2008

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Human–Wildlife Conflicts 2(1):102–109, Spring 2008

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Abstract: Burgeoning deer populations in urban and suburban areas, along with the inherent problems stemming from this increase, are becoming increasingly widespread. To address these problems, wildlife biologists need quality baseline data of herd composition for harvest and treatment forecasts for management and fertility control research programs. In this study, we provide white-tailed deer (*Odocoileus virginianus*) population data from 4 areas where localized suburban white-tailed deer populations were substantially reduced utilizing sharpshooting as a management tool. In each area, legal hunting was nonexistent for >10 years preceding the sharpshooting program. The areas ranged in size from 300 ha to 3,000 ha. We annually culled from 124 to 566 deer per area and reduced herds by 35% to 90% in a given year. Biological traits were gathered from harvested deer (n = 3,242) at each site to ascertain herd demographics and fitness. The results from these harvest programs indicate that sex and age structure of non-hunted deer populations are fairly uniform and predictable. There were consistently 60% females and 40% males in these environments. Also, these deer populations were comprised of ~40% yearling and adult females, ~20% yearling and adult males, and ~40% fawns.

Key words: demographics, human–wildlife conflict, immunocontraception, *Odocoileus virginianus*, sharpshooting, suburban, white-tailed deer, wildlife damage management

In recent decades, wildlife biologists and resource managers have been faced with the challenge of managing escalating populations of white-tailed deer (*Odocoileus virginianus*) in suburban and natural areas. Many significant problems have arisen along with these population increases, including destruction of agricultural crops (DeVault et al. 2007) and planted ornamentals, deer–vehicle collisions (DVCs), increasing incidence of Lyme disease, and severe disruption of forest health and reproduction (Conover et al. 1995, McShea et al. 2008, Ng et al. 2008).

The sustainability of healthy ecosystems and minimization of deer–human conflicts often requires active deer population management (Hussain 2007, Grovenburg et al. 2008). A spectrum of options has been assessed to manage suburban deer populations, including controlled hunting, sharpshooting, live capture, euthanasia, relocation, and fertility control (DeNicola et al. 2000, Curtis et al. 2008, Miller et al. 2008, Rutberg and Naugle 2008). Prior to the initiation of one of these management options, a population estimate typically is generated to determine the number of deer that need to be removed to meet management objectives. These estimates typically are derived using helicopter counts over snow (Beringer et al. 1998), aerial infrared (IR) censuses (Naugle et al. 1996, Haroldson et al. 2003), or distance sampling along transects (Koenen et al. 2002).

In most situations, female deer are targeted for removal to reduce the reproductive potential of the residual population, particularly when using fertility control agents. It is important to understand the demographic composition of the target population to better predict how many females should be removed or treated so that the remaining population is within desired limits (Dolbeer 1998). Therefore, our objective was to document the composition of non-hunted suburban deer populations killed during sharpshooting management programs.

Study areas

We implemented suburban sharpshooting management projects in DuPage County Forest Preserve District, Illinois; Eden Prairie, Minnesota; Iowa City, Iowa; and Peaks Island, Maine. Management activities were focused in a 10-km^2 area of the DuPage County Forest Preserve District, a 30-km^2 area of Eden Prairie, a 15.5-km^2 area in Iowa City, and all of Peaks Island

(3 km²). Municipal sites (i.e., Eden Prairie, Iowa City, and Peaks Island) were typical suburban developments that were composed of a matrix of suburban and commercial development, with intermingled small agricultural plots and undeveloped open spaces. DuPage County Forest Preserves, located in the suburbs of Chicago, Illinois, were comprised of forested public lands maintained for conservation (Etter et al. 2000).

Public safety concern over increasing DVCs was the reason elected officials approved the use of sharpshooting to reduce the local deer herd in Eden Prairie and Iowa City. Whereas on Peaks Island, potential loss of biodiversity due to high deer herbivory rates and concern about Lyme disease were the incentive for management action. Deer removal efforts in the DuPage County Forest Preserves were initiated to reduce the impact of deer on plant biodiversity.

None of the deer populations in these areas had been managed or hunted for >10 years, resulting in high deer densities. Initial estimated deer densities in the 4 management areas were 68 deer/km² in DuPage County Forest Preserve, 15 deer/km² in Eden Prairie, 50 deer/km² in Iowa City, and 80 deer/km² on Peaks Island.

Methods

We used sharpshooting techniques to kill deer (DeNicola et al. 1997). We selected bait sites throughout the area of operation before sharpshooting was initiated to maximize the efficiency and safety of removal efforts. We attempted to have a minimum of 2 bait sites per km². Whole-kernel corn was placed on the ground 3 weeks in advance of shooting at locations. We placed approximately 0.5 to 1 kg of corn per deer daily at each site, with the number of deer calculated from helicopter counts over snow. Deer were euthanized (i.e., killed with a shot to the center of the brain) at sharpshooting sites from a vehicle or from a tree stand, during the daytime and after dark. Human safety was ensured by shooting only when there was a known earthen backstop created through the shooter's relative elevation (e.g., tree stand) or topography. Deer were shot only when circumstances were safe (i.e., no humans in the removal zone) and fewer than 9 deer were present to prevent educating deer to the procedure. Although we shot deer on a first opportunity basis, when possible antlerless deer were prioritized.

A herd of white-tailed deer.

The sharpshooting program in DuPage County Forest Preserve District was conducted in December–March 1993 (253 deer harvested), 1994 (566 deer harvested), 1995 (166 deer harvested), 1996 (322 deer harvested), and 1997 (228 deer harvested). We implemented the sharpshooting program in Eden Prairie during November 1997 (160 deer harvested over 15 days), November 1998 (124 deer harvested over 11 days), November 1999 (125 deer harvested over 8 days), and November 2000 (125 deer harvested over 7 days). In Iowa City, management efforts were conducted in January 2000 (360 deer harvested over 10 days), December 2000–January 2001 (340 deer harvested over 21 days), and December 2001 (250 deer harvested over 18 days). We culled deer on Peaks Island during February and March 2000 (223 deer harvested over 8 days).

We recorded age (Severinghaus 1949), sex, weight, reproductive status using fetal counts (when feasible), and general health (e.g., body fat observations using Kistner scores; Kistner et al. 1980) and the kidney fat index (Watkins et al. 1991) on most deer harvested. Yearling and adult age classes were combined because of potential inaccuracies when diffentiating yearling from 2-year-old deer (i.e., after premolar replacement, Gilbert and Stolt 1970).

Population estimates were derived annually using helicopter counts over snow, following methods described in Beringer et al. (1998), in DuPage County Forest Preserves. When possible, we conducted snow counts each year in advance of sharpshooting. We completed counts during the culling if inadequate snow cover (i.e., <10 cm) prevented counts before culling was initiated. Biologists from the Iowa Department of Natural Resources conducted less systematic helicopter counts over snow in Iowa City (1999–2002). Iowa City counts were completed a year prior to the first culling period and within a few months (dependent on snow conditions) after each annual cull. Personnel from the Eden Prairie Department of Parks and Recreation also conducted less systematic annual helicopter counts over snow in Eden Prairie (1996–2000). As in Iowa City, Eden Prairie counts were completed a year prior to the first culling period and post-cull thereafter. In Eden Prairie and Iowa City, counts were done annually by the same personnel using the same methods. Therefore, the Eden Prairie and Iowa City counts were minimum estimates and were not adjusted for detection rates. Population estimates on Peaks Island were derived through reconstructions of post-harvest counts of deer observed (i.e., seen but not killed) and killed during culling efforts. Count data in Eden Prairie and Iowa City were complemented by conducting simple population projections (DeNicola, unpublished data) based on observed demographics. We assumed that 60% of the populations were female, 33% of females were fawns, and recruitment rates were 1:1 (doe:fawn ratio). We then included approximations of non-culling mortality, i.e., DVC data and approximate mortality rates for urban deer derived from the literature (Etter et al. 2002). Immigration and emigration were assumed to be equal.

We included demographic data from annual culling programs until there were noticeable demographic changes, which indicated density dependent or behavioral responses (e.g., reduced male dispersal or increased male immigration). Of particular significance was a decrease in the doe:fawn ratio, indicating an increase in survival and recruitment of fawns.

Results

We harvested 3,242 deer from 4 locations representing states in the Northeast and Midwest over 9 years (Table 1). Among all locations, there was on average (± SE) 20.8% ± 0.8% yearling and adult males, 39.0% ± 3.9% yearling and adult females, and 40.2% ± 3.2% fawns (Table 2). In Eden Prairie, the mean age-sex structure across years (± SD) was 21.6% ± 1.3% yearling and adult males, 33.5% ± 2.7% yearling and adult females, and 44.9% ± 3.3% fawns (1:1.3 doe:fawn ratio; Table 3). A slightly higher doe to fawn ratio (1:1) was documented in DuPage County with 39.4% ± 6.0% yearling and adult females, and 39.7% ± 2.5% fawns (21.1% ± 4.6% yearling and adult males; Table 4). Similar demographics were observed in Iowa City (20.9% ± 2.5% yearling and adult males, 40.3% ± 1.4% yearling and adult females, and 38.7% ± 1.2% fawns; Table 5) and Peaks Island (19.7% yearling and adult males, 42.6% yearling and adult females, and 37.7% fawns; Table 2).

To assess if demographics became skewed because of culling efforts, we compared data from the first year of each program to the average of the remaining selected years. If only the first year data are included, the demographics were 19.7 ± 1.2% SD yearling and adult males, 40.6 ± 3.7% SD yearling and adult females, and 39.8 ± 3.8% SD fawns. There was minimal difference in demographic of the harvest from the first year data compared to demographics of the select subsequent years, with 21.9 ± 0.7% SE yearling and adult males, 37.1 ± 3.6% SE yearling and adult females, and 41.1 ± 3.5% SE fawns.

Most deer were in good to excellent health based on fecundity rates and assessments of body condition. During the first year in DuPage County and Peaks Island yearling and adult does contained an average of 1.5 and 1.4 fetuses, respectively. In Eden Prairie Kistner scores for adult does were 83 ± 2.4 SD. Fetal count data were available only in 2003 when culling was conducted in March, with 1.8 fetuses for yearling and adult does combined. First year data from Iowa City revealed 1.2 fetuses for each yearling or adult and a kidney fat index for adult does of 232 ± 30.7 SD. Yearling and adult does on Peaks Island contained 1.4 fetuses.

Discussion

Demographics from the 4 populations sampled were highly consistent among sites, as well as across years (~20% yearling or adult males, ~40% yearling or adult female, and ~40% fawns). Although additional annual harvest data were recorded, we included only sequential annual data until we noted significant changes in demographic trends.

Table 1. Site locations and size, population estimation technique, and percentage of total deer population harvested from 4 communities in the Northeast and Midwest, 1993–2001.

Location	Harvest period	Area (km²)	Population estimation method	Initial population estimate	Total harvested	Final population estimate
DuPage County, Ill.	1993–1997	10	Helicopter counts	680	1535	150
Eden Prairie, Minn.	1997–2000	30	Helicopter counts	460	534	300
Iowa City, Ia.	2000–2001	15.5	Helicopter counts	750	950	150
Peaks Island, Me.	2000	3	Culling observations	240	223	18

Table 2. Age and sex composition of deer culled in 4 suburban communities, 1993–2001, where hunting had not occurred for more than a decade.

Location	Yearling and adult male (%)	Yearling and adult female (%)	Fawn male (%)	Fawn female (%)
DuPage County, Ill.	294 (21.1)	638 (39.4)	309 (20.7)	295 (19.0)
Eden Prairie, Minn.	115 (21.6)	179 (33.5)	138 (25.9)	102 (19.0)
Iowa City, Ia.	197 (20.9)	384 (40.3)	197 (20.9)	172 (17.8)
Peaks Island, Me.	44 (19.7)	95 (42.6)	41 (18.4)	43 (19.4)

Table 3. Age class and sex distribution of deer harvested in Eden Prairie, Minn., 1997–2000.

Year	Yearling and adult male (%)	Yearling and adult female (%)	Fawn male (%)	Fawn female (%)
1997	32 (20.0)	56 (35.0)	40 (25.0))	32 (20.0)
1998	27 (21.8)	41 (33.1)	26 (21.0)	30 (24.2)
1999	27 (21.6)	37 (29.8)	37 (29.6)	24 (19.2)
2000	29 (23.2)	45 (36.0)	35 (28.0)	16 (12.8)

Table 4. Age class and sex distribution of deer harvested in DuPage County, Ill., 1993–1997.

Year	Yearling and adult male (%)	Yearling and adult female (%)	Fawn male (%)	Fawn female (%)
1993	53 (20.9)	108 (42.7)	44 (17.4)	48 (19.0)
1994	80 (14.1)	271 (47.9)	101 (17.8)	114 (20.1)
1995	45 (27.1)	55 (33.1)	40 (24.1)	26 (15.7)
1996	67 (20.8)	123 (38.2)	80 (24.8)	53 (16.5)
1997	49 (21.5)	81 (35.5)	44 (19.3)	54 (23.7)

Table 5. Age class and sex distribution of deer harvested in Iowa City, Ia., 2000–2001.

Year	Yearling and adult male (%)	Yearling and adult female (%)	Fawn male (%)	Fawn female (%)
January 2000	65 (18.1)	151 (41.9)	80 (22.2)	64 (17.8)
December 2000	76 (22.4)	133 (39.1)	60 (17.6)	71 (20.9)
December 2001	56 (22.4)	100 (40.0)	57 (22.8)	37 (14.8)

We documented an adult female to adult male sex ratio of 2:1 consistently. This is significantly smaller than that typically found in hunted populations (3:1 to 6:1; Mattfeld 1984, Van Deelen et al. 1997, Vercauteren and Hygnstrom 2000, Campbell et al. 2005) because hunters prefer to shoot bucks. We did note a change in the adult sex ratio in Eden Prairie, after we took a year off in 2001. There was a 50% increase in males harvested (~30% of the total harvest) in 2002–2004. Therefore, we included harvest data from 1997–2000 only. A similar pattern was observed in Iowa City. After we took a year off in 2002, males comprised 41% of the total harvest, nearly doubling the percentage from the previous 3 years. This could be the result of lower dispersal of yearling males or an increase in immigration of males with fewer adult does and lower deer densities.

Males are more likely to disperse than are females (Holzenbein and Marchinton 1992) and are subject to increased rates of mortality (Nixon et al. 1994). There also may be disproportionately high male mortality rates during the breeding season in suburbia, including (1) a significant increase of DVCs in November and December and (2) the potential for males to sustain severe injury while competing for females (Gavin et al. 1984). In contrast, it has been demonstrated that suburban females experience very low mortality rates (~10%–15%) in the absence of hunting (Etter et al. 2002, Kilpatrick et al. 2004, Rutberg et al. 2004).

Eden Prairie demographic data demonstrated a slightly greater portion of the population represented by fawns (doe:fawn ratio of 1:1.35). Eden Prairie densities were significantly less than at the other locations, and this likely resulted in increased recruitment, as fetal counts were only slightly higher than other locations. When fetal counts increased from 1.2 in 2000 to 1.6 in 2001 for yearling and adult does in Iowa City, recruitment rates remained the same (doe: fawn ratio of 1:1). In 1998, the doe:fawn ratio in DuPage County decreased to 1:1.8 after yearling and adult fetal counts increased to 1.85 and fawns comprised 48% of the total harvest. It was at this point that we discontinued the collection of demographic data for inclusion in this study.

Overall, approximately 1 fawn was recruited annually for each yearling and adult female, and the sex ratio of fawns was close to 1:1. Typically, there were ~1.8 fetuses per yearling and adult female that were in good physical condition in the Northeast and Midwest (Mattfeld 1984). In Eden Prairie, there were 1.8 fetuses per yearling and adult doe, and the doe:fawn ratio was 1:1.35. In the other locations there was on average 1.4 fetuses per yearling and adult doe, and the doe:fawn ratio was 1:1. Therefore, there is considerable postpartum mortality (~30%) prior to fall recruitment in the suburban deer populations under consideration. This falls into the range of postpartum mortality of 0.28–0.59 reported by Vreeland et al. (2004) and Campbell et al. (2005). Postpartum mortality may be the result of competition for quality fawning sites, predation (e.g., fox and coyote), and deer–vehicle collisions.

Overall comparisons could not be made in relative health among sites because of variability in harvest timing. Regardless, fetal counts and fat indices, when compared to regional data, were indicative of healthy deer. The Eden Prairie Kistner scores for adult does were 83, comparable to the healthiest deer sampled in Indiana (Swihart et al. 1998). Fetal count data in Eden Prairie were available only in March 2003 when culling was conducted. There were 1.8 fetuses for yearling and adult does combined. In Iowa City, during the first year of culling, there were 1.2 fetuses for each yearling and adult and kidney fat index scores for adult does were 232, which correlates with Kistner scores of 77–78 (Swihart et al. 1998). These scores indicate that deer were in good condition. Fetal counts during the first year in DuPage County and Peaks Island (1.5 and 1.4, respectively) also were comparable to deer in good health in Indiana.

We believe that this observed demographic composition is representative of typical non-hunted suburban deer populations because deer of all ages and sexes had reasonably equivalent probabilities of being culled. To help ensure that all deer were equally vulnerable, we placed enough bait so all deer whose home range overlapped each bait site could obtain one feeding (~ 0.5 kg/deer). This maximized the number of deer that would visit bait sites regularly. In addition, bait was placed over a 20-m radius to minimize both competition while feeding and displacement of females by dominant bucks. Even though antlerless deer were prioritized, euthanasia was initiated only if a high percentage (i.e., >80%, including males, if present) of animals could be removed. Even though we prioritized antlerless deer, it was the rare occasion that a male escaped if it also was in the bait site area. Unhunted suburban deer are very naive to gunshots, and males were particularly reluctant to flee a bait site once shooting was initiated. Given the aforementioned methods and suburban deer behavior, we are confident that the number of each age and sex category culled likely corresponded closely with their proportion in the population.

The described demographic pattern is further supported by similar harvest compositions, regardless of the percentage of the population removed (35%–90% reduction). If a certain component of the herd was more vulnerable, we would see different demographics for populations reduced by different percentages. Moreover, to verify our approach, we found that all GPS-collared deer (male and female fawns, adult males, and adult females) adjusted their home range usage when these baiting methods were used at a 250-ha property with high deer densities (~100 deer/km^2; DeNicola, unpublished data). This affinity for the above-mentioned demographic breakdown also may apply in areas with light hunting pressure. Kilpatrick et al. (2004) observed a similar demographic composition in a suburban deer population with only 16% hunting mortality (plus crippling loss).

In conclusion, in most suburban areas where deer become problematic, populations usually exceed 20 deer/km^2, and densities of >40 deer/km^2 are common. Unless densities approach biological carrying capacity, which is rare in suburban environments because of an abundance of food resources, demographic composition appears to be fairly consistent. Therefore, we are confident that initial demographic projections can be made before a management program is begun. We believe that these data will allow managers to predict numbers of each age and sex class with only population estimates available. Refinements in determining local population compositions can be made after completing management initiatives.

Acknowledgments

We would like to thank the DuPage County Forest Preserve District, the local municipal governments from Iowa City, Iowa, Eden Prairie, Minnesota, and Peaks Island, Maine, as well as all the cooperating landowners. In addition, we would like to extend our gratitude to the Illinois Department of Natural Resources, Iowa Department of Natural Resources, the Minnesota Department of Natural Resources, and the Maine Department of Inland Fisheries and Wildlife for all their cooperation and assistance.

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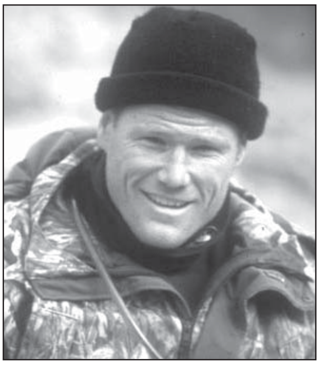

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