ISSN : 0974 - 7435 Volume 8 Issue 5

BioTechnology
An Indian Journal

FULL PAPER

BTAIJ, 8(5), 2013 [670-675]

Study on indirect method determination of typical wetland canopy LAI, South China

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ABSTRACT

LAI (leaf area index Leaf Area Index,) is the study of green plant atmosphere O2/CO2 exchange, water cycle and water loss, solar energy utilization efficiency and conversion of the important basic work. Through the gap ratio (gap-fraction)principle, LAI digital imaging indirect method are described systematically. Through the determination of the South China different typical wetland canopy 9 observation points, the leaf area index, extinction coefficient, radiation through the characteristic index coefficient of community canopy. And by measuring height LAI characteristics of different stages of secondary forest. The CI110 digital canopy imager (Digital Plant Canopy Imager CI110) method to reduce human error. Also discusses the reasons of south China typical single and mixed forest of mountain rain-forest in LAI than in LAI minor. And the canopy LAI of different types of comparative analysis. The results provide scientific basis for the study of atmospheric environment effect for Hainan coastal vegetation.

KEYWORDS

LAI;
Canopy;
Indirect method;
Carbon sequestration;
South China.

PREFACE

LAI (leaf area index) in 1947 by the Watson is defined as "leaf area per unit land area". LAI on plant many important ecological processes, including total NPP, transpiration and PAR through canopy penetration, is very important in[1]. LAI can provide quantitative information structure and energy conversion for the description of the canopy surface material, atmosphere O2/CO2 exchange, is to estimate the parameters of plant canopy function, which is the most important environmental and ecological system structure parameter of [2]. LAI is an important index of dynamic understanding and mastering the plant canopy gaps and balance. In addition, LAI and biomass accumulation are closely related, is closely related with the various scale ecosystem productivity. Quantitative analysis of LAI is an important ecological parameters of energy exchange properties of the earth, the researchers also suggest that it be the forest pressure of the reference value [3].

In general, the leaf area measurement method has two categories: direct method and indirect method. The direct method is by getting all of the leaves were measured or area — weight ratio to obtain results [4]. The direct method is simple,but requires a large amount of manpower, the plants are destructive, time-consuming,

but also need to repeat the work to reduce sampling error. The indirect method measurement method does not cause damage to the plant. The contact frequency, Wilson and Reeve Warren in 1959 by testing leaf to measure the LAI[5]. In 1972 Bonhomme and Charter initiated by light penetration ratio calculation method of canopy leaf area index. Its theoretical basis is the canopy light radiation, the fitting relationship and superposition status of canopy leaves and light with quantitative factor. Lang argues that for the concave and convex leaves, define LAI as the unit of land area on plant photosynthetic active radiation(photo-synthetically active radiation, PAR) the total interception area ratio is defined as the ability to express the vertical projection area on unit land area or the maximum projected area has better. Because PAR total interception area also reflects[6] physical meaning and connotation of ecological plant canopy. LAI is a dimensionless parameters, dynamic, with the changes of leaf number change. In addition, growth and plant species of plant leaves its characteristics, external environment condition and artificial management mode. Different definitions and assumptions plus LAI resulted in the difference of LAI value measurement. After the maturity of technology, through the software and computer interface to the LAI directly in the field of measurement. After testing, in addition to coniferous forest,indirect method is used on various vegetation types can reflect the real situation. Due to the climax rainforest trees tall structure is complex, the direct method of LAI estimation is not operable. In this paper, through canopy digital imaging technology of indirect method measurement of typical wetland South China LAI of the canopy,and the correlation analysis.

THE BASIC SITUATION

A survey of research destination

Select Hainan Wanning Shi Mei Bay in order to study. Take off the southeastern coast of Shi Mei Bay in Hainan Island. In 1980 the establishment of *Vatica hainanensis* forest nature reserve. It is mainly secondary forest, a small amount of the original green rainforest. As a result of a hard material corrosion, the reign of Qing Emperor Guangxu carved stone tablet, the period of the Republic of China in two people with a gun parade. The *Vatica mangachapoi* forest strip, about 50 meters from the coast tidal line. *Vatica hainanensis* forest at an altitude of 6-12 meters,the total area of 14234 acres. The core area of 4784 acres. Wanning green forestry tropical rain forest single branch. In the original state area more than 1000 mu. Is a unique soil climax [7]. Are rare in the world.

The Shi Mei Bay is located in tropical north along the. Genus of tropical marine monsoon climate, yearround hot, no cold and frost, with an average annual temperature of 24.50C, lighting rate of 50%, about 2230 hours. For many years the average annual precipitation 2032mm, rainfall concentrated in the 5-10 month,precipitation throughout the year accounted for 89%. The coastal beach distribution is advanced marine new sand deposition and modern beach sediments. The lithology is light yellow, gray white sand, thickness 1.5-8m. Water depth of 2-5M, is a typical South China wetland.

Sample selection

Kind of homogeneous, experimental test with continuity. Need to have a large enough area, so as not to affect the scattering of light. Try to avoid coniferous forest. The 9 observation points: 3 plantation, respectively (*Cocos nucifera*) forest coconut, betel nut (Areca catechu) forest, mango (*Mangifera indica*) forest, 6 natural forest, respectively is the seaside bushes, crown height, crown height 3M secondary *v. mangachapoi* forest 6m secondary *v.mangachapoi* forest, crown height 9m secondary *v.mangachapoi* forest the original climax, green tree layer, original climax *v.mangachapoi* forest (green forest and shrub layer climax,tree layer. And uniform distribution. So the observation point on the ground and the height of 1.5m). 3 times each point acquisition of digital image. Bush plant *Cerbera manghas*, *Clerodendrum inerme*, green forest characteristics of plant there textilis (*Vatica hainanensis*) fruit (*Mischocarpus sundaicus*), handle, section nine (*Psychotria rubra*), (*Salacia grandiflora*),(*Randia spinosa*) mountain, (*Uvaria grandiflora*),in the sample selection covers from the coast to the gradient of hilly canopy.

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TESTING PRINCIPLE AND METHOD

Radiation and extinction coefficient, LAI.

The canopy layer of light radiation interception is the solution and key factors aregrowth and production capacity. According to the Beer rule, the relationship in the ilayer in the light emission intensity of Ii and leaf area index of the following[8,9]:

$$I_i = I_0 e^{-kL_i} \quad (1)$$

k as the extinction coefficient, Li for leaf area index (LAI), radiation intensity I0 for canopy outside. The canopy extinction coefficient and LAI control of light attenuation degree. The extinction coefficient of determination of the distribution of the blade angle to calculate. If the direct very time-consuming for blade measurement, can be based on the spherical, cylindrical or conical surface blade distribution calculation[10]. In 1986 Campbell is proposed based on the general formula of spherical angle distribution.

Gap ratio (gap-fraction) and canopy structure

Their relationship as early as 1953 by Monsi Wilson. Forest gap and canopy leaves than P zenith angle and azimuth angle relationship *r*:

$$p = e^{-k_{\theta,\gamma} L / \cos\theta} \quad (2)$$

The arrangement position in space of extinction coefficient *k* and leaf. If canopy leaf arrangement is random, then the gap in large samples with small probability event. Can satisfy the Poisson distribution (Poisson). The calculation of K can be obtained through corresponding formula.

Conversion[11]

The angle θ_i, light radiation through the ratio of Pi and leaf area index, extinction coefficient has the following relationship:

$$-\ln P_i = \sum_{j=1}^{N_j} f_j k_{ij} \quad (3)$$

$$L = \sum_{j=1}^{N_j} f_j \quad (4)$$

The formula of *L* for canopy leaf area index. f_j for leaf area index *j* leaf inclination angle. Series *N* are divided into leaf inclination angle. Extinction coefficient K_{ij} incertain zenith angle theta *i*, leaf angle is *j*.

In the *j* leaf stage, the extinction coefficient K_{ij} and the zenith angle and the mean leaf angle $\theta_i 0\alpha_j$

$$k_{ij} = \cos\alpha_j \quad (\theta_i \text{d}" 90-\alpha_j) \quad (5)$$

$$k_{ij} = \cos\alpha_j \frac{1+2(\tan y - y)}{p} \quad (\theta_i \ddot{y} 90-\alpha_j) \quad (6)$$

$$y = \cos^{-1}(\cot\alpha_j \cot\theta_i) \quad (7)$$

CI110 and field using the method

In this paper, the field was measured by CID company CI110 digital plant canopy image analyzer. Composed of fisheye image acquisition device, portable computer and canopy analysis software. Software for digital processing of the acquired images, including the proportion of the sky, transmission coefficient for radiation penetration, radiation coefficient.

The user determines the spatial range to be observed according to the zenith and azimuth angle settings. In the plane direction azimuth values of 0~3600, the vertical direction perpendicular to plane direction from the values of 0~900. So will the whole image is divided into a number of areas (see Figure 1). In the calculation,according to the actual situation and needs can choose different sectors and grid. Then the software on the basis of forest gap than the conversion mode of selected areas of the visible sky pixel

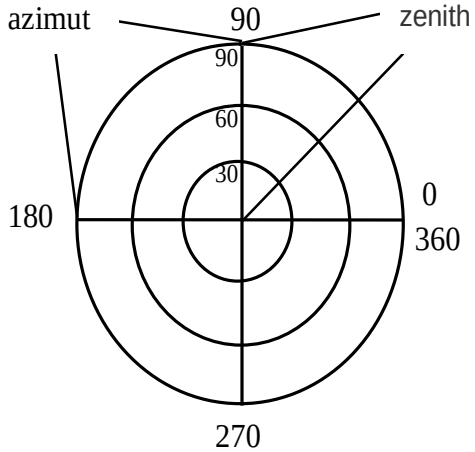

Figure 1 : Grids and sectors for analyzing fish-eye images

count. According to the matrix transformation. Finally,the calculated data include leaf area index, distribution, mean leaf angle, extinction coefficient, radiation

penetration coefficient.

RESULTS AND ANALYSIS

The results of experiment.

Digital image and the results obtained are the important foundation. To select the typical community, uniformity and canopy components. In order to ensure the accuracy of the calculation procedure. Image acquisition from fisheye probe hemisphere. The following is the community observation points have digital image representative (Figure 2 and Figure 10). From the digital canopy of view, there is a blank image in coastal scrub. Mainly because of the natural community plant species and uneven distribution of the formation of the blade. Irregular betel nut, Coconut Community community image forming massive visible sky part is due to artificial single forest, density of artificial control.

Canopy LAI and related index.

The LAI value is not high. TABLE 1 for calculated

Figure 2 : Digital canopy image of *Areca catechu*

Figure 3 : Digital canopy image of *Cocos nucifera*

Figure 4 : Digital canopy image of *Mangifera indica*

Figure 5 : Digital canopy image of coastal shrubs

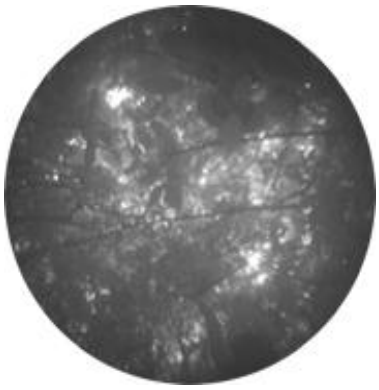

Figure 6 : Digital canopy image of *Vatica hainanensis* secondary forest(height 3m)

Figure 7 : Digital canopy image of *Vatica hainanensis* secondary forest(height 6m)

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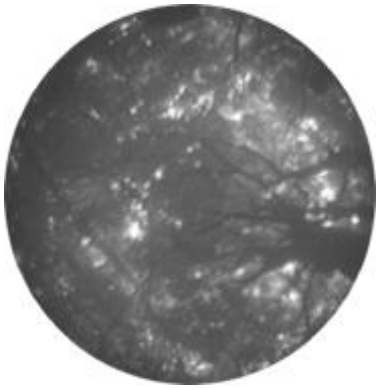

Figure 8 : Digital canopy image of *Vatica hainanensis* secondary forest(height 9m)

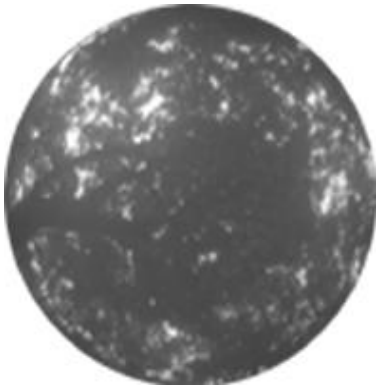

Figure 9 : Digital canopy image of *Vatica hainanensis* climax community(tree layer)

Figure 10 : Digital canopy image of *Vatica hainanensis* climax community(total)

the index results showed that: LAI is the smallest betel nut forest 1.664, followed by the shrub communities in 1.808. The other two artificial community coconut trees and mango trees are respectively 2.081, 2.233, LAI. Climax *v.mangachapoi* forest LAI was the highest, 3.554. The tree layer, shrub layer of 3.261 0.2933m, 6m, 9m *Vatica hainanensis*. LAI are respectively 2.073, 2.743, 3.177. *Vatica hainanensis* forest in the development process, the LAI and the woods are highly related, but there is no linear relationship. Slope betel nut forest plantations, with the latitude and secondary *v.mangachapoi* forest LAI is huge.

From the LAI data, the typical wetland forest leaf area index is distribution. LAI along with the elevation increasing. Characteristics of canopy in ascending order: shrub - coconut forest - mango forest secondary *v.mangachapoi* forest - the original green forest, in the 1.868 to 3.554 range. But on the slopes of the betel nut plantation as special case. Manual control is not representative.

DISCUSSION AND CONCLUSION

Not in the direct method, the indirect method similar to canopy digital imaging technique for determination of LAI has obvious advantages: fast, no damage, no plant needs a large number of artificial. In particular, has a strong practical field detection of tall trees. In addition, this method can implement continuous determination. In the selection of sampling points, determination of the seasonal variations in community LAI significantly different stages. In addition, to consider the optical reasons.

TABLE 1 : LAI and relative indexes of *Vatica hainanensis* forest with various height and communities around

Community	I	II	III	IV	V	VI	VII	VIII	IX
LD	0.68	0.77	0.86	0.81	0.90	0.93	0.94	0.96	0.97
TR	0.22	0.17	0.12	0.27	0.16	0.10	0.10	0.06	0.04
TD	0.31	0.24	0.12	0.22	0.13	0.09	0.08	0.05	0.04
K	0.97	0.84	0.97	0.97	0.97	0.97	0.97	0.97	0.97
LAI	1.664	1.808	2.233	2.081	2.073	2.734	3.177	3.261	3.554

I Areca catechu community; II coastal shrubs; III Mangifera indica community; IV Mangifera indica community; d! Vatica hainanensis secondary forest(height 3m); V Vatica hainanensis secondary forest(height 6m); VI Vatica hainanensis secondary forest(height 9m); VII Vatica hainanensis climax community(tree layer); VII Vatica hainanensis climax community(total)

In the specific operation of instruments, field test image, carefully selected communities and test points. Distribution plots for homogeneous species. Test points above avoid obstacle. On coniferous forest to consider the error determination. The image calculated, correctly setting the threshold is very crucial,range 1% - 100%. Different communities and different measurement time threshold.To just cover all the blade shall prevail. To avoid glare. Light reflection and refraction will cause misunderstanding digital pixel. The calculation result is lower than the actual value. Can be set up to eliminate this effect, or by time selection to avoid errors.

South China Wetland canopy LAI from the gradient, numerical value from 1.664 to3.554. From the shore line, to the low hills in elevation. A continuous linear increase trend of distribution. The single feature of tropical rain forests in *Vatica hainanensis* forest for 3.554 LAI. Presented with Barbour L.W. tropical rain forest LAI values of 11-12[12] difference. Research and Ren results differ with[13]. The main reason is: is a unique type of *Vatica* forest in the forest. According to the field sample records show. *Vatica hainanensis* forest is a forest. The highest *Vatica hainanensis* climax tree for 21m. According to the 1990 Arnold Newman[14] report, tropical rainforest tree height up to 60m. In Sarawak, the highest record of the tree is 84m. In addition, the vertical structure can be divided into 3 layers of green forest. Instead of mixed forest of 5 layer. Leaf blade green forest LAI mainly came from the tree layer, its contribution rate is 92%. V*atica hainanensis* forest surrounding shrubs LAI 1.808. Betel nut forest plantation, a minimum of 1.664 LAI. Artificial forest LAI is far lower than the original rainforest and secondary forest.

ACKNOWLEDGEMENT

This paper is supported by Financial supported by key scientific project from the Department of Education of Hunan province (No: 11A042) and Financial supported by project from the Hunan province college students study and innovation experimental program (2012, GaoHao)

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