# A new biomarker approach to reconstruct past vegetation patterns

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We developed a new biomarker approach to reconstruct past vegetation dynamics and applied it to reconstruct shifts in upper forest line positions in the Ecuadorian Andes in the last 6000 years BP. The approach is based on plant-specific concentration patterns of n-alkanes and n-alcohols with chain-lengths of 20-36 carbon atoms originating from the epicuticular wax layers on leaves and roots of terrestrial higher plants and preserved in sediments or soils. Unique concentration ratios of several lipids of different chain-lengths are species-specific, and not the individual lipids themselves. As a result until now progress was hampered by the lack of a suitable method to unravel the mixture of lipids of various chain-lengths in soils or other archives (e.g. peat deposits) into the species-specific concentration ratios. We first constructed a biomarker database for dominant present-day vegetation in the Ecuadorian study area, and established that in most cases biomarker based separation was possible at the species level. To enable interpretation of the mixed biomarker signal, we subsequently developed the VERHIB model: a constrained linear regression model that describes how vegetation development over time at a certain location results in accumulation of biomarkers in a suitable archive. Paleo-vegetation is reconstructed from the accumulated biomarker signal by inverting the forward model. VERHIB was applied to reconstruct vegetation from three soil cores along an altitudinal transect in the Ecuadorian setting, containing the current volcanic ash soil and two paleosols developed in previous ash deposits. Combined with pollen data from the same core, the new method gave a vegetation reconstruction with high spatial resolution and level of separation, far beyond that obtainable by pollen analysis alone. This allowed us to reconstruct the natural upper forest line position in the northern Ecuadorian Andes and thereby guide sustainable reforestation efforts in this area.