Spatial Variation of Forest Structure and Aboveground Biomass in Jaru Reserve, Rondonia, Brazil

Sassan.S. Saatchi[a] R.C. dos Santos Alvala[b],
Yifan Yu[a]

[a]NASA/Jet Propulsion Laboratory
California Institute of Technology
4800 Oak Grove Drive, Pasadena, California 91109
Tel: 818-354-1051
Fax: 818-393-5285
Email: saatchi@congo.jpl.nasa.gov

[b]Instituto Nacional de Pesquisas Espaciais–INPE,
São José dos Campos, SP. – Brazil

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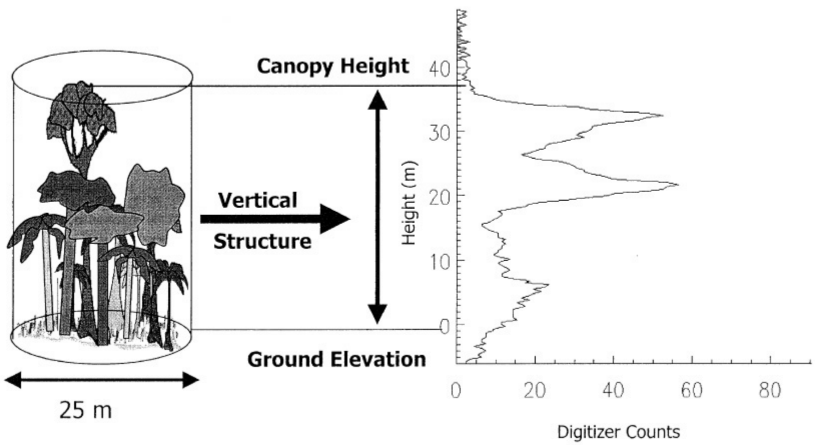
Regional Biomass Estimation

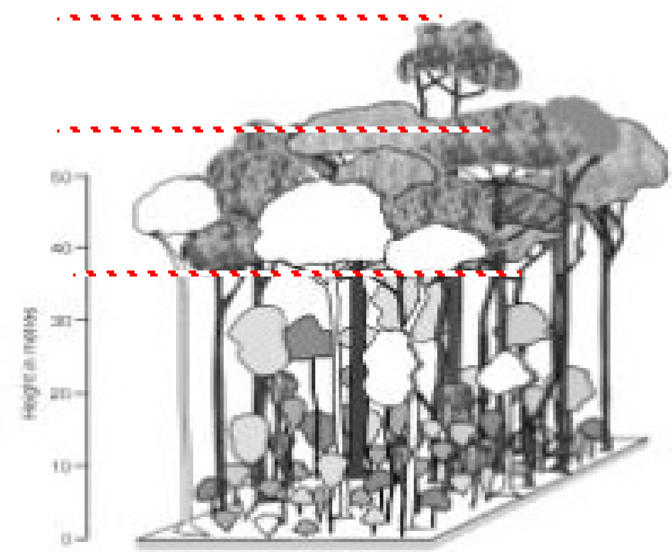
1. Plots are small and not representative of structural variations
2. No mechanism exists to scale up from plots to landscapes to regions
3. Structural variability in forests are not well represented in allometric equations.
4. Plots are not well located in remote sensing images and are not often representative of an image pixel.
5. In the absence of direct remote sensing measurement, statistics of forest structure are well developed.

Vertical Variations in Forest Structure

Vertical: distribution of plants is a central problem of structure and difficult to stratify:

1. **Tree leaves and branches corresponding to emergent trees**
2. **Main canopy**
3. **Subcanopy at lower heights**



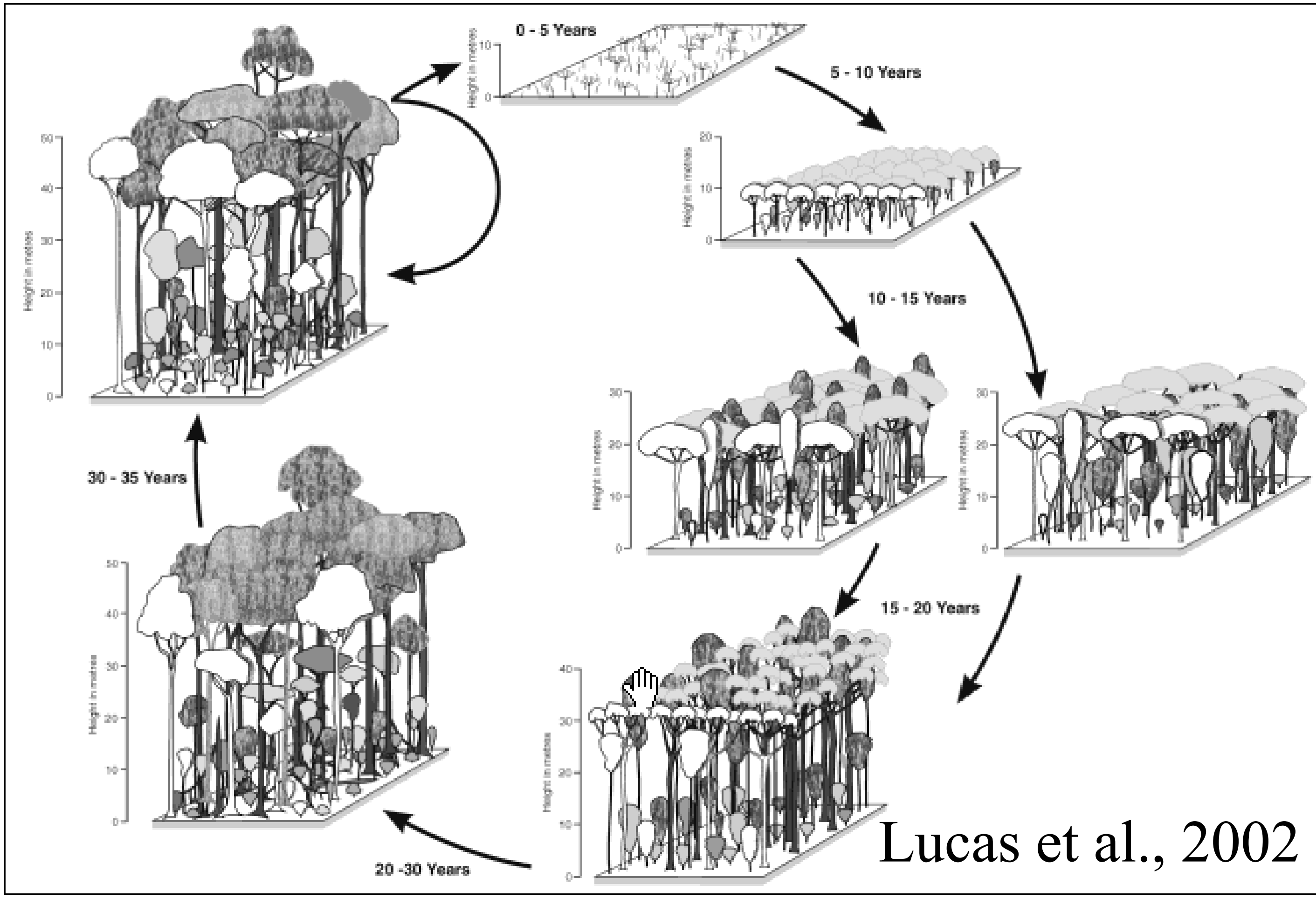


Bioclimatic and biologic factors such as CO_2 rate, humidity, temperature, evaporation, light waves, and brightness, inter-and intra-specific competition impact the vertical structure especially the leaf mass and profile.

Maximum height is obtained over well-drained, fertile soils with high rainfall. Very wet, infertile, or mountainous sites have low stature forests.

Qualitative and Quantitative data exists over limited sites.

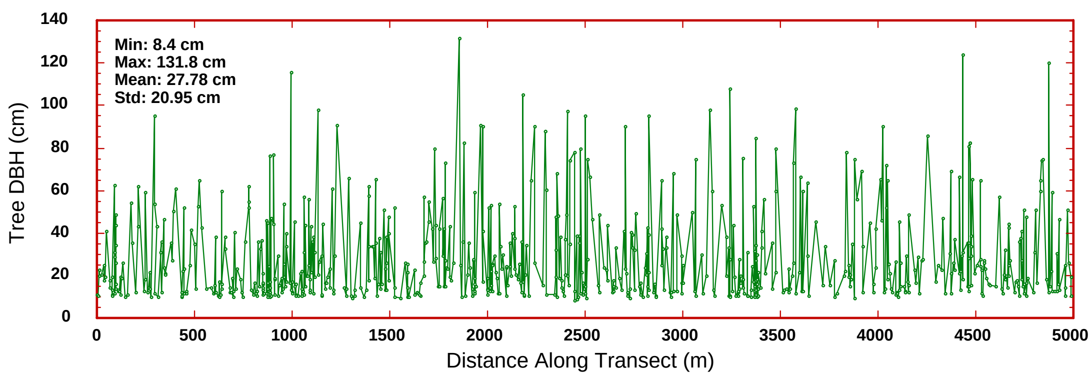
Stratification avoids dynamic nature of the canopy due to local factors and disturbance regimes

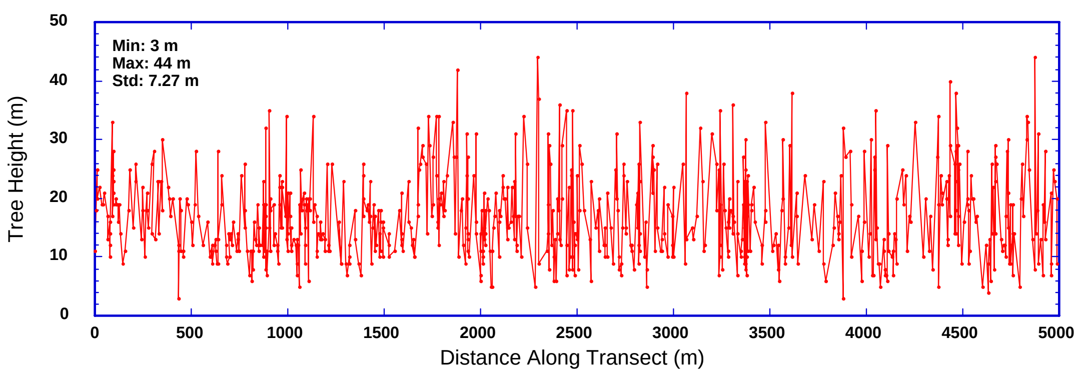



10-22-2002

11-01-2002

Horizontal Variations in Forest Structure

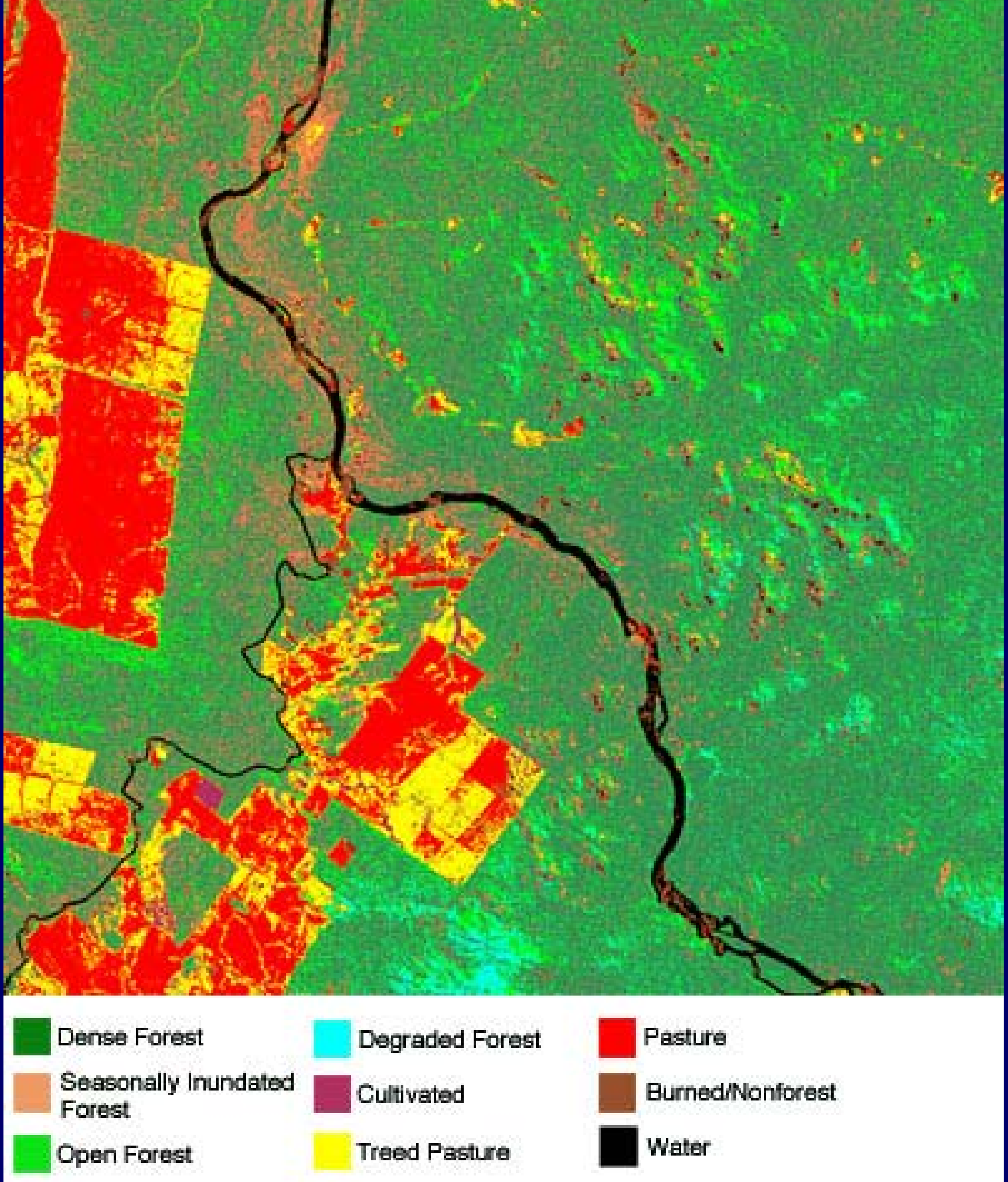




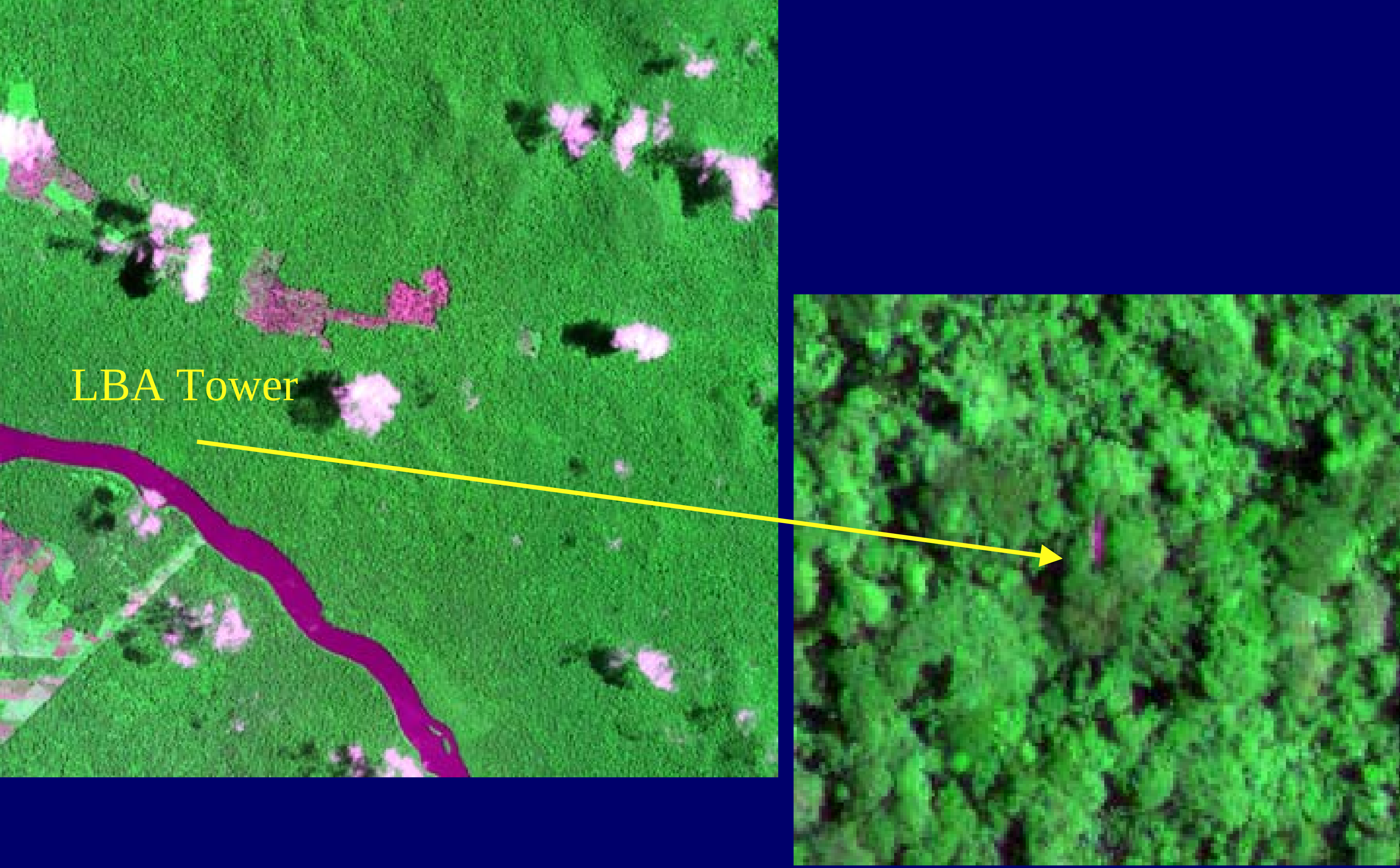
Environmental variables such as climate, soil, topography, surface moisture, flooding frequency, and local conditions such as frequency of fog or wind direction may impact diversity and structure of forests.

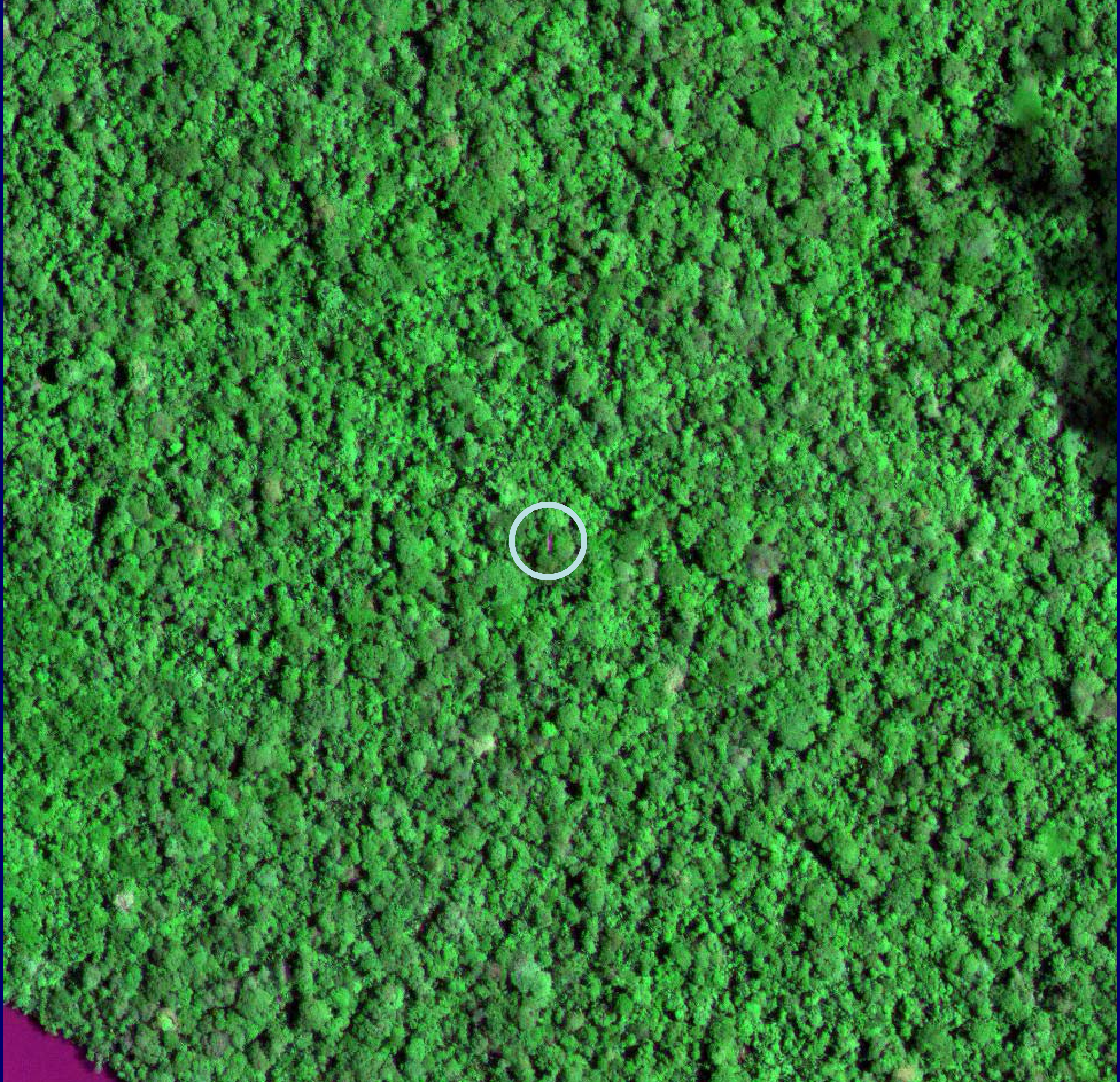
Stratification based on type does not include variations within a type.

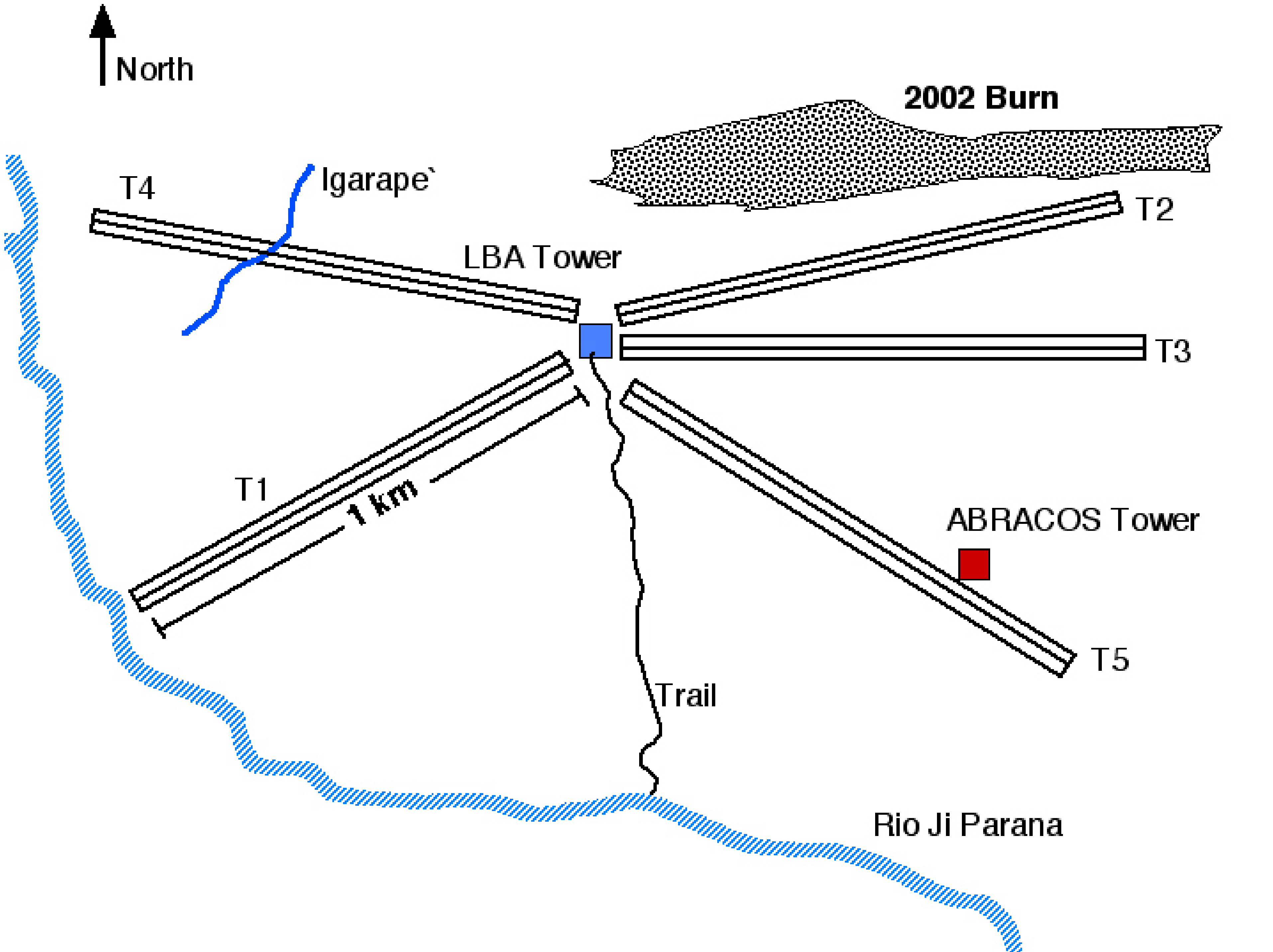
Forest structure depends on geographical and ecological units… Within each unit species and structure occur various scales of probabilistic nature

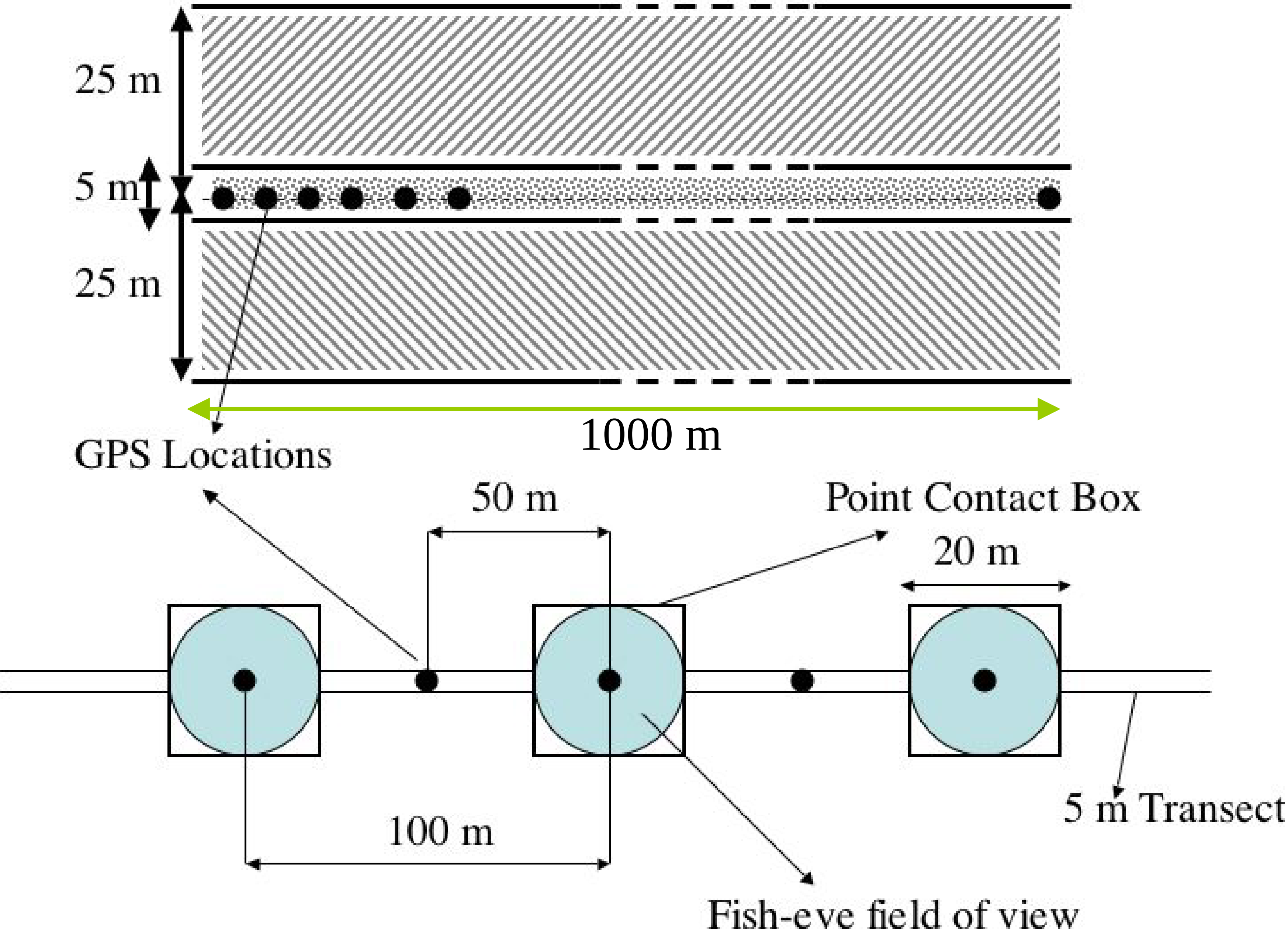


Classification of ASTER Image Acquired on 5-4-2002


LBA Tower

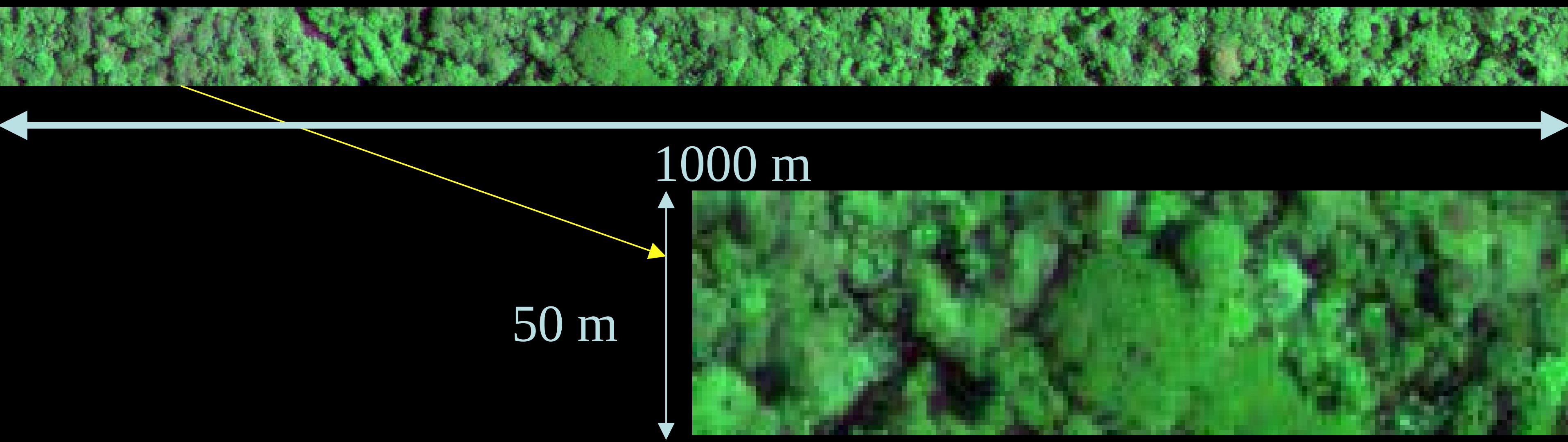



North
2002 Burn
Igarape`
T4
T2
LBA Tower
T3
T1
1 km
ABRACOS Tower
T5
Trail
Rio Ji Parana



5 m Transect: Trees DBH > 5 cm

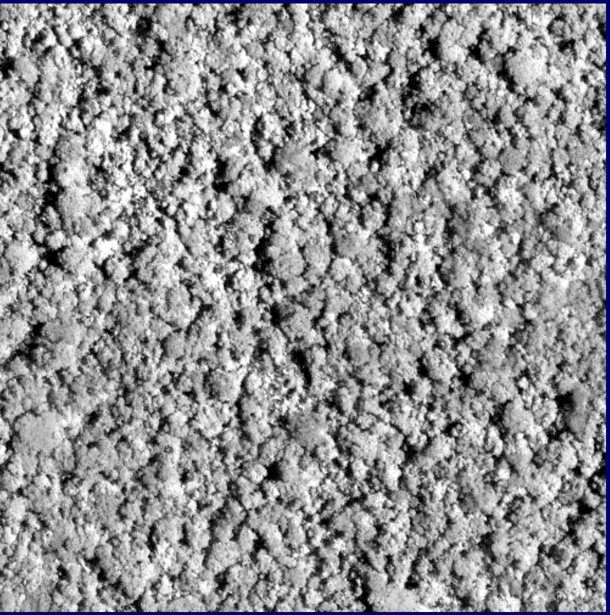
50 m Transect: Trees DBH > 35 cm

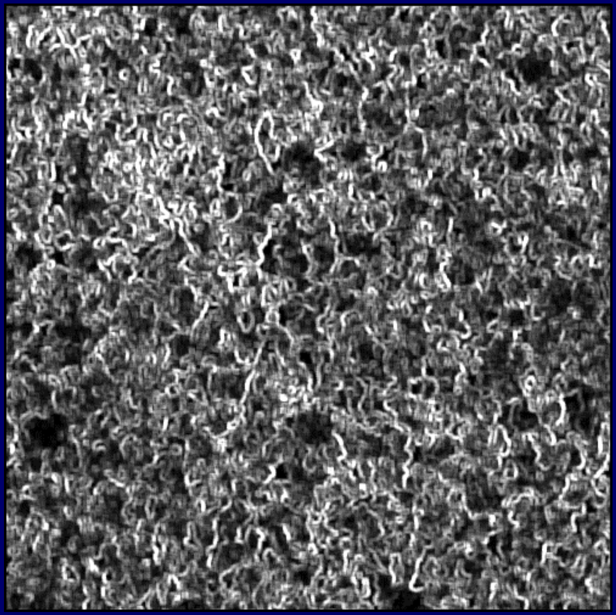


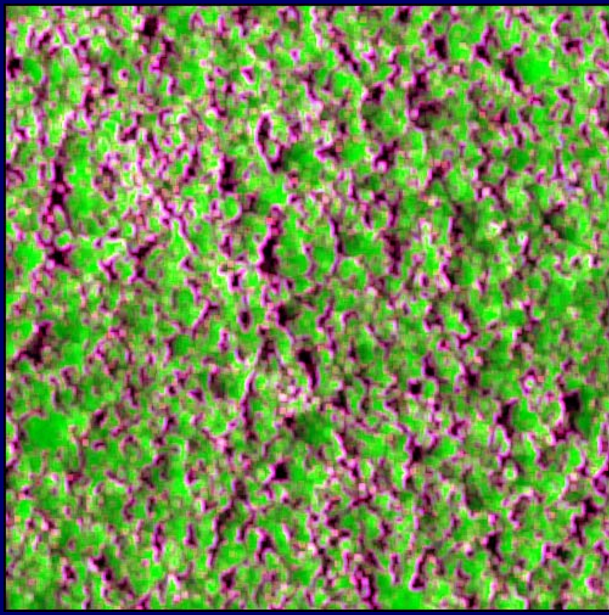
Stereo Digital Photography of Forest Canopy

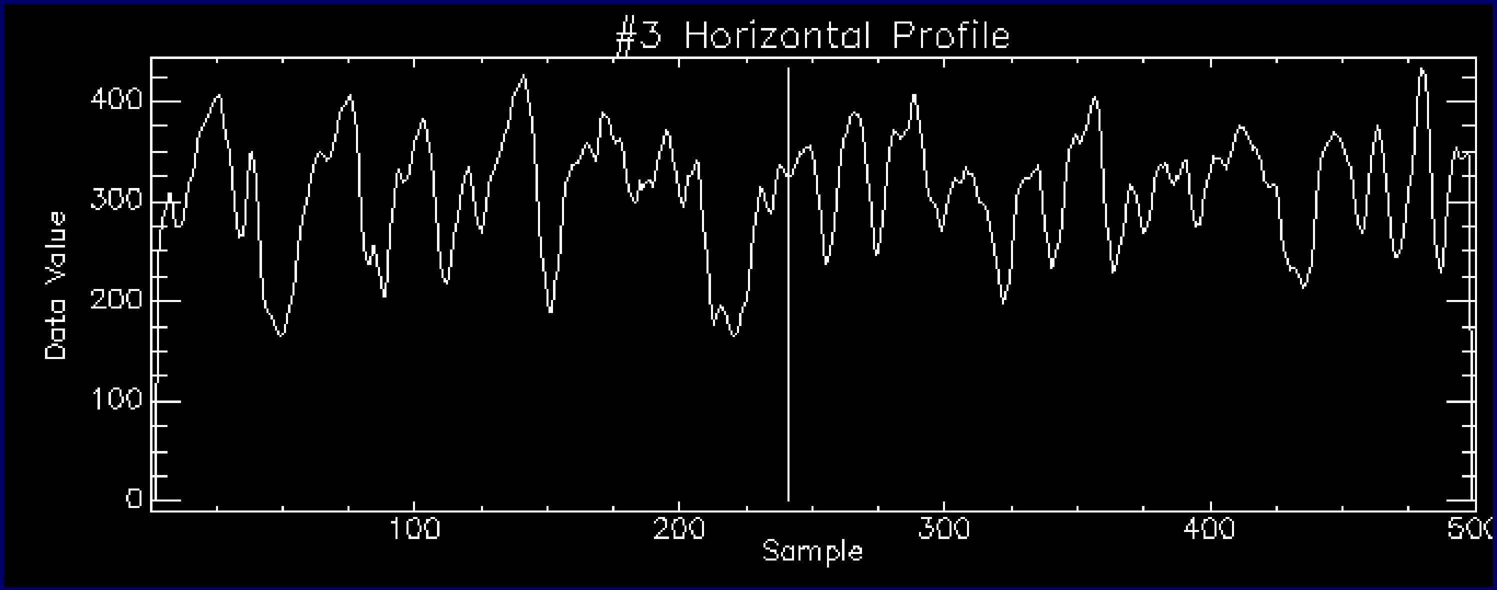
1. Measurements are done with a Nikon COOLPIX 950 at a height of 1.3 m from ground on a tripod.
2. Stereo pictures are taken by moving the camera on a 1 cm interval and find the best correlations.

Structure and Biomass/Carbon







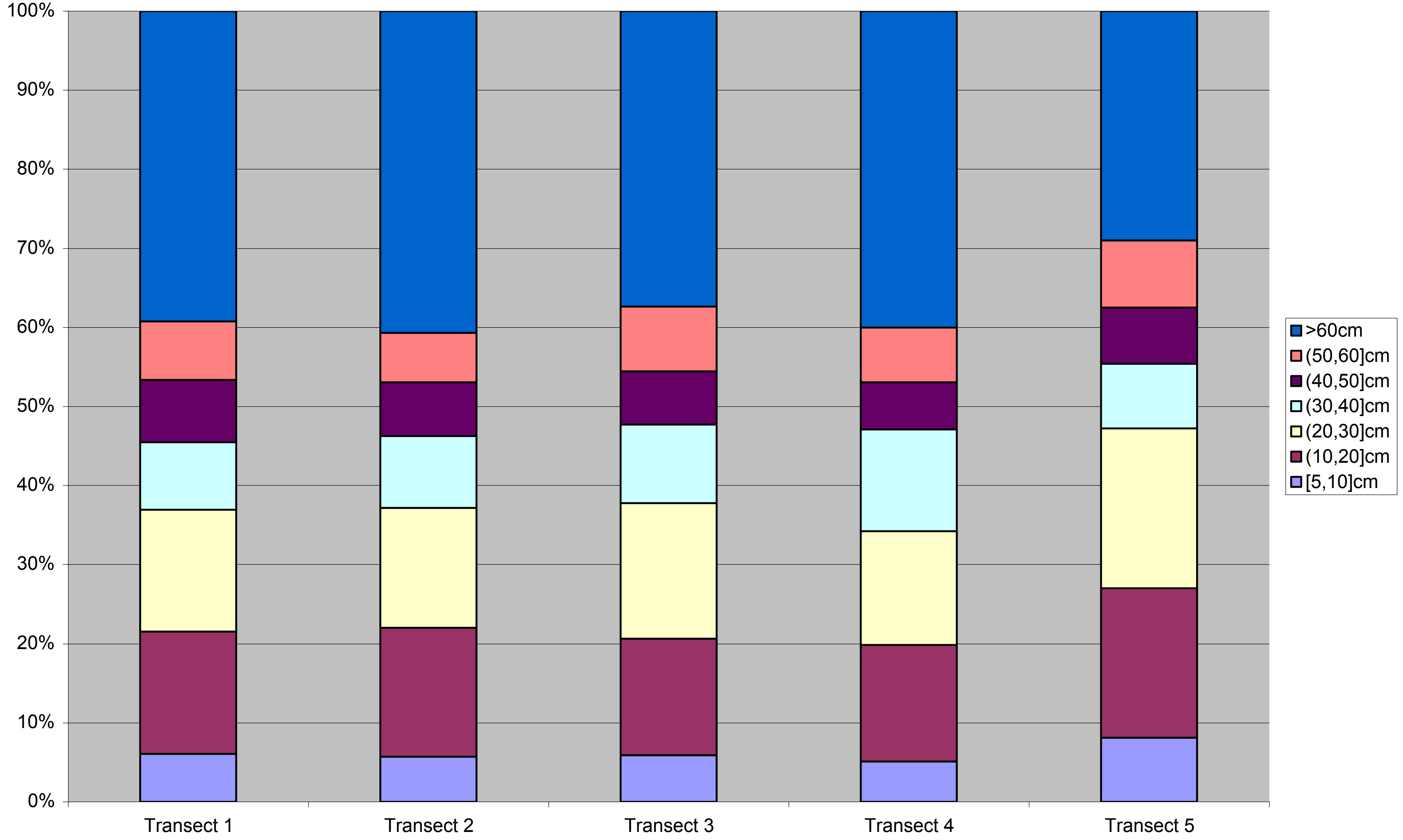


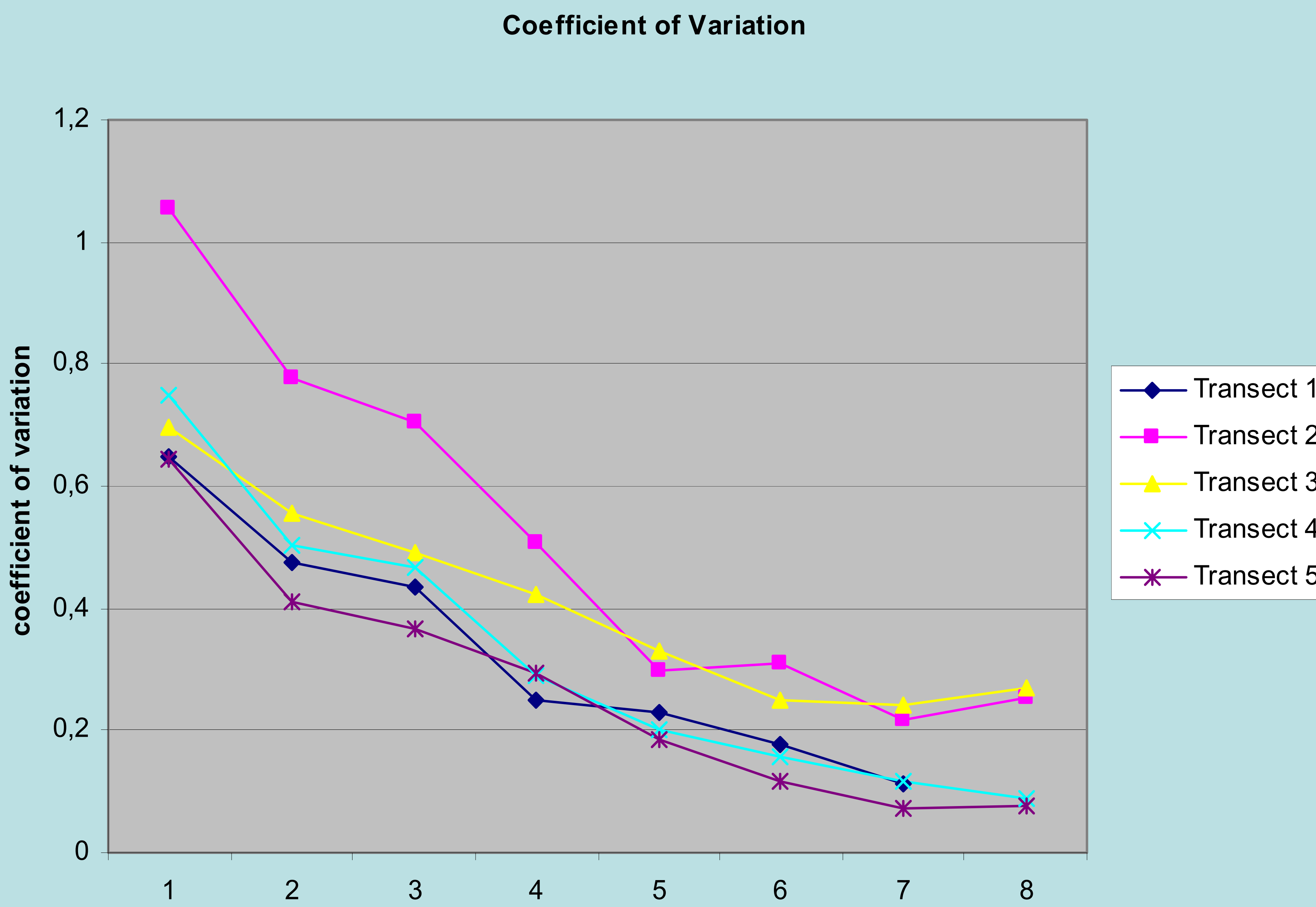
Tree Density and Species Distribution

5 m Inner Transect					
Transect	# Trees	# Species	Sp1(#)	Sp2(#)	Sp3(#)
T1	437	90	Canela(29)	Jito(28)	Canel‹o(26)
T2	473	99	Sedagor(43)	Breu(32)	Canel‹o(31)
T3	470	75	Sedagor (33)	Baba¨u(32)	Breu(31)
T4	523	79	Sedagor(43)	Espeteiro(36)	Breu(33)
T5	637	86	Arapoca(64)	Sedagor(43)	Guapeba(32)

45 m Outer Transect					
Transect	# Trees	# Species	Sp1(#)	Sp2(#)	Sp3(#)
T1	119	56	Gapeba (11)	Breu(10)	Sedagor(9)
T2	223	77	Breu(28)	Tamarino(12)	Roxinho(12)
T3	216	69	Roxinho(17)	Tamarino(10)	Sedagor(10)
T4	212	64	Mata mata (18)	Roxinho(15)	Breu(14)
T5	204	65	Breu(19)	Mata mata (12)	Tamarino(12)

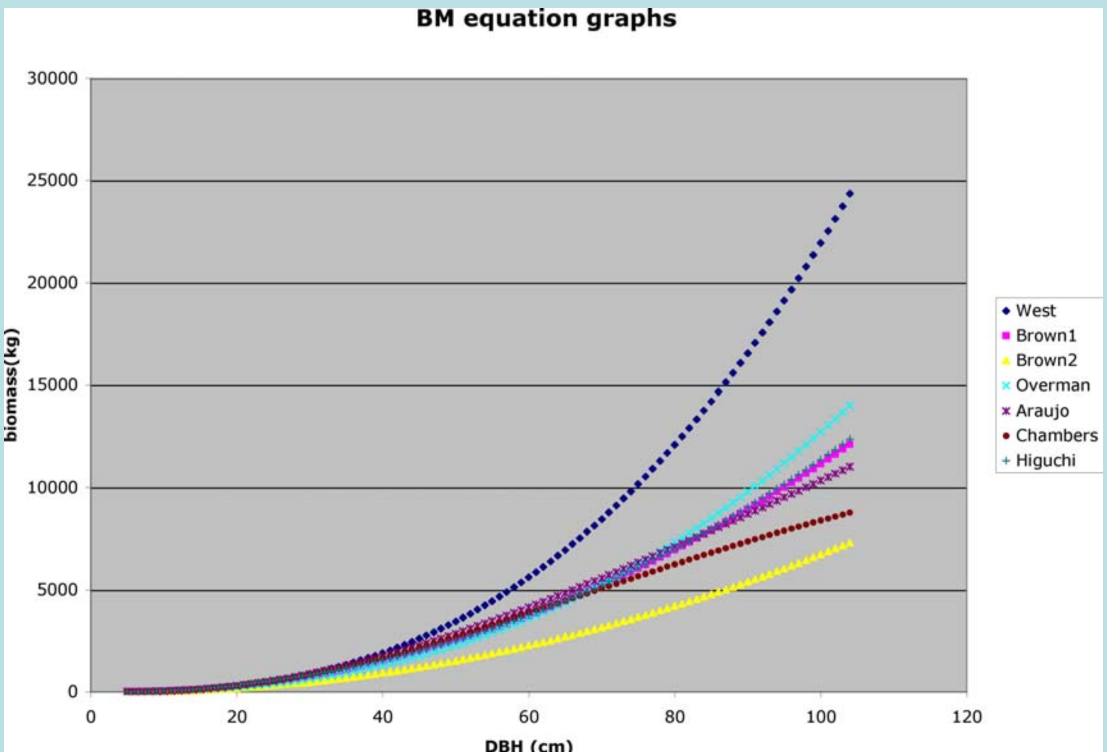
Contribution of Tree Size to Basal Area



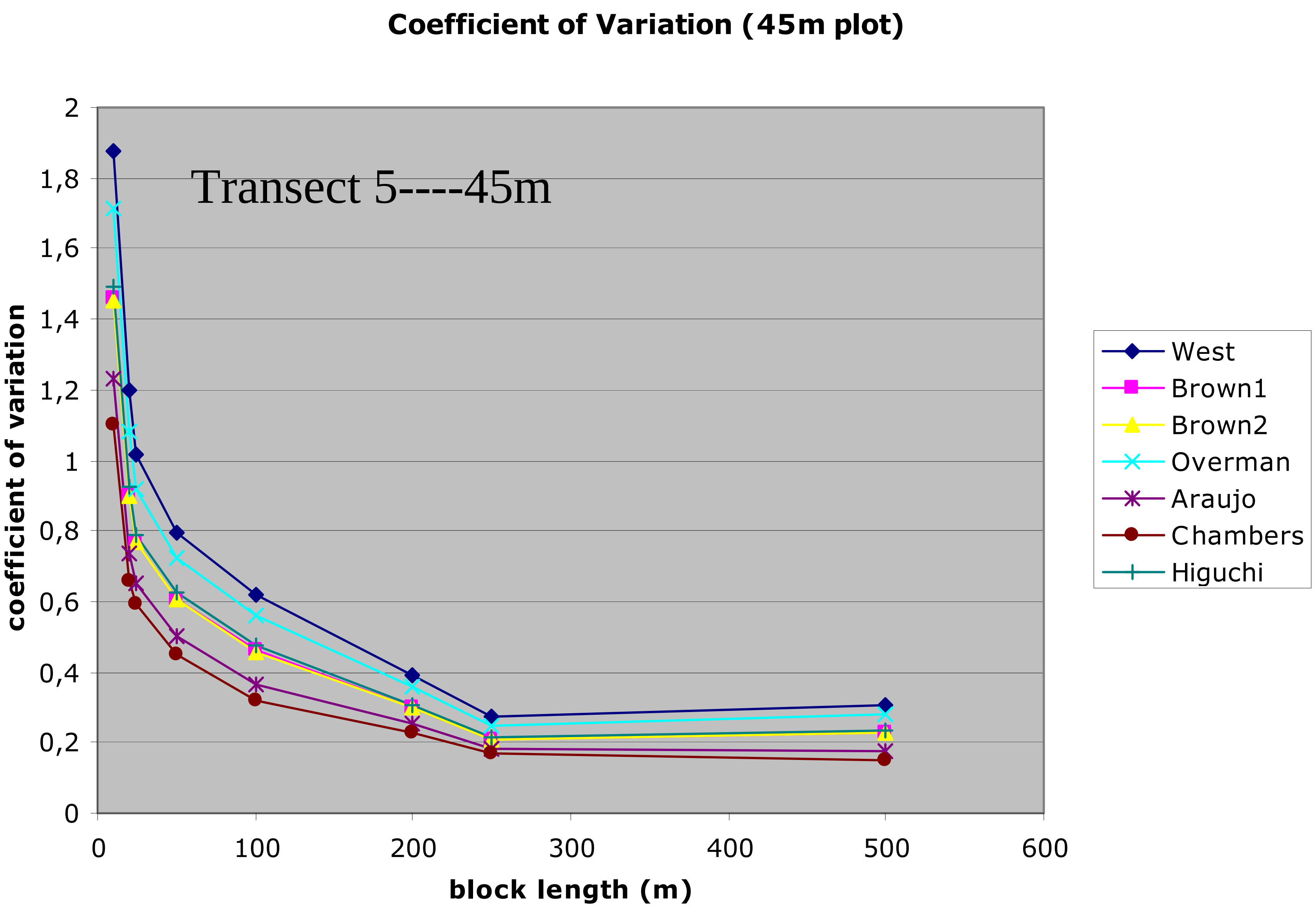


Coefficient of Variation
coefficient of variation
1,2
1
0,8
0,6
0,4
0,2
0
1
2
3
4
5
6
7
8
Transect 1
Transect 2
Transect 3
Transect 4
Transect 5

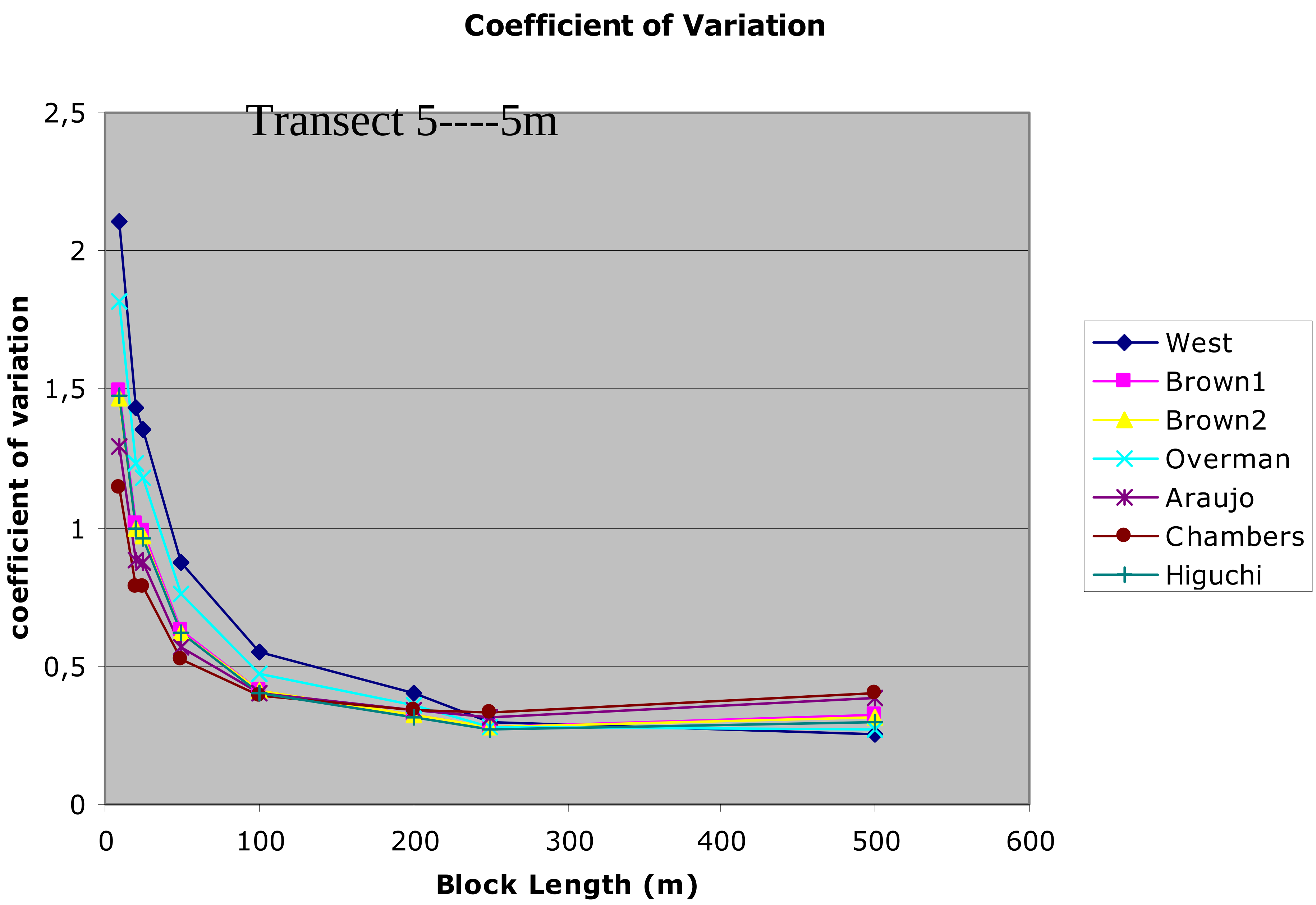
Parameter	Equation	Source
Trees 5-20 cm DBH	$\exp[0.604 \times (-1.754 + 2.665 \times \ln(D))]$	
Trees >20 cm DBH	$\exp[0.604 \times (-1.151 + 2.17 \times \ln(D))]$	
	$\exp[(\alpha + \beta_1 \ln(D) + \beta_2 \ln^2(D) + \beta_3 \ln^3(D)]$ $\alpha = -0.370,\ \ \beta_1 = 0.333,\ \ \beta_2 = 0.933,\ \ \beta_3 = -0.122$	
	$\exp[-6.03 + 5.03 \times \ln(D) - 0.372 \ln^2(D)]$	
	$\exp[-1.97 + 1.24 \times \ln(D^2)]$	
	$42.7 - 12.8 \times D + 1.24 \times D^2$	
	$21.3 - 6.95 \times D + 0.74 \times D^2$	
	$\exp[-2.30 + 2.67 \times \ln(D)]$	

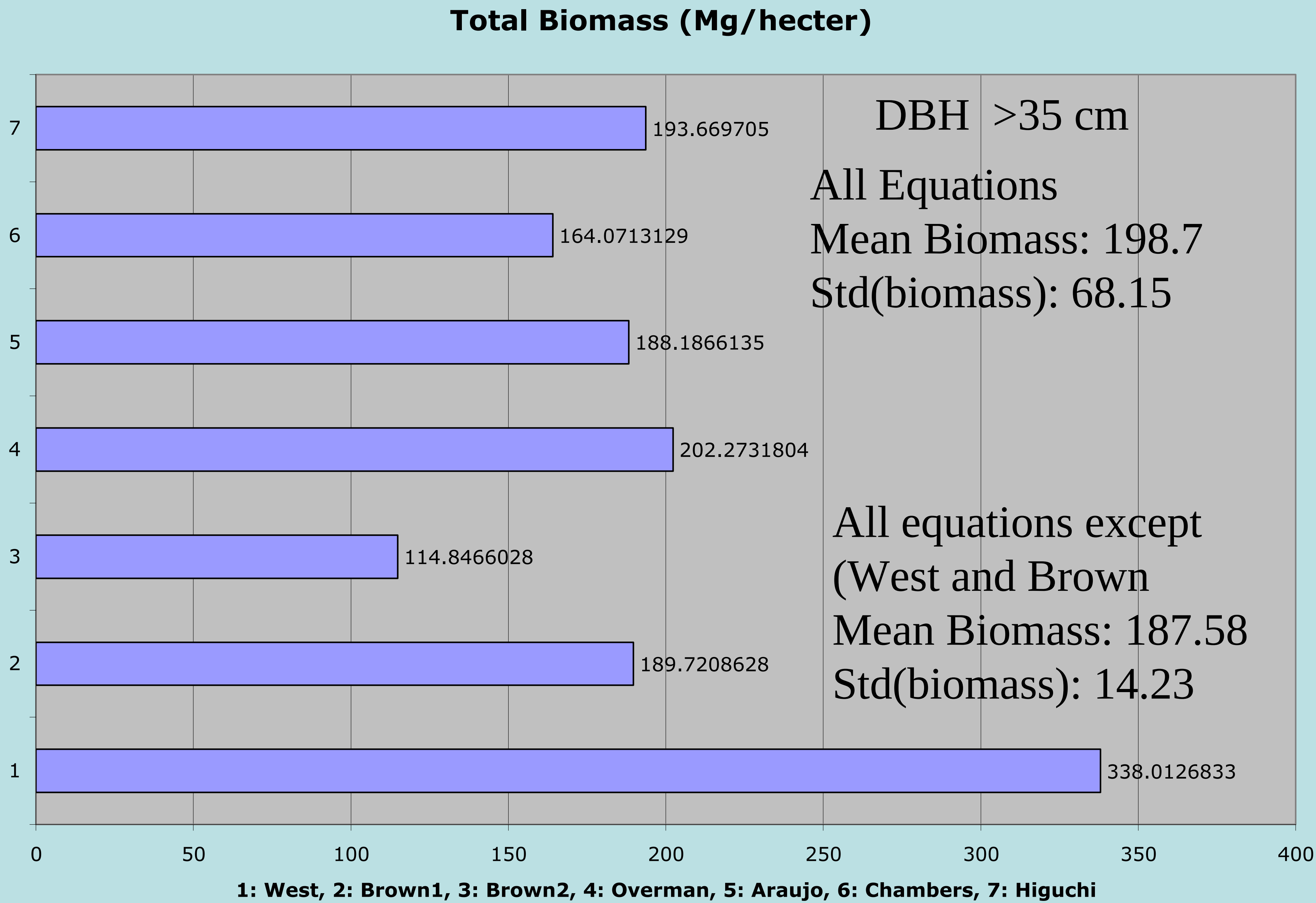


Role of Allometric Equations on Biomass Estimation

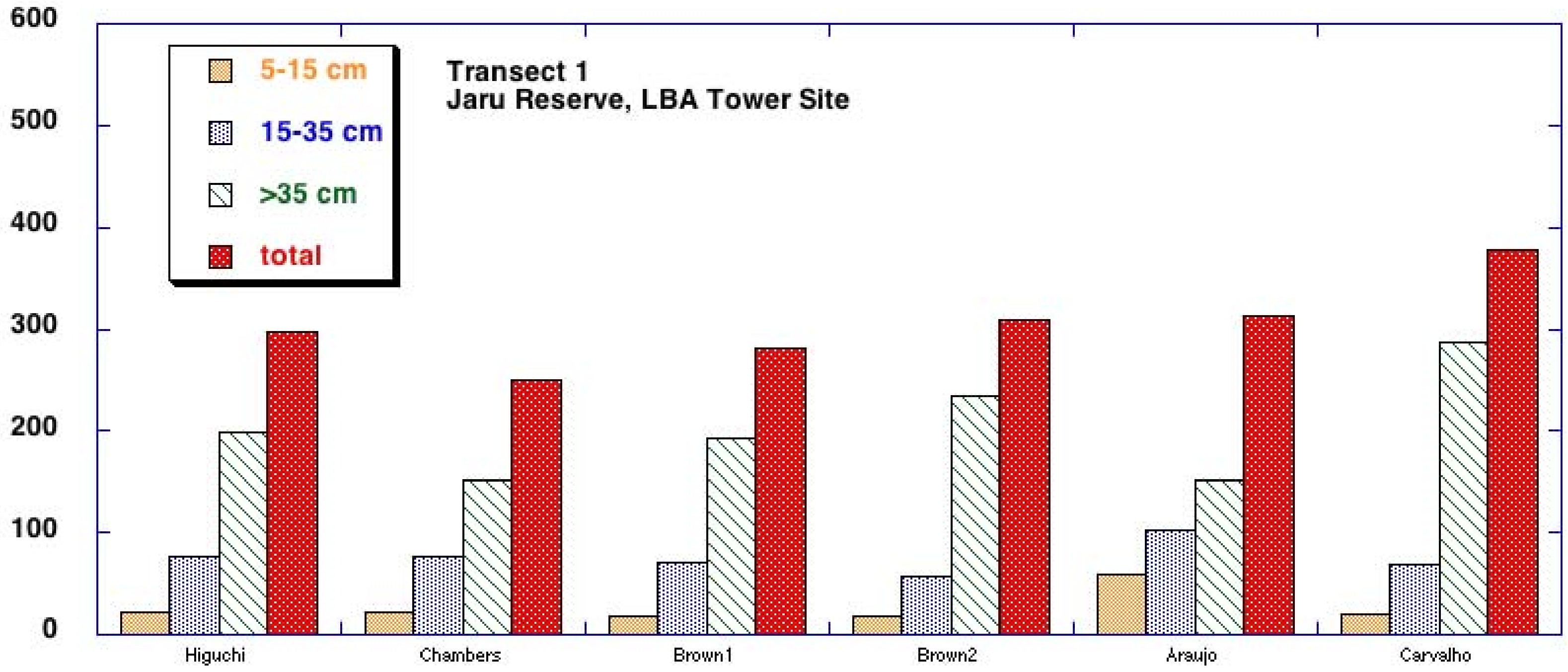


Role of Allometric Equations on Biomass Estimation

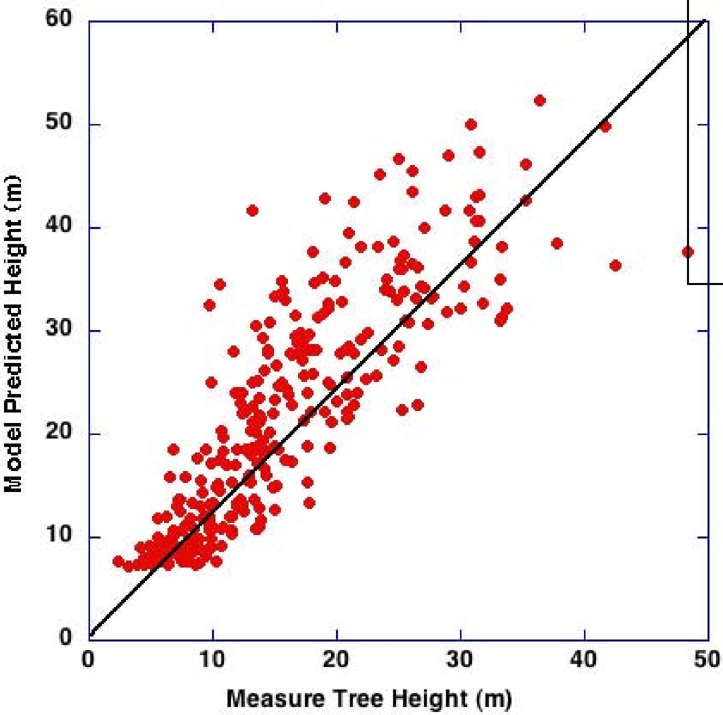




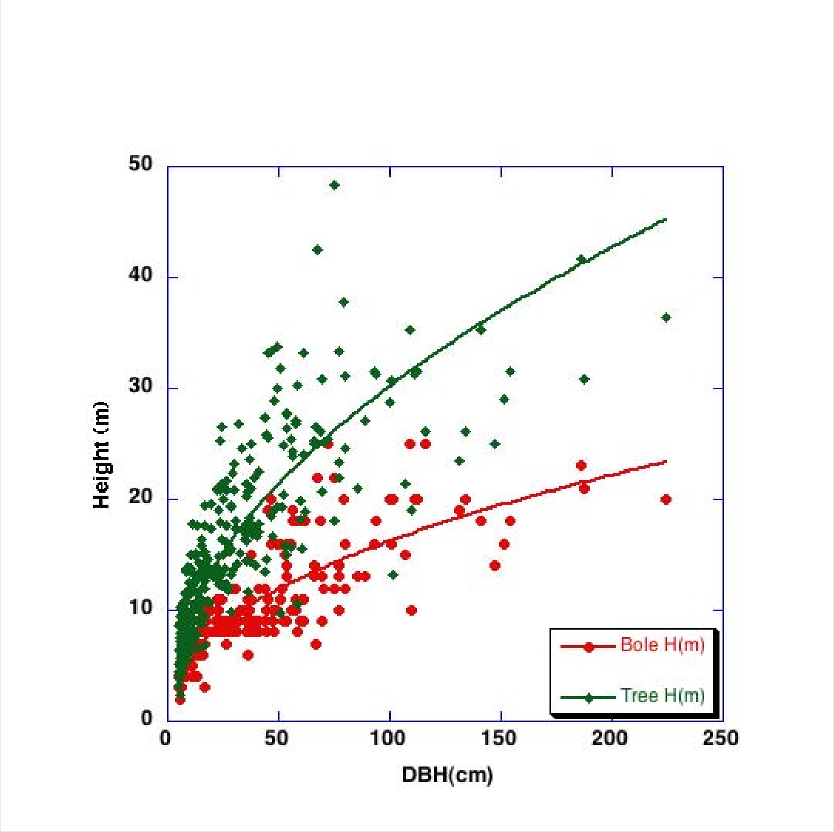
Total Biomass (Mg/hecter)
DBH >35 cm
All Equations
Mean Biomass: 198.7
Std(biomass): 68.15
All equations except
(West and Brown
Mean Biomass: 187.58
Std(biomass): 14.23
7
6
5
4
3
2
1
193.669705
164.0713129
188.1866135
202.2731804
114.8466028
189.7208628
338.0126833
0
50
100
150
200
250
300
350
400
1: West, 2: Brown1, 3: Brown2, 4: Overman, 5: Araujo, 6: Chambers, 7: Higuchi



600
500
400
300
200
100
0
5-15 cm
15-35 cm
>35 cm
total
Transect 1
Jaru Reserve, LBA Tower Site
Higuchi
Chambers
Brown1
Brown2
Araujo
Carvalho


Model Predicted Height (m)
Measure Tree Height (m)
0
10
20
30
40
50
60

Parameter	Equation	Source
Trees < 20 cm DBH	$1.0438 \times \exp[0.6387 + 0.7988 \times \ln(D)], R^2 = 0.85, N = 40$	
Trees > 20 cm DBH	$0.9999 \times [-19.5873 + 13.2823 \times \ln(D)], R^2 = 0.64, N = 89$	
	$\exp[0.2453 + 1.0888 \times \ln(D) + -0.092 \times \ln^2(D)], R^2 = 0.7$	
	$\exp[0.4425 + 0.6376 \times \ln(D) + -0.029 \times \ln^2(D)], R^2 = 0.7$	
	$\exp[0.606 + 0.7183 \times \ln(D)], R^2 = 0.73, N = 150$	
	$\exp[1.607 + 0.3697 \times \ln(D)], R^2 = 0.62, N = 147$	



Height Variations

	5m Transect		45 m Transect	
Transect	<H>	Std(H)	<H>	Std(H)
T1	15.18	3.51	33.83	3.85
T2	14.92	3.35	33.80	3.42
T3	15.35	3.60	34.25	4.03
T4	16.73	4.58	34.16	3.53
T5	15.86	4.08	33.38	3.08

$$h_p = f_1 \times < h >_{45} + (1 - f_1) \times < h >_5$$

f_1 : fraction of cover derived from fisheye photos

$< h >_{45}$: average height of 45 m transect

$< h >_5$: average height of 5 m transect

Transect	<H> m	Std(H) m
T1	29.4	4.6
T2	28.0	5.2
T3	30.1	3.8
T4	27.1	5.9
T5	29.8	4.8

Summary

1. Forest structure variability converges in larger than 1 hectare, 100-250 m pixel resolution.
2. Canopy gap and forest height variations can be captured converges at smaller scales and can be measured by existing high resolution RS systems.
3. Variability in forest structure and allometric equation introduce 10-25% error in biomass estimation from ground measurements.