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# Past vegetation influence on the hydrological cycle in the Chihuahuan Desert, North Mexico as indicated by data of four pollen sites

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A B S T R A C T

Pollen studies of four sites in the Laguna Mayran region of North Central Mexico, along with sedimentary data reconstruct changes of vegetation and hydrology of both upland and lowland zones in the southern Chihuahuan Desert region of the past 13,000 years. Dual palynology–sedimentology data sets presented here are indicative of major vegetation influence on the hydrological cycle that represents a factor in the interpretation of climate changes. Most significant reconstructions include the development *Ulmus–Quercus* woodland along edges of the Laguna Mayran and increased evapo-transpiration. In contrast, Late Holocene environments contain opportunistic wetland plants in a desert setting. This suggests that higher lake levels may result at least from lower transpiration and that major precipitation events as such are episodic in the Late Holocene. Ponding also occurs at higher elevation, with lower transpiration according to a prominence of cool steppe plants at the site of La Angostura in the Late Pleistocene, when evaporation levels are also lower. Carbon isotope data at examined sites is also suggestive of an importance of local factors in the prominence of C3 versus C4 plants.



## 1. Introduction

The Chihuahuan Desert region in North-Central Mexico considered in this palaeo-ecological study is arid to semi-arid and dominated by desert scrub in both lowlands, bordered in both the east and west by north–south trending mountain ranges of the Sierra Madre (SM), that has undergone significant changes of natural environment since the Pleistocene (Fig. 1). Today, desert bottomlands contain intermittent play basins that are sensitive to hydrological variation may form short-term lake bodies after heavy summer rains, with monsoon systems originating in the Gulf of Mexico being a key source of moisture. The largest of such basins in the Chihuahuan Desert is the Laguna Mayran (LM) in South Coahuila, itself subjected to major flooding three times during the 20th Century and as recently as 1992 (Fig. 2). This (LM) basin is a focus of present study at the sites of LM Cuota 2 and LM Cuota 7, and smaller basins indeed have been a focus of climate history studies in the region (e.g., Metcalfe et al., 2002; Roy et al., 2014) with a view to changing hydrological conditions since the Pleistocene. However, a limitation in many studies is that pollen data are sparse, and particularly after the Pleistocene. A poverty of Holocene pollen data further restricts an understanding of hydrological changes at the Pleistocene–Holocene boundary. The flora of both upland and lowland basins is comprised of significantly different vegetation in the Late Pleistocene versus Early Holocene, and a Late Holocene vegetation of an increasingly arid type.

Palynology as well as sedimentology study of four reported sites in lowland and upland settings dating from Late Pleistocene to Modern times are part of the University of Texas Laguna Project examining hydrological change. The Laguna Project as a whole comprises a 40 site fluvial-geomorphological database, and has enhanced previously sparse palaeo-environmental work in the region to a significant extent. Presently reported sites represent discontinuous periods from the Late Pleistocene to Late Holocene, as individual sites contain multiple unconformities which may be related to periodic xeric conditions. Lowland–upland contrasts examined here also include a consideration of a small basin from the SM Oriental at the La Angostura (LA) Pond and Equid sites, (Figs. 3–4, 7) that are contra-posed to the lowland sites of LM Cuota 2 and 7. A utility of palynology with in-situ sedimentology lies in that differences in local flora that may influence hydrology can be assessed vis a vis context sedimentological changes. Here it is especially observed that herbaceous flora supporting a less-substantial rhizosphere than arboreal flora have a much lower impact in water tables than arboreal flora in Chihuahuan Desert

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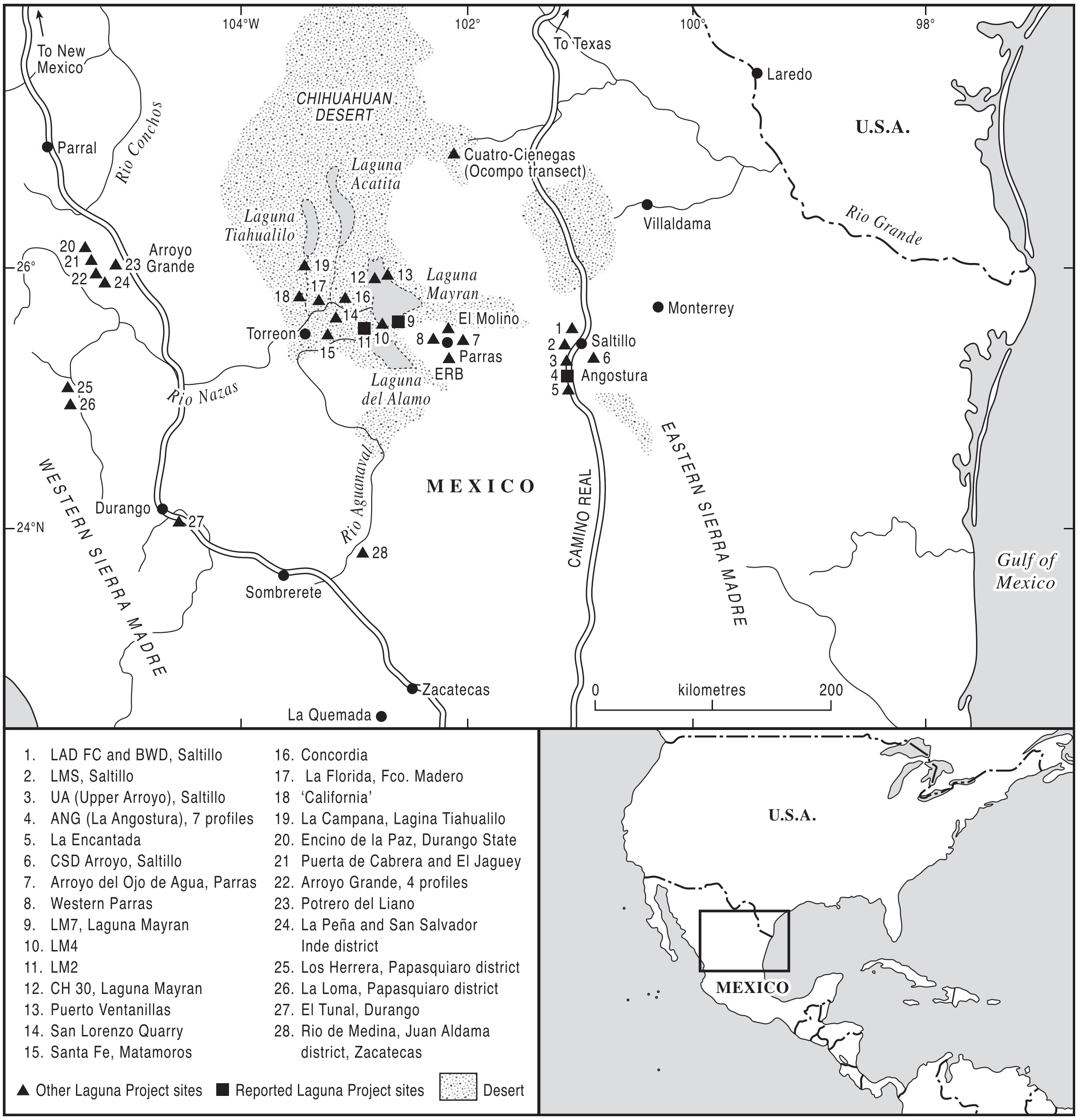


**Fig. 1.** Regional map, Laguna Project and Chihuahuan Desert, North-Central Mexico, reported sites are indicated as large squares. Sites of LM Cuota 2 and LM Cuota 7 are designated here as LM2 and LM 7. Figure courtesy of Karl Butzer, D. Geography and Environment, U. Texas at Austin.

settings, so that under a given precipitation level, water tables will be lower under arboreal versus herbaceous cover. These factors influencing changes of soil moisture are expressed by the equation (http://water.usgs.gov/edu/watercycleevapotranspiration.html, Wilcox and Thurow, 2006):

$$\Delta S = P - E(T) - D$$

Where S signifies soil moisture content, P precipitation, E (T) evapo-transpiration and D drainage. Herein, Micro-topographic changes including rill and gulley erosion also influences drainage (D) as well as vegetation change as this influences evapo-transpiration (E [T]), a variable that comprises focus of this work. Some changes like vegetation changes are complicated in their influence on soil moisture content because increased biomass promoted through increased precipitation also increases evapo-transpiration. Such negative feedbacks between increased precipitation and increased evapo-transpiration can be very significant in the Chihuahuan Desert, where experimental data (Scanion et al., 2005) from small plots consisting of vegetated and non-vegetated lysimeters indicate that major changes in soil moisture content ($\Delta$ S) occur not only according to weather conditions (esp. ENSO variability, cf. P), but also vegetation type at a given site. Significantly, increases of soil moisture retention ($\Delta$ S) occur at depth with decreased desert scrub vegetation independent of short-term weather conditions by a factor of approximately 50%. It is possible also that more profound vegetation change, may influence hydrological variation.

With a view to influences of the hydrological cycle in relation to vegetation changes, problems of interpretation arise then in single proxy data that leave vegetation changes undefined. In the case of the previously cited study from the northern rim of the Chihuahuan Desert region (Scanion et al., 2005), changes of soil chemistry is measured according to water-soluble Chloride concentration. In examined soil profiles in this study, low