TREE DIAMETER INCREMENT IN AN UPPER MONTANE FOREST OF PUERTO RICO[1] /

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Resumen

El incremento periódico anual del DAP en un rodal, previamente entresacado, localizado en bosque montano alto (bosque colorado) en el sudeste de Puerto Rico, creció a un promedio de 0.25 cm/año durante 27 años. El incremento a largo plazo era el doble de cualquier otro registrado en otro bosque colorado en la isla.

Introduction

Information on growth rates and stand dynamics are scarce in the neotropics, and both are vital to forest planning and management. Such information is needed for a variety of sites and stand conditions, including climax and secondary forests. In this paper, periodic annual diameter increment (PAI), ingrowth, mortality, basal area, and species composition are summarized for a small plot in southeastern Puerto Rico. Estimates are based on measurements that span 27 years.

The study area

The Sierra de Cayey, an isolated range of Cretaceous monadnocks Beinroth (3) in southeastern Puerto Rico, rises to slightly over 900 m. The weathering of igneous rocks has created areas of shallow and deep clays. The climax vegetation included four montane types Beard (1, 2): Lower Montane (tabonuco forest) at lower elevations; Upper Montane (colorado forest) at higher elevations; dwarf forest on the isolated summits near Cerro La Santa; and interspersed in the tabonuco and colorado types, particularly in the latter, zones dominated by palm. A recent study classified most of the area as Subtropical Wet Forest; a small zone encompassing Cerro La Santa was classified as Lower Montane Wet Forest Ewel and Whitmore (4). Mean temperature ranges from 25°C at the base of the mountains to about 21°C at the summits, and rainfall varies from 1900 through 2500 mm/yr Picó *et al.* (8).

Methods

In 1951, at 725 m elevation in previously undisturbed colorado forest, a 0.10 ha plot was thinned to 1700 stems/ha with a basal area of 11.4 m^2/ha. Deep clay soil underlies the plot. Rainfall approaches 2500 mm/yr, and the mean annual temperature is about 22°C.

All trees $\geqslant$ 4.1 cm were measured with a steel tape at D.B.H. and permanetly marked with numbered tags at 15 cm below D.B.H. to prevent errors that swelling might cause in future measurements. Crown classes also were recorded. The plot was visited again in 1956, 1964, and 1978, and in each instance, diameters and crown classes were recorded; ingrowth $\geqslant$ 4.1 cm was measured; and mortality was noted. A brief visit in 1953 provided preliminary observations of stand development.

Results and discussion

Observations two years after thinning showed that weeds slightly over 1 m in height had invaded the larger openings; no vines, however, were observed.

1 Received for publication July 12, 1980.

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Table 1: Ranking of species by density and basal area (BA) dominance in previously thinned colorado forest (Subtropical Wet Life Zone) in Cayey from 1951 to 1978.

Species[2]	1951		1978		Ingrowth[1]		Mortality by D.B.H. class, 1951-78				
	Stems (No./ha)	BA (m^2/ha)	Stems (No./ha)	BA (m^2/ha)	Stems (No./ha)	BA (m^2/ha)	5	10	20	40	Total
									No./ha		
Miconia prasina	430	0.80	50	0.25	30	0.15	350	60	–	–	410
Micropholis chrysophylloides	310	4.10	370	9.68	100	0.27	20	20	–	–	40
Calycogonium squamulosum	270	2.15	300	4.02	80	0.20	10	10	–	30	50
Inga laurina	150	1.77	120	4.42	–	–	20	10	–	–	30
Psychotria berteriana	150	0.36	20	0.03	20	0.03	100	50	–	–	150
Swietenia macrophylla	80	0.39	20	0.32	–	–	20	20	20	–	60
Myrcia splendens	70	0.31	60	0.77	20	0.09	20	–	10	–	30
Ocotea spathulata	30	0.24	30	0.65	–	–	–	–	–	–	–
Rapanea ferruginea	30	0.14	20	0.27	10	0.10	–	10	10	–	20
Ocotea leucoxylon	30	0.07	–	–	–	–	20	10	–	–	30
Nectandra coriacea	30	0.06	10	0.05	–	–	20	–	–	–	20
Alchornea latifolia	*20*	*0.19*	30	0.50	20	0.18	–	–	10	–	10
Cordia borinquensis	20	0.17	110	0.45	90	0.23	–	–	–	–	–
Inga vera	10	0.22	–	–	–	–	–	–	10	–	10
Haenianthus salicifolius	10	0.10	10	0.75	–	–	–	–	–	–	–
Sloanea berteriana	10	0.10	10	0.41	–	–	–	–	–	–	–
Casearia arborea	10	0.09	80	1.09	70	0.44	–	–	–	–	–
Cordia nitida	10	0.05	–	–	–	–	–	10	–	–	10
Rondeletia portoricensis	10	0.02	–	–	–	–	10	–	–	–	10
Didymopanax morototoni	10	0.01	20	0.61	10	0.07	–	–	–	–	–
Myrcia deflexa	10	0.01	10	0.05	–	–	–	–	–	–	–
Prestoea montana	–	–	70	1.93	70	1.93	–	–	–	–	–
Cecropia peltata	–	–	50	2.03	50	2.03	–	–	–	–	–
Eugenia stahlii	–	–	10	0.02	10	0.02	–	–	–	–	–
Ditta myricoides	–	–	10	0.01	10	0.01	–	–	–	–	–
TOTAL	1700	11.35	1410	28.31	590	5.75	590	200	60	30	880

1 Ingrowth refers to stems present in the final survey but absent in the initial survey; mortality, stems recorded initially but absent in the final survey. Mortality D. B. H. classes increase geometrically from the 5 cm through the 40 cm class: 5 cm (4.1 – 6.5), 10 cm (6.6 – 14.1), 20 cm (14.2 - 26.8), and 40 cm (26.9 – 54.6). Stems that entered the lowest D. B. H. class (i.e. 4.1 cm) after the initial survey, but died before the final survey, were not tallied.

2 Nomenclature in this and following tables taken from: Little and Wadsworth (10) and Little, Woodbury and Wadsworth (7).

After a 1956 hurricane, little regeneration was found, and the plot remained more open than undisturbed colorado forest. Only minor damage was caused by high winds.

By 1978, the number of stems had decreased from 1700 to about 1400/ha, but the basal area increased from 11.4 to 28.3 m^2/ha (Table 1). Ingrowth amounted to 590 stems/ha, adding 5.7 m^2 of basal area, and mortality eliminated 880 stems/ha. Net basal area increase during the 27 years amounted to 16.9 m^2/ha.

Ingrowth and mortality resulted in changes in stand composition (Table 1). *Miconia prasina* and *Psychotria berteriana*, both short-lived secondary species, decreased substantially in number. *Cecropia peltata*, another secondary species, invaded the stand, probably because of the availability of growing space. *Micropholis chrysophylloides*, a climax overstory species, increased in number. *Prestoea montana*, a climax species ubiquitous in Montane Forests in Puerto Rico, invaded the plot.

Differences in increment were found among species (Table 2). PAI's ranged from 0.18 cm/yr for *Ocotea spathulata* and *Cordia borinquensis* to 1.05 cm/yr for *Casearia arborea*. Species that were

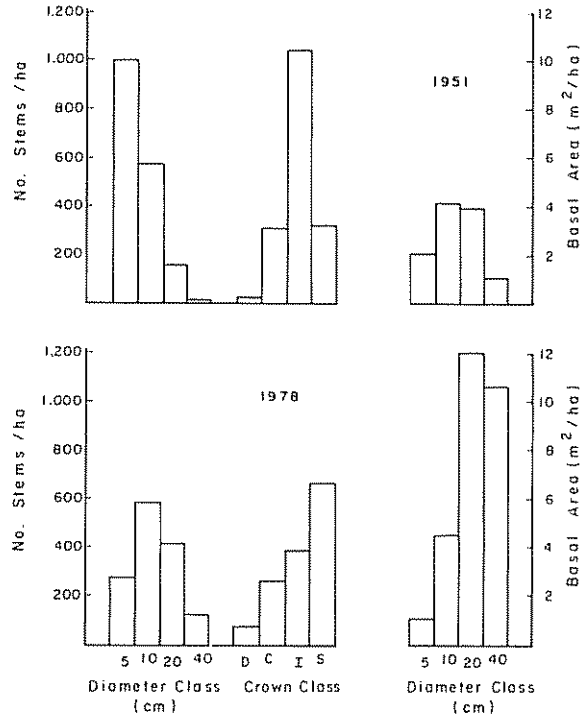

Fig. 1. Number of Stems/ha by D.B.H. Class, Number of Stems/ha by Crown Class, and Basal Area/ha by D.B.H. Class for Thinned Colorado Forest (Subtropical Wet Life Zone) in 1951 and 1978.

Table 2. Periodic annual diameter increment by species from 1950 to 1978 in thinned colorado forest (Subtropical Wet Life Zone) in Cayey for all trees that survived the entire period.

Species	1951–56	1956–64	1964–78	1951–78 Statistics			D.B.H. Range
	cm/yr			Mean	CV[1] (%)	Stems (No.)	1951 (cm)
Miconia prasina	0.25	0.06	0.01	0.06	28	2	4–7
Micropholis chrysophylloides	0.46	0.27	0.24	0.29	44	27	4–39
Calycogonium squamulosum	0.34	0.18	0.13	0.18	45	22	4–18
Inga laurina	0.38	0.29	0.25	0.28	74	12	4–26
Swietenia macrophylla	0.25	0.19	0.12	0.16	76	2	11–16
Myrcia splendens	0.30	0.21	0.22	0.24	52	4	5–21
Ocotea spathulata	0.18	0.23	0.24	0.23	76	3	12–20
Rapanea feruginea	0.58	0.42	0.12	0.30	–	1	14
Nectandra coriacea	0.20	0.10	0.02	0.08	–	1	8
Alchornea latifolia	0.75	0.40	0.05	0.28	–	1	20
Cordia borinquensis	0.18	0.05	0.01	0.05	71	2	11–12
Haenianthus salicifolius	0.88	0.95	0.55	0.72	–	1	30
Sloanea berteriana	0.35	0.40	0.42	0.40	–	1	22
Casearia arborea	1.05	0.65	0.52	0.65	–	1	28
Didymopanax morototoni	0.82	0.52	0.98	0.82	–	1	26
Myrcia deflexa	0.42	0.08	0.08	0.15	–	1	8
Mean/Total	0.40	0.25	0.21	0.25	66	82	4–39

1 CV = Coefficient of variation.

better represented on the plot, *Calycogonium squamulosum, Inga vera,* and *Micropholis chrysophylloides,* ranged from 0.34 through 0.46 cm/yr. From 1951-56, the codominant crown class grew the fastest at 0.45 cm/yr, followed by the dominants at 0.38, the intermediates at 0.26, and the suppressed stems at 0.22 cm/yr.

The PAI for stems that survived the entire period was 0.25 cm/yr, and ranged from 0.05 cm/yr for *Cordia borinquensis* to 0.82 cm/yr for *Didymopanax morototoni* (Table 2). Most of the species declined in PAI, probably because of a gradual closing of the stand. The heavy mortality in the 5 and 10 cm D.B.H. classes, and the fact that by 1978 the stand had attained a ground cover approaching that of undisturbed colorado forest, support this contention.

Undisturbed colorado forest in Puerto Rico usually has a basal area around 40 m^2/ha and contains from 40-50 species (ITF Files). The long-term PAI in both thinned and undisturbed climax colorado forests in Maricao and Luquillo averaged 0.10-0.12 cm/yr (Wadsworth (10); Tropical Forest Experiment Station (9); Weaver (11); ITF Files). In thinned colorado ecotone in Toro Negro and Guilarte Forests, the PAI was about 0.14 cm/yr (ITF Files). In all cases, the estimates are for stems $\geqslant$ 4.1 cm in D.B.H., regardless of species or crown class. Individual stands vary in size, species composition, and exposure; rainfall ranges from 2500-4000 mm/yr, elevation from 670-930 m, and basal area from 11-53 m^2/ha. Except for Maricao on serpentine, all stands are on clay soil. Tree ages are unknown. All measurements span 24-30 years.

The PAI's for colorado forest are well within the range of those reported for temperate forest trees of the United States Fowells (5). Within the colorado forests that were studied, the long-term PAI of the Cayey stand was twice that of all others. Although direct comparisons among colorado stands are hampered because of differences in site characteristics and species composition, the low basal area at the beginning of measurement in the Cayey stand probably accounts for the difference observed.

Abstract

Periodic annual diameter increment on a previously thinned small plot in upper montane forest (colorado forest) in southeastern Puerto Rico averaged 0.25 cm/yr over 27 years. Long-term increment was twice that recorded for other colorado forests on the island.

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