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FURTHER NOTES ON SOME CLIMATIC CONDITIONS OF OHIO.

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An attempt was made in a former article* to present in brief form some of the conclusions reached in a study of the climatic conditions of Ohio from an ecological point of view. Further work along this line has shown that a more extended compilation of data is very desirable, if not actually necessary, in anything approaching a comprehensive study of Ohio climate as an ecological factor.

So, in order to get a better basis for study, data were compiled relative to (*a*) wind velocity and direction, (*b*) relative humidity, and (*c*) average date of first and last killing frost of the season.

WIND,—DIRECTION AND VELOCITY.

Plate 12. Map IX.

In attempting to derive as accurate general averages as possible, use was made of records as taken by self-registering instruments of the U. S. Weather Bureau stations at Cincinnati, Columbus, Cleveland, Toledo, Sandusky and Pittsburg. These records extend back to 1892, thus giving readings of ten consecutive years.

As generally supposed the prevailing direction of the wind in Ohio is south-west. The direction in the region of Cincinnati seems to be very uncertain ; it is given on our map as south-west based on averages reported by the U. S. Weather Bureau in 1896 for a period previous to that date, but for the period 1892 to 1902

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the prevailing direction has been south-east, so that there is no very decisive evidence in favor of any particular direction. Cleveland shows a prevailing south-east wind, but Pittsburg is decidedly a station of north-west winds.

For most of the stations the windiest month of the year is March, and the calmest month August, although Cleveland's highest winds are in November. In the course of the year there are some interesting variations in wind direction at some of the stations, as the table below will show. At the three lake stations the wind seems to show during the earlier part of the year a tendency to veer to a more westerly direction than is taken during the later months.

WIND, DIRECTION AND VELOCITY.

Stations.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean for the year.
Cincinnati ..	Prevailing direction,	s w	n w	n w	s e	n w	s e	s w	n e	s e	s e	s e	s e	s e
	Miles per hour.....	8.7	9.2	9.3	8.4	7.1	6.3	6.4	5.7	6 2	6.4	8.2	8.3	7.5
Columbus ...	Prevailing direction,	s w	w	w	n w	s w	s w	s w	s w	n w	s e	s w	s w	s w
	Miles per hour.....	9.0	9 8	9.9	9.2	7.5	6.9	6.5	6.0	6.6	7.1	8.6	9.8	8.1
Cleveland ...	Prevailing direction,	s w	s w	w	s e	s e	s e	s e	s e	s e	s e	s e	s w	s e
	Miles per hour.....	15.6	15.4	15.2	13.4	12.5	11.0	10 9	10.6	13 0	14.1	16.8	16·1	13.7
Toledo	Prevailing direction,	w	w	w	n w	w	w	s w	s w	s w	s w	s w	s w	s w
	Miles per hour.....	11.1	11.4	11 6	11.4	9.8	8.3	8.7	7.7	8.7	9.3	11.1	10.9	10.0
Pittsburg....	Prevailing direction,	n w	n w	n w	n w	n w	n w	n w	n w	n w	n w	n w	n w	n w
	Miles per hour.....	7.6	7.9	7.6	6.9	6.0	5.6	5.2	4 8	5.5	6 7	7.1	7.1	6.5
Sandusky ...	Prevailing direction,	s w	w	s w	e	s w	s w	s w	n e	s w	s w	s w	s w	s w
	Miles per hour.....	9.4	9.7	10.3	9 4	8.6	7.4	7.2	6.9	7.6	7 8	9.8	9.3	8.6

KILLING FROST,—DATE OF FIRST AND LAST.

The date of the last killing frost in the spring and the first one in the fall, is perhaps to be ranked as one of the most determinative factors in ecology, since upon it depends in a measure the length of the growing season.

The data used in this compilation cover a period of ten years for most of the stations, although many of these have only partial records for the earlier years. Records from twenty-eight stations throughout the State were used, but the results are so conflicting that only a few general conclusions can now be stated.

In a general way the immediate Ohio valley shows a longer growing season than the central part of the State, but about the same length of season as the region immediately adjoining the lake. Sandusky, with a growing season of 201 days, and Marietta, with 186 days, stand at one extreme, while Hillhouse (Lake county), with 131 days, and Bowling Green and Defiance, each with 141 days, stand at the other extreme.

FIRST AND LAST KILLING FROST.

STATIONS.	Last Killing Frost in Spring.	First Killing Frost in Fall.	No. Days in Growing Season.	STATIONS.	Last Killing Frost in Spring.	First Killing Frost in Fall.	No. Days in Growing Season.
Akron	Apr. 23	Oct. 7	167	Greenville	Apr. 24	Oct. 8	167
Ashland	Apr. 27	Oct. 9	165	Hillhouse	May 18	Sept. 26	131
Ashtabula	Apr. 23	Oct. 10	170	Marietta	Apr. 16	Oct. 19	186
Bowling Green	May 7	Sept. 25	141	Milligan	May 5	Sept. 25	144
Canton	Apr. 25	Sept. 30	158	Montpelier	Apr. 28	Sept. 25	151
Cincinnati	Apr. 14	Oct. 18	187	New Alexandria	Apr. 27	Oct. 9	165
Clarksville	Apr. 20	Oct. 2	165	Norwalk	May 9	Oct. 2	146
Cleveland	Apr. 21	Oct. 21	183	Pomeroy	Apr. 19	Oct. 5	169
Columbus	Apr. 18	Sept. 21	156	Portsmouth	Apr. 16	Oct. 11	178
Dayton	Apr. 21	Oct. 8	170	Sandusky	Apr. 11	Oct. 29	201
Defiance	May 5	Sept. 23	141	Tiffin	Apr. 28	Sept. 18	143
Elyria	Apr. 24	Oct. 8	167	Toledo	Apr. 18	Oct. 13	178
Findlay	Apr. 30	Sept. 30	153	Van Wert	Apr. 27	Oct. 2	158
Granville	Apr. 21	Oct. 1	163	Wooster	May 5	Sept. 29	147

RELATIVE HUMIDITY.

Plate 12. Maps X, XI and XII.

By the term relative humidity, is meant the relation (ratio) of the amount of moisture actually present in the air—at any given conditions of temperature and pressure—to the amount of moisture necessary to produce saturation under the given conditions. This ratio is usually expressed as a percentage. This is not to be confused with the *absolute* humidity, which is simply a statement of the amount of water present without reference to the saturation point, and is usually expressed as so much weight or volume per unit of air.

The observations for relative humidity are taken at a few scattered stations only as compared to many other phases of the weather, and so the stations are farther apart than desirable for close work. The daily averages are derived from observations taken at 8 A. M. and 8 P. M. seventy-fifth meridian time, and inasmuch as the relative humidity depends to a large extent upon the temperature of the air, it is evident that the relative humidity during the warmer hours of midday may be an altogether different thing than the averages given would indicate. The averages as derived from Ohio conditions probably fall short of giving the actual contrast between the Lake Erie stations and those in more central or southern portions of the State, so that it perhaps devolves upon us to make the most possible of any differences apparent.

Just to what extent we must reckon with relative humidity as an ecological factor is pretty difficult to determine. In the case of plants it must be of some ecological importance even in winter. If the soil about the roots of some of the trees exposing much surface to the air—as the evergreens—be frozen or so cold that

root action is practically nothing, then evaporation into an air of low relative humidity may take place to such an extent as to prove injurious. No water is taken by the roots from the soil to take the place of that evaporated. During the growing season the effect of a low relative humidity, as in case of hot, dry winds, is too well known to need further comment.

The relative humidity of the Northern and Western United States is from five to ten per cent. higher in winter than in summer, but in the Gulf States and lower Atlantic States conditions are fairly constant the year through. The highest relative humidity is to be found along the northern Pacific coast and to the east and southeast of Lake Superior. The westerly air currents rising from the Pacific to the crest of the mountains are considerably cooled and saturation is produced to such an extent that much of the moisture is precipitated and never gets over the mountains. In this manner a high relative humidity is brought about along the coast.

In the case of the Great Lakes we have another factor in operation. The westerly air currents in drifting across the waters are often considerably cooled and also take up more or less moisture, so that a region of high relative humidity must result east of the lakes.

Ohio presents some rather peculiar conditions with respect to humidity. As may be seen in the plate, the January map shows a streak coming down from the northwest and traversing the State diagonally in which the relative humidity is above eighty per cent. The air in that streak is just as "moist" as the air of Florida. From Map II of the January article referred to it may be seen that this streak includes that part of the State having the least total annual precipitation, and only a small part of those sections of the State having the greatest annual precipitation. The total annual precipitation and the relative humidity appear to have no connection whatever.

Turning again to the January article, Map VII shows that during winter the least average minimum temperatures occur in the northwestern and central portions of the State, and are central in the region of high relative humidity. The inference to be drawn is that the higher relative humidity results from the lower temperature. It is not readily apparent, however, why this region should have its longer direction at right angles to the prevailingly southwestern direction of the winds, but perhaps this may be due in some measure to the difference in temperature of winds from different directions. The general direction of storms in our region is from west to east. Around the areas of low barometric pressure, usually the warm stormy areas, the winds revolve in a counter-clockwise direction, while around areas of high barometric pressure, those of clear cold weather, the revolution of the wind is in

the same direction as that of the hands of a clock. Thus the winds in advance of a "Low," as the low-pressure areas are termed, are warmer, and with us in Ohio usually southerly or southwesterly, while the winds in advance of the high-pressure area following the rainy "Low" are from the north or northwest and colder. It is probably due to such cold northwest winds blowing over a region left moist and warm by the preceding storm that the areas of low temperatures can be traced in a northwest to southeast direction, and so likewise the area of high relative humidity, if determined indirectly by the same cause, would follow the same direction.

In July, which we may take as being about the middle of the growing season, Ohio again presents some interesting problems in connection with its relative humidity. The main body of the State has an average of between sixty-five and seventy per cent. (Map XI). The highest per cent. is in the southeast, while in the western part, and extending over southern Indiana as well, is a section with a relative humidity for July of less than sixty-five per cent. For July this is the driest region in the United States east of Kansas or Nebraska. The region is not in the right position, with prevailing southwest winds, to derive any benefit from the Great Lakes, and the atmosphere is apparently pretty well dried out after its passage over the broad, level region to the west.

The following tables were taken from the Report of the Chief of the U. S. Weather Bureau, 1901-1902, and include the period 1888 to 1901:

MONTHLY AND ANNUAL MEAN RELATIVE HUMIDITY.

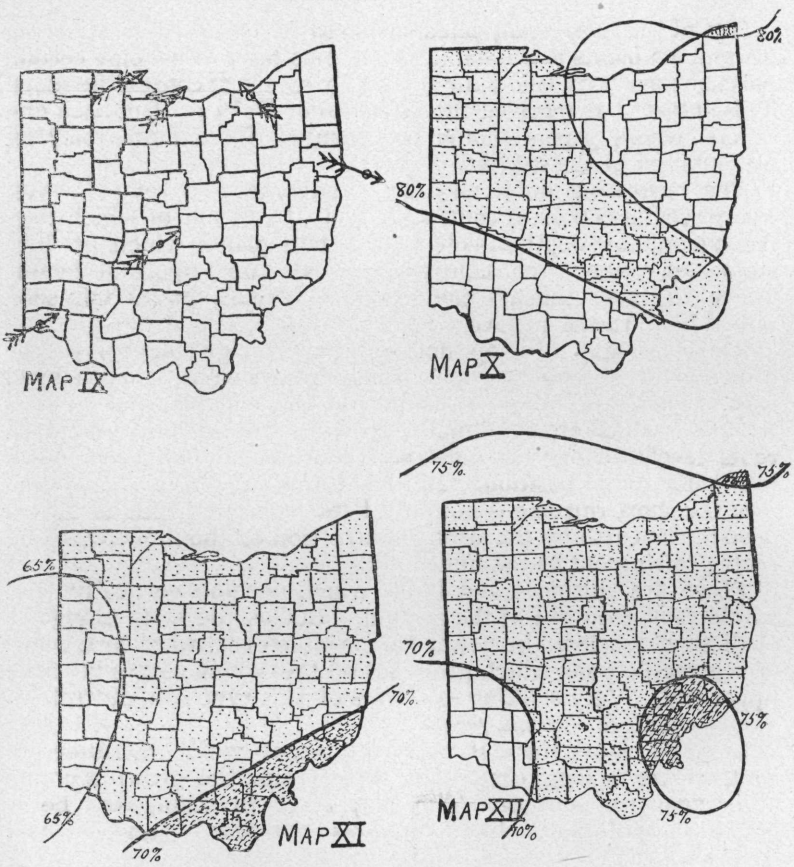
Stations.	Average Per Cent. in Each Month.												Annual Mean.	Least Monthly Per Cent.		Greatest Monthly Per Cent.	
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.		Month.	Amt.	Month.	Amt.
Toledo	82.4	80.4	75.5	69.1	69.0	69.9	67 1	70.1	72.2	73.3	77.6	79 9	73.9	July	67.1	Jan.	82.4
Sandusky	79 8	78.6	75.4	69.4	69 1	70.9	67 7	69 4	70.4	71.0	74.8	76.6	74.4	July	67.7	Jan.	79.8
Columbus	80.2	78.0	73.8	66.7	67.9	69.1	66.9	69.9	70.3	71 8	77 0	79.0	72 6	July	66.9	Jan.	82.0
Cleveland	77.6	77.2	75 1	70.0	71.1	70 6	68.2	70.5	72 8	72.4	74.0	75.0	72 9	July	68 2	Jan.	77.6
Cincinnati	76.6	73.6	70.0	62.0	64.4	64.8	64 8	66.8	68.0	68.9	72.9	75.4	69.0	Apr.	62.0	Jan.	76.6
Detroit	82 7	80.6	76.4	69.6	69.5	69.6	66.9	69.8	73.4	74.8	78.8	81.3	74.4	July	66 9	Jan.	82.7
Pittsburg	78.9	77.2	75.0	68.4	69.2	69.7	67.8	69.0	71.4	69.1	74.8	75 9	72 2	July	67.8	Jan.	78.9
Indianapolis	77.9	76.2	70.9	64.4	66.0	66.5	62.8	65.1	67 0	67.7	71 5	75.0	69 2	July	62.8	Jan.	77.9
Erie	80.9	82.4	79.5	77.1	74.4	73.0	69 3	71 1	73.3	73 1	76 6	78 9	75.5	July	69.3	Feb.	82 4

Now, with regard to the application of some of the foregoing conclusions to ecological work, it must be remembered that deficiencies of one factor may often be counterbalanced by a surplus of another factor. It is thus necessary to consider the factors collectively as well as individually. In the ecology of Ohio it is

doubtful if more than a very few of the phases of species distribution can be explained from the standpoint of any one factor alone. It is not to be assumed that all the climatic factors of ecological connection have been considered in these two articles, and neither does it follow that any of the factors have been considered in all their possible phases as related to ecology, but yet enough has been considered to afford more or less of a basis for further work. It is to be regretted that the edaphic conditions, such as soil moisture, soil texture, etc., are not more completely worked out for Ohio. They take a very important part among the ecological factors, and in many cases are almost inseparably linked with meteorological factors.

For a concrete instance of some of the problems of plant ecology, comparison may be made, for instance, between Ashtabula and Cincinnati, although localities differing more widely may be found in the State. The two stations have the same average range (100° Fahr.) between the average minimum and maximum temperatures, but Cincinnati is five degrees warmer in mean annual temperature, thus having decidedly an advantage as to the needs of many plants. The annual precipitation is the same in both localities, but Ashtabula has sixty inches of snow to less than twenty inches for Cincinnati. Now, perhaps for many plants the protection offered by the extra forty inches of snow at Ashtabula is a greater advantage than is the extra five degrees of temperature at Cincinnati. Again, the monthly distribution of the precipitation is another important factor—Cincinnati has a maximum of 5.69 inches in March, while Ashtabula has a maximum of 6.95 inches in July, at about the middle of the growing season and just when needed for the majority of plants. Furthermore, Cincinnati has a very drying atmosphere (low relative humidity) as compared with Ashtabula, but to counteract this the higher wind velocity at Ashtabula indicates the ability of the air to carry away more water. Cincinnati is farther south and would thus be more directly under the sun's rays, but Ashtabula has less cloudy weather and so perhaps gets more sunlight than does Cincinnati.

In problems like the above, where each climatic factor may have some certain influence upon any particular species, a debit and credit account might be imagined in which the factors are balanced, and if something is known of the requirements of the species, perhaps some light might be thrown upon the problems of distribution or the possibilities open to introduced species.



JENNINGS on "Some Climatic Conditions of Ohio."

EXPLANATION OF MAPS.

Map IX. Wind Direction. Arrows denote prevailing direction of wind.

Map X. Normal Relative Humidity for January. Shaded portion has a relative humidity of above 80 per cent.; the unshaded portion, below 80 per cent.

Map XI. Normal Relative Humidity for July. More heavily shaded portion represents regions having a relative humidity of above 70 per cent.; the less heavily shaded, between 65 and 70 per cent., and the unshaded, below 65 per cent.

Map XII. Normal Annual Relative Humidity. More heavily shaded portion denotes a relative humidity of 75 per cent. or above; less heavily shaded portion, 70 to 75 per cent., and unshaded portion, less than 70 per cent.