Understory Herbage Production as a Function of Rocky Mountain Aspen Stand Density

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Abstract

The effects of aspen overstory basal area on herbaceous understory production on the Bears Ears District of the Routt National Forest in northwest Colorado were investigated. Using regression, a coefficient of determination of .61 was found between herbage production and overstory basal area. For overstory basal areas less than 10.0 meter²/hectare, herbaceous understory production varied considerably and was often double that found at higher densities of overstory basal area. Herbage production at higher densities (10.0 to 18.9 m²/ha) showed less variation with an average production of 1100 kilograms/hectare. The best opportunities for herbaceous understory production in unmanaged, pure aspen stands occur at overstory basal areas less than 10.0 m²/ha.

Rocky Mountain aspen (*Populus tremuloides* Michx.) stands have significantly more herbage in their understory than other forest types. These stands are widely used for grazing by both domestic livestock and big game animals. The wood fiber can be used to produce a number of different wood products (Koepke 1976). Proper management of the aspen for both herbage and wood fiber must consider joint production relationships. The objective of this study was to investigate the relationship between overstory density and herbage production in aspen stands located within the Bears Ears District of the Routt National Forest, Colorado.

Competition for space, light, water and nutrients between overstory trees and herbaceous understory plants have been studied in a variety of forest types, with differing results. Jameson (1967) in a study in northern Arizona, found that understory herbaceous production decreased as ponderosa pine *(Pinus ponderosa)* overstory basal area and pinyon-juniper (*Pinus edulis*/*Juniperus* spp.) canopy coverage increased. The understory consisted primarily of shrubs and grasses producing a range of 675 to 750 kg/ha (dry weight). Ehrenreich and Crosby (1958) investigated this overstory/understory relationship in oak/hickory (*Quercus marilandica* /*Carya* spp.) stands in Missouri and found herbage production (primarily grasses) decreased as overstory canopy cover increased, especially when the canopy cover was above 50%. An 80% canopy cover produced 279 kg/ha, while 1905 kg/ha was produced at densities lower than 50%.

There have been several previous studies involving forage production in aspen stands. Paulsen (1969) investigated the overstory/understory relationship in aspen near Grand Junction, Colo., and found half as much forage produced under the aspen canopy as in adjacent grasslands. Ellison and Houston (1958), in a study in central Utah, showed that herbaceous understory production was greater under an aspen canopy than in adjacent open grasslands. However, aspen roots under the study area canopy had been trenched (severed), which significantly reduced competition for water and nutrients, and possibly altered the total effect of density. They suggest that the trenching could have affected the herbaceous production and also point out that the grassland soils were severely compacted by heavy grazing. They state that this combination of factors could have influenced their results. Harper (1973), also in central Utah, concluded that aspen overstory basal area was not correlated with herbaceous understory production unless conifers were mixed with the overstory stand. He found understory production decreased by 50% where the overstory was composed of a significant percentage of conifers (>50%). Severson and Krantz (1976) investigated aspen overstory basal area and herbaceous understory production in western South Dakota and reported no high degree of relationship (R^2 less than .30) between the two factors. They chose aspen stands from a variety of sites and suggested higher correlations might have been found if they had grouped their stands by similar site characteristics.

Study Area and Methods

In this study, 20 research sites with pure aspen overstories and varying stand densities were sampled in such a way as to follow the suggestions of Severson and Kranz (1976). That is, the research sites were chosen so as to minimize the differences in site characteristics. To reduce climatic variation, research sites were chosen from one geographic area, the Bears Ears District of the Routt National Forest. To further reduce variation, the sites were chosen so that elevation varied by no more than 90 m and slope by less than 20%. All sites selected had a southern aspect. The 20 sites had overstory basal areas ranging from 1.8 to 18.9 m²/ha (20 increments of .9 m²). Unlike Harper's (1973) study each individual research site was a pure aspen stand (with no conifers in the overstory or understory) of at least 17 hectares in size with the entire stand exhibiting the same general overstory density. Ten circular .5 m² wire forage cages were randomly located in the understory within the site boundaries of each of the 20 sites. The herbage samples were collected in August after all of the understory herbage had reached maximum growth. The herbage species composition and their frequency of occurrence were identified using Daubenmire's (1959) method. The herbage in each of the cages was clipped, sorted into grass and forb classes, and oven dried at 85° C for 48-72 hours. Finally the total data set was analyzed using regression, with herbage production being the dependent variable and stand basal area the independent variable.

Results and Discussion

The 20 sites produced herbage ranging in dry weight from 558 to 2273 kg/ha. An average production of 1661 kg/ha occurred on sites with overstory basal areas less than 10.8 m²/ha (50% canopy coverage). Ten sites with overstory basal areas ranging from 10.8 to 18.9 m²/ha produced an average of 1100 kg/ha dry weight herbage.

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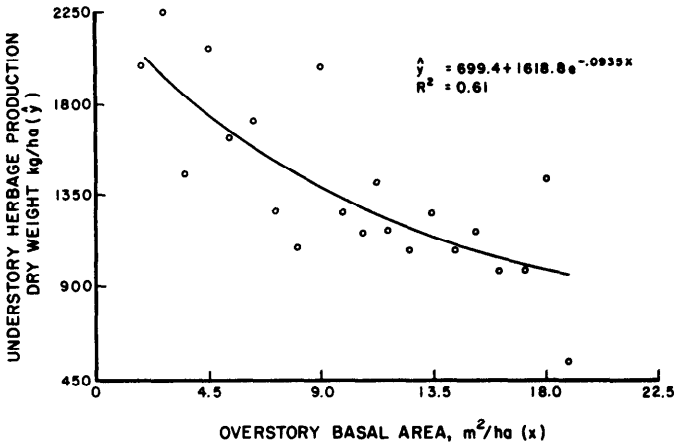

Fig. 1. *Understory herbage production on 20 aspen research sites on the Bears Ears District of the Routt National Forest in northwestern Colorado.*

Figure 1 shows the overall decrease in herbaceous understory production as overstory density increased. Regression analysis (Fig. 1) was used to analyze the relationship between dry weight understory herbage production and aspen overstory density (m^2/ha). After testing several hypothesized models, the negative exponential form shown in Figure 1 was considered the most appropriate model to use. This model form is similar to herbage production models developed for conifer stands. These also have been primarily exponential in shape (Jameson 1967, Clary and Ffolliott 1966, Pase 1958). Our data set did not contain any data points for sites below 1.8 m^2/ha basal area. If these low basal area cases were included the exponential fit would have probably indicated a more pronounced negative slope at the lower stand densities.

On sites below 10.0 m^2/ha aspen overstory basal area (approximately 50% canopy coverage) did not appear to be the only factor influencing herbage production on the site. There is more variation in herbage production between these sites than between those of higher densities (Fig. 1). In such cases, other site factors influencing competition within the herbaceous understory itself seem to have an effect on dry weight production. As the aspen overstory decreases, the trees' demands on the site are reduced, and growth factors (light, water and nutrients) become available for herbaceous plant growth.

At overstory basal areas greater than approximately 10.0 m^2/ha the increase in overstory density seems to have less of an effect on herbaceous understory production, dry weight. There was less variation in herbage production between these sites (Fig. 1); most of the sites produced about 1100 kg/ha, varying only by 100-200 kg/ha. On these higher density sites, the aspen overstory produces an environment with a minimum of ground light after full leaf flush (mid-July), cool and stable soil temperatures, and a continuous recycling of the necessary macro and micro nutrients (Daubenmire 1953). Salisbury (1916) refers to this situation as a "competitive equilibrium" between the overstory canopy and the understory herbaceous vegetation. The understory vegetation is said to complement the tree canopy in attaining maximum exploitation of available light.

In this study analysis of the understory species composition and frequency of occurrence of each species indicated a balanced mixture of herbaceous understory plants with various rooting depths that promote more completely use of available water and nutrients. No one herbaceous species dominated these sites, and collectively their habitat requirements ranged from dry to moist soil conditions (Vories and Sims 1977). This herbaceous understory condition could further contribute to the consistent dry weight produced on the higher stand density sites.

The best opportunities for herbaceous understory production in unmanaged pure aspen stands occur at overstory basal areas less than 10.0 m^2/ha (approximately 50% canopy coverage). Thinning denser stands to basal areas less than 10.0 m^2/ha should significantly increase understory production. These thins may also contribute to individual tree growth. The application of such prescriptions should consider both timber and range management objectives as well as other multiple use requirements.

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