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Root biomass of a dry deciduous tropical forest in Mexico

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Abstract

The deciduous tropical dry forest at Chamela (Jalisco, Mexico) occurs in a seasonal climate with eight rainless (November through June) and four wet months (700 mm annual precipitation). The forest reaches a mean height of 10 m. Tree density in the research area was 4700 trees per ha with a basal area at breast height of 23 m^2 per ha. The above- and below-ground biomass of trees, shrubs, and lianas was 73.6 Mg ha^{-1} and 31 Mg ha^{-1}, respectively. A root:shoot biomass ratio of 0.42 was calculated. Nearly two thirds of all roots occur in the 0–20 cm soil layer and 29% of all roots have a diameter of less than 5 mm.

Introduction

More than 40% of all forests in tropical and subtropical regions are dry forests and experience a seasonal drought. This seasonality is more pronounced in regard to dry and wet periods than to seasonal fluctuations in temperature. Lack of information regarding the biology of these forests has been discussed recently (Murphy and Lugo, 1986a).

The deciduous dry forest in the coastal area of Jalisco, Mexico, with a four months wet season and about 700 mm annual rainfall, belongs to the driest forests of this type. Climate (Bullock, 1986), floristic diversity and structure (Lott *et al.*, 1987), and litter production (Martinez, 1984) have been studied, and estimates of aboveground tree biomass will be available shortly (Martinez, pers. commun.). However, the paucity of data concerning the belowground biomass of this forest type is extreme (Vogt *et al.*, 1986). The objective of this study is to determine belowground biomass for a deciduous forest in Chamela, in the coastal area of Jalisco. The rapidly increasing demand for agricultural land, even of low quality, on the steep slopes of this area makes the task an urgent one (Maass *et al.*, 1988).

Materials and methods

Study site

The study area lies within the boundaries of the Estación de Biología Chamela, a teaching and research facility of the Insituto de Biología, Universidad Nacional Autónoma de México. The station is located at 19°30′N, about 150 km south of Puerto Vallarta and 2 km inland from the coast of the Pacific Ocean. The vegetation has been classified as a tropical deciduous forest (Rzedowski, 1978), and is about 10 m tall in this area. Mean annual precipitation over the past 10 years was 707 mm (1978–1988). The dry season extends from the end of November to mid-June, with August and September being the wettest months. Mean annual January and August air temperatures are 20°C and 27°C, respectively (Bullock, 1986). The soil consists of a 50–100 cm deep sandy loam with low organic matter content (1–5%). The pH values range from 6.0 to 7.0 (Maass *et al.*, 1988).

Two sites of 10 × 10 m each were chosen on a 30% SW-facing slope. These sites were representative of the low deciduous forest which dominates the slopes of this landscape. *Bursera excelsa* (HBK) Eugl., *Caesalpinia eriostachys* Benth., and *Jatropha stanleyi* Steyerm. are important tree species in the two 100 m^2 root excavation sites. An extensive list of trees in this area has been made available by Bullock (1985).

Aboveground tree and shrub biomass

All plants with a stem thicker than 3.2 cm at B.H. in the two sites were considered trees. For these only basal area at B.H. was measured. To estimate biomass, data collected at a similar site 2 km distant (for another study; Martinez, unpublished data), where entire trees were harvested, were used to derive a regression equation relating dry weight to basal area:

$$\text{Log dry weight (kg)} = -0.506 + 0.986 \text{ Log Basal Area } (\text{cm}^2)$$
$$(R^2 = 0.865; SE = 0.217).$$

Our measurements, as well as those by Martinez were made during the dry period when leaves had been shed.

All shrubs, lianas, and trees with diameters <3.2 cm at B.H., were harvested from nine randomly selected square meters at each of the two sites. Dead branches and stems were discarded. Lianas with stems that extended above 2 m height into the tree crowns were harvested to 2 m height only. Weights of these samples were recorded after drying for 7 days at 78°C.

Root biomass

Five trenches 0.5 m × 2 m each were placed randomly at both sites. The trenches were excavated with pick and shovel in 20 cm soil layers. All roots were harvested, using axe, saw, or pruning scissors, and were transported to the laboratory for further processing. Excavation proceeded to a depth of 60–80 cm where a hardpan layer inhibited further downward root penetration and, at the same time, deeper excavation. Since it was difficult to harvest the fine- and small-root fraction (diameter <5 mm) by this procedure, we used fine-root biomass values of a different site in the same watershed. The site chosen for the coarse-root extraction was similar to the one for the fine-root assessment. Tree density, elevation, slope and aspect were close. Since the fine-root collection site formed part of an extended study, the site could not be used for the relatively destructive excavation of the larger roots (>0.5 cm). We are confident, however, that the fine-root data represent adequately the standing fine-root biomass of the large-root excavation sites. The fine-root extraction methods differed from the one used for the larger roots. Twelve randomly chosen 40 cm long soil cores (4.2 cm diameter) had been estracted with a steel tube from two 10 × 10 m plots each, both with the same aspect and vegetation. The sandy nature of the soil and the low soil moisture content (2.7% soil moisture, gravimetrically measured) made possible fine-root extraction by means of dry sieving through standard soil sieves (2 mm and 0.5 mm). For a detailed description of the method, see Kummerow *et al.*, 1978). Soil core extraction, as well as trench excavation, were made between April 24 and May 6, 1989, *i.e.*, towards the end of the drought period. Roots were sorted into the diameter classes of <0.5, 0.6–1.0, 1.1–2.0, and >2.0 cm. No effort was made to separate live and dead roots, although we estimated that about 10% of the larger roots were dead. Fresh and dry weights (78°C, 6 days) were recorded.

Results and discussion

The basal areas of 23.4 and 22.6 m^2 ha^{-1} on trenching sites 1 and 2, respectively, showed the similarity of the two sites. By using the above described regression of basal area on tree biomass, an aboveground tree biomass of 68.6 Mg ha^{-1} was calculated. The biomass of the actually harvested shrubs and lianas amounted to 5 Mg ha^{-1} (range: 4.0–6.1 Mg ha^{-1}). Thus, 73.6 Mg ha^{-1} was the total aboveground biomass of this part of the Chamela forest. This amount fits into the lower range (28–266 Mg ha^{-1}) of aboveground biomass described for tropical dry forests in general (Murphy and Lugo, 1986a), and is also less than the 150 Mg ha^{-1} average for subtropical deciduous forests (Rodin and Bazilevich, 1967; Table 1).

We estimated a total belowground biomass of 30.9 Mg ha^{-1}. Of this 22.7 Mg ha^{-1} or 73% (S.E. = 5.61, n = 10) was coarse roots (diameter > 5 mm), as estimated from the trench excavation (Table 2) and 8.2 Mg ha^{-1} or 27% (S.E. = 0.92, n = 12) fine and small roots (diameter < 5 mm) based on the soil cores.

More than 62% of the root biomass was found in the 0–20 cm soil layer and 91% in the upper 40 cm. About one third of all roots belonged to the fine root category and another 37.5% to the thick roots (diameter > 2 cm, Fig. 1). The root biomass of the Chamela forest is smaller than the 45 Mg ha^{-1} (S.E. = 9.7, n = 8) found for a deciduous dry forest in Guanica, Puerto Rico (Murphy and Lugo, 1986b). While in the Guanica forest a root:shoot biomass ratio of 0.5 was calculated, this value for the Chamela forest was 0.4 (Table 1).

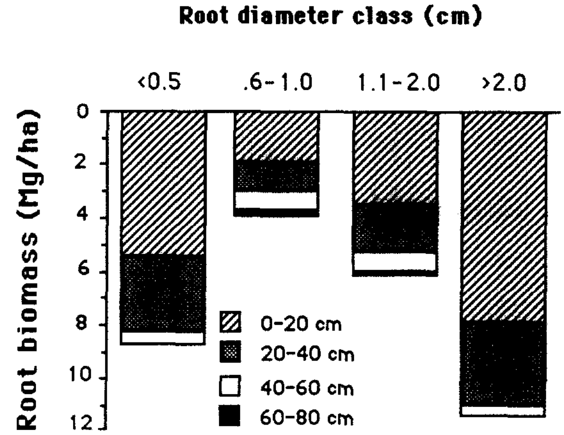

Fig. 1. Cumulative root biomass by size class and vertical distribution. Each column is the mean of ten excavated plots. All values are in Mg ha^{-1}.

The root biomass values reported here should contribute to close the gap in knowledge about the belowground biomass of the dry tropical deciduous forest in Mexico. The similarity with the results from a Puerto Rico dry forest strengthens the hypothesis that with increasing drought conditions relatively more carbon is allocated to the root system. These results also show the danger of deforestation of the relatively

Table 1. Root and shoot biomass of different forest types as compared to the tropical dry forest at Chamela

	Density stems ha^{-1}	Root biomass Mg ha^{-1}	Shoot biomass Mg ha^{-1}	R:S	Reference
Tropical, dry deciduous	4700	31	74	0.42	This study
Tropical, dry deciduous	12000	45	89	0.50	Murphy and Lugo, 1986b
Pseudotsuga menziesii	650	17	155	0.11	Hellman and Gessel, 1963
Fagus sylvatica	240[d]	51	324	0.16	Nihlgård, 1972
Subtropical deciduous	not reported	82	326	0.25	Rodin and Bazilevich, 1967

Table 2. Mean dry weight of coarse (diam. >5 mm) root biomass per m^2 and depth. Sites 1 and 2 were combined because differences between sites were not significant. Numbers in parentheses indicate one S.E.

Depth cm	Mean dry weight m^{-2} kg (n = 10)	Range of dry weights	% root biomass per 20 cm soil layer
0–20	1.33 (0.28)	0.30–3.19	59.5
20–40	0.62 (0.18)	0.20–2.08	28.4
40–60	0.22 (0.05)	0.10–0.61	7.9
60–80	0.12 (0.09)	0.06–0.88	4.2

steep slopes which are protected from erosion by the strong and dense network of fine and small roots in the upper 20-cm soil layer.

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