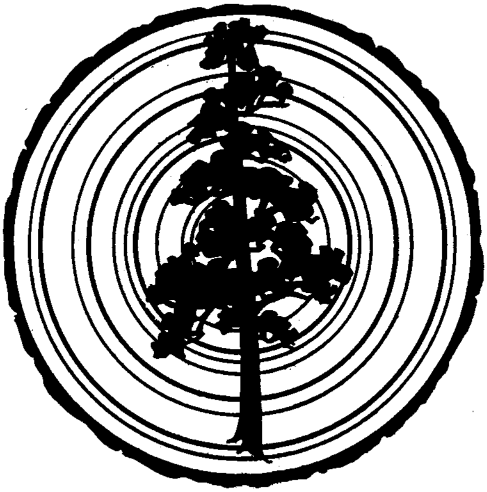
TREE-RING BULLETIN

Vol. 11 | JULY, 1944 | No. 1

A Quarterly



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PUBLISHED BY THE TREE-RING SOCIETY

with the cooperation of

THE LABORATORY OF TREE-RING RESEARCH

UNIVERSITY OF ARIZONA

Annual Subscription, $1.50 Single Copy, 50c

TREE-RING WORK IN SCANDINAVIA

EDMUND SCHULMAN

Introduction. Tree-ring chronologies in Scandinavia exceed in volume those for any other region outside of the Southwestern United States. Two factors seem largely responsible: the major economic importance of forests and the stimulus of the work since 1879 of DeGeer[1] on the annual clay-layers or varves. The field work of Douglass[2] in Scandinavia in the winter of 1912-13 also seems to have directed much attention to dendrochronology.

The widespread European researches on ring growth, largely botanical in nature, were synthesized by Antevs[3] in 1917. In recent years especially, a number of extensive reports on specific dendrochronologies in Scandinavia have been published.[4] Two of the most recent, Erlandsson's[5] on Sweden in 1936, Ording's[6] on Norway in 1941, are among the most competent and comprehensive studies which have yet appeared anywhere. These limited notes are intended particularly to provide a wider accessibility to some of the factual material in these two papers.

General notes on chronology. It has long been evident that the general character of the ring chronology in polar regions is fundamentally different from that in the sub-tropical dry lands. Problems associated with the recognition and dating of false annual or locally-absent rings, which in the Southwest have demanded special and rigorous techniques not required in the usual forestry work, are almost non-existent in the simple though narrow-ringed arctic series. On the other hand, arctic chronologies tend to be relatively complacent, and to vary from site to site more than in the Southwest. These differences lead to an emphasis on different aspects of dendrochronologic work in the cold lands as compared with the dry lands. Nevertheless, it seems clear that the fundamental principles of selection of material, crossdating of chronologies, and sensitivity in chronologies underlie proper work in all latitudes.

The chronology map. Figure 1 is based on the tables of ring measures in Erlandsson and Ording, who have also summarized the work of Boman and

[1]G. De Geer, Geochronologia Suecica Principles, Kungl. Svenska Vet. Akad. Handl. *18,* no. 6, 367 pp., Stockholm, 1940; Smithsonian Report for 1928, 687-696. See also Ebba Hult De Geer, Jahresringe und Jahrestemperatur, Geografiska Annaler *18,* 277-297, 1936.

[2]A. E. Douglass, Climatic Cycles and Tree Growth, Carnegie Inst. Washington Pub. 289,*I,* 30-37, 1919.

[3]E. Antevs, Die Jahresringe der Holzgewächse und die Bedeutung derselben als klimatischer Indikator, Progressus Rei Bot., *5,* 285-386, Jena, 1917. Recent titles are listed in Tree-Ring Bull. *8,* 27-39, 1940.

[4]Among others:
E. Eide, Medd. Det Norske Skogforsöksvesen *2,* 87-104 Oslo, 1926.
A. Boman, Acta Forestalia Fennica *32,* no. 4, 177 pp., Helsingfors, 1927.
S. Aandstad, Nytt Mag. f. Naturvid. *74,* 121-154, Oslo, 1934; *Ibid., 78,* 201-268, 1938.
G. Kolmodin, Skogs. Tidskrift *33,* 321-379, Stockholm, 1935 (U. S. Forest Serv. Translation 259, Washington, 1936).

[5]S. Erlandsson, Dendrochronological Studies, Stockholms Högskolas Geokronol. Inst. Data *23,* 119 pp., Uppsala, 1936 (Ph.D. thesis, Univ of Uppsala).

[6]A. Ording, (Annual Ring Analysis in Spruce and Pine), Medd. Det Norske Skogforsöksvesen 7, 105-354, Oslo, 1941. (In Norwegian; English summary, pp. 314-345).

Aandstad respectively; no other long chronologies for Scandinavia have come to the writer's attention.

Variations in chronology. Uniformity within the tree proved to be high, but different species from the same locality show substantial differences in chronology. However, on the most severe drought sites in the Southwest species differences tend to disappear: sites in southern Utah and Colorado have been studied by the writer for which the mean growth curves for *Pinus ponderosa, P. edulis,* and *Pseudotsuga taxifolia* are almost identical for some 500 years. Further work in Scandinavia may perhaps show parallel conditions.

Ording finds that both pine and spruce from nearby sites crossdate well, but that the chronology is increasingly variant with distance. Even across the 600 miles from Oslo to No. Sweden, however, there is some persistence in record, though at this distance chronologies differ widely in the Southwest.

Giddings has shown[7] that in the spruce of Alaska there exist great differences in chronologies as related to timberline or to river-bottom conditions. The extremely mountainous topography of Scandinavia and the associated differences in local climates suggest that systematic local differences in ring records may well exist there also.

Correlations with climate. Fluctuations in growth can be related, in varying degree, to fluctuations in mean summer temperature, particularly that of the June-July interval.

Archaeological dating. No unqualified "blind" dating of ruin material, as in the Southwest, has yet been accomplished in Scandinavia.

By deriving the mean growth of timbers which crossdated well among themselves and then comparing it with the growth curve of living trees, Aandstad has dated six structures in Norway (60°40'N, 12°+E), whose ages had been known approximately:

Beams	No. Rings in Each	Inner Date—Outer Date
8	47- 95	1772-1870
12	99-165	1689-1853
3	108-140	1713-1852
12	55-130	1655-1784
11	81-132	1639-1770
5	47-117	1621-1734

Ording suggests that a portion of the beam record should not be used in the original comparisons; its correlation coefficient with the master curve may then be a check on the dating. By this method he has certified the dates of old stumps. This procedure is similar to the "forecast" tests after trial dating by skeleton plot according to the Douglass method, the rigorous application of such tests being essential to valid dating.

Cycle studies. Among other lengths, an outstanding cycle of the order of 23 years, so dominant in many tree groups of the Southwest and elsewhere, is reported.

Future possibilities. A close network of centuries-long series should provide important data both on systematic local differences and on long-period changes in Scandinavian climate. Of still greater importance may well be the contribution of such series to the understanding of zonal climatic changes when an extensive circumpolar network of chronologies is available.

Abundant sources of beam material exist in Scandinavia: old buildings, old roads, and lake-covered structures, from some of which thousands of

[7] J. L. Giddings, Jr., Dendrochronology in Northern Alaska, Univ. Arizona Bull. *12,* No. 4: Univ. Alaska Pub. *4,* 107 pp., Tucson, 1944.
——————Tree-Ring Bull. *9,* 26-32, 1943.

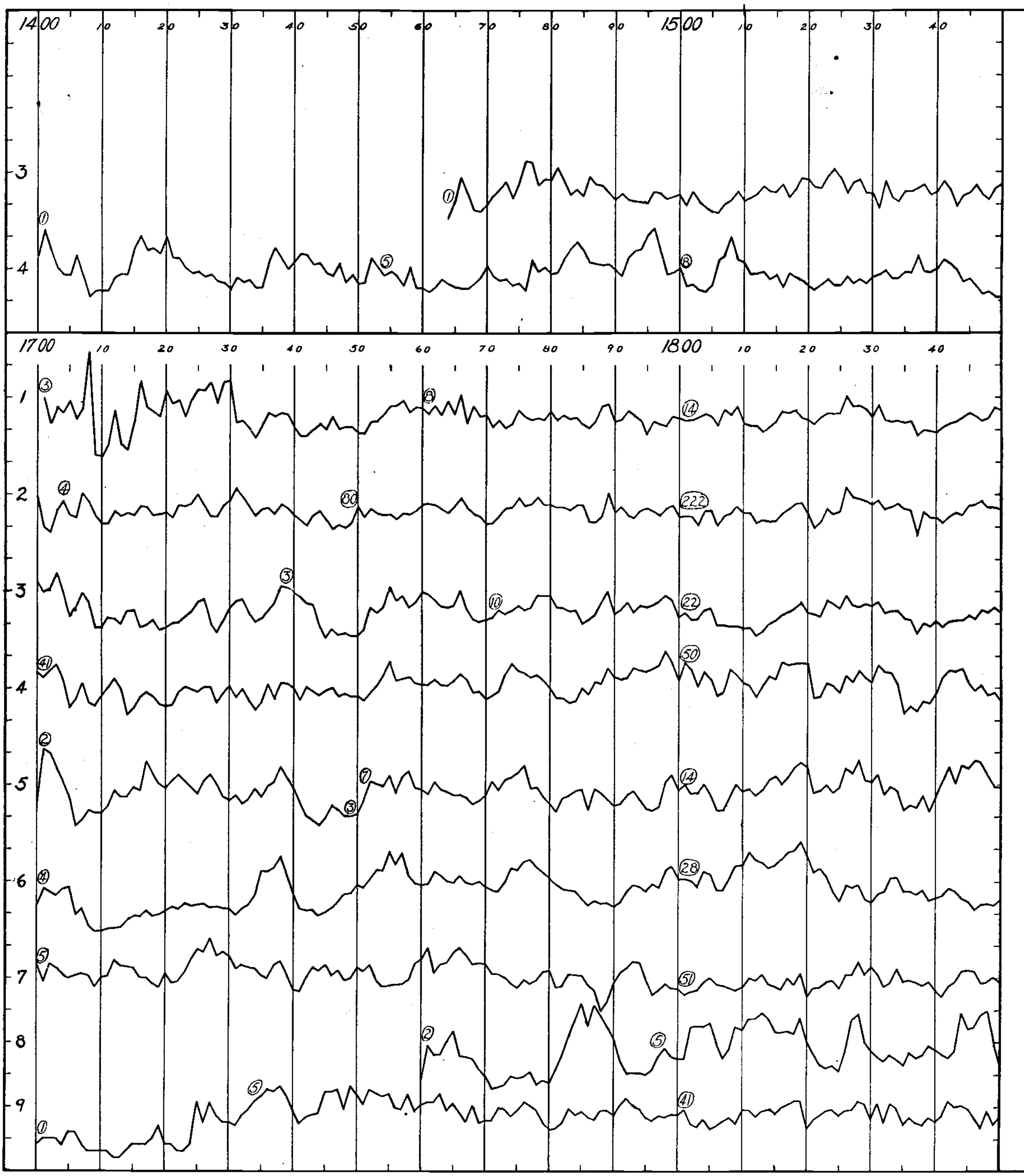
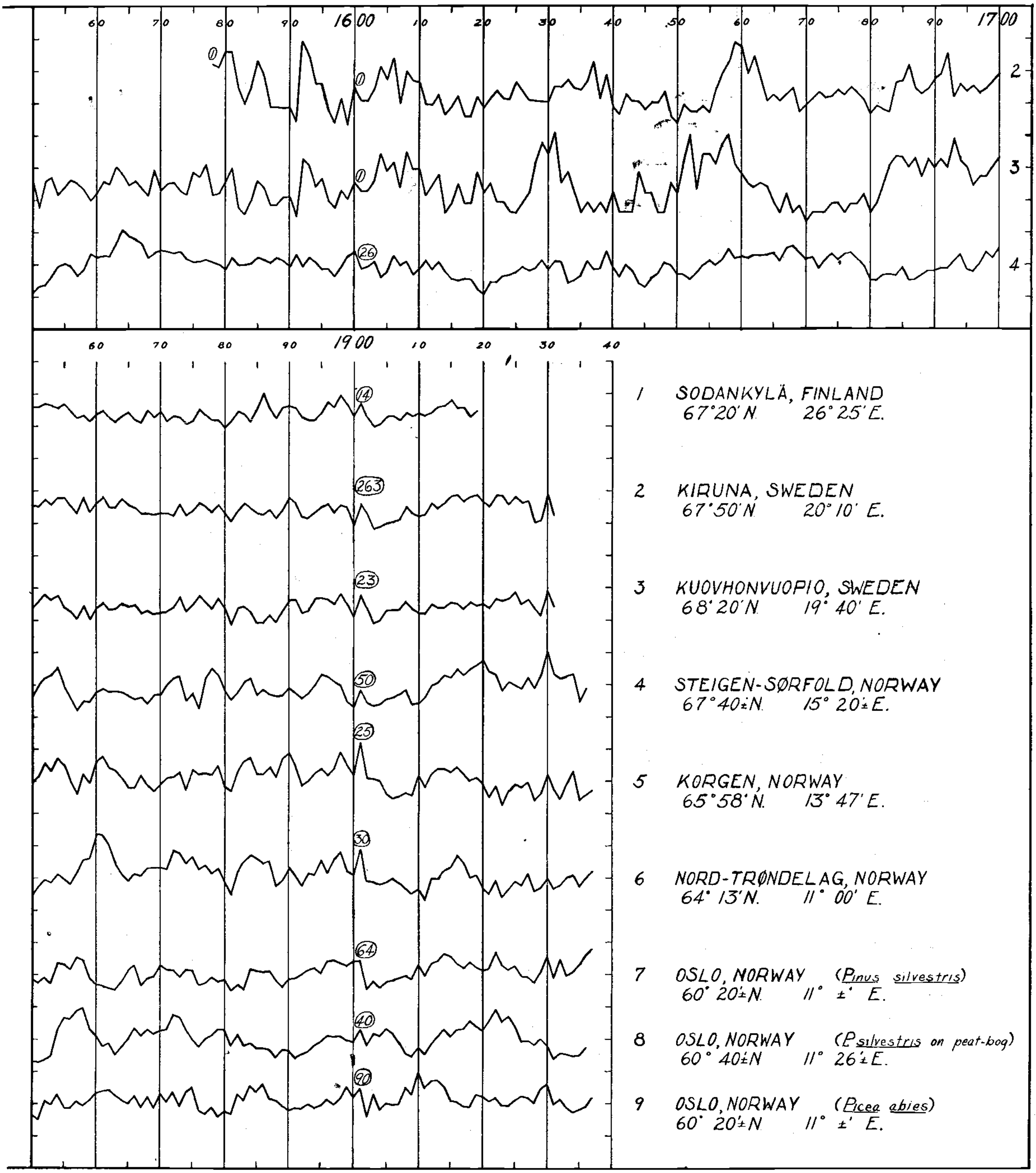


Fig. 1. Mean growth curves for various regions of Scandinavia. These are based on the analysis of full sections; the circled figures give the number of trees entering each curve at various dates. By completing the coordinate grid it should be possible to read off the ordinates of each curve.

The chronologies are arranged roughly in order of decreasing latitude and from east to west. The Finnish series, No. 1, was derived by Boman and is given in Erlandsson's work; the site qualities are not reported. The Swedish series, Nos. 2 and 3, are Erlandsson's. He followed the work



of Douglass closely and went to the forest limits of Scotch pine in northern Sweden for these groups; the sites were rocky and apparently fairly well drained. Nos. **4** to **9** for Norway were developed by Ording, who concentrated attention on the common forest sites of northern regions, poorly drained or on bog; only the Oslo sites 7 and 9 are not in this category. Some series developed by Aandstad were included by Ording in curves **4** and 7. All curves have been plotted from a zero base line. The Norway curves have their means at two scale units above this base, the Swedish and Finnish about one and a half units.

logs have been recovered. Dating the ring records in bog wood may extend the chronology several thousand years into prehistory, according to the recent workers.

If it becomes possible to crossdate tree-rings and varves the climatic significance of fluctuations in the 15,000 year varve series in Sweden should become better understood; in the writer's opinion this may have consequences of the utmost importance for glacial chronology as well as for climatology.

ALEPPO PINE AS A MEDIUM FOR TREE-RING ANALYSIS

By J. GINDEL

Introduction. Aleppo pine (*Pinus halepensis* Mill.) is indigenous to Palestine and other countries around the Mediterranean Sea. Its natural growth is confined to soils of limestone formation in the hilly country. In ancient times Palestine was rich in pine forests, particularly in the Judean hills, but for many centuries they suffered severely from destruction by its inhabitants so that nowadays only scarce remnants of forests can be found. Judging from the 100-110 years old Aleppo pine forests on the rocky ridges of the Judean hills (Beth Mahsir), this species attains its full maturity approximately in its 100th year of growth. But if grown in deep soil and scattered it attains a much greater age. (For instance, the pine tree grown on the grounds of the Rockefeller Museum, Jerusalem, is suggested to be nearly 200 years old.) Its extraordinary resistance to drought and to rocky soil condition, as well as its relatively fast growth in height and girth, make this pine an excellent tree for afforestation. The artificial forests established in Palestine during the last two or three decades consist mainly of Aleppo pine trees.

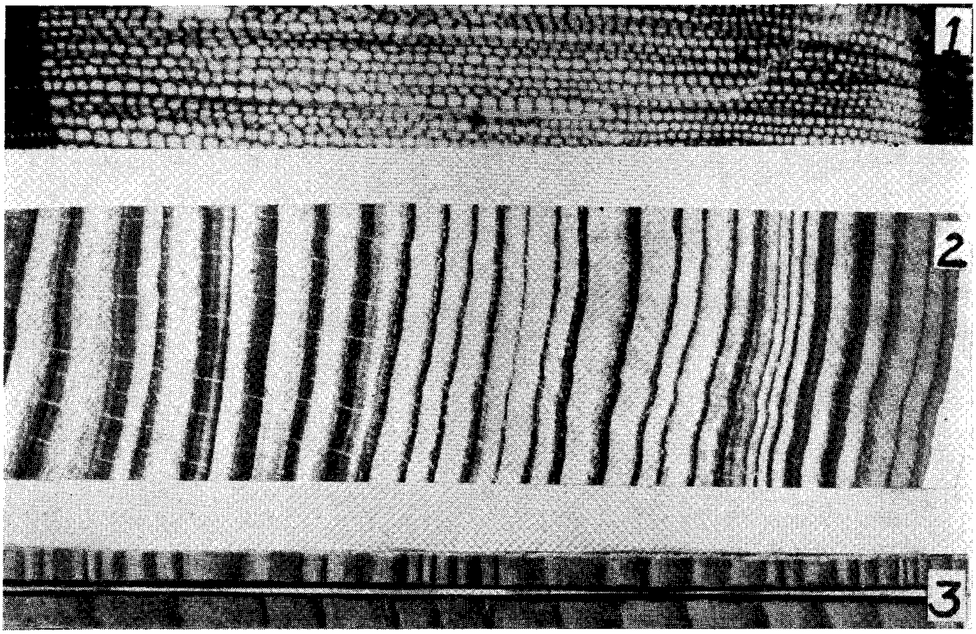
The formation of the tree-ring in Aleppo pines. Generally, the climate of Palestine resembles that of California, particularly in regard to seasonal rain distribution (rainless summer) and temperatures. But the hot dry winds called "khamsins" blowing from the Syrian desert at the beginning and end of the rainy season are a specific feature of the Palestinian climate not known to California. These winds exhaust the water reserves of the soil and consequently shorten cambium activity. A logical sequence exists between the seasonal features of the climate and the form of the tree-ring.

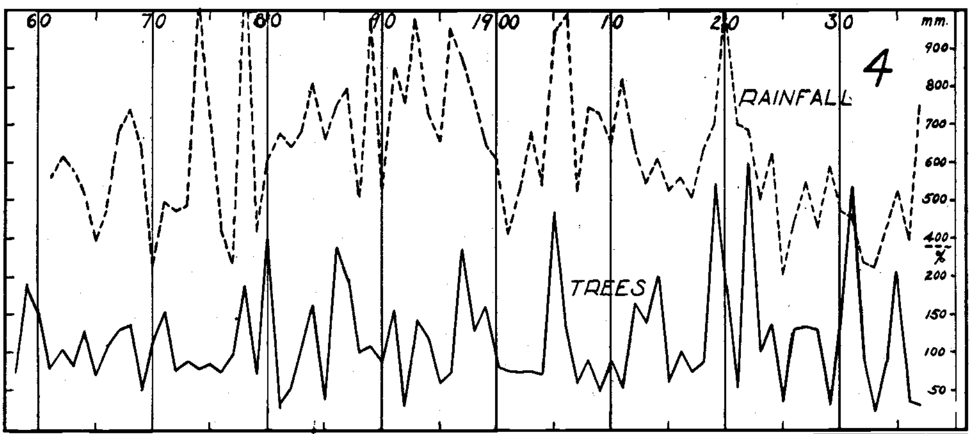
Aleppo pine is a thermophilous species; it does not grow during the larger part of the rainy season because of the low temperature prevailing during that time. The tree starts its growth when the curve of the minimum daily temperature, after reaching the lowest point, begins to rise, i. e., during the end of February or March, and continues to add earlywood during the months of April, May, and even June, depending upon the occurrence of khamsins and high temperatures.*

Figure 1 illustrates a typical ring structure. Deviations from such a structure are caused by fluctuations in the climatic condition during the growing season.

Figure 2 represents a tree nearly 50 years old, grown in the Shfeya forest on Mt. Carmel. Here we may observe different types of rings in Aleppo pine. Some show a small amount of latewood, caused by high summer temperatures and many khamsin days which interrupt the activity of the cambium early in summer. Others show larger amounts of latewood, due to milder temperatures and fewer khamsin days during the rainless months. If the rains accumulate during the coldest months (December-January) and if during the favorable months (March-May) many khamsin days or too low temperatures occur, then a very small layer of earlywood is formed.

*[Circumstances did not permit verification of whether this extraordinarily early ring-growth season is applicable to pines on dry, rocky sites.—E. S.]





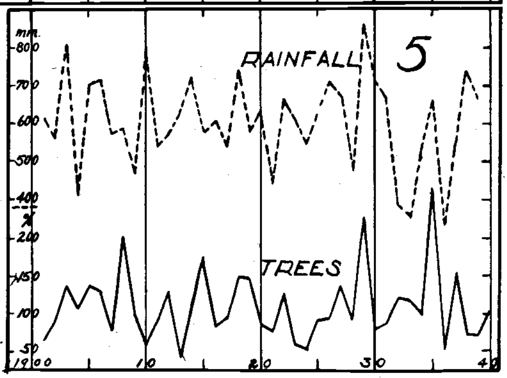


Fig. 1. Transverse section of Aleppo pine. Only a part of one season's growth of earlywood is shown; at left is a portion of the preceding year's latewood.

Fig. 2. Different types of rings in a pine from Mount Carmel, Palestine.

Fig. 3. Sensitive rings (upper) from a dry site as compared with complacent rings (lower) from a moist site at Mount Carmel.

Fig. 4. Tree growth at the Beth Mahsir forest compared with seasonal rainfall at the American Meteorological Station, Jerusalem, 20 kilometers distant.

Fig. 5. Tree growth at Mount Carmel compared with seasonal rainfall.

The formation of false rings. Some rings in Fig. 2 possess at their outer side some additional layers resembling tree-rings, while their color is almost similar to that of the latewood on which they border. The climatic conditions under which such false rings are formed on Mt. Carmel in this country are somewhat similar to those described by Schulman[1] in Monterey pine at Carmel, California: early rains during September, October, or even at the beginning of November, accompanied by favorable temperatures as well as lack of khamsin winds. Contrary to inner false rings, the outer rings are usually ill-defined.

Typical inner false rings are formed by exceptionally late rains (May-June) preceded by a short period of drought and khamsin conditions favorable for the formation of latewood. Again, the subsequent late rains and mild temperatures favor the formation of a very small line of spring tracheids. In this connection, it might be useful to mention the inner, false rings formed in Arizona as described by Douglass[2] in ponderosa pine. A false inner ring formed under climatic conditions similar to those described above was observed for 1877-1878 in all trees tested in the Judean hills. Here, however, the amount of latewood formed during the drought period, before the sporadic late rains, is negligible, whereas the amount of early-wood caused by the late rains is large.

The correlation between relative ring-width and yearly rainfall in Aleppo pine.—As a relatively short-lived species, Aleppo pine very soon starts to be sensitive to rainfall, if grown on rocky ridges. Fig. 3 represents two neighboring pine trees nearly 50 years old and grown at the Beth-Oren settlement on Mt. Carmel. The upper boring, which shows many diagnostic rings (and relatively high sensitivity to rain), has been taken from a tree in rocky soil on the top of the hill. The lower boring, from a tree at the foot of the hill, shows very complacent rings.

In Fig. 4, tree growth at the Beth Mahsir forest is compared with Jerusalem rainfall for the year ending June 30; the rain station is 20 kms from the forest and under different topographical conditions. The growth of five trees from Beth-Oren on Mt. Carmel and the seasonal rainfall are presented in Fig. 5; the fluctuations in the two curves correspond with each other, for the last 25 years, to 68%.

The discrepancies in these curves are related to rain distribution and the occurrence of khamsins or of too low temperatures during the period of growth. Consequently, in years with smaller amounts of rain but favorable distribution trees will grow faster than in years with larger amounts of rain but unfavorable distribution.

Conclusions.—Although Aleppo pine shows early and great sensitivity to climatic elements, particularly to rains and temperature, discrepancies appear between the relative ring-width and the amount of annual (winter) rainfall. These discrepancies are due to unfavorable distribution of rains, too high or too low temperature, and the intensity of khamsin winds during the seasonal growth. The dynamics of these climatic factors form also conditions favorable for the formation of false rings which are sometimes inner but more frequently outer rings. The formation of the outer, usually ill-defined false rings on Mt. Carmel, Palestine, takes place under climatic conditions similar to those in which false rings are formed at Carmel in California.

The similarity of tree growth at the two Carmel sites which are distant 6,350 miles from each other is very suggestive.

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[1]Edmund Schulman, Precipitation Records in California Tree-Rings, Proc. Sixth Pacific Science Congress, (Berkeley, 1939), *3*,707-717, 1941. See also Tree-Ring Bulletin, *4*(3), 4-7, 1938.

[2]A. E. Douglass, Climatic Cycles and Tree Growth, Carnegie Inst. Washington Pub. 289, *I*, 18-20, 1919.