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# Forest Vegetation of the Black Hills National Forest of South Dakota and Wyoming: A Habitat Type Classification

George R. Hoffman and Robert R. Alexander



### **Abstract**

A vegetation classification based on concepts and methods developed by Daubenmire was used to identify 12 forest habitat types and one shrub habitat type in the Black Hills. Included were two habitat types in the *Quercus macrocarpa* series, seven in the *Pinus ponderosa* series, one in the *Populus tremuloides* series, two in the *Picea glauca* series, and one in the *Cercocarpus montanus* series. A key to identify the habitat types and the management implications associated with each are provided.

**Cover Photo.—View of Hamey Peak, and former lookout, as seen from Limestone Hills west of Custer. Nearly all the forest area seen is dominated by *Pinus ponderosa*.**

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## INTRODUCTION

Many earlier studies of forest vegetation of the Black Hills have been conducted, but this study provides a comprehensive categorization and description of the forest vegetation based on quantitative data and Daubenmire methodology. Most of these earlier studies of Black Hills vegetation had floristic orientation; some involved descriptions of vegetation and some related to the management of *Pinus ponderosa*.

Plant collections have been made in the Black Hills since the 1800s, beginning with the early military and geological expeditions of Reynolds (1866), Custer (1875), Ludlow (1875), and Newton and Jenney (1880). Rydberg (1896), who made the first concentrated study of Black Hills flora, identified 688 species. Others continued to collect plants to complete the floristic list of the region. Buttrick (1914) discussed the origins of Black Hills flora. Hayward (1928) and McIntosh (1930, 1949) described the vegetation and some of the successional sequences as they interpreted them. These reports are significant only as historical documents providing a record of plants collected and the general nature of vegetation present. More recently, Thilenius (1972) and Severson and Thilenius (1976) described, in somewhat more detail, vegetation types in the Black Hills. Thilenius (1972) sampled along transects established originally to estimate numbers of deer in the Black Hills. Sampling on those areas selected for deer pellet studies limited the choices in selecting sampling sites and, therefore, the possibility of producing vegetation data that expressed biotic potential of the area. Because most of the sample sites were not in mature stands, Thilenius's (1972) "habitat units" coincide only coincidentally with habitat types. Severson and Thilenius (1976) classified aspen stands in the Black Hills and Bear Lodge Mountains. Their random selection of sample sites and virtual lack of successional interpretations leaves only correlational information among plants and abiotic factors.

This cooperative study<sup>2</sup> was started in 1982 to (1) identify and describe the forest habitat types on the Black Hills National Forest on the basis of both reconnaissance and intensively sampled plots well distributed throughout the whole forest, (2) relate habitat types to soils and climate, and (3) relate Black Hills National Forest habitat types to other Rocky Mountain forests with similar classifications. The habitat type classification,<sup>3</sup> completed in 1986, is based on concepts and methods

<sup>2</sup>Funded by a cooperative agreement (28-C2-203) with the Rocky Mountain Forest and Range Experiment Station (RWU-4252) located at Rapid City, S. Dak.

<sup>3</sup>Hoffman, George R. An ecological study of the vegetation of the Black Hills National Forest of South Dakota and Wyoming: a habitat type classification. 191 p. Unpublished report on file at Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

developed by Daubenmire (1952) and Daubenmire and Daubenmire (1968), and refined by others (Hoffman and Alexander 1976, 1980, 1983; Pfister and Arno 1980; Pfister et al. 1977; Steele et al. 1981, 1983).

The results reported here are intended for two primary audiences: forest managers and land-use planners who want a working tool to use on the Black Hills National Forest, and ecologists who want a research tool to use in related studies. Not all readers will find each category of information of equal value.

## STUDY AREA

### PHYSIOGRAPHY AND GEOLOGY

The Black Hills and associated Bear Lodge Mountains of South Dakota and Wyoming (fig. 1) are located on the Missouri Plateau of the Great Plains Province (Fenneman 1931). These mountains are a maturely dissected domal uplift with a central crystalline core surrounded by steeply dipping sedimentary deposits. The Black Hills extend about 124 miles (200 km) north to south and 62 miles (100 km) east to west. Harney Peak in the Central Core is the highest peak at 7,241 feet (2,207 m). Seven other peaks are 6,000 feet (1,829 m) or higher. The plains that surround the Black Hills are 3,002 feet (915 m) to 3,494 feet (1,065 m) in elevation. The Black Hills exhibit four distinct geomorphic sections: (1) the Central Core of granitic and metamorphic rocks; (2) the Limestone Plateau that surrounds the Central Core; (3) the Red Valley that nearly encircles the Black Hills, but is best developed on the east side; and (4) the Hogback Ridge just outside the Red Valley (Darton and Paige 1925).

The Central Core consists of Precambrian granites, schists, and metasediments and is located somewhat east of central of the domal structure. Following uplifts, this core was exposed by erosion of the overlying sedimentary deposits over vast periods of time. Although domal uplift of the Black Hills apparently began over 600 million years ago and occurred intermittently for more than 500 million years, the major uplift occurred sometime between late Cretaceous and early Tertiary. A final uplift during late Tertiary and early Quaternary left the Black Hills with their present configuration (Thornbury 1965) (fig. 2). The Central Core area is characterized by broad valleys, mountain peaks, and canyons. In addition to Harney Peak, other high peaks in this area are Bear Mountain [7,165 feet (2,184 m)], Terry Peak [7,070 feet (2,155 m)], and Custer Peak [6,795 feet (2,071 m)]. The soils of this area generally are acidic, coarse textured, and shallow, especially on slopes and at higher elevations.

The Limestone Plateau surrounding the Central Core consists of limestones, dolomites, and sandstones of early

to late Paleozoic. It is most prominent and broader in the northwestern part of the Black Hills, where in places it is more than 18 miles (30 km) wide. Over much of its area, it is nearly level but at somewhat higher elevation than much of the Central Core area. On the east side of the Black Hills, the plateau is much reduced in size and becomes more of a homoclinal ridge. Soils of the Limestone Plateau are relatively fertile and fine textured.

The Red Valley is outside of the Limestone Plateau and encircles the Black Hills. It is derived from red shales of the Permian and Triassic Spearfish formation. It is essentially a nonforested valley, about 2 miles (3 km) in width between the more gentle backslope of the Limestone Plateau and the sharply dipping escarpment of the Dakota Hogback. The approximately 655-foot (200-m) thick layer of Spearfish sands and shales between the heavy limestone below and the Dakota sandstones above are fairly susceptible to weathering, and form a valley of substrates more suitable for steppe vegetation. Soils are fine textured and generally deep.

The Dakota Hogback forms the outer rim of the Black Hills. Its inner face rises abruptly above the Red Valley, and its backslope tapers gradually to the plains outside of the Black Hills. It is formed from sandstone of Cretaceous age. Soils on the inner face are coarse textured; those on the outer slope (backslope) are fine tex-

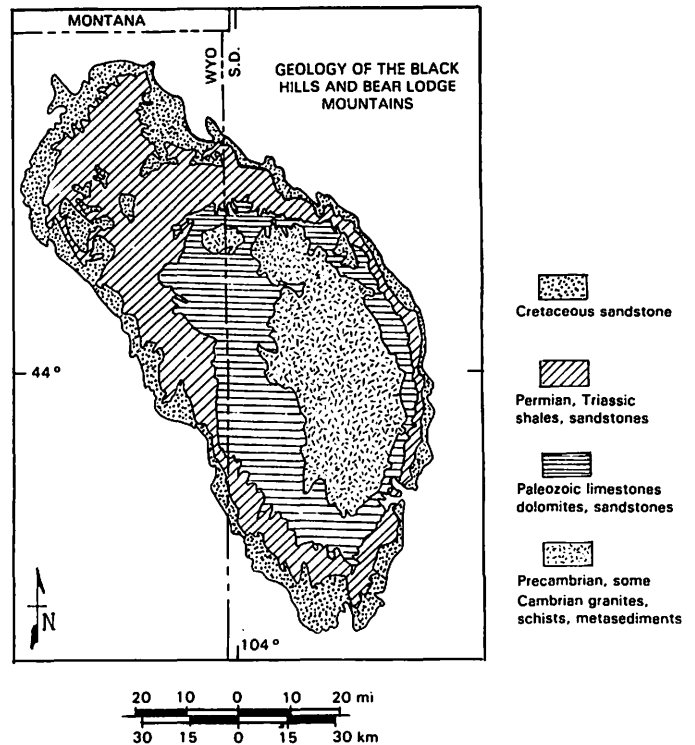


Figure 2.—General surface geology of the Black Hills and Bear Lodge Mountains.

ured due to the influence of Pierre shale. In general, the soils of the Black Hills are classified as Eutroboralfs (gray wooded) (Radeke and Westin 1963).

The Bear Lodge Mountains northwest of the Black Hills also are a domal structure, but much smaller in size. The highest elevation is Warren Peak at 6,657 feet (2,029 m). The sedimentary rocks are the same as in the Black Hills.

## CLIMATE

In the northern Great Plains, the climate surrounding the Black Hills is that of continental grassland, with low winter temperatures and high summer temperatures. Annual precipitation of the surrounding plains ranges from 13 inches (34 cm) to 18 inches (46 cm) (fig. 3) (table 1). Ardmore, Hot Springs, New Castle, Sundance, Belle Fourche, and Rapid City surround the Black Hills and are somewhat representative of the continental grassland climate. These stations receive 70% to 80% of their precipitation during the six warm months of the year, and record their highest and lowest mean temperatures in July and January, respectively. Most weather stations within the Black Hills receive more than 20 inches (50 cm) of precipitation annually. Two exceptions in table 1 are Deerfield and Custer, with 18 inches (46 cm) and 17 inches (44 cm), respectively. Among the weather stations within the Black Hills, precipitation during the six warm months ranges from 60% to 73% of the total, indicating that a larger proportion of the annual precipitation falls during the six cool months than on the surrounding plains.

The northern Black Hills usually receives more precipitation than the southern Black Hills and normal-

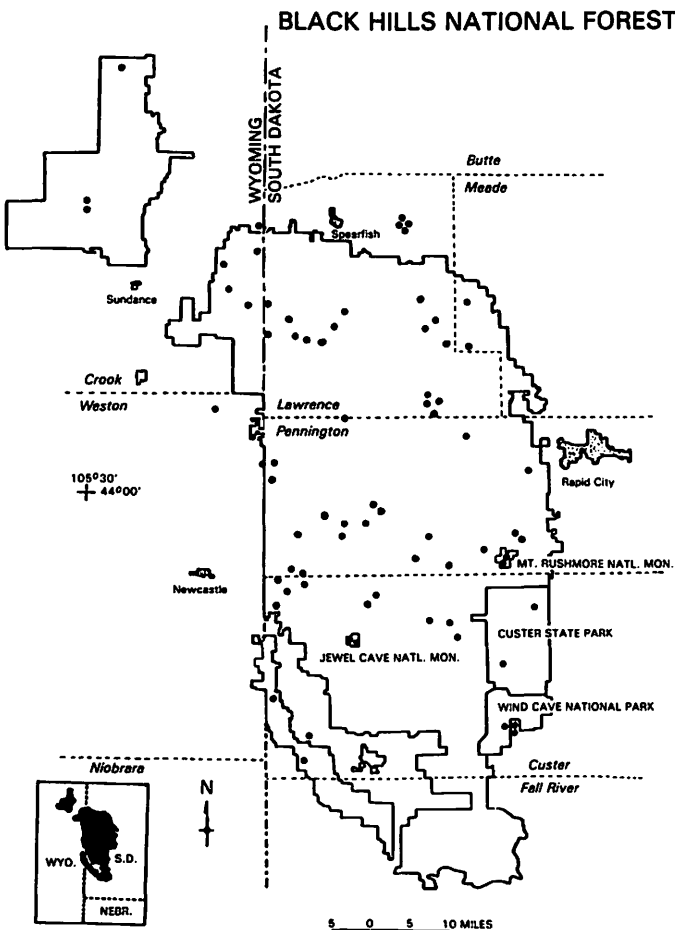


Figure 1.—Map of the Black Hills National Forest showing locations of intensively sampled stands.

ly are cooler. Mean temperatures of the Black Hills generally are higher in the winter and lower in the summer than on the surrounding Great Plains. Also, yearly temperature extremes generally are less in the Black Hills than on the surrounding plains. For example, January means at Lead and Deadwood are 23° F (-5° C) and 24° F (-4.5° C), respectively, while those at Ardmore and Sundance are 19° F (-7° C) and 18° F (-8° C). July means at Lead and Deadwood are 68° F (20° C) and 67° F (19.5° C), respectively. The same monthly means at Ardmore and Sundance are 74° F (23.5° C) and 73° F (23° C). How climate influences vegetation patterns is discussed below.

The Black Hills are small in areal extent and in elevational range, compared to the massive blocks of mountains that make up the main chain of the Rocky Mountains. Forests in the Black Hills extend from approximately 3,658 feet (1,200 m) to about 6,400 feet (2,100 m), a span of 2,745 feet (900 m). Forests in the Colorado Rocky Mountains range from approximately 6,000 feet (1,830 m) to 10,365 feet (3,400 m), an elevational range great enough to delineate a well-defined climatic gradient varying from warm and dry at low elevations to cool and moist at upper elevations. Forests along this gradient occupy zones perpendicular to the gradient and exhibit characteristics that change from xeric to mesic as elevation increases (table 2). Warm, dry environments at low elevations, which support *Pinus ponderosa* forests, are

especially conspicuous in the southwestern corner of the Black Hills. Along the northeastern perimeter of the Black Hills, at slightly higher elevations, the environments are more moist and exhibit considerably richer undergrowths, but still support *Pinus ponderosa* forests. *Pinus ponderosa* forests, which extend upward to elevations of 6,516 to 6,890 feet (2,000 m to 2,100 m), overlap *Populus tremuloides* and *Picea glauca* forest zones. Thus, zonation of vegetation in the Black Hills is less conspicuous, partly because of a weaker climatic gradient from low to high elevation that is associated with a small mountain mass. Complex topography, variable wind patterns, transfers of moisture, various depths of snowpack and times of melting, and other results of exposure and elevation all tend to obscure simple and direct relationships between elevation and temperature or precipitation in the Black Hills. The distribution of climax, or near climax, vegetation can be a more reliable indicator of climatic conditions in the Black Hills than weather stations scattered across the region.

### METHODOLOGY

Preliminary work began in 1982 with a reconnaissance survey of about 200 sites throughout the Black Hills National Forest. Reconnaissance involved traveling over all the roads and trails and giving rather uniform attention to the entire area traveled. The object was to locate the oldest and least disturbed stands of forest in the region. When stands were located, they were examined for both overstory and undergrowth characteristics, and the topographic position, slope, aspect, and elevation were noted. The surface soil texture and the parent material also were estimated. Within the area chosen for reconnaissance, all the vascular plant species present were listed and coverage of the more important ones were estimated. Plant specimens also were collected for herbarium vouchers. Based on field notes and data collected, a list of possible habitat types then was developed. *Pinus ponderosa* is climax over much of the Black Hills, and it dominates most of the stands examined. Because it also is seral to *Picea glauca* in the Black Hills, it was first determined if *P. ponderosa* was the climax dominant of the stand examined. Whatever tree species is climax in a given stand is one of the first things to be determined based on size-class distribution of trees in the population and on the vegetation of the immediately surrounding area. Where "mixed" stands of *P. ponderosa*, *P. glauca*, *Populus tremuloides*, and *Betula papyrifera* occur in the Black Hills, the status of *P. glauca* was assessed first, because it may be the climax species. It seldom moves downslope onto drier sites following disturbance, but the other species more commonly move upslope onto more moist sites following disturbance. In the absence of *P. glauca*, mixed stands must be evaluated in terms of dominant species that appear to be self-reproducing and present in all or most size classes. It is important to be familiar with the range of possible tree mixtures and their successional relationships at various locations and elevations in the Black Hills. Because competition eliminates all or most of the seral trees, or leaves only relict popula-

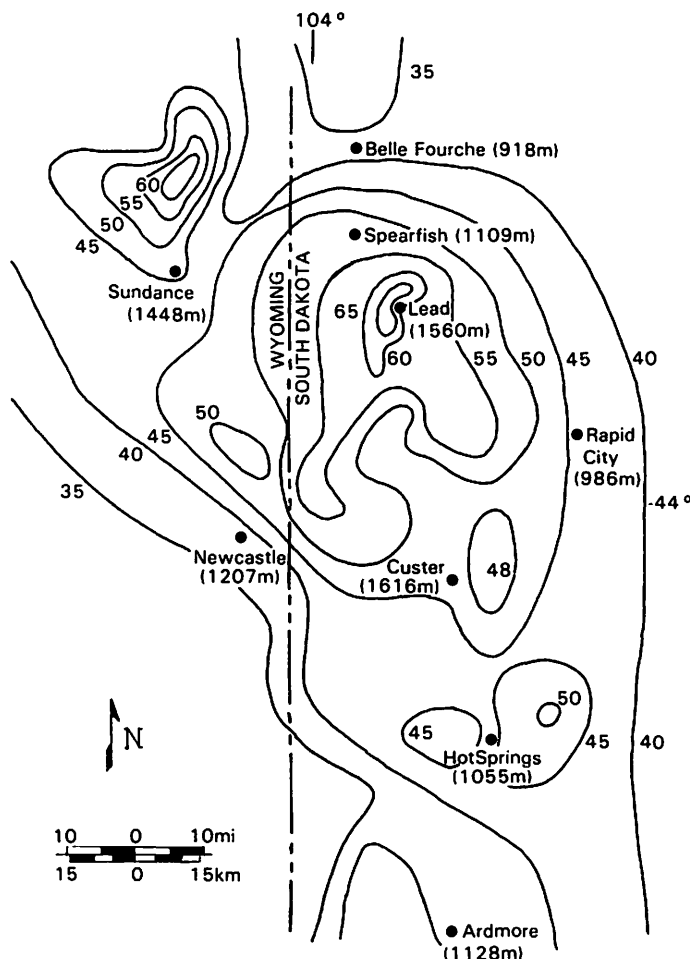


Figure 3.—Isohyets of annual precipitation (cm) in the Black Hills.

Table 1.—Mean monthly temperatures (°C) and precipitation (mm) from selected weather stations in and near the

Location	Elevation (m)	Jan.		Feb.		Mar.		Apr.		May		Month June	
		Temp.	Ppt.	Temp.	Ppt.	Temp.	Ppt.	Temp.	Ppt.	Temp.	Ppt.	Temp.	Ppt.
Sundance	1,454	--	18.8	--	15.6	--	29.0	--	43.2	--	64.8	--	85.9
Belle Fourche	920	-5.5	6.6	-4.2	5.8	-0.3	16.3	+7.7	47.2	+13	53.3	+18	80.0
Spearfish	1,112	--	15.2	--	13.0	--	24.9	--	57.1	--	91.7	--	42.2
Fort Meade	1,006	-4.2	14.2	--	18.0	--	39.1	--	50.3	--	117.0	--	90.9
Rapid City	957	-4.2	10.7	-2.9	10.9	+0.1	27.4	+7.6	50.8	+13	70.4	+18	87.6
Hermosa	1,006	-5.6	8.6	--	7.9	--	17.8	--	41.0	--	98.6	--	82.0
Hot Springs	1,111	-3.8	10.4	-2.3	13.2	+1.3	28.5	+8.2	48.5	+14	77.2	+19	76.5
New Castle	1,316	-4.9	11.4	-3.1	9.1	+0.1	20.6	+7.1	36.6	+13	58.9	+18	65.3
Deadwood	1,382	+1.6	29.2	+1.6	26.4	+7.3	58.2	+12.0	96.0	+17	116.0	+24	93.7
Lead	1,621	-4.3	28.2	-3.5	22.1	1.3	43.2	+5.2	75.2	+11	99.1	+16	104.0
Dumont	1,890	--	35.2	--	22.1	--	44.2	--	64.3	--	84.1	--	90.4
Greenmont	1,932	--	35.6	--	33.0	--	43.2	--	87.6	--	87.1	--	78.7
Hardy Ranger Station	2,012	--	42.9	--	30.7	--	39.4	--	50.5	--	60.5	--	69.1
Harveys Ranch	1,915	--	40.9	--	34.3	--	46.2	--	62.5	--	64.1	--	103.0
Buskala Ranch	1,859	--	32.2	--	22.1	--	44.7	--	79.0	--	102.0	--	108.0
Rochford	1,609	--	21.8	--	18.3	--	28.5	--	55.1	--	74.7	--	80.3
Silver City	1,524	--	18.0	--	23.4	--	50.0	--	58.2	--	88.9	--	104.0
Deerfield	1,829	--	15.0	--	10.4	--	19.8	--	44.7	--	67.6	--	84.8
Custer	1,621	--	10.4	--	9.7	--	25.4	--	47.8	--	78.5	--	78.5
Elk Mountain	1,432	--	15.8	--	11.7	--	15.8	--	33.3	--	49.8	--	69.1

Table 2.—Selected topographic and edaphic characteristics of the habitat types in the Black Hills and Bear Lodge Mountains.

Habitat type	Stands sampled	Elevation m	Soil texture <sup>1</sup> (range)	PH	Organic matter <sup>1</sup> percent
<i>Picea glauca</i> / <i>Linnaea borealis</i>	5	1768-1958	loam	5.4-7.3	2.7-10.5
<i>Picea glauca</i> / <i>Vaccinium scoparium</i>	5	1737-2040	loam-silty clay loam	4.9-6.9	2.3-7.7
<i>Populus tremuloides</i> / <i>Corylus cornuta</i> <i>Pteridium aquilinum</i> phase <i>Aralia nudicaulis</i> phase	9	1219-1902	sandy loam- silt loam	5.5-6.2	2.2-8.7
<i>Pinus ponderosa</i> / <i>Quercus macrocarpa</i>	4	1256-1615	sandy loam- clay loam	5.3-6.9	4.6-9.5
<i>Pinus ponderosa</i> / <i>Physocarpus monogynus</i>	3	1567-1737	loam	6.5-7.1	4.5-11.3
<i>Pinus ponderosa</i> / <i>Juniperus communis</i>	7	1384-1989	sandy loam- clay loam	5.1-6.5	4.6-9.7
<i>Pinus ponderosa</i> / <i>Symphoricarpos albus</i> <i>Oryzopsis asperifolia</i> phase <i>Balsamorhiza sagittata</i> phase	12	1288-1820	sandy loam- silt loam	5.1-7.0	3.5-16.6
<i>Pinus ponderosa</i> / <i>Arctostaphylos uva-ursi</i>	10	1548-2042	sandy loam- clay loam	4.7-6.7	2.0-10.3
<i>Pinus ponderosa</i> / <i>Carex heliophila</i>	3	1372-1576	loamy sand- loam	4.8-5.8	1.5-4.7
<i>Pinus ponderosa</i> / <i>Juniperus scopulorum</i>	1	1189	sandy loam	7.3	6.9
<i>Quercus macrocarpa</i> / <i>Ostrya virginiana</i>	5	1067-1250	sandy loam- clay loam	5.6-7.4	3.6-8.5
<i>Quercus macrocarpa</i> / <i>Symphoricarpos occidentalis</i>	1	1280	loam	6.0	7.2
<i>Cercocarpus montanus</i> / <i>Bouteloua curtipendula</i>	3	1265-1493	loam-clay loam	7.6-7.8	1.2-5.5

<sup>1</sup>Upper 1 dm of soil.

Black Hills. Data are from the U.S. Department of Agriculture (1933) and U.S. Department of Commerce (1960).

July		Aug.		Sep.		Oct.		Nov.		Dec.		Ann.	
Temp.	Ppt.	Temp.	Ppt.	Temp.	Ppt.	Temp.	Ppt.	Temp.	Ppt.	Temp.	Ppt.	Temp aver.	Ppt. tot.
—	42.2	—	27.7	—	35.1	—	25.2	—	19.8	—	17.5	—	425
+23	33.8	+21	30.7	+16	30.0	+9.5	19.6	+1.7	10.7	-3.3	5.6	+8.1	340
—	35.8	—	39.9	—	24.1	—	18.8	—	12.7	—	12.7	—	445
+22	76.0	—	50.0	—	33.3	—	31.0	—	11.4	—	17.5	—	549
+24	47.0	+22	42.4	+17	24.9	+11.0	24.1	+2.9	9.9	-1.7	7.9	+8.9	414
+22	67.3	—	53.1	—	36.6	—	27.2	—	9.9	—	11.7	—	462
+24	53.9	+23	43.4	+17	33.8	+11	19.6	+2.7	9.4	-1.7	9.1	+9.3	423
+24	39.6	+22	43.2	+16	22.9	+9.7	21.1	+1.6	11.9	-1.7	10.4	+8.3	351
+27	98.6	+26	63.2	+21	59.4	+14.0	52.3	+7.7	32.5	+2.0	36.6	+14.0	762
+11	52.8	+20	42.7	+15	39.9	+8.9	33.5	+1.3	29.0	-2.2	24.1	+7.2	594
—	53.9	—	44.7	—	35.1	—	28.7	—	31.2	—	24.9	—	559
—	72.4	—	65.0	—	41.7	—	42.9	—	31.8	—	34.5	—	654
—	57.7	—	46.2	—	42.9	—	41.2	—	26.9	—	31.5	—	539
—	91.4	—	58.4	—	38.9	—	35.8	—	28.7	—	25.9	—	651
—	65.8	—	45.7	—	37.6	—	32.0	—	28.2	—	24.9	—	622
—	72.6	—	57.7	—	35.3	—	32.5	—	20.6	—	17.5	—	515
—	60.7	—	44.5	—	33.3	—	15.5	—	22.4	—	16.3	—	535
—	74.7	—	54.9	—	35.0	—	27.9	—	14.5	—	10.2	—	459
—	50.4	—	64.0	—	26.7	—	26.7	—	9.9	—	9.1	—	437
—	67.1	—	43.2	—	38.9	—	26.9	—	16.8	—	13.0	—	401

tions, old-growth forest stands are less complicated in terms of tree populations.

After the overstory was evaluated, the undergrowth was examined for disturbance before the stand was deemed acceptable for either reconnaissance or intensive sampling. The presence of numerous alien plant species in the undergrowth is a good indication of significant disturbance. Some weedy species persist indefinitely after a disturbance, though perhaps only in rather depauperate condition. This must be recognized and considered. When the sample plot was considered acceptable for sampling, its exact location was noted subjectively, usually by its proximity to the largest tree in the stand, as long as the plot was not adjacent to a game trail, an ecotone, or other disturbed area.

In the Black Hills, intensive management has occurred for so long that most of the forest land supports young to medium-aged forests. Few areas in the Black Hills are inaccessible, and timber harvesting has occurred over most of the region. Finally, the devastation of widespread fires and periodic outbreaks of mountain pine beetles during the early days have further reduced the number of sites supporting older stands of trees. Because of past disturbance by logging, fire, insects, and grazing, undisturbed old-growth stands were not available in every locality. Stands sampled were representative of forest and shrub communities dominated by the following species: *Cercocarpus montanus*, *Quercus macrocarpa*, *Pinus ponderosa*, *Populus tremuloides*, and *Picea glauca*.

In each stand, a 49.2- by 82.0-foot (15- by 25-m) plot was laid out with the long dimension parallel to the contour, in the most homogeneous part of the stand. Each main plot then was subdivided into three 16.4- by 82.0-foot (5- by 25-m) subplots. Within each 4,036-square-foot

(375-m<sup>2</sup>) main plot, all trees taller than 3.28 feet (1 m) were measured and recorded by 0.328-foot (1-dm) diameter classes. Trees less than 3.28 feet (1 m) tall were counted and recorded in two 3.28- by 82.0-foot (1- by 25-m) transects along the inner sides of the central subplot.

Canopy coverage of all understory shrubs, forbs, and graminoids was estimated in 50 7.9- by 19.7-inch (2- by 5-dm) microplots placed systematically along the inner sides of the central subplot. Canopy coverage of each species was recorded as one of six coverage classes (1-5%, 6-25%, 26-50%, 51-75%, 76-95%, and 96-100%) (Daubenmire 1959). Also listed were those species not occurring in the 50 microplots but present in the 4,036-square-foot (375-m<sup>2</sup>) main plot.

Finally, 25 cores representing the upper decimeter of the mineral soil were collected from each of the 68 stands. These samples were air dried in the field, then composited for laboratory analysis.

Tree-size class data were combined according to habitat type, and mean values for each size class in each forest habitat type are recorded (table A-1). In the *Cercocarpus*-dominated shrub habitat type where no trees were present, only the canopy coverage of shrubs and forbs was recorded.

For each microplot examined, the midpoints of the coverage classes were used to calculate average percent coverage for each shrub, graminoid, and forb species. Frequency, the percentage of microplots in which a species occurs in each stand, also was determined for each species. Coverage and frequency data for all understory species plus site data are shown in appendix tables A-2 through A-10. Species coverage and selected stand characteristics were transferred to an association table, then stands were arranged and rearranged to group those with



similar floristic composition and climax tree species. Habitat type separation was based on a consideration of both overstory and major shrubs, graminoids, and forbs (Daubenmire 1952, Daubenmire and Daubenmire 1968, Mueller-Dombois and Ellenberg 1974).

Soil texture was determined by a modified Bouyoucos method (Moodie and Koehler 1975). Other soil characteristics determined were pH (using a glass electrode on the saturated soil paste), cation-exchange capacity and base saturation (by addition), exchangeable Ca and Mg (EDTA titration method), K and P (bicarbonate extraction method), pH lime requirement (Ohio SMP method), and organic matter (dichromate method).

All plants in this study were identified to species where possible. Nomenclature follows Van Bruggen (1976). There were a few taxonomic curiosities, mainly resulting from a lack of flowering or fruiting specimens. It is possible some hybridization was encountered. *Osmorhiza depauperata*, *O. chilensis*, and *O. longistylis* occur and were identified. An occasional specimen of *Osmorhiza* was encountered that could not be identified as any one of these species, or any other *Osmorhiza* species known to occur in this region. There were minor problems with *Allium*, *Viola*, and *Carex*, particularly on certain sites where they appeared to be growing poorly and producing no flowers. The vegetative forms of *Fragaria virginiana* and *F. vesca* overlapped, and it was not possible to consistently separate them. Some *Ribes* species proved difficult to identify in certain locations. *Ribes oxycanthoides* and/or *R. setosum* could not be distinguished in all places, and certain *R. lacustre* plants appeared similar to *R. oxycanthoides*. Where considerable variation made it impossible to determine species, only genera were used.

## ECOLOGIC TERMS AND CONCEPTS

Because terminology in ecology is not uniformly used or understood, the terms and concepts used in this paper are defined. Unless stated otherwise, all terms follow usage proposed by Daubenmire and Daubenmire (1968).

"Climax vegetation" is that which has attained a steady state with its environment; without disturbance, species of climax vegetation successfully maintain their population sizes. Tansley (1935) proposed recognizing climatic, edaphic, and physiographic climaxes; he also discussed fire and biotic climaxes. Daubenmire (1952) used this approach, with modifications, in his classification of forests in the northern Rocky Mountains. Daubenmire (1968) further elaborated on the definition, usage, and limitations of the polyclimax concept. "Climatic climax" vegetation develops on normal topography with fairly deep, well-drained, loamy soil. The absence of recurrent disturbance also is critical in defining "climatic climax" vegetation. Where soils or topography exert sufficient influence to produce self-perpetuating vegetation distinct from the climatic climax, the terms "edaphic climax" and "topographic climax," respectively, are used to describe the steady-state vegetation. Where special topographic conditions also favor the development of edaphic conditions distinct from the normal, the term "topo-edaphic climax"

often is used in descriptions of the resulting steady-state vegetation.

Where recurring disturbance, such as grazing or fire, exerts a predominant influence on the composition or structure of steady-state vegetation, the term "disclimax" is used. Two common disclimaxes are the "zootic climax" and the "fire climax." In the absence of disturbance, it is possible the vegetation will revert to the primary climax.

Habitat type is the basic unit in classifying lands or sites based on potential (climax) natural vegetation. A habitat type represents, collectively, all parts of the landscape that support or have the potential of supporting the same climax vegetation; each habitat type is named for its climax plant association. The next higher category of classification is the series, which groups all habitat types having the same overstory climax dominant (Hoffman and Alexander 1976). For example, all habitat types with *Pinus ponderosa* as the potential climax dominant are grouped into the *P. ponderosa* series. There is an ecologic basis for grouping habitat types into series. The *P. ponderosa* series, for example, occupies areas that generally are warmer and drier than the *Populus tremuloides* series. At higher elevations or in more moist, cool canyons of the Black Hills, *Picea glauca* becomes the dominant species. In the absence of adequate on-site climatic data, it is assumed that the distributions of these self-perpetuating populations of dominant trees are more reflective of macroclimate than the undergrowth vegetation, which is related more to microclimate and soils. In general, undergrowth species are distributed fairly independently of overstory species. On the structure of plant communities, the "union" is the smallest unit. It can consist of only one species that has a distinct ecology, or it can consist of several to many species that have similar ecological requirements, distributions, or even life forms.

Many stands in a series have the same general appearance regardless of whether they are in the Black Hills National Forest or in nearby forests of Colorado and Wyoming (Alexander et al. 1986; Hess and Alexander 1986; Hoffman and Alexander 1976, 1980, 1983). Habitat types within a series are distinguished on the basis of undergrowth vegetation. For example, in western Colorado, several habitat types occur in the *Populus tremuloides* series. All are distinguished on the basis of the undergrowth vegetation. The presence of the floristically rich *Thalictrum fendleri* union indicates the *P. tremuloides*/*T. fendleri* habitat type. On some sites, the addition of *Heracleum sphondylium* in the undergrowth indicates another habitat type. Thus, *P. tremuloides*/*T. fendleri* and *P. tremuloides*/*H. sphondylium* are two distinct habitat types, although the *T. fendleri* union is well represented in both.

Because of past disturbances, very little of the Black Hills National Forest currently supports climax vegetation. It is possible that much of the area occupied by a habitat type will never attain climax status. Nevertheless, it is possible and important to interpret land units in terms of their potential status. The practical value of habitat type classifications is only beginning to be real-



ized in areas of tree productivity, disease and insect susceptibility, potential for producing forage and/or cover, soil moisture, and tree regeneration (Arno and Pfister 1977; Daubenmire 1961, 1973; Layser 1974; Pfister 1972). The habitat type concept offers a useful approach to classifying and managing forest resources.

## FOREST HABITAT TYPES

Forest vegetation in the Black Hills National Forest ranges from the xerophytic *Quercus macrocarpa*-dominated vegetation at the warmer, drier, low elevations to the mesophytic *Picea glauca*-dominated vegetation at the cooler, moister, higher elevations.

### QUERCUS MACROCARPA SERIES

The *Quercus macrocarpa* series occurs at low elevations of the northern Black Hills, where it forms woodland communities in which *Q. macrocarpa* dominates stands of closely spaced small trees. The stands have physiognomic similarities to those of *Quercus gambelii* of the central Rocky Mountains. *Q. macrocarpa* also occurs as a shrub under *Pinus ponderosa* and as a tree in lowland riparian forests with *Fraxinus pennsylvanica*, *Ulmus americana*, *Celtis occidentalis*, *Pinus ponderosa*, and *Acer negundo*. *Q. macrocarpa* apparently does not occur south of French Creek and is near its westernmost limit of distribution in the Black Hills. Previous hybridization between *Q. macrocarpa* and *Q. gambelii* in the Black Hills (Maze 1968) has resulted in some taxonomic anomalies. Whether it also resulted in ecologic differentiation within *Q. macrocarpa* in the Black Hills is unknown, but this species is the only one in this region that occurs as a full-statured tree, a small tree, and a shrub.

The *Q. macrocarpa* series was sampled in six stands and two habitat types that were on east- to north-facing slopes at elevations of 3,500 to 4,200 feet (1,067 to 1,280 m) (table 2). Although most *Q. macrocarpa*-dominated stands in the Black Hills are heavily grazed, the sampled stands were ungrazed or only lightly grazed. Dominant *Q. macrocarpa* in these stands ranged from 66 to 185 years old at breast height. Basal areas on the study plots ranged from 104 to 139 square feet per acre (24 to 32 m<sup>2</sup>/ha). Tree sizes ranged from seedlings to the 16- to 20-inch (4- to 5-dm) d.b.h. class. Tree populations and undergrowth data for *Q. macrocarpa* stands are shown in tables A-1 and A-2.

#### *Quercus macrocarpa/Ostrya virginiana*

**Description.**—The *Quercus macrocarpa/Ostrya virginiana* habitat type was sampled in five stands. Four of these were sampled along the north fringe of the Black Hills, just outside the forest boundary. The fifth stand was in Dark Canyon, along Rapid Creek. Because of the moist conditions, this stand is less representative of the *Q. macrocarpa/O. virginiana* habitat type than the other four stands.



Figure 4.—*Quercus macrocarpa/Ostrya virginiana* habitat type. Interior of stand 45. The meter stick in this and subsequent photographs is painted in decimeter segments.

This habitat type is recognized by the presence and reproductive success of *Q. macrocarpa*, and by the presence and abundance of *O. virginiana* both in the undergrowth and the understory (fig. 4). Because *O. virginiana* is a vigorous shrub reaching 6 to 10 feet (2 to 3 m) at maturity, it is included with the tree species in table A-1. An occasional *Fraxinus pennsylvanica*, *Ulmus rubra*, *Betula papyrifera*, and *Pinus ponderosa* occur in this habitat type, but only *P. ponderosa* normally persists beyond the seedling stage. The undergrowth coverage in this habitat type varies considerably from stand to stand. In addition to *O. virginiana*, undergrowth species with high constancy are *Berberis repens*, *Prunus virginiana*, *Ribes* spp., *Symphoricarpos occidentalis*, *Carex foenea*, *Disporum trachycarpum*, *Smilacina stellata*, and *Woodsia scopulina*. Because it is more characteristic of mesic lowland forests where *Q. macrocarpa* also occurs, stand 20 has more than twice the number of undergrowth species than are found in the other stands sampled in this habitat type. The *Q. macrocarpa/O. virginiana* habitat type has not been reported elsewhere.

**Management implications.**—The *Q. macrocarpa/O. virginiana* habitat type is not managed for wood production. Treatments, including tree harvesting, are directed toward maintaining or enhancing forage production for livestock, habitat for wildlife, and watershed protection. Fuelwood may be a by-product of treatments. The habitat type is spring-fall range for livestock and winter range for deer. It also is an important food source (acorn mast) for turkey and fox squirrels that also require adjacent mature *P. ponderosa* stands for dens, roosts, and cover.

If the *Q. macrocarpa* habitat type is treated, cutting, burning, etc., can be directed toward improving the vigor and growth of *Q. macrocarpa* and increasing the proportion of *O. virginiana* and other shrubs, such as *P. virginiana*, and associated graminoids in the undergrowth. Although cattle and deer are not directly competitive in their preferred food supply, proper grazing management, in terms of stocking and season of use by livestock, is essential to prevent depletion of deer winter range. Numerous birds that feed on *O. virginiana* buds and small mammals also inhabit areas occupied by these habitat types.

Average annual precipitation is below average for the Black Hills and Bear Lodge Mountains, and the potential for increasing water production is low. Developed and dispersed recreation and the potential for increasing recreation use is lower than in *P. ponderosa*-dominated habitat types.

***Quercus macrocarpa/Symphoricarpos occidentalis***

**Description.**—This habitat type occurs along the northern fringe of the Black Hills and westward a short distance outside the Black Hills. The best developed stands are in the foothills between Sundance, Wyo., and Whitewood, S. Dak. Most of the stands are heavily grazed and not suitable for sampling. The single stand sampled is west of Whitewood on the east slope of Elkhorn Peak. Because this stand is rather high on the slope and distant from a water supply, it is utilized only minimally by cattle.

The *Quercus macrocarpa/Symphoricarpos occidentalis* habitat type is recognized by the overstory dominance of *Q. macrocarpa* and the abundance of *S. occidentalis* in the undergrowth. The undergrowth is dominated by shrubs that provide 50% coverage. In addition to *S. occidentalis*, other important shrubs are *Amelanchier alnifolia*, *Berberis repens*, *Prunus virginiana*, *Rubus idaeus*, and *Toxicodendron rydbergii*; Herbaceous species are less important. The most significant are *Carex foenea*, *Poa pratensis*, and *Galium* spp. This habitat type has not been reported elsewhere.

**Management implications.**—*Q. macrocarpa/S. occidentalis* is an incidental habitat type with management implications similar to those for *Q. macrocarpa/Ostrya virginiana* habitat type, but it occurs on somewhat drier sites. It has slightly less potential for livestock forage because of lower production of herbaceous vegetation and the unpalatability of *S. occidentalis*.

**PINUS PONDEROSA SERIES**

*Pinus ponderosa* is the most abundant and most widely distributed tree in the Black Hills. It occurs from low to high elevation on all soil types and on all aspects. According to Boldt et al. (1983), stands of climax *P. ponderosa* occupy 1,482,000 acres (600,000 ha) in the Black Hills. This tree is absent from only those areas that generally are treeless. It is a seral or an occasional species in *Picea glauca*- and *Populus tremuloides*-dominated forests, and an occasional tree in more xerophytic *Quercus macrocarpa*-dominated woodlands or in shrub-steppe or steppe vegetation. *P. ponderosa* may be invading areas it had occupied earlier before a major disturbance, but more documentation is needed. If this is the case, then the steppe or shrub-steppe is actually a *Pinus*-dominated habitat type (figs. 5 and 6). There is no question that *P. ponderosa* in the Black Hills is aggressive; reproduction is prompt and in sufficient quantities to maintain the population (fig. 7). Within the *P. ponderosa* series, it has little competition from other tree species; after fire or log-



Figure 5.—Scattered *Pinus ponderosa* in the grasslands of the southern Black Hills. A few trees have established in the fenced enclosure.



Figure 6.—*Andropogon scoparius* in the foreground. Where *Pinus ponderosa* forms closed stands, as in the background, *A. scoparius* is much reduced or shaded out entirely.



Figure 7.—*Pinus ponderosa* is an aggressive species over much of the Black Hills. It is reestablishing here on a road cut in soils derived from igneous rock.



ging, it reestablishes and often produces extremely dense stands. *P. tremuloides*, the only other tree of consequence that offers competition to *P. ponderosa*, forms stands on some sites; but overall, *P. tremuloides* is a minor tree in the Black Hills. The combination of early uncontrolled fires, mountain pine beetle outbreaks, intense forest management activities, and accessibility to grazing animals has influenced the present status of *P. ponderosa*-dominated forests in the Black Hills. *P. ponderosa* may be the climax tree over much of the land area of the Black Hills, as Boldt et al. (1983) indicated, but because of intense past use, existing forests usually are in seral states. Also, the blended undergrowth vegetation makes habitat type identification more difficult than in other areas of the Rocky Mountains.

The *P. ponderosa* series was sampled in 40 stands, representing seven habitat types, ranging in elevations from 3,900 to 6,700 feet (1,190 to 2,042 m) (table 2). Ages of dominant *P. ponderosa* ranged from 90 to 290 years at breast height. Basal areas on the study plots ranged from 78 to 218 square feet per acre (18 to 50 m<sup>2</sup>/ha). Tree sizes ranged from seedlings to the 24- to 28-inch (6- to 7-dm) d.b.h. class. Tree populations and undergrowth data for *P. ponderosa* are shown in tables A-1 and A-3 through A-7.

### *Pinus ponderosa*/*Symphoricarpos albus*

**Description.**—*Pinus ponderosa*/*Symphoricarpos albus* is the most common *P. ponderosa*-dominated habitat type in the Black Hills. This habitat type, sampled in 12 stands, is recognized by the overstory dominance and reproductive success of *P. ponderosa*, and the dominance of *S. albus* in the undergrowth (fig. 8). Tree populations show a wide range of size classes. Some stands are distinctly two- or three-aged, with gaps apparent in the middle diameter classes. In addition to *S. albus*, other important shrubs are *Amelanchier alnifolia* and *Rosa woodsii*. The herbaceous layer is dominated by *Oryzopsis* spp., *Achillea millefolium*, *Anemone patens*, *Antennaria plantaginifolia*, *Balsamorhiza sagittata*, and *Campanula rotundifolia* (table A-3).



Figure 8.—*Pinus ponderosa*/*Symphoricarpos albus* habitat type. All diameter classes up to and including 16- to 20-inch (4- to 5-dm) d.b.h. class are present. Total coverage of undergrowth in this stand (59) is 60%.



Figure 9.—*Pinus ponderosa*/*Symphoricarpos albus* habitat type; *Balsamorhiza sagittata* phase. This phase is best developed in the southwestern Black Hills.

Two phases of the *P. ponderosa*/*S. albus* habitat type were recognized in the Black Hills.

1. ***Balsamorhiza sagittata* phase.**—This is a minor phase with restricted distribution along the western edge of the Black Hills. The *B. sagittata* phase, sampled in two stands, is recognized by the codominance of *B. sagittata*, with *S. albus* in the undergrowth (fig. 9). The undergrowth in the stands sampled in this phase show considerable variability (table A-3).

2. ***Oryzopsis asperifolia* phase.**—This phase was sampled in four stands in the Central Core region. The undergrowth is characterized by the conspicuous presence of *O. asperifolia*, and the occurrence of *S. albus* and its associates. *Arctostaphylos uva-ursi* is prominent in two of the stands sampled (table A-3).

The *P. ponderosa*/*S. albus* habitat type is the richest in species of all habitat types in the Black Hills. Elsewhere, this habitat type also is rich in species (Daubenmire and Daubenmire 1968, Pfister et al. 1977). The *P. ponderosa*/*S. albus* habitat type occurs in eastern Washington and northern Idaho (Cooper,<sup>4</sup> Daubenmire and Daubenmire 1968), east-central and southwestern Montana (Pfister et al. 1977), and in central Idaho (Steele et al. 1981). Many of the undergrowth species common in the Black Hills also occur in this habitat type in the northern Rocky Mountains.

**Management implications.**—Timber production potential of *P. ponderosa* varies considerably in this habitat type (Hornibrook 1939, Meyer 1938). While all silvicultural systems and cutting methods can be used in this habitat type, a two-cut shelterwood is a preferred even-aged method of harvesting *P. ponderosa* in stands without a manageable stand of advanced reproduction. Generally, prompt and dense subsequent regeneration is characteristic of this habitat type under well-executed shelterwood cuts. In stands with a manageable stand of advanced reproduction, a simulated shelterwood should be used to remove the overstory and release the understory (Alexander 1987).

<sup>4</sup>Cooper, Steven, Kenneth Neiman, and Robert Steele. Forest habitat types of northern Idaho. Manuscript in preparation. Intermountain Research Station, Ogden, Utah.

### *Pinus ponderosa-Juniperus scopulorum*

Uneven-aged management with individual tree and group selection cutting can reduce stand susceptibility to mountain pine beetle by removing the most susceptible host trees. Group selection cutting is a possibility in stands with irregular structure, but individual tree selection in stands not attacked by mountain pine beetles generally is appropriate only in recreation and scenic view areas, or in situations where it is desirable to maintain vertical diversity. Growth usually will be reduced with either uneven-aged cutting method. However, reproduction usually is easily obtained with any partial cutting method (Alexander 1987).

In young *P. ponderosa* sapling and pole stands, thinning almost always is needed to reduce basal area and improve soil moisture conditions. Growing stock levels (GSLs) of 120 to 140 are most appropriate for timber production in stands where mountain pine beetle risk is low (Alexander and Edminster 1981).

The *P. ponderosa/S. albus* habitat type is mild season range for livestock and yearlong or transition range for big game (Thilenius 1972). Forage production potential is moderate. Prescribed burning can be used to increase the amount of palatability of shrubs and graminoids in the undergrowth. However, increasing the palatability of graminoids may increase livestock grazing pressure on the burned areas at the expense of big game. Since increases in forage are inversely proportional to the amount of overstory retained, low stocking levels (GSLs 40 to 60) are more appropriate than the higher GSLs suggested for timber production (Krantz and Linder 1973, Pase 1958). If browse species are absent and the stand is to be managed as big game cover, a three-step shelterwood with a residual stocking maintained at  $GSL \geq 80$  is recommended. In addition to big game, the *P. ponderosa/S. albus* habitat type provides food and cover for fox squirrel, turkey, and for numerous nongame animals that require den or nest trees.

Precipitation in this habitat type varies considerably, depending somewhat on elevation and location in the Black Hills. Under average conditions, streamflow is about 25% of the annual precipitation, which can vary from 16 to 28 inches (41 to 71 cm). In the northern Black Hills where precipitation is heaviest, water yields from untreated *P. ponderosa* forests on the Sturgis watershed averaged about 7 inches (18 cm) from 1964 to 1969 (Orr and VanderHeide 1973). Streamflow can be increased by reducing stand density (Orr 1975). Increases are inversely proportional to the reduction in stand density—clearcutting, group shelterwood, and group selection are more efficient than standard shelterwood or individual tree cutting, or thinning. If stands are clearcut, openings must be kept very small, because effective seeding distance of *P. ponderosa* limits the diameter of the opening to about 250 feet (76 m) (Boldt and Van Deusen 1974). Erosion and sedimentation potentials are moderate but can be accelerated by timber harvesting unless careful consideration is given to road location, construction, and maintenance. The potential for developed and dispersed recreation, and scenic values of this habitat type are relatively high because of the area involved and the elevations where it occurs.

**Description.**—The *Pinus ponderosa-Juniperus scopulorum* habitat type occurs in the dry southern part of the Black Hills, mainly on steep, rocky slopes. Stands vary from open to closed. This incidental habitat type, which occurs mainly outside the forest boundary, was sampled on only one plot but was observed in five other stands during the reconnaissance survey. The *P. ponderosa-J. scopulorum* habitat type is recognized by the overstory dominance of *P. ponderosa*, the presence of *J. scopulorum* as a major shrub, and a rather poorly defined and unevenly dispersed undergrowth (fig. 10). Principal undergrowth species are *Bouteloua curtipendula*, *Oryzopsis micrantha*, *Anemone patens*, *Artemisia frigida*, and *Campanula rotundifolia* (table A-4). Despite the wide distribution of both *P. ponderosa* and *J. scopulorum* in the Rocky Mountains, the *P. ponderosa-J. scopulorum* habitat type has not been reported elsewhere (Alexander 1985).

**Management implications.**—Timber production potential in this dry, low-elevation habitat type is low. Moreover, because of low precipitation and competition from *J. scopulorum*, regeneration of *P. ponderosa* is less reliable than on more productive habitat types. Stands are harvested mostly for fuelwood. The *P. ponderosa-J. scopulorum* habitat type is spring-fall range for livestock and winter range for big game. It has low to moderate potential for forage production for livestock and moderate potential for deer. Use by deer can be heavy in the winter, however. Timber harvesting and thinning activities in the *P. ponderosa-J. scopulorum* habitat type should be directed at maintaining hiding cover for big game.

Average annual precipitation in this habitat type is low for the Black Hills—17 inches (43 cm) or less—and the potential for significant increases in streamflow is low. This habitat type provides watershed protection. The potential for developed and dispersed recreation is low to moderate.



Figure 10.—*Pinus ponderosa-Juniperus scopulorum* habitat type. Both dominant species are abundant in this stand. Undergrowth is sparse.



### *Pinus ponderosa*/*Carex heliophila*

**Description.**—The *Pinus ponderosa*/*Carex heliophila* habitat type, represented by three stands, is scattered mainly in peripheral locations of the Black Hills. It is recognized by the overstory dominance and reproductive success of relatively widely spaced *P. ponderosa*, and the presence and abundance of *C. heliophila* (23% to 48% coverage) in the undergrowth (fig. 11). *Quercus macrocarpa* may occur as an understory tree in some stands. Shrubs and forbs are not very important in this habitat type. Graminoids constitute 67% to 90% of the total undergrowth coverage. In addition to *C. heliophila*, *Danthonia spicata* and *Poa pratensis* are important graminoids (table A-4).

The *P. ponderosa*/*C. heliophila* habitat type has been reported by Hansen and Hoffman (in prep.) on the Custer National Forest in northwestern South Dakota and southeastern Montana where *C. heliophila* and *Agropyron spicatum* were the most important undergrowth species. This habitat type has not been reported elsewhere in the Rocky Mountains (Alexander 1985), and *C. heliophila* does not occur in any of the drier *P. ponderosa*-dominated habitat types reported.

**Management implications.**—Timber productivity in this relatively dry habitat type is average to below average for Black Hills *P. ponderosa*. Partial cutting methods that minimize soil disturbance and maintain overhead shade are appropriate. Regeneration of *P. ponderosa* usually establishes readily both under an overstory and in clearings with a heavy sod cover. Heavy cutting may either increase or decrease the amount of *C. heliophila* and associated graminoids, depending upon the amount of ground disturbance. This habitat type is spring-fall range for livestock and spring-summer range for big game. The potential for increasing forage production is moderate for both livestock and big game. Heavy grazing by either livestock or big game may deplete the *C. heliophila* sod cover.

The potential for increasing water yield is moderate to low for the *P. ponderosa* series. Average annual precipitation varies from 15 to 18 inches (38 to 46 cm). Under average conditions, about 25% of the annual precipitation becomes runoff. Although no data are available on amount, streamflow can be increased by reducing stand density. The increase is directly related to the amount of precipitation received and inversely proportional to the reduction in stand density. Erosion, sedimentation, and mass movement potentials generally are low.

### *Pinus ponderosa*/*Physocarpus monogynus*

**Description.**—The *Pinus ponderosa*/*Physocarpus monogynus* habitat type, represented by three stands, occurs in the southern and southwestern Black Hills, usually on north- to northwest-facing slopes. This habitat type is recognized by the overstory dominance and reproductive success of *P. ponderosa*, and the presence and abundance of *P. monogynus* (23% to 79% coverage) in the undergrowth (fig. 12). The most important undergrowth



Figure 11.—*Pinus ponderosa*/*Carex heliophila* habitat type in the Elk Mountains, southwestern Black Hills. The undergrowth is characterized by nearly complete cover of *C. heliophila*, with a few other species present. Abundant *P. ponderosa* seedlings and saplings are present in the background.



Figure 12.—*Pinus ponderosa*/*Physocarpus monogynus* habitat type. *P. monogynus* dominates the relatively dense undergrowth of this stand in Boles Canyon.

species, primarily shrubs and forbs, include *P. monogynus*, *Prunus virginiana*, *Rosa acicularis*, *Symphoricarpos albus*, *Agropyron caninum*, *Anemone patens*, *Galium boreale*, and mosses and lichens (table A-4).

Where the *P. ponderosa*/*P. monogynus* habitat type occurs, succession after fire appears to include a stage of *Cercocarpus montanus* that eventually is shaded out by the overstory canopy of *P. ponderosa*. But, some stands in this area with *Pinus* and *Cercocarpus* are not habitat types. The population structures of *Pinus* and *Cercocarpus* is unstable, and there is little evidence to suggest that *Pinus* will form a closed canopy and *Cercocarpus* will be eliminated from the undergrowth. Some stands are ecotonal between *Pinus*-dominated forests and *Cercocarpus*-dominated shrub-steppe and are likely to remain in this state indefinitely.

Hoffman and Alexander (1976) described a *P. ponderosa*/*P. monogynus* habitat type in the Bighorn Mountains, Wyo., but few floristic similarities are found with the same habitat type in the Black Hills. Cooper,<sup>4</sup> Daubenmire and Daubenmire (1968), and Steele et al. (1981) described a *P. ponderosa*/*Physocarpus malvaceus*

habitat type in northern and central Idaho and eastern Washington that is dominated by tall shrubs, but there is little floristic similarity to the *P. ponderosa*/*P. monogynus* habitat type in the Black Hills.

**Management implications.**—This habitat type occupies less favorable sites than those that support *P. ponderosa*/*Juniperus communis*, *P. ponderosa*/*S. albus*, and *P. ponderosa*/*Arctostaphylos uva-ursi* in the Black Hills. Although timber production potential is high for the *P. ponderosa* series and most cutting methods are applicable, all of the stands examined occupied relatively small areas that were on steep slopes. Any timber harvesting activities under these circumstances are likely to increase the potential for erosion and subsequent sedimentation. Moreover, it may be difficult to restock the stands with subsequent natural regeneration if logging results in soil movement.

The *P. ponderosa*/*P. monogynus* habitat type is summer-fall livestock range and fall-winter deer range. Livestock forage production is variable, and the potential for increase depends upon the density and composition of the undergrowth and the density of the overstory (Krantz and Linder 1973, Pase 1958). Big game forage production is higher than in the drier *P. ponderosa* habitat types. Winter use by deer may be heavy. This habitat type also provides food and cover for numerous birds and small mammals, providing that den and nest trees are left uncut.

Runoff from this habitat type is relatively high for the Black Hills. Streamflow can vary from 8 inches (20 cm) in years of high precipitation to 4 inches or less ( $\leq 10$  cm) in years of low precipitation. However, because of the small and scattered occurrence of this habitat type on difficult to log sites, it probably is not realistic to attempt to increase streamflow by timber harvesting.

### *Pinus ponderosa*/*Quercus macrocarpa*

**Description.**—The *Pinus ponderosa*/*Quercus macrocarpa* habitat type, represented by four stands, occurs in the northern Black Hills but is most conspicuous in the Bear Lodge Mountains. The sampled stands were all on calcareous soils, but the habitat type also may occur on soils derived from igneous rocks in the northwestern Black Hills. *P. ponderosa* is the sole dominant overstory species. *Q. macrocarpa* is a tall shrub in this habitat type and dominates (4% to 26% coverage) the undergrowth (fig. 13). Other important shrubs are *Amelanchier alnifolia*, *Berberis repens*, *Prunus virginiana*, and *Spiraea betulifolia*. Graminoids with high constancy are *Carex foenea* and *Oryzopsis asperifolia*. Important forbs are *Aster ciliolatus*, *Galium boreale*, *Lupinus argenteus*, and *Smilacina stellata* (table A-5). The *P. ponderosa*/*Q. macrocarpa* habitat type has not been identified elsewhere in the Rocky Mountains (Alexander 1985).

**Management implications.**—Timber production potential is low to moderate in this habitat type. If the *P. ponderosa*/*Q. macrocarpa* habitat type is managed for *P. ponderosa*, shelterwood cutting is most appropriate; overstory competition is needed to control *Q. macrocarpa*. If a market exists for *Q. macrocarpa* removed in treatment, it is for fuelwood. An important value of this

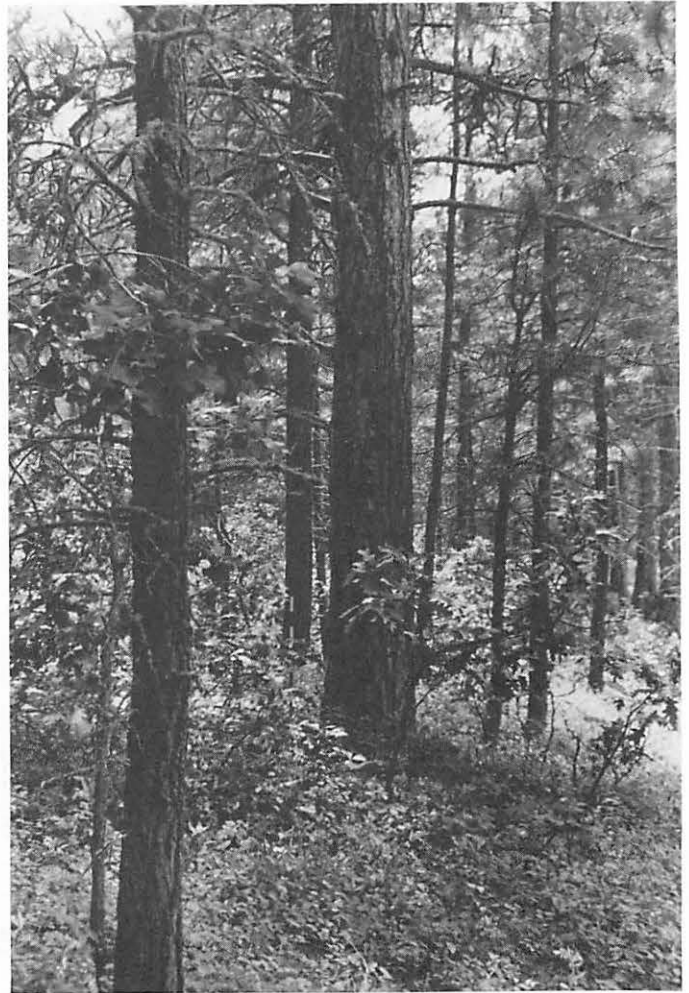


Figure 13.—*Pinus ponderosa*/*Quercus macrocarpa* habitat type. Although *Q. macrocarpa* becomes a tall shrub, it does not reach the canopy level. *P. ponderosa* is present in several size classes in this stand in the Bear Lodge Mountains.

habitat type is for forage and mast production, and the potential for increase is moderate to high. The *P. ponderosa*/*Q. macrocarpa* habitat type is spring-fall range for livestock, winter range for deer, and provides year-long habitat for turkey and fox squirrels. Timber cutting in this habitat type can be directed toward opening up the stand by removing overstory *P. ponderosa* to release *Q. macrocarpa* and increase mast production. Subsequent increases in associated undergrowth also improves forage production. Individuals or groups of large *P. ponderosa* retained on the site are critical den and/or nest sites and roosts. To stimulate production of browse, clumps of *Q. macrocarpa* that are declining in vigor can be cut, burned, or poisoned to stimulate sprouting. Sufficient new *P. ponderosa* also must become established periodically to ultimately replace the existing old-growth. If management emphasis is on big game winter range, shelterwood cutting and maintaining a residual stocking of  $GSL \geq 80$  are appropriate. The *P. ponderosa*/*Q. macrocarpa* habitat type also provides food and cover for numerous birds and nongame animals that feed on tree seeds and acorns. Acorn production can be maintained by retaining larger diameter *Q. macrocarpa* on the site. To maintain larger



trees, prescribed burning should be done in the fall while the trees still retain their leaves. Wildfires strongly favor *Q. macrocarpa* communities established from sprouts. These can provide severe competition for *P. ponderosa* and results in very slow invasion of burned over areas by *P. ponderosa*.

Mean annual precipitation in this habitat type is average for the Black Hills and Bear Lodge Mountains; both streamflow and the potential for increasing streamflow also are average. Ground disturbance associated with treatment should be minimized to maintain potential losses to erosion, sedimentation, and mass movement at low levels. Dispersed recreation potential is good for hunting of turkey and deer.

### *Pinus ponderosa*/*Arctostaphylos uva-ursi*

**Description.**—The *Pinus ponderosa*/*Arctostaphylos uva-ursi* habitat type is widespread over the Central Core region and also occurs on calcareous soils in the Black Hills. This habitat type, sampled in 10 stands, is recognized by the dominance and reproductive success of *P. ponderosa* in the overstory, and the presence and abundance of *A. uva-ursi* (10% to 85% coverage) in the undergrowth (fig. 14). *Populus tremuloides* and *Quercus macrocarpa* were present as seedlings, but did not occur as older trees in the stands sampled. In addition to *A. uva-ursi*, other important undergrowth species are *Rosa acicularis*, *Symphoricarpos albus*, *Oryzopsis asperifolia*, *Achillea millefolium*, *Fragaria virginiana*, and *Lathyrus ochroleucus* (table A-6).

DeVelice et al. (1986) identified a *P. ponderosa*/*A. uva-ursi* habitat type in southern Colorado and northern New Mexico, but it has little floristic similarity to the *P. ponderosa*/*A. uva-ursi* habitat type in the Black Hills. This habitat type has not been identified elsewhere in the Rocky Mountains (Alexander 1985).

**Management implications.**—Timber production potential of the *P. ponderosa*/*A. uva-ursi* habitat type is low to moderate. Regeneration usually establishes more readily with partial cutting methods than with those that create openings, but reproduction usually can be ob-



Figure 14.—*Pinus ponderosa*/*Arctostaphylos uva-ursi* habitat type on the Black Hills Experimental Forest. Note the complete development of the undergrowth.

tained with any cutting method (Alexander 1987). Reproduction of *P. ponderosa* following shelterwood cutting or wildfires often is extremely dense. In dense, young stands, thinning to GSLs 120 to 140 are required to maximize timber production (Alexander and Edminster 1981).

This habitat type is summer-fall range for livestock and big game. Forage production potential is moderate to very low. Forage production can be improved by prescribed burning that increases the amount of palatable shrubs and graminoids. Partial cutting also is likely to increase the shrub and forb layers somewhat and to improve diversity, but may not substantially increase forage production unless GSLs are maintained at low levels (20 to 40) (Severson and Boldt 1977). If browse species are absent and the stand is to be managed for big game cover, a three-step shelterwood with residual stocking maintained at  $GSL \geq 80$  is recommended. This habitat type is most valuable to big game when adjacent to grasslands. The *P. ponderosa*/*A. uva-ursi* habitat type also provides food and cover for numerous nongame birds and mammals that require a combination of trees and open nonforested areas.

The potential for water production is moderate. Average precipitation varies from 15 to 25 inches (38 to 64 cm). About 25% [3 to 6 inches (8 to 15 cm)] of the precipitation is available as streamflow. Natural runoff can be increased by reducing stand density. The greatest increases will occur in years of high precipitation in areas where small openings are created throughout the stand (Orr 1975). To be effective, partial cutting and thinning must reduce stand density to GSLs 60 to 80. Erosion, sedimentation, and mass movement potentials generally are low unless roads are constructed among stream channels or in valley bottoms. Developed and dispersed recreation potentials are moderate.

### *Pinus ponderosa*/*Juniperus communis*

**Description.**—The *Pinus ponderosa*/*Juniperus communis* habitat type is widely distributed on the Limestone Plateau in the western part of the Black Hills. It also can occur on soils derived from igneous rock. The elevational range of this habitat type overlaps all *Pinus*-dominated habitat types, except the *P. ponderosa*-*Juniperus scopulorum* habitat type at lower elevations (table 1). The *P. ponderosa*/*J. communis* habitat type was sampled in seven stands located on gentle southwest- to northeast-facing slopes. This habitat type is recognized by the dominance and reproductive success of *P. ponderosa* in the overstory, and the presence and abundance of *J. communis* (4% to 42% coverage) in the undergrowth (fig. 15). *Populus tremuloides* can be an important seral species in this habitat type following wildfires. *Betula papyrifera* and *Picea glauca* also may occur occasionally in both the overstory and as reproduction. Shrubs are the most important undergrowth life forms. In addition to *J. communis*, *Arctostaphylos uva-ursi*, *Berberis repens*, *Rosa acicularis*, *Spiraea betulifolia*, and *Symphoricarpos albus* have high constancy. The most important herbaceous species are *Bromus inermis*, *Achillea millefolium*, *Fragaria virginiana*, and *Lupinus argenteus* (table A-7). The

undergrowth of this habitat type is similar to that of the *P. ponderosa*/*A. uva-ursi* habitat type but is distinguished primarily by the presence of *J. communis*, *B. repens*, and *L. argenteus*, and the absence of *Lathyrus ochroleucus* and *Oryzopsis asperifolia*.

Some *P. ponderosa*/*J. communis* communities are seral to *Picea glauca*-dominated vegetation (see *P. glauca* series). In some locations, *P. glauca* is succeeding *P. ponderosa* (fig. 16). This is typical of the late seral stage of the *P. glauca*/*Linnaea borealis* habitat type.

Hoffman and Alexander (1976) described a *P. ponderosa*/*J. communis* in the Bighorn Mountains, Wyo., but there is little floristic similarity to the Black Hills *P. ponderosa*/*J. communis* habitat type. This habitat type has not been reported elsewhere in the Rocky Mountains (Alexander 1985).

**Management implications.**—Timber productivity for this habitat type is average to above average for *P. ponderosa*. Shelterwood cutting methods are the preferred timber harvesting alternative in even-aged stands to be managed for timber production. Either group selection or individual tree selection cutting can be used where even-aged management does not meet the requirements



Figure 15.—*Pinus ponderosa*/*Juniperus communis* habitat type. *J. communis* has 28% coverage and 52% frequency in this stand. *P. ponderosa* is present in all size classes up to and including 16 to 20 inches (4 to 5 dm) d.b.h.



Figure 16.—A seral *Pinus ponderosa* stand on a *Picea glauca*/*Linnaea borealis* habitat type. Note *Juniperus communis* in the undergrowth.

of other resources (Alexander 1987). Regeneration usually is prompt after shelterwood cutting. It is less certain following clearcutting, seed-tree cutting, and wildfires. At higher elevations where lush stands of graminoids and forbs become established, regeneration of *P. ponderosa* can be precluded for long periods of time. *P. tremuloides* can be readily regenerated by clearcutting or fire if it is present as a seral species in stands in this habitat type. *P. tremuloides* is sensitive to overgrazing and can be eliminated by livestock and/or big game use. Growing stock levels of 120 to 160 are appropriate for timber production in stands where mountain pine beetle populations are low (Alexander and Edminster 1981).

The *P. ponderosa*/*J. communis* habitat type is summer-fall range for livestock and big game (Thilenius 1972). Forage production potential for livestock is low to moderate, but can be increased in proportion to the amount of graminoids in the undergrowth by reducing overstory density with a two-step shelterwood to low stocking levels (GSL 40 to 60) and with proper grazing management (Krantz and Linder 1973, Pase 1958). Big game forage production may be higher than in the drier *P. ponderosa* habitat types, but the potential for production of shrubby browse on winter range is low. If big game management emphasis in this habitat type is for big game cover, shelterwood cutting with residual stocking levels maintained at  $GSL \geq 80$  are recommended. This habitat type also provides food and cover for a large number of birds and small mammals. *J. communis* typically is important nesting cover for turkey. Prescribed burning can greatly decrease the amount of fire-sensitive *J. communis*, and increase the representation of graminoids and forbs in the undergrowth. However, the increase in potential livestock forage production is at the expense of big game cover. Introduced graminoids, such as *Oryzopsis* spp., can grow well in this habitat type, especially in the seral stages.

Average precipitation in this habitat type ranges from 18 to 28 inches (46 to 71 cm). Natural streamflow ranges from 3 to 7 inches (8 to 18 cm), but runoff can be increased by reducing stand density. The increase is inversely proportional to the reduction in stand density and the amount of precipitation received (Orr 1975). Cutting methods that create small openings are more effective than partial cutting. Erosion, sedimentation, and mass movement potentials may be higher than in the drier *P. ponderosa* habitat types. The potential for developed and dispersed recreation also is higher than in the drier *P. ponderosa*-dominated habitat types.

## POPULUS TREMULOIDES SERIES

*Populus tremuloides* is not an important timber species in the Black Hills, covering only about 5% of the area (Severson and Thilenius 1976). Forests dominated by *P. tremuloides* provide wildlife and livestock habitat and esthetic amenities that are more valuable than the limited extent of the forests might suggest.

Hayward (1928) and McIntosh (1930) reported *P. tremuloides* as a seral species in the Black Hills. Sever-



son and Thilenius (1976) classified *P. tremuloides* stands in the Black Hills but did not report on their successional status. Although *P. tremuloides* is seral over much of its range, it also is climax in various habitats. In the Black Hills, it is common for *P. tremuloides* to occur between conifer forests on coarse-textured soils on mountain slopes and adjacent grassland parks with fine-textured soils (fig. 17). Most stands of this tree species are initiated by destruction of coniferous forests (Hoffman and Alexander 1980). Mueggler (1976) suggested the only reliable evidence of succession from *P. tremuloides*-dominated forests to conifer-dominated forests is a multilayered understory of climax coniferous species. In the Black Hills as elsewhere, an occasional conifer in a *Populus*-dominated stand is not evidence of succession to conifers. In Utah, Mueggler (1976) suggested that even in the absence of fire, 1,000 years or more might be required for the succession of *P. tremuloides*-dominated forests to climax coniferous-dominated forests. If this time span is accurate, self-reproducing forests of *P. tremuloides* showing no evidence of succession toward conifer-dominated forests should be considered climax and the sites classified as habitat types (Hoffman and Alexander 1980). In the Black Hills, seral communities of *P. tremuloides* most commonly occur on sites where *Picea glauca* is climax; succession is evident in a number of these stands (fig. 18). Control of fires has changed the distribution of *P. tremuloides* in the Black Hills. Where management includes prescribed burning, *Populus* sprouts are not uncommon in habitat types, such as *P. ponderosa*/*Arctostaphylos uva-ursi* and *P. ponderosa*/*Juniperus communis*. However, these sprouts do not persist. Some stands of *P. tremuloides* are seral to one or both of these *Pinus*-dominated habitat types. In a recently built enclosure in Custer State Park, *P. tremuloides* developed a dense stand of saplings within 2 years following the exclusion of grazing (fig. 19). This suggests that grasslands may be occupying forest sites in some instances.

In most *Populus*-dominated stands, *Betula papyrifera* is a codominant species; its height is less than that of *Populus*, and in numerous places, its ecologic role is that of an undergrowth shrub. Hayward (1928) and McIntosh



Figure 17.—The lower edge of the coniferous-dominated forest is fringed by *Populus tremuloides*. Extending into the area adjacent to the stream is a stand of *Salix* spp. that is gradually being eliminated by domestic livestock.



Figure 18.—A *Populus tremuloides* community occupying a *Picea glauca*-dominated habitat type. *P. glauca* has become well established in the understory.



Figure 19.—A 2-year-old enclosure in Custer State Park. The absence of animal activity has resulted in *Populus tremuloides* developing a dense stand already 1 to 2 m tall.

(1930) both described *P. tremuloides*-*B. papyrifera* forests on recently burned areas of the Black Hills. From their lists of undergrowth species, it is likely their *Populus*-*Betula*-dominated forests occupied sites that were either *P. glauca*-dominated habitat types or the *P. ponderosa*/*J. communis* habitat type.

The *P. tremuloides* series was sampled in nine stands, representing one habitat type and two phases, ranging in elevation from 3,966 to 6,240 feet (1,219 to 1,902 m) (table 2). The average age of dominant *P. tremuloides* was 115 years in one stand (55) (fig. 20). Most other *Populus*-dominated stands were less than 100 years old. Basal areas on the study plots ranged from 122 to 226 square feet per acre (28 to 52 m<sup>2</sup> / ha). Tree sizes ranged from seedlings to the 16- to 20-inch (4- to 5-dm) d.b.h. class. Tree population and undergrowth data for *P. tremuloides* are shown in tables A-1 and A-8.

#### *Populus tremuloides*/*Corylus cornuta*

**Description.**—The *Populus tremuloides*/*Corylus cornuta* habitat type is recognized by the overstory dominance

and reproductive success of *P. tremuloides*, and the dominance of *C. cornuta* in the undergrowth (fig. 20). *Betula papyrifera* usually is a subdominant tree species. *Quercus macrocarpa* is well represented in stands in the central Black Hills. *Pinus ponderosa* and *Picea glauca* rarely occur. This habitat type is second in undergrowth species richness to the *P. ponderosa*/*Symphoricarpos albus* habitat type. *C. cornuta* forms a dense tall shrub layer. Other shrubs with high constancy are *Amelanchier alnifolia*, *Berberis repens*, *Lonicera dioica*, *Prunus virginiana*, *Pyrola asarifolia*, *Rosa acicularis*, *Rubus idaeus*, *Spiraea betulifolia*, and *S. albus*. Below the shrub layer is a rich layer of herbaceous species including *Actaea rubra*, *Aralia nudicaulis*, *Aster ciliolatus*, *Fragaria virginiana*, *Galium triflorum*, *Lathyrus ochroleucus*, *Maianthemum canadense*, *Osmorhiza chilensis*, *Pteridium aquilinum*, *Sanicula marilandica*, *Smilacina stellata*, *Thalictrum dasycarpum*, *Viola canadensis*, and *Oryzopsis asperifolia*.

Two phases of the *P. tremuloides*/*C. cornuta* habitat type were recognized in the Black Hills.

1. ***Pteridium aquilinum* phase.**—This phase, represented by three stands in the Bear Lodge Mountains, is



Figure 20.—*Populus tremuloides*/*Corylus cornuta* habitat type. The large *P. tremuloides* next to the meter stick is in the 16- to 20-inch (4- to 5-dm) d.b.h. class. Both *Betula papyrifera* and *Ostrya virginiana* are present in the shrub layer.



Figure 21.—*Populus tremuloides*/*Corylus cornuta* habitat type; *Pteridium aquilinum* phase. *P. aquilinum* has a coverage of 33% in this stand (26). *Amelanchier alnifolia* and *Corylus cornuta* form a large but not dense shrub layer.

recognized by the abundance of *P. aquilinum* (23% to 33% coverage) under *C. cornuta* in the undergrowth (fig. 21). Other undergrowth species present in this phase, but with low constancy in the typical phase, are *Melica subulata*, *Anaphalis margaritacea*, *Pyrola elliptica*, *Habenaria viridis*, *Heuchera richardsonii*, *Ranunculus abortivus*, and *Carex sprengei*. However, only *Pteridium*, *Melica*, *Anaphalis*, and *Pyrola* have average coverages greater than 0.5%. Additionally, only *Pteridium* and *Melica* have frequencies greater than 50%.

*P. aquilinum* establishes readily following fire, and it may persist for a long time. In Finland, Oinonen (1967) found *P. aquilinum* had occupied the same site for 1,200 years. In the Black Hills, some stands of *Populus*/*Pteridium* are nearly 100 years old, with *Pteridium* still vigorous and dominant in the undergrowth. These stands appear stable and should be considered a habitat type.

The soils in this phase are somewhat distinct from those of both the typical *P. tremuloides*/*C. cornuta* habitat type and the *A. nudicaulis* phase. Under the *P. aquilinum* phase, the upper 4 inches (1 dm) of the soil contains more exchangeable Ca and Mg, a higher cation-exchange capacity (C.E.C.), and more organic matter.

2. ***Aralia nudicaulis* phase.**—This phase, represented by only one stand, is distinguished primarily on the basis of abundant *A. nudicaulis* that dominates the undergrowth (fig. 22). It also has conspicuous amounts of *R. idaeus*, *A. ciliolatus*, *Halenia deflexa*, *S. marilandica*, and *Toxicodendron rydbergii*. Abundant grasses are *Poa pratensis* and *Phleum pratense*, both of which are introduced and tend to increase with grazing pressure.

The *P. tremuloides*/*C. cornuta* habitat type has not been reported elsewhere in the Rocky Mountains (Alexander 1985). However, a *P. tremuloides*/*P. aquilinum* habitat type has been reported in western Colorado on the Routt National Forest (Hoffman and Alexander 1980), White River National Forest (Hoffman and Alexander 1983), Gunnison National Forest (Komarkova et al.<sup>5</sup>), and the Un-

<sup>5</sup>Komarkova, Vera, Robert R. Alexander, and Barry Johnston. Forest vegetation of the Gunnison and parts of the Uncompahgre National Forests: a preliminary habitat type classification. Manuscript in preparation. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.



compahgre National Forest (Hoffman<sup>6</sup>). This habitat type has some floristic similarities to the *P. tremuloides*/*C. cornuta* habitat type, *P. aquilinum* phase in the Black Hills.

**Management implications.**—Timber productivity for *P. tremuloides* is low in this habitat type (Edminster et al. 1985), and there is little potential for increasing it. The timber is of low quality and value; its market is primarily for fuelwood. On more productive sites, *Populus* is seral to *P. ponderosa* or *P. glauca*. Moreover, climax *Populus* stands in the Black Hills tend to occur as stringers or small groves adjacent to or interspersed with other vegetation, rather than in large contiguous stands. These stands are valuable chiefly for wildlife and scenic beauty, and cutting should be directed toward maintaining or enhancing those values. While clearcutting usually is the best method of perpetuating *P. tremuloides*, other methods of harvesting may better meet the requirements of other resources. Prescribed burning can be used after clearcutting to reduce undergrowth competition and stimulate sprouting.

The *P. tremuloides*/*C. cornuta* habitat type is one of the most productive and varied plant associations in the Black Hills for resources other than timber. It is preferred

<sup>6</sup>Hoffman, George R. Unpublished data on file. South Dakota University, Vermillion, S. Dak.



Figure 22.—*Populus tremuloides*/*Corylus cornuta* habitat type; *Aralia nudicaulis* phase. *A. nudicaulis* has 47% coverage in this stand (43). *Betula papyrifera* is an abundant subdominant.

summer-fall range for domestic livestock. However, because of the limited area in this habitat type, use by livestock may be too heavy unless care is taken to control the number and distribution of animals and the season of use. Under proper grazing management, high forage yields can be maintained. This habitat type is summer-fall range for deer and yearlong habitat for ruffed grouse (Severson and Thilenius 1976). However, the preferred *Populus* habitat for deer is late seral *Populus*, which contains *P. ponderosa* (Krantz and Linder 1973). On the other hand, the preferred habitat for ruffed grouse does not include coniferous trees, because they provide optimum cover for ruffed grouse predators (Gullion and Svoboda 1972). Since ruffed grouse feed mostly on *Populus* male flower buds and *Corylus* buds in the winter, management should be directed toward maintaining a high proportion of *Corylus* in the undergrowth and creating a series of *Populus* age and density classes. The *P. tremuloides*/*C. cornuta* habitat type also provides food and cover for numerous birds and nongame animals.

Climax *P. tremuloides* stands have good scenic quality but exhibit less favorable color contrast than late seral mixed *Populus*-conifer stands. Dispersed recreation potential is high, but developed recreation potential is low, because *Populus* is damaged easily and does not survive well under this kind of use. The potential for increasing streamflow is of little consequence because of the small area in *Populus*. Erosion, sedimentation, and mass movement potentials are low.

#### PICEA GLAUCA SERIES

The *Picea glauca* series in the Black Hills occurs at the high elevations and in cool canyon bottoms. Temperature apparently is more important as a controlling factor than soils, because *P. glauca* forests occur on soils derived from both igneous and limestone rocks. The Black Hills area is one of the few in the Rocky Mountains, south of the United States-Canadian border, where apparently pure populations of *P. glauca* occur. In the Bighorn Mountains to the west, *P. glauca* populations show evidence that introgression has occurred between *Picea engelmannii* and hybrids of *P. engelmannii* x *P. glauca* (Daubenmire 1974).

The *P. glauca* forests in the Black Hills constitute the "subalpine" forests, although alpine areas are absent here. Additionally, *Abies* spp. are absent, so the *Picea*-*Abies* zone, typical of the Rocky Mountains, generally is represented in the Black Hills by *P. glauca* without the *Abies* component as a climax tree. *Pinus contorta*, also common in subalpine forests over much of the Rocky Mountains, has a very restricted distribution in the Black Hills.

*Pinus ponderosa*, *Populus tremuloides*, and *Betula papyrifera* are common seral species in the *P. glauca* zone. However, *P. glauca* rarely occurs in vegetation dominated by either *P. ponderosa* or *P. tremuloides*; it is not aggressive as a seral species, although it appears to be expanding or reinvading certain areas (fig. 23).

The *P. glauca* series in the Black Hills constitutes a rather small fraction of the total forested area but does represent the high-elevation coniferous forests. It is of

historical interest because of the presence of certain undergrowth plants that accompanied *P. glauca* to the Black Hills during Pleistocene time and became disjunct from their relatives in the Bighorn Mountains, Wyoming, or the Boreal Forest in Canada.

The *P. glauca* series was sampled in 10 stands, representing two habitat types, ranging in elevation from 5,699 to 6,693 feet (1,737 to 2,040 m) (table 2). The age of *P. glauca* varied from 80 to 180 years. Basal areas on the study plots ranged from 135 to 222 square feet per acre (31 to 51 m<sup>2</sup>/ha). Tree sizes ranged from seedlings to the 20- to 24-inch (5- to 6-dm) d.b.h. class. Tree population and undergrowth data for *P. glauca* are shown in tables A-1 and A-9.

### *Picea glauca*/Linnaea borealis

**Description.**—The *Picea glauca*/Linnaea borealis habitat type, represented by five stands, generally occurs on northwest- to northeast-facing slopes. This habitat type is recognized by the presence and reproductive success of *P. glauca*, and the presence and abundance of *L. borealis* (6% to 36% coverage) in the undergrowth (fig. 24). *Pinus ponderosa* and *Populus tremuloides* occur as major seral species in most stands in this habitat type. *P. ponderosa* typically shows size class distributions indicative of a seral species gradually being replaced by another species. *P. tremuloides* was present in the stands sampled in only the small size classes, with little evidence its population is expanding. Like *P. ponderosa*, *P. tremuloides* probably is a remnant of the last major disturbance of *Picea*-dominated forests and may always be a component of these forests. Even in the oldest stands sampled, scattered *Pinus* and *Populus* persist.

In addition to *L. borealis*, important shrubs in the rich mixture of undergrowth species include *Arctostaphylos uva-ursi*, *Juniperus communis*, *Rosa acicularis*, *Shepherdia canadensis*, and *Symphoricarpos albus*. Major graminoids are *Oryzopsis asperifolia* and *Poa pratensis*. The forb layer is dominated by *Fragaria virginiana*, *Galium boreale*, *Hedysarum alpinum*, and *Viola adunca*. Mosses and lichens also are abundant. Most of these



Figure 24.—*Picea glauca*/Linnaea borealis habitat type. Various size classes of *P. glauca* are present; a few *Pinus ponderosa* also are evident.

undergrowth species also have high constancy in the *P. ponderosa*/A. *uva-ursi* and *P. ponderosa*/J. *communis* habitat types. Those that are more characteristic of the *P. glauca*/L. *borealis* habitat type are *L. borealis*, *S. canadensis*, and *H. alpinum*. However, only *L. borealis* has sufficient coverage to make it easily visible (fig. 25). For practical purposes, the combination of a self-maintaining population of *P. glauca*, abundant *L. borealis*, and the absence of *Vaccinium scoparium* in the undergrowth identify this habitat type.

The *P. glauca*/L. *borealis* habitat type has not been identified elsewhere in the Rocky Mountains (Alexander 1985). However, *L. borealis* is an important undergrowth species in *P. glauca*-dominated forests in Canada (Eis 1981; LaRoi 1967; Moss 1952, 1955; Mueller-Dombois 1964). A *Picea engelmannii*/L. *borealis* habitat type has been identified in Montana, east of the Continental Divide, and in northwestern Wyoming that bears some floristic similarities to the *P. glauca*/L. *borealis* habitat type in the Black Hills (Pfister et al. 1977, Steele et al. 1983).

**Management implications.**—Management of *P. glauca* for timber in this habitat type is similar to the *P. glauca*/V. *scoparium* habitat type, but sites in the *P. glauca*/L. *borealis* habitat type usually are more productive than in the *P. glauca*/V. *scoparium* habitat type. Undergrowth changes slowly after major disturbance. Competition, while not severe between tree seedlings and undergrowth, is more intense than in the *P. glauca*/V. *scoparium* habitat type. Cutting practices for water production suggested for the *P. glauca*/V. *scoparium* habitat type also are appropriate for the *P. glauca*/L. *borealis* habitat type.

This habitat type provides summer range for livestock but is more important for summer-fall range for big game. *P. glauca* forests also provide thermal and hiding cover for big game, especially in uncut forests and those where cutting maintains an irregular stand structure. The *P. glauca*/L. *borealis* habitat type provides habitat for numerous nongame animals; but, because these forests have limited distribution and contrast distinctly with the more extensive *P. ponderosa* forests, their contribution to wildlife and visual diversity is very important. The



Figure 23.—*Populus tremuloides* typically forms a fringe separating the *Picea glauca* forests from parks. Here *P. glauca* has begun to regenerate beyond the *P. tremuloides* stand into the park.



potential for developed and dispersed recreation is limited by the small area occupied by this habitat type.

### *Picea glauca/Vaccinium scoparium*

**Description.**—The *Picea glauca/Vaccinium scoparium* habitat type, represented by five stands, is found growing on calcareous soils and soils derived from igneous rock in the Black Hills. Stands in this habitat type usually occupy cool and moist sites at somewhat higher elevations than other forest habitat types. This habitat type is recognized by the dominance and reproductive success of *P. glauca* in the overstory, and the presence and abundance of *V. scoparium* in the undergrowth (fig. 26). *Pinus ponderosa* and *Populus tremuloides* can be important seral species in the overstory. Although *V. scoparium* is the diagnostic undergrowth species, its coverage is variable. Other important shrubs include *Arctostaphylos uva-ursi*, *Berberis repens*, *Juniperus communis*, *Rosa acicularis*, *Spiraea betulifolia*, and *Symphoricarpos albus*. Major herbaceous species are *Achillea millefolium*, *Antennaria plantaginifolia*, *Fragaria virginiana*, *Galium boreale*, *Lathyrus ochroleucus*, *Oryzopsis asperifolia*, and *Poa pratensis* (fig. 27).

The *P. glauca/V. scoparium* habitat type is the Black Hills equivalent of the *Abies lasiocarpa/V. scoparium* habitat types common over much of the Rocky Mountains (Alexander et al. 1986; Daubenmire and Daubenmire 1968; Hess and Alexander 1986; Hoffman and Alexander 1976, 1980, 1983; Pfister et al. 1977; Steele et al. 1981, 1983), although, as indicated earlier, *A. lasiocarpa* is absent in the Black Hills. This has never been fully understood, but the low elevation and correspondingly warm temperatures of the Black Hills may be partially responsible for the lack of *Abies*. In the Bighorn Mountains and in northern Utah, a *Picea engelmannii/V. scoparium* habitat type in which *A. lasiocarpa* is absent also occurs at somewhat lower elevation on warmer sites (Hoffman and Alexander 1976, Mauk and Henderson 1984). Although the distribution of *Abies* is not the concern of the present study, its absence is one of the unique characteristics of the Black Hills. The *P. glauca/V.*



Figure 26.—*Picea glauca/Vaccinium scoparium* habitat type. *Pinus ponderosa* is a seral species in this stand.



Figure 27.—*Picea glauca/Vaccinium scoparium* habitat type. Undergrowth is dominated by *V. scoparium*. *Berberis repens*, *Juniperus communis*, *Rosa acicularis*, and *Solidago* spp. also are present. *Picea glauca/V. scoparium* habitat type has not been reported elsewhere in the Rocky Mountains (Alexander 1985).

**Management implications.**—Timber productivity for *P. glauca* varies considerably in this habitat type. Undergrowth changes slowly after major disturbance. Competition is not severe between tree seedlings and undergrowth vegetation, except where coverage of forbs and/or graminoids is high. Reproduction usually is not difficult to obtain under a wide variety of cutting methods if well planned and executed. Moreover, the reproductive potential of seral *P. ponderosa* is significantly lower than on adjacent *P. ponderosa* habitat types. Large clearcuts, seed-tree cuts, and burned areas sometimes are dominated by thick stands of graminoids that preclude conifer regeneration for long periods of time. There may be a manageable stand of advanced reproduction in much of the *P. glauca/V. scoparium* habitat type. While all silvicultural systems and most cutting methods can be used, uneven-aged management with group selection and/or individual tree selection cutting often is used in this habitat type.<sup>7</sup> These cutting methods perpetuate the naturally occurring irregular

<sup>7</sup>Land and Resource Management Plan (Report). USDA Forest Service, Black Hills National Forest, Custer, S. Dak.



Figure 25.—*Picea glauca/Linnaea borealis* habitat type. *L. borealis* in flower. In this stand (40), *Fragaria virginiana* and *Oryzopsis asperifolia* also are conspicuous.

stand structure. Group selection cutting is likely to perpetuate the existing species mix but may increase the proportion of *Pinus ponderosa* if the openings are near the maximum size [2 acres (0.8 ha)]. Individual tree selection cutting will favor *P. glauca* over *P. ponderosa*, especially if the initial cutting removes a large proportion of the *P. ponderosa*.

Some form of shelterwood cutting is preferred if even-aged management is desired. Shelterwood cutting in mixed *P. glauca*/*P. ponderosa* stands can increase the proportion of seral *P. ponderosa* in the replacement stand. However, in mixed stands, standard and modified shelterwood cutting can be used to manipulate the amount of *P. glauca* in the stand by controlling the proportion of *P. ponderosa* removed and the degree of canopy opening at each entry.

If clearcutting is used, openings should be small [3 to 5 acres (1 to 2 ha)] when natural reproduction is the method of regenerating new stands. If *P. tremuloides* is present in stands of this habitat type, it can be increased by clearcutting or wildfire. Growing stock levels of 120 to 160, suggested for the *A. lasiocarpa*/*V. scoparium* in the central Rocky Mountains (Alexander and Edminster 1980), should be appropriate for managed even-aged stands of *P. glauca* in the Black Hills when timber production is a management objective.

The *P. glauca*/*V. scoparium* habitat type occupies the highest water-yielding areas in the northern Black Hills. Runoff is about 25% of the average annual precipitation of about 28 inches (71 cm) (Orr 1975). Streamflow can be significantly increased by reducing stand density, thereby lowering consumptive use of water by trees. Increases in water available for streamflow are inversely proportional to the reduction in stand density and the amount of precipitation received. Clearcutting in small openings, and group selection and group shelterwood when openings are near the maximum size, are more efficient than standard shelterwood or individual tree selection. Although timber harvesting can result in an increase in water available for streamflow, the habitat type occupies an area too small to have much impact on overall changes in streamflow. The potential for developed and dispersed recreation also is low because of the limited acreage of this habitat type.

The *P. glauca*/*V. scoparium* habitat type is used by livestock, is summer-fall range for big game, and provides habitat for a number of birds and nongame mammals. The potential for increasing forage production is moderate to high in cleared areas. Increases are relative to the amount of overstory removed and the composition of the undergrowth.

This habitat type is cold relative to the regeneration microenvironment required for seral *P. ponderosa*. Susceptibility of *P. ponderosa* to root rots and mountain pine beetles also may serve to accelerate succession to *P. glauca*.

## SHRUB-STEPPE HABITAT TYPES

A comprehensive study of shrub-steppe vegetation in the Black Hills National Forest was beyond the scope of



Figure 28.—View in Boles Canyon in the southwestern Black Hills showing a *Cercocarpus montanus*-dominated community on a steep slope with coarse-textured soils.

this study; however, a conspicuous shrub-steppe habitat type was included in this study, because it is rather closely related to the forest habitat types in the southern Black Hills.

## CERCOCARPUS MONTANUS SERIES

*Cercocarpus montanus* is a shrub, up to 6.6 feet (2 m) tall at maturity. It dominates a shrub-steppe vegetation at low elevations on xeric sites around the southern one-third of the Black Hills. In the southwestern part of the Black Hills, well-developed stands occur southeast of New Castle, Wyo., and on fairly steep hillsides in Boles, Redbird, and Hells Canyons (fig. 28). The vegetation is patchy and does not form a continuous zone around the southern perimeter of the Black Hills. In the Black Hills, *C. montanus* is at the northern and easternmost limits of its distribution, and the vegetation that it dominates has the physiognomy of chaparral in the Southwest, where it is an important shrub. In the Black Hills, *Cercocarpus* stands are adjacent to *Pinus ponderosa*-dominated vegetation above and other steppe or shrub-steppe vegetation below.

The *C. montanus* series in the Black Hills is represented by three stands and one habitat type. Stands sampled range in elevation from 4,150 to 4,898 feet (1,265 to 1,493 m). Undergrowth data for *C. montanus* are shown in table A-10.

### *Cercocarpus montanus*/*Bouteloua curtipendula*

**Description.**—The *Cercocarpus montanus*/*Bouteloua curtipendula* habitat type was sampled in stands on moderate (21% to 38%) slopes with a variety of aspects.

*C. montanus* dominates the overstory (41% to 45% coverage). *Rhus aromatica* is a smaller but constant shrub associate (2% to 8% coverage). *Cercocarpus* and *Rhus* are rather evenly spaced, with herbaceous species and low-growing shrubs occupying the spaces between the tall shrubs (fig. 29). An occasional *Pinus ponderosa* or *Juniperus scopulorum* occurs in stands of this habitat



type, but neither appears to be increasing its numbers. *B. curtispindula* (24% to 37% coverage) dominates the undergrowth. Species composition is relatively sparse, with fewer than 20 species sampled in any one stand. Most of the undergrowth species also occur in the adjacent steppe vegetation. Associated undergrowth species with 100% constancy include *Aristida longiseta*, *Artemisia frigida*, *Aster oblongifolius*, *Hedeoma hispida*, *Oryzopsis hymenoides*, and *Sitanion hystrix*.

Although combinations of undergrowth species differ, *C. montanus*-dominated communities occur over considerable areas of the Rocky Mountain West; all appear to occupy the same relative position in the vegetation zonation (Brotherson et al. 1984, Greenwood and Brotherson 1978, Johnson 1959). The communities form a low-elevation fringe of vegetation below the xeric border of the coniferous forests.

**Management implications.**—The *C. montanus*/*B. curtispindula* habitat type is a valuable range and wildlife resource. This habitat type is late spring and early summer range for livestock and winter range for big game. Forage production potential is moderate to high. *B. curtispindula* is highly palatable to cattle, but it is a mild season graminoid that is less readily eaten when cured. *C. montanus* is a preferred food for deer on winter range. Although cattle and deer are not directly competitive in their preferred food supply, proper grazing management, in terms of stocking and season of use by cattle, is essential if deer winter range is to be maintained in good condition.

The *C. montanus*/*B. curtispindula* habitat type occurs at elevations where average annual precipitation is low; consequently, runoff is low. There is no potential for significantly increasing water production. Dispersed and developed recreation is low because of the treeless nature of the habitat type. The potential for erosion and sedimentation increases in proportion to the decrease in cover.

## OTHER VEGETATION

There are other forest and woodland plant communities in the Black Hills National Forest. Those described



Figure 29.—*Cercocarpus montanus*/*Bouteloua curtispindula* habitat type.



Figure 30.—*Pinus ponderosa*/*Prunus virginiana* community in the northern Black Hills. *Symphoricarpos albus* also is abundant in the undergrowth.

below were of limited occurrence and were not sampled quantitatively and, therefore, were not assigned habitat type status.

### *Pinus ponderosa*/*Prunus virginiana*

**Description.**—The *Pinus ponderosa*/*Prunus virginiana* plant community is limited to a few locations in the northern Black Hills. *P. ponderosa* dominates the overstory and appears to be successfully reproducing and maintaining its population. *P. virginiana* and *Amelanchier alnifolia* are abundant and characterize the undergrowth (fig. 30). Other important undergrowth species are *Berberis repens*, *Spiraea betulifolia*, and *Apocynum androsaemifolium*.

Northward, in the Custer National Forest of southeastern Montana and northwestern South Dakota, a *P. ponderosa*/*P. virginiana* habitat type was described that shares a number of species with this plant community (Hansen and Hoffman 1986). In the Black Hills, it may represent another phase of the *P. ponderosa*/*Symphoricarpos albus* habitat type previously described. This plant community also has some similarities with the *P. ponderosa*/*Physocarpus monogynus* habitat type in the southwestern Black Hills.

**Management implications.**—The management implications of this limited plant community are not well known, but it probably can be managed in much the same manner as the *P. ponderosa*/*S. albus* habitat type. However, its potential for production of palatable browse for big game winter range is notably higher than that of most other Black Hills habitat types. Cutting and/or burning *P. virginiana* increases the number of suckers that are highly palatable to deer on winter range.

### *Pinus contorta*/*Vaccinium scoparium*

**Description.**—The *Pinus contorta*/*Vaccinium scoparium* plant community also has a limited distribution. It is found only in a small area in the Black Hills west of Nahant. Although *P. contorta* is of limited extent, it has



been part of the Black Hills flora since at least the Pleistocene. Figure 31 shows the relationship of the *P. contorta*/*V. scoparium* community to other plant communities on a ridge south of Tillson Creek. *Picea glauca*, *Populus tremuloides*, and *Pinus ponderosa* are found on the northerly aspects, but only *P. ponderosa* grows on southerly aspects. The *P. contorta* community is best developed along the upper part of the ridge just below the crest. *V. scoparium* is an important indicator species in this community. *P. contorta* is rather dense and reproducing in this location, and appears to be a climax species. Other undergrowth species include *Arctostaphylos uva-ursi*, *Berberis repens*, *Juniperus communis*, *Rosa acicularis*, *Rubus idaeus*, *Spiraea betulifolia*, *Symphoricarpos albus*, *Anemone patens*, *Arnica cordifolia*, *Campanula rotundifolia*, *Clematis tenuifolia*, *Galium boreale*, *Lathyrus ochroleucus*, *Vicia americana*, *Oryzopsis asperifolia*, and *Schizachne purpurascens*.

**Management implications.**—The management implications for this limited plant community are not known, but it probably can be handled much the same way as the *P. contorta*/*V. scoparium* habitat type on the Medicine Bow National Forest in Wyoming (Alexander et al. 1986).

### *Pinus flexilis* Community

**Description.**—A very small *Pinus flexilis* community occurs in the Cathedral Spires area of the central Black Hills. Most of the trees are on very steep north-facing slopes that are inaccessible. *Pinus ponderosa*, *Picea glauca*, and scattered, short *Populus tremuloides* and *Betula papyrifera* also are present in the overstory. The undergrowth is relatively scattered and sparse. Representative species are *Arctostaphylos uva-ursi*, *Juniperus communis*, *Agrostis scabra*, *Carex concinna*, *Campanula rotundifolia*, and *Woodsia oregana* (Thilenius 1970).

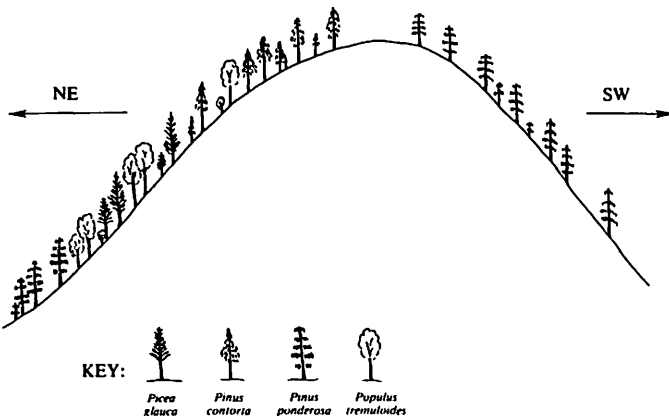


Figure 31.—Diagram of a ridge west of Nahant showing distribution of trees along the northeast and southwest slopes. The forest is not well developed along the crest of the ridge.

**Management implications.**—The management implications for this plant community are not known.

### *Salix* spp. Community

**Description.**—This community once was widespread along the stream courses throughout the Black Hills, but the area now occupied is much reduced. Possibly disease and/or insects decimated some populations of *Salix* spp. (Froiland 1962). It also is likely that grazing animals, directly or indirectly, have eliminated much of the *Salix* spp. plant community in the Black Hills. Animals grazing, resting, or trailing back and forth to water can retard or eventually eliminate regeneration of these streamside communities. Most photos that compare early to modern vegetation show streamside shrub *Salix* spp. communities were more abundant and more dense before settlement of early farmers and ranchers.

**Management implications.**—The management implications for this plant community are not well known. Exlosures have indicated that protection from livestock and big game will significantly increase dominance by *Salix* spp. *Poa pratensis* typically dominates the undergrowth on sites that are heavily grazed.

### Riparian Forest Communities

**Description.**—Some of the larger streams in the Black Hills once supported riparian forests dominated by species of *Ulmus*, *Fraxinus*, *Acer*, and *Celtis*. Occasionally, coniferous trees or *Quercus macrocarpa* were part of this vegetation. Close to the larger streams, *Populus deltoides* formed a pioneer community. Although most of this vegetation no longer exists, large trees still are present along the stream near "Ranch A" along the South Dakota-Wyoming border, south of Beulah. The undergrowth is now altered, and most of the shrubs and young trees are gone. The species of large trees will be perpetuated only if planted, because they are not now self-regenerating at that location. Custer State Park provides the best examples of riparian vegetation that may perpetuate itself.

**Management implications.**—Forage production potential for livestock and big game may be high, but heavy grazing pressure in the past has caused production to be low. Grazing pressure has reduced shrubs and increased the proportion of less palatable graminoids. Diversified recreation use is heavy because of close proximity to water. This habitat type provides food and cover for a wide variety of nongame wildlife. Protection from excessive livestock use is essential for regeneration of riparian tree species.

## KEY TO HABITAT TYPES

The following key to the major forest and woodland, and one shrub-steppe vegetation associations has been prepared to identify the habitat types and phases present in relatively undisturbed stands in the Black Hills.

1. Vegetation is forest or woodland; *Cercocarpus montanus* is absent or rare.
2. Coniferous trees dominant and reproducing; deciduous trees may be present but are seral.
3. *Pinus ponderosa* and *Juniperus scopulorum* present and reproducing; other conifers absent or not reproducing adequately to maintain the population; undergrowth sparse . . . *Pinus ponderosa*-*Juniperus scopulorum* H.T.
3. *Pinus ponderosa* present and reproducing; *Juniperus scopulorum* and other conifers absent or not reproducing adequately to maintain the population.
4. Undergrowth dominated by *Symphoricarpos albus*; *Amelanchier alnifolia*, *Arctostaphylos uva-ursi*, *Rosa woodsii*, and *Spiraea betulifolia* may be abundant. *Balsamorhiza sagittata* and *Oryzopsis asperifolia* absent or sparse . . . . . *Pinus ponderosa*/*Symphoricarpos albus* H.T.
5. *Balsamorhiza sagittata* common in the undergrowth; *Oryzopsis asperifolia* absent or rare . . . . . *Pinus ponderosa*/*Symphoricarpos albus* H.T.  
     . . . . . *Balsamorhiza sagittata* phase
5. *Oryzopsis asperifolia* common in the undergrowth; *Balsamorhiza sagittata* absent or rare . . . . . *Pinus ponderosa*/*Symphoricarpos albus* H.T.  
     . . . . . *Oryzopsis asperifolia* phase
4. Undergrowth dominated by species other than *Symphoricarpos*, *Amelanchier*, and/or *Rosa*.
6. Undergrowth dominated by *Carex heliophila* . . . . . *Pinus ponderosa*/*Carex heliophila* H.T.
6. Undergrowth not dominated by *Carex heliophila*.
7. Undergrowth dominated by *Physocarpus monogynus*; *Prunus virginiana* and *Rosa acicularis* may be present . . . . . *Pinus ponderosa*/*Physocarpus monogynus* H.T.
7. Undergrowth not dominated by *Physocarpus monogynus*.
8. Undergrowth dominated by *Quercus macrocarpa*; *Berberis repens* and *Prunus virginiana* may be abundant . . . . . *Pinus ponderosa*/*Quercus macrocarpa* H.T.
8. Undergrowth not dominated by *Quercus macrocarpa*.
9. Undergrowth dominated by *Arctostaphylos uva-ursi*; *Spiraea betulifolia* and *Symphoricarpos albus* may be present and abundant, but not dominant . . . . . *Pinus ponderosa*/*Arctostaphylos uva-ursi* H.T.
9. Undergrowth dominated by *Juniperus communis*; *Arctostaphylos uva-ursi* also may be common, but not dominant . . . . . *Pinus ponderosa*/*Juniperus communis* H.T.
3. *Pinus ponderosa* may be present and abundant, but is seral. *Picea glauca* present and reproducing adequately to maintain populations.
10. *Vaccinium scoparium* absent or rare; undergrowth dominated by *Linnaea borealis* and/or *Juniperus communis* . . . . . *Picea glauca*/*Linnaea borealis* H.T.
10. Undergrowth dominated by *Vaccinium scoparium*; *Juniperus communis* may be abundant and *Linnaea borealis* may be present, but neither is dominant . . . . . *Picea glauca*/*Vaccinium scoparium* H.T.
2. Deciduous trees dominant and reproducing. Occasional coniferous trees may be present, but not reproducing adequately to maintain populations.
11. *Quercus macrocarpa* dominant and reproducing overstory species. Other tree species absent or rare.
12. Undergrowth dominated by *Ostrya virginiana*; *Prunus virginiana* and *Symphoricarpos albus* may be present and abundant, but not dominant . . . . . *Quercus macrocarpa* /*Ostrya virginiana* H.T.
12. Undergrowth dominated by *Symphoricarpos occidentalis*; *Amelanchier alnifolia*, *Ostrya virginiana*, and *Prunus virginiana* may be present but not dominant . . . . . *Quercus macrocarpa*/*Symphoricarpos occidentalis* H.T.  
     . . . . . *Quercus macrocarpa*/*Symphoricarpos occidentalis* phase
11. *Populus tremuloides* dominant and reproducing overstory species. *Quercus macrocarpa* and/or other tree species rare or occasional.
13. Undergrowth dominated by *Corylus cornuta*; *Symphoricarpos albus* may be abundant; *Aralia nudicaulis*, and/or *Pteridium aquilinum* may be present but not abundant . . . . . *Populus tremuloides*/*Corylus cornuta* H.T.  
     . . . . . *Populus tremuloides*/*Corylus cornuta* phase
13. Undergrowth dominated by either *Aralia nudicaulis* or *Pteridium aquilinum*. *Corylus cornuta* usually is present and abundant.
14. Undergrowth dominated by *Aralia nudicaulis*; *Berberis repens* may be abundant but not dominant. *Pteridium aquilinum* absent or not abundant . . . . . *Populus tremuloides*/*Corylus cornuta* H.T.  
     . . . . . *Aralia nudicaulis* phase
14. Undergrowth dominated by *Pteridium aquilinum*. *Corylus cornuta* usually present; *Aralia nudicaulis* absent or not abundant . . . . . *Populus tremuloides*/*Corylus cornuta* H.T.  
     . . . . . *Pteridium aquilinum* phase
1. Vegetation is shrub-steppe; *Cercocarpus montanus* is dominant; forest and woodland tree species may be present but are sparse. Graminoid and herb layer dominated by *Bouteloua curtipendula* . . . . . *Cercocarpus montanus*/*Bouteloua curtipendula* H.T.  
     . . . . . *Cercocarpus montanus*/*Bouteloua curtipendula* H.T.

The distribution and successional status of tree species in relation to habitat type are shown in table 3.

## DISCUSSION AND SUMMARY

### VALIDITY OF HABITAT TYPE CLASSIFICATION

The practical value of the habitat type classifications has only begun to be realized in relation to vegetation mapping, tree growth, tree susceptibility to diseases, production of browse species for game animals, and providing a framework within which to relate additional basic or applied biological studies (Daubenmire 1961, 1973, 1976).

The classification system, while using vegetation as the indicator of site potentials, combines available related information on soil and climate. While initially using vegetation as the criterion of delimiting habitat types, this approach also takes a holistic view of units of land area. The older the stands observed, the more closely they approximate the potential (climax or near climax) of the landscape units studied (Daubenmire 1976).

This classification system utilizes both overstory and undergrowth vegetation in recognizing habitat types. Although the major vegetation zone in this study is dominated by *Pinus ponderosa*, in some areas *Picea glauca*, *Populus tremuloides*, and *Quercus macrocarpa* are climax species.

The classification of habitat types recognizes climax tree species in an area; these are given primary consideration, and important seral species are noted. Undergrowth vegetation then is used to indicate habitat types within the zone where a given tree species is climax.

### DISTRIBUTION OF TREE SPECIES IN THE BLACK HILLS

*Pinus ponderosa* is easily the most prominent tree in the Black Hills. It is climax over vast areas from low to high elevations, and where it is not climax, it is an important seral species (table 3). *P. ponderosa* is aggressive and invades and establishes in *Picea glauca*-dominated habitat types after the latter have been disturbed. It is a major seral species in both the *P. glauca/Linnaea borealis* and *P. glauca/Vaccinium scoparium* habitat types. *P. ponderosa* also occurs along major streams as an occasional species in *Quercus macrocarpa*-dominated habitat types. *P. glauca* is an occasional species in only a few other habitat types. *Populus tremuloides* is a climax species in some areas of the Black Hills, and it is a conspicuous seral species in certain habitat types dominated by *P. ponderosa* and *P. glauca*. As in much of the Rocky Mountain region, *Populus* becomes established after fire in several habitat types in the Black Hills. It is a major seral species in *P. ponderosa/Juniperus communis*, *P. ponderosa/Arctostaphylos uva-ursi*, and *P. glauca/L. borealis* habitat types.

*Q. macrocarpa* occurs mainly along the northern fringe of the Black Hills, but it also is a sizable tree along some streams in the central Black Hills. It occurs as far south as French Creek in Custer State Park. Along the northern fringe of the Black Hills, it is relatively small stunted and forms dense stands with a physiognomy similar to that of *Quercus gambelii* of the central Rocky Mountains.

*Q. macrocarpa* is another species that spread during the period of uncontrolled fires. It became established on both *P. ponderosa*- and *P. tremuloides*-dominated habitat types, and is still present in some of those habitat types.

*Betula papyrifera* occurs mainly as a subdominant in stands of *P. tremuloides*. Like *P. tremuloides*, *B. papyrifera* is present as a seral species following disturbance of *P. glauca*- and more mesic *P. ponderosa*-dominated stands.

*Fraxinus pennsylvanica* and *Ulmus rubra* are members of a riparian vegetation complex not included in this study, but a few seedlings of both occur in *Q. macrocarpa*-dominated vegetation.

### SPECIES RICHNESS

Species richness of the undergrowth vegetation for all habitat types is shown in table 4. Median numbers per stand range from 11 in the *Pinus ponderosa/Carex heliophila* habitat type to 36 in the *P. ponderosa/Quercus macrocarpa* habitat type. Because some habitat types were sampled in more stands than others, comparing and evaluating species richness must be done carefully. Most of the following discussion omits the *Q. macrocarpa/Symphoricarpos albus* and *P. ponderosa-Juniperus scopulorum* habitat types, because each is an incidental habitat type represented by only one stand.

In general, the number of species tends to increase as sites become wetter. Included in the group with the fewest species are the *P. ponderosa/C. heliophila*, *P. ponderosa/Physocarpus monogynus*, *P. ponderosa/Juniperus communis*, and *Cercocarpus montanus/Bouteloua curtipendula* habitat types. The range of median numbers is 11 to 18. A second group of habitat types includes *P. ponderosa/S. albus*, *P. ponderosa/Arctostaphylos uva-ursi*, and *Q. macrocarpa/Ostrya virginiana*. The range of median numbers for this group is 20 to 22. The third group of habitat types, with the most species, includes *P. ponderosa/Q. macrocarpa*, *Populus tremuloides/Corylus cornuta*, *Picea glauca/Linnaea borealis*, and *P. glauca/Vaccinium scoparium*. The range of median species numbers is 31 to 36. The above groupings are arbitrary, because they are based solely on one criterion, and exceptions to the groups are obvious. For example, the *P. ponderosa/P. monogynus* and *P. ponderosa/J. communis* habitat types are wetter than their positions above indicate. The *P. ponderosa/P. monogynus* habitat type occurs on north- to northwest-facing slopes on topographic positions with more moisture than those supporting the *P. ponderosa/S. albus* habitat type. The *P. ponderosa/J. communis* habitat type generally occupies sites comparable to *P. ponderosa/S. albus* and *P. ponderosa/A. uva-ursi* habitat types. The *P. ponderosa/J. communis* habitat type may have *P. tremuloides* as a major seral species and both *Betula papyrifera* and *P. glauca* as occasional trees. However, there is evidence that some stands with a *P. ponderosa* overstory and *J. communis* in the undergrowth are a *P. ponderosa/J. communis* community type that is seral to a *P. glauca*-dominated vegetation, even though their current vegetation is very nearly identical to the *P. ponderosa/J. communis* habitat type.



Table 3.—The ecological roles of tree species in the habitat types in the Black Hills.

C = major climax species      S = major seral species  
 c = minor climax species      s = minor seral species  
 o = occasional species

Species	<i>Fraxinus pennsylvanica</i>	<i>Ulmus rubra</i>	<i>Ostrya virginiana</i>	<i>Juniperus scopulorum</i>	<i>Quercus macrocarpa</i>	<i>Betula papyrifera</i>	<i>Populus tremuloides</i>	<i>Pinus ponderosa</i>	<i>Picea glauca</i>
<b>Habitat type</b>									
<i>Quercus macrocarpa</i> / <i>Ostrya virginiana</i>	o	o	C		C	o			
<i>Quercus macrocarpa</i> / <i>Symphoricarpos albus</i>					C				
<i>Pinus ponderosa</i> - <i>Juniperus scopulorum</i>				C				C	
<i>Pinus ponderosa</i> / <i>Carex heliophila</i>					s			C	o
<i>Pinus ponderosa</i> / <i>Symphoricarpos albus</i> <sup>1</sup>					o	o		C	
<i>Pinus ponderosa</i> / <i>Physocarpus monogynus</i>				o				C	
<i>Pinus ponderosa</i> / <i>Quercus macrocarpa</i> <sup>2</sup>								C	
<i>Pinus ponderosa</i> / <i>Juniperus communis</i>					s	o	S	C	o
<i>Pinus ponderosa</i> / <i>Arctostaphylos uva-ursi</i>					o	o	S	C	o
<i>Populus tremuloides</i> / <i>Corylus cornuta</i> <sup>1</sup>					s	c	C	o	o
<i>Picea glauca</i> / <i>Linnaea borealis</i>						o	S	S	C
<i>Picea glauca</i> / <i>Vaccinium scoparium</i>						s	s	S	C

<sup>1</sup>Phases of these habitat types have no tree species with status different than the typical phases.

<sup>2</sup>*Quercus macrocarpa* is a shrub in this habitat type.

Table 4.—Species richness of undergrowth vegetation in the Black Hills habitat types.

Habitat type	Number of stands sampled	Median number of undergrowth		Range of numbers <sup>1</sup>
		Shrubs <sup>1</sup>	Herbs <sup>1</sup>	
<i>Quercus macrocarpa</i> / <i>Ostrya virginiana</i>	5	4	16	15-42
<i>Quercus macrocarpa</i> / <i>Symphoricarpos occidentalis</i>	1	7	13	—
<i>Pinus ponderosa</i> - <i>Juniperus scopulorum</i>	1	2	11	—
<i>Pinus ponderosa</i> / <i>Carex heliophila</i>	3	3	8	9-18
<i>Pinus ponderosa</i> / <i>Symphoricarpos albus</i> <sup>2</sup>	12	7	15	14-28
<i>Pinus ponderosa</i> / <i>Physocarpus monogynus</i>	3	8	8	13-21
<i>Pinus ponderosa</i> / <i>Quercus macrocarpa</i>	4	7	29	27-44
<i>Pinus ponderosa</i> / <i>Juniperus communis</i>	7	6	11	14-27
<i>Pinus ponderosa</i> / <i>Arctostaphylos uva-ursi</i>	10	5	16	13-29
<i>Populus tremuloides</i> / <i>Corylus cornuta</i> <sup>2</sup>	9	11	24	26-44
<i>Picea glauca</i> / <i>Linnaea borealis</i>	5	8	23	14-36
<i>Picea glauca</i> / <i>Vaccinium scoparium</i>	5	8	25	20-41
<i>Cercocarpus montanus</i> / <i>Bouteloua curtipendula</i>	3	4	14	17-19

<sup>1</sup>Numbers based on sampling 1,452 square feet (125 m<sup>2</sup>) per stand.

<sup>2</sup>Numbers include those of the habitat type phases also.

The number of shrub species in the undergrowth may reflect more closely the moisture relationships of habitat types. As shown in table 3, the most xeric habitat types have two to four shrub species. The most mesic, those dominated by *P. tremuloides* and *P. glauca*, have 8 to 11 shrub species. The *P. ponderosa*/*P. monogynus* habitat type also has eight shrubs. This more closely indicates its moisture regime as influenced by topographic position. If this evidence holds, the *P. ponderosa*/*J. communis*

habitat type, with six undergrowth shrubs, is among a group that is intermediate in its moisture relationships.

### SOME PRACTICAL CONSIDERATIONS

Though the habitat type concept is a basic approach to land and vegetation classification, it has practical value for land managers. Daubenmire (1961) showed it to be

useful in predicting growth rates of *Pinus ponderosa* in the northern Rocky Mountains. Preliminary observations in the Black Hills indicate that there are differences in growth rates of *P. ponderosa* among habitat types.

This study indicates the successional status of tree species that greatly improves the predictability of tree regeneration, composition, and success in response to disturbances. Control of species composition is vital to resource management for any particular stand, and habitat types outline the basic possibilities.

Considerably more information would have come from the study of Thilenius (1972) had the habitat types been known then. His classification grouped sites on the basis of deer usage. In contrast, relating deer use to habitat type would help explain the biotic potential of the browsed sites.

The potential use of habitat types in the Black Hills to indicate grazing potentials has yet to be studied. A few studies have been done on production and nutritive value of forest undergrowth species (Krantz and Linder 1973, Pase 1958, Pase and Hurd 1957, Severson 1982). How the undergrowth of various habitat types responds to logging,



Figure 32.—The view is upstream from Castle Creek. Photograph (a) was taken from one of the Custer camps in 1874. Note the sparse vegetation on the slopes in the background. Photograph (b) was taken from the same location in 1974. Control of fire has been primarily responsible for the development of the forests. *Populus tremuloides* on the right has matured and probably is climax at that location. The riparian *Salix* spp. vegetation evident in the foreground in 1874 is completely gone in 1974.

thinning, and/or fire has yet to be fully studied. Results of such a study could relate directly to grazing potentials of disturbed sites of habitat types.

## LONG-TERM VEGETATIONAL CHANGES

Graves (1899) indicated that uncontrolled fires during the 1800s, and probably earlier, destroyed much of the timber in the Black Hills, especially *Pinus ponderosa* forests. Repeated fires left the forest “irregular and broken, and composed in many places of defective and scrubby trees” (Graves 1899). Early records of the Black Hills flora and vegetation have essentially no quantitative data. Photographic records often are the best available in assessing long-term vegetational changes. The Custer Expedition into the Black Hills in 1874 was documented in part by photographs. In 1974, a number of the photographic sites were relocated and new photos taken to show changes in the vegetation (fig. 32). From the photos, it is apparent that with fires mainly controlled, succession has resulted in more dense stands of vegetation. The stand of *Populus tremuloides* in the right of figure 32 not only has developed to become a mature stand, it also shows little evidence of change toward a coniferous-dominated stand.

It is of interest also that riparian vegetation, once common along most streams in the Black Hills, has been greatly reduced as more herbaceous vegetation was made available to domestic animals.

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### Appendix

Table A-1.—Tree population structures for each habitat type. Numbers of trees listed are based on sample plot data for 357 m<sup>2</sup> per stand.

Habitat types and species	Stands sampled	Mean basal area m <sup>2</sup> /ha	Diameter (d.b.h.) classes in dm							
			0-1		1-2	2-3	3-4	4-5	5-6	6-7
			<0.5	>0.5						
			----- number of trees -----							
<i>Quercus macrocarpa</i>										
<i>Ostrya virginiana</i>	5	26.6								
<i>Quercus macrocarpa</i>			116	2	10	4	1	( <sup>1</sup> )		
<i>Ostrya virginiana</i>			2,355	53	10					
<i>Pinus ponderosa</i>			5	( <sup>1</sup> )	( <sup>1</sup> )	( <sup>1</sup> )				
<i>Betula papyrifera</i>			8	( <sup>1</sup> )	1					
<i>Ulmus rubra</i>			8	1	( <sup>1</sup> )					
<i>Fraxinus pennsylvanica</i>			3	( <sup>1</sup> )						
<i>Quercus macrocarpa</i>										
<i>Symphoricarpos occidentalis</i>	1	25.7								
<i>Quercus macrocarpa</i>			383	13	32	5	1			
<i>Pinus ponderosa</i>										
<i>Symphoricarpos albus</i>	12	35.8								
<i>Oryzopsis asperifolia</i> phase	(4)									
<i>Balsamorhiza sagittata</i> phase	(2)									
<i>Pinus ponderosa</i>			428	15	17	5	3	2	( <sup>1</sup> )	( <sup>1</sup> )
<i>Picea glauca</i>				( <sup>1</sup> )	( <sup>1</sup> )					
<i>Betula papyrifera</i>				( <sup>1</sup> )	( <sup>1</sup> )					
<i>Quercus macrocarpa</i>			5	( <sup>1</sup> )						
<i>Pinus ponderosa</i>										
<i>Juniperus scopulorum</i>	1	17.8								
<i>Pinus ponderosa</i>			207	4	8	3	1			
<i>Juniperus scopulorum</i>			87	27	22	7				
<i>Pinus ponderosa</i>										
<i>Carex heliophila</i>	3	44.6								
<i>Pinus ponderosa</i>			306	2	9	15	6	1	( <sup>1</sup> )	
<i>Quercus macrocarpa</i>			13	1	( <sup>1</sup> )					
<i>Pinus ponderosa</i>										
<i>Physocarpus monogynus</i>	3	37.7								
<i>Pinus ponderosa</i>			501	13	30	13	1			
<i>Juniperus scopulorum</i>			( <sup>1</sup> )							
<i>Pinus ponderosa</i>										
<i>Quercus macrocarpa</i>	4	36.2								
<i>Pinus ponderosa</i>			236	1	8	10	2	1	1	( <sup>1</sup> )
<i>Pinus ponderosa</i>										
<i>Arctostaphylos uva-ursi</i>	10	39.8								
<i>Pinus ponderosa</i>			228	16	14	10	4	2	( <sup>1</sup> )	
<i>Populus tremuloides</i>			2							
<i>Quercus macrocarpa</i>			2							
<i>Pinus ponderosa</i>										
<i>Juniperus communis</i>	7	36.6								
<i>Pinus ponderosa</i>			56	7	11	6	5	2		
<i>Picea glauca</i>				( <sup>1</sup> )	( <sup>1</sup> )		( <sup>1</sup> )			
<i>Populus tremuloides</i>			14							
<i>Betula papyrifera</i>			( <sup>1</sup> )							
<i>Populus tremuloides</i>										
<i>Corylus cornuta</i>	9	34.1								
<i>Pteridium aquilinum</i> phase	(3)									
<i>Aralia nudicaulis</i> phase	(1)									
<i>Populus tremuloides</i>			144	7	8	10	3	( <sup>1</sup> )		
<i>Picea glauca</i>			1							
<i>Pinus ponderosa</i>			3		( <sup>1</sup> )					
<i>Betula papyrifera</i>			23	11	9	1	( <sup>1</sup> )			
<i>Quercus macrocarpa</i>			23	1	( <sup>1</sup> )	1	( <sup>1</sup> )			
<i>Picea glauca</i>										
<i>Linnaea borealis</i>	5	42.3								
<i>Picea glauca</i>			118	12	11	6	2	( <sup>1</sup> )	( <sup>1</sup> )	
<i>Ponderosa pine</i>			2	1	7	5	3	( <sup>1</sup> )		
<i>Populus tremuloides</i>			4	( <sup>1</sup> )	( <sup>1</sup> )					
<i>Picea glauca</i>										
<i>Vaccinium scoparium</i>	5	43								
<i>Picea glauca</i>			137	3	3	5	2			
<i>Ponderosa pine</i>			( <sup>1</sup> )	2	9	9	3	( <sup>1</sup> )	1	
<i>Populus tremuloides</i>			32							
<i>Betula papyrifera</i>			4		( <sup>1</sup> )					

<sup>1</sup>Species with less than 1 tree per d.b.h. class.



Table A-2.—Location, topographic position, coverage (percent), and frequency (percent) of undergrowth species in stands of *Quercus macrocarpa/Symphoricarpos occidentalis* and *Quercus macrocarpa/Ostrya virginiana* habitat types.

	<i>Quercus/ Symphoricarpos</i>		<i>Quercus/Ostrya</i>				
	Stand number	3	45	11	10	4	20
<b>Location:</b>							
Quarter		SE	NE	NE	SE	SW	SE
Section		13	16	18	7	19	14
Township		6N	52N	6N	6N	6N	1N
Range		3E	60W	4E	4E	4E	6E
<b>Topographic position:</b>							
Slope (percent)		16	16	25	18	14	29
Aspect (degrees)		84	90	10	334	320	334
Elevation (meters)		1,280	1,250	1,158	1,067	1,158	1,140
<b>Coverage/Frequency<sup>1</sup></b>							
<b>Shrubs</b>							
<i>Amelanchier alnifolia</i>		4.6/42	--	--	--	--	5/18
<i>Berberis repens</i>		12/64	+ /8	--	1.2/16	1.3/12	+ /8
<i>Cornus stolonifera</i>		--	--	--	--	--	*
<i>Corylus cornuta</i>		--	--	--	--	--	3/6
<i>Crataegus succulenta</i>		--	--	--	--	--	*
<i>Juniperus communis</i>		--	--	--	--	--	3.9/20
<i>Lonicera dioica</i>		--	--	--	--	--	2.3/14
<i>Physocarpus opulifolius</i>		--	--	--	--	--	+ /6
<i>Prunus virginiana</i>		11/58	+ /2	--	7.1/34	14/76	4/26
<i>Ribes</i> spp.		0.8/2	+ /2	*	*	+ /2	4.1/20
<i>Rosa acicularis</i>		0.9/6	*	--	--	--	+ /2
<i>Rubus idaeus</i>		4.8/38	--	--	--	--	--
<i>Shepherdia canadensis</i>		--	--	--	--	--	*
<i>Spiraea betulifolia</i>		0.9/14	--	--	--	+ /4	10/40
<i>Symphoricarpos albus</i>		--	--	--	--	--	4.1/38
<i>Symphoricarpos occidentalis</i>		12/68	0.6/14	*	0.6/12	11/74	--
<i>Toxicodendron rydbergii</i>		2.8/36	+ /2	--	*	--	6/28
<b>Graminoids</b>							
<i>Agrostis hiemalis</i>		--	--	1/10	--	--	0.8/4
<i>Bromus inermis</i>		--	--	--	--	--	2.2/18
<i>Carex blanda</i>		--	--	*	+ /2	--	--
<i>Carex foenea</i>		9.4/58	--	+ /2	21/80	22/86	5.4/58
<i>Carex saximontana</i>		--	--	1.7/16	+ /6	--	0.8/10
<i>Carex</i> spp.		--	2.2/20	--	--	--	--
<i>Carex sprengei</i>		3.5/18	*	*	0.8/2	--	--
<i>Elymus virginicus</i>		--	1.4	--	10	--	--
<i>Festuca</i> spp.		--	--	1.2/16	--	--	--
<i>Melica subulata</i>		1.8/16	--	--	--	--	--
<i>Oryzopsis asperifolia</i>		--	+ /2	--	--	*	3.4/48
<i>Poa pratensis</i>		5.5/38	--	*	5.8/30	1.2/16	--
<i>Schizachne purpurascens</i>		--	--	--	--	*	2.5/30
<b>Forbs</b>							
<i>Achillea millefolium</i>		--	--	--	*	+ /2	0.6/14
<i>Actaea rubra</i>		--	--	--	--	--	*
<i>Antennaria plantaginifolia</i>		--	--	--	--	--	+ /2
<i>Apocynum androsaemifolium</i>		--	--	--	--	--	+ /6
<i>Aquilegia canadensis</i>		--	--	--	--	--	1/10
<i>Arabis divaricata</i>		--	--	--	--	--	+ /2
<i>Aralia nudicaulis</i>		--	--	--	--	--	12/56
<i>Arenaria lateriflora</i>		--	--	--	--	--	+ /8
<i>Arnica rydbergii</i>		--	--	--	--	--	+ /2
<i>Aster ciliolatus</i>		--	--	--	--	--	1.5/18
<i>Campanula rotundifolia</i>		--	--	--	--	--	+ /2
<i>Cerastium nutans</i>		--	--	*	+ /4	--	0.7/6
<i>Delphinium nuttallianum</i>		*	--	0.9/26	1.5/4	+ /6	--
<i>Disporum trachycarpum</i>		--	*	+ /4	--	1.7/40	1.9/36
<i>Dodecatheon pauciflorum</i>		--	--	+ /4	--	--	*
<i>Dodecatheon pulchellum</i>		--	--	1.2/8	--	--	--
<i>Erigeron philadelphicus</i>		--	--	--	--	--	*

Table A-2.—Continued.

Stand number	<i>Quercus/ Symphoricarpos</i>		<i>Quercus/Ostrya</i>			
	3	45	11	10	4	20
<i>Fragaria virginiana</i>	--	*	--	--	+ /2	*
<i>Galium aparine</i>	1.9/27	--	2/32	2/38	0.7/18	--
<i>Galium boreale</i>	3.5/62	*	--	+ /8	--	1.8/30
<i>Galium triflorum</i>	--	+ /6	--	--	1.7/30	+ /6
<i>Hackelia deflexa</i>	--	+ /4	--	--	--	--
<i>Heuchera richardsonii</i>	--	--	--	--	+ /2	+ /4
<i>Lathyrus ochroleucus</i>	1.5/22	--	--	+ /6	1.9/26	4/48
<i>Lithophragma parviflora</i>	--	--	2/44	--	--	--
<i>Maianthemum canadense</i>	--	--	--	--	--	4.7/48
<i>Mertensia lanceolata</i>	--	--	0.9/6	--	--	--
<i>Microsteris gracilis</i>	--	--	1.5/40	2.5/50	--	--
<i>Monarda fistulosa</i>	--	*	--	--	--	--
<i>Montia perfoliata</i>	--	--	+ /2	--	--	--
<i>Orobanche fasciculata</i>	--	--	+ /4	--	--	--
<i>Osmorhiza chilensis</i>	--	--	--	--	2/32	--
<i>Osmorhiza longistylis</i>	--	+ /2	--	--	--	0.7/6
<i>Osmorhiza</i> spp.	--	*	--	--	--	--
<i>Parthenocissus vitacea</i>	--	+ /14	--	--	--	--
<i>Polygonatum biflorum</i>	--	--	--	--	--	*
<i>Sanicula marilandica</i>	--	--	--	--	+ /2	9.5/8
<i>Senecio integerrimus</i>	--	--	+ /4	*	--	--
<i>Smilacina racemosa</i>	--	--	--	--	--	*
<i>Smilacina stellata</i>	+ /10	0.7/6	+ /8	1.3/22	+ /12	5.3/56
<i>Smilax herbacea</i>	--	*	--	--	--	--
<i>Taraxacum officinale</i>	--	--	0.9/14	0.7/8	--	0.7/8
<i>Thalictrum</i> spp.	0.7/6	+ /2	--	+ /8	--	0.8/10
<i>Trifolium repens</i>	--	--	--	+ /6	--	--
<i>Vicia americana</i>	+ /2	--	--	--	+ /2	+ /2
<i>Viola adunca</i>	--	--	--	--	--	+ /4
<i>Viola</i> spp.	+ /6	2/30	--	*	--	--
<i>Woodsia</i> spp.	--	--	2.4/24	+ /6	0.9/10	*
Species in microplots (no.)	20	15	18	20	20	42
Coverage of shrubs	50	1	--	9	27	43
Coverage of graminoids	20	4	4	38	23	15
Coverage of forbs	8	4	13	9	10	47
Total coverage (percent)	78	9	17	56	60	105

<sup>1</sup> + = Coverage of less than 0.5%.

\* = Species present in the macroplot but absent from the microplots.





Table A-3.—Continued.

	Pinus/Symphoricarpos						Oryzopsis phase						Balsamorhiza phase		
	Stand number	12	21	39	42	54	59	24	32	6	14	13	61		
<i>Carex xerantica</i>	--	--	--	--	--	--	2.6/36	--	+2	--	--	--	--		
<i>Danthonia spicata</i>	--	--	--	3/1.4	--	1.1/14	--	1.1/14	--	--	--	--	--		
<i>Elymus canadensis</i>	--	--	--	*	--	--	--	--	--	--	--	--	--		
<i>Elymus interruptus</i>	--	--	*	--	--	--	--	--	--	--	--	--	--		
<i>Elymus virginicus</i>	--	--	--	--	--	+4	--	--	--	--	--	--	2.6/10		
<i>Festuca idahoensis</i>	--	--	--	--	--	--	--	--	--	--	--	--	--		
<i>Festuca ovina</i>	--	0.8/30	0.6/4	--	--	--	--	--	+4	--	--	--	--		
<i>Koeleria pyramidata</i>	--	*	--	--	--	--	--	--	2.1/14	2.6/52	--	--	--		
<i>Oryzopsis asperifolia</i>	0.9/18	--	--	--	--	--	+2	10/74	5.6/34	3.9/58	--	--	--		
<i>Oryzopsis hymenoides</i>	--	+4	--	--	--	--	--	--	0.7/8	--	--	--	--		
<i>Oryzopsis micrantha</i>	2.6/52	--	4.8/36	--	--	--	--	--	--	*	--	--	--		
<i>Poa interior</i>	--	--	--	--	--	--	1.8/14	--	--	--	--	--	--		
<i>Poa pratensis</i>	+8	+10	--	--	*	12/76	--	--	0.7/6	4/40	--	--	--		
<i>Schizachne purpurascens</i>	--	--	--	--	--	--	--	+2	0.9/8	+8	--	--	--		
<i>Stipa occidentalis</i>	--	--	--	--	--	--	--	--	--	+10	--	--	4.6/28		
<b>Forbs</b>															
<i>Achillea millefolium</i>	+12	+8	+8	--	--	*	1.2/10	*	+12	2/40	+18	1/28	2.6/24		
<i>Agoseris glauca</i>	--	--	--	--	--	*	--	--	--	--	--	--	--		
<i>Allium canadense</i>	--	+2	--	--	--	--	--	--	--	--	--	--	--		
<i>Amorpha canescens</i>	--	--	1.7/18	--	--	--	--	+4	--	--	--	--	--		
<i>Amorpha nana</i>	--	--	--	--	--	+2	--	--	--	--	--	--	--		
<i>Anaphalis margaritacea</i>	--	--	--	--	--	--	--	--	--	--	--	--	--		
<i>Androsace septentrionalis</i>	--	--	--	--	--	--	+4	--	--	--	--	--	--		
<i>Anemone patens</i>	+4	+2	0.8/10	--	+2	--	+2	--	--	--	--	--	+6		
<i>Antennaria neglecta</i>	--	+10	--	--	--	--	--	--	--	--	--	--	--		
<i>Antennaria plantaginifolia</i>	+2	+10	+2	--	+4	1.8/8	--	+8	4.3/44	+12	--	+4	0.7/6		
<i>Apocynum androsaemifolium</i>	*	*	--	--	+4	3.2/22	--	1.3/14	*	--	--	--	--		
<i>Aralia nudicaulis</i>	--	--	--	--	--	--	--	3.5/24	*	--	--	--	--		
<i>Arenaria lateriflora</i>	--	--	--	--	--	--	+4	--	--	--	--	--	--		
<i>Arnica lonchophylla</i>	--	--	--	--	--	--	--	--	+8	--	--	--	--		
<i>Artemisia ludoviciana</i>	+2	--	--	--	--	--	--	--	--	+4	--	--	1.8/16		
<i>Aster ciliolatus</i>	+8	--	--	--	--	--	+6	+6	+8	+16	--	0.7/6	1.5/12		
<i>Astragalus alpinus</i>	--	+4	--	--	--	1.6/4	--	--	--	--	--	--	--		
<i>Astragalus</i> spp.	--	--	--	--	--	--	--	--	--	+4	1.8/30	--	12/60		
<i>Balsamorhiza sagittata</i>	1.1/6	--	--	--	--	--	2.2/18	--	--	--	--	--	--		
<i>Besseyia wyomingensis</i>	--	--	--	--	--	--	1.1/40	--	--	--	--	--	--		
<i>Campanula rotundifolia</i>	--	+2	+4	--	--	+6	--	--	+2	+6	--	--	--		
<i>Cerastium arvense</i>	+2	--	--	--	--	--	--	--	--	--	--	--	--		
<i>Cirsium</i> spp.	--	--	--	--	--	+2	*	--	*	0.6/4	--	--	--		
<i>Corallorhiza maculata</i>	--	--	--	--	--	--	--	--	--	--	--	--	--		
<i>Disporum trachycarpum</i>	*	--	--	--	--	--	--	--	--	--	--	+2	--		
<i>Delphinium nuttallianum</i>	--	--	--	--	--	--	+2	--	--	--	--	+2	--		
<i>Dodecatheon pauciflorum</i>	--	--	--	--	--	--	--	--	--	--	--	--	--		
<i>Erigeron speciosus</i>	--	+8	--	--	--	--	--	--	--	--	--	--	--		
<i>Fragaria virginiana</i>	+4	--	1/20	--	--	--	12/56	--	--	--	--	1/18	--		
<i>Galium boreale</i>	--	+2	+4	--	--	--	2.1/34	+2	--	1.3/12	0.7/62	--	1.9/18		
<i>Galium obtusum</i>	+8	--	--	--	2.1/42	--	2.1/34	--	--	1/20	3/52	1/28	--		
<i>Geum triflorum</i>	--	--	*	--	--	--	1.3/12	--	--	--	--	--	--		
<i>Goodyera repens</i>	--	--	--	--	--	--	--	--	+4	--	--	--	--		
<i>Halenia deflexa</i>	--	--	--	--	--	--	--	--	*	--	--	--	--		

Table A-3.—Continued.

	Pinus/Symphoricarpos						Oryzopsis phase				Balsamorhiza phase	
	12	21	39	42	54	59	24	32	6	14	13	61
<i>Hedysarum alpinum</i>	--	*	--	--	--	--	--	--	--	2.4/24	--	--
<i>Heuchera richardsonii</i>	--	*	--	--	--	+/2	+/14	+/8	--	--	--	--
<i>Hymenoxys acaulis</i>	--	--	+/2	--	--	--	--	--	--	--	--	--
<i>Lathyrus ochroleucus</i>	+/2	--	+/2	--	--	--	--	--	1.6/44	6.8/58	--	+/6
<i>Lucocrinum montanum</i>	--	--	--	--	--	--	--	--	--	+/6	--	--
<i>Lilium philadelphicum</i>	--	--	--	--	--	--	--	--	--	+/2	--	--
<i>Lupinus argenteus</i>	--	--	--	--	--	--	--	--	--	--	6.2/52	--
<i>Maianthemum canadense</i>	--	--	--	--	--	--	--	*	--	--	--	--
<i>Melilotus albus</i>	--	--	--	--	--	--	--	--	5.8/52	--	--	--
<i>Monarda fistulosa</i>	--	--	+/4	+/2	--	--	--	--	+/16	--	--	--
<i>Oxytropis campestris</i>	--	*	--	--	--	--	--	--	--	+/4	--	--
<i>Potentilla fissa</i>	--	+/2	--	--	--	+/2	--	--	--	--	--	--
<i>Potentilla gracilis</i>	--	--	--	--	--	+/2	--	--	--	--	--	--
<i>Pteralea esculenta</i>	--	--	--	--	--	--	--	--	--	--	--	+/2
<i>Pterospora andromedea</i>	--	+/2	--	--	--	--	--	*	--	--	--	--
<i>Sanicula</i> spp.	--	--	--	--	--	--	--	--	+/4	--	--	--
<i>Senecio canus</i>	--	--	+/8	+/6	--	--	--	--	--	--	--	--
<i>Senecio platensis</i>	--	--	--	--	--	--	--	--	--	+/8	--	--
<i>Smilacina racemosa</i>	0.7/16	--	+/12	--	--	--	--	--	--	--	--	--
<i>Smilacina stellata</i>	--	--	--	--	--	1.1/22	+/2	--	+/4	--	--	--
<i>Solidago</i> spp.	--	--	--	--	3.7/30	--	--	--	--	--	--	--
<i>Solidago speciosa</i>	--	--	--	--	+/6	--	--	--	--	--	--	--
<i>Taraxacum officinale</i>	--	--	+/2	--	--	+/2	--	--	--	+/4	--	--
<i>Thalictrum dioicum</i>	--	--	+/2	--	--	--	--	--	+/4	+/6	--	--
<i>Tragopogon dubius</i>	--	--	+/2	--	--	--	--	+/2	+/4	--	1/8	0.9/6
<i>Vicia americana</i>	*	--	--	*	--	--	--	--	+/4	0.7/8	+/8	--
<i>Viola adunca</i>	--	--	--	--	--	+/8	--	--	+/4	--	--	--
<i>Woodсия oregana</i>	--	--	--	--	--	--	--	--	--	--	--	--
<i>Zigadenus elegans</i>	--	*	--	--	--	--	--	+/8	--	--	--	--
<i>Zizia aptera</i>	*	*	--	--	--	--	--	+/6	--	0.9/38	--	--
Mosses and Lichens	--	--	1.5/12	3.4/16	*	--	--	0.8/10	--	--	--	--
Species in microplots	22	17	28	14	18	28	21	23	28	28	19	20
Coverage of shrubs	18	10	16	45	33	17	9	1	16	15	26	13
Coverage of graminoids	4	1	14	2	13	17	13	13	10	10	1	24
Coverage of forbs	4	2	7	6	8	26	6	7	15	19	19	22
Total coverage (percent)	26	13	37	53	54	60	28	21	41	44	46	59

1+ = Coverage of less than 0.5%.

\* = Species present in the macroplot but absent from the microplots.

Table A-4.—Location, topographic position, coverage (percent), and frequency (percent) of undergrowth species in stands of *Pinus ponderosa*/*Physocarpus monogynus*, *Pinus ponderosa*/*Carex heliophila*, and *Pinus ponderosa*-*Juniperus scopulorum* habitat types.

	<i>Pinus/Physocarpus</i>			<i>Pinus/Carex</i>			<i>Pinus-Juniperus</i>
	Stand number	57	64	65	49	23	63
<b>Location:</b>							
Quarter	SW	SE	SW	NE	SE	NW	SW
Section	2	4	33	11	31	8	1
Township	4S	3S	2S	55N	3S	5S	6S
Range	2E	1E	1E	63W	5E	1E	1E
<b>Topographic position:</b>							
Slope (percent)	33	43	46	17	5	--	24
Aspect (degrees)	326	0	334	264	226	--	340
Elevation (meters)	1,737	1,567	1,585	1,372	1,576	1,431	1,189
<b>Coverage/Frequency<sup>1</sup></b>							
<b>Shrubs</b>							
<i>Amelanchier alnifolia</i>	2.4/2	--	+ /2	3/30	--	--	--
<i>Amelanchier humilis</i>	--	+ /2	1.8/8	--	--	--	--
<i>Berberis repens</i>	--	+ /4	14/66	11/62	--	--	--
<i>Cercocarpus montanus</i>	--	+ /2	--	--	--	--	--
<i>Juniperus communis</i>	--	+ /2	11/24	*	--	--	--
<i>Physocarpus monogynus</i>	23/66	73/100	29/82	--	--	--	--
<i>Prunus virginiana</i>	0.7/8	0.8/2	8.6/38	*	--	--	--
<i>Quercus macrocarpa</i>	--	--	--	1.2/2	--	--	--
<i>Rhus aromatica</i>	--	--	--	--	--	--	*
<i>Ribes cereum</i>	--	--	--	--	--	*	*
<i>Ribes odoratum</i>	*	--	--	--	--	--	--
<i>Ribes setosum</i>	--	--	+ /2	--	--	--	--
<i>Rosa acicularis</i>	2/16	+ /2	3.2/28	--	--	--	--
<i>Rosa woodsii</i>	--	--	+ /2	--	--	--	--
<i>Shepherdia canadensis</i>	3.1/8	--	--	0.6/14	--	--	--
<i>Spiraea betulifolia</i>	--	*	--	3.5/26	--	--	--
<i>Symphoricarpos albus</i>	9.7/64	1.1/14	16/74	0.5/10	--	--	--
<b>Graminoids</b>							
<i>Agropyron caninum</i>	3.2/30	+ /2	*	+ /2	--	--	--
<i>Agropyron smithii</i>	--	--	--	--	--	--	+ /2
<i>Andropogon scoparius</i>	--	--	--	--	--	--	*
<i>Bouteloua curtipendula</i>	--	--	--	--	--	--	1.4/8
<i>Carex fillifolia</i>	--	--	--	--	--	--	+ /8
<i>Carex foenea</i>	--	--	--	11/60	--	--	--
<i>Carex heliophila</i>	--	--	--	40/66	23/100	48/98	+ /4
<i>Danthonia spicata</i>	--	--	--	5.2/24	7.8/38	--	--
<i>Festuca idahoensis</i>	*	--	--	--	--	--	--
<i>Koeleria pyramidata</i>	--	--	--	--	--	--	*
<i>Oryzopsis hymenoides</i>	*	--	--	--	--	--	*
<i>Oryzopsis micrantha</i>	--	--	--	1.3/4	--	--	1.1/60
<i>Poa pratensis</i>	--	--	--	*	10/66	+ /6	--
<i>Schizachne purpurascens</i>	--	+ /2	--	--	--	--	--
<i>Sitanion hystrix</i>	--	--	--	--	--	--	*
<i>Stipa occidentalis</i>	--	+ /2	--	*	*	--	--
<b>Forbs</b>							
<i>Achillea millefolium</i>	--	--	--	0.8/10	--	--	--
<i>Agoseris glauca</i>	--	--	--	--	--	--	+ /4
<i>Anemone patens</i>	0.8/14	+ /2	--	--	+ /2	--	6.4/48
<i>Antennaria parvifolia</i>	1.6/16	--	--	--	--	--	--
<i>Antennaria plantaginifolia</i>	--	*	*	--	0.7/8	+ /2	*
<i>Antennaria neglecta</i>	--	--	--	0.8/10	--	--	--
<i>Apocynum androsaemifolium</i>	+ /2	--	--	*	--	--	--
<i>Artemisia frigida</i>	--	--	--	*	--	--	+ /4
<i>Artemisia ludoviciana</i>	--	--	--	--	1.4/16	+ /2	--
<i>Aster ciliolatus</i>	1/8	--	--	--	2.5/40	--	5.6/16
<i>Aster ericoides</i>	--	--	--	--	*	--	--
<i>Astragalus alpinum</i>	0.8/14	--	--	*	*	--	--
<i>Campanula rotundifolia</i>	--	--	--	--	+ /2	+ /2	1.2/18
<i>Cerastium arvense</i>	--	--	--	+ /6	*	--	--



Table A-4.—Continued.

	<i>Pinus/Physocarpus</i>			<i>Pinus/Carex</i>			<i>Pinus-Juniperus</i>	
	Stand number	57	64	65	49	23	63	58
<i>Corallorhiza maculata</i>	--	--	--	--	+ 12	--	--	--
<i>Disporum trachycarpum</i>	+ 14	+ 12	--	--	--	--	--	--
<i>Erigeron glabellus</i>	--	--	--	--	*	--	--	--
<i>Fragaria vesca</i>	--	--	*	--	--	--	--	--
<i>Fragaria virginiana</i>	+ 16	--	--	1.3/12	--	--	--	--
<i>Galium boreale</i>	3.8/52	+ 14	--	--	*	--	--	*
<i>Hedeoma hispida</i>	--	--	--	--	--	--	--	--
<i>Hedysarum alpinum</i>	--	--	*	--	--	--	--	--
<i>Heuchera richardsonii</i>	0.6/4	--	*	--	--	--	--	--
<i>Hieracium umbellatum</i>	--	--	--	--	--	+ 12	--	--
<i>Liatris punctata</i>	--	--	--	--	--	+ 12	--	--
<i>Mertensia lanceolata</i>	--	--	--	--	*	--	--	--
<i>Polygala alba</i>	--	--	--	--	--	--	--	+ 14
<i>Potentilla hippiana</i>	--	--	--	--	+ 12	--	--	--
<i>Psoralea argophylla</i>	--	--	--	--	--	+ 12	--	--
<i>Senecio integerrimus</i>	--	--	+ 12	--	--	--	--	--
<i>Smilacina racemosa</i>	--	--	--	--	*	--	--	--
<i>Smilacina stellata</i>	+ 12	--	--	--	+ 14	--	--	--
<i>Solidago speciosa</i>	5.6/30	--	--	+ 12	--	--	--	--
<i>Thermopsis rhombifolia</i>	--	--	--	+ 12	--	--	--	--
<i>Viola adunca</i>	+ 16	--	+ 12	--	--	--	--	--
<i>Zigadenus elegans</i>	--	+ 14	--	--	--	+ 12	--	--
<i>Zizia aptera</i>	1.1/14	--	--	--	--	--	--	--
Mosses and Lichens	12/58	4.3/28	71/42	4/10	--	--	--	0.5/8
Species in microplots	21	16	13	18	11	9		13
Coverage of shrubs	41	76	84	20	3	--		11
Coverage of graminoids	3	1	--	58	41	48		3
Coverage of forbs	28	5	271	8	3	1		9
Total coverage (percent)	72	82	155	86	47	49	23	

<sup>1</sup> + = Coverage of less than 0.5%.

\* = Species present in the macroplot but absent from the microplots.

<sup>2</sup> Mosses and lichens provide 71% of the coverage in this stand.

Table A-5.—Location, topographic position, coverage (percent), and frequency (percent) of undergrowth species in stands of *Pinus ponderosa*/*Quercus macrocarpa* habitat type.

	Stand number	28	27	44	68
<b>Location:</b>					
Quarter		NW	SE	SW	NE
Section		30	20	33	28
Township		53N	53N	6N	5N
Range		63W	63W	60W	5E
<b>Topographic position:</b>					
Slope (percent)		19	21	6	29
Aspect (degrees)		264	135	306	0
Elevation (meters)		1,448	1,615	1,503	1,256
<b>Coverage/Frequency<sup>1</sup></b>					
<b>Shrubs</b>					
<i>Amelanchier alnifolia</i>		1.9/18	3.7/32	8.5/48	—
<i>Amelanchier humilis</i>		--	--	--	5.2/28
<i>Arctostaphylos uva-ursi</i>		--	1.5/10	--	—
<i>Berberis repens</i>		10/84	0.8/12	5.1/5	14/58
<i>Crataegus succulenta</i>		+ /2	*	--	—
<i>Juniperus communis</i>		0.6/4	--	--	—
<i>Ostrya virginiana</i>		--	--	--	1.3/4
<i>Prunus virginiana</i>		7.5/30	+ /4	--	45/92
<i>Prunus americana</i>		--	--	5.9/40	—
<i>Quercus macrocarpa</i>		20/48	20/46	26/50	4/14
<i>Ribes missouriense</i>		+ /4	--	--	—
<i>Rosa acicularis</i>		1.4/18	*	1/10	*
<i>Shepherdia canadensis</i>		*	--	--	—
<i>Spiraea betulifolia</i>		0.6/14	6.6/64	20/84	7.2/38
<i>Symphoricarpos albus</i>		3.8/52	--	--	1.6/16
<i>Symphoricarpos occidentalis</i>		--	2/40	4.3/34	—
<i>Toxicodendron rydbergii</i>		--	--	--	7.5/34
<b>Graminoids</b>					
<i>Agropyron caninum</i>		*	+ /6	3.3/22	—
<i>Bromus pubescens</i>		*	--	--	—
<i>Carex foenea</i>		1.1/34	0.6/24	9/42	0.6/4
<i>Carex microptera</i>		--	--	--	1.6/10
<i>Carex torreyi</i>		+ /14	--	--	—
<i>Danthonia spicata</i>		--	1/20	1.8/6	*
<i>Elymus canadensis</i>		--	--	--	1.6/16
<i>Elymus virginicus</i>		+ /6	*	--	—
<i>Oryzopsis asperifolia</i>		1/20	--	11/48	1.6/4
<i>Poa interior</i>		+ /4	+ /16	--	—
<i>Poa palustris</i>		+ /4	--	--	*
<i>Poa pratensis</i>		--	--	4/8	—
<i>Schizachne purpurascens</i>		+ /4	--	--	—
<i>Stipa occidentalis</i>		*	--	--	+ /2
<b>Forbs</b>					
<i>Achillea millefolium</i>		+ /2	*	--	—
<i>Amorpha canescens</i>		--	--	--	1.4/10
<i>Antennaria neglecta</i>		--	--	--	*
<i>Antennaria plantaginifolia</i>		*	*	--	*
<i>Apocynum androsaemifolium</i>		--	1.1/14	+ /2	+ /2
<i>Artemisia ludoviciana</i>		--	+ /8	--	—
<i>Aster cillolatus</i>		1.4/16	1/10	--	+ /2
<i>Campanula rotundifolia</i>		--	+ /2	+ /2	*
<i>Cerastium arvense</i>		--	+ /2	--	—
<i>Collomia linearis</i>		--	+ /10	--	—
<i>Disporum trachycarpum</i>		--	--	--	0.8/4
<i>Erigeron subtrinervis</i>		--	--	--	0.8/2
<i>Gallium boreale</i>		1.1/22	0.9/34	2.2/36	—
<i>Hedysarum alpinum</i>		*	--	--	—
<i>Heuchera richardsonii</i>		*	--	--	—
<i>Lathyrus ochroleucus</i>		--	+ /2	1.2/18	—
<i>Lupinus argenteus</i>		*	3.4/20	+ /2	—
<i>Monarda fistulosa</i>		+ /2	--	+ /4	*
<i>Petalostemon candidum</i>		--	--	--	*

Table A-5.—Continued.

	Stand number	28	27	44	68
<i>Pterospora andromedea</i>		--	--	--	*
<i>Sanicula marilandica</i>		1.1/12	--	--	—
<i>Smilacina racemosa</i>		--	*	--	—
<i>Smilacina stellata</i>		0.7/16	--	1.8/30	1.5/20
<i>Smilax herbacea</i>		0.4/4	+ /2	--	—
<i>Taraxacum officinale</i>		*	--	--	—
<i>Thalictrum dioicum</i>		1.9/18	--	0.9/8	—
<i>Vicia americana</i>		0.6/4	*	+ /2	—
<i>Viola canadensis</i>		2.6/24	--	--	—
Mosses and Lichens		--	--	1.3/12	—
Stand number		28	27	44	68
Species in microplots		27	21	22	19
Coverage of shrubs		46	35	71	86
Coverage of graminoids		3	2	29	6
Coverage of forbs		10	8	8	5
Total coverage (percent)		59	45	108	97

<sup>1</sup>+ = Coverage of less than 0.5%.

\* = Species present in the macroplot but absent from the microplots.



Table A-6.—Location, topographic position, coverage (percent), and frequency (percent) of undergrowth species in stands of *Pinus ponderosa*/*Arctostaphylos uva-ursi* habitat type.

Stand number	16	17	18	19	34	37	41	62	66	70
<b>Location:</b>										
Quarter	NE	SW	NW	NE	SW	SW	SE	SE	SE	NW
Section	10	34	33	4	1	23	25	12	13	29
Township	2N	3N	3N	2N	4S	1S	2S	2S	2S	1S
Range	4E	4E	4E	4E	2E	1E	1E	5E	5E	4E
<b>Topographic position:</b>										
Slope (percent)	3	6	16	10	21	--	3	10	20	20
Aspect (degrees)	10	282	48	46	320	--	242	30	56	172
Elevation (meters)	1,638	1,577	1,634	1,676	1,623	2,042	1,913	1,573	1,548	1,939
<b>Coverage/Frequency<sup>1</sup></b>										
<b>Shrubs</b>										
<i>Amelanchier alnifolia</i>	1.2/16	--	0.9/18	+ /2	1.8/22	--	2/40	--	--	--
<i>Amelanchier humilis</i>	--	--	--	--	--	--	--	--	+ /2	0.7/8
<i>Arctostaphylos uva-ursi</i>	10/64	25/88	13/60	21/84	9.5/68	18/80	29/56	76/100	85/100	42/74
<i>Berberis repens</i>	--	--	8.1/68	+ /2	--	9.6/76	--	--	--	--
<i>Juniperus communis</i>	--	*	+ /2	*	1.1/4	2.9/10	--	--	--	+ /2
<i>Physocarpus monogynus</i>	--	--	--	--	4.2/38	--	--	--	--	--
<i>Prunus pennsylvanica</i>	--	--	--	--	--	--	--	--	--	+ /2
<i>Prunus virginiana</i>	*	--	--	--	0.9/6	--	--	--	+ /2	--
<i>Pyrola</i> spp.	--	--	*	--	--	--	--	--	--	--
<i>Ribes missouriense</i>	--	--	--	--	--	--	--	--	+ /2	--
<i>Rosa acicularis</i>	0.9/16	*	--	0.9/14	--	+ /10	0.7/18	1/10	+ /2	--
<i>Rosa woodsii</i>	--	--	--	--	--	--	--	+ /2	--	+ /2
<i>Rubus idaeus</i>	--	--	--	--	--	--	--	--	1.4/8	--
<i>Shepherdia canadensis</i>	1.1/6	+ /2	9/28	9/44	+ /2	--	--	--	--	--
<i>Spiraea betulifolia</i>	3.3/26	2/28	1.4/24	2.8/44	--	--	0.7/16	3.4/26	3.3/42	--
<i>Symphoricarpos albus</i>	3.5/42	+ /2	0.9/14	+ /4	2.7/46	2.1/42	5.5/62	3/32	4.9/32	11/70
<b>Graminoids</b>										
<i>Agropyron caninum</i>	--	--	--	--	--	--	--	--	+ /2	--
<i>Agropyron</i> spp.	--	--	--	--	--	--	*	--	--	--
<i>Bromus ciliatus</i>	--	--	--	--	--	--	2.3/14	--	--	--
<i>Bromus inermis</i>	--	--	--	--	--	0.9/6	--	+ /4	--	--
<i>Bromus porteri</i>	--	--	--	--	+ /2	--	+ /4	--	--	--
<i>Carex foenea</i>	--	--	--	--	--	6.9/40	--	--	--	17/68
<i>Carex heliophila</i>	--	--	+ /2	*	--	--	9.6/50	--	--	--
<i>Danthonia intermedia</i>	--	--	--	--	--	8.9/46	--	--	--	--
<i>Danthonia spicata</i>	2.1/4	1.4/26	+ /4	--	--	--	1.7/8	--	1.1/4	+ /2
<i>Festuca ovina</i>	--	--	*	--	+ /2	0.9/8	--	--	--	--
<i>Koeleria pyramidata</i>	--	--	--	--	+ /8	2/12	--	--	--	--
<i>Oryzopsis asperifolia</i>	+ /4	1/10	5.2/64	+ /2	--	11/36	--	8.8/40	14/48	+ /2
<i>Oryzopsis micrantha</i>	--	--	--	*	--	--	--	--	--	--
<i>Oryzopsis pungens</i>	--	*	+ /2	--	--	--	--	--	--	--
<i>Panicum leibergii</i>	--	--	--	--	--	--	--	--	--	0.8/8
<i>Stipa occidentalis</i>	--	--	--	--	--	1.8/12	--	--	--	--
<i>Stipa richardsonii</i>	--	--	--	--	--	--	2.4/16	--	--	+ /4
<b>Forbs</b>										
<i>Achillea millefolium</i>	*	+ /4	+ /2	+ /2	*	3.5/40	0.9/14	+ /4	+ /2	+ /4
<i>Agoseris glauca</i>	--	--	--	--	--	--	--	--	+ /2	--
<i>Androsace septentrionalis</i>	--	--	*	--	--	--	--	--	--	--
<i>Anemone canadensis</i>	--	--	--	--	--	--	--	--	--	+ /4
<i>Anemone multifida</i>	--	--	+ /6	--	+ /2	--	--	--	--	--
<i>Anemone patens</i>	*	--	--	--	--	+ /4	+ /8	+ /2	--	--
<i>Antennaria neglecta</i>	*	0.6/12	+ /4	--	+ /2	--	+ /6	--	--	--
<i>Antennaria plantaginifolia</i>	--	--	--	--	--	2.9/10	--	--	--	--
<i>Apocynum androsaemifolium</i>	+ /2	+ /6	*	*	--	--	--	+ /2	+ /2	--
<i>Artemisia ludoviciana</i>	--	--	--	--	--	+ /4	+ /1	0.6/4	--	+ /2
<i>Arnica</i> spp.	--	--	--	--	*	--	--	--	--	--
<i>Aster ciliolatus</i>	+ /4	+ /8	+ /2	--	--	+ /6	--	1.7/8	--	--
<i>Astragalus alpinus</i>	*	*	--	*	--	--	--	--	--	--
<i>Astragalus miser</i>	--	--	--	--	--	--	+ /6	--	--	--
<i>Astragalus</i> spp.	--	--	--	--	--	2.1/14	--	--	--	--
<i>Balsamorhiza sagittata</i>	--	--	--	--	--	--	4.6/22	--	--	--
<i>Campanula rotundifolia</i>	*	*	--	+ /4	--	--	--	+ /2	+ /2	1.3/12

Table A-6.—Continued.

Stand number	16	17	18	19	34	37	41	62	66	70
<i>Castilleja sulphurea</i>	--	--	--	--	--	1.1/6	+ /2	--	--	--
<i>Cirsium ochrocentrum</i>	--	--	--	--	--	--	--	--	+ /2	--
<i>Corallorhiza maculata</i>	*	*	+ /2	--	--	--	--	--	--	0.5/2
<i>Fragaria virginiana</i>	--	+ /6	+ /6	+ /6	+ /2	2.6/34	0.8/20	+ /2	0.7/8	--
<i>Galium boreale</i>	--	--	--	--	+ /10	+ /18	1.1/22	--	--	--
<i>Geum triflorum</i>	--	--	--	--	0.6/14	--	--	--	--	--
<i>Glycyrrhiza lepidota</i>	--	--	--	--	--	--	--	6.4/36	--	--
<i>Halenia deflexa</i>	--	--	--	--	--	+ /4	--	--	--	--
<i>Hedysarum alpinum</i>	*	*	*	+ /2	1.4/8	4.6/36	--	--	--	--
<i>Heuchera richardsonii</i>	--	--	+ /2	--	+ /2	--	--	--	+ /2	--
<i>Hieracium albiflorum</i>	--	--	--	--	--	--	--	--	+ /2	--
<i>Lathyrus ochroleucus</i>	+ /4	0.8/10	+ /2	5.7/50	--	2.6/44	0.7/16	12/68	+ /2	--
<i>Lupinus argenteus</i>	--	--	--	--	--	4/42	0.7/16	--	--	--
<i>Monarda fistulosa</i>	--	--	--	--	+ /2	--	--	--	+ /2	--
<i>Oxytropis campestris</i>	--	*	--	*	--	--	--	--	--	--
<i>Oxytropis lambertii</i>	--	--	--	--	--	--	0.4	--	--	--
<i>Potentilla fissa</i>	--	--	--	--	--	--	--	--	1.6/16	0.7/8
<i>Psoralea argophylla</i>	--	--	--	--	--	--	--	--	--	+ /2
<i>Pterospora andromedea</i>	--	--	*	*	--	--	--	--	+ /2	--
<i>Senecio plattensis</i>	--	--	--	--	+ /4	--	--	--	--	--
<i>Senecio pseudoaureus</i>	--	--	--	--	--	--	+ /10	--	--	--
<i>Smilacina stellata</i>	--	--	--	--	--	--	--	1.3/20	+ /2	+ /2
<i>Solidago speciosa</i>	+ /4	+ /12	--	+ /12	--	--	--	+ /2	--	+ /8
<i>Swertia radiata</i>	--	--	--	--	+ /6	--	--	--	--	--
<i>Sysyrinchium angustifolium</i>	--	--	--	--	--	+ /2	--	--	--	--
<i>Thelypodium integrifolium</i>	--	--	--	--	*	--	--	--	--	--
<i>Thermopsis rhombifolia</i>	--	--	--	--	--	--	*	--	3.4/20	--
<i>Vicia americana</i>	--	--	0.9/8	0.7/6	+ /2	+ /8	--	1.2/10	--	--
<i>Viola adunca</i>	+ /8	+ /2	+ /6	+ /8	--	+ /10	--	--	--	--
<i>Woodsia oregana</i>	--	--	--	--	--	--	--	--	--	+ /2
<i>Zigadenus elegans</i>	--	--	--	--	+ /8	--	--	--	--	--
<i>Zizia aptera</i>	--	--	--	*	+ /12	--	--	--	--	--
Mosses and Lichens	--	--	--	--	+ /2	0.6/4	0.9/8	--	--	--
Species in microplots	13	14	21	16	24	29	24	19	25	21
Coverage of shrubs	20	27	34	34	20	33	38	84	95	54
Coverage of graminoids	2	2	6	--	1	32	16	9	15	18
Coverage of forbs	1	3	3	8	4	26	11	24	8	4
Total coverage (percent)	23	32	42	42	25	91	65	117	118	76

<sup>1</sup>+ = Coverage of less than 0.5%.

\* = Species present in the macroplot but absent from the microplots.

Table A-7.—Location, topographic position, coverage (percent), and frequency (percent) of undergrowth species in stands of *Pinus ponderosa*/*Juniperus communis* habitat type.

Stand number	1	5	7	8	29	38	53
<b>Location:</b>							
Quarter	SW	SW	SW	NW	SW	SE	NW
Section	33	14	14	11	8	17	32
Township	2S	4E	4E	1E	3E	1E	60W
Range	3E	4N	4N	4N	3S	1N	51N
<b>Topographic position:</b>							
Slope (percent)	12	17	12	32	--	5	14
Aspect (degrees)	328	186	232	276	--	226	306
Elevation (meters)	1,394	1,554	1,554	1,737	1,645	1,989	1,859
<b>Coverage/Frequency<sup>1</sup></b>							
<b>Shrubs</b>							
<i>Amelanchier alnifolia</i>	--	1.4/16	+ /4	--	0.6/22	--	1.3/14
<i>Arctostaphylos uva-ursi</i>	9.1/48	*	--	14/80	1.9/10	31/92	--
<i>Berberis repens</i>	+ /2	12/82	6.2/42	2.1/44	*	1.7/28	6.6/82
<i>Chimaphila umbellata</i>	--	--	--	+ /2	--	--	--
<i>Juniperus communis</i>	28/52	27/42	38/62	20/62	42/78	16/44	4.2/6
<i>Prunus americana</i>	--	--	--	--	--	--	+ /8
<i>Prunus virginiana</i>	--	--	+ /2	+ /6	--	--	--
<i>Pyrola secunda</i>	--	--	--	0.7/16	--	--	--
<i>Ribes cereum</i>	--	--	+ /2	+ /6	--	--	--
<i>Rosa acicularis</i>	+ /6	0.6/24	+ /10	1.3/20	*	+ /2	--
<i>Shepherdia canadensis</i>	4.5/16	--	--	5.1/22	0.8/2	--	1.3/20
<i>Spiraea betulifolia</i>	--	0.6/12	2.5/22	3.9/48	+ /2	--	9.4/74
<i>Symphoricarpos albus</i>	2.9/34	19/88	23/94	+ /8	1.7/38	12/28	--
<i>Toxicodendron rydbergii</i>	--	+ /2	--	--	--	--	--
<b>Graminoids</b>							
<i>Agropyron smithii</i>	--	--	--	--	--	--	*
<i>Bromus inermis</i>	0.9/24	0.8/32	+ /14	1.3/30	--	--	--
<i>Bromus pubescens</i>	--	--	--	--	+ /6	--	--
<i>Carex foenea</i>	--	--	+ /8	--	--	1.4/14	5.2/18
<i>Carex heliophila</i>	+ /2	--	--	--	--	--	--
<i>Danthonia spicata</i>	--	--	--	--	--	2.5/14	0.6/4
<i>Oryzopsis asperifolia</i>	--	--	--	2.6/22	--	3.3/18	1.3/10
<i>Poa interior</i>	--	--	--	--	+ /6	--	--
<i>Poa pratensis</i>	--	3.5/22	+ /10	--	--	--	*
<i>Stipa occidentalis</i>	--	--	--	--	--	*	*
<b>Forbs</b>							
<i>Achillea millefolium</i>	--	1.1/14	+ /6	+ /6	*	0.7/8	*
<i>Anemone patens</i>	--	+ /4	+ /2	+ /14	+ /2	--	--
<i>Antennaria neglecta</i>	+ /2	--	--	--	--	--	--
<i>Antennaria plantaginifolia</i>	--	+ /4	+ /6	--	--	--	--
<i>Apocynum androsaemifolium</i>	--	+ /2	--	--	+ /2	--	*
<i>Artemisia ludoviciana</i>	--	+ /2	+ /8	--	--	--	*
<i>Arnica cordifolia</i>	--	--	--	+ /6	--	--	--
<i>Astragalus alpinus</i>	--	--	--	--	*	--	--
<i>Astragalus spp.</i>	--	+ /2	*	--	--	--	--
<i>Balsamorhiza sagittata</i>	--	--	--	--	--	*	--
<i>Campanula rotundifolia</i>	--	--	--	--	*	+ /6	--
<i>Cerastium arvense</i>	--	--	+ /2	--	--	--	--
<i>Clematis pseudoalpina</i>	--	--	--	+ /2	--	--	--
<i>Clematis tenuiloba</i>	0.6/24	--	--	--	--	--	--
<i>Fragaria virginiana</i>	4/16	+ /4	+ /6	0.9/26	+ /8	+ /8	--
<i>Galium boreale</i>	--	--	--	--	+ /14	+ /8	+ /6
<i>Galium obtusum</i>	--	0.6/14	1.3/22	+ /14	--	--	--
<i>Geum triflorum</i>	+ /4	--	--	--	--	--	--
<i>Haplopappus armerioides</i>	--	--	--	--	*	--	--
<i>Hedysarum alpinum</i>	--	--	--	--	--	1.9/12	--
<i>Iris missouriensis</i>	0.7/18	--	--	--	*	--	--
<i>Lathyrus ochroleucus</i>	--	--	--	0.6/12	--	1.2/18	--
<i>Lupinus argenteus</i>	--	0.7/16	+ /4	*	*	+ /2	*
<i>Melilotus albus</i>	--	0.9/14	1.3/12	--	--	--	--
<i>Musineon tenuifolium</i>	+ /4	--	--	--	+ /2	--	--
<i>Monarda fistulosa</i>	--	--	+ /2	--	--	--	--

Table A-7.—Continued.

Stand number	1	5	7	8	29	38	53
<i>Phlox alyssifolia</i>	+ /6	--	--	--	--	--	--
<i>Potentilla fruticosa</i>	--	--	--	*	--	--	--
<i>Potentilla hippiana</i>	*	--	--	--	*	--	--
<i>Senecio</i> spp.	--	--	*	--	--	--	--
<i>Smilacina racemosa</i>	--	--	*	+ /4	--	--	--
<i>Smilacina stellata</i>	+ /10	--	--	--	+ /10	--	1.2/18
<i>Swertia radiata</i>	--	--	--	+ /8	*	--	--
<i>Taraxacum officinale</i>	--	+ /6	+ /2	--	--	--	--
<i>Thalictrum venulosum</i>	--	--	--	1.7/12	--	--	--
<i>Thalictrum dioicum</i>	--	--	--	--	--	--	+ /4
<i>Thermopsis rhombifolia</i>	--	--	*	--	--	--	--
<i>Toxicodendron rydbergii</i>	--	+ /2	--	--	--	--	--
<i>Vicia americana</i>	--	0.8/10	*	*	*	--	--
<i>Viola adunca</i>	+ /4	--	*	+ /6	--	--	+ /40
<i>Viola canadensis</i>	--	--	--	+ /2	--	--	--
<i>Zigadenus elegans</i>	--	--	--	0.6/14	+ /2	--	--
<i>Zizia aptera</i>	--	--	--	+ /10	--	--	--
Mosses and Lichens	--	--	--	--	--	--	0.9/6
Species in microplots	17	22	22	27	15	15	14
Coverage of shrubs	45	61	71	48	47	61	23
Coverage of graminoids	1	4	1	4	--	7	7
Coverage of forbs	7	6	4	6	1	5	3
Total coverage (percent)	53	71	76	58	48	73	33

<sup>1</sup>+ = Coverage of less than 0.5%.

\* = Species present in the macroplot but absent from the microplots.



Table A-8.—Location, topographic position, coverage (percent), and frequency (percent) of undergrowth species in stands of *Populus tremuloides*/*Corylus cornuta* habitat type, including the *Pteridium aquilinum* and *Aralia nudicaulis* phases.

	<i>Populus/Corylus</i>					<i>Pteridium</i> phase			<i>Aralia</i> phase	
	Stand number	67	69	55	2	31	25	26	30	43
Location:										
Quarter		NW	SW	NE	SE	SE	NW	SW	NE	SW
Section		11	30	27	34	31	8	5	8	30
Township		2S	5N	5N	1S	5N	52N	52N	51N	4N
Range		5E	1E	4E	6E	1E	63W	63W	60W	5E
Topographic position:										
Slope (percent)		--	7	9	40	7	--	--	7	12
Aspect (degrees)		--	56	8	30	38	--	--	295	340
Elevation (meters)		1,533	1,902	1,387	1,219	1,874	1,737	1,653	1,585	1,554
<b>Coverage/Frequency<sup>1</sup></b>										
<b>Shrubs</b>										
<i>Amelanchier alnifolia</i>		0.6/4	2.5/6	+ /4	*	4.5/8	0.7/8	2.9/20	13/42	1/8
<i>Berberis repens</i>		--	+ /2	2/20	--	2/28	5.7/50	0.9/16	5.4/44	1.7/16
<i>Corylus cornuta</i>		87/100	43/86	--	70/100	73/96	47/92	4.7/24	28/62	12/62
<i>Crataegus succulenta</i>		--	--	--	--	--	*	+ /2	1.5/4	--
<i>Lonicera dioica</i>		3.8/32	3.9/16	0.7/8	1.4/18	--	0.8/2	--	0.7/8	+ /6
<i>Ostrya virginiana</i>		--	--	8.9/62	--	--	--	--	--	--
<i>Physocarpus monogynus</i>		*	--	--	5.4/28	--	--	--	--	--
<i>Prunus virginiana</i>		+ /2	--	+ /10	3.4/24	+ /4	1/4	--	1.7/20	1.3/10
<i>Pyrola asarifolia</i>		15/66	--	+ /6	5.4/46	3/58	--	--	0.9/28	--
<i>Pyrola elliptica</i>		--	--	0.6/12	--	--	0.9/26	+ /4	--	--
<i>Pyrola secunda</i>		+ /2	--	+ /4	1.2/20	*	--	--	--	0.8/12
<i>Quercus macrocarpa</i>		--	--	--	--	--	--	--	*	--
<i>Ribes odoratum</i>		0.7/8	--	+ /4	0.7/6	--	*	--	3.6/22	+ /6
<i>Rosa acicularis</i>		+ /2	1/6	0.7/16	1.1/14	--	--	7.5/62	3/34	2/28
<i>Rubus idaeus</i>		--	+ /2	+ /6	0.6/6	1.1/14	1.5/12	+ /4	1.2/10	19/78
<i>Rubus parviflorus</i>		--	2.5/6	--	--	*	*	*	+ /2	--
<i>Rubus pubescens</i>		3.4/26	0.5/8	1.7/10	--	--	--	--	--	3.9/22
<i>Spiraea betulifolia</i>		--	0.5/8	1.3/10	2.8/34	+ /10	9.7/42	2.9/20	11/54	+ /2
<i>Symphoricarpos albus</i>		0.9/6	1.8/12	8.1/44	2.6/38	2.9/36	+ /4	3.6/34	5.1/46	4.1/42
<i>Symphoricarpos occidentalis</i>		0.7/8	2/12	--	--	--	--	--	--	--
<b>Graminoids</b>										
<i>Agropyron repens</i>		--	--	--	--	--	--	--	--	0.9
<i>Bromus ciliatus</i>		--	--	--	--	--	--	--	--	+ /2
<i>Calamagrostis canadensis</i>		--	--	--	--	--	--	+ /2	--	1.1/6
<i>Carex aurea</i>		--	--	+ /4	--	--	--	--	--	--
<i>Carex deweyana</i>		--	+ /4	--	--	--	--	--	--	--
<i>Carex foenea</i>		--	--	--	--	--	--	1/10	--	--
<i>Carex saximontana</i>		8/24	--	--	2.4/22	--	--	+ /2	--	--
<i>Carex sprengeii</i>		+ /2	--	--	--	--	+ /2	+ /6	+ /2	--
<i>Danthonia spicata</i>		--	--	--	--	--	--	--	--	*
<i>Elymus virginicus</i>		4.8/36	7.8/46	--	--	--	3.7/28	1.6/22	+ /2	4/28
<i>Festuca subulata</i>		--	1.1/8	--	--	--	--	--	--	--
<i>Melica subulata</i>		--	--	--	--	--	13/80	4.7/62	1.5/32	--
<i>Oryzopsis asperifolia</i>		--	2.8/26	19/86	3.3/44	1.8/24	1.3/12	+ /2	3.6/48	14/58
<i>Phleum pratense</i>		--	--	--	--	--	--	--	--	9.6/50
<i>Poa pratensis</i>		--	2.2/16	--	--	1.4/14	+ /4	1/30	--	7/32
<i>Schizachne purpurascens</i>		--	--	--	--	6.1/64	--	--	--	--
<b>Forbs</b>										
<i>Achillea millefolium</i>		*	--	--	*	*	*	0.6/12	+ /4	+ /4
<i>Actaea rubra</i>		1.1/6	9.8/52	--	1.1/8	12/56	--	*	+ /2	--
<i>Adenocaulon bicolor</i>		--	--	--	--	--	--	--	+ /2	--
<i>Agrimonia striata</i>		--	--	--	--	--	--	+ /2	--	*
<i>Anaphalis margaritacea</i>		--	--	--	--	*	0.6/4	1.4/16	--	--
<i>Anemone canadensis</i>		*	+ /2	--	--	--	--	--	--	--
<i>Anemone cylindrica</i>		--	--	--	--	--	--	--	--	+ /6
<i>Apocynum androsaemifolium</i>		--	--	+ /2	+ /6	--	--	+ /2	+ /2	+ /2
<i>Aquilegia canadensis</i>		--	--	--	0.7/8	--	--	--	--	--
<i>Aralia nudicaulis</i>		27/8	1.5/10	2.3/14	6.9/50	7.5/32	3/12	+ /2	2.8/12	47/96
<i>Arnica cordifolia</i>		--	5/50	1.7/48	--	13/44	1.1/6	2.9/18	0.9/28	--
<i>Artemisia ludoviciana</i>		--	--	--	--	--	--	+ /4	--	--

Table A-8.—Continued.

Stand number	<i>Populus/Corylus</i>					<i>Pteridium</i> phase			<i>Aralia</i> phase
	67	69	55	2	31	25	26	30	43
<i>Aster ciliolatus</i>	+ /2	3.2/28	1.4/24	+ /12	7.3/64	1/18	1.7/18	—	19/80
<i>Astragalus alpinus</i>	—	—	—	—	—	—	—	—	0.6/4
<i>Cornus canadensis</i>	—	—	*	—	—	—	—	—	—
<i>Delphinium nuttallianum</i>	—	—	—	—	—	*	—	—	—
<i>Disporum trachycarpum</i>	—	9.1/40	0.8/20	—	9.2/64	+ /2	*	2.8/46	2.6/42
<i>Dodecatheon</i> spp.	—	—	—	*	—	—	—	—	—
<i>Fragaria virginiana</i>	3.4/24	1.6/16	—	1.7/28	2.8/40	2/20	2.8/52	0.6/14	1.4/14
<i>Galium boreale</i>	*	—	—	—	—	+ /8	1.7/38	+ /4	1/20
<i>Galium triflorum</i>	1.4/26	7.8/42	0.8/8	+ /10	0.9/16	2.9/20	1.4/16	1.4/26	—
<i>Geranium bicknellii</i>	—	—	+ /2	—	—	—	—	—	—
<i>Geranium richardsonii</i>	2.8/22	+ /6	—	—	6.7/42	—	1/10	—	—
<i>Goodyera repens</i>	—	—	+ /2	—	—	—	—	—	—
<i>Habenaria viridis</i>	—	—	—	—	—	+ /2	+ /2	—	+ /2
<i>Halenia deflexa</i>	—	—	—	—	—	—	—	—	2.7/36
<i>Hedysarum alpinum</i>	—	—	—	1/4	—	—	—	—	—
<i>Heracleum sphondylium</i>	*	3.6/20	—	*	12/74	2.6/24	2.3/12	+ /6	4/26
<i>Heuchera richardsonii</i>	—	—	—	*	—	*	+ /2	—	—
<i>Hieracium umbellatum</i>	—	—	+ /2	—	—	—	—	7.2/62	—
<i>Lathyrus ochroleucus</i>	—	3.2/20	+ /2	+ /6	1.7/18	+ /4	1.9/16	0.7/10	3.7/30
<i>Linnaea borealis</i>	—	—	2.3/12	—	—	—	—	—	—
<i>Lupinus argenteus</i>	—	—	—	—	—	—	—	+ /4	—
<i>Maianthemum canadense</i>	4.6/48	0.9/25	2.5/70	5.1/68	1.5/50	—	—	+ /10	2/38
<i>Nepeta cataria</i>	—	—	—	+ /2	—	—	—	+ /2	—
<i>Osmorhiza chilensis</i>	*	4.9/40	+ /4	—	15/84	15/80	7.5/76	3.8/52	—
<i>Osmorhiza depauperata</i>	—	2.4/20	—	—	—	—	—	—	—
<i>Parthenocissus vitacea</i>	—	—	*	—	—	—	—	—	—
<i>Pteridium aquilinum</i>	—	6.4/27	3/14	—	2.4/10	23/74	33/96	21/76	—
<i>Pterospora andromedea</i>	—	—	—	*	—	—	—	—	—
<i>Ranunculus abortivus</i>	—	—	—	—	—	+ /2	*	—	—
<i>Sanicula marilandica</i>	0.6/12	2.1/22	—	+ /12	1.8/20	3.2/36	7.2/54	1/22	6.3/64
<i>Smilacina racemosa</i>	—	—	—	+ /4	—	—	—	—	—
<i>Smilacina stellata</i>	1/8	2.8/26	+ /2	0.7/8	1.1/14	1.6/22	1.9/24	0.7/8	+ /2
<i>Smilax herbacea</i>	—	—	*	—	—	—	—	—	—
<i>Taraxacum officinale</i>	—	+ /12	0.6/12	—	0.9/6	2.2/20	7.3/66	+ /12	2/20
<i>Thalictrum dasycarpum</i>	0.8/10	3.9/22	1.1/34	0.6/4	6.4/42	1.7/8	4.6/30	2.4/36	+ /4
<i>Toxicodendron rydbergii</i>	*	—	—	1.8/24	—	—	—	+ /2	5.6/44
<i>Trifolium repens</i>	—	0.5/12	—	—	+ /2	—	+ /14	+ /2	—
<i>Vicia americana</i>	—	—	—	—	+ /6	*	0.9/16	+ /6	1.4/16
<i>Viola adunca</i>	—	—	—	—	—	—	—	+ /10	+ /2
<i>Viola canadensis</i>	7.3/58	20/89	+ /6	1.6/24	15/86	19/96	9.8/68	1/2	1.3/42
<i>Viola renifolia</i>	—	—	—	—	—	—	*	—	—
<i>Woodsia</i> spp.	—	—	—	+ /2	—	—	—	—	—
<i>Zizia aptera</i>	—	—	—	+ /2	—	—	—	—	—
Mosses and Lichens	3.3/8	—	2/12	—	—	—	—	—	—
Species in microplots	26	37	35	32	31	33	42	44	41
Coverage of shrubs	113	58	25	95	87	68	23	75	46
Coverage of graminoids	13	14	19	6	9	18	9	6	37
Coverage of forbs	54	89	20	23	118	80	91	49	102
Total coverage (percent)	180	161	64	124	214	166	123	130	185

<sup>1</sup>+ = Coverage of less than 0.5%.

\* = Species present in the macroplot but absent from the microplots.

Table A-9.—Location, topographic position, coverage (percent), and frequency (percent) of undergrowth species in stands of *Picea glauca*/*Vaccinium scoparium* and *Picea glauca*/*Linnaea borealis* habitat types.

	<i>Picea-Vaccinium</i>					<i>Picea-Linnaea</i>					
	Stand number	47	46	9	51	48	15	40	52	50	60
<b>Location:</b>											
Quarter	NE	NW	SE	SW	NW	NE	SW	SE	NW	SE	
Section	23	12	14	26	4	11	5	28	7	21	
Township	4N	4N	4N	4N	2N	1S	1N	4N	2S	1N	
Range	2E	2E	1E	1E	2E	2E	1E	1E	4E	2E	
<b>Topographic position:</b>											
Slope (percent)	29	10	25	2	35	17	26	32	16	26	
Aspect (degrees)	12	271	330	166	231	320	334	300	312	18	
Elevation (meters)	1,813	2,040	1,737	1,935	1,913	1,768	1,958	1,852	1,829	1,957	
<b>Coverage/Frequency<sup>1</sup></b>											
<b>Shrubs</b>											
<i>Amelanchier alnifolia</i>	0.7/6	+ /2	--	--	--	*	+ /2	+ /2	--	+ /2	
<i>Arctostaphylos uva-ursi</i>	+ /4	2.2/22	4/30	3.7/32	--	+ /10	1.3/2	0.7/6	7.1/38	--	
<i>Berberis repens</i>	2.8/34	4.5/50	7.2/72	+ /4	4.9/48	+ /2	4.2/30	11/80	--	--	
<i>Betula occidentalis</i>	--	--	--	--	--	*	--	--	--	--	
<i>Cornus canadensis</i>	+ /4	--	--	--	--	--	--	--	--	--	
<i>Juniperus communis</i>	6.2/36	14/46	11/42	8.5/18	--	5.2/38	17/46	10/34	+ /4	1.1/6	
<i>Linnaea borealis</i>	11/76	--	--	--	19/70	11/54	36/96	6.4/28	24/66	19/78	
<i>Lonicera dioica</i>	*	--	--	--	+ /2	*	0.6/4	0.6/4	+ /2	--	
<i>Prunus virginiana</i>	--	--	--	--	--	--	--	*	--	--	
<i>Pyrola secunda</i>	+ /4	+ /6	0.2/16	--	2.2/26	*	1.6/32	+ /4	--	1.2/16	
<i>Pyrola virens</i>	--	--	--	--	0.9/24	--	+ /10	--	--	--	
<i>Ribes setosum</i>	--	--	--	--	--	--	--	--	*	--	
<i>Rosa acicularis</i>	2.4/34	1/12	1.1/34	1.4/26	4.6/46	+ /6	5.7/58	+ /4	5.4/64	1.6/16	
<i>Rubus idaeus</i>	--	--	--	--	*	--	--	--	--	--	
<i>Salix scouleriana</i>	--	+ /2	--	--	--	--	--	--	--	--	
<i>Shepherdia canadensis</i>	*	3.7/6	*	--	--	+ /2	1.8/14	+ /2	1.6/14	--	
<i>Spiraea betulifolia</i>	13/68	7.3/52	5.5/62	6.3/56	--	4.2/58	--	*	--	--	
<i>Symphoricarpos albus</i>	+ /14	+ /6	--	+ /4	1.3/14	+ /6	+ /8	2/28	0.8/12	1/10	
<i>Vaccinium scoparium</i>	2.3/30	4.7/100	18/70	58/86	17/58	--	--	--	--	--	
<b>Graminoids</b>											
<i>Bromus inermis</i>	--	--	--	--	--	--	1.9/14	--	--	--	
<i>Carex concinna</i>	1.5/18	4/28	--	--	1.3/10	--	0.7/6	4.3/20	--	--	
<i>Carex foenea</i>	--	+ /6	--	5/26	--	--	--	0.7/8	3.1/28	--	
<i>Carex microptera</i>	--	0.5/10	--	+ /4	--	+ /8	--	--	1.2/14	+ /2	
<i>Carex spp.</i>	--	--	--	--	*	+ /2	--	--	--	--	
<i>Danthonia spicata</i>	--	1.9/26	--	3.3/24	--	--	--	--	--	--	
<i>Elymus innovatus</i>	--	--	--	+ /4	--	--	--	--	--	--	
<i>Festuca ovina</i>	--	--	--	--	--	--	0.8/2	--	--	--	
<i>Oryzopsis asperifolia</i>	12/62	+ /8	2/30	3.3/26	10/48	1/22	12/50	6.5/30	--	5/30	
<i>Oryzopsis pungens</i>	--	--	--	--	--	+ /6	--	--	0.7/8	--	
<i>Poa interior</i>	+ /8	--	0.5/14	--	--	--	+ /4	--	*	--	
<i>Poa ovina</i>	--	--	*	--	+ /4	--	--	0.7/10	--	--	
<i>Poa pratensis</i>	1.6/14	*	0.5/24	+ /10	3.5/26	+ /2	3.2/18	+ /4	4.6/28	--	
<i>Schizachne purpurascens</i>	--	--	--	--	1.5/10	--	5.7/20	--	4.2/22	--	
<b>Forbs</b>											
<i>Achillea millefolium</i>	+ /10	+ /2	+ /4	+ /2	--	+ /6	+ /4	+ /4	--	--	
<i>Aconitum columbianum</i>	*	--	--	*	2.6/18	--	--	--	*	--	
<i>Actaea rubra</i>	--	--	--	--	*	--	*	--	--	--	
<i>Anaphalis margaritacea</i>	--	--	--	0.8/4	--	--	--	--	--	--	
<i>Anemone cylindrica</i>	--	--	--	--	--	--	--	+ /8	--	--	
<i>Anemone multifida</i>	+ /10	--	--	--	+ /2	--	--	--	--	--	
<i>Anemone spp.</i>	--	--	--	--	--	+ /6	+ /2	--	--	--	
<i>Antennaria plantaginifolia</i>	0.6/12	1.7/10	--	1/12	+ /4	4/32	+ /2	*	0.7/8	--	
<i>Apocynum androsaemifolium</i>	--	1.5/20	--	--	--	--	--	--	+ /18	--	
<i>Aquilegia canadensis</i>	--	--	--	--	*	--	--	--	--	*	
<i>Arenaria lateriflora</i>	--	+ /4	--	--	--	--	--	--	--	--	
<i>Arnica cordifolia</i>	--	--	--	--	+ /2	*	+ /4	+ /6	--	--	
<i>Arnica rydbergii</i>	0.8/4	--	--	--	--	--	--	+ /4	--	--	
<i>Aster ciliolatus</i>	--	1/8	--	--	5/28	--	*	+ /2	--	--	
<i>Astragalus alpinus</i>	--	--	--	--	--	0.6/12	--	--	0.9/8	--	

Table A-9.—Continued.

Stand number	<i>Picea-Vaccinium</i>					<i>Picea-Linnaea</i>				
	47	46	9	51	48	15	40	52	50	60
<i>Campanula rotundifolia</i>	0.7/6	0.8/10	--	1/10	*	+ /2	--	--	*	--
<i>Castilleja sulphurea</i>	1.2/16	*	--	--	*	--	+ /2	--	--	--
<i>Cirsium</i> spp.	--	--	--	--	--	--	--	--	+ /2	--
<i>Clematis tenuiloba</i>	10/74	--	1.2/28	--	2.7/28	--	7.9/72	1/18	--	--
<i>Corallorhiza maculata</i>	--	*	--	*	--	*	--	--	--	--
<i>Disporum trachycarpum</i>	+ /4	--	+ /4	--	+ /2	--	--	1.6/6	--	--
<i>Dodecatheon pauciflorum</i>	+ /4	--	--	--	--	0.7/8	--	--	--	--
<i>Epilobium angustifolium</i>	--	*	--	--	+ /2	--	*	--	0.6/12	--
<i>Fragaria virginiana</i>	0.7/26	+ /2	0.8/20	+ /6	2.1/44	1.4/24	6.8/64	+ /10	2.8/42	1.6/12
<i>Galium boreale</i>	1.2/18	0.8/20	+ /4	+ /2	2.3/32	--	4.7/40	+ /12	+ /2	0.6/6
<i>Galium triflorum</i>	--	--	--	--	0.7/6	--	--	--	--	--
<i>Gentiana amarella</i>	--	--	--	*	*	--	--	--	+ /4	--
<i>Geranium richardsonii</i>	--	--	--	--	*	--	--	--	--	--
<i>Goodyera oblongifolia</i>	+ /4	--	--	--	--	--	--	--	--	--
<i>Goodyera repens</i>	+ /10	--	+ /6	+ /4	--	--	--	--	--	--
<i>Habenaria viridis</i>	1/10	--	--	--	--	+ /2	--	--	+ /4	--
<i>Halenia deflexa</i>	+ /6	--	--	--	+ /14	--	--	--	0.7/26	--
<i>Hedysarum alpinum</i>	--	--	0.6/14	*	0.7/8	+ /2	+ /4	+ /2	1.5/18	--
<i>Heuchera richardsonii</i>	--	--	--	--	*	+ /8	--	--	+ /10	--
<i>Hieracium albiflorum</i>	--	--	--	2.2/26	--	--	--	--	--	--
<i>Hieracium umbellatum</i>	2.8/22	+ /8	--	+ /2	+ /4	--	--	*	--	--
<i>Lathyrus ochroleucus</i>	0.6/12	5.9/32	+ /10	+ /6	2.1/24	+ /4	1.8/12	--	+ /2	--
<i>Lilium philadelphicum</i>	--	--	--	--	--	*	--	--	--	--
<i>Lupinus argenteus</i>	+ /2	--	--	*	--	+ /2	--	--	--	--
<i>Maianthemum canadense</i>	--	0.9/16	--	--	--	--	--	--	1.5/40	--
<i>Monarda fistulosa</i>	--	+ /4	--	--	--	--	--	--	--	--
<i>Osmorhiza chilensis</i>	--	--	--	--	2.1/26	--	+ /4	--	--	3.2/28
<i>Osmorhiza</i> spp.	--	--	*	+ /2	--	--	--	--	--	--
<i>Oxytropis campestris</i>	--	--	--	--	--	*	--	--	--	--
<i>Phlox alyssifolia</i>	--	--	--	--	--	+ /4	--	--	--	--
<i>Polygala senega</i>	+ /2	--	--	--	--	--	--	--	--	--
<i>Potentilla gracilis</i>	--	--	--	--	+ /2	--	--	--	--	--
<i>Pteridium aquilinum</i>	--	--	--	14/40	--	--	--	--	--	--
<i>Rudbeckia hirsuta</i>	+ /10	--	--	--	--	--	--	--	--	--
<i>Senecio plattensis</i>	+ /10	--	--	--	0.8/12	+ /6	+ /2	--	+ /18	--
<i>Smilacina stellata</i>	--	+ /2	--	--	3.5/34	--	--	1.4/8	--	*
<i>Solidago</i> spp.	--	0.6/14	--	--	--	--	--	--	--	--
<i>Swertia radiata</i>	2.3/22	--	--	--	1/10	--	1/4	--	--	+ /2
<i>Taraxacum officinale</i>	--	--	+ /8	--	1.3/10	+ /6	1/12	*	--	--
<i>Thalictrum dioicum</i>	+ /4	+ /6	--	0.6/4	+ /2	--	--	+ /4	--	--
<i>Trifolium repens</i>	*	--	--	--	--	0.8/4	--	--	--	--
<i>Valeriana edulis</i>	--	--	--	--	*	--	--	--	--	--
<i>Vicia americana</i>	*	0.7/6	--	--	--	--	0.7/6	--	--	--
<i>Viola adunca</i>	+ /10	+ /4	--	+ /2	+ /8	+ /8	+ /2	2.4/26	+ /4	--
<i>Viola renifolia</i>	--	--	--	--	--	--	--	--	0.7/16	--
<i>Zigadenus elegans</i>	2/20	--	0.6/14	--	+ /4	--	2.5/22	+ /4	+ /2	--
<i>Zizia aptera</i>	--	--	--	--	--	--	--	--	--	0.6/12
Mosses and Lichens <sup>2</sup>	17/68	+ /4	--	12/40	30/84	16/64	18/58	10/48	17/84	24/72
Species in microplots	41	34	20	28	38	31	36	30	31	14
Coverage of shrubs <sup>3</sup>	39	38	47	78	50	21	69	32	39	24
Coverage of graminoids <sup>3</sup>	15	7	3	12	17	2	25	12	14	5
Coverage of forbs <sup>3</sup>	44	16	4	33	59	26	46	18	28	30
Total coverage (percent)	98	61	54	123	126	49	140	62	81	59

<sup>1</sup> + = Coverage less than 0.5%.

\* = Species present in the macroplot but absent from the microplots.

<sup>2</sup>In summing species in microplots, mosses and lichens are counted as one forb in each stand where they occurred.<sup>3</sup>In calculating coverage sums, + is taken to be 0.2%.



Table A-10.—Location, topographic position, coverage (percent), and frequency (percent) of undergrowth species in stands of *Cercocarpus montanus*/*Bouteloua curtipendula* habitat type.

Stand number	35	36	56
<b>Location:</b>			
Quarter	SW	NW	NE
Section	9	32	18
Township	5S	5S	3S
Range	2E	6E	1E
<b>Topographic position:</b>			
Slope (percent)	21	38	32
Aspect (degrees)	140	80	82
Elevation (meters)	1,463	1,265	1,493
<b>Coverage/Frequency<sup>1</sup></b>			
<b>Shrubs</b>			
<i>Artemisia frigida</i>	1.3/6	0.8/6	0.6/4
<i>Cercocarpus montanus</i>	45/95	41/90	41/90
<i>Gutierrezia sarothrae</i>	1.1/6	5.2/22	—
<i>Juniperus scopulorum</i>	--	--	4.6/26
<i>Rhus aromatica</i>	1.7/2	6.7/18	8.4/22
<b>Graminoids</b>			
<i>Agropyron dasystachyum</i>	+ /4	--	—
<i>Andropogon scoparius</i>	--	--	2.7/8
<i>Aristida longiseta</i>	3.5/28	+ /4	+ /4
<i>Bouteloua curtipendula</i>	24/70	37/88	29/76
<i>Bromus japonicus</i>	--	+ /12	*
<i>Carex filifolia</i>	+ /4	*	—
<i>Oryzopsis hymenoides</i>	2.1/8	1/4	1.7/12
<i>Oryzopsis micrantha</i>	--	10/28	3.6/12
<i>Sitanion hystrix</i>	4.2/34	2/14	+ /2
<i>Sporobolus cryptandrus</i>	--	1.3/6	—
<i>Stipa comata</i>	--	9.5/42	0.7/2
<b>Forbs</b>			
<i>Allium</i> spp.	+ /2	--	*
<i>Argemone polyanthemus</i>	*	--	—
<i>Artemisia ludoviciana</i>	--	2.2/30	—
<i>Aster oblongifolius</i>	0.9/16	3.3/28	*
<i>Astragalus gracilis</i>	+ /2	--	—
<i>Cryptantha celosioides</i>	+ /2	--	—
<i>Euphorbia fendleri</i>	*	--	+ /2
<i>Evolvulus nuttallianus</i>	+ /4	--	—
<i>Hedeoma hispida</i>	2/34	2.6/30	2.2/30
<i>Helianthus maximiliani</i>	--	*	—
<i>Linum perenne</i>	--	--	2.3/32
<i>Lithospermum incisum</i>	0.8/14	--	—
<i>Mentzelia oligosperma</i>	--	0.8/6	—
<i>Opuntia polyacantha</i>	+ /2	--	—
<i>Phlox hoodii</i>	--	--	0.6/16
<i>Polygala alba</i>	*	+ /14	—
<i>Sphaeralcea coccinea</i>	--	--	+ /12
<i>Tragopogon dubius</i>	--	+ /2	—
<i>Yucca glauca</i>	--	*	3.2/8
Mosses and Lichens	+ /4	--	—
Species in microplots	19	18	17
Coverage of shrubs	49	54	55
Coverage of graminoids	34	61	38
Coverage of forbs	5	9	9
Total coverage (percent)	88	124	102

<sup>1</sup> + = Coverage of less than 0.5%.

\* = Species present in the macroplot but absent from the microplots.

Hoffman, George R.; Alexander, Robert R. 1987. Forest vegetation of the Black Hills National Forest of South Dakota and Wyoming: a habitat type classification. Res. Pap. RM-276. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 48 p.

A vegetation classification based on concepts and methods developed by Daubenmire was used to identify 12 forest habitat types and one shrub habitat type in the Black Hills. Included were two habitat types in the *Quercus macrocarpa* series, seven in the *Pinus ponderosa* series, one in the *Populus tremuloides* series, two in the *Picea glauca* series, and one in the *Cercocarpus montana* series. A key to identify the habitat types and the management implications associated with each are provided.

**Keywords:** Vegetation classification, habitat types, *Quercus macrocarpa*, *Pinus ponderosa*, *Populus tremuloides*, *Picea glauca*, *Cercocarpus montanus*

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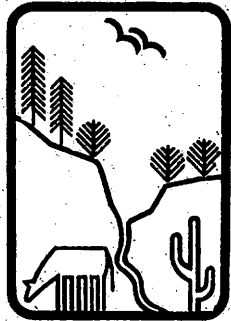
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Rocky  
Mountains



Southwest



Great  
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Forest Service

## Rocky Mountain Forest and Range Experiment Station

The Rocky Mountain Station is one of eight regional experiment stations, plus the Forest Products Laboratory and the Washington Office Staff, that make up the Forest Service research organization.

### RESEARCH FOCUS

Research programs at the Rocky Mountain Station are coordinated with area universities and with other institutions. Many studies are conducted on a cooperative basis to accelerate solutions to problems involving range, water, wildlife and fish habitat, human and community development, timber, recreation, protection, and multiresource evaluation.

### RESEARCH LOCATIONS

Research Work Units of the Rocky Mountain Station are operated in cooperation with universities in the following cities:

Albuquerque, New Mexico  
Flagstaff, Arizona  
Fort Collins, Colorado\*  
Laramie, Wyoming  
Lincoln, Nebraska  
Rapid City, South Dakota  
Tempe, Arizona

\*Station Headquarters: 240 W. Prospect St., Fort Collins, CO 80526