Carbon Dynamics in Coarse Woody Debris Pools at the Tapajos National Forest in Brazil

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Coarse Woody Debris Study

- CO_2 emissions to the atmosphere from two sites: km 67 and km 83

- Km 67 (Undisturbed forest)
* Decay classes (substrate quality)
* Size (diameter)

- Km 83 (5 selectively logged areas – from 1999 to 2003)
* Effect of tree species
* Size (diameter)
* Decay classes (substrate quality)

- Determine the effects of physical variables on controlling the rates of decomposition
* Temperature
* Moisture

CO_2 Flux from Coarse Woody Debris at the FLONA Tapajos, Brazil

1 – Coarse Woody Debris (CWD)

- Large Pieces of wood > 10cm (diameter)
- Intermediate size > 5 to 10 cm (diameter)
- Small size > 2 to 5cm (diameter)

3 - Why study CWD?

- CWD in forests accounts for 16-64% of organic matter (OM)

- 3-16% of N returned to forest floor is stored in CWD

- Little is known about its dynamics, why? Decomposition is a relatively slow process

4 - Why in Tropical Forests?

- 12% of Earth's land surface is covered by Tropical Forests

- CWD information in Tropical forests are especially limited (Chambers *et al*. 2001, Lang and Knight 1979, Harmon *et al*. 1995, and Clark *et al*. (2002)

5 - Study site

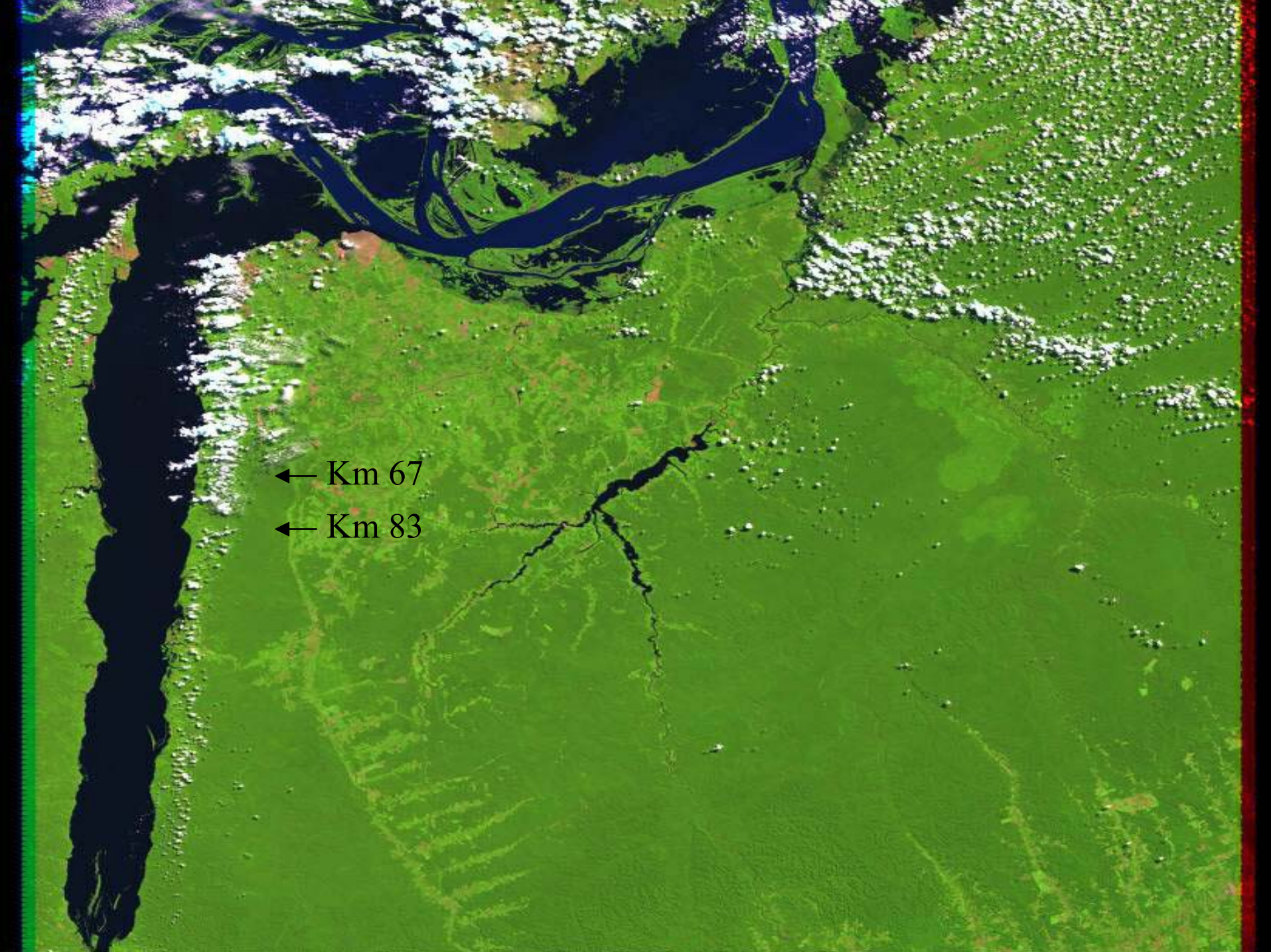
- The study was carried out at the Tapajos National Forest (TNF)- south of Santarem, Para - Brazil. Research sites of the Brazilian led Large-scale Biosphere Atmosphere experiment in Amazonia - LBA Project

- The mean annual temperature is 25^{o}C and precipitation is 2000 mm (Parrotta *et al.* 1995)

- The areas are dominated by clay textured Oxisol interspersed with smaller areas sandy Ultisol (Silver *et al*. 2000)

The km 67 site: an undisturbed old growth forest

The site at Km 83: within the same forest but the area was selectively logged


← Km 67
← Km 83

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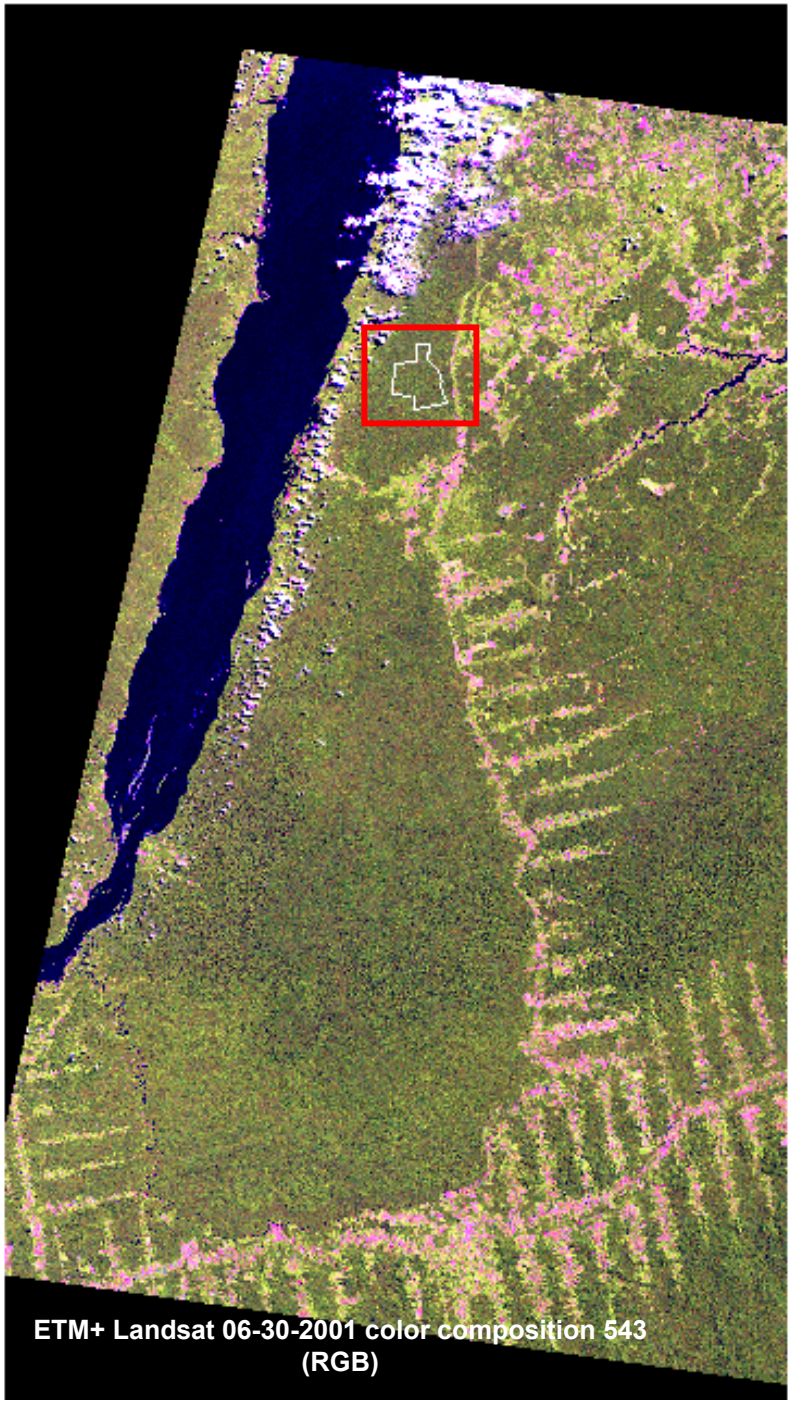
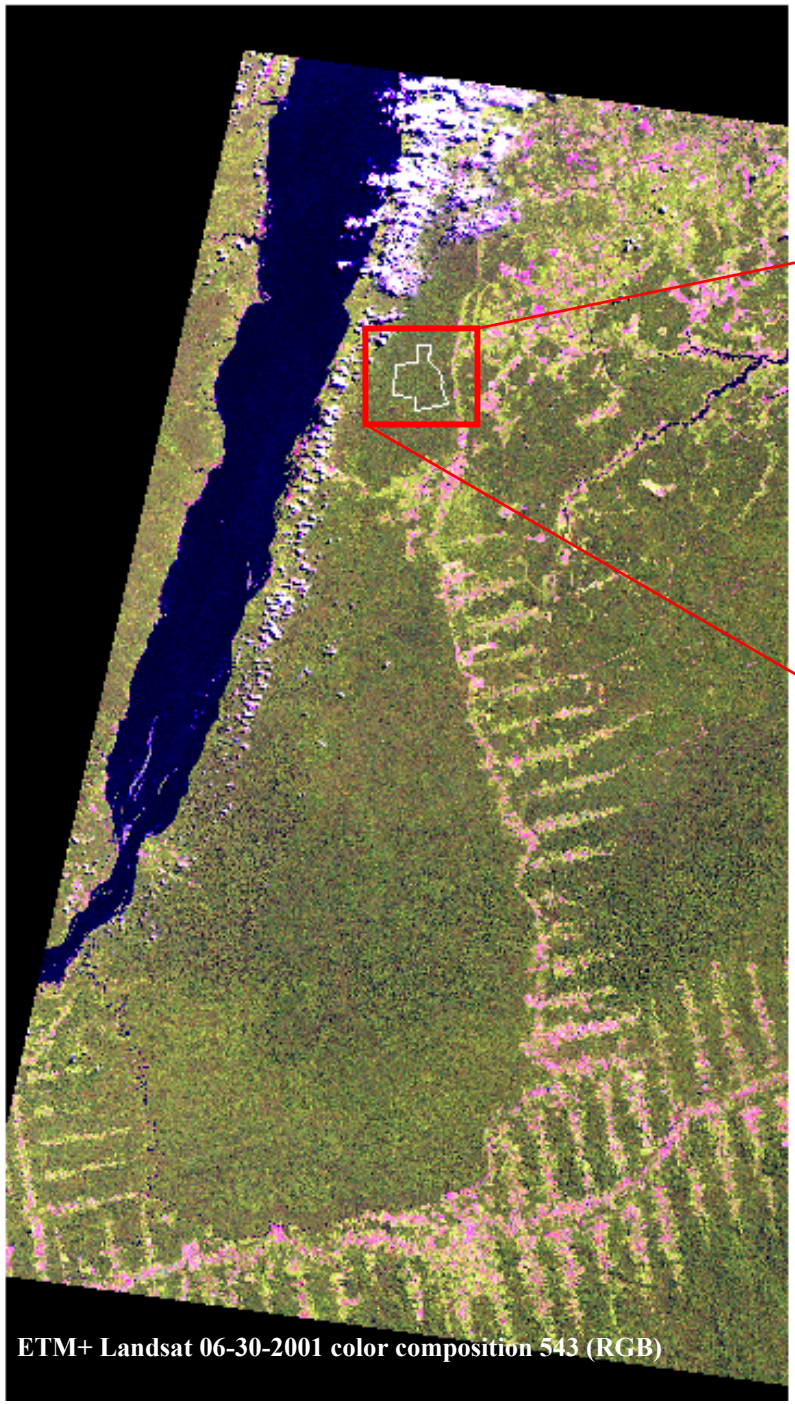
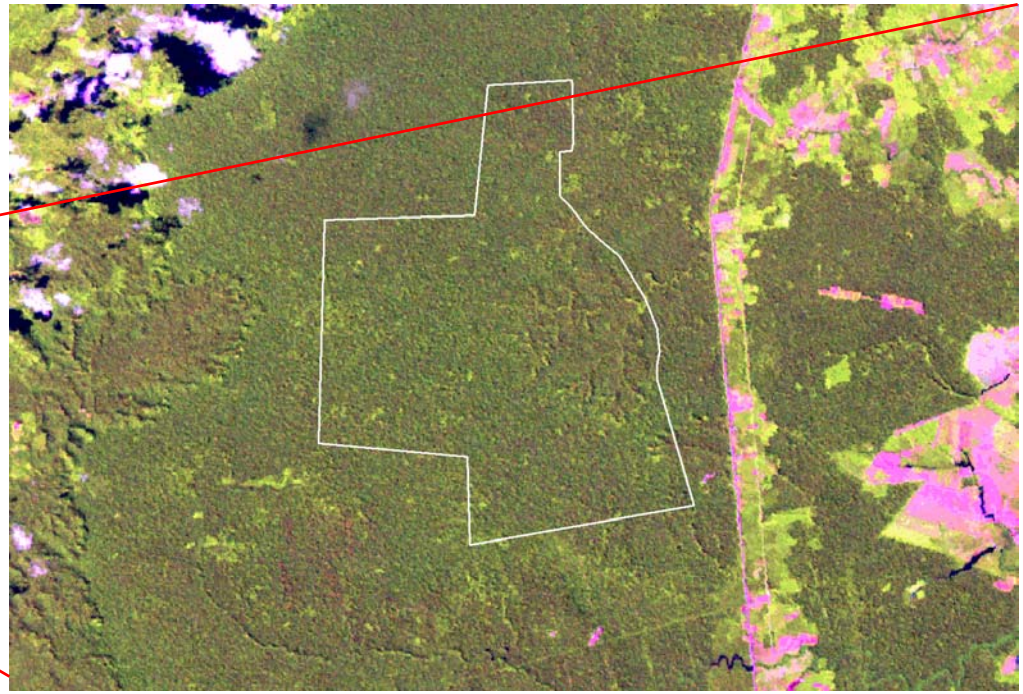


ETM+ Landsat 06-30-2001 color composition 543 (RGB)



ETM+ Landsat 06-30-2001 color composition 543 (RGB)



6 - Comparisons between undisturbed and logged areas

- Undisturbed forest
*Different patterns of CWD input – natural mortality
*Low quality substrate
*More stable climatic conditions than disturbed areas

- Logged areas
*Increased input of material into CWD pool due logging
*Larger amount of higher quality substrate to decompose (large trees)
*Extreme variations in environmental conditions

Coarse woody debris pool at km 67 – Undisturbed forest

6 – Site characteristics - undisturbed and logged areas

- Undisturbed forest
*Different patterns of CWD input – natural mortality
*Low quality substrate
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- Logged areas
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*Extreme variations in environmental conditions


Tree fall gap at km 83


- Logged areas, due to canopy remove, allow more sun light to reach the ground increasing temperatures and during wet season, increasing moisture content


km 83 – primary
forest logged in 2001

7 - Methodologies to estimate the net fluxes of CO_2 from CWD decomposition

1- Incubation chambers
- Small pieces of CWD (branches <10cm in diameter)

2- Surface chambers
- Measure the release of CO_2 directly from the surface of logs. This is a non destructive method that will allow us to revisit the same locale and measure the fluxes in different seasons


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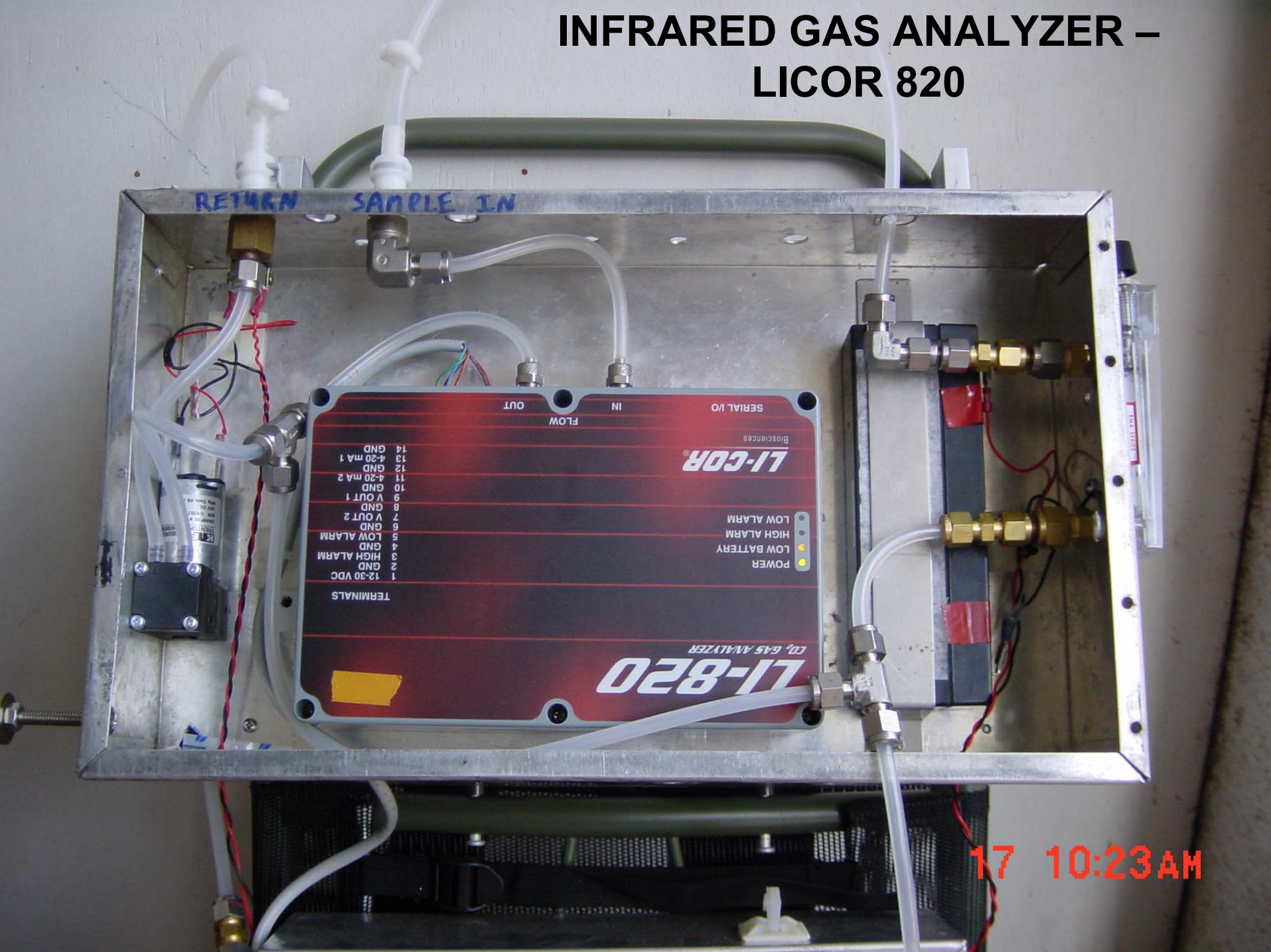
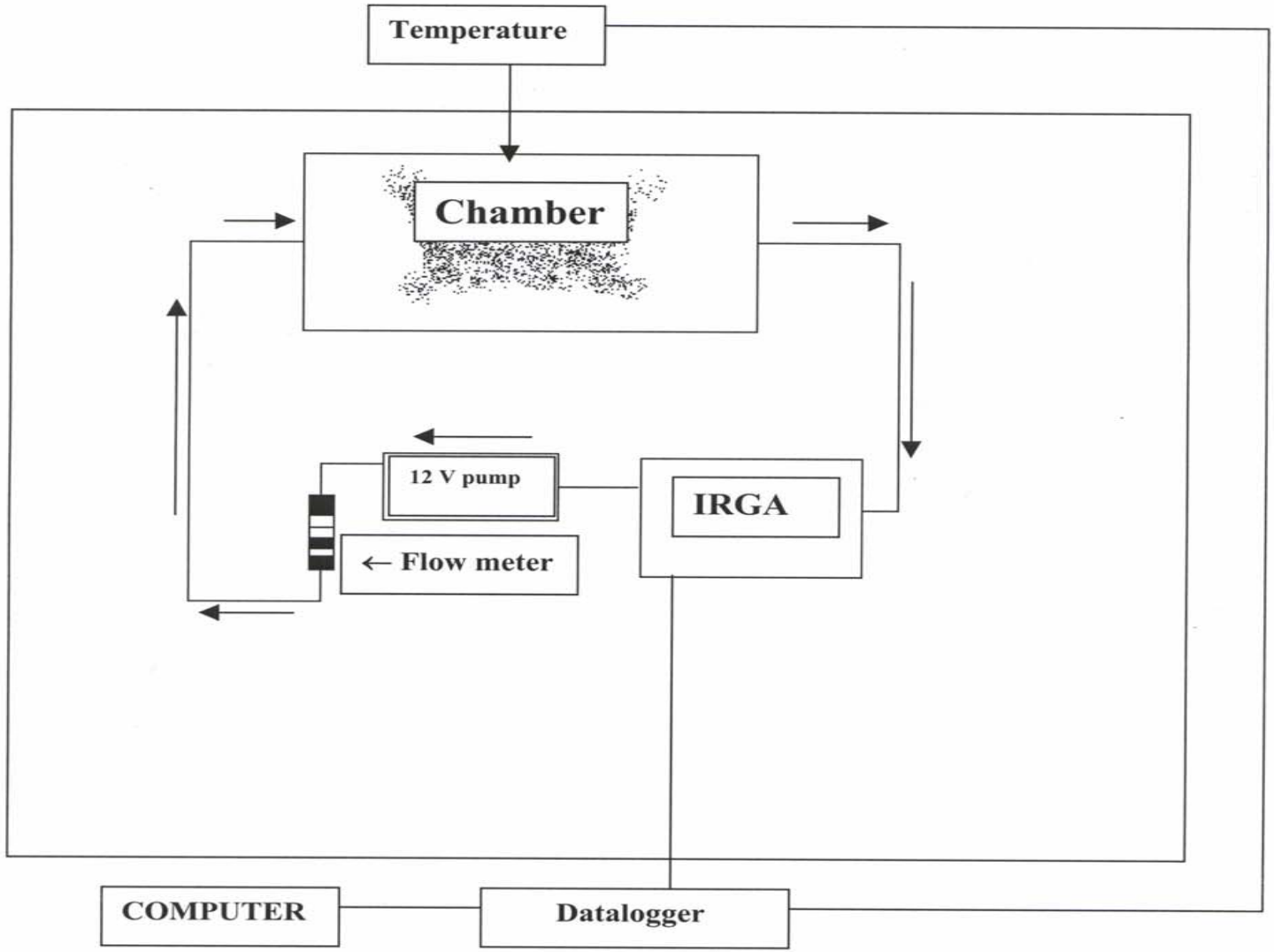
INFRARED GAS ANALYZER – LICOR 820



Coarse Woody Debris System



8 - Methods km 67 and km 83

Km 67 (undisturbed forest)

- CWD was sampled using line intersect methods
Any piece of wood ≤ 2 cm in diameter

***CWD > 10 cm (diameter)**
Air and wood temperature
- Wood water content (GANN moisture meter)

***CWD < 10 cm (diameter)**
- CWD was oven dried to estimate wood water content.
Air temperature

Km 83 (logged area)

CWD > 10 cm (diameter)
- random points were selected in the gap to be measured permanently
- Wood water content (Gann moisture meter)
- Air temperature
- wood temperature

CWD < 10 cm (diameter)
- CWD was oven dried to estimate wood water content.
- CWD volume and surface area
- air temperature.

Table 2. Summarizes the results from km 83 (selectively logged area). CO_2 fluxes are expressed as µmol m^{-2} $_{wood\ surface}$ s^{-1} (avg ± stdv)

- Tree species table order is andiroba (*Carapa guianensis*), Maçaranduba (*Manilkara huberi*), and Tauari (*Couratari stellata*).
- Fluxes at km 83 were separated into decay class categories. Seasonality summarizes the values for wet season (WS), dry season (DS) and intermediate period (IP).
- Significance tests: * for < 0.05, ** for < 0.01 and * for < 0.001.**

Average CO_2 flux***	Seasonality***	Tree species***	AHA ***	Decay classes
3.22 ± 3.1 n = 1316	2.9 ± 2.7 (WS) 3.8 ± 3 (IP) 3.2 ± 3.3 (DS) n = 1209	3.7 ± 3.6 (A) 2 ± 1.6 (M) 3.9 ± 3.2 (T) n = 1206	3.1 ± 3.5 (1) 3.2 ± 2.1 (2) 3 ± 2.8 (3) 3.5 ± 3.4 (4) 3.1 ± 3.2 (5) n = 1316	2.1 ± 1.3 (1) 3.4 ± 3.3 (2) 2.9 ± 2.9 (3) 3.1 ± 2.2 (4) 2.9 ± 2.8 (5) n = 1206

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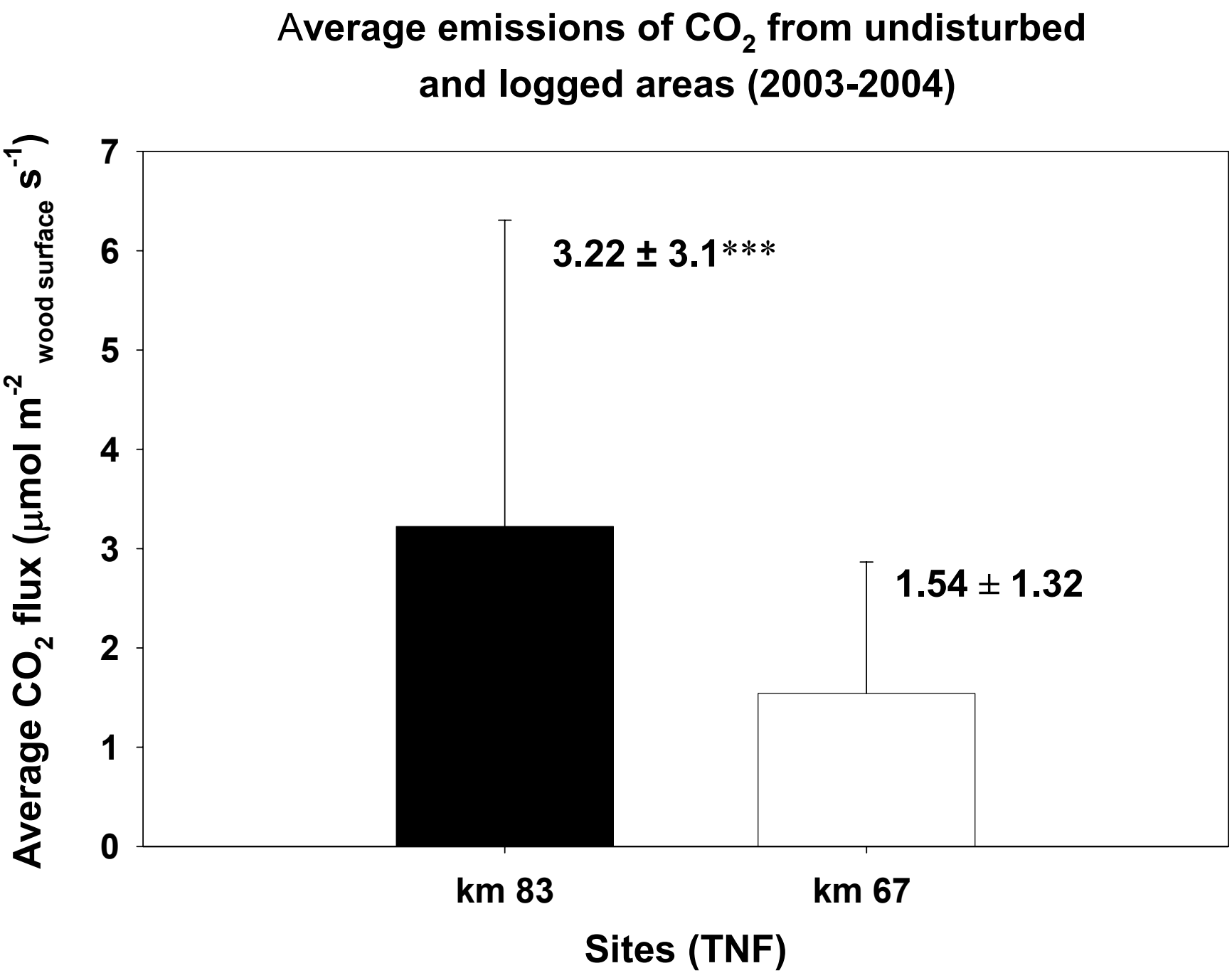
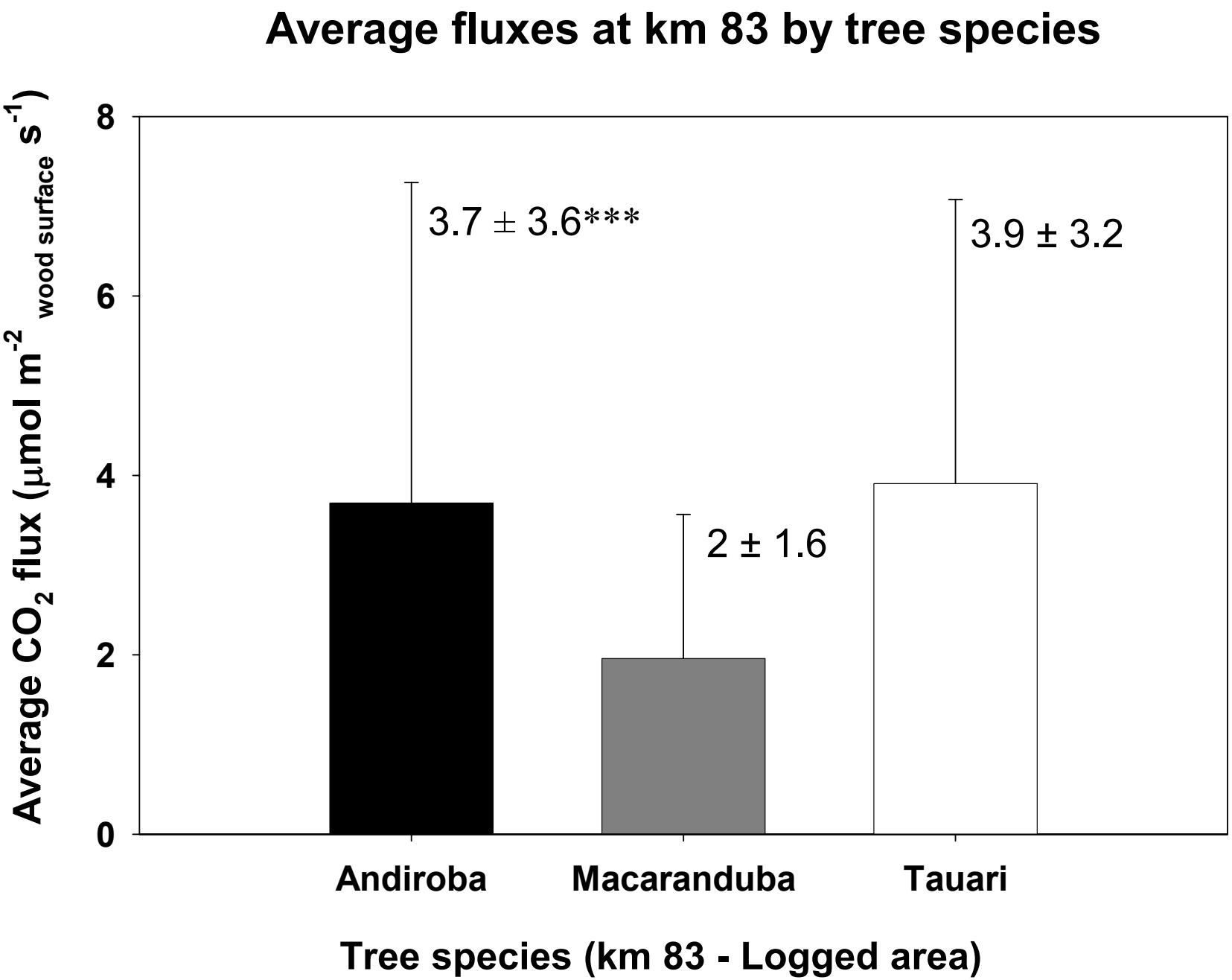
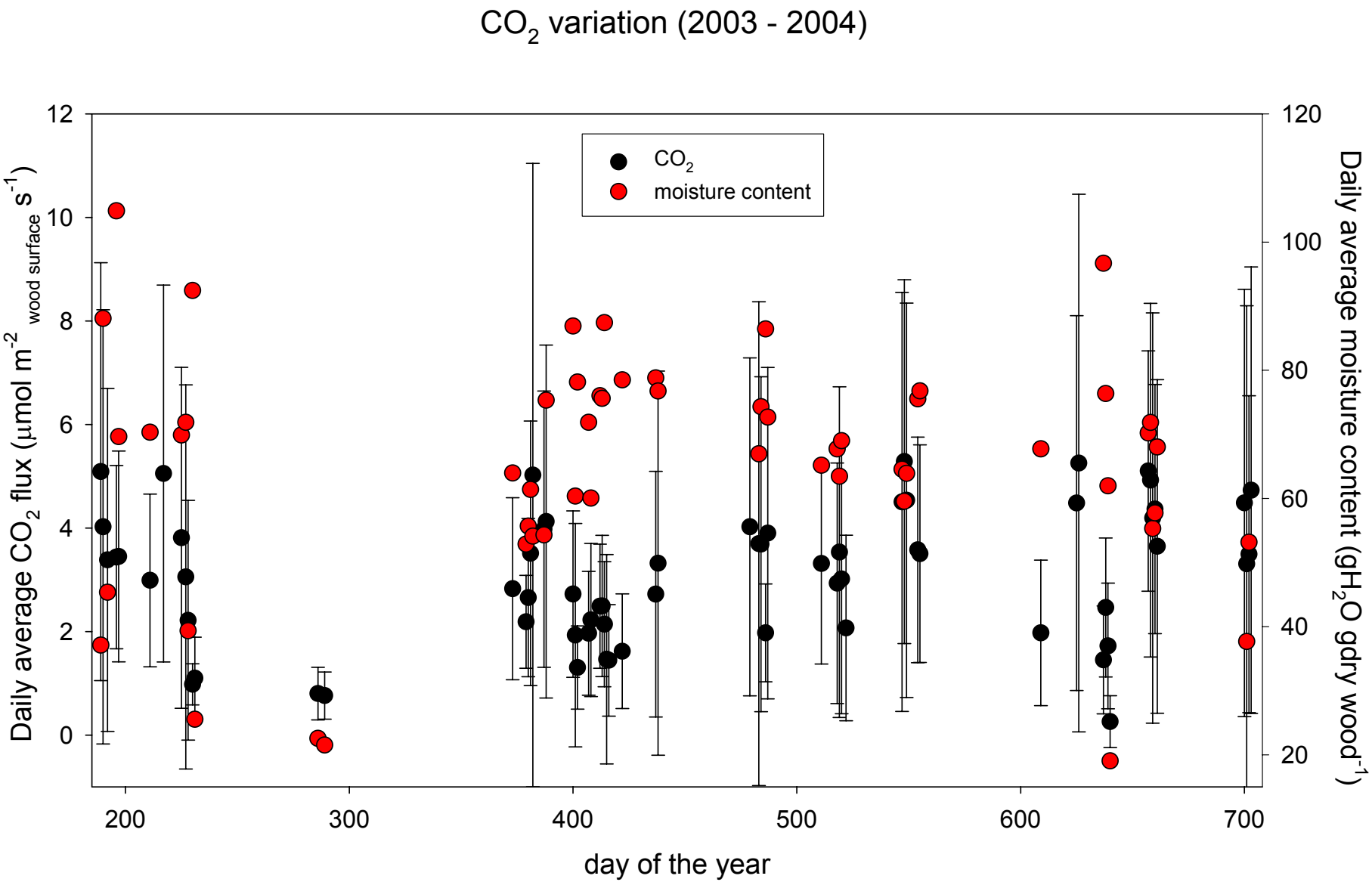
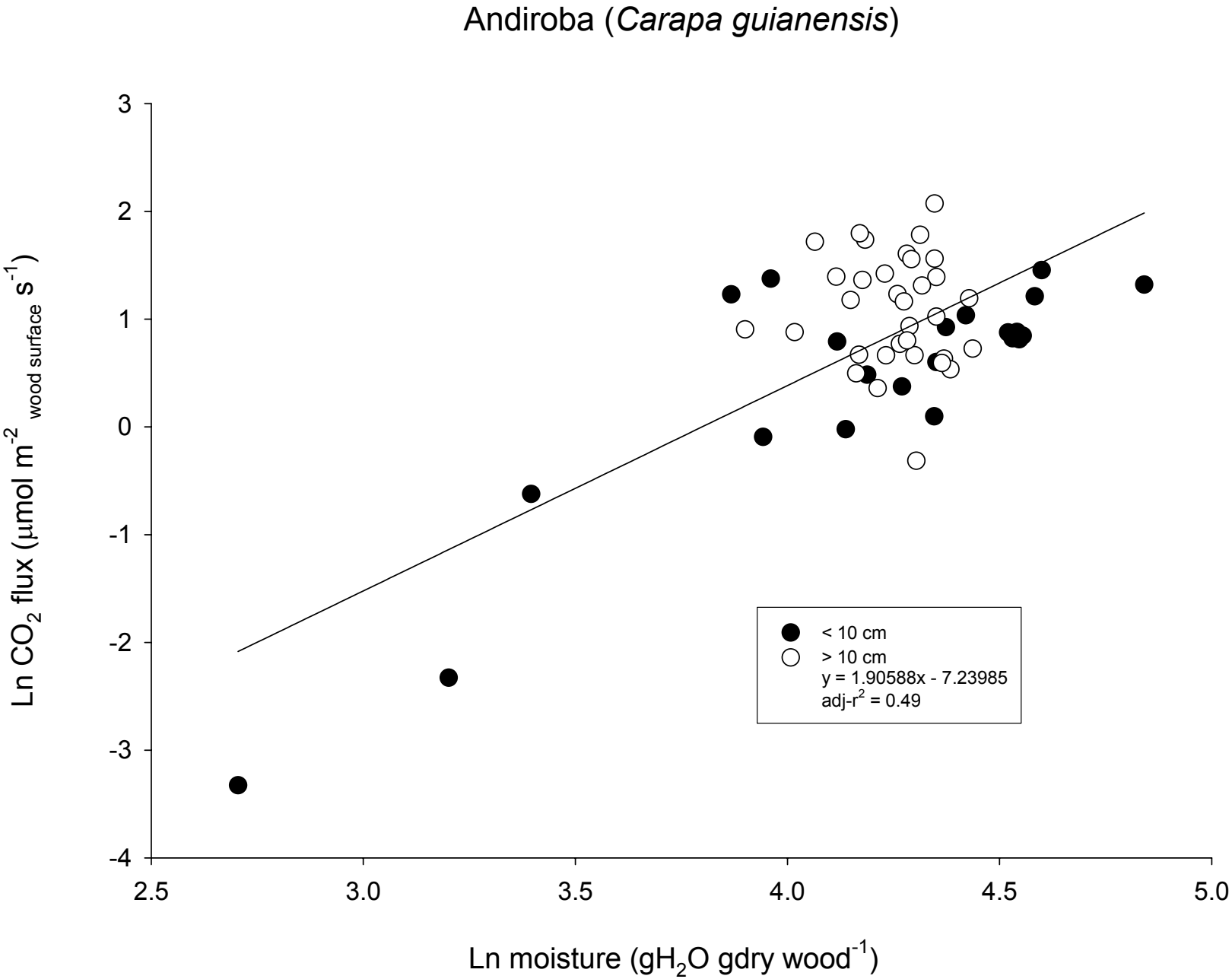
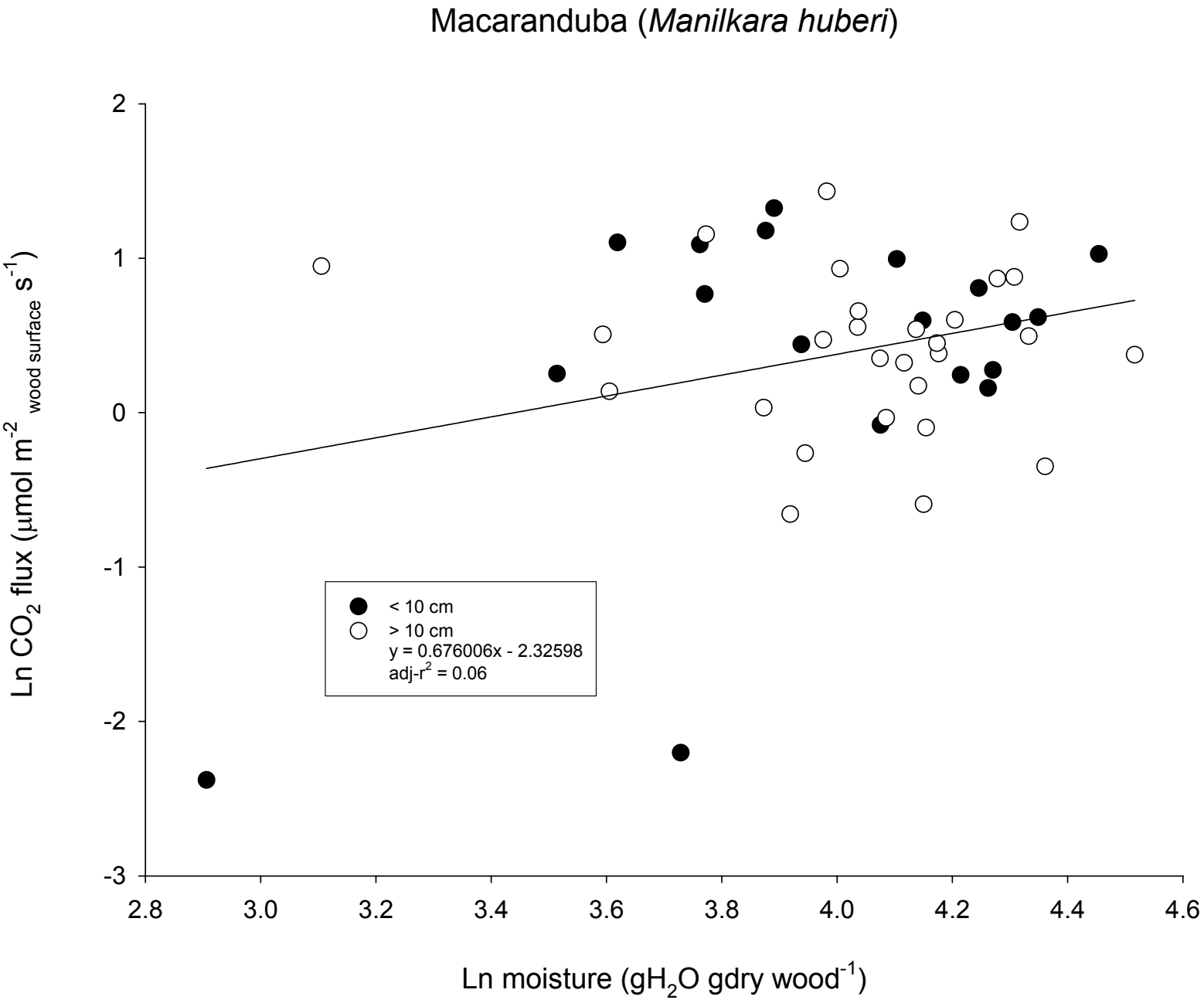
Average CO_2 flux***	Seasonality***	CO_2 flux by decay classes
1.54 ± 1.32 n = 324	1.5 ± 1.2 (wet season) 2 ± 1.3 (Interm. Per.) 1.5 ± 1 (dry season) n = 324	1.6 ± 0.8 (1) 1.5 ± 1 (2) 1.5 ± 1.5 (3) 1.5 ± 1 (4) 1.2 ± 1 (5) n = 236

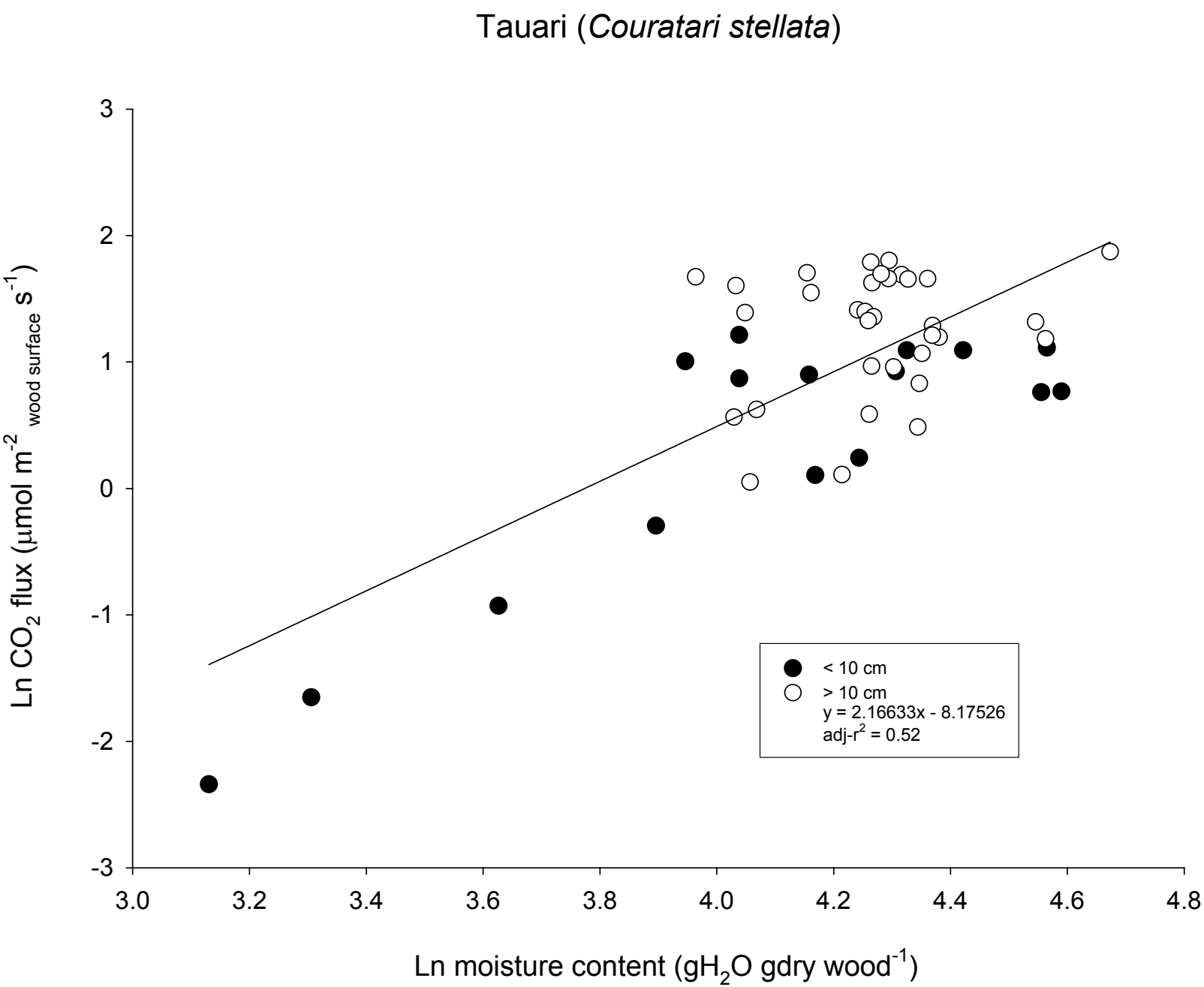

Average emissions of CO_2 from undisturbed and logged areas (2003-2004)
Average CO_2 flux (μmol m^{-2} wood surface s^{-1})
0
1
2
3
4
5
6
7
3.22 ± 3.1***
1.54 ± 1.32
km 83
km 67
Sites (TNF)

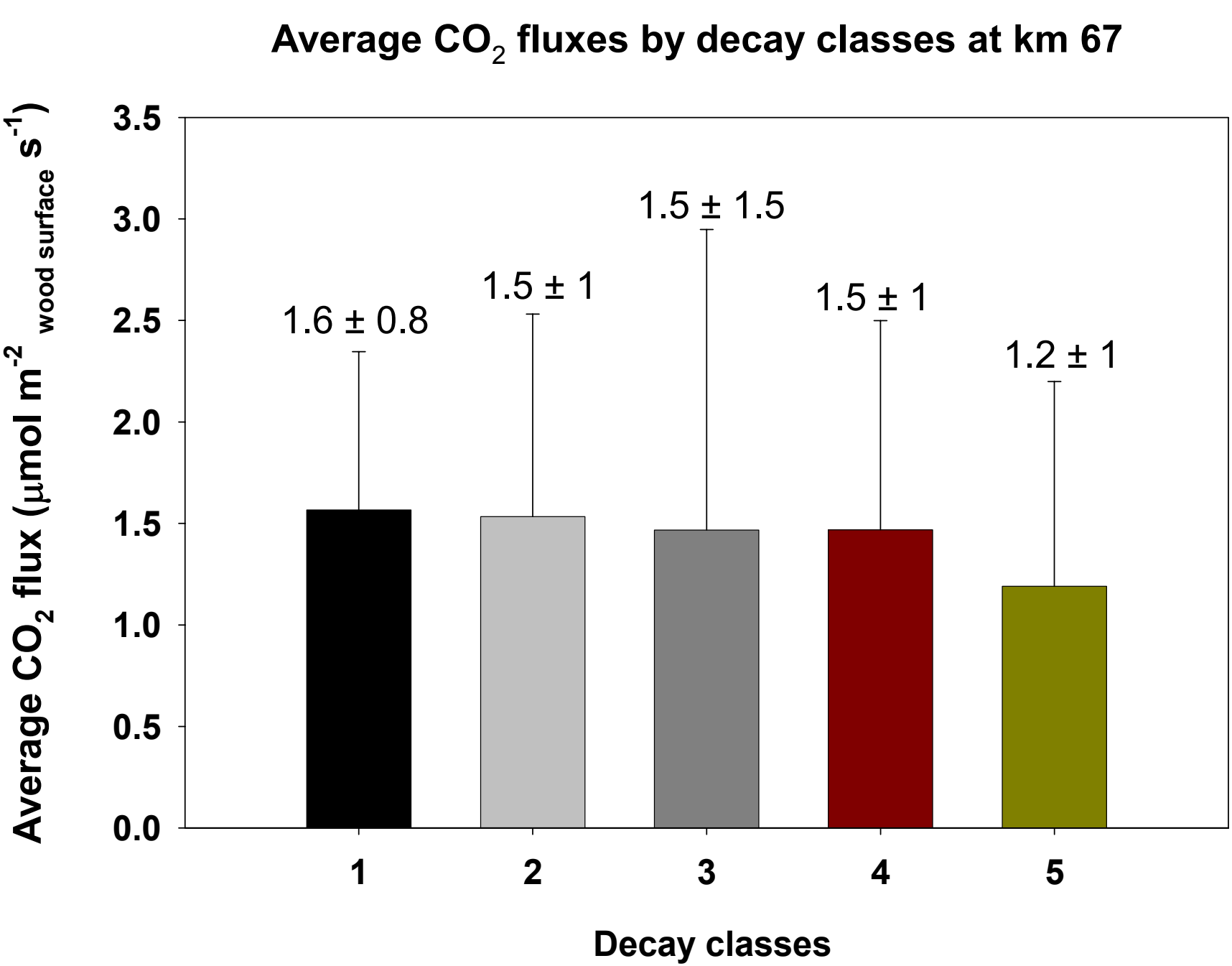

Average fluxes at km 83 by tree species
Average CO2 flux (µmol m-2 wood surface s-1)
8
6
4
2
0
3.7 ± 3.6***
2 ± 1.6
3.9 ± 3.2
Andiroba
Macaranduba
Tauari
Tree species (km 83 - Logged area)

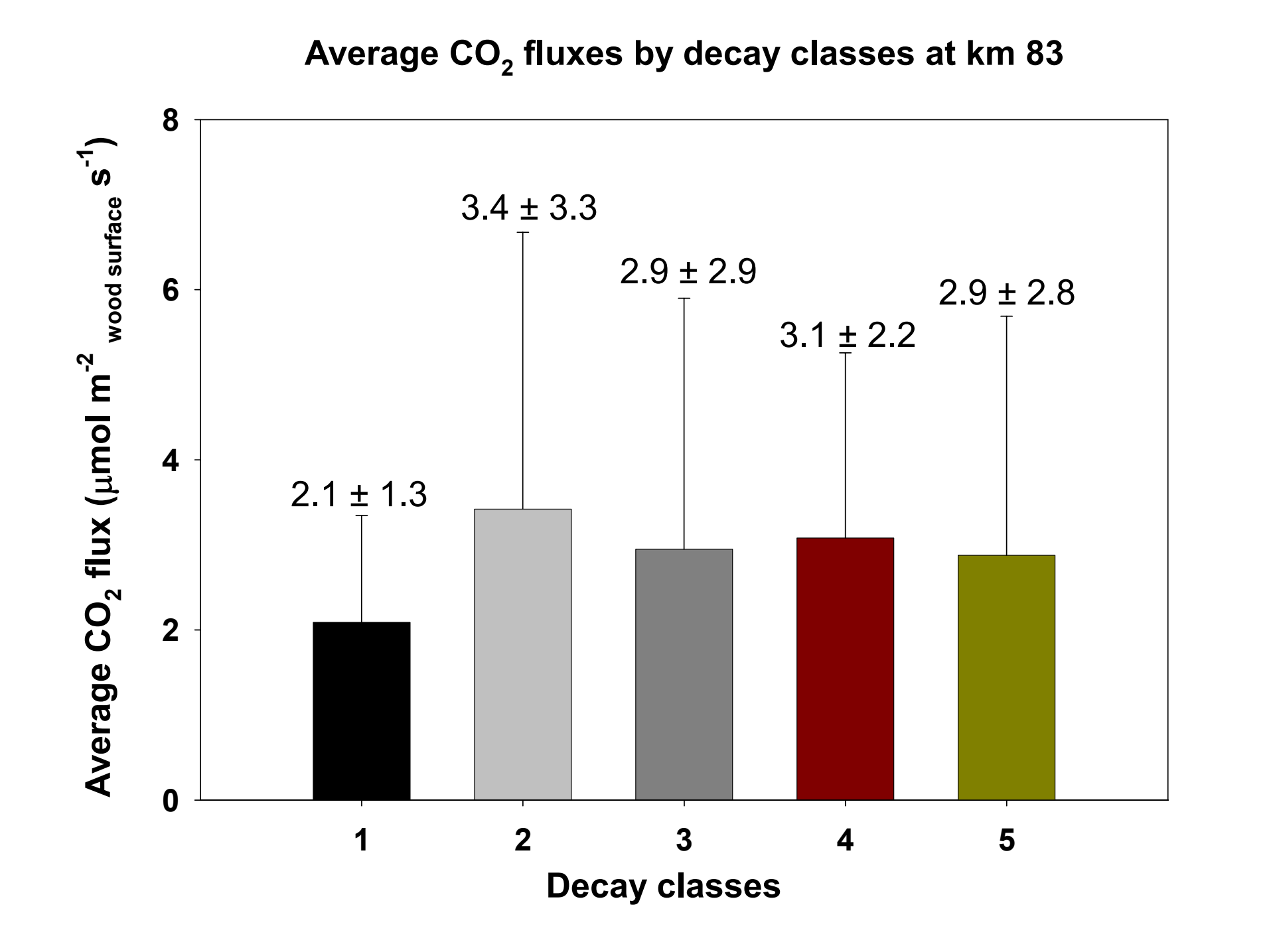

CO2 variation (2003 - 2004)
CO2
moisture content
Daily average CO2 flux (µmol m-2 wood surface s-1)
Daily average moisture content (gH2O gdry wood-1)
day of the year
0
2
4
6
8
10
12
20
40
60
80
100
120
200
300
400
500
600
700

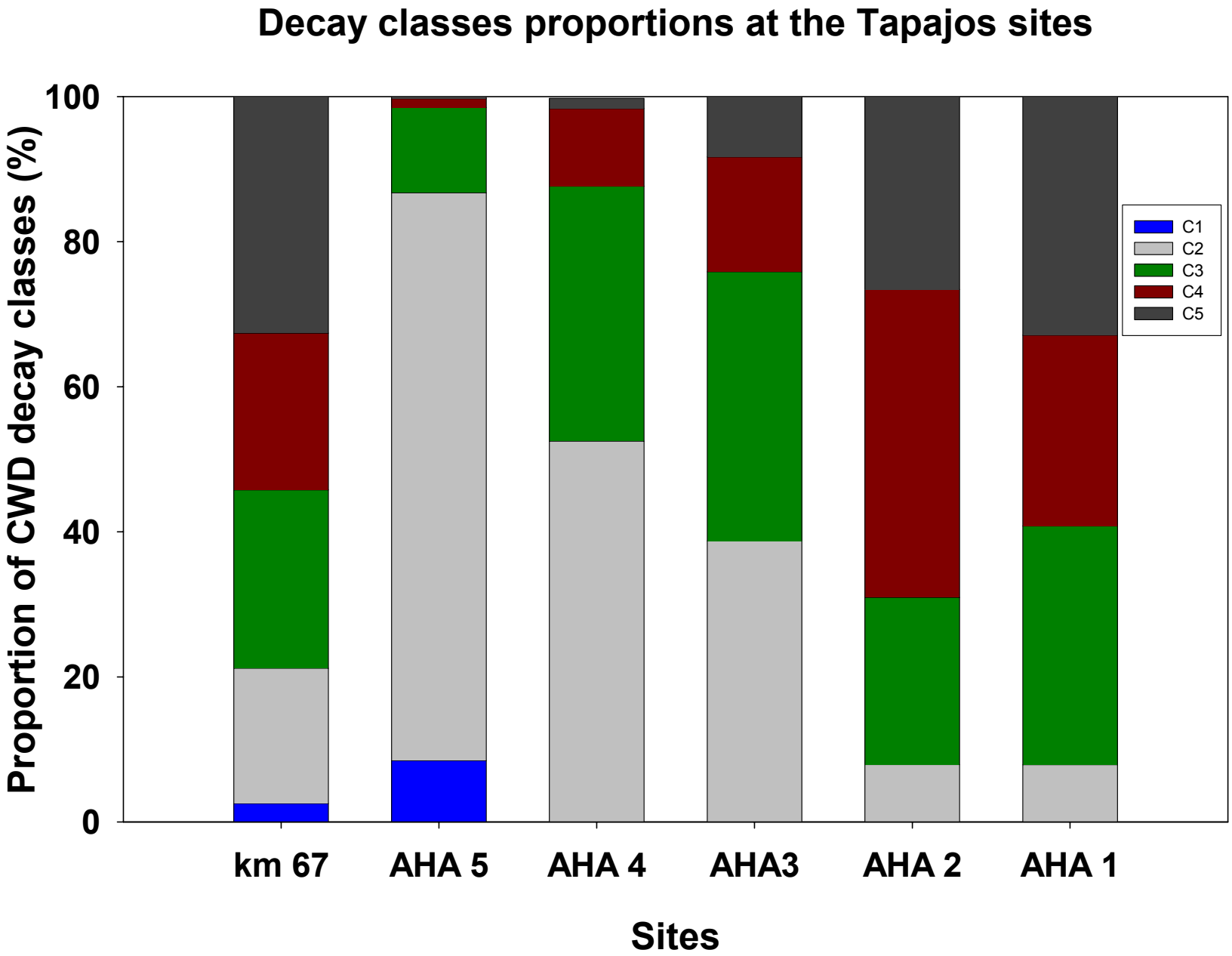

Andiroba (*Carapa guianensis*)
Ln CO_2 flux (µmol m^{-2} $_{wood\ surface}$ s^{-1})
Ln moisture (gH_2O gdry $wood^{-1}$)
3
2
1
0
-1
-2
-3
-4
2.5
3.0
3.5
4.0
4.5
5.0
< 10 cm
> 10 cm
y = 1.90588x - 7.23985
adj-r^2 = 0.49

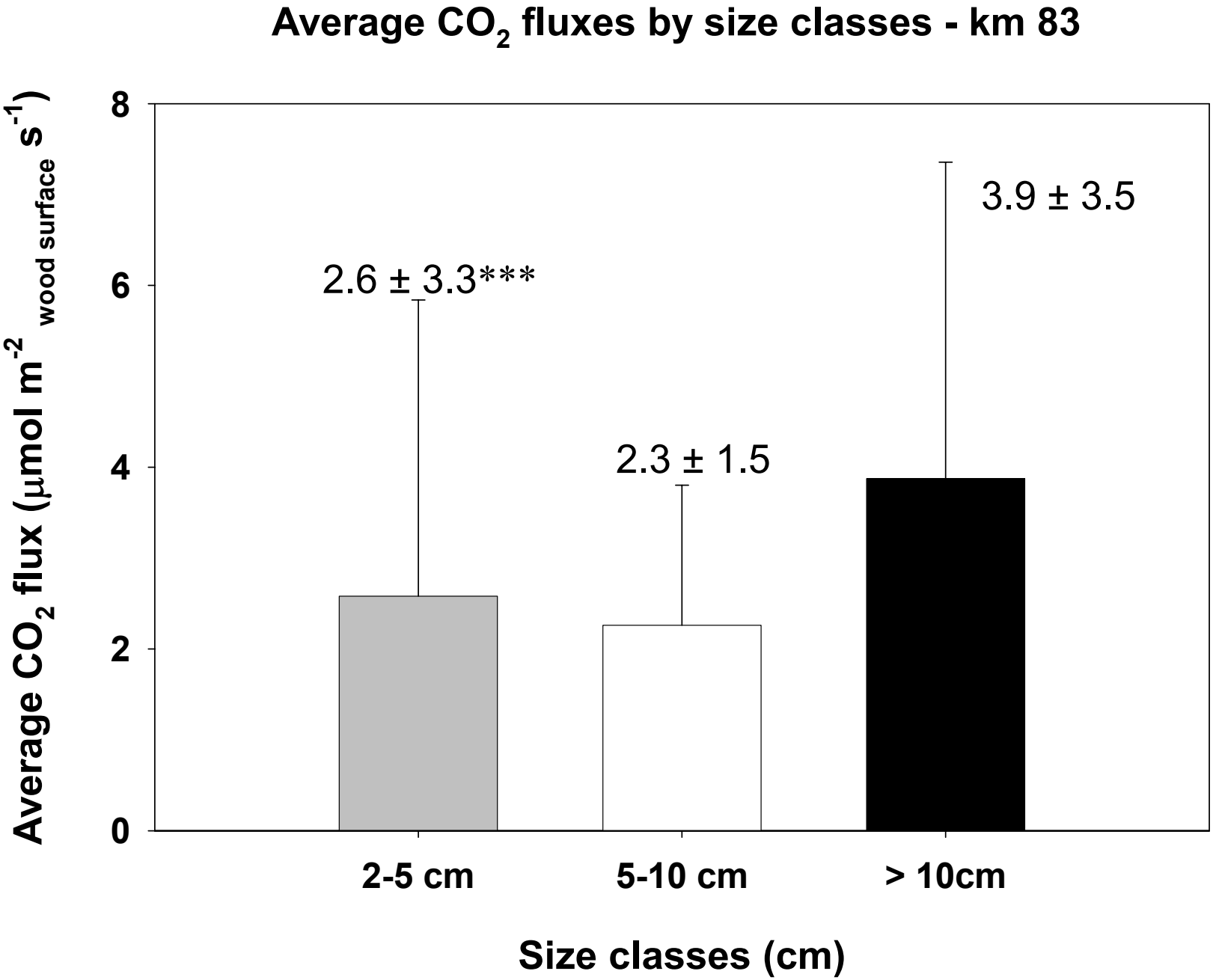

Macaranduba (*Manilkara huberi*)
Ln CO_2 flux (µmol m^{-2} $_{wood\ surface}$ s^{-1})
Ln moisture (gH_2O gdry $wood^{-1}$)
2
1
0
-1
-2
-3
2.8
3.0
3.2
3.4
3.6
3.8
4.0
4.2
4.4
4.6
< 10 cm
> 10 cm
y = 0.676006x - 2.32598
adj-r^2 = 0.06

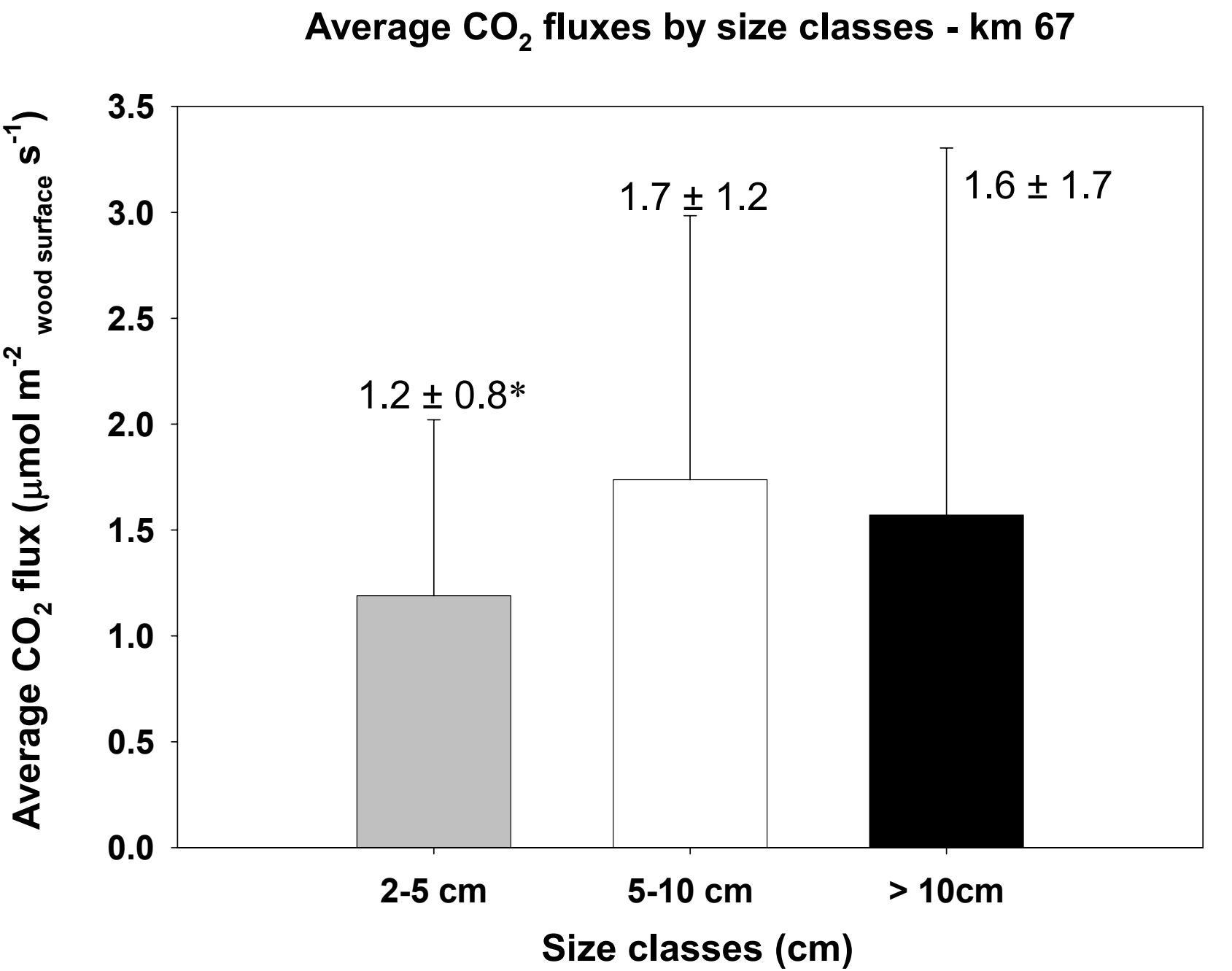

Tauari (*Couratari stellata*)
Ln CO_2 flux (µmol m^{-2} $_{wood\ surface}$ s^{-1})
Ln moisture content (gH_2O gdry $wood^{-1}$)
3
2
1
0
-1
-2
-3
3.0
3.2
3.4
3.6
3.8
4.0
4.2
4.4
4.6
4.8
< 10 cm
> 10 cm
y = 2.16633x - 8.17526
adj-r^2 = 0.52

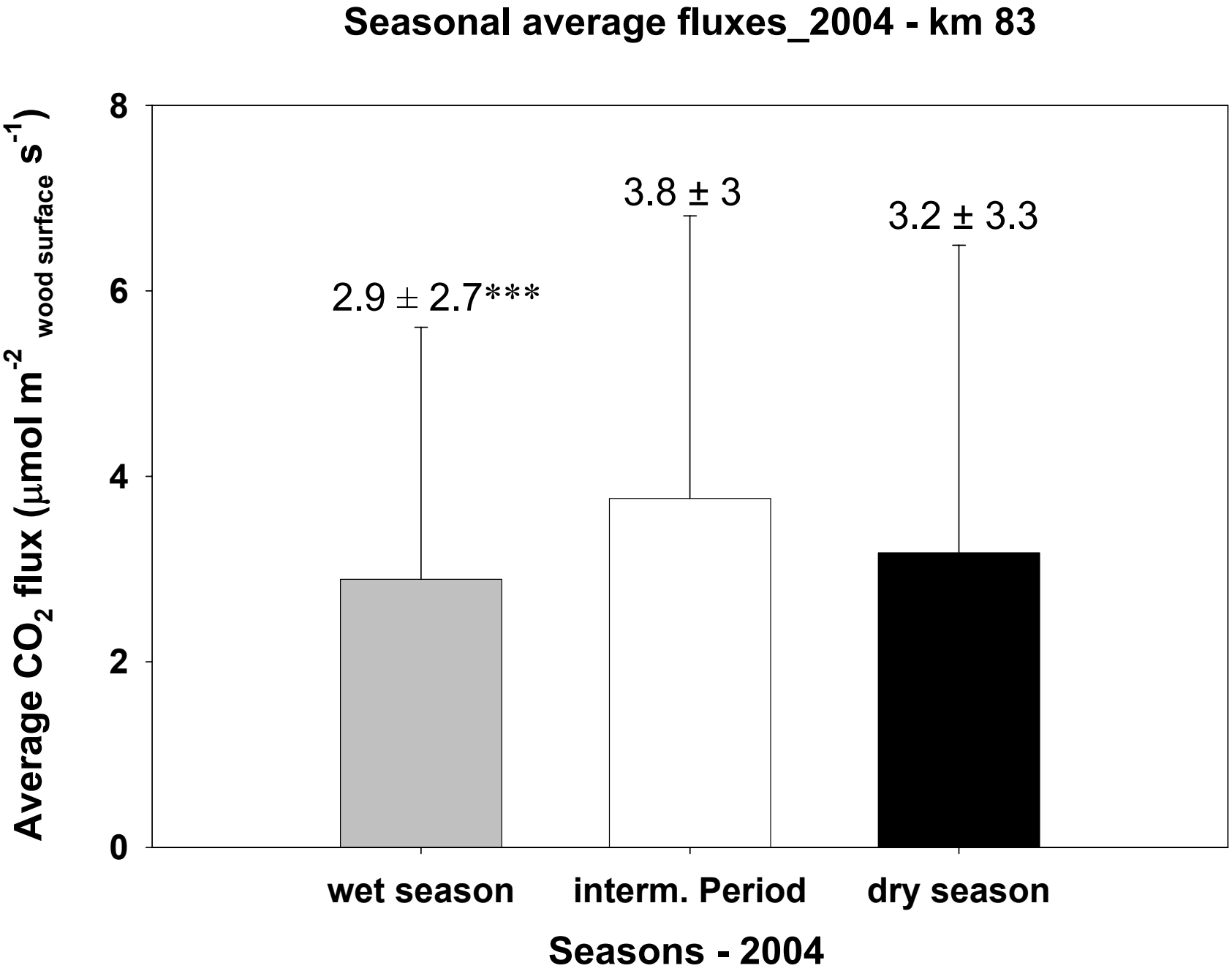

Average CO_2 fluxes by decay classes at km 67
Average CO_2 flux (μmol m^{-2} wood surface s^{-1})
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.6 ± 0.8
1.5 ± 1
1.5 ± 1.5
1.5 ± 1
1.2 ± 1
1
2
3
4
5
Decay classes


Average CO_2 fluxes by decay classes at km 83
Average CO_2 flux (μmol m^{-2} wood surface s^{-1})
0
2
4
6
8
2.1 ± 1.3
3.4 ± 3.3
2.9 ± 2.9
3.1 ± 2.2
2.9 ± 2.8
1
2
3
4
5
Decay classes


Decay classes proportions at the Tapajos sites
Proportion of CWD decay classes (%)
100
80
60
40
20
0
C1
C2
C3
C4
C5
km 67
AHA 5
AHA 4
AHA3
AHA 2
AHA 1
Sites


Average CO_2 fluxes by size classes - km 83
Average CO_2 flux (μmol m^{-2} wood surface s^{-1})
8
6
4
2
0
2.6 ± 3.3***
2.3 ± 1.5
3.9 ± 3.5
2-5 cm
5-10 cm
> 10cm
Size classes (cm)


Average CO_2 fluxes by size classes - km 67
Average CO_2 flux (μmol m^{-2} wood surface s^{-1})
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.2 ± 0.8*
1.7 ± 1.2
1.6 ± 1.7
2-5 cm
5-10 cm
> 10cm
Size classes (cm)


Seasonal average fluxes_2004 - km 83
Average CO_2 flux (μmol m^{-2} wood surface s^{-1})
8
6
4
2
0
2.9 ± 2.7***
3.8 ± 3
3.2 ± 3.3
wet season
interm. Period
dry season
Seasons - 2004

Conclusions

- Increase in CWD post-logging greatly increased CO_2 emissions

- Km 67 has large amount of CWD in very decayed classes, which may reduce the fluxes due to more recalcitrant substrate (lignin) to be decomposed

- CO_2 emissions were controlled by wood water content

- Large diameter logs emitted higher amounts of CO_2 by showing more stable microclimatic conditions allowing to preserve water even during dry season favoring microbial activity

cont.

- Reduced emissions of CO_2 during wet season in 2004 were due to increase in wood water content limiting oxygen availability

- High fluxes during the intermediate period are result from optimal environmental conditions when water is not a reduced limiting factor nor limits aerobic conditions

- At km 67, the turnover of CWD, based on the measurements of CWD pool from Keller *et al*. (2004) and the emission rates we captured was about 0.032 yr^{-1}

- CO_2 fluxes at km 67 contributed with an amount of 1.6 Mg C ha^{-1} yr^{-1}

- CO_2 fluxes at km 83: 3.22 µmol CO_2 m^{-2} $_{wood\ surface}$ s^{-1}

Acknowledgements

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IBAMA

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