INDEXING DEER NUMBERS WITH SPOTLIGHTING: A LONG-TERM STUDY OF A MANAGED DEER POPULATION

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Abstract: Knowledge of trends in deer abundance is required to manage deer populations effectively. We analyzed 18 years of spotlighting data to determine the minimal effort required to index a white-tailed deer (*Odocoileus virginianus)* population with a high degree of confidence on a 778-ha property in southeastern New York. Spotlight counts obtained from 2 and 4 nights of spotlighting were highly correlated ($r > 0.94$) with those obtained from 6–11 nights, suggesting that a modest spotlighting effort can suffice as a useful index to changes in local deer numbers. Spotlighting counts revealed an average 2% annual increase in deer numbers from 1981 to 1998. Environmental parameters such as mean temperature, relative humidity, and wind speed did not correlate well with spotlight counts. The number of deer harvested in the prior year did not predict numbers counted in the present year. We suggest that a modest annual spotlighting effort can produce accurate indices of deer abundance while saving time and resources for agencies and organizations that index deer numbers.

Key Words: deer counts, deer surveys, New York, night surveys, *Odocoileus virginianus*, population trend, spotlight counts, white-tailed deer

Management of any wildlife species requires an understanding of the biological, ecological, and demographic characteristics of that species and knowledge of population size. Abundant deer populations are common in the eastern United States and elsewhere in North America where deer populations often exceed both biological and cultural carrying capacity (McShea et al. 1997). The ability of deer to live in close proximity to humans makes the management of this species particularly challenging. Successful management of deer populations in the future will require accurate estimates of population trends both for planning management programs and for assessing the effectiveness of any management actions.

Public licensed hunting has long been the cornerstone of deer population management in the United States (Smith and Coggin 1984). Using licensed hunters under a controlled-access program has been employed to manage deer at the Mary Flagler Cary Arboretum (MFCA) in southeastern New York State since 1970 (Davis 1975, Winchcombe 1993). The primary objective of these hunts has been to stabilize or reduce local deer numbers. From 1981 – 1998, fall spotlight counts of deer were used at the MFCA to assess the effectiveness of these controlled-access hunts in reaching that objective.

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Methods used to estimate abundance and determine trends in deer populations are varied and include pellet group counts (Rogers et al. 1958, Downing et al. 1965), trail counts (McCaffery 1976), drive counts (Downing et al. 1965), track counts (Downing et al. 1965, Mooty et al. 1984), aerial counts (Rice and Harder 1977, DeYoung 1985, Beringer et al. 1998), ground based photography (Jacobson et al. 1997, Koerth et al. 1997), hunter observations (Downing et al. 1965, Zagata and Haugen 1974), daytime vehicle route counts (Roseberry and Woolf 1991), and night spotlighting counts (Progulske and Duerre 1964, Dealy 1966, McCullough 1982). The diversity of methods is the result of researchers seeking accurate, easily applied methods that are cost-effective to implement across differing landscapes.

In many studies of deer ecology, spotlighting has played a prominent role. Spotlighting has been used to survey deer numbers, to determine productivity, to evaluate habitat preferences, and to discern the age and sex composition of specific herds (Anderson 1959, Progulske and Duerre 1964, Dealy 1966, McCullough 1982). Factors that may influence or bias spotlight data include habitat type (Anderson 1959), seasons (McCullough 1982), deer behavior (Beier and McCullough 1990), environmental variables (Dealy 1966), diel period (Progulske and Duerre 1964), and food availability including variable, high quality foods, such as acorns (Carbaugh et al. 1975, McCullough 1982, McShea and Schwede 1993). McCullough (1982) suggested using repetitive samples with a standard technique over fixed routes to reduce the impact potential biases might have on results.

Our main objectives were to determine the trend in deer abundance in the heavily managed herd at MFCA using intensive spotlighting counts over the 18-year period and to assess the minimum spotlighting effort necessary to generate precise representative counts. Secondary objectives were to assess potential abiotic (climatic) and biotic (acorn production, prior year's harvest) causes of variation in spotlighting counts among years.

STUDY AREA

Located in southeastern New York in central Dutchess County, the 778-ha MFCA is owned and managed by the Institute of Ecosystem Studies (IES). IES programs focus on ecological research and education and include a horticultural program. The property is diverse in vegetative cover and topography. Hardwood forests and mixed hardwood–conifer forests make up about half the property. In these areas, 33% of canopy trees were oaks (*Quercus* spp.) (Glitzenstein et al. 1990) and in certain areas up to 70% of the basal area were oaks (Jones et al. 1998). Overgrown old fields, open fields and swamp–marsh habitats make up approximately 20%, 28% and 2% respectively of the remaining land. Details of land use history, topography, soils and forest species were described by Glitzenstein et al. (1990). A combination of public and private roads provided excellent access to all areas used in this study.

Lands adjoining the IES property are also diverse in both their use and stage of succession. Neighboring properties include commercial businesses and residential development, undeveloped woodlands, actively managed hayfields, pastures, and lands in an old-field stage of development. Deer management on these properties varies from no hunting being allowed to actively hunted. All lands in this area are in New York Wildlife Management Unit 3G. Annual controlled-access hunts, focused on removing adult females, have been held on the MFCA since the mid-1970s.

METHODS

We conducted fall spotlighting counts of deer from 1981–1998. Our spotlighting season ran from late September through mid-November, which is immediately preceding the firearms hunting season. Two trips were scheduled each week with at least 2 days between surveys; we averaged 8 surveys per year. We used 2 hand-held spotlights (300,000 – 400,000 candle power) powered by the electrical system of a 4-wheel-drive pickup truck. Spotlight surveys began 1 hour after sunset and lasted approximately 2.5 hours for the 19.7-km long route. Anderson (1959) and Progulske and Duerre (1964) reported deer activity was highest during these early evening hours. Only open fields and immediate roadsides along the route were searched for deer. The areas spotlighted were a combination of MFCA property and neighboring lands. We searched for deer over about 81 hectares, or 10% of the MFCA. All fields used in this study were mowed or hayed by late August.

The basic crew included a driver, data recorder, 2 spotlight operators, and the primary spotter. Additional crew members (range 1–4) assisted in spotting and in identifying deer. All personnel had binoculars to assist with identification.

When on the route and searching for deer, the driver maintained a speed of 10-20 km/hr. As deer were spotted, the driver received instructions via a colored light panel in the cab indicating where to maneuver the vehicle or to stop. Each field was searched to obtain a total deer count. We also attempted to identify individual deer as bucks, does, or fawns. Unidentifiable deer were classed as unknowns. We were cautious not to double-count any deer, particularly if deer moved through hedgerows to adjacent fields not yet examined. No spotlighting was conducted during heavy rain or dense fog.

Environmental parameters including mean relative humidity, temperature, wind speed and maximum wind speed were measured and data stored at an environmental monitoring site located on the MFCA. Environmental data were available from 1988–1998. Ambient air temperature and relative humidity were collected using HMP45C temperature and relative humidity probes (Campbell Scientific Inc., Logan, Utah, USA). Temperature data were logged every 2 seconds using a micro-logger and at the end of every hour, maximum, minimum, and average temperature for the hour were calculated and stored. Relative humidity measurements were taken with a relative humidity probe that used a capacitive polymer H chip (Vaisala Inc., Woburn, Massachusetts, USA). The data were summarized in the same manner as the temperature data. Wind speed data were collected using a Model 014A sensor (Campbell Scientific Inc., Logan Utah, USA) located on a tower approximately 10 m above the ground. The data were logged every 2 seconds. Maximum, minimum and average wind speeds were calculated and stored for each hour of the day. In order to assess annual variation in acorn production we estimated acorn production using 20 0.5-m^2 seed traps from 1995–1998. Seed traps (Ostfeld et al.1998) were established under mature oak trees in August or September and acorns were counted every 3–4 weeks through 31 December.

Counts of deer for all trips for each year were averaged to produce an annual mean number of deer counted. To examine trends in deer numbers across years, we log-transformed the spotlight counts to stabilize the variance and regressed them against year. To examine the stability of our counts within years, we analyzed the coefficient of variation (CV) in our spotlight counts over all trips within each year. To determine if any measured environmental parameters influenced our spotlight counts, we ran a correlation analysis of these parameters for the specific hours we spotlighted, against our spotlight counts. To ascertain any possible influence of acorn availability on our counts, we used the residuals of the spotlighting regression to test the hypothesis that in years of increased acorn production, observations of deer during spotlighting counts would decrease because acorns would attract deer to oak forests (McShea and Schwede 1993). Results were considered to be significant at $\alpha \leq 0.05$.

RESULTS

Spotlighting counts revealed that the deer population at the MFCA grew at an average rate of 2% per year between 1981 and 1998 and that this growth rate was significantly different from zero ($r^2 = 0.54$, df = 18, $P = 0.001$; Fig. 1). The average CV across all 18 years was 18.1%. This 2% per year population growth occurred despite an average annual hunter harvest of 72 deer (9.2 deer/km^2) following the spotlighting periods.

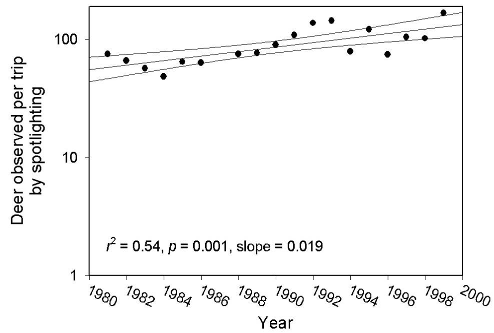

Fig. 1. Average number of deer seen per spotlighting trip each year at Mary Flagler Cary Arboretum, 1981–1998. Number of trips ranged from 6–11 per year.

The residuals of the regression of deer numbers against year were not significantly correlated with the prior year's harvest, thus rejecting the hypothesis that heavy harvests would reduce deer abundance in the following year (bucks $r^2 = 0.08$, df = 17, $P > 0.05$; does $r^2 = 0.04$, df = 17, $P > 0.05$; total harvest $r^2 = 0.00$, df = 17, $P = 0.97$). An analysis of environmental variables indicated no correlation between total deer counted and mean temperature, mean relative humidity, and mean or maximum wind speed ($r = 0.01$, $r = 0.00$, $r = 0.00$, and $r = -0.07$ respectively). We also found a nonsignificant ($r^2 = 0.42$, df = 5, $P = 0.08$) negative association between the residual value of spotlight counts for each year and the acorn index for that year.

Because spotlighting was conducted for 6–11 nights each year, we tested whether a truncated sampling regime would provide data on trends in deer abundance similar to those provided by the full sampling program. Deer counts from the first 2 ($\bar{x} = 91.7$, SE = 8.9) or 4 ($\bar{x} = 91.3$, SE = 8.3) trips each year were strongly correlated (r = 0.94 and 0.96 respectively) with counts from the total trips ($\bar{x}$ = 88.2, SE = 7.5). High correlation coefficients existed regardless of whether the 2 trips were in one week, in consecutive weeks (r = 0.94 and 0.95 respectively), or if the 4 trips were spread across two or four consecutive weeks (r = 0.96 and 0.99 respectively).

DISCUSSION

Deer populations have great potential to expand rapidly when protected from substantial mortality (McCullough 1984). The primary goal of the MFCA hunts was to stabilize the local deer herd. Even with average annual harvests of 9.2 deer/km^2 and a long-term adult harvest sex ratio of 0.9 to 1.0, does to bucks, our data indicate that deer numbers increased an average of 2% per year over the 18-year study period. This rate of population increase is low compared to what is expected without hunt-induced mortality (McCullough 1997). Spotlight counts at our site were significantly correlated with buck harvests in the township (Winchcombe and Ostfeld 2001) suggesting that they accurately represent abundance.

Anderson (1959), Progulske and Duerre (1964), Dealy (1966), McCullough (1982) and others, have used spotlight counts to determine trends in deer abundance. We had a road system that provided excellent access by vehicle to all areas we spotlighted. Our spotlight efforts were focused on open field areas where we were likely to see and count all deer present. While testing for detection rates in different habitat types, Anderson (1959) and Storm et al. (1992) reported that 95% of eye reflectors and deer silhouettes placed in open areas were found by observers. We employed a standardized technique over a fixed route with several replicate trips annually to reduce potential biases. Analysis of the CV in spotlighting counts over all trips within each year suggested high stability of the spotlighting data within years (mean CV = 18.1%). Therefore, we are satisfied our estimation of population trend was sufficiently robust (Harris 1986), and our spotlighting effort provided a consistent means of indexing deer abundance at our site.

Spotlight counts are influenced by a number of factors. For example, Anderson (1959), Progulske and Duerre (1964), Dealy (1966), Carbaugh et al. (1975), Fafarman and DeYoung (1986), and Beier and McCullough (1990) reported that time of year, weather conditions, and diel period can influence spotlight counts. The availability and distribution of preferred foods and are other factors that may affect spotlight counts. McShea and Schwede (1993) reported that female deer in Virginia adjusted their home ranges to access acorn-producing areas during mast-fall. During years of high mast production, acorns comprise a large proportion of the autumn diet (Harlow et al. 1975, McCullough 1985, Pekins and Mautz 1987). Examination of the regression residuals of deer counts across years suggests a possible trend of decreasing deer counts during years when acorn production is high. We feel this is likely the result of deer being drawn to forested sites and subsequently not being counted. This trend suggests that the possibility that heavy acorn production reduces the efficiency of spotlighting in open field habitats should be pursued with larger data sets. As a consequence, we suggest caution in interpreting spotlighting counts in years of heavy acorn production.

Various subsamples of the total count each year were highly correlated with the total count for that year. Means of the initial 2 or 4 trips each year were similar to the mean for all trips (n = 6–11 trips). This was true for 2 trips in one week, 1 trip per week for 2 weeks, 2 trips per week for 2 weeks, and for 1 trip per week for 4 weeks. Such similarity in counts indicates wide flexibility for managers in applying this technique under similar conditions and suggests that modest spotlighting efforts provide comparable results to more intensive survey efforts.

MANAGEMENT IMPLICATIONS

Whether the objective is to increase, decrease, or stabilize a deer herd, effective assessment must include a reliable index of deer abundance. When properly applied, spotlight counts can provide such an index (Progulske and Duerre 1964, Dealy 1966, Gunson 1979 and McCullough 1982). Our data also revealed that spotlight data from as few as 2 or 4 nights can still provide reliable information for managers. The reduced effort can save agencies both time and money when using spotlighting for indexing deer abundance.

ACKNOWLEDGMENTS

We thank the various members of the spotlighting crew especially J. DiMetro and J. Dorney, our drivers; D. DiMetro, B. Fanelli, M. Schroeder Sr. and R. Tierney, who handled the spotlights; F. Gerth and F. Welsh, our data recorders; and M. Fargione and D. Wohlbach for their continued participation over the years. We thank adjoining neighbors J. Olson, C. Smith, H. Croner, H. Kelly and T. Bucklin for allowing us to spotlight their land. We also thank C. Canham, IES staff scientist, for providing the acorn mast data, V. Kelly for the environmental data, and F. Keesing for her intellectual input and statistical advice. We are most grateful to M. Ellingwood and H. Kilpatrick for their review and critical comments on an early draft of the manuscript. We dedicate this paper to Daren J. DiMetro who was an integral part of this project for many years and who left this life much too soon. This publication is a contribution to the program of the Institute of Ecosystem Studies.

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