

Herbage Production and Composition under Immature Ponderosa Pine Stands in the Black Hills

CHARLES P. PASE

Range Conservationist, Rocky Mountain Forest and Range Experiment Station¹, Forest Service, U. S. Department of Agriculture, Fort Collins, Colorado

Approximately half of the 3.5 million acres in the Black Hills of South Dakota and Wyoming is dominated by ponderosa pine (*Pinus ponderosa*). The understory vegetation available to livestock and wildlife is strongly affected by this pine overstory. Timber management practices, while primarily designed to improve timber production and quality, exert a strong influence on the potential food supply for 60,000 to 80,000 deer and about 30,000 head of livestock. Under present management practices, these forested ranges produce an estimated 80 to 90 percent of the deers' annual food supply and 10 to 15 percent of the livestock's annual food supply.

Thinning as a silvicultural practice has been extensively used in the Hills. During the 1930's approximately 250,000 acres of second-growth pine were thinned by the Civilian Conservation Corps. At present, about 3,500 acres are thinned annually by the Black Hills National Forest. Thinning of dense second-growth pine stands on private land is encouraged by partial payment of cost through the Agricultural Conservation Practices program. An expanding pulpwood market may also increase commercial thinning in the near future.

Observations readily show that dense pine stands have little or no understory vegetation, but more open stands have varying amounts of grasses, forbs, and shrubs (Figure 1). In 1956 a study was made to determine if there was a consistent relationship between the amount and kind of understory vegetation and density of crown canopy, basal area, and pine litter produced by pine stands.

The influence of the forest overstory on herbage production has been studied in recent years, particularly in the southern pine belt. Gaines, *et al.*, (1954) found that herbage decreased on southern Alabama longleaf pine lands from 1,000 pounds per acre at zero basal area to 475 pounds at 110 square feet basal area, and then increased slightly as basal area increased further. Production generally tends to level off under the denser canopies (Halls, 1955; Gaines, *et al.*, 1954). Campbell and Cassady (1949) and Cassady (1951) found herbage production 5 to 10 times greater under very open savannah-like longleaf pine than in well-stocked plantations or second-growth stands. Read (1951) found that "poor" hardwood forest stands on south and west exposures produced 53 percent more herbage than the "good" hardwoods on the better north and east exposures.

Study Area

The Black Hills and Bear Lodge Mountains are located in southwestern South Dakota and

northeastern Wyoming. The commercial ponderosa pine area, ranging from 4,300 to 7,000 feet in elevation, covers about 1.4 million acres. Annual precipitation is 18 to 30 inches within this zone, with approximately 75 percent falling during the growing season. Soils range from sandy loams to clay loams, and are derived from sandstones, limestones, schists, and granites.

Ponderosa pine makes up 95 percent of the commercial timber volume in the study area. White spruce (*Picea glauca*), generally found on moist northerly slopes at the higher elevations, accounts for the remaining 5 percent. Paper birch (*Betula papyrifera*) and aspen (*Populus tremuloides*) occupy cool, moist sites throughout the northern half of the Black Hills, often forming dense stands on old burns. Bur oak (*Quercus macrocarpa*) occurs commonly on the northern fringe of the Hills and in the Bear Lodge Mountains. Except for the mountain mahogany (*Cercocarpus montanus*) type in the western foothills, no extensive shrub communities are found in the Hills. Understory shrubs in varying amounts include common juniper (*Juniperus communis*) bearberry (*Arctostaphylos uva-ursi*), chokecherry (*Prunus virginiana*), snowberry (*Symphoricarpos occidentalis*), eastern hop-hornbeam (*Ostrya virginiana*), and hazelnut (*Corylus rostrata*). Understory herbaceous species include Pennsylvania sedge (*Carex pennsylvanica*), Kentucky bluegrass (*Poa pratensis*), roughleaf ricegrass (*Oryzopsis asperifolia*) poverty oatgrass (*Danthonia spicata*), pussytoes (*Antennaria* spp.) and goldenrod (*Solidago* spp.).

Methods

Thirty-one sample areas were located on timber sites within commercial pine stands. Locations were selected on the basis

¹Central headquarters maintained in cooperation with Colorado State University at Fort Collins. Research reported here was conducted in cooperation with the South Dakota School of Mines and Technology at Rapid City.



FIGURE 1. Two adjacent ponderosa pine stands with same slope and exposure. *Left:* A 70 percent pine crown cover and 34 pounds of air-dry herbage per acre in 1956. *Right:* A 53 percent pine crown cover and 265 pounds of air-dry herbage per acre in 1956; stand thinned in 1933.

of estimated percentage of crown cover, with approximately five areas selected for each 10 percent crown cover class. Crown cover ranged from 0 to 71 percent. Basal area within the same stands ranged from 0 to 215 square feet per acre. (Basal area is the square feet of cross-sectional area per acre of all trees at breast height.) All sample areas were located in even-aged second-growth ponderosa pine having but one distinguishable crown canopy level. None of the sample areas had been logged or thinned within the past nine years.

Herbage production by species was determined by the weight-estimate method (Pechanec and Pickford, 1937). Twenty 9.6-square-foot circular plots were used at each sample area. The plots were located at 10-foot intervals on two parallel 100-foot transects. The transects were spaced 10 feet apart. Composition was based on air-dry herbage production.

Crown density was determined with a "moosehorn" crown density estimator (Garrison, 1949). Readings were made at the center of alternate 9.6-square-foot plots.

Basal area of the ponderosa pine stand was determined with a Bitterlich stick at a point mid-

way between the two transects by using the method described by Grosenbaugh (1952). Four of the 31 basal area values were compared to subsequently cal-

culated values, with an error of -5 to +16 percent.

Litter was collected from a one-square-foot sample at the center of alternate 9.6-square-

Table 1. Herbage production (pounds per acre air-dry) and composition (weight basis) under immature ponderosa pine in the Black Hills, 1956.

Species	Pine crown cover classes							
	0-19%		20-39%		40-59%		60-71%	
	Lbs.	%	Lbs.	%	Lbs.	%	Lbs.	%
Fuzzyspike wildrye	59	4.3	0	0	0	0	0	0
Kentucky bluegrass	191	14.1	67	10.8	4	1.7	1	1.7
Little bluestem	20	1.5	1	.2	10	4.2	0	0
Poverty oatgrass	45	3.3	105	17.0	19	8.0	1	1.7
Prairie dropseed	122	9.0	3	.5	1	.4	0	0
Roughleaf ricegrass	111	8.2	23	3.7	19	8.0	12	20.0
Sedges	139	10.2	82	13.2	67	28.2	26	43.2
Other grasses (31 spp.)	210	15.5	44	7.1	11	4.6	1	1.7
Total grasses & sedges	897	66.1	325	52.5	131	55.1	41	68.3
Cream peavine	9	.7	2	.3	3	1.3	0	0
Goldenrod	24	1.8	9	1.5	tr.	tr.	1	1.7
Strawberry	24	1.8	3	.5	1	.4	0	0
Western yarrow	12	.9	20	3.2	2	.8	tr.	tr.
White clover	10	.7	12	1.9	tr.	tr.	0	0
Other forbs (58 spp.)	124	9.0	46	7.4	25	10.5	3	5.0
Total forbs	203	14.9	92	14.8	31	13.0	4	6.7
Aspen*	17	1.3	1	.2	5	2.1	0	0
Bearberry	93	6.8	159	25.7	6	2.5	5	8.3
Chokecherry	0	0	tr.	tr.	3	1.3	tr.	tr.
Common juniper	85	6.3	0**	0	30	12.6	1	1.7
Oregon grape	tr.	tr.	15	2.4	2	.8	3	5.0
Rose	11	.8	5	.8	5	2.1	tr.	tr.
Serviceberry	8	.6	1	.2	2	.8	tr.	tr.
Snowberry	29	2.1	19	3.1	16	6.7	5	8.3
Other shrubs (10 spp.)	15	1.1	2	.3	7	3.0	1	1.7
Total shrubs	258	19.0	202	32.7	76	31.9	15	25.0
Grand Total	1,358	100.0	619	100.0	238	100.0	60	100.0

*Aspen included in shrubs.

**Juniper was present in the area, but did not occur on the sample plots.

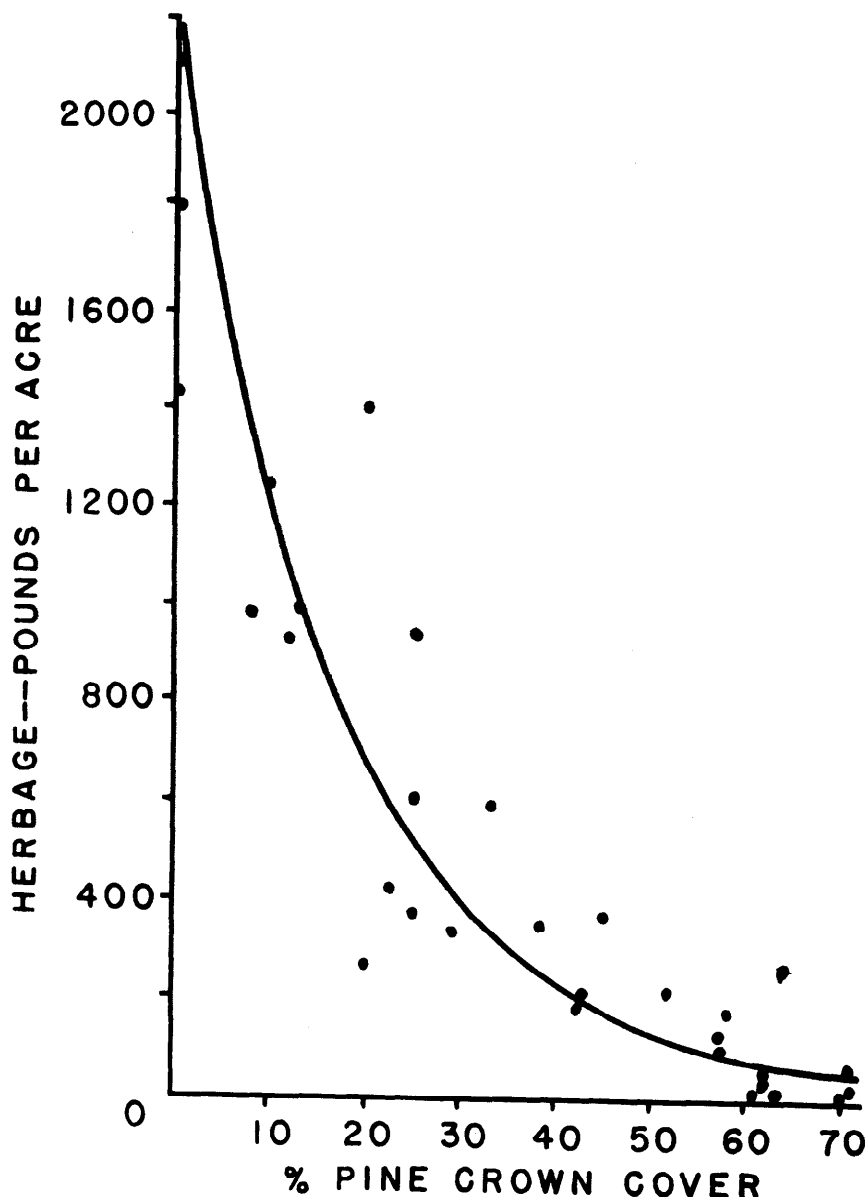


FIGURE 2. Production of understory vegetation as related to the density of the ponderosa pine canopy.

foot plots. This material was weighed in the field, and as with herbage, samples were taken for air-dry determination. Litter included all unincorporated organic matter from the pine overstory, pine needles, cones, bark, twigs, and small branches up to three-fourths inch diameter.

Herbage weights were transformed to logarithms, and statistical analysis followed Snedecor (1946).

Results

Herbage production decreased

as crown cover increased. Although 2,160 pounds of air-dry herbage per acre was produced on clearcut areas, only 40 pounds per acre was produced under a crown cover of 70 percent (Fig. 2). This relationship is expressed by the equation $\log Y = 3.33545 - 0.02466 X$, where "Y" equals pounds of air-dry herbage per acre and "X" equals crown cover of the pine overstory in percent. The standard error of estimate was ± 0.29806 .

All groups—grasses, forbs, and shrubs—increased as crown cov-

er decreased (Fig. 3). However, grasses showed the greatest response in pounds per acre to reduction in crown cover; they averaged 25 pounds under the densest pine stands compared with 1,730 pounds on clearcut areas. Forbs increased from 5 pounds per acre under the densest pine stands to 305 pounds in clearcut areas, while shrubs showed the least response, increasing from 10 to 125 pounds per acre. (In constructing the family of curves in Figure 3, shrub and forb curves were calculated separately and then summed. The difference between this sum and total herbage production represents the production of grass and grass-like plants.)

A 40-percent crown cover approaches a normally-stocked stand of post-sized timber. Under such a stand, total herbage production was 225 pounds per acre. Grass production was 170 pounds, forbs 25 pounds and shrubs 30 pounds per acre, air-dry.

Herbage production and basal area also showed a logarithmic relationship ($\log Y = 3.22260 - 0.00936 X$). Dense crown cover was generally associated with high basal area. While basal area ranged up to a maximum of 215 square feet per acre (one plot), the maximum crown cover (71 percent) occurred between 150 and 180 square feet basal area. Combinations of high crown cover and high basal area were always associated with low herbage yields.

Herbage production also decreased as pine litter increased (Fig. 4). This relationship is apparently curvilinear, in contrast to the linear relationship found by Gaines, *et al.*, (1954) under longleaf pine in Alabama. In the Black Hills, ponderosa pine litter production ranged from 0 on clearcut areas to 19 tons per acre under dense pine canopies. Branches and small stems

smaller than three-fourths inch in diameter contributed substantially to the high litter values. Litter production greater than 10 tons per acre was usually associated with crown cover of 55 to 70 percent, and with basal areas greater than 110 square feet per acre.

Species reacted differently to changes in crown canopy (Table 1). Pennsylvania sedge and roughleaf ricegrass, abundant in the open areas, persisted under moderately dense (40-59 percent) and dense (60-71 percent) canopies. Poverty oatgrass, although abundant at intermediate crown densities, was relatively unimportant under either very open or very dense stands. Kentucky bluegrass, the most abundant species in openings, virtually disappeared at crown densities greater than 40 percent, as did fuzzyspike wildrye (*Elymus innovatus*) and prairie dropseed (*Sporobolus heterolepis*). Little bluestem (*Andropogon scoparius*) was erratic in occurrence, but was generally most abundant under open stands with southerly exposures.

Few of the 63 species of forbs persisted under even moderately dense canopies. White clover (*Trifolium repens*), American strawberry (*Fragaria vesca* var. *americana*), and western yarrow (*Achillea lanulosa*) were usually most abundant in openings, clear-cut areas or relatively open stands. However, goldenrod and cream peavine (*Lathyrus ochroleucus*) were persistent under moderately dense canopies.

Bearberry, common juniper, and snowberry were the most abundant of the 19 species of shrubs. Bearberry decreased sharply under crown canopies greater than 40 percent, while common juniper persisted under 40 to 49 percent crown cover. Snowberry decreased gradually as crown cover increased. Rose (*Rosa* spp.) and aspen were prac-

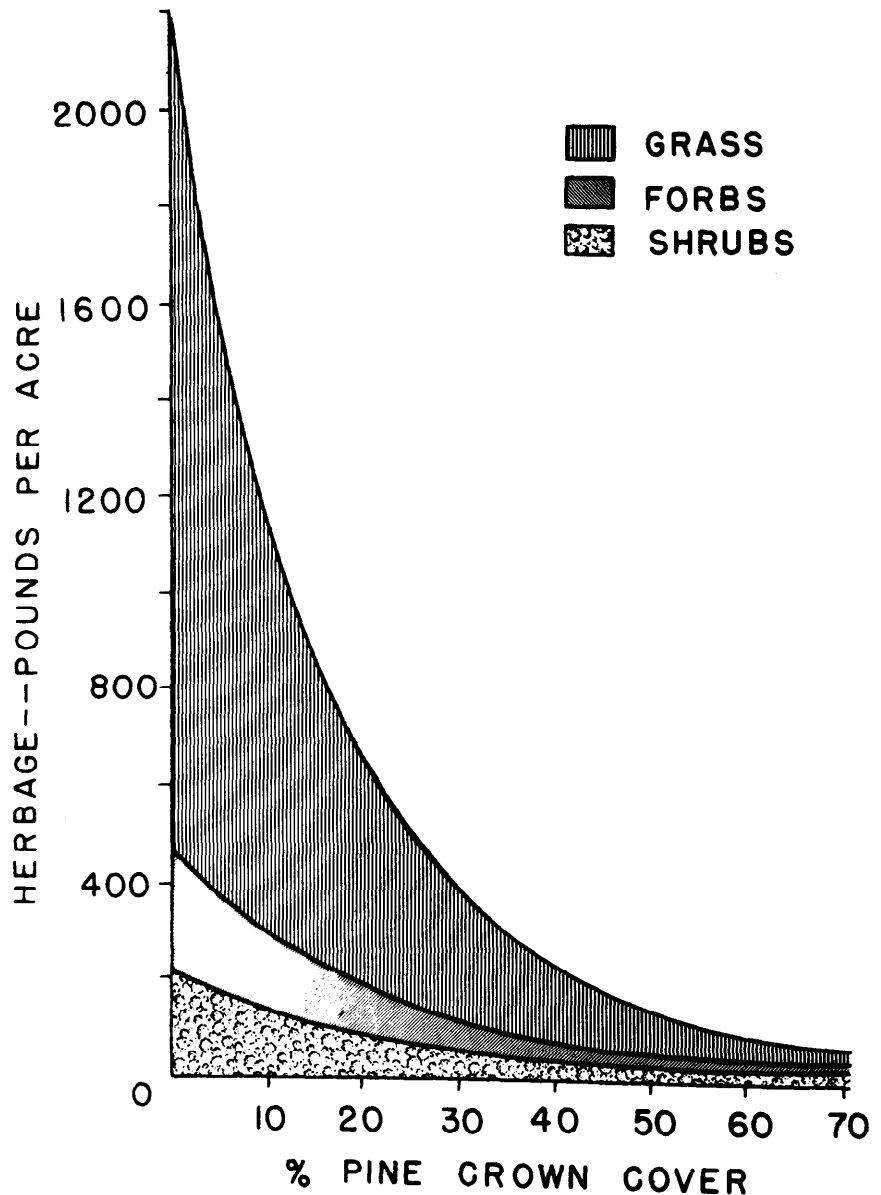


FIGURE 3. Calculated production of grass, forbs, and shrubs as related to crown cover of pine overstory.

tically absent under dense canopies, while Oregon grape (*Mahonia repens*) was most abundant at intermediate to high crown densities. Serviceberry (*Amelanchier alnifolia*) and chokecherry, while not heavy producers on timber sites, were widespread and apparently persistent under moderate crown densities.

The relative importance of species based on herbage produced changed as crown density increased. Sedges produced 10.2 percent of the total herbage un-

der light crown canopies, but accounted for 43.2 percent of the limited production under dense stands. Similarly, roughleaf ricegrass rose from 8.2 to 20.0 percent and Oregon grape from a trace to 5.0 percent. Less shade tolerant species such as Kentucky bluegrass, fuzzyspike wildrye, and prairie dropseed decreased in percent composition as well as in actual production. Forbs occupied an ever decreasing part of total herbage production as density of the pine canopy increased.

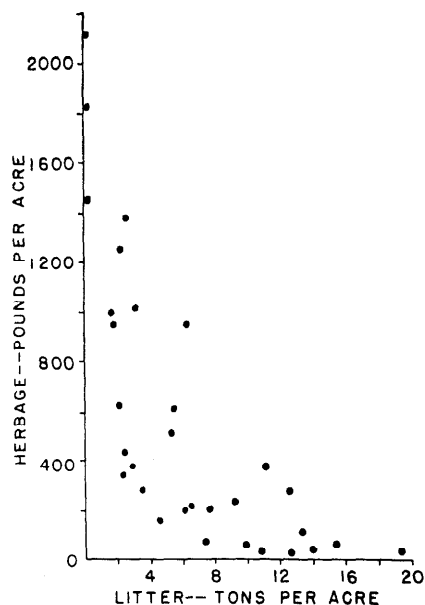


FIGURE 4. Production of understory vegetation as related to pine litter.

Discussion

Use of increased vegetation under thinned stands presents some management problems. Of the 1,300 pounds average difference in herbage production between open and dense stands, grasses and grass-like plants contribute 66 percent, while forbs contribute 15 percent, and shrubs 19 percent (Table 1). Much of this difference, therefore, would be most suitable for livestock use. Observations and a current preliminary study on livestock use of timber ranges indicate that cattle tend to avoid shade-grown vegetation where possible, even though apparently palatable species — *e.g.*, Kentucky bluegrass — are present. Sheep allowed free run of fenced suballotments in the timber type appear to graze shade-grown vegetation more freely. Intensive livestock use of this understory vegetation may lead to undesirable competition with deer for certain favored plant species.

Although all eight species of shrubs listed in Table 1 are important winter deer browse, bearberry, Oregon grape, and common juniper provide the bulk of the forage during the

critical January-March period (Hill, 1946). The response of shrubs to more open pine stands was less than either forbs or grasses. This may be due to lack of an adequate seed source, inherent slow growth of some species, intensive use by deer, and perhaps other causes. In an explanatory study on the effect of silvicultural thinning on deer browse in the Black Hills, Bever (1952) concluded that with browse plants, the principal increase in production comes from parent plants in the area at time of thinning. This study supports Bever's conclusion. Absence of an adequate nearby seed source was thought to be a limiting factor in many cases. In such instances, thinning might have to be followed by planting of browse seeds or seedlings for maximum gains.

In the Black Hills, deer tend to winter at lower elevations but still within the ponderosa pine belt, generally preferring south and west slopes. These slopes, while of great importance to the wintering deer herds, are among the least productive for timber. Thinning such second-growth timber stands to and perhaps beyond accepted silvicultural standards appears to be one way of increasing the forage supply on critical deer winter ranges.

Summary

Herbage production was determined under ponderosa pine stands in the Black Hills in 1956. A logarithmic relationship was found between total herbage production and pine crown canopy, basal area, and pine litter. Total herbage production ranged from 40 pounds per acre air-dry under a 70 percent crown canopy to 2,160 pounds on clearcut areas. Grass, forb, and shrub production on clearcut areas was 1,730, 305, and 125 pounds per acre, air-dry, compared with only 25, 5, and 10 pounds under dense unthinned stands, respectively. Under thinned stands with a pers-

ent crown canopy of 40 percent, grass, forb, and shrub production was 170, 25, and 30 pounds per acre, respectively.

Kentucky bluegrass, the heaviest producer under open stands and in clearcut areas, decreased both in pounds per acre and in relative importance as pine crown cover increased, as did little bluestem, prairie dropseed and fuzzyspike wildrye. The more shade-tolerant roughleaf ricegrass and sedges decreased in total herbage but increased in relative importance.

Bearberry, common juniper, and snowberry were the most abundant shrubs. Bearberry produced more pounds of browse than any other shrub under pine canopies of 0 to 40 percent. Common juniper was more persistent under denser pine canopies. Snowberry decreased gradually in production but increased slightly in relative importance as crown density increased.

Basal area ranged from 0 to 215 square feet per acre, crown cover from 0 to 71 percent, and pine litter production from 0 to 19 tons per acre.

Thinning immature pine stands on critical deer winter range to and beyond accepted silvicultural standards appears to be one way of increasing the forage supply.

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