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DEER POPULATION MANAGEMENT THROUGH HUNTING IN A SUBURBAN NATURE AREA IN EASTERN NEBRASKA

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ABSTRACT: The Fontenelle Forest Nature Area (FF) maintained a hands-off management policy for 30 years until it was recognized that white-tailed deer (*Odocoileus virginianus*) populations had grown to such levels that they were severely degrading native plant communities. In 1995, members of a community task force decided to sponsor annual nine-day hunting seasons on FF after learning that densities exceeded 28 deer/km^2. Archers harvested 85 antlerless deer in the FF upland areas adjacent to residential Bellevue, Nebraska during 1996 to 1998. Muzzleloader hunters removed 53 antlerless deer from the FF lowland areas. Archery and muzzleloader hunters harvested 297 deer during the same period in Gifford Point (GP), a state-owned wildlife management area adjacent to the FF lowlands. Overall deer densities declined from 28 deer/km^2 in 1995 to 14 deer/km^2 in 1998. Densities were at or near over-winter goals in all areas by 1998, except for the unhunted residential area, which still maintained 20 deer/km^2. Annual survival rates for radio-marked adult and yearling female deer were 0.70 and 0.59, respectively. Archery was the primary mortality factor (20%) for radio-marked deer across years. Population models predict that densities would increase to 55 deer/km^2 in five years if hunting seasons were abandoned in FF. Hunter behavior in FF has been reported as excellent and little public opposition exists.

KEY WORDS: archery, hunting, muzzleloader, *Odocoileus virginianus*, radiotelemetry, suburban, white-tailed deer

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INTRODUCTION

The floodplain forest and wooded uplands of the Gifford Point (GP) and Fontenelle Forest Nature Area (FF) complexes are bounded to the west by the metropolis of Omaha-Bellevue, Nebraska and to the east by the channelized Missouri River and miles of intensively-farmed Iowa cropland. It is an island of native habitat surrounded by human development. In 1992, noted conservation biologist Jared Diamond visited FF. Diamond (1992) noted that overabundant white-tailed deer were degrading the forest and causing "reverse succession."

The greatest concern in the GPFF area since the late 1980s has been the perceived overabundance of deer. Without a reasonable estimate of the deer density, management strategies are limited and vulnerable to public criticism. Therefore, our first objective was to estimate the density of deer at GPFF. In addition, we estimated the population sex and age structure, determined levels of cause-specific mortality, and calculated annual survival rates. These factors were incorporated into a dynamic population model to estimate future deer population densities given various harvest scenarios. This project was approved by the University of Nebraska Institutional Animal Care and Use Committee (#95-02-007).

METHODS

We helped establish the Bellevue Deer Task Force in 1994 to address the issues associated with the local deer population. It consisted of stakeholder representatives from the surrounding community who shared concerns about the irrupting deer population and associated problems. The Task Force provided a forum for all to express their points of view, evaluate research results, review land-use practices, and discuss deer management options. The members recognized the need and provided support for our research.

Population Estimation

We conducted aerial censuses of deer by helicopter during the winters of 1995, 1997, and 1998. Transects covering the study area were flown at 0 to 50 km/h (0 to 30 mi/h). To avoid flushing the deer and disturbing area residents, the transects were flown at 53 m (175 ft) over the floodplain, 76 to 91 m (250 to 300 ft) over the upland forest, and 91 m (300 ft) over the residential area. Two observers spotted deer while one observer recorded deer numbers and locations on a map. The same pilot and observers conducted the census each year.

Doe:Fawn Ratios

We determined fawn recruitment on GPFF through multiple counts (70 to 80) of does and fawns from August to October, 1995 and 1996 (Nixon et al. 1991; Hansen et al. 1997). Fawns were differentiated from the dams they accompanied during this period by size and behavior (Downing et al. 1977).

Buck:Doe Ratios

We similarly recorded multiple counts (25 to 40) of adult bucks and does from August to October, 1995 and 1996. Adult bucks were identified and differentiated from the does they accompanied during this period by behavior and the presence of antlers.

Mortality

We captured 99 deer from March 1995 to March 1996, primarily with netted-cage traps (VerCauteren et al. 1999). We radio-marked 51 females and 2 males (21 adults, >12 months old; 32 juveniles, 8 to 12 months old) with collars that were labeled with our return address and marked 46 males with colored and numbered eartags. We concentrated our telemetry efforts on females because: 1) deer adopt matriarchal social family groups that are led by adult females and these groups make up the largest proportion of the population (Porter et al. 1991; Mathews and Porter 1993; Aycrigg and Porter 1997); and 2) knowledge of female survival dynamics is important for understanding and predicting population changes (Porter et al. 1991; Mathews and Porter 1993; Aycrigg and Porter 1997; Hansen et al. 1997).

Forty-eight of the transmitters were equipped with mortality sensors (Advanced Telemetry Systems, Isanti, Minnesota, USA and Wildlife Materials, Carbondale, Illinois, USA). We determined the cause of mortality for each radiomarked deer as shortly after death as possible.

At the end of the study we classified each radio-marked deer as alive, dead, or censored. Censored individuals were those whose fates were unknown (Van Deelen et al. 1997). We further classified mortalities as due to archery, firearms, automobile, train, disease (EHD), predators (coyotes and domestic dogs), starvation, other (fence entanglement and poaching), and unknown. We used MICROMORT software to estimate survival and cause-specific mortality rates from the number of radio-days each marked individual survived during the study period (Heisey and Fuller 1985). We calculated annual survival rates for adult and yearling does with an annual period from 1 June to 31 May.

Annual adult survival did not differ across years ($P=0.11$, $n=3$ years) so we pooled the data. We used 2-tailed Z-tests to determine that yearling survival could be pooled across years ($P=0.14$, $n=2$ years). Data for adults and yearlings were significantly different ($P<0.001$) and could not be pooled. Pooling made sample sizes more meaningful, increased our confidence in comparisons, and provided a better indication of survival over time.

Population Modeling

We used simulation modeling software (Stella, High Performance Systems, Hanover, New Hampshire, USA) to develop an interactive population model. Our model was based on the general population model:

$$N_{t+1} = N_t + N_t(b_t + i_t - d_t - e_t)$$

where N_t is population size (or density if divided by area) at time t and b_t, i_t, d_t, and e_t are per capita rates of birth, immigration, death, and emigration at time t, respectively. The initial female population was increased by annual births, as estimated by doe:fawn ratios. We limited the model to the female portion of the population because of the previously-stated importance of female deer in the population, and because we did not have adequate survival data from males. We did not collect data on immigration and assumed the immigration rate was near 0 due to the physical and ecological barriers surrounding GPFF, deer sociobiology at high densities (Miller and Ozaga 1997), and source and sink dynamics (Meffe and Carroll 1994). We felt this was appropriate because of the high density on GPFF as compared to adjacent areas. The population was decreased by cause-specific mortality and emigration.

Values in the model were mean annual estimates of demographic rates and density for females on GPFF. For each demographic rate, we incorporated the same amount of variation in the model as we found in the field by including a function that randomly chose a rate within the 95% CI of the rates mean. The model is an ongoing process driven by interdependent closed loops. Through simulation, we predicted the changes in population density for the next five years in response to varied harvest rates.

RESULTS AND DISCUSSION

Population Estimation

Total counts of deer in the 18.2-km^2 (7-mi^2) study area in 1995, 1997, and 1998 were 495, 316, and 233, respectively. The deer, when flown over during the first two censuses, typically stood up from their beds but did not flush. The observers felt that their count approached the total number of deer in the study area. During the third census, ground visibility was impaired because of blowdowns from a storm in late October 1997 and several deer stayed bedded during the flyover. Therefore, we adjusted the 1998 census data by +10% (256 total) to account for deer that may have not been counted. Adequate snowcover is the most important factor in a good aerial survey (Gladfelter 1980), and we consistently had 10 to 15 cm (4 to 6 in) of fresh snow. Two Midwestern studies using helicopters have reported detection rates of 78% (Beringer et al. 1998) and 99% (Stoll et al. 1991).

Relative deer densities during the three study years were 27, 17, and 14 deer/km^2 (71, 45, and 37 deer/mi^2), respectively. The goal of most wildlife agencies in the Midwest is to maintain overwinter deer populations at 10 to 13 deer/km^2 (25 to 35 deer/mi^2), to provide sufficient hunting and viewing opportunities and yet minimize crop damage complaints and deer-vehicle collisions (Menzel 1984). Clearly, the GPFF deer population was well over contemporary goals in 1995, but by 1998, it had declined by nearly 50% and was near goal.

The deer were unevenly distributed throughout the study area during the three counts. The highest density, 45 deer/km^2 (116 deer/mi^2), occurred in the FF uplands in 1995. By 1998, the number of deer in the FF uplands had declined by 74% ($n=-127$) to a level consistent with contemporary goals. Hunting seasons on the FF property in 1996 and 1997 resulted in the harvest of 67 female and 15 male deer, and no doubt contributed to the dramatic reduction in the local population. Hunter behavior was reported as excellent during both hunts (Gary Garabrandt unpubl. report). Public opposition to the hunts was minimal and media coverage declined considerably in 1997 and 1998.

The deer population in the GP lowland declined 48% over the three-year study period. The flooding of lowland areas by the Missouri River in June 1996 increased emigration rates, and likely mortality rates, but regulated hunter harvest was the greatest factor influencing deer population levels in GPFF and throughout the Midwest (Gladfelter 1984; Nixon et al. 1991; Hansen et al. 1997).

As of January 1998, all of the population densities were within population goals, with the exception of the BR area, which was still at 20 deer/km^2 (51 deer/mi^2). Deer were not observed in the residential area until the 1980s, after-which they appeared frequently in the uplands (Gary Garabrandt, pers. commun.). Respondents to a FF Association-sponsored survey of residential communities in 1995 indicated that deer numbers were increasing and that they were seeing deer more frequently. Hunting has not yet been allowed in the residential upland because of local ordinances and safety concerns. Deer densities and associated problems will likely continue to increase in the residential area unless actions are taken to reduce the population. Several landowners in the residential area started feeding deer in the early 1990s and now some put out as much as 23 to 46 kg/day (50 to 100 lbs/day). Supplemental feeding can detrimentally concentrate deer-use of habitat and natural forage (Doenier et al. 1997) and may enhance survival of local deer (Swihart et al. 1995). In addition, associations have been made between high deer densities, deer feeding, and the occurrence of chronic wasting disease and tuberculosis (Nettles 1997). Both diseases are contagious in deer populations and in some cases call for the eradication of the infected populations. Homeowners should be educated about the problems associated with deer feeding and options for preventing deer damage to their property (Hygnstrom and Baxter 1991; Craven and Hygnstrom 1994).

Doe:Fawn Ratios

Ratios varied considerably between 1995 (1 doe:1.5 fawns) and 1996 (1 doe:0.4 fawns). Such differences in recruitment can have dramatic impacts on subsequent population densities. Ratios at the nearby DeSoto National Wildlife Refuge (DNWR) were stable (1 doe: 1.2 fawns) during both 1995 and 1996 (VerCauteren 1998). Our 1995 doe:fawn ratio was similar to, if not slightly higher than, those reported in Illinois (1:1.3, Nixon et al. 1991), Missouri (1:1.1, Hansen et al. 1997), and Michigan (1:1.3, Ozoga et al. 1994). Without experimental controls we can only speculate on why the GPFF doe:fawn ratio in 1996 was so low. On June 23, 1996, the Missouri River flooded its banks and inundated much of the floodplain area for two to three weeks. Several deer abandoned their original home ranges and moved to higher ground. The flood came shortly after fawning and likely added to fawn mortality. In addition, for 30 years, deer in the lowlands have been dependent on crops produced on GP. It was not uncommon to see >200 deer in the crop fields at night during the growing season. Adult does on high quality diets typically have higher reproductive rates than does on low quality diets (Verme 1965; Ozaga and Verme 1982). In August 1995, construction of a 2.4 m (8 ft) high woven-wire fence was initiated around the 100 ha (250 a) cropland area in GP. The 5 km (3 mi) long fence was completed in April 1996. Even during the construction period, the fence had a noticeable impact on the distribution of deer in the GP lowlands, and many deer were excluded from an important food source. Available forage in the lowlands is limited because of overbrowsing. The resultant low quality diets may have contributed to the low reproductive rate in 1996.

Buck:Doe Ratios

The ratios were the same for the GPFF area (1 buck:2.9 does) in 1995 and 1996. The relatively low differentials between males and females are indicative of deer populations in which sex-specific mortality rates are similar. Deer harvest on GP, however, has traditionally been biased toward males and against females. Harvest management strategies (i.e., buck only, either sex, or antlerless only) and hunter preference can alter the sex and age structures of a population. Even in unhunted areas, the mortality rates for adult males are higher than for adult females (Gavin et al. 1984; Jacobson and Guynn 1995), due to their poorer physical condition entering winter and increased susceptibility to predation (McCullough 1979). Increased harvest of adult females on GP could help to maintain more balanced sex and age ratios because of the resultant reduced harvest of yearling males (≤18 months old) and increased male natality (McCullough 1979, 1984; Jacobson and Guynn 1995). Further, increased adult female harvest may reduce emigration rates of yearling males (Holzenbein and Marchinton 1992) and lead to decreased juvenile female emigration when populations are at or near their social carrying capacity. Managers should consider the effects of management strategies on deer population structure, social behavior, and demography (Miller 1997). The annual mortality rate of females, and its impact on density, determines the response of the overall population, including the size and age structure of the buck population (McCullough 1984).

Mortality

Data on primary mortality factors, and their combined impacts on a population, are important in deer population management (Dusek et al. 1989; Fuller 1990). We included 50 radio-marked deer in the survival-mortality analysis. Twenty-one were adults and 29 were yearlings. At the end of the study, 19 of the radio-marked females were still alive, 2 were censored, and 29 were dead. The annual survival rate of adult and yearling radio-marked females was 0.70 (CI=0.60 to 0.82) and 0.59 (0.45 to 0.80), respectively (Table 1). The mean annual survival rates for radiomarked females at the nearby DNWR were 0.76 for adults and 0.82 for yearlings. High annual survival rates for females (80% to 100%) have also been reported elsewhere in the Midwest (Fuller 1990; Nelson and Mech 1986; Nixon et al. 1991; Hansen et al. 1997; Van Deelen et al. 1997).

Human-related mortality factors (archery and firearm hunting, automobiles, and trains) were associated with the deaths of 83% and 79% of the marked deer in 1995 and 1996, respectively. A similar human-related mortality rate (82%) was determined for female deer on DNWR during 1991-1997 (VerCauteren unpubl. data). Archery was the primary mortality factor (20%).

Trains were a surprising cause of mortality in GPFF and adult deer appeared to be more susceptible to trains than yearlings (Table 1). Adult does may have crossed the railroad tracks more frequently when trains were running or their home ranges may have overlapped the tracks more than yearlings. Automobiles killed only three marked deer. Considerably higher deer mortality rates have been attributed to automobiles in other parts of the

Table 1. Annual survival and cause-specific mortality rates of radio-marked does in the Gifford Point-Fontenelle Forest area, 1995-1997.

	Age Class	
	Juvenile	Adult
n[a]	30	43
Censored Deer	1	1
Radio Days	8,524	19,692
Deaths	11	18
Rate[b]	0.59	0.70
95% CI	0.45-0.80	0.60-0.82
Archery	0.13	0.12
Firearm	0.08	0.03
Poaching	0.04	0.00
Auto	0.08	0.03
Train	0.00	0.06
Natural	0.08	0.03
Unknown	0.00	0.03

[a]Number of deer-records from 1995, 1996, and 1997 pooled.
[b]Adjusted for small sample bias (Heisey and Fuller 1985).

Midwest (30% in east-central Illinois and 13% in north-central Missouri; Hansen et al. 1997), but traffic and road conditions differ in these areas.

Non-human or "natural" causes of mortality, including disease, predators, and starvation, were a minor source of known deer mortality during the study (n=4, 14%). Several other studies have also reported that <25% of adult deer mortality is due to natural causes (Fuller 1990; Nixon et al. 1991; Hansen et al. 1997). Outbreaks of EHD occur infrequently throughout the Midwest when climatic conditions are favorable for disease vectors (Gladfelter 1984). The Missouri River Valley has a history of EHD and 30% to 40% of the region's deer population was lost in 1976 (Menzel and Havel 1977). A minor outbreak of EHD occurred on GPFF in 1995 and caused the deaths of two radio-marked females. Coyotes can be a major predator and scavenger of deer, selecting primarily for fawns, old, wounded, and dead individuals (Gladfelter 1984; Huebschman et al. 1998). Though no marked deer were lost to coyotes, we did document seven kills in 1996. All were closely associated with the woven-wire deer fence that was constructed around GP cropfields, leading us to speculate that coyotes may have been using the fence as a barrier to aid in their hunting.

Population Modeling

The density of adult females will remain relatively stable if demographic rates continue to operate as they did during 1995 to 1997. The deer density will remain relatively static if hunter harvest rates are the same or up to 25% higher than the harvest rates in 1995 through 1997. If the hunting seasons are discontinued, the density would increase exponentially, to 55 deer/km^2 (145 deer/mi^2) in only five years. If the harvest rate was halved the density would climb, to 29 deer/km^2 (77 deer/mi^2) in five years.

The model that we used incorporated rates that varied relative to the stochasticity we found in the actual population. Our changing rates, however, may not have been as dynamic as reality, where they are constantly changing on a myriad of temporal and spatial scales due to a variety of natural and human-induced factors. Annual rates of birth, immigration, death, and emigration vary depending on several intrinsic and extrinsic factors and affect population density (VerCauteren and Hygnstrom 1994). It is important for managers to consider the impacts of changing demographic rates on density.

MANAGEMENT IMPLICATIONS

Winter helicopter censuses of deer in the GPFF area were a useful and efficient tool for determining overwinter population levels, directing deer population management, and justifying deer harvest strategies.

The survival of adult females in the GPFF area was relatively high. Natural causes of mortality are of minor importance, with the exception of occasional EHD outbreaks and possible increased fawn mortality due to flooding. We attributed most deer mortality to human causes. The manipulation of deer survival through regulated hunting is the key to population management in the GPFF area. Increased harvest of antlerless deer will reduce population densities (McCullough 1984; McNulty et al. 1997) and associated environmental and social problems. Regulated deer hunts should be continued in the FF upland and lowland areas to maintain the annual deer density at or near an established overwinter goal that promotes the preservation of native plant communities and provides for viewer recreation. The deer population at GP should be managed at or near the level of maximum sustainable yield to maintain a high level of deer harvest and hunter recreation. Some caution should be exercised to avoid overharvesting deer in the area to avoid the possible consequences of additive mortality that could occur in the event of extensive flooding (especially during the fawning period) and/or outbreaks of EHD. Forest openings and old field areas in GP could be managed to maximize forage production to increase the reproductive rate of deer on GP and possibly to lure deer from the FF uplands and BR area.

The next problem that should be dealt with in the GPFF area is the overabundance of deer in the residential area. Officials of the City of Bellevue should explore options to curtail residents from feeding deer within the city limits. If a public education program is ineffective, ordinances that prohibit the activity may be necessary. Officials should also consider regulated hunts or other deer removal practices in open-space areas to reduce deer densities to levels consistent with overwinter goals that lead to the reduction of deer damage and deer-vehicle collisions. A public education program should be implemented to increase landowner awareness of registered deer repellents, practical exclusion methods, and deer-resistant plants for landscaping.

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LITERATURE CITED

AYCRIGG, J. A., and W. F. PORTER. 1997. Socio-spatial dynamics of white-tailed deer in the central Adirondack Mountains, New York. Journal of Mammalogy 78:468-482.

BERINGER, J., L. P. HANSEN, and O. SEXTON. 1998. Detection rates of white-tailed deer with a helicopter over snow. Wildlife Society Bulletin 26:24-28.

CRAVEN, S. R., and S. E. HYGNSTROM. 1994. Deer. Pages D25-40 *in* Prevention and Control of Wildlife Damage, S. E. Hygnstrom, R. M. Timm, and G. E. Larson, eds. University of Nebraska Cooperative Extension, Lincoln.

DIAMOND, J. 1992. Must we shoot deer to save nature? Natural History 8:2-8.

DOENIER, P. B., G. D. DELGIUDICE, and M. R. RIGGS. 1997. Effects of winter supplemental feeding on browse consumption by white-tailed deer. Wildlife Society Bulletin 25:235-243.

DOWNING, R. L., E. D. MICHAEL, and R. J. POUX, JR. 1977. Accuracy of sex and age ratio counts of white-tailed deer. Journal of Wildlife Management 41:709-714.

DUSEK, G. L., R. J. MACKIE, J. D. HERRIGES, JR., and B. B. COMPTON. 1989. Population ecology of white-tailed deer along the lower Yellowstone River. Wildlife Monographs 104.

FULLER T. K. 1990. Dynamics of a declining white-tailed deer population in north-central Minnesota. Wildlife Monographs 110.

GAVIN, T. A., L. H. SURING, P. A. VOHS, JR., and E. C. MESLOW. 1984. Population characteristics, spatial organization, and natural mortality in the Columbian white-tailed deer. Wildlife Monographs 91.

GLADFELTER, H. L. 1980. Deer population estimators in the Midwest farmland. Pages 5-12 *in* White-tailed Deer Population Management in the North Central States, R. L. Hine and S. Nehls, eds. North Central Section of The Wildlife Society. Urbana, IL.

GLADFELTER, H. L. 1984. Midwest agricultural region. Pages 427-440 *in* White-tailed deer: ecology and management, L. K. Halls, ed. Stackpole Books, Harrisburg, PA.

HANSEN, L. P., C. M. NIXON, and J. BERINGER. 1997. Role of refuges in the dynamics of outlying deer populations: two examples from the agricultural Midwest. Pages 327-345 *in* The science of overabundance: deer ecology and population management, W. J. McShea, H. B. Underwood, and J. H. Rappole, eds. Smithsonian Institution Press, Washington, DC.

HEISEY, D. M., and T. K. FULLER. 1985. Evaluation of survival and cause-specific mortality rates using telemetry data. Journal of Wildlife Management 49:668-674.

HOLZENBEIN, S., and R. L. MARCHINGTON. 1992. Emigration and mortality in orphaned male white-tailed deer. Journal of Wildlife Management 43:872-879.

HUEBSCHMAN, J. J., S. E. HYGNSTROM, and J. A. GUBANYI. 1997. Coyote food habits at DeSoto National Wildlife Refuge, Nebraska. The Prairie Naturalist 29:99-110.

HYGNSTROM, S. E., and W. BAXTER. 1991. Deer damage control in Nebraska. University of Nebraska Cooperative Extension, Lincoln. 4 pp.

JACOBSON, H. A., and D. C. GUYNN, JR. 1995. White-tailed deer population biology. Pages 81-111 *in* Quality whitetails: the why and how of quality deer management, K. V. Miller and R. L. Marchinton, eds. Stackpole Books, Harrisburg, PA.

MATHEWS, N. E., and W. F. PORTER. 1993. Effect of social structure on genetic structure of free-ranging white-tailed deer in the Adirondack mountains. Journal of Mammalogy 74:33-43.

McCULLOUGH, D. R. 1979. The George Reserve deer herd: population ecology of a K-selected species. University of Michigan Press, Ann Arbor, MI.
McCULLOUGH, D. R. 1984. Lessons from the George Reserve, Michigan. Pages 211-242 *in* White-tailed deer: ecology and management, L. K. Halls, ed. Stackpole Books, Harrisburg, PA.
McNULTY, S. A, W. F. PORTER, N. E. MATHEWS, and J. A. HILL. 1997. Localized management for reducing white-tailed deer populations. Wildlife Society Bulletin 25:265-271.
MEFFE, G. K., and C. R. CARROLL. 1994. Principles of conservation biology. Sinauer Associates, Sunderland, MA, USA.
MENZEL, K. E. 1984. Central and Southern Plains. Pages 449-456 *in* White-tailed deer: ecology and management, L. K. Halls, ed. Stackpole Books, Harrisburg, PA.
MENZEL, K., and R. HAVEL. 1977. Surveys and management of deer. Nebraska Game and Parks Commission, Pitman-Robertson Project W-15-R-33. Lincoln, NE.
MILLER, K. V. 1997. Considering social behavior in the management of overabundant white-tailed deer populations. Wildlife Society Bulletin 25:279-281.
NELSON, M. E., and L. D. MECH. 1986. Mortality of white-tailed deer in northeastern Minnesota. Journal of Wildlife Management 50:691-698.
NETTLES, V. F. 1997. Feeding wildlife ... food for thought. Southeastern Cooperative Wildlife Disease Study Newsletter 13:2-3.
NIXON, C. M., L. P. HANSEN, P. A. BREWER, and J. E. CHELSVIG. 1991. Ecology of white-tailed deer in an intensively farmed region of Illinois. Wildlife Monographs 118.
OZOGA, J. J., and L. J. VERME. 1982. Physical and reproductive characteristics of a supplementally fed white-tailed deer herd. Journal of Wildlife Management 46:281-301.
OZOGA, J. J., R. V. DOEPKER, and M. S. SARGENT. 1994. Ecology and management of white-tailed deer in Michigan. Michigan Department of Natural Resources Research Project W-127-R-12.
PORTER, W. F., N. E. MATHEWS, H. B. UNDERWOOD, R. W. SAGE, and D. F. BEHREND. 1991. Social organization in deer: implications for localized management. Environmental Management 15:809-814.
STOLL, R. J., JR., M.W. McCLAIN, J. C. CLEM, and T. PLAGEMAN. 1991. Accuracy of helicopter counts of white-tailed deer in western Ohio farmland. Wildlife Society Bulletin 19:309-314.
SWIHART, R. K., P. M. PICONE, A. J. DENICOLA, and L. CORNICELLI. 1995. Ecology of urban and suburban white-tailed deer. Pages 35-44 *in* Urban deer: A manageable resource?, J. B. McAninch, ed. 55th Midwest Fish and Wildlife Conference, St. Louis, MO.
VAN DEELEN, T. R., H. CAMPA III, J. B. HAUFLER, and P. D. THOMPSON. 1997. Mortality patterns of white-tailed deer in Michigan's Upper Peninsula. Journal of Wildlife Management 61:903-910.
VERCAUTEREN, K. C. 1998. Dispersal, home range fidelity, and vulnerability of white-tailed deer in the Missouri River Valley. Dissertation. University of Nebraska, Lincoln, NE.
VERCAUTEREN K. C., and S. E. HYGNSTROM. 1994. A review of white-tailed deer movements in the eastern Great Plains relative to environmental conditions. Great Plains Research 4:117-132.
VERCAUTEREN K. C., J. BERINGER, and S. E. HYGNSTROM. 1999. Netted-cage traps for white-tailed deer. Pages 155-164 *in* Mammal trapping, G. Proulx, ed. Alpha Wildlife Research and Management, Sherwood Park, Alberta, Canada.
VERME, L. J. 1965. Reproductive studies of penned white-tailed deer. Journal of Wildlife Management 29:74-79.