

FIG. 5.—Annual curves of relative humidity at 7 a. m., 2 p. m., and 9 p. m., in percentages. (Average of 30 years.)

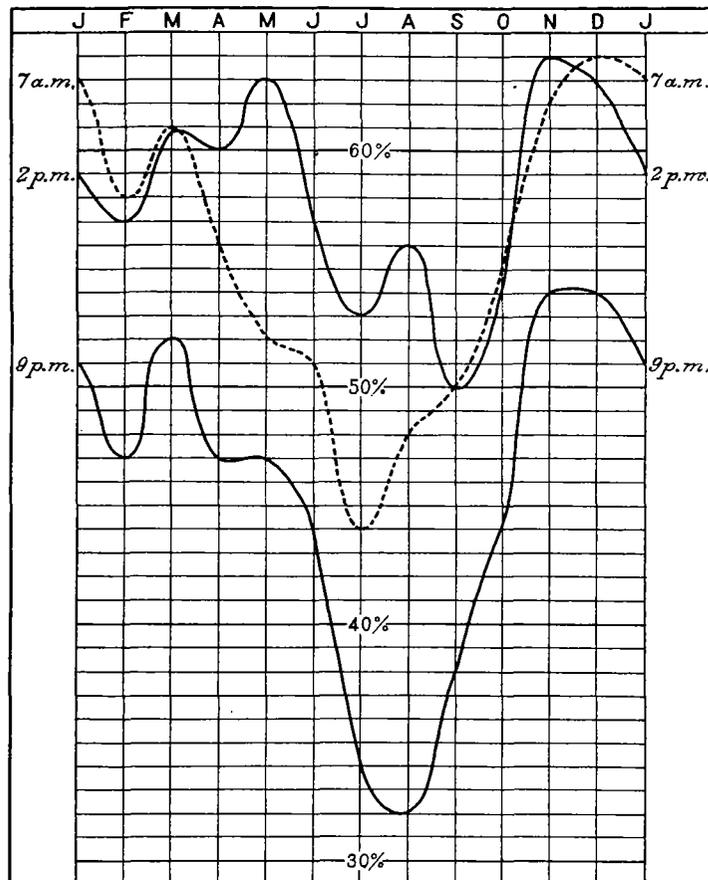


FIG. 6.—Annual curves of cloudiness at 7 a. m., 2 p. m., and 9 p. m. (Average of 26 years.)

two directions prevail nearly equally. The following table shows the number of times during the past 36 years that each direction has prevailed during the various months:

|                | N. | NE. | E. | SE. | S. | SW. | W. | NW. | Vari-<br>able. |
|----------------|----|-----|----|-----|----|-----|----|-----|----------------|
| January.....   | 2  | 1   | 0  | 0   | 4  | 8   | 7  | 14  | 0              |
| February.....  | 3  | 0   | 0  | 0   | 5  | 4   | 8  | 16  | 0              |
| March.....     | 5  | 1   | 0  | 0   | 3  | 1   | 7  | 17  | 2              |
| April.....     | 3  | 3   | 1  | 3   | 7  | 6   | 6  | 5   | 1              |
| May.....       | 3  | 5   | 2  | 3   | 8  | 7   | 0  | 5   | 2              |
| June.....      | 4  | 0   | 3  | 2   | 11 | 10  | 3  | 2   | 1              |
| July.....      | 4  | 0   | 0  | 3   | 8  | 11  | 2  | 8   | 1              |
| August.....    | 2  | 1   | 0  | 0   | 18 | 5   | 1  | 8   | 1              |
| September..... | 0  | 1   | 2  | 0   | 21 | 7   | 0  | 5   | 0              |
| October.....   | 1  | 0   | 0  | 3   | 14 | 8   | 4  | 6   | 0              |
| November.....  | 3  | 1   | 0  | 1   | 7  | 4   | 4  | 15  | 1              |
| December.....  | 2  | 0   | 0  | 1   | 6  | 5   | 9  | 12  | 1              |

**TORNADO INSURANCE.<sup>1</sup>**

By HOWARD E. SIMPSON, Instructor in Geology, Colby College. Dated Waterville, Me., December 30, 1905.

INTRODUCTION.

Much attention has been given by those interested in meteorology to the study of tornadoes, and an agreement has practically been reached as to their origin. The United States Weather Bureau goes as far as is deemed advisable in predicting from time to time "that conditions are favorable for severe local storms." All realize that the prevention of such storms is beyond human control. The little attention that is now being given to the subject is in the direction of the preservation of human life and security of property.

It is not intended that the present paper shall enter into a discussion of the relation of tornadoes to human life and safety, for the dangers have already been grossly exaggerated and the few practical means of avoiding them frequently pointed out. It is intended to show something of what has been done in the United States to afford protection by means of insurance against loss of property through tornadoes and lesser windstorms. Some conclusions will also be drawn regarding the tornado insurance business from the view point of one interested in its meteorological side.

While tornado insurance is almost unknown in some parts of the United States, or is heard of only after some particularly violent windstorm, in other portions of the country it is considered an important branch of the insurance business.

EARLY HISTORY.<sup>2</sup>

Little is known concerning the origin of tornado insurance, but as early as 1865 there were as many as seventeen companies organized under the laws of a single State writing this kind of insurance in connection with that of fire and lightning. In this period, however, the business was without a proper basis and has been aptly described as "The betting of stockholders' money on opinions." Another authority, as late as February, 1883, says, "It is at present only on a basis of guesswork, the business is limited, and the statistics few." Speaking further of the extent of the business and of the rates charged, the same authority gives several glimpses of its unstable character:

Just how many companies have made a business of writing tornado risks in the West we have not ascertained, but that the business has been much more extensively prosecuted than eastern underwriters suspect is quite probable. Not less than 30 companies, and probably not more than 50, have made more or less of a specialty of tornado insurance, and with a tolerably even average of experience, leading in the same direction—that of disaster. \* \* \* There being no guides to the business, each company ran according to its own mode of guessing, one charged one per cent for five years, another two, another six, and none could tell why this or that rate was charged.

<sup>1</sup> Written as a portion of the work done in the course in general climatology given by Prof. R. DeC Ward, of Harvard University, during the year 1904-5.

<sup>2</sup> The author is indebted to the Insurance Monitor, February to September, 1883, for many data regarding the early history of tornado insurance.

The business was, therefore, of an experimental nature, without reliable information on which to base calculations. Up to 1885, at least, tornado insurance was written largely in the form of a paster to an ordinary fire policy. This was certainly a very poor method for meeting such a peculiar risk.

LATER HISTORY.

The early eighties marked, in a way, the beginning of a new period in the history of tornado insurance. The studies on this subject by Prof. H. A. Hazen and Lieut. J. P. Finley of the United States Signal Service, and others, resulted in the publication of much data which formed a basis on which insurance calculations might be made. Of special value were the statistics concerning the frequency and distribution of tornadoes, and the damage resulting therefrom. Their conclusions were gravely at fault in not taking into account the relative areas of the respective States.<sup>3</sup> With the more reliable information, came lower and more uniform rates and an increased volume of business as may be seen from the tables which follow.

The results of the study of even the more recent history of the subject are far from satisfactory. One of the chief reasons is the confusion which exists in the popular mind regarding the use of the terms tornado, cyclone, hurricane, etc. This confusion is common in the newspapers where tornadoes are usually reported as "cyclones" and inaccuracies have crept into the United States Weather Service reports when straight winds have been reported by the voluntary observers as tornadoes. The Weather Bureau is however doing much to correct these errors by increasing the number of trained observers, by a careful selection of the voluntary observers, and the general circulation of meteorological information among the people.

From what has been said it is not surprising that practically all forms of windstorm policies are known as "cyclone insurance" and even to-day the majority of the companies write against "cyclones, tornadoes and windstorms." There is a recent tendency on the part of the leading companies to recognize in the tornado the greatest source of loss from wind, and some are using the term "tornado insurance" to cover all policies insuring against damage by wind. In this they include large amounts written in the Gulf and South Atlantic States for protection from the tropical hurricanes which occasionally strike that region with great violence. This might be termed "hurricane insurance" since its hazard is quite distinct and the risk, judged by the present rates, far exceeds that of the tornado in the Mississippi Valley.

Another serious obstacle to the study of tornado insurance is the fact that a large portion of the business is written by companies also engaged in fire and marine insurance and no separate record is kept, or at least no separate report is given out. It is impossible to form an accurate estimate of the amount of the business done by these companies. This fact should be borne in mind in reading the statistics given hereafter in this paper.

A third difficulty, largely perhaps the result of the preceding one, is the fact that very few States require their departments of insurance to make separate reports of this business. Only in the State of Missouri is a complete and distinct report on tornado insurance made. In several other States, as Illinois, Iowa, and Wisconsin, reports are made of the companies doing an exclusive tornado business. In Minnesota tornado is combined with hail insurance, a new and rapidly increasing class of business, which in this State is already far in excess of the tornado insurance.

The following extracts from several of the most valuable of the State and United States reports, covering the past 25 years,

<sup>3</sup> C. Abbe's "Tornado frequency per unit area," Monthly Weather Review, June 1897, p. 250, and Annual Report Smithsonian Institution, 1888, p. 420.

will give some idea of the development and extent of tornado insurance, and afford a basis for some brief conclusions.

The Eleventh Census of the United States furnishes the only available general view of the business of tornado insurance. Unfortunately these statistics are not very recent and probably far from complete, owing to the reasons already stated in this paper. They cover, however, a very interesting period in the history of tornado insurance and include the transition from the period of experimentation to the beginnings of a scientific basis. The amount of the business by years, from 1880 to 1889, inclusive, is given in Table 1. It is a matter of great regret that the Twelfth Census has made no investigation relating to insurance, and the need is not supplied by any other bureau of the Government.

Perhaps the most striking fact shown by Table 1 is the steady growth of the business from \$4,000,000 to over \$21,000,000 in the decade from 1880 to 1890, the only marked exception being the falling off of about \$2,000,000 in the year 1887. While no definite information is at hand, all indications point to the fact that there was but a small business in this line before 1880, perhaps a few millions a year at most, and that this was handled largely by the fire insurance companies without a separation of risks. The rapid growth in the early years of this decade may be accounted for in part by the publicity accorded the subject during these years through the reports of the United States Signal Service, and the general agitation of the subject in the press of the country at that time. Another good reason seems to lie in the fact that several very severe tornadoes occurred during this group of years, especially in 1882 to 1884, inclusive. Judging from the reports of the United States Signal Service, this was a period of unusual tornado severity. This may also have been the cause of the public agitation of the subject.

TABLE 1.—Tornado insurance business during the years 1880-1889.  
[Compiled from the Eleventh United States Census.]

| Year. | Amount written or renewed. | Premium received. | Losses paid. | Average amount of premium per \$100 risk. | Average amount of loss per \$100 risk. | Average amount of loss paid for each \$1 premium |
|-------|----------------------------|-------------------|--------------|---|--|--|
| 1880  | \$3,928,200                | \$74,702          | \$24,703     | 1.9017                                    | 0.6289                                 | 0.3307   |
| 1881  | 5,642,254                  | 105,192           | 31,554       | 1.8644                                    | 0.5592                                 | 0.3000   |
| 1882  | 10,655,811                 | 191,618           | 52,112       | 1.7966                                    | 0.4887                                 | 0.2720   |
| 1883  | 14,629,036                 | 240,611           | 66,325       | 1.6447                                    | 0.4534                                 | 0.2757   |
| 1884  | 17,806,024                 | 319,758           | 83,618       | 1.7958                                    | 0.4696                                 | 0.2615   |
| 1885  | 18,416,581                 | 303,762           | 87,951       | 1.6494                                    | 0.4776                                 | 0.2895   |
| 1886  | 21,390,669                 | 306,213           | 95,871       | 1.4315                                    | 0.4482                                 | 0.3131   |
| 1887  | 19,469,476                 | 278,768           | 111,541      | 1.4318                                    | 0.5729                                 | 0.4001   |
| 1888  | 20,223,327                 | 266,884           | 90,866       | 1.3197                                    | 0.4493                                 | 0.3405   |
| 1889  | 21,295,370                 | 277,614           | 90,762       | 1.3036                                    | 0.4262                                 | 0.3269   |
| Total | \$153,466,748              | \$2,365,117       | \$735,313    | 1.5411                                    | 0.4791                                 | 0.3109   |

The rapid rise during these three years was followed by a much slower rise in the two following years and by a decided decrease in 1887. This was probably due to a decrease of interest and to the fact that it was the custom to write these policies for a period of three or five years, and therefore many written in the years 1882 to 1884 expired at this time and were not renewed, the general fear being somewhat allayed. This is a peculiar characteristic of tornado insurance in its earlier history.

This decade was also a period of rapid development of tornado insurance on the local mutual plan, especially through the agricultural districts of the Middle West.

The distribution of tornado insurance by States, as compiled from the Eleventh Census, is shown in Table 2 and on the accompanying map, fig. 1. The thousands written are shown in roman and the losses paid by thousands in italics in the several States. It is of interest to note that in a general way the figures correspond to the distribution and frequency of tornadoes as shown in Lieutenant Finley's report.

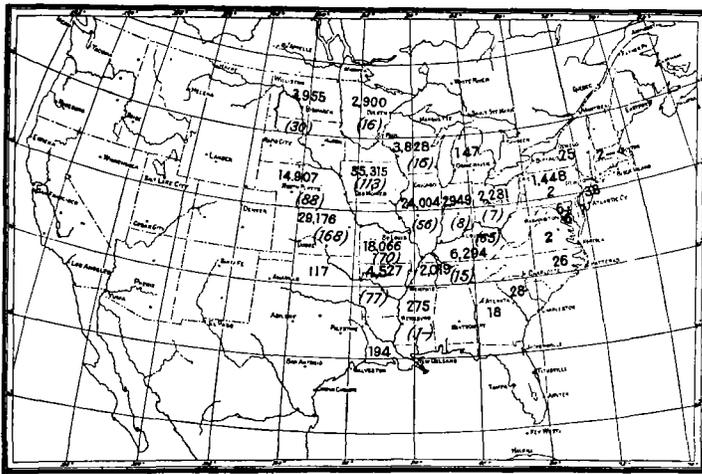


FIG. 1.—Map showing the distribution of tornado insurance by States—1880-1890. Compiled from data of the Eleventh United States Census.

TABLE 2.—Tornado insurance business in the United States\* for the years 1880-1890.

[Compiled from the Eleventh United States Census.]

| State. †                    | Risks written. | Received premium, or assessments. | Paid losses. | Average premium per \$100 risk. | Average loss per \$100 risk. | Average amt of loss paid for each \$1 premium. |
|-----------------------------|----------------|-----------------------------------|--------------|---------------------------------|------------------------------|--|
| Arkansas.....               | \$4,527,154    | \$124,198                         | \$77,099     | \$2.7434                        | \$1.7030                     | \$0.6208                                       |
| North and South Dakota..... | 3,954,610      | 67,461                            | 29,595       | 1.7059                          | 0.7484                       | 0.4387   |
| Illinois.....               | 24,004,062     | 388,186                           | 56,209       | 1.6172                          | 0.2342                       | 0.1448   |
| Indiana.....                | 2,949,336      | 27,160                            | 7,755        | 0.9209                          | 0.2629                       | 0.2885   |
| Iowa.....                   | 18,450,622     | 11,092                            | 1,845        | 0.1513                          | 0.0219                       | 0.1676   |
| Kansas.....                 | 26,864,547     | 365,530                           | 111,072      | 1.3361                          | 0.4125                       | 0.3087   |
| Kentucky.....               | 29,175,693     | 540,647                           | 168,242      | 1.8531                          | 0.5167                       | 0.3112   |
| Minnesota.....              | 6,294,337      | 122,739                           | 65,338       | 1.9500                          | 1.0380                       | 0.5332   |
| Missouri.....               | 2,900,078      | 34,292                            | 15,830       | 1.1825                          | 0.5458                       | 0.4616   |
| Nebraska.....               | 18,065,839     | 258,572                           | 70,320       | 1.4313                          | 0.3892                       | 0.2720   |
| Ohio.....                   | 14,906,836     | 304,845                           | 88,440       | 2.0426                          | 0.5933                       | 0.2905   |
| Pennsylvania.....           | 2,231,425      | 23,120                            | 7,034        | 1.0361                          | 0.3152                       | 0.3042   |
| Tennessee.....              | 161,600        | 177                               | 0            | 0.2873                          | .....                        | .....  |
| Wisconsin.....              | 1,886,909      | 3,217                             | 1,600        | 0.2320                          | 0.1154                       | 0.4974   |
| Total United States         | \$153,466,748  | \$2,365,117                       | \$735,313    | \$1.5411                        | \$0.4791                     | \$0.3109                                       |

\*The whole amount of tornado insurance is not shown, as most of the companies include the tornado business with the fire business and report it all under the head of the latter. In the accompanying table only tornado business reported separately is shown.  
 †States having less than \$1,000,000 are omitted from table.  
 ‡Business marked thus is by companies doing business on the mutual plan and insuring only dwellings and contents of farm property. All other is by companies having joint stock capital.

The annual reports of the various State commissioners or superintendents of insurance, while very complete on most lines, give little practical information to the student of tornado insurance, since in most cases only the business transacted by the local mutual companies doing an exclusive tornado business is reported as such. The State Superintendent of Insurance of Missouri has, however, presented a complete report for the last few years and the statistics given in Table 3 compared with those of the United States, already given, form an interesting study. The Missouri report begins practically where the United States report ends and in that way they supplement each other.

The data regarding tornado insurance in Missouri are of interest from the fact that they have been carefully compiled, especially since 1896, and for the reason that, according to the reports of Lieutenant Finley of the United States Signal Service, Missouri is the State most frequently visited by tornadoes. The history of the business from 1890 to 1900 as shown in Table 3, bears a strong resemblance to that of the United States in the preceding decade.

Starting in 1890 with about the same amount that was written in the whole United States in 1880, the business seems to continue uniform for a couple of years. A marked increase

for two years is followed by as marked a decrease for another two years. Of this the State Actuary, Mr. August A. Harvey, to whom much is due for the excellent series of State reports, says in his Annual Report of 1895: "The tornado business has fallen off, because cyclones(?) did not prevail during the years 1893 and 1894 as in 1892." In this statement he accounts, in part at least, for the marked increase already mentioned.

TABLE 3.—Tornado insurance business in Missouri for the years 1889-1903.

| Year.      | Risks written.  | Premiums received. | Losses paid. |
|------------|-----------------|--------------------|--------------|
| 1889.....  | \$ 2,363,700.00 | .....              | .....        |
| 1890.....  | 2,409,000.00    | \$ 31,635.69       | \$ 2,412.44  |
| 1891.....  | 2,340,700.00    | 31,508.61          | 470.05       |
| 1892.....  | 2,784,800.00    | 34,914.99          | 6,604.05     |
| 1893.....  | 4,484,993.00    | 50,269.22          | 6,698.65     |
| 1894.....  | 2,964,600.00    | 39,234.41          | 1,709.76     |
| 1895.....  | 1,781,589.00    | 20,873.74          | 2,511.62     |
| 1896*..... | 12,233,167.00   | 65,092.78          | 60,203.57    |
| 1897.....  | 17,733,373.00   | 89,340.19          | 12,461.06    |
| 1898.....  | 15,963,441.00   | 85,309.64          | 22,895.32    |
| 1899.....  | 31,458,796.17   | 134,671.56         | 17,544.83    |
| 1900.....  | 22,006,701.00   | 90,129.67          | 10,440.55    |
| 1901.....  | 28,435,469.44   | 124,110.55         | 5,307.03     |
| 1902.....  | 23,326,518.00   | 118,246.29         | 16,457.78    |
| 1903.....  | 24,606,083.55   | 140,008.94         | 24,174.18    |

\*The estimated business for 1896 is \$16,233,167.00. William D. Murray, Deputy Superintendent of the Insurance Department of Missouri, in the report for 1897, says: "The tornado items for 1895 and 1896 are not true. The great disaster of last May brought out the fact that some thirteen companies wrote tornado risks in Missouri of which no report had been made to the insurance department."

The phenomenal advance in business in 1896 is a still greater testimony to the effect of severe tornadoes on the purchase of tornado insurance. The St. Louis tornado, referred to in the report of the year following as "The May Disaster," carried the sales up from \$2,000,000 to \$12,000,000 and revealed the fact that several companies were still doing tornado business, and reporting it as fire, to an amount estimated at \$4,000,000. The impetus thus given caused a still further increase to nearly \$18,000,000 of business in 1897, but the fright having lessened it fell away somewhat in the year following.

Greater than either of the advances mentioned, came the boom of 1899. This was probably the combined result of two principal causes whose relative individual importance can not be determined. In this year came both the noted Kirksville tornado with its great destruction of life and property, and the reduction of the cost of tornado insurance by about 50 per cent. The latter was brought about through the efforts of the State Insurance Department and went into effect at the beginning of the year. That such a reduction of rates was possible, shows something of the unscientific basis of this form of insurance as late as 1899. That it was carried out voluntarily is much to the credit, not only to the superintendent of insurance, but also to the companies doing business in the State.

While the figures show a great fluctuation in the amount of tornado insurance written, they indicate, on the whole, a very decided increase in the business. The incomplete data furnished by the reports from the other States show that the growth was general and, taken as a whole, not subject to the fluctuations characteristic of any one local area.

The early rates, as already suggested, were based on the merest guesswork, varying with the different companies from 1 to 6 per cent for five years, increasing in proportion for shorter periods. In 1883 the rate of 50 cents per hundred for a single year seems to have been generally adopted, with \$1 and \$1.50 for three and five years, respectively. This applied only to well built structures, while churches with steeples, three story buildings, etc., called for a decided advance. This rate was not based on ascertained data, but appears to have been adopted experimentally. Owing to the supposed greater destructiveness of tornadoes in Missouri and Kansas the rates were highest in these States; Illinois, Iowa, Wisconsin, Minnesota, and the other States of the upper Mississippi

Valley closely following. In general we may say that at this time the rates in tornado insurance were equal to those of fire and lightning combined, though it was beginning to be recognized that there ought to be a great difference between them in favor of the former.

The American Meteorological Journal of May, 1884 (Vol. I, p. 10), commenting on State Actuary Harvey's report for Missouri, says: "Both nature and the companies have discriminated a little against Missouri," and gave the following data:

|  | Per cent. |
|--|-----------|
| Average rate of premium in general         | 1.41      |
| Average rate of premium in Missouri        | 1.59      |
| Average loss of amount written in general  | .17       |
| Average loss of amount written in Missouri | .44       |
| Average loss of premium in general         | 12.21     |
| Average loss of premium in Missouri        | 27.59     |

The general scaling down of rates in this State already mentioned, which came fifteen years after this report was published, was certainly needed in view of these facts.

There seems to have been a considerable uniformity in limiting the amount of a single risk to either \$3000 or \$5000. Many companies also limited the minimum amount adjustable in a single loss to \$10, \$25, or \$50 owing to the cost of adjustment. In this way the damages from slight gales were not included in the risk.

THE PRESENT STATUS OF TORNADO INSURANCE.

The amount of tornado insurance now written can not be calculated, but from the best data at hand in seems that \$500,000,000 annually would not be an over estimate. This compared with some other classes of the insurance business is small, but is believed to be slowly increasing. The business is still largely handled by the fire insurance stock companies and this part of it is steady and reasonably permanent. A considerable portion is, however, written by the local mutual companies, much of it on the assessment plan, and is, therefore, more subject to fluctuation from local causes. On the whole it will probably remain a small but important and permanent branch of insurance in this country, especially in the Mississippi Valley and along the south Atlantic and Gulf coasts.

Twenty-two years ago the editor of the insurance Monitor said, regarding rates: "It would seem that less than a fifth or perhaps a tenth of 1 per cent, under judicious policy form, should furnish abundant security against actual risk in sections most liable to tornadoes." The wisdom of his estimate, in view of the current rates to-day, may be seen by a quotation of the rates of one of the leading stock companies now doing business throughout the United States. Their risks are limited to \$5000 and subject to further careful restrictions.

TABLE OF CURRENT RATES.

|  | 1 year. | 3 years. | 5 years. |
|--|---------|----------|----------|
| Dwellings and other substantial buildings              | .10     | .25      | .40      |
| Barns  | .15     | .37½     | .60      |
| Churches with steeples and towers                      | .25     | .62½     | 1.00     |
| <i>Southern cities, 50 miles from seacoast.</i>        |         |          |          |
| Dwellings and other substantial buildings              | .25     | .50      | .75      |
| Barns, with dwellings                                  | .30     | .60      | .90      |
| Churches with steeples, stocks, and tobacco warehouses | .50     | 1.00     | 1.50     |
| <i>Southern States, seaport cities.</i>                |         |          |          |
| All substantial buildings                              | .75     | 1.87½    | 3.00     |

From these rates it may be inferred that the hurricane risk on the southern coast is believed by the companies to be seven and one-half times as great as the tornado risk in the States where tornado insurance is generally purchased.

Fire insurance has been reduced to a scientific basis. So much can not be said of tornado insurance. The hazard in the latter is probably far less than the former, but is just as real. The tornado hazard varies in different localities, but

this variation could be determined as it has been in the case of fire. Great storms, such as the Louisville and St. Louis tornadoes and the Galveston hurricane, would overturn these calculations and embarrass some companies as the Boston, Chicago, and Baltimore fires did in fire insurance; the results, however, would be but temporary.

That the law of chances applies in tornadoes can not be doubted, since they are natural phenomena and are, therefore, apt to occur in any district with some degree of uniformity since the conditions which produce them are climatic. The popular belief that tornadoes are on the increase is unwarranted by any recorded observations.

The increase in the amount of destruction and the number reported is due to the increased settlement of the country. Prof. Cleveland Abbe, in 1884, 1888, and 1897, called attention to the fact that the popular idea of the destructiveness and frequency of these storms in some States has resulted, to a large extent, from the neglect to make proper allowance for the relative areas of the respective States and the tornado itself, and that the risk can only be deduced from a study of the frequency per unit area.\* He has computed a table (Table 4) showing the annual average frequency of tornadoes per unit area for the different States, based on the observations of sixteen years as compiled by Lieutenant Finley and Mr. A. J. Henry, and shows that even in the so-called tornado States the probability that any specific area the size of an average farm will be struck by a tornado is much less than one-sixteenth of one per cent per century, which is less than the probability that it will be devastated by fire or lightning. The table is repeated here in order to show how greatly exaggerated has been the fear of tornado destruction in certain States. It may be noted that unit areas (of 100 miles square) in Massachusetts, Maryland, or New Jersey have about the same percentage of destructive tornadoes per century as in Iowa, Kansas, or Illinois.

The tornado risk has some peculiar phases. The criminal hazard is wanting. Houses can neither be blown down for indemnity nor blown away through carelessness. The tornado path is limited in extent, being but a few yards to a half mile in width and a few miles in length. The tornado moves in an easterly direction, usually from southwest to northeast. There is, however, a tendency to a simultaneous appearance of several small tornadoes in the same region, moving along parallel lines. The tornado season is practically limited to the summer, 65 per cent occurring from April to August. The violence varies greatly in different regions, in different seasons, and in different parts of the same storm.

While it is true that no building will withstand the power of the wind in the vortex of a tornado, yet the side winds are of such varying strength that the degree of injury and therefore value of the risk depends largely on the material and construction of buildings. Among the risks prohibited by the conservative companies, are the following:

Thatched, frail, very old and dilapidated structures of all kinds.

Buildings on posts, or open at the bottom.

Buildings in course of construction, until roof, windows, and doors are all in place and secure.

Windmills, metal smokestacks, sheds, trees, and fences.

Awnings, signs, and large plate-glass windows.

Hay and grain in the stack.

Personal property in prohibited buildings.

Live stock, except when within insured buildings.

To these may be added many risks which are prohibited unless built with special care, such as buildings with towers, cupolas, and steeples; elevators; shaft houses; warehouses and hothouses.

\* See Smithsonian Report for 1888, pp. 403 and 420.

The fact that windmills are generally prohibited on account of the great hazard involved has caused the formation of wind-mill insurance companies in several States which insure wind-mills of substantial construction at the rate of one dollar per year.

TABLE 4. — Tornado frequency.

| States.                            | Area in units of 10,000 square miles. | Total number of tornadoes. |                   |                | Annual average. |                |
|------------------------------------|---------------------------------------|----------------------------|-------------------|----------------|-----------------|----------------|
|                                    |                                       | 1874-1881. Finley.         | 1889-1896. Henry. | Sixteen years. | Per State.      | Per unit area. |
| Alabama.....                       | 5.1                                   | 12                         | 18                | 25             | 1.56            | 0.30           |
| Alaska.....                        | 51.7                                  | 0                          | 0                 | 0              | 0.00            | 0.00           |
| Arizona.....                       | 11.4                                  | 2                          | 0                 | 2              | 0.12            | 0.01           |
| Arkansas.....                      | 5.2                                   | 8                          | 18                | 26             | 1.62            | 0.31           |
| California.....                    | 15.8                                  | 1                          | 0                 | 1              | 0.06            | 0.00           |
| Colorado.....                      | 10.4                                  | 1                          | 1                 | 2              | 0.12            | 0.01           |
| Connecticut.....                   | 0.5                                   | 2                          | 0                 | 2              | 0.12            | 0.24           |
| Delaware.....                      | 0.2                                   | 0                          | 0                 | 0              | 0.00            | 0.00           |
| District of Columbia.....          | 0.0                                   | 0                          | 0                 | 0              | 0.00            | 0.00           |
| Florida.....                       | 5.9                                   | 5                          | 1                 | 6              | 0.38            | 0.07           |
| Georgia.....                       | 5.8                                   | 29                         | 12                | 41             | 2.56            | 0.44           |
| Idaho.....                         | 8.6                                   | 0                          | 0                 | 0              | 0.00            | 0.00           |
| Illinois.....                      | 5.5                                   | 50                         | 29                | 79             | 4.94            | 0.90           |
| Indiana.....                       | 3.4                                   | 24                         | 7                 | 31             | 1.94            | 0.57           |
| Oklahoma and Indian Territory..... | 6.9                                   | 1                          | 13                | 14             | 0.88            | 0.13           |
| Iowa.....                          | 5.5                                   | 26                         | 28                | 54             | 3.38            | 0.61           |
| Kansas.....                        | 8.1                                   | 55                         | 47                | 102            | 6.38            | 0.79           |
| Kentucky.....                      | 3.8                                   | 5                          | 11                | 16             | 1.00            | 0.27           |
| Louisiana.....                     | 4.1                                   | 11                         | 7                 | 18             | 1.12            | 0.28           |
| Maine.....                         | 3.5                                   | 3                          | 3                 | 6              | 0.38            | 0.11           |
| Maryland.....                      | 1.1                                   | 8                          | 3                 | 11             | 0.69            | 0.63           |
| Massachusetts.....                 | 0.8                                   | 7                          | 1                 | 8              | 0.50            | 0.62           |
| Michigan.....                      | 5.6                                   | 13                         | 5                 | 18             | 1.12            | 0.20           |
| Minnesota.....                     | 8.4                                   | 21                         | 22                | 43             | 2.69            | 0.32           |
| Mississippi.....                   | 4.7                                   | 9                          | 15                | 24             | 1.50            | 0.32           |
| Missouri.....                      | 6.5                                   | 40                         | 16                | 56             | 3.50            | 0.54           |
| Montana.....                       | 14.4                                  | 1                          | 0                 | 1              | 0.06            | 0.00           |
| Nebraska.....                      | 7.6                                   | 14                         | 22                | 36             | 2.25            | 0.31           |
| Nevada.....                        | 11.2                                  | 1                          | 0                 | 1              | 0.06            | 0.00           |
| New Hampshire.....                 | 0.9                                   | 3                          | 0                 | 3              | 0.19            | 0.21           |
| New Jersey.....                    | 0.8                                   | 5                          | 8                 | 13             | 0.69            | 0.86           |
| New Mexico.....                    | 12.1                                  | 1                          | 0                 | 1              | 0.06            | 0.00           |
| New York.....                      | 4.7                                   | 20                         | 5                 | 25             | 1.56            | 0.33           |
| North Carolina.....                | 5.1                                   | 14                         | 2                 | 16             | 1.00            | 0.20           |
| North Dakota.....                  | 7.1                                   | 4                          | 2                 | 6              | 0.38            | 0.05           |
| Ohio.....                          | 4.0                                   | 21                         | 8                 | 29             | 1.81            | 0.45           |
| Oregon.....                        | 9.5                                   | 0                          | 0                 | 0              | 0.00            | 0.00           |
| Pennsylvania.....                  | 4.6                                   | 17                         | 13                | 30             | 1.88            | 0.41           |
| Rhode Island.....                  | 0.1                                   | 0                          | 0                 | 0              | 0.00            | 0.00           |
| South Carolina.....                | 3.4                                   | 13                         | 3                 | 16             | 1.00            | 0.30           |
| South Dakota.....                  | 7.7                                   | 5                          | 21                | 26             | 1.62            | 0.21           |
| Tennessee.....                     | 4.6                                   | 15                         | 10                | 25             | 1.56            | 0.34           |
| Texas.....                         | 27.4                                  | 18                         | 35                | 53             | 3.31            | 0.12           |
| Utah.....                          | 8.4                                   | 0                          | 0                 | 0              | 0.00            | 0.00           |
| Vermont.....                       | 1.0                                   | 2                          | 0                 | 2              | 0.12            | 0.12           |
| Virginia.....                      | 6.1                                   | 9                          | 2                 | 11             | 0.69            | 0.11           |
| Washington.....                    | 7.0                                   | 0                          | 0                 | 0              | 0.00            | 0.00           |
| West Virginia.....                 | 2.3                                   | 1                          | 0                 | 1              | 0.06            | 0.03           |
| Wisconsin.....                     | 5.3                                   | 11                         | 10                | 21             | 1.31            | 0.25           |
| Wyoming.....                       | 9.8                                   | 1                          | 0                 | 1              | 0.06            | 0.01           |

Most companies write policies only for one, three, and five years, limiting the amount on a single risk to \$5000. They also require the insured to maintain tornado insurance on the property to at least 50 per cent of its cash value. The minimum limit of damage adjustable for any single loss has now been generally abandoned.

The careful distribution of risks is an important factor in successful tornado insurance. Special rules are not generally necessary for large companies doing business over wide areas in several States, the law of chances being relied on to prevent great loss. The present system of State, county, and township tornado mutual insurance companies is, however, open to serious criticism since, as a rule, careful distribution is not strictly enforced. A single tornado is in such cases as destructive to the companies as to the property in its path.

THE LOCAL MUTUAL COMPANIES.

The local mutual tornado insurance companies so common in the States of the Middle West have been developed from the local fire mutuals from which many of them have never been distinctly separated. Their history is varied, and, in most cases, a sad one. For this there are several reasons. In some States they have in turn taken up hail insurance which is as far from being established on a scientific basis as tornado insurance was 25 years ago. Little or no regard has been paid to the distribution of the risks. The failure of a

large percentage of the members to pay their assessments, after receiving protection for the time agreed, has caused the failure of many companies and the embarrassment of more.

The Insurance Commissioner of Minnesota, in his report for 1904, says:

It is clearly evident in view of failure on the part of a large percentage of the members to pay their assessment fees, that the only practical course to be pursued in conducting this class of business is to require the payment of the full premium in cash or secured bankable notes upon the delivery of the policies. In other words, no company should assume a dollar of liability on account of losses through hail, cyclones, or other contingency, until the cash funds with which to pay the same have been actually collected from the members or policy holders.

This is now required by law in Minnesota.

Regarding the township mutual fire insurance companies, the same report says:

I have no hesitancy in stating, and without fear of contradiction, that no other class of business, whether that of insurance or any other line, is conducted so eminently successfully at such a very small cost. The average cost per \$100 of insurance on account of losses by fire during 1904 was 10 cents. The average cost of expenses was but 5 cents, making a total cost of but 15 cents per annum for fire insurance under this method.

This goes to show not only the success but the cheapness of local insurance companies under proper restrictions. Mutual tornado insurance can be made equally successful with the proper restrictions and precautions. The provision for the payment of the premiums in advance in order to secure an ample reserve fund is as necessary as in the case of the fire companies cited above.

The next precaution to be taken should be the careful selection of risks. Risks should be well scattered across the wind lines rather than along them, and for this purpose the system of land surveying common in the Western States is admirably adapted. But one risk should be taken on a single section.<sup>5</sup> A township is too small and compact to be regarded as proper territory by a single company. Ranges of townships, or of fractions of townships, in a north and south line are far better adapted to this purpose. County tornado insurance companies should not be permitted to exist since the storm lines are far too long in relation to the size of the area.

Even these rules place several risks in the same storm line,

<sup>5</sup> Note on the term "section" for the information of European readers:

The entire public domain of the United States is divided in accordance with a plan inaugurated in 1802 by Colonel Mansfield, then surveyor of the Northwestern Territory, into parts called *land districts*, each of which is put in charge of an official called a *surveyor general* who controls all the surveys in his district. In each district a meridian line is run, extending through the entire district, and from some point of this meridian an east and west line is run, which also extends through the district. These lines are determined astronomically, and when located serve as axes to which the subdivisions of the district are referred. Parallel to the axes, and on each side of them, other lines are run six miles apart, dividing the whole territory into squares, each containing 36 square miles. These squares are called *townships*. To take into account the obliquity of the meridians, suitable offsets are made in accordance with an established system. The townships lying between two consecutive meridians six miles apart constitute a *range*, and the ranges are numbered from the principal meridians both east and west. In each range the townships are numbered both north and south from the principal east and west line or *base line* as it is called. Thus, if a township lies twelve miles east of the principal meridian and eighteen miles north of the base line it is called township 3 north, range 2 east. Each township is divided by meridians and east and west lines into squares having a mile on each side. These are called *sections* and each contains 640 acres more or less. The sections of a township are numbered from the northeast corner, running along the northern tier of sections to No. 6, thence backward to No. 12, which lies exactly south of No. 1, and so on alternately running from right to left and from left to right to the southeasterly corner, which is No. 36. If the land is very valuable, the sections are divided into half sections by meridians and sometimes into quarter sections by lines running east and west, and these again into eighths by meridians. To designate one of these subdivisions, we say, for example, that it is the west half of the southwest quarter of section No. 16, township No. 7 north, range 3 west, and if necessary we add the name of the land district.—ED.

and should be still further limited in small local companies. A safe plan would be to place no more risks in positions such that all might be lost in a single tornado, than the company would be willing to carry as a single risk.

## CONCLUSIONS.

Tornado insurance is a legitimate form of insurance and is a valuable protection in large portions of the United States. It now properly covers loss or damage from other windstorms since the distinction is a technical and scientific one. The business can be conducted on such sound principles and at such reasonable rates that it shall bring a just profit to the companies and at the same time give valuable protection, without burden to the insured.

This end can only be attained by the establishment of the business on a scientific basis, such as that on which fire insurance now rests. This basis is being approached by the better companies, but the end may be sooner reached by the active cooperation of those interested in insurance and meteorology.

The meteorologists working on the well-founded theories of Ferrel and along the lines of statistical research so well begun by Finley, Hazen, Henry, and Abbe could determine the hazard and predict the losses for all portions of the United States, preferably by unit areas within State lines.

The insurance companies could, by a careful separation of the windstorm business from the other forms of insurance with which it is now confused, also determine the hazard and predict the losses in the territory in which they are working. They could in addition predict the expenses and adjust the premiums accordingly.

Cooperation in this line would bring about a more equitable adjustment of rates, a general reduction of the cost of windstorm insurance, and increased security to both the companies and their patrons.

The Census Bureau could render most valuable assistance to this very important branch of business by again taking up the compilation of statistics on insurance so unfortunately omitted by the Twelfth Census.

The departments of insurance in the individual States could render great service by requiring careful reports on all tornado business, by enforcing certain necessary restrictions on the companies incorporated or operating within their States, and by recommending such legislation as would secure for their people insurance at the lowest cost consistent with safety to the insured and just remuneration to the insurer.

## REFERENCES.

The following list of references will be found of value to anyone desiring to make a study of this subject. Those marked thus (\*) have been found of special value in the preparation of this report:

\* 1. Ferrel, Wm.; Cyclones, Tornadoes, and Waterspouts. Professional papers, United States Signal Service, No. XII, pp. 51-59. Washington, 1882.

\* 2. Ferrel, Wm.; Recent Advances in Meteorology. Report of the Chief Signal Officer, 1885, Part II, pp. 287-334. Washington, 1885.

\* 3. Davis, W. M.; Whirlwinds, Tornadoes, and Cyclones. In Science, Volumes II and III, 1883-4, and separately. Boston, 1884.

\* 4. Hazen, H. A.; The Tornado. Science, Vol. XV, and separately. New York, 1890.

\* 5. Finley, J. P.; Characteristics of Six Hundred Tornadoes. Professional paper, United States Signal Service, No. VII. Washington, 1884.

\* 6. Finley, J. P.; Tornado Studies for 1884. Professional Paper, United States Signal Service, No. XVI. Washington, 1885.

7. Finley, J. P.; The Special Characteristics of Tornadoes, with Practical Directions for the Protection of Life and Prop-

erty. United States Signal Service Notes, No. XII. Washington, 1884.

8. Finley, J. P.; Tornadoes. 12mo. New York, 1887. 196 pages.

\* 9. Finley, J. P.; State Tornado Charts. American Meteorological Journal, Vol. V, 1888, p. 466, etc.

10. Hinrichs, Dr. Gustavus; Tornadoes and Derechos. American Meteorological Journal, Vol. V, 1888-1889.

11. Henry, A. J.; Tornadoes. Monthly Weather Review, 1896.

\* 12. Abbe, Cleveland; Tornado Frequency per Unit Area. Annual Report of Smithsonian Institution, 1888, pp. 403-422. Monthly Weather Review, June, 1897, p. 250.

\* 13. The American Meteorological Journal, Ann Arbor, Mich.

\* 14. The Monthly Weather Review, United States Weather Bureau, Washington, D. C.

15. Fassig, O. L.; Bibliography of Meteorology, Part IV, Storms.

## NORWAY'S CONTRIBUTIONS TO THE NATURAL SCIENCES.

By R. S. N. SARTZ. Dated Weather Bureau, Washington, D. C., October 25, 1905.

Norway, the land of the midnight sun, with scarcely two million inhabitants, can well be proud of her contributions to the world's progress in the past hundred years.

That the traditions of the old Vikings should still be able to inspire a Nansen and a Sverdrup to brave the dangers and seek fame and adventure by exploring the regions around the North Pole, as did their ancestors of old, seems natural enough. That the grandeur and beauty of the natural scenery, the almost incredibly brilliant coloring of the arctic night, where the midnight sun gives way to a moon so bright that one can read the finest printed book by its light, where the aurora borealis seems only an incident in the brilliantly illuminated heavens, should stimulate the imagination and create poets of high order, is easy to understand. Ibsen, Bjornsen, Garborg, Kjelland, Lie,<sup>1</sup> and others are the high priests of the Arctic, as are Grieg, Svendsen, and others its singers. They set to words and music a nature so grand that it would seem strange indeed if works, thus inspired, should not compare favorably with the literature and music of the rest of the world. But in the realm of exact science we should not expect to find the little country represented on the ladder of progress, and even at the very top.

It is, however, a fact that Norway has the distinction of having produced the two greatest mathematicians of the nineteenth century. Nils Henrik Abel, who was born August 5, 1802, and died in 1829, held the helm in the beginning of the century, and Sophus Lie (born in 1842, died in 1898) has been recognized as the greatest mathematical genius at the end of the same century. Abel's discoveries in the realm of algebra and Lie's in that of geometry are known to the scientific world, and we need but mention them here. Among other distinguished Norwegian scientists, we recall the following:

Christoffer Hansteen (1784-1873), the first professor of applied mathematics and astronomy in the University of Christiania, was, in his day, one of the most famous scientists of Europe. He explored Siberia, located the north magnetic pole and founded the Observatory of Christiania, thereby opening the way for the introduction into Norway of the then new branches of science, magnetism and meteorology.

Ole Jakob Broch (1818-1882), professor of pure mathematics in the University of Christiania, had a world-wide reputation in science, and was also a noted statesman and political economist. He was for many years a member of the Storting (the Norwegian congress), and served a few years as secretary of the treasury. He was Norway's delegate to the International Monetary Conference at Paris, 1871, and made one of the best

<sup>1</sup> Pronounced "Lee."