PREDICABILITY OF DEER FORAGES USING OVERSTORY MEASUREMENTS [a]

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Abstract: Seasonal prediction models for understory production from simple overstory measurements were developed using regression analysis. During the summer of 1976 and winter of 1976-1977, production of understory vegetation was recorded by species or species groups in timber stands on the Savannah River Plant using a 100% clip method. Overstory density and basal area were also recorded. Sampled timber stands ranged from pine regeneration sites with measurable overstory (stems > 3 cm dbh) to immature sawtimber of pine and upland hardwoods. Quadratic equations using basal area of all stems yielded seasonal regressions for woody leaf and twig production and combined woody production. Variation in the total understory forage yield (fungi, grasses and sedges, herbaceous plants and woody plants) was also explained with quadratic equations using either basal area of all stems or basal area of only large stems. No sacrifice in model stability was observed when basal area of large stems (> 11 cm dbh) was used. Therefore economy and efficiency in sampling can be achieved using standard plotless sampling methods.

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Much white-tailed deer (*Odocoileus virginianus*) habitat now occurs in areas under timber management. To meet projected wood demands, more forest acreage will need to be placed under intensive timber management. These practices will affect all wildlife and responsible management of deer will require the ability to predict more accurately the potential impacts of various silvical treatments on their habitat.

Models predicting production of browse, grasses, and forbs in loblolly pine (*Pinus taeda*) plantations from overstory measurements have been presented by Blair (1967) and Myers (1977). Halls and Schuster (1965) developed regressions for grasses and total herbage production in pine and hardwood stands. However, additional models are needed which can predict production of these vegetational components in an array of timber stands of various successional stages and species composition. If models are to have management value, accurate predictions of understory forage must be achieved. The information required for prediction equations must be easily obtained so that the cost of formulating models are not prohibitive to the land manager. Therefore, the objectives of this study were to measure understory production of all vegetational components available to deer and determine its predictability by overstory measurements.

MATERIALS AND METHODS

Site Description

Field research was conducted in cooperation with the U.S. Forest Service on the U.S. Department of Energy's 81,000 ha Savannah River Plant (SRP) located in Aiken and Barnwell Counties, South Carolina. The Forest Service has been conducting intensive timber management on the SRP since 1952 (Langley and Marter 1973) and presently reports 68,000 ha in forested land (Personal communication).

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The SRP is divided into 50 wildlife compartments each varying in size and containing numerous forest stands. Three compartments were chosen for study. Compartments 14 (1490 ha) and 18 (1890 ha) are physiographically similar and are in the upland region of the plant site. This area is characterized by well-drained sandy soils. Compartment 44 (1514 ha) is in the lowland region of the SRP, which borders the Savannah River Swamp.

Continuing Forest Service inventories were used to stratify the stands in each compartment according to stand condition, stand composition, and stand age (Table 1). Thirteen strata were identified in the 3 study areas. Eleven strata occurred in Compartment 18, whereas both 14 and 44 contained 8. All compartments contained successional stages of pine plantations ranging from regeneration stands to immature sawtimber; old home sites; and some hardwood stands.

Table 1. Criteria for grouping forest stands into strata.

Strata	*Forest Stand Composition*	*Stand Condition*	*Stand Age (yrs.)*
A	Pine (loblolly, slash, *P. ellioti,* longleaf *P. palustris*)	Regeneration	0-5
B	Pine	Seedlings and sapplings adequately stocked	6-12
C	Pine	Immature poletimber; seedlings and sapplings adequately stocked	13-24
D	Pine	Immature poletimber; Immature sawtimber	25+
E	Pine	Sparse poletimber; Sparse sawtimber	Mixed[a]
F	Pine	Non-stocked	Mixed
G	Pine-Hardwoods (*Quercus alba*)	Immature sawtimber	25+
H	White Oak (*Quercus alba*), Red Oak (*Q. rubra*), Hickory (*carya sp.*)	Low quality poletimber	Mixed
I	White Oak, Red Oak, Hickory	Immature sawtimber	25+
J	Sweetgum, (*Liquidambar styraciflua*), Nuttal Oak (*Q. nuttali*), Willow Oak (*Q. phelos*)	Seedlings and Sapplings adequately stocked	6-12
K	Sweetgum, Nuttal Oak, Willow Oak	Immature poletimber Immature sawtimber	25+
L	Red Maple, (*Acer rubrum*), Sweet Bay (*Magnolia virginiana*), Swamp Tupelo (*Nyssa aquatica*)	Immature poletimber	25+
M	Old home sites		25+

[a]No dominant age group.

Understory Sampling Method

Each stratum was sampled during mid-summer to early fall and again during the winter season. Understory forage production was determined in each stratum using the 100% clip method described by Harlow (1977). All green vegetation and current annual growth twigs in a 1 m^2 plot up to a height of 1.5 m were clipped, weighed, and recorded by species. A green weight sample for each species clipped in a stratum was oven-dried at 80 C. The ratio of oven-dried weight to green weight was used to express all weights in kilograms per hectare oven-dried weight. New dry weight values were determined for each species and a mean forage production calculated for each stratum during a sampling period.

Overstory Sampling Method

Overstory measurements were made in each stratum and compartment where understory sampling occurred. Two survey methods were used to provide data on overstory species composition, density, and basal area. A 1 m factor prism was used to sample stems with diameter at breast height (dbh) greater than 11 cm. The diameter and species of each stem in the plot according to the prism were recorded. A fixed plot of 0.01 ha was also used to record stems between 3 and 11 cm. The same plot center was used for each method.

Overstory measurements were made during spring 1977. Average basal area and density of stems were calculated for all but 1 stratum in 1 compartment. The regeneration stratum in Compartment 44 had no overstory, thus no observation was available.

Regression Procedure

Multiple regression analyses were used to evaluate the feasibility of predicting forage production of various understory components from overstory measurements of basal area and density for each stratum. Before regressions were developed the data were blocked according to season (summer vs. winter), diameter class, strata groups and vegetational groups. In an effort to determine if certain sizes of trees more strongly influenced forage production than others, basal area and density were blocked into 3 diameter classes: small stems including stems 3-11 cm dbh; large stems including stems greater than 11 cm dbh; and total stems which included small and large stems.

Understory forage was separated into four vegetational groups (fungi, grasses and sedges, herbaceous plants, and woody plants). Woody plants were further separated into woody leaves and annual growth twigs. Each group, including total forage production, was used in regression analyses. Known food species of deer on the SRP were also used in separate regressions. Only those species which occurred in stomachs of deer taken from the SRP were considered (Harlow et al. 1979).

RESULTS AND DISCUSSION

During the summer sampling period, July to mid-November 1976, green weights of 124 species or species groups were recorded from 1305 sample plots. The winter survey, December 1976 through March 1977, yielded green weights for 96 species from 1322 sample plots. Available forage by weight decreased by 68% from summer to winter. This reduction was observed in all strata except wet bottomland strata J, K, and L. Evergreen species (*Leucothoe* spp., *Myrica* spp., and *Ilex* spp.) in these wet bottomlands made up 62% of the total understory forage by weight, and may have accounted for high forage yields being maintained during the winter period. Since these wet strata differed markedly from other strata, they were deleted from regression analyses. Old homesites were considered atypical timber stands and were also deleted from regression analyses.

Understory and Overstory Relationships

All regressions and prediction equations were evaluated at the 0.05 significance level. Preliminary examination of graphs of basal area and understory production indicated a curvilinear relationship (Figs. 1 and 2). Therefore, quadratic equations using only total basal area or basal area of large stems were used in regression models.

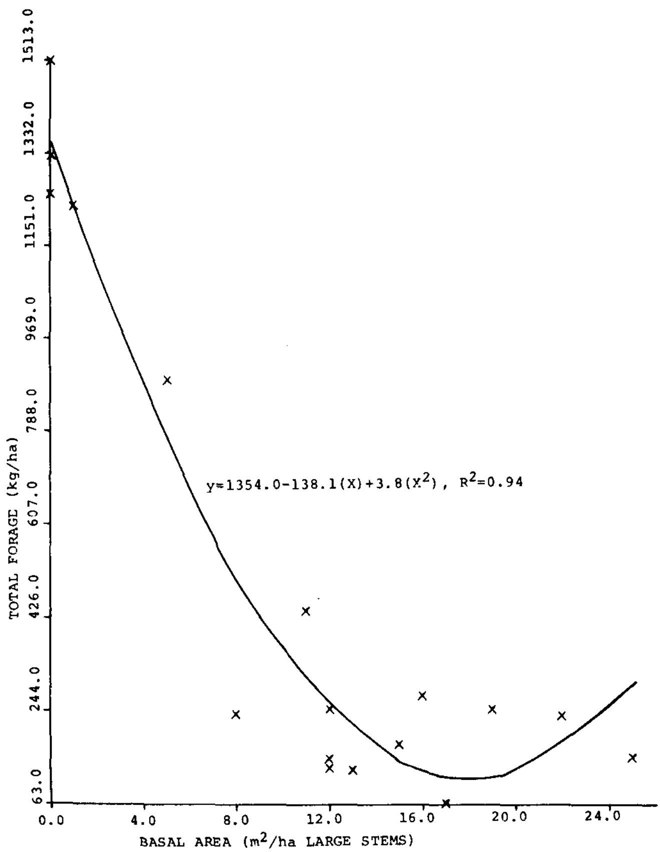

Fig. 1. Relationship of total forage production with basal area of large stems in the summer, on the Savannah River Plant 1976.

Correlations of other overstory measurements with production of various understory components were also examined. High correlations were indicated for density of small pines (< 11 cm dbh) and density of all large stems (> 11 cm dbh) with woody leaves, woody twigs and combined woody production. Density of small pines was positively related to production of these vegetational components, whereas density of large stems was inversely related. However, an insufficient range in observations for these two overstory parameters precluded development of reliable models. Multi-variable models using basal area and density were also tested. These models were unacceptable due to poor R^2 values (< 0.59) and/or estimates that were not significantly different from zero. The colinearity of basal area and density probably resulted in poor model stability.

Predictability of Production of Vegetational Components

Basal area measurements successfully explained variation in production by woody vegetation. When all stems were included in the basal area data significant regressions

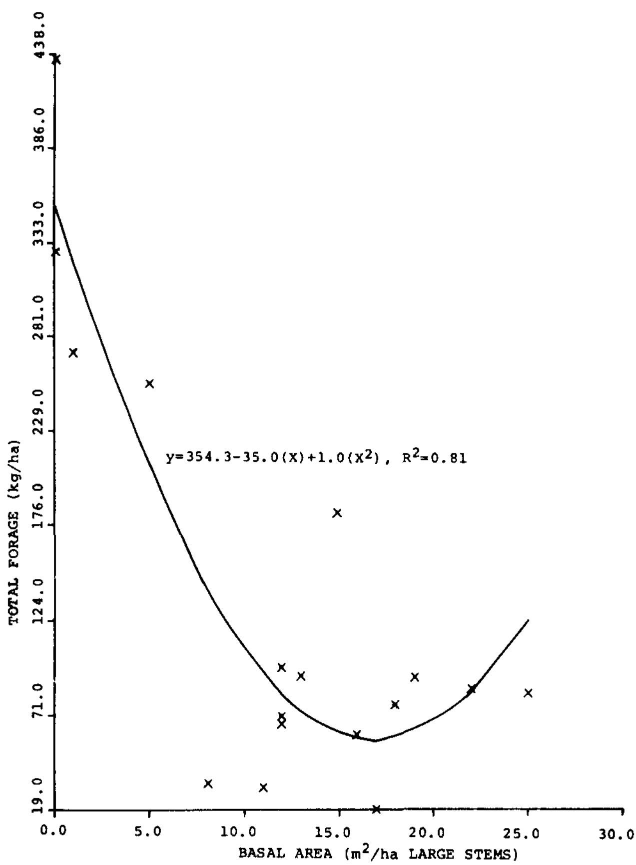

Fig. 2. Relationship of total forage production with basal area of large stems in the winter on the Savannah River Plant 1976-77.

were developed for woody leaf production, woody twig production, and combined woody production for the summer and winter sampling periods (Table 2). A seasonal difference in predictability was evident with woody leaf production having a slightly higher R^2 value in the summer than winter and woody twig production having a much higher R^2 value in the winter than summer. This is consistent with the time of year when each of these components is the dominant part of the deciduous woody vegetation.

When only the basal area of large stems (> 11 cm dbh) was used in the regression models, R^2 values were increased on the average by 0.12 in all but 2 cases (Table 3). In these 2 models R^2 values were decreased by 0.01 and 0.05 for combined woody and woody leaf production in the winter respectively. Again seasonal changes in predictability were evident with higher R^2 values for woody leaf production in the summer and woody twig production in the winter.

Because of the importance of pine in southern timber management, and in an effort to reduce variability by using more homogeneous strata separate regression equations were developed using data only from the pine strata. Resulting regression models were very similar to those already presented for pine and upland hardwood strata and differences in R^2 values were less than 0.05.

Table 2. Prediction equations for understory components production for pine and upland hardwood strata using basal area of all stems (≥ 3 cm).

Dependent Variable	*Season*	*Intercept*	*BA*	*BA^2*	*R^2*
Woody leaf	Summer	1149.8(.001)[a]	- 99.3(.001)	+2.3(.008)	0.77(.003)
Woody leaf	Winter	324.2(.001)	- 27.3(.001)	+0.6(.001)	0.73(.001)
Woody twigs	Summer	159.9(.001)	- 13.2(.008)	+0.4(.030)	0.51(.001)
Woody twigs	Winter	152.8(.001)	- 13.8(.001)	+0.4(.001)	0.74(.001)
Woody combined	Summer	1309.8(.001)	-112.5(.001)	+2.6(.003)	0.76(.001)
Woody combined	Winter	477.0(.001)	- 41.1(.001)	+1.0(.001)	0.79(.001)
Total forage	Summer	1936.2(.001)	-157.9(.001)	+3.4(.001)	0.92(.001)
Total forage	Winter	510.7(.001)	42.3(.001)	+1.0(.001)	0.81(.001)

[a]Probability of a greater F-ratio.

Table 3. Prediction equations for understory components production for pine and upland hardwood strata using basal area of only large stems (> 11 cm).

Dependent variable	*Season*	*Intercept*	*BA*	*BA^2*	*R^2*
Woody leaf	Summer	815.9(.001)[a]	- 91.0(.001)	+2.7(.001)	0.89(.001)
Woody leaf	Winter	216.3(.001)	- 21.1(.001)	+0.6(.010)	0.68(.001)
Woody twigs	Summer	118.4(.001)	- 11.9(.001)	+0.4(.010)	0.65(.001)
Woody twigs	Winter	105.9(.001)	- 10.8(.001)	+0.4(.001)	0.82(.001)
Woody combined	Summer	934.3(.001)	102.8(.001)	+3.1(.003)	0.89(.001)
Woody combined	Winter	322.4(.001)	- 32.3(.001)	+1.0(.001)	0.78(.001)
Total forage	Summer	1354.0(.001)	-138.1(.001)	+3.8(.001)	0.94(.001)
Total forage	Winter	354.3(.001)	- 35.0(.001)	+1.0(.001)	0.81(.001)

[a]Probability of a greater F-ratio.

Overstory measurements produced unreliable estimates for fungi, grasses and sedges, and herbaceous plants production. Regressions that were determined for these vegetational groups were successful in explaining less than 55% of the variation in production. The lack of success of these models was due in part to the sparseness of these vegetational components in the older aged strata and the high variability in plot to plot production. However, relationships of production by these vegetational groups to overstory cover or other specific overstory parameters have been reported. Blair and Enghardt (1976) reported herbage yields in 30 year old pine stands to be influenced greatest by pine basal area. In 40 or more year old stands they reported herbage yield variation to be more closely related to midstory hardwoods stocking and basal area. Halls and Schuster (1965) reported a closer relationship of grasses and herbage production to tree cover than basal area. They found 64% of the variation in production by grasses and 71% of herbage yield variation to be accounted for by the logarithmic transformation of tree cover +1. Using basal area only, 46% and 43% of the yield variations for grasses and herbage were accounted for. Similar relationships between tree cover and understory grasses and herbage yields were reported by Ehrenreich and Crosby (1960).

The curvilinear relationship between woody plant production and overstory basal area presented in this paper agrees with that found by Blair (1967). Using regression models which incorporated basal area or the logarithm of basal area of pine and hardwoods of 4 cm dbh or more, he accounted for 62 and 69% of the variation in browse yields, respectively. Blair and Enghardt (1976) found pines to be sufficiently high and sparse by stand age of 40 years to allow transmission of sunlight, resulting in midstory hardwood stocking and basal area exerting the greatest influence on browse yields. These overstory parameters accounted for 76% of the variation in browse production.

Predictability of Production of Known Deer Foods

Regressions were attempted to predict production by known deer food plants from overstory measurements. However, no successful regressions could be developed. Wide fluctuations in production by deer food species within similar strata were observed. In many instances these fluctuations were the result of individual species being present or absent within given stands of a stratum. Apparently, factors which govern species diversity and occurrence (land use history, soils, site preparation, etc.) need to be included when attempting to predict production by specific species or species groups. Unless stratafication criteria were expanded to include a variety of these site qualities; it seems unlikely that the occurrence and therefore production of a few specific species can be predicted by simple gross measurements of the overstory.

Predictability of Production of Total Forage

Production of all vegetational components in a stratum were combined into a total understory forage yield. Quadratic equations using either basal area of all stems or basal area of only large stems (Figs. 1 and 2) were each successful in explaining variation in total forage yields (Tables 2 and 3). The use of large stem basal area in the regression model gave slightly higher values of R^2 in each season than when basal area of all stems were used. In all cases values of R^2 for total forage production were higher than for any single vegetational component. Total forage production regressions were the only successful models that included production by non-woody vegetation and afforded at least observations in gross changes in total vegetation production in a variety of timber types. When only pine strata were used in the regression model values of R^2 were not sufficiently increased to warrant development of separate models for these strata.

Summary and Conclusions

In an attempt to develop seasonal prediction models for understory production from simple overstory measurements, 100% clip plots with accompanying overstory measurements of density and basal area were made in an array of timber types during the summer and winter period. Quadratic equations using basal area yielded successful models. No sacrifice in model stability was observed when only large stem basal area was used in the regression equations. Economy and efficiency in sampling can thus be achieved without loss of information by sampling only those stems greater than 11 cm dbh. Generally, models showed seasonal difference, with better models developed for a particular understory component when that component made up the largest proportion of the understory. Thus woody leaf and total forage production had higher values of R^2 in the summer and woody twig production had higher R^2 values in the winter.

The successful models that are given for woody component production and total forage production, with accompanying good values of R^2, indicate the feasibility of using models to predict understory production. Although prediction models of known deer foods were unsuccessful, the other models presented should provide guidelines for managing forest lands for deer habitat by simulating changes in forage availability in various forest stands.

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