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Edited by

J. E. Potzger
The Butler University Botanical Studies journal was published by the Botany Department of Butler University, Indianapolis, Indiana, from 1929 to 1964. The scientific journal featured original papers primarily on plant ecology, taxonomy, and microbiology. The papers contain valuable historical studies, especially floristic surveys that document Indiana’s vegetation in past decades. Authors were Butler faculty, current and former master’s degree students and undergraduates, and other Indiana botanists. The journal was started by Stanley Cain, noted conservation biologist, and edited through most of its years of production by Ray C. Friesner, Butler’s first botanist and founder of the department in 1919. The journal was distributed to learned societies and libraries through exchange.

During the years of the journal’s publication, the Butler University Botany Department had an active program of research and student training. 201 bachelor’s degrees and 75 master’s degrees in Botany were conferred during this period. Thirty-five of these graduates went on to earn doctorates at other institutions.

The Botany Department attracted many notable faculty members and students. Distinguished faculty, in addition to Cain and Friesner, included John E. Potzger, a forest ecologist and palynologist, Willard Nelson Clute, co-founder of the American Fern Society, Marion T. Hall, former director of the Morton Arboretum, C. Mervin Palmer, Rex Webster, and John Pelton. Some of the former undergraduate and master’s students who made active contributions to the fields of botany and ecology include Dwight. W. Billings, Fay Kenoyer Daily, William A. Daily, Rexford Daudenmire, Francis Hueber, Frank McCormick, Scott McCoy, Robert Petty, Potzger, Helene Starcs, and Theodore Sperry. Cain, Daubenmire, Potzger, and Billings served as Presidents of the Ecological Society of America.

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TEMPERATURE INVERSIONS IN THE PINYON-JUNIPER ZONE OF A NEVADA MOUNTAIN RANGE

By W. D. BILLINGS

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Prominent on the sides of the Great Basin mountain ranges of Nevada is an open woodland zone of small conifers in which the dominants are pinyon (Pinus monophylla T. and F.) and juniper (Juniperus osteosperma (Torr.) Little). It is apparent even to the casual observer that this dark green zone is almost entirely restricted to the slopes; the grayish sagebrush valley bottoms are treeless except for willows and cottonwoods along the drainages. Also treeless are most of the ridges and peaks which rise above the two or three thousand vertical feet covered by the woodland. Within the dwarf conifer zone, even small valleys, bowls, and flats are open and sagebrush-covered. Around the edges of most of the valleys and depressions, the bronze-green junipers form a prominent border with relatively few pinyons, but higher on the slopes the gray-green pinyon dominates, often in pure stands.

In 1948, preliminary investigations were begun on the ecology of the pinyon-juniper zone. In the autumn of that year, maximum-minimum thermometers and rain gauges were set up across a small valley near the crest of the Virginia Mountains southeast of Reno. One station was located on the pinyon-covered south-facing slope at an elevation of about 6675 feet, another at the same elevation on the north-facing slope about 400 yards across the valley and in similar vegetation, while the third station was in the relatively flat bottom of the valley and about 200 feet lower in elevation. The latter area was sagebrush-covered with only a few scattered junipers and an occasional pinyon. The air thermometers were installed at a height of 2 feet on the north sides of tree trunks. The thermometers and rain gauges were read at intervals of 3 or 4 weeks for a year and then the instruments were moved to new locations.

Since there are practically no climatic data from weather stations in the pinyon-juniper zone of Nevada, it was decided to install ther-
mometers and rain gauges just inside the lower and upper elevational limits of the zone on the west side of the Virginia Range and also in
the region of maximum development of the vegetation near the middle
of the zone. This was done in October, 1949, and the stations con­
tinued in operation until May, 1953. A total of six stations was set
up on north- and south-facing slopes of ridges at elevations of 4825
feet, 5640 feet, and 6780 feet. The air thermometers were placed
in open aluminum shelters on the north sides of tree trunks at heights
of 1 meter above the ground. Readings were made at intervals of
3 or 4 weeks for most of the 3 years and 8 months of the study's
duration. Only an analysis of the air temperature data from these
two studies is reported here.1

RESULTS

An analysis of the air temperature data in comparison with those
from the official U. S. Weather Bureau station at Hubbard Field
in the sagebrush valley bottom shows immediately that the most
prominent feature of the temperature climate is an inversion of
minimum temperatures on the sides of the mountain range. This
produces a thermal belt which is practically coincidental with the
pinyon-juniper zone and, of course, is the result of cold air drainage
into the valley at night through the sparsely vegetated canyons. It
seems to be present most of the time throughout the year in the early
morning hours as indicated in Figure 1 since a single cold night at
the normal lapse rate in the 3 or 4 weeks of a measurement period
would eradicate the records of the inversion on the maximum­
minimum thermometers. This apparently occurred only once or twice
during the entire period of observation.

Using the minimum temperature in the valley bottom (at 4397
feet) as zero, the relative minimum temperatures of the south-facing
stations are plotted for each period in Figure 1. Temperatures at
north-facing stations at the same elevations are not plotted here; they
are usually a degree or two colder than those at the south-facing
stations except occasionally in the summer. However, the inversion
is so marked (often as much as 10° to 18° F.) at the 4825 foot and

1 It is a pleasure to acknowledge the assistance of the many ecology students
at the University of Nevada whose cheerful cooperation made the servicing of
the stations possible.
5640 foot stations that the north-facing slopes at these elevations are also almost always warmer at night than the level valley bottom. Only near the upper edge of the zone, 2400 feet above the valley, do the minimum temperatures approach those of the valley bottom.
The layer of cold air in the valley bottom is apparently not very deep since the mean minimum only 425 feet above was 8° higher. Very early on a cold winter morning, the cold air part of the inversion is indicated by the depth of the smoke haze over Reno; it appears to be less than 200 feet deep and often under 100 feet.

Maximum temperatures in the valley bottom and at the 4825 and 5640 foot levels are almost identical. This results in a smaller diurnal temperature range in the pinyon-juniper than in the sagebrush of the valley floor. However, maximum temperatures at the 6780 foot level are distinctly cooler, usually being 10° to 15° lower than those at Hubbard Field.

Temperatures recorded in 1948 and 1949 across the small valley high in the range are shown in Table I together with those from the Reno station (Hubbard Field) in the bottom of the valley to the west of the range. While both slopes are usually warmer than Reno even though almost 2300 feet higher, the small flat between them was always colder than Reno. This was an unusually severe winter for the region and during the coldest weather, minimum temperatures in the small flat were usually 12° to 13° colder than the below-zero temperatures only 200 feet above on the slopes.

DISCUSSION

In mountainous western North America, particularly in the drier parts with sparse vegetation, temperature inversions are probably not rare (see Shreve 1914 for southern Arizona, Young 1920, 1921 for southern California and southern Oregon, and Hayes 1941 for northern Idaho). Baker (1944) points out that in many parts of the West such inversions tend to mask any relation between lowest observed temperatures and elevation. However, Price and Evans (1937) in central Utah found little temperature inversion in a series of weather stations ranging from 5575 to 10100 feet on the west front of the Wasatch Plateau. Nevertheless, there is a dearth of information on such inversions and resultant thermal belts since most Weather Bureau stations are located in the fertile and flat valley bottoms. This is particularly true of the Great Basin across its 500 mile width. In fact, Baker states that climatic data are so scanty for this region that no altitudinal temperature trends can be determined.
TABLE I

Minimum and maximum temperatures (°F.) across a small flat-bottomed valley near crest of Virginia Mountains, Nevada, with comparative data from Reno.

<table>
<thead>
<tr>
<th>Ste.</th>
<th>Elec.</th>
<th>14.10.48 to 20.10.48</th>
<th>2.11.48 to 17.2.49</th>
<th>5.1.49 to 17.2.49</th>
<th>21.2.49 to 7.4.49</th>
<th>19.5.49 to 13.6.49</th>
<th>Monthly Mean* for period</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-facing</td>
<td>6675 ft.</td>
<td>20</td>
<td>15</td>
<td>-1</td>
<td>-6</td>
<td>21</td>
<td>15</td>
</tr>
<tr>
<td>Flat</td>
<td>6475 ft.</td>
<td>13</td>
<td>5</td>
<td>-14</td>
<td>-18</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>N-facing</td>
<td>6675 ft.</td>
<td>21</td>
<td>14</td>
<td>-4</td>
<td>-8</td>
<td>18</td>
<td>16</td>
</tr>
<tr>
<td>Reno</td>
<td>4397 ft.</td>
<td>14</td>
<td>7</td>
<td>-7</td>
<td>-16</td>
<td>20</td>
<td>16</td>
</tr>
</tbody>
</table>

Minimums

| S-facing | 76 | 67 | 52 | 50 | 60 | 64 | 74 | 75 | 94 | 68.0 |
| Flat | 71 | 61 | 51 | 51 | 66 | 66 | 75 | 73 | 91 | 67.2 |
| N-facing | 67 | 56 | 50 | 46 | 56 | 62 | 74 | 71 | 93 | 63.9 |
| Reno | 79 | 70 | 56 | 60 | 66 | 72 | 81 | 82 | 98 | 73.8 |

Maximums

* Both mean minimum and mean maximum temperatures are somewhat weighted downward because of the greater frequency of winter readings over summer readings.
It may be significant that the mean altitudinal limits of the thermal belt on the west side of the Virginia Range correspond very closely to the upper and lower limits of the pinyon-juniper vegetation on this range. Certainly other factors are involved in restricting pinyon-juniper to the slopes, such as the possible detrimental effects of alluvium on growth of the conifers, precipitation totals, and especially depth and persistence of snow at the upper levels. Further data are needed on the possible relationships between the lower edge of the pinyon-juniper and the variation in depth of the cold valley air at critically low temperatures. During the very cold winter of 1948-1949, pinyon showed considerable cold damage and some winter-killing around the edges of some of the western Nevada valleys particularly to the south of the study area. Low soil moisture was also a factor at this time because of two years of drought.

In this region, the average depth of the thermal belt appears to be about 2000 to 2200 feet. More information is needed on the elevation having highest minimum temperatures. Apparently, on the ridges, this is close to 1000 feet above the valley floor. It would not be surprising if such thermal belts exist on most of the mountain ranges of the central and western Great Basin since the Virginia Range topography and vegetation are rather typical of the mountain ranges of most of Nevada south of the Truckee and Humboldt Rivers.

SUMMARY

Maximum and minimum temperatures were measured for 3 years and 8 months at 6 stations located near the lower edge, in the middle, and near the upper edge of the pinyon-juniper zone in the Virginia Mountains of western Nevada. Temperatures were measured for an additional year across a small valley near the crest of the range. Comparison with temperatures for the same periods in the sagebrush-covered valley to the west of the range shows that minimum temperatures in the valley bottom are as much as 10° to 15° colder than those on the slopes 400 to 1300 feet above. These inversions seem to be present for most of the year and also occur in small valleys within the range itself. The resultant thermal belt above the layer of cold night air seems to be coincidental with the pinyon-juniper zone in this mountain range.
LITERATURE CITED


