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LIGHTNING AND FOREST FIRES IN THE NORTHERN ROCKY MOUNTAIN REGION

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[Northern Rocky Mountain Forest Experiment Station May 14, 1926]

During the past 18 years lightning has caused 39 per cent of the forest fires in the northern Rocky Mountain district, which includes Montana, northern Idaho, and a small portion of northeastern Washington. For the seasons of 1924 and 1925 the figures are 51 per cent and 80 per cent, respectively. As long as such conditions prevail it should be of decided value to know everything possible about the occurrence, behavior, and characteristics of lightning storms in time and place.

In this summary are presented the facts so far brought to light by a compilation of the lightning storm reports prepared largely by the Forest Service fire lookouts, based upon the conditions of 1924 and 1925.

horizon and with a man on duty constantly, insure the reporting of nearly every electrical storm occurring in the northern Rocky Mountain region, at least during the period July 1 to September 1, when nearly all the lookouts are manned.

OCCURRENCE OF LIGHTNING STORMS

As a result of the excellence of these locations it is to be expected that the reports obtained indicate a more frequent occurrence of lightning storms than do the records of the United States Weather Bureau obtained at fewer stations, all located at lower elevations and with much more limited horizons. The Atlas of American Agriculture, Part II, Climate, prepared by the United States Weather Bureau, shows for northern Idaho and western Montana an average of from 15 to 30 thunderstorm days per year, based on their records of 1904 to 1913. The lookout records show that between June 1 and September 30 one or more stations reported the occurrence of lightning storms on 85 days in 1924 and on 95 days in 1925, or more than three times the number of days indicated by the Weather Bureau.

Some of this difference between the Forest Service and the Weather Bureau reports may be due to a greater prevalence of lightning storms in recent years as compared to the period 1904 to 1913. It is the rather popular belief that such an increase has taken place. The Forest Service lookout records do not as yet cover a period of years long enough to warrant dependable conclusions on this phase of the problem. It is believed, however, that the Weather Bureau records are correct for the horizon covered by their stations, and that the greater part of the difference between the two sets of records is due to the almost complete observation of the entire horizon in this region by the Forest Service lookouts.

Some variations in the occurrence of thunderstorms are shown for the past four summers by Figure 2. In considering this chart, one should remember that it shows the number of stations reporting electrical storms each day, and not the exact number of storms. Very often from two to six or more stations observe and report the same storm. The chart shows, nevertheless, that thunderstorms occur in waves which vary considerably from year to year. During 1922, 1923, and 1924, the number of storms was rather evenly distributed throughout July and August. During 1925, however, it was concentrated very largely in July and seems to exhibit the presence of some major control, slowly building up, reaching a peak of activity, and then dying off rather rapidly.

Probably the greatest value of such charts will be to meteorologists, who will be able, by comparing the peaks of storm occurrence with the weather maps, to determine what combinations of atmospheric conditions caused these peaks. With this knowledge the official forecasters

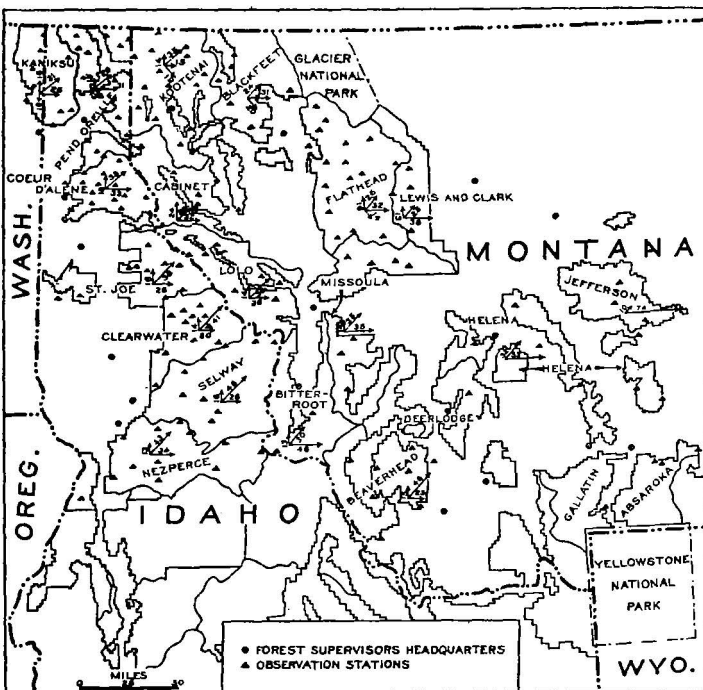


FIG. 1

BASIC INFORMATION

A special form, standard for all national forests west of the Mississippi River, is used in reporting the characteristics of each lightning storm seen by Forest Service fire lookouts.

During the four seasons 1922 to 1925, inclusive, reports have been received from approximately 170 stations in this district. The locations of 166 of these lookouts are shown in Figure 1. The number and distribution of these observation points, together with their location largely on the higher mountain tops with an extensive

may be able to predict storm periods more dependably and perhaps at longer range.

Our records show that July and August are decidedly the thunderstorm months in this region. Of the total number of reports received in 1924 and 1925, 7 per cent showed storms in June, 51 per cent in July, 30 per cent in August, and 12 per cent in September. As the full number of lookout stations are not manned and reporting throughout June and September, however, it is probable that these two months experience more storms than are indicated.

It is well known that the subdivisions of the northern Rocky Mountains undergo very different degrees of fire danger, and the present compilation shows marked variations in the behavior of the lightning factor in this problem. In combining the records of individual National Forests to determine regional characteristics of lightning storms, a grouping of the Forests according to some of the more important fire-weather factors involved (this grouping was devised by Mr. Flint, inspector in charge of fire control in this district) has here been followed. Certain important regional differences are shown in Table 1 and Figure 3.

TABLE 1.—Occurrence of lightning storms

Group	National forests	Per cent of total area studied	Per cent of total number of reports received	Number of storm days				Total
				1924		1925		
				July	August	July	August	
I	Beaverhead.....	20	12	24	17	23	23	87
	Helena.....							
	Jefferson.....							
II	Lewis & Clark.....	12	9	13	11	24	15	54
	Bitterroot.....							
	Missoula.....							
III	Blackfoot.....	37	35	22	13	22	21	78
	Flathead.....							
	Cabinet.....							
IV	Kootenai.....	15	19	10	11	20	16	57
	Lolo.....							
	Pend Oreille.....							
V	Clearwater.....	16	25	14	12	22	17	65
	Coeur d'Alene.....							
	Kaniksu.....							
V	St. Joe.....	16	25	14	12	22	17	65
	Nezperce.....							
	Selway.....							
	All forests named.....	100	100	28	21	29	28	106

From this grouping of forests, it is evident that the greatest number of thunderstorm days occur in eastern Montana (Group I), even though the ratio of number of reporting stations to area involved is there the least. It does not follow from this, however, that the fire danger from lightning is greatest in eastern Montana. In fact, almost the reverse seems to be true. Groups IV and V which experience a noticeably smaller number of thunderstorm days, suffer by far the greater proportion of lightning fires. The explanation of this condition probably lies in the fact that thunderstorm days are usually rainy; therefore the more thunderstorms the more rain, and the fewer the fires because the rains maintain a higher moisture content in the fuels. The variable character of timber growth also may have an important effect.

CHARACTERISTICS OF LIGHTNING STORMS

The records of 1924 and 1925 show that in the lightning storms in this district it usually rains, on the average, for about 11 minutes before the lightning begins to strike, and about 34 minutes after the lightning has ceased.

There is a slight difference in this respect between those storms which start fires and those which do not. About 700 observations of fire-starting storms show an average of 9 rain minutes ahead of the lightning, and rain for 30 minutes following it; a total of 39 minutes, exclusive of the duration of the lightning overhead. The average of about 1,100 reports of nonfire-starting storms show 12 minutes of rain before, and 38 minutes following; or a total of 50 minutes rain, excluding the duration of the lightning. This difference of only 11 minutes may or may not be significant, but it is worth noting that those storms with a total of more than 40 minutes of rain before and after the lightning probably are less dangerous than those with appreciably less rain. It is easy for the lookouts to time the duration of rainfall, to estimate its intensity, and to report these facts to the district rangers so that more dependable opinions may be formed as to the probable danger which will result from each storm, and hence the action necessary.

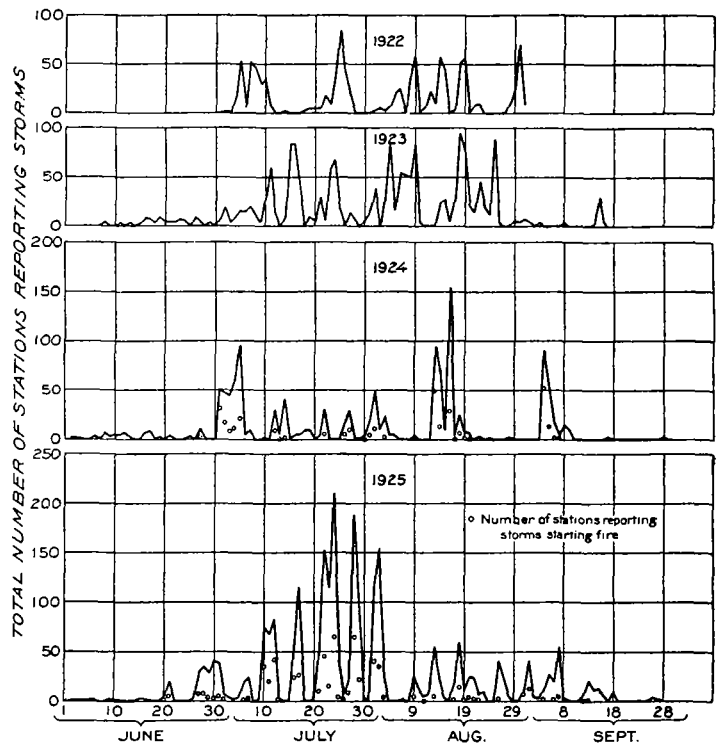


FIG. 2. - NUMBER OF LOOKOUT STATIONS REPORTING LIGHTNING STORMS

These records of duration of rainfall before and after the lightning also exhibit regional differences of appreciable amount, and are as follows:

Group	Number of minutes rainfall		Group	Number of minutes rainfall	
	Safe storms	Dangerous storms		Safe storms	Dangerous storms
I	42	23	IV	60	44
II	37	20	V	57	41
III	53	37	District	50	39

The conclusion indicated by the above tabulation, that there is less fire danger with longer rain, is substantiated by the reports for 1924 which show a total of 53 minutes rain before and after the average storm, whereas in 1925 the average was only 41 minutes. There were 691

lightning fires in 1924 and 1,242 in 1925. Not all of this difference can be ascribed to the 12-minute difference in average rainfall, but this probably was a contributing factor.

A further factor, undoubtedly contributing to the greater number of lightning fires in 1925, was the percentage of lightning bolts striking the earth. The average for both 1924 and 1925 is 33 per cent, based on 3,232 reports. For 1924, however, only 30 per cent of the lightning was reported as striking, for 1925 the average was 34 per cent—another small but possibly significant difference which helped to cause more fires during 1925.

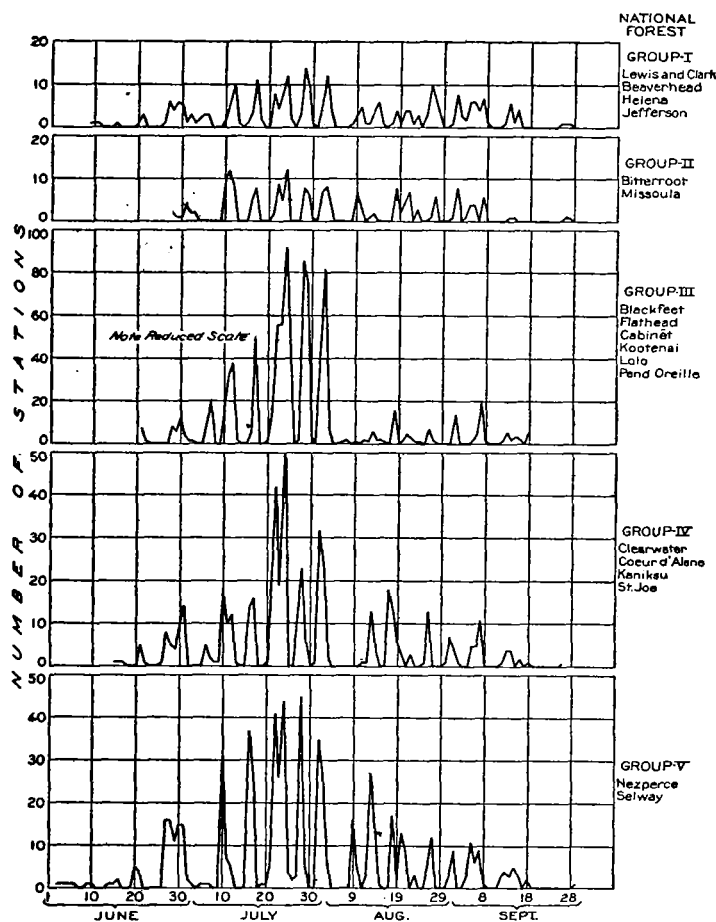


FIG. 3.—NUMBER OF STATIONS REPORTING LIGHTNING STORMS — 1926

The shorter rainfall, the greater percentage of lightning striking, the difference of 10 more thunderstorm days in 1925, and the concentration of the storms into one month instead of two, seem to have been the major factors resulting in nearly twice as many lightning fires in 1925 as compared to 1924.

Just as there was a difference between regions in the number of storm days and in the duration of rainfall, so also there appears to be a significant difference in the percentage of lightning striking the ground, the most lightning striking in northern Idaho where the most lightning fires commonly occur. These differences are as follows:

Group	Percentage of lightning striking the earth		Group	Percentage of lightning striking the earth	
	Safe storms	Dangerous storms		Safe storms	Dangerous storms
I.....	28	49	IV.....	26	48
II.....	27	41	V.....	36	42
III.....	31	39	District.....	30	43

This table is based only on those 2,186 reports which stated definitely whether or not the storm observed was a fire starter. One thousand and forty-six additional reports gave the percentage of lightning confined to the clouds, but failed to classify the storm as "safe" or "dangerous," in so far as it failed to start, or did start, forest fires.

For the national forest district as a whole, the records indicate that during 1924 and 1925 about 25 per cent of the storms were first seen in the morning. For 1924 the figure was 22.6 per cent, and for 1925 it was 23.6 per cent, showing no significant difference. There also appears to be no difference between the four months, June to September. By groups, however, there does appear to be a noticeable difference in the percentage of storms first sighted in the morning, as shown by Table 2.

TABLE 2.—Morning discovery of lightning storms

Group	Total number of reports	Number of morning reports	Number storms first seen in morning	Group	Total number of reports	Number of morning reports	Number storms first seen in morning
I.....	469	95	20	IV.....	712	173	24
II.....	336	44	13	V.....	954	265	28
III.....	1,328	307	23	District.....	3,790	884	23

Apparently Group II has the smallest percentage of storms appearing in the morning, whereas Group V has the highest. There is no definite evidence to indicate whether or not the first appearance of storms in the morning, rather than in the afternoon, provides a better warning of approaching danger, but as the most common hours of occurrence of thunderstorms are from 2. p. m. to 6 p. m., it would seem that Group V should be better forewarned than Group II, if the fire lookouts report to the forest rangers as soon as storms are sighted.

The reports for 1924 and 1925 also show that only 4 per cent of the storms last through midnight. [AUTHOR'S NOTE.—The lightning storm of July 12–13, 1926, which started over 200 forest fires on the Kaniksu Forest alone, began about 10 p. m. and continued until about 3 a. m.]

It has been suggested that rain gauges should be installed at all lookout stations and the amount of the rain with thunderstorms measured instead of timing the duration of the rain. The reports show, however, that only 47 per cent of the lightning storms pass directly over the lookout stations, consequently if the rain gauge system were used it would provide measurements on only half the storms. Nevertheless, a few selected lookouts are being equipped with rain gauges, and as these stations report the amount of rain with each storm additional information of value will be obtained.

The ratio of safe to dangerous storms shows appreciable variation. For the district as a whole, it appears that during 1924 and 1925 about 6 storms out of 10 were safe, and 4 dangerous. The principal variation occurs between the subdivisions of the district, as follows:

Group	Percentage of safe storms		Percentage of fire-starting storms		Group	Percentage of safe storms		Percentage of fire-starting storms	
	1924	1925	1924	1925		1924	1925	1924	1925
I.....	87	94	13	6	IV.....	42	35	58	65
II.....	79	74	21	26	V.....	41	48	59	52
III.....	63	58	37	42	District.....	59	59	41	41

Thus, although the eastern Montana region experiences the most thunderstorm days, only 1 storm out of 10 is a fire-starter. In Groups IV and V, comprising all of the national forests in northern Idaho, except the Pend Oreille, well over half the storms, which were definitely classified, were dangerous.

In Figure 2 the charts for 1924 and 1925 show the number of reports of fire-starting storms and the total number of reports each day, so that the ratio is evident. Usually, with from two to five successive thunderstorm days in a wave, the first day or two brings the greatest percentage of reports indicating that fires resulted. This condition is most obvious in only one of the peaks of thunderstorm occurrence in 1925; it is very clear in three of the peaks of 1924, and it was shown by several cases in 1922 and 1923. The explanation probably lies in the fact that lightning, in the first day of a peak, strikes generally drier fuels than on the third or fourth day when rain has raised the fuel moisture contents high enough to reduce the ease of ignition appreciably. Consequently, warnings from the lookouts that thunderstorms are approaching should be given most attention immediately following any period that has been free from storms.

The compilation of the common direction of movement of storms on the different national forests brings out nothing not generally known before. The reports show the following percentage of storms moving in each of eight directions:

Storm moving toward the—	Group					
	I	II	III	IV	V	District
	Per cent of storms					
North.....	10	14	15	16	16	14
Northeast.....	33	33	31	37	47	36
East.....	39	40	28	26	26	30
Southeast.....	6	5	13	5	4	8
South.....	3	1	4	4	1	3
Southwest.....	3	1	3	5	1	3
West.....	2	3	3	2	0	2
Northwest.....	4	3	3	5	3	3
Stationary.....	0	0	0	0	2	1

There are rather slight differences between these subdivisions and it appears that approximately 88 per cent of the storms move north, northeast, east, or southeast. The most common directions of movement for each of the national forests are shown by the arrows in Figure 1, the lengths of the arrows being proportional to the percentage represented. Arrows are shown only for those directions in which 10 per cent or more of the storms moved.

LIGHTNING FIRES

One of the most interesting and practical phases of this study is the determination of the number of hours between first sighting each lightning storm and the time of discovering each fire caused by it. The summary for 1922 and 1923 indicated that in this period of elapsed time there lies a very appreciable warning which should be of use in preparing to fight lightning fires. The reports for 1924 and 1925 strongly substantiate this conclusion.

In the following summary, attention is paid only to the first four fires because there were only a few reports which gave the elapsed time on more than four fires cause by any one storm.

TABLE 3.—Elapsed time between first sighting of lightning storm and discovery of first four fires caused by average storm

Elapsed time (hours)	Per cent discovered				
	First fire	Second fire	Third fire	Fourth fire	All four
Less than one-half.....	9	5	5	4	7
One-half to 1.....	13	11	8	7	11
1 to 2.....	14	12	10	12	13
2 to 4.....	15	17	18	12	16
4 to 6.....	8	8	7	9	8
6 to 8.....	6	9	9	8	7
8 to 12.....	8	11	11	15	10
12 to 18.....	10	9	9	10	9
18 to 24.....	4	4	3	5	4
24 to 36.....	4	4	7	4	4
Over 48.....	9	10	13	14	11
Total.....	100	100	100	100	100

When these data are reduced to graphic form, as in Figure 4, it is more apparent that after the reports of the first fires are made by the lookouts, a much smaller per cent of the later fires is discovered within a few hours of sighting the storm, and a much larger per cent has a longer period of elapsed time. This is even more evident when reduced again to tabular form as follows:

Number of hours after first sighting storm	Percentage of fire reports which should be received				
	First fire	Second fire	Third fire	Fourth fire	First four fires
5.....	56	51	46	41	51
10.....	69	67	62	60	67
15.....	79	78	73	72	77
20.....	85	83	78	78	83
25.....	87	86	80	82	86
30.....	89	88	83	84	87
35.....	90	89	85	85	88
48 or more.....	100	100	100	100	100

This tabulation shows that there was a 5-hour warning for 49 per cent of the first four fires, a 10-hour warning for 33 per cent, 15 hours for 23 per cent, 20 hours for 17 per cent, 25 hours for 14 per cent, 30 hours for 13 per cent, and 35 hours for 12 per cent. It is therefore apparent that the lookouts should report the first appearance of a lightning storm to their district headquarters where the information should be recognized as a warning of impending danger. As has been shown, for the entire region only 4 storms out of 10 are usually fire-starters, but for northern Idaho practically half the storms are dangerous. In either case it may be better to be unnecessarily prepared occasionally, rather than unprepared for the impending danger. Even without recourse to the thunderstorm forecasts by the United

States Weather Bureau, it is evident that fair warnings of lightning storm danger are already in the forester's hands if he knew how to use them.

There is one rather startling fact made apparent by the 1924 and 1925 reports of lightning fires. It is that 64 per cent of the lightning fires not discovered until more than 48 hours after the storm was first seen, are either the first or second fires in the order of discovery. One might think that nearly all the 48-hour fires would be fourth, fifth, sixth, or later in the order of discovery; that the first fire would be found within a few hours, the second a little later, etc., until after several fires had been discovered and 48 hours had elapsed, then would come the bulk of these so-called 48-hour fires. It is decidedly obvious, however, that this is not the case. Out of 155 reports of fires not discovered until after a lapse of 48 hours, 43 per cent were the first fire ascribed

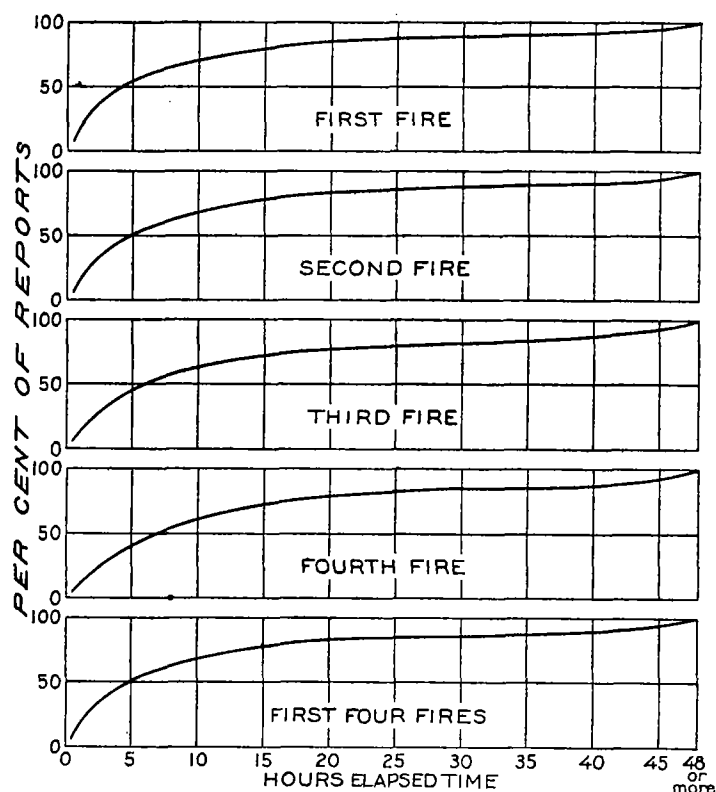


FIG 4. ELAPSED TIME IN DISCOVERY OF FIRST FOUR FIRES CAUSED BY AVERAGE STORM

to the storm, 21 per cent the second fire, 16 per cent the third fire, 10 per cent the fourth, and only 10 per cent were fifth or later.

The explanation of this peculiar condition may lie in the fact that very frequently the lightning strikes wet fuels, few fires are set, and those few do not show up for over 48 hours. Hence it would seem that vigilant detection should not be at all relaxed by the lookouts after a storm has passed merely because no fires are found within the following 48 hours. About 9 per cent of all the lightning fires of 1924 and 1925 appear to have been 48-hour fires. Whether or not this appreciable percentage can be reduced by increased vigilance on the part of the lookouts remains to be determined.

The usable reports so far obtained are not yet sufficient in number to warrant a dependable comparison of one National Forest against another in respect to the speed of detection of lightning fires following the first

sighting of the storm. If better records are obtained during the next two or three seasons, such a comparison should produce usable information.

By groups there are certain differences in the speed of detection brought out by the 1924 and 1925 records. These differences for the first fire are as follows:

Number of hours after first sighting storm	Group					
	I	II	III	IV	V	District
	Percentage of first fire detections made					
5.....	54	70	50	64	58	56
10.....	70	80	62	75	74	69
15.....	77	83	72	83	83	79
20.....	80	87	80	87	88	85
25.....	80	90	84	90	92	87
30.....	81	92	84	92	93	89
35.....	86	93	85	93	94	90
48 or more.....	100	100	100	100	100	100

It is evident from this tabulation that Groups I and III, or the Montana forests excepting the Bitterroot-Missoula, are rather below the district average in the percentage of first fires discovered in less than 48 hours. The Bitterroot and Missoula National Forests as a group show the highest percentage of any group for first fires found within 10 hours after first sighting the storm.

These differences are undoubtedly due to several factors, and certainly should not be charged purely to the efficiency of the lookout personnel and locations. It would seem probable that the low percentage of first fires found within 10 hours in eastern Montana may be due partly to the greater wetness of the fuels which thereby burn more slowly, as well as to the relative lack of high elevation lookouts in that region. Furthermore, some of the minor differences undoubtedly are due to insufficient records, this entire comparison of regions being based on only 722 reports of first fires.

SUMMARY

Between June 1 and September 30 thunderstorms may be expected to occur in the northern Rocky Mountain region from 85 to 95 days out of the 122. There were 10 more thunderstorm days in 1925 than in 1924.

Peaks of thunderstorm occurrence, when over 50 stations report storms in one day, may be expected from 8 to 15 days, generally confined to July and August. The recording of these peaks should be of value in a study of the conditions which produced them, and so furnish a basis for better Weather Bureau forecasts.

The eastern Montana forests appear to experience the most thunderstorm days, but the least danger of lightning fires. It is believed that this is in part because nearly all thunderstorms bring rain and because the more rainy days the wetter the fuels and therefore the smaller number of fires.

For the past two years the records indicate that with the average lightning storm there is usually about 11 minutes of rain before the lightning begins to strike, and about 34 minutes rain after the lightning has ceased. Fire-starting storms showed an average of 9 minutes rain before, and 30 minutes following the lightning. Nonfire-starting lightning storms showed an average of 12 minutes rain before and 38 minutes following. The storms of 1925 brought an average of 12 minutes less rain than those of 1924.

A higher percentage of lightning bolts was also reported as striking the ground in 1925 as compared to 1924, the figures being 34 per cent and 30 per cent, respectively.

For the region as a whole, about 23 per cent of the lightning storms are first seen in the morning, the Selway-Nezperce group showing the highest per cent, and the Bitterroot-Missoula the lowest. Only 4 per cent of the storms last through midnight, and only 47 per cent pass directly over the lookouts.

About 6 storms out of 10 appear to be safe, and about 4 out of 10, fire-starters. Subdivisions of the district showed marked differences in this respect, the eastern Montana forests having a ratio of about 9 safe to 1 dangerous storm, and the Idaho forests a ratio of 1 to 1.

Usually the first day or two of a wave of lightning storms brings the greatest percentage of fires, the following storm days being less dangerous.

About 88 per cent of the lightning storms in this region travel toward the north, northeast, east, or southeast. Sixty-six per cent go northeast or east.

THE JANUARY STORMS OVER THE NORTH ATLANTIC AND THE STROPHS OF THE GREENLAND ANTICYCLONE

551.515 (261.1) (988)

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The exceptional severity of the storms in January, 1925, over the North Atlantic has been brought home to us through the loss of a number of vessels, including the *Antinoe* after her crew had been rescued by the *President Roosevelt*. Sir Napier Shaw in an article published in the London Times of February 6 drew attention to the close parallel between the atmospheric conditions over the Atlantic last January and during the famous storms of the winter of 1898 and 1899 (1).

In each case there developed a vast depression within the atmosphere in the area south of Greenland—an area with a diameter of about 2,000 miles from which there had been removed, according to computations, about two million million tons of air.

The present writer was so struck by the peculiar twin depressions which followed each other during the closing week of last January that the possibility occurred to him of establishing a connection in time between the storm depressions over the Atlantic and the outrushes of cold air from the inland ice of Greenland (2).

Study of the recorded observations (3) upon wind force and direction at the Greenland weather stations had already indicated that the wind from the inland ice seldom reached hurricane velocity at these stations due to overriding in the lee of the steep marginal slope of the glacier (4). To this general rule there appeared, however, to be partial exceptions in the cases of the Danish stations of Angmagsalik on the southeast coast and of Nanortalik on the south coast. These stations are farther removed than the others from the margin of the glacier, and for this reason they feel the strophs of the anticyclone during the winter season, though hardly with their full intensity. At Angmagsalik, where the station is distant 60 miles from the ice margin, the winds blowing down off the glacier arrive from the northerly or northeasterly quarter. In this vicinity the inland ice pushes far out to the eastward and northeastward of the station on its northern side, and the slope winds which start radially outward from the interior are deviated to the right by earth rotation and as a consequence reach the station coming as a rule from the north or northeast.

The time elapsing between first sighting a lightning storm and the discovery of the fires caused by it offers a very material warning period in which to prepare for the impending danger. About 56 per cent of the first discoveries will be made within five hours after first sighting the storm, that period being available to prepare for 44 per cent of the first discoveries, 49 per cent of the second, 54 per cent of the third, and 59 per cent of the fourth discoveries. Nine per cent of the first discoveries are not made till more than 48 hours after the storm is first seen, and of all those not discovered till after 48 hours 43 per cent are first discoveries, not preceded by any other fires. Among the subdivisions of the district there are marked differences in the speed of discovery of the first fire, and in the percentage of fires not discovered till after 48 hours. The Bitterroot-Missoula group shows the quickest discovery of the first fires, whereas the other western Montana forests show the greatest elapsed time in this respect, as well as the highest percentage of fires not found for more than 48 hours after the storm was first seen.

Through the courtesy of Dr. D. La Cour, Director of the Meteorological Institute at Copenhagen, the writer has obtained the radio reports upon wind force and direction at Angmagsalik for the month of January and the first half of February.¹

For the month of January these data are as follows, the strophs being inclosed in boxes:

TABLE 1.—Wind force and direction at Angmagsalik, January, 1926

Date	Wind direction	Wind force (Beaufort)	Date	Wind direction	Wind force (Beaufort)
Jan. 1.....		0	Jan. 16.....	SW.....	1
2.....	NE.....	3	17.....	S.....	1
3.....	NE.....	9	18.....		0
4.....	W.....	1	19.....	NW.....	1
5.....	N.....	3	20.....	N.....	1
6.....	N.....	6	21.....		0
7.....	SE.....	1	22.....	W.....	1
8.....	W.....	1	23.....	NE.....	5
9.....	S.....	6	24.....	NE.....	9
10.....	SW.....	1	25.....	E.....	1
11.....	SW.....	2	26.....	N.....	5
12.....	E.....	2	27.....	NE.....	9
13.....	S.....	2	28.....		0
14.....	W.....	1	29.....	N.....	2
15.....	SE.....	2	30.....	S.....	3
			31.....	E.....	1

From these data it appears that there were during the month of January four strophs from the glacial anticyclone, and these are grouped in a twin relation with a 24-hour interval which is valuable for purposes of identification. Dr. George C. Simpson, head of the British Meteorological Office, has kindly furnished the writer with copies of the synoptic weather charts for the northeastern Atlantic and western Europe for the month of January, and from these it appears that marked atmospheric minima were centered in the general region lying south of Greenland upon the following dates:

¹ These, it appears, are regularly issued in the Icelandic weather bulletins sent out by "Vedurstofan," Reykjavik.