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Forest Vegetation of the Gunnison and Parts of the Uncompahgre National Forests: A Preliminary Habitat Type Classification

Vera Komarkova, Robert R. Alexander, and Barry C. Johnston

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Abstract

A vegetation classification based on a combination of concepts and methods developed by Braun-Blanquet and Daubenmire was used to identify 37 *tentative* forest habitat types on the Gunnison National Forest. Woodland habitat types comprised two series with a total of 3 habitat types, and forest habitat types included nine series with a total of 34 habitat types. A key to identify the habitat types is provided and the management implications associated with each are discussed.

Cover Photo.—Subalpine forests near Los Pinos Pass, Gunnison National Forest.

[1]Headquarters is in Fort Collins, in cooperation with Colorado State University.

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INTRODUCTION

Although forest vegetation on the Gunnison National Forest and adjacent areas had been studied previously, this study is the first attempt to comprehensively categorize and describe all forested habitat types based on quantitative data. The flora of several specific regions within the study area have been investigated. The most extensive study was by Barrell (1969), who listed the species occurring in the Gunnison Basin. Considerable research on vegetation in the Crested Butte area has been done by the Rocky Mountain Biological Laboratory in Gothic, Colo. Included in this effort were vegetation descriptions of several biotic communities (Langenheim 1962), plant succession (Barclay 1941, McCullough 1948), and general ecology of aspen communities (Morgan 1969). Adjacent to the Gunnison National Forest, Hoffman and Alexander (1980, 1983) described 11 forested habitat types each on the Routt and White River National Forests. Six of these also occur on the Gunnison National Forest. Hess and Wasser[2] also described the forested habitat types on the White River National Forest. Eight of the 18 habitat types they identified also occur on the Gunnison National Forest.

In 1982, a cooperative study, jointly funded by the Rocky Mountain Forest and Range Experiment Station and the Rocky Mountain Region, was started by Komarkova[3] to (1) identify and describe forested and nonforested habitat types on the Gunnison National Forest and part of the Uncompahgre National Forest, based on plots well distributed over the study area; (2) relate habitat types to environmental parameters; and (3) relate Gunnison National Forest habitat types to similar classifications in other Rocky Mountain forests. The habitat type classification completed in 1986 is based, in part, on concepts and methods developed by Daubenmire and Daubenmire (1968) and modified by Pfister and Arno (1980) and others, and in part on the floristic-sociological Braun-Blanquet concepts (Westhoff and van der Maarel 1978).

Although Komarkova[3] classified both forested and nonforested lands on the Gunnison National Forest, the results reported here are restricted to forest vegetation. They are intended for two primary audiences—forest managers and land-use planners who want a working tool to use on the Gunnison National Forest, and ecologists who want a research tool to use in related studies. However, many of the habitat types reported here are represented by only one or two stands and must be recognized as *preliminary*. Further intensive sampling must be conducted before results should be regarded as conclusive and before the extent of and variations within habitat types can be estimated.

STUDY AREA

The study area includes the Gunnison National Forest and a small part [76,500 acres (30,970 ha)] of the Uncompahgre National Forest. This area encompasses 1,767,700 gross acres (715,670 ha) (fig. 1). The Gunnison National Forest extends southward from the Elk Mountains and White River National Forest to the San Juan Mountains adjacent to the Uncompahgre, San Juan, and Rio Grande National Forests. It extends eastward to the Sawatch Mountains and the San Isabel National Forest; westward it is bordered by the Grand Mesa and Uncompahgre National Forests and non-Forest Service lands. Elevations within the study area range from 6,440 feet (1,963 m) to Castle Peak at 14,265 feet (4,490 m).

PHYSIOGRAPHY AND GEOLOGY

The study area is geologically diverse, varying from volcanic shaped mountains and mesas in the south, predominately sedimentary rocks and granites in the north, and Precambrian and other rocks exposed by erosion in the central part of the area (Barrell 1969). Upper Cenozoic igneous rocks of the San Juan Mountains are predominately volcanic, while those of the Elk Mountains are largely epizonal plutonic; the age and sequence of petrologic types are similar in the two areas (Lipman et al. 1969). Glacial events may have occurred throughout the Holocene and may be continuing at present, as indicated by rock glaciers and small cirque glaciers (Meierding and Birkeland 1980).

The Elk Mountain Range to the north is relatively small [40 by 20 miles (64 by 32 km)] and lies in a northwest to southeast direction. Only the southern portion is included in the study area. Topography is dominated by cirques, glacial moraines, aretes, extensive talus accumulations, and rock glaciers; the latter are prevalent in areas of igneous and coarse clastic rock. Fossil and

[2] *Hess, Karl, and Clinton H. Wasser. 1982. Grassland, shrubland, and forestland habitat types on the White River-Arapaho National Forests. (Final report, 53-82FT-1-19, on file, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.)*

[3] *Komarkova, Vera. 1986. Habitat types on selected parts of the Gunnison and Uncompahgre National Forests. (Final report, 28K2-234, on file, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.)*

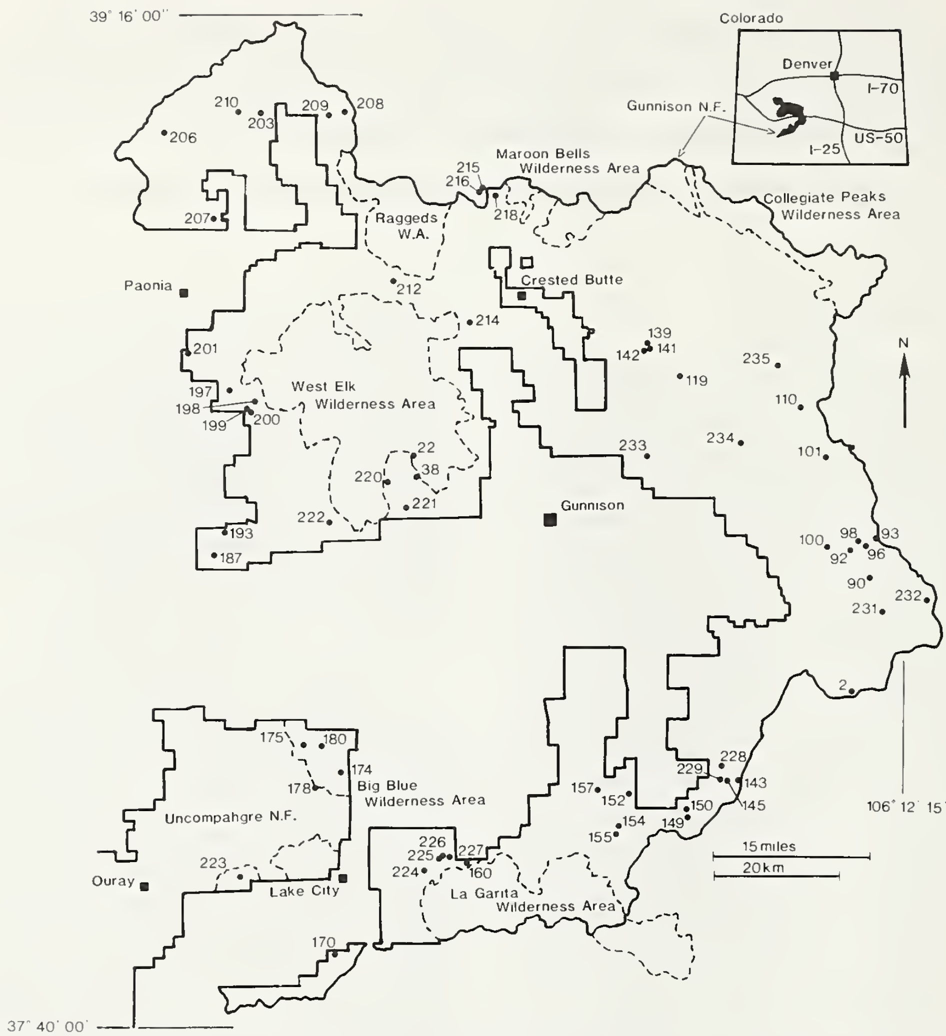

Figure 1.—Gunnison National Forest and selected parts of the Uncompahgre National Forest showing study plots.

possibly active frost features, such as stone polygons, turf-banked terraces, and rock stripes, occur. Most streams originate in cirque ice fields. Although the high erosion potential of the predominately sedimentary formations contributes to steep valley profiles, active mass wasting processes tend to obliterate them over time. Meandering stream patterns occur in thick glacial till underlying the Slate and East River valleys near Crested Butte. Rock outcrops are primarily of sedimentary origin, but igneous and metamorphic rocks also occur as surface outcroppings. The highest elevations of the Elk Mountains in the study area exceed 14,000 feet (4,270 m). These mountains are formed by steeply folded and overturned Paleozoic and Mesozoic sediments intruded by several mid-Cenozoic stocks and overridden by the Elk Range thrust carrying flat-lying Pennsylvanian, Permian Gothic, and Maroon Formations (Goodknight et al. 1981). Coarse clastic rocks occur in about 60% of the area; fine clastic rocks in about 20%; and calcareous rocks cover 6%. Igneous rocks also occur as stocks, dikes, and sills, in addition to a small area of Archean granite, gneiss, and schist. The granodiorite stock forms several rugged peaks (Mutschler et al. 1981).

In the south, the Elk Mountains consist of the Oligocene West Elk Breccia bluffs of the Gunnison River and floodplain alluvium. Some of the lower mountains are capped with Miocene basalt flows with underlying interbedded Miocene volcaniclastics. Most of the slopes are multiple debris flow complexes of coarse angular volcanic rock fragments developed in Mancos Shale. Crested Butte [12,175 feet (3,711 m) elevation] consists of a laccolith fine-grained granodiorite porphyry resting on Mancos Shale (Goodknight et al. 1981). Mount Emmons, in the Crested Butte area, includes the southern flanks of the Elk Mountains and areas of lower topography to the south and southeast. The higher peaks in the Elk Mountains have been glaciated and rise to above 12,000 feet (3,660 m) elevation. Bedrock geology is diverse and includes igneous, sedimentary, and metamorphic rocks. Surface deposits include alluvium, colluvium, talus, rock glaciers, lake deposits, glacial moraines, glacial-fluvial deposits, and slope-failure deposits (landslides, debris flows, mudflows). The latter are extensive and tend to occur in Mancos shale and shaly units of the Mesa Verde Formation, such as in Alkali Basin.

The Ruby Range area lies in the southern Elk Mountains. The immediate surroundings of Robinson Basin (north of Kebler Pass in the Lake Irwin area) rise above 13,000 feet (3,960 m) elevation in Mount Owen. Former alpine glacial episodes have left hanging valleys, U-shaped valleys, glacial striations, and other such features. The Ruby Range is formed by a series of mid-Cenozoic quartz monzonite porphyries intruded into the Mancos, Mesa Verde, Ohio Creek, and Wasatch Formations (Goodknight et al. 1981). Faulting has occurred, and talus slopes are prominent.

The Taylor River area, described by Fox and Cline (1977), is bounded on the north and east by the Sawatch Range and contains two large mountain parks (Taylor and Union). Glacial deposits that occur as moraines and outwash are extensive. North of Pitkin and in the Sawatch and Elk Mountains, alpine features occur on the higher peaks that occasionally exceed 13,000 feet (3,960 m) elevation. Stream profiles are V-shaped in unglaciated parts of the region and U-shaped elsewhere, and have steep flow gradients. There are more than 85 lakes and ponds that have been created mainly through glacial action and by beavers. The walls of Taylor River Canyon are composed of steeply dipping Precambrian metasediments and metabasalts cut by Precambrian granites, a thick sequence of metamorphics, and a series of gabbro to granite intrusions. The Mesozoic sections in the upper part are capped by Dakota sandstone. The canyon was caused by more easily eroded late Paleozoic and Mesozoic sedimentary rocks being juxtaposed against the more resistant Precambrian complex (Goodnight et al. 1981). Granite is the most extensive surface rock type in the area. It occurs as Precambrian intrusives. Other intrusive rocks are of early Tertiary age and include stocks, sills and dikes of rhyolite, quartz diorite, andesite, quartz diorite porphyry, and quartz monzonite porphyry. Metamorphic rocks are moderately extensive; they include Precambrian schist, gneiss, and granitic gneiss. The latter forms resistant outcrops and escarpments. Sedimentary rocks also occur over much of the area.

The main San Juan Mountain mass, with the exception of Mesa Seco in the northeast, was glaciated during the Pleistocene. A small glacier developed in the Powderhorn Wilderness area to the north. Fossil-patterned ground features (e.g., solifluction terraces, sorted polygons, and nets) occur. The most extensive landslide in the Basin occurred west of Slumgullion Pass. Saturated surface bedrocks moved towards the west, possibly during late glacial or neoglacial time to create a large earthflow complex in the vicinity of Lake City (Trench 1978). A collapsed caldera also occurs near Lake City. At Cochetopa Creek, there are outcrops of Precambrian, weakly metamorphosed, pyroclastic felsic volcanic rocks. The central part of the Cochetopa Park caldera is dominated by Cochetopa Dome, which is a complex of quartz latitic lava (Goodknight et al. 1981). Volcanism persisted in the San Juan Mountains long after it had ended in the West Elk Mountains (Hansen 1981). The Mesa Seco Plateau is situated in an area subject to repeated volcanism, erosion, and uplift. Surface rocks are mainly Tertiary volcanics, but older Precambrian metamorphosed schists and gneisses occasionally outcrop, as well as sedimentary rocks of Paleozoic, Mesozoic, and Tertiary ages. Volcanic eruptions and flows in these mountains commenced in the Miocene and ended in the Pliocene, or even early Pleistocene, with the cessation of the Hinsdale Formation episode. Mesa Seco is capped by Hinsdale latite-basalt and underlain by Hinsdale rhyolite and an older rhyolite (Johnson 1970).

The higher West Elk Mountain Peaks in the south represent a center of volcanic activity, somewhat comparable in time to activity in the San Juan Mountains (Gaskill et al. 1981). Intrusive rocks (grandiorite plutons) penetrated sedimentary and other bedrock in parts of the Elk, Ruby, and West Elk Ranges in early-Middle Oligocene time, forming laccoliths, such as Tater Heap and Mount Gunnison [12,719 feet (3,876 m) elevation]. The Castles on West Elk Peak [13,035 feet (3,973 m) elevation] are composed of stratified West Elk breccia, a series of andesitic volcanoclastic rocks (Goodknight et al. 1981). One of the more unusual features of the region is the volcanic dome and swarms of radial dikes near the center of volcanic activity in the West Elk Wilderness. In addition to formations mentioned above (Dakota, Morrison, Mesa Verde, and Mancos shale), several others predate the volcanism of mid- to late-Tertiary periods. The oldest of these is the Entrada Sandstone (Jurassic) and the youngest sedimentary formation in the area is the Wasatch (Eocene and Paleocene). Widespread landslides and earthflows occur extensively in western and northeastern boundaries of the West Elk volcanic field (Soap and West Elk Creeks, and the Black Canyon of the Gunnison River). The mesas north of the Black Canyon of the Gunnison are part of the Gunnison uplift still capped by the Dakota sandstone (Hansen 1981). Black Mesa, the western extremity of the Elk Mountains, is capped by a layer of volcanic material, principally Piedra rhyolite and Huerta andesite (Paulsen 1969). A cycle comparable to the Miocene Hinsdale (described above) occurred in the area. Prior to that, an extensive outflow of welded and nonwelded ashflow tuffs were ejected to form various units of the West Elk breccia.

CLIMATE

Temperature and precipitation data are available from numerous climatic stations in or near the study area (U.S. Department of Agriculture, Weather Bureau 1930; U.S. Department of Commerce, Weather Bureau 1952, 1964). Additional climatic data also are available from the literature; for example, snow depth measurements in the East River Valley (Langenheim 1953), and snow depth and water content measurements for Slumgullion Pass (Johnson 1970). Limited climatic data also have been collected at the Rocky Mountain Biological Laboratory at Gothic and at the Black Mesa Experimental Area near Cimarron.

Climatic records indicate a considerably warmer and drier weather in the center of the Gunnison Basin and in its southern part than in the north and at the perimeter of the Basin. In part this is an effect of higher elevations at the perimeter. For example, a very humid and cold climate occurs at a weather station near Independence Pass at 10,500 feet (3,200 m) elevation, just outside the study area. However, there also is a clear north-south gradient from humid to drier climate at similar elevations (Crested Butte versus Lake City). Precipitation is highest locally at Ruby and Marble (near Gothic). These areas have fairly high precipitation, even when compared to other Colorado mountain stations. The Paonia area, which is outside of the basin and at the lowest elevation included in the study, shows the driest weather because of the influence of the climate in the dry western part of Colorado (U.S. Department of Commerce, Environmental Science Services Administration 1968). Precipitation is higher at comparable elevations in the Gunnison National Forest than on the East Slope of the Rocky Mountains, because it is on the windward side of the moisture-bearing Pacific air masses. Higher elevations in the East River area (near Gothic and Crested Butte) may have an annual mean precipitation as high as 41 inches (104 cm).[4] Low precipitation totals in January and February at Taylor Park may reflect low moisture content of snow in that very cold area. The second lowest temperature [−60°F (−51°C)] recorded in Colorado was measured in Taylor Park in 1951. Average annual snowfall varies from 52 inches (132 cm) at Cochetopa Creek to 211 inches (536 cm) near Sapinero and at Crested Butte. Snowfall probably is higher in the mountains but no records are available. The average growing season in Gunnison County is 49 days. Temperature inversions occur almost daily in the mountain valleys.

The temperature and precipitation data from published records are useful in characterizing the Gunnison National Forest in broad, general terms. However, in regions with massive mountain ranges, deep valleys and canyons, and high plateaus, precipitation and temperatures are so variable that it is difficult to provide any meaningful climatic information for a given locality, without on-site climatic data.

ECOLOGICAL 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).

The fundamental unit of plant community classification is the "plant association," defined as the climax plant community that is "represented by stands occurring in places where environments are so closely similar that there is a high degree of floristic uniformity in all layers" (Daubenmire 1978). Forested plant associations are distinguished from one another primarily on the basis of the tallest tree layers, and secondarily on the basis of undergrowth vegetation. For example, *Populus tremuloides* is widely distributed as a seral and climax tree species in Colorado. Where it is climax, several combinations of undergrowth species occur. The most luxuriant combination is one characterized by *Thalictrum fendleri*, which usually also includes *Carex geyeri*. On some climax sites, however, the more luxuriant forbs are absent and the undergrowth is dominated by *C. geyeri* alone; these stands belong to the *P. tremuloides/C. geyeri* plant association. Thus, *P. tremuloides/T. fendleri* and *P. tremuloides/C. geyeri* are two distinct plant associations, although *C. geyeri* may be present in both.

Plant associations are grouped together into a "plant series" based on the same climax dominant overstory species. For example, all plant associations having *Pinus ponderosa* as a climax dominant are grouped into the *P. ponderosa* series. The series is more than an artificial grouping of habitat types using the potential climax overstory dominant as the convenient thread of continuity. There is an ecological basis for grouping habitat types into series. For example, *Pinus ponderosa* occupies areas warmer and drier than areas where *Pseudotsuga menziesii* is climax. Continuing higher into the mountains, *Populus tremuloides*, *Pinus contorta*, and *Abies lasiocarpa* and *Picea engelmannii* successively become the dominant species.

The "habitat type" is the fundamental unit of classification of land into sites based on their potential (climax) natural vegetation. A habitat type represents all parts of the landscape that support, or have the potential to support, the same climax plant association (Daubenmire 1978, Daubenmire and Daubenmire 1968). Therefore, one habitat type corresponds to only one plant association; each habitat type is named for the plant association which describes its potential.

A climax plant association is that plant community which has attained a steady state with its environment. Without disturbance, plant species of climax vegetation successfully maintain their population sizes or regularly fluctuate around a stable equilibrium (Daubenmire 1978). When different climax plant associations are compared, it can be seen that there are different relationships between vegetation and environment that lead toward and maintain the climax. Tansley (1935) originally proposed distinguishing between different kinds of climax, called "climatic," "edaphic," and "physiographic climaxes;" he also discussed "fire" and "biotic climaxes." Daubenmire (1952) used this approach with minor modifications in his classification of forest vegetation in the northern Rocky Mountains. Daubenmire (1968) and Daubenmire and Daubenmire (1968) further elaborated on the definition, usage, and limitations of this approach, called the "polyclimax concept." A "climatic climax" association develops on normal topography with fairly deep, well-drained, loamy soil. The absence of recurring disturbance is also 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 plant association. Where special topographic con-

[4]*Unpublished data on file, Gunnison National Forest.*

ditions also favor the development of edaphic conditions distinct from the normal, the term "topoedaphic climax" is often used to describe the resulting steady-state plant association.

Where recurring disturbance, such as grazing or fire, has a predominant influence on succession and on the resulting steady state, the term "disclimax" is used. Two common disclimaxes are the "zootic climax" and the "fire climax." If the disturbances responsible for the disclimax are removed, the vegetation may revert to the primary climax.

"Seral" vegetation is that which has not attained a steady state; current populations of some species are being replaced by others. In some instances, trends toward the climax vegetation can be identified; in others, these trends are not evident; and in still others, the vegetation may not attain the climax. The term "community type" has been used to identify vegetation which may be either (1) climax, but about which there is uncertainty, or (2) seral, but the trend toward climax is not evident. Moreover (3), the recognized plant community in place varies at any given time. Community types have one or more overstory dominants and characterisitic undergrowth species. The undergrowth may be climax, but the overstory dominants are often long-lived, seral species that may be self-perpetuating because of repeated disturbance that prevents or slows down the succession to climax vegetation.

In the absence of adequate climatic data for the Gunnison National Forest, it is assumed that the self-perpetuating, climax populations of dominant trees are related to the macroclimate, soils, and past disturbances. Stands within a plant association usually have the same general appearance whether they are on the Gunnison National Forest or in nearby forests of Colorado (DeVelice et al. 1986; Hess and Wasser;[2] Hoffman and Alexander 1980, 1983).

The Gunnison National Forest has been disturbed by fire, logging, diseases, insects, and grazing for many years. Because of these disturbances, most of the forested land area currently does not support climax vegetation. Much of the area occupied by a habitat type may never attain the climax stage. Nevertheless, the land units called habitat types best represent the units that reflect each site's potential. It is important to consider sites in terms of their potential status, because classification by potential vegetation results in the most significant biogeographic classification of the land surface (Daubenmire 1952). The practical value of habitat type classifications is only beginning to be realized in activities such as mapping tree productivity; disease and insect susceptibility; potential for producing forage, browse and cover; soil moisture; and tree regeneration (Arno and Pfister 1977; Daubenmire 1961, 1973; Layser 1974; Monsured 1984; Pfister 1972). The habitat type concept offers a useful approach to classifying and managing forest resources.

METHODS

During 1982 and 1983, a systematic survey was made through all vegetation types to select mature, relatively undisturbed stands across as many environmental gradients as possible. The choice of the stands—partly based on historical records, maps, and aerial photographs, but mainly on on-the-ground investigation—was done subjectively but without preconceived bias—a method recommended by Mueller-Dombois and Ellenberg (1974). At each sampling site, plants present were listed, their cover and abundance were noted, and successional status of the stand and dominant tree species were estimated. For each study site brief descriptions, including physiographic factors and soil features, were noted. In addition, potential sampling sites were marked on topographic maps and photographed. The first approximation of potential habitat types was made by analysis of the first year's data.

During the summers of 1982 and 1983, 65 woodland and forest stands also were sampled somewhat more intensively. The forest stand sample was small because of the time devoted to sampling nonforest vegetation. The primary emphasis in the 65 forest stands was on sampling climax zonal vegetation (consisting of relatively undisturbed stands), with secondary emphasis on azonal vegetation (vegetation sustained by natural or human disturbance, such as grazing). The least emphasis was placed on successional vegetation (vegetation recovering after infrequent disturbance of varying intensity, such as fire or cutting). Stands were representative of forest and woodland communities characterized by the following species: *Juniperus osteosperma*, *Quercus gambelii*, *Pinus ponderosa*, *Pseudotsuga menziesii*, *Picea pungens*, *Pinus flexilis*, *Pinus contorta*, *Populus angustifolia*, *Populus tremuloides*, *Abies lasiocarpa*, *Picea engelmannii*, and *Pinus aristata*.

In stands sampled, plots varying in size from 215 square feet (20 m^2) to 4,036 square feet (375 m^2) were established (actual size for each plot is shown in appendix tables). The diameters of all trees, within selected plots only, beginning with the 2-inch d.b.h. (5 cm) class, were measured at breast height and recorded by 0.328-foot (1-dm) classes. All trees less than the 2-inch d.b.h. (5 cm) class were recorded by three height classes—0 to 24 inches (0 to 60 cm), 24 to 94 inches (61 to 240 cm), and >94 inches (>240 cm).

To determine cover for each undergrowth species, percentage cover was estimated for each species present on the entire plot using the Braun-Blanquet floristic-sociological concept (Westhoff and van der Maarel 1978). This method differs from the standard Daubenmire methodology which divides each plot into three subplots.

At each location, soil profiles, depths, and properties were determined, and a soil sample taken from each horizon. The pH values were determined in saturated paste in the laboratory. Soil profiles were described (Komarkova[3]) according to standard soil taxonomy (U.S. Department of Agriculture, Soil Survey Staff 1975). It is not possible to assign these soils to taxonomic classes because sampling was not deep enough.

Tree size class data, for those plots where the data were collected, were combined according to habitat type, and mean values for each size class within each habitat type were calculated (table A-1).

For each plot examined, the actual percentage of cover estimated for each shrub, graminoid, and forb species is shown in appendix tables A–2 through A–8. Tabulated cover by species and selected site and stand characteristics were arranged and rearranged to group stands with similar floristic composition and climax tree species using the Braun-Blanquet methodology (Westhoff and van der Maarel 1978). Differences between this and Daubenmire's (1952) approach are minor. Tabulation of data and rearrangement of association tables to arrive at habitat types and their indicator species groups are similar, and both approaches utilize numerical methods to analyze vegetation and environmental data (Franklin et al. 1970, Pfister and Arno 1980). Initial habitat type separation was based on consideration of tree overstory and major undergrowth shrubs, graminoids, and forbs (Mueller-Dombois and Ellenberg 1974).

The habitat types initially partitioned by this methodology were quantitatively verified using a combination of numerical methods. Similarity indexes were used to determine whether the initial habitat type delineation was justified on either a floristic or environmental basis (Mueller-Dombois and Ellenberg 1974). DECORANA (a detrended correspondence analysis based on reciprocal averaging) was used to portray the relationship of habitat types to environmental gradients in the ordination space (Hill 1979). Thirty-seven habitat types in 11 series were delineated by this multitiered analysis. Because many habitat types are represented by only one or two stands, the habitat types are recognized as tentative until confirmed by more intensive sampling. However, many of the habitat types identified here have been described on the surrounding National Forests (Hess and Wasser;[2] Hoffman;[5] Hoffman and Alexander 1980, 1983). Johnston (1987) also recognized many of these habitat types in his Plant Associations of the Rocky Mountain Region.

Nomenclature for plants collected in this study follows Weber (1987). Although plants were collected at various times during the growing season, some taxonomic difficulties persisted. Most of these resulted from hybridization among two or more species that have not been studied systematically to clarify the taxonomy. Other taxonomic difficulties related to lack of flowering specimens. Where considerable variation made it impossible to determine species, only genera were used.

WOODLAND HABITAT TYPES

Woodland vegetation in the Gunnison National Forest consists of the *Juniperus osteosperma*- and *Quercus gambelii*-dominated vegetation at the warmer, drier low elevations.

JUNIPERUS OSTEOSPERMA SERIES

The *Juniperus osteosperma* series does not occur in the Gunnison Basin and is rare on the Paonia District. Most stands in this series are located at low elevations outside the Gunnison National Forest boundary, except for the lower west-facing slopes of Landsend Peak. These are some of the warmest and driest sites in the foothill and lower montane zones of the study area (table 1). The *Juniperus osteosperma* series is closely related to the *Pinus edulis* series described by DeVelice et al. (1986), Francis (1986), and Moir and Carlton (1987).

The *J. osteosperma* series is represented by only one plot in a stand around Todd Reservoir at an elevation of 7,162 feet (2,183 m). Tree size data are not available for this series. Plant species data for *J. osteosperma* stands are shown in table A–2. Distribution of habitat types within this series in the western United States is poorly known, because *Juniperus*-dominated stands are not included in many forest habitat type studies.

Juniperus osteosperma/Symphoricarpos oreophilus

Description.—The *Juniperus osteosperma/Symphoricarpos oreophilus* habitat type, originally described by Komarkova[3] as a *J. osteosperma/Mahonia fremontii* habitat type, was sampled in only one small stand on the Paonia District on a gentle (5%), exposed, rocky, southeast-facing slope. Soils in this stand, derived from limestone, vary from a loamy sand to a sandy loam (table 1). Other stands in this habitat type occur below the Gunnison National Forest boundary.

Open-grown *Juniperus osteosperma* dominates the overstory. *Pinus edulis* was absent in the stand sampled. Undergrowth is dominated by *Symphoricarpos oreophilus* (65% cover) (fig. 2). There is some evidence that the prevalence of *S. oreophilus* may be the consequence of repeated fires, but there is no evidence that it is being replaced in the stand sampled. Other important shrubs are *Mahonia fremontii* and *Rosa woodsii*. However, *M. fremontii* is a rare species in Colorado, being more common in the Southwest; consequently it is not a good indicator species in Colorado. Grazing also probably significantly affected the herbaceous layer, which is dominated by *Carex geyeri* and *Bromus tectorum*. Other important graminoids are *Poa nemoralis* ssp. *interior* and *Stipa pinetorum*. The forb layer contains a number of species, but cover of individual species is low. Major forbs include *Achillea lanulosa*, *Galium septentrionale*, *Senecio serra*, *Thalictrum fendleri*, and *Viola canadensis*.

Although *J. osteosperma* is widespread throughout the southern Rocky Mountains, the *J. osteosperma/S. oreophilus* habitat type has not been previously reported in Colorado (Alexander 1987) or elsewhere. Hess and Wasser[2] reported a very different *J. osteosperma/Cercocarpus montanus* habitat type on the White River National Forest. The *J. osteosperma/S. oreophilus* habitat type also seems to be related to the *Pinus edulis/Quercus gambelii-Carex geyeri* habitat type described by Hess and Wasser[2] on the White River National Forest.

Management implications.—This very dry habitat has low potential for fuelwood production because growth is very slow and trees are widely spaced. Livestock

[5]*Personal correspondence with Dr. George R. Hoffman, University of South Dakota, Vermillion, S. Dak.*

Table 1.—Selected topographic and edaphic characteristics in the Gunnison National Forest.

Habitat type	Number of stands sampled	Elevation (m)	Soil texture	Depth sampled (cm)	pH
Juniperus osteosperma/Symphoricarpos oreophilus	1	2183	Sandy loam-loamy sand	7–17	7.9
Quercus gambelii/Amelanchier alnifolia	2	1963–2929	Sandy loam-clay	17–60	6.1–7.1
Quercus gambelii/Prunus virginiana	1	2793	Sandy loam	8–15	6.5
Pinus ponderosa/Festuca arizonica	2	3012–3030	Sandy loam	28–50	7.1
Pinus ponderosa/Festuca idahoensis	1	2670	Sandy loam-loam	10–20	7.1
Picea pungens/Festuca arizonica	2	2973–3014	Sandy loam-sandy loam	--	--
Picea pungens/Amelanchier alnifolia	2	2039–2407	Sandy loam-loam	12–60	6.2–6.5
Pseudotsuga menziesii/Purshia tridentata	2	2829–2988	Sandy loam-loam	16–60	6.3–7.2
Pseudotsuga menziesii/Jamesia americana	1	2988	Loam	6–15	7.4
Pseudotsuga menziesii/Paxistima myrsinites	1	3024	Sandy loam	--	--
Pseudotsuga menziesii/Symphoricarpos oreophilus	2	2720–2836	Sandy loam-loam	31–82	6.2–7.5
Pseudotsuga menziesii/Carex geyeri	2	2426–2975	Sandy loam	--	--
Pseudotsuga menziesii/Festuca idahoensis	1	3024	Sandy loam	13–15	7.4
Populus tremuloides/Amelanchier alnifolia-Prunus virginiana	2	2450–2456	Loamy sand-sandy loam	11–30	6.2
Populus tremuloides/Symphoricarpos oreophilus	3	2554–2842	Sandy loam	17–52	6.1–7.3
Populus tremuloides/Festuca arizonica	1	2973	Sandy loam	12–31	6.3
Populus tremuloides/Pteridium aquilinum	2	2573–2682	Sandy loam-loam	10–18	7.3
Populus tremuloides/Thalictrum fendleri	1	3049	Loam	8–10	7.2
Populus tremuloides/Arctostaphylos adenotricha	1	3186	Loam	44–60	6.5
Populus tremuloides/Festuca thurberi	3	3164–3170	Sandy loam	27–30	6.7–6.9
Populus angustifolia/Alnus incana-Swida sericea	1	2186	Sandy loam	0–10	6.6
Pinus contorta/Juniperus communis	2	2636–3243	Sandy loam	25–30	6.0
Pinus contorta/Vaccinium scoparium	1	3250	Sandy loam	50–80	5.8
Pinus contorta/Carex geyeri	1	2361	Sandy loam	--	--
Pinus flexilis/Ciliaria austromontana	1	2744	Sandy loam	7–23	6.9
Pinus aristata/Festuca thurberi	1	3616	Loam	30–62	7.7
Pinus aristata/Festuca arizonica	5	2878–3042	Sandy loam-loam	6–38	6.0
Pinus aristata/Juniperus communis	1	3060	Sandy loam	15–30	6.4
Abies lasiocarpa/Juniperus communis	2	3152–3195	Sandy loam	7–30	6.4–6.7
Abies lasiocarpa/Vaccinium myrtillus	3	2850–3517	Sandy loam-loam	3–60	5.9–6.4
Abies lasiocarpa/Vaccinium scoparium	1	3231	Sandy loam	--	--
Abies lasiocarpa/Carex geyeri	4	2693–3282	Sandy loam-loam	7–25	6.0–7.0
Abies lasiocarpa/Calamagrostis canadensis	1	2720	Loam	38–50	6.6
Abies lasiocarpa/Polemonium pulcherrimum	2	3228–3369	Sandy loam	4–12	6.0
Abies lasiocarpa/Arnica cordifolia	2	2845–3314	Loam	15–20	6.3
Abies lasiocarpa/Senecio triangularis	1	3075	Sandy loam-loam	--	--
Abies lasiocarpa/Moss spp.	3	2970–3219	Sandy loam	11–29	5.3–6.5

Figure 2.—*Juniperus osteosperma/Symphoricarpos oreophilus* habitat type at Todd Reservoir, Paonia District. *S. oreophilus*, *Mahonia fremontii*, *Bromus tectorum*, and *Carex geyeri* dominate the undergrowth in this stand.

forage production is low. The *J. osteosperma/S. oreophilus* habitat type is moderately important as mule deer winter range because *S. oreophilus* can be a significant food source. Overstory trees adjacent to grasslands may provide cover for a variety of wildlife. This habitat type has no potential for increasing water production but it provides watershed protection. Its potential for developed and dispersed recreation is low.

Fire, which can be an effective tool for regenerating *Juniperus*-dominated stands, plays an important role in maintaining them. *Juniperus* taller than 4 feet (1.2 m) are moderately resistant to fire. *Symphoricarpos oreophilus* sprouts prolifically after fire, especially a "cool" surface fire. These shrubs probably would assist in carrying a fire in this habitat type because they are less resistant to fire than *Juniperus* (Wright et al. 1979).

QUERCUS GAMBELII SERIES

Quercus gambelii occupies a zone between the *Artemisia tridentata*-dominated shrub-steppe and the wetter forest habitat types at higher elevations usually dominated by *Populus tremuloides*. In the Gunnison Basin, *Q. gambelii*-dominated vegetation usually occurs at elevations that are below the Gunnison National Forest boundary, but in the Paonia District, it forms a fairly wide belt at elevations just above the forest boundary. *Q. gambelii* may occur as a small tree and a shrub. For example, shrub *Q. gambelii* frequently dominates shrublands with several associated shrubs. In other locations, small-statured *Q. gambelii* forests with a recognizable undergrowth develop. Most of the *Quercus*-dominated stands have been grazed to varying degrees. In this series, descriptions of vegetation and management implications provided by Steinhoff[6] and Kufeld (1983) apply to the western part of the Gunnison National Forest.

The *Q. gambelii* series is represented by three plots and two habitat types located at elevations ranging from 6,440 to 9,610 feet (1,963 to 2,929 m) (table 1). Plant species data for *Q. gambelii*-dominated stands are shown in table A–2. Distribution of habitat types in this series in the western United States is poorly known, because *Q. gambelii*-dominated stands are excluded from many forest habitat type studies.

Quercus gambelii/Amelanchier alnifolia

Description.—The *Quercus gambelii/Amelanchier alnifolia* habitat type was sampled in two stands; one stand is in the vicinity of Long Gulch, near Black Mesa on the Paonia District, on a moderate (27%) southeast-facing slope. The second stand is in Hubbard Creek Canyon, Paonia District, on a moderate (27%) east-facing slope. Stand 207 was originally classified by Komarkova[3] as a *Q. gambelii/Prunis virginiana-Paxistima myrsinites* habitat type. The soils in the two stands range from a sandy loam to a loamy sand (table 1). Within the habitat type, slopes are steep; soils are coarse, deep, and not drained well enough to support trees.

The overstory is dominated by *Quercus gambelii*, which also may occur in the undergrowth. This habitat type characteristically appears as a mixture of tall- and medium-height shrubs, but the undergrowth is dominated by *Amelanchier alnifolia* (6–15% cover) (fig. 3). *Acer glabrum* (stand 207), *Mahonia repens*, *Paxistima myrsinites* (stand 207), *Prunus virginiana*, *Rosa woodsii*, *Swida sericea* (stand 207), and *Symphoricarpos oreophilus* are important shrub associates. The most important herbaceous species present are *Bromis pumpellianus*, *Carex geyeri*, *Elymus trachycaulus*, *Achillea lanulosa*, *Galium septentrionale*, *Heliomeris multiflora*, *Lathyrus leucanthus*, *Linum lewisii*, *Lomatium dissectum*, *Osmorhiza depauperata*, and *Smilacina stellata*.

The *Q. gambelii/A. alnifolia* habitat type has not been identified previously in the Rocky Mountains by investigators using standard habitat type methodology, but a *Q. gambelii/A. alnifolia* plant community with similar characteristics has been identified in western Colorado (Bunin 1975, Steinhoff[6]). A number of the undergrowth species in the *Q. gambelii/A. alnifolia* habitat type are also present in the *Q. gambelii/S. oreophilus* habitat type, where *A. alnifolia* is a codominant, identified on the Grand Mesa, Routt, White River and Uncompahgre National Forests to the north and west of the Gunnison National Forest (Hess and Wasser;[2] Hoffman;[5] Hoffman and Alexander 1980, 1983). A *Q. gambelii/S. oreophilus* plant community is also widespread through the northern Great Basin. The close relationship between the *Q. gambelii/A. alnifolia* and *Q. gambelii/S. oreophilus* habitat types suggests that additional sampling will be required to determine whether separation into two habitat types is justified.

Figure 3.—*Quercus gambelii/Amelanchier alnifolia* habitat type near Long Gulch, Black Mesa. *A. alnifolia, Prunus virginiana, Symphoricarpos oreophilus, Carex geyeri*, and *Lathyrus leucanthus* have high coverage in this stand.

Management implications.—*Quercus gambelii* is a clonal species that sprouts vigorously following clearcutting, spraying, burning, etc. Consequently, most attempts to control *Q. gambelii* have failed. Thinning individual clumps to increase acorn production, however, usually releases the residual stems so they can grow to larger sizes. Moreover, since sprouting is not much stimulated by thinning, it usually creates a *Quercus* "savanna," with improved livestock and wildlife forage and cover. Visual values are also maintained and/or improved.

Q. gambelii has high value as fuelwood in some localities (Wagstaff 1984). Cutting usually is a small-scale operation with light equipment. Burning increases *Q. gambelii* and decreases other shrubs in the first 10 years after treatment. Total forb, graminoid, and other shrub production initially increases, then decreases between 2 and 5 years after burning, followed by another increase 10 years after treatment (Kufeld 1983). Most birds and mammals are tolerant of or indifferent to burning, but *Accipiters* and shrub-nesting birds are intolerant of hot burns (Steinhoff[6]).

Grazing decreases graminoid and forb cover and has the effect of increasing *Q. gambelii* at the expense of *A. alnifolia*. *Q. gambelii* stands that have aggressively

[6]*Steinhoff, Harold W. 1978. Management of Gambel oak associations for wildlife and livestock. (Report.) Rocky Mountain Region, Denver, Colo.*

sprouted create difficult access for grazing animals. The Q. gambelii/A. alnifolia habitat type has high potential for deer and elk spring-fall range and may be an important component of winter range. Hiding cover can be variable, and there is often a large quantity of palatable shrubs for big game (Kufeld 1983, Steinhoff[6]). High priority should be placed on protecting and/or improving this habitat type where stands are in or near big game winter range.

Quercus gambelii/Prunus virginiana

Description.—The *Quercus gambelii/Prunus virginiana* habitat type, originally classified as a *Q. gambelii/Symphoricarpos oreophilus* habitat type by Komarkova,[3] was sampled in one small stand in Buckhorn Gulch, near Black Mesa on the Paonia District. The sampled stand is on a gentle to moderate (11%) slope, with a southeast-facing aspect. Soils are fairly deep, well-drained sandy loams (table 1). This habitat type normally occurs on lower to middle slopes with coarse, well-drained soils where moisture availability limits stand extent. *Populus tremuloides* occurs occasionally with *Quercus gambelii* in the overstory. The undergrowth is dominated by the tall shrub *Prunus virginiana* (15% cover) (fig. 4). Other important shrubs include *Mahonia repens* and *Symphoricarpos oreophilus*. Important graminoids are *Carex geyeri*, *Festuca thurberi*, and *Stipa nelsonii*. The forb layer is dominated by *Conioselinum scopulorum*, with *Lathyrus leucanthus* present in significant amounts.

The *Q. gambelii/P. virginiana* habitat type was identified previously on the White River National Forest by Hess and Wasser.[2] This habitat type is related to the *Q. gambelii/A. alnifolia* habitat type, but differs in the absence of *A. alnifolia*, *Elymus trachycaulus*, and *Smilacina stellata* and the high coverage of *Festuca thurberi* and *Conioselinum scopulorum* in the stand sampled. The *Q. gambelii/P. virginiana* habitat type also appears to be related to the *Q. gambelii/Symphoricarpos oreophilus* habitat type identified on the Grand Mesa,

Figure 4.—*Quercus gambelii/Prunus virginiana* habitat type near Buckhorn Gulch, Black Mesa. *P. virginiana, Carex geyeri, Festuca thurberi*, and *Conioselinum scopulorum* have high coverage.

Routt, White River and Uncompahgre National Forests (Hess and Wasser;[2] Hoffman;[5] Hoffman and Alexander 1980, 1983). Considerably more sampling will be required to identify and describe the *Q. gambelii*-dominated habitat types on the Gunnison National Forest.

Management implications.—The management implications of the *Q. gambelii/P. virginiana* habitat type are similar to those of the *Q. gambelii/A. alnifolia* habitat type, except that this habitat type has higher value for early season livestock grazing where there is significant cover of *Festuca thurberi*.

FOREST HABITAT TYPES

Forest vegetation on the Gunnison National Forest ranges from the *Pinus ponderosa*-dominated vegetation at the lower, drier elevations to the *Abies lasiocarpa-Picea engelmannii*-dominated vegetation at the cooler, moister high elevations.

PINUS PONDEROSA SERIES

The *Pinus ponderosa* series occurs infrequently at the lower elevations between forest and nonforest vegetation on the Gunnison National Forest. Some investigators have concluded that *P. ponderosa* is being eliminated from the Gunnison Basin, because there was no recruitment in the reproduction classes (Barrell 1969). However, the current study indicated that some *P. ponderosa* reproduction is occurring. In any case, *P. ponderosa* has always been a minor component of the coniferous forest zone in the Gunnison Basin. The series occurs on southeast to easterly aspects at elevations ranging from 8,760 to 9,880 feet (2,670 to 3,012 m), within environments that, while dry, are moister than in the *Juniperus*- and *Quercus*-dominated vegetation (table 1).

The *P. ponderosa* series was sampled on three plots, representing two habitat types. Tree sizes on the one plot where they were measured ranged from the 2- to 4-inch (0.5- to 1-dm) to the 24- to 28-inch (6- to 7-dm) d.b.h. classes. Tree size classes and plant species data for *P. ponderosa* stands are shown in tables A–1 and A–3.

Pinus ponderosa/Festuca arizonica

Description.—The *Pinus ponderosa/Festuca arizonica* habitat type is represented by two stands. One is located on Blue Creek near McDonough Reservoir, and the other on Cochetopa Pass. The *P. ponderosa/F. arizonica* habitat type occurs on moderate to steep (12–31%) southeast- to east-facing slopes. Within the habitat type soils are deep, well-drained sandy loam (table 1).

This habitat type is recognized by the constant presence and limited reproductive success of open-grown *Pinus ponderosa*, and the abundance and dominance of *Festuca arizonica* (18–30% cover) in the undergrowth (fig. 5). *Pseudotsuga menziesii* and *Pinus aristata* are occasional associates in the overstory. Shrubs are sparse; the most important are *Juniperus communis, Ribes cereum,* and *Ribes inerme.* In addition to *F. arizonica,* other important graminoids are *Carex geophila, Elymus elymoides, Koeleria macrantha, Muhlenbergia montana,* and *Oryzopsis hymenoides.* Forbs with highest cover include *Antennaria rosea, Artemisia frigida, Chaenactis douglasii, Erigeron glabellus, Geranium caespitosum, Hymenoxys richardsonii,* and *Potentilla hippiana.*

The *P. ponderosa/F. arizonica* habitat type has been reported throughout southern Colorado, on the Pike, Rio Grande, and San Juan National Forests (DeVelice et al. 1986, Radloff 1983). It also occurs in New Mexico and Arizona (Alexander et al. 1987, DeVelice et al. 1986, Fitzhugh et al. 1987, Hanks et al. 1983).

Management implications.—The potential for timber production in the *P. ponderosa/F. arizonica* habitat type is low to very low because of low stand density and poor site quality. *P. ponderosa* regeneration is patchy and irregular, occurring only in rare instances when favorable seed and climatic years coincide. Moreover, regeneration is not likely to be improved by seedbed preparation unless it is keyed to favorable environmental conditions and seed supply. Standard shelterwood and seed-tree even-aged cutting methods are appropriate for this habitat type. Group selection and group shelterwood mimic natural stand configurations. Individual tree selection is usually not appropriate because of the likelihood of sporadic reproduction which results in incomplete representation of age or size classes (Alexander 1986c).

Forage production for livestock is moderate to high, depending on range condition and grazing management. *F. arizonica* and *M. montana* are palatable to cattle, especially early in the season, but overgrazing may result in site degradation and reduced forage production. The grazing system should program rest every few years where establishment of *P. ponderosa* regeneration is critical. The habitat type has moderate potential for early winter or transitional range for big game. The *P. ponderosa/F. arizonica* habitat type has limited potential

Figure 5.—*Pinus ponderosa/Festuca arizonica* habitat type west of Cochetopa Pass. *F. arizonica, Muhlenbergia montana,* and *Hymenoxys richardsonii* are the principal undergrowth species.

Figure 6.—*Pinus ponderosa/Festuca idahoensis* habitat type along Alpine Road in Narrow Grade Creek. *Artemisia tridentata, Carex geophila, F. idahoensis,* and *Lupinus argenteus* are important undergrowth species.

for increasing water yield but does provide watershed protection. The potential for developed and dispersed recreation is limited by the fragmented occurrence of *P. ponderosa*-dominated vegetation on the Gunnison National Forest.

Pinus ponderosa/Festuca idahoensis

Description.—The *Pinus ponderosa/Festuca idahoensis* habitat type occurs throughout the Gunnison Basin, but usually below the study area. This habitat type, originally classified as a *P. ponderosa/Artemisia tridentata* plant association by Komarkova,[3] was sampled on one plot on a gentle to moderate (11%) southerly slope, located along the Alpine Road in Narrow Grade Creek on that part of the Uncompahgre National Forest included in the study area. Within the habitat type, slopes usually are gentle and sites cool and dry. Soils are well drained and moderately deep loams (table 1).

This habitat type is recognized by the constant presence and limited reproductive success of *Pinus ponderosa,* with no other tree species present. The undergrowth in the stand sampled is dominated by *Artemisia tridentata* (65% cover) that increased because of past grazing use that also reduced the *Festuca idahoensis* cover (fig. 6). *Mahonia repens* is the only other important shrub. Major graminoids include *Carex geophila, F. idahoensis* (6% cover), and *Koeleria macrantha.* The forb layer contains a number of species, but only *Lupinus argenteus* has more than 1% cover.

The *P. ponderosa/F. idahoensis* habitat type has been described throughout the northern Great Basin, but the stand on the Gunnison National Forest is the southernmost known occurrence. This habitat type has been reported in eastern Washington (Daubenmire and Daubenmire 1968), Idaho (Cooper et al. 1987, Steele et al. 1981), central and southeastern Montana (Hansen and Hoffman 1987, Pfister et al. 1977), northern Utah (Mauk and Henderson 1984), and in the Bighorn Mountains of north-central Wyoming (Hoffman and Alexander 1976).

Management implications.—Timber productivity in the *P. ponderosa/F. idahoensis* habitat type is low and tree reproduction difficult to obtain after any kind of cutting (Alexander 1986c). Cutting should be directed toward improving visual appearance, recreation, or forage production. Stands can be harvested by removing the older, less vigorous, and diseased trees individually or in groups or patches. Forage production potential for livestock depends upon the amount of palatable graminoids in the undergrowth. This habitat type is considered poor range for deer (Dealy 1971); but this stand, with good representation of *Artemisia tridentata* in the undergrowth, has somewhat greater potential.

Partial cutting has the potential for increasing the shrub and herbaceous layers, thereby improving both forage production and diversity. However, this often is at the expense of the tree population. Burning tends to reduce *A. tridentata* and increase graminoids and forbs, thereby improving the forage value for cattle and elk at the expense of deer. This habitat type has no real potential for increasing water yields but does provide watershed protection. Potential sediment production can be relatively high.

PICEA PUNGENS SERIES

Picea pungens occurs throughout the Gunnison National Forest, but *P. pungens*-dominated stands are small and occur mainly in the southern part of the study area, either on rocky slopes in canyons at elevations ranging from 9,800 to 9,900 feet (2,987 to 3,017 m) or on riparian sites in valley bottoms at elevations of 6,700 to 7,900 feet (2,042 to 2,407 m) (table 1).

The *Picea pungens* series occurs as upland stands in the southwestern United States, where it is part of the "mixed conifers" (DeVelice et al. 1986, Moir and Ludwig 1979). The *P. pungens* series also occurs as riparian habitat types throughout the Rocky Mountains, usually in the montane zone (Johnston 1987).

The *P. pungens* series was sampled in four stands on the Gunnison National Forest representing two habitat types, one on dry, rocky upland slopes and one in riparian situations. Tree sizes on those plots where measurements were made ranged from seedlings to the ≥28-inch (≥7-dm) d.b.h. class. Tree size classes and plant species data for *P. pungens* stands are shown in tables A–1 and A–3.

Picea pungens/Festuca arizonica

Description.—The *Picea pungens/Festuca arizonica* habitat type is represented by two stands located in Cebolla Creek Canyon. This rocky habitat type was sampled on moderate (12–20%), warm, dry, south- to southeast-facing slopes. The rocks are of moderate size on slopes that are unstable. Soils are sandy loams (table 1).

The *P. pungens/F. arizonica* habitat type is recognized by very open, low-density stands of *Picea pungens* that contain seedlings, poles, and mature trees, indicating that *P. pungens* is perpetuating itself. Other tree species are absent or occasional. *Pinus ponderosa* may be seral on gentle, more stable, lower slopes, and *Pinus aristata* on steeper, less stable, upper slopes. The undergrowth is dominated by *Festuca arizonica* (18% cover) (fig. 7). The shrub layer is sparse, with *Ribes cereum* and *Rosa woodsii* having the highest cover. In addition to *F. arizonica*, important graminoids are *Carex geophila*, *Danthonia parryi*, *Elymus longifolius*, *Koeleria macrantha*, and *Muhlenbergia montana*. *D. parryi* is more conspicuous on gentle slopes where *P. ponderosa* reproduction is more evident. Forbs with the highest coverage are *Artemisia frigida*, *Geranium cespitosum*, *Heterotheca villosa*, *Mertensia lanceolata*, and *Selaginella densa*.

Figure 7.—*Picea pungens/Festuca arizonica* habitat type in Cebolla Creek Canyon. *Ribes cereum*, *Rosa woodsii*, *Danthonia parryi*, *Muhlenbergia montana*, and *Artemisia frigida* are important undergrowth associates.

The *P. pungens/F. arizonica* habitat type has been identified on the San Juan National Forest by DeVelice et al. (1986), but it has not been reported elsewhere in Colorado (Alexander 1987). This habitat type also occurs in northern New Mexico (DeVelice et al. 1986, Fitzhugh et al. 1987).

Management implications.—The potential for timber production in the *P. pungens/F. arizonica* habitat type is very low because of poor site quality and low tree density. Moreover, timber harvesting would risk initiating mass soil movement. *F. arizonica*, *M. montana*, and especially *D. parryi* are highly palatable to cattle early in the grazing season. The relatively stable, gentle lower slopes with good representation of *D. parryi* have the highest forage potential in the habitat type. Care must be used in grazing this habitat type; overuse by livestock may also initiate erosion and subsequent mass soil movement. Big game may use this habitat type as transitory range. The *P. pungens/F. arizonica* habitat type has little value for increased water yields but does provide watershed protection if left undisturbed.

Picea pungens/Amelanchier alnifolia

Description.—The *Picea pungens/Amelanchier alnifolia* habitat type, represented by two plots, occupies a small acreage throughout the Rocky Mountains, but it is a highly conspicuous and important habitat type. It is common along stream channels classified as A or B in the montane zone throughout Colorado and Wyoming (Rosgen 1985). On the Gunnison National Forest, it occurs on steep (36–70%) northwest- to east-facing benches adjacent to streams, which occupy well-drained bottomlands, and on well-drained north-facing escarpments, especially around Cathedral. The stands sampled, located on Muddy Creek, Paonia District, and in Coal Creek Valley near the Paonia Reservoir, are typically small *P. pungens*-dominated vegetation growing on well-defined, relatively well-drained, and high gradient streamside benches, adjacent to less well-drained, lower gradient channels dominated by *Salix* spp. (Rosgen 1985). Soils are well-developed loams derived from fluvium and alluvium deposits (table 1).

The *P. pungens/A. alnifolia* habitat type is recognized by the dominance and reproductive success of *Picea pungens* in the overstory and the presence of *Amelanchier alnifolia* (6–8% cover) in the undergrowth (fig. 8). *Pseudotsuga menziesii*, *Pinus ponderosa*, and *Populus angustifolia* are the most common associates, although they are not well represented in the stands sampled. The shrub layer is well represented. Included are *A. alnifolia*, *Lonicera involucrata*, *Paxistima myrsinites*, *Prunus virginiana*, *Ribes inerme*, *Rosa woodsii*, *Salix* spp., *Swida sericea*, and *Symphoricarpos oreophilus*. Important graminoids include *Agrostis hyemalis*, *Bromus porteri*, *Calamagrostis canadensis*, *Carex* spp., *Elymus trachycaulus*, and *Festuca thurberi*. Forbs with the highest cover are *Achillea lanulosa*, *Antennaria rosea*, *Cirsium* spp., *Equisetum arvense*, *Fragaria virginiana*, *Geranium richardsonii*, *Geum rivale*, *Heracleum sphondylium*, *Osmorhiza depauperata*, *Rubeckia ampla*, *Senecio serra*, *Smilacina amplexicaulis*, *Smilacina stellata*, *Solidago multiradiata*, and *Viola vallicola*.

The *P. pungens/A. alnifolia* habitat type has been reported on the White River National Forest to the north of the Gunnison National Forest (Hess and Wasser[2]). Hoffman[5] identified a *P. pungens/Alnus incana* habitat type on the Grand Mesa and Uncompahgre National Forests to the west of the Gunnison National Forest that is similar to this habitat type. This habitat type also closely resembles the *P. pungens/Poa pratensis* and *P. pungens/Cornus stolonifera* (*P. pungens/S. sericea*) habitat types identified in northern New Mexico (Alexander et al. 1984, DeVelice et al. 1986, Fitzhugh et al. 1987, Moir and Ludwig 1979) and in western Wyoming (Youngblood et al. 1985). A plant community similar to this habitat type has been observed on the Routt National Forest in Colorado and on the Bighorn National Forest in north-central Wyoming.

Figure 8.—***Picea pungens/Amelanchier alnifolia*** **habitat type in Coal Creek Valley near Paonia Reservoir.** ***A. alnifolia, Ribes inerme, Rosa woodsii, Symphoricarpos oreophilus,*** **and** ***Swida sericea*** **dominate the undergrowth.**

Management implications.—The primary value of this riparian, bottomland habitat type is for recreational use and as food and cover for wildlife. Many stands have roads through them because of their easy accessibility. Management activities, therefore, are highly visible. Timber production potential is relatively high, but the value for timber is low in relation to other resources. The first choice in this habitat type should be non-manipulative management. Any timber harvesting should be light, using either shelterwood or selection cutting to open up the stand just enough to reduce the likelihood of associated species of more tolerant tall shrubs replacing *P. pungens*. The initial entry should remove the smaller trees, because cutting the large trees is likely to result in top breakage to the smaller trees. The potential for increasing forage production is high, especially where past use has decreased the amount of

Carex spp. and increased the more palatable graminoids. However, any timber harvesting or livestock use must be rigidly controlled because of the sensitivity of soils and landforms to disturbance. Because this habitat type naturally provides good all-season cover and palatable forage for elk, any cutting that increases forage production improves elk habitat, as long as adequate hiding cover is retained. The potential for increasing water yield is high, but management directed toward this objective (as well as other manipulative treatments) needs to be weighed against goals of the special prescription applied to riparian sites. Developed recreation must be carefully situated because of the sensitivity of soils to compaction and subsequent site degradation.

PSEUDOTSUGA MENZIESII SERIES

The *Pseudotsuga menziesii* series most often occurs on steep north-facing slopes with shallow soils, but also may be found on gentler east- and west-facing slopes with deep soils. *P. menziesii* grows in the montane zone on the Gunnison National Forest at elevations that range from 7,960 feet (2,426 m) to 9,920 feet (3,024 m). *P. menziesii* generally occupies cooler sites at the same elevations occupied by *Pinus ponderosa* (table 1). *P. menziesii* also commonly occurs as a seral species in stands dominated by other tree species in the montane zone.

The *P. menziesii* series was sampled in nine stands representing six habitat types. Tree sizes in measured stands range from seedlings to the ≥28-inch (≥7-dm) d.b.h. class. Tree size classes and plant species data for *P. menziesii* stands are given in tables A–1 and A–4.

Pseudotsuga menziesii/Paxistima myrsinites

Description.—The *Pseudotsuga menziesii/Paxistima myrsinites* habitat type is found at upper elevations within the series on the Gunnison National Forest. It was sampled in only one stand on a steep (58%), northwest-facing lower slope, south of Kebler Pass. Soils are a shallow, sandy loam (table 1). Within the habitat type, slopes are steep to very steep and rocky, with soils derived from sedimentary rock. The *P. menziesii/P. myrsinites* habitat type is one of the coolest within the series and often is found adjacent to the subalpine forest zone.

The *P. menziesii/P. myrsinites* habitat type is recognized by the presence and reproductive success of *Pseudotsuga menziesii*, and by the abundance and dominance of the low shrub *Paxistima myrsinites* (12% cover) in the undergrowth (fig. 9). Other important shrub species are *Amelanchier alnifolia*, *Holodiscus dumosus*, *Mahonia repens*, *Ribes inerme*, and *Symphoricarpos oreophilus*. Important graminoids are *Bromus pumpellianus*, *Carex geyeri*, *Festuca thurberi*, and *Poa leptocoma*. The most conspicuous forbs are *Helianthella quinquenervis*, *Heracleum sphondylium*, *Urtica gracilis*, and *Veratrum tenuipetalum*. The high cover of *V. tenuipetalum* in this stand may reflect heavy past grazing use despite the instability of site.

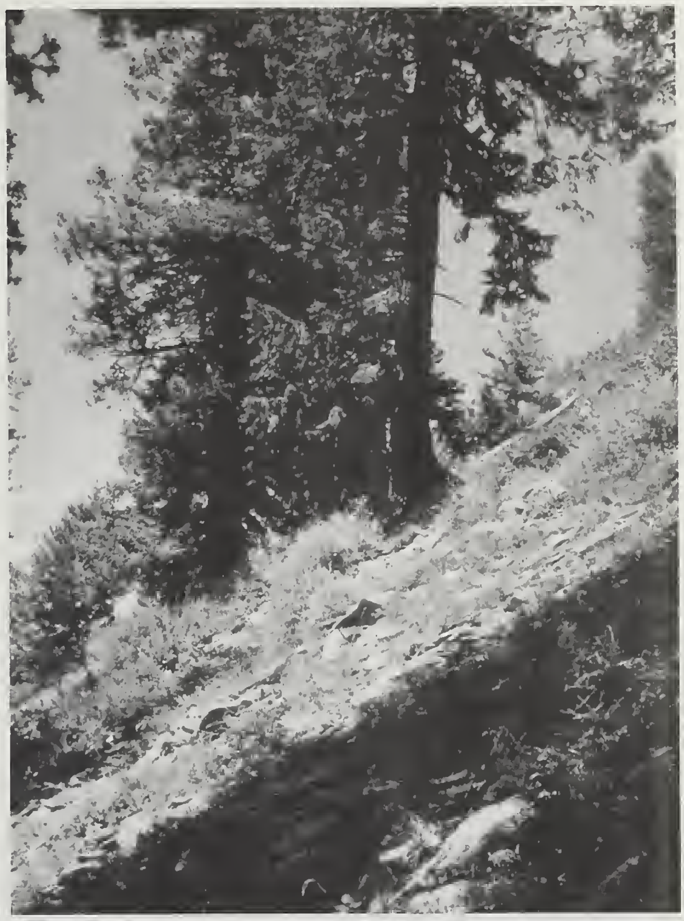

Figure 9.—*Pseudotsuga menziesii/Paxistima myrsinites* habitat type on a scree slope south of Kebler Pass. *P. myrsinites*, *Carex geyeri*, and *Urtica gracilis* dominate the undergrowth.

Hoffman and Alexander (1980, 1983) and Hess and Wasser[2] described this habitat type on the Routt and White River National Forests in Colorado, located north of the Gunnison National Forest. The *P. menziesii/P. myrsinites* habitat type has not been reported elsewhere in the Rocky Mountain or Intermountain regions by investigators using standard habitat type methodology, despite the fact that *Paxistima myrtinites* is well represented throughout these regions (Alexander 1985, 1988). It may be that its widespread distribution has caused many ecologists to reject *P. myrsinites* as an indicator species.

Management implications.—Information available on the management of the *P. menziesii/P. myrsinites* habitat type is limited. Timber productivity and livestock forage production are both low, because the habitat type occurs in dry, rocky situations. Clearcut openings may be especially difficult environments for successful *P. menziesii* regeneration because of limited moisture. Moreover, because of the steep slopes and instability associated with this habitat type, any timber harvesting or livestock grazing increases the risk of mass soil movement. Big game may browse the taller shrub species at times, and hiding cover usually is very good. The potential for increasing water yield is low because of instability, but the habitat type does provide watershed protection if undisturbed.

Pseudotsuga menziesii/Purshia tridentata

Description.—The *Pseudotsuga menziesii/Purshia tridentata* habitat type was sampled in two stands. One stand is on a moderate (21%) south-facing slope on Major Creek near the Old Monarch Pass road in the Sawatch Range, and the other is on a moderate (14%) southwest-facing slope below Black Sage Pass in the Sawatch Range. These stands were originally classified as *Pseudostuga menziesii/Arctostaphylos adenotricha* (stand 92) and *Pinus ponderosa/Artemisia tridentata* (stand 100) habitat types, respectively, by Komarkova.[3] Soils are loams (table 1). The *P. menziesii/P. tridentata* habitat type occurs elsewhere in the study area on gentle to moderate, rocky, dry slopes with relatively deep soils.

This habitat type is recognized by the dominance and reproductive success of *Pseudotsuga menziesii* in the overstory, and the abundance and dominance of the shrub *Purshia tridentata* (15–30% cover) in the undergrowth (fig. 10). *Pinus ponderosa, Pinus contorta,* and/or *Populus tremuloides* may be associated seral tree species, and any one of these may dominate the overstory in late seral stages. *Arctostaphylos adenotricha, Juniperus communis,* and *Mahonia repens* are important associated shrubs. In one stand (100), *Artemisia tridentata* has very high (60%) cover because of past grazing use. In stand 92, *A. adenotricha* has high cover (15%), but is not as good an indicator as *P. tridentata* (30% cover). Important herbaceous species include *Carex foenea, Carex geyeri, Koeleria macrantha, Antennaria rosea, Fragaria virginiana,* Senecio spp., and *Solidago multiradiata.*

Figure 10.—*Pseudotsuga menziesii/Purshia tridentata* habitat type near Old Monarch Pass, Sawatch Range. *Pinus contorta* is a seral species in this stand. *P. tridentata, Arctostaphylos adenotricha,* and *Carex geyeri* dominate the undergrowth.

The *P. menziesii/P. tridentata* habitat type has not been reported in Colorado (Alexander 1987) or elsewhere in the Rocky Mountain or Intermountain regions (Alexander 1985, 1988). However, it does have undergrowth similar to the *P. menziesii/Arctostaphylos uva-ursi* (*A. adenotricha*) habitat type described in southwestern New Mexico by Fitzhugh et al. (1987) and in Montana by Pfister et al. (1977); also, there is some evidence that the *P. menziesii/P. tridentata* plant community is seral to *P. menziesii/A. uva-ursi* habitat type in the northern Rockies. The *Pinus ponderosa/P. tridentata* habitat type on the Roosevelt National Forest in the Colorado Front Range (Hess and Alexander 1986) and in southern Utah (Youngblood and Mauk 1985) has undergrowth similar to the *P. menziesii/P. tridentata* habitat type on the Gunnison National Forest. This *P. ponderosa*-dominated "habitat type" may be a long-lived seral plant community that will ultimately be succeeded by the *P. menziesii/P. tridentata* plant association.

Management implications.—Timber productivity potential in the *P. menziesii/P. tridentata* habitat type is very low, and tree regeneration may be difficult to obtain, especially on disturbed soils which tend to be very dry. Forage production potential for livestock is low because of slow plant growth associated with thin, rocky soils and low precipitation. This habitat type has the potential to be good spring-fall range for mule deer, because *P. tridentata* is potentially very palatable to deer. Partial cutting increases the shrub and herbaceous layers, improving both diversity and forage production. Deer also use the habitat type for food and hiding cover in the summer, especially stands with good representation of *Artemisia tridentata.* Potential is low for increasing water yield, but stands do provide watershed protection.

Pseudotsuga menziesii/Symphoricarpos oreophilus

Description.—The *Pseudotsuga menziesii/Symphoricarpos oreophilus* habitat type is represented by two stands; one on the Lake Fork of the Gunnison River, the other in Spring Creek Canyon. These stands occur on moderate (21%) to very steep (70%) slopes. Aspect varies from west- to east-facing. Soils in the sampled stands are loams (table 1). The habitat type may occur on sedimentary soils, on steep, rocky slopes at lower elevations within the forested zone.

This is the most widespread *P. menziesii*-dominated habitat type on the Gunnison National Forest. It occurs on all but south aspects and generally on gentler slopes well below the subalpine zone. At lower elevations, the *P. menziesii/S. oreophilus* habitat type integrates with plant associations dominated by *Quercus gambelii* and/or *Amelanchier alnifolia.*

The *P. menziesii/S. oreophilus* habitat type is recognized by the overstory dominance and reproductive success of *Pseudotsuga menziesii*. *Pinus flexilis* is an occasional overstory associate. The undergrowth is dominated by *Symphoricarpos oreophilus* (4–10% cover) (fig. 11). *Ribes inerme* and *Rosa woodsii* are the only other major shrubs. Important graminoids include *Carex geyeri*, *Elymus longifolius*, *Festuca idahoensis*, *Koeleria macrantha*, and *Poa nemoralis* ssp. *interior*. The forb layer is dominated by *Atragene columbiana*, *Artemisia frigida*, *Fragaria ovalis*, *Mertensia lanceolata*, *Selaginella densa*, *Solidago multiradiata*, and *Thalictrum fendleri*.

The *P. menziesii/S. oreophilus* habitat type has been reported in the White River National Forest to the north by Hess and Wasser;[2] it has also been described from the Piceance Basin in northwestern Colorado by Tiedeman (1978). A *P. menziesii/S. oreophilus* habitat type has been reported in southeastern Montana (Pfister et al. 1977), central Idaho (Steele et al. 1981), northwestern Wyoming (Steele et al. 1983), and in Utah (Mauk and Henderson 1984, Youngblood and Mauk 1985).

Management implications.—Timber productivity in this warm, dry habitat type is below average for *P. menziesii*. Regeneration is likely to be sporadic and difficult to obtain, especially if stands are clearcut, and they occur as small islands of trees. Sites tend to dry out rapidly because water loss from soil and vegetation is accelerated

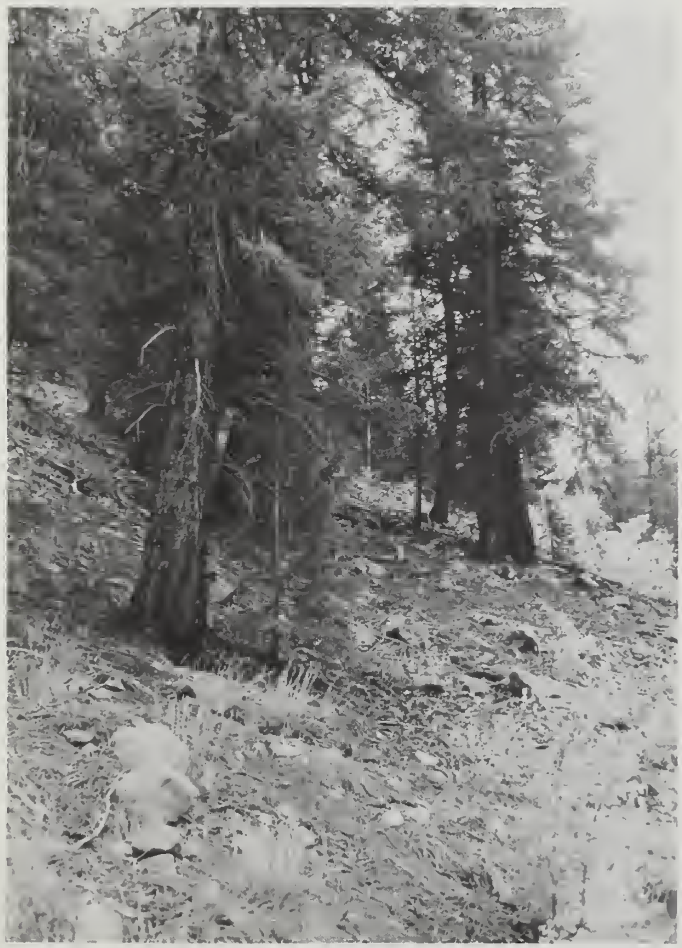

Figure 11.—*Pseudotsuga menziesii/Symphoricarpos oreophilus* habitat type in Spring Creek Canyon. *Pinus flexilis* is present in the overstory. *S. oreophilus*, *Rosa woodsii*, and *Festuca idahoensis* are important undergrowth species.

Figure 12.—*Pseudotsuga menziesii/Carex geyeri* habitat type, East Red Creek, West Elk Mountains. *Rosa woodsii* and *Symphoricarpos oreophilus* are the principal associates of *C. geyeri* in the undergrowth.

when the overstory is removed. Group selection, and group and uniform shelterwood cuttings approximate the regeneration patterns found in natural stands. Forage potential for livestock varies, depending on the abundance of palatable graminoids in the undergrowth; however, heavy grazing will remove these graminoids, with little chance that they will reestablish. Big game may use the *P. menziesii/S. oreophilus* habitat type for winter food and cover, especially where stands are adjacent to shrublands that also provide winter food. The potential for increasing water yield is low. The habitat type provides watershed protection, but erosion hazard is high and soil-loss tolerance low on steep slopes.

Pseudotsuga menziesii/Carex geyeri

Description.—The *Pseudotsuga menziesii/Carex geyeri* habitat type is represented by two stands on the Gunnison National Forest. One stand is in East Red Creek in the Elk Mountains, the other in Soap Creek Canyon. These stands are on gentle to moderate (11–21%) slopes, with aspects varying from northeast to southwest. Soils are relatively deep, well-drained, sandy loams (table 1). Within this habitat type, slopes usually are steep to very steep, with northerly aspects, and well-drained. Soils are derived from sedimentary rock.

This habitat type is recognized by the overstory dominance and reproductive success of *Pseudotsuga menziesii*. In some stands in this habitat type, *Pinus ponderosa* may be a seral codominant. *Picea pungens* and *Populus tremuloides* are occasional overstory associates. The undergrowth is dominated by *Carex geyeri* (35–60% cover) (fig. 12). Major shrub species include *Amelanchier alnifolia*, *Arctostaphylos adenotricha*, *Juniperus communis*, *Mahonia repens*, *Prunus virginiana*, *Purshia tridentata*, *Ribes inerme*, *Rosa woodsii*, and *Symphoricarpos oreophilus*. *S. oreophilus* has high cover (25%) in one stand (222), which may represent a phase of this habitat type comparable to the *P. menziesii/C. geyeri* habitat type, *S. oreophilus* phase reported from central Idaho by Steele et al. (1981). However, this cannot be confirmed on the Gunnison National Forest without additional sampling. In addition to *C. geyeri*, important graminoids are *Bromus canadensis*, *Festuca arizonica*, *Koeleria macrantha*, and *Poa* spp. The forb layer is dominated by *Achillea lanulosa*, *Antennaria* spp., *Erigeron speciosus*, *Galium septentrionale*, *Lathyrus leucanthus*, and *Thalictrum fendleri*.

Hess and Alexander (1986) identified the *P. menziesii/C. geyeri* habitat type on the Arapaho National Forest. This habitat type has not been reported elsewhere in Colorado (Alexander 1987), but it is closely related to the *P. menziesii/S. oreophilus* habitat type in the study area and in the White River National Forest (Hess and Wasser[2]). Pfister et al. (1977) in Montana east of the Continental Divide, Cooper et al. (1987) in northern Idaho, and Steele et al. (1981) in central Idaho reported a *P. menziesii/C. geyeri* habitat type, but the plant species differ from the habitat type on the Gunnison National Forest.

Management implications.—The potential for timber production in the *P. menziesii/C. geyeri* habitat type is moderate to low. Moreover, this habitat type often occurs on steep slopes. If *P. menziesii* is harvested, cutting methods that maintain overstory shade and minimize soil disturbance are most appropriate for natural reproduction because sites are dry and become drier when opened up. Clearcutting may result in a significant increase in *C. geyeri* in the undergrowth, especially if disturbance during logging is not severe. However, regeneration of *P. menziesii* is likely to be difficult to obtain with any cutting method, especially where there is pressure from big game and/or precipitation is below average. The potential for forage production for livestock is moderate, and moderate to high for big game on or near winter range. This habitat is valuable to big game mostly as hiding and thermal cover. Heavy livestock or big game use, or heavy mechanical seedbed preparation may deplete the *C. geyeri* sod, increase erosion and sedimentation potentials, and facilitate invasion by *Artemisia* spp. The potential for increasing water yield is lower than in subalpine forests.

Pseudotsuga menziesii/Festuca idahoensis

Description.—The *Pseudotsuga menziesii/Festuca idahoensis* habitat type was sampled in only one stand on a moderate (14%) east-facing slope along the Cold Spring Road, near Upper Dome Reservoir. Soils are a deep, sandy loam (table 1). Stands in this habitat type are typically patchy, with a more open canopy than other *Pseudotsuga*-dominated habitat types. They often are heavily grazed.

The *P. menziesii/F. idahoensis* habitat type is recognized by the dominance and reproductive success of open-grown *Pseudotsuga menziesii*, and the abundance and dominance of *Festuca idahoensis* (40% cover) in the undergrowth (fig. 13). Occasionally, *Pinus ponderosa* occurs in the overstory. Shrubs are sparse with only *Juniperus communis* and *Ribes cereum* present. In addition to *F. idahoensis*, other important graminoids include

Figure 13.—*Pseudotsuga menziesii/Festuca idahoensis* habitat type, Cold Springs, Upper Dome Reservoir. Condition of *P. menziesii* reflects difficult site. *F. idahoensis* and *Koeleria macrantha* dominate the undergrowth.

Carex geyeri and *Koeleria macrantha*. *Arabis drummondii* and *Descurainia richardsonii* are the major forbs in the sampled stand.

The *P. menziesii/F. idahoensis* habitat type has not been reported elsewhere in Colorado (Alexander 1987). This habitat type has been reported in southwestern Montana (Pfister et al. 1977), and northern and central Idaho (Cooper et al. 1987, Steele et al. 1981). However, the composition of the undergrowth in this northern *P. menziesii/F. idahoensis* habitat type is considerably different from the habitat type described here.

Management implications.—Timber productivity in the *P. menziesii/F. idahoensis* habitat type is low because of poor tree growth and low stand density. Establishment of regeneration following any cutting method is likely to be slow because both seed supply and available soil moisture are limited. While partial cutting will tend to increase graminoids in the undergrowth, clearcutting generally will result in conversion to grassland, with very slow reinvasion of *P. menziesii*. Removal of individual trees in a light sanitation-salvage cutting will permit timber harvest and still protect the site. Since this habitat type occurs on gentle to moderate slopes, it is compatible with livestock grazing. The potential for forage production for livestock, primarily cattle, is moderate, but may improve where removal of the overstory increases the representation of *F. idahoensis* in the undergrowth. Although the potential for big-game browse production is low, deer and elk may use the *P. menziesii/F. idahoensis* habitat type both for early and late season forage and cover. The potential for water yield improvement is low, but the habitat type provides watershed protection.

Pseudotsuga menziesii/Jamesia americana

Description.—The *Pseudotsuga menziesii/Jamesia americana* habitat type has some of the oldest *P. menziesii* encountered on the Gunnison National Forest. It was sampled in only one stand, located on a moderate (21%) south-facing slope on the west side of Monarch

Pass near Sargents. Soils are a shallow, coarse loam derived from igneous or metamorphic rock (table 1). Within the habitat type, sites have steep slopes with large boulders. The stands in which the sample plot was located are the first evidence of the occurrence of the *P. menziesii/J. americana* habitat type west of the Continental Divide.

This habitat type is recognized by the overstory dominance and reproductive success of *Pseudotsuga menziesii*, and the conspicuous presence of *Jamesia americana* (7% cover) in the undergrowth (fig. 14). *Pinus ponderosa* may be a seral overstory associate, and *Juniperus scopulorum* also may be present. Major shrub associates of *J. americana* include *Arctostaphylos adenotricha, Mahonia repens*, and *Rosa woodsii*. On the eastern slope of the Continental Divide, there usually is a greater variety of medium to tall shrubs present. The herbaceous layer is dominated by *Carex brevipes, Poa pratensis, Apocynum androsaemifolium, Senecio fendleri*, and *Solidago multiradiata*.

The *P. menziesii/J. americana* habitat type was reported on the Roosevelt National Forest by Hess and Alexander (1986) and on the Pike National Forest by Radloff (1983). It has not been reported elsewhere in the Rocky Mountain or Intermountain regions by investigators using standard habitat type methodology (Alexander 1985, 1988).

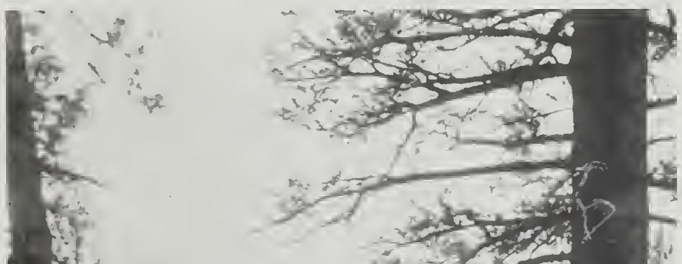

Figure 14.—*Pseudotsuga menziesii/Jamesia americana* habitat type near Monarch Ridge, Sawatch Range. *Pinus contorta* is a seral overstory species. *J. americana, Arctostaphylos adenotricha*, and *Mahonia repens* have high coverage in the undergrowth.

Management implications.—Although this habitat type occurs in a moister environment than some other *P. menziesii*-dominated habitat types, the potential for timber production is low because of low site quality associated with shallow, rocky soils. Moreover, steep slopes and surface roughness generally preclude any harvesting of stands in the *P. menziesii/J. americana* habitat type with conventional methods. The potential for forage production for livestock is low. The sampled stand showed little evidence of grazing. There is moderate potential for big game on winter range as hiding and thermal cover; the shrubs generally are not browsed. The potential for increasing streamflow is low because of the difficulty in harvesting stands and low precipitation. This habitat type does provide watershed protection, however.

POPULUS ANGUSTIFOLIA SERIES

Populus angustifolia is a deciduous forest tree species of the upper foothills and lower montane zones in the Gunnison Basin. It dominates rocky riparian areas, such as narrow benches of small streams and in the floodplains of larger streams, at elevations of 6,500 to 7,800 feet (1,981 to 2,377 m) (table 1). This series is represented by one stand and one habitat type located at 7,170 feet elevation (3,048 m). Tree size data are not available for this series. Plant species data for the *P. angustifolia* stand are shown in table A–5.

Populus angustifolia/Alnus incana-Swida sericea

Description.—The *Populus angustifolia/Alnus incana-Swida sericea* habitat type generally occurs on level to near level terrain that is subject to spring flooding and has a constantly high water table. The sampled stand is on Smith Fork, Paonia District. Soils are sandy loams. They are alluvium and colluvium, derived from parent materials of mixed geologic origin (table 1).

The *P. angustifolia/A. incana-S. sericea* habitat type is characterized by an overstory dominated by *Populus angustifolia*, with *Salix amygdaloides* as a codominant, and an undergrowth dominated by the shrubs *Alnus incana* and *Swida sericea* (10–55% cover). Other shrub species with high cover include *Acer glabrum, Prunus virginiana, Rosa woodsii, Salix exigua, S. ligulifolia, S. lutea*, and *Sambucus racemosa*. Major herbaceous species are *Dactylis glomerata, Elymus trachycaulus, Poa plaustris, Heracleum sphondylium, Hippochaete hyemalis, Smilacina stellata*, and *Solidago* spp. (fig. 15).

Although the sampled stand was not heavily grazed, this habitat type historically has been heavily utilized for grazing livestock and big game, and for recreation. Heavy use has resulted in significant vegetational changes on many sites in this habitat type, resulting in a stable undergrowth composed of introduced species, such as *Poa pratensis, Bromus inermis, Dactylis glomer-*

ata, and *Taraxacum officinale*. In these circumstances, the existing vegetation may be termed a zootic climax.

A closely related *P. angustifolia/Salix exigua* habitat type, with similar characteristics, has been reported in the Front Range on the Roosevelt National Forest by Hess and Alexander (1986), and in eastern Idaho by Youngblood et al. (1985). This habitat type also appears to be closely related to the *P. angustifolia/Amelanchier alnifolia* habitat type described by Hess and Wasser[2] on the White River National Forest. Although the *P. angustifolia/A. incana-S. sericea* habitat type has not been reported elsewhere in the Rocky Mountain and Intermountain regions, it is probably widespread throughout western Colorado, Utah, and western Wyoming.

Management implications.—Timber production is moderate, but *P. angustifolia* and *Salix amygdaloides*, which make up most of the volume in this habitat type, are not commercial forest tree species. Forage and browse production potential for livestock and big game may be high, but heavy grazing will decrease herbaceous production and *P. angustifolia* regeneration. Grazing and browsing reduce shrubs and increase the proportion of graminoids, which, with the exception of *Poa* spp., have low palatability. Diversified recreation use and road-building often are heavy because of close proximity to water, and these activities frequently have resulted in site degradation. This habitat type also provides cover for big game, and food and cover for a wide variety of non-game wildlife.

Figure 15.—*Populus angustifolia/Alnus incana-Swida sericea* habitat type, Smith Fork, Paonia District. *Salix* spp., *Acer glabrum, Alnus incana, Rosa woodsii, Hippochaete hyemalis*, and *Swida sericea* have high coverage in the undergrowth.

POPULUS TREMULOIDES SERIES

The *Populus tremuloides* series occurs throughout the montane and subalpine forest zones on the Gunnison National Forest. It also occurs on part of the Uncompahgre National Forest. The *P. tremuloides* series occupies a wide range of mesic environments on sites where high available moisture, coupled with favorable topographic positions, favors retention of soil moisture. This series occurs at elevations of 8,040 to 10,450 feet (2,450 to 3,185 m) (table 1).

There has been considerable discussion regarding the role of *P. tremuloides* as a climax and/or seral species in the Rocky Mountain and Intermountain regions; both assessments may be correct (Mueggler 1985a). In some areas, *P. tremuloides* dominates sites where fires apparently have destroyed coniferous forests. In time, on some of these sites, conifers gradually replace *P. tremuloides*. In other situations, conifer invasion is virtually nonexistent, even where fires occurred many years ago. Succession to coniferous forests apparently is slowed significantly by changes in soil properties resulting from site occupancy by the deciduous *P. tremuloides*. In other areas, *P. tremuloides* forests appear to be climax without evidence of conifer invasion. According to Mueggler (1976), complete conversion of *Populus* stands to coniferous climax forest on some sites may require more than a thousand fire-free years. The origin of both seral and climax *P. tremuloides*-dominated forests may be the same—destruction of coniferous forest by repeated fires.

P. tremuloides may more commonly be climax in western Colorado, where it occurs in large, apparently stable stands. Here, *P. tremuloides* tends to form stands on less stable sites with deeper, loamier soils that are less well drained compared to adjacent stands dominated by conifers. Part of *P. tremuloides*' success on a given site is its ability to develop loamy soils that are more favorable to the perpetuation of *Populus* than invasion and replacement by conifers. The latter tend to become established as climax species on shallower, coarse-textured, well-drained soils.

Many *P. tremuloides* forests are even-aged (or even-sized) (Jones and DeByle 1985); the trees originate from sprouts that occur shortly after a disturbance. In stands where older trees die naturally over a short time span, an even-aged replacement stand also may develop (Mueggler 1985a). Other stands are uneven-aged or multisized, and sprouts apparently provide enough young trees to perpetuate the species indefinitely. Two-storied stands also are relatively common and can develop when surface fires burn quickly through mature stands without killing all trees, thereby stimulating sprouting.

The *P. tremuloides* series was sampled in 13 stands representing seven habitat types. Tree sizes for those stands where measurements are available ranged from seedlings to the 20- to 24-inch (5- to 6-dm) d.b.h. class. Tree populations and plant species data for the *P. tremuloides* stands are shown in tables A–1 and A–5.

Populus tremuloides/Arctostaphylos adenotricha

Description.—The *Populus tremuloides/Arctostaphylos adenotricha* habitat type was sampled in only one stand in the subalpine forest zone. The sampled stand is on an unstable, rocky slope near Middle Quartz Creek on a steep (40%) south-facing aspect. Soils are a coarse loam (table 1). *P. tremuloides* is represented by all age classes, including some very large trees.

This habitat type is recognized by the overstory dominance and reproductive success of *Populus tremuloides*. Other tree species are absent. Undergrowth cover is sparse (fig. 16). The most abundant shrubs are *Arctostaphylos adenotricha*, *Ribes inerme*, *Shepherdia canadensis*, and *Symphoricarpos oreophilus*. Herbaceous species with significant cover are *Bromus porteri*, *Carex geophila*, and *Poa nemoralis* ssp. *interior*.

Powell[7] reported a *P. tremuloides/A. adenotricha* community type on the Pike and San Isabel National Forests,

[7] *Powell, David C. Aspen community types of the Pike and San Isabel National Forests in south-central Colorado. (Manuscript in preparation.)*

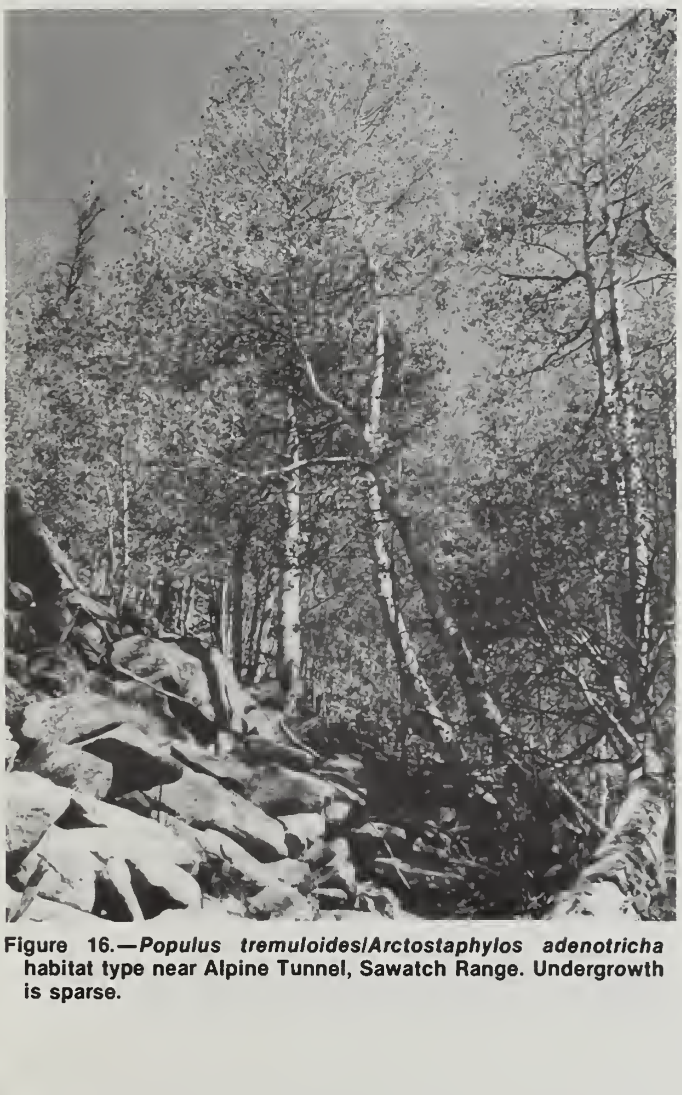

Figure 16.—*Populus tremuloides/Arctostaphylos adenotricha* habitat type near Alpine Tunnel, Sawatch Range. Undergrowth is sparse.

but the composition of the undergrowth is different. The *P. tremuloides/A. adenotricha* habitat type has not been reported elsewhere in the Rocky Mountain or Intermountain regions (Alexander 1985, 1988). The combination of *P. tremuloides* and *A. adenotricha*, a tree species with relatively high moisture requirements and a low shrub that normally indicates a dry soil, is unusual and suspicious. Successional relationships to *Pinus contorta/Arctostaphylos uva-ursi* (*A. adenotricha*) (Hoffman and Alexander 1976, Mauk and Henderson 1984, Radloff 1983) are suspected because of excessive soil drainage here and floristic similarities. Additional sampling is needed to confirm this relationship on the Gunnison National Forest.

Management implications.—The potential for timber production in the *P. tremuloides/A. adenotricha* habitat type is moderate to low. However, because of the instability of the site, any timber harvesting is likely to increase the risk of mass soil movement. Stands in this habitat type have low probability of being successfully burned, because medium-height shrubs are uncommon, and herbaceous fuels are seldom dense enough to carry a fire. Any successful burning probably would require fuels created by cutting.

The potential for forage production is low to moderate, but the sites are too unstable for livestock grazing. Big game may use this habitat type as transitional range, and the undergrowth has moderate to high big game forage suitability. Big game browsing may damage *P. tremuloides* sprouts. Although the habitat type occurs in relatively high precipitation zones, there is little opportunity to increase streamflow, because sites are very well drained and opportunities to harvest timber are limited by instability. Visual contrast is low because of the absence of conifers, and the low density of shrubs does not provide much texture or variety in seasonal color in the foreground.

Populus tremuloides/Festuca arizonica

Description.—The *Populus tremuloides/Festuca arizonica* habitat type was sampled in only one stand in the lower subalpine zone, along the Mexican Joe Gulch road. This isolated stand, located on an unstable, rocky slope, showed no evidence of replacement of *P. tremuloides* by conifers. Soils on this gentle to moderate (11%) east-facing aspect are sandy loams (table 1).

This habitat type is recognized by the overstory dominance and reproductive success of open-grown *Populus tremuloides*. Other tree species are absent. The undergrowth is dominated by *Festuca arizonica* (28% cover) (fig. 17). The shrub layer is sparse. In addition to *F. arizonica*, important graminoids are *Carex geyeri*, *Festuca thurberi*, and *Muhlenbergia montana*. Important forbs include *Achillea lanulosa*, *Lupinus argenteus*, *Oxytropis deflexa*, and *Senecio* spp.

The *P. tremuloides/F. arizonica* habitat type has not been identified elsewhere in the Rocky Mountain or Intermountain regions (Alexander 1985, 1988). It appears closely related to the *P. tremuloides/Festuca thurberi* habitat type; but it occurs on warmer sites with thinner soils or outside the range of *F. thurberi*.

Management implications.—The potential for timber production in the *P. tremuloides/F. arizonica* habitat type is low, despite the relatively good growth of *P. tremuloides*, because the instability of the site limits timber harvesting. Moreover, since most stands in this habitat type are small and occur in meadows, timber harvesting may eliminate *P. tremuloides*. *F. arizonica*, *F. thurberi*, and *M. montana* are highly palatable to cattle, especially early in the grazing season; but despite the potentially high value for forage production, soil conditions are too unstable to risk grazing by livestock. Big game, especially elk, may use this habitat type as transitional range. The *P. tremuloides/F. arizonica* habitat type has little potential for increased water yields but does provide watershed protection. Visual contrast in the foreground is low because of the absence of conifers and shrub species.

Figure 18.—*Populus tremuloides/Festuca thurberi* **habitat type near Beaver Creek.** ***F. thurberi, Arctostaphylos adenotricha, Carex geyeri, Arnica cordifolia,*** **and** ***Lathyrus leucanthus*** **are important undergrowth species.**

Populus tremuloides/Festuca thurberi

Description.—*Populus tremuloides/Festuca thurberi* habitat type was sampled in three stands. One stand (233), near Beaver Creek on a gentle southeast-facing slope, initially was described as a *P. tremuloides/Lathyrus leucanthus* community type successional to *Pinus contorta* (Komarkova[3]). This assumption was based on the occurrence of *P. contorta* seedlings near the sampled area. The remaining two stands are north of Mill Creek in northeast Hillsdale County on gentle east-facing slopes. These were originally described as *Populus tremuloides/Festuca thurberi* and *P. tremuloides/Danthonia intermedia* community types successional to *Abies lasiocarpa* and *Picea engelmannii* (Komarkova[3]), based on the occurrence of a few scattered *P. engelmannii* seedlings in the stands but with no clear evidence that *P. tremuloides* is seral. Without documented evidence of replacement of *P. tremuloides* by conifers within the stands sampled, they tentatively are classified as a *P. tremuloides/F. thurberi* habitat type. Additional sampling is necessary to confirm this habitat type in the study area. Soils in the sampled stands are sandy loams (table 1).

Figure 17.—*Populus tremuloides/Festuca arizonica* **habitat type, Mexican Joe Gulch, Cochetopa Hills. Undergrowth is dominated by** ***F. arizonica, Festuca thurberi,*** **and** ***Muhlenbergia montana.***

The habitat type is recognized by the overstory dominance and reproductive success of *Populus tremuloides*. *P. tremuloides* is generally young in the stands sampled, and the only conifer associates present are a few scattered *Picea engelmannii* seedlings in stand 173. The undergrowth is recognized by the abundance of the graminoid *Festuca thurberi* (10–65% cover) (fig. 18). Major shrubs are *Arctostaphylos adenotricha* and *Rosa woodsii*. Other important graminoids include *Bromus carinatus*, *Carex geyeri*, *Danthonia intermedia*, *Elymus trachycaulus*, and *Festuca idahoensis*. Forbs with significant cover are *Achillea lanulosa*, *Arnica cordifolia*, *Erigeron speciosus*, *Fragaria virginiana*, *Lathyrus leucanthus*, *Solidago* spp., and *Thalictrum fendleri*. The high cover of *L. leucanthus* in stand 233 indicates considerable past grazing pressure reduced cover by more palatable herbaceous plants.

The *P. tremuloides/F. thurberi* habitat type has been described on the Arapaho, Roosevelt, and White River National Forests in Colorado by Hess and Alexander (1986), Hess and Wasser,[2] and Johnston and Hendzel.[8] Powell[7] described a *P. tremuloides/F. thurberi* community type on the Pike and San Isabel National Forests. Mueggler[9] described a *P. tremuloides/F. thurberi* community type in southern Utah that probably is successional to *Abies lasiocarpa*. It has not been reported elsewhere in the Rocky Mountain or Intermountain regions (Alexander 1985, 1988). *P. tremuloides/F. thurberi* stands are often adjacent to and related to *F. thurberi* grasslands, and the possibility exists that the small and marginal stands in this habitat type developed through expansion into the grasslands by *P. tremuloides* clones.

[8]*Johnston, Barry C., and Leonard Hendzel. 1985. Examples of aspen treatment, succession, and management of western Colorado. (Report) Rocky Mountain Region, Denver, Colo.*

[9]*Mueggler, Walter F. Aspen community types in the Intermountain region. (Manuscript in preparation. Supersedes Mueggler and Campbell 1982, 1986; Youngblood and Mueggler 1981.)*

Management implications.—Timber productivity in the dry *P. tremuloides/F. thurberi* habitat type is moderate to low. Clearcutting usually is an effective way to regenerate a new *P. tremuloides* stand. However, it is somewhat risky in this habitat type, because stands often are small and adjacent to *F. thurberi* grasslands, and there is a good chance of converting these stands to *F. thurberi* when the *P. tremuloides* overstory is removed. However, if the objective is enhancement of the grasslands, clearcutting should be beneficial. Success in regenerating stands in this habitat type is enhanced by burning immediately after clearcutting to reduce competition from undergrowth species. The potential for forage production is high on sites in good condition with a high cover of *F. thurberi* and associated graminoids. Forage is more palatable to cattle than sheep, but these stands usually are not very important rangelands, because they are small and *F. thurberi* is only moderately palatable in late spring-early summer. This habitat type can be heavily used by big game in the late fall and winter for food and cover. Heavy winter use by big game animals can damage mature *P. tremuloides* stems and can eliminate all sprouts. The potential for increasing streamflow is unknown. Erosion, sedimentation, and mass movement potentials are low. The *P. tremuloides/F. thurberi* habitat type usually has low visual potential in the foreground. Color contrast is low because of the absence of conifers, and the low density of shrubs does not provide much texture or variety in seasonal color. However, isolated stands in grasslands or shrublands can be locally important where the interstand contrast is visible. The potential is moderate for dispersed recreation, but it is low for developed recreation because of the isolated character of the stands and the susceptibility of *P. tremuloides* to disease resulting from injury and soil compaction.

Populus tremuloides/Symphoricarpos oreophilus

Description.—The *Populus tremuloides/Symphoricarpos oreophilus* habitat type was sampled in three stands on the Gunnison National Forest. One stand is in Smith Fork, Paonia District, on a gentle (7%) northeast-facing slope; the second stand is south of McClure Pass on a gentle (5%) east- to northeast-facing slope; and the third stand is in Buckhorn Gulch, near Black Mesa, on a moderate (14%) west-facing slope. Within the habitat type, sites are on protected benches and slopes, usually on gentle slopes and relatively stable sites. Stands are typically patchy, with grassy openings within the *P. tremuloides* matrix. Soils are relatively deep, sandy loams, but are moderately well drained (table 1).

The *P. tremuloides/S. oreophilus* habitat type is recognized by the consistent presence and reproductive success of *Populus tremuloides*, and the abundance and dominance of *Symphoricarpos oreophilus* (10–65% cover) in the undergrowth (fig. 19). This habitat type occurs near the lower edge of the *Populus* zone on the Forest and is one of the warmest *P. tremuloides*-dominated habitat types. As sites become still drier, *P. tremuloides* is replaced by *Quercus gambelii*- or *Artemisia tridentata*-dominated vegetation. If replaced by *Q. gambelii*, it may form the *Q. gambelii/S. oreophilus* habitat type.

Figure 19.—***Populus tremuloides/Symphoricarpos oreophilus*** **habitat type in Smith Creek, Paonia District. *S. oreophilus, Carex* spp., *Achillea lanulosa,* and *Thalictrum fendleri* are principal undergrowth species.**

In addition to *S. oreophilus*, important shrubs are *Amelanchier alnifolia, Mahonia repens, Prunus virginiana,* and *Rosa woodsii.* In one stand (188), the cover of *M. repens* is very high (70%), and Komarkova[3] originally classified this plot as a *P. tremuloides/M. repens* habitat type. However, since a *P. tremuloides/M. repens* habitat type has not been previously identified in Colorado (Alexander 1987), it is more likely a *M. repens* phase of the *P. tremuloides/S. oreophilus* habitat type. Additional sampling will be required to determine the status of *M. repens* in *P. tremuloides* stands in the study area.

The most important graminoids in this habitat type are *Bromus* spp., *Carex geyeri, Carex hoodii,* and *Elymus trachycaulus.* The rich forb layer is dominated by *Achillea lanulosa, Aquilegia coerulea, Conioselinum scopulorum, Erigeron glabellus, Fragaria virginiana, Galium septentrionale, Geranium richardsonii, Osmorhiza depauperata, Rudbeckia ampla, Senecio bigelovii, Thalictrum fendleri,* and *Viola canadensis.*

Hoffman and Alexander (1980, 1983), Hess and Wasser,[2] Hoffman,[5] and Johnston and Hendzel[8] identified this habitat type on the Grand Mesa, Routt, White River, Uncompahgre, and San Juan National Forests in

Colorado. Powell[7] described a *P. tremuloides/S. oreophilus* community type on the Pike and San Isabel National Forests. Tiedeman (1978) also described it in the Piceance Basin of northwestern Colorado. In the Medicine Bow National Forest and in the Bighorn Mountains, there are no undergrowth unions under *P. tremuloides* dominated by *Symphoricarpos* (Alexander et al. 1986, Hoffman and Alexander 1976). In western Wyoming, northern Utah, eastern Nevada, and central and southeastern Idaho, Mauk and Henderson (1984), Mueggler,[9] and Steele et al. (1981) identified *P. tremuloides/S. oreophilus*-dominated vegetation with similar associated undergrowth. Mueggler[9] described this vegetation as a community type, but indicated that *P. tremuloides/S. oreophilus* community types probably were stable and very likely valid habitat types.

Management implications.—This is the most common *Populus*-dominated habitat type on the Gunnison National Forest. Timber productivity is low to moderate in this mesic habitat type, depending on geographic location. While stands in the *P. tremuloides/S. oreophilus* habitat type may be self-regenerating, clearcutting usually is the preferred way to regenerate a new stand. This habitat type has the highest potential of any *P. tremuloides* habitat type for successful prescribed burning because of the combination of medium shrub and herbaceous fuels.

Annual precipitation is at least 18 inches (46 cm), with about 9 inches (23 cm) of runoff. Potential for increasing streamflow under management is unknown. This habitat type is spring and fall big game range, and use may be heavy. In years of low snowfall, it may be used all winter. Browse production is moderate because *S. oreophilus* is moderately palatable to big game. The habitat type is summer range for livestock. The potential is high for sheep and moderate for cattle. Under proper grazing management, herbage production may be as high as 800 to 1,000 pounds per acre (900 to 1,120 kg/ha). This habitat type has fairly good scenic quality, but generally less favorable foreground color contrast than mixed *Populus*-conifer stands. Mature and open stands generally are more visually attractive, with the shrub understory providing both texture diversity and variety in seasonal color. The potential for developed recreation is low because of the susceptibility of *P. tremuloides* to disease and subsequent death from injury and soil compaction. Slumping may be common, especially where slopes are steeper; these should be avoided in planning roads and trails.

Populus tremuloides/ Amelanchier alnifolia-Prunus virginiana

Description.—The *Populus tremuloides/Amelanchier alnifolia-Prunus virginiana* habitat type was sampled in two stands. One stand is in Smith Fork, on the Paonia District, on a moderate (21%) west-facing slope. The other stand is south of McClure Pass on a moderate (21%) southeast-facing slope. Soils are relatively deep, sandy loams (table 1).

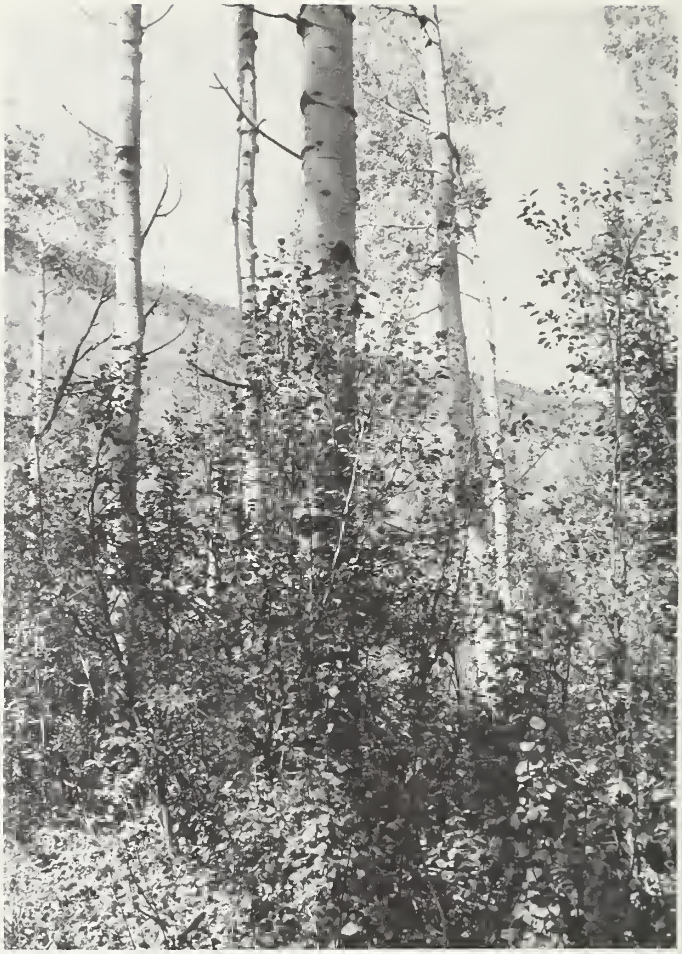

Figure 20.—*Populus tremuloides/Amelanchier alnifolia-Prunus virginiana* habitat type west of McClure Pass. *A. alnifolia, P. virginiana, Rosa woodsii, Symphoricarpos oreophilus*, and *Thalictrum fendleri* dominate the undergrowth.

The *P. tremuloides/A. alnifolia-P. virginiana* habitat type is recognized by overstory dominance and reproductive success of *Populus tremuloides*, and the near absence of conifer species. The undergrowth is dominated by tall shrubs, either *Amelanchier alnifolia* (0–30% cover) and/or *Prunus virginiana* (4–45% cover), often approaching *P. tremuloides* in height (fig. 20). On the Gunnison National Forest, this habitat type is usually limited to protected lower slopes and valley bottoms on the Paonia District. The habitat type usually occurs near the lower limits of the *Populus* zone, and often is adjacent to *Quercus*- or *Amelanchier*-dominated woodlands and shrublands.

The undergrowth is a rich, multilayered mixture of tall shrubs, low- to medium-height shrubs, and herbaceous vegetation. Major tall shrubs are *Acer glabrum, Amelanchier alnifolia*, and *Prunus virginiana*. Low to medium shrubs are *Paxistima myrsinites, Ribes inerme, Rosa woodsii, Rubus parviflorus, Salix scouleriana*, and *Symphoricarpos oreophilus*. Important herbaceous species include *Bromus* spp., *Carex hoodii, Elymus trachycaulus, Achillea lanulosa, Delphinium nuttallianum, Fragaria virginiana, Galium triflorum, Geranium richardsonii, Heracleum sphondylium, Osmorhiza depauperata,* Solidago spp., *Smilacina stellata*, *Streptopus fassettii*, and *Thalictrum fendleri*.

This habitat type has been reported on the San Juan National Forest by Johnston and Hendzel.[8] Powell[7] reported a *P. tremuloides/A. alnifolia* community type on the Pike and San Isabel National Forests. Mueggler[9] identified a number of *P. tremuloides/A. alnifolia*-dominated community types in southeastern Idaho, northwestern Wyoming, northern Utah, and eastern Nevada in which the associated undergrowth is similar to the *P. tremuloides/A. alnifolia-P. virginiana* habitat type reported here. Some of these community types probably are stable and, therefore, represent habitat types. This habitat type also has some similarity to the *P. tremuloides/Symphoricarpos oreophilus* habitat type described by Hess and Wasser[2] and Hoffman and Alexander (1980, 1983) on the Routt and White River National Forests; but, it is distinguished by the conspicuous presence of tall shrubs, such as *A. alnifolia*, *P. virginiana*, and sometimes *Acer glabrum* and *Quercus gambelii*.

Management implications.—Timber productivity in the *P. tremuloides/A. alnifolia-P. virginiana* habitat type is low to moderate; stem form is often crooked and stands often grow on steep slopes. Clearcutting usually is the preferred timber harvesting option to regenerate stands and usually is very successful. The potential for increasing streamflow under management is unknown. Forage production for livestock is highly variable but this habitat type can be fairly productive, especially for sheep [average 1,000 pounds per acre (1,120 kg/ha)], where the undergrowth consists of palatable forage plants. Heavy grazing, especially by sheep, may reduce the vigor and abundance of the tall shrubs. This habitat type generally provides good to excellent big game habitat because of the great amount of structural diversity contributed by the tall and low shrub layers, and the presence of quantities of good browse. Where stands in this habitat type are adjacent to critical big game winter range, the value is increased. The *P. tremuloides/A. alnifolia-P. virginiana* habitat type has fairly good foreground scenic quality, especially where there is considerable *Acer glabrum* in the undergrowth. Moreover, in addition to providing a variety in seasonal color, the multilayerd shrub understory provides texture diversity. Edges interfingered with shrubland may provide color contrast and enhance deer, elk, and antelope hiding cover. The potential for dispersed recreation is moderate, but the potential for developed recreation is low because of the susceptibility of *P. tremuloides* to disease and subsequent death from injury and soil compaction.

Populus tremuloides/Pteridium aquilinum

Description.—The *Populus tremuloides/Pteridium aquilinum* habitat type has limited distribution, and occurs in small stands on the Gunnison National Forest. It was sampled in two stands: one in Smith Fork, Paonia District, on a gentle (3%), sheltered, east-facing slope; the other south of McClure Pass on a moderate (11%) south-facing slope. Soils associated with this habitat type are deep and loamy (table 1).

Figure 21.—*Populus tremuloides/Pteridium aquilinum* habitat type west of McClure Pass. A variety of shrubs, graminoids, and forbs are associated with *P. aquilinum* in the undergrowth.

Populus tremuloides is the only tree species in these stands, and it is perpetuating itself. The undergrowth is dominated by *Pteridium aquilinum* (40–65% cover) (fig. 21). *P. aquilinum*, like *P. tremuloides*, establishes readily after fire, and cured, late-season vegetation can help carry a fire. Major shrub associates are *Amelanchier alnifolia*, *Prunus virginiana*, *Ribes inerme*, and *Symphoricarpos oreophilus*. Important graminoids are *Bromus pumpellianus*, *Carex geyeri*, *Elymus longifolius*, *Elymus trachycaulus*, and *Poa fendleriana*. There is a large variety of forbs; in addition to *Pteridium aquilinum*, forbs with high cover are *Achillea lanulosa*, *Cirsium* spp., *Delphinium nuttallianum*, *Dipsacus sylvestris*, *Erigeron* spp., *Galium septentrionale*, *Geranium richardsonii*, *Lathyrus leucanthus*, *Osmorhiza depauperta*, *Polemonium pulcherrimum*, *Thalictrum fendleri*, and *Viola canadensis*.

The *P. tremuloides/P. aquilinum* habitat type has been identified in Colorado on the Routt National Forest where it was confined to poorly drained areas, and on the Grand Mesa, Uncompahgre, and White River National Forests (Hoffman and Alexander 1980, 1983; Hoffman[5]). Powell[7] described a *P. tremuloides/P. aquilinum* community type on the Pike and San Isabel National Forests. Mueggler[9] described a *P. tremuloides/P. aquilinum* community type in northern Utah, but the successional status of that community type is uncertain. Hoffman and Alexander (1987) described a *P. tremuloides/Corylus cornuta* habitat type with a *P. aquilinum* phase in the Black Hills, but the composition of the undergrowth is so different that is appears unrelated to the *P. tremuloides/P. aquilinum* habitat type described here. The *P. tremuloides/P. aquilinum* habitat type has not been described elsewhere in the Rocky Mountain or Intermountain regions (Alexander 1985, 1988).

Management implications.—This habitat type is restricted to small stands, but timber productivity is average to above average. While clearcutting in small blocks or patches is the common practice used to regenerate aspen, it may create problems in this habitat type where drainage is poor by raising the water table. Moreover, the *P. tremuloides/P. aquilinum* habitat type is most likely to occur in cold air drainage situations where *P. tremuloides* is subject to frost damage in cleared openings. Infiltration is less than in other *Populus*-dominated habitat types, and the potential for erosion, surface runoff, and mass movement is higher. The potential for soil damage from roadbuilding and logging equipment is high, especially when soils are wet.

Undergrowth production in this habitat type may be moderate to high, but it has low value for livestock forage because *P. aquilinum* is poisonous (oxalic acid) and unpalatable. It may be an indicator of soils capable of producing highly acidic vegetation. The *P. tremuloides/P. aquilinum* habitat type has low to moderate value for wildlife, because it lacks both structural diversity and palatable food species. Moreover, because most stands are open, the habitat type seldom qualifies as summer thermal cover. This habitat type has fair scenic quality where the shrub layer is developed well enough to provide seasonal color contrast.

Populus tremuloides/Thalictrum fendleri

Description.—The *Populus tremuloides/Thalictrum fendleri* habitat type, represented by only one stand, is found in the wettest situations associated with the *P. tremuloides* series in the Gunnison National Forest. Although the *P. tremuloides/T. fendleri* habitat type appears to be well represented on the Gunnison National Forest, it occupies considerably less area than the *P. tremuloides/Symphoricarpos oreophilus* habitat type. The sampled stand lies just below Rainbow Lake in the West Elk Mountains on gentle (7%) southeast-facing slope. Soils are a well-developed, moderately deep loam (table 1).

The *P. tremuloides/T. fendleri* habitat type is recognized by the constant reproductive success of *Populus tremuloides* and the high cover (35%) of *Thalictrum fendleri* in the undergrowth (fig. 22). *P. tremuloides* was the only tree species present in the sampled stand. Except for a few *Rosa woodsii*, shrubs are absent in this stand. Significant graminoids include *Bromus porteri, Carex geyeri, Elymus trachycaulis, Festuca idahoensis,* and *Poa epilis*. In addition to *T. fendleri*, important forbs are *Achillea lanulosa, Chamerion angustifolium, Cirsium* spp., *Erigeron speciosus, Fragaria virginiana, Helianthella quinquenervis, Lathyrus leucanthus, Lupinus argenteus,* and *Senecio serra*.

P. tremuloides/T. fendleri is one of the most widely distributed *P. tremuloides* habitat types in the central Rocky Mountains. In Colorado, it has been reported on the Grand Mesa and Uncompahgre National Forests by Hoffman,[5] on the White River National Forest by Hoffman and Alexander (1983) and Hess and Wasser,[2] on the Routt National Forest by Hoffman and Alexander (1980), on the Arapaho and Roosevelt National Forests by Hess and Alexander (1986), and on the San Juan National Forest by Johnston and Hendzel.[8] This habitat type also occurs on the Medicine Bow National Forest in southeastern Wyoming (Alexander et al. 1986). Mueggler[9] described a similar community type in southeastern Idaho, eastern Nevada, northern Utah, and western Wyoming. Powell[7] also described a *P. tremuloides/T. fendleri* community type on the Pike and San Isabel National Forests in Colorado. This habitat type appears closely related to the *P. tremuloides/Ligusticum porteri* habitat type found on the Pike, San Isabel, San Juan, and Uncompahgre National Forests (Johnston and Hendzel,[8] Powell[7]). These two habitat types may in fact be the same habitat type, but at present are distinguished by the amount of *L. porteri* cover, which often increases where the water table is near the surface or drainage is poor.

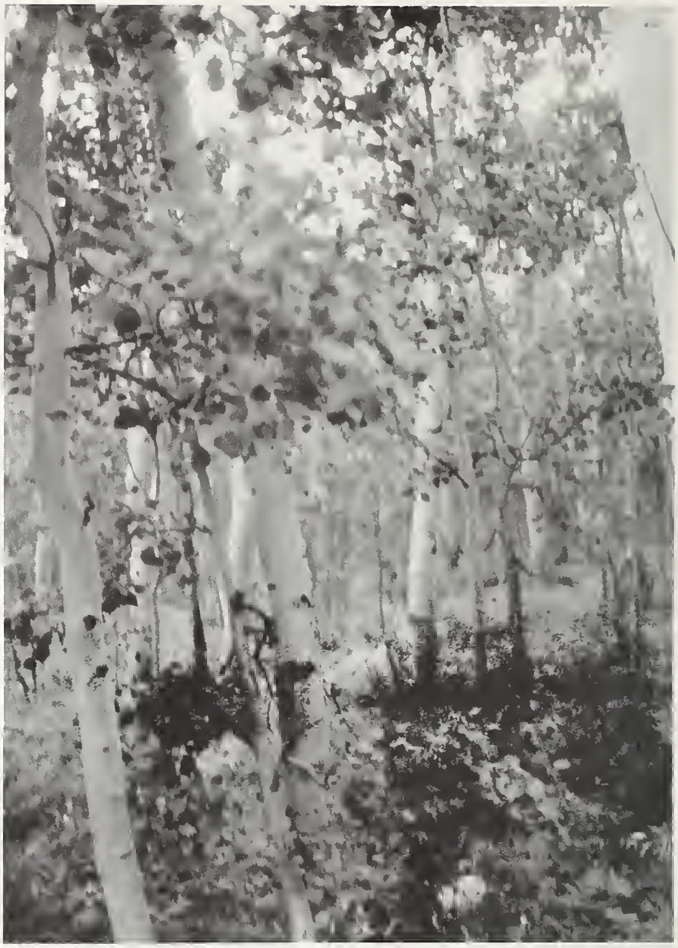

Figure 22.—*Populus tremuloides/Thalictrum fendleri* habitat type below Rainbow Lake, West Elk Mountains. *T. fendleri, Carex geyeri, Lathyrus leucanthus,* and *Lupinus argenteus* dominate the undergrowth.

Management implications.—The *P. tremuloides/T. fendleri* habitat type is the most productive for timber and forage in the *Populus* series. Site quality ranges from average to high. Clearcutting in patches or small blocks to effect regeneration of new stands is the most effective way to harvest these stands. Stands in this habitat type have moderate probability of being successfully burned, but only if livestock are excluded for at least one season before burning and fires are initiated after undergrowth vegetation has cured.

This habitat type is the best *Populus*-dominated habitat for big game and domestic sheep summer range. Although forage production under proper grazing management can be as high as 3,000 pounds per acre (3,360 kg/ha) for the first few years after clearcutting, sustained production under a *Populus* overstory is closer to 1,500 pounds per acre (1,680 kg/ha). Much of the forage is better for sheep than cattle.

This habitat type is the "classic" *Populus*-forb rangeland that provides a significant amount of the forage produced on western ranges. However, heavy livestock use, especially by sheep, can reduce the cover of forbs and, consequently, usable forage production. With severe overuse, *Lathyrus leucanthus*, which is unpalatable to livestock, may increase at the expense of palatable forbs. Ultimately this habitat type can be degraded into a *P. tremuloides/L. leucanthus* disclimax that may not recover.

The *P. tremuloides/T. fendleri* habitat type also provides habitat for numerous nongame animals, but management implications for them are unknown. This habitat type has the most visually appealing foreground of all *Populus*-dominated habitat types because of the usually wide spacing of large-diameter trees and the abundance of wildflowers in the undergrowth. Soils are well developed, and erosion usually is not a problem, except on deteriorated ranges. In some situations, potential for soil mass movement appears to be high, especially on steeper slopes or if the overstory is removed in large clearcut blocks. Annual precipitation is 25 to 40 inches (64 to 102 cm), with about one-half becoming runoff. Potential for increasing streamflow under management is unknown. The potential for dispersed recreation is moderate, but the potential for developed recreation is low because of susceptibility of *P. tremuloides* to damage.

PINUS CONTORTA SERIES

The *Pinus contorta* series forms a major forest type throughout the Gunnison National Forest in the upper montane and lower subalpine zones, except in the southern part of the study area, at elevations of 7,745 to 10,660 feet (2,861 to 3,250 m) (table 1). *P. contorta*'s occurrence in the Gunnison National Forest and elsewhere in the Rocky Mountains usually is attributed to widespread and repeated fires. There has been less agreement on its successional status. Many ecologists and foresters considered *P. contorta* a seral species that, in the absence of fire, would be replaced by forests dominated by *Picea engelmannii* and *Abies lasiocarpa* at higher elevations, and *Pseudotsuga menziesii* and *Pinus ponderosa* at lower elevations (Clements 1910, Daubenmire 1943, Mason 1915).

More recently, investigators have concluded that *P. contorta* is climax, or at least a long-lived subclimax species, in certain topoedaphic situations, especially on cold sites with thin, excessively drained soils. Moir (1969) and Radloff (1983) reported it to be climax within the upper montane zone of the Front Range of Colorado. Hoffman and Alexander (1976, 1980), Hess and Alexander (1986), and Alexander et al. (1986) described climax *P. contorta* forests in the Bighorn Mountains, Wyoming, occurring on soils derived from granites, and on the Arapaho, Medicine Bow, Roosevelt, and Routt National Forests. Hess and Wasser[2] also described climax *P. contorta* stands on the White River National Forest. Climax *P. contorta* forests are described in the Wind River and Absaroka Mountains, western Wyoming, by Steele et al. (1983). Cooper et al. (1987), Pfister et al. (1977), and Steele et al. (1981) reported apparently stable and climax *P. contorta* forests in Montana and Idaho. Mauk and Henderson (1984) also described climax *P. contorta* forests in northern Utah. Alexander (1988) summarized all plant associations in the Intermountain and Rocky Mountain Regions in which *P. contorta* is climax.

In the Gunnison National Forest, *P. contorta* was infrequently encountered in *P. menziesii*-, *P. ponderosa*-, and *Populus tremuloides*-dominated forests, but it was a common seral species in *A. lasiocarpa-P. engelmannii* forests. Seral *P. contorta* is more likely to be even-aged and bear a high proportion of serotinous cones. Where *P. contorta* is the dominant self-reproducing species, it may exhibit a population structure of several age classes and is not adversely affected by competition from its common associates. Climax *P. contorta* stands are more likely to contain a higher proportion of trees bearing nonserotinous cones.

In some areas, especially on dry, thin, excessively drained soils, *P. contorta* forms dense dog-hair stands with little undergrowth. In these situations, *P. contorta* may be a seral species that will occupy the site for hundreds of years, either because there is no seed source of climax species available for reinvasion, or establishment of *A. lasiocarpa*, *P. engelmannii*, and *P. menziesii* is so slow and difficult that *P. contorta* will never be fully replaced.

This series is represented by four stands and three habitat types. Tree sizes for those stands where measurements are available ranged from seedlings to the 20- to 24-inch (5- to 6-dm) d.b.h. class. Tree size and plant species data for *P. contorta* stands are shown in tables A–1 and A–6.

Pinus contorta/Juniperus communis

Description.—The *Pinus contorta/Juniperus communis* habitat type, represented by two stands, occurs in the warmest sites occupied by the *P. contorta* series. One stand in Taylor Canyon is on a nearly level stream terrace. The other stand is in the Slaughterhouse Creek Valley, west of Tincup, on a gentle (9%) southeast-facing slope about 2,000 feet (610 m) higher in elevation than the first stand. This infrequent topographic climax is confined to warm, rocky sites. Soils are moderately deep, coarse-textured sandy loams derived from a variety of parent materials (table 1).

The *P. contorta/J. communis* habitat type is recognized by the dominance and reproductive success of *Pinus contorta* in the overstory, and the dominance of *Juniperus communis* (7–10% cover) in the undergrowth (fig. 23). *Picea engelmannii* and *Pseudotsuga menziesii* may occur occasionally, but there is no evidence of sufficient reproduction to replace *P. contorta*. Important shrubs in addition to *J. communis* are *Arctostaphylos adenotricha* and *Rosa woodsii*. Major species in the depauperate herbaceous layer include *Calamagrostis purpurascens*, *Carex geyeri*, *Festuca idahoensis*, *Poa* spp., *Antennaria* spp., *Fragaria virginiana*, *Senecio neomexicana*, and *Selaginella densa*.

In Colorado, Hess and Alexander (1986) and Radloff (1983) described a *P. contorta/J. communis* habitat type on the Arapaho, Pike, and Roosevelt National Forests. This habitat type also occurs on the Medicine Bow National Forest in southeastern Wyoming (Alexander et al. 1986). In northwestern Wyoming and southwestern Idaho, Steele et al. (1983), and in northern Utah, Mauk and Henderson (1984) reported a *P. contorta/J. communis* community type that is similar to the habitat type described above, except that its successional status is unclear. This habitat type was not described on the Routt nor the White River National Forests (Hess and Wasser;[2] Hoffmann and Alexander 1980, 1983)). The *P. contorta/J. communis* habitat type is closely related to the *P. contorta/Arctostaphylos uva-urai* (*A. adenotricha*) habitat type described on the Pike National Forest (Radloff 1983), Bighorn National Forest in Wyoming (Hoffman and Alexander 1976), and in northern Utah (Mauk and Henderson 1984). The two habitat types can be difficult to distinguish when both *J. communis* and *A. adenotricha* are present.

Figure 23.—*Pinus contorta/Juniperus communis* habitat type in Slaughterhouse Creek Valley west of Tincup. *Carex geyeri* is the principal undergrowth associate of *J. communis*.

Management implications.—The *P. contorta/J. communis* habitat type has the lowest timber production potential of the *P. contorta* series. Regeneration is likely to be more difficult to obtain in this dry habitat type than in other *P. contorta*-dominated habitat types. Clearcutting or shelterwood cutting can be used in sawlog-sized stands regardless of cone habit. Scarification may improve natural regeneration success by reducing competitive vegetation, thereby conserving soil moisture. On south slopes and in tension zones, a long regeneration period usually follows clearcutting because of limited soil moisture. In those situations, a standard shelterwood system is more likely to result in regeneration success, but a shelterwood should not be used in dwarf mistletoe-infested stands. On other aspects, clearcutting usually is successful but can result in either too much or too little reproduction, depending on the cone habitat, amount of seed available, and slash disposal treatment (Alexander 1974, 1986b).

If a clearcut option is used in stands with nonserotinous cones, openings should be limited to small [3- to 5-acre (1- to 2-ha)] patches or narrow [400-foot (122-m) wide] strips where natural regeneration is desired. Large clearcut openings will require fill-in planting. In stands with serotinous cones, clearcut openings up to 40 acres (16 ha) may be used if the stand is heavily infested with dwarf mistletoe or infested with mountain pine beetles. Care must be used in slash disposal in these stands so that the seed source is not destroyed. Group selection cutting is a possibility in stands with irregular structure, but individual-tree selection cutting generally is appropriate only in recreation and critical wildlife areas when the objective is to create multistoried stands.

In young *P. contorta* pole stands, thinning is needed to reduce basal area and improve soil moisture. Growing stock levels (GSL) of 80 to 120 are most appropriate for timber production (Alexander and Edminster 1981). Forage production usually is increased slightly for a short time following clearcutting, but the potential for increasing forage production for either livestock or big game is low in this habitat type. Natural runoff in the *P. contorta/J. communis* habitat type is at least 8 inches (20 cm) annually. Much of the precipitation falls as snow. Streamflow can be increased by clearcutting in small patches, or using group shelterwood and group selection when the openings are near the maximum size [2 acres (0.8 ha)].

Pinus contorta/Carex geyeri

Description.—The *Pinus contorta/Carex geyeri* habitat type occurs in more mesic environments than the *P. contorta/Juniperus communis* habitat type. The *P. contorta/C. geyeri* habitat type occurs at the lowest elevations [7,800 feet (2,361 m)] in the *P. contorta* series (table 1). This habitat type was sampled in one stand on the west side of Marshall Pass on a gentle (3%) south-facing slope, but it commonly occurs throughout the *P. contorta* zone in Colorado. Soils in the sampled stand are a sandy loam.

This habitat type is recognized by the overstory dominance and reproductive success of *Pinus contorta*, and the dominance and abundance of *Carex geyeri* (40–65% cover) in the undergrowth (fig. 24). The sparse shrub layer is represented by *Ribes montigenum, Rosa woodsii* and *Symphoricarpos oreophilus*. Herbaceous vegetation dominates the undergrowth. In addition to *C. geyeri, Bromus porteri, Calamagrostis canadensis, Festuca saximontana, Achillea lanulosa, Arnica cordifolia, Astragalus alpinus, Erigeron subtrinervis, Fragaria virginiana*, and *Thermopsis montana* have significant cover.

A *P. contorta/C. geyeri* habitat type has been reported in Colorado on the Arapaho and Roosevelt National Forests by Hess and Alexander (1986), on the White River National Forest by Hess and Wasser,[2] and on the Medicine Bow National Forest in Wyoming by Alexander et al. (1986). Hoffman and Alexander (1976, 1980, 1983) did not identify this habitat type on either the Routt or White River National Forest in Colorado, or in the Bighorn Mountains of north-central Wyoming; but, *P. contorta* is a long-lived seral member of the *A. lasiocarpa/C. geyeri* habitat type on these forests. *P. contorta*-dominated stands seral to the *A. lasiocarpa/C. geyeri* habitat type are less evident on the Gunnison National Forest. In northwestern Wyoming and central Idaho, Steele et al. (1981, 1983) reported a *P. contorta/C. geyeri* community type that has similar characteristics, although there are some differences in floristic composition.

Figure 24.—*Pinus contorta/Carex geyeri* habitat type, west side of Marshall Pass. Undergrowth is dominated by *C. geyeri*, but *Arnica latifolia* and *Fragaria virginiana* are well represented.

Management implications.—Timber productivity in this habitat type is average to below average. Site indexes are likely to be below average (Alexander 1966). Even-aged management, under either a clearcutting or shelterwood alternative, is recommended for most stands (Alexander 1986b). However, natural regeneration may be difficult to obtain after clearcutting because the *C. geyeri*-dominated undergrowth competes severely with tree seedlings. A shelterwood cutting alternative has the advantage of better control over undergrowth development and may better meet wildlife cover and visual requirements.

Although most stands in the *P. contorta/C. geyeri* habitat type bear serotinous cones, clearcutting in large openings is not recommended, even in those situations where stands are infested with dwarf mistletoe or susceptible to attack by mountain pine beetles, because competition between seedlings and *C. geyeri* offsets the probable reduction in insect and disease losses by increasing the likelihood that large openings will take a long time to regenerate. A better option would be to use the opening size recommended for stands with nonserotinous cones.

Regardless of the size of opening, in stands with serotinous cones care must be used in slash disposal and seedbed preparation so that the seed source is not destroyed.

Uneven-aged management under individual-tree or group selection cutting can reduce stand susceptibility to mountain pine beetles 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 areas. Growth will be substantially reduced, however, with either uneven-aged cutting method.

In young *P. contorta* pole stands, thinning is needed to reduce basal area to improve growth and soil moisture. GSLs of 100 to 120 are most appropriate for timber production (Alexander and Edminster 1981). Forage production is fair to poor and not likely to be improved by cutting. Wildlife habitat is poor, and the potential for increasing it is low. Big game use is limited, and nongame bird and small mammal populations are sparse. Stands often are dominated solely by *P. contorta* and *C. geyeri*.

Natural runoff in the *P. contorta/C. geyeri* habitat type is 8 to 10 inches (20 to 25 cm) annually. Much of the precipitation falls as snow. Streamflow can be increased substantially by clearcutting about one-third of the area in small [3- to 5-acre (1- to 2-ha)] patches interspersed with uncut timber (Leaf 1975, Leaf and Alexander 1975, Troendle 1983, Troendle and King 1985). If larger openings are cut, slash should be left in place to create surface roughness needed to retain the snowpack. Streamflow also can be increased by partial cutting on north slopes, but runoff may be less than with clearcutting (Troendle and Meiman 1984). Group shelterwood and group selection cutting can be nearly as favorable for water production as clearcutting if the openings are near the maximum size [2 acres (1 ha)].

Pinus contorta/Vaccinium scoparium

Description.—The *Pinus contorta/Vaccinium scoparium* habitat type was sampled in only one stand on the Gunnison National Forest, but it extends to the upper altitudinal limits of the *P. contorta* series throughout Colorado. It grows on sites that appear too shallow, rocky, and well drained to permit establishment of *Abies lasiocarpa* and *Picea engelmannii* in sufficient numbers to replace *P. contorta*. The stand sampled is below Old Monarch Pass on a gentle (9%) west-facing slope. Soils are a shallow sandy loam (table 1).

This habitat type is recognized by the overstory dominance and reproductive success of *Pinus contorta*. The presence of an occasional *Abies lasiocarpa* and *Picea engelmannii* is not sufficient to indicate replacement of *P. contorta*. The depauperate undergrowth is dominated by *Vaccinium scoparium* (18% cover) (fig. 25). The only other shrub in the sampled stand was *Juniperus communis*. Herbaceous vegetation, which is unconspicuous and poorly represented, includes *Carex brevipes*, *Poa pratensis*, *Antennaria* spp., *Sedum lanceolatum*, *Senecio neomexicanus*, and *Solidago multiradiata*.

A *P. contorta/V. scoparium* habitat type was reported in the Bighorn Mountains by Hoffman and Alexander (1976), on the Arapaho and Roosevelt National Forests by Hess and Alexander (1986), and on the Medicine Bow National Forest by Alexander et al. (1986). Although Hoffman and Alexander (1980, 1983) did not report this habitat type on the Routt National Forest or on the White River National Forest, they described an *A. lasiocarpa/V. scoparium* habitat type that had *P. contorta* as a long-lived seral. A similar community type was reported in Montana by Pfister et al. (1977), in central Idaho by Steele et al. (1981), in northwestern Wyoming by Steele et al. (1983), in northern Idaho by Cooper et al. (1987), and in the Uinta Mountains, Utah, by Mauk and Henderson (1984).

Figure 25.—*Pinus contorta/Vaccinium scoparium* habitat type below Old Monarch Pass, Sawatch Range. *V. scoparium* and *Juniperus communis* are the principal undergrowth species.

Management implications.—Site indexes and timber productivity in the *P. contorta/V. scoparium* habitat type are the highest in the *P. contorta* series (Alexander 1966), but are average to below average and much lower than in stands of *P. contorta* that are seral to *Abies lasiocarpa* and *Picea engelmannii*. Even-aged management under either a clearcutting or shelterwood cutting alternative is recommended for most stands (Alexander 1986b). A shelterwood system has the advantages of meeting wildlife cover and visual management requirements, while at the same time providing shade needed to conserve soil moisture and control overstocking. It also provides some control over dwarf mistletoe and bark beetles, although clearcutting is a more effective silvicultural pest control. Clearcutting can result in either too much or too little reproduction, depending on the cone habit, amount of seed available, climatic factors, and slash disposal treatments (Alexander 1974, 1986b).

If a clearcut option is used in stands with nonserotinous cones, openings should be 3- to 5-acre (1- to 2-ha) patches or narrow 400-foot (122-m) wide strips where natural regeneration is desired. Large clearcut openings will require fill-in planting. In stands with serotinous cones, clearcut openings up to 40 acres (16 ha) may be used if the stand is heavily infested with dwarf mistletoe or infested with mountain pine beetles. However, smaller openings, 5 to 20 acres (2 to 8 ha), better meet the objectives of multiresource management. Care must be used in slash disposal so that the seed source is not destroyed.

Uneven-aged management under individual-tree or group selection cutting can reduce stand susceptibility to mountain pine beetles 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 wildlife areas. Growth will be substantially reduced, however, with either uneven-aged cutting method.

Poletimber stands in this habitat type have better spacing and crown class differentiation than in other *P. contorta*-dominated habitat types. Thinning to GSLs of 120 to 160 is most appropriate for individual tree and stand growth (Alexander and Edminster 1981).

The *P. contorta/V. scoparium* habitat type is fair high-elevation summer range for wildlife. Forage production is moderate to fair for livestock and big game but can be increased substantially [to 500 pounds per acre (560 kg/ha)] for short periods of time after clearcutting, provided that there is a good response by herbaceous vegetation. Larger increases may be possible but are not likely because sites are cold, with a short growing season. Natural runoff in the *P. contorta/V. scoparium* habitat type is 12 to 15 inches (30 to 38 cm). Much of the precipitation falls as snow. Streamflow can be increased substantially by clearcutting about one-third of the area in small [3- to 5-acre (1- to 2-ha)] patches interspersed with uncut timber (Leaf 1975, Leaf and Alexander 1975, Troendle 1983, Troendle and King 1985). If larger openings are cut, slash should be left in place to create surface roughness needed to retain the snowpack. Streamflow also can be increased by partial cutting on north slopes, but runoff may be less than with clearcutting (Troendle and Meiman 1984). Group shelterwood and group selection cutting can be nearly as favorable for water production as clearcutting if the openings are near the maximum size. The potential for developed and dispersed recreation is moderate because of the elevations at which this habitat type occurs and the limited acreage.

PINUS FLEXILIS SERIES

The *Pinus flexilis* series is relatively rare on the Gunnison National Forest. It usually occurs on exposed, windswept, concave rocky ledges and ridgetops. The *P. flexilis* series was sampled in only one well-developed stand at 9,005 feet elevation (2,744 m) (table 1). Tree size data are not available for this series. Plant species data for *P. flexilis* are shown in table A–7.

Pinus flexilis/Ciliaria austromontana

Description.—The *Pinus flexilis/Ciliaria austromontana* (*Saxifraga bronchialis*) habitat type was sampled in only one stand on a steep (53%) southwest-facing canyon side in Spring Canyon. Soils are a shallow sandy loam (table 1).

The *P. flexilis/C. austromontana* habitat type is recognized by the overstory dominance and reproductive success of *Pinus flexilis*, and the abundance of *Ciliaria austromontana* (10% cover) in the undergrowth (fig. 26). *Pseudotsuga menziesii* is an occasional tree associate. The shrub layer includes *Juniperus communis, Ribes inerme, Rosa woodsii,* and *Symphoricarpos oreophilus*. Graminoids with significant cover are *Agrostis hiemalis, Carex geophila, Festuca thurberi, Poa nemoralis* ssp. *interior*, and *Poa reflexa*. In addition to *C. austromontana, Fragaria virginiana* is the only forb with significant cover.

The *P. flexilis/C. austromontana* habitat type has not been reported elsewhere in Colorado (Alexander 1987) or in the Rocky Mountain and Intermountain regions (Alexander 1988). This habitat type is somewhat similar to the *P. flexilis/J. communis* habitat type reported on the Arapaho and Roosevelt National Forests by Hess and Alexander (1986), except that the composition of the forb layer is different.

Management implications.—This dry habitat type has very low productivity for timber production because of low stand density and slow tree growth. Forage value for big game is low to moderate; the habitat type is probably used by mule deer in the spring and fall. Overstory trees adjacent to grasslands may provide cover for wildlife. The rocky ridges with sparse tree canopy can be important transitional range for bighorn sheep. *P. flexilis* seeds are large and are food for birds and small mammals. High surface temperatures and low soil moisture may impede regeneration or revegetation, especially on disturbed areas. There is little or no potential for increasing streamflow, but the *P. flexilis/C. austromontana* habitat type provides watershed protection.

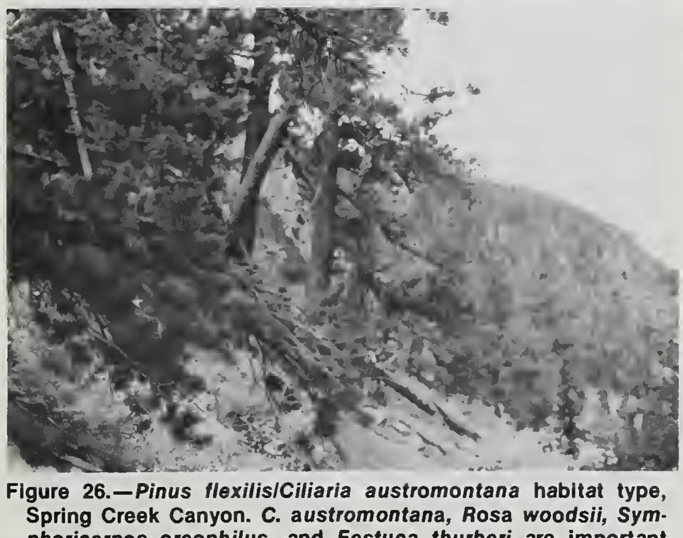

Figure 26.—*Pinus flexilis/Ciliaria austromontana* habitat type, Spring Creek Canyon. *C. austromontana, Rosa woodsii, Symphoricarpos oreophilus,* and *Festuca thurberi* are important undergrowth species.

PINUS ARISTATA SERIES

Pinus aristata is not a major forest tree species on the Gunnison National Forest. It occurs mainly in the southern part of the study area, with the largest stands centered around Cochetopa Pass, at elevations ranging from 9,940 to 11,865 feet (2,878 to 3,616 m) (table 1). Small isolated stands occur further north. This series is represented by seven stands and three habitat types. Tree sizes for those stands where measurements were made ranged from seedlings to the ≥28-inch (≥7-dm) d.b.h. class. Tree populations and plant species data for *P. aristata* are shown in tables A–1 and A–7.

Pinus aristata/Festuca thurberi

Description.—The *Pinus aristata/Festuca thurberi* habitat type was sampled in one stand below Cumberland Pass on a moderate (21%) west-facing slope. Soils are shallow and loamy (table 1).

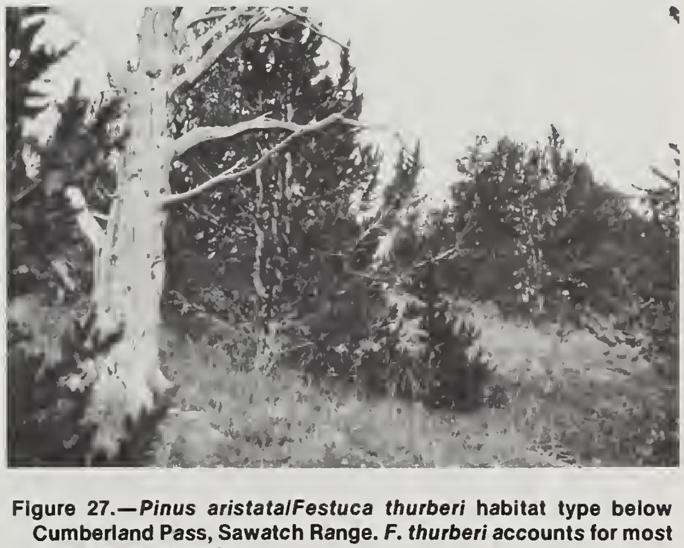

Figure 27.—*Pinus aristata/Festuca thurberi* habitat type below Cumberland Pass, Sawatch Range. *F. thurberi* accounts for most of the undergrowth.

The *P. aristata/F. thurberi* habitat type is recognized by the overstory dominance and reproductive success of *Pinus aristata*. *Picea engelmannii* is a minor codominant in the sampled stand. *Festuca thurberi* has the highest coverage (15%) in the undergrowth (fig. 27). *Juniperus communis* and *Ribes montigenum* were the only shrubs present. In addition to *F. thurberi*, other graminoids include *Elymus trachycaulus*, *Koeleria macrantha*, and *Poa glauca*. The forb layer is a rich mixture of species, but no individual species had more than 2% cover. The *P. aristata/F. thurberi* habitat type has been reported in southern Colorado and northern New Mexico (DeVelice et al. 1986). It has not been reported elsewhere in Colorado (Alexander 1987) or in the Rocky Mountain and Intermountain regions (Alexander 1988).

Management implications.—Timber productivity in this habitat type is very low because of poor site quality and low stand density; *Pinus aristata* is the oldest and slowest growing tree in the Rocky Mountains, with a maximum age of about 1,600 years. Stands in the *P. aristata/F. thurberi* habitat type generally have a park-like appearance, with widely spaced trees or occasional groups of trees interspersed with *Festuca*-dominated meadows. The potential for forage production is high on sites with high cover of *F. thurberi*. Forage is more palatable to cattle than sheep, but stands usually are not important rangelands because *F. thurberi* is only moderately palatable to cattle and only in the early season. Moreover, the generally remote locations of this habitat type make access difficult. The *P. aristata/F. thurberi* habitat type is important summer range for elk. This habitat type also is important for watershed protection. It is esthetically valuable because of the usually pleasing appearance of the old and gnarled *P. aristata*.

Pinus aristata/Juniperus communis

Description.—The *Pinus aristata/Juniperus communis* habitat type was sampled in one stand near Cochetopa Pass on a moderate (14%) southeast-facing slope below a rocky ridge. The soil is a shallow sandy loam (table 1).

The *P. aristata/J. communis* habitat type is recognized by the overstory dominance and reproductive success of *Pinus aristata*, and the presence and abundance of *Juniperus communis* (16% cover) in the undergrowth (fig. 28). *Pinus flexilis* is an overstory associate. Major shrubs are *J. communis* and *Rosa woodsii*. The most important graminoids are *Carex geyeri*, *Koeleria macrantha*, *Muhlenbergia montana*, and *Poa fendleriana*. Forbs with the highest coverage include *Androsace septentrionalis*, *Artemisia dracunculus*, *Artemisia frigida*, and *Erigeron subtrinervis*. This habitat type has not been identified elsewhere in Colorado (Alexander 1987) or in the Rocky Mountain and Intermountain regions (Alexander 1988).

Management implications.—Timber productivity is very low in this habitat type. Trees are open grown, short, and slow growing. The potential for forage production is low because of the paucity of palatable forage species. The habitat type may have some use as summer elk habitat and transitory bighorn sheep range. The *P. aristata/J. communis* habitat type provides watershed production and scenic beauty.

Figure 28.—*Pinus aristata/Juniperus communis* habitat type below Cochetopa Pass, Cochetopa Hills. *J. communis*, *Koeleria macrantha*, and *Poa fendleriana* are the principal undergrowth species.

Pinus aristata/Festuca arizonica

Description.—The *Pinus aristata/Festuca arizonica* habitat type is represented by five stands. Two of these stands (160, 229) were originally classified by Karmakova[3] as a *Pinus aristata/Muhlenbergia montana* habitat type. This habitat type is the most widespread in the *P. aristata* series. Sampled stands are located below Cochetopa Pass and in Cebolla Creek Canyon, on gentle (9%) to steep (51%) slopes with southern to eastern aspects. Soils are shallow sandy loam (table 1).

The *P. aristata/F. arizonica* habitat type is recognized by the overstory dominance and reproductive success of *Pinus aristata*. *Populus tremuloides*, *Picea pungens*, and *Pinus flexilis* are occasional tree associates. The undergrowth is dominated by *Festuca arizonica* (9–20% cover) and *Muhlenbergia montana* (2–25% cover) (fig. 29). The major shrub species is *Ribes cereum*. In addition to *F. arizonica* and *M. montana*, graminoids with significant cover are *Carex geyeri*, *Danthonia parryi*, *Elymus elymoides*, and *Koeleria macrantha*. Forbs are sparse, with *Artemisia frigida* and *Geranium caespitosum* having the highest cover. The *P. aristata/F. arizonica* habitat type has been reported in the San Juan National Forest and Sangre de Cristo Mountains of northern New Mexico (DeVelice et al. 1986). It has not been identified elsewhere in Colorado (Alexander 1987) or in the Rocky Mountain and Intermountain regions (Alexander 1988).

Management implications.—Timber productivity and stand conditions in the *P. aristata/F. arizonica* habitat type are similar to other habitat types in the *P. aristata* series. The potential for forage production is high, because both *F. arizonica* and *M. montana* have high cover. Both species are more palatable to cattle than sheep. Moreover, the stands in this habitat type are accessible to livestock, except when they occur on steep slopes. The *P. aristata/F. arizonica* habitat type is summer range for elk, providing both food and cover. This habitat type provides watershed protection and a pleasing esthetic appearance.

ABIES LASIOCARPA SERIES

The *Abies lasiocarpa* series represents the subalpine zone throughout the Gunnison study area. It occupies the highest and coldest coniferous forest zone on the Gunnison National Forest, dominated by *A. lasiocarpa* and *Picea engelmannii* (table 1). Throughout much of the Rocky Mountains, the subalpine forest zone is widespread and supports forests of considerable importance. On the Gunnison National Forest, it is found on all aspects at elevations ranging from 8,835 to 11,540 feet (2,693 to 3,517 m), a span of 2,705 feet (824 m) (table 1). It has been reported as low as 8,000 feet (2,440 m) to as high as 11,800 feet (3,870 m) in the central Rocky Mountains. On the Gunnison National Forest, the lower elevational limits of *A. lasiocarpa-Picea engelmannii*-dominated forests and the upper elevational limits of the *Pinus contorta*-dominated forests overlap considerably. The upper limit of *Populus tremuloides* also overlaps somewhat, but is below the upper limit of *Pinus contorta*. Aspect and soils also play some part in the distribution of forest tree species.

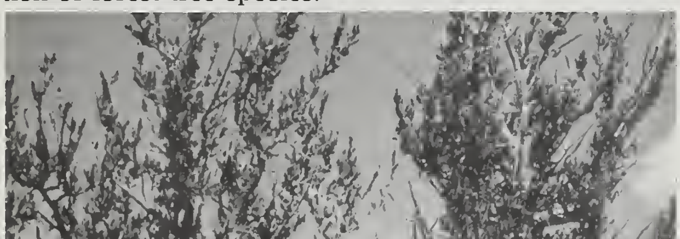

Figure 29.—*Pinus aristata/Festuca arizonica* habitat type in Cebolla Creek Canyon. *F. arizonica* and *Muhlenbergia montana* dominate the undergrowth.

Although *Picea engelmannii* may be the climax or sole dominant on some plots sampled, the habitat types described in this series are all named for *Abies lasiocarpa* as the climax dominant to be consistent with usage elsewhere (Alexander et al. 1986; Daubenmire and Daubenmire 1968; Hess and Alexander 1986; Hoffman and Alexander 1976, 1980, 1983; Mauk and Henderson 1984; Pfister et al. 1977; Steele et al. 1981, 1983). On the Gunnison National Forest, *P. engelmannii* usually is a co-climax dominant with little evidence that it will ever be completely replaced by *A. lasiocarpa*. Young *A. lasiocarpa* often outnumber the young *P. engelmannii*, because *A. lasiocarpa* is more tolerant and reproduces by layering and from seed, whereas *P. engelmannii* reproduces almost entirely from seed. Because *P. engelmannii* live longer, they are nearly always the largest trees in the stand. An exception occurs in stands where *P. engelmannii* has been severely attacked by the spruce beetle (*Dendroctonus rifipennis* Kirby) (Schmid and Hinds 1974). In some instances, *P. engelmannii* may be the dominant species in both the overstory and the understory. Moreover, some stands may contain only *A. lasiocarpa* or *P. engelmannii*.

In many stands, *P. contorta* and/or *P. tremuloides* are present as seral species. After disturbance, *P. tremuloides* may establish initially to be succeeded by *P. contorta*, which in turn is replaced by *A. lasiocarpa* and *P. engelmannii*. *P. tremuloides* or *P. contorta* may establish after disturbance and be directly replaced by *A. lasiocarpa* and *P. engelmannii*. *A. lasiocarpa* and *P. engelmannii* can reestablish immediately with or without *P. contorta* and/or *P. tremuloides*, depending on the topographic situation, the type of disturbance, and the availability of coniferous tree seed or the sprouting capacity of *Populus*.

The Gunnison National Forest is near the southeastern limit of the natural distribution of *P. contorta*. To the south in the Rocky Mountains, there is no comparable seral tree species in the *A. lasiocarpa* series above the upper limit of *P. tremuloides* stands. On the western slope of Colorado, *P. contorta*'s distribution is nearly the complement of *P. ponderosa*, in areal extent and elevation. Based on the distribution of tree species, there appears to be a major climatic break in forest composition near the southern boundary of the Gunnison National Forest. This change in climate is paralleled by the gradual replacement of *Vaccinium scoparium*, a common undergrowth species in subalpine forests to the north, by *V. myrtillus*, a common undergrowth species in subalpine forests to the south. This break also coincides with the gradual replacement of *Carex geyeri*, common to the north, by other *Carex* species to the south.

This series is represented by 19 stands and nine habitat types.[10] In those stands where measurements were made, tree sizes ranged from seedlings to the ≥28-inch (≥7-dm) d.b.h. class. Tree size and plant species data for *A. lasiocarpa* stands are shown in tables A–1 and A–8.

[10]*Komarkova*[3] *identified an Abies lasiocarpa/Salix glauca (Abies lasiocarpa-Picea engelmannii/Salix glauca) habitat type on the Gunnison National Forest. It is omitted from this paper because it is krummholz, not a forest habitat type.*

Abies lasiocarpa/Carex geyeri

Description.—The *Abies lasiocarpa/Carex geyeri* habitat type is represented by four stands located on warm, moderately dry sites ranging from the upper montane to the middle subalpine zones. Two of the sampled stands, near the Overland Reservoir and in the East Fork Creek Valley of the West Elk Creek Mountains, are in climax *Abies lasiocarpa-Picea engelmannii* stands. The third and fourth stands, on Alpine Plateau and in Gold Creek Valley, northwest of Pitkin, are late-seral *Populus tremuloides-A. lasiocarpa/C. geyeri* (stand 178) and *Pinus contorta/Carex geyeri* (stand 234) community types successional to the *A. lasiocarpa/C. geyeri* habitat type. In Komarkova's[3] original classification, stand 234 was identified as a *P. contorta/C. geyeri* habitat type, but *P. contorta* shows no evidence of self-perpetuation. These stands are on gentle (2–7%) east- to southeast-facing slopes. Soils are loamy to sandy loams (table 1).

This habitat type is distinguished by the dominance of *Carex geyeri* in the undergrowth, and the scarcity or near absence of *Vaccinium myrtillus* and *Vaccinium scoparium* (fig. 30). The overstory dominants are *Abies lasiocarpa* and *Picea engelmannii. Pinus contorta* and *Populus tremuloides* are common overstory seral species that may dominate mid to late seral stages, but neither

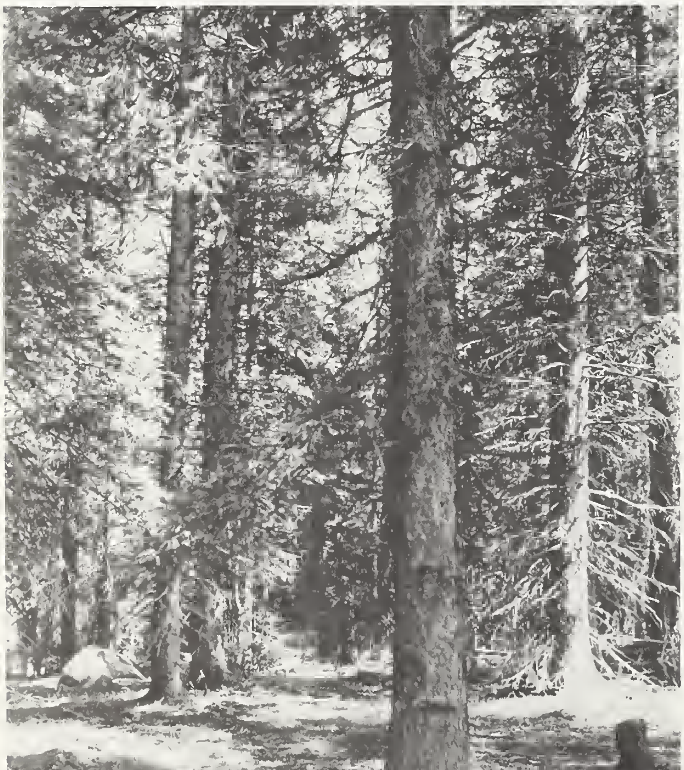

Figure 30.—*Abies lasiocarpa/Carex geyeri* habitat type near Overland Reservoir, Paonia District. *Lupinus argenteus* is the principal undergrowth associate of *C. geyeri.*

species shows any significant evidence of long-term self-perpetuation. *Pseudotsuga menziesii* occurred as an occasional in one stand. Important undergrowth species in addition to *Carex geyeri* (3–65% cover) are *Juniperus communis, Mahonia repens, Paxistima myrsinites, Vaccinium caespitosum, Arnica cordifolia, Arnica latifolia, Fragaria virginiana, Lathyrus leucanthus, Thalictrum fendleri,* and *Veronica americana*. The high cover of *P. myrsinities* (18%) in one stand (234) suggests the possibility that this seral stand may ultimately develop into an *Abies lasiocarpa/Paxistima myrsinites* habitat type. However, the site characteristics are not what is normally associated with *P. myrsinites*-dominated undergrowth. Additional sampling is needed to confirm the occurrence of an *A. lasiocarpa/P. myrsinites* habitat type on the Gunnison National Forest.

The *A. lasiocarpa/C. geyeri* habitat type was described in the Routt National Forest by Hoffman and Alexander (1980), in the White River National Forest by Hoffman and Alexander (1983) and Hess and Wasser,[2] in the Arapaho National Forest by Hess and Alexander (1986), in the Grand Mesa and Uncompahgre National Forests by Hoffman,[5] and in the Medicine Bow National Forest by Alexander et al. (1986). This habitat type also has been reported in western Wyoming in Yellowstone National Park and the Teton National Forest (Steele et al. 1983), and in the mountains of central and southern Utah (Youngblood and Mauk 1985). In Montana, *A. lasiocarpa/C. geyeri* is a minor habitat type, occurring on cold, dry sites (Pfister et al. 1977) but is common in central Idaho on granitic soils (Steele et al. 1981).

Management implications.—In stands where *P. tremuloides* is present as a seral species in the *A. lasiocarpa/C. geyeri* habitat type, it usually sprouts vigorously after disturbance. These stands typically produce large amounts of undergrowth vegetation quickly after disturbance (Johnston and Hendzel[8]). *P. tremuloides* may dominate a long midseral stage in which there are a number of cycles of *Populus* before *A. lasiocarpa* and *P. engelmannii* dominate, especially in the absence of a conifer seed source. These stands may have high value as livestock forage and wildlife habitat. They are high-quality, summer range for deer and elk, and the mixed stand of *P. tremuloides* and seedling-sapling conifers provides a large diversity of habitats for birds and small mammals. Where *P. tremuloides* is a desirable species for timber management, these stands provide an excellent opportunity for manipulative management directed toward maintaining *P. tremuloides* in the stand, since they occupy more stable sites than climax *P. tremuloides* habitat types. In addition, there are substantial forage and wildlife benefits associated with arresting natural succession.

Stands where *Pinus contorta* is seral in the *A. lasiocarpa/C. geyeri* habitat type are not common on the Gunnison National Forest; but where they occur, undergrowth vegetation recovers slowly from major disturbance. Reproduction of conifers is more difficult to obtain, and competition between tree seedlings and undergrowth vegetation is more evident than in the *A. lasiocarpa/Vaccinum scoparium* habitat type. In fact, if tree seedlings are slow to establish after clearcutting, the site may become fully occupied by *C. geyeri*. *P. contorta* will likely be better able to compete successfully with *C. geyeri* following major disturbance than either *A. lasiocarpa* or *P. engelmannii*.

Stands where *P. contorta* is seral have limited potential for forage production and wildlife. Moreover, soils exposed as a result of management activities may be more difficult to revegetate than soils where *P. tremuloides* is seral. Timber productivity for *P. contorta*, *A. lasiocarpa*, and *P. engelmannii* is average to below average. Productivity for *P. tremuloides* may be moderately high. Cutting methods applicable are similar to those suggested for the *A. lasiocarpa/V. scoparium* habitat type; however, seral stands of *P. contorta* are more likely to be susceptible to mountain pine beetle in the *A. lasiocarpa/C. geyeri* habitat type (Alexander 1986a). Where there is an appreciable amount of either *P. contorta* or *P. tremuloides* in the stands, clearcutting or simulated shelterwood is likely to increase their representation in the new stand. GSLs of 120 to 140 are most appropriate for climax stands managed for timber (Alexander and Edminster 1980).

Natural runoff [12 to 15 inches (30 to 38 cm)] usually is less than in the *A. lasiocarpa/V. scoparium* habitat type but can be increased significantly using the same cutting methods suggested for *A. lasiocarpa/V. scoparium* habitat type. The potential for dispersed recreation is moderate, but developed recreation may be high where *P. tremuloides* is seral because of site stability combined with high visual values. However, care must be exercised to minimize damage to *P. tremuloides* that can result in subsequent decay and eventual death of the stand. Potential for developed recreation in stands without *P. tremuloides* is moderate.

Abies lasiocarpa/Vaccinium scoparium

Description.—Although the *Abies lasiocarpa/Vaccinium scoparium* habitat type occurs extensively throughout the central Rocky Mountains, it is found only to a limited extent at higher elevations on the Gunnison National Forest. Most *A. lasiocarpa-Picea engelmannii*-dominated stands in the study area with *Vaccinium* have *Vaccinium myrtillus* in their undergrowth; the transition occurs from north to south at the approximate middle of the study area. The *A. lasiocarpa/V. scoparium* habitat type is represented by only one stand near Schofield Pass on a moderate (12%) northwest-facing slope. Soils are shallow, coarse-textured sandy loams (table 1).

The habitat type is recognized by the almost constant presence and reproductive success of *Abies lasiocarpa*, and by the abundance and undergrowth dominance of *Vaccinium scoparium*, sometimes in association with *Vaccinium myrtillus*. *Picea engelmannii* is present as a self-reproducing co-climax species (fig. 31). The overstory of most of the stands is dominated by *P. engelmannii*, with *A. lasiocarpa* as a codominant. *Pinus contorta* is an important seral species and still dominates some of the stands in late stages of succession. However, the

Figure 31.—*Abies lasiocarpa/Vaccinium scoparium* habitat type near Schofield Pass. *Vaccinium myrtillus* is the principal undergrowth associate of *V. scoparium*.

self-reproducing species in these stands are *A. lasiocarpa* and *P. engelmannii*. *Populus tremuloides* is only an occasional seral species. Ground cover varies from sparse to luxuriant. In general, undergrowth species richness declines as stands progress from seral to climax and from young to old. In addition to *V. scoparium* and *V. myrtillus*, which constitute more than 50% of the cover, other important undergrowth species include *Ribes coloradense*, *Arnica cordifolia*, *Caltha leptosepala*, *Castilleja rhexifolia*, *Pedicularis racemosa*, *Polemonium pulcherrimum*, and *Senecio triangularis*.

The *A. lasiocarpa/V. scoparium* habitat type, or others very similar to it, occur throughout the northern and central Rocky Mountains (Alexander et al. 1986; Cooper et al. 1987; Hess and Alexander 1986; Hoffman;[5] Hoffman and Alexander 1976, 1980, 1983; Mauk and Henderson 1984; Moir and Ludwig 1979; Pfister et al. 1977; Steele et al. 1981, 1983). However, there is considerable variability in the cover of *V. scoparium* within this habitat type. Additionally, more broad-leaved herbaceous dicots occur in this habitat type on the western slope of the Rocky Mountains than on the eastern slope.

Management implications.—Timber productivity for the climax species in the *A. lasiocarpa/V. scoparium* habitat type varies considerably (Alexander 1967). Productivity for *P. contorta* can be moderately high. Undergrowth vegetation changes slowly after major disturbance, and competition is not severe between tree seedlings and undergrowth vegetation, except where cover of herbaceous dicots is high. *P. engelmannii* reproduction may be difficult to obtain on south slopes and other dry situations. There may be a manageable stand of advanced *Abies* and *Picea* reproduction in much of this habitat type, especially in late seral stages.

While most silvicultural systems can be used (Alexander 1986a), complete removal of the mature overstory by clearcutting in mixed stands, where *P. contorta* makes up part of the overstory, may result in an even-aged replacement stand of seral *P. contorta*. This also can happen with the final harvest cut under shelterwood methods, unless extreme care is taken in logging to protect advanced regeneration of *A. lasiocarpa* and *P.*

engelmannii. In these mixed stands, using a standard or modified shelterwood system, the proportion of P. contorta retained in the first cut can be used to manipulate the amount of A. lasiocarpa and P. engelmannii in the stand. Clearcutting, even in small 3- to 5-acre (1- to 2-ha) or 400-foot wide (122-m) openings, is likely to eliminate the chance for regeneration of P. engelmannii on southerly exposures for extremely long periods of time. GSLs of 120 to 160 are appropriate for stands managed for timber (Alexander and Edminster 1980).

Where protection from direct solar radiation and reduction of excessive moisture losses from soil and seedlings are necessary for survival of P. engelmannii, standard or modified shelterwood is an appropriate even-aged cutting method (Alexander 1977, 1986c, 1986d). P. contorta may have to be planted on south aspects to maintain forest cover if clearings occur or are desired in this habitat type.

Uneven-aged management with group and/or individual-tree selection cutting can be used in irregular-structured stands, or where the combination of openings and high forest is required to enhance recreational opportunities and other amenities. Group selection is likely to perpetuate the existing species mix, but may increase the proportion of P. contorta.

Individual-tree selection will favor A. lasiocarpa over P. engelmannii, in mixed stands containing P. contorta; the proportion of both A. lasiocarpa and P. engelmannii will be increased, especially if the initial cutting removes a large proportion of P. contorta. The A. lasiocarpa/V. scoparium habitat type is not usually used by livestock but is medium-quality big game summer range. This habitat type also provides habitat for many birds and mammals. It occupies areas with the greatest potential for water yield [up to 15 inches (38 cm) of natural runoff annually] on the Gunnison National Forest. Small patch [3- to 5-acre (1.2- to 2.0-ha)] or strip [400-foot wide (122-m)] clearcuts result in greater forage production for big game [450 to 500 pounds per acre (504 to 560 kg/ha)] and larger increases in water available for streamflow than either shelterwood, group selection, or individual-tree selection cutting (Alexander 1977, 1986d; Alexander and Edminster 1980; Leaf 1975; Leaf and Alexander 1975; Regelin and Wallmo 1978; Wallmo et al. 1972). If larger openings are cut, slash should be left in place to create surface roughness needed to retain snowpack. Streamflow in these openings will be about 66% to 75% of the runoff in small patch or strip clearcuts.

Streamflow can be increased with partial cutting on north slopes, but the average increase may not be as great as with clearcutting in small patches or strips (Troendle and Meiman 1984). Because of the increase in tree reproduction, forage production begins to decline in about 15 to 20 years, and water production in 20 to 30 years. Therefore, new openings must be cut periodically to maintain increases in forage and water.

Abies lasiocarpa/Vaccinium myrtillus

Description.—*Abies lasiocarpa/Vaccinium myrtillus* is the most widespread habitat type in this series on the Gunnison National Forest. Here, it occurs in the upper montane and lower subalpine zones at lower elevations than occupied by the A. lasiocarpa/Vaccinium scoparium habitat type, although further to the south the replacement becomes more complete at all elevations. The A. lasiocarpa/V. myrtillus habitat type is represented by three stands. One stand is on Sargents Mesa on a gentle (3%) southeast-facing slope; another is near Marshall Pass on a gentle (5%) northeast-facing slope; and the third stand is just below Monarch Pass on a steep (31%) southwest-facing slope. One stand (231) originally was classified by Komarkova[3] as a late seral Pinus contorta/V. myrtillus community type successional to the A. lasiocarpa/V. myrtillus habitat type. Another stand (93) was originally classified by Komarkova[3] as a P. contorta/V. myrtillus habitat type, but there is no evidence that P. contorta is self-perpetuating in this stand. Soils in this habitat type are loamy (table 1).

Figure 32.—*Abies lasiocarpa/Vaccinium myrtillus* habitat type on Sargents Mesa, Cochetopa Hills. *V. myrtillus* is the principal undergrowth species. *Vaccinium scoparium* is absent.

The A. lasiocarpa/V. myrtillus habitat type is normally recognized by the almost constant presence and reproductive success of Abies lasiocarpa, and by the abundance and undergrowth dominance of Vaccinium myrtillus and near absence of Vaccinium scoparium. Picea engelmannii is usually present as a self-reproducing co-climax species (fig. 32). In two of the stands sampled (93 and 231) A. lasiocarpa was not present. This suggests the possibility of either a *P. engelmannii/V. myrtillus* habitat type or an *A. lasiocarpa/V. myrtillus* habitat type, *P. engelmannii* phase. A *P. engelmannii/V. myrtillus* habitat type has been described in northern and southwestern New Mexico, and the Front Range and southern Colorado (DeVelice et al. 1986, Fitzhugh et al. 1987, Moir and Ludwig 1979, Radloff 1983). However, *A. lasiocarpa* was either a minor dominant or at least present in the stands sampled. Because the sampled stands on the Gunnison National Forest were small and the sample size limited, the absence of *A. lasiocarpa* may be an artifact of sampling; thus the occurrence of a *P. engelmannii/V. myrtillus* habitat type cannot be confirmed without additional sampling.

The overstory of most stands in this habitat type is dominated by *Picea engelmannii*, with *Abies lasiocarpa* as a codominant, although either species may be absent in individual plots sampled within stands. *P. contorta* is an important seral species and still dominates some of the stands in late stages of succession. However, the self-perpetuating species in these stands are *A. lasiocarpa* and *P. engelmannii. Populus tremuloides* is only an occasional seral species. In addition to *Vaccinum myrtillus* (28–70% cover), other important undergrowth species are *Juniperus communis, Ribes montigenum, Carex foenea, Festuca thurberi, Koeleria macrantha, Arnica cordifolia, Arnica latifolia, Pyrola* spp., *Solidago* spp., and *Thermopsis montana. Vaccinium scoparium, Carex geyeri*, and *Pedicularis racemosa* are absent or very inconspicuous.

The *A. lasiocarpa/V. myrtillus* habitat type, or others very similar to it, occur throughout the southern Rocky Mountain and Intermountain regions (Alexander et al. 1987, DeVelice et al. 1986, Fitzhugh et al. 1987, Hoffman,[5] Moir and Ludwig 1979, Youngblood and Mauk 1985). However, there is considerable variability in undergrowth composition and cover within this habitat type.

Management implications.—Timber productivity for the climax species varies considerably in the *A. lasiocarpa/V. myrtillus* habitat type, but can be higher than in the *A. lasiocarpa/Vaccinium scoparium* habitat type (Alexander 1967). Moreover, timber productivity may be relatively high for seral *P. contorta* in this habitat type. Undergrowth vegetation changes slowly after major disturbance, and competition is not severe between tree seedlings and undergrowth vegetation, except where cover of herbaceous dicots is high. *P. engelmannii* reproduction may be difficult to obtain on south slopes and other dry situations. There may be a manageable stand of advanced reproduction in much of this habitat type, especially in the late seral stages.

Cutting methods and growing stock levels are similar to those suggested for the *A. lasiocarpa/V. scoparium* habitat type (Alexander 1986a). Where there is an appreciable amount of either *P. contorta* or *P. tremuloides* in the stands, clearcutting or simulated shelterwood is likely to increase their representation in the new stand.

This habitat type provides summer forage for livestock and big game; but forage production is low, and there is little potential for increasing it by cutting timber. Natural runoff in the *A. lasiocarpa/V. myrtillus* habitat type usually is slightly less than in the *A. lasiocarpa/V. scoparium* habitat type, but can be increased significantly using the same cutting methods suggested for *A. lasiocarpa/V. scoparium* habitat type. The potential for developed and dispersed recreation is the highest in the *A. lasiocarpa* series.

Abies lasiocarpa/Juniperus communis

Description.—The *Abies lasiocarpa/Juniperus communis* habitat type was sampled in two successional stands. One stand (154), on the Perfecto Creek Road on a gentle (7%) northeast-facing slope, is a late seral *Populus tremuloides-Picea engelmannii/Juniperus communis* community type (Komarkova [3]). The other stand (155), near Perfecto Creek on a gentle (9%) east-facing slope, is a midseral *P. tremuloides-P. engelmannii/J. communis-Festuca idahoensis* plant community (Komarkova[3]). Soils in both stands are shallow, rocky, sandy loams (table 1).

This habitat type is normally recognized by the reproductive success of *Picea engelmannii* and *Abies lasiocarpa*; but, *A. lasiocarpa* was not present in the stands sampled, suggesting the possibility of a *P. engelmannii/J. communis* habitat type. Because the plots sampled are small and successional, and the sample size is limited, the absence of *A. lasiocarpa* may be an artifact of sampling. Although a *P. engelmannii/J. communis* habitat type has been identified in northwest Wyoming by Steele et al. (1983), this habitat type has not been previously identified in the National Forests adjacent to the Gunnison National Forest (Hess and Wasser;[2] Hoffman;[5] Hoffman and Alexander 1980, 1983). Moreover, stands dominated only by *P. engelmannii* are not common in Colorado. The occurrence on the Gunnison National Forest of a *P. engelmannii/J. communis* habitat type cannot be confirmed without additional sampling. Although the overstory in the sampled stands is presently dominated by *Populus tremuloides*, there is no evidence that it is self-perpetuating. *Pinus contorta* was absent in the stands sampled. The undergrowth is recognized by the abundance of *Juniperus communis* (5–12% cover) in the shrub layer, even though *Festuca idahoensis* has high coverage (30%) in one stand (fig. 33). Other undergrowth species with high cover are *Arctostaphylos adenotricha, Shepherdia canadensis, Carex geophila, Koeleria macrantha, Achillea lanulosa, Fragaria virginiana, Potentilla hippiana, Senecio* spp., and *Solidago multiradiata*.

This habitat type has not been reported previously in the central and southern Rocky Mountains (Alexander 1988). It occurs further north in central Idaho, northwestern Wyoming, and Utah (Mauk and Henderson 1984; Steele et al. 1981, 1983; Youngblood and Mauk 1985). The *A. lasiocarpa/J. communis* habitat type also occurs south of the Gunnison National Forest in northern Arizona and New Mexico (Moir and Ludwig 1979).

Management implications.—Timber productivity potential in the dry, rocky *A. lasiocarpa/J. communis* habitat type is low. Regeneration is more difficult to obtain than in the *A. lasiocarpa/Vaccinium* spp. habitat types in this series. *Picea engelmannii* can be expected to dominate all stages of succession, with the exception of early stages which may be dominated by *Populus tremuloides*. Consequently there are fewer options available for managing *P. tremuloides*-dominated stands in this habitat type. Competition from *A. lasiocarpa* for dominance in climax stands is less common than in the *A. lasiocarpa/Vaccinium* spp.-dominated habitat types. These sites are very stable. In natural stands, regeneration is sporadic and limited to the moister sites. Consequently, standard silvicultural practices that remove all of the overstory in one operation are not likely to be successful in regenerating a new stand within an acceptable time frame. Even with partial cutting, regeneration will be slow and erratic. Forage production potential for livestock is low in climax stands, but may be moderate to high in early successional stands dominated by *P. tremuloides*, on sites with loamy soils and a high cover of palatable graminoids in the undergrowth. Big game may use the habitat type for both cover and forage, but most use will be related to proximity to other plant communities with higher forage production potential. Open stands on ridges may have potential as bighorn sheep transitional range if the open canopy can be maintained. Natural runoff in the *A. lasiocarpa/J. communis* habitat type may be relatively high [10 to 12 inches (25 to 30 cm)]; but, potential for increasing streamflow is low because timber harvesting options are limited.

Abies lasiocarpa/Arnica cordifolia

Description.—The *Abies lasiocarpa/Arnica cordifolia* habitat type is represented by two stands. One stand is near Rainbow Lake on a gentle (9%) northeast-facing slope. This stand is one of several scattered stands occurring in sheltered situations that are more moist than the *A. lasiocarpa/Vaccinium* spp.-dominated habitat types, but drier than the associated *A. lasiocarpa/Polemonium pulcherrimum* and *A. lasiocarpa/Senecio triangularis* habitat types. The second stand is a lower elevation,

Figure 33.—*Abies lasiocarpa/Juniperus communis* habitat type on the Perfecto Creek road. Note late seral stage *Populus tremuloides* still persists in this stand. *Arctostaphylos adenotricha, Shepherdia canadensis*, and *Koeleria macrantha* are important undergrowth associates of *J. communis*.

Figure 34.—Abies lasiocarpa/Arnica *cordifolia* habitat type near Kebler Pass. *A. cordifolia, Aquilegia coerulea, Erigeron* spp., and *Fragaria virginiana* are the principal undergrowth species.

older, less disturbed representative of this habitat type. It is near Kebler Pass on a gentle (7%) northwest-facing slope. Soils in this habitat type are relatively deep loams (table 1).

This habitat type is recognized by the overstory dominance of *Picea engelmannii*, the constant abundance of *Abies lasiocarpa* in both the overstory and tree reproduction, and the abundance of *Arnica cordifolia* in the undergrowth (6–10% cover) (fig. 34). *Pinus contorta* and *Populus tremuloides* were absent in the stands sampled. Major shrubs in the undergrowth are *Lonicera involucrata, Ribes inerme*, and *Ribes montigenum*. In addition to *A. cordifolia*, herbaceous species with high cover include *Carex geyeri, Aquilegia coerulea, Erigeron formosissimum, Fragaria virginiana, Osmorhiza depauperata, Pedicularis racemosa, Pseudocymopterus montanus*, and *Senecio intergerrimus*.

Hoffman and Alexander (1976) reported an *A. lasiocarpa/A. cordifolia* habitat type on the Bighorn National Forest in Wyoming that represented some of the oldest *Abies-Picea* stands in the Bighorn Mountains. Further north, Pfister et al. (1977) and Steele et al. (1981, 1983) reported this habitat type in Montana, east-central Idaho, and northwestern Wyoming. However, the composition of undergrowth in this northern *A. lasiocarpa/A. cordifolia* habitat type is different than that reported for western Colorado. Moreover, the northern version of the habitat type often has *P. contorta* as a conspicuous seral species.

Management implications.—On the Gunnison National Forest, there does not appear to be any seral tree species in the *A. lasiocarpa/A. cordifolia* habitat type. Undergrowth vegetation does not appear to compete severely with tree seedlings after cutting. Timber productivity may be lower in this habitat type than in the *A. lasiocarpa/Vaccinium myrtillus* habitat type. Even- and uneven-aged cutting methods and growing stock levels—which benefit timber and water production, recreation, and esthetics—suggested for the *A. lasiocarpa/Vaccinium scoparium* habitat type are applicable here. Management with advanced reproduction is likely to result in a replacement stand predominantly of *A. lasiocarpa*, however. In older stands, some treatment of down material is necessary for future management. Younger stands provide some forage for livestock and big game, but older stands are used primarily for bedding grounds. The potential for increasing forage production by harvesting timber is not great in this habitat type.

Abies lasiocarpa/Senecio triangularis

Description.—The *Abies lasiocarpa/Senecio triangularis* habitat type was sampled in only one stand, but it has been reported elsewhere in Colorado under similar circumstances (Alexander 1987). The *A. lasiocarpa/S. triangularis* habitat type occurs occasionally on the Gunnison National Forest in small stands, in relatively wet sites, in valley bottoms, drainages, and in depressions at higher elevations. The sampled stand is in the Gothic Research Natural Area on a gentle (2%) south-facing slope. Soils in this habitat type are loams (table 1). Soils generally are well drained at the beginning of the growing season but remain at or near field capacity during the growing season.

This habitat type is recognized by the overstory dominance and reproductive success of *Abies lasiocarpa* and *Picea engelmannii*, and the dominance of the undergrowth by *Senecio triangularis* and/or *Streptopus fassettii*. *S. triangularis* is the most constant, but cover is fairly low (4%) in the sampled stand (fig. 35). *Pinus contorta* is rarely seen in this habitat type on the Gunnison National Forest, and *Populus tremuloides* is usually absent. The only shrubs present are *Lonicera involucrata* and *Vaccinium myrtillus*. Herbaceous species with high cover values include *Carex* spp., *Equisetum arvense, Pseudocymopterus montanus, S. triangularis*, and *S. fassettii*.

In Colorado, Hess and Alexander (1986) reported this habitat type on the Arapaho and Roosevelt National Forests. It has not been observed elsewhere in the Rocky Mountain and Intermountain regions (Alexander 1985, 1988). However, Cooper et al. (1987) and Steele et al. (1981, 1983) reported an *A. lasiocarpa/Streptopus amplexifolius* habitat type in northwestern Utah and southern Idaho that closely approximates the *A. lasiocarpa/S. triangularis* habitat type described here. Mauk and

Figure 35.—*Abies lasiocarpa/Senecio triangularis* habitat type near Gothic Natural area. *Equisetum arvense, Pseudocymopterus montanus*, and *Streptopus fassettii* are principal undergrowth associates of *S. triangularis*.

Henderson (1984) and Steele et al. (1983) reported a *P. engelmannii/Caltha leptosepala* habitat type in northern Utah, northwestern Wyoming, and southeastern Idaho that has many of the associated undergrowth species found in the *A. lasiocarpa/S. triangularis* habitat type.

Management implications.—Timber productivity in the *A. lasiocarpa/S. triangularis* habitat type is average to above average, but the high water table associated with the habitat type severely hampers any timber management activity, including road construction and maintenance. Road and trail costs are expected to be maximum in this habitat type. Moreover, the small area occupied by the habitat type limits its importance as a timber resource; conversely, the small stand size makes it easier to avoid. Clearcutting will cause the water table to rise to the ground surface and initially preclude establishment of tree species. Recovery after disturbance is extremely slow. Partial cutting increases the risk of blowdown. Forage production for livestock is moderately high, but the potential for trampling damage and soil compaction also is very high. The potential for increasing streamflow may be high, but management for water production is not a viable alternative because of the effect timber harvesting has on the water table and soil compaction. These stands are also subject to the special management prescriptions applied to riparian areas in

Forest Plans in the Rocky Mountain region. The principal value of the *A. lasiocarpa/S. triangularis* habitat type is for watershed and streamside protection, big game summer range, and habitat for birds and small mammals. However, trampling damage by big game can also cause soil compaction and subsequent erosion.

Abies lasiocarpa/Polemonium pulcherrimum

Description.—The *Abies lasiocarpa/Polemonium pulcherrimum* is a high-elevation habitat type. It occurs on sites within the range of the *A. lasiocarpa/Vaccinium myrtillus* habitat type, except that it usually occurs at higher elevations and on moister sites. This habitat type is drier than the *A. lasiocarpa/Senecio triangularis* habitat type and wetter than the *A. lasiocarpa/Vaccinium* spp.-dominated habitat types. This habitat type is represented by two stands, one just north of Schofield Pass on a gentle (9%) northwest-facing slope. The second stand sampled is on Alpine Plateau on a gentle (3%) northwest-facing slope. This habitat type is recognized as tentative, because there is some evidence to suggest that one stand (215) may be a *P. pulcherrimum* phase of the *A. lasiocarpa/Vaccinium myrtillus* habitat type; and the other stand (180) may be an *A. lasiocarpa/Ribes* spp.-dominated habitat type. Until additional sampling either confirms or refutes it, an *A. lasiocarpa/P. pulcherrimum* habitat type is recognized. Soils in the stands sampled are sandy loams (table 1).

The *A. lasiocarpa/P. pulcherrimum* habitat type is recognized by the overstory dominance and reproductive success of *Abies lasiocarpa* and *Picea engelmannii*, and the abundance of *Polemonium pulcherrimum* (8% cover in both stands) in the undergrowth (fig. 36). *Pinus contorta* and *Populus tremuloides* were absent from the stands sampled. Shrubs include *Ribes coloradense* (4% cover, stand 215), *Ribes inerme* (8% cover, stand 180), and *Vaccinium myrtillus* (6% cover, stand 215). The herbaceous undergrowth is dominated by *P. pulcherrimum*, *Arnica cordifolia*, *Arnica latifolia*, *Caltha leptosepala*, *Cardamine cordifolia*, *Lupinus argenteus* , *Mertensia ciliata*, *Mitella pentandra*, and *Pryola* spp.

Figure 36.—*Abies lasiocarpa/Polemonium pulcherrimum* habitat type north of Schofield Pass. *Caltha leptosepala* and *Arnica cordifolia* are undergrowth associates with high cover.

The *A. lasiocarpa/P. pulcherrimum* habitat type has not been identified in Colorado (Alexander 1987) or elsewhere in the Rocky Mountain and Intermountain regions (Alexander 1985, 1988). However, in northern New Mexico and southern Colorado, DeVelice et al. (1986) described similar stands as a *Picea engelmannii/Vaccinium myrtillus* habitat type, *P. pulcherrimum* phase, in which *Abies lasiocarpa* often was a codominant. This further suggests that stands with high cover of *P. pulcherrimum* may belong to a phase of either an *A. lasiocarpa/V. myrtillus* or a *P. engelmannii/V. myrtillus* habitat type.

Management implications.—Timber productivity in the *A. lasiocarpa/P. pulcherrimum* habitat type is comparable to the *A. lasiocarpa/Vaccinium myrtillus* habitat type, but this habitat type occurs on colder and moister sites. Reproduction may be slow to establish, but undergrowth vegetation does not compete severely with tree seedlings after cutting. Cutting practices and growing stock levels—which benefit timber and water production, recreation, and esthetics—suggested for the *A. lasiocarpa/Vaccinium scoparium* habitat type are applicable here. Forage production is low in this habitat type, with little potential for increasing it by cuttting timber. Big game use in this habitat is primarily for resting and hiding cover.

Abies lasiocarpa/Calamagrostis canadensis

Description.—This minor habitat type, represented by one stand in Spring Creek Canyon, occurs in small stands on the Gunnison National Forest; however, it has been recognized elsewhere in Colorado. The *Abies lasiocarpa/Calamagrostis canadensis* habitat type has the coldest and wettest environment in the *A. lasiocarpa* series because of high groundwater levels and cold air drainage from surrounding uplands. It occurs in bottomlands on benches adjacent to streams. The sampled stand is on a gentle (5%) south-facing slope. Despite the cold, wet environment, the soils are primarily mineral, with a high organic content, and are poorly drained (table 1).

This habitat type is usually distinguished by an open canopy dominated by *Abies lasiocarpa* and *Picea engelmannii*. However, in the sampled stand, *A. lasiocarpa* was absent. *Populus tremuloides* may be a seral species in some stands, but *Pinus contorta* is usually absent. The undergrowth is dominated by *Calamagrostis canadensis* (55% cover) (fig. 37). Shrub associates include *Lonicera involucrata*, *Rosa woodsii*, *Salix glauca*, and *Swida sericea*. Important graminoids are *C. canadensis*, *Carex geyeri*, *Carex utriculata*, and *Poa leptocoma*. *Equisetum arvense*, *Heracleum sphondylium*, and *Smilacina stellata* are the major forb associates.

An *A. lasiocarpa/C. canadensis* habitat type has been reported on the Arapaho and Roosevelt National Forests by Hess and Alexander (1986), but it has a richer mixture of undergrowth species. Further north, an *A. lasiocarpa/C. canadensis* habitat type with ecological and floristic similarity, has been reported in northern Idaho by Cooper et al. (1987), in central Idaho by Steele et al. (1981), in Montana by Pfister et al. (1977), in southeastern Idaho and northwestern Wyoming by Steele et al. (1983), and in northern Utah by Mauk and Henderson (1984).

Management implications.—The management implications for this habitat type are similar to the *A. lasiocarpa/Senecio triangularis* habitat type. However, the *A. lasiocarpa/C. canadensis* habitat type is even more difficult to regenerate, especially if it is clearcut, because of intense competition from undergrowth species, saturated soils, and colder sites. Because of the high water table, partial cutting is likely to result in heavy windthrow. Clearcutting initially causes the water table to rise to the ground surface; therefore, this habitat type should be avoided for road, trail, or recreational development because of saturated soils and the potential for soil compaction and mass movement. The *A. lasiocarpa/C. canadensis* habitat type may have moderately high potential for livestock forage production, but grazing should be avoided when soils are saturated because of potential for trampling damage. The value of this habitat type is for watershed protection and wildlife habitat; however, trampling damage by big game also can cause soil compaction and subsequent erosion.

Abies lasiocarpa/Moss

Description.—The *Abies lasiocarpa*/Moss habitat type generally occurs on zonal surfaces at higher elevations in the study area. This cold, moderately dry habitat type was sampled in three stands on Mexican Joe Gulch, Alpine Plateau, and North Fork Valley. These stands occur on gentle (3–5%) north- to east-facing slopes. Soils are shallow sandy loams (table 1).

This cold and dry habitat type is recognized by the overstory dominance of *Abies lasiocarpa* and *Picea engelmannii*, although two of the stands sampled did not contain *A. lasiocarpa*. Whether the absence of *A. lasiocarpa* is an artifact of sampling or an indication of a possible *P. engelmannii*/Moss habitat type cannot be confirmed without additional sampling. *Pinus contorta* was rarely seen in this habitat type in the Gunnison National Forest, but *Populus tremuloides* was an occasional overstory associate. The diagnostic feature of this habitat type is a sparse undergrowth of shrubs, graminoids, and forbs; moss spp. cover is evident because of the scarcity of other undergrowth. In some stands, lichen spp. cover may be higher than cover by moss spp. (fig. 38).

Figure 37.—*Abies lasiocarpa/Calamagrostis canadensis* habitat type, Spring Creek Canyon. Important undergrowth associates include *Lonicera involucrata, Swida sericea,* and *Equisetum arvense.*

Figure 38.—*Abies lasiocarpa*/Moss habitat type high in the North Fork Valley south of Lake City. Note the sparse undergrowth.

This habitat type has been described in northern New Mexico by DeVelice et al. (1986) and on the Medicine Bow National Forest in southern Wyoming by Alexander et al. (1986). The *A. lasiocarpa*/Moss habitat type has not been reported elsewhere in the Rocky Mountain or Intermountain regions (Alexander 1985, 1988), but a *P. engelmannii*/Moss habitat type with similar characteristics was reported from northern New Mexico by Alexander et al. (1987), Fitzhugh et al. (1987), and Moir and Ludwig (1979), and in the Pike National Forest in the Colorado Front Range (Radloff 1983). In the Southwest, *A. lasiocarpa* may occur as a minor dominant in the *P. engelmannii*/Moss habitat type; but *P. engelmannii* also may occur in pure stands at higher elevations [above 11,500 feet (3,505 m)], a circumstance not frequently encountered in the central Rocky Mountains, where both *P. engelmannii* and *A. lasiocarpa* normally form the timberline forests.

Management implications.—Timber productivity in the *A. lasiocarpa*/Moss habitat type is very low because growth is slow. The potential for improvement also is low because of poor site quality. Regeneration, although slow to establish, is likely to be ultimately successful after either clearcutting in small openings or partial cutting, because there is little undergrowth to compete with tree seedlings. Until more information is available, cutting methods suggested for perpetuating the *A. lasiocarpa/Vaccinium scoparium* habitat type probably are applicable to this habitat type, although regeneration may be more difficult to obtain following clearcutting. Livestock forage production is low, and there is little potential for improvement. Big game summer use is moderate, largely as cover for deer and elk that feed in adjacent habitat types. Small game and birds use these stands, and they appear to be good habitat for tree owls. Natural runoff probably is equal to the *A. lasiocarpa/V. scoparium* habitat type. Whether streamflow in the *A. lasiocarpa*/Moss habitat type can be increased by the cutting methods suggested for the *A. lasiocarpa/V. scoparium* habitat type is unknown.

KEY TO FOREST HABITAT TYPES

The following key will enable users to identify the habitat type of most forested and woodland stands on the Gunnison National Forest. The key will work best on climax or late seral stands. Caution must be exercised when attempting to project stand succession forward in early seral or midseral stands.

1. Coniferous trees dominant and reproducing; deciduous trees may be present but are rare or not reproducing sufficiently to become dominant, or are being replaced by coniferous trees .... (2)
2. *Juniperus osteosperma* dominant and reproducing; other conifers absent or not dominant; undergrowth dominated by shrubs *Symphoricarpos oreophilus* and *Mahonia fremonti*. Lowest elevations within forested zones, on sedimentary soils ..... *JUNIPERUS OSTEOSPERMA/SYMPHORICARPOS OREOPHILUS* H.T.
2. *Juniperus osteosperma* absent or not dominant; higher elevations, on a variety of soils .... (3)
3. *Pinus ponderosa* dominant and reproducing on warm dry sites; other conifers absent or, if present, not dominant or reproducing successfully .... (4)
4. *Festuca idahoensis* present in significant amounts, but undergrowth may be dominated by *Artemisia tridentata* because of past grazing use; *Muhlenbergia montana* absent .... *PINUS PONDEROSA/FESTUCA IDAHOENSIS* H.T.
4. *Festuca idahoensis* absent or sparse. Undergrowth dominated by *Festuca arizonica*; *Muhlenbergia montana* may have high cover; shrubs and forbs are sparse ... *PINUS PONDEROSA/FESTUCA ARIZONICA* H.T.
3. *Pinus ponderosa* absent, rare, or clearly seral; cooler and/or moister sites; other conifers present and reproducing successfully .... (5)
5. *Pseudotsuga menziesii* climax and reproducing successfully; other conifers may be present, but not dominant or reproducing .... (6)
6. Undergrowth dominated by shrubs; graminoids present but not dominant .... (7)
7. *Purshia tridentata* usually dominates the undergrowth; *Artemisia tridentata* may be dominant in some stands because of past grazing use; *Arctostaphylos adenotricha* and *Juniperus communis* usually present and cover may be high, but not dominant; *Symphoricarpos oreophilus*, *Jamesia americana* and *Paxistima myrsinites* absent or rare .... *PSEUDOTSUGA MENZIESII/PURSHIA TRIDENTATA* H.T.
7. *Purshia tridentata* and *Artemisia tridentata* absent or sparse. *Symphoricarpos orephilus*, *Jamesia americana* or *Paxistima myrsinites* may be abundant .... (8)
8. *Symphoricarpos oreophilus* dominant in the undergrowth. *Jamesia americana* and *Paxistima myrsinites* absent or sparse; *Mahonia repens* also absent or sparse .... *PSEUDOTSUGA MENZIESII/SYMPHORICARPOS OREOPHILUS* H.T.
8. *Symphoricarpos oreophilus* absent or sparse; *Jamesia americana* or *Paxistima myrsinites* may be abundant (9)
9. *Jamesia americana* dominates the undergrowth; *Paxistima myrsinites* absent or sparse; *Mahonia repens* and *Arctostaphylos adenotricha* present but not dominant .... *PSEUDOTSUGA MENZIESII/JAMESIA AMERICANA* H.T.
9. *Jamesia americana* absent or sparse; *Paxistima myrsinites* dominates the undergrowth; *Holodiscus dumosus*, *Mahonia repens*, and *Ribes inerme* may be present but not dominant; *Carex geyeri* may be conspicuous . ... *PSEUDOTSUGA MENZIESII/PAXISTIMA MYRSINITES* H.T.
6. Undergrowth dominated by graminoids .... (10)
10. *Carex geyeri* dominates the undergrowth; *Symphoricarpos oreophilus* may have high cover, but not dominant. *Mahonia repens*, *Rosa woodsii*, and *Festuca idahoensis* also may be present .... *PSEUDOTSUGA MENZIESII/CAREX GEYERI* H.T.
10. *Carex geyeri* and *Koeleria macrantha* may be present but not dominant; *Festuca idahoensis* dominates the undergrowth; shrubs absent or sparse ...... *PSEUDOTSUGA MENZIESII/FESTUCA IDAHOENSIS* H.T.
5. *Pseudotsuga menziesii* may be present, and reproducing but not dominant at climax; other conifers dominate both moist and dry sites .... (11)
11. *Picea pungens* climax and reproducing well; riparian or other cool, moist sites .... (12)
12. Undergrowth dominated by shrubs characteristic of streamside and riparian situations. *Amelanchier alnifolia* is dominant; *Prunus virginiana*, *Ribes inerme*, *Rosa woodsii*, *Swida sericea*, and *Symphoricarpos oreophilus* are present; graminoids present but not dominant .... *PICEA PUNGENS/AMELANCHIER ALNIFOLIA* H.T.
12. Shrubs absent or present; undergrowth dominated by graminoids; *Festuca arizonica* is dominant; *Danthonia parryi* may have high cover; *Koeleria macrantha* and *Muhlenbergia montana* usually present .... *PICEA PUNGENS/FESTUCA ARIZONICA* H.T.

11. *Picea pungens* absent or sparse; other conifers present and reproducing vigorously; on exposed, well-drained or dry, rocky sites ....(13)
13. *Pinus flexilis* present and reproducing on dry, rocky sites; other conifers absent or not reproducing well; shrubs and graminoids present but not dominant; *Ciliaria austromontana* dominates the undergrowth .... *PINUS FLEXILIS/CILIARIA AUSTROMONTANA* H.T.
13. *Pinus flexilis* absent or sparse, other conifers present and self-reproducing ....(14)
14. *Pinus contorta* dominant and climax; other conifers may be present but not reproducing well enough to replace *Pinus contorta* ....(15)
15. Shrubs dominate the undergrowth. Graminoids not common or not dominant ....(16)
16. *Juniperus communis* dominates the sparse undergrowth; *Arctostaphylos adenotricha* may be codominant; *Vaccinium* spp. absent or sparse; herbaceous layer depauperate; lower elevation colluvial benches .... *PINUS CONTORTA/JUNIPERUS COMMUNIS* H.T.
16. *Juniperus communis* absent or sparse; undergrowth depauperate, dominated by *Vaccinium scoparium*; higher elevation ridges and slopes .... *PINUS CONTORTA/VACCINIUM SCOPARIUM* H.T.
15. Shrubs poorly represented in the undergrowth; *Carex geyeri* dominates the undergrowth; other graminoids present but not dominant; *Arnica cordifolia* and *Fragaria virginiana* may be conspicuous .... *PINUS CONTORTA/CAREX GEYERI* H.T.
14. *Pinus contorta* absent or not reproducing vigorously, not climax; other conifers reproducing vigorously and will replace *Pinus contorta* ....(17)
17. *Abies lasiocarpa* and *Picea engelmannii* usually present and reproducing successfully, but either species may be absent in any given stand; *Picea engelmannii* may dominate both overstory and understory; *Populus tremuloides* and *Pinus contorta* may be present and dominating the overstory, but not reproducing well, not climax. *Pinus aristata* absent ....(18)
18. Shrubs dominate the undergrowth; graminoids and forbs, mosses and lichen may be present but not dominant ....(19)
19. *Juniperus communis* dominates the undergrowth; *Arctostaphylos adenotricha* or *Shepherdia canadensis* may be present but not dominant; *Vaccinium* species absent .... *ABIES LASIOCARPA/JUNIPERUS COMMUNIS* H.T.
19. *Juniperus communis* absent or sparse; undergrowth dominated by *Vaccinium* spp. ....(20)
20. Undergrowth dominated by *Vaccinium scoparium*; *V. myrtillus* may be present but not dominant .... *ABIES LASIOCARPA/VACCINIUM SCOPARIUM* H.T.
20. *Vaccinium scoparium* absent or sparse; undergrowth dominated by *Vaccinium myrtillus* .... *ABIES LASIOCARPA/VACCINIUM MYRTILLUS* H.T.
18. Shrubs generally absent or sparse, or if present not dominant; undergrowth dominated by graminoids, forbs or moss and lichen ....(21)
21. Undergrowth dominated by graminoids; forbs, mosses and lichen may be present but not dominant (22)
22. *Carex geyeri* abundant, dominates the undergrowth; *Calamagrostis canadensis* may be present, but not dominant .... *ABIES LASIOCARPA/CAREX GEYERI* H.T.
22. *Carex geyeri* sparse; undergrowth dominated by *Calamagrostis canadensis*; *Swida sericea* and *Equisetum arvense* may have significant cover .... *ABIES LASIOCARPA/CALAMAGROSTIS CANADENSIS* H.T.
21. Graminoids present but not dominant. Undergrowth dominated by forbs or mosses or lichens ....(23)
23. Undergrowth dominated by forbs; mosses and lichen may be present but not dominant ....(24)
24. *Arnica cordifolia* abundant and dominant; *Erigeron* spp. and *Osmorhiza depauperata* may have significant cover but are not dominant .... *ABIES LASIOCARPA/ARNICA CORDIFOLIA* H.T.
24. *Arnica cordifolia* present but not dominant ....(25)
25. *Polemonium pulcherrimum* abundant and dominant; *Caltha leptosepala* may have high cover but not abundant in all stands .... *ABIES LASIOCARPA/POLEMONIUM PULCHERRIMUM* H.T.
25. *Polemonium pulcherrimum* absent or sparse; *Senecio triangularis* present but cover varies; coverage of *Equisetum arvense* and *Streptopus fassettii* may be high .... *ABIES LASIOCARPA/SENECIO TRIANGULARIS* H.T.
23. Undergrowth dominated by mosses and/or lichens; forbs sparse, not dominant .... *ABIES LASIOCARPA/MOSS* H.T.
17. *Abies lasiocarpa* absent or sparse, *Picea engelmannii* may be present and reproducing, but not dominant; *Pinus contorta* and *Populus tremuloides* absent or sparse. *Pinus aristata* dominant, reproducing, and climax (26)
26. Shrubs dominate the undergrowth; graminoids and forbs present but not dominant. *Juniperus communis* dominant; *Rosa woodsii* may have abundant cover .... *PINUS ARISTATA/JUNIPERUS COMMUNIS* H.T.
26. Shrubs usually absent or sparse, not dominant; undergrowth dominated by graminoids; forbs present but also sparse ....(27)
27. *Festuca arizonica* dominates the undergrowth; *Muhlenbergia montana* may be a codominant .... *PINUS ARISTATA/FESTUCA ARIZONICA* H.T.
27. *Festuca arizonica* and *Muhlenbergia montana* absent or sparse; undergrowth dominated by *Festuca thurberi* .... *PINUS ARISTATA/FESTUCA THURBERI* H.T.

1. Coniferous trees absent or minor, not reproducing; deciduous trees present and reproducing ....(28)
28. *Quercus gambelii* present and reproducing successfully; conifers and *Populus tremuloides* may be present but not dominant ....(29)
29. Undergrowth dominated by the tall shrub *Amelanchier alnifolia; Prunus virginiana* and *Symphoricarpos oreophilus* present but not dominant; graminoids and forbs may also be present .... *QUERCUS GAMBELII/AMELANCHIER ALNIFOLIA* H.T.
29. *Amelanchier alnifolia* absent or sparse; undergrowth dominated by the tall shrub *Prunus virginiana; Carex geyeri* may be present but not dominant .... *QUERCUS GAMBELII/PRUNUS VIGINIANA* H.T.
28. *Quercus gamebelii* absent or not reproducing successfully; other deciduous trees present and reproducing (30)
30. *Populus angustifolia* present and reproducing successfully; conifers and *Populus tremuloides* may be present but not dominant; *Alnus incana, Swida sericea,* and *Salix* spp. well represented .... *POPULUS ANGUSTIFOLIA/ALNUS INCANA-SWIDA SERICEA* H.T.
30. *Populus angustifolia* and *Salix* spp. absent or poorly represented; *Populus tremuloides* present and reproducing successfully; conifers and other deciduous trees may be present but not dominant ....(31)
31. Undergrowth dominated by shrubs; graminoid and forb layers form a rich mixture but are not dominant (32)
32. Undergrowth dominated by tall or medium shrubs; *Amelanchier alnifolia* and *Prunus virginiana,* or *Symphoricarpos oreophilus* may be important ....(33)
33. Undergrowth dominated by *Amelanchier alnifolia* and *Prunus virginiana; Symphoricarpos oreophilus* may be present but not dominant .... *POPULUS TREMULOIDES/AMELANCHIER ALNIFOLIA-PRUNUS VIRGINIANA* H.T.
33. *Amelanchier alnifolia* and *Prunus virginiana* present but not dominant; undergrowth dominated by the medium shrub *Symphoricarpos oreophilus*; cover of low shrub *Mahonia repens* may be high .... *POPULUS TREMULOIDES/SYMPHORICARPOS OREOPHILUS* H.T.
32. Undergrowth dominated by low shrubs; sparse; *Arctostaphylos adenotricha* present and indicative of this dry site .... *POPULUS TREMULOIDES/ARCTOSTAPHYLOS ADENOTRICHA* H.T.
31. Undergrowth dominated by graminoids or forbs; shrubs present but not dominant ....(34)
34. Undergrowth dominated by graminoids ....(35)
35. *Festuca arizonica* dominates the undergrowth; *Festuca thurberi, Muhlenbergia montana,* and *Carex geyeri* present but not dominant .... *POPULUS TREMULOIDES/FESTUCA ARIZONICA* H.T.
35. *Festuca thurberi* dominates the undergrowth; *Festuca arizonica* and *Muhlenbergia montana* absent or sparse; *Arctostaphylos uva-ursi* and *Carex hoodii* may have significant cover .... *POPULUS TREMULOIDES/*FESTUCA THURBERI H.T.
34. Undergrowth dominated by forbs; shrubs and graminoids contribute to a rich mixture in the undergrowth but are not dominant ....(36)
36. Undergrowth dominated by tall forbs; *Thalictrum fendleri* usually present and dominant; *Lupinus argenteus, Lathyrus leucanthus, Ligusticum* spp. and *Polemonium pulcherrimum* may have significant cover .... *POPULUS TREMULOIDES/THALICTRUM FENDLERI* H.T.
36. *Thalictrum fendleri* and other tall forbs may be present but not dominant; *Pteridium aquilinum* dominates the undergrowth .... *POPULUS TREMULOIDES/PTERIDIUM AQUILINUM* H.T.

The distribution and successional status of tree species in relation to habitat type are shown in table 2.

DISCUSSION

VALIDITY OF HABITAT TYPE CLASSIFICATION

The practical value of the habitat type classifications has only begun to be realized as it relates to vegetation mapping, tree growth, tree susceptibility to diseases, and production of browse species for game animals. It also provides 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. 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).

The classification of forested habitat types recognizes climax tree species in an area; these are given primary consideration, and important seral species are noted. In this study, the major vegetation zones are dominated by *Pseudotsuga menziesii, Populus tremuloides, Pinus contorta,* and *Abies lasiocarpa* and *Picea engelmannii.* Undergrowth vegetation then is used to indicate habitat types within the forested portion of the zone named for a given tree species.

VERTICAL ZONATION OF FOREST TREE SPECIES

The most conspicuous forest distribution patterns in the study area are related to environmental changes associated with changes in elevation. For example, as elevation increases, temperature decreases and moisture increases. While, in general, the upper and lower eleva-

Table 2.—The ecological role of tree species in habitat types on the Gunnison National Forest.
C = major climax; c = minor climax; S = major seral species; s = minor seral species; *o* = occasional species

Habitat type \ Species	*Juniperus osteosperma*	*Quercus gambelii*	*Pinus ponderosa*	*Picea pungens*	*Pseudotsuga menziesii*	*Populus angustifolia*	*Salix amygdaloides*	*Populus tremuloides*	*Pinus contorta*	*Pinus flexilis*	*Picea engelmannii*	*Abies lasiocarpa*	*Pinus aristata*
Juniperus osteosperma/Symphoricarpos oreophilus	C	•	•	•	•	•	•	•	•	•	•	•	•
Quercus gambelii/Amelanchier alnifolia	•	C	•	•	•	•	*o*	•	•	•	•	•	•
Quercus gambelii/Prunus virginiana	•	C	•	•	•	•	•	•	•	•	•	•	•
Pinus ponderosa/Festuca arizonica	•	•	C	•	s	•	•	•	•	•	•	•	*o*
Pinus ponderosa/Festuca idahoensis	•	•	C	•	•	•	•	•	•	•	•	•	•
Picea pungens/Festuca arizonica	•	•	•	C	•	•	•	•	•	•	•	•	*o*
Picea pungens/Amelanchier alnifolia	•	•	*o*	C	s	•	•	*o*	•	•	•	•	•
Pseudotsuga menziesii/Paxistima myrsinites	•	•	•	•	C	•	•	•	•	•	•	•	•
Pseudotsuga menziesii/Purshia tridentata	•	•	S	•	C	•	•	S	S	•	•	•	•
Pseudotsuga menziesii/Symphoricarpos oreophilus	•	•	•	•	C	•	•	•	•	•	*o*	•	•
Pseudotsuga menziesii/Carex geyeri	•	•	c	*o*	C	•	•	s	•	•	•	•	•
Pseudotsuga menziesii/Festuca idahoensis	•	•	•	•	C	•	•	•	•	•	•	•	•
Pseudotsuga menziesii/Jamesia americana	•	•	•	•	C	s	•	•	S	s	•	•	•
Populus angustifolia/Alnus incana-Swida sericea	•	•	•	•	•	C	C	•	•	•	•	•	•
Populus tremuloides/Arctostaphylos adenotricha	•	•	•	•	•	•	•	C	•	•	•	•	•
Populus tremuloides/Festuca arizonica	•	•	•	•	•	•	•	C	•	•	•	•	•
Populus tremuloides/Festuca thurberi	•	•	•	•	•	•	•	C	•	•	•	•	o
Populus tremuloides/Symphoricarpos oreophilus	•	•	•	•	•	•	•	C	•	•	•	*o*	•
Populus tremuloides/Amelanchier alnifolia-Prunus virginiana	•	•	•	•	•	*o*	•	C	•	•	•	•	•
Populus tremuloides/Pteridium aquilinum	•	•	•	•	•	•	•	C	•	•	•	•	•
Populus tremuloides/Thalictrum fendleri	•	•	•	•	•	•	•	•	•	•	•	•	•
Pinus contorta/Juniperus communis	•	•	•	•	s	•	•	C	C	•	*o*	•	•
Pinus contorta/Carex geyeri	•	•	•	•	•	•	•	•	C	•	*o*	•	•
Pinus contorta/Vaccinium scoparium	•	•	•	•	•	•	•	•	C	•	*o*	•	•
Pinus flexilis/Ciliaria austromontana	•	•	•	•	*o*	•	•	•	•	C	•	•	•
Pinus aristata/Festuca arizonica	•	•	•	•	•	•	•	o	•	*o*	•	•	C
Pinus aristata/Juniperus communis	•	•	•	•	•	•	•	s	•	S	*o*	•	C
Pinus aristata/Festuca thurberi	•	•	•	•	•	•	•	•	•	•	*o*	•	C
Abies lasiocarpa/Carex geyeri	•	•	•	•	*o*	•	•	S	S	•	C	C	•
Abies lasiocarpa/Vaccinium scoparium	•	•	•	•	•	•	•	s	s	•	C	C	•
Abies lasiocarpa/Vaccinium myrtillus	•	•	•	•	•	•	•	s	S	•	C	C	•
Abies lasiocarpa/Juniperus communis	•	•	•	•	•	•	•	S	•	•	C	C	•
Abies lasiocarpa/Arnica cordifolia	•	•	•	•	•	•	•	•	•	•	C	C	•
Abies lasiocarpa/Senecio triangularis	•	•	•	•	•	•	•	•	•	•	C	C	•
Abies lasiocarpa/Polemonium pulcherrimum	•	•	•	•	•	•	•	•	•	•	C	C	•
Abies lasiocarpa/Calamagrostis canadensis	•	•	•	•	•	•	•	•	•	•	C	C	•
Abies lasiocarpa/Moss	•	•	•	•	•	•	•	s	•	•	C	C	•

tional limits of forest vegetation in the study area increases from north to south as climate becomes drier and more continental, the most significant variations in vegetational zonation are in response to local topography and climate. The different forested elevational zones support very different plant associations, ranging from treeline vegetation of the upper subalpine forest zone through closed-canopy forests of the subalpine and montane zone to woodlands and shrublands at the lower limits of forests. Also included are grassland parks on mountain ridges within the forested zones.

Within each elevational zone, two kinds of plant associations were distinguished: (1) zonal, which reflect the local climate and consist of relatively undisturbed stands; and (2) azonal, which are controlled by biotic or abiotic environmental factors and/or persistent disturbance factors, such as soils, grazing, and wind. Except for temporal implications, the forest habitat types that are zonal plant associations generally are climatic climaxes, while the azonal plant associations are edaphic, topographic, or topoedaphic climaxes or disclimaxes. Elevational zones are recognized on the basis of the differences in landforms and vegetation between them. In general, the forest stands in the subalpine zones have a considerably higher percentage of climax stands than the montane and woodland zones, because disturbance usually is greater at lower than higher elevations. Azonal plant associations may overlap elevational zones. For example, in the Gunnison National Forest, *Pinus contorta* is a widely distributed tree; several *P. contorta*-dominated plant associations occur in the upper and lower subalpine zones, and in the upper montane zone.

In both zonal and azonal plant associations, the maturity of forest vegetation is indicated by a balanced distribution of tree sizes, ranging from seedlings to very old trees. Mature zonal forest stands persist for long periods of time in the absence of catastrophic disturbance. Azonal forest stands persist as long as the disturbance or environmental factor that controls their stability persists.

The uppermost forested elevational zone in the study area is the upper subalpine zone that occurs from 10,500 feet (3,200 m) to timberline at about 11,500 feet (3,505 m). *Abies lasiocarpa*, *Picea engelmannii*, and *Pinus aristata* are the most common treeline species. These are also the dominant climax species throughout the entire upper subalpine zone, with *Pinus contorta* and *Pinus flexilis* forming open-grown plant associations. Relatively extensive mountain grasslands dominated by *Festuca thurberi*, *Danthonia intermedia*, and *Deschampsia cespitosa* also occur in the zone. Riparian sites may be shrublands, dominated by *Salix* spp.; grasslands, with *D. cespitosa*; or wetlands, with *Carex* spp.

The lower subalpine zone occurs at elevations of 9,500 to 10,500 feet (2,895 to 3,200 m). *P. engelmannii*-, *A. lasiocarpa*-, *P. contorta*-, and *Populus tremuloides*-dominated stands occur extensively throughout the zone. *P. aristata*- and *P. flexilis*-dominated stands have only local distribution. *A. lasiocarpa* usually is subordinate to *P. engelmannii* in the overstory and may be dominant, subordinate, or absent in the understory. *P. tremuloides* generally dominates stands that are successional to conifers but is climax under certain topoedaphic circumstances. *P. contorta* dominates large areas recovering from disturbance. It may be either a long-lived seral or a climax if there is no evidence of replacement. The latter circumstance may be due to a lack of seed source from competing species or topoedaphic conditions that preclude the establishment of other species.

The upper montane zone lies between 8,500 and 9,500 feet (2,590 and 2,895 m) elevation. The most common trees are *P. tremuloides*, *Pseudotsuga menziesii*, and *P. contorta*. *Pinus ponderosa* is an infrequent dominant but may occur as a seral species. *P. tremuloides* and *P. contorta* dominate primarily long-lived seral stands, but *P. contorta* may also be a topoedaphic climax. *P. menziesii* is the dominant climax species. *Picea pungens* may be a dominant species in riparian habitats or, occasionally, on dry uplands. *A. lasiocarpa* and *P. engelmannii* may occur along streams and in cold, moist valley bottoms.

The lower montane zone, between 7,500 and 8,500 feet (2,286 and 2,590 m), normally is dominated by *P. ponderosa* and *P. menziesii*, but *P. ponderosa* has only limited distribution in the Gunnison National Forest. *P. contorta* may occur at the upper limits of the zone, usually as a long-lived seral. *P. tremuloides* frequently forms climax stands. *P. pungens* may be climax on upland sites but more often is confined to bottomlands and rocky sites. *Quercus gambelii* may occur as a climax at the lower limits of this zone.

The woodland zone occurs at elevations of 6,500 to 7,800 feet (1,981 to 2,590 m). *P. tremuloides* and *Q. gambelii* plant associations commonly occur as climaxes. *Juniperus osteosperma* and/or *Pinus edulis* generally are rare. *Populus angustifolia* and *P. pungens* dominate riparian forests. *P. menziesii* and *P. ponderosa* also are rare.

VEGETATION CLASSIFICATION AND RECOVERY AFTER DISTURBANCE

Emphasis of this study was on the identification of climax plant associations and their landforms. A few successional communities were sampled to determine which species might identify successional status. These species then could be used to indicate the degree of disturbance of the presumably climax plant communities. In most of the study area, climax plant communities are relatively rare in azonal habitats. During the last 100 years, mining, railroads, and other disturbances directly affected only small portions of the Gunnison National Forest. However, the associated effects of disturbances, such as grazing, fires, disease, insects, and logging, affected almost the entire forested area, particularly at lower elevations. The relatively high disturbance level in the study area enabled many disturbance-induced plant species to become established in the undergrowth of climax forests. The ubiquity of these successional plant species is one of the reasons why it was very difficult to develop an objective classification based on sampled stands that would correlate with the habitat type classification presented here. The classification was produced primarily on the basis of a subjective comparison of the species composition of the sampled stands with the species composition of similar stands sampled elsewhere.

Many of the major forest habitat types sampled on the Gunnison National Forest are represented by a single stand. This also contributed to the difficulty of developing an objective classification, because the full range of the species composition and cover in each habitat type was not known. This information was missing not only for the Gunnison National Forest habitat types, but often also for the habitat types with which the Gunnison National Forest stands were compared. Placements of some stands in habitat types described elsewhere are tentative. Some previously described habitat types may have been floristically the same or different from the habitat types sampled in the study area. The low number of stands sampled for each habitat type also was a source of difficulties in deciding whether low-altitude and high-altitude related stands belong to the same or different habitat types. An example is the *Abies lasiocarpa/Arnica cordifolia* habitat type, which occurs in both the upper subalpine and upper montane zones. Some of the associated undergrowth species are different at different elevations.

The habitat type classification presented here can only be considered a preliminary classification and has to be refined by further work on a considerably larger number of samples from a greater geographical area.

Stands were considered successional under the following circumstances. (1) They were dominated by plant species not normally associated with climax vegetation;

also, there was evidence of previous disturbance, but the future direction of succession could be predicted. (2) There was strong evidence of severe disturbance in the stand. In forest stands, recovering or successional status may be suggested by invading young tree seedlings of climax species that are not among present overstory dominants; this indicates that the composition of the climax plant association will be different from the composition of the present plant association. An example is a young *Pinus contorta* stand with *Picea engelmannii* and/or *Abies lasiocarpa* seedlings, and evidence of fire. Strongly disturbed stands were placed directly under the climax habitat type when the presumably original dominants were present and there was no evidence of their replacement. Some of these preliminary habitat types later may be found to be successional. For example, the high cover of successional plant species in some sampled stands was attributed to a high degree of grazing disturbance, and was disregarded in classifying and naming these units; despite a high cover of *Bromus tectorum* in a very old stand of *Pseudotsuga menziesii*, the stand was placed in the *P. menziesii/Festuca idahoensis* habitat type on the basis of evidence from remnants of the original undergrowth.

Misinterpretation of the successional status of a stand also may occur, because some plant species that usually dominate successional communities on zonal surfaces also dominate climax communities in azonal habitats where zonal dominants cannot grow. For example, *Populus tremuloides* and *P. menziesii* may dominate climax communities on rocky sites, and also are very successful dominants of recovering and grazing-maintained plant communities in zonal habitats.

One of the most difficult disturbance factors to analyze is grazing. Some plant communities presently are recovering from a severe, one-time disturbance initiated by grazing that may have changed the species composition completely. Other communities occasionally may be disturbed by infrequent livestock grazing that produces a slight but persistent change in species composition. For example, in the subalpine zone, cattle grazing usually decreases the dominance of native graminoids, and increases the cover of various forbs and/or introduced graminoids; sheep grazing may reduce palatable forbs. Other plant communities may be maintained by grazing. These zootic climax plant communities have a species composition very unlike the original natural vegetation.

All these stands probably could be included within a habitat type named for the original climax vegetation. However, how long climax undergrowth vegetation persists under a continuing grazing regime is unknown. Moreover, it eventually may produce a different but stable plant community and a different soil type. The stand then probably should be classified as a new habitat type or at least a different community type.

The stands that were evaluated as successional because of human or fire disturbance were placed under a climax habitat type, into which they presumably would develop in the future. Usually, these were neighboring stands relatively undisturbed, which represented a control for the disturbance. Only control series could be determined when there was no obvious climax habitat type in the vicinity. It was not possible to objectively demonstrate consistent relationships between the stands recovering from disturbance and relatively undisturbed stands.

Both zonal and azonal climax forest communities recover after catastrophic disturbance in various successional stages. Recovering vegetation usually consists of successional plant communities that may be specific for different climax plant communities. Several recovering plant communities may follow each other in a successional sequence before the stage of a climax plant community is reached. For example, a *Populus tremuloides/Festuca thurberi* plant community may be succeeded by a *Pinus contorta/Vaccinium myrtillus* plant community that is in turn succeeded by an *Abies lasiocarpa/Vaccinium myrtillus* habitat type that is climax. Even for the same control or climax plant association, recovering plant communities may be different in each elevational zone, but they also may overlap between zones. In the study area, extensive logging keeps much of the forest vegetation in a successional or disturbed state. The recovery usually is more complex at middle than at higher or lower elevations, and in zonal than in azonal habitat types. In the latter, the recovery may lead directly to the original forest vegetation without the development of successional plant communities.

ECOSYSTEM PATTERNS

There are three major geographical divisions of the study area based on differences in local climate: (1) the northern part of the Gunnison Basin is cooler and receives considerably more precipitation than the rest of the study area; (2) the southern part of the Gunnison Basin has temperatures higher than average for the Basin and is drier; and (3) the Paonia District has considerably higher temperatures and lower precipitation than the Gunnison Basin. Some of the landforms and vegetation within these three areas are strikingly different.

The Paonia District is the only area within the Gunnison National Forest with extensive woodland zone plant communities of *Quercus gambelii* and *Juniperus osteosperma*. *Q. gambelii* is not an important successional species in the study area; it is much more important in this role to the south of the Gunnison National Forest (DeVelice et al. 1986). *Picea pungens* dominates other than streamside plant communities only in the southern part of the Gunnison Basin. Its importance increases toward the south, especially south of the study area; *Pinus edulis* and *Abies concolor*, which also are important in the southwest (DeVelice et al. 1986, Moir and Ludwig 1979), were not found during the present study. In the southern part of the study area, *P. pungens* and *Pseudotsuga menziesii* form a dryland forest near Cathedral (Barrell 1969). *P. menziesii-P. pungens*-dominated forests also occur on well-drained sites southeast of Sargents in the eastern part of the study area. However, these forest associations were not sampled during the present study. The relatively high precipitation in the Gothic area and in the Ruby Mountains probably maintains the luxuriant subalpine forest and undergrowth vegetation in this area. These local climate-related differences are strongest at lower elevations, although they still are noticeable in the upper subalpine zone. Precipitation increases and temperature decreases with elevation, and the differences among local areas are shifted to the area of humid conditions where they do not affect the vegetation as strongly as in the areas of low precipitation where environmental conditions for many species are marginal.

Climatic and edaphic differences may contribute to the predominance of *Pinus contorta* in the Taylor Park region and in the southern part of the study area. These forests, like *Populus tremuloides* forests, may be maintained by fire reoccurring at long time intervals. *Pinus aristata* stands probably are the result of both the distribution opportunity and local climatic differences; large stands are limited to the southern part of the Gunnison National Forest. Poorly developed *Juniperus scopulorum* stands were observed only near Almont and on Alpine Road but were not sampled. According to Barrell (1969), *Abies lasiocarpa* is considerably less frequent in the southern part of the Gunnison Basin, but it was sampled there during the present study.

Soil chemistry may influence vegetation locally; Langenheim (1962) observed a restrictive edaphic situation on North Italian Mountain near Crested Butte and in two other localities. The major influence of soil is through topography. For example, the San Juan Mountains in that part of the Uncompahgre National Forest sampled are considerably steeper than the rest of the study area, except for small sections like the Gothic Natural Research Area in the north. The steep areas have significantly higher erosion rates, particularly if precipitation is higher also, and support more scree vegetation types than areas with gentler topography. In the steep, humid areas, the vegetation also is significantly affected by frequent landslides and snow avalanches that do not occur in arid areas with gentle topography. Soils with high clay content in the Paonia District and in the southern part of the study area may contribute to the predominance of some species there.

A number of habitat types that may occur in the study area were not sampled. The survey was limited to the vicinity of roads; old forest stands that have not been logged may occur in inaccessible areas. Moreover, the plots sampled were frequently small and limited in number. Two habitat types that were not identified in the present study, but may occur at Snodgrass Mountain north of Crested Butte, are *Populus tremuloides/Carex geyeri* and *Abies lasiocarpa/Paxistima myrsinites*.[11] The latter occurs on cool, dry, rocky, steep north slopes. Another habitat type that may occur at cold, dry, higher elevations, such as Alpine Plateau, is *Abies lasiocarpa/Ribes* spp. There is probably at least one *Pseudotsuga menziesii/Picea pungens*-dominated dry land habitat type near Cathedral and southwest of Sargents. Komarkova[3] also identified a *Pinus contorta/Carex foenea* habitat type in an open, dry, south slope below Old Monarch Pass. However, this plant community appears to be successional to an *A. lasiocarpa*-dominated overstory with undetermined undergrowth.

Forest soils, like forest vegetation, also exhibit regional patterns. The northern part of the study area and the neighboring areas to the north appear to have more leached soils than the southern part of the study area or the Paonia District, where the soils are drier and include more clay. These differences probably are more related to the local climate, which is more humid in the north and drier in the south and in the Paonia District. In general, there was little evidence of leaching in the subsurface horizons, and relatively few alfisols were found. These soils are considerably more common in northern Colorado areas, such as the Front Range (Hess and Alexander 1986). The basic geological material probably influences the soil types to some degree. For example, soils in areas with parent materials that produce rounded topography are considerably better developed than in those that produce steep, rocky slopes, such as the Gothic Research Natural Area and the San Juan Mountains.

[11]The Populus tremuloides/Carex geyeri and Abies lasiocarpa/Paxistima myrsinites habitat types were identified and described on the White River National Forest to the north of the Gunnison National Forest by Hess and Wasser[2] and Hoffman and Alexander (1983).

FURTHER STUDIES IN RELATION TO THE HABITAT TYPES

Several areas of research logically should follow this study. The production of undergrowth vegetation in relation to habitat types needs to be examined. Ellison and Houston (1958) and Mueggler (1985b) have suggested that production of vegetation under *Populus tremuloides* could be used as an indicator of forage production and, therefore, range condition. In the Gunnison National Forest, both cattle and sheep utilize—sometimes quite heavily—vegetation under *Populus*. It would be valuable to know the relationship between habitat types and potential undergrowth productivity.

A correlation may be found between the growth rates of important timber trees and the habitat types in this area similar to the relationship of growth rates of *Pinus ponderosa* and the habitat types in the northern Rocky Mountains described by Daubenmire (1961).

Numerous fungi attack *P. tremuloides* in Colorado (Juzwik et al. 1978). Some *Populus* habitat types may be more susceptible to various species of fungi than others are. In northern Idaho and eastern Washington, *Arceuthobium* infects *P. ponderosa* in the *P. ponderosa/Agropyron spicatum* and *P. ponderosa/Purshia tridentata* habitat types but not in other habitat types dominated by *P. ponderosa* (Daubenmire 1961). Susceptibility of *Picea engelmannii* to insect infestation may be correlated with habitat types in Colorado (Shepherd 1959).

The relationship of forest habitat types and their successional stages to wildlife management also needs further research.

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Table A-1.—Tree populations for selected habitat types. Numbers of trees listed are based on sample plot data adjusted to 375 m^2.

Habitat type and species	Stands sampled	Seedling height (dm)			Diameter classes (d.b.h.) dm							
		0-6	6-24	24+	0.5-1	1-2	2-3	3-4	4-5	5-6	6-7	7+
Pinus ponderosa/ Festuca arizonica	1											
Pinus ponderosa		0	0	0	1	1	5	1	1	1	1	0
Picea pungens/ Festuca arizonica	1											
Picea pungens		3	6	1	2	6	2	0	0	1	0	0
Pinus aristata		1	0	0	0	0	0	0	0	0	0	0
Picea pungens/ Amelanchier alnifolia	1											
Picea pungens		11	5	13	21	11	6	2	3	0	0	3
Pseudotsuga menziesii		2	3	3	0	1	0	0	0	0	0	0
Pinus ponderosa		0	0	0	0	0	0	2	0	0	0	0
Pseudotsuga menziesii/ Paxistima myrsinites	1											
Pseudotsuga menziesii		4	2	2	0	1	0	1	1	2	2	11
Pseudotsuga menziesii/ Carex geyeri	2											
Pseudotsuga menziesii		8	12	10	6	12	3	3	2	2	0	0
Pinus ponderosa		0	0	0	3	4	3	([1])	([1])	([1])	0	0
Picea pungens		0	2	0	0	0	0	0	0	0	0	0
Populus tremuloides/ Symphoricarpos oreophilus	1											
Populus tremuloides		35	23	79	9	4	14	12	3	1	0	0
Populus tremuloides/ Pteridium aquilinum	1											
Populus tremuloides		29	8	4	13	20	16	9	2	0	0	0
Populus tremuloides/ Amelanchier alnifolia-Prunus virginiana	1											
Populus tremuloides		49	155	55	0	9	31	19	0	0	0	0
Pinus contorta/ Juniperus communis	1											
Pinus contorta		22	7	5	16	21	4	1	2	2	0	0
Picea engelmannii		2	0	0	0	0	0	0	0	0	0	0
Pinus contorta/ Carex geyeri	1											
Pinus contorta		2	0	3	5	10	4	4	2	1	0	0
Picea engelmannii		0	1	1	0	0	0	0	0	0	0	0
Pinus aristata/ Festuca arizonica	3											
Pinus aristata		1	2	2	1	6	8	4	2	0	0	([1])
Picea pungens		2	0	0	0	0	0	0	0	0	0	0
Populus tremuloides		([1])	([1])	0	0	0	0	0	0	0	0	0
Abies lasiocarpa/ Vaccinium scoparium	1											
Abies lasiocarpa		40	12	3	1	3	8	0	0	0	0	0
Picea engelmannii		28	16	3	4	6	5	7	1	3	1	0
Abies lasiocarpa/ Polemonium pulcherrimum	1											
Abies lasiocarpa		3	5	1	1	1	1	0	0	0	0	0
Picea engelmannii		8	12	5	10	5	1	2	6	4	3	1
Abies lasiocarpa/ Moss	1											
Abies lasiocarpa		0	0	0	0	0	0	0	0	0	0	0
Picea engelmannii		5	8	1	4	12	16	4	5	2	0	0
Abies lasiocarpa/ Carex geyeri	2											
Abies lasiocarpa		24	12	([1])	3	2	([1])	([1])	0	0	0	0
Picea engelmannii		28	25	11	9	10	4	0	([1])	2	1	2
Pinus contorta		([1])	4	3	2	4	2	2	4	([1])	0	0
Abies lasiocarpa/ Arnica cordifolia	1											
Abies lasiocarpa		76	20	8	13	22	15	2	2	0	0	0
Picea engelmannii		0	1	2	1	4	5	2	3	3	1	2

[1]*Less than one tree per class.*

Table A-2.—Percentage canopy cover of plant species in *Juniperus osteosperma* and *Quercus gambelii* habitat types on the Gunnison National Forest.

	J. osteosperma/ Symphoricarpos oreophilus	*Q. gambelii/ Amelanchier alnifolia*		*Q. gambelii/ Prunus virginiana*
Stand number	**201**	**187**	**207**	**193**
Plot size (m^2)	75	55	55	50
Location:				
Quarter section	NE	SE	NE	SE
Section	5	21	34	16
Township	15S	49N	12S	49N
Range	91W	6W	91W	6W
Landform:				
Slope (%)	5	27	27	11
Aspect	ESE	SE	E	SE
Elevation (m)	2,183	2,929	1,963	2,793
Elevation (ft)	7,160	9,615	6,440	9,165
Tree d.b.h. (cm)	75.0	0.0	0.0	0.0
Shrub d.r.c (cm)	3.0	10.0	12.0	12.0
Tree height (m)	7.0	0.0	0.0	0.0
Shrub height (m)	1.0	2.7	5.0	3.0
Soil pH	7.9	7.4	6.1	6.5
Trees				
Juniperus osteosperma	85.0	--	--	--
Shrubs				
Acer glabrum	--	--	3.0	--
Amelanchier alnifolia	0.4	15.0	6.0	--
Artemisia tridentata	0.2	--	--	--
Mahonia fremontii	3.0	--	--	--
Mahonia repens	--	8.0	15.0	3.0
Paxistima myrsinites	--	--	5.0	--
Prunus virginiana	--	12.0	2.0	15.0
Quercus gambelii	--	65.0	85.0	90.0
Rosa woodsii	3.0	8.0	0.2	--
Swida sericea	--	--	6.0	--
Symphoricarpos oreophilus	65.0	15.0	5.0	7.0
Graminoids				
Bromus carinatus	6.0	--	--	--
Bromus pumpellianus	--	--	3.0	--
Bromus tectorum	18.0	--	--	--
Carex geyeri	20.0	35.0	10.0	40.0
Elymus elymoides	3.0	--	--	--
Elymus trachycaulus	3.0	5.0	0.2	--
Festuca thurberi	--	--	--	12.0
Poa nemoralis ssp. *interior*	8.0	--	--	--
Stipa nelsonii	--	--	--	3.0
Stipa pinetorum	6.0	--	--	--
Forbs				
Achillea lanulosa	3.0	2.0	0.2	--
Allium geyeri	1.0	--	--	--
Castilleja linearifolia	2.0	--	--	--
Chenopodium fremontii	0.4	--	--	--
Cirsium undulatum	0.6	--	--	--
Conioselinum scopulorum	--	--	--	20.2
Erigeron speciosus	2.0	--	--	0.2
Fragaria virginiana	--	--	--	--
Frasera speciosa	2.0	--	--	--
Galium septentrionale	3.0	6.0	--	--
Geranium richardsonii	2.0	--	--	0.2
Heliomeris multiflora	--	4.0	--	--
Lathyrus leucanthus	--	25.0	0.2	2.0
Linum lewisii	--	2.0	--	--
Lomatium dissectum	--	2.0	--	--
Lupinus argenteus	--	6.0	--	--
Osmorhiza depauperata	2.0	--	2.0	--
Senecio serra	3.0	--	--	--
Smilacina stellata	--	1.0	8.0	--
Streptopus fassettii	--	--	1.0	--
Taraxacum officinale	0.4	--	--	--
Thalictrum fendleri	5.0	--	--	--
Vicia americana	0.2	--	--	--
Viola canadensis	3.0	--	--	--
Tree layer	85.0	0.0	0.0	0.0
Shrub layer	4.0	85.0	98.0	93.0
Herbaceous layer	30.0	65.0	30.0	55.0
Rock	2.0	5.0	5.0	1.0
Bare soil	24.0	20.0	3.0	3.0
Moss and lichen	15.0	0.5	12.0	0.0

Table A-3.—Percent canopy cover of plant species in *Pinus ponderosa* and *Picea pungens* habitat types of the Gunnison National Forest.

	P. ponderosa/ Festuca arizonica		*P. ponderosa/ Festuca idahoensis*	*P. pungens/ Festuca arizonica*		*P. pungens/ Amelanchier alnifolia*	
Stand number	157	228	174	225	227	203	211
Plot size (m^2)	300	375	200	375	375	20	375
Location:							
Quarter section	NE	NW	NE	SE	NW	SW	SE
Section	15	14	3	25	30	4	28
Township	45N	45N	46N	44N	44N	11S	13S
Range	1E	3E	4W	3W	2W	90W	89W
Landform:							
Slope (%)	31	12	11	12	20	70	36
Aspect	E	SE	S	ESE	E	E	NW
Elevation (m)	3,012	3,030	2,670	3,014	2,973	2,407	2,039
Elevation (ft)	9,880	9,940	8,760	9,890	9,820	7,900	6,690
Tree d.b.h. (cm)	75.0	35.0	35.0	25.0	30.0	40.0	40.0
Shrub d.c.r. (cm)	1.5	1.0	5.0	0.8	1.0	1.0	3.0
Tree ht. (m)	25.0	25.0	9.0	20.0	30.0	18.0	30.0
Shrub ht. (m)	1.2	0.9	0.6	0.8	0.5	0.9	1.0
Soil pH	7.1	--	7.1	--	6.7	--	--
Trees							
Picea pungens	--	--	--	25.0	35.0	85.0	70.0
Picea aristata	--	3.0	--	0.2	10.0	--	--
Pinus ponderosa	35.0	40.0	50.0	--	--	--	4.0
Populus tremuloides	--	--	--	--	--	3.0	--
Pseudotsuga menziesii	5.0	--	--	--	--	--	8.0
Shrubs							
Amelanchier alnifolia	--	--	--	--	--	6.0	8.0
Artemisia tridentata	--	--	65.0	--	--	--	--
Juniperus communis	--	1.0	--	--	2.0	--	--
Lonicera involucrata	--	--	--	--	--	4.0	--
Mahonia repens	--	--	1.0	--	--	--	3.0
Paxistima myrsinites	--	--	--	--	--	2.0	2.0
Prunus virginiana	--	--	--	--	--	3.0	2.0
Quercus gambelii	--	--	--	--	--	0.2	3.0
Ribes cereum	3.0	--	--	4.0	7.0	--	--
Ribes inerme	--	3.0	--	--	--	6.0	5.0
Rosa woodsii	--	--	0.2	2.0	5.0	6.0	8.0
Salix drummondii	--	--	--	--	--	2.0	--
Salix exigua	--	--	--	--	--	--	3.0
Swida sericea	--	--	--	--	--	--	8.0
Symphoricarpos oreophilus	--	--	--	--	--	6.0	6.0
Graminoids							
Agrostis hiemalis	--	--	1.0	--	--	7.0	3.0
Bromus porteri	--	--	--	--	--	8.0	4.0
Calamagrostis canadensis	--	--	--	--	--	2.0	--
Carex geophila	3.0	--	4.0	2.0	--	--	--
Carex geyeri	--	--	--	--	3.0	6.0	--
Carex lanuginosa	--	--	--	--	--	--	6.0
Carex utriculata	--	--	--	--	--	--	2.0
Danthonia parryi	--	--	--	8.0	1.0	--	--
Elymus elymoides	--	2.0	--	--	1.0	--	--
Elymus longifolius	--	0.5	0.2	2.0	1.0	--	--
Elymus trachycaulus	--	0.5	--	--	--	4.0	2.0
Festuca arizonica	30.0	18.0	--	18.0	18.0	--	--
Festuca idahoensis	--	--	6.0	--	--	--	--
Festuca thurberi	--	--	--	--	--	8.0	--
Koeleria macrantha	0.2	3.0	2.0	3.0	2.0	--	--
Muhlenbergia montana	--	22.0	--	2.0	--	--	--
Oryzopsis hymenoides	2.0	0.5	--	1.0	0.5	--	--
Poa nemoralis ssp. *interior*	3.0	--	--	--	--	--	--

Table A-3.—Continued.

Stand number	*P. ponderosa/ Festuca arizonica*		*P. ponderosa/ Festuca idahoensis*	*P. pungens/ Festuca arizonica*		*P. pungens/ Amelanchier alnifolia*	
	157	228	174	225	227	203	211
Forbs							
Achillea lanulosa	--	--	--	--	--	2.0	3.0
Androsace septentrionalis	--	1.0	--	--	0.2	--	--
Antennaria rosea	--	2.0	--	1.0	--	0.2	4.0
Arabis spp.	0.2	0.5	--	0.5	--	--	--
Artemisia frigida	2.0	3.0	0.2	3.0	2.0	--	--
Castilleja spp.	--	1.0	0.2	--	--	--	--
Chaenactis douglasii	0.2	2.0	--	--	--	--	--
Chamerion angustifolium	--	--	--	--	--	--	2.0
Cirsium spp.	--	--	0.2	--	--	--	4.0
Equisetum arvense	--	--	--	--	--	3.0	--
Erigeron glabellus	--	8.0	--	--	--	--	--
Erigeron speciosus	--	--	--	--	--	--	3.0
Erigeron subtrinervis	1.0	1.0	0.2	--	--	--	--
Fragaria virginiana	--	--	--	--	--	0.2	3.0
Galium triflorum	--	--	--	--	--	2.0	--
Geranium cespitosum	--	3.0	--	2.0	3.0	--	--
Geranium richardsonii	--	--	--	--	--	3.0	3.0
Geum rivale	--	--	--	--	--	2.0	--
Heracleum sphondylium	--	--	--	--	--	--	3.0
Heterotheca villosa	--	--	--	3.0	1.0	--	--
Hippochaete laevigata	--	--	--	--	--	--	2.0
Hymenoxys richardsonii	4.0	8.0	--	--	--	--	--
Lathyrus leucanthus	--	--	--	0.5	--	--	1.0
Lupinus argenteus	--	--	5.0	--	--	--	--
Mertensia lanceolata	--	--	--	1.0	3.0	--	--
Osmorhiza depauperata	--	--	--	--	--	3.0	6.0
Penstemon teucrioides	--	--	0.5	--	--	--	--
Potentilla hippiana	--	2.0	1.0	0.5	1.0	--	--
Pulsatilla patens	--	--	1.0	--	--	--	--
Rudbeckia ampla	--	--	--	--	--	--	4.0
Selaginella densa	--	--	--	3.0	--	--	--
Senecio neomexicanus	0.2	--	--	--	0.5	--	--
Senecio serra	--	--	--	--	--	--	3.0
Smilacina amplexicaulis	--	--	--	--	--	--	5.0
Smilacina stellata	--	--	--	--	--	5.0	2.0
Solidago multiradiata	0.2	--	--	--	--	4.0	--
Thalictrum fendleri	--	--	--	--	--	--	3.0
Valeriana acutiloba	--	--	0.2	--	--	--	--
Viola vallicola	--	--	--	--	--	2.0	5.0
Tree layer	45.0	40.0	50.0	25.0	45.0	85.0	75.0
Shrub layer	3.0	4.0	65.0	7.0	7.0	30.0	35.0
Herbaceous layer	40.0	75.0	18.0	30.0	28.0	55.0	45.0
Rock	5.0	10.0	8.0	70.0	70.0	5.0	4.0
Bare soil	60.0	75.0	25.0	60.0	30.0	15.0	1.0
Moss and lichen	2.0	2.0	--	4.0	2.0	8.0	20.0

Table A-4.—Percentage canopy cover of plant species in *Pseudotsuga menziesii* habitat types of the Gunnison National Forest.

	P. menziesii/ Purshia tridentata		*P. menziesii/ Jamesia americana*	*P. menziesii/ Paxistima myrsinites*	*P. menziesii/ Symphoricarpos oreophilus*		*P. menziesii/ Carex geyeri*		*P. menziesii/ Festuca idahoensis*
Stand number	**100**	**92**	**90**	**214**	**141**	**170**	**222**	**221**	**152**
Plot size (m^2)	200	200	200	375	200	150	375	375	150
Location:									
Quarter section	NW	SW	NW	NW	--	NE	SW	SE	SW
Section	20	22	1	23	34	8	32	20	19
Township	49N	49N	48N	14S	14S	42N	50N	50N	45N
Range	3E	5E	5E	87W	84W	4W	89W	88W	2E
Landform:									
Slope (%)	14	21	32	58	21	70	11	21	14
Aspect	SW	S	S	NW	E	W	ENE	SW	E
Elevation (m)	2,829	2,988	2,988	3,024	2,720	2,836	2,426	2,975	3,024
Elevation (ft)	9,280	9,600	9,600	9,900	8,925	9,305	7,960	9,760	9,920
Tree d.b.h. (cm)	35.0	38.0	67.0	80.0	60.0	40.0	30.0	38.0	85.0
Shrub d.c.r. (cm)	8.0	1.5	1.5	2.0	1.5	1.5	1.0	0.5	1.5
Tree ht. (m)	12.0	11.0	18.0	35.0	28.0	20.0	30.0	29.0	18.0
Shrub ht. (m)	0.6	0.6	0.9	0.9	0.4	1.6	0.7	0.6	1.5
Soil pH	6.3	7.2	7.4	--	6.2	7.5	--	--	7.4
Trees									
Picea pungens	--	--	--	--	--	--	1.0	--	--
Pinus contorta	--	25.0	20.0	--	--	--	--	--	--
Pinus flexilis	--	--	6.0	--	1.0	--	--	--	--
Pinus ponderosa	20.0	--	--	--	--	--	45.0	--	--
Populus tremuloides	0.2	12.0	8.0	--	--	--	--	2.0	--
Pseudotsuga menziesii	15.0	25.0	35.0	38.0	60.0	75.0	35.0	70.0	55.0
Shrubs									
Amelanchier alnifolia	--	--	--	3.0	--	--	4.0	--	--
Arctostaphylos adenotricha	--	12.0	4.0	--	--	--	4.0	--	--
Artemisia tridentata	60.0	1.0	0.2	--	--	--	--	--	--
Holodiscus dumosus	2.0	--	--	6.0	--	--	--	--	--
Jamesia americana	--	--	7.0	--	--	--	--	--	--
Juniperus communis	4.0	5.0	1.0	--	--	--	5.0	--	0.2
Mahonia repens	3.0	2.0	8.0	6.0	--	--	20.0	6.0	--
Paxistima myrsinites	1.0	--	--	12.0	--	--	1.0	1.0	--
Prunus virginiana	--	--	--	--	--	--	0.5	--	--
Purshia tridentata	15.0	30.0	--	--	--	--	3.0	--	--
Quercus gambelii	--	--	--	--	--	--	3.0	--	--
Ribes cereum	--	--	--	--	--	--	--	--	3.0
Ribes coloradense	--	--	--	2.0	--	--	--	--	--
Ribes inerme	--	--	0.2	6.0	3.0	3.0	--	5.0	--
Rosa woodsii	--	2.0	2.0	--	2.0	1.0	2.0	33.0	--
Symphoricarpos oreophilus	--	0.2	0.2	3.0	10.0	4.0	25.0	3.0	--
Graminoids									
Agrostis hiemalis	--	--	--	0.5	--	--	--	--	--
Bromus canadensis	--	--	--	--	--	--	--	4.0	--
Bromus pumpellianus	--	--	--	6.0	--	0.2	2.0	--	--
Carex brevipes	--	--	3.0	--	--	--	--	--	--
Carex foenea	--	8.0	--	--	--	--	--	--	--
Carex geyeri	8.0	0.2	--	30.0	1.0	1.0	35.0	60.0	2.0
Elymus elymoides	--	--	0.1	2.0	--	--	0.5	0.5	0.2
Elymus longifolius	0.2	--	--	--	2.0	--	--	--	--
Elymus trachycaulus	--	--	1.0	2.0	--	0.2	--	1.0	--
Festuca arizonica	2.0	--	--	--	--	--	4.0	--	--
Festuca idahoensis	--	--	--	--	4.0	--	--	--	40.0
Festuca thurberi	--	--	--	4.0	--	1.0	--	--	--
Koeleria macrantha	4.0	4.0	1.0	--	3.0	3.0	0.5	4.0	8.0
Muhlenbergia montana	2.0	--	--	--	--	--	--	--	--
Poa fendleriana	--	--	--	--	--	--	2.0	--	--
Poa leptocoma	--	--	--	3.0	--	--	--	--	--
Poa nemoralis ssp. *interior*	--	--	--	1.0	1.0	2.0	--	1.0	--
Poa pratensis	--	--	2.0	--	--	--	--	--	--
Poa spp.	--	--	--	--	--	--	--	4.0	--
Trisetum spicatum	--	--	--	--	2.0	--	--	--	--

Table A-4.—Continued.

	P. menziesii/ Purshia tridentata		*P. menziesii/ Jamesia americana*	*P. menziesii/ Paxistima myrsinites*	*P. menziesii/ Symphoricarpos oreophilus*		*P. menziesii/ Carex geyeri*		*P. menziesii/ Festuca idahoensis*
Stand number	**100**	**92**	**90**	**214**	**141**	**170**	**222**	**221**	**152**
Forbs									
Achillea lanulosa	0.2	0.2	0.2	1.0	--	1.0	1.0	1.0	--
Androsace septentrionalis	--	--	--	--	--	0.2	--	--	0.2
Antennaria pulcherrima	--	--	--	--	--	--	2.0	0.5	--
Antennaria rosea	0.2	1.0	--	--	0.2	--	3.0	1.0	0.2
Apocynum androsaemifolium	--	--	2.0	--	--	--	--	--	--
Arabis drummondii	0.2	--	1.0	--	--	0.2	0.2	--	3.0
Arnica cordifolia	--	--	--	1.0	--	--	--	--	--
Artemisia frigida	--	0.2	--	--	1.0	0.2	--	--	0.2
Atragene columbiana	--	--	--	--	--	5.0	--	--	--
Castilleja rhexifolia	--	--	--	--	--	--	--	2.0	--
Chamerion angustifolium	--	--	1.0	--	--	--	--	--	--
Descurainia richardsonii	--	--	--	--	--	3.0	--	--	1.0
Draba aurea	--	--	--	--	0.2	0.2	--	--	--
Erigeron speciosus	--	--	--	--	--	--	3.0	3.0	--
Erigeron subtrinervis	0.2	0.4	--	--	--	--	--	--	0.2
Fragaria virginiana	0.2	1.0	--	--	0.2	2.0	0.2	1.0	--
Galium septentrionalie	--	--	--	--	--	--	2.0	1.0	--
Geranium richardsonii	--	--	--	--	--	--	1.0	--	--
Helianthella quinquenervis	--	--	--	10.0	--	--	--	--	--
Heracleum sphondylium	--	--	--	2.0	--	--	--	--	--
Lathyrus leucanthus	--	--	--	1.0	--	--	2.0	2.0	--
Machaeranthera canescens	1.0	--	--	--	--	--	--	--	--
Mertensia ciliata	--	--	--	1.0	--	--	--	--	--
Mertensia lanceolata	--	--	--	--	0.2	7.0	--	--	--
Osmorhiza depauperata	--	--	--	1.0	--	--	--	--	--
Penstemon spp.	0.2	0.5	0.5	1.0	--	--	--	--	--
Potentilla hippiana	0.2	0.4	--	--	--	--	--	--	0.2
Potentilla pulcherrima	--	--	--	--	--	--	1.0	--	0.2
Pulsatilla patens	0.2	--	--	--	--	--	2.0	--	--
Selaginella densa	--	--	--	--	2.0	--	--	--	--
Senecio fendleri	--	--	2.0	--	--	--	--	--	0.2
Senecio neomexicanus	0.2	--	--	--	--	--	--	--	--
Senecio werneriaefolius	--	2.0	--	--	--	--	--	--	--
Smilacina stellata	--	0.2	--	0.5	--	--	1.0	--	--
Solidago multiradiata	--	1.0	2.0	--	--	5.0	1.0	--	--
Thalictrum fendleri	--	--	--	--	0.2	5.0	1.0	1.0	--
Urtica gracilis	--	--	--	25.0	--	--	--	--	--
Veratrum tenuipetalum	--	--	--	90.0	--	--	--	--	--
Vicia americana	--	--	--	1.0	0.4	--	--	1.0	--
Tree layer	35.0	60.0	60.0	38.0	60.0	75.0	75.0	70.0	55.0
Shrub layer	65.0	35.0	10.0	18.0	15.0	8.0	35.0	40.0	3.0
Herbaceous layer	20.0	28.0	25.0	60.0	10.0	35.0	75.0	75.0	50.0
Rock	3.0	5.0	18.0	80.0	18.0	18.0	5.0	2.5	20.0
Bare soil	8.0	18.0	12.0	15.0	25.0	12.0	10.0	1.0	8.0
Moss and lichen	10.0	15.0	5.0	4.0	9.0	5.0	5.0	7.0	2.0

Table A-5.—Percentage canopy cover of plant species in *Populus tremuloides* and *Populus angustifolia* habitat types of the Gunnison National Forest.

	P. tremuloides/ Amelanchier alnifolia-Prunus virginiana		*P. tremuloides/ Thalictrum fendleri*	*P. tremuloides/ Symphoricarpos oreophilus*			*P. tremuloides/ Festuca arizonica*	*P. tremuloides/ Pteridium aquilinum*		*P. tremuloides/ Arctostaphylos adenotricha*	*P. tremuloides/ Festuca thurberi*			*P. angustifolia/ Alnus incana-Swida sericea*
Stand number	**198**	**209**	**38**	**188**	**200**	**210**	**150**	**199**	**208**	**101**	**169**	**233**	**173**	**197**
Plot size (m^2)	60	375	100	150	35	375	35	30	375	300	100	100	100	80
Location:														
Quarter section	SE	SW	SE	NW	SW	SE	NE	SW	SW	SE	SW	SE	NW	SE
Section	32	3	10	21	12	1	36	12	3	32	35	33	23	24
Township	15S	11S	50N	49N	15N	11S	45N	51N	11S	51N	44N	51N	43N	15S
Range	90W	89W	3W	6W	5W	91W	2E	5W	89W	5E	3W	2E	3W	91W
Landform:														
Slope (%)	21	21	7	14	7	5	11	11	3	40	7	--	7	0
Aspect	W	SE	ESE	W	NE	E	E	E	S	S	E	SE	E	Flat
Elevation (m)	2,456	2,450	3,049	2,842	2,718	2,554	2,973	2,573	2,682	3,186	3,179	3,164	3,170	2,186
Elevation (ft)	8,060	8,040	10,000	9,390	8,920	8,380	9,755	8,440	8,800	10,450	10,430	10,380	10,400	7,170
Tree d.b.h. (cm)	40.0	28.0	18.0	28.0	25.0	30.0	35.0	25.0	20.0	35.0	15.0	22.0	15.0	65.0
Shrub d.r.c. (cm)	8.0	3.5	1.0	8.0	1.0	2.5	1.5	6.0	2.0	2.0	1.0	0.2	1.5	11.0
Tree ht. (m)	25.0	20.0	15.0	12.0	8.0	18.0	8.0	9.0	29.0	10.0	10.0	9.0	10.0	30.0
Shrub ht. (m)	4.0	3.0	0.3	0.3	0.7	0.7	0.3	3.0	0.8	0.5	0.2	0.3	0.4	6.0
Soil pH	6.2	--	7.2	7.3	6.1	--	6.5	7.3	--	6.3	6.9	--	6.7	6.6
Trees														
Abies lasiocarpa	--	--	--	--	--	0.2	--	--	--	--	--	--	--	--
Picea engelmannii	--	--	--	--	--	--	--	--	--	--	+	--	1.0	--
Populus angustifolia	--	--	--	--	--	--	--	--	--	--	--	--	--	50.0
Populus tremuloides	75.0	80.0	80.0	88.0	85.0	85.0	60.0	65.0	85.0	40.0	80.0	78.0	80.0	--
Pseudotsuga menziesii	0.2	--	--	--	--	--	--	--	--	--	--	--	--	--
Salix amygdaloides	--	--	--	--	--	--	--	--	--	--	--	--	--	30.0
Shrubs														
Acer glabrum	--	6.0	--	18.0	--	--	--	--	--	--	--	--	--	20.0
Alnus incana ssp. *tenuifolia*	4.0	--	--	--	--	--	--	--	--	--	--	--	--	10.0
Amelanchier alnifolia	45.0	30.0	--	--	0.4	6.0	--	--	3.0	--	--	--	--	--
Arctostaphylos adenotricha	--	--	--	--	--	--	--	--	--	2.0	4.0	22.0	--	--
Clematis ligusticifolia	--	--	--	--	--	--	--	--	--	--	--	--	--	20.0
Juniperus communis	--	--	--	--	--	--	1.0	--	--	--	1.0	--	1.0	--
Mahonia repens	--	--	--	70.0	--	1.0	--	--	--	--	--	--	--	--
Paxistima myrsinites	--	3.0	--	--	--	--	--	--	--	--	--	--	--	--
Prunus virginiana	45.0	4.0	--	6.0	--	3.0	--	6.0	--	--	--	--	--	3.0
Ribes inerme	1.0	4.0	--	--	--	--	--	4.0	--	3.0	--	--	--	--
Rosa woodsii	15.0	6.0	2.0	6.0	3.0	--	--	--	--	--	--	--	--	30.0
Rubus parviflorus	--	5.0	--	--	--	--	--	--	--	--	--	4.0	--	--
Salix exigua	--	--	--	--	--	--	--	--	--	--	--	--	--	5.0
Salix ligulifolia	--	--	--	--	--	--	--	--	--	--	--	--	--	2.0
Salix lutea	--	--	--	--	--	--	--	--	--	--	--	--	--	5.0
Salix scouleriana	--	3.0	--	--	--	--	--	--	--	--	--	--	--	--
Sambucus racemosa	--	--	--	--	--	--	--	--	--	2.0	--	--	--	--
Shepherdia canadensis	--	--	--	--	--	--	--	--	--	1.0	1.0	--	--	--
Swida sericea	--	--	--	--	--	--	--	--	--	--	--	--	--	55.0
Symphoricarpos oreophilus	25.0	5.0	--	10.0	65.0	26.0	--	12.0	7.0	2.0	--	--	--	--
Graminoids														
Bromus carinatus	--	--	--	--	6.0	--	--	--	--	--	--	3.0	--	--
Bromus porteri	--	--	12.0	--	--	--	--	--	--	1.0	--	--	--	--
Bromus pumpellianus	--	4.0	--	2.0	--	2.0	--	6.0	4.0	--	1.0	--	2.0	--
Bromus tectorum	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Bromus spp.	5.0	--	--	--	--	--	--	--	--	--	--	--	--	--
Carex geophila	--	--	--	--	--	--	--	--	--	2.0	--	--	--	--
Carex geyeri	--	--	12.0	12.0	20.0	--	6.0	--	8.0	--	2.0	30.0	2.0	--
Carex hoodii	--	15.0	--	--	--	30.0	--	--	--	--	--	--	--	--
Dactylis glomerata	--	--	--	--	--	--	--	--	--	--	--	--	--	6.0
Danthonia intermedia	--	--	--	--	--	--	--	--	--	--	12.0	--	60.0	--
Elymus longifolius	--	--	--	--	--	--	--	--	8.0	0.4	1.0	--	--	--
Elymus trachycaulus	--	8.0	3.0	--	3.0	3.0	--	15.0	2.0	--	--	3.0	--	2.0
Festuca arizonica	--	--	--	--	--	--	28.0	--	--	--	--	--	--	--
Festuca idahoensis	--	--	8.0	--	--	--	--	--	--	--	--	--	10.0	--
Festuca thurberi	--	--	--	--	--	--	18.0	--	--	--	65.0	10.0	15.0	--
Muhlenbergia montana	--	--	--	--	--	--	8.0	--	--	--	--	--	--	--
Poa agassizensis	--	--	--	--	--	18.0	--	--	--	--	--	--	--	--
Poa epilis	--	--	3.0	--	--	--	--	--	--	--	--	--	--	--
Poa fendleriana	--	--	--	--	--	--	--	8.0	--	--	--	--	--	--
Poa nemoralis ssp. *interior*	1.0	--	--	--	--	--	--	--	--	2.0	1.0	--	--	--
Poa palustris	--	--	--	--	--	--	--	--	--	--	--	--	--	4.0
Trisetum spicatum	--	--	--	0.5	--	0.5	--	--	--	0.2	--	--	--	--
Forbs														
Achillea lanulosa	2.0	2.0	4.0	--	3.0	5.0	2.0	3.0	2.0	--	2.0	2.0	2.0	--
Agoseris glauca	--	--	--	--	--	--	--	--	--	--	2.0	3.0	0.2	--
Angelica ampla	--	--	--	1.0	--	--	--	--	3.0	--	--	--	--	--
Aquilegia coerulea	--	--	2.0	6.0	--	1.0	--	--	--	--	--	--	--	--
Arnica cordifolia	--	--	--	--	--	--	--	--	--	--	--	6.0	--	--
Astragalus alpinus	--	--	--	--	--	--	--	--	--	--	3.0	--	--	--
Chamerion angustifolium	--	2.0	35.0	--	--	--	--	--	1.0	0.2	--	1.0	--	--
Cirsium spp.	--	3.0	5.0	--	--	--	--	2.0	2.0	--	--	--	--	--
Conioselinum scopulorum	--	--	--	6.0	--	0.2	--	--	--	--	--	--	--	--
Delphinium nuttallianum	5.0	--	--	--	--	--	--	--	6.0	--	--	--	--	--
Dipsacus sylvestris	2.0	--	--	--	--	--	--	3.0	4.0	--	--	--	--	--

Table A-5.—Continued.

	P. tremuloides/ Amelanchier alnifolia-Prunus virginiana		*P. tremuloides/ Thalictrum fendleri*	*P. tremuloides/ Symphoricarpos oreophilus*			*P. tremuloides/ Festuca arizonica*	*P. tremuloides/ Pteridium aquilinum*		*P. tremuloides/ Arctostaphylos adenotricha*	*P. tremuloides/ Festuca thurberi*			*P. angustifolia/ Alnus incana-Swida sericea*
Stand number	198	209	38	188	200	210	150	199	208	101	169	233	173	197
Erigeron glabellus	--	--	--	--	--	5.0	--	--	--	--	--	--	--	--
Erigeron speciosus	--	--	3.0	--	2.0	--	--	--	4.0	--	--	3.0	--	--
Erigeron spp.	2.0	--	--	--	--	--	--	2.0	--	--	1.0	--	0.2	--
Fragaria virginiana	1.0	4.0	5.0	--	2.0	5.0	--	--	3.0	0.2	3.0	1.0	2.0	--
Frasera speciosa	1.0	--	--	--	2.0	--	--	--	--	--	--	--	--	--
Galium triflorum	5.0	5.0	--	3.0	--	--	--	--	--	--	--	--	--	--
Galium septentrionale	--	2.0	--	--	2.0	5.0	--	3.0	3.0	--	--	2.0	--	1.0
Geranium richardsonii	3.0	4.0	--	2.0	2.0	6.0	--	2.0	8.0	--	2.0	--	--	--
Helianthella quinquenervis	--	--	4.0	--	--	--	--	--	--	--	--	2.0	--	--
Heracleum sphondylium	5.0	5.0	--	--	--	--	--	--	6.0	--	--	--	--	6.0
Hippochaete hyemalis	--	--	--	--	--	--	--	--	--	--	--	--	--	15.0
Iris missouriensis	--	--	--	--	--	--	--	--	--	--	3.0	--	--	--
Lathyrus leucanthus	--	3.0	35.0	--	--	0.5	--	--	8.0	--	--	37.0	--	--
Lupinus argenteus	4.0	--	15.0	1.0	2.0	--	15.0	--	--	--	--	0.2	--	--
Mertensia lanceolata	--	--	--	--	--	--	--	--	2.0	--	--	--	--	--
Osmorhiza depauperata	8.0	5.0	--	12.0	2.0	4.0	--	--	6.0	--	--	--	--	--
Oxytropis deflexa	--	--	--	--	--	--	3.0	--	--	--	--	--	--	--
Polemonium pulcherrimum	--	--	--	--	--	--	--	5.0	--	--	--	--	--	--
Potentilla hippiana	--	--	--	--	--	--	1.0	--	--	--	1.0	--	2.0	--
Potentilla pulcherrima	--	--	--	--	--	2.0	--	--	--	--	--	--	--	--
Pseudocymopterus montanus	--	--	--	--	--	--	0.2	--	--	0.2	1.0	2.0	0.2	--
Pteridium aquilinum	--	3.0	--	--	--	--	--	40.0	65.0	--	--	--	--	--
Rudbeckia ampla	--	2.0	--	--	--	6.0	--	--	--	--	--	--	--	--
Senecio bigelovii	--	--	--	--	--	6.0	--	--	--	--	--	--	--	--
Senecio serra	3.0	--	5.0	--	3.0	--	--	--	3.0	--	--	2.0	--	--
Senecio spp.	--	--	--	--	--	--	2.0	--	--	0.4	--	--	0.2	--
Smilacina amplexicaulis	--	--	--	2.0	--	--	--	--	--	--	--	--	--	--
Smilacina stellata	3.0	4.0	--	--	--	--	--	--	2.0	--	0.2	--	0.2	6.0
Solidago multiradiata	--	--	--	--	--	--	--	3.0	--	--	2.0	--	--	--
Solidago spp.	6.0	--	--	0.2	--	--	--	--	--	--	--	2.0	2.0	2.0
Streptopus fassettii	--	4.0	--	--	--	--	--	--	0.2	--	--	--	--	--
Taraxacum officinale	--	--	--	--	0.4	2.0	0.2	--	2.0	--	--	0.2	0.2	0.2
Thalictrum fendleri	8.0	5.0	35.0	--	5.0	8.0	--	3.0	6.0	--	--	2.0	2.0	--
Urtica gracilis	--	2.0	--	--	--	--	--	2.0	--	--	--	--	--	--
Valeriana acutiloba	--	--	--	--	0.2	1.0	--	--	--	--	--	--	--	--
Veratrum tenuipetalum	--	--	--	--	--	--	--	--	2.0	--	--	--	--	--
Verbascum thapsus	--	--	--	--	--	--	--	3.0	--	--	--	--	--	--
Vicia americana	--	2.0	--	--	20.0	1.0	--	--	--	--	--	--	--	1.0
Viola canadensis	--	4.0	--	--	3.0	4.0	--	3.0	1.0	--	--	--	--	--
Viola vallicola	5.0	--	--	--	--	--	--	--	--	--	--	--	--	--
Tree layer	75.0	80.0	80.0	88.0	85.0	85.0	60.0	65.0	85.0	40.0	80.0	78.0	85.0	80.0
Shrub layer	75.0	45.0	2.0	28.0	65.0	30.0	1.0	18.0	10.0	6.0	2.0	4.0	3.0	80.0
Herbaceous layer	65.0	80.0	95.0	80.0	65.0	80.0	80.0	85.0	90.0	6.0	80.0	93.0	75.0	30.0
Rock	1.0	2.0	2.0	1.0	1.0	2.0	8.0	3.0	1.0	90.0	1.0	1.0	2.0	1.0
Bare soil	4.0	6.0	4.0	5.0	10.0	25.0	5.0	5.0	5.0	3.0	8.0	1.0	15.0	3.0
Moss and lichen	4.0	2.0	--	0.5	1.0	--	8.0	3.0	--	4.0	2.0	--	3.0	--

Table A-6.—Percent canopy cover of plant species in *Pinus contorta* habitat types of the Gunnison National Forest.

	P. contorta/ Juniperus communis		*P. contorta/ Vaccinium scoparium*	*P. contorta/ Carex geyeri*
Stand number	**119**	**235**	**98**	**232**
Plot size (m^2)	200	375	200	375
Location:				
Quarter section	SE	SE	NE	SW
Section	18	11	14	24
Township	15S	15S	49N	48N
Range	83W	82W	5E	6E
Landform:				
Slope (%)	0	9	9	3
Aspect	Flat	SE	W	S
Elevation (m)	2,636	3,243	3,250	2,361
Elevation (ft)	8,650	10,640	10,660	7,745
Tree d.b.h. (cm)	45.0	28.0	60.0	30.0
Shrub d.r.c. (cm)	3.0	2.0	1.0	0.5
Tree ht. (m)	15.0	18.0	12.0	15.0
Shrub ht. (m)	0.3	0.3	0.3	0.3
Soil pH	6.0	--	5.8	--
Trees				
Abies lasiocarpa	--	--	--	--
Picea engelmannii	5.0	5.0	5.0	0.5
Pinus contorta	45.0	70.0	50.0	75.0
Pseudotsuga menziesii	10.0	--	--	--
Shrubs				
Arctostaphylos adenotricha	4.0	5.0	--	--
Juniperus communis	7.0	10.0	3.0	--
Mahonia repens	0.2	--	--	--
Paxistima myrsinites	0.2	--	--	--
Pentaphylloides floribunda	--	2.0	--	--
Ribes montigenum	--	--	--	1.0
Rosa woodsii	0.2	1.0	--	1.0
Shepherdia canadensis	1.0	--	--	--
Symphoricarpos oreophilus	--	--	--	1.0
Vaccinium scoparium	--	--	18.0	--
Graminoids				
Agrostis hiemalis	--	--	--	--
Bromus porteri	--	--	--	4.0
Bromus spp.	--	0.5	--	--
Calamagrostis canadensis	--	--	--	4.0
Calamagrostis purpurascens	--	4.0	--	--
Carex brevipes	--	--	2.0	--
Carex geyeri	0.2	18.0	--	40.0
Elymus elymoides	--	1.0	--	1.0
Elymus trachycaulus	--	--	--	1.0
Festuca idahoensis	--	2.0	--	--
Festuca saximontana	--	1.0	--	6.0
Festuca thurberi	--	--	--	2.0
Koeleria macrantha	0.4	--	--	2.0
Poa fendleriana	0.2	--	--	--
Poa nemoralis ssp. *interior*	--	2.0	--	1.0
Poa nervosa	--	--	--	--
Poa pratensis	--	--	2.0	--
Stipa nelsonii	--	--	--	2.0
Trisetum spicatum	--	0.5	--	2.0

Table A-6.—Continued.

Stand number	*P. contorta/ Juniperus communis* 119	*P. contorta/ Juniperus communis* 235	*P. contorta/ Vaccinium scoparium* 98	*P. contorta/ Carex geyeri* 232
Forbs				
Achillea lanulosa	--	--	--	5.0
Androsace septentrionalis	--	0.2	0.2	--
Antennaria spp.	0.2	3.0	1.0	--
Arabis spp.	0.2	0.5	--	--
Arnica cordifolia	--	--	--	25.0
Astragalus alpinus	--	--	--	3.0
Chamerion angustifolium	--	0.5	--	0.5
Erigeron subtrinervis	--	--	--	3.0
Erigeron spp.	0.2	--	--	--
Eriogonum umbellatum	0.2	--	0.2	--
Fragaria virginiana	--	3.0	--	20.0
Oreochrysum parryi	--	--	--	1.0
Oreoxis alpina	--	1.0	--	--
Potentilla spp.	--	1.0	--	1.0
Pulsatilla patens	0.2	--	--	--
Sedum lanceolatum	--	1.0	1.0	--
Selaginella densa	1.0	3.0	--	--
Senecio neomexicanus	--	2.0	1.0	--
Smilacina stellata	--	1.0	--	--
Solidago multiradiata	--	--	1.0	--
Solidago spathulata	--	0.5	--	--
Thlaspi montanus	--	--	0.2	--
Thermopsis montana	--	--	--	4.0
Tree layer	60.0	75.0	55.0	75.0
Shrub layer	8.0	12.0	3.0	3.0
Herbaceous layer	5.0	30.0	25.0	85.0
Rock	18.0	10.0	55.0	3.0
Bare soil	3.0	25.0	20.0	1.0
Moss and lichen	5.0	11.0	20.0	3.0

Table A-7.—Percent canopy cover of plant species in *Pinus aristata* and *Pinus flexilis* habitat types of the Gunnison National Forest.

	P. aristata/ Festuca thurberi	***P. aristata/ Festuca arizonica***					***P. aristata/ Juniperus communis***	***P. flexilis/ Ciliaria austromontana***
Stand number	**110**	**145**	**160**	**224**	**226**	**229**	**143**	**142**
Plot size (m^2)	55	150	75	375	375	375	200	35
Location:								
Quarter section	NE	NE	NW	SE	NE	NW	NE	SW
Section	11	14	21	25	25	14	14	34
Township	51N	45N	44N	44N	44N	45N	45N	14S
Range	4E	3E	2W	3W	3W	3E	3E	84W
Landform:								
Slope (%)	21	14	14	21	51	9	14	53
Aspect	W	SE	E	S	ESE	SE	SE	SSW
Elevation (m)	3,616	3,023	2,878	3,042	3,024	3,011	3,060	2,744
Elevation (ft)	11,865	9,920	9,440	9,980	9,920	9,880	10,040	9,000
Tree d.b.h. (cm)	45.0	35.0	35.0	35.0	30.0	28.0	50.0	50.0
Shrub d.r.c. (cm)	0.8	1.0	2.0	1.0	0.8	1.0	2.0	1.0
Tree ht. (m)	8.0	10.0	12.0	6.0	20.0	15.0	12.0	12.0
Shrub ht. (m)	0.2	0.3	0.8	0.6	0.6	1.0	0.3	0.4
Soil pH	7.7	--	6.0	--	--	--	6.4	6.9
Trees								
Picea engelmannii	15.0	--	--	--	--	--	--	--
Pinus aristata	40.0	58.0	60.0	65.0	40.0	55.0	40.0	--
Pinus flexilis	--	8.0	--	--	--	--	8.0	42.0
Populus tremuloides	--	--	--	1.0	--	--	4.0	--
Pseudotsuga menziesii	--	--	--	--	--	--	25.0	3.0
Shrubs								
Juniperus communis	4.0	--	--	--	--	--	16.0	3.0
Pentaphylloides floribunda	--	--	--	1.0	--	--	--	--
Ribes cereum	--	4.0	2.0	4.0	7.0	5.0	--	--
Ribes inerme	--	--	--	--	--	--	--	3.0
Ribes montigenum	1.0	--	--	--	--	--	--	--
Rosa woodsii	--	--	--	--	--	0.5	2.0	3.0
Symphoricarpos oreophilus	--	--	--	--	--	--	--	5.0
Graminoids								
Agrostis hiemalis	0.2	--	--	--	--	--	--	3.0
Calamagrostis purpurascens	0.5	--	--	--	--	--	--	--
Carex foenea	1.0	--	--	--	--	--	--	--
Carex geophila	--	--	--	0.5	--	0.5	--	4.0
Carex geyeri	--	3.0	3.0	--	2.0	4.0	2.0	--
Danthonia parryi	--	2.0	5.0	3.0	1.0	8.0	0.2	--
Elymus elymoides	--	0.2	--	4.0	1.0	--	--	--
Elymus trachycaulus	2.0	--	--	--	--	--	0.4	--
Festuca arizonica	--	18.0	--	20.0	15.0	20.0	--	--
Festuca idahoensis	--	--	9.0	--	--	1.0	--	--
Festuca thurberi	15.0	--	--	--	--	--	1.0	4.0
Koeleria macrantha	2.0	--	2.0	5.0	1.0	3.0	2.0	--
Muhlenbergia montana	--	5.0	23.0	3.0	2.0	25.0	4.0	--
Oryzopsis hymenoides	--	--	--	--	3.0	--	--	--
Poa fendleriana	0.2	--	--	--	--	--	3.0	--
Poa glauca	3.0	--	--	--	--	--	--	--
Poa nemoralis ssp. *interior*	--	--	--	--	--	--	--	3.0
Poa reflexa	--	--	--	--	--	--	--	2.0

Table A-7.—Continued.

	P. aristata/ Festuca thurberi	*P. aristata/ Festuca arizonica*					*P. aristata/ Juniperus communis*	*P. flexilis/ Ciliaria austromontana*
Stand number	110	145	160	224	226	229	143	142
Forbs								
Achillea lanulosa	2.0	--	--	--	--	2.0	--	1.0
Androsace septentrionalis	--	0.2	0.2	0.5	0.2	1.0	2.0	--
Antennaria parvifolia	2.0	3.0	--	--	--	1.0	--	--
Arabis spp.	--	--	--	1.0	--	0.2	0.2	0.2
Artemisia dracunculus	--	0.2	--	--	--	--	2.0	--
Artemisia frigida	--	3.0	2.0	4.0	5.0	--	2.0	--
Astragalus agrestis	2.0	--	--	--	--	--	--	--
Astragalus hallii	--	0.2	--	--	--	3.0	--	--
Chaenactis douglasii	0.2	1.0	--	--	--	1.0	0.2	--
Chamerion angustifolium	1.0	--	--	--	--	--	--	--
Ciliaria austromontana	--	--	--	--	--	--	--	10.0
Draba aurea	--	--	--	0.2	--	0.5	--	0.2
Descurainia richardsonii	--	1.0	--	1.0	--	1.0	0.2	0.2
Eremogone fendleri	--	--	--	--	--	1.0	--	--
Erigeron peregrinus	2.0	0.2	--	--	--	--	--	--
Erigeron pinnatisectus	1.0	--	--	--	--	--	--	--
Erigeron subtrinervis	0.2	2.0	--	--	--	1.0	2.0	--
Fragaria virginiana	0.2	--	--	--	--	--	0.2	4.0
Frasera speciosa	2.0	--	--	--	--	--	--	--
Geranium caespitosum	--	1.0	3.0	3.0	3.0	--	--	--
Gilia calcarea	--	--	--	--	--	--	--	1.0
Heterotheca villosa	2.0	--	0.4	0.5	1.0	--	--	0.2
Hymenoxys richardsonii	--	4.0	--	1.0	--	0.5	0.2	--
Lathyrus leucanthus	--	--	--	0.5	--	--	--	--
Machaeranthera canescens	--	--	--	--	--	18.0	--	--
Mertensia lanceolata	0.2	--	0.2	0.3	3.0	--	--	--
Oreoxis alpina	2.0	--	--	--	--	--	--	--
Penstemon spp.	--	--	--	1.0	--	0.5	--	--
Potentilla hippiana	0.2	4.0	0.2	2.0	0.5	1.0	--	0.2
Potentilla pulcherrima	2.0	1.0	--	--	--	0.5	--	--
Pseudocymopterus montanus	2.0	--	--	--	--	--	--	--
Pulsatilla patens	2.0	--	--	--	--	--	--	--
Sedum lanceolatum	1.0	--	--	--	--	--	--	--
Senecio neomexicana	--	--	0.2	2.0	1.0	--	--	--
Senecio werneriaefolia	1.0	--	--	--	--	0.5	--	--
Solidago multiradiata	--	0.2	0.2	--	--	--	--	--
Taraxacum officinale	--	0.2	--	--	--	0.2	--	--
Thlaspi montanus	0.2	--	--	--	--	--	0.2	0.2
Trifolium dasyphyllum	2.0	--	--	--	--	--	--	--
Vicia americana	--	1.0	--	--	--	0.2	--	--
Tree layer	65.0	65.0	60.0	65.0	40.0	55.0	70.0	45.0
Shrub layer	5.0	4.0	2.0	5.0	7.0	5.0	18.0	15.0
Herbaceous layer	35.0	50.0	45.0	40.0	30.0	85.0	15.0	30.0
Rock	2.0	10.0	20.0	90.0	90.0	10.0	12.0	20.0
Bare soil	6.0	65.0	10.0	60.0	60.0	60.0	8.0	10.0
Moss and lichen	6.0	4.0	3.0	2.0	2.0	3.0	4.0	10.0

Table A-8 — Percentage canopy cover of plant species in *Abies lasiocarpa* habitat types on the Gunnison National Forest

[illegible]

Komarkova, Vera; Alexander, Robert R.; Johnston, Barry. C. 1988. Forest vegetation of the Gunnison and parts of the Uncompahgre National Forests: a preliminary habitat type classification. Gen. Tech. Rep. RM-163. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 65 p.

A vegetation classification based on a combination of concepts and methods developed by Braun-Blanquet and Daubenmire was used to identify 37 *tentative* forest habitat types on the Gunnison National Forest. Woodland habitat types comprised two series with a total of 3 habitat types, and forest habitat types included nine series with a total of 34 habitat types. A key to identify the habitat types is provided and the management implications associated with each are discussed.

Keywords: Vegetation classification, habitat type, *Abies lasiocarpa, Picea engelmannii, Pinus aristata, Pinus contorta, Pinus flexilis, Populus tremuloides, Picea pungens, Pseudotsuga menziesii, Pinus ponderosa, Populus angustifolia, Quercus gambelii, Juniperus osteosperma*

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