Dendrochronological studies in the Peruvian North coast relate to ENSO.

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1. Abstract

Dendrochronological studies in the Peruvian north coast to find records of past El Niño-Southern Oscillation (ENSO) events began on the late 80's. The Peruvian north coast is the west-most area of South America, close to Equator (05o S, 80o W) and to the Sechura desert, is a very sensitive area to the climatic changes due to ENSO.

An initial selection of several regional trees have been done for study. The study includes phenological observations and tree ring characteristics analysis as well as radial growth control of tree trunks and branches. The species more intensively studied and suitable to find records due to the ENSO are Palo Santo, Hualtaco and Sapote.

A relatively long record of radial growth for these three species are presented. The period includes dry and ENSO years, including the extraordinary 1997-1998 event. Palo Santo and Hualtaco show very high sensitivity to ENSO with high probabilities to contain records of such events. Sapote grows in the desert area and its radial growth is controlled mainly by subsoil water because it present growth variation according with seasons and rain periods. This species does not present complete tree ring.

Palo Santo and Hualtaco grow on foothills and well drained areas that surrounding the flat coastal desert. These species do present complete tree rings with a width that depend on the local rains. In the driest areas (close to the ocean) they grow only during the occurrence of ENSO whereas in the wettest areas, they grow every year during the rainy season. In both areas they respond very quickly to rain few centimeters. They quickly respond with new leaves and grow a new ring. During the dry seasons they go dormant, with no leaves nor grow. Dormant periods can last for years specially in dry areas. Most of the trees were under observation present during the last warm-ENSO events in 1987, 1992 and 1998.

A preliminary analysis of the correspondence between rainfall and Palo Santo growth shows high correlation and the potential of this species to render an annual past chronology of rainfall intensity and hence of past ENSO occurrence and others climatic variations. These dendrochronological series also are potentially useful to reconstruct SST and rains, and in turn useful for patterns of climatic variability.

These studies will be intensified and extended after the next installation of a dendrochronological laboratory at the Universidad de Piura, Peru.

2. Description of Peruvian north coast.

The arid northern coast of Peru lies roughly between 3.5 and 7 south latitude along the west coast - the most western area - of the South America continent. This region - known as the Sechura Desert- is relatively flat and considerably wider than the rest of the Peruvian coast, extending some 140 km from the coast to the Andean foothills. The northern portion of this relatively flat desert region is interrupted by a NE/SW chain of low-lying hills called the "Cerros de Amotape". Typical of the entire Peruvian coastline, this desert littoral is traversed by three main rivers that flow westward through fertile valleys, from the foothills to the coast.This rivers are Tumbes, Chira and Piura.

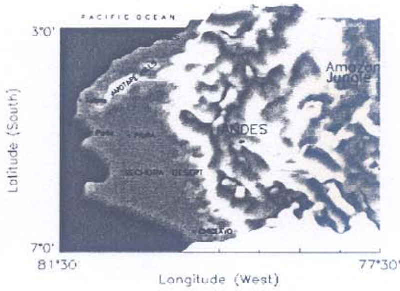


Figure 1 Geographical characteristics of the Northwest of the Peru

3. Normal Climate and ENSO effects

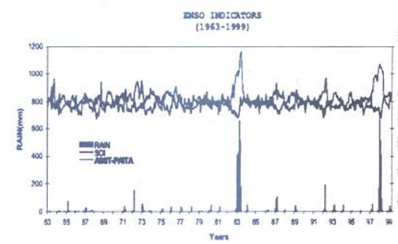
3.1 Normal climate

The climate of the northern coast of Peru is normally warm, dry and desert like. The mean yearly rainfall in the region amounts to only about 75 mm. Most of this rain falls during the summer (January to April) season near the eastern edge of the region in the Andean foothills, where the Tumbes, Chira and Piura rivers originate. Thus, the Sechura desert to the west of the foothills experiences a proportionally smaller rainfall than the above-stated value. SSTs along the Peruvian coastline, on the other hand, are quite cold, and are due to the upwelling of abyssal oceanic waters that have been pushed northward from Antarctica.

3.2 Climate during the ENSO

The initial observable effect of an ENSO event in the vicinity of the northern Peruvian coast is a warming of the Coastal water arising from the eastward surge of warm surface waters into the eastern equatorial Pacific. SSTs along the coast increase sharply, with mean temperature changes exceeding 8 (C) during a major event. Typically, these SST increases are associated with decreased atmospheric pressure and a concomitant sharp increase in local rainfall throughout the region. The rainfall during ENSO events is located primarily near the coast, so that the normal rainfall gradient (more in the foothills, less near coast) is reversed. The enhanced rainfall in the desert produces disastrous flooding in the major river valleys and in the smaller dry washes ("quebradas") as well. This flooding in turn, results in heavy casualties and damage throughout the entire region.

Figura 2. Mains "ENSO" Indicators: Sea Surface Temperature Anomaly of Paita (SSTA), South Oscilation Index (SOI) and Monthly Rain of Piura, historical data since 1963 until 1999. SSTA with Base Period 1963 – 1996



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4. Habitat types

The following table list the four typical of habitat in Piura region by their names, types of soil, height, density of vegetation, yearly mean rain, mean contrast of rain between no ENSO and ENSO year and type of vegetation.

Name	*Floor type*	*Height (msl)*	*Density of vegetation*	*Rains Average (mm/year)*	*Precipitation Contrast (mm)*	*Vegetation*
Desert	Sand (Dune)	0-50	Scarce,	< 100	(1/50-1/30)	Algarrobo Sapote
Uninhabited	Wavy Sand Vegetable covering	50-200	Middle	100-150	(1/30-1/20)	Algarrobo Sapote Vichayo
Valleys	Vegetable covering	0-2000	High	250	(1/50-1/20)	Typicals cultivations of the region
Piedemonte	clay gritty stony	200-300	Half discharge	300	(1/20-1/10)	Hualtaco Sapote Palosanto Charan Huayacan Barbasco (Cactus)

Table 1: Ecological environments: name, floor type, altitude, vegetation density, rain for year, climatic contrast and types of vegetation of the ecological environments of the north coast where the arboreal species grow.

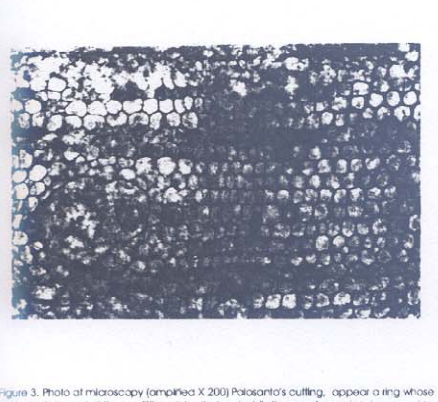

Figure 3. Photo at microscopy (amplified X 200) Palosanto's cutting, appear a ring whose principal characteristics are little celules that probabily they are formed during drought period and the tree haven't any water .

5. Tree species of this region

The following table list the names of typical species that growth in Piura region by their common names, scientific names, the habitat where they grow, maximum dimensions (height and diameter) of samples found, some popular use and some important observations about the specie.

Ordinary Name	*Scientific Name*	*Habitat*	*Max Size*		*Uses*	*Properties*	*Observations*
			Height (m.)	Diam. (cm.)			
Sapote	Capparis Angulata	Desert Uninhabited	< 8	80	Artisanship, firewood	White, hard	Aged, always green
Hualtaco	Loxopterigium Huasango	Piedemonte (< 500 m)	< 20	70	To floor, fences	Dark, hard	Quick recovery
Palo Santo	Bursera Graveolens	Piedemonte (< 500 m)	< 10	50	Box for transport fruit	White, soft	Quick recovery
Guayacán	Tecoma sp	Piedemonte (< 500 m)	< 15	50	Pieces of furniture	Dark, veined, hard	
Algarrobo	Prosopis sp	Desert, Uninhabited, Valleys	<		Firewood	Dark, very hard	To be able to hunting
Palo Verde	Cercidium Praecox Huarango Caesalpinia praecox	Uninhabited Piedemonte	< 5	25	Artisanship, Tablespoon	White, hard	
Palo Blanco	Celtis iguanea Celtis Triflora		< 15	55			
Frejolillo (o Sune)	Capparis Mollis HBK	Piedemonte	< 5			White, dark	
Charán	Caesalpinia Corymbosa	Piedemonte	< 6	80		White, very hard	
Palque	Acacia Tortuosa o Macracanta	Uninhabited, Piedemonte	<				
Barbasco	Jacobo Carpus sicov	Piedemonte	<			White, middle	
Pasayo	Bombax Discolor						
Vichayo	Capparis Ovalifolia	Uninhabited	< 3	20		White, hard	
Ceibo	Ceiba Pentandra o Eriodendron anfractuosum	Piedemonte	< 15	80		White, soft	
Pole Pole		Piedemonte	< 15	80		White, soft	

Table 2: Selected species: name common and scientific, habitat, maximum dimensions (height and diameter), some uses and properties of the species.

6. Graphics Results of tree ring growth

Modernized graphics of radial growth and of corresponding monthly rain at Piura and SSTA - Paita since 1987 to 1999. Radial growth of Palosanto (Bursera Gravedlens) and Hualtaco (Loxopterigium Huasango) at Poechos (04°41'35" South, 80°27'49" West). Radial growth of Sapote Z9 (Capparis Angulata) at South of Piura (5°32'31" South, 08°35'08 West).

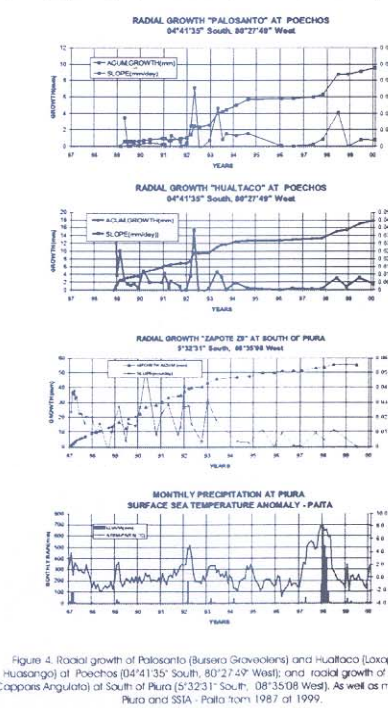

Figure 4. Radial growth of Palosanto (Bursera Graveolens) and Hualtaco (Loxopterigium Huasango) at Poechos (04°41'35" South, 80°27'49" West); and radial growth of Sapote Z9 (Capparis Angulata) at South of Piura (5°32'31" South, 08°35'08 West). As well as monthly rain in Piura and SSTA - Paita from 1987 at 1999.

7. Discussion and Conclusions

The observations and carried out control of growth have allowed to establish clearly that:

- The species of PaloSanto and Hualtaco develop their leaves and they only grow when and so soon the rains begin, they stop to grow and they lose their leaves very soon after of finishing these. They remain this way sleeping, without leaves and without growing, for successive years in those that it doesn't rain. This sensibility to the rains you can appreciate in the curves of growth shown in the figure 4.
- On the other hand, observations macroscopicas and microscopic made to sections of Palosanto and Hualtaco they allow to appreciate closed rings delineated by narrow fringes with cells of smaller size and borders of more intense coloration clearly (to see figure 3) which corresponds to periods of drought since the width of the ring depends that the tree has received rain more or less.

To both species, Hualtaco and Palosanto, they are found in areas that go from the driest in the studied region, as "Quebrada Paloma" at El Alto, to the rainiest, as they are it the near mountains to the "Las Lomas". In the first one, it only rains during strong events of "El Niño", in second zone, still in the dry years it rains, although little compared with other years. In both it only rains during the station of rains. In the dry area the two species register in their only rung the occurrence of strong events of "El Niño" (see figure 2) with more thickness according to the intensity of these. In the rainiest area it is expected a rung yearly and with it the potential of producing a chronology of the intensity of the rains. Used on the whole they could produce a chronology of strong events "El Niño" of the past.