RELATIONSHIP OF CLIMATE TO THE SPECIFIC GRAVITY OF FOUR COSTA RICAN HARDWOODS[1]

An Exploratory Study

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ABSTRACT

In the summer of 1970, increment cores were removed at breast height from trees of four hardwood species growing on ten different sites in Costa Rica. On the basis of Holdridge's Life Zone Classification System, these sites ranged from Tropical Dry to Premontane Rain.

Expressed in terms of Holdridge's Life Zone System, climate has the most pronounced effect on the specific gravity of *Cordia alliodora*;—specific gravities for Tropical Dry and Premontane Moist sites being significantly greater than those for Tropical Moist, Premontane Wet and Tropical Wet sites. The specific gravities of *Virola Koschnyi* and *Cedrela mexicana* are also significantly different on some sites. For *Brosimum* spp., no significant differences in specific gravity were found.

Additional keywords: Cordia alliodora, Virola Koschnyi, Cedrela mexicana, Brosimum spp., increment cores, life zones, Organization for Tropical Studies, tropical hardwoods, specific gravity.

In recent years, the effect of environment on the specific gravity of wood has received much consideration for temperate climates (Tappi 1962; U.S. Forest Service 1965). Considerably less is known about this relationship for wood grown in the tropics. Yet knowledge about this relationship can be of value to managers of tropical forests as these forests become an increasingly important source of the world's timber supply. This information promises to be especially useful in second growth tropical forests, which appear to be on the increase in importance for possible management schemes (Budowski 1966).

This study took an exploratory approach to the effect of climate on specific gravity because adequate data on specific environmental features such as precipitation were not available. Dr. L. R. Holdridge[2] kindly arranged for me to sample four commercially important tree species growing on sites in Costa Rica that have different climates. A detailed description of these sites was recorded when they were classifed during 1964–66 using the Life Zone Classification System of Holdridge as illustrated in Fig. 1 (Holdridge et al. 1971). This system evolved on the basis of distribution of natural vegetation in response to climate. The basic postulate of this bioclimatic system is that the primary influences on vegetation are those factors that make up climate: heat, precipitation, and humidity.

The objective of this research was to examine the relation between specific gravity and climate expressed in terms of Holdridge's Life Zone Classification System.

PROCEDURE

Field work was carried out in Costa Rica during July and August of 1970. Four species of commerically important trees were selected for study: *Cordia alliodora*

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[2] Dr. Holdridge is Head, Tropical Science Center, San José, Costa Rica.

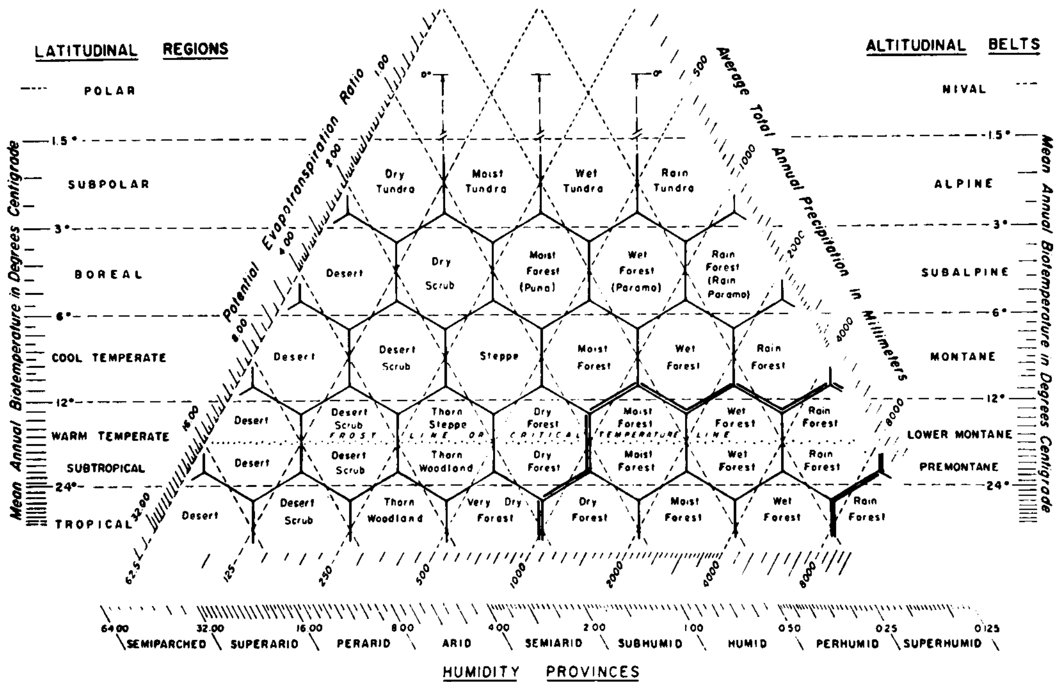

FIG. 1. Diagram for the classification of world Life Zones. Study sites are in the six Life Zones included within the double line. (By permission, from Holdridge et al. 1971.)

(R. & P.) Cham., *Virola Koschnyi* Warb., *Cedrela mexicana* Roem., and *Brosimum* spp. Ten sites were sampled in six of Holdridge's Life Zones as shown in Table 1. The locations of these sites in Costa Rica are shown in Fig. 2. This figure is a modification of an ecological map by Tosi[3] and reflects the wide diversity of Costa Rica's climatic patterns, which is due to variation in amount of precipitation, annual distribution of precipitation, and mean annual temperature (Scott 1966).

The six Life Zones studied vary from Tropical Dry to the Premontane Rain forests. One Tropical Dry site receives approximately 65 inches (1,650 mm) of rain a year. The climate is monsoonal, with 5 months each year having virtually no rain. In this tropical deciduous forest, the crowns of the tall trees give an 80% cover to the open, grassy, somewhat parklike area below (Holdridge et al. 1971).

[3] Joseph A. Tosi Jr., Centro Cientifico Tropical, San José, Costa Rica.

In contrast, the Premontane Rain site receives approximately 200 inches (5,080 mm) of rain, which is more evenly distributed throughout the year. The canopy of this evergreen forest is formed by the first two (of three) crown layers. The very dense understory is made up of tree ferns, large herbs, lianas, and small palms. This site would be classified by many authors as tropical rain forest (Dansereau 1957; Richards 1952; Walter 1971).

When present, three trees each of the four species were sampled on each site (Table 1). Sampling was restricted to healthy mature trees that were free of defects. *Cedrela mexicana* was the only species found growing in all six Life Zones. On some sites fewer than three trees of a given species were available for sampling. Two 10-mm-diameter increment cores, approximately 4 inches long, were removed from each tree at breast height. Whenever possible, one core was removed from a buttress or swollen part of the trunk while the other core was removed from a concave

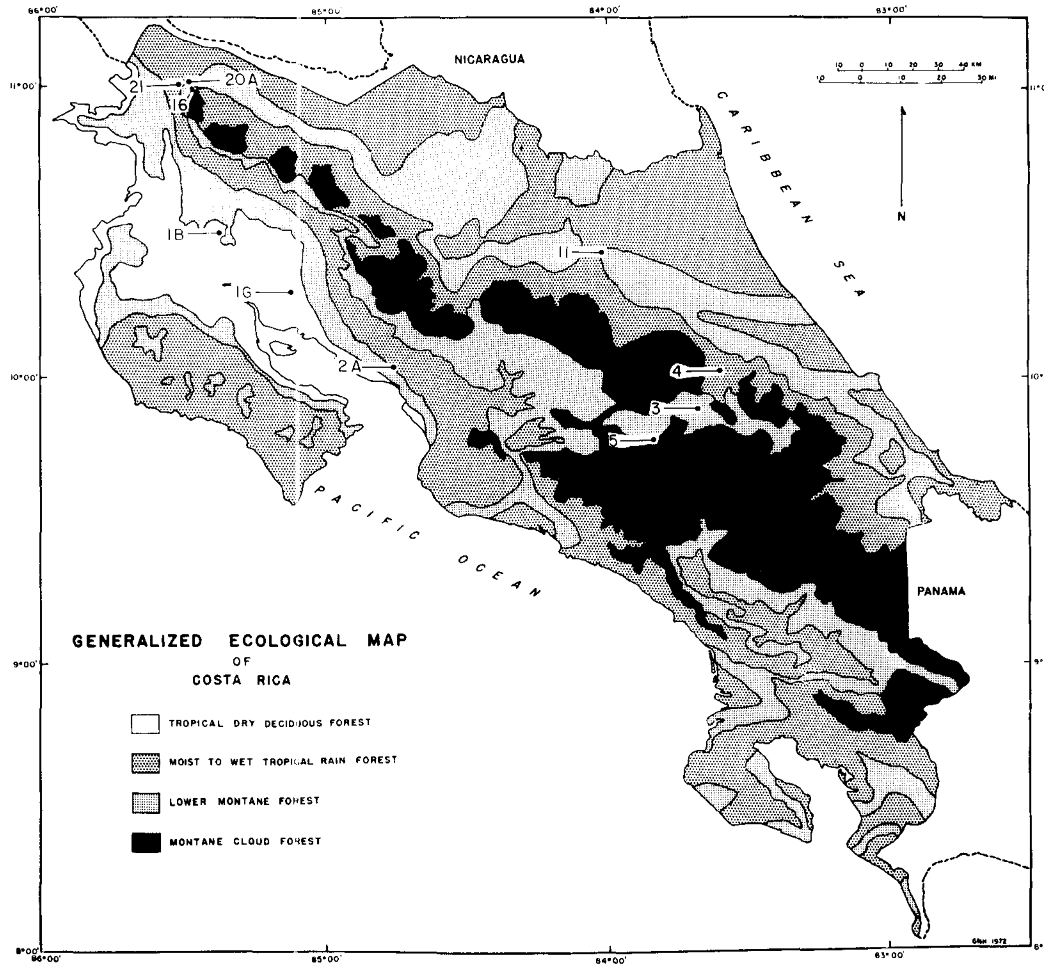

FIG. 2. Locations of the ten sites sampled in Costa Rica.

part of the trunk regardless of cardinal directions. The cores were dipped in a solution of formalin, then kept cool and wet. The ages of the trees were not known nor could they be determined from the cores.

Laboratory analysis was done in the Wood Utilization Laboratory of the College of Forestry, Wildlife, and Range Sciences at the University of Idaho. Basic specific gravity was found for the first 35 mm of the core in from the bark by the water-immersion method (Smith 1955).

Variability in basic specific gravity associated with site and bole eccentricity was tested by analysis of variance, recognizing inequality of subclass numbers. Specific gravities were analyzed using Duncan's new multiple range test (Duncan 1955).

RESULTS AND DISCUSSION

Effect of life zones

Specific gravities are ranked in Table 1. In Fig. 3, specific gravities are shown with sites arranged according to Holdridge's Life Zone Model.

The relation between specific gravity and Life Zone is most pronounced for *Cordia alliodora*. Here the specific gravities for Tropical Dry and Premontane Moist sites are significantly greater than those for Tropical Moist, Premontane Wet, and

TABLE 1. *Site classifications and descriptions of the four species studied. Means bracketed by the same line are not significantly ($P \leq 0.05$) different.*

Species	Site No.[a]	Life Zone	Number of Trees Sampled	Mean % Crown	Position of Crown[b] D	C	I	Mean dbh (in.)	Mean Basic Specific Gravity
Cordia alliodora	1B	Tr. Dry	3	43		X	X	8.9	0.624
	1G	Tr. Dry	3	33		X		8.3	.590
	21	Prem. Moist	3	27		X		9.0	.554
	4	Tr. Wet	3	20	X			16.2	.446
	20A	Tr. Moist	3	15		X	X	16.1	.423
	11	Prem. Wet	3	28	X	X		18.3	.408
	3	Tr. Moist	3	17		X	X	13.1	.384
Virola Koschnyi	3	Tr. Moist	3	16		X	X	10.7	.461
	20A	Tr. Moist	3	22			X	13.1	.453
	16	Prem. Wet	3	18		X	X	17.3	.425
	11	Prem. Wet	3	17		X	X	10.9	.409
	4	Tr. Wet	3	17		X	X	11.7	.375
Cedrela mexicana	4	Tr. Wet	3	40	X			19.2	.401
	3	Tr. Moist	3	60	X	X	X	20.6	.384
	21	Prem. Moist	1	50	X			17.9	.374
	11	Prem. Wet	3	33	X	X		27.6	.369
	5	Prem. Rain	3	23	X			26.4	.334
	1B	Tr. Dry	3	43		X		8.9	.329
	1G	Tr. Dry	3	33		X	X	8.3	.325
Brosimum spp.	21	Prem. Moist	3	28		X	X	15.9	.623
	1B	Tr. Dry	3	34		X	X	17.6	.618
	3	Tr. Moist	3	15	X		X	13.8	.613
	1G	Tr. Dry	3	42		X	X	25.3	.609
	2A	Tr. Moist	2	55			X	15.8	.595
	16	Prem. Wet	3	22	X	X	X	20.4	.587
	11	Prem. Wet	3	23		X	X	11.9	.563
	20A	Tr. Moist	3	23		X	X	16.8	.562
	4	Tr. Wet	3	37	X	X	X	17.3	.562

[a] A detailed description of these numbered sites has been recorded (Holdridge et al. 1971)

[b] Dominant, Co-dominant, Intermediate

Tropical Wet sites. Trees on the drier sites were smaller, were reported to be slower growing, and were much more resistant to penetration by the increment borer. This contrasts with the situation in temperate climates where diffuse porous hardwoods show little relationship between specific gravity and rate of growth (Panshin et al. 1964).

For *Virola Koschnyi*, the trend of the relationship between specific gravity and Life Zone is similar to that for *Cordia alliodora*. Specific gravity varies inversely with precipitation. For *Virola Koschnyi*, the specific gravity of one of the two Tropical Moist sites is significantly greater than that of the Tropical Wet site.

In contrast to *Cordia alliodora* where the two Tropical Dry sites have the highest specific gravities, for *Cedrela mexicana* the two Tropical Dry sites have the lowest specific gravities. Indeed, these specific gravities for *Cedrela mexicana* on the Tropical Dry sites are significantly lower than the specific gravity on the Tropical Wet site. For *Brosimum* spp. no Life Zones have significant differences in specific gravity. Although *Brosimum* specimens were obtained from all except one of the sites visited, the range of specific gravity measured for these specimens was less than for other species even though stem diameter varied widely.

Correlation between specific gravity and other features

For each species, correlations were computed between specific gravity and dbh, percent crown, position of crown (whether dominant, codominant, or intermediate) and whether the wood was formed in or between buttresses. No correlations were

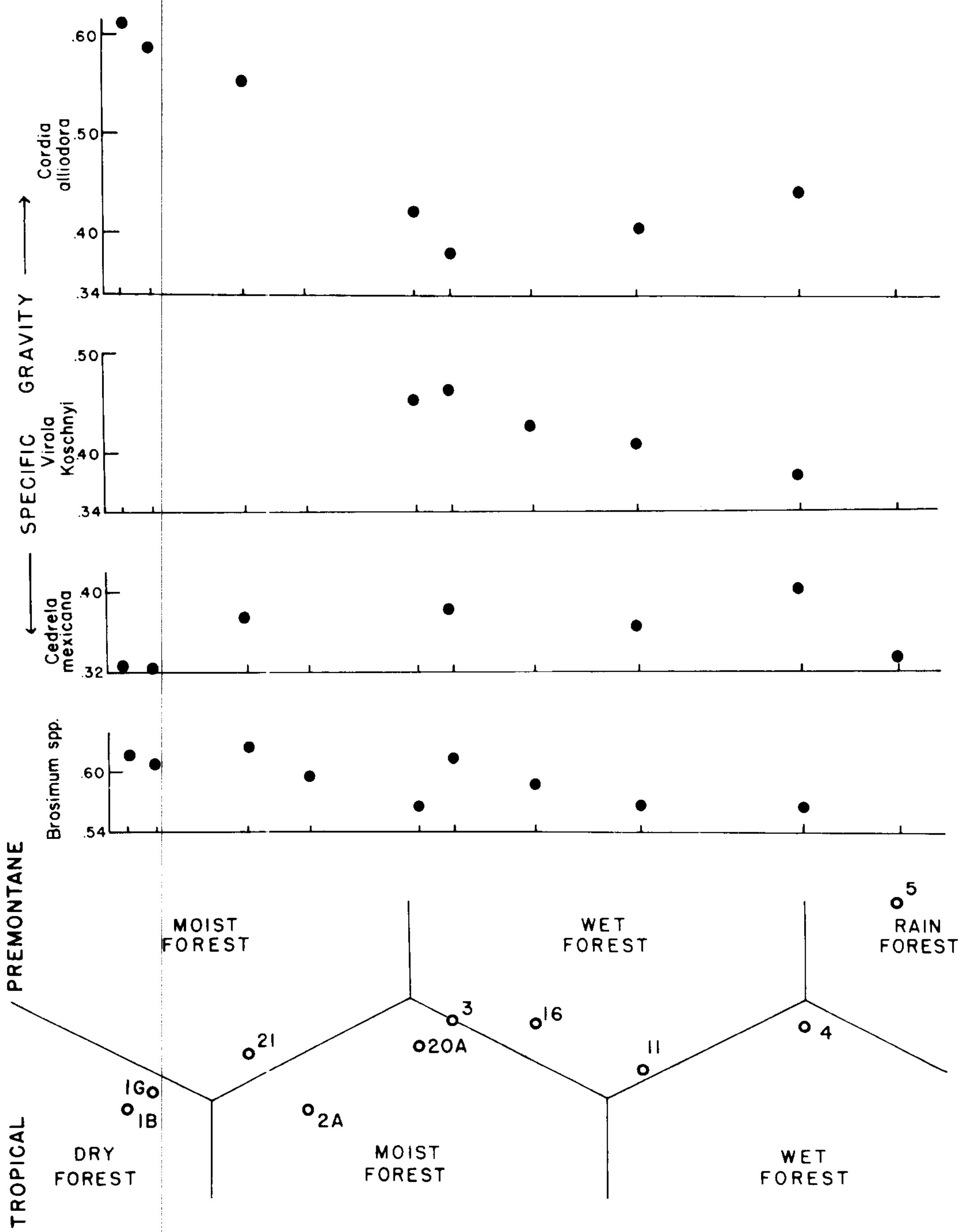

FIG. 3. Average specific gravity at each site. Sites are arranged according to Holdridge's Life Zone Model.

significant except for *Cordia alliodora*, which showed a highly significant negative correlation between specific gravity and dbh as well as a highly significant positive correlation between specific gravity and percent crown.

CONCLUSIONS

On the basis of Holdridge's Life Zone classification system, climate significantly influences the specific gravities of *Cordia alliodora*, *Virola Koschyni*, and *Cedrela mexicana* but does not significantly influence the specific gravity of *Brosimum* spp. *Cordia alliodora* was also the only species for which significant relationships between specific gravity and dbh and percent crown were obtained. This suggests that wood quality of the first three mentioned species can be selectively affected by forest management practices. A more complete explanation of the above relationships will require more detailed observations in the field and additional laboratory analyses of the wood of these species.

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