Home Range of Male White-tailed Deer in Hunted and Non-hunted Populations

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Abstract: In many areas, hunting season coincides with rut, and movements associated with breeding activities may confound interpretation of hunting-related deer movements. This study provided an opportunity to evaluate the respective influences of separate rut and hunting seasons on home range sizes of adult male deer. Home ranges of 54 radio-collared male white-tailed deer (*Odocoileus virginianus*) were compared between Big Cypress National Preserve (BCNP; hunted) and Everglades National Park (ENP; non-hunted), Florida, during 1989–1991. Annual home range size of males was larger ($P = 0.001$) in BCNP (7.0 km^2) than in ENP (2.9 km^2) and exceeded those reported for other non-migratory populations. Home ranges of adult males in BCNP were larger ($P < 0.05$) than those in ENP for 2 6-month hydrological and 4 3-month biological seasons. Impact of hunting season disturbances on home range sizes of BCNP deer was minor, and home ranges were similar (1990, $P = 0.85$; 1991, $P = 0.77$) among biological seasons within years. Home range sizes of deer in ENP were largest during rut and smallest during hunting and posthunting seasons. High water levels, which coincided with rut, did not appear to limit movements of males. Adult males in BCNP did not move to ENP to avoid hunting activities. Mean harvest rate in BCNP was 53%, including 67% in 1991, the wettest year of the study. High harvest rates during wet years may diminish herd productivity in subsequent years.

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White-tailed deer often expand their home ranges and undertake frequent long-distance movements during the hunting season (Downing et al. 1969, Pilcher and Wampler 1982, Root et al. 1988). Sparrowe and Springer (1970) determined that hunting activities influenced deer movements more than any other factor, although adult males apparently do not move to refuge areas to avoid

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hunters (Hawkins et al. 1971, Kammermeyer and Marchinton 1976, Pilcher and Wampler 1982, Root et al. 1988). However, the hunting season in many areas coincides with rut, and movements associated with breeding activities may confound interpretation of hunting-related deer movements.

Richter and Labisky (1985) noted that timing of reproduction among deer herds in Florida may differ by up to 6 months. Breeding activity of deer in the Everglades ecosystem peaks during August–September, prior to the hunting season (Loveless 1959, Boulay 1992, Sargent 1992). This study provided an opportunity to evaluate the respective influences of separate rut and hunting seasons on home range sizes of adult male deer. We hypothesized that: (1) home range sizes of male deer in BCNP would be largest during the hunting season; (2) male deer in the hunted population (BCNP) would not move to refugia (ENP) during the hunting season; and (3) seasonal flooding would restrict home range sizes of male deer.

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Methods

The study area included approximately 200 km^2 of contiguous wet prairie/tree hammock habitat, extending from the Stairsteps Unit of BCNP southward into the upper Shark River Slough of ENP. The region has a distinct dry winter season (Nov–Apr) and wet summer season (May–Oct). Mean annual rainfall is 136 cm, two-thirds of which occurs during summer (Duever et al. 1986). Lower than average rainfall was recorded in 1989 (112 cm) and 1990 ($\geq$78 cm; data not available for July). In contrast, 1991 was moderately wet due to increased rainfall (134 cm) and water releases from the water conservation areas of upper Shark River Slough.

The study area was dominated by 2 habitats: 80% in wet prairie (prairie) and 6% in mixed hardwood hammocks (tree islands) (Miller 1993). Sloughs and small tree islands were more abundant in ENP relative to BCNP (R. A. Sargent, pers. observ.). The prairie is seasonally flooded for roughly 50–150 days per year (Duever et al. 1986). Common plants of the prairie include maidencane (*Panicum hemitomon*), sand cordgrass (*Spartina bakeri*), and sawgrass (*Cladium ja-*

maicense). Common tree and herbaceous vegetation on the hammocks are wax myrtle (*Myrica cerifera*), gumbo-limbo (*Bursera simaruba*), and coco plum (*Chrysobalanus icaco*) (Duever et al. 1986).

In 1990, use of swamp buggies in BCNP was restricted to designated trails in upland areas, nearly eliminating their use in the study area. Airboats were the principal means of transportation in the Stairsteps Unit during this study, and activity was slight outside the hunting season (R. A. Sargent, pers. observ.). Motorized vehicles were prohibited within ENP.

Deer populations in southern Florida typically exist at low densities (Harlow and Jones 1965). Mean deer densities within the study area were 4.5 and 3.3 deer/km^2 for ENP and BCNP, respectively (R. F. Labisky, unpubl. data). The primary cause of mortality for radio-collared males in BCNP was hunting (R. F. Labisky, unpubl. data). The 3-year (1989–91) mean harvest rate for BCNP males was 53% (range 42%–67%). Harvest rate was lowest during the driest year (1990), and highest during the wettest year (1991) (Sargent 1992).

Deer were captured by helicopter-netgunning (Barrett et al. 1982), and each deer was aged and fitted with expandable radio-collars (Wildlife Materials, Inc., Carbondale, Ill). We relocated each radio-collared deer with fixed-wing aircraft during diurnal hours. Monitoring was divided into 4 periods: sunrise to 2 hours post-sunrise; 2 hours post-sunrise to noon; noon to 2 hours pre-sunset; and 2 hours pre-sunset to sunset. Locations were segregated equally among the 4 daylight periods, and each radio-instrumented deer was located once every 5 days, yielding 72 locations/animal/year. Radio-telemetry accuracy was evaluated (Hoskinson 1976), and verified with a Global Positioning System receiver.

We used HOME RANGE microcomputer software (Ackerman et al. 1989) to analyze home range sizes of adult male deer (≥2 years old) for annual and seasonal trends. The "biological year" was designated as 1 April–31 March, timed to begin when >90% of gravid females were post-parturition (Boulay 1992). The year was divided into 4 3-month "biological seasons" that delineated population reproductive phenology and hunting activities: prerut = 1 April–30 June; rut = 1 July–30 September; hunt = 1 October–31 December; and post-hunt = 1 January–31 march. We determined the rutting season by backdating the 3-year mean parturition date (23 Feb [Boulay 1992]) by a 201-day mean gestation period (Hesselton and Hesselton 1982). Additionally, home range sizes were examined in relation to hydroperiod. Wet and dry seasons were 1 May–31 October and 1 November–30 April, respectively (Duever et al. 1986).

Only individual deer monitored for the entire 3-month period were included in the analysis for a given biological season. The observation-area curve technique was used to determine sufficient radio-location sample size for annual and hydrological season data analysis (Odum and Kuenzler 1955). We estimated annual and seasonal home range sizes by the 95% minimum convex polygon (MCP) method (Michener 1979). The MCP was chosen over other techniques because it is the most robust procedure for home range analysis based on limited fixes (Harris et al. 1990). Mean core area size for adult males was determined by plotting home range area against progressively increasing MCP isopleth values (scale = 30%–100%; 5% increments) and identifying the largest change in the gradient of the slope (Harris et al. 1990). The 65% isopleth represented the mean inflection point for area curves examined and was used to represent the core area.

Non-parametric data analysis procedures were employed because data normality assumptions were violated (PROC UNIVARIATE, SAS Inst. 1985). Differences among means were tested using the Wilcoxon rank-sum and Kruskal-Wallis tests for data sets with 2 or >2 levels, respectively (PROC NPAR1WAY, SAS Inst. 1990).

Deer were classified as residents of BCNP or ENP if ≥75% of an individual's locations occurred in 1 area (Root et al. 1988). Changes in area-use patterns for legally harvestable males (≥12.5 cm antler length) were detected by comparing percentage of locations recorded in each area for 4 periods: peak rut = 1 July–30 September, the 4 weeks immediately preceding the general gun hunt (GGH), the initial 4 weeks of the GGH (1989, 28 Oct–24 Nov; 1990 and 1991, 17 Nov–14 Dec), and the 4 weeks immediately following the GGH. Only deer whose home ranges occurred within 2.5 km of the boundary separating the park areas were included in this analysis.

Results

We captured and radio-instrumented 30 and 24 males in BCNP and ENP, respectively, and obtained 4,427 radio-locations from April 1989 to March 1992. Mean radio-location error was ±50 m, or <1 ha. Additionally, 31% of all radio-locations were verified by visual observation of the study animals (R. F. Labisky, unpubl. data).

Observation-area Curves

The largest increase in annual home range area per location occurred during the June–November interval; most observation-area curves reached an asymptote during September–November. Curve asymptotes were correlated more strongly with inclusion of specific temporal blocks of locations than with total numbers of radio-locations. Consequently, radio-locations from the June–November and June–October intervals were sufficient to estimate annual and wet-season home ranges, respectively. Observation-area curves for the dry season frequently did not reach asymptotes, particularly in BCNP. Therefore, analysis for the dry season was restricted to deer monitored throughout the November–April interval.

Home Range

No differences (P >0.05) in home range size were detected among years within parks; therefore, data among years were pooled, unless otherwise noted.

Table 1. Mean annual home range size and core area size for adult male white-tailed deer in Big Cypress National Preserve (BCNP) and Everglades National Park (ENP), Florida, during the biological year, 1 April–31 March, 1989–1991 pooled.

	Annual home ranges/core areas (km^2)			
	N[a]	Mean	SE	Range
Home range[b]				
BCNP	10	7.0A[c]	1.4	2.2–17.4
ENP	23	2.9B	0.4	0.4–8.4
Core area[d]				
BCNP	10	3.3B	1.1	0.3–12.6
ENP	23	1.0C	0.2	0.2–3.3

[a]Number of males.
[b]95% minimum convex polygon.
[c]Means followed by the same letter are not different ($P > 0.05$).
[d]65% minimum convex polygon.

Table 2. Mean home range size for adult male white-tailed deer in Big Cypress National Preserve (BCNP) and Everglades National Park (ENP), Florida, during wet (May–Oct) and dry (Nov–Apr) seasons, 1989–1991 pooled.

	Hydrological-season home ranges (km^2)			
Season	*N*[a]	Mean[b]	SE	Range
Wet				
BCNP	12	5.5A[c]	0.9	1.7–10.5
ENP	23	3.2B	0.5	0.3–8.5
Dry				
BCNP	7	3.7AB	0.9	0.5–6.5
ENP	32	1.0C	0.2	0.1–2.8

[a]Number of males.
[b]95% minimum convex polygon.
[c]Means followed by the same letter are not different ($P > 0.05$).

Mean annual home range of adult males was larger ($P = 0.001$) in BCNP (7.0 km^2) than in ENP (2.9 km^2) (Table 1). Similarly, mean annual core area of adult males was larger ($P = 0.01$) in BCNP (3.3 km^2) than in ENP (1.0 km^2).

Mean dry-season home range of adult males did not differ ($P = 0.29$) from wet-season home range in BCNP (Table 2). In contrast, mean wet-season home range was larger ($P < 0.001$) than dry-season home range in ENP. Home ranges of adult males in BCNP exceeded those of males in ENP during both the wet and dry seasons for all years (Table 2).

Biological-season home ranges of adult males in BCNP did not differ

Table 3. Mean home range size for adult male white-tailed deer in Big Cypress National Preserve (BCNP) and Everglades National Park (ENP), Florida, during 4 biological seasons, 1989–1991 pooled.

	Biological-season home ranges (km^2)			
	N[a]	Mean[b]	SE	Range
BCNP				
Prerut	12	3.5A[c]	0.9	0.4–9.3
Rut	15	3.9A	0.7	0.5–9.3
Hunt	9	4.2A	1.2	0.3–10.6
Posthunt	5	2.6AB	1.0	0.2–5.5
ENP				
Prerut	21	1.5C	0.2	0.3–3.6
Rut	29	2.4B	0.3	0.4–7.3
Hunt	34	1.0D	0.2	0.1–3.9
Posthunt	21	0.6D	0.1	0.1–2.1

[a]Number of males.
[b]95% minimum convex polygon.
[c]Means followed by the same letter are not different ($P > 0.05$).

among seasons within years (1989, insufficient data; 1990, $P = 0.85$, 3 df; 1991, $P = 0.77$, 2 df) (Table 3). In ENP, biological home range sizes differed among seasons in 1990 ($P = 0.001$, 3 df) and 1991 ($P = 0.01$, 2 df), but not in 1989 ($P = 0.12$, 2 df). Hunt and posthunt home ranges in ENP did not differ ($P = 0.18$); however, home range size during rut was larger than during prerut ($P = 0.04$), hunt ($P < 0.001$), and posthunt ($P < 0.001$) (Table 3).

Biological home ranges of adult males in BCNP exceeded those of males in ENP (prerut, $P = 0.03$; rut, $P = 0.03$; hunt, $P = 0.001$; posthunt, $P = 0.03$). Further, mean hunt home range in BCNP was larger ($P = 0.06$) than mean rut home range in ENP.

ENP as a Refuge

Mean percentages of locations recorded within BCNP for male deer classified as residents of BCNP during 4 periods were: peak rut = 98%; 4 weeks pre-general gun hunt (GGH) = 93%; initial 4 weeks of GGH = 85%; and 4 weeks post-GGH = 100% (Table 4). Mean percentages of locations within BCNP for resident males of ENP during 4 periods were: peak rut = 13%; 4 weeks pre-GGH = 6%; initial 4 weeks of GGH = 2%; and 4 weeks post-GGH = 4%. Three adult males accounted for 94% of all locations of ENP deer within BCNP; 91% of these locations occurred prior to the GGH.

No differences ($P = 0.64$, 3 df) in use of BCNP by resident male deer were detected among the 4 periods. Males in BCNP did not travel regularly into ENP during the hunting season or rut. In contrast, 4 resident males in ENP were located in BCNP more frequently ($P = 0.02$) during rut than during GGH. No

Table 4. Percentage of radio-locations recorded within Big Cypress National Preserve (BCNP) for BCNP and Everglades National Park (ENP) male (≥1-year-old) white-tailed deer during 4 periods, 1989–1991.

	Peak rut[a]	Prehunt[b]	Hunt[c]	Posthunt[d]
1989				
BCNP	96(3)[e]	100(3)	58(2)	100(2)
ENP	0(5)	11(5)	0(5)	6(3)
1990				
BCNP	90(1)	86(1)	100(1)	100(1)
ENP	18(5)	0(5)	0(5)	7(5)
1991				
BCNP	100(5)	90(5)	100(4)	100(1)
ENP	18(7)	7(7)	6(7)	0(7)
Years pooled				
BCNP	98(9)A[f]	93(9)A	85(7)A	100(4)A
ENP	13(17)B	6(17)B	2(17)C	4(15)B

[a] 1 Jul–30 Sep.
[b] The 4-week period immediately preceding general gun hunt.
[c] The first 4 weeks of general gun hunt.
[d] The 4-week period immediately following general gun hunt.
[e] Numbers in parentheses indicate sample sizes.
[f] Means followed by the same letter are not different ($P > 0.05$).

ENP males known to have traveled regularly into BCNP were harvested by hunters. Mean annual harvest rate of males in BCNP was 53%, ranging from 42% in 1990 to 67% in 1991, the wettest year of the study.

Discussion

Reported annual home range sizes of adult male white-tailed deer in non-migratory populations range from 1.0–4.9 km² (Smith 1970, Dickinson and Garner 1980, Gavin et al. 1984). In this study, home ranges of adult males in BCNP were larger than those of deer from other non-migratory populations. Loveless (1959) described the food resources of the Everglades as well-distributed and sufficiently nutritious for deer, except during flood periods. Large home ranges may reflect the sparse distribution of cover, which is characteristic of the wet prairie, and seasonal changes in food availability.

Although deer can and do swim, deep water often impedes movements (Byford 1970, Hood 1971). High water levels (>0.6 m) in the Everglades can restrict deer movements or lead to their confinement and subsequent starvation on tree islands (Loveless 1959). During this study, water levels did not exceed 0.3 m (D. Sekema, Natl. Park Serv., pers. commun.). Home range sizes of adult males were largest in ENP during the wet season, but those in BCNP were similar in wet and dry seasons. Large home ranges of adult males during peak water levels were likely from the coincident occurrence of rut, a time of increased movement for male white-tailed deer (Downing et al. 1969).

The largest biological season home range for males in ENP was during rut; home range sizes in the remaining seasons were statistically smaller. Mean home range size of males in ENP decreased 58% from rut to the hunting season. In contrast, mean home range size of males in BCNP was similar for all biological seasons, and increased only 7% from rut to hunting season. Hunting season disturbances appeared to have a minor impact on deer home range sizes. The larger home ranges of deer in BCNP relative to deer in ENP suggested differences in resource distribution between the 2 areas.

Male deer in BCNP did not move regularly to ENP to avoid hunters, a result supported by observations of Hawkins et al. (1971), Kammermeyer and Marchinton (1976), Pilcher and Wampler (1982), and Root et al. (1988). However, 4 male deer from ENP entered BCNP to participate in rut and then returned to ENP prior to the hunting season. The ENP males exhibiting this behavior were large, potentially dominant individuals that inhabited areas within 1 km of the boundary. These males may have experienced reduced competition for breeding access to females in BCNP relative to ENP.

Our research suggests that harvest rates may be influenced by water levels in BCNP (i.e., deep water facilitates hunting from airboats). In dry years much of the study area may be inaccessible to airboats before the hunting season is completed (R. A. Sargent, pers. observ.). The large home range sizes of males in BCNP during the hunting season may make these deer more susceptible to harvest, because the probability of chance encounters with hunters is high. High harvest rates during wet years could depress the already low deer density in the prairie by diminishing female fecundity, because females must increase energy expenditures to seek mates (Holzenbein and Schwede 1989). We recommend further research on the relationship between wet-year harvest rates and subsequent herd productivity.

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