Growth and Yield of Giant Sequoia[1]

David J. Dulitz [2]

Abstract: Very little information exists concerning growth and yield of giant sequoia (*Sequoiadendron giganteum* [Lindl.] Buchholz). For old-growth trees, diameter growth is the single factor adding increment since maximum height has been obtained. Diameter growth averages 0.04 inches per year in normal old-growth trees but will fluctuate with changes in the surrounding environment. Growth plots in natural California young-growth stands indicate stand yields of 629 board feet per acre mean annual increment at age 86. Planted European stands 76 to 122 years old have shown yields of between 285 and 601 cubic feet per acre mean annual increment. Growth of giant sequoia has far surpassed the volume production from other North American conifers grown in West Germany or Belgium.

Available information on growth and yield of giant sequoia (*Sequoiadendron giganteum* [Lindl.] Buchholz) is limited, partly due to its restricted natural range and its relative unimportance as a commercial timber species. Giant sequoia has been established in plantations both inside and outside of its natural range. Natural and artificial stands are being considered for timber management in some areas. With this added emphasis on management of the species, along with the maturing of artificially regenerated stands, information on growth and yield has gained importance.

Giant sequoia rarely grows naturally in pure stands. It is most often a minor component in the mixed conifer type in the Sierra Nevada. Estimates of stand growth must be inferred from individual tree growth information, rarely occurring pure natural stands, or from plantations.

Growth of giant sequoia is dependent on site quality. In natural stands giant sequoia tends to dominate high quality sites, Dunnings' site I and II (Dunning 1942). This, in a way, tends to expand the applicability of local yield information over a broad range of natural stands because they occur on similar sites.

OLD GROWTH

Maximum heights of individual old growth trees tend to be site dependent, averaging 250-275 feet (Hartesveldt 1975). Maximum heights tend to decrease towards the south in the tree's natural range. Because maximum height has been obtained in almost all old growth trees, diameter growth is the single factor adding increment to the tree's volume.

Studies in the Mariposa Grove within Yosemite National Park show that in normal undisturbed old-growth trees, radial growth is fairly constant, averaging 0.04 inch per year (Hartesveldt 1962). Fluctuations in diameter growth can occur after a disturbance such as road building, paving, soil trampling, or a change in soil moisture in the vicinity of a tree. In many cases these types of disturbances resulted in an increase in diameter growth. This was mainly due to an increase in soil moisture from a reduction in competing vegetation.

Visual observations of historical diameter growth on windfallen trees in Mountain Home State Forest, Tulare County, show a cyclical growth fluctuation in some cases, which may be due to crown damage from wind, snow, or lightning. This damage would result in a reduction in the photosynthetic potential of the tree's crown. Changes in the surrounding stand may also cause a cyclical diameter-growth pattern due to a change in competition for light or water.

A release study on Mountain Home State Forest showed an increase in diameter growth of individual trees after removal of the surrounding stand in a logging operation. Twelve trees, 24 to 62 inches in diameter, averaged 0.13 inch of diameter growth per year before logging of the surrounding stand. After logging, the trees averaged 0.31 inch of diameter growth per year. These trees in general appearance resembled old growth giant sequoia more than they did young growth, but their sizes, forms, scarcity of fire scars, and their relatively fast growth before logging indicated that they were younger than the typical fire-scarred veteran. These results showed that the diameter growth of individual trees will respond positively to a decrease in competition from the surrounding stand.

YOUNG GROWTH

Growth and mortality plots were established during 1952-1953 on the Mountain Home State Forest, Tulare County, two of which contained a substantial amount of giant sequoia. These plots were selected to represent the typical cutover condition on the State Forest for determining growth and yield of the second-growth stand.

Plot 3 was established at 6,160 feet elevation on a south-facing slope that had been heavily logged in 1945. As a result of soil disturbance during the logging, the site became crowded with reproduction. There were 5,420 seedlings per acre on the plot when it was established. Current analysis of stand composition indicates that 45 percent of merchantable trees on the plot are giant sequoia.

Plot No. 4 was established at 6,250 feet elevation on a south-facing slope. The stand resulted from logging in the area in 1890. The plot was considered to be even-aged, containing 90 percent redwood, when measured in 1976.

Gen. Tech. Rep. PSW-95. Berkeley, CA. Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 1986.

[1]Presented at the Workshop on Management of Giant Sequoia, May 24-25, 1985, Reedley, California.

[2]Forest Manager, California Department of Forestry, Mt. Home State Forest, P.O. Box 517, Springville, California 93265.

Table 1-*Combined growth data for Mountain Home giant sequoia plots 3 and 4*

Plot and stand age (years)	Total volume	Ingrowth	Mortality	Periodic annual increment	Mean annual increment
	Scribner board foot volumes per acre				
Plot 3					
7	0	0	0		0
13	0	0	0	0	0
18	188	188	0	38	10
22	743	291	0	139	34
31	5,938	2,966	0	577	192
Plot 4					
63	24,237	0	0	572	385
73	35,801	641	0	1,156	490
77	40,320	69	22	1,130	524
83	49,714	295	24	1,566	599
86	54,077	204	0	1,454	629

Because of the similarity of these two plots, the data were combined to provide yield information for a longer range of stand age classes. All trees in growth plot 3 became established after the 1945 logging; stand information exists for ages 7 through 31 years for the trees on that plot. Similarly, for growth plot 4, stand information is available for year 63 through year 86. Volumes for young growth giant sequoia are from local volume tables for Mountain Home State Forest (Wensel and Schoenheide 1971). Results of these 86 years of growth on typical cutover giant sequoia stands on the Mountain Home State Forest are shown in *table 1* and *figure 1* (Cook and Dulitz 1978).

On a ¼-acre, 102-year-old, growth plot of pure giant sequoia on the University of California's Whitakers Forest in Tulare County, the largest trees are 26 to 28 inches in diameter. Maximum height of the trees in the stand was 125-135 feet. Some .trees on the plot have grown only 1-2 inches in diameter in 67 years.

Some information is available for young growth giant sequoia plantations in Europe. A 0.62-acre plantation in Belgium, planted in 1906, had an average annual growth of 529 cubic feet per acre in 1951. In 1982, the same stand averaged 628 cubic feet per acre of annual growth (Kleinschmit 1984). A 3.71-acre German plantation, planted in 1862, had a volume of 17,871 cubic feet per acre at an age of 122 years. Maximum heights were 154 feet with mean heights of 127 feet. Maximum diameters were 48 inches at breast height with a mean diameter of 33 inches. Although not fully stocked, this plantation is growing at the rate of 285 cubic feet per acre per year (Kleinschmit 1984). Seven other small plantations in Germany and Belgium exhibited an average annual growth of between 515 and 601 cubic feet per acre per year (Guinon and others 1983, Knigge and others 1983).

Some general observations of the European stands show that the growth of giant sequoia far surpassed the known volume production of other North American softwood species grown in West Germany and Belgium. Investigations of diameter growth, taper, annual ring width, and specific gravity of stands in California were the same as those of European plantings (Knigge and Lewark 1984).

Some of these European yields are greater than those reported from natural stands in California. This difference may be due to the limited natural stand yield data available. Also, it is unknown what volume tables or equations were used to estimate individual tree volumes in Europe. Direct comparisons with other stand data may not be valid.

Giant sequoia will undoubtedly continue to gain importance as a commercial species. More growth information is needed from natural stands to accurately predict yields from the maturing young-growth stands that became established after the extensive logging 80-100 years ago in the Sierra Nevada. Giant sequoia will also continue to be an important plantation tree outside of its natural range. As these plantations develop, growth and yield information will be needed. Current volume tables for this species should be studied and refined to accurately estimate individual tree volume. These research needs will continue to present themselves as challenges in management of giant sequoia.

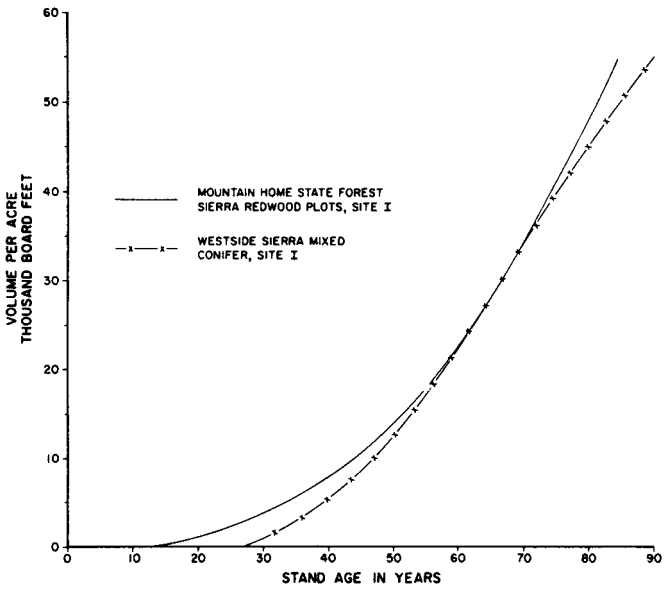

Figure 1-Comparative yield in thousands of board feet (Scribner Log Rule) of giant sequoia growing in a typical cutover stand on Mountain Home State Forest and on a mixed conifer site in the westside Sierra Nevada.

REFERENCES

Cook, Norman W; Dulitz, David J. Growth of young Sierra redwood stands on Mountain Home State Forest. State Forest Notes No. 72, California Department of Forestry; 1978.

Dunning, Duncan. A site classification for the mixed-conifer selection forests of the Sierra Nevada. Res. Note 28. Berkeley: California Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 1942.

Guinon, Von M.; Hapla, F; Lewark, S.; Schroder, C. Die Holzeigenschaften des Mammutbaumes in sechs mitteleuropaischen Versuchsanbauten (Teil 1). Holz-Zentralblatt, Stuttgart, Mittwoch, 27. July 1983.

Hartesveldt, Richard J. The effects of human impact upon *Sequoia gigantea* and its environment in the Mariposa Grove, Yosemite National Park, California. Ann Arbor: Univ. of Michigan; 1962. Dissertation.

Hartesveldt, Richard J. The giant sequoia of the Sierra Nevada, National Park Service, U.S. Department of the Interior; 1975. 180 p.

Kleinschmit, J. Der Mammutbaum Nur Eine Faszinierende Exotenart? Zurich: Veroffentlicht im Beiheft zur Schweizerischen Zeitschrift fur Forstwesen 72: 61-67; 1984.

Knigge, Von W; Pellinen, P.; Schilling, T. Untersuchungen von Zuwachs, Astigkeit Verkernung and Rindenstarke westeuropaischer Anbauten des Mammutbaumes (*Sequoiadendron giganteum* [Lindl.] Buchholz), Sonderdruck aus Forstarchiv 54(2): 1983; March/April.

Knigge, Von W; Lewark, S. Investigations on wood quality of giant sequoias from second-growth stands in California. Sonderdruck aus Forstarchiv 55(1): 1984; Jan./Feb.

Wensel, L. C.; Schoenheide, Richard L. Young-growth gross volume tables for Sierra redwood. Hilgardia 41(4): 1971.