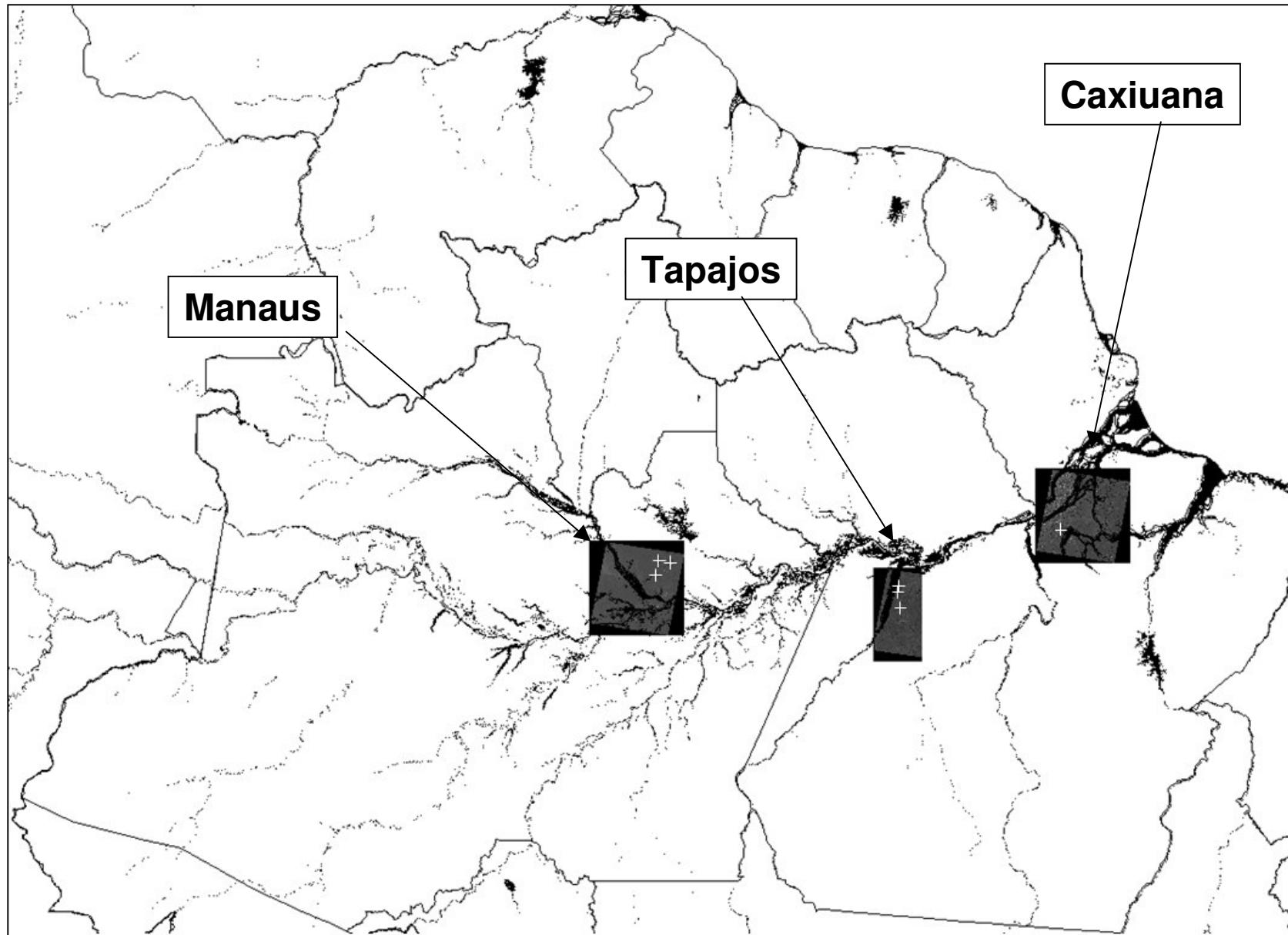


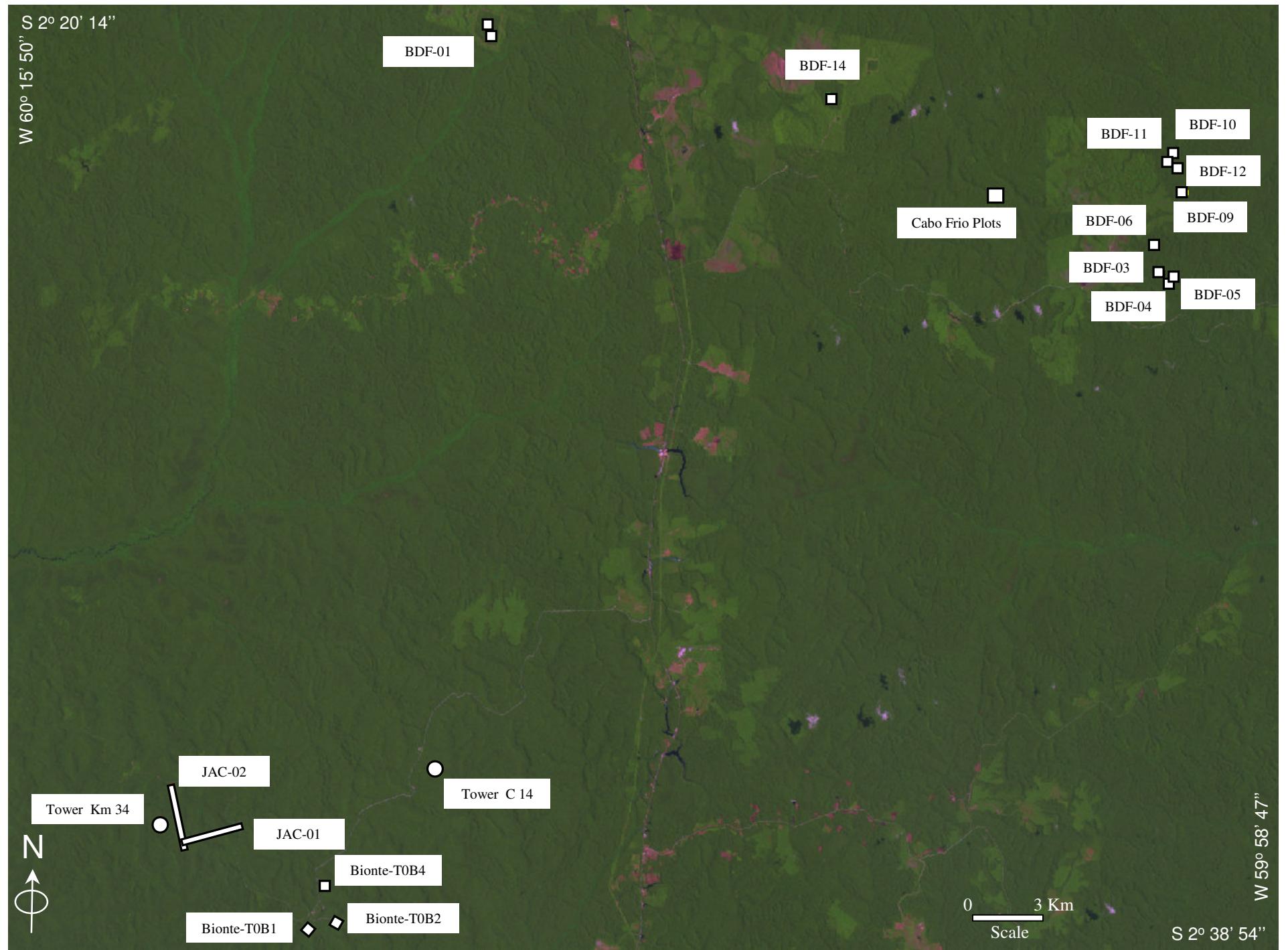
# **Carbon allocation and cycling in tropical forests at Manaus, Tapajos and Caxiuana**

**Yadvinder Malhi, Luiz Aragao, Carlos Quesada, Sandra Patino, Liana Anderson, Daniel Metcalfe**

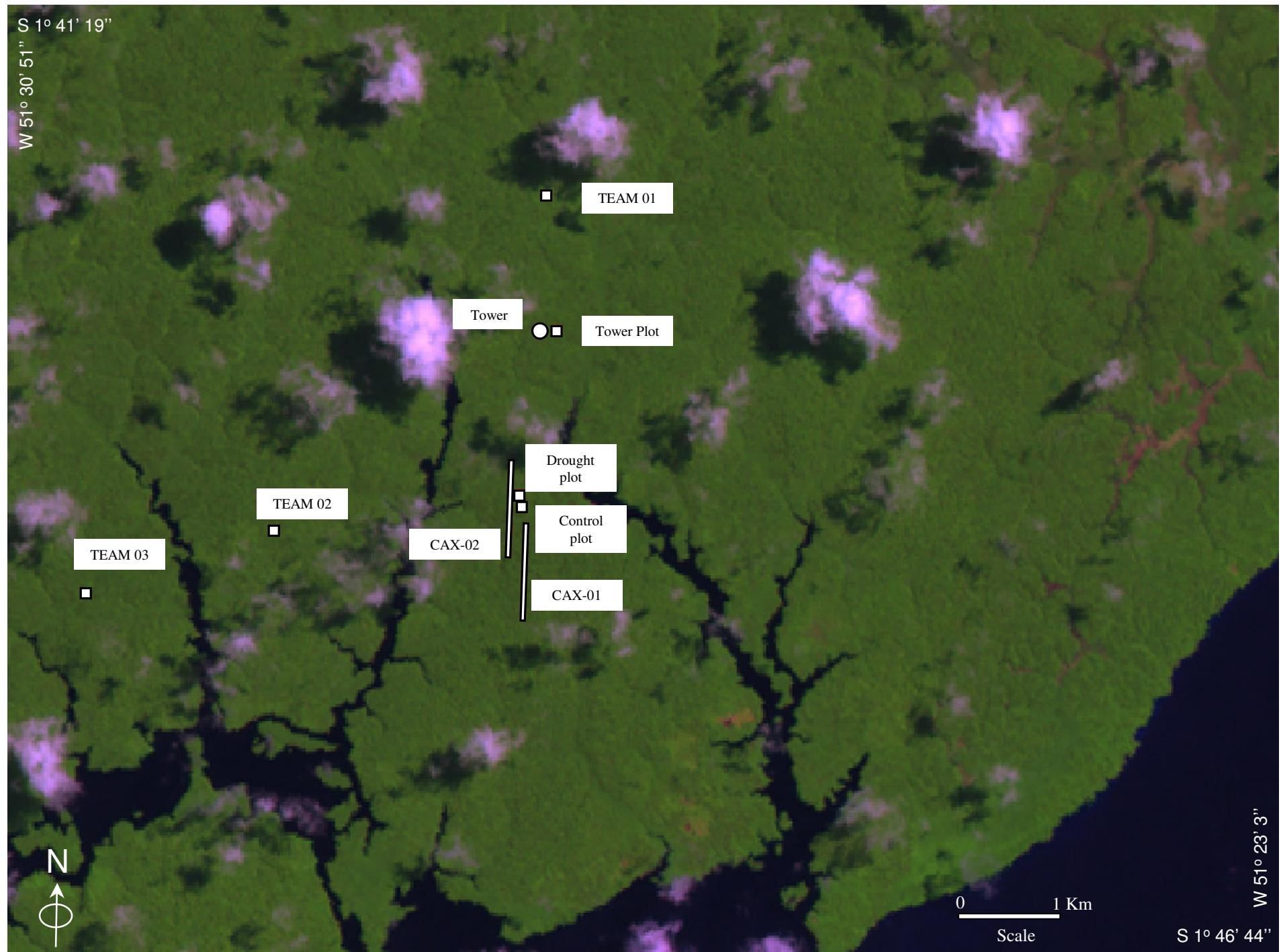
# Aims

- Quantify the magnitude and uncertainty of the components of production and metabolism
- Interpret differences between sites in terms of forest disturbance and soil fertility
- Validate component measurements against gas exchange from soil respiration chambers and gas towers







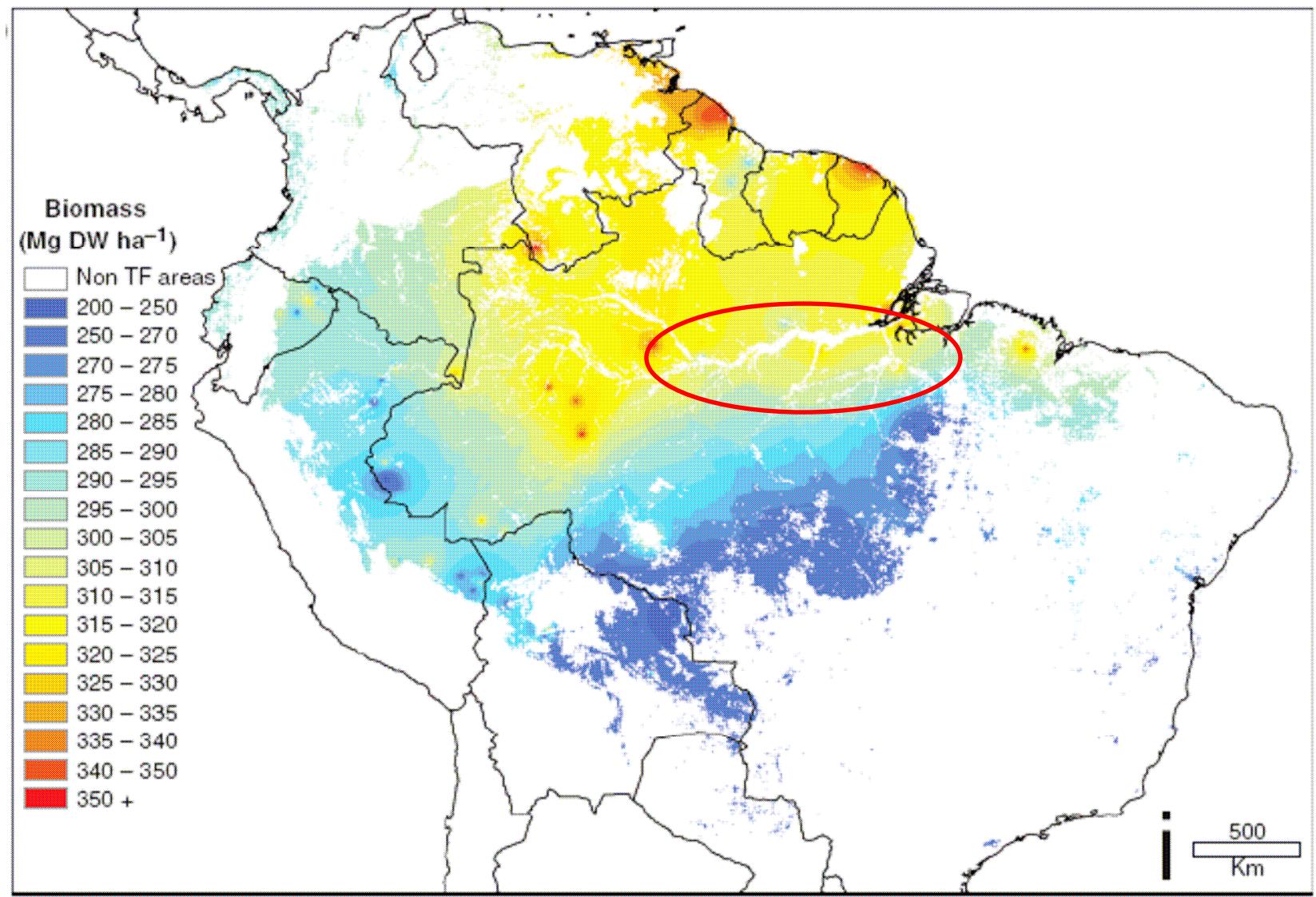


# Above-ground wood productivity



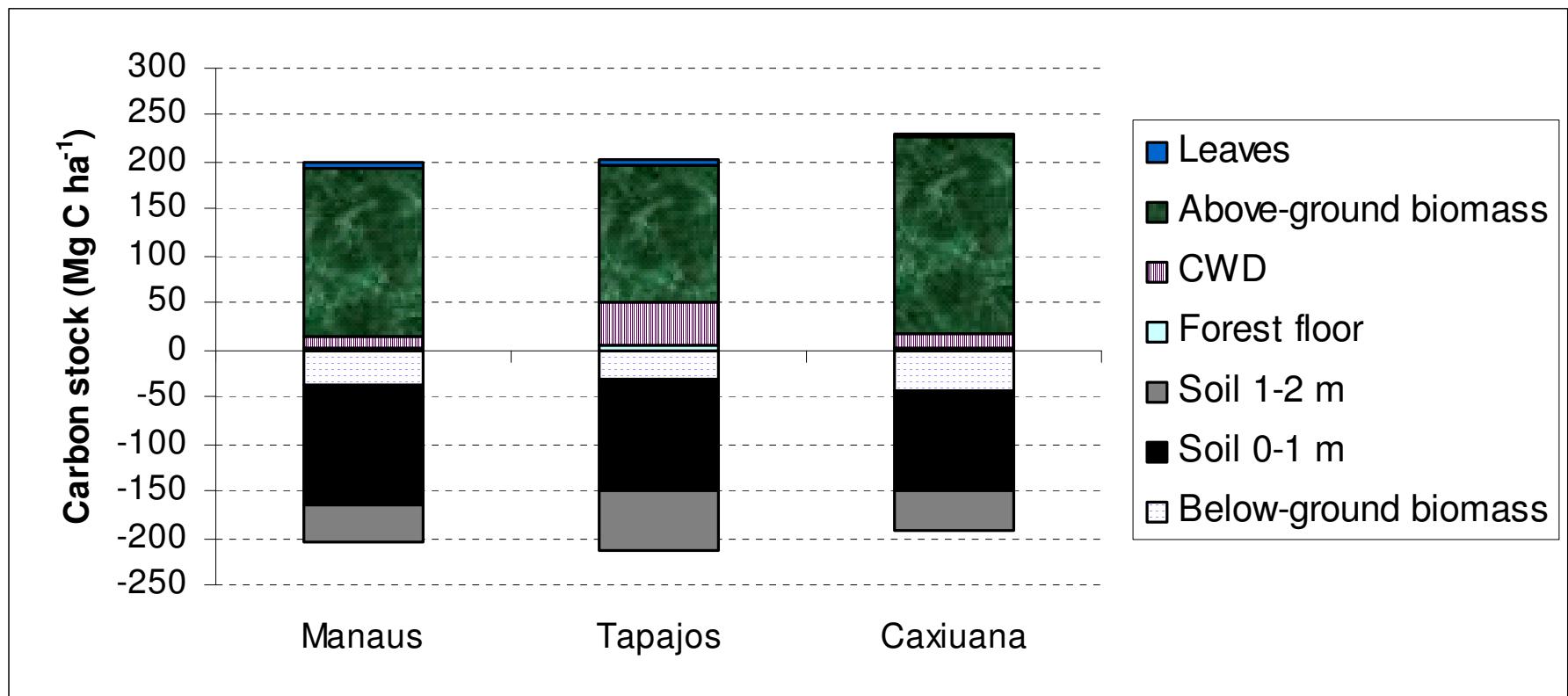
Malhi *et al* (2004), The above-ground coarse wood productivity of 104 Neotropical forest plots, *Global Change Biology*

# Above-ground biomass



Malhi *et al* 2006, Regional variations in the above ground biomass of Amazonian forests *Global Change Biology*

# Above-and below-ground carbon stores



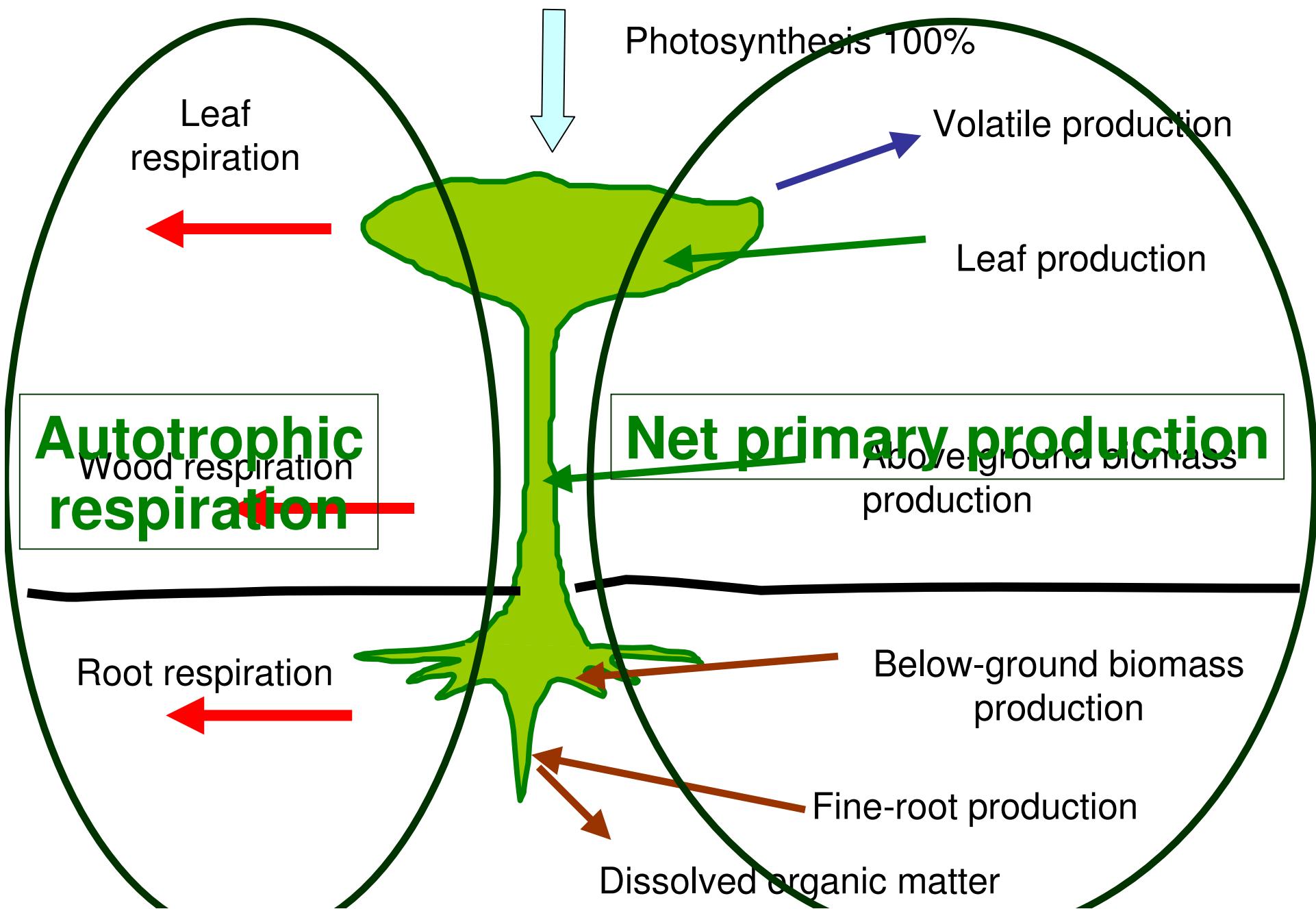
# Leaf nutrient status

	Site	Manaus	Tapajos	Caxiuana
	n	19	33	19
LMA	g m <sup>-2</sup>	103+6	96+5	90+7
N	mg g <sup>-1</sup>	23.1+1.3	22.9+1.3	19.8+1.2
C	%	50.0+0.6	48.0+0.7	48.0+0.7
Al	mg g <sup>-1</sup>	0.32+0.15	2.75+1.08	0.21+0.03
Ca	mg g <sup>-1</sup>	3.06+0.46	7.93+0.74	3.87+0.59
K	mg g <sup>-1</sup>	4.03+0.45	3.58+0.35	1.95+0.23
Mg	mg g <sup>-1</sup>	2.12+0.24	2.56+0.23	2.24+0.28
P	mg g <sup>-1</sup>	0.64+0.04	0.75+0.04	0.60+0.04

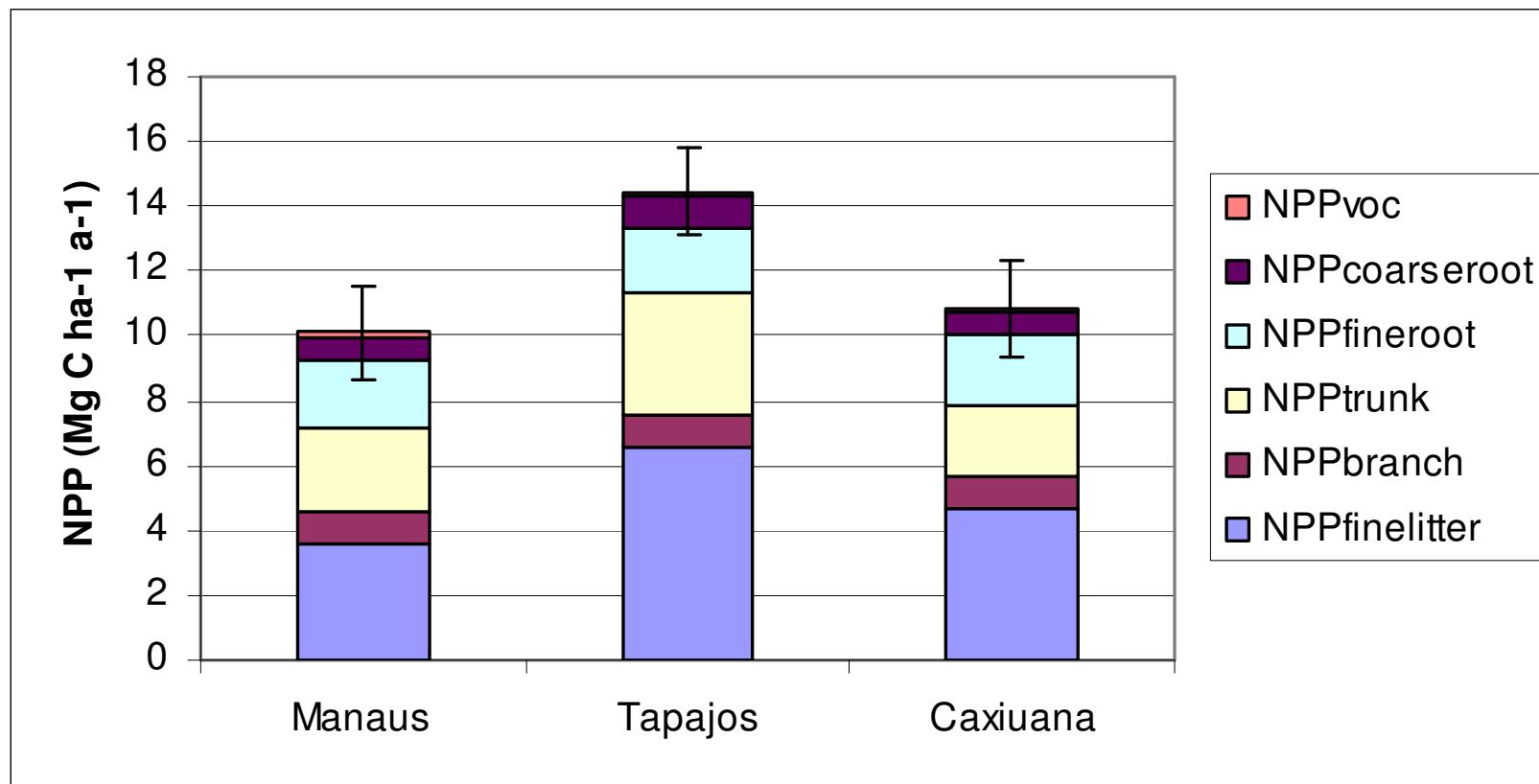
# Soil properties

Site and Subsite	Units	Manaus Jacaranda Valley	Plateau	Tapajos km 67 tower	Caxiuana tower plot
pH		4.73	3.94	3.84	3.79
Resin P	mg kg <sup>-1</sup>	0.97	1.84	7.63	2.34
Readily available P	mg kg <sup>-1</sup>	9.21	12.92	20.08	12.31
N (%)	%	0.08	0.15	0.17	0.13
C (%)	%	1.34	2.59	2.54	1.68
C/N ratio		16.06	16.79	15.16	13.09
Ca	cmol kg <sup>-1</sup>	0.025	0.111	0.303	0.129
Mg	cmol kg <sup>-1</sup>	0.055	0.101	0.225	0.147
K	cmol kg <sup>-1</sup>	0.041	0.095	0.073	0.048
Na	cmol kg <sup>-1</sup>	0.013	0.063	0.040	0.083
Al	cmol kg <sup>-1</sup>	0.18	1.82	2.33	1.88
Sum of bases	cmol kg <sup>-1</sup>	0.13	0.37	0.64	0.41
Exchangeable CEC	cmol kg <sup>-1</sup>	0.31	2.19	2.97	2.28
Al saturation	cmol kg <sup>-1</sup>	57.27	83.16	78.45	82.20
V	%	42.73	16.84	21.55	17.80
Sand fraction	%	71.82	20.97	2.86	32.54
Clay fraction	%	1.38	66.21	89.25	53.76
Silt fraction	%	1.80	12.81	7.89	13.70

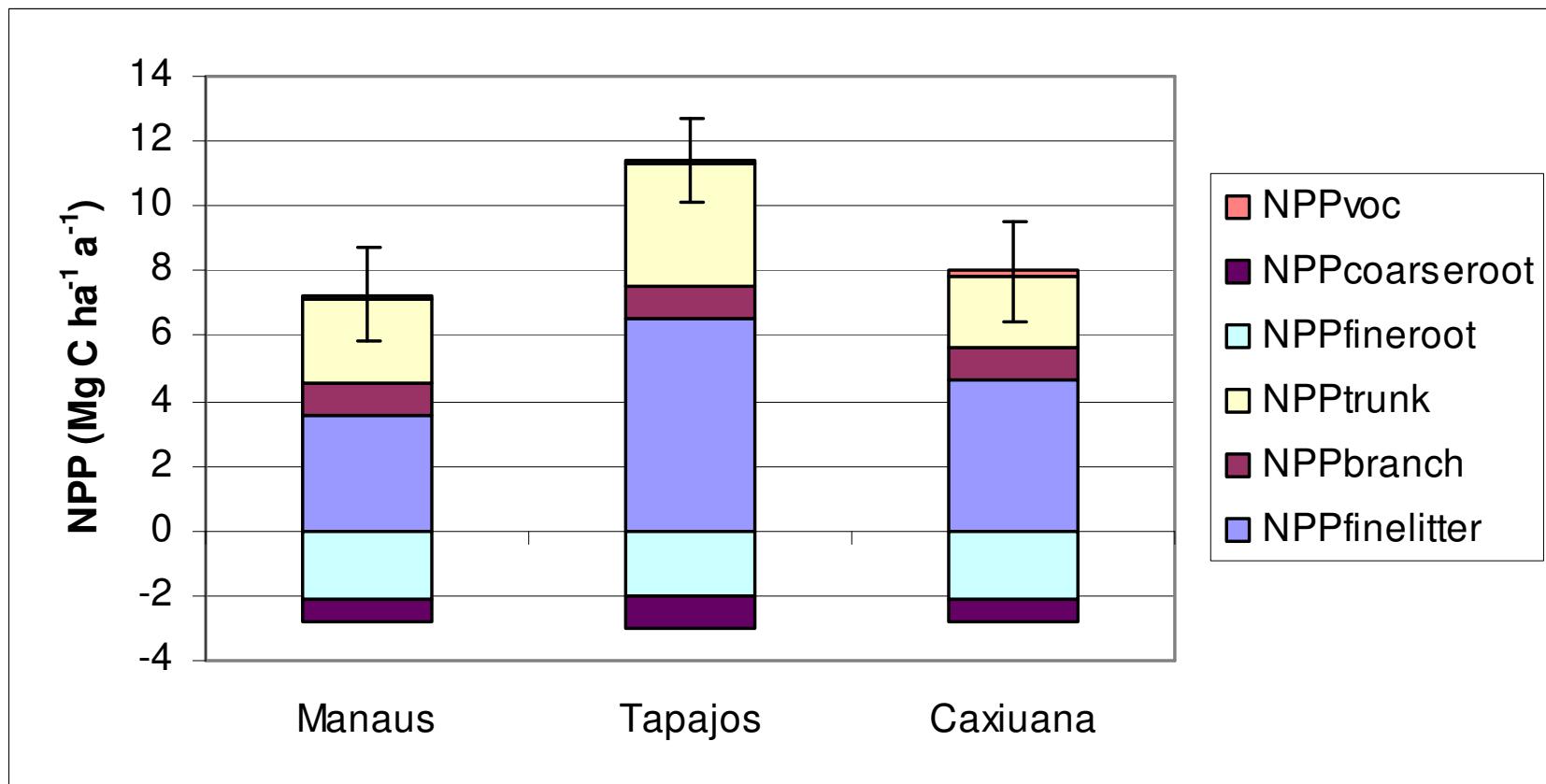
# The Carbon Allocation of Tropical Forests



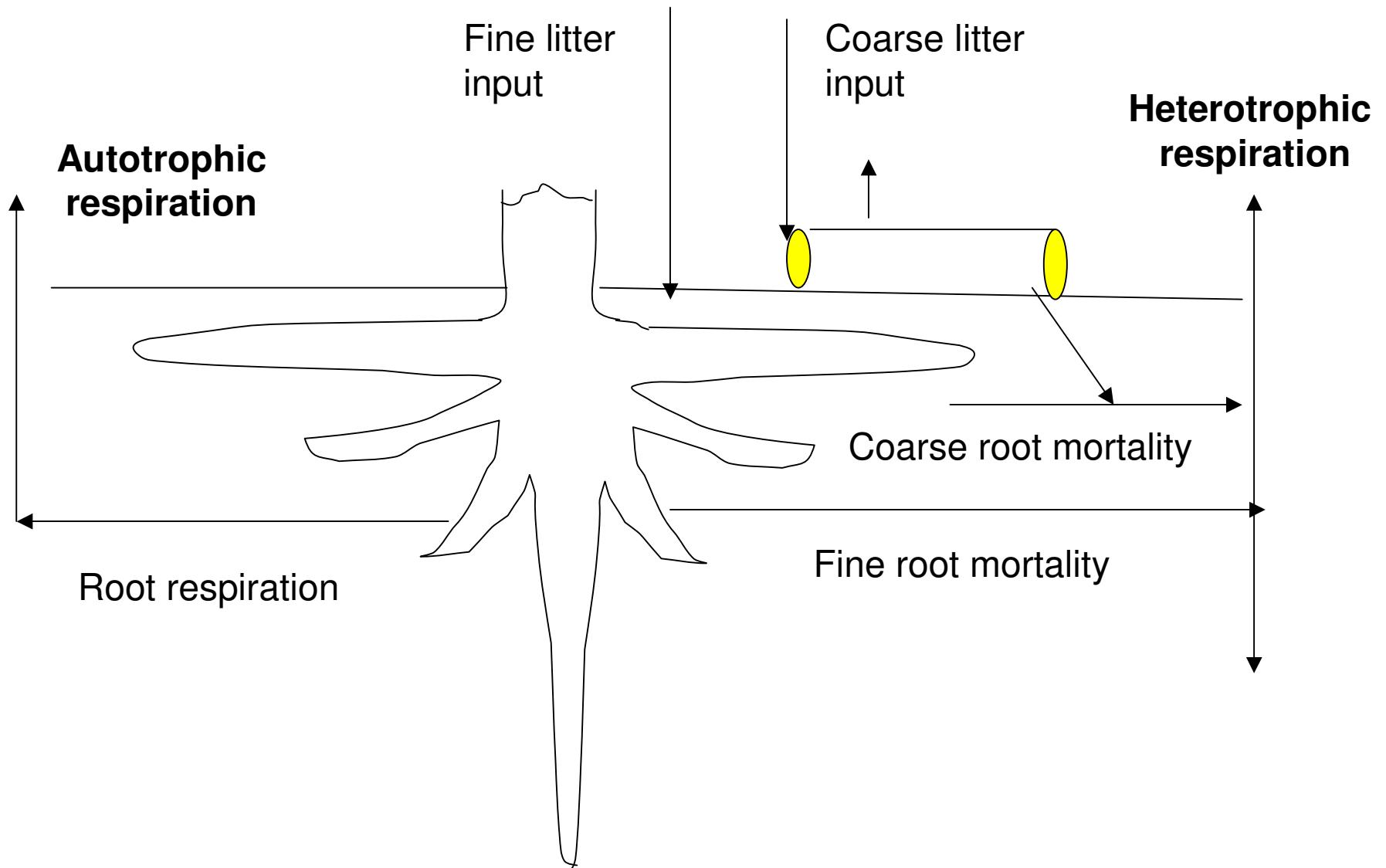
# Components of net primary productivity, $N_p$



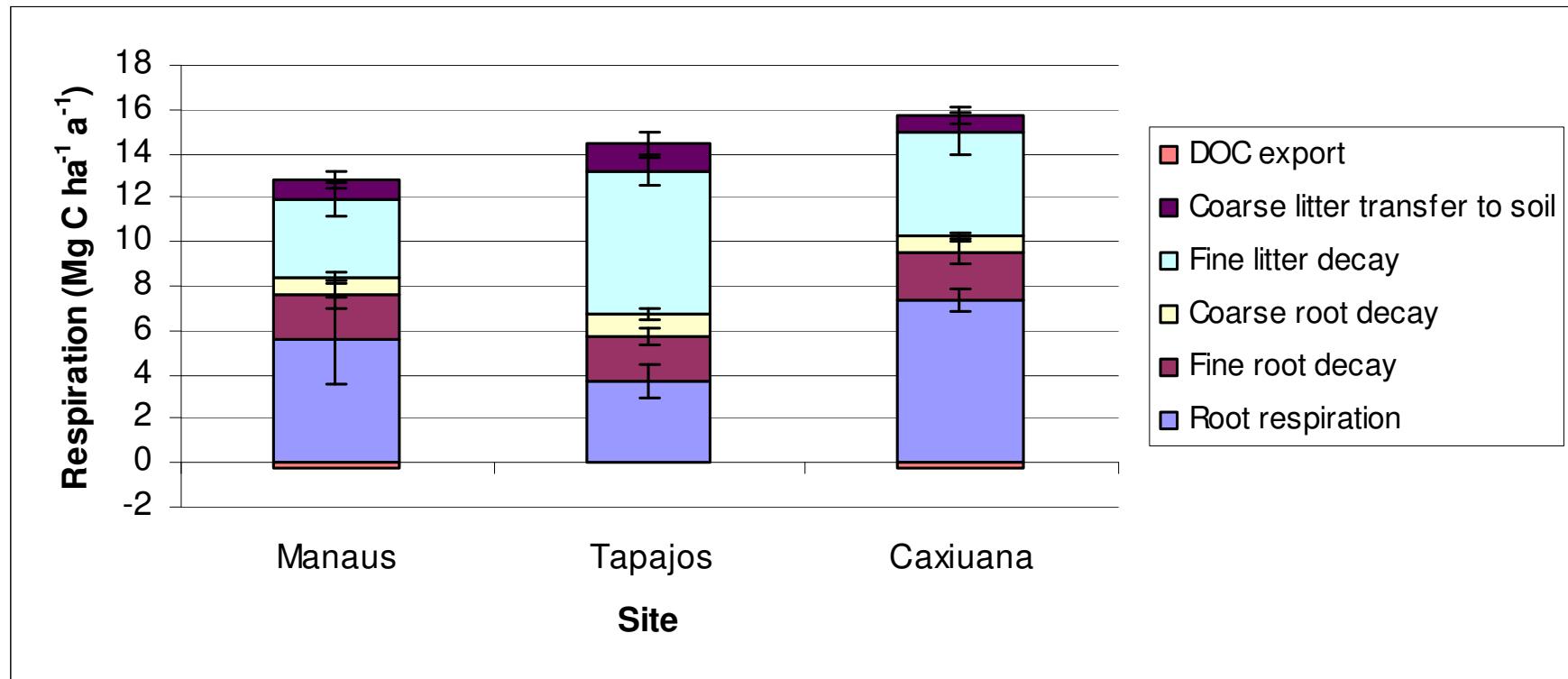
# Components of net primary productivity, $N_p$



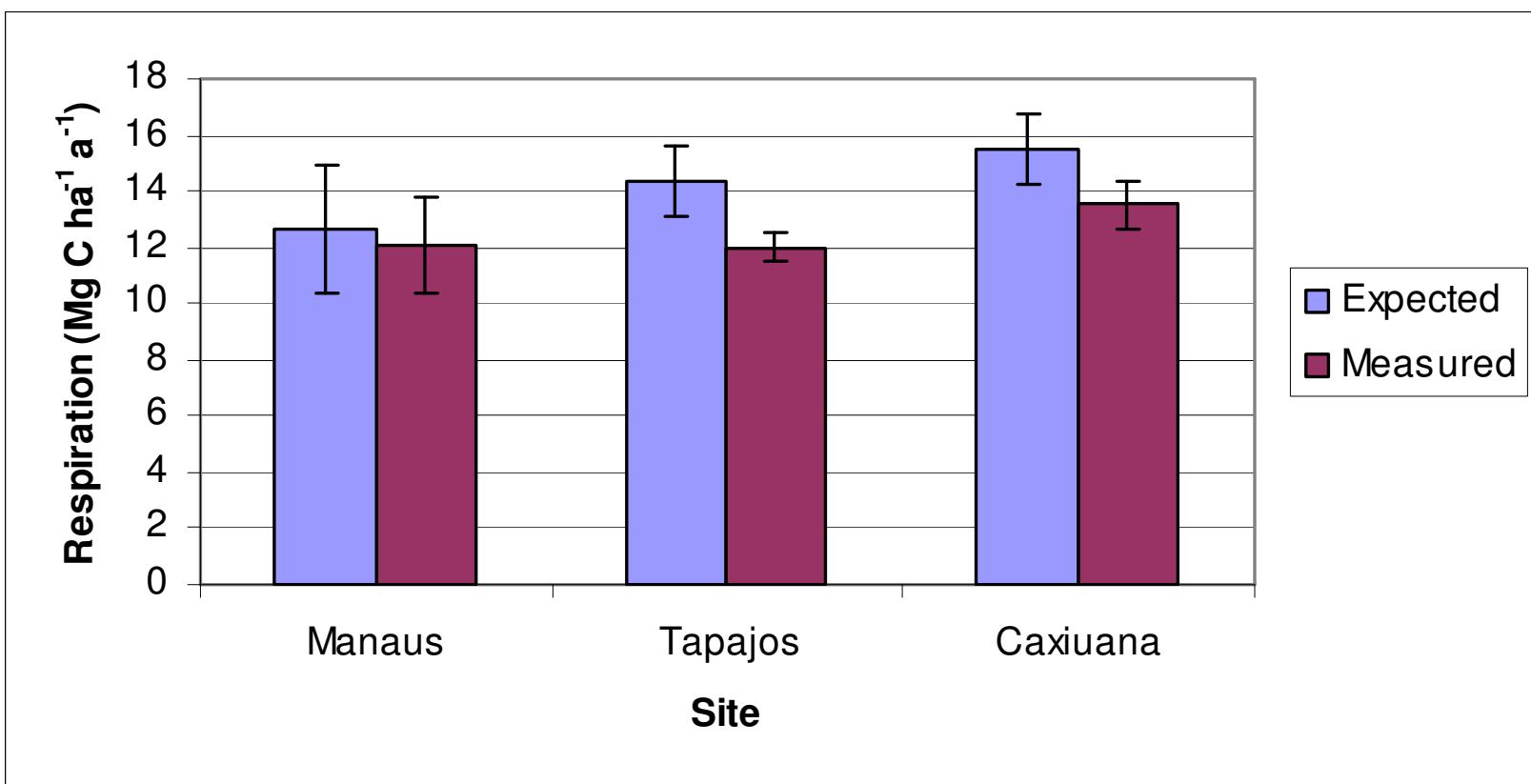
# Components of soil respiration



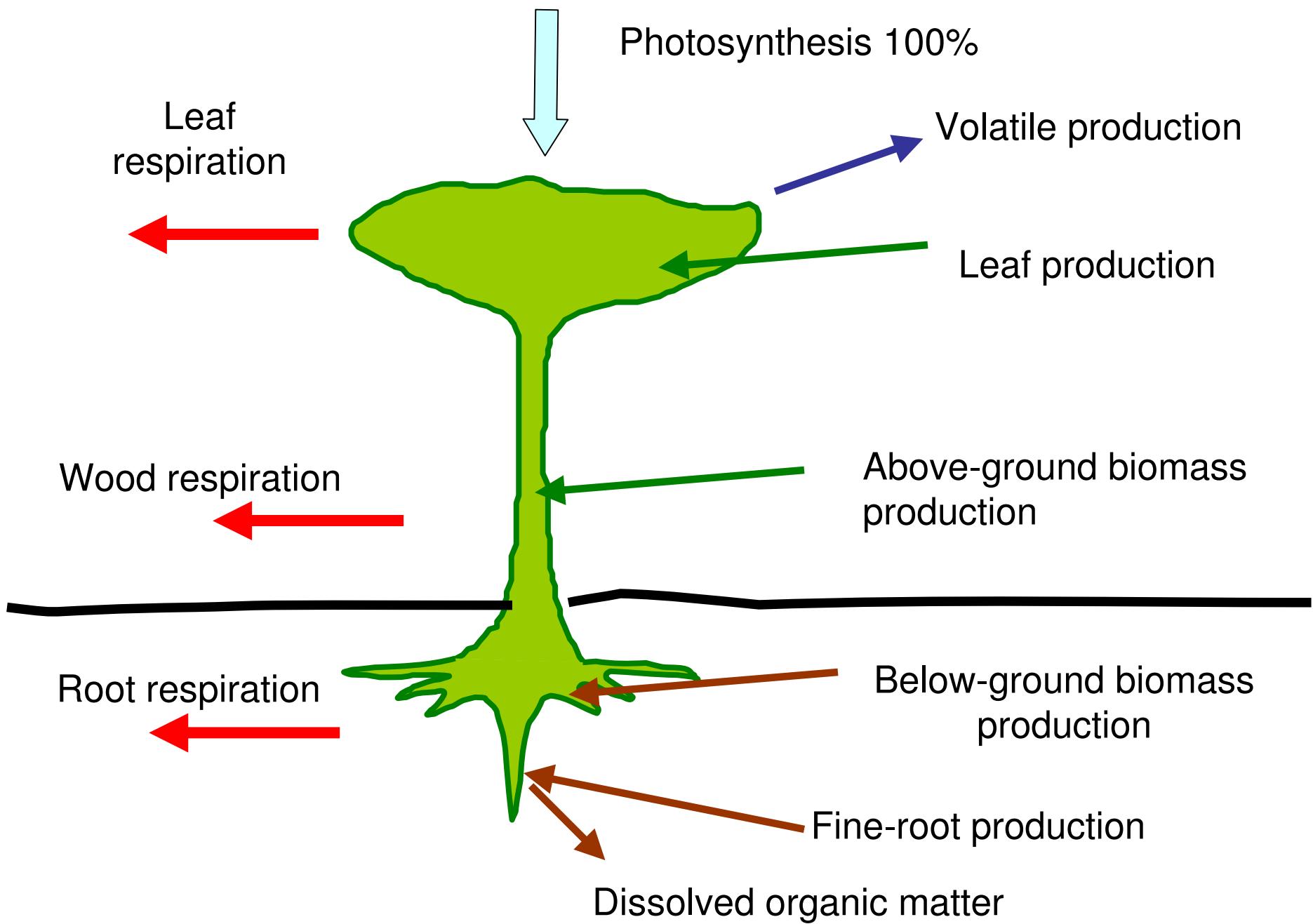
# Contributing terms to soil respiration



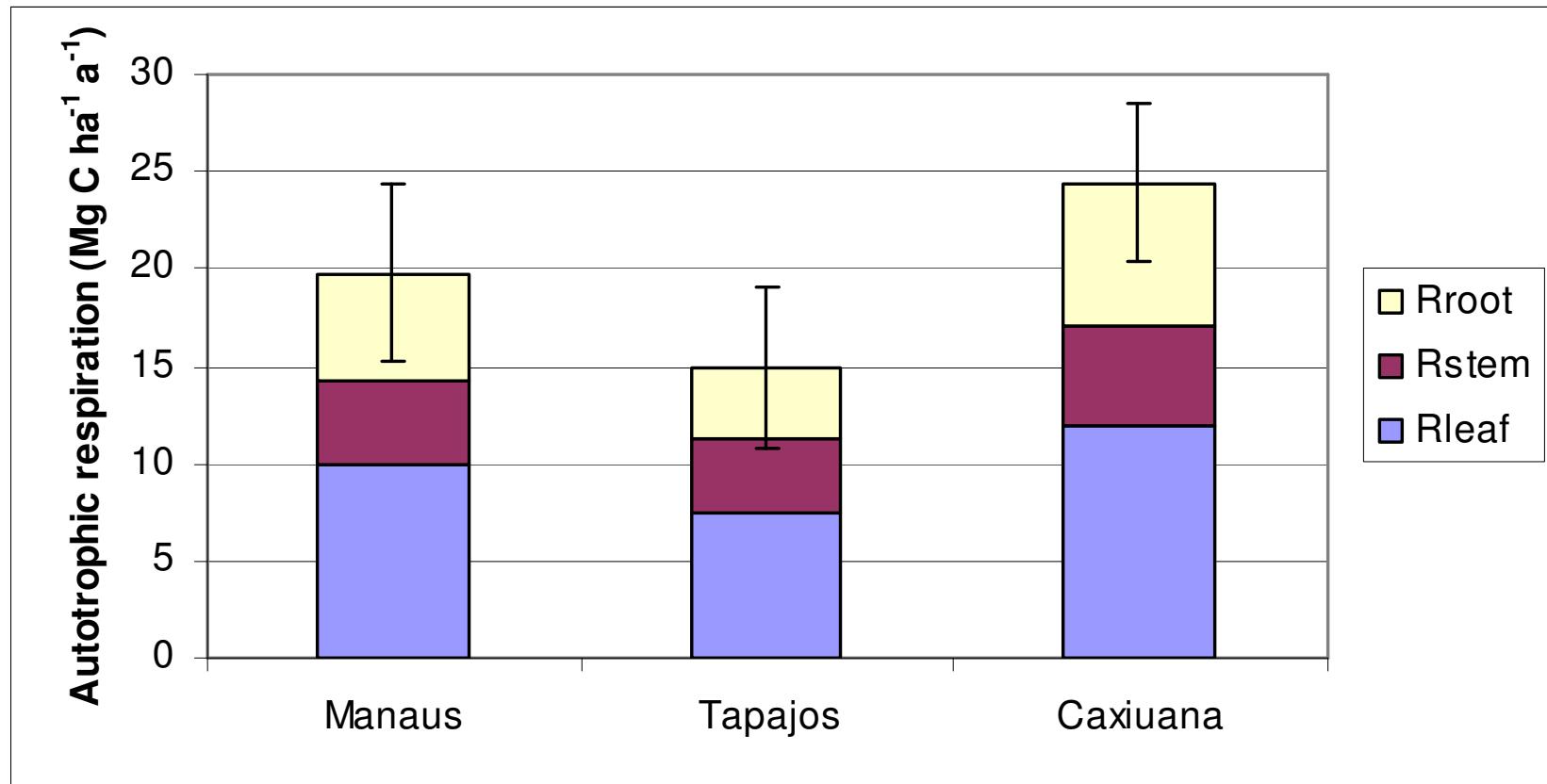
# Comparison against direct soil respiration measurements



# The Carbon Allocation of Tropical Forests



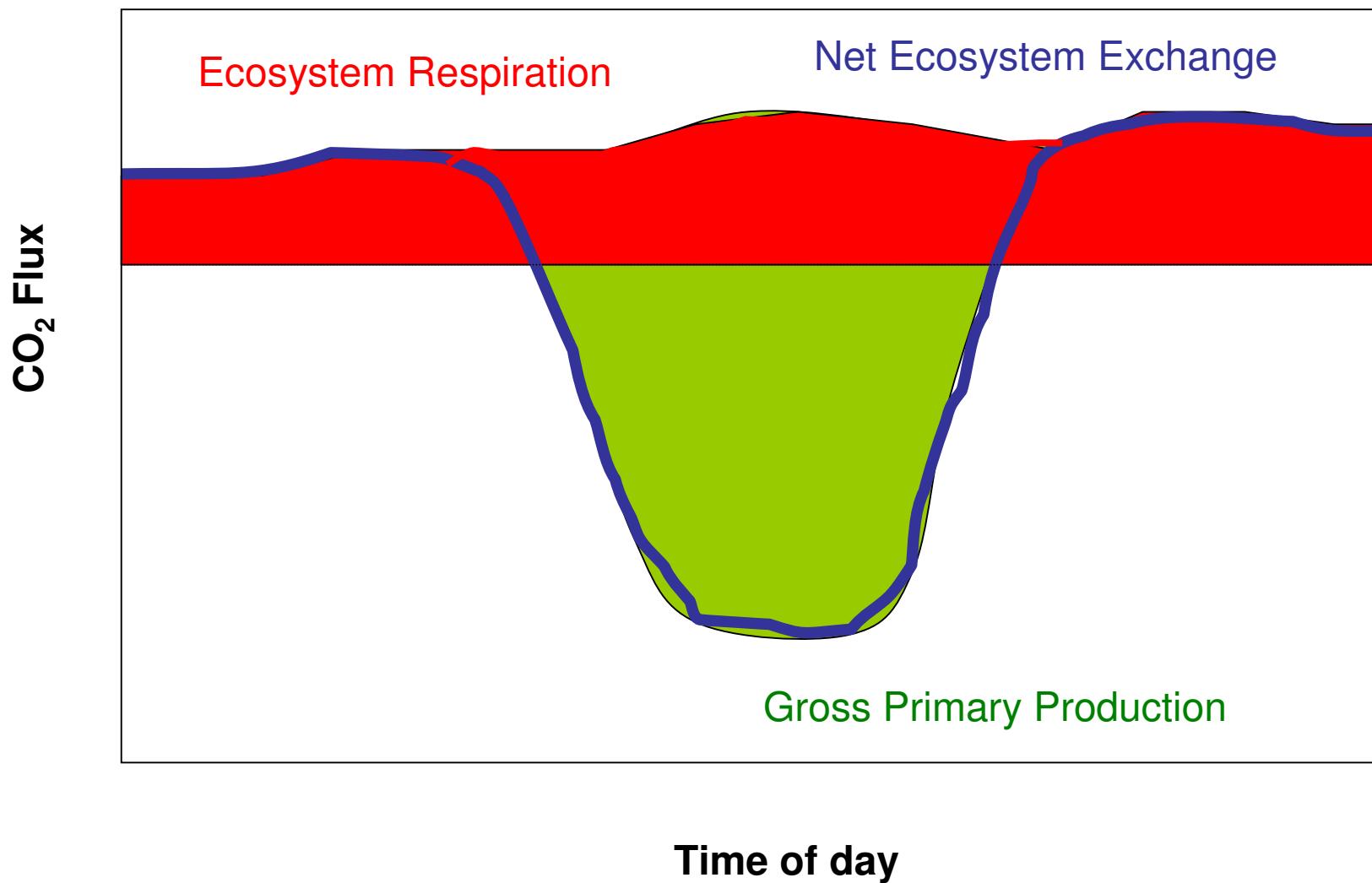
# Components of plant respiration



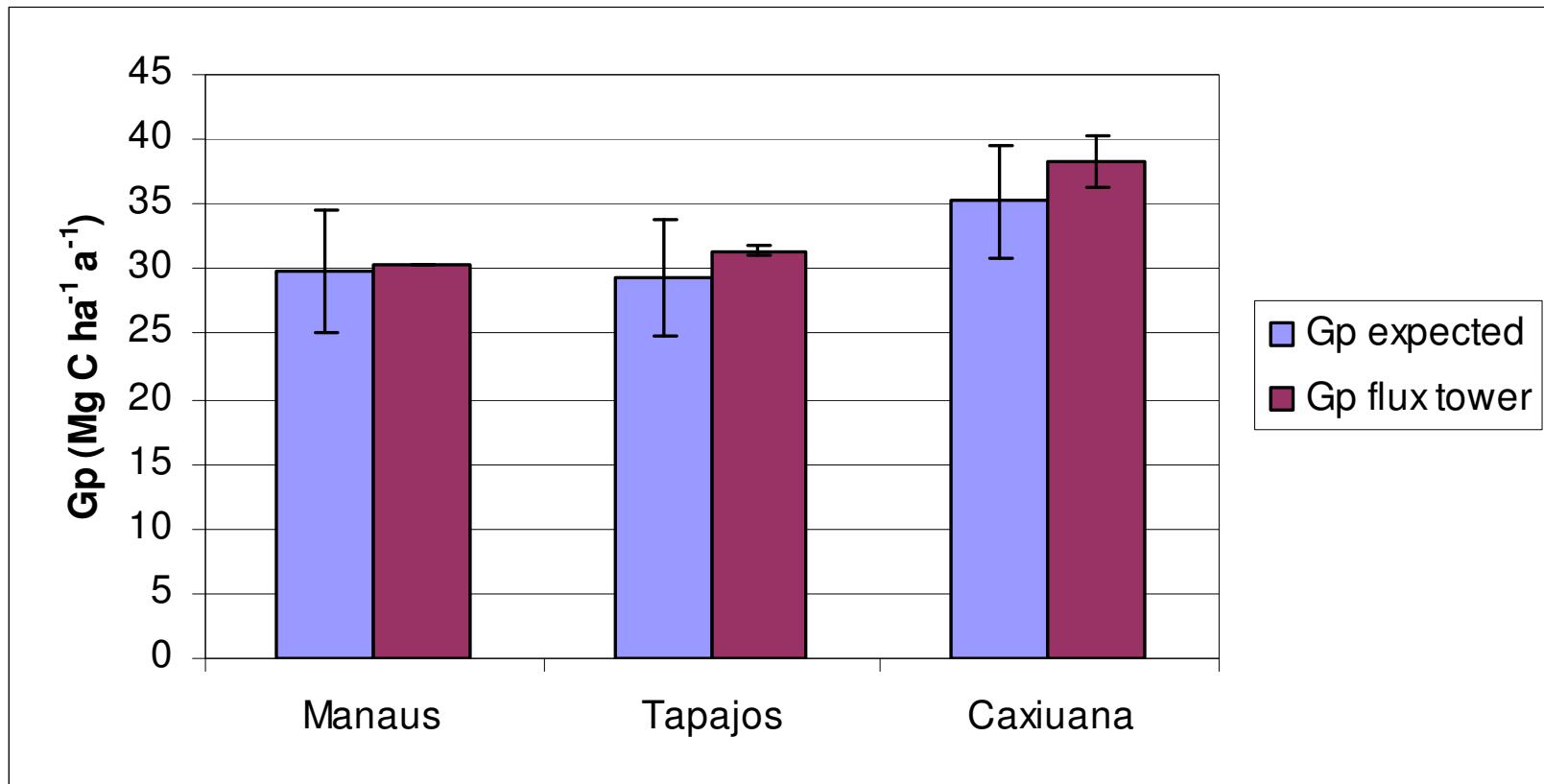
## **Bottom-up estimations of gross primary production, $G_p$**

$$G_p = N_p + R_{\text{autotrophic}}$$

# Top-down estimations of gross primary production, $G_p$



# Calculation of gross primary production and comparison with flux towers

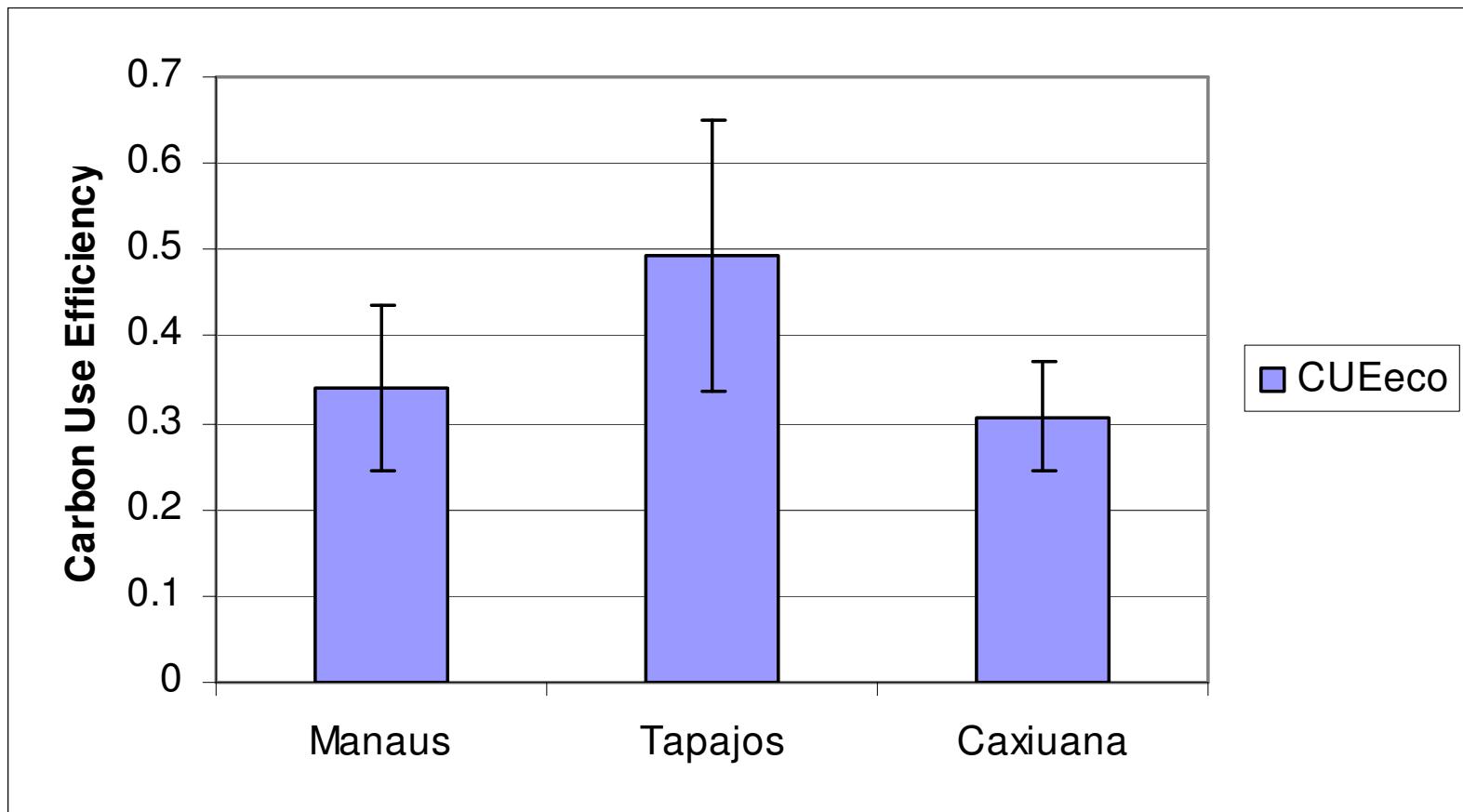


## **Estimations of carbon use efficiency, CUE**

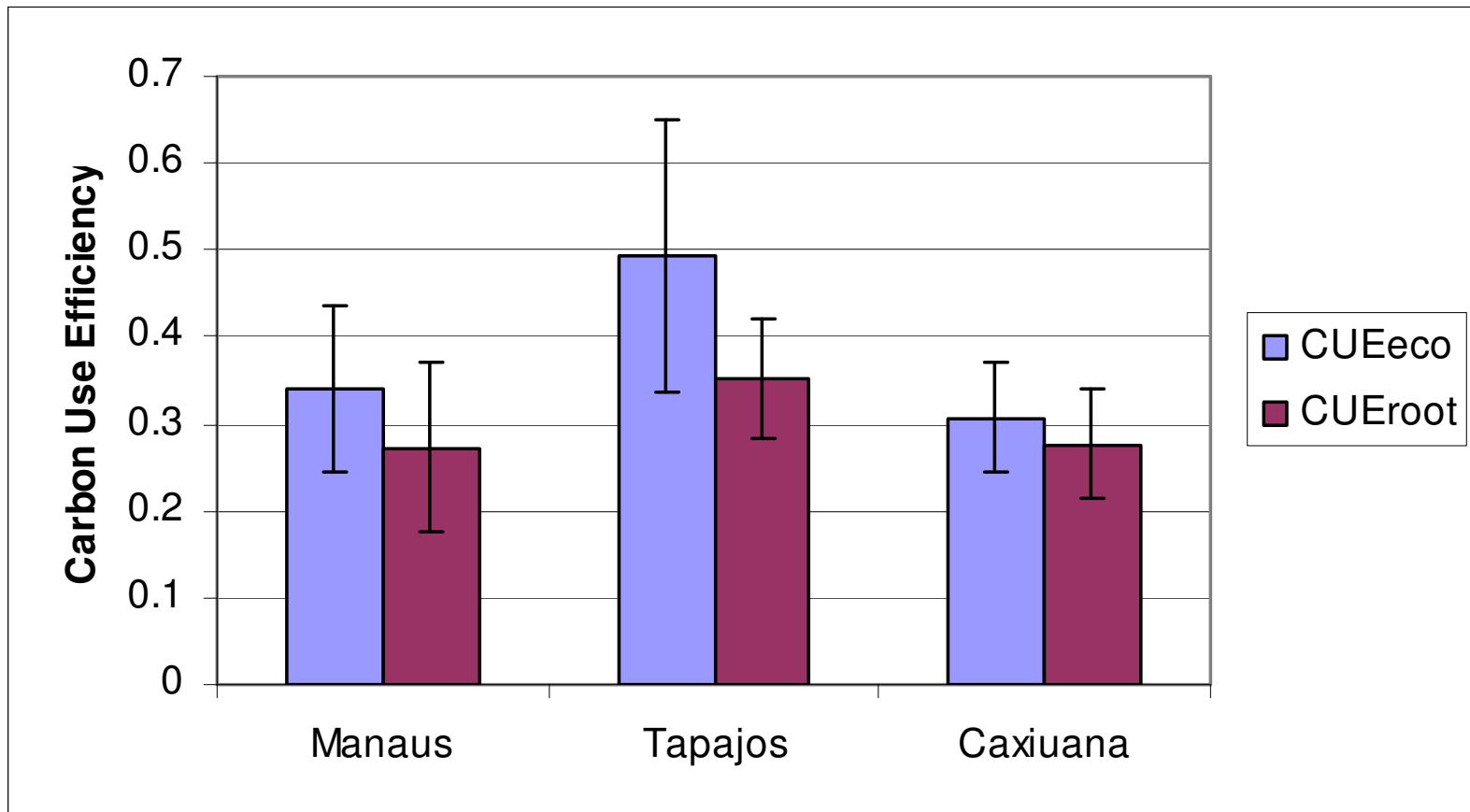
$$\text{CUE} = N_p / G_p$$

$$= N_p / (G_p + R_{\text{autotrophic}})$$

# Carbon use efficiencies



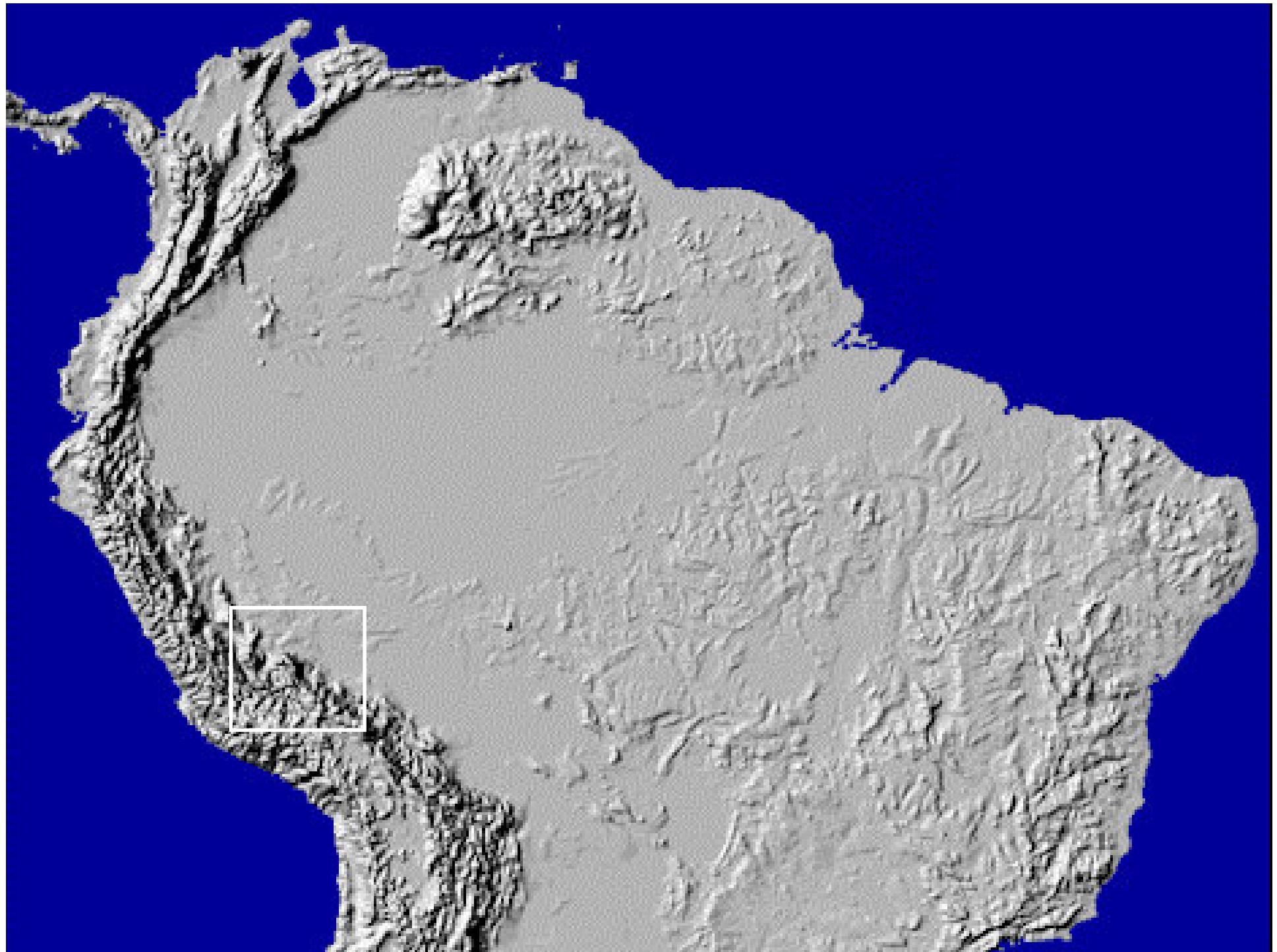
# Carbon use efficiencies

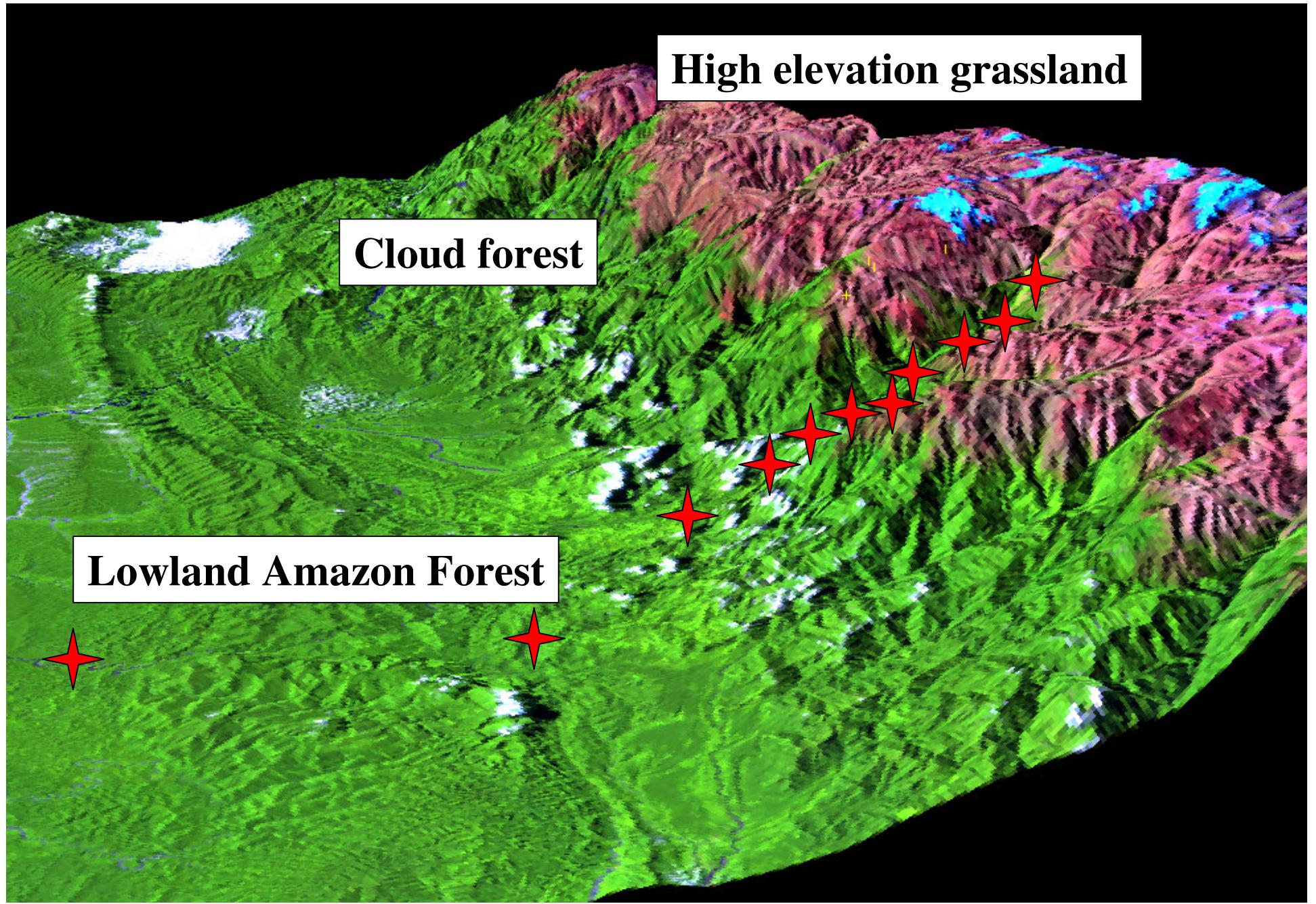


# Conclusions

- “Bottom-up” approaches agree quite well with flux towers, increasing confidence in both
- There are hints of “missing” soil respiration fluxes – possible CO<sub>2</sub> transport in xylem water flow?
- Forests at Caxiuana and Manaus have similar low carbon use efficiencies (~ 30%)
- The forests at Tapajos allocate disproportionately to above-ground wood and leaf production, and have a carbon use efficiency of 50% , similar to many temperate broadleaf forests
- This suggests that the low CUEs in the tropics are associated with low disturbance stands and/or low soil fertility, rather than high tropical temperatures.
- Conversely, recently disturbed forests may have higher carbon use efficiencies.







## **Focal study system**

Kosnipata Valley, Cuzco, Peru

17 ha (montane)  
300m to 3450m elevation  
250m intervals



