A CITY MICROCLIMATE IN THE MACROCLIMATE OF THE GREAT PLAINS

by

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INTRODUCTION

This study was conducted to compare and evaluate the microclimate in a small city within the macroclimate of the great plains.

A microclimate has been defined by Geiger (8) as "the climate in a small space," and by Wolfe, Wareham, and Scofield (27) as "a complex of above ground conditions distinct with respect to location or meterological phenomena."

Microclimates have been recognized for centuries, although not always understood. A former president of the United States, Thomas Jefferson (16) observed and recorded interesting phenomena regarding the microclimatic influence around Monticello as early as 1779. He observed, among other things, that blossoming fruit trees on the hill slopes received less frost damage than those in the valleys.

According to Janick (14) the climate at the ground may differ considerably from that at thirty feet above the ground. The climatic differences are of vital importance to man and his agriculture. We become aware of the microclimate as we drive into and out of fog pockets on chilly mornings.

Many plants cannot be grown in certain areas because of specific limiting climatic factors. These plants are commonly grown in an unfavorable macroclimate if a favorable microclimate can be developed. Human living conditions could be made more comfortable through microclimatic modifications in an unfavorable climate.

Microclimatic data should be of interest to all people who wish to learn about the average conditions of life near the ground. People interested in plant life, farmers, foresters, gardeners, nurserymen; people interested in animal life, farmers, entomologist, zoologists, those interested in the state of the ground, conservationists, architects, highway engineers, city planners, even financial experts who should realize the influence of microclimate on land values, should be concerned.

In seeking the relations between weather regimes and living organisms over a long period of time, Wolfe, Wareham, and Scofield (28) feel that more knowledge of the actual sequence of the weather types occurring in plant and animal habitats appears desirable and necessary. That a great variety of weather types occurs in both time and space in a given small area is obvious by simple inspection. The shaded cities and sunlit open fields differ materially and sensibly as to conditions or atmospheric moisture, light, temperature, and air movement.

The objectives of this study were:

1. To develop a better understanding of the causes and effects of microclimates.
2. To study the extent of microclimatic effects in a city as compared to the macroclimate of an area.

REVIEW OF LITERATURE

In a comparison of temperatures in different environments of the same climatic area, Chapman et al. (4) showed plainly the tendency of the forest and bog to be cooler than dunes on warm days but warmer than the open dunes on cool days during the summer. This indicates the effect of the forest in preventing air currents and in intercepting the sun's heat in the crowns as well as preventing the re-radiation of heat absorbed.

Franklin (6) in his study of microclimate and environment worked with soil and vegetation temperatures, effects of windbreaks and water vapor among other climatic factors. He found that on the bare soil the hottest point by day was at the surface, with a steep drop in temperature in rising above or going below the surface. With a crop cover the hottest point was generally about the level of the top of the crop. The dense canopy of the leaves, which during the day have been a good absorber of the sun's radiation, turns after sunset into an efficient radiator and quickly looses its heat to the clear sky and so becomes the coolest place at night. Franklin found the most effective windbreak was one having a fairly solid windbreak to reduce the wind velocity, followed by an open one to break up the eddies.

He also revealed the importance of water vapor as an important source of available moisture for plants, in collecting dew equal to over a hundredth of an inch of rain per night.

Hellman (11) found, in his study on the cooling of the air near the ground at night, that on a clear night the temperature increases with height. On the average the difference of temperature from the ground to 50 cm. was 3.7°C. An increase of (1°) cloudiness reduced this difference by .3°C. Cloudiness was observed as tenths of the area of the sky that was covered. A cloudless sky is indicated by 0° while 10° represents a sky with complete cloud cover. An overcast sky gave no difference in temperature with height. Rainy and windy weather decreases the temperature of the air near the ground a few tenths of a degree.

In studying the temperature from the ground surface upward Geiger (8) reported that the temperature is determined by surface conditions, regardless of effects of the surrounding area. Daily fluctuation of temperature is inversely proportional with distance from the ground, and extremes are delayed farther from the ground. Stormy conditions cause all temperature differences to vanish by mixing the air completely.

Wolfe, Wareham and Scofield (27) observed in the microclimates of Neotoma, a small valley in Ohio, that in the forests the temperature range was least after the closing of the canopy and the variations from year to year were not great. The greatest range in the maximum temperature occurred in the spring and fall. The average minimum temperature range was greatest in winter when there was no canopy retarding exterration. They also found that the relative humidity varied in the various habitats because of temperature differences.

Jefferson (16) in his climatic observations in Virginia noted frost that killed "hiccory" trees around Monticello but no frost injury occurred in the mountain orchards. He also reported that the northeast winds from the sea were cold, moist and depressing, while winds from the mountains of the northwest were dry, cooling, elastic, and animating.

In studying the microclimates of Washington, D. C., Wollum (28) found a greater range in average monthly minimum temperatures than average monthly maximum temperatures over the area. He stated that "each city and town has a heat island which is produced by the general climate, topography, and heat induced by buildings, factories, automobiles, paved roads and other sources."

In studying the temperature of large cities Mitchell (18) reported that the urban heat island is more evident at night. In July the relative warmth of the city is largest at night and virtually absent during most of the day time. The city continues to retain its heat in the late afternoon, after temperatures have begun to decline in the suburbs. Maximum and minimum temperatures are reached somewhat later in the city than in the suburbs. In February the city tends to remain warmer than its suburbs both day and night.

Duckworth and Sandberg (5) studied the effect of cities upon horizontal and vertical temperature gradients with automobile-mounted thermisters, and vertical temperature gradients in the lowest 1,000 ft. were measured by wiresonde simultaneously at urban centers and peripherial open areas. They found that temperature increased from peripherial open lands to built-up centers in direct proportion to structure density. Vertical temperature data showed that build-up areas frequently caused instability up to about three times roof height in otherwise stable air and that a "crossover" point sometimes exists above which the air over the urban center was cooler than that over surrounding country.

In a study of the heat islands in Corvallis, Oregon, Hutcheon et al. (13) found three heat islands. Two were hill tops and the other was the commercial city center or the true heat island.

Rider (20), Jaworski (15), and Guyot (9) showed that the reduction of wind velocities with various windbreaks conserves soil moisture, and tends to stabilize temperature and water vapor.

Thornwaite (25) pointed out that in order to evaluate the moisture factor in climate, the moisture supply or the precipitation must be compared with the water needs or the potential evapotranspiration. When the precipitation is in excess of need, the surplus goes to charge ground-water and produce runoff. When the precipitation does not equal the need, there is a deficiency which results in a drouth.

Bark (1) reported that the annual precipitation in Kansas decreases 1 inch for about every 17 miles west of the Missouri border. The pattern of precipitation is the major factor in determining the distribution of agriculture production. Practically the only source of moisture for precipitation in Kansas is the Gulf of Mexico. Sixty-five to eighty per cent of the total precipitation falls during the growing season with a sharp decrease in July.

Humphreys (12), in discussing the ways of the weather, reported that the things affecting the humidity of the atmosphere at a particular place are temperature, convection, nature of immediate surroundings, wind velocity and wind direction. He also stated that relative humidity decreases with an increase in temperature.

Chandler (3) found that urban areas in England cool more slowly in evenings and warm more slowly in the mornings than do rural areas. The absolute and relative humidity were lower in London than rural areas because of higher temperatures and less evaporation and transpiration. He also reported that precipitation between urban and rural areas was difficult to compare because of it's inconsistent pattern.

In studying atmospheric moisture and temperature Sprague (22) found that the average moisture content of the air decreased from ground level to 60 inches. Moisture was greatest at noon or soon thereafter and was greater during the day than at night. Variations during the day at the 60 in. height were small. More water was in the air on cloudy days than on clear days. Relative humidities were greater near the ground level than above at both maximum and minimum air temperatures. The largest differences occurred during daily maximum air temperatures. Relative humidities were highest at daily minimum air temperatures.

Steubing (23) observed that on windy nights hedges increased dew formation up to 200 per cent. Air moisture was higher and evaporation slower in protected plots. Maximum dew formation was at a distance 2-3 times the height of hedge.

Shreve (24) reported that under desert conditions the light shade of a tree or bush supports a heavier stand of herbaceous annuals and seedling perennials that will be found in the open.

Biel (2) describes various problems and applications of climatology in respect to both physical and biological investigations. The soil is considered an "active surface" since it is heated by solar insolation and cooled by terrestrial radiation. The lowest layer of air is both heated and cooled from the ground, governed to a large extent by the time of day and color of the absorbing surface. Plant cover also contributes to its own environmental temperature. Horizontal or umbrella-shaped plants intercept a higher portion of the light than vertical types. Grass 3 ft. high intercepts about 80 per cent of the solar energy at the top of the vegetative cover allowing the soil surface only about 1/5 of the light intensity. Biel reported that foresters have long been aware of the great climatic differences between the interior and surroundings of a woodland because canopy interference, windbreak trees, and other factors. Based on this type of knowledge man has learned to alter the microclimate by using various physical factors to increase reflection or absorption of solar energy. Other applications include optimum times for spraying and dusting, length of growing season, winter kill, storage of farm products, influence on the most successful rearing of livestock, water storage, and human comfort.

In Robb's (21) observation of Scott County, which is located in the high plains area of the Great Plains, he reports that it has a dry and invigorating continental climate. He stated that "the area is deficient in rainfall because the moist air that flows northward from the gulf passes mostly to the east, and the Rockies to the west form a barrier to precipitation from the Pacific. Native short grasses and treeless plains are evidence of the deficient rainfall."

Robb discusses the discomfort of the wide range of daily, seasonal and annual temperatures which are more bearable with the low humidity and prevalent breeze. He reported that "the more noticeable and frequent changes in weather are in spring and fall."

Gates (7) stated that "the climate of Kansas is one of great extremes and sudden changes in temperature, precipitation and wind. Rain often comes in torrential storms between which are long periods of drought."

Weaver and Albertson (26) stated that:

> Climatic conditions over the Mixed Prairie are difficult to describe. The climate is one of extremes. It is commonly called semiarid but in some years it is humid and in others desert-like. It is not a permanently established climate but a dynamic one with large scale fluctuations and wet and dry trends. Located in the interior of the continent, the climate is subject to pronounced changes in temperature. Hot summers with cool nights, occur throughout.

MATERIALS AND METHODS

Two weather stations were established in Scott County, Kansas, from December 4, 1965 to September 8, 1966. Scott County is located midway between the Oklahoma and Nebraska borders, and is the third county east from the Colorado line, with an elevation of around 3,000 ft.

One weather station was located in the heart of Scott City under the moderately dense canopy of trees. However, the station itself was not actually under a tree. The rural weather station was located in an open plain area on short grass sod approximately three miles west of Scott City.

The climatic data collected included temperature, relative humidity, precipitation, and air movement. Temperature and relative humidity instruments were housed in standard instrument shelters, U. S. Weather Bureau Spec. No. 450, which protected the instruments from radiation and precipitation, but were well ventilated. The stations were supported on stands one and one-half meters from the surface of the ground.

The instruments and their U. S. Weather Bureau Spec. No., used in collecting the data include hygrothermographs No. 450.8202, maximum and minimum registering therometers No. 450.1016 and, sling psychrometers No. 450.1016. Totalizing anemometers, U.S.W.B. No. 450.6104, were also used.

Readings were taken each Monday and periodically throughout the week. Servicing the hygrothermograph was required each week and included changing charts, winding the clock and re-inking the pens.

The maximum minimum registering thermometers were used to check the accuracy of the thermograph and were recorded and reset each time the station was visited. The official U.S.W.B. thermometer was used to check the accuracy of the other thermometers.

Corrections for the hygrometer readings were made with the wet and dry bulb sling psychrometer.

The totalizing anemometers were placed on a 3/4" tapered shaft attached to the upper corner of the shelters. Only total miles of horizontal air movement were recorded each week.

The rain and snow gauges were placed on flat wood bases securely anchored to the soil. These gauges were located so the instrument shelters would not affect the amount of precipitation sampled.

The paired T test was used to determine the significance between the various records of the rural and urban station.

RESULTS

Climatic factors that were observed at the two stations include horizontal air movement, continuous air temperatures, relative humidity, and precipitation.

Air Movement

Four times more horizontal air movement was recorded at the rural station than was recorded at the urban station. From December 5, 1965, to September 6, 1966, 59,781 miles of air movement was recorded for the rural station as compared to 14,604 miles of air movement at the urban station. Two weeks of high air movement were recorded during March 7-13 and June 27 to July 3. Figure 1.

Highest weekly rural air movements generally occurred from March 7 through July 11, 1966. The urban winter and spring weekly anemometer readings were higher than the urban summer readings.

Only the week of March 7 had high enough urban air movement to exceed the two lowest weekly rural air movements of December 6 and August 29 during the study.

From March 7 through July 11 the rural station recorded all 15 weeks as exceeding 1,500 miles of air movement per week. The week of December 27 was the only other one having over 1,500 miles of air movement during the study.

The difference between the rural and urban readings was greater during late spring and summer.

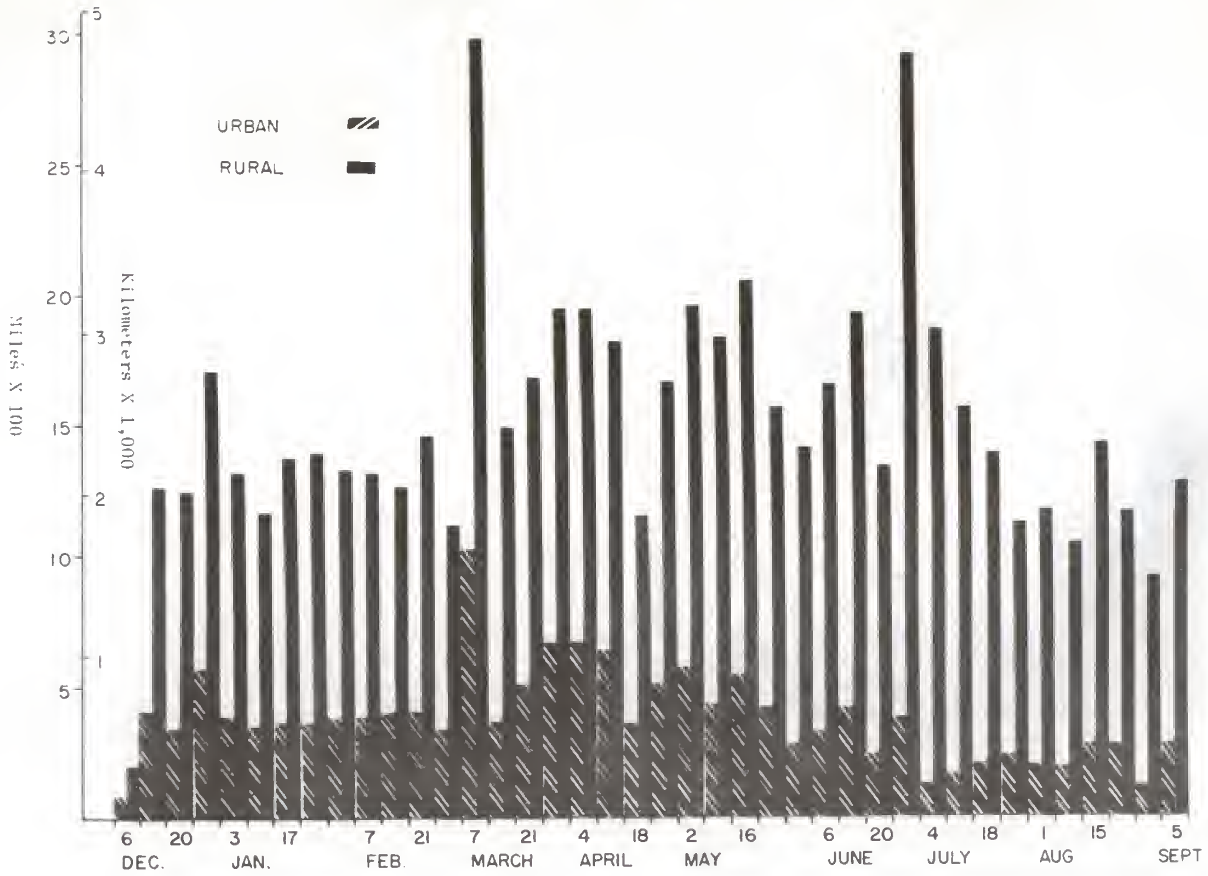

Fig. 1. A comparison of horizontal air movement per week for the urban and rural weather stations.

The rural station had significantly greater horizontal air movement than did the urban station for the entire study period.

Maximum and Minimum Temperatures

The rural station's temperature at times reached the maximum for the day nearly one hour earlier than the urban station. On sunny days the rural temperature remained near the maximum longer, gradually dropping until near sundown, then dropped rapidly until approximately 10:00 p.m. where it again decreased gradually until sunrise. The urban station's temperature developed a sharper peak than the rural station's temperature. Figure 6.

The temperature at the urban station was reduced to near the diurnal mean during the irrigation of the lawn in the immediate area, as seen in Fig. 6 on Tuesday between the hours of 9:00 a.m. and 12:00 noon.

The maximum temperature peak at both stations was normally reached between 3:00 and 4:00 p.m. and the minimum temperature was reached at or shortly after sunrise.

The urban station had significantly higher weekly mean temperatures, especially in the winter and spring, than did the rural station.

The rural station recorded a maximum temperature of 106°F which was 3°F higher than the urban station on the same day. The lowest temperature recorded was -12°F at the rural station, which was 5°F lower than the urban station at that time. Highest and lowest recorded temperatures at Scott City are 114°F and -26°F respectively.

The rural station had 1.77°F greater average variation than the urban station between the weekly mean's of the maximum and minimum temperatures. Figure 2.

At approximately 4:30 p.m. each sunny spring day the urban temperature developed a brief plateau before receding for the afternoon.

The urban U.S.W.B. cooperative station's weekly mean maximum temperature was 1.73°F higher than the weekly mean maximum temperature of the urban station under study. The U.S.W.B. weekly mean minimum averaged only .088°F higher than the mean minimum temperature of the urban station, and during the summer the mean temperatures were either at or above the urban readings. Figure 3. The U.S.W.B. cooperative station was located 88 meters south of the urban station.

Relative Humidity

The mean maximum and minimum relative humidity at both stations was lower during the spring. The weekly mean minimum relative humidity was considerably more erratic than the weekly mean maximum relative humidity especially during winter and summer. The relative humidity minimum and maximum weekly means decreased sharply after high air movements. Figure 4.

The urban weekly mean maximum relative humidity was significantly higher than the rural weekly mean maximum. Table 1.

The urban weekly mean minimum relative humidity was significantly higher than the rural weekly mean minimum.

The relative humidity normally reached the daily peak at sunrise and at the same time the minimum temperature is reached, as seen in

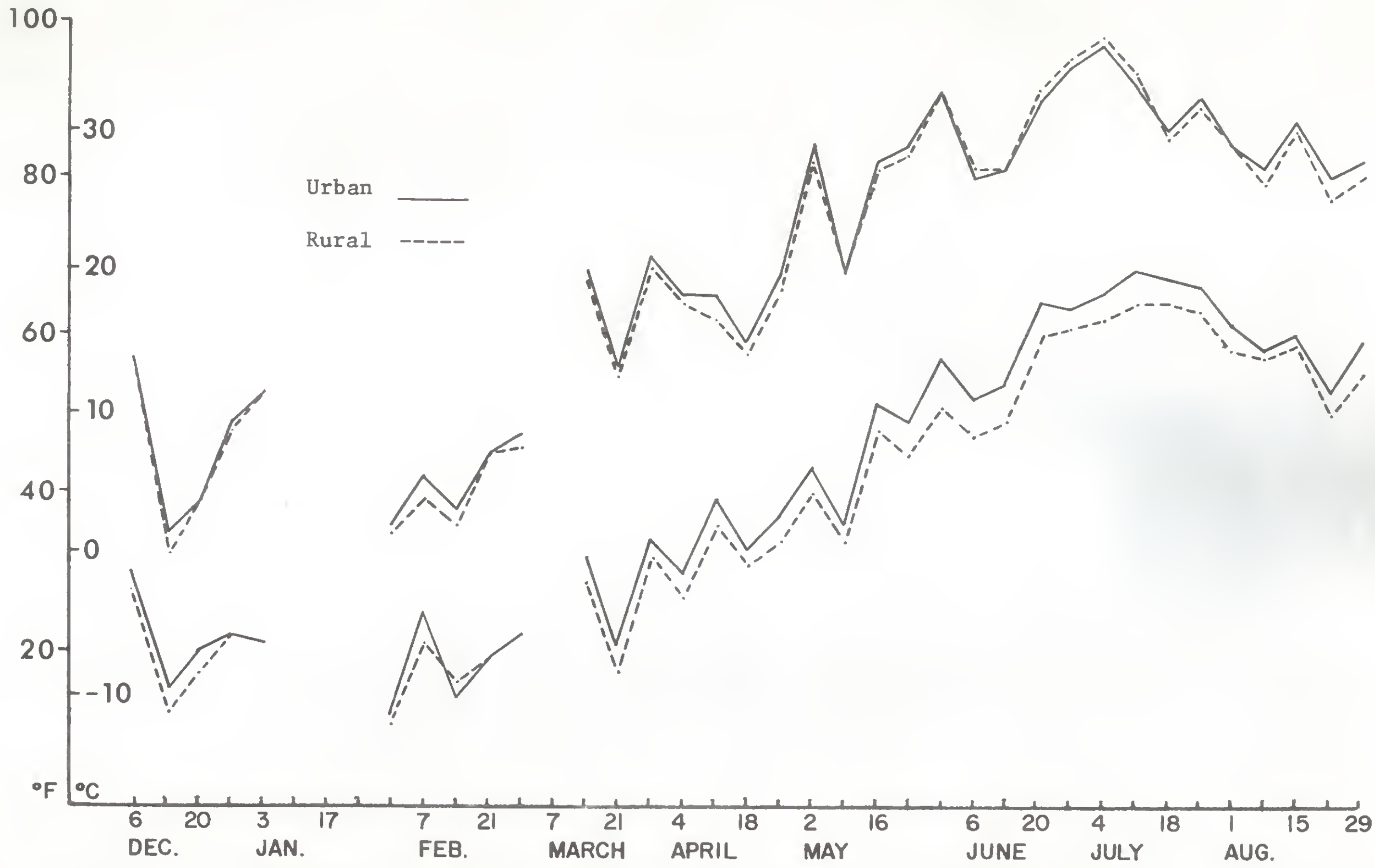

Fig. 2. A comparison of the weekly mean maximum and minimun temperatures of the urban and rural stations from Dec. 6, 1965 to Aug. 29, 1966.

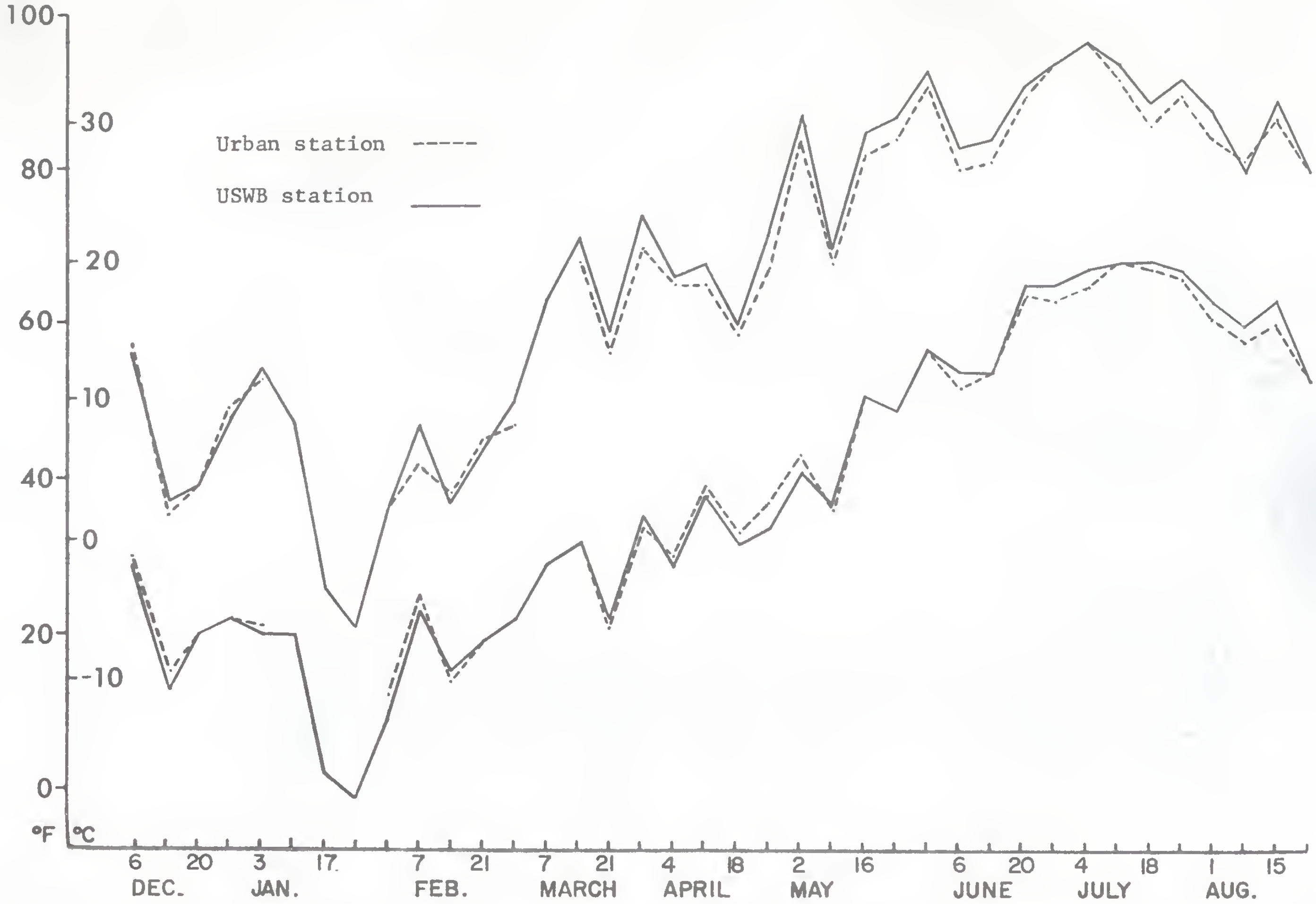

Fig. 3. Graphic comparison of the average weekly maximum and minimum temperature at the urban station and the USWB station from Dec. 6, 1965 through Aug. 22, 1966.

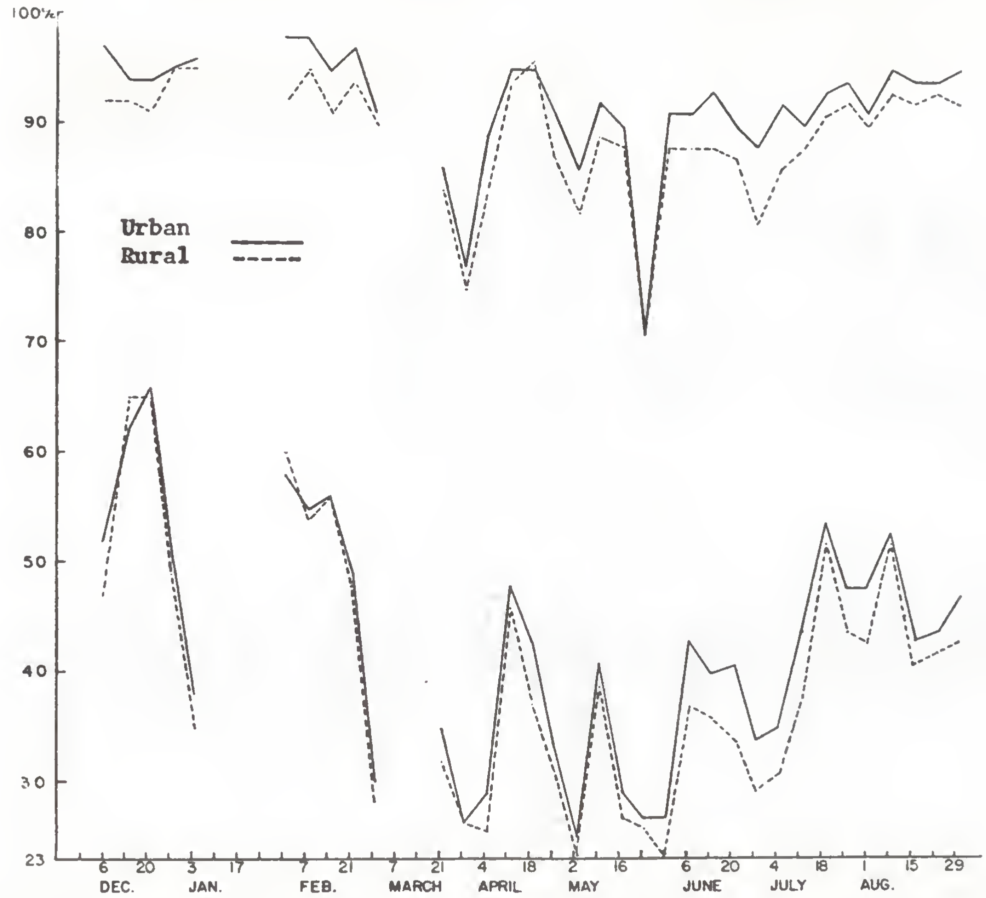

Fig. 4. A comparison of the weekly mean maximum and minimum relative humidity of the urban and rural weather stations. Data for the weeks of Jan. 10,17,24, & March 7 & 14 not available.

Fig. 6. Essentially the hygrometer charts are smaller mirror images of the thermograph records.

Table 1. Paired T test on the minimum and maximum weekly mean differences of relative humidity and temperature; and the weekly total differences of air movement and precipitation between the urban and rural weather stations.

Treatments	n	t
Maximum Temperature	35	4.05*
Minimum Temperature	35	10.34*
Maximum Relative Humidity	34	9.30*
Minimum Relative Humidity	34	6.33*
Air Movement	38	18.15*
Precipitation	22	1.55**

*Indicates significance at .01
**Indicates no significance

The rural and especially the urban mean maximum relative humidities became more stable from June 13 through the end of the study. The occurrence of general lawn irrigation throughout the city had no apparent effect on the urban relative humidity. Only lawn irrigation in the immediate area of the station raised the relative humidity to any degree. As seen in Fig. 6, the relative humidity of the urban station was raised over 25 per cent by lawn irrigation around the station. The major portion of the recorded precipitation occurred during the same time. Air movement, as seen in Fig. 1, was also lower from June 13 through September 6 with the exception of the week of June 27 which was followed by the lower weekly mean maximum and minimum relative humidity of July 4. Figure 4.

The general area was experiencing a drouth until June 18, 1966, when .50 in. of rain fell at the urban station and .30 in. fell at the rural station. Table 2.

Higher temperatures had an adverse effect on the per cent of relative humidity.

Precipitation

A major portion of the precipitation fell as rain in June, July and August at both stations. Figure 5. A small amount of snow fell in December and January. The urban station recorded 17.09 inches of precipitation for the entire sampling period, while the rural station sampled 14.04 inches of precipitation. No significant difference was found between the two stations. Table 1.

The urban U.S.W.B. cooperative weather reporting station reported 16.87 in. of precipitation compared to 16.53 in. recorded at the urban station during the same recording period. These differences were not significant.

The summer rainy period was accompanied by lower weekly air movements, a more stable temperature with less weekly mean variation, and with a more stable maximum weekly mean relative humidity and higher minimum weekly mean relative humidity.

Table 3, in comparing the storm precipitation received at the rural station and a rural U.S.W.B. station which is 13 miles north of

Table 2. A comparison of storm precipitation in inches at the urban, rural, and urban U.S.W.B. stations during the study period of December 6 to August 29.

Storm Dates	Urban	U.S.W.B.(urban)	Rural
12-10-1965	.10	.08	.09
12-11	T	--	.01
12-14	.50	.43	.18
12-15	.11	.14	.07
12-23	.15	.18	.13
1-15-66	.34	.59	.34
1-20	.60	.40	.22
2-8	.42	.46	.33
3-21	.04	.04	T
4-12	.10	.11	.11
4-14	.05	.04	.05
4-20	.17	.24	.17
5-19	.12	.11	.12
6-7	.02	.02	.03
6-9	.04	.04	.04
6-19	.50	.51	.30
6-22	.81	.92	.55
6-27	.88	.71	.77
7-7	2.84	3.07	1.36
7-15	2.00	1.91	1.20
7-21	2.40	1.68	1.82
7-29	.97	1.21	1.58
8-7	.46	.66	.54
8-12	1.87	1.90	1.99
8-20	1.04	.89	1.50
9-3	.56	--	.44

Scott City, shows as much as 2.28 inches difference in the amount of precipitation received from the storm of July 21.

The monthly precipitation pattern of the rural and urban stations differs from the 30 year monthly average at Scott City as seen in Fig. 5.

Table 3. A comparison of the storm precipitation in inches for the summer months at the rural station and the U.S.W.B. rural station 13 miles north of Scott City.

1966 Storm Date	Rural	U.S.W.B.(rural)
6-7	.03	.03
6-9	.04	.06
6-11	--	.26
6-13	--	.17
6-19	.30	.23
6-22	.55	.28
6-27	.77	.39
7-7	1.36	.35
7-15	1.20	.63
7-21	1.82	4.10
7-22	--	.41
7-29	1.58	1.07
8-7	.54	.46
8-10	--	.71
8-12	1.99	.65
8-20	1.50	.73
8-24	--	.07

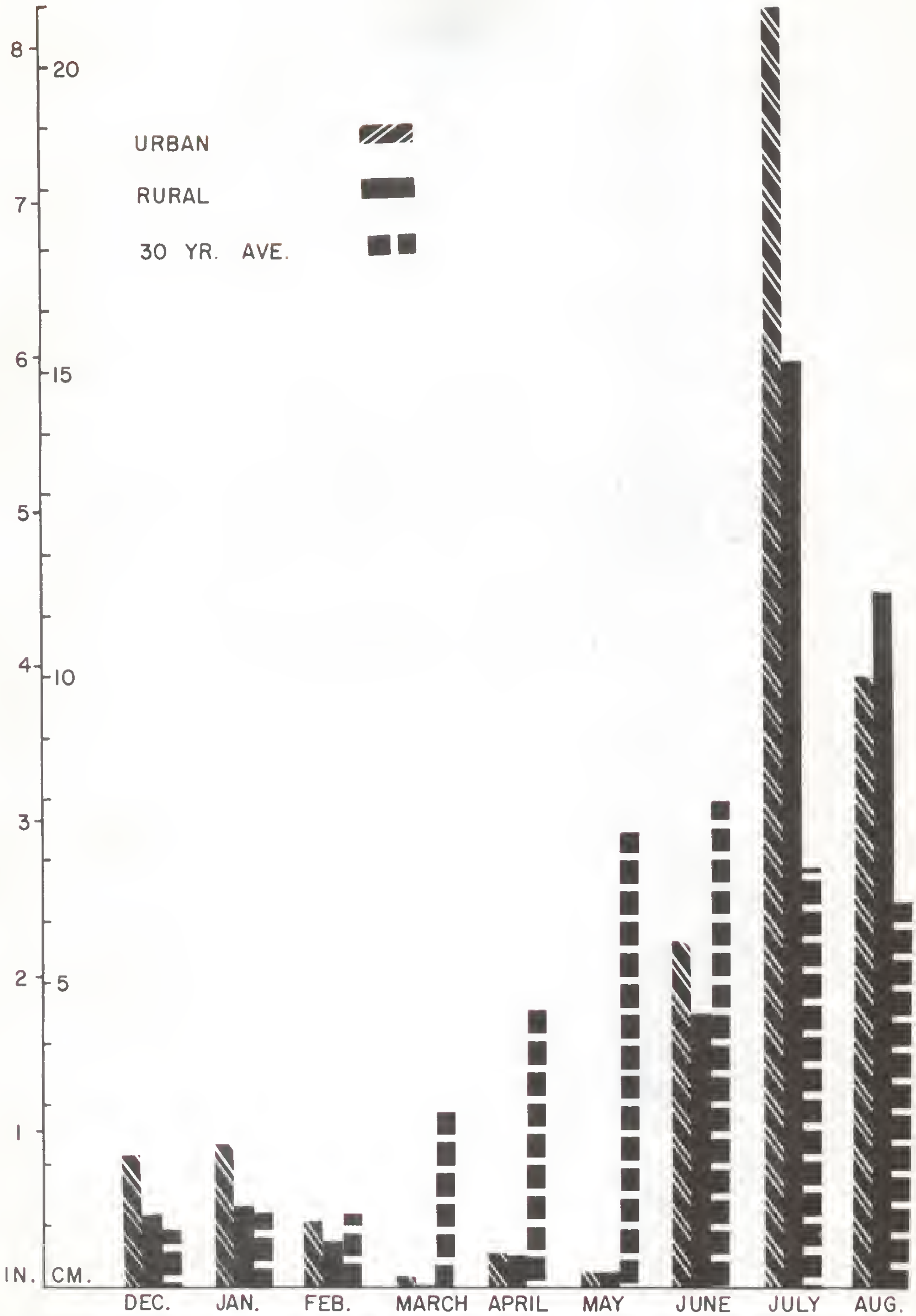

Fig. 5. Comparison of monthly precipitation of the urban, rural, and the 30 year average at Scott City from 1931 to 1960.

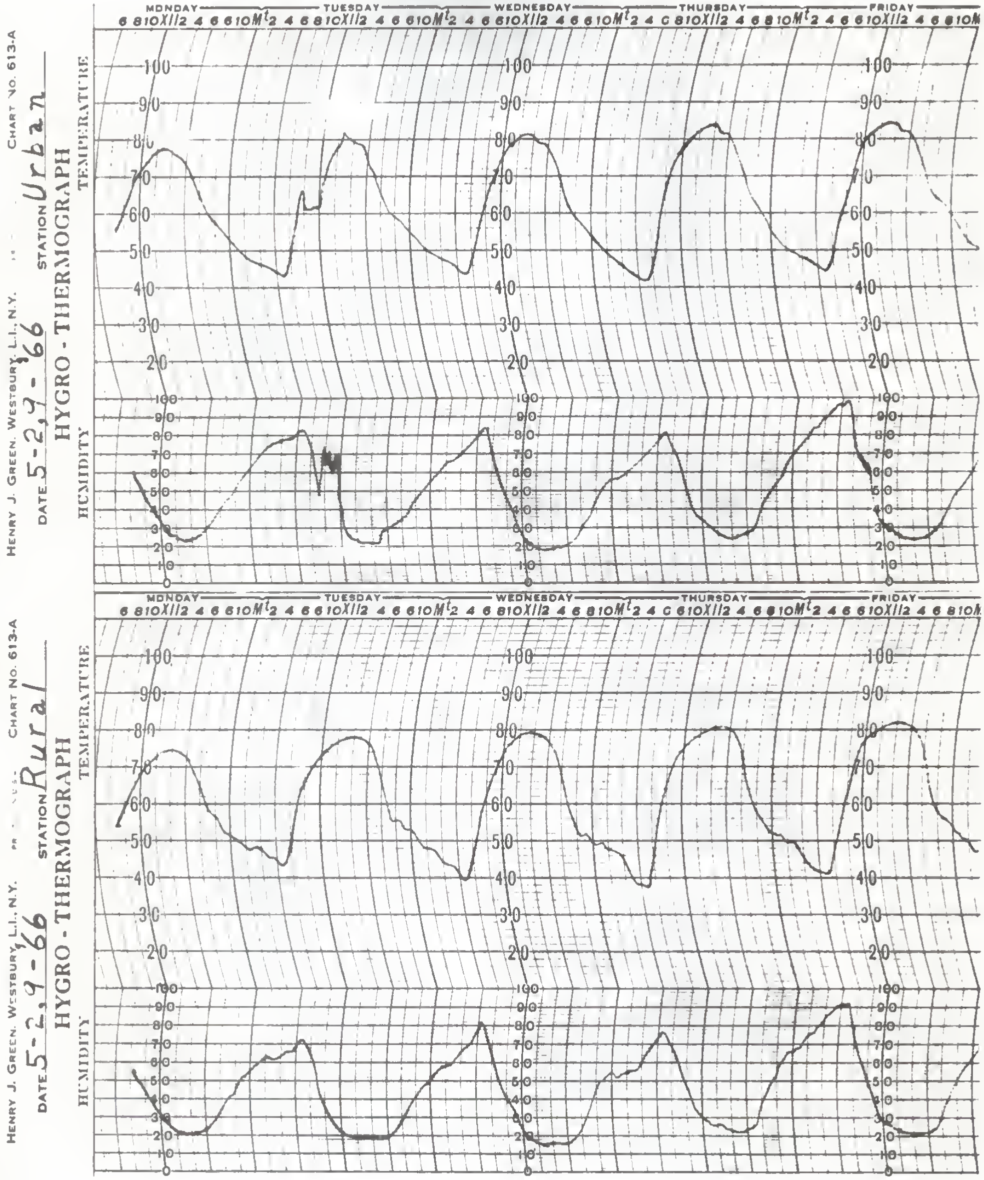

Fig. 6. Reproduction of graphs made by the urban & rural stations during the week of May 2, 1966.

DISCUSSION

Air Movement

The fact that there was less horizontal air movement in the city was due to the windbreak or forest effect of the large number of trees in the city.

The station was located in an area representative of the major residential area of the city.

Of the two weeks of extremely high rural horizontal air movement, March 7 and June 27, only the week of March 7 observed high air movement at the urban station because of the northerly wind direction and the relatively more open area to the north of the urban station. Figure 1.

High air movement is one of the important characteristics of the macroclimate of the high plains. The rural air movement of the weeks of March 7 and June 27 averaged nearly 18 miles per hour. This confirms Robb's (21) observations of the highest monthly average wind speed of about 17 miles per hour during March.

In general the urban winter and spring readings were higher because of predominant northerly winds and the more open area to the north of the station, as well as the fact that the trees were bare.

Southerly winds prevailed during the late spring and summer months and the canopy had closed causing a more dense canopy, which resulted in considerably less air movement in the urban area as compared to the rural area. This illustrates the effect of windbreaks which agrees with studies by Franklin (6), Rider (20), Jaworski (15), Guyot (9), and Molga (19).

Maximum and Minimum Temperature

The faster rise and earlier occurrence of the maximum temperature in spring during sunny days at the rural station, was due to the quicker radiant heating of the surface, causing a sharp rise in rural temperature on sunny spring mornings. The mixing effect of air currents near the ground develops a stabilizing effect which flattens and broadens the thermal peak for the day, which agrees with Geiger's (8) studies. After mid-afternoon the gradual decline becomes quite sharp until near 10:00 p.m. where it again starts a gradual decline until sunrise. The mid-afternoon decline is primarily due to the change from incoming radiation to outgoing radiation at the earth's surface. Figure 6.

Gates (7) agreed that most meterological data are reported as averages, but it is the extremes that have the greatest effect on plants and animals. Evidence of less extreme temperatures in the city, mentioned in the results, can be found in the established plants. Plant materials not adapted to the high plains area that are thriving in the city include: Albizia julibrissin, Betula pendula, Salix babylonica, Taxus cuspidata and Thuja occidentalis.

Less spring and summer variation between the maximum and minimum temperatures was reported at the urban station because of the effect of shading from trees in the city by day, and the re-radiation from water vapor and CO_2 in the air, trees, buildings, streets, etc. at night, as found by Chandler (3) and Mitchell (18). The brief plateau recorded on the thermograph on sunny spring afternoons at the urban station was caused by a short period of direct shading from a huge tree near-by which was intercepting the sun's radiant heat. Later in the season the sun's angle narrowed, thus eliminating the shade on the station.

Chapman et al. (4) and Wolfe et al. (27) also found that the predominantly higher winter and spring urban temperatures, shown in Fig. 2, were the result of the windbreak effect of the many trees in the city and from the radiation and re-radiation previously discussed.

The urban U.S.W.B. station's variations in temperature from the urban station under study is attributed to the less dense canopy of trees near it's location.

Relative Humidity

The main source of water vapor for the air layer near the ground comes from the soil, according to studies of Franklin (6), and Chandler (3). Droughty soil conditions during the spring of 1966 prevented a very high concentration of water vapor in the air.

Relative humidity is the per cent saturation of the atmosphere at an ambient temperature. Due to little evaporation from the dry soil and increased temperatures the relative humidity was approximately 10 per cent lower during the spring.

The lowest relative humidity recorded was 11 per cent on June 4 at the rural station and was associated with high and dry horizontal air movement. The urban relative humidity was only 3 per cent higher at the same time. However, humidity records as low as 3 per cent are reported by the U.S.W.B. for this area.

Dry winds coupled with warm temperatures reduced the minimum relative humidity considerably because of more uniform mixing at the level at which the hygrometer was located.

Minimum relative humidity normally occurs during the day time when winds and temperatures tend to be the highest, causing faster air mixing and eddy diffusion, which agrees with Humphreys (12) and Sprague (22). Extreme maximum relative humidity was most frequently associated with cold, still, early, winter mornings.

The higher weekly mean maximum and minimum relative humidities in the urban area, Fig. 4, during the late spring and summer developed as a result of the vegetation reducing the air movement by the windbreak effect, by lower daily temperatures from reduced solar radiation, irrigation of lawn, and plant transpiration.

High relative humidity in the winter primarily resulted from the reduced temperature and lower saturation point of the atmosphere. The windbreak effect would still apply to the urban station though somewhat reduced.

Geiger (8) reported that lower night time temperatures coupled with decreased eddy diffusion and increasing water vapor content raises the relative humidity in the air near the ground. This process is reversed shortly after sunrise as the soil warms and heats the atmosphere near it which increases its saturation point until mid-afternoon.

The evaporation of rain water or dew from vegetation and moist surfaces aids in prolonging the night relative humidity.

Precipitation

The fact that weather records show June as having the highest average rainfall and July as having a sharp decrease, as reported by Bark (1), indicates that 1966 was not a normal year as far as precipitation is concerned. See Fig. 5.

The sampling of 17.09 in. of precipitation at the urban station and 14.04 in. at the rural station represents the erratic type of thunderstorm that can develop in a continental macroclimate of the Great Plains. Table 2.

The thunderstorm type precipitation predominates in the Great Plains. The amount of precipitation varied as much as 2.28 in. within a few miles as seen in Table 3, for the storm of July 21.

Weaver and Albertson (26) reported that climatic conditions over the "Mixed Prairie" experience large scale fluctuations which is illustrated by the different monthly precipitation patterns in Fig. 5.

Differences in precipitation samples at the two stations may also be attributed to inaccurate sampling by the gauges. Hamilton (10) discussed the error in vertical gauge sampling versus the accuracy of a tilted and oriented gauge. Landsberg (17) agreed that precipitation data only represents a sample of the amount of precipitation and not a measurement.

In open areas where rain or snow may be driven at acute angles by the wind, a smaller portion of the opening of the gauge could receive the precipitation. In the same sense in protected areas, trees may intercept the precipitation before it reached the gauge.

Variations shown in Table 2 between the U.S.W.B. urban station, and the urban station may be in the degree of protection received at each location.

Precipitation builds up the reserve moisture in the soil which later is evaporated, used by plants, stored or lost by other means. A moist soil has a direct effect on the relative humidity. This evaporation takes place over a period of time and tends to stabilize relative humidity.

The anomaly in the urban hygrothermograph chart, Fig. 6, on Tuesday morning was caused by the sprinkler irrigation of the lawn near the station. The temperature lowered to near the diurnal mean temperature until the irrigation had finished. Also the relative humidity raised considerably during the irrigation. The sharp peak at 2:30 p.m. Tuesday identified the checking time when the thermograph was exposed to direct solar radiation.

Of the 26 storms during the study period, the 12 through June, July and August yielded over 84 per cent of the precipitation. Table 2. According to Robb (21) nearly 50 thunderstorms occur yearly in Scott County. Blizzards consisting of fine snow, strong winds, and intense cold are also characteristic of weather in the great plains.

SUMMARY

The main objective of this study was to better understand the cause and effects of a city microclimate within a Great Plains macroclimate.

Weather data taken from an urban and a rural location were used as the quantitative data for the study. Supporting data was taken from two U.S.W.B. stations in the area.

A comparative analysis of urban and rural air movement, temperature, relative humidity, and precipitation was made.

Over four times more horizontal air movement (59,781 miles) was recorded at the rural station than at the urban station (14,604 miles). The highest air movement at the rural station was from March through June. The urban station received its highest air movements during the winter and spring because of less protection from the dormant deciduous trees and more exposure to the prevailing northerly winds.

The rural station had 1.77^{o}F more variation between the weekly mean maximum and minimum temperatures for the study period than did the urban station.

The urban weekly mean maximum relative humidity was 2.68 per cent higher than the rural weekly mean maximum. The urban weekly mean minimum relative humidity was 2.48 per cent higher than the rural weekly mean minimum.

Over 84 per cent of the precipitation fell as rain in June, July and August at both stations. The urban station received 3.05 more inches of precipitation than the rural station for the entire study period.

Supplemental watering of horticultural plants is generally required to insure their existence in the area studied.

Horticultural plant varieties not recommended or adapted to the macroclimate of the area have been planted and are growing in the city.

Many horticultural plants adapted to the macroclimate show more mechanical injury and less vigor in unprotected rural areas as compared to the protected urban areas.

A more accurate and comprehensive study is needed to determine the more significant causes of a microclimate and to determine the extent of interaction between the various climatic factors.

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A CITY MICROCLIMATE IN THE MACROCLIMATE OF THE GREAT PLAINS

by

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This study compared the climatic conditions at two weather stations located in Scott County, Kansas, during the winter, spring and summer of 1966. One station was located within Scott City while the other station stood on an open plain near the city. The weather data collected included: temperature, relative humidity, precipitation, and horizontal air movement. The hygrothermographs were housed in U.S.W.B. shelters approximately one and one-half meters above ground level. The totalizing anemometer was located atop the shelter approximately two and one-half meters above the ground level. Readings were taken weekly and checks were made periodically during the week.

The statistical results showed that there was a significant difference between the two stations in all treatments except precipitation.

The horizontal air movement recorded at the rural station was 59,781 miles while the urban station recorded 14,604 miles during the study. Greater differences in air movements occurred during the spring and early summer between the two stations. The highest urban air movements occurred during the winter and early spring.

A maximum of 106°F and a minimum of a -12°F was recorded as the extreme temperatures at the rural station, which was 3°F higher and 5°F lower than the extremes at the urban station. The urban station consistently had higher weekly mean temperatures in the winter and spring than did the rural station.

The urban weekly mean maximum relative humidity averaged 2.68 per cent higher than the rural weekly maximum. Both stations have a less variable mean maximum relative humidity during the summer. The urban station showed more stability. Extreme maximum relative humidity occurred more frequently during winter. The lowest relative humidity of 11 per cent was recorded at the rural station, June 4, which was 3 per cent lower than the urban station at that time. Essentially the hygrometer charts are smaller mirror images of the thermograph charts.

Contrary to the normal rainfall pattern, of less rain during July than June and August, the month of highest precipitation during the study was July. The urban station received 3.05 in. more precipitation than the rural station for the total study period.