Predicting the Effects of Dry Climate on Landscape Development in the Mojave Desert and Southern Colorado Plateau, with Implications for Resource Management

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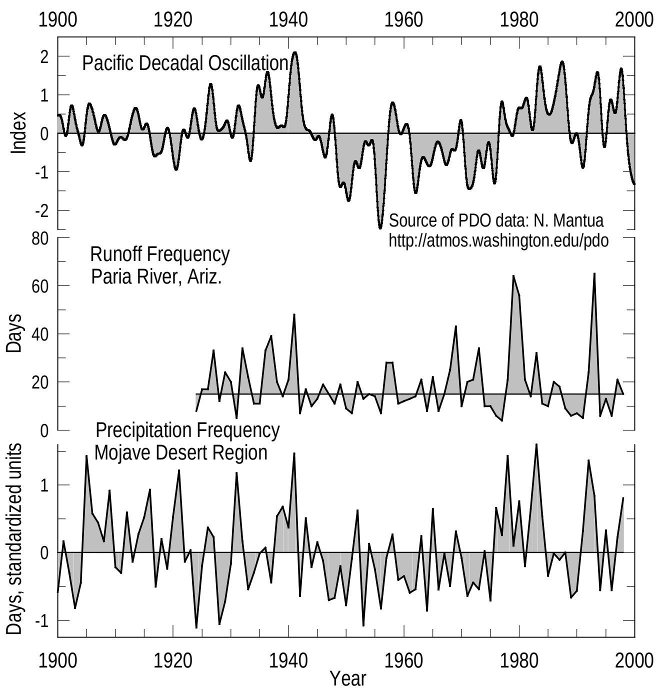
Predicting the effects of climate on landscape development is no less difficult than predicting climate itself. Nevertheless, one can make several broad generalizations by assuming future climate will have about the same effect on alluvial processes as in the recent past. The historic (post-1900) precipitation patterns of the Mojave Desert and southern Colorado Plateau are roughly similar. Precipitation in both regions is influenced moderately by global-climate fluctuations of sea-surface temperature (SST) and atmospheric pressure operating on two time scales; specifically the inter-annual variations of El Niño and La Niña as expressed by the Southern Oscillation Index and the long-term variations of the Pacific Decadal Oscillation (PDO). For example, during 50 percent of the Los Niños cool-season precipitation was above normal while in 70 percent of them warm-season rainfall was below normal. Conversely, during 80 percent of the Los Niñas cool-season precipitation was below normal, but 50 percent had above normal warm-season rainfall. The PDO (an index of the relative SST of the Northern Pacific Ocean) influences precipitation over time scales of 2–3 decades. The recent cool phase of the PDO from the 1940s–1977 reduced precipitation in the desert and runoff on the plateau, whereas, the recent warm phase from 1978–1998 produced unusually wet conditions in the desert and frequent runoff on the plateau for most of the period.



Top—smoothed monthly indices. *Middle*—frequency of daily runoff ≥ 95th percentile by year. *Bottom*—average annual frequency of daily precipitation ≥ 90th percentile at each of 52 weather stations.

These long-term changes in precipitation patterns affected hillslope runoff in the central Mojave Desert and alluvial processes in high-order channels of both regions. Although the interpretation is evolving because the data are incomplete, the frequency of overland flow during the cool-phase PDO was low in 50 percent of the studied basins ranging from 0.1 to 10 km^2. Alluvial channels on the southern Colorado Plateau as well as the Amargosa River, Kingston, Death Valley, and Watson washes in the Mojave Desert developed floodplains and aggraded their channels. In the southern Colorado Plateau, alluviation was related to a reduction in the frequency of large floods, a situation enhancing sediment storage in high-order channels. Large, destructive floods were rare in both regions at this time probably because the frequency of high-intensity precipitation was suppressed. In contrast, during the present warm phase of the PDO, high-intensity rainfall was relatively frequent, particularly during the unusually strong and persistent Los Niños that were characteristic of the period. Several relatively large floods in the early 1980s and 1990s eroded the channels and floodplains, producing a terrace in the southern Colorado Plateau streams and scoured floodplain-like features in the desert washes.

If the PDO shifts to a cool phase similar to the 1940s to 1977, as many climatologists infer, stream channels and hillslopes will likely adjust to the new precipitation regimen. The frequency of high-intensity precipitation may be reduced, even during active ENSO seasons. Alluvial channels are expected to recover or heal from the floods of 1980s–1990s, as large floods will be uncommon. Floods will still occur, but they should enhance sediment storage on developing floodplains. Riparian vegetation may flourish in this flood regimen where groundwater levels do not drop substantially. Sediment yield, moreover, is likely to decrease because of infrequent hillslope runoff and sediment storage in high-order alluvial channels.

Finally, land managers should consider the potential influence of relatively dryer and warmer climate when planning restoration projects and monitoring biological components of the 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 unusually favorable. In the near future, persistent dry conditions will stress the flora and fauna of both regions, 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 one recovery times will be longer and the ecosystem will be more sensitive to disturbance.

[1]Global Change Climate-History Program–Southwest Project–Climate and Fluvial Processes and Mojave Desert Ecosystem Science Project