PLANT ADAPTATIONS IN MESIC AND XERIC COMMUNITIES IN A TROPICAL DRY FOREST

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Abstract (D.G.)

This study described the adaptations that trees and shrubs make to xeric and mesic conditions in a tropical dry forest. Describing these differences reveals how the plant community may adapt to xeric conditions and the effect these adaptations have on the community physiognomy.

Deciduousness occurred 5 times as much in the xeric community, suggesting that water stress is more limiting than nutrient loss through leaf absision and depressed growth in these conditions. We found a significantly higher average leaf area for the mesic site trees, significant differences in leaf morphology, and a difference in presence of vestitures between the study sites. We suspect the main factor affecting these differences, and thus the make-up of the forest community, to be the amount of available water during the dry season. The xeric canopy was open with shrubs and herbaceous plants dominating the understory. The mesic canopy was closed and competition for space limited erosion size and light for understory plants.

The study indicates that due to lower environmental stress in the mesic site, plants that are adapted to xeric communities cannot compete with species that allocate more resources to growth.

Introduction (E.G.)

In this study we tried to demonstrate that forest vegetation characteristics, both at the levels of forest structure and the type of leaves present, will be associated with different environmental conditions with a region. The terrain on higher elevations at Palo Verde is primarily exposed limestone and has very shallow soil depth, is more exposed to wind, and drains rapidly. The drainage basin region at the foot of these ridges have greater soil depth and are more protected from winds (Janzen, 1983). Higher elevations are xeric habitats, lower elevations are relatively mesic. As a result of differential water stress, vegetation on the xeric terrain will have different adaptations than the vegetation of the more mesic, lower elevation forest. These differences will manifest themselves through leaf types, and the physiognomy and distribution of vegetation.

The implications of forest structure and plant strategies are numerous. By being differently adapted, plants are able to occupy a vast range of environmental gradients.

How these plants are adapted affects the productivity, vitality, and diversity of the plant community. This has a strong influence on the structure of the associated animal community, which the plants support directly. The nature of the plant community also plays an important role in determining environmental conditions such as microclimate, nutrient cycling, erosion, and soil quality.

Methods (E.G.)

We selected two sample sites based on topography and accessibility. The xeric site was the limestone ridge at the top of the Guayacancito Trail. The more mesic site was along the west bank of a stream bed (just north of the mango grove) at the base of the high ridge behind the hacienda. These sites were chosen based on the fact that the limestone ridges hold less water and drain more rapidly than the deep soil regions at the base of the ridges (Janzen, 1983).

We sampled the vegetation along a 100m section of the Guayacancito ridge, surveying the entire 15m width of the ridge top. Similarly, we sampled a 100m x 15m strip of forest in the mesic site. To describe the sites, a variety of abiotic and biotic factors were recorded. They were soil depth, presence and exposure; canopy height, consistency of cover, and average crown diameter; percent of canopy trees which were deciduous; herbaceous cover; and understory characteristics.

Leaf samples were taken from both the shrub and canopy layers, and from the lianas of the mesic region. We collected leaves from all species we found in the study plot. In cases where tree leaves were not accessible, a general description was recorded. All leaves were analyzed for surface area the average sized leaflet, morphology (simple or compound), shape (linear, elliptic, oval, or orbicular), and vestitures (i.e. leaf hairs) (present or absent). Cuticle thickness was estimated by leaf thickness, stiffness, and texture, and recorded as thin, medium, or thick.

Qualitative descriptive analysis was performed on site characteristics. Contingency tables of qualitative leaf characteristics were made to compare shrubs in the two sites, and trees in the two sites. Leaf surface areas for trees and for shrubs were also each compared between mesic and xeric sites.

Results (D.G.)

Site data on table one reveals several significant trends between the two communities. These data were subjective and thus not testable.

Mean surface area per leaf was significantly greater in the mesic site than the xeric site for trees, ($n_1 = 13$, $n_2 = 11$, $U_s = 122$, $P = 0.001$) but not for shrubs ($n_1 = 15$, $n_2 =$

6, U_S = 45, P > 0.1) (Table 2). Trees with compound leaves were more common in the mesic area, while simple leaves were more common in the xeric area (Gadj = 3.823, P = 0.05) (Table 2). Leaf shape similarities compared between mesic and xeric areas were insignificant for trees (G = 3.62, P >0.1) and for shrubs (G = 3.38, P > 0.1) (Table 2). The presence of vestitures was significantly higher in the xeric area for trees (Gadj = 3.823, p = 0.05) but not for shrubs (G = 0.044, p > 0.1) (Table 2). Lastly, cuticle thickness was not correlated with study area for trees nor for shrubs, though no precise method for determining cuticle thickness was devised.

Discussion (E.G., D.G.)

There were significant differences between the physiognomy, distribution, and leaf characteristics of the vegetation on the xeric and mesic sites. These differences reflected the environmental conditions of the forest sites, particularly the known differences in water stress and soil depth. We cannot attribute frequency of leaf shape, nor any of the particular leaf characteristics of the shrubs to a difference in habitat, because we didn't see any significant differences between the sites in terms of these measures.

As expected, site topographies were very different. The xeric site had shallow soil, which was interspersed with large limestone rocks and outcroppings. There were also high winds which increase evapotranspiration from the site. This sites topography indicate it was much drier than the deep, water absorbing soil of the low wind mesic site.

Physiognomy was accordingly very different. The xeric canopy had only about 60% cover, as compared to the dense, 100% cover mesic canopy. Thus appears that space is a major limiting resource in the mesic community, which would affect competitive strategies and favor particular adaptation for high space competition. Xeric tree crown sizes are limited due to water and soil stresses. Similarly, we attribute differences in understory to light limitations and space in the mesic site and water competition in the xeric site.

A major factor associated with water availability is productivity. As water availability decreases, productivity declines. Hence, the mesic site had greater leaf cover and leaf size which is indicative of greater productivity. As water stress reaches a certain level, the presence of leaves can stress a plant through water loss more than the plant might benefit from actively photosynthesizing. In xeric communities, trees will be favored if they are deciduous and shut down during the dry season. Accordingly, we saw a 5 times greater presence of deciduousness in the xeric habitat than the mesic site.

Herbaceous cover was higher in the xeric community, and this too we attribute to water stress. These annual herbs can re-establish each rainy season, and they have lots of light, which is absent on the mesic forest floor, due to the inability of trees to form a

complete canopy.

Trends in leaf types of trees are more evidence that different environments foster different types of plants and communities. Leaves of large surface area generally have high water demand and high productivity. These are traits suitable for more mesic conditions, and our data bears this out. Xeric leaves are smaller. Xeric leaves also have the adaptation of greater presence of vestitures in leaf types. These cut down transpiration, which isn't as important a factor on the mesic site. We attribute the compound leaves of the mesic site to the fact that each leaf can have a larger surface area, but when it has a single leaflet it is more susceptible to damage from rain and wind. One difference we also expected to see, but wasn't born out by the data, was that since thick cuticles conserve water, but are more costly to produce, it would only be selected for in xeric plants. This wasn't so, although our cuticle determining technique is likely to have been inaccurate, because it couldn't adjust for such things as leaf thickness not being correlated to cuticle thickness and that hairs make cuticle estimation difficult.

Lianas were another element of the vegetation which differed greatly between sites. The lianas composed a significant portion of the biomass in the mesic site, but we have no strong evidence for why this might have been.

Environmental conditions do have a large influence on vegetation communities and the adaptations found in the communities. This study indicates that the lower frequency of xeric plant traits occurrence in the mesic site means that plants adapted to xeric conditions cannot compete with species that allocate more resources to growth, storage or reproduction; mesic plants can't establish in xeric sites because they are adapted for less stressful environments. What adaptions are selected for, and that they are, provides the diversity and complexity of terrestrial ecology.

Table 1 Comparison of selected plant community attributes in mesic and xeric areas.

Characteristic	Xeric	Mesic
Soil		
Depth	0-4cm	~300cm
Presence	many rocky outcrops & boulders	no exposed rocks
Exposure	high ridge, high winds	protected, less wind
Canopy		
Height up to 15m	15-20m, one 50m.	
Cover	uneven, ~60%	even, 100%
Ave. Crown diam.	5-10m, none > 10m	5-10m, several >15m
Deciduousness	25-35%	<5%
Herbaceous Cover	95%	20%
Understory	Scattered, low representation	indescernable, mostly lianas

Table 2 Frequency of selected plant community attributes in mesic and dry areas.

Trees (thin/med/thick)	Mean Surface Area (cm^2)	Morph-ology (simple/ compound)	Shape narrow to wide	Ventitures Presence with/w/o	Cuticle Thickness
Xeric	29.9	10/3	1/9/2/1	8/5	3/7/4
Mesic	163.0	4/7	2/4/5/0	2/9	2/4/4
Shrubs					
Xeric	43.1	16/1	9/4/4	4/14	5/12/0
Mesic	35.3	6/0	0/5/1	1/5	2/3/1

Literature Cited

Janzen, D.H. Costa Rican Natural History, p. 127-129. Univ. of Chicago Press, Chicago, 1983.