Pinyon-Juniper Litter Reduces Growth of Blue Grama

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Highlight

What is there about pinyon and juniper trees which reduces growth of blue grama? This study shows that the chief influence is due to tree litter, not canopy.

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Pinyon (*Pinus* spp.) and juniper (*Juniperus* spp.) woodlands cover millions of acres in the semiarid Southwest. These trees have increased in recent years (Johnsen, 1962), and the increase has been associated with declining forage production (Arnold, Jameson, and Reid, 1964). Trees have been controlled on many acres of rangelands in an attempt to restore the forage production. Although the reduction of grass cover with increasing trees has been reported, the nature of the effect of the trees on grasses has not been carefully studied. Trees can conceivably influence the understory grasses by (1) competition for water, (2) shade, (3) rainfall interception, (4) litter, and (5) phytotoxic root exudates. The influence of these factors may well be different for various grass species. This study reports results on part of the overall problem, that is, the influence of tree litter and tree cover on blue grama (*Bouteloua gracilis,* (H.B.K.) Lag.).

Review of Literature

Arnold et al. (1964) reported that pinyon and juniper trees reduced basal intercept of blue grama on several widely spaced plots in northern Arizona. Basal intercept of blue grama averaged 2.36% with no tree cover and 0.34% with 85% tree cover. Intermediate degrees of tree cover had intermediate blue grama basal intercepts. Arnold (1964) showed that the influence of one-seed juniper *(J. monosperma* (Engelm.) Sarg.) trees on blue grama is largely localized under the crown. Blue grama basal intercept at different locations was: Under the middle of the tree, 0.0; under outer parts of the tree, 0.62; from canopy edge to 17 ft beyond the canopy, 1.48; more than 17 ft beyond the canopy, 1.38. Johnsen (1962) found that roots of a juniper tree 9.5 ft tall extended 2.5 to 3 times as far as the tree was tall. Blue grama roots in Johnsen's study weighed 0.9 g per 0.25 ft^3 of soil at the edge of the juniper canopy, 8.8 g 5 ft beyond the canopy edge, and 13.1 g 25 ft from the canopy edge and beyond.

Tree canopies influence light and rainfall interception. Skau (1960) found that juniper trees intercept about 40% of the precipitation that falls on the crown. A small portion of the intercepted rainfall is recovered as stem flow, and in some storms this may provide additional moisture near the base of the tree (Johnsen, 1962).

Blue grama is sensitive to heavy shade (Benedict, 1941; Johnsen, 1962) and a juniper tree can intercept up to 80% of the direct sunlight. Reflected light, however, can greatly augment the total radiation received under the tree canopy. Shirley (1945) reviewed the effect of light competition on plants, and concluded that juniper and pinyon trees rarely cast enough shadow to cause any harm to understory vegetation.

Tree litter is, of course, associated with tree cover, but can have its own independent effect on grass growth. For example, Jameson (1961) found that water extracts of pinyon and juniper foliage reduced growth of wheat radicles as follows: Utah juniper *(J. osteosperma* (Torr.) Little) 85%; alligator juniper *(J. deppeana* Steud.) 83%; one-seed juniper 79%, and pinyon *(Pinus edulis* Engelm.) 67%. Similar reductions have also been found in the growth of blue grama radicles (U. S. Forest Service, 1963).

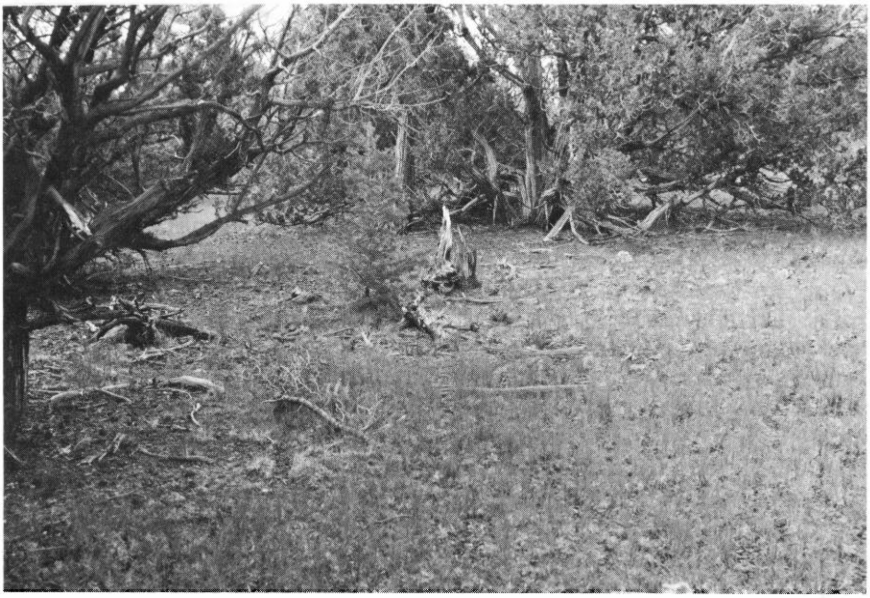

FIG. 1. One-seed juniper, pinyon, and blue grama on basaltic soil.

Study Areas and Measurements

The study areas included two 1-acre plots about 35 miles northwest of Flagstaff, Arizona, and one 1-acre plot about 30 miles south of Seligman, Arizona. Both areas have a divided winter-summer rainfall pattern, and blue grama grows primarily during the summer rainy period. The plots were suitable for the analysis presented here because the understory vegetation was mostly blue grama (Fig. 1). The location, soils, and rainfall of the various plots are described in Table 1. The basaltic soil became a clay below 2 inches; the other soils retained their surface texture throughout the profile.

The tree stands were made up mostly of mature and overmature trees. Tree cover ranged from 13% on the granitic soil to 31% on the limestone soil. The contribution of blue grama to total herbage weight ranged from 76% on the limestone soil to 89% on the granitic soil.

At each plot, 50 subplots were selected at random. Three measurements were taken at each subplot:

(1) Tree cover was sampled with a spherical densiometer (Lemmon, 1956). This device provides means of estimating the canopy intercept in an inverted cone over the subplots. Where more than one tree species occurred, the proportion of cover made up by each species on each subplot was estimated.

(2) Litter, rock, and basal area of plants were sampled with a point frame. A 1x1 m frame with 50 points spaced 1x2 dm was used.

(3) Weight of herbaceous vegetation was estimated. One-fifth of the subplots were clipped to provide a conversion factor of estimated fresh weight to actual dry weight.

Table 1. Characteristics of the study areas.

Location	Soil	Soil depth inches	Approximate inches annual precipitation	Dominant trees
NW Flagstaff	Stony silt loam (basalt parent material)	24	12	Pinyon, one-seed juniper
NW Flagstaff	Gravelly silt loam (Kaibab limestone parent material)	12	12	Pinyon
S Seligman	Gritty clay loam (granite parent material)	48	14	Utah juniper

Analysis of Data

Multiple regression techniques outlined by Goulden (1952) were used to analyze the data. By this approach, the influence of each factor could be separated from the influence of other factors. All attributes measured were included in the analyses of data from the basaltic and limestone soils. On the granitic soil plot, rocks and other plants were so infrequent that the few subplots which did contain these attributes were simply eliminated from the calculations. Both basal area and weight of blue grama were used as dependent variables on the basaltic soil and limestone soil plots. On the granitic soil plot, many annual weeds were present when the weight estimates were taken. These weeds may have influenced the growth of blue grama, so the weight figures were not used.

In all cases, litter was the most important factor influencing blue grama. The partial regression coefficients, which were similar for data from all plots, ranged from -0.042 to -0.058 when the dependent variable was basal area and -0.33 to -0.36 when the dependent variable was weight. The effect of litter was statistically significant in all cases. On the basaltic soil plot, the regression coefficients did not change greatly when litter was the only independent variable used. On the other plots, the use of litter alone as an independent variable resulted in nonsignificant regressions.

Tree cover, whether pinyon or juniper, was not significantly related to blue grama in any case. In 6 of 9 cases, however, the sign of the regression coefficient for tree cover was positive. On the granitic soil plot, the effect of juniper cover approached significance and the sign was positive. These positive coefficients indicate it is unlikely that tree cover had a real negative effect on blue grama. Including tree cover in the regression calculation greatly improved the fit in both the limestone soil and granitic soil data.

Since litter was the chief factor related to a decrease of blue grama, the contribution of pinyon cover and juniper cover to total tree litter on the basaltic soil plot was determined. Both of the tree species contributed about the same to total tree litter; the regression coefficient was 0.64 for pinyon and 0.68 for juniper.

In multiple regression analysis, a strong correlation between independent variables can lead to misleading and inconsistent regression coefficients between the independent variables and the dependent variables. In this case, however, both the sign and value of the regression coefficients were similar under a variety of circumstances, which indicates that the regression coefficients express a real effect.

Relationship to Other Studies and Management Problems

These calculations show that pinyon and juniper litter is associated with a reduction of basal area and production of blue grama, and that tree cover, if it has any influence at all, is associated with an increase of blue grama. Although the shade and rainfall interception of the canopy may be detrimental to blue grama, these effects are offset by beneficial effects which probably include reduced evapotranspiration or more desirable temperatures.

This study did not investigate the influence of root competition between trees and blue grama. Johnsen (1962) has shown that juniper roots and blue grama roots are concentrated in different soil depths, and Arnold (1964) reported no difference in basal intercepts of blue grama near a juniper tree and more than 17 ft from the edge of the canopy. The data of Arnold et al. (1964) also provide another line of evidence. If the blue grama is assumed to be entirely in the intertree spaces, and the grass intercept is calculated to include only the intertree space, there is little influence of tree cover on blue grama. For example, at 85% cover the basal intercept of blue grama was 0.34%. If all of the blue grama were growing in the intertree spaces, the basal intercept of blue grama between the trees would be 0.34/0.15=2.27%. This compares to the figure of 2.36% for transects with no tree cover.

These relationships are important in managing pinyon-juniper ranges. Because the influence of trees on blue grama is concentrated in the litter-covered areas, little response of blue grama to tree removal should be expected where the litter covers only a small part of the area. In the litter-covered areas, the response of blue grama may be delayed until the litter at least partially decomposes. Increases in forage production should be sought from species which more likely show root competition, such as western wheatgrass (*Agropyron smithii* Rydb.) (Arnold, 1964). Management following tree control should favor the grasses which have been held more in check by competition from trees.

Summary

Multiple regression analyses of data from plots with the vegetation consisting mostly of pinyon-juniper and blue grama showed that tree litter was the major factor associated with reduction of blue grama. Tree cover either did not influence blue grama, or perhaps was beneficial. This study provides no data on the influence of root competition from trees on blue grama, but data from other studies indicate that root competition is probably slight. Other grass species, particularly those which are deeper rooted than blue grama or which

grow at a different season, may have a different relationship with tree cover, roots, and litter.

Because the effect of litter on blue grama is great, while root competition from trees is apparently small, little immediate increase in blue grama should be expected following pinyon-juniper control.

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