Climate at the Arnold Arboretum

Climate has been defined as a generalization of weather conditions of a region. Factors such as temperature, pressure, humidity, precipitation, sunshine, cloudiness, and wind throughout the year, averaged over a series of years, comprise the climate. Climate is the principal factor that limits which plants may or may not be grown in a specific region. At the Arnold Arboretum some woody plants cannot tolerate the heat and dryness of summer, but the survival of most plants is determined by various aspects of temperature which involve cold. Some plants which start growth early can be injured by spring frosts. Others may be killed by freezing in autumn before they have properly hardened in preparation for winter. The principal determining factor, however, is severe winter cold.

Arboretum Weather Station. Climatological records are significant to botanical institutions that are concerned with living plants. With such data, it becomes possible to compile information which adds to the knowledge concerning the climatic tolerances of plants. Frequently, the exact date when winter injury occurred can be determined.

Since August 15, 1962, the Arnold Arboretum has maintained a simple climatological substation in cooperation with the U.S. Weather Bureau. A representative of the Weather Bureau approved a site for the instruments, supervised their installation, and checked the thermometer for accuracy. Daily at 8:00 A.M. observations of temperatures and precipitation covering the previous 24 hours are entered on forms which the Weather Bureau provides. Mr. Artur Norietis, a member of the Dana Greenhouse staff and resident watchman, has been largely responsible for operating the station. Despite the fact that records only apply to a relatively short seven-year period, some interesting data have been accumulated.

Equipment. The equipment consists of a maximum and minimum self-registering thermometer furnished by the Arboretum and an eight-inch nonrecording precipitation gauge provided by the Weather Bureau.

Microclimates. Those familiar with the Arnold Arboretum are aware of the wide variety of topographical features that are present within the bounds of this relatively small 265 acre area. Elevations range from 50 to 233 feet. The terrain is comprised of summits, ridges, valleys, slopes of varying degrees, flat areas, and so on. These features lead to an assortment of exposures which face all points of the compass. With such geographical variation there is also a wide diversity of climatic differences. Some are subtle and others are obvious. These deviations from the overall climatic picture are known as microclimates and can occur within feet and even inches of one and other.

In November 1934, Dr. Hugh M. Raup, then a member of the Arboretum staff, chose eight locations in the Arboretum and set up a station at each where temperatures could be recorded. Some of these records remained when Dr. Raup left and from them have been extracted some interesting microclimatic data.

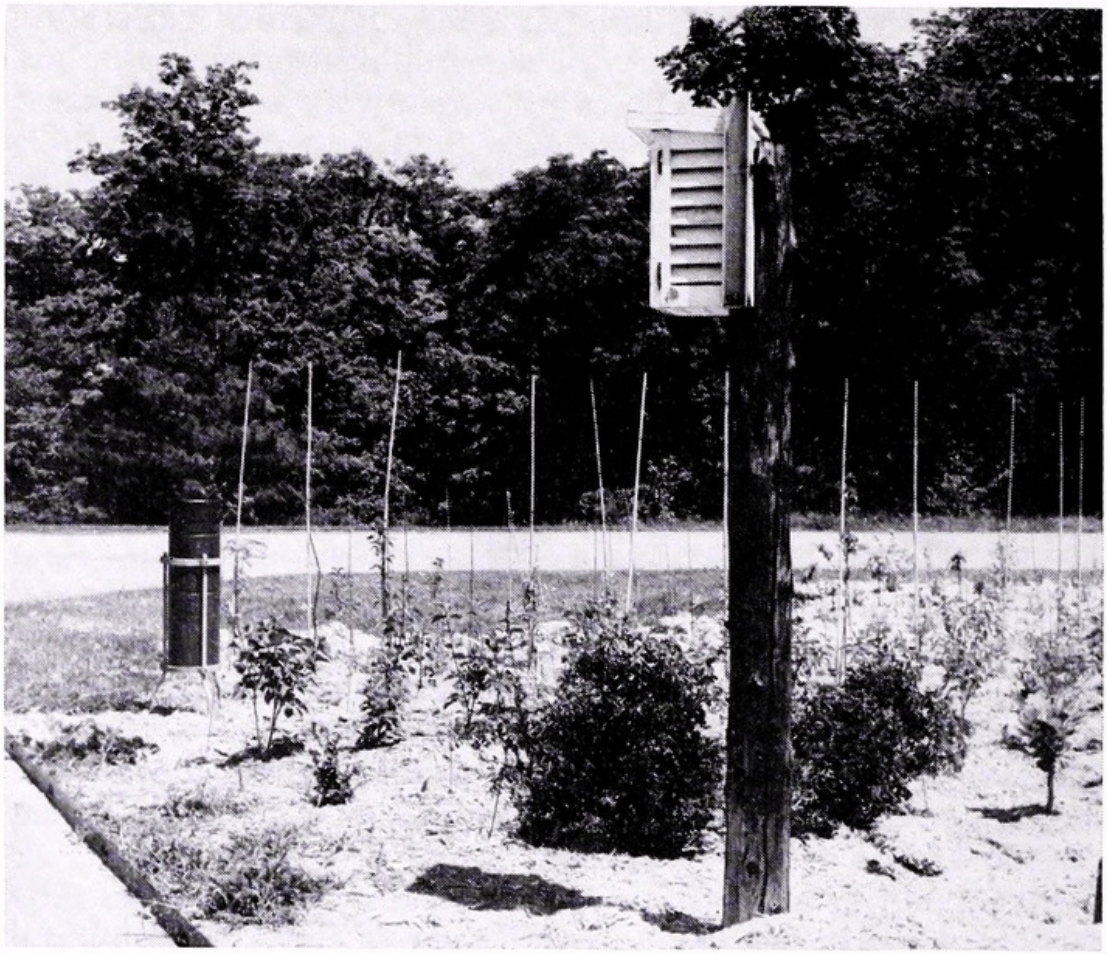
Station 1 was positioned at the southwest side of the Administration Building where the land slopes gently toward the meadow and where the station was sheltered from the north, east, and west.

Station 2 was situated on flat land in the shrub order. The shrub order is in one of the lowest areas of the Arboretum and the land slopes toward it from all directions, making it an ideal location for a cold pocket.

Station 3 was located on Bussey Hill about 50 yards south of the summit and on a crest — an ideal position for good air drainage.

A site for Station 4 was chosen on a gentle southeast slope near the Centre Street Path. It was well protected from the north and west by higher elevations and has proven to be one of the most favorable microclimates in the Arboretum.

Station 5 was located in the Juniper collection on a small plateau well sheltered from wind by surrounding slopes and hills. It is of interest that many Indian artifacts were found here. This would indicate that an Indian camp site existed there despite the fact that it proved to be one of the Arboretum's coldest microclimates according to the Raup records. Indians lived close to nature and though they had no knowledge of microclimates, they did know that some sites were more suitable to comfort than others. This awareness would be of prime importance to those living through a harsh New England winter under primitive circumstances. Several considerations may well account for their choosing this location. Nearby to



The Weather Station in the Dana Greenhouse Nursery. Rain gauge at left. Box for thermometer at right.

the south was a free-flowing brook and to the north was a spring. The area is well sheltered from bitter winds of winter and they could avoid the chill factor which can lead to much greater human discomfort than severe cold. Together with these features it seems reasonable to suppose the area at that time was wooded and, therefore, could have a climate which differed somewhat from that shown by the Raup records.

Station 6, the most sheltered site of all, was placed on Hemlock Hill. The area then was populated by massive hemlocks, many of which were later lost in the 1938 hurricane.

At Station 7 in the isolated Peters Hill area, observations were recorded for about one month when they were discontinued with the notation, "thermometer stolen."

Station 8 was near the Arboretum greenhouses which were then located off South Street on property of the Bussey Institution. The site was a small plateau with the land falling away in all directions. The discovery of numerous Indian relics reveals that a camp site also existed here. Although shown by the Raup records to be the most favorable microclimate of all,

it was exposed to the wind from all directions. Again, the area was perhaps wooded, a condition that would tend to mitigate the chill factor associated with winter winds.

Interpretation of Some Temperature Gradients. The following examples of temperature gradients have been selected from the Raup records. Each morning during the winter of 1934–35 observations pertaining to the previous night were recorded at about 9:00 A.M. For purpose of illustration, easily interpreted extremes have been chosen and they concern only minima.

Table 1 shows low temperatures and wide variation in the gradients. They are typical of calm, clear nights. Under such conditions air loses heat to outer space through radiational cooling. Temperature drop is often greater during winter than at other seasons because the long nights which prevail allow radiational cooling to take place over a maximum period of time. With the absence of wind, cold air drains from the higher elevations and settles in lower areas (frost or cold pockets) leading to wide diversity of minima in the microclimates. These are the nights during which our lowest temperatures occur and they are the most damaging to plants. At such times, the shrub collection usually had the coldest temperature while the area near the greenhouse had the warmest. It is interesting that the temperature stations which showed the greatest extremes were the closest together — about 200 yards. However, the topography is such that the same differences would prevail at the edge of the greenhouse plateau and in the flat area below which contains the shrub collection — a distance of about 90 or 100 feet with a difference in elevation of 30 feet.

TABLE 1

Minima Under Clear Conditions, Winds Light to Very Light

1	2	3	4	5	6	7	8
−16.0	−26.0	−16.9	−20.7	−25.1	−17.8		− 7.5
− 6.9	−15.4	− 8.3	− 9.2	−19.4	− 6.8		− 5.3
− 3.7	−14.3	− 2.9	− 7.0	−12.0	− 3.8		− 6.0
16.7	8.0	17.8	15.0	9.6	18.0		18.0

These examples are typical of calm, clear nights when heat is lost to atmosphere through radiational cooling. In the absence of wind, cold air drains from higher elevations and settles in the low areas.

Table 2 shows minimal differences in temperature. Brisk winds led to a mixing and stirring of the atmosphere and therefore minima showed only slight variation at all stations. Under

conditions of high winds, Station 8, which usually had the warmest microclimate, often showed lower temperatures due to its exposed position.

TABLE 2

Minima Under Clear Conditions, Estimated Wind Velocity Medium to Brisk

Station	1	2	3	4	5	6	7	8
	8.0	7.1	6.9	7.2	6.4	7.3		6.1
	11.7	11.2	10.5	11.3	10.3	11.5		10.2
	11.2	11.0	10.1	11.0	10.1	11.5		10.8
	17.8	17.0	16.2	17.0	16.1	17.4		16.1

Brisk winds led to a mixing and stirring of the atmosphere and therefore temperatures were quite similar at all stations.

Table 3 illustrates the uniformity that was evident in the minima under cloudy conditions. If calm nights such as these had been clear, there would have been wide variations. However, the cloud blanket intercepted and prevented the radiation of heat from below. In the absence of radiational cooling, there is a pattern of uniformity despite light winds. As would be expected, similar gradients frequently came about during periods of rain and snow.

TABLE 3

Minima Under Cloudy Conditions, Estimated Wind Velocity Light to Very Light

Station	1	2	3	4	5	6	7	8
	28.0	28.0	27.4	28.0	28.0	28.0		—
	16.3	17.1	17.0	15.1	15.9	15.9		19.5
	17.1	17.0	16.0	16.9	16.2	17.0		16.5
	28.0	28.0	27.5	28.0	27.7	28.0		29.3

The cloud cover intercepted and prevented the radiation of heat from below. In the absence of radiational cooling, only slight differences appeared in the minima despite relative calm.

TABLE 4

Average Minimum Temperatures at Arboretum Stations January 1935

Station	1	2	3	4	5	6	7	8
	14.2	11.6	14.0	13.0	10.9	14.2		15.9

Those responsible for planting the Arboretum in its early years were aware of the more favorable microclimates in the vicinities of Stations 1, 3, 4, and 6 and set out many plants of questionable hardiness in those areas.

Factors which Influence the Climate at Boston. In the Annual Summary of Boston Climatological Data (1968), published by the U.S. Department of Commerce, the Boston climate is described as follows:

> "Three important influences are responsible for the main features of Boston's climate. First, the latitude (42'N) places the city in the zone of prevailing west to east atmospheric flow in which are encompassed the northward and southward movements of large bodies of air from tropical and polar regions. This results in variety and changeability of the weather elements. Secondly, Boston is situated on or near several tracks frequently followed by systems of low air pressure. The consequent fluctuations from fair to cloudy or stormy conditions reinforce the influence of the first factor, while also assuring a rather dependable precipitation supply. The third factor, Boston's East Coast location, is a moderating factor effecting temperature extremes of winter and summer."

Boston's official weather station is located at Logan International Airport in East Boston. It is situated seven miles northeast of the Arnold Arboretum. Its climate is modified by proximity to the sea and is quite different from that at the Arnold Arboretum. Temperatures are usually cooler in summer, warmer in winter, and have less range in the extremes. To show these differences data concerning the past three years have been brought together in *Table* 5.

TABLE 5
Comparative Data Official Boston and Arnold Arboretum Weather Stations

	1966		1967		1968	
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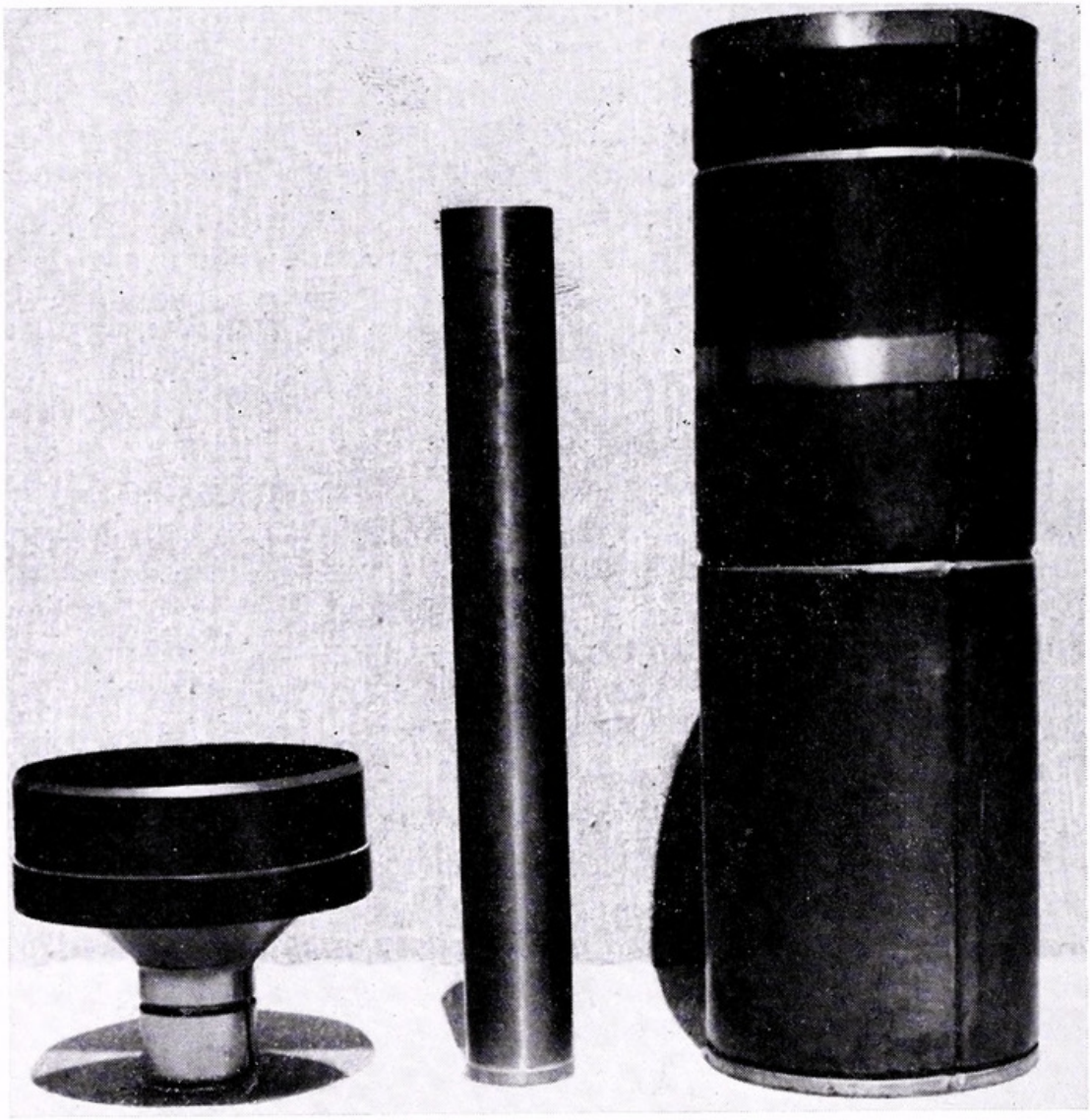
January	24.5	28.8	29.8	35.1	20	25.6
July	73.6	74.9	74.5	73.0	76	75.2
Maximum	100	97	97	94	98	98
Minimum	−1	3	−9	−3	−6	−4
Growing season (days)	169	216	154	210	172	249
Last frost	Apr. 27	Mar. 29	May 7	Apr. 13	May 8	Mar. 26
First frost	Oct. 13	Oct. 31	Oct. 8	Nov. 9	Oct. 27	Nov. 30

Growing Season. The growing season is defined as the number of days between the last day of killing frost in the spring and the first day with killing frost in autumn. This time

is determined by the last spring and the first fall temperature of 32 degrees F. or lower.

Those concerned with gardening realize the considerable year-to-year variation that can occur in length of the growing season. During one year in the Boston area, frost may take place in early September while it might not occur until November in the more favorable microclimates. Note in Table 5 that Boston



The eight-inch nonrecording precipitation gauges. Left to right: funnel to be attached at top of gauge, gauge proper, reservoir in which the gauge is set.

was favored with 47, 56, and 77 more growing days during the three years concerned than the Arboretum.

Importance of Small Differences in Temperature. On occasion, small differences in temperature can be of critical im-

portance. During a two-day period on December 28 and 29, 1968, precipitation amounting to 1.29 inches was recorded at the Arboretum. Temperatures at that time flirted with the freezing point — 30 to 34 degrees F. There was little if any build-up of ice and no damage occurred in the plant collections. However, at the Case Estates of the Arnold Arboretum, 13.5 miles further inland at Weston, conditions were quite different. The temperature there is usually a few degrees colder than at Jamaica Plain. Precipitation which fell as rain in Jamaica Plain became freezing rain at Weston. Enormous weights of ice formed on the branches of trees until they could no longer support the burden and snapped or split.

On the other hand, the Arboretum in Jamaica Plain may suffer damage while the Case Estates at Weston may not. On February 9, 1969, snow began to fall at 5:30 A.M. The temperature was 31 degrees F. Snow continued through that day, the following night, and finally stopped at 1:00 P.M. on February 10, leaving an accumulation of 15.8 inches temperatures during the period showed a maximum of 32 degrees F. and a minimum of 30 degrees F. The near-freezing temperature resulted in snow that was heavy and moist. Each flake seemed to remain where it fell. Plants became so overburdened with the accumulation of wet snow that damage was devastating. Many trees of weak structure such as magnolias, Douglas firs, and carpinus were broken and split to pieces. A lace-bark pine, which is an especially weak-wooded tree, broke off at ground level. Evergreens, which hold their foliage and therefore have more snow catching surface, were particularly vulnerable. Some junipers were broken in half and some were literally pulled out of the ground by the great weight of the snow. Much of the Arboretum was in shambles. Meanwhile, the temperature at the Case Estates was apparently a bit colder and the snow was drier. It did not cling so did no harm. It is interesting that at this time the temperature along the shore south of Boston was slightly warmer and precipitation was in the form of rain.

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