

EARLY ASSESSMENT OF THE TREES OF THE LUQUILLO MOUNTAINS

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ABSTRACT

This is a description of the composition of a forest in Puerto Rico almost unique in that it probably had not received human modification. It comes from a 1948 inventory of 4,570 hectares of what today is the El Yunque National Forest in the Luquillo Mountains. The inventory, preparatory to a forest management plan, was a search for sustainable level of timber volume utilization. The data presented are from 40 apparently undisturbed 1/10 ha samples out of 914 inventory plots along parallel transects. The description covers structure and composition of the two most prominent forest associations. This forest, essentially never humanly modified was distinct from the forests generally over the island today.

RESUMEN

Esto es una descripción de un bosque temprano de Puerto Rico que aparentemente no había recibido modificación humana. Viene de un inventario en 1948 de 4.570 ha del hoy Bosque Nacional de El Yunque en las montañas de Luquillo. El inventario, hecho en preparación para un plan de manejo forestal, buscaba la cantidad de madera que se podría utilizar sosteniblemente. Los datos son de una selección de 40 muestras de 0.1 ha de bosque aparentemente intacto de 914 parcelas seleccionadas de fajas paralelas de brújula. Incluye descripción de la composición y la estructura de las dos asociaciones más prominentes. La composición de estos bosques, que nunca recibieron modificación sustancial humana, era diferente de la de los bosques comunes en Puerto Rico hoy.

Key words: Puerto Rico, Luquillo, subtropical forest, forest composition, forest structure.

INTRODUCTION

National Forests are sustained by guidance from successive management plans. In 1948 the 1937 inventory of the Caribbean National Forest (Now El Yunque National Forest) had become obsolete. More land had been added to the forest. The sale of timber had been authorized. Through timber sales near the roads the removal and use of those trees suitable only for charcoal, the Forest Service was releasing from competition other trees suited for more valuable products. Despite this, parts of the interior of the forest apparently

remained unmodified. The 1948 inventory has been described (Wadsworth 1951).

Since most of the National Forest did not utilize timber these lands were excluded from the inventory. There were 743 ha reserved apparently in entirely natural condition; 1,815 ha because of susceptibility to soil erosion; 1,254 ha kept natural for the parrots, and 628 ha for recreation. Two forest associations, the palm forest of the steep slopes and riparian river edges, subtropical rain forest (Ewel and Whitmore 1973), that covered 2,051 ha and the dwarf forest of the peaks, subtropical lower

montane wet and rain forest, that covered 455 ha, were excluded from the inventory.

The remaining 6,147 ha included two forest associations, the lower subtropical wet tabonuco forest on 4,314 ha and the upper subtropical rain colorado forest on 3,403 ha. The separation of these two was found to occur at about 600 meters elevation, near the isotherm of 23°C. These forests in three watersheds were also excluded from the inventory because they were expected to remain inaccessible for tree removal during the planning period. So remaining to be inventoried were 2,510 ha of tabonuco forest and 2,060 ha of colorado forest.

METHODS

The inventory was completed between April and August 1948. Parallel compass lines through the forest were so spaced as to provide about a 2 percent sample. Out 5 m on each side of the taped compass lines were recorded trees of ≥ 9 cm dbh (diameter at 1.4m above the ground) by species, crown position in the canopy (Daniel *et al.* 1979), and dbh. Upon completing 5 surveyor's chains of line (100m) the data were marked to define plots of 0.1 ha (10 x 100m). In total 914 plots were tallied.

Data from 40 of the plots (4 ha), thought to be the least modified were reduced to per ha in Table 1. Difficulties of field identification at the time of the inventory led to the grouping of some species of the Lauraceae, Melastomataceae, and Myrtaceae. DFD values for selected tree species, derived by summing their percentages of number of trees, percent of plots in which found, and percent of basal area appear in Table 2. The percents of trees of each principal species within the two forests in 1948 and in Puerto Rico as a whole in 2003 (Brandeis, *et al.* 2007) appear in Table 3. The proportion of the species in the 40 plots from different natural ranges within Puerto Rico, the Caribbean, and beyond appears in Fig. 1.

RESULTS

- The trees of the lower tabonuco forest, with much less rainfall (Ewel and Whitmore 1973), rise to about double the height of the trees of the colorado forest.
- Forest basal area in the selected tabonuco plots ranged between 32 and 55 m²/ha, about 10 m² denser than in the upper colorado forest.
- Thirty percent of the tree species of the lower tabonuco forest were not found also in the colorado forest (table 1). In contrast, 94 percent of the tree species of the colorado forest were found also in the tabonuco forest.
- The upper, more isolated colorado forest is composed of trees of more local geographic distribution than the tabonuco forest (Little and Wadsworth 1964, Fig. 1). The lower forest has many more tree species found also in the Caribbean or in Central and South America. Extreme ranges of tree species of these forests are *Andira inermis*, native also to West Africa, and with *Ficus citrifolia*, and *Cyrilla antillana*, extending to the southeastern United States.
- *Prestoea* is heavily and equally represented in the two forests (Table 2). *Magnolia* and *Micropholis garcinifolia* also have prominent DFD values in both forests.
- In the lower forest the rarity of *Ochroma* suggests a lack of continuous openings. The abundance of *Cecropia* and *Schefflera* in the lower forest appears to reflect brief hurricane openings.
- The appearance of *Syzygium jambos*, a tree of the other hemisphere in Puerto Rico for more than a century, seems to refute the presumed lack of disturbance. Among the many exotic trees in Puerto Rico it is a rare true invader into closed forest.
- The isolation of Luquillo Mountain forests from those elsewhere on the island is indicated by differences in the percentages of trees of certain species in the forests of the two areas (Table 3). In particular it is apparent that *Dacryodes*, *Henriettia*, *Micropholis*, *Prestoea*, and *Sloanea* are concentrated more in the Luquillo Mountains, while *Andira*, *Guarea*, and *Tabebuia*, are much more abundant elsewhere on the island.
- The upper forest has more endemic species while the lower forest has many more tree species found also in the Caribbean

TABLE 1. The mean number of trees ≥ 9 cm and ≥ 30 cm dbh per ha in the 40 plots of 0.1 ha each. (Wadsworth 1949).

Species	Tabonuco forest		Colorado forest	
	≥ 9 cm	≥ 30 cm	≥ 9 cm	≥ 30 cm
<i>Alchornea latifolia</i> Sw (Achiotillo)	10.2	1.0	1.0	0.2
<i>Alchorneopsis floribunda</i> (Benth.) Muell. (Palo de gallina)	13.0	2.2		
<i>Andira inermis</i> (W. Wr.) DC. (Moca)	1.8	0.2		
<i>Antirrhoea obtusifolia</i> Urban (Quina)	0.2		0.2	
<i>Buchenavia tetraphylla</i> (Aublet) Howard (Granadillo)	2.2	0.8	0.2	0.2
<i>Byrsonima spicata</i> (Cav.) DC. (Maricao)	0.8			
<i>Byrsonima wadsworthii</i> Little (Almendrillo)	3.0	0.2	1.8	0.2
<i>Calophyllum antillanum</i> Britt. (Maria)	0.2			
<i>Cananga caribaea</i> (Urban) Britt. (Ausubillo)	0.5	0.2		
<i>Casearia arborea</i> (L.C.Rich) Urban (Rabo de ratón)	1.0			
<i>Casearia decandra</i> Jacq. (Palo blanco)	3.8		0.2	
<i>Cecropia schreberiana</i> Mig. (Yagrumo hembra)	87.5	13.5	5.8	1.5
<i>Chionanthus domingensis</i> Lam. (Hueso blanco)	4.5	0.2	5.0	1.0
<i>Clusia gundlachii</i> Stahl (Cupey)			15.5	4.2
<i>Coccoloba rugosa</i> Desf. (Ortegón)	3.0	0.5	0.8	
<i>Cordia borinquensis</i> Urban (Muñeco)	7.0		6.2	
<i>Cordia sulcata</i> DC. (Moral)	2.8			
<i>Croton poecilanthus</i> Urban (Sabinón)	20.2		34.5	
<i>Cyrilla antillana</i> Michx. (Palo colorado)	13.5	7.8	65.9	42.8
<i>Dacryodes excelsa</i> Vahl. (Tabonuco)	103.2	53.0	10.2	9.0
<i>Ditta myricoides</i> Griseb. (Ditta)	2.8		5.8	
<i>Eugenia borinquensis</i> Britt. (Guayabota de sierra)			1.0	
<i>Eugenia stahlii</i> (Kiaersk.) (Guayabota)	5.8	0.8	2.0	0.8
<i>Ficus americana</i> Aubl. (Jaguey colorado)	3.0	0.2	2.2	0.2
<i>Guarea guidonia</i> (L.) Sleumer (Guaragua)	10.5	1.8		
<i>Henriettia squamulosa</i> (Cogn.) Judd. (Camasey jusillo)	21.5	2.2	154.0	35.0
<i>Hirtella triandra</i> Sw. (Teta de burra)	4.2			
<i>Homalium racemosum</i> Jacq. (Caracolillo)	4.5	2.8	0.2	0.2
<i>Hymenaea courbaril</i> L. (Algarrobo)	0.5	0.2		
<i>Ilex nitida</i> (Vahl.) Maxim. (Hueso prieto)	3.8	0.2	21.2	6.8
<i>Inga laurina</i> (Sw.) Willd. (Guamá)	16.5	2.2	2.2	0.2
<i>Inga vera</i> Willd. (Guaba)	12.5	1.5		
<i>Laetia procera</i> Eichler (Yuquilla)	3.0	0.5		
Lauraceae (Laurel)	8.2	0.8	0.5	
<i>Magnolia sprengens</i> Urb. (Laurel sabino)	7.2	5.0	28.0	13.2
<i>Manilkara bidentata</i> (A. DC.) Chev. (Ausubo)	15.0	0.2	1.2	
<i>Matayba domingensis</i> (DC.) Radlk. (Negra lora)	18.5	1.2	5.8	0.8
Melastomataceae (Camasey)	33.0	0.8	8.2	
<i>Meliosma herbertii</i> Rolfe (Aguacatillo)	7.7	1.2		
<i>Micropholis guyanensis</i> (A. DC.) Pierre (Caimitillo)	35.2	8.8	86.0	9.5
<i>Micropholis garcinifolia</i> Pierre (Caimitillo verde)	50.5	17.0	158.2	54.0
<i>Myrcia deflexa</i> (Poir.) DC. (Cieneguillo)	0.2		0.2	
Myrtaceae (Hoja menuda)	1.5		3.8	
<i>Ochroma pyramidale</i> (Cav. Ex Lam.) Urban (Guano)	0.2			
<i>Ocotea leucoxydon</i> (Sw.) Mez. (Laurel geo)	1.5	0.2		
<i>Ocotea moschata</i> (Meissn.) Mez. (Nuez moscada)	1.2	0.2	0.8	
<i>Ocotea spathulata</i> Mez. (Nemocá)	9.5	2.8	51.0	5.8

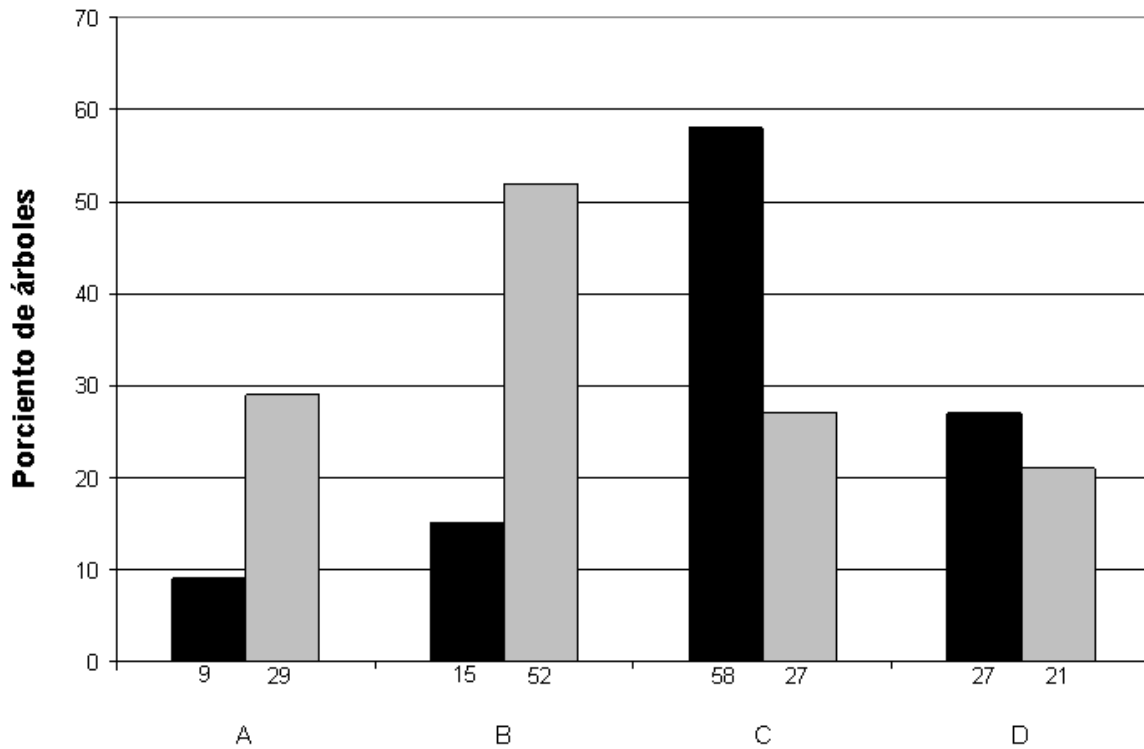
TABLE 1. The mean number of trees ≥ 9 cm and ≥ 30 cm dbh per ha in the 40 plots of 0.1 ha each. (Wadsworth 1949). (continued).

Species	Tabonuco forest		Colorado forest	
	≥ 9 cm	≥ 30 cm	≥ 9 cm	≥ 30 cm
<i>Ormosia krugii</i> Urban (Palo de matos)	9.0	1.0		
<i>Oxandra laurifolia</i> (Sw.) A. Rich. (Yaya)	0.8	0.2		
<i>Prestoea montana</i> (R. Graham) Nichols (Palma de sierra)	171.0		92.5	
<i>Quararibea turbinata</i> (Sw.) Poir. (Garrocho)	4.8		0.2	
<i>Sapium laurocerasus</i> Desf. (Manzanillo)	11.2	1.5	1.2	
<i>Schefflera morototoni</i> (Aubl.) Maguire (Yagrumo macho)	25.2	2.8	2.0	0.5
<i>Sloanea berteriana</i> Choisy (Cacao motillo)	33.2	8.8	1.2	0.5
<i>Syzygium jambos</i> (L.) Alst. (Pomarrosa)	0.2			
<i>Tabebuia heterophylla</i> (DC.) Britt. (Roble blanco)	2.8	0.2	2.0	0.8
<i>Tabebuia rigida</i> Urb. (Roble de sierra)			8.0	1.0
<i>Tetragastris balsamifera</i> (Sw.) Kuntze (Masa)	3.0	0.5		
<i>Trichilia pallida</i> Sw. (Gaeta)	0.2			
<i>Zanthoxylum martinicense</i> (Lam.) DC. (Espino rubial)	0.2			
Other species (13) (10)	17.7		14.0	
Totals, ≥ 9 cm dbh	(70 sp.) 835.7		(49 sp.) 800.8	
Totals, ≥ 30 cm. dbh	(39 sp.) 145.2		(23 sp.) 187.9	

TABLE 2. DFD values for the more prominent tree species. Summed percentages as to number of trees, number of plots in which found, and forest basal area.

Species	DFD Values	
	Tabonuco	Colorado
<i>Alchornia latifolia</i>	55	28
<i>Alchorneopsis floribunda</i>	53	3
<i>Cecropia schreberiana</i>	109	58
<i>Cordia borinquenses</i>	33	59
<i>Croton poecilanthus</i>	40	93
<i>Cyrilla antillana</i>	34	124
<i>Dacryodes excelsa</i>	130	30
<i>Henriettia squamulosa</i>	72	108
<i>Inga laurina</i>	74	26
<i>Inga vera</i>	46	3
<i>Magnolia splendens</i>	47	57
<i>Matayba domingensis</i>	34	41
<i>Micropholis guyanensis</i>	12	86
<i>Micropholis garcinifolia</i>	83	121
<i>Ocotea spathulata</i>	47	83
<i>Prestoea montana</i>	132	131
<i>Sapium laurocerasus</i>	42	21
<i>Schefflera morototoni</i>	72	33
<i>Sloanea berteriana</i>	89	34

FIGURE 1. Representations by geographical sources of the tree species in the tabonuco (black) and colorado (gray) forests. A = Species endemic to eastern Puerto Rico; B = all species endemic to Puerto Rico (including A); C = Species of the Caribbean islands; and D = Species native also to Central and/or South America.



or in Central and South America (Fig. 1). Extreme ranges of tree species of these forests are *Andira inermis*, native also to West Africa, and with *Ficus citrifolia*, and *Cyrilla antillana*, extending to the southeastern United States.

DISCUSSION

Both forests evidenced storied structure, with 88 percent of the tree species in the tabonuco forest and 76 percent in the colorado less than 30 cm dbh (Little and Wadsworth 1964). Ninety-seven percent of the trees in the tabonuco forest and ninety-eight percent in the colorado forest were evergreen. Leaves of 86 percent of the trees in the unmodified tabonuco forest and 95 percent in the colorado forest, were simple, without leaflets. Leaf arrangements were alternate in 87 percent of the tree species in

the tabonuco forest and 80 percent of those in the colorado forest. Continuous or repeated flowering and fruiting during the year characterizes about 50 percent of the tree species in the two forests. An extreme example of the difference between the unmodified flora of the Luquillo Mountains and that elsewhere on the island, is *Spathodea campanulata*, an exotic product of deforestation, totally absent from the old-growth Luquillo forest despite more than 113 million trees in the rest of the island's forests (Brandies *et al.* 2007).

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TABLE 3. Comparative proportions of numbers of trees in the two forests in 1948 and in the 2003 inventory of all of Puerto Rico (Brandeis *et al.* 2007).

Species	Percent of all trees		
	Tabonuco	Colorado	Puerto Rico
	%	%	%
<i>Andira inermis</i>	<1	0	5
<i>Cecropia schreberiana</i>	10	9	7
<i>Citharexylum fruticosum</i>	0	0	<1
<i>Cordia sulcata</i>	<1	0	3
<i>Croton poecilanthus</i>	2	4	0
<i>Cyrilla antillana</i>	2	8	0
<i>Dacryodes excelsa</i>	12	1	0
<i>Dendropanax arboreus</i>	0	0	2
<i>Guarea guidonia</i>	1	0	17
<i>Henriettia squamulosa</i>	2	19	0
<i>Hymenaea courbaril</i>	<1	0	3
<i>Inga laurina</i>	2	0	4
<i>Inga vera</i>	2	0	5
<i>Magnolia splendens</i>	1	4	0
<i>Micropholis guyanensis</i>	4	11	0
<i>Micropholis garcinifolia</i>	6	20	<1
<i>Ocotea leucoxydon</i>	<1	0	5
<i>Ocotea spathulata</i>	1	6	0
<i>Prestoea montana</i>	20	12	3
<i>Roystonea borinquena</i>	0	0	1
<i>Schefflera morototoni</i>	2	2	4
<i>Sloanea berteriana</i>	4	0	0
<i>Syzygium jambos</i>	<1	0	8
<i>Tabebuia heterophylla</i>	<1	<1	8

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