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Forest Service

Pacific Southwest Region

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In cooperation with:

U.S.D.A. Natural Resource Conservation Service

Regents of the University of California (Agricultural Experiment Station)

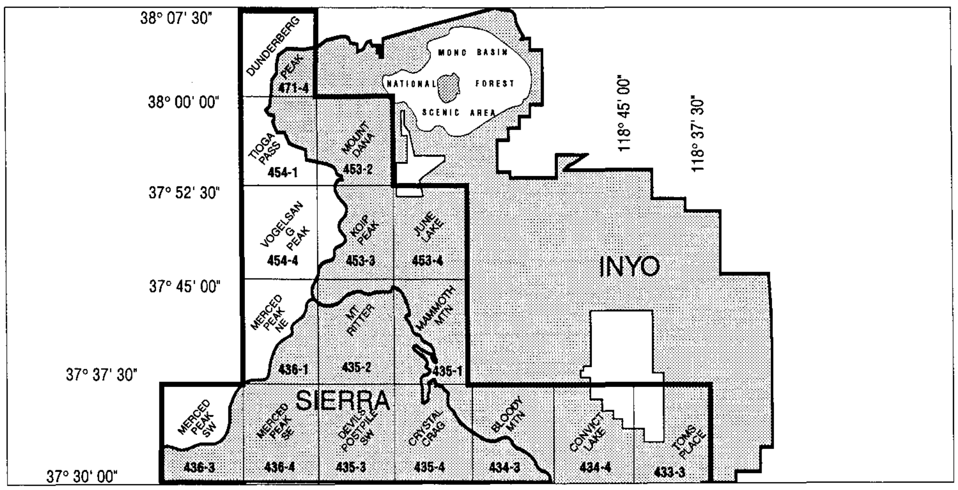
Soil Survey
High Sierra Area California

How To Use This Soil Survey

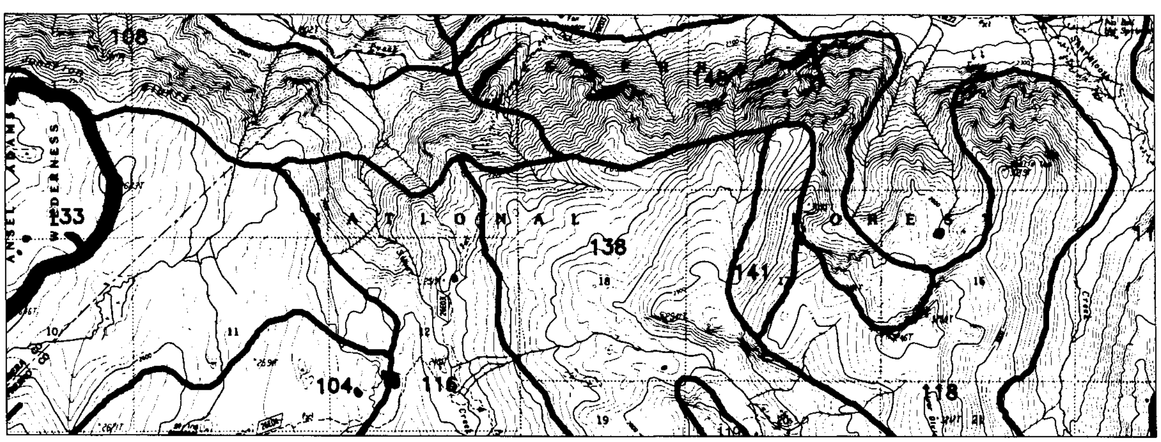
The Soil Maps

The soil maps show the arrangement of the soils and miscellaneous land types on the landscape. They are intended to help the wilderness user understand and appreciate the relation of the various soils to each other and to overall ecosystem form and function, as well as to aid in planning the use and management of the survey area.

To find information about your area of interest, locate the area on the **Index to Map Sheets,** which preceeds the soil maps. Note the number of the appropriate map sheet, then turn to that sheet.



Locate your area of interest on the map sheet. Note the map unit symbol for that area. Turn to the **Index to Map Units** (see Contents), to find the name of the map unit and the page on which the unit is described. Also, refer to the index for **Soil Descriptions: The Taxonomic Units** (also in Contents) to find the pages on which detailed soil description are given. Detailed laboratory data for many soils can be found in the **Soil Characterization Tables** (see List of Tables).



High Sierra Area, California

This soil survey is a publication of the United States Department of Agriculture, Forest Service, Pacific Southwest Region. As part of the National Cooperative Soil Survey, this survey is a joint effort between the Forest Service and the USDA Natural Resources Conservation Service. The Forest Service was responsible for field work, technical quality control, and manuscript preparation. The Natural Resources Conservation Service, which has leadership for the National Cooperative Soil Survey, correlated the soils in consultation with the Forest Service. The Natural Resources Conservation Service National Soil Survey Laboratory in Lincoln, Nebraska analyzed selected soils.

The soil survey area consists of the Wildernesses administered by the Sierra and Inyo National Forests. Major field work was performed in the summers of 1987 through 1991. Soil names and descriptions were approved in 1993. Unless otherwise indicated, statements in this publication refer to conditions in the survey area between 1987 and 1993.

Issued 1995

Front Cover: Coyote Lake and vicinity, John Muir Wilderness.

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In wilderness, lies the ballast of civilization.
RDT

Foreword

Wilderness is wild, but wilderness use must be managed. Proper management requires understanding an ecosystem's features, conditions, and dynamics. Moreover, guidelines issued by the Council on Environmental Quality (40 CFR, Part 1500–1508) for implementing the National Environmental Policy Act (NEPA) (Public Law 91–190) require public agencies to assess environmental impacts of alternative management actions before those actions are implemented. Soil survey characterizes terrestrial ecosystems and records their condition. It documents the system's composition, structure, processes, and linkages to help meet NEPA requirements.

The Soil Survey of the High Sierra Area, California is intended to accomplish the following: (i) provide a soil data base for broad planning and management of land for wilderness and other values, including recreation, grazing, watershed, and wildlife, (ii) assess the potential environmental impacts of ecosystem disturbances, including fire and acidic deposition, and (iii) fulfill USDA's goal for soil surveys on all lands. Due to its broad-based approach, the survey is not suitable for detailed management planning or project level work without further field verification.

This survey completes soil mapping on the Sierra and Inyo National Forests for updating of the Forests' Land and Resource Management Plans; moreover, it completes general soil mapping for planning purposes in Region 5 of the National Forest System.

We hope that this soil survey will add to your appreciation, understanding, and enjoyment of the magnificent High Sierra country, while at the same time it furthers the Forest Service goal of prudent stewardship of these valued ecosystems.

James L. Boynton
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Sierra National Forest

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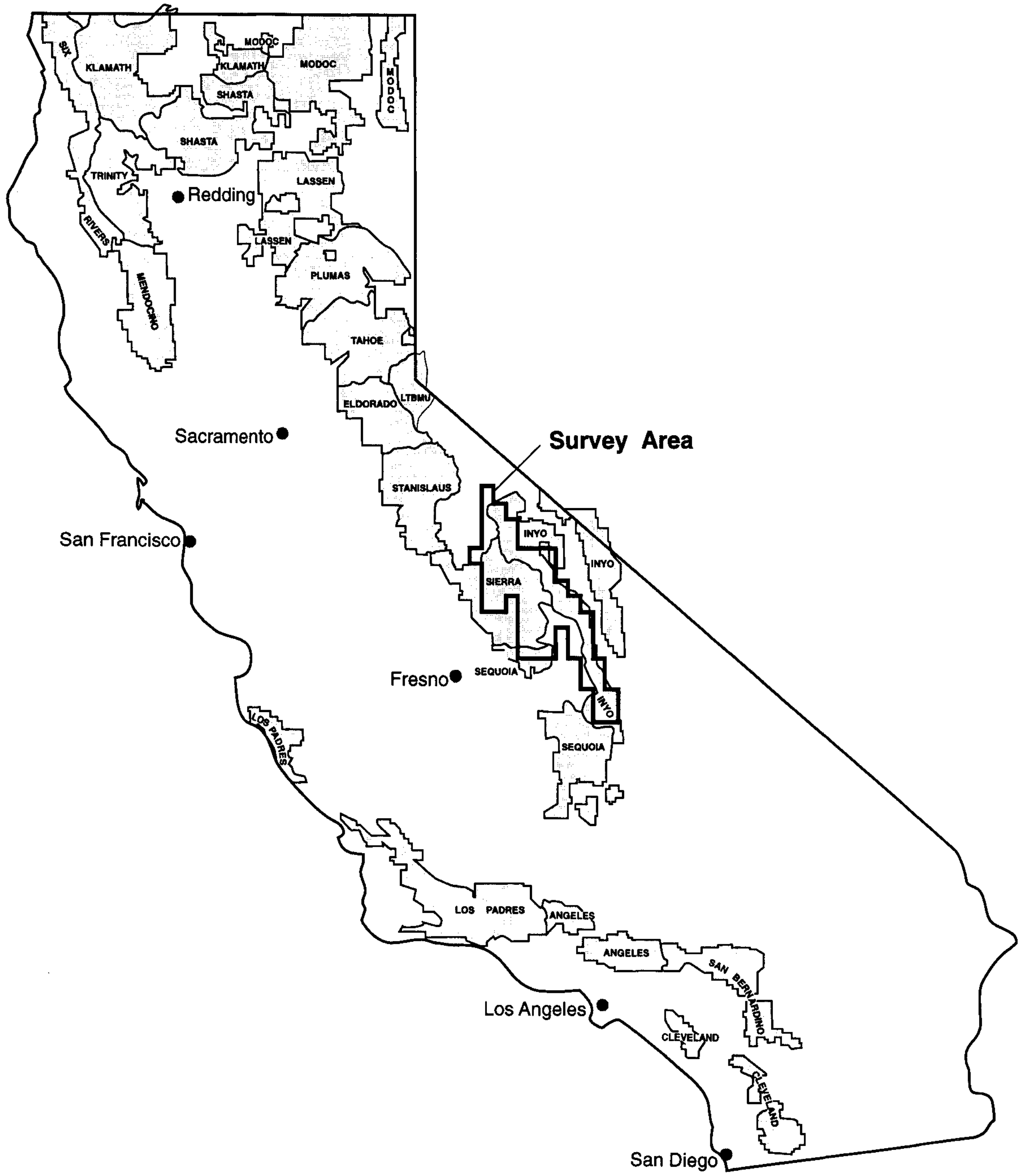
Location of the High Sierra Area

California



Soil Survey of
High Sierra Area,
California

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Introduction

This is a broad-based, order-4, soil survey; as such it is intended for general land planning and management—it is not suitable for detailed management planning or project level work without further field verification.

Purpose and Use of the Survey

The Soil Survey of the High Sierra Area describes the arrangement of soils and related ecosystem components in wildernesses of the Sierra and Inyo National Forests (Figure 1). The survey provides a soil data base for broad planning and management; it assesses the potential environmental impacts of certain ecosystem disturbances; and it can be used as needed to update National Forest Land and Resource Management Plans.

The Wilderness Act of 1964 (Public Law 88-577) established the National Wilderness Preservation System to ensure that lands within the United States are "designated for preservation and protection in their natural condition." In addition to maintaining their wilderness character unimpaired, wildernesses shall be administered in part "for the gathering and dissemination of information regarding their use and enjoyment as wilderness." Moreover, the Act recognizes that wildernesses may contain "ecological, geological, or other features of scientific, educational, scenic, or historical value." This survey presents information on the morphology, development, distribution, and conditions of the native soils, which, as part of the wilderness character, deserve full recognition and preservation under the Act.

One use of this soil survey is to help determine if the objectives of the Act are being met or compromised. The survey can help to identify durable sites, problem areas, and sites

Figure 1. Location of the High Sierra Area.

of greatest and least susceptibility to erosion or alteration; it can help in developing mitigation measures and compatible ways of maintaining or rehabilitating the resource. Interpretations include those needed for recreation, grazing, wildlife, watershed values, fire, and future environmental studies, including acid precipitation effects. This survey also can be used to select areas for more intensive study.

How This Survey Was Made

Field work for the High Sierra Soil Survey was conducted during the summers of 1987 through 1991. The survey follows the concepts and procedures presented in the *National Soil Survey Handbook* (Soil Survey Staff, 1993), the *Soil Survey Manual* (Soil Survey Division Staff, 1993), and *Soil Taxonomy* (Soil Survey Staff, 1975), and taxonomic classifications presented in *Keys to Soil Taxonomy* (Soil Survey Staff, 1992).

This fourth order soil survey is based on general information. Soil boundaries were located by interpretation from aerial photographs, and sites for detailed soil descriptions and boundary verifications were selected according to the judgement of the survey leader. The survey is intended for extensive, rather than intensive, land planning, applications, and interpretations; it is not suitable for project–level work without additional field verification.

Following a preliminary field study, tentative soil map units were delineated by interpretation from black and white aerial photographs taken in 1973 at a scale of 1:63,360 (1 inch = 1 mile). Interpretations were based on recognizable soil forming factors, including topography and landform, parent materials, and vegetation, all under known climatic conditions. These interpretations were aided by reference to topographic and geologic maps published by the United States Geological Survey, and to soil information available from adjoining soil surveys (Giger and Schmitt, 1993; Gallegos, 1995). Tentative interpretations were verified or corrected according to the results of extensive field reconnaissance and selected laboratory analyses. Field locations were described according to public land survey system references (section, township, range) printed on topographic maps of the John Muir and Ansel Adams Wildernesses issued by US Forest Service in 1983, and on United States Geological Survey (USGS) topographic maps covering the Kaiser Wilderness issued in 1984.

The number of field descriptions was limited by difficult access to the survey area and arduous digging conditions. Access was gained entirely on foot or horseback by established trails and across difficult terrain. Average sampling intensity was approximately one detailed soil and site description per 3,700 acres. Sampling intensity was greater in heterogeneous ecosystems and less in expansive zones of rock outcrop. These detailed descriptions were supplemented by numerous cursory inspections. The depth of soil descriptions was limited by the depth to which a hole could be dug by hand within a few hours—commonly two to four feet. Under these conditions, one person usually could describe no more than one soil in a ten to twelve hour work day. Conditions at depths greater than actual observations were inferred from landscape features, including topography, bedrock, and geomorphology.

Soil samples collected from selected sites were chemically analyzed according to standard procedures by the National Soil Survey Laboratory in Lincoln, Nebraska (National Soil Survey Laboratory, 1983; Soil Survey Laboratory Staff, 1992).

After completion of the field work and mapping on aerial photographs, delineations were transferred from the photographs to 7.5 minute USGS topographic maps (1984 issue), at a scale of 1:24,000, which then were reduced to 1:63,360 for inclusion in the final report.

This soil survey adjoins completed soil surveys of Sierra National Forest and Sequoia National Forest, and on-going soil surveys of Inyo National Forest, Yosemite National Park, and Kings Canyon National Park. Although this survey was coordinated with neighboring surveys, some discrepancies may appear in matching map units and soil boundaries. The reasons for these discrepancies are as follows: (i) Survey area boundaries sometimes fall directly on natural soil boundaries, such as those caused by changes in slope steepness, aspect, or elevations which correspond to soil temperature regime changes. (ii) Soil classifications may have changed because of new information provided by additional pedon descriptions, soil temperature measurements, or chemical analyses; or because of recent changes in the taxonomic system. (iii) Some discrepancies may be apparent, but not real, because of different mapping intensities across survey boundaries. For example, soils in this order-4 survey are mapped to the subgroup taxonomic level, whereas soils in adjoining order-3 surveys are mapped to the more specific family or series levels. Although the adjoining family or series may fall within the subgroup of this survey, the map units are named differently, with this survey having the more general name and the adjoining survey having the more specific name.

Assumptions

The lack of intensive field and laboratory data required that several assumptions be made in conducting the survey and preparing the final report:

- Precipitation values given in the map unit descriptions were taken from the isohyetal map "Mean Annual Precipitation in the California Region" (Rantz, 1972), or extrapolated from nearest snow course data (California Cooperative Snow Surveys, 1993) by assuming that water content of average April 1 snow pack is 80 percent of average annual precipitation (Douglas Powell, University of California, Berkeley, personal communication). Values obtained by these two methods were nearly equal for comparable areas.
- Usually, the soil moisture regime was assumed to be xeric (i.e., moist winters, dry summers) except in the red-fir and some higher elevation zones, where it was assumed to be udic (i.e., soil moisture is available to plants through much of summer) based on unpublished data collected in other parts of the Sierra Nevada (Dr. Gordon Huntington, University of California, Davis, personal communication), and in the desert shrub zone, where it was assumed to be torric (i.e., arid).
- Soil temperature regimes were determined from soil temperatures measured with each soil description. Although soil temperature regimes cannot be conclusively determined from a single temperature measurement, the assumption was made that if by mid–summer the soil temperature only barely had reached the minimum required annual average for a given regime, the soil could not fall into that regime, and was classified into the next colder regime.

Similar logic was used in separating soils in the cryic regime from those in the frigid regime, which have similar mean annual temperatures, but different mean summer temperatures. For example, if the mean summer temperature requirement for the frigid regime was greater than 59° F, and the soil barely had reached that temperature by late summer, the assumption was made that the average would not exceed 59° F, and the soil was classified as cryic. In addition, for temperature regime purposes, *Keys to Soil Taxonomy* (Soil Survey Staff, 1992) distinguishes between soils having an O horizon and those lacking an O horizon, but it does not specify a minimum thickness of O horizon. In this survey, a minimum O horizon thickness was set at two inches, after consulting numerous soil scientists in Natural Resources Conservation Service, Forest Service, universities, and the Soil Survey Staff in Lincoln, Nebraska (Dr. John Witty, Soil Survey Staff, personal communication).

Soil temperature regimes are determined by average summer and winter temperatures at 20 inches soil depth. Although Soil Taxonomy recognizes the three summer months as June, July, and August, most soils in the survey area probably are warmest in July, August, and September, because they do not begin warming until after snow melt and do not begin to cool until early fall. This survey followed the June–August requirement, even though future work might prove July–September to be more appropriate. If the taxonomic definition were to be changed from June–August to the three warmest months, some soils mapped as cryic in this survey would be changed to frigid. Moreover, further clarification of the O horizon requirement, which reflects shading of the soil, could cause a reclassification of soils currently mapped as cryic or frigid.

- Classification of many soils depends on laboratory measurements of base saturation. Generally, data from this survey and from neighboring surveys indicate that base saturations are lower in soils west of the Sierran Crest than in soils east of the Crest. A notable exception is those east-side soils containing volcanic ash, which tend to have low base saturations. When taxonomic decisions were made in the absence of laboratory data, base saturations were assumed to be less than 50 percent in west-side soils and in east-side soils containing volcanic ash; they were assumed to be greater than 50 percent in other east-side soils.

Naming the Soils

The soils in this survey are named and indexed according to the technical classification of *Soil Taxonomy* (Soil Survey Staff, 1975) and *Keys to Soil Taxonomy* (Soil Survey Staff, 1992). Names in the Taxonomy are created by combining various formative elements derived from Latin and Greek. Each formative element denotes an important physical or chemical soil characteristic: for example, cry- means cold, torr- means hot and dry, psamm- means sandy, and orth- means true or common. Combining these Latin and Greek elements gives a taxonomic name, which may seem unusual to first-time users, but which ultimately is informative and useful.

The system uses a hierarchy of five categories, which, progressing from general to specific, are order, suborder, great group, subgroup, and family. A sixth category, soil series, often is used to name natural groupings of soils within families. Series normally are named for the location in which the soils commonly are found. Soils mapped in this survey were differentiated only to the subgroup level; soil series names were not assigned.

Depending on their properties, soils are classified into one of eleven soil orders: **Alf**isol, **And**isol, Ar**id**isol, **Ent**isol, Hi**st**osol, Inc**ept**isol, **Moll**isol, **Ox**isol, Sp**od**osol, **Ult**isol, and **Vert**isol. The bold faced portion of each word indicates the abbreviation for the order, which is placed at the end of a soil name. For example, a soil classified as Entic Xerumbrept is in the order Inceptisol. (Think of inc**ept**ion, or beginning. Inceptisols are young soils—those that are weakly developed, although they are somewhat more developed than Entisols, which are the youngest. For Entisols, think of rec**ent**ly formed.)

Note that the broadest taxonomic category, the soil order, is given at the end of the name, and that the most specific category, in this case the subgroup, is given at the beginning. The example of Entic Xerumbrept is broken down from right to left, and a possible family classification is added to aid understanding (Table 1). Additional definitions and information are given in the Glossary.

Soil map units in this survey are named according to the subgroup of the dominant soil in the unit; for example, Typic Cryorthents, 15 to 45 percent slopes. Each map unit description begins with the general meaning of each formative element. For more specific definitions, refer to *Soil Taxonomy* (Soil Survey Staff, 1975) or *Keys to Soil Taxonomy* (Soil Survey Staff, 1992).

General Nature of the Survey Area

Location

The survey area, which stretches 150 miles along California's "backbone," encompasses approximately 835,157 acres of dominantly high elevation lands on the western and eastern slopes of the central Sierra Nevada in the following Wildernesses: John Muir, Ansel Adams, Kaiser, Dinkey Lakes, Monarch, Hoover, and Golden Trout. The area is bounded on the north by Yosemite National Park and Toiyabe National Forest, on the east by the nonwilderness portion of Inyo National Forest and Kings Canyon National Park, on the south by Sequoia National Forest, and on the west by the nonwilderness portion of Sierra National Forest. The survey area lies dominantly in the Sierra and Inyo National Forests, and includes small segments of the Toiyabe and Sequoia National Forests;

TABLE 1. Understanding a soil's taxonomic name.

Taxonomic Category	Taxonomic Name	Soil Characteristics
Soil Order	Inceptisol	Soil having moderately weak development.
Suborder	Umbrept	Inceptisol having a dark colored, organic rich, and low base saturation surface horizon, called an umbric epipedon.
Great Group	Xerumbrept	An Umbrept having a xeric moisture regime—that is dry summers and moist winters.
Subgroup	Entic Xerumbrept	A Xerumbrept having virtually no subsoil development.
Family	coarse-loamy, mixed, frigid Entic Xerumbrept	An Entic Xerumbrept having coarse texture, mixed mineralogy, and frigid temperature regime—that is very cold in winter, but warming in summer.

it includes portions of the following counties: Fresno, Inyo, Madera, Mono, and Tulare.

History

The earliest known human use of the High Sierra region was by Native Americans who hunted game, collected edible plants, and traded with neighbors across the mountains. Northern Paiute people dominated the east side and high basins, while Western Mono, or Monache, and Miwok tribes inhabited the west side. Several mountain passes served as important east–west trade routes; the most heavily used included Mammoth, Mono, Piute, and Kearsarge Passes. Drainages on either side of these passes are littered with obsidian flakes and, occasionally, shell fragments.

Trails established by Native Americans were followed by early Euroamerican prospectors, trappers, and adventurers. The rugged terrain, especially as seen from the east side, discouraged early settlers from attempting these passes, although Mono Pass served as a military route through the Sierra in the 1860's (USDA Forest Service, 1978, 1978a). These same trails today are used by hundreds of wilderness visitors each year.

Early ranchers on both sides of the mountains discovered grass for sheep and cattle along stream bottoms and in high elevation meadows. Grazing was heaviest in the late 1800's to early 1900's, when more than 10,000 sheep per year grazed portions of present-day wilderness in Mono County alone. Over-grazing, which severely degraded meadows and streams, resulted in extreme soil erosion that remains evident a century later (Figure 2). Observations made for this soil survey suggest that some heavily grazed meadows lost more than one foot of top soil.

Grazing was reduced substantially beginning in the late 1920's and early 1930's, apparently because severely degraded range conditions combined with the short grazing season no longer made the arduous livestock drives profitable. Moreover, USDA Regulation L-20, passed in 1931, granted primitive area status to much of the High Sierra. Grazing by domestic sheep was eliminated completely from the west side in 1946 and from the east side in 1969. Additional reductions in cattle grazing were made between the early 1940s and 1971, when most high country allotments were declared vacant. Removing cattle from these rangelands allowed for increased use by recreational pack stock. Several allotments, mostly at lower elevations, remain open and are grazed under allotment management plans.

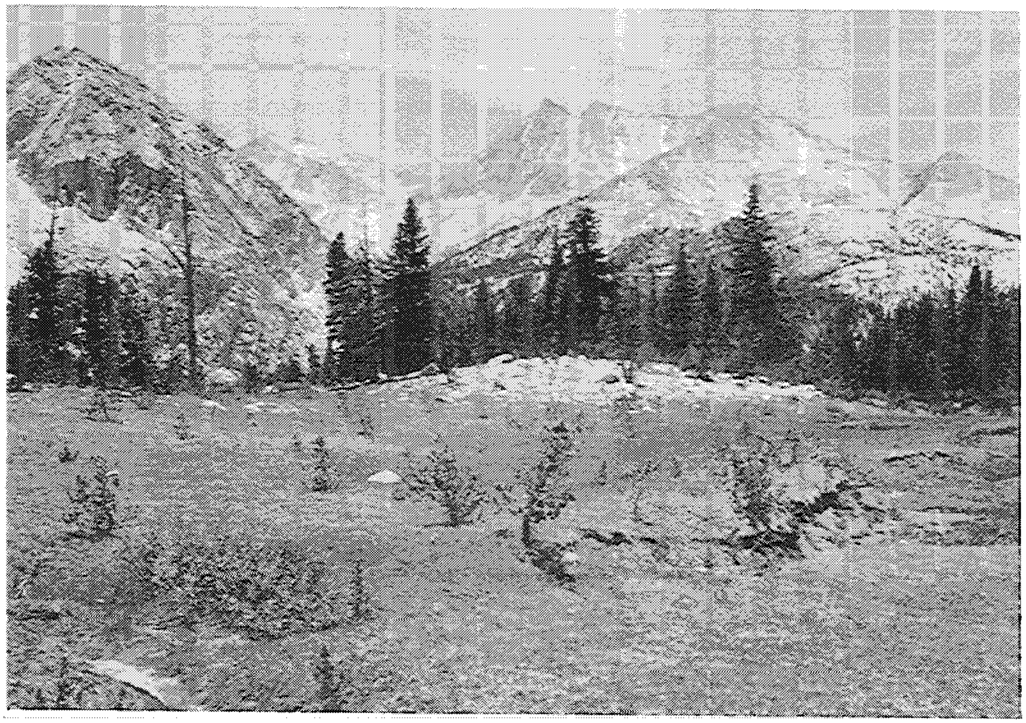


Figure 2. High elevation meadow in Pioneer Basin suffering soil erosion and encroachment by lodgepole pine. The soil, which classifies as a Humic Xeric Vitricryand, is enriched with fine volcanic ash.

Mining has had little overall impact on the Wildernesses, although a half-dozen patented mining claims and a score of inactive diggings of various types are scattered throughout. The main minerals of interest are tungsten, molybdenum, silver, cobalt, and gold. Most of the claims are concentrated along the eastern escarpment, where a few remnants of roads, cabins, and mills remain. All mining sites were greatly disturbed, but in most cases disturbance was contained in a small area around the digging. Most abandoned equipment and debris has been removed; nonetheless, evidence remains that the area has been "trammeled by man." Although these high elevation sites are slow to recover, the resource damage noted at the few diggings visited in this survey cannot reasonably be rehabilitated. The Wilderness Act closed the wildernesses to prospecting and new mining claims as of December 31, 1983.

The greatest mining activity in the region is Union Carbide's tungsten operation in upper Pine Creek on the Inyo National Forest. The mine and tailings are outside of, but adjacent to, the John Muir Wilderness. Possible effects on wilderness soils caused by atmospheric deposition from this operation were not investigated and are unknown.

Early loggers harvested timber and operated sawmills in South Fork Bishop Creek, on Shingle Mill Bench, and in Sawmill Creek from the late 1800's to early 1900's. Some evidence of these operations, a few of which employed oxen to haul logs, remains a century or more later. Shingle Mill Bench and another logging site on nearby Stecker Flat are particularly interesting in that these sites have deep to very deep soils that support Jeffrey pine and red fir. The soils formed in granitic colluvium and alluvium more or less on the Sierra Nevada fault. The alluvium, which appears particularly out of place on the ends of these ridges some 4,000 feet above the Owens Valley floor, probably was laid down in the Tertiary period prior to uplift of the Sierra Nevada, and carried to its present position by the rising mountains. Apparently, an unusual combination of geological, pedological, and biological circumstances and events came together eventually to produce the only significant, albeit small, stands of timber available to early nonnative settlers in the central Owens Valley.

Few cultural features remain in the Wildernesses except for several trapper's or miner's cabins and related structures. One cabin, which was constructed prior to 1912 by John Beck, stands at the junction of the Beck Lakes and King Creek trails. Perhaps the most notable structure is a stone ashram, or monastery, constructed in the Tuttle Creek drainage southeast of Lone Pine Peak.

Several laws have shaped the recent course of use and management of the High Sierra area. The Wilderness Act of 1964 (P.L. 88–577) established the National Wilderness Preservation System to ensure that lands within the United States are "designated for preservation and protection in their natural condition." According to the Act, a wilderness is an area "where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain." Wildernesses may contain "ecological, geological, or other features of scientific, educational, scenic, or historical value." Native soils, as part of the wilderness character, deserve full recognition and preservation under the law.

The John Muir, Minarets, and Hoover Wildernesses were established as a result of the Wilderness Act. The Kaiser Wilderness was added to the system in 1976 (Public Law 94–557), followed by the Golden Trout in 1978 (P.L. 95–237). Finally, the California Wilderness Act of 1984 (P.L. 98–425) created the Ansel Adams Wilderness by combining adjacent roadless areas with the existing Minarets Wilderness. The 1984 Act also established the Dinkey Lakes and Monarch Wildernesses, and added substantial land to the John Muir Wilderness.

The Middle Fork Kings River was declared wild and scenic under the Wild and Scenic Rivers Act of 1968 (P.L. 90–542); other rivers have been inventoried for possible designation, including North and Middle Forks San Joaquin River above Mammoth Pool Reservoir and South Fork San Joaquin River above Florence Lake. Also, in 1968, when Congress established the National Trails System (P.L. 90–543), the John Muir Trail, which runs north and south through the central portion of the survey area, was declared part of the Pacific Crest National Scenic Trail.

Climate

The High Sierra is characterized by cold, high snow-fall winters and warm, dry summers. Atmospheric temperatures decrease with increasing elevation at a rate of approximately 1°F for each 350 feet rise in elevation, with the summertime rate being slightly greater than the winter rate (Major, 1977).

Average annual precipitation in the survey area ranges from 6 inches near Owens Lake to 70 inches near Mammoth Mountain (Figure 3). Approximately 80 to 85 percent of the precipitation falls as snow. Late summer to early fall thunderstorms bring sporadic, localized rains that contribute little to soil moisture recharge. These precipitation and temperature patterns cause the soils to have a dominantly xeric moisture regime (i.e., wet in winter, dry in summer). Exceptions to the xeric moisture regime occur above Owens Lake where the regime is torric (i.e., arid), and at middle elevations on the west side in portions of the red fir zone, where the moisture regime is udic (i.e., summer moisture is available to plants) because of soil moisture recharge by higher elevation snow melt that continues into summer. (Moisture and temperature regimes are defined and described in the Glossary and in the section "Soils of the High Sierra.")

Except for snow pack and its water content, accurate climatic data are scarce for the High Sierra. Precipitation as indicated by snow pack water content tends to increase with increasing elevation within a watershed. Nonetheless, correlations of precipitation to elevation are weak because of large topographic variations that divert air masses, and alter winds and temperatures, creating localized rain cells and shadows. The strongest correlations are in the Kings River watershed, where the correlation coefficient (r) is 0.63 for a simple linear relationship (Figure 4). (The correlation coefficient expresses the degree of linearity between elevation and water content. The closer r is to 1, the stronger the interrela-

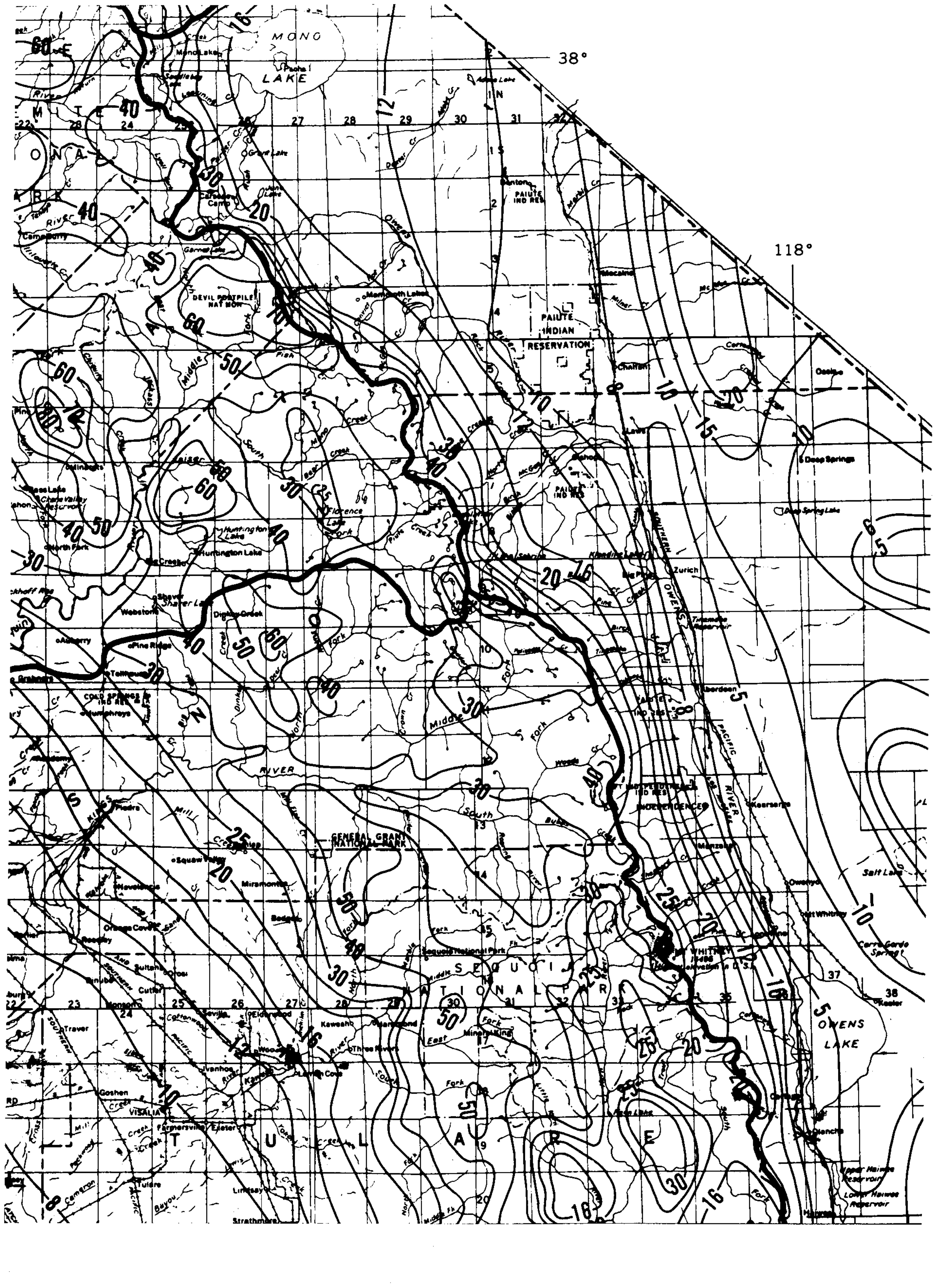


Figure 3. Isohyetal map, showing lines of equal average annual precipitation in inches (taken from map compiled by Rantz, 1972).

tion between the two variables.) Correlations are weaker east of the Sierran Crest than on the west side, and nearly negligible when combined watersheds are evaluated (Figure 4). These data show that common assumptions relating precipitation to elevation are poorly supported and unreliable.

Average water content in the snow pack is approximately 30 inches, measured on April 1 for 40 to 60 years in or near the wilderness portions of the San Joaquin and Kings River watersheds. Average water contents for individual snow course stations range from 7.7 inches at Florence Lake to 38.5 inches at Kaiser Pass, less than ten miles to the west.

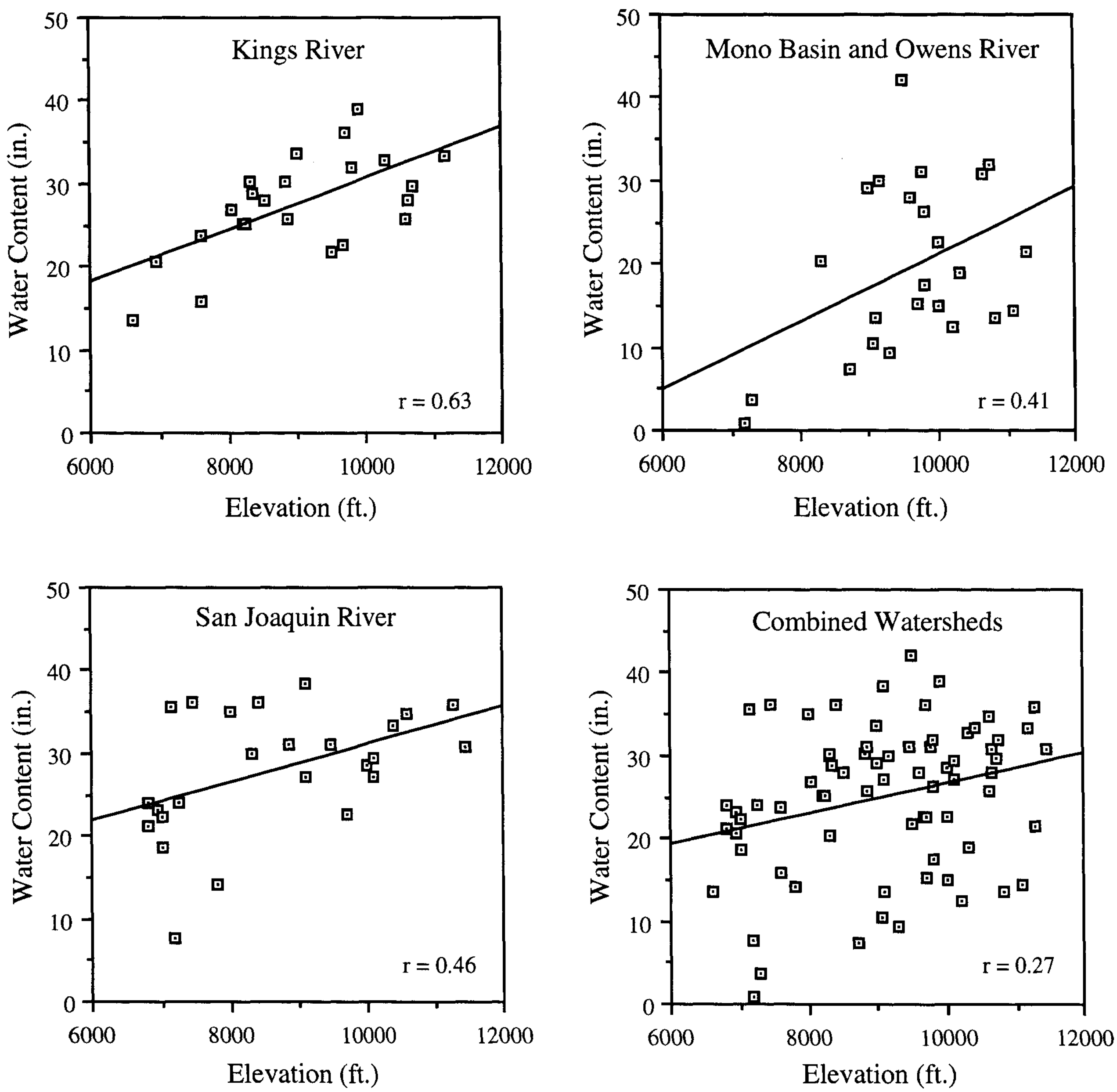


Figure 4. Average water content of snow pack at various elevations in the Kings River, San Joaquin River, and Mono Basin and Owens River watersheds; and in the combined watersheds (data from Cal. Dept. Water Resources, 1993).

These data demonstrate the strong influence of Kaiser Ridge in throwing a rain shadow across the Florence Lake area.

In the Mono Lake Basin and Owens River system, the average water content in wilderness snow pack is substantially less, at approximately 22 inches. The range is from 12.5 inches at Cottonwood Lakes to 42.1 inches at Mammoth Pass. Mammoth Pass, just outside the wilderness and barely into the Owens River watershed, has the highest precipitation in the region. The second highest snow pack water content is 32 inches—ten inches less—at Gem Pass. Also, average values for the Mono Lake Basin are approximately ten inches greater than for the Owens River drainage (California Department of Water Resources, 1993).

Physiography and Geology

The survey area ranges in elevation from approximately 1,800 feet in the lower Middle Fork Kings River to 14,495 feet at the top of Mt. Whitney. The average elevation is 8,200 feet. The average low elevation of map units is approximately 6,300 feet, and average high elevation is 10,100 feet.

The survey area is dominated by the Sierra Nevada batholith, from its weathered lower elevation rock masses to its majestic spires, peaks, and domes. The batholith tilted to the west as it was uplifted, resulting in an overall gently sloping western flank and precipitous eastern flank, each marked by north-south trending faults. The Sierra Nevada fault, on the eastern flank, is a major structural feature in the survey area (major west-side faults are outside the survey area). As a result of the mountain range's uneven westerly tilt, drainages west of the crest tend to be wider, more gently sloping valleys; whereas, those east of the crest are narrow, steep canyons, more commonly descending from cirque basins and alpine fell-fields. Below their glacially scoured upper reaches, most valleys and canyons are filled with glacial till and more recent alluvium.

The batholith is granitic rock consisting of a few large plutons and interspersed smaller plutons separated by thin partitions of metamorphic and mafic igneous rock. The main body of the batholith is flanked by older metamorphic rock, and capped in a few scattered places by remnants of metamorphic roof pendants. Younger volcanic rocks crop out in numerous locations throughout the area. Most of these rock masses have been carved by glaciers or covered by their debris.

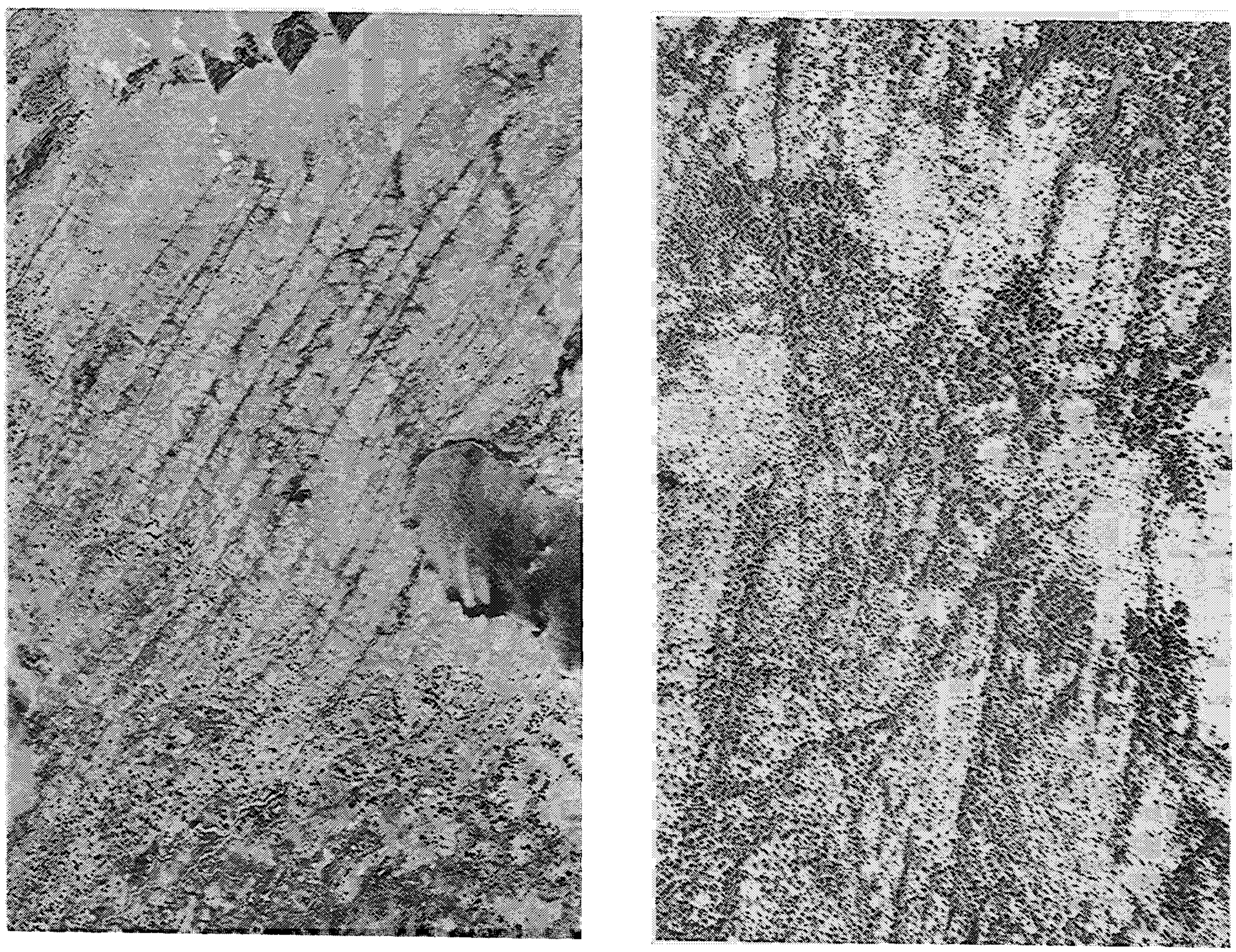
The granitic rock, which is strongly jointed throughout (Figure 5), shows a trend from granodiorite and diorite at lower elevations to granodiorite and quartz monzonite at higher elevations. The quartz monzonite, being richer in the felsic minerals quartz, orthoclase, and muscovite, is more resistant to chemical weathering than is diorite, which has less quartz and is richer in plagioclase and ferromagnesian minerals, including biotite. At low elevation, soils formed from diorite tend to be more developed than those formed from quartz monzonite, but at high elevation (generally above about 8,000 feet) differences in rock composition appear to be of little importance to weathering and soil development. This elevational anomaly presumably reflects the dominance of chemical weathering at lower, warmer elevations and of physical weathering at higher, colder elevations.

Volcanic rocks include andesite, basalt, some quartz latite, and a few rhyolite flows, as well as pyroclastic tuff-breccias and unconsolidated tephra deposits. The highest grade metamorphic rocks, which are best represented along the Sierra Nevada fault, east of the Sierran crest, consist of hornfels, marble, slate, quartzite, and small amounts of gneiss. Lower grade metamorphic rocks, which retain characteristics of their parent rocks, include various metasediments and metavolcanic tuffs, breccias, and latites.

A synopsis of the geologic history of the Sierra Nevada (Bateman et al., 1963; Rinehart and Ross, 1964; Huber and Rinehart, 1967; Lockwood and Lydon, 1975; Norris and Webb, 1976) can help in understanding the relation of geology to soils and the present-day distribution of soils in the survey area. During the Paleozoic Era, nearly a half billion years before the mountains were formed, thick deposits of sediments began collecting in a shallow ocean that covered the region. The sediments built up and hardened into sedimentary rock, which also crumpled and folded, over a period of roughly three hundred million years. Then beginning in the early Mesozoic Era, about 225 million years ago (Triassic Period), and continuing intermittently for perhaps 100 million years, volcanic eruptions partially metamorphosed and buried the rock in many places with volcanic ash and lava.

Meanwhile, granitic rock that was to become the Sierra Nevada batholith began forming deep in magma chambers. Rock overlying the chambers either dropped into the magma or melted partially and sagged into the chambers, eventually becoming metamorphosed "roof pendants." The granitic development, which progressed for some 100 million years through the main part of the Cretaceous Period, was completed by about the end of the Mesozoic. Heat and pressure generated from the magma chambers and from tectonic forces metamorphosed the sedimentary and volcanic rocks, creating the metamorphic, metasedimentary, and metavolcanic assemblages seen scattered about and flanking today's Sierra Nevada. The granitic rock, which by now was overlain by former sedimentary and volcanic rock in various stages of metamorphism, gradually was forced toward the surface in the early stages of mountain building.

With mountain building comes erosion. Rain water carried away surface materials and created stream channels, eventually exposing the underlying granitic rock, so that by the



A B

Figure 5. Aerial photographs showing (A) northeast-southwest trending fractures in bedrock in upper French Canyon, near French Lake; and (B) vegetation patterns reflecting soil development in bedrock fractures in Silver Creek drainage. Scale: 4 in. = 1 mi.

early Tertiary Period, some 65 million years ago, the ancestral Sierra Nevada probably consisted of low rolling hills and broad valleys. These processes apparently continued at an exceedingly slow rate through much of the Tertiary Period, until the middle Miocene Epoch roughly 12 million years ago, when volcanic activity resumed and uplift increased along with westward tilting of the central block. Scattered volcanic eruptions became more frequent, while uplift and westward tilting accelerated greatly through the Pliocene Epoch. The greatest rates of ascent occurred about three to four million years ago, when the structure of the present-day Sierra Nevada took shape.

No sooner were the mountains built, than glaciation began to tear them down. Global cooling during the Pleistocene Epoch, from about two and a half million to ten thousand years ago, produced great ice masses that sculpted cirques and U-shaped valleys in the stone block, and pushed the debris into jumbled masses of glacial till. Streams running through the till subsequently reworked it into alluvium in the drainage bottoms. Volcanic activity continued, with recent eruptions by Mono Craters and other nearby volcanos spewing thin layers of tephra (volcanic ash and cinders) across portions of the High Sierra landscape.

Vegetation

The survey area lies in the South Sierran Ecological Province of California as identified by the Calveg system (Parker and Matyas, 1979). It supports coniferous forests and smaller areas of alpine dwarf scrub, sagebrush shrub, and herbaceous vegetative types, followed by minor amounts of chaparral and desert shrub. The vegetation series, which are defined in the section "Soil Map Units," generally occur in the following sequence from coldest, highest elevation soils to warmest, lowest elevation soils: alpine dwarf scrub, whitebark and foxtail pine, lodgepole pine, sedge and perennial grass, red fir, western white pine, Jeffrey pine, mixed conifer, ponderosa pine, sagebrush shrub, chaparral, and desert shrub. This sequence may vary with latitude and slope aspect; the herbaceous series of sedges and grasses tends to have a wider range than other series.

Vegetative development and diversity generally are greater west of the Sierran Crest than to the east, because of the west side's greater precipitation, soil development, and plant-available water during the growing season. This trend is exemplified by greater coniferous forest on the west side, and sagebrush shrub on the east side. In addition, low elevation, dry sites on the west side may support chaparral; whereas, comparable locations on the east side may support desert shrub. The contrast is further shown by the presence of large, tall, closed canopy red fir stands on the west side and small open stands on the east side.

Plant growth and ecosystem development are limited by low atmospheric and soil temperatures throughout the high elevation portion of the survey area. At lower elevations, where temperatures are warmer, vegetative development is limited by lack of plant-available moisture. These conditions are reflected in the soils' taxonomic names, which place the more limiting factor higher in the hierarchy than a less limiting factor. For example, a loamy-skeletal, mixed Typic Cryorthent has a cryic temperature regime, which means that the soil's average annual temperature is between 32° F (0° C) and 47° F (8° C), and its average summer temperature is no higher than 59° F (15° C)—not cold enough to maintain permafrost, but also not warm enough to support substantial biological activity regardless of water availability. In contrast, a loamy-skeletal, mixed, frigid Dystric Xerorthent has a frigid temperature regime, which means that its average annual temperature is the same as cryic, but in summer the soil is warm enough for significant biological activity. The limiting factor in this soil is its xeric moisture regime, which means that it is moist in winter, but too dry in most summers for bountiful plant growth. Note that in these two examples, the more limiting factor—temperature or moisture—for biological activity is expressed at the great group level, and the less limiting factor either is not included or is expressed at the lower, family level.

An interesting soil-vegetation relationship is found in the vicinity of Devil's Post Pile National Monument where Jeffrey pine grows on soils derived from andesitic and basaltic lava flows and lodgepole pine stands are more common on soils developed in loose pumice. Although these conditions could not be delineated at the scale of this survey, research in other areas has shown that soils derived from these contrasting materials typically have different heat capacities. Soils derived from mafic lava flows usually warm to greater depths and hold more heat than do soils derived from pumice. Correspondingly, soil temperature requirements of Jeffrey pine are higher than those of lodgepole pine.

A few miles west of Devil's Post Pile, one of the world's largest lodgepole pines (*Pinus contorta*, var. *murrayana*) (Figure 6) grows in pumice-rich soil classified as Xeric Vitricryand. The tree stands 112 feet tall and measures 6 feet, 4 inches diameter at breast height. It can be seen near the trail in upper Stairway Creek drainage about a mile southwest of Granite Stairway.

Many high elevation meadows are being encroached by lodgepole pine (Figure 2), and some including Stairway Meadow, southwest of Devil's Post Pile, virtually have been taken over. Most of these meadows lie in broad depressional areas or are otherwise bordered by higher landscapes that allow volcanic ash and cinders as well as cold air to accumulate. These conditions contribute to the development of deep, cold, moist soils that are favorable for lodgepole pine as well as for grasses and forbs. The apparent reasons for the success of the pine encroachment are control of fire and elimination of moderate grazing, along with past heavy grazing. Although it is unproved, the common hypothesis is that these conditions decrease the meadow species' competitive edge allowing lodgepole pine to invade their habitat (Ratliff, 1985).

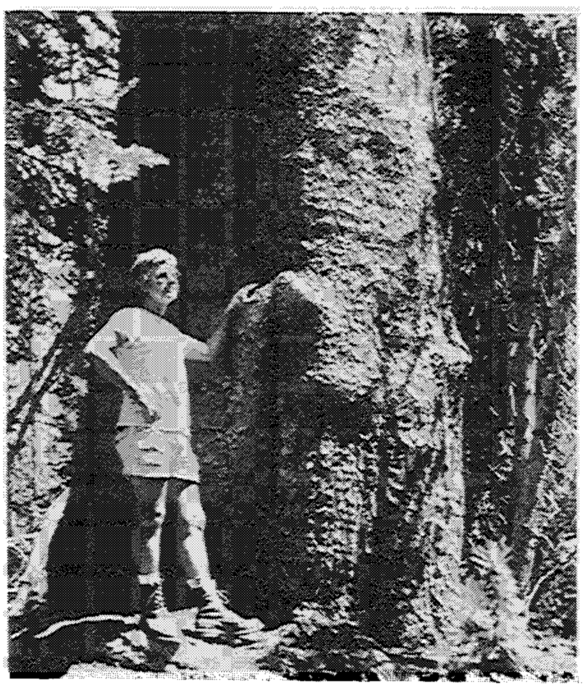


Figure 6. One of the world's largest lodgepole pines, growing in a Xeric Vitricryand in upper Stairway Creek drainage.

An interesting phenomenon throughout most of the high country, especially near timberline and in areas of massive rock outcrop, is the growth of trees under seemingly inhospitable conditions (Figures 5 and 7). How do trees survive in bedrock cracks and weakly developed, infertile soils near timberline, where release of nutrients from bedrock weathering is exceedingly slow? A major portion of nutrients in these systems might be supplied by pollen that collects in bedrock cracks and depressions after being blown up from lower elevation forests. This phenomenon was observed many times while conducting field work for this survey.

Water

Three of California's most heavily used rivers—the San Joaquin, Kings, and Owens—begin their flow in the High Sierra survey area. The San Joaquin and Kings Rivers, which drain the west side of the mountain range, are major suppliers of irrigation water to farms of the San Joaquin Valley and foothills; the Owens River system, which drains the east side, supplies most of the water used by Los Angeles. In addition to the flow through streams and rivers, surface water is stored in nearly 1,000 lakes and ponds. High chemical purity and low biological contamination make these some of the cleanest waters in the world.

Wilderness, which comprises approximately 40 percent of the Sierra National Forest, supplies at least two-thirds of the total annual water yield of the Forest. The Forest's average annual water yield is approximately 2.6 million acre feet—at least 1.7 million acre

Figure 7. Open forest growing in weakly developed, deep soils in an area dominated by rock outcrop.

feet come from the High Sierra survey area. The wildernesses undoubtedly contribute more water than these data indicate for the following reason: Wilderness water yields were calculated according to the proportional area in wilderness of each main watershed on the Forest. This calculation does not account for the proportionally greater productivity of high elevation subwatersheds as compared with low elevation subwatersheds, for which data were not available. In addition, 75 percent of the snow zone of the southern Sierra Nevada is in wilderness or national park. By considering all of these factors, one could infer that the true contribution of wilderness to water yield likely exceeds three-fourths of the total. (Comparable data for the Inyo National Forest were not available at the time of this writing.)

Although this survey did not investigate water storage and yield directly, soil depth measurements and estimates suggest that water storage in soil and rock fractures very likely has been underestimated in the past. Earlier reports, including the John Muir Wilderness Plan (USDA Forest Service, 1978) and Soil–Vegetation Maps of California (Calif. Forest and Range Exp. Sta., 1956–1960), assume that the High Sierra is dominated by shallow soils and rock outcrop, which capture and store very little water. The wilderness plan states that most natural water storage is in snow pack and lakes; nonetheless, this survey shows that soils more often are moderately deep to very deep than shallow, and that soils are interspersed throughout most rock outcrop areas (Figures 5, 7, and 8). These soils and rock fractures probably can capture and store more water than generally has been assumed—this point should be investigated in future studies.

In addition to their significant depth, Cryorthents and associated poorly developed soils are important watershed components because of their large spatial extent. Their function is analogous to the cone of a funnel, which collects high quality snow-melt and rain water from a large area and directs it to deep bedrock fractures for additional storage and transport. Moreover, water released by these soils is cold and pure because of the slow release of ions from bedrock and soil. This function often is overlooked in evaluating the hydrologic value of high country soils.

Fish and Wildlife

The high purity of High Sierra water, which makes it favorable for agricultural and urban uses, may make it less favorable for aquatic insects and fish because of the lack of nutrients. Waters flowing from areas of poorly weathered, acid igneous rocks and their associated infertile, coarse textured soils are expected to be especially impoverished in nutrients. In contrast, waters originating from areas of more weathered basic igneous rock, marble, and metavolcanics, which have richer soils, may contribute to more productive fisheries, although this correlation is unproved.

Fish are not native to most High Sierra lakes. In the late 1800s, lakes were stocked by hauling in cans of fish on the backs of mules; later, in 1947, the California Department of Fish and Game began aerial stocking, which it continues with five species of trout. Fish planting has encouraged increased recreational use around the stocked lakes. Some lakes have maintained their fishery after initial planting, whereas others have not. The less productive lakes must be replanted periodically to maintain the fishery because of inadequate spawning areas and insufficient nutrients.

All but the highest elevation lands serve as summer range for transitory animals, including mule deer, black bear, mountain lion, bobcat, and, in the Sawmill, Baxter Pass, and Mt. Williamson areas, bighorn sheep. Smaller mammals such as rabbits, squirrels, and numerous rodents use the lower elevation regions year-round. Deep, coarse textured soils can provide good summer and winter habitat for burrowing and hibernating mammals. The burrowing mammals, along with arthropods and gastropods, mix the soil, incorporate organic matter, and create channels that eventually fill in to form krotovinas. Krotovinas , formed in old burrows and root channels, are rich in nutrients and humus. They are the most productive portion of the mineral soil, and commonly make up one-fourth to one-third or more of the soil body.

Fire

The impact of fire in the High Sierra ranges from negligible to severe. High elevation rock outcrop units are virtually immune to fire's effects; whereas, lower elevation thickly forested or brush covered units can experience frequent, intense fires. Moreover, ecosystems east of the Sierran Crest are far less susceptible to fire than are those west of the Crest.

In high elevation regions characterized by expansive rock outcrops, alpine fell-fields, and thrifty subalpine forests, lightning commonly strikes isolated trees and small stands growing between bedrock joints. The result is small, infrequent, low-intensity fires that spread either slowly or not at all. At these elevations, snow often does not melt until midsummer, revealing light, discontinuous ground fuels and drainages that support fire-resistant riparian vegetation.

Upper midrange elevations exhibit barren rocky areas, sparsely vegetated ridges, and moist drainages amid more fire-prone lodgepole pine and red fir stands. This zone experiences more frequent moderate intensity fires, but large, high intensity fires are retarded by the natural fire breaks and surface moisture, especially in large logs and related fuels west of the Crest. Lower midrange elevation areas support denser, more continuous red fir forests and Jeffrey pine stands having heavier ground and aerial fuels that can carry large, intense fires.

The lowest elevation regions near the western fringe of the survey area often support fire-adapted plant communities, including Jeffrey pine, ponderosa pine, mixed conifer–pine, and chaparral. These communities suffer the largest, most intense fires in the survey area.

Aggressive fire prevention and suppression efforts have reduced the incidence and intensity of wildfires, and sometimes allowed uncharacteristically high fuel accumulations, especially in midrange to low elevations. The wilderness plans, which recognize fire's ecological role, call for allowing natural ignitions to burn within prescriptive bounds to reduce accumulated fuel and help return ecosystems to more natural conditions (USDA Forest Service, 1978 and 1978a).

Soils of the High Sierra

General Nature of the Soils

Soil Development

Soils of the survey area tend to be weakly developed; that is, with a few exceptions, they have little clay, weak structure, and few horizons. Most soils classify as Entisols or Inceptisols, although Andisols and a few Alfisols and Mollisols can be found. The generally high elevation restricts the growing season and maintains cold soil temperatures for most of the year in all but southerly, lower elevation sites. This condition, in turn, limits the activity of plants, burrowing animals, soil insects, and microorganisms. Soil development increases as biological activity and mineralogical weathering increase with decreasing elevation—provided moisture is adequate.

Soil development is controlled by the five soil forming factors: climate, parent material, topography, organisms, and time. Differences in any of these factors produce differences in soil characteristics. Cold temperatures and dry summers, combined with generally resistant granitic rock, limit chemical weathering and soil development in most of the High Sierra. High surface erosion from the generally steep slopes further retards soil development. Frost action is the major physical weathering process in the area.

Conventional notions, as well as earlier reports, incorrectly assume that high country soils are shallow to bedrock as well as weakly developed (e.g., California Forest and Range Experiment Station, 1956–1960; John Muir Wilderness Area Management Plan, 1978). Even though the soils may support sparse vegetation, are associated with bedrock outcrops, and show little horizon differentiation, they usually are moderately deep to very deep because of physical weathering and accumulation of detritus in deep, nearly vertical bedrock fractures. Shallow soils most often are limited to a narrow fringe around granitic rock outcrops and to small, shallow, bedrock depressions (Figures 5, 7, and 8).

Warm, low elevation soils in the Monarch and Golden Trout Wildernesses, in the southern portion of the survey area, also show little development, even though they may be moderately deep to very deep. These soils lack the water necessary for significant chemical weathering and biological activity. In most of the remaining survey area soil development increases somewhat with decreasing elevation; nonetheless, few mature soils are found. Exceptions can be found in some of the meadows, in wide, gently sloping valley bottoms, and on unglaciated volcanic plateaus. A notable example of a well developed soil is a clay-rich Alfisol found on Junction Bluffs, between Middle and South Forks San Joaquin River. This appears to be one of the oldest soils in the High Sierra, having formed on an apparently unglaciated, three million year old lava flow.

Many soils predicted to be Inceptisols on the basis of their vegetation, topography, and apparent age classified as less developed Entisols because they lack a cambic diagnostic horizon. The cambic horizon is a subsoil zone specially defined for taxonomic purposes. The idea is that the subsoil shows some signs of soil development, but that these are too weak to classify the soil into a more mature soil order. Cambic horizons must have a texture of very fine sand, loamy very fine sand, or finer. The soils in question, having formed from coarse grained, acid igneous rock, dominated by resistant minerals, do not meet this requirement. As a result, many soils, especially on the east side, that support mature, nearly closed-canopy forests are mapped as Entisols.

Organisms are an important soil forming factor in the High Sierra. Especially noteworthy are burrowing animals and insects, which construct channels, incorporate organic matter, and mix the soil. Old, filled-in animal and insect burrows and root channels, called krotovinas, often comprise as much as one-third of the soil. Krotovinas, which are rich in humus and nutrients, account for a substantial portion of soil productivity.

Patterns of Soil Distribution

Soils west of the Sierran crest tend to be somewhat more developed and support more vegetation than those east of the crest, because the west side receives more precipitation from oceanic air masses, and more soil accumulates on the somewhat gentler sloping west side.

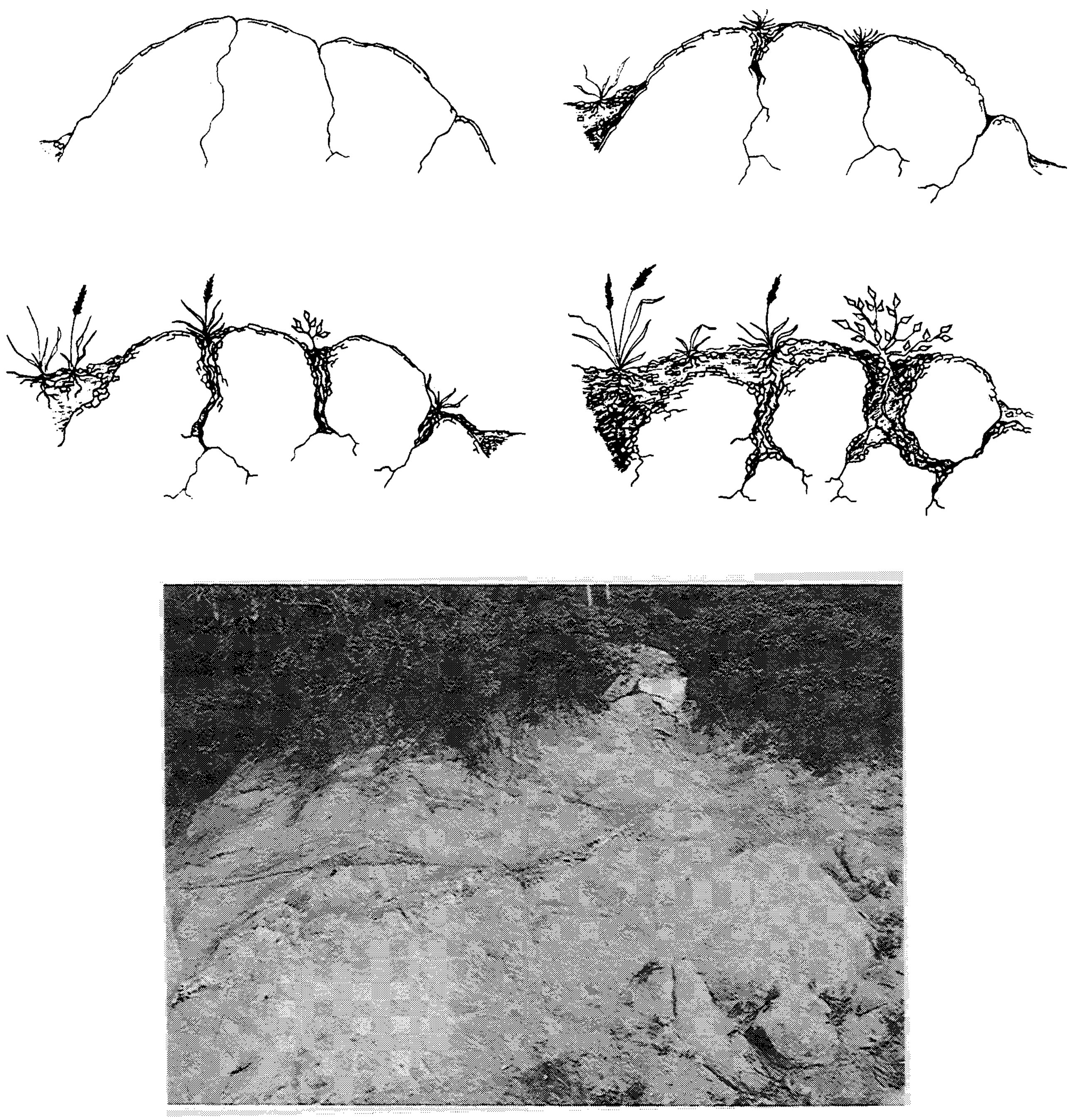


Figure 8. Typical sequence of granitic bedrock fracturing and soil development (four stages). Deeper soils form in the fractures; whereas, shallower soils are found in narrow fringes around rock outcrops. With continued chemical weathering, especially at elevations below about 8,000 feet, the tops of rock outcrops weather to form soil (photograph).

The east side, in contrast, lies in the rain shadow, and has relatively more exposed ground surface and overall steeper slopes that suffer more frost heave, soil creep, and surface erosion. The east side also experiences higher summertime soil temperatures at given elevations and more rapid runoff of snowmelt and rain water, leaving less water for soil development. In addition, west-side soils generally are more leached, having lower base saturations, than east-side soils, which are less leached and richer in bases. A significant exception to this trend is in east-side soils containing volcanic ash, which tend to have low base saturations.

An interesting trend in west side soils is seen in the distribution of Dystric Cryochrepts and Typic Cryorthents. Although the two soils fall into the same temperature and moisture regimes, Dystric Cryochrepts (more developed soils) tend to occur at lower elevations and on more gentle, concave slopes than do Typic Cryorthents (less developed soils). Vegetative cover may be similar on both soils, but often it is more dense on the Dystric Cryochrepts. Moreover, Dystric Cryochrepts seem to develop more readily in glacial deposits—which may be more stable—than in colluvium.

Apart from climatic conditions and topographic position, parent material appears to be the main factor controlling formation of some soils. On the west side of the Sierra Nevada, Cryumbrepts tend to form in basaltic or andesitic parent material; whereas, Cryochrepts tend to form in granitic parent material. Umbrepts are weakly developed soils, having deep, dark colored, organic rich surface horizons of low base saturation. Ochrepts are somewhat less developed than Umbrepts, having thinner, or lighter colored surface horizons. Presumably, the dark color and large amount of easily weatherable mafic minerals in the volcanic rocks promote development of umbric epipedons (topsoils) more readily than does the light color and larger amount of resistant minerals in the granitic rock. Umbrepts also tend to form from dark colored hornfels, a hardened, clay-rich metamorphic rock, on the east side.

Different types of granitic rocks often weather to different soils, but this relationship was not found in most of the High Sierra, especially above about 8,000 feet. Under favorable chemical weathering conditions, the more basic igneous rocks diorite and granodiorite produce soils having higher clay content, water holding capacity, and fertility than do the more acid igneous rocks granite and quartz monzonite. The more basic rocks contain appreciable amounts of the easily weathered minerals plagioclase, biotite, amphiboles and perhaps pyroxenes; whereas the more acidic rocks are made up of more of the resistant minerals quartz, orthoclase, and muscovite. Chemical weathering is slow enough under the high elevation conditions that even calcic plagioclase and biotite remain relatively fresh. The result is soils having coarse texture, low fertility, high permeability, and little horizon differentiation, regardless of granitic rock type.

Thin deposits of volcanic ash and cinders, collectively called tephra, are scattered throughout the survey area, but are most common in the northern portion and east of the Crest. Also, the soils of most high elevation meadows are rich in volcanic ash. In places the tephra is clearly visible as pumice, occasionally the size of popcorn or larger, on the soil surface, but in other places, where it occurs as fine ash, it is detectable only by an experienced person or by laboratory analysis. Soils containing weathered fine volcanic ash often feel smeary, and tend to be reddish colored. Color darkening from the dry to wet states may be striking, with Munsell color values decreasing as much as four units. Soils rich in fine ash tend to have low bulk densities and high water holding capacities; they are light and fluffy when dry, and when exposed can be exceptionally dusty. The presence of tephra also seems to affect soil chemical properties, with tephritic soils having low base saturation.

Some soils in the survey area have sufficient tephritic influence that they qualify as Andisols. These soils are characterized by high concentrations of iron, aluminum, and volcanic glass, and by high phosphorus retention. This survey includes the first mapping of Xeric Vitricryands and Humic Xeric Vitricryands in California. In addition, this is the lowest latitude mapping of these soils to date.

Rock Fragments

Most soils of the High Sierra are characterized by a high rock fragment content, which often exceeds 35 percent of the soil volume. The rocks are in all size classes: gravel, cobbles, stones, and boulders, with gravel and cobbles being the most common. Although rock abundance tends to increase with soil depth, the distribution of rocks across the landscape is highly variable, even over short distances. This variability is a major cause of complexity in soil map units.

The main effect of the rocks is to occupy space, thereby causing a relative decrease in fine soil volume and increased concentration of water and nutrients in the fine soil. Moreover, the rocks comprise the soil's skeleton, which, although it is discontinuous and unconnected, provides physical protection, support, and strength, including resistance to erosion and compaction. The soil mass is further bound and stabilized by plant roots that are deflected in their growth and forced to follow a tortuous path around the rocks.

The low surface area per unit volume of rock fragments contributes little to water holding capacity, cation exchange capacity, and heat capacity. Plant-available water capacity contributed by rock fragments probably is about 1 percent greater for volcanic and metavolcanic rocks than for granitic rocks because of the generally higher porosity of the volcanic and metavolcanic rocks. These differences are expected to increase to about 5 to 10 percent as the rocks weather. Considering the whole soil, a rock fragment content of 35 percent is expected to result in an available water content that is approximately 2/3 (in granitics) to 3/4 (in volcanics) of that of otherwise comparable soil containing no rock fragments. Saturated hydraulic conductivity, or soil permeability, also decreases with increasing rock content because of the decreased pore space available for water flow.

The influence of rock fragments on soil heat capacity and heat transfer is confounded by the soil's water content. Rock fragments store less heat than does an equal amount of water, but they transmit heat more readily. For this reason, rocky soils, which hold less water, may warm more rapidly than rock-free soils in early spring. This earlier warming would allow earlier initiation of biological activity. In wet soils, the higher the rock content, the lower the heat capacity because rocks take up space that might otherwise be occupied by water. As the soils dry, those having more rock will have greater heat capacity. These relations are of great ecological significance in the High Sierra: they help explain the striking diversity in plant communities and ecological succession in high elevation meadows having low rock content as compared to surrounding landscapes having high rock content.

Soil Temperature Regimes

Soil temperature regimes are mostly cryic or frigid, but possibly range from pergelic to thermic. Temperature regimes are based primarily on average annual temperatures at 20 inches (50 cm) depth and on differences between winter and summer soil temperatures. The average annual temperature in the pergelic regime is less than 32° F (0° C), and in the cryic regime it is between 32° C and 47° F (8° C). The coldest soil measured in the survey area was on Dana Plateau, where the soil temperature was 38° F (3° C) in late July 1991, a warm, dry year. The average annual temperature of this soil is assumed to meet the pergelic criterion, but frost was not present, as also is required for pergelic classification. Ultimately, a compromise was made, and the soil was classified cryic, partially to avoid making a new map unit solely for this small location.

Frigid soils have average annual temperatures that are the same as cryic soils, but summer temperatures are higher, allowing greater biological activity. Many summertime temperature readings taken for this survey were lower than expected from elevational and vegetational predictors. As a result, cryic temperature regimes were mapped into the mixed conifer-pine vegetation series to as low as 6,400 feet on northerly facing slopes and in shaded canyons on the west side. More commonly, the lower elevation limit of cryic soils falls at about 7,000 feet. This mapping extends the cryic regime 1,000 to 2,000 feet lower than that mapped at comparable latitudes in the adjoining Soil Survey of Sierra National Forest, California (Giger and Schmitt, 1993). Conversely, east of the Sierran Crest the low elevation limit of cryic soils falls at about 9,000 feet, higher than was predicted. Frigid soils can be found to 9,500 feet, or perhaps a bit higher, on southerly aspects near bedrock outcrops.

For shallow soils (that is, those less than 20 inches deep and identified by Lithic subgroups) the break between frigid and cryic temperature regimes tends to fall at elevations 500 to 1,000 feet higher than that of deeper soils. The temperature measurement for shallow soils is taken at the soil–rock interface, which is at a depth less than 20 inches, and, therefore, more responsive to summer warming than are deeper measurements.

Mesic temperature regime soils are warmer than frigid soils. These have average annual temperatures between 47° F and 59° F (15° C), which is warm enough for significant biological activity. Mesic soils are found at the lowest elevations in the survey area, below about 7,000 feet on south-facing aspects, and 6,000 to 6,500 feet on north-facing aspects. Although temperatures are favorable, insufficient soil moisture limits plant growth on these sites.

Thermic soils, which have an average annual temperature between 59° F and 72° F (22° C), were not mapped in the survey area. Nonetheless, some soils on southerly aspects in the extreme southern portions of the survey area east of the Sierran Crest may have a thermic temperature regime. Additional, long-term temperature data are needed to test this hypothesis.

Soil Moisture Regimes

Soil moisture regimes in the survey area range from aquic(wet) to torric (dry). Aquic soils are saturated with water to the degree that dissolved oxygen is eliminated or precluded. This regime is found in some wet meadows, especially near streams, but in areas too small to map. Torric soils, also called aridic in certain categories of the taxonomy, are dry most of the time when soil temperatures are warm enough for significant biological activity (i.e., above 41° F (5° C)). These soils occur at low elevations on the east side south of Cottonwood Creek, in the desert shrub and sagebrush shrub vegetation series.

Most soils in the survey area fall into the xeric moisture regime, followed by the udic regime. Xeric soils experience moist, cool winters and dry, warm summers, typical of mediterranean climates. Most moisture comes at the time of minimum biological activity and plant uptake, which leaves a considerable portion of the water for leaching of these coarse textured soils. The xeric regime is common on both sides of the Crest, probably in all except the desert shrub vegetation series.

Soils in the udic moisture regime have more plant-available water in summer than do soils in the xeric regime. Soil moisture recharge from summer snow melt plus summer rain provide sufficient moisture for evapotranspiration through most of the growing season. Some soils in the red fir vegetation series and higher elevation forests fall in the udic moisture regime, as indicated by soil water potential measurements on comparable sites outside the survey area (Dr. Gordon Huntington, University of California, Davis, personal communication, 1993).

In this survey, most of the potentially udic soils in the frigid temperature regime are mapped as Dystric Xerochrepts because of lack of confirming data. Placing these soils in the udic moisture regime would change their classification to Typic Dystrochrepts. Also, some Xerumbrepts would become Haplumbrepts, and some Xerorthents would become Udorthents. A moisture regime change would not affect the classification of cryic temperature regime soils in this survey.

Erosion and Other Disturbances

Sheet and rill erosion are common on moderately steep to very steep, granitically derived, immature soils throughout most of the survey area. These losses retard soil horizon differentiation on the eroded sites, while they add soil material to the sites below. Commonly, one to two inches of slope wash cover ground surfaces below these eroded slopes. Typically, the soil buried by the slope wash is somewhat finer textured than the deposited material, although both layers are coarse textured.

Frost heave can occur at any elevation, but appears limited to medium textured soils having adequate silt and clay to hold water. Bare soils in basins and meadows are particularly susceptible to frost heave. Most other soils are too coarse and dry near the surface most of the year to suffer frost heave. High elevation soils, especially those in alpine fell-fields and near snow and rock glaciers, are susceptible to frost churning; nonetheless, patterned ground, solifluction lobes, and other nivational features are uncommon in the area.

Stream activity and snow avalanches also can cause diverse soil changes on different sites. Soil formation in high elevation drainage bottoms frequently is disrupted by fluvial activity that reworks the previously deposited sediments, arresting soil development at the stage of Typic Cryorthents. Alluvial materials that are spread out and deposited in a more stable and hospitable environment lower in the watershed tend to develop into more mature soils in a given time span. Similarly, snow avalanches dislodge trees and soil, setting back soil maturity on the hill slope, while depositing new parent material below. Depending on other conditions of soil formation, the fresh overburden may disrupt short-term soil development while ultimately contributing to the formation of deeper, more complex soils.

Water Repellency

Water repellency, or hydrophobicity, is a common phenomenon that decreases the permeability and increases the erodibility of surface soils. It is caused by complex organic coatings on soil particle surfaces, and is more prevalent in coarse textured (i.e., sandy) soils than in fine textured (i.e., clayey) soils, because of the low specific surface area of coarse textured soils. In addition, dry soils usually are more prone to becoming water repellent than are moist soils.

Soil hydrophobicity in the High Sierra is exacerbated by volcanic ash and by fire, but often is present without clear evidence of either. During fire, a water repellent layer normally forms between one-fourth and three inches below the ground surface. This layer decreases water intake and can render the upper soil highly susceptible to sheet and rill erosion. Nonetheless, water repellent layers are discontinuous and of variable intensity, even over very small areas. Moreover, they are perforated by numerous open channels created by burrowing animals, insects, and burned-out and decayed roots. Ultimately, water repellent layers may be beneficial for post-fire recovery of the ecosystem in that they may restrict evaporative loss of soil moisture and limit the depth of erosional loss, although these points are not fully substantiated.

Meadow Soils

Soils of the meadows contrast dramatically to those of surrounding landscapes. Meadow soils are derived dominantly from alluvial deposits, with lesser amounts of eolian, colluvial, and glacial debris. They tend to be very deep, well stratified, and relatively free of rock fragments. They are rich in decayed organic matter and often have a high water table, which makes them fertile, dark colored, and often mottled at depth. The depth of mottling reflects the depth to a seasonal water table. Wet meadows typically have gleyed soils at depth; that is dark, blue-black color caused by severe chemical reduction of metallic compounds in an oxygen starved environment. Characteristics of this type that are caused by chemical reduction and oxidation of metallic ions are referred to taxonomically as "redoximorphic features."

Meadow soils normally are wetter than other soils for two reasons: First, their position on the landscape allows them to catch abundant snow fall in winter and receive runoff water in spring and summer. Second, they are somewhat finer textured and contain fewer rocks than most other soils, and they often contain a significant amount of medium and fine volcanic ash, each of which gives them a higher water holding capacity.

Soils of high elevation Sierran meadows are distinguished primarily by their water regime, texture, stratification, and volcanic ash content. Although most wet and moist meadows have seasonally high water tables, the soils in some portions of wet meadows may be permanently saturated at shallow depths. Soils in the wettest portions of meadows include, but are not limited to, Humic Cryaquepts, Typic Cryaquents, and very likely Typic Cryaquands, although the latter soils are not described in this survey. Each of these soils is cold (cryic) and saturated much of the year (aquic). Humic Cryaquepts are further distinguished by having a thick, dark colored, organic rich, low base status surface horizon, known as an umbric epipedon. Typic Cryaquents are too weakly developed to have an umbric epipedon or mature subsoil horizons. Typic Cryaquands typically would contain appreciable volcanic glass from ashfall and high iron and aluminum concentrations, and would have low bulk densities.

Common soils on moist meadow sites include Aquic Cryumbrepts, Vitrandic Cryumbrepts, Andic Cryumbrepts, Aquic Cryorthents, Vitrandic Cryorthents, Aquic Vitricryands, and Humic Xeric Vitricryands. Soils having andic, vitri-, or vitrandic elements have properties commonly associated with volcanic deposition, such as high content of iron, aluminum, and volcanic glass. Many soils of the dry meadows fall into subgroups that also are common in the forested lands; these include Typic Cryorthents and Typic Cryumbrepts. The volcanically influenced soils Vitrandic Cryumbrepts, Xeric Vitricryands, and Humic Xeric Vitricryands, which also are found in forested lands in the eastern portion of the survey area, are particularly notable in dry meadows near the Sierran Crest (Figure 2).

Unfortunately, meadow soils could not be mapped in this survey because of their small extent. They deserve more intensive investigation in future projects.

Interpretations and Uses

This section explains processes and activities that affect wilderness soils, and it identifies opportunities for using soils information. It gives background information pertaining to the survey area as a whole; more specific interpretations are found in the map unit descriptions.

Soil Compaction

Compaction can bring about either negative or positive consequences in wilderness soils. Compactive pressure applied to the soil surface results in decreased porosity, increased bulk density, and increased strength. Compacted soils often have hardened surfaces and platy structure, which increase resistance to root penetration and decrease permeability to water and gases, leading to increased surface runoff and erosion, and decreased gas exchange for plant roots and microorganisms. Compaction on heavily used surfaces, such as trails, increases trafficability while decreasing dust problems and erosion.

The degree of compaction is controlled by the intensity and recurrence of applied pressure, and by soil characteristics, including texture and rock content, structure, consistence, organic matter content, and water content. The coarse texture and high rock content of most high elevation wilderness soils make them more resistant to compaction than finer textured soils; nevertheless, compaction of these soils, especially under wet, spring conditions, can result in significant ecosystem damage.

Soils containing appreciable amounts of fine volcanic ash are particularly susceptible to damage by compaction. These soils are more porous and usually hold more water than soils without ash, and they lack the strength needed to hold up under applied pressure. Unlike pebble-sized pumice (called lapilli), fine volcanic ash is not easily recognized, especially when it is mixed with granitic sands; it has a smeary feel, unusually low bulk density, and often a rusty-red color when weathered. Meadows, which tend to be richer in ash than more steeply sloping lands, are most easily damaged, because of their ash and water content, and their attractiveness to large grazing animals.

Recovery from compaction depends on the degree of compaction, other soil conditions, biological activity, and environmental factors, including freeze-thaw events. Temperate forest soils that have been disturbed and compacted by hikers and horses may recover as much as one-half of their pore space and litter cover during winter periods of nonuse. Nevertheless, the absolute recovery of macropore space typically is less than 3 percent (Legg and Schneider, 1977). These soils do not fully recover because deterioration usually resumes the following recreational season; thus, the effects are cumulative. Moreover, soil lost to erosion cannot be renewed within the time of human use.

Erosion and Dust

Soil erosion, which involves detachment and transport of soil particles, may be caused by water, wind, or direct disturbance by humans or animals. It may occur as displacement of individual particles or small aggregates, as in sheet, rill, and gully erosion, or of soil *en masse*, as in soil creep and landslides. A soil's erosional potential is a function of soil and site properties and erosional forces. Soil and site properties include texture, aggregate stability, degree of protective cover, infiltration capacity, permeability, and slope steepness and length; erosional forces include precipitation and surface runoff intensity, wind speed, and degree of disturbance.

Most soils in the survey area are highly susceptible to sheet and rill erosion, because their coarse texture, low organic content, and water repellency provide little resistance to detachment on steep slopes. Soils immediately below rock outcrops are particularly susceptible to erosion during spring snow melt and summer rains.

Accelerated erosion caused by human or livestock activities can be curtailed by controlling the detachment or transport of soil particles. Effective practices include proper routing of trails to avoid wet areas, armoring trail surfaces across fragile sites, maintaining proper trail steepness, providing steps on unavoidably steep trails, providing switch-backs with deterrents to minimize short-cutting, constructing water diversions, prohibiting and discouraging heavy use near water bodies and wet meadows, and encouraging proper restraint of pack animals in camp areas. Details of engineering practices are given in "Standard Specifications for Construction of Trails" (Engineering Staff, 1984).

Dust kicked up by pack stock and hikers is a greater problem on some soils than others. The most severe dust problems develop on soils derived from metavolcanic rock material and those containing substantial amounts of fine volcanic ash. Although they compact easily, soils rich in volcanic ash also have low cohesive strength and low particle density—properties which make them especially susceptible to forming dust when exposed and disturbed. Once a trail has been established on these soils, little can be done to alleviate the dust problem, except to armor trails with local material.

Soil erosion hazards for sheet and rill erosion were rated low, moderate, high, or very high as determined from Form R5–2500–14, issue 4176, which integrates the following conditions: climate, water movement in the soil, surface runoff from adjacent areas, slope length and steepness, and soil cover (USDA Forest Service, Region 5, 1990).

Recreation

The carrying capacity of a soil to sustain recreational use is determined in large measure by the soil's resistance to, and resilience after, compaction, erosion, and chemical change. Resistance and resilience are controlled by soil texture and structure, amount and type of surface protection (by organic litter and rock fragments), humus content, drainage, severity of impact, and environmental factors (Klock and McColley, 1979). Generally, wilderness soils are part of sensitive ecosystems that are difficult to rehabilitate. Excessive impacts should be avoided. Nonetheless, moderate limitations can be overcome by careful planning and design, and prudent maintenance.

Soils derived from high-elevation granitic parent materials typically have low strength and do not compact well, making them particularly susceptible to erosion and dust formation on trails and in camp sites. Despite their moderate to low resistance, granitically derived soils usually are superior to soils developed from volcanic ash, which are more easily disturbed. Rutting, surface erosion, and severe dust problems can readily develop on these soils. Comparable conditions have been noted in other regions (Helgath, 1975).

Few trail segments are constructed through areas of high water table or restricted drainage in the High Sierra; nonetheless, these areas can present inordinate problems to trail maintenance and resource protection. Impacts can be minimized by rerouting traffic away from sensitive areas, installing log puncheons, and improving trafficability by applying rock to the trail (Engineering Staff, 1984).

Likewise, many trails, especially those in low landscape positions, are damaged by heavy spring runoff and summer storms. Often these trails, as well as those on other sensitive sites, can be built on raised beds.

Given the severe damage that can be done in a short time to weakly developed, high elevation soils by concentrated or tied packstock, and the extended time for recovery, temporary closures to pack animals do not seem effective for ecosystem recovery. Permanent livestock restrictions should be considered for particularly sensitive areas.

Apart from the limitations and challanges presented by certain soils to recreational use, soils provide unusual interpretive opportunities for wilderness rangers and visitors. Many people interested in plants, animals, birds, and geology very likely would be fascinated by the role of soils in ecosystem evolution, structure, and functioning if only they were aware. For example, few wilderness users are aware that volcanic ash and cinders, erupted from Mono Craters, cover the ground in many parts of the Wildernesses, even on the west side. Much of the productivity of mountain meadows for grass, wild flowers, and wildlife is related to weathered fine volcanic ash mixed in the soil (Figure 2). This ash typically feels smeary, is reddish color, and has unusually low bulk density and high water holding capacity. Soils rich in finely divided volcanic ash tend to be thixotropic; that is, they exist as a moist solid in the undisturbed state, but liquify upon disturbance. This phenomenon is similar to the behavior of mayonnaise, which liquifies upon shaking.

The Alfisol found on Junction Bluffs, between Middle and South Forks San Joaquin River, could be interesting to some visitors. This soil is unusual for the High Sierra in that it is a well developed soil surrounded by immature soils. The soil's parent material, development, and location suggest that this could be one of the oldest land surfaces in the High Sierra, dating back nearly three million years, instead of the more common 10 to 20 thousand years.

Several other points of interpretive interest are given in the map unit descriptions.

Grazing

Although dispersed grazing of recreational and commercial packstock is allowed throughout most of the survey area, fewer than half the cattle allotments are open to active grazing under allotment management plans; the remainder have been vacant for several decades. The active allotments, most of which are in the 1984 wilderness additions, provide primary forage in meadows and secondary forage for dispersed use outside of meadows. Cattle use secondary forage incidentally as they drift between meadows. The grazing season typically lasts from July 1 to September 15 or 30. In Fall, after the first frost kills favorable meadow forbs, cattle tend to move from primary forage in meadows to secondary forage in forested areas.

The most productive High Sierran soils for livestock use are found in moist and wet meadows, followed by dry meadows. Productivity of meadows in the Sierra Nevada as a whole decreases with increasing elevation (Figure 9). For example, herbage production of moist meadows in good condition ranges from about 3,100 lbs/ac/yr at 5,000 feet elevation to 1,500 lbs/ac/yr at 11,000 feet. At similar elevations, the productivity of moist meadows in poor condition and of dry meadows in good condition is less than half this amount (Ratliff et al., undated).

Whereas proper grazing can enhance forage productivity, improper grazing can greatly decrease it. The soils in the High Sierra capable of producing the most forage—namely those in wet and moist meadows—also are the most easily damaged by heavy or poorly timed livestock use (Figure 2). These soils, which tend to be medium textured and often contain medium to fine volcanic ash, have high water holding capacity, but also are easily compacted and eroded. Once degraded, these soils and plant communities normally require several decades to recover. Most meadows are improving from past over-grazing, and today are in fair to good condition, except for localized sites that have not recuperated from severe abuse suffered a century ago.

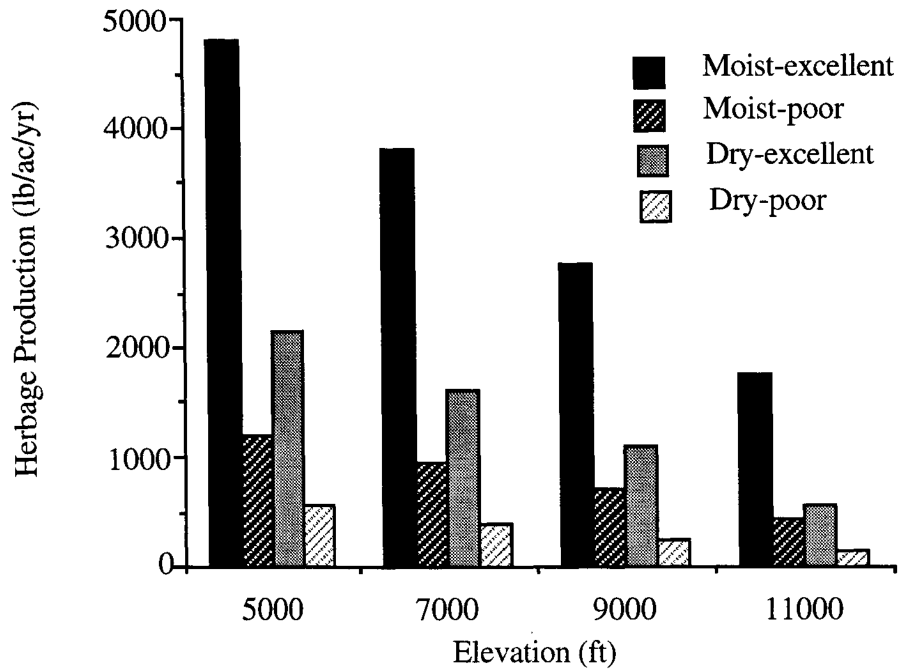


Figure 9. Estimated herbage production by elevation for moist and dry meadows in excellent and poor condition (data from Ratliff et al., undated).

Wildlife

Overall, wildlife find less forage and winter cover in the survey area than in lower elevation adjoining lands, because of colder temperatures, greater snowfall, and less soil development at the generally higher elevations of the survey area. Within the area, species richness of plants and wildlife decrease along with soil development as elevation increases. These trends hold more often on the west slopes of the Sierra Nevada than along the steep eastern escarpment, where low elevation habitat is limited by arid conditions. Habitat diversity on the east side increases with increasing elevation and available moisture until cold temperatures become the limiting factor.

The most productive habitats in the High Sierra are associated with meadows and water courses, where soils are deep, organic-rich, and moist. Wet and moist meadows lie in depressions and along drainage bottoms that continually are supplied with runoff water and sediments, and that have accumulated volcanic ash blown in from surrounding uplands. These inputs, combined with fewer losses than surrounding uplands, stimulate development of the most productive and species-rich communities in the survey area.

Apart from low to middle elevation meadows and riparian zones, sites supporting the mixed conifer, Jeffrey pine, and ponderosa pine vegetation series have the greatest wildlife diversity, because of favorable climatic conditions and high variety of trees, shrubs, forbs, and grasses that provide food, cover, and nesting sites. Moreover, the natural fire regime of these areas is characterized by frequent, low intensity surface fires that stimulate a vigorous, multilayered plant community favorable to birds and animals.

At higher elevations, growing season and soil temperatures decrease in the red fir, lodgepole pine, and related vegetation series, where surface fires, although of low intensity, are less frequent and less stimulating to wildlife habitat. Nonetheless, red fir stands commonly are uneven-aged, exhibiting more favorable spatial gaps and structural diversity than the more even-aged lodgepole pine stands. Moreover, compared to lower and higher elevation sites, soils in the red fir zone may have greater plant-available moisture for wildlife forage in summer, especially in early stages of forest succession. Shrubs and herbs decrease considerably under closed canopies in late seral stage red fir forests.

Vertical habitat diversity, browse species, herbaceous ground cover, and surface litter continue to decrease along with wildlife species richness into the subalpine forest and alpine dwarf scrub zones. Rock outcrops are extensive here, and soils are cold, infertile, and very weakly developed, although they may be deep to very deep.

Overall, Umbrepts are the forest soils most suitable for wildlife habitat. Alfisols and Andisols also are well suited, but are of minor extent. Some sites having less developed soils, such as Ochrepts or Orthents, also may be well suited if temperature and moisture conditions are favorable. Although Mollisols often are considered suitable for wildlife habitat, their value is low in the survey area because they occur on sites too dry to support abundant essential vegetation.

Habitat for hibernating rodents generally is good, even in high elevation, coarse textured, low productivity soils. Soil strength is weak enough for easy digging, and soil depth provides adequate insulation. Although sands and loamy sands normally are considered poorly suited for animal burrows because of loose consistence and tendency to collapse, the high rock fragment and root content of most High Sierra soils provides natural walls and ceilings. The least suitable soils for burrowing are those in Lithic subgroups, because of shallow depth, and Torripsamments, found above Owens Lake, because of loose consistence and lack of supporting rocks or roots.

Fisheries

In addition to metering and filtering water delivered to streams by runoff, soils affect the physical, chemical, and biological properties of streams. Eroded soil often becomes sediment in the stream, contributing to the bedload, suspended sediments, and turbidity. Streams in the High Sierra generally have gravelly to sandy beds, transient suspended sediments, and low turbidity, because of the coarse texture and low humus content of soils in the watershed.

Stream and lake waters in the High Sierra have neutral acidity (pH 7), as indicated by numerous random measurements using a colorometric indicator during the course of this survey. The pH of stream water is partly controlled by the chemistry of soil and its parent material; the pH, in turn affects nutrient solubility.

Ions and chemical compounds in the soil can leach or erode to streams, providing nutrients that are passed up the food chain to fish. Productivity of a fishery, then, is partially dependent on the fertility of soils in the watershed. Some High Sierra lakes must be restocked periodically to maintain fish populations because of inadequate spawning areas and insufficient nutrients caused by limited weathering of the bedrock and low soil fertility. Additional, more detailed work is needed to quantify the correlation between soil and parent material properties and fish productivity.

Fish stocking has led to increased recreational pressure and increased soil impacts around lakes. One way of controlling recreational impacts might be to limit fish stocking efforts in sensitive areas.

Watershed

Watershed values include quality, quantity, and rate and timing of release of water from surface and aquifer storage. Although water quality, surface storage, and rate and timing of release are well recognized for the survey area, the value of soils and weathered rock in transmitting and storing subsurface water probably has been greatly underrated. General perception and earlier reports, based largely on superficial observations and aerial photographic interpretations, predicted the common High Sierra soils to be shallow (i.e., less than 20 inches) to bedrock. In this survey, depths greater than 40 inches commonly were measured, and depths greater than 60 inches commonly were projected in soils previously assumed to be less than 20 inches (a number of observations led to bedrock depth projections greater than ten feet). Soils in narrow bedrock cracks also tend to be very deep, suggesting that the role of bedrock fracturing may have been underestimated in the past.

The major factors that limit the watershed value of these deep soils include low water retention caused by low clay content (often less than 5 percent), presence of abundant rock fragments, general lack of saprolite (weathered, clay-rich bedrock), and steepness of ground and bedrock surfaces.

On average, the 835,000–acre survey area collects approximately 2.5 million acre feet of precipitation per year. (This value was calculated from the average water content in the April 1 snow pack for all snow courses in or immediately adjacent to the wildernesses (California Cooperative Snow Surveys, 1993), and assuming that snow pack water is 80 percent of total average annual precipitation.) The area apparently supplies nearly three fourths of the total water yield from the Sierra National Forest. Although comparable yield estimates could not be made for the Inyo National Forest because of lack of data, the wilderness lands also are known to produce a substantial amount of water on that forest.

The area releases some of the highest quality water in the world. The high watershed value results from the area's great extent and high elevation, which allow it to release high purity water from deep winter snow packs. In addition, many of the high elevation soils allow ready passage of water without contributing significant nutrients or contamination.

Most water is assumed to be stored in the snow pack and lakes, followed by deep, weakly weathered glacial till deposits and bedrock fractures. Although soils supply water to vegetation, they store little water for watershed purposes. Their main function is to capture water from snow melt and summer rain, and transmit it to streams and aquifers. The most common map unit components in the survey area include Typic Cryorthents, Dystric Cryochrepts, and Typic Cryumbrepts, which commonly have moderate to low water retention; and Rock Outcrop–Rubblelands, which have low to negligible water intake as well as retention.

The presence of water repellent soil layers slows infiltration, but does not inhibit it completely. Commonly, water runs over bare, hydrophobic soil surfaces for short distances before infiltrating the soil through animal and insect burrows old root channels, or intermittent zones of wettable soils. Significant overland flow can occur on slope gradients as low as about 8 percent. Water infiltration and percolation in the absence of hydrophobic layers usually is judged to be rapid to very rapid, a rate exceeding 6 inches of water transmission per hour. Subsurface flow is expected to be at least moderately rapid in most of the soils. These water transmission rates are estimated from soil texture, structure, and consistence; actual measurements are needed to test their validity.

The low porosity of granitic rock, which underlies most of the survey area, typically increases about 2 to 5 percent with initial fracturing. Weathering along the fractures and the presence of three-dimensional perpendicular joints often increase the porosity to 10 to 20 percent. Intense physical disintegration and chemical decomposition can increase porosity to 30 to 60 percent. The porosity of weathered rock available for water storage above the hard lithic surface probably is about 20 percent by volume; in fractures beneath the lithic surface, the porosity is probably about 10 percent. These values can reach 40 percent in the upper vadose zone (i.e., the unsaturated zone above a water table, including the soil). Specific yields, that is the volume of water that drains from saturated rock per unit of total rock volume, have not been measured.

Steep slopes and abundant rock outcrop, combined with coarse textured, often hydrophobic soils make for rapid hydrograph responses during snow melt and rain storms.

Fire

The impact of fire on wilderness ecosystems is highly variable. Fire can advance soil development by intensifying physical and chemical weathering, or it can set back development by accelerating soil erosion. For example, heat from an intense fire can break rocks by a process called spalling, which is the exfoliation of thin, curved, sharp-edged rock pieces (Figure 10). This process increases the exposed rock surface, thereby enhancing potential for chemical weathering. At the same time, the soil's protective vegetative cover can be destroyed, and organic compounds that cement soil particles can be volatilized.

Fire's vegetative impacts can be extreme; nonetheless, fire usually has only slight to moderate impact on wilderness soils. Most areas have insufficient fuel to carry an intense or long duration ground fire. The ecological effects are negligible in units of rock outcrop, even though lightning strikes are frequent, because of the paucity of fuels and cool night temperatures at high elevations. Impacts are slight to moderate in complexes and associations of Typic Cryorthents and rock outcrop that support open forest stands and patches of continuous fuels. Impacts can be severe in units of Typic Cryumbrepts and Dystric Xerochrepts that support nearly closed forest stands with heavy continuous fuels, including a well developed duff layer.

Sites that have a significant duff layer lose part of their organic material into the atmosphere as smoke, but a substantial portion of the organic carbon and associated nutrients remain on the site, and are translocated to the mineral soil, where they become available for biological use.

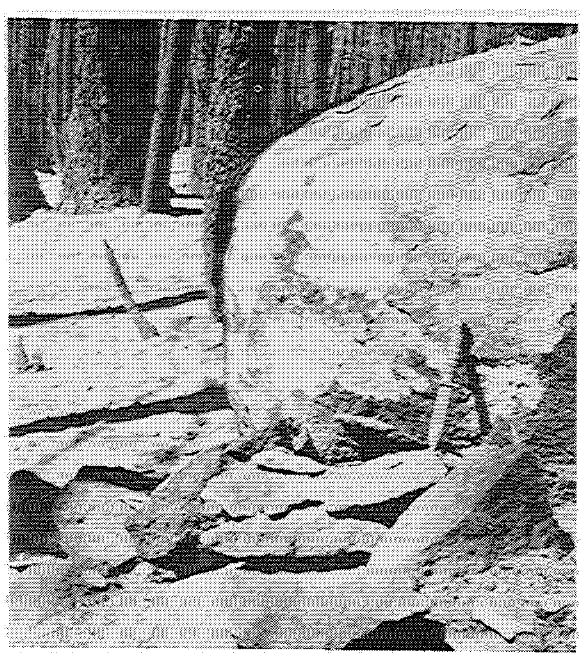


Figure 10. Spalling of a granitic boulder caused by intense heating during a forest fire. (Photograph was taken outside of the survey area, but at a site similar to many in the area.)

Some volatilized organic compounds are driven beneath the ground surface where they condense on cooler particle surfaces, rendering them hydrophobic. This phenomenon often decreases top soil permeability, thereby increasing surface runoff and erosion. Water repellency is most notable in coarse textured, dry soils exposed to moderate or high intensity fire. (In some cases, high intensity fire near the ground can completely volatilize the hydrophobic components into the atmosphere, leaving the burned soil wettable.) After the fire, rain water readily soaks into the surface layer, but is strongly repelled when it encounters the hydrophobic zone, usually at one-fourth to three inches depth. The upper soil layer may suffer severe sheet and rill erosion, but the depth of rills often is limited by the water repellent surface.

In previously unburned soils that are water repellent at the surface, fire likely will drive the hydrophobic layer below ground, thus increasing the permeability of the surface, but decreasing the permeability just below the surface. Water passes through the hydrophobic zone via root channels and animal and insect burrows. This water spreads out below ground, and some of it moves back upward by capillary action, wetting the topsoil within a few days (Figure 11). Over time, perhaps several years, the hydrophobic compounds rehydrate, allowing the overall water percolation rate gradually to increase. Although this process model appears to be common in the coarse textured soils of the survey area, models can vary considerably with soil characteristics and conditions.

Fire effects also are limited by the soils' commonly cool temperatures, low thermal conductivity, and low heat capacity. Dry, coarse textured soils under localized heavy fuel can reach very high surface temperatures (>500° C), but significant heat rarely is transmitted more than one to two inches downward. These soils cool rapidly once the heat is removed.

Apart from increased soil erosion and hydrophobicity, the greatest readily measurable impact of fire would be to raise the soil pH (i.e., decrease the acidity), which could go up by three pH units on strongly acidic soils

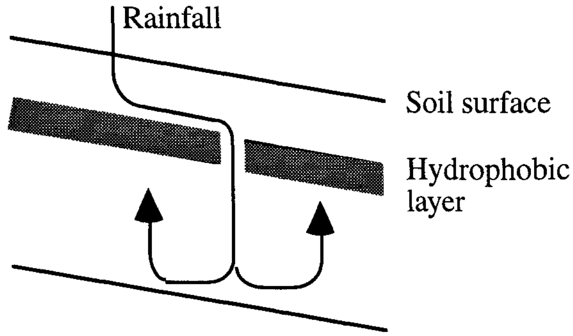


Figure 11. One model of water flow through an open channel in a hydrophobic layer. Soil suffers sheet and rill erosion above the layer.

supporting large fuel accumulations. A pH increase of this magnitude increases the availability of nonmetallic plant nutrients, including calcium, magnesium, potassium, and nitrogen, although considerable nitrogen can be lost in the smoke. (Half of the nitrogen can be lost at temperatures as low as 300° C.) Sodium availability also increases, and the element may be taken up by plants and microorganisms, although it is not considered universally essential for plants.

The chemical changes lead to increased rates of organic mineralization and nitrification in the fire zone and surrounding areas affected by significant ash fall. This flush of nutrients, which often is called the "ash bed effect" can stimulate new plant growth after the fire. The most significant plants to recolonize a burned site are nitrogen fixers, including lupine and vetch, which replenish the plant-available nitrogen supply within a few years.

Acidic conditions will return after the fire, with the rate of recovery being controlled by soil and environmental factors as well as by fire intensity and amount of fuel burned. Generally, the low buffering capacity of these soils would allow the pH to drop to within one unit of prefire levels within about two to four years after the fire, and to regular levels within a decade. In extreme cases of completely burned heavy fuel on fine textured soils, evidence of the chemical changes could persist for several decades.

The rate of full ecosystem recovery after fire is slow in most of the survey area, because of the short growing season, limited summer moisture, and generally low soil fertility. Nonetheless, recovery into the first post-fire seral stage, leading to site stabilization, can occur by the end of the next growing season. Throughout most of the survey area, fire is not expected to affect the soils in a manner that would be highly detrimental to human values, except for a temporary aesthetic effect. Artificial post-fire rehabilitation measures normally are not warranted, unless sites have been disturbed significantly by fire suppression activities.

Acidic Deposition

In this survey, acidic deposition refers to any airborne addition to the soil, including fog, rain, snow, and particulates, having a pH lower than that of normal atmospheric inputs (Binkley et al., 1989). This survey predicts the likely effect of acidic depositions on the soils, and identifies map units or locations thought to be suitable for potential monitoring sites.

Deleterious effects of acidic precipitation include soil acidification, accelerated nutrient loss, and mobilization of soluble aluminum and other potentially toxic metals. These effects are most pronounced in coarse textured, organic poor, weakly developed soils formed from granitic parent materials—characteristics common to the majority of High Sierra soils. Although this survey identifies soils that are most sensitive and least sensitive to potential effects of acidic precipitation, evaluations are confounded by vegetation type and abundance, dry deposition, and mineral weathering. Proper detection and interpretation require intensive and extensive monitoring of atmospheric inputs and of soil solution chemistry. The monitoring should be done throughout the year, when plants are actively growing and when they are dormant.

The potential effect of acidic deposition on a soil depends on the soil's buffering capacity and its degree of base saturation. The buffering capacity is a measure of the soil's ability to resist chemical change, most notably cation leaching and a change in pH. Generally, soils having a high surface area to volume ratio, such as clays and organic-rich soils, are strongly buffered; whereas, those having a low surface area to volume ratio, such as sandy, organic-poor soils, are weakly buffered. The dominant soils of the High Sierra, which are coarse textured and humus-poor, are weakly buffered, meaning that they are susceptible to chemical change should they receive substantial acidic inputs. Notable exceptions are soils of the meadows, which tend to be organic-rich, and Alfisols, which tend to be clay-rich.

Base saturation indicates the relative proportion of calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^{+}), and sodium (Na^{+}) (i.e., common cations other than hydrogen (H^{+}) and aluminum (Al^{3+})) on soil particle surfaces, collectively called the "exchange complex." Although base saturation does not influence a soil's resistance to atmospheric inputs, ecosystems whose soils have a high base saturation are expected to be more affected by acidic deposition than are ecosystems whose soils have low base saturation, because low-base systems naturally are more adapted to acidic conditions.

Soil base saturations tend to increase from the western to the eastern side of the Sierra. This change may or may not be indicated by the soil's taxonomic name. For example, soils designated "dystric" or "umbric" have base saturations less than 60 or 50 percent, but other soils having low base status, such as some Typic Cryorthents, are not designated by name.

Most west-side forest soils receiving light to moderate acidic depositions probably would remain biologically suitable for at least several generations, because their organisms are well adapted to acidic conditions. Concerns generated by possible heavy acidic depositions generally are for indirect, long-term impacts. For example, aluminum toxicity might be increased and soil fertility decreased. Alternatively, acidic precipitation may speed weathering of rocks, which would increase nutrient release and clay formation.

Mining

As an extractive industry, mining necessarily devastates portions of the landscape. Once an ecosystem has been destroyed, its soil excavated, and off-site damages accrued, the cost of comprehensive, effective reclamation usually is extremely high. Although physical improvements may be feasible, correcting chemical and biological degradations often is technically difficult, if not impossible. Fortunately, most ecological damage from mining operations in the wildernesses is contained in the vicinity of the operations. At the few mines and test holes visited in this survey, including Pick and Shovel, Hilton Creek, and several unnamed diggings, no evidence was noted of resource damage that reasonably can be mitigated. The sites are remote, and have dry, unproductive soils and short growing seasons. Although rehabilitation may be possible, its high costs and resource requirements would preclude most effective restoration activities. Nevertheless, some abandoned mining sites perhaps should be reclaimed, especially if off-site damage is continuing. These areas require specific site investigations to assess the problems and plan remediation measures.

Research and Monitoring

The High Sierra survey area offers numerous opportunities for studies and environmental monitoring of air, water, soil, vegetation, wildlife, and climate in ecosystems that are virtually undisturbed by human activities. Perhaps the greatest opportunity lies in the value of wilderness ecosystems as reference areas or standards against which impacts of land management outside of wilderness might be judged. The main restrictive criterion of all studies is that they be kept nondestructive, unobtrusive, and within the limitations and intent of the Wilderness Act. The following topics, conditions, and processes, which were noted during the course of this survey, merit more detailed investigation:

- watershed characteristics and hydrology, including water budgets in high elevation expanses of fractured bedrock and deep, coarse textured soils between rock joints;
- periglacial and nivational processes in alpine fell-fields and high elevation glaciated canyons, including those at Dana Plateau, Pioneer Basin, Humphrey Basin, and upper Bloody Canyon;
- natural soil erosion, especially of coarse textured materials derived from granitic parent materials, soils containing volcanic

debris, and soils of meadows and riparian zones;

- soil water repellency, especially without clear evidence of fire history;
- wildfire effects and ecosystem response and recovery without artificial rehabilitation;
- soil temperature and moisture regimes as related to vegetation, elevation, topography, latitude, climate, and geographic location, and the elevation above which low soil temperature becomes more limiting than low soil moisture to ecosystem development;
- mineral weathering and soil formation, especially the relative lack of soil development in granitically derived materials under moderate to heavy vegetative cover and after thousands of years of exposure;
- the formation of a well developed Alfisol at moderately high elevation in volcanic rock on Junction Bluff;
- the formation of deep soils and the related forest on Stecker Flat and Shingle Mill Bench;
- the formation of Psamments on east-facing mountain slopes above Owens Lake;
- the development and ecological significance of a slightly hard, apparently silica cemented layer that may be an incipient fragipan, but which allows root penetration, in pumiceous materials southeast of Devil's Postpile;
- occurrence and significance of volcanic ash in high elevation basins, and the subsequent development of Andisols;
- soil base saturations and related chemical and mineralogical properties across the Sierran Crest, especially for future acidic precipitation interpretations;
- regeneration of red fir related to surface litter and mineral soil conditions;
- meadow soils, ecology, and erosion, with and without livestock grazing;
- fish habitat in natural watersheds, especially as affected by soil and geologic conditions.

Soil Map Units

Special Definitions and Criteria

Vegetation Series

The vegetation series designations conform as closely as possible to those defined in "Calveg, A Classification of California Vegetation" (Parker and Matyas, 1979). The series given in each description is that most typical of the map unit at the time of sampling. The series are based on existing vegetation, with the name being taken from the dominant overstory plants. The vegetation series found in the survey area are as follows:

- Ponderosa pine series: This series is found mainly as open stands of ponderosa pine (*Pinus ponderosa*) at low elevation, above chaparral and hardwoods and below the mixed conifer – fir series. Associated species include incense cedar (*Calocedrus decurrens*), sugar pine (*P. lambertiana*), and white fir (*Abies concolor*).
- Mixed conifer – pine series: The principal species include ponderosa pine and sugar pine, with associated white fir, incense cedar, and occasional hardwoods. Shrubs include manzanita (*Arctostaphylos* spp.) and ceanothus (*Ceanothus* spp.).
- Mixed conifer – fir series: This series may include white fir and sugar pine, with red fir (*A. magnifica*), lodgepole pine (*P. contorta,* var. *murrayana*), incense cedar, and ponderosa pine as occasional associates. Stand structure and local dominance may be highly variable.
- Jeffrey pine series: Although Jeffrey pine (*P. jeffreyii*) is dominant, the series may include occasional red fir or lodgepole pine, and single leaf pinon (*P. monophylla*) or big sage (*Artemesia tridentata*) east of the Sierran Crest. West of the Crest, the Jeffrey pine series normally is found at higher elevations and on colder soils than the ponderosa pine series, and east of the Crest it occurs between sagebrush at lower elevation and red fir at higher elevation.
- Red fir series: This series occurs above the mixed conifer – fir series and usually below the lodgepole pine series on the west side, and often above the Jeffrey pine series on the east side. Red fir stands commonly are pure and dense, but lodgepole pine, incense cedar, and mountain hemlock (*Tsuga mertensiana*) are occasional associates.
- Western white pine series: This series, dominated by western white pine (*P. monticola*), occasionally can be found associated with red fir, lodgepole pine, and mountain hemlock on dry, moderate to high elevation ridges.
- Lodgepole pine series: This high elevation series occurs on cold soils, mostly at elevations above red fir. Lodgepole pine is a common invader of meadows, and reproduces well following fire.
- Mountain hemlock series: Mountain hemlocks are uncommon in the survey area, occurring mostly on cold, moist slopes. Associated species include lodgepole pine, western white pine, red fir, and foxtail pine (*P. balfouriana*).
- Whitebark pine series: Whitebark pine (*P. albicaulis*) persists on high, wind-swept ridges, and often develops a krummholz form. Associates may include lodgepole pine and foxtail pine.
- Limber pine series: Limber pine (*P. flexilis*) persists on dry, high elevation, coarse, rocky sites where white bark pine is absent.
- Foxtail pine series: This high elevation series is found in the Cottonwood Lakes region, on the east side. Its main associated plants are various shrubs.
- Single leaf pinon series: This series consists of open stands of pinon pine and associated western juniper (*Juniperus occidentalis*) and shrubs, including mountain mahogany (*Cercocarpus ledifolius*), big

sage, bitter brush (*Persia tridentata*), and rabbit brush (*Chrysothamnus* spp.). The series is virtually restricted to east of the Sierran Crest.

- Alpine dwarf scrub series: This series is found in cushion plant dominated fell-fields that support squirrel tail (*Sitanion hystrix*), phlox (*Phlox covillei*), and sedge (*Carex*). It is typical at the highest elevations in the survey area.
- Perennial grass series: This series occurs in meadows, in openings in red fir and lodgepole pine forests, and on broad grass covered lower back slopes to toe slopes above Owens Valley. Common plant genera include *Poa, Bromus, Elymus, Stipa, Lupinus,* and *Calyptridium.*
- Green leaf manzanita series: In the survey area, green leaf manzanita (*Arctostaphylos patula*) grows dominantly on the east side, in the Mono Basin drainage. Mixed conifer – fir, red fir, and Jeffrey pine may be associated.
- Big sage series (part of sagebrush shrub): Big sage and bitter brush often grow together, along with juniper, manzanita, rabbit brush, and various grasses on the east side.
- Curl leaf mountain mahogany series (part of sagebrush shrub): This series is closely associated with single leaf pinon and juniper east of the Sierran Crest.
- Desert shrub series: Dominant species include Mormon tea (*Ephedra* spp.), creosote bush (*Larrea divaricata*), various cacti (*Opuntia* spp. and *Echinocactus* spp.), and an occasional joshua tree (*Yucca brevifolia*). The series is restricted to the extreme southeastern portion of the survey area.

Drainage Class

Soil drainage class is a function of the degree, frequency, and duration of soil wetness, which in turn affects soil aeration. It is inferred from soil morphology, most notably color, and landscape position. Seven drainage classes are recognized:

- Very poorly drained: The water table remains at or near the surface most of the year, and soil is mottled or gleyed. Slopes usually are nearly level or depressed. Surface horizons may be peaty or mucky.
- Poorly drained: The soil remains wet much of the time, with the water table seasonally near the surface for prolonged periods. Soils are mottled to near the surface, and commonly gleyed at depth. Peaty or mucky surface horizons usually are not present.
- Somewhat poorly drained: Soil is wet for significant periods, but not year around. A slowly permeable layer or high water table usually is present. Soil A horizons usually are thick and dark, and mottles are found at depth.
- Moderately well drained: Soil is wet for a small, but significant part of the year, usually because of a slowly permeable layer, a high or seasonally high water table below five feet, surface runoff from upslope, or some combination of these conditions. Surface horizons tend to be thick and dark and faint mottling occurs at depth.
- Well drained: Water drains from the soil readily, but not rapidly. Soils are well aerated and not mottled. Textures normally are intermediate to coarse, but may be fine in dry climates.
- Somewhat excessively drained: Water drains from the soil rapidly. Soils are not mottled, usually have little horizon differentiation, coarse textures, and may be shallow.
- Excessively drained: Water drains very rapidly. Soils are very porous, coarse textured, and often are shallow and on steep slopes. Colors are similar to well drained soils.

Water Repellency

Soil water repellency, or hydrophobicity, is determined by the water drop penetration test, which is accomplished by noting the wetting angle within a water drop placed on the soil (Figure 12) and by the time required for the drop to be absorbed by the soil (DeBano, 1981). The wetting angle and penetration time increase with increasing hydrophobicity. A soil is considered water repellent if the penetration time exceeds five seconds; it is extremely water repellent if the penetration time exceeds five minutes or the initial wetting angle is greater than 90 degrees. (Theoretically, if the angle exceeds 90 degrees, water will evaporate before it can be absorbed by the soil.) Intermediate repellency ratings used in this survey are slight and moderate.

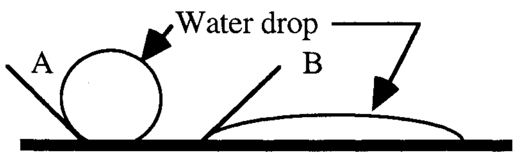


Figure 12. Wetting angle (A) greater than 90 degrees and (B) less than 90 degrees.

Hydraulic Conductivity

Hydraulic conductivity is the rate (distance/time) of water flow through the soil. It may be evaluated in either the unsaturated state or saturated state, with the saturated state being more commonly used because of relative ease in measurements and calculations. (Saturated hydraulic conductivity is equivalent to permeability.) Either way, hydraulic conductivity can be highly variable, even for a single soil, because it changes with physical, chemical, and biological processes, as well as with temperature and chemistry of the water.

Although classes of unsaturated hydraulic conductivity have not been defined for soil survey, classes of saturated hydraulic conductivity have been defined in various ways. This survey follows the definitions and criteria for saturated hydraulic conductivity given in the *Soil Survey Manual* (Soil Survey Division Staff, 1993), but it also evaluates unsaturated hydraulic conductivity in a general sense when useful for interpretations, as in the case of rain or snow melt on hydrophobic soils.

The saturated hydraulic conductivity classes in metric and English units are listed below. These units are more comprehensible if one considers that soil having a very high rating could transmit more than 28 feet of water per day; whereas, soil having a very low rating could transmit only 0.03 inches (about the thickness of a penny) of water per day.

	Rate	
Class	µm/sec	in/hr
Very high	>100	>14
High	100–10	14–1.4
Moderately high	10–1	1.4–0.14
Moderately low	1–0.1	0.14–0.01
Low	0.1–0.01	0.014–0.0014
Very low	<0.01	<0.0014

Overland Flow

Overland flow indicates the rate at which water moves across the soil surface; it is the difference between the amount of water that a site receives from either precipitation or run-on from an adjacent area and the amount that infiltrates the soil in a given time. It varies with most soil properties, including hydrophobicity and soil water content. It is presented here to augment hydraulic conductivity ratings, especially for dry, hydrophobic soils. It is distinguished from runoff, in that the water often flows only short distances across the ground surface, without reaching the stream channel. Ratings for overland flow are as follows:

Ponded: Free water stands on the ground surface for significant periods. Ponding occurs only on level to nearly level depressional surfaces.

Very slow: Incoming water may stand on the ground surface for significant periods, and slowly flow down slope, or it may be immediately absorbed by the soil. Soils are level or nearly level, or they are sufficiently open to allow free entry of water, leaving very little to move across the ground surface.

Slow: Incoming water may stand on the ground surface for moderate periods while slowly flowing down slope, or it may be rapidly absorbed by the soil. Soils are nearly level or gently sloping, or, if they are steeper, they absorb water very rapidly.

Medium: Incoming water may stand on the ground surface for only short periods. Part of it flows off, while the remainder enters the soil. Soils are gently sloping to moderately sloping, or, if they are steeper, they absorb water rapidly.

Rapid: Incoming water flows away fast enough that the concentration period is brief, and free water does not stand on the surface. Only a portion of the water enters the soil. Soils are strongly sloping to moderately steep, and may have moderate to slow infiltration.

Very rapid: Incoming water flows away so fast that the concentration period is very brief, and free water does not stand on the surface. Soil are steep to extremely steep, and may have slow infiltration.

Plant-Available Water Capacity

Plant-available water capacity, or simply available water capacity (AWC), is the maximum relative amount of water a soil can hold against gravity and be extracted by plants. It is considered to be the percent water held between field capacity and permanent wilting point. These terms were defined originally for common agricultural soils and crops; therefore, in other applications, AWC can be used only as a comparative index, rather than a literal interpretation.

In this survey, plant-available water capacity is given as a percent by volume, which is the same as depth of plant-available water held per depth of soil. One percent water by volume equals 0.01 inches of water per 1 inch of soil. Ratings are as follows:

	Percent	Inches/Inch
Very low	0 to 4	0 to 0.04
Low	4 to 8	0.04 to 0.08
Moderate	8 to 12	0.08 to 0.12
High	12 to 16	0.12 to 0.16
Very high	> 16	> 0.16

Erosion Hazard Rating

Soil erosion hazard ratings (EHR) follow the criteria and guidelines in the Soil and Water Conservation Handbook, Chapter 50–Soil Erosion Hazard Rating, which is contained in Forest Service Handbook R-5, 1990, Amendment 2. The ratings assign a relative risk of maximum accelerated erosion based on the long-term average occurrence of two-year interval, six-hour intensity storms. They apply only to sheet and rill erosion accelerated by human or animal activities, or by fire. Moreover, they are based on the assumption of less than 10 percent soil organic cover, which is the most severe condition, giving the maximum soil erosion hazard rating. The ratings are intended for general, broad scale applications, and should be recalculated using actual cover factors for site-specific work. The four ratings are defined as follows:

- Low EHR: Accelerated erosion is not likely to occur, except during above average storm intensities or in areas where the rating approaches moderate. If accelerated erosion does occur, adverse effects are expected to be minimal.
- Moderate EHR: Accelerated erosion is likely in most years. Adverse effects on soil productivity and water quality may occur during above average storm intensities and in areas where the rating approaches high.
- High EHR: Accelerated erosion will occur in most years. Adverse effects on soil productivity and water quality are likely, especially during above average storms.
- Very high EHR: Accelerated erosion will occur in most years. Adverse effects on soil productivity and water quality are very likely, even during below average storms.

Landscape Stability Hazard

This interpretation assesses the soil's potential for land sliding, based on slope steepness; bedrock type, orientation, and condition; drainage pattern; soil strength (cohesive and interlocking, as judged in the field); and occurrence of existing land failures. Rating classes are ranked relative to each other as follows: very high, high, moderately high, moderately low, low.

Recreational Use

Criteria and ratings for recreational use interpretations are adapted from the *National Soil Survey Handbook* (Soil Survey Staff, 1993), with modifications to reflect wilderness use and values. Suitability of the soils or rock outcrop areas for camp sites and trails is rated as follows:

- Well suited: Sites generally are favorable for the use, with no significant limitations that can be identified at the intensity of this survey. Good performance, ecosystem resilience, and low maintenance are expected.
- Suitable: Sites are moderately favorable for the use. One or more soil or site limitations exist. Careful planning and prudent maintenance are required to ensure safety and preservation of wilderness values.
- Poorly suited: One or more soil or site limitations make the area unfavorable for the use. Overcoming limitations requires special design, extra maintenance, costly alteration, or serious compromises of wilderness integrity.
- Unsuitable: Resource attributes required for the use do not exist, expected outcomes are unacceptable, or extreme measures are needed to overcome the limitations.

Livestock Grazing

Grazing potential and limitations are evaluated for untended cattle and tended pack stock according to the following ratings:

- Well suited: Forage production potential is adequate, and erosion hazard rating is low or moderate. No significant limitations can be identified at the intensity of this survey. For cattle, allotments are active. Good performance, ecosystem resilience, and low maintenance are expected.
- Suitable: Sites are moderately favorable for grazing. One or more soil or site limitations exist, such as limited forage production potential, high or very high erosion hazard rating, or poor trafficability. Sites usually are more suitable for tended pack stock than for untended cattle.
- Poorly suited: One or more soil or site limitations make the area unfavorable for grazing. Limitations include inadequate forage, or high or very high erosion hazard rating combined with poor trafficability. Sites may be suitable for limited use by tended pack stock but not by cattle. Potential for resource damage is high.
- Unsuitable: Forage is inadequate, cattle allotments are vacant, or erosion hazard rating is very high and trafficability is poor.

Wildlife Habitat

Criteria and ratings for wildlife habitat interpretations are adapted from the *National Soil Survey Handbook* (Soil Survey Staff, 1993), with consideration for management constraints in wilderness. Habitat elements considered include availability of forage and cover, and suitability of soil for burrowing mammals and reptiles. Ratings are as follows:

- Good: Habitat elements generally are favorable and adequate for the wildlife specified, with no significant limitations that can be identified at the intensity of this survey.
- Fair: Habitat elements are moderately favorable for the wildlife specified. One or more soil or site limitations exist.
- Poor: Habitat elements are seriously deficient in quality or extent, or are missing.

Watershed Rating

Criteria for watershed ratings of each map unit are based on watershed elements consisting of landscape features, soil and parent material properties, and bedrock characteristics. These elements fall into three broad categories: (i) those that pertain to receiving or capturing snow or water from the atmosphere or from units higher in the survey area; (ii) those that influence the transmission of water by overland flow or subsurface flow; or (iii) those that control storage of surface water or ground water (Table 2).

Overall watershed rating of each map unit is given as high, moderately high, moderate, moderately low, or low based on composite field evaluations and judgments made from information available from other sources.

TABLE 2. Elements used for map unit watershed ratings.

Receiving Elements	Transmission Elements	Storage Elements: Surface Storage	Storage Elements: Subsurface Storage
Precipitation Size of map unit Elevation Slope steepness Proximity to higher elevation transmitting units	Slope steepness Depth to bedrock Soil permeability Vegetation Rock outcrop Bedrock weathering Bedrock fracturing Bedrock permeability Bedrock slope	Snow retention Evaporation rate Slope steepness Vegetation	Rock outcrop Water-holding ability of soil and substratum Depth to bedrock Bedrock weathering Bedrock fracturing Bedrock porosity Bedrock slope

Fire Effects

Fire effects are rated according to a fire's anticipated intensity and impacts on soil, including potential for ecosystem recovery. Intensity ratings are as follows:

- Low: Aerial fuels may be scorched, but trees are not killed. Ground fuel may be partially consumed, including loss of the uppermost portion of O horizons. Mineral soil is little affected, except for creation or aggravation of a hydrophobic layer within 1/4 inch of the surface.
- Moderate: Tree crowns are burned, and up to 50 percent of the trees may be dead, but foliage, that can provide post-fire ground cover, remains on the trees. Most woody root crowns and perennial herbaceous roots are alive. Ground fuels, including O horizons, may be completely consumed in places, but not in the majority of the area. Patches of white ash may be present immediately after the fire, but mineral soil color is unchanged, except for some blackening of the surface. Soil structure may be altered by loss of cementing humus to a depth of about 1/4 inch. A pH increase of 1 to 2 units may be noted in the surface horizon. A hydrophobic layer may be created or aggravated within about the upper two inches of soil.
- High: Tree crowns are burned, and more than 50 percent of the trees are dead. Little foliage remains. Many woody root crowns and perennial herbaceous roots are dead. Vegetative ground cover is completely consumed. White ash is common and several inches deep. In places of highest intensity, mineral soil color may have been altered to a yellowish red. Soil structure is altered, usually to a massive condition, to a depth of about 2 inches. A pH increase of 2 to 3 units is common. A strong hydrophobic layer may be created within about the upper three inches of soil, or it may be lacking because of loss of organic compounds.

Criteria for predicting fire impacts are based on prefire fuel and soil conditions, and predicted post-fire soil conditions. Criteria include the amount and distribution (i.e., continuity) of aerial and ground fuels; slope steepness and, in some cases, uninterrupted slope length; amount of rock outcrop; elevation and summer temperature; erosion hazard rating; presence of O horizons and substrate for microorganisms; soil texture; plant-available water capacity; soil thermal conductivity and permeability; soil buffering capacity; and presence of a hydrophobic layer. Impact ratings are as follows:

- Slight: O horizons, if present, are left largely intact, although loose litter may be destroyed. Plant roots are unburned, and erosion hazard by piping is negligible. Actual soil erosion hazard rating increases no more than one rank. The soil will recover all of its natural surface stability within 1 year after the fire. Increases in water repellency generally are limited to the upper 1/2 inch of mineral soil. Soil structure is unchanged. Soil reaction (i.e., pH) increases less than 1 pH unit in the upper 1 inch of mineral soil. Except for localized minor carbon and nitrogen losses, nutrient loss is negligible, although organic matter decomposition rates may be increased.

- Moderate: O horizons, if present, are partially destroyed, or completely destroyed in small, discontinuous patches. Plant roots, including those of dead tree stumps, are partially burned, creating a moderate hazard for soil erosion by piping. Actual soil erosion hazard rating increases by no more than two ranks, and the soil suffers significant erosion, but no more than 25 yd^3/acre. (This loss is about 0.2 inches/acre, or approximately 30 tons/acre for soil having a bulk density of 85 lb/ft^3.) The soil will recover 2/3 of its natural surface stability within 1 year after the fire. Increases in water repellency generally are limited to the upper 1 inch of mineral soil. Soil structure may be altered in the upper 1/2 inch of mineral soil. Soil reaction (i.e., pH) increases less than 2 pH units in the upper 1 inch of mineral soil, and returns to normal within 5 years. Ecosystems may suffer moderate carbon and nitrogen losses, but loss of other nutrients is negligible. Organic matter decomposition rates and nitrification rates may be increased significantly.
- Severe: O horizons, if present, are completely destroyed over a significant area. Plant roots, including those of dead tree stumps, are burned, creating a high hazard for soil erosion by piping. Actual soil erosion hazard rating may increase by more than two ranks, and the soil suffers significant erosion, including dry ravel on steep to extremely steep slopes. The soil recovers less than 2/3 of its natural surface stability within 1 year after the fire. Increases in water repellency may extend more than 1 inch into mineral soil. Soil structure may be altered deeper than 1/2 inch into mineral soil. Soil reaction (i.e., pH) increases by more than 2 pH units, and may require more than 5 years to return to normal. Ecosystems suffer high carbon and nitrogen losses, as well as possible losses of other nutrients.

Acidic Precipitation

Criteria for judging whether or not a map unit is susceptible to the effects of acidic precipitation include the soils' buffering capacity and the unit's average annual precipitation. Depth to bedrock is considered in shallow soils, but not in deeper soils because relative impact is assumed to be greatest in deeper soils. Slope steepness is considered on very steep and extremely steep landscapes. Units that appear particularly well suited for research and monitoring of the effects of atmospheric deposition are identified.

Map Unit Components

Individual areas outlined on the soil maps are delineations of the various map units. A map unit, which may have single or multiple components, is a named and defined set of similar or geographically related soils and miscellaneous areas (e.g., rock outcrop). The map units are listed, with the acreage and proportional extent of each, in the Map Unit Legend (Table 3). The map unit name identifies the dominant components in the unit, but it does not identify minor components, called inclusions. All components are addressed in the map unit descriptions.

Soils in the map units are identified as phases of taxonomic subgroups, such as Typic Cryorthents, tephritic surface, or Dystric Xerochrepts, 15 to 45 percent slopes. The map units are referenced by a three digit map unit symbol, and are presented alphabetically according to their taxonomic classification, beginning with soil order and progressing through suborder, great group, subgroup, and phase.

Each map unit description begins with the general meaning of each formative element in the subgroup names. A brief explanation of the soil taxonomic system was given in the Introduction under the heading "Naming the Soils," and additional definitions are given in the Glossary. Precise taxonomic criteria and definitions are given in *Keys to Soil Taxonomy* (Soil Survey Staff, 1992). Soils in the map units are not identified to the more specific family or series categories because of insufficient field data to support that level of precision. Nonetheless, individual soil pedons, which are fully described under "Soil Descriptions: The Taxonomic Units," are classified to the taxonomic family level. Moreover, the range of some observed properties may extend beyond the limits defined for a taxonomic class because of the characteristic variability of natural phenomena. Finally, the representative soil pedon that is described briefly within a map unit description may be taken from a different map unit having similar soil.

The arrangement of map unit delineations reveals a pattern of soils and rock outcrops in the survey area. Although the delineations are reliable for the intended mapping precision, other arrangements of the natural patterns are possible, because they unavoidably are as much a function of the surveyor's judgment as they are of natural groupings. For example, when two or more soils are closely related, either spatially or morphologically, the surveyor must decide whether or not to combine them into one or more map units; and if they are combined, he must decide the best aggregation. Obviously, many choices are available for each situation.

The broad scope of this survey (order-4) usually does not allow individual soil subgroups to be shown as separate units; therefore, the map units normally consist of associations or complexes of different soils or soils and rock outcrops. Associations and complexes consist of two or more significant, but dissimilar, components occurring in a regularly repeating pattern. They differ in that associations can be separated and mapped at a scale of about 1:24,000, but complexes cannot because of the small size of the resulting units. (Soils in this survey were mapped at the scale of 1:63,360.)

The maps and map unit descriptions can be used for wilderness management planning and to determine the potential and suitability of a unit for various wilderness uses. They can not be used for detailed management planning or site specific interpretations without further field verification.

TABLE 3. Legend, acreage, and proportional extent of the map units.

Map Unit Symbol and Name	Acres	Percent
101—Mollic Cryoboralfs – Typic Cryumbrepts association, 0 to 30 percent slopes.	2,357	0.28
102—Xeric Vitricryands, 0 to 30 percent slopes.	7,022	0.84
103—Xeric Vitricryands, 25 to 55 percent slopes.	1,805	0.21
104—Xeric Vitricryands – Typic Cryorthents, tephritic complex, 0 to 45 percent slopes.	9,164	1.09
105—Typic Cryorthents, 0 to 35 percent slopes.	7,183	0.86
106—Typic Cryorthents, 15 to 50 percent slopes.	10,338	1.23
107—Typic Cryorthents, 50 to 85 percent slopes.	3,379	0.40
108—Typic Cryorthents – Dystric Cryochrepts complex, 15 to 60 percent slopes.	17,092	2.04
109—Typic Cryorthents – Dystric Cryochrepts – Rock outcrop complex, 0 to 30 percent slopes.	16,159	1.93
110—Typic Cryorthents – Dystric Cryochrepts – Rock outcrop association, 15 to 45 percent slopes.	8,576	1.02
111—Typic Cryorthents – Typic Cryochrepts – Rock outcrop complex, 0 to 45 percent slopes.	16,738	2.00
112—Typic Cryorthents – Entic Cryumbrepts complex, 0 to 45 percent slopes.	14,153	1.69
113—Typic Cryorthents – Typic Cryumbrepts – Rock outcrop complex, 0 to 45 percent slopes.	12,093	1.44
114—Typic Cryorthents – Rock outcrop complex, 0 to 45 percent slopes.	39,962	4.78
115—Typic Cryorthents – Rock outcrop complex, 40 to 85 percent slopes.	50,388	6.03
116—Typic Cryorthents – Rock outcrop – Lithic Cryorthents complex, 0 to 30 percent slopes.	12,614	1.51
117—Typic Cryorthents – Rock outcrop – Lithic Cryorthents complex, tephritic, 0 to 30 percent slopes.	16,989	2.03
118—Typic Cryorthents – Rock outcrop – Lithic Cryorthents complex, tephritic, 30 to 65 percent slopes.	5,197	0.62
119—Typic Cryorthents – Xeric Vitricryands – Rock outcrop complex, volcanic, 0 to 45 percent slopes.	5,289	0.63
120—Typic Torriorthents, 5 to 25 percent slopes.	1,217	0.14
121—Typic Torriorthents – Xeric Torriorthents association, 45 to 75 percent slopes.	1,593	0.19
122—Xeric Torriorthents – Typic Torriorthents – Rock outcrop association, 40 to 85 percent slopes.	4,644	0.55
123—Dystric Xerorthents – Dystric Xerochrepts complex, 15 to 50 percent slopes.	4,156	0.49
124—Dystric Xerothents – Dystric Xerochrepts – Rock outcrop complex, 40 to 85 percent slopes.	4,441	0.53
125—Dystric Xerothents – Typic Xerumbrepts – Rock outcrop complex, 15 to 45 percent slopes.	6,710	0.80
126—Dystric Xerorthents – Rock outcrop – Typic Xerumbrepts complex, 0 to 30 percent slopes.	2,411	0.28
127—Typic Xerorthents – Entic Haploxerolls complex, 15 to 50 percent slopes.	6,099	0.73
128—Typic Xerorthents – Entic Haploxerolls – Typic Xerochrepts complex, 35 to 75 percent slopes.	9,013	1.07

129—Typic Xerorthents – Rock outcrop complex, 15 to 50 percent slopes.	917	0.10
130—Typic Xerorthents – Rock outcrop complex, 40 to 85 percent slopes.	19,001	2.27
131—Typic Torripsamments, 25 to 55 percent slopes.	1,404	0.16
132—Typic Torripsamments – Typic Torriorthents – Rock outcrop complex, 25 to 55 percent slopes.	2,056	0.24
133—Dystric Cryochrepts – Typic Cryorthents association, 0 to 30 percent slopes.	9,275	1.11
134—Dystric Cryochrepts – Entic Cryumbrepts – Typic Cryorthents complex, 0 to 45 percent slopes.	9,336	1.11
135—Typic Xerochrepts, 15 to 45 percent slopes.	760	0.09
136—Entic Cryumbrepts – Mollic Cryoboralfs association, 0 to 25 percent slopes.	1,369	0.16
137—Typic Cryumbrepts, 0 to 30 percent slopes.	1,317	0.15
138—Typic Cryumbrepts – Xeric Vitricryands – Rock outcrop complex, volcanic, 0 to 45 percent slopes.	7,317	0.87
139—Typic Cryumbrepts – Typic Cryorthents – Rock outcrop complex, 0 to 30 percent slopes.	10,470	1.25
140—Typic Cryumbrepts – Dystric Cryochrepts – Typic Cryorthents complex, 0 to 30 percent slopes.	18,626	2.23
141—Typic Cryumbrepts – Dystric Cryochrepts – Typic Cryorthents complex, 15 to 45 percent slopes.	6,267	0.75
142—Entic Xerumbrepts – Dystric Xerorthents – Rock outcrop association, 40 to 85 percent slopes.	14,202	1.70
143—Typic Xerumbrepts – Entic Xerumbrepts – Dystric Xerorthents complex, 5 to 30 percent slopes.	3,679	0.44
144—Entic Haploxerolls – Typic Cryoborolls association, 15 to 45 percent slopes.	2,584	0.30
145—Entic Haploxerolls – Typic Cryoborolls – Rock outcrop association, 50 to 85 percent slopes.	6,032	0.72
146—Rock outcrop and Rubble land.	148,694	17.80
147—Rock outcrop – Typic Cryorthents complex, 0 to 45 percent slopes.	83,799	10.03
148—Rock outcrop – Typic Cryorthents complex, 40 to 85 percent slopes.	137,555	16.47
149—Rock outcrop – Typic Cryorthents – Lithic Cryorthents complex, 0 to 30 percent slopes.	15,642	1.87
150—Rock outcrop – Typic Cryorthents complex, volcanic, 10 to 45 percent slopes.	10,064	1.20
151—Rock outcrop – Typic Cryorthents – Lithic Cryorthents association, volcanic, 0 to 30 percent slopes.	6,027	0.72
152—Rock outcrop – Typic Cryorthents – Typic Cryoborolls complex, volcanic, 25 to 50 percent slopes.	3,797	0.45
153—Rock outcrop – Dystric Xerorthents complex, 30 to 75 percent slopes.	10,327	1.23
154—Rock outcrop – Dystric Xerorthents – Dystric Xerochrepts complex, 15 to 50 percent slopes.	7,048	0.84
155—Rock outcrop – Typic Torriorthents complex, 25 to 55 percent slopes.	806	0.09

Map Unit Descriptions

101—Mollic Cryoboralfs - Typic Cryumbrepts association, 0 to 30 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Mollic: dark colored surface horizon;

Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, or clayey);

Cry(o): very cold, with little warming in summer;

bor: cold;

umbr: dark colored, organic-rich surface horizon having low base saturation;

alf: Alfisol, a soil order; well developed soil having a clay-enriched B horizon;

ept: Inceptisol, a soil order; significantly less developed than Alfisols.

This map unit is limited to the Junction Bluffs area, east of the Middle Fork San Joaquin River in the western portion of the survey area. It is found on broad, nearly level to moderately steep, unglaciated ridges and mountain sides and alluvial bottoms at elevations between 6,200 and 8,300 feet. The soils formed in residuum, colluvium, and alluvium weathered from andesite and granodiorite.

Mean annual precipitation ranges from 15 to 30 inches, most of which falls as snow. Vegetation series include mixed conifer and red fir.

The map unit, which comprises 0.28 percent of the survey area, is approximately 45 percent Mollic Cryoboralfs, 45 percent Typic Cryumbrepts, and 10 percent inclusions. Mollic Cryoboralfs developed from andesitic lava flows on gently sloping to moderately steep slopes; whereas, Typic Cryumbrepts developed from dominantly granitic parent materials on nearly level to moderately steep slopes. The unit contains small scattered inclusions of Typic Cryumbrepts, volcanic formed from andesite; and Typic Cryoboralfs, Entic Cryumbrepts, and Dystric Cryochrepts on the granitic parent materials.

Mollic Cryoboralfs are moderately coarse to moderately fine textured, very cold, moderately deep to very deep, well drained soils formed in andesitic residuum. They have a superficial layer of slightly decomposed organic material less than three inches thick. In a representative soil, the surface mineral layer is 8 inches of brown to dark brown, stony sandy loam or very stony sandy loam having weak granular or subangular blocky structure. It is very strongly acid and water repellent. The subsoil, which is 31 inches thick, is brown, very cobbly loam or very cobbly sandy clay loam with evidence of clay accumulation from above. It has subangular blocky structure or is massive. It is strongly acid, and slightly water repellent. This material is underlain by saprolite (chemically weathered bedrock). This is one of the few places in the survey area where saprolite is found. In addition, these soils are among the best developed in the survey area, and are rare in the High Sierra, a point which would make them particularly interesting for scientific study.

The Typic Cryumbrepts are coarse to moderately coarse textured, very cold, deep to very deep, and well drained to somewhat excessively drained. They formed in colluvium derived from biotite and hornblende diorite and granodiorite. The soils normally have a superficial layer of slightly decomposed organic material less than two inches thick. In a representative soil, the surface mineral layer is 10 inches of yellowish brown sandy loam having weak granular structure. It is strongly acid and slightly water repellent. The subsoil, which is about 20 inches thick, is yellowish brown to dark yellowish brown sandy loam or gravelly sandy loam, having moderate granular structure. It is strongly acid, and is not water repellent (some comparable soils are slightly water repellent in the subsoil). The underlying material, which extends to at least

41 inches depth, is dark brown very gravelly coarse sandy loam having moderate granular structure, and strongly acid reaction.

Hydraulic conductivity is decreased significantly by chemically induced hydrophobicity. It is moderately low if the soils have been dry prior to rainfall; and may increase once the soils become wetted to moderate on Mollic Cryoboralfs and moderately high on Typic Cryumbrepts. Overland flow, which varies with hydrophobicity, is medium on gently sloping sites and rapid on moderately steep sites. Plant-available water capacity is moderate to high in Mollic Cryoboralfs and low to moderate in Typic Cryumbrepts. Effective rooting depth is greater than 36 inches in the unit.

Maximum erosion hazard rating is moderate on nearly level to strongly sloping sites, and high on moderately steep sites. Approximately half of the unit is rated moderate, and half is rated high. Mollic Cryoboralfs resist erosion more than most other soils in the survey area because of their higher clay content and greater cohesive strength. Typic Cryumbrepts are more susceptible to erosion, especially if they have developed from granitic rock, because of their lower cohesive strength. Surface rock fragments cover 10 to 20 percent of the Mollic Cryoboralfs and 20 to 30 percent of the Typic Cryumbrepts. These fragments help protect bare surfaces from raindrop impact, but they also decrease the amount of surface available for water intake. Landscape stability hazard is low in this unit.

These soils are well suited for trails throughout most of the unit, and for campsites on nearly level to gently sloping ground. Soils developed from volcanic parent materials are susceptible to dust formation. Other limitations such as overland flow on bare soil are easily overcome by normal planning and prudent maintenance.

Meadows and other grassy areas in this unit are suitable for commercial livestock grazing. They fall in the Bohna Ranch grazing allotment, which normally is available to cattle from July through September. Meadows are recovering from past abuse, and today are in fair to good condition.

Habitat is good for deer, bear, fur bearers, and burrowing animals. The soils support good cover and browse for summer use, and soil depth provides adequate thermal protection for burrowing animals.

Watershed rating is moderately high for the survey area. The soils have significant depth to bedrock and better water retention than most other parts of the survey area. Snow retention is moderately high, and hydrograph response is moderately rapid.

Fire impacts are expected to be moderate because of adequate fuel production, although concentrations of ground and canopy fuels are variable. The pH normally will return to nearly prefire levels within three to five years, although this time period may be doubled under intense fire on Mollic Cryoboralfs. Fire in this unit can lead to significant increases in soil erosion and possible sediment production. Post-fire recovery rate is expected to be among the most rapid in the survey area.

These soils are susceptible to potential effects from acidic precipitation, because of their low buffering capacity. They are well suited for monitoring the environmental effects of atmospheric pollutants, because of their accessibility and diversity of soils and ecosystems.

102—Xeric Vitricryands, 0 to 30 percent slopes.

The soil's taxonomic name reflects the following characteristics:

Xeric: dry in summer, moist in winter;

Vitri: contains weakly weathered volcanic glass that holds less than 15 percent water at permanent wilting point;

cry: very cold, with little warming in summer;

and: Andisol, an order of soils that have andic properties and that usually form from volcanic ejecta.

This map unit is found east of the Sierran crest near Devils Postpile National Monument. It occurs on nearly level to moderately steep glacial moraines and mountain sides at elevations between 7,600 and 10,800 feet.

The soils formed in volcanic ash and lapilli-sized pumice overlying and mixed with glacial till, colluvium, and alluvium. Underlying parent materials developed from granodiorite and diorite, andesite and basalt, and pyroclastic and metavolcanic rocks.

Mean annual precipitation ranges from 40 to 60 inches, most of which falls as snow. Vegetation series include mixed conifer, red fir, lodgepole pine, whitebark pine, and alpine dwarf scrub.

The map unit, which comprises 0.84 percent of the survey area, is 75 percent Xeric Vitricryands. It contains approximately 15 percent inclusions of Typic Cryorthents, tephritic and Dystric Cryochrepts, tephritic. These soils have partial andic properties, but do not meet all criteria of Andisols. Also included are small areas of Typic Cryumbrepts and Entic Cryumbrepts, as well as Typic Cryoborolls, tephritic in the Reds Meadow area south of Sotcher Lake. Rock outcrop occupies about 10 percent of the unit.

Xeric Vitricryands are coarse to medium textured, very cold, moderately deep to very deep, and well drained to somewhat excessively drained. They may or may not have a surface layer of slightly decomposed organic material that, if present, is less than three inches thick.

In a representative soil, the surface mineral layer is 9 inches of light gray extremely gravelly coarse sand consisting dominantly of volcanic lapilli and ash (tephra). It is single grain and very strongly acid. The underlying material, which extends to at least 39 inches, is light gray to brownish yellow, very gravelly coarse sand to loamy coarse sand. It is massive and slightly hard in its upper portion, and has weak granular structure or is massive below. It is strongly acid to moderately acid.

Hydraulic conductivity of the soils is decreased significantly by chemically induced hydrophobicity that ranges from slight to extreme, but that most commonly is moderate to extreme, in the surface mineral soil. Hydraulic conductivity is low to moderately low if the soils have been dry prior to rainfall; it may increase to moderately high once the soils become wetted. Overland flow is medium to rapid because of the hydrophobicity. Plant-available water capacity is moderate to high. Effective rooting depth is greater than 36 inches for this unit.

Maximum erosion hazard rating is moderate on nearly level to strongly sloping sites, and high on moderately steep sites. Approximately half of the unit is rated moderate, and half is rated high. These soils are susceptible to sheet, rill, and gully erosion when unprotected by vegetative cover, because of their low cohesive strength. Moreover, the volcanic ash makes these soils more hydrophobic and more prone to creating dust than their nonashy counterparts. Surface rock fragments, which can range up to 90 percent, provide protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion. The superficial pumice is spherical and light weight, which makes it particularly susceptible to detachment and transport. Landscape stability hazard is low under normal conditions.

These soils generally are suitable for trails and for campsites on nearly level to gently sloping sites. The major limitations, apart from moderately steep slopes, are caused by the soils' loose consistence, low density, and water repellency, which increase erodibility and dustiness, and decrease trafficability.

These soils are poorly suited for livestock grazing, because of low forage production and high susceptibility to sheet and rill erosion during and following disturbance. They are used incidentally by cattle and pack stock as the animals travel through the area.

Wildlife habitat, which decreases in quality with increasing elevation, generally is good. Burrowing animals and insects are active in these soils, although burrows in the top soil do not hold up well because of the soil's very loose consistence. Abundant rock fragments also interfere with digging. Soil depth is great enough to provide habitat for winter hibernation and protection from summer heat.

Watershed rating is moderately high. Ground water storage is low to moderate; precipitation and snow retention are high; and hydrograph response is moderately rapid.

The impact of fire is slight to moderate because of low and discontinuous fuel production and limited soil development. Locally intense fire can alter surface soil mineralogy by fusing volcanic glass and chemically altering related mineral components.

These soils are susceptible to potential effects from acidic precipitation, because of their low buffering capacity.

103—Xeric Vitricryands, 25 to 55 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Xeric: dry in summer, moist in winter;

Vitri: contains weakly weathered volcanic glass that holds less than 15 percent water at permanent wilting point;

cry: very cold, with little warming in summer;

and: Andisol, an order of soils that have andic properties and that usually form from volcanic ejecta.

This map unit is found east of the Sierran crest near Devils Postpile National Monument. It occurs on moderately steep to very steep glacial moraines and mountain sides at elevations between 7,300 and 10,000 feet. The soils formed in volcanic ash and lapilli overlying and mixed with glacial till, colluvium, and alluvium, and with material in bedrock joints. The underlying parent materials developed from granodiorite and diorite, andesite and basalt, and pyroclastic and metavolcanic rocks.

Mean annual precipitation ranges from 40 to 60 inches, most of which falls as snow. Vegetation series include mixed conifer, red fir, lodgepole pine, whitebark pine, and alpine dwarf scrub. A few small areas of western hemlock also can be found.

The map unit which comprises 0.21 percent of the survey area, is approximately 75 percent Xeric Vitricryands and 25 percent inclusions of rock outcrop, Typic Cryorthents, tephritic, and Dystric Cryochrepts, tephritic. The included soils have partial andic properties, but do not meet all criteria of Andisols. Generally, northerly facing concave slopes having more plant-available water, greater vegetation density, and more organic matter accumulation support soils that are more developed than those on southerly facing convex slopes.

Xeric Vitricryands are coarse to medium textured, very cold, moderately deep to very deep, and well drained to somewhat excessively drained. They may or may not have a surface layer of slightly decomposed organic material that, if present, is less than three inches thick.

In a representative soil, the surface mineral layer is 9 inches of light gray extremely gravelly coarse sand consisting dominantly of volcanic lapilli and ash (tephra). It is single grain and very strongly acid. The underlying material, which extends to at least 39 inches, is light gray to brownish yellow, very gravelly coarse sand to loamy coarse sand. It is massive and slightly hard in its upper portion, and has weak granular structure or is massive below. It is strongly acid to moderately acid.

Hydraulic conductivity of the soils is decreased significantly by chemically induced hydrophobicity. Hydraulic conductivity of these coarse textured soils is low if the soils have been dry prior to rainfall; it may increase to moderately high once the soils become wetted. Overland flow is rapid to very rapid because of the hydrophobicity and slope steepness. Plant-available water capacity is low to moderate. Effective rooting depth is greater than 36 inches for this unit.

Maximum erosion hazard rating is high to very high on moderately steep to steep sites, and very high on steep to very steep sites. Approximately half of the unit is rated high, and half is rated very high. These soils are highly susceptible to sheet, rill, and gully erosion when unprotected by vegetative cover, because of their steep and very steep slopes and low cohesive strength. Moreover, the volcanic ash makes these soils more hydrophobic and more prone to creating dust than their nonashy counterparts. Surface rock fragments, which can range up to 40 percent, provide protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion. The superficial pumice is spherical and light weight, which makes it particularly susceptible to detachment and transport. Landscape stability hazard is moderately low under normal conditions.

Soils in this unit are suitable for trails, and generally unsuitable for campsites. The major limitations are steep slopes, loose consistence, low density, and water repellency.

These soils are poorly suited for livestock grazing, because of low forage production, steep slopes, and high susceptibility to sheet and rill erosion during and following disturbance. They are used incidentally by cattle and pack stock as the animals travel through the area.

Wildlife habitat, which decreases in quality with increasing elevation, generally is good. Burrowing animals and insects are active in these soils, although burrows in the surface soil do not hold up well because of the soils' loose consistence. Abundant rock fragments also interfere with digging. Soil depth is great enough to provide habitat for winter hibernation and protection from summer heat.

Watershed rating is moderately high. Ground water storage is low to moderate; precipitation and snow retention are high; and hydrograph response is rapid. The unit lies in one of the greatest snowfall regions of the Sierra Nevada; as a result, it can supply considerable high quality water to lower lying watersheds.

Although fuel production is low and discontinuous, and soils are weakly developed, fire impacts are moderate because of steep slopes. Fire in this unit will lead to moderate increases in soil erosion and sediment production in localized areas. Locally intense fire can alter surface soil mineralogy by fusing volcanic glass and chemically altering related mineral components.

These soils are susceptible to potential effects from acidic precipitation, because of their low buffering capacity.

104—Xeric Vitricryands - Typic Cryorthents, tephritic complex, 0 to 45 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Xeric: dry in summer, moist in winter;

Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, clayey, or low in bases);

Vitri: contains weakly weathered volcanic glass that holds less than 15 percent water at permanent wilting point;

Cry: very cold, with little warming in summer;

orth: common form of the soil order (e.g., not unusually wet or sandy);

and: Andisol, an order of soils that have andic properties and that usually form from volcanic ejecta;

ent: Entisol, a soil order; a young, weakly developed soil.

Tephritic indicates a superficial covering of volcanic ash and cinders.

This complex is located primarily in the upper Middle Fork San Joaquin River drainage in areas where significant volcanic ash and cinders have accumulated. It occurs on nearly level to steep ridges, mountain sides, glacial moraines, and alluvial bottoms at elevations between 6,400 and 9,400 feet. The soils formed in tephra mixed, to varying degrees, with deposits derived from granitic, volcanic, and metavolcanic rock.

Mean annual precipitation ranges from 40 to 60 inches, most of which falls as snow. Vegetation series include lodgepole pine, red fir, western white pine, mixed conifer-fir, and their associated perennial grass meadows.

The complex, which comprises 1.09 percent of the survey area, is approximately 45 percent Xeric Vitricryands, 35 percent Typic Cryorthents, tephritic, and 20 percent inclusions. The various components individually are too small and intricately mixed on the landscape to be delineated separately. The inclusions consist of Dystric Cryochrepts, tephritic and minor amounts of rock outcrop and possibly Typic Vitricryands, and Andic or Vitrandic Cryochrepts.

The Xeric Vitricryands are coarse to medium textured, very cold, moderately deep to very deep, and well drained to somewhat excessively drained. They formed in volcanic ash and cinders overlying and mixed with glacial till, colluvium, and alluvium. They may or may not have a surface layer of slightly decomposed organic material that, if present, usually is less than three inches thick.

In a representative soil, the surface mineral layer is 9 inches of light gray extremely gravelly coarse sand consisting dominantly of volcanic lapilli and ash (tephra). It is single grain and very strongly acid. The underlying material, which extends to at least 39 inches, is light gray to brownish yellow, very gravelly coarse sand to loamy coarse sand. It is massive and slightly hard in its upper portion, and has weak granular structure or is massive below. It is strongly acid to moderately acid.

Although these soils were mapped in the xeric moisture regime, many of them actually may have sufficient moisture through the growing season to classify in the udic regime, which would make them Typic Vitricryands. Soils most likely to be udic are in the highest precipitation areas and under the red fir vegetation series.

The Typic Cryorthents, tephritic are coarse to moderately coarse textured, very cold, deep to very deep, and well drained to somewhat excessively drained. They formed in colluvium, glacial till, alluvium, and minor amounts of residuum derived from granitic, volcanic and metavolcanic rocks of varying composition. Volcanic ash and cinders (tephra) cover the surface and are mixed in the topsoil, but are not sufficient to classify the soil as Andisol. The soils may or may not have a superficial layer of slightly decomposed organic material that, if present, usually is less than one inch thick.

In a representative soil, the surface mineral layer is 4 inches of light brownish gray, very gravelly loamy coarse sand consisting dominantly of pumice (lapilli and ash). It has weak granular structure, and is very strongly acid and extremely water repellent. This is underlain by 10 inches of pale brown, gravelly sandy loam consisting of granitic material. This layer has moderate granular structure, and is very strongly acid and wettable. The substratum to at least 26 inches depth is brownish yellow, extremely cobbly sandy loam derived from glacially deposited granitic material. It has weak granular structure, and is very strongly acid and wettable.

The included Dystric Cryochrepts, tephritic are concentrated in the Stairway Creek drainage, in the western-most delineation of the map unit, and on westerly facing slopes that are lee-ward to tephra falls from the Mono Craters area.

Although the soils are coarse to moderately coarse textured, hydraulic conductivity of dry soils generally is low to moderately low because of chemically induced hydrophobicity. Most water infiltration in the nonwettable soils is through channels created by insects, soil animals, and plant roots. Once wetted the hydrophobic soils have moderately high hydraulic conductivity. Overland flow, which varies with hydrophobicity, is medium on gently sloping sites and rapid to very rapid on steep sites. Plant-available water capacity is low to moderate. Effective rooting depth is greater than 36 inches for this unit.

Maximum erosion hazard rating is moderate on nearly level to strongly sloping sites, and high to very high on moderately steep and steep sites. Soils having the highest tephra content tend to have the highest erosion hazard. Approximately 45 percent of the unit is rated moderate, 40 percent is rated high, and 15 percent is rated very high.

Soils on moderately sloping to steep slopes are highly susceptible to sheet, rill, and gully erosion when unprotected by vegetative cover, because of low cohesive strength caused by their high pumice content. Surface rock fragment cover typically is less than 30 percent, but ranges to 90 percent in the vicinity of Red Cones, where lapilli-sized pumice covers the ground surface. Although these fragments provide some protection from rain drop impact on bare surfaces, they are easily detached, and they restrict water intake which speeds overland flow, leading to further accelerated erosion. Landscape stability hazard is low to moderately low under normal conditions.

These soils are suitable for trails and for campsites on nearly level to gently sloping sites. Steeper sites are unsuitable for campsites. As with others having significant volcanic ash, these soils become exceptionally dusty when disturbed. Other limitations include rapid water runoff, loose consistence, and moderately steep to steep slopes.

This unit generally is poorly suited for livestock grazing because of low forage production and high susceptibility to sheet and rill erosion during and following disturbance. The included meadows and nearly level to strongly sloping portions of the delineation surrounding Rock Creek Lake pose the least limitations for grazing pack stock.

Wildlife habitat is fair to good for all species in the area. The unit has suitable summer range for deer and bear. Burrowing animals and insects are active in these soils, but burrows are subject to caving because of the soils' low cohesive strength. Soil depth is great enough to provide habitat for winter hibernation and protection from summer heat. Wildlife diversity and populations in this unit are smaller than in units having less snow, warmer, more developed soils, and greater variety of vegetation.

Watershed rating is moderately high. Although ground water storage per unit volume of aquifer is low to moderate, the unit lies in one of the greatest snowfall regions of the Sierra Nevada; as a result, it can supply considerable high quality water to lower lying watersheds. Watershed rating is limited by low-porosity bedrock and coarse texture of the weathered materials. Snow retention is high, and hydrograph response is moderately rapid.

Fire impacts are slight to moderate in this unit of high elevation, cold, and infertile soils having light, discontinuous fuels. Fuels tend to be somewhat more concentrated on Xeric Vitricryands than on Typic Cryorthents, tephritic, but still are limited. Locally intense fire can alter surface soil mineralogy by fusing volcanic glass and chemically altering related mineral components.

These soils are susceptible to potential effects from acidic precipitation, because of their low buffering capacity.

105—Typic Cryorthents, 0 to 35 percent slopes.

The soil's taxonomic name reflects the following characteristics:

Typic: soil is characteristic of the great group to which it belongs (e.g., not unusually moist, shallow, or clayey);

Cry: very cold, with little warming in summer;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ent: Entisol, a soil order; a young, weakly developed soil.

Delineations of this map unit are scattered throughout the survey area adjacent to or surrounded by larger, comparable units complexed with rock outcrop. They occur on nearly level to steep ridges, mountain sides, glacial moraines, and alluvial bottoms at elevations between 7,100 and 11,800 feet. The soils formed in deposits and residuum weathered primarily from granitic rock

Mean annual precipitation ranges from 20 to 50 inches, most of which falls as snow. Typic Cryorthents support a wide range of vegetation series, including upper mixed conifer, Jeffrey pine, red fir, lodgepole pine, whitebark pine, and alpine dwarf scrub. Forest stand densities range from scattered to closed crown. Little correlation exists between the soil and vegetative cover, except for the presence of an O horizon under the heaviest cover.

The map unit, which comprises 0.86 percent of the survey area, is about 75 percent Typic Cryorthents and 25 percent inclusions. Inclusions consist of granitic and metamorphic rock outcrop, Dystric Cryochrepts, Typic Cryochrepts, Typic Cryumbrepts, and Entic Cryumbrepts, as well as small scattered areas of soils having a superficial mantle of volcanic ash and cinders (i.e., tephra). Cryoborolls are included in this unit near Horseshoe Meadow, in the Cottonwood Lakes region. A number of high elevation meadows occur throughout the map unit area.

Typic Cryorthents in this unit are coarse to moderately coarse textured, very cold, deep to very deep, and moderately well drained to somewhat excessively drained. The moderately well drained soils are in grassy, nearly level positions that receive subsurface runoff water from adjacent slopes. Typic Cryorthents formed from colluvial, glacial, alluvial, and residual deposits, including those in granitic bedrock joints. Parent materials developed mainly from various granitic rocks, including biotite and hornblende diorite and granodiorite at lower elevations, and quartz monzonite at higher elevations, especially near the crest of the Sierra Nevada. Parent materials derived from metamorphic rocks, most of which are noncalcareous and low-grade, are found east of the Sierran crest and in minor amounts on the west side.

Somewhat more than half of these soils have a slightly decomposed surface organic layer that commonly is less than one inch thick, but that may reach 3 inches thickness. These O horizons are found in or below the lodgepole pine vegetation zone. The surface mineral soils often contain fine pumice, and usually are water repellent. Underlying materials normally have lighter, brighter colors and greater rock fragment content, but little or no pumice, and they may have slightly better developed structure, although structures seldom are more pronounced than weak granular. Distinctive subsoil horizons are not well developed, even under a closed canopy of mature trees, presumably because of the high proportion of resistant minerals and limited conditions for chemical weathering.

In a representative soil, the surface mineral layer is 6 inches of light gray cobbly sandy loam having an admixture of volcanic ash. It has a massive arrangement that breaks to weak granular structure, and is very strongly acid. The underlying material, which extends to at least 34 inches depth, is light brownish gray to very pale brown, very cobbly sandy loam. It has weak subangular blocky to moderate granular structure, and is very strongly acid.

Hydraulic conductivity of Typic Cryorthents is moderately high to high; overland flow is medium on wettable, gently sloping sites and rapid on hydrophobic and moderately steep to steep sites. Plant-available water capacity is low. Effective rooting depth is greater than 40 inches.

Maximum erosion hazard rating is moderate on nearly level to strongly sloping sites, and high on moderately steep sites. Approximately half of the unit is rated moderate, and half is rated high. These soils are susceptible to sheet, rill, and gully erosion when unprotected by vegetative cover, because of their low cohesive strength. Surface rock fragments, which can range up to 85 percent, provide protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion. Recovery from disturbance generally is slow, especially on the moderately steep and steep slopes. Landscape stability hazard is low under normal conditions.

These soils generally are suitable for trails and for campsites on nearly level to gently sloping sites. The major limitations, apart from moderately steep and steep slopes, are caused by the soils' loose consistence, which increases erodibility and decreases trafficability, and by water repellency, which increases erodibility. Runoff water often becomes concentrated in trails and is conducted along their length, eroding the surface. These effects can be minimized by proper construction and spacing of water bars. Trails and campsites constructed in these soils tend to be dusty when dry, but generally are less dusty than soils derived from metavolcanic rock or those which contain appreciable amounts of fine volcanic ash.

Typic Cryorthents, in general, are poorly suited and little used for commercial livestock grazing, and most allotments in this unit are vacant. Nonetheless, some of the lower elevation meadows are well suited for grazing, and are used by cattle under active allotments. These meadows are recovering from past overgrazing, and today are in fair to good condition. Soil and vegetative recovery of abused meadows normally requires several decades. Apart from the meadows, areas of Typic Cryorthents provide secondary forage for pack stock and for cattle in active allotments. The short growing season, low forage productivity, difficult accessibility, and high erodibility limit the grazing use of these areas.

Wildlife habitat is fair. Its quality decreases with increasing elevation. This unit supports fewer animal species than do units having warmer, more developed soils and greater vegetative diversity. Soil conditions are suitable for burrowing animals and insects, although the high proportion of rock fragments increases the difficulty of digging.

Watershed rating is moderately low to moderately high, largely because of the great range of precipitation throughout the unit. Ground water storage is low because of limited depth to bedrock (which, nonetheless, is greater than traditionally has been thought), lack of saprolite, and low porosity in the bedrock and overlying material. Snow retention is high. Hydrograph response is moderately rapid during snow melt and rainstorms, because of rapid transmission rates to stream channels. Snow melt and rainfall from this unit provide substantial high purity water to recharge reservoirs.

The impact of fire is slight to moderate because of scattered, discontinuous fuel production, including duff layers, and limited soil development. Thermal conductivity of the soils is very low to low. The low buffering capacity of these soils would allow the pH to drop to nearly normal levels within about three to four years after the fire.

Typic Cryorthents are susceptible to potential effects from acidic precipitation, because of the soils' low buffering capacity. Mineral weathering probably would be little affected by acidic precipitation, because of the low temperatures and the soils' high silica content, which has low solubility under acidic conditions.

106—Typic Cryorthents, 15 to 50 percent slopes.

The soil's taxonomic name reflects the following characteristics:

Typic: soil is characteristic of the great group to which it belongs (e.g., not unusually moist, shallow, or clayey);

Cry: very cold, with little warming in summer;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ent: Entisol, the soil order; a young, weakly developed soil.

This map unit occurs near the Sierran crest in two widely separated groups, one in the vicinity of Duck Lake and Mt. Morrison, and the other near Kearsarge and Independence Peaks. It occurs on strongly sloping to steep mountain sides and glacial moraines at elevations between 8,800 and 13,200 feet. The soils formed in deposits weathered from dominantly granitic rock, with a minor amount of noncalcareous metamorphic rock east of the Sierran crest.

Mean annual precipitation ranges from 25 to 50 inches, most of which falls as snow. Vegetation series include Jeffrey pine, lodgepole pine, whitebark pine, and alpine dwarf scrub. Forest stand densities range from scattered to closed crown, with little correlation between soil characteristics and vegetative cover, except for presence of an O horizon under the heaviest cover.

The map unit, which comprises 1.23 percent of the survey area, is about 80 percent Typic Cryorthents and 20 percent inclusions. It is similar to map unit 105, Typic Cryorthents, 0 to 35 percent slopes, except for somewhat steeper slopes and higher elevational extent. The unit contains scattered inclusions of granitic and metamorphic rock outcrop and Lithic Cryorthents. In addition, the northern delineations may include Pergelic Cryorthents (mean annual soil temperature of 32° F or lower), Dystric Cryochrepts, and possibly Vitrandic Cryorthents or Xeric Vitricryands in areas of aerial volcanic deposition; whereas, the southern delineations include Typic Cryochrepts.

Typic Cryorthents are coarse to moderately coarse textured, very cold, deep to very deep, and moderately well drained to somewhat excessively drained. They formed in colluvium and glacial till, and in granitic bedrock joints. Parent materials developed primarily from quartz monzonite, secondarily from granodiorite at lower elevations, and, to a minor extent, from noncalcareous metamorphic rock east of the Sierran crest.

A slightly decomposed surface organic layer less than one inch thick may or may not be present. These O horizons are found in or below the lodgepole pine zone. Surface mineral horizons may contain fine pumice, and usually are water repellent. The underlying mineral soil normally has lighter, brighter colors and greater rock fragment content, but little or no pumice, and may have slightly better developed structure, although structures seldom are more pronounced than weak granular. Distinctive subsoil horizons are not well developed, even under a closed canopy of mature trees, because of the high proportion of resistant minerals and limited conditions for chemical weathering.

In a representative soil, the surface mineral layer is 6 inches of light gray, cobbly sandy loam having an admixture of volcanic ash. It has a massive arrangement that breaks to weak granular structure, and is very strongly acid. The underlying material, which extends to at least 34 inches depth, is light brownish gray to very pale brown, very cobbly sandy loam. It has weak subangular blocky to moderate granular structure, and is very strongly acid.

Hydraulic conductivity of Typic Cryorthents is moderately high; overland flow is rapid to very rapid because of slope steepness and soil hydrophobicity. Plant-available water capacity is low; effective rooting depth is greater than 40 inches.

Maximum erosion hazard rating is high on moderately steep sites, and very high on steep sites. Approximately half of the unit is rated high, and half is very high. These soils are susceptible to sheet, rill, and gully erosion when unprotected by vegetative cover, because of their low cohesive strength and steep slopes. Surface rock fragments, which can range up to 70 percent, provide protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion. Recovery from disturbance generally is slow, especially on the steep slopes. Landscape stability hazard is moderately low under normal conditions.

These soils are suitable for trails, but are unsuitable for campsites (except for a few scattered level sites) because of slope steepness. Other limitations are caused by the soils' loose consistence, which increases erodibility and decreases trafficability, and by water repellency, which increases erodibility. Runoff water often becomes concentrated in trails and is conducted along their length, eroding the surface. These effects can be minimized by proper construction and spacing of water bars. Trails constructed in these soils tend to be dusty when dry, but generally are less dusty than in soils derived from metavolcanic rock or those that contain appreciable amounts of fine volcanic ash.

This map unit is unsuitable for commercial livestock grazing because of low forage production, difficult accessibility, and high susceptibility to sheet and rill erosion during and following disturbance.

Wildlife habitats are fair to poor. This unit supports fewer animal species than do units having warmer, more developed soils and greater vegetative diversity. Soil conditions are suitable for burrowing animals and insects, although the high proportion of rock fragments increases the difficulty of digging. Forage abundance is low. Forage quality is moderately low to low because of low soil fertility.

Watershed rating is moderate. Ground water storage is low. Snow retention is high. Hydrograph response is moderately rapid during snowmelt and rainstorms, because of rapid transmission rates to stream channels. Snowmelt and rainfall from this unit provide high purity water to recharge reservoirs.

The impact of fire is slight to moderate because of scattered, discontinuous fuel production, including duff layers, and limited soil development. Thermal conductivity of the soils is very low to low. The low buffering capacity of these soils would allow the pH to drop to nearly normal levels within about three years after the fire, although full recovery could require a decade. Increased runoff and sediment production, as well as dry ravel on the steepest slopes, are expected.

Typic Cryorthents are susceptible to potential effects from acidic precipitation, because of the soils' low buffering capacity. Mineral weathering probably would be little affected by acidic precipitation.

107—Typic Cryorthents, 50 to 85 percent slopes.

The soil's taxonomic name reflects the following characteristics:

Typic: soil is characteristic of the great group to which it belongs (e.g., not unusually moist, shallow, or clayey);

Cry: very cold, with little warming in summer;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ent: Entisol, the soil order; a young, weakly developed soil.

This map unit occurs in small, scattered delineations throughout the survey area. It occurs on very steep to extremely steep mountain sides and glacial moraines at elevations between 7,800 and 11,200 feet. The soils formed from granitic colluvium and glacial till.

Mean annual precipitation ranges from 30 to 50 inches, most of which falls as snow. Vegetation series include Jeffrey pine, lodgepole pine, whitebark pine, and alpine dwarf scrub. Forest crown densities are less than 50 percent.

The unit, which comprises 0.40 percent of the survey area, is about 85 percent Typic Cryorthents and 15 percent inclusions of small, randomly distributed rock outcrops.

Typic Cryorthents are coarse to moderately coarse textured, very cold, deep to very deep, and moderately well drained to somewhat excessively drained. They formed dominantly from colluvium and glacial till composed of quartz monzonite and granodiorite; some small areas east of the Sierran crest formed from noncalcareous metamorphic rock.

A slightly decomposed surface organic layer less than one-half inch thick may be present under coniferous vegetation. The surface mineral layer usually is water repellent. In a representative soil, the surface mineral layer is 6 inches of light gray, cobbly sandy loam having an admixture of volcanic ash. It has a massive arrangement that breaks to weak granular structure, and is very strongly acid. The underlying material, which extends to at least 34 inches depth, is light brownish gray to very pale brown, very cobbly sandy loam. It has weak subangular blocky to moderate granular structure, and is very strongly acid.

Hydraulic conductivity of the soils is moderately high; overland flow is very rapid because of very steep and extremely steep slopes and soil hydrophobicity. Plant-available water capacity is low; effective rooting depth is greater than 40 inches.

Maximum erosion hazard rating is very high. These soils are extremely susceptible to sheet, rill, and gully erosion, because of their very steep and extremely steep slopes, low cohesive strength, and water repellency. Surface rock fragments, which can range up to 70 percent, provide protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion. Recovery from disturbance is slow. Landscape stability hazard is high to very high. Deep-seated soil creep is common in this unit, and these soils are susceptible to failure by debris avalanches, especially during heavy rainstorms on previously wetted soils.

These soils are poorly suited for trails, and unsuitable for campsites because of slope steepness. Loaded pack animals meeting from opposite direction must use extreme caution in passing. Runoff water often becomes concentrated in trails and is conducted along their length, eroding their surface. These effects can be minimized by proper construction and spacing of switch backs and water bars. Trails through this map unit will require intensive maintenance.

This map unit is unsuitable for any livestock grazing because of slope steepness, low forage production, difficult accessibility, and extreme susceptibility to sheet and rill erosion.

Wildlife habitat is poor. This unit supports fewer animal species than do units on flatter, warmer slopes, having more developed soils and greater vegetative diversity.

Soil conditions are difficult for burrowing animals because of soil creep and the high proportion of rock fragments. Forage abundance is low. Forage quality is moderately low to low because of low soil fertility.

Watershed rating is low because of the unit's small size, as well as slope steepness, coarse textured soil, presence of abundant rock fragments, lack of saprolite, and limited depth to bedrock. Snow retention is moderate. Hydrograph response is very rapid during snowmelt and rainstorms.

Fire impact is slight throughout most of the unit. It is limited by scattered, discontinuous ground and aerial fuels and limited soil development. Thermal conductivity of the soils is very low to low. Soil erosion, including that due to dry ravel, can increase significantly following fire. The increased erosion cannot be controlled by any practicable measures, except for increased trail maintenance.

Soils are moderately susceptible to potential effects from acidic precipitation. Although soil buffering capacity is low, slope steepness is great enough to promote rapid water runoff.

108—Typic Cryorthents - Dystric Cryochrepts complex, 15 to 60 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, or clayey);

Dystric: base saturation less than 60 percent; generally low fertility, but adequate for acid-loving plants;

Cry: very cold, with little warming in summer;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ochr: light colored, organic-poor, or thin surface horizon;

ent: Entisol, a soil order; a young, weakly developed soil;

ept: Inceptisol, a soil order, slightly more developed than Entisols.

This map unit is found in the western portion of the survey area, with most delineations in the Middle Fork San Joaquin River drainage. It occurs on moderately steep to very steep mountain sides and glacial moraines at elevations mostly between 7,900 and 11,000 feet, but which drop to 6,400 feet along north-facing slopes above Fish Creek, in the Middle Fork San Joaquin River drainage. The soils formed in colluvium and glacial till derived primarily from granodiorite and quartz monzonite, and secondarily from volcanic and metavolcanic rocks of andesitic composition.

Mean annual precipitation ranges from 35 to 50 inches, most of which falls as snow. Vegetation series include mixed conifer, red fir, lodgepole pine, whitebark pine, and alpine dwarf scrub.

The complex, which comprises 2.04 percent of the survey area, is approximately 50 percent Typic Cryorthents, 30 percent Dystric Cryochrepts, and 20 percent inclusions. Although the soils are too intricately arranged on the landscape to be mapped separately, some general relations can be noted: Typic Cryorthents are dominant soils on the steepest slopes and at middle and highest elevations; Dystric Cryochrepts tend to occur most frequently on less steep northerly aspects at lower elevations, especially on heavily vegetated glacial till. The unit includes Entic Cryumbrepts derived from andesitic parent material on steep and very steep, easterly-facing slopes above Middle Fork San Joaquin River and on southerly-facing slopes above Fish Creek. Also included are small areas of granitic and volcanic rock outcrop and rubble. Lithic Cryorthents are associated with the rock outcrop at high elevations. The soils merge with Dystric Xerorthents below elevations of about 7,500 feet. A few sites have slopes that exceed 60 percent steepness.

The Typic Cryorthents are coarse to moderately coarse textured, very cold, deep to very deep, and moderately well drained to somewhat excessively drained. They formed in glacial till, colluvium, alluvium, and, less commonly, residuum derived from diorite, granodiorite, and quartz monzonite. The soils may or may not have a superficial layer of slightly decomposed organic material which, if present, is less than one inch thick. The surface mineral layer usually is water repellent, but underlying layers are somewhat less water repellent.

In a representative soil, the surface mineral layer is 6 inches of light gray, cobbly sandy loam having an admixture of volcanic ash. It has a massive arrangement that breaks to weak granular structure, and is very strongly acid. The underlying material, which extends to at least 34 inches depth, is light brownish gray to very pale brown, very cobbly sandy loam. It has weak subangular blocky to moderate granular structure, and is very strongly acid.

The Dystric Cryochrepts are coarse to moderately coarse textured, very cold, deep to very deep, and well drained to somewhat excessively drained. They formed in glacial till and colluvium derived from diorite, granodiorite, and quartz monzonite, with occasional influence of mafic volcanics. The soils usually have a superficial layer of slightly decomposed organic matter up to two inches thick. The surface mineral layer usually is water repellent, but the underlying layers usually are not water repellent.

In a representative soil, the surface mineral layer is 10 inches of pale brown, coarse sandy loam having moderate granular structure. It is very strongly acid and slightly water repellent. The subsoil, which is 22 inches thick, is very pale brown, gravelly coarse sandy loam and light gray, very gravelly coarse sandy loam having moderate granular to moderate subangular blocky structure and strongly acid reaction. The underlying material, which extends to 41 inches, is light gray, very gravelly coarse sandy loam that has weathered in place, and is massive and strongly acid.

Hydraulic conductivity of these coarse textured soils is decreased significantly by chemically induced hydrophobicity. It is low if the soils have been dry prior to rainfall, but may increase to moderately high once the soils become wetted. Overland flow, which varies with slope steepness and hydrophobicity, is rapid to very rapid. Plant-available water capacity is low in Typic Cryorthents, and low to perhaps moderate in Dystric Cryochrepts. Effective rooting depth is greater than 40 inches in the unit.

Maximum erosion hazard rating is high on moderately steep sites, and very high on steep and very steep sites. Approximately half of the unit is rated high, and half is very high. These soils are highly susceptible to sheet, rill, and gully erosion because of their moderately steep to very steep slopes and low cohesive strength. Surface rock fragment cover typically is about 20 to 70 percent. These fragments provide some protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion. Landscape stability hazard is moderately low to moderately high under normal conditions. Sites steeper than about 40 percent often undergo soil creep, and very steep colluvial inclusions are susceptible to failure by debris avalanche.

These soils are suitable for trails on moderately steep and steep slopes, but they are poorly suited on very steep slopes. They are unsuitable for campsites (except for a few scattered level sites) because of slope steepness. Limitations to trail building include rapid water runoff, loose consistence, and steep unstable slopes.

This map unit is unsuitable for commercial livestock grazing because of low forage production, high susceptibility to sheet and rill erosion during and following disturbance, and, on some sites, slope steepness.

Wildlife habitat is good to fair, primarily because of irregular forage availability, which decreases with increasing elevation. Burrowing animals and insects may be active in these soils. Abundant rock fragments often interfere with digging, and animal burrows in top soil having loose consistence do not hold up well, especially if the site is susceptible to soil creep. Soil depth is great enough to provide habitat for winter hibernation and protection from summer heat.

Watershed rating varies from moderately low on the steepest slopes to moderately high on the most gentle slopes. The soils have significant depth to bedrock and readily transmit high purity snowmelt water to underground storage. The unit receives subsurface flow from higher in the watershed and transmits the water to lower lying areas. The steep slopes cause surface and subsurface runoff to be rapid to very rapid. Snow retention is high, and hydrograph response is rapid.

Fire impacts generally increase with decreasing elevation. They are slight at higher elevations, where Typic Cryorthents are more common, fuels are more irregular and discontinuous, and air and soil temperatures are cooler; they are moderate at lower elevations, where Dystric Cryochrepts are more common, fuels are more abundant, and temperatures are warmer. Soils on steep slopes are subject to dry ravel during and after fire.

These soils are susceptible to potential effects from acidic precipitation, because of their low buffering capacity.

109—Typic Cryorthents - Dystric Cryochrepts - Rock outcrop complex, 0 to 30 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, or clayey);

Dystric: base saturation less than 60 percent; generally low fertility, but adequate for acid-loving plants;

Cry: very cold, with little warming in summer;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ochr: light colored, organic-poor, or thin surface horizon;

ent: Entisol, a soil order; a young, weakly developed soil;

ept: Inceptisol, a soil order, slightly more developed than Entisols.

This map unit occurs in the western portion of the survey area on nearly level to moderately steep mountain sides, glacial moraines, and alluvial bottoms at elevations between 8,100 and 11,200 feet. The soils formed in colluvium, glacial till, and, to a lesser extent, alluvium and residuum weathered from granitic rock.

Mean annual precipitation ranges from 35 to 50 inches, most of which falls as snow. Vegetation series include red fir, lodgepole pine, whitebark pine, and alpine dwarf scrub.

The complex, which comprises 1.93 percent of the survey area, is approximately 40 percent Typic Cryorthents, 25 percent Dystric Cryochrepts, 25 percent rock outcrop, and 10 percent inclusions. These components are too intricately mixed on the landscape to be delineated separately; nonetheless, the Dystric Cryochrepts tend to be more common at lower elevations, on nearly level, slightly concave positions that accumulate water and detritus, and support heaviest vegetation. Included in the map unit are Lithic Cryorthents in shallow bedrock depressions and in narrow fringes around the rock outcrops; and Typic Cryumbrepts under forest canopy in small areas of basaltic rock near Volcanic Knob.

The Typic Cryorthents are coarse to moderately coarse textured, very cold, deep to very deep, and moderately well drained to somewhat excessively drained. They formed in glacial till, colluvium, alluvium, and residuum derived from diorite, granodiorite, and quartz monzonite. A few small areas have formed from volcanic or metamorphic rock. Surface mineral soils usually are water repellent; water repellency decreases with increasing depth.

The soils may or may not have a superficial layer of slightly decomposed organic material which, if present, is less than one inch thick. In a representative soil, the surface mineral layer is 6 inches of light gray cobbly sandy loam having an admixture of volcanic ash. It has a massive arrangement that breaks to weak granular structure, and is very strongly acid. The underlying material, which extends to at least 34 inches depth, is light brownish gray to very pale brown, very cobbly sandy loam. It has weak subangular blocky to moderate granular structure, and is very strongly acid.

The Dystric Cryochrepts are coarse to moderately coarse textured, very cold, moderately deep to deep, and well drained to somewhat excessively drained. They formed in glacial till and colluvium derived from diorite, granodiorite, and quartz monzonite, with occasional influence of mafic volcanics. Volcanic ash may occur as a thin superficial layer or be mixed in the surface mineral layer. Water repellency, which is common in the surface mineral layer, decreases with increasing soil depth.

The soils usually have a superficial layer of slightly decomposed organic matter up to two inches thick. In a representative soil, the surface mineral layer is 10 inches of pale brown, coarse sandy loam having moderate granular structure. It is very strongly acid and slightly water repellent. The subsoil, which is 22 inches thick, is very pale brown, gravelly coarse sandy loam and light gray, very gravelly coarse sandy loam having moderate granular to moderate subangular blocky structure and strongly acid reaction. The underlying material, which extends to 41 inches, is light gray, very gravelly coarse sandy loam that has weathered in place, and is massive and strongly acid.

The rock outcrop consists of bedrock and rubble dominated by biotite and hornblende diorite and granodiorite at lower elevations, and by quartz monzonite at midrange and higher elevations. Although they have different minerals, these rocks show little difference in weathering in the elevational range of this map unit. The rocks have developed a characteristic pattern of deep parallel joints that collect water, pollen, and dust, and that normally are filled with soil (Figure 8). The soil in these fractures most often classifies as Typic Cryorthent.

Hydraulic conductivity of the soils is decreased significantly by chemically induced hydrophobicity. It is low if the soils have been dry prior to rainfall, but may increase to moderately high once the soils become wetted. Overland flow, which varies with hydrophobicity, is medium on gently sloping sites and rapid to very rapid on moderately steep sites. Plant-available water capacity is low in Typic Cryorthents and low to perhaps moderate in Dystric Cryochrepts. Effective rooting depth is greater than 40 inches in the unit.

Maximum erosion hazard rating is moderate on nearly level to strongly sloping sites, and high on moderately steep sites. Approximately 25 percent of the unit is rated low, 40 percent is moderate, and 35 percent is high. Sites immediately below rock outcrop approach a very high rating. These soils are highly susceptible to sheet, rill, and gully erosion when unprotected by vegetative cover, because of their moderately steep slopes and low cohesive strength. Surface rock fragment cover typically is about 20 to 60 percent. These fragments provide some protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion. This phenomenon is especially notable immediately below areas of rock outcrop and shallow soils. Landscape stability hazard is low under normal conditions.

These soils are well suited for trails and for campsites on nearly level to gently sloping sites. Limitations include rapid water runoff, loose consistence, and moderately steep slopes.

This map unit is poorly suited for commercial livestock grazing except in included meadows, because of the large proportion of rock outcrop, low forage production, and high susceptibility to sheet and rill erosion during and following disturbance. Areas may be used incidentally by pack stock as they travel through the region.

Wildlife habitat is good to fair, primarily because of irregular forage availability and cover related to rock outcrop. Burrowing animals and insects may be active in these soils, and rodents adapted to high elevation find habitat in rock rubble. Abundant rock fragments often interfere with digging, and animal burrows in soil having loose consistence do not hold up well. Soil depth is great enough to provide habitat for winter hibernation and protection from summer heat.

Although watershed rating of the soils is moderately high, that of the map unit as a whole is limited by the amount of rock outcrop. The soils have significant depth to bedrock and readily transmit high purity snowmelt water to underground storage. Snow retention is high, and hydrograph response is rapid.

Fire impacts are slight to moderate in this unit of high elevation, cold, and infertile soils. Fuel continuity is disrupted by rock outcrop and areas of low production, especially on Typic Cryorthents. Fuels are more concentrated on Dystric Cryochrepts, but still are limited.

These soils are susceptible to potential effects from acidic precipitation, because of their low buffering capacity.

110—Typic Cryorthents - Dystric Cryochrepts - Rock outcrop association, 15 to 45 percent slopes.

The soils' taxonomic names reflect the following characteristics:

- Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, or clayey);
- Dystric: base saturation less than 60 percent; generally low fertility, but adequate for acid-loving plants;
- Cry: very cold, with little warming in summer;
- orth: common form of the soil order (e.g., not unusually wet or sandy);
- ochr: light colored, organic-poor, or thin surface horizon;
- ent: Entisol, a soil order; a young, weakly developed soil;
- ept: Inceptisol, a soil order, slightly more developed than Entisols.

This map unit occurs west of the Sierran crest, and mostly north of Lake Thomas A. Edison on strongly sloping to steep mountain sides and glacial moraines at elevations between 8,300 and 11,600 feet. The soils formed primarily in colluvium and glacial till derived from granitic rock.

Mean annual precipitation ranges from 35 to 50 inches, most of which falls as snow. Vegetation series include red fir, lodgepole pine, whitebark pine, and alpine dwarf scrub.

The association, which comprises 1.02 percent of the survey area, is approximately 40 percent Typic Cryorthents, 30 percent Dystric Cryochrepts, 25 percent rock outcrop, and 5 percent inclusions. Typic Cryorthents are found throughout the unit, but they are dominant at middle and high elevations and in bedrock joints. Dystric Cryochrepts tend to occur most frequently at lower elevations, on glacial till, on the most gently sloping northerly aspects, under heaviest vegetative cover. Rock outcrops occur randomly in the unit, and are easily recognized on aerial photographs. Included in this map unit are Lithic Cryorthents in shallow bedrock depressions and in narrow fringes around the rock outcrops.

The Typic Cryorthents are coarse to moderately coarse textured, very cold, deep to very deep, and moderately well drained to somewhat excessively drained. They formed in glacial till, colluvium, alluvium, and residuum derived from diorite, granodiorite, and quartz monzonite. The soils may or may not have a superficial layer of slightly decomposed organic material which, if present, is less than one inch thick. The surface mineral horizon, which may have an admixture of volcanic ash, usually is water repellent, but underlying horizons are somewhat less water repellent.

In a representative soil, the surface mineral layer is 6 inches of light gray, cobbly sandy loam having an admixture of volcanic ash. It has a massive arrangement that breaks to weak granular structure, and is very strongly acid. The underlying material, which extends to at least 34 inches depth, is light brownish gray to very pale brown, very cobbly sandy loam. It has weak subangular blocky to moderate granular structure, and is very strongly acid.

The Dystric Cryochrepts are coarse to moderately coarse textured, very cold, deep to very deep, and well drained to somewhat excessively drained. They formed in glacial till and colluvium derived from diorite, granodiorite, and quartz monzonite, with occasional influence of mafic volcanics. The soils usually have a superficial layer of slightly decomposed organic matter up to two inches thick. The surface mineral layer, which may have an admixture of volcanic ash, usually is water repellent, but the subsoil usually is not water repellent unless it contains volcanic ash.

In a representative soil, the surface mineral layer is 10 inches of pale brown, coarse sandy loam having moderate granular structure. It is very strongly acid and slightly water repellent. The subsoil, which is 22 inches thick, is very pale brown, gravelly coarse sandy loam and light gray, very gravelly coarse sandy loam having moderate granular to moderate subangular blocky structure and strongly acid reaction. The underlying material, which extends to 41 inches, is light gray, very gravelly coarse sandy loam that has weathered in place, and is massive and strongly acid.

The rock outcrop consists of bedrock and rubble dominated by biotite and hornblende diorite and granodiorite at lower elevations, and by quartz monzonite at midrange and higher elevations. Although they have different minerals, these rocks show little difference in weathering in the elevational range of this map unit. The rocks have developed a characteristic pattern of deep parallel joints and fractures which collect water, pollen, and dust, and which normally are filled with soil.

Hydraulic conductivity of the soils is decreased significantly by chemically induced hydrophobicity. It is low if the soils have been dry prior to rainfall, but may increase to moderately high once the soils become wetted. Overland flow, which varies with slope steepness and hydrophobicity, is rapid to very rapid. Plant-available water capacity is low in Typic Cryorthents and low to perhaps moderate in Dystric Cryochrepts. Effective rooting depth is greater than 40 inches in the unit.

Maximum erosion hazard rating is high on moderately steep sites, and very high on steep sites, most notably those immediately below rock outcrop. Approximately 25 percent of the unit is rated low because of rock outcrop, 35 percent is high, and 40 percent is very high. The soils are highly susceptible to sheet, rill, and gully erosion when unprotected by vegetative cover, because of their slope steepness and low cohesive strength. Surface rock fragment cover typically is about 20 to 60 percent. These fragments provide some protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion. This phenomenon is especially notable immediately below areas of rock outcrop and shallow soils. Landscape stability hazard is low under normal conditions.

These soils are suitable for trails, but are unsuitable for campsites (except for a few scattered level sites) because of steep slopes. Limitations to trail construction and use include steep slopes, rapid water runoff, loose consistence, and dustiness.

This map unit is unsuitable for commercial livestock grazing because of large proportion of rock outcrop, low forage production, and high susceptibility to sheet and rill erosion during and following disturbance.

Wildlife habitat is good to fair, primarily because of irregular forage availability and cover related to rock outcrop. Habitat quality also decreases with increasing elevation. Burrowing animals and insects may be active in these soils, and rodents adapted to high elevation find habitat in rock rubble. Abundant rock fragments often interfere with digging, and animal burrows in top soil having loose consistence do not hold up well. Soil depth is great enough to provide habitat for winter hibernation and protection from summer heat.

Watershed rating is moderate. It is limited by rock outcrop and steep slopes, which cause surface and subsurface runoff to be rapid to very rapid. The soils have significant depth to bedrock and readily transmit high purity snowmelt water to underground storage. Snow retention is high, and hydrograph response is rapid.

Fire impacts are slight to moderate in this unit of high elevation, cold, and infertile soils. Fuel continuity is disrupted by rock outcrop and areas of low production, especially on Typic Cryorthents. Fuels are more concentrated on Dystric Cryochrepts, but still are limited.

These soils are susceptible to potential effects from acidic precipitation, because of their low buffering capacity.

111—Typic Cryorthents - Typic Cryochrepts - Rock outcrop complex, 0 to 45 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, or clayey);

Cry: very cold, with little warming in summer;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ochr: light colored, organic-poor, or thin surface horizon;

ent: Entisol, a soil order; a young, weakly developed soil;

ept: Inceptisol, a soil order, slightly more developed than Entisols.

This map unit occurs over nearly the full length of the survey area east of the Sierran crest on nearly level to steep glacial moraines, ridges, mountain sides, and alluvial bottoms at elevations between 8,000 and 11,600 feet. The soils developed most commonly from granitic materials, and less commonly from metamorphic materials in some of the northern delineations.

Mean annual precipitation ranges from 20 inches in the southern-most delineations to 50 inches in the northern areas, most of which falls as snow. The most common vegetation series are whitebark pine and lodgepole pine; less common are limber pine in the central region, and foxtail pine in Cottonwood Basin.

The complex, which comprises 2.00 percent of the survey area, is approximately 40 percent Typic Cryorthents, 30 percent Typic Cryochrepts, 20 percent rock outcrop, and 10 percent inclusions. These components are too intricately mixed on the landscape to be delineated separately; nonetheless, the Typic Cryochrepts tend to be more common at lower elevations, on nearly level, slightly concave positions that accumulate water and detritus, and support heaviest vegetation. The delineation in the vicinity of Hilton Creek Lakes contains only a minor amount of rock outcrop. The unit contains the following inclusions: Lithic Cryorthents in shallow bedrock depressions and in narrow fringes around granitic rock outcrops; Typic Cryorthents, tephritic mainly in the northern delineations influenced by volcanic ash; and Dystric Cryochrepts in the high precipitation regions and in soils containing pumice.

The Typic Cryorthents are coarse to moderately coarse textured, very cold, deep to very deep, and moderately well drained to somewhat excessively drained. They formed in colluvium and glacial till, as well as alluvium and residuum derived primarily from granitic rocks and secondarily from volcanic and metamorphic rocks. The rock types include diorite, granodiorite, quartz monzonite, felsic tuff and latite, hornfels, low-grade schist, and gneiss. The soils may or may not have a superficial layer of slightly decomposed organic material which, if present, is less than one inch thick.

In a representative soil, the surface mineral layer is 6 inches of light gray, cobbly sandy loam having an admixture of volcanic ash. It has a massive arrangement that breaks to weak granular structure, and is very strongly acid. The underlying material, which extends to at least 34 inches depth, is light brownish gray to very pale brown, very cobbly sandy loam. It has weak subangular blocky to moderate granular structure, and is very strongly acid.

The Typic Cryochrepts are coarse to moderately coarse textured, very cold, moderately deep to very deep, and well drained to somewhat excessively drained. They formed in glacial till and colluvium derived from biotite and hornblende diorite, granodiorite, and quartz monzonite, or infrequently from metamorphic rocks. The soils may or may not have a superficial layer of slightly decomposed organic matter up to one inch thick.

In a representative soil, the surface mineral layer is 4 inches of dark grayish brown, gravelly sandy loam having moderate granular structure. It is strongly acid and slightly to moderately water repellent. The subsoil, which is 11 inches thick, is very pale brown, very gravelly sandy loam having moderate granular structure. It is moderately acid and slightly water repellent. The substratum, which extends to at least 26 inches, is very pale brown to white, extremely gravelly loamy sand. It is massive, breaking to single grain, moderately acid, and wettable.

The rock outcrop consists of bedrock and rubble dominated by biotite and hornblende diorite and granodiorite at lower elevations, and by porphyritic quartz monzonite at midrange and higher elevations. Although they have different minerals, these rocks show little difference in weathering in the elevational range of this map unit. The rocks have developed a characteristic pattern of deep parallel joints that collect water, pollen, and dust, and that normally are filled with soil (Typic Cryorthents).

Hydraulic conductivity is moderately high to high, although it may be decreased significantly by chemically induced hydrophobicity. Overland flow, which varies with hydrophobicity, is medium on gently sloping sites and rapid to very rapid on moderately steep and steep sites. Plant-available water capacity is low in Typic Cryorthents and low to perhaps moderate in Typic Cryochrepts. Effective rooting depth is greater than 36 inches in the unit.

Maximum erosion hazard rating is moderate on nearly level to strongly sloping sites, and high on moderately steep and steep sites. Approximately 20 percent of the unit is rated low, 40 percent is moderate, and 40 percent is high. Steeply sloping sites immediately below rock outcrop have a very high rating.

These soils are highly susceptible to sheet, rill, and gully erosion when unprotected by vegetative cover, because of their moderately steep slopes and low cohesive strength. Sheet erosion is notable in these soils regardless of surface cover. Surface rock fragment cover ranges from 10 to 80 percent. These fragments provide some protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion. This phenomenon is especially notable immediately below areas of rock outcrop and shallow soils. Landscape stability hazard is low under normal conditions.

These soils are well suited for trails and for campsites on nearly level to gently sloping sites. Limitations include rapid water runoff, loose consistence, and moderately steep and steep slopes.

This map unit is poorly suited for commercial livestock grazing because of the large proportion of rock outcrop, low forage production, and high susceptibility to sheet and rill erosion during and following disturbance. Areas may be used incidentally by pack stock as they travel through the region.

Wildlife habitat is fair because of low forage production. Burrowing animals and insects may be active in these soils, and rodents adapted to high elevation find habitat in rock rubble. Abundant rock fragments often interfere with digging, and animal burrows in top soil having loose consistence do not hold up well. Soil depth is great enough to provide habitat for winter hibernation and protection from summer heat.

Watershed rating ranges from moderately low to moderately high, primarily because of the large variation in precipitation among the various map unit delineations. It is limited by the amount of rock outcrop and high rock fragment content of the soils. These sites intercept snowmelt and rainfall water, then transfer it to lower lying receiving watersheds. Snow retention is high, and hydrograph response is rapid.

Fire impacts are slight to moderate in this unit of high elevation, cold, and infertile soils. Fuel continuity is disrupted by rock outcrop and areas of low production, especially on Typic Cryorthents. Fuels are more concentrated on Dystric Cryochrepts, but still are limited.

These soils are susceptible to potential effects from acidic precipitation, because of their low buffering capacity.

112—Typic Cryorthents - Entic Cryumbrepts complex, 0 to 45 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Typic:	soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, or clayey);
Entic:	lack of subsoil development;
Cry:	very cold, with little warming in summer;
orth:	common form of the soil order (e.g., not unusually wet or sandy);
umbr:	dark colored, organic-rich surface horizon having low base saturation;
ent:	Entisol, a soil order; a young, weakly developed soil;
ept:	Inceptisol, a soil order, slightly more developed than Entisols.

This map unit occurs west of the Sierran crest on nearly level to steep ridges, mountain sides, glacial moraines, and alluvial bottoms at elevations between 7,000 and 10,400 feet. The soils formed in colluvium, glacial till, and alluvium weathered from granitic rock.

Mean annual precipitation ranges from 30 to 45 inches, most of which falls as snow. Vegetation series include mixed conifer, red fir, lodgepole pine, whitebark pine, and alpine dwarf scrub.

The complex, which comprises 1.69 percent of the survey area, is approximately 50 percent Typic Cryorthents, 40 percent Entic Cryumbrepts, and 10 percent inclusions. Although the soils are too intermingled on the landscape to be mapped separately, some general relations are noted: Typic Cryorthents dominate on the steepest slopes and at middle and high elevations; Entic Cryumbrepts tend to occur most frequently on the more gently sloping glacial till deposits at lower elevations, and especially under grass and sedge. Included in this unit are small areas of granitic rock outcrop and rubble. Lithic Cryorthents are associated with the rock outcrop, usually at elevations above about 8,000 feet. Dystric Xerorthents occur at the lowest elevations, especially on southerly aspects in the southern portion of the survey area.

The Typic Cryorthents are coarse to moderately coarse textured, very cold, deep to very deep, and moderately well drained to somewhat excessively drained. They formed from colluvium and glacial till, and less commonly from alluvium and residuum derived primarily from granitic rocks. The surface horizon of some pedons may be enriched with volcanic ash, but usually the ash is not a major component. The soils may or may not have a superficial layer of slightly decomposed organic material which, if present, usually is less than two inches thick.

In a representative soil, the surface mineral layer is 6 inches of light gray, cobbly sandy loam having an admixture of volcanic ash. It has a massive arrangement that breaks to weak granular structure, and is very strongly acid. The underlying material, which extends to at least 34 inches depth, is light brownish gray to very pale brown, very cobbly sandy loam. It has weak subangular blocky to moderate granular structure, and is very strongly acid.

The Entic Cryumbrepts are coarse to moderately coarse textured, very cold, moderately deep to very deep, and well drained to somewhat excessively drained. They formed in colluvium, glacial till, and alluvium derived from granitic or, less commonly, metamorphic rocks. The soils may or may not have a superficial layer of slightly decomposed organic material which, if present, is less than two inches thick.

In a representative soil, the surface mineral layer is 2 inches of grayish brown, gravelly loamy coarse sand that is single grained. It is very strongly acid and extremely water repellent. This is underlain by 25 inches of grayish brown, loamy coarse sand having weak granular structure, strongly acid reaction, and extreme to very slight water repellence. The substratum, to at least 64 inches depth, is grayish brown, light brownish gray, or light yellowish brown, loamy coarse sand or gravelly loamy coarse sand that is massive to weak granular. It is strongly acid and wettable.

Chemically induced hydrophobicity allows only low hydraulic conductivity of dry surface soil. Once the soil becomes wetted, hydraulic conductivity increases to moderately high. Overland flow, which varies with slope steepness and hydrophobicity, is medium to very rapid. Plant-available water capacity is low. Effective rooting depth is greater than 36 inches in the unit.

Maximum erosion hazard rating is moderate on nearly level to strongly sloping sites, and high on moderately steep and steep sites. Approximately 40 percent of the unit is rated moderate, and 60 percent is rated high. These soils are highly susceptible to sheet, rill, and gully erosion when unprotected by surface cover. Surface rock fragment cover typically is about 15 to 70 percent. These fragments provide some protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion, especially on downslope sites. Landscape stability hazard is low under normal conditions.

These soils are well suited for trails, and for campsites on nearly level to gently sloping sites. Limitations include rapid water runoff, loose consistence, and moderately steep and steep erodible slopes.

This map unit is poorly suited for commercial livestock grazing except in included meadows because of low forage production and high susceptibility to sheet and rill erosion during and following disturbance, especially on moderately steep and slopes. These areas can be used incidentally by pack stock.

Wildlife habitat is good to fair. It decreases in quality with increasing elevation. Burrowing animals and insects are active in these soils. Abundant rock fragments often interfere with digging, and animal burrows in top soil having loose consistence do not hold up well. Soil depth generally is great enough to provide habitat for winter hibernation and protection from summer heat.

Watershed rating generally is moderately high for the survey area because of the soils' significant depth to bedrock and the large amount of high purity water collected and transmitted to underground storage. Snow retention is high, and hydrograph response is rapid.

Fire impacts are moderate on these soils. Above ground fuels normally are adequate to carry a fire through the unit, but surface fuels usually are too light and scattered to result in more than a low or moderate intensity burn. Fire impacts decrease with increasing elevation because of decreasing temperatures and fuel concentrations.

These soils are susceptible to potential effects from acidic precipitation, because of their low buffering capacity.

113—Typic Cryorthents - Typic Cryumbrepts - Rock outcrop complex, 0 to 45 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, or clayey);

Cry: very cold, with little warming in summer;

orth: common form of the soil order (e.g., not unusually wet or sandy);

umbr: dark colored, organic-rich surface horizon having low base saturation;

ent: Entisol, a soil order; a young, weakly developed soil;

ept: Inceptisol, a soil order, slightly more developed than Entisols.

This map unit occurs in the northwestern part of the survey area on nearly level to steep mountain sides and glacial moraines, at elevations between 8,000 and 10,400 feet. The soils formed primarily in colluvium and glacial till developed from granodiorite, diorite, and quartz monzonite.

Mean annual precipitation ranges from 35 to 50 inches, most of which falls as snow. Vegetation series include red fir, lodgepole pine, whitebark pine, and alpine dwarf scrub.

The map unit, which comprises 1.44 percent of the survey area, is approximately 35 percent Typic Cryorthents, 35 percent Typic Cryumbrepts, 20 percent rock outcrop, and 10 percent inclusions. Although the soils are too intermingled on the landscape to be mapped separately, some general relations are noted: Typic Cryorthents occur most commonly on upper, more convex landscapes and bouldery glacial moraines that support less vegetation than Typic Cryumbrepts. They are more likely than Typic Cryumbrepts to have developed from quartz monzonite. Typic Cryumbrepts occur most commonly on lower landscape positions and on northerly facing slopes having a closed forest canopy or heavy grass or sedge cover. The forested sites usually have an organic litter layer, and all sites have dark colored topsoil. At high elevations, grasses and sedges can provide adequate organic matter from annual root decay to develop the A horizon necessary for the formation of Typic Cryumbrepts. The unit contains small scattered inclusions of Entic Cryumbrepts and Typic Cryochrepts. Lithic Cryorthents are in very narrow fringes around rock outcrops; wet Typic Cryumbrepts occur in meadows; and Aquic Cryumbrepts occur in the bottom of Fish Valley and in riparian zones.

The Typic Cryorthents are coarse to moderately coarse textured, very cold, deep to very deep, and moderately well drained to somewhat excessively drained. More than half the soils have a slightly decomposed surface organic layer that commonly is less than one inch thick, but that may reach three inches thickness. The surface mineral layer typically is water repellent, and may contain an admixture of volcanic ash. The underlying mineral soil normally has lighter, brighter colors and greater rock fragment content, and it may have slightly better developed structure, although structures seldom are more pronounced than weak granular. Distinctive subsoil horizons are not well developed, even under a closed canopy of mature trees, because of the high proportion of resistant minerals and limited conditions for chemical weathering.

In a representative soil, the surface mineral layer is 6 inches of light gray, cobbly sandy loam having an admixture of volcanic ash. It has a massive arrangement that breaks to weak granular structure, and is very strongly acid. The underlying material, which extends to at least 34 inches depth, is light brownish gray to very pale brown, very cobbly sandy loam. It has weak subangular blocky to moderate granular structure, and is very strongly acid.

Typic Cryumbrepts are coarse to moderately coarse textured, very cold, deep to very deep, and well drained to somewhat excessively drained. The soils normally have a superficial layer of slightly decomposed organic material less than two inches thick. Typically, the surface mineral layer may be moderately water repellent, and contain an admixture of volcanic ash. The subsoil usually has slight to no water repellency.

In a representative soil, the surface mineral layer is 10 inches of yellowish brown sandy loam having weak granular structure. It is strongly acid and slightly water repellent. The subsoil, which is 20 inches thick, is yellowish brown to dark yellowish brown sandy loam or gravelly sandy loam, having moderate granular structure. It is strongly acid, and is not water repellent (some comparable soils are slightly water repellent in the subsoil). The substratum, which extends to at least 41 inches depth, is dark brown very gravelly coarse sandy loam having moderate granular structure, and strongly acid reaction.

Rock outcrop consists of hard bedrock and rubble dominated by hornblende-bearing, biotite diorite and granodiorite at lower elevations, and quartz monzonite at higher elevations. These rocks have developed a characteristic pattern of deep perpendicular joints and fractures that collect water, pollen, and dust. The joints normally are filled with soil that can support a well developed plant community. The various rock types show little difference in weathering over the elevational range of this map unit.

Hydraulic conductivity is moderately high, unless the topsoil is water repellent. Overland flow is medium to rapid. Plant-available water capacity is low. Effective rooting depth is greater than 40 inches in the unit.

Maximum erosion hazard rating is moderate on nearly level to strongly sloping sites, high on moderately steep sites (except those immediately below rock outcrop, which are very high), and very high on steep sites. Approximately 30 percent of the unit is rated low, 20 percent is moderate, 25 percent is high, and 25 percent is very high. These soils are susceptible to sheet, rill, and gully erosion when unprotected by vegetative cover, because of their steep slopes and low cohesive strength. Surface rock fragment cover averages approximately 40 percent on Typic Cryorthents and 25 percent on Typic Cryumbrepts, with a total range from 0 to 70 percent. These fragments provide some protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion. Overland flow can be particularly acute immediately below rock outcrops. Landscape stability hazard is moderately low under normal conditions.

These soils are well suited for trails, and well suited to unsuitable for campsites because of slope steepness. Limitations to trail building include rapid water runoff, loose consistence, and steep slopes.

Most of this unit is unsuitable for livestock grazing because of high erosion hazard, rock outcrop, and low forage production, especially on Typic Cryorthents. Recreational pack stock can make incidental use of the unit.

Wildlife habitat, which decreases in quality with increasing elevation, is good to fair. It appears to be better on Typic Cryumbrepts, and poorer on Typic Cryorthents. The Typic Cryumbrepts support good summer habitat for deer and other migratory species. Burrowing animals and insects easily can find adequate depth for winter hibernation and summer thermal protection, although rock fragments may interfere with digging. Rodents often find suitable habitat in rock rubble.

Watershed rating is moderate. The unit receives above average precipitation for the survey area, but much of this water is shed rapidly by rock outcrops. The principal watershed importance of the complex is to collect and temporarily store high quality water and conduct it to lower elevation storage areas. Snow retention is high, and hydrograph response is rapid.

The impact of fire is slight to moderate because of rock outcrop and light, scattered fuels. Soil and atmospheric temperatures are low enough to limit fuel production and fire hazard.

These soils are susceptible to potential effects from acidic precipitation, because of their low buffering capacity. They are well suited for monitoring the environmental effects of atmospheric pollutants, because of their accessibility and diversity of soils and ecosystems.

114—Typic Cryorthents–Rock outcrop complex, 0 to 45 percent slopes.

The soil's taxonomic name reflects the following characteristics:

Typic: soil is characteristic of the great group to which it belongs (e.g., not unusually moist, shallow, or clayey);

Cry: very cold, with little warming in summer;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ent: Entisol, the soil order; a young, weakly developed soil.

This map unit is found most commonly in the western portion of the survey area; a few delineations are in the northern portion of the area east of the Sierran crest, and two small delineations are in the southeastern portion, below Mount Whitney. Generally, delineations in this complex lie further from the crest than do those in map unit 147, in which rock outcrop dominates over Typic Cryorthents.

The map unit occurs on nearly level to steep mountain sides, glacial moraines, and alluvial bottoms, and in granitic bedrock joints at elevations between 7,100 and 12,200 feet. The soils formed in colluvium, glacial till, alluvium, and, less commonly, residuum weathered from granitic rock.

Mean annual precipitation ranges from 20 to 45 inches, most of which falls as snow. Vegetation series include upper elevation mixed conifer-fir, Jeffrey pine, red fir, lodgepole pine, and whitebark pine.

The complex, which comprises 4.78 percent of the survey area, is 50 percent Typic Cryorthents, 35 percent rock outcrop, and 15 percent inclusions. Although the soils are too intricately interspersed among the rock outcrops to allow them to be separated at the mapping intensity of this survey, most of the soils are easily distinguished from rock outcrop by ground reconnaissance or interpretation from aerial photographs. The unit contains the following inclusions: Dystric Cryochrepts at low elevations west of the Sierran crest, on heavily vegetated, nearly level to gently sloping, concave sites; Lithic Cryorthents and Lithic Cryumbrepts in very narrow fringes around rock outcrops and in shallow rock depressions; Entic Cryumbrepts on heavily vegetated, depressional sites overlying basaltic parent material; and Andic Cryumbrepts in tephra-enriched deposits in Lone Pine Creek, above Whitney Portal.

The Typic Cryorthents are coarse to moderately coarse textured, very cold, deep to very deep, and moderately well drained to somewhat excessively drained. A slightly decomposed surface organic layer less than one inch thick can be found under forest canopies, especially on nearly level to strongly sloping sites, where it may attain three inches thickness. The surface mineral horizon usually is water repellent, and may contain an admixture of fine pumice. Horizontal plant roots often are concentrated near the bottom of this layer.

The underlying soil normally has lighter, brighter colors, fewer roots, and greater rock fragment content, but little or no pumice. It may have slightly better developed structure, although structures seldom are more pronounced than weak granular. Distinctive subsoil horizons are not well developed, even under a closed canopy of mature trees, because of the high proportion of resistant minerals and limited conditions for chemical weathering. Water repellence decreases significantly from top soil to underlying materials.

In a representative soil, the surface mineral layer is 6 inches of light gray, cobbly sandy loam having an admixture of volcanic ash. It has a massive arrangement that breaks to weak granular structure, and is very strongly acid. The underlying material, which extends to at least 34 inches depth, is light brownish gray to very pale brown, very cobbly sandy loam. It has weak subangular blocky to moderate granular structure, and is very strongly acid.

Rock outcrop consists of hard bedrock and rubble dominated by hornblende–bearing, biotite diorite and granodiorite at lower elevations, and biotite quartz monzonite at higher elevations, especially near the crest of the Sierra Nevada. These rocks have developed a characteristic pattern of deep parallel joints which collect water, pollen, and dust. The joints normally are filled with soil that can support a well developed plant community. Below about 8,000 feet elevation, diorite and granodiorite tend to weather more readily than quartz monzonite, because they contain more weatherable minerals such as plagioclase, biotite, and hornblende.

Hydraulic conductivity of Typic Cryorthents is moderately high, although it may be decreased significantly by chemically induced hydrophobicity. Considerable water infiltration in the nonwettable soils is through open channels created by insects, soil animals, and plant roots. The hydraulic conductivity of hydrophobic soils increases after they become wetted. Overland flow is medium on wettable, gently sloping sites, and rapid on hydrophobic and moderately steep sites. Plant–available water capacity is low. Effective rooting depth is greater than 40 inches.

Maximum erosion hazard rating is moderate on nearly level to strongly sloping sites, high on moderately steep sites (except immediately below rock outcrop, where it is very high), and very high on steep sites. Approximately 35 percent of the unit is rated low (including rock outcrop), 20 percent is moderate, 25 percent is high, and 20 percent is very high. These soils are susceptible to sheet, rill, and gully erosion when unprotected by vegetative cover, because of their low cohesive strength. Surface rock fragments, which can range up to 70 percent, provide protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion. Erosion hazard is greatest directly below rock outcrops, because of the excessive amount of overland flow water. Recovery from disturbance generally is slow, especially on the moderately steep slopes. Landscape stability hazard is low under normal conditions.

These soils generally are well suited for trails and for campsites on nearly level to gently sloping sites. The major limitations, apart from moderately steep slopes, are caused by the soils' loose consistence, which increases erodibility and decreases trafficability, and by water repellence, which increases erodibility. Runoff water often becomes concentrated in trails and is conducted along their length, eroding the surface. These effects can be minimized by proper construction and spacing of water bars. Trails and campsites constructed in these soils tend to be dusty when dry, but generally are less dusty than soils derived from metavolcanic rock or which contain appreciable amounts of fine volcanic ash.

Although this map unit in general is little used for commercial livestock grazing, some of the meadows are well suited for grazing, and are grazed by cattle under active allotments. These meadows are recovering from past over-grazing, and today are in fair to good condition. Soil and vegetative recovery of abused meadows normally requires several decades. Most grazing allotments are vacant, but they still are used extensively by recreational and commercial pack stock. Apart from the meadows, areas of Typic Cryorthents provide secondary forage for pack stock and for cattle in active allotments. The short growing season, low forage productivity, difficult accessibility, and high erodibility limit the grazing use of these areas.

Wildlife habitats, which decrease in quality with increasing elevation, are fair to poor. Limited forage production and quality supports fewer animal species than do units having warmer, more developed soils and greater vegetative diversity. Soil conditions are suitable for burrowing animals and insects, although the high proportion of rock fragments increases the difficulty of digging. Rodents adapted to high elevation find habitat in rock rubble.

Watershed rating of this unit ranges from moderately high to moderately low, because of the range in precipitation and occurrence of bedrock. The relatively large extent of the unit is a significant component of its watershed importance. Bedrock fractures and joints probably are significant conduits of cold, high purity water to lower elevation, higher porosity regions. Snow retention is high. Hydrograph response is rapid during snow melt and rainstorms, because of rapid transmission rates to stream channels. Snow melt and rainfall from this unit provide substantial high purity water to recharge reservoirs.

The impact of fire is slight because of low, discontinuous fuel production and limited soil development.

Typic Cryorthents are susceptible to potential effects from acidic precipitation, because of the soils' low buffering capacity.

115—Typic Cryorthents - Rock outcrop complex, 40 to 85 percent slopes.

The soil's taxonomic name reflects the following characteristics:

Typic: soil is characteristic of the great group to which it belongs (e.g., not unusually moist, shallow, or clayey);

Cry: very cold, with little warming in summer;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ent: Entisol, the soil order; a young, weakly developed soil.

This map unit occurs throughout the survey area on steep to extremely steep mountain sides and glacial moraines at elevations ranging from 6,700 to 13,900 feet. The soils formed in colluvium and glacial till, as well as minor amounts of alluvium, derived dominantly from granitic rock.

Mean annual precipitation ranges from 20 to 50 inches, most of which falls as snow. Vegetation series include upper elevation mixed conifer-fir, Jeffrey pine, red fir, lodgepole pine, and whitebark pine.

The complex, which comprises 6.03 percent of the survey area, is 55 percent Typic Cryorthents, 30 percent rock outcrop, and 15 percent inclusions. Approximately 10 percent of the unit, most notably in the Kaiser Wilderness, includes soils on slopes to about 20 percent steepness. Although the soils are too intricately interspersed among the rock outcrops for them to be separated at the mapping intensity of this survey, soils are easily distinguished from rock outcrop by ground reconnaissance or aerial photograph interpretations.

The unit contains minor inclusions of Lithic Cryorthents in very narrow fringes around rock outcrops, and Dystric Cryochrepts, Typic Cryochrepts, and Entic Cryumbrepts in some bedrock joints and pockets, especially on the most gentle slope positions and along alluvial bottoms. Dystric Cryochrepts are west of the Sierran crest, and Typic Cryochrepts are east of the crest; Umbrepts seem to be most common in basaltic parent materials. Minor areas of Typic Cryoborolls occur east of the Sierran crest. Typic Xerorthents occur on some south-facing slopes below about 9,000 feet elevation in the south eastern portion of the survey area.

Rock outcrops, which are best exposed in glacially scoured canyons, consist of hard bedrock and rubble, including talus and rock glaciers. Although small areas of basaltic and metamorphic rock are included, the rock is dominated by hornblende-bearing, biotite diorite and granodiorite at lower elevations, and biotite quartz monzonite at higher elevations, especially near the crest of the Sierra Nevada. These rocks have developed a characteristic pattern of deep, three-dimensional, mutually perpendicular joints and miscellaneous fractures which collect water, pollen, and dust. These fissures normally are filled with soil which may support a well developed plant community. Below about 8,000 feet elevation, diorite and granodiorite tend to weather more readily than quartz monzonite, because they contain more weatherable minerals such as plagioclase, biotite, and hornblende.

The Typic Cryorthents typically are coarse to moderately coarse textured, very cold, deep to very deep, and moderately well drained to somewhat excessively drained. A slightly decomposed surface organic layer less than one inch thick may be found under forest canopies. The surface mineral horizon usually is water repellent, and often contains fine pumice, especially in the northern portion of the survey area. Plant roots, which dominantly are parallel to the ground surface, tend to be concentrated near the bottom of this layer.

The underlying soil normally has lighter, brighter colors, fewer roots, and greater rock fragment content, but little or no pumice. It may have slightly better developed structure, although structures seldom are more pronounced than weak granular. Distinctive subsoil horizons are not well developed, because of the high proportion of resistant minerals and limited conditions for chemical weathering. Water repellency decreases significantly from top soil to underlying material.

In a representative soil, the surface mineral layer is 6 inches of light gray, cobbly sandy loam having an admixture of volcanic ash. It has a massive arrangement that breaks to weak granular structure, and is very strongly acid. The underlying material, which extends to at least 34 inches depth, is light brownish gray to very pale brown, very cobbly sandy loam. It has weak subangular blocky to moderate granular structure, and is very strongly acid.

Hydraulic conductivity of Typic Cryorthents is moderately high; overland flow is very rapid, especially on hydrophobic soils. Plant-available water capacity is very low to low. Effective rooting depth is greater than 40 inches.

Maximum erosion hazard rating is very high. These soils are highly susceptible to sheet, rill, and gully erosion because of the very steep slopes, limited vegetative cover, and the soils' low cohesive strength. Surface rock fragments, which can range up to 70 percent, provide protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion. Erosion hazard is greatest directly below rock outcrops, because of the excessive amount of overland flow water. Recovery from disturbance generally is very slow. Landscape stability hazard is high to very high. Soils commonly undergo soil creep, and are highly susceptible to debris avalanches and, in drainage bottoms, debris torrents.

These soils are poorly suited for trails and are unsuitable for campsites, because of the very steep slopes, loose soil consistence, hydrophobicity, and generally very high erosion hazard. Trails must be carefully constructed and maintained, especially with regard to water diversions and switchbacks.

This map unit is unsuitable for livestock grazing, except for occasional over-night or transitory use by recreational pack stock on gently sloping inclusions.

Wildlife habitats range from good to poor, following the gradient of decreasing forage production with increasing elevation and slope steepness, and decreased production is areas of rock outcrop. This map unit supports fewer animal species than do units having warmer, more developed soils and greater vegetative diversity on more gentle slopes. Burrowing animals are limited by slope steepness, which allows soil creep and landslides, and the high proportion of rock fragments, which increase the difficulty of digging. Rodents adapted to high elevation find habitat in rock rubble.

Watershed rating is moderately low to moderate, primarily because of the great variation in precipitation throughout the unit, and limitation of very steep and extremely steep slopes. Soil permeability and depth are adequate to collect significant snowmelt and rain water and transfer it to streams or to bedrock fractures and joints which eventually conduct it to lower elevation, higher porosity aquifers. Snow retention is high. Hydrograph response is rapid. The large size of this unit augments its watershed importance.

The impact of fire is slight because of low, discontinuous fuel production and limited soil development.

Typic Cryorthents are susceptible to potential effects from acidic precipitation, because of the soil's low buffering capacity.

116—Typic Cryorthents - Rock outcrop - Lithic Cryorthents complex, 0 to 30 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, or clayey);

Lithic: shallow, depth to bedrock less than 20 inches;

Cry: very cold, with little warming in summer;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ent: Entisol, a soil order; a young, weakly developed soil;

This map unit is found in the northern portion of the survey area on each side of the Sierran crest. It occurs on nearly level to moderately steep ridges and mountain sides at elevations between 6,700 and 11,600 feet in areas of granitic rock. The soils formed in granitic colluvium, glacial drift, and alluvium, as well as from residuum to a minor extent; and in bedrock fractures.

Mean annual precipitation ranges from 35 to 45 inches, most of which falls as snow. Vegetation series include mixed conifer, red fir, lodgepole pine, whitebark pine, and alpine dwarf scrub.

The complex, which comprises 1.51 percent of the area, is approximately 50 percent Typic Cryorthents, 25 percent rock outcrop, 15 percent Lithic Cryorthents, and 10 percent inclusions. Lithic Cryorthents are closely associated with rock outcrop; these associations are distributed randomly throughout the unit, and cannot be separated from Typic Cryorthents at the intensity of mapping used in this survey. The unit contains the following inclusions: Entic Cryumbrepts under heavy grass or sedge cover, and in moist depressional sites, especially those supporting deciduous trees and shrubs mixed with conifers; Dystric Cryochrepts scattered through the unit west of the Sierran crest under well developed vegetative communities; Dystric Xerorthents below about 7,500 feet elevation.

The Typic Cryorthents are coarse to moderately coarse textured, very cold, deep to very deep, and moderately well drained to somewhat excessively drained. They formed in glacial till, colluvium, alluvium, and residuum derived from diorite, granodiorite, and quartz monzonite. A few small areas derived from volcanic or metamorphic rock. The soils may or may not have a surface layer of slightly decomposed organic material that, if present, is less than one inch thick. In a representative soil, the surface mineral layer is 6 inches of light gray cobbly sandy loam having an admixture of volcanic ash. It has a massive arrangement that breaks to weak granular structure, and is very strongly acid. The underlying material, which extends to at least 34 inches depth, is light brownish gray to very pale brown, very cobbly sandy loam. It has weak subangular blocky to moderate granular structure, and is very strongly acid.

The rock outcrop consists of bedrock and rubble dominated by biotite and hornblende diorite and granodiorite at lower and midrange elevations, and by quartz monzonite at higher elevations. These rocks have a characteristic pattern of deep parallel joints that collect water, pollen, and dust, and that normally are filled with soil (commonly Typic Cryorthents). At elevations below about 8,000 feet, diorite and granodiorite tend to weather more readily than quartz monzonite because they contain more nutrient-rich, weatherable minerals, including plagioclase, biotite, and hornblende.

Lithic Cryorthents are coarse to moderately coarse textured, very cold, very shallow to shallow, and well drained to somewhat excessively drained. They occur primarily in shallow bedrock depressions and in fringes around rock outcrops at elevations above 8,000 feet. Surface organic layers are absent or less than one-half inch thick. In a representative soil, the surface mineral horizon is 6 inches of light brownish gray, gravelly to very gravelly loamy coarse sand having single grain arrangement or weak granular structure. It is moderately to extremely water repellent and very strongly acid. The underlying material is 3 inches of light brownish gray, very gravelly loamy coarse sand having weak granular structure, slight to moderate water repellency, and very strongly acid reaction. The substratum to 16 inches depth is light gray, very gravelly loamy coarse sand. It is massive, and very strongly acid.

Hydraulic conductivity of these coarse textured soils is decreased significantly by chemically induced hydrophobicity. It is low if the soils have been dry prior to rainfall, but may increase to moderately high once the soils become wetted. Overland flow, which varies with hydrophobicity, is medium on gently sloping sites and rapid on moderately steep sites. Plant-available water capacity is low. Effective rooting depth is greater than 40 inches in Typic Cryorthents, and less than 20 inches in Lithic Cryorthents.

Maximum erosion hazard rating is moderate on nearly level to strongly sloping sites, and high on moderately steep sites. Approximately 25 percent of the unit is rated low, 45 percent is moderate, and 30 percent is high. Sites immediately below rock outcrop and Lithic Cryorthents approach a very high rating. These soils are highly susceptible to sheet, rill, and gully erosion when unprotected by vegetative cover, because of their moderately steep slopes, low cohesive strength, and in the case of Lithic Cryorthents shallow depth to bedrock. Surface rock fragment cover is 40 to 50 percent on Typic Cryorthents and approximately 30 percent on Lithic Cryorthents. These fragments provide some protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion. This phenomenon is especially notable immediately below rock outcrops and areas of Lithic Cryorthents, which cause unusually high concentrations of runoff water. Landscape stability hazard is low under normal conditions.

These soils are well suited for trails and for campsites on nearly level to gently sloping sites. Limitations include rapid water runoff, loose consistence, and moderately steep slopes.

Except for included meadows, this map unit is poorly suited for commercial livestock grazing because of the large proportion of rock outcrop and shallow soils, low forage production, and high susceptibility to sheet and rill erosion during and following disturbance. Areas of Typic Cryorthents may be suitable for cattle as they travel through areas in active grazing allotments, and for incidental use by pack stock.

Wildlife habitat is good to fair. Its quality is decreased with increasing elevation, and in areas of rock outcrop and Lithic Cryorthents, where forage production is low. Burrowing animals and insects may be active in Typic

Cryorthents, and rodents adapted to high elevation find habitat in rock rubble. Abundant rock fragments often interfere with digging, and animal burrows in top soil having loose consistence do not hold up well. Depth of Typic Cryorthents is great enough to provide habitat for winter hibernation and protection from summer heat, but depth of Lithic Cryorthents is not.

Watershed rating is moderate to low. The unit receives a moderate amount of precipitation for the survey area. Typic Cryorthents transmit incoming water to subsurface runoff and to aquifer storage; whereas rock outcrop and Lithic Cryorthents transmit water rapidly by overland flow. Snow retention is high; and hydrograph response is rapid. Hydrologically, these units are most important in collecting high quality snowmelt and rainfall and directing the water to bedrock fractures and lower elevation storage areas.

Fire impacts are slight to moderate on Typic Cryorthents, depending on fuel accumulation. Fuels are discontinuous and sparse throughout most of the unit and forest stand canopies generally are open. Fuels are most concentrated under nearly closed forest canopies; nonetheless, soil and atmospheric temperatures are low enough to limit production and fire hazard.

These soils are susceptible to potential effects from acidic precipitation, because of their low buffering capacity and shallow depth of Lithic Cryorthents.

117—Typic Cryorthents - Rock outcrop - Lithic Cryorthents complex, tephritic, 0 to 30 percent slopes.

The soil's taxonomic name reflects the following characteristics:

- Typic: soil is characteristic of the great group to which it belongs (e.g., not unusually moist, shallow, or clayey);
- Lithic: shallow, depth to bedrock less than 20 inches;
- cry: very cold, with little warming in summer;
- orth: common form of the soil order (e.g., not unusually wet or sandy);
- ent: Entisol, a soil order; a young, weakly developed soil.

Tephritic indicates a superficial covering of volcanic ash and cinders.

This map unit is found in the upper Middle Fork San Joaquin River near Devils Postpile National Monument, and in Fish Creek and upper Silver Creek. It occurs on nearly level to moderately steep ridges and mountain sides, in bedrock cracks and joints, and in alluvial bottoms at elevations between 7,000 and 10,500 feet. The soils formed in granitic colluvium, glacial till, and minor amounts of alluvium. Near Devils Postpile the soils have formed in volcanic ejecta overlying vesicular, porphyritic andesite or basalt.

Mean annual precipitation ranges from 40 to 60 inches, most of which falls as snow. Vegetation series include red fir, lodgepole pine, and white bark pine. Common understory plants include lupine, sedge, bunch grasses, penny royal, and currant. Forest crown cover ranges from 10 to 70 percent, and averages about 20 to 30 percent. The most dense crown cover is in mature red fir stands on Typic Cryorthents; red firs generally do not grow on Lithic Cryorthents. Tree crown cover, which consists almost entirely of lodgepole pine, is less than 20 percent on Lithic Cryorthents.

The complex, which comprises 2.03 percent of the survey area, is approximately 45 percent Typic Cryorthents, tephritic, 30 percent granitic rock outcrop, 15 percent Lithic Cryorthents, tephritic, and 10 percent inclusions. These components are too intricately mixed on the landscape to be delineated separately on the soil map. Included in this unit are scattered areas of Xeric Vitricryands, Dystric Cryochrepts, Typic Cryumbrepts, and Entic Cryumbrepts.

The Typic Cryorthents, tephritic are coarse to moderately coarse textured, very cold, deep to very deep, and well drained to somewhat excessively drained. They formed on nearly level to moderately steep mountain sides, glacial moraines, and alluvial bottoms, and in granitic bedrock joints. Parent materials developed primarily from hornblende-bearing, biotite granodiorite and diorite, and to a lesser extent quartz monzonite at the higher elevations in the unit. A discrete layer of tephra, consisting of 80 to 90 percent ash and 10 to 20 percent lapilli-sized pumice, covers the surface to a depth of one to four inches; this material may be somewhat mixed with the underlying soil. Krotovinas are common in these soils, and may make up 30 percent of the soil volume.

These soils may or may not have a superficial layer of slightly decomposed organic material that typically is less than one inch thick under lodgepole pine, and up to three inches thick under red fir. In a representative soil, the surface mineral layer is 4 inches of light brownish gray, very gravelly loamy coarse sand consisting dominantly of pumice (lapilli and ash). It has weak granular structure, and is very strongly acid and extremely water repellent. This is underlain by 10 inches of pale brown, gravelly sandy loam consisting of granitic material. This layer has moderate granular structure, and is very strongly acid and wettable. The substratum to at least 26 inches depth is brownish yellow, extremely cobbly sandy loam derived from glacially deposited granitic material. It has weak granular structure, and is very strongly acid and wettable.

The rock outcrop is dominated by hornblende-bearing, biotite granodiorite at lower elevations, and biotite quartz monzonite at higher elevations. These rocks have developed a characteristic pattern of deep parallel joints that collect water, pollen, and dust. The joints normally are filled with soil that can support trees. Andesitic tuff comprises approximately 5 percent of the rock outcrop in the area southwest of Devils Postpile. Most rock outcrop and rubble can be delineated from the soils by interpretation of aerial photographs or ground reconnaissance.

Lithic Cryorthents, tephritic are coarse textured, very cold, very shallow to shallow, and well drained to somewhat excessively drained. They occur primarily in shallow bedrock depressions and in fringes around rock outcrops at elevations above about 8,000 feet. Surface organic layers are absent or less than one-half inch thick. In a representative soil, the surface mineral horizon is 1 inch of gray and light brownish gray loamy coarse sand dominated by volcanic ash and lapilli. It has weak granular structure, moderate to extreme water repellency, and strongly acid reaction. The underlying soil is 7 inches of very pale brown, very cobbly sandy loam having weak granular structure, moderate to extreme water repellency, and strongly acid reaction. The substratum, which extends to 18 inches, is brownish yellow, very stony coarse sandy loam having weak granular structure, slight water repellence, and strongly acid reaction.

Hydraulic conductivity of these coarse textured soils is decreased significantly by chemically induced hydrophobicity. It is low if the soils have been dry prior to rain fall, but may increase to moderately high once the soils become wetted. Overland flow, which varies with hydrophobicity, is medium on gently sloping sites, and rapid on moderately steep sites; it decreases as the soils become wetted. Infiltration capacity and hydraulic conductivity are greatly enhanced by open animal burrows and krotovinas. Plant-available water capacity is low. Effective rooting depth is greater than 40 inches in Typic Cryorthents, and less than 20 inches in Lithic Cryorthents.

Maximum erosion hazard rating is moderate on nearly level to strongly sloping sites, and high on moderately steep sites. An estimated 30 percent of the unit is rated as low, 35 percent is moderate, and 35 percent is high. These soils are susceptible to sheet, rill, and gully erosion when unprotected by vegetative cover, because of their low cohesive strength. Moreover, the volcanic ash makes these soils more hydrophobic and more prone to creating dust than their nonashy counterparts. Surface rock fragments, which can range up to 50 percent, provide protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion. Landscape stability hazard is low under normal conditions.

Typic Cryorthents, tephritic generally are well suited, and Lithic Cryorthents, tephritic are suitable for trails and for campsites on nearly level to gently sloping sites. The major limitations, apart from moderately steep slopes, are caused by the soils' loose consistence, which increases erodibility and decreases trafficability, and by water repellency, which increases erodibility. Runoff water often becomes concentrated in trails and is conducted along their length, eroding the surface. These effects can be minimized by proper construction and spacing of water bars. Trails and campsites constructed in these soils tend to be dusty when dry, due to the easy detachment of the fine volcanic ash. Trails in wet areas near meadows are susceptible to rutting.

With the exception of meadows within the map unit, Typic Cryorthents, tephritic are poorly suited, and Lithic Cryorthents, tephritic are unsuitable for livestock grazing, because of low forage production and high susceptibility to sheet and rill erosion during and following disturbance. The meadows are recovering from past over-grazing, and today are in fair to good condition. They provide forage for recreational and commercial pack stock, and a few remain in active grazing allotments.

Wildlife habitat is good on Typic Cryorthents at lower elevations, and fair to poor at higher elevations and in areas of rock outcrop and Lithic Cryorthents, where forage production is limited. Burrowing animals and insects are active in Typic Cryorthents, although burrows in the surface soil do not hold up well because of the soil's very loose consistence. Abundant rock fragments also interfere with digging. Bedrock cracks and soil depth, except in Lithic Cryorthents, are great enough to provide habitat for winter hibernation and protection from summer heat.

Watershed rating is moderate to moderately high. Precipitation is moderate to high for the survey area. Typic Cryorthents transmit incoming water to subsurface runoff and to aquifer storage; whereas rock outcrop and Lithic Cryorthents transmit water rapidly by overland flow. This unit collects cold, high quality water from a wide area, and funnels it to deep bedrock fractures for additional storage and ultimate transport to wells and storage reservoirs. Snow retention is high. Hydrograph response is moderately rapid during snow melt and rainstorms.

The impact of fire is slight in most of the unit because of low fuel production and limited soil development; it is moderate in dense stands of red fir, which can carry ground fire through the forest floor, as well as crown fire. Locally intense fire can alter surface soil mineralogy by fusing volcanic glass and chemically altering related mineral components.

These soils are susceptible to potential effects from acidic precipitation, because of their low buffering capacity.

118—Typic Cryorthents - Rock outcrop - Lithic Cryorthents complex, tephritic, 30 to 65 percent slopes.

The soil's taxonomic name reflects the following characteristics:

Typic: soil is characteristic of the great group to which it belongs (e.g., not unusually moist, shallow, or clayey);

Lithic: shallow, depth to bedrock less than 20 inches;

cry: very cold, with little summer warming;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ent: Entisol, a soil order; a young, weakly developed soil.

Tephritic indicates a superficial covering of volcanic ash and cinders.

This map unit is found in the upper Middle Fork San Joaquin River and Sharktooth Creek drainages. It occurs on steep to very steep mountain sides and ridges at elevations between 6,400 and 10,800 feet. The soils formed in granitic colluvium and glacial till, as well as in bedrock fractures.

Mean annual precipitation ranges from 35 to 45 inches, most of which falls as snow. Vegetation series include mixed conifer, red fir, and lodgepole pine. Common understory plants include lupine, sedge, bunch grasses, penny royal, and currant. Forest crown cover ranges from 5 to 40 percent.

The complex, which comprises 0.62 percent of the survey area, is approximately 40 percent Typic Cryorthents, tephritic, 35 percent granitic rock outcrop, 15 percent Lithic Cryorthents, tephritic, and 10 percent inclusions. These components are too intricately mixed on the landscape to be delineated separately on the soil map. Included in this map unit are Dystric Xerorthents and Lithic Xerorthents along Middle Fork San Joaquin River below about 7,000 feet elevation, and scattered areas of Xeric Vitricryands, Dystric Cryochrepts, Typic Cryumbrepts, and Entic Cryumbrepts at higher elevations.

The Typic Cryorthents, tephritic are coarse textured, very cold, deep to very deep, and well drained to somewhat excessively drained. They formed on mountain sides, glacial moraines, and small benches at elevations mostly above 7,000 feet, although they occasionally occur as low as 6,400 feet on steep, north facing slopes and in shaded canyons. Parent materials developed primarily from hornblende-bearing, biotite granodiorite and diorite, and to a lesser extent from quartz monzonite at higher elevations in the unit. A discrete layer of tephra, consisting of 80 to 90 percent ash and 10 to 20 percent lapilli-sized pumice, covers the surface to a depth of one to four inches; this layer may be somewhat mixed with the underlying soil. Krotovinas are common in these soils, and may constitute one-third of the soil volume.

These soils may or may not have a surface layer of slightly decomposed organic material less than one inch thick. In a representative soil, the surface mineral layer is 4 inches of light brownish gray, very gravelly loamy coarse sand consisting dominantly of pumice (lapilli and ash). It has weak granular structure, and is very strongly acid and extremely water repellent. This is underlain by 10 inches of pale brown, gravelly sandy loam consisting of granitic material. This layer has moderate granular structure, and is very strongly acid and wettable. The substratum to at least 26 inches depth is brownish yellow, extremely cobbly sandy loam derived from glacially deposited granitic material. It has weak granular structure, and is very strongly acid and wettable.

The rock outcrop is dominated by hornblende-bearing, biotite granodiorite at lower elevations, and biotite quartz monzonite at higher elevations. These rocks have developed a characteristic pattern of deep parallel joints that collect water, pollen, and dust. The joints normally are filled with soil that can support trees. Most rock outcrop can be delineated from the soils by interpretation of aerial photographs or ground reconnaissance.

Lithic Cryorthents, tephritic are coarse textured, very cold, very shallow to shallow, and well drained to somewhat excessively drained. They occur in fringes around rock outcrops on the most gently sloped sites, usually above about 8,000 feet elevation. Surface organic layers are absent or less than one-half inch thick. In a representative soil, the surface mineral horizon is 1 inch of gray and light brownish gray loamy coarse sand dominated by volcanic ash and lapilli. It has weak granular structure, moderate to extreme water repellency, and strongly acid reaction. The underlying soil is 7 inches of very pale brown, very cobbly sandy loam having weak granular structure, moderate to extreme water repellency, and strongly acid reaction. The substratum, which extends to 18 inches, is brownish yellow, very stony coarse sandy loam having weak granular structure, slight water repellence, and strongly acid reaction.

Hydraulic conductivity of these coarse textured soils is decreased significantly by chemically induced hydrophobicity. It is low if the soils have been dry prior to rainfall, but may increase to moderately high once the soils become wetted. Overland flow is rapid to very rapid because of slope steepness and hydrophobicity. Infiltration capacity and hydraulic conductivity are greatly enhanced by open spaces around protruding rock fragments, open animal burrows, and krotovinas. Plant-available water capacity is low. Effective rooting depth is greater than 40 inches in Typic Cryorthents, and less than 20 inches in Lithic Cryorthents.

Maximum erosion hazard rating is high to very high on moderately steep sites, with the very high rating being immediately below areas of rock outcrop and Lithic Cryorthents; it is very high on steep and very steep sites. An estimated 40 percent of the unit is rated low, 15 percent is high, and 45 percent is very high.

These soils are extremely prone to sheet, rill, and gully erosion, especially when unprotected by vegetative cover, because of their low cohesive strength and the steep slopes. Moreover, the volcanic ash makes these soils more hydrophobic and more prone to creating dust than their nonashy counterparts. Surface rock fragments, which can range up to 70 percent, provide protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion. Landscape stability hazard is moderately high to very high. Soil creep is common in these soils. Lithic Cryorthents, tephritic are subject to sliding off smooth bedrock surfaces and the deeper Typic Cryorthents, tephritic are susceptible to failure by debris avalanche.

These soils generally are poorly suited for trails and are unsuitable for campsites, except on isolated benches, because of the steep slopes and high to very high erosion hazard. Trails tend to be very dusty when dry, due to the easy detachment of the fine volcanic ash. Lithic Cryorthents, tephritic are unsuitable for trails on slopes steeper than about 40 percent.

This map unit generally is unsuitable for livestock grazing because of steep slopes, high to very high erosion hazard, and low forage production.

Wildlife habitat is good on Typic Cryorthents, tephritic at lower elevations, and fair to poor at higher elevations, and in areas of rock outcrop and Lithic Cryorthents, tephritic, where forage production is limited. Burrowing animals and insects are active in Typic Cryorthents, tephritic, although soil creep and loose soil consistence tend to destroy the burrows except in areas where roots of grasses and sedges bind the soil. Abundant rock fragments also interfere with digging. Bedrock cracks and soil depth, except in Lithic Cryorthents, tephritic, are great enough to provide habitat for winter hibernation and protection from summer heat.

Watershed rating is moderate. Precipitation is moderate for the survey area. Typic Cryorthents transmit incoming water to subsurface runoff and to aquifer storage; whereas rock outcrop and Lithic Cryorthents transmit water rapidly by overland flow. The major watershed function of the unit is to collect cold, high quality water, and transmit it to deep bedrock fractures and lower elevation areas. Snow retention is moderately high to high. Hydrograph response is rapid during snowmelt and rainstorms, because of the large amount of rock outcrop, steep slopes, and low water retention capacity of the soils.

The impact of fire is slight in most of the unit because of scattered, low-volume fuels, which are interrupted by rock outcrop. Red fir stands on Typic Cryorthents, tephritic produce the greatest amounts of aerial and ground fuel, but even these are not highly concentrated. Except for isolated areas such as under logs, low to moderate fuel production combined with the soils' low thermal conductivity limit the depth of significant soil heating to less than two inches. Locally intense fire can alter surface soil mineralogy by fusing volcanic glass and chemically altering related mineral components.

These soils are susceptible to potential effects from acidic precipitation, because of their low buffering capacity.

119—Typic Cryorthents - Xeric Vitricryands - Rock outcrop complex, volcanic, 0 to 45 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, clayey, or low in bases);

Xeric: dry in summer, moist in winter;

Cry: very cold, with little warming in summer;

Vitri: contains weakly weathered volcanic glass that holds less than 15 percent water at permanent wilting point;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ent: Entisol, a soil order; a young, weakly developed soil;

and: Andisol, an order of soils that have andic properties and that usually form from volcanic ejecta.

This complex is located in the upper Middle Fork San Joaquin River north of Devils Postpile National Monument in areas of volcanic and metavolcanic rock. It occurs on nearly level to steep ridges, mountain sides, glacial moraines, and alluvial bottoms at elevations between 8,200 and 10,700 feet. The soils formed in colluvium, glacial till, alluvium, and minor amounts of residuum. They are covered with a layer of volcanic ash and cinders (tephra).

Mean annual precipitation ranges from 40 to 60 inches, most of which falls as snow. The most common vegetation series is lodgepole pine, followed by red fir and mountain whitethorn. Species intermingled in the lodgepole pine series include Jeffrey pine, red fir, western hemlock, and minor amounts of western white pine.

The complex, which comprises 0.63 percent of the survey area, is approximately 35 percent Typic Cryorthents, volcanic, 25 percent Xeric Vitricryands, 20 percent rock outcrop, and 20 percent inclusions. The various components are individually too small and intricately mixed on the landscape to be delineated separately. Inclusions of Entic Cryumbrepts, volcanic, tephritic, and possibly Typic Vitricryands, and Andic or Vitrandic Cryochrepts, are on nearly level to moderately steep, slightly concave positions that accumulate volcanic ash, water, and detritus, and that support heaviest vegetative cover, including grasses. Also, Lithic Cryorthents, tephritic, are in narrow fringes around rock outcrop, and in shallow bedrock depressions.

The Typic Cryorthents, volcanic are moderately coarse textured, very cold, deep to very deep, and well drained. They formed in colluvium, glacial till, and, to a minor extent, residuum derived from andesite, basalt, and mafic metavolcanic rocks. Volcanic ash and cinders (tephra) cover the surface and are mixed in the topsoil. More intensive field and laboratory work may reveal that some of the soils containing tephra have sufficient andic properties to be reclassified as Andisols. If so, they most likely would be classified as Xeric Vitricryands if they have a xeric moisture regime, or Typic Vitricryands if they have a udic moisture regime. The surface mineral horizon often is water repellent. The soils may or may not have a surface layer of slightly decomposed organic material that, if present, is less than two inches thick.

In a representative soil, the surface mineral layer is 11 inches of light brownish gray, sandy loam having an admixture of volcanic ash and fine lapilli. It has fine granular structure, and is very strongly acid. The underlying material, which extends to at least 31 inches depth, is brownish yellow, extremely gravelly fine sandy loam to extremely cobbly fine sandy loam. It has very fine granular structure to massive arrangement, and is very strongly acid.

The Xeric Vitricryands are coarse to moderately coarse textured, very cold, moderately deep to very deep, and well drained to somewhat excessively drained. They formed in volcanic ash and cinders overlying and mixed with glacial till, colluvium, and alluvium. They may or may not have a surface layer of slightly decomposed organic material that, if present, is less than three inches thick.

In a representative soil, the surface mineral layer is 9 inches of light gray extremely gravelly coarse sand consisting dominantly of volcanic lapilli and ash (tephra). It is single grain and very strongly acid. The underlying material, which extends to at least 39 inches, is light gray to brownish yellow, very gravelly coarse sand to loamy coarse sand. It is massive and slightly hard in its upper portion, and has weak granular structure or is massive below. It is strongly acid to moderately acid.

The rock outcrop is bedrock and rubble consisting of highly varied metavolcanic and lava-flow rock. The metavolcanic rock varies in texture from tuffaceous to crystalline and in composition from rhyolitic to basaltic, with most being dacitic to andesitic. The lava-flow rock dominantly is vesicular andesite. These rocks tend to produce somewhat finer textured soil than do the surrounding granitic rocks.

The included Entic Cryumbrepts seem to occur more commonly on the mafic volcanics than on felsic volcanics. The surface layer of these soils is thicker, darker colored, and richer in organic matter than that of other soils in the map unit.

Hydraulic conductivity is moderately high to high, although it may be decreased significantly by chemically induced hydrophobicity. Most water infiltration in the nonwettable soils is through channels created by insects, soil animals, and plant roots. Overland flow, which varies with hydrophobicity, is moderate on gently sloping sites and rapid to very rapid on steep sites. Plant-available water capacity is low. Effective rooting depth is greater than 36 inches in the unit.

Maximum erosion hazard rating is moderate on nearly level to strongly sloping sites, and high on moderately steep and steep sites. Approximately half of the unit is rated moderate, and half is rated high. An estimated 20 percent of the unit is rated low, 40 percent is moderate, and 45 percent is high. Soils on moderately sloping to steep slopes are highly susceptible to sheet, rill, and gully erosion when unprotected by vegetative cover, because of low cohesive strength caused by their high pumice content. Surface rock fragment cover typically is about 20 to 60 percent. These fragments provide some protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion. This phenomenon is especially notable immediately below areas of rock outcrop and shallow soils. Landscape stability hazard is low under normal conditions.

These soils are well suited to suitable for trails, and suitable for campsites on nearly level to gently sloping sites. Steeper sites are unsuitable for campsites. As with others formed from metavolcanic materials or having significant volcanic ash at the surface, these soils become exceptionally dusty when disturbed. Other limitations include rapid water runoff, loose consistence, and moderately steep slopes.

This unit generally is poorly suited for livestock grazing because of low forage production, abundant rock outcrop, and high susceptibility to sheet and rill erosion during and following disturbance.

Wildlife habitat, which decreases in quality with increasing elevation, is fair to poor. Wildlife diversity and populations in this unit are smaller than in units having less snow, warmer, more developed soils, greater variety of vegetation, and less rock outcrop. Burrowing animals and insects are active in these soils, and rodents adapted to high elevation find habitat in rock rubble. Soil depth is great enough to provide habitat for winter hibernation and protection from summer heat.

Watershed rating is moderately high. Precipitation is high to moderate for the survey area. Watershed importance of the unit is expected to be greater than that of nearby granitic units because of greater porosity and hydraulic conductivity in the bedrock and overlying mantle. Parts of the unit lie in one of the greatest snowfall regions of the Sierra Nevada; as a result, considerable high quality water is supplied to lower lying watersheds. Watershed importance is limited by the amount of rock outcrop, limited weathering of the rock, and small size of the unit. Snow retention is high, and hydrograph response is moderately rapid.

Fire impacts are slight to moderate in this unit of high elevation, cold, and infertile soils. Fuel continuity is disrupted by rock outcrop and areas of low production, especially on Typic Cryorthents. Fuels are more concentrated on Typic Cryochrepts and Entic Cryumbrepts, but still are limited. Locally intense fire can alter surface soil mineralogy by fusing volcanic glass and chemically altering related mineral components.

These soils are susceptible to potential effects from acidic precipitation, because of their low buffering capacity. Soils formed on metavolanic parent materials may respond to atmospheric inputs differently from granitically derived soils; this point merits further investigation.

120—Typic Torriorthents, 5 to 25 percent slopes.

The soil's taxonomic name reflects the following characteristics:

Typic: soil is characteristic of the great group to which it belongs (e.g., not unusually moist, shallow, or clayey);

Torri: arid to semiarid, and commonly hot in summer;

orth: common form of the soil order (e.g., not unusually wet or sandy;

ent: Entisol, the soil order; a young weakly developed soil.

This unit is in the Owens River drainage, in the extreme southeastern portion of the survey area above Owens Lake. The soils formed on moderately sloping to moderately steep southerly to easterly facing backslopes of alluvial cones and colluvial aprons at elevations between 3,700 and 5,000 feet. Soil parent materials consist of mixed alluvial and colluvial deposits derived from quartz monzonite and granodiorite with lesser amounts of mafic lava rock, and augmented with granitic eolian sands.

Mean annual precipitation ranges from 7 to 10 inches of rain. Vegetation series are desert shrub and sagebrush shrub. The unit supports scattered cholla, Joshua trees and creosote bush. This is the only unit in the survey area where creosote bush is found.

The unit, which comprises 0.12 percent of the survey area, is 90 percent Typic Torriorthents. It includes approximately 10 percent granitic rock outcrop in scattered locations, and Typic Torripsamments on eolian-influenced colluvial aprons near the unit's upper boundary; the Typic Torripsamments appear not to occur on alluvial cones.

The Typic Torriorthents are coarse to moderately coarse textured, warm, dry, moderately deep to very deep, and somewhat excessively drained to excessively drained. Soils in this unit usually do not have a surface organic layer, but the surface is covered by 40 to 75 percent spheroidal gravel. These soils normally are wettable, although surface horizons may show very slight water repellency. In a representative soil, the surface mineral layer is 26 inches of brown to dark yellowish brown extremely gravelly coarse sand or very gravelly coarse sand having a single grain arrangement. It is strongly to moderately acid and very slightly water repellent. The underlying material, to a depth of at least 36 inches, is yellowish brown extremely gravelly coarse sand having massive arrangement. It is moderately acid and wettable.

Hydraulic conductivity of the soil surface is very high; nonetheless, overland flow can vary from slow to rapid because of the large amount of surface gravel which helps to concentrate overland flow water. Plant-available water capacity is very low to low. Effective rooting depth is at least 40 inches, but most frequently is greater than 60 inches.

Maximum erosion hazard rating is low on moderately sloping to strongly sloping sites, and moderate on moderately steep sites. Lack of vegetative protection and low soil cohesive strength often make these soils susceptible to sheet and rill erosion in their natural state. Landscape stability hazard is low.

These soils are poorly suited for trails and campsites, because of the sandy texture which has no cohesive strength and little resistance to traffic.

Typic Torriorthents are unsuitable for livestock grazing. They do not produce adequate forage, and they are unable to withstand livestock traffic.

Wildlife habitat overall is poor because of low forage production, most of which is provided by bitterbrush, Mormon tea, and big sage. Habitat is good for burrowing reptiles adapted to the area.

Watershed rating is low, because of low precipitation, nearly all of which is rain. Hydrograph response is rapid during rainstorms, because of the low water retention capacity of the soils.

The impact of fire is negligible because of low fuel production and limited soil development.

Susceptibility of these soils to the effects of acidic precipitation is negligible, because of low precipitation.

121—Typic Torriorthents - Xeric Torriorthents association, 45 to 75 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Typic: soil is characteristic of the great group to which it belongs (e.g., not unusually moist, shallow, or clayey);

Xeric: dry in summer, moist in winter;

Torri: arid to semiarid and commonly hot in summer;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ent: Entisol, the soil order; a young weakly developed soil.

This map unit occurs in the extreme southeastern portion of the survey area, above Owens Lake. The soils formed on generally easterly facing, steep to very steep backslopes, shoulders, and footslopes at elevations between 4,000 and 7,200 feet. Dominant parent materials are mixed colluvial deposits derived from hornblende, biotite diorite, quartz monzonite, and granodiorite, with minor amounts of epidote-bearing granite. Colluvial activity, most notably soil creep, mixes the soil and retards development.

Mean annual precipitation ranges from 8 to 12 inches. Vegetation series are single leaf pinon pine on upper slopes, sagebrush shrub on intermediate slopes, and desert shrub on lower slopes. Mormon tea, bitterbrush, buck wheat, and needle grass are common associated species.

The association, which comprises 0.19 percent of the survey area, is approximately 50 percent Typic Torriorthents, 40 percent Xeric Torriorthents, and 10 percent inclusions. The Typic Torriorthents occur at the lower elevations, mainly on drier southerly aspects, in the desert shrub and lower sagebrush shrub vegetation series; whereas, the Xeric Torriorthents occur at the higher elevations, on slightly moister, more northerly aspects, in the upper sagebrush shrub and single leaf pinon pine vegetation series. The unit includes several small granitic rock outcrops. It merges with, and includes, Typic Xerorthents at the upper elevation margin, and Typic Torripsamments along the lower elevation margin.

The Typic Torriorthents are coarse to moderately coarse textured, warm, dry, moderately deep to very deep, and somewhat excessively drained to excessively drained. Soils in this unit usually do not have a surface organic layer, but the surface is covered by 40 to 75 percent spheroidal gravel. These soils normally are wettable, although surface horizons may show very slight water repellency. In a representative soil, the surface mineral layer is 26 inches of brown to dark yellowish brown extremely gravelly coarse sand or very gravelly coarse sand having a single grain arrangement. It is strongly to moderately acid and very slightly water repellent. The underlying material, to a depth of at least 36 inches, is yellowish brown extremely gravelly coarse sand having massive arrangement. It is moderately acid and wettable.

The Xeric Torriorthents are coarse textured, warm, dry, deep to very deep, and somewhat excessively drained to excessively drained. They have an intermittent to discontinuous superficial litter layer less than 1/2 inch thick, consisting primarily of pinon pine needles and twigs. The ground surface is 40 to 75 percent covered by spheroidal granitic gravel. The surface mineral layer in this unit commonly contains clean, slope-washed gravel and sand, and its upper 6 inches often is looser and less dense than the underlying soil, which is significantly more resistant to penetration. The surface layer is moderately water repellent, with water repellency decreasing with increasing soil depth.

In a representative soil, the surface mineral layer is 11 inches of dark grayish brown, grayish brown, or dark brown, very gravelly coarse sand or very gravelly loamy coarse sand having single grain arrangement or weak, fine granular structure. It is very strongly acid in its upper part and slightly acid in its lower part. It is moderately water repellent throughout. The underlying material to a depth of at least 25 inches is dark yellowish brown to yellowish brown extremely gravelly loamy coarse sand or soft rock having massive arrangement. It is slightly acid and wettable.

Hydraulic conductivity of Typic Torriorthents is very high; nonetheless, overland flow is rapid to very rapid because of slope steepness. Hydraulic conductivity of the Xeric Torriorthents is moderately high to high, depending on the degree of hydrophobicity and the density of the subsoil; overland flow is rapid to very rapid because of slope steepness, hydrophobicity, and dense subsoil. Plant-available water capacity of both soils is very low to low. Effective rooting depth is greater than 40 inches in the unit.

Maximum erosion hazard rating is very high. Surface soils are extremely susceptible to sheet, rill, and dry ravel erosion, because of slope steepness, lack of vegetative protection, and lack of cohesive strength. Wildlife can detach and move soil with each step. Summer winds commonly trigger dry ravel and miniature debris avalanches of several cubic inches on slopes steeper than about 65 percent. Notwithstanding the steep and very steep slopes, overall landscape stability hazard is moderately low to moderately high under normal conditions because of competent bedrock, but debris avalanches can be triggered by unusually high pore water pressures and by earthquakes.

These soils are very poorly suited for trails, and are unsuitable for campsites, because of the very steep slopes, lack of cohesive strength, very high erosion hazard, and very low resistance to traffic.

Soils in this unit are unsuitable for livestock grazing, because of low forage productivity, low trafficability, and very high soil erosion hazard.

Wildlife habitat is fair for burrowing animals and reptiles adapted to the area, but is poor for larger animals because of lack of forage.

Watershed rating is low, because of low precipitation, nearly all of which is rain. Hydrograph response is rapid during rainstorms, because of slope steepness and low water retention capacity of the soils.

Although fire can run rapidly through this unit, its impacts are slight because of low fuel production and limited soil development.

Susceptibility of these soils to the effects of acidic precipitation is negligible, because of low precipitation.

122—Xeric Torriorthents – Typic Torriorthents – Rock outcrop association, 40 to 85 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Xeric: dry in summer, moist in winter;

Typic: soil is characteristic of the great group to which it belongs (e.g., not unusually moist, shallow, or clayey);

Torri: arid to semiarid and commonly hot in summer;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ent: Entisol, the soil order; a young weakly developed soil.

This map unit occurs in the extreme southeastern portion of the survey area, above Owens Lake. The soils formed on steep to extremely steep backslopes, shoulders, angular ridges, and footslopes, primarily of canyon walls, at elevations between 4,400 and 7,200 feet. Dominant parent materials are mixed colluvial deposits derived from hornblende, biotite diorite, quartz monzonite, and granodiorite. Colluvial activity, most notably soil creep and debris avalanches, mixes the soil, retarding its development.

Mean annual precipitation ranges from 8 to 12 inches. Vegetation series are single leaf pinon pine on upper slopes and northerly facing aspects, sagebrush shrub on intermediate slopes, and desert shrub on lower slopes and intermediate southerly facing aspects. Mormon tea, bitterbrush, buck wheat, and needle grass are common associated species.

The association, which comprises 0.55 percent of the survey area, is approximately 45 percent Xeric Torriorthents, 30 percent Typic Torriorthents, 20 percent rock outcrop, and 5 percent inclusions. The Xeric Torriorthents occur at the higher elevations, on slightly moister, northerly aspects, in the upper sagebrush shrub and single leaf pinon pine vegetation series; whereas, the Typic Torriorthents occur at the lower elevations, mainly on drier south facing aspects, in the desert shrub and lower sagebrush shrub vegetation series. Rock outcrop tends to be more common on north facing canyon walls than on south facing wall. The unit merges with Typic Xerorthents, which are inclusions, at the upper elevation margin.

The Xeric Torriorthents are coarse textured, warm, dry, deep to very deep, and somewhat excessively drained to excessively drained. They have an intermittent to discontinuous superficial litter layer less than 1/2 inch thick, consisting primarily of pinon pine needles and twigs. The ground surface is 40 to 75 percent covered by spheroidal granitic gravel. The surface mineral layer in this unit commonly contains clean, slope-washed gravel and sand. It is moderately water repellent, with water repellency decreasing with increasing soil depth.

In a representative soil, the surface mineral layer is 11 inches of dark grayish brown, grayish brown, or dark brown, very gravelly coarse sand or very gravelly loamy coarse sand having single grain arrangement or weak, fine granular structure. It is very strongly acid in its upper part and slightly acid in its lower part. It is moderately water repellent throughout. The underlying material to a depth of at least 25 inches is dark yellowish brown to yellowish extremely gravelly loamy coarse sand or soft rock having massive arrangement. It is slightly acid and wettable.

The Typic Torriorthents are coarse to moderately coarse textured, warm, dry, moderately deep to very deep, and somewhat excessively drained to excessively drained. Soils in this unit usually do not have a surface organic layer, but the surface is covered by 40 to 75 percent spheroidal gravel. These soils normally are wettable, although surface horizons may show very slight water repellency. In a representative soil, the surface mineral layer is 26 inches of brown to dark yellowish brown extremely gravelly coarse sand or very gravelly coarse sand having a single grain arrangement. It is strongly to moderately acid and very slightly water repellent. The underlying material, to a depth of at least 36 inches, is yellowish brown extremely gravelly coarse sand having massive arrangement. It is moderately acid and wettable.

Hydraulic conductivity of the Xeric Torriorthents is moderately high to high, depending on the degree of hydrophobicity. Overland flow is rapid to very rapid because of slope steepness and hydrophobicity. Hydraulic conductivity of Typic Torriorthents is very high; nonetheless, overland flow is rapid to very rapid because of slope steepness. Plant-available water capacity of both soils is very low to low. Effective rooting depth is greater than 40 inches in the unit.

Maximum erosion hazard rating is very high. Surface soils are extremely susceptible to sheet, rill, and dry ravel erosion, because of slope steepness, lack of vegetative protection, and lack of cohesive strength. Wildlife can detach and move soil with each step. Summer winds commonly trigger dry ravel and miniature debris avalanches of several cubic inches on slopes steeper than about 65 percent. Landscape stability hazard is moderately high to very high. The soils are susceptible to failure by debris avalanche.

These soils are poorly suited for trails, except on the least steep slopes, and are unsuitable for campsites, because of the very steep slopes, lack of cohesive strength, very high erosion hazard, and very low resistance to traffic.

This unit is unsuitable for livestock grazing, because of low forage productivity, low trafficability, slope steepness, and very high soil erosion hazard.

Wildlife habitat is poor because of lack of forage and instability of these steep to extremely steep slopes.

Watershed rating is low, because of low precipitation, nearly all of which is rain. Hydrograph response is rapid during rainstorms, because of slope steepness and low water retention capacity of the soils.

Although fire can run rapidly through this unit, its impacts are slight because of low fuel production, rock outcrop, and limited soil development.

Susceptibility of these soils to the effects of acidic precipitation is negligible, because of low precipitation.

123—Dystric Xerorthents - Dystric Xerochrepts complex, 15 to 50 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Dystric:	base saturation less than 60 percent; generally low fertility, but adequate for acid-loving plants;
Xer:	dry in summer, moist in winter;
orth:	common form of the soil order (e.g., not unusually wet or sandy);
ochr:	light colored, organic-poor, or thin surface horizon;
ent:	Entisol, the soil order; a young, weakly developed soil;
ept:	Inceptisol, a soil order, slightly more developed than Entisols.

This map unit occurs along the western margin of the survey area on moderately steep to steep mountain sides and glacial moraines at elevations between 5,900 and 8,400 feet. The soils formed in colluvium and glacial till derived from granitic rock.

Mean annual precipitation ranges from 30 to 40 inches, most of which falls as snow. Vegetation series include mixed conifer-pine, mixed conifer-fir, Jeffrey pine, and red fir.

The complex, which comprises 0.49 percent of the survey area, is approximately 40 percent Dystric Xerorthents, 40 percent Dystric Xerochrepts, and 20 percent inclusions. The soils are too intricately mixed on the landscape to be separated in mapping; nonetheless, Dystric Xerorthents seem to be concentrated on sparsely vegetated southerly-facing aspects, and Dystric Xerochrepts appear to dominate on more densely vegetated northerly-facing aspects. The unit contains scattered inclusions of Typic Xerumbrepts and rock outcrop, as well as Typic Cryorthents along the upper elevation margin.

The Dystric Xerorthents are coarse to moderately coarse textured, moderately deep to very deep, and well drained to somewhat excessively drained. They may or may not have a superficial layer of slightly decomposed organic material that typically is less than 3 inches thick. In a representative soil, the surface mineral layer is 10 inches of pale brown, gravelly coarse sandy loam having moderate, very fine granular structure and very strongly acid reaction. It has an admixture of pumice, and is moderately water repellent. The underlying material, to at least 47 inches depth, is very pale brown to light yellowish brown, very gravelly coarse sandy loam to extremely gravelly coarse sandy loam having weak, very fine granular structure or massive arrangement. It is very strongly acid or strongly acid and very slightly water repellent in its upper portion.

The Dystric Xerochrepts are coarse to medium textured, deep to very deep, and well drained to somewhat excessively drained. They commonly have a surface layer of slightly decomposed organic material less than three inches thick. The surface mineral horizon may be water repellent and may contain an admixture of volcanic ash, which imparts a somewhat smeary feel when moist. In a representative soil, the surface mineral layer is 4 inches of dark grayish brown gravelly sandy loam having moderate, very fine granular structure and moderately acid reaction. The subsoil, which is 18 inches thick, is light yellowish brown, very cobbly coarse sandy loam having weak, very fine subangular blocky structure and strongly acid reaction. The substratum, to a depth of at least 35 inches, is light yellowish brown, very cobbly coarse sandy loam having weak, very fine granular structure and strongly acid reaction.

Hydraulic conductivity is moderately high to high, and overland flow generally is rapid. Plant-available water capacity is low, although it may be slightly higher on Dystric Xerochrepts than on Dystric Xerorthents. Effective rooting depth is greater than 36 inches in the unit.

Maximum erosion hazard rating is high on moderately steep slopes, and very high on steep slopes. Approximately half of the unit is rated high, and half is very high. These soils are highly susceptible to sheet, rill, and gully erosion, especially on unprotected surfaces because of slope steepness and low cohesive strength. Landscape stability hazard is moderately low to moderately high. Mass movement in the form of debris avalanches and debris torrents can occur on the steepest slopes.

These soils are suitable for trails, but normally are unsuitable for campsites because of slope steepness and high erosion hazard on disturbed sites.

This unit is poorly suited for commercial livestock grazing because of low forage production and slope steepness. Recreational pack stock may find adequate forage for incidental use in forest openings and a few small meadows.

Wildlife habitat is good to fair. It varies greatly with slope steepness and aspect. Generally, habitat is more favorable on the more productive northerly and easterly facing Dystric Xerochrepts than on the less productive southerly and westerly facing Dystric Xerorthents. Compared to other map units having cryic temperature regime soils, browsing animals can use this unit earlier in spring and later in fall.

Watershed rating is moderately low because of the unit's small size, as well as its slope steepness, rapid runoff, and low water retention. Precipitation and snow retention are moderate for the survey area.

Although fire impacts generally are slight, because fuels are light and scattered, fire impacts can be moderate to high on localized sites having heavier fuel concentrations, especially on long steep slopes having very high erosion hazard.

These soils are susceptible to potential effects from acidic precipitation because of their low buffering capacity.

124—Dystric Xerorthents - Dystric Xerochrepts - Rock outcrop complex, 40 to 85 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Dystric: base saturation less than 60 percent; generally low fertility, but adequate for acid-loving plants;

Xer: dry in summer, moist in winter;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ochr: light colored, organic-poor, or thin surface horizon;

ent: Entisol, the soil order; a young, weakly developed soil;

ept: Inceptisol, a soil order, slightly more developed than Entisols.

This map unit occurs in the Middle Fork Kings River drainage, in the southwestern portion of the survey area, on steep to extremely steep mountain sides at elevations between 2,600 and 8,000 feet. The soils formed in colluvium and minor amounts of glacial till derived from granitic rock.

Mean annual precipitation ranges from 30 to 40 inches. Vegetation series include whiteleaf manzanita, mixed conifer-pine, mixed conifer-fir, and Jeffrey pine, with scattered black oak.

The complex, which comprises 0.53 percent of the survey area, is approximately 40 percent Dystric Xerorthents, 25 percent Dystric Xerochrepts, 25 percent granitic rock outcrop, and 10 percent inclusions. The soils are too intricately mixed on the landscape to be separated in mapping; nonetheless, Dystric Xerorthents are found mostly on unstable land surfaces where soil development is retarded by soil creep and shallow landslides; Dystric Xerochrepts tend to occur on the less steep, most stable, densely vegetated sites, especially on northerly facing aspects. The unit contains inclusions of Entic Xerumbrepts, Entic Haploxerolls, and, near the upper elevation limit, Typic Cryorthents.

The Dystric Xerorthents are coarse to moderately coarse textured, moderately deep to very deep, and well drained to somewhat excessively drained. They may or may not have a superficial layer of slightly decomposed organic material that typically is less than 3 inches thick. In a representative soil, the surface mineral layer is 10 inches of pale brown, gravelly coarse sandy loam having moderate, very fine granular structure and very strongly acid reaction. It has an admixture of pumice, and is moderately water repellent. The underlying material, to at least 47 inches depth, is very pale brown to light yellowish brown, very gravelly coarse sandy loam to extremely gravelly coarse sandy loam having weak, very fine granular structure or massive arrangement. It is very strongly acid or strongly acid and very slightly water repellent in its upper portion.

The Dystric Xerochrepts are coarse to moderately coarse textured, deep to deep, and well drained to somewhat excessively drained. Typically, they have a superficial layer of slightly decomposed organic material less than 2 inches thick. In a representative soil, the surface mineral layer is 4 inches of dark grayish brown gravelly sandy loam having moderate, very fine granular structure and moderately acid reaction. The subsoil, which is 18 inches thick, is light yellowish brown, very cobbly coarse sandy loam having weak, very fine subangular blocky structure and strongly acid reaction. The substratum, to a depth of at least 35 inches, is light yellowish brown, very cobbly coarse sandy loam having weak, very fine granular structure and strongly acid reaction.

The rock outcrop, consisting of bedrock and rubble, is dominated by granodiorite.

Hydraulic conductivity is moderately high to high, and overland flow is rapid to very rapid. Plant-available water capacity is low throughout the unit. Effective rooting depth is greater than 36 inches in the unit.

Maximum erosion hazard rating is high on steep slopes (except immediately below rock outcrop, where it is very high), and very high on very steep and extremely steep slopes. Approximately 25 percent of the unit is rated low (including rock outcrop), 20 percent is high, and 55 percent is very high. These soils are highly susceptible to sheet, rill, and gully erosion because of slope steepness. Landscape stability hazard is moderately high to very high. Mass movement in the form of debris avalanches and debris torrents are common.

These soils are poorly suited for trails, and are unsuitable for campsites because of slope steepness and very high erosion hazard.

This unit is unsuitable for livestock grazing because of lack of forage, extent of rock outcrop, and slope steepness.

Wildlife habitat, which decreases in quality with slope steepness and elevation, is fair to poor. It is limited by low forage production, and very steep and extremely steep slopes that are subject to creep and debris avalanches.

Watershed rating is moderately low because of slope steepness, rapid runoff and low water retention, and low snow retention, especially in the low elevation areas. Precipitation is moderate for the survey area.

Although fuels generally are light, fire impacts are moderate to high because of long steep and extremely steep slopes and very high erosion hazard.

These soils are susceptible to potential effects from acidic precipitation because of their low buffering capacity.

125—Dystric Xerorthents - Typic Xerumbrepts - Rock outcrop complex, 15 to 45 percent slopes.

The soils' taxonomic names reflect the following characteristics:

- Dystric: base saturation less than 60 percent; generally low fertility, but adequate for acid-loving plants;
- Typic: soil is characteristic of the great group to which it belongs (e.g., not unusually moist, shallow, or clayey);
- Xer: dry in summer, moist in winter;
- orth: common form of the soil order (e.g., not unusually wet or sandy);
- umbr: dark colored, organic-rich surface horizon having low base saturation;
- ent: Entisol, the soil order; a young, weakly developed soil;
- ept: Inceptisol, a soil order, slightly more developed than Entisols.

This map unit is found in the San Joaquin River drainage, in the northwestern portion of the survey area, and in the Middle Fork Kings River drainage, in the southwestern portion of the survey area. It occurs on moderately steep to steep ridges and mountain sides at elevations between 5,200 and 9,200 feet. The highest elevation delineations are on southerly facing aspects in the Middle Fork Kings River drainage. In the San Joaquin River drainage, to the north, the highest elevation is nearly 1,200 feet lower. The soils formed in colluvium and glacial drift derived from mixed granitic and basaltic rock, and in bedrock joints and depressions.

Mean annual precipitation, most of which falls as snow, ranges from 30 to 40 inches in the Middle Fork Kings River drainage, and 40 to 50 inches in the San Joaquin River drainage. Vegetation series include mixed conifer-pine, mixed conifer-fir, whiteleaf manzanita, and Jeffrey pine, with scattered black oak.

The complex, which comprises 0.80 percent of the survey area, is approximately 40 percent Dystric Xerorthents, 30 percent Typic Xerumbrepts, 15 percent rock outcrop, and 15 percent inclusions. The soils are too intricately mixed on the landscape to be separated in mapping; nonetheless, Typic Xerumbrepts tend to occur on the most densely vegetated, northerly facing sites, and under manzanita. The unit contains inclusions of Dystric Xerochrepts mainly on nearly level to strongly sloping sites under open forest canopy, and Pachic Xerumbrepts (which have a dark colored, organic-rich surface horizon 20 inches or more thick) under dense, old-growth tree cover of mixed conifer dominated by incense cedar and scattered black oak. The soils merge with Typic Cryorthents at the highest elevations.

The Dystric Xerorthents are coarse to moderately coarse textured, moderately deep to very deep, and well drained to somewhat excessively drained. They may or may not have a superficial layer of slightly decomposed organic material that typically is less than 3 inches thick. In a representative soil, the surface mineral layer is 10 inches of pale brown, gravelly coarse sandy loam having moderate, very fine granular structure and very strongly acid reaction. It has an admixture of pumice, and is moderately water repellent. The underlying material, to at least 47 inches depth, is very pale brown to light yellowish brown, very gravelly coarse sandy loam to extremely gravelly coarse sandy loam having weak, very fine granular structure or massive arrangement. It is very strongly acid or strongly acid and very slightly water repellent in its upper portion.

The Typic Xerumbrepts are coarse to moderately coarse textured, deep to very deep, and well drained to somewhat excessively drained. Typically, they have a superficial layer of slightly decomposed organic material up to 4 inches thick. In a representative soil, the surface mineral layer is 6 inches of dark grayish brown, coarse sandy loam having massive arrangement or moderate, fine subangular blocky structure. It is strongly acid and extremely water repellent. The subsoil is 18 inches of light olive brown or light yellowish brown, sandy loam or gravelly loamy coarse sand having massive arrangement or moderate, fine granular structure. It is strongly acid and wettable. The substratum, which extends to at least 34 inches, is light olive brown, very cobbly loamy coarse sand having weak fine granular structure. It is strongly acid and wettable.

The rock outcrop, consisting of bedrock and rubble dominantly in the northern delineations, is hornblende, biotite granodiorite, and quartz monzonite. The bedrock exhibits roughly north-south oriented joints and fractures that collect water, pollen, and dust, and that are filled with soil.

Hydraulic conductivity is moderately high to high, and overland flow is medium to rapid. Overland flow from soil is highest on sites immediately below rock outcrop and on hydrophobic soils. Hydraulic conductivity of hydrophobic soils increases as the soils become wetted. Plant-available water capacity is low, although it may be slightly greater in Typic Xerumbrepts than in Dystric Xerorthents. Effective rooting depth is greater than 36 inches in the unit.

Maximum erosion hazard rating, which increases with slope steepness, is moderate to high on moderately steep slopes, high on steep slopes, and very high on steep slopes immediately below rock outcrop. Approximately 20 percent of the unit is rated low (including rock outcrop), 35 percent is moderate, 30 percent is high, and 15 percent is very high. These soils are moderately to highly susceptible to sheet, rill, and gully erosion, especially when unprotected. Surface rock fragment cover is 5 to 50 percent. Landscape stability hazard is moderately low to moderately high. The steepest, west facing slopes in the northern delineations are subject to failure by debris avalanche.

These soils are suitable for trails, except on sites subject to debris avalanches; they are unsuitable for campsites because of slope steepness and erosion hazard.

This unit is unsuitable for livestock grazing because of lack of forage, extent of rock outcrop, and slope steepness.

Wildlife habitat, which decreases in quality with increasing elevation, is good to fair. It is limited by forage production and rock outcrop. It is most favorable on the Typic Xerumbrepts and Pachic Xerumbrept inclusions, and on delineations in the Middle Fork Kings River drainage. Except for rock outcrop, conditions generally are good for burrowing animals.

Watershed rating overall is moderate. Precipitation and snow retention are greater in the San Joaquin River drainage, which is glacially scoured and more sparsely vegetated, and less in the Middle Fork Kings River drainage, which has the greatest depth to bedrock and heaviest vegetative cover.

Fire impacts in the San Joaquin River drainage are slight on Dystric Xerorthents, where fuels are thin and scattered, and moderate on Typic Xerumbrepts and the associated Pachic Xerumbrept inclusions, where ground and aerial fuels are heaviest. Fire impacts are moderate in Middle Fork Kings River, where fuels are heavier and temperatures warmer.

These soils are susceptible to potential effects from acidic precipitation because of their low buffering capacity.

126—Dystric Xerorthents - Rock outcrop - Typic Xerumbrepts complex, 0 to 30 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Dystric: base saturation less than 60 percent; generally low fertility, but adequate for acid-loving plants;

Typic: soil is characteristic of the great group to which it belongs (e.g., not unusually moist, shallow, or clayey);

Xer: dry in summer, moist in winter;

orth: common form of the soil order (e.g., not unusually wet or sandy);

umbr: dark colored, organic-rich surface horizon having low base saturation;

ent: Entisol, the soil order; a young, weakly developed soil;

ept: Inceptisol, a soil order, slightly more developed than Entisols.

This map unit is located in the San Joaquin River drainage, in the northwestern portion of the survey area near Balloon Dome. It occurs on nearly level to moderately steep ridges and mountain sides at elevations between 4,800 and 7,100 feet. The soils formed in colluvium and glacial drift derived from granodiorite, as well as in granitic bedrock joints and depressions.

Mean annual precipitation ranges from 40 to 50 inches, most of which falls as snow. Vegetation series are mixed conifer-pine and mixed conifer-fir, dominated by incense cedar, with smaller amounts of sugar pine, ponderosa pine, and scattered associated black oak. The understory includes incense cedar, sugar pine, and ponderosa pine reproduction, as well as honeysuckle, and scattered grasses.

The complex, which comprises 0.28 percent of the survey area, is approximately 35 percent Dystric Xerorthents, 30 percent rock outcrop, 25 percent Typic Xerumbrepts, and 10 percent inclusions of Dystric Xerochrepts mainly on nearly level to strongly sloping sites under open forest canopy.

The Dystric Xerorthents are coarse to moderately coarse textured, moderately deep to very deep, and well drained to somewhat excessively drained. They may or may not have a superficial layer of slightly decomposed organic material that typically is less than 3 inches thick. In a representative soil, the surface mineral layer is 10 inches of pale brown, gravelly coarse sandy loam having moderate, very fine granular structure and very strongly acid reaction. It has an admixture of pumice, and is moderately water repellent. The underlying material, to at least 47 inches depth, is very pale brown to light yellowish brown, very gravelly coarse sandy loam to extremely gravelly coarse sandy loam having weak, very fine granular structure or massive arrangement. It is very strongly acid or strongly acid and very slightly water repellent in its upper portion.

The bedrock is hornblende, biotite granodiorite exhibiting roughly north-south oriented joints and fractures that collect water, pollen, and dust, and that are filled with soil.

The Typic Xerumbrepts are coarse to moderately coarse textured, deep to very deep, and well drained to somewhat excessively drained. Typically, they have a superficial layer of slightly decomposed organic material less than 2 inches thick. In a representative soil, the surface mineral layer is 6 inches of dark grayish brown, coarse sandy loam having massive arrangement or moderate, fine subangular blocky structure. It is strongly acid and extremely water repellent. The subsoil is 18 inches of light olive brown or light yellowish brown, sandy loam or gravelly loamy coarse sand having massive arrangement or moderate, fine granular structure. It is strongly acid and wettable. The substratum, which extends to at least 34 inches, is light olive brown, very cobbly loamy coarse sand having weak fine granular structure. It is strongly acid and wettable.

Hydraulic conductivity is moderately high to high. Overland flow is slow on nearly level to gently sloping sites, medium on gently sloping to strongly sloping sites, and rapid on moderately steep to steep sites. Overland flow from soil is greatest on moderately steep sites immediately below rock outcrop. Plant-available water capacity is low, although it may be slightly greater in Typic Xerumbrepts than in Dystric Xerorthents. Effective rooting depth is greater than 36 inches in the unit.

Maximum erosion hazard rating is moderate on nearly level to strongly sloping sites, and high on moderately steep and steep sites. Approximately 20 percent of the unit is rated low (including rock outcrop), 40 percent is moderate, and 40 percent is high. Sites immediately below rock outcrop approach a very high rating. Under normal, undisturbed conditions, these soils are slightly to moderately susceptible to sheet, rill, and gully erosion. Surface rock fragment cover is 5 to 50 percent. Landscape stability hazard is low.

These soils are well suited for trails and suitable for campsites on nearly level to gently sloping sites.

This unit is poorly suited for livestock grazing because of low forage production and extent of rock outcrop.

Wildlife habitat generally is good. It is limited by rock outcrop and forage production. Except for rock outcrop, conditions generally are good for burrowing animals.

Watershed rating is moderately low, because of moderate precipitation, low snow retention, low water retention of the soils, amount of rock outcrop, and the unit's small size.

Fire impacts are slight through out most of the unit, because of light, scattered fuel production. Impacts can be severe in localized areas of heavy fuels.

These soils are susceptible to potential effects from acidic precipitation because of their low buffering capacity.

127—Typic Xerorthents - Entic Haploxerolls complex, 15 to 50 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, or clayey);

Entic: lacking clear subsoil development;

Xer: dry in summer, moist in winter;

Haplo: simple soils, having no unusually distinctive features in the suborder;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ent: Entisol, the soil order; a young, weakly developed soil;

oll: Mollisol, an order of soils that have a thick, dark colored, organic-rich, high base status surface horizon.

This map unit is found in widely separated delineations in the Mono Basin and Owens River drainages, along the eastern margin of the survey area. It occurs on moderately steep to steep mountain sides and glacial moraines at elevations between 6,100 and 10,200 feet. The soils formed in mixed granitic colluvium, glacial till, and minor amounts of alluvium.

Mean annual precipitation ranges from 8 to 20 inches, most of which falls as rain in the southern, lower precipitation, delineations, and as snow in the northern, higher precipitation, regions. Vegetation series include Jeffrey pine, green leaf manzanita, single leaf pinon pine, big sagebrush, curl leaf mountain mahogany, and perennial grass. Thick stands of aspen grow in avalanche tracks in the northern delineations.

The map unit, which comprises 0.73 percent of the survey area, is approximately 50 percent Typic Xerorthents, 35 percent Entic Haploxerolls, and 15 percent inclusions of rock outcrop and Typic Xerochrepts, intricately mixed on the landscape, and Typic Cryorthents at the highest elevations. Talus slopes and shallow debris avalanches occur on very steep inclusions in the northern reaches of the unit. Nearly level to strongly sloping alluvial bottoms also are included.

The Typic Xerorthents are coarse to moderately coarse textured, moderately deep to very deep, and well drained to somewhat excessively drained. They may or may not have a superficial layer of slightly decomposed organic material that typically is less than three inches thick. The mineral surface horizon may contain volcanic ash, especially in the northern-most delineations of the map unit, and it may be water repellent.

In a representative soil, the surface mineral layer is 5 inches of grayish brown sandy loam having weak, very fine granular structure and very strongly acid reaction. It contains approximately 5 percent volcanic ash, and is water repellent. The underlying material, which extends to at least 44 inches, is pale brown to light yellowish brown gravelly sandy loam to extremely cobbly loamy coarse sand having weak, very fine granular structure, or massive or single grain arrangement. It is very strongly acid and moderately water repellent in the upper portion to wettable in the lower portion.

The Entic Haploxerolls are coarse to moderately coarse textured, moderately deep to very deep, and well drained to somewhat excessively drained. Typically, they have a superficial layer of slightly decomposed organic material less than 2 inches thick. The surface mineral soil often is water repellent. In a representative soil, the surface mineral layer is 17 inches of grayish brown or brown, very gravelly sand or extremely gravelly loamy coarse sand having weak, very fine granular structure. It is very strongly acid to moderately acid and moderately water repellent. The underlying material, which extends to at least 35 inches, is light olive brown, very bouldery loamy coarse sand having massive arrangement. It is moderately acid and moderately water repellent.

Hydraulic conductivity is moderately high to very high, and overland flow is rapid. Hydraulic conductivity may be decreased significantly by chemically induced hydrophobicity, which dissipates as the soil is wetted. Plant-available water capacity is low. Effective rooting depth is greater than 36 inches in the unit.

Maximum erosion hazard rating is high on moderately steep slopes, and very high on steep and very steep slopes. Approximately 60 percent of the unit is rated as high, and 40 percent is rated very high. These soils are highly susceptible to sheet, rill, and gully erosion because of slope steepness and lack of cohesive strength. Soils on the steepest slopes are subject to dry ravel. Landscape stability hazard is moderately low to moderately high.

These soils are suitable for trails, and are poorly suited for campsites because of slope steepness and high erosion hazard.

This unit is poorly suited for livestock grazing because of lack of forage and erosion hazard.

Wildlife habitat, which decreases in quality with increasing elevation, generally is fair. It is limited by low forage production and cover.

Watershed rating is low because of low rainfall, low water retention, and rapid runoff.

Fire impacts are slight, because of low fuel production. Nonetheless, except for aspen stands in avalanche tracks, fire can run rapidly through this unit.

Acidic precipitation is not a concern in these soils because of the dry climate.

128—Typic Xerorthents - Entic Haploxerolls - Typic Xerochrepts complex, 35 to 75 percent slopes.

The soils' taxonomic names reflect the following characteristics:

- Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, or clayey);
- Entic: lacking clear subsoil development;
- Xer: dry in summer, moist in winter;
- Haplo: simple soils, having no unusually distinctive features in the suborder;
- orth: common form of the soil order (e.g., not unusually wet or sandy);
- ochr: light colored, organic-poor, or thin surface horizon;
- ent: Entisol, the soil order; a young, weakly developed soil;
- oll: Mollisol, an order of soils that have a thick, dark colored, organic-rich, high base status surface horizon;
- ept: Inceptisol, a soil order; significantly less developed than Alfisols.

This map unit occurs in the Middle Fork Kings River and Owens River drainages, in the extreme southwestern and southeastern portions of the survey area, respectively. The soils formed on steep to very steep backslopes, shoulders, sharp ridge tops, and narrow canyon bottoms at elevations between 2,500 and 9,400 feet. Parent materials are mixed granitic colluvium and minor amounts of alluvium.

Mean annual precipitation ranges from 30 to 40 inches in Middle Fork Kings River drainage, and 10 to 20 inches east of the Sierran crest in Owens River drainage. Soil temperature regimes are frigid in the upper elevation portions of the unit and mesic in the lower elevation portions. Vegetation series include green leaf manzanita, white leaf manzanita, and mixed conifer-pine west of the Sierran crest, and big sagebrush and single leaf pinon pine east of the crest.

The map unit, which comprises 1.07 percent of the survey area, is approximately 35 percent Typic Xerorthents, 30 percent Entic Haploxerolls, 20 percent Typic Xerochrepts, and 15 percent inclusions, all intricately mixed on the landscape. Typic Xerorthents occur on all aspects, but generally are above Typic Xerochrepts on southerly facing aspects. Entic Haploxerolls tend to occur most commonly on northerly facing aspects and under heaviest brush accumulations. Typic Xerochrepts are found most frequently on lower colluvial backslopes and footslopes, generally in southerly facing aspects. The unit contains inclusions of rock outcrop and Lithic Xeric Torriorthents on northerly facing aspects where soil commonly is removed by debris avalanches. Significant rock outcrop is found in the lowest elevation, southern-most delineation below Junction Ridge in the Middle Fork Kings River drainage.

The Typic Xerorthents are coarse to moderately coarse textured, moderately deep to very deep, and well drained to somewhat excessively drained. They may or may not have a superficial layer of slightly decomposed organic material that typically is less than three inches thick. The mineral surface horizon may be water repellent.

In a representative soil, the surface mineral layer is 5 inches of grayish brown sandy loam having weak, very fine granular structure and very strongly acid reaction. It contains approximately 5 percent volcanic ash, and is water repellent. The underlying material, which extends to at least 44 inches, is pale brown to light yellowish brown gravelly sandy loam to extremely cobbly loamy coarse sand having weak, very fine granular structure, or massive or single grain arrangement. It is very strongly acid and moderately water repellent in the upper portion to wettable in the lower portion.

The Entic Haploxerolls are coarse to moderately coarse textured, moderately deep to very deep, and well drained to somewhat excessively drained. Typically, they have a superficial layer of slightly decomposed organic material less than 2 inches thick. The surface mineral soil often is water repellent. In a representative soil, the surface mineral layer is 17 inches of grayish brown or brown, very gravelly sand or extremely gravelly loamy coarse sand having weak, very fine granular structure. It is very strongly acid to moderately acid and moderately water repellent. The underlying material, which extends to at least 35 inches, is light olive brown, very bouldery loamy coarse sand having massive arrangement. It is moderately acid and moderately water repellent.

The Typic Xerochrepts are coarse to moderately coarse textured, deep to very deep, and somewhat excessively drained. They may or may not have a superficial layer of slightly decomposed organic material that typically is less than one inch thick. The mineral surface horizon commonly is water repellent. In a representative soil, the surface mineral layer is 3 inches of very dark grayish brown, extremely gravelly coarse sand having single grain arrangement to weak, very fine granular structure. The subsoil, which is 20 inches thick, is light gray extremely gravelly sandy loam, and massive to weak, very fine granular. The substratum, to a depth of at least 32 inches, is white, extremely cobbly sandy loam, massive weathered bedrock.

Hydraulic conductivity is high to very high, and overland flow is very rapid. Plant-available water capacity is very low to low. Effective rooting depth is greater than 36 inches in the unit.

Maximum erosion hazard rating is very high. These soils are extremely susceptible to sheet, rill, and gully erosion because of slope steepness, lack of cohesive strength, and, on many sites, low plant cover. Soils are subject to dry ravel and failure by debris avalanche, especially on north facing aspects. Landscape stability hazard is moderately high to very high.

These soils are suitable for trails on steep sites, and poorly suited on very steep sites. They are unsuitable for campsites because of slope steepness and high erosion hazard.

This unit is unsuitable for livestock grazing because of lack of forage, slope steepness, and erosion hazard.

Wildlife habitat, which decreases in quality with increasing elevation and slope steepness, generally is fair. It is limited by low forage production and cover.

Watershed rating is low in the Owens River watershed, where precipitation is low, and moderately low to moderate in the Middle Fork Kings River drainage, where precipitation is moderate. In addition to precipitation, watershed importance is limited by low snow retention, low water retention of the soils, and rapid runoff. Hydrograph response is rapid.

Fire impacts generally are slight because of low fuel production. An exception, where fire hazard and potential impacts are moderately high, is in the southern-most delineation, below Junction Ridge in Middle Fork Kings River drainage. The effects of steep slopes and warm summer temperatures in this area are partially offset by rock outcrop, which disrupts fuel continuity.

Acidic precipitation is not expected to have significant impact in this unit because of low summer precipitation.

129—Typic Xerorthents – Rock outcrop complex, 15 to 50 percent slopes.

The soil's taxonomic name reflects the following characteristics:

Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, or clayey);

Xer: dry in summer, moist in winter;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ent: Entisol, the soil order; a young, weakly developed soil.

This map unit occurs in the Owens River drainage, in the southeastern portion of the survey area, on moderately steep to very steep backslopes, shoulders, and narrow alluvial bottoms at elevations between 5,200 and 9,300 feet. The soils formed in mixed granitic colluvium and minor amounts of alluvium.

Mean annual precipitation ranges from 8 to 12 inches. Vegetation series include perennial grass, green leaf manzanita, big sagebrush, Jeffrey pine, and single leaf pinon pine.

The map unit, which comprises 0.10 percent of the survey area, is approximately 45 percent Typic Xerorthents, 45 percent rock outcrop, and 10 percent inclusions, all intricately mixed on the landscape. The inclusions are nearly level to strongly sloping areas, as well as Typic Xerochrepts and Xeric Torriorthents in the low elevation fringes.

The Typic Xerorthents are coarse to moderately coarse textured, moderately deep to very deep, and well drained to somewhat excessively drained. They may or may not have a superficial layer of slightly decomposed organic material that typically is less than three inches thick. The mineral surface horizon may contain volcanic ash, especially in the northern-most delineations of the map unit, and it may be water repellent.

In a representative soil, the surface mineral layer is 5 inches of grayish brown sandy loam having weak, very fine granular structure and very strongly acid reaction. It contains approximately 5 percent volcanic ash, and is water repellent. The underlying material, which extends to at least 44 inches, is pale brown to light yellowish brown gravelly sandy loam to extremely cobbly loamy coarse sand having weak, very fine granular structure, or massive or single grain arrangement. It is very strongly acid and moderately water repellent in the upper portion to wettable in the lower portion.

Hydraulic conductivity is moderately high to very high, and overland flow is rapid. Hydraulic conductivity may be decreased significantly by chemically induced hydrophobicity, which dissipates as the soil is wetted. Plant-available water capacity is very low to low. Effective rooting depth is greater than 36 inches in the unit.

Maximum erosion hazard rating is high on moderately steep slopes, and very high on steep slopes. It is very high on sites immediately below rock outcrop. Approximately 45 percent of the unit is rated low (including rock outcrop), 25 percent is rated high, and 30 percent is rated very high. These soils are highly susceptible to sheet, rill, and gully erosion because of slope steepness, lack of cohesive strength, and extent of rock outcrop, which sheds water onto soils below. Soils on the steepest slopes are subject to dry ravel. Landscape stability hazard is moderately low to moderately high.

These soils are suitable for trails, but are unsuitable for campsites because of slope steepness, high erosion hazard, and rock outcrop.

This unit is poorly suited for livestock grazing because of lack of forage, erosion hazard, and rock outcrop.

Wildlife habitat is fair to poor. It is limited by low forage production, lack of cover, and rock outcrop.

Watershed rating is low because of low rainfall, low water retention, rock outcrop, and rapid runoff.

Although fire can run rapidly through this unit, its impacts are slight because of low fuel production.

Acidic precipitation is not a concern in these soils because of the dry climate.

130—Typic Xerorthents - Rock outcrop complex, 40 to 85 percent slopes.

The soil's taxonomic name reflects the following characteristics:

Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, or clayey);

Xer: dry in summer, moist in winter;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ent: Entisol, the soil order; a young, weakly developed soil.

This map unit occurs in the Owens River drainage, in the southeastern portion of the survey area, on steep to extremely steep midrange to lower mountain sides at elevations between 5,800 and 9,000 feet. The soils formed in mixed granitic colluvium and minor amounts of alluvium. Soil development is limited partly by soil creep and superficial movement.

Mean annual precipitation ranges from 10 to 18 inches. Vegetation series include perennial grass, green leaf manzanita, big sagebrush, Jeffrey pine, and single leaf pinon pine.

The map unit, which comprises 2.27 percent of the survey area, is approximately 55 percent Typic Xerorthents, 35 percent rock outcrop, and 10 percent inclusions, all intricately mixed on the landscape. The inclusions are Xeric Torriorthents in the low elevation fringes, Typic Cryorthents on northerly aspects along the high elevation fringes, and Lithic Xerorthents around rock outcrops, especially on the least steep slopes.

The Typic Xerorthents are coarse to moderately coarse textured, moderately deep to very deep, and well drained to somewhat excessively drained. They may or may not have a superficial layer of slightly decomposed organic material that typically is less than three inches thick. The mineral surface horizon may contain volcanic ash, especially in the northern-most delineations of the map unit, and it may be water repellent.

In a representative soil, the surface mineral layer is 5 inches of grayish brown sandy loam having weak, very fine granular structure and very strongly acid reaction. It contains approximately 5 percent volcanic ash, and is water repellent. The underlying material, which extends to at least 44 inches, is pale brown to light yellowish brown gravelly sandy loam to extremely cobbly loamy coarse sand having weak, very fine granular structure, or massive or single grain arrangement. It is very strongly acid and moderately water repellent in the upper portion to wettable in the lower portion.

The rock outcrop consists of exposed granitic and metamorphic bedrock near sharp ridge lines and on extremely steep side slopes, and rubble of talus slopes and debris avalanches.

Hydraulic conductivity is moderately high to very high, and overland flow is rapid to very rapid. Hydraulic conductivity may be decreased significantly by chemically induced hydrophobicity, which dissipates as the soil is wetted. Plant-available water capacity is very low to low. Effective rooting depth is greater than 36 inches in the unit.

Maximum erosion hazard rating is very high. These soils are extremely susceptible to sheet, rill, gully, and dry ravel erosion because of slope steepness, lack of cohesive strength, and extent of rock outcrop, which sheds water onto soils below. Landscape stability hazard is high to very high. Soils on the steepest slopes are extremely susceptible to mass movement by debris avalanche.

These soils are poorly suited to unsuitable for trails and unsuitable for campsites because of slope steepness, very high erosion and debris avalanche hazard, and rock outcrop.

This unit is unsuitable for livestock grazing because of slope steepness, lack of forage, very high erosion hazard, and rock outcrop.

Wildlife habitat generally is poor, but is fair on the least steep slopes for burrowing animals and reptiles adapted to the area. It is limited by low forage production, rock outcrop, and landscape instability.

Watershed rating is low because of low rainfall, low water retention, rock outcrop, and very rapid runoff.

Although fire can run rapidly through this unit, its impacts are slight, because of very low fuel production.

Acidic precipitation is not a concern in these soils because of the dry climate and very rapid runoff.

131—Typic Torripsamments, 25 to 55 percent slopes.

The soil's taxonomic name reflects the following characteristics:

Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, or clayey);

Torri: arid to semiarid, and commonly hot in summer;

psamm: very sandy, with less than 35 percent rock fragments;

ent: Entisol, the soil order; a young, weakly developed soil.

This map unit is limited to the extreme southeastern portion of the survey area above Owens Lake. It occurs on moderately steep to very steep southeasterly facing back slopes and foot slopes at elevations between 4,000 and 6,400 feet. The soils formed in granitic deposits of apparently eolian sandy materials overlying granitic colluvium.

Mean annual precipitation ranges from 8 to 12 inches. Vegetation series is desert shrub, including the genera *Eriogonum*, *Gutierrezia*, *Crysothamnus*, *Ephedra*, *Tetrademia*, *Stipa*, as well as a few scattered cholla and Joshua trees.

The map unit, which comprises 0.16 percent of the survey area, is 90 percent Typic Torriorthents with 10 percent inclusions of Typic Torriorthents in weakly developed ephemeral drainages, and Xeric Torriorthents near the upper boundary of the map unit. The inclusions contain a significant amount of colluvial granitic rock fragments not found in the Typic Torripsamments.

Typic Torripsamments are coarse to moderately coarse textured, warm, dry, deep to very deep, and excessively drained. They formed in sandy colluvial or eolian deposits derived from quartz monzonite and porphyritic granite. They are unusual in the survey area in that their textures almost entirely are sand, and they contain less than 15 percent gravel and no cobbles, even to a depth of four feet. Their odd occurrence on the landscape makes them a scientific curiosity, worthy of further investigation.

Although the soils do not have a surface organic layer, they often have a thin desert pavement consisting of angular fine gravel. The mineral soil is nearly uniform throughout its depth. In a representative soil, the surface mineral layer is 3 inches of very pale brown to light gray sand having massive or single grain arrangement. It is slightly acid and wettable. The underlying material, to a depth of at least 47 inches, is pale brown, light yellowish brown, or yellow loamy sand having massive arrangement. It is slightly acid and wettable.

Hydraulic conductivity is very high, and overland flow is slow. Plant-available water capacity is very low. Effective rooting depth is greater than 40 inches.

Maximum erosion hazard rating is high on moderately steep slopes, and very high on steep and very steep slopes. Approximately 75 percent of the unit is rated high, and 25 percent is rated very high. Surface soils are highly susceptible to sheet, rill, and gully erosion, because of slope steepness, lack of vegetative protection, and lack of cohesive strength. Wildlife activity can displace significant amounts of topsoil. Landscape stability hazard is moderately low under normal conditions.

These soils are poorly suited for trails, and are unsuitable for campsites, because of the slope steepness, lack of cohesive strength, very high erosion hazard, and low trafficability.

The soils are unsuitable for livestock grazing, because of low forage productivity, low trafficability, and very high erosion hazard.

Wildlife habitat is poor, because of low forage production, lack of cover, and loose soil consistence, which renders the soil poorly suited for burrows.

Watershed rating is low, because of low rainfall, low water retention, and rapid runoff. Hydrograph response is rapid during rainstorms.

The impact of fire is nearly negligible because of low fuel production and limited soil development.

Acid rain is not expected to significantly affect these soils because rainfall is low; nonetheless, the soils have very low buffering capacity, which makes any soil solution readily susceptible to induced chemical changes.

132—Typic Torripsamments - Typic Torriorthents - Rock outcrop complex, 25 to 55 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Typic: soil is characteristic of the great group to which it belongs (e.g., not unusually moist, shallow, or clayey);

Torri: arid to semiarid and commonly hot in summer;

psamm: very sandy, with less than 35 percent rock fragments;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ent: Entisol, the soil order; a young, weakly developed soil.

This unit is limited to the extreme southeastern portion of the survey area on generally easterly facing slopes above Owens Lake. It occurs on moderately steep to very steep lower mountain sides at elevations between 4,200 and 6,800 feet. The soils formed in granitic colluvial and eolian deposits, and in minor amounts of metamorphic colluvium.

Mean annual precipitation ranges from 8 to 12 inches. Vegetation series are desert shrub and sagebrush shrub, with minor areas of single leaf pinon pine in the upper elevation portion of the unit.

The complex, which comprises 0.24 percent of the survey area, is approximately 50 percent Typic Torripsamments, 30 percent Typic Torriorthents, and 15 percent rock outcrop. It contains about 5 percent inclusions of Xeric Torriorthents associated with single leaf pinon pine in the upper elevation portions of the unit.

The Typic Torripsamments are found on southeasterly-facing eolian or colluvial footslopes and backslopes above Owens Lake. The soils are unusual in the survey area because their textures are almost entirely sand, and they contain less than 15 percent gravel and no cobbles, even to a depth of four feet. The soils support the desert shrub vegetation series, which includes the genera *Eriogonum*, *Gutierrezia*, *Crysothamnus*, *Ephedra*, *Tetrademia*, *Stipa*, as well as a few scattered cholla and Joshua trees.

The Typic Torripsamments are coarse textured, warm, dry, deep to very deep, and excessively drained. They formed in eolian sands and colluvium derived from quartz monzonite, porphyritic granite, and minor amounts of granodiorite. Although these soils do not have a surface organic layer, they often have a thin desert pavement consisting of angular fine gravel. The mineral soil is nearly uniform throughout its depth. In a representative soil, the surface mineral layer is 3 inches of very pale brown to light gray sand having massive or single grain arrangement. It is slightly acid and wettable. The underlying material, to a depth of at least 47 inches, is pale brown, light yellowish brown, or yellow loamy sand having massive arrangement. It is slightly acid and wettable.

The Typic Torriorthents are found in drainages and swale positions, and near the upper boundary of the map unit. These soils support desert shrub and sagebrush shrub vegetation series, with the major sagebrush shrub plants being big sage, Mormon tea, bitterbrush, buckwheat, and needle grass. Sagebrush shrub merges with single leaf pinon pine near the upper elevation margin of the unit.

The Typic Torriorthents are coarse to moderately coarse textured, warm, dry, moderately deep to very deep, and somewhat excessively drained to excessively drained. They formed from granitic, and less commonly, metamorphic rock. They usually do not have a surface organic layer. The surface is covered by 40 to 75 percent angular, spheroidal gravel. In a representative soil, the surface mineral layer is 26 inches of brown to dark yellowish brown extremely gravelly coarse sand or very gravelly coarse sand having a single grain arrangement. It is strongly to moderately acid and very slightly water repellent. The underlying material, to a depth of at least 36 inches, is yellowish brown extremely gravelly coarse sand having massive arrangement. It is moderately acid and wettable.

Rock outcrops and rubble, which are scattered throughout the unit, consist of porphyritic and nonporphyritic quartz monzonite and granite (some of which are epidote-bearing); hornblende, biotite diorite and granodiorite, and occasional low grade noncalcareous metamorphic rock consisting of gneiss and metavolcanics.

Hydraulic conductivity is very high, and overland flow is slow. Plant-available water capacity is very low. Effective rooting depth is greater than 40 inches.

Maximum erosion hazard rating of Typic Torripsamments is very high; and of Typic Torriorthents it is high on moderately steep to steep slopes, and very high on steep to very steep slopes. The rating is very high on all soils immediately below rock outcrop. Approximately 20 percent of the unit is rated low (including rock outcrop), 30 percent is high, and 50 percent is very high.

Surface soils are highly susceptible to sheet, rill, and gully erosion, because of steep slopes, lack of vegetative protection, and lack of cohesive strength. Wildlife activity can displace significant amounts of topsoil. Landscape stability hazard is moderately low to moderately high under normal conditions.

These soils are poorly suited for trails, and are unsuitable for campsites, because of the slope steepness, lack of cohesive strength, very high erosion hazard, and low trafficability.

The soils are unsuitable for livestock grazing, because of low forage productivity, low trafficability, and very high erosion hazard.

Wildlife habitat is poor except for the uppermost elevational portion of the unit, which is fair. Habitat is limited by low forage production, rock outcrop, lack of cover, and loose soil consistence, which renders the soil poorly suited for burrows.

Watershed rating is low, because of low rainfall, low water retention, slope steepness, rock outcrop, and rapid runoff. Hydrograph response is rapid during rainstorms.

The impact of fire is nearly negligible because of low fuel production and limited soil development.

Acid rain is not expected to significantly affect these soils because of low rainfall and large amount of rock outcrop. Nonetheless, the soils have very low buffering capacity, which makes any soil solution readily susceptible to induced chemical changes.

133—Dystric Cryochrepts - Typic Cryorthents association, 0 to 30 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Dystric: base saturation less than 60 percent; generally low fertility, but adequate for acid-loving plants;

Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, or clayey);

Cry: very cold, with little warming in summer;

ochr: light colored, organic-poor, or thin surface horizon;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ept: Inceptisol, a soil order, slightly more developed than Entisols;

ent: Entisol, a soil order; a young, weakly developed soil;

This map unit is found in the western portion of the survey area, in the South Fork San Joaquin River and North Fork Kings River drainages. It occurs on nearly level to moderately steep glacial moraines and mountain sides at elevations between 7,200 and 10,500 feet. The soils formed in glacial till, colluvium, and alluvium derived from, granodiorite, diorite, and quartz monzonite, and between bedrock joints.

Mean annual precipitation ranges from 30 to 45 inches, most of which falls as snow.

Vegetation series include mixed conifer, red fir, and lodgepole pine.

The map unit, which comprises 1.11 percent of the survey area, is approximately 40 percent Dystric Cryochrepts, 40 percent Typic Cryorthents, and 20 percent inclusions. The soils are not evenly distributed in the survey area. Dystric Cryochrepts (more developed soils) are dominant in the southern group of delineations, located east of Courtright and Wishon Reservoirs at a median elevation of 8,900 feet. Typic Cryorthents (less developed soils) are dominant in the northern group, located east and north of Edison Lake (on Bear Ridge and Junction Bluffs) at a median elevation of 9,400 feet. Dystric Cryochrepts tend to occur at lower elevations and on more gentle, concave slopes than do Typic Cryorthents. Although vegetative cover may not differ between the two soils, it often is more dense on Dystric Cryochrepts than on Typic Cryorthents. Dystric Cryochrepts seem to develop more readily in glacial deposits than in colluvium.

Included in this map unit are Typic and Entic Cryumbrepts under heavy vegetative cover in the northern delineation near Volcanic Knob, where soil development is influenced by mafic (high magnesium and iron) volcanic materials, and a few Aquic Cryumbrepts in wet meadows.

The Dystric Cryochrepts are coarse textured, very cold, deep to very deep, and well drained to somewhat excessively drained. They formed in glacial till and colluvium derived from diorite, granodiorite, and quartz monzonite, with occasional influence of mafic volcanics. The soils normally have a surface layer of slightly decomposed organic matter up to two inches thick. Usually, the surface mineral layer is water repellent, but subsoils are wettable. In a representative soil, the surface mineral layer is 10 inches of pale brown, coarse sandy loam having moderate granular structure. It is very strongly acid and slightly water repellent. The subsoil, which is 22 inches thick, is very pale brown, gravelly coarse sandy loam and light gray, very gravelly coarse sandy loam having moderate granular to moderate subangular blocky structure and strongly acid reaction. The underlying material, which extends to at least 41 inches, is light gray, very gravelly coarse sandy loam that has weathered in place, and is massive and strongly acid.

The Typic Cryorthents are coarse to moderately coarse textured, very cold, deep to very deep, and moderately well drained to somewhat excessively drained. Somewhat more than half of these soils have a slightly decomposed surface organic layer that commonly is less than one inch thick, but that may reach 3 inches thickness. These O horizons are found in or below the lodgepole pine vegetation zone. The surface mineral layer commonly is water repellent. The underlying mineral soil normally has lighter, brighter colors and greater rock fragment content, and it may have slightly better developed structure, although structures seldom are more pronounced than weak granular. Distinctive subsoil horizons are not well developed, even under a closed canopy of mature trees, because of the high proportion of resistant minerals and limited conditions for chemical weathering.

In a representative soil, the surface mineral layer is 6 inches of light gray, cobbly sandy loam having an admixture of volcanic ash. It has a massive arrangement that breaks to weak granular structure, and is very strongly acid. The underlying material, which extends to at least 34 inches depth, is light brownish gray to very pale brown, very cobbly sandy loam. It has weak subangular blocky to moderate granular structure, and is very strongly acid.

Hydraulic conductivity of the soils is decreased significantly by chemically induced hydrophobicity. Hydraulic conductivity of these coarse textured soils is low if the soils have been dry prior to rainfall; it may increase to moderately high once the soils become wetted. Overland flow, which varies with hydrophobicity, is medium on gently sloping sites and rapid to very rapid on moderately steep sites. Plant-available water capacity is low, although it may approach moderate for Dystric Cryochrepts. Effective rooting depth is greater than 40 inches in the unit.

Maximum erosion hazard rating is moderate on nearly level to strongly sloping sites, and high on moderately steep and steep sites. Approximately half of the unit is rated moderate, and half is rated high. These soils are susceptible to sheet, rill, and gully erosion when unprotected by vegetative cover, because of their moderately steep slopes and low cohesive strength. Surface rock fragment cover is between 20 and 60 percent. These fragments provide some protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion. This phenomenon is especially notable immediately below areas of rock outcrop and shallow soils. Landscape stability hazard is low under normal conditions.

These soils are well suited for trails and for campsites on nearly level to gently sloping sites. Limitations include rapid water runoff, loose consistence, and moderately steep slopes.

Except for included meadows, which are suitable, this map unit is poorly suited for commercial livestock grazing because of low forage production, and high susceptibility to sheet and rill erosion during and following disturbance. These areas may be used incidentally by pack stock traveling through the unit.

Wildlife habitat, which decreases in quality with increasing elevation, generally is good. It is limited by forage production at high elevation. Burrowing animals and insects commonly are active in these soils, although abundant rock fragments often interfere with digging. Animal burrows in Typic Cryorthents probably do not hold up as well as those in Dystric Cryochrepts. Soil depth is great enough to provide habitat for winter hibernation and protection from summer heat.

Watershed rating is moderately high because of the soils' significant depth to bedrock and the large amount of high purity water collected and transmitted to underground storage. Precipitation is moderate. Snow retention is high, and hydrograph response is rapid.

Fire impacts are moderate to slight on these soils, depending on fuel accumulation. Fuels are somewhat heavier and more continuous on Dystric Cryochrepts than on Typic Cryorthents; fuel production and fire hazard on both soils are limited by soil and atmospheric temperatures. Although fire in this unit will lead to increased soil erosion and sediment production, ecosystem recovery is expected to be rapid for this elevational range.

These soils are susceptible to potential effects from acidic precipitation, because of their low buffering capacity.

134—Dystric Cryochrepts - Entic Cryumbrepts - Typic Cryorthents complex, 0 to 45 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Dystric: base saturation less than 60 percent; generally low fertility, but adequate for acid-loving plants;

Entic: lack of subsoil development

Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, or clayey);

Cry: very cold, with little warming in summer;

ochr: light colored, organic-poor, or thin surface horizon;

umbr: dark colored, organic-rich, low base saturation surface horizon;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ept: Inceptisol, a soil order; slightly more developed than Entisols;

ent: Entisol, a soil order; a young, weakly developed soil.

This map unit is found in the Kaiser Wilderness and along Mono Creek and Hooper Creek, in the South Fork San Joaquin River drainage. It occurs on nearly level to steep alluvial bottoms, mountain sides, and glacial moraines at elevations between 8,000 and 12,000 feet. Overall, slopes in Kaiser Wilderness and the lower part of Hooper Creek tend to be steeper than those along Mono Creek. The soils formed in alluvium, colluvium, and glacial till derived from granitic materials.

Mean annual precipitation ranges from 30 to 60 inches, most of which falls as snow. The highest precipitation areas are in the Kaiser Wilderness. Vegetation series include mixed conifer-fir, lodgepole pine, and whitebark pine, with lodgepole pine being dominant.

The map unit, which comprises 1.11 percent of the survey area, is approximately 35 percent Dystric Cryochrepts, 25 percent Entic Cryumbrepts, 20 percent Typic Cryorthents, and 20 percent inclusions. The various components are individually too small and intricately mixed on the landscape to be delineated separately. Inclusions are Typic Cryumbrepts, dominantly on nearly level to strongly sloping sites that support lodgepole pine or whitebark pine and at least 50 percent grass cover, and rock outcrop on glacially scoured mountain sides.

Along the southern boundary of Kaiser Wilderness, this map unit borders the *Soil Survey of Sierra National Forest, California*, in which the adjoining, lower elevation, soils are mapped as Dystric Xeropsamments. Soils mapped in the wilderness for this survey do not classify as Xeropsamments because they are too cold in summer, have rock fragment content greater than 35 percent, and have too little sand.

The Dystric Cryochrepts are coarse to moderately coarse textured, very cold, deep to very deep, and well drained to somewhat excessively drained. They may have a surface organic layer of slightly decomposed organic matter up to two inches thick. The surface mineral layer may be water repellent, but the subsoil is wettable. In a representative soil, the surface mineral layer is 10 inches of pale brown, coarse sandy loam having moderate granular structure. It is very strongly acid and slightly water repellent. The subsoil, which is 22 inches thick, is very pale brown, gravelly coarse sandy loam and light gray, very gravelly coarse sandy loam having moderate granular to moderate subangular blocky structure and strongly acid reaction. The underlying material, which extends to at least 41 inches, is light gray, very gravelly coarse sandy loam that has weathered in place, and is massive and strongly acid.

The Entic Cryumbrepts are coarse to moderately coarse textured, very cold, moderately deep to very deep, and well drained to somewhat excessively drained. They may or may not have a surface layer of slightly decomposed organic material that, if present, is less than two inches thick. In a representative soil, the surface mineral layer is 2 inches of grayish brown, gravelly loamy coarse sand that is single grained. It is very strongly acid and extremely water repellent. This is underlain by 25 inches of grayish brown, loamy coarse sand having weak granular structure, strongly acid reaction, and extreme to very slight water repellence. The substratum, to at least 64 inches depth, is grayish brown, light brownish gray, or light yellowish brown, loamy coarse sand or gravelly loamy coarse sand that is massive to weak granular. It is strongly acid and wettable.

The Typic Cryorthents are coarse to moderately coarse textured, very cold, deep to very deep, and moderately well drained to somewhat excessively drained. The soils may or may not have a surface layer of slightly decomposed organic material which, if present, is less than one inch thick. In a representative soil, the surface mineral layer is 6 inches of light gray, cobbly sandy loam having an admixture of volcanic ash. It has a massive arrangement that breaks to weak granular structure, and is very strongly acid. The underlying material, which extends to at least 34 inches depth, is light brownish gray to very pale brown, very cobbly sandy loam. It has weak subangular blocky to moderate granular structure, and is very strongly acid.

Hydraulic conductivity is moderately high to high, except in dry water repellent soils. Once saturated, the hydraulic conductivity of water repellent soils is comparable to that of wettable soils. Overland flow, which increases with increasing hydrophobicity, varies from slow on nearly level sites to rapid on moderately steep and steep sites. Plant-available water capacity is low, although it may approach moderate in Dystric Cryochrepts and Entic Cryumbrepts. Effective rooting depth is greater than 36 inches in the unit.

Maximum erosion hazard rating is moderate on nearly level to strongly sloping sites, and high on moderately steep and steep sites.

Approximately 50 percent of the unit is rated moderate, and 50 percent is rated high. These soils are susceptible to sheet, rill, and gully erosion, especially on moderately steep and steep slopes, when they are unprotected by vegetative cover because of their low cohesive strength. Surface rock fragment cover ranges from negligible on nearly level sites on the Mono Creek flood plain to 50 percent on moderately steep and steep mountain sides. Landscape stability hazard is low to moderately low under normal conditions.

Soils in this unit are well suited for trails and for campsites on nearly level to gently sloping sites. Limitations include rapid water runoff, loose consistence, and moderately steep and steep slopes.

Portions of this unit on nearly level to strongly sloping sites and in included meadows are suitable for livestock grazing. Areas of moderately steep and steep slopes are poorly suited because of low forage production, and high susceptibility to sheet and rill erosion during and following disturbance. These areas may be suitable for incidental use by pack stock traveling through the unit.

Wildlife habitat generally is good, although its quality decreases with increasing elevation. The unit contains some of the most suitable wildlife habitat in the survey area especially on Cryumbrepts in the Mono Creek flood plain, which support good cover and forage for browsing and grazing animals. Burrowing animals and insects commonly are active in these soils. Animal burrows in Typic Cryorthents probably do not hold up as well as those in Dystric Cryochrepts or Entic Cryumbrepts. Soil depth is great enough to provide habitat for winter hibernation and protection from summer heat.

Watershed rating is moderately high to high because of the soils' significant depth to bedrock and the large amount of high purity water collected and transmitted to underground storage. Precipitation is moderate to high. Snow retention is high, especially in the Kaiser Wilderness, and hydrograph response is rapid.

Fire impacts are moderate to slight on these soils, depending on fuel accumulation. Fuels are somewhat heavier and more continuous on Dystric Cryochrepts and Entic Cryumbrepts than on Typic Cryorthents. Fuel production and fire hazard are limited by soil and atmospheric temperatures. Although fire in this unit will lead to increased soil erosion and sediment production, ecosystem recovery is expected to be rapid for this elevational range.

These soils are susceptible to potential effects from acidic precipitation, because of their low buffering capacity.

135—Typic Xerochrepts, 15 to 45 percent slopes.

The soil's taxonomic name reflects the following characteristics:

Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, or clayey);

Xer: dry in summer, moist in winter;

ochr: light colored, organic-poor, or thin surface horizon;

ept: Inceptisol, a soil order; a soil in adolescent stage of development.

This small map unit is located in the Sawmill Creek drainage, in the southeastern portion of the survey area, on moderately steep to steep glacial moraines, mountain sides, and alluvial bottoms at elevations between 6,600 and 10,100 feet. The soils formed in glacial till, colluvium, and alluvium derived from biotite-hornblende-granodiorite rock.

Mean annual precipitation ranges from 15 inches at lowest elevation to 25 inches at highest elevation. The dominant vegetation series is mixed conifer-fir, with perennial grass on south-facing slopes low in the unit.

The map unit, which comprises 0.09 percent of the survey area, is 80 percent Typic Xerochrepts with 20 percent inclusions of Typic Cryorthents near its upper elevation limit and scattered areas of Typic Xerorthents.

Typic Xerochrepts are coarse to moderately coarse textured, moderately deep to very deep, and well drained to excessively drained. They may or may not have a surface layer of slightly decomposed organic material that typically is less than one inch thick. The mineral surface horizon commonly is water repellent. In a representative soil, the surface mineral layer is 3 inches of very dark grayish brown, extremely gravelly coarse sand having single grain arrangement or weak, very fine granular structure. The subsoil, which is 20 inches thick, is light gray extremely gravelly sandy loam, and massive or weak, very fine granular. The substratum, to a depth of at least 32 inches, is white, extremely cobbly sandy loam, massive weathered bedrock.

Hydraulic conductivity is moderately high to high, and overland flow is rapid. Plant-available water capacity is low throughout the unit. Effective rooting depth is greater than 40 inches in the unit.

Maximum erosion hazard rating is moderate to high on moderately steep slopes, and high on steep slopes. Approximately 40 percent of the unit is rated moderate, and 60 percent is high. These soils are susceptible to sheet, rill, and gully erosion when unprotected by vegetation because of slope steepness and low cohesive strength. Landscape stability hazard is moderately low under normal conditions.

These soils are well suited for trails, and poorly suited for campsites, except on nearly level slope inclusions.

This unit is poorly suited for livestock grazing, except in small included meadows, which are suitable, because of low forage production.

Wildlife habitat generally is good for browsing and burrowing wildlife throughout most of the unit

Watershed rating is moderate. Precipitation is moderate to low. Snow retention is moderate. Hydrograph response is moderate. Soil's have significant depth, and underlying bedrock is interpreted to be intensely fractured.

Fire impacts are expected to be moderate in this area of moderate and discontinuous fuel accumulation.

These soils are susceptible to potential effects from acidic precipitation because of their low buffering capacity.

136—Entic Cryumbrepts - Mollic Cryoboralfs association, 0 to 25 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Entic: lacking clear subsoil development;

Mollic: dark colored surface horizon;

Cry: very cold, with little warming in summer;

umbr: dark colored, organic-rich surface horizon having low base saturation;

bor: cold;

ept: Inceptisol, a soil order; a soil in adolescent stage of development;

alf: Alfisol, a soil order; well developed soil having a clay-enriched B horizon.

This small map unit is located on Table Mountain in the Bishop Creek drainage, in the eastern portion of the survey area. It occurs on a nearly level to moderately steep plateau between 11,200 and 11,700 feet elevation. The soils formed in ancient alluvium that apparently was uplifted with the Sierra Nevada, as well as in glacial till and colluvium derived from granodiorite.

Mean annual precipitation is approximately 20 to 25 inches. Vegetation series include alpine dwarf scrub, whitebark pine having krummholz form, and perennial grass.

The map unit, which comprises 0.16 percent of the survey area, is approximately 55 percent Entic Cryumbrepts, 35 percent Mollic Cryoboralfs, and 10 percent inclusions. The Entic Cryumbrepts tend to be associated with the alpine dwarf scrub and perennial grass vegetation series, whereas the Mollic Cryoboralfs are more associated with whitebark pine and ancient alluvium. Inclusions of Typic Cryorthents occur primarily near the margin of the unit, and small rock outcrops are scattered throughout.

The Entic Cryumbrepts are coarse to moderately coarse textured, very cold, moderately deep to very deep, and well drained to somewhat excessively drained. They formed in gravelly or cobbly glacial till, colluvium, and alluvium derived from granitic rock. The soils may or may not have a surface layer of slightly decomposed organic material that, if present, is less than one inch thick. In a representative soil, the surface mineral layer is 2 inches of grayish brown, gravelly loamy coarse sand that is single grained. It is very strongly acid and extremely water repellent. This is underlain by 25 inches of grayish brown, loamy coarse sand having weak granular structure, strongly acid reaction, and extreme to very slight water repellence. The substratum, to at least 64 inches depth, is grayish brown, light brownish gray, or light yellowish brown, loamy coarse sand or gravelly loamy coarse sand that is massive to weak granular. It is strongly acid and wettable.

The Mollic Cryoboralfs are coarse to moderately coarse textured, very cold, moderately deep to very deep, and moderately well drained to somewhat excessively drained. They may or may not have a slightly decomposed surface organic layer that is less than one inch thick. They often have a thin surface layer of clean sand that was eroded from up slope. The mineral soil normally is wettable. In a representative soil, the surface mineral material is 8 inches of brown to dark brown, stony or very stony sandy loam having weak granular or subangular blocky structure and very strongly acid reaction. The subsoil, which is 31 inches thick, is brown, very cobbly loam or very cobbly sandy clay loam with evidence of clay accumulation from above. It is strongly acid and has subangular blocky structure or is massive. This material is underlain by saprolite (chemically weathered bedrock).

Hydraulic conductivity is moderately high to high in Entic Cryumbrepts, and moderately low to moderate in Mollic Cryoboralfs. Overland flow is slow to rapid. Plant-available water capacity is low throughout the unit. Effective rooting depth is greater than 36 inches in the unit.

Maximum erosion hazard rating is low on nearly level to moderately sloping sites, and moderate on strongly sloping and moderately steep sites. Approximately 40 percent of the unit is rated low, and 60 percent is rated high. These soils are susceptible to sheet and rill erosion despite their relatively gentle slopes and an armoring of rock fragments that commonly covers more than 50 percent of the ground surface. The vegetative protection is discontinuous and the soils have low cohesive strength in the surface layer. Landscape stability hazard is low.

These soils are well suited for trails and campsites, except that the mechanical disturbance of intensive use can greatly damage these fragile ecosystems. Recovery from disturbance is very slow at these high elevations.

This unit is unsuitable for livestock grazing because of susceptibility to mechanical disturbance, overall low forage production, and short growing season.

Wildlife habitat generally is poor, except that burrowing animals commonly are active in these soils. Main limitations are low forage production, lack of cover, and abundant rock fragments that interfere with digging for burrowing animals.

Watershed rating is low because of the unit's small size, relatively low precipitation, and high evaporation potential.

Fire impacts are slight because of lack of fuel.

These soils are susceptible to potential effects from acidic precipitation because of their low buffering capacity.

137—Typic Cryumbrepts, 0 to 30 percent slopes.

The soil's taxonomic name reflects the following characteristics:

Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, or clayey);

Cry: very cold, with little warming in summer;

umbr: dark colored, organic-rich surface horizon having low base saturation;

ept: Inceptisol, a soil order; a soil in the adolescent stage of development.

This map unit is found in the western portion of the survey area adjacent to, and usually downslope from, rock outcrops and Typic Cryorthents. The soils formed on nearly level to moderately steep mountain sides and glacial moraines and in stable alluvial bottoms at elevations between 8,000 and 10,600 feet. Soil parent materials include glacial till, colluvium, and alluvium derived from diorite, granodiorite, and, to a lesser extent, quartz monzonite. A few small areas developed from volcanic or metamorphic rock.

Mean annual precipitation ranges from 30 to 45 inches, most of which falls as snow. Vegetation series include red fir, lodgepole pine, whitebark pine, and alpine dwarf scrub. At high elevations, roots of grasses and sedges can provide adequate organic matter to develop the A horizon necessary for Umbrept formation.

The unit, which comprises 0.15 percent of the survey area, is approximately 90 percent Typic Cryumbrepts. It contains 10 percent small inclusions of Typic Cryochrepts under moderate vegetative cover and Typic Cryorthents on highest landscape positions supporting least plant cover.

Typic Cryumbrepts are coarse to moderately coarse textured, very cold, deep to very deep, and well drained to somewhat excessively drained. They normally have a surface layer of slightly decomposed organic material less than two inches thick, but which may reach three inches thickness. The surface mineral soil may be moderately water repellent, but subsoils are wettable, or they exhibit only slight water repellency. In a representative soil, the surface mineral layer is 10 inches of yellowish brown sandy loam having weak granular structure. It is strongly acid and slightly water repellent. The subsoil, which is 20 inches thick, is yellowish brown to dark yellowish brown sandy loam or gravelly sandy loam, having moderate granular structure. It is strongly acid, and is not water repellent (some comparable soils are slightly water repellent in the subsoil). The substratum, which extends to at least 41 inches depth, is dark brown very gravelly coarse sandy loam having moderate granular structure, and strongly acid reaction.

Hydraulic conductivity is moderately high to high in wettable soils; it is moderately low in hydrophobic soils until the soil becomes wetted, when it increases to moderately high. Overland flow is medium on gently sloping sites and rapid on moderately steep sites. Plant-available water capacity is low. Effective rooting depth is greater than 40 inches in the unit.

Maximum erosion hazard rating is low to moderate on nearly level to strongly sloping sites, and high on moderately steep and steep sites. Approximately 30 percent of the unit is rated low, 35 percent is rated moderate, and 35 percent is rated high. These soils are susceptible to sheet, rill, and gully erosion when unprotected by vegetative cover, because of their moderately steep slopes and low cohesive strength. Surface rock fragment cover averages about 25 percent and ranges from 0 to 50 percent. These fragments provide some protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion. This phenomenon is especially notable immediately below rock outcrops and Lithic Cryorthents, which cause unusually high concentrations of runoff water. Landscape stability hazard is low under normal conditions.

Typic Cryumbrepts are well suited for trails and for campsites on nearly level to gently sloping sites. Limitations include rapid water runoff, loose consistence, and moderately steep slopes.

This map unit is not used and is poorly suited for commercial livestock grazing because of its small size and low forage production. The area may be used incidentally by pack stock.

Wildlife habitat is good for browsing animals. Burrowing animals and insects are active in these soils, although rock fragments may interfere with digging. The soils have adequate depth for winter hibernation and protection from summer heat.

Watershed rating is moderate. Precipitation is moderate for the survey area. The rating is limited by low water retention capacity of the soil and small size of the unit. Snow retention is high. Hydrograph response is rapid during snowmelt and rainstorms . Snowmelt and rainfall from this unit provide high purity water to recharge deeper, lower elevation aquifers.

Fire impacts are expected to be moderate in this unit because of adequate fuel production. Fuels are discontinuous throughout most of the unit and forest stand canopies generally are open. Fuels are more concentrated under nearly closed canopies; nonetheless, soil and atmospheric temperatures are low enough to limit production and fire hazard.

These soils are susceptible to potential effects from acidic precipitation, because of their low buffering capacity.

138—Typic Cryumbrepts - Xeric Vitricryands - Rock outcrop complex, volcanic, 0 to 45 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, or clayey);

Xeric: dry in summer, moist in winter;

Cry: very cold, with little warming in summer;

Vitri: contains weakly weathered volcanic glass that holds less than 15 percent water at permanent wilting point;

umbr: dark colored, organic rich surface horizon having low base saturation;

ept: Inceptisol, a soil order; a soil in the adolescent stage of development;

and: Andisol, an order of soils that have andic properties and that usually form from volcanic ejecta.

This map unit occurs as a few small delineations along the western margin of the survey, in the areas of Madera Creek, Volcanic Knob, and Woodchuck Country. The soils formed on nearly level to steep ridges, mountain sides, and glacial moraines at elevations between 7,700 and 11,100 feet. Dominant soil parent materials are from mafic volcanic flows, with minor granitic deposits.

Mean annual precipitation ranges from 40 to 55 inches, most of which falls as snow. Vegetation is typical of the lodgepole pine series, consisting primarily of nearly closed stands of lodgepole pine with minor amounts of red fir, western white pine, and Jeffrey pine. Sites usually have good ground cover of grass or sedge and litter, as well as forbs, including lupine and arnica. Annual decay of grass and sedge roots, combined with conifer litter, provide adequate organic matter to develop the dark topsoil necessary for Umbrept formation.

The unit, which comprises 0.87 percent of the area, is approximately 40 percent Typic Cryumbrepts, volcanic, 25 percent Xeric Vitricryands, 25 percent rock outcrop, and 10 percent inclusions. The Typic Cryumbrepts, volcanic are concentrated on stable, nearly level to strongly sloping landscapes where organic matter has accumulated. The Xeric Vitricryands are most common in the Woodchuck Country, where inclusions of Humic Xeric Vitricryands are associated with them. Also included in the map unit are Entic Cryumbrepts, volcanic, Dystric Cryochrepts, and Typic Cryorthents, some of which have formed on small deposits of granitic parent material.

The Typic Cryumbrepts, volcanic are coarse to moderately coarse textured, very cold, deep to very deep, and well drained to somewhat excessively drained. They formed in colluvium, residuum, and, less often, glacial till derived from andesitic or basaltic parent rock, with occasional granitic erratics. The soils normally have a surface layer of slightly decomposed organic material less than two inches thick and may have a thin, scattered covering of granitic slope wash. The surface mineral soil may or may not be slightly water repellent; subsoils normally are not water repellent. In a representative soil, the surface mineral layer is 9 inches of brown very gravelly sandy loam having moderate, medium granular structure. It is strongly acid and slightly water repellent. The subsoil, which is 26 inches thick, is brown cobbly loam or very cobbly loam, having weak, fine subangular blocky structure or massive arrangement. It is strongly acid, and is not water repellent. The substratum, which extends to at least 37 inches depth, is pale brown extremely stony sandy loam having a massive arrangement.

The Xeric Vitricryands are coarse to medium textured, very cold, moderately deep to very deep, and well drained to somewhat excessively drained. They are covered by a layer of volcanic ash and cinders (tephra) that also is mixed into the topsoil. They may or may not have a surface layer of slightly decomposed organic material that, if present, is less than 3 inches thick. In a representative soil, the surface mineral layer is 9 inches of light gray, extremely gravelly coarse sand consisting dominantly of volcanic lapilli and ash (tephra). It is single grain and very strongly acid. The underlying material, which extends to at least 39 inches, is light gray to brownish yellow, very gravelly coarse sand to loamy coarse sand. It is massive and slightly hard in its upper portion, and has weak granular structure or is massive below. It is strongly acid to moderately acid.

Although these soils were mapped in the xeric moisture regime, many of them actually may have sufficient moisture through the growing season to classify in the udic regime, which would make them Typic Vitricryands. Soils most likely to be udic are in the highest precipitation areas and under the red fir vegetation series.

The rock outcrop is bedrock and rubble primarily consisting of andesite, basalt, or olivine trachybasalt.

Hydraulic conductivity, which is decreased somewhat in dry hydrophobic soils, is moderately high to high in Typic Cryumbrepts, volcanic; low to moderately low in dry Xeric Vitricryands; and moderately high in wet Xeric Vitricryands. Overland flow is slow on nearly level sites, medium on gently sloping sites, and rapid on moderately steep sites. Plant-available water capacity is low. Effective rooting depth is greater than 36 inches in the unit.

Maximum erosion hazard rating is moderate on nearly level to strongly sloping sites, and high on moderately steep and steep sites. The rating approaches very high on steep slopes immediately below rock outcrop. Approximately 30 percent of the unit is rated low (including rock outcrop), 40 percent is moderate, and 30 percent is high.

Soils on moderately steep to steep slopes are susceptible to moderate sheet and rill erosion and minor gully erosion when unprotected by vegetative cover. The potential for surface erosion is greatest on Xeric Vitricryands because of their easily detachable pumice surface. Overall surface rock fragment cover ranges from about 30 to 60 percent. These fragments provide some protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion. Landscape stability hazard is low to moderately low under normal conditions.

Typic Cryumbrepts, volcanic are well suited for trails and for campsites on nearly level to gently sloping sites. These soils tend to become very dusty when disturbed. Other limitations include rapid water runoff, loose consistence, and moderately steep slopes. Xeric Vitricryands, which are more susceptible to erosion, compaction, and dust formation, are suitable.

Much of the unit is well suited for livestock grazing. Forage production generally is good for high elevation open–forest rangeland. The map unit falls in active grazing allotments in the Madera Creek drainage and near Volcanic Knob; allotments in Woodchuck Country are vacant (i.e., ungrazed).

Wildlife habitat, which decreases in quality with increasing elevation, generally is good for browsing animals. Burrowing animals and insects are active in these soils, although rock fragments may interfere with digging. The soils have adequate depth for winter hibernation and protection from summer heat.

Watershed rating of the unit is moderately high. It is limited primarily by rock outcrop. Precipitation is moderate to high. Ground water storage under these soils probably is greater than under neighboring, granitically derived soils, because of somewhat greater porosity and hydraulic conductivity in the bedrock and overlying mantle. Snow retention is high. Hydrograph response is moderately rapid. Snowmelt and rainfall from this unit provide high purity water to recharge deeper, lower elevation aquifers.

Fire impacts are expected to be slight to moderate in this unit because of discontinuous ground fuels and broken forest canopy. Fuels are more concentrated under nearly closed canopies; nonetheless, soil and atmospheric temperatures are low enough to limit production and fire hazard. Locally intense fire can alter surface soil mineralogy of Xeric Vitricryands by fusing volcanic glass and chemically altering related mineral components.

These soils are susceptible to potential effects from acidic deposition, because of their low buffering capacity. Their response to atmospheric inputs may be different from surrounding granitically derived soils, in that these soils may be more strongly buffered. Sites in this map unit may be particularly well suited for studies of potential differences in ecosystem response to atmospheric depositions.

139—Typic Cryumbrepts - Typic Cryorthents - Rock outcrop complex, 0 to 30 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, or clayey);

Cry: very cold, with little warming in summer;

umbr: dark colored, organic-rich surface horizon having low base saturation;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ept: Inceptisol, a soil order, slightly more developed than Entisols;

ent: Entisol, a soil order, a young, weakly developed soil.

This map unit is found mostly near the western boundary of the survey area in the San Joaquin and North Fork Kings River drainages. It occurs on nearly level to moderately steep ridges, mountain sides, glacial moraines, and alluvial bottoms at elevations between 8,600 and 10,900 feet. The soils formed in glacial till, colluvium, and alluvium derived from granodiorite, diorite, and quartz monzonite, and between bedrock joints.

Mean annual precipitation ranges from 30 to 60 inches, most of which falls as snow. Vegetation series include red fir, lodgepole pine, whitebark pine, and alpine dwarf scrub.

The map unit, which comprises 1.25 percent of the survey area, is approximately 35 percent Typic Cryumbrepts, 30 percent Typic Cryorthents, 25 percent rock outcrop, and 10 percent inclusions. The pattern of soils on the landscape is too intricate for further separation to be practical.

Typic Cryumbrepts occur most commonly on lower landscape positions, in stable drainages, and on gentle northerly-facing slopes having a closed forest canopy or heavy grass or sedge cover; the forested sites usually have an organic litter layer, and all sites have dark colored topsoil. At high elevations, grasses and sedges can provide adequate organic matter from annual root decay to develop the A horizon necessary for Typic Cryumbrept formation. The Typic Cryorthents occur most commonly on upper, more convex landscapes and bouldery glacial moraines that support less vegetation. Typic Cryorthents are more likely than other soils to have developed from quartz monzonite. The unit contains small scattered inclusions of Entic Cryumbrepts and Typic Cryochrepts.

Typic Cryumbrepts are coarse textured, very cold, deep to very deep, and well drained to somewhat excessively drained. They formed in glacial till, colluvium, and alluvium derived from diorite, granodiorite, and, to a lesser extent, quartz monzonite. A few small areas in this unit developed from volcanic rock. The soils normally have a surface layer of slightly decomposed organic material that typically is less than two inches thick, but that may reach three inches thickness. The surface mineral layer may be moderately water repellent, but the soil becomes wettable or only slightly repellent below the subsoil. In a representative soil, the surface mineral layer is 10 inches of yellowish brown sandy loam having weak granular structure. It is strongly acid and slightly water repellent. The subsoil, which is 20 inches thick, is yellowish brown to dark yellowish brown sandy loam or gravelly sandy loam, having moderate granular structure. It is strongly acid, and is not water repellent (some comparable soils are slightly water repellent in the subsoil). The substratum, which extends to at least 41 inches depth, is dark brown very gravelly coarse sandy loam having moderate granular structure, and strongly acid reaction.

The Typic Cryorthents are coarse to moderately coarse textured, very cold, deep to very deep, and moderately well drained to somewhat excessively drained. More than half the soils have a slightly decomposed surface organic layer that commonly is less than one inch thick, but that may reach three inches thickness. The surface mineral layer commonly is water repellent. The underlying mineral soil normally has lighter, brighter colors and greater rock fragment content, and it may have slightly better developed structure, although structures seldom are more pronounced than weak granular. Distinctive subsoil horizons are not well developed, even under a closed canopy of mature trees, because of the high proportion of resistant minerals and limited conditions for chemical weathering. In a representative soil, the surface mineral layer is 6 inches of light gray, cobbly sandy loam having an admixture of volcanic ash. It has a massive arrangement that breaks to weak granular structure, and is very strongly acid. The underlying material, which extends to at least 34 inches depth, is light brownish gray to very pale brown, very cobbly sandy loam. It has weak subangular blocky to moderate granular structure, and is very strongly acid.

Rock outcrop consists of hard bedrock and rubble dominated by hornblende-bearing, biotite diorite and granodiorite at lower elevations, and quartz monzonite at higher elevations. These rocks have developed a characteristic pattern of deep perpendicular joints that collect water, pollen, and dust. The joints normally are filled with soil that can support a well developed plant community. These rocks show little difference in weathering in the elevational range of this map unit.

Hydraulic conductivity is moderately low in dry, hydrophobic soils, but it increases to moderately high once the soils become wetted. Initial water intake into dry hydrophobic soils is through macropores connected to the surface; surface intake rates increase with continued rainfall as the soils become wettable. Overland flow is medium on gently sloping sites and rapid on moderately steep sites. Plant-available water capacity is low. Effective rooting depth is greater than 40 inches in the unit.

Maximum erosion hazard rating is low to moderate on nearly level to strongly sloping sites, and high on moderately steep and steep sites. Erosion hazard is greatest immediately below rock outcrop. Approximately 35 percent of the unit is rated low (including rock outcrop), 35 percent is rated moderate, and 30 percent is rated high.

These soils are susceptible to sheet, rill, and gully erosion when unprotected by vegetative cover, because of their moderately steep slopes and low cohesive strength. Surface rock fragment cover averages about 25 percent on Typic Cryumbrepts and 40 percent on Typic Cryorthents, with a total range from 0 to 70 percent. These fragments provide some protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion. Overland flow and the attendant erosion can be particularly acute immediately below rock outcrops. Landscape stability hazard is low under normal conditions.

These soils are well suited for trails and for campsites on nearly level to gently sloping sites. Limitations include rapid water runoff, loose consistence, and moderately steep slopes.

Most of this unit is unsuitable for livestock grazing because of the large proportion of rock outcrop and rubble and low forage production, especially on Typic Cryorthents. The unit encompasses several montane meadows, that are in fair to good condition, and that are suitable for carefully controlled grazing, although most commercial cattle allotments have been vacant for several decades, after having suffered years of over grazing by cattle and sheep. Many areas in the unit continue to be grazed by recreational pack stock.

Wildlife habitat, which decreases in quality with increasing elevation, is good to fair. It appears to be better on Typic Cryumbrepts than on Typic Cryorthents. The Typic Cryumbrepts support good summer habitat for deer and other migratory species. Burrowing animals and insects easily can find adequate depth for winter and summer thermal protection, although rock fragments may interfere with digging. Rodents often find suitable habitat in rock rubble.

Watershed rating is moderate to moderately high. It is limited by the amount of rock outcrop. Precipitation is moderate to high. The soils have significant depth to bedrock and readily transmit high purity snowmelt and rain water to underground storage. Snow retention is high, and hydrograph response is rapid.

The impact of fire is slight to moderate because of rock outcrop and light, scattered fuels. Soil and atmospheric temperatures are low enough to limit fuel production and fire hazard.

Soils in this unit are susceptible to potential effects from acidic precipitation, because of their low buffering capacity. Many areas in the unit are well suited for monitoring environmental effects of atmospheric pollutants, because of their accessibility and diversity of soils and ecosystems.

140—Typic Cryumbrepts - Dystric Cryochrepts - Typic Cryorthents association, 0 to 30 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, or clayey);

Dystric: base saturation less than 60 percent; generally low fertility, but adequate for acid–loving plants;

Cry: very cold, with little warming in summer;

umbr: dark colored, organic-rich surface horizon having low base saturation;

ochr: light colored, organic-poor, or thin surface horizon;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ept: Inceptisol, a soil order, slightly more developed than Entisols;

ent: Entisol, a soil order, a young, weakly developed soil.

This map unit is found in the North Fork San Joaquin River and upper Piute Creek (tributary to South Fork San Joaquin River) drainages, in the western portion of the survey area. It occurs on nearly level to moderately steep ridges, mountain sides, glacial moraines, and alluvial bottoms at elevations between 7,700 and 10,700 feet. The soils formed in glacial till, colluvium, and alluvium, and between bedrock joints, in material developed primarily from granodiorite, diorite, and quartz monzonite, and to a minor extent from volcanic rock.

Mean annual precipitation ranges from 40 to 60 inches, most of which falls as snow. The southern delineations receive the least precipitation, and the northern delineations receive the most precipitation. Vegetation series include red fir, lodgepole pine, whitebark pine, and alpine dwarf scrub.

The map unit, which comprises 2.23 percent of the survey area, is approximately 40 percent Typic Cryumbrepts, 30 percent Dystric Cryochrepts, 20 percent Typic Cryorthents, and 10 percent inclusions. Typic Cryumbrepts occur most commonly on lower landscape and stable alluvial positions, and gentle northerly-facing slopes supporting a nearly closed forest canopy or heavy grass or sedge cover. The forested sites usually have an organic litter layer, and all sites have noticeable organic matter incorporated into the topsoil. At high elevations, grasses and sedges can provide adequate organic matter from annual root decay to develop the A horizon necessary for Typic Cryumbrept formation.

The Dystric Cryochrepts occur primarily on gently sloping, glacial and colluvial deposits at somewhat higher landscape positions that are well vegetated, but that have more open forest stands and less soil organic matter than do the Typic Cryumbrepts. The Typic Cryorthents occur most commonly in the North Fork San Joaquin River watershed, on upper, convex landscapes and bouldery glacial moraines that support the least vegetation. Typic Cryorthents are more likely than the other two soils to have developed from quartz monzonite. The unit contains small scattered inclusions of Entic Cryumbrepts and rock outcrop, as well as Aquic Cryorthents, wet Typic Cryumbrepts, and eroded Typic Cryumbrepts in meadows. Inclusions of Xeric Vitricryands occur in French Canyon on sites that have accumulated volcanic ash.

Typic Cryumbrepts are coarse textured, very cold, deep to very deep, and well drained to somewhat excessively drained. They formed in glacial till, colluvium, and alluvium derived from diorite, granodiorite, and, to a lesser extent, quartz monzonite. A few small areas in the northern portion of this unit developed from volcanic rock. The soils normally have a surface layer of slightly decomposed organic material less than two inches thick, but which may reach three inches thickness. The surface mineral layer may be moderately water repellent, but underlying layers are wettable or only slightly water repellent.

In a representative soil, the surface mineral layer is 10 inches of yellowish brown sandy loam having weak granular structure. It is strongly acid and slightly water repellent. The subsoil, which is 20 inches thick, is yellowish brown to dark yellowish brown sandy loam or gravelly sandy loam, having moderate granular structure. It is strongly acid, and is not water repellent (some comparable soils are slightly water repellent in the subsoil). The substratum, which extends to at least 41 inches depth, is dark brown very gravelly coarse sandy loam having moderate granular structure, and strongly acid reaction.

The Dystric Cryochrepts are coarse textured, very cold, deep to very deep, and well drained to somewhat excessively drained. The soils usually have a surface layer of slightly decomposed organic matter up to two inches thick. The surface mineral layer usually is water repellent; the subsoil usually is not water repellent. In French Canyon, these soils sometimes have a thin surface covering or mixture of volcanic ash.

In a representative soil, the surface mineral layer is 10 inches of pale brown, coarse sandy loam having moderate granular structure. It is very strongly acid and slightly water repellent. The subsoil, which is 22 inches thick, is very pale brown, gravelly coarse sandy loam and light gray, very gravelly coarse sandy loam having moderate granular to moderate subangular blocky structure and strongly acid reaction. The underlying material, which extends to at least 41 inches, is light gray, very gravelly coarse sandy loam that has weathered in place, and is massive and strongly acid.

The Typic Cryorthents are coarse to moderately coarse textured, very cold, deep to very deep, and moderately well drained to somewhat excessively drained. Somewhat more than half of the soils have a slightly decomposed surface organic layer that commonly is less than one inch thick, but that may reach three inches thickness. Water repellency, which is common in the surface mineral layer, decreases with increasing depth. Soil color becomes lighter and brighter, and rock fragment content increases with increasing depth. Subsoil horizons are poorly developed, even under a closed canopy of mature trees, because of the high proportion of resistant minerals and limited conditions for chemical weathering.

In a representative soil, the surface mineral layer is 6 inches of light gray, cobbly sandy loam having an admixture of volcanic ash. It has a massive arrangement that breaks to weak granular structure, and is very strongly acid. The underlying material, which extends to at least 34 inches depth, is light brownish gray to very pale brown, very cobbly sandy loam. It has weak subangular blocky to moderate granular structure, and is very strongly acid.

Hydraulic conductivity is moderately low in dry, hydrophobic soils, but it increases to moderately high once the soils become wetted. Initially, water intake is restricted to macropores in dry, hydrophobic surface layers, but the intake rate increases as the soil becomes wet, allowing micropores to become increasingly important for water transport. Overland flow is medium on gently sloping sites and rapid on moderately steep sites. Plant-available water capacity is low. Effective rooting depth is greater than 40 inches in the unit.

Maximum erosion hazard rating is low to moderate on nearly level to strongly sloping sites, and high on moderately steep and steep sites. Approximately 30 percent of the unit is rated low, 30 percent is rated moderate, and 40 percent is rated high. These soils are susceptible to sheet, rill, and gully erosion when unprotected by vegetative cover, because of their moderately steep slopes and low cohesive strength. Surface rock fragment cover averages about 25 percent on Typic Cryumbrepts and Dystric Cryochrepts, and 40 percent on Typic Cryorthents, with a total range from 0 to 70 percent. These fragments provide some protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion. Landscape stability hazard is low under normal conditions.

These soils are well suited for trails and for campsites on nearly level to gently sloping sites. Limitations include rapid water runoff, loose consistence, and moderately steep slopes.

This unit encompasses several montane meadows, which makes it well suited for livestock grazing. Although the higher elevation grazing allotments have been vacant since mid-century, the lower allotments continue to be commercially grazed by cattle into the 1990's. Meadows throughout the unit are grazed by recreational pack stock. Nearly all meadows are recovering from past overgrazing, and today are in fair to good condition. Soil and vegetative recovery of abused meadows requires several decades. Apart from the meadows, this unit provides secondary forage for pack stock and for cattle in active allotments. The short growing season, low forage productivity, difficult accessibility, and high erosion hazard make these areas poorly suited for grazing.

Wildlife habitat, which decreases in quality with increasing elevation, is good to fair. It appears to be better on Typic Cryumbrepts than on Typic Cryorthents. The Typic Cryumbrepts support good summer habitat for deer and other migratory species. Burrowing animals and insects easily can find adequate depth for winter and summer thermal protection, although rock fragments may interfere with digging. Rodents often find suitable habitat in rock rubble.

Watershed rating is high because of high precipitation, generally gentle slopes, and the soils' significant depth to bedrock. High purity water collected and transmitted to underground storage. Snow retention is high, and hydrograph response is moderately rapid.

Fire impacts are expected to be moderate in this unit because of adequate fuel production. Concentration of ground and canopy fuels is most variable on Typic Cryorthents, which usually support an open forest canopy. Soil and atmospheric temperatures are low enough to limit fuel production and fire hazard.

These soils are susceptible to potential effects from acidic precipitation, because of their low buffering capacity. They are well suited for monitoring environmental effects of atmospheric pollutants, because of their accessibility and diversity among ecosystems.

141—Typic Cryumbrepts – Dystric Cryochrepts – Typic Cryorthents complex, 15 to 45 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, or clayey);

Dystric: base saturation less than 60 percent; generally low fertility, but adequate for acid–loving plants;

Cry: very cold, with little warming in summer;

umbr: dark colored, organic-rich surface horizon having low base saturation;

ochr: light colored, organic-poor, or thin surface horizon;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ept: Inceptisol, a soil order, slightly more developed than Entisols;

ent: Entisol, a soil order, a young, weakly developed soil.

This map unit occurs west of the Sierran crest on moderately steep to steep mountain sides and glacial moraines at elevations between 7,700 and 11,600 feet. The soils formed primarily in glacial till and colluvium developed from granodiorite, diorite, and quartz monzonite, with minor amounts of volcanic rock.

Mean annual precipitation ranges from 35 to 55 inches, most of which falls as snow. Vegetation series include red fir, lodgepole pine, whitebark pine, and alpine dwarf scrub.

The map unit, which comprises 0.75 percent of the survey area, is approximately 35 percent Typic Cryumbrepts, 30 percent Dystric Cryochrepts, 25 percent Typic Cryorthents, and 10 percent inclusions. Typic Cryumbrepts occur most commonly on lower landscape positions and northerly-facing slopes having a closed forest canopy or heavy grass or sedge cover; the forested sites usually have an organic litter layer, and all sites have noticeable organic matter incorporated into the topsoil. At high elevations, grasses and sedges can provide adequate organic matter from annual root decay to develop the A horizon necessary for Typic Cryumbrept formation. The Dystric Cryochrepts occur primarily on glacial and colluvial deposits at somewhat higher landscape positions that are well vegetated, but that have more open forest stands and less soil organic matter than do the Typic Cryumbrepts. The Typic Cryorthents occur most commonly on upper, more convex landscapes and bouldery glacial moraines that support less vegetation. Typic Cryorthents are more likely than the other two soils to have developed from quartz monzonite. The unit contains small scattered inclusions of Entic Cryumbrepts and rock outcrop.

The Typic Cryumbrepts are coarse textured, very cold, deep to very deep, and well drained to somewhat excessively drained. They formed in glacial till and colluvium derived from diorite, granodiorite, and, to a lesser extent, quartz monzonite. A few small areas in this unit developed from volcanic rock. The soils normally have a surface layer of slightly decomposed organic material less than two inches thick. The surface mineral layer may be moderately water repellent, but the subsoil is only slightly water repellent or wettable. In a representative soil, the surface mineral layer is 10 inches of yellowish brown sandy loam having weak granular structure. It is strongly acid and slightly water repellent. The subsoil, which is 20 inches thick, is yellowish brown to dark yellowish brown sandy loam or gravelly sandy loam, having moderate granular structure. It is strongly acid, and is not water repellent (some comparable soils are slightly water repellent in the subsoil). The substratum, which extends to at least 41 inches depth, is dark brown very gravelly coarse sandy loam having moderate granular structure, and strongly acid reaction.

The Dystric Cryochrepts are coarse textured, very cold, deep to very deep, and well drained to somewhat excessively drained. The soils usually have a surface layer of slightly decomposed organic matter up to two inches thick. The surface mineral layer usually is water repellent, but the subsoil usually is no more than slightly water repellent. In a representative soil, the surface mineral layer is 10 inches of pale brown, coarse sandy loam having moderate granular structure. It is very strongly acid and slightly water repellent. The subsoil, which is 22 inches thick, is very pale brown, gravelly coarse sandy loam and light gray, very gravelly coarse sandy loam having moderate granular to moderate subangular blocky structure and strongly acid reaction. The underlying material, which extends to at least 41 inches, is light gray, very gravelly coarse sandy loam that has weathered in place, and is massive and strongly acid.

The Typic Cryorthents are coarse to moderately coarse textured, very cold, deep to very deep, and moderately well drained to somewhat excessively drained. More than half of the soils have a slightly decomposed surface organic layer that commonly is less than one inch thick. The surface mineral layer commonly is water repellent. Distinctive subsoil horizons are not well developed, even under a closed canopy of mature trees, because of the high proportion of resistant minerals and limited conditions for chemical weathering. In a representative soil, the surface mineral layer is 6 inches of light gray, cobbly sandy loam having an admixture of volcanic ash. It has a massive arrangement that breaks to weak granular structure, and is very strongly acid. The underlying material, which extends to at least 34 inches depth, is light brownish gray to very pale brown, very cobbly sandy loam. It has weak subangular blocky to moderate granular structure, and is very strongly acid.

Hydraulic conductivity is moderately low in dry, hydrophobic soils, but it increases to moderately high once the soils become wetted. Water intake and permeability of hydrophobic soils increase as the soils become moist. Overland flow tends to be rapid. Plant-available water capacity is low. Effective rooting depth is greater than 40 inches in the unit.

Maximum erosion hazard rating is moderate on moderately steep slopes, and high on steep slopes. Approximately half of the unit is rated moderate, and half is rated high. These soils are susceptible to sheet, rill, and gully erosion when unprotected by vegetative cover, because of their steep slopes and low cohesive strength. Average surface rock fragment cover ranges from about 25 percent on Typic Cryumbrepts to 40 percent on Typic Cryorthents, with a total range from 0 to 70 percent. These fragments provide some protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion. Landscape stability hazard is moderately low under normal conditions.

These soils are suitable for trails, but are unsuitable for campsites (except for a few scattered level sites) because of slope steepness. Limitations to trail building include rapid water runoff, loose consistence, and moderately steep to steep slopes.

Most of this unit is unsuitable for livestock grazing because of the large proportion of rock outcrop, high erosion hazard, and low forage production, especially on Typic Cryorthents. Recreational pack stock can make incidental use of the unit.

Wildlife habitat, which decreases in quality with increasing elevation, is good to fair. It appears to be better on Typic Cryumbrepts than on Typic Cryorthents. The Typic Cryumbrepts support good summer habitat for deer and other migratory species. Burrowing animals and insects easily can find adequate depth for winter and summer thermal protection, although rock fragments may interfere with digging. Rodents often find suitable habitat in rock rubble.

Watershed rating is moderate to moderately high. It is limited by the unit's small size and, somewhat by slope steepness. The unit is a small, but good supplier of high purity water to lower elevation areas. Snow retention is high, and hydrograph response is moderately rapid.

Fire impacts are moderate in this unit because of adequate fuel production. Concentration of ground and canopy fuels is most variable on Typic Cryorthents, which usually support an open forest canopy. Soil and atmospheric temperatures are low enough to limit fuel production and fire hazard.

These soils are susceptible to potential effects from acidic precipitation, because of their low buffering capacity. The map unit well suited for monitoring the environmental effects of atmospheric pollutants, because of its accessibility and diversity of soils and ecosystems.

142—Entic Xerumbrepts – Dystric Xerorthents – Rock outcrop association, 40 to 85 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Entic: lacking clear subsoil development;

Dystric: base saturation less than 60 percent; generally low fertility, but adequate for acid-loving plants;

Xer: dry in summer, moist in winter;

umbr: dark colored, organic-rich surface horizon having low base saturation;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ept: Inceptisol, a soil order, slightly more developed than Entisols;

ent: Entisol, the soil order; a young, weakly developed soil.

This map unit occurs in the Middle Fork Kings River drainage, in the southwestern portion of the survey area, on steep to extremely steep mountain sides at elevations between 3,000 and 9,600 feet. The soils formed in colluvium derived from granitic and, less commonly, metamorphic rock.

Mean annual precipitation ranges from 30 to 40 inches. Vegetation series include whiteleaf manzanita, mixed conifer-pine, mixed conifer-fir, and Jeffrey pine, with scattered black oak trees.

The association, which comprises 1.70 percent of the survey area, is approximately 45 percent Entic Xerumbrepts, 25 percent Dystric Xerorthents, 20 percent granitic and metamorphic rock outcrop, and 10 percent inclusions. Entic Xerumbrepts tend to occur on the less steep, most stable, densely vegetated, brushy sites, especially on northerly facing aspects. Dystric Xerorthents occur mostly on unstable land surfaces where soil development is retarded by soil creep and shallow landslides. Inclusions are Entic Haploxerolls, mostly in drainage bottoms, and Typic Cryorthents near the upper elevation limit.

The Entic Xerumbrepts are coarse to moderately coarse textured, moderately deep to very deep, and well drained to somewhat excessively drained. They have a surface layer of fresh or slightly decomposed organic material less than one inch thick. In a representative soil, the surface mineral layer is 8 inches of dark gray, coarse sandy loam having single grain arrangement and an admixture of volcanic ash in the upper 4 inches. It is very strongly acid throughout and moderately water repellent in the upper 4 inches. This is underlain by 12 inches of very dark gray, cobbly coarse sandy loam having single grain arrangement and very strongly acid reaction. The substratum, which extends to at least 40 inches depth, is brown, extremely stony coarse sandy loam having single grain arrangement and very strongly acid reaction.

The Dystric Xerorthents are coarse to moderately coarse textured, moderately deep to very deep, and well drained to somewhat excessively drained. They may or may not have a superficial layer of slightly decomposed organic material that typically is less than 3 inches thick. In a representative soil, the surface mineral layer is 10 inches of pale brown, gravelly coarse sandy loam having moderate, very fine granular structure and very strongly acid reaction. It has an admixture of pumice, and is moderately water repellent. The underlying material, to at least 47 inches depth, is very pale brown to light yellowish brown, very gravelly coarse sandy loam to extremely gravelly coarse sandy loam having weak, very fine granular structure or massive arrangement. It is very strongly acid or strongly acid and very slightly water repellent in its upper portion.

The rock outcrop, consisting of bedrock and rubble, is dominated by granodiorite and metamorphic rock.

Hydraulic conductivity is moderately high to high, and overland flow is rapid to very rapid. Plant-available water capacity is very low to low. Effective rooting depth is greater than 36 inches in the unit.

Maximum erosion hazard rating is very high. These soils are extremely susceptible to sheet, rill, and gully erosion because of slope steepness. Landscape stability hazard is high to very high. Mass movement in the form of debris avalanches and debris torrents are common.

These soils mostly are poorly suited for trails; they are unsuitable on extremely steep slopes. They are unsuitable for campsites because of slope steepness and very high erosion hazard.

This unit is unsuitable for livestock grazing because of lack of forage and slope steepness.

Wildlife habitat ranges from good to poor, with fair and poor being dominant. It decreases in quality with increasing elevation and slope steepness. It is limited by low forage production, rock outcrop, and soil instability on very steep and extremely steep slopes.

Watershed rating is moderately low because of slope steepness, rock outcrop, rapid runoff, and low water retention of the soils. Precipitation is moderate. Snow retention is low, especially in the low elevation areas. Hydrograph response is rapid.

Fire impacts are slight in areas of rock outcrop and light fuel accumulation. They are moderately high in areas of brush fields on Entic Xerumbrepts where slopes are long and steep to extremely steep, and erosion hazard is very high.

These soils are susceptible to potential effects from acidic precipitation because of their low buffering capacity.

143—Typic Xerumbrepts - Entic Xerumbrepts - Dystric Xerorthents complex, 5 to 30 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Typic: soils are characteristic of the great group to which they belong (e.g., not unusually moist, shallow, or clayey);

Entic: lacking clear subsoil development;

Dystric: base saturation less than 60 percent; generally low fertility, but adequate for acid-loving plants;

Xer: dry in summer, moist in winter;

umbr: dark colored, organic-rich surface horizon having low base saturation;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ept: Inceptisol, a soil order; somewhat more developed than Entisols;

ent: Entisol, a soil order; a young, weakly developed soil.

This map unit is in a few scattered delineations in the western portion of the survey area on moderately sloping to moderately steep glacial moraines and mountain sides at elevations between 6,300 and 8,500 feet. The soils formed in glacial till, colluvium, and minor amounts of alluvium derived from granitic and mafic volcanic rock.

Mean annual precipitation is approximately 40 inches, most of which falls as snow. Dominant vegetation series are red fir, mixed conifer-fir, and, at highest elevations, lodgepole pine.

The unit, which comprises 0.44 percent of the survey area, is approximately 30 percent Typic Xerumbrepts, 30 percent Entic Xerumbrepts, 25 percent Dystric Xerorthents and 15 percent inclusions of Dystric Xerochrepts associated with the Dystric Xerorthents, and Typic Cryorthents along the high elevation margins.

The Typic Xerumbrepts are coarse to moderately coarse textured, deep to very deep, and well drained to somewhat excessively drained. Typically, they have a surface layer of slightly decomposed organic material less than 2 inches thick. In a representative soil, the surface mineral layer is 6 inches of dark grayish brown, coarse sandy loam having massive arrangement or moderate, fine subangular blocky structure. It is strongly acid and extremely water repellent. The subsoil is 18 inches thick, light olive brown or light yellowish brown, sandy loam or gravelly loamy coarse sand having massive arrangement or moderate, fine granular structure. It is strongly acid and wettable. The substratum, which extends to at least 34 inches, is light olive brown, very cobbly loamy coarse sand having weak fine granular structure. It is strongly acid and wettable.

The Entic Xerumbrepts are coarse to moderately coarse textured, moderately deep to very deep, and well drained to somewhat excessively drained. They have a surface layer of fresh or slightly decomposed organic material less than one inch thick. In a representative soil, the surface mineral layer is 8 inches of dark gray, coarse sandy loam having single grain arrangement and an admixture of volcanic ash in the upper 4 inches. It is very strongly acid throughout and moderately water repellent in the upper 4 inches. This is underlain by 12 inches of very dark gray, cobbly coarse sandy loam having single grain arrangement and very strongly acid reaction. The substratum, which extends to at least 40 inches depth, is brown, extremely stony coarse sandy loam having single grain arrangement and very strongly acid reaction.

The Dystric Xerorthents are coarse to moderately coarse textured, moderately deep to very deep, and well drained to somewhat excessively drained. They may or may not have a surface layer of slightly decomposed organic material that typically is less than 3 inches thick. In a representative soil, the surface mineral layer is 10 inches of pale brown gravelly coarse sandy loam having moderate, very fine granular structure and very strongly acid reaction. It has an admixture of pumice, and is moderately water repellent. The underlying material, to at least 47 inches depth, is very pale brown to light yellowish brown, very gravelly coarse sandy loam to extremely gravelly coarse sandy loam having weak, very fine granular structure or massive arrangement. It is very strongly acid or strongly acid and very slightly water repellent in its upper portion.

Hydraulic conductivity is moderately low in dry, hydrophobic soils, but it increases to moderately high once the soils become wetted. Overland flow, which increases with increasing slope steepness, is from medium to rapid. Plant-available water capacity is low to moderate. Effective rooting depth is greater than 40 inches in the unit.

Maximum erosion hazard rating is low on moderately sloping sites, and moderate on strongly sloping and most moderately steep sites; it is high on the steepest sites. Approximately 25 percent of the unit is rated low, 55 percent is moderate, and 20 percent is high. These soils are susceptible to sheet, rill, and gully erosion when unprotected by vegetative cover, because of their moderately steep slopes and low cohesive strength. Surface rock fragment cover, which averages less than 25 percent, usually is not sufficient to provide adequate protection from rain drop impact on bare surfaces. Landscape stability hazard is low.

This map unit is well suited for trails and suitable for camp areas on the most gently sloping sites. Limitations include rapid water runoff, loose consistence, moderately steep slopes, and dust formation on volcanically-derived soils.

This map unit is suitable, but not highly productive, for commercial livestock grazing, especially in the Middle Fork Kings River drainage, where it has several small stringer meadows and a small amount of livestock forage in forest openings. The area is suitable for incidental use by pack stock.

Wildlife habitat is good. Burrowing animals are active in these soils, although rock fragments may interfere with digging. The soils have adequate depth for winter hibernation and protection from summer heat.

Watershed rating is moderate. It is limited by moderate precipitation and the small size of the unit. On a per unit area basis, the unit probably is more favorable for watershed purposes than most other soils in the survey area, because of slightly higher water retention in the soils, overall greater depth to bedrock, and small amount of rock outcrop. Snow retention is moderate. Hydrograph response is moderately rapid. Snowmelt and rainfall provide high purity water to recharge deeper, lower elevation aquifers.

Fire impacts are moderate in this unit because of adequate fuel production. Fuels are discontinuous throughout most of the unit, and are most concentrated under nearly closed forest canopies. Soil and atmospheric temperatures are low enough to limit fuel production and fire hazard.

Although these soils are susceptible to potential effects from acidic precipitation, they probably are less susceptible than most other soils in the survey area because of their organic matter gives them slightly higher buffering capacity.

144—Entic Haploxerolls – Typic Cryoborolls association, 15 to 45 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Entic: lacking clear subsoil development;

Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, or clayey);

Haplo: simple soils, having no unusually distinctive features in the suborder;

Cryo: very cold, with little warming in summer;

xer: dry in summer, moist in winter;

bor: cold;

oll: Mollisol, an order of soils that have a thick, dark colored, organic-rich, high base status surface horizon.

This map unit is found in small delineations along the southeastern margin of the survey area, in the Owens River watershed. It occurs on moderately steep to steep mountain sides and glacial moraines at elevations between 7,300 and 10,900 feet. The soils formed in mixed granitic colluvium and glacial till dominated by granodiorite and quartz monzonite. Some surface mineral layers, especially in the northern delineations, have an admixture of volcanic ash.

Mean annual precipitation ranges from 8 to 20 inches. Soil temperature regimes are frigid at elevations below about 9,000 feet and cryic at higher elevations. Vegetation series include Jeffrey pine, curl leaf mountain mahogany, single leaf pinon pine, big sagebrush, and perennial grass.

The map unit, which comprises 0.30 percent of the survey area, is approximately 50 percent Entic Haploxerolls, 40 percent Typic Cryoborolls, and 10 percent inclusions. The Entic Haploxerolls occur below about 9,000 feet elevation; whereas the Typic Cryoborolls occur above about 9,000 feet. Inclusions of Typic Xerorthents are at the lower elevations, and Typic Cryorthents are at the higher elevations. Small inclusions of rock outcrop are scattered throughout the unit.

The Entic Haploxerolls are coarse to moderately coarse textured, moderately deep to very deep, and well drained to somewhat excessively drained. Typically, they have a superficial layer of slightly decomposed organic material less than 2 inches thick. The surface mineral soil often is water repellent. In a representative soil, the surface mineral layer is 17 inches of grayish brown or brown, very gravelly sand or extremely gravelly loamy coarse sand having weak, very fine granular structure. It is very strongly acid to moderately acid and moderately water repellent. The underlying material, which extends to at least 35 inches, is light olive brown, very bouldery loamy coarse sand having massive arrangement. It is moderately acid and moderately water repellent.

The Typic Cryoborolls are coarse to moderately coarse textured, very cold, deep to very deep, and well drained to somewhat excessively drained. A layer of partially decomposed organic material less than 1 inch thick may be present. The soils generally are not water repellent. In a representative soil, the surface mineral layer is 9 inches of dark grayish brown, extremely gravelly loamy sand having single grain arrangement. It has neutral reaction and is extremely water repellent. The subsoil, which is 27 inches thick, is brown or pale brown extremely gravelly coarse sandy loam having weak, very fine granular structure, and neutral reaction. It is moderately water repellent in the upper 11 inches and wettable in the lower 16 inches. The underlying material, which is weathered rock extending to at least 44 inches, is pinkish gray, extremely gravelly sandy loam having massive arrangement.

Hydraulic conductivity is moderately high to very high, and overland flow is rapid. Hydraulic conductivity may be decreased by chemically induced hydrophobicity, which dissipates with prolonged soil wetting. Plant-available water capacity is low to perhaps moderate. Effective rooting depth is greater than 36 inches in the unit.

Maximum erosion hazard rating is moderate on moderately steep slopes, and high on steep slopes. Approximately half of the unit is rated moderate, and half is high. These soils are susceptible to sheet and rill erosion when unprotected by vegetative cover because of slope steepness and low cohesive strength. Surface rock fragment cover, which normally is less than 40 percent offers a minor amount of protection from erosion. Landscape stability hazard is moderately low.

These soils are suitable for trails, but are unsuitable for campsites except on nearly level inclusions. Generally, areas such as this along the eastern fringe of the survey area are not highly favored as recreation sites.

This unit is poorly suited for livestock grazing because of its isolation, difficult access, lack of forage, and erosion hazard.

Wildlife habitat, which decreases in quality with increasing elevation, is good to fair. This map unit is more suitable for browsing animals than are most neighboring units because of the presence of browse species and vegetative cover.

Watershed rating is low to moderately low, because of low rainfall, low water retention, rapid runoff, and the small size of the unit.

Although fire can move rapidly through this unit, its impacts generally are slight because of discontinuous fuels. Impacts can approach moderate in localized areas of concentrated fuels.

These soils are susceptible to the effects of acidic precipitation, but compared to soils in neighboring map units, they are expected to be somewhat more strongly buffered because of their higher organic matter content and base saturation.

145—Entic Haploxerolls - Typic Cryoborolls - Rock outcrop association, 50 to 85 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Entic: lacking clear subsoil development;

Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, or clayey);

Haplo: simple soils, having no unusually distinctive features in the suborder;

Cryo: very cold, with little warming in summer;

xer: dry in summer, moist in winter;

bor: cold;

oll: Mollisol, an order of soils that have a thick, dark colored, organic-rich, high base status surface horizon.

This map unit is found in small delineations along the southeastern margin of the survey area, in the Owens River watershed. It occurs on generally southerly-facing, very steep to extremely steep mountain sides and glacial moraines at elevations between 6,800 and 11,200 feet. The soils formed in mixed granitic colluvium and glacial till, and minor amounts of residuum, dominated by hornblende granodiorite and quartz monzonite.

Mean annual precipitation ranges from 10 to 25 inches. Soil temperature regimes are frigid at elevations below about 9,000 feet and cryic at higher elevations. Vegetation series include Jeffrey pine, curl leaf mountain mahogany, single leaf pinon pine, big sagebrush, and, at the highest elevations, limber pine.

The map unit, which comprises 0.72 percent of the survey area, is approximately 40 percent Entic Haploxerolls, 30 percent Typic Cryoborolls, 15 percent rock outcrop, and 15 percent inclusions. The Entic Haploxerolls occur below about 9,000 feet elevation; whereas, the Typic Cryoborolls occur above about 9,000 feet. Inclusions of Typic Xerorthents at the lower elevations, and Typic Cryorthents are at the higher elevations.

The Entic Haploxerolls are coarse to moderately coarse textured, moderately deep to very deep, and well drained to somewhat excessively drained. Typically, they have a superficial layer of slightly decomposed organic material less than 2 inches thick. The surface mineral soil often is water repellent. In a representative soil, the surface mineral layer is 17 inches of grayish brown or brown, very gravelly sand or extremely gravelly loamy coarse sand having weak, very fine granular structure. It is very strongly acid to moderately acid and moderately water repellent. The underlying material, which extends to at least 35 inches, is light olive brown, very bouldery loamy coarse sand having massive arrangement. It is moderately acid and moderately water repellent.

The Typic Cryoborolls are coarse to moderately coarse textured, very cold, deep to very deep, and well drained to somewhat excessively drained. A layer of partially decomposed organic material less than 1 inch thick may be present. The soils generally are not water repellent. In a representative soil, the surface mineral layer is 9 inches of dark grayish brown, extremely gravelly loamy sand having single grain arrangement. It has neutral reaction and is extremely water repellent. The subsoil, which is 27 inches thick, is brown or pale brown extremely gravelly coarse sandy loam having weak, very fine granular structure, and neutral reaction. It is moderately water repellent in the upper 11 inches and wettable in the lower 16 inches. The underlying material, which is weathered rock extending to at least 44 inches, is pinkish gray, extremely gravelly sandy loam having massive arrangement.

The rock outcrop consists primarily of hornblende granodiorite and quartz monzonite. Under soil accumulations, the granodiorite may weather to slightly clay-rich saprolite, whereas the quartz monzonite tends to weather to angular, coarse textured sands and fine gravel, called grus. Small basaltic extrusions and localized low-grade metamorphic rocks are included.

Hydraulic conductivity is moderately high to very high, and overland flow is rapid. Hydraulic conductivity may be decreased by chemically induced hydrophobicity, which dissipates with prolonged soil wetting. Plant-available water capacity is low. Effective rooting depth is greater than 36 inches in the unit.

Maximum erosion hazard rating is very high. These soils are highly susceptible to sheet and rill erosion because of slope steepness and low cohesive strength. Surface rock fragments, which can range up to 75 percent, provide protection from rain drop impact on exposed surfaces, but are only moderately effective at protecting sites from sheet erosion. Many of the soils have a thin covering of slope wash, consisting of clean sand and fine gravel, with mixed organic matter, deposited from up-slope. Sites immediately below rock outcrop are especially susceptible to erosion. Landscape stability hazard generally is moderately high. Many sites are susceptible to failure by shallow debris avalanches.

These soils are poorly suited for trails on very steep sites, and unsuitable on extremely steep sites. They are unsuitable for campsites because of slope steepness and very high erosion hazard.

This unit is unsuitable for livestock grazing because of slope steepness, lack of forage, and very high erosion hazard.

Wildlife habitat, which decreases in quality with increasing elevation and slope steepness, is fair to poor. It is limited by low forage productivity and lack of cover on the dry south-facing slopes. The best habitat is in mountain mahogany and sagebrush ecosystems. Animal burrows do not hold up well because of loose soil consistence, and digging is difficult because of the soils' high rock fragment content.

Watershed rating is low because of low rainfall, slope steepness, rock outcrop, low water retention, and rapid runoff.

Although fire can move rapidly through the lower elevation portions of this unit, and erosion would increase on these very steep slopes, overall fire impacts are slight, because of light, scattered fuels and high elevation.

These soils are susceptible to the potential effects of acidic precipitation because of their low buffering capacity, although the buffering capacity of these Mollisols is expected to be greater than that of neighboring Entisols.

146—Rock outcrop and rubble land.

Rock outcrop and rubble land run along the backbone of the Sierra Nevada, spanning the entire length of the survey area above 8,100 feet elevation. Rock outcrops are best exposed on mountain peaks and glacially scoured mountain sides and canyon walls. Rubble land includes rock glaciers, talus slopes, and unvegetated glacial drift.

Mean annual precipitation ranges from 20 to 70 inches, most of which falls as snow. Vegetation series found on included soils range from upper mixed conifer, to alpine scrub. Lichens and mosses have colonized most moist rock surfaces.

The unit, which comprises 17.80 percent of the survey area, is 85 percent rock outcrop and rubble land, with about 15 percent inclusions of Typic Cryorthents, Lithic Cryorthents, Dystric Cryochrepts, Typic Cryochrepts, Entic Cryumbrepts, and Xeric Vitricryands. Apart from those in Lithic subgroups, most of the included soils are deep to very deep. The shallow (i.e., lithic) soils have formed mainly in narrow fringes, often only a few yards wide, around rock outcrops or in shallow depressions in the rock. The deep and very deep soils occur in deeply incised bedrock joints and fractures. These relationships are illustrated in Figures 5, 7, and 8, in the section "General Nature of the Survey Area."

At low elevations in the unit, the rock is dominated by hornblende and biotite diorite and granodiorite, and at midrange and higher elevations by micaceous quartz monzonite, some of which is porphyritic. These rocks have developed a characteristic pattern of deep, three-dimensional, mutually perpendicular joints and miscellaneous fractures that collect water, pollen, and dust. These fissures normally are filled with soil, and support small, often elongated plant communities (Figure 5). The various granitic rocks show little difference in chemical weathering in this elevational range.

Minor amounts of gneiss and other closely related, foliated metamorphic rocks, which originated as plutonic roof pendants, are scattered through the unit. Lower grade, nonfoliated metamorphic rocks, including hornfels and marble are found along the very steep eastern flank of the mountains above Owens Valley. Volcanic rocks include andesitic and basaltic lava flows, especially concentrated near Volcanic Knob and Devil's Postpile, and pyroclastic rocks, including rhyolitic to dacitic tuff and pumice near Mammoth Mountain. Metavolcanic rocks comprise the Minarets area.

Rates of overland flow are medium to very rapid, depending on the steepness of bedrock surfaces.

Maximum erosion hazard ratings of included soils vary from low to high. Runoff water flowing onto soils below rock outcrop causes sheet and rill erosion, especially on soils which are inadequately protected by vegetative cover. For this reason, ground disturbing activities, including trail construction, should be discouraged immediately below rock outcrops. Landscape stability hazard ranges from low in areas of solid rock to moderately high in areas of loose rubble.

This unit is suitable to unsuitable for trails. Trails across rock outcrop must be located to assure adequate footing for hikers and pack stock, especially for wet weather conditions and in areas of springs and minor surface seeps, which can promote the growth of algae, mosses, and lichens on rock surfaces. Except for a scattered suitable inclusions, the unit is unsuitable for campsites because of rock outcrop.

This unit is unsuitable for livestock grazing because of lack of forage.

Wildlife habitat is poor, except that rodents adapted to high elevation can find summer and winter habitat in rock rubble.

Watershed rating is high, because of the unit's large size. Precipitation ranges from moderately low to high. Rock outcrop areas are significant collectors of high quality water for aquifer recharge at lower elevations. Snow retention generally is high, especially on north-facing aspects and in depressional areas. Springs that provide water throughout the Summer often are found within short distances below rubble and rock outcrops. Rates of water runoff from snowmelt and summer storms are rapid to very rapid, resulting in rapid hydrograph responses in stream channels.

The impact of fire is negligible because of the lack of significant continuous fuel.

Effects of acidic precipitation are negligible in this unit, except in soil inclusions.

147—Rock outcrop – Typic Cryorthents complex, 0 to 45 percent slopes.

The soil's taxonomic name reflects the following characteristics:

Typic: soil is characteristic of the great group to which it belongs (e.g., not unusually moist, shallow, or clayey);

Cry: very cold, with little warming in summer;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ent: Entisol, the soil order; a young, weakly developed soil.

This map unit is found dominantly in the western portion of the survey area, with the largest delineations being in the Kings River and South Fork San Joaquin River drainages. It is similar to map unit 114, except for the reversed domination of Typic Cryorthents over rock outcrop in that unit. Moreover, delineations of this map unit generally are at higher elevation and closer to the Sierran crest, although the total range of elevations is similar in the two map units.

The unit occurs on nearly level to steep mountain sides, glacial moraines, and alluvial bottoms, and in granitic bedrock joints at elevations between 7,100 and 13,100 feet. Soil parent materials include colluvium, glacial till, alluvium, and minor amounts of residuum derived primarily from granitic rock, and occasionally from volcanic or metavolcanic rock.

Mean annual precipitation ranges from 40 to 50 inches, most of which falls as snow. Vegetation series include mixed conifer-fir, Jeffrey pine, red fir, lodgepole pine, whitebark pine, and alpine dwarf scrub.

The complex, which comprises 10.03 percent of the survey area, is 60 percent rock outcrop, 30 percent Typic Cryorthents, and 10 percent inclusions. Although the soils are too intricately interspersed among the rock outcrops to allow them to be separated at the mapping intensity of this survey, they are easily delineated by ground reconnaissance or interpretation from aerial photographs. The inclusions are Dystric Cryochrepts at low elevations west of the Sierran crest, on heavily vegetated, nearly level to gently sloping, concave sites; Lithic Cryorthents in very narrow fringes around rock outcrops and in shallow rock depressions; Entic Cryumbrepts on heavily vegetated, depressional sites mostly overlying basaltic parent material; and Xeric Vitricryands on sites having significant deposits of volcanic ash.

Rock outcrop consists of hard bedrock and rubble, including glacially scoured cirque basins and rock glaciers. The rocks are dominated by hornblende-bearing, biotite diorite and granodiorite at lower elevations, and by biotite quartz monzonite at higher elevations, especially near the crest of the Sierra Nevada. These rocks have developed a characteristic pattern of deep parallel joints that collect water, pollen, and dust. The joints normally are filled with soil that can support a well developed plant community. Below about 8,000 feet elevation, diorite and granodiorite tend to weather more readily than quartz monzonite, because they contain more weatherable minerals such as plagioclase, biotite, and hornblende. Above about 8,000 feet, the granitic rocks vary little in chemical weathering.

The Typic Cryorthents typically are coarse textured, very cold, deep to very deep, and moderately well drained to somewhat excessively drained. A slightly decomposed surface organic layer less than one inch thick can be found under forest canopies, especially on nearly level to strongly sloping sites, where it may attain three inches thickness. The surface mineral layer may contain fine pumice, and usually is water repellent. Plant roots, which dominantly are horizontal, tend to be concentrated near the bottom of this layer. The underlying soil normally has fewer roots and greater rock fragment content, but little or no pumice. Distinctive subsoils are not well developed, even under a closed canopy of mature trees, because of the high proportion of resistant minerals and limited conditions for chemical weathering. Water repellency decreases significantly with increasing soil depth.

In a representative soil, the surface mineral layer is 6 inches of light gray, cobbly sandy loam having an admixture of volcanic ash. It has a massive arrangement that breaks to weak granular structure, and is very strongly acid. The underlying material, which extends to at least 34 inches depth, is light brownish gray to very pale brown, very cobbly sandy loam. It has weak subangular blocky to moderate granular structure, and is very strongly acid.

Hydraulic conductivity of Typic Cryorthents is moderately high; overland flow is medium on wettable, gently sloping sites, and rapid on hydrophobic and moderately steep sites. Plant-available water capacity is very low to low. Effective rooting depth is greater than 40 inches.

Maximum erosion hazard rating is moderate on nearly level to strongly sloping sites (except immediately below rock outcrop, where it is high), and high on moderately steep and steep sites. Approximately 65 percent of the unit is rated low (including rock outcrop), 20 percent is moderate, and 15 percent is high. These soils are susceptible to sheet, rill, and gully erosion when unprotected by vegetative cover, because of their low cohesive strength. Surface rock fragments, which can range up to 70 percent, provide protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion. Erosion hazard is greatest directly below rock outcrops, because of the excessive amount of overland flow water. Recovery from disturbance generally is slow, especially on the moderately steep slopes. Landscape stability hazard is low to moderately low under normal conditions.

These soils generally are well suited for trails and for campsites on nearly level to gently sloping sites. The major limitations, apart from moderately steep slopes, are caused by the soil's loose consistence, which increases erodibility and decreases trafficability, and by water repellency, which increases erodibility. Runoff water often becomes concentrated in trails and is conducted along their length, causing rilling and rutting of the surface. These effects can be minimized by proper construction and spacing of water bars. Trails and campsites constructed in these soils tend to be dusty when dry, but generally are less dusty than soils derived from metavolcanic rock or that contain appreciable amounts of fine volcanic ash.

Although this map unit in general is little used for commercial livestock grazing, parts of it are suitable. Some meadows are grazed by cattle under active grazing allotments. These meadows are recovering from past over-grazing, and today are in fair to good condition. Soil and vegetative recovery of abused meadows normally requires several decades. Most of the grazing allotments have been removed from use by commercial cattle and sheep operations, but still are used extensively by recreational and commercial pack stock. Apart from the meadows, areas of Typic Cryorthents provide secondary forage for pack stock and for cattle in active allotments. The short growing season, low forage productivity, difficult accessibility, and high erodibility limit the grazing use of these areas.

Wildlife habitat, which decreases in quality with increasing elevation, is poor to fair. It is limited by rock outcrop and low forage production, especially at high elevations. Soil conditions are suitable for burrowing animals and insects, although the high proportion of rock fragments increases the difficulty of digging. Rodents adapted to high elevation find habitat in rock rubble.

Watershed rating ranges from moderate to high. The rating is enhanced by the unit's large size, high elevation, and generally gentle slopes, which make this unit an important snow catchment and storage area. It is limited by low ground water storage capacity and rapid runoff, and in some areas moderate precipitation. Hydrograph response is rapid during snowmelt and rainstorms, because of the large amount of rock outcrop and low water retention capacity of the soils.

The impact of fire is slight to negligible because of low, discontinuous fuel production, limited soil development, and high elevation.

Typic Cryorthents are susceptible to potential effects from acidic precipitation, because of low buffering capacity.

148—Rock outcrop – Typic Cryorthents complex, 40 to 85 percent slopes.

The soil's taxonomic name reflects the following characteristics:

Typic: soil is characteristic of the great group to which it belongs (e.g., not unusually moist, shallow, or clayey);

Cry: very cold, with little warming in summer;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ent: Entisol, the soil order; a young, weakly developed soil.

This map unit is located primarily in the northern to central portion of the survey area, near the crest of the Sierra Nevada. It occurs on steep to extremely steep mountain sides and glacial moraines at elevations between 6,100 to 14,000 feet. The rock outcrops are best exposed on glacially scoured mountain sides and in canyons. The soils formed in colluvium and glacial till derived primarily from granitic rock, and occasionally from volcanic or metavolcanic rock.

Mean annual precipitation ranges from 20 to 65 inches, most of which falls as snow. Vegetation series include upper mixed conifer, Jeffrey pine, red fir, lodgepole pine, whitebark pine, and, in the far southeastern portion of the survey area, single leaf pinon pine.

The complex, which comprises 16.47 percent of the survey area, is 70 percent rock outcrop, 25 percent Typic Cryorthents, and 5 percent inclusions. Approximately 10 percent of the unit includes soils on slopes less than 40 percent steepness. The inclusions are Lithic Cryorthents in very narrow fringes around rock outcrops, and Dystric Cryorthents, Typic Cryorthents, and Entic Cryumbrepts in some bedrock joints and pockets. Dystric Cryorthents are west of the Sierran crest, and Typic Cryorthents are east of the crest; Entic Cryumbrepts seem to be most common on basaltic or metavolcanic parent materials. Some included soils have tephritic surfaces; laboratory analyses probably would reveal these to be Andisols.

The rock outcrop consists of hard bedrock and rubble, including talus and rock glaciers. The rock is dominated by hornblende-bearing, biotite diorite and granodiorite at lower elevations, and biotite quartz monzonite at higher elevations, especially near the Sierran crest. These rocks have developed a characteristic pattern of deep, three-dimensional, mutually perpendicular joints and miscellaneous fractures that collect water, pollen, and dust. These fissures normally are filled with soil that may support a well developed plant community. Below about 8,000 feet elevation, diorite and granodiorite tend to weather more readily than quartz monzonite, because they contain more weatherable minerals such as plagioclase, biotite, and hornblende. In addition to the granitic rock, several delineations of basaltic, metamorphic, and metavolcanic rock, including a portion of that in the Ritter Range, are incorporated in the unit.

The Typic Cryorthents typically are coarse textured, very cold, deep to very deep, and moderately well drained to somewhat excessively drained. A slightly decomposed surface organic layer less than one inch thick may be found under forest canopies. The surface mineral layer may contain fine pumice, and usually is water repellent. Plant roots, which dominantly are horizontal, tend to be concentrated near the bottom of this layer. The underlying soil normally has fewer roots and greater rock fragment content, but little or no pumice. Distinctive subsoils are absent because of the high proportion of resistant minerals and limited conditions for chemical weathering, as well as continual disruption by soil creep, especially on very steep and extremely steep slopes. Water repellency decreases significantly with increasing soil depth.

In a representative soil, the surface mineral layer is 6 inches of light gray, cobbly sandy loam having an admixture of volcanic ash. It has a massive arrangement that breaks to weak granular structure, and is very strongly acid. The underlying material, which extends to at least 34 inches depth, is light brownish gray to very pale brown, very cobbly sandy loam. It has weak subangular blocky to moderate granular structure, and is very strongly acid.

Hydraulic conductivity of the soils is moderately high; overland flow is very rapid, especially on hydrophobic soils. Plant-available water capacity is low. Effective rooting depth is greater than 40 inches.

Maximum erosion hazard rating is very high. These soils are extremely susceptible to sheet, rill, and gully erosion because of slope steepness, limited vegetative cover, and low cohesive strength. Surface rock fragments, which can range up to 70 percent, provide protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion. Erosion hazard is greatest directly below rock outcrops, because of the excessive amount of overland flow water. Recovery from disturbance generally is very slow. Landscape stability hazard is high to very high. Soils commonly undergo soil creep, and are highly susceptible to debris avalanches and, in drainage bottoms, debris torrents.

These soils are suitable for trails on steep sites, poorly suited on very steep sites, and unsuitable on extremely steep sites. They are unsuitable for campsites, because of slope steepness, loose soil consistence, hydrophobicity, and generally extreme erosion hazard. Trails must be carefully constructed and maintained, especially with regard to water diversions and switchbacks.

This map unit is unsuitable for livestock grazing, except for occasional over-night or transitory use by recreational pack stock on gently sloping inclusions.

Wildlife habitat, which decreases in quality with increasing elevation and slope steepness, generally is poor. It is limited by rock outcrop, soil creep and landslides, and low forage production, especially at high elevations. Typic Cryorthents on steep slopes are suitable for burrowing animals and insects, although the high proportion of rock fragments increases the difficulty of digging. Rodents adapted to high elevation find habitat in rock rubble.

Watershed rating ranges from low to high. The rating is enhanced by the unit's large size, dominantly high elevation, and, in some parts, high precipitation, which make this unit an important snow catchment and storage area. It is limited by slope steepness, low ground water storage capacity and rapid runoff, and, in some parts, moderately low precipitation. Soil permeability and depth are adequate to collect significant snowmelt and rain water and transfer it to streams or to bedrock fractures and joints that eventually conduct it to lower elevation, higher capacity aquifers. Snow retention is high. Hydrograph response is very rapid during snowmelt and rainstorms, because of rapid transmission rates to stream channels. Snowmelt and rainfall from this unit provide substantial high purity water to recharge reservoirs.

The impact of fire is slight to negligible, because of low, discontinuous fuel production, limited soil development, and large extent of high elevation land. The small areas of adequate fuels on very steep and extremely steep slopes are subject to erosion by dry ravel.

Typic Cryorthents are susceptible to potential effects from acidic precipitation, because of their low buffering capacity.

149—Rock outcrop - Typic Cryorthents - Lithic Cryorthents complex, 0 to 30 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, or clayey);

Lithic: shallow, depth to bedrock less than 20 inches;

Cry: very cold, with little warming in summer;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ent: Entisol, a soil order; a young, weakly developed soil.

This map unit is located in the western portion of the survey area, in the North Fork Kings River and South Fork San Joaquin River drainages. It occurs on nearly level to moderately steep mountain sides, ridges, and glacial moraines at elevations between 7,600 and 11,000 feet. The soils formed in glacial till, colluvium, alluvium, and residuum derived from granitic rock, and occasionally from volcanic or metavolcanic rock.

Mean annual precipitation ranges from 40 to 50 inches, most of which falls as snow. Vegetation series include mixed conifer, red fir, lodgepole pine, whitebark pine, and alpine dwarf scrub.

The complex, which comprises 1.87 percent of the survey area, is approximately 55 percent rock outcrop, 25 percent Typic Cryorthents, 15 percent Lithic Cryorthents, and 5 percent inclusions. Typic Cryorthents occur over most of the land between rock outcrops, in bedrock joints, and in drainage bottoms that frequently are reworked by fluvial activity. Lithic Cryorthents are found along the fringes of rock outcrops and in shallow bedrock depressions. The inclusions are Entic Cryumbrepts under heavy cover of grass or sedge, and in moist depressional sites, especially those supporting deciduous trees and shrubs mixed with conifers; Dystric Cryochrepts scattered through the unit west of the Sierran crest under well developed vegetative communities; and Dystric Xerorthents at low elevations in the unit.

Rock outcrop consists of bedrock and rubble dominated by biotite and hornblende diorite and granodiorite at lower and midrange elevations, and by quartz monzonite at higher elevations. These rocks have developed a characteristic pattern of deep parallel joints that collect water, pollen, and dust. The joints normally are filled with soil (Typic Cryorthents). At elevations below about 8,000 feet, diorite and granodiorite tend to weather more readily than quartz monzonite because they contain more mafic, nutrient-rich, weatherable minerals and less silica. Above 8,000 feet the various granitic rocks show little difference in weathering tendencies.

The Typic Cryorthents are coarse textured, very cold, deep to very deep, and moderately well drained to somewhat excessively drained. They formed in glacial till, colluvium, alluvium, and residuum derived from diorite, granodiorite, and quartz monzonite. A few small areas developed from volcanic or metamorphic rock. The surface mineral layer usually is water repellent, with repellency decreasing with increasing soil depth. The soils may or may not have a surface layer of slightly decomposed organic material that, if present, is less than one inch thick. In a representative soil, the surface mineral layer is 6 inches of light gray, cobbly sandy loam having an admixture of volcanic ash. It has a massive arrangement that breaks to weak granular structure, and is very strongly acid. The underlying material, which extends to at least 34 inches depth, is light brownish gray to very pale brown, very cobbly sandy loam. It has weak subangular blocky to moderate granular structure, and is very strongly acid.

The Lithic Cryorthents are coarse textured, very cold, very shallow to shallow, and well drained to somewhat excessively drained. They occur primarily in shallow bedrock depressions and in fringes around rock outcrops. The surface mineral layer normally is water repellent. Surface organic layers are absent or less than one-half inch thick. In a representative soil, the surface mineral horizon is 6 inches of light brownish gray, gravelly to very gravelly loamy coarse sand having single grain condition or weak granular structure. It is moderately to extremely water repellent and very strongly acid. The underlying material is 3 inches of light brownish gray, very gravelly loamy coarse sand having weak granular structure, slight to moderate water repellency, and very strongly acid reaction. The substratum to 16 inches depth is light gray, very gravelly loamy coarse sand. It is massive, and very strongly acid.

Hydraulic conductivity of the soils is decreased significantly by chemically induced hydrophobicity. Hydraulic conductivity of these coarse textured soils is low if the soils have been dry prior to rainfall; it may increase to moderately high once the soils become wetted. Overland flow, which varies with hydrophobicity, is medium on gently sloping sites and rapid to very rapid on moderately steep sites. Plant-available water capacity is low. Effective rooting depth is greater than 40 inches in Typic Cryorthents and less than 20 inches in Lithic Cryorthents.

Maximum erosion hazard rating is moderate on nearly level to strongly sloping sites (except immediately below rock outcrop, where it is high), and high on moderately steep and steep sites. Approximately 60 percent of the unit is rated low (including rock outcrop), 20 percent is moderate, and 20 percent is high.

These soils are highly susceptible to sheet, rill, and gully erosion when unprotected by vegetative cover, because of their moderately steep slopes, low cohesive strength, and in the case of Lithic Cryorthents shallow depth to bedrock. Surface rock fragment cover is about 40 to 50 percent on Typic Cryorthents and about 30 percent on Lithic Cryorthents. These fragments provide some protection from rain drop impact on bare surfaces, but they also restrict water intake which speeds overland flow, leading to accelerated erosion. This phenomenon is especially notable immediately below rock outcrops and Lithic Cryorthents, which cause unusually high concentrations of runoff water. Landscape stability hazard is low under normal conditions.

These soils are well suited for trails and for campsites on nearly level to gently sloping sites. Limitations include rapid water runoff, loose consistence, and moderately steep slopes.

Except for included meadows, this map unit overall is poorly suited for commercial livestock grazing because of the large proportion of rock outcrop and shallow soils, low forage production, and high susceptibility to sheet and rill erosion during and following disturbance. Areas of Typic Cryorthents may be used incidentally by pack stock and by cattle as they travel through areas in active grazing allotments, although overall these soils are poorly suited. Lithic Cryorthents are unsuitable for grazing.

Wildlife habitat, which decreases in quality with increasing elevation, is poor to good. It is limited by rock outcrop and low forage production, especially at high elevations. Burrowing animals and insects may be active in Typic Cryorthents, and rodents adapted to high elevation find habitat in rock rubble. Abundant rock fragments often interfere with digging, and animal burrows in top soil having loose consistence do not hold up well. Depth of Typic Cryorthents is great enough to provide habitat for winter hibernation and protection from summer heat, but depth of Lithic Cryorthents is not.

Watershed rating is moderately low to moderate. It is limited by the unit's small size, rock outcrop and shallow soils, and low water retention capacity of the deeper soils. It is enhanced by moderately high precipitation, and generally gentle slopes. Snow retention is high. Hydrograph response is rapid during snowmelt and rainstorms because of the large amount of rock outcrop and low water retention capacity of the soils. Snowmelt and rainfall from this unit provide high purity water to recharge lower elevation aquifers.

Fire impacts generally are slight to negligible in this association, although they may be moderate in localized areas of Typic Cryorthents having significant fuel accumulation. Fuels are discontinuous and sparse throughout most of the unit and forest stand canopies generally are open. Fuels are more concentrated under nearly closed canopies; nonetheless, soil and atmospheric temperatures are low enough to limit production and fire hazard.

These soils are susceptible to potential effects from acidic precipitation, because of their low buffering capacity.

150—Rock outcrop - Typic Cryorthents complex, volcanic, 10 to 45 percent slopes.

The soil's taxonomic name reflects the following characteristics:

Typic: soils are characteristic of the great group to which they belong (e.g., not unusually moist, shallow, clayey, or low in bases);

Cry: very cold, with little warming in summer;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ent: Entisol, a soil order, a young, weakly developed soil.

This map unit is located in the upper Middle Fork San Joaquin River drainage in the vicinity of Thousand Island Lake and Garnet Lake, northwest of Devils Postpile National Monument. It occurs on moderately steep to very steep mountain sides, ridges, and glacial moraines at elevations between 8,700 and 11,200 feet. The soils formed in glacial till, colluvium, alluvium, and residuum derived from metavolcanic and volcanic rock. Volcanic ash covers the surface or is mixed into the topsoil on many sites.

Mean annual precipitation is between 35 and 45 inches, as estimated from snow pack at Agnew Pass. The dominant vegetation series is lodgepole pine, followed by mountain whitethorn, red fir, and Jeffrey pine mostly in the lower one-fourth of the elevational range. Individual plants scattered throughout the unit include mountain hemlock, whitebark pine, ribes, and various grasses and sedges.

The complex, which comprises 1.20 percent of the survey area, is approximately 55 percent rock outcrop and rubble land, 40 percent Typic Cryorthents, volcanic, and 5 percent inclusions. The inclusions are Xeric Vitricryands and Typic Cryumbrepts, volcanic, tephritic surface in depressional areas and in deep accumulations between bedrock fractures. Minor inclusions of Lithic Cryorthents are associated with the rock outcrop.

Most of the deepest, best developed soils formed in northwest–southeast trending rock fractures and contact zones. Tree cover often is greater on southwest facing slopes than on northeast facing slopes, a relationship that is reversed from normal in most of the western United States, including the survey area, where plant-available soil moisture is the limiting factor in ecosystem development. This reversed relationship occurs perhaps because of warmer near–ground and soil temperatures and less frost heave and rock rubble on southwest facing slopes than on northeast facing slopes. This unusual ecological relationship deserves further study.

The rock outcrop is bedrock and rubble consisting of varied metavolcanic outcrops generally oriented northwest to southeast, with granodiorite flanking Thousand Island Lake and Garnet Lake to their northwest and southeast. The metavolcanic rock varies in texture from tuffaceous to crystalline and in composition from dacitic to basaltic. These rocks tend to produce somewhat finer textured soil than do the surrounding granitic rocks.

The Typic Cryorthents, volcanic are moderately coarse textured, very cold, deep to very deep, and well drained. They formed in colluvium, glacial till, and, to a minor extent, residuum derived from andesite, basalt, and mafic metavolcanic rocks. Volcanic ash and cinders (tephra) cover the surface and are mixed in the topsoil on many sites, but not throughout the unit. More intensive field and laboratory work may reveal that some of the soils containing tephra have sufficient andic properties to be reclassified as Andisols. If so, they most likely would be classified as Xeric Vitricryands if they have a xeric moisture regime, or Typic Vitricryands if they have a udic moisture regime. The surface mineral horizon often is water repellent. The soils may or may not have a surface layer of slightly decomposed organic material that, if present, is less than two inches thick.

In a representative soil, the surface mineral layer is 11 inches of light brownish gray, sandy loam having an admixture of volcanic ash and fine lapilli. It has fine granular structure, and is very strongly acid. The underlying material, which extends to at least 31 inches depth, is brownish yellow, extremely gravelly fine sandy loam to extremely cobbly fine sandy loam. It has very fine granular structure to massive arrangement, and is very strongly acid.

Hydraulic conductivity of the soils is moderately high to high, although it may be decreased significantly in dry soil by chemically induced hydrophobicity. Most water infiltration in the nonwettable soils is through channels created by insects, soil animals, and plant roots. Overland flow, which varies with hydrophobicity, is medium on gently sloping sites and rapid to very rapid on steep sites. Plant-available water capacity is moderate. Effective rooting depth is greater than 40 inches.

Maximum erosion hazard rating is moderate on strongly sloping sites, and high on moderately steep and steep sites. Approximately half of the unit is rated low (including rock outcrop), 20 percent is moderate, and 30 percent is high. Erosion is particularly notable immediately below rock outcrop. These soils are highly susceptible to sheet, rill, and gully erosion when unprotected by vegetative cover, because of their slope steepness and low cohesive strength caused by cohesionless silt and medium to very fine sand, often with fine to medium pumice. Surface rock fragment cover typically is about 5 to 35 percent. Landscape stability hazard is low to moderately low under normal conditions.

These soils are well suited to suitable for trails, but are poorly suited to unsuitable for campsites. They can suffer considerable damage by heavy use. As with other soils formed from metavolcanic materials or having significant volcanic ash at the surface, these soils become exceptionally dusty when disturbed. Other limitations include rapid water runoff, loose consistence, and slope steepness.

This unit generally is poorly suited for livestock grazing because of low forage production, abundant rock outcrop, and high susceptibility to sheet and rill erosion during and following disturbance.

Wildlife habitat is poor to fair. It is limited by rock outcrop and low forage production. Burrowing animals and insects are active in these soils, and rodents adapted to high elevation find habitat in rock rubble.

Watershed rating is moderately high. It is limited by rock outcrop and the amount of precipitation, which is moderate. It is enhanced by greater porosity in the bedrock and overlying mantle than in adjacent granitic units. The unit collects considerable snowfall that supplies high quality water to lower lying watersheds. Snow retention is high, and hydrograph response is rapid.

Fire impacts are slight to negligible in this unit of high elevation, cold, and infertile soils. Fuel continuity is disrupted by rock outcrop and areas of low production.

These soils are susceptible to potential effects from acidic precipitation, because of their low buffering capacity. Soils formed on metavolcanic parent materials may respond to atmospheric inputs differently from granitically derived soils; this point merits further investigation.

151—Rock outcrop - Typic Cryorthents - Lithic Cryorthents association, volcanic, 0 to 30 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, clayey, or low in bases);

Lithic: less than 20 inches deep to a lithic contact, such as bedrock surface;

Cry: very cold, with little warming in summer;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ent: Entisol, a soil order; a young, weakly developed soil.

This map unit is located in the North Fork San Joaquin River drainage above Hemlock Crossing in areas of metavolcanic rock of the Ritter Range. Generally, its boundaries run roughly parallel to water courses. The unit is characterized by exposed rock surfaces, glacially scoured drainages with several small hanging valleys, and irregular pockets of soil covered by trees and sedges. It occurs on nearly level to moderately steep alluvial bottoms, mountain sides, and glacial moraines at elevations between 8,000 and 11,100 feet. The soils formed in depressions of colluvium, glacial till, and alluvium, and on strongly sloping to moderately steep colluvial mountain sides in material derived from metavolcanic rock. Whitish volcanic ash is mixed into the topsoil on many sites.

Mean annual precipitation, as extrapolated from measured snow pack at Cora Lakes, is approximately 50 inches, most of which falls as snow. The dominant vegetation series is lodgepole pine, followed by red fir and mountain whitethorn.

The association, which comprises 0.72 percent of the survey area, is approximately 50 percent rock outcrop and rubble land, 25 percent Typic Cryorthents, volcanic, 15 percent Lithic Cryorthents, and 10 percent inclusions. Typic Cryorthents, volcanic occur in glacial, colluvial, and alluvial deposits; whereas, Lithic Cryorthents occur primarily in shallow bedrock depressions and in fringes around rock outcrops. Inclusions of Dystric Cryochrepts occur in some gently sloping depressional areas and bedrock fractures, and Vitricryands have formed in tephra deposits.

The rock outcrop consists of bedrock and rubble of metavolcanic tuff breccias, mainly of dacitic to andesitic composition. Colluvial, glacial, and alluvial deposits contain fragments of intermediate to mafic granitic rocks mixed with metavolcanics.

The Typic Cryorthents, volcanic are moderately coarse textured, very cold, deep to very deep, and well drained. They formed in colluvium, glacial till, and, to a minor extent, alluvium and residuum derived from metavolcanic tuff breccia with some admixed diorite or gabbro. Volcanic ash and cinders (tephra) cover the surface and are mixed in the topsoil on many sites, but not throughout the unit. These pockets of volcanic ash tend to support the greatest root concentrations. More intensive field and laboratory work may reveal that some of the soils containing tephra have sufficient andic properties to be reclassified as Andisols. If so, they most likely would be classified as Xeric Vitricryands if they have a xeric moisture regime, or Typic Vitricryands if they have a udic moisture regime. The surface mineral horizon often is water repellent, especially if tephra is present. The soils may or may not have a surface layer of slightly decomposed organic material that, if present, is less than about one inch thick. Soils at the base of mountain sides often are covered by a thin veneer of slope wash having the texture of very gravelly coarse sandy loam.

In a representative soil, the surface mineral layer is 11 inches of light brownish gray, sandy loam having an admixture of volcanic ash and fine lapilli. It has fine granular structure, and is very strongly acid. The underlying material, which extends to at least 31 inches depth, is brownish yellow, extremely gravelly fine sandy loam to extremely cobbly fine sandy loam. It has very fine granular structure to massive arrangement, and is very strongly acid.

The Lithic Cryorthents are coarse textured, very cold, very shallow to shallow, and well drained to somewhat excessively drained. Surface organic layers are absent or less than one-half inch thick. The surface mineral layer consists of metavolcanic detritus, and often is water repellent. In a representative soil, the surface mineral horizon is 6 inches of light brownish gray, gravelly to very gravelly loamy coarse sand having single grain arrangement or weak granular structure. It is moderately to extremely water repellent and very strongly acid. The underlying material is 3 inches of light brownish gray, very gravelly loamy coarse sand having weak granular structure, slight to moderate water repellency, and very strongly acid reaction. The substratum to 16 inches depth is light gray, very gravelly loamy coarse sand. It is massive, and very strongly acid.

Dystric Cryorthent inclusions are found in depressions under red fir and lodgepole pine at low elevations in the unit. They commonly are deep, have a two to four inch thick O horizon, and loamy textures, with pockets and lenses of whitish volcanic ash mixed in the A horizon. Plant roots are more concentrated in the ash and organic layer than in other parts of the soil.

Hydraulic conductivity of the soils is moderately high to high, although it may be decreased significantly by chemically induced hydrophobicity. Hydrophobicity has little effect once the soils become saturated. Overland flow, which varies with hydrophobicity, is slow on nearly level sites, medium on gently sloping sites, and rapid to very rapid on steep sites. Plant-available water capacity is moderate. Effective rooting depth is greater than 40 inches in Typic Cryorthents, and less than 20 inches in Lithic Cryorthents.

Maximum erosion hazard rating is moderate on nearly level to strongly sloping sites (except immediately below rock outcrop, where it is high), and high on moderately steep and steep sites. Approximately 60 percent of the unit is rated low (including rock outcrop), 20 percent is moderate, and 20 percent is high.

The soils are moderately susceptible to sheet and rill erosion on gentle slopes in protected depressions, and highly susceptible on steeper unprotected slopes. High overland flow from snowmelt and rain water across expansive rock outcrops can result in severe surface erosion. Surface rock fragment cover typically is about 2 to 20 percent. Landscape stability hazard is low under normal conditions.

Soils in this unit are well suited for trails and for campsites on nearly level to gently sloping sites They can become very dusty when disturbed.

This unit generally is unsuitable for livestock grazing, except for limited pack stock use in meadows, because of abundant rock outcrop, low forage production, and high susceptibility to sheet and rill erosion during and following disturbance.

Wildlife habitat, which decreases with increasing elevation, is poor to fair. It is limited by rock outcrop, low forage production, and lack of cover. Burrowing animals and insects find habitat in Typic Cryorthents, volcanic and rodents adapted to high elevation live in rock rubble.

Watershed rating is moderate. Precipitation is high. The rating is limited by the unit's small size and amount of rock outcrop. Snow retention is high. Hydrograph response is rapid.

Fire impacts are slight to negligible, because of low fuel availability and continuity.

These soils are susceptible to potential effects from acidic precipitation, because of their low buffering capacity.

152—Rock outcrop - Typic Cryorthents - Typic Cryoborolls complex, volcanic, 25 to 50 percent slopes.

The soils' taxonomic names reflect the following characteristics:

- Typic: soils are characteristic of the great groups to which they belong (e.g., not unusually moist, shallow, clayey, or low in bases);
- Cry: very cold, with little warming in summer;
- orth: common form of the soil order (e.g., not unusually wet or sandy);
- Bor: cold to very cold;
- ent: Entisol, a soil order; a young, weakly developed soil;
- oll: Mollisol, a soil order; soil has thick, dark colored, organic-rich, high base status surface horizon.

This map unit is located in upper Middle Fork San Joaquin River drainage near San Joaquin Mountain. It occurs on moderately steep to steep, glacially scoured mountain sides underlain by volcanic, metavolcanic, and metamorphic rock at elevations between 8,900 and 11,600 feet. The soils formed dominantly in colluvium and glacial till derived from these rock types.

Mean annual precipitation, most of which falls as snow, is approximately 40 to 50 inches, as estimated from snow pack at Agnew Pass and Mammoth Pass. Vegetation series include red fir and Jeffrey pine at lower elevations, followed by sagebrush, lodgepole pine, whitebark pine, and alpine dwarf scrub at higher elevations.

The complex, which comprises 0.45 percent of the survey area, is approximately 40 percent rock outcrop and rubble land, 35 percent Typic Cryorthents, volcanic, 20 percent Typic Cryoborolls, and 5 percent inclusions. The deepest, best developed soils formed in narrow northwest–southeast trending rock fractures and benches, and in ancient avalanche tracks. Tree cover is greatest on old avalanche tracks. At the base of mountain sides, the ground surface often is covered by a thin layer of slope wash having a texture of very gravelly coarse sandy loam. The inclusions are Typic Cryochrepts associated with Typic Cryoborolls. Approximately 10 percent of the unit consists of gently to strongly sloping surfaces on northwest to southeast trending benches on the mountain side .

The rock outcrop is bedrock and rubble consisting of volcanic, metamorphic, and metavolcanic outcrops generally oriented northwest to southeast. The volcanic rock, located along the lower elevation portion of the unit to the northwest, is dominated by andesite, much of which is vesicular, with smaller outcrops of quartz latite nearer the ridge top in the southeastern portion of the unit. The metamorphic rock, found at low elevation in the southeastern portion of the unit, consists primarily of hornfels. The metavolcanics consist of metamorphosed tuffs and tuff breccias at the lower elevation margin of the unit. Talus is the most common form of rubble. Apart from scattered outcrops, much of the upper elevation portion of the unit is unconsolidated rock debris of various types with weak soil development.

The Typic Cryorthents, volcanic are moderately coarse textured, very cold, deep to very deep, and well drained. They formed in colluvium and glacial till derived from vesicular andesite, hornfels, quartz latite, and metavolcanic rocks. Volcanic ash and cinders (tephra) cover the surface and are mixed in the topsoil on many sites, but not throughout the unit. Additional investigation could reveal that some of these soils could be reclassified as Andisols. The soils under tree cover usually have only a very thin (about 1/2 inch or less) surface layer of slightly decomposed organic material. Water repellency may be present, but is less common than in most other soils in the survey area.

In a representative soil, the surface mineral layer is 11 inches of light brownish gray, sandy loam having an admixture of volcanic ash and fine lapilli. It has fine granular structure, and is very strongly acid. The underlying material, which extends to at least 31 inches depth, is brownish yellow, extremely gravelly fine sandy loam to extremely cobbly fine sandy loam. It has very fine granular structure to massive arrangement, and is very strongly acid.

The Typic Cryoborolls are coarse to moderately coarse textured, very cold, deep to very deep, and well drained to somewhat excessively drained. They formed in colluvium and small localized glacial deposits on benches and the most gently sloping mountain sides in the unit. These areas often support inclusions of small meadows fringed with whitebark pine. Rodent activity usually has mixed the soil and formed numerous krotovinas. Volcanic ash often is mixed in the topsoil and in the krotovinas. A layer of partially decomposed organic material less than 1 inch thick may be present, especially under tree cover. The soils generally are not water repellent.

In a representative soil, the surface mineral layer is 9 inches of dark grayish brown, extremely gravelly loamy sand having single grain arrangement. It has neutral reaction and is extremely water repellent. The subsoil, which is 27 inches thick, is brown or pale brown extremely gravelly coarse sandy loam having weak, very fine granular structure, and neutral reaction. It is moderately water repellent in the upper 11 inches and wettable in the lower 16 inches. The underlying material, which is weathered rock extending to at least 44 inches, is pinkish gray, extremely gravelly sandy loam having massive arrangement.

Hydraulic conductivity of the soil is moderately high to high. Overland flow is medium on moderately steep slopes and gently sloping inclusions, and rapid to very rapid on steep slopes. Plant-available water capacity is moderate. Effective rooting depth is greater than 40 inches.

Maximum erosion hazard rating is high on moderately steep and steep slopes to about 40 percent steepness (except immediately below rock outcrop, where it approaches very high), and very high on slopes steeper than 40 percent. Approximately 40 percent of the unit is rated low (including rock outcrop), 30 percent is high, and 30 percent is very high. The Typic Cryorthents, volcanic being on steeper slopes and supporting less vegetative cover, are much more susceptible to sheet and rill erosion than are the Typic Cryoborolls. Cover by surface rock fragments may be as high as 70 percent. Landscape stability hazard is moderately low to moderately high. Soils on the steepest slopes are highly susceptible to failure by shallow debris avalanches.

These soils are suitable for trails, but are unsuitable for campsites except for occasional use on included benches. Camps with pack stock should be discouraged because of steep slopes and limited forage. Meadows are small and easily damaged by trampling. These soils can become exceptionally dusty when disturbed.

This unit is unsuitable for livestock grazing because of low forage production, abundant rock outcrop, and high susceptibility to sheet and rill erosion during and following disturbance.

Wildlife habitat, which decreases with increasing elevation, is poor to fair. It is limited by rock outcrop, low forage production, and lack of connected cover. Burrowing animals and insects are active in these soils, especially on the small benches, and rodents adapted to high elevation find habitat in rock rubble.

Watershed rating moderately low, because of the unit's small size, slope steepness, large amount of rock outcrop, and generally southwest facing aspect, which promotes moderately rapid snow melt and evaporation. Hydrograph response is rapid.

Fire impacts are slight to negligible in this unit of high elevation, cold, and infertile soils. Fuels are light and scattered.

These soils are susceptible to potential effects from acidic precipitation, because of their low buffering capacity. Soils formed on volcanic and metavolanic parent materials may respond to atmospheric inputs differently from granitically derived soils elsewhere in the survey area; this point merits further investigation.

153—Rock outcrop - Dystric Xerorthents complex, 30 to 75 percent slopes.

The soil's taxonomic name reflects the following characteristics:

Dystric: base saturation less than 60 percent; generally low fertility, but adequate for acid-loving plants;

Xer: dry in summer, moist in winter;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ent: Entisol, a soil order; a young, weakly developed soil.

This map unit occurs along the Middle Fork San Joaquin River on steep to very steep mountain sides and ridges, and in related strongly sloping drainage bottoms at elevations between 4,000 and 6,900 feet. The soils formed primarily in colluvium and glacial till, and in detritus accumulated in bedrock fractures, and secondarily in residuum derived from granodiorite and quartz monzonite. The deepest soils formed in bedrock joints and fractures.

Mean annual precipitation is 35 to 40 inches, most of which falls as snow. Vegetation series is mixed conifer-pine with mixed conifer-fir at higher elevations. Dominant tree species include ponderosa pine, Jeffrey pine, incense cedar, sugar pine, and occasional interior live oak and black oak. Forest crown cover tends to be sparse, generally averaging 20 to 30 percent, except on Dystric Xerochrepts and inclusions of Typic Xerumbrepts, where it may exceed 50 percent.

The map unit, which comprises 1.23 percent of the survey area, is approximately 40 percent rock outcrop and rubble, 35 percent Dystric Xerorthents, and 25 percent inclusions of Dystric Xerochrepts, Typic Xerumbrepts, and Lithic Xerorthents. These soils can occur on any land forms and slope positions (except on rock outcrop and rubble) in the map unit; nonetheless, Dystric Xerorthents are found most commonly on the steepest, least stable sites; Dystric Xerochrepts and Typic Xerumbrepts are most common in bedrock fractures and depressions, especially on north-facing aspects; and Lithic Xerorthents are immediately adjacent to rock outcrops and in shallow bedrock depressions.

The rock outcrop is almost entirely biotite and hornblende granodiorite that is characterized by smooth surfaces, numerous fractures, and small, shallow depressions on minor benches. The fractures and depressions normally are filled with soil that collect water, pollen, and dust, and that can support trees. Rock outcrop can be delineated from the soils by air photo interpretation or ground reconnaissance. Debris avalanches and talus slopes are common in the unit.

The Dystric Xerorthents are moderately coarse to coarse textured, moderately deep to very deep, and well drained to somewhat excessively drained. Being dominantly in the frigid temperature regime, they are cold in winter, but warm significantly more in summer than do their higher elevation counter parts Typic Cryorthents. They often have a surface layer of slightly decomposed organic material less than 3 inches thick. In a representative soil, the surface mineral layer is 10 inches of pale brown gravelly coarse sandy loam having moderate, very fine granular structure and very strongly acid reaction. It has an admixture of pumice, and is moderately water repellent. The underlying material, to at least 47 inches depth, is very pale brown to light yellowish brown, very gravelly coarse sandy loam to extremely gravelly coarse sandy loam having weak, very fine granular structure or massive arrangement. It is very strongly acid or strongly acid and very slightly water repellent in its upper portion.

Hydraulic conductivity of the soil is moderately high to high, and overland flow is rapid to very rapid. Plant-available water capacity is very low to low. Effective rooting depth is greater than 36 inches.

Maximum erosion hazard rating is very high. These soils are highly susceptible to sheet and rill erosion because of slope steepness, low cohesive strength, and abundance of rock outcrop. Erosion is most severe on sites immediately below rock outcrops and Lithic Xerorthents, where overland flow is greatest. Landscape stability hazard varies from moderately low to very high, with debris avalanches and debris torrents being common on the steepest slopes.

This map unit is suitable to poorly suited for trails, and unsuitable for campsites, because of slope steepness, high erosion hazard on disturbed sites, and abundance of steep, slippery rock outcrop. Nonetheless, a few suitable campsites can be found just above the Middle Fork San Joaquin River and on nearly level to gently sloping inclusions in the unit.

This unit is unsuitable for commercial livestock grazing because of rock outcrop, low forage production and slope steepness.

Wildlife habitat is poor to fair. It is limited by rock outcrop and associated Lithic Xerorthents, which offer little cover and forage. Generally, habitat is most favorable along the river and along bedrock fractures and forested depressions. Dystric Xerorthents are deep enough for burrowing animals, although rock fragments often can interfere with digging.

Watershed rating is moderately low, because of the amount of rock outcrop, slope steepness, rapid to very rapid runoff, and low subsurface water retention. The unit's major watershed function is to collect high purity snow and rain and transmit the water to storage reservoirs lower in the watershed. Precipitation is moderate, snow retention is moderately low, and hydrograph response is rapid.

Fire impacts are slight to negligible in this area of light, scattered fuels. Small, localized sites on very steep slopes having adequate fuel for intense fire are subject to erosion by dry ravel.

These soils are susceptible to potential effects from acidic precipitation because of their low buffering capacity.

154—Rock outcrop – Dystric Xerorthents – Dystric Xerochrepts complex, 15 to 50 percent slopes.

The soils' taxonomic names reflect the following characteristics:

Dystric: base saturation less than 60 percent;

Xer: dry in summer, moist in winter;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ochr: light colored, organic-poor, or thin surface horizon;

ent: Entisol, a soil order; a young, weakly developed soil;

ept: Inceptisol, a soil order; somewhat more developed than Entisols.

This map unit is found in the Middle Fork and North Fork San Joaquin River drainages and in North Fork Kings River drainage, near Wishon and Courtright Reservoirs. It occurs on moderately steep to steep ridges and mountain sides, and in related strongly sloping drainage bottoms and glacially scoured troughs at elevations that mostly are between 4,000 and 7,800 feet, but that range to 9,300 feet in areas of rock outcrop in North Fork Kings River. The soils formed primarily in colluvium and glacial till, and in detritus accumulated in bedrock fractures, and secondarily in residuum derived from granodiorite and quartz monzonite.

Mean annual precipitation ranges from 30 to 40 inches, most of which falls as snow. Vegetation series is mixed conifer-pine and mixed conifer-fir, with minor areas of red fir. Dominant tree species include Jeffrey pine, incense cedar, red fir, lodgepole pine, and occasional interior live oak and black oak at low elevations. Forest crown cover tends to be sparse (generally averaging 20 to 30 percent) except on Dystric Xerochrepts, where it may be higher.

The map unit, which comprises 0.84 percent of the survey area, is approximately 40 percent rock outcrop, 35 percent Dystric Xerorthents, 20 percent Dystric Xerochrepts, and 5 percent inclusions. Dystric Xerorthents can occur on any land form and slope position in the map unit (except on rock outcrop and rubble); whereas, Dystric Xerochrepts tend to be limited to material accumulated in bedrock fractures and depressions, and on the most gentle slope positions, especially near water courses. Moreover, the Dystric Xerochrepts support denser vegetation and tree cover than the Dystric Xerorthents. The unit contains inclusions of Lithic Xerorthents immediately adjacent to rock outcrops; Xeric Torriorthents along low elevation extremes and on southerly facing slopes in the southern-most delineations, near Wishon and Courtright Reservoirs; and Typic Cryorthents along the high elevation extremes.

The rock outcrop is almost entirely biotite and hornblende granodiorite that is characterized by smooth surfaces, numerous fractures, and small, shallow depressions on minor benches. The fractures and depressions normally are filled with soil that collect water, pollen, and dust, and that can support trees. Rock outcrop can be delineated from the soils by air photo interpretation or ground reconnaissance.

The Dystric Xerorthents are coarse to moderately coarse textured, moderately deep to very deep, and well drained to somewhat excessively drained. Being dominantly in the frigid temperature regime, they are cold in winter, but warm significantly more in summer than do their higher elevation counter parts Typic Cryorthents. They often have a surface layer of slightly decomposed organic material less than 3 inches thick. In a representative soil, the surface mineral layer is 10 inches of pale brown gravelly coarse sandy loam having moderate, very fine granular structure and very strongly acid reaction. It has an admixture of pumice, and is moderately water repellent. The underlying material, to at least 47 inches depth, is very pale brown to light yellowish brown, very gravelly coarse sandy loam to extremely gravelly coarse sandy loam having weak, very fine granular structure or massive arrangement. It is very strongly acid or strongly acid and very slightly water repellent in its upper portion.

The Dystric Xerochrepts are coarse to medium textured, deep to very deep, and well drained to somewhat excessively drained. They commonly have a surface layer of slightly decomposed organic material less than three inches thick. The surface mineral horizon may be water repellent and may contain an admixture of volcanic ash, which imparts a somewhat smeary feel when moist. In a representative soil, the surface mineral layer is 4 inches of dark grayish brown gravelly sandy loam having moderate, very fine granular structure and moderately acid reaction. The subsoil, which is 18 inches thick, is light yellowish brown, very cobbly coarse sandy loam having weak, very fine subangular blocky structure and strongly acid reaction. The substratum, to a depth of at least 35 inches, is light yellowish brown, very cobbly coarse sandy loam having weak, very fine granular structure and strongly acid reaction.

Hydraulic conductivity of the soil is moderately high to high, and overland flow generally is rapid. Plant-available water capacity is low, but may be slightly higher on Dystric Xerochrepts than on Dystric Xerorthents. Effective rooting depth is greater than 36 inches.

Maximum erosion hazard rating is high on moderately steep slopes (except immediately below rock outcrop, where it is very high), and very high on steep slopes. Approximately 45 percent of the unit is rated low (including rock outcrop), 25 percent is moderate, and 30 percent is high. These soils are highly susceptible to sheet and rill erosion on unprotected surfaces because of slope steepness and low cohesive strength. Generally, the Dystric Xerorthents appear to suffer more erosion than do the Dystric Xerochrepts. Erosion is most severe on sites immediately below rock outcrops and Lithic Xerorthents. Landscape stability hazard varies from low to moderately high. Although mass movement is not common, debris avalanches and debris torrents can occur on the steepest slopes.

These soils are suitable for trails, but normally are unsuitable for campsites, because of slope steepness and high erosion hazard on disturbed sites. Nonetheless, excellent campsites can be found on nearly level to gently sloping inclusions in many parts of the unit.

This unit is poorly suited for commercial livestock grazing because of rock outcrop, low forage production and slope steepness. Adequate forage for incidental use by recreational pack stock can be found in some alluvial bottoms and glacial troughs, as well as a few small meadows.

Wildlife habitat is poor to fair. It is limited by rock outcrop and associated Lithic Xerorthent inclusions, which offer little cover and forage. Generally, habitat is most favorable on the more productive northerly and easterly facing Dystric Xerochrepts than on the less productive southerly and westerly facing Dystric Xerorthents. Burrowing animals and insects are active in the two major soils, although rock fragments often can interfere with digging. Burrows probably are more stable in Dystric Xerochrepts than in Dystric Xerorthents.

Watershed rating is low because of the amount of rock outcrop, slope steepness, rapid runoff, low water retention, and small size of the unit. Precipitation is moderate The unit's major watershed function is to collect high purity snow and rain and transmit the water to storage reservoirs lower in the watershed.

Fire impacts are slight to negligible in this area of light, scattered fuels.

These soils are susceptible to potential effects from acidic precipitation because of their low buffering capacity.

155—Rock outcrop - Typic Torriorthents complex, 25 to 55 percent slopes.

The soil's taxonomic name reflects the following characteristics:

Typic: soils are characteristic of the great group to which they belong (e.g., not unusually moist, shallow, or clayey);

Torri: arid to semiarid and commonly hot in summer;

orth: common form of the soil order (e.g., not unusually wet or sandy);

ent: Entisol, the soil order; a young, weakly developed soil.

This map unit is found east of the Sierran crest in the southern portion of the survey area above Owens Lake. It occurs on moderately steep to very steep mountain sides ranging in elevation from 4,000 to 7,200 feet. The soils formed in colluvium and, to a minor extent, alluvium derived mostly from mixed deposits of quartz monzonite and porphyritic granite. Soil development is limited by the warm, dry climatic conditions, and by moderate soil creep, which disrupts horizon differentiation.

Mean annual precipitation is between 10 and 16 inches, most of which falls as rain. Vegetation series is desert shrub.

The complex, which comprises 0.09 percent of the survey area, is approximately 45 percent rock outcrop, 45 percent Typic Torriorthents, and 10 percent inclusions. The rock outcrop protrudes irregularly throughout the unit. Inclusions are Xeric Torriorthents near the upper elevational extent of the unit, and areas of gently sloping Typic Torriorthents in alluvial bottoms.

The rock outcrop consists primarily of rubble and precenozoic granitic rock dominated by quartz monzonite and porphyritic granite, with lesser amounts of hornblende-bearing, biotite granodiorite. The rock weathers to angular, coarse textured sands and fine gravel, called grus. Basaltic extrusions and localized low-grade noncalcareous metamorphic rocks are included.

The Typic Torriorthents are coarse to moderately coarse textured, warm, dry, moderately deep to very deep, and somewhat excessively drained to excessively drained. The soils usually do not have a surface organic layer, but the surface is covered by 40 to 75 percent spheroidal gravel. These soils normally are wettable, although surface horizons may show very slight water repellency. In a representative soil, the surface mineral layer is 26 inches of brown to dark yellowish brown extremely gravelly coarse sand or very gravelly coarse sand having a single grain arrangement. It is strongly to moderately acid and very slightly water repellent. The underlying material, to a depth of at least 36 inches, is yellowish brown extremely gravelly coarse sand having massive arrangement. It is moderately acid and wettable.

Hydraulic conductivity of the soil is very high, and overland flow can be medium to rapid because of slope steepness. Plant-available water capacity is very low. Effective rooting depth is greater than 40 inches.

Maximum erosion hazard rating is high on moderately steep slopes (except below rock outcrop, where it is very high), and very high on steep and very steep slopes. Surface soils are highly susceptible to sheet and rill erosion, because of slope steepness, lack of vegetative protection, and lack of cohesive strength. Wildlife activity can cause significant topsoil movement. Landscape stability hazard is moderately low to moderately high under normal conditions.

These soils are poorly suited for trails, and are unsuitable for campsites, because of the slope steepness, lack of cohesive strength, high erosion hazard, and low trafficability.

The soils are unsuitable for livestock grazing, because of low forage productivity, low trafficability, and high erosion hazard.

Wildlife habitat is poor, although it is suitable for burrowing animals and reptiles adapted to desert conditions. The habitat is limited by low forage production and lack of cover.

Watershed rating is low, because of low precipitation, rock outcrop, slope steepness, and small size of the map unit. Hydrograph response is rapid during rainstorms and snow melt from higher elevation lands.

Fire impacts are negligible, because of low fuel production and limited soil development.

Soils in this unit probably are little affected by acidic precipitation because of low rainfall.