TRIALS TO DETERMINE RELATIVE DEER RANGE CARRYING CAPACITY VALUES IN CONNECTION WITH THE GEORGIA FOREST SURVEY

By WILLIAM H. MOORE *
THOMAS H. RIPLEY and JEROME L. CLUTTER †

Widely adopted concepts of multiple-use forest management and more intensive management practices have created need for research to afford a better knowledge of the forest community, including wildlife habitat. If forest wildlife populations are to thrive in the forests of the South, methods of integrating habitat management techniques with timber management and stand improvement practices are of great importance. Badly needed, also, are methods for conducting rapid, precise, yet extensive inventories of habitat and determining their relationship to land management and community development, especially on forested areas.

Many studies have been concerned with the relation between requirements of wildlife species and the environment. White-tailed deer, the most important big-game species of Southern forests, has received much attention. Habitat and life history studies have led to an understanding of population dynamics and trends, nutritional requirements, and effects of browsing on range conditions.

Cassady (1953) has made important contributions by studying the effects of browsing on the survival and production of browse species. Goodrum and Reid ‡ have pointed out that deer production is greatly influenced by food supply. Burke (1956) has concluded that range condition is not only affected by the pattern and intensity of browsing, but also by the composition, density, pattern of occurrence, and height of the forest overstory. Harlow (1955), Ruff,¶ and Goodrum and Reid (op. cit.) worked on the composition of plant communities under different forest types, but did not describe these types in terms of range condition and trends.

When either land-use practices or natural habitat succession or both produce an optimum range, deer populations increase, often reaching densities which threaten continued forage production. Lay (1956), recognizing this problem, pointed out the difficulty of detecting over-populations and range deterioration at an early stage. Goodrum and Reid (op. cit.) concluded that one of the most important problems in deer management is that of maintaining a productive habitat. Extensive, rapid inventories of range would greatly assist in detecting habitat problems and prescribing management needs.

These studies have all shown that the information concerning the abundance and distribution of habitat components is basic. Yet, little work has been done to determine the effect of the various aspects of community condition and trend in relation to range carrying capacity.

Present research needs include a knowledge of the natural trends in forage producing vegetation resulting from variations in timber stand characteristics. Needed are analyses and descriptions of the communities under different forest types and stand structures, together with an understanding of ecological relationships which will serve as a guide to relative carrying capacity. Burke (1956) has stated that "one of the primary research goals is to furnish administrators with accurate, ecologically sound, sensitive, but practical and rapid means of measuring the productivity, condition, and trend of the southern ranges."

When deer exceed the carrying capacity, "die-offs" and range deterioration are common (Lay, 1956). Under optimum range conditions, depleted deer populations can be quickly re-established but depletions of herds are rare. Overused range, however, requires many years to recover; and this serious situation constitutes one of the most important problems of deer management. A method of evaluating condition and trend of the range in time to prevent extensive damage is vitally needed.

---

* Georgia Game and Fish Commission, Game Management Division.

‡ Goodrum, Phil D., and Reid, Vincent H. White-tailed deer in relation to their browse. 1954. (Unpublished manuscript, U. S. Fish and Wildlife Service.)

¶ Ruff, Fred J. The white-tailed deer on the Pisgah National Game Preserve, North Carolina. U. S. Forest Service Southern Region. 1938.

† U. S. Forest Service, Southeastern Forest Experiment Station, Asheville, N. C.

METHODS

The Georgia Forest Survey is part of a continuing and comprehensive survey to provide up-to-date, accurate information for management of the nation's timber supply. Recent developments in survey sampling methods, used for the first time in Georgia by the Southeastern Forest Experiment Station, have provided an excellent opportunity for sampling game habitat.

The present system of forest inventory is a two-step method which includes land-use classification of points on aerial photographs followed by a ground sampling of plots. The county is the basic work unit. Estimates of the acreage of various land-use classes are determined by classifying points printed on every third photograph on alternate north-south flight lines within each county. This estimate of acreage is later field-checked. Ground sample plots are systematically located at intervals determined by the proportional acreage within each land-use class, and by established limits of error. Statewide, the Survey will involve proportional area sampling of Georgia's principal forest types using approximately 8,500 plots.

Each plot is actually sampled using two distinct procedures. The first is designed to determine overstory characteristics by a plotless cruise method. Field crews record measurements and observations on a variable plot with a basal are factor of 10 to obtain data on timber volume, quality, growth, and cut. Detailed information, such as d.b.h., crown class, damage, saw-log and cordwood lengths, cull, and grade is recorded for each tree tallied. Growth estimates are based on increment borings, and timber and mortality are computed from tallies of stumps and dead trees. Each plot is described according to land use, site index, ownership, timber cutting history, and turpentine working status.

The second procedure involves sampling systematically arranged points along a square, six-chain traverse placed around the plot center. This procedure is designed to describe the vegetation on a sample acre. Twenty points are located on this traverse 30 links apart, numbered in a clockwise direction beginning in the northeastern corner of the square (45 degrees). Observations are made at each point regarding stand size, type stocking, disturbance, seed source, and size class.

There is little question that deer use a great variety of vegetable material, with foods ranging from forbs, grasses, and browse to mushrooms, depending upon the season. Although forbs are unquestionably important, and certain rosettes are available along with semi-herbaceous vines and greens, these materials are least abundant in mid-winter. Although it may be locally of minor importance (Dunkeson, 1955), browse still serves as a major item in the white-tail's winter diet (Hosley, 1956). It is generally accepted that as the density of white-tails increases, herds tend to turn more toward woody browse materials. This fact is apparent by the presence of browse lines in heavily used range. On the basis of these considerations, browse materials have been selected as representing, collectively, probably the best character of the habitat to sample to determine relative carrying capacity for deer range.

In accordance with these considerations, browse frequency sampling was carried out as a trial run in the Forest Survey of Laurens County, Georgia. Separate frequency samples were obtained at the 20 traverse points surrounding each survey plot in an attempt to obtain index values indicative of relative carrying capacity values for deer. Although first efforts were confined to deer habitat requirements, the method would apply equally well to other game species. No attempt was made to determine the actual carrying capacity. In defining carrying capacity we mean the maximum number of animals that can be carried through the critical period. Accordingly, attention was focused on attributes that can be measured and will describe the carrying capacity during this period.

No deviation from the normal sampling procedure by Forest Survey crews was involved. Measurements were taken in a cylindrical plot delineated by projecting the circular milacre upward 4.5 feet. A list of woody species expected to occur in the shrub stratum was drafted and assigned code numbers. As additional species were encountered, they were assigned code numbers and added to the list. If living materials of any woody plant were found in the cylindrical plot, the species was tallied by its appropriate code number. Where more than one species occurred in a plot, species were tallied in order of abundance.

Frequency data were summarized for each plot by sorting the most abundant species at each point into preference classes(preferred, staple, emergency, stuffing, and no browse). Distributions were coded and punched on cards for electronic sorting. Cards were sorted and analyzed to study differences within and between major types and stand-condition classes, and to permit an investigation of the relationship between certain overstory measurements and the understory characteristics.

RESULTS

Although the trial sampling in Laurens County included several major timber types, only the slash pine, pine-hardwood, and water oak-gum types supplied sufficient data for analysis. Figure 1 shows the frequency distributions of browse preference classes for the three types analyzed. From Table I it can be seen that of the 700 points located in the slash pine type, only 2 percent were dominated by preferred browse. Browse class two, or staple foods, were found as dominant plants at only 10 percent of the slash pine points. Collectively, emergency foods, stuffing foods, and all plots with no browse, totalled 88 percent.

Figure 1.--Percentage distribution of browse preference classes by cover type.

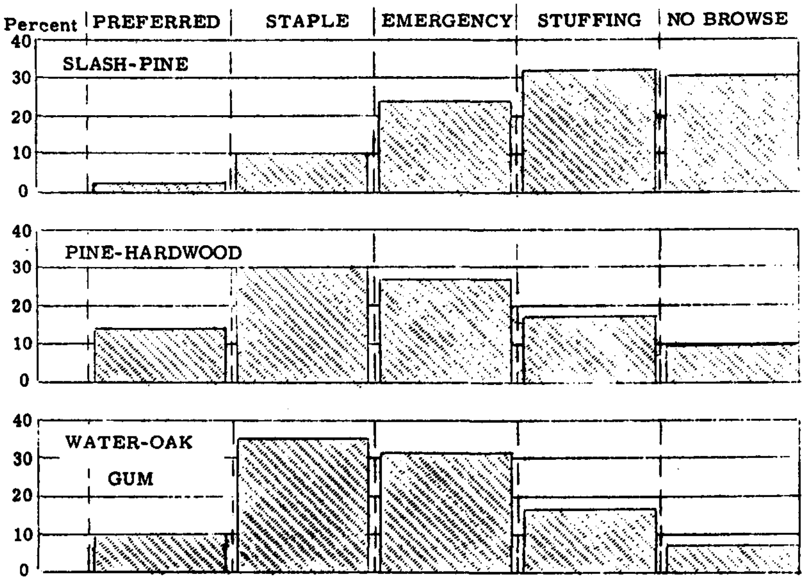


TABLE I

PERCENTAGE DISTRIBUTION OF SAMPLE POINTS BY BROWSE CLASSES WITHIN FOREST TYPES

Browse Classes	*Slash Pine Slash Pine Type Percent*	*Pine-Hardwood Pine-Hardwood Type Percent*	*Water Oak- Water Oak-Gum Type Percent*
Preferred Foods	2.0	14.5	10.0
Stample Foods	10.1	31.4	35.0
Emergency Foods	24.6	27.7	31.7
Stuffing Foods	32.3	17.3	16.2
Unoccupied Points	31.0	9.1	7.1
	100.0	100.0	100.0
	Number	*Number*	*Number*
Sampling Points (20n)	700	220	420
Sampling Clusters (n)	35	11	21

In contrast, pine-hardwood and water oak-gum types averaged 45 percent of points dominated by staple and preferred browse plants, with 55 percent dominated by emergency and stuffing food or not occupied by any browse.

Chi-square analysis was performed to determine whether the observed differences in browse distributions seen in Figure 1 were significant. A total chi-square value between all types was highly significant. This value was then partitioned into two portions—the first representing the difference between the water oak-gum and pine-hardwood types, and the second representing the difference between the average of these two types and the slash pine type. Partitioning indicated that there was no significant difference between the water oak-gum and pine-hardwood types, but that the slash pine type showed a highly significant difference from the average of the other two types. These chi-square values clearly support the visible differences seen in Figure 1, where highly similar distribution patterns between the pine-hardwood and the water oak-gum types are evident as contrasted to a vastly different distribution patterns for the slash pine type:

Source of Variation	*Degrees of Freedom*	*Chi-Square*
Between Water Oak-Gum and Pine-Hardwood Types	4	4.68 *
Between Slash Pine and Combined Hardwood Types	4	263.08 †
Total between Types	8	267.76 †

* Not significant. † Significant at the 1 percent level.

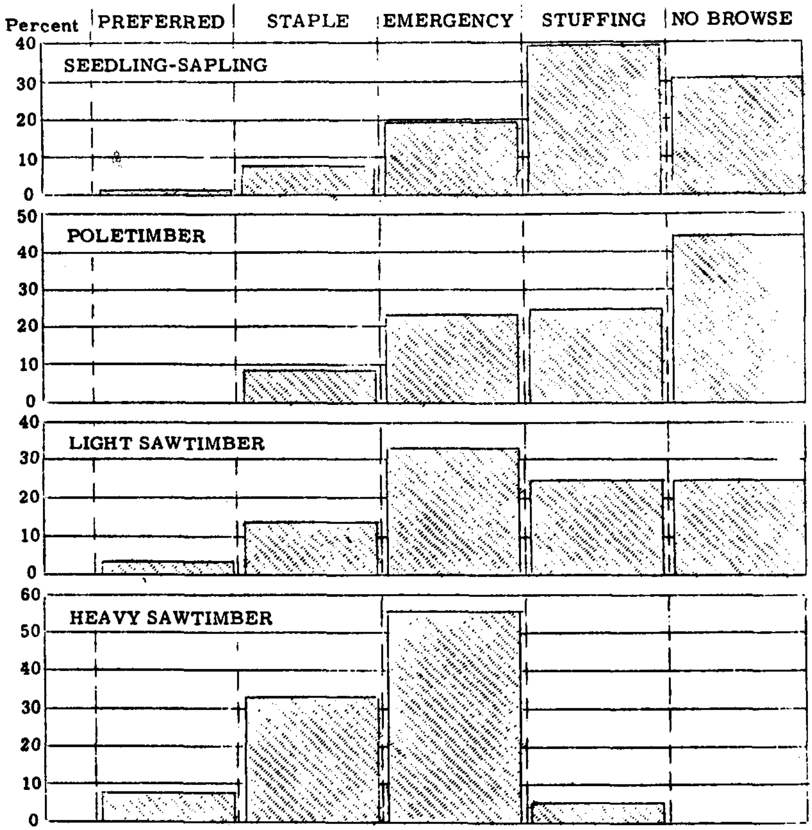
The analysis was then extended to determine if the types sampled were homogeneous units of browse class distributions, or if within-type differences existed which should be considered. Because of further limitations of data, these analyses were confined to the slash pine and water oak-gum types, where stand size and site were selected as logical criteria for possibly defining within-type areas with different browse distribution patterns. The percent distributions of browse classes by stand sizes for both types are given in Table II, while the browse class distribution patterns for different stand sizes within the slash pine type only are illustrated in Figure 2. Chi-square analysis was again used to determine whether the observed differences in the forage distributions between stand size classes were significantly different, or could be reasonably considered a result of sampling error. As part of this same analysis, computations were made to determine whether areas of the same stand size but of differing site indices, could be considered as homogeneous areas with respect to browse distribution patterns. The chi-square table for these analyses is as follows:

TABLE II

BROWSE CLASS DISTRIBUTION BY STAND SIZE CLASS WITHIN FOREST TYPES

	Stand Size Class			
Browse Classes	*Seedlings and Saplings*	*Pole-timber*	*Light Sawtimber*	*Heavy Sawtimber*
SLASH PINE TYPE	*Percent*	*Percent*	*Percent*	*Percent*
Preferred Food	1.7	0.0	3.3	7.5
Staple Food	7.6	8.3	13.3	32.5
Emergency Food	19.5	23.3	33.3	55.0
Stuffing Food	39.3	24.2	25.0	5.0
Unoccupied Points	31.9	44.2	25.0	0.0
	Number	*Number*	*Number*	*Number*
Sampling Points	420	120	120	40
WATER-OAK GUM TYPE	*Percent*	*Percent*	*Percent*	*Percent*
Preferred Food	12.0	8.8	8.6	20.0
Staple Food	29.0	43.8	34.1	40.0
Emergency Food	31.0	36.2	32.3	10.0
Stuffing Food	12.0	11.2	19.5	20.0
Unoccupied Points	16.0	0.0	5.5	10.0
	Number	*Number*	*Number*	*Number*
Sampling Points	100	80	220	20

Figure 2.--Percentage distribution of browse preference classes by stand sizes for slash pine type.



SLASH PINE TYPE

Source	*Degrees of Freedom*	*Chi-Square*
Between Stand Size Groups	12	97.24 *
Between Site Index Classes within Stand Sizes	28	131.76 *
Total between Stand Size-Site Index Classes	40	229.00 *

WATER OAK-GUM TYPE

Source	*Degrees of Freedom*	*Chi-Square*
Between Stand Size Groups	12	31.39 *
Between Site Index Classes with Stand Sizes	16	119.57 *
Total between Stand Size-Site Index Classes	28	150.96 *

* Significant at the 1 percent level.

Differences between stand sizes within types were highly significant for both the slash pine and water oak-gum types. Site index differences within stand size groups were also highly significant for both forest types. Although the analyses did indicate significant differences in this instance, the data for distributions of browse by site index classes within stand size groups were too meager to warrant further biological discussion. For this reason a tabulation of these data is not included in this paper.

In an attempt to derive a single index figure to represent the browse distribution patterns, the percentages for preferred and staple classes were combined by types. The sampling errors are computed using standard statistical formulas for the variance of estimates obtained from cluster sampling for proportions. These percentages and their estimated sampling errors are:

Type	*Estimated Percentage of Points Dominated by Preferred or Staple Foods*	*Standard Error*
Slash Pine	12.1	2.6
Water Oak-Gum	45.9	5.1
Pine-Hardwood	45.0	6.1

The sampling errors presented here should be useful in the practical task of choosing sample sizes for browse surveys. It must be pointed out, however, that since the individual points are samples from a binomial distribution, the size of the sampling error will depend upon the actual percentage of points in the population dominated by preferred or staple browse. Variation in estimates of this percentage will be greatest at or near 50 percent. As the percentage of staple and preferred browse decreases or increases away from 50 percent, estimates will become more accurate for any given sample size. For example, data from 21 plots in the water oak-gum type yielded an estimate of 45.9 as the percentage of points dominated by preferred or staple browse species. The standard error of this estimated percentage is 5.1 or a percentage error of approximately 11 percent. In contrast, 35 plots in the slash pine type yielded an estimated percentage of 12.1 with a standard error of 2.6. If, in the water oak-gum type, it were desired to reduce the percentage error to 5 percent, an approximation of sample size could be obtained using the assumption that the true population percentage is 45.9. Under this assumption, sample size to obtain a standard error equal to 5 percent of the mean would be 109 clusters or 2,180 points.

DISCUSSION

The primary objective of these trial samplings in one Georgia county was to determine if the frequency sampling techniques suggested here provide a sensitive and realistic index to the amount and quality of browse materials present in any given forested area. The results just presented indicate that the percentages of points dominated by the several classes of browse foods furnish sensitive and reasonably stable statistics which are strongly associated with stand conditions that might be reasonably expected to affect the amount and quality of browse material. Although it is not startling that there are differences between browse preference distribution patterns for the three types analyzed in this paper, the magnitude and the nature of these differences are extremely interesting. For example, the fact that only 8 percent of the points sampled in hardwood types (on the average) were not occupied by browsable material in contrast to the pine type where 31 percent of all points sampled had no browsable material is important. In addition, it is interesting that the pine type has only 12 percent of the points dominated by preferred and staple foods, whereas the hardwood types (together) had approximately 45 percent of all points dominated by preferred and staple foods.

Certain of the within-type distribution patterns are also worthy of discussion. One such pattern is illustrated in Figure 2, which shows the relation between the distribution of browse preference classes and the size of slash pine stands. This figure suggests that as stands mature from poletimber through light sawtimber to heavy sawtimber, the percentage of points not occupied by browse decreases from 55 percent to 0. At the same time, points occupied by preferred or staple browse species increases from 8 percent to 40 percent. Hence, it appears that not only does the browse quantity increase, but also that quality improves greatly. The conclusions indicated by these data are certainly not contrary to our usual concepts of community developments in the slash pine type. It should be noted, however, that a similar pattern of community development is not indicated by the data in the water oak-gum type. It is suspected that this results from elemental ecological differences between hardwood and pine communities. One basic difference between hardwood and pine stands, insofar as browse is concerned, is that hardwoods, as seedlings and young saplings, contribute directly to browse supplies. A second important factor is the difference in relative shade tolerance between the species occurring in the hardwood types and those in the slash pine type.

The sampling techniques used in this trial did not provide a means of recording utilization of sampled forage. Subsequent sampling (which includes the Piedmont counties) involves frequency sampling for degree of utilization. Data on utilization will add much to the interpretation of future surveys and should grealy strengthen information concerning deer preference for individual browse species, thus leading to a better understanding of forage differences between units of deer range.

It is clearly recognized that the browse sampling procedures reported in this paper permit no quantitative estimates of browse per unit area. The trial has shown, however, that the technique may prove useful in relating browse conditions to conventionally measured characteristics of forest overstories, thus permitting a ranking of type, stand, and site differences in terms of relative values indicative of deer-carrying capacity. It is felt that such an index should be useful in indicating to the forester and game manager which types and stand conditions might be perpetuated and developed through silvical techniques for maximum deer forage production.

SUMMARY

The Forest Survey is part of a continuing inventory of forest resources conducted by the Forest Service to provide accurate, up-to-date information for the management of the nation's timber. Developments in survey sampling methods, used for the first time in Georgia, provided an opportunity to sample other attributes of forest land, especially game habitat. Laurens County, Georgia, was selected to test sample for occurrence and quality of woody browse. This involved frequency sampling of 20 cylindrical milacre plots, 4½ feet high on a 1½-chain square traverse for the presence of woody browse at each sampling location. Individual browse species were sorted into preference classes, and the distributions were analyzed for differences between major forest types, stand sizes, and site indices.

The three major types tested (slash pine, pine-hardwood, water oak-gum) differed significantly in distributions of browse. Partitioning indicated that major and highly significant differences existed between pine and the two hardwood types, but there was no significant differences between hardwood types. Other analyses included tests and detection of significant difference in browse distributions on the basis of stand size and site.

Although the data do not give a quantitative estimate of the browse present, results show that this type of sampling gives a sensitive measure of occurrence and relative qualitative difference in communities. Further, these data should suggest silvical practices which would provide high, long-term yields of forage.

LITERATURE CITED

Burke, Hurbert D. 1956. Wildlife Habitat Research Needs in Southern Forests. U. S. Forest Serv., South. Forest Expt. Sta., Occas. Paper 149.

Cassady, John T. 1953. Herbage Production on Bluestem Range in Central Louisiana. Jour. Range Mangt., 6:38-43.

Dunkeson, R. L. 1955. Deer Range Appraisal for the Missouri Ozarks. Jour. Wildlife Mangt., 19:358-364.

Harlow, Richard F. 1955. Preliminary Report on a Deer Browse Census Based on 100 Percent Clipping Method. Proc. Southeast. Assoc. Game and Fish Comm.

Hosley, N. W. 1956. Management of the White-tailed Deer in Its Environment. *In,* The Deer of North America. The Stackpole Co., Harrisburg, Pa.

Lay, Dan W. 1956. Some Nutrition Problems of Deer in the Southern Pine Type. 10th Ann. Conf. Southeast. Assoc. Game and Fish Comm. Proc.