# SOILS AND PHYSICAL CONDITIONS OF MANITOU EXPERIMENTAL FOREST

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JOHN L. RETZER, Soil Scientist



Rocky Mountain Forest and Range Experiment Station

Fort Collins, Colorado

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A survey was made of the soils and the physical conditions of the Manitou Experimental Forest during the summers of 1946, 1947, and 1948. The survey was made as a basis for (1) selection of sites for future experiments, (2) interpretation of results for experiments already in progress, and (3) obtaining a detailed knowledge of the soils of an area representative of the Pike National Forest and much of the Colorado Front Range.

The field work was done on aerial photographs and placed upon a controlled base by the Division of Engineering in the Denver Regional Office of the Forest Service.

The survey has certain definite characteristics. The soils were classified on a soil series and type basis, but because of time and mapping limitations, the cartographic units in some instances contain more than one soil. For example, the soil area on the map shown as developed from granitic bedrock includes several different soils, such as those developed on north slopes, those developed on south slopes, and variations from acid podzolic soils on top of the Rampart Range to less acid and less podzolized soils at low elevations. For plots and areas where intensive research is concentrated, it will be necessary to make a much more refined soil study.

## GEOLOGY

The Manitou Experimental Forest is located in the valley formed by the Ute Fault. The fault line is shown on the map (see folder in back) although it is not clearly visible throughout its entire length. In places it has been covered by recent granitic alluvium and in the north end of the area it appears to branch or to occupy an area of considerable width. It may also be that other fracture lines are buried in the trough of the valley by deep deposits of alluvium.

The basement rock of the entire area is the coarse-textured Pikes Peak granite. Lying over this granite are three sedimentary rocks. The lowermost sedimentary bed is the Sawatch quartzite, the next is Madison limestone, and the topmost is the Fountain arkose. The Sawatch and Madison formations outcrop on the east side of the valley and occur within a relatively narrow band. The Fountain arkose occurs chiefly on the east side of the valley, but erosion pedestals remain in a few places on the west side. Below the outcropping formations, which occur on the valley sides, the valley basin has been filled with deep alluvial deposits eroded chiefly from the granitic areas. These coalescing alluvial fans occur throughout the entire valley portion of the area and extend westward to near the Ute Fault on the west side of the valley.

## Pikes Peak granite

The Pikes Peak granite is composed of quartz, orthoclase and microcline, with biotite being the accessory mineral. This rock is very coarse textured and, as the biotite weathers, the large crystals are freed from the rock mass. Weathering is very deep in these granites and may even be pre-Cambrian. Soils developed from these rocks are relatively infertile and highly erosive. The pink color is due to the feldspars, orthoclase, and microcline. Other than the Ute Fault, there are few fractures or faults in this granite mass, and none are important so far as soil development is concerned. Some small areas of finer-textured and duller-colored granite are present, but they do not appear to have influenced soil development.

Since soil fertility is strongly influenced by the composition of the parent rocks, the data of table 1 show the composition of nine rock samples from nearby localities. Of interest is the low content of CaO, $Na_2O$, $K_2O$, and $P_2O_5$. It should likewise be remembered that these elements are freed at very low rates from the rock by weathering processes.

## Sawatch quartzite

The Sawatch quartzite lies directly upon the Pikes Peak granites. Within the area, the total outcropping thickness of these beds range from about 10 to as much as 30 or 40 feet. These gray or pink sandstones are metamorphosed at the sharp contact line between the formation and the granite, but are much less altered farther away. The top 5 to 10 feet of this formation consist of a very red not overly consolidated sandstone. This red member persists throughout the entire outcrop. For the most part, the Sawatch formation is a cliff-former. In a few places the red top member retreats down the slope for 50 to 100 feet from the strike line, and gives rise to very red sandy soils which appear to be somewhat high in lime. For the most part, however, this red top member is also a cliff-former and is not extensive enough to show on the map. This formation is of early Cambrian age. This red top member is known in some areas as the Peerless member of the Sawatch formation.

The Peerless is composed mostly of quartz, feldspar, and mica with some lime. The lower white bed is nearly pure quartz.

## Madison limestone

The Madison limestone (also known as the Manitou limestone) consists of pink or red and gray slightly to moderately metamorphosed limestone lying over the Sawatch formation. This formation is several hundred feet thick. It outcrops in extensive areas in the northern part of the surveyed area, but in the southern part it is covered with alluvium in places or may occupy only a narrow band of the landscape. Fossils of both trilobites and brachiopods have been found, but metamorphism has destroyed most of these. Scattered over the top of the pink lower beds of this formation are rounded flint or cherty boulders. These boulders are very dense and hard, and are

Table 1. Chemical analyses of granitic rocks from localities in the Pikes Peak region[1]

| Location | Rock type | Percentage | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | FeO | MgO | CaO | $Na_2O$ | $K_2O$ | $H_2O$[2] | $TiO_2$ | $P_2O_5$ | MnO | F | Traces |
| Currant Creek | Granite | 74.40 | 14.43 | 0.22 | 0.89 | 0.07 | 0.58 | 1.58 | 6.56 | 1.07 | 0.12 | 0.22 | T[3] | 0.04 | BaO, $Li_2O$ |
| Sentinel Point | Biotite granite | 77.03 | 12.00 | 0.76 | 0.86 | 0.04 | 0.80 | 3.21 | 4.92 | 0.44 | 0.13 | T | T | 0.36 | BaO, $Li_2O$ |
| Currant Creek | Granite | 73.90 | 13.65 | 0.28 | 0.42 | 0.14 | 0.23 | 2.53 | 7.99 | 0.49 | 0.07 | 0.05 | T | -- | BaO, $Li_2O$ |
| Middle Beaver Creek | Granite | 73.51 | 13.28 | 0.94 | 0.97 | 0.05 | 1.11 | 3.79 | 5.22 | 0.78 | 0.18 | T | T | 0.55 | BaO, $Li_2O$ |
| Colo.Sprgs. Waterworks | Granite | 75.17 | 12.66 | 0.23 | 1.40 | 0.05 | 0.83 | 2.88 | 5.75 | 0.78 | 0.10 | 0.03 | T | 0.31 | BaO, $Li_2O$ |
| Near Florissant | Granite | 75.92 | 12.96 | 0.33 | 1.40 | T | 0.15 | 4.60 | 4.15 | 0.48 | 0.05 | T | 0.04 | 0.12 | BaO, $Li_2O$ |
| St. Peters Dome | Aplitic granite | 77.31 | 12.45 | 0.43 | 0.33 | None | 0.50 | 4.72 | 3.84 | 0.82 | 0.06 | None | 0.01 | 0.15 | BaO, $ZrO_2$ |
| Twin Creek | Granite gneiss | 66.90 | 14.86 | 0.93 | 3.41 | 0.31 | 1.23 | 5.56 | 5.02 | 0.47 | 0.43 | 0.12 | 0.15 | 1.00 | BaO, $Li_2O$ |
| Pikes Peak | Granite | 75.17 | 12.66 | 0.23 | 1.40 | 0.05 | 0.82 | 2.88 | 5.75 | 0.82 | 0.10 | 0.03 | T | 0.31 | BaO, $Li_2O$ |

1/ Data from Henry Stephens Washington "Chemical Analyses of Igneous Rocks." U.S.G.S. Prof. Paper 99. 1917.

2/ Reported by author as water above and below 110°C.

3/ Traces (T)

often attractively banded with blue and gray colors. They range from an inch to several inches in diameter, and where they occur, one can be sure that the top of the pink lower member occurs at that level. Soils developed from this formation reflect the color of the parent rock; that is, the red rock gives rise to relatively rich brown soils, whereas the gray top limestone which occurs extensively in the northern part of this area, will produce dark gray and in some cases nearly black soils. Where these rocks are extensive the drainage pattern which has developed in them is distinctly different from that developed in the granites or other rocks of the Manitou valley area.

Since the soils developed from granite in this vicinity are considered infertile and are acid, analyses were made of these limestones to determine their neutralizing value in terms of $CaCO_3$. Samples of the bottom red member were collected from the quarry in Missouri Gulch and in Illinois Gulch. Samples of the gray top member were collected near the mouth of Illinois Gulch and from another spot in that vicinity. The analyses were made by digesting a known weight of pulverized stone in a known quantity of acid and weighing the residue after $CO_2$ loss. The results are as follows:

| Sample | Limestone | Neutralizing value | Average |
|---|---|---|---|
| 233 | Red | 84% | |
| 234 | Red | 90% | 87% |
| 235 | Gray | 111% | |
| 236 | Gray | 107% | 104% |

The values in excess of 100 percent for the gray limestone are commonly explained by the presence of $MgCO_3$ in addition to $CaCO_3$ in the sample, but no test was made for Mg in this instance. The residue from the red limestone was high in silica. These data indicate that:

1. The gray limestone exceeds the red limestone in neutralizing value by 17 percent;
2. The gray limestone would be an excellent soil amendment where neutralization of soil acidity is required for the growth of legumes and grasses. The presence of Mg is an added asset of considerable value.

Both types of rock are readily accessible, but the hardness of the red limestone is several times greater than that of the gray.

Fountain arkose

The Fountain formation overlies the Madison limestone. It consists of fine- and coarse-textured, highly interbedded and cross-bedded layers of material washed from adjacent granitic areas. The different layers consist of light shades of red, gray, and purple. The purple layers are very characteristic of this formation. In a few places fine-textured clay layers may occur near the top of the formation and at first appear to be well-developed subsoils. The soils developed from this formation are not greatly different from those developed from granite. The coarse grains are loose and highly erodible. The soil is infertile. These beds are most extensive

in the north end of the area east of the valley. In many places they are buried or covered with Quaternary alluvium. Huge pedestals 15 to 30 or more feet high occur on the west side of the valley in a few places. An extensive outcrop of this rock cuts across the valley from the west to the east side in the southern part of the mapped area. These pedestals do not appear to have been very significant in soil development.

The Fountain is believed to underlie much of the west side of the valley, but the depth to which it is buried varies much. Figure 1 shows the contact of the overlying alluvium and the Fountain in the bank at the reservoir outlet. Newly exposed road cuts in the northwest corner of the area indicate that the Fountain is exposed in several places but the soils do not differ noticeably from those developed from granitic alluvium.

Figure 1.--Contact of the underlying Fountain and the capping recent alluvium in the exposed bank at the reservoir outlet.

## Valley alluvium

Much of the valley is filled with alluvium eroded from granite. Above the present flood plain of Trout Creek which is filled with very recent alluvium there exists three sets of older alluvial fans, each above the other. The oldest occurs at highest elevation on both sides of the valley. The old high fans are dissected with drainageways, but drainage waters originate on their area and not from areas above. The restricted drainage area accounts for the preservation of these older fans. The second lower-lying fans are dissected in a few places by such major streams as Missouri Gulch, Hotel Gulch, and Illinois Gulch. On the western side of the valley the older fans have in some places been buried by more recent alluvium.

Since different soils have developed on each of the three fans, this burying of the older fans by more recent material leads to a complex soil pattern and one which is extremely difficult to map out. Although these alluvial materials are almost entirely of granitic origin, the soils that develop from them have deeper profiles and especially deeper surface soils than the soils which developed from granitic bedrock on the areas above the sedimentary rock outcrops. This is due to the loose, unconsolidated nature of the alluvial sediment.

## LAND FORMS

The land forms of the area can be divided into four classes, namely, (1) stream flood plains, (2) alluvial fans, (3) the sedimentary rock belt, and (4) the granitic belt. Each land form has a particular set of slope and drainage characteristics. Elevations range from about 7,600 feet in the valley to 9,200 feet on the Rampart Range. Mount Deception has an elevation of about 9,000 feet.

### Stream flood plains

The flood plain of Trout Creek is typical of many mountain meadows. It varies in width from 25 to 200 or 300 feet in places. The area is flooded during the spring runoff. The stream itself meanders back and forth across this flood plain. In some places it is downcutting, while in others, loose, gravelly alluvium is distributed over the area. Side drains contributing to this flood plain are primarily of the gully type and do not have flood plains of their own.

### Alluvial fans

The alluvial fans occupy the Manitou Park Basin and are about 2 or 3 miles in width considering both sides of the valley. They slope downward from both sides into the Trout Creek flood plain at angles of 10 to 20 percent. Locally within this area, and especially on the higher and older alluvial fans, side slopes range upward of 30 percent. Main drainageways such as Hotel and Missouri Gulches, originating in higher areas, cross this alluvial fan belt in relatively straight lines and without the formation of alluvial flood plains, except that small fans may form at or near the point where the streams enter the Trout Creek flood plain. Deep active gullies have developed in some places within the alluvial fan belt. For the most part they are due to roads or trails, or to excessive runoff from cultivated fields or higher-lying areas. The old drainageways which originate within the fan belt are straight lines with few branches. This is true particularly of the streams which drain the older alluvial fans. Most of the runoff waters originate within the alluvial fans themselves, none being contributed from the higher-lying granitic area, and relatively little from the adjacent sedimentary rock area.

Sedimentary rock area

The sedimentary rock area has slopes ranging upward from about 30 percent, although in some places slopes on the limestone rock are near 15 percent. Opposite the Mount Deception Uplift the sedimentary rocks are tilted vertically, while both north and south from this area they assume a more gently sloping aspect. Neither the Sawatch nor the Fountain formations occur in areas wide enough to develop a characteristic drainage pattern of its own. However, the limestone area is wide enough in several places to develop a trellis or blocky type of drainage system. These drainages do not necessarily run directly up and down the common slope as in the case of the alluvial fans. Instead, they may branch out perpendicular to the main drainage and carve the area into blocks of gently sloping or rounded hills. The best development of this type of drainage lies north of Missouri Gulch. In the extreme northern part of the area the drainage pattern has eaten down below the sedimentary rock into the granite, leaving islands of Sawatch sandstone capped by limestone well above the general terrain. No particular drainage pattern has developed on these islands primarily because most of them are only a few acres in extent.

Bedrock area

The granitic bedrock area is the most mature and well-developed zone of the entire Experimental Forest. Slopes range upward from 30 percent, and 50-percent slopes are very common. A very well-developed dendritic drainage system penetrates most of the area. In many places it is possible to stand on the ridge tops and look directly down both slopes into the adjacent valleys. The fine texture of this drainage system is due to the steep slopes and to the loose and erodible nature of the granite rock. The Missouri drainage system, that is, the north and south branches of Missouri Gulch, are due to a local fault or some other local geologic event. The eastern wall of these two drainages is extremely steep. However, above this wall and along most of the northeastern edge of the Experimental Forest, the mountain top of the Rampart Range levels out. This is an old peneplain and the drainage pattern is coarse and not well developed.

## CLIMATE

Total average annual precipitation ranges from 17 inches in the valley to 19 inches on the Rampart Range. Of this amount, about 75 percent occurs as summer showers. Because of their light and scattered nature, it is estimated that only about 50 percent of these showers are effective for vegetation growth. Snows can be expected from late September through May and snows have occurred in June. Commonly the snows melt within a few days. Those that remain all winter are exceptional.

Summers are cool, the average temperature being 56°F. Winters are cold but not severely so. Average winter temperatures are 25°F. but extremes of -31°F. occur. Usually the winters can be thought of as open and mild, especially in the valley. Grasses start growing in late April and mature in August.

## SOILS

The soils of Manitou Experimental Forest are representative of more extensive areas throughout the Front Range. Because of the variety of parent materials--alluvial deposits, sandstones, limestones, quartzites, and coarse-textured granites--many different types of soil have developed here in an area of nearly uniform vegetation. Some of the soils developed are perhaps classic examples of their kind and for this reason much can be learned of soil genesis by a study of their characteristics.

Some of these soils are unstable and highly erodible. Since they represent extensive areas, much should and can be learned of their behavior that will be of benefit to watershed management. The most stable are those developed from limestone, while the most unstable are those from granite bedrock. The others have varying degrees of stability. Granitic alluviums, for example, have deep porous gravel layers beneath the soil surface that aid in infiltration and deep moisture movements. This may not be at all true for soils developed from bedrock. Those soils with dense clay subsoils and those with only moderately dense subsoils provide an opportunity to study soil characteristics in relation to infiltration and surface runoff.

The soils range from the very productive ones developed from limestone, to the infertile ones as those from quartzite and granite bedrock. These are inherent differences and should be considered in range and timber experiments. The more fertile soils such as those from limestone and deep granitic alluvium are not extensive throughout the Front Range, whereas those from granite bedrock are extensive.

Because of the circumstances of a wide range of slopes, land forms, and different types of drainage, there is an opportunity here to study soils in relation to these other factors to determine their relative importance in land management.

### Wet meadow soils developed on flood plains

The soils developed on the flood plain of Trout Creek are typical of those developed in many wet mountain meadows. The surface soils are black loams or gravelly loams often as much as 24 inches thick. Their organic-matter content is high. The subsoils are commonly rust brown and gray mottled, showing the effects of poor drainage. The entire profile is stratified (fig. 2) to some degree, but this varies a great deal from place to place. These soils are especially noted for their lack of profile uniformity.

The soils are covered with willows and dense sedge indicative of their wet or moist condition.

The local relief is level or nearly flat with small depressional areas occurring back from the present channel in places. The channel meanders considerably and some of the depressions on the flood plain are caused by old meanders. It also is cutting in parts of its length and depositing loose gravelly material in other places.

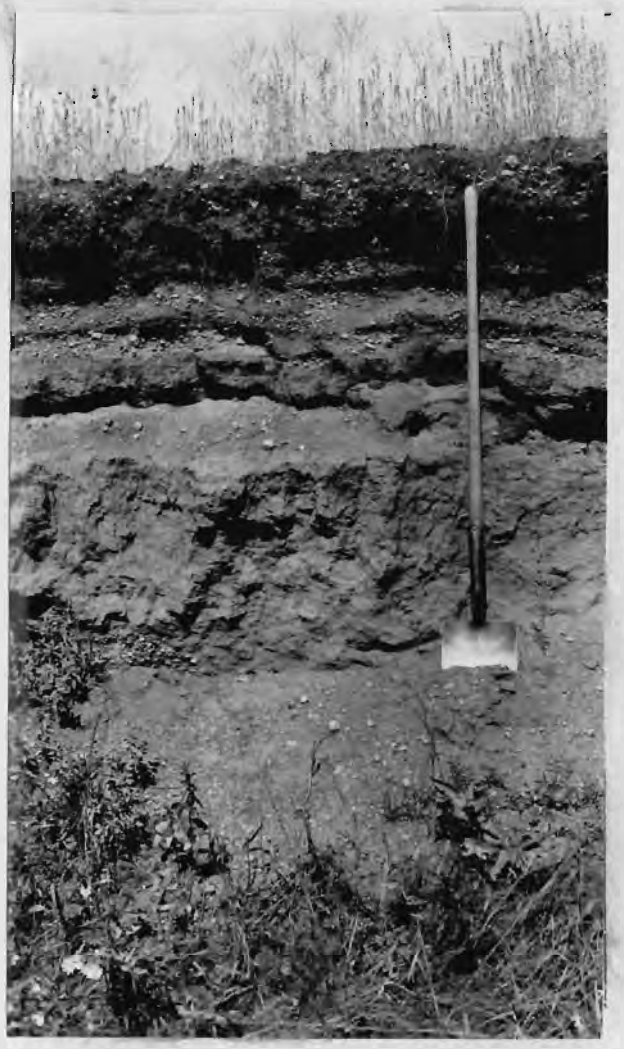


Figure 2.--Profile typical of wet meadow flood plain. Note highly stratified condition and the thick black surface.

The best use of these soils is for grazing, wild hay, and channel protection. It is doubtful that willows and other channel-protecting vegetation should be removed from the creeks in such areas. Channels should not be straightened lest the increased grade result in rapid downcutting and gully development.

Soils developed on recent alluvial fans

These soils occupy large areas adjacent to the Trout Creek flood plain and are found in small pockets and narrow bands along some of the streams tributary to Trout Creek. Slopes range from about 6 to 15 percent. In places they are cut by gullies and in some places new materials are being added to the surface by streams during floods.

These soils have developed from stratified loose sands and gravels eroded from granite (fig. 3). The surface soils are brown to dark brown sandy or gravelly loams. The common depth is 10 inches, but depths of

15 to 18 inches are not uncommon. The pH of this surface ranges from 6.0 to 7.0, but 6.2 to 6.5 is the most common range. The soils are open, loose, granular and absorb moisture readily. When dry they are somewhat hard and compact.

Figure 3.--Profile on recent alluvial fan at mouth of Hotel Gulch. Alternating layers of fine and coarse materials are common.

These soils have no subsoils. The second layer consists of loose gravelly parent material. It has a bright brown color with a reddish cast. The pH values range from 6.5 to 8.0 in places. This layer offers little resistance to the passage of water.

In places these soils are very coarse and gravelly. In a few locations adjacent to the limestone rocks in the north part of the area they contain some limestone gravels and have thicker and darker surface soils.

Erosion is severe on these soils when the surface is improperly protected or where trails and roads are neglected. The coarse angular gravels are active erosion agents.

For the most part these soils are covered by grass, although ponderosa pine is present in places. A considerable area of these soils is to be found in the experimental pastures and reseeded areas.

On the west side of the valley these recent materials have been deposited over the older alluvial fans, often burying them, but in other places, just filling up low-lying areas to a common level with the older fans. This results in a very complex soil pattern and one that is difficult to map. The soils map in this part of the area is somewhat generalized. More detailed work will be required where intensive work on plats is in progress.

## Soils developed on intermediate alluvial fans

These soils occupy alluvial fans above the recently deposited fans and below the oldest fans. They occur in relatively large areas. Slopes range from 5 to 15 percent and the surfaces are usually smooth. Drainage channels pass through these areas and some gullies occur. The Lodge is located on a typical area.

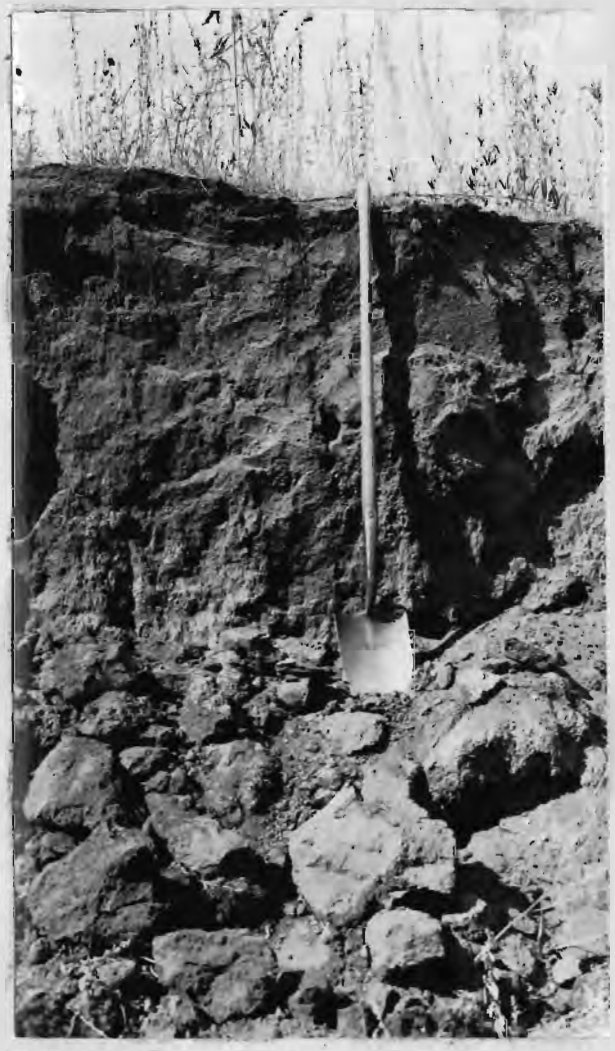


Figure 4.-- Moderately developed profile on intermediate alluvial fan.

These soils have developed from loose stratified alluvial materials of granitic origin. The surface soils are brown to dark brown gravelly or sandy loams. They are 8 to 10 inches thick. The pH values range from 6.0 to 6.5. The subsoils are bright brown or reddish brown, sandy or gravelly clay loams. They are moderately dense and compact. The parent materials are loose unconsolidated granitic alluvium. The profile is moderately permeable, but will erode rapidly if abused. The moderately developed subsoils are not as restrictive of soil-moisture movements as in soils on the oldest fans.

These soils are covered in about equal proportions with open pine and grass.

There is some overwash of recent alluvial material on the west side of the valley. This mixing results in a complex soil pattern that was not completely segregated on the map.

Soils developed on old alluvial fans

These soils occupy old high alluvial fans in the Trout Creek Basin. They occur in large areas, especially on the east side of the valley. Slopes range from 10 to 20 percent along the surfaces of the fans. A well-developed drainage system consisting of straight, seldom branching, and closely paralleling intermittent streams occurs throughout the entire area. Side slopes into these streams are often as steep as 40 to 60 percent for short distances.

The brown or reddish brown surface soils are about 10 inches thick. They have sandy or gravelly loam textures and a weak granular structure. When dry, they are moderately hard or compact. The subsoils are dense, compact, heavy, gritty clays, having a blocky structure best developed in the upper part. This subsoil may be as much as 8 to 20 inches or more thick. It definitely retards the free movement of downward percolating waters. The substratum consists of loose sandy loams or loamy sand and gravel. Figure 5 is a typical profile.

These soils attain their maximum degree of development on level areas and ridge tops. The surface soils are thicker and the subsoils less dense on the lower parts of slopes, and development is absent in the beds of the small drains.

Erosion has not been severe on these soils due to the good vegetative cover and because the areas receive little runoff from higher-lying areas. Most of the runoff originates within the area itself; however, when not protected by vegetation, it is probable that these soils will erode badly.

These soils are almost entirely covered with ponderosa pine, with a thin understory of grasses and weeds. The pine needles form an effective erosion-preventing litter in most places.

These soils can be expected to be the least receptive of moisture and rapid infiltration of all soils on the Experimental Forest.

Figure 5.--
Profile developed
on old alluvial
fan showing well-
developed clay
subsoils

In the northwest part of the area some of these high ridges appear to have developed in the Fountain formation, but the soils appear to be about the same as those developed from true alluvium.

Soils developed from Fountain arkose

These soils occur chiefly on the east side of the valley, but there are extensive areas west of the valley north of Missouri Gulch. The common slope range is from 10 to 20 percent, but some areas are nearly level, while others are as steep as 40 percent. Drainageways pass through this belt, but a well-developed drainage system does not occur within the areas. Erosion does not appear to be overly active at present, but the soils are very shallow so that erosion is probably rapid following fires.

The brown or grayish-brown surface soils have depths ranging from 5 to 20 inches, but are commonly shallow. They are loose and

coarse textured. The common pH value is 6.3 or 6.4, but the range is from 5.0 to 7.0. A thin cover of pine needles occurs over much of the area. There is no B-horizon. The substratum consists of moderately consolidated coarse sandstone with a considerable range of colors. Its pH values range from 5.5 to 8.0. The sandstones are rotting. These are not fertile soils.

Both surface and internal drainage are good, but the shallow bedrock can be expected to retard internal moisture movements locally.

Soils developed from Madison limestone

The soils developed from the Madison limestone occur only on the east side of the valley. They extend from the south to the north in a little broken band which widens both north and south of the Mount Deception area. Slopes are sometimes as great as 40 percent, but 10 to 25 percent are the more common slopes.

The reddish-brown or grayish-brown surface soils are 8 to 15 inches thick. They are loams or stony loams with an excellent soft granular structure. They are loose and open. The soil is calcareous and contains a high percentage of fragmented rock. The substratum consists of rock fragments with fine soil material in the fissures. The mass is very loose and open (fig. 6).

Figure 6.--Soils developed from limestone are fertile, very loose and open, and have excellent moisture relationships

These soils are very fertile and have excellent moisture relations. The rock fragments and fine material should make a good fertilizer amendment for the more acid and less fertile soils of the area, especially those developed from granite. The crushed rock would of course be better.

Erosion is not severe and is rarely a problem. Gullies are few and are usually grassed over in a short time. These soils seem to recover quickly after overgrazing.

These limestone soils are covered in part with an open ponderosa pine stand. However, a larger part is covered with shrub and grass which distinguishes them from other soils in the area.

## Soils developed from Sawatch quartzite

These red or gray soils occur only in a narrow belt on the east side of the valley at the contact between the sedimentary and granitic rocks. They are often cliff-forming, and considerable areas may be bare of soil or contain loose sand only between large flat rocks.

The soils are loose, gray or red fine sands, or fine sandy loams. They are rarely more than 10 inches thick and may be much shallower. They are low in organic matter, although the red sands contain more than the gray sands. The pH values range from 5.0 to as high as 8.0 in some places. In general, these soils are little more than disintegrated bedrock.

The soil grains are mostly quartz and fine clays are absent. Therefore, they erode badly. Few gullies develop because of the high percent of exposed, hard bedrock.

These soils are covered with ponderosa pine and Douglas fir. The topmost red soils which have the highest pH values often have a cover of shrubs and grass.

These are among the least important or valuable soils of the area, both because of their small extent and their general lack of fertility.

## Soils developed from Pikes Peak granite

These are by far the most extensive soils on the Experimental Forest and in the Front Range of Colorado. They occupy the steep slopes in the upland on both sides of the surveyed area. The fine-textured dendritic drainage system is well developed and fingers into every corner of the area. Runoff is rapid. Ridge top and valley bottoms tend to develop sharp angles. Slopes range from 10 to 60 percent or more, but 40 percent is a common slope.

As mapped, this area contains three general types of soil profiles. Profiles on south slopes have light brown, loose, gravelly surface soils rarely more than 10 inches thick. These soils on north slopes have thicker surface soils and are usually covered with a good litter of Douglas fir needles. They have gravelly textures and are loose. These soils developed under lodgepole at higher elevations tend to have grayish surface soils under the needle litter. They are likewise sandy and gravelly. All of these soils are acid to some degree, but tend to become more basic with depth. Figure 7 (A) and (B) shows a representative profile.

A.--A scanty grass and thin litter protecting the surface from erosion ——————

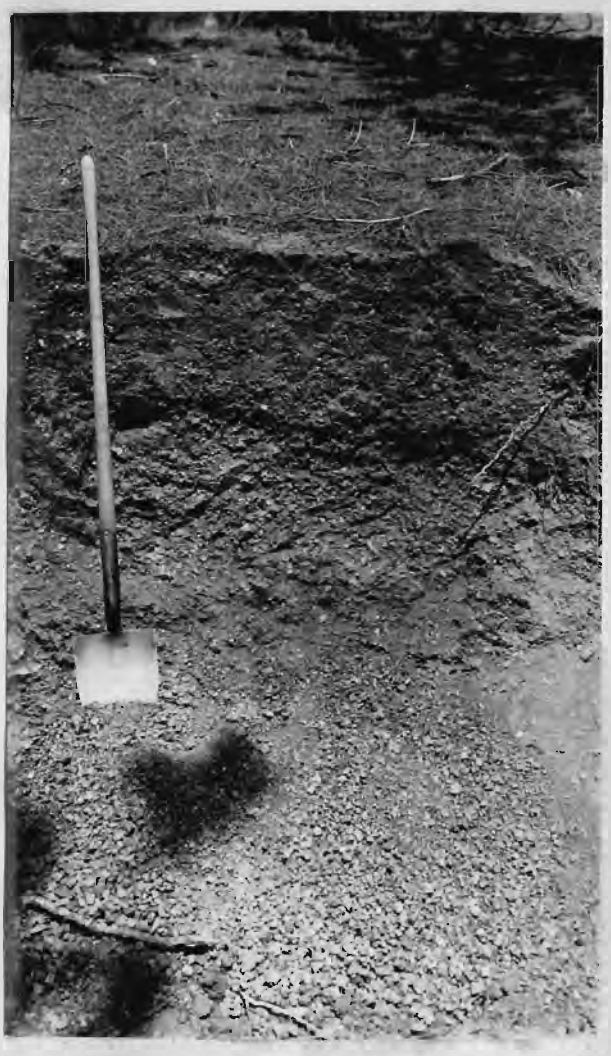


Figure 7.--Soils developed from Pikes Peak granite have shallow gravelly surface soils which rest directly on disintegrating rock without the development of subsoils. Both profiles are on south exposures

B.--Dense needle litter under young stand of ponderosa pine ——————→

The vegetative cover has been seriously disturbed by fires, logging, and grazing. Only a few virgin areas remain on the Experimental Forest. This disturbance has resulted in considerable erosion and channel cutting-in over much of the upland area.

Alluvial fills occur in many of the small valleys, but because of their very small size no attempt was made to separate them on the map.

These are not fertile soils. Vegetation responds slowly. Soils develop slowly from the disintegrating bedrock. Loose gravels commonly make up 50 percent or more of the soil.

Many important questions as to watershed, range, and timber management remain to be answered for these soils which are so extensive in the Front Range.

The acreages of each of the soils mapped are given in table 2. Because the mapped area is somewhat larger than the Experimental Forest, a breakdown is made on that basis.

Table 2.--Acres and percent of area of soils in Manitou Experimental Forest and in the total surveyed area

| Soils developed from | Map symbol | Experimental Forest | | Total surveyed area | |
|---|---|---|---|---|---|
| | | Acres | Percent | Acres | Percent |
| Wet meadows | 0 | 310.5 | 1.72 | 837.0 | 2.18 |
| Young alluvial fans | 1 | 1,157.0 | 6.41 | 1,870.0 | 4.87 |
| Middle alluvial fans | 2 | 2,694.0 | 14.94 | 3,256.5 | 8.49 |
| Old alluvial fans | 3 | 2,131.0 | 11.81 | 4,667.5 | 12.17 |
| Fountain arkose | 4 | 605.0 | 3.35 | 914.0 | 2.38 |
| Madison limestone | 5 | 809.0 | 4.49 | 2,325.0 | 6.06 |
| Sawatch quartzite | 6 | 393.0 | 2.18 | 937.5 | 2.44 |
| Granite | 7 | 9,938.0 | 55.09 | 23,320.5 | 60.79 |
| Ute Fault | UF | 1.5 | 0.01 | 237.0 | 0.62 |
| | | 18,039.0 | 100.00 | 38,365.0 | 100.00 |

## LAND-USE POTENTIALS

The potential uses of soils in this region are limited both because of the high elevations and short growing seasons, and because most of the soils are themselves naturally infertile and highly erodible. Under cultivation they have been used for grain (chiefly oats) and vegetables (chiefly potatoes). The low nitrogen, potash, and phosphate contents will continue to limit yields of such crops. In most places continuous cropping has so exhausted the fertility that the fields have been abandoned. Most abandoned fields were not reseeded to forage plants with the result that subsequent gully and sheet erosion have been severe and constitute a menace to watershed values.

Highest values for these and similar soils throughout the vicinity are for watershed, range, and timber growing, in that order. With proper cultural practices such as adequate seedbed preparation, the inclusion of some legume in the seed mixture, perhaps fertilization, and proper use management following establishment, most of the soils developed on alluvial fans can be expected to produce a reasonable quantity of forage. Unquestionably such treatment will check the destructive erosion now common in most abandoned fields and will enhance watershed values. Although the percentage of soils developed from alluvium is high in the Experimental Forest, it is low in the Pike National Forest and in the Front Range generally.

Most of the timber growing on the Experimental Forest is located on the granitic soils developed from bedrock. Because Trout Creek runs generally north, most of the tributary streams run east and west and the ridges produced have north-south exposures. The south exposures are hot and dry in the summer and probably freeze and thaw at frequent intervals during the winter. Ponderosa pine and aspen grow on these sites in open poor stands. The understory consists of scattered shrubs and bunchgrass, chiefly Arizona fescue and mountain muhly. The litter from all sources is insufficient to adequately protect the surface. Such sites will always be poor for timber and the growth rate of ponderosa pine will generally be very slow.

North slopes have enough effective soil moisture to support Douglas fir with occasionally some ponderosa pine on more rocky spots. Aspen is common. Such slopes are well protected from erosion by a dense ground litter and a canopy of shrubs and trees. These are the best timber-growing sites.

Lodgepole pine is common on top of the Rampart Range. It is clearly the result of past fires. Evidence is reasonably conclusive that most of the Experimental Forest has burned at intervals in the past.

Broadly speaking, observations indicate that the highest values to be expected from timber growing is watershed protection. Improper logging—skidding and the location of roads in valley bottoms—has resulted in a rejuvenation of the erosion cycle in this area that will increase in destructiveness before regrowth is able to check it again in the future. The continual grazing of such eroding areas accelerates the destructiveness and postpones recovery. It is suggested that the upland granitic areas are chiefly water-producing lands, that timber may be harvested from selected local areas in the future, and that livestock use should be excluded permanently.

Some of the essential data are summarized for each of the soils in table 3. Likewise, an attempt is made to evaluate the several soils for the three major uses—watershed, range, and timber. These are comparative evaluations and no attempt is made to establish numerical values.

Table 3. Some characteristics of the soils mapped and comparative evaluations for different uses

| Soil | Slope range % | Natural fertility | Moisture-holding capacity | Rock and gravel content (approx.) | Common acidity of surface (pH) | Watershed | | | Range | | Timber | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Permeability | | Erodibility | Common value | Condition | Common value for trees | Trees |
| | | | | | | Surface | Subsoil | | | | | |
| Soils developed in wet meadows on flood plains | 0- 3 | High | High water table | Highly variable | 6.0-7.0 | Very | Very | Local deposition | Excellent | Excess moisture and silting | Excellent | Spruce aspen |
| Soils developed on recent alluvial fans | 5-15 | Medium | Medium | Highly variable | 6.2-6.5 | Very | Very | High | Moderate | Erodible; infertile | Moderate | Ponderosa |
| Soils developed on intermediate alluvial fans | 5-15 | Medium | Medium(clay loam subsoils) | 40% | 6.0-6.5 | Very | Moderate | High | Moderate | Erodible; infertile | Moderate | Ponderosa |
| Soils developed on old alluvial fans | 10-20 (30-40) | Medium to low | Medium(heavy clay subsoils) | 40% | 6.0-6.5 | Very | Very slow | High | Low | Erodible; mostly timber-covered | Moderate | Ponderosa |
| Soils developed from Fountain arkose | 3-40 | Low | Medium | 40% | 6.0-6.5 | Very | Shallow bedrock | Very high | Very low | Timber-covered; erodible;infertile | Low to moderate | Ponderosa |
| Soils developed from Madison limestone | 5-40 | Very high | High | 30% | Calcareous | Very | Very | Low | Excellent | Open timber;shrubs; good grass; Fertile | Poor | Shrub Ponderosa |
| Soils developed from Sawatch quartzite | 5-20 | Very low | Low (shallow bedrock) | 50% | 6.0-7.0 | Very | Shallow bedrock | Very high | Very low | Shrubs;exposed rock; very infertile | Poor | Shrub |
| Soils developed from Pikes Peak granite (south and southwest slopes) | 10-60 | Low | Low | 50% | 5.5-6.5 | Very | Moderate | Very high | Extremely low | | Moderate | Ponderosa |
| (north and northeast slopes) | 10-60 | Medium | Medium | 40% | 5.5-6.5 | Very | Moderate | Very high | None | | Moderate | Fir aspen |
| (at high elevations) | 10-60 | Low | Medium | 40% | 4.5-6.0 | Very | Moderate | Very high | Extremely low | | Moderate | Lodgepole fir; aspen |

# APPENDIX

A generalized description of the different soils and their associated physical conditions is given in the body of this report. However, in order to be more specific on the genetic and morphologic features, a more technical discussion has been prepared for each of the soils. The soils have not yet been given series names. This would seem necessary before the data can be widely used in papers.

SOIL AREA--Soils developed in wet meadows on flood plains

The wet-meadow soils developed on the Trout Creek flood plain appear to be typical of extensive areas of similar soils developed elsewhere in the Pikes Peak granite area. They have an A-C profile, the genesis of which is almost completely dominated by wet marshy conditions. The profile is highly stratified. It is distinguished by dark surface soils high in organic matter and by mottled, poorly drained subsoils.

I. Soil profile

A Dark gray to nearly black gravelly or sandy loams, or loams. High in organic matter and almost peaty in places. A weak, granular structure, but a platy structure may be present in places where recent alluvium has been added to the surface. Highly stratified. Some lighter-colored or coarse-textured layers are rust mottled. Thickness varies much locally--maybe as much as 24 inches in places.

C Coarse-textured stratified gravel and loamy gravel. Mottled and streaked with rust brown, gray, or olive in places. Characteristically poorly drained.

II. Variations: The thickness of the surface soil varies from a few to as much as 24 inches. The organic-matter content varies, depending on local drainage conditions. Surface textures vary depending on the recency and coarseness of overwashed material.

III. Pedologic differences: These are the only soils of their kind developed in the area.

IV. Parent rocks and materials: Deep alluvial materials derived almost entirely from biotite granite.

V. Natural vegetation: Willows and sedge.

VI. Topography: Flood plain dissected by meandering stream channels. Alternate cutting and filling occurs over flood plains.

VII. Drainage: Subject to floods. High water table. Local depressions and poorly drained spots.

VIII. Distribution: Along Trout Creek in the bottom of Manitou Park.

SOIL AREA--Soils developed on recent alluvial fans

These soils, developed from recently deposited granitic alluvium, have dark brown to brown surface soils. The textures are sandy or gravelly loams. The surface soils are granular, loose, and open, but are somewhat compact and hard when dry. This is an A - C profile without a B-horizon. The parent materials are loose gravels or gravelly loams. They have a light brown color.

I. Soil profile

A The surface soils are brown to dark brown sandy or gravelly loams. They are commonly 10 inches deep, but may extend down to 18 inches. They have a weak granular structure and are loose and open when moist. When dry they are somewhat dense and compact. The reaction ranges from pH 6.0 to 7.0, with a more common range of 6.2 to 6.5. The organic-matter content is moderate to low.

C The parent materials are brown or bright brown gravels or loamy gravels that are often highly stratified. pH values range from 6.5 to as high as 8.0 in places.

II. Variations: Chiefly in thickness of surface soils and locally in textures. Textures are coarser near active channels. In a few places these soils have been influenced by alluvium from limestone. In such places the surface soils are deeper, darker, and have a better developed granular structure.

III. Pedologic differences: These soils, unlike those soils from the intermediate and old alluvial fans, show no evidence of profile development.

IV. Parent rocks and materials: Coarse-textured alluvium from biotite granite.

V. Natural vegetation: Chiefly grass and weeds with open ponderosa pine in a few places.

VI. Topography: Moderately long even slopes of 5 to about 15 percent. Dissected in many places by active V or straight-sided U gullies. Commonly a distinct alluvial fan in contour.

VII. Drainage: Good surface and almost excessive internal drainage.

VIII. Distribution: Generally a band or series of fans just above the flood plain, but also widely distributed in the intermediate and old fan areas. This latter condition is most prevalent on the west side of the valley where these recent deposits may lie over or adjacent to older fans. This results in a difficult mapping task.

SOIL AREA--Soils developed on intermediate alluvial fans

These brown to dark brown soils have slightly to moderately developed reddish subsoils. The B -horizon is moderately compact when dry, but when moist is soft and friable. The surface soils are commonly 8 to 10 inches thick and contain a moderate amount of organic matter. These soils have developed from granitic alluvium on fans intermediate in position between the high old fans and the lower new fans.

I. Soil profile

A Brown to drak brown gravelly or sandy loam about 8 to 10 inches thick. Moderate granular structure with soft consistence when moist, but firm when dry. pH values range from 6.0 to 6.5. Surface covered with a thin litter layer under pines.

B Bright brown or light reddish brown gravelly sandy clay loam moderately dense and firm when dry. Thickness ranges from 8 to 15 inches. Structureless in profile, but breaks into irregular lumps. pH values from 6.5 to 7.0.

C Loose, pale brown loamy gravel or gravelly loam. pH about 6.5 or higher.

II. Variations: Chiefly in thickness of surface soil and degree of development of the subsoil. In places it appears that some recent alluvium has been added to the surface, especially on the west side of the valley. Under pine a thin grayish layer may occur under the needles, but this may be mycelia of molds.

III. Pedologic differences: These soils are closely related to the adjacent soils developed on old and recent fans. Their subsoils represent a degree of development intermediate between that of the old fans and no development of the new fans.

IV. Parent rocks and materials: Granite alluvium intermediate in age of deposition between the older higher-lying fans and the newer lower-lying fans.

V. Natural vegetation: About even proportions of ponderosa pine and grass.

VI. Topography: Smooth fan surfaces with slopes of 5 to 10 percent. Usually dissected by streams from above. Gullies developed in a few places, but without a well-developed drainage pattern of their own.

VII. Drainage: Good surface and internal drainage.

VIII. Distribution: All within the valley of Manitou Park on both sides of the flood plain.

SOIL AREA--Soils developed on old alluvial fans

These soils have developed on alluvial fans of early Pleistocene Age. The brown or reddish-brown surface soils are 5 to 10 inches thick. The red or reddish-brown subsoils are dense heavy clays which may be very thick. The substratum is loose layers of granitic alluvium.

I. Soil profile

$A_2$ Beneath the layer of pine needles and litter, a brown or grayish-brown layer about 2 inches thick is found. It is a gravelly or coarse sandy loam with a weak granular structure and a loose consistence when moist. Its pH values range from 6.0 to 6.5, but 6.3 is the mean value.

$A_3$ This horizon ranges in thickness from 3 to 5 inches. It is a loam or gravelly loam and is moderately dense when dry. The poor granular structure is easily destroyed. pH values range from 6.4 to 7.0, but the common value is 6.6.

B The subsoil has a yellowish-brown or reddish-brown color. It has a dense, heavy, gritty clay texture, and a well-developed moderate blocky structure. The faces of the blocks are often coated with brown stains. Roots tend to follow the cleavage lines. It ranges from 8 to 20 inches thick, but may be thicker in places. pH values range from 6.5 to 7.2, but 6.7 is a common value. Not infrequently a narrow $B_1$-horizon occurs. This dense layer is slowly permeable to water, but there is no evidence of poor drainage.

C The substratum is a light reddish-brown loamy sand or gravel. It is loose and structureless. pH values range from 6.5 to 8.0, but the common value is 7.1.

II. Variations: The surface soils may be very shallow, especially on ridge tops and shoulders where erosion has been active. The clay subsoils are sometimes as much as 30 inches thick, but the red color tends to fade with depth. Typical profiles are best developed on the more level areas such as level ridge tops. On the lower parts of slopes the subsoils become less dense and the surface soil thicker. Soils in the bottoms of numerous drainageways throughout the old fan area rarely contain clay subsoils.

III. Pedologic differences: These are the best developed soils in the Experimental Forest. They are the best developed of the soils on the alluvial fans of the three ages.

IV. Parent rocks and materials: Coarse-textured granitic alluvium deposited as alluvial fans in early Pleistocene time.

V. Natural vegetation: Chiefly ponderosa pine with a thin scattering of grasses.

VI. Topography: These fans have long, even, and continuous slopes toward the valley floor. The grades range from 10 to 20 percent. Main drainageways from higher areas cross this zone. These old fans were deposited by these same main drains, but at a time when the channels were 50 to 100 feet higher than at present.

These fans are large enough and have been in position long enough to develop a drainage system of their own. These drains originate within the fan area, and are long straight, little-branching lines. They frequently parallel each other at close intervals. Slopes into these local drains from the fan top may be as steep as 30 or 40 percent. The toes of these coalescing fans have been truncated by the meandering ancestor of Trout Creek when the flood plain was much wider and higher than at present. This condition is most apparent on the east side of the valley. On the west side of the valley many of the old fans have been destroyed, leaving only occasional ridges.

It is not uncommon for pedestals of the Fountain formation to be found in this zone.

VII. Drainage: Good to excessive surface drainage, and definitely restricted internal drainage.

VIII. Distribution: On old, high alluvial fans in the valley of Trout Creek well above the present flood plain, similar soils have been observed in the wide belt of old alluvium occurring north and west of Pikes Peak.

SOIL AREA--Soils developed from Fountain arkose

These soils have developed from rotting Fountain arkosic sandstone. This material was originally derived from granitic outwash and was later consolidated into sandstone. It is cross-bedded and is usually coarse-textured, but some lenses of clay occur. Likewise, colors of the rock range from pure white through red to purple, and these are often reflected in soil colors. The soil profiles are usually shallow and irregular in arrangement of horizons, but $A_2$ and $A_3$ are commonly present. Typically, these sandy profiles have an A - C arrangement.

I. Soil profile

$A_2$ This layer is commonly 2 inches thick and ranges in texture from a fine sandy loam to a coarse loamy sand or gravel. It is structureless or has a very weak granular structure. pH values range from 6.0 to 6.5, with 6.3 being a common value. This surface soil is commonly overlaid by very thin $A_0$- and $A_{00}$-horizons, but in places one or both of these may be absent.

$A_3$ This brown or grayish-brown layer averages about 6 inches thick, but may range from 3 to 15 inches, depending on local conditions of the parent material. The material is loose and open. Structure is usually absent. 6.4 is a common pH value, but the values may range from 4.5 to 7.0. Gravels and soft lumps of sandstone may occur. The organic-matter content is very low in this horizon.

C The parent material is soft, disintegrating bedrock consisting of a wide range of textures, colors, and degree of consolidation. Occasionally a fine-textured layer gives the appearance of a B-horizon, but it is a false one. pH values range from 5.5 to 8.0.

II. Variations: A wide range in textures, but all are on the sandy side. The horizon thickness varies considerably, but the soils are commonly thin and shallow over bedrock. Colors reflect the variations of the parent rock. The wide range in pH values apparently reflect parent-material differences.

III. Pedologic differences: These soils are not directly related to any other soils in the area.

IV. Parent rocks and materials: These soils have developed from a coarse-textured and often conglomeratic arkosic sandstone. It is moderately consolidated. The materials were originally deposited as alluvium from eroding granitic bedrock not too far distant from the depositional area. This material undoubtedly went through one weathering cycle previous to deposition. During deposition they were cross-bedded to a moderate degree and some segregation of materials of different size occurred. These characteristics explain the variations in the soils which are now developing from these sandstones.

V. Natural vegetation: Chiefly ponderosa pine with an undercover of poor shrub and scattered grasses and weeds. In places the surface may be free of all protecting vegetation or litter.

VI. Topography: Slopes range from 3 to 40 percent. Most of the areas have slopes between 10 and 20 percent. The steeper areas occur on the east side of the valley. The drainage system is not well developed, but in the larger areas local drainageways occur. Main drains and gullies pass through this belt from areas above.

VII. Drainage: Good surface and moderate internal drainage.

VIII. Distribution: The three largest areas occur south of Missouri Gulch east of the valley, in the east central part of the area, and north of Missouri Gulch west of the valley. In many places along the east side of the valley the formation is not exposed at all. A few large pedestals occur in the valley west of the road. These appear to indicate that these beds were once much thicker but have been eroded away. These pedestals do not appear to have materially influenced the adjacent soils.

SOIL AREA--Soils developed from Madison limestone

These soils have developed from limestone. They are the most fertile and erosion resistant of all soils on the Forest. The surface soils are reddish brown to dark gray, very open and granular, and are calcareous. Subsoils are rarely present or well developed. The substratum consists of loose fragmented limestone with some fine material between the fragments. The soil contains a high percentage of fragmented rocks throughout.

I. Soil profile

$A_1$ The surface soil ranges in thickness from 2 to 4 inches. It is a dark-brown, reddish-brown, or grayish-brown granular loam. The granules are small and soft. Though sometimes absent, this layer is chiefly distinguished by its higher content of roots and organic matter. It is calcareous and contains a high percent of limestone rock. The presence of ponderosa pine has apparently had little effect on soil development as far as podsolization is concerned.

$A_3$ This horizon has a brown or reddish-brown color and a loam texture. A small granular structure is well developed. Common thicknesses range between 4 and 8 inches. The horizon is calcareous. The organic-matter content is lower here than in the $A_1$.

B The B-horizon may or may not be present. When present, it has a reddish-brown or grayish-brown color, a heavy loam or clay loam texture. A weak blocky structure mixed with a good granular structure is common. The rock content is high. The soil is calcareous. When present this horizon does not restrict moisture penetration or rate of movement over that in the layers above.

C The parent material is calcareous. It consists of 80 to 90 percent limestone rocks with some loose granular loam between the fragments. This layer is deep--the unweathered bedrock (D-horizon) having never been reached in a profile pit although it is exposed in deep stream cuts.

II. Variations: Chiefly in colors which are inherited from the parent rocks and may range from reddish brown to dark gray. The B-horizon is more often absent than present, especially on the steeper slopes. There is no sharp change from profile to parent materials. The fine soil material has either developed or infiltered into the C-horizon.

Those soil areas contain many small valleys and drainageways which have been filled with alluvium from adjacent slopes. Those valleys were too small to map as independent units.

III. Pedologic differences: These are the only soils of their kind developed in the Experimental Forest.

IV. Parent rocks and materials: These soils have developed from the Madison (Manitou) limestones. This formation as it occurs on the Experimental Forest includes both white and pink or reddish rocks. The beds, especially the lower layers, have been metamorphosed. According to some descriptions, these rocks are dolomitic in places. The surface layers have been well weathered and are fragmented.

V. Natural vegetation: These soils are covered in part with an open stand of ponderosa pine, but other areas consist only of shrubs (mountain mahogany), and good grass. Grass appears to grow exceptionally well and it is believed that recovery after heavy use is rapid.

VI. Topography: Slopes range from about 5 to 40 percent. The steeper areas lie west of the Mount Deception disturbance. Both north and south of this area the slopes are much less severe. In the larger areas, especially in those areas north and south of Missouri Gulch, a typical drainage pattern has developed in these soils. It is a trellis type, with the drains tending to produce blocks of hills with gentle slopes. These drains are often perpendicular to the main downhill drains.

VII. Drainage: Excellent surface and internal drainage.

VIII. Distribution: An almost continuous belt from the north to the south end of the area. The larger and more representative areas occur in the vicinity of Missouri Gulch. In the north central part erosion has cut well down into the granites, leaving many islands well above the valley bottoms. Soldier Mountain in the southern part of the area is an example of this type of development.

SOIL AREA--Soils developed from Sawatch quartzite

These soils have developed from the gray basal sedimentary rock which rests directly on the granite bedrock. For the most part, these are cliff-forming rocks, and soils developed from them are limited in the area. The loose, sandy surface soils are moderately acid and shallow. They rest directly on disintegrating sandstone or quartzite.

I. Soil profile

A This loose, structureless, loamy fine sand or fine sandy loam layer is rarely more than 10 inches thick, and is commonly only 4 or 5 inches thick. It contains little organic matter. Common pH values range between 6.0 and 7.0, although occasionally a thin lense may be very acid. Many soft sandstone rocks are present.

C Hard or soft disintegrating bedrock whose acidity is usually pH 5.0 or less. Colors range from white to pink, and textures are usually fine sand.

II. Variations: These soils are usually shallow and stony. Bedrock is exposed in many places due to rapid erosion of the loose sand grains as they are freed by weathering. Colors range from nearly white to pink.

The Sawatch is capped by a soft, very red, fine-textured sandstone 6 to 10 feet thick. It is usually exposed only as a low cliff somewhat back from the face of the white Sawatch proper, but in a few places it gives rise to a soil where the Madison has retreated downslope.

III. Pedologic differences: The red and gray soils in the Sawatch formation differ from each other chiefly in color. The red member appears to have more organic matter and generally a higher pH value. This latter may be in part due to the adjacent limestone influence. Vegetation appears to grow better on the red than on the gray soils.

These soils differ from those developed from the Fountain sandstone in having much finer textures, having shallower profiles, and in being derived largely from quartz as compared to a mixture of quartz and feldspars in the Fountain sandstone.

IV. Parent rocks and materials: Primarily a uniformly fine-textured silica sandstone. The lower rocks are more metamorphosed than those higher up in the formation. The top 6 to 10 feet consists of a very red, soft, fine-textured sandstone. Occasional thin lenses are a very deep red from the iron effects. The bedding in both rocks is commonly fine.

V. Natural vegetation: Commonly a thin stand of ponderosa pine. The red soils may support some grass and shrub where extensive enough.

VI. Topography: Primarily a cliff-former with the escarpment facing uphill. The hardness of the rock has retarded downslope erosion to a degree that granite walls 10 to 30 feet high often occur beneath the sandstone. The contacts between the two rocks is sharp and is visible for considerable distances.

Occasionally the overlying limestone has retreated downslope 50 to 100 feet leaving the sandstones exposed at angles of 5 to 20 percent. It is on such areas that soils are developed.

These rocks have not developed a drainage pattern of their own. Usually drainage is lateral to the general westerly slope, and is usually at the contact line between the sandstone and limestone. Depending on the locality and the angle of dip of the rocks, the limestone may be some higher than the sandstone. In other places this is not true.

VII. Drainage: Good to excessive surface and moderate internal.

VIII. Distribution: Occurs as a narrow but nearly continuous band along the entire east side of the area at the contact of the sedimentary with the igneous rocks. Because of their very small aerial distribution, the red top member was not separated on the map from the white lower member.

SOIL AREA--Soils developed from Pikes Peak (biotite) granite

Soils from biotite granite are by far the most extensive and important on the Experimental Forest. The surface soils are shallow, gravelly, low in organic matter, and infertile. The bedrock is reddish brown, disintegrating granite. The terrain is steep and dissected by numerous gullies and drainageways often to an extreme degree. Both the soils and rock where exposed are highly erodible when not protected by vegetation.

The complexity of this area made it impractical to map all soil differences. Accordingly, the unit on the map contains three important soils; namely (1) those developed on south and southwest slopes under dry conditions, (2) those developed on north and east slopes under relatively moist conditions, and (3) those developed at high elevations--above an approximate elevation of 8,500 feet--under lodgepole pine and mixed Douglas fir-ponderosa pine. Each profile will be described.

I. Soil profile
(Soils developed on south and southwest slopes)

$A_1$ The brown or pale brown surface soils are 2 to 3 inches thick and are gravelly loams or loamy gravel. They are loose and open. A moderate granular structure is weakly developed. Grass roots concentrate in this layer and produce a moderate to low amount of organic matter. pH values range from 5.5 to 6.5, but the reaction is usually above 6.0. This surface soil is overlaid in places with a thin layer of pine needles. The pH value of the $A_{oo}$ is nearly always 8.00. In other places only a thin scattering of grass residue occurs, while in still others a gravel pavement is the only surface protection. There is always a finer textured soil beneath this gravel pavement.

$A_3$ The $A_3$-horizon contains less organic matter and has a lighter color than the $A_1$. It averages 6 inches thick, but may be thicker in places. It has a gravelly or loamy sand texture and a pH range from 6.0 to 7.5 with 6.5 being the average. It has a poor granular structure, is loose and open, and contains a high percentage of angular gravels. Grass-root penetration usually stops in this layer.

C The substratum consists of a light brown loamy gravel or gravel. The gravels are sharply angular and can be dug out of their position in the rotten granite bedrock. pH values range from 6.5 to 7.5.

I. Soil profile (continued)
(Soils developed on north and northeast slopes)

$A_0^{oo}$ The duff or litter layer is well developed and is usually 1 to 2 inches thick. The top is made up of coarse needles and the lower part is a black, oily mass of disintegrated needles. White mycelial filaments may permeate the mass. The pH is 6.5 to 7.0 or more.

$A_1$ A grayish brown layer about 4 inches thick. It has a weak granular structure and a sandy loam or gravelly sandy loam texture. It is loose and open. Its pH values range from 5.5 to 6.5. The organic-matter content is low.

$A_3$ This horizon has a brownish-gray or grayish-brown color and a gravelly sandy-loam texture. It is moderately loose and open. The organic-matter content is less than for the $A_1$. pH values range from 5.5 to about 7.0. This horizon may be 7 to 10 inches thick.

C The parent material consists of gravelly material resulting from rotting granite bedrock. It may be either loose or firmly held in the rock. Some fine material has developed between the larger rock fragments.

(Soils developed at high elevations chiefly under lodgepole pine)

$A_0^{oo}$ A good layer of pine needles 1 to 2 inches thick. The lower part is soft and disintegrated. pH 4.5 to 6.5.

$A_2$ A gray or white layer 3 to 5 inches thick. Often contains a brown cast. A very poor granular structure and a gravelly sandy-loam texture. Low in organic matter. pH values range from 4.5 to 6.0.

$A_3$ A light brown coarse gravelly sandy loam. The organic-matter content is low. pH values range between 6.0 and 6.5.

C The parent material is a loamy gravel from disintegrating granite. The gravel content is very high. pH values range from 6.0 to more than 7.0.

II. Variations
(Soils developed on south and southwest slopes)

Chiefly in depths of surface soil and the amount of litter or protective cover. In areas where accelerated erosion has been held to a minimum the surface soils may be 12 to 15 inches thick. It is thought that the more shallow soils are the result of erosion from fires, logging, and grazing.

II. Variations (continued)
(Soils developed on north and northeast slopes)

Chiefly in thickness of surface soil. In some protected spots a reddish-brown clay subsoil has developed, but this is rare.

(Soils developed at high elevations chiefly under lodgepole pine)

A wide range in the degree of development of the $A_2$-horizon. It may be absent in many places. Thickness of the surface soils vary a great deal. In some of the more level and protected areas there is a tendency for a heavy textured subsoil to develop.

III. Pedologic differences: The pedologic differences occurring within these soils have been discussed above. This group of soils differ from those developed in the valley from granitic alluvium by having shallower profiles, a less permeable condition in the parent materials and less organic matter in the surface soils.

IV. Parent rocks and materials: Disintegrating coarse-textured biotite granite.

V. Natural vegetation: The southern slopes have an open ponderosa pine-grass cover, while north slopes have a moderately dense cover of Douglas fir with aspen in places. At higher elevations the density of the Douglas fir increases and a thick stand of lodgepole pine comes in in places.

VI. Topography: Slopes range from 10 to 60 percent or greater in places. Forty percent is a very common slope. The entire area has a characteristic and well-developed drainage system. The drains are dendritic in nature and finger into all parts of the area. They are often so close together that an observer standing on a ridge top can look down both sides of the slopes. Both valley bottoms and ridge tops tend to be V-shaped. This type of terrain is in part responsible for the rapid destruction of these landscapes by erosion.

East of Missouri Gulch the top of the Rampart Range is much more level and drainageways are incised to only a small degree.

VII. Drainage: Excessive surface runoff in most places due to the steep terrain. The degree of internal drainage is not well known. It is probably less than in the alluvial deposits in the valley.

VIII. Distribution: Extensive in the upland areas on both sides of the valley. The most extensive area occurs on the east side of the valley. These soils are very extensive in the Front Range of Colorado and in some parts of Wyoming.

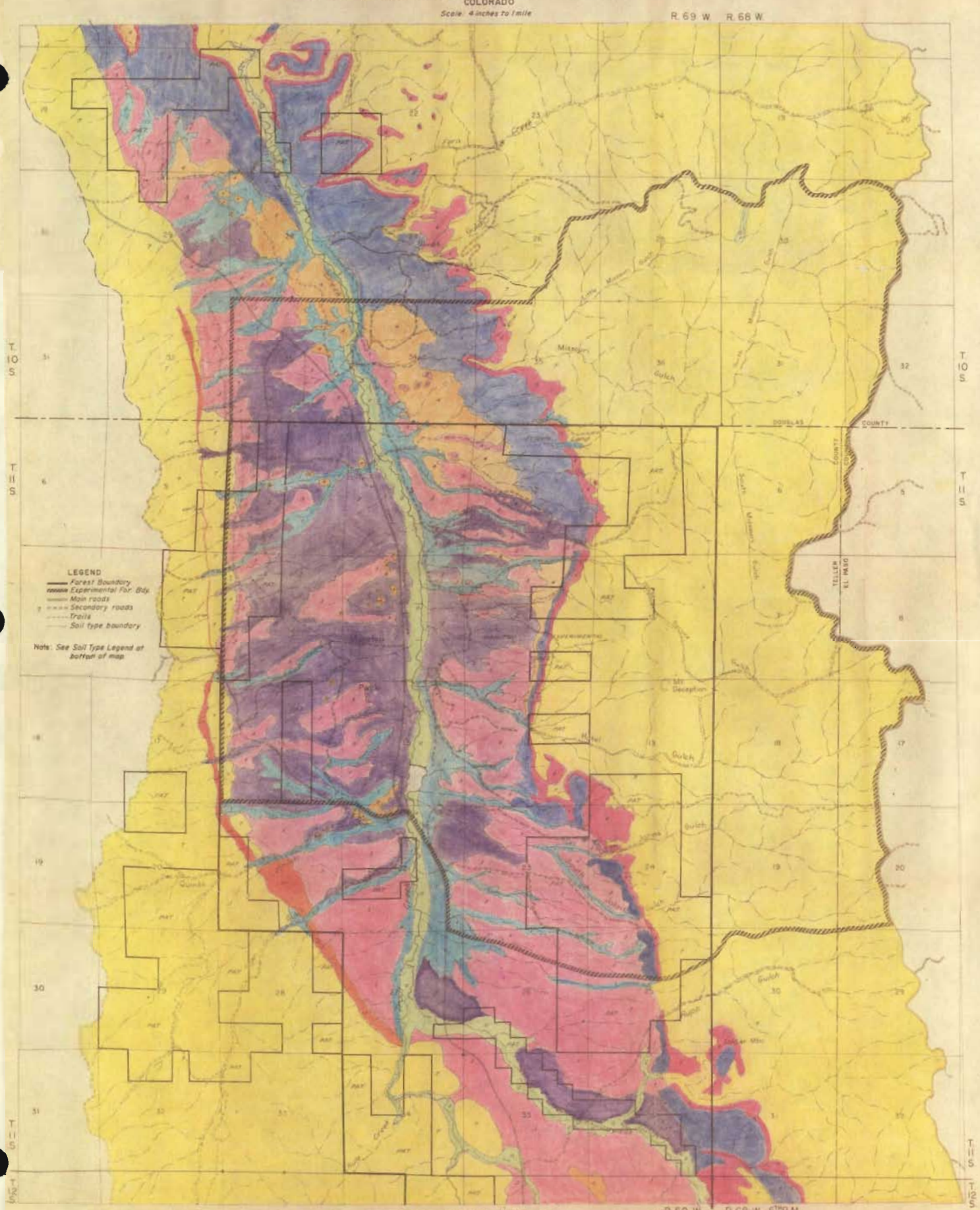
R-2

FOREST SERVICE

# SOIL MAP of MANITOU EXPERIMENTAL FOREST and VICINITY

COLORADO

*Scale: 4 inches to 1 mile*




SOIL TYPE LEGEND

| Symbol | Soil Developed from |
|---|---|
| 0 | Wet meadows or flood plains |
| 1 | Young alluvial fans |
| 2 | Middle alluvial fans |
| 3 | Old alluvial fan |
| 4 | Fountain Arkose |
| 5 | Madison Limestone |
| 6 | Sawatch Quartzite |
| 7 | Granite |
| UF | Ute fault |

SCALE IN MILES

PLANIMETRIC MAP OF MANITOU EXPERIMENTAL FOREST AND VICINITY