TABLE 2.—*Calculation of value below which the winter minimum will fall once in 10 years, on the average, at Portland, Oreg.*

Year.	Minimum temperature.	d.	d^2.	d^3.
	°F.	°F.		
1888	−2	−19	361	−6,859
1875	3	−14	196	−2,744
1879	3	−14	196	−2,744
1909	6	−11	121	−1,331
1883	7	−10	100	−1,000
1884	7	−10	100	−1,000
1893	8	− 9	81	− 729
1887	9	− 8	64	− 512
1889	9	− 8	64	− 512
1890	10	− 7	49	− 343
1896	11	− 6	36	− 216
1902	13	− 4	16	− 64
1907	13	− 4	16	− 64
1886	15	− 2	4	− 8
1885	17	0	0	0
1905	17	0	0	0
1873	18	1	1	1
1882	18	1	1	1
1894	18	1	1	1
1880	19	2	4	8
1900	19	2	4	8
1876	20	3	9	27
1892	20	3	9	27
1912	20	3	9	27
1898	21	4	16	64
1910	21	4	16	64
1897	22	5	25	125
1906	22	5	25	125
1913	22	5	25	125
1889	23	6	36	216
1891	23	6	36	216
1908	23	6	36	216
1911	23	6	36	216
1881	24	7	49	343
1903	24	7	49	343
1877	25	8	64	512
1895	25	8	64	512
1901	26	9	81	729
1904	28	11	121	1,331
Sums		−13	2,121	−12,889
Mean	16.67			

COMPUTATION.

Quantity.	Symbol.	Value.
Number of years of observation	n	39
Mean winter minimum	M_0	+16.67°F.
Convenient number near the mean	M	+17°
Departure from M	d	
Sum of column d	Σd	−13
Average departure from M	$\Sigma d/n$	− 0.33
Sum of column d^2	Σd^2	+2,121
Average of square of departures from M	$\Sigma d^2/n$	+54.38
Average of square of departures from the mean[1]	$\frac{\Sigma d^2}{n}-\left(\frac{\Sigma d}{n}\right)^2$	+54.27
Standard deviation	$\sigma=\sqrt{\frac{\Sigma d^2}{n}-\left(\frac{\Sigma d}{n}\right)^2}$	7.37
Sum of column d^3	Σd^3	−12,889
Average of cube of departures from M	$\Sigma d^3/n$	−330.48
Average of cube of departures from the mean[1]	$\mu_3=\frac{\Sigma d^3}{n}-3\left(\frac{\Sigma d}{n}\right)\left(\frac{\Sigma d^2}{n}\right)+2\left(\frac{\Sigma d}{n}\right)^3$	−276.23
k	$k=\sqrt{\mu_3/\sigma^3}$	−0.69
Value from Table 1, for $k=-0.69$, and *average interval*=10	z/σ	−1.378
Departure below mean that will be exceeded in 1/10 of the years	$x=1.378\sigma$	10.16°F.
Value below which winter minimum will fall in 1/10 of the years	M_0-x	+6.51°F.

[1] See *Davenport, C. B.*: Statistical methods, ed. 3, 1914, pp. 20–21, for formulæ reducing these quantities to the true mean. The notation in the table is different from that used by Davenport.

TABLE 3.—*Abstract of computation of values of minimum winter temperatures (t) which should be exceeded, on the average, once in 10 years.*

State.	Station.	Number of observations, n.	Mean minimum temperature.	σ	k	$\frac{z}{\sigma}$ (from Table 1).	Departures of t from mean.	t.	Number of observations below t.
			°F.				°F.	°F.	
Alabama	Mobile	42	+21.19	6.29	−0.93	1.427	− 8.98	+12.21	3
Do.	Montgomery	41	+16.95	6.30	−1.02	1.448	− 9.12	+ 7.83	2
California	San Diego	42	+35.62	2.95	−0.45	1.338	− 3.95	+31.67	1
Do.	San Francisco	39	+37.00	2.74	−0.33	1.322	− 3.62	+33.38	4
Dist. of Columbia.	Washington	39	+ 2.85	7.33	−0.85	1.411	−10.34	− 7.49	4
Florida	Key West	39	+50.64	3.89	−0.41	1.332	− 5.18	+45.46	5
Georgia	Augusta	39	+16.97	5.45	−0.66	1.373	− 7.48	+ 9.49	5
Do.	Savannah	39	+21.51	5.29	−0.65	1.371	− 7.25	+14.26	4
Illinois	Cairo	42	+ 0.26	7.09	−0.23	1.308	− 9.27	− 9.01	3
Indiana	Indianapolis	42	− 8.88	6.62	−0.13	1.296	− 8.58	−17.46	4
Iowa	Davenport	41	−15.02	6.53	0.00	1.282	− 8.36	−23.38	4
Do.	Des Moines	35	−17.91	6.30	−0.21	1.306	− 8.23	−26.14	4
Do.	Keokuk	42	−13.36	6.73	−0.17	1.302	− 8.76	−22.12	4
Kansas	Dodge City	39	−10.67	7.01	+0.02	1.279	− 8.97	−19.64	3
Kentucky	Louisville	41	− 0.88	7.29	−0.39	1.330	− 9.70	−10.58	2
Louisiana	New Orleans	39	+25.80	5.72	−0.99	1.440	− 8.24	+17.56	3
Do.	Shreveport	39	+15.38	6.97	−0.67	1.375	− 9.58	+ 5.80	3
Maryland	Baltimore	43	+ 5.63	5.63	−0.76	1.390	− 7.83	− 2.20	4
Mississippi	Vicksburg	39	+16.90	6.36	−0.86	1.411	− 8.97	+ 7.93	3
Nebraska	North Platte	39	−18.69	8.35	−0.12	1.295	−10.81	−29.50	3
Do.	Omaha	39	−16.10	6.77	−0.32	1.320	− 8.94	−25.04	4
New Jersey	Atlantic City	39	+ 3.62	5.58	+0.07	1.274	− 7.11	− 3.49	5
New Mexico	Santa Fe	39	− 2.46	5.56	−0.15	1.298	− 7.22	− 9.68	5
New York	New York	42	+ 1.95	4.79	+0.27	1.256	− 6.02	− 4.07	4
North Carolina	Wilmington	39	+17.08	4.82	−0.17	1.301	− 6.27	+10.81	5
Ohio	Cincinnati	43	− 2.28	6.25	−0.18	1.302	− 8.14	−10.42	4
Oregon	Portland	39	+16.67	7.37	−0.69	1.378	−10.16	+ 6.51	4
Pennsylvania	Pittsburgh	39	− 2.69	5.45	−0.68	1.377	− 7.50	−10.19	3
South Carolina	Charleston	39	+21.69	5.50	−0.81	1.380	− 7.59	+14.10	6
Tennessee	Knoxville	43	+ 4.14	8.43	−0.59	1.362	−11.48	− 7.34	5
Do.	Memphis	39	+ 7.97	7.00	−0.36	1.327	− 9.29	− 1.32	4
Do.	Nashville	39	+ 3.33	7.73	−0.15	1.299	−10.01	− 6.71	4
Texas	Galveston	42	+25.33	6.36	−0.44	1.337	− 8.50	+16.83	3
Utah	Salt Lake City	39	+ 0.05	6.72	−1.16	1.459	− 9.82	− 9.77	5
Virginia	Cape Henry	39	+14.59	4.71	−0.23	1.309	− 6.20	+ 8.39	5
Do.	Lynchburg	39	+ 6.10	6.68	−0.23	1.308	− 8.74	− 2.64	7
Do.	Norfolk	39	+13.64	5.12	−0.30	1.318	− 6.75	+ 6.89	5
Wyoming	Cheyenne	41	−18.71	7.78	−0.11	1.294	−10.07	−28.78	4

GRAPHIC METHOD OF REPRESENTING AND COMPARING DROUGHT INTENSITIES.[1]

By THORNTON T. MUNGER.

[U. S. Forest Service, Portland, Oreg., Nov. 1, 1915.]

It is a matter of interest among foresters to find a way for expressing in some graphic quantitative fashion the comparative forest fire risk of various years, and to determine the relative fire risk in various regions. There are so many factors that combine to create a fire hazard in our forests that it is difficult to express them in a statistical or graphic form.

The most influential meteorological factors are the infrequency of soaking rains, the total amount of rain in the dry season, the depth of the winter snow and the time of its disappearance, the humidity of the atmosphere, the frequency of very hot days, the occurrence of high winds, particularly of dry winds, and the seasonal temperatures as they affect the time at which the herbaceous vegetation matures and dries up. All these factors of precipitation, temperature, and wind movement are so complexly interwoven that it seems to be impossible to combine them and consider them jointly. The one single factor that has the most important influence on

[1] This method of showing drought severity was described by District Forecaster E. A. Beals at the meeting of the Western Forestry and Conservation Association on Dec. 7, 1914, using diagrams modeled after those originated by the author.

the fire hazard in the Pacific Northwest is the infrequency of soaking rains—i. e., the intensity of the droughts.[2] For a period of from 20 to 50 days in July and August there is, as a rule, practically no precipitation. It is this drought that dries out the forests so that fires become epidemic at this time, both their number and particularly their severity being closely related to the duration of the drought. To show the comparative severity of the summer droughts of several years, a table of their duration is not adequate, because their parching effect is not directly proportional to their length. It increases in geometric relation to the length of the dry period—thus a 30-day drought is much more than twice as intense as a 15-day drought. Let us assume that the intensity of droughts increase as the square of their duration, an arbitrary but probably fair assumption in the case of forest desiccation. On this hypothesis a 30-day drought would be four times as intense as a 15-day drought.

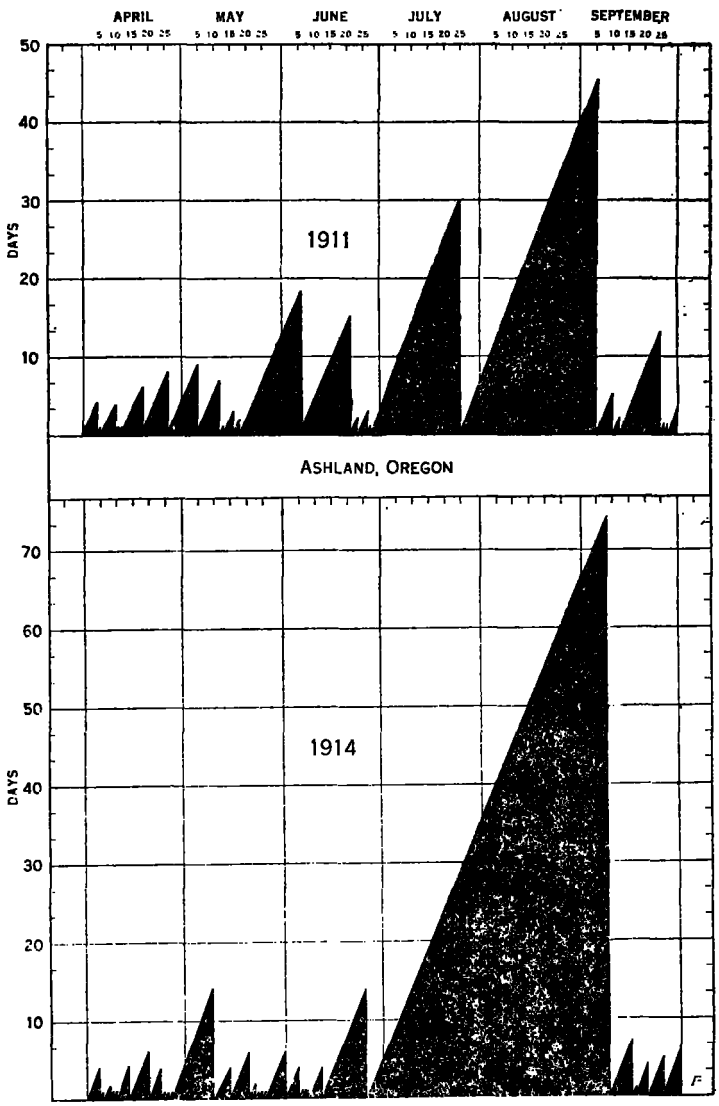

FIG. 1. Graphic representations of the drought intensities at Ashland, Oreg., during the summers of 1911 and 1914. Ordinates and abscissæ both represent duration of dry periods having less than 0.05 inch precipitation on any one day (midnight to midnight).

To present drought intensity graphically, using this hypothesis, a series of diagrams was drawn on coordinate paper, using the single variable the length of the period without a 24-hour rainfall of 0.05 inch. The intensity of the drought was represented by a right-angle triangle, whose height and base were both proportional to the duration of the drought. A set of these diagrams for two contrasting years is shown in figure 1. Whether or not the scale of the abscissæ and ordinates is equal, is immaterial. In these particular diagrams it was considered that any rain of 0.05 inch (in 24 hours) broke the drought. The righthand edges of the triangles therefore mark the dates on which rain fell to this amount or more.

The value of these diagrams is in showing at a glance the relative intensity of droughts in a series of years for any one place, and partly in showing the comparative drought intensity (or fire hazard) of various localities. This can be reduced to an absolute quantitative expression by actually measuring the areas of all the triangles in each year's diagram. The actual fire risk in the vicinity of Ashland, Oreg., judged by the experience of the Forest Service in fighting fire, was for the years 1911 and 1914 about as shown by the above sample diagrams.

Where it is not desired to show graphically the intensity of the drought, it may be computed directly by a formula first suggested by Mr. A. A. Griffin, viz—

$$\text{Severity of drought} = \text{length of drought} \times \tfrac{1}{2} \text{ length of the drought.}$$

Thus a drought of 30 days would have an intensity value of $30 \times \frac{1}{2}30 = 450$; while in the same period 5 droughts, one of 10 days and four of 5 days each, would have an intensity value of—

$$10 \times \tfrac{1}{2}10 + 5 \times \tfrac{1}{2}5 + 5 \times \tfrac{1}{2}5 + 5 \times \tfrac{1}{2}5 + 5 \times \tfrac{1}{2}5 = 100.$$

Using this formula (or actually measuring the areas of the triangles) the drought severity factor for Ashland, Oreg., is found to be 1,839 for 1911 and 3,206 for 1914. The average for the seven years, 1908–1914, is 2,142. Thus, the droughtiness of the year 1911 was 303 units, or 14 per cent, below the average, while the year 1914 was 1,064 units, or 49 per cent, above the average. Similarly a comparison of the average for various localities may be made.

Using the assumption that the intensity of a drought increases as the square of its duration, it is possible that this form of illustrating drought intensity might have a number of uses wherever the prolonged absence of precipitation is of economic importance—in agriculture, forestry, or in any industry affected by precipitation. By this method the distribution of the rainfall day by day could be most beautifully shown. The places with an evenly distributed rainfall would have an even-topped sawtooth diagram, the more frequent the rains the finer the teeth, while places with a long dry season would have a conspicuous high peak or two in the year's diagram.

Drought severity is so much more important in agricultural pursuits and in the prevention of forest fires than drought duration that a means of expressing it is needed. For educational purposes this method of showing comparative meteorological conditions is recommended because it is so graphic. It is thought that it also has practical value as a means of determining the normal year, the departures from the normal year, the relative conditions in various localities, and expressing these conditions in quantitative terms.

[2] The meteorological aspects of droughts, in comparison with their agricultural and other aspects, were clearly pointed out in this REVIEW, August, 1894, 22:393-394.—C. A., jr.