AN ANALYSIS OF FACTORS AFFECTING NEAR-GROUND TEMPERATURE DIFFERENCES BETWEEN THREE MID-WILLAMETTE VALLEY STATIONS

ABSTRACT: Significant temperature differences were found to exist among three similarly situated stations in the Mid-Willamette Valley of Oregon. The stations were McMinnville, Salem, and Corvallis. Factors known to influence temperatures were compared with the temperature differences of the stations using available weather data. Factors examined included elevation, latitude, cloud cover, precipitation, heat islands, slope, aspect, ground cover, surrounding terrain, cold air drainages, and obstructions to air flow. No one single factor fully explained the temperature differences among the three stations.

AN ANALYSIS OF FACTORS AFFECTING NEAR-GROUND TEMPERATURE DIFFERENCES BETWEEN THREE MID-WILLAMETTE VALLEY STATIONS

by

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AN ANALYSIS OF FACTORS AFFECTING NEAR-GROUND TEMPERATURE DIFFERENCES BETWEEN THREE MID-WILLAMETTE VALLEY STATIONS

PURPOSE AND OBJECTIVE

The purpose of this study was to determine whether or not significant differences in temperatures existed between three selected Mid-Willamette Valley weather stations, and if significant differences were found, to identify the factors influencing the temperature differences and to measure their effects.

STATIONS

Three stations were selected based on their positions in the Willamette Valley, their positions along a north-south line, their nearly equidistant separation along this north-south line, their similarity in elevation, and their freedom from unusual influences such as the major cold air drainage through the Columbia Gorge or the air stagnation problems at the upper (southern) end of the valley.

TABLE 1

SELECTED STATIONS

Station	Latitude	Longitude	Elevation, Ft.	Observer
McMinnville	44 14	123 11	148	Radio Station KMCM
Salem	44 55	123 01	196	Nat. Weather Svc.
Corvallis	44 38	123 12	225	Oregon State Univ.

Source: NOAA, Climatological Data, Oregon

PRELIMINARY SURVEYS AND DATA SELECTION

To test the probability of temperature differences between stations an initial random sampling of thirty observations was taken from a population of 1000 days (January 1, 1972 to August 17, 1974, Appendix A) from National Oceanic and Atmospheric Administration (NOAA) Climatological Data, Oregon (1). This survey showed significant temperature differences. In looking at the data some unexpected facts emerged: the average maximum temperature and average daily range increased from the southernmost station, Corvallis, to the northernmost station, McMinnville, and the average minimum temperature decreased.

A subsequent survey consisting of a random sampling of 100 observations from a population of 10,000 days (January 1, 1948 to May 18, 1975) taken from NOAA, Climatological Data, Oregon, showed identical relationships to the results of the initial survey.

A serious problem emerged when it was discovered that the Corvallis station, up to May, 1952, had moved their instruments twice-a-year. During the autumn and winter months, the instruments were moved from a rooftop location to a nearby ground site. Furthermore, on May 22, 1952, the entire weather station was moved from the Corvallis State College campus to a new position six miles to the northeast (2).

The semi-annual changes in instrument positions made the observations unreliable for purposes of this study. The distance of the station move was also too great to retain reliable continuity of data. Therefore, all manipulations of data from this survey are based on random sampling of 81 observations from a population of 8,395 days (May 23, 1952 to May 18, 1975, Appendix B).

Further examination of data revealed more station changes, however,

these were not of such magnitude as to affect temperature and precipitation readings (Table 2).

TABLE 2

CHANGES IN STATION LOCATIONS AND NAMES

Date	Station	Change and Information Source
Apr 9, 1958	Corvallis St. Coll.	All equip. moved 0.3 miles ENE. Vol. 64, No. 13, p. 227.
Dec 1958	McMinnville	All equip. moved 100 ft. SSW. Vol. 58, No. 13, p. 195.
Jul 27, 1960	McMinnville	All equip. moved 120 ft. SSE. Vol. 66, No. 13, p. 229.
Oct, 1963	McMinnville	Equip. moved 20 ft. ESE. Vol. 69, No. 13, p. 255.
May 27, 1969	McMinnville	Equip. moved 160 ft. W. Vol. 75, No. 13, p. 251.
Feb 1972	Corvallis St. Coll.	Changed to Corvallis, OSU. Vol. 78, No. 13, p. 271.

Source: NOAA, Climatological Data, Oregon

Complete temperature and precipitation data were not available for all three stations. For the period 1953 through 1975 only the Salem data were complete. Corvallis data were complete for only 21 years, and McMinnville data were complete for only eight of the 23 years.

At this point, the decision was made to use only those years which yielded complete data for all three stations (Appendices C, D, E, and F). The selected years were: 1953, 1956, 1958, 1959, 1965, 1966, 1967, and 1971.

To avoid confusion as to the data source, the term "eight-year data" will be used when discussing data from these eight years, and "survey

data" will be used in reference to data obtained from the second random sampling.

INSTRUMENTATION

Temperature recording instruments were not standard among the three stations (Table 3).

TABLE 3

TEMPERATURE RECORDING INSTRUMENTS

Station	Instrument
McMinnville	Minimum and maximum thermometers in Stevenson screen
Salem	Hygrothermometer in continuously aspirated thermal shield
Corvallis	Minimum and maximum thermometers in Stevenson screen

TEMPERATURE

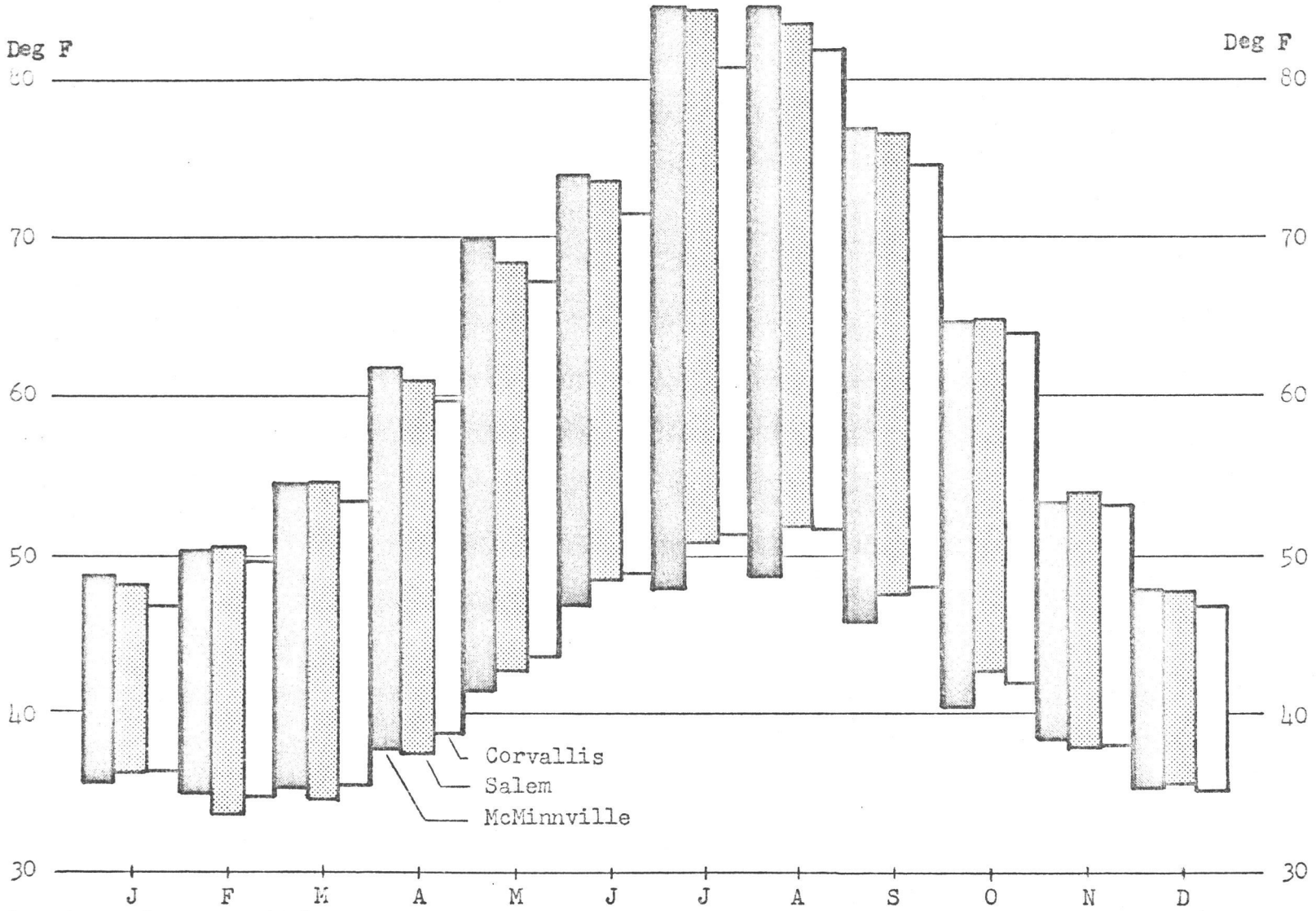
The existence of significant temperature differences among stations were shown in the eight-year temperature data (Table 4 and Figure 1)[1].

TABLE 4

AVERAGE ANNUAL TEMPERATURES

	McMinnville	Salem	Corvallis
Maximum	64.15	63.76	62.28
Minimum	40.63	41.45	41.84
Average	52.36	52.64	52.30
Range	23.51	22.31	20.44

1 NOAA, Climatological Data, Oregon, the main source of information for this study, records temperature in degrees F., precipitation in inches,



Based on eight-year data

Figure 1. Three station comparison of average monthly maximum, minimum, and range.

In comparing McMinnville with Salem the following observations were noted; McMinnville had:

1) higher average maximums in all months except February, March, October, and November, and of these four months, the differences for February and October were insignificant;

2) lower average minimums from May through October, and in December; and

3) wider ranges in all months except in February, March, and November.

In comparing Salem with Corvallis, the following observations were notable; Salem had:

1) higher average maximums in every month;

2) lower average minimums from March through July and in September; and

3) wider ranges in every month.

For all three stations, the temperature ranges increased during the spring and summer months. This was attributable to the increased number of clear days which allow greater solar heat loading during the daylight periods and greater loss of radiant energy from the ground and lower atmosphere during the nights.

The amount of solar radiation transmitted to the earth's surface is the primary direct determinant of near-surface temperatures. Unfortunately, radiation data in langleys was available only for the Corvallis station. Therefore comparisons using this factor were not possible.

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elevation in feet, and horizontal distance in feet and miles. These units of measurement are used throughout this paper for the sake of consistency.

The amount of solar radiation available to strike the surface is influenced by several factors, the most important being cloud cover. Cloud cover data were available only for Salem and Corvallis. Corvallis had a significantly greater number of clear and partly cloudy days (Table 5).

TABLE 5

CLOUD COVER

Station	Sky Condition		
	Clear	Partly Cloudy	Cloudy
Salem	75	87	203
Corvallis	106	130	129

Source: NOAA, Climatological Data, Oregon.
Based on 30-year period, 1931-1960

The figures in Table 5 would lead one to assume that Corvallis would have a higher average maximum temperature, a lower average minimum temperature, and an associated smaller average temperature range. However, the data in Table 4 has shown that the exact opposite was true.

Another factor influencing the amount of incident solar radiation is the difference in latitude. In this study, the latitudinal differences between the northernmost and southernmost stations amounted to only 24 minutes, a unit too small to explain the observed temperature differences.

Elevational differences did not contribute much to the explanation of the differences in average annual temperature (Table 6).

Another method of checking temperature differences among stations is by examination of freeze data and length of frost-free periods. The information in Tables 7 and 8 reinforce the conclusions drawn from the data in Table 4 and Figure 1.

TABLE 6

COMPARISON OF ACTUAL WITH EXPECTED TEMPERATURES DUE TO ELEVATION

Station	Difference in Elevation, Ft.	Expected Temp. Diff., Deg F.*	Observed Temp. Diff. Avg. Max.	Avg. Min.
McMinnville: Salem	48	0.17	0.39	-0.82
Salem: Corvallis	29	0.10	1.48	-0.39

* Based on Griffith's (1966) general lapse rate of 3 degrees F/1000 ft (3).

TABLE 7

AVERAGE DATES OF SELECTED FREEZING TEMPERATURES

Station	Average Last Spring Min. of 28 Deg or Below	Average Last Spring Min. of 32 Deg of Below	Average First Fall Min. of 28 Deg or Below	Average First Fall Min. of 32 Deg or Below
McMinnville	Apr 9	May 18	Oct 3	Nov 4*
Salem	Apr 1	May 4	Oct 23	Nov 5*
Corvallis	Mar 16	Apr 19	Nov 3	Nov 18

* The "28 Degree or Below" data from the year 1965 for Salem and McMinnville appear to be anomolies or recording or reporting errors (Appendix G). A 65-day difference was reported (Salem: Sep 17, McMinnville, Nov 25). When these questionable dates were deleted, the new computed average dates were Salem: Nov 5, and McMinnville: Nov 4. These latter dates were used in Tables 7 and 8.

TABLE 8

FROST-FREE PERIODS

Station	Day of Year From	To	Nr. Frost-Free Days
McMinnville	138	308*	170
Salem	124	309*	185
Corvallis	109	322	213

* Based on the Nov 4 and Nov 5 dates in Table 7.

PRECIPITATION-TEMPERATURE RELATIONSHIPS

The cooling power of evaporation is known to affect ground and air temperatures (4). Therefore, precipitation was suspected of being partly responsible for the temperature differences among the stations. However, no distinct correlation was found between annual precipitation and lowest average maximum and minimum temperatures.

TABLE 9

COMPARISON OF ANNUAL PRECIPITATION WITH TEMPERATURES

Station	Average Annual Temp. in Deg. F.	Average Annual Precip. in Inches
McMinnville	52.36	42.64
Salem	52.64	39.90
Corvallis	52.30	42.02

If precipitation significantly affected near-ground air temperatures, the temperatures at the station recording precipitation could also be expected to record the lowest temperatures. Comparison of precipitation, when occurring at only one station, with the lowest maximum and minimum temperatures showed no significant correlation. Instead, the number of occurrences were distributed as would be expected if all conditions were identical, both for precipitation on day of (Table 10) and precipitation on day before (Table 11) the date of temperature readings.

An interesting observation is that for the lowest maximum temperatures, all of the recorded "yeses" for both precipitation on day of and precipitation on day before were for the Corvallis station. This phenomenon deserves further investigation.

TABLE 10

COMPARISON OF PRECIPITATION (DAY OF) WITH TEMPERATURES

Date	Station Recording Precipitation	Station Recorded Lowest Maximum	Minimum
Jan 14, 1955	Salem	No	No
May 18, 1960	McMinnville	No	No
May 13, 1962	Corvallis	Yes	No
Sep 11, 1963	Corvallis	Yes	No
Nov 23, 1963	Corvallis	No	No
Apr 6, 1965	McMinnville	No	Yes
Jan 7, 1967	Corvallis	No	Yes
Apr 18. 1968	Corvallis	Yes	No
Mar 5, 1970	Salem	No	Yes
Feb 14, 1973	Salem	No	No

TABLE 11

COMPARISON OF PRECIPITATION (DAY BEFORE) WITH TEMPERATURES

Date	Station Recording Precipitation	Station Recorded Lowest Maximum	Minimum
Jul 9, 1953	McMinnville	No	Yes
Feb 14, 1955	Corvallis	No	No
Jul 3, 1955	Corvallis	Yes	No
May 6, 1960	Corvallis	No	Yes
Aug 18, 1962	Salem	No	No
Oct 15, 1966	Corvallis	Yes	Yes
Mar 5, 1970	Corvallis	No	No
Apr 29, 1970	Corvallis	No	No
Feb 14, 1973	McMinnville	No	Yes
Mar 26, 1975	Corvallis	Yes	No

HEAT ISLAND

The occurrence of heat islands have been reported in numerous articles (5, 6). Heat islands are caused by the local increase in the heat capacity of urbanized areas. The areas of higher temperatures are usually centered over the commercial city centers. Rates of temperature changes in relationship to distances from the true heat islands in some of the studies are shown in Table 12.

TABLE 12

HEAT ISLAND TEMPERATURE-DISTANCE RELATIONSHIP

City	Distance in Miles of Expected 1 Deg. F. Temp. Change
San Francisco	0.30 - 0.40
San Jose	0.15 - 0.25
Palo Alto	0.05 - 0.15
Corvallis	0.07 - 0.15

Sources: E. T. Stringer, Techniques of Climatology. W. H. Freeman and Co., San Francisco, 1972
Richard J. Hutcheon, Richard H. Johnson, Wm. P. Lowry, Charles H. Black and Donald Hadley, "Observations of the Urban Heat Island in a Small City" in Bull. of Am. Met. Soc., Vol. 48, 1967, p. 7-9.

The Corvallis study by Hutcheon, et. al., reported temperature ranges of 13 degrees F. on Jan 31, 1966 and 10 degrees F. on April 18, 1966. Using the higher temperature range of 13 degrees F. and the higher distance per 1 degree F. change, and relating them to the McMinnville, Salem and Corvallis stations, we can expect that the Salem and Corvallis stations would be outside the area affected by the urban heat islands (Table 13).

TABLE 13

DISTANCE AND DIRECTION OF STATIONS FROM POTENTIAL URBAN HEAT ISLANDS

Station	Distance in Miles From Central Business District	Direction in Degrees CBD to Station
McMinnville	1.4	43
Salem	3.1	143
Corvallis	6.0	38

The McMinnville station could possibly be affected by the urban heat island. However, the probability would be very low if several factors are considered. First, the city size is much smaller than Corvallis and would therefore possess a smaller heating capacity. Second, in the California studies, it was assumed that 4 degrees F. was the lowest urban-rural differential of interest or practical value. If this assumption was also applied to McMinnville, the station would not be within the area influenced by the heat island. Third, even if the first two considerations were not taken into account, the prevailing winds would extend the urban heat plume or flow only during the late autumn and winter months. Figure 1, however, has shown that during the seven-month period of October through April, when prevailing winds could cause air flow from the Central Business District (CBD) to the station, McMinnville showed average maximum temperatures higher than those of Salem only in January and April. Therefore, heat islands appear not to significantly affect the temperatures at the McMinnville station.

SITE FACTORS

The Salem and Corvallis stations were situated on level sod covered ground with no nearby obstructions to wind flow (Figures 2-4). The temperature recording instrument at Salem is located between the runways. The large expanse of paved area in Figure 2 is the parking ramp which is several thousand feet from the instruments.

Figure 2. Salem station. Shelter is white speck in the center of the white circle. View is to the southeast.

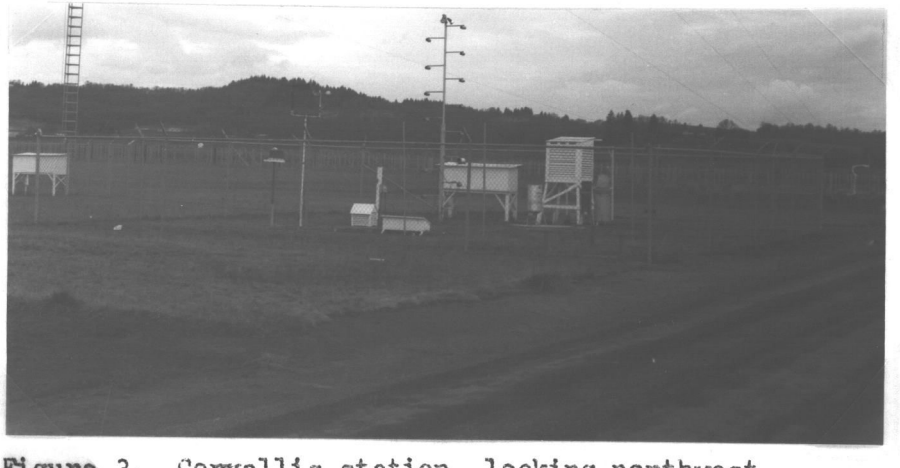

Figure 3. Corvallis station, looking northwest.

Figure 4. Corvallis station, looking southeast.

The McMinnville station was the only station situated on sloping ground. The instrument shelter was near the midpoint of a very slight rise on the northeast facing slope (Figure 5). From the shelter the ground sloped downward at 4 degrees over 150 feet to the bottom of a shallow drainage basin. The instruments were at a level 10 feet higher than the low spot visible at the base of the radio tower.

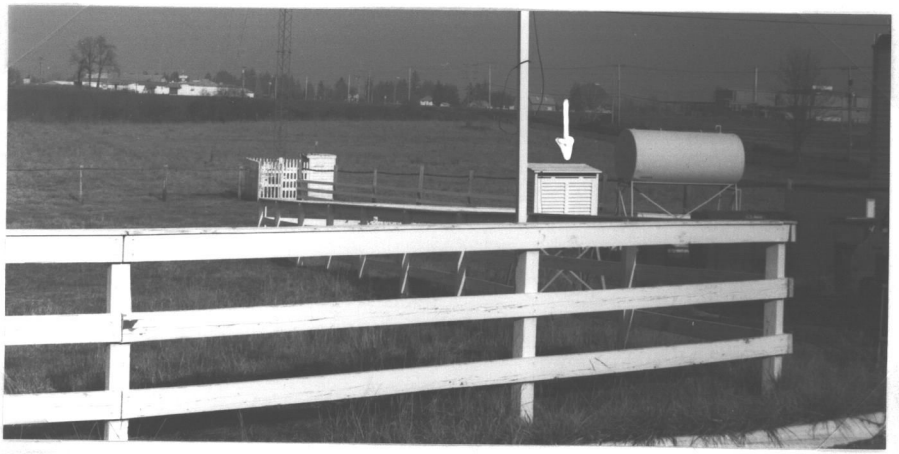

Figure 5. McMinnville station, looking northeast.

Tall equipment sheds up to 24 feet in height were within 100 feet to the west of the shelter. There was also a wooded area with trees over 50 feet in height just beyond the sheds (Figure 6).

Figure 6. McMinnville station, looking northwest.

On the eastern side of the instrument shelter stands the building housing the radio station. This building is 20 feet high and blocks winds from directions ranging from 50 to 95 degrees (Figure 7)

Figure 7. McMinnville station, looking east.

The reliability of the McMinnville station temperatures as being representative of the ambient near-ground temperatures is doubtful because of the probable turbulence-causing effect of the nearby obstructions.

COLD AIR DRAINAGE

Cold air, because of its greater density than warmer air, will tend to flow downhill in similar manner to water (7,8,9). Thus, air drainage patterns can be perceived by examining topographic maps in a manner similar to visualizing surface water drainage patterns by examining contour lines on maps.

Using this technique the three sites were evaluated in relationship of surrounding terrain to the expected general and local cold air drainages. McMinnville was found to be the most affected by cold air drainages from the nearby Coast Range. The funnel shaped pattern of nearby hillsides appeared to concentrate the downward flowing cold air directly over the McMinnville station.(Figures 8, 9).

Salem was affected to a lesser degree. Some of the cold air draining down the North Santiam River valley appeared to flow over the Salem station. This station is situated on a long, flat, low area which could also act as a frost hollow (Figures 10, 11).

Corvallis was the least affected. It was partially protected from the Coast Range air drainages by Logsden Ridge. The station's position on a slight rise provided further protection against cold air encroachment (Figures 12, 13).

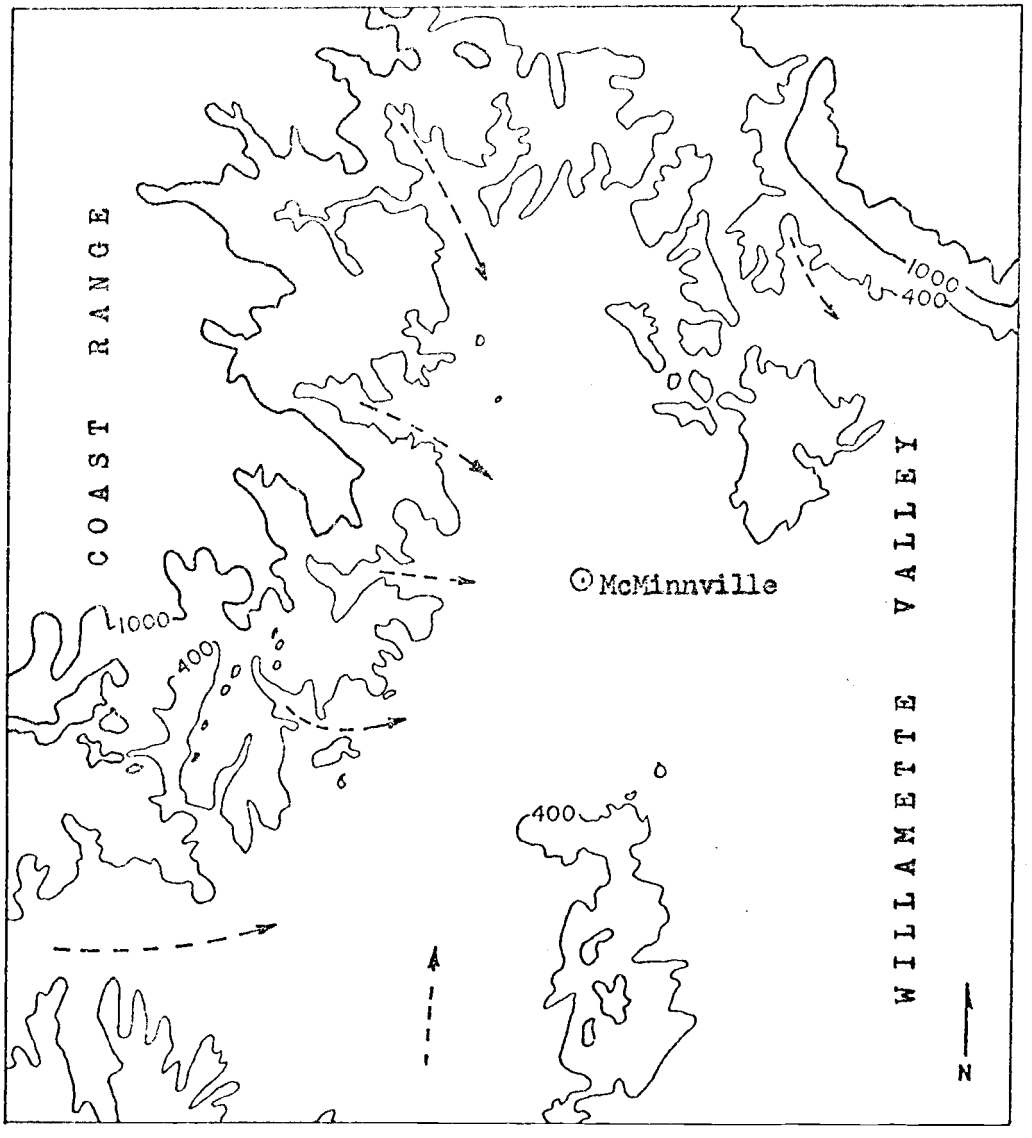

Figure 8. Expected General Cold Air Drainages, McMinnville.
Scale approx. 1:360,000 Only 400 and 1000 ft. contours.
Contours generalized from USGS map, 1:250,000

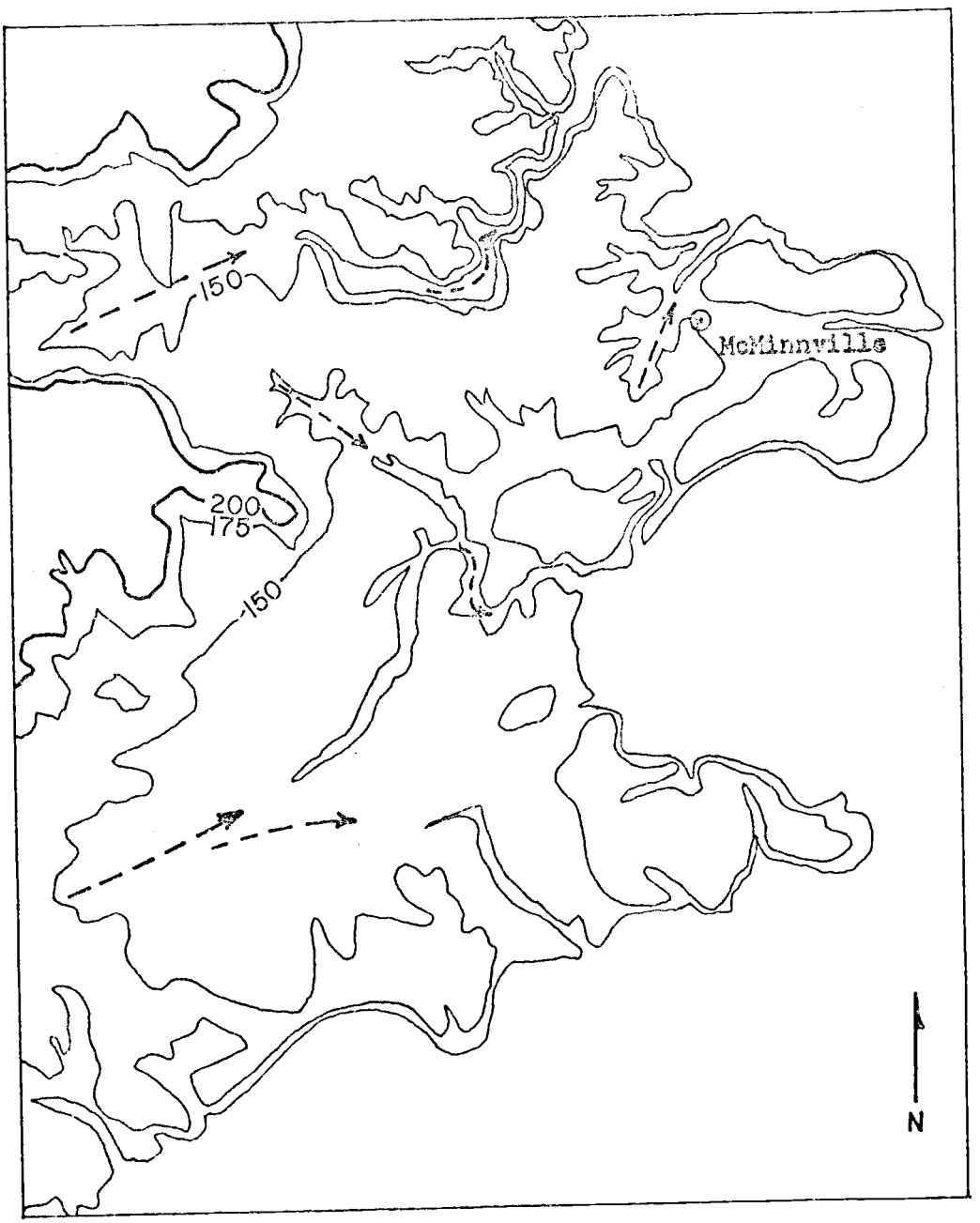

Figure 9. Expected Local Cold Air Drainages, McMinnville.
Scale 1:62,500 Only 125 to 200 ft. contours shown.
Contours generalized from USGS Map, 1:62,500

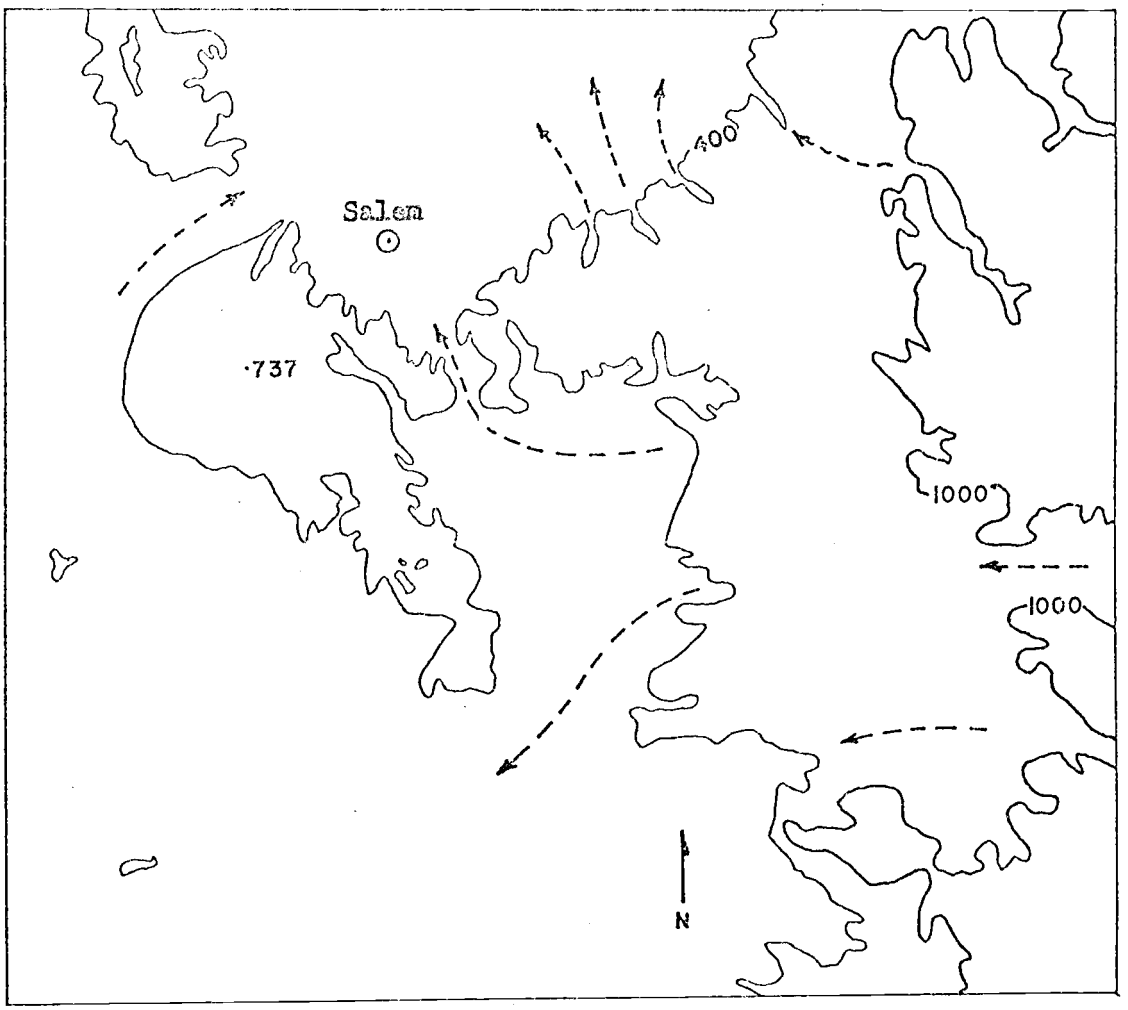

Figure 10. Expected General Cold Air Drainage, Salem.
Scale approx. 1:360,000 Only 400 and 1000 ft. contours.
Contours generalized from USGS map, 1:250,000

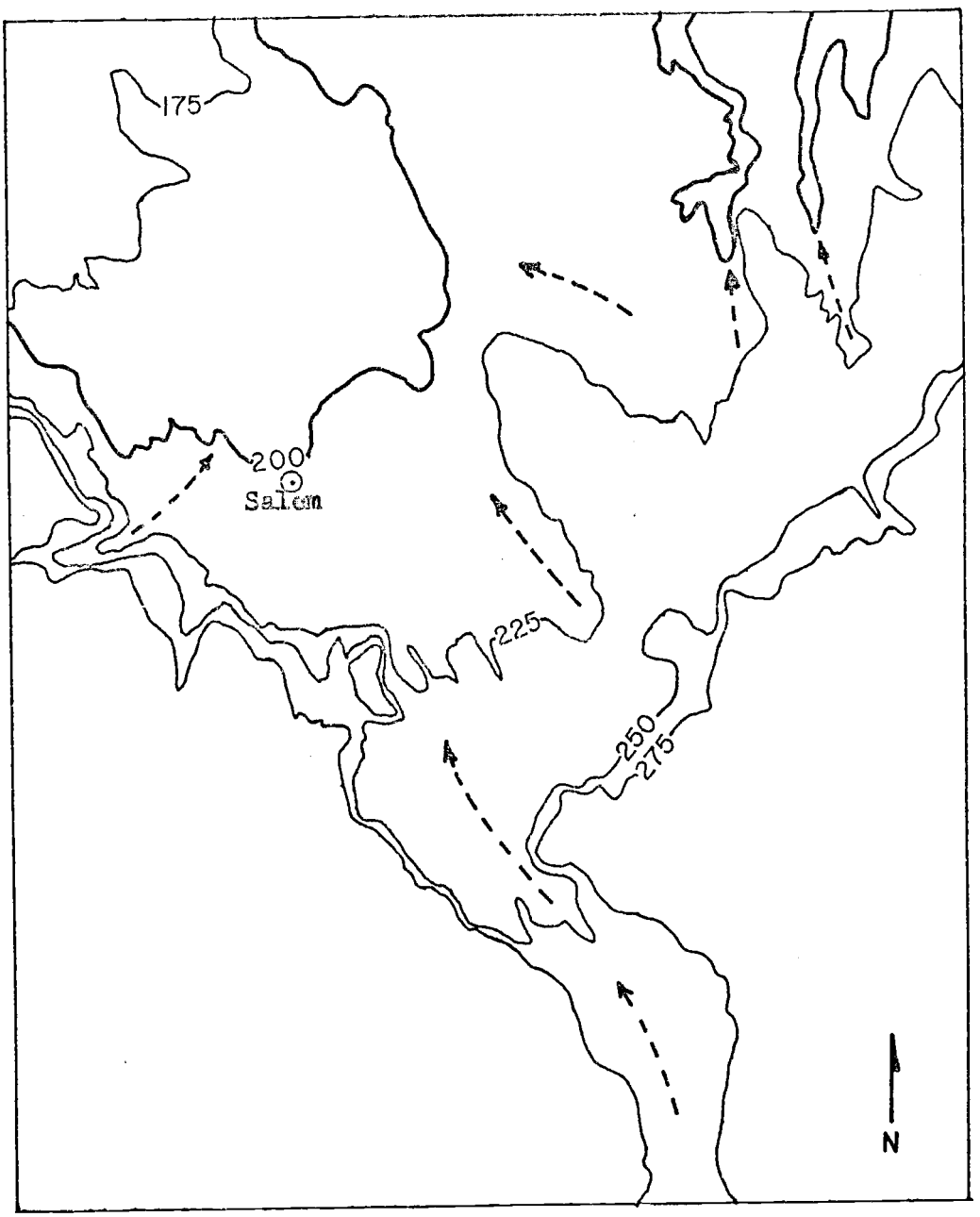

Figure 11. Expected Local Cold Air Drainages, Salem.
Scale 1:62,500 Only 175 to 275 ft. contours shown
Contours generalized from USGS map, 1:62500

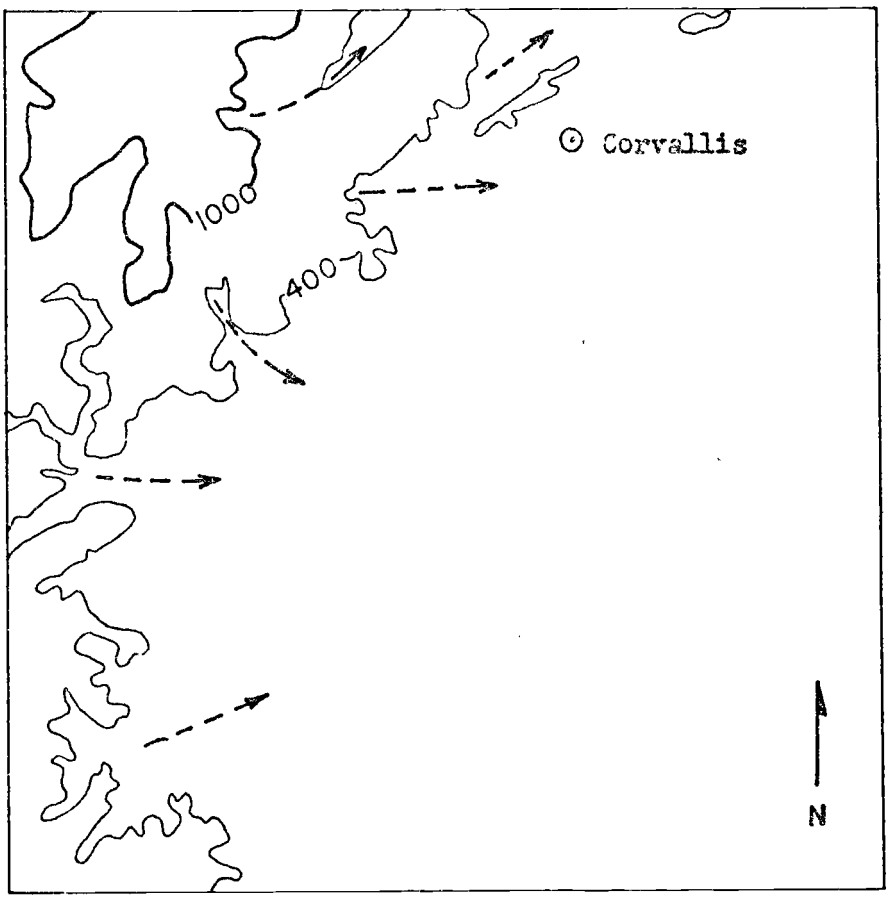

Figure 12. Expected General Cold Air Drainages, Corvallis
Scale 1:250,000 Only 400 and 1000 ft.
contours shown
Contours generalized from USGS map, 1:250,000

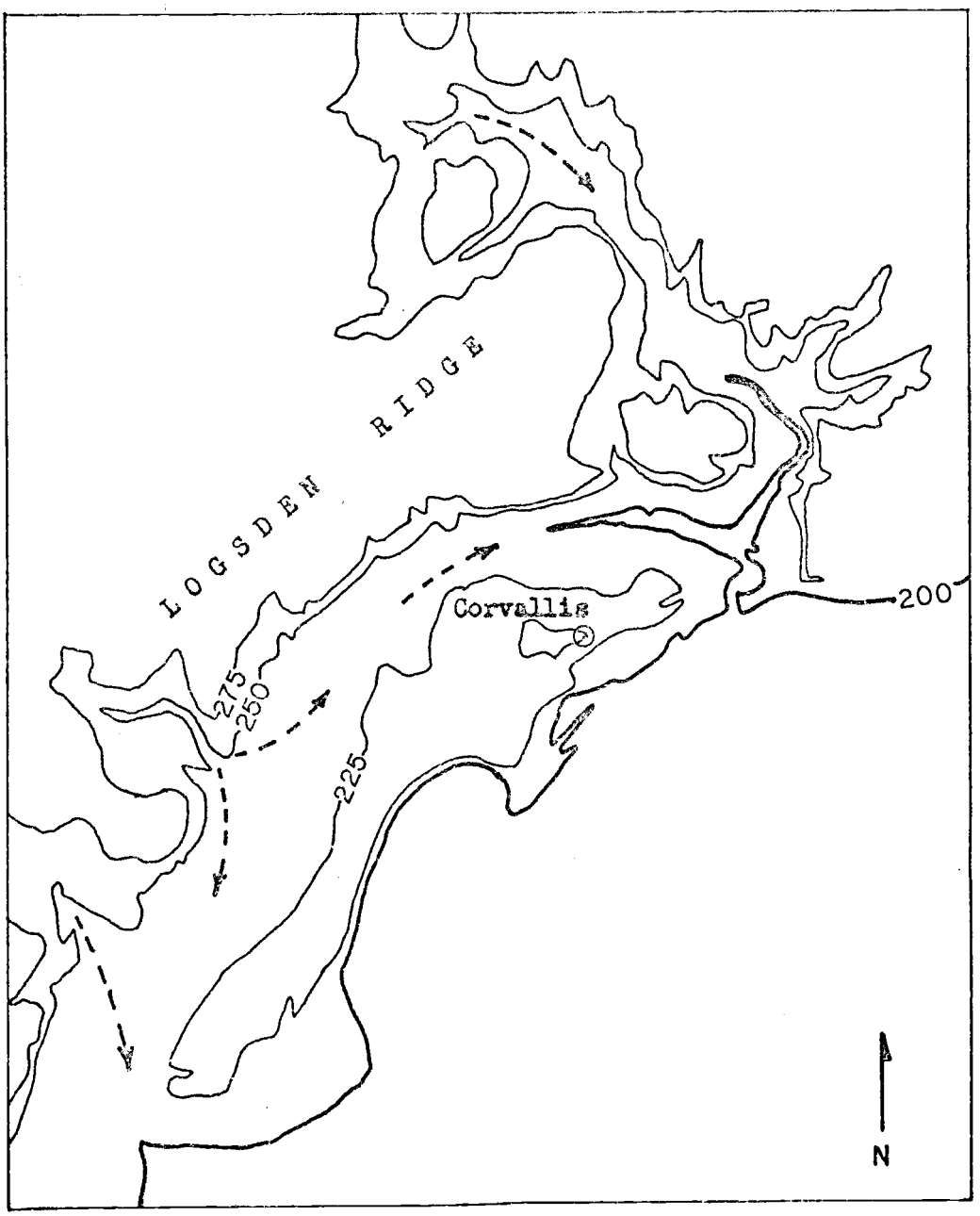

Figure 13. Expected Local Cold Air Drainages, Corvallis.
Scale 1:62,500 Only 200 to 275 ft contours shown
Contours generalized from USGS map, 1:62,500

CONCLUSIONS

This study provided some insights to the relative contributions to temperature differences by the various factors which were considered. No one single factor emerged as the prime determinant of the temperature differences among the three stations. Still, some unexpected findings were notable, such as the low relationship of precipitation to temperature when examining lowest temperatures with precipitation on day of and day before the temperature reading, and when that precipitation occurred at only one of the three stations. It should be noted that this study did not fully consider the offsetting effects of combinations of factors.

The study has raised more questions that it has answered, but has pointed to the directions for further research. The need for more accurate and detailed data for the study area was clearly demonstrated, particularly in the areas of solar and terrestrial radiation, winds, turbulence, humidity, albedo and heat conduction of soils.

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APPENDICES

A. INITIAL SURVEY, EXTRACT OF CLIMATIC DATA

		McMinnville		Salem		Corvallis	
n	Date	Max	Min	Max	Min	Max	Min
1	Mar 23, 72	55	32	55	36	52	36
2	Mar 30, 72	63	30	60	30	57	31
3	Apr 11, 72	-	-	54	41	54	37
4	Apr 18, 72	-	-	55	30	52	32
5	Apr 28, 72	-	-	51	38	70	38
6	Aug 19, 72	83	51	83	50	73	51
7	Aug 25, 72	88	46	90	48	84	52
8	Nov 5, 72	62	39	60	44	60	41
9	Nov 10, 72	59	39	59	35	54	39
10	Nov 25, 72	52	35	55	42	46	40
11	Jan 8, 73	31	19	38	20	32	21
12	Jan 23, 73	39	31	48	30	45	28
13	Apr 25, 73	70	34	68	33	62	40
14	May 3, 73	67	44	65	48	60	46
15	May 9, 73	61	41	61	41	63	46
16	May 10, 73	63	35	63	34	61	36
17	May 11, 73	77	34	79	33	64	40
18	Jul 21, 73	78	55	74	57	72	55
19	Jul 26, 73	92	48	93	56	90	58
20	Sep 12, 73	80	40	82	47	81	48
21	Sep 13, 73	79	42	78	45	82	49
22	Nov 29, 73	-	-	47	41	52	41
23	Dec 20, 73	-	-	54	45	49	39

		McMinnville		Salem		Corvallis	
n	Date	Max	Min	Max	Min	Max	Min
24	Jan 12, 74	36	22	49	27	32	13
25	Mar 8, 74	51	20	49	25	44	26
26	Apr 19, 74	-	-	56	40	58	41
27	Apr 26, 74	-	-	59	38	61	40
28	Apr 27, 74	-	-	56	45	59	42
29	Jun 9, 74	76	48	77	44	72	48
30	Aug 12, 74	-	-	72	54	77	49
	Sum	1362	785	1890	1197	1818	1203
	n	21	21	30	30	30	30
	Average	64.86	37.38	63.00	39.90	60.60	40.10
	Average Range	27.48		23.10		20.50	

B. SECOND SURVEY, EXTRACT OF CLIMATIC DATA

		McMinnville				Salem				Corvallis			
		Temp		Precip		Temp		Precip		Temp		Precip	
n	Date	Max	Min	Day Before	Day of	Max	Min	Day Before	Day of	Max	Min	Day Before	Day of
1	Feb 25, 48	53	43	x	x	56	45	-	-	58	43	o	o
2	Sep 28, 48	62	48	x	x	64	45	o	x	-	-	x	x
3	Feb 24, 49	62	38	x	t	62	39	o	o	64	41	x	o
4	May 14, 49	73	47	o	x	68	52	o	x	76	51	o	o
5	Jun 23, 49	76	54	o	o	75	53	o	o	76	53	o	o
6	Sep 28, 49	65	54	o	x	62	55	o	x	65	53	o	x
7	Oct 14, 49	65	32	o	o	67	32	o	o	65	34	o	o
8	Oct 21, 49	56	28	o	o	59	30	o	o	62	30	o	o
9	Dec 19, 49	34	23	x	x	34	24	x	t	41	27	x	x
10	Feb 7, 50	45	33	x	x	49	37	x	x	45	34	x	x
11	Apr 2, 50	54	42	x	x	52	34	x	x	49	41	x	x
12	May 20, 50	74	46	o	o	76	42	o	o	75	42	o	o
13	Sep 14, 50	73	43	o	o	75	50	o	o	73	54	o	o
14	May 24, 51	69	45	x	t	69	53	t	t	70	54	x	o
15	Jun 22, 50	88	38	o	o	83	46	o	o	84	46	o	o

		McMinnville				Salem				Corvallis			
		Temp		Precip		Temp		Precip		Temp		Precip	
n	Date	Max	Min	Day Before	Day of	Max	Min	Day Before	Day of	Max	Min	Day Before	Day of
16	Oct 31, 51	53	33	o	o	52	31	o	o	51	37	o	o
17	Nov 14, 51	53	31	x	o	51	34	x	x	58	36	x	o
18	Jan 10, 52	42	33	x	x	42	34	x	x	41	32	x	x
19	Jan 21, 52	47	26	x	x	39	29	x	x	38	30	x	x
20	Jul 26, 52	90	50	o	o	89	51	o	o	90	49	o	o
21	Aug 18, 52	70	55	o	o	72	50	o	o	74	54	o	o
22	Sep 28, 52	78	40	o	o	77	44	o	o	75	45	o	o
23	Jan 20, 53	52	43	x	x	54	40	x	x	54	46	x	x
24	Feb 7, 53	58	48	x	x	54	41	x	x	58	49	x	x
25	Jul 9, 53	87	47	x	o	87	50	o	o	82	49	o	o
26	Nov 29, 53	53	41	x	x	60	44	x	x	51	41	x	x
27	Apr 20, 53	68	38	o	o	62	37	o	o	60	40	o	o
28	Jun 10, 53	64	43	x	o	61	48	x	t	58	45	x	t
29	Jul 3, 54	78	38	t	o	78	43	t	o	74	40	o	o
30	Aug 14, 54	73	52	t	o	73	52	t	t	71	47	o	o
31	Jan 14, 55	42	30	x	o	45	30	x	x	46	27	x	t
32	Feb 14, 55	57	35	o	o	53	32	o	o	58	34	x	o

		McMinnville				Salem				Corvallis			
		Temp		Precip		Temp		Precip		Temp		Precip	
n	Date	Max	Min	Day Before	Day of	Max	Min	Day Before	Day of	Max	Min	Day Before	Day of
33	Apr 2, 55	52	33	x	x	49	35	x	x	49	31	x	x
34	Jul 3, 55	74	38	o	o	73	42	o	o	65	39	x	t
35	Aug 16, 55	79	38	o	o	78	48	o	o	81	46	o	o
36	Aug 29, 55	85	44	o	o	85	48	o	o	82	47	o	o
37	Mar 15, 55	54	26	o	o	61	28	o	o	55	28	o	o
38	Jul 6, 56	75	54	o	o	77	50	t	o	72	42	t	o
39	Aug 8, 56	87	42	o	o	85	48	o	o	82	53	o	o
40	Feb 7, 57	46	26	t	x	45	28	o	x	51	28	t	o
41	Jun 28, 59	68	50	x	x	67	50	x	x	69	50	t	o
42	Aug 27, 59	69	52	o	o	75	55	o	o	79	59	o	o
43	Nov 15, 59	47	26	o	o	54	32	o	t	47	25	o	o
44	Feb 18, 60	48	34	o	x	45	29	t	x	42	35	x	x
45	Feb 20, 60	51	27	o	o	50	34	x	x	51	34	x	x
46	May 6, 60	65	52	o	x	64	50	o	x	68	43	x	t
47	May 18, 60	63	40	x	x	60	42	x	t	55	40	x	t
48	Aug 19, 60	88	49	o	o	78	49	o	o	89	50	o	o
49	Oct 18, 60	75	41	o	o	70	43	o	o	77	41	o	o

		McMinnville				Salem				Corvallis			
		Temp		Precip		Temp		Precip		Temp		Precip	
n	Date	Max	Min	Day Before	Day of	Max	Min	Day Before	Day of	Max	Min	Day Before	Day of
50	Dec 3, 60	51	42	t	x	51	33	x	x	53	35	x	x
51	Dec 9, 60	43	27	o	o	41	23	o	o	45	22	o	o
52	Oct 4, 61	82	35	o	o	80	40	o	o	80	39	o	o
53	Mar 5, 62	50	41	x	x	51	42	x	x	52	42	x	x
54	May 13, 62	59	33	t	t	58	40	x	t	56	42	x	x
55	Aug 18, 62	77	56	t	o	77	55	x	o	75	53	o	t
56	Aug 30, 62	88	46	o	o	90	50	o	o	83	55	t	o
57	Sep 11, 62	70	41	x	t	68	47	x	o	61	45	t	x
58	Nov 23, 62	42	29	o	o	40	34	x	o	51	32	x	x
59	Dec 23, 62	44	37	o	o	43	26	o	o	43	37	o	o
60	Jul 10, 63	73	44	x	o	68	50	x	x	68	54	t	x
61	Mar 23, 64	53	34	x	x	51	31	x	x	52	36	x	o
62	Apr 6, 65	50	26	x	x	55	29	x	t	48	29	x	o
63	Feb 20, 66	58	41	x	x	59	37	x	x	48	38	t	x
64	May 21, 66	71	48	o	o	59	38	o	o	74	45	o	o
65	Oct 15, 66	60	38	o	o	60	35	t	t	53	33	x	t

		McMinnville				Salem				Corvallis			
		Temp		Precip		Temp		Precip		Temp		Precip	
n	Date	Max	Min	Day Before	Day of	Max	Min	Day Before	Day of	Max	Min	Day Before	Day of
66	Jan 7, 67	44	36	x	o	46	36	x	o	45	32	x	x
67	Sep 23, 67	88	45	o	o	88	41	o	o	75	51	o	o
68	Oct 21, 67	60	45	o	x	64	50	o	x	55	39	o	x
69	Apr 18, 68	55	31	x	o	52	30	o	x	55	30	x	t
70	Nov 14, 68	45	32	o	o	43	30	x	o	-	-	-	-
71	Mar 21, 69	66	39	o	o	66	30	o	o	65	38	o	o
72	Aug 19, 69	77	47	o	o	82	52	o	o	80	51	o	o
73	Nov 26, 69	53	29	o	o	52	30	t	t	40	31	o	o
74	Feb 21, 70	57	33	o	o	61	26	o	o	60	29	o	o
75	Mar 5, 70	51	30	o	o	57	26	o	x	56	30	x	o
76	Apr 29, 70	54	34	o	x	49	33	t	x	58	35	x	x
77	May 9, 70	54	34	x	x	56	38	x	x	59	41	x	x
78	Oct 29, 70	64	24	o	o	60	25	o	o	57	28	o	o
79	Jan 3, 71	35	22	o	o	35	25	o	o	31	27	o	o
80	Feb 8, 71	53	25	o	o	49	22	o	o	43	27	o	o
81	Mar 3, 71	45	36	x	x	44	33	x	x	41	34	t	x

		McMinnville				Salem				Corvallis			
		Temp		Precip		Temp		Precip		Temp		Precip	
n	Date	Max	Min	Day Before	Day of	Max	Min	Day Before	Day of	Max	Min	Day Before	Day of
82	Jul 14, 71	87	43	o	o	89	49	o	o	82	50	o	o
83	Jul 27, 71	94	52	o	o	87	57	o	o	92	56	o	o
84	Aug 1, 71	85	59	o	o	87	57	o	o	79	51	o	t
85	Jan 17, 72	46	41	x	x	46	42	x	x	50	31	o	x
86	Jan 2, 73	44	31	t	x	46	31	x	x	50	30	x	x
87	Feb 14, 73	49	35	x	o	49	36	o	x	52	36	o	t
88	Jul 13, 73	94	56	o	o	96	50	o	o	84	55	o	o
89	Aug 31, 73	-	-	-	-	70	44	x	o	67	40	o	o
90	Oct 19, 73	-	-	-	-	62	45	o	o	64	46	x	o
91	Nov 3, 73	-	-	-	-	44	24	o	x	48	27	x	o
92	Dec 22, 73	-	-	-	-	49	43	x	x	55	43	x	x
93	Apr 7, 74	-	-	-	-	61	41	x	t	55	41	x	x
94	May 3, 74	-	-	-	-	66	34	o	o	60	38	t	o
95	Aug 23, 74	-	-	-	-	80	54	o	o	85	53	o	o
96	Oct 25, 74	70	33	o	o	66	37	o	o	69	33	o	o
97	Feb 5, 75	42	34	x	x	46	35	x	x	44	36	x	x

		McMinnville				Salem				Corvallis			
		Temp		Precip		Temp		Precip		Temp		Precip	
n	Date	Max	Min	Day Before	Day of	Max	Min	Day Before	Day of	Max	Min	Day Before	Day of
98	Mar 26, 75	52	35	o	o	52	31	o	o	51	33	x	t
99	Apr 18, 75	54	32	x	x	56	43	t	x	52	37	x	x
100	Apr 28, 75	53	35	x	o	54	34	o	o	53	30	x	t
	Sum	5782	3615			6177	3962			6010	3921		
	n	93	93			100	100			98	98		
	Average	62.17	38.87			61.77	39.62			61.33	40.01		
	Average Range	23.30				22.15				21.32			

- = data missing

x = measurable precipitation greater than .01 inch

o = no precipitation

t = trace

Source: NOAA, Climatological Data, Oregon

C. EXTRACT OF CLIMATIC DATA, McMINNVILLE

Year	Avg	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Avg
1953	Max	51.6	51.3	54.2	60.9	66.8	70.3	81.8	80.7	78.7	65.6	55.0	55.0	52.5
	Min	41.6	34.4	45.8	38.6	42.1	45.5	44.7	48.1	44.2	40.9	39.8	36.7	
1956	Max	47.0	41.8	51.0	65.3	73.4	71.4	85.1	80.7	75.7	60.2	51.1	45.3	50.7
	Min	32.7	29.5	34.7	37.1	42.7	44.4	47.6	48.1	44.6	40.7	33.9	33.6	
1958	Max	57.1	54.7	54.6	60.8	74.8	76.9	88.7	87.7	76.3	69.0	52.2	50.8	54.7
	Min	35.6	41.0	34.6	40.0	44.5	51.0	50.2	47.9	46.0	39.5	39.2	39.0	
1959	Max	47.1	49.4	54.6	62.9	66.0	72.8	84.3	81.1	70.3	63.8	53.0	46.3	51.2
	Min	35.4	34.9	36.2	38.0	40.6	48.0	46.9	43.7	44.5	42.2	34.2	33.0	
1965	Max	45.8	51.7	61.3	63.8	66.8	76.5	86.2	82.6	76.4	67.5	53.8	41.5	52.5
	Min	35.0	35.7	35.2	40.1	38.6	43.7	48.6	51.8	42.8	42.5	41.0	31.9	
1966	Max	45.2	49.4	54.3	64.2	71.9	74.4	78.5	83.0	77.4	64.2	54.3	48.0	52.4
	Min	34.6	34.4	35.9	38.0	39.6	47.7	49.2	46.8	48.0	40.3	39.7	37.8	
1967	Max	48.1	52.5	52.5	56.5	70.1	79.4	86.0	92.6	85.0	64.6	55.5	46.7	53.6
	Min	37.6	33.4	33.9	33.7	40.7	49.7	48.5	49.9	47.7	43.7	40.8	36.0	
1971	Max	45.9	50.4	51.8	60.5	69.6	70.1	83.9	86.0	73.4	62.7	52.4	44.7	51.3
	Min	32.3	34.5	35.1	37.0	40.9	43.3	46.8	51.5	45.9	39.5	37.5	34.0	

D. EXTRACT OF CLIMATIC DATA, SALEM

Year	Avg	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Avg
1953	Max	52.5	52.3	54.6	60.4	64.5	68.4	81.4	78.8	77.7	66.2	55.2	48.8	52.7
	Min	41.4	33.7	35.1	37.9	43.7	46.6	47.9	51.9	47.3	42.1	40.0	36.2	
1956	Max	47.5	42.7	52.1	64.2	71.7	70.7	84.5	79.9	76.7	61.4	51.4	45.9	51.6
	Min	34.7	31.2	35.7	38.3	45.4	46.2	51.1	50.4	46.7	41.9	33.3	34.2	
1958	Max	49.8	55.5	55.7	60.8	75.0	76.1	88.4	87.4	76.6	68.9	53.9	51.9	55.4
	Min	35.9	41.0	34.3	39.6	46.9	53.8	53.9	53.1	48.2	41.8	39.9	39.1	
1959	Max	48.6	50.4	55.5	63.1	65.8	72.9	84.8	81.5	71.9	65.5	54.4	46.6	52.5
	Min	36.9	35.3	36.4	38.4	42.2	50.2	51.1	49.4	48.4	43.2	34.1	32.6	
1965	Max	45.5	50.9	60.5	61.4	64.3	73.5	84.3	80.8	75.2	65.8	54.5	43.3	52.2
	Min	35.4	35.2	32.7	39.2	40.0	44.3	50.1	52.6	43.9	44.8	41.3	32.3	
1966	Max	45.6	49.9	54.3	63.6	70.2	76.1	80.7	83.5	77.5	64.5	54.8	50.4	52.6
	Min	33.5	31.2	34.8	37.4	39.5	47.5	49.6	50.3	48.9	40.7	39.4	38.0	
1967	Max	50.1	53.1	52.0	56.1	68.2	78.7	85.3	91.1	81.9	64.5	54.5	47.6	53.3
	Min	38.1	32.1	34.1	33.1	40.5	49.6	49.8	52.1	47.9	44.1	38.3	36.3	
1971	Max	44.7	48.5	50.9	59.0	66.4	69.5	82.7	84.2	72.4	61.5	51.5	44.7	50.8
	Min	33.4	30.3	32.9	35.2	40.2	46.8	51.9	54.0	45.8	39.7	37.5	34.2	

E. EXTRACT OF CLIMATIC DATA, CORVALLIS

Year	Avg	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Avg
1953	Max	51.5	51.4	53.3	58.8	62.3	66.2	79.7	77.5	76.6	64.8	54.3	47.7	52.3
	Min	41.0	35.1	35.6	39.4	43.6	46.9	49.8	52.3	49.8	41.2	39.8	35.8	
1956	Max	46.4	41.6	51.3	62.2	69.9	68.6	82.8	79.7	76.5	61.2	50.5	45.0	51.0
	Min	35.4	30.2	35.7	39.0	46.0	46.6	50.8	50.6	47.1	40.8	32.7	33.8	
1958	Max	47.2	54.4	53.9	58.6	73.0	73.7	86.0	86.7	75.4	67.6	53.5	51.0	54.5
	Min	34.7	41.2	34.6	40.9	46.7	53.6	54.5	52.7	48.6	41.5	38.9	38.2	
1959	Max	47.6	48.8	54.3	61.2	63.5	71.4	83.7	81.2	70.0	64.0	53.6	45.4	51.7
	Min	35.9	33.6	35.8	39.1	42.7	49.0	51.4	49.2	47.8	43.9	34.1	33.5	
1965	Max	44.1	50.5	59.0	61.3	64.6	72.3	82.6	79.9	74.9	65.8	54.2	43.6	52.3
	Min	35.0	35.9	35.9	40.7	40.8	46.2	50.5	53.1	46.1	43.8	41.4	32.6	
1966	Max	45.0	48.9	52.5	63.0	69.1	73.7	78.5	81.6	76.0	64.2	53.9	49.1	52.5
	Min	34.2	32.6	36.6	39.3	42.2	48.3	50.9	50.7	49.7	40.9	39.7	38.5	
1967	Max	48.8	52.6	52.0	54.7	68.2	76.9	83.9	88.9	82.1	63.1	54.0	46.5	53.1
	Min	37.5	33.6	35.3	34.8	41.8	49.9	50.4	52.9	48.8	42.6	39.7	35.4	
1971	Max	44.1	48.5	50.2	58.0	66.5	67.5	80.9	83.1	72.0	61.0	50.5	44.5	50.6
	Min	34.5	33.3	34.5	37.8	42.6	46.5	50.6	51.9	45.5	39.4	37.1	33.4	

F. AVERAGE MAXIMUM AND MINIMUM TEMPERATURE AND TEMPERATURE RANGE BY MONTH*

Station	Avg	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Avg.	Avg. Temp.
	Max	48.48	50.15	54.29	61.86	69.93	73.98	84.31	84.30	76.65	64.70	53.41	47.70	64.15	
McMinnville	Min	35.60	34.73	35.18	37.81	41.21	46.66	47.81	48.48	45.46	41.16	38.28	35.25	40.63	52.36
	Range	12.88	15.42	19.11	24.05	28.72	27.32	36.50	35.82	31.19	23.54	15.15	12.45	23.51	
	Max	48.04	50.41	54.45	61.08	68.26	73.24	84.01	83.40	76.24	64.79	53.78	47.40	63.76	
Salem	Min	36.16	33.75	34.50	37.39	42.30	48.13	50.68	51.73	47.14	42.29	37.98	35.36	41.45	52.64
	Range	11.88	16.66	19.95	23.69	25.69	25.11	33.33	31.67	29.10	22.50	15.80	12.04	22.31	
	Max	46.84	49.59	53.31	59.73	67.14	71.28	80.58	81.08	74.19	63.95	53.06	46.60	62.28	
Corvallis	Min	36.02	34.44	35.50	38.88	43.30	48.38	51.05	51.68	47.93	41.76	37.93	35.15	41.84	52.30
	Range	10.82	15.15	17.81	20.85	23.84	22.90	29.53	29.40	26.26	22.19	15.13	11.45	20.44	

Source: NOAA, Climatological Data, Oregon.
* Based on eight-year data

G. FREEZING TEMPERATURES

McMinnville	Last Spring Min. of 28 Deg. or Below	Last Spring Min. of 32 Deg. or Below	First Fall Min. of 32 Deg. or Below	First Fall Min. of 28 Deg. or Below
1953	Apr 10	May 11	Sep 25	Nov 2
1956	Mar 6	May 13	Sep 22	Oct 28
1958	Mar 16	May 13	Sep 23	Nov 16
1959	Apr 6	May 3	Oct 29	Oct 29
1965	May 6	Jun 27	Sep 17	Nov 25
1966	May 27	May 28	Oct 9	Oct 18
1967	Apr 16	May 1	Oct 20	Dec 12
1971	Mar 21	May 20	Sep 30	Oct 17
Salem 1953	Apr 10	Apr 10	Nov 1	Nov 2
1956	Mar 15	Apr 17	Oct 28	Nov 19
1958	Mar 11	May 13	Nov 15	Nov 15
1959	Mar 14	Apr 19	Oct 29	Nov 5
1965	Apr 3	May 14	Sep 17	Sep 17
1966	Apr 19	May 28	Oct 13	Oct 14
1967	Apr 19	May 1	Nov 5	Nov 21
1971	Apr 12	May 21	Oct 16	Oct 27
Corvallis '53	Mar 4	Apr 11	Nov 2	Nov 3
1956	Apr 5	Apr 5	Oct 28	Nov 20
1958	Mar 16	Apr 5	Nov 15	Nov 16
1959	Apr 6	Apr 15	Oct 28	Nov 6
1965	Mar 19	May 6	Nov 25	Dec 13
1966	Mar 3	Apr 27	Oct 13	None
1967	Mar 6	Apr 30	Nov 23	Dec 12
1971	Mar 8	Apr 24	Oct 17	Oct 28

H. ANNUAL PRECIPITATION, INCHES

Year	McMinnville	Salem	Corvallis
1953	E[1] 49.17	52.99	50.21
1956	E[2] 42.06	39.17	40.59
1958	42.15	41.11	42.72
1959	38.13	35.38	32.84
1965	E[3] 36.55	33.73	37.12
1966	41.92	35.20	39.99
1967	34.09	32.44	35.54
1971	E[4] 57.04	49.19	57.15
Ann. Avg.	42.64	39.90	42.02

E = amount of precipitation is totally or partially estimated for months of:
1 - April
2 - December
3 - December
4 - January, December

Source: NOAA, Climatological Data, Oregon