FOREST SERVICE
U.S.DEPARTMENT OF AGRICULTURE
P.O. BOX 245, BERKELEY, CALIFORNIA 94701

# PACIFIC SOUTHWEST Forest and Range Experiment Station

# TEMPERATURE, HUMIDITY, AND PRECIPITATION... at the Redwood Experimental Forest

Kenneth N. Boe

*USDA Forest Service Research Note PSW-222*
1970

*ABSTRACT:* Temperature and humidity were compared and precipitation measured during an 8-year period (1958-1966) for two types of harvest cuttings on the Redwood Experimental Forest, north coastal California. Only small differences in temperature and humidity were found between clearcuttings and selection cuttings in old-growth stands on west-facing and east-facing aspects, and between westerly and easterly clearcuttings. The bioclimate data reported can help researchers in evaluating regeneration and growth studies and in extending the experimental results to other areas, and in ecological studies of the redwood region.

*OXFORD:* 174.7 *Sequoia sempervirens:*111.86:221.0.
*RETRIEVAL TERMS: Sequoia sempervirens;* bioclimate; cutting systems; ambient temperature; humidity; precipitation; Redwood Experimental Forest.

Forest events such as seed germination, seedling establishment, height development, and vegetation encroachment and growth are affected by many environmental factors, including air temperature, relative humidity, and precipitation. When all or only part of the forest cover is removed in harvesting the timber, there is often conjecture about what changes have been made in the forest environment and their effects. Some changes are beneficial to renewal of the forest; others are harmful if some limiting factors may have been created. As an illustration of possible improvement, average air temperatures may be changed by removing all forest cover. Recent research has determined that under controlled laboratory conditions, redwood seedlings showed optimal growth at a day temperature of 66°F. and night temperature of 59°F.[1] If temperatures near these levels are achieved during the growing season, seedlings should respond in kind—unless other environmental factors are limiting.

To find out if air temperature and relative humidity differed between silvicultural cuttings on two different aspects, these bioclimate elements were measured during an 8-year period (1958-1966) on the Redwood Experimental Forest, north coastal California *(fig. 1)*. The paired weather stations were installed on a clearcutting and a selection cutting for 1 year on west-facing aspects, for another year on east-facing aspects, and a third year on a west-facing and an east-facing clearcutting. At one site on the Experimental Forest, precipitation was measured for 8 years.

The differences we found in temperature and humidity between cuttings and aspects may appear to be small and not particularly significant. But the real values of these bioclimate measurements lie in their use as reference records. Such records can—along with other information—help explain seedling success, stand development, vegetation changes and responses, and other forest events. And the data will be helpful

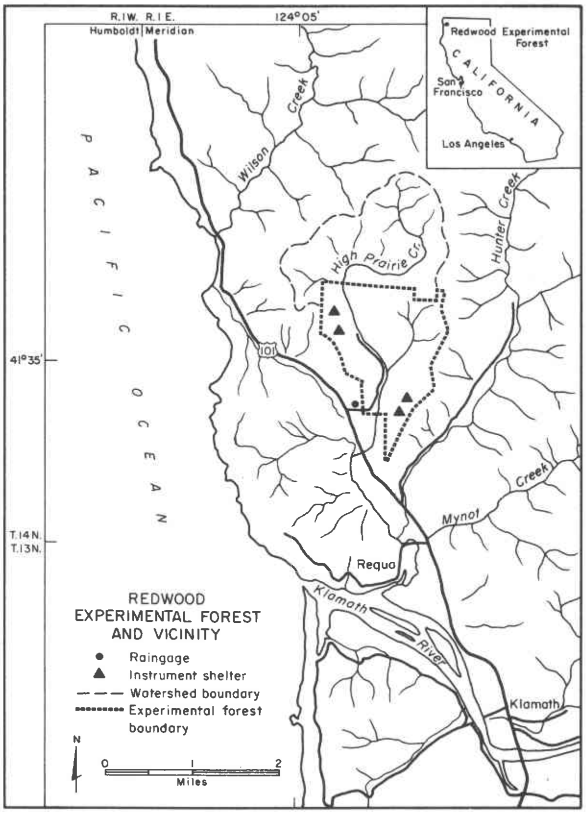


Figure 1–*Location of Redwood Experimental Forest and study areas.*

in interpreting results of current and future studies at the Redwood Experimental Forest. When augmented by such reports as "The Climate of Humboldt and Del Norte Counties"[2] and "Climate of California,"[3] the data provide a broad base for interpretation and expansion of results of the studies to other parts of the redwood region. Therefore, the information and observations reported here should be of value to foresters, ecologists, biologists, and others concerned with redwood forest lands.

## THE STUDY

U.S. Weather Bureau-type hygrothermographs, maximum and minimum thermometers, and sling psychrometers were housed in instrument shelters to measure air temperature and relative humidity *(fig. 2).* Each standard shelter was oriented with its door to the north and its floor elevated 4 feet above ground. One shelter was set up on each of two harvest cuttings and one aspect for 1 year, then moved to the other study sites in turn for a year's record each, as follows:

1. A selection cutting at 525 feet elevation and a clearcutting at 450 feet elevation on a westerly aspect.

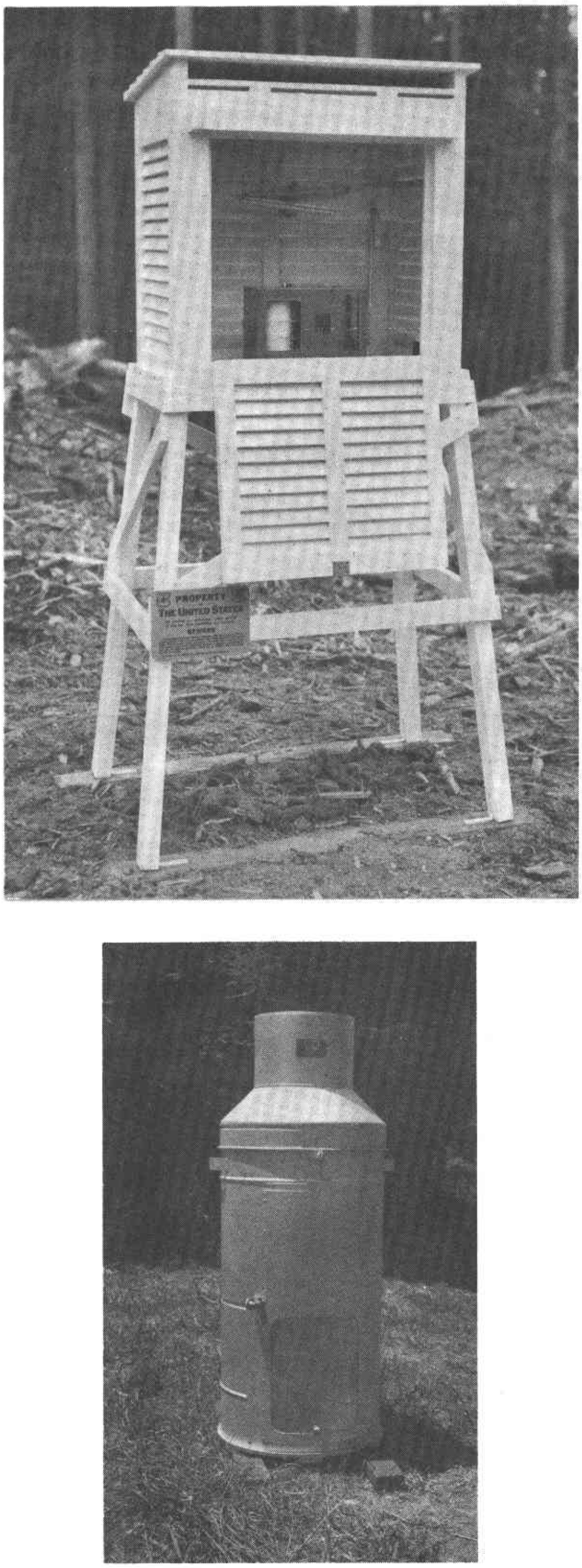

Figure 2–*Instrument shelters and a rain gauge were set up on the Redwood Experimental Forest, Del Norte County, California to record temperature, relative humidity, and precipitation.*

2. The westerly-facing clearcutting and an easterly-facing clearcutting, both at 450 feet elevation and about 1-1/8 miles apart.

3. A selection cutting at 550 feet elevation and a clearcutting at 450 feet elevation on an easterly aspect.

On both selection cuttings, trees of many sizes provided intermittent shade. The number of trees per acre, by d.b.h. size group, averaged:

| | Selection cutting | |
|---|---|---|
| | West-facing | East-facing |
| | *(No. trees/acre)* | |
| D.b.h. size group (inch): | | |
| 1-10 | 4.2 | 5.5 |
| 11-30 | 4.8 | 7.8 |
| 31-60 | 7.8 | 7.8 |
| 61+ | 8.0 | 10.8 |
| All sizes | 24.8 | 31.9 |

No trees were left standing on the clearcuttings. Only scattered shrubs, from 2 to 3 feet tall, were growing on both selection and clearcuttings during the study.

In the general vicinity of the instrument shelters on westerly aspects, the slopes averaged 15 to 25 percent; and on easterly aspects, 20 to 30 percent.

Precipitation was measured by a recording rain gauge installed at the administration building near the mouth of the Experimental Forest watershed, at an elevation of 100 feet. The gauge was 1/2 to 1 mile air line distance from the temperature-humidity study sites.

## RESULTS

### Temperature

#### West-Facing Clear and Selection Cuttings

The two contrasting silvicultural cuttings—clearcuttings and selection—were expected to cause some difference in air temperature because of partial shading on the selection cut. But the largest mean monthly difference for the year studied (1960-61) was only 1°F. higher on the clearcutting, in August *(fig. 3A)*. During that year, monthly mean temperatures ranged from 45° to 57°F. *(table 1)*.

Mean maximum and extreme maximum temperatures tended to be higher throughout the year by 1° to 5°F. on the westerly-slope clearcutting than on the selection cutting *(fig. 3A)*. Again the greatest mean difference was in August.

The mean minimum monthly temperatures tended to be the same or slightly lower on the clearcutting while the extremes were more variable – lower on the selection in August and on the clearcutting in December *(fig. 3A)*.

An examination of mean air temperature by each hour within a month was explored next to determine any relationships between cuttings and by day or night *(fig. 3B)*. During all daylight hours, temperatures averaged slightly higher on the westerly clearcutting than on the westerly selection cutting for the four selected months—April, June, August, October—measured in 1960.

Temperatures during night hours were mainly alike on the two cuttings in April, June, and August. But in October there was a consistent pattern for slightly higher temperatures on the selection cutting. Except in April, night temperatures averaged close to 50°F.

The maximum day temperatures indicate the level of heat stress that new plants will be subjected to. The general characteristic pattern of maximum temperatures, by days, in four representative growing-season months *(fig. 3C)* suggests that they were slightly higher on the clearcutting than on the selection cutting on the westerly aspect. The amount of difference varied from about 1 to 5 degrees.

The time of occurrence of the daily maximum temperature on the selection cutting relative to that on the clearcutting varied throughout the study period. Maximum temperatures were not consistently earlier or later on the selection cutting than on the clearcutting. Such variability could be caused by fog, clouds, wind, and partial shading affecting the weather instruments at slightly different times because they were one-fourth mile apart.

Not only are high temperatures important to the young plants, but perhaps more critical is their duration. The hygrothermograph charts show this duration for a particular day. This information can be useful for pinpointing the temperature factor in relation to a specific event. To show the more general relationships and to compare between cuttings, the frequency that each high temperature was of the total hours for the month were plotted *(fig. 3D)*. During the 4 selected months—April, June, August, October—high temperatures were more frequent on the clearcutting than selection cutting. In June 1960, while the clearcutting experienced 102°F. and a frequency of 0.4 percent of total hours, the selection cutting had 98°F. and a frequency of 0.3 percent.

#### East-Facing Clear and Selection Cuttings

The other main aspect available for study of air temperature differences between a clearcutting and selection cutting was east-facing. Like those recorded on the westerly aspects, monthly mean temperatures between selection and clearcuttings on east aspects varied only slightly *(fig. 4A)*. The greatest difference was only 2°F. higher in the selection cutting, which for the year of record (1964) was in February *(table 1)*.

Like the relationships on the westerly cuttings, the mean maximum temperatures (range: 48° to 66°F.) were slightly higher in the easterly clearcutting than those in the selection cutting *(fig. 4A)*. Extreme maximums were alike for 6 months and variable the remainder.

The mean minimum and extreme minimum monthly temperatures were the same or slightly lower in the easterly clearcutting compared to the adjoining selection cutting.

The comparison of mean air temperature by each hour within a month showed differences between cuttings and between aspects. A similar daytime temperature pattern prevailed in both the east-facing *(fig. 4B)* and west-facing cuttings *(fig. 3B)*. Temperatures were higher in the clearcutting than in the

Table 1 —*Temperature means and extremes, by silvicultural cutting and aspect, Redwood Experimental Forest, 1960-1964*

| Cutting and aspect | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Degrees F. | | | | | | |
| Clearcutting-west:[1] | | | | | | | | | | | | |
| Highest | 67 | 61 | 65 | 71 | 68 | 102 | 71 | 88 | 75 | 82 | 72 | 58 |
| Mean maximum | 56 | 52 | 52 | 54 | 57 | 67 | 62 | 66 | 59 | 61 | 54 | 52 |
| Mean | 49 | 46 | 45 | 47 | 50 | 57 | 54 | 56 | 51 | 53 | 48 | 45 |
| Mean minimum | 43 | 39 | 39 | 40 | 44 | 49 | 48 | 49 | 45 | 46 | 42 | 40 |
| Lowest | 32 | 33 | 33 | 34 | 36 | 44 | 45 | 46 | 42 | 39 | 36 | 31 |
| Selection-west:[1] | | | | | | | | | | | | |
| Highest | 64 | 58 | 62 | 69 | 66 | 98 | 70 | 87 | 74 | 78 | 68 | 57 |
| Mean maximum | 54 | 51 | 51 | 53 | 56 | 66 | 62 | 63 | 60 | 59 | 53 | 49 |
| Mean | 49 | 46 | 45 | 47 | 50 | 56 | 54 | 55 | 52 | 52 | 49 | 45 |
| Mean minimum | 44 | 40 | 39 | 41 | 44 | 49 | 49 | 48 | 47 | 47 | 44 | 40 |
| Lowest | 34 | 33 | 34 | 33 | 37 | 43 | 46 | 43 | 42 | 39 | 37 | 35 |
| Clearcutting-west:[2] | | | | | | | | | | | | |
| Highest | 62 | 62 | 60 | 73 | 74 | 72 | 72 | 68 | 83 | 75 | 57 | 65 |
| Mean maximum | 52 | 51 | 50 | 57 | 57 | 63 | 66 | 62 | 62 | 61 | 51 | 54 |
| Mean | 42 | 44 | 44 | 48 | 49 | 53 | 55 | 55 | 54 | 51 | 44 | 46 |
| Mean minimum | 35 | 39 | 38 | 41 | 41 | 44 | 45 | 49 | 49 | 45 | 38 | 40 |
| Lowest | 28 | 25 | 31 | 35 | 37 | 39 | 42 | 45 | 45 | 38 | 30 | 31 |
| Clearcutting-east:[2] | | | | | | | | | | | | |
| Highest | 61 | 60 | 59 | 72 | 73 | 72 | 80 | 70 | 82 | – | 58 | 66 |
| Mean maximum | 51 | 50 | 51 | 57 | 58 | 65 | 69 | 63 | 62 | – | 51 | 53 |
| Mean | 40 | 45 | 44 | 49 | 51 | 54 | 56 | 56 | 55 | – | 45 | 45 |
| Mean minimum | 33 | 40 | 39 | 42 | 44 | 46 | 46 | 51 | 50 | – | 38 | 39 |
| Lowest | 29 | 23 | 30 | 36 | 40 | 42 | 44 | 48 | 45 | – | 30 | 29 |
| Clearcutting-east:[3] | | | | | | | | | | | | |
| Highest | 55 | 71 | 63 | 62 | 63 | 65 | 68 | 82 | 92 | 86 | 67 | 59 |
| Mean maximum | 50 | 55 | 51 | 54 | 56 | 60 | 63 | 66 | 66 | 64 | 53 | 51 |
| Mean | 42 | 43 | 43 | 46 | 49 | 53 | 55 | 57 | 56 | 54 | 46 | 47 |
| Mean minimum | 36 | 35 | 35 | 37 | 43 | 47 | 49 | 50 | 48 | 48 | 41 | 43 |
| Lowest | 32 | 30 | 29 | 32 | 32 | 40 | 43 | 45 | 43 | 39 | 29 | 31 |
| Selection-east:[3] | | | | | | | | | | | | |
| Highest | 51 | 69 | 63 | 64 | 62 | 65 | 68 | 82 | 96 | 83 | 68 | 58 |
| Mean maximum | 48 | 55 | 50 | 54 | 55 | 58 | 60 | 65 | 66 | 63 | 52 | 50 |
| Mean | 43 | 45 | 43 | 46 | 48 | 53 | 54 | 57 | 56 | 55 | 47 | 47 |
| Mean minimum | 37 | 37 | 37 | 39 | 43 | 47 | 48 | 51 | 48 | 49 | 43 | 42 |
| Lowest | 32 | 32 | 33 | 35 | 33 | 43 | 46 | 45 | 44 | 42 | 32 | 32 |

[1]Apr.-Dec., 1960; Jan.-Mar., 1961. [2]Feb.-Dec., 1962; Jan. 1963. [3]Jan.-Dec.,1964.

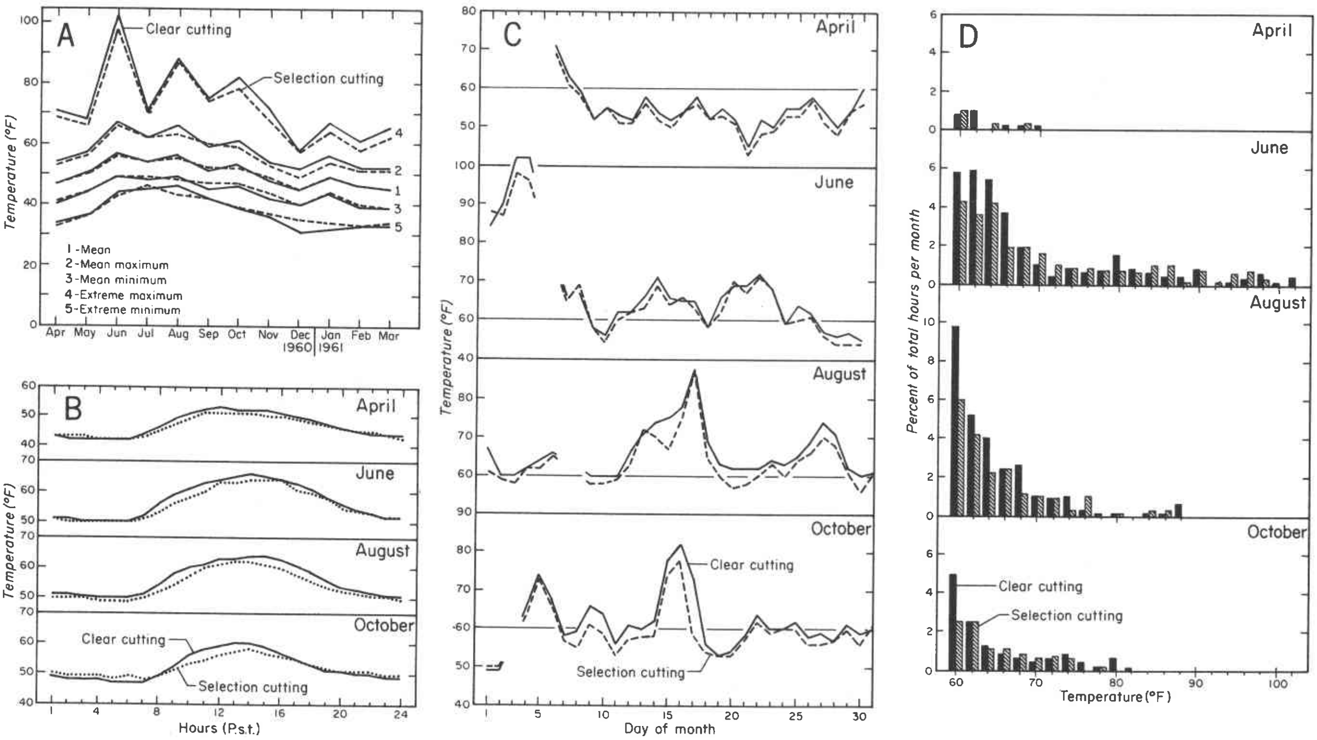


Figure 3–*Air temperatures were compared on a west-facing clearcutting and a selection cutting in old-growth redwood, at 450 to 525 feet elevation:* (A) *monthly means and extremes, and for selected growing season months;* (B) *hourly means;* (C) *daily maximums; and* (D) *frequency of high hourly temperatures.*

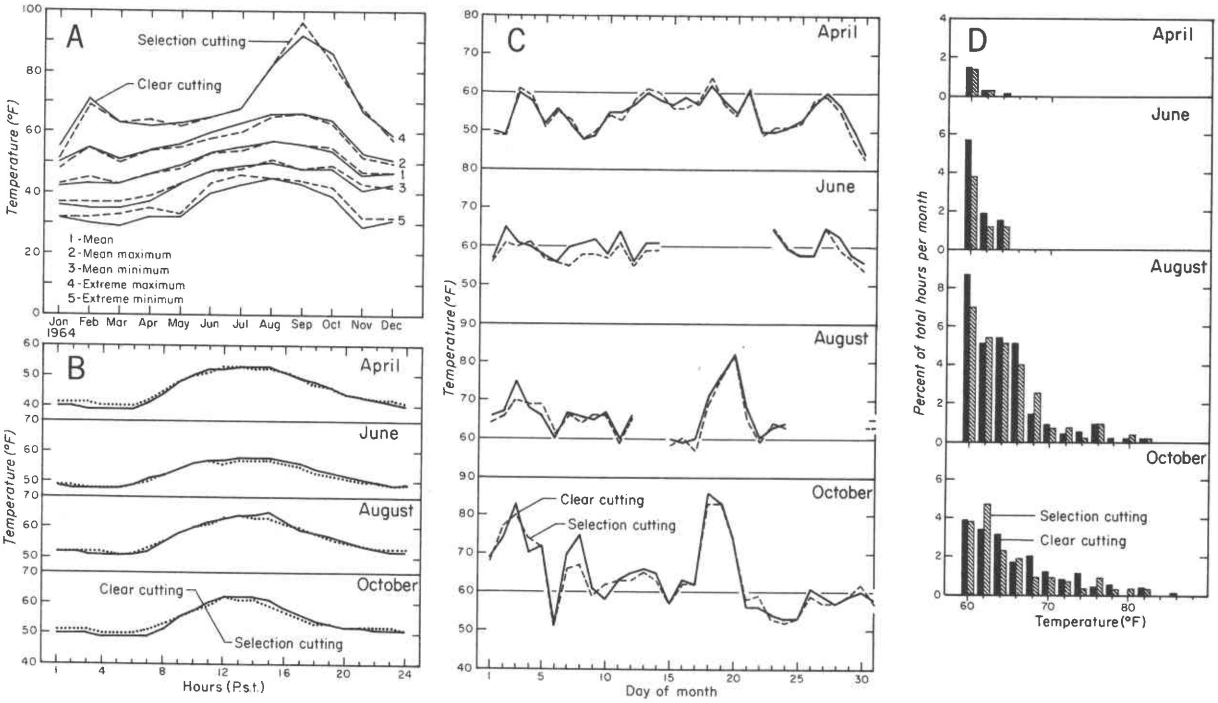


Figure 4–*Air temperatures were compared on an east-facing clearcutting and a selection cutting in old-growth redwood, at 450 to 550 feet elevation:* (A) *monthly means and extremes, and for selected growing season months;* (B) *hourly means;* (C) *daily maximums; and* (D) *frequency of high hourly temperatures.*

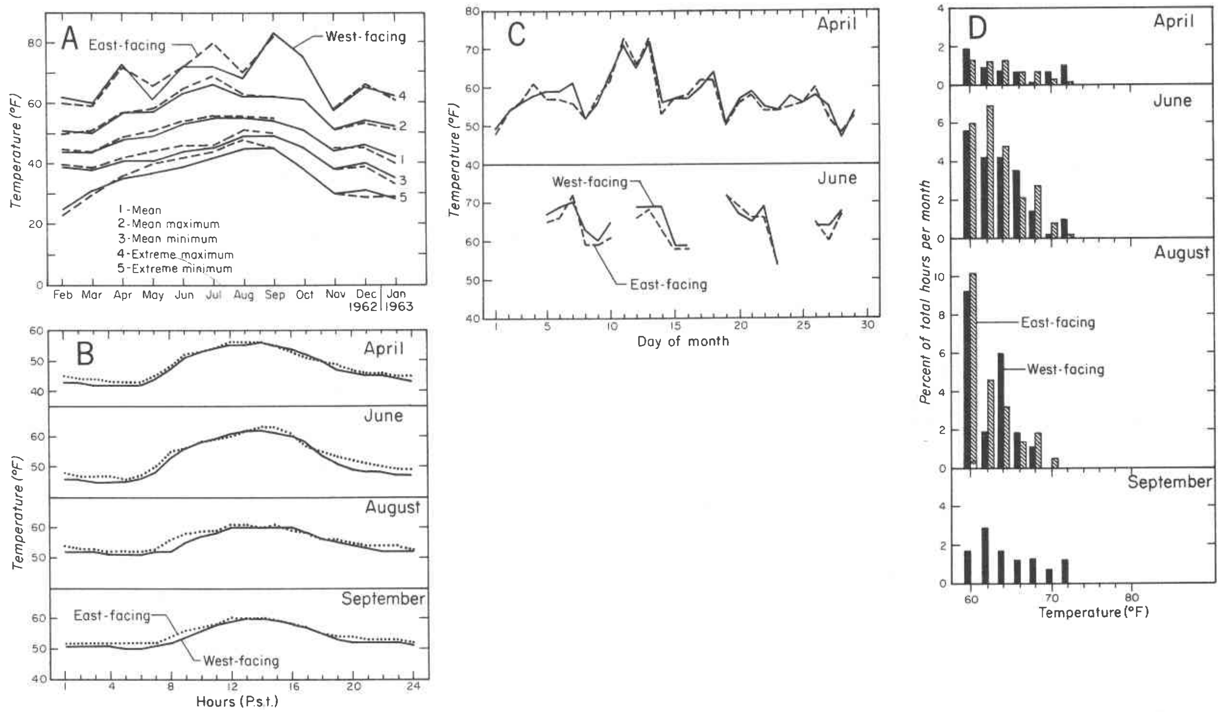


Figure 5—*Air temperatures were compared on a west-facing and an east-facing clearcutting in old-growth redwood, at 450 feet elevation:* (A) *monthly means and extremes, and for selected growing season months;* (B) *hourly means;* (C) *daily maximums; and* (D) *frequency of high hourly temperatures (in October, the hygrothermograph on the east-facing cutting was not in service).*

selection cut. But this difference was much less on easterly slopes than on the westerly slopes.

Night temperature profile relationships on easterly cuttings essentially matched those on westerly slopes.

The maximum temperatures in the selection cutting and in the clearcutting on the easterly aspects were quite similar for most of the 4 representative months of record *(fig. 4C).* During several consecutive days in June and August, however, the highest temperatures were measured on the clearcuttings.

On easterly slopes *(fig. 4D),* the clearcutting had high temperatures only slightly more often than did the selection cuts.

**West- and East-facing Clearcuttings**

Temperature measurements on two opposite facing clearcuttings show only small differences both in degree and time of occurrence. Between easterly- and westerly-facing clearcuttings *(fig. 5A),* mean temperatures were virtually the same; they ranged from 40° to 56°F.

Slightly higher mean maximum temperatures and corresponding extremes occurred in summer in the east-facing clearcutting than in the west-facing cutting. Differences, however, were only 1 to 3°F. maximum and 8°F. extreme.

Mean minimum and extreme temperatures were mainly alike *(fig. 5A).* In 1962, the lowest temperature was 23°F. in February *(table 1).*

Whether warmer mornings will have a greater influence on developing vegetation on east-facing clearcuttings than on west-facing has yet to be determined. The morning daylight hours were up to 4°F. warmer in the east-facing clearcutting than in the west-facing cutting—mainly in August and September *(fig. 5B).* No temperature differences were found during the other daylight hours. The afternoon ocean breeze may have helped to equalize temperatures; usually west slopes have been considered warmest because of the afternoon sun.

Night temperatures were consistently higher by 1 to 3°F. in the east-facing cutting *(fig. 5B)*. In spring, night temperatures averaged 45°F., and summer, 50°F.

Maximum temperatures, by days of selected months, verified similarities between east and west aspects. For two spring months (April and June) maximum temperatures differed only slightly *(fig. 5C)*.

The duration of higher temperatures in the west-facing clearcutting, as depicted by frequencies of total hours, was slightly greater in April and June *(fig. 5D)* than in the east-facing cuttings. A slight reversal of this trend was measured in August. Incomplete records prevented comparisons in October.

## Relative Humidity

### West-Facing Clear and Selection Cuttings

The effect on relative humidity of removing all timber compared to partial removal is not known for redwood in its coastal climate. This environmental factor relates to transpirational stress and surface drying of the soil. Low humidity can be a critical factor—especially in the growth of tiny seedlings. The relative humidity monthly means (range: 77 to 89 percent) did not vary much and were only slightly different between the westerly-facing clearcutting and selection cutting *(fig. 6A; table 2)*. In June, when highest temperatures were recorded, the mean humidity dropped to the yearly low.

Mean maximum humidities on the clearcutting tended to be the same as that on the selection cutting or slightly higher. In July and August, maximum humidity remained consistently high in both cuttings *(fig. 6A)* because of frequent fog.

As might be expected, the mean minimum humidities, with two exceptions, were consistently higher in the selection cut than the clearcutting. Extreme humidities were also generally higher. Partial shading and perhaps less wind on the selection cutting may have accounted for the differences.

Relative humidities during daylight hours in the west-facing clearcutting and selection cutting were virtually the same in April and June but consistently lower on the clearcutting in August and October *(fig. 6B)*. Lowest humidities were at noon in April but later during the summer.

Nighttime humidity was always higher in the west clearcutting than on the selection cutting *(fig. 6B)*. The relatively small differences would not appear to have much impact on plant development.

### East-Facing Clear and Selection Cuttings

In the easterly cuttings, humidity profiles showed a consistent, but small, difference. The mean relative humidity *(fig. 7A)* was the same in the easterly clearcutting and the selection cutting in 4 winter months, then averaged consistently lower in the clearcutting by 2 to 7 percent for the remainder of the year *(table 2)*.

Maximum humidities were essentially alike in the two cuttings. And they were consistently highest in the summer (fog) months.

Besides showing the same profile as mean relative humidities, the mean minimum and extremes were lower in all months in the easterly clearcutting *(fig. 7A)*. Could these minimum humidities be sufficiently lower on clearcutting to cause an unfavorable environment for seedling establishment?

The daytime relative humidity profiles showed lower percents in the easterly clearcutting than on selection for all 4 sample months *(fig. 7B)*. By comparison to profiles in westerly cuttings, but in a different year *(fig. 6B)*, only profiles in August and October were similar.

Except for the night hours in October, night humidity was always higher on selection cuttings than clearcuttings on easterly slopes *(fig. 7B)*. The opposite relationship was found for the westerly slopes, with humidity recorded in a different year. Again differences were small and perhaps not significant.

### West- and East-Facing Clearcuttings

The mean relative humidity was consistently lower in the westerly clearcutting by 2 to 6 percent than in the easterly clearcutting *(fig. 8A; table 2)*. Only once, in July, did the average drop below 80 percent.

Mean maximums averaged consistently about 98 percent in both cuttings during late winter, spring and summer months, dropping only slightly in fall and early winter.

The average minimum and extreme humidities, by months, were generally lower on west-facing clearcuttings *(fig. 8A; table 2)*.

The average humidity for all daylight hours and for the sample growing season months—April-September—was lower on the west-facing clearcutting than on the east-facing cutting *(fig. 8B)*. This difference suggests localized causes other than aspect because temperatures were so nearly alike *(fig. 5B)*. The east-facing cutting was more sheltered from prevailing northerly summer winds. Daytime fog probably persisted longer there.

Except for April, for which no explanation seems apparent, night humidities were alike in all cuttings *(fig. 8B)*.

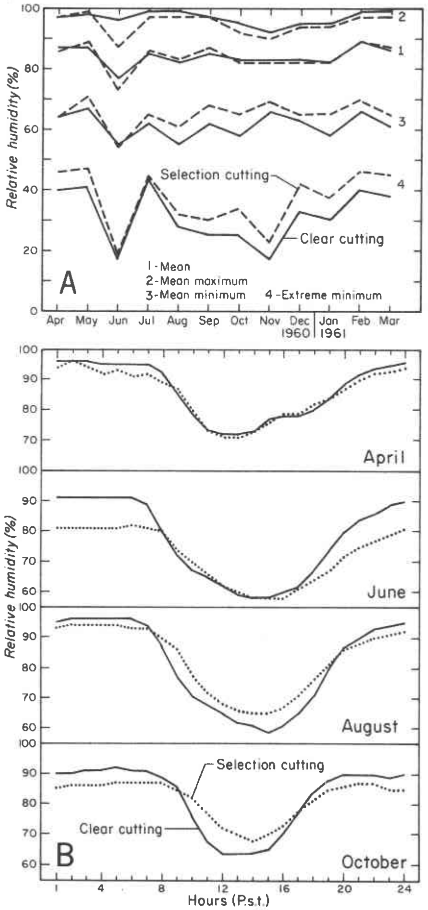


Figure 6–*Relative humidity was compared on a west-facing clearcutting and a selection cutting in old-growth redwood at 450 to 525 feet elevation:* (A) *monthly means and extremes; and* (B) *hourly means for selected growing season months.*

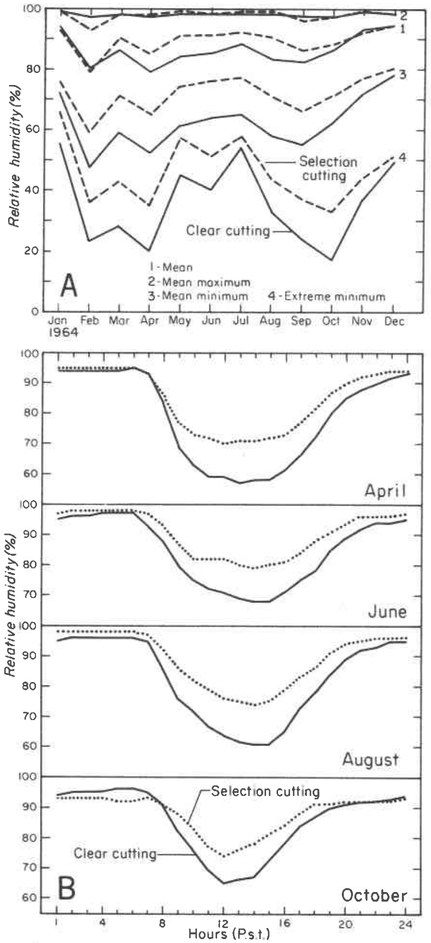


Figure 7–*Relative humidity was compared on an east-facing clearcutting and a selection cutting in old-growth redwood at 450 to 550 feet elevation:* (A) *monthly means and extremes; and* (B) *hourly means for selected growing season months.*

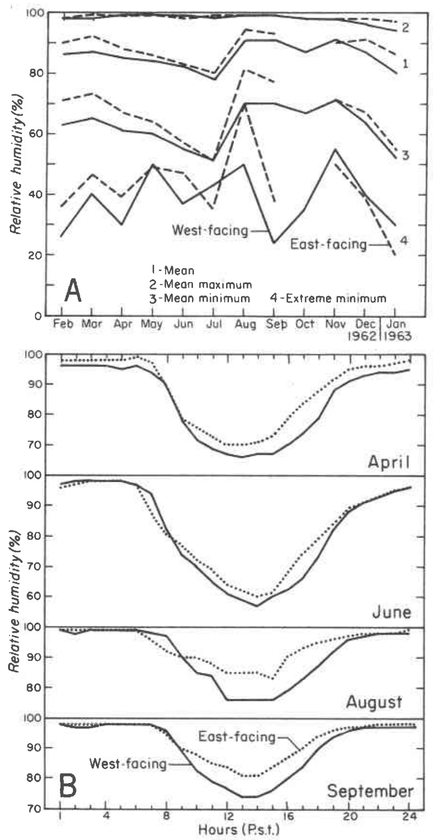


Figure 8–*Relative humidity was compared on a west-facing and an east-facing clearcutting in old-growth redwood at 450 feet elevation:* (A) *monthly means and extremes; and* (B) *hourly means for selected growing season months.*

Table 2 –*Means and extremes in relative humidity, by silvicultural cutting and aspect, Redwood Experimental Forest, 1960-1964*

| Cutting and aspect | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Percent* | | | | | | | | | | | |
| Clearcutting-west:[1] | | | | | | | | | | | | |
| Highest | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Mean maximum | 95 | 99 | 99 | 97 | 98 | 96 | 99 | 99 | 97 | 95 | 92 | 95 |
| Mean | 82 | 89 | 86 | 87 | 87 | 77 | 85 | 82 | 85 | 83 | 83 | 83 |
| Mean minimum | 58 | 66 | 61 | 64 | 67 | 55 | 62 | 55 | 62 | 58 | 66 | 63 |
| Lowest | 30 | 40 | 38 | 40 | 41 | 17 | 44 | 28 | 25 | 25 | 17 | 33 |
| Selection-west:[1] | | | | | | | | | | | | |
| Highest | 100 | 100 | 100 | 100 | 100 | – | 100 | 100 | 100 | 99 | 99 | 100 |
| Mean maximum | 94 | 97 | 97 | 97 | 99 | – | 97 | 97 | 97 | 92 | 90 | 94 |
| Mean | 82 | 89 | 87 | 86 | 89 | – | 86 | 83 | 87 | 82 | 82 | 82 |
| Mean minimum | 65 | 70 | 65 | 64 | 71 | – | 65 | 61 | 68 | 65 | 69 | 65 |
| Lowest | 38 | 46 | 45 | 46 | 47 | – | 45 | 32 | 30 | 34 | 23 | 42 |
| Clearcutting-west:[2] | | | | | | | | | | | | |
| Highest | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Mean maximum | 94 | 98 | 98 | 99 | 99 | 99 | 98 | 99 | 99 | 98 | 98 | 96 |
| Mean | 80 | 86 | 87 | 85 | 84 | 82 | 78 | 91 | 91 | 87 | 91 | 87 |
| Mean minimum | 52 | 63 | 65 | 61 | 60 | 55 | 51 | 70 | 70 | 67 | 71 | 64 |
| Lowest | 30 | 26 | 40 | 30 | 50 | 37 | 43 | 50 | 24 | 35 | 55 | 40 |
| Clearcutting-east:[2] | | | | | | | | | | | | |
| Highest | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | – | 100 | 100 |
| Mean maximum | 97 | 98 | 99 | 99 | 99 | 98 | 99 | 99 | 99 | – | 98 | 98 |
| Mean | 86 | 90 | 92 | 88 | 86 | 83 | 80 | 94 | 93 | – | 90 | 91 |
| Mean minimum | 55 | 71 | 73 | 67 | 64 | 57 | 51 | 81 | 77 | – | 71 | 67 |
| Lowest | 20 | 36 | 46 | 39 | 49 | 47 | 35 | 70 | 38 | – | 50 | 39 |
| Clearcutting-east:[3] | | | | | | | | | | | | |
| Highest | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Mean maximum | 99 | 97 | 98 | 97 | 98 | 98 | 98 | 98 | 97 | 97 | 99 | 98 |
| Mean | 94 | 80 | 86 | 79 | 84 | 85 | 88 | 83 | 82 | 86 | 93 | 94 |
| Mean minimum | 72 | 47 | 59 | 52 | 61 | 64 | 65 | 58 | 55 | 62 | 72 | 78 |
| Lowest | 56 | 23 | 28 | 20 | 45 | 40 | 54 | 33 | 24 | 17 | 37 | 49 |
| Selection-east:[3] | | | | | | | | | | | | |
| Highest | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Mean maximum | 99 | 93 | 98 | 98 | 99 | 98 | 99 | 99 | 96 | 97 | 99 | 98 |
| Mean | 93 | 79 | 90 | 85 | 91 | 91 | 92 | 90 | 86 | 88 | 92 | 94 |
| Mean minimum | 76 | 59 | 71 | 65 | 74 | 76 | 77 | 71 | 66 | 71 | 77 | 80 |
| Lowest | 66 | 36 | 43 | 35 | 57 | 51 | 65 | 44 | 37 | 33 | 44 | 51 |

[1]Apr.-Dec., 1960; Jan.-Mar., 1961. [2]Feb.-Dec., 1962; Jan.,1963. [3]Jan.-Dec., 1964.

## Precipitation

Wet winters and dry summers are characteristic of the climate at the Redwood Experimental Forest and of north coastal California *(table 3)*. About 75 percent of the average annual precipitation (76 inches, 8-year average) falls from November to March. The amount of rainfall for a specific month over a period of years varies widely; for example, in November the rainfall ranged from 1.8 inches to 20.2 inches during 8 years. December rains ranged from 5.7 inches in 1963 to 28.6 inches in 1964—a year of disastrous floods in northern California. Only about 3 percent of the total rainfall comes in June, July, and August. Beginning in April, average rainfall decreases consecutively each month until July and August, generally the two driest months of the year. Increasing rain in September and October usually precede the wet winter months.

The winter rains varied greatly in intensity, duration, and time between precipitation periods in the

Table 3 –*Precipitation at the Redwood Experimental Forest, California, 1958-1965, by month*

| Year | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Inches* | | | | | | | | | | | | |
| 1958 1959 | 0.08 | 0.00 | 1.65 | 3.65 | 11.10 | 8.00 | 17.90 | 14.15 | 8.95 | 1.32 | 1.98 | 0.70 | 69.48 |
| 1959 1960 | .00 | .00 | 4.30 | 4.11 | 1.80 | 6.31 | 9.15 | 11.60 | 19.60 | 6.40 | 12.41 | .00 | 75.68 |
| 1960 1961 | .00 | .20 | .30 | 3.82 | 17.97 | 5.92 | 7.87 | 16.53 | 19.79 | 4.85 | 8.54 | .93 | 86.72 |
| 1961 1962 | .00 | .51 | 1.54 | 6.19 | 13.75 | 9.67 | 4.02 | 10.05 | 8.49 | 3.88 | 2.77 | .47 | 61.34 |
| 1962 1963 | .04 | 4.22 | 1.72 | 12.21 | 12.33 | 7.04 | 3.37 | 10.50 | 9.78 | 14.19 | 8.23 | .73 | 84.36 |
| 1963 1964 | .41 | .00 | 1.96 | 8.66 | 19.55 | 5.67 | 22.38 | 2.38 | 9.15 | 1.48 | 1.97 | 2.08 | 75.69 |
| 1964 1965 | 1.98 | .08 | .20 | 1.43 | 20.18 | 28.57 | 13.57 | 3.58 | 1.74 | 9.99 | 1.59 | .48 | 83.39 |
| 1965 1966 | .00 | 1.16 | .00 | 2.00 | 11.11 | 13.17 | 20.10 | 6.93 | 14.01 | 2.85 | ([1]) | 1.10 | 72.43 |
| Average | .31 | .77 | 1.46 | 5.26 | 13.47 | 10.54 | 12.30 | 9.46 | 11.44 | 5.62 | 4.69 | .81 | 76.14 |

[1]Trace.

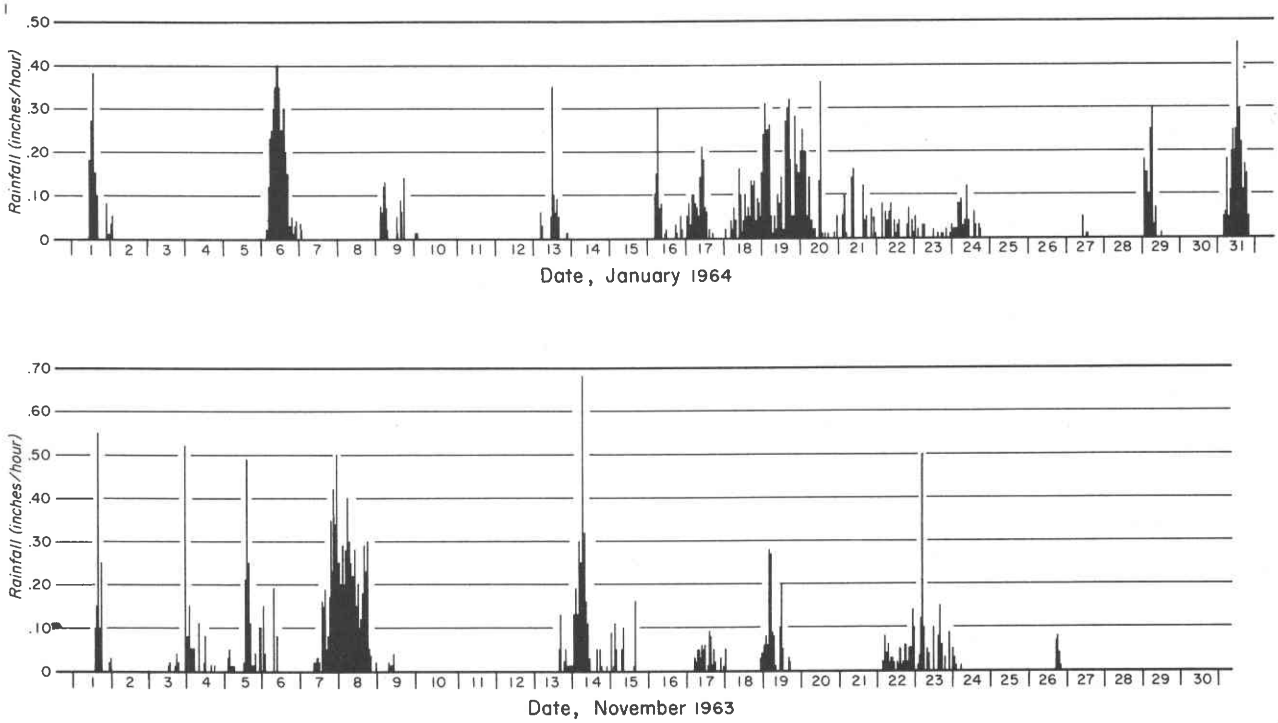


Figure 9–*Intensity of winter rains at the Redwood Experimental Forest was interpolated from rain gauge charts based on 1-hour intervals.*

8-year period. To illustrate these characteristics, the data for November 1963 and January 1964 were compared *(fig. 9)*. Rainfall intensities were interpolated for hourly intervals from the 7-day charts of the automatic recording rain gauge. This intensity interval is one often used in climatology reports.

Winter rains during the period measured were of "storm" types that reached moderate to high intensity rates per hour for only a small portion of the total rain period *(fig. 9)*. Included were moderate periods of light rain and drizzle, such as during the January 18-20 storm. This entire 51-hour precipitation period, however, was generally regarded as stormy because of several intensity rates of more than 0.3 inch per hour. A short storm lasting about 5 hours with a high and moderate peak intensity was recorded on November 1. Another of moderate length was recorded on November 7 and 8 when there were several high intensity peaks during a 36-hour rain storm.

The highest intensity per hour was 0.68 inch during a November storm *(fig. 9)*. Precipitation from five other storms in November and two in January exceeded 0.40 inch per hour.

The periods between storms, of no rainfall, can last from one to many days. Four days was the longest such period recorded in November 1963 and January 1964.

## NOTES

[1]Hellmers, Henry. *Growth response of redwood seedlings to thermo-periodism.* Forest Sci. 12(3): 276-283, illus. 1966.

[2]Elford, C. Robert, and Max. R. McDonough. *The climate of Humboldt and Del Norte Counties.* Univ. Calif. Agr. Ext. Serv., 34 p., illus. 1964.

[3]Dale, Robert F. *Climate of California.* Climatography of the U.S. No. 60-4. U.S. Weather Bur., Washington, D. C. 37 p., illus. 1959, rev. 1966.

**The Author**

**KENNETH N. BOE** is in charge of the Pacific Southwest Station's research in the silviculture of redwood and associated species, with headquarters at Arcata, California. Native of Montana, he earned bachelor's and master's degrees in forestry at Montana State University. He joined the Forest Service's experiment station in California in 1956.

GPO 980-283

**The Forest Service of the U.S. Department of Agriculture**

. . . Conducts forest and range research at more than 75 locations from Puerto Rico to Alaska and Hawaii.

. . . Participates with all State forestry agencies in cooperative programs to protect and improve the Nation's 395 million acres of State, local, and private forest lands.

. . . Manages and protects the 187-million-acre National Forest System for sustained yield of its many products and services.

**The Pacific Southwest Forest and Range Experiment Station**

represents the research branch of the Forest Service in California and Hawaii.