COLORADO MOUNTAIN SOILS

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I. Introduction

A. General

About forty percent of the state of Colorado is contained in the westward extension of the Great Plains. The remaining sixty percent is mountainous, mostly at high elevations. The mountains make up the majority of what Feniman (1931) calls the Southern Rocky Mountain Province. Extensions from this massif into adjoining states are the Front and Medicine Bow Ranges into Wyoming on the north and the Sangre de Christo and San Juan Ranges into New Mexico on the south. On the west the mountains merge into the Colorado Plateau (or the Basin and Range Province of Feniman (1931)).

Some 40% (41,698 square miles) of the state's 104,247 square miles are above 7,000' with considerable area in the 5-7,000' range which could be considered mountainous. The highest point in the state is 14,431 feet above sea level, 830 other peaks have elevations in the 11,000 to 14,000 foot range, and there are 53 peaks which have elevations greater than 14,000 feet. The passes in these mountains are at elevations of 9-12,000 feet compared to elevations of 7-8,000 feet where roads cross the continental divide in Wyoming to the north and New Mexico to the south.

The state covers four degrees of latitude (57° to 41° N) for a linear distance of about 275 miles and the mountains occupy about four degrees of longitude (104° 30' to 109°) or a distance of some 260 miles east to west. Some 65-70,000 square miles could be called mountainous land.

This immense watershed provides the starting place for many of the rivers of the western United States. The North and South Platte rivers head in the north and central mountains and make their way to the Gulf of Mexico by way of the Missouri and Mississippi rivers. Rising to the west of the drainage of the South Platte is the Arkansas which also drains to the Mississippi and the Gulf. The Rio Grande, rising in the south central mountains, flows directly to the Gulf of Mexico. Central and western Colorado mountains give birth to the Colorado and its tributary, the Gunnison, and also to the White and Yampa rivers which ultimately join the Colorado but first flow into the Green in Utah. The southwestern mountains give rise to the San Juan and its tributaries which also flow into the Colorado and eventually into the Gulf of Lower California.

B. Geology and Physiography

The western high plains terminate along a north-south line approximating the 105th meridian at elevations of 5-7,000 feet. West of this line rises the main body of the Colorado Rockies. The bulk of these mountains were formed during the Laramide mountain building period of post Cretaceous times (some 70 million years ago). There are evidences of early mountain building and erosion prior to this time. The present mountains were extensively glaciated in recent times.

Immediately west of the high plains rises the Front Range, a belt of mountains about forty miles wide and extending from Wyoming to the

Arkansas drainage on the south. The northern extensions of the Front Range are called the Medicine Bow and Laramie Mountains in Wyoming. These mountains are composed primarily of siliceous crystalline rocks. Pikes Peak marks the south end of the Front Range where it rises abruptly from the plains to an elevation of 14,110 feet. South of the Front Range are the Wet Mountains and an area of recent volcanics which have given rise to the Spanish Peaks with their associated dikes. West of the Wet Mountains and the Spanish Peaks lies a very narrow range of mountains which rise south of the Arkansas River and continue into New Mexico. These are the Sangre de Christo mountains which are composed of essentially the same rocks as the Front Range.

West of the Front Range and the Sangre de Christos along a line approximating 106° West longitude is a series of topographic and structural basins called parks. These are relatively flat, treeless expanses where the local relief is considerably more subdued than that of the mountains around. The northern three parks are called North, Middle and South Parks respectively. North Park, located just south of the Wyoming state line and in the headwaters of the North Platte River, is a rough ellipse ninety miles long and thirty-five miles wide. This single basin has an average elevation of 8,100 feet. The floor of the basin is largely made up of Cenozoic sedimentary rocks with some recent volcanics in the southern part. Middle Park on the upper drainage of the Colorado River is much less well defined than any of the other parks. Its rocks are similar to those of North Park. South Park, on the drainage of the South Platte River, is much the highest of the three named parks with an average elevation near 10,000 feet. This basin is floored with sedimentary rocks and bordered on the south by extensive areas of felsitic extrusives. South of the

named parks are the Upper Arkansas Valley and the San Luis Valley, both of which have features in common with the afore-mentioned parks. The Upper Arkansas Valley is some sixty miles long, but rarely exceeds a few miles in width. The rocks in this area are sedimentary, many of recent origin.

The largest of the parks is the San Luis Valley, a structural basin lying between the Sangre de Christo mountains on the east and the San Juan mountains on the west. This valley is nearly one hundred miles long and is fifty miles wide at its broadest point. The floor of the valley was a lake during Pleistocene times and hence is flat and featureless. The average elevation of this valley is 7,500 feet. The Rio Grande traverses the valley on its way to New Mexico.

On the west side of the Northern parks lie the Park,Gore and Mosquito Ranges which are about forty miles wide and extend from just north of the Wyoming state line to the Arkansas River. The southward extension of these mountains is taken up by the Sangre de Christo range. The bulk of these mountains is made up of siliceous igneous rocks.

West of the Park and Gore Ranges lies an area of complex mountains, plateaus and mesas. The Sawatch range, parallel to and west of the mountains discussed above, is the highest block of mountains in the state. Within a fifty mile traverse, five peaks exceed 14,000 feet in elevation, including Mt. Elbert, the highest point in the state. This range is made up of siliceous crystalline rocks. To the north and west of the Sawatch range lies the White River Plateau, the Grand, Embattlement, Blue and Black Mesas. These are extensive, relatively flat areas with average elevations in the neighborhood of 10,000 feet. The top of much of this area is capped with basalt which has protected them from down-cutting. Still west of the White River Plateau lies the

Roan Plateau, an area of sedimentary rocks with an average elevation of about 8,500 feet.

West of the San Luis Valley lies the San Juan Mountains, an extensive area of Cenozoic volcanics. Extending northwest from the San Juans is the Uncompahgre Plateau, a relatively high (7,000 - 10,000 feet) plateau-like area about 25 miles wide formed from mesozoic sedimentary rocks.

The principal products of this vast mountain complex are water and grazing for livestock. A small lumbering industry also is maintained. The only intensive agriculture is carried out in the San Luis Valley where potatoes, alfalfa, barley and vegetable crops are grown. Of the area above 7,000 feet in the state, 90% is federally owned and administered. Private holdings are largely concentrated along the stream bottoms and these are largely involved in cattle raising operations, except as indicated above.

C. Climate

The area under consideration is far inland. A thousand miles and several ranges of mountains separate it from the Pacific. Another thousand miles of open prairie separate it from the Gulf of Mexico. Storms move into Colorado from the west during the winter and what moisture has not been lost in the mountains of California, Nevada and Utah is dropped on the western sides of the Colorado Rockies. These same storm fronts pass too far north of Colorado during the summer to provide much moisture.

Movement of moist Gulf air up the slopes of the plains brings moisture to the east face of the Rockies during the spring. When the storm track from the west moves south through Arizona and New Mexico and combines with or causes northward flows of Gulf air, the southern

and eastern mountains receive precipitation. Connective thunderstorm activity releases moisture in the mountains during the summer. The highest total precipitation in the state occurs in the San Juan Mountains. Here a winter and summer maximum of precipitation occurs. The western Colorado mountains have a winter maximum, the eastern mountains a summer maximum. Some selected, representative precipitation and temperature data are presented in Table I.

The data in the high mountains probably do not reflect the true total (for total precipitation) for these areas. Most of the data are from passes and other accessible locations, and no, or only piece-meal, data is available for the bulk of the mountain mass above 11,000 feet. The highest recorded precipitation in the mountains is at Cumbres Pass on the eastern edge of the San Juan range near the San Luis Valley. The precipitation here is 36.4 inches, which includes annual snowfall of 264 inches. Some thirty miles east of Cumbres Pass in the San Luis Valley, Manassa receives 6.8 inches total precipitation, including an average of only 18 inches of snow.

A generalized summary of the precipitation pattern in the mountains would suggest a maximum precipitation at the highest elevations of perhaps 40 inches. Moving down the slopes to the mountain valleys and parks, rainfall decreases rapidly to an average of near 10 inches. In general, the southern and western mountains are wetter by an estimated 6-10 inches annually than the northern and eastern ones.

In the area above 7,500 feet the average annual temperatures are low. The highest figures in Table I are for the San Luis Valley with an average annual temperature of about 42°. The mountain area is also subjected to extremes of temperature. In the San Luis Valley the extremes are from the mid 90's to -40 to -50° F. With the exception of

the San Luis Valley and the Upper Arkansas Valley frost can be expected any day during the growing season. At Gunnison (elevation 7,758', 10.3" precipitation, average annual temperature 38.5°) an examination of temperature data shows that there has been recorded a temperature below 32° F. on every day in every month in some years throughout the growing season (71 days). There are also areas from which cold air cannot drain readily. The Frazer-Tabernash area in Middle Park is typical of this phenomenon. Frazer has an elevation of 8,568 feet, average annual precipitation of 16.8 inches, and an average annual temperature of 33.8° F. The recorded maximum at this station is 86° and the minimum -50° F. Quite often this is the coldest spot in the 48 states.

Table I

Representative Total Precipitation and Average Annual Temperatures for Mountain Stations in Colorado

Station	Elevation	Precipitation	Temperature
High Altitude Parks and Valleys			
General area: San Luis Valley			
Alamosa	7,531	7.0	41.5
Saguache	7,697	7.6	42.9
Manassa	7,710	6.8	42.1
General area: Upper Arkansas Valley			
Salida	7,050	10.8	46.3
Buena Vista	8,020	9.1	43.3
General area: South Park			
Hartsel	8,866	10.7	-
General area: Middle Park			
Kremmling	7,322	10.6	37.7
General area: North Park			
Walden	8,340	9.5	37.1

Table I (continued)

High Mountains

General area: San Juan Mountains			
Cumbres Pass	10,015	36.4	35.1
Wolf Creek Pass	9,425	30.3	38.2
Summitville	11,350	35.9	31.9
Telluride	8,711	25.5	39.4
Cascade	8,853	28.7	-
General area: Central Colorado Rockies			
Leadville	10,158	19.6	36.2
Independence Pass	10,500	29.7	-
Aspen	7,913	19.4	40.5
Crested Butte	8,950	22.4	35.7
General area: Northern Colorado Rockies			
Willow Creek	7,250	22.0	40.7
Longs Peak	8,956	21.5	37.9
Allenspark	8,500	22.3	40.3
Silver Lake	10,200	28.2	-

D. Vegetation

At lower elevations the climate in the Colorado Rockies borders on that of a desert. Except for the relatively low temperatures, water supply would not be large enough to meet the demand of anything but desert-type vegetation. Such vegetation does in fact appear in the mountain parks, particularly in the San Luis Valley. At higher elevations larger amounts of rainfall and increasingly cooler temperatures produce a more abundant and varied flora. At few locations, however, does the amount of vegetation approach that of the eastern or Pacific coast mountains. Curtis (1960) perhaps best expresses the point by writing, "The impressive geologic features of Colorado..... are especially well exposed because of a dry climate and lack of soil cover". He might also have added that little vegetation impeded the view.

With as little total precipitation as occurs and with the extremes in elevation within short distances there is a considerable diversity in vegetation with altitude and aspect. The plant community will vary depending on whether the aspect is north or south, e.g., Ponderosa pine on south slopes, Douglas fir on north at a given elevation. The elevation range a community will traverse varies from east to west aspect, e.g., the pinon-juniper complex is found from about 6000 to 7500 feet on the western slope, from about 5500 to 8500 feet on the eastern slope. Because of these differences, and the huge areas involved, only a very generalized description of the vegetation will be attempted.

Five vegetation zones or communities will be considered (adapted from Costello 1954): the Desert Shrub, the Pinon-Juniper, the Ponderosa Pine - Douglas Fir, the Spruce - Fir and the Al

Although there is considerable overlap in the elevations at which these groups occur, in general the Pinon - Juniper community is found at 5500 - 8500'; the Ponderosa pine - Douglas fir from 6500 - 9500'; the Spruce - Fir community from 8500 to 11,500 and the Alpine above 11,500 which is the average elevation of timberline. The Desert Shrub complex occurs primarily in the mountain parks and valleys below 10,000'.

The Desert Shrub complex appears in areas where the rainfall is less than ten inches. A community composed of greasewood, Sarcobatus vermiculatus; foxtail barley, Hordeum jubatum; grama grass, Bouteloua gracilis; wheatgrass, Agropyron dasystachyum; dropseed, Sporobolus airoides; kochia, Kochia scoparea; salt brush, Atriplex canescens and rabbitbrush, Chrysothamnus spp., is found where the water table is high, the soil saline and highly alkaline. Where the soils are better drained and drier a community which is dominated by salt brush, Atriplex spp., is formed. On deep non-saline soils the predominant plant is big sagebrush, Artemisia tridentata, with wheatgrasses, Agropyron smithii, dasystachyum, spicatum; bluegrasses, Poa fendleriana and nevadensis; junegrass, Koeleria cristata; ricegrass, Oryzopsis hymenoides; russian thistle, Salsola kali tenuiflora; sandwort Arenaria hookeri; balsam-root, Balsamorhiza sagittata; golden aster, Chrysopsis villosa.

The Desert Shrub complex in which greasewood predominates is common in the San Luis Valley; the saltbrush complex is common at lower elevations on the western slope of the Rockies. Vast areas are dominated by big sagebrush in North and Middle Parks, on the lower slopes along the upper Gunnison River and its tributaries and in northwest Colorado.

In southern and southwestern Colorado large areas are dominated by an association of pinon pine, Pinus edulis; and juniper, Juniperus scopulorum, monosperma and utahensis. The elevation at which this occurs varies from 5500 to 8500 feet with the widest elevational range being present in the southwest. Also present in the area are shrubs such as mountain mahogany, Cercocarpus montanus, and ledifolius; service-berry, Amelanchier alnifolia; chokecherry, Prunus virginiana melanocarpa; sumac, Rhus trilobata; bitterbrush, Purshia tridentata; and big sagebrush, Artemisia tridentata. Among the grasses are found ricegrass, Oryzopsis hymenoides; bluegrass, Poa fendleri; junegrass, Koeleria cristata; grama grass, Bouteloua gracilis; and needlegrass, Stipa comata. Common forbs would be golden aster, Chrysopsis villosa; globe mallow, Sphaeralcea coccinea; russian thistle, Salsola kali; and wild daisies, Erigeron spp.

Transitional between the pinon juniper and the montane zone are areas where scrub oak, Quercus gambelii, completely dominates the plant community. This is particularly true in the southwest, west, and northwest mountains. Scrub oak, however, does not appear in the mountain parks or on the eastern slope to any extent.

The montane zone in the Colorado Rockies consists of two major vegetational types, the Ponderosa pine - Douglas fir association and the Spruce - Fir, the latter occurring just below timberline for about 3000'. In the Ponderosa pine - Douglas fir zone, the Ponderosa pine, Pinus ponderosa, often occurs on south slopes, usually in open stands and the north shopes at the same elevation are occupied by Douglas fir, Pseudotsuga taxifolia (or Psuedotsuga menziesii). Ponderosa pine is more common in the east and southern mountains, while Douglas fir is preponderant in the west and north. In open timber stands

grasses such as the fescues, Festuca arizonica, and Festuca idahoensis; muhly, Muhlenbergia montana; spike fescue, Hesperochloa kingii; and oatgrass, Danthonia intermedia, are common. Shrubs such as fringed sage, Artemisia frigida; mountain mahogany, Cercocarpus montanus; New Jersey tea, Ceanothus fendleri; gooseberry, Ribes cereum; chokecherry, Prunus virginiana melanocarpus; and shrubby cinquefoil, Potentilla fruticosa, are found. Common forbs are geranium, Geranium fremonti; milkvetch, Astragalus agrestis; and dandelion, Taraxacum officinale. In low areas where moisture is favorable stands of quaking aspen, Populus tremuloides, are common and cover extensive areas in western and southern Colorado. Associated with aspen are many forbs such as meadow rue, Thalictrum fendleri; vetch, Vicia americana; golden pea, Thermopsis montana; yarrow, Achillea lanulosa; delphinium, Delphinium barbeyi; cow parsnip, Heracleum lanatum; lovage, Ligusticum porteri; lousewort, Pedicularis racemosa. Grasses included would be wildrye, Elymus glaucus; fescue, Festuca thurberi; brome, Bromus carinatus; wheatgrass, Agropyron trachycaulum; junegrass, Koeleria cristata. The principal shrubs would be snowberry, Symphoricarpos oreophilus; and chokecherry, Prunus virginiana melanocarpa. Along stream bottoms blue spruce, Picea pungens; willow, Salix spp.; birch, Betula occidentalis, and B. glandulosa; and dogwood, Cornus stolonifera, are the principal woody species with grasses such as hairgrass, Deschampsia caespitosa; reedgrass, Calamagrostis canadensis; bluegrasses, Poa pratensis and P. compressa; plus numerous sedges, Carex spp.; and rushes, Juncus spp.

The dense Spruce - Fir forests are made up largely of Engleman spruce, Picea engelmanni; and subalpine fir, Abies lasiocarpa. In addition there are large areas of lodgepole pine, Pinus contorta latifolia, which is considered to be an invader of burned-over forest

as well as aspen, Populus tremuloides, in the moister areas. Less frequent than the above, but still common to this community, are white fir, Abies concolor; cork bark fir, Abies lasiocarpa arizonica; bristle cone pine, Pinus aristata; blue spruce, Picea pungens; and limber pine, Pinus flexilis. Beneath the spruce-fir forest there is little ground cover, the forbs usually found being blueberry (huckleberry), Vaccinium spp.; arnica, Arnica cordifolia; mules ears, Wyethia amplexicaulis; columbine, Aquilegia elegantula; pipsissewa, Chimpaphila umbellata; groundsel, Senecio serra; and peavine, Lathyrus leucanthus. The grasses encountered would be needlegrass, Stipa lettermani; bedstraw, Galium boreale; fescue, Festuca ovina; brome, Bromus anomolous; timothy, Phleum alpinum; and numerous Carex spp. Where lodgepole pine predominates the ground cover would consist of sedges, Carex geyeri; arnica, peavine, small leaved huckleberry, Vaccinium scoparium; common juniper, Juniperus communis; and buffaloberry, Sheperdia canadensis. In the grassland parks in the Spruce - Fir zone will be found many sedges, Carex spp.; needlegrass, Stipa lettermani; bluegrass, Poa reflexa; bent grass, Agrostis scabra; timothy, Phleum alpinum; trisetum, Trisetum spicatum; fescue, Festuca thurberi; and forbs such as lupines, Lupinus wyethii; mules ears, Wyethia amplexicaulis; cinquefoil, Potentilla pulcherrima; sneezeweed, Helenium hoopesii; yarrow, Achillea lanulosa; knotweed, Polygonum aviculare; collomia, Collomia linearis; and tarweed, Madia glomerata. There are areas where the sagebrush community extends into the spruce-fir zone.

There are extensive areas of alpine in Colorado. One estimate compared the areal extent of alpine in Colorado with the total area of the state of Delaware. Timberline varies somewhat in the state from about 11,000 to 11,400 feet. Between the ture alpine and the

spruce-fir below there is a zone of tension often called the sub-alpine.

The alpine is a zone where the climatic environment is very severe. Extremes in temperature are wide and there are few days throughout the summer season when freezing does not occur. The plants under such conditions are low growing and stunted. No trees are commonly found.

On the mountain tops, ridges and steep slopes are found grasses such as kobresia, Kobresia bellardi; several bluegrasses, Poa alpina, P. lettermani, P. pattersoni and P. rupicola; trisetum, Trisetum spicatum; many sedges such as Carex drummondiana and C. chimaphila; cushion plants such as draba, Draba oligosperma; podistera, Podistera eastwoodae; sandwort, Arenaria rossii; false strawberry, Sibbaldia procumbens; dryad, Dryas octopetala; and several low growing willows such as Salix petrophila and S. nivalis.

On the more sheltered slopes and benches and on level areas the alpine meadow plants are found. Grasses are common with alpine bent grass, Agrostis humilis; tufted hairgrass, Deschampsia caespitosa; alpine timothy, Phleum alpinum; trisetum, Trisetum spicatum; several bluegrasses, Poa alpina, P. arctica, P. lettermani, P. rupicola; numerous sedges, Carex atrata, C. chalciolepis, C. nigricans, C. nova and C. vernacula; ruses such as Juncus drummondii and J. parryi are found. The forbs in this community are commonly yarrow, Achillea lanulosa; actinea, Hymenoxys grandiflora; agoseris, Agoseris aurantica; gumweed, Arnica mollis; willoweed, Epilobium alpinum; avens, Geum turbinatum; alpine bluebells, Mertensia alpina; penstemons, Penstemon hallii and harbourii; bistorts, Polygonum bistortoides and viviparum; groundsels, Senecio taraxacoides and soldanella; and meadow rue,

Thalictrum alpinum.

Near timberline and associated with wet areas are large numbers of willows such as Salix brachycarpa, S. planifolia, S. pseudolapponum and low growing recumbent forms such as Salix anglorum (or petrophila), S. nivalis and S. saximontana.

The alpine bog is largely populated with sedges such as Carex albo-nigra, C. arapahoensis, C. bella, C. illota, and C. physocarpa. Also found are spikesedge, Eleocharis macrostachya; cottonsedge, Eriophorum angustifolium; elkslip marshmarigold, Caltha leptosepala; quillwort, Isoetes bolanderi; pedicularis, Pedicularis groenlandica.

II. General Soil Patterns

The soil pattern in any given landscape in the mountainous areas of Colorado is apt to be complex, depending upon the combination of soil-forming factors effective in that specific locality. Since the magnitude of these factors changes rapidly within short distances, it is impossible to divide the mountainous areas into regions in which specific soil series occur, or in which soil patterns of specific series can be predicted.

It is possible to divide the mountainous areas into general regions in which certain Great Soil Groups predominate, and in which distribution patterns of Great Soil Groups can be predicted relative to vertical zonation, slope aspect, or type of vegetation. Such regional subdivisions are, of necessity, very broad, but they are useful in understanding general soil patterns of the mountainous areas and in giving some insight into the genetic factors active in the formation of the major Great Soil Groups.

In his publication "Ecosystems of the East Slope of the Front Range in Colorado", Marr defines eight ecosystems, but deals in detail with only the four climax regions. These are (1) Lower Montane, (2) Upper Montane, (3) Subalpine, and (4) Alpine. As used by Marr, these are geographic subdivisions that are reasonably homogeneous as to organisms, environmental factors, and ecological processes. Since this concept of ecosystems embraces, and in a general way defines the magnitude of most of the major soil-forming processes, these same regional subdivisions can be used as a basis for discussing the soil patterns of the mountainous areas of Colorado.

For the purpose of studying soil differences it is advantageous to distinguish one additional regional subdivision that is unique in

regard to the kinds of soils and the types of soil patterns that develop in it. We have chosen to assign the name of "Mountain Parks and Meadows" to this general subdivision. In Marr's treatment of the ecosystems these areas were considered parts of the four major regions previously listed.

It must be emphasized that, as used in this paper, the five subdivisions selected as a basis for discussion are used primarily with regard to the kinds of soil they contain, and the kind of soil pattern that develops in them. Thus, they may depart in some respects from the concept of the ecosystem as developed by Marr but they should still serve as a common ground of understanding and provide some continuity between disciplines. It should also be emphasized that, in regard to kinds of soil or soil patterns, the boundaries of these major subdivisions are arbitrary and there is a considerable overlapping between regions. For example, representatives of the Gray Wooded soils are found in the Lower Montane, Upper Montane, and Subalpine regions, but their slope relationship, and the patterns they assume with other soils, are generally different.

A. Mountain Parks and Meadows

This regional subdivision has been selected for discussion first because it is unique in not having the strong vertical zonation bias that characterizes the other regions. Typically, these are mountain valleys varying in size from a few to several hundred square miles. They occur at various elevations ranging from approximately 7,500 feet in the floor of the Alamosa Valley to 8,500 to 9,000 feet in North and South Parks, and 9,000 to 10,500 feet in Taylor Park.

Soil climate is cold and relatively dry. Average annual soil temperatures range from approximately 36 to 42° F. in high mountain

valleys to approximately 40 to 46° F. in the San Luis Valley. Average summer soil temperatures range from 40° to 56° F. at high elevations to 60 to 70° F. at lower elevations. Frequently, temperature inversion phenomena cause unusually cold temperatures in these areas. Average annual precipitation ranges from approximately 7 to 20 inches. Although average annual rainfall is low, these are catchment areas for runoff or ground water, and many areas of the valley floor have moving water tables within a few feet of the ground surface.

These are primarily grasslands with only scattered stands of timber occurring on sheltered north-facing slopes, or along the higher rims of the valleys.

The character of the soil parent material is variable, but in many areas is gravelly and cobbly glacial till or outwash. Outwash beds having loamy or loamy skeletal upper sections underlain by water-worn gravel, cobble, and sand are particularly prominent. Other parent materials include alluvial fan sediments from sedimentary and crystalline rocks, a few areas of aeolian deposits, and a minor amount of material weathering residually from underlying bedrock. Mineralogically, the parent sediments are mixed and usually calcareous.

Principal soils are representatives of frigid families or cryic subgroups of Alluvial soils and Regosols (Haplorthents and Psamments), Brown soils (Orthids), Humic Gley soils (Aquolls), and Chestnut soils (Ustolls). Minor components of the soil pattern include Chernozems (Borolls), Calcisols (Calciorthids), Bog soils (Histosolls), Lithosols (Lithic Haplorthent), Brunizems (Udolls), Brown Forest soils (Haplustolls), and Grey Wooded soils (Glossoboralfs). Typical profiles of all of these Great Soil Groups are

described in detail later in this paper.

Although these are comparatively dry areas in terms of annual precipitation, a large percentage of the soil pattern in well-drained areas have mollic epipedons. This can be attributed to the cold temperatures of the area.

The most extensive group of soils in the mountain parks and meadows belong to frigid families of Chestnut soils. They occupy the well-drained, gently to moderately sloping portions of landscapes, and are found developing in most of the parent materials of the region. They occur on both north and south slopes, and are associated with representatives of the Brown soils (Argids) on south-facing slopes, at lower elevations, and with Chernozem or Gray Wooded soils on north-facing slopes at higher elevations. The profile described under III, L. is representative of these soils.

Representatives of the Brown soils occur in the drier, more excessively drained parts of the landscape. They are most often found on moderately steep to steeply sloping areas and are generally associated with the coarser textured parent materials. They occur in association with Chestnut soils on south-facing slopes, or on steeply sloping portions of north-facing slopes. The profile described under VI, E. is typical of these soils.

Alluvial soils and Regosols are found throughout the valleys on the very youthful parts of landscapes, or at the focal points of geologic erosion. They occur most extensively on nearly level flood plains or terraces, or on steeply sloping alluvial fans or slopes where sediments are so youthful that little or no soil horizonation has developed. They may be found in the uplands in association with nearly all of the other Great Soil Groups, but are most common in

landscapes predominated by Chestnut and Brown soils. In the flood plains they are usually in association with Humic Gley soils or Peats and Mucks. Extensive areas of sand dunes and very sandy soils occur on the eastern edge of the San Luis Valley. The profiles described under II, A.; II, R., 1 and II, R., 2. are typical of these soils.

Humic Gley soils are confined to the flood plains and terraces of streams draining these areas, or to small seepage areas bordering the outer rims of the valleys. They occupy the poorly drained, nearly level to slightly concave portions of the landscape where fluctuating water tables are near the surface most of the year. In many places, however, this is a moving water table that does not promote the extreme degrees of mottling and gleying common to similar degrees of wetness where the water table is stagnant. This phenomena of wetness associated with soils of comparatively bright chroma is a common feature of mountain soils in all regional subdivisions. The profile described under II, N. is typical of these soils.

Other minor components of the soil pattern are: (1) Lithosols, which occur where ever bedrock is shallow, (2) Bog soils, which occur in the poorly drained areas, (3) Chernozems, which occur in moist areas near the higher rims of the valleys, (4) Brunizems, which occur where parent materials are low in bases, (5) Brown Forest soils, which occur in youthful landscapes or on steep slopes under the scattered stands of conifer and aspen, (6) Gray Wooded soils, which occur under the scattered stands of timber on north slopes or the outer valley rims where environment has favored the development of mature profiles, and (7) Calcisols, which occur in the dryer valleys, where very calcareous parent sediments outcrop. Detailed profile description for

each of these soils occurs in section II of this paper.

B. Lower Montane Region

As used in this paper, this is the region lying between 6,000 and 8,000 feet elevation. It embraces the foothill regions and lower mountain slopes, and is an area of rough, steep topography. Stream channels are deeply incised in relatively narrow, steep-sided valleys, while ridge crests may be either broad or narrow.

Compared to other parts of the mountains, the soils of this region are comparatively warm. Average annual soil temperatures range from approximately 42 to 50° F. in the southern parts of the state to approximately 42 to 47° F. in the northern parts. Average summer soil temperature ranges from 60 to 70° F. in the north to approximately 66 to 74° F. in the south.

Average annual precipitation is 15 to 22 inches a year with much of it falling during the summer months as daytime thunder shower activity. Late fall and spring moisture is usually in the form of wet snows, but late summer and early fall months are comparatively dry.

These are areas of scattered timber and accompanying grasslands. Most of the south slopes are in grass or brush with stands of timber occurring mostly on north-facing slopes. Timber stands are, for the most part, thin and open.

Ecologists have pointed out that the present vegetative patterns are strongly influenced by fire, lumbering, mining, and attempts at agriculture. Its present character is not that under which the soils developed, and, consequently, modern vegetation is often not typical of the soil on which it grows. For example, Gray Wooded soil profiles may now be found under grass and shrubs where the original timber stands

have been destroyed.

Like most areas of the mountains, the soil parent materials are extremely variable, but consist mainly of alluvial fan or residual materials. Glacial deposits are found in places either as moraines as outwash plains or as remnants of old till sheets. Generally speaking, this region contains more sedimentary rocks than the others, although exposures of crystalline rock are plentiful. A few deposits of aeolian materials are found in the southwestern and northwestern parts of the state.

Major Great Soil Groups of this region include Gray Wooded soils (Glossoboralfs), Brown Forest soils (Haplustolls), and representatives of frigid families of Chestnut soils (Ustolls), Alluvial soils (Orthents), and Lithosols (Lithic Orthents). Intermediate in Great Soil Group status, but an important component of the soil pattern, are soils intergrading between the typical Gray Wooded soils and the typical Chernozem soils (Mollic Glossoboralfs).

Minor components of the soil pattern include Bog soils (Histosols), the frigid families of Brown soils (Argids), Regosols (Orthents), Brunizems (Udolls), and Humic Gley soils (Aquolls).

The Chestnut soils are the predominate zonal soils in the soil pattern of the Lower Montane region, but are only slightly more extensive than the Gray Wooded soils. They are found on all slope aspects at lower elevations, and on the south-facing slopes at the higher elevations. They occur in association with the Gray Wooded soils (Glossoboralfs) and Lithosols (Lithic Orthents) in most landscapes. The profile described under III, L. is typical of these soils.

Gray Wooded soils and their associated intergrades to Chernozems

are the second most plentiful zonal soils in this region. The typical Gray Wooded soils occur under the more dense stands of timber on north-facing slopes. The intergrade soils are found under the more open stands of timber on northeast and northwest facing slopes at lower elevations, and southeast and southwest facing slopes at the higher elevations. Both types of soil occur in association with the Chestnut soils and Lithosols in most landscapes. Most of the Gray Wooded soils of the Lower Montane region are slightly acid to alkaline in reaction, and weak horizons of calcium carbonate accumulation are not unusual below the solum. The profile described under III, M., 1. is an example of the typical Gray Wooded soils of this region, while the profile described under III, K. is representative of the intergrading group.

Brown Forest soils occur extensively in the Lower Montane region. They are usually found in the transition zones between the Chestnut soils and the Gray Wooded soils where timber stands are thin and there is a good understory of brush and grass. The profile described under III, F. is typical of these soils.

Alluvial soils are a major component of the soil pattern in this region. They are confined mainly to the more youthful parts of the landscape, such as flood plains and comparatively recent alluvial fans. They may occur on all slope aspects, and in association with any of the other soils of the area. The profile described under III, A. is typical of these soils.

Lithosols occur extensively in this region where bedrock occurs close to the surface. They are generally found on the steeper slopes or on abrupt slope breaks, and are often associated in complex patterns with bare rock outcrops. They are found in association with

most of the other soils of this region. The profile described under III, O. is typical of these soils.

Minor components of the soil pattern are: (1) Bog soils, which occur in places on the very poorly drained flood plains or seepage areas, (2) Brown soils, which occur on south slopes or steeply sloping areas at low elevations, (3) Regosols, which occur on the youthful portions of the landscape or focal points of geologic erosion, (4) Brunizems, which occur where parent sediments are low in bases, and (5)Humic Gley soils, which occur on imperfectly to poorly drained flood plains.

C. Upper Montane Region

As used in this paper, the Upper Montane region is that portion of the mountainous areas lying between approximately 8,000 and 9,300 feet elevation. Topographically, it resembles the Lower Montane region, except that it contains a larger percentage of stream valleys whose upper ends are glaciated and comparatively wide, but which narrow with decreasing elevation. Interstream divides, as a rule, are wider than in the Lower Montane region, although there is still a large percentage of the area that is steeply sloping. Glacial moraines are common features in the valleys, particularly in their upper ends.

Soil climate is colder and more humid than that of the Lower Montane region. Average annual soil temperatures range from 40 to 47° F. in the southern part of the state to approximately 38 to 47° F. in the north. Average summer soil temperatures range from approximately 54 to 66° F. in the south to about 54 to 64° F. in the north.

Rainfall is variable throughout the region ranging from 15 to 25 inches, but as a whole the region is more moist and soil moisture

is more effective than in the Lower Montane region. Most of the summer moisture falls as daytime thunder storms, while winter moisture falls as snow.

Vegetation in this region is mainly open to dense stands of Douglas fir and ponderosa pine at the lower elevations becoming intermingled with more and more lodgepole pine as elevation increases. Grassland areas are fewer in number and smaller than in the Lower Montane region. Small valleys contain growths of willows and shrubs.

As is true of most of the mountain areas, soil parent materials are varied and mixed. Glacial deposits, alluvial fan sediments, stream alluvium, and materials weathered residually from country bedrock predominate. Minor deposits of aeolian sediment may occur in southwestern and northwestern areas and a few areas of volcanic ash are found in the south. Crystalline rocks, such as granite, gneiss, schist, granodiorite, and rhyolite predominate the bedrocks of the region.

Gray Wooded soils (Glossoboralfs), Bog soils (Histosols), Brown Forest soils (Haplustolls), and representatives of frigid families of Brunizems (Udolls), Chestnut soils (Ustolls), Humic Gley soils (Aquolls), or Lithosols (Lithic Orthents) predominate the soil pattern in this region. Chernozems (Borolls), Alluvial soils (Orthents), Brown Podzolic soils (Spodosols), and the intergrades between Gray Wooded soils and Chernozems (Mollic Glossoboralfs) are minor components.

The Gray Wooded soils, including all four of the major varieties, are the most extensive soils of the Upper Montane region. They occur throughout the area and on all slope aspects, although the alkaline variety is most common on south-facing slopes at lower elevations.

They are most commonly found in association with Brunizem and Chestnut soils. The profiles described under III M 1, III M 2, III M 3 and III M 4 are representatives of the four varieties of Gray Wooded soils found in this region.

Because of the predominance of parent sediments that are relatively low in calcium carbonate, Brunizems are a more common component of the soil pattern of this region than in the Lower Montane, or Mountain Park and Meadows. They occur throughout the region, but are found most frequently under mixed grassland and open timber stands on south-facing slopes. They occur in association with the Gray Wooded and Chestnut soils. The profile described under III H is typical of these soils.

Chestnut soils occur principally on south-facing slopes, and are most frequently found at the lower elevations. They are less extensive than in the Lower Montane region. They occur principally in association with the Brunizems. The profile described under III L is typical of these soils.

Brown Forest soils occur in smaller acreage in the Upper Montane region than in the Lower. They are usually found under open timber stands in the transition areas between Chestnut soils and Gray Wooded soils or on the younger parent materials of stream terraces or alluvial fans. They are found most frequently on south-, east-, or west-facing slopes. The profile described under III F is typical of these soils.

Humic Gley soils occur extensively in the upper ends of stream valleys in this region. They are confined to the poorly drained parts of the landscape, such as seepage areas or stream flood plains and terraces. They are associated with the Bog soils. The profile

described under III N is typical of these soils. Lithosols occur extensively in this region wherever bedrocks occur at or near the surface. They are found most frequently on the steeper slopes or at abrupt slope breaks. They are usually associated in complex patterns with barren rock outcrops, but may occur with any of the soils of this region. The profiles described under III Q are typical of these soils.

Bog soils occur frequently in association with Humic Gley soils in the broader upper stream valleys in this region. They include both sedge and woody peats and minor areas of muck. The profiles described under III D are typical of these soils.

Minor components of the soil pattern are: (1) Chermozem soils, which occur in moist areas of high elevation, (2) Alluvial soils, which occur thoughout the region on young alluvial fans and narrow flood plains, (3) Brown Podzolic soils, which occur under stands of timber on the youthful portions of the landscape and (4) Chernozem - Graywooded intergrades, which occur under open stands of timber or mixed timber and grassland areas on south-facing slopes.

D. Subalpine Areas

As used in this paper, these are the mountainous areas between elevations of 9,300 feet and timber line. These are areas of steep mountain slopes with glacier-carved valleys that are characteristically broad at the lower edges of the region, but become narrow and steep sided as they approach the Alpine-tundra areas. Many of the valleys terminate in the lower slopes of glacial cirques. Ridgecrests are narrow and inclined toward the higher mountain summits.

Soil climate is cold and moist. Average annual soil temperatures range from 36 to 44° F. in the southern parts of the state to

about 32 to 42° F. in the north. Average annual summer soil temperatures range from 46 to 54° F. in the south to 40 to 54° F. in the north. Average annual precipitation ranges from 25 to 30 inches. Snow accumulates to considerable depth and remains on the ground later in the spring than in the Montane regions. Periods of damp foggy days are common in any season.

These are areas of dense evergreen forests broken occasionally by wet mountain stream valleys and a few open brush areas. Unless the original timber stand has been destroyed by fire, lumbering or mining, the cover is unusually uniform. Even slope aspect has little influence on either density or species. Spruce, fir, and limber pine are the principal varieties. Scattered growths of aspen and willow occur in some areas.

Soil parent materials are varied, and their character is often determined by the character of the bedrock from which they came. Crystalline rocks predominate, although sedimentary rocks occur in some parts of the state. Many of the valleys have been glaciated, and glacial or fluvioglacial deposits are common. Aeolian materials are uncommon, but may occur in some areas.

Brown Podzolic soils (Orthods), Podzol soils (Orthods), Ground water Podzols (Aquods), Lithosols (Orthents), Brown Forest soils (Haploborolls), Grey Wooded soils (Glossoboralfs), and Bog soils (Histosols) are the predominant Great Soil Groups found in the area. Sols Bruns Acides (Dystrochrepts), Humic Gley soils (Aquolls), Alluvial soils (Orthents), Chernozems (Borolls), and Brunizems (Udolls) are minor components of the soil pattern.

Brown Podzolic soils are found throughout the subalpine region, but are most frequently found at both the upper and lower margins.

Recent surveys in the mountain areas indicate that these soils may predominate the transition zones just below timberline. Slope aspect does not have a clear-cut influence on their distribution, although they may favor south-facing slopes in the northern-most parts of the state. They are associated in most landscapes with the Podzol soils. The profile described under III G is typical of these soils.

Classic Podzol profiles occur extensively throughout the Subalpine region. Slope aspect has little influence on their distribution, except that they may be slightly more prevalent on north-facing slopes in the southern part of the state. They are most strongly developed on medium to coarse textured parent materials. They are associated in most landscapes with the Brown Podzolic soils and Gray Wooded soils. The profile described under III P is typical of these soils.

Ground water Podzols occur in the more poorly drained or seeped areas of the region. The profile described under Il N is typical of these soils.

Gray Wooded soils occur less extensively in the Subalpine region than in the Montane regions. They are found in areas where the timber stands were less dense, and they favor the finer textured parent materials. The medium to strongly acid varieties predominate. They occur in many landscapes in association with the Brown Forest soils and Podzols. The profiles described under III M 2 and III M 4 are typical of these soils.

Brown Forest soils occur most extensively at the lower margins of Subalpine regions, or on the stream terraces and valley sideslopes. They are most frequently found on recently deposited, alkaline parent materials where timber stands are mixed conifer and aspen, or where understory growths are the most dense. They occur in association

with the Gray Wooded or Alluvial soils. The profile described under III F is typical of these soils.

Because of the relatively steeply sloping nature of the terrain in this region, Lithosols occur extensively wherever bedrocks outcrop or are close to the surface. They usually occur in a complex pattern with exposures of bare rock outcrop. They are found in association with nearly all of the other Great Soil Groups. The profile described under III O is typical of these soils.

Bog soils occur extensively in the stream valleys of the Subalpine region, or they may be found in poorly drained concave areas on the mountain slopes. Both woody and sedge peats are plentiful. Some areas of muck may occur intermixed with peats. They are usually associated with Humic Gley soils in the stream valleys. The profiles described under III D are typical of these soils.

Minor components are: (1) Sols Bruns Acides, which occur most frequently at the lower elevations and in the transition zones adjacent to Podzols or Brown Podzolic soils, (2) Humic Gley soils, which occur in poorly drained flood plains or seepage areas, (3) Alluvial soils, which occur on flood plains or young Alluvial fans, (4) Chernozems, which occur under grass, open conifer or aspen stands in moist valleys, and (5) Brunizems, which occur under grass, open conifer or aspen stands where parent materials are low in bases.

E. Alpine-Tundra Areas

This area consists of the grassland areas above timberline on the crests of mountain peaks and ridges. Its lower limit is the tree line between 11,000 and 11,400 feet in most locations. In Colorado this region extends to more than 14,000 feet.

Topographically, this is an area of contrasts. Prominent to the

eye are the steeply sloping rock faces of the mountain peaks, but much of the Alpine-tundra area consists of undulating to rolling land surfaces that terminate abruptly in cliff or cirque faces.

Soil climate is cold and moist. Average annual soil temperatures range from 28 to 36° F. in the southern part of the state to about 28 to 32° F. in the north. Average summer soil temperature ranges from 40 to 47° F. in the south to 40 to 45° F. in the north. The effect of slope aspect on soil temperature is relatively small with only one or two degrees variation between north and south slopes. Average annual precipitation ranges from 25 to 35 inches.

The effect of soil temperature on soil genesis in this region is extreme. In addition to strongly influencing the type, intensity, and duration of biological and chemical processes, there is a considerable amount of mechanical mixing of soil resulting from congeliturbation and associated forces. Stone garlands, polygons, stripes and frost boils are common features in this area.

These are grassland areas predominated by perennial grasses, sedges, shrubs and herbs. The overall density of vegetation is much greater than the impression gained by viewing these areas from a distance. They are used extensively as summer rangelands in many areas.

Soil parent materials are mixed and variable, and their character is dependent upon the bedrock from which they were derived. Many areas have been glaciated, and thin deposits of pre-Wisconsin glacial till mantle the broad ridges, divides and interfluves. Till and fluvioglacial deposits of Wisconsin age occur in cirque basins and glacial valleys. Sediments weathered residually, or only locally transported from crystalline rock, are common; while a few

areas, particularly in the southern part of the state, are covered by sediments weathered from sedimentary rock. Red and maroon colored conglomerate, sandstone and shale have contributed to the regolith in places. A few patches of aeolian material may be found.

With the exception of the sediments derived from sedimentary rock, most of the parent materials are acid and contain a large amount of stone and rock. Predominate textures range from stony or very stony clay loam to sandy loam. Sediments derived from sedimentary rocks are generally neutral to calcareous in reaction, contain much less stone, and are more silty in texture. Numerous rock talus slopes occur in the Alpine-tundra area.

The soil pattern in these areas is relatively uniform in terms of Great Soil Groups. It consists mainly of the Alpine Turf soils (Cryorthods), Alpine Meadow soils (Cryaquods), Lithosols (Lithic Haplorthents), Chernozems (Borolls), and Bog soils (Histosols). Humic Gley soils (Cryaquolls), Alluvial soils (Cryorthent), Regosols (cryorthents) and Rock slides (Cryopsamments) are minor components.

The Alpine Turf soils are the most extensive soils of the Alpine-tundra area. They occur on the mountain slopes, rolling divides or interfluve areas, and are developing in nearly all kinds of parent materials, except the materials from the calcareous and fine textured sedimentary rocks. They occur in association with the Alpine Meadow soils in most landscapes. The profile described under III C is typical of these soils.

The Alpine Meadow soils occur in cirque basins and in imperfectly drained concave or depressional areas in association with the Alpine Turf and Bog soils. They are extensive soils and occur throughout the region. The profile described under III B is typical

of these soils.

Lithosols occur extensively in the Alpine-tundra regions wherever bedrocks occur at or near the surface of the ground. They usually occur in a complex pattern with areas of bare rock outcrop, and are found near sharp breaks in the landscape or on very steep slopes. The profile described under III O is typical of these soils.

Chernozems occur in the Alpine-tundra region where parent materials have been derived from alkaline to calcareous sedimentary rock. They are well-drained soils occupying the same topographic positions as the Alpine Turf soils developing in more acid parent materials. They occur in association with Humic Gley and Regosols. The profile described under III J is typical of these soils.

Bog soils (Histosols) occupy the poorly drained portions of cirque basins or depressional areas on broad divides and interfluve areas. They are mainly sedge peats, except in some areas where willow growth is heavy. They occur throughout the area and are associated with all kinds of parent materials. The profiles described under III D are typical of these soils.

Minor components of the soil pattern are: (1) Alluvial soils, which occur on the youthful alluvial fans in the cirque basins, (2) Regosols, which occur in the younger parts of the landscape or in snow burn areas where snow accumulates and stays most of the year, (3) Rock slides, which are accumulations of rock and stone at the base of steep slopes and (4) Humic Gley soils, which occur in poorly drained areas where parent materials are calcareous to alkaline.

III. Characteristics of the Soils of the Mountains of Colorado

The preceding section of this paper has dealt with general patterns of soils as they relate to broad geographic subdivisions of the mountainous areas. This section will concern itself with more detailed descriptions of the character of the soils in each of the Great Soil Groups, and the variations that may be encountered.

As in the preceding section, it must be emphasized that the scope of the subject is much too broad to permit very detailed discussions of the individual soils in the limited space of this paper. It is hoped that by describing a central concept of each Great Soil Group and then discussing variations from it, the reader may obtain a general knowledge of the kinds of soils presently identified in the mountainous areas of Colorado. The following discussions are in alphabetical order by Great Soils Group names to facilitate easy reference.

A. Alluvial Soils

These are young soils developing in alluvial parent sediments and characterized by little or no genetic horizonation other than a darkened surface horizon or inconsistent accumulation of secondary soluble salts. Because of the manner in which their parent sediments were deposited, these soils may have strongly contrasting textural horizonation. This is considered a characteristic of the parent sediment and not the result of soil development. The following is a typical profile representative of this group of soils.

A1 0-6" Grayish-brown (10YR 5/2, dry) to dark grayish-brown (10YR 4/2, moist) loam; moderate fine granular structure; soft dry, very friable moist; many grass roots; 5 percent gravel; calcareous, pH 8.0; gradual smooth boundary.

C 6-60" Light brownish-gray (10YR 6/2, dry) to grayish-brown (10YR 5/2, moist) predominantly loam stratified with 2- to 4-inch lenses of clay loam and fine sandy loam; massive; hard dry, very friable moist; 5 percent gravel; few small faint dark yellowish-brown (10YR 4/4 mottles) in lower 12 inches; calcareous, pH 8.2.

At higher elevations in well-drained sites, the soils included in this group are usually noncalcareous and have 6- to 12-inch surface horizons that are typically grayish-brown (10YR 5/2, dry) to very dark grayish-brown (10YR 3/2, moist). For the purposes of this paper they are included with the Alluvial soil group, but in the new system of soil classification such soils would be placed in frigid families of Haplustolls, Hapludolls or Haploboralls since they are considered to have mollic epipedons.

With increasing poor drainage, at low elevations these soils lacking mollic epipedons become strongly mottled with both bright and low chroma mottlings, and the mottling occurs higher in the profile. In the new system of classification such soils would be considered aquic Haplorthents, but for the purpose of this paper they are included in the Alluvial soils.

With increasing elevation and poor drainage these soils tend to develop thin dark-colored surface horizons, or thin peaty horizons, in addition to the mottling and gleying previously described. For the purpose of this paper such soils have been included in the Alluvial Great Soil Group, if the dark-colored horizons are not thick enough to be considered mollic epipedons.

B. Alpine Meadow Soils

As defined by the 1938 Yearbook, this is an intrazonal group of dark colored soils of open or sparsely timbered and usually rather wet meadows found at high altitudes near and above timberline. This definition embraces a wide variety of individual soils and kinds of soils. It has an exceedingly strong bias towards geographic distribution and landscape positions with little or no relevance given to the kind of genetic profile.

In subsequent work in the mountainous areas of Colorado, Retzer attempted to bring a somewhat greater degree of genetic relevance to this major Great Soil Group. He proposed the separation of soils, which he called the Alpine Turf soils, from the Alpine Meadow soils. Fundamentally, this was a division based largely on degree of drainage with the Alpine Turf soils occupying the well-drained position in Alpine areas.

Subsequent work in the Alpine regions has indicated that there is still a wide variation of soils within the Alpine Meadows, even as defined by Retzer. Although our knowledge is still far from complete, we now realize that within the Alpine Meadow areas are profiles which are extremely acid and whose major genetic process involves the translocation of iron and humis (cryaquods). In other areas, particularly where calcareous materials are exposed, the soils that develop are very similar to the other Humic Gley soils of lower elevation, except that they have a much colder soil temperature (cryaquolls).

For the purposes of this paper, the Alpine Meadow soils group has been limited to those areas that are imperfectly to poorly drained, acid in reaction, and which have evidence of translocation

sesquioxides and humus. The more alkaline members have been included in the major group of Humic Gley soils, while the well-drained areas will be discussed in connection with the Alpine Turf group. The following is a typical profile representative of the Alpine Meadow soils.

A1 0-4" Dark gray (10YR 4/1 dry) to black (10YR 2/1, moist) stony coarse sandy loam; weak coarse granular structure; soft dry, very friable moist; 20 percent stone and cobble; very strongly acid, pH 4.6; clear smooth boundary.

A3 4-11" Dark grayish-brown (10YR 4/2, dry) to dark brown (10YR 2/2, moist) stony sandy loam; weak fine and medium subangular blocky structure breaking to coarse granuales; slightly hard dry, friable moist; 15 percent stone; very stongly acid, pH 4.6; clear smooth boundary.

B2irg 11-24" Light yellowish-brown (10YR 6/4, dry) to yellowish-brown (10YR 5/4, moist) stony sandy loam; weak to moderate medium subangular blocky structure; slightly hard dry, very friable moist; dark coatings on sand grains and dark fine pellets; common medium sized distinct 10YR 5/6 and 2.5Y 5/1 mottles; 20 percent stone; very strongly acid, pH 4.6; diffuse wavy boundary.

Cg 24-30" Light yellowish-brown (2.5Y 6/4, dry) to light olive-brown (2.5Y 5/4, moist) coarse sandy loam stratified with thin layers of coarse sand; massive; slightly hard dry, very friable moist; many medium sized distinct 10YR 5/6 and 5Y 5/1 mottles; approximately 40 percent stone; a free water table at 50 inches; strongly to very strongly acid, pH 5.0.

As drainage improves mottling becomes less intense and occurs deeper in the profile. The B2ir horizon increases in hue or chroma and these soils grade into the Alpine Turf soils (cryorthods).

With decreasing elevation and increasing timber cover the A1 horizon decreases in thickness and A2 horizons start to develop. Eventually they grade into the Brown Podzolic or classic podzols (orthods).

With increasing alkalinity in the parent sediments the B2ir horizon becomes weaker, silicate clay accumulation starts and these soils grade in Humic Gley soils (cryaquolls).

C. Alpine Turf Soils

These are well-drained soils occurring on rolling to steeply sloping Alpine areas. They have thick very dark colored surface horizons that are very high in organic matter, and bright colored very acid B2ir horizons. They are found developing under alpine grasses in a variety of parent materials usually weathered from acid igneous or metasedimentary rock. The following is a typical profile of the soils of this group.

A1 0-8" Very dark gray (10YR 3/1, dry) to black (10YR 2/1, moist) loam; moderate to strong medium and coarse crumb structure; soft dry, very friable moist; very strongly acid, pH 4.6; clear wavy boundary.

A3 8-12" Dark grayish-brown (10YR 4/2, dry) to very dark brown (10YR 2/2, moist) sandy loam; moderate fine and very fine subangular blocky structure breaking to moderate to strong fine and medium granules; soft dry, very friable moist; very strongly acid, pH 4.6; clear wavy boundary.

B2ir 12-25" Light yellowish-brown (10YR 6/4, dry) to yellowish-brown (10YR 5/4, moist) coarse sandy loam; moderate fine subangular blocky structure; slightly hard dry, very friable moist; dark coatings on sand grains and many dark pellets; very strongly acid, pH 4.6; gradual wavy boundary.

C 25-30" Light yellowish-brown (2.5Y 6/3, dry) to light olive brown (2.5Y 5/4, moist) very stony sandy loam; massive; slightly hard dry, very friable moist; 70 percent stone and gravel; very strongly acid, pH 4.6; gradual wavy boundary.

R 30" Weakly weathered and partially fractured gneiss and schist bedrock less than 5 percent fine material in the cracks between the rock.

With increasing poor drainage these soils become highly mottled at or near the surface and they grade to the Alpine Meadow soils (cryaquods).

With decreasing elevation into the forested areas of the mountains the A1 horizon of these soils becomes thinner, an A2 horizon develops and they eventually grade into the Brown Podzolic or Classic Podzol (orthods).

With increasing degrees of alkalinity in the parent sediments the B2ir horizons become weaker, silicate clay starts to accumulate, lose the bright chromas and hues of their B2ir horizons and grade into the Brunizem or Chernozem soils (Udolls or Ustolls).

D. Bog Soils

The Bog soils of the mountainous areas of Colorado are mainly organic soils. They are of two major types, depending upon the character of the organic material incorporated into them. In the forested areas where the organic debris was mainly wood, bark and twigs a coarser textured wood peat has developed. In the Alpine and grassland

areas where native vegetation was mainly hydrophitic grasses and sedges the organic material is much finer textured and there is a greater tendency to form mucks. The following is a typical profile in areas of timber.

1 0-20" Very dark gray (10YR 3/1, dry) to black (10YR 2/1, moist) a massive layer of woody peat. The outline of individual branches, twigs, and occasionally needles can be seen throughout the horizon. Very strongly acid, pH 4.6;this horizon rests abruptly on the one below.

2 20-25" Very dark gray (10YR 3/1, dry) to black (10YR 2/1, moist) highly organic gravelly loam; weak to moderate coarse crumb structure; soft dry, very friable moist; this is a mineral horizon that contains a high percent of organic material and is transitional to the horizon below; very strongly acid, pH 4.6; gradual smooth boundary.

3 25-40" Gray (5Y 5/1, dry) to very dark gray (5Y 3/1, moist) sandy clay loam; massive; slightly hard dry, friable moist; this horizon coincides with the top of the standing water table at the site described.

The following is typical of these soils developing under rushes, sedges and grasses.

1 0-20" Very dark gray (10YR 3/1 dry) to black (10YR 2/1, moist) massive fibrous peat; very strongly acid, pH 4.6; the outline of some leafy plants are still visible. The lower 2 to 3 inches of this horizon is muck-like in character; the horizon rests abruptly on the horizon below.

2 20-60" Light brownish-gray (10YR 6/2, dry) to dark grayish [illegible] (10YR 4/2, moist) fine gravelly sandy loam; massive;

slightly hard dry, very friable moist; very strongly acid, pH 4.6.

As drainage tends to improve and the water table becomes somewhat less stagnant, the peat layers at the surface of the soil become thinner until eventually these soils grade into the Humic Gley soils (Aquolls or Cryaquolls).

E. Brown Soils

These are light colored, zonal soils developing in well-drained sites on gently to moderately steeply sloping mountain sides, valley sideslopes, and old terrace levels. Typically they have light-colored, granular surface horizons, horizons of silicate clay accumulation, and distinct horizons of calcium carbonate or calcium sulfate accumulation. The following is a typical profile of these soils.

A1 0-4" Light grayish-brown (10YR 6/2, dry) to dark grayish-brown (10YR 4/2, moist) loam; weak coarse subangular blocky structure breaking to moderate fine granules; soft dry, very friable moist; noncalcareous, pH 7.0; weakly platy in the upper 1/2-inch; clear smooth boundary.

B1 4-7" Brown (10YR 5/3, dry) to brown or dark brown (10YR 4/3, moist) heavy loam; weak medium prismatic structure breaking to moderate fine subangular blocks; hard dry, friable moist; a few thin patchy clay films on both horizontal and vertical faces of the soil aggregates; noncalcareous, pH 7.0; clear smooth boundary.

B2t 7-15" Brown (7.5YR 5/3, dry) to brown or dark brown (7.5YR 4/3, moist) clay loam; moderate to strong fine prismatic structure breaking to moderate to strong fine and medium subangular blocks; very hard dry, friable moist; thin

continuous clay films; noncalcareous, pH 7.2; clear smooth boundary.

B3ca 15-20" Pale brown (10YR 6/3, dry) to brown (10YR 5/3, moist) light clay loam; weak to moderate medium subangular blocky structure; very hard dry, friable moist; a few thin patchy clay films; a weak ca horizon with visible secondary calcium carbonate occurring as concretions, and in thin seams and streaks; calcarous, pH 8.0; gradual smooth boundary.

C1ca 20-30" Light gray (10YR 7/2, dry) to brown (10YR 5/3, moist) light clay loam; massive; very hard dry, friable moist; a moderate ca horizon with visible calcium carbonate occurring as concretions, in thin seams and streaks, and in finely divided forms; calcareous, pH 8.0; gradual smooth boundary.

C2ca 30-64" Pale brown (10YR 6/3, dry) to brown (10YR 5/3, moist) loam; massive; very hard dry, friable moist; a moderate ca horizon with visible calcium carbonate occurring as concretions, in thin seams and streaks, and in finely divided forms; calcareous, pH 8.0; gradual smooth boundary.

With increasing elevation and correspondingly colder soil temperatures, or with increases in effective soil moisture, the surface horizons of these soils become darker, the profile tends to thicken, the depth to visible secondary calcium carbonate accumulation increases, and generally the upper part of the solum is somewhat less alkaline until eventually they grade into the Chestnut soils (Ustolls).

With decreasing age the horizonation of these soils becomes less contrasting and they grade into Regosols or Alluvial soils (Orthents).

With increasingly poor drainage the surface horizons of these soils become darker and thicker, mottling develops and rises higher

in the profile, and they grade into the Humic Gley soils (Aquolls).

F. Brown Forest Soils

Considerable difference of opinion regarding the Brown Forest soils as a Great Soil Group requires that, for the sake of clarity, the term be defined as it is used in this paper. The following definition is not intended as a suggested definition for the Great Soil Groups in other areas and is presented solely as a means of clarifying the use of the term for this paper.

As used here, it identifies soils developing under forests whose profiles are characterized by thick, dark-colored, friable, surface horizons that grade into C horizons of lighter color. Soils having B2 horizons qualifying as cambic horizons of the new system of classification are included in the group, but soils having distinct horizons of silicate clay accumulation, or accumulation of sesquioxide and humus are excluded. The soils may be moderately acid to moderately alkaline in reaction, although neutral to alkaline reactions predominate. The following is a soil profile representative of this group.

01	2-1"	Undecomposed organic material, principally needles, twigs, barks and leaves.
02	1-0"	Partially decomposed organic material like that of the horizon above.
A1	0-12"	Dark grayish-brown (10YR 4/2, dry) to very dark brown (10YR 2/2, moist) gravelly loam; moderate medium and fine crumb structure; soft dry, very friable moist; neutral, pH 7.0; gradual smooth boundary.
AC	12-16"	Grayish-brown (10YR 5/2, dry) to very dark grayish-brown (10YR 3/2, moist) gravelly loam; weak medium subangular blocky structure breaking to moderate fine crumb structure;

slightly hard dry, very friable moist; 15 percent gravel; neutral, pH 7.0; gradual smooth boundary.

C 16-60" Light yellowish-brown (2.5Y 6/3, dry) to light olive brown (2.5Y 5/3, moist) gravelly heavy sandy loam or light loam; massive; slightly hard dry, very friable moist; 25 percent gravel; mildly alkaline, pH 7.4.

With decreasing soil moisture, increasing soil temperature, and a decreasing density of grass in the native cover, the dark surface horizons of these soils become lighter colored and thinner and the soils grade into Alluvial soils or Regosols (Orthents or Psamments).

With increasing soil temperature, an increasing percentage of grasses in the native cover, and advancing age of landscapes, these soils start to develop horizons of silicate clay accumulation and grade into Chestnuts (Ustolls) or Brunizems (Udolls). With constant or decreasing soil temperature, advanced age, and increased density of conifer growth these soils start to develop elluvial horizons, and illuvial horizons of silicate clay or sesquioxides and humus and eventually grade into the Gray Wooded (Glossaboralfs) or Brown Podzolic soils (Orthods).

G. Brown Podzolic Soils

As used in this paper this soil group consists of well-drained, strongly acid soils of mountain sideslopes and ridges developing in a variety of neutral to acid parent sediments. Typically they have thin to moderately thick dark-colored, crumb-structured A horizons that overlie bright-colored contrasting B2ir horizons of sesquioxide and humus accumulation. Typically there is no discernible A2 horizons, although thin inconsistent A2 horizons may occur in places.

The following is a description of a typical profile of this soil group.

01 2-1" Undecomposed organic material; mainly needles, bark and twigs.

02 1-0" Partially decomposed organic material like that of the horizon above.

A1 0-4" Grayish-brown (10YR 5/2, dry) to very dark grayish-brown (10YR 3/2, moist) stony sandy loam; moderate fine crumb structure; soft dry, very friable moist; 20 percent stone; strongly acid, pH 5.4; abrupt smooth boundary.

B2ir 4-16" Reddish-brown (5YR 5/4, dry) to(5YR 4/4, moist) stony sandy loam; weak medium subangular blocky structure breaking moderate very fine subangular blocks; slightly hard to hard dry, very friable moist; dark coatings on sand grains and many dark pellets; 20 percent stone; strongly acid, pH 5.0; gradual smooth boundary.

B3 16-21" Yellowish-brown (10YR 5/4, dry) to dark yellowish-brown (10YR 4/4, moist) stony sandy loam; massive or weak coarse subangular blocky structure; soft dry, very friable moist; 30 percent stone; strongly acid, pH 5.4; gradual smooth boundary.

C 21-60" Light olive brown (2.5Y 5/4, dry) to olive brown (2.5Y 4/4, moist) very stony loamy coarse sand; single grained; loose dry or moist; 60 percent stone and cobble; medium acid, pH 5.8.

With increasing density of spruce and fir cover, the dark surface horizons of these soils tend to thin, and continuous A2 horizons develop until they grade into the classic Podzols(Orthods).

With increasing grass and cover, decreasing soil temperatures, as in areas near timberline, the A horizon tends to thicken, and they grade into the Alpine turf soils (Cryorthods).

With increasing grass or broadleaf trees and brush cover, increasing soil temperatures, decreasing effective soil moisture, and increasing alkalinity, the horizons of sesquioxide and humus accumulation weaken and they grade to the Brown Forest soils (Haplustolls, Hapludolls or Haploboralls).

H. Brunizem Soils

As used in this paper, these are well-drained, moderately dark colored, neutral to moderately acid, grassland soils developing on gently to moderately steeply sloping alluvial fans or mountain sideslopes. Typically they have thick, moderately dark colored, granular surface horizons, distinct horizons of silicate clay accumulation, and soil reaction of pH 7.0 or less that decreases or remains constant with depth. The following is a description of a typical soil of this Great Soil Group.

A1 0-6" Dark grayish-brown (10YR 4/2, dry) to very dark grayish-brown (10YR 3/2, moist) fine sandy loam; moderate very fine granular structure; soft dry, very friable moist; 5 percent gravel; slightly acid, pH 6.5; clear smooth boundary.

A3 6-10" Brown or dark brown (10YR 4/3, dry) to dark brown (10YR 3/3, moist) fine sandy loam; weak medium subangular blocky structure breaking to moderate fine granuales; slightly hard dry, very friable moist; 5 percent gravel; slightly acid, pH 6.3; clear wavy boundary.

B2t 10-26" Brown (7.5YR 5/4, dry) to brown or dark brown (7.5 YR 4/4, moist) gravelly sandy clay loam; weak coarse prismatic structure breaking to moderate medium subangular blocks; hard dry, very friable moist; there are moderate numbers of thin patchy clay films on both horizontal and vertical faces of the soil aggregates; 20 percent gravel and stone; slightly acid, pH 6.2; gradual wavy boundary.

B3 26-32" Brown (7.5YR 5/4, dry) to brown or dark brown (7.5YR 4/4, moist) heavy gravelly sandy loam; weak medium subangular blocky structure; hard dry, very friable moist; a few thin patchy clay films; 20 percent gravel and stone; slightly acid, pH 6.2; gradual wavy boundary.

C 32-60" Light yellowish-brown (10YR 6/4, dry) to yellowish-brown (10YR 5/4, moist) gravelly sandy loam; massive; slightly hard dry, very friable moist; 30 percent stone and gravel; slightly acid, pH 6.2.

With increasing alkalinity in the parent sediments, solum reaction becomes more alkaline and increases with depth until these soils grade into the Chestnut soils (Ustolls).

With increasing moisture, decreasing soil temperature, and in increasing proportion of conifer in the native cover, the A horizon thins and becomes lighter in color and elluvial A2 horizons start to develop. Under these conditions these soils eventually grade into Gray Wooded soils (Glossoboralfs), or into Chernozem-Gray Wooded intergrades (Molic Glossoboralfs).

With increasing degrees of poor drainage these soils develop mottling and gleying and eventually grade into Humic Gley soils (Aquolls). With decreasing age of landscape, or increasing degree of slope, the

horizons of secondary clay accumulation weaken and these soils grade into Alluvial soils or Regosols (Orthents).

I. Calcisols

These are well-drained, light-covered, calcareous soils developing on alluvial fans and sideslopes in strongly calcareous parent materials usually derived from calcareous sedimentary rock or limestone. Typically they have light-colored, granular surface horizons overlying thick horizons of strong secondary calcium carbonate accumulation. The following is a description of a representative soil of this group.

A1 0-6" Light brownish-gray (10YR 6/2, dry) to dark grayish-brown (10YR 4/2, moist) loam; moderate fine granular structure; soft dry, very friable moist; 5 percent gravel; calcareous, pH 8.0; gradual smooth boundary.

AC 6-12" Light brown (7.5YR 6/3, dry) to brown or dark brown (7.5YR 4/3, moist) loam; weak medium prismatic structure breaking to moderate medium subangular blocks; hard dry, very friable moist; 5 percent gravel; calcareous, pH 8.2; gradual smooth boundary.

C1ca 12-30" Pinkish-white (7.5YR 8/2, dry) to pinkish-gray (7.5YR 6/2, moist) loam; massive; hard dry, friable moist; a strong horizon of secondary calcium carbonate accumulation with visible calcium carbonate occurring as concretions, in thin seams and streaks, and in finely divided forms; 5 percent gravel; calcareous, pH 8.4; diffuse wavy boundary.

C2ca 30-60" Pinkish-gray (7.5YR 6/2, dry) to brown (7.5YR 5/2, moist) loam; massive; hard dry, very friable moist; a moderate

horizon of secondary calcium carbonate accumulation with visible calcium carbonate mostly as concretions, and in thin seams and streaks; 10 percent gravel; calcareous, pH 8.4.

With decreasing age of landscapes, or sharply increasing slope gradient, the strong horizons of secondary calcium carbonate weaken and these soils grade into Alluvial soils or Regosols (Orthens or Psamments). With increasing age of landscape these soils become non-calcareous in their upper horizons and start to develop B2 horizons of silicate clay accumulation. Under these conditions they eventually grade into Brown soils (Argids).

With increasing soil moisture the surface horizons darken and the horizons of maximum secondary calcium carbonate accumulation moves downward. For the purposes of this paper, soils that have developed mollic epipedons and have retained a strong horizon of secondary calcium carbonate accumulation are still included in the Calcisol group. In the new system of classification such soils would be considered to be Calciustolls. If given sufficient age so that horizons of silicate clay accumulation can develop, these soils will eventually grade into Chestnut soils (Ustolls).

J. Chernozems

These are well-drained, dark-colored, neutral to alkaline soils developing on alluvial fans, mountain sides, or old terrace levels in a variety of parent materials, but mainly those derived from calcareous sedimentary rock or bedrock high in bases. Typically they have dark-colored, granular A horizons of low chroma, horizons of secondary silicate clay accumulation, and weak horizons of secondary calcium carbonate accumulation. The following is a description of a typical soil of this group:

A1 0-8" Dark gray (10YR 4/1, dry) to black (10YR 2/1, moist) loam; moderate to strong fine crumb and granular structure; soft dry, very friable moist; noncalcareous, pH 7.2; clear wavy boundary.

B1 8-12" Brown or dark brown (7.5YR 4/2, dry) to very dark brown (7.5YR 2/2, moist) heavy loam; moderate fine subangular blocky structure breaking to medium granules; slightly hard dry, very friable moist; thin patchy clay films; noncalcareous, pH 7.2; clear smooth boundary.

B2t 12-34" Reddish-brown (5YR 5/4, dry) to (5YR 4/4, moist) heavy clay loam; weak coarse prismatic structure breaking to moderate coarse and medium angular blocks; extremely hard dry, very plastic wet; thick continuous clay films; 5 percent stone; noncalcareous, pH 7.4; gradual wavy boundary.

B3ca 34-40" Reddish-brown (5YR 5/4, dry) to (5YR 4/4, moist) clay loam; weak to moderate medium angular and subangular blocky structure; extremely hard dry, very plastic wet; many thin patchy clay films; 10 percent stone; a weak horizon of secondary calcium carbonate accumulation with visible calcium carbonate occurring mostly in large concretions; calcareous, pH 7.8; gradual wavy boundary.

Cca 40-60" Light reddish-brown (5YR 6/4, dry) to reddish-brown (5YR 5/4, moist) stony clay loam; massive; extremely hard dry, plastic wet; 15 percent stone some of which are well weathered; a moderate to strong ca horizon with visible calcium carbonate occurring as large concretions, and in finely divided forms; calcareous, pH 8.0.

With decreasing soil temperature, or decreasing effective soil

moisture, the surface horizons tend to brighten in chroma and these soils grade into the Chestnut soils (Ustolls). With increasingly poor degrees of drainage these soils develop mottling and gleying, and grade into the Humic Gley soils (Aquolls).

With increasing soil moisture, decreasing soil temperature, and an increasing proportion of conifers in the vegetative cover, the A horizon thins, becomes lighter in color and elluvial A2 horizons start to develop. Under these conditions these soils grade into the Gray Wooded soils (Glossoboralfs), or the Chernozem-Gray Wooded intergrades (Mollic Glossoboralfs). With decreasing age of landscape the horizons of silicate clay weaken and the surface horizons sometimes, but not always, develop brighter chroma. For the purpose of this paper such soils having mollic epipedons but no disctinct argillic horizons (Haplustolls or Haploborolls) are included in the Alluvial soils and Regosols.

K. Chernozem-Gray Wooded Intergrades

This group of soils is generally not assigned a Great Soil Group status, but is considered to be an intergrade between Chernozem soils and Gray Wooded soils. It is treated as a Great Soil Group in this paper because it is a significant kind of soil found in the mountains of Colorado, and because it has a well developed but unique kind of horizonation.

These are well-drained, moderately acid to mildly alkaline soils developing in transitional areas between grasslands and forest on mountain slopes or in foothill areas. Typically they have moderately thick, dark-colored, granular A1 horizons, and light-colored alluvial A2 horizons that tongue into underlying horizons of silicate clay accumulation. In places they may have weak horizons of secondary

calcium carbonate accumulation below the B2t horizon. The following is a description of a typical soil of this group:

A1 0-8" Grayish-brown (10YR 5/2, dry) to very dark grayish-brown (10YR 3/2, moist) gravelly sandy loam; strong very fine granular or crumb structure; soft dry, very friable moist; 15 percent gravel; neutral, pH 6.8; clear smooth boundary.

A2 8-13" Light brownish-gray (10YR 6/2, dry) to grayish-brown (10YR 5/2, moist) gravelly sandy loam; moderate very fine subangular blocky structure breaking to strong very fine granules; soft dry, very friable moist; vesicular; 20 percent gravel; neutral, pH 6.8; clear smooth boundary.

A & B 13-24" Variegated colors ranging from grayish-brown (10YR 5/2 dry) or brown (10YR 5/3, dry) to brown or dark brown (10YR 4/3, moist); gravelly sandy clay loam; moderate medium subangular blocky structure; slightly hard dry, very friable moist; this horizon consists of nodules and seams of material like that of the underlying horizon surrounded by lighter colored materials like those of the overlying horizon; 20 percent gravel; slightly acid, pH 6.6; gradual wavy boundary.

B2t 24-48" Brown (10YR 5/3, dry)to brown or dark brown (10YR 4/3, moist) gravelly sandy clay loam or light clay loam; moderate medium subangular blocky structure; extremely hard dry; very firm moist; thin continuous clay films on the surfaces of the soil aggregates, and channel fillings of silicate clay; 30 percent gravel; slightly acid, pH 6.4; gradual wavy boundary.

B3 48-54" Brown (10YR 5/3, dry) to brown or dark brown (10YR 4/3,

moist) gravelly light sandy clay loam; weak medium subangular blocky structure; extremely hard dry, very friable moist; thin patchy clay films on the faces of soil aggregates, and a few seams and channel fillings of silicate clay; 30 percent gravel; neutral, pH 6.8; gradual wavy boundary.

C 54-60" Brown (10YR 5/3, dry) to brown or dark brown (10YR 4/3, moist) gravelly sandy loam; massive; hard dry, very friable moist; neutral, pH 6.8.

With decreasing soil moisture, increasing soil temperature, and an increasing proportion of grasses in the vegetative cover the A1 horizon tends to thicken, and the A2 and A & B horizons thin. Under this condition these soils grade into Chestnut soils (Ustolls) or Brunizems (Udolls), depending upon the reaction of the solum and C horizon.

With constant or decreasing soil temperature and a higher percentage of grasses in the native cover the A1 horizon tends to thicken and lose chroma. The A2 and A & B horizons thin until these soils grade into the Chernozems (Boralls). With a greater percentage of conifers in the native cover the A1 horizon thins and becomes lighter in color. Under these conditions these soils grade into the Gray Wooded soils (Glossoboralfs).

With decreasing age the A2 and A & B horizons thin and the horizon of silicate clay weaken. Under these conditions these soils grade into the Brown Forest soils (Haplustolls, Hapludolls or Haploborolls).

L. Chestnut Soils

These are well-drained, neutral to moderately alkaline soils developing on alluvial fans, mountain slopes, and old terrace levels

in a wide variety of parent materials, but predominantly those that are high in calcium carbonate or other bases. They have moderately dark colored, granular A horizons, distinct horizons of silicate clay accumulation, and weak to strong horizons of secondary calcium carbonate accumulation. The following is a description of a typical soil of this group:

A1 0-5" Grayish-brown (10YR 5/2, dry) to very dark grayish-brown (10YR 3/2, moist) loam; a moderate medium granular structure; slightly hard dry, very friable moist; 5 percent gravel; noncalcareous, pH 7.0; clear smooth boundary.

B1 5-8" Grayish-brown (10YR 5/2, dry) to very dark grayish-brown (10YR 3/2, moist) light clay loam; weak coarse prismatic structure breaking to moderate medium and fine subangular blocks; hard dry, very friable moist; a few thin patchy clay films; 5 percent gravel; noncalcareous, pH 7.0; clear smooth boundary.

B21t 8-22" Brown (7.5YR 5/2, dry) to brown or dark brown (7.5YR 4/2, moist) clay loam; moderate medium prismatic structure breaking to moderate medium and fine subangular blocks; very hard dry, friable moist; thin continuous clay films; 5 percent gravel; noncalcareous, pH 7.2; clear smooth boundary.

B3ca 22-30" Grayish-brown (10YR 5/2, dry) to dark grayish-brown (10YR 4/2, moist) light clay loam; weak coarse and medium subangular blocky structure; hard dry, friable moist; 5 percent gravel; a few thin patchy clay films; a weak ca horizon with some visible secondary calcium carbonate occurring as concretions and in thin seams and streaks;

calcareous, pH 8.0; gradual smooth boundary.

Cca 30-60" Pale brown (10YR 6/3, dry) to brown (10YR 5/3, moist) gravelly clay loam; massive; hard dry, friable moist; a moderate ca with visible secondary calcium carbonate occurring in finely divided forms, as small concretions, and in thin seams and streaks; 20 percent gravel; calcareous, pH 8.4.

With decreasing soil moisture, increasing temperature, or increasing slope gradient, the Al horizon thins and becomes lighter in color, the solum thins and these soils grade into Brown soils (Argids).

With decreasing age the horizon of silicate clay and secondary calcium carbonate accumulation weaken and these soils grade into Alluvial soils or Regosols with mollic epipedons (Haplostolls). For the purpose of this paper, soils having mollic epipedons, but lacking argillic or calcic horizons, have been placed in the Alluvial and Regosol Great Group.

With decreasing soil moisture, rapidly increasing slope gradient, and decreasing age, the Al horizon thins and becomes lighter in color and the horizons of silicate clay accumulation and calcium carbonate accumulation weaken. Under these conditions these soils grade into Alluvial soils or Regosols without mollic epipedons (Orthents). With decreasing alkalinity in the parent sediments or increasing rainfall the horizon of secondary calcium carbonate accumulation weakens and moves to greater depth and the soil and C horizon become more acid. Under these conditions these soils grade into Brunizems (Udolls).

With decreasing soil temperature and increasing soil moisture the A horizons become duller in chroma and these soils grade into the Chernozems (Borolls). With increasingly poor degrees of drainage these

soils become mottled and gleyed and they grade into the Humic Gley soils (Aquolls).

M. Gray Wooded Soils

As used in Colorado the Gray Wooded Great Soil Group has included a number of kinds of soils. Generally speaking, any forested soil having elluvial A2 horizons and illuvial horizons of silicate clay accumulation have been included in this group. For the purpose of this paper, four major varieties will be discussed as members of the Gray Wooded Great Soil Group. A fifth variety, usually included in the Gray Wooded soils, has been discussed separately under section IIK as Chernozem-Gray Wooden intergrades.

1. Slightly Acid to Alkaline Gray Wooded Soils

These are well-drained, slightly acid to alkaline, forest soils developing on alluvial fans, mountain slopes, and old terrace levels in parent sediments having a high base status. The following is a description of a typical profile of this variety of Gray Wooded soils.

O1 2-½" Undecomposed organic material; chiefly, needles, twigs, bark and grass remains.

O2 ½-0" Partially decomposed organic material like that of the horizon above.

A1 0-1" Grayish-brown (10YR 5/2, dry) to very dark grayish-brown (10YR 3/2,moist) gravelly sandy loam; moderate very fine crumb structure; soft dry, very friable moist; 15 percent gravel; noncalcareous, pH 6.5; clear smooth boundary.

A2 1-5" Light brown (7.5YR 6/3, dry) to brown (7.5YR 5/3, moist) gravelly sandy loam; weak fine platy structure breaking to moderate to strong very fine granules; soft dry, very friable moist; vesicular; 15 percent fine gravel;

noncalcareous, pH 6.9; abrupt wavy boundary.

A & B 5-9" Variegated colors ranging from light brown (7.5YR 6/3, dry) or reddish-brown (5YR 5/3, dry) to brown (7.5YR 5/3, moist) or reddish-brown (5YR 4/3, moist) clayey nodules and lamellae like that of the underlying horizon imbedded in lighter colored and lighter textured material like that of the A2 horizon; composite texture is a gravelly sandy clay loam; moderate fine and very fine angular and subangular blocky structure; hard to slightly hard dry, very friable moist; clay films on some of the clayey aggregates; 15 percent fine gravel; noncalcareous, pH 7.0; clear wavy boundary.

B2t 9-22" Reddish-brown (5YR 5/3, dry) to (5YR 4/3, moist) gravelly sandy clay loam; moderate medium angular and subangular blocky structure; hard dry, very friable moist; thin continuous clay films on the surfaces of the soil aggregates; 30 percent gravel; noncalcareous, pH 7.0; gradual smooth boundary.

B3 22-32" Reddish-brown (5YR 5/4, dry) to (5YR 4/4, moist) very gravelly loam; weak medium subangular blocky structure; hard dry, very friable moist; a few patchy clay films; 50 percent fine gravel; noncalcareous, pH 7.6; gradual wavy boundary.

Cca 32-48" Light reddish-brown (5YR 6/4, dry) to reddish-brown (5YR 4/4, moist) very gravelly sandy loam; massive; hard dry, very friable moist; 60 percent gravel; a very weak accumulation of visible secondary calcium carbonate occurring as concretions and as coatings on the gravel

fragments; calcareous in spots with part of the soil mass noncalcareous, pH of the mixed material is 8.0; diffuse broken boundary.

R 48-60" Weakly weathered and partially fractured bedrock containing less than 5 percent fine material.

2. Moderately Acid to Strongly Acid Gray Wooded Soils

These are well-drained, light-colored, acid, forest soils developing on mountain slopes, alluvial fans, and old terrace levels in parent materials having a low base status. Generally this variety of Gray Wooded soils is associated with higher elevations, lower soil temperature, and more effective soil moisture than the neutral to alkaline variety. The following is a description of a typical profile of this variety of Gray Wooded soils:

01 1-½" Undecomposed organic material, principally needles, bark, and twigs.

02 ½-0" Partially decomposed organic material like that of the horizon above.

A1 0-1" Dark grayish-brown (10YR 4/2, dry) to very dark grayish-brown (10YR 3/2, moist) loam; moderate fine granular structure; soft dry, very friable moist; medium acid, pH 6.0; abrupt smooth boundary.

A2 1-8" Light yellowish-brown (10YR 6/4, dry) to yellowish-brown (10YR 5/4, moist) sandy loam; weak fine granular structure; soft dry, very friable moist; vesicular; very strongly acid, pH 5.0; gradual wavy boundary.

A & B 8-12" Variegated colors ranging from light yellowish-brown (10YR 6/4, dry) or brown (7.5YR 5/4, dry) to yellowish-brown (10YR 5/4, moist) or brown or dark brown (7.5YR 4/4,

moist); sandy clay loam nodules and lamellae imbedded in a matrix of light-colored sandy loam; weak to moderate fine subangular blocky structure; slightly hard dry, very friable moist; very strongly acid, pH 5.0; gradual wavy boundary.

B2t 12-24" Brown (7.5YR 5/4, dry) to brown or dark brown (7.5YR 4/4, moist) clay loam; moderate medium subangular blocky structure; hard dry, friable moist; thin nearly continuous clay films; there is some weak and inconsistent gray coatings on the aggregates; very strongly acid, pH 5.0; gradual wavy boundary.

B3 24-30" Yellowish-brown (10YR 5/6, dry) to brown or dark brown (7.5YR 4/4, moist) light sandy clay loam; weak medium subangular blocky structure; hard dry, friable moist; many thin patchy clay films; sand grains have dark-colored coatings presumed to be organic matter; strongly acid, pH 5.5; gradual wavy boundary.

C 30-60" Yellow (10YR 7/6 dry) to yellowish-brown (10YR 5/6, moist) sandy loam; massive; soft dry, very friable moist; 10 percent fine gravel; strongly acid, pH 5.5.

3. Thick Gray Wooded Soils

Very little is known about the genesis or distribution of this variety of Gray Wooded soils. It has been observed in several locations in the Colorado mountains but none of them were within progressive survey areas where they were studied in detail. Only thick profiles of slightly acid to alkaline Gray Wooded soils have been observed to date and it is not known if such soils exist with more acid reaction.

These are well-drained, light-colored, forested soils developing

on mountain slopes and alluvial fans in transported sediments. Typically they have thick elluvial A2 horizons, thick A & B horizons, and thick horizons of silicate clay accumulation. Solum thickness exceeds 5 feet and may be as thick as 12 or more feet in places. The following is a descritpion of a typical soil of this variety of Gray Wooded soils.

01 3-1" Undecomposed organic material, principally needles, twigs, and bark.

02 1-0" Partially decomposed organic material like that of the horizon above.

A1 0-4" Gray (10YR 5/1, dry) to very dark gray (10YR 3/1, moist) gravelly sandy loam; moderate coarse subangular blocky structure breaking to moderate granules; slightly hard dry, very friable moist; 30 percent gravel; slightly acid, pH 6.2; gradual wavy boundary.

A2 4-21" Light gray (7.5YR 7/1, dry) to brown (7.5YR 5/2, moist) stony loam; weak medium subangular blocky structure breaking to moderate fine granules; weakly platy in places; slightly hard dry. very friable moist; vesicular; 30 percent rock; slightly acid, pH 6.2; clear wavy boundary.

A & B 21-33" Variegated colors ranging from light gray (7.5YR 7/1, dry) or brown (7.5YR 5/2, dry) to brown (7.5YR 5/2, moist) or brown or dark brown (7.5YR 4/4, moist); stony loam; the horizon consists of nodules, seams, and lamellae of clayey material like the underlying horizons imbedded in a lighter-colored matrix like that of the overlying horizon; moderate fine subangular blocky structure; hard to slightly hard dry, very friable moist; thin continuous clay films on the surfaces of the clayey material; 40 percent stone;

slightly acid, pH 6.5; gradual wavy boundary.

B21t 33-66" Brown (7.5YR 5/3, dry) to brown or dark brown (7.5YR 4/4, moist) stony light clay; moderate to strong medium angular blocky structure; extremely hard dry, firm moist; thick continuous clay films; 50 to 60 percent rock; neutral, pH 6.7; diffuse wavy boundary.

B22t 66-77" Variegated colors ranging from reddish-brown (5YR 5/3, dry) or light reddish-brown (5YR 6/3, dry) to reddish-brown (5YR 5/5, moist) or light reddish-brown (5YR 6/4, moist) very stony sandy clay;moderate to strong fine angular blocky structure; very hard dry, friable moist; 75 percent stone; thick continuous clay films mildly alkaline, pH 7.5; gradual wavy boundary.

B3 77-96" Variegated colors ranging from white (5YR 8/1, dry) or reddish-brown (5YR 5/3, dry) to pinkish-gray (5YR 7/2, moist) or reddish-brown (5YR 5/4, moist) very stony clay loam; moderate medium subangular blocky structure; extremely hard dry, friable moist; moderate continuous clay films; 70 percent rock; a few small calcium carbonate concretions; noncalcareous to weakly calcareous, pH 8.0.

4. Gray Wooded Soils with Lamellar Horizons of Silicate Clay Accumulation

These are well-drained, light-colored, acid Gray Wooded soils developing in medium to coarse textured sediments on alluvial fans, mountain slopes, and terraces. Typically they have thin, dark-colored A1 horizons, elluvial A2 horizons, and horizons of silicate clay accumulation in which the clay is accumulating in thin lammelae imbedded in coarser textured materials. The following is a description of a typical example of this variety of Gray Wooded soils:

01 1-½" Undecomposed organic material consisting mainly of needles, twigs, and bark.

02 ½-0" Partially decomposed organic material like that of the horizon above.

A1 0-2" Dark grayish-brown (10YR 4/2, dry) to very dark grayish-brown (10YR 3/2, moist) gravelly sandy loam; moderate fine crumb structure; soft dry, very friable moist; 15 percent gravel; strongly acid, pH 5.5; abrupt smooth boundary.

A2 2-10" Pale brown (10YR 6/3, dry) to brown or dark brown (10YR 4/3, moist) gravelly sandy loam; moderate very fine granular structure; soft dry, very friable moist; vesicular; 15 percent gravel; strongly acid, pH 5.2; clear wavy boundary.

A & B 10-18" Pale brown (10YR 6/3, dry) to brown or dark brown (10YR 4/3, moist) gravelly sandy loam containing ½ to 1-inch nodules of accumulated silicate clay; composite texture is a heavy sandy loam or light sandy clay loam; weak to moderate medium subangular blocky structure; soft dry, very friable moist; 15 percent gravel; strongly acid, pH 5.0; clear wavy boundary.

B2t 18-45" Very pale brown (10YR 7/4, dry) to yellowish-brown (10YR 5/4, moist) gravelly sandy loam containing ½ to 2-inch lamellae of accumulated silicate clay; composite texture is a heavy loam or light sandy clay loam; color of the lamellae is light brown (7.5YR 6/4, dry) to brown or dark brown (7.5YR 4/4, moist); weak to moderate medium subangular blocky structure; soft to slightly hard dry, very friable moist; strongly acid, pH 5.5; clear wavy boundary.

C 45-60" Pale brown (10YR 6/3, dry) to light yellowish-brown (10YR 5/4, moist) gravelly loamy coarse sand; single grained; loose dry or moist; 20 percent gravel; strongly acid, pH 5.5.

With an increasing proprotion of grasses in the native cover, the A1 horizons of all varieties of the Gray Wooded tend to thicken and these soils will grade into the Chernozem-Gray Wooded intergrade (Mollic Glossoboralfs). With decreasing age of landscape or increasing slope gradient, these soils lose their contrasting horizonation and grade into the Brown Forest soils (Haplustolls, Hapludolls or Haploborolls).

With increasing soil moisture and decreasing soil temperature, the horizons of silicate clay accumulation in the coarser textured, more acid varieties or the varieties having horizons of silicate clay accumulation occurring as lamellae weaken and the soils grade into the Brown Podzolic or Podzolic soils (Orthods).

N. Humic Gley Soils

These are imperfectly to poorly drained, dark-colored, acid to alkaline soils developing on flood plains and in concave or depressional areas on terraces.alluvial fans, or mountain slopes. Typically they have dark granular surface horizons overlying strongly mottled or gleyed substratums. As used in this paper, this group includes soils with and without horizons of silicate clay accumulation (Hapluquolls and Argiuquolls). In the mountainous areas of Colorado poorly drained soils without horizons of silicate clay accumulation are the most common. The following is a description of a typical soil of this group:

A1 0-8" Dark gray (10YR 4/1, dry) to black (10YR 2/1, moist) loam; strong fine crumb structure; soft dry, very friable moist; neutral, pH 7.0; gradual smooth boundary.

ACg 8-14" Grayish-brown (10YR 5/2, dry) to very dark grayish-brown (10YR 3/2, moist) stony loam; weak medium subangular blocky structure; slightly hard dry, very friable moist; common numbers of medium-sized, distinct 10YR 5/4 and 4/1 mottles; 15 percent stone and gravel; noncalcareous, pH 7.2; gradual smooth boundary.

C1g 14-30" Light olive brown (2.5Y 5/3, dry) to olive brown (2.5Y 4/3, moist) stony loam; massive; hard dry, very friable moist; 30 percent stone; many large prominent 2.5Y 5/6 and 2.5Y 4/1 mottles; noncalcareous, pH 7.0; gradual smooth boundary.

C2g 30-60" Olive (5Y 5/3, dry) to (5Y 4/3, moist) stony loam; massive; hard dry, very friable moist; approximately 40 percent stone; many prominent medium-sized 2.5Y 5/6 and 2.5Y 5/1 mottles; noncalcareous, pH 7.4.

With increasing poor drainage and heavy willow or hydrophytic plant life, these soils develop peat or muck layers at their surface and grade into the Bog soils.

With improved degrees of drainage, these soils lacking horizons of silicate clay accumulation lose their mottled and gleyed horizons and grade into Alluvial soils, or Regosols with mollic epipedons (Haplustolls or Hapludolls). With improved degrees of drainage these soils having horizons of silicate clay accumulation lose their mottled and gleyed horizons. Under these conditions at high elevation and cold soil temperatures they grade into the Chernozem soils (Borolls). At lower elevations and warmer soil temperatures they grade into Chestnut or Brunizem soils (Ustolls or Udolls), depending upon the reaction of the solum and parent sediment.

O. Lithosols

These are well-drained, shallow, usually stony soils developing on moderately to steeply sloping areas on mountain sides and ridge crests where bedrock occurs at or near the surface. Typically they have no horizonation other than a slightly darkened surface horizon. For the purpose of this paper, no distinction is made between hard crystalline bedrock and soft bedrock such as clay shale. Thin soils having mollic epipedons are also included in this group. The following is a description of a typical profile of this group:

A1 0-6" Grayish-brown (10YR 5/2, dry) to dark grayish-brown (10YR 4/2, moist) stony loam; moderate fine granular structure; soft dry, very friable moist; 10 percent stone; calcareous, pH 8.0: clear smooth boundary.

C 6-14" Light brownish-gray (10YR 6/2, dry) to grayish-brown (10YR 5/2, moist) stony loam; massive or very weak coarse subangular blocky structure; slightly hard dry, very friable moist; 30 percent stone; calcareous, pH 8.2; abrupt wavy boundary.

R 14" Hard sandstone bedrock.

With increasing depth of regolith these soils grade into Regosols (Orthents).

With increasing age and increasing depth of regolith, these soils having ochric epipedons develop contrasting genetic horizons and grade into the Brown soils (Argids). With increasing age, increasing effective soil moisture, and increasing thickness of regolith, these soils having mollic epipedons, and occurring at lower elevation and warmer soil temperature, develop more contrasting genetic horizonation and grade into Chestnut soils or Burnizems (Ustolls or Udolls).

At high elevations and cold soil temperatures, but under grass vegetation, these soils having neutral to alkaline reaction develop A horizons of low chroma, and horizons of silicate clay accumulation, and grade into Chernozem soils (Borolls).

At very high elevations above timberline, very cold soil temperatures, increased soil moisture, and under alpine grass vegetation, the coarser textured soils on acid parent materials tend to develop horizons of sesquioxide and humus accumulation and grade into the Alpine Turf soils (Cryorthods).

At high elevations, cold soil temperatures, increased soil moisture, and under a conifer vegetative cover, these soils develop elluvial A2 horizons and horizons of sesquioxide and humus accumulation, and grade to Brown Podzolic or Podzolic soils (Orthods).

P. Podzols

These are well-drained, light-colored, strongly acid soils developing in medium to coarse textured parent materials on mountain sides, alluvial fans, and terraces. Typically they have light-colored, platy, elluvial A2 horizons overlying bright-colored illuvial horizons of sesquioxide and humus accumulation. The following is a description of a typical soil of this group:

O1 3-2" Undecomposed organic material consisting mainly of needles, twigs, and bark.

O2 2-0" Partially decomposed organic material consisting of decayed material like that of the horizon above.

A2 0-4" Light gray (10YR 7/2, dry) to light brownish-gray (10YR 6/2, moist) sandy loam; moderate coarse and medium platy structure breaking to fine crumbs or granules; soft dry, very friable moist; 15% gravel; very strongly acid, approximate pH 4.2; clear smooth boundary.

B2ir 4-16" Brown (7.5YR 5/4, dry) to brown or dark brown (7.5YR 4/4, moist) gravelly sandy loam; weak to moderate fine subangular blocky structure breaking to fine granules; slightly hard dry, friable moist; dark coatings on sand grains and many dark silt sized pellets; 25% gravel; very strongly to strongly acid, pH 5.0; gradual wavy boundary.

C 16-60" Light brownish-gray (2.5Y 6/2, dry) to light olive brown (2.5Y 5/3, moist) gravelly sandy loam; massive; slightly hard dry, friable moist; 30 percent gravel and stone; medium acid, pH 5.8.

At high elevations near timberline, with decreasing conifer cover, increasing alpine grass cover, and very cold soil temperature the elluvial A2 horizon weakens and these soils grade into Brown Podzolic soils or Alpine Turf soils (Cryorthods). At lower elevations, increasing soil temperatures, and an increasing understory cover of grasses and brush the A horizon thickens and becomes darker, and these soils grade into Brown Forest soils (Ustolls or Udolls).

Q. Regosols

As used in this paper, the Regosol Great Soil Group includes three major varieties of soil on the basis of texture of the regolith and mode of origin. More detailed classifications may separate these soils and some may question whether the colluvial rockslide areas should be considered soil at all. For the sake of brevity, this paper combines them into a single group.

1. Moderately Coarse to Fine Textured Regosols

These are well-drained, acid to calcareous, youthful soils developing on the mountain sides in parent materials originating in some manner other than movement of water. Typically they have no horizonation

other than a darkening of their surface horizons or weak accumulation of soluble salts. For the purposes of this paper, soils having mollic epipedons but no other horizonation (Haplustolls, Hapludolls, or Haploborolls) are included in this group. The following is a description of a typical soil of this variety of Regosols.

A1 0-4" Grayish-brown (10YR 5/2, dry) to dark grayish-brown (10YR 4/2, moist) clay loam; moderate fine granular structure; soft dry, very friable moist; 5 percent gravel; calcareous, pH 8.0; clear smooth boundary.

AC 4-10" Brown (10YR 5/3, dry) to brown or dark brown (10YR 4/3, moist) clay loam; weak medium and coarse subangular blocky structure; hard dry, very friable moist; 5 percent gravel; calcareous, pH 8.0; gradual smooth boundary.

C 10-60" Brown (10YR 5/3, dry) to brown or dark brown (10YR 4/3, moist) clay loam; massive; hard dry, very friable moist; 5 percent gravel; calcareous, pH 8.2.

2. Sands

These are well to excessively drained, acid to calcareous, youthful soils developing on mountain slopes or the sides of valleys in parent materials originating in some manner other than the movement of water. In most instances the parent sediments are aeolian sands. The following is a description of a typical profile of this variety of Regosols.

A1 0-6" Light brownish-gray (10YR 6/2, dry) to dark grayish-brown (10YR 4/2, moist) loamy fine sand; single grained; soft dry, very friable moist; noncalcareous, pH 7.0; gradual smooth boundary.

C 6-60" Pale brown (10YR 6/3, dry) to brown or dark brown (10YR 4/3, moist) fine sand; single grained; loose dry or moist; non-calcareous, pH 7.2.

3. Rock Slides

These are accumulations of boulders, gravel, and sand occurring at the base of cliffs and very steep rocky slopes. Some may wish to question whether such deposits can be rightfully called soil, however, they are a significant component of many landscapes, particularly in the subalpine and alpine tundra regions. For this reason, they have been included in the Regosols in this paper. As the name implies, these are accumulations of rock and boulders with little or no fine material.

With increasing age, under grass cover, and in regions below the subalpine the moderately coarse to fine textured Regosols develop horizons of silicate clay accumulation and grade into Chestnut or Brunizem soils (Ustolls or Udolls).

With increasing age and under forest cover, the moderately coarse to fine textured Regosols develop thick, dark surface horizons and grade into the Brown Forest soils (Haplustolls, Hapludolls or Haploborolls).

With increasing age, increasing soil temperature, increasing soil moisture, and under thick conifer cover, the coarse to medium textured Regosols develop elluvial A2 horizons, and/or horizons of sesquioxide and humus accumulation, and grade into the Podzols of Brown Podzolic soils (Orthids). With increasing age, very cold soil temperature, and alpine grass cover the coarse to moderately fine textured Regosols develop thick, dark surface horizons and horizons of sesquioxide and humus accumulation, and grade into the Alpine Turf soils (Cryorthods).

With increasingly poor degrees of drainage these soils with the exception of rockslides, develop thick, dark surface horizons and horizons of mottling and gleying, and grade into the Humic Gley soils (Aquolls).

R. Sols Bruns Acides

These are well-drained, strongly acid, coarse to medium textured soils developing on mountain sides, alluvial fans, glacial deposits, or old terraces. Typically they have thin, dark-colored, granular A1 horizons, weakly developed elluvial A2 horizons of low color contrast, and brown or yellowish-colored B2 horizons lacking distinct accumulations of silicate clay and having only very weak accumulation of iron oxides and humus. The following is a description of a typical profile of this group:

O1 2-1" Undecomposed organic material, principally needles, twigs, and bark.

O2 1-0" Partially decomposed organic material like that of the horizon above.

A2 0-2½" Grayish-brown (10YR 5/2, dry) to dark grayish-brown (10YR 4/2, moist) gravelly sandy loam; very weak coarse platy structure breaking to weak to moderate fine crumbs; soft dry, very friable moist; very strongly acid, pH 4.9; gradual wavy boundary.

B2ir 2½-9" Brown (10YR 5/3, dry) to brown or dark brown (10YR 4/3, moist) gravelly sandy loam; weak medium subangular blocky structure breaking to weak to moderate granules; slighly hard dry, very friable moist; strongly acid, pH 5.2; gradual wavy boundary.

B3 9-16" Pale brown (10YR 6/3, dry) to brown (10YR 4/3, moist) gravelly sandy loam; very weak medium subangular blocky structure; slightly hard dry, friable moist; strongly acid, pH 5.2; gradual wavy boundary.

C 16-26" Light yellowish-brown (2.5Y 6/3, dry) to light olive brown (2.5Y 5/3, moist) gravelly loamy sand; massive or single grained; slightly hard dry, friable moist; 40 percent gravel and stone; medium acid, pH 6.0; clear smooth boundary.

R 26" Unweathered gneiss and biotite schist bedrock.

With increasing age these soils develop more contrasting horizonation and grade into Podzolic soils (Orthods).

With decreasing age, increasing soil temperature, and a decreasing proportion of spruce and fir in the vegetative cover, these soils grade into Brown Forest soils or Regosols (Haplustolls, Hapludolls, Haploborolls or Orthents).

S. Other Soils

In addition to the major kinds of soils, which have been discussed in detail, there are a number of other kinds of soils that may be significant locally, but which are not found in great acreage throughout the entire mountain region. The more important of these soils are described briefly in the following paragraphs.

1. Solonchalks

These are generally imperfectly to poorly drained soils of the flood plains of lower mountain valleys in which large amounts of soluble salts have accumulated. They are characterized by a white crust of salt effervescence in dry periods by soft, very strongly granular, puffy surface horizons, and by strong accumulations of soluble salt

in the surface and subsoil horizons. Reaction varies, depending upon the kind and concentration of salts present.

2. Solonetz Soils

These soils occur locally in some of the mountain valleys. They are found in greatest acreage in the San Luis Valley, but have been found in some of the smaller mountain valleys as well. They are characterized by thin, light-colored A2 horizons overlying very strongly developed, columnar horizons of silicate clay accumulation. Reaction is generally pH 9.0 or higher near the surface, and exchangeable sodium percentage is 15 percent or higher in most of the B2t horizons.

3. Planosols

These soils are uncommon in the mountanous areas and are generally associated with exposures of clay shales. They are characterized by dark, granular A1 horizons if under grasses, thin light A1 horizons if under timber, and light-colored bleached A2 horizons that rest abruptly on fine textured, blocky horizons of silicate clay accumulation.

4. Grumusols

These soils occur infrequently, and are generally associated with exposures of clay shale or basalt bedrock. They are characterized by thin, granular surface horizons overlying clay subsoils that shrink and crack on drying, and swell on wetting. Properties of self-mixing are characteristic, but the degree of such movement varies locally.