Effects of Aridity and Vegetation on the δD of Modern Lake Sediment Plant Waxes

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Introduction

The hydrogen isotopic composition of plant-wax molecules is systematically related to the δD of precipitation, providing a basis to reconstruct paleoprecipitation δD and paleohydrology. However, climate and physiological factors also affect δD making the interpretation of plant-wax δD signatures a challenge.

We analyzed the deuterium content of plant-wax *n*-alkanes from surface lake sediments in 31 watersheds that span a range of precipitation δD, vegetation types and climates to better understand how each of these variables shape plant-wax δD.

Modern Lake Sites

Our samples (Fig. 1) integrate vegetation sources in each lake's watershed over multiple years, providing a temporal average of the watershed ecosystem analogous to many ancient sediments.

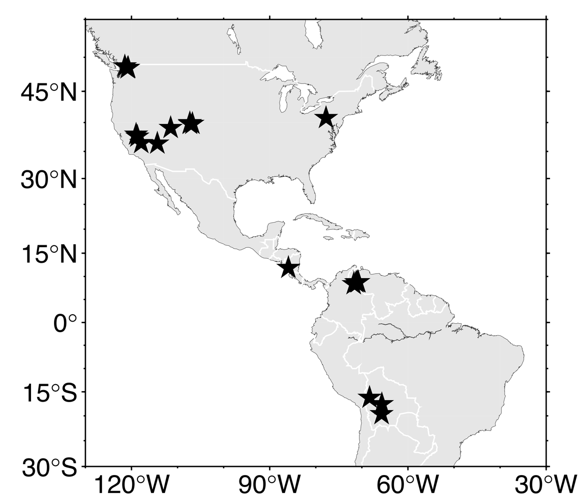


Figure 1 – Sampling sites.

n-Alkane/Precipitation δD

Precipitation δD is the first-order control on plant wax δD (Fig. 2). Expressing *n*-alkane δD as an isotopic fractionation relative to precipitation highlights the effects of vegetation and climate on plant-wax δD:

$$\varepsilon_{C_{29}/ppt} = (\delta D_{C_{29}} + 1)/(\delta D_{ppt} + 1) - 1$$

Values for $\varepsilon_{C_{29}/ppt}$ are different for each ecosystem suggesting vegetation plays a determining role in plant-wax δD (Fig. 3). Vegetation can influence δD through species-dependent leafwater enrichment, soil evaporation and biosynthetic effects.

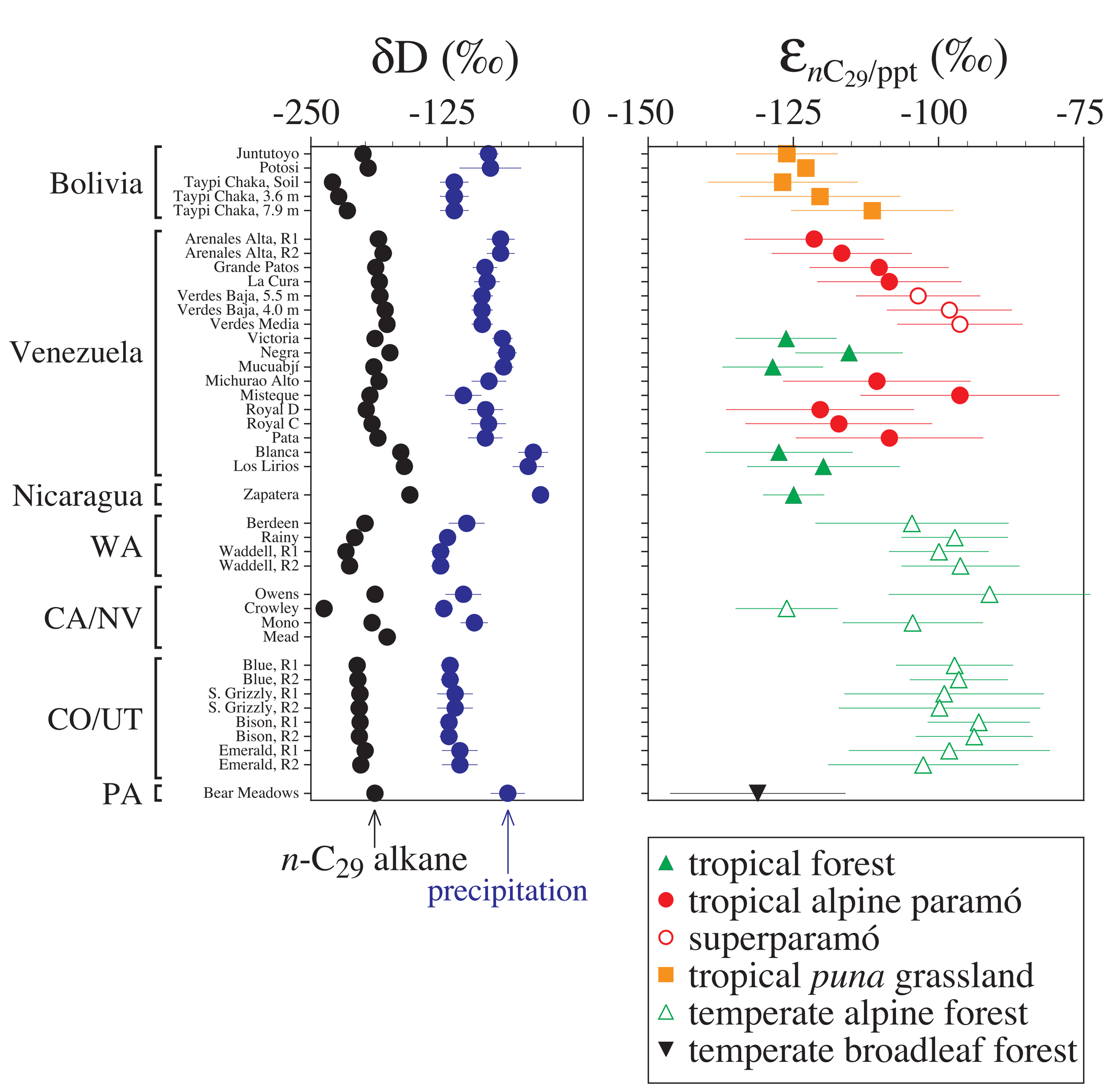


Figure 2 – Alkane and precipitation δD, and $\varepsilon_{C_{29}/ppt}$.

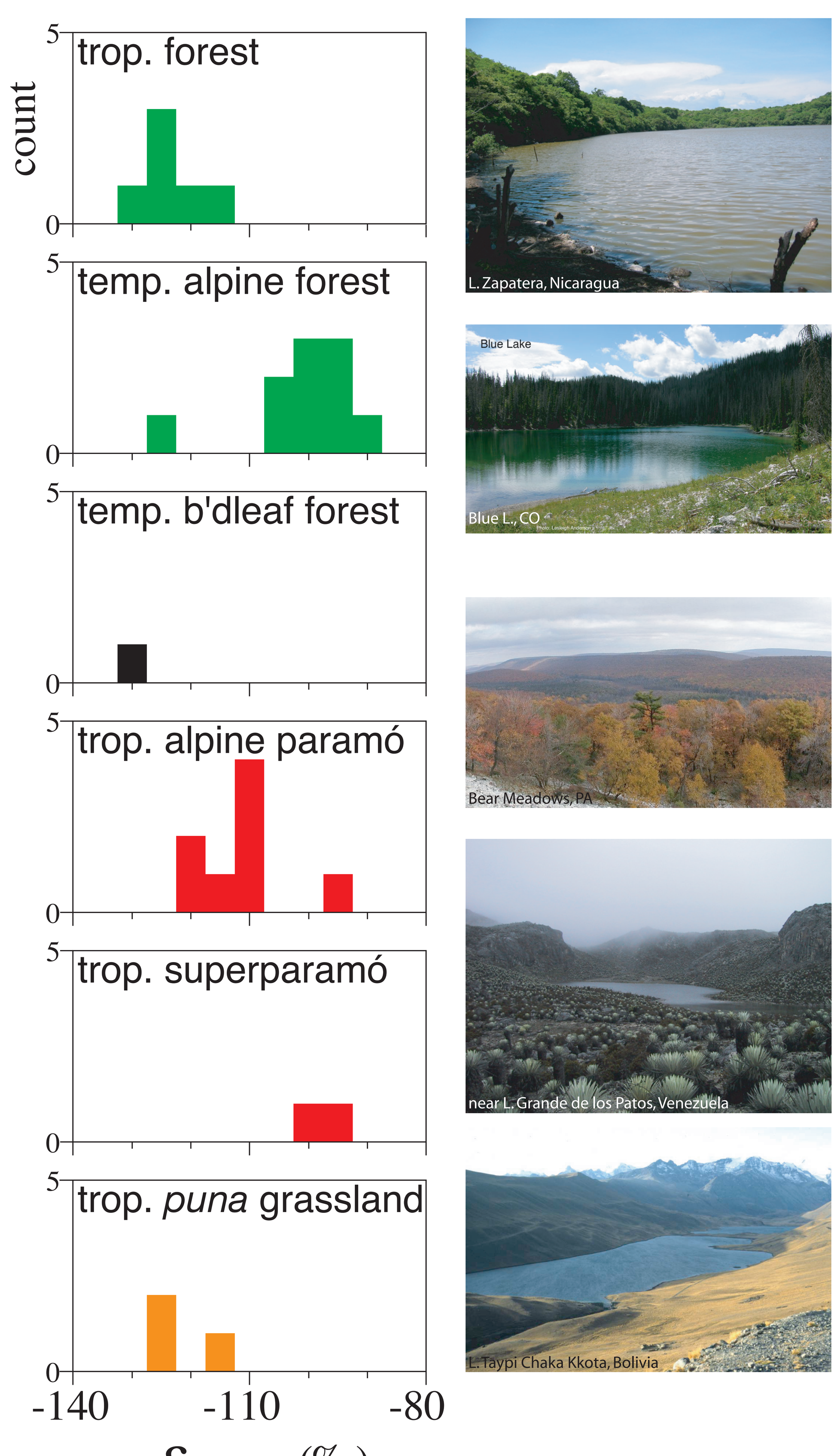


Figure 3 – $\varepsilon_{C_{29}/ppt}$ grouped by biome.

Aridity Increases *n*-Alkane δD

The evaporative enrichment of lakewater isotopes depends upon many of the same variables responsible for soil- and leaf-water enrichment (temperature, relative humidity, precip./evap. ratio). We compare $\varepsilon_{C_{29}/ppt}$ with lakewater enrichment in each watershed as a qualitative indicator for isotope effects from aridity.

We find that isotopic fractionation of $\varepsilon_{C_{29}/ppt}$ *n*-alkane/ precipitation increases with aridity (Fig. 4). The rate of increase is different for each ecosystem suggesting that vegetation influences how plant-wax δD responds to climate.

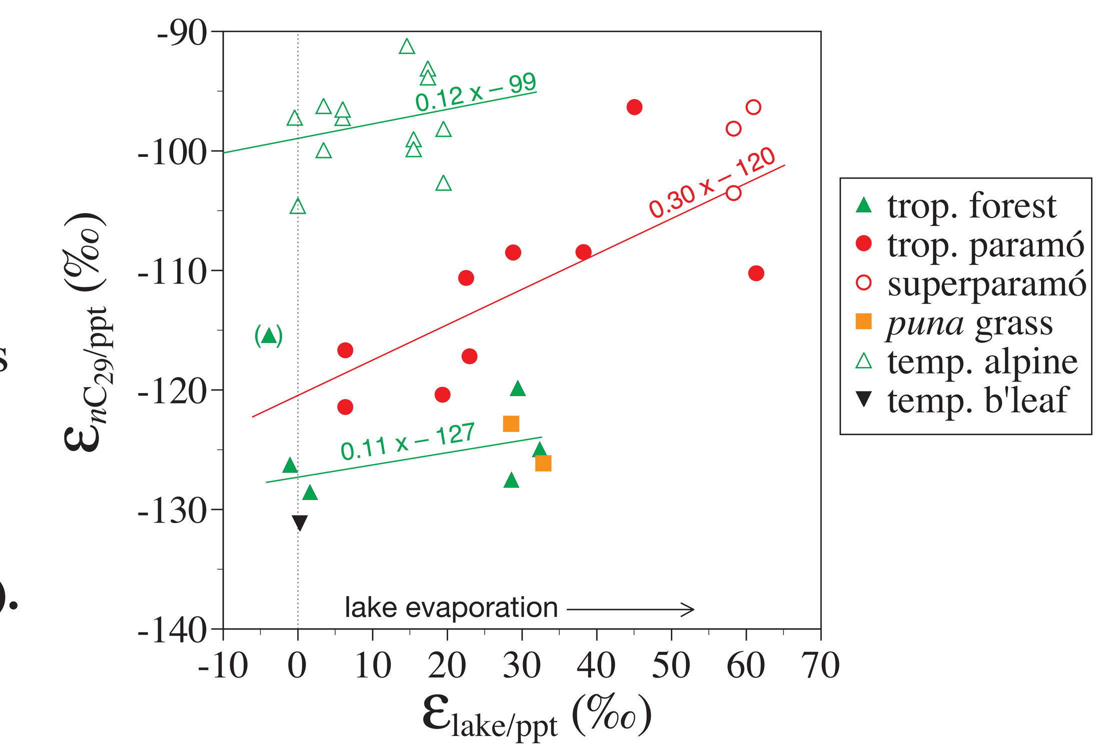


Figure 4 – $\varepsilon_{C_{29}/ppt}$ and lakewater enrichment.

Isotopic Modeling

Isotope models illustrate the relationship between lakewater enrichment and leaf-wax δD as a function of climate and lake/watershed area (Fig. 5). Ongoing work aims to quantitatively model each watershed to differentiate the effects of soil evaporation from leaf transpiration (Box 1).

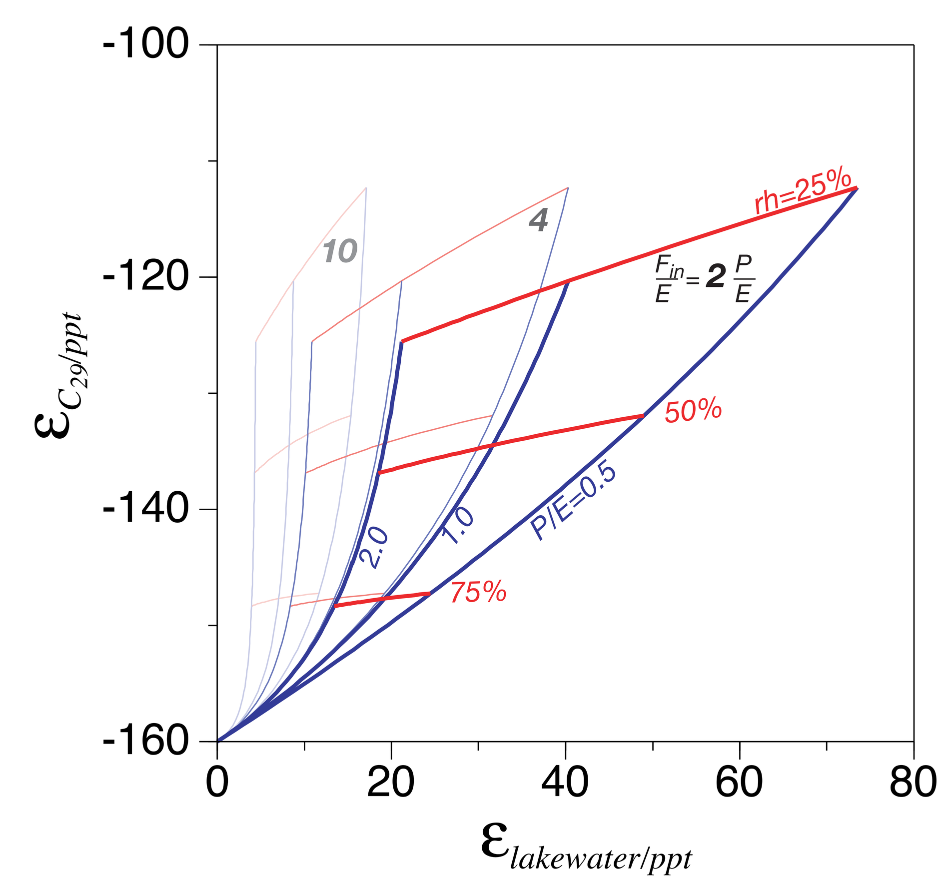
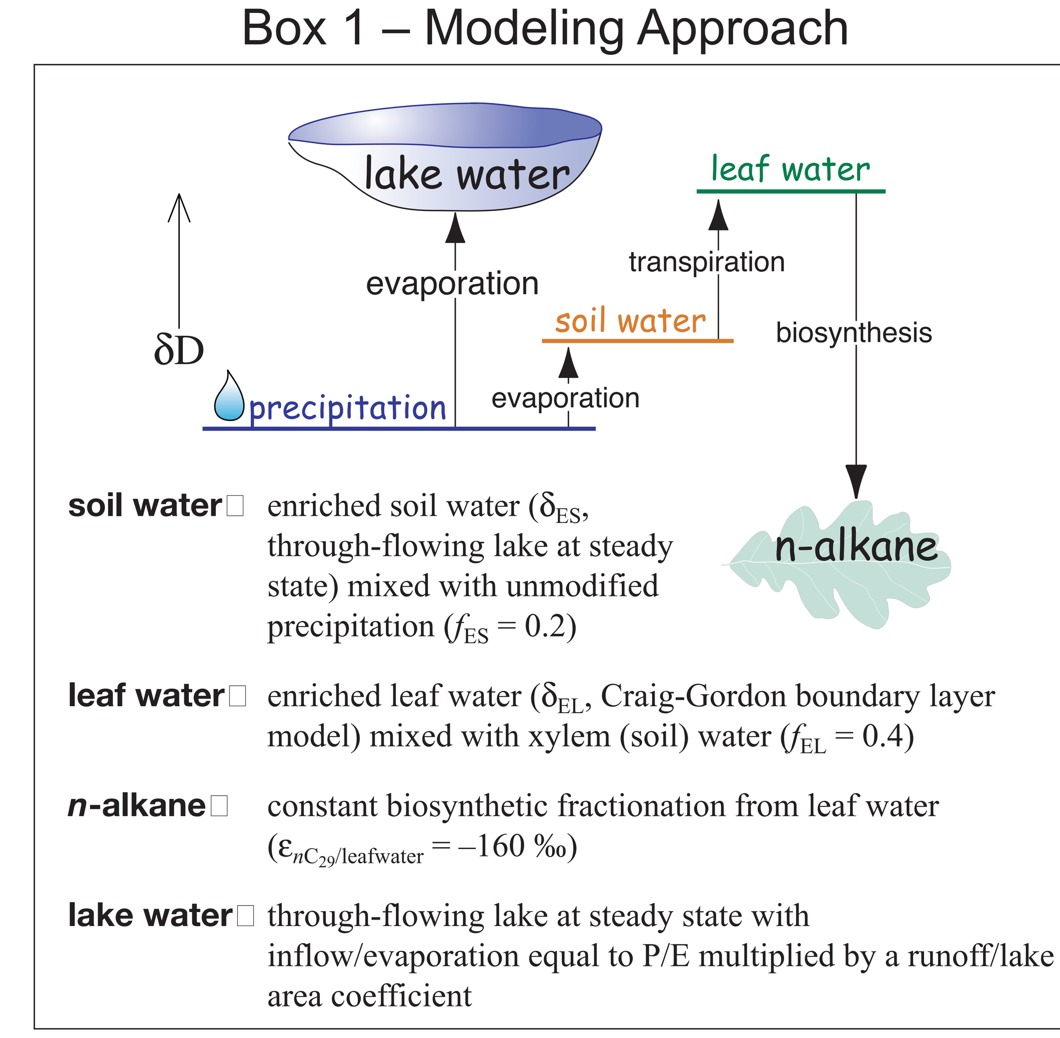


Figure 5 – Effects of climate on leaf- and lakewater enrichment and $\varepsilon_{C_{29}/ppt}$.

Box 1 – Modeling Approach



Conclusions

Our results demonstrate both climate and vegetation are determinants of the isotopic fractionation between precipitation and *n*-alkane hydrogen. Both must be considered when interpreting the δD of ancient plant waxes.

Isotopic differences between ecosystems reflect the influence of both plant physiology and the physical layout of the ecosystem on isotopic effects during soil evaporation and transpiration. Biosynthetic differences may also play a role but cannot be separately evaluated from the data.

Isotope models for soilwater, leafwater and lipid δD may further our understanding of evaporative and biosynthetic effects, however these models are not well constrained at present.

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