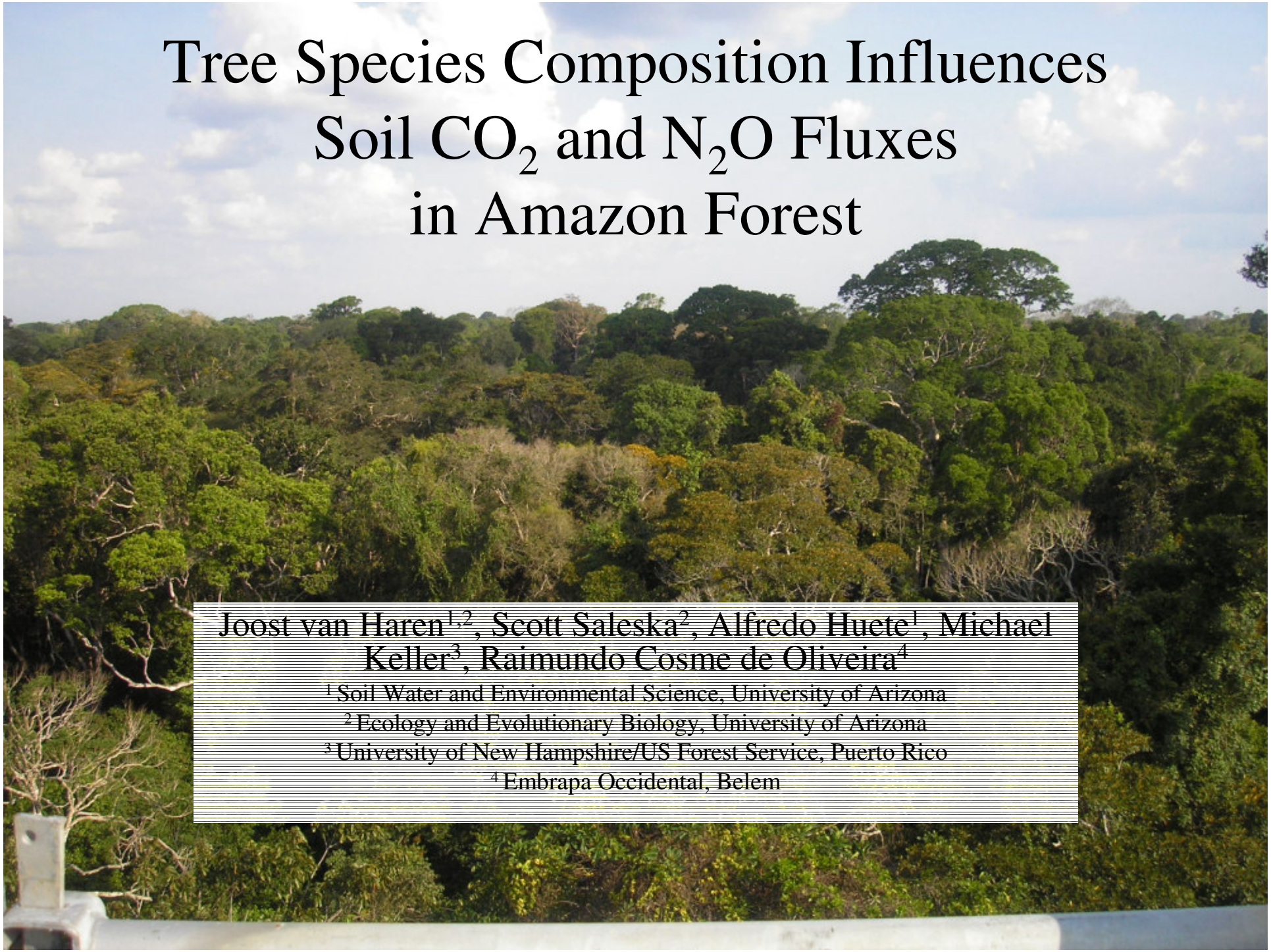
Tree Species Composition Influences Soil CO_2 and N_2O Fluxes in Amazon Forest



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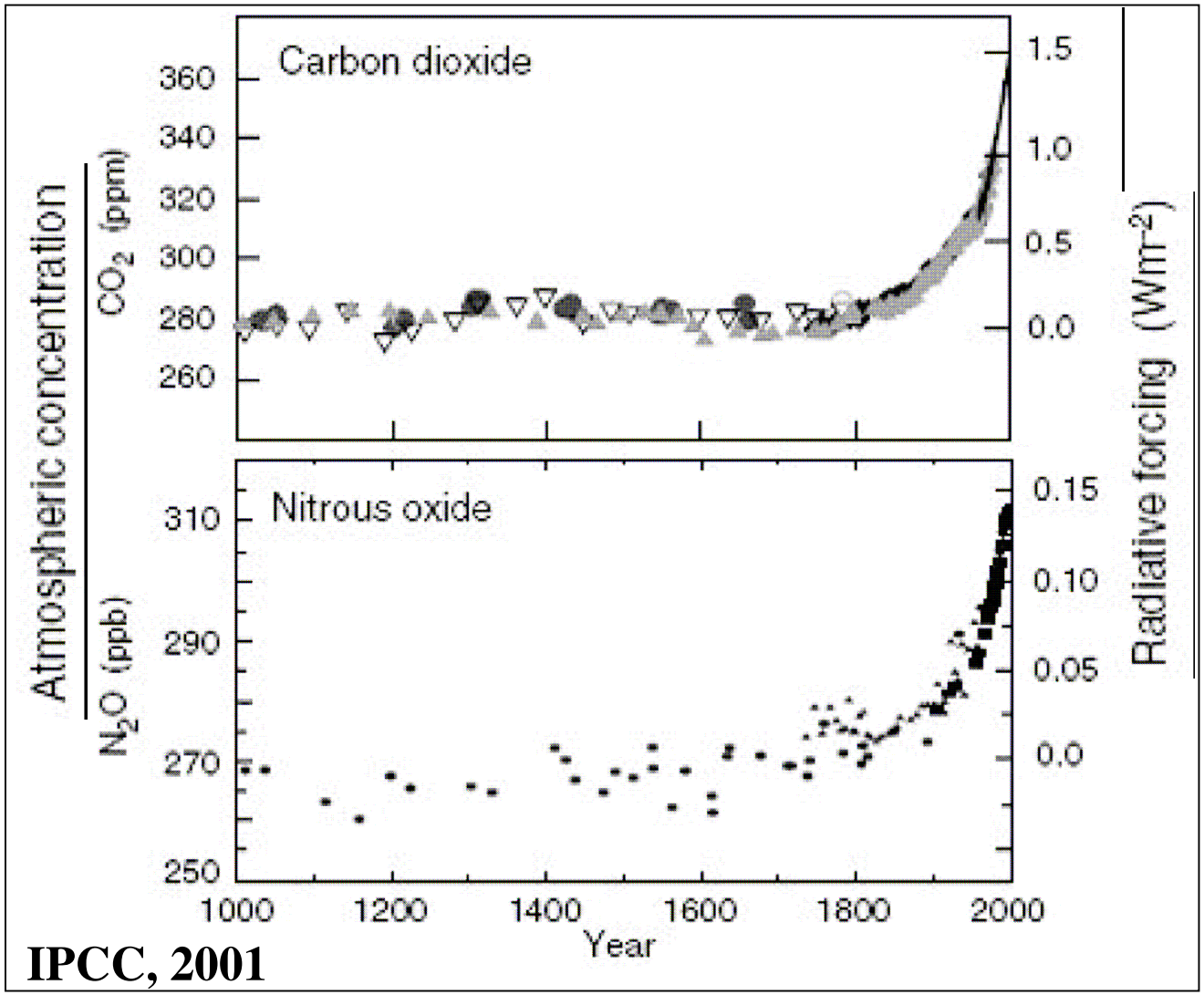
[4] Embrapa Occidental, Belem

Why measure tropical soil CO_2 and N_2O fluxes?



IPCC, 2001

Contribution of tropical soils to global budget

CO_2: largest soil source (Raich and Schlesinger, 1992)

N_2O: ~20% all natural sources (Bouwman et al., 1993)

Biogeochemical models

- Include:
  - Temperature
  - Precipitation
  - Soil Parameters
    - Moisture
    - Texture
    - C/N
  - Substrate quality and quantity

NGAS (Parton et al. 1996)

ECOSYS (Grant & Pattey, 1999)

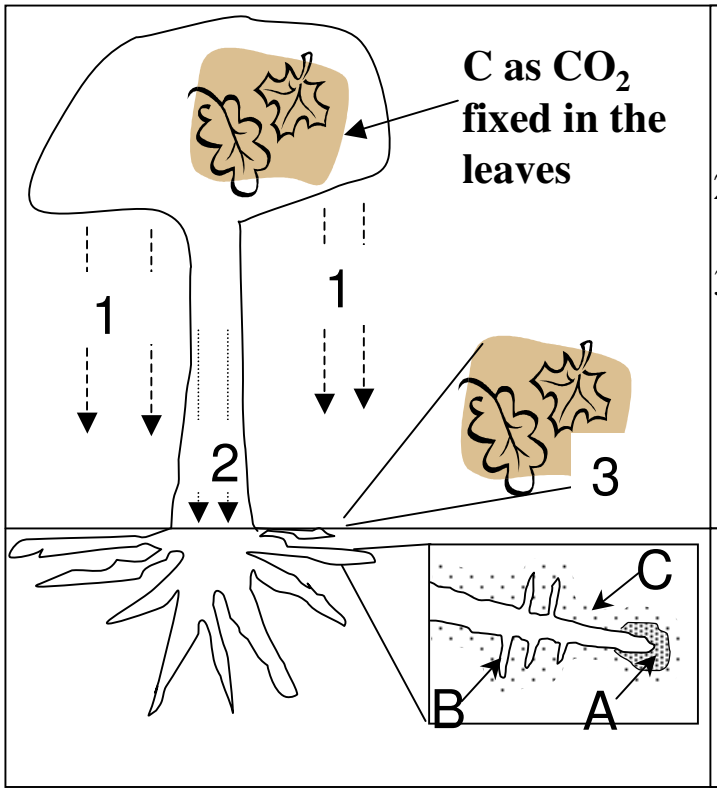
Century (Liu et al. 2000)

PnET-N-DCDN (Li et al. 2000)

NASA-CASA (Potter et al. 2001)

Tree species are not explicitly considered

Plants influence on soil C

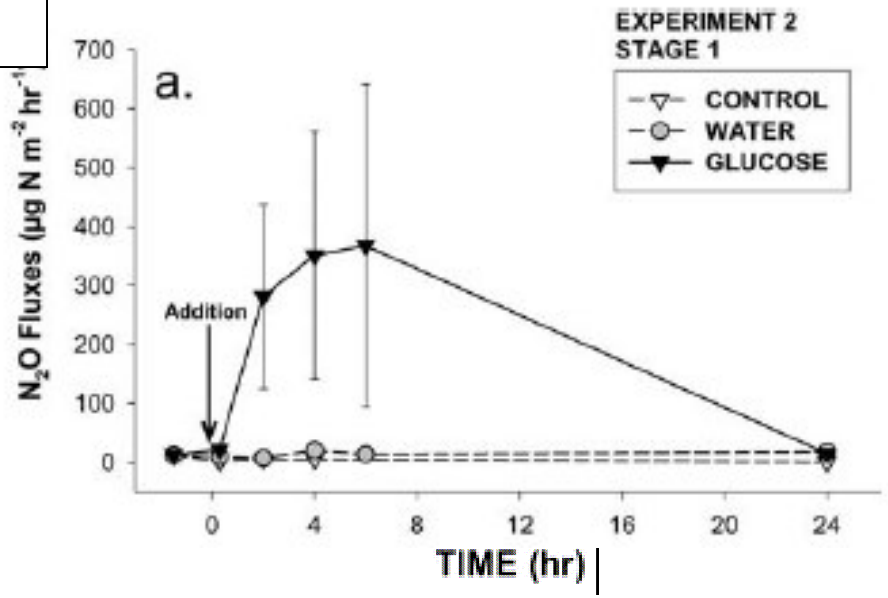


1. C transport to soil through leaf drop
2. C transport in phloem
3. Leaf and root decomposition

A. border cell and mucilage
B. respiration
C. exudation

and available C on heterotrophic denitrifiers

Garcia-Montiel et al. (2003) added water and glucose to forest soil in Rondonia



Glucose amplifies N_2O fluxes

Hypotheses

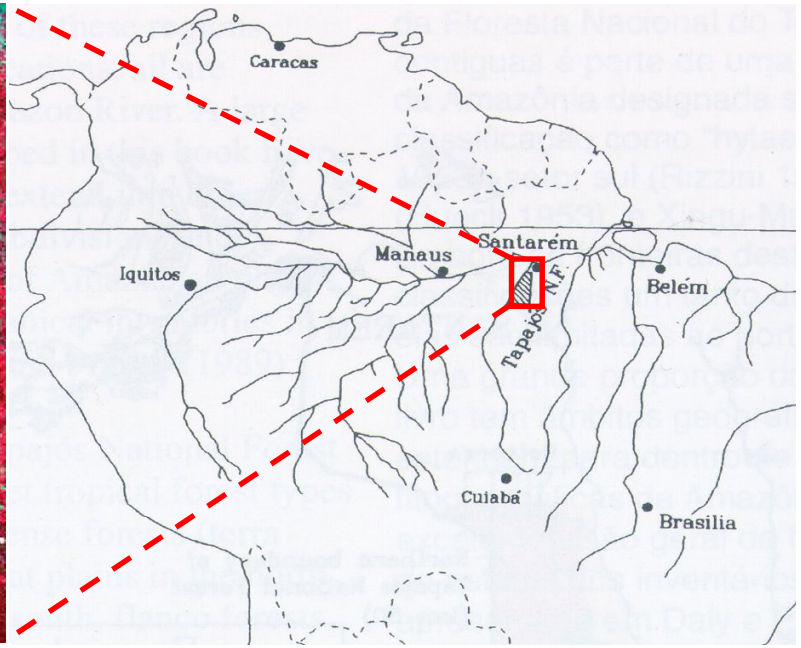
- **Plant species traits and biomass significantly influence soil CO_2 and N_2O fluxes.**

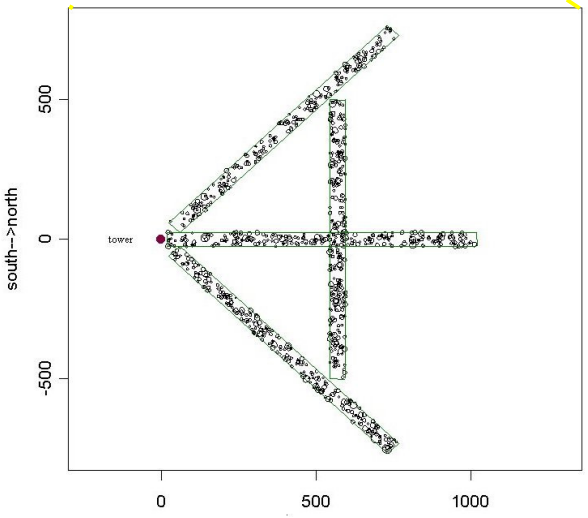
- **Satellite based remote sensing could help scale trace gas fluxes, through detecting species traits (such as leaf N content) and biomass.**

Tapajós National Forest

Belterra Plantation

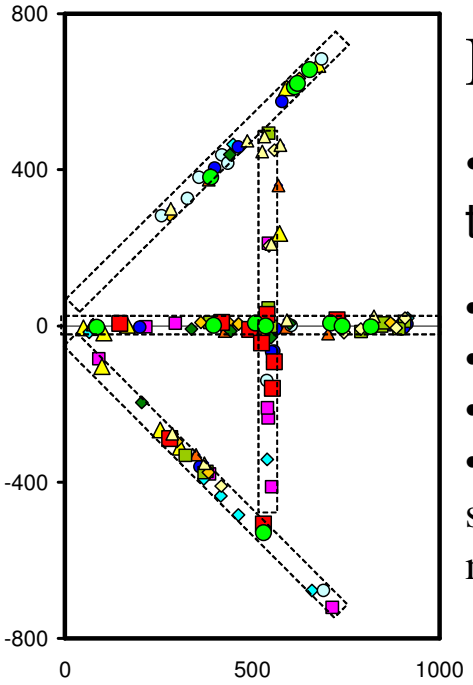
- Mature trees planted in 1978
- Pure and mixed species plots
- Soil texture: >80% clay and < 5% sand





Km 67 Tower location

- Standing Biomass inventory since 1999
- Very diverse: 263 tree species
- Soil texture: >80% clay and < 5% sand



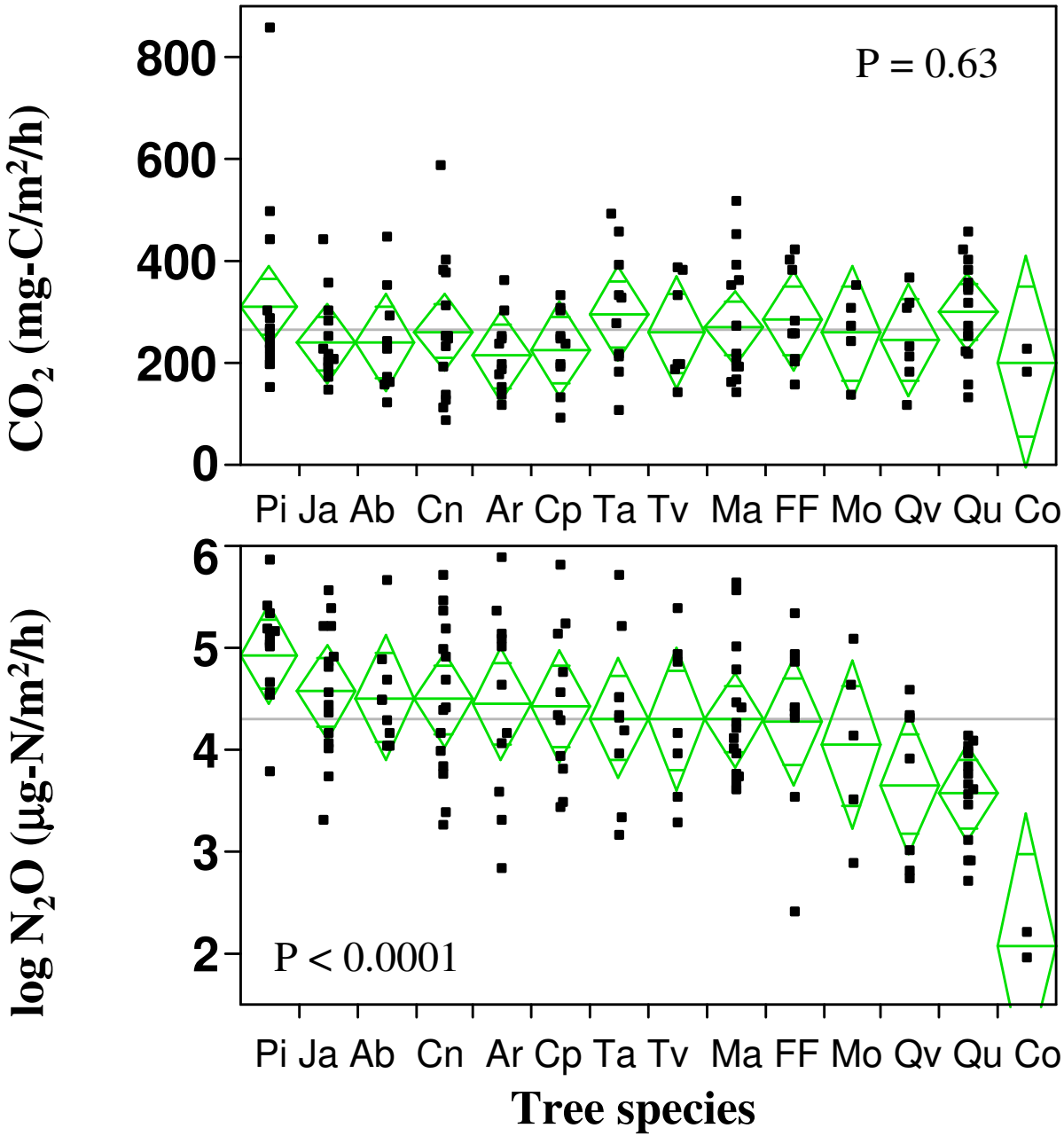
Field measurements

- 167 flux locations near 14 tree species

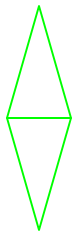
- Gas flux
- air and soil T
- 0-3 cm BD and %WFPS
- DBH of main tree and DBH and species of all trees > 1 cm within a 3 m radius

Tree species (C = canopy, E = emergent, P = pioneer)		**Base area % of total**
Caryocar villosum (Piquiá, E)	PI	3.3
Bertholletia excelsa (Castanha de para, E)	CP	2.1
Chamaecrista sp. xinguensis (Coração de negro, C)	CN	6.2
Couratari stellata (Tauarí, E)	TA	6.4
Erisma uncinatum (Quarubarana, E)	QU	16.3
Lecythis lurida (Jarana, E)	JA	7.0
Manilkara huberi (Maçaranduba, E)	MA	9.6
Schefflera morototoni (Morototo, P)	MO	0.5
Pseudopiptadenia psilostachya (Fava folha fina, E)	FF	2.3
Sclerolobium chrysophyllum (Tachi vermelho, C)	TV	3.5
Pouteria reticulata (Abiu, C)	AB	1.4
Vochysia maxima (Quaruba verdadeira, E)	QV	3.6
Astronium lecointei (Aroeira, C)	AR	0.74
Copaifera multijuga (Copaíba, C)	CO	3.0

Km 67 Forest Fluxes



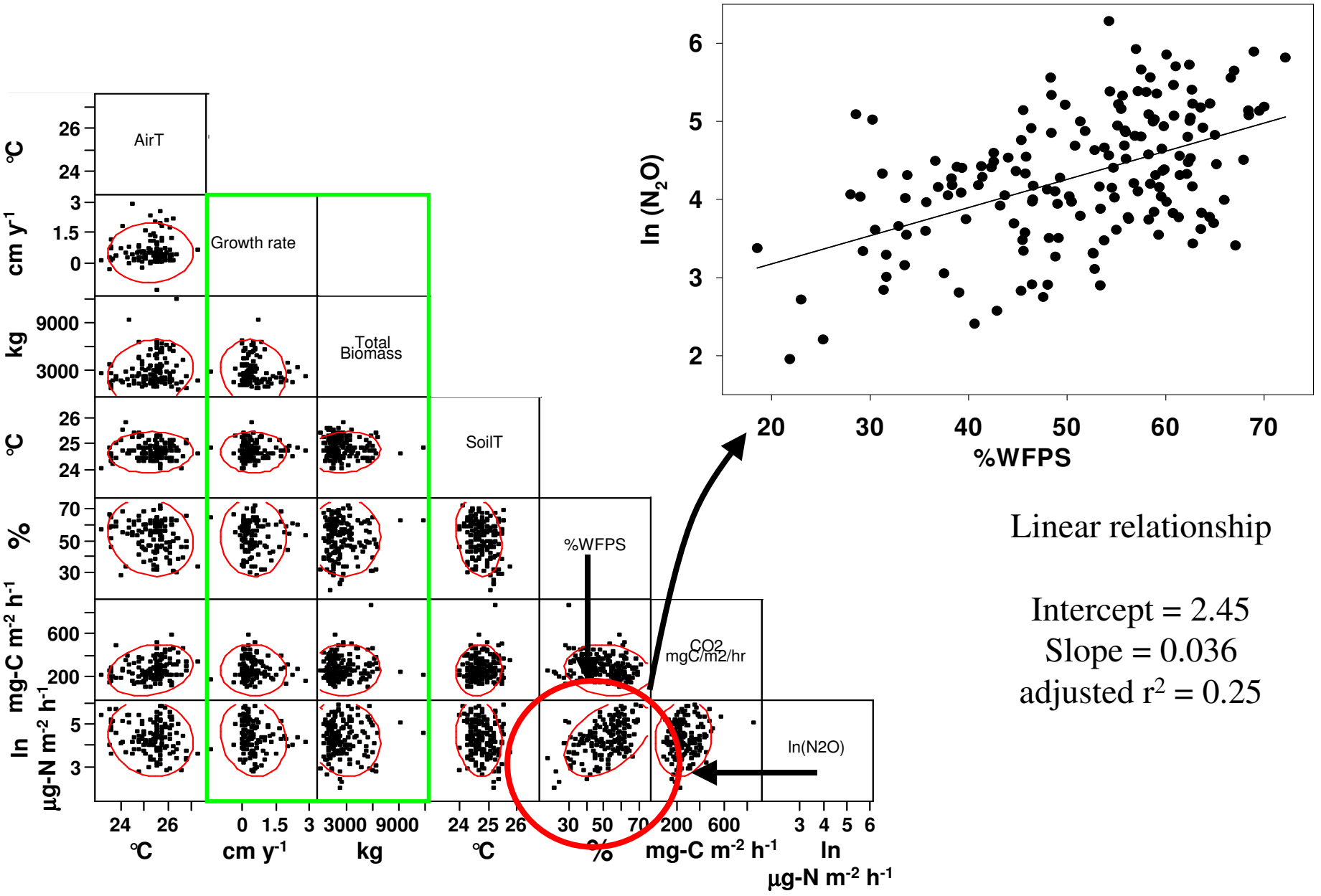
Data do not support that forest tree species composition alters soil CO_2 flux



Mean ± 95% CI

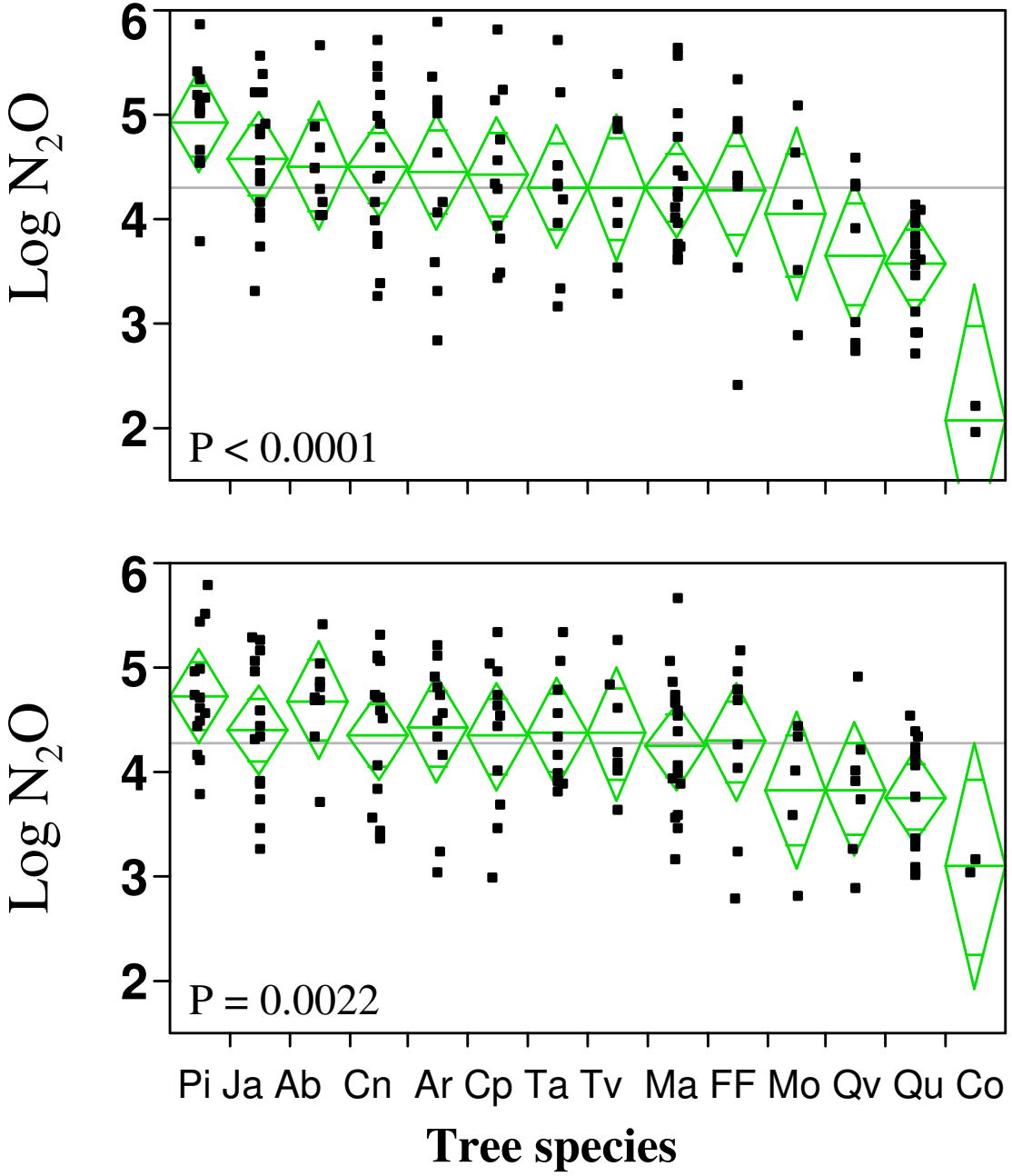
- Soil N_2O fluxes are different from overall mean
- Soil N_2O flux close to PI > QV, QU, and CO (at $\alpha = 0.05$ using Tukey-Kramer HSD test)

Effects of biological and physical parameters



Linear relationship

Intercept = 2.45
Slope = 0.036
adjusted r^2 = 0.25



Soil N_2O flux close to Pi > Qv, Qu, and Co (at α = 0.05 using Tukey-Kramer HSD test)

Correct for %WFPS

Soil N_2O flux close to Pi and Ab > Qu (at α = 0.05 using Tukey-Kramer HSD test)

Mean ± 95% CI

Forest conclusions and last note

1. Soil CO_2 emissions appear to be unaffected by tree species composition
2. Soil N_2O emissions are consistently higher close to *Caryocar villosum* (Piquiá) relative to *Erisma uncinatum* (Quarubarana).
3. Even when corrected for %WFPS

N_2O flux $\mu g\text{-}N\ m^{-2}\ hr^{-1}$	Mean	-95%	+95%
Grand mean	71.9	63.5	81.3
Species means	67.9	45.4	102.1
Background mean	38.9	50.4	30.0

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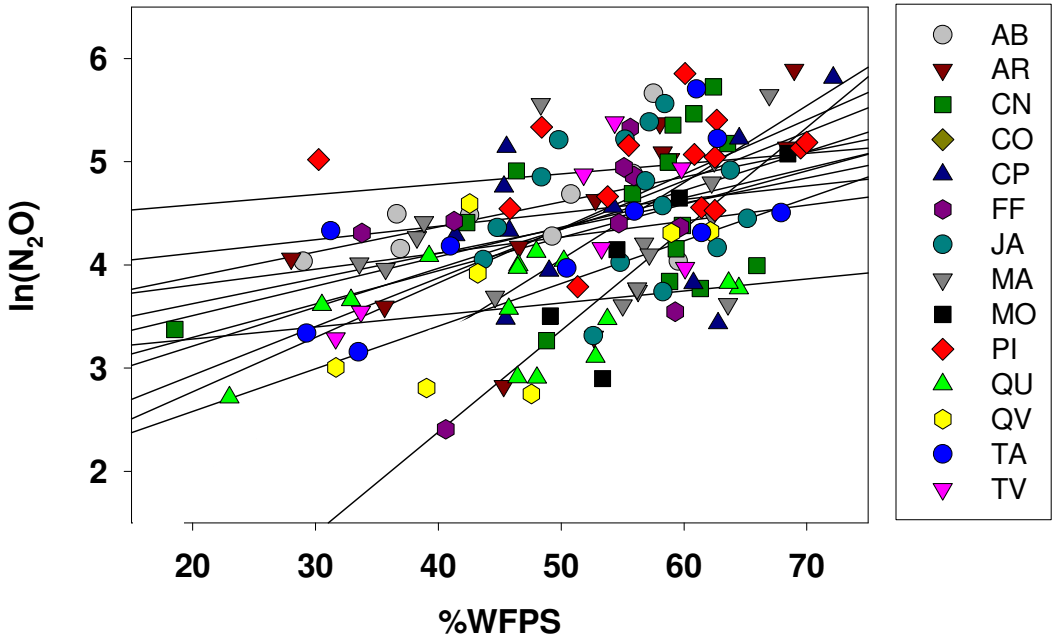
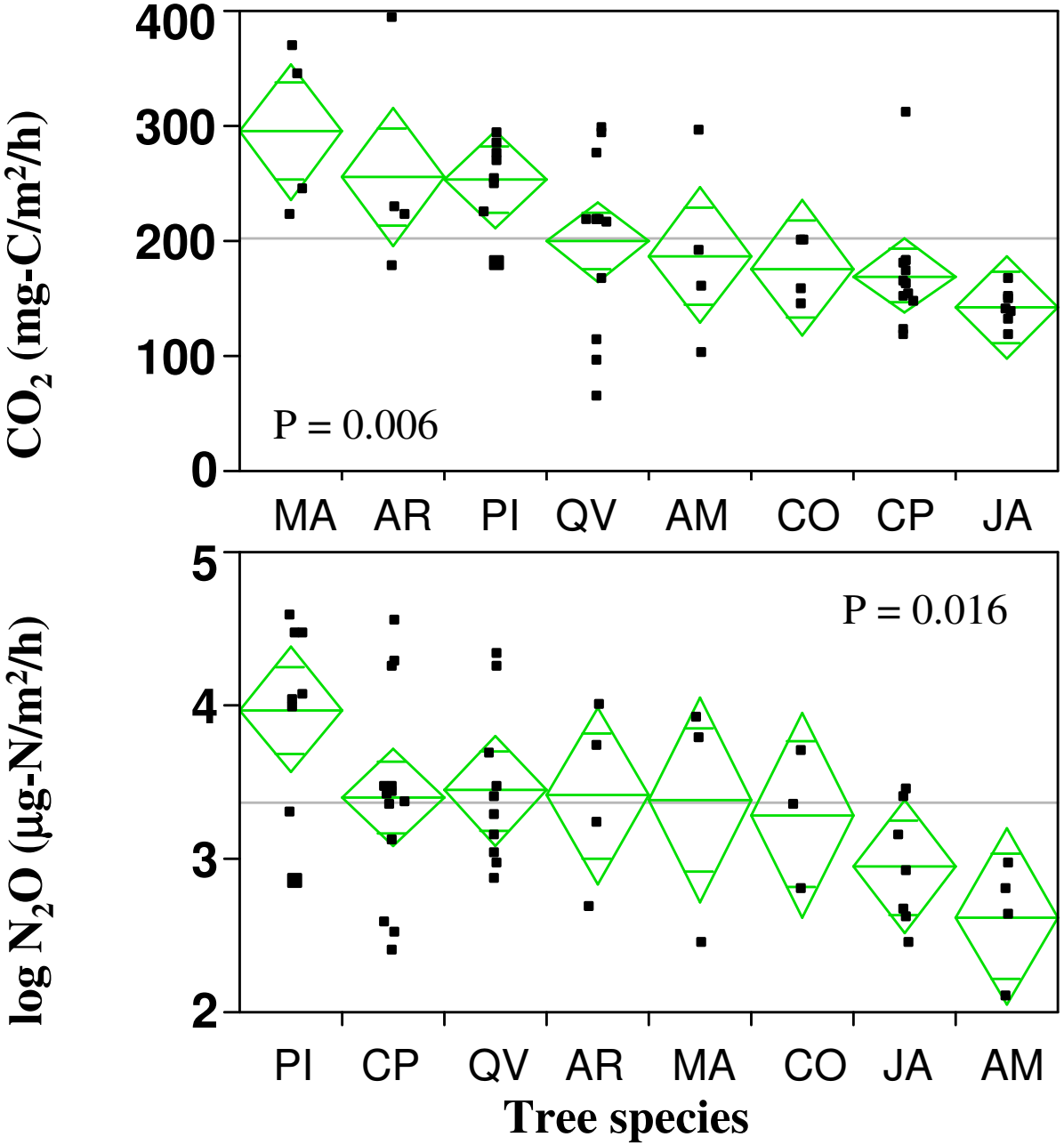
However:



The relationship between %WFPS and $\ln(N_2O)$ might be species dependent

Belterra Plantation Fluxes

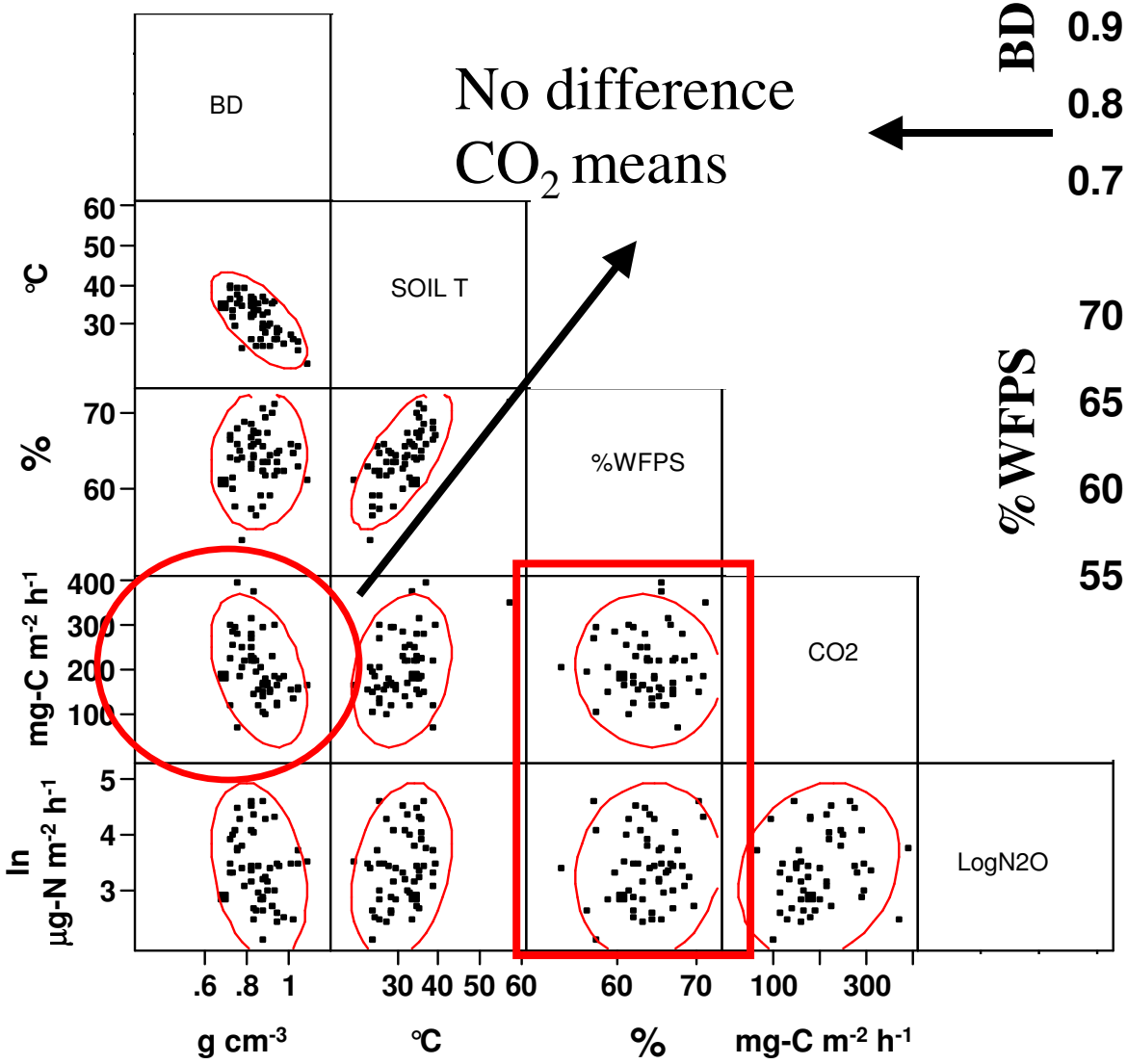


Soil CO_2 fluxes under MA and PI > CP and JA

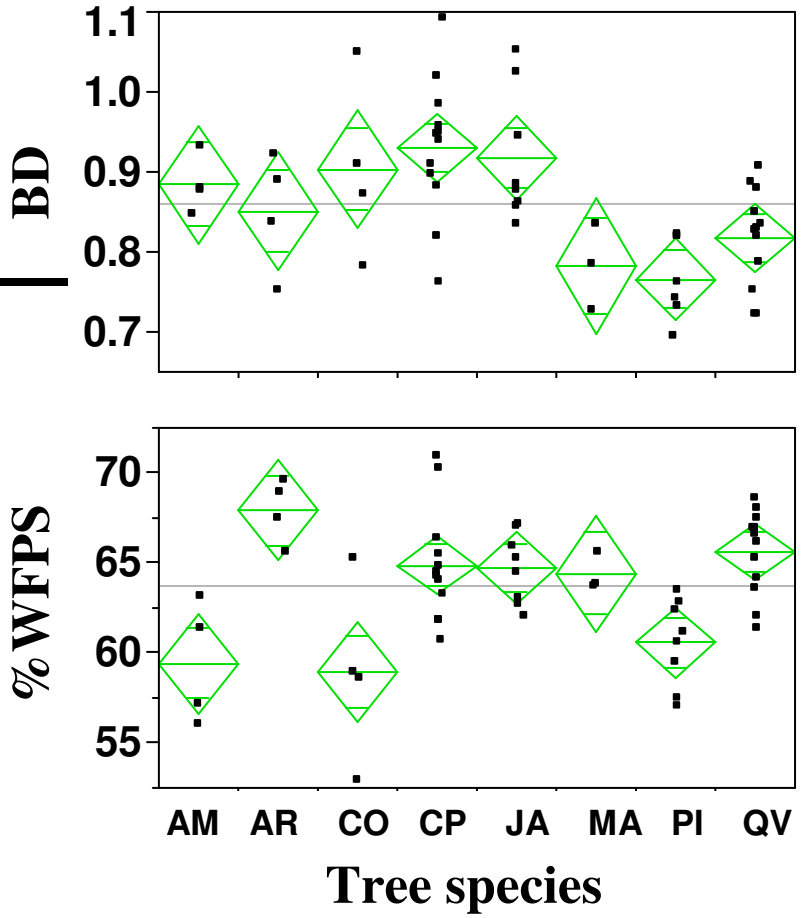
Mean ± 95% CI

Soil N_2O fluxes under Pi > JA and AM

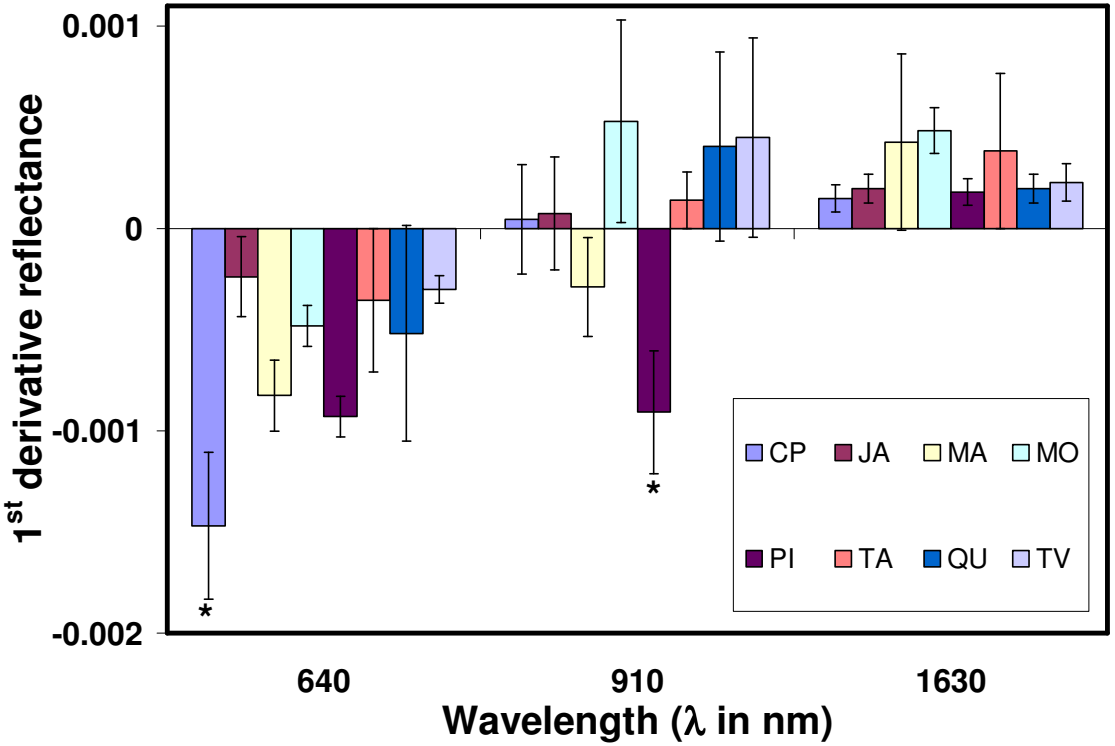
Effects of physical parameters



No difference CO_2 means



No correlation between %WFPS and ln(N_2O)

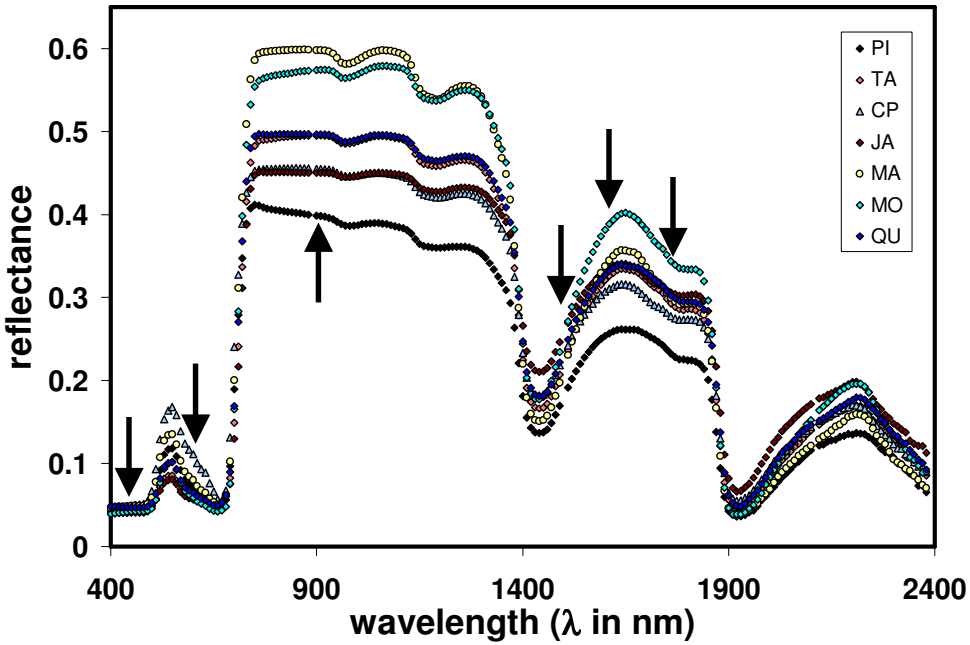


Remote sensing

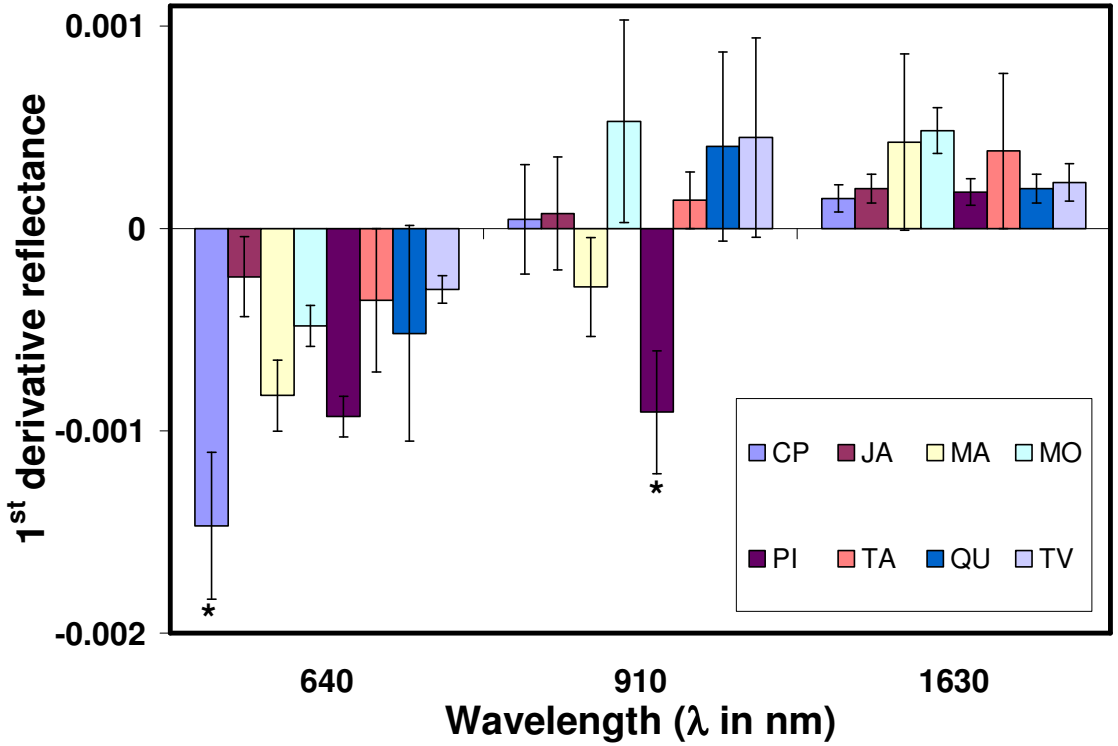
Leaf reflectance of key tree species in the Tapajos Forest are different at know N and protein absorption wavelengths

Leaf samples collected and measured with handheld ASD hyperspectral spectrometer by Timoaki Miura

Mean leaf reflectance spectra



Arrows indicate key N and protein Absorption bands



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Tree species means

Using PLS regression with spectral areas of known N and protein absorption features

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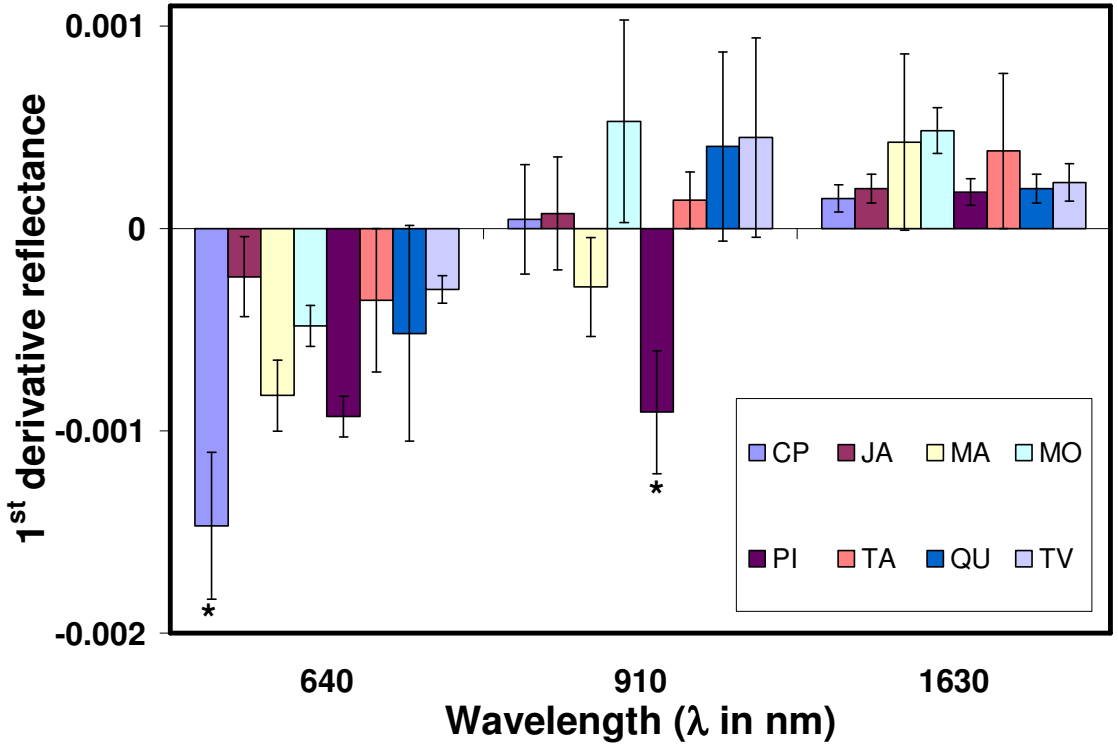

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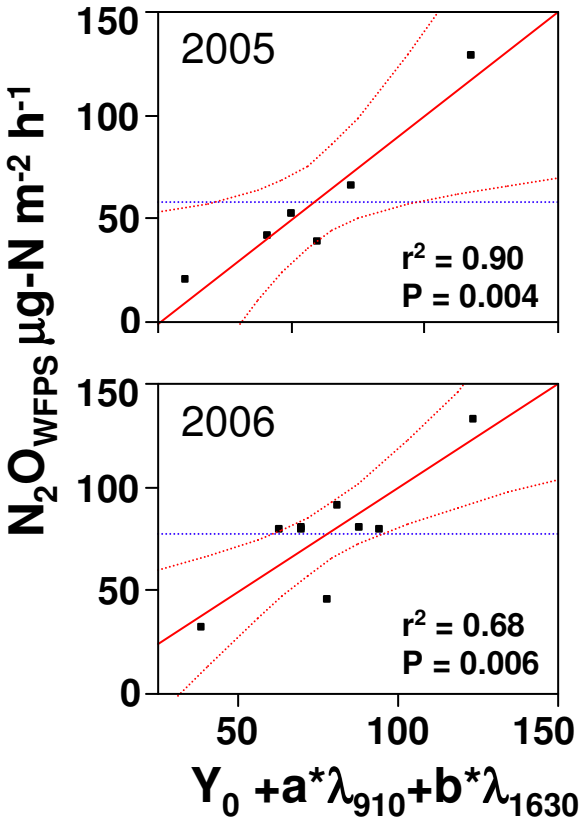

Conclusions

- Forest soil N_2O fluxes close to Piqua trees are greater than Quarubarana trees
- On the plantation tree species appear to influence both soil CO_2 and N_2O fluxes
- Hyperspectral techniques are able to distinguish tree species and could be used to predict plantation soil fluxes and determine soil N_2O 'hotspots' in forests.

This work would have been impossible without the fantastic help from the Santarem Field staff. Especially: