The Effect of Food Plots, Roads, and Other Variables on Deer Harvest in Northeastern Georgia

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Abstract: White-tailed deer (*Odocoileus virginianus*) harvests from wildlife management areas in northeastern Georgia were compared with habitat variables, population variables from the previous fall harvest and hunters/km^2. Three years of harvest data from 8 Blue Ridge Mountain areas and 12 years of data from an Upper Piedmont area were analyzed. A significant stepwise multiple regression model (R^2 = 0.57) related deer harvest numbers to the following habitat variables for the mountain areas: number and hectares of agricultural food plots, kilometers of roads, hectares of oak timber (all positive), and hectares of clearcuts (negative). On the Piedmont area, similar analyses yielded a model (R^2 = 0.60) with number of bucks harvested related to number of hunters, number of food plots, food plot hectares (all positive), pine timber hectares (negative), and percent population harvested the previous year (negative). Despite a food plot component of only 0.13% of the total land area, much of the variability in the mountain deer harvest was explained by food plots and associated road access. These components were possibly responsible for 4 additional deer harvested/ha of food plot and approximately 40% of the current deer harvest. The Piedmont harvest was influenced by similar habitat factors plus hunting pressure and deer population characteristics from the previous year. Overall, analyses indicated that an increase in food plot hectares and hunter access in both study areas increased deer harvest.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 44:364–373

Deer managers often are unable to explain annual fluctuations in harvest on given management units and failure of certain habitat units to reach harvest potential. To some degree, harvest prediction will always be inexact due to the difficulty in measuring the multitude of variables involved in deer hunting and population analyses (Halls 1978). Managers must consider a wide variety of factors when making deer management decisions (Burgoyne 1980). Some of the more complex factors include weather, efficiency of hunting methods, deer movement, timing of rut, actual population densities, and vulnerability of individual animals to hunting.

Several variables, including timber characteristics, food plots, access, hunting pressure, and population parameters developed from kill records, can be quantified sufficiently to explain much of the variability associated with differences in deer harvest among management units.

Larson (1969) pointed out the need for research examining agricultural clearings, their benefit to white-tailed deer, and their role in management. Wentworth et al. (1987) documented heavy seasonal use of food plots in the Southern Appalachians in conjunction with very light use of woody browse in clearcuts. Kammermeyer et al. (1984) reported preliminary data associating higher harvests with increased food plots. Recent studies in Louisiana and Mississippi have shown both heavy production and utilization of winter agricultural plantings (Johnson et al. 1987, Davis et al. 1988) and high hunter success rates associated with these plantings (Vanderhoff and Jacobson 1988). Our objectives were (1) to evaluate the impact of an expanded food plot program on deer harvests on wildlife management areas in northeastern Georgia, and (2) to identify factors that could be manipulated to increase deer harvest and recreational opportunities on vast acreages of inaccessible, heavily forested land with low harvest potential.

Much of the field work on this study was conducted by D. M. Carlock, R. E. Howarth, C. L. Hastings, and D. C. Wofford. B. A. Sanders of the U.S. Forest Service was most helpful in providing data on forest types and mast capability. We gratefully acknowledge the assistance of L. E. McSwain, A. S. Johnson, P. E. Hale, and J. M. Wentworth for their advice in data organization and manuscript review. This project was partially funded by Pittman-Robertson Funds from the U.S. Fish and Wildlife Service.

Methods

Our study area included 9 northeastern Georgia Wildlife Management Areas (WMAs) located on the Chattahoochee National Forest. Hunters were required to bring harvested deer to check stations on all areas, thus we sampled essentially 100% of the legal harvest. We divided the areas into 2 separate units based on differences in topography and vegetation associated with the Upper Piedmont and Blue Ridge Mountain Physiographic Regions (Harlow et al. 1975, Lentz et al. 1980).

The 8 mountain WMAs totalled 73,250 ha in physically separate units ranging from 4,452 ha to 16,997 ha. Mature, oak-dominant timber type accounted for about 64% of the land area. Six of 8 areas had a recent history of limited either sex harvests and 7 of 8 previously had overpopulation and habitat damage. Mean annual deer harvest during the study period was 1.3 deer/km^2. Although harvest data (including age and condition indicators) have been collected for many years on all areas, only 3 years of data (1981–1983) could be included in this study due to lack of deer kill locations by compartment prior to 1981.

The 6,800-ha Lake Russell WMA study area, located in the Upper Piedmont, contained only 19% mature oak timber type. Harvest and condition records, as well as buck kill locations, recorded during 1972–83 verified this area's long history of high harvest numbers and either-sex hunting (during this study $\bar{x}$ = 3.2 deer/km^2/year). Analyses of harvest numbers for the areas were confined to buck-only hunts, since doe kill locations were not collected prior to 1980.

Both harvest and habitat data were recorded by U.S. Forest Service timber compartments, which averaged about 445 ha. One hundred sixty-seven compartments were included in the mountain analyses and 16 in the Lake Russell analyses. Data were combined by contiguous groups of compartments to reduce effects of 2 major variables on deer harvest, i.e., deer movements across compartment boundaries and false location of kills in the wrong compartment.

Two compartment grouping schemes were employed for the analyses of both data sets. First, grouping compartments by similarities in food plot hectares resulted in 9 high and 12 low food plot compartment groups for the mountains and 2 high and 2 low groups for the Piedmont area. Compartments also were grouped by geographic location within a WMA resulting in 36 compartment groups for the mountains and 4 for the Piedmont area. Compartment boundaries were used to segregate blocks of adjoining compartments approximating 2,000 ha for analysis. For this analysis, food plots, roads, deer harvest, and habitat factors were not considered when grouping compartments.

Habitat characteristics of compartments were determined from several sources. We obtained age and type of timber from the U.S. Forest Service and divided it into 6 timber categories: 0–10 age class, all types; 11–29 age class, all types; ≥30 age class, pine (*Pinus* sp.) dominant types; ≥30 age class, oak (*Quercus* sp.) dominant (mast-bearing) types; ≥30 age class, other timber types; and ≥30 age class, unknown timber types. Timber categories were used to separate, as much as possible, relative quantities of browse and mast produced.

Roads open to vehicular traffic during the hunting season were measured to the nearest 0.2 km. The number of food plots, food plot hectares, and a food quality index were measured for each compartment. The quality index was based on a scale of 1 to 3 with preferred and productive cover types rated highest. Winter annual grasses (rye, ryegrass, wheat), clover, orchard grass, sorghum, corn, and clover-fescue rated highest; fescue (except that containing clover) rated next; and wild, native grass (*Andropogen* sp., *Panicum* sp.) and brush rated lowest. Ladino clover-grass mixtures composed the great majority of food plots in this study.

Finally, an annual hard mast survey was conducted on all WMAs in early September (Whitehead 1969, Wentworth 1989). White and red oak groups were combined to form 1 mast survey index value per WMA. A weighted mast production index was determined for each compartment and consisted of the mast survey index value multiplied by hectares in all mature oak types. Mast surveys began in 1977 and thus were not available for the 1972–1976 period on Lake Russell WMA.

Deer population parameters were based on kill data from the previous years' harvest and included average annual reduction rate of adult males, sex ratio, recruitment, and total prehunt population (Lang and Wood 1976). Harvest/km^2 and percent of the population harvested also were included.

The number of deer harvested in each group of compartments was regressed against all of the above habitat, hunt, and population variables. Models were developed using a stepwise multiple regression analysis procedure from the Statistical Analysis System (SAS Institute, Cary, N.C.). Interrelationships among deer and habitat variables were investigated by principal components analysis (PCA) in order to aid in the interpretation of stepwise regressions (Johnston 1972). Many of the variables were interrelated and one would often supercede, override, or change the sign of other related variables in the model (Table 1). The PCA analysis therefore resulted in far fewer variables explaining the majority of the variation. Those variables important in a component contributed most to that component. These independent components were then subjected to a stepwise multiple regression analysis. Interpretation thus was aided by examining how the original variables contributed to the component in the regression model.

Results

PCA revealed interrelationships of habitat and population variables for both areas (Table 1). Though not related to deer harvest, these preliminary analyses helped explain relationships in subsequent models described below.

Table 1. Summary of principal components analyses on data from northeastern Georgia (1972–83) showing groups of interrelated variables and their sign.[a]

		Variables[b] contributing to the component				
Dataset	Subset description	Component 1	Component 2	Component 3	Component 4	Variation explained
Mountain	Habitat (by 2,000-ha blocks)	NFP, FPH FPQ, RK	-PIT, OAT WMPI	CT, POT		71%
Mountain	Habitat plus population parameters	PE2, PSE HPSK	SR, REC	-PELW, PPH AARR	PELW, PPH -NH	90%
Lake Russell	Habitat (by 2,000-ha blocks)	NFP, FPH FPQ, RK	OAT, OTT	CT, -POT Y	-PIT, Y	86%
Lake Russell	Habitat plus population parameters	PELW, PE2 PSE, HPSK -AARR, NH	PSE, -PPH SR, REC	HPSK, PPH AARR	-SR, REC NH	96%

[a] These analyses, though not related to deer harvest, helped explain relationships in stepwise multiple regression models.

[b] Abbreviations for variables are as follows: AARR (average annual reduction rate), CT (clearcut hectares), FPH (food plot hectares), FPQ (food plot quality), HPSK (harvest/km^2), MSI (mast survey index), NFP (number of food plots), NH (number of hunters), OAT (oak timber hectares), OTT (other timber hectares), PTO (polestage timber hectares), PELW (population estimate—Lang and Wood), PE2 (population estimate—combined methods), PSE (postseason estimate), REC (recruitment), RK (road km), SR (sex ratio), WMPI (qweighted mast production index), Y (years).

Mountain Data

Regression analyses of mountain data indicated that food plot characteristics, roads, oak timber, and clearcuts (aged 0–10 years) were the most important factors in predicting deer kill in all 3 tests: (1) by compartment (R^2 = 0.33, total degrees of freedom [TDF] = 490); (2) by high and low food plot groupings of compartments (R^2 = 0.70, TDF = 61); and (3) by geographic location (R^2 = 0.57, TDF = 107). Grouping the data by geographic location in 2,000 ha blocks (Table 2), resulted in a strong interrelationship (component 1) between all food plot and road variables but no relationship between clearcuts and mature oak timber (Table 1). The food plot—road component and oak timber component had positive effects on deer kill, while clearcuts had a negative effect (Table 2).

To separate food plot effects from road effects on deer harvest, we noted that food plot hectares entered the equation first with an R^2 value of 0.34. The inclusion of 3 more variables raised R^2 to 0.57. In another test to separate food plot from road effects, we segregated all compartments with no food plots and tested road kilometers against deer harvest. The result was a weak relationship (R^2 = 0.08, TDF = 207). Finally, using all 9 WMAs as separate entities (Piedmont included) for the 3-year period from 1981 through 1983, we regressed food plot ha/km^2 against deer harvest/km^2 (R^2 = 0.78, TDF = 26).

Piedmont Data

Lake Russell WMA had a much greater diversity of deer habitat with 12 years of data available. Several different models were tested due to lack of mast data in early years and large variation in buck harvest among years.

With compartments arranged by geographic location, a 12-year habitat model showed that number of hunters and food plots were positively related, and pine timber was negatively related to deer harvest (R^2 = 0.60, TDF = 47) (Table 3). Arranged by the same geographic locations with analysis including population characteristics and lag habitat variables (based on 10 years of data), the model

Table 2. Northeastern Georgia mountain WMA model summary from stepwise multiple regression analyses with numbers of deer harvested from 1981 through 1983 as the dependent variable.[a]

Significant variables	Effect on deer harvest	$P > F$
Number of food plots	+	0.0001
Food plot hectares	+	0.0001
Oak timber	+	0.0001
Road kilometers	+	0.0239
Clearcut timber	−	0.0013

[a] Compartments combined to form 2,000 ha blocks. The equation was highly significant (R^2 = 0.57, $P < 0.0001$, TDF = 107).

Table 3. Northeastern Georgia Piedmont (Lake Russell WMA) model summary from stepwise multiple regression analyses with numbers of deer harvested from 1972 through 1983 as the dependent variable.[a]

Significant variables	Effect on deer harvest	$P > F$
Number of hunters	+	0.0001
Number of food plots	+	0.0002
Food plot hectares	+	0.0883
Pine timber	−	0.0002

[a] Compartments combined to form 2,000 ha blocks. The equation was highly significant ($R^2 - 0.60$, $P < 0.0001$, TDF = 107).

improved ($R^2 = 0.71$, TDF = 39). All population variables except sex ratio were inter-related and were related to number of hunters. Together they formed PCA component one (Table 1).

Compared to mountain data, population parameters were more related to deer harvest since their addition to the habitat model increased the R^2 by 0.11 (versus less than 0.05). It should be noted that roads were highly related to the 3 food plot variables and the percent population harvested was highly related to 5 other population parameters (Table 1).

For Lake Russell, many more variables were related to deer harvest than in the mountains. The influences of each variable may have been tenuous, however, as indicated by changes in results according to number of years included.

Discussion

For mountain WMAs, the food plot—deer harvest relationship was strong at all levels of testing among blocks ranging from 400-ha average size (individual compartments) up to entire 17,000-ha WMAs. Mountain study areas were characterized by very few hectares of food plots (0.13% of the total land area), limited accessibility, low numbers of hunters ($\bar{x}$ = 14.8 hunters/km^2), poor habitat with little diversity, inaccurate population estimates, low deer populations, low harvest, and low turnover rates. In contrast, the Piedmont area had 0.37% of the total land in food plots and 25.4 hunters/km^2. Consequently, some deer harvest relationships (i.e. food plots and roads) were stronger in the mountains than in the Piedmont. Also, tested relationships dealt with the adult buck harvest rather than the entire deer harvest, and the analyses extended over all or portions of a 12-year period. Still, we feel that the difference between the variables significant in each data set is biological rather than statistical and is caused by short-term changes in population size, limiting factors, and hunter density, along with differences in habitat (and food plots) between the areas.

Over the 3-year period in the mountains, food plots, roads, and oak timber were highly correlated with deer harvest. The cultivated food plots no doubt attracted both hunters and deer even in good mast years. The attractiveness of food plots to hunters and deer and a consequent increase in harvest has been shown previously in Mississippi (Vanderhoof and Jacobson 1988 and Davis et al. 1988). In addition, roads leading to the plots provided hunter access (James et al. 1964).

Whether food plots actually increased the carrying capacity and total deer density in a heavily forested environment remained an unanswered question. We strongly suspected that they did, but were unable to prove it in this study lacking data on population size, condition, and food habits during late winter when carrying capacity was most limited. Two other studies in the same physiographic region illustrated heavy deer consumption of agronomic forages (Wentworth et al. 1990) and heavy seasonal use of food plots (Wentworth et al. 1987). Our analyses strongly indicated higher deer harvests where food plots were most abundant. Regardless of the cause, where there were more food plots, more deer were harvested. In regression equations where food plot hectares entered the procedure first and alone, on average, 4 more deer were harvested/ha of food plot (R^2 = 0.34). Theoretically, if we suddenly eliminated our total of 96.3 ha of mountain food plots and their associated access, the model suggested a corresponding drop in the deer harvest of nearly 400 animals (40% of the 1983 kill).

The use of intensively maintained agricultural clearings has been controversial because of high cost and lack of conclusive evidence of their benefit to white-tailed deer (Larson 1969). More recent research has demonstrated the cost effectiveness of supplemental feed (Ozoga and Verme 1982) and the benefits of food plots to deer condition and population numbers (Johnson et al. 1987). Our research has demonstrated a significant impact on deer harvest with only 0.13% of the land area in food plots. Johnson et al. (1987) found that 40% of cool season diets of deer came from food plots totalling <1% of the habitat. Previous research (Murphy and Coates 1966, Short 1969) has demonstrated the lack of important nutrients in southeastern native forages and the effect of deficiencies on deer condition and reproduction. Fertilized agricultural food plots provide a means of meeting nutritional needs of deer during periods of critical food shortage (Kammermeyer 1982, Johnson et al. 1987, Davis et al. 1988), while also helping to increase harvest. Establishment of food plots and associated hunter access allowed us to increase deer harvest on vast areas of national forest land with <10 deer/km^2 and chronic underharvest problems.

It is unclear why mountain clearcuts (<10% of the land area) were negatively related to deer harvest. We can speculate that: (1) fewer deer used clearcuts during daylight hunting season hours in the fall, (2) heavy escape cover in older cuts made harvest difficult, or (3) less hunting pressure probably occurred in clearcuts.

The positive relationship of oak timber with deer kill implied relatively higher deer densities, good hunting conditions including high visibility and/or good fall mast supplies in those areas.

As shown by other studies (Wentworth et al. 1990), mast was probably more important to deer harvest (and deer populations) than our models indicated. Our measurement of mast was not sensitive enough to detect differences in production between small blocks of compartments or account for variation due to elevation, aspect, and species of oak.

Number of hunters was not significantly related to deer harvest in the mountains likely because these WMAs averaged only 14.8 hunters/km^2, a low hunting pressure compared with other areas. Consequently, a relatively low percentage of the deer population was harvested (as determined by our population models).

Population parameters were relatively unimportant in determining harvest for mountain WMAs. Moreover, due to small harvest (and consequently poor sample size) on some areas, population parameters could not be estimated as accurately as those of Lake Russell.

Lake Russell WMA contained twice the road density of the mountains and 3 times the number of hunters. Food plots were 3 times more numerous than those of the mountains and still showed a significant correlation with deer harvest despite a much more diverse habitat. The negative influence of pine timber on deer harvest was probably a result of either lower hunter density or lower deer density due to limited availability of fall food supplies and lack of escape cover.

The Lake Russell harvest, unlike the mountain harvest, was large and appeared to be controlled by hunting pressure and deer population characteristics in addition to food plots and roads. Large sample sizes of harvested deer permitted more accurate population analyses, therefore making relationships easier to detect.

Management Implications

Deer populations in this study were divided into 2 categories: (1) those inhabiting remote, heavily forested mountainous areas where poor habitat limits population size, and low hunting pressure and poor access limits the deer harvest; and (2) a heavily harvested population (Lake Russell WMA) where the size and sex composition of the previous harvest (and population) was inversely related to the current harvest. The latter was typified by heavy hunting pressure, high accessibility, good habitat diversity, and high deer populations.

Management plans must be tailored to reduce limiting factors on any population, yet prevent habitat destruction. In mountainous areas, management to increase cool-season food supplies and overall habitat diversity can further increase deer harvest without reducing the population because of stimulated recruitment response resulting from high quality forage. Creating more food plots, well dispersed throughout a heavily forested environment can be a very good way to accomplish this. Hunter access into remote areas should be encouraged by temporarily opening gated roads to disperse hunters and increase harvest. Number of hunters should increase automatically as success increases.

For areas with currently adequate harvests, stabilization of harvests can occur at high levels approximately 4 to 5 deer or more/km^2. Nevertheless, opportunities to increase agricultural food plots (and thus increase harvest and population) should not be overlooked, especially in blocks of compartments which currently contain less than 1% in agricultural openings. Conversion of hardwood to pine type, such as that which occurred on Lake Russell, may negatively impact deer harvest and should be discouraged.

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