

Drouths In Indiana

STEPHEN S. VISHER, Indiana University

Although Indiana is relatively fortunate as compared with most of the world in its rainfall dependability, and seldom has prolonged severe drouths, nevertheless local deficiencies of rainfall occur for at least short periods nearly every year. As part of a comprehensive study of the climate of the State, studies have been made of the frequency and intensity of drouths, and of their regional contrasts within the state. Part of this investigation was aided by a research grant from the Academy made in 1940.

Drouths in Indiana are of three chief types: those due to a) little precipitation, b) exceptionally great water requirement at a time when only a moderate amount is available, and c) a poor distribution of precipitation. The first of these types usually occurs whenever less than about half of the normal amount of precipitation falls during any months or season. The second type occurs, despite what in cool weather would have been a moderate amount of rainfall, whenever excessive evaporation is induced by exceptionally high temperatures for some weeks, or when there are hot drying winds. The third type of drouth occurs when, despite a normal monthly or seasonal total of rain, it falls torrentially at long intervals with much of it running away from sloping land. For example, a summer rainfall of two inches a month is not adequate to prevent a drouth on hillsides in Indiana if the four inches received in two successive summer months occur as "cloud bursts" at the beginning of the first month and the end of the second, with no rain at all for nearly two months between these rains.

Drouths occur in all parts of Indiana but there is considerable regional contrast in frequency and severity. Evidence of this is given in some detail beyond, but here a summary is desirable. Southern Indiana has more summer drouths than central Indiana. This is partly because it occasionally has more prolonged dry spells, and partly because there is more runoff from torrential rains, as a result of greater physiographic relief and a less absorbant average soil. The normal soil of southern Indiana is a poorer absorbant of hard rainfall than is that of central Indiana for two chief reasons. One is that much of southern Indiana was never glaciated and the rest was glaciated relatively long ago, since which time the soil has been much modified and no longer is a typical glacial soil. The other reason is that because of the much greater and more often torrential winter rainfall in southern than in northern Indiana, more of the top soil has been removed from sloping land by erosion. The top soil usually is a much more absorbing layer than is the subsoil.

Dry spells occur rather frequently in winter in northwestern Indiana, but aside from facilitating wind erosion of sandy soil and reducing domestic water supplies by lowering the water levels in

wells and streams, they do relatively little damage to agriculture. Indirectly they have in one respect aided agriculture by helping make much of that section a prairie region rather than a forested one. The drouths would, however, interfere with extensive industrial development except where water is readily available, as from Lake Michigan.

A third regional contrast in drouth in Indiana is an appreciably greater frequency of drouth in the western third of the state than in the eastern third. This is due partly because the average precipitation is less in the western third than in the eastern third; partly because drying winds from the drier west reach western Indiana relatively more often; third, because the western third of the state has a higher summer temperature, associated with its lower altitude and its position nearer the center of the continent, which warms up more in summer than does the eastern, higher, more humid region.

Exceptionally Dry Years

If a major drouth occurs whenever the annual precipitation is less than 85 per cent of normal, between 1880 and 1941 there have been seven drouths: 1894, 1895, 1901, 1914, 1930, 1934, and 1936. The deficiencies of precipitation for the average of the State were 9.7 inches in both 1930 and 1934, 8.9 inches in 1901, 8.4 inches in 1895, 7.9 inches in 1914, and 7.2 inches in 1894. The deficiency was only 5.6 inches in 1936, almost the worst year so far as crop damage is concerned, because of the very hot dry summer. The relatively large annual total of precipitation in 1936 was largely due to abundant rains near the beginning and end of the year.

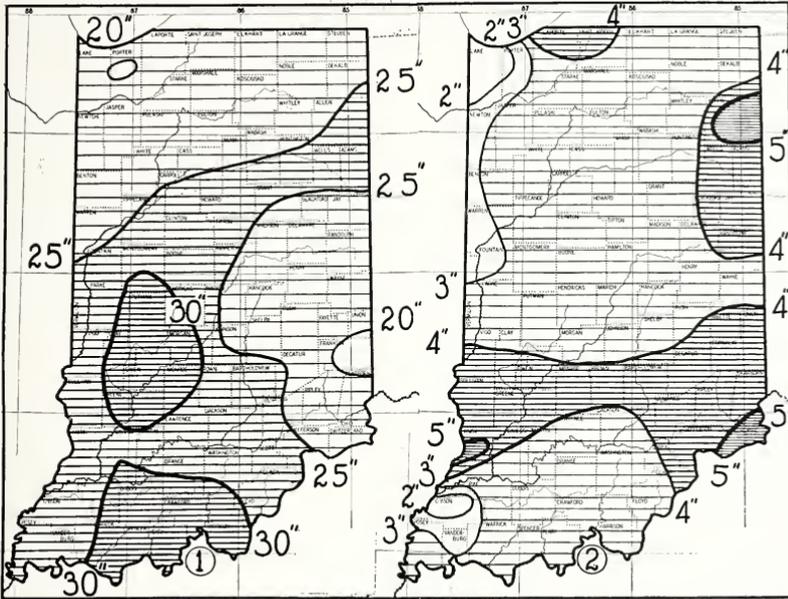
The two driest years (1930 and 1934) had state averages of 29.7 inches of precipitation, instead of the normal average of about 39 inches. They thus had about three-fourths the normal total. In almost half of the State, the driest year of record received less than 25 inches; two small areas have received less than 19 inches (Valparaiso, 18.1 in 1899; Brookville, 18.7 in 1934).

In the two worst drouth years, southern Indiana fared much worse than northern Indiana. In 1930 a zone bordering the Ohio River had a deficiency of rainfall (below the normal total received) totaling from 13 to 18 inches. Thus that zone received only about two-thirds of the normal total. In 1934, parts of south-central and southeastern Indiana had deficiencies of 20 to 23 inches; thus those areas received little more than half of the normal total. Figure 1 shows the precipitation in the driest year of record (not the same year everywhere).

Exceptionally Dry Seasons

A series of graphs have been prepared of the fluctuations in rainfall 1913-1939 for the northern, central, and southern thirds of the State, and for the state as a whole, and also for each of the four chief seasons and for the year as a whole. They reveal that the driest springs for the State as a whole were those of 1934, 1930, 1925, and 1914. In southern Indiana, 1914, 1925, 1930, and 1934 had exceptionally dry springs. Northern Indiana's driest springs were those of 1915, 1925,

1928, and 1934. Three consecutive springs, those of 1930, 1931, and 1932 were dry, and after a wet spring in 1933, 1934 was the driest for the 27 years studied. The driest summers of 1913-1939 in Indiana were those of 1936, 1930, 1933, 1922, 1913, in order of decreasing dryness. Dry autumns occurred in 1914, 1922-1924, 1938, and 1939 (the driest of that period). Northern Indiana had exceptionally dry autumns in 1914 and 1924, and southern Indiana, in 1929, 1935, and 1939. Of the winters, those of 1919, 1936 and 1938 were exceptionally dry (state average). The driest winters for northern Indiana were 1917, 1919, 1925, 1931, 1935, and 1936; for southern Indiana the driest winters were 1936 and 1925.



Figs. 1-2: Least Annual and Least Summer Precipitation ever officially recorded.

Regional contrasts in the frequency and severity of summer droughts are shown by various maps some of which are not here reproduced. Figure 2 shows that in the driest summer of record, a total of only from 3 to 4 inches was received in most of the State; three western stations received less than 2 inches. The largest totals (5.3, 5.5, and 5.6 inches) were received near the eastern margin of the State and at Vincennes.

Any summer month in Indiana which receives less than 1.5 inches of rainfall is distinctly dry. On this basis, the southern third of Indiana has more summer droughts than does Central Indiana, parts of it nearly twice as many. An area in south-central Indiana receives in one-ninth of the years, less than half of the normal summer rainfall. Figure 3 shows, however, that such dry summers are less than half as common in eastern as in western Indiana.

Dry Months

In April most of the State receives in the driest one-fifth of the years between 2 and 2.5 inches. The driest areas are in the north and the wettest in the south. In a dry May the total received is approximately 2.5 inches, least at the southwest, most in the northeast. In a relatively dry June the total for most of the State is close to 2 inches, with part of the southeast and extreme south receiving 2.5 inches. In a relatively dry July likewise, the total received is approximately 2 inches, with the driest areas situated in the southwestern quarter. Parts of Southern Indiana receive less than 1.5 inches during one-fifth of the Julys. For August, most of the State receives about 1.9 inches, with the least falling at the northwest and southwest. For September, the total is approximately 1.7 inches, with least in the southeast and the largest area of over 1.8 situated in the north. For October, also, the southeast receives least; central Indiana gets close to 1.4 inches.

The percentages of each of the months April-September which have received less than 1.5 inches of rainfall reveals an interesting increase month by month in the average percentage of such dry months. May (the wettest month in the year for the average of southern Indiana) has been a dry month a relatively large percentage of the time. June displays considerably less regional contrast than most of the months. During June, for most of Indiana, only one year in about fifteen receives less than an inch and a half of rain. Along the eastern border of the State only one year in twenty, on the average, is this dry in June, while on the western border approximately one June in ten receives 1.5 inches or less.

July is a more critical month than is June for Indiana farmers, because the yield of corn depends to no small degree upon July rainfall. July is also warmer than June, and hence water shortage is more serious. Moreover soil moisture, which normally accumulates in the winter and spring, is partly depleted by July. Indianapolis and most of the southwest quarter of the State receive in July less than 1.5 inches of rainfall during one-fifth of the Julys. A large part of the northern half of the State suffers from such drouths distinctly less frequently on the average than does the southern half.

The Driest Months of Record

Nearly all parts of the State have had during their driest June less than one inch of rain instead of the State average of nearly four inches. Stations which have had about one inch of rain in their driest June are Indianapolis, Vincennes, Vevay, Muncie, and South Bend. Cities which have had only half an inch in their driest Junes are Richmond, Bloomington, and Evansville; those which had less than one-fourth inch (the equivalent of only a moderate shower) during June include Fort Wayne, Madison, and Kokomo. Record dry Junes of less than one-tenth of an inch have been experienced at Terre Haute, Greencastle, and Princeton.

The driest Julys on record are decidedly dry. Almost all Indiana cities have had a July with as little as a half inch of rain. The chief

exceptions are in the northeastern corner, where about one inch fell in the driest July. Cities which during their driest July have received less than one-fourth inch of rainfall include Gary, Vincennes, Evansville, and Richmond.

August is somewhat less subject to extreme drouths than is July. Most of the Indiana Weather Bureau stations have recorded more than half an inch of rainfall in their driest August, and many of them have had about an inch. (For Indianapolis, the driest July and the driest August each received four-tenths of an inch.) The least rainfall recorded in any August was in three corners of the State: At Vevay, at the southeast, less than 0.1 inch; at Mt. Vernon, at the southwest, less than 0.14 inch; at Valparaiso, at the northwest, less than 0.25. Shelbyville and Connersville have also had an August with less than a quarter-inch.

The dates of the driest 3 of each of the 12 months have sufficient interest to justify their inclusion. The driest is given first, the least dry, third.

January 1925, 1931, 1919; February 1907, 1895, 1934; March 1910, 1915, 1937; April 1889, 1915, 1899; May 1934, 1925, 1932; June 1933, 1936, 1922; July 1901, 1894, 1936; August 1889, 1893, 1897; September 1897, 1908, 1939; October 1908, 1924, 1934; November 1904, 1917, 1914; December 1925, 1930, 1913.

Of these 36 exceptionally dry months during 1887-1939, 5 of them received a state average of less than half an inch of rain. Four of these were during 1904-1910 (Feb., Mar., Oct., Nov.) and the other in October 1924. Thus, although several months of 1930-1936 are included among the 36 driest months of these 53 years (636 months), and parts of the state had little rain, the state as a whole was less dry in any month than it was in the worst months of 1901-1910. (3 months of 1934 are among the 36 driest of record, 2 of 1936, but 1925 also had 3, and 1889, 1897, 1904, 1915 each had 2.)

Driest Groups of Months

May and June combined have been driest in southern Indiana, with a total rainfall of less than 2 inches. In the driest consecutive June and July, a total of less than an inch has been received in parts of northwestern and southeastern Indiana. In the driest July and August combined, three areas have received less than 1.5 inches, two in the south and one in the northwest.

In nine-tenths of the May-June and June-Julys, fully twice as much rain is received as in the very driest such pairs. In the drier one-tenth of the years, fully an inch more rainfall is received in eastern than western Indiana. July-August display less regional contrast, most of the State receiving between 3 and 3.5 inches.

In the driest one-tenth of the years a summer total of only 5.5-6.0 inches is received in most of Indiana; the corresponding data for the summer plus May is between 8 and 9 inches (fifty per cent greater). All four of these months are seldom dry in Indiana. For the driest summer and May combined, the totals for most of the State are between

6 and 7 inches; the largest area which received less than 6 inches was situated in the south. The driest pairs of months of 1888-1939 for the state as a whole were March-April, 1915, and August-September, 1897.

Percentages of the Warmer Months Receiving Less than Half the Normal Rainfall

Western Indiana is distinctly less fortunate than eastern Indiana with respect to this type of drouth. For May-June the longitudinal contrast or range averages about 50 per cent; for June-July it averages fully 75 per cent; and for July-August it is more than 100 per cent. Hence such dry July-Augusts are twice as frequent in western as in eastern Indiana. Thus while exceptionally severe drouths affect eastern Indiana somewhat less severely than they do the western counties, of the less severe drouths, eastern Indiana has a notably larger advantage, as it has far fewer lesser drouths than western Indiana. For the summer-plus-May, there is an average increase from the northeast to the southwest in the percentage of the years receiving less than half of the normal rainfall. Such drouths are more than twice as frequent for the average of the State's southwestern quarter as in the northeastern.

Length of Periods with Little or No Rainfall

Drouth-frequency-studies based on the year, season, or calendar month are inadequate because of the arbitrary limits of these periods. A harmful period of inadequate rainfall may be divided between two months, each of which had a normal total rainfall. Hence a study was made of the daily rainfall records of eight Indiana stations for the summer months of 22 years, 1914-1936. Three levels of rainfall deficiency were noted: the consecutive number of days 1) on which less than 0.1 inch fell, 2) on which as much as 0.25 did not fall in one day or 0.4 in two days, and 3) on which 0.5 inch of rain did not fall in one day or 0.6 in two days. The first of these limits means, during the summer, practically a rainless period so far as crops are concerned, although a rainfall of 0.1 inch may help grass somewhat. The second limit was chosen as a result of studies at the agricultural experiment station at Madison, Wisconsin, which indicate that as much as a quarter inch in one day or 0.4 inch in two days usually is necessary during a drouth to greatly help the corn crop. The limit of half an inch in a day or 0.6 in two days was selected because such a rain nearly always affords a real break in a dry spell. The stations chosen for study are rather well distributed over the State.

The following statements summarize the average number of times per summer that various sorts of dry periods occurred, based on the records for 22 summers at these eight stations.

About five or six times during an average summer a period of five consecutive days pass without as much as one-tenth inch of rain falling in any one day; about twice each average summer there are periods of ten consecutive days with that little rain; about once each average summer there are 15 such days. Twenty consecutive days with this small amount of rainfall occur only in about a third of the summers.

Thirty consecutive days of this type were not experienced at four of the eight stations; Indianapolis, however, had two such thirty day periods and Collegeville four. In the summer of greatest drouth of 1914-1936 (partly different summers at different stations) two such twenty-day dry periods occurred, four ten-day periods and seven to nine five-day periods. The greatest total number of consecutive days with no more than one-tenth inch of rain on any one day was 38 at Indianapolis, 35 at Collegeville; the least was 25 at Ft. Wayne. In the summer which had the fewest intervals without a tenth of an inch of rainfall, there were two or three four-day intervals and at three of the eight stations, one ten-day period.

Rainfall of a quarter inch in one day or 0.4 in two consecutive days are next considered. The average number of times in three summer months that five or more days passed with so little rain was between five and six. Ten-day periods of this type occurred an average of about three times a summer, fifteen-day periods occur in about two-thirds of the summers; twenty-day periods occur in about half the summers. In the 22 summers, there were an average total of nearly four

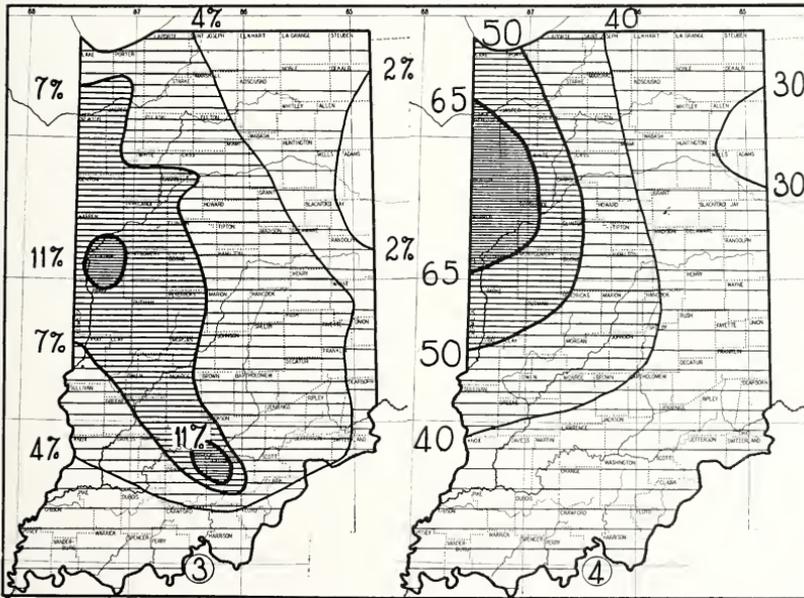


Fig. 3: Percent of Summers Having Less than Half the Normal Rainfall.

Fig. 4: Length of Summer Dry Spells. Greatest number of consecutive days without $\frac{1}{4}$ inch of rain (or 0.4 inch in 2 consecutive days).

spells of 30 consecutive days of this type. The maximum number of times per summer that five consecutive days of this type occurred was eight, the least number was three; the maximum number of ten consecutive days of this sort was five; the minimum was one or two; of

fifteen-day intervals, the maximum number was three, the minimum was zero; the maximum for twenty-day periods was two, the minimum was zero. The greatest number of consecutive summer days of 1914-1930 which did not have a quarter inch rain on any one day vary from thirty at Ft. Wayne to 65 at Lafayette and Collegeville. (Fig. 4)

Rainfalls of a half inch in a day or 0.6 in two days are not much less common in dry summers than are falls of a quarter inch. This is because dry spells usually are terminated by powerful thunderstorms most of which yield at least a half an inch of rain. In the average summer there are about three ten-day spells without a half inch rain; about two fifteen-day spells, and an average of more than one twenty-day spell. Thirty-day spells of this type occur in almost half of the years. The maximum number of consecutive days without a half inch rain varied in the 22 years from 42 to 92.

Another Study of Drouth Expectancies

A study by the U. S. Soil Conservation Service of drouth expectancies in the United States included three Indiana stations, Delphi, at the northwest, Greencastle, at the west-central, and Madison, at the southeast. From data of numerous stations scattered over the nation a series of seasonal maps were prepared. The Indiana parts of these maps may appropriately be described. This is especially appropriate as the detailed study summarized in the preceding paragraphs dealt only with the summer while the study now to be summarized includes each of the seasons.

These maps reveal that Indiana is comparatively free from prolonged drouths, if a drouth is defined as a period during which for more than ten consecutive days the total precipitation is less than one-tenth of an inch on any two consecutive days.

During each normal Indiana spring there is one period of about two weeks in duration without this much rain; in one spring out of five, such a drouth lasts about 2½ weeks, except in an area near the south end of Lake Michigan where it lasts about three weeks.

In the driest spring in an average decade, a spring drouth as here defined prevails for three to four weeks, except in the north-eastern one-eighth of the State, which has a drouth for somewhat less than three weeks.

During each average summer in Indiana an almost rainless period of about two weeks' duration is to be expected in all parts of the State. Once in five years, a three-week drouth occurs, while once in a decade, a summer period of about four weeks occurs during which almost no rain falls.

Normally every autumn all of Indiana has a drouth lasting for about two weeks. Once in five years, the autumn drouth lasts for three to four weeks. Once in a decade it lasts for about thirty days except just east of the south end of Lake Michigan and also in the southeastern corner of the State where its duration is slightly less than thirty days.

During every normal winter all parts of Indiana have a drouth as here defined of about two weeks' duration. Once in five winters, three to four consecutive weeks without appreciable precipitation occur, except at the southwest where the rainless period is somewhat less than three weeks long. In the driest winter of a normal decade all of Indiana has about four consecutive weeks with little or no precipitation.

In other words, during each quarter of each normal year, there is a period of about two weeks in length with very little rainfall, once in five years the drouth period extends to about three weeks, and during the driest year of a decade, drouth prevails for about a month, or a third of the length of each quarter-year, except in spring when the maximum duration is somewhat less than four weeks. Once in twenty years, the study summarized in the previous section of this paper shows, there are periods of little rainfall which are appreciably more protracted than are the longest such periods of a normal decade.

Growing-Season Precipitation Effectiveness Contrasts

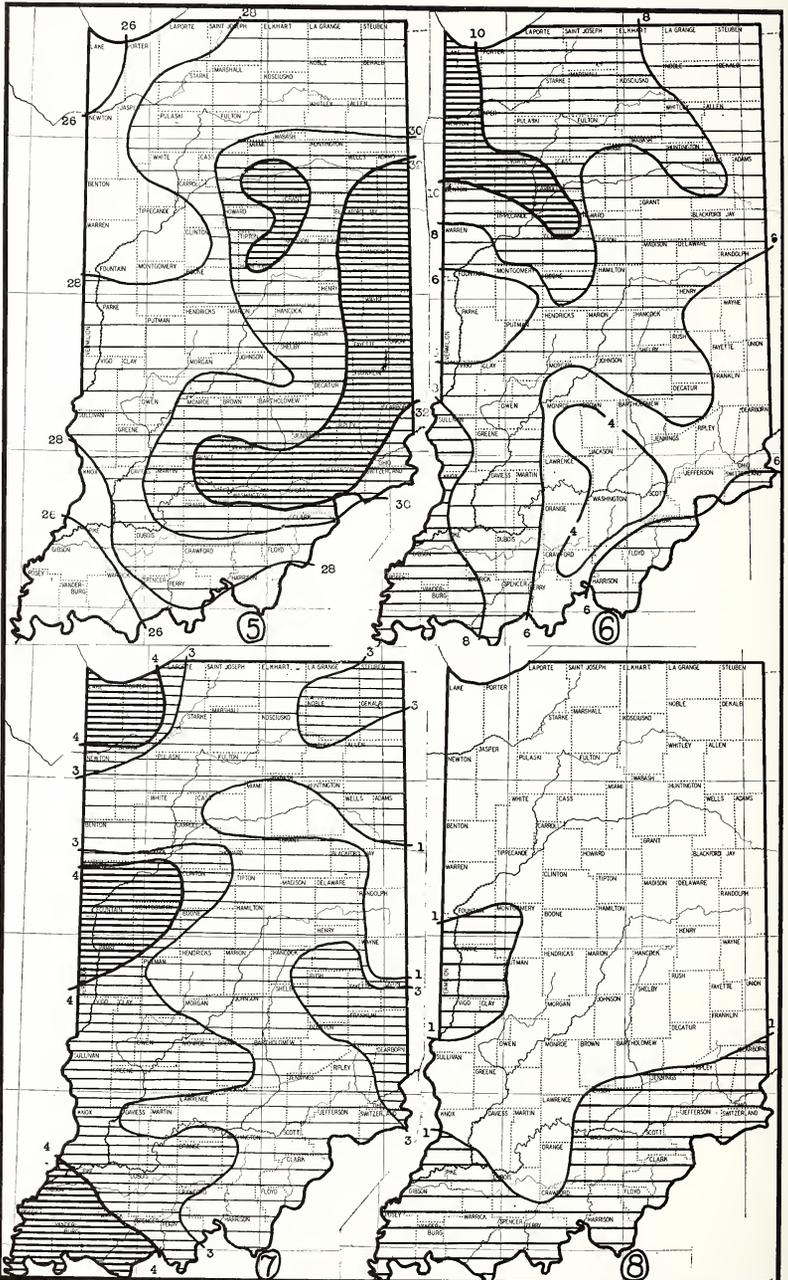
The Atlas of Climatic Types of the United States 1900-1939 was issued in 1942 by the Soil Conservation Service of the U. S. Department of Agriculture. A series of 40 maps for the growing season (March through August) shows the areas which, in each of the 40 years, were arid, semiarid, subhumid, and humid. Results of a detailed study of the Indiana parts of those maps by the present writer may advantageously be summarized.

The accompanying 4 maps were made by combining the relevant data of each of the 40 maps. Map 5 shows that for the eastern part of the State, about four-fifths of the crop-growing seasons are moist enough to be classed as humid. Along the western border of the State, however, only about two-thirds of the crop seasons are humid. In the southwestern and northwestern corners of the State, only about 26 of the 40 years studied were humid.

Map 6 shows the number of crop seasons which were moist subhumid, the type next drier than humid. This map shows that this type is most frequent at the northwest, where about a fifth of the crop seasons are moist subhumid; such seasons are less common at the southeast, occurring in less than a sixth of the years.

Map 7 shows that in the western part of the State, about a tenth of the crop seasons are dry enough to be classed as dry subhumid. Midway between the eastern and western margins of the State, only about two seasons in 40 were this dry. Most of the southern half of the State had about 3 such seasons while much of the northern half of the State had only one or two which were that dry.

Although the crop seasons of 1934, 1936, 1941 and various other years were locally dry enough during parts of the season to seriously damage the corn crop, the crop-season as a whole was driest in 1930. Then a wide belt along the Ohio River and also a section including Vermillion, Parke, and parts of the adjacent counties (see Map 8) were dry enough to be classed as semiarid, a rainfall condition characteristic of the short-grass plains of western Kansas and Montana.



Figs. 5-8: Climatic Type Prevailing During The Crop-Growing Season (March-August). Times per 40 years (1900-1939) that each type prevailed: Fig. 5, Humid; 6, Moist Subhumid; 7, Dry Subhumid; 8, Semiarid.

The most favored part of the state so far as rareness of relatively dry crop-seasons, according to the data analyzed on these maps, is the northeastern central part of the State. The least favored areas are the southwest and northwest corners, and an area along the western margin about midway between these corners. The counties bordering the Ohio River are apparently most likely to be exceptionally dry in summer.

The prospects, therefore, that any crop-growing season will be normally moist are about three to one in most of the State; they are four to one near the eastern margin. The chance that it will be moderately dry (dry subhumid) are only about one in ten; that it will be decidedly dry (semiarid) are less than 1 in 40 in most of the State, except the southern counties and part of the western margin of the State. The chance that the crop-growing season will be somewhat drier than normal (moist subhumid instead of humid, which is the normal condition) is about one in five in the southwestern and in most of the northwestern quarter; in part of the latter area, however, the chances of a moist subhumid condition rather than a humid one are about one in four. The chances of such moisture conditions are about one in seven in much of eastern Indiana, where several counties in the belt extending from Wayne (Richmond) to Crawford counties have only about one chance in eight or ten of having a moist subhumid growing season. In other words, a moist subhumid growing season occurs only about half as frequently in the southeastern part of the State as in the northwestern.*

* In addition to a grant from the Academy, this study was aided by help supplied by the National Youth Administration and by a grant from the Graduate School Research Fund of Indiana University.