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A CLUSTER ANALYSIS OF SOUTHERN CALIFORNIA DESERT CLIMATE DATA

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California's vast desert region has been of interest to many geographers. Generally, two or three subregions have been recognized within this area. These have been determined mainly on a physical basis, including such factors as landforms, climate, and vegetation. For example, Lantis, Steiner, and Karinen have divided this extensive area into the Trans-Sierra, the Mojave Desert, and the Colorado Desert.[1] Hartman has similarly identified the Basin and Range, the Mojave Desert, and the Colorado Desert provinces.[2]

Our study focuses on climatic similarities and differences within this area. Objectives of this paper are to cluster analyze climatic data from twenty-six stations in order to determine subregions and to describe the major elements and controls which possibly affect the various subdivisions.

Data and Study Area

Twenty-six weather stations with a continuous record were selected from the *Climatological Data, Annual Summary* publications for a study period of seventeen years (from 1962 through 1978).[3] Figure 1 is a map of the locations of the twenty-six sites. The study area ranges from Death Valley in

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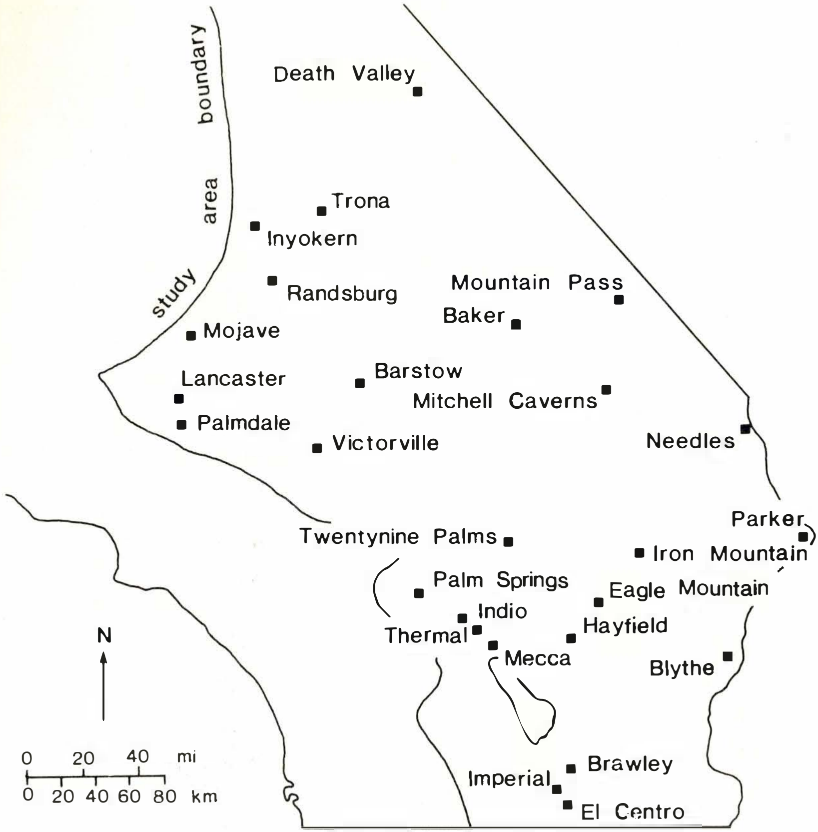

Figure 1. The Study Area

the north at approximately 36°30′N latitude south to the Mexican border; the southern Sierra Nevada, Garlock Fault, Tehachapi Mountains, Transverse Ranges, and Peninsular Ranges form the western boundary, and the Nevada state line and Colorado River border the east.

Nine climatic variables were subjected to cluster analysis. Six dealt with temperature: January average temperature, July average, annual average, extreme high temperature for the year, extreme low temperature, and number of days between the last frost of spring and the first frost of fall (if any). The extreme values and frost-free data are important in determining desert subregions. For example, winter frost is a prime limiting factor of many desert plants.[4]

Precipitation is definitely a major consideration in any study of the desert lands. Three of the nine climatic variables were: annual precipitation total, winter precipitation total, and summer total. In our report, winter was defined as January, February, and March; summer was July, August, and September. We do realize that December is an important winter month in terms of precipitation; however, we did not wish to combine data from two different calendar years. The summer convectional and hurricane-generated precipitation patterns are more typical of the southernmost part of the study area and, therefore, should contribute to the differentiation into subregions.

Data Analysis

The average value for each of the nine climatic variables was calculated for the seventeen-year period. The data for the twenty-six locations were then subjected to cluster analysis. Our computer program was modified from that of P. M. Mather of the University of Nottingham, England.[5] The purpose of cluster analysis is to select subsets of mutually similar data from the large set of all such data. A cluster is initially formed by the most similar pair; other clusters or groupings are formed based on similarity coefficients. Eventually, all the data will form one large group at a high similarity coefficient. Therefore, through cluster analysis, significant groupings can be obtained.

Results and Discussion

The results of cluster analysis are presented in the form of a linkage tree (Figure 2). The twenty-six stations form the vertical axis; the similarity coefficients are along the horizontal. The most similar locations pair off early at low similarity coefficients in the linkage tree. Note that all the stations belong to

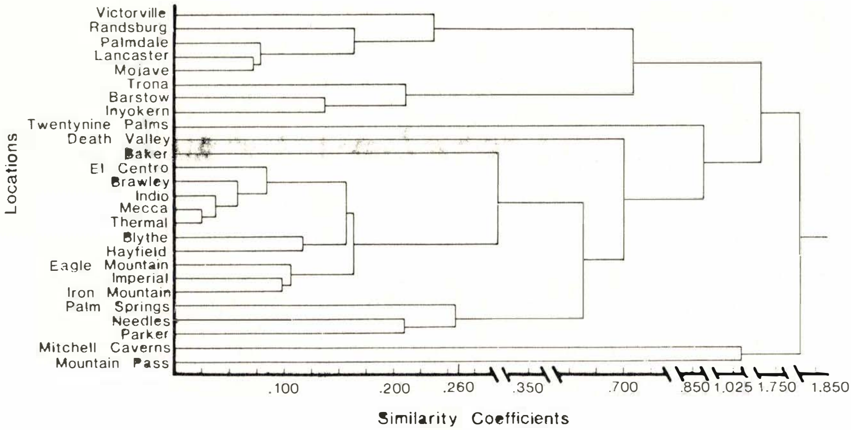

Figure 2. Desert Climates Linkage Trade

one large group at the highest similarity coefficient—a value of approximately 1,800.

Using a similarity coefficient value of approximately 0.260, four major groups occur: Group I: Victorville, Randsburg, Palmdale, Lancaster, and Mojave; Group II: Trona, Barstow, and Inyokern; Group III: El Centro, Brawley, Indio, Mecca, Thermal, Blythe, Hayfield, Eagle Mountain, Imperial, and Iron Mountain; and Group IV: Palm Springs, Needles, and Parker. Twentynine Palms, Death Valley, and Baker, as well as Mitchell Caverns and Mountain Pass, do not belong to any groups at the 0.260 level.

Figure 3 is a map of the general subregions. Although the boundaries are by no means concrete, this map organizes the findings of cluster analysis for visual display. Of the four major subregions previously described, two appear to be the northwestern Mojave Desert, one the more southern Colorado Desert, and one along the Colorado River with the inclusion of Palm Springs in this latter group. A fifth minor subregion consisting of Twentynine Palms, Baker, and Death Valley, appears to be more related to the Colorado Desert and Colorado River groupings, joining them on the linkage tree at the 0.875 level (Figure 2, Figure 3).

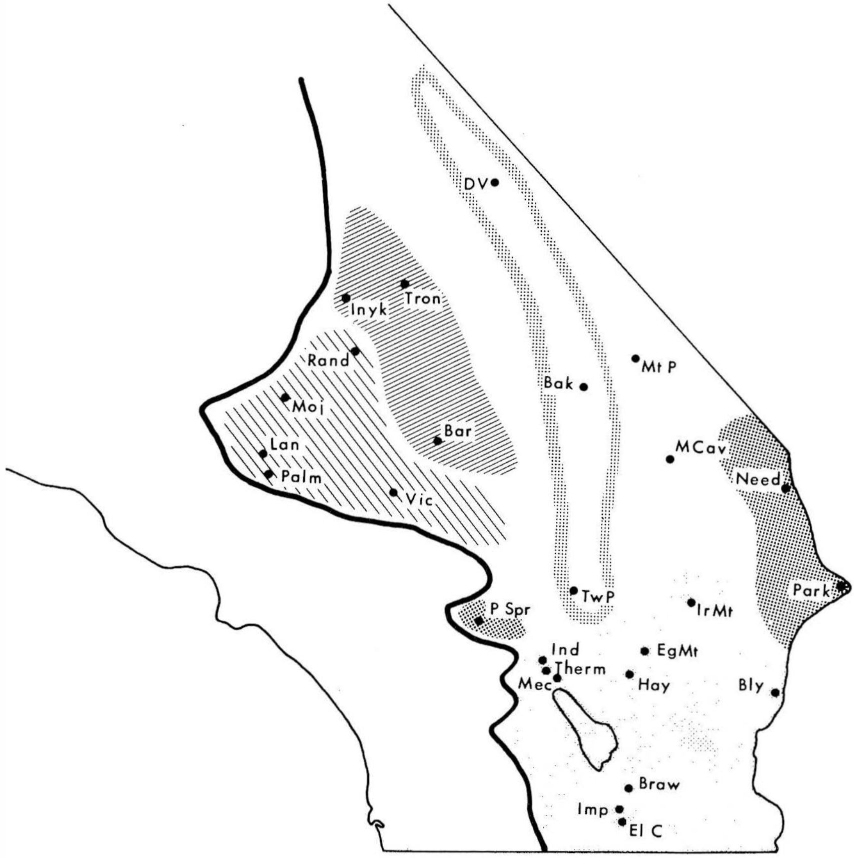

Figure 3. Major Climatic Groups

Table 1 presents additional data concerning the four major groups. Groups I and II are isolated from the larger Group III based upon latitude. The Mojave Desert (Groups I and II) is generally considered to have the higher latitudes; the Colorado Desert (Group III) includes the lower latitude locations. Parker and Needles of Group IV have relatively high latitudes as well; however, their climate is affected by virtue of location along the Colorado River. It is hard to define a sharp boundary between the Mojave and Colorado Deserts. Vegetational analyses have shown that tongues of Sonoran (Colorado

Table 1

Group	Location	Latitude	Elevation	Annual Prec.	W/S PPT	Frost-Free Days
	Victorville	34°32′N	2858 feet	5.34 inches	2.60	207 days
	Randsburg	35°22′	3570	5.70	4.21	232
I	Palmdale	34°35′	2596	6.74	5.00	222
	Lancaster	34°30′	2356	6.23	3.95	210
	Mojave	35°03′	2735	6.04	4.77	218
	Trona	35°47′	1695	4.22	2.25	250
II	Barstow	34°54′	2162	3.75	1.71	226
	Inyokern	35°39′	2440	4.48	2.51	208
	El Centro	32°46′	-30	2.33	0.91	314
	Brawley	32°57′	-100	3.13	0.76	300
	Indio	33°44′	11	3.28	1.10	305
	Mecca	33°34′	-180	2.71	0.85	297
III	Thermal	33°38′	-112	2.74	1.01	307
	Blythe	33°37′	268	3.74	0.85	287
	Hayfield	33°42′	1370	3.14	0.98	289
	Eagle Mountain	33°48′	973	2.92	0.67	362
	Imperial	32°51′	-64	2.59	0.89	340
	Iron Mountain	34°08′	922	3.08	0.96	348
	Palm Springs	33°49′	411	5.04	2.56	325
IV	Needles	34°46′	913	4.34	0.82	336
	Parker	34°17′	738	4.87	1.56	358

Desert) types of vegetation project northward into the Mojave, particularly along the Colorado River.[6]

Concerning elevation (Table 1), Groups I and II have values generally above 2,000 feet; those of Groups III and IV are basically below 1,000 feet, with several stations below sea level. Elevation is a significant control of temperature and precipitation.

The highest annual precipitation totals are found in Group I, and the lowest overall totals are in Group III (Table 1). A winter/summer precipitation ratio (W/S PPT) was also calculated for each site in Table 1. Values greater than 1.00 indicate a dominance of winter precipitation; those less than 1.00 signify more summer rainfall. The Colorado Desert Group III has most of its stations below 1.00, reflecting the effects of the Gulf of California and the Gulf of Mexico in the form of convectional summertime precipitation and spin-off from late summer hurricane activity. This is expected for these low latitude locations. On the other hand, the two Mojave Desert regions, Groups I and II, have the highest W/S PPT values. Most of their precipitation is frontal from the northwest.

The number of frost-free days (Table 1) is the greatest in Groups III and IV. Values over 300 are common. The smallest number, under 250 days, is typical of the two Mojave Desert groups. The more northern locations and the higher elevations are significant factors concerning temperature.

It is interesting to note that Mitchell Caverns and Mountain Pass did not link out until the end. These stations have the highest elevations of all—about twice as high as the Mojave Desert groups—at 4,730 and 4,330 feet, respectively. Elevation certainly would affect the precipitation totals (adiabatic effects, for example) as well as the temperature regimes (generally cooler in both the summer and the winter).

Summary

Cluster analysis can be a valuable tool for geographers in regionalization. In our study of nine climatic variables for twenty-six weather stations in the southern California desert, four subregions were defined at the 0.260 similarity coefficient level. With the exception of Palm Springs, which was more related to the Colorado River stations, each of the four groups contained locations in close geographical proximity. Basically, two of the groups belonged to the traditional Mojave Desert, and the other two were a part of the Colorado Desert. Climatic controls such as latitude and elevation as well as the elements of temperature and precipitation serve to explain why the subregions occurred.

ACKNOWLEDGEMENTS

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NOTES

1. David W. Lantis, Rodney Steiner, and Arthur E. Karinen, *California: Land of Contrast* (Dubuque, Iowa: Kendall/Hunt, 1981).
2. David N. Hartman, *California and Man* (Santa Ana, California: Pierce Publishers, 1977).
3. U.S. Department of Commerce, NOAA, *Climatological Data, Annual Summary: California* (Asheville, North Carolina: National Climatic Data Center, 1962-1978).
4. For an excellent overview and superb bibliography on California desert vegetation, refer to Michael G. Barbour and Jack Major, eds., *Terrestrial Vegetation of California* (New York: John Wiley and Sons, 1977). Chapters of particular interest include: Jack Major, "California Climate in Relation to Vegetation," pp. 11-74; Frank C. Vasek and Michael G. Barbour, "Mojave Desert Scrub Vegetation," pp. 835-867; Jack H. Burk, "Sonoran Desert," pp. 869-889.
5. P. M. Mather, *Computational Methods of Multivariate Analysis in Physical Geography* (New York: John Wiley and Sons, 1976), pp. 309-419.
6. Barbour and Major, op. cit. (footnote 4).