environmental assessment draft
development concept

SEQUOIA - KINGS CANYON
GIANT FOREST-LODGE POLE COMPLEX

NATIONAL PARKS / CALIFORNIA

DRAFT

ENVIRONMENTAL ASSESSMENT

DEVELOPMENT CONCEPT PLAN

GIANT FOREST-LODGEPOLE COMPLEX
SEQUOIA-KINGS CANYON NATIONAL PARK

DENVER SERVICE CENTER
NATIONAL PARK SERVICE

DEPARTMENT OF THE INTERIOR

May 23, 1974

SUMMARY

(X) Draft ( ) Final Environmental Assessment

Denver Service Center, National Park Service

1. Type of action: (X) Administrative ( ) Legislative

2. Brief description of action: Development Concept Plan for for the Giant Forest-Lodgepole Complex involving about 15,000 acres in Sequoia-Kings Canyon National Park, California, to guide new development and relocation of existing development, based on general and implied mandates and National Park Service administrative policies.

3. Summary of environmental impact and adverse environmental effects:
   a. Adverse effects to wildlife habitat and vegetation by the development of a tram interpretive access way to a little used natural area.
   b. Inconvenience to some of the public because of not being allowed to tour and park in the sequoias with their private autos.
   c. Improved visitor orientation and interpretation program through guided tours via a new tram route.
   d. Better dispersal of visitor use and less disturbance of the natural scene by controlled interpretation and removal of visitor facilities from the prime resource sequoias.
   e. Improved traffic flow and reduced air pollution in the sequoia stands.

4. Alternatives considered:
   a. One-way self interpreting auto loop road.
   b. One-way bypass road at Camp Kaweah.
   c. No change.
   d. Campground alternatives.
   e. Utility alternatives.

5. Comments have been requested from the following: During the drafting stage, the authors consulted at length with many staff members of Sequoia and Kings Canyon National Parks and the DSC. The 1971 Master Plan was reviewed and the concessionaire was consulted along with federal and state agencies such as the U.S. Forest Service, California Division of Forestry, University of California and numerous authors for their technical expertise. Contacts and author research are noted in the Bibliography.

6. Data made available to the CEQ and the public:

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I. DESCRIPTION OF THE PROPOSAL

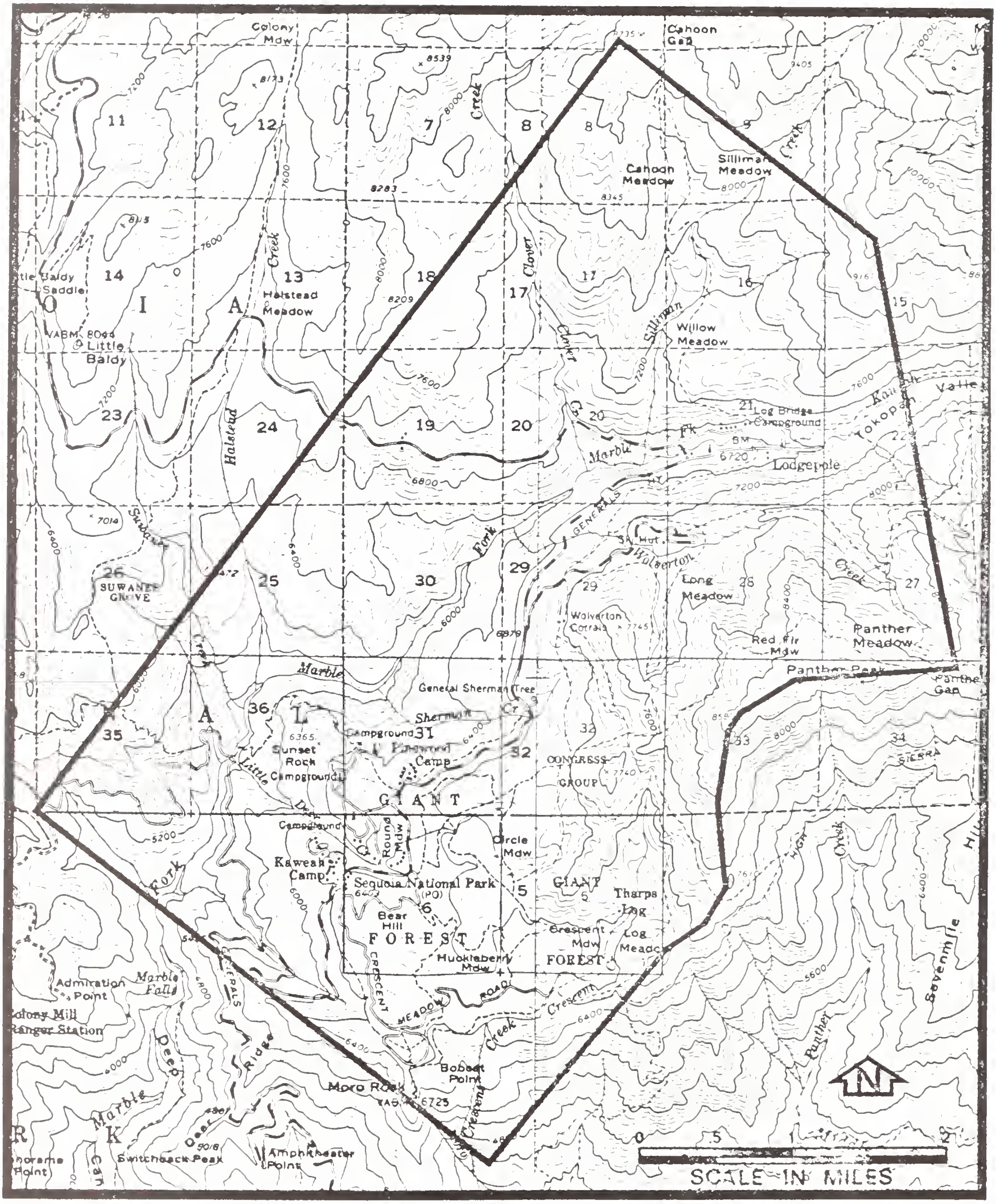
Introduction

Sequoia National Park was established by an Act of Congress on September 25, 1890, and was dedicated and set apart as a public park, or pleasuring ground, for the benefit and enjoyment of the people and "for the preservation from injury of all timber, mineral deposits, natural curiosities or wonders" and their retention in their natural conditions [U.S. Department of the Interior, 1971a].

Sequoia National Park, together with the adjacent Kings Canyon National Park, contains the most notable and extensive giant sequoia groves in the world. The mountainous terrain and exposed granitic faces bear testimony to the majestic forces of alpine glaciation of recent geologic history. The ecologically complex interrelationships between climate, hydrology, geology, soils, and vegetation in the park present an opportunity for the study and observation of a number of interesting and unique ecosystems, with a wide diversity in plant and animal species.

To facilitate appreciation and understanding of the natural environment of the park, the National Park Service has for a period of years allowed the installation of visitor accommodations and concessionaire facilities within the boundaries of the sequoia redwood groves in Giant Forest, and in the environs of the spectacularly glaciated Lodgepole Valley. The existing land use in these areas and the overall land use pattern of the Master Plan study area are presented in Figs. 1-5.

Overnight lodging, two restaurants, a bar, and a tourist and variety store are presently located in Giant Forest, and a gas station, general store, Park Visitor Information Center, and a 310 unit campground are located at Lodgepole.



STUDY AREA

FIG. 1

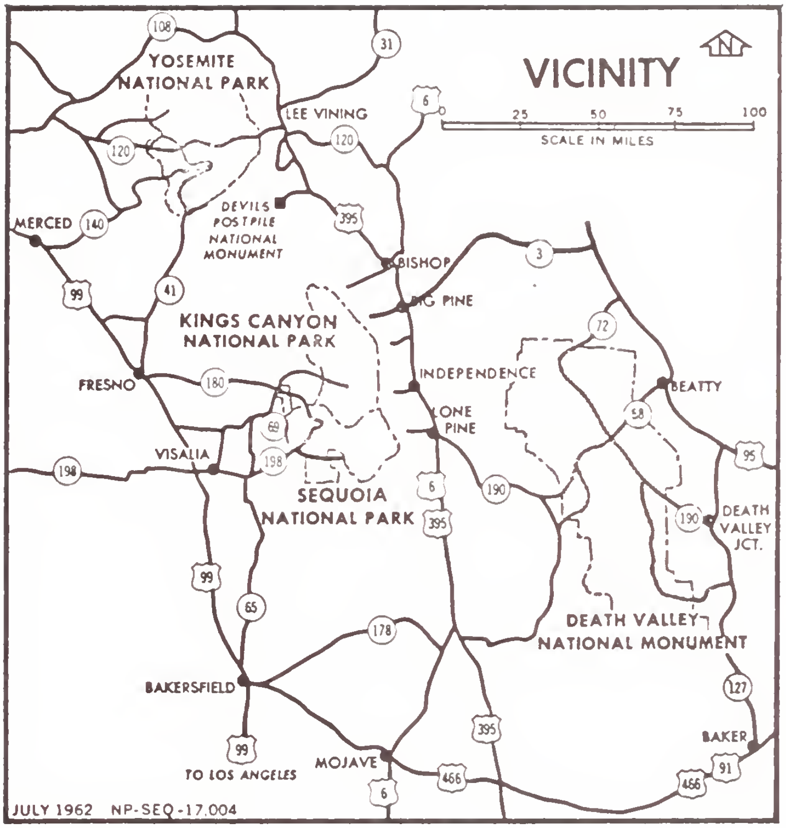
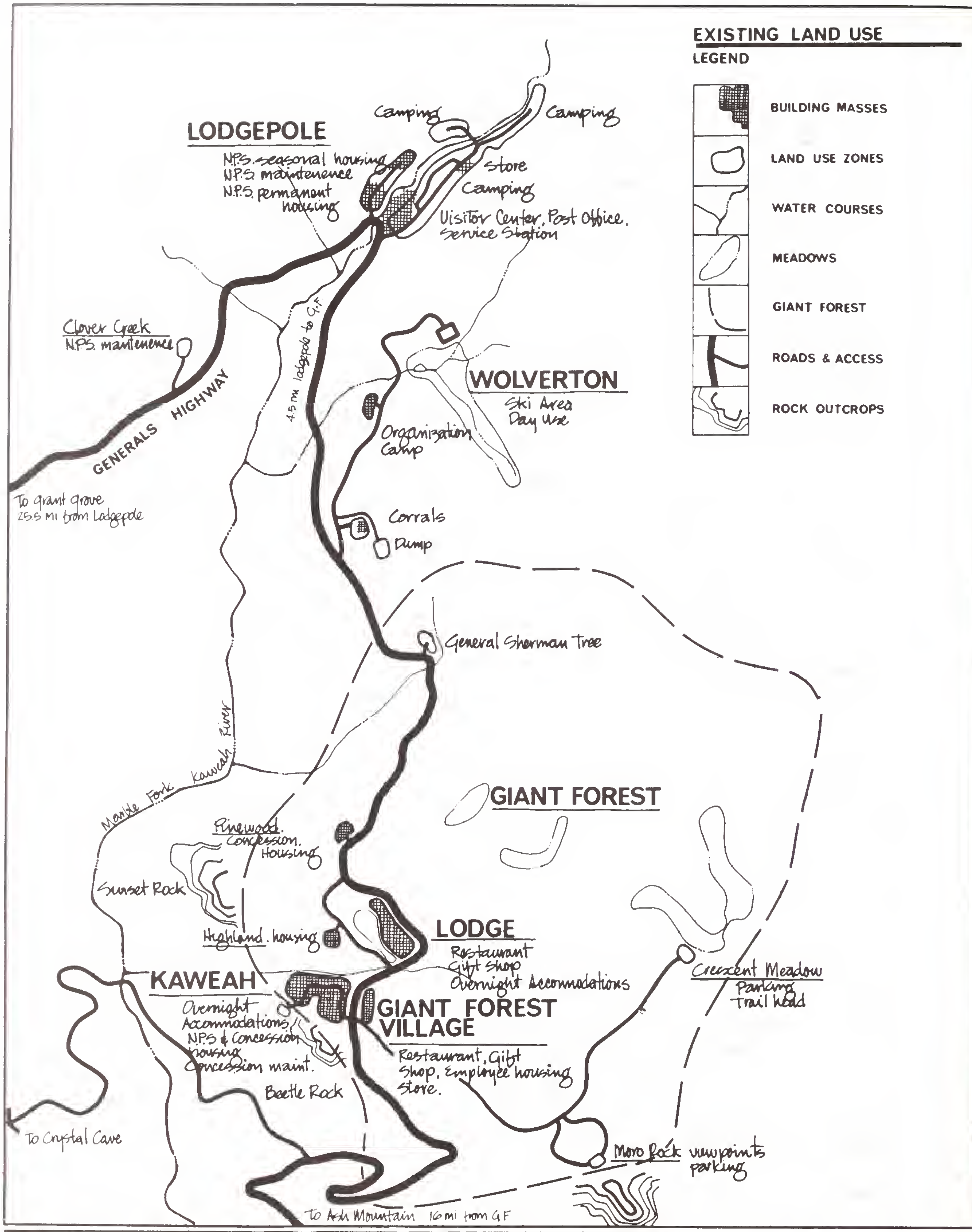

VICINITY
N
0 25 50 75 100
SCALE IN MILES
YOSEMITE NATIONAL PARK
LEE VINING
DEVILS POSTPILE NATIONAL MONUMENT
MERCED
BISHOP
BIG PINE
KINGS CANYON NATIONAL PARK
INDEPENDENCE
FRESNO
LONE PINE
BEATTY
VISALIA
SEQUOIA NATIONAL PARK
DEATH VALLEY JCT.
DEATH VALLEY NATIONAL MONUMENT
BAKERSFIELD
BAKER
TO LOS ANGELES
MOJAVE
JULY 1962 NP-SEQ-17,004

FIG. 2



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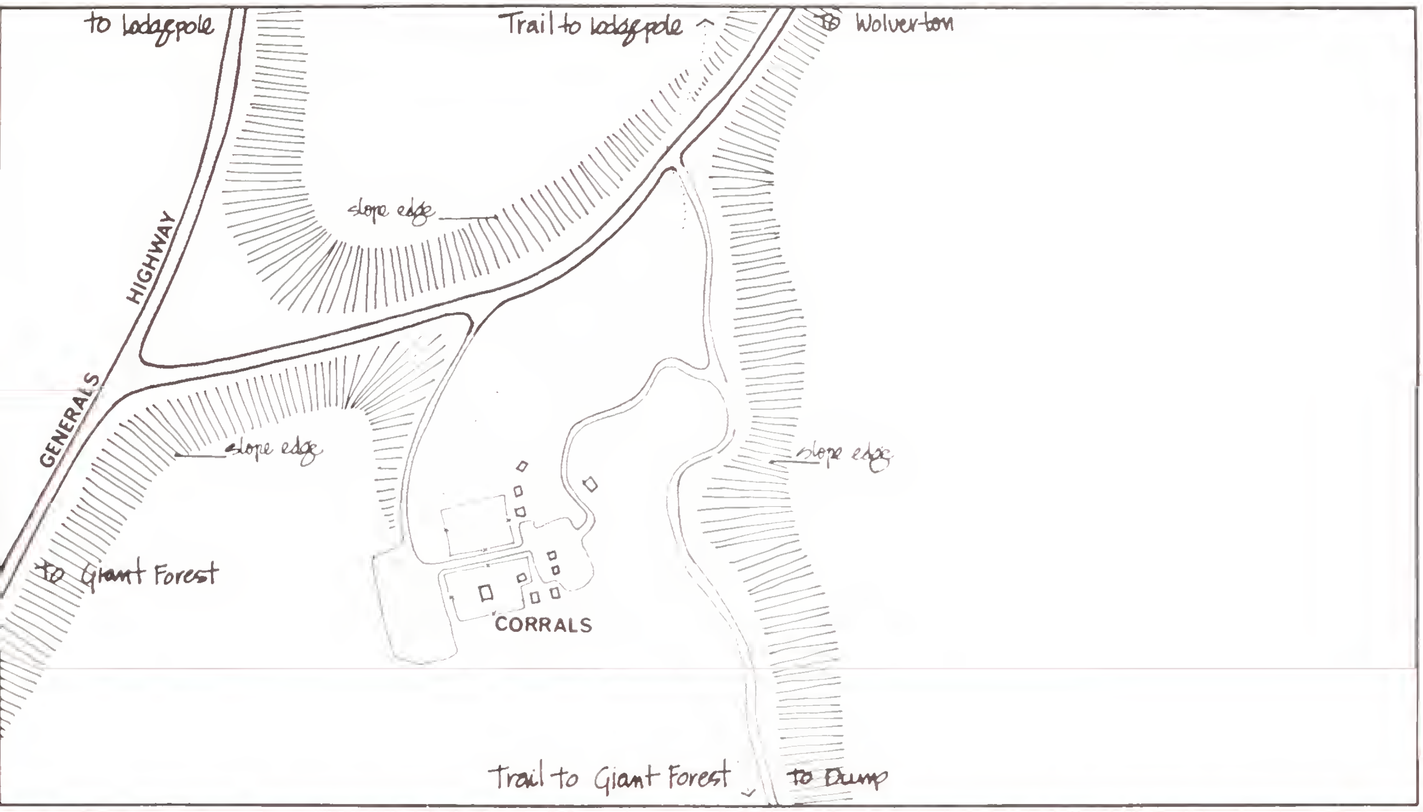
Development Concept Plan
Giant Forest - Lodgepole Complex
Sequoia/Kings Canyon National Park, California

Existing Land Use

Fig. 3



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Giant Forest - Lodgepole Complex
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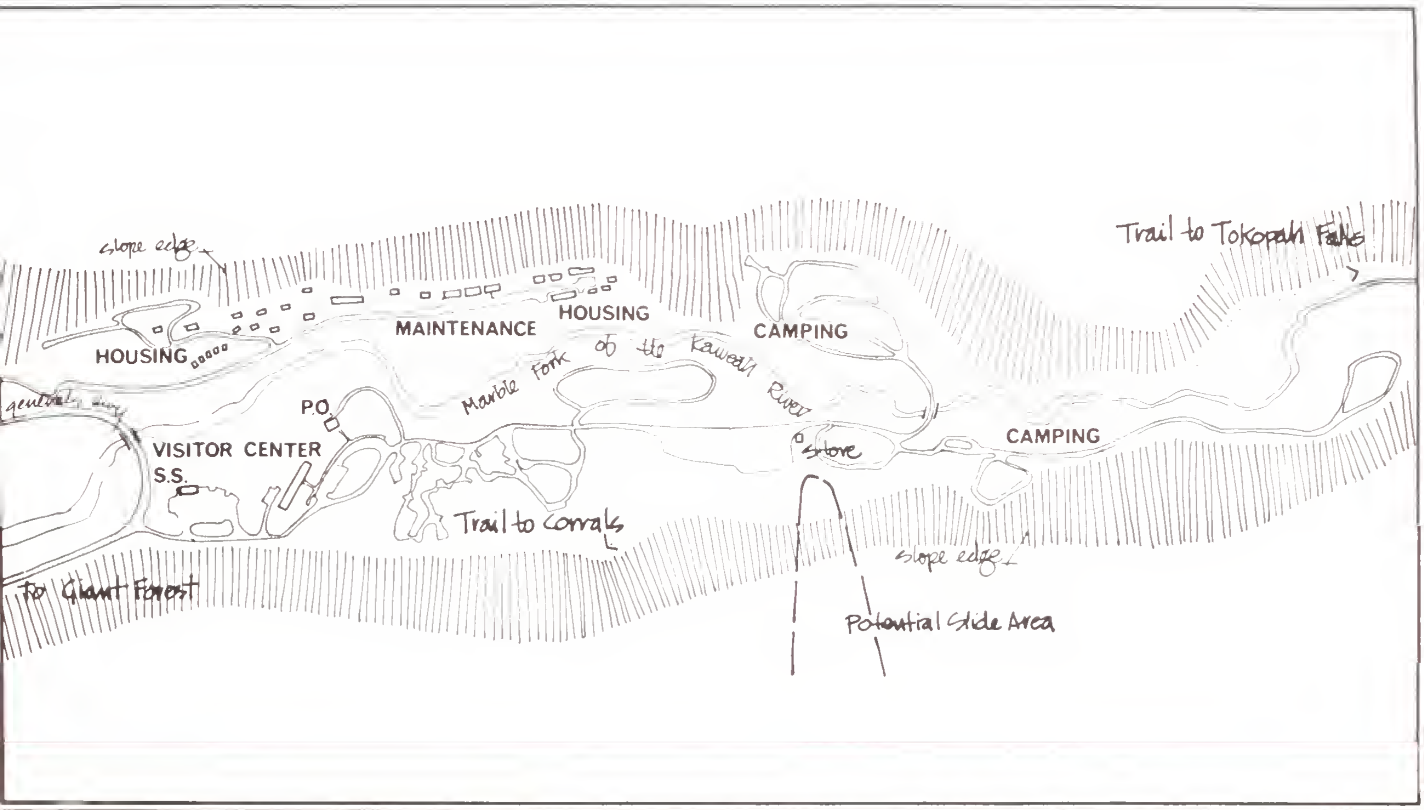
Corral Area
Existing Land Use



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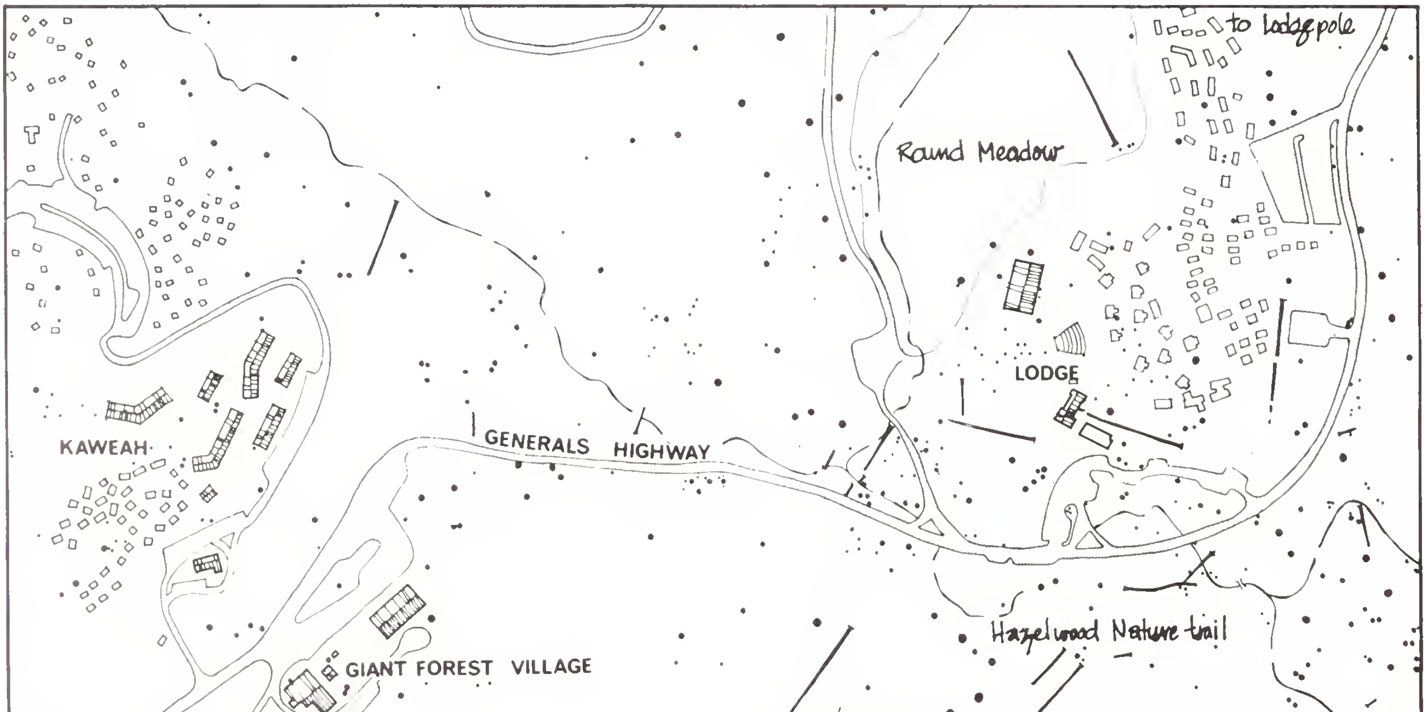
Development Concept Plan
Giant Forest - Lodgepole Complex
Sequoia/Kings Canyon National Park, California

Lodgepole
Existing Land Use

Fig. 4



Development Concept Plan
Giant Forest - Lodgepole Complex
Sequoia/Kings Canyon National Park, California

Giant Forest
Existing Land Use

Fig. 5

Development of land use patterns in the giant sequoia groves has been inconsistent with the intent of original Congressional legislation and of the policies and management programs of the National Park Service. The resultant development over the years has left buildings and improvements in a substandard condition, with overaged structures, an obsolete transportation system, and inadequate utility services. These are all centered within the prime resource of the park, the giant sequoia trees.

The fact that these trees are still awe-inspiring in this unnatural environment reflects the majesty of their size, and yet, the park visitor is unable to fully appreciate and understand the complex interrelationships of the giant sequoia ecology under present interpretive limitations. Regardless of the individual needs, the most common interpretive experiences can be described as either hit-and-miss by automobile and/or a solitudinal experience as one walks through this prime resource. This allows for several types of interpretive experiences; none would seem to be as comprehensive as necessary, nor possessing the continuity that the situation demands.

Besides the impact of current land uses on the visual experience of the sequoias, increasing concern has been focused on the direct impact of humans on the ecology of the sequoia environment. These concerns, that of providing a rewarding instructive experience for park visitors and of protecting the natural environment of the park, represent the goals of the National Park Service. The contradiction between present land use and goals of the park and the need to redefine goals and priorities was recognized by the park service in their master plan for Sequoia and Kings Canyon National Park of January, 1971 [U.S. Department of Interior, 1971].

These goals as described in the "Sequoia-Kings Canyon

National Park Master Plan" include the following.

1. Expand resource management programs.
2. Stimulate and coordinate research needs.
3. Upgrade developments.
   a) Relocate developments from Giant Forest Area.
   b) Replace substandard employee housing.
   c) Relocate and phase out overnight camping in favor of day use activities.
4. Expand circulation.
5. Expand interpretation.
6. Coordinate planning with other federal agencies.

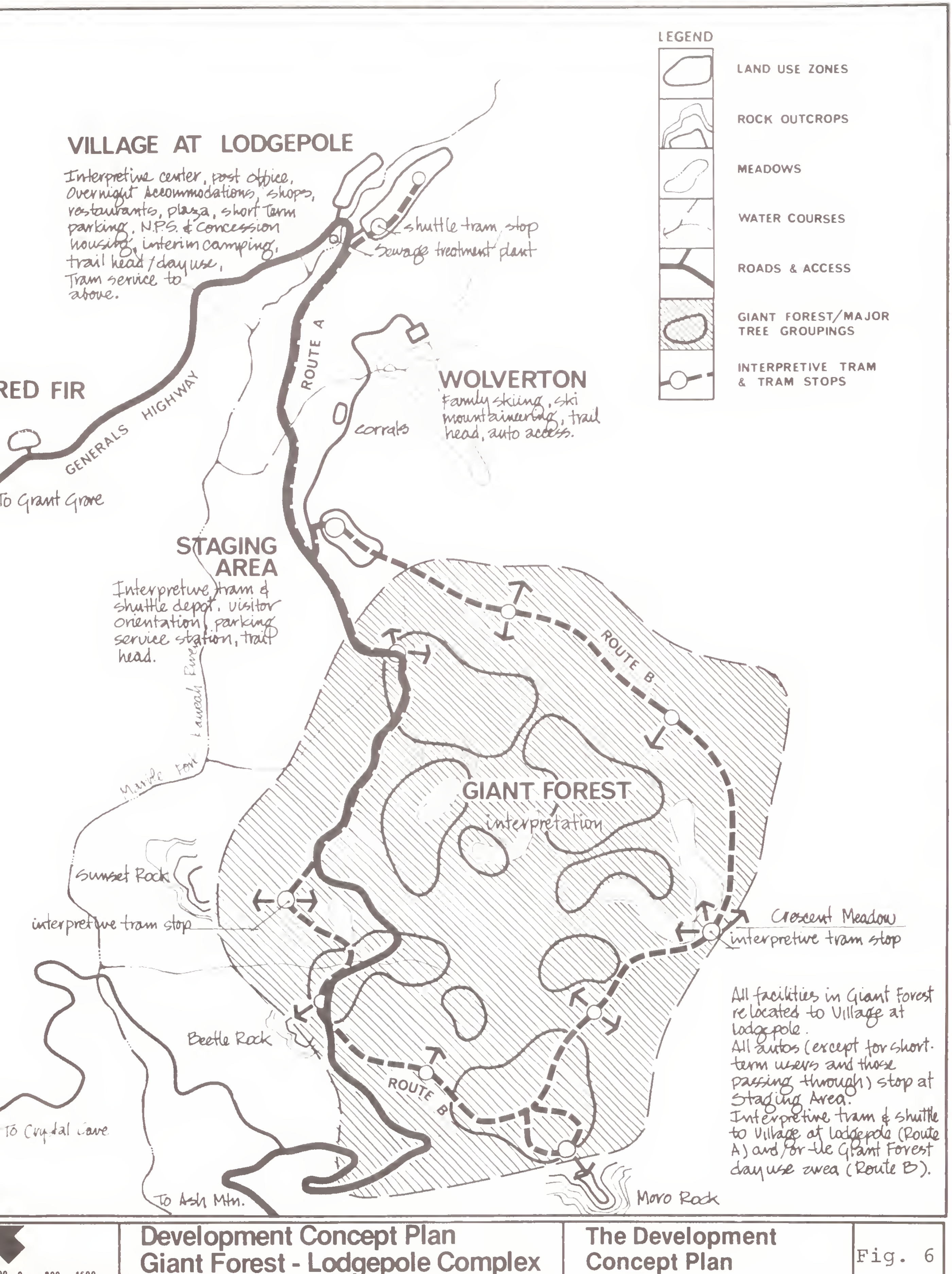
The "Conceptual Development Plan and Environmental Impact Statement" is the second step in the process of meeting these goals and of reestablishing, for this portion of Sequoia National Park, the essence of recreation consistent with a stature befitting the area and restoring the character and integrity befitting the largest living entity in the world--the giant sequoia.

The Development Concept Plan

A detailed description of the proposals of the Development Concept Plan are contained in a separate document. The following description of the proposal is presented at a level necessary to evaluate the environmental impacts of the proposed action (Fig. 6).

Previous analysis and interpretations of the natural resources of the Giant Forest-Lodgepole complex has indicated areas of high sensitivity, generally conforming to the existing land classification plan for this portion of the park, as well as identifiying those areas that are more tolerant to human habitation and development. (See Appendix E for methodology).

The general recommendation of the development plan involves phased relocation of the facilities from the Giant Forest area to the Lodgepole area. Multistory buildings for visitor accommodations are proposed for the Lodgepole Complex, including a restaurant, store, and gift shop facilities. Improvements will also be made for National Park Service and



Development Concept Plan
Giant Forest - Lodgepole Complex
Sequoia/Kings Canyon National Park, California

The Development Concept Plan

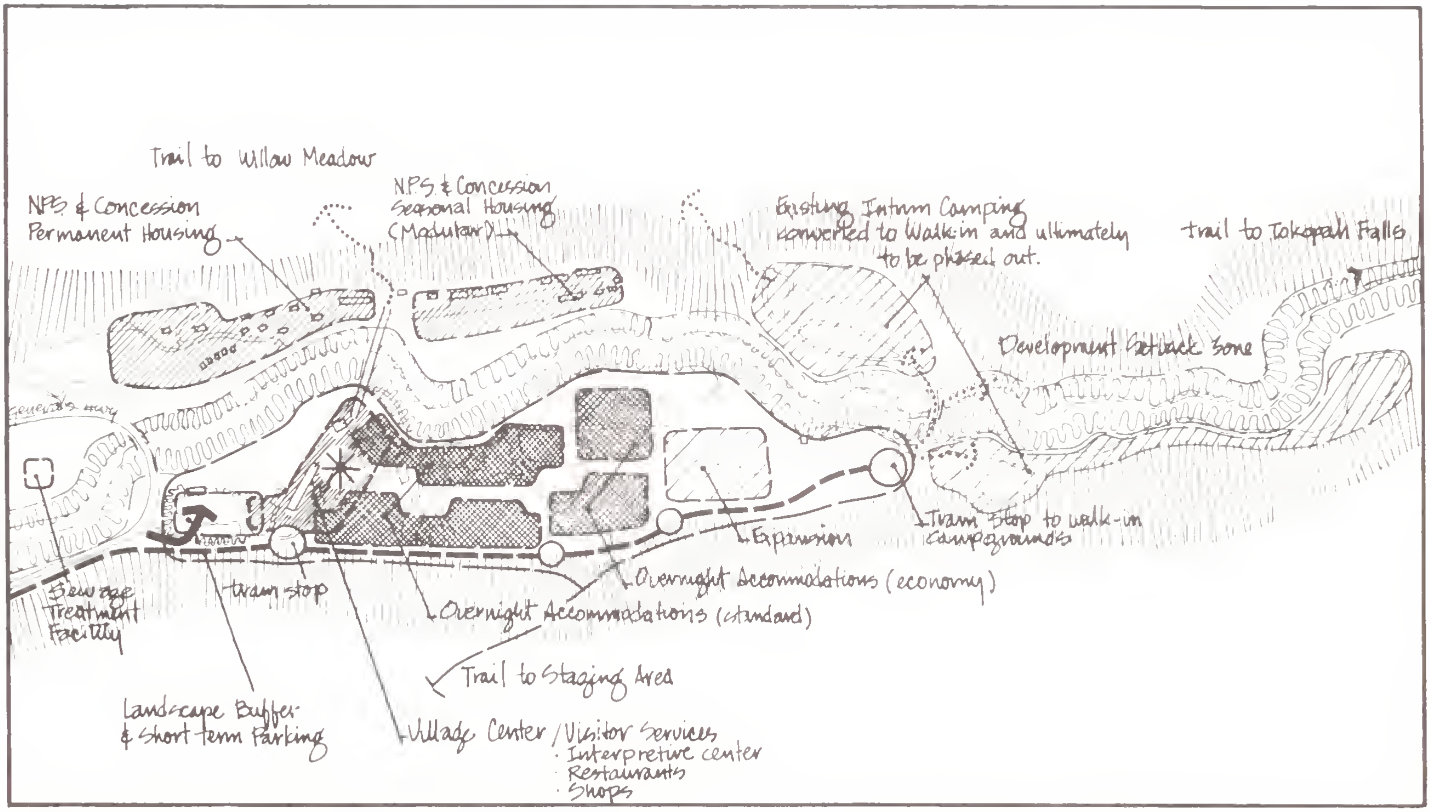
Fig. 6

concessionare employee housing in the Lodgepole area. A change from auto-camper oriented sites to a walk-in campground is proposed for the east end of the valley; however, camping may ultimately be phased out in the park. The village at Lodgepole is conceived as being completely pedestrian and will act as a medium for formal interpretation of the Sierra Nevada at the interpretive center (Fig. 7).

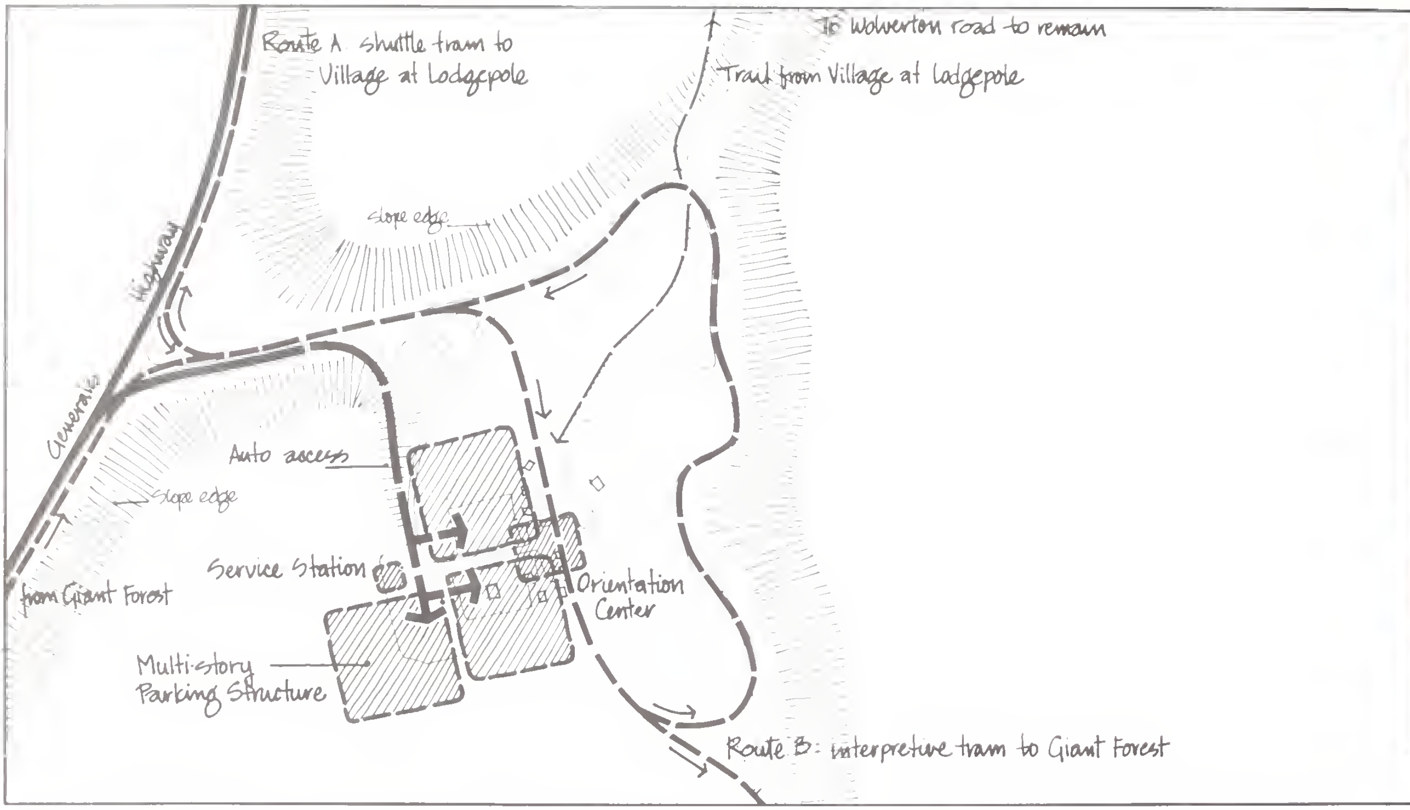
By developing low-rise structures along with other lower-profile buildings, it is estimated that the same total number of accommodations and service facilities in the Giant Forest area can be relocated to Lodgepole and placed on a fraction of the amount of land area. The economies of space, utilities, and maintenance are self-evident.

Day use accommodations will be provided at Sunset Rock, and it is expected that visitors will continue to make daily visits to the General Sherman Tree, Moro Rock, and Crystal Cave. The General Sherman Tree will not be emphasized in future interpretive programs and the existing parking lot across the highway from the tree will be closed since the tree is only a short distance south from the corral or proposed staging area (Figs. 3 and 8). The proposed tram will take visitors to Crescent Meadow, Moro Rock, Beetle Rock, and Sunset Rock. Busses will take visitors to Crystal Cave from the staging area. Access to the ski facilities to Wolverton will be by auto. The facilities will be improved for safety reasons, but no new lifts or ski runs are proposed.

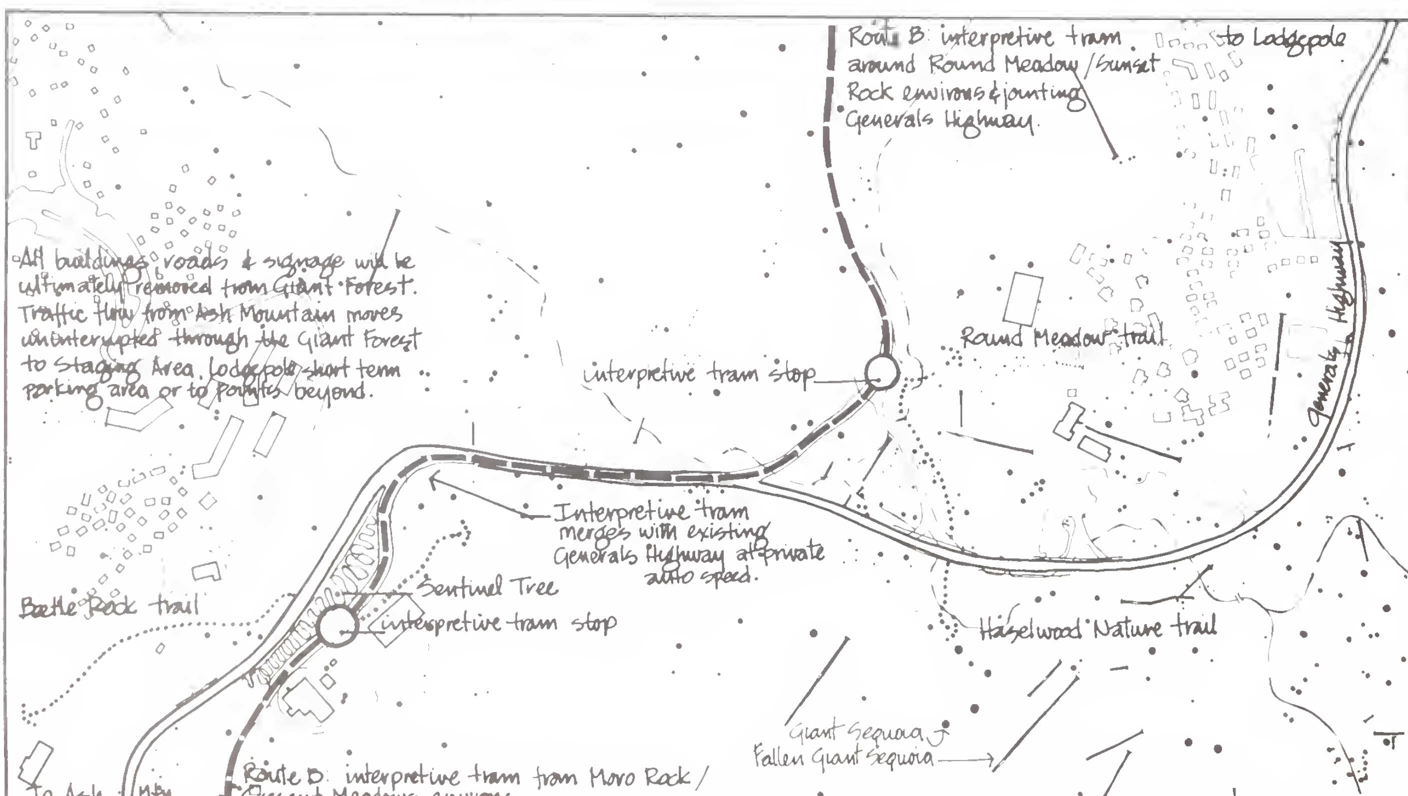
In keeping with the approach to develop a high density core replacing the existent scattered facilities in Giant Forest it is proposed that all vehicles be parked in a structured area near the present corral and dump area on the road into Wolverton. This staging area could have the flexibility of providing parking for several thousand automobiles in a minimal amount of land space resulting from multi-level parking.



0 400	**Development Concept Plan** **Giant Forest - Lodgepole Complex** Sequoia/Kings Canyon National Park, California	**Village at Lodgepole Concept Plan**	Fig. 7



0 200	**Development Concept Plan** **Giant Forest - Lodgepole Complex** Sequoia/Kings Canyon National Park, California	**Staging Area** **Concept Plan**



0 200	**Development Concept Plan** **Giant Forest - Lodgepole Complex** Sequoia/Kings Canyon National Park, California	**Giant Forest** **Concept Plan**	Fig. 8

This area could thus become the nucleus for the dispersion of visitors either by tram into the village at Lodgepole or by interpretive tram into the Giant Forest itself. Short-term parking is proposed at Lodgepole for visitors wishing to stop for food and orientation as they progress in either direction. The displaced corral would be moved to the organization camp area approximately 1/2 mile north of its present location.

No attempt will be made to realign or relocate the existing General's Highway running through the Giant Forest complex and continuing on past Lodgepole, ulitmately reaching the Grant Grove end of the park. This road has been in existence for some forty-plus years and any type of major ecological barrier resulting from the implacement of this highway has been minimized over this time span. Any re-location of this highway would doubtlessly create much more environmental havoc than is existing today.

An interpretive tram as noted in Fig. 6 will substantially replace automobile traffic within the Giant Forest-Lodgepole Complex. Visitors from the Ash Mountain entrance on the south will not be able to park until they reach the staging area. Visitors from the north may stop at the interpretive center at Lodgepole first or, in response to good signing, proceed to the staging area. Overnight and day-use vehicles will be confined to this parking area. After orientation, visitors will be transported to points of use and interest from the staging area.

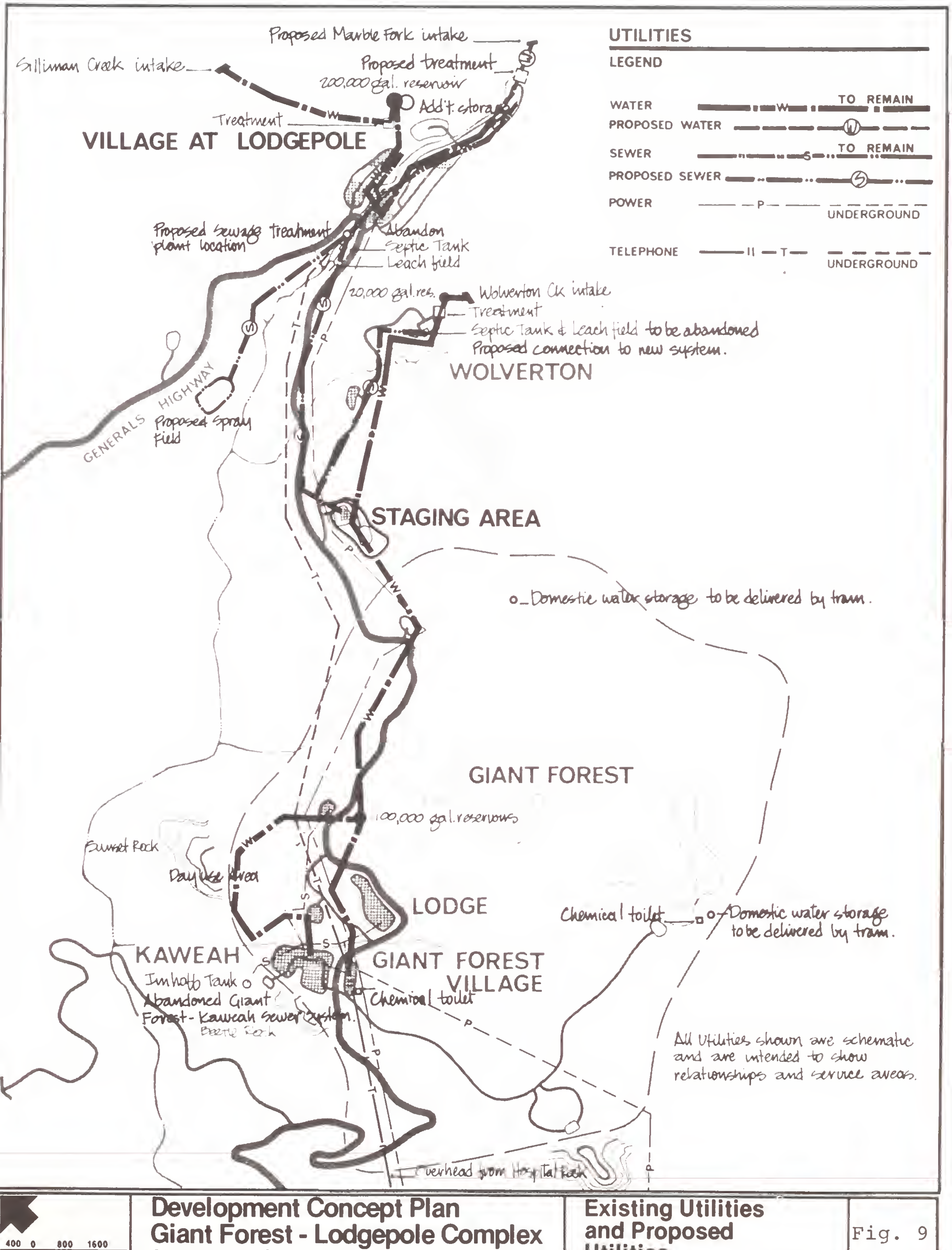
The interpretive tram is meant to provide a flexible medium for viewing and experiencing the giant sequoia. The loop for the staging area will take approximately one hour to complete. There will be stops at major points of interest, allowing visitors to get off the tram and walk into the forest. A tram system initially consisting of ten modules with a seating capacity of 36 persons per module will be utilized. The tram system will initially be designed for a carrying capacity of 3,600 people per day, while specifications for the bus system have yet to be developed. Although the use of such systems have proven successful at Yosemite National Park, more detailed specifications as to types of vehicles, seating needs, and scheduling will require further traffic studies and experiences gained through use.

A new sewage treatment plant and water facilities adequate for the ultimate development are proposed to accommodate the conceptual plan (Fig. 9). Current water demands on the Wolverton aquifer will be greatly reduced by building relocation of the Giant Forest complex. Water from Wolverton Creek will serve only the Wolverton staging area. The Lodgepole complex will be served by an existing intake on Silliman Creek hooked to an existing 200,000 gallon storage reservoir and a new intake on the Kaweah River above Lodgepole. A sewage treatment plant is proposed to service the Lodgepole area with treated effluent disposed of on spray fields below the Red Fir maintenance area.

Relationship of the Concept Plan to Other Projects

This "Development Concept Plan" covers about 15,000 acres of Sequoia National Park. The scope of this study has been to identify a methodology for achieving the goals of the "Sequoia-Kings Canyon National Park Master Plan" of January, 1971, for this area. As described in the previous section, these goals cover both parks and may require separate conceptual planning and environmental impact analysis for each planning area. The logical division for future planning area studies would be based on the Land Classification system devised by the Park Service for the Sequoia-Kings Canyon area. Under this approach, outstanding natural and primitive areas would receive separate attention and planning would focus on establishing and monitoring trail systems, on reaching management decisions, and on assessing the environmental impacts of back country user groups.

A major part of this Development Concept Plan involves the



Development Concept Plan
Giant Forest - Lodgepole Complex
Sequoia/Kings Canyon National Park, California

Existing Utilities and Proposed Utilities

Fig. 9

gradual transition of this planning area from providing general overnight accommodations to providing largely day use interpretive experience. In achieving this transition, the National Park Service has engaged in cooperative and coordinated regional planning with the U.S. Forest Service for improvement and expansion of camping facilities on adjacent Sequoia National Forest lands. Campgrounds are to be located within an hour's drive of the Giant Forest area. These areas are located on the General's Highway between the area of Giant Grove and the Sequoia National Park entrance at Lost Grove.

The Forest Service has identified areas for future studies in the area of Big Meadows and Bearskin Meadow. The Regional Plan will identify the best campground locations from an environmental viewpoint, keeping in mind the needs and desires of both the forest and park visitors.

ECOLOGICAL SETTING

Sequoia National Park occupies a 252 square mile area of the western slope of the Sierra Nevada in Tulare County, California. Elevations range from 1,700 feet at the Ash Mountain Headquarters to 14,495 feet at the top of Mt. Whitney on the Sierra Crest. This elevational range encompasses the five life zones of (in order of increasing elevation) Upper Sonoran, Transition, Canadian, Hudsonian, and Arctic-Alpine. Each of these zones have characteristic indicator plants, animals, and climatic conditions which ecologically distinguish them. A discussion of these life zones may be found in Sumner and Dixon [1953].

Sequoia National Park was established in 1890 to preserve its scenic and recreational values. The greatest ecological attraction in the park, and the primary reason for its establishment as a national park, is the giant sequoias. These giant redwoods are found in only a few groves on the west side of the Sierra Nevada. The Giant Forest grove, which is part of the planning area for this report, is one of the largest forests of giant sequoias in the world, covering 2,387 acres with over 3,000 trees.

Another important and interesting ecological feature of the park is its geology. The Sierra Nevada consists of a large block of the earth's crust which slopes gradually to the west from the crest line and abrubtly to the east. Several features within the park provide evidence of glacial action, avalanche sculpture, and volcanic actions.

Sequoia National Park serves as an important part of the cultural environment of the people who visit it. Thousands of people visit the park each year to view the giant sequoias, the wildlife, and other natural features of the park, as well as to take part in recreational activies such as camping, hiking, and general relaxation.

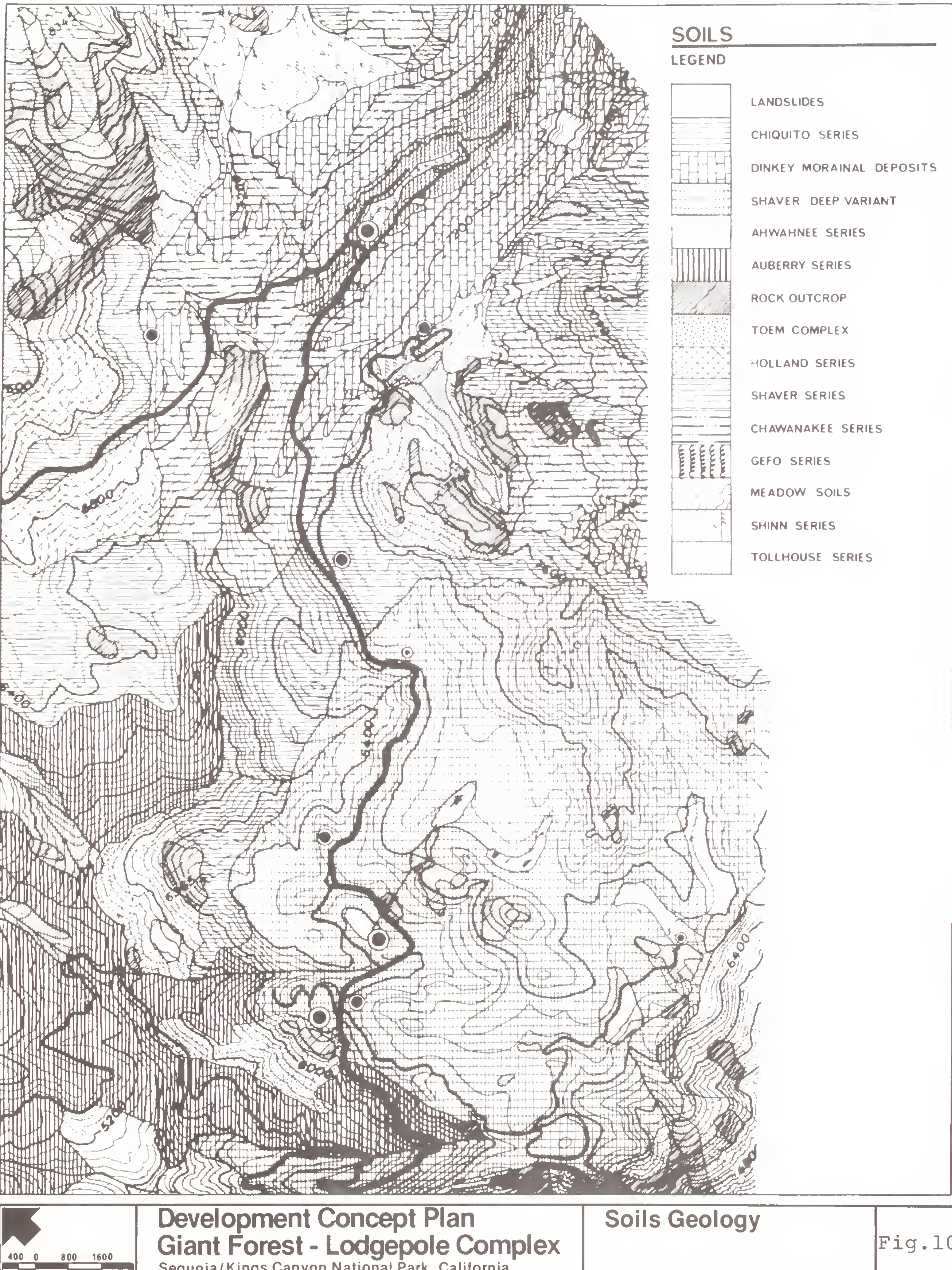
II. DESCRIPTION OF THE ENVIRONMENT

This section describes the natural and cultural elements of the environment as it presently exists and is designed to establish the necessary baseline information for planning purposes and the environmental impact analysis.

Soils/Geology/Geomorphology

Introduction. The soils of the Sequoia National Park have not been mapped, other than at a very high scale reconaissance level by the California State Division of Forestry [1972]. The bedrock geology of the area has been investigated by Ross [1958] and a more detailed mapping of the glacial geology of parts of the park has been completed by Birman [1962]. As the soils in these upland areas are closely related to geologic parent materials and physiographic position, a generalized soils/geology map was constructed from an examination of available geologic information, soil engineering investigations, stero-paired photographs, and limited field investigations. Mapping units were established according to a key of granitic soils developed by Huntington [1971], and were modified to reflect both soil and geologic considerations into a composite soils/geology map (Fig. 10).

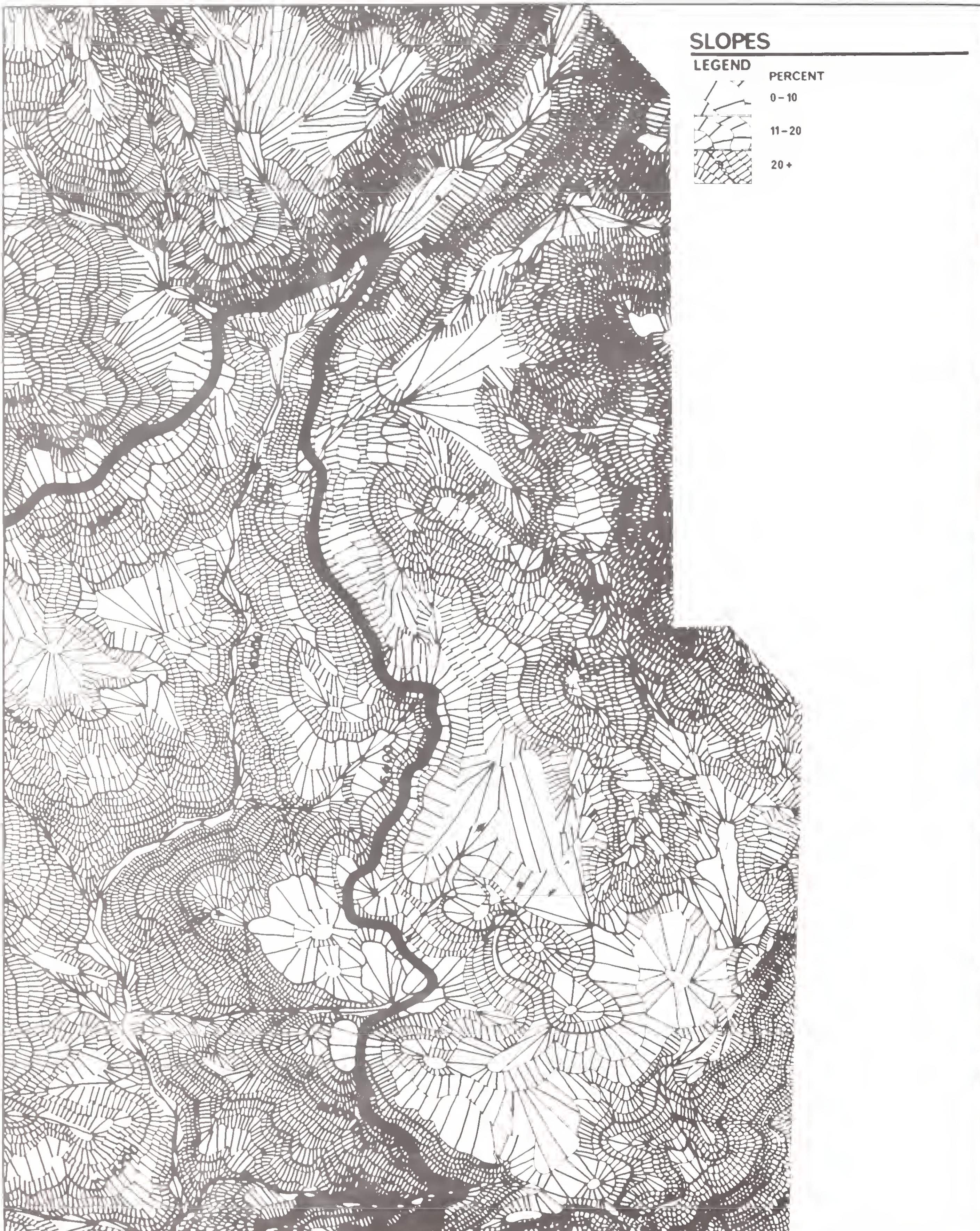
The geology of the Giant Forest area may be divided into two sections: the Lodgepole-Upper Kaweah area, consisting of granitic basement rock which have experienced four separate periods of glacial advance and retreat during Pleistocene times, and the Giant Forest village area, which consists of Cretaceous granitic rocks in various stages of weathering. Advances of the Wisconsin age glaciers (Tioga, Tenaya, and Tahoe), and some post-Wisconsin glacial activity have left extensive morainal deposits of large granitic boulders forming the walls of the Lodgepole Campgrounds, as well as



Development Concept Plan
Giant Forest - Lodgepole Complex
Sequoia/Kings Canyon National Park, California

Soils Geology

Fig.10



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Giant Forest - Lodgepole Complex
Sequoia/Kings Canyon National Park, California

Slopes

Fig.11

cobbles and sheet till on mountain slopes, and glacial outwash deposits in the Willow Meadow and Wolverton areas. The Upper Kaweah area has the topography and appearance of an area which has experienced alpine glaciation, with steep sided cliffs and exposed-rock surfaces. The Upper Kaweah watershed consists of many cirque-lakes.

Differences in climatic patterns and associated vegetation have been the factors responsible for variations in weathering and soil profile development in the non-glaciated areas of the park. Mean annual temperatures tend to decrease with the increase in elevation from the floor of the Giant Forest area eastward to Silliman Meadow and Panther Meadow. This trend is modified locally by the effects of aspect of ridge and canyon slopes. Precipitation follows similar patterns, increasing with elevation, but locally modified by ridges and canyons. The combination of differences in mean annual temperature and mean annual precipitation results in three basic zones which have significance in soil profile development and associated land-use constraints. These zones are:

1) the warm to hot, relatively dry areas at lower elevations; moisture is the limiting factor for weathering and soil formation in this zone,

2) the warm to cool, moist, middle mountain elevations; here weathering and soil forming process, and an abundant vegetative cover, are least limiting to soil profile development, and

3) the cool to cold, moist areas of the upper Sierra; temperature, is the limiting factor in soil profile development in these areas.

The residual granitic soils of the non-glaciated areas of the park reflect the sequence of climatic conditions up or down slope, and the influence of aspect and drainage.

The following sections describe the combined soils/geology mapping units and their sensitivities and constraints to various land uses. The limits of these mapping units should be recognized, to insure proper interpretation of the map. Detailed mapping using slope and depth classes cannot be achieved at this level. Inclusions of small areas of wet spots and rock outcrops will occur which cannot be designated without more detailed field investigations. Although specific soil series have been delineated on the map, large areas of soil inclusions of associated soils can be expected. Boundaries were set by vegetative patterns and slope and aspect differences, and areas were delineated according to the soil series which would most likely develop on the geologic materials in that environment. The map should be interpreted in conjunction with the slope map (Fig. 11) in establishing tentative areas of land use that are sensitive to both soil and slope conditions. The confirmation of the tentative designation should be made by more detailed site mapping of soil and geologic conditions, and foundation investigations.

Soils Of Glaciated Areas

Dinkey Series - Morainal Deposits (DD /Qm). The soils of this mapping unit formed on the glacial moraines of the Wisconsin age. The parent material consists of granitic boulders in various stages of weathering imbedded in a coarse loamy sand material. Large boulders may occupy over 50 percent of the soil volume in this mapping unit, and depth to granitic bedrock generally exceeds well over ten feet. A compacted or silica cemented till occurs at a depth of about three and one-half feet, and plant roots are restricted to the zone above this. The till consists of igneous rocks of from gravel to large boulder size in a matrix of sandy detritus from the rocks. Vegetation associated with this mapping unit includes conifers and lodgepole pine.

The presence of large boulders presents some constraints to certain land uses, as excavation would be restricted, and would require removal of the spoil from the area. Soils on slopes less than 15 percent are considered to have slight erosion hazards; however, the possibility of debris slides (particularly in areas of less dense tree cover and on or below steep slopes and mapped slides) should be investigated before any land uses are assigned to this mapping unit.

Shinn Series - Glacial Fluvial Deposits (Sh/Qy). The soils of this mapping unit formed on the glacio-fluvial deposits of the Wisconsin age. These soils occur on gently sloping areas, with slopes of from two to nine percent, but locally to 15 percent. Soil texture is a coarse sandy loam from 48 to 60 inches deep. A silica cemented pan generally occurs at about this depth, and a perched water table with water moving downslope at this interface usually occurs during spring snowmelt. A softly consolidated coarse sand occurs below the silica cemented pan and is of varying thickness to granitic bedrock, the total depth determined to be between 25 and 40 feet in the Wolverton area [U.S.G.S., 1969]. Vegetation associated with this mapping unit includes lodgepole pine and other conifers.

Soil erosion is a major constraint in this mapping unit on slopes greater than nine percent. Grading to expose the silica pan will make revegetation difficult, and may intercept and alter the hydrologic features of this mapping unit. Applied fertilizers and irrigation water will procede downslope on top of the pan, and may cause problems by introducing nutrients into streams. Activities that minimize grading and control erosion would seem feasible in this mapping unit.

Gefo Series - Glacio-Fluvial Outwash (Gf/Qg). This soil series has been extensively mapped on glacial fluvial outwash in the Lake Tahoe Basin [U.S. Forest Service, 1972a]. These soils occur on gently sloping glacial fluvial outwash deposited on top of older alluvium. Soil texture is a gravely coarse sandy loam with cobbles occuring throughout the profile and some large boulders occurring in the substratum. This mapping unit has been investigated earlier by Brandley [1964] relative to foundation conditions for the Lodgepole Visitor Center. The investigation indicates that the soil profile contains some four to five feet of a compact decomposed granitic material with quartz diorite boulders imbedded. Below this is a gray decomposed granitic material of recent alluvium intermixed with boulders. Their investigations conclude that the soils are a decomposed granite which is compact and stable. As in the Shinn Series, a silica cemented pan occurs at depths between 40 and 60 inches, but may be shallower or absent locally. A perched water table is likely to develop above this pan during spring snowmelt. Vegetation associated with this mapping unit is largely lodgepole pine and brush.

Sensitivities and constraints are similar to the Shinn series in this mapping unit, although some drier sites occur on south facing slopes and in coarse textured sediments. If the cover is removed revegetation plans using indigenous species will be needed in these areas for both erosion control and for aesthetic reasons.

Landslides and Debris Flows (Qls). This mapping unit designates areas of larger landslides and debris flows. These geologic units may be very unstable when disturbed, and extreme care should be exercised if specific land uses are planned in the area of these slides. Extensive foundation testing should be required if development is considered in these areas.

Chawanakee Series - With Glacial Till (Ch-t/Qt). This soil developed from Cretaceous granitic rock, but has since been covered by various depths of glacial till deposited during Pleistocene glaciation. This series with glacial till has been mapped by Zinke [1963] in his soil-vegetation survey of the Yosemite Valley, and he reports little apparent influence of the till on soil development. This soil is probably somewhat deeper than would be expected as typical of the series, being 32 to 40 inches deep. It contains rounded cobbles and stones not found in non-glaciated areas of the Chawanakee series. The soil matrix consists of a coarse sandy loam throughout the soil depth. The associated vegetation is coniferous forest.

This soil has moderate to high soil erosion hazards because it commonly occurs on moderate to steep, excessively drained slopes.

Soils of Non-Glaciated Areas

Ahwahnee Series (Ah/Gr). The Ahwahnee series developed residually on the lower elevation steep granitic rocks of the Upper Sonoran Life Zone. Low precipitation and rapid runoff has limited vegetation to zerophytic shrubs and has retarded soil profile development. Depth to weathered granitic bedrock is less than 20 inches in these soils. Texture throughout the soil profile is a coarse sandy loam. The Auberry soil series is associated with the Ahwahnee.

Steep slopes, rapid runoff, and a low vegetative cover create a situation of very severe soil erosion hazards.

This mapping unit is best left in its natural condition as watershed and wildlife habitat.

Auberry Series (Au/Gr). The Auberry series developed residually on the lower elevation granitic rocks on the coolest, more moist sites. The vegetation associated with this mapping unit includes oak, digger pine, buckeye, manzanita, squaw brush, and annual grasses and herbs. The soil varies between 36 and 60 inches in depth, largely depending on slope. The soil surface is a sandy loam with a sandy loam subsoil, and a coarse sandy loam substratum. This mapping unit may be found on several slope classes, and runoff and soil erosion hazard are largely a function of slope. Slopes greater than 15 percent should be considered moderately erodible, and slopes over 25 percent have severe erosion hazards. The Ahwahnee soil series is associated with the Auberry series.

Soil erosion is the major constraint in this mapping unit, although natural revegetation may be successful.

Tollhouse Series (To/Gr). The Tollhouse series is restricted to the steep canyon walls and fault scarps of the Upper Sonoran Life Zone. Vegetation associated with this mapping unit includes canyon and interior live oak, California buckeye, buckbrush, whitethorn, and manzanita. The soil is very shallow, 3 to 20 inches deep, has many granitic rock outcrops, and has a texture profile of a stony or rocky coarse sandy loam.

Areas in which this mapping unit are located are too steep for most types of land-use, and are best left as watershed and wildlife habitat.

Rock Outcrop - Toem Complex (R/T, Gr). This complex has been mapped extensively by the U.S. Forest Service [1972] in their soil survey of the Lake Tahoe Basin. Members of this complex occur on steep slopes, or on hard granitic rocks that are resistant to weathering. Soil depth is less than 20 inches in this mapping unit, and there are large areas of exposed bedrock. Texture throughout the soil profile is a gravelly loamy coarse sand, with some rock fragments and exfoliation from adjacent boulders. Vegetation associated with this mapping unit includes sparse stands of pine and fir.

Areas in which this mapping unit occurs are very susceptible to soil erosion, and natural revegetation of these areas would be very difficult to achieve. Road cuts and grading should be avoided in these areas, and specific plans for revegetation and the control of erosion and runoff should be a part of any specific land use plan that disturbs the native cover.

Holland Series (Hl/Gr). The Holland series developed residually on the granitic rocks of the warmest, driest parts of the Sierran Transition Life Zone. Vegetation associated with this mapping unit includes ponderosa pine, incense cedar, sugar pine, manzanita, whitethorn, and buck brush. Soil depth in this series varies from 36 to 60 inches, but may be much shallower locally, with rock outcrops and exposed rock surfaces. Texture throughout the soil profile is a coarse sandy loam. The Chawanakee and Shaver series are associated soils.

The Holland series should be considered moderately susceptible to erosion, severe on slopes greater than 25 percent. This soil is somewhat intolerant of development requiring road cuts to be revegetated and control of runoff from the shoulders of roads.

Chiquito Series (Ch/Gr). The Chiquito series has developed residually on granitic rocks at the higher elevation, colder areas of the park. These soils are shallow, 12 to 20 inches deep, and have a coarse sandy loam surface and a loamy coarse sand subsoil. Vegetation associated with this soil includes lodgepole pine, Jeffrey pine, sugar pine, and red and white fir.

This soil is intolerant to development in that soil erosion and the shallow depth to bedrock are major problems on this mapping unit.

Shaver Series (Au/Gr). The Shaver series developed residually on the intermediate elevation granitic rocks on the coolest, most moist portions of the Sierran Transition Life Zone. Soil depth varies between 38 and 60 inches, but may be locally much shallower on steep slopes or dry areas. Texture throughout the soil profile is a coarse sandy loam or sandy loam. Vegetation associated with this mapping unit includes ponderosa and Jeffrey pine, sugar pine, white fir, incense cedar, mountain whitethorn, and manzanita. The Chawanakee and Holland series are associated soils.

When this mapping unit occurs on slopes less than nine percent, it is less susceptible to soil erosion and has the lowest number of development constraints of any of the mapping units delineated in the study area. Natural revegetation is highest in this mapping unit, although plans for the control of runoff and erosion and for revegetation should be developed to ensure the maintenance of high water quality in the Kaweah River.

Shaver - Deep Variant (Sud/Gr). This variant of the Shaver series receives moisture from groundwater sources providing a habitat for the high moisture requiring giant sequoia, as well as vigorous growth of associated pine and fir. Ample year round moisture supplies have created deep weathering in this variant; soil depth ranges from 54 inches to well over six feet in some areas. According to Rundel [1966], the soil profile differs little from the adjacent soils lacking sequoia trees, both in their physical and chemical properties. The critical difference controlling grove boundaries apparently is the availability of summer moisture. Although sequoias were once widely distributed throughout the northern hemisphere, the sequoia is thought to have been reduced to its present boundaries by volcanic eruptions, glaciation, and climatic changes [Cook, 1961]. Descriptions of the soils in which the sequoias are found, as well as some laboratory testing have been made in studies conducted by Zinke and Crocker [1961].

These soils have a deep surface litter, two to three inches deep, with a sandy loam soil texture throughout the mineral portion. The bottom of the soil profile shows gleyed colors indicative of a fluctuating water table, and weathered gruss occurs below the mineral soil. There is some evidence to suggest that ample jointing patterns in the granitic basement rock with proper aspect for conditions of water flow from upper watershed storm events is the source of summer moisture flow. The jointing patterns have been mapped by Ross, and a good correlation between upper watershed summer storms and subsurface moisture tensions in the sequoia groves was found by Rundel [Ross, 1958; Rundel, 1972].

The area mapped as the Shaver series, deep variant, may be variable in its properties, with surface litter and the darkened surface mineral soil eroded by foot traffic. Areas of rock outcrops and elevated areas with shallow soils, as well as poorly drained soils, have not been delineated in this mapping unit. Rather, soil boundaries were set to correspond with the Sequoia boundaries on the vegetation map. Large areas of the Holland series probably occur in this mapping unit.

Much research has been accumulated relative to the impact of park visitors on soil conditions in the Giant Forest area, as well as secondary impact on the giant sequoias trees. Observations have been made by Hartesveldt [1965] and others on the effects of removal of the protective surface litter and the physical wearing of the mineral surface soils (up to three feet in some areas) by the constant pounding of foot traffic. The danger of creating unfavorable conditions for water and air movement to the relatively shallow rooted giant sequoias as a result of soil compaction by the "enthusiastic but unconsciously predatory population of visitors" was noted as early as 1926 by Meinecke [1926]. Quantitative measurements of changes in soil bulk density from the present human impacts have been shown to be significant by Hartesveldt [1962, 1965] but correlations with incremental growth rates indicate that the growth of mature trees apparently have not as of yet been directly affected. Apparently, groundwater sources of moisture compensate for the decreased infiltration of water from rainfall resulting from soil compaction.

However, incremental growth rate may not be the best variable for documenting adverse impacts of soil structure deterioration. Statistically, this measurement may not be sensitive enough to differentiate between natural climatic fluctuations, long term climatic changes, and impeeded growth responses in sequoias.

Apart from direct impacts on the sequoias, there are other continuing secondary impacts on the vegetation associated with the Shaver mapping unit that should be described. These impacts remain hypothetical at this time, and need further observations and research to substantiate.

The continued long-term erosion of soil surfaces adjacent to the shallow-rooted giant sequoia trees may increase the probability of tree toppling during extreme conditions of saturated soils and high winds. Tree toppling is believed to be one of the greater causes of mortality of mature sequoia. The secondary impacts of the fall of a 1,500* ton tree are obvious, and will not be further elaborated. Soil compaction, reducing soil areation in the rooting zone of the sequoias and other conifers of the grove, may increase the likelihood of attacks by root pathogens, reducing the strength of the rooting systems of the trees.

The direct destruction of seedlings and young saplings as well as other understory vegetation under foot traffic has been well documented in research carried out in other parks and forest recreation areas [see D.W. Lime and G.H. Stankey, 1971]. The exposure of bare mineral surfaces and changes in moisture relationships may be a significant factor in decreased seed germination and early growth of plants. The loss of understory vegetation and a change in the runoff characteristics of soil surfaces would also accelerate rainfall erosion.

It should be remembered that these are existing impacts that have been occurring continuously since the park was

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* Gen Sherman, 272' tall, 102' circumference at the base, 600,120 Bd. Ft.

established in 1890, with little apparent damage to the park's prime resource the Sequoia gigantea. However, the influence of park visitors on the associated vegetation of the sequoia groves has been significant to the extent that the visitor can no longer perceive the sequoia in their native habitat. Such continuing and existent impacts should be viewed as a function of the number of visitors per unit area. The long term recreational carrying capacity of natural areas has yet to be determined.

Meadow Soils (Qal). These soils are of a recent age and lack any significant profile development. Many of the meadow areas may have been water impoundments created by morained damming of streams during glacial activity, which have subsequently been filled by granitic alluvium and decaying organic matter. These soils are well stratified containing deposits of unsorted sands and gravels mixed with organic materials, and larger cobbles. Most meadow soils are deep, exceeding ten feet in depth, with a water table at or near the surface year round. Vegetation associated with this mapping unit includes grasses, rushes, sedges, willow, and lodgepole pine.

Both continuously wet meadows, and meadows in which the surface dries in summer months exist in the study area, but no attempt has been made to further differentiate this mapping unit.

Poor drainage conditions and flooding hazards during snowmelt periods present a major constraint to development on this mapping unit. Meadow areas are major recharge areas for groundwater, and meadow vegetation may be adversely affected by activities which indirectly raise or lower the water table, or by the introduction of nutrients from sewage disposal sites. The maintenance of the natural vegetation associated with meadow soils creates a major constraint to any type of activity near the meadow that generates an increased use. Meadow soils may be subject to compaction under heavy foot traffic, to deterioration of soil structure, and direct damage to vegetation. Foot paths worn through meadow areas may effectively drain the surface soil, lowering the water table and changing the natural characteristics of the meadow. Vegetative changes as a result of man's activities, have been noted in research conducted in Sequoia National Park by VanKat [1970], Leonard, et al, [1968], and Hubbard, et al, [1966].

Description of Soil Limitations, Sensitivities, and Constraints. The soil and geologic mapping units previously described are summarized in Table A and interpreted in Table B. A soil sensitivity map has been constructed to represent areas in which development on designated soil and geologic materials would not be desirable either because site location would be difficult, costly and dangerous, or would create adverse environmental impacts which could not be mitigated. Included in the categories of very high, high, medium, and low sensitivities are such factors as the geologic hazard of landslides, the limitation for site location of shallow soils, and the environmentally sensitive soils which are subject to erosion and soil compaction. The following criteria were used in determining the sensitivity ratings:

Slight	All interpretations slight to moderate
Moderate	1 high limitation or hazard permissible
High	2 high limitations or hazards permissible
Very High	1 very high, or 3 high and very high

For general planning purposes the map identifies areas to be avoided in the location of facilities. In many instances the map serves to locate areas in which construction activities would not be prohibitied but would require special precautionary measures to avoid undesirable effects. As an example, some geologic and soil constraints including some landslide hazards are indicated in the Lodgepole area; these will require

TABLE A

SOIL CHARACTERISTICS AND QUALITIES*

Soil Name	Surface Texture	Subsoil Texture	Substratum	Effective Depth (inches)	Available Water-holding Capacity (inches/inches)	Drainage	Permeability	Runoff
Landslides	large boulders	tallus	rocks	--	--	excessive	--	rapid
Dinkey-Morainal Deposits	loamy coarse sand, c/ boulders	loamy, coarse sand c/ boulders	morainal deposits	36->60	3-5	excessive	rapid	slow
Shaver Deep Varriant	sandy loam	sandy loam	granitic	45-60+	5-8	apparent subsurface flow	moderate	medium
Ahwahnee	sandy loam	sandy loam	granitic	24-45	3-5	well	moderately rapid	medium
Auberry	sandy loam	sandy loam	granitic	30-48	3-8	well	moderate	medium
Rock Outcrop	granitic rock land	--	granitic	variable	<1	excessive	--	rapid
Toem Complex	gravelly loamy coarse sand	gravelly loamy coarse sand	granitic	3-20	1-3	well	rapid	rapid
Holland Series	sandy loam	sandy clay loam	granitic	40-60	8	well	moderate	medium
Shaver Series	sandy loam	coarse sandy loam	granitic	35-45	5	well	rapid	medium
Chawanakee Series	sandy loam	sandy loam	granitic	10-24	1-2	excessive	rapid	medium
Gefo Series	coarse sandy loam	coarse sandy loam to silica pan	glacial fluvial	>60"	3-5	well	moderately rapid	medium
Meadow Soils	sandy loam, organic overburden	stratified silts, sands and gravels	stratified alluvium	>60"	3-8	poor to somewhat poor	inundated	slow, subj. to flooding
Shinn Series	sandy loam	sandy loam to silica pan	glacial-fluvial	>60"	5-8	well	moderately rapid	medium
Tollhouse Series	stony coarse sandy loam	stony coarse sandy loam	granitic	3-20"	1-2	excessive	moderate	rapid

* Data modified from California Division of Forestry, 1972.

TABLE B

SOIL INTERPRETATIONS *

Soil Name	Unified Soil Class	Erosion Hazard**	Compaction Hazard	Dust Hazard	Shrink-Swell Potential	Bearing Capacity	Fertility Moisture Regime	Sensitivity Constraint Rating***
Landslides	GP	very high stability problems	slight	slight	slight	severe	low	very high
Dinkey-Morainal Deposits	GW	slight to moderate	slight	slight	slight	moderate	moderate	slight
Shaver-Deep Variant	SM	moderate to high	high	slight	slight	moderate	high	moderate
Ahwahnee	SM	very high	high	slight	slight	moderate	low	very high
Auberry	SM	high	high	slight	slight	moderate	low	high
Rock Outcrop	--	very high	slight	slight	slight	slight	low	high
Toem Complex	SW	high	slight	slight	slight	severe	low	high
Holland Series	SM	moderate	high	slight	slight	moderate	moderate	moderate
Shaver Series	SM	slight to moderate	high	slight	slight	moderate	high	high
Chawanakee Series	SM	moderate to high	high	slight	slight	severe	moderate	moderate
Gefo Series	SM	high	high	slight	slight	--	moderate	high
Meadow Soils	SM	slight	very highly compressible	slight	probable high shrink-low swell if drained	severe	high	very high
Shinn Series	SM	high	moderate	slight	slight	--	moderate	high
Tollhouse Series	SW	very high	high	slight	slight	severe	low	very high

* Modified from S.C.S., F.S., criteria and other studies.
** Depending on slope
*** See note on Soil Sensitivity in text.

specific design and engineering solutions in the site planning phase.

The soil mapping units are divided into four sensitivity classes for purposes of environmental impact assessment, but for planning purposes and mechanics of the composite sensitivity interpretations only three classes were delineated. The high and very high classes were categorized together as undevelopable, while compaction hazard was not considered a high criteria for site location.

Climate

The climate of the Giant Forest area is characterized by warm dry summers and moderately cold, wet winters. Table C presents mean monthly temperature and extreme temperatures, mean monthly and extreme precipitation, and mean and extreme snowfall.

Ninety-three percent of the annual precipitation falls in the period from October through April, mostly in the form of snow. Summer precipitation may be classified in three general categories [Hannaford and Williams, 1967]: isolated thundershower activity consisting of thundershowers scattered in time and space; generalized thundershower activity covering larger areas and lasting several days; and general storms resembling, in many respects, winter cyclonic storms.

The Sierra Nevada acts as a barrier to air masses moving easterly. The air mass is cooled as it is forced over the Sierra, and because of the inverse relationship between temperature and water holding capacity of an air mass, it is precipitated out resulting in an increase in precipitation with elevation. This effect is readily seen in the mean annual precipitation of stations located near Giant Forest: Ash Mountain (Elevation 1,700 feet) which receives 27.78 inches, Giant Forest (6,400 feet) 42.60 inches, and the higher elevation areas estimated to receive from 27 to 60 inches depending upon height and exposure.

TABLE C

CLIMATIC DATA

GIANT FOREST, CALIFORNIA
(1951-1960)*

	Temperature (°F)					Precipitation (inches)		
	Highest	Mean Maximum	Mean	Mean Minimum	Lowest	Mean Montly	Max. Monthly	Mean Snowfall**
Jan	50	36.9	29.9	22.8	0	9.02	19.13	44.4
Feb	59	41.1	32.2	23.4	4	6.70	10.74	44.2
Mar	64	46.1	35.5	24.9	2	6.36	17.90	43.3
Apr	73	51.4	40.9	30.2	11	4.87	11.46	19.5
May	82	57.2	46.2	35.3	17	2.48	11.26	4.1
Jun	86	66.8	55.2	43.6	23	.43	.98	.1
Jul	87	75.8	63.5	51.1	38	.08	.23	0
Aug	88	74.9	61.8	48.6	33	.13	.94	0
Sep	90	72.1	58.8	45.3	28	.65	7.82	.1
Oct	79	60.8	49.2	37.7	18	1.01	3.04	2.5
Nov	65	46.9	38.1	29.3	4	3.21	5.58	12.1
Dec	60	39.6	32.7	25.8	3	8.30	28.31	34.9
Ann	90	55.8	45.3	34.8	0	43.23	61.50	205.2

*Source: Department of Commerce, 1964.
**Source: Department of Commerce, 1953, period of record 1931-1952.

Air Quality

No information is currently available to determine the status of existing air quality within the study area. There has been no monitoring of pollutant levels and no meteorological measurements or modeling attempts within the park area. Therefore, only estimations of possible conditions will be made which should be used to indicate the need for more serious examination of the problem.

The study area lies on the western slopes of the Sierra Nevada above the more populated San Joaquin Valley. Sources of pollutants in the vicinity include the heavy vehicular traffic that passes over General's Highway, natural emissions of hydrocarbons from vegetation and primary and/or secondary pollutants transported into the area from out of the valley.

Vehicular. Table D presents some calculated values of vehicular emissions based on estimated vehicular miles driven within the study area (see "Transportation and Circulation"-baseline). Vehicular miles (VM) were multiplied by emission factors used by the California Division of Highways [Beaton, et al, 1972] and the Environmental Protection Agency [Environmental Protection Agency, 1972] for modeling emission inventories similar to this attempt.

Actual emissions will probably differ from amounts in Table D as a result of several factors. No attempt was made to adjust emission factors for the differences in vehicle operation at high altitudes when they are tuned for lower elevations. Carbon monoxide (CO) and hydrocarbons (HC) are especially prone to increased emissions under these conditions. No estimations of bus or truck traffic were included in the calculations since no reliable values were available. Finally, no estimation was attempted for the total idling time of each vehicle. Emissions of CO and HC are again prone to increase during idle and acceleration.

TABLE D

ESTIMATED VEHICULAR EMISSIONS IN VICINITY OF STUDY AREA*
(tons/day)

POLLUTANT	NON-PEAK DAY	PEAK DAY	MAXIMUM PEAK DAY
Carbon Monoxide	1.10	2.05	3.22
Hydrocarbons	.14	.27	.42
Nitrogen Oxides	.11	.21	.33
Particulate Matter	.006	.01	.02

*Based on estimated vehicular miles driven in study area.

Vegetation. In a study of air quality at Yosemite National Park, it was estimated that vegetation contributes HC in amounts that were comparable to those produced by man-made sources [Aerovironment, 1973]. Reactive HC are known to be produced by trees (including redwood) common to the study area, but no estimation of the quantity can be made in the absence of on-site measurements [Rasmussen and Went, 1965; Rasmussen, 1972; Public Health Service, 1970]. It can be stated that the most active period of emissions is during the warm summer days that are also high traffic days in the study area [Rasmussen, 1972].

Transport. The study area may receive pollutants from upwind sources on the floor of the San Joaquin Valley. During the summer, a strong upslope flow of air moves into the Sierra Nevada from the valley floor, especially during the afternoon. Studies in various parts of the Sierra Nevada have observed pollutants in this flow [see Bell, 1969, Miller and Millecan, 1971; Miller et al, 1972].

No estimation of the extent of this phenomenon in the study area can be made since little data are available for analysis. However, Mineral King, an area somewhat similar to the study area and 15 miles to the southeast, was the subject of a study by Miller, et al. [1972], and some of the basic mechanisms observed there can be extended to the study area.

In the Mineral King study [Miller, et al., 1972] it was found that the oxidant (O_x) level was significantly higher at night and at comparable levels during the day when Mineral King ranger station was compared to the more densely populated Fresno. Oxidants and precursors of O_x were probably moved up to Mineral King during the afternoon, accumulated under a shallow inversion layer, and remained through the night. When the sun rose the next morning, the ultraviolet radiation acted upon the O_x precursors (e.g. nitrogen oxides and hydrocarbons) and formed more oxidants. It was felt that the destruction of ozone (the principal oxidant) did not take place or was reduced by the absence of free nitric oxide (NO), which would not be as abundant at Mineral King in the absence of any significant vehicular traffic. Therefore, the morning level of O_x was already quite high and was increased by the newly formed O_x.

The study area differs from Mineral King to some extent. While it does lie in the Kaweah River tributary system, as does Mineral King, the wind flow route is somewhat more circuitous to the study area. The study area lies at an elevation of 500 to 1,000 feet lower in a valley which is wider, somewhat shallower, and which may not be as subject to inversion as Mineral King. Traffic volumes are much higher in the study area.

Extrapolation from the Mineral King study to the study area, considering the differnces between the two sites and the results of the Yosemite study, indicates that conditions that may be expected would include: 1) the precursors of photochemical oxidants would be abundant in the study area resulting from the vehicle emissions and possibly from naturally occurring hydrocarbons produced by the trees in the area; 2) some pollutants may be added to the areas burden by transport from the San Joaquin Valley; and 3) pollutant levels are probably above ambient air quality standards for hydrocarbons, at least on some peak-traffic days and maximum peak days. Oxidants may exceed standards at times in the summer but other pollutants are probably not in danger of exceeding standards.

The effects of various pollutants are being investigated by several people [e.g. Millecan, 1971; Miller and Millecan, 1971]. Much is not understood about the actual mechanism or the pollutant concentrations that cause damage.

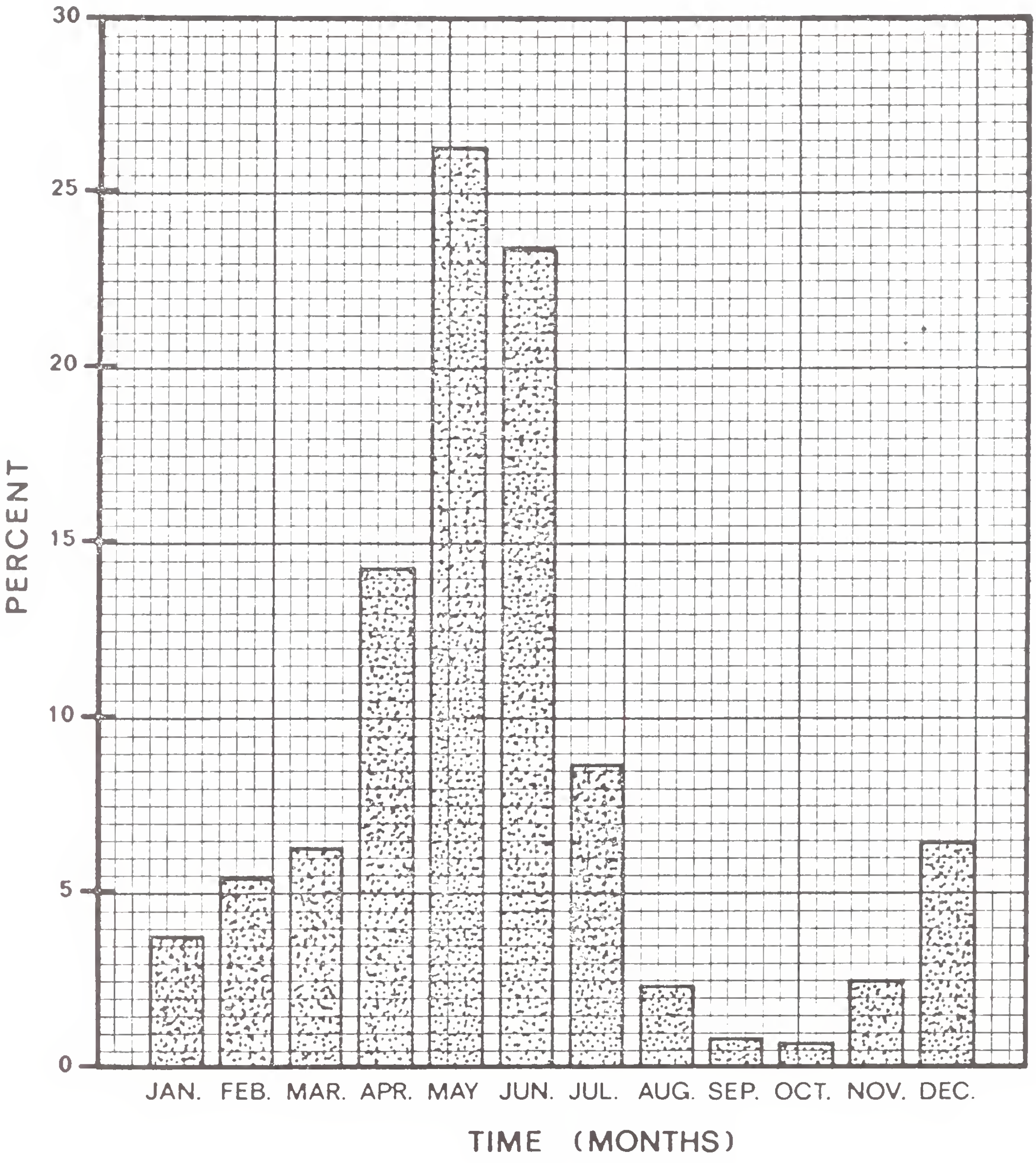
A checklist of various trees and their sensitivity to oxidants is available from the Forest Service and has been used to compare the characteristics of trees common to the study area (Table E). The sequoia and sugar pine are considered to be affected the least of the trees on the list. In the Lake Arrowhead area of southern California, sequoias are being planted to replace the ponderosa pine that have been adversely affected or killed by high oxidant levels [Millecan, 1973].

An additional contaminant that has not been examined is lead. The principal lead pollutant source is believed to be the emissions of motor vehicles using gasoline with anti-knock additives [Stern, 1968]. No estimations of amounts of lead that are present in the study area have been made. Some portion of particulates (Table D) are made up of lead particles [Environmental Protection Agency, 1972]. Lead particles are not considered to be a serious threat to the well being of vegetation. Particles are found at their highest concentrations on the plant surfaces (leaves bark, etc.) and are easily washed off by rain. Apparently very little or no heavy metals are assimilated by plants [Millecan, 1973] and the only possible danger to an organism is if lead particulate coated leaves are ingested as a major portion of its diet over a long period of time.

<u>Hydrology</u>

The Giant Forest-Lodgepole complex is within the Marble Fork drainage of the Kaweah River system. The Marble Fork is a 32,896 acre watershed ranging in elevation from 2,150 feet at the U.S. Geological Survey gaging station number 11-2080 to an 11,485 foot peak north of Table Meadows [U.S. Department of Interior, 1971b].

Mean annual streamflow is 100 cubic feet per second (cfs) with extremes of 1.6 cfs and 12,500 cfs. Fig. 12 presents monthly discharges as a percentage of annual flow. Distribution of streamflow through the year is typical of mountain watersheds receiving most precipitation in the form



MONTHLY DISCHARGE AS A PERCENT OF ANNUAL DISCHARGE
MEASURED AT POTWISHA ON THE MARBLE FORK
OF THE KAWEAH

FIG. 12

TABLE E

PARTIAL LISTING OF OXIDANT TOLERANCE OF TREES COMMON TO SEQUOIA AND KING CANYON NATIONAL PARK

Common Name	Tolerance
Giant sequoia	Good
Sugar pine	Good
Incense cedar	Fair
White fir	Fair
Ponderosa pine	Poor
Aspen	Poor
Willow	Poor
Mountain alder	Poor

Source: Adapated from USDA Forest Service, 1972b of snow. Greater than 63 percent of the annual runoff occurs during the April through June period while nearly 50 percent occurs during the months of May and June. Once the snowmelt period has ended, stream flow is supported by base flow until November when the autumn rains begin.

Floods are of two types: snowmelt floods, characterized by large volumes of water distributed over a relatively long period of time, and winter rain-on-snow events, characterized by relatively low volumes of water but occurring in short periods of time [Blair-Westfall Associates, 1963]. The highest peak discharge recorded at the gaging station on Marble Fork (12,500 cfs) was such a rain-on-snow event occurring in December, 1955. Blair-Westfall Associates [1963] estimates the peak 100-year discharge to be 38,000 cfs.

Most precipitation occurs during the winter in the form of snow. Table C presents the distribution of precipitation and temperature during the year. Two snow courses are located within the Marble Fork drainage, at Panther Meadow and Giant Forest. Mean snow depth on April 1 at Panther Meadow is 91 inches (water content 34.6 inches) and at Giant Forest it is 41 inches (water content 16.5 inches). Summer precipitation is in the form of widely scattered thunderstorms.

The Giant Forest grove of sequoias is essentially contained within three small watersheds: Sherman Creek, Little Deer Creek, and an unnamed tributary south and west of Giant Forest. The only substantial portion of the grove outside these three watersheds lies in the Crescent Creek Fork of Moro Creek in the Middle Fork Kaweah River. All watersheds have a northwest aspect except Moro Creek which has a south aspect. The aspect will significantly affect snow accumulation and melt rates.

There is strong evidence indicating that available soil moisture is a limiting factor in the local occurrence of giant sequoia [Rundel, 1972], i.e., the giant sequoia are found in those areas having a higher soil moisture content than the surrounding area. In his analysis of soil moisture, Rundel found that soil moisture was consistently higher within the grove compared to outside the grove and actually increased in mid-summer, especially at lower soil depths. The source of this mid-summer water in the absence of recorded precipitation is imperfectly understood. Possibly, this recharge is attributable to a summer dormancy experienced by the mixed conifer stand found at the higher elevations of the watershed. If the giant sequoia do not experience a summer dormancy, their continued transpiration will increase soil moisture tensions within the root zone, and water available from the higher elevations, will slowly move downslope to augment the soil moisture within the grove.

It is also conceivable that the water is moving through the joints in the bedrock. Such a hypothesis would be partially supported by the strike of the igneous foliation [Ross, 1958]. The actual process taking place, even whether or not soil moisture is significant in the location of the giant sequoia, is hypothetical and demands more intensive investigation. Another question needing study is whether the giant sequoia are located where they are because of the soil moisture recharge or whether the recharge occurs because of the presence of the giant sequoia.

An estimate of the potential evapotranspiration has been computed using the Thornthwaite method [Chow, 1964]. This method was selected because of a lack of more extensive data for the Giant Forest area. A correction factor was applied for latitude (Table F). A soil moisture capacity of 1.2 inches was assumed based on a moderately coarse soil [Soil Conservation Service, 1969]. Further, assuming a soil depth of 60 inches, the total soil mositure capacity is 6 inches. Table F indicates a soil mositure deficiency existing in July. This deficiency could actually occur in late June marking the start of the mixed conifer summer dormancy.

TABLE F

SIMPLIFIED WATER BALANCE FOR THE GIANT FOREST AREA

Month	Precip. (P) (inches)	Potential Evapotranspiration (PE_t) (inches)	$P-PE_t$	Soil Moisture (inches)
Jan	6.34	0.10	+6.24	6.00
Feb	8.77	0.21	+8.56	6.00
Mar	6.51	0.67	+5.84	6.00
Apr	4.74	1.20	+3.54	6.00
May	1.60	2.21	-0.61	5.39
Jun	0.70	3.24	-2.54	2.85
Jul	0.13	4.43	-4.30	-1.45
Aug	0.09	4.01	-3.92	-5.37
Sep	0.29	3.03	-2.74	-8.11
Oct	1.92	1.89	+0.03	-8.08
Nov	4.23	0.92	+3.31	-4.77
Dec	7.28	0.35	-6.93	+2.16
	42.60	22.26	+20.34	

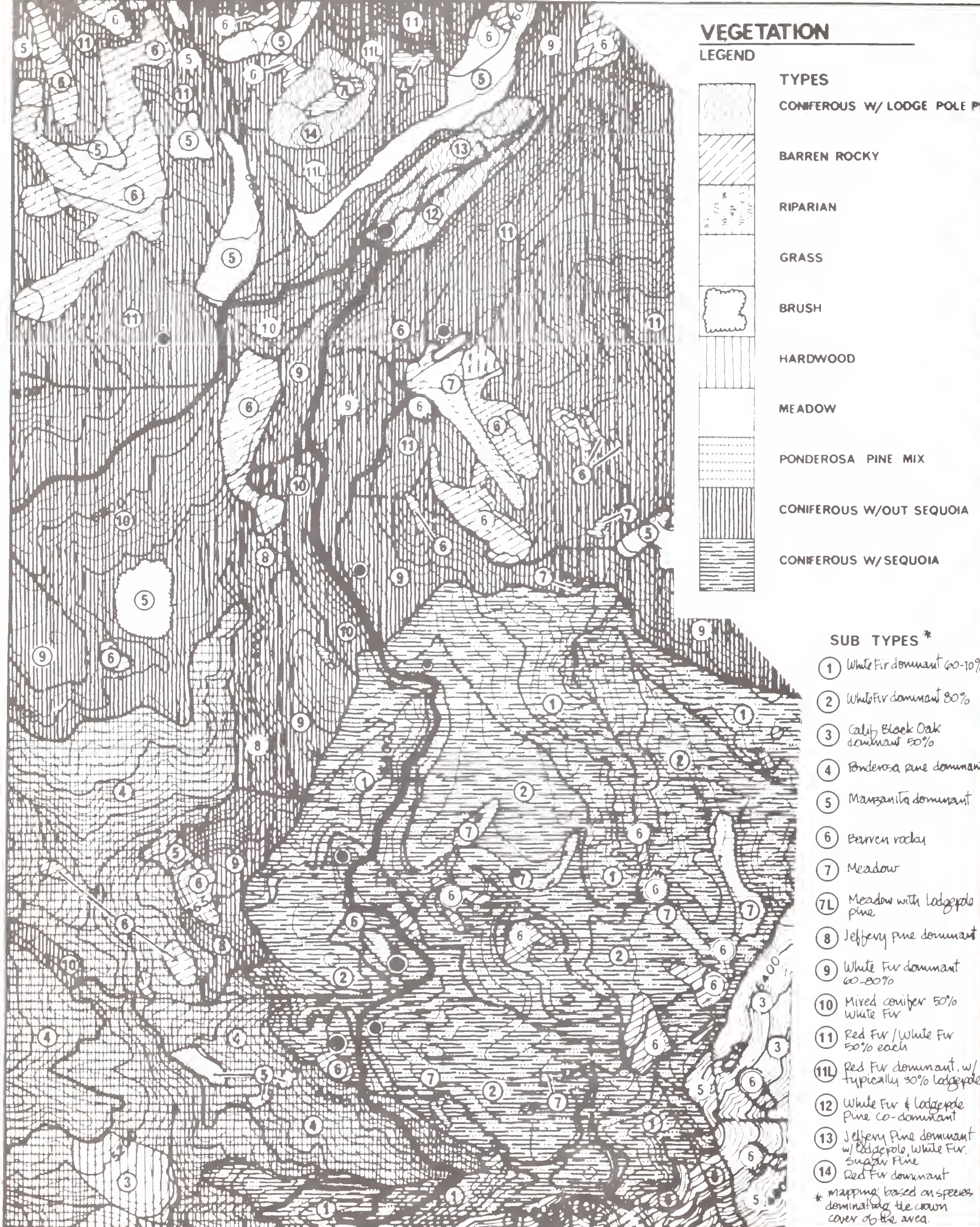
Vegetation

The study area has a great diversity of vegetation as would be expected over the elevation range of approximately 5,000 feet. The variety of vegetation has developed in response to a dry summer climate and a cool, moist winter climate wherein most of the precipitation, about 43 inches annually at Giant Forest, falls in the form of snow.

The vegetation was mapped for the study area in a form and was accomplished to the degree of detail that should provide an adequate basis for the conceptual planning. While considerable field checking was done, most of the species determination and determination of plant associations was based on the authors' extension of data, relying on their knowlege of the areas ecology and photo interpretation. Because of the need for an extensive approach involving an area in excess of 15,000 acres, it is recommended that specific areas be scrutinized more closely in the field after a plan is adopted to make sure that there is conformity. Except for prominent features, i.e., meadows and rock outcrops, the mapping consisted of 40-acre minimums.

The vegetation types and additional subtypes were mapped as noted in Fig. 13. The subtypes were delineated on the basis of dominant species as determined by crown cover and in some cases are within broader types. The results are a bit complicated with some overlapping subtypes, but this is hopefully justified in an attempt to put maximum emphasis on the prime resource sequoias and other sensitive types. Please refer to Table G for a partial list of vegetation species in the study area.

Coniferous with Sequoia. The vegetation of the sequoia stands at Giant Forest is numerically dominated by white fir, but sugar pine is also a characteristic associate. Red fir becomes more common at higher elevations, while incense cedar is a frequent lower elevation associate.



Development Concept Plan
Giant Forest - Lodgepole Complex
Sequoia/Kings Canyon National Park, California

Vegetation

Fig.13

TABLE G

PARTIAL LIST OF VEGETATION SPECIES IN STUDY AREA

COMMON NAME	SCIENTIFIC NAME
TREES	
Giant sequoia	Sequoia gigantea
Jeffrey pine	Pinus jeffreyi
Western white pine	Pinus monticola
Lodgepole pine	Pinus contorta
Sugar pine	Pinus lambertiana
Ponderosa pine	Pinus ponderosa
Mountain hemlock	Tsuga mertensiana
Incense cedar	Libocedrus decurrens
White fir	Abies concolor
Red fir	Abies magnifica
Sierra juniper	Juniperus occidentalis
California black oak	Quercus kelloggii
Aspen	Populus tremuloides
Willows	Salix spp.
Mountain alder	Alnus tenuifolia
Creek dogwood	Cornus californica
SHRUBS	
Mountain gooseberry	Ribes montigenum
Mountain white thorn	Ceanothus cordulatus
Snow brush	Ceanothus velutinus
Squaw carpet	Ceanothus prostratus
Chinquapin	Castanopsis sempervirens
Green manzanita	Arctostaphylos patula
Pinemat manzanita	Arctostaphylos nevadensis
Bitter cherry	Prunus emarginata
Red elderberry	Sambucus racemosa

TABLE G CONTINUED

Western azalea	*Rhododendron occidentale*
Sierra laurel	*Leucothol davisial*
Labrador tea	*Ledum glandulosum*
Service berry	*Amelanchier alnifolia*

SEDGES, GRASSES AND HERBS

Sedge	*Carex lanuginosa*
Sedge	*Carex rostrata*
Sedge	*Carex Nebrascensis*
Sedge	*Carex festivella*
Sedge	*Carex vicaria*
Sedge	*Carex spectabilis*
Sedge	*Carex subnigricons*
Grass	*Poa pratensis*
Snow plant	*Sarcodes sanguinea*
Lotus	*Lotus crassifolius*
Bracken fern	*Pteridium aquilinum*
Woodwardia fern	*Woodwardia fimbriata*
Sword fern	*Polystichum munitum*
Rush	*Juncus mertensiona*
Currant	*Ribes viscosissismum*
Sierra gooseberry	*Ribes roezlii*

With the exception of the giant sequoia, the vegetation of the associated forest stands is not unique. The numerous species are widely distributed over the Sierra Nevada conifer forest belt.

In the sequoia forest type, the sequoia typically do not dominate the canopy coverage (only about five percent in Sequoia and Kings Canyon National Park) but they often account for more than 50 percent of the total basal area [Rundel, 1971].

Understory shrubs and ground cover vegetation are extremely variable, but chinquapin has been observed to be the most consistent shrub associate [Vankat, 1970].

Subtype (1). White Fir is the dominant species but is well mixed with red fir, sugar, ponderosa pine, Jeffrey pine, and sequoia. This combination of species is found within the boundary of the "Coniferous With Sequoia" type and typically is about 60 to 70 percent fir, 20 to 30 percent pine, and 3 to 10 percent sequoia by crown cover. This represents a heavy pine mixture within the sequoia stand; as a matter of fact, some 5 to 10 acre parcels within the stand are mostly pine, but the 40 acre minimum unit obscures this fact. Typically the drier, more rocky ridge areas have Jeffrey pine and the less exposed areas have sugar pine. White fir dominates the fir stands in most cases but at higher elevations and on cooler exposures, red fir is common. The sequoias may average less than five percent crown cover in this subtype but account for 20 to 50 percent of the basal area.

Subtype (2). White fir is dominant. These fir dominant areas are typically 80 percent fir by crown cover and are within the stand boundaries of the sequoias. White fir is the dominant species but red fir is more common than in the above mix (Subtype 1 areas). Sequoias account for about five percent of the crown cover and sugar pine most of the remainder. Neither Jeffrey nor ponderosa are common within this species mix.

A more detailed discussion of the sequoias is found in the ecological section on Page 54.

The following mapping units numbered 3-7 are not considered to be particularly associated with the broad types.

Subtype (3). California Black Oak is the dominant species, occupying about 50 percent of the crown cover. Occasional ponderosa pine and incense cedar trees are found in the overstory. Manzanita and ceanothus brush species are most common in the understory. Other species scattered over this area include interior live oak, canyon live oak, and tan oak.

Subtype (4). Ponderosa Pine dominates the tree species crown cover in this area with black oak and manzanita common understory species. On areas too small to map, black oak, white fir, incense cedar, or manzanita dominate within this ponderosa pine area.

Subtype (5). Manzanita dominates in association with ceanothus species. Most of this association is on poor, rocky soil and has low vegetation density. On the higher elevation brush sites, Jeffrey pine is the most common tree species. The southfacing slope across the Marble Fork of the Kaweah River from the visitor center is an example of this type.

Subtype (6). The Barren Rocky type is scattered throughout the study area, inside and outside of the sequoia stands. While this type is dominated by large areas of bare granite, many characteristic plant species are found on the intermittent soil pockets, including Jeffrey pine as the dominant tree species along with minor associations of white fir, incense cedar, Sierra juniper, and manzanita.

Subtype (7). The Meadow and Associated Riparian types are observed throughout the study area. The meadows are typically open areas of predominately perennial sedges, herbs, rushes, and grasses associated with willow, aspen, and lodgepole pine. The riparian meadow association is exemplified by the wet area at the intersection of Wolverton Creek and Long Meadow. Other riparian areas are strips along streams and locations adjacent to seeps, springs, and other wet meadows. Willow, creek dogwood, alder, aspen, and lodgepole pine are often included in the riparian types.

Coniferous Without Sequoia. This type is widely distributed over the study area and is dominated by white and red fir, but many other species including Jeffrey pine, sugar pine, incense cedar, mountain hemlock, white bark pine, and Sierra juniper are not uncommon.

Subtype (8). Jeffrey pine is the dominant species with white fir the most common associate. This subtype typically is found below 6,500 feet on the steeper and warmer exposures.

Subtype (9). White fir is the dominant species with the crown cover usually in the range of 60-80 percent white fir and red fir; Jeffrey pine and sugar pine are common associates. This subtype forms the north and east boundary for the sequoia stands.

Subtype (10). This mixed conifer stand is usually dominated by white fir but typically white fir makes up less than 50 percent of the stand. Sugar and Jeffrey pines, incense cedar, and red fir are the most common associates with the pines typically accounting for 30 percent of the stand.

Subtype (11). This subtype is fir dominated with red and white fir typically about equally represented. Less than ten percent of the stand is sugar and Jeffrey pines.

Subtype (11L). This subtype is dominated by red fir with white also a common associate. This subtype is also associated with lodgepole pine which may account for 30 percent of the crown cover.

Coniferous Mix with Lodgepole Pine. This mixture is found throughout the park within the elevational range of

6,700 to 11,000 feet. On the basis of crown cover, stem density, and basal area, lodgepole pine is typically not the dominant species except on small areas, but lodgepole pine is an important constituent, with red fir and white fir the most common associates. Many shrub and herbaceous species are found in this type, but mountain gooseberry is the most consistent shrub association [Vankat, 1970]. In Sequoia National Park, lodgepole pine often occupies glaciated soils, and at the lower extension of its range in the park it is most common on north-facing slopes and edges of meadows and stream channels.

Lodgepole pine is aggressive in reproducing itself in open, disturbed areas; whereas its fir associates are more shade tolerant. Mountain pine beetle, (*Dendroctonus monticolae*) and the lodgepole needle miner (*Recurvaria milleri*) are the most destructive enemies of lodgepole pine and have destroyed large stands in Yosemite National Park.

Subtype (12). This subtype is a white fir dominant area with a substantial representation of red fir. Lodgepole pine typically occupies less than 40 percent of the crown cover but becomes dominant on small areas along the Marble Fork of the Kaweah River.

Subtype (13). This subtype is dominated by Jeffrey pine with lodgepole pine, white fir, and sugar pine typically nearly equal constituents of the stand. Again, lodgepole pine is most common near the river.

Subtype (14). Red fir is decidedly the dominant species in this meadow proximity area; however, lodgepole pine is dominant or codominant in small areas.

Ecological and Survival Aspects of the Giant Sequoias. Since the sequoia trees are very long lived, resistant to attacks from insects and disease, and older trees are fire resistant, their continued existence seems assured. Only moderate tolerance to the shade of competing vegetation and activities of man appear to be the most serious enemies of this species. Since white and red fir are much more able to reproduce within the coniferous stands with sequoias, it would appear that the sequoia trees will disappear when the climax species, white fir, has had sufficient time to exert its influence. Some sequoia ecologists, including Hartesveldt [1967] and Biswell [1961], believe that frequent wildfires have interrupted this successional process prior to man's association with these forests and that these frequent fires may be necessary to perpetuate the sequoias. The subject of fire ecology and the sequoias will not be discussed further here since it is the subject of a great deal of research and since preliminary conclusions are controversial in the forestry profession.

With an even start, giant sequoias are capable of outgrowing any of the associated species [Metcalf, 1948]. Because of its longevity and resistance to fire and other enemies, it is difficult to consider the sequoia as a successional species in the same context as its short lived associates. Also, the disturbances created by the crashing of a fallen forest giant may provide sufficient opportunity for natural regeneration. In any case, studies indicate that the sequoia stands of Giant Forest have neither shrunk nor substantially expanded during the last 500 years [Rundel, 1971]. Studies at Giant Forest indicate that only two sequoia seedlings would have to germinate and survive each year to equal the rate of mortality [Rundel, 1971].

It appears that past and continuing man-caused disturbances are potentially a more serious problem, but specific proof of this has not been clearly established at Sequoia National Park. Giant Forest has been subjected to substantial building and highway construction, especially in and near Camp Kaweah; while the visual impact is obvious, the ecological impact is uncertain. Since automobiles have only been allowed to bring visitors to the park since 1913, and since the visitor level was only approximately 10,000 per year by 1916, most of man's impacts are relatively recent. The potential dangers of soil compaction, polluted air, and other disturbances would appear to be more serious by 1954 when the annual visitor population reached 1,000,000 [Strong, 1968].

The cause of the sequoia stand limitation is not 100 percent clear, but this evaluation could also be important to its future existence. It appears that the glaciers historically may have influenced the present location of the sequoias at Giant Forest since the species is absent from glaciated areas and cold drainage areas associated with the glaciers. But a soil moisture difference between the forest stands with and without sequoia trees appears well substantiated and a more acceptable reason for sequoia stands limitation. Soil moisture transects indicate that Sequoia stands at Giant Forest have substantially more and more continuous moisture [Rundel, 1972]. Since the sequoias have established their ability to survive over a wide climatic range, it appears that the complete answer regarding distribution of sequoias lies in a sophisticated explanation involving the sequoia's relative ability to compete with associated vegetation under certain edaphic and climatic conditions. It is difficult to believe that the sequoia is especially sensitive to the environment outside of competitive and balance factors since it is indigenous to areas with precipitation ranges of 18 to 60 inches and grows on a wide variety of soils from shallow rocky to deep sandy loams [U.S. Forest Service, 1908]. A more complete discussion of the ecology and silvical characteristics of the giant sequoia may be found in Appendix C.

Wildlife

Sequoia National Park is inhabited by a great variety of animal life forms which, together with the trees and other plant life, make up the complex biological environment of this region. Several detailed papers and books have been written on the wildlife of the park; some of these are listed in the bibliography. For purposes of this report, the discussion is limited to the detail necessary to be useful as a baseline for planning purposes.

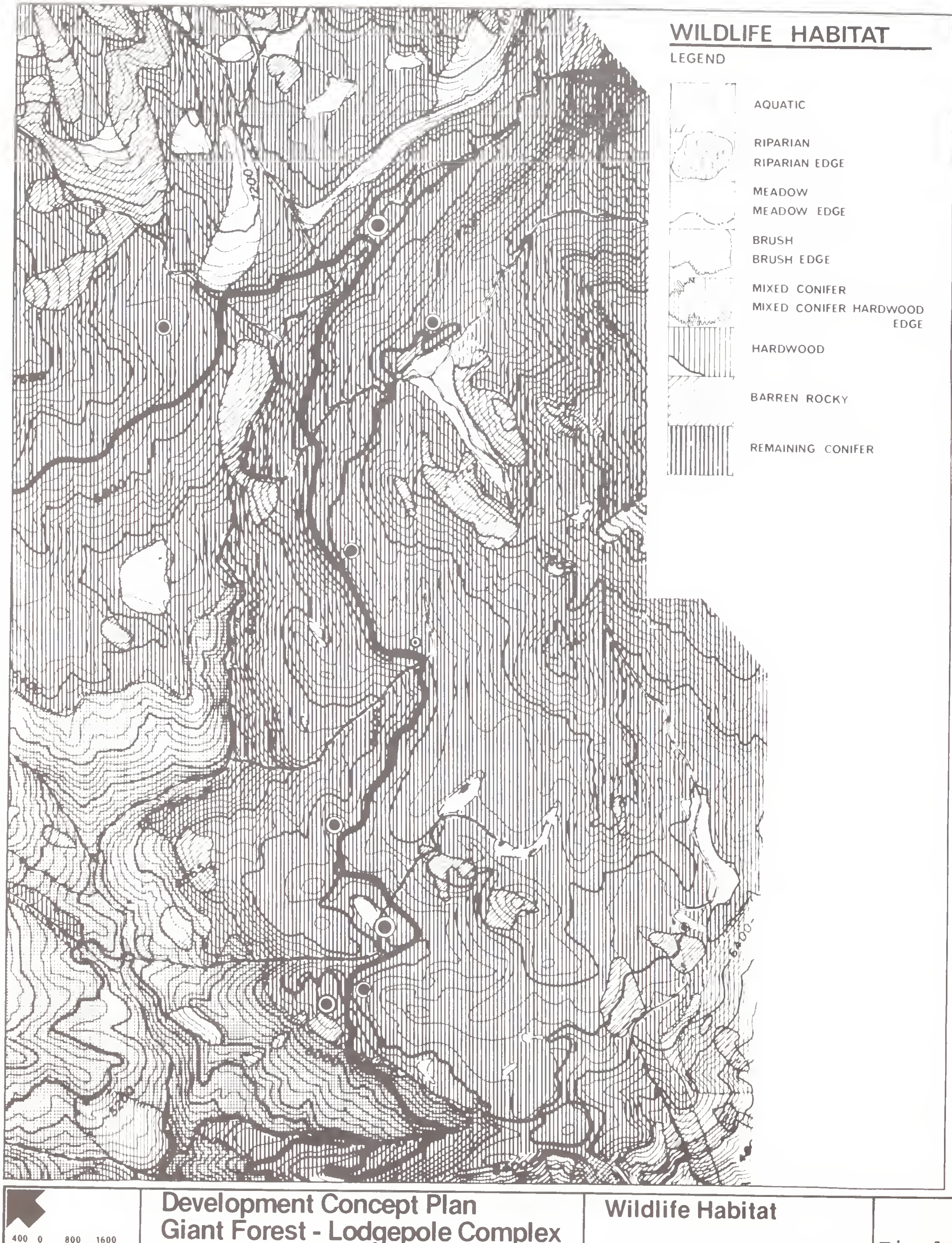
The Giant Forest and Lodgepole study areas within the park are part of the Sierra Nevadan Wildlife Region [Brown and Livezey, 1962]. Elevations in the project area range from approximately 4,400 feet to about 9,100 feet and include primarily the Transition and Canadian Life Zones. The following discussion of the wildlife community is broken into the two general categories of habitat types and the major wildlife groups and species themselves.

Habitat Types. A habitat is simply the particular combination of living and non-living elements in the environment which form an animal's "home." Some species of wildlife are very adaptable and find many different habitats favorable. Other animals have evolved highly specialized adaptations to certain habitats and cannot survive in others. Several habitat types are found in the study area and are briefly described in the following paragraphs (see Fig. 14 for locations).

Riparian. Riparian habitat is associated with abundant available water and is characteristically found along rivers and streams, and near springs and seeps. The vegetation is usually lush and thick, providing excellent food and cover. An example of this high-value habitat type is found in one small area at the northeast corner of Long Meadow where Wolverton Creek intersects it. It is also present in scattered locations along streams throughout the study area. Furbearers, birds, and amphibians are common inhabitants of this habitat, which is capable of supporting very high densities of wildlife populations.

Meadow. Middle mountain forest meadows are typically comprised of a wide variety of grasses and forbs. They provide excellent habitat and are especially valuable when they occur as occasional isolated breaks in forest environments. The vegetation provides food for grazing by deer and other aminals. Burrowing rodents, other small mammals, reptiles, and birds are common inhabitants. Birds of prey find this habitat highly favorable for hunting because of the abundance of prey.

Aquatic. This habitat includes all of the streams in the study area. These streams provide a primary source



Development Concept Plan
Giant Forest - Lodgepole Complex
Sequoia/Kings Canyon National Park, California

Wildlife Habitat

Fig.14

of drinking water for many animals and also provide a home for fish, amphibians, and a variety of aquatic insects.

Brush. The brush fields in the project area provide good cover for many bird and mammal species. Some of the brush species, such as bitter cherry and snow brush, furnish important food for the local California mule deer.

Hardwood. This type occurs in limited quantities below 7,000 feet elevation and consists primarily of oak trees with a variety of understory shrubs. This is good deer habitat because of the food and cover afforded by both the oaks and the understory plants.

Conifer. The coniferous forests grouped under this classification include the sequoias of Giant Forest, the firs and lodgepole, sugar, ponderosa, western white, Jeffrey, and other pines of the area. The value of this habitat to wildlife varies with the forest's condition relative to its successional stages, extent of understory vegetation, amount and availability of water, and the occurrence of other habitat types (such as meadows) within the forest. Basically, the younger forests with a good understory, available water, and interspersed meadows provide a better habitat for a diverse wildlife community. Generally, the forests dominated by fir species do not support as high a diversity and abundance of wildlife as do the forests dominated by pine species. These sub-types within the coniferous forest habitat are delineated on the natural resource base map for vegetation (Fig. 13). Small mammals such as chipmunks and squirrels as well as deer, insectivorous birds, and a variety of forest insects are common.

Mixed Conifer-Hardwood. This is a combination of these two types which have been previously described. Because it is a combination, it is more diverse in its surface environment and, hence, supports a more diverse wildlife community. Species common to both types are likely to be present.

Barren and Rocky. This category essentially includes all areas that are devoid of vegetation and/or are rocky. Overall wildlife value is much lower here than in the other listed habitats, but some species of reptiles and mammals thrive in rocky areas which contain crevices. Marmots find rocky areas very favorable.

"Edge" Habitat. The "edge effect" means that wherever two habitat types come together, the edge between the two types will be more favorable as wildlife habitat than either type considered alone. It is often the amount of "edge" in a given environment that determines its wildlife carrying capacity. A meadow-forest "edge" is valuable to deer, for example, because it has the forage value of the meadow grasses with the security of the cover afforded by the nearby forest. Both species diversity and total biomass are greater in "edge" areas.

Wildlife Groups and Species. A very diverse wildlife community exists within the limits of the Giant Forest and Lodgepole study area. This is a reflection of the great elevational range and variety of habitats found there. Table H presents a representative list of the wildlife species which can be expected to occur in the study area, some of these animals are discussed in more detail as follows:

California Mule Deer. The California mule deer (*Odocoileus hemionus californicus*) is a common resident in the project area during the summer. During the winter, the animals migrate west to the lower elevations in the foothills and concentrate in areas such as Hospital Rock, Ash Mountain, Yucca Basin, and Clough Cove [Dixon, 1942]. The herds that summer in the Giant Forest area winter near Hospital Rock. The winter migration usually begins around November with the first hard snows. The spring migration back to the higher elevation summer range begins around March. The deer usually follow the receeding snow line, feeding on

TABLE H

A PARTIAL LIST OF EXPECTED WILDLIFE SPECIES

OF THE GIANT FOREST AND LODGEPOLE STUDY AREA

Common Name	Scientific Name
	Mammals
California mule deer	Odocoileus hemionus californicus
Black bear	Euarctos americanus califormensis
Mountain lion	Felis concolor
Bobcat	Lynx rufus
Gray fox	Urocyon cinereoargenteus
Yellow-bellied marmot	Marmota flaviventris
Raccoon	Procyon lotor
Ringtail	Bassariscus astutus
Marten	Martes americana
*Fisher	Martes Pennanti
*Wolverine	Gulo luscus
Striped skunk	Mephitis mephitis
Spotted skunk	Spilogale gracilis
Porcupine	Erethizon dorsatum
White-tailed jackrabbit	Lepus townsendii
Douglas squirrel (Chicaree)	Tamiasciurus douglasii
White-footed mice	Peromyscus spp.
Woodrats	Neotoma spp.
Moles	Microtus spp.
Shrews	Family Soricidae
Bats	Order Chiroptera
	Birds
Golden eagle	Aquila chysaetos
Red-tailed hawk	Buteo jamaicensis
Goshawk	Accipiter gentilis
Cooper's hawk	Accipiter cooperii
Sparrow hawk	Falco sparverius
Blue grouse	Dendragapus obscurus
Mountain quail	Oreortyx pictus
Spotted sandpiper	Actitis macularia
Band-tailed pigeon	Columba fasciata
Screech owl	Otus asio
Great horned owl	Bubo virginianus
Belted kingfisher	Megaceryle alcyon
Red-shafted flicker	Colaptes cafer
Hairy woodpecker	Dendrocopos villosus

TABLE H CONTINUED

Black phoebe	*Sayornis nigricans*
Violet-green swallow	*Tachycineta thalassina*
Steller's jay	*Cyanocitta stelleri*
Clark's nutcracker	*Nucifraga columbiana*
Mountain chickadee	*Parus gambeli*
Western bluebird	*Sialia mexicana*
Brewer's blackbird	*Euphagus cyanocephalus*
Reptiles	
Western fence lizard	*Sceloporus occidentalis*
Rubber boa	*Charina bottae*
Common kingsnake	*Lampropeltis getulus*
Western aquatic garter snake	*Thamnophis couchi*
Amphibians	
California newt	*Taricha torosa*
Ensatina	*Ensatina eschscholtzi*
California slender salamander	*Batrachoseps attenuatus*
Western toad	*Bufo Boreas*
Pacific treefrog	*Hyla regilla*
Mountain yellow-legged frog	*Rana muscosa*
Fish	
Rainbow trout	*Salmo gairdnerii*
Eastern brook trout	*Salvelinus fontinalis*
Brown trout	*Salmo trutta*
Western sucker	*Catostomus occidentalis*
Hard head	*Mylopharodon conocephalus*

the new spring grasses and forbs as they go. There are no known established migration routes as such through the project area. Fall migration movement within and immediately out of the summer range tends to be much more dispersed with more established routes formed on the intermediate range.

Feeding behavior of these animals varies considerably throughout the year. Grasses and forbs are an important food source during the spring and fall when they are most abundant. Shrub species such as bitterbrush, snow brush, bitter cherry, and manzanita are browsed by deer in summer and winter when herbaceous vegetation becomes scarce. During the summer, meadows and riparian zones are important to deer because they provide nutritious herbaceous food not available in other areas.

Fawns are born on the summer range during June-July. Nutritional requirements are high for both doe and fawn during this period. Requirements during the fawning period include adequate cover, good herbaceous food, and available water. Glades, springs, seeps, meadows, and riparian habitat are traditional fawning grounds.

The deer population in the Sequoia National Park region is presently considered to be at or near carrying capacity. There are, however, no serious problems with respect to over-utilization of the available food supply [Zardus, 1973].

Bighorn Sheep. The bighorn sheep (*Ovis canadensis*) occurs in the higher mountains to the east of the project area, and therefore, is not considered in detail here.

Black Bear. The Sierra Nevada black bear (*Euarctos americanus californiensis*) is a common resident in the study area and the remainder of Sequoia National Park. This animal is omnivorous, eating vegetation, berries, insects, honey, carrion, fish, frogs, fruit, and nuts. It also relishes human foods and is not adverse to raiding garbage cans in campgrounds or taking handouts when it can get them. It usually dens up and goes into hibernation for varying lengths of time during the winter. The young are born during this period, usually in January. A variety of habitats are occupied by the black bear, including forests, meadows, and brush.

The bear is not a serious problem at the present time, but occasionally a bear that becomes a "pest" is transported to higher back country.

Fisher. The fisher (*Martes pennanti*) is a member of the weasel family and is carnivorous. Its occurrence in the park is rare and it is seldom seen. They are wilderness creatures and do not tolerate human disturbance. Forest habitats are preferred.

Other Large Mammals. Several other large mammals are found in the study area. Among those that are carnivorous are the mountain lion, coyote, bobcat, grey fox, pine marten (uncommon), and the weasel. These carnivores play an important role in controlling the populations of rodents and other small aminals. Several other animals which fall into this category are listed in Table H.

Small Mammals. Many species of small mammals are found in the study area, particularly in the meadows and brush fields and other areas where good ground cover is present. They play a key role in the food chain as prey for larger mammals, birds, and reptiles. Included in this group are the squirrels, chipmunks, wood rats, mice, moles, and gophers.

Birds. Numerous species of birds occur in the study area--too many to discuss in detail. Those that deserve special consideration, however, are the birds of prey.

Hawks, eagles, and owls are predators which prey on small animals and help to keep their populations in balance with the rest of the wildlife community. They are also very majestic birds and possess considerable aesthetic appeal.

Because they are at the top of the food chain, they occur in low densities compared to other species of birds.

Meadows and other open areas are ideal hunting grounds for these predators. Nests of hawks and eagles are often built on high rocky cliffs or in tall trees.

Reptiles and Amphibians. Reptiles occur in most habitats within the study area. Lizards and snakes are the common forms. Some feed on smaller animals including mammals and other reptiles.

Amphibians are much more restricted than reptiles because of their requirement for water. They, therefore, are found in highest concentrations in meadows, riparian habitat, near streams, and very shady forests.

Insects. Some insects can be very destructive to forest trees and wildlife as parasites. However, others are valuable in that they provide a primary source of food to the local fisheries, insectivorous birds, reptiles, amphibians and some mammals.

Endangered, Rare, and Status-Undetermined Species

Rare and Endangered Species. The following wildlife species are considered to be threatened with extinction according to the Bureau of Sport Fisheries and Wildlife and/or the California Department of Fish and Game. These are all species for which known habitat preferences, existing distributaries, and past records indicate their possible presence within the Sequoia National Park boundary. With the exception of the spotted owl, it is highly unlikely that these species are found within the Lodgepole-Giant Forest study area.

California bighorn sheep (*Ovis canadensis californiana*). Classified as rare by the California Department of Fish and Game, its existing range includes the high mountain areas on the eastern boundary of the park.

Wolverine (*Gilo luscus*). Listed as rare by California Department of Fish and Game, this animal is intolerant of human disturbance and occurs primarily at elevations above 8,000 feet.

California condor (Gymnogyps californianus). Classified as endangered by California Department of Fish and Game, this species, the largest North American land bird, is not a resident or common visitor of the park, but occasional sightings are reported.

Southern bald eagle (Haliaeetus leucocephalus leucocephalus). This bird is listed as endangered by the California Department of Fish and Game. It commonly nests near lakes and rivers. It is listed as an "accidental" species on a checklist of birds for Sequoia National Park [Sequoia Natural History Association, Inc., 1972].

Spotted owl (Stirix occidentalis). This species is considered to be "threatened with extinction" by the U.S. Bureau of Sport Fisheries and Wildlife. It is an uncommon resident of the park and is not often seen. The preferred habitat is old growth timber.

Status Undetermined Species. A status-undetermined species or subspecies is one that has been suggested as possibly threatened with extinction, but there is not enough information to determine its status. All animals in this category are classed as such by the U.S. Bureau of Sport Fisheries and Wildlife [1973].

Pine marten (Martes americana). This fur-bearing carnivore prefers dense uncut fir forests and does not tolerate disturbance by man. They are becoming increasingly scarce, but are occasionally reported in the park.

Fisher (Martes pennanti). The fisher is larger than the pine marten and more rare. It is a carnivore with great strength and agility. This species is also intolerant of human disturbance and prefers the wilderness.

Sierra red fox (Vulpes fulva necator). This subspecies of the red fox was described by Dixon [1942] as a "rare resident in the higher mountains of the Sierra Nevada and the Sequoia region, usually found at or near timber line."

Fisheries

There is very little recorded data on fisheries in Giant Forest and Lodgepole. Almost all of the game fish in the creeks are rainbow and eastern brook trout. Some brown trout have established themselves in the Kaweah River. Some golden trout are located in the high country outside the project area, but these are not pure strains [Zardus, 1973]. Table I briefly describes the life history and habitat data for the species of trout found in or near the study area.

Some problems have been experienced with non-game fish in the lower part of the Kaweah River. Sucker (*Catostomus occidentalis*) and hard head (*Mylopharodon conocephalus*) have established themselves here and compete with the trout. The populations of these non-game fish increased disproportionately after some water diversions from the Kaweah River. Presently there are no serious problems with non-game fish in other parts of the park, including the study area.

Recreation

Visitor facilities and recreation opportunities and capacities are discussed in the Development Concept Plan report. Also, a Visitor Profile for Sequoia National Park is found in this report in Appendix A.

Archaeology

To be provided by the Denver Service Center. Refer to Appendix D.

Traffic and Circulation

During the months of June through August, 1973, approximately 230,586 vehicles entered and left Sequoia and Kings Canyon National Parks [Schmidt, 1973]. Based on an average of 3.5 persons per vehicle, approximately 1,157,050 visitors were accommodated during this period. A consultant report in 1969 [Faustman, 1969] calculated that approximately 58 and 42 percent of the vehicles entered the parks by way of Big Stump and Ash

TABLE I

LIFE HISTORY AND HABITAT DATA FOR TROUT IN SEQUOIA NATIONAL PARK

Species	Temperature Tolerance	Habitat	Spawning Period	Spawning Areas	Food Habits	Hybridization	Comments
Rainbow (Salmo gairdnerii)	32°-80° +F	Steams, Lakes, Reservoirs	Feb.-June (July-Aug. in cold, high elevations)	Streams	Miniature Chironomids, terrestrial insects, zoo-plankton	Readily, with golden, cut-throat	Widespread
Eastern Brook (Salvelinus fontinalis)	32°-75° F	High altitude lakes and streams	Aug.-Jan.	Lakes and streams	Aquatic, ter-restrial insects planktonic crustacea	Uncommon	Generally regarded as easy to catch
Brown (Salmo trutta)	32°-80° +F	Lakes and streams	Nov.-Dec.	Stream gravel	Wide range of insects, crus-taceans, inver-tebrates and fish	Occasionally cross with brook trout	Strong homing
Golden (Salmo aquabonita)	Up to 72° F	Lakes and streams about 6,300-1,200 ft.	June-late August	Lakes and streams	Wide range of insects	Readily with rainbow trout	Do not do well under competition

Source: Calhoun, 1966.

Mountain, respectively, and approximately one-half of the vehicles continued on and left by the other exit (did not leave at the point of entry). Assuming this to be true in 1973, (as it appeared to be in 1969), then approximately 165,293 vehicles traveled one way on General's Highway between Lodgepole and Ash Mountain from June through August.

Daily traffic for each of three categories based on the season totals were calculated using the values generated by Faustman [1969] and are presented in Table J. Average daily traffic volumes for non-peak (weekdays), peak (weekend), and maximum peak (holiday) days are related to one another by the approximate ratio of 1.87 and 1.60 for vehicles entering at Ash Mountain and 2.06 and 1.79 for those entering at Big Stump. The values are only approximate but relate adequately to those calculated by Faustman in 1969. Also presented in Table J are estimated daily vehicular miles driven by these vehicles within the study area. The distances used to calculate these values are again only approximations that have been estimated in the absence of specific data. The approximate distance from below the village and above Lodgepole via the General's Highway is four miles. Each vehicle entering the park at Ash Mountain or exiting at Ash Mountain (after entering at Ash Mountain or Big Stump) was assumed to travel this distance at least once. About half of the vehicles entering Ash Mountain were assumed to have stayed overnight and the vehicular mileage generated by this action was approximately 12 miles within the study area.

No attempt was made to estimate the travel of park service and concessionaire personnel travel, and no estimations are made for travel off General's Highway.

If the assumptions approximate conditions existing in the study area, then on an average non-peak day (weekday)

TABLE J

CALCULATED TRAFFIC VALUES

DAILY VARIATIONS IN VEHICLE ENTRIES (ONE-WAY)
June-August, 1973
(Estimated)*

	Ash Mountain	Big Stump
Average Non-Peak Day (66 Days) (week day)	1,189	1,580
Average Peak Day (26 Days) (week end)	2,204	3,002
Maximum Peak Day (1 Day) (holiday)	3,526	4,383

DAILY AVERAGE VEHICULAR TRAFFIC VOLUMES
WITHIN STUDY AREA

Average Non-Peak Day	Vehicles	Vehicular/Miles
Entering at Ash Mountain	1,189	4,756
Exiting at Ash Mountain (entered at Ash Mountain)	594	2,376
Existing at Ash Mountain (entered at Big Stump)	814	3,256
Overnighter internal travel	594	7,128
TOTAL		17,516
Average Peak Day		
Entering at Ash Mountain	2,204	8,816
Exiting at Ash Mountain (entered at Ash Mountain)	1,110	4,440
Exiting at Ash Mountain (entered at Big Stump)	1,546	6,184
Overnighter internal travel	1,110	13,320
TOTAL		32,760
Maximum Peak Day		
Entering at Ash Mountain	3,526	14,104
Exiting at Ash Mountain (entered at Ash Mountain)	1,763	7,052
Exiting at Ash Mountain (entered at Big Stump)	2,257	9,028
Overnighter internal travel	1,763	21,156
TOTAL		51,340

*After Faustman, 1969.

about 17,516 vehicular miles (VM) will be traveled within the study area increasing to 32,760 VM and 51,340 VM on peak (weekend) and maximum peak (holiday) days, respectively. Road capacity has not been considered in these calculations.

III. THE ENVIRONMENTAL IMPACT OF THE PROPOSED ACTION

The following paragraphs describe the impacts of the Development Concept Plan upon the natural and cultural environment of the area affected by it. Consideration is also given to proposed Alternative Plans A and B.

Soils/Geology/Geomorphology

Impact. The Soil-Geology related impacts in the Sequoia National Park will depend on several factors:

1) the location and nature of development with respect to soil/geologic constraints and hazards, thus affecting the level of construction activity needed,

2) the location and nature of development with respect to variation in soil erosion hazard and the natural revegetation capacity of the soil, as well as other soil sensitivities,

3) the phasing of development changes over time; this may be thought of in terms of short-term massive impacts or long-term low level impacts, and

4) the type of construction activities and the effectiveness of mitigation measures.

Since the extent of environmental impacts will be dependent upon the nature and location of proposed developments, impact assessment can be achieved by comparing development location and land use changes with characteristics of soil and geology mapping units.

The proposed Development Concept Plan phases existing visitor facilities from the Giant Forest Village area (mapped as a variant of the Shaver series) to the Lodgepole area, in which several glacially-derived soils have been described. As the facilities are phased out of the village area a decrease in the number of visitor trips over certain key areas can be anticipated, due to a decline in the offering of services in the area, and a greater dispersal is probable from the use of a tram transportation system. Several other possibilities using discrete trail markings and unobtrusive trail obstructions are being investigated to disperse park visitors over a larger portion of the park, and to restrict their travel over sensitive areas. Assuming environmental impacts on soil conditions (soil compaction and soil erosion) can be correlated with the number of visitor trips in a given area, removal of the current facilities from the Giant Forest area and introduction of a controlled transportation system and other systems of visitor dispersal will result in an improved condition, a beneficial environmental impact.

Some soil disturbance will occur as a result of the gradual removal of the facilities from the village area, particularly from the use of construction equipment. Exposed, bare surfaces, retaining the visual appearance of building pads, should be viewed as being adverse environmental impacts created by building removal. This impact potential may be mitigated by procedures discussed in the mitigation section.

The plan phases the removal of visitor facilities from the Giant Forest Village area with the construction of new concessionaire and visitor facilities at the Lodgepole Campground area, and construction of a number of seasonal and permanent facilities in the Wolverton Corral area. These facilities are to be placed on a number of soil mapping units, which may be considered collectively as being coarse textured, moderately erodible soils with slopes less than about 15 percent. Some removal of protective vegetative cover and grading for access road construction and pad prepartion will be required.

Some soil and geologic constraints including landslide hazards, occur in the Lodgepole area which will require specific design and engineering solutions. Construction of buildings in the Lodgepole area should be viewed as a replacement of environmental impacts generated from current camper use of the area with impacts resultant from construction activities and residential use.

An increase in visitor accommodations in the Lodgepole area would likely increase day use visitation of the immediate surrounding lands. The morainal soils and soils with glacial till developed around Lodgepole have a coarse particle size distribution and should be considered to be moderately erodible and moderately susceptible to compaction under increased foot traffic. It seems unlikely that visitors using the developed accommodations in the Lodgepole area would increase demands on the more fragile upper Kaweah watershed, as two distinct user groups are involved.

The Wolverton area apparently also receives moderate use, both by winter sport enthusiasts, and by hikers and horseback riders during the summer months. This area will continue to be used in the same manner as it is now, so additional impacts would be related to increased popularity.

The establishment of new corrals in the existing organization camp is not expected to have a substantial additional impact in that the area is already disturbed and is located along the existing trail system. There is a potential for some sedimentation of Wolverton Creek during heavy summer rain storms due to sheet erosion.

An expansion of the present ski facilities in the Wolverton ski area is not advocated in the Development Concept Plan. Present rope tow alignments traverse areas mapped as the glacial morainal Dinkey series, as well as the glacial-fluvial Shinn series. These soils are considered highly erodible when vegetative cover is removed and the surface soil is disturbed, but revegetation with indigenous grasses has reduced long-term soil loss. Since expansion of the facilities is not proposed, current erosional soil losses will likely continue at about the same level. Reseeding the area at 40 lbs/acre mixed grass seed with scattered planting of manzanita would greatly control impacts from this land use.

Most adverse environmental impacts are short-term and are primarily associated with construction activities which disturb and expose soil surfaces. An increased sediment yield to Wolverton Creek and to the Marble Fork of the Kaweah River is likely to occur as a result of institution of this plan. Relating sediment yields to specific storm or hydrologic events which have land management or environmental implications, is not, as of yet, possible. Development of rough estimates requires detailed hydrologic data, a longer period of record, the use of a computer, and in terms of the scope of this report, is not justified by the results that would be obtained.

However, several studies have been made monitoring sediment production on forested granitic soils which provide information of a comparable nature. Such studies indicate that large scale soil disturbance, as in a logging operation (or a subdivision construction) may increase sediment loads in streams up to 17 times that of an undisturbed watershed. But by the time of completion of activities, the area restabilizes to a yield of roughly twice that of the predisturbed level [U.S.D.A.-G.P.S., 1963]. A study of the erosion of glacial granitic soils in the Lake Tahoe Basin concludes that roadways create the most significant long term source of sedimentation, equalling that of the other two sources, streambank and sheet erosion [California State Division of Soil Conservation, 1969]. These measurements were made for disturbed areas and along roadways without erosion control practices.

A tramway has been proposed with the right of way passing through an area in which members of the moderately erodible Holland-Chawanakee-Shaver soil association occurs. Most of the area is within the 5 to 20 percent slope class, although the proposed tramway follows grade over some areas south of Long Meadow with slopes greater than 30 percent.

Cut and fill operations probably requiring some blasting in the hard granitic rocks would be needed for road construction in these areas. The amount of cut and fill necessary has been minimized by the preliminary route selection following grade, and by the fact that only a narrow road base will be required for the one-way destination.

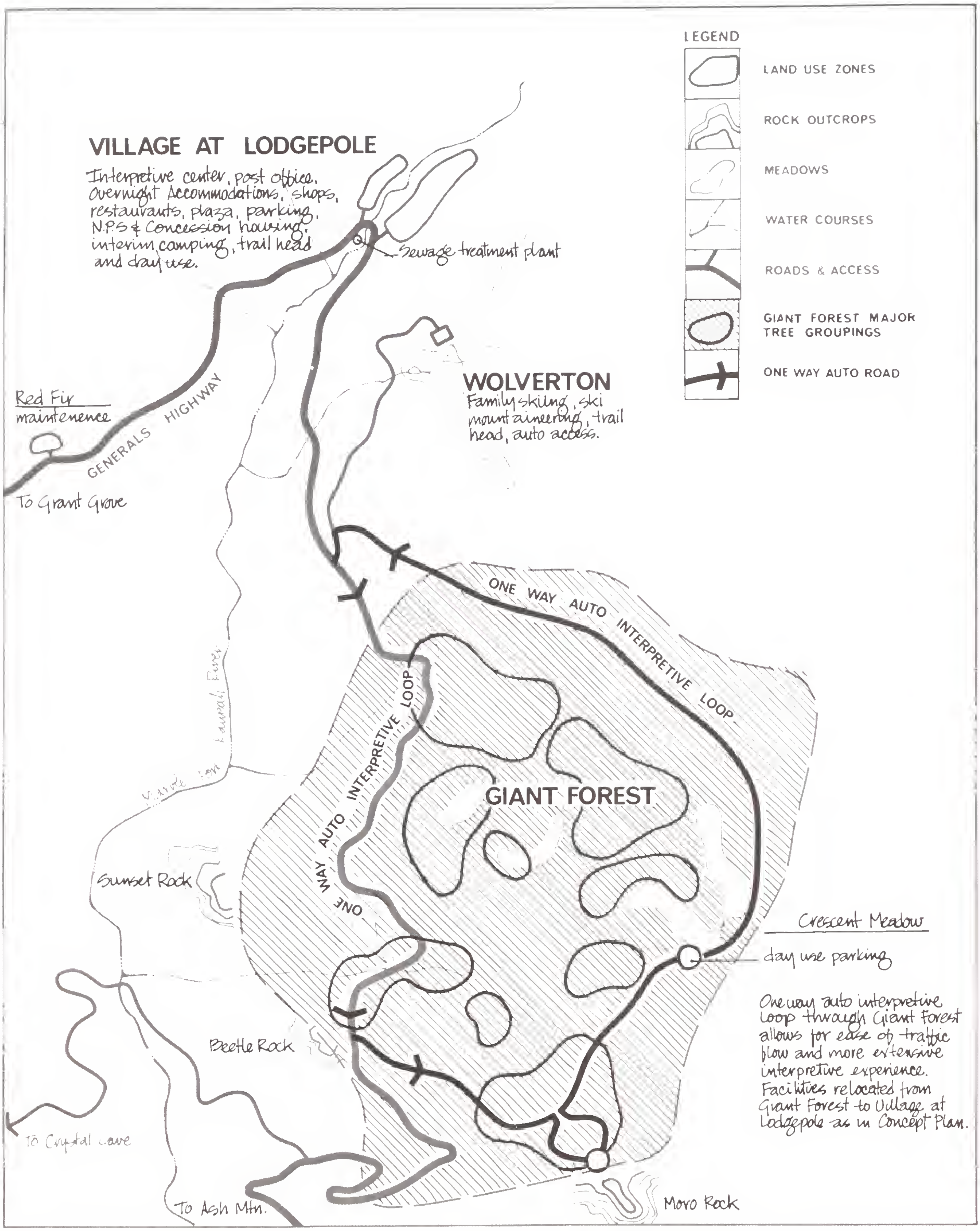
Some consideration was given to the possibilities of a walk-in campground located adjacent to Clover Creek and an auto oriented campground located at the more distant Willow Meadow area. The Willow Meadow campground alternative was dismissed as the access road would have to traverse some shallow, boulder strewn granitic soils with a strongly sloping topography and a dry exposure. Erosion hazard is considered severe along the considered access route, and natural revegetation of cut slopes would be difficult to achieve.

Some problems of soil compaction and deterioration of Willow Meadow would probably occur with campsite development, due to an increased number of visitations to the meadow. The glacial-fluvially derived soils have a high particle size distribution and are probably near optimum moisture content year-round, making them susceptible to soil compaction. The short visitor-use season and a relatively longer period for natural recovery of soil structure by the mechanisms of freeze-thaw and shrink-swell actions may reduce incremental soil compaction, but would probably create a more erosive condition by heaving blocks to expose small rills and channels. A well designed campsite layout with trails which disperse visitors and restrict their travel over sensitive areas, in conjunction with monitoring and regulation by the National Park Service, would be mandatory if this alternative were considered.

An alternative walk-in campsite at Clover Creek would seem feasible only if the site were well monitored and regulated by Park Service personnel. The granitic soils in the Clover Creek area are deeper but are also highly susceptible to soil compaction because of a wide particle size distribution. Some pockets of shallow soils, rock outcropings, and hanging alluvial meadows occur immediately adjacent to Clover Creek and should be considered as being a fragile environment. Although it may be feasible to design a campsite in which sensitive areas are avoided through unobtrusive trail markings and visitor dispersal techniques, the probable low use permitted of the area has been judged by the authors of the Development Concept Plan and this report to be incompatible with the amount of expenditures necessary to manage the area. Also, the impacts on a natural area would be severe as compared with nearby camping opportunities available on adjacent, less sensitive Forest Service land.

From a viewpoint of impacts related to geologic and soils conditions, Alternate Plan A (Fig. 15) differs from the conceptual plan in that less regulation and visitor dispersal over the Giant Forest Area would result. A larger road base with more frequent turnouts would also be required to accommodate auto and trailer traffic. With a larger road base and more turnouts, a greater amount of soil disturbance would occur. The reduced degree of regulation and visitor dispersal in self-guided auto tours would perpetuate soil structural damage, erosional soil loss, and vegetative damage currently impacting the Giant Forest area.

As in Alternate Plan A, a reduced degree of visitor dispersal would occur if Plan B (Fig. 16) were implemented. Soil disturbance and construction damage to sequoias, as well as secondary impacts on soil conditions from relocation and concentration of visitors to lower Kaweah would occur. Plan B proposes a loop road around Beetle Rock. The road would pass over steep terrain on shallow, erodible granitic soils.



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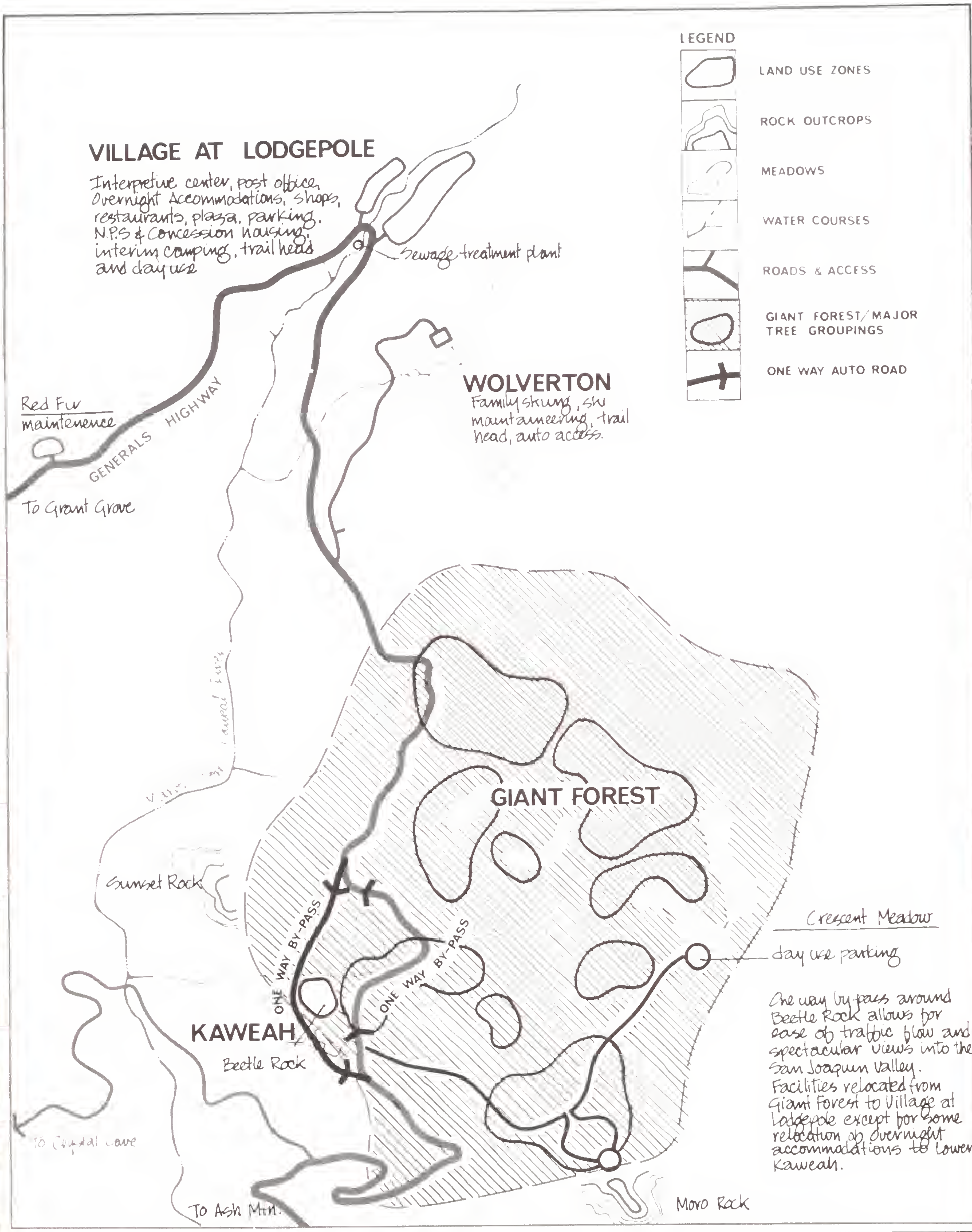
Development Concept Plan
Giant Forest - Lodgepole Complex
Sequoia/Kings Canyon National Park, California

Alternate Plan A

Fig.15



Development Concept Plan
Giant Forest - Lodgepole Complex
Sequoia/Kings Canyon National Park, California

Alternate Plan B

Fig.16

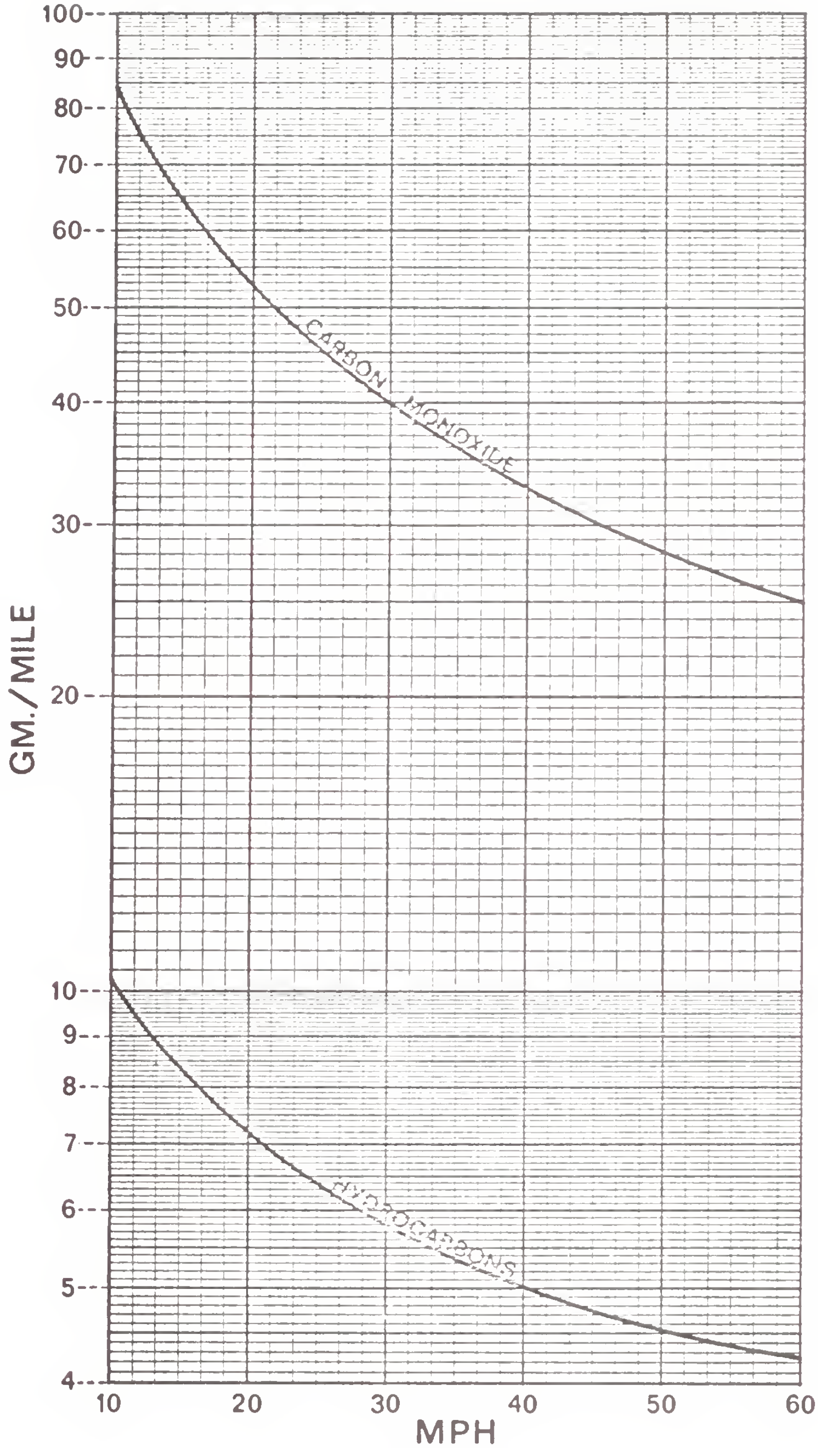
Air Quality

The proposed traffic and circulation plan will tend to reduce traffic volume (and daily vehicular miles), smoothing flows and increasing the speed of traffic. Emissions will tend to decrease in direct proportion to any decrease in VM. The improvement in flow and increase in average speed will also tend to decrease the emissions of carbon monoxide and hydrocarbons [Beaton, et al, 1972; EPA, 1972]. The reduction in CO and HC emissions as a function of increased vehicle speed is presented in Fig. 17. However, the relative impact of improved emissions resulting from the implementation of the traffic and circulation plan will be very small compared with the improvement by the anticipated more stringent emissions rates. After 1986, emissions per vehicle of carbon monoxide and hydrocarbons are anticipated to decrease to approximately 10 percent of 1973 emissions.

Another benefit from the implementation of the plan will be the reduction of emissions on the side roads off of General's Highway. It is probable that the tram or bus emissions will not approach those of the present traffic on these side roads such as the one to Crystal Cave or to Moro Rock. However, a relatively pristine area will be exposed to emissions after Moro Road is extended to General's Highway if pollutant emitting trams are used.

Hydrology

Establishing and maintaining a tram road, as called for in the Development Concept Plan, circumscribing the Giant Forest grove of sequoias, will call for slight modification of the hydrologic pattern. The most serious aspect to be considered is the danger of disrupting the midsummer flow of groundwater into the Giant Forest, a process that is apparently the limiting factor in the distribution of the giant sequois [Rundel, 1972]. Significant modification of this process could have far reaching implications for the



EMISSION FACTORS
VS
AVERAGE SPEED
(1974)

SOURCE: ADAPTED FROM BEATON, ET AL, 1972.

FIG. 17

future of the grove. Road cuts could intercept the flow of groundwater causing it to be either evaporated directly from the soil surface or transpired by shallow rooted plants.

Compaction of the tram road could have as far reaching implications as road cuts. Excessive compaction could create a subsurface dam, impounding the groundwater and forcing it to the surface to be evaporated or transpired.

Other modes of transportation such as rail and hovercraft are simply variations of a theme in that they require subgrades not much different from that of a paved road. The transportation system which would have the least impact on groundwater flow to the Giant Forest grove would be an elevated system such as a monorail. The obstruction to groundwater flow provided by the support system would be negligible on an area-wide basis, allowing groundwater to move freely into the grove.

Removing the existing facilities from Giant Forest will probably have no impact on groundwater movement.

During and immediately following construction, the general water quality of Sherman Creek, Little Deer Creek, and the unnamed tributary south and west of Giant Forest will be degraded by increased suspended sediments from exposed soil surfaces. This effect will be most noticeable during the spring snowmelt period when there is surface runoff. Intense summer storms could also cause a short-lived degradation in water quality from the same source.

The source of soil particles available for transport wlll be the soil surface exposed during construction. Construction necessarily involves the removal of vegetation and the protective litter layer, both of which protect the soil from raindrop impact and compaction from equipment. Compaction reduces the infiltration capacity of the soil, resulting in concentrated surface flow which, in turn, increases the erosive power of the water.

Once the tram road has been constructed and is operational, routine maintenance should suffice. There will be an increase in the volume of water running off the road due to its impervious nature. (A pervious asphalt that can use a rock base and an uncompacted grade is being investigated but all of the specifications are not available at this time.)

Dependance on the tram as a means of viewing the giant sequoias will cause a reduction in traffic, both foot and auto, within the grove proper. Consequently, compaction will be decreased and infiltration capacities increased.

The staging area (Fig. 8) will be a large tar-topped impermeable surface. Because of this, local runoff patterns will be altered by increasing the volume of surface runoff and concentrating it. Such concentration could result in accelerated erosion and degraded stream water quality.

If the staging area is used during the winter, e.g., ski area parking, chemicals used for ice control may find their way into Marble Fork. The stream course carrying the drainage from the staging area flows only during the spring snowmelt and would thus carry a rather large load of chemicals concentrated in a short period of time. When the parking at the staging area is covered and the cleanup water is put into the sewer system, the above impacts will be substantially less.

Runoff from all paved surfaces will contain various pollutants. Studies by the Environmental Protection Agency (EPA) [Sartor and Boyd, 1972] have shown that runoff from a hypothetical city during the first hour of a moderate to heavy storm contributes a pollutional load to the receiving waters greater than raw sanitary sewage, except for total Coliform bacteria, during an equivalent period of time. Of course, Giant Forest is not a city in the strict sense of the word. Yet traffic densities approach those of shopping centers and central business districts in such cities as San Jose and Phoenix. Whether the pollutional load from a parking area near Giant Forest would be the same as that from an equivalent area in a small to medium sized city is unknown. Quantitative determination of the concentrations of substances, their composition and form, demands a program of sampling and analysis.

Street surface contaminants, though not concentrations, would be approximately the same for a parking lot at Giant Forest or a street in San Jose. Sources of contaminants are motor vehicles, vegetation, runoff from adjacent land, litter, spills, and anti-skid compounds. The relative importance of the sources would depend on the season. Contaminants from motor vehicles, litter, and spills would most likely occur during the summer, the season of greatest use. Vegetation, runoff from adjacent land, and anti-skid compounds would be significant during the fall-winter-spring period.

Those sources associated with human activities, e.g., motor vehicles, litter, spills, and anti-skid compounds, produce the contaminants of greater concern. Motor vehicles contribute petroleum products, fine particles from tires and clutch and brake linings, particulate exhaust emissions, particles from the underside of vehicles, and vehicle components such as glass, plastic, and metal. Litter is paper, plastic, glass, etc. Spills may be associated with overflows from self contained recreational vehicles such as motor homes and campers. The anti-skid compounds are mostly salt (NaCl) applied during the winter for ice control. Each of these contaminants will have an effect on water quality, though to what degree cannot be stated in view of the lack of quantitative data.

Some degradation of water quality from suspended sediment and increased nutrients is expected to occur as a result of converting the existing organization camp to corrals because the site is upslope from Wolverton Creek. The degree of increased degradation is expected to be minimal because the area is already impacted and receives horse traffic now.

If a secondary treatment sewage plant is to be constructed on-site to handle waste water from Lodgepole, it will be located immediately downstream of the bridge crossing the Marble Fork at Lodgepole (Fig. 9). Following treatment, the liquid effluent will be sprayed on a 34 acre spray field at a rate of four inches per week. Solid wastes will be collected and removed from the site.

The existing sewer lines within General's Highway will be upgraded so as to carry the anticipated load from the staging area. This program will involve excavating in the present road and replacing the pipe.

An access road will have to be built into the sewage treatment plant site. At the time of construction, the sewer line will be laid in the road to minimize disturbance to the surrounding forest land.

Construction of an access road will cause the removal of vegetation from the right-of-way and will create sediment problems during summer thunderstorms and during the spring snowmelt.

Construction of the sewage plant will involve clearing all vegetation from the site and an indeterminate amount of grading. During construction and immediately afterwards, there will be loose soil materials available for transport to the stream courses.

Once the treatment plant is operational, liquid effluent will be sprayed onto the forest floor. The effluent will be high in nitrates, phosphates, and other nutrients, resulting in a dense lush growth of vegetation.

Application of four inches of treated effluent per week will maintain soil moisture at near capacity. Since no soil moisture deficit will have to be met, any rain falling on the spray field will probably run off as surface flow. This excess runoff could cause local high peak flows and contribute to an accelerated rate of erosion.

An alternative to be considered in disposing of liquid wastes is to pipe the effluent downstream and spray it onto the brush fields along Highway 198. Such an action would dispose of the effluent and at the same time somewhat alleviate the fire hazard at the lower elevations. This scheme would require a great deal more investigation before being seriously considered.

The problem of sewage disposal is a subject needing more intensive study to determine the system and degree of treatment most compatible with the prime resource. Once the technical questions are resolved (degree of treatment, facility capacity), the environmental impacts may be identified and evaluated and appropriate mitigation measures proposed.

Removing the existing facilities from Giant Forest will cause a reduction in the impermeable surfaces and thus reduce the total volume of surface water running off during summer storms and the spring snowmelt. This effect will be especially significant during summer storms in allowing more water to infiltrate and meet soil moisture deficiencies. Conversely, expansion of the facilities at Lodgepole will result in an increase in the area of impermeable surfaces, a decrease in total infiltration, and an increase in total surface runoff.

Because of the proximity of Lodgepole to the Marble Fork, there will be greater opportunity for chemicals used in snow removal to reach the river and be transported downstream. If the Lodgepole complex is to be used during the winter, contingency plans will be made for the removal of snow from parking lots and other avenues of foot and auto traffic.

Snow removal operations result in the accumulation of large volumes of snow, usually inter-mixed with road salts, at a single point. If, upon melting, the chemicals enter a small stream, the concentration of road salts could affect the aquatic community.

Increasing the number of facilities at Lodgepole may result in encroachment upon the flood plain of the Marble Fork. During periods of high water, there would be the danger of property damage and personal risk if the buildings were occupied and the flood unexpected.

Concentrating all facilities at Lodgepole (Fig. 7) will demand an increase in the capacity of the water distribution system and the sewage collection system. Temporary vegetative disruption and periodic degradation of water quality may be expected.

Water for the Lodgepole complex may be obtained from either of two sources--Silliman Creek or the Marble Fork of the Kaweah River. A long term quantitative determination of the flows in Silliman Creek would have to be made to determine its feasibility as a water source. Not only must there be sufficient water to meet domestic needs, but also sufficient excess flow to meet the demands of the aquatic community below the point of diversion.

Table K presents a rough estimate of water yield from Silliman Creek during the June-July-August-September period based on mean annual precipitation at Giant Forest, stream flow and monthly evapotranspiration, domestic water consumption at Lodgepole and Giant Forest [Lewis, 1973], and excess water after diversion. Stream flow is normally low in late summer and early autumn and would be reduced even more if Silliman Creek were the sole source of water.

Withdrawal of water from the Kaweah River would probably be the better alternative. Table L shows the volume of water use at Giant Forest and Lodgepole [Lewis, 1973], mean monthly flow of the Marble Fork of the Kaweah River at Potwisha, and the percent of this monthly flow going to domestic consumption. The Marble Fork would be a more dependable source of water, especially in dry years. Its quality should

TABLE K

SILLIMAN CREEK AS A WATER SOURCE DURING THE LOW FLOW PERIOD AND HIGH DEMAND

Month	Yield (acre/feet)	Consumption (acre/feet)	Percent of Flow
June	1,067.78	18.96	1.78
July	394.09	26.27	6.67
August	99.96	30.44	30.45
September	37.32	24.45	65.51

TABLE L

KAWEAH RIVER AS A WATER SOURCE DURING THE
LOW FLOW PERIOD AND HIGH DEMAND

Month	Yield (acre/feet)	Consumption (acre/feet)	Percent of Flow
June	15,769.05	18.96	0.12
July	6,012.40	26.27	0.44
August	1,524.33	30.44	2.00
September	553.26	24.45	4.42

be such as to require a minimum of treatment.

Construction of the diversion works and the laying of the pipe will involve disturbing the vegetation and soil, resulting in less than pleasing landscapes. Pipe for carrying water from the Kaweah River could be buried in an existing road for a portion of the distance. The water distribution system within Lodgepole would be constructed at the time new facilities are built.

The portion of Clover Creek Campground, an alternate campground site that could be developed as a walk-in camp, would not experience the soil and vegetative disruptions nor the extensive compaction associated with campgrounds open to vehicular traffic. Consequently, total infiltration would be reduced by a relatively small amount, surface runoff would be minimized, and surface water quality would be maintained at near natural levels.

Establishment of the campground would involve laying pipe for domestic and waste water with the attendant impact on vegetation and water quality. Further, a source of freshwater would have to be found to supply the new camp.

Impacts associated with alternate plans will be similar to those already discussed. The only major difference would be regarding the tram road. Should it be rejected as a viable alternative, those impacts will be avoided. However, it would be replaced by another road designed to carry one-way traffic through the grove. This road in Alternate Plan A would be built to highway standards and have significantly greater impacts than a tram road.

Vegetation

The proposed removal of visitor housing, visitor services, and concessionaire administrative facilities from the Camp Kaweah area is expected to have significant impacts, mostly positive. Presently the out of scale man-made improvements detract from the natural vegetative scenery which is dominated by many large sequoia trees. The forest floor in these areas is now subjected to heavy foot traffic; the lack of attractive ground cover vegetation is one result, while the ultimate effect of damage to the soil is more difficult to determine. The removal of buildings and asphalt coverage will again allow precipitation to percolate into the soil and the effective root areas of many giant sequoias will be expanded. Because people uses and traffic will be less congested in the area, there will be a decrease in air pollutants from fires and auto emissions within the prime resource of Sequoia National Park.

The potential negative impact on vegetation caused by the removal of existing improvements is that caused by heavy equipment. Care must be taken to avoid excessive soil disturbances and mechanical damage from use of equipment.

The construction of an auto staging area at the Wolverton Stables could involve the negative impacts of tree removal, creation of impervious surfaces, concentration of auto emissions, and ecological disturbances to surrounding areas from foot traffic, vandalism, litter, etc.

The proposed use changes at Lodgepole, wherein visitor housing is proposed to accommodate 1,240 pillows per night along with commercial and service activities, may not cause significant impacts to vegetation since the area is already subjected to intensive uses associated with camping, commercial operations and an Interpretive Center. The available open spaces and easy topography will allow construction to proceed with a minimum of disturbance to the soil and vegetation. Also, large areas of paved parking already exist so that heavy equipment can be stored and maintained away from undisturbed areas. There will be an increase in impervious surfaces, primarily from roof tops, so a decrease in the total "root reservior" is to be expected. Also, buildings are expected to obscure some of the vegetative scenery as you would view it looking south from the Marble Fork of the Kaweah River. The addition of the combined

Park Service Concessionaire housing on the north of the river at Lodgepole will also involve minimal vegetation impacts since the units will be replacing existing garages and maintenance buildings. Utilities are already in place so that disturbances for this purpose are also unnecessary or minimal.

The placement of corrals at the existing organization camp is not expected to substantially affect vegetation in that adequate openings in the forest are in existence and ground vegetation has been displaced by present uses.

The proposed tram perimeter road in Giant Forest is expected to have both negative and positive impacts. The positive impacts result from more people being able to enjoy more of this outstanding giant sequoia forest and a better dispersal of these visitors when compared with the pattern at Camp Kaweah and the General Sherman tree. Also, less visitor viewing from the highway will promote better traffic movement and should result in a decrease in air pollutants from auto emissions that are potentially damaging to many plants. On the negative side, some presently relatively undisturbed areas will be exposed to people traffic and the new roadway will cause a visual impact on the forest scene and will necessitate some vegetation removal. If the road is not carefully designed and constructed, hydrological patterns could be disturbed by impervious surfaces and deep cuts. These hydrological changes might endanger the health of the giant sequoias located in the down-slope area due to a change in moisture supply.

A new sewer plant, extended discharge line, and spray field to be located due west of the proposed Lodgepole complex would have some impact on the area's vegetation. The proposed area is noted on the utilities map (Fig. 9) and the vegetation types affected are mixed conifer and white fir. The plant itself will be utilizing a semi-open area which has been used for parking; the pipe line will extend for about 3,600 feet, mostly through a semi-open forest to a nearly level area that is covered with white fir. Few trees will have to be removed, but some root damage is unavoidable in building the pipeline. The spray field will cause little damage so long as it is spread over an adequate area, utilizing alternating sections to avoid continued soil saturation. The net apparent result is to increase ground vegetation and growth. Improperly managed, prolonged saturation could kill the trees and allow effluent to be carried directly into the Marble Fork of the Kaweah River. Sedimentation is usually minimal since the resulting lush vegetation holds the soil.

The impacts from camping and campground development will be negligible to non-existent if the proposed conceptual plan is adopted and campgrounds are phased out at Lodgepole with no replacements. A possible alternative campground on Clover Creek would appear to be the most feasible undeveloped location from the standpoint of proximity, ease of access, and other environmental factors. If the site had a maximum of 100 walk-in campsites, the damages would be substantially less than those being sustained at Lodgepole. However, some vegetation would have to be removed since much of the area is dominated by a dense, mature, red fir stand. Also, natural travel routes along Clover Creek would sustain increased use and the fragile, miniature meadows and other riparian vegetation parallel to the creek may be destroyed or damaged. In much of the area the vegetation should be able to sustain itself on the deep soil and easy topography. Further damage to vegetation would be expected from the development of utilities; also, if campground water was diverted from Clover Creek, some damage to riparian vegetation and fisheries could be sustained. Obviously, if already developed nearby camping areas in the National Forests could be expanded to accommodate the proposed displacement, serious impacts on certain park natural areas could be avoided.

Construction activities that require cuttings of fir and pine trees can increase the chances of insect epidemics from bark beetles if preventive measures are not taken.

Wildlife

The basic conceptual plan for the Giant Forest and Lodgepole study areas as proposed by Sasaki, Walker Associates, Inc., will have relatively minor impacts upon the local wildlife community. The basic ideas behind the plan which help to achieve this include the discouragement and minimization of automobile traffic and the concentration of major activity centers in a few large clusters. These major activity areas are also located in areas that basically avoid the highly valuable key wildlife habitats.

Removal of the present lodging and concession services west of Round Meadow will have the positive effect of returning this area to a near natural habitat condition. Activity during the removal period will create some additional disturbing factors in the immediate area, but these will be minor and temporary. Automobiles will still pass through this same area enroute to the parking lot at the proposed staging area. This will be a disturbing factor, but only represents a continuation of present traffic conditions.

The staging area, which will include parking, orientation facilities, and the terminal for the shuttle and tram systems, will be placed in an area where the Wolverton corrals presently exist. Construction here will necessitate the removal of some coniferous forest habitat. This will result in the displacement of local resident species from the immediate area. However, as noted in the mitigation sections, the fact that this is within the coniferous forest habitat will help in maintaining the desired habitat diversity of the region.

The establishment of corrals in the existing organization camp is not expected to substantially change the disturbance caused by present uses.

Existing ski facilities are located at the north end of Long Meadow. Some disturbances of the valuable meadow habitat now occur, and the current plan does not intensify the impacts to wildlife now experienced.

The concession services will be relocated in Lodgepole near the site of the present visitor information center. Housing for National Park Service presonnel will also be located here. Here again, the concentration of these facilities in the coniferous forest habitat type will cause a local displacement of some species, but overall this is a relatively mild impact. However, since the Marble Fork of the Kaweah River flows through this area, potential water quality problems exist. These can be avoided by implementation of effective mitigation measures which are discussed in the mitigation section.

It is also proposed that the existing campgrounds at Lodgepole be phased out over a period of time. The abandoned campground at Lodgepole could then potentially return to a somewhat natural state.

At one time during development of the plan, alternate campgounds at Clover Creek and Willow Meadow were considered. The potential adverse impacts to wildlife and other environmental parameters were judged to be high for Willow Meadow. The Clover Creek site was proposed as a walk-in camp for at least 50 percent of its users and, although not as serious as those anticipated at Willow Meadow, adverse impacts could still be significant. Both of these proposals, therefore, have been abandoned; however, careful planning could, in our judgement, effectively minimize adverse effects to wildlife for a 100 percent walk-in campground, and this alternative could perhaps be considered again at some time in the future.

Archaeology

To be provided by the Denver Service Center. Refer to Appendix D.

Traffic and Circulation

The proposed traffic and circulation plan for the study area is intended to replace a portion of the present vehicular traffic volume (see Fig. 6). The plan will consist of limiting traffic to the General's Highway and denying any pulloff parking along the highway. A tram system will be initiated from the proposed staging area that will transport visitors through Giant Forest, stopping at points of interest and returning to the point of beginning and Lodgepole. Parking will be limited to the Lodgepole area, Wolverton ski area, and in a parking structure to be erected at the site of the old stables on the road to Wolverton. Parking in the Lodgepole area will be for short periods only for visitors to the Interpretive Center.

The attractiveness of the tram will be expanded by including the fare in the park entrance fee, and visitors will be encouraged to embark and disembark at any scheduled stop in areas of particular interest. On each of the trams a park employee will provide a commentary on what is being observed from the tram.

Another feature of the plan is a scheduled bus trip to Crystal Cave. The fare for this trip will not be included in the park entrance fee, but will be minimal.

It is anticipated that visitors will use personal vehicles only to enter and leave the area and will either walk or use the tram for any movement from place to place. It is probable that most of the visitors will ultimately see more of the park area and gain a more thorough understanding of what they have seen than from the present system.

An additional benefit of the new traffic plan is to improve the flow of traffic on General's Highway. The denial of parking and pulling off along the highway will remove traffic slowing elements, and as the overall traffic volume will be reduced somewhat, overall vehicular speed will improve to some extent. The bottleneck previously formed by the village complex will be removed when the area is served only by the tram system.

Actual reduction in traffic volumes cannot be determined at this time. However, some probable effects can be estimated. Assuming the tram system proves attractive enough to encourage full usage for all travel, except to and from the staging area, and the capacity of the tram is enough to satisfy the needs of visitors without undue waiting, reductions in daily vehicular miles may be expected to appear primarily in those values that have been estimated for overnight visitors. If the model approaches reality, this reduction will amount to about 40 percent of the present estimated total VM generated in the study area.

Some of the anticipated improved traffic flow may be reduced by the encroachment of the tram route on General's Highway. The present plan envisions the tram route crossing the highway at three points and traveling on the highway for approximately one-and-a-half miles. A ten module slow moving tram is expected to delay traffic at three intersection points. Also, it may slow traffic for over a third of the distance from the village to Wolverton staging area or to the Lodgepole area at about one-half hour intervals. On peak traffic days this is very probably going to reduce the benefit of the tram system and perhaps expose visitors to danger from accidents.

Ultimately, if this improvement in traffic flow and efficient utilization of the tram system attracts new visitors to the park, traffic volumes will approach those experienced in 1973. Faustman [1969] estimated a visitor growth rate of approximately four percent for Sequoia and Kings Canyon National Parks. This value was based on conditions that existed in 1969 and may not be applicable now, as the rate may be somewhat larger. In July of 1973, visitors to the parks increased by 24 percent over the same period in 1972. Many factors probably accounted for this, including the economic situation and gasoline shortages. Gas shortages and dollar devaluations may have changed traveler habits enough that the national parks near major population centers have gained attractiveness in inverse relation to the availability of gasoline. Further gas shortages could have a greatly reducing effect, however.

IV. MITIGATING MEASURES INCLUDED IN THE PROPOSED ACTION

This section describes the mitigation measures which may be employed to aid in reducing or eliminating the anticipated adverse environmental impacts associated with implementation of the Development Concept Plan.

Soils/Geology/Geomorphology

The principal mitigations to be implemented in removing buildings and other man-made facilities from the Giant Forest area are as follows:

1. Restrict building removal activities during the rainy season and do not operate heavy vehicles during conditions when the ground surface is wet, to prevent conditions of soil erosion and soil compaction. Allow vehicles off access roads only where necessary, and fence off areas in which heavy activity is occurring.

2. All waste materials from improvements must be immediately removed from the Giant Forest area to an unobtrusive area of the park. The disposal site needs to be determined in response to environmental constraints, and site rehabilitation plans established.

3. Exposed building site surfaces can be reshaped using a minimal amount of equipment, hand raked, and covered with a surface of indigenous mulch.

The principal mitigations to be implemented in the construction at Lodgepole, the staging area, the tram road, and sewer plant are as follows:

1. Restrict development activities to the dry season of the year.

2. Avoid development on slopes greater than 20 percent, and minimize the need for grading and cut and fill slopes through design considerations.

3. Stockpile and return topsoil and/or a surface mulch to all construction sites. Develop specific plans for revegetation of disturbed sites using native species of grass. Consider temporary erosion control measures

(including chemical stabilizers, fiber-mulches, and netting) if revegetation has not been satisfactorily completed by the start of the rainy season.

4. Integrate selection of road design and location with hydrologic considerations and aquatic habitat considerations mentioned in the hydrology section of this report.

5. Avoid unstable soil and rock units. Select bench locations and follow contours where possible in road planning.

6. Limit need for road cut and fill, provide drainage diversion at top of cut and fill slope, and leave support for toe of slope. Minimize slope and terrace as needed. Mulch and revegetate.

7. Install lined or non-erosive drainage ditches along roadways. Protect culvert inlets and outlets against erosion, using energy dissipators at points of discharge, and sedimentation basins where necessary.

The Clover Creek Campground alternative proposal mitigation measures are:

1. Clear a marked access trail and sign it to follow natural contours, and design other trails about the campsite to restrict travel from sensitive riparian areas.

2. A well designed campsite layout and controlled use in conjunction with monitoring of this area should limit impacts, i.e. close trails and replace if wear becomes excessive, also develop new travel routes and move individual campsites if necessary.

Air Quality

The principal mitigation measure that is feasible and necessary at this time is to gain a better understanding of what is actually occurring in the study area. Apparently little attention has been focused on air quality problems in the past and no data are available to assess the extent of the problem. The parks should be opened for research which should be encouraged by making available personnel, facilities, and funds in order to study the problem. The results of a comprehensive meteorological modeling and emissions evaluation program will provide the answers needed to define the effects on and by the air quality on future uses of the park.

It may become apparent that problems are much more severe at certain times that can be predicted and a graduated level of activity must be maintained in order to protect the well being of visitors and the principal resources of the park. In an extreme case, if high levels of oxidants are resulting from transport alone, it may be advisable to restrict or eliminate all personal vehicular use until upwind sources have been reduced to tolerable levels.

Hydrology

The tram road is to be paved and will involve a minimum of cut and fill type grading. All areas of shallow soils will be either avoided entirely or have a minimum of depth fill. This section will minimize the impact of the tram road on the ground water flow.

Minimizing the grading operations will go far towards protecting the natural water quality of the streams draining Giant Forest. Other protection measures will include seeding exposed soils to native plants and mulching, and diverting drainage water onto the forest floor where the suspended sediments will be filtered out by the litter layer.

Seeding will hasten the re-establishment of vegetation while the mulch will protect the soil from raindrop impact and aid in conserving soil moisture. The sooner vegetation is re-established, the sooner the soil particles will be bound into place and will become unavailable for transport under normal hydrologic conditions.

No mitigation is deemed necessary to offset the reduction of foot and auto traffic within Giant Forest.

The system draining the staging area will be designed so as to divide the staging area into several small drainages such that the total runoff is not concentrated at one point. This will necessitate the installation of one culvert for each subdrainage within the staging area. The runoff being diverted to several points along General's Highway minimizes the prospect of accelerated erosion and the concentration of snow melting chemicals at any single point. There will be greater opportunity for soil organisms to assimilate the pollutant load if it is spread over a relatively large area.

The sewage treatment plant will involve secondary treatment utilizing a two-stage trickling filter to remove the biochemical oxygen demand (BOD). Liquid effluent will be sprayed onto a 34 acre spray field at a rate of four inches per week. This will accomodate a peak daily flow of 500,000 gallons.

The practice of spraying secondary treated effluent onto the forest floor has met with success. Sopper and Kardos [1972] in a project conducted in Pennsylvania, monitored the quality of water at different depths on plots receiving varying volumes of effluent and on a control plot. There was no evidence of any detrimental effects on either water quality, soil structures or vegetation with the exception of red pine (Pinus resinosa Ait.) which suffered some deterioration of mechanical properties.

This system has the advantage of renovating sewage effluent without the cost of a tertiary treating plant and also returns a large proportion of the water to the Kaweah River system for reuse downstream.

Excavation and replacement of the existing sewer line will involve the disruption of areas already considered disrupted, i.e., General's Highway.

The access road for the treating plant will be of minimum width to minimize grading operations. Upon completion, measures will be taken to re-establish native vegetation. Raw soil banks will be mulched to prevent excessive erosion until vegetation is established. Similar measures will be taken at the treating plant site.

If the soil moisture capacity is met, excess water will move downslope through the subsurface recharging the soil not directly influenced by the sprinkler system. The dense growth of vegetation generated by the additional water will impede the occurrence of accelerated erosion and its subsequent effect on water quality.

Runoff from the impermeable surfaces at Lodgepole will drain directly into Marble Fork. The flow into Marble Fork from the Lodgepole area relative to the flow of Marble Fork will be insignificant. Therefore, no special mitigation measures are deemed necessary.

No permanent structures will be built within the 100-year flood plain at Lodgepole. Parking lots may occupy the flood plain thus not only protecting the integrity of the flood plain but also providing a disposal site for snow clearing operations.

Immediately following construction activities at the alternative Clover Creek Campground site, a program would be implemented to re-establish the vegetative cover of the area.

Vegetation

Little or no damage need be sustained in removing improvements at Giant Forest if equipment is fenced out of most areas. Where heavy equipment needs to work next to trees, the trees will be double wrapped with snow fencing to protect the trunks. Also, heavy equipment will not be allowed to compact wet soil, so work must be suspended during wet periods.

The construction contractors at the staging area and at other construction locations can minimize impacts by: 1) limiting cut and fill around trees, 2) fencing off all areas where equipment is not required, 3) protecting individual susceptible trees by wrapping snow fencing around trunks, 4) disallowing impervious surfaces to cover tree roots, and 5) using treated wood or rock barriers to minimize fill and cut encroachments around trees. The impacts on the staging area are somewhat offset by utilizing the already impacted corral areas and phasing out the corrals.

To lessen the impact of increased vegetative disturbances and impervious surfaces at Lodgepole, multi-storied tourist units are planned. Also, the steep backdrop south of the development will minimize the visual impact in an area that is not characterized by unique vegetation or scenery.

The impact of the tram road will be limited by fitting a narrow road to the slope contours and by not compacting the road base. This may be accomplished by using a recently developed pervious asphalt on a rock base providing that this product has suitable specifications. Also, the proposed location will avoid penetration of any significant sequoia groves and no sequoia tree older than 50 years will be removed while attempting to preserve all trees.

The proposed sewer system's line will not remove any mature trees and wherever possible the lines will be placed under large roots rather than cutting them. The spray fields will be large enough in size to allow for alternate use of different segments so that little, if any, damage should be sustained by the vegetation. Also, the deep soils and southern exposure should aid in accommodating the effluent disposal.

Impacts on the alternative Clover Creek Camp area can be minimized by leaving brushy vegetation along the stream and by discouraging traffic parallel to the stream with felled dead trees. Also, a carefully developed trail system that radiates to Clover Creek and close proximity points of interest would help to lessen streamside disturbances. Probably the strongest mitigation would be a strict limitation on the number of users. Whenever pine and fir trees need to be felled the material should be felled late in the fall or be removed or be mechanically treated within 30 days to avoid bark beetle build-up.

Wildlife

The potential for impact upon rare or endangered species is low; no known California rare or endangered species will be adversely affected. It is possible, however, that some old-growth conifer habitat may be disturbed. This is the favored habitat of the spotted owl, which is listed as "threatened with extinction" by the U.S. Bureau of Sport Fisheries and Wildlife.

Alternate Plan A (Fig. 15) has the same features as the Development Concept Plan with the primary changes being the removal of the staging area and the replacement of the tram system with a one-way auto interpretive loop which follows the same route. Day use parking would also be retained at Crescent Meadow under this plan. The major disadvantage of Plan A as compared to the Development Concept Plan with respect to wildlife would be the undesirable effects resulting from automobile use. In addition to the direct effects of noise, air pollution, and higher road kills, indirect effects could include undesirable feeding of wildlife by motorists, which is less likely to occur with the tram system.

Alternate Plan B also relocates most exisiting facilities as does the Development Concept Plan, but no loop route for autos or tram is provided through Giant Forest. Instead, a one-way bypass is provided in the Kaweah area to help relieve traffic congestion. This plan would reduce the amount of habitat disturbance necessary for road construction, but does not reduce the other disturbing factors associated with automobiles.

One of the primary goals of planning for wildlife in Sequoia National Park should be the maintenance of the animal community in its natural complexity and diversity. Planning, therefore, should not favor any one species over the other, but rather should strive toward maintaining a reasonable ecological balance among all species.

Most wildlife are highly dependent upon vegetation in one form or another as an important part of their habitat. The quickest and most effective management of wildlife communities is through habitat management. Combinations of habitat types are key factors in determining the diversity of the wildlife community. The most important and guiding general planning consideration should, therefore, be the preservation of habitat diversity and identification and protection of key habitats in the area.

For the Giant Forest and Lodgepole areas (from the standpoint of wildlife considerations), major centers of activity would be least harmful if they were situated in the coniferous forests rather than in some of the other habitats which occupy smaller surface areas. This would aid in maintaining the derived habitat diversity of the region by disturbing a relatively small portion of the most abundant habitat type.

Key habitats which deserve special consideration because of their high wildlife value and relative uncommonness in terms of total surface area include the riparian, meadow, and aquatic habitats and their corresponding "edge" areas. Disturbance or destruction of these habitats would have a greater impact in terms of reducing overall habitat diversity, as well as adversely affecting habitats which are important to a wide variety of species.

Special attention should always be given to any rare, endangered, or uncommon species which might be adversely affected. The fisher and wolverine are two species of primary concern in this general region. Because of their intolerance of human activity, they are now seldom seen in the study area. Therefore, no special considerations for individual species beyond those mentioned are considered necessary.

Although the basic conceptual plan as it now stands is a good one in terms of minimizing harmful impacts to the wildlife community, some specific mitigation measures will help even further.

In all areas proposed for construction near streams, a minimum setback of 200 feet from each side of the bank will occur. This will help to reduce the potential impacts upon water quality and, therefore, the fisheries, by reducing the chance of siltation and chemical pollution during construction and post-construction activities. Naturally, distances greater than 200 feet would be even more beneficial. This consideration will be particularly important at the Lodgepole area, the Wolverton ski area, and the location of National Park Service housing.

Any future activities or structures located near meadows should be situated so that constant disturbance to the meadow itself is minimized. Roads and campsites should be located so that a reasonable buffer of trees and other vegetation is provided between the meadow and the activity. As a general rule, this zone should be wide enough to screen out most of the sight and sound of the activity.

Erosion control practices will be followed during construction, especially in areas close to streams. Use of small settling ponds or catch basins are common methods.

Vegetation, especially trees and shrubs, will be preserved whenever possible and planted where feasible for landscaping purposes. Only native species will be utilized.

It is recommended that a survey for spotted owls be conducted in all areas in which vegetation removal will be necessary for implementation of the proposed plan. In the event any are found, the NPS wildlife biologists should be consulted for possible protection measures.

Archaeology

To be provided by the Denver Service Center. Refer to Appendix D.

Traffic and Circulation

The one basic drawback to the plan utilizing a tram system is the potential exposure of passengers to the hazard of crossing the General's Highway. At present, traffic is controlled only by its density and the speed limit. An operator controlled stoplight at crossings will provide control over traffic and reduce hazard to negligible levels.

The light should be constructed in such a manner that only the operator of the tram is able to set up a red light cycle. This may be accomplished through the use of a key, magnetic key card, or by a light or ultrasonic device similar to those used to open garage doors. This last means offers the benefit of triggering a cycle while the tram is moving and eliminates stopping and then accelerating. Ideally, the crossing point should intersect General's Highway at right angles, and an unobstructed view of both the crossing point and a section of the highway should be available. Warning signs should be placed on the roadway on both sides of the crossing informing drivers of the possibility of a stop cycle. The light itself could be a continously flashing yellow for a caution back up to the drivers, then a brief red; or, to avoid clashing with the environmental setting, the light could be dark until a yellow-red-green cycle, then dark again when traffic has begun to move at the normal pace.

An additional hazard, though probably somewhat less significant, is presented when the tram utilizes the highway as a portion of its route. The slow moving (necessitated by its inherent design and to enable passengers to enjoy the scenery) tram may be an obstruction to the flow of traffic (in an extreme example, it may precipitate an accident by an impatient motorist attempting to pass in an unsafe manner). Unless the roadway can be widened or the lanes adjusted to allow a corridor solely for the use of the tram, trunouts may be the only solution. Of course, turnouts may encourage visitors to use them and in turn return to previous traffic patterns.

V. ANY ADVERSE EFFECTS THAT CANNOT BE AVOIDED SHOULD THE PROPOSAL BE IMPLEMENTED

When the various actions called for in the conceptual plan are implemented, the following adverse ecological and social effects might not be avoided, even though most can be substantially mitigated.

1) The development necessary to accomplish the concepts of this plan will remove a portion of the available resources. Presently relatively undisturbed acreage will be required within the current park holdings to accommodate the proposed buildings, parking areas, tram interpretive road, access roads, trails, sewer, and other facilities. The predominant use area, as designated in the Development Concept Plan, Fig. 6, will be the Lodgepole area. This area currently receives high summer use, is presently a disturbed environment, and has qualitatively been described as having a low "environmental sensitivity" (see discussion, pg. 74 and composite Sensitivity Map, Development Concept Plan). Disturbance of the natural environment will be minor and local in nature should this plan be initiated.

2) The additional development will result in some removal and modification of vegetation and wildlife habitation. Increased soil erosion and runoff will also result. No rare or unique wildlife or vegetative species will be affected.

3) The increased number of motor vehicles anticipated by the improvement of facilities will tend to produce more air and noise pollution. This will occur principally along access roads and highways outside the park proper as more visitors are attracted to expanded and innovative park programs. It is anticipated that the flow of traffic will be improved and the miles driven will be decreased because of the proposed transportation system within Sequoia National Park. When engine controls are refined to meet more stringent federal and state emission standards, it is likely that the net effect will be an improvement in air quality.

4) Some of the visiting public who will have to use the tram and shuttle system will find it less convenient than use of their private automobiles. This may result in a change in visitor habits and in the type and origin of park visitors until the

public becomes adjusted to the new and innovative park management policies. It is problematic whether this should be considered an adverse impact.

VI. THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The objectives of a national park include a policy of managing the park ecosystem in such a way as to maintain and enhance the natural qualities of the park while at the same time permitting compatible land uses within the park boundary to enhance the appreciation and instructiveness perceived by park visitors. The goals and policies of Sequoia National Park have been discussed on pages 7 and 8. Thus, in this situation, the National Park Service is not a local short-term consumptive user of the Sequoia Park resources but rather a long-term steward of the park's unique ecosystem. As discussed on pages 1 and 7, this objective has not always been a conscious and compatible part of the park's development history. As a result, short-term use has affected the long-term productivity and stability of the park's ecosystem.

The time has come for the National Park Service to initiate a plan and program to achieve its stated goals. The Giant Forest and Lodgepole Development Concept Plan is one step toward arriving at this objective. Achievement of the objective will require certain environmental and sociological "tradeoffs" which are inherent in the Development Concept Plan. The tradeoff concept is that the current facilities and improvements located in the park's prime resource, the Giant Forest sequoias, and the environmental damage that occurs through misuse of these resources, be displaced to less significant and less sensitive areas of the park. Current visitor impacts on the sequoias are discussed on pages 29-31 and page 55. Specific impacts of this proposal have been discussed under appropriate topics in Section III of this EIS, and unavoidable adverse impacts have been summarized in Section V. The tradeoff, in essence, transfers short-term uses with resultant deleterious effects on productivity occurring within the Giant Forest area to less sensitive areas of the park.

Viewing this subject from an ecologic viewpoint, the Development Concept Plan proposes removing approximately 12 acres of the park from biological productivity by covering forest soils with impermeable materials in the form of roads, parking lots, and buildings. As has been discussed, the locations and sitings of these man-made improvements have been transferred from an environmentally sensitive and unique ecosystem to less sensitive and less productive areas of the park (see pg. 8 and the Natural Resource Base Composite Sensitivity Map in the Development Concept Plan). A net gain of less than ten acres will be returned to biological productivity. Apart from the hydrological ramifications of such disturbances on the existence of the sequoias, the loss or gain of the biomass involved is insignificant when compared with the total biomass of the park. Viewed from a geological time frame the proposed changes in land use represent a very local short-term use of the environment; this is also true when compared with the age of the Sequoias.

The conceptual plan establishes a plan for resource use that will stabilize environmental quality for the short and long-term and allow the regeneration and protection of the natural environment in areas that have previously deteriorated.

VII. ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES THAT WOULD BE INVOLVED IN THE PROPOSED ACTION SHOULD IT BE IMPLEMENTED

The implementation of the Giant Forest - Lodgepole Development Plan would not result in any irreversible or irretrievable commitments of the park's resources beyond those mandated by the Establishment Act which requires conservation of natural resources for outdoor recreation use. Although such recreation uses are not irreversible commitments of resources, new areas will be utilized for parking, buildings, roads, and other developments called for by the conceptual plan.

The fact that the Development Concept itself proposes removal of the facilities from Giant Forest and the return of this unique grove to its natural splendor exemplifies the point that this plan is short-term and does not necessarily involve an irreversible and irretrievable commitment of resources. It is also anticipated that initiation of this plan will allow a higher level of management in regard to impacts of the visitors to Sequoia National Park.

VIII. ALTERNATIVES TO THE PROPOSED ACTION

The legislation that established Sequoia National Park plus the administrative policies of the Park Service set definitive limits within which the service must operate in the management and development of this park. These clearly limit the range of possible alternative management actions.

The various alternative policy considerations can be visualized as lying between two points on a development intensity spectrum - conservation and maximum development. These alternatives are presented graphically on the following chart.

Greatly expand and improve facilities at Giant Forest				Remove all facilities to less sensitive area of park	
Greatly expand facilities at Giant Forest and throughout park to accommodate increased visitors	Retain and maintain facilities at Giant Forest	Retain as is, no project	Remove some of facil-ities from Giant Forest	Remove all facilities from park, allow visitation with management	Remove all facilities, return to wilderness

Each of these alternative policy choices portends various costs and benefits in terms of environmental costs and benefits of visitor utilization. Maximum visitor utilization with mini-mum environmental damage is, in fact, the principal directive of the National Park Service. For the purpose of this evaluation, that directive is also the definition of recrea-tional carrying capacity.

At present, a system of determining the recreational carrying capacity of natural areas defined in terms of man days per season of use (without resource degradation occurring) is largely based on the subjective analysis by professional resource scientists of the various components of the natural environment. J.A. Wager defines recreational carrying capacity as "the level of use at which quality remains constant" [Wager, 1964]. However, the perception of quality of environment and the quality of a recreational experience varies among people. Thus, there must be some management objective on which to base a satisfactory level of quality and capacity, and permit use and appreciation of a resource by a wide variety of people with different needs and perspectives. This is the central concept inferred in the chart on the previous page and is the basis for decision making on the selection of alternative land use plans for Sequoia National Park. A unique and quality experience is an appropriate objective for this magnificant park.

Within this broad definition of a plan based on an acceptable Recreation Carrying Capacity, a number of alternative choices exist as to specific location layout, design, and density of proposed facilities and improvements. Site specific land capabilities and specific environmental impacts must be analyzed and weighed when discussing proposed uses at this level of the planning program. Some alternatives have been discussed with reference to particular components of the environment in "The Environmental Impact of the Proposed Action" section of this report. We have attempted to put these alternatives in perspective in this section of the EIS.

With this introduction in mind, the following paragraphs describe briefly the various alternative plans considered for Sequoia National Park, and the general rationale for acceptance or dismissal of the alternatives. Criteria for the selection of the proposed alternatives were: compatibility with the goals and policies of the National Park Service for Sequoia National Park, environmental sensitivities and anticipated environmental impacts, cost and engineering feasibility, and social-cultural input considerations.

No Action Alternative

The deficiences of the present facilities and programs at Sequoia National Park have been discussed on pages 1, 7, 29-31, and 55 of this Environmental Impact Statement, as well as in the introductory section of the Development Concept Plan. Development of land use patterns in the giant sequioa groves has been inconsistent with the intent of original congressional legislation and of the policies and management programs of the National Park Service. As discussed in Mr. Lee's findings, the present park program attracts a narrow cross section of the visitor public, who originate mainly from the Los Angeles Metropolitan Area. The resultant development over the years has left buildings and improvements in a substandard condition, with overaged structures, an obsolete transportation system, and inadequate utility services. These are all centered within the prime resources of the park, the giant sequoia.

Selection of the "No Action Alternative" would thus perpetuate the trends of deterioration of buildings and facilities within Sequoia Park and of continued damage to the environment of the sequoias. This alternative is thus inconsistent with the legislation and directives guiding operation of Sequoia National Park.

Improve and Update Buildings and Utilities at Giant Forest and in Other Established Areas of the Park

Selection of this alternative would result in the mitigation of the adverse visual and cultural aspects associated with the present inadequate facilities and utilities of the park. Under this alternative, a higher level of consumer and concessionaire services could be offered to park visitors. This present inadequacy is a key factor affecting the quality of the recreation experience for one portion of the visiting public. However, a number of adverse environmental and social aspects of the present park program would remain. It is doubtful that a transportation program not oriented around the automobile could be established if Giant Forest were to provide both visitor facilities and the interpretive focal point. Noise, confusion, air pollution, and aesthetic considerations attendant with use of the automobile as in the present visitor access system would remain unabated. Further building and construction activity may adversely affect the hydrologic system of the sequoia groves. A rewarding interpretive program would be difficult to develop for this unique area amid the confusion of automobiles, buildings, and undirected visitors. Management of the park environment would be difficult under these circumstances and visitor inflicted environmental impacts would continue.

Remove or Relocate Only Those Concession Facilities Within the Prime Resource Area of Giant Forest

This alternative presents the least number of adverse environmental impacts. Adverse environmental impacts would involve only acts associated with the demolition and removal of the present facilities. These are temporary impacts and it is expected that with proper rehabilitation and management, Giant Forest can be returned to a near natural condition.

Implementation of this plan would create a large unmet demand if present visitor accommodations were not replaced within access to Giant Forest. A portion of the present park visitor population would thus be excluded from utilization of the park if some basic facilities provided at Giant Forest were not made available elsewhere.

Increase Private Vehicle Use for Interpretation

Alternate Plan A would allow for extensive expansion of high standard highways by originating a one-way auto loop system near Camp Kaweah as depicted in Fig. 16. The highway would be built to state highway standards and contain a sub-base and base of compacted materials. The loop would bypass facilities at Giant Forest traveling west to day use facilities located at Crescent Meadow. From Crescent

Meadow the proposed road would continue in a northwesterly direction to connect with the General's Highway above the road leading to Wolverton. General's Highway would be designated as one-way traveling southwest to return to the Camp Kaweah starting point. The northern portion of the General's Highway would remain unchanged. The plan would, with proper signing and orientation, reduce congestion at Camp Kaweah adjacent to the existing highway, allow for greater dispersal of visitors, and allow a convenient drive-by view of more of the Giant Forest. Plan A would also eliminate the need for the parking and staging area at Wolverton Stables. This plan could also be used in tangent with improvement of facilities at Giant Forest, or as a separate proposal concurrent with removal of Giant Forest facilities.

The plan is not favored because of possible major impacts on the area's hydrology and, subsequently, the sequoias from the development of a high grade highway. As discussed on page 80, the most serious impact is the potential disruption of groundwater movement by construction of a subsurface barrier or interception of subsurface flow. Considerable disturbance of plant and animal habitat would be caused along with increased air and noise pollution. While Plan A would promote better traffic flow, the one-way concept would require redundant trips over a portion of the highway for those wishing to enter the park from the south and exit from the north, or vice versa. Since many people wish to exercise the drive-through option, there would be an increase in mileage within Giant Forest plus increased noise and air pollution. If the visitor is allowed to drive the loop road, a more continuous disturbance of animal habitat would result compared with day use only by an interpretive tram. Finally, it is believed that the visitor experience from this type of vehicle use is substandard to other alternatives since it does not allow for liesurely viewings and interpretation.

By-Pass Road Around Camp Kaweah with Main Village at Lodgepole and Sub Village at Camp Kaweah

This alternative Plan B is depicted in Fig. 16. Plan B would relieve traffic congestion at Camp Kaweah and to some extent the adverse ecological impacts from overuse of that area. The plan was discarded because of the adverse impacts and costs necessitated by new highway construction in a steep, rocky area, because it is only a compromise on the important considerations of overuse at Camp Kaweah, and it would not allow dispersed use of the seldom visited portions of Giant Forest. Since continued overnight accommodations would be allowed at Lower Kaweah, a presently overused and deteriorated area would continue to receive a disproportionate amount of use. Besides the difficulty in assessing direct impacts on the sequoias from compacted soil and destruction of ground cover vegetation from trampling, the negative visual impacts from the buildings in the sequoias and lack of ground cover will be continuing impacts. Even if all of the accommodations were moved to Lodgepole under Plan B, the area would probably continue to be overused because of the lack of opportunity for dispersal within Giant Forest. Again, the lack of opportunity to see much of the presently unused Giant Forest and have it interpreted is a failing of Plan B.

Campground Alternatives

Camping alternatives could be related to one or more of the above plan alternatives and are discussed in some detail within the different environmental elements in addition to this section. The 310 unit campground at Lodgepole could be phased out as proposed in the conceptual plan, or a part or all of it could be retained. Retention of the campground, as is, would have the advantage of accommodating many people near the park's prime resources. Also, this would eliminate the impacts upon a needed replacement area.

Factors against retention of part or all of the campground include:

1) it is located in a high value riparian area where it would be desirable to have a natural area;

2) excess activity has eliminated ground cover, and rain storms readily carry sediment into the adjacent river;

3) most campers stay beyond the time that they require for interpreting the nearby sequoias; and

4) campers have reasonable alternatives in nearby National Forest campgrounds; a cooperative agreement between the Department of Interior and the Department of Agriculture is planned to add to this supply so that camping can be outside of the park's natural areas.

A new campground inside the park at Clover Creek was carefully considered as an alternative. The proposed site was highly regarded from the standpoint of access, proximity, topography, and soil depth, but is not favored because of the negative impacts that would be involved (as noted above), and cold exposure and other ecological impacts, including the impacts caused by providing access and utilities. Please refer to the different sections of the physical environment for a more detailed discussion of Clover Creek Campground impacts.

Utility Alternatives

The principal alternatives involved the location of a sewer treatment plant and a water source. The sewer plant and spray field location selected in the conceptual plan was made on the basis that it was the only location within several miles that could accommodate the proposed volumes with the least impacts. While a more detailed inspection of the proposed site is advisable, it appears to be located in a low sensitivity area that is adaptable to the use. A more detailed discussion is found in the utilities section of the Development Concept Plan.

The proposed water sources include a continuing or decreasing level of use from Silliman Creek and greatly decreased use from Wolverton Creek, with additional needs being satisfied by taking water from the Marble Fork of the Kaweah River above Lodgepole. It is believed that the alternatives of taking additional water needs from Silliman might excessively damage downstream riparian animal and plant life and that the continued level of water intake from Wolverton is also detrimental to the riparian ecology of that stream. It is believed that removing additional quantities of water from the Marble Fork of the Kaweah will have some negative impacts on riparian life and that the construction of water intake and transmission facilities will have some minor negative impacts on the riparain ecology. Since all of the proposed water use is from the same watershed, the net downstream effects will be similar regardless of the alternative selected. It appears that the water acquisition as proposed in the conceptual plan would have far less risk of riparian ecological damage than might be expected by taking a high percentage of the stream flow from such small streams as Wolverton Creek or Silliman Creek.

IX. CONSULTATION AND COORDINATION

The planning team of Sasaki, Walker Associates, Incorporated and the environmental team of James A. Roberts Associates, Inc., consulted at length with all levels of the staff of Sequoia-Kings Canyon National Park. This consultation was augmented by a review of the Park Service's 1971 Master Plan and discussions with the planning staff from the Denver Service Center. Also, we received considerable information from the recently retired concessionaire's administrator, Mr. John Klug.

The teams consulted often with federal and state agencies, especially with representatives of the U.S. Forest Service, California State Division of Forestry, and with the Davis and Berkeley campuses of the University of California. All conceptual proposals were subjected to scrutiny by the development teams in an attempt to avoid severe adverse impacts and to obtain the most beneficial visitor experience. Mr. Henry Schmidt, Superintendent, Sequoia-Kings Canyon National Park, was very helpful with his information, in committing his staff to our needs for inquiries, and in allowing us full use of the park's library.

Please refer to the Bibliography for additional information sources.

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APPENDIX A

VISITOR PROFILE

FOR

SEQUOIA NATIONAL PARK

VISITOR PROFILE

FOR

SEQUOIA NATIONAL PARK

Prepared for:

Sasaki, Walker and Associates
2200 Bridgeway Boulevard
Sausalito, California

Prepared by:

Robert G. Lee

August 11, 1973

I. The Problem

Site planning for recreational developments requires specific information on visitor expectations and use patterns if facilities are to satisfy the various publics who may use them. This report summarizes data describing the visitor population that is likely to visit Lodgepole Visitor Center and Giant Forest in Sequoia National Park, California.

The best available information regarding population characteristics and use patterns was gathered and summarized in a form useful to park planners. Suggestions were made for relating visitor characteristics to problems of site planning and facility management.

II. Procedures

A complete search of available reports was made with the purpose of characterizing the visitor population at Sequoia National Park. The only data available for the Park were visitation statistics. Therefore, household surveys of participation in outdoor recreation were used to typify National Park visitors residing in those geographical areas where relevant surveys had been made in the last ten years. These statistics provide a general description of the kinds of visitors that will be most likely to visit these facilities if future patterns of recreation participation remain the same as they were when sampled. It is important to note that these statistics may be used with confidence as to their accuracy only for the population sampled and the geographical areas of visitation described in the sample. However, it is reasonable to expect that many of these general patterns will be the same for visitors to Sequoia National Park and the facilities at Lodgepole and Giant Forest.

These general patterns of visitation and use were used to suggest implications for the design and management of outdoor recreation spaces. Possibilities for changing the visitor profile by changing the design and management of spaces were also suggested.

III. Results

Results from this investigation are reported below in two groups: 1) magnitude of past use as indicated by visitation statistics; and 2) social characteristics of visitors that have implications for the planning and management of park spaces.

A. Magnitude of Use: Visitation Statistics

- Total visits to Sequoia National Park increased 21% between 1962 and 1972 (See Figure A-1)

- Total overnight stays in Sequoia National Park decreased 33% between 1962 and 1972 (See Figure A-1)

- There was a sharp increase in the ratio of visits to overnight stays in Sequoia National Park in 1969 (See Table A-1)

IMPLICATIONS: These statistics represent levels of consumption and, hence, in no way may be interpreted as the quantity of resources required or demanded by the public. The reduction in overnight stays and resulting increase in the ratio of visits to stays may be attributed to a reduction in the supply of sites for overnight accommodations and improved access to the park. The relationships between the supply and demand for facilities can only be determined from systematic analysis.

B. Characteristics of the Visitor Population and their Relationship to the Planning and Management of Park Spaces

The relationship between the social and cultural characteristics of park visitors and the design and management of park spaces is schematically illustrated in Figure B-1. Park spaces are usually defined to satisfy visitor requirements for transportation, overnight accommodations, food, education, entertainment and inspiration. The specific nature of visitor requirements for spaces varies with place of residence, social composition, subculture and social class of the visitor population. The following generalizations point out some implications for the design of spaces at Sequoia National Park based on visitor characteristics.

- No data are available for emerging life style variations such as the youth counter-culture

IMPLICATIONS: Parks become repositories for the values of particular cultures or subcultures. Many minorities perceive National Parks as white territory because they tend to identify places by who uses them as much as by the natural characteristics or intended use. Similarly, counter-cultural young people identify with particular park spaces and use them as gathering places. On the whole, Sequoia National Park is a repository for the values of the American white middle and upper middle class. For the park to become a repository for a more widely shared set of values, attention should be given to the symbols attached to spaces by signs, names, and other assignment of identities. Trees and trails named after popular presidents or other public figures promote a sense of collective identity. Small functional spaces could be diversified by symbols and tastes. Offerings of food and music peculiar to different subcultural groups world permit them to identify with a part of the park as their "own", yet share the larger cultural meanings of the park as a whole. Giant Forest could be designed and managed as an inspirational "sanctuary" symbolizing cultural meanings in which all people could share by removing all overnight facilities and communicating to visitors a sense of wonder and humility before nature.

IV. Suggestions for Planning and Management.

Results reported above indicate that Sequoia is a highly "local" park, and National Parks in general are used disproportionately by the young, higher status and white. If planning and management proceed on the basis of tradition, decisions will tend to perpetuate these use patterns. It is, therefore, suggested that efforts be made to:

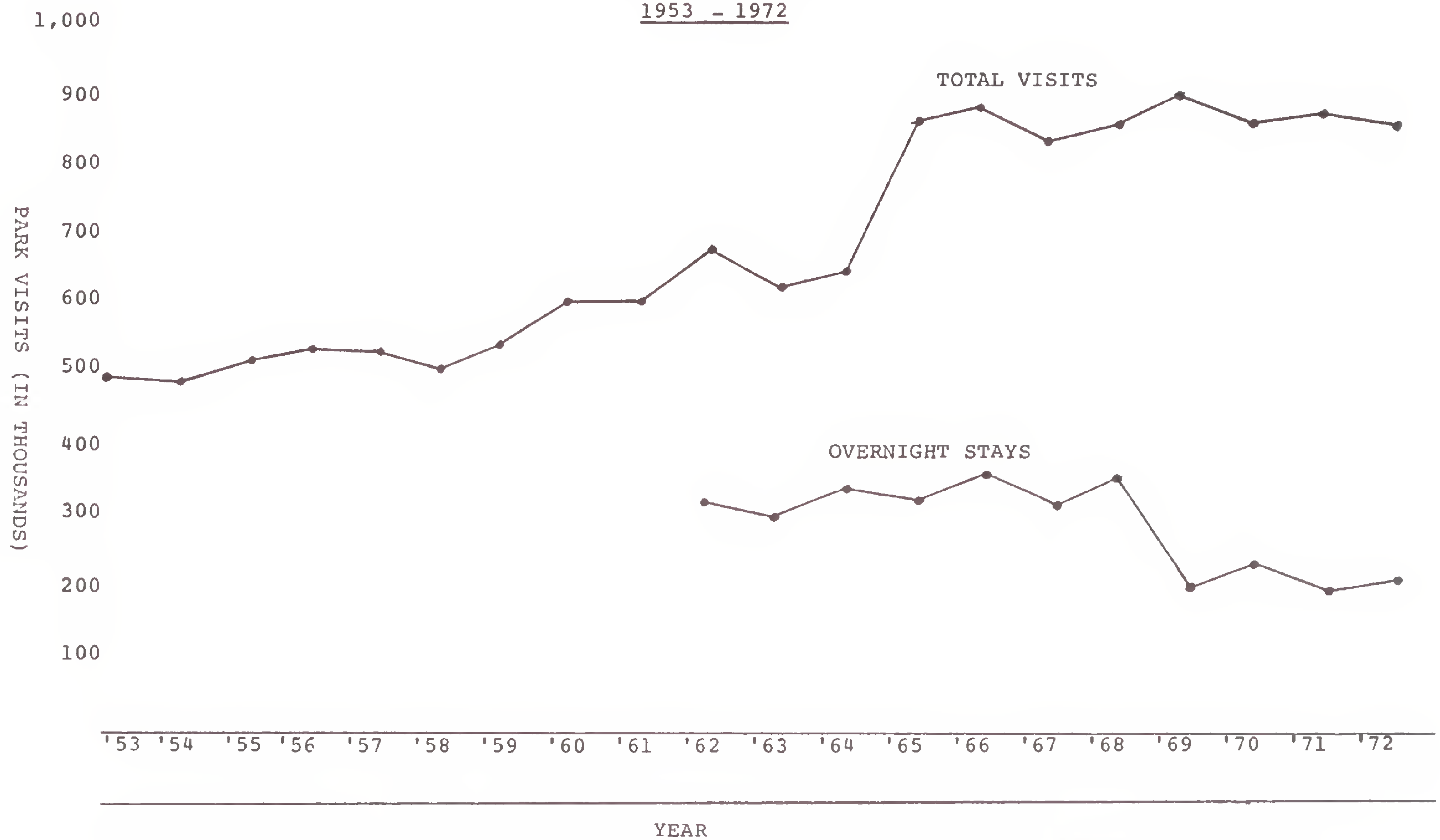
- Experiment with encouraging a more heterogeneous user population by diversifying values assigned to some spaces and broadening values assigned to others; this might involve site manipulation as well as media exposure.

- Establish inventory and analysis procedures to monitor visitor characteristics and use patterns in relation to changes in planning and management decisions. The magnitude of change planned for Sequoia presents an ideal opportunity for monitoring of visitor reactions.

FIGURE A-1

SEQUOIA NATIONAL PARK VISITS AND OVERNIGHT STAYS

1953 - 1972

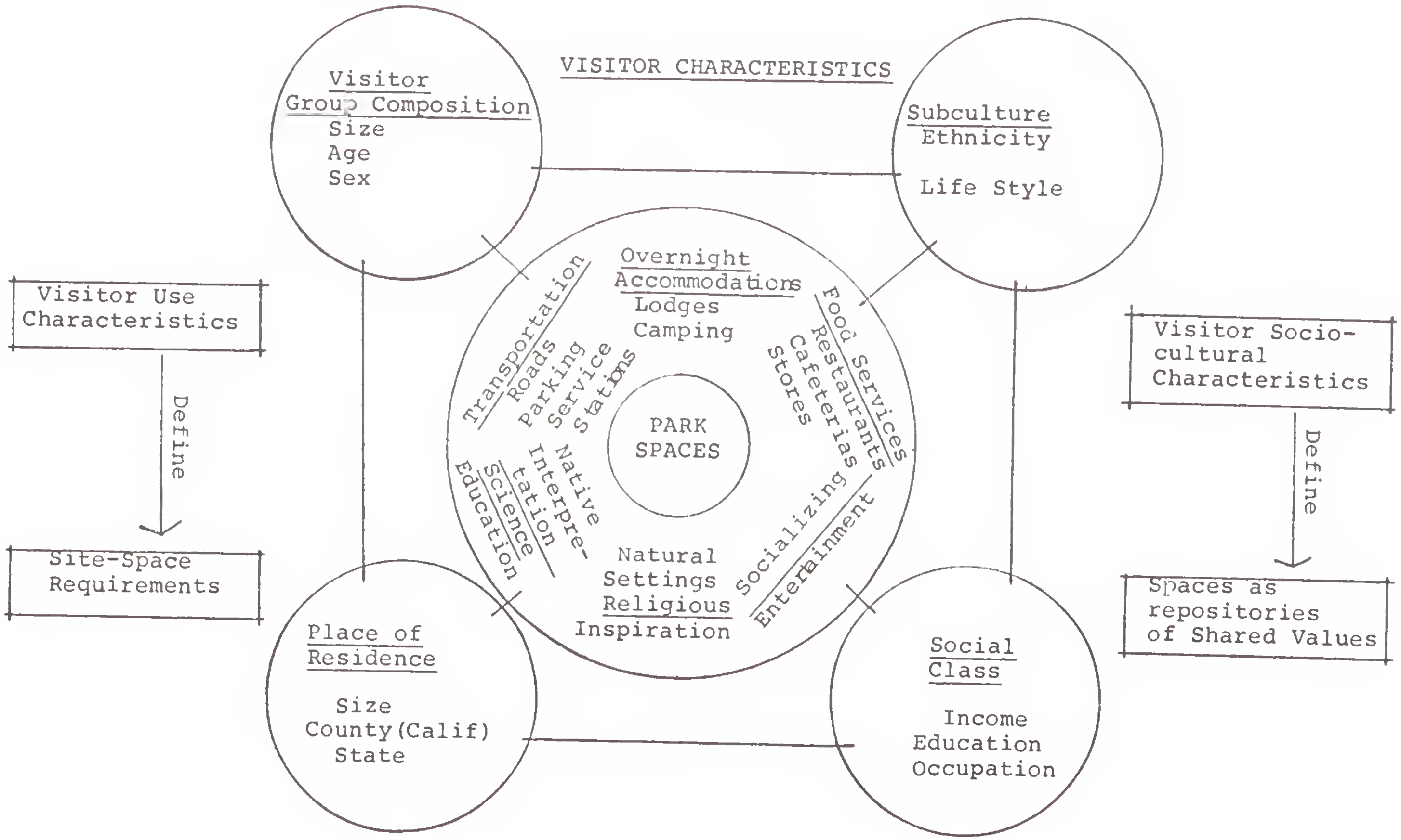


Source: United States Department of the Interior, National Park Service, Public Use of the National Parks: A Statistical Report (1953 through 1972)

FIGURE B-1

VISITOR POPULATION IN RELATION TO THE

PLANNING AND MANAGEMENT OF PARK SPACES



APPENDIX B

Recreation, Travel, Time Zones for

Selected California Metropolitan Areas

1. Place of Residence and Resulting Use Pattern

- For the U.S. as a whole residents of small cities visit National Parks more than residents of large cities.

- California residents accounted for about 90% of the visits to Sequoia-Kings Canyon National Parks in 1969 (for source see footnote 1 of Table B-1)

- Residents of Los Angeles, Orange, Fresno and Tulare Counties accounted for about two-thirds of the visits to Sequoia-Kings Canyon National Parks by Californians in 1969 (see Table B-1)

- Sequoia National Park is located in the 4+ hours travel time zone for all but two major metropolitan areas in California (See maps of Recreation Travel Time Zones for Selected California Metropolitan Areas)

- Only 12% of the 1965 California population travels more than 4 hours to a recreation area, while 41% travel less than 1 hour and 14% travel 2 to 4 hours, but almost half of all camping in California takes place in the 2 to 4+ hour travel time zones.

- Eighty percent of visits made to Sequoia-Kings Canyon National Parks in the summer of 1969 were in a passenger car or pickup.

- Over half of visits to Sequoia-Kings Canyon National Parks in the summer of 1969 lasted less than 1 day.

- For the U.S. as a whole there is very little relationship between place of residence and participation in hiking, automobile sightseeing, nature walks, picnicking and camping, even though residents of suburban areas are more active participants in all of these activities but nature walks.

IMPLICATIONS: The majority of visitors to Sequoia National Park come from a restricted geographical area, i.e. the Los Angeles area and San Juaquin Valley area in the vicinity of the park. The park may serve numerous recreational functions for highly mobile residents of nearby areas as well as providing a unique natural attraction. If this local population is to be satisfied, then more must be learned about what they come to the park for and what they do while there. Rationing of use or other access restrictions must be designed so as not to favor the local population over visitors from longer distances.

2. Visitor Group Composition

- For the U.S. as a whole, males and females are equally likely to visit National Parks.

- For the U.S. as a whole, younger individuals (ages 18 to 29) are far more likely to visit National Parks, while older individuals (ages 60+) are less likely.

- For West Coast residents, the mean size of the group visiting a National Park was 4.2; two-thirds of all such individuals attended a park with a group of four or more individuals.

- Over 93% of selected West Coast individuals visited a National Park with friends or family; only 5% going alone.

- For the U.S. as a whole, individuals who were members of households with children were equally likely to visit a National Park as individuals from households without children.

- For the U.S. as a whole, there is very little relationship between sex and hiking, and sightseeing by automobile, although women appear more likely to camp.

- For the U.S. as a whole, the younger the age of an individual the more they will hike, sightsee by automobile, picnic and camp, but there is very little relationship between age and taking nature walks.

IMPLICATIONS: Spaces must be designed to accommodate intimate social groups rather than individuals. Specific spatial requirements depend upon the sex and ages of group members. Multipurpose spaces should be designed to serve the needs of single individuals, families and groups of friends; singles may want to explore on their own in inspirational or educational spaces, but meet others in spaces used for entertainment or eating; friends will generally be of the same age and will make similar uses of the environment, with each age group having peculiar requirements; families will consist of different ages with different requirements. Parents will often engage in more serious "housekeeping" chores, or inspirational, relaxing or educational activities, at the same time as they are supervising children who want to play, rest, or find friends. Spaces might be designed so that parents using campgrounds or visitor education facilities could easily monitor children at play. A short-term child care service would permit parents to take time for activities they would not otherwise engage in.

3. Social Class and Resulting Use Patterns.

- For the U.S. as a whole, the higher the level of education, the more likely an individual will visit a National Park.

- For the U.S. as a whole, individuals with higher occupational status or blue-collar positions are more likely to visit National Parks than individuals with manual, service or farm occupations.

- For the U.S. as a whole, the higher the income, the more likely an individual will visit a National Park.

- The higher the income level of an individual, the more likely it is he/she will hike, sightsee by automobile. picnic, take nature walks, and camp.

IMPLICATIONS: These statistics indicate that spatial requirements for outdoor recreation increase with social class. Spaces such as lodging, transportation, and trails might be designed to give the visitor the feeling of being able to use or enjoy a great deal of space without interference from others. This requirement is far less important to the working class person, for whom the practical aspects of spaces take on far more meaning, i.e. an efficient and safe transportation system, practical accommodation, etc. Mechanized recreational camping vehicles may, therefore, appeal more to the lower than upper classes. Opportunities to use such vehicles in parks might have to be provided to encourage use by lower status individuals who prefer practical to "environmental" amenities.

4. Subculture and Related Use Patterns.

- For the U.S. as a whole, whites are much more likely to be users of National Parks than non-whites.

TABLE A-1

Ratios of Sequoia National Park Visits to Overnight Stays - 1962 - 1972 [1]

Year	Ratio of Visits To Overnight Stays
1962	2.1:1
1963	2.1:1
1964	1.9:1
1965	2.6:1
1966	2.1:1
1967	2.3:1
1968	2.4:1
1969	4.4:1
1970	3.6:1
1971	4.2:1
1972	3.9:1

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1 Source: United States Department of the Interior, National Park Service, *Public Use of the National Parks: A Statistical Report*, (1962 through 1972)

TABLE B-1

California County of Origin for Vehicles

Entering Sequoia and Kings Canyon

National Parks in the Summer of 1969.[1]

County	Entrance: Ash Mountain Per Cent	Entrance: Big Stump Per Cent
Alameda	1.51	2.72
Contra Costa	.43	1.78
Fresno	2.91	31.61
Kern	7.12	2.63
Kings	6.37	2.53
Los Angeles	40.17	21.11
Merced	1.07	.38
Monterey	.75	.47
Orange	7.01	4.69
Placer	.21	.00
Riverside	1.83	.75
Sacramento	.75	1.13
Solano	.43	.28
Santa Barbara	1.40	1.22
Santa Clara	1.72	2.81
San Bernardino	2.26	1.97
San Diego	3.67	3.00
San Francisco	1.18	1.69
San Joaquin	.32	.28
Tulare	14.25	13.60
Ventura	2.59	1.69
Other	1.94	3.66

1 Source: D. Jackson Faustman, Consulting Traffic Engineer, Traffic Analysis Master Plan Studies: Sequoia and Kings Canyon National Parks, California. (Sacramento, California, 1969)

APPENDIX C

SILVICAL CHARACTERISTICS OF GIANT SEQUOIA

SILVICAL CHARACTERISTICS OF GIANT SEQUOIA

By Gilbert H. Schubert, Forester
Division of Forest Management Research

Technical Paper No. 20 November 1957

CALIFORNIA FOREST AND RANGE EXPERIMENT STATION
FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE

The Experiment Station is maintained at Berkeley, California in cooperation with the University of California.

Agriculture--Forest Service, Berkeley, California

CONTENTS

SILVICULTURAL CHARACTERISTICS OF GIANT SEQUOIA

By Gilbert H. Schubert, Forester,
Division of Forest Management Research

Giant sequoia (*Sequoia gigantea* (Lindl.) Decne) is the world's largest tree in terms of volume (23). Within its natural range it occurs in more or less isolated groves on the western slopes of the Sierra Nevadas in central California. These groves, variously listed at 25 to 72 by different authorities (6, 8, 10, 11, 13, 14, 20, 23, 26, 28), lie in a narrow belt approximately 260 miles long (fig. 1). The northernmost grove, consisting of six trees, is along the Middle Fork of the American River in Placer County. The southernmost grove with 100 trees in it, is near Deer Creek in Tulare County.

HABITAT CONDITIONS

CLIMATIC

The climate in the areas where giant sequoia grows is cooler and drier than where the redwoods (*Sequoia sempervirens* (D. Don) Endl.) occur (26, 28). Annual precipitation, which varies with altitude and from year to year, ranges from 18 inches to more than 60 inches (23, 26, 28). The best stands grow in protected locations where the average annual precipitation is from 45 to 60 inches (23).

Most of the precipitation occurs in form of snow during the months of September through May. Summer storms are infrequent. Snow falls throughout the range of giant sequoia and accumulates in places up to 10 or more feet. During the winter of 1905-1906, snow in the Giant Forest (Sequoia National Park) was 29 feet deep; in protected spots, snow was still 12 feet deep by mid-summer (10).

The temperature occasionally drops to -12°F. and seldom exceeds 100°F. In the Giant Forest, one of the largest and best developed groves, the minimum temperature is -5°F. and the maximum is 94°F. The average growing season in this grove is 124 days--June 2 to October 4 (27).

EDAPHIC

Giant sequoia grows on a wide variety of soils from shallow rocky, to deep sandy loams (28). Although it grows on shallow moderately dry soils, it does best on moist, deep, well-drained soils slightly to moderately acid in reaction. These soils are generally developed from granitic, dioritic, and andesitic rocks. The most common soil series are: Holland, Olympic, and Sierra.

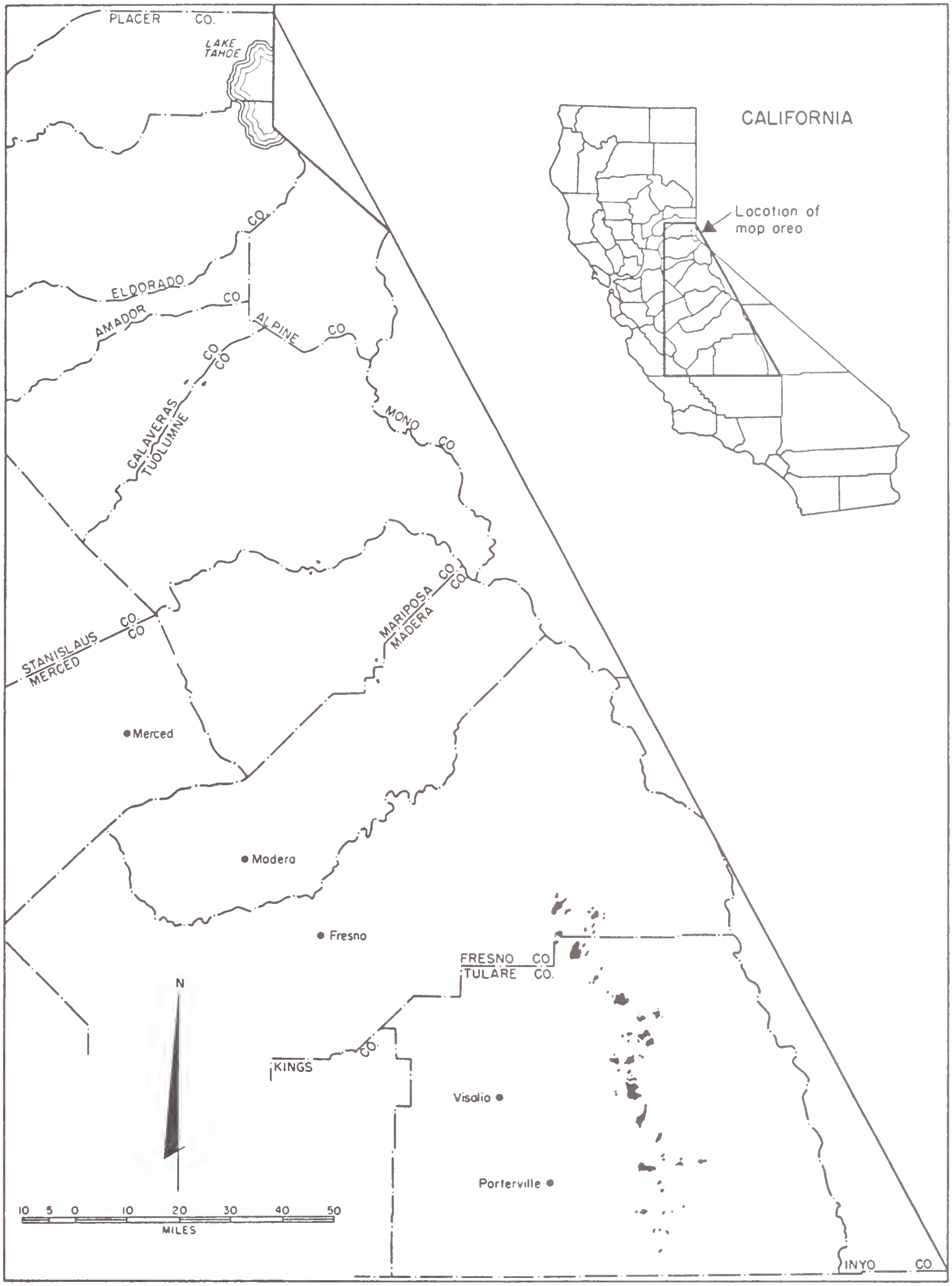

Figure 1.--The natural range of giant sequoia. (Adapted from California Department of Natural Resources (6).)

PHYSIOGRAPHIC

Most of the groves are at elevations between 4,500 and 7,500 feet (6, 23). Some occur as low as 3,000 feet and a few grow at 8,900 feet. At the northern part of its range the trees occur at 4,500 to 5,500 feet; in the central part, at 5,400 to 7,000 feet; and at the southern end, at 6,000 to 8,000 feet.

Giant sequoias grow on slopes of all aspects. The groves are generally found in canyons where soil moisture is always adequate but also occur on or near the tops of high exposed ridges where underground water is available (6, 11, 28).

BIOTIC

Giant sequoias occur in small groves within the ponderosa pine-sugar pine-fir type (25). They never make up pure stands except over small areas.

Trees commonly associated with giant sequoia are:

White fir (*Abies concolor* (Gord. & Glend.) Lindl.)
Sugar pine (*Pinus lambertiana* Dougl.)
Ponderosa pine (*P. ponderosa* Laws.)
Incense-cedar (*Libocedrus decurrens* Torr.)
California black oak (*Quercus kelloggii* Newb.)

Other trees found growing with giant sequoia are:

Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco)
California red fir (*A. magnifica* A. Murr.)
Jeffrey pine (*P. jeffreyi* Grev. & Balf.)
Pacific dogwood (*Cornus nuttallii* Audubon)
Bigleaf maple (*Acer macrophylum* Pursh)
Canyon live oak (*Q. chrysolepis* Liebm.)
White alder (*Alnus rhombifolia* Nutt.)
Bitter cherry (*Prunus emarginata* Dougl.)

Common brush species occurring with giant sequoia are:

Greenleaf manzanita (*Arctostaphylos patula* Green)
Mountain whitethorn (*Caenothus cordulatus* Kell.)
Deerbrush (*C. integerrimus* H. & A.)
Snowbrush (*C. velutinus* Dougl.)
Littleleaf ceanothus (*C. parvifolius* Trel.)
Bearmat (*Chamaebatia foliolosa* Benth.)
Bush chinkapin (*Castanopsis sempervirens* Dudley)
Scouler willow (*Salix scouleriana* Barr.)
Western azalea (*Rhododendron occidentale* Gray)

LIFE HISTORY

SEEDING HABITS

Flowering and Fruiting

Male and female flower buds are formed on the same tree during late summer, but are not discernible until the following spring when they begin to swell and open (4). The ovule-bearing strobili originate on the larger twigs near the tips of branches but rarely on the leaders. The pollen-bearing strobili are formed on the smaller twigs.

Pollination usually occurs between the middle of April and the first of May when the conelets are only 2 to 3 times as large in diameter as the twigs on which they are borne (4). By the end of the first growing season the conelets are about one-third mature size. They reach mature size of 2 to 3.5 inches in length at the end of the second growing season (5).

In one study the number of seeds per cone varied from 97 to 306, and averaged about 230 (10). The greatest number of seeds reported from a single cone was 329 (10).

Seed Production

Giant sequoias usually begin to produce large numbers of cones only after they have reached an age of 150 to 200 years (11). Cones have been observed on 18- to 24-year-old saplings, but they usually contain only infertile seeds (11, 23, 28). Heavy cone crops with viable seeds have been reported on some trees 50 to 75 years old (17).

Cones are generally produced each year and enormous quantities are borne on the largest trees (28). The immense size of the tree and the relatively small size of the cones make it impossible to count accurately all the cones on a tree.

Not all cones which first appear on the tree survive to maturity. One instance was reported when all 1-year-old cones were frozen in the early summer of 1906 (10). None of the 2-year-old cones on the same trees were affected. Some immature cones may have been destroyed by freezing during other years, but no other report on freezing injury was located.

Squirrels, particularly the Douglas squirrel (Tamiasciurus douglasii Backman) cut down and cache vast numbers of mature cones for their winter food supply (10). These cone caches provide a convenient seed source for seed collectors.

No seed or cone insects or diseases of economic importance have been reported for giant sequoia.

Seed Dissemination

In contrast with the habit of most conifers, giant sequoia seeds are not usually released the first year after the cones mature (4, 10). Viable seeds may be retained in the cones for more than 14 years (10). One cone, on a branch broken off a large tree during a wind storm, was 19 years old (4). This cone still contained 137 seeds--more than half the average number of seeds normally found in cones at maturity.

The tissue in the peduncle of mature cones that remain closed on the tree produce annual rings (4). Cones with only 2 growth rings in the peduncle are immature, whereas those having 3 or more rings are mature. Annual rings continue to form in cones that have not shed all their seeds and therefore can be used to determine the age and maturity of the cones. Cones which open and release all of their seeds die, turn brown, and do not form annual rings thereafter.

Giant sequoia seeds are very light and may be carried for great distances by air currents. The number of seeds varies from 54,000 to 132,000 per pound; the average is 91,000 (19, 28). Exact distances that wind will carry these light seeds are not known; however, it is believed to be several hundred yards (11). In one instance seeds were carried by wind for 580 feet (10).

VEGETATIVE REPRODUCTION

Giant sequoia does not produce sprouts from roots or stumps as is common in redwood, but tall broken stubs and crowns sprout vigorously (26) and form new tops if sufficient live foliage remains below the point of breakage.

SEEDLING DEVELOPMENT

Establishment

Giant sequoia seeds germinate best on exposed mineral soil and in loose ashes on a freshly burned area (23, 28, 29). Very few seedlings are found in the northern groves where the litter is deep and dry. In the central and southern groves reproduction is abundant only where the soil has been disturbed following logging, fire, erosion, windthrow, or road construction (fig. 2).

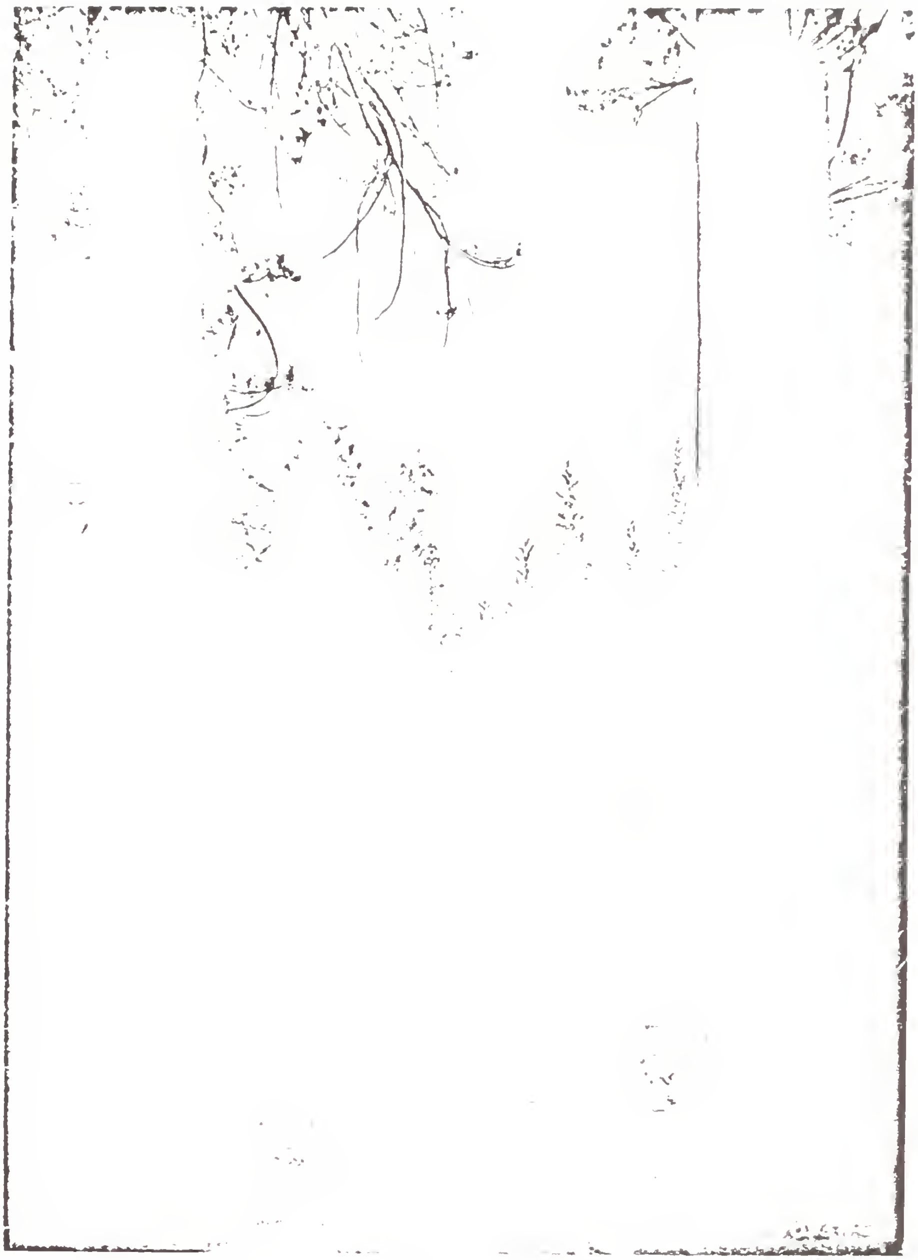

Figure 2.--Dense giant sequoia reproduction along road.

Field germination and survival, even on the better sites, are low. Although exact records have never been made, probably only one seed in a million germinates under natural conditions and only a small percentage of these survive (10). One of the main reasons for poor establishment has been an inadequate moisture supply, especially on areas covered with competing vegetation or dry litter.

Seeds stored in cones on the tree and in cold storage retain their viability for long periods (4, 10, 22). Two seed lots held in cold storage at 5°C. (41°F.) still had a viability of 41 to 43 percent after 16 and 17 years (22).

During the initial stages of seedling establishment some shade may be required. In a nursery study, none of the seedlings survived full exposure to sunlight, 16 percent survived under partial shade, and 68 percent survived in full shade (24). Since giant sequoia seedlings do survive in the open under natural conditions, other causes of mortality, such as excessive heat or drying, may have been the deciding factors in the nursery study.

Heavy losses of seedlings are frequently noted for giant sequoia. Sparrows (Zonotrichia spp.), the California purple finch (Carpodacus purpureus californicus), cutworms (Noctuidae spp.), ground squirrels (Citellus spp.), and chipmunks (Eutamias spp.) destroy many seedlings during the first few months after germination. Many seedlings also die in areas where the soil is too wet or too dry. Severe root competition for the limited soil-moisture supply is a factor in preventing the establishment of seedlings in old stands (17).

Early Growth

Height growth of giant sequoia seedlings is slow during the first year but increases rapidly after the second or third year (23). One-year-old seedlings are from 1 to 3 inches tall. By the end of the second year they are 3 to 6 inches, and after 3 growing seasons 6 to 12 inches. Trees 35 years old average between 45 and 87 feet tall depending on site quality and competition with older trees (17). With an even start, giant sequoias are capable of outgrowing any of the associated species (17).

Exact root growth measurements have not been reported; but root elongation is probably rapid. During the first few years, the main root system consists of a taproot with few laterals (20). After 6 to 8 years lateral root growth is predominate, and elongation of the taproot practically stops. Later in the life of the giant sequoia, the lateral root system may spread over an area of 2 to 3 acres with none of the roots more than 6 to 8 feet deep (10, 20). This wide-spread root system provides excellent support for the trees throughout their life span.

SEASONAL GROWTH

There are no published data on beginning dates or duration of seasonal radial or height growth of giant sequoia.

SAPLING STAGE TO MATURITY

Growth and Yield

Although giant sequoia is not the tallest species, and although occasional individuals of other species may surpass it in basal circumference, it is the most massive tree in the world (23). The highest volume of a single tree was estimated to be 600,120 board-feet; many trees have a gross volume of more than 500,000 board-feet (8).

The General Sherman tree in the Giant Forest has the greatest circumference of the measured trees. It has a basal circumference of 101.6 feet at 4.5 feet and a height of 272 feet (1). The tallest giant sequoia (California tree in the General Grant Grove, Kings Canyon National Park) is reported to be 310 feet high (23). Trees with an average basal diameter of 20 feet and a height of 275 feet are common in the southern groves where the best stands are found (21, 28).

Giant sequoias are long-lived (28). Trees in many groves range from 2,000 to 3,000 years old, and a few are over 3,000 years (23, 28). The maximum age has been reported to be over 4,000 years (28), but no authentic records are available to substantiate this claim. The actual age of the oldest living tree is a subject of much speculation and only crude estimates can be made. Ring counts on felled trees indicate ages up to 3,200 years (23). Huge old trees, which were too big to cut in early years and which are now protected, may be much older.

Giant sequoias grow rapidly during their youth; in old age growth is rather slow. Trees under 75 years of age increase in diameter at an average rate of 1 inch every 3 to 5 years, but ancient overmature trees may require more than 20 years to grow 1 inch in diameter (9).

Giant sequoias less than 100 years old retain most of their branches. In contrast, trunks of mature trees are generally free of branches to a height of 100 to 150 feet.

Most giant sequoia groves are on public lands withdrawn from cutting; only 12 percent of the total acreage is in private ownership (6). Very few trees are being cut. In 1952, the latest year of record, about 2,000,000 board-feet were harvested (7). One of the main reasons for the small volume cut is the strong public desire to preserve old-growth trees. Since most "specimen" or "museum" trees are in virgin stands of which 92 percent are publicly owned, the amount cut in the future will probably continue to be small (6).

Although giant sequoias are prized chiefly for their esthetic value, some of the stands could be placed under management for their timber products. In the northern part of the range, there are too few trees to be of economic importance. But in the southern part the trees are more numerous and the areas are better adapted to silvicultural treatments.

Mixed forests in which giant sequoia is an important component could be managed to increase the quality and quantity of this species. About 34 percent of the area growing giant sequoias has been cut-over and is in need of silvicultural treatment. Some cut-overs are poorly-stocked or non-stocked and should be brought up to acceptable stocking standards by planting or special site preparation measures to encourage natural regeneration. Other areas contain overdense thickets which should be thinned to prevent further stagnation and to increase the growth rate of crop trees. And still other areas require stand-improvement measures to release potential crop trees from competition and increase the proportion of giant sequoias in the final stand. In the young stands dominant large saplings and small poles will require pruning to produce clear lumber in rotations of less than 150 years.

Periodic annual growth rates of giant sequoia have not been determined. However, rotation ages for second-growth stands will probably be based mainly on the size of tree that can be harvested without serious loss due to breakage, which runs 45 to 50 percent in old trees. In general, breakage is not a serious factor in young trees.

Reaction to Competition

The capacity of giant sequoia to develop and grow in close competition with other trees is still open to considerable debate. In the revised tolerance table, 25 percent of those receiving the questionnaire rated giant sequoia as tolerant, 50 percent as intermediate, and 25 percent as intolerant (3). Much depends on the period in the life span during which the trees were rated as to tolerance. For best development, giant sequoias require full overhead light (26, 28).

The trees are able to endure more shade during youth than in old age (11, 28). In dense thickets growth is very poor and when released the spindling trees recover slowly; however, after the crown has filled out, growth is rapid. During the first few years, adequate soil moisture is more critical than light for seedling establishment. Young reproduction is generally found only in openings where root competition for moisture has been reduced (17, 18). Small openings are preferable to large ones, mainly because of the lower evaporation rate of soil moisture and the partial shade in the smaller more protected areas. However, good reproduction has filled in some large areas when logging was followed by a good seed year and favorable climatic conditions.

Principal Enemies

Giant sequoia has few important natural enemies other than fire (12, 28). Ground fires are especially destructive during the seedling and sapling stages (23, 28). Mature trees, protected by an asbestos-like bark up to 2 feet thick, are able to survive repeated fires without serious loss (23). However, after the bark has been burned off, repeated hot fires may hollow-out large trees. Few of the veterans have been destroyed by fire alone, but some have been windthrown where roots were destroyed by fire, road construction or were exposed by erosion following fires. Most of the trees larger than 10 feet in diameter have fire scars (9). Soil compaction by the thousands of tourists that visit the groves each year has seriously reduced the vigor of many large trees (16). Trampling around the base of these trees has destroyed the many feeder-roots necessary to supply the vast quantities of water required by the trees, reduced the water-holding capacity of the soil, and lowered the amount of water penetration into the soil around the trees.

Once established, giant sequoia is noted for its resistance to insect and disease attacks (9, 23, 28). None of the insects reported on giant sequoia has caused the death of a single tree (15). An unidentified brown heartrot has caused some decay in large trees where heartwood has been exposed but no trees have been killed by this disease (28). Old trees which fell centuries ago show very little evidence of decay in the heartwood (23). The 2- to 3-inch layer of sapwood rots away in a few years.

SPECIAL FEATURES

A high content of tannin in the wood, bark, and cones of giant sequoia protects the tree from seed formation to maturity against attacks by insects or diseases.

The cones contain a highly-colored water-soluble pigment (73 percent tannin, 3 percent organic matter, 1.5 percent ash, and 22 percent water) which has been reported (10) to:

- Protect the cones from fungus
- Increase the germinative capacity of the seed
- Increase the retention of viability of the seeds
- Increase the vigor of seedlings
- Reduce the susceptibility of seedlings to insect and disease attacks.

RACES AND HYBRIDS

There are no known races or hybrids of giant sequoia. Two horticultural clons--blue giant sequoia (Sequoia glauca) and columnar giant sequoia (Sequoia pendula)--are listed in Standardized Plant Names (2).

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APPENDIX D

ARCHEOLOGY AND HISTORY

In accordance with the Advisory Council on Historic Preservation "Procedures for Protection of Historic and Cultural Properties" (36 CFR Part 800, Section 800.4), the following steps have been taken:

1. The 1974 annual listing of National Register properties (Federal Register, Vol. 39, No. 34, Part II, and subsequent National Register supplements through May 7, 1974, were consulted. The following properties are listed on the National Register or appear to be potentially eligible for the National Register:

    Auto Log

    Cattle Cabin

    General Sherman Tree

    Squatter's Cabin

2. Generalized professional archeological and historical surveys have been conducted and more intensive surveys within the project areas will be completed and evaluated before any development is approved.

3. The California State Historic Preservation Officer will be asked if he has any information about other historic resources in the project area.

4. The Regional Director and the California State Historic Preservation Officer will jointly apply the National Register criteria to all sites located by the surveys to determine if any sites may be eligible for National Register listing.

5. The Regional Director, in consultation with the California State Historic Preservation Officer will apply the Advisory Council's Criteria for Effect and for Adverse Effect, and documentation of their determination

will be forwarded by letter to the Advisory Council with a request for Council comment.

6. The National Park Service will comply with all requirements of the Advisory Council's procedures and with its own historic preservation directives and policies in planning and implementing this project.

7. In particular, developments will be designed to eliminate or satisfactorily mitigate any adverse effects upon historical resources caused directly or indirectly by the proposed project. Plans will also be prepared to prevent or minimize any alteration, destruction, or damage to historic resources scheduled for preservation. These will include measures to prevent or control vandalism, ensure appropriate maintenance, and avoid accidental damage.

8. The survey reports, comments and data from the California State Historic Preservation Officer, and the comments of the Advisory Council will be included in the final environmental impact statement.

APPENDIX E

RECREATIONAL CARRYING CAPACITY AND ENVIRONMENTAL ASSESSMENT METHODOLOGY

At present, a system of determining the recreational carrying capacity of natural areas defined in terms of man days per season of use (without resource degradation occurring) is largely based on the subjective analysis by professional resource scientists of the various components of the natural environment. The analysis is achieved by correlating experiences gained from observations and studies on other parks and natural areas and applying known and theoretical considerations from experiences gained in related fields. Although some studies have quantitatively assessed impacts on vegetation and soil conditions by comparing vegetative densities, incremental growth rates, and soil bulk densities in used and unused campsite areas, no attempts have been made to relate these findings to specific soil and vegetative mapping units, to such properties as particle size distribution, or to user statistics [see Lime and Stankey, 1971]. Professional judgement is thus involved in translating information from various sources to the Sequoia Park study area.

The approach used in developing the Sequoia National Park Conceptual Plan, and one that has been used successfully by the U.S. Forest Service in the Cleveland National Forest, has been to rank the various components of the environment in terms of their sensitivities and constraints to mans use, as determined by professional judgement and correlation of specific studies [U.S.F.S, 1971]. The components used in the development of the Sequoia National Park Conceptual Plan include soils-geology, slope, vegetation, wildlife habitat, and hydrologic-water quality parameters. The interrelationships of these parameters was noted particularly with respect to the occurrence of the Sequoia groves, but such interrelationships cannot be mapped. In addition, a sociologic evaluation was completed and depicted graphically. These paramenters were first mapped in the basic resource inventory, and then interpreted according to their sensitivity to man's use. A composite evaluation of the combined sensitivities of the environmental parameters was completed in a technique somewhat similar to the approach used by Ian McHarg, and this map when combined with the goals and policies of the National Park Service served as the basis for the evolution of the subsequent Development Concept Plan [McHarg, 1969]. The Environmental Impact Analysis was then achieved by comparing development and improvement locations with the previously defined environmental sensitivities. Mitigation measures suggested in the Environmental Impact Statement would be affectuated to minimize the adverse impacts of the plan.

Although this approach does not provide a methodology for establishing a specific recreational carrying capacity, it is felt that the conceptual framework provided by this approach can guide the planners in arriving at specific densities and site locations. It is suggested that minimal densities be designated first, and that allowable densities be expanded in conjunction with site monitoring and management plans developed by the National Park Service.

Sasaki, Walker Associates, Incorporated, Sausolito, California and James A. Roberts Associates, Carmichael, California, under contract with the National Park Service, developed the basic resource inventory, impact analysis and graphics, and drafted components for this environmental assessment.

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