Climate Variation since 1900 in the Mojave Desert Region Affects Geomorphic Processes and Raises Issues for Land Management

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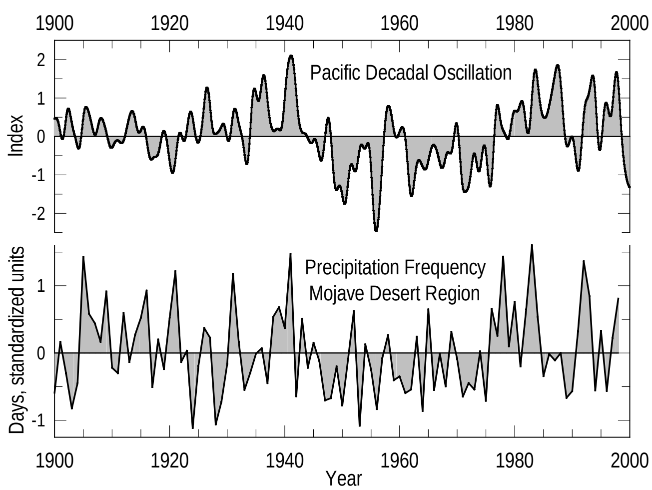
Precipitation in the Mojave Desert region varied substantially in the 20th century, causing landscape change and raising questions for land management. Precipitation patterns in this region are influenced by global-climate fluctuations of sea-surface temperature (SST) and atmospheric pressure operating on two time scales: the 4–7 year periodicity of the Southern Oscillation (SOI: El Niño and La Niña) and the decadal variations of the Pacific Decadal Oscillation (PDO), an index of the relative SST of the Northern Pacific Ocean. The average annual occurrence of daily precipitation ≥ 90th percentile, whose regional average is ≥ 15 ± 3 mm, has varied considerably, evidently in phase with the PDO. The frequency of this high-intensity precipitation, which is highly correlated with annual precipitation, was relatively large from the early 1900s to early 1940s and again from the late 1970s to 1998, whereas precipitation frequency was low in the intervening period of the early 1940s to mid-1970s. Dry years occurred during the two wet intervals but they were typically less frequent and of shorter duration than during the dry period. Likewise, wet years occurred during the dry period; these were of short duration, however, and regional precipitation was only slightly above normal.



Top—smoothed monthly indices, note sharp downward shift beginning late 1998. *Bottom*—annual frequency of daily precipitation ≥ 90th percentile averaged year-by-year at each of 52 weather stations, note increased frequency beginning 1976.

Our results suggest these long-term changes in precipitation patterns affected overland flow and alluvial processes in the central Mojave Desert. Indeed, the physical landscape—the substrate of the desert ecosystem—was altered by the precipitation patterns of the 20th century. The Mojave River, the major drainage in the region, had large floods during nearly all Los Niños for which discharge records are available. Beginning around the mid-century, alluvial channels of large-basin streams such as the Amargosa River and Kingston, Death Valley, and Watson washes aggraded and developed floodplain-like surfaces, a likely response to few large floods which enhances sediment storage. Large, destructive floods were probably rare at this time because high-intensity precipitation was infrequent. In contrast, during the recent wet interval, several relatively large floods in the early 1980s and 1990s eroded the channels, scouring the floodplain-like surfaces.

Long-term precipitation variability alters the frequency of overland flow, which in turn affects sediment yield, surface stability, and replenishment of shallow aquifers. The frequency of overland flow and sediment yield are currently being reconstructed at 20 sites in the central

Mojave Desert using artificially-ponded alluvial deposits. This alluvium occurs on the upslope side of several railbeds constructed around 1906 extending from Ludlow, California to north of Beatty, Nevada (Hereford and Webb, 1997; Myrick, 1992). The deposits record the number of times water and sediment entered the impoundments. Sedimentologic studies show that runoff large enough to deposit recognizable sedimentary layers occurred between 7 and 39 times across the region in the past century in basins ranging in size from 0.1 to 10 km^2. Using the presence of ^{137}Cs as a time-stratigraphic marker of the post-1952 atomic era, it appears that runoff frequency was relatively low after 1952 in at least 50 percent of the studied basins, suggesting the dry period affected runoff in small basins as well as large ones.

The response of the desert landscape to the climate variation of the past century provides a basis for predicting how the desert might respond to future climate. Current long-term climate predictions based on the PDO suggest that climate of the next 20 years may be similar to the 1940s–1970s. If so, this future climate is likely to produce several predictable responses in the desert ecosystem. Stream channels and hillslopes will likely adjust to the new precipitation regimen, as they respond to the expected decrease in the frequency of high-intensity precipitation. Alluvial channels are expected to recover or heal from the floods of the 1980s–1990s, as large floods will be relatively uncommon in the next several decades. Less-damaging floods will occur and should enhance sediment storage on developing floodplains; riparian vegetation may flourish in this flood regimen where ground-water levels do not drop substantially. Sediment yield is likely to decrease because of infrequent hillslope runoff and sediment storage in the alluvial channels of large basins. Infrequent runoff, however, could reduce recharge of shallow alluvial aquifers, although mountain-front recharge may not be significantly different from long-term rates.

Land managers should consider the potential influence of relatively dryer climate when planning restoration projects and monitoring biological components of the desert ecosystem. Restoration projects, investigations of landscape recovery, and studies of floral and faunal population dynamics undertaken in the previous 20 years were done when conditions were favorable for plant and animal growth. In the near future, persistent dry conditions will stress the flora and fauna, decrease surface runoff and replenishment of shallow aquifers, and increase recovery times from human disturbances. From the perspective of land management, the differences between the two climates are that in the dry regimen recovery times will be longer and the ecosystem will be more sensitive to disturbance.

Additional Information

Climate History Web Site: www-wmc.wr.usgs.gov/mojave/climate-history/
PDO data is from N. Mantua, http://atmos.washington.edu/pdo (accessed June 19, 2000)

Selected References

Hereford, Richard, and Webb, R.H., 1997, How often does rainfall cause overland flow in the arid Mojave Desert? A study of reservoir deposits in Valjean Valley (abs.): San Bernardino County Museum Association Quarterly, v. 44, p. 14.

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