

ning the relation between present vegetation and pollenproduction, the data concerning temperature and rainfall distribution as gathered along the transects. Other data of meteorological importance from the various stations in Colombia concerning climate and weather. The first step in the construction of the model will be to establish the relation between the actual change in vegetation along the transect and the variation observed in the physical parameters.

In a first approach we will take temperature magnitude of rainfall and distribution of rainfall over time as

the independant variables and a compilation of the vegetational data as dependant variables. The compilation of the vegetation data will be done by programs for arranging multivariate data in ordered two way table by classification of the individuals and attributes.

The established relation between climate and vegetation dataset can be used to reconstruct maps of the temperature and rainfall in the past. From the arising patterns the relation to the general circulation patterns can be constructed in the same way by analysing the response surfaces with contour algorithms.

The Pliocene and Quaternary history of the northern Andes

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The final upheaval of the northern Andes takes place in the Early to Middle Pliocene. It is then that the higher mountain environments are created. During the Tertiary, however, hills and low mountains were formed during pre-Andean and proto-Andean orogenic phases, possibly not higher than 1 000 m. In these hills and low mountains the evolution of the Andean montane flora started already, but during and after the Pliocene upheaval to the present elevations (locally up to approx. 5 800 m), the present montane and páramo flora and vegetation came into being by evolution-adaptation and immigration. As at the same time the isthmus of Panama came into being, immigration could take place not only from the southern temperate area, but especially also from North America. The first immigrants from the north are elements from the subtropical to warm temperate Tertiary Laurasian flora; later follow more temperate elements. In the páramo flora about 50 % of the genera is of temperate origin, but going downward via the upper and lower montane forests, this cipher decreases fastly, and below 1 000 m almost all the genera are of neotropical origin.

Palynological study of Pliocene sediments in the area of the high plain of Bogotá revealed the gradual uplift of the area to the present elevation of 2 580 m, showing the change of tropical to montane and páramo vegetation.

A large lake is formed in the area of this high plain, towards the end of the Pliocene; it continues to exist (with temporal fluctuations of the lake level) until

some 30 000 years ago. However, the lake of Fúquene, at the same elevation as the high plain of Bogotá, continues to exist till the present day. The total sequence of lake sediments is at least 400 m. Pollenanalysis of these sediments has revealed a long sequence of glacial and interglacial periods. The forest limit is depressed 1 000-1 200 m or more during the cold periods. The temperature may then have been 6°-8° C lower than today. The montane forest belts were also depressed. In the Occidental Cordillera the oak forest, today between approx. 2 000-3 000 m altitude, was present at 1 500 m during the Last Glacial, but the temperatures at sea-level were probably only some 2° lower than today. This means that the temperature gradient must have been much steeper, in the order of 0.8-0.9 °C.

During the strong tectonic movements of the Pliocene large mud streams, often with large blocks of rock, were formed, often closely associated with faults. During the early Pleistocene, much angular breccious material was still being deposited in the marginal area of the high plain, probably by solifluction. At the same time, gravels of probably fluvio-glacial origin were deposited, and palynological data indicate a very cold climate. Volcanic ash layers from immediately below were dated around 3 million years, and the complex might represent the first larger Glacial.

The Last Glacial is known with much more detail. There is a cool and very wet period during the Middle Pleniglacial, when lake levels were high and a broad zone of Polyëpis was present in the hills around the

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high plain. This is followed by a very cold and dry period, culminating shortly after 20 000 B.P. During the wet phase, the páramo zone was very narrow, glacial extension was at its maximum, and glaciers were locally in contact with the forest. During the cold and dry Upper Pleniglacial, the páramo zone was very broad, the forest limit at its lowest position, and glaciers had already retreated considerably. Locally, on the slopes of interandean valleys, the open páramo vegetation was in contact with open xerophytic

vegetation below, leaving there no forest at all. Large extensions of open areas were thus created, where large herds of mega-fauna developed (Mastodon, etc.).

This situation changed fundamentally at the beginning of the Holocene ; the rapidly extending forest reduced greatly the original habitat of these animals. This fact, together with the hunting activities of Man since some 12 000 years ago, resulted finally in the extinction of the mega-fauna.