THE INFLUENCE OF SEVERAL FACTORS OF SITE ON THE GIANT SEQUOIAS

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The Giant Sequoias (*Sequoia gigantea* or *Sequoiadendron giganteum*) are among the more interesting members of the earth's flora. Their great age and size has attracted attention since the trees were first classified by John Lindley in 1853.

Specimens of these trees have been planted and grow in over 50 different localities in the world. However, they occur natively only in a narrow belt 220 miles long by about 10 miles wide between approximately 4400 and 8000 feet elevation on the western or windward slope of the Sierra Nevada in Central California. Within this belt the Sequoias occur in a series of about 70 groves, each definitely separated from the other (Figure 1). The aggregate area usually included in the groves is slightly less than 36,000 acres. The distribution of groves, moreover, is not even. Except for 8 groves, the bulk is concentrated in the southernmost one-third of the belt in which they occur. These are: Redwood Mountain (RM),[1] Giant Forest (GF), Converse Basin (CB), and Windy Gulch (WG) between the King's River and the Middle Fork of the Kaweah; Garfield Grove (G) on the South Fork of the Kaweah; Mountain Home (MH) in the Tule River drainage. Groves on both ends of the Sequoia belt are small in area and contain relatively few mature giants.

It was this very spotty and limited occurrance of the Giant Sequoias which led the author to investigate some aspects of their ecology in hopes of accounting for the present pattern of growth. This paper is an outgrowth of a part of that study, which continues. Among the more obvious but nonetheless important factors here considered are those of site; namely, elevation, exposure, position on the slope, and proximity to water. Data were available for 65 of the 70 groves.

Elevation

The mean elevation for each grove was approximated as closely as possible by means of USGS topographic maps (Figure 2). The average elevation of the 65 groves is 6400 feet.[2] The lowest, South Calaveras (SC), is 4400 feet and the highest, Big Baldy (BB), is 7600 feet. The seven northernmost groves have a mean elevation of 5400 feet compared to 6600 feet for 11 groves in the middle Kaweah section. Forty-one groves (63%) are found between 6000 and 7000 feet elevation. Occasionally, individual trees are found beyond the limits of the groves. The highest Sequoia is at 8800 feet above the Atwell Mill Grove (AM) and the lowest is at 3000 feet on the South Fork of the Kaweah River.

The elevation of a grove seems to be closely associated with climate. There is more precipitation in the northern part of the Sequoia belt than in the middle or southern part. Calaveras Big Trees receives about 55 inches on the average per year while Giant Forest gets 42 inches. Average monthly temperatures at Big Trees are about 5° F. warmer than those of Giant For-

[1] The groves mentioned are identified by letters and located on Figure 1.

[2] Most groves occur over a vertical distance of several hundred feet. Elevations expressed are averages to the nearest 100 feet.

est. However, Calaveras Big Trees is 4800 feet compared to 6600 feet for Giant Forest. It would seem, therefore, that the warmth of the lower northern sites is compensated for by additional moisture.

Exposure

The average or dominant exposure, measured in terms of north, south, east, or west for each grove was calculated from the available data. In addition, some groves were measured in the field. The data are plotted here against elevation (Figure 2).

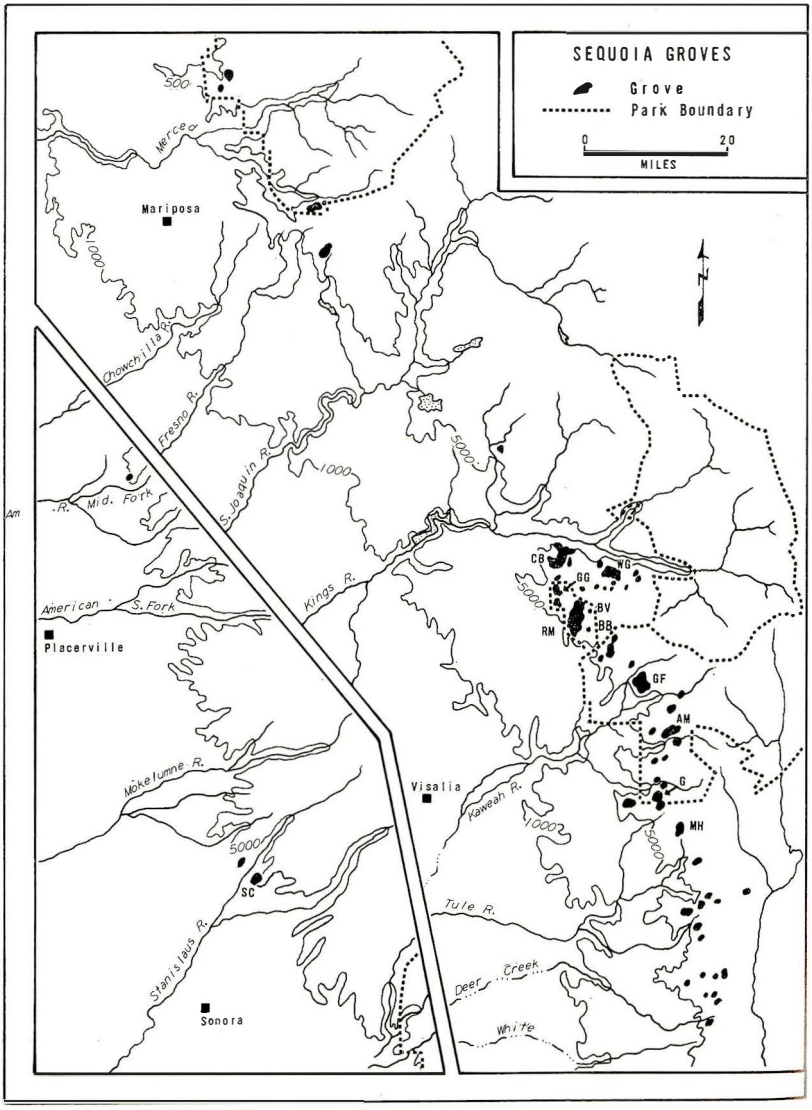


Figure 1

(100s of feet)

Group	Dominant Exposure				
	North	West	South	East	None
	57	52	53		
North of		48	60		
San Joaquin River		44			
		64			
	56	64	72	70	64
	66	70			
	62	62			
	60	62			
Kings River	62				
	68				
	68				
	68				
	64				
	56	62	68		62
		72			
		76			
Middle and		66			
Marble Forks,		66			
Kaweah River		64			
		64			
		66			
		58			
	68	72	70		
South Fork,	56	56			
Kaweah River	64	66			
	60	60			
	64	68			
	64	64	68	64	66
	56	68	70		
Tule River and	56		70		
South	60		72		
	60		68		
	60		52		
	66				
	64				
	54				
Average	62	62	66		

FIGURE 2. SEQUOIA GROVES—EXPOSURE COMPARED WITH ALTITUDE

A few groves have only one cardinal direction of exposure. Some have a combination of two, such as northwest or southeast. In reality, the majority have trees growing on slopes facing in every direction. In most cases it was necessary to select the one dominant direction of exposure. In three instances, Grant Grove (GG), Redwood Mountain, and Mountain Home, this was not possible; none was truly dominant.

Of the 62 groves with a dominant exposure, 25 (40%) have a major exposure to the north and 24 (39%) to the west. Eleven have exposures to the south and only 2 face east. South facing groves have an average elevation of 6600 feet while those which face either west or north have an average of 6200 feet. The higher elevations of the south facing groves may be the reaction to greater amounts of insolation and evaporation than is received on the north slopes. The difference, 400 feet, however, is small.

A consideration of only low and high groves is more revealing. The percentage of low (below 6000 feet) groves increases from south, through west, to north with 18.1, 20.8, and 28.0% respectively. Contrariwise, the proportion of high (7000 feet and above) groves decreases in the same direction. High groves include 45.4% of those facing south and 16.6% of those facing west. No north facing grove is in this group. Cooler, moister conditions occurring on north facing slopes compared to south facing slopes as a result of less insolation is responsible for the lower elevations of the Sequoia groves there. The intermediate position of those slopes which face west is apparent.

There appears to be some areal grouping regarding the exposures of different groves. In the Tule River and to the south there are 18 groves; of these 9 face north, 2 west, and 5 south. Of the 16 groves in the Kings River area, 9 face north, and 4 face west. All but one is on the south side of the river. Both the Tule and the Kings flow toward the west and both are intermittently bordered by benches (or terraces) of Pliocene age. These benches, situated for the most part between 3000 and 4000 feet above the valley bottom, have deeper soils and are generally forested. They slope down to the north and/or south toward the rivers. Benches of the North, Marble, and Middle Forks of the Kaweah River slope down to the west, inasmuch as these branches of the Kaweah flow to the south. The groves thereon, then, face west.

Generalizations such as have been made must be used with care. While elevation and exposure seem to be interrelated and reflected in the climate of the individual groves, the presence or absence of suitable soil as expressed on the less steep land is also a strong influence on Sequoia location.

Position on the Slope

Relationships between the position on the slope and the occurrance of Sequoias are difficult to establish. Individual Big Trees and groves may be found in all positions—top, mid-slope, and bottom. Each site has something to offer. The ridge tops have good air drainage, exposure to the sun, and may be influenced by rising warm air currents. On the other hand, soils tend to be thin and ground water is less abundant.

A mid-slope position offers shelter from wind and sun, especially on the north facing slope. Those slopes which face south, however, receive

the direct rays of the sun. Moisture is likely to be in greater supply part way down the slope than on the ridges. Some groves or portions thereof occupy rather steep mid-slope sites. Buena Vista (BV), a small grove north of Giant Forest, is entirely on a 60% slope. Parts of many groves occur on slopes that exceed 30%.

Slope sites are of distinct value to the propogation of the Sequoias. Big Tree seeds require mineral soil in which to germinate. The likelihood of this being present on a slope where erosion and gravity has a chance to remove organic litter is greater than on level land.

A position on or near the bottom of the slope will be cooler, have less evaporation, more water, and, sometimes, significant accumulations of alluvium. Many groves occur in such locations. Individual trees commonly occur in the bottoms of ravines and depressions.

Proximity to Water

There is a tendency for the Sequoias to grow near water regardless of their position on the slope. Muir,[3] Jepson,[4] and others have made this observation. Favorite sites are adjacent to a meadow, along a stream course, and in swales and other moise spots.

Giant Forest as an Example of the Factors of Site

The Giant Forest Grove may be used to illustrate some of the several site factors. It is one of the finest examples of a Sequoia Forest. The Sequoia is dominant over about 2400 acres. Early discovery (in 1858) and hoped-for exploitation during the 1880's, accessibility by good roads, and the concentration of visitor services have all served to make it perhaps the best known of the groves.

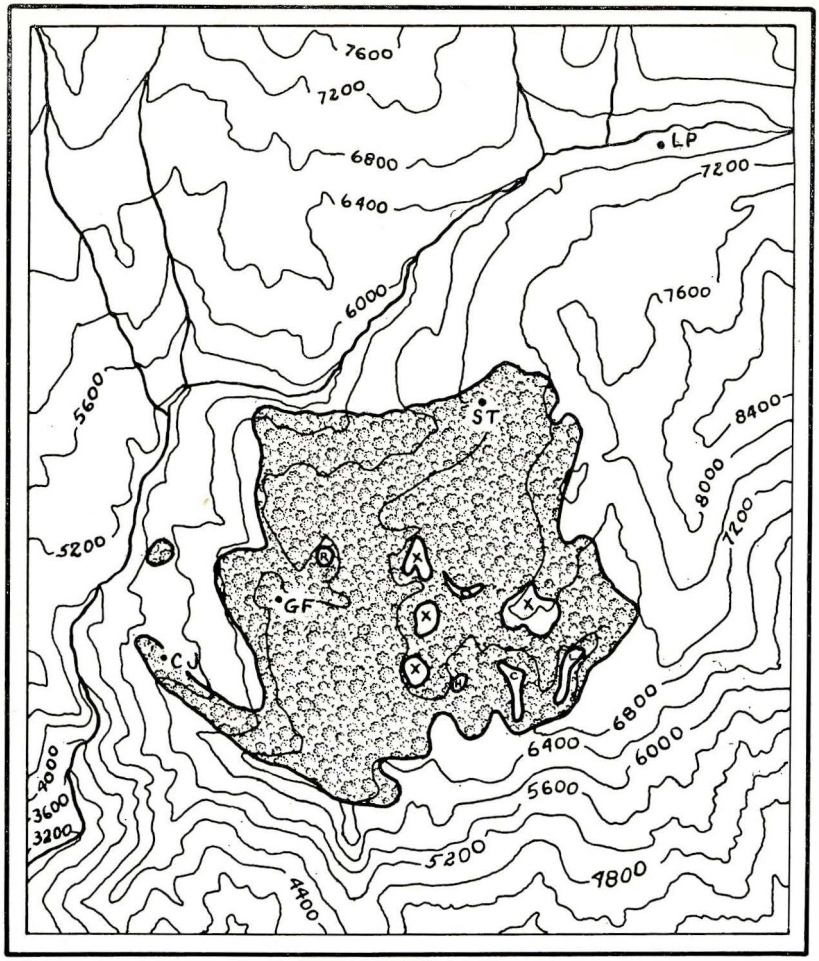
Essentially, Giant Forest is on a plateau-like surface, probably a terrace formed during the Pliocene and now being eroded from the west by the Marble Fork of the Kaweah River (Fig. 3). The extent of this rolling upland is limited by deep canyons on three sides. To the south the Middle Fork of the Kaweah River is 3000 feet below the forest and, on the west and north, the Marble Fork is from 1000 to 3500 feet lower than the terrace. Elevations range from 5300 feet on the west to approximately 7200 feet on the east.

Big Trees occur at all levels within Giant Forest. While the major exposure is to the west, Sequoias may be found on slopes of other orientations. Dense forests occur on north facing slopes in 3 places, on a ridge that extends toward Crystal Cave, in the vicinity of Giant Forest settlement, and near the General Sherman Tree. In this latter area, at an elevation of 6900 feet, fine examples of the Big Trees also occur on west facing slopes. Not unexpectedly, Big Trees occur on a wide range of slopes varying from zero to 50%. The larger trees are usually on slight inclinations but Giants over ten feet in diameter may be found on slopes of 45%.

Water plays an important part in the distribution of Sequoias within Giant Forest. All of the lower meadows—Round, Huckleberry, Circle,

[3] John Muir, "The New Sequoia Forests of California," *Harper's Magazine*, 57 (1878), p. 827.

[4] Willis L. Jepson, *The Silva of California*, (Berkeley: University of California Press, 1910), p. 142.



ONE MILE

AFTER U.S.G.S.

GIANT FOREST

LEGEND

CJ	CAVE JUNCTION	C	CRESCENT MDW.
GF	GIANT FOREST	O	CIRCLE MDW.
ST	SHERMAN TREE	H	HUCKLEBERRY MDW.
LP	LODGEPOLE	L	LOG MDW.
X	ROCKY AREA	R	ROUND MDW.

Figure 3

Crescent, and Log—have Big Trees around their margins and on adjacent slopes. Small streams may be found flowing in many of the other concentrations or near individual trees.

The Sequoias are not evenly distributed within the area of Giant Forest. The meadows, of course, do not contain trees, but their margins do. There are four localities where the Sierra Nevada batholith appears at the surface as rocky, relatively treeless areas. No Sequoias occur on these slopes which have comparatively little soil or water. The central three rocky areas are apparently the edge of a secondary bench-like surface approximately 300 feet above the western part of Giant Forest. The relatively level surfaces have allowed soils to be more deep and more mature and dense concentrations of Sequoias occur on both levels. Sequoias growing just above the rocky area may tap water forced to the surface by the underlying granite. The Washington Tree, one of the largest (28 feet in diameter), is situated here, on the upper level.

The escarpments to the north, west, and south effectively limit the extent of the "plateau" of the Giant Forest. The slopes with their less mature soil rapidly decrease in elevation into a warmer and drier climatic zone not conducive to the growth of a Sequoia forest.

Conclusion

It is clear that no one factor may be singled out, yet, as a limiting factor in the distribution of the Giant Sequoias. Certainly, temperature, moisture, and soil are of great importance to the Sequoias and undoubtedly play a significant role in their distribution along the Sierra Nevada. In light of inconclusive data, it is necessary to say that the current spread of the Sequoias is a result of a combination, or interaction, of several factors of site and of the physical environment.