FIRE AND GRAZING

The Relationship of Tree Overstory and Herbaceous Understory Vegetation

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Highlight

For study of the effect of trees on understory vegetation, a good mathematical equation is very helpful. This article presents an equation which fits overstory-understory data better than previously used equations.

Trees adversely affect the growth of herbaceous plants around them; clearings in a forest produce much more herbaceous material than do similar areas with a dense tree cover. Because of competition for light, water, and nutrients, and possible antagonistic chemical effects, this inverse relationship is entirely reasonable and has often been reported in the literature. A few examples are the ponderosa pine (Pinus ponderosa) ranges of South Dakota (Pase, 1958), Oregon (McConnell and Smith, 1965), and Arizona (Reynolds, 1962; Pearson, 1964); southern pine ranges (Gaines et al., 1954; Hall and Schuster, 1965); hardwood areas in Missouri (Ehrenreich and Crosby, 1960); and chaparral and woodland ranges of Arizona (Pond, 1961; Arnold et al., 1964). Mathematical expressions of the relationship between trees and the herbaceous understory do not point out the basic causes of the relationship; nevertheless, they have many useful applications.

Several investigators have fitted regression lines to their data. The measurement of trees is taken as the independent variable (x) and the measurement of herbage as the dependent variable (y). The relationship between these variables is clearly curvilinear, and mathematical models published include log y = a + b x, log (x + 1), and y = a + b x + c x^2. The model y = a + b log (Kx + 1) has also been suggested (Batachelet, 1966). Other models could also be fitted; for example, y = a + b x + c x^2 + d x^3 gives a good fit in some cases.

All of these models were tried with three sets of Arizona data, and none were satisfactory. The simpler models generally gave a poor fit with the data, especially as x approached zero. The polynomial models were illogical, a fact which became very apparent as the computed lines were extended beyond the limits of the data.

Recently, Grosenbaugh (1965) included as one of several generalized growth functions a 5-parameter transition sigmoid growth curve given by

\[ Y = H + A \left(1 - \frac{B}{(X - G)}\right)^{M+1} \]

where X is the independent variable, Y is the estimated value of the dependent variable, and H and A are the upper and lower asymptotes, respectively. B provides the necessary curvature, M adjusts the inflection point, and G adjusts the value of X so that X = G = 0 when Y = H.

For overstory-understory relationships, the X origin may be taken as zero so that G = 0. Also the sigmoid shape (M > 0) may not be necessary, so that values of M > -1 were allowed, that is, (M + 1) > 0. For 0 < (M + 1) < 1 the inflection point has a negative abscissa value, and the curves are concave upward in the first quadrant.

Three sets of data were used for computation. The collection of two of the sets was described by Pearson (1964). These data were collected in a ponderosa pine forest in northern Arizona. Basal area of trees was measured with a 10-foot prism using the plotless "Bitterlich" method (Grosenbaugh, 1952). Basal area ranged from 10 ft^2 through 200 ft^2/acre. Tree canopy cover was also measured at each point with a canopy mirror (Lemmon, 1956). In addition, 30 points were taken at random in a cleared area. At each point all herbaceous vegetation from a 9.6-ft^2 circular plot was clipped to ground level, oven-dried at 104 C for 48
hr, and weighed. About 36% of the weight of the herbaceous material was made up of Arizona fescue (*Festuca arizonica*) and 49% of mountain muhly (*Muhlenbergia montana*). The remaining 15% included 4 species of grass, 1 sedge, and some 40 forbs.

The results of these clippings were first averaged for each basal area class, and expressed as total pounds of herbage per acre. The data were then regrouped by canopy classes, and the average herbage weights for each class were determined for the second set of data.

The third set of data was from Arnold et al. (1964). These data were collected at 14 locations in the pinyon-juniper (*Pinus edulis, Juniperus spp.*) type in northern and central Arizona. A total of 220 50-ft transects were measured. Tree cover was measured with the line intercept technique of Canfield (1941). Herbage samples were obtained by clipping a 4-inch strip along each transect. Important herbaceous species included blue grama (*Bouteloua gracilis*) and herbaceous portions of snakeweed (*Gutierrezia sarothrae*). The results of these clippings were grouped by cover classes, and means of each canopy class were calculated.

A computer program was designed to approximate values of $B$ and $M + 1$ in the equation by iteration, and solve for $H$ and $A$ in the usual least squares procedure for regression equations. For the three sets of data, the best fit, with the equations, is shown in Fig. 1. The curve for pine basal area (Fig. 1A) was the only one that was sigmoid.

When $X = 0$ the maximum departure of $Y$ from the actual plot values was 9 lb/acre, and the curve fit the data well along the rest of the lines. Since the curves do fit the data well, this model is suggested as a general model for overstory-understory relationships.

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**Fig. 1.** Relationship of herbage production ($Y$) to tree measurements ($X$). Numbers near the data points refer to the number of plots for the class.
OVERSTORY—UNDERSTORY

The Osage rangeland of Oklahoma, an area of gently rolling hills, is world renowned for its grass-fattened cattle. The region lies at the southern end of one of the last large segments of true prairie in the United States. The northern portion of this segment is known as the Kansas Flint Hills (Anderson, 1953). The general regional climate is one of hot summers with wet springs and falls. The mean annual precipitation is 32.8 inches with about three-fourths during the growing season.

The principle range site, loamy prairie, is characterized by fertile, deep, upland clay loam soils (Gray and Galloway, 1959). These soils are nearly black, highly granular, and permit good root penetration. Low permeability and rolling topography with many steep, winding ravines make cultivation difficult, therefore, native grass is the most practical vegetation. Many acres of claypan soils of the Par- sons silt loam type also occur throughout the area in patchwork fashion, and were described in an earlier publication (Hazell, 1965).

Four important grass species (hereafter referred to as the big four), big bluestem (Andropogon gerardi Vitman), little bluestem (A. scoparius Michx.), indiangrass (Sorghastrum nutans (L.) (Nash), and switchgrass (Panicum virgatum L.) are the principal dominants on the loamy prairie site.

Overstocking is a major problem of the region. The purpose of this study was to compare the effect of two different grazing intensities on botanical composition, forage production, and plant vigor.

Effect of Grazing Intensity on Plant Composition, Vigor, and Production

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LITERATURE CITED


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