Efficacy of a Controlled Hunt for Managing White-tailed Deer on Fair Hill Natural Resource Management Area, Cecil County, Maryland

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Abstract: As exurbia becomes more dominant in our landscape, the number of white-tailed deer (*Odocoileus virginianus*) populations in parklands surrounded by housing increases and creates new challenges in deer management. Traditional harvest regimes often are not possible in areas with heavy human use. Instead, many managers use controlled hunts to reduce deer abundance. We studied the efficacy of a two-day controlled shotgun hunt on Fair Hill Natural Resource Management Area, Cecil County, Maryland. Deer density was 48 deer/km^2, adult sex ratio was 5.3 does/buck (SE = 1.45), and fawn-doe ratio was 0.88 fawns/doe (SE = 0.054). The average fecundity for adults, yearlings, and fawns were 1.76, 1.44, and 0.06 fetuses/doe, respectively. Survival rate of adult does was 0.66 (SE = 0.07), with harvest as the most prominent mortality cause (85.7%), followed by deer auto collisions (14.3%). To examine the effect of the controlled hunt, we created a female-based population model, which included age-structured fecundity and survival rates. The model indicated the Fair Hill NRMA deer population was relatively stable (average $\lambda = 0.981$). To decrease the deer density on Fair Hill NRMA, doe survival must remain consistently <0.66 because survival rates ≥0.66 allowed for stable or increasing deer abundance. We recommend adding an archery harvest on Fair Hill NRMA to increase the mortality rate and keep the doe survival <66% to reduce deer density.

Key words: controlled hunt, exurban, Maryland, *Odocoileus virginianus,* white-tailed deer

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Overpopulation of white-tailed deer (*Odocoileus virginianus*) causes considerable ecological and economical damages (McShea and Rappole 1997). High deer densities can alter plant composition, threaten ground nesting bird species, and disrupt forest succession (DeCalesta 1997, McShea and Rappole 1997). Deer overpopulation also increases the severity of deer-human conflicts, such as crop damage, zoonotic diseases, landscape and garden damage, and deer-auto collisions (Conover 1997). Deer-human conflicts are most common in areas with high deer densities near high human densities. In areas with housing developments and high human activity, controlled hunts are a common technique used to control population numbers.

Controlled hunts allow managers to reduce deer abundance in a specified area while minimizing the interference from and risk to the public during the harvest. Research indicates that an intensive, localized removal creates low deer densities that may persist for several years (McNulty et al. 1997, Oyer and Porter 2004). This method can manage deer locally, even in small areas, if at least one entire matrilineal family group of does is removed (Porter et al. 1991, McNulty et al. 1997, Oyer and Porter 2004). Unlike yearling males, female dispersal is uncommon in yearlings and even rarer in older does (Campbell et al. 2004). Two-year-old does tend to form home ranges overlapping those of their mothers and then form a home range a short distance away at 3 years (Ozoga et al. 1982, Mathews 1989, Porter et al. 1991). Does >3 years old have high home range fidelity (Ozoga et al. 1982, Kilpatrick et al. 2001, Campbell et al. 2004). Therefore, if an entire matrilineal group of does is removed, the removal area is only repopulated by the slow expansion of neighboring matrilineal home ranges or the uncommon occurrence of dispersing does (Porter et al. 1991, McNulty et al. 1997, Oyer and Porter 2004). However, a removal area may be repopulated more quickly if the area is adjacent to areas with high deer densities (McNulty et al. 1997).

Despite the evidence of sustained herd reduction, controversy remains over the effectiveness of controlled hunts for managing deer populations (Doerr et al. 2001, Kilpatrick et al. 2002, Giles and Findlay 2004). The main reason for this controversy lies in indications that reproductive rate (Verme 1991, Swihart et al. 1998, Patterson and Power 2002, Porter et al. 2004) and survival rate (Carroll and Brown 1977, Dumont et al. 2000) are density dependent, so reducing deer density to a value below carrying capacity could increase the growth rate of a population (McCullough 1999).

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However, studies have shown hunting negatively affects population growth by altering the age structure to younger does, which have lower reproductive capacity (Richter and Labisky 1985, Scanlon 1998, Porter et al. 2004).

For managers to understand the efficacy of a controlled hunt they need to know not only the immediate effect it has on deer abundance, but also its effect on the population growth rate to estimate future densities. Resource managers at Fair Hill Natural Resource Management Area (hereafter Fair Hill NRMA), an exurban state owned property, used a controlled shotgun hunt since 1994 to manage deer. However, since little population information was known about deer on the area, managers did not know the effect of the existing hunting regime. Therefore, we created a population model to estimate population growth to enable managers to choose management strategies most appropriate for the deer herd on their property. Our objectives were to estimate deer abundance and sex ratio using spot-light surveys, estimate age structure and the influence of age on fecundity using hunter harvested does, estimate survival and cause-specific mortality rates using radio-telemetry, and use population data to develop a population model to understand the effect of the controlled hunt on the white-tailed deer population on Fair Hill NRMA.

Study Area

We conducted our research on the northern portion of Fair Hill NRMA (2,272 ha), Cecil County, Maryland, that managed white-tailed deer with an annual controlled hunt. Fair Hill NRMA (39.69N 75.87W) is bordered by Pennsylvania to the north and was approximately 1 km west of Delaware. Most of the Pennsylvania property north of Fair Hill NRMA was in agricultural production. To the east and west of Fair Hill NRMA were suburban housing developments. The southern boundary of the area was bordered by a mixture of small subdivisions, individual house lots, and small farms. The exurban park contained 121 km of roads and trails frequented by equestrians, bikers, and hikers year round and cross-country skiers during the winter months. Fair Hill NRMA was 45% mixed hardwood forests, 38% hayfields, 12% farmland (including equestrian centers), and 5% idle land. The controlled shotgun hunt, which began in 1994, took place the first week in January each year. The hunt was two to six days (two days during this study) of antlerless-only hunting, except in 2004–2006, when a random drawing awarded 10 antlered deer tags.

Methods

From February 2004 through March 2005, we used drop-nets (Conner et al. 1987) and dart guns (Kilpatrick et al. 1997) to capture and radio collar (Model No.M2610, Advanced Telemetry Systems, Isanti, Minnesota) 66 adult does (≥1.5 years old). We conducted fixed road transect spotlight surveys (McCullough 1982, Kie and Boroski 1995) from September 2004–January 2005 and September 2005–January 2006. Surveys started a half-hour after sunset on nights with no fog or precipitation and wind <16 km/hr. During surveys, the vehicle traveled ≤16 km/hr (Kie and Boroski 1995). To conduct the surveys, we used 10 × 42 binoculars and a 1 million candlepower spotlight. A cluster of deer was ≥1 deer spotted together during a survey. We recorded time and distance along the transect (truck odometer) at which each cluster of deer was sighted. Using a rangefinder (6x magnification, target deer 10-274 m , Yardage Pro Scout, Bushnell Corporation, Denver, Colorado), we recorded perpendicular distance from the transect to the cluster. We also recorded number of deer in each cluster and age class (fawn versus adult), sex (adults only), and presence of collars or tags of each deer within the clusters. We classified deer >200 m from the transect as "unknown" because detecting small antlers made sex and age determination unreliable. We calculated fawn-doe and adult sex ratios from surveys conducted before 15 October because the muzzleloader deer hunting season began on surrounding lands and deer visibility and availability began to vary by sex and age (Ebersole 2006). We estimated deer abundance with line-transect estimates (Thomas et al. 2002) using the software DISTANCE (Thomas et al. 2003) and mark-resight estimates (Minta and Mangel 1989) using the software NOREMARK (White 1996) using all survey data. For mark-resight estimates, we considered collared deer as marked and used the joint hypergeometric maximum likelihood estimator of a mark-resight estimate for a population with immigration and emigration in NOREMARK (White 1996). If 95% CIs for abundance estimates did not overlap between years or methods, then we concluded these estimates were different (Sokal and Rohlf 1998).

The controlled hunt was the first Monday and Tuesday of each January in 2005–2006. Approximately 85 hunters participated each day and they had a four antlerless deer limit. Hunting was permitted from 0600 until 1400. We summarized the harvest on our study area using historical data provided by the Fair Hill NRMA staff for 1994–2004 and the harvest data we collected during 2005–2006. The length of the controlled hunt was six days in 1994–1995, five days in 1996, four days in 1997, three days in 1998, and two days in 1999–2006. Each year, the number of hunters participating in the controlled hunt varied by day, so hunt effort also varied by year and day. We calculated the average daily harvest for each year by dividing total annual harvest by the number of days in the hunt. Because hunters could only participate in the controlled hunt one day per year, we also calculated average daily harvest per hunter by dividing average daily harvest by the average daily number of hunters. We calculated annual hunter success rate by dividing the number of hunters who harvested at least one deer by the total number of hunters.

To compare age to fecundity, we aged all harvested deer in January 2005 and 2006 using tooth wear and replacement (Severinghaus 1949) and collected reproductive tracts from harvested does to count fetuses and corpora lutea of pregnancy (Harder 2005). Pregnancy rates were compared among three doe age classes (fawns, yearlings, and adults) using a Cochran-Mantel-Haenszel χ^2 test. To determine if the number of fetuses per doe (i.e., all does including those not pregnant) differed among the three age classes, we used an ANOVA with the main effect of age class blocking on year. We used Tukey's honestly significant difference as a means separation test. We conducted all analyses using SAS (version 9.1, Cary, North Carolina) with an alpha level of 0.05.

At least once every week from March 2004–March 2006, we located radio-collared deer using biangulation. We visually located deer to determine mortality causes when the collar emitted a mortality signal or the deer did not move for two consecutive locations. We used the radio-telemetry data to estimate annual survival and survival during the controlled hunt using a Kaplan-Meier staggered-entry design with the program KAPLAN (Pollock et al. 1989). The time span for the estimate of survival during the controlled hunt included the two days before hunt, two days during hunt, and three days after hunt. We estimated cause-specific mortality rates using the program MICROMORT (Heisey and Fuller 1985) with three mortality causes (harvest, unrecovered harvest, and deer-automobile collisions [DAC]). To determine the proportion of deer mortalities resulting from the controlled hunt, we also conducted a MICROMORT analysis with two mortality causes: controlled hunt mortalities and mortalities from other causes.

Population Model

We projected population growth for white-tailed deer exposed to the Fair Hill NRMA controlled hunt using a female-based model we built in Microsoft Office Excel 2003 (Microsoft Corporation, Redmond, Washington; Fig. 1). We ran the model using our estimates of fecundity and the three survival values for female deer on Fair Hill NRMA (Table 1). We projected female abundance 10 years after spring 2006 ($t = 0$) and replicated the model 1000 times. We assumed annual survival was identical for yearlings and deer ≥2 years old (Nelson and Mech 1986, Fuller 1990, Etter et al. 2002), so we used two age classes in the model: adult (≥1 year old) and fawn (<1 year old).

We determined the initial female abundances for each age class in year 0 from the 2005 average of the DISTANCE and NOREMARK deer abundance estimates, buck-doe ratio, and fawn-doe ratio, assuming a 50:50 fawn sex ratio (Verme 1983). In years $t>0$, adult abundance was the number of adults and fawns that survived the previous year. Fawn abundance was the number of

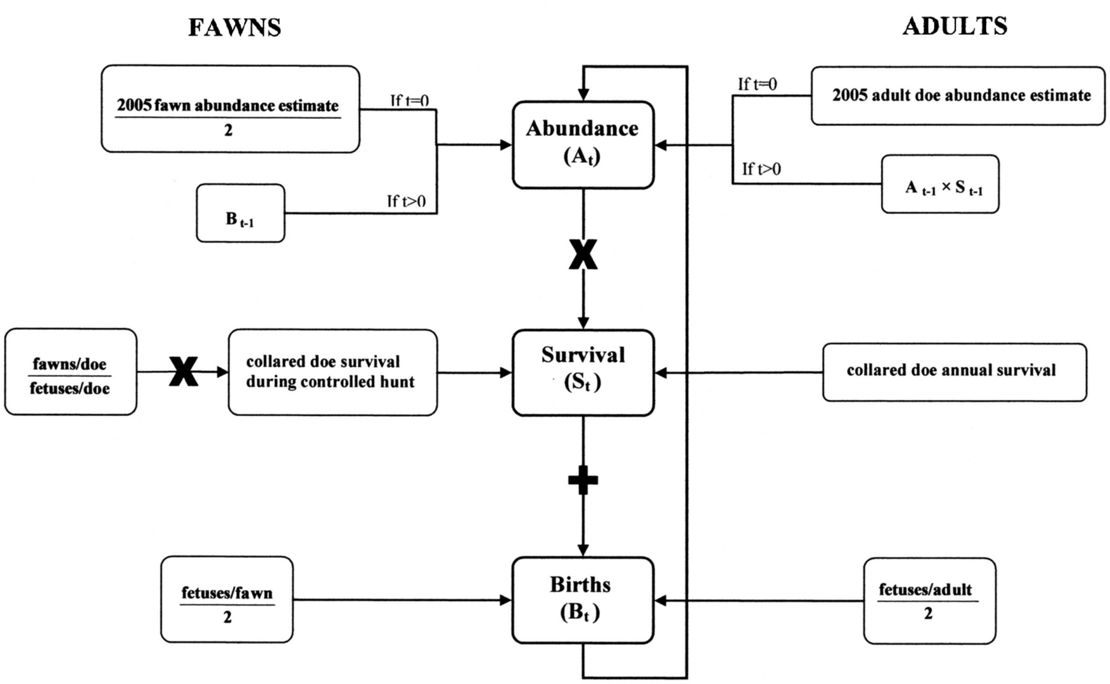

Figure 1. Female-based model projecting the annual finite rate of increase for the white-tailed deer population years after 2006 on Fair Hill Natural Resource Management Area, Cecil County, Maryland.

Table 1. Input values for the female-based white-tailed deer (*Odocoileus virginianus*) population model for Fair Hill Natural Resource Management Area, Cecil County, Maryland.

Model input	Mean	SD	Lower bound	Upper bound
2004 doe survival	0.56	0.272	0.286 = 1 SD	0.831 = 1 SD
2005 doe survival	0.74	0.260	0.478 = 1 SD	0.999 = 1 SD
Pooled doe survival[a]	0.66	0.227	0.434 = 1 SD	0.888 = 1 SD
Fawns/doe	0.83	0.021	none[b]	none[b]
Fetuses/doe[c]	1.16	0.899	fawns/doe value	2.059 = 1 SD
Controlled hunt survival	0.76	0.262	0.5025 = 1 SD	1 = highest possible
Fetuses/adult	1.69	0.538	1.151 = 1 SD	2 = highest possible w/ yearlings
Fetuses/fawn	0.06	0.295	0 = lowest possible	0.355 = 1 SD

a. Pooled survival data from 2004 and 2005
b. Value did not have an upper or lower bound
c. Includes both adult and fawn does

female births projected from the previous year. Because annual survival of collared does varied among years, we ran the model using survival rates from 2004, 2005, and both years pooled. We estimated annual fawn survival by combining estimates of pre-hunt fawn survival and survival during the controlled hunt. We assumed male and female fawns had equal survival rates (Wickham et al. 1993, Brinkman et al. 2004). Pre-hunt fawn survival was the proportion of fetuses (fawns) that survived until the pre-hunt spotlight surveys, calculated using the formula: pre-hunt survival = (fawns / doe) / (fetuses / doe). During the fall and winter, we assumed fawn survival was similar to adult survival (Nixon et. al 1991, Etter et. al 2002, Brinkman et. al 2004). Because the controlled hunt is the primary mortality cause during fall and winter, we used adult survival during the controlled hunt to represent fawn survival rate during these seasons. To determine if hunters harvested doe fawns and adult does equal to their availability in the population during the controlled hunt, we used Cochran-Mantel-Haenszel χ^2 test to compare the 2004 and 2005 estimated fall fawn and adult doe population sizes on the property and the number of fawns and adult does harvested each year. We multiplied the pre-hunt and hunt survival rates to estimate fawn annual survival. We estimated female births each year using fetus-doe ratios for the two age classes, assuming a 50:50 fetus sex ratio. From annual female abundance, we calculated the finite rate of increase (λ) for each year *t*. If the 95% confidence interval of λ overlapped one in a given year, we considered the population stable.

Results

Controlled Hunt

Although daily harvest varied among years, hunter success remained stable (Table 2). The average daily harvest per hunter from 2000–2006 was 0.82, but varied with annual hunt conditions. Hunters harvested an average of 186 deer annually from 1994–2006 and 144 deer annually from 1999–2006 (two days of hunting).

Population Structure

Line-transect (2004 = 53.2, 95% CI = 45.1 – 62.7; 2005 = 48.3, 95% CI = 43.3 – 55.0) and mark-resight (2004 = 45.1, 95% CI = 34.5 – 61.6; 2005 = 48.4, 95% CI = 40.0 – 59.5) estimates produced similar density estimates. Average adult sex ratio was 5.26 does:buck (SE = 1.45) and the average fall fawn:doe ratio was 0.875 (SE = 0.05). Assuming a 50:50 fawn sex ratio, the sex ratio for all deer (fawns and adults) was 2.29 does per buck.

Fecundity

The average pregnancy rates differed among adults, yearlings, and fawns ($\chi^2_2 = 180.58$, $P < 0.001$; Table 3). Most (68%) harvested does were pregnant (Table 3). The average fetuses per doe, including unbred does, were 1.16 (SE = 0.06), 1.76 (SE = 0.51), 1.44 (SE = 0.56), and 0.06 (SE = 0.30) for all ages, adults, yearlings, and fawns, respectively. Adults had more fetuses than yearlings and yearlings had more fetuses than fawns ($F_{2, 201} = 288.42$, $P < 0.001$). Most (72%) pregnant adult does had two fetuses, while yearlings were nearly evenly divided with one (50%) or two (47%) fetuses.

Survival Rates and Mortality Causes

During this study, 62 collared females were vulnerable to the controlled hunt and used for survival estimates. The annual survival rate was 0.56 (SE = 0.07) in 2004, 0.72 (SE = 0.07) in 2005, and 0.66 (SE = 0.05) in both years pooled. Survival rate during the controlled hunt was 0.82 (SE = 0.06) in 2005, 0.74 (SE = 0.07) in 2006, and 0.74 (SE = 0.07) for the years pooled. Mortality causes were 57.1% harvest, 28.6% unrecovered harvest, and 14.3% deer-auto collisions. The controlled hunt accounted for 60.7% of all deer mortalities on an annual basis.

Table 2. Harvest data for the controlled female white-tailed deer (*Odocoileus virginianus*) hunt on Fair Hill Natural Resource Management Area, Cecil County, Maryland 1994–2006.

Year	Number of hunt days	Total annual harvest	Average daily harvest[a]	Average daily harvest/hunter	Hunter success rate
1994	6	250	41.7		
1995	6	216	36.0		
1996	5	318	63.6		
1997	4	324	81.0	0.83	0.69
1998	3	157	52.3		
1999	2	168	84.0		
2000	2	94	47.0	0.65	0.65
2001	2	130	65.0	0.79	0.62
2002	2	151	75.5	0.82	0.62
2003	2	177	88.5	0.82	0.67
2004	2	147	73.5	0.75	0.65
2005	2	166	83.0	1.04	0.57
2006	2	121	60.5	0.87	0.67

a. For 1994, 1995, 1996, 1998, and 1999 no daily hunt data were available

Table 3. Reproductive data for white-tailed deer collected during controlled hunts in January 2005 and 2006 on Fair Hill Natural Resource Management Area, Cecil County, Maryland.

Female demographic classes	2005 Pregnancy rate (n^a)	2005 Fetuses/pregnant doe (n^b, SE)	2006 Pregnancy rate (n)	2006 Fetuses/pregnant doe (n, SE)	Combined Years Pregnancy rate (n)	Combined Years Fetuses/pregnant doe (n, SE)
All age classes	0.72 (116)	1.64 (83, 0.079)	0.63 (89)	1.80 (56, 0.103)	0.68 (205)	1.71 (139, 0.063)
Adults and yearlings	0.99 (81)	1.65 (80, 0.057)	0.98 (57)	1.80 (56, 0.075)	0.99 (138)	1.71 (136, 0.046)
Adults	0.98 (61)	1.73 (60, 0.063)	1.00 (45)	1.84 (45, 0.078)	0.99 (106)	1.78 (105, 0.049)
Yearlings	1.00 (20)	1.40 (20, 0.112)	0.92 (12)	1.64 (11, 0.195)	0.97 (32)	1.48 (31, 0.100)
Fawns	0.09 (35)	1.33 (3, 0.068)	0.00 (32)		0.04 (67)	1.33 (3, 0.036)

a. Number of does sampled in each age class
b. Number of pregnant does sampled in each age class

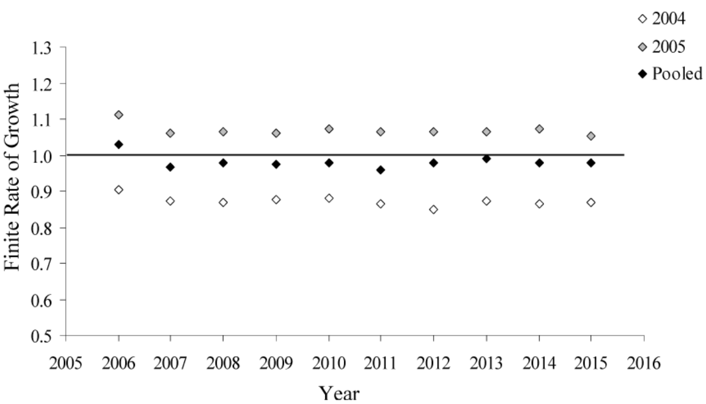

Figure 2. Projection of female white-tailed deer (*Odocoileus virginianus*) population finite rate of growth (λ) with survival rates from 2004, 2005, and both years pooled on Fair Hill Natural Resource Management Area, Cecil County, Maryland.

Population Model

In 2005, adult doe and fawn abundances were 315 and 252, respectively. During the controlled hunt, fawns and adult does were harvested equal to their availability in the population ($\chi^2_1 = 0.21$, $P = 0.645$), so we estimated annual fawn survival as 0.548. The average finite rates of growth over 10 years were 0.87 (SE = 0.01, 95% CI = 0.87 – 0.88), 1.07 (SE = 0.01, 95% CI = 1.06 – 1.08), and 0.98 (SE = 0.01, 95% CI = 0.97 – 0.99) in 2004, 2005, and both years pooled, respectively (Fig. 2).

Discussion

Controlled Hunt

Average daily deer harvest was lowest during the first two years of the hunt when the controlled hunt was the longest, which may have resulted from poor success during later days due to changes in deer density or behavior. Kilpatrick et al. (2002) found hunter success decreased from 38% to 17% over the first two days of a stand hunt. However, it is also possible the poor harvest efficiency in 1994 and 1995 was a result of the learning curve associated with beginning a new program and inefficiency in hunt organization those first years. Although annual hunter unit effort varied, we could not correlate this variation with total harvest each year. Since we lacked daily data from the first several years of the hunt, we could not compare day of hunt (i.e., 1st day, 2nd day) to daily harvest.

Despite the variation in annual harvest, hunter success remained rather consistent from 2000–2006, averaging 63%. If the hunter success rate does not vary with the number of hunters, then increasing hunter density could increase deer harvest. Giles and Findlay (2004) found a strong relationship between total hunter number and deer kill. Inasmuch as increased hunt length only weakly raised total harvest, greater hunter density could be the most efficient way to increase deer harvest.

Deer Density

The estimates of deer density on Fair Hill NRMA between years and methods were similar. In an area of Maryland subjected to a two-week shotgun season where 84% of harvested deer were antlerless, the deer density was 50 deer/km^2, which was very similar to Fair Hill NRMA (Rosenberry et al. 1999). Hansen and Beringer (1997) recommended a density of 15 deer/km^2 in urban areas to provide adequate viewing opportunities for the public while minimizing deer-human conflicts. Additionally, DeCalesta (1994) found song bird nesting decreased with deer densities ≥8 deer/km^2, suggesting deer density on Fair Hill NRMA is too great and should be reduced. Based on these studies, the density we documented is above the culture and ecological carrying capacities.

Fecundity

Some researchers have suggested that reproductive rates (Verme 1991, Swihart et al. 1998, Patterson and Power 2002, Porter et al. 2004) are density dependent. Richter and Labisky (1985) found the proportion of does with twins in a non-hunted population was 14% and in a hunted population was 38%. Kilpatrick et al. (2001) reduced density from 20 deer/km^2 to 11 deer/km^2 and adult does with twins increased from 16% to 56%. Our rate of twins was 45% and similar to the low density estimates for these studies but much greater than high density estimate of either of these studies. Additionally, pregnancy rates were 99% in adult does and only slightly lower in yearling does (97%), so despite the high density, doe fecundity remained high suggesting a lack of density dependence for these age classes. Fawns are the age class most sensitive to density and herd health (Verme 1989, Swihart et al. 1998, Patterson and Power 2002) and only 4% of fawns bred on Fair Hill NRMA, thus density dependence could be affecting fawn reproductive rates.

Survival Rates and Mortality Causes

Our estimate of doe survival was 0.66 for both years pooled (0.558 and 0.716 in 2004 and 2005, respectively). These estimates are similar to a hunted population in Minnesota (Fuller 1990). Fuller (1990) reported that survival was 0.60 for does 1 to 2 years old and 0.71 for does ≥2 years old. Survival rates in hunted deer populations are a function of deer harvest, because non-harvest mortality rates are more similar across studies (Fuller 1990, Nixon et al. 1991, Etter et al. 2002, Brinkman et al. 2004, Porter et al. 2004). In deer populations vulnerable to hunting, harvest is usually the greatest mortality cause (Fuller 1990, Rosenberry et al. 1999). Harvest was the most frequent mortality cause in our study, with 61% of mortalities resulting from the controlled hunt.

Population Model

When the survival data were pooled for both years, deer abundance was stable; but when the annual survival rates were calculated independently for 2004 and 2005, abundance was declining or increasing, respectively. The differences in model predictions demonstrated how annual variations in survival (i.e., harvest) at Fair Hill NRMA may influence population growth. The pooled survival data indicated deer abundance was generally stable over a longer time interval. From 1999–2006, when the controlled hunt lasted two days, the average annual harvest was 144 deer, which was also the average annual harvest during our study years combined. To further decrease the deer density on Fair Hill NRMA, doe survival must remain consistently <0.66, because survival rates ≥0.66 allowed for stable or increasing deer abundance. Based on the average annual harvest at Fair Hill NRMA, the harvest should exceed 144 deer to achieve a survival rate of <0.66.

Our study used an indirect method to estimate fawn survival because no fawns were radio-collared. In Pennsylvania, fawn survival rates until the end of the hunting season were 52.9% in an agricultural area and 37.9% in a forested area (Vreeland et al. 2004). Natural causes (e.g., starvation and disease) were more prominent in the agricultural area and predation was greater in the forested area (Vreeland et al. 2004). Fair Hill NRMA has heavily fragmented forests and few fawn predators, and the fawn survival estimate was 54.8%, similar to that of the agricultural area in the Vreeland et al. (2004). The similar fawn survival rates suggest our fawn survival estimate is reasonable, but further research on fawn survival on Fair Hill NRMA would be necessary for more accurate values.

Management Implications

The 48 deer/km^2 in 2005 on Fair Hill NRMA greatly exceeded the 15 deer/km^2 recommended by Hansen and Beringer (1997) to provide adequate viewing opportunities for the public while minimizing deer-human conflicts in urban areas. A greater density may be acceptable in the exurban landscape surrounding Fair Hill NRMA due to the lower human density; however, ecological damage occurs at lower densities than deer-human conflicts (DeCalesta 1994). Based on Hansen and Beringer (1997) and DeCalesta (1994), we suggest that the deer density on Fair Hill NRMA should be decreased.

Because the finite rate of growth projected by the model was close to $\lambda = 1$ when survival rates were pooled, a decrease in fecundity or survival could change the model from indicating a stable population to a continuous decline in abundance. Because contraception is not a viable option at this time (Warren 2000), fecundity cannot be altered. However, an increase in harvest would reduce deer survival on Fair Hill NRMA. The structured nature of a controlled hunt allows for easy manipulation of the harvest effort on an area in a given year. The model results with the 2004 and 2005 survival data demonstrate how changes in survival influence population growth. One method for increasing harvest would be to increase the number of hunters each day (Giles and Findlay 2004) in combination with limiting refuge areas (Rhoads 2006). However, safety concerns may prevent the implementation of this change. Hunter success decreases with hunt length (Kilpatrick et al. 2002), so implementing a second hunt after at least a week could increase harvest (Rhoads 2006). However, expanding the controlled hunt would involve additional costs and administrative effort as well as placing a greater burden on the already taxed staff at Fair Hill NRMA. Another option for increasing doe harvest is opening the area to the regular archery season (September 15–January 31). The logistics of archery hunting are better than the current controlled hunt because of the lower costs and staff effort involved. Even in residential communities, archery hunters can harvest deer without conflicts with non-hunters (Kilpatrick and Walter 1999), so archery hunting should not affect other recreational activities on Fair Hill NRMA. Adding an additional mortality source, like archery harvest, to the deer population would help annual deer harvest remain consistently high enough to keep doe survival <66% and reduce deer density. If additional hunts are added or hunter density changed on Fair Hill NRMA, we recommend that hunter success and doe-survival rates are measured so doe populations can be monitored and management techniques modified if necessary.

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