Some Microclimates Produced by Lake Texoma

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Despite the many claims and theories advanced by proponents of lake building programs concerning the extensive microclimatic effects of lakes and ponds, there are extremely few data available either to support or to discredit such claims and theories. Jensen (1, 2), during the dry summers of 1935 and 1936, studied the effects of several small lakes (largest, about 3½ miles by 10 miles) in Ottertail County, Minnesota, on relative humidity and air temperature. Air temperatures, in the afternoon, were shown to be somewhat lower and the relative humidities at the same time higher on the leeward shore of a lake than on the windward, the difference in temperature being as great as 8.5° F. and of relative humidity as great as 19 percent.

The present investigation was carried out at the University of Oklahoma Biological Station from June 20 to August 2, 1951. Experiments were designed to determine the influence of Lake Texoma on relative humidity, air temperature, and evaporation on its shores[1] and any modifications of these factors resulting from variations in wind direction and intensity. A determination of the distance from the water that any pronounced effect could be detected was another goal of this investigation.

Materials and Methods

By careful reconnaissance, grassland areas essentially free of trees for about one-half mile from the water were located on the north and south shores of Lake Texoma. The area on the north was located just west of the University of Oklahoma Biological Station, while that on the south was located across the lake to the southwest of the station. The lake was approximately three miles wide at the location of the study areas. Instrument stations were located at 10, 60, 160, 360, 660, and 880 yards from the water on the north shore. All stations were located at similar positions on the south shore with one exception; one was located at 560 yards from the water and none at 660 yards. The grasses were kept mowed or grazed quite short at each station with the exception of the one located 880 yards from the water on the south shore and that located 660 yards from the water on the north shore. At those stations the grasses were about two feet tall during most of the period of the investigation.

All measurements were taken at four feet above ground to minimize as much as possible any effects due to the vegetation. Weksler maximum-minimum thermometers were used for the spot checks of air temperature and to determine the weekly maximum and minimum temperatures. These thermometers were mounted in small shelters to prevent the sun from shining directly on them (Fig. 1). Two Taylor recording thermographs were used for a continuous comparison of air temperatures at 10 yards and 440 yards from the water on the north shore. Friez aspirator type psychrometers were used for the determination of relative humidities. White Livingston atmometer spheres were used for the measurement of evaporation.

[1] The term "shore" is used in a broad sense in this paper to refer to the area out to one-half mile from the water's edge.

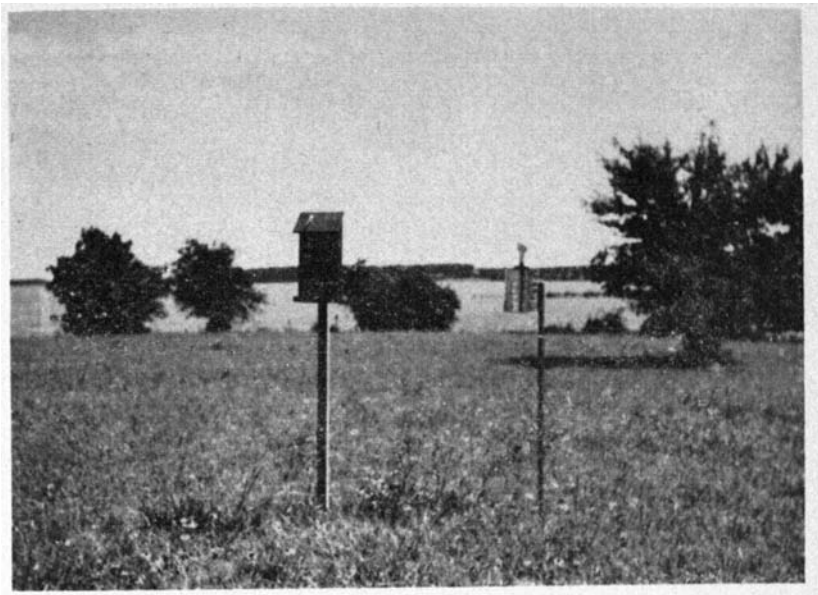

FIGURE 1. Maximum-Minimum Thermometer and Atmometer Cup in Place in Field.

Results and Discussion

The influence of Lake Texoma on relative humidities on its shores varied with wind velocity and direction (Tables 1 and 2 and Figs. 2 and 3). Moderate to strong south winds resulted in fairly pronounced increases in relative humidities on the north shore, the distance of the effect depending

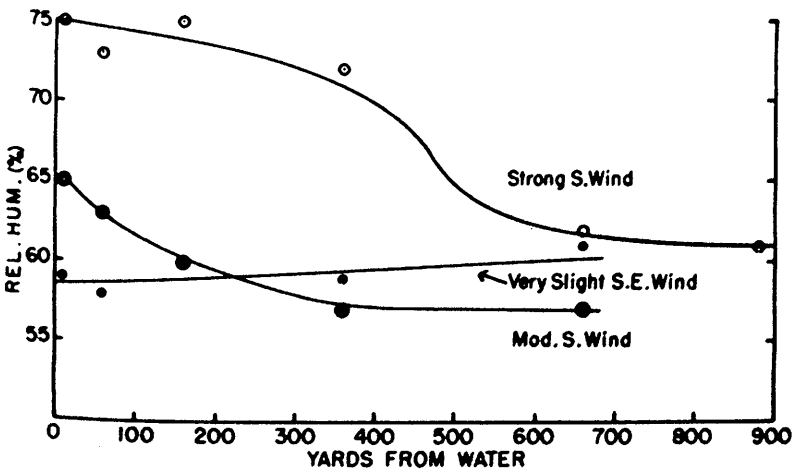

FIGURE 2. Relative Humidity at Four Feet Above Ground on North Shore as Affected by Wind Direction and Velocity and by Distance from Water.

on the relative intensity of the wind. During such times the relative humidities on the south shore were not essentially affected by the lake (Table 2). The reverse situation resulted when moderate to strong winds blew from the north. During periods of calm or very slight winds, regardless of direction, the lake had very little effect on relative humidities

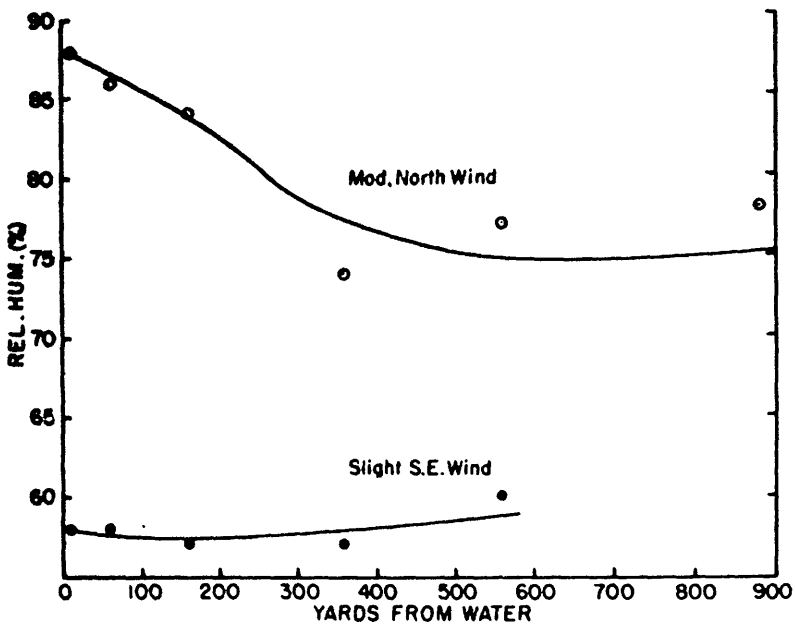

FIGURE 3. Relative Humidity at Four Feet Above Ground on South Shore as Affected by Wind Direction and Velocity and by Distance from Water.

TABLE 1

Relative Humidity on North Shore at 5 Feet above Ground in Shade

DATE	TIME (P.M.)	WIND DIRECTION & INTENSITY	RELATIVE HUMIDITY (%) 10*	60*	160*	360*	660*	880*
June 25	1:25- 2:00	Strong, S.	75	73	75	72	62	61
June 27	12:30- 1:10	Strong, S.	63	65	65	62	59	52
July 9	2:45- 3:20	Fairly Strong, S.	56	54	58	61	56	50
July 11	2:40- 3:15	Mod., S.	65	63	60	57	57	—
July 16	1:00- 1:20	Slight, S.E.	51	51	51	47	48	—
July 25	4:20- 5:00	Slight, N.E.	51	52	53	55	58	—
July 30	3:15- 4:00	Mod., E.	45	41	38	37	37	—
Aug. 1	10:00-10:40†	Very Slight, S.E.	59	58	60	59	61	—

* Distance from water in yards.
† A.M.

TABLE II

Relative Humidity on South Shore at ½ Feet above Ground in Shade

DATE	TIME (P.M.)	WIND DIRECTION & INTENSITY		RELATIVE HUMIDITY (%) 10*	60*	160*	360*	560*	880*
June 25	3:00- 3:30	Strong,	S.	67	62	62	60	70	65
June 27	3:00- 4:00	Strong,	S.	52	48	56	59	47	—
July 4	9:20-10:15†	Mod.,	N.	88	86	84	74	77	78
July 9	1:00- 1:40	Fairly Strong,	S.	55	54	55	50	53	53
July 11	1:00- 1:30	Mod.,	S.	58	58	58	56	57	—
July 25	2:30- 3:15	Slight,	E.	60	52	54	54	54	52
Aug. 1	7:55- 8:30†	Slight,	S.E.	58	58	57	57	60	—

* Distance from water in yards.
† A.M.

along its shores. On relatively windy days, the pronounced break in relative humidity on the leeward shore occurred usually between 360 and 660 yards from the edge of the water. The difference in relative humidity at the water's edge and at 660 yards away on the leeward shore was as great as 13 percent on one windy day. Measurements made at various distances from the water out to a point 12 miles north of the lake on a day when a slight wind was blowing from the southeast indicated that the lake may have some very slight effect on humidity as far as two to four miles from the water on the leeward shore although a pronounced effect occurred only up to approximately 360 yards.

The influence of the lake on air temperatures varied with wind direction and intensity also (Tables 3 and 4). The greatest effect on temperature

TABLE III

Air Temperatures at ½ Feet above Ground on North Shore

DATE	TIME (P.M.)	WIND DIRECTION & INTENSITY		AIR TEMPERATURE (°F.) 10*	160*	660*
June 25	1:25- 2:00	Strong,	S.	87	90	96.5
June 27	12:30- 1:10	Strong,	S.	89	91.2	94
July 9	2:45- 3:20	Fairly Strong,	S.	94	94	96
July 11	2:40- 3:15	Mod.,	S.	89	94	96
July 16	1:00- 1:20	Slight,	S.E.	106	103	104
July 18	2:30- 2:50	Slight,	N.E.	104	98	100
July 25	4:20- 5:00	Slight,	N.E.	101	101.5	101

* Distance from water in yards.

TABLE IV

Air Temperatures at ½ Feet above Ground on South Shore

DATE	TIME (P.M.)	WIND DIRECTION & INTENSITY		AIR TEMPERATURE (°F.) 10*	160*	560*
June 25	3:00- 3:30	Strong,	S.	91.5	95	92
June 27	3:00- 4:00	Strong,	S.	95	96.5	95.2
July 4	9:20-10:15†	Mod.,	N.	74	78	80.5
July 9	1:00- 1:40	Fairly Strong,	S.	93	94	93.5
July 11	1:00- 1:30	Mod.,	S.	94.5	94.5	94.5
July 18	1:00- 1:30	Slight,	N.E.	96	98.5	100
July 25	2:30- 3:15	Slight,	E.	95	96.5	96.5
Aug. 1	7:55- 8:30†	Slight,	S.E.	89	90.5	85.5

* Distance from water in yards.
† A.M.

occurred on the north shore on June 25 when the wind was blowing quite hard from the south. On that date the air temperature was 9.5° F. higher at 660 yards from the water than at 10 yards from it. When a very slight wind was blowing off the lake, or when the wind was blowing toward it, the air temperature was often higher next to the water than some distance from it (Table 3). The increase next to the water was probably due to the reflection of the sun's rays from the water toward the nearby instruments. Present data are insufficient to indicate how far from the water air temperatures are affected when the wind is blowing hard off the lake since no temperature stations were located more than 660 yards from the water on the north shore or 560 yards from it on the south shore.

With the exception of the week ending June 27, the minimum weekly air temperature at four feet above the surface of the ground on the north shore did not fall as low at the station next to the water as at those more distant from it (Table 5). On the south shore the weekly minima were always higher next to the water than at the more distant stations (Table 6). This seemed quite surprising at first for the summertime, because one usually thinks of cold weather when considering the temperature increasing effect of a body of water. Such a similar effect in warm weather is quite logical, however, and the explanation is simple. The temperature of the lake water became relatively high during the summer and the loss of heat from it at night kept the air close by considerably warmer than that farther back on the shore. The effect was very striking when walking close to the water at night, the breeze blowing on shore being noticeably hot at times.

TABLE V

Maximum and Minimum Weekly Air Temperatures (°F.) at 4 Feet above Ground on North Shore

FOR WEEK ENDING	10*		160*		660*	
	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.
June 27	73.2	92	74	98	73.2	94.5
July 4	73	104.5	66	102	66	100
July 11	73	95	70	97	70.5	97
July 18	75	110	74.5	110	72	108
July 25	74	111	73	110	73	106
Aug. 1	74	109	72	107	71	105

* Distance from water in yards.

TABLE VI

Maximum and Minimum Weekly Air Temperatures (°F.) at 4 Feet above Ground on South Shore

FOR WEEK ENDING	10*		160*		560*	
	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.
June 27	80.5	96.5	72	98	72.5	96.5
July 4	71	97.5	67	97.5	67	99
July 11	81	98	72	98.5	73	98
July 18	—	104	70	105	71	103
July 25	76	106	74	107	73.5	107.5
Aug. 1	77.5	104	72	105.5	77	104

* Distance from water in yards.

The weekly maximum air temperatures were usually similar at all stations on the south shore (Table 6). The slight variation which did occur exhibited no correlation with the location of the water. The weekly

maximum air temperatures were quite different at the various stations on the north shore at times, but again there was no apparent correlation with the distance from the water (Table 5). The general weather conditions, particularly the prevailing direction and intensity of the wind, probably played a prominent role in determining which station on either shore had the maximum weekly air temperature.

Mean air temperatures (average of hourly temperatures) four feet above the surface of the ground were found to be almost identical at 10 yards from the water and at one-fourth mile from it during some weeks, despite the pronounced differences in temperature which occurred between these stations on days when the wind blew hard off the lake. Differences in mean temperatures between the above two stations were evident, however, during some periods. During the period July 30 to August 2, the mean night temperature (7:00 p.m. to 6:00 a.m.) next to the water was 82.7°F. and that at 440 yards was 82.3°F. During the same period, the mean day temperature (7:00 a.m. to 6:00 p.m.) next to the water was 87.8° F. whereas that a quarter-mile away was 89.6° F.

Considering the generally higher relative humidities and lower temperatures next to the water on the north shore than farther away from it, (Tables 1 and 3) one would expect evaporation to be considerably less next to the water. This proved to be true only to a relatively limited

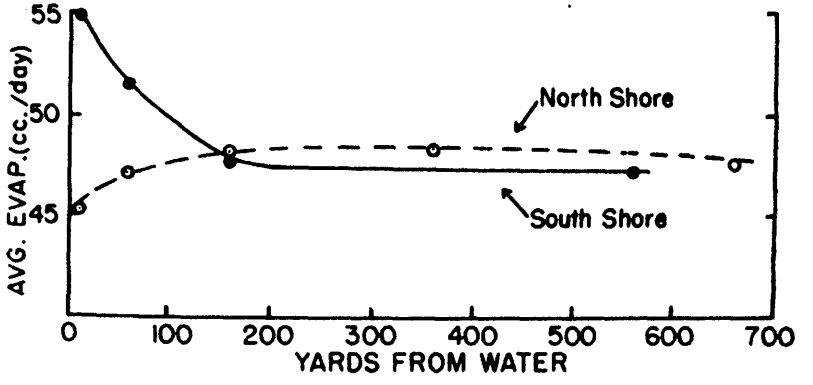

FIGURE 4. Influence of Lake on Average Daily Evaporation from White Livingston Spheres Four Feet Above Ground on North and South Shores.

extent (Fig. 4). In actual magnitude the difference was so slight that it was probably insignificant. On the south shore, the average evaporation was actually higher next to the water than farther back on the shore. Probably the chief causes of the higher evaporation rates next to the water were the higher night temperatures at that location and the greater wind velocities. Since evaporation is affected by wind, insolation, relative humidity, and temperature, it is without doubt the best single criterion of the overall effect of a given environment on the growth of plants in that environment. Present data suggest, therefore, that the influence of Lake Texoma on the overall microclimate on the north shore is so small, at least during the summer months, that it would have almost no effect on plants growing there. If there is any notable effect on the growth of plants on the south shore, which is doubtful, it is apparently a detrimental effect. It should be emphasized that the above conclusions are concerned solely with the microclimatic effects along the lake.

SUMMARY

Lake Texoma increased the relative humidity on its leeward shore quite markedly, the magnitude and distance of the effect increasing with increasing wind velocity. On relatively windy days, the pronounced break in relative humidity on the leeward shore occurred usually between 360 and 660 yards from the water. There was no detectable effect of the lake on relative humidity on the windward shore.

Air temperatures during the day were usually lower next to the water on the leeward shore, gradually increasing with distance from the water, the magnitude and distance of the effect depending on wind direction and intensity. When a slight wind was blowing off the lake or when the wind was blowing toward it, the air temperature was often higher next to the water than at some distance away.

The *mean* day air temperature (7:00 a.m. to 6:00 p.m.) was higher a quarter mile from the water on the north shore than at the water's edge. The mean night air temperature (7:00 p.m. to 6:00 a.m.) was higher next to the water than a quarter mile away on the north shore.

The *highest* weekly minimum air temperature was always recorded next to the water on both north and south shores with the exception of the north shore in the week ending June 27.

The weekly maximum air temperatures were usually quite similar at all stations from the water outward on the south shore. They varied considerably on the north shore but there was no apparent correlation with distance from the water.

Daily evaporation was almost the same at every station on the north shore from the water outward despite the usually higher relative humidities and lower temperatures next to the water during the day. On the south shore, the average daily evaporation was actually higher at the stations closest to the water. These unexpected results concerning evaporation were probably due to the higher night temperatures next to the water and possibly to higher wind velocities at that position.

LITERATURE CITED

1. JENSEN, J. C. 1936. Evaporation and rainfall studies in the northwest Minnesota lake region. Proc. Am. Phil. Soc. 76: 747-759.
2. ———. 1938. Evaporation and rainfall studies in the northwest Minnesota lake region. Proc. Am. Phil. Soc. 78: 651-670.