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The Role of Mangrove Ecosystems: Mangrove leaf area indices

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MANGROVE LEAF AREA INDICES

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Introduction

Leaf area is one parameter which may be used to estimate the photosynthetic capacity of individual plants or entire ecosystems. It is thus one index of the conversion of solar energy to chemical energy (yielding carbohydrates that are used in plant metabolism). Leaves of individual species can be arranged or stacked in multilayers, monolayers, or as small or large leaves, shade tolerant or sun leaves. However, when considering all plants or trees collectively on any given area of forest, the total leaf area tends to be predictable. Leaf area index (LAI) or total leaf surface per unit ground area is one of the most widely used values for quantifying leaf area. The literature gives many techniques for determining LAI, but the particular method employed depends on degree of accuracy desired, and expense, and the time available. In this research project, leaf area indices were evaluated for each of the sites (and plots) indicated in Figure 1. The resulting LAI values (m^2/m^2) can then be used for relating metabolic rates, determined elsewhere, to particular sites.

Methods

The following techniques were used for determining LAI in mangroves:

(1) All leaves from a meter-square prism (extending from the forest floor to the canopy) were collected, traced, dried,

and weighed. Leaf area was then determined using planimetric techniques. This method is quite time consuming, but yields reproducible results.

(2) Leaves collected from a meter-square prism were pressed in plant presses and then placed on a light table with a constant light source. A sensitive photocell connected to a reflectance meter (PhotoVolt) determined the quantity of light blocked out by leaves obstructing the light source. After calibration (Figure 2) the amount of light transmitted is then convertible to a known leaf area. Biomass of leaves is correlated with leaf area in Figure 3.

(3) Plumb line method. A weighted cord was extended from the canopy downward toward the forest floor. The single line reduces the meter-square prism to a finite locus of points and all leaves touching the cord were recorded. One leaf in contact with line equals LAI 1. Assuming a straight line, three leaves in contact with the cord results in an LAI of 3, or 3 meters of leaf surface per meter square of ground surface. This method is quick and easy and therefore allows for a larger sample size.

(4) Photographic records of forest canopy structure were taken at the three experimental sites. Visual interpretation is helpful in evaluating amount of leaves and canopy closure in various-aged mangrove forests.

(5) Canopy closure, indirectly related to number of leaves in forest, was measured with hand densiometer at individual sites. Results are given as the average of 20 readings per site.

(6) Light readings from two Weston 600 light meters were used as an estimate of light transmittance through forest canopies. Thirty simultaneous readings were taken at each site with one light meter on the forest floor and the other in full sunlight; the difference equal to light blocked or absorbed by the canopy.

Results

The objectives of these measurements were to provide input values for mangrove canopy structure and serve as a basis for comparing mangrove study sites. Leaf area of mangroves measured ranged from 0.8 to 5.1 m^2/m^2 as shown in Table 1. Miller (1972) measured leaf areas of red mangroves and found LAI to vary between 0.99 and 2.89 in eight different stands in south Florida. Red mangroves with closed canopies had leaf area indices over 1.50. Golley, et al. (1962) reported LAI of 4.4 for red mangroves in Puerto Rico. The higher leaf area indices measured in the current study probably reflect the measurement of a more mature (steady-state) forest containing mixtures of red, black, and white mangroves.

All sites had a canopy closure over 95 percent even though 33 percent of the incident light (radiation) was reaching the forest floor in plot 7 which consisted of only red mangroves. One reason for the relatively large amount of light transmitted through the red mangrove canopy in plot 7, is that early successional ecosystems have leaf area indices somewhat lower than later successional seres (i.e., mixtures of red and black mangroves - plot 13). Under these increased light levels, growth of seedlings is facilitated.

Plots 13 and 14 had about twice as many total leaves (2800 compared with 1201) as plot 7, and consequently total leaf area was about twice as much (4.5 as compared with 2.4). With the exception of one plot, medium sized leaves were more abundant and had a greater area than either small or large leaves as shown in Table 2.

Table 2. - Size class distribution of mangrove leaves per meter square.

		SMALL			MEDIUM			LARGE			TOTAL		
Site	Species*	Total No. of leaves	LAI m^2/m^2	Wt. g/m^2	Total No. of leaves	LAI m^2/m^2	Wt. g/m^2	Total No. of leaves	LAI m^2/m^2	Wt. g/m^2	Total No. of leaves	LAI m^2/m^2	Wt. g/m^2
Little Wood River	all										2724	4.05	769.1
	R	368	.34	47.2	554	.99	149.4	214	.58	85.6	1136	1.92	282.2
	B	629	.51	113.1	756	1.18	252.6	195	.43	121.2	1588	2.13	486.9
Site 5, Plot 13	all										2895	4.47	803.7
	R	1091	.21	44.3	662	.72	125.9	225	1.18	200.2	1978	2.11	370.4
	W	161	.73	162.5	389	.92	161.8	367	.61	109.0	917	2.36	433.3
Site 3, Plot 7	all											2.35	524.4
	R	249	.30	72.4	638	1.16	262.1	314	.88	189.9	1201	2.35	524.4

R = Red mangrove *Rhizophora mangle*

B = Black mangrove *Avicennia nitida*

W = White mangrove *Laguncularia racemosa*

FIGURE F-1.-LEAF AREA INDICES FOR SELECTED STUDY SITES IN SOUTH FLORIDA.

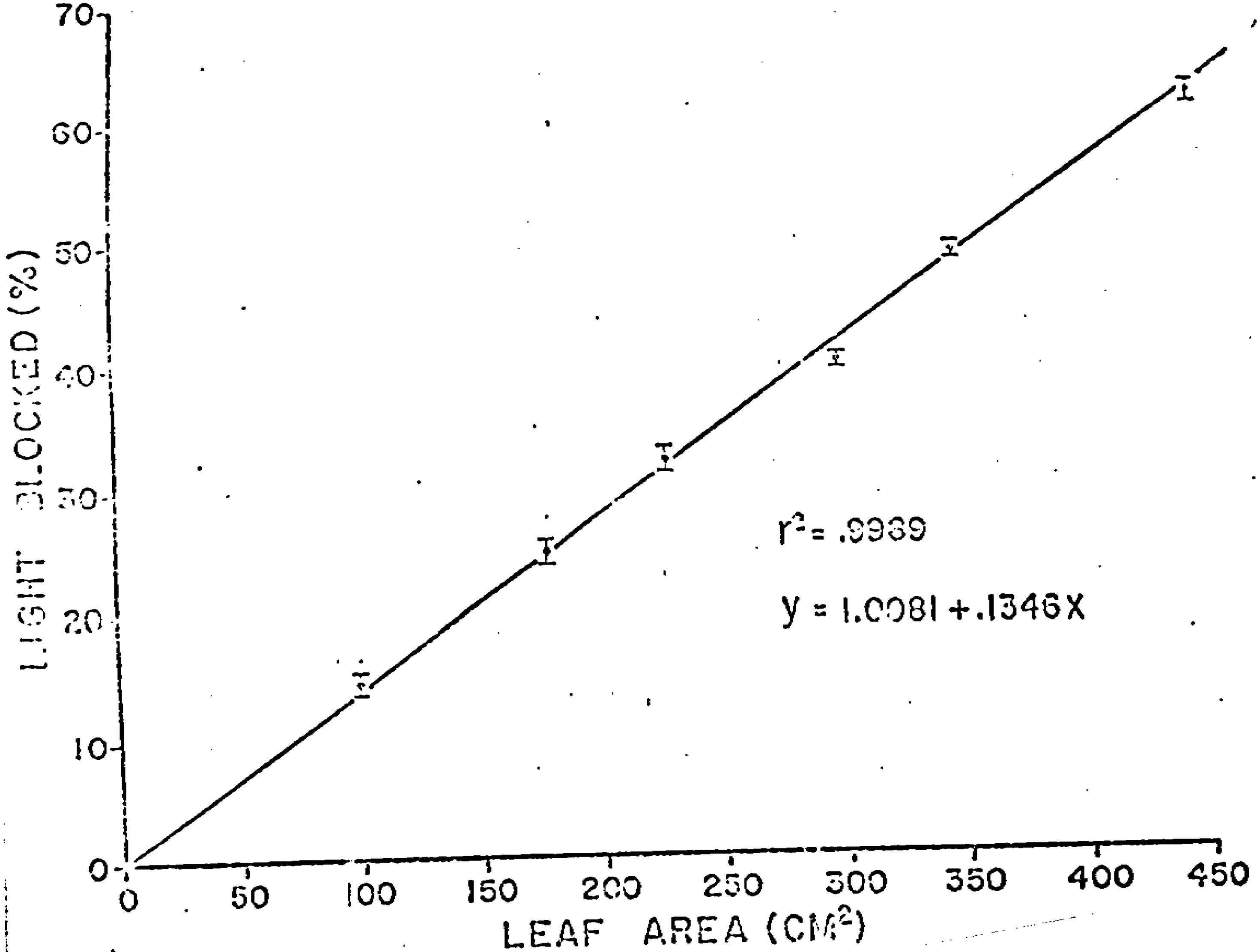
LOCATION	DATE	LEAF BIOMASS g m-2	LEAF AREA INDICES: CALCULATED BY REGRESSION	LEAF AREA INDICES: PLANIMETER	LEAF AREA INDICES: LIGHT TABLE	LEAF AREA INDICES: PLUMB LINE	% CANOPY CLOSURE	% LIGHT TRANSMISSION	LEAF BIOMASS (RANDOM PRISMS) g m-2
Rookery Bay (tot. forest)	AUG 71					3.3			
Red mangrove seedlings	FEB 72			0.8					210.
Black & white mangroves	"			5.1					1377.
Red & black mangroves	"			3.5					549.
Site #1 and 2:									
Plot 1 - White mangrove	JAN 72	62.	0.30						
" 2 - " "	"	289.	1.51						
" 3 - " "	"	169.	0.67						
" 4 - " "	"	156.	0.80						
" 5 - " "	"	308.	1.61						
" 6 - " "	"	345.	1.00						
Site #3									
Plot 7 (total forest)	FEB 72	726.	3.82		2.4		97.4	32.6	524.
Red mangroves	"	3[illegible]2.	2.05						
White mangroves	"	34[illegible].	1.80						
Plot 8 (total forest)	"	695.	3.65						
Red mangroves	"	694.	3.65						
Site #5									
Plot 11 (total forest)	MAR 72	594.	3.12						
Red mangroves	"	573.	3.01						
White mangroves	"	16.	0.06						
Plot 12 (total forest)	"	504.	3.07						
Red mangroves	"	407.	2.[illegible]						
White mangroves	"	97.	0.49						
Plot 13 (total forest)	APR 72	731.	2.84		4.5		99.0	74.5	803.
Red mangroves	"	580.	3.05		2.1				370.
White mangroves	"	151.	0.77		2.4				433.
Site #6									
Plot 14 (total forest)	APR 72	381.	1.99						
Red mangroves	"	367.	1.92						
Black mangroves	"	14.	0.05						
Plot 15 (total forest)	"	951.	5.01						
Red mangroves	"	169.	0.87						
Black mangroves	"	780.	4.10						
Random (total forest)	MAY 72				4.1		95.8	8.5	769.

Discussion

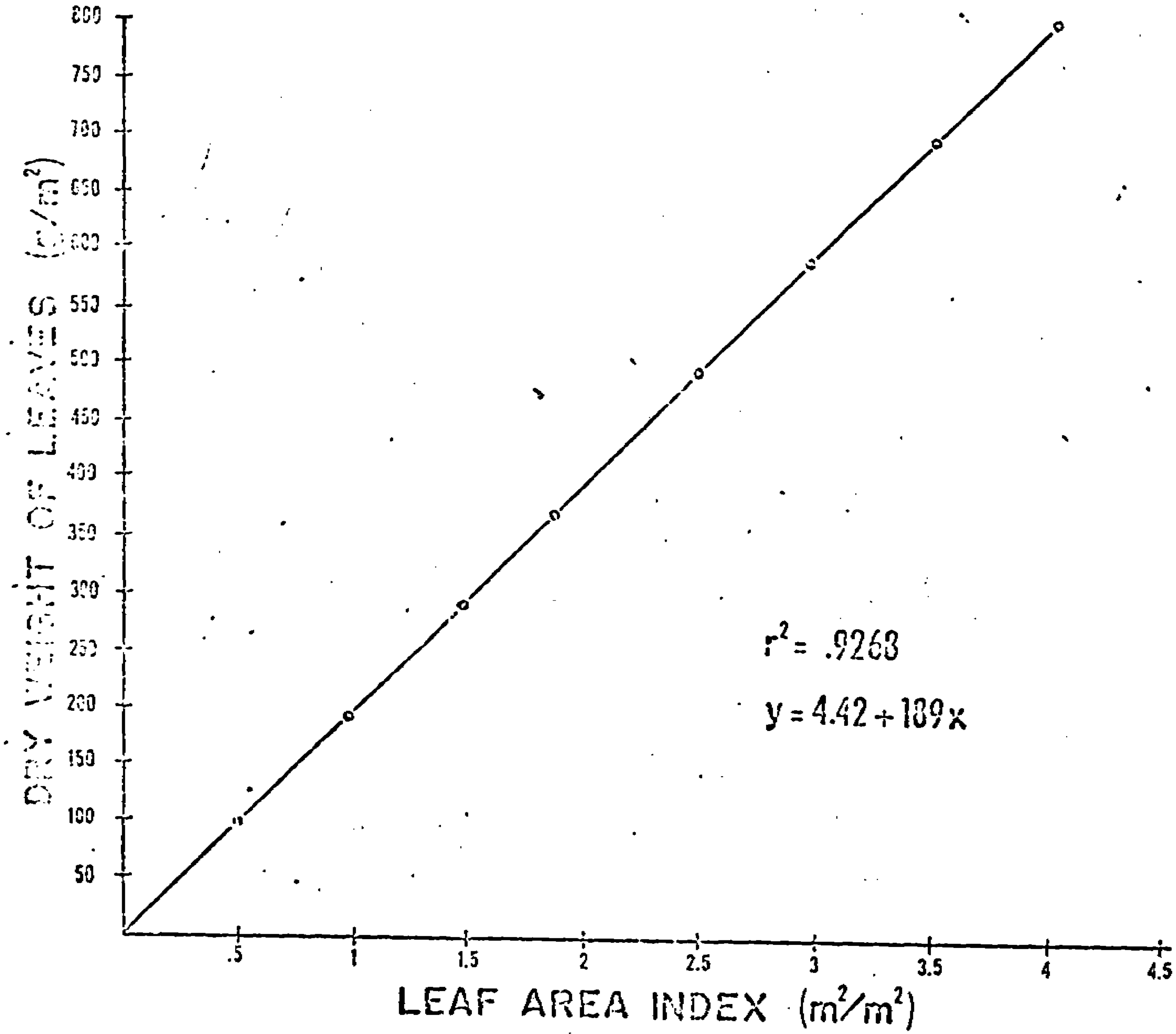
In a developing ecosystem such as a successional mangrove forest, ecosystem characteristics such as diversity, complexity, stability, biomass, productivity, including leaf area change with time (generally increase with the exception of net production) and then reach a maximum (no change per unit time) in a mature or steady-state forest. Leaf area is a measure of the photosynthetic biomass or size of the photosynthetic system which converts solar energy to chemical energy. Leaf area index values increase during early successional stages and then level off at a maximum in mature ecosystems.

Ovington (1962), Rodin and Bazilevich (1967), Snedaker (1970), and Odum (1970) present evidence to show that total leaf biomass per unit land area is uniform under a broad range of environmental conditions. Similarly, LAI is also a predictable value. For example, temperate oak forests have LAI of 3.1 (Mar:Möller, 1945) and hardwood forests in Florida have LAI of 6.2 (Lugo, et al., 1971). Tropical forests have a higher LAI of 9-12 (Odum, 1970).

LAI measured in this study is dependent on the various aged stands of mangroves where samples were taken. Much of the area studied had been disturbed by high winds and hurricanes, the most recent disturbance resulting from Hurricane Donna in 1966. Consequently, the study sites are in various stages of succession. Also, tree falls and broken limbs create large light gaps in the forest canopy, thus allowing more light to reach the forest floor which facilitates the development of mangrove seedlings.



70
60
50
40
30
20
10
0
LIGHT BLOCKED (%)
r^2 = .9989
y = 1.0081 + .1346X
0
50
100
150
200
250
300
350
400
450
LEAF AREA (CM^2)



DRY WEIGHT OF LEAVES (g/m²)
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
.5
1
1.5
2
2.5
3
3.5
4
4.5
LEAF AREA INDEX (m²/m²)
r² = .9268
y = 4.42 + 189x

In agricultural crops, there is an optimum LAI which corresponds to an optimum leaf arrangement for maximum photosynthesis. Similarly there is an upper limit of leaf area where mutual shading results in net photosynthesis or zero or photosynthesis equals respiration. A maximum LAI of 5 reported for mangroves may or may not be the maximum LAI possible because of frequent hurricane disturbance and tree falls which tend to act as a controlling mechanism to keep photosynthetic biomass at an optimum level for maximum energy flow. Assuming no disturbances mature (steady-state) mangrove forests reach maximum LA at approximately 20 years (Lugo, Snedaker, Sell, 1973).

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