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A comparison of Aspen and Pine Communities in the Northern Black Hills

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A COMPARISON OF ASPEN AND PINE COMMUNITIES IN THE NORTHERN BLACK HILLS

BY

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

A COMPARISON OF ASPEN AND PINE COMMUNITIES

IN THE NORTHERN BLACK HILLS

Abstract

Jeremiah J. Kranz

Three study areas, each containing an aspen (Populus tremuloides) community, a pine (Pinus ponderosa) community, and a mixed aspen-pine community, were studied during the summers of 1968, 1969, and 1970. Soil chemistry, plant chemistry, overstory density, understory production, and use by whitetail deer (Odocoileus virginianus) and cattle (Bos taurus) were determined for each community in each study area.

Pine and aspen communities of one study area were sampled for soil and plant chemistry. Soil phosphate and potassium levels were higher in the aspen community, while soil nitrates were higher in the pine community. Soil pH was similar in the two communities. Plant chemical composition was quite variable from the aspen to the pine community. Vetchling (Lathyrus ochroleucus) had higher levels of phosphorus, potassium, and nitrogen in the aspen community than in the pine community, while bearberry (Arctostaphylos uva-ursi) chemical composition did not change with overstory type.

Overstory density, although visually appearing similar, was greatest in the pine communities, intermediate in mixed aspen-pine, and least in the aspen communities, with basal areas (dbh) averaging 180.5, 133.6, and 89.7 square feet per acre, respectively. Understory

production was inversely related to overstory density. The greatest production (589 lb/acre air-dried forage) was found under the least dense aspen stands, intermediate production (415 lb) under the moderately dense mixed aspen-pine stands, and least production (215 lb) under the most dense pine stands. Aspen communities appeared to represent better feeding areas for both deer and cattle than mixed aspen-pine or pine communities. However, use by whitetail deer, estimated by pellet group density, was greatest in the mixed aspen-pine communities, intermediate in aspen, and least in the pine communities. Cattle use, estimated by chip density, was greatest in the aspen communities, intermediate in mixed aspen-pine, and least in the pine communities.

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INTRODUCTION

In recent years, aspen stands in the Black Hills of South Dakota have been subjected to a program of type conversion to ponderosa pine by the United States Forest Service in an attempt to increase timber production. This practice has been questioned by local sportsmen, ranchers, and South Dakota Department of Game, Fish and Parks personnel because of possible detrimental effects on wildlife and livestock production.

Aspen has usually been considered a subclimax or secondary sere species that usually develops from root suckers of remnant trees after fire, logging or other disturbance. Only in rare instances in the western United States has aspen been considered a climax species, and this possibly resulted from lack of a conifer seed source (Baker 1918, 1925). Aspen stands normally develop on spruce-fir climax sites and on some of the better pine climax sites following disturbance, while oak (*Quercus* spp.), buckthorn (*Ceanothus* spp.), or mountain mahogany (*Cercocarpus* spp.) stands usually develop on average pine sites (Daubenmire 1943).

Aspen has not traditionally been a valuable wood product when compared to ponderosa pine, but aspen stands have been esteemed among sightseers, picnickers, and campers because of their beauty (Ellison and Houston 1958).

Several investigators (Lutz and Chandler 1946, Daubenmire 1953) have reported that aspen trees favorably influence the development of soils by increasing organic matter, pH, and some soil nutrients, thus favorably affecting the development of associated understory species. It has long been established that deer reproduction and development are influenced by summer range conditions (Cheatum and Severinghaus 1950), and since aspen communities appear to be heavily used by deer during summer (Schneeweis 1969), any detrimental effect to aspen range may adversely affect the local deer population.

Many ranchers in the northern Black Hills with grazing permits believe aspen communities are extensively used by cattle. Ellison and Houston (1958) indicated aspen communities in some Rocky Mountain areas have been so heavily grazed that the more palatable understory species have been eliminated.

To determine the value of Black Hills aspen communities to deer and cattle, the South Dakota Department of Game, Fish and Parks initiated a study of deer and cattle use of aspen communities in 1968. Objectives of the study were: (1) to compare overstories and understories of aspen communities to those of pine, and (2) to determine deer and cattle preference for aspen or pine communities.

DESCRIPTION OF STUDY AREA

The Black Hills of South Dakota and Wyoming occupy approximately 2,000,000 acres of rolling and mountainous terrain at elevations from 3,500 feet to 7,241 feet. They consist of an exposed crystalline core of igneous and metamorphic rock surrounded by eroded sedimentary formations of limestone and sandstone.

Most of the soils are shallow, rocky, badlands soils modified by local physiography. Moisture occurs mostly as rainfall during the growing season (April through September), and ranges from 17 inches per year in the south at Custer to 28 inches per year near Deadwood (U. S. Dept. of Agric. and U. S. Dept. of Int. 1967).

Three areas, with pine and aspen stands in the northern half of the Black Hills, were studied from 1968 through 1970: "A" (T5N, R2E, Sec. 7) and "B" (T5N, R1E, Sec. 15) located about 9 miles west of Deadwood, South Dakota, and "C" (T3N, R4E, Sec. 30) located about 12 miles south of Deadwood. All three areas contained aspen communities, mixed aspen-pine communities, and pine communities on gray wooded soils (Radeke and Westin 1963).

Soils of area "A" were of limestone origin with similar depths in the aspen, mixed aspen-pine, and pine communities. Site exposure was northwest in the aspen community and southwest in the mixed aspen-pine and pine communities. Slope varied from 5 to 15 percent in the three communities. Soils of area "B" were also of limestone origin; however, soil depth varied between communities, decreasing in depth from the aspen through the pine community. Exposure was easterly in the three communities at 5 to 15 percent slope. Soils of area "C" resulted from breakdown of metamorphic rock and sandstones. Communities had similar soil depths and had a common northerly exposure of 5 to 10 percent.

Climax communities for all sites appeared to be ponderosa pine as all communities had various amounts of pine reproduction. Baker (1918) and Oosting (1948) state that pine reproduction in aspen communities indicates a pine climax. The aspen, mixed aspen-pine, and pine communities also contained paper birch (Betula papyrifera), bur oak (Quercus macrocarpa), serviceberry (Amelanchier alnifolia), and white spruce (Picea glauca).[a]

Herbivores common to the areas include whitetail deer, elk (Cervus canadensis), chipmunk (Eutamias minimus), whitetail jackrabbit (Lepus townsendi), porcupine (Erethizon dorsatum), beaver (Castor canadensis), red squirrel (Tamiasciurus hudsonicus), and domestic cattle.[b]

Deer were present in the study areas for about 8 months each year, generally being absent from December through March. Grazing by cattle was permitted during the period June 16 to September 20, in both 1969 and 1970.

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[a] Identification of plants based on Rydberg (1922) and Fernald (1950)

[b] Identification of mammals based on Burt and Grossenheider (1952)

METHODS

In the spring of 1968 study areas "A" and "B" were established in the northern Black Hills west of Deadwood using aerial photos, contour maps and aerial reconnaissance of the area. Using the same procedure, study area "C" was established in the central Black Hills south of Deadwood in the fall of 1968. Criteria used to select study areas were: (1) each study area contain nearly pure communities of aspen, pine, and a 50-50 mixture of each, (2) different communities within each study area be within one-half mile of each other, (3) communities within each study area be extensive enough to insure proper sampling without bias due to edge effect, and (4) communities within each study area contain overstories with similar basal areas and crown cover.

Nine belt transects (1,000 x 6 feet) were established, one in each community type in each study area to measure overstory basal area, overstory crown cover, understory forage production, understory cover, and deer and cattle use. The transects were located at least 100 feet from any disturbed areas (roads, logged areas etc.) or from the edge of the community type, except in area "C" where the mixed aspen-pine community was actually an edge between the aspen and pine community. The belt transects were marked with center stakes at 100-foot intervals to facilitate relocation.

Measurements of overstory basal areas were made in 1970 from the centerline of the nine belt transects using a ten-factor, wedge prism at five randomly selected points per 100 feet of transect. They were recorded as square feet of basal area at diameter breast height (dbh) for each overstory species.

Overstory crown cover was measured using the line intercept method over the centerline of each belt transect, and was recorded as percent of the area occupied by the crowns of each overstory species.

Measurements of understory forage production in pounds per acre were started July 8, 1968, and completed July 17, 1968, for areas "A" and "B". Measurements of understory forage production on area "C" were started August 10, 1969, and were completed August 11, 1969. Annual production for three classifications (shrubs, forbs, and grass) was determined by clipping annual growth from one 9.6 square foot plot located at random in each 100-foot segment of each belt transect. These clipped samples were placed in paper sacks, weighed in grams, and allowed to air dry for 2 weeks before re-weighing for dry weights. Forage production in pounds per acre was obtained by multiplying each plot sample by 10.

Measurements of understory cover were made from July 9-19, 1968, on areas "A" and "B", and from August 7-9, 1969, on area "C". Percent cover for understory species was estimated using five randomly selected 1-square foot plots along the centerline of each 100-foot segment of the belt transects. Plants which were inside or portions of plants extending into the plots to a height of four feet were recorded. Cover estimates were made for each species with the exception of grasses and sedges which were treated as a group.

Soil and plant chemistry was determined during the summer of 1970. Four plots (200 x 200 feet) were established in area "C"; two plots were located in the aspen community and two in the pine. Aspen plots were 400 feet from their respective paired pine plots, while the plots within each community were separated by 800 feet in distance and 50 feet in elevation.

Soil chemical data were obtained from three samples taken at 50-foot intervals along the north-south centerline in each plot. These samples, collected from the A1, A2, and B2 horizons, were air-dried in paper sacks, and analyzed by the soils testing laboratory at South Dakota State University, Brookings, to determine the following: (1) percent organic matter using chromic acid digestion (Jackson 1958), (2) water soluble nitrates using the phenoldisulfonic acid procedure (Jackson 1958), (3) soluble phosphorus using the Bray and Kurtz No. 1 method described by Laverty (1963), (4) exchangeable potassium using a flame photometer (Jackson 1958), and (5) pH using the glass electrode method (Jackson 1958).

Leaves of five species of plants were collected from each of the four study plots, weighed in the field, air-dried for 2 weeks in paper sacks, and re-weighed to obtain ratios of wet to dry weights. These plant samples were sent to the soils testing laboratory at South Dakota State University and analyzed to determine: (1) nitrogen using the Kjeldahl procedure with copper sulfate and potassium sulfate digestion (Association of Official Agricultural Chemists 1960), (2) phosphorus using the metavanadate yellow procedure after digestion with nitric and perchloric acid (Barton 1948), (3) potassium using a flame photometer after nitric and perchloric acid digestion (Slavin 1962), and (4) calcium as measured by atomic absorption after nitric and perchloric acid digestion (Slavin 1962).

Deer and cattle use of aspen, mixed aspen-pine, and pine communities was estimated using counts of deer pellet groups and cattle chips as described by Bennet et al. (1940) and Hart (1958). Accumulated groups and chips found on the nine belt transects were painted with yellow paint in October 1968. Fresh unpainted groups and chips found on the belt transects in September 1969 and 1970 were painted and recorded.

RESULTS AND DISCUSSION

Overstory Composition and Density

All communities contained a variety of overstory species, but were classified as aspen if the dominant species was aspen, and were classified as pine if the dominant species was pine. Even though the mixed aspen-pine communities appeared visually to be 50 percent aspen and 50 percent pine, the average basal area was 29.4 square feet per acre (22 percent) for aspen and 104.2 square feet per acre (78 percent) for pine (Table 1).

Table 1. Basal area of overstory species for three community types in three study areas, Black Hills, 1970

		Square Feet Per Acre (dbh)		
Area	Community	Aspen[a]	Pine[b]	Total
"A"	Aspen	95.9	3.3	99.2
	Mixed	32.2	122.0	154.2
	Pine	4.0	198.4	202.4
"B"	Aspen	73.4	25.2	98.6
	Mixed	25.4	124.4	149.8
	Pine	2.6	187.1	189.7
"C"	Aspen	61.4	10.0	71.4
	Mixed	30.5	66.3	96.8
	Pine	5.8	143.7	149.5
Average	Aspen	76.9	12.8	89.7
	Mixed	29.4	104.2	133.6
	Pine	4.1	176.4	180.5

[a] Includes birch, bur oak and serviceberry

[b] Includes spruce

Overstory density was least for aspen communities (89.7 square feet per acre), intermediate for mixed aspen-pine (133.6), and greatest for pine (180.5). Analysis of variance (Steel and Torrie 1960) indicated a significant difference ($P < 0.01$) in basal areas between aspen, mixed aspen-pine, and pine communities, and also between study areas "A", "B", and "C". Basal areas for all overstory species in each community of each study area are shown in Appendix Tables 1, 2, and 3.

Overstory horizontal crown cover in the aspen communities averaged 104.7 percent to 83.1 percent for the pine communities (Table 2),

Table 2. Crown cover of overstory species for three community types in three study areas, Black Hills, 1970

		Percent Crown Cover		
Area	Community	Aspen[a]	Pine[b]	Total
"A"	Aspen	107.7[c]	2.3	110.0
	Mixed	55.8	54.4	110.2
	Pine	3.9	82.6	86.5
"B"	Aspen	107.3	18.6	125.9
	Mixed	45.1	63.6	108.7
	Pine	2.6	78.0	80.6
"C"	Aspen	75.1	3.2	78.3
	Mixed	39.1	40.5	79.6
	Pine	11.8	70.4	82.2
Average	Aspen	96.7	8.0	104.7
	Mixed	46.7	52.8	99.6
	Pine	6.1	77.0	83.1

[a] Includes birch, bur oak, and serviceberry

[b] Includes spruce

[c] Cover sometimes exceeds 100 percent due to overlapping crowns of different species

while their respective basal areas were 89.7 and 180.5 square feet per acre (Table 1). For an equivalent basal area, aspen overstories had more than twice the horizontal crown cover of pine overstories. However, vertical crown cover appeared to be much less for the aspen overstories. Crown cover for all overstory species in each community of each study area is shown in Appendix Tables 3, 4, and 5.

Understory Composition and Production

Fifty-nine species of shrubs and forbs were tallied for all communities. Of the 59 species, 54 were tallied for the aspen communities, 49 for the mixed aspen-pine communities, and 39 for the pine communities. Increased sampling probably would have increased the number of species found in all communities, especially the mixed aspen-pine and pine communities; however, the change in cover values would have been negligible.

Percent cover for all understory species was greatest in the aspen communities, intermediate in mixed aspen-pine, and least in the pine communities, averaging 172.65, 140.32, and 68.62 percent. The cover of most species was greatest in the aspen communities; bearberry was a notable exception with 10.17 percent cover in the pine communities and 4.33 percent in the aspen. Species composition and percent cover for understory species in each community of each study area are shown in Appendix Tables 7 through 15.

The five most preferred species listed by Schneeweis (1969) in his summer study of deer food habits in the northern Black Hills generally decreased in abundance from aspen to mixed aspen-pine to pine communities (Table 3). The relative abundance of these preferred species indicates the aspen communities should be preferred feeding areas for deer.

Table 3. Percent cover of five understory species preferred by deer in three community types, Black Hills, 1968 and 1969

	Percent Cover		
Species	Aspen Community	Mixed Community	Pine Community
Vetchling (*Lathyrus ochroleucus*)	11.8	4.8	2.1
Serviceberry (*Amelanchier alnifolia*)	4.6	1.7	2.0
Bur oak (*Quercus macrocarpa*)	0.4	0.0	0.0
American vetch (*Vicia americana*)	1.9	2.0	0.6
Aster (*Aster sp.*)	10.7	4.3	1.1
Average	5.9	2.6	1.2

The total understory production decrease from aspen to mixed aspen-pine to pine communities was significant ($P < 0.01$) using analysis of variance factorial design (Table 4). A significant interaction ($P < 0.01$) also indicated a difference in the rate of change of shrubs versus forbs and grasses. Generally shrub production in the mixed aspen-pine and pine understories did not decrease as rapidly as forb and grass production. While shrub production was 25 percent less in the pine than aspen understories, forb and grass production was 80 percent and 69 percent less, respectively. In his study of aspen and adjacent coniferous forests in Arizona, Reynolds (1969) found 76 percent less forb production and 93 percent less grass production in pine than in aspen understories.

Table 4. Shrub, forb, and grass production for three aspen, mixed aspen-pine, and pine communities, Black Hills, 1968 and 1969

		Production (lb/acre)			
Area	Community	Shrub	Forb	Grass	Total
	Aspen	229	207	56	492
"A"	Mixed	127	145	47	319
	Pine	146	18	12	176
	Aspen	213	195	64	472
"B"	Mixed	171	60	10	241
	Pine	128	38	20	186
	Aspen	179	200	424	803
"C"	Mixed	159	193	333	685
	Pine	189	67	139	395
	Aspen	207	201	181	589
Average	Mixed	152	133	130	415
	Pine	154	41	57	252

Differences in total understory production may have been caused by different overstory densities, as densities of aspen overstories were less than mixed aspen-pine which in turn were less than pine (Fig. 1). Pase (1958), Pearson (1964), and Jameson (1967) in studies of pine communities with variable densities have found understory production inversely related to overstory production.

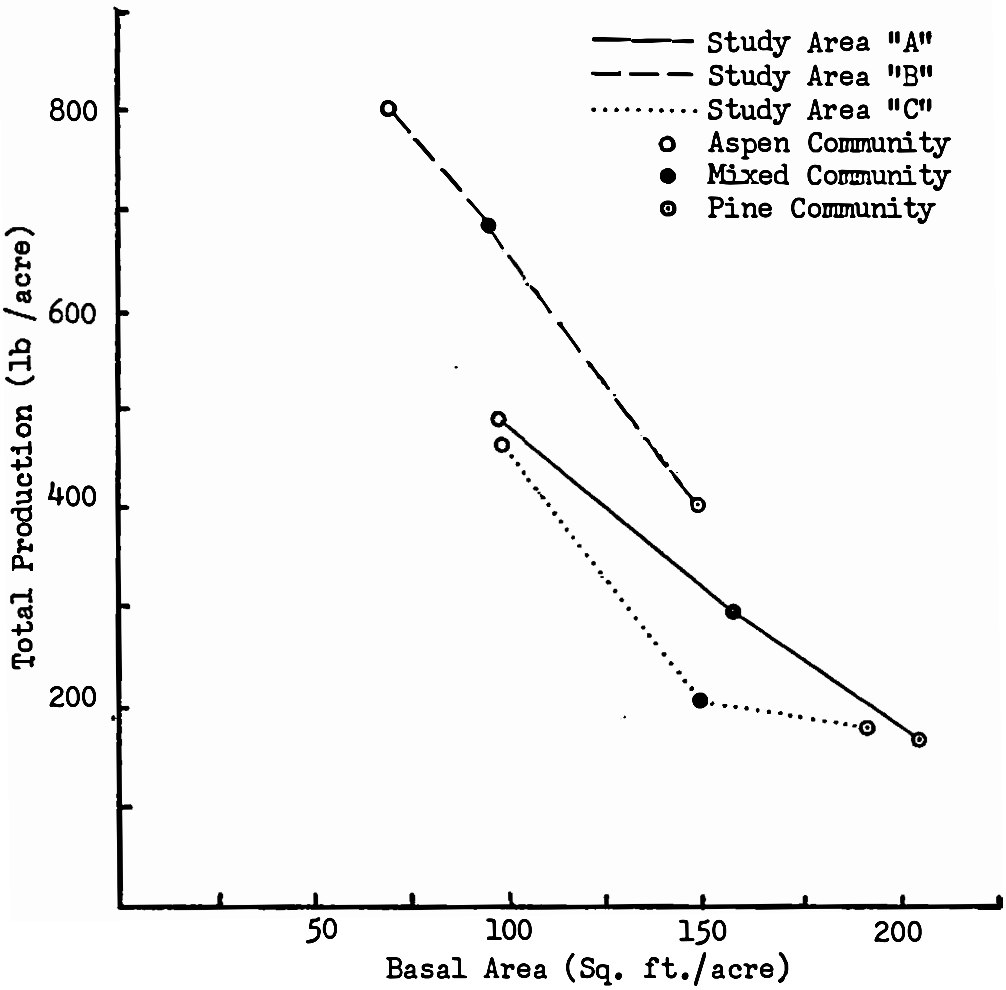

Figure 1. Total understory production (lb/acre air-dried forage) as related to overstory basal area.

Soil Chemistry

The soil chemistry was extremely variable (Table 5), analysis of variance indicating a significant difference ($P < 0.01$) between the three samples within each plot for all chemicals sampled. Zinke (1962) also found that forest soils vary considerably in short distances.

Table 5. Chemical analysis of soils collected from three horizons at four sites in Study Area "C", summer, 1970

	Soil Horizon	Lower Aspen	Upper Aspen	Lower Pine	Upper Pine
Organic matter[a]	A1	8.0	6.7	7.6	7.6
	A2	1.7	1.6	1.9	1.8
	B2	1.2	.7	.7	.5
Nitrate[b]	A1	1.8	2.4	3.5	1.4
	A2	.7	.5	1.1	1.4
	B2	.5	.5	1.0	1.2
Phosphorus[c]	A1	60.0	21.0	41.0	14.0
	A2	29.0	20.0	12.0	7.0
	B2	19.0	4.0	11.0	12.0
Potassium[d]	A1	459.0	425.0	285.0	345.0
	A2	168.0	195.0	168.0	220.0
	B2	405.0	388.0	292.0	391.0
pH	A1	6.0	6.3	6.2	6.4
	A2	6.1	6.3	6.1	6.2
	B2	6.0	6.2	5.6	6.0

[a] Percent Organic Matter by Weight

[b] H_2O Soluable Nitrates; NO_3-N ppm

[c] Soluable Phosphorus; lb/acre

[d] Exchangeable Potassium; lb/acre

Chemical differences between soil horizons (A1, A2, and B2) were significant ($P < 0.01$) for all soil nutrients measured, with the A1 horizon usually ranking highest in nutrients. Soil chemistry varied between aspen and pine and also between upper and lower plots.

Soil organic matter for all plots combined averaged 7.2, 1.8, and 0.8 percent in the A1, A2, and B2 horizons, but was not significantly different ($P > 0.05$) between aspen and pine, or between upper and lower plots. Lutz and Chandler (1946) stated that different species of trees growing under similar conditions appeared to return about the same quantity of organic matter to the soil annually. However, some investigators indicate quality of organic matter is dependent upon the species, with aspen litter generally ranking higher in nutrient content than pine litter (Lutz and Chandler 1946, Daubenmire 1953).

Available soil nitrates for all plots combined averaged 2.3, 0.9, and 0.8 ppm in the A1, A2, and B2 horizons. Nitrate content was significantly greater ($P < 0.05$) in the pine soils averaging 1.6 ppm for the three soil horizons to 1.1 ppm for the aspen soils. Lutz and Chandler (1946) found greater soil nitrates in more open forests, whereas, samples collected from this area indicated greater soil nitrates in the more dense pine community.

Soluble phosphorus in pounds per acre for all plots combined averaged 34, 17, and 11 for the A1, A2, and B2 soil horizons. Phosphorus in the aspen soil was greater than in the pine soil with an average of 25 and 16 pounds per acre, respectively. In addition, soils in the lower elevation plots had higher phosphorus levels than soils in the upper elevation plots, averaging 28 and 13 pounds, respectively. These differences were significant ($P < 0.01$). Several investigators (Lutz and Chandler 1946, Daubenmire 1953) are of the opinion that phosphorus is brought to the surface and deposited more rapidly in aspen litter than coniferous litter. Therefore higher phosphorus levels in the aspen soil could have resulted from either naturally higher soil phosphorus content, and/or greater deposition of phosphorus in the aspen litter.

Exchangeable potassium for all samples combined averaged 378, 188, and 369 pounds per acre for the A1, A2, and B2 soil horizons. Soil potassium was significantly greater ($P < 0.05$) in the aspen plots averaging 340 pounds per acre to 283 pounds for the pine plots. Lutz and Chandler (1946) and Daubenmire (1953) stated that aspen litter was richer in potassium than pine litter. Therefore higher potassium levels in the aspen soil could have resulted from either naturally greater soil potassium, and/or greater deposition of potassium in aspen litter.

The soil pH in the A1, A2, and B2 soil horizons for all samples combined averaged 6.2, 6.2, and 5.9, respectively. Lutz and Chandler (1946) and Voigt et al. (1957) found the opposite with the B2 horizon having the highest pH. In addition the A1 horizon in the pine samples had a significantly higher ($P < 0.05$) pH than the aspen A1 horizon. This also was opposite that expressed by Lutz and Chandler, who stated that aspen litter increased pH in the upper soil horizons.

Plant Chemistry

Analysis of variance indicated wet-to-dry weight ratios were significantly different ($P < 0.05$) between samples from aspen and pine communities (Table 6). The greatest difference was noted for new Oregon grape leaves which were less mature in the aspen area.

Table 6. Plant chemistry for five species from four sites in Study Area "C", summer, 1970

	Species	Lower Aspen	Upper Aspen	Lower Pine	Upper Pine
Wet-Dry Weight Ratio	Ricegrass	2.14	2.14	2.16	2.17
	Vetchling	2.97	3.05	3.00	2.82
	Bearberry	2.13	2.14	2.24	2.14
	New Oregon grape[a]	3.12	3.01	2.87	2.90
	Old Oregon grape[b]	2.05	2.02	2.08	2.00
Nitrogen (Percent)	Ricegrass	1.72	1.77	1.71	1.69
	Vetchling	3.25	3.39	3.23	3.07
	Bearberry	1.10	1.13	1.10	1.02
	New Oregon grape	2.35	2.19	2.20	2.22
	Old Oregon grape	1.81	1.81	1.84	1.50
Protein[c] (Percent)	Ricegrass	10.8	11.1	10.7	10.6
	Vetchling	20.3	21.2	20.2	19.2
	Bearberry	6.9	7.1	6.9	6.4
	New Oregon grape	14.7	13.7	13.8	13.9
	Old Oregon grape	11.3	11.3	11.5	9.4
Phosphorus (Percent)	Ricegrass	.199	.243	.183	.230
	Vetchling	.184	.201	.141	.164
	Bearberry	.150	.155	.150	.145
	New Oregon grape	.271	.228	.245	.285
	Old Oregon grape	.198	.227	.206	.199
Potassium (Percent)	Ricegrass	1.48	1.43	1.45	1.50
	Vetchling	1.87	1.87	1.59	1.87
	Bearberry	.60	.73	.66	.63
	New Oregon grape	1.33	1.30	1.14	1.29
	Old Oregon grape	.81	.81	.76	.64
Calcium (Percent)	Ricegrass	.27	.29	.27	.26
	Vetchling	1.51	1.52	1.51	1.93
	Bearberry	.66	.66	.61	.63
	New Oregon grape	.26	.24	.28	.24
	Old Oregon grape	.53	.53	.47	.58

[a] New Oregon grape consists of current year's leaves

[b] Old Oregon grape consists of previous year's leaves

[c] Percent protein = percent nitrogen x 6.25

Percent nitrogen averaged significantly greater ($P < 0.05$) in the plants sampled from the aspen plots (Table 6). Plants sampled from the aspen plots averaged 2.05 percent nitrogen; those from pine plots averaged 1.96 percent. This was the reverse of soil nitrogen, as the pine soils had more nitrogen.

Protein content of plants sampled from the aspen plots was slightly greater than samples from the pine plots, averaging 12.8 and 12.2 percent, respectively (Table 6). Vetchling had the highest protein level and bearberry the lowest, averaging 20.2 and 6.8 percent, respectively. Protein is essential for growth and antler development of deer, with from 13 to 16 percent in the diet considered optimum (Magruder et al. 1957).

Plant phosphorus is also important to growth and antler development of deer. Optimum deer growth is obtained at about 0.56 percent phosphorus with stunted growth occurring on diets with phosphorus levels below 0.30 percent (Magruder et al. 1957). All five plant species at the time of sampling were below minimum levels with new leaves of Oregon grape having the highest level at 0.26 percent (Table 6). Samples of plant species collected from the aspen plots averaged significantly ($P < 0.05$) higher phosphorus levels than plants from the pine plots. However, bearberry showed little difference in phosphorus levels between aspen and pine plots, while vetchling showed the greatest difference. In addition to the difference between aspen and pine plots, there was also a significant difference ($P < 0.01$) between phosphorus levels in the plants of the upper and lower plots. The plants from the upper plots had more phosphorus, except for bearberry, which did not show a difference with position on the slope.

Plant potassium in percent for all samples combined averaged 1.19 for the five species, with a low of 0.66 for bearberry and a high of 1.80 for vetchling (Table 6). Plant potassium was significantly greater ($P < 0.05$) in the aspen than in the pine plots; however, most of the difference was found in vetchling and Oregon grape.

Plant calcium in percent for all samples combined averaged 0.67 for all species, with a low of 0.26 for new Oregon grape leaves and a high of 1.62 for vetchling (Table 6). No significant difference ($P > 0.05$) was noted between the average plant calcium of the aspen plots and the pine plots; however, vetchling calcium was considerably greater in the upper pine plot. Since soil calcium was not measured this variation is not explained.

Deer and Cattle Use

Pellet group and cattle chip counts made in 1969 and 1970 were used to estimate preference for the community types by deer and cattle. I believe deer defecate mostly while feeding, whereas cattle defecate when feeding and loafing. The term "use" is meant to include both feeding and loafing. Analysis of variance using orthogonal comparisons indicated mixed aspen-pine communities had significantly ($P < 0.01$) more use by deer than aspen or pine communities (Table 7). Aspen communities had significantly ($P < 0.05$)

Table 7. Deer pellet groups found on belt transects in three community types of three study areas, Black Hills, 1969 and 1970

Area "A"			Area "B"			Area "C"		
Aspen	Mixed	Pine	Aspen	Mixed	Pine	Aspen	Mixed	Pine
50	60	15	26	39	27	30	53	31

greater use than pine communities. The high counts associated with mixed aspen-pine communities suggest use by deer was not governed by single factors such as overstory type, overstory density, or understory production, but by multiple habitat factors including overstory type, overstory density, and understory production. Annual pellet group counts for each community of each study area are shown in Appendix Table 16.

Assuming a defecation rate of 13 pellet groups per deer per day (Hart 1958), deer use was estimated at 9.9 days per acre per year for the aspen communities, 12.9 for the mixed aspen-pine, and 6.8 for the pine communities. These are considerably less than the average of 25.8 deer days per acre per year for all of the Black Hills as found using 107 belt transects in 1970 (Thompson and Hausle 1971). However, the presence of cattle on the areas may have reduced usage by deer. Also, these areas are summer range only, while the 107 belt transects include some of the more heavily used winter ranges.

Cattle use was estimated through chip counts in the same manner as deer pellet group counts (Table 8). Counts were significantly different ($P < 0.05$) between communities with 84 chips found in the

Table 8. Cattle chips found on belt transects in three community types of three study areas, Black Hills, 1969 and 1970

Area "A"			Area "B"			Area "C"		
Aspen	Mixed	Pine	Aspen	Mixed	Pine	Aspen	Mixed	Pine
9	11	2	22	5	4	53	50	15

aspen, 66 in the mixed aspen-pine, and 21 in the pine. These counts were correlated ($P < 0.01$) with understory grass production with a correlation coefficient of $r = 0.95$. Other investigators have also shown a close relationship between grass production and cattle use (Julander 1955, Reynolds 1966). Annual chip counts for each community of each study area are shown in Appendix Table 17.

Assuming a defecation rate of 12 chips per cow per day (Fuller 1928 as in U. S. Dept. of Agric. 1963), cattle use was estimated at 7.8 days per acre per year for the aspen communities, 6.1 for the mixed aspen-pine, and 2.0 for the pine communities.

CONCLUSIONS

The aspen communities studied appeared to represent subclimax communities with ponderosa pine as the climax species. Overstory basal areas (sq. ft./acre, dbh) were least in the aspen communities, intermediate in the mixed aspen-pine, and greatest in the pine communities, averaging 89.7, 133.6, and 180.5, respectively. Total understory production (lb/acre air-dried forage) was greatest in the aspen communities, intermediate in the mixed aspen-pine, and least in the pine communities, averaging 589, 415, and 252. However, most, if not all, of the greater understory production in the aspen communities probably resulted from less dense overstories, and if the pine overstories had been thinned to the same density as the aspen overstories, both communities may have produced similar quantities of understory plants.

Understory plant species had different chemical reactions to various overstories and soil factors. Bearberry chemical composition did not change with overstory type, overstory density or soil chemical composition, whereas, vetchling chemical composition often changed significantly with these factors. Soil chemistry was variable within and between communities. Most of the variations could not be explained.

Deer use of the three types of communities, estimated by density of pellet groups, indicated the mixed aspen-pine communities, aspen communities, and pine communities were preferred in that order.

Preference for the mixed aspen-pine communities indicated use by deer was not governed by single habitat factors such as overstory type, overstory density or understory production, but by multiple factors which may include overstory type, overstory density, and understory production. Cattle use of the three types of communities, estimated by density of chips, indicated the aspen communities, mixed aspen-pine communities, and pine communities were preferred in that order. Cattle use was directly related to understory grass production.

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APPENDIX

Appendix Table 1. Basal area of overstory species for the aspen community in each study area, summer, 1970

Species	Square Feet Per Acre (dbh)			
	Area "A"	Area "B"	Area "C"	Average
Aspen (Populus tremuloides)	42.4	51.3	41.9	45.2
Ponderosa pine (Pinus ponderosa)	3.3	25.2	1.9	10.1
Paper birch (Betula papyrifera)	45.9	20.8	19.3	28.7
Bur oak (Quercus macrocarpa)	6.9	.1	0	2.3
Serviceberry (Amelanchier alnifolia)	.7	1.2	.2	.7
White spruce (Picea glauca)	0	0	8.1	2.7
Totals	99.2	98.6	71.4	89.7

Appendix Table 2. Basal area of overstory species for the mixed aspen-pine community in each study area, summer, 1970

Species	Square Feet Per Acre (dbh)			
	Area "A"	Area "B"	Area "C"	Average
Aspen (*Populus tremuloides*)	22.7	20.9	28.3	24.0
Ponderosa pine (*Pinus ponderosa*)	121.7	124.4	65.0	103.7
Paper birch (*Betula papyrifera*)	8.5	4.5	2.2	5.1
Bur oak (*Quercus macrocarpa*)	1.0	0	0	.3
White spruce (*Picea glauca*)	.3	0	1.3	.5
Totals	154.2	149.8	96.8	133.6

Appendix Table 3. Basal area of overstory species for the pine community in each study area, summer, 1970

Species	Square Feet Per Acre (dbh)			
	Area "A"	Area "B"	Area "C"	Average
Aspen (Populus tremuloides)	3.8	1.2	5.0	3.3
Ponderosa pine (Pinus ponderosa)	198.2	187.1	143.7	176.3
Paper birch (Betula papyrifera)	.2	1.4	.8	.8
White spruce (Picea glauca)	.2	0	0	.1
Totals	202.4	189.7	149.5	180.5

Appendix Table 4. Crown cover of overstory species for the aspen community in each study area, summer, 1970

	Percent Crown Cover			
Species	Area "A"	Area "B"	Area "C"	Average
Aspen (*Populus tremuloides*)	38.0	62.2	49.7	50.0
Ponderosa pine (*Pinus ponderosa*)	2.3	18.6	.3	7.1
Paper birch (*Betula papyrifera*)	60.5	39.9	25.4	41.9
Bur oak (*Quercus macrocarpa*)	7.1	0	0	2.4
Serviceberry (*Amelanchier alnifolia*)	2.1	5.2	0	2.4
White spruce (*Picea glauca*)	0	0	2.9	1.0
Totals	110.0	125.9	78.3	104.7
Open Area	11.4	8.5	29.0	16.3
Species Overlap	21.4	34.4	7.3	21.0

Appendix Table 5. Crown cover of overstory species for the mixed aspen-pine community in each study area, summer, 1970

Species	Percent Crown Cover			
	Area "A"	Area "B"	Area "C"	Average
Aspen (*Populus tremuloides*)	32.1	31.1	33.0	32.1
Ponderosa pine (*Pinus ponderosa*)	54.4	63.6	40.5	52.8
Paper birch (*Betula papyrifera*)	23.2	13.7	6.1	14.3
Bur oak (*Quercus macrocarpa*)	.5	0	0	.2
Serviceberry (*Amelanchier alnifolia*)	0	.3	0	.1
Totals	110.2	108.7	79.6	99.5
Open Area	10.0	8.7	27.7	15.5
Species Overlap	20.2	17.4	7.3	15.0

Appendix Table 6. Crown cover of overstory species for the pine community in each study area, summer 1970

	Percent Crown Cover			
Species	Area "A"	Area "B"	Area "C"	Average
Aspen (Populus tremuloides)	3.4	1.1	6.2	3.6
Ponderosa pine (Pinus ponderosa)	82.2	78.0	70.4	76.9
Paper birch (Betula papyrifera)	.5	1.5	5.6	2.5
White spruce (Picea glauca)	.4	0	0	.1
Totals	86.5	80.6	82.2	83.1
Open Area	16.4	20.0	22.8	19.7
Species Overlap	2.9	.6	5.0	2.8

Appendix Table 7. Percent cover and dry weight production of understory species in Area "A" aspen community, summer, 1968

Species	Percent Cover	Lb/Acre[a] Production
Shrub Species		
Filbert (Corylus cornuta)	23.60	
Oregon grape (Mahonia repens)	12.35	
Snowberry (Symphoricarpos sp.)	7.65	
Serviceberry (Amelanchier alnifolia)	5.70	
Wild rose (Rosa sp.)	2.50	
Spiraea (Spiraea lucida)	2.50	
Aspen (Populus tremuloides)	1.55	
Prince's pine (Chimaphila umbellata)	.65	
Chokecherry (Prunus virginiana)	.20	
Ponderosa pine (Pinus ponderosa)	.15	
Bur oak (Quercus macrocarpa)	.05	
Thimbleberry (Rubus parviflorus)	.05	
Subtotal	56.95	229
Forb Species		
Aster (Aster sp.)	20.55	
Vetchling (Lathyrus ochroleucus)	15.90	
Pasture brake (Pteridium aquilinum)	15.80	
Clover (Trifolium repens)	9.90	
Meadowrue (Thalictrum venulosum)	7.05	
Wild bergamot (Monarda fistulosa)	3.75	
Black snakeroot (Sanicula marylandica)	3.65	
Wild strawberry (Fragaria ovalis)	3.45	
Dwarf blueberry (Vaccinium scoparium)	3.15	
Lupine (Lupinus argenteus)	2.50	

Appendix Table 7. (Continued)

Species	Percent Cover	Lb/Acre[a] Production
	Forb Species	
Yarrow (*Achillea lanulosa*)	2.30	
Wild sarsaparilla (*Aralia nudicaulis*)	2.25	
Wild-lily-of-the-valley (*Maianthemum canadense*)	1.80	
Dogbane (*Apocynum androsaemifolium*)	1.70	
Shinleaf (*Pyrola* sp.)	1.70	
Arnica (*Arnica cordifolia*)	1.30	
American vetch (*Vicia americana*)	.90	
Spurred gentian (*Halenia deflexa*)	.85	
Yellow mandarin (*Disporum lanuginosum*)	.60	
Bedstraw (*Galium boreale*)	.30	
Dandelion (*Taraxacum officinale*)	.30	
Anemone (*Anemone globosa*)	.15	
Bluebell (*Campanula rotundifolia*)	.05	
False solomon's seal (*Smilacina stellata*)	.05	
Fringed sage (*Artemisia ludoviciana*)	.05	
Violet (*Viola* sp.)	.05	
Subtotal	100.05	207
	Grasses and Sedges	
(Several species)	13.20	
Subtotal	13.20	56
Total	170.20	492

[a] Lb/Acre not measured for individual species

Appendix Table 8. Percent cover and dry weight production of understory species in Area "A" mixed aspen-pine community, summer, 1968

Species	Percent Cover	Lb/Acre[a] Production
Shrub Species		
Oregon grape (*Mahonia repens*)	16.80	
Spiraea (*Spiraea lucida*)	11.25	
Snowberry (*Symphoricarpos* sp.)	9.40	
Wild rose (*Rosa* sp.)	2.25	
Juniper (*Juniperus* sp.)	2.05	
Serviceberry (*Amelanchier alnifolia*)	1.35	
Paper birch (*Betula papyrifera*)	1.25	
Bearberry (*Arctostaphylos uva-ursi*)	1.10	
Aspen (*Populus tremuloides*)	.90	
Chokecherry (*Prunis virginiana*)	.35	
Prince's pine (*Chimaphila umbellata*)	.05	
Bur oak (*Quercus macrocarpa*)	.05	
Subtotal	46.80	127
Forb Species		
Clover (*Trifolium repens*)	14.80	
Pasture brake (*Pteridium aquilinum*)	9.40	
Aster (*Aster* sp.)	7.25	
Arnica (*Arnica cordifolia*)	5.35	
Wild-lily-of-the-valley (*Maianthemum canadense*)	3.70	
Yarrow (*Achillea lanulosa*)	2.40	
Wild bergamot (*Monarda fistulosa*)	2.35	
Bedstraw (*Galium boreale*)	1.75	
Dwarf raspberry (*Rubus pubescens*)	1.55	
Wild strawberry (*Fragaria ovalis*)	1.30	

Appendix Table 8. (Continued)

Species	Percent Cover	Lb/Acre[a] Production
Forb Species		
Vetchling (*Lathyrus ochroleucus*)	1.25	
American vetch (*Vicia americana*)	.95	
Hawkweed (*Hieracium* sp.)	.75	
Meadowrue (*Thalictrum venulosum*)	.60	
Lupine (*Lupinus argenteus*)	.40	
Bluebell (*Campanula rotundifolia*)	.35	
Dandelion (*Taraxacum officinale*)	.35	
Fringed sage (*Artemisia ludoviciana*)	.30	
Violet (*Viola* sp.)	.30	
Pussytoes (*Antennaria* sp.)	.10	
Spurred gentian (*Halenia deflexa*)	.10	
Dogbane (*Apocynum androsaemifolium*)	.05	
Shinleaf (*Pyrola* sp.)	.05	
Subtotal	55.40	145
Grasses and Sedges		
(Several species)	17.65	
Subtotal	17.65	47
Total	119.85	319

[a] Lb/Acre not measured for individual species

Appendix Table 9. Percent cover and dry weight production of understory species in Area "A" pine community, summer, 1968

Species	Percent Cover	Lb/Acre[a] Production
Shrub Species		
Oregon grape (Mahonia repens)	12.85	
Spiraea (Spiraea lucida)	8.40	
Snowberry (Symphoricarpos sp.)	5.85	
Juniper (Juniperus sp.)	3.45	
Serviceberry (Amelanchier alnifolia)	2.85	
Wild rose (Rosa sp.)	2.30	
Chokecherry (Prunis virginiana)	1.35	
Bearberry (Arctostaphylos uva-ursi)	.75	
Poison ivy (Rhus radicans)	.30	
Aspen (Populus tremuloides)	.15	
Subtotal	38.25	146
Forb Species		
Aster (Aster sp.)	1.70	
American vetch (Vicia americana)	.75	
Wild bergamot (Monarda fistulosa)	.70	
Bedstraw (Galium boreale)	.35	
Pussytoes (Antennaria sp.)	.20	
Yarrow (Achillea lanulosa)	.10	
Violet (Viola sp.)	.10	
Dogbane (Apocynum androsaemifolium)	.05	
Subtotal	3.95	18
Grasses and Sedges		
(Several species)	5.80	
Subtotal	5.80	12
Total	48.00	176

[a] Lb/Acre not measured for individual species

Appendix Table 10. Percent cover and dry weight production of understory species in Area "B" aspen community, summer, 1968

Species	Percent Cover	Lb/Acre[a] Production
Shrub Species		
Oregon grape (*Mahonia repens*)	12.35	
Filbert (*Corylus cornuta*)	10.85	
Snowberry (*Symphoricarpos* sp.)	7.55	
Serviceberry (*Amelanchier alnifolia*)	6.80	
Hop hornbeam (*Ostrya virginiana*)	5.85	
Spiraea (*Spiraea lucida*)	5.65	
Wild rose (*Rosa* sp.)	2.95	
Chokecherry (*Prunis virginiana*)	2.75	
Bearberry (*Arctostaphylos uva-ursi*)	1.45	
Bur oak (*Quercus macrocarpa*)	1.30	
Dwarf blueberry (*Vaccinium scoparium*)	1.15	
Paper birch (*Betula papyrifera*)	.35	
Aspen (*Populus tremuloides*)	.10	
Thimbleberry (*Rubus parviflorus*)	.05	
	59.15	213
Forb Species		
Clover (*Trifolium repens*)	19.65	
Vetchling (*Lathyrus ochroleucus*)	12.45	
Aster (*Aster* sp.)	9.70	
Pasture brake (*Pteridium aquilinum*)	8.80	
Meadowrue (*Thalictrum venulosum*)	6.65	
Lupine (*Lupinus argenteus*)	4.65	
American vetch (*Vicia americana*)	4.40	
Wild bergamot (*Monarda fistulosa*)	3.75	
Wild strawberry (*Fragaria ovalis*)	2.05	

Appendix Table 10. (Continued)

Species	Percent Cover	Lb/Acre[a] Production
Forb Species		
Wild-lily-of-the-valley (Maianthemum canadense)	2.05	
Dwarf raspberry (Rubus pubescens)	1.90	
Anemone (Anemone globosa)	1.70	
Dandelion (Taraxacum officinale)	1.60	
Yarrow (Achillea lanulosa)	1.50	
Arnica (Arnica cordifolia)	1.30	
Bluebell (Campanula rotundifolia)	1.05	
False solomon's seal (Smilacina stellata)	.80	
Bedstraw (Galium boreale)	.75	
Black snakeroot (Sanicula marylandica)	.60	
Everlasting (Anaphalis margaritacea)	.40	
Beard tongue (Penstemon glaber)	.35	
Wild sarsaparilla (Aralia nudicaulis)	.30	
Shinleaf (Pyrola sp.)	.30	
Dogbane (Apocynum androsaemifolium)	.05	
Yellow mandarin (Disporum lanuginosum)	.05	
Subtotal	86.80	195
Grasses and Sedges		
(Several species)	22.15	
Subtotal	22.15	64
Total	168.10	472

[a] Lb/Acre not measured for individual species

Appendix Table 11. Percent cover and dry weight production of understory species in Area "B" mixed aspen-pine community, summer, 1968

Species	Percent Cover	Lb/Acre[a] Production
Shrub Species		
Bearberry (*Arctostaphylos uva-ursi*)	12.90	
Oregon grape (*Mahonia repens*)	11.45	
Snowberry (*Symphoricarpos* sp.)	9.20	
Spiraea (*Spiraea lucida*)	6.65	
Dwarf blueberry (*Vaccinium scoparium*)	2.30	
Serviceberry (*Amelanchier alnifolia*)	2.05	
Chokecherry (*Prunis virginiana*)	2.00	
Juniper (*Juniperus* sp.)	1.75	
Wild rose (*Rosa* sp.)	.65	
Aspen (*Populus tremuloides*)	.60	
Ponderosa pine (*Pinus ponderosa*)	.45	
Subtotal	50.00	171
Forb Species		
Vetchling (*Lathyrus ochroleucus*)	6.75	
Lupine (*Lupinus argenteus*)	3.80	
Clover (*Trifolium repens*)	3.30	
Pasture brake (*Pteridium aquilinum*)	3.05	
American vetch (*Vicia americana*)	2.75	
Aster (*Aster* sp.)	1.60	
Wild bergamot (*Monarda fistulosa*)	1.40	
Meadowrue (*Thalictrum venulosum*)	1.40	
Pussytoes (*Antennaria* sp.)	1.05	
Everlasting (*Anaphalis margaritacea*)	.70	
Wild strawberry (*Fragaria ovalis*)	.65	

Appendix Table 11. (Continued)

Species	Percent Cover	Lb/Acre[a] Production
Forb Species		
Hawkweed (*Hieracium* sp.)	.65	
Violet (*Viola* sp.)	.45	
Yarrow (*Achillea lanulosa*)	.35	
Bedstraw (*Galium boreale*)	.35	
Dogbane (*Apocynum androsaemifolium*)	.30	
Wild-lily-of-the-valley (*Maianthemum canadense*)	.05	
False Solomon's seal (*Smilacina stellata*)	.05	
Subtotal	28.65	60
Grasses and Sedges		
(Several species)	11.75	
Subtotal	11.75	10
Total	90.40	241

[a] Lb/Acre not measured for individual species

Appendix Table 12. Percent cover and dry weight production of understory species in Area "B" pine community, summer, 1968

Species	Percent Cover	Lb/Acre Production
Shrub Species		
Oregon grape (*Mahonia repens*)	10.70	
Spiraea (*Spiraea lucida*)	8.55	
Juniper (*Juniperus* sp.)	3.95	
Bearberry (*Arctostaphylos uva-ursi*)	2.45	
Serviceberry (*Amelanchier alnifolia*)	1.80	
Snowberry (*Symphoricarpos* sp.)	1.00	
Wild rose (*Rosa* sp.)	.80	
Chokecherry (*Prunis virginiana*)	.70	
Ponderosa pine (*Pinus ponderosa*)	.10	
Subtotal	30.05	128
Forb Species		
Yarrow (*Achillea lanulosa*)	1.65	
Lupine (*Lupinus argenteus*)	1.20	
Aster (*Aster* sp.)	.75	
Wild strawberry (*Fragaria ovalis*)	.75	
Pasture brake (*Pteridium aquilinum*)	.75	
Vetchling (*Lathyrus ochroleucus*)	.70	
Meadowrue (*Thalictrum venulosum*)	.65	
Clover (*Trifolium repens*)	.60	
Arnica (*Arnica cordifolia*)	.40	
Wild bergamot (*Monarda fistulosa*)	.30	
Spurred gentian (*Halenia deflexa*)	.10	
Indian paintbrush (*Castellija coccinea*)	.05	
Violet (*Viola* sp.)	.05	
Subtotal	7.95	38
Grasses and Sedges		
(Several species)	2.35	
Subtotal	2.35	20
Total	40.35	186

[a] Lb/Acre not measured for individual species

Appendix Table 13. Percent cover and dry weight production of understory species in Area "C" aspen community, summer, 1969

Species	Percent Cover	Lb/Acre[a] Production
Shrub Species		
Bearberry (Arctostaphylos uva-ursi)	11.55	
Oregon grape (Mahonia repens)	10.65	
Snowberry (Symphoricarpos sp.)	3.25	
Wild rose (Rosa sp.)	2.80	
Twinflower (Linnaea borealis)	1.85	
Serviceberry (Amelanchier alnifolia)	1.30	
Spiraea (Spiraea lucida)	1.20	
Russet buffaloberry (Shepherdia sp.)	1.05	
White spruce (Picea glauca)	.75	
Aspen (Populus tremuloides)	.70	
Ponderosa pine (Pinus ponderosa)	.10	
Paper birch (Betula papyrifera)	.05	
Filbert (Corylus cornuta)	.05	
Subtotal	35.30	179
Forb Species		
Clover (Trifolium repens)	32.70	
Milk vetch (Astragalus sp.)	6.80	
Vetchling (Lathyrus ochroleucus)	7.15	
Wild sarsaparilla (Aralia nudicaulis)	5.20	
Wild strawberry (Fragaria ovalis)	4.50	
Aster (Aster sp.)	1.95	
Wild-lily-of-the-valley (Maianthemum canadense)	1.90	
Yarrow (Achillea lanulosa)	1.65	
Wild bergamot (Monarda fistulosa)	1.30	
Bedstraw (Galium boreale)	1.25	

Appendix Table 13. (Continued)

Species	Percent Cover	Lb/Acre[a] Production
Forb Species		
Dandelion (*Taraxacum officinale*)	1.20	
Thistle (*Cirsium* sp.)	1.05	
Shinleaf (*Pyrola* sp.)	.90	
Meadowrue (*Thalictrum venulosum*)	.80	
Hawkweed (*Hieracium* sp.)	.70	
American vetch (*Vicia americana*)	.45	
Gentian (*Gentiana* sp.)	.35	
Dwarf raspberry (*Rubus pubescens*)	.35	
Golden alexander (*Zizia aptera*)	.35	
Everlasting (*Anaphalis margaritacea*)	.30	
Pussytoes (*Antennaria* sp.)	.30	
False solomon's seal (*Smilacina stellata*)	.25	
Black snakeroot (*Sanicula marlandica*)	.20	
Anemone (*Anemone globosa*)	.15	
Indian paintbrush (*Castilleja coccinea*)	.05	
Bunchberry (*Cornus canadensis*)	.05	
Subtotal	71.85	200
Grasses and Sedges		
(Several species)	72.50	
Subtotal	72.50	424
Total	179.65	803

[a] Lb/Acre not measured for individual species

Appendix Table 14. Percent cover and dry weight production of understory species in Area "C" mixed aspen-pine community, summer, 1969

Species	Percent Cover	Lb/Acre[a] Production
Shrub Species		
Bearberry (*Arctostaphylos uva-ursi*)	27.30	
Oregon grape (*Mahonia repens*)	8.50	
Snowberry (*Symphoricarpos* sp.)	6.10	
Wild rose (*Rosa* sp.)	3.50	
Serviceberry (*Amelanchier alnifolia*)	1.60	
Spiraea (*Spiraea lucida*)	1.45	
Ponderosa pine (*Pinus ponderosa*)	1.10	
Aspen (*Populus tremuloides*)	.35	
Russet buffaloberry (*Shepherdia* sp.)	.30	
Subtotal	50.20	159
Forb Species		
Clover (*Trifolium repens*)	26.85	
Yarrow (*Achillea lanulosa*)	12.30	
Vetchling (*Lathyrus ochroleucus*)	6.45	
Wild bergamot (*Monarda fistulosa*)	5.85	
Milk vetch (*Astragalus* sp.)	5.30	
Wild strawberry (*Fragaria ovalis*)	4.70	
Aster (*Aster* sp.)	4.05	
Bedstraw (*Galium boreale*)	3.25	
Everlasting (*Anaphalis margaritacea*)	2.70	
American vetch (*Vicia americana*)	2.40	
Bluebell (*Campanula rotundifolia*)	1.60	
Dandelion (*Taraxacum officinale*)	1.60	
Meadowrue (*Thalictrum venulosum*)	1.10	
Fringed sage (*Artemisia ludoviciana*)	1.05	

Appendix Table 14. (Continued)

Species	Percent Cover	Lb/Acre[a] Production
Forb Species		
Shooting star (*Dodecatheon* sp.)	1.05	
Wild sarsaparilla (*Aralia nudicaulis*)	.75	
False solomon's seal (*Smilacina stellata*)	.70	
Wild-lily-of-the-valley (*Maianthemum canadense*)	.50	
Lupine (*Lupinus argenteus*)	.10	
Black snakeroot (*Sanicula marlandica*)	.10	
Golden alexander (*Zizia aptera*)	.10	
Anemone (*Anemone globosa*)	.05	
Gentian (*Gentiana* sp.)	.05	
Bunchberry (*Cornus canadensis*)	.05	
Hawkweed (*Hieracium* sp.)	.05	
Unidentified forb	.05	
Subtotal	82.75	193
Grasses and Sedges		
(Several species)	77.75	
Subtotal	77.75	333
Total	210.70	685

[a] Lb/Acre not measured for individual species

Appendix Table 15. Percent cover and dry weight production of understory species in Area "C" pine community, summer, 1969

Species	Percent Cover	Lb/Acre[a] Production
Shrub Species		
Bearberry (Arctostaphylos uva-ursi)	42.95	
Oregon grape (Mahonia repens)	6.65	
Snowberry (Symphoricarpos sp.)	3.10	
Juniper (Juniperus sp.)	1.70	
Spiraea (Spiraea lucida)	1.45	
Wild rose (Rosa sp.)	1.35	
Serviceberry (Amelanchier alnifolia)	1.30	
Ponderosa pine (Pinus ponderosa)	.70	
Twinflower (Linnaea borealis)	.60	
Aspen (Populus tremuloides)	.40	
Subtotal	60.20	189
Forb Species		
Clover (Trifolium repens)	7.00	
Vetchling (Lathyrus ochroleucus)	5.50	
Yarrow (Achillea lanulosa)	2.85	
Wild strawberry (Fragaria ovalis)	1.55	
Bedstraw (Galium boreale)	1.15	
Shooting star (Dodecatheon sp.)	1.10	
American vetch (Vicia americana)	1.00	
Aster (Aster sp.)	.95	
Wild bergamot (Monarda fistulosa)	.95	
Milk vetch (Astragalus sp.)	.70	
Golden alexander (Zizia aptera)	.40	
Everlasting (Anaphalis margaritacea)	.10	

Appendix Table 15. (Continued)

Species	Percent Cover	Lb/Acre[a] Production
Forb Species		
Anemone (*Anemone globosa*)	.10	
Pussytoes (*Antennaria* sp.)	.10	
Wild sarsaparilla (*Aralia nudicaulis*)	.05	
Gentian (*Gentiana* sp.)	.05	
Wild-lily-of-the-valley (*Maianthemum canadense*)	.05	
Black snakeroot (*Sanicula marylandica*)	.05	
False solomon's seal (*Smilacina stellata*)	.05	
Subtotal	23.70	67
Grasses and Sedges		
(Several species)	33.60	
Subtotal	33.60	139
Total	117.50	395

[a] Lb/Acre not measured for individual species

Appendix Table 16. Deer usage measured by pellet group counts

Area		Number of Pellet Groups		
		1969[a]	1970[b]	1969 & 1970
Area "A"	Aspen Transect	22	28	50
	Mixed Transect	22	38	60
	Pine Transect	4	11	15
Area "B"	Aspen Transect	17	9	26
	Mixed Transect	26	13	39
	Pine Transect	22	5	27
Area "C"	Aspen Transect	15	15	30
	Mixed Transect	32	21	53
	Pine Transect	12	19	31
Total Areas "A","B", "C"	Aspen Transect	54	52	106
	Mixed Transect	80	72	152
	Pine Transect	38	35	73

[a] October 29, 1968, to September 10, 1969

[b] September 10, 1969, to September 5, 1970

Appendix Table 17. Cattle usage measured by chip counts

Area		Number of Pellet Groups		
		1969[a]	1970[b]	1969 & 1970
Area "A"	Aspen Transect	3	6	9
	Mixed Transect	8	3	11
	Pine Transect	1	1	2
Area "B"	Aspen Transect	10	12	22
	Mixed Transect	5	0	5
	Pine Transect	0	4	4
Area "C"	Aspen Transect	27	26	53
	Mixed Transect	19	31	50
	Pine Transect	2	13	15
Total Areas "A", "B", "C"	Aspen Transect	40	44	84
	Mixed Transect	32	34	66
	Pine Transect	3	18	21

[a] October 29, 1968, to September 10, 1969

[b] September 10, 1969, to September 5, 1970