Considering scale when assessing wetland methane emissions: Wetland forest soils versus wetland forests.

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Orlando (Florida), 5th June 2012

The Open University CEPSAR
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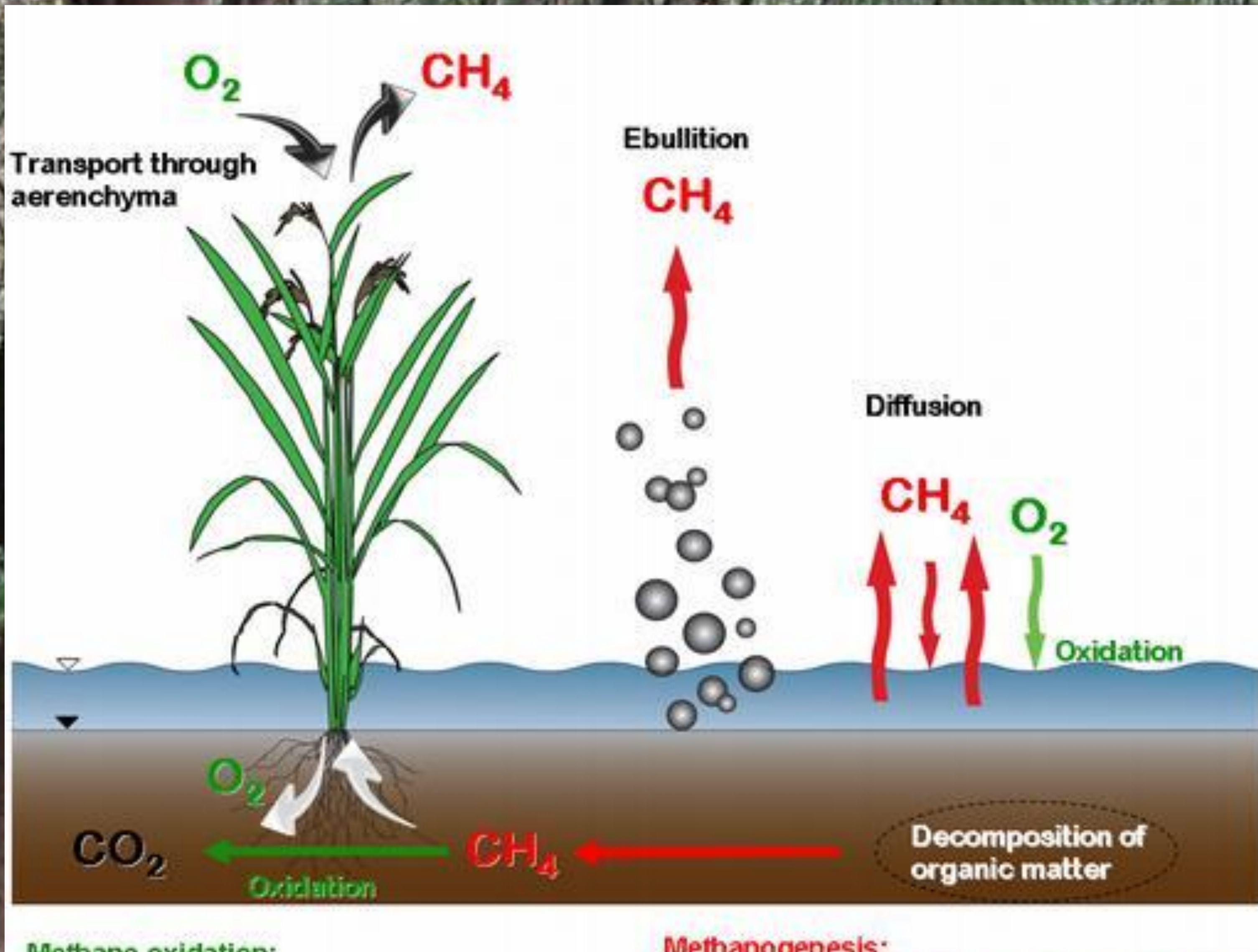
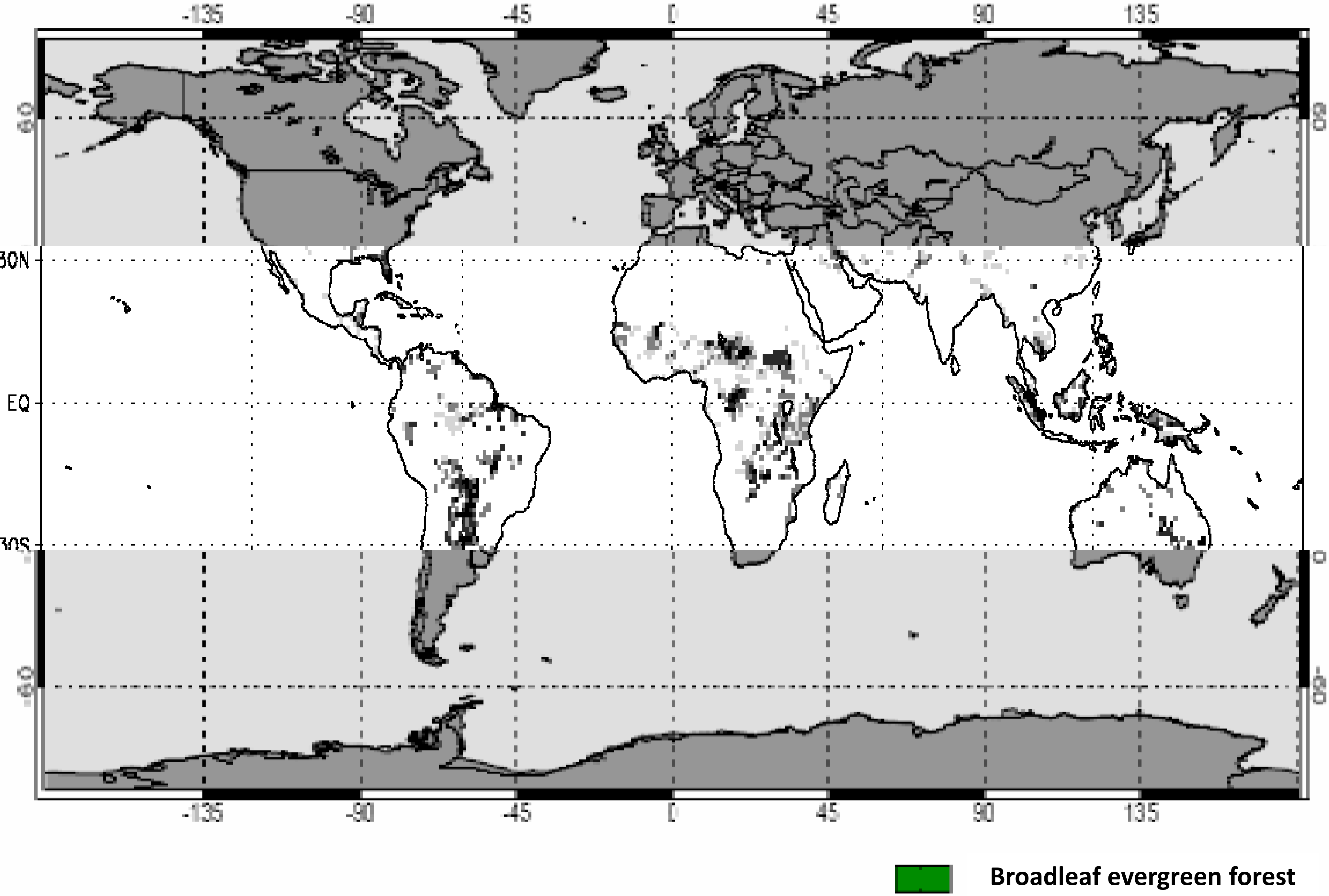
METHANENET

Do we know all the transport pathways?




-135
-90
-45
0
45
90
135
60
30N
EQ
30S
-60
Broadleaf evergreen forest

GEOPHYSICAL RESEARCH LETTERS, VOL. 37, L03807, doi:10.1029/2009GL041565, 2010

Emissions of anaerobically produced methane by trees

Andrew L. Rice,[1] Christopher L. Butenhoff,[1] Martha J. Shearer,[1] Doaa Teama,[1]
Todd N. Rosenstiel,[2] and M. Aslam K. Khalil[1]

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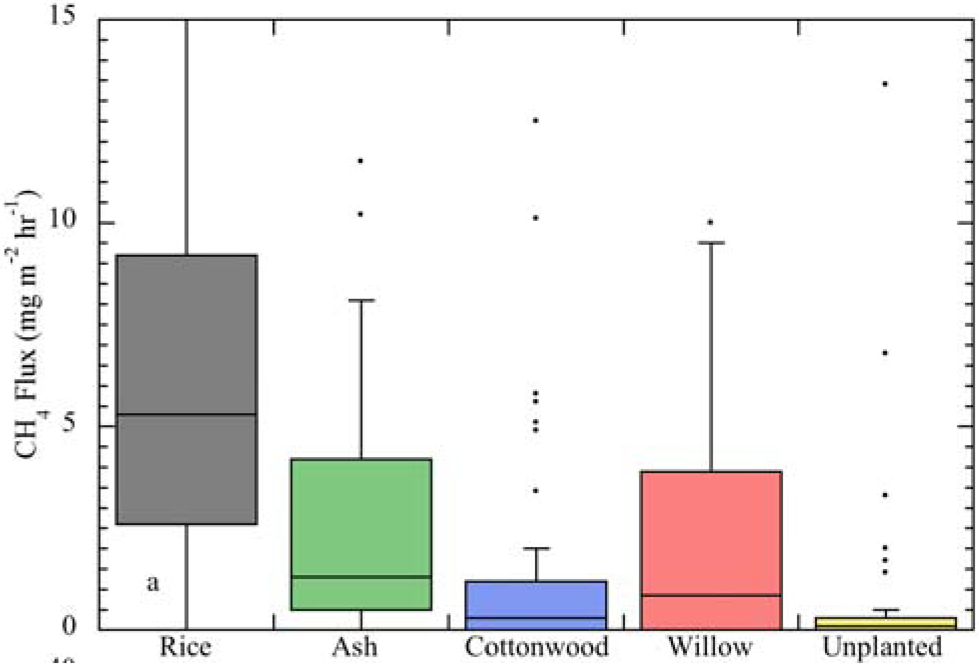

- Greenhouse study on pot grown tree seedlings in rice soil.
- Emission pathways not identified (assumed to be transpiration in leaves).
- Emissions scaled to the globe using LAI
- Estimate that wetland trees contribute around 60Tg CH_4

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ATMOSPHERIC ENVIRONMENT

Short communication

Woody stem methane emission in mature wetland alder trees

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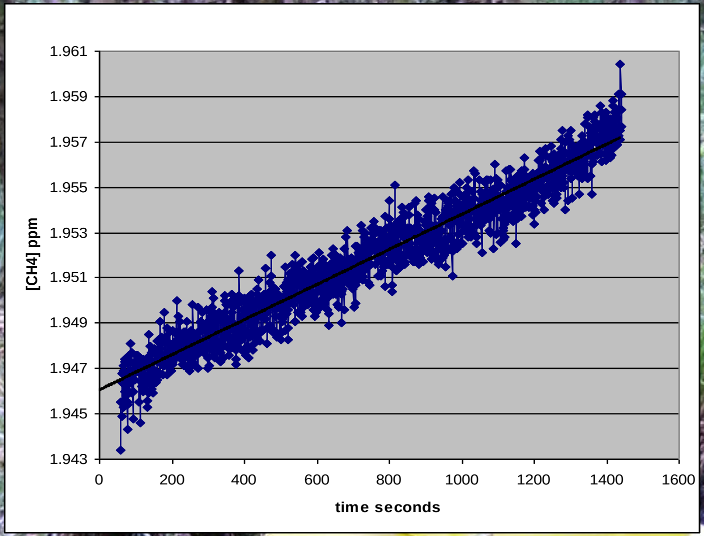


Methods: Approach to understanding tree contributions to forested wetland CH_4 emissions at the ecosystem scale.

- A mesocosm study to examine the controls and pathways of tree emission.
- A one-year *in situ* study in a temperate alder carr ecosystem
- An *in situ* study in tropical peat swamp forest in Kalimantan

MethaneNet

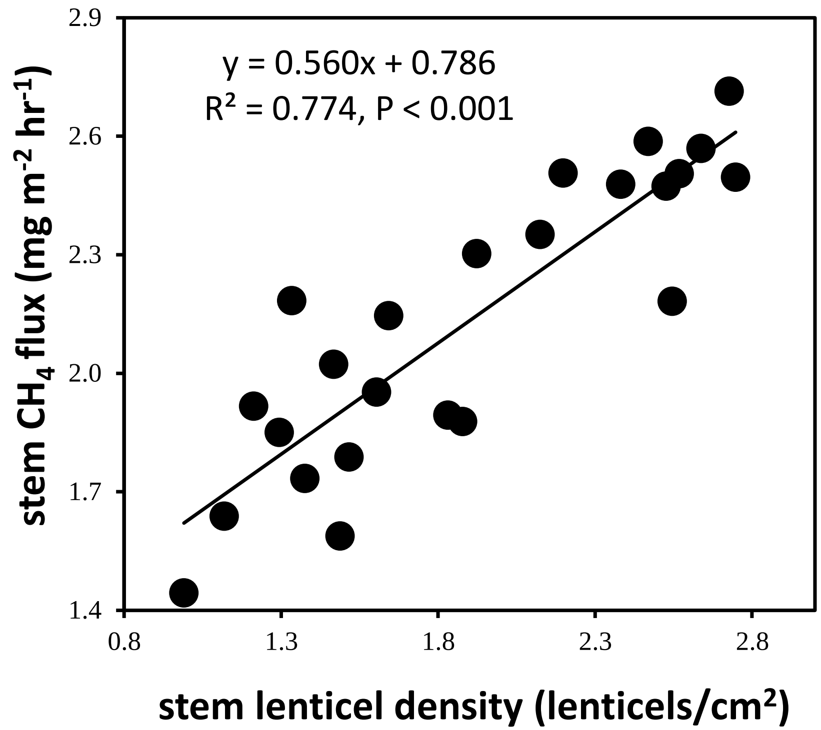
Mesocosm study: Alder saplings

Mesocosms:


Concentration ppm
[CH4] = 2.284 ppm
2.60
2.50
2.40
2.30
2.20
2.10
2.00
1.90
1.80
1.70
1.60
50
100
150
200
250
Time (seconds)

What is the methane exit pathway?

Image courtesy of Sunitha Pangala



Significant relationship also observed between CH_4 emissions and porewater [CH_4]. No relationship observed between emissions and leaf area Pangala *et al.* (New Phytologist under revision).

Relationship between whole-mesocosm CH_4 emissions (mg hr^{-1} $mesocosm^{-1}$) and measured variables between 9 am and 4 pm during the observation period (July and August, 2011). *, P<0.05%; **, P < 0.01%; ***, P < 0.001% uncertainty. 1, stem lenticel density measured between 2-22 cm stem height.

Measured variable	Range	Relationship between whole-mesocosm CH_4 emissions and variables (R^2)
Concentrations of CH_4 dissolved in pore water (µmol l^{-1})	10 cm below the soil surface	
	693 ± 12	y = 0.000237x + 0.0331 (0.31) **
	20 cm below the soil surface	
	785 ± 16	y = 0.000221x + 0.0234 (0.48) ***
	30 cm below the soil surface	
	778± 15	y = 0.000232x + 0.0169 (0.48) ***
Stem lenticel density (lenticels/cm^2)[1]	1.67 ± 0.10	y = 0.042.0x + 0.127 (0.69) ***
Stem surface area (m^{-2})	0.106±0.02	y = 1.325x + 0.0565 (0.40) ***
Stem diameter at the base (cm)	4.23 ± 0.05	y = 0.0391x + 0.032 (0.15)
Assimilation (µmol m^{-2} s^{-1})	13.3±0.24	y = 0.00844x + 0.0852 (0.16) *
Stomatal conductance (mmol m^{-2} s^{-1})	133±3.2	y = 0.000557x + 0.123 (0.12)
Transpiration (mmol m^{-2} s^{-1})	1.1±0.05	y = 0.0374x + 0.158 (0.13)
Leaf surface area (m^{-2})	1.64±0.07	y = 0.0164x + 0.170 (0.05)

Pangala *et al.* New Phytologist (under revision)

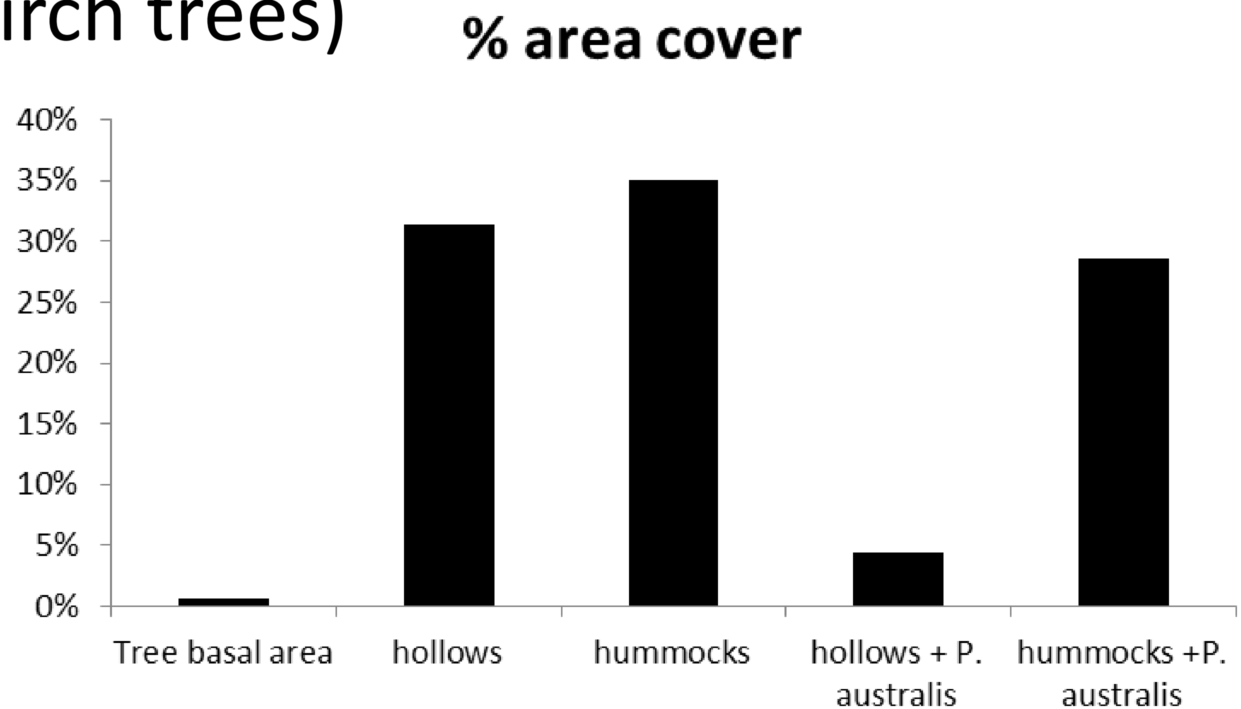
Alder Carr ecosystem, *in situ* measurements
Flitwick Moor, Bedfordshire, UK





Methods

- Mapped 20 x 30m plot (including area of hollows, hummocks, areas dominated by *Phragmites australis,* tree basal area and the number of alder and birch trees)

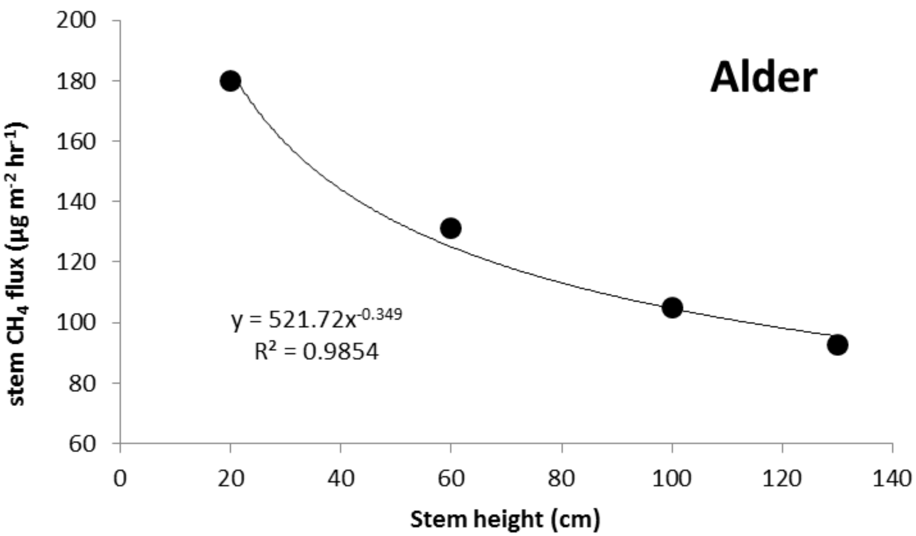


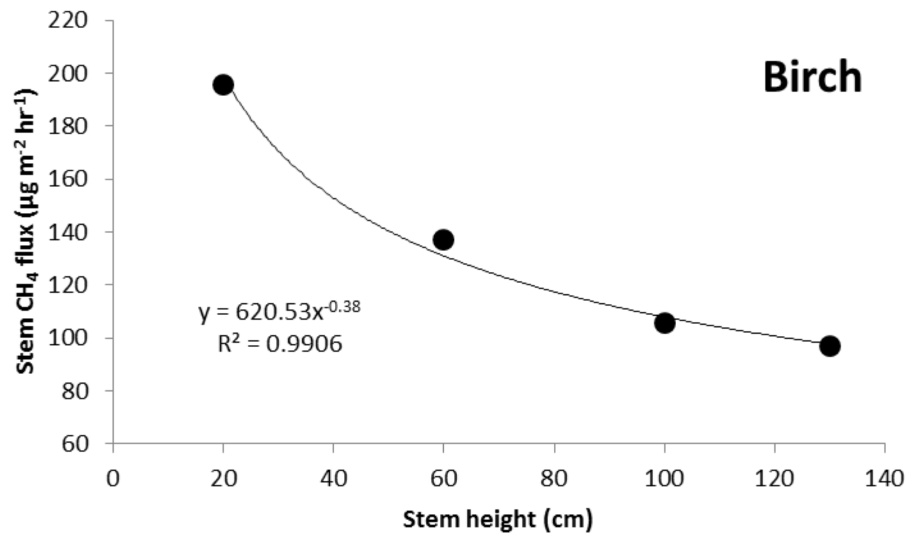
Methods

- Measurements every 2-4 weeks from tree stems (on occasion at 4 tree stem heights) and soil surfaces.

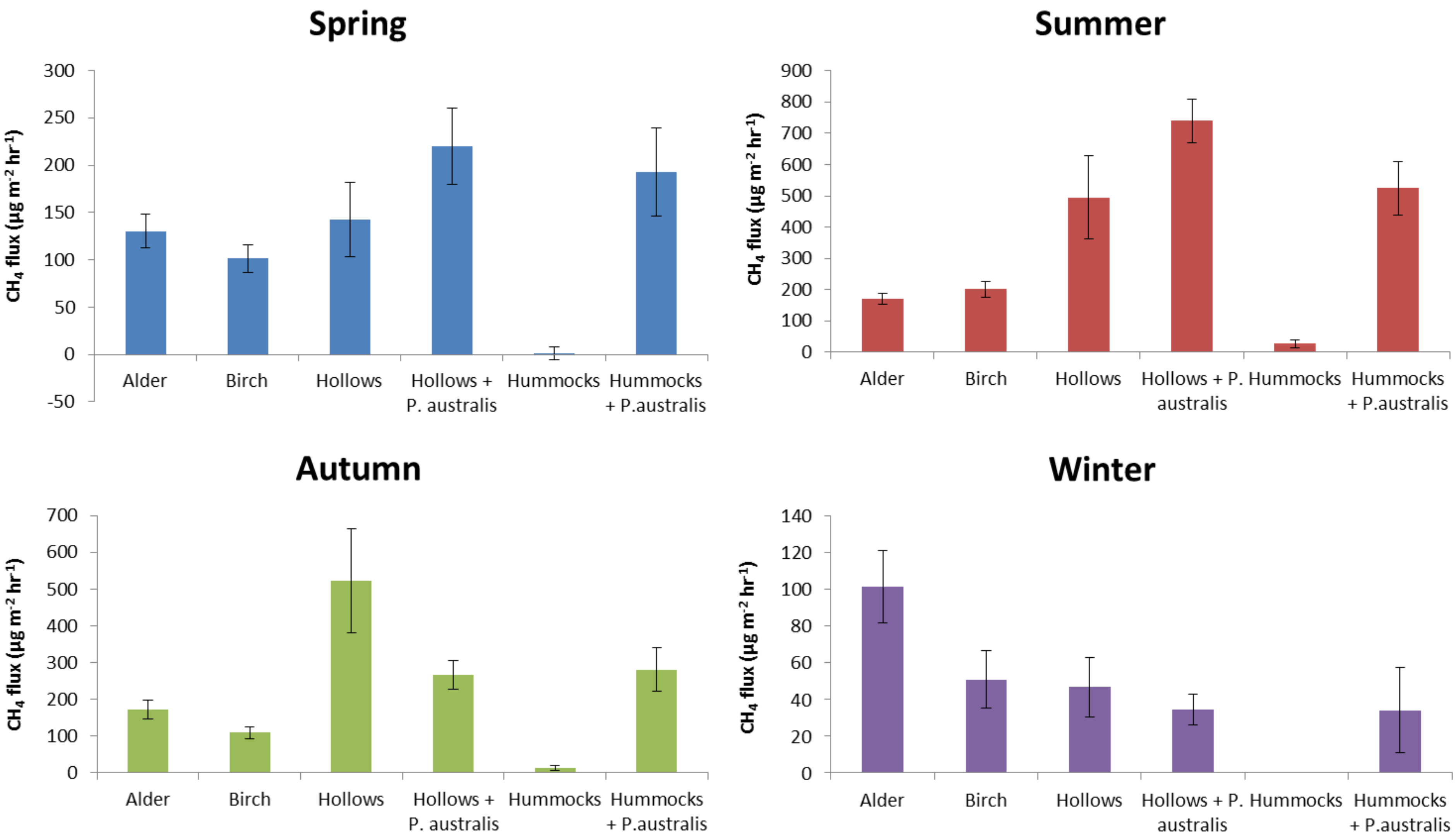
- Syringe samples taken at regular intervals in triplicate and analysed via CRDS in the laboratory.

Fluxes decrease up tree stems



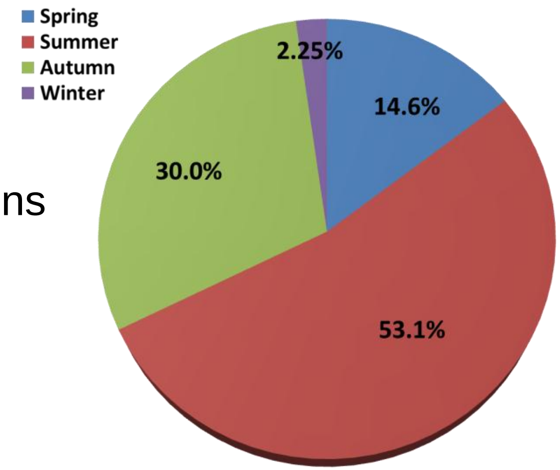


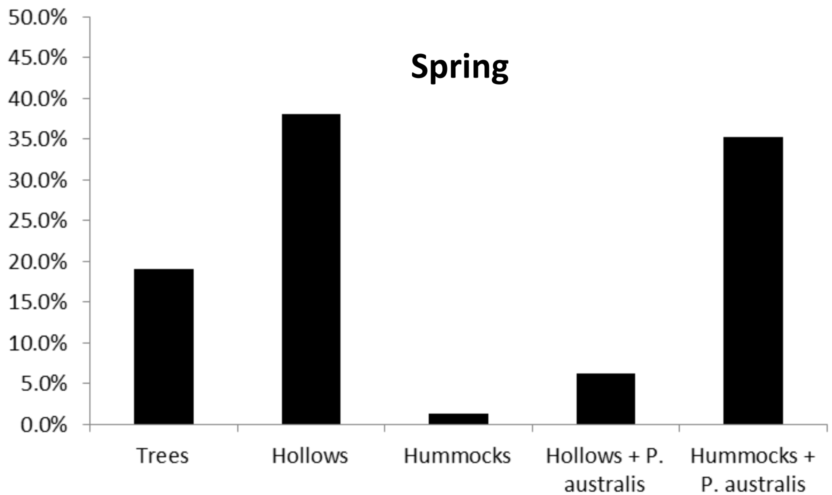
Fluxes from different forest surfaces

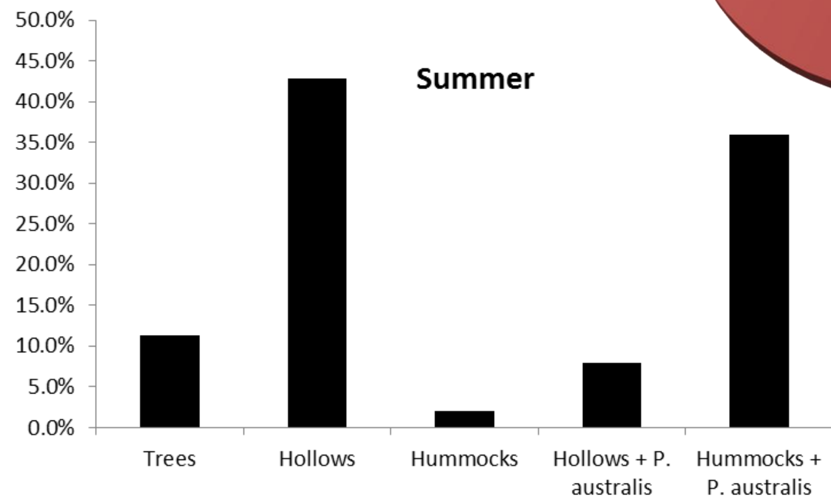


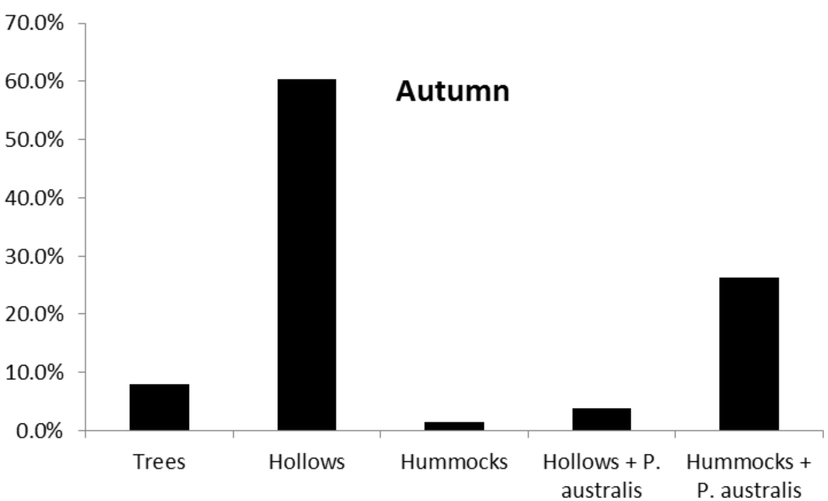
Contribution of trees and peat surfaces to ecosystem CH_4 emission.

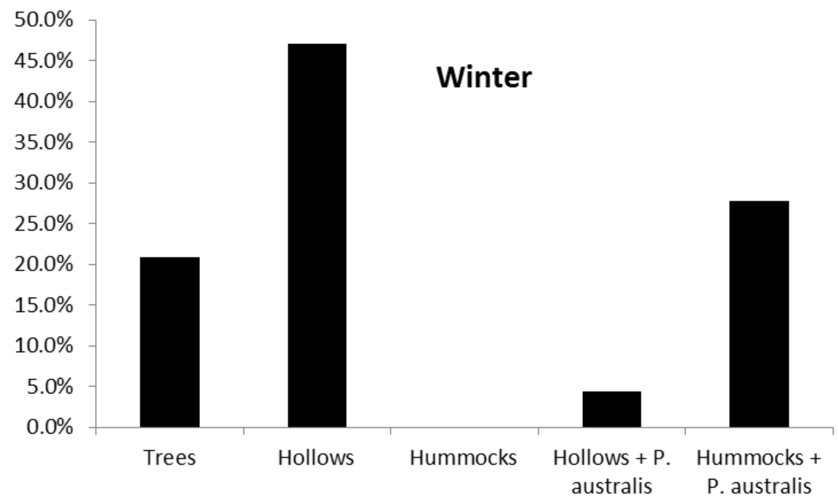
Seasonal Contribution to annual emissions



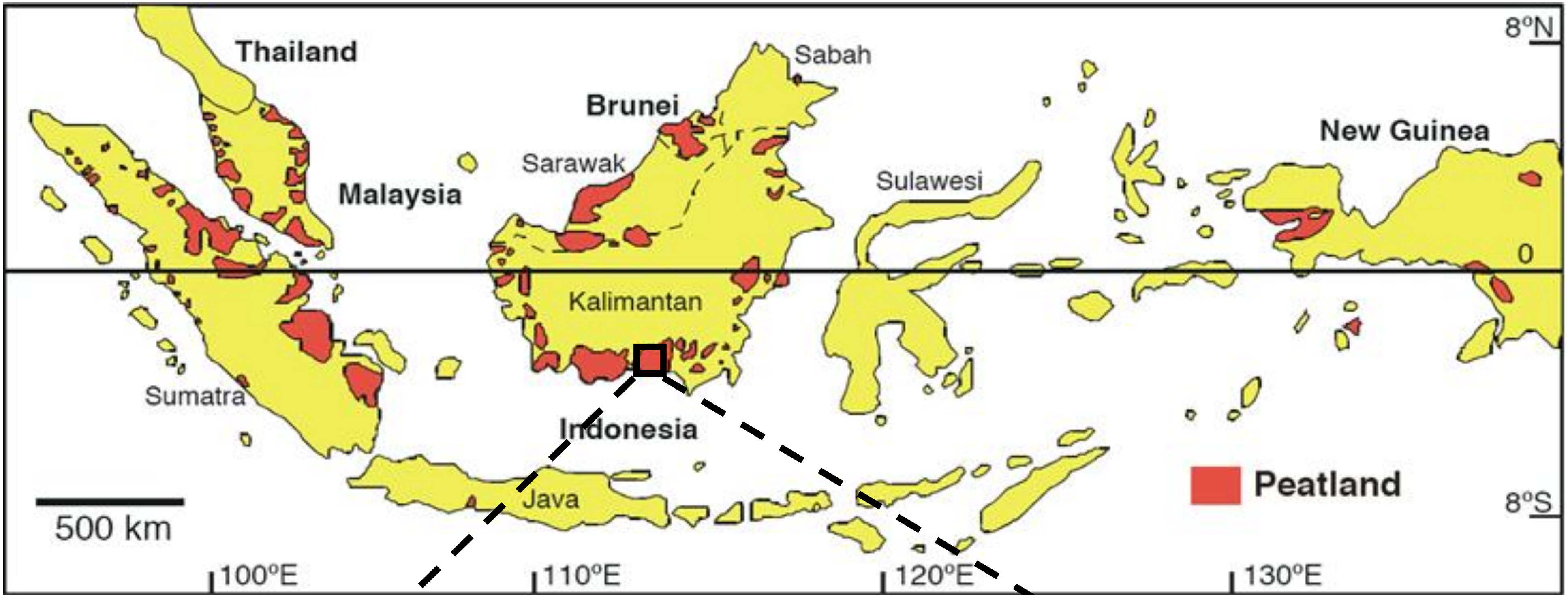






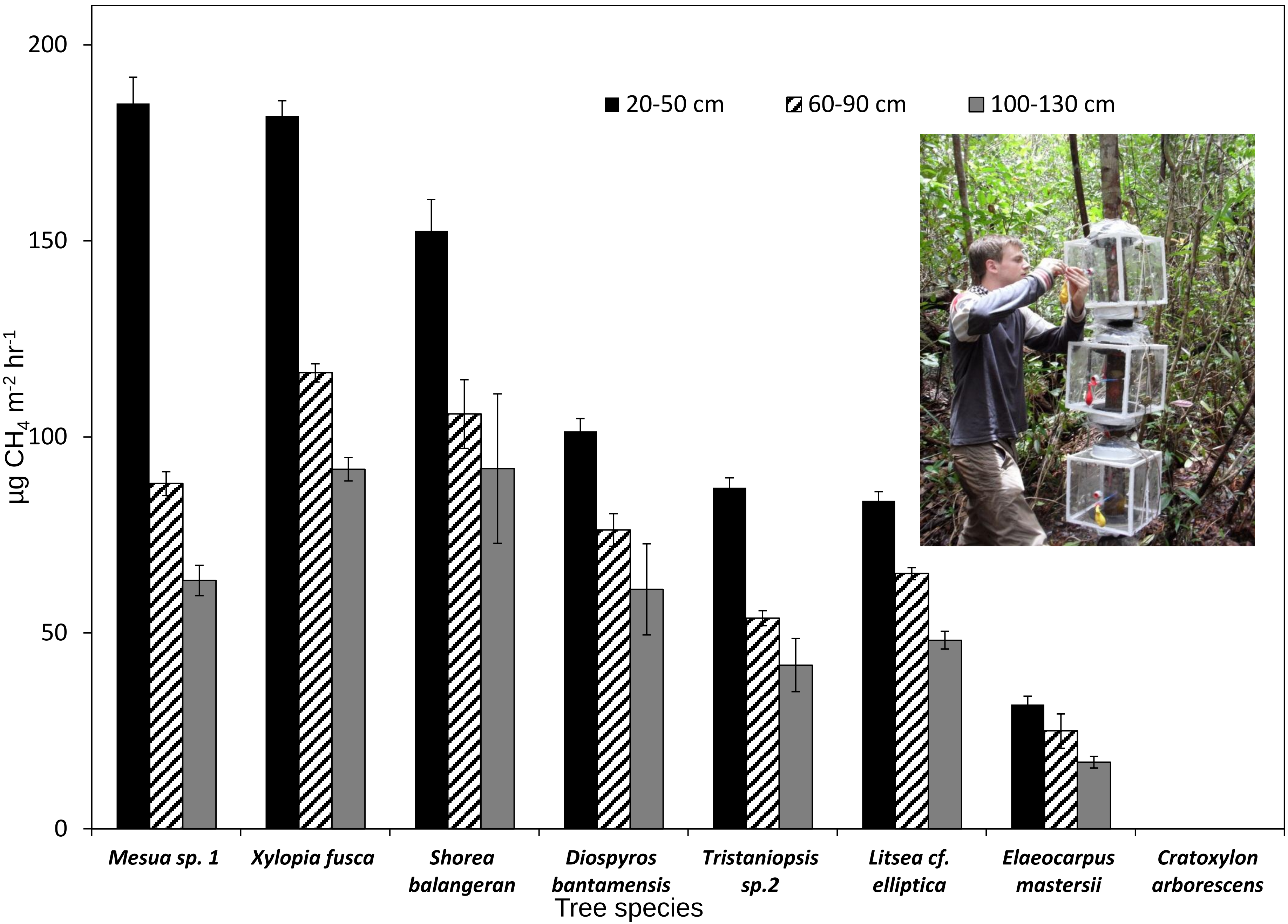


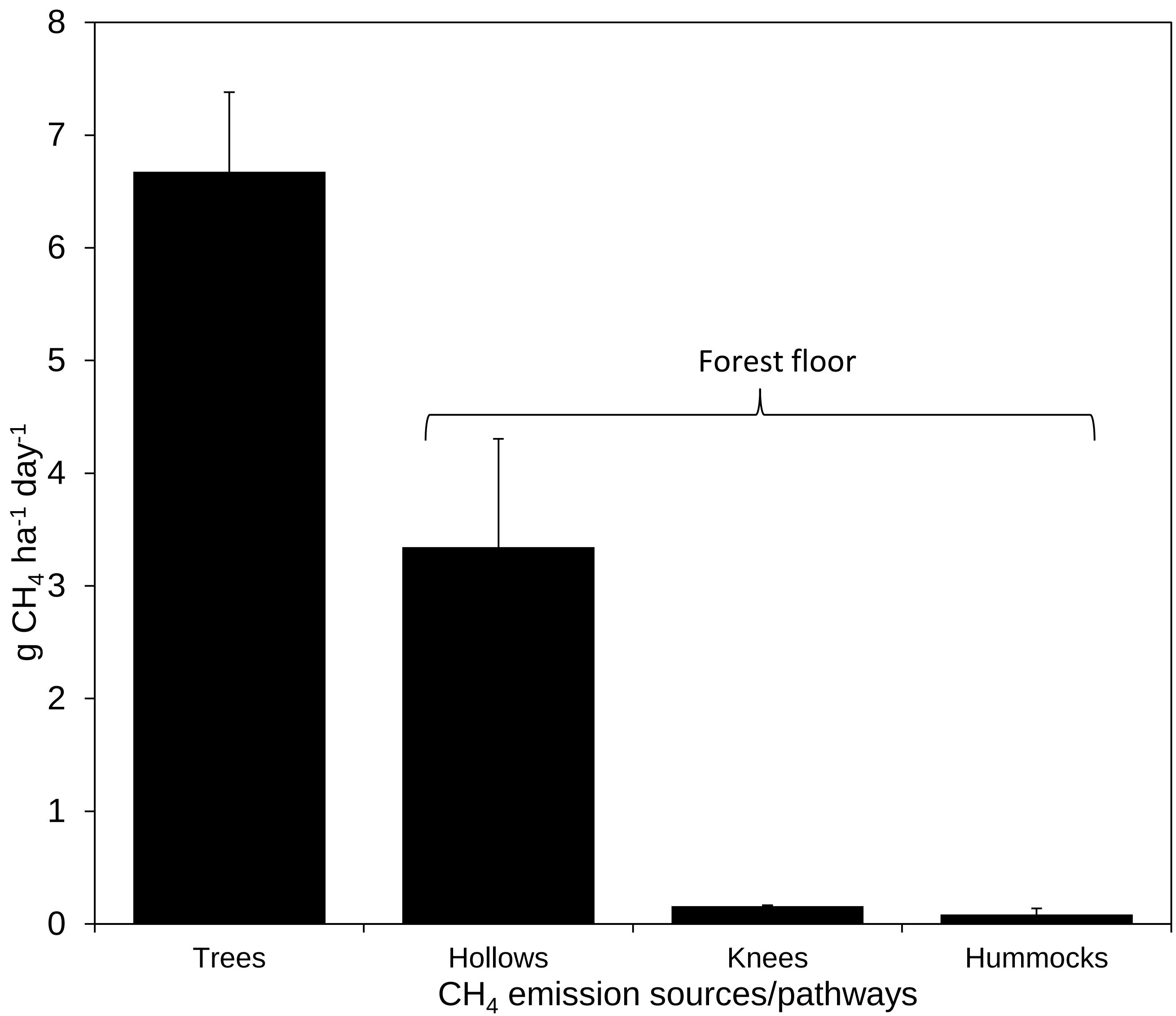
Peat swamp forests, Borneo, Central Kalimantan, Indonesia



Trees undergo morphological adaptations to survive flooded conditions




200
150
100
50
0
20-50 cm
60-90 cm
100-130 cm
μg CH_4 m^{-2} hr^{-1}
Mesua sp. 1
Xylopia fusca
Shorea balangeran
Diospyros bantamensis
Tristaniopsis sp.2
Litsea cf. elliptica
Elaeocarpus mastersii
Cratoxylon arborescens
Tree species



Trees make a 67% contribution to ecosystem CH_4 emission when considering the bottom-most 3m of tree stem but 89% when the whole tree is considered.

Sunitha R. Pangala[1], Sam Moore[1,2], Edward R.C. Hornibrook[3] and Vincent Gauci[1*] (under Review)

Annual CH_4 emissions from trees (E_a) in Southeast Asian tropical peat forests estimated using the following equation:

$$E_a = F \times D \times A \times d$$

Where

F is the average CH_4 emission per tree (2.5 to 10.6 mg CH_4 $tree^{-1}$ d^{-1} based upon stem surface area for 3 and 15 m tree heights);

D is the density of trees (2689 trees ha^{-1}; diameter ≥ 7 cm at ~1.3 m height above soil surface);

A is the area of Southeast Asian tropical peat forest (112,140 km^2); and

d is the number of CH_4 emitting days (244 days; CH_4 emissions are assumed to be zero during the dry season (June to September) as CH_4 emissions from trees were not measured during this season and water table drawdown in dry season in Southeast Asian tropical peat are known to impact CH_4 emissions).

Importance of trees at the regional scale

- Methane fluxes from peatlands in SE Asia are small: 0.03 to 0.15 Tg a^{-1} or 0.01 – 0.08 Tg a^{-1}, including or excluding tree fluxes, respectively.
- But soil methane is extremely well oxidised in tropical peatlands.
- What about other, more productive forested wetland ecosystems?

Summary

- Trees are important contributors to total ecosystem methane emission.
- Stem emissions seem to be more important than leaf emissions.
- Temperate wetland trees (alder, birch) contribute 10-20% of total ecosystem flux.
- In tropical peatlands tree stem emissions contribute 67%-89% of total ecosystem flux.

Acknowledgements

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Sam Moore (Oxford University)

The Royal Society

More to see at INECOL…

METHANE EMISSIONS THROUGH TREES IN TROPICAL AND TEMPERATE FORESTED WETLANDS

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Wednesday 2pm Bonaire 3&4