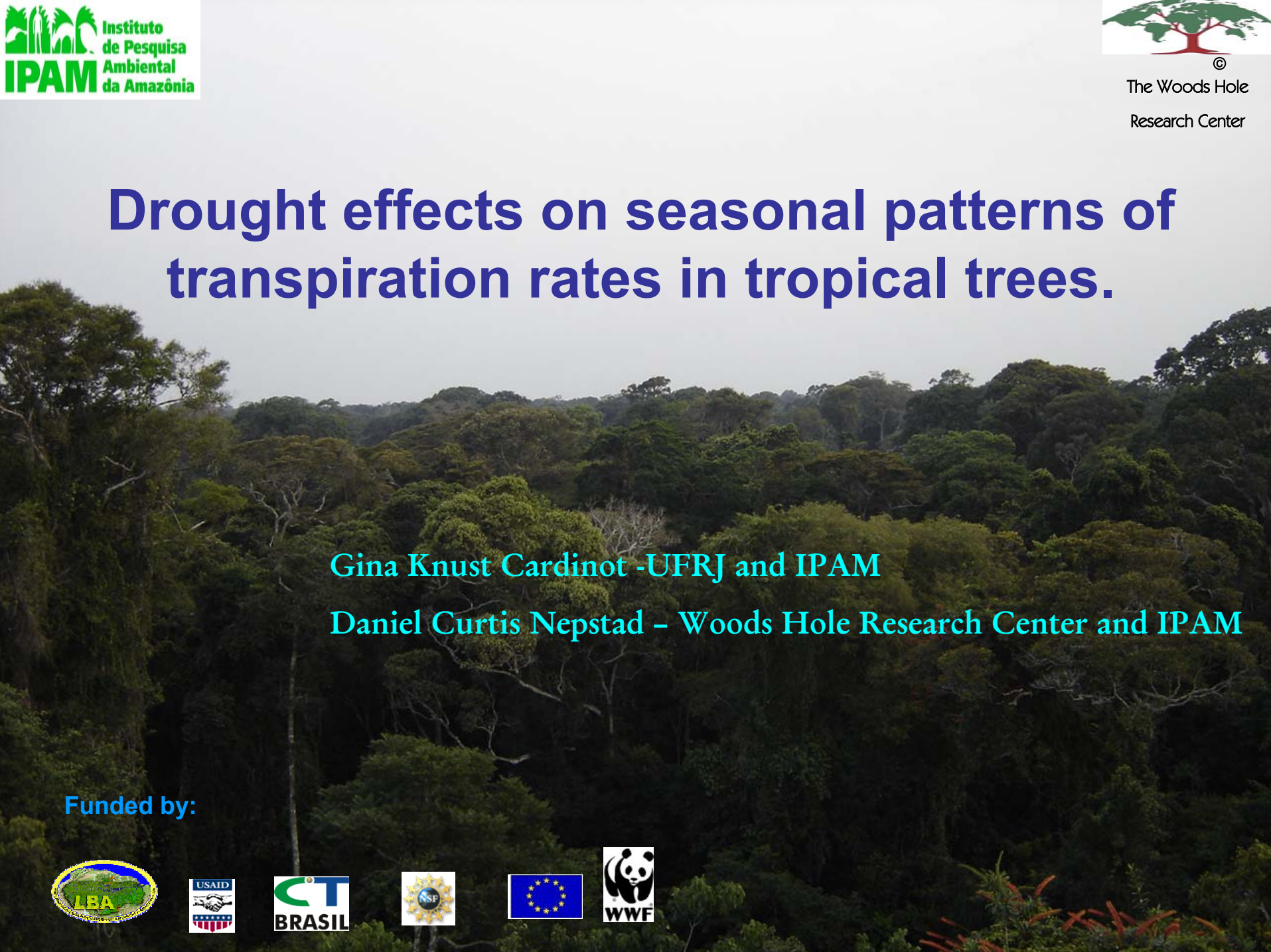

Drought effects on seasonal patterns of transpiration rates in tropical trees.

Gina Knust Cardinot -UFRJ and IPAM

Daniel Curtis Nepstad – Woods Hole Research Center and IPAM

Funded by:

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✓Much of the rain water in the Amazon is recycled following a cycle of:

precipitation –soil –plant- atm – precipitation

✓Forest cover plays an important role in the regional water cycle, where about 50% of precipitation falling in Amazonia is the result of water recycled through evapotranspiration;

✓Two sources of water vapour are soil evaporation and plant transpiration;

✓Moreira *et. al* 1997 - transpiration is the major source of forest ambient vapour.

✓A reduction of only 10-20% in normal precipitation would be sufficient to cause severe alterations in hydrological cycle-- direct effect on actual ecological balance.

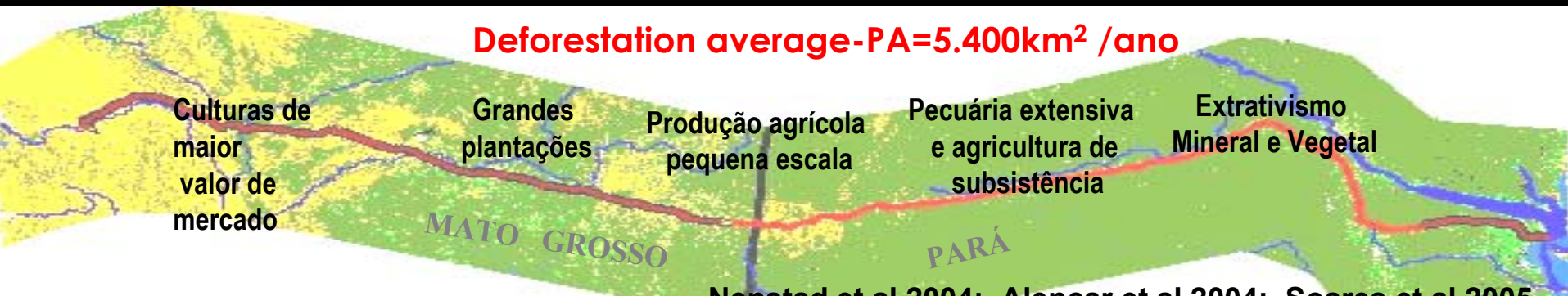
Land-use changes: BR 163 study case





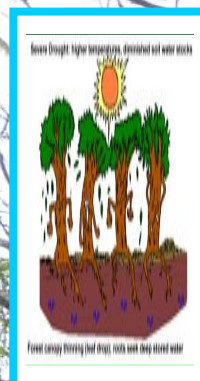




- Deforestation rates have risen sharply since 1995 and reached the second highest value of 26,130 km2 from August 2003 to August 2004
- 6% more deforestation than the previous year (INPE).

The consequences of these droughts include potentially large effects on forest metabolism, reproductive biology, tree mortality, biogeochemistry, tree mortality, and forest flammability



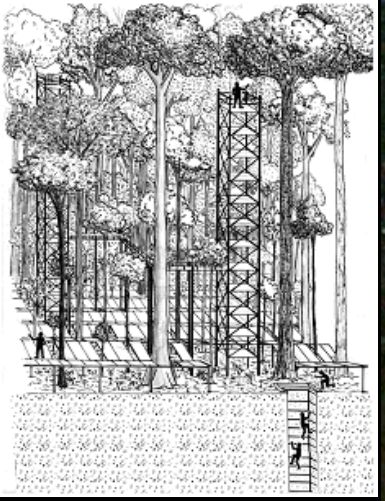
Improve our ability to simulate the responses of moist tropical forests to severe drought

Our research was carried out within the context of the world's largest rainfall exclusion experiment.

Eastern Amazônia; Pará State/Brazil

Floresta Nacional do Tapajós-Santarém/PA

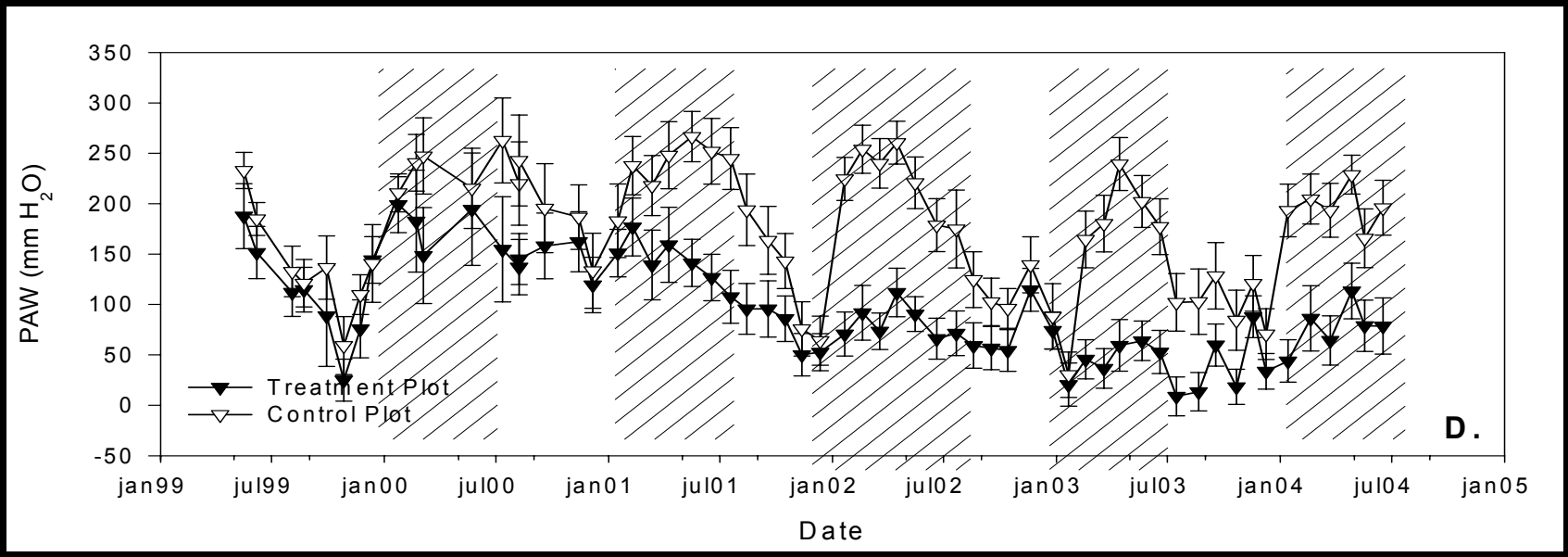
Projeto Seca Floresta (Throughfall Exclusion Experiment)

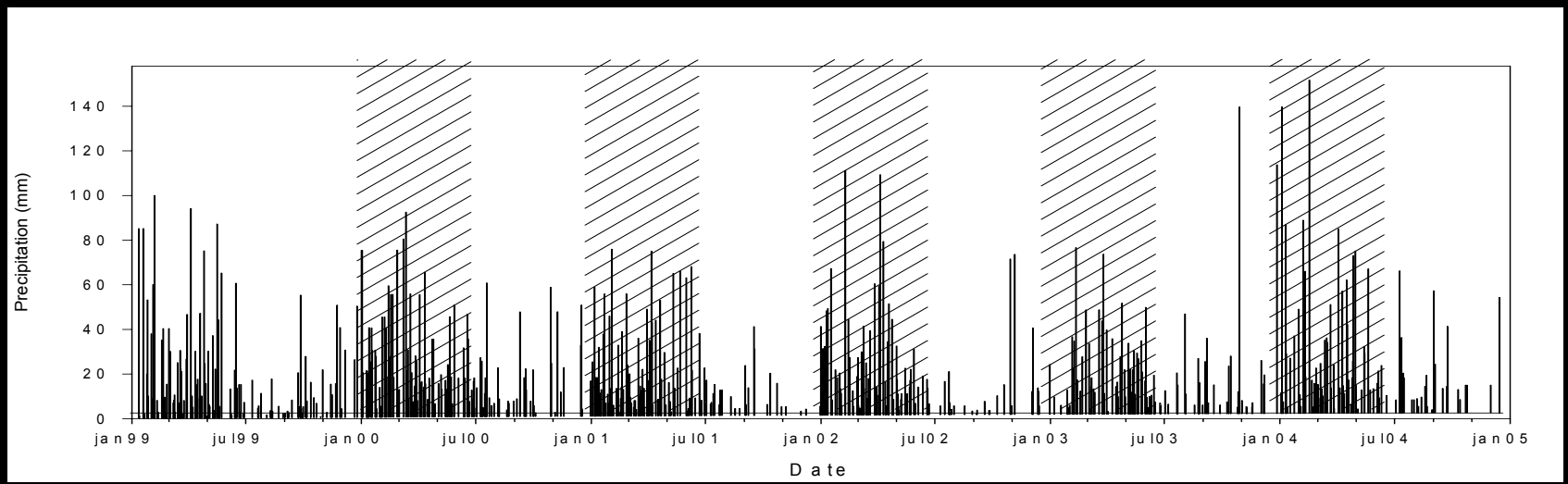


- Paired 1 ha plots
- The panels cover ~75% of the ground area and drain into elevated gutters. They are left in place during the ~6 month wet season between January and July since 2000.
- The treatment prevents ~50% of incoming precipitation from entering the soil.
- Baseline measurements were made for 1 yr prior to throughfall exclusion, beginning in Jan 1999

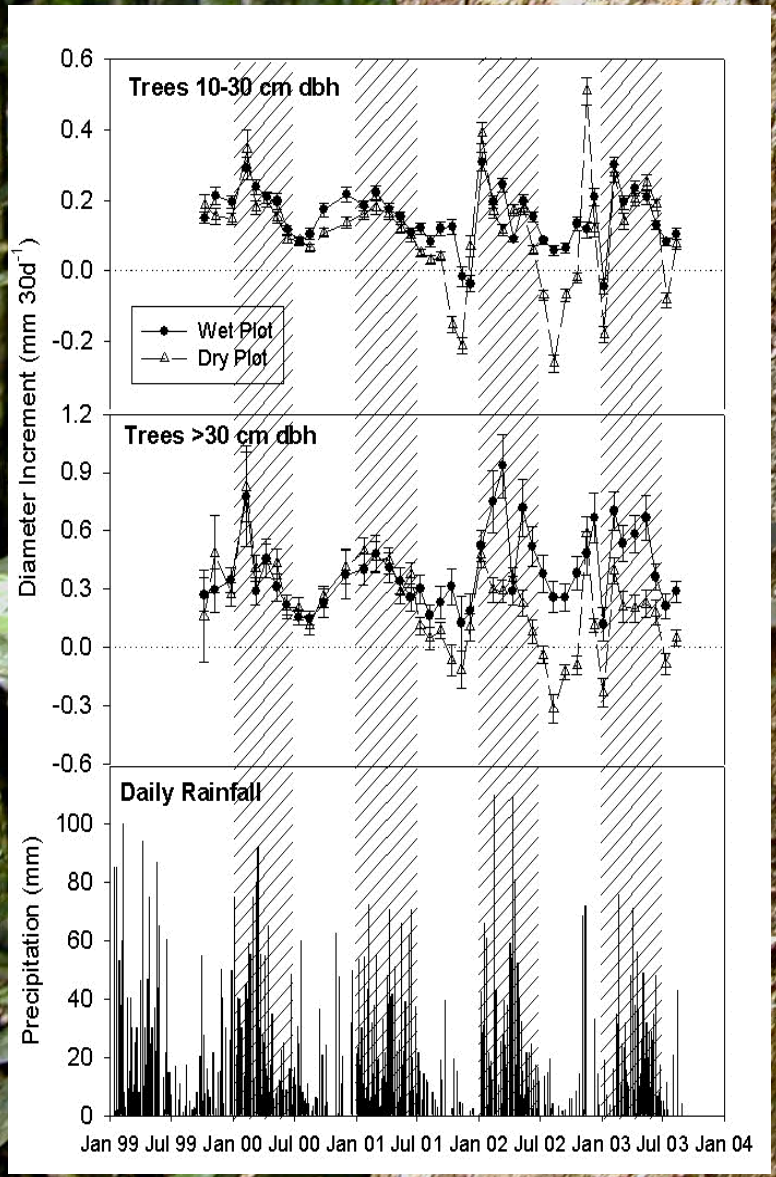
Nepstad et al. 2002 J. Geophys. Res. Atm. 107, 1-18

Plant available water (PAW)





Carbon accumulation

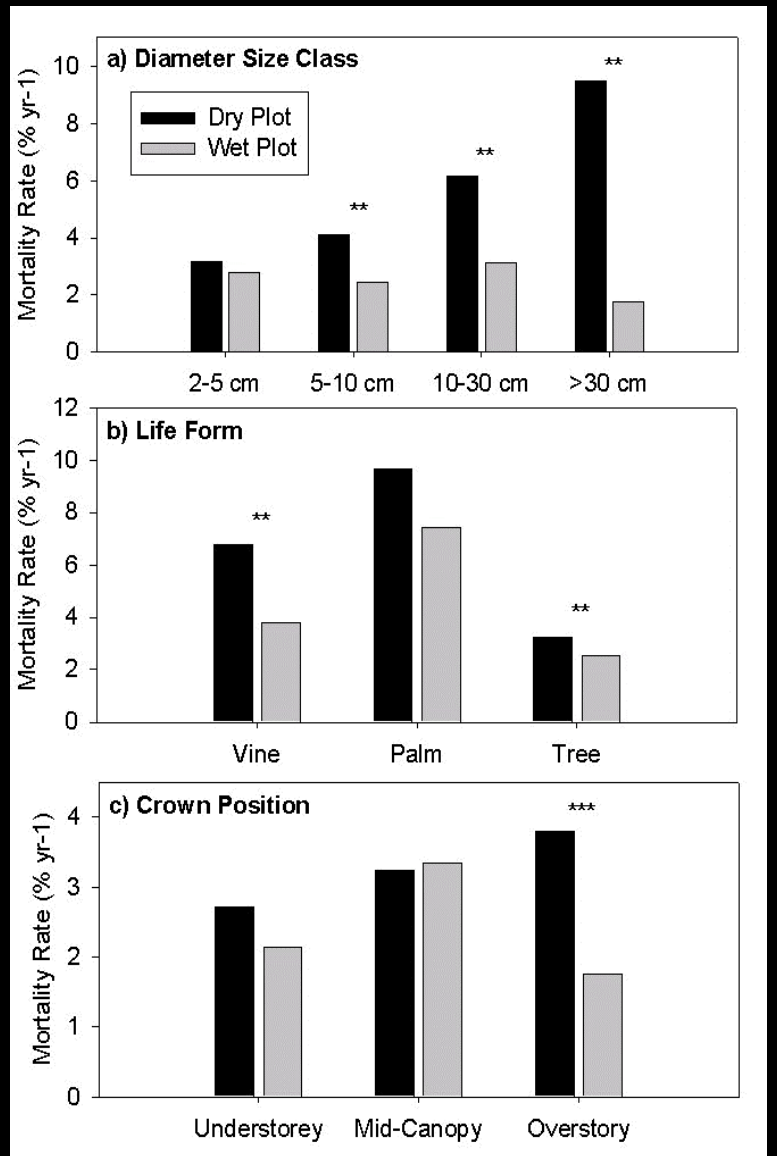


Seca

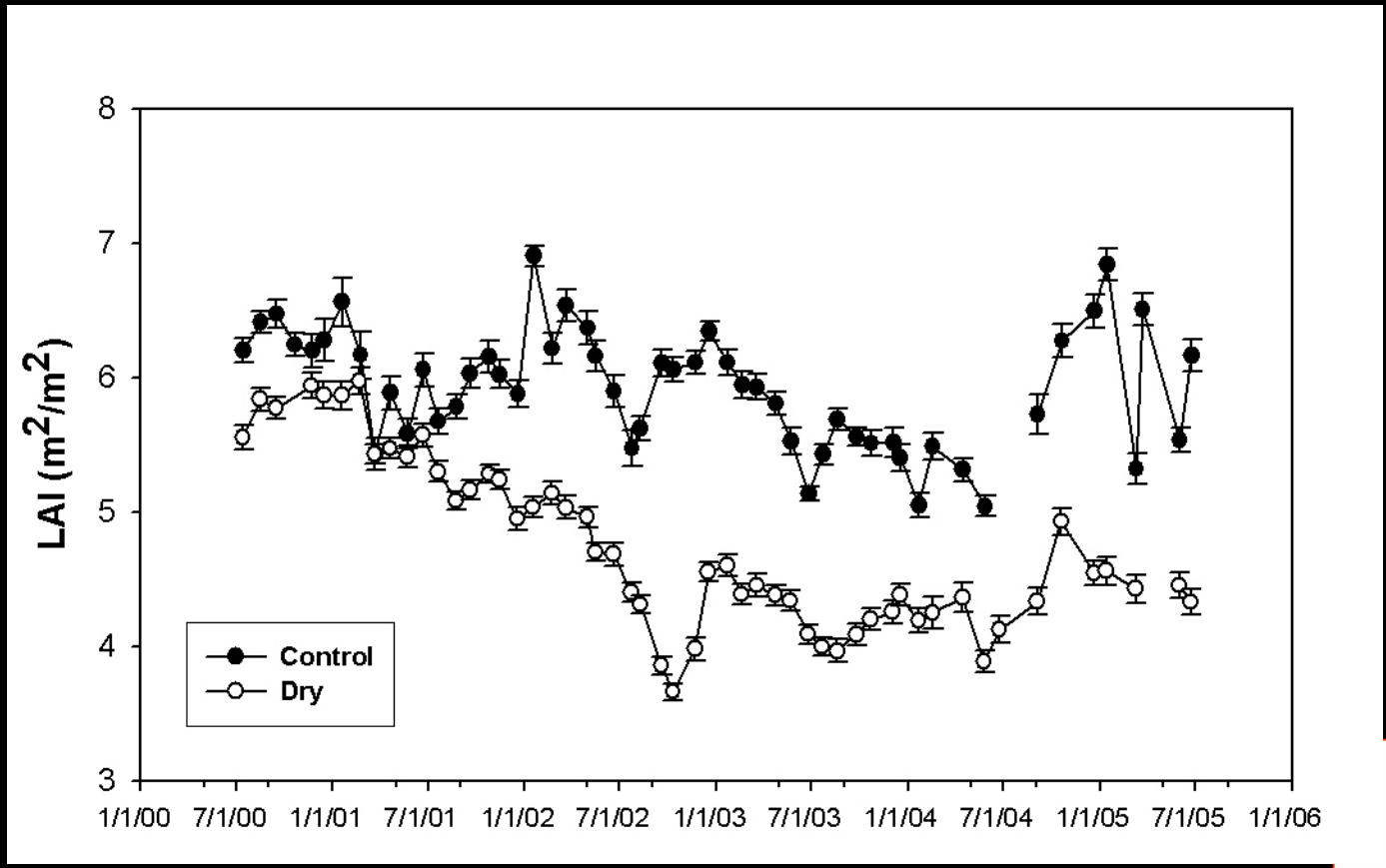
- 1.7 Mg/ha/yr less carbon accumulation
- 25% of the Amazon, this would mean 170 million tons of C remaining in the atmosphere each year

Mortality

Seca Floresta: 2.72% yr-1 p/ 3.77 % yr-1 (38%)



Canopy openness



Estimates of LAI are often used in studies and modelling of basic ecophysiological processes such as evapotranspiration, transpiration, etc.

Figura 12. Instrumento para as medidas de LAI.

Sap flow was measured using the constant heating method described by Granier (1985 and 1987)

- ✓ Sapflow measurements are a good approximation of tree transpiration;
- ✓Provide a mean at the tree level to estimate forest stand transpiration;
- ✓This technique is especially well suited for determining the effects of species composition and other heterogeneous conditions.

The sensors consist of 2 cylindrical probes of 2 mm diameter. The probes were inserted one above the other and were about 10cm apart. The sensors were installed at a height of 1.5m in the stems.

The upper probe contained a heating element of constantan, which is heated at a constant power by Joule effect. Each probe contained a copper-constantan thermocouple.

Sap flow was recorded at 30 min intervals controlled by a data logger (Model DL 2 Logger, AT-Delta-T Devices LTD, UK)

- 27 individuals/plot
- ~13sp per plot

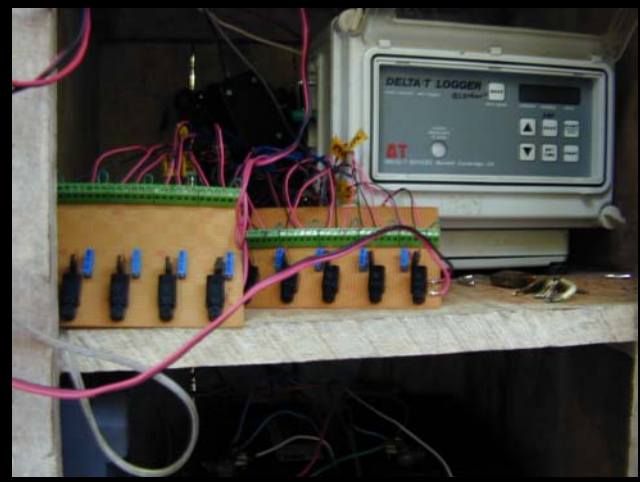
This technique allows at the estimation of sap flux density.

Sap flow density was calculated from the temperature difference between the probes using a standard empirical relationship-Granier 1895 e 1987

$$K = 0.0206\, u^{0.8124}$$

Mass flow of sap was obtained by multiplying flow density by sapwood cross-sectional area calculated from stem diameter-sapwood area relationships determined for each species.

$$F = u^{*} S_A \quad (g\ m^{-2}\ s^{-1})$$



Sap flow: scaling up from tree to stand

Whole-tree transpiration (E) was estimated by multiplying the xylem flux density by the hydroactive xylem area

Stand transpiration was calculated as:

$$E_T = S_T \Sigma_{p_i} F_{D_i}$$

S_T = stand sapwood area per unit of ground area

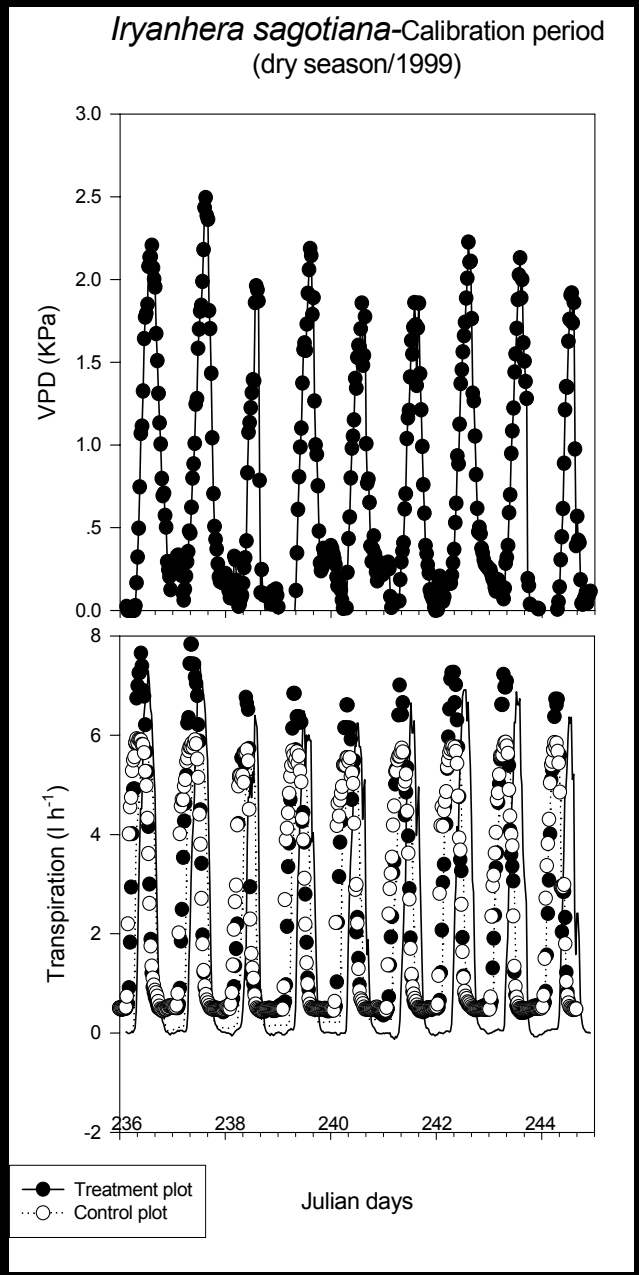
p_i = proportion of sapwood in the class i

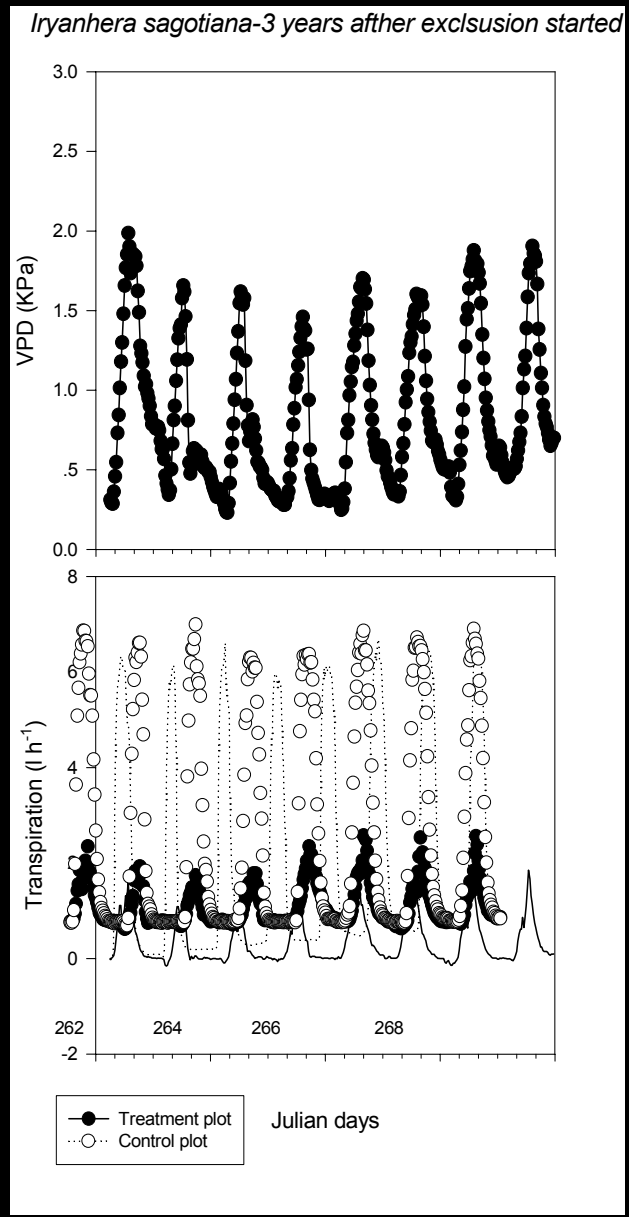
F_{D_i} = average sap flux density in the class i

Objective were to analyse transpiration:

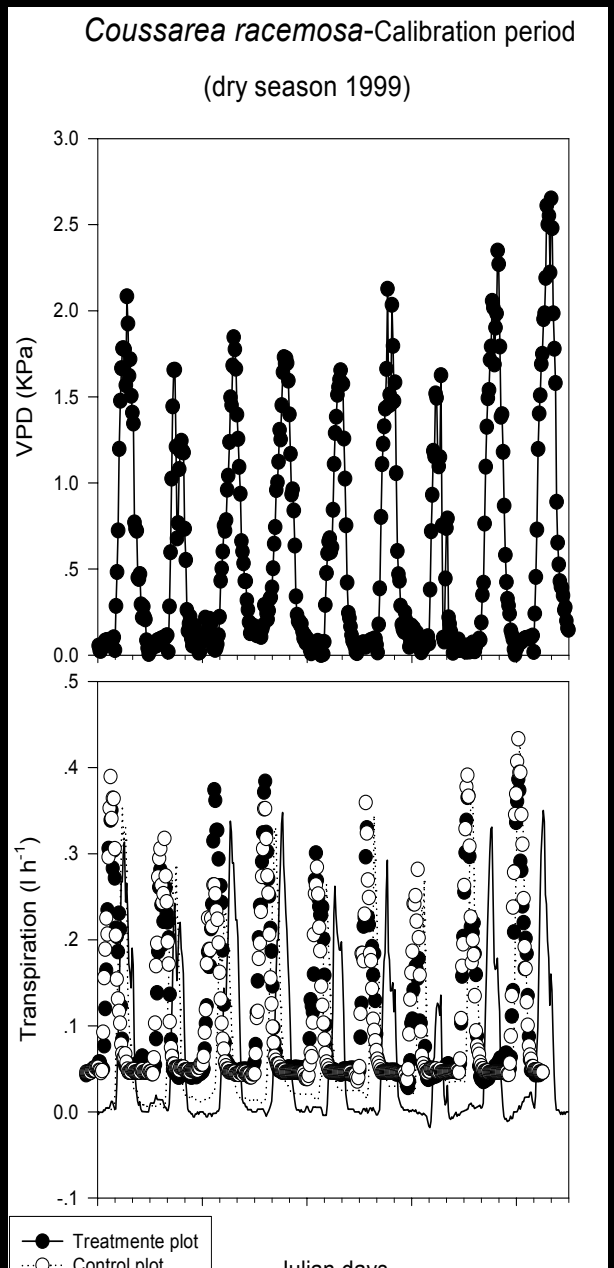
- Through sap flow measurements performed on several major species
- At stand level, to analyse the dependence of transpiration to climatic factors, by scaling up tree to stand.

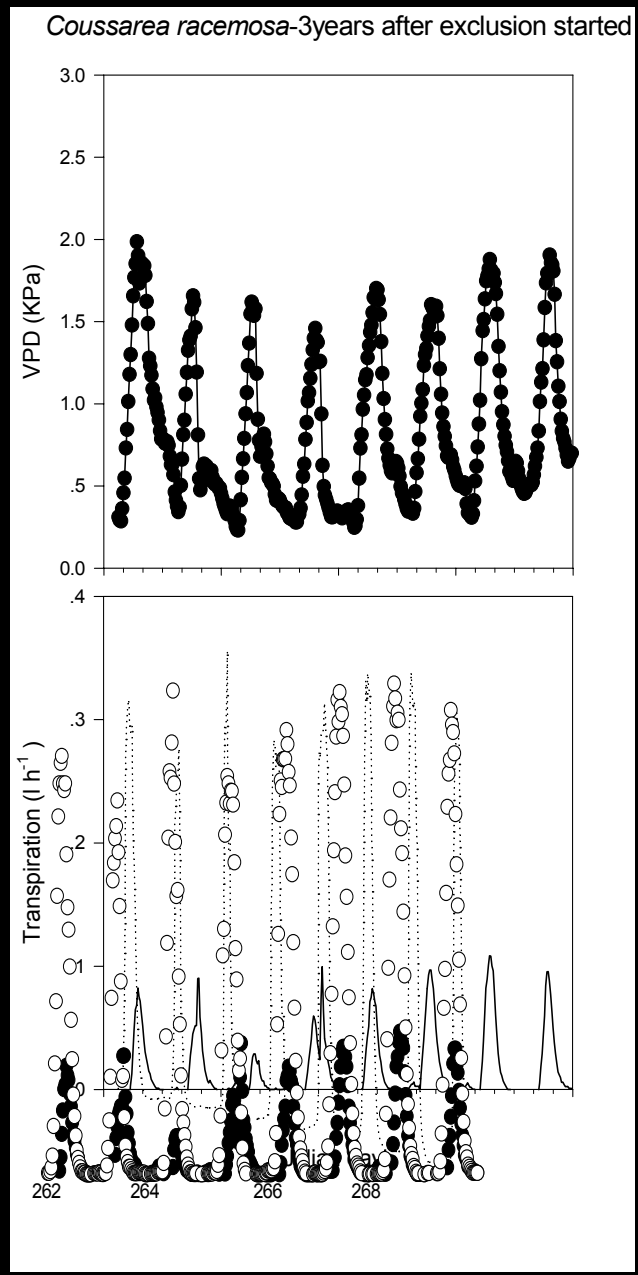
Ucuubarana


Iryanhera sagotiana-Calibration period
(dry season/1999)
VPD (KPa)
3.0
2.5
2.0
1.5
1.0
.5
0.0
Transpiration (l h-1)
8
6
4
2
0
-2
236
238
240
242
244
Treatment plot
Control plot
Julian days


Iryanhera sagotiana-3 years afther exclsusion started
VPD (KPa)
3.0
2.5
2.0
1.5
1.0
.5
0.0
Transpiration (l h-1)
8
6
4
2
0
-2
262
264
266
268
Treatment plot
Control plot
Julian days

Caferana

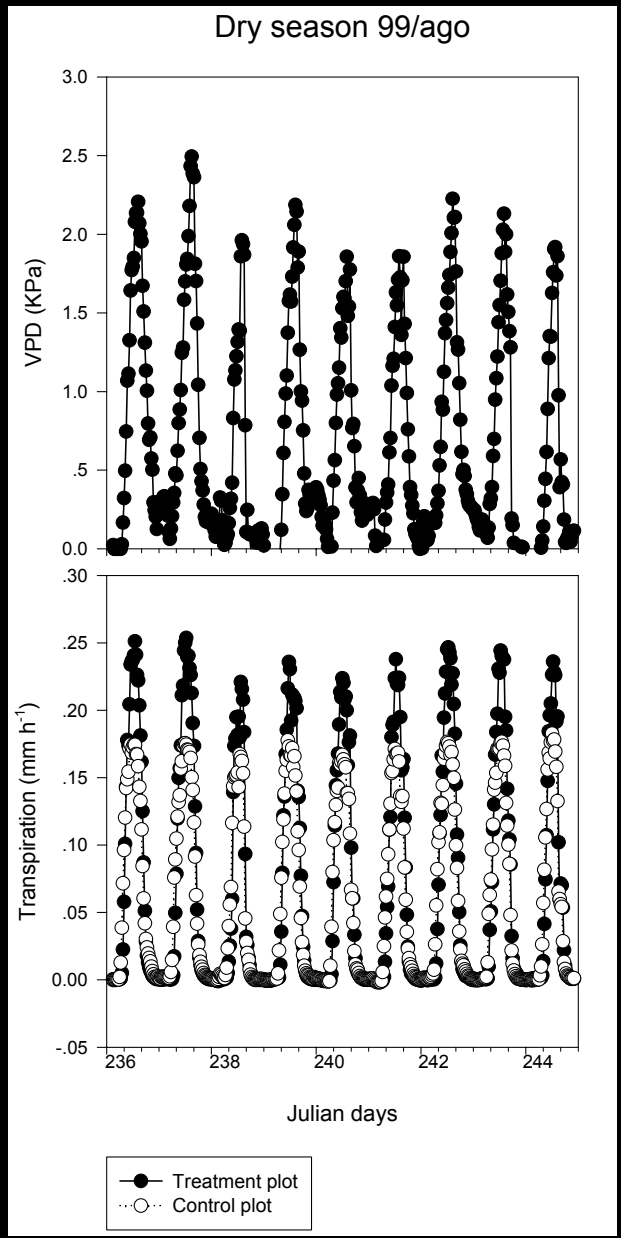

Coussarea racemosa-Calibration period
(dry season 1999)
VPD (KPa)
Transpiration (l h-1)
Treatmente plot
Control plot
Julian days

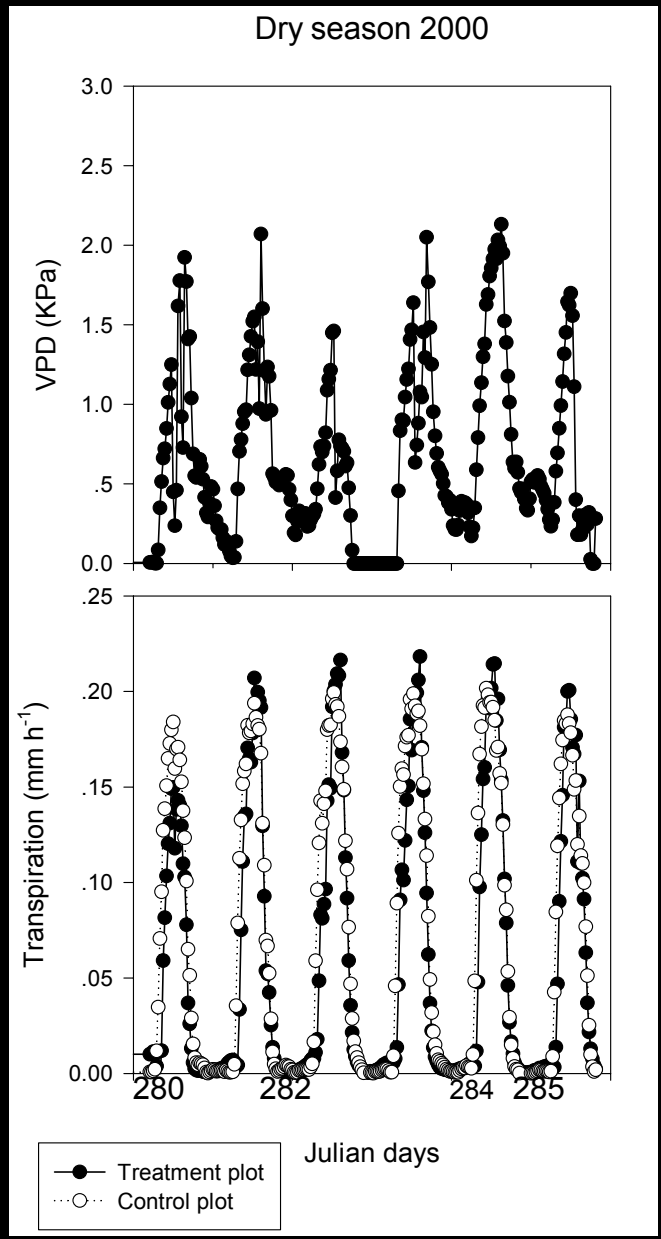

Coussarea racemosa-3years after exclusion started
VPD (KPa)
Transpiration (l h-1)
Julian days

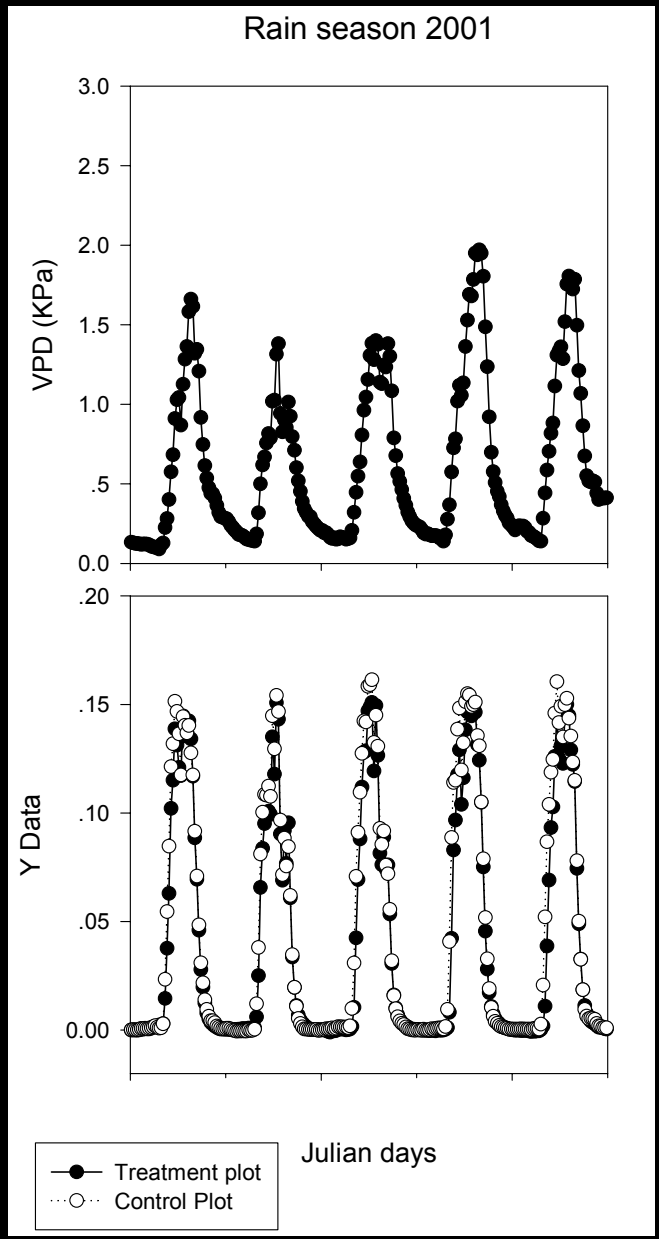
Daily flux: dry season 2002

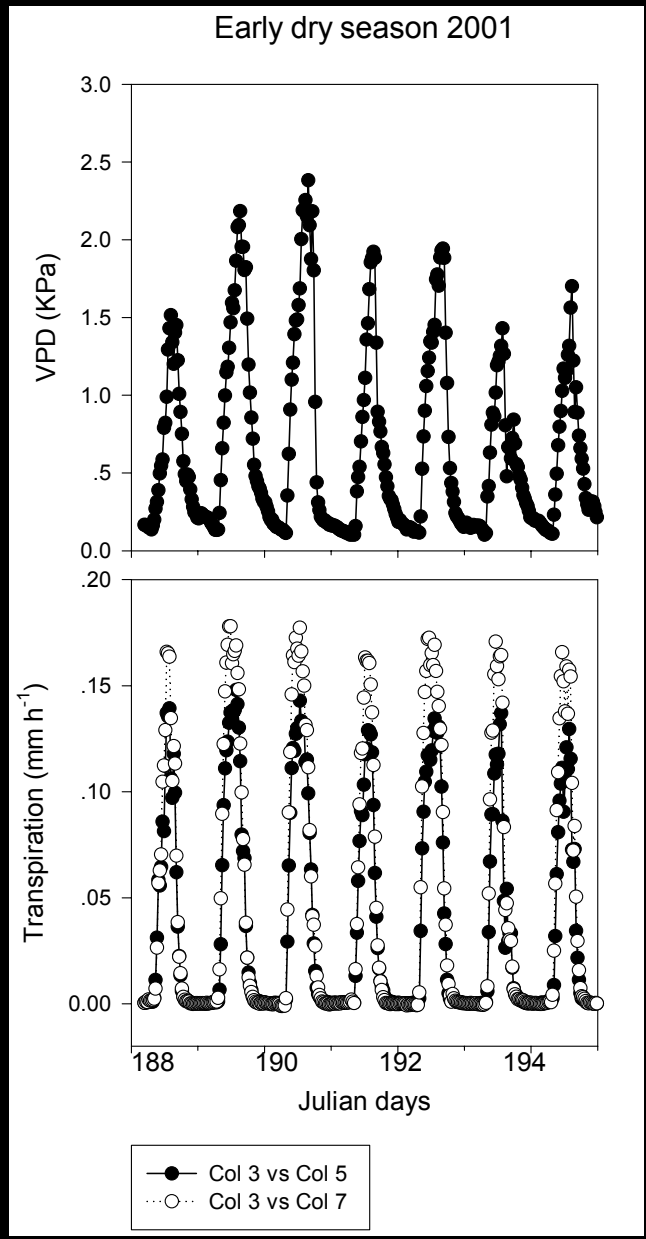
Treatment plot species	Total daily Control plot flux (l/day)	Total daily Treatment plot flux (l/day)	% less water to atm
Coussarea racemosa Ac. Rich ex DC	4.774417	2.069364	56%
Miconia egensis Cogn	9.881325	2.177515	78%
Sclerolobium chrysophyllum Poepp & Endl	16.487	1.416721	91%
Iryanhera sagotiana (Bth) Warb	64.84652	33.59375	48%
Eschweilera pedicellata (Richard) Mori	13.40236	1.804585	86%
Sclerolobium chrysophyllum Poepp & Endl	16.446	5.437519	67%
Manilkara huberi (Ducke) Standley (Maçaranduba)	15.2234	5.111721	66%
Anthodon decusatum R.T.P.	47.171	1.174792	97%
Erisma uncinatum Warm (Quarubarana)	491.776	42.1974	91%
Lecythis lurida (Miers) Mori (Jarana)	107.704	14.97278	86%
Caryocar villosum Pres. (Piquiá)	229.674	25.26812	88%

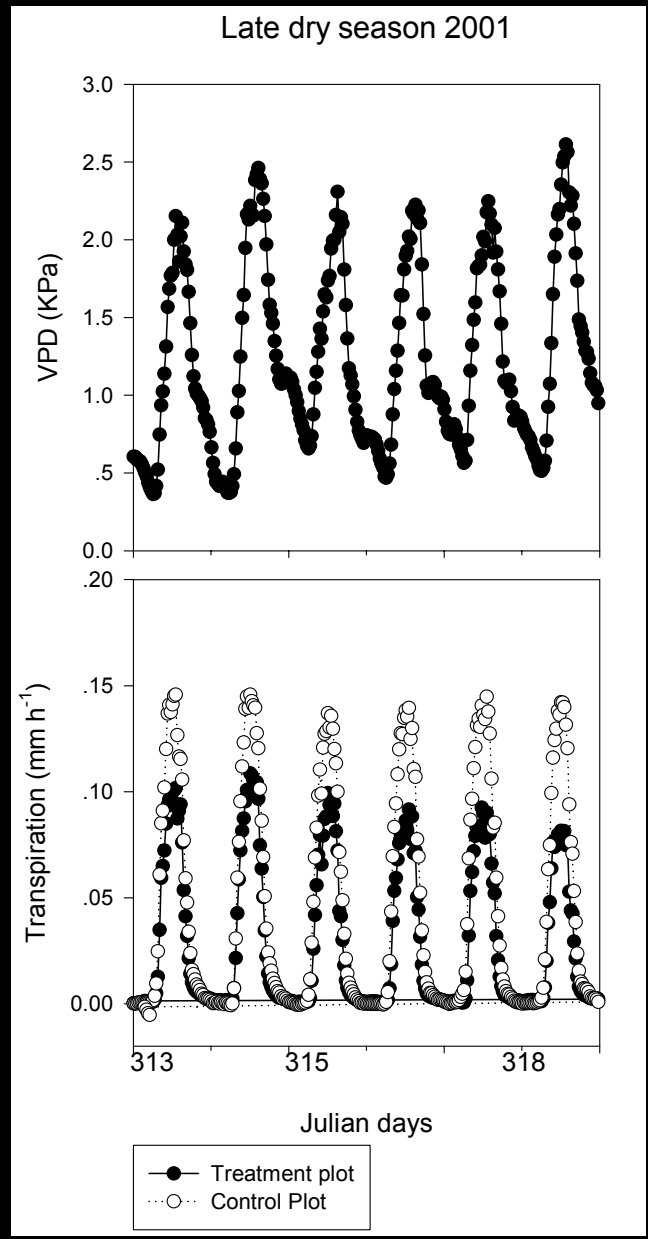
- In the tropical rain forest ecosystem, there is an exceptional biodiversity, and very contrasting water use strategies are probably found mixed at the same place.

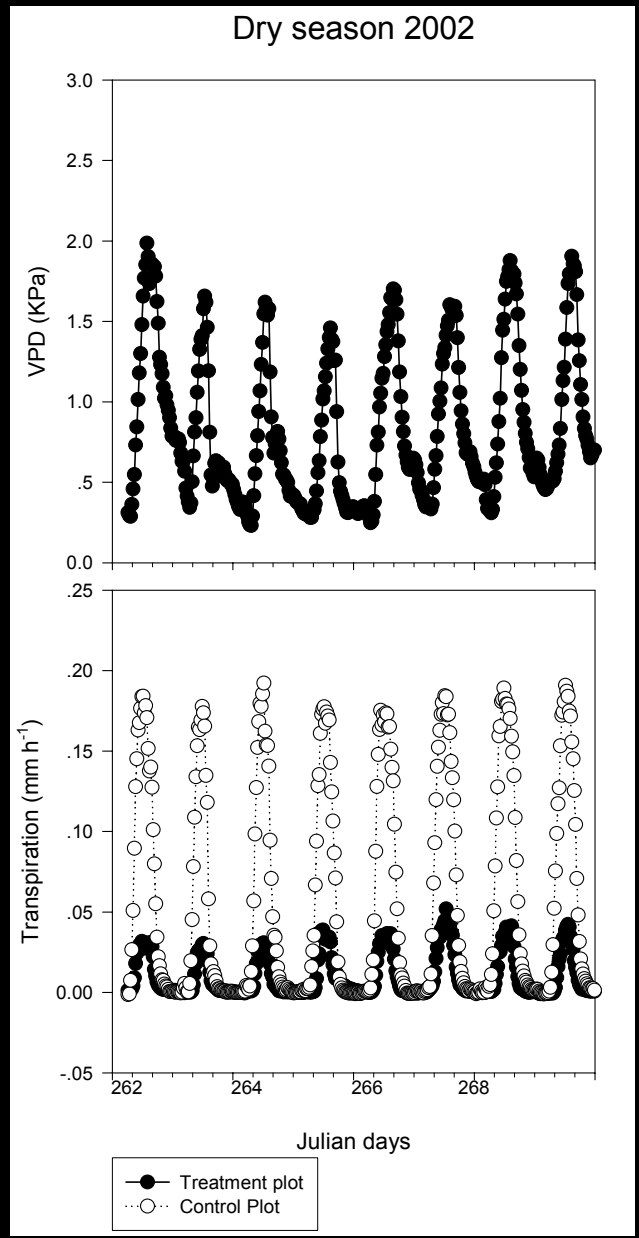

Dry season 99/ago
VPD (KPa)
3.0
2.5
2.0
1.5
1.0
.5
0.0
Transpiration (mm h-1)
.30
.25
.20
.15
.10
.05
0.00
-.05
236
238
240
242
244
Julian days
Treatment plot
Control plot

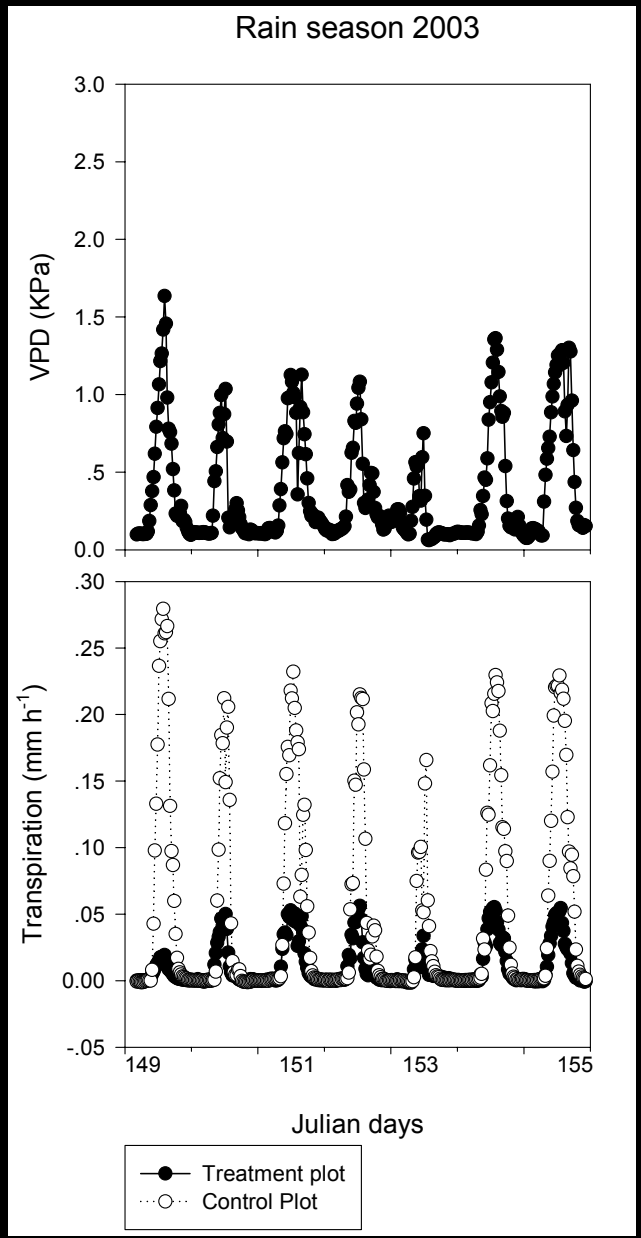

Dry season 2000
VPD (KPa)
3.0
2.5
2.0
1.5
1.0
.5
0.0
Transpiration (mm h-1)
.25
.20
.15
.10
.05
0.00
280
282
284
285
Julian days
Treatment plot
Control plot

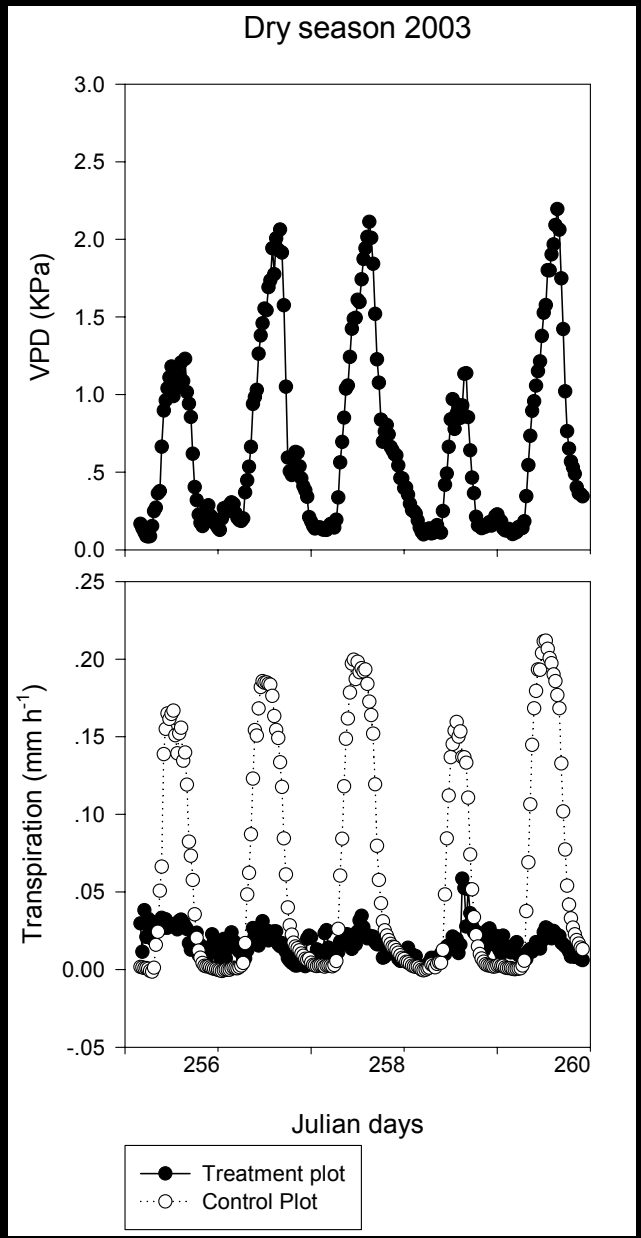

Rain season 2001
VPD (KPa)
3.0
2.5
2.0
1.5
1.0
.5
0.0
Y Data
.20
.15
.10
.05
0.00
Julian days
Treatment plot
Control Plot


Early dry season 2001
VPD (KPa)
3.0
2.5
2.0
1.5
1.0
.5
0.0
Transpiration (mm h-1)
.20
.15
.10
.05
0.00
188
190
192
194
Julian days
Col 3 vs Col 5
Col 3 vs Col 7

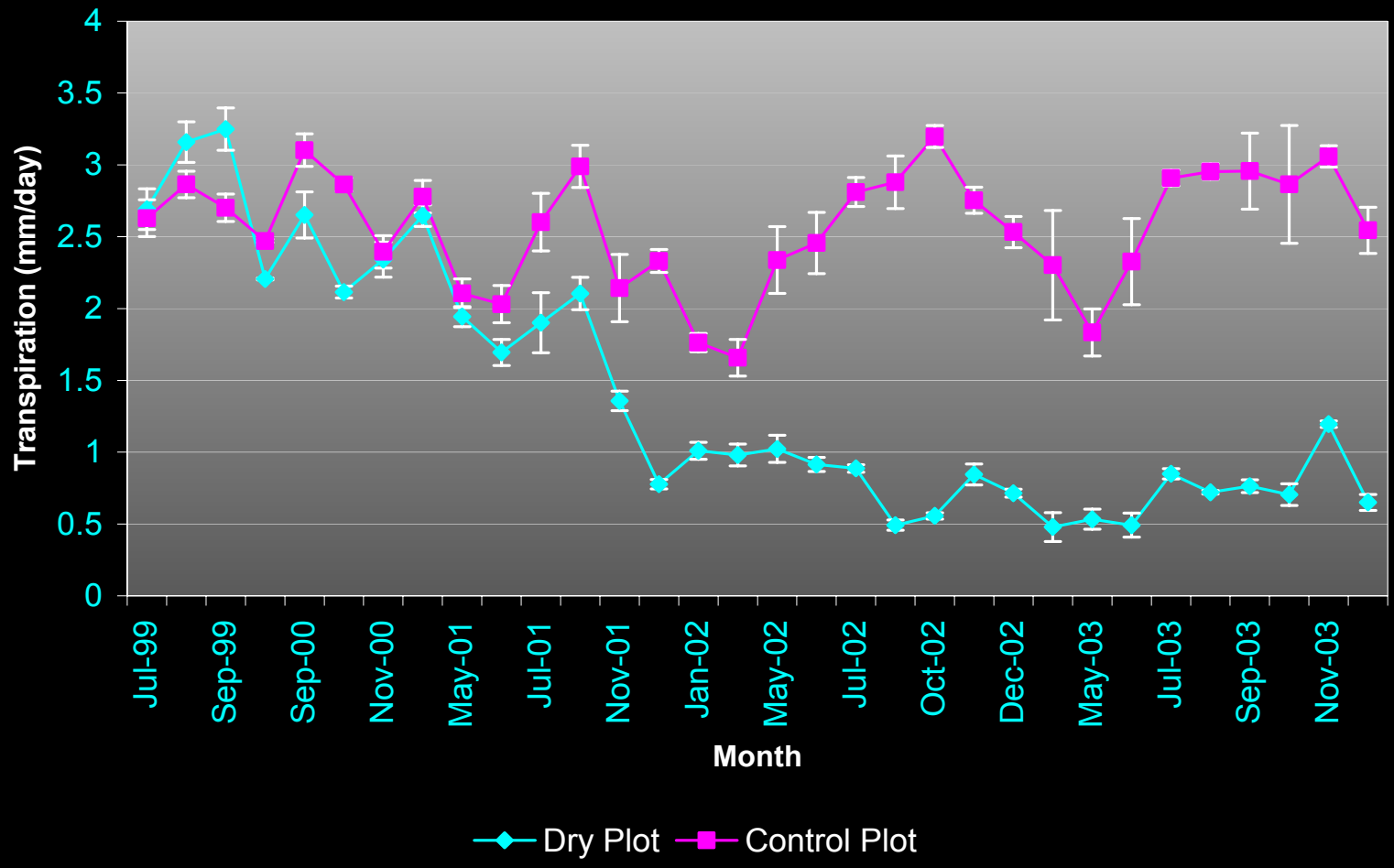

Late dry season 2001
VPD (KPa)
3.0
2.5
2.0
1.5
1.0
.5
0.0
Transpiration (mm h-1)
.20
.15
.10
.05
0.00
313
315
318
Julian days
Treatment plot
Control Plot

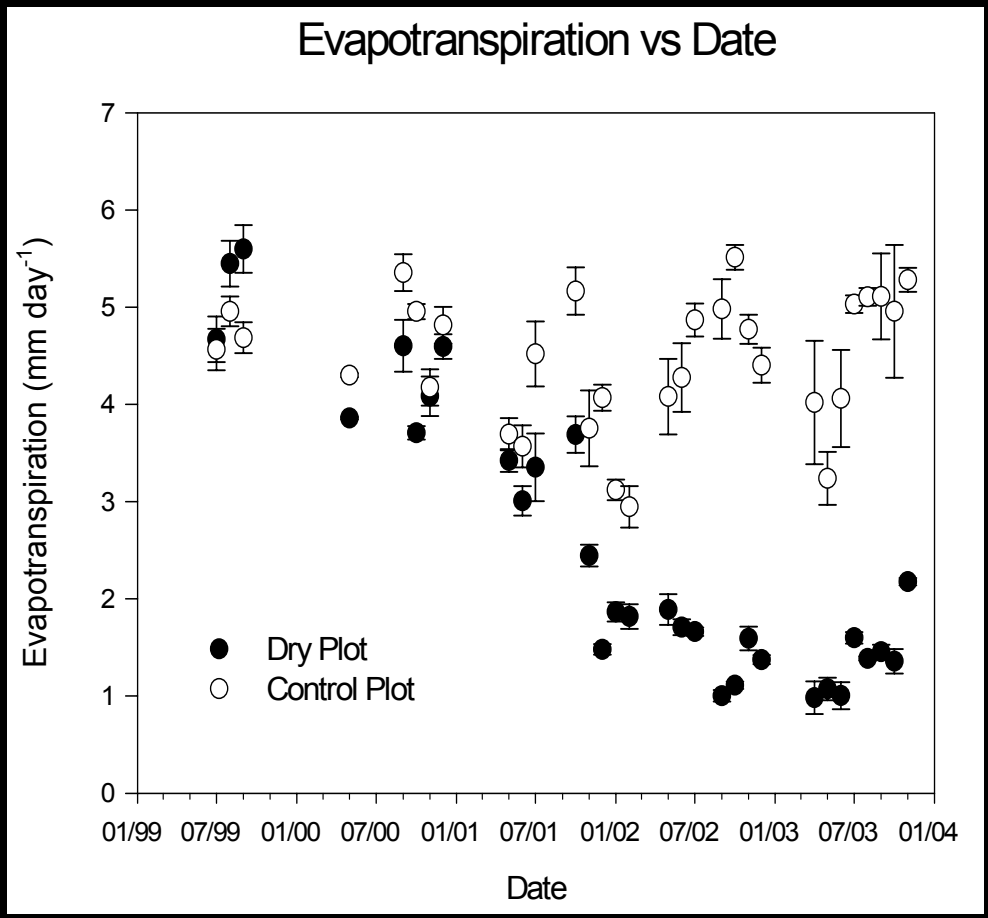

Dry season 2002
VPD (KPa)
3.0
2.5
2.0
1.5
1.0
.5
0.0
Transpiration (mm h-1)
.25
.20
.15
.10
.05
0.00
-.05
262
264
266
268
Julian days
Treatment plot
Control Plot


Rain season 2003
VPD (KPa)
3.0
2.5
2.0
1.5
1.0
.5
0.0
Transpiration (mm h-1)
.30
.25
.20
.15
.10
.05
0.00
-.05
149
151
153
155
Julian days
Treatment plot
Control Plot

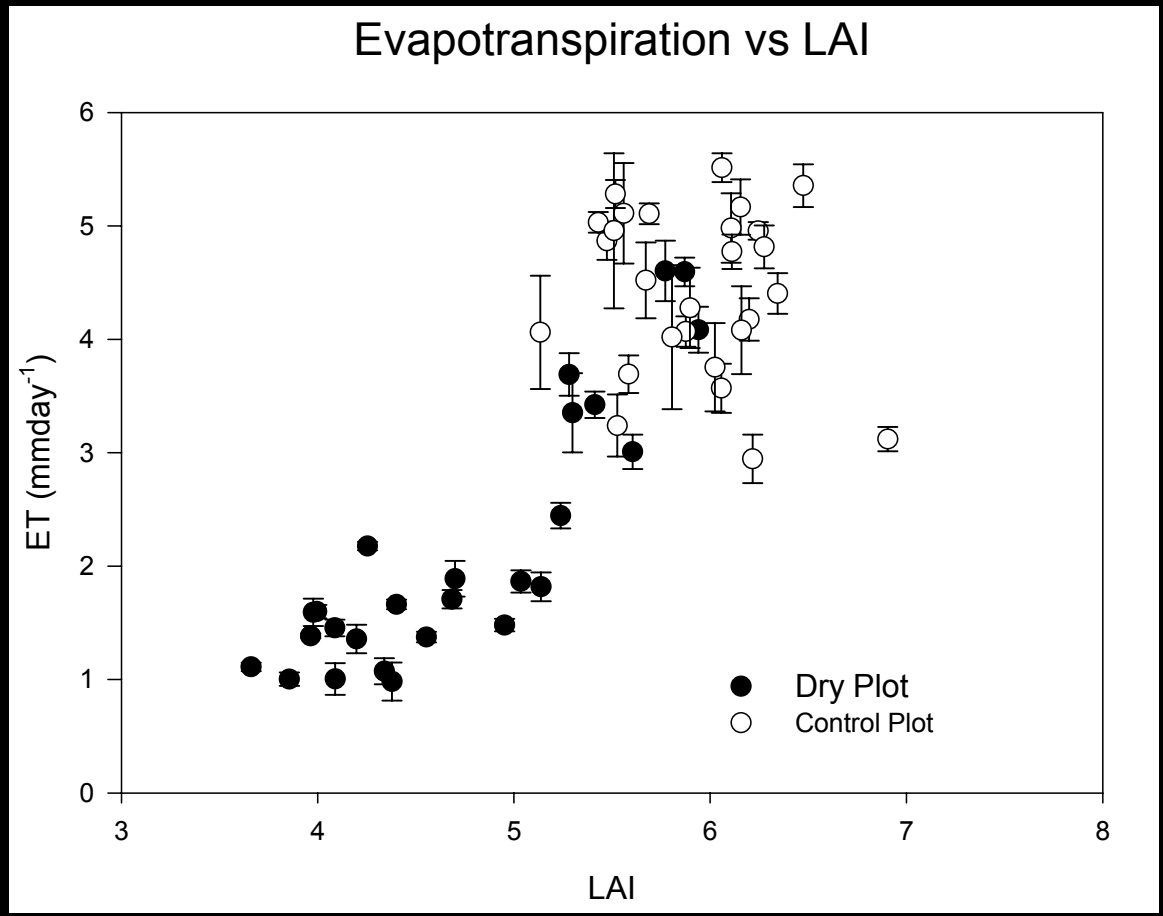

Dry season 2003
VPD (KPa)
3.0
2.5
2.0
1.5
1.0
.5
0.0
Transpiration (mm h-1)
.25
.20
.15
.10
.05
0.00
-.05
256
258
260
Julian days
Treatment plot
Control Plot

Plot Transpiration





- ✓Dry season/2002-dry plot had returned ~74% less water
- ✓Rain season/2003-dry plot returned 76% less water
- ✓Dry season /2003-dry plot had returned 70% less water to atm.



*LAI-Dry plot had better match for LAI

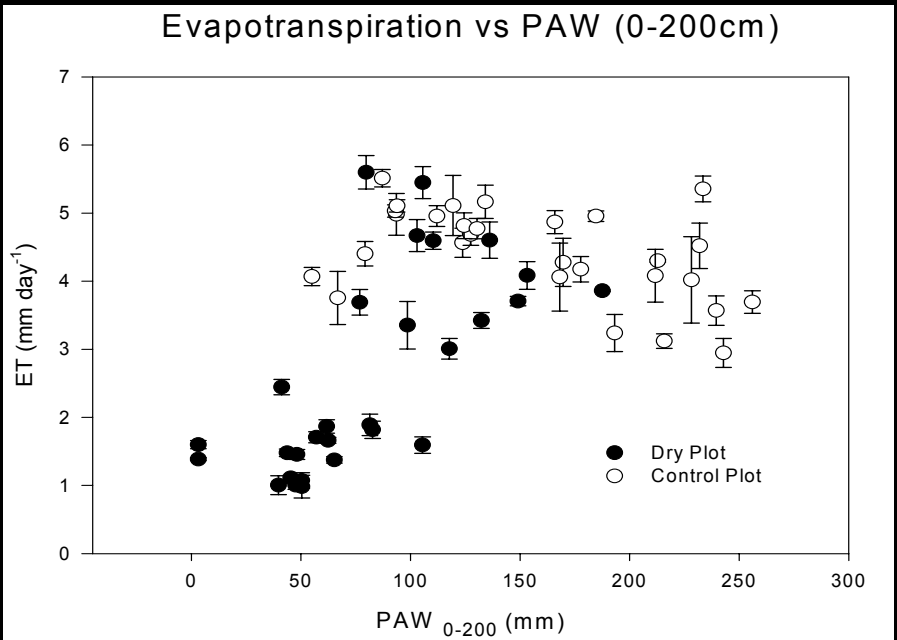
y = 1.4526x - 4.7103

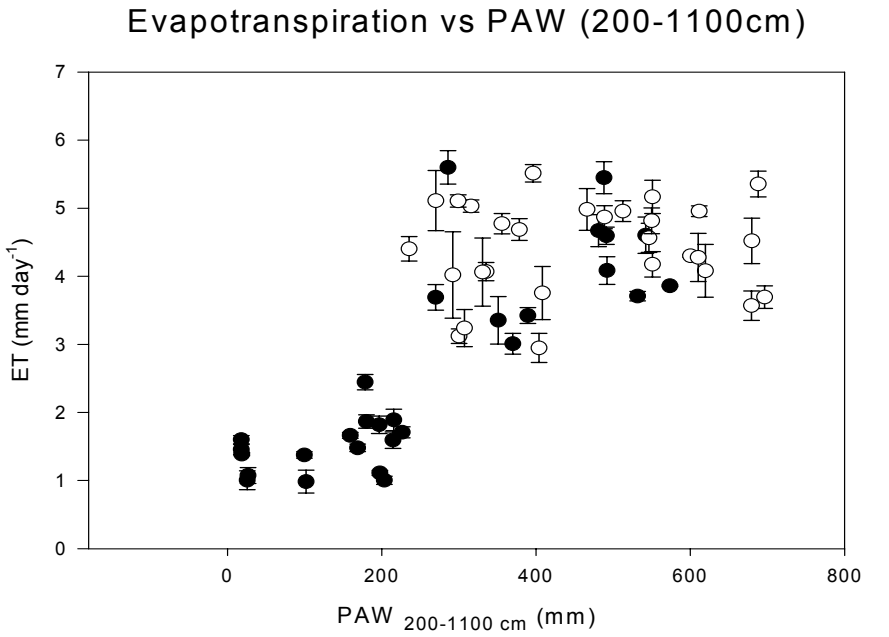
R2 = 0.7595

Control plot didn't show relationship between Et and LAI

y = -0.2938x + 6.1797

R2 = 0.0254





ET/dry plot– match with PAW (dry plot only)

***0-200cm**

y = 0.022x + 0.8519

R2 = 0.4576

***200-1100cm**

y = 0.0069x + 0.8137

R2 = 0.6985

- Emphasize the importance of plant cover in the water cycle
- Deforestation could cause a drying of the system by removing this biological water pump

❖THANKS!

Paul Lefebvre, Karen Schwalbe, David Ray, William Riker, Paulo Brando, Wanderley Rocha and field technicians (Levi Seixas, Osvaldo Portela e Roberto Baena).

IBAMA

CAPES

(Fellowship to Cardinot)