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TITLE: Behavioral Responses of White-tailed Deer Along
the Spatial Transition Between Hunted and
Nonhunted Populations

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EXECUTIVE SUMMARY

This research investigation was designed to elucidate the interactive spatial dynamics of a protected population of white-tailed deer (*Odocoileus virginianus*) in Everglades National Park and a hunted population of deer in the immediately adjacent Big Cypress National Preserve. The primary hypothesis was that deer resident in the sanctuary area would disperse into the proximate hunted area from which population density has been reduced by recreational harvest (density-dependent population response). The study area, which parallels the boundary between the 2 land management units, encompasses about 62 km² of contiguous wet prairie/tree island habitat.

Sixty-eight deer were captured by helicopter net-gunning, radio-instrumented, and entered into the sample population during July/August 1993 (n=48) and August 1994 (n=20). Additionally, 10 adult radio-instrumented deer (4 males and 6 females), captured during 1989-92, that resided in, or near, the boundary study area were monitored for survival. The status of this sample of 78

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Needs to give credit
to NPS personnel
who already compiled
information included
in this report.
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radio-instrumented deer, as of 31 March 1995, was: censored (transmitter failure/longevity), 13 (17%); dead, 39 (50%); and alive/transmitting, 26 (33%).

The 68 radio-instrumented deer entered into the sample population during 1993 and 1994 were radio-located, by fixed-wing aircraft, a total of 6,052 times between the date of capture and 31 March 1995; visual sightings of the radio-instrumented deer were recorded for 1,865 (30.8%) of the radio-locations.

Eighty-four (80%) of 105 deer pursued during helicopter net-gunning operations were captured; helicopter time per capture, which was selective for age/sex, averaged 0.65 hours.

Rainfall for the 2 biological years, April 1993-March 1994 and April 1994-March 1995, totalled 58.46 inches (148.5 cm) and 71.68 inches (182.1 cm), respectively; these rainfall amounts, respectively, were 9.2% and 33.9% above the long-term mean of 58.46 inches (136 cm). Monthly water depths exceeded 0.6 m (1.97 feet), the depth above which deer potentially are impacted due to restricted mobility, in all months of 1993-94 and 1994-95, except April and May of 1994. Importantly, monthly water depths exceeded 1.0 m (3.28 feet) throughout the 6-month period, October 1994-March 1995; the maximum water depth, 1.29 m (4.24 feet), was recorded in January 1995.

*where are
rainfall and
water level
gauges? How
do they relate
to the study
area?*

Survival rates of adult and yearling deer of both sexes were lower during 1993-94 and 1994-95 than during the 3-year period, 1989-92. Given the low recruitment rate of females (<25%) in this breeding population, the survival rates of females recorded in 1993-94 (adults, 0.7875; yearlings, 0.8889) and 1994-95 (adults, 0.4798; yearlings, 0.6000) were indicative of declining populations. Population recovery in 1995 will be depressed substantially because of the low level of productivity (fawn production) among females that survived the flood.

Thirty-nine deaths of radio-instrumented deer were recorded during the 2 biological years, 15 (13 males: 2 females) in 1993-94 and 24 (11 males: 13 females) in 1994-95. Cause of deaths were attributable to various factors: undetermined causes, 19 (49%); harvest (legal and illegal), 7 (18%); stress/malnutrition, 6 (15%); stress/predation, 4 (10%); and predation, 3 (8%). The deaths of all 24 deer in 1994 occurred after water depths had reached 0.9 m (3.0 feet); ≥ 18 (75%) of the deaths appeared to be associated with these high-water levels. Thus, although the movements of deer are likely compromised at water depths of 0.6 m, survival of deer in this wet prairie/tree island habitat may not be jeopardized critically until water depths exceed 0.9 m.

Findings from 1993-94 indicated that males (n=13) resident in the higher-density, nonhunted ENP population did not emigrate into the adjacent, lower-density hunted BCNP population, even

though males in the latter population had been reduced by 69% (principally by hunting) during the fall of 1993. This strong exhibition of site fidelity, coupled with the matriarchal social system of the species, may preclude the manifestation of density-dependent spatial responses in deer.

Pre-flood (August/September 1994) and post-flood (March/April 1995) home ranges of 27 radio-instrumented deer (14 males, 13 females) were documented to evaluate the impacts of flood waters on the responses of deer with respect to dispersal and site fidelity behaviors. This analysis revealed that 8 (30%) of the 27 deer exhibited the response of **no dispersal** from their established home ranges, 12 (44%) exhibited the response of **dispersal/return**, and 7 (26%) exhibited the response of **dispersal/no return**. Thus, 20 (74%) of the 27 deer demonstrated site tenacity under catastrophic environmental conditions, which provides additional support for the manifestation of strong site fidelity in white-tailed deer.

INTRODUCTION

The white-tailed deer has had a long and rich history in North America. Widely distributed on the continent, the white-tailed deer probably reached its peak level of abundance, conjecturally about 24-34 million, in about 1,500 A. D. (Downing 1987). The arrival of European man on the continent in the 1600s signaled the beginning of a 300-year downward trend in the abundance of the species. The North American population declined, due to the combined impacts of over-exploitation and habitat degradation, to a population level of about 350,000 in the early 1900s (McCabe and McCabe 1984). Fortunately, the pendulum of deer abundance swung to the positive side after the turn of the last century, and, particularly, after the Great Depression of the 1930s. Factors influencing the rising fortunes of the white-tailed deer included legal protection, e.g., the Lacey Act of 1900; the shift of the rural population to cities; the wholesale abandonment of small farms that reverted to deer habitat via succession; and the advent of a scientific basis for managing all wildlife, including deer. By the mid-1980s, white-tailed deer abundance in North America had rebounded to a population level of about 14 million, with an estimated annual sport harvest of 3 million animals (Stransky 1984). However, there was a negative side to the escalation in abundance of the white-tailed deer: overpopulation on restricted land areas. In fact, the issue of the over-abundance of native ungulates on National Park Service (NPS) lands was addressed 3 decades ago by Leopold et al. (1963).

In addition to being North America's foremost game animal among consumptive-resource users, the white-tailed deer is held in high esteem as an aesthetic resource by the public at large.

The latter is manifest in the partitioning of "values" derived from deer into various components, such as evolutionary, cultural, ecological, economic, social, psychological, and political (Langenau et al. 1984). Thus, sound ecological management of deer herds within the capacity of their environments is emerging as a complex process, particularly on public lands in the eastern U. S. (Soukup et al. 1990, Warren 1991, Underwood and Porter 1991, Porter 1992, Porter et al. 1994). The complexity becomes even more acute when selected segments of the public, such as animal-rights and anti-hunting advocates, oppose regulating herd abundance through traditional harvest techniques, e.g., Smithsonian Conservation and Research Center, Front Royal, Virginia in 1982 (McShea et al. 1993); Florida Everglades in 1982 (Brantly 1982); Angel Island State Park, San Francisco, California (*O. hemionus columbianus*) (Goldsmith 1982, O'Bryan and McCullough 1985); Air Force Academy, Colorado in 1988 (R. F. Labisky, pers. observ.); and Chicago Metropolitan Area in the 1980s (Witham and Jones 1987, 1990).

Potential strategies for controlling white-tailed deer populations within allowable ecological limits on public lands include: (1) **"do nothing"**, which is unacceptable in that it potentially jeopardizes herd health and that it conflicts with other mandated policies, e.g., maintenance of biological diversity (Warren 1991); (2) **chemo-sterilization**, which has been either relatively unsuccessful or cost-prohibitive (Harder and Peterle 1974, Bell and Peterle 1975, Roughton 1979, Matschke 1980); (3) **translocation of animals**, a practice which, although championed by animal rights and anti-hunting advocates and fueled by the media, is neither cost-effective, ecologically successful (Hawkins and Montgomery 1969, O'Bryan and McCullough 1985, Pais 1987), nor prudent; (4) **immunocontraceptives**, such as porcine zona pellucida (Turner et al. 1992), which, although offering promise in controlling fecundity in the future, are not yet "deliverable" to free-ranging populations; and (5) **removal** by harvest (mandated reduction or recreational hunting), which is unacceptable to various segments of society, particularly if implemented on public lands. Potentially, however, some control of excess deer abundance on protected public lands may be achievable through recreational hunting on adjacent lands, i.e., deer from protected areas (source population) may disperse into hunted areas where population density has been reduced by hunting (sink population). Currently, information to either support or reject this premise is lacking, although there is evidence suggesting that adult males do not move to protected areas to seek refuge when subjected to hunting activities (Hawkins et al. 1971, Kammermeyer and Marchinton 1976, Pilcher and Wampler 1982, Root et al. 1988, Sargent 1992).

RESEARCH OBJECTIVES

This investigation was designed to elucidate the interactive spatial dynamics of a protected population of white-tailed deer and an immediately adjacent ~~population~~ hunted population of deer in the contiguous wet prairie/hardwood tree island habitat of the Everglades system in south Florida.

Primary hypothesis:

- H₀₁ Deer resident in sanctuary areas disperse into proximate hunted areas in which the population density has been reduced by recreational harvest (density-dependent population response).

Secondary hypotheses:

- H₀₂ Deer resident in hunted areas seek refuge in proximate sanctuary area during the hunting season (harassment response).
- H₀₃ Deer resident in hunted areas seek the most proximate habitat that provides enhanced concealment during the hunting season (escape response).

STUDY AREA

The principal study area, approximately 62.5 km² in size, is centered on the boundary between the Everglades National Park (ENP) and Big Cypress National Preserve (BCNP); it extends approximately 2.5 km southward into ENP (nonhunted), 2.5 km northward into BCNP (hunted), and 2.5 km eastward and 10 km westward from Ten-mile Corner (Fig. 1). (**Note:** The 2.5 km distance represents the mean radius of the annual home ranges of 41 radio-instrumented male deer studied in BCNP/ENP during the 3 years, 1989-92.)

The region is characterized by a subtropical climate. Mean annual temperature is 23 C, with mean monthly temperatures ranging from a low of 14 C in January to a high of 28 C in August; mean annual precipitation is 136 cm, two-thirds of which falls during the months of April-October (Duever et al. 1986). Thus, usually, the region has a wet summer season (May-October) and a dry winter season (November-April). The onset and duration of wet seasons are highly variable; thus, periods characterized by droughts or floods are not uncommon. Surface water flow is southwesterly over a topographic gradient of 9 cm/km (Duever et al. 1986).

Vegetation on the study area is comprised principally of wet prairie (93%), which is typified by a hydroperiod of 50-150 days, and mixed hardwood tree islands (7%) (Duever et al. 1986; Miller 1993). The wet prairie community is dominated principally by grasses and sedges; common species include sawgrass (*Cladium jamaicensis*), maidencane (*Panicum hemitomon*), sand cordgrass (*Spartina bakeri*), muhly grass (*Muhlenbergia filipes*), love grass (*Eragrostis maicense*), beakrush (*Rynchospora* spp.), spikerush (*Eleocharis* spp.), white water-lily (*Nymphaea odorata*), flag (*Sagittaria lancifolia*), and pickerelweed (*Pontederia lanceolata*) (Duever et al. 1986). Tree islands are characterized by both temperate and tropical hardwoods, including red bay (*Persea palustris*), sweet bay (*Magnolia virginiana*), wax myrtle (*Myrica cerifera*), dahoon holly (*Ilex cassine*), cabbage palm (*Sabal palmetto*), live oak (*Quercus virginiana*), water oak (*Q. nigra*), wild tamarind (*Lysiloma bahamensis*), gumbo limbo (*Bursera simaruba*), strangler fig (*Ficus aurea*), and cocoplum (*Chrysobalanus icaco*).

No hunting via AB in Arch Muz
The density of deer at the onset of the study in 1993 approximated 3.3 deer/km² in BCNP, and 4.5 deer/km² in ENP (Labisky et al. 1992). With respect to productivity, the number of fetuses per pregnant female averaged 1.44 (44% with twins) in BCNP and 1.00 (0% with twins) in ENP during 1989 and 1989 (Forrester 1991, Forrester and Wright 1989). Adults in ENP were characterized by an older age profile than those in BCNP (Labisky et al. 1992). BCNP is the focus of an intensive males-only (antler length ≥ 12.5 cm) harvest annually; in 1993, the season spanned 92 days (archery, primitive weapon, and general gun), and the daily and seasonal bag limits were 1 and 2, respectively. In 1994, however, deer hunting in BCNP was prohibited due to the occurrence of unusually high water levels (severe flood). Hunting in ENP is prohibited.

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 1987, 1989; 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 legs together with cord. Biological data recorded from each deer included: sex; age (Severinghaus 1949); neck and chest circumference (cm); hind foot and total body length (cm); body weight (kg); antler measurements for males--points (right and left), beam circumferences (mm), inside antler spread (cm), and beam lengths (cm); pregnancy/lactation status for females; tail-fat condition index (Stockle et al. 1978); and ectoparasite index. Each deer was marked with numbered No. 49 monel eartags in both right and left ears, and a radio-transmitter/collar (150-152 MHz frequency range), equipped with motion-sensitive activity (2X signal pulse) and mortality (4X signal pulse) modes (Wildlife Materials, Inc., Carbondale, IL). Processing time averaged about 20 minutes per animal (for a 2-person team), after which time the deer was released at the capture site.

Radio-telemetry Monitoring

The relatively remote location of the study area (a portion being in the Everglades where ground access by vehicle is prohibited), the seasonally fluctuating hydroperiod, and the areal expanse of the study area essentially limit the obtainment of radio-locations of instrumented deer to aerial telemetric monitoring (by fixed-wing aircraft), which, in turn, restricts the location-monitoring to daylight hours. Given these logistical restrictions, a biological-clock regime was designed to obtain unbiased daylight monitoring data, 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 hours post-sunrise; 2 hours post-sunrise to mid-day; mid-day to 2 hours pre-sunset; and 2 hour pre-sunset to sunset. Thus, all radio-locations for any given animal were equally divided among the 4 discrete daytime monitoring periods. The location error associated with aerial-based telemetry in this wet prairie terrain, estimated from the blind placement of "dummy" radio-collars, is ≤ 30 m (Miller 1993).

The interval at which individual deer were radio-located varied, depending on seasonal events (e.g., hunting, flooding), from 1 location every 7.5 days (4 per month) to 1 location every 3 days (10 per month), but averaged 1 location every 4 days (8 per month); the latter rate equates to 96 locations per deer surviving a 12-month period. Additionally, all radio-instrumented deer were monitored with respect to mortality on every radio-location flight.

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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.

Mortality/Survival

NO
Detection of death.--All radio-instrumented deer for which death was indicated by the emittance of the transmitter-mortality signal (4X pulse) were investigated upon occurrence (fixed-wing flight). This airborne investigation generally isolated one of 3 outcomes: (1) a false-mortality signal, which was usually detected by "buzzing" the site of radio-location, thereby disturbing the deer and reactivating the normal activity switch (1X pulse); (2) sighting the carcass of the dead radio-instrumented animal; or (3) failure to either sight the dead radio-instrumented animal or to verify a false-mortality signal. In the latter 2 instances, efforts were made to reach the site as soon as possible by helicopter (ENP) or by either helicopter, airboat, or 4-wheel ATVs (BCNP) to verify death, and if verified, to determine cause and time of death as well as to recover the carcass, pending the usefulness of its condition, for subsequent necropsy.

Survival analyses.--Annual survival rates of radio-instrumented deer were derived by the product-limit estimator procedure (Kaplan and Meier 1958), modified to allow for the staggered entry of new radio-instrumented animals that were added to the sample population as the study progressed in calendar time (Pollock et al. 1989). The biological year for deer in the BCNP/ENP was designated to begin 01 April, at which time the peak of fawning season has been reached; the median date of fawning in this deer population is 22 February (Boulay 1992). Annual survival rates for adults represent the 12-month period, 01 April-31 March. However, survival rates for yearlings represent only a 7-month period because capture was accomplished principally in the month of August during 1993 and 1994; thus, yearlings were not entered into the sample population until 01 September.

(Note: No radio-instrumented animal was added to the sample herd prior to 7 days post-capture, the interval after which the probability of occurrence of death from capture myopathy

[Chalmers and Barrett 1982] in the Everglades environment was low [R. F. Labisky, unpubl. data].)

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); if present, scat 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 (*Felis concolor coryi*) (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; the latter was enhanced due to the diel predatory habits of alligators coupled with high water-levels in the study area in 1994 and early 1995.

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.

Home Range Analyses

Preliminary estimates of home range size were calculated by the HOME RANGE software program (Ackerman et al. 1989). Centers of activity were computed by the harmonic mean procedure (Dixon and Chapman 1980).

FINDINGS/DISCUSSION

Study Sample

Sixty-eight deer were captured by the helicopter net-gun technique, radio-instrumented, and entered into the sample population during July/August 1993 (n=48) and August 1994 (n=20) (Tables 1 and 2). The 1993 sample of 48 deer (24 captured in BCNP, 24 in ENP) included 16 adult males, 13 adult females, 8 yearling males, 9 yearling females, and 2 fawns (female). The 1994 sample of 20 deer (14 captured in BCNP, 6 in ENP) included: 8 adult males, 2 adult females, 5 yearling males, and 5 yearling females. Additionally, 10 adult radio-instrumented deer (4 males and 6 females), captured during 1989-92, that resided in, or near, the boundary study area were monitored for survival. The

status of this sample of 78 radio-instrumented deer, as of 31 March 1995, was: censored (transmitter failure/longevity), 13 (17%); dead, 39 (50%); and alive/transmitting, 26 (33%). The 26 extant deer include 13 adult males and 13 adult females.

The 68 radio-instrumented deer entered into the sample population during 1993 and 1994 were radio-located, by fixed-wing aircraft, a total of 6,052 times between the date of capture and 31 March 1995; visual sightings of the radio-instrumented deer were recorded for 1,865 (30.8%) of the radio-locations.

Capture Efficiency

A total of 84 individual deer was captured by helicopter netgunning during 54.7 hours of helicopter time during 1993 and 1994, an average of 0.65 hours of helicopter time per captured deer (Tables 2 and 3). Capture was selective because the research design required that the sample population include approximately the same number of deer in each of the 4 age/sex cohorts (adult males, adult females, yearling males, and yearling females) in both BCNP and ENP. The increase in the hours of helicopter time required to capture a deer in 1994 (0.78 hours), in comparison to 1993 (0.58 hours), reflected both the need for increased "screening" in order to capture of animals for specific age/sex cohorts and a reduced number of yearlings in the population. The latter was the result of poor fawn recruitment in 1993, the year following Hurricane Andrew. (Note: Only 8 fawns were observed during 31.1 helicopter-hours of capture effort in 1993; in contrast, >100 fawns were observed in 23.6 helicopter-hours of capture effort in 1994.)

Eighty-four (80%) of 105 deer pursued by helicopter during 1993 and 1994 were captured (Table 3). The shooting efficiency (net-gun shots per captured deer), which averaged 66%, was hampered by the combination of high-water levels and rank (tall) vegetation. High-water levels often prohibited the taking of a net-gun shot when a deer was in the "shooting cone", and the rank vegetation often prevented the net from "settling" over an animal to cause entanglement.

Rainfall/Water Levels

Annual rainfall in the region exceeded the long-term mean of 53.46 inches (136.0 cm) in both 1993-94 and 1994-95 (Fig. 2). Rainfall for the 2 biological years, April 1993-March 1994 and April 1994-March 1995, totalled 58.46 inches (148.5 cm) and 71.68 inches (182.1 cm), respectively. Thus, rainfall amounts were 9.2% and 33.9% above the long-term mean in 1993-94 and 1994-95, respectively. Notably, in 1994, rainfall during the 4-month period, August-November, totalled 41.02 inches (104.2 cm); thus, rainfall in these 4 months constituted 76.7% of the total annual rainfall typical of the region. (Note: Tropical Storm Gordon

added "insult to injury" by depositing as much as 8 inches of rainfall in portions of BCNP and ENP on 15-16 November 1994.)

Water depths on the study area during 1993-94 and 1994-95 exceeded long-term monthly means for all months (Fig. 3). Loveless (1959) reported that high-water levels (>0.6 m) in the Everglades restricted the travel of deer, which, in turn, could result in their confinement, and subsequent starvation, on tree islands. Monthly water levels exceeded 0.6 m (1.97 feet) in all months of 1993-94 and 1994-95, except during April and May of 1994 (Fig. 3). Importantly, water depths exceeded 1.0 m (3.28 feet) monthly throughout the 6-month period, October 1994-March 1995; the maximum water depth, 1.29 m (4.24 feet), was recorded in January 1995. In essence, the study area was characterized by a perpetual wet season from June 1993 through March 1995, with severe flood conditions persisting throughout the 6-month period, October 1994-March 1995.

Survival/Mortality

Survival rates were derived from the radio-instrumented population using the product-limit estimator procedure (Kaplan and Meier 1958), modified to allow for the "staggered" entry of animals captured and added to the sample population during the study period (Pollock et al. 1989) (Table 4; Appendix A, Tables 1-8). Survival rates of adult and yearling deer of both sexes were lower during both 1993-94 and 1994-95 than during the 3-year period, 1989-92 (Table 4). Given the low recruitment rate of females ($<25\%$) in this breeding population (Boulay 1992), the survival rates of females recorded in 1993-94 (adults, 0.7875; yearlings, 0.8889) and 1994-95 (adults, 0.4798; yearlings, 0.6000) were indicative of declining populations (Fuller 1990, R. F. Labisky, unpubl. data). Population recovery will be especially prolonged not only because of the low survival of females in 1994-95 but also because of the lack of fawn production in 1995 by those females surviving the "flood".

(Note: No fawns were observed with radio-instrumented dams during radio-location flights in January, February, March, or April 1995; in contrast, 36 fawns were observed with radio-instrumented dams during the same months in 1994. The stress exerted on pregnant females by high-water levels during the fall-winter period of 1993-94 apparently reduced their physiological condition to a level that precipitated embryo resorption, fetus abortion, or early natal mortality of fawns.)

Thirty-nine deaths of radio-instrumented deer were recorded during the 2 biological years, 15 (13 males: 2 females) in 1993-94 and 24 (11 males: 13 females) in 1994-95. Cause of deaths were attributable to various factors: undetermined causes, 19 (49%); harvest (legal and illegal), 7 (18%); stress/malnutrition, 6 (15%); stress/predation, 4 (10%); and predation, 3 (8%) (Table 5).

where were
gays in relation
to deer most?
Need H₂O levels
where deer were
lost.

No

The occurrence of deaths in 1994-95, under the condition of high-water levels, merits special mention. Although water depths exceeded the 0.6-m level during June (0.64 m), July (0.73 m), and August (0.80 m) of 1994, no deaths occurred among the radio-instrumented sample. All 24 deaths of radio-instrumented deer occurred thereafter (September, 2; October, 2; November, 5; December, 2; January, 5; February, 3; and March, 5), which coincided with the period during which water depths exceeded 0.9 m (3.0 feet) (Table 5; Fig.3). Of the 24 deaths that occurred after water depths exceeded 0.9 m, ≥ 18 ($\geq 75\%$) appeared either directly or indirectly (e.g., predisposed to predation) related to impacts generated by the flooded environment (Table 5). Thus, although the movements of deer are likely compromised at water depths of 0.6 m (Loveless 1959), the survival of deer in the wet prairie/tree island habitat of the Everglades system may not be jeopardized critically until water depths attain or exceed 0.9 m.

P. 34
Not 100%
of deer

Density-dependent Response of Males to Population Reduction

A principal objective of this research undertaking was to determine if the removal of deer from an area by recreational hunting annually would result in the influx of deer from an immediately adjacent area in which hunting was not permitted. The study area along the boundary of BCNP and ENP constituted a ideal experimental site for 3 reasons: (1) the deer populations in BCNP and ENP had been studied intensively during the 3 years, April 1989-March 1992 (Labisky et al. 1992, Boulay 1992, Sargent 1992, Zultowsky 1992, Miller 1993); (2) the deer population in the BCNP is subject to the intensive hunting of males annually (mean rate of male harvest was 53% for the 3 years, 1989-91 [Sargent 1992]) whereas deer hunting in ENP is prohibited; and (3) deer abundance in the sanctuary population in ENP (4.5 deer/km²) exceeds that in the hunted population in BCNP (3.3/km²) (Labisky et al. 1992), thereby enhancing the potential of a measurable density-dependent response.

Thirteen radio-instrumented males, including 8 adults and 5 yearlings, were available for harvest at the onset of the general-gun hunting season in BCNP in November 1993. Hunting accounted for the deaths of 62% of the available males, including 4 (50%) of the 8 adults and 4 (80%) of the 5 yearlings; an additional adult male died of undetermined causes in November. Thus, at the close of the hunting season in December 1993, only 4 of the 13 males survived; the radio-instrumented male population in BCNP had been reduced by 69%.

Harvested
in
1993

Concurrently, the spatial locations of 13 radio-instrumented males, including 9 adults and 4 yearlings, in the adjacent non-hunted population in ENP were monitored during prehunt (October) and posthunt (January). These 13 males exhibited no substantial shift in the locations of their home ranges between the prehunt and posthunt periods, although 5 males did exhibit a minor shift

(<1 km) in the center of activity within their home ranges (Fig. 4). Thus, the short-term response of males available to move from a sanctuary area to a hunted area where the male population had experienced a 69% reduction in density was negative. Although these data will be subjected to additional analyses to reflect the possibility of delayed shifts in the location of their home ranges, the findings suggest preliminarily that males in this subtropical environment do not abandon established home ranges to occupy adjacent areas where the density of deer, and presumably the competition for resources and mates, is lower.

This preliminary finding that male deer from a higher-density nonhunted population did not emigrate into an adjacent, lower-density hunted population, especially after the males in the latter population were reduced by 69%, corroborates the concept of strong site fidelity among deer (Tierson et al. 1985, Nelson and Mech 1992). This strong exhibition of site fidelity, coupled with the matriarchal social system of the species (Hawkins and Klimstra 1970, Hirth 1977, Porter et al. 1991), may preclude the manifestation of density-dependent spatial responses in deer.

The strength of site fidelity in deer is reflected also in the apparent reluctance of hunted males to seek sanctuary. Sargent (1992), who studied this same BCNP/ENP deer population in 1989-92, reported that males from the intensively hunted BCNP population did not seek sanctuary in the nonhunted ENP during the hunting season; however, dominant males from ENP, who resided with 2 km of the BCNP/ENP boundary did travel into BCNP during the summer rut period, presumably to take advantage of the reduced competition for female breeding rights, but then returned to ENP prior to the opening of the hunting season in BCNP. Thus, in this case, the sanctuary area acted as a genetic reservoir of males.

Site Fidelity: The Response to High-water Levels

? — The high-water levels that inundated the study area during the summer, fall, and winter of 1994-95 (Fig. 3) not only resulted in high mortality rates and low fecundity among the sample population of radio-instrumented deer (see above), but also restricted their mobility and access to food resources. Deer, exposed to the elevated water levels, had 2 options, either of which could result in survival or death: (1) remain within their established home ranges or (2) abandon their home ranges to search for better coverts i.e., higher ground and available forages. Both options provided the opportunity to further evaluate the concept of site fidelity in deer. Three major behavioral responses could be predicted: (1) deer could remain within their established home ranges, i.e., **no dispersal**; (2) deer could disperse from their established home ranges, establish new temporary home ranges, and then return to their established

home ranges after the water had receded, i.e., **dispersal/return**; and (3) deer could disperse from their established home ranges and establish new home ranges, i.e., **dispersal/no return**.

To evaluate site fidelity in this context, the pre-flood (August/September 1994) and post-flood (March/April 1995) home ranges of 27 radio-instrumented deer (14 males, 13 females) were documented (Table 6). Findings indicated that 8 (30%) of the 27 deer exhibited the response of **no dispersal**, 12 (44%) exhibited the response of **dispersal/return**, and 7 (26%) exhibited the response of **dispersal/no return**. Responses were similar between ages (yearlings vs. adults) and sexes. Thus, 20 (74%) of the 27 deer demonstrated site tenacity under catastrophic environmental conditions, which provides additional support for the concept of strong site fidelity in white-tailed deer (Dasmann and Taber 1956, Tierson et al. 1985, Porter et al. 1991, Nelson and Mech 1992, Sargent 1992, Zultowsky 1992.)

PRELIMINARY ASSESSMENT

The hypotheses that (1) deer from populations of higher density emigrate to populations of lower density (density-dependent population response), (2) deer in areas subjected to recreational hunting seek refuge in adjacent sanctuary area during the hunting season (harassment response), and (3) deer in hunted populations seek habitats that provide enhanced concealment during the hunting season (escape response) are tentatively subject to rejection. The tentative falsification of these hypotheses is based on the finding that deer in this Everglades system exhibit unusually strong site-fidelity behavior, even when confronted with catastrophic environmental conditions. Thus, the management strategy to reduce the population abundance of deer on nonhunted public lands as an indirect result of the removal of deer via recreational hunting on adjacent lands should be viewed as potentially invalid.

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Table 1. Statistics on radio-instrumented white-tailed deer monitored along boundary between Big Cypress National Preserve (BCNP) and Everglades National Park (ENP), Florida, 1 April 1993-31 March 1995. Number of transmitter-days and number of radio-locations are presented for each deer from date of capture (recapture) through 31 March 1995, or date of death/censoring.

Deer ID ^a	Capture date	Capture location	Sex	Age at capture (yrs) ^b	Body weight (kg)	Radio frequency (MHz)	31 March 1995		
							Transmitter days	Radio locations ^c	Status
BC93202	26 Jul 93	ENP	M	1.5	38.6	151.652	431	108/37	Dead: panther/bear predation, 30 Sep 94
BC93203	26 Jul 93	ENP	M	(1.5)	37.6	151.730	117	23/11	Dead: legal kill, 20 Nov 93
BC93204	26 Jul 93	ENP	M	(2.5)	41.7	151.386	417	93/10	Dead: undetermined cause, 16 Sep 94
BC93205	26 Jul 93	ENP	F	(2.5)	40.4	151.847	585	147/64	Dead: undetermined cause (probable stress), 3 Mar 95
BC93206	26 Jul 93	ENP	F	1.5	35.8	151.375	470	116/28	Censored ^d : 22 Nov 94
BC93207	27 Jul 93	BCNP	M	2.5	56.2	151.115		153/19	Alive/transmitting
BC93208	27 Jul 93	BCNP	F	2.5	44.1	151.832		157/59	Alive/transmitting
BC93209	27 Jul 93	BCNP	M	4.5	63.5	151.481	98	N/A	Dead: undetermined cause, 03 Dec 93
BC93210	27 Jul 93	BCNP	F	1.5	30.8	151.823	557	138/73	Dead: stress/malnutrition, 31 Jan 95
BC93211	28 Jul 93	BCNP	F	1.5	29.4	151.520	561	147/24	Dead: stress/malnutrition, 6 Feb 95
BC93212	28 Jul 93	BCNP	F	4.5	41.7	151.709		157/74	Alive/transmitting
BC93213	28 Jul 93	BCNP	M	(1.5)	37.6	151.541	108	21/04	Dead: legal kill, 14 Nov 93
BC93214	02 Aug 93	BCNP	F	1.5	26.7	151.815	473	114/61	Dead: stress/alligator predation, 18 Nov 94
BC93215	02 Aug 93	ENP	F	3.5	46.3	151.129	282	67/50	Censored: 11 May 94
BC93216	02 Aug 93	ENP	F	1.5	34.0	151.370		154/65	Alive/transmitting
BC93217	02 Aug 93	ENP	FF	(0.9)	24.5	151.979	226	68/41	Dead: undetermined cause, 16 Mar 94
BC93218	02 Aug 93	ENP	F	1.5	27.7	151.490		150/51	Alive/transmitting
BC93219	02 Aug 93	ENP	F	4.5	41.7	151.950		154/30	Alive/transmitting
BC93220	03 Aug 93	BCNP	F	(2.5)	37.6	150.978	554	143/38	Dead: undetermined cause (probable stress), 11 Jan 95
BC93221	03 Aug 93	BCNP	M	(1.5)	35.4	151.765	614	149/35	Dead: stress/malnutrition, 12 Mar 95
BC93222	03 Aug 93	BCNP	M	(6.5)	46.3	151.600	25	2/00	Dead: bobcat predation, 28 Aug 93
BC93223	03 Aug 93	BCNP	FF	0.4	20.4	151.195 (BA)	157	54/23	Censored: 07 Jan 94
BC93224	03 Aug 93	BCNP	M	(3.5)	43.1	151.438	137	33/07	Dead: legal kill, 20 Dec 93
BC93225	03 Aug 93	BCNP	F	(1.5)	32.2	151.040	584	151/61	Dead: stress/malnutrition, 13 Mar 95
BC93226	03 Aug 93	ENP	M	2.5	44.4	151.884		138/53	Alive/transmitting
BC93227	04 Aug 93	BCNP	F	2.5	38.6	150.229		153/75	Alive/transmitting
BC93228	04 Aug 93	ENP	M	(4.5)	50.8	150.781	117	35/00	Dead: undetermined cause, 29 Nov 93
BC93229	04 Aug 93	ENP	F	3.5	34.5	150.090	195	144/63	Dead: undetermined cause (probable stress), 15 Feb 95
BC93230	04 Aug 93	ENP	M	(2.5)	59.0	151.355	52	10/00	Dead: undetermined cause, 25 Sep 93
BC93231	04 Aug 93	ENP	M	2.5	42.2	151.009		153/01	Alive/transmitting
BC93232	04 Aug 93	ENP	F	2.5	36.7	151.535	24	2/00	Dead: illegal kill (poaching), 28 Aug 93
BC93233	04 Aug 93	ENP	M	(1.5)	36.7	151.564	487	120/20	Dead: undetermined cause, 4 Dec 94
BC93234	09 Aug 93	ENP	M	2.5	40.8	150.148	554	148/57	Censored: 15 Feb 95
BC93235	09 Aug 93	ENP	F	(1.5)	34.5	150.048	548	143/94	Dead: undetermined cause (probable stress), 8 Feb 95
BC93236	09 Aug 93	ENP	M	(1.5)	36.3	151.337	454	113/10	Dead: undetermined cause, 6 Nov 94
BC93237	10 Aug 93	ENP	F	1.5	28.1	150.170		154/68	Alive/transmitting
BC93238	10 Aug 93	BCNP	M	(1.5)	30.8	151.421	102	21/01	Dead: legal kill, 20 Nov 93
BC93239	11 Aug 93	BCNP	M	2.5	39.9	151.595	94	21/00	Censored: 12 Nov 93

Table 1. Continued, 2 of 2.

Deer ID	Capture date	Capture location	Sex	Age at capture (yrs)	Body weight (kg)	Radio frequency (MHz)	31 March 1995		
							Transmitter days	Radio locations	Status
BC93240	11 Aug 93	BCNP	M	(1.5)	36.3	150.884	95	19/07	Dead: legal kill, 14 Nov 93
BC93241	11 Aug 93	BCNP	M	5.5	50.8	151.771	467	134/10	Dead: undetermined cause, 21 Nov 94
BC93242	11 Aug 93	BCNP	M	(2.5)	39.5	151.905	102	12/03	Dead: legal kill, 21 Nov 93
BC93243	11 Aug 93	ENP	M	(7.5)	65.8	151.835	117	35/02	Dead: undetermined cause, 13 Dec 93
BC8914R ^c	08 Aug 93	BCNP	F	7.5	38.1	151.322		159/24	Alive/transmitting
BC8960R	11 Aug 93	ENP	M	7.5	52.2	151.874	565	146/31	Dead: undetermined cause (probable stress), 27 Feb 95
BC9069R	10 Aug 93	ENP	F	6.5	38.1	151.031	503	149/85	Dead: undetermined cause (probable stress), 27 Dec 94
BC90131R	11 Aug 93	BCNP	F	(5.5)	37.2	151.805	444	100/61	Dead: stress/malnutrition, 29 Oct 94
BC90135R	09 Aug 93	BCNP	F	5.5	37.2	151.612		157/74	Alive/transmitting
BC91189R	10 Aug 93	BCNP	M	(3.5)	47.2	151.746	456	114/08	Dead: stress/alligator predation, 9 Nov 94
BC94244	01 Aug 94	BCNP	M	5.5	41.7	151.355		67/14	Alive/transmitting
BC94245	01 Aug 94	BCNP	M	2.5	47.2	151.730		71/01	Alive/transmitting
BC94246	02 Aug 94	ENP	F	1.5	30.8	151.913		67/21	Alive/transmitting
BC94247	02 Aug 94	BCNP	M	4.5	51.3	150.008		67/04	Alive/transmitting
BC94248	02 Aug 94	BCNP	M	(1.5)	32.7	151.541	224	67/11	Dead: stress/malnutrition, 14 Mar 95
BC94249	02 Aug 94	BCNP	F	(1.5)	32.7	150.848	163	52/14	Dead: stress/bobcat predation, 12 Jan 95
BC94250	02 Aug 94	ENP	M	2.5	42.6	150.906		62/07	Alive/transmitting
BC94251	02 Aug 94	BCNP	F	1.5	45.4	151.590		71/12	Alive/transmitting
BC94252	03 Aug 94	BCNP	M	1.5	30.8	150.044		68/06	Alive/transmitting
BC94253	04 Aug 94	BCNP	M	1.5	33.1	151.979	180	51/12	Dead: undetermined cause (probable stress), 31 Jan 95
BC94254	04 Aug 94	BCNP	M	1.5	45.4	151.469	102	26/05	Censored: 14 Nov 94
BC94255	04 Aug 94	BCNP	M	1.5	32.7	151.519		70/34	Alive/transmitting
BC94256	08 Aug 94	ENP	F	1.5	29.5	151.992	98	26/21	Dead: stress/alligator predation, 14 Nov 94
BC94257	09 Aug 94	BCNP	M	4.5	47.6	151.884		69/06	Alive/transmitting
BC94258	09 Aug 94	BCNP	M	2.5	40.8	150.782		69/11	Alive/transmitting
BC94259	09 Aug 94	BCNP	M	4.5	49.4	151.904		68/04	Alive/transmitting
BC94260	10 Aug 94	BCNP	M	(5.5)	51.3	151.531	155	42/08	Dead: undetermined cause, 12 Jan 95
BC94261	10 Aug 94	ENP	F	2.5	37.2	150.209		67/19	Alive/transmitting
BC94262	10 Aug 94	ENP	F	1.5	33.6	151.601		70/33	Alive/transmitting
BC94263	10 Aug 94	ENP	F	3.5	33.6	151.511	81	23/10	Dead: alligator predation, 30 Oct 94

^a The first two digits in the alpha-numeric code denote the year of initial capture. In addition to deer captured (recaptured) and radio-instrumented in 1993 and 1994, some deer from the previous study were located within the boundary study area on 1 April 1993. These deer, although monitored for mortality, were not located regularly because of the probability that transmitter failure would eliminate them from the sample early in the study. This group of deer, which was used for analysis of survival, included: males--BC8946, BC8952, BC91190, BC91201; females--BC8945, BC8958, BC90124, BC90125, BC90141, BC91198.

^b Ages enclosed in parentheses were verified or corrected by examination of jawbones at death.

^c Total number of radio-locations/number of locations for which deer was also sighted visually.

^d Censored indicates failure of radio-transmitter, i.e., loss of signal.

^e R indicates recapture of previously radio-instrumented deer.

Table 2. Age and sex of white-tailed deer captured by helicopter netgunning, Big Cypress National Preserve (BCNP)/Everglades National Park (ENP), July-August 1993 and August 1994.

Location	Number of deer captured						Total
	Adults		Yearlings		Fawns		
	Male	Female	Male	Female	Male	Female	
1993							
BCNP	8 ^a	8 ^b	4	4	1 ^c	2 ^d	27 ^c
ENP	10 ^f	6 ^g	4	5	0	2 ^h	27 ⁱ
Total	18	14	8	9	1	4	54 ^j
1994							
BCNP	7	4 ^k	5	3 ^l	3 ^m	2 ^m	24 ⁿ
ENP	1	2	0	3	0	0	6 ^o
Total	8	6	5	6	3	2	30 ^p

^a Includes: 1 recapture (BC91189).

^b Includes: 3 recaptures (BC8914, BC9091311, BC90135); 1 capture-related mortality.

^c One male fawn released, not radio-instrumented.

^d One female fawn radio-instrumented; 1 female fawn released, not radio-instrumented.

^e Radio-instrumented deer (n=24): adult males = 8; adult females = 7; yearling males = 4; yearling females = 4; fawns (female) = 1.

^f Includes: 1 recapture (BC8960); 2 capture-related mortalities (BC90149, BC91197).

^g Includes: 1 recapture (BC9069).

^h One female fawn radio-instrumented; 1 female fawn released, not radio-instrumented.

ⁱ Radio-instrumented deer (n=24): adult males = 8; adult females = 6; yearling males = 5; yearling females = 4; fawns (female) = 1.

^j Radio-instrumented deer (n=48): adult males = 16; adult females = 13; yearling males = 8; yearling females = 9; fawns (female) = 2.

^k Includes: 2 recaptures (BC93205, BC93225); 2 released, not radio-instrumented.

^l Includes: 1 capture-related mortality (recapture, BC93223).

^m Fawns released, not radio-instrumented.

ⁿ Radio-instrumented deer (n=14): adult males = 7; adult females = 0; yearling males = 5; yearling females = 2.

^o Radio-instrumented deer (n=6): adult males = 1; adult females = 2, yearling males = 0, yearling females = 3.

^p Radio-instrumented deer (n=20): adult males = 8; adult females = 2; yearling males = 5; yearling females = 5.

Table 3. Efficiency of capturing white-tailed deer by helicopter netgunning, Big Cypress National Preserve (BCNP)/Everglades National Park (ENP), July-August 1993 and August 1994.

Location	Capture efficiency			Technique efficiency		Helicopter time efficiency ^a	
	Number of deer pursued	Number of deer captured	Percentage captured	Number of netgun shots	Percentage shooting efficiency	Hours of helicopter time	Helicopter hours/captured deer ^b
1993							
26/28 Jul	21	14	67	28	50	9.1	0.65
02/04 Aug	26	22	85	31	71	10.8	0.49
0911 Aug	21	18	86	24	75	11.2	0.62
Sub-total/mean	68	54	79	83	65	31.1	0.58
1994							
01/04 Aug	24	20	83	30	67	15.3	0.76
08/10 Aug	13	10	77	14	71	8.3	0.83
Sub-total/mean	37	30	81	44	68	23.6	0.78
Grand total/mean	105	84	80	127	60	54.7	0.65

^a Selective capture of individuals, i.e., efforts were made to capture (1) individuals for specific age/sex cohorts, and (2) radio-instrumented animals previously captured in 1989-91.

^b Includes processing time.

Table 4. Comparison of annual survival rates of radio-instrumented white-tailed deer, by sex/age cohorts, in Big Cypress National Preserve and Everglades National Park for the 3 biological years (April-March), 1989-92, with the individual biological years, 1993-94 and 1994-95.^a Survival rates derived from the product-limit estimator procedure (Kaplan and Meier 1958), modified to allow for "staggered" entry of animals captured and added to the sample population during the study year (Pollock et al. 1989).

Sex/Age	Survival rates		
	1989-92 ^b	1993-94	1994-95 ^c
Males			
Adult	0.6752 (n=74)	0.4751 (n=20)	0.5675 (n=22)
Yearling	0.6667 (n=12)	0.5000 (n=08) ^d	0.5000 (n=05) ^d
Females			
Adult	0.8114 (n=94)	0.7875 (n=20)	0.4798 (n=24)
Yearling	1.0000 (n=09)	0.8889 (n=09) ^d	0.6000 (n=05) ^d

^aWater-level conditions for biological years: **below average** in 1989-90 and 1990-91; **near average** in 1991-92; **above average** in 1993-94; and **markedly above average (flood)** in 1994-95.

^bAnnual survival rates for adults represent an arithmetic mean; annual survival rates for yearling represent a pooled mean (due to small sample population).

^cHunting of deer, allowed in Big Cypress National Preserve in preceding years, was curtailed during the 1994 season due to the prevailing high water-levels.

^dSeven-month survival rates (01 September-31 March) due to fact that yearlings were not captured and entered into sample population until August of the biological year.

Table 5. Causes of death of radio-instrumented deer "at risk" in boundary zone of Big Cypress National Preserve (BCNP)/Everglades National Park (ENP), 1 April 1993-15 March 1995. Deaths of deer that occurred during capture or after radio-censoring are not included.

Deer ID ^a	Sex	Age at death (yr)	Area	Date of death	Cause of death
BC91198	F	(4.5)	ENP	20 Jul 93	Undetermined
BC8952	M	(6.5) ^b	ENP	16 Aug 93	Undetermined
BC93222	M	(6.5)	BCNP	28 Aug 93	Bobcat predation
BC93232	F	2.5 ^c	ENP	28 Aug 93	Illegal kill (poached)
BC93230	M	(2.5)	ENP	25 Sep 93	Undetermined
BC93209	M	4.5	BCNP	03 Dec 93	Undetermined
BC93213	M	(1.5)	BCNP	14 Nov 93	Legal kill
BC93240	M	(1.5)	BCNP	14 Nov 93	Legal kill
BC93203	M	(1.5)	BCNP	20 Nov 93	Legal kill
BC93238	M	(1.5)	BCNP	20 Nov 93	Legal kill
BC93242	M	(2.5)	BCNP	21 Nov 93	Legal kill
BC93228	M	(4.5)	BCNP	29 Nov 93	Undetermined
BC93243	M	(7.5)	ENP	13 Dec 93	Undetermined (probable natural causes)
BC93224	M	(3.5)	BCNP	20 Dec 93	Legal kill
BC93217	M	(1.5)	ENP	16 Mar 94	Undetermined
BC93204	M	3.5	BCNP	16 Sep 94	Undetermined
BC93202	M	2.5	ENP	30 Sep 94	Panther/bear predation
BC90131	F	(6.5)	BCNP	29 Oct 94	Stress/malnutrition
BC94263	F	3.5	ENP	30 Oct 94	Alligator predation
BC93236	M	2.5	ENP	06 Nov 94	Undetermined
BC91189	M	4.5	BCNP	09 Nov 94	Stress/alligator predation
BC94256	F	1.5	ENP	14 Nov 94	Stress/alligator predation
BC93214	F	2.5	BCNP	18 Nov 94	Stress/alligator predation

No
Nov 14

#241

Table 5. Continued, 2 of 2.

Deer ID ^a	Sex	Age at death (yr)	Area	Date of death	Cause of death
BC93241	M	7.0	BCNP	21 Nov 94 NO	Undetermined - Kristi had him alive in Apr 95
BC93233	M	(2.5)	ENP	04 Dec 94	Undetermined
BC9069	F	8.0	ENP	27 Dec 94	Undetermined (probable stress)
BC93220	F	(4.0)	ENP	11 Jan 95 Feb 10	Undetermined (probable stress) NO
BC94260	M	(6.0)	ENP	12 Jan 95	Undetermined
BC94249	F	(2.0)	ENP	12 Jan 95	Stress/bobcat predation
BC93210	F	3.0	BCNP	31 Jan 95	Stress/malnutrition
BC94253	M	(2.0)	ENP	31 Jan 95	Undetermined (probable stress)
BC93211	F	(3.0)	BCNP	06 Feb 95	Stress/malnutrition
BC93235	F	(3.0)	ENP	08 Feb 95	Undetermined (probable stress)
BC93229	F	(4.0)	ENP	15 Feb 95	Undetermined (probable stress)
BC8960	M	9.0	ENP	27 Feb 95	Undetermined (probable stress)
BC93205	F	(4.0)	ENP	03 Mar 95	Undetermined (probable stress)
BC93221	M	(3.0)	ENP	12 Mar 95	Stress/malnutrition
BC93225	F	(3.0)	BCNP	13 Mar 95	Stress/malnutrition
BC94248	M	(2.0)	ENP	14 Mar 95	Stress/malnutrition

^a First two numerical digits in alpha-numeric code indicate year of capture.

^b Age at death within parentheses indicates age confirmed by examination of recovered jawbones.

^c Age at death not within parentheses was extrapolated from estimated age at capture, i.e., jawbone(s) not recovered.

Table 6. Movements from established home ranges by radio-instrumented white-tailed deer in response to high water-level conditions (flooding) in Big Cypress National Preserve and Everglades National Park, 1994-95. Movement responses were based on pre-flood home ranges, as determined during August and September 1994, and post-flood home ranges, as determined during March and April 1995.

Response behavior	Males (n=14)		Females (n=13)	
	Deer ID	Age ^a	Deer ID	Age ^a
No dispersal (30%)	BC91190	5.0	BC93208	4.0
	BC93207	4.0	BC93218	3.0
	BC93226	4.0	BC93219	6.0
	BC94252	2.0 ^b	BC94261	3.0
Dispersal/ return (44%)	BC94245	3.0	BC8914	9.0
	BC94248	2.0 ^b	BC90135	7.0
	BC94250	3.0	BC93212	6.0
	BC94258	3.0	BC93216	3.0
	BC94259	5.0	BC93225	3.0
			BC93227	4.0
			BC94251	2.0 ^{b,c}
Dispersal/no return (26%)	BC93231	4.0	BC93237	3.0
	BC94244	6.0	BC94262	2.0 ^b
	BC94247	5.0		
	BC94255	2.0 ^b		
	BC94257	5.0		

^aAge as of 31 March 1995.

^bYearlings at time of potential dispersal.

^cBehavior of deer suggests the possibility of a second dispersal.

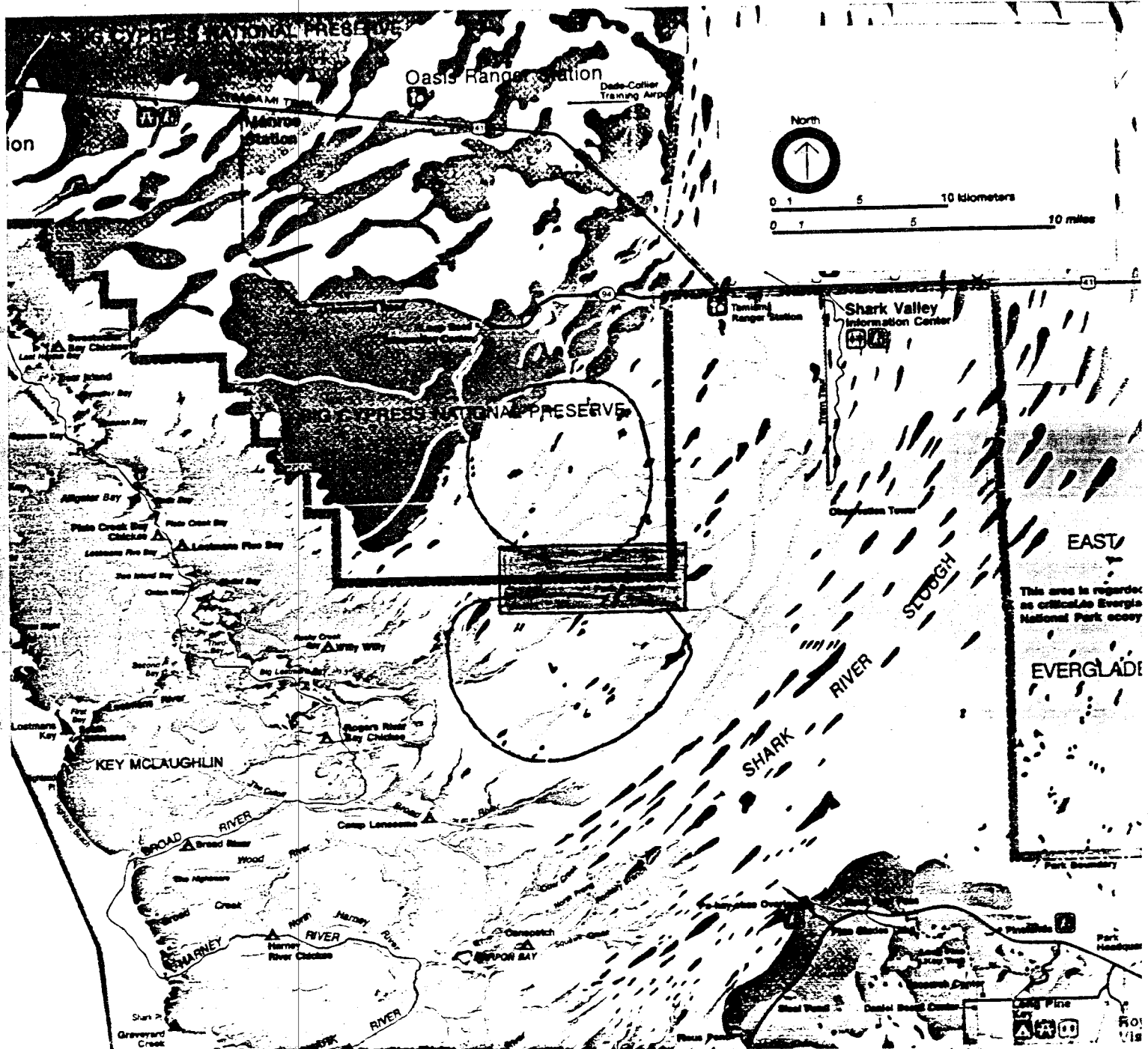


Fig. 1. Location of study area, approximately 5 x 12.5 km, is depicted by the shaded rectangle along the boundary of the Big Cypress National Preserve and Everglades National Park. The areas depicted by ovals identify the study areas in which deer ($n=201$) were captured, radio-instrumented, and monitored during the 3 years, 1 April 1989-31 March 1992.

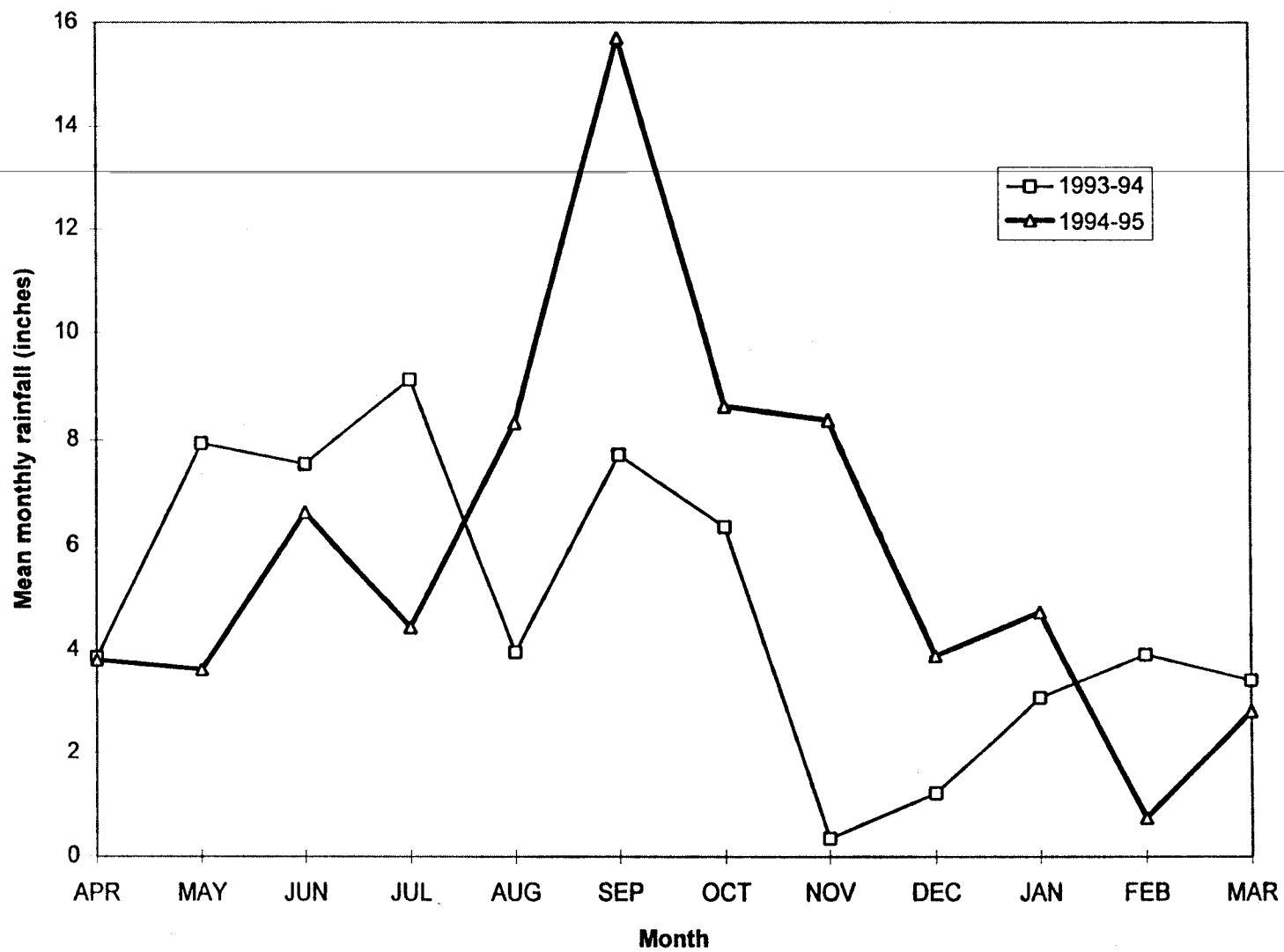


Fig. 2. Mean monthly rainfall recorded at Oasis Ranger Station, Big Cypress National Preserve, April 1993-March 1995.

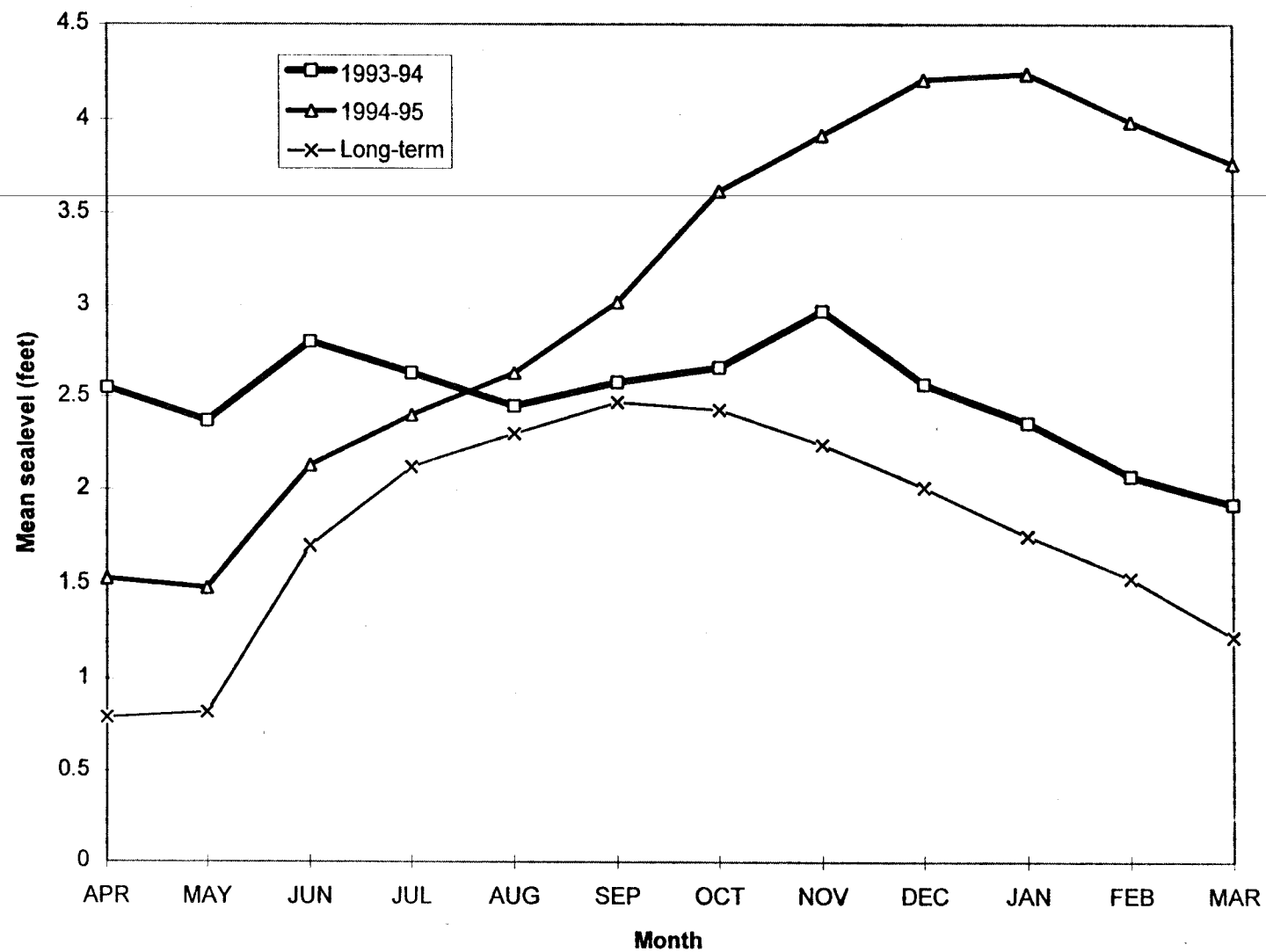


Fig. 3. Mean monthly water depths, measured as mean sea level, recorded at P-34 Hydrostation in Everglades National Park, April 1993-March 1995. P-34 Hydrostation is located in the western sector of the study area. The long-term mean spans the 42 years, 1953-94. Tropical Storm Gordon impacted the study area on 15-16 November 1994.

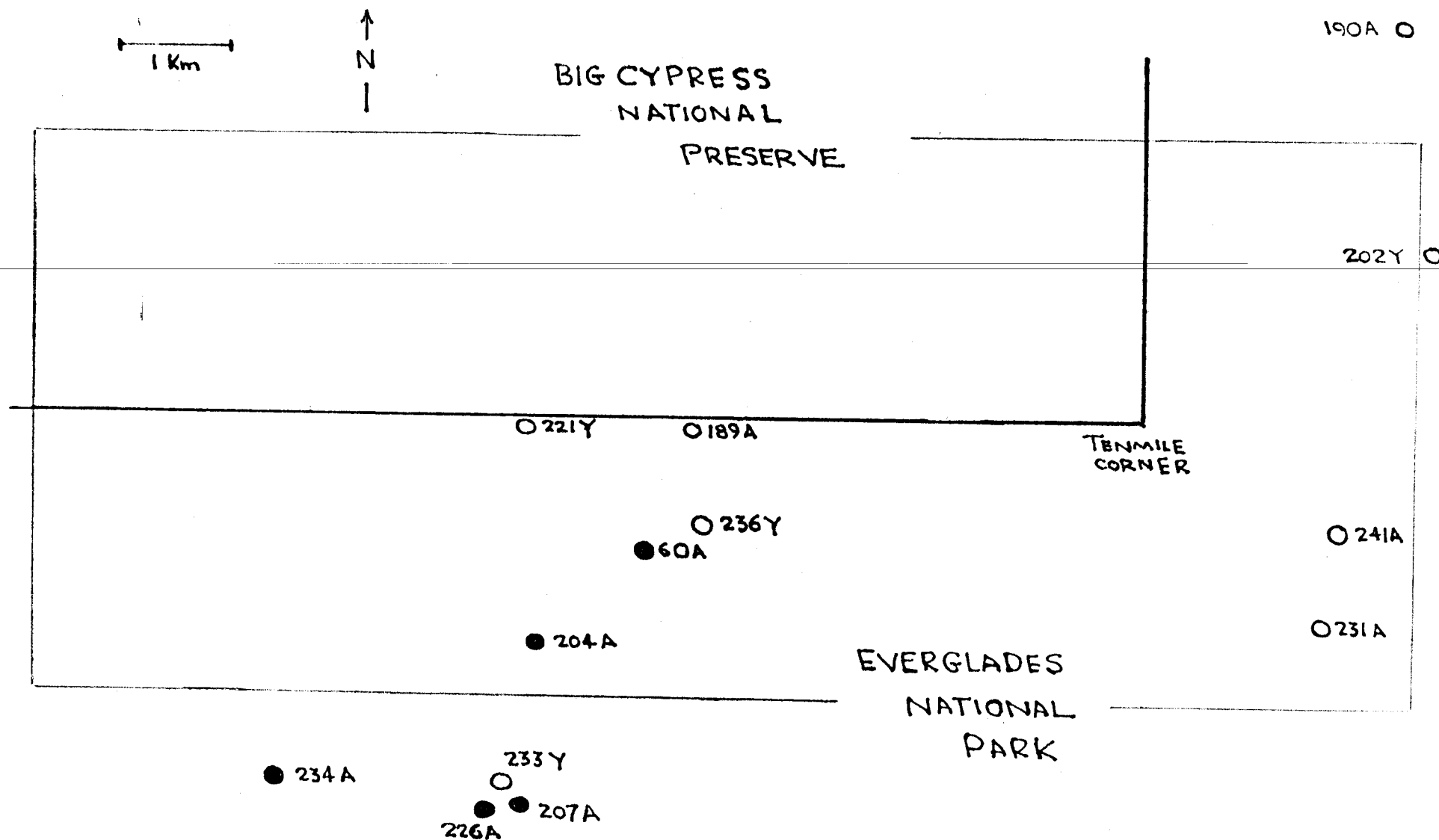


Fig. 4. Locations of prehunt (October 1993) and posthunt (January 1994) home ranges of 13 radio-instrumented male white-tailed deer in the non-hunted Everglades National Park, which lies adjacent to the hunted Big Cypress National Preserve. The heavy line denotes the boundary between the Park and the Preserve; the light line denotes the primary study area. Deer are identified by numerals; the letter A denotes adult, and Y, yearling. Open circles (O) indicate centers of activity did not differ from prehunt to posthunt; closed circles (●) indicate minor shifts (<1km) in centers of activity.

**APPENDIX A: SURVIVAL RATES OF AGE/SEX COHORTS OF RADIO-INSTRUMENTED
DEER ALONG BOUNDARY ZONE OF BIG CYPRESS NATIONAL PRESERVE AND
EVERGLADES NATIONAL PARK.**

Tables 1-4. Survival rates, 1993-94.

Tables 5-8. Survival rates, 1994-95 (flood year).

APPENDIX A, Table 1. Annual survival rate of radio-instrumented adult male (>2 years) white-tailed deer (n=20) along boundary of the Big Cypress National Preserve/Everglades National Park, 01 April 1993-31 March 1994. Survival rate derived from the product-limit estimator procedure (Kaplan and Meier 1958), modified to allow for the "staggered" entry of radio-instrumented animals captured during the course of the study (Pollock et al. 1989).

Month	Number at risk (r_j)	Number of deaths (d_j)	Number censored ^a	Number added	Survival (S_t)
Apr 93	6	0	0	0	1.0000
May	6	0	0	0	1.0000
Jun	6	0	0	0	1.0000
Jul	6	0	1	3	1.0000
Aug	8	2	0	11	0.7500
Sep	17	1	0	0	0.7058
Oct	16	0	0	0	0.7058
Nov	16	2 (1) ^b	1	0	0.6176
Dec	13	3 (1)	0	0	0.4751
Jan 94	10	0	0	0	0.4751
Feb	10	0	0	0	0.4751
Mar	10	0	0	0	0.4751

^aNumber of deer for which radio-transmitter malfunctioned.

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

APPENDIX A, Table 2. Annual survival rate of radio-instrumented adult female (>2 years) white-tailed deer (n=20) along boundary of the Big Cypress National Preserve/Everglades National Park, 01 April 1993-31 March 1994. Survival rate derived from the product-limit estimator procedure (Kaplan and Meier 1958), modified to allow for the "staggered" entry of radio-instrumented animals captured during the course of the study (Pollock et al. 1989).

Month	Number at risk (r_j)	Number of deaths (d_j)	Number censored ^a	Number added	Survival (S_t)
Apr 93	8	0	0	0	1.0000
May	8	0	0	0	1.0000
Jun	8	0	0	0	1.0000
Jul	8	1	0	3	0.8750
Aug	10	1	1	9	0.7875
Sep	17	0	0	0	0.7875
Oct	17	0	1	0	0.7875
Nov	16	0	0	0	0.7875
Dec	16	0	0	0	0.7875
Jan 94	16	0	2	0	0.7875
Feb	14	0	0	0	0.7875
Mar	14	0	0	0	0.7875

^aNumber of deer for which radio-transmitter malfunctioned.

APPENDIX A, Table 3. Seven-month survival rate of radio-instrumented yearling (born in 1992) male white-tailed deer (n=8) along boundary of the Big Cypress National Preserve/Everglades National Park, 01 September 1993-31 March 1994. Survival rate derived from the product-limit estimator procedure (Kaplan and Meier 1958), modified to allow for the "staggered" entry of radio-instrumented animals captured during the course of the study (Pollock et al. 1989).

Month	Number at risk (r_j)	Number of deaths (d_j)	Number censored ^a	Number added	Survival (S_t)
Sep 93	8	0	0	0	1.0000
Oct	8	0	0	0	1.0000
Nov	8	4 (4) ^b	0	0	0.5000
Dec	4	0	0	0	0.5000
Jan 94	4	0	0	0	0.5000
Feb	4	0	0	0	0.5000
Mar	4	0	0	0	0.5000

^aNumber of deer for which radio-transmitter malfunctioned.

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

APPENDIX A, Table 4. Seven-month survival rate of radio-instrumented yearling (born in 1992) female white-tailed deer (n=9) along boundary of the Big Cypress National Preserve/Everglades National Park, 01 September 1993-31 March 1994. Survival rate derived from the product-limit estimator procedure (Kaplan and Meier 1958), modified to allow for the "staggered" entry of radio-instrumented animals captured during the course of the study (Pollock et al. 1989).

Month	Number at risk (r_j)	Number of deaths (d_j)	Number censored *	Number added	Survival (S_t)
Sep 93	9	0	0	0	1.0000
Oct	9	0	0	0	1.0000
Nov	9	0	0	0	1.0000
Dec	9	0	0	0	1.0000
Jan 94	9	0	0	0	1.0000
Feb	9	0	0	0	1.0000
Mar	9	1	0	0	0.8889

*Number of deer for which radio-transmitter malfunctioned.

APPENDIX A, Table 5. Annual survival rate of radio-instrumented adult male (>2 years) white-tailed deer (n=22) along boundary of the Big Cypress National Preserve/Everglades National Park, 01 April 1994-31 March 1995. Survival rate derived from the product-limit estimator procedure (Kaplan and Meier 1958), modified to allow for the "staggered" entry of radio-instrumented animals captured during the course of the study (Pollock et al. 1989).

Month	Number at risk (r_j)	Number of deaths (d_j)	Number censored ^a	Number added	Survival (S_t)
Apr 94	14	0	1	0	1.0000
May	13	0	0	0	1.0000
Jun	13	0	0	0	1.0000
Jul	13	0	0	0	1.0000
Aug	13	0	0	8	1.0000
Sep	21	2	0	0	0.9048
Oct	19	0	0	0	0.9048
Nov	19	3	0	0	0.7619
Dec	16	1	0	0	0.7143
Jan 95	15	1	0	0	0.6667
Feb	14	1	1	0	0.6191
Mar	12	1	0	0	0.5675

^aNumber of deer for which radio-transmitter malfunctioned.

APPENDIX A, Table 6. Annual survival rate of radio-instrumented adult female (>2 years) white-tailed deer (n=24) along boundary of the Big Cypress National Preserve/Everglades National Park, 01 April 1994-31 March 1995. Survival rate derived from the product-limit estimator procedure (Kaplan and Meier 1958), modified to allow for the "staggered" entry of radio-instrumented animals captured during the course of the study (Pollock et al. 1989).

Month	Number at risk (r_j)	Number of deaths (d_j)	Number censored ^a	Number added	Survival (S_t)
Apr 94	22	0	0	0	1.0000
May	22	0	1	0	1.0000
Jun	21	0	0	0	1.0000
Jul	21	0	0	0	1.0000
Aug	21	0	0	2	1.0000
Sep	23	0	1	0	1.0000
Oct	22	2	0	0	0.9090
Nov	20	1	1	0	0.8636
Dec	18	1	0	0	0.8156
Jan 95	17	2	0	0	0.7197
Feb	15	3	0	0	0.5758
Mar	12	2	0	0	0.4798

^aNumber of deer for which radio-transmitter malfunctioned.

APPENDIX A, Table 7. Seven-month survival rate of radio-instrumented yearling (born in 1993) male white-tailed deer (n=5) along boundary of the Big Cypress National Preserve/Everglades National Park, 01 September 1994-31 March 1995. Survival rate derived from the product-limit estimator procedure (Kaplan and Meier 1958), modified to allow for the "staggered" entry of radio-instrumented animals captured during the course of the study (Pollock et al. 1989).

Month	Number at risk (r_j)	Number of deaths (d_j)	Number censored *	Number added	Survival (S_t)
Sep 94	5	0	0	0	1.0000
Oct	5	0	0	0	1.0000
Nov	5	0	1	0	1.0000
Dec	4	0	0	0	1.0000
Jan 95	4	1	0	0	0.7500
Feb	3	0	0	0	0.7500
Mar	3	1	0	0	0.5000

*Number of deer for which radio-transmitter malfunctioned.

APPENDIX A, Table 8. Seven-month survival rate of radio-instrumented yearling (born in 1993) female white-tailed deer (n=5) along boundary of the Big Cypress National Preserve/Everglades National Park, 01 September 1994-31 March 1995. Survival rate derived from the product-limit estimator procedure (Kaplan and Meier 1958), modified to allow for the "staggered" entry of radio-instrumented animals captured during the course of the study (Pollock et al. 1989).

Month	Number at risk (r_j)	Number of deaths (d_j)	Number censored ^a	Number added	Survival (S_t)
Sep 94	5	0	0	0	1.0000
Oct	5	0	0	0	1.0000
Nov	5	1	0	0	0.8000
Dec	4	0	0	0	0.8000
Jan 95	4	1	0	0	0.6000
Feb	3	0	0	0	0.6000
Mar	3	0	0	0	0.6000

^aNumber of deer for which radio-transmitter malfunctioned.

APPENDIX B: ASSESSMENT OF PROJECT OBJECTIVES

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ASSESSMENT OF PROJECT OBJECTIVES

This research investigation was designed to elucidate the interactive spatial dynamics of a protected population of white-tailed deer and an immediately adjacent population hunted population of deer in the contiguous wet prairie/hardwood tree island habitat of the Everglades system in south Florida. Hypotheses included:

Primary

- H₀1 Deer resident in sanctuary areas disperse into proximate hunted areas in which the population density has been reduced by recreational harvest (density-dependent population response).

Secondary

- H₀2 Deer resident in hunted areas seek refuge in proximate sanctuary areas during the hunting season (harassment response).
- H₀3 Deer resident in hunted areas seek the most proximate habitat that provides enhanced concealment during the hunting season (escape response).

The initial experimental design focused on the capture, radio-instrumentation, and monitoring of a sample population of deer (≥ 40 individuals) that was to be distributed equally on both sides of the boundary separating BCNP (hunted) and ENP (protected) for a period of 2 years, 1993-94 and 1994-95. This research design was implemented and executed in 1993-94. In August 1994, the sample population was augmented by additional captures for the conduct of the second year of data collection. However, the hunting season in BCNP was curtailed in 1994 due to unprecedented high-water levels. Thus, the study design was violated in 1994. The lack of budget, and the probable closure of the hunting season in BCNP again in 1995 due to the high mortality of deer in late 1994 and early 1995, essentially precludes a "make-up" year to satisfy the initial study design.

The current study has provided a wealth of new data for evaluating the concept of site fidelity in white-tailed deer. Preliminary analyses of the data garnered from this study have indicated that the degree of site fidelity exhibited by this population of deer, even when confronted with catastrophic environmental conditions (flood), is unprecedentedly strong. The further analysis and evaluation of site fidelity data for this deer population are imperative because the concept of site fidelity underpins the 3 test hypotheses.