SOME POPULATION PARAMETERS OF THE CADES COVE DEER HERD, GREAT SMOKY MOUNTAINS NATIONAL PARK

THOMAS L. BURST, Department of Forestry, Wildlife and Fisheries, University of Tennessee, Knoxville, TN 37916

MICHAEL R. PELTON, Department of Forestry, Wildlife and Fisheries, University of Tennessee, Knoxville, TN 37916

Abstract: A study of white-tailed deer (*Odocoileus virginianus*) in Cades Cove, Great Smoky Mountains National Park was conducted during the summer of 1977 to determine population density, herd behavior, habitat utilization, and general condition of the herd. Thirty-seven counts were conducted and 2,172 deer observed. The minimum summer population was estimated at 519 deer using the method of bounded counts; the sex ratio was 90.8 bucks per 100 does. Fawn-at-heel counts yielded a ratio of 49.5 fawns per 100 does. Deer utilized hayfields and horse pastures but avoided cow pastures. Feeding was the primary activity during all observation periods; bedding occurred primarily at night. Recommended management was removal of 125 deer with a 9:10 sex ratio. The large number of deer using the Cove, the apparent importance of food as an attractant, and the fair to good reproduction were the critical factors determining the recommendations.

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The white-tailed deer in Cades Cove (the Cove) is an important and conspicuous component of the Great Smoky Mountains National Park (GSMNP or Park) ecosystem and a popular attraction to Park visitors. The large but irregular opening in the eastern deciduous forest provided by the historical preservation of the Cove creates several deer-related management problems. The opening attracts deer from the surrounding forest and concentrates their activities in a relatively small area. Habitat degradation in the Cove and the nearby forest is a likely result. Close association of deer with domestic livestock (cattle and horses) and other deer also presents parasite and disease problems for both deer and cattle (Trainer and Hanson 1962, Fox and Pelton 1973, and Anonymous 1977a).

Consequently, information pertaining to deer and Park management practices which directly or indirectly affect the herd should be of value to the Park administration. The easily observable herd provided an exceptional opportunity to collect this information. Despite the nearly ideal research conditions, prior information concerning the population was limited to 1 published report of an epizootic (Fox and Pelton 1973), 1 unpublished report (LaFollette 1974), and Park records including unpublished management reports. This study reports on some basic herd behavioral and organizational characteristics.

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STUDY AREA

Cades Cove (Fig. 1) is a 977 ha, gently rolling historical area within the Park located in Blount County, Tennessee. As an historical area, 747 ha (76.5%) of the Cove are maintained as pastures or hayfields. A few small vegetable gardens and homestead sites are also maintained for demonstration purposes. The remainder of the Cove and the surrounding mountain slopes are forested. The pasture and hayfields are maintained by permittees under supervision of the National Park Service.

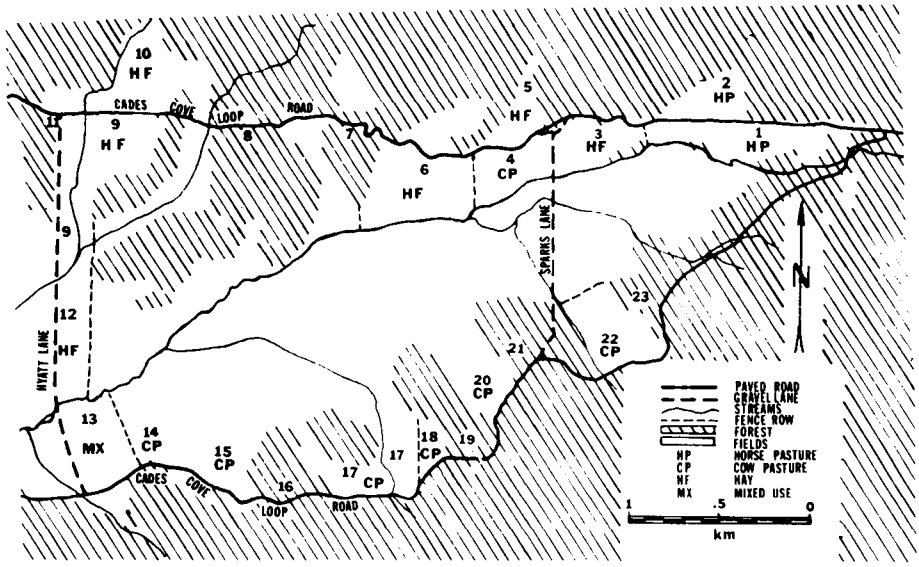

Fig. 1. Cades Cove and the primary study area.

There are 24 km of roads in the Cove primarily consisting of a paved 18 km one-way loop around the periphery of the Cove with 2 gravel lanes (Sparks and Hyatt) crossing the Cove and connecting the loop (Fig. 1). Hyatt Lane was closed to visitor traffic for most of the study period. Park visitors primarily use the Loop Road; visitors are prohibited from entering the Cove by locked gates between sunset and sunrise.

The primary study area consisted of 220.7 ha of selected fields and woodlots (viewing 1 side only) along 11.6 km of road located east of Hyatt Lane, and adjacent to Hyatt Lane and the Loop Road. The fields were classified, depending on the management practiced during the study, as hayfields (90.3 ha and 4.5 km of road), cow pastures (78.5 ha and 2.6 km), horse pastures (18.6 ha and 1.5 km), woods (7.8 ha and 2.2 km), and 1 field of mixed use which was both grazed by cattle and mowed during the study period (25.5 ha and 0.8 km) (Fig. 1 and Table 1). Each wooded area adjacent to a road was considered 35 m into the woods, the greatest distance at which a deer was observed in the woods. Other fields were bounded by woods or fence rows. Fertilization schedules of the fields and pastures were not maintained by the permittees.

All native wild animals within the Park are completely protected by the National Park Service and the deer in Cades Cove have become semi-tame. They generally exhibit no flight response to vehicles, particularly if the deer are greater than 50 m from the road.

Habitat use in the study area was biased by 4 factors. 1) The hayfields and horse pastures are adjacent to south-facing slopes while most cow pastures are adjacent to north-facing slopes. 2) The hayfields and horse pastures are generally not as wide as the cow pastures, presenting more frontage per unit area to the adjacent forest. 3) A greater proportion of the hayfields and horse pastures would be within range of the spotlight. 4) All counts started at the same point beginning at Field 1 and going in order to Field 23. On the morning counts this should increase observation in the first field sampled and decrease observations in the later fields. The evening counts should work just the opposite. The total effect of this bias is unknown. The first 3 biases should tend to increase observations in hayfields and horse pastures with respect to the cow pastures.

Table 1. Field number, habitat type, area, length of road frontage, number of deer observed, and number of times field observed of selected fields and woodlots, Cades Cove, Great Smoky Mountains National Park, 1977.

Field Number	*Habitat type*	*Area (ha)*	*Length of road frontage (km)*	*Number of deer observed*	*Number of times[b] field observed*
1	Horse pasture	10.1	0.93	184	37
2	Horse pasture	8.5	0.56	200	37
3	Hayfield	8.1	0.67	212[a]	37
4	Cow pasture	9.3	0.53	15	37
5	Hayfield	4.9	0.40	79	37
6	Hayfield	17.8	0.58	477	37
7	Woods	1.7	0.48	8	35
8	Woods	1.5	0.42	1	35
9	Hayfield	23.9	1.54	177	37
10	Hayfield	20.2	0.61	174	37
11	Hayfield	<0.1	<0.1	0	37
12	Hayfield	15.4	0.68	302	36
13	Mix	25.5	0.80	154	36
14	Cow pasture				
15	Cow pasture	28.3	0.64	22	35
16	Woods	1.8	0.52	1	32
17	Cow pasture	4.5	0.48	27	35
18	Cow pasture	2.0	0.29	43	35
19	Woods	1.1	0.32	7	30
20	Cow pasture	18.2	0.24	72	34
21	Woods	0.6	0.16	5	30
22	Cow pasture	16.2	0.40	6	34
23	Woods	1.1	0.32	3	30
TOTAL		220.7	11.58	2,170	
			undetermined	2	
				2,172	

[a]Twenty deer observed in narrow open pine woods between the loop road and the field.
[b]Darkness prevented completion of the count on some evening runs. All fields were observed on all night counts.

METHODS

Data were collected from 9 June 1977 to 17 September 1977. As weather permitted, observations were made 3 times per week using 7 x 35 binoculars or a 15-60 variable-power spotting scope. Each week 1 count started at sunrise (AM), 1 started approximately 1.5 hours prior to dark (PM), and 1 started shortly after dark. Neither the binoculars nor the spotting scope were used at night. When deer were observed, the following parameters were recorded as conditions permitted: (1) group size, (2) distance from road, (3) distance from woods, (4) sex and age (male, spike, female, or fawn), (5) habitat type (hayfield, cow pasture, horse pasture, mixed use or woods), (6) activity (bedded, standing, feeding, walking, or running) (7) field.

Differentiation between groups was determined on the basis of behavior and distance between deer. Generally deer within 50 m of one another were considered to be in the same group.

The minimum number of deer using the study area was estimated using the method of bounded counts (Overton 1971). This method was chosen because the assumptions required are not stringent and it yields a conservative estimate.

In order to evaluate habitat use with as little bias as possible, several criteria were used. 1) Results are considered significant only if habitat use has $P < 0.01$. 2) Several tests using different methods of reducing the biases are considered before evaluating the results. The tests were: a) standard normal variate tests for a single proportion (Hays 1973: 724) using the proportions of the areas of the habitat types as the expected proportion of deer in each habitat type; b) repeated using the proportion of the length of road passing the habitat types as the expected proportion of deer in each habitat type. Fields 1, 4, and 6 (Fig. 1) were compared exclusive of the remaining study area. These 3 fields represent the 3 main habitat types and are all on the north side of the Cove and near the beginning of the route.

To assess count variability, the Mann-Whitney-Wilcox (M-W-W) test (Gibbons 1976: 159) was used when the sample size was too small for the t-test. Chi-squared goodness-of-fit and contingency tests were used to test sex ratios and activity patterns.

Since reobservation of deer from count to count undoubtedly occurred, the assumption of independence of observations was violated. However, sufficient time was allowed between counts to allow deer movement to different habitat types. At no time did an AM count occur on the morning following a night count, nor did a night count ever follow a PM count, and only once did a night count follow a morning count.

In determining the sex ratio, 6 paired AM and PM counts made after 28 July were used. This follows work by Mirarchi et al. (1977) describing white-tailed deer antler growth in Virginia and work by Downing et al. (1977) determining the accuracy of sex ratio counts and the best time to conduct counts for that purpose. In making fawn-at-heel counts only paired AM and PM counts after 7 August were used (Downing et al. 1977). The end of the fawning period and the first observation of large numbers of fawns were also considered.

RESULTS AND DISCUSSION

A total of 2,172 deer was observed in 692 groups on 37 different counts. Night lighting yielded the most observations (1,230); morning counts were the least productive (393) (Table 2). Most deer could not be sexed or aged (1,145); 362 "adult" males, 78 spikes, 508 females, and 79 fawns were identified mostly during daylight counts. The sex ratio was 90.8 males per 100 females ($n = 142$ does). The mean group size was 3.1. Individual deer were not recognized and no groups could be consistently recognized.

Population estimation

An estimated 173 deer were using the study area (95% confidence limits of 169 and 245). Since less than one-fourth of the Cove and slightly less than one-third of the fields within the Cove were actually within the study area, a conservative estimate of the deer using the Cove would be triple the number found in the study area. This resulted in an estimate of 519 deer in the Cove (1.92 ha/deer). This estimate is nearly double that reported by Fox and Pelton (1973) for their July estimates. Since Fox and Pelton (1973) required part of the deer's body to be seen before being counted, the higher estimate of the present study may be expected.

Productivity

Reproduction could not be accurately determined since yearling females could not be identified and fawns are generally less observable than does (Downing et al. 1977). Instead, fawn-at-heel counts were conducted; the observed ratio for 10 morning and evening counts (5 each) made after the first week in August was 49.5 fawns per 100 does ($n = 95$ does). The low ratio is due primarily to the large number of females observed without fawns. A minimum of 12 sets of twins and 1 set of triplets was observed at this time. Two fawns observed with 2 does were considered singles.

Table 2. Roadside counts of deer for an 11.6 km route in Cades Cove, Great Smoky Mountains National Park, Summer, 1977.

Time	*Number trips*	$\bar{X}$ *Number deer/trip*	*Range*	*Number deer km*	*Number deer ha*	*Total deer*	*Standard deviation*
Morning	15	26	2-50	2.25	0.12	393	13.9
Evening	12	46	3-111	3.97	0.21	549	33.8
Night	10	123	80-169	10.62	0.56	1230	32.1
Total	37		2-169			2172	

Comparison with fawn-at-heel counts made in August and September by Carroll and Brown (1977) and Downing et al. (1977) indicates that productivity is fair to good. The count for the Cove is higher than counts reported by Carroll and Brown (1977) in Texas for 2 of 3 years reported. The Cove count is also higher than those reported by Downing et al. (1977) for 2 years in Texas. The Cove counts are about equal to counts reported by Downing et al. (1977) during 3 years for an enclosed Virginia population. The deer population in the Virginia study had an independently estimated reproductive rate of 0.58. The Texas population (Downing et al. 1977) had independently estimated reproductive rates of 0.54 and 0.29 for 2 years. The other Texas population had known severe fawn mortality, generally occurring within 1 month of birth.

The reproductive rate in the Cove is probably close to that of the Virginia population (neither population was hunted although removals from the Virginia population did occur and the population was maintained nearly constant throughout the study). The reproductive rate of 0.58 is low compared to rates reported by Severinghaus and Cheatum(1961) for numerous statewide deer herds.

In contrast to the low reproductive rate, the amount of twinning is considered moderate to high, especially for a protected population. The apparent conflict between the two indicators of herd condition would indicate that fawn mortality is high or that a high percentage of fawns do not follow their does into the fields.

Habitat Use

Including only those counts when all habitat types were surveyed, 1,225 deer were counted in hayfields, 339 in horse pastures, and 182 in cow pastures. All but one of the habitat-use tests were significant (Tables 1 and 3). Cow pastures were obviously used less than hayfields and horse pastures, but the test results between hayfields and horse pastures are conflicting.

The apparent avoidance of cattle by *Odocoileus* sp. has been previously reported (Hood and Inglis 1974 and Dusek 1975), but the comparatively high use of horse pastures is surprising. Hood and Inglis (1974) felt that deer avoided horses more than cattle on their study area, but they probably were referring to horses with riders. It is also possible that the deer were avoiding the cow pastures instead of or in addition to the cattle. While casual observation indicated approximately equal grazing pressure of horse and cow pastures, species composition or forage quality could have differed.

Count variability

Variability between counts was high (Fig. 2). Fog appeared to be responsible for low values on some nights; limited visibility was encountered on the nights of 7 and 13 July and 18 August in Field 12. Counts in this field were lower on these nights (M-W-W, P = 0.033). Even though counts on the whole study area were not lower for these nights (M-W-W, P 0.058); the probability was considered low enough to eliminate those nights with limited visiblity from further analysis of the variability.

Table 3. Test results comparing deer use of different habitat types, Cades Cove, Great Smoky Mountains National Park, Summer, 1977.

Type of comparison	*Method of determining proportion*	X^2	$\sqrt{X^2}$	Z	*P*	*Alternate[a] hypothesis*	*n*	*Degrees of freedom*
All Hayfield & Cow Pasture	AREA	694	26.3	<0.000001	Hayfield	1381	1
All Hayfield & Cow Pasture	LENGTH	372	19.3	< 0.000001	Hayfield	1381	1
Hayfield & Cow Pasture (Fields 6 & 4)	AREA	213	14.6	< 0.000001	Hayfield	492	1
Hayfield & Cow Pasture (Fields 6 & 4)	LENGTH	507	22.5	< 0.000001	Hayfield	492	1
All Horse Pasture & Cow Pasture	AREA	707	26.6	< 0.000001	Horse Pasture	521	1
All Horse Pasture & Cow Pasture	LENGTH	181	13.5	< 0.000001	Horse Pasture	521	1
Horse Pasture & Cow Pasture (Fields 1 & 4)	AREA	129	11.3	< 0.000001	Horse Pasture	199	1
Horse Pasture & Cow Pasture (Fields 1 & 4)	LENGTH	96	9.8	< 0.000001	Horse Pasture	199	1
All Hayfield & Horse Pasture	AREA	25.30	5.03	> 0.999997[b]	Hayfield	1760	1
All Hayfield & Horse Pasture	LENGTH	11.09	3.33	0.0004	Hayfield	1760	1
Hayfield & Horse Pasture (Fields 6 & 1)	AREA	20	4.47	0.00003	Hayfield	661	1
Hayfield & Horse Pasture (Fields 6 & 1)	LENGTH	318	17.8	<0.00001	Hayfield	661	1

[a]If the former deer use proportionately greater in _____.

[b]If alternate hypothesis had been Horse Pasture, it would have been significant.

The counts at the end of August and during September were lower than the remaining counts (M-W-W, P = 0.029). Both Fox and Pelton (1973) and LaFollette (1974) reported decreased deer use of the fields in September. Fox and Pelton (1973) attributed the decline to an epizootic, but LaFollette found a similar decline when no signs of an epizootic were present. She suggested that the decline might be due to the availability of mast in the forest, reduced attractiveness of the fields, or some dispersal mechanisms.

In 1977 there was no difference between the pre- and post-decline sex ratios (P > 0.50). This indicated dispersal was not the cause of the decline.

In light of both the present results and the work of LaFollette (1974), attributing Fox and Pelton's (1973) September decline in deer use solely to the epizootic must be considered questionable. However, the presence of 52 dead deer and 11 dead cattle cannot be overlooked.

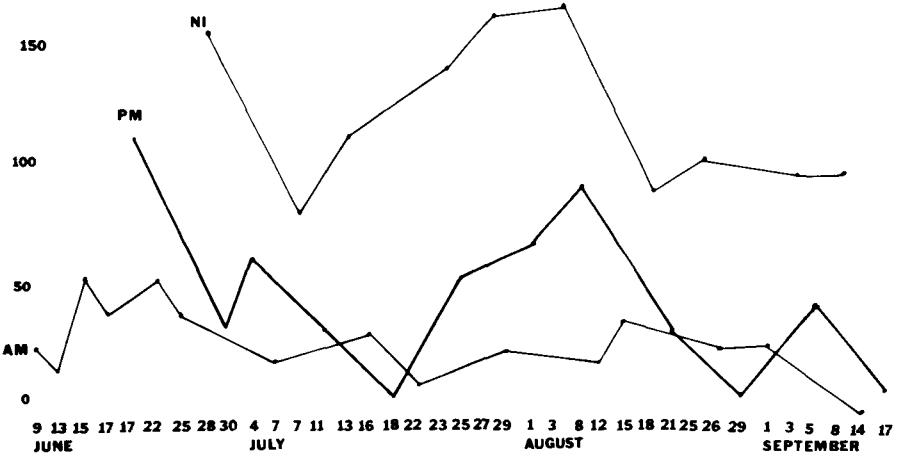

Fig. 2. Number of deer observed on each count in Cades Cove, Great Smoky Mountains National Park, Summer, 1977.

Variability of the daylight counts is greater than that of the night counts (Fig. 2), probably as a result of variations in the time that deer entered the fields. The correlation coefficient between the number of deer observed on the PM counts and the start time of those counts (measured as the amount of time between dusk and the start time) is only 0.34. A higher correlation would have been expected if the deer entered the fields at the same time each night.

This type of movement also affects night counts. LaFollette (1974) completed 8 paired nightly counts under similar weather conditions. A paired t-test of her ha/deer values from her Table 4 demonstrates a large difference between the pairs ($P < 0.001$).

Activity patterns

There was no difference in activity patterns of the 4 sex and age classes when activity was classified as running, walking, feeding or bedded ($P > 0.50$, Table 4).

Deer used the fields for bedding and feeding (Tables 4-5); most bedding occurred at night (Table 5). Feeding occurred during all observation periods (Table 5). This indicates that the fields were visited primarily for feeding and that bedding occurred between feeding periods. This agrees with previous work by Montgomery (1963).

CONCLUSIONS

The present study is not directly comparable to the other 2 Cades Cove deer studies because of technique differences. Both Fox and Pelton (1973) and LaFollette (1974) not only required eye shine, but also a portion of the deer's body to be visible prior to counting a deer to keep from mistaking livestock for deer. Sighting a portion of a deer's body was found to be unnecessary in this study since only 34 deer were observed in horse pastures or cow pastures at night at a distance from the road of greater than 100 m.

Despite the change in techniques, a large deer population is obviously utilizing Cades Cove and the surrounding forest. The major attraction for the deer is forage in the pastures and hayfields. This may also indicate that preferred food is scarce in the surrounding forest much of the year. Reproduction, while not maximum, is still capable of increasing the herd unless mortality and dispersal are much greater than expected.

Table 4. Frequency of activity classes of deer by sex and age classes in Cades Cove, Great Smoky Mountains National Park, Summer 1977.

	Bedded	*Feeding*	*Walking*	*Running*	*Total*
Males	16	217	30	10	273
Spikes	3	53	6	1	63
Females	27	342	34	8	411
Fawns	6	41	6	1	54
TOTAL	52	653	76	20	801

Table 5. Frequency of activity classes of deer in hayfields by time of observation in Cades Cove, Great Smoky Mountains National Park, Summer, 1977.

	Bedded	*Feeding*	*Walking*	*Running*	*Total*
Morning	10	256	30	4	300
Evening	4	335	21	10	370
Night	252	193	28	5	478
TOTAL	266	784	79	19	1,148

Fig. 1. Cades Cove and the primary study area.

Fig. 2. Number of deer observed on each count in Cades Cove, Great Smoky Mountains National Park, Summer, 1977.

Overpopulation with habitat degradation and a high probability of an epizootic is anticipated and, in fact, may already exist.

Two management alternatives are presently available: 1) no action, and 2) population reduction by trapping and removal or killing. The consequences of the various alternatives have been adequately presented in the environmental assessment (Anonymous 1977b) of the Tennessee Wildlife Resources Agency proposed transplant. Removal (killing or transplanting) is the most biologically sound alternative; however, it is only a temporary solution and would need to be repeated.

Under present conditions, the number of deer removed per year to maintain a stable population should be approximately 125 with a sex ratio of 9 males to 10 females. This would remove a maximum of 25% of the summer population and would not affect the present sex ratio. The 25% removal approximately equals the minimum estimated age-specific reproductive rate (half the fawn-at-heel ratio). If removal is done in the winter, the percentage removed would be less than calculated since winter use is greater than summer use (Fox and Pelton 1973).

Further information concerning the deer herd is obviously desirable. A telemetry study should be initiated to find the actual areas used by deer in the Cove. An indepth population study should be conducted to determine seasonal density and distribution and condition (reproductive or otherwise) of the deer.

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