F	5.0 yr	ENP	16 Mar 90	bobcat predation
29	BC8944	M	(1.0 yr)	ENP	17 Mar 90	panther predation
30	BC9096	M	4.0 yr	ENP	29 Mar 90	capture-myopathy
31	BC9094	F	(3.0 wk)	BCNP	30 Mar 90	capture myopathy
32	BC9088	M	(1.0 mo)	ENP	02 Apr 90	bobcat predation
33	BC9070	F	(5.0 yr)	BCNP	03 Apr 90	bobcat predation
34	BC90100	F	(2.0 mo)	BCNP	18 Apr 90	undetermined cause

35	BC90113	M	(1.5 mo)	ENP	29 Apr 90	bobcat predation
36	BC9097	M	(3.0 yr)	ENP	13 May 90	bobcat predation
37	BC8916	F	(2.0 yr)	ENP	20 May 90	bobcat predation
38	BC9095	M	(2.5 mo)	BCNP	30 May 90	bobcat predation
39	BC90116	M	(3.0 mo)	ENP	02 Jun 90	bobcat predation
40	BC9080	F	(4.0 mo)	BCNP	05 Jun 90	undetermined cause
41	BC90117	M	(3.0 mo)	BCNP	08 Jun 90	bobcat predation
42	BC9075	M	(1.0 yr)	ENP	09 Jun 90	malnutrition
43	BC90108	M	(3.0 mo)	BCNP	10 Jun 90	bobcat predation
44	BC9086	F	(4.0 mo)	BCNP	12 Jun 90	undetermined cause
45	BC9090	M	(5.0 mo)	ENP	17 Jun 90	bobcat predation
46	BC90115	M	(4.0 mo)	ENP	24 Jun 90	undetermined cause
47	BC90112	M	(4.5 mo)	ENP	02 Jul 90	bobcat predation
48	BC9098	M	(4.5 mo)	BCNP	03 Jul 90	bobcat predation
49	BC90103	F	(5.0 mo)	ENP	05 Jul 90	undetermined cause
50	BC90110	M	(3.5 mo)	ENP	06 Jul 90	bobcat predation
51	BC9082	F	(5.0 mo)	ENP	17 Jul 90	bobcat predation
52	BC90102	M	(5.0 mo)	BCNP	21 Jul 90	bobcat predation
53	BC9083	F	(5.0 mo)	BCNP	04 Aug 90	undetermined cause
54	BC90126	M	(4.0 yr)	ENP	14 Aug 90	capture-related
55	BC8956	M	(2.5 yr)	BCNP	08 Sep 90	legal kill ^b
56	BC8927	M	(4.5 yr)	BCNP	15 Sep 90	illegal kill (poached)
57	BC90137	F	(3.5 yr)	ENP	08 Oct 90	undetermined cause
58	BC9093	F	(9.0 mo)	ENP	18 Oct 90	bobcat predation
59	BC90118	M	(3.5 yr)	BCNP	19 Nov 90	legal kill
60	BC8917	M	(2.5 yr)	BCNP	26 Nov 90	legal kill ^b
61	BC9077	M	(3.5 yr)	BCNP	01 Dec 90	legal kill
62	BC8959	F	(4.0 yr)	BCNP	12 Jan 91	bobcat predation
63	BC90105	F	(1.0 yr)	ENP	17 Feb 91	bobcat predation
64	BC8926	F	(4.0 yr)	ENP	02 Mar 91	undetermined cause
65	BC91147	M	(5.0 wk)	BCNP	08 Mar 91	capture myopathy
66	BC91148	M	(1.0 wk)	BCNP	10 Mar 91	capture myopathy
67	BC91156	F	(5.0 wk)	BCNP	16 Mar 91	bobcat predation
68	BC91166	M	(2.0 wk)	ENP	23 Mar 91	capture myopathy
69	BC91144	F	(1.5 mo)	BCNP	27 Mar 91	bobcat predation
70	BC91159	F	(5.0 wk)	ENP	31 Mar 91	undetermined cause
71	BC91179	M	(1.0 mo)	ENP	16 Apr 91	capture myopathy
72	BC91168	F	(2.0 mo)	ENP	24 Apr 91	bobcat predation
73	BC91162	M	(3.0 mo)	ENP	08 May 91	undetermined cause
74	BC91158	M	(3.0 mo)	BCNP	21 May 91	undetermined cause
75	BC91180	F	(2.5 mo)	BCNP	24 May 91	bobcat predation
76	BC91170	M	(3.5 mo)	BCNP	24 May 91	undetermined cause
77	BC91161	F	(3.0 mo)	BCNP	27 May 91	undetermined cause
78	BC91172	M	(3.0 mo)	ENP	28 May 91	bobcat predation
79	BC91155	F	(3.5 mo)	BCNP	29 May 91	undetermined cause
80	BC91181	F	(2.0 mo)	BCNP	01 Jun 91	bobcat predation

81	BC91177	F	(3.0 mo)	ENP	03 Jun 91	bobcat predation
82	BC91176	M	(3.5 mo)	ENP	04 Jun 91	bobcat predation
83	BC91143	F	(3.5 mo)	BCNP	07 Jun 91	undetermined cause
84	BC91152	F	(3.0 mo)	ENP	07 Jun 91	bobcat predation
85	BC91184	M	(1.5 yr)	BCNP	07 Jun 91	capture-
86	BC91165	M	(5.0 mo)	ENP	12 Jun 91	bobcat predation
87	BC91178	F	(4.5 mo)	ENP	27 Jun 91	malnutrition
88	BC91142	M	(5.5 mo)	BCNP	01 Jul 91	bobcat predation
89	BC91145	F	(4.5 mo)	BCNP	17 Jul 91	bobcat predation
90	BC91153	M	(6.5 mo)	ENP	19 Jul 91	undetermined cause
91	BC91163	F	(5.5 mo)	ENP	22 Jul 91	bobcat predation
92	BC91167	M	(5.0 mo)	ENP	28 Jul 91	bobcat predation
93	BC91175	F	(4.5 mo)	ENP	11 Aug 91	malnutrition
94	BC91164	M	(5.5 mo)	ENP	12 Aug 91	bobcat predation
95	BC8904	F	6.5 yr	BCNP	02 Sep 91	alligator predation
96	BC90121	M	(5.5 yr)	BCNP	26 Sep 91	panther predation
97	BC91186	M	(1.5 yr)	BCNP	16 Nov 91	legal kill
98	BC9078	M	(2.5 yr)	BCNP	16 Nov 91	legal kill
99	BC90122	M	(4.5 yr)	BCNP	17 Nov 91	legal kill
100	BC90109	M	5.5 yr	ENP	18 Nov 91	illegal kill (poached)
101	BC91187	M	(2.5 yr)	BCNP	25 Nov 91	legal kill
102	BC8961	M	(5.5 yr)	ENP	28 Nov 91	undetermined cause
103	BC8913	M	5.5 yr	BCNP	09 Dec 91	legal kill
104	BC91185	M	(1.5 yr)	BCNP	13 Dec 91	legal kill
105	BC8936	M	(3.5 yr)	BCNP	26 Dec 91	legal kill
106	BC90188	M	(1.5 yr)	BCNP	29 Dec 91	legal kill
107	BC90130	M	5.5 yr	ENP	08 Nov 92	undetermined cause
108	BC9091	M	6.5 yr	ENP	04 Dec 92	undetermined cause
109	BC91193	M	5.5 yr	ENP	05 Dec 92	legal kill
110	BC90119	M	5.5 yr	BCNP	26 Dec 92	legal kill
111	BC90107	F	(3.0 yr)	BCNP	01 Jan 93	undetermined cause
112	BC91198	F	4.5 yr	BCNP	20 Jul 93	undetermined cause
113	BC91197	M	(2.5 yr)	ENP	10 Aug 93	capture-related
114	BC91149	M	(2.5 yr)	ENP	11 Aug 93	capture-related
115	BC8952	M	(6.5 yr)	ENP	16 Aug 93	undetermined cause
116	BC90131	F	(6.5 yr)	BCNP	29 Oct 94	stress/malnutrition
117	BC91189R	M	(4.5 yr)	BCNP	09 Nov 94	alligator predation
118	BC9069R	F	8.0 yr	ENP	27 Dec 94	undetermined cause
119	BC9060R	M	9.0 yr	ENP	27 Feb 95	undetermined cause

* Ages within parentheses were verified by age at capture for fawns ≤ 2 months in age, and by examination of pattern of tooth replacement/wear at death for fawns > 2 months in age, yearlings, and adults.

^b Considered a legal kill by law enforcement personnel despite apparent violation of hunting regulations.