Overseas Development Report

Natural Environment Research Council

First draft prior to revision by INPE

ANGLO-BRAZILIAN AMAZONIAN

CLIMATE PROJECT

(proposed September 1990, as "Anglo-Brazilian Amazonian Climate Observation Study" [ABRACOS])

INTERIM REPORT NO 8
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Contents

1. Summary

1.1

The six month reporting period coincided with the completion of fieldwork with the addition of a short mission 6 at Marabá.

1.2

The routine measurements of climate and soil moisture are proceeding without major problems.

1.3

Analysis has shown that the seasonal trend in forest albedo is closely associated with soil moisture changes.

1.4

Successful operation of the "hydra" eddy correlation equipment at Marabá coincided with the onset of rain at the end of the dry season and the recovery of transpiration capacity of the pasture.

1.5

Detailed *in situ* and *ex situ* measurements of soil hydraulic conductivity have been made at the ABRACOS sites.

1.6

Plant physiology studies have shown a lowering of stomatal conductance, net photosynthesis and leaf area in the pasture areas in response to soil drying.

1.7

Leaf area index of the three ABRACOS forest sites has been estimated from litter fall data and shows interesting site differences.

1.8

Good progress has been made in incorporating ABRACOS data into the Hadley Centre GCM.

1.9

Plans are well advanced for disseminating data, results and findings at the end of ABRACOS.

1.10

The training programme has continued with one more scientist completing a visit from Brazil to IH.

2. Progress

2.1 INTRODUCTION

The middle of this six months reporting period coincided with the completion of the last field mission in Brazil. Since there effort has been directed towards data analysis and quality control, preparing data bases and writing articles. Plans are well advanced for activities associated with dissemination of results and findings of ABRACOS which should coincide with the final few months of the project.

2.2 CLIMATOLOGY AND MICROMETEOROLOGY

2.2.1 Climatology

The analysis of albedo data from all the forest and pasture sites has continued. As shown in Figure 2.2.1a the albedo at all the forest sites has a strong seasonal cycle. This cycle is particularly marked at Marabá where the albedo reaches a value of 0.16, a similar value to that observed over pasture at some times of the year. It is thought that the variation of albedo is probably related to leaf age or condition since it correlates with variations in soil moisture and appears to be a physiological effect. The results from the pasture, shown in Figure 2.2.1b, do not show such an obvious annual cycle as the results from the forest. This fact is probably because in the pasture, as well as the effect of soil moisture, there are other factors, such as grass height and the proportion of visible bare soil, which also change during the year. Three site mean albedos have been calculated for the forest and for the pasture sites. For the forest the mean is 0.134 and for the pasture it is 0.18. These mean results are close to the values used in recent general circulation model simulations of Amazonian deforestation, however, the inclusion of the observed seasonal variation in future simulations may have a significant effect on the results. A paper describing these results is in preparation.

2.2.2 Micrometeorology

Missions 4 and 5
The final two scheduled missions of detailed micrometeorological measurements, Missions

4 and 5, were combined to produce an extended final period spanning several months and encompassing significant seasonal change. Hourly flux measurements at the Ji Paraná forest and pasture sites began in early April and continued through to mid July 1993. In May, the measurement systems were managed by scientists from São Paulo (INPE) with assistance from local scientist from the University of Rondonia and INCRA. During the final three weeks, the flux measurement systems were maintained by Brazilian scientists to support the Rondonia Boundary Layer Experiment (RBLE).

Figure 2.2.2 shows some of the preliminary flux analysis. Compared with the missions operated in the Manaus area, similar responses to the developing dry season are shown, except that the rate of decrease of evaporation flux from the pasture is not so rapid. This is due to the different soil and deeper rooting depth of the pasture. As with all other studies, the forest evaporation shows no response to the dry absence of significant rainfall in May and June.

Marabá Mission

A short mission of five weeks was operated in October 1993 in the Marabá area. Flux measurements were recorded over the forest and pasture by installing a Hydra eddy correlation device at each site. This means that flux measurements have now been recorded at all three pairs of sites.

Although some instrument problems were encountered, there are two important facets to the recovered data.

1. 14 days of concurrent data from both sites were recorded for direct comparison.

2. The timing of the mission was not frustrated by abnormal seasonality and the period of measurement includes significant seasonal change. The first rain of the wet season occurred at the beginning of the mission and there is a noticeable increase in soil moisture and pasture evaporation during the five weeks.

Figure 2.2.3 shows comparative flux from the forest and pasture sites for the 8 October 1993. Although it was more cloudy at the forest site the different partitioning of energy into sensible heat and evaporation can clearly be seen, especially the higher heat flux in the pasture.

For this mission, Ari Marques from INPA Manaus, joined scientists from EMBRAPA, UFPa and IH in maintaining the measurement systems and doing the preliminary analysis of Hydra data.

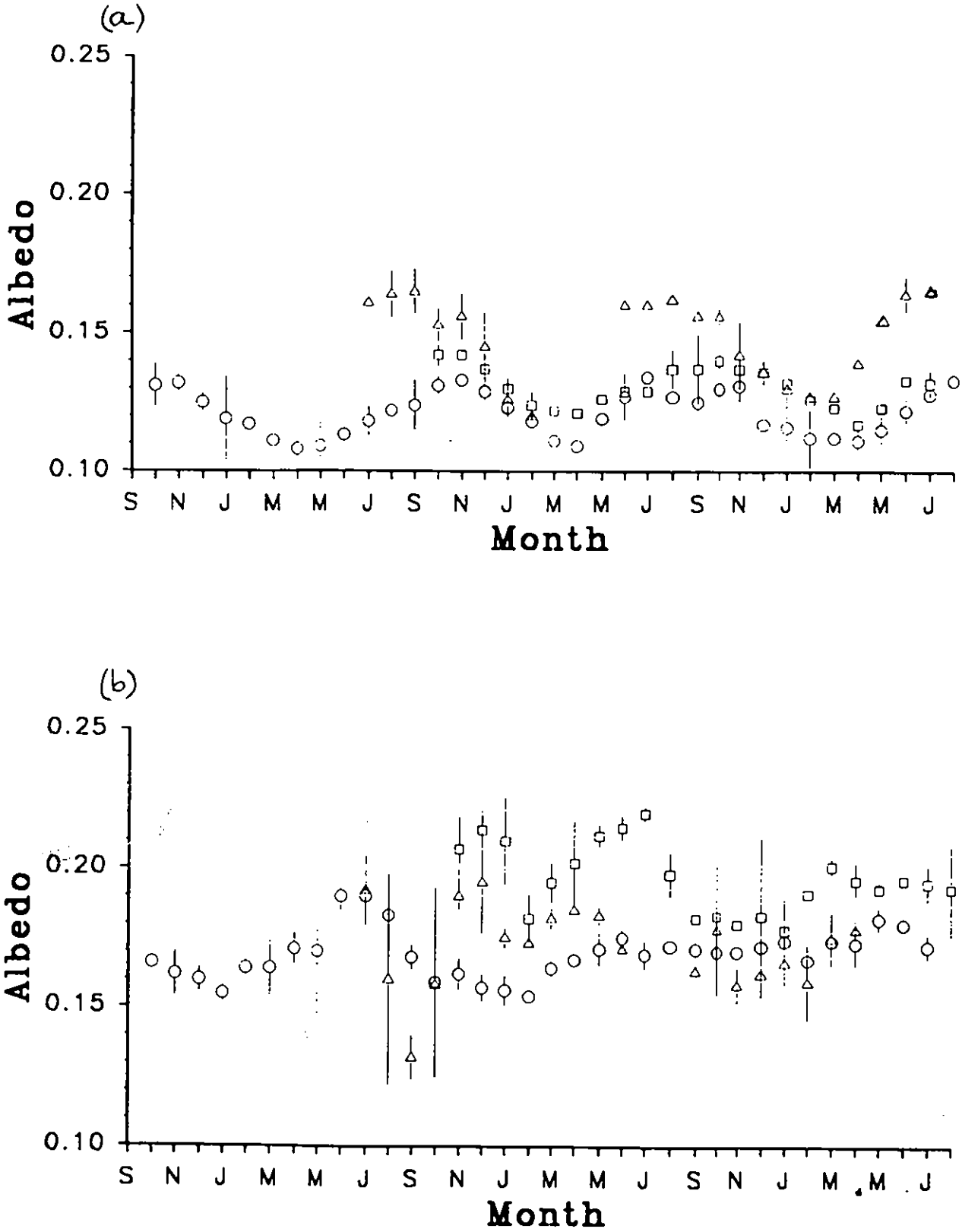

Figure 2.2.1 *Monthly average values of daily albedo. The error bars indicate plus and minus one standard deviation from the mean. a) Forest sites; - ○ - Reserva Ducke; △ - Reserva Vale do Rio Doce; - □ - Reserva Jaru. b) Ranchland sites; - ○ - Fazenda Dimona; △ - Fazenda Boa Sorte; □ - Fazenda Nossa Senhora da Aparecida*

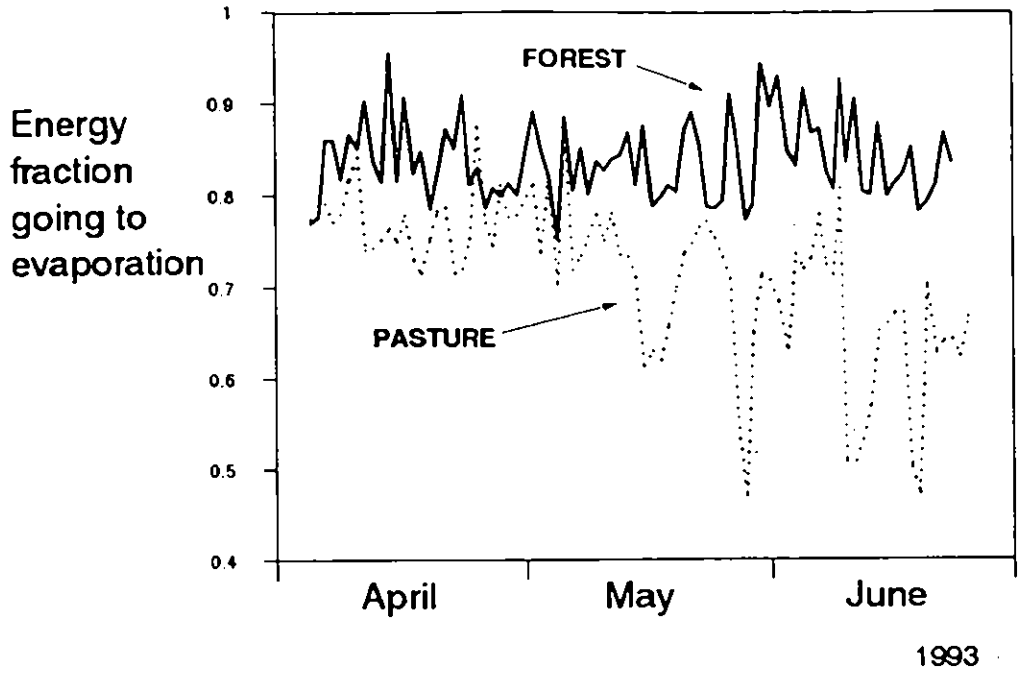

Figure 2.2.2 *Divergence of energy partitioning in response to the developing dry season at the forest (Reserva Biologia Jaru, Rondonia) and pasture (Fazenda Nossa Senhora da Aparecida) sites, Ji-Paraná, Rondonia.*

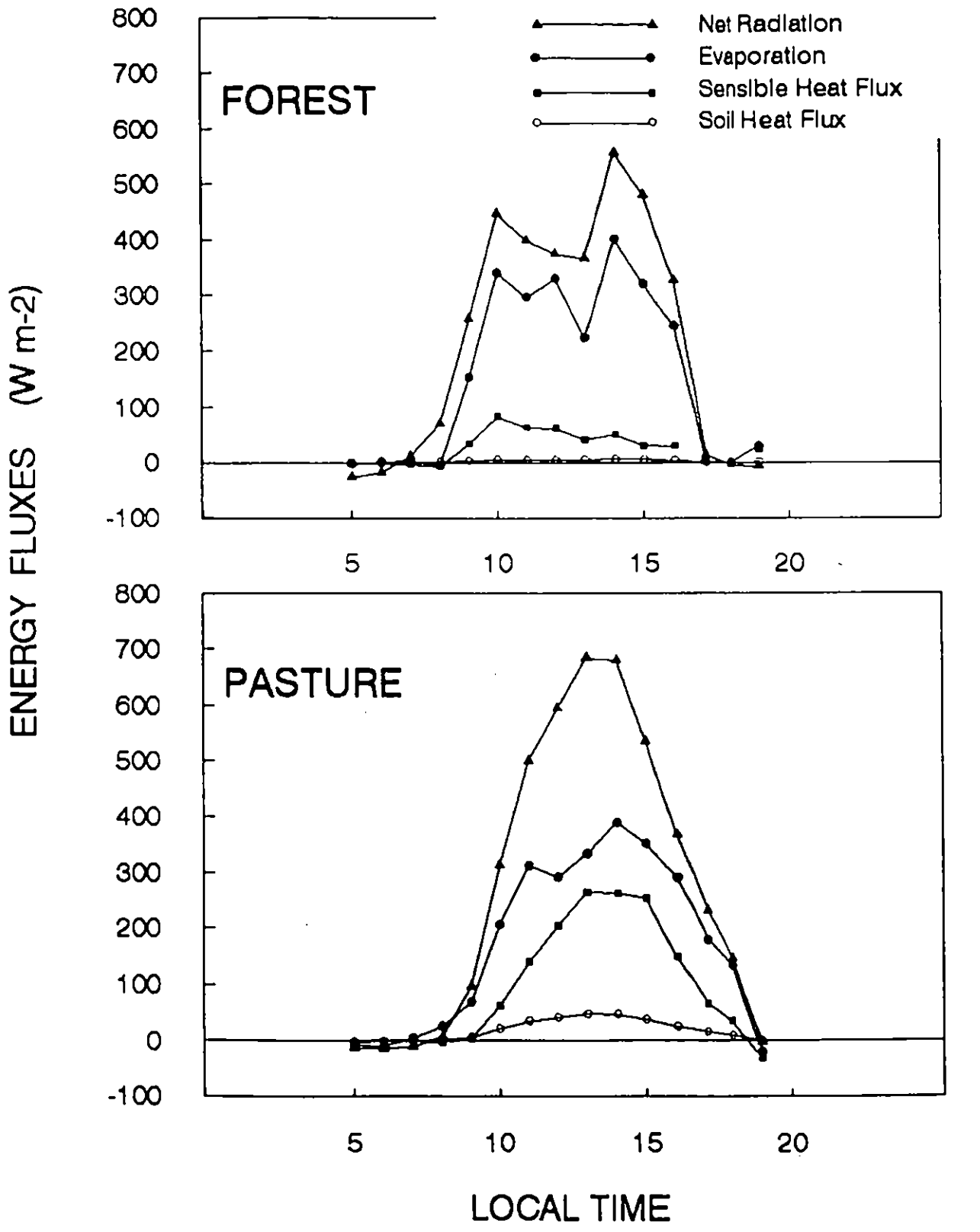

Figure 2.2.3 *Comparative fluxes at the forest (Reserva Florestal Vale do Rio Doce) and pasture (Fazenda Boa Sorte) sites near Marabá, Para on 8 October 1993.*

2.3 PLANT PHYSIOLOGY

2.3.1 Ji-Paraná Site

All the plant physiological measurements for ABRACOS have now been successfully completed and analyses are well on the way.

Some preliminary results are given below.

(a) *Forest* Leaf litter was collected over a 12 month period and leaf area index (LAI) was estimated, assuming a leaf life-span of one year. Figure 2.3.1 compares the LAI estimates from leaf litter in all three ABRACOS sites for the same annual period (but not the same year for Manaus where leaf litter was collected prior ABRACOS).
From these results it can be seen that the Reserva Jaru site has the lowest LAI (4.7 +/- 1.3; mean +/- STD). This number compares well with an estimate of 4.8 by Professor Grace (TIGER project) in the previous year using the gap fraction technique.

Figure 2.3.2 shows the trees immediately surrounding the tower which have now been identified, mostly to species level. Figures 2.3.3 and 2.3.4 show diurnal rhythms of stomatal conductance (g_s) and water potential on a sample day during the rainy season (3 April 1993) and the dry season (9 June 1993). Maximum conductances were attained by *Cedrella odorata* (M) of 566 mmol m^{-2} s^{-1} (L18) and 587 mmol m^{-2} s^{-1} on 3 April. All conductances of the canopy species declined during the day. Values of g_s for *Inga* spp (T1) and *Protium polybotrium* (T2) were not measured for the whole day since the leaves remained moist until 1000 and 1300 hrs, respectively. However, it was possible to measure water potentials throughout the day. Even though the g_s fell throughout the day, the water potentials did not show much recovery in any of the canopy species except *P. polybotrium*, which consistently shows lower conductances and is in a more sheltered area of the canopy (see Figure 2.3.2). In *Inga* spp (3 April), leaf water potentials decreased from -1.5 MPa to -2.4 MPa, whereas *C. odorata* reached -2.6 MPa. By 9 June, *C. odorata* had lost its leaves, so the main emergent was *Inga* spp. Higher g_s was observed for this species at that time due probably to higher illuminations and a new set of leaves), the maximum reached was 420 mmol m^{-2} s^{-1}. Water potentials did show partial recovery once the stomata started to close in all 3 canopy species, and were not as negative as in April (lowest value -2 MPa cf. -2.4 in April in *Inga* spp.). Stomatal conductances were similar for both the wet and dry days except for the *Theobroma microcarpum* (G1), which maintained higher conductances during the wet season (maximum conductance 212 mmol m^{-1} s^{-2} 3 April compared with 164 mmol m^{-2} s^{-1}, 9 April). Water potentials did not vary much between season, except for *Maxmiliana maripa* (P1) which had the least negative water potentials in April (lowest attained -1.2 MPa) and the most negative in June (-2.6 MPa). This species was the only palm species measured and shows that it was much more sensitive to changes in the soil moisture, presumably because it has less deeper rooting. In summary, the forest species did not show much change in their g_s or leaf water status after 2 months of limited rainfall. Instead, the canopy species showed consistently high g_s in parallel with low water potentials, while the within-canopy species had much lower conductances and higher water potentials.

(b) *Fazenda* Figure 2.3.5 shows the diurnal pattern of g_s and water potential (an average of 5 days) in March (wet season) and June (dry season) for *Brachiaria brizantha*. The effect of the change in season is far more marked in the vegetation in the Fazenda compared with the forest. During the wet season, maximum conductance reached was 621 mmol m^{-2} s^{-1}, while after 2 months of limited rainfall the stomatal conductance barely reached 200 mmol

m^{-1} s^{-2}. This value compares well with maximum g_s of 211 mmol m^{-2} s^{-1} found for *B. brizantha* at the beginning of field mission 3 (see Fig. 2.2.1.A ODA report no. 6). The pattern of diurnal water potential responded to the patterns of g_s; in the wet season they were less negative (-1.3 MPa at 1400 hrs; Fig 2.3.5), and in the dry season, with the grass more stressed, the water potential reached -1.8 MPa (Fig 2.3.5). In both seasons the water potentials in the grasses managed to regain turgor by the end of the night. Maximum net photosynthesis decreased from 21.6 umol m^{-2} s^{-1} (March) to 16 umol m^{-2} s^{-1} (June), even though the patterns of PAR were equivalent (Fig 2.3.6). In both the wet and dry seasons there was a correlation between stomatal conductance and photosynthetically active radiation (PAR), and between net photosynthesis and PAR (Fig 2.3.7).

Leaf, stem and plant area indices and biomass data collected over all the missions carried out at Fazenda Nossa Senhora are listed in Table 2.3.1. The values of LAI relate well to seasonal changes in soil moisture content. The lowest LAI was found at the end of the dry season (1.31), the highest (3.15) during the peak of the wet season, but declined after 2 months of limited rainfall (LAI of 2.14, 18 June 1993).

Ongoing analyses
Individual leaf conductances will be scaled up using LAI to give canopy conductances. This, combined with the microclimate data collected from Reserva Jaru and Fazenda Nossa Senhora, will be used in the multi-layer canopy transpiration model (CLATTER) to give total forest and Fazenda transpiration.

2.3.2 Marabá site

The preceding report (ABRACOS ODA Interim Report 7) showed that rainfall in the wet season 1992-93 did not fully replenish the soil moisture store particularly in the forest at Marabá. In addition to Missions 4 and 5 which were conducted at Ji-Paraná and Marabá in 1993 an additional Mission 6 was held at Marabá in October. The purpose of the mission was to obtain additional physiology data at the end of the 1993 dry season in which the possible influence of the low rainfall of the previous wet season was examined. During this mission "Hydras" were deployed at the pasture and forest sites in Marabá also. Some data from these instruments are given in Figure 2.2.3 which indicated similar qualitative comparative responses to dry soils by the of the forest and pasture as has been observed elsewhere in the ABRACOS study (Manaus and Ji-Paraná). Physiological studies at this time indicate that soil water deficits have little effect on stomatal conductances measured in the forest but a substantial reduction is observed in species measured in the pasture although the effect is less for the Babaçu palm presumably because of deeper rooting.

Litter collections in the forest at Marabá have now been maintained for over two and a half years. Figure 2.3.1 shows a comparable portion of the data from Marabá in a comparison with the data from the Ji-Paraná and Manaus forests. If the assumption is made that the average leaf life span is twelve months then the leaf area index at Marabá is around 5.5 intermediate between that of Manaus and Ji-Paraná. It is not unreasonable to assume that leaf area index is a function of the availability of water and nutrients.

The multi-layer canopy transpiration model CLATTER requires leaf area index values distributed in canopy layers. This information has been obtained at Manaus from destructive sampling but has not been a feasible option at the other two sites. A non-destructive approach is being investigated which involves defining the frequency distribution of specific leaf area

in forest litter. Specific leaf area varies systematically with vertical position in a forest canopy and is a consequence of the vertical gradient in solar radiation through the canopy. The frequency distribution of specific leaf area classes in the liier will reveal the vertical pattern of leaf area index and followed seasonally may indicate when different parts of the canopy are being lost into the litter fraction.

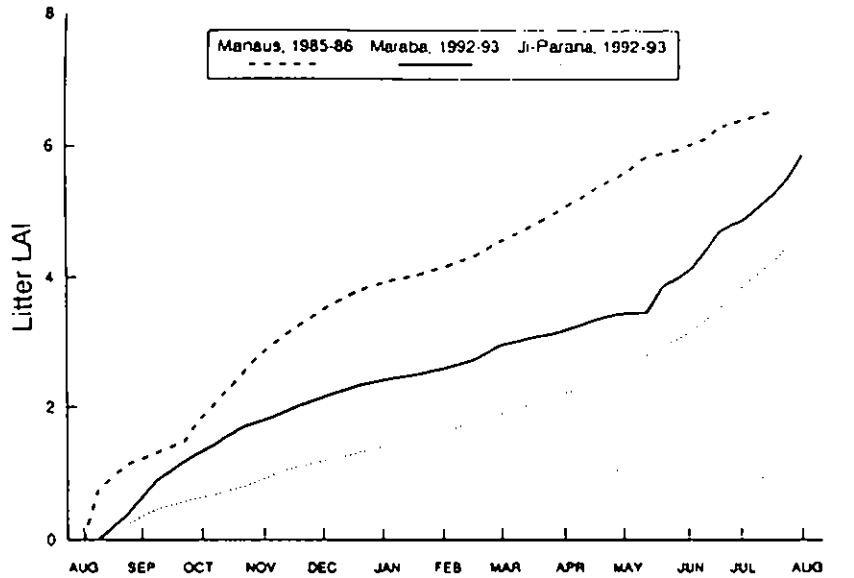

Figure 2.3.1 *Cumulative litter leaf area index for a 12 month period at the three ABRACOS sites.*

Description of trees surrounding the tower at Reserva Jaru, Rondonia

TREE/LEVEL	SCIENTIFIC NAME	FAMILY
M/L18,L16	*Cedrella odorata*	Meliaceae
T1/L16,L13 L14	*Inga* sp.	Leg-Mimosaceae
C1/L16	*Dioclea cf bicolor* Bth.	Leg-Pap
C2/L16,L14	*Strychnos amazonicus* Krukoff	Loganiaceae
T2/L10	*Protium polybotrium* (Turcz) Engl	Burseraceae
T3/L8,L5	*Leonia glycicarpa* Ruiz	Violaceae
C3/L8	*Derris pterocarpa* (DC) Killip	Leg-Pap
T7/L7	*Guarea cf da visii* Sandvit	Meliaceae
T4/L3	*Hirtella hispidula* Steud.	Chrysobalanaceae
T5/L1	*Erythroxylum cf. macrophyllum* Cav	Erythroxylaceae
G1/L0	*Theobroma microcarpum* Mart.	Sterculaceae
P1/L0	*Maximiliana maripa* (Corre Serre) Drude	Palmae

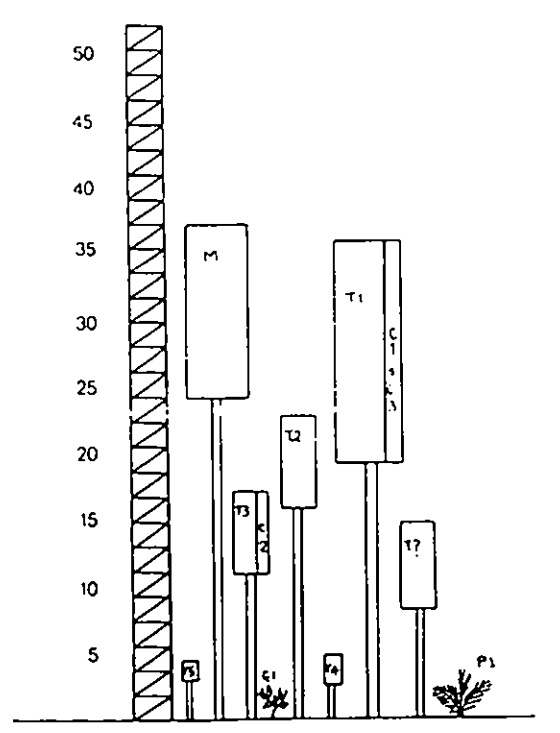

Figure 2.3.2 *Schematic diagram showing the vertical positions and canopy lengths of tree species accessible from the forest tower for physiological studies at Reserva Jaru, Ji-Paraná.*

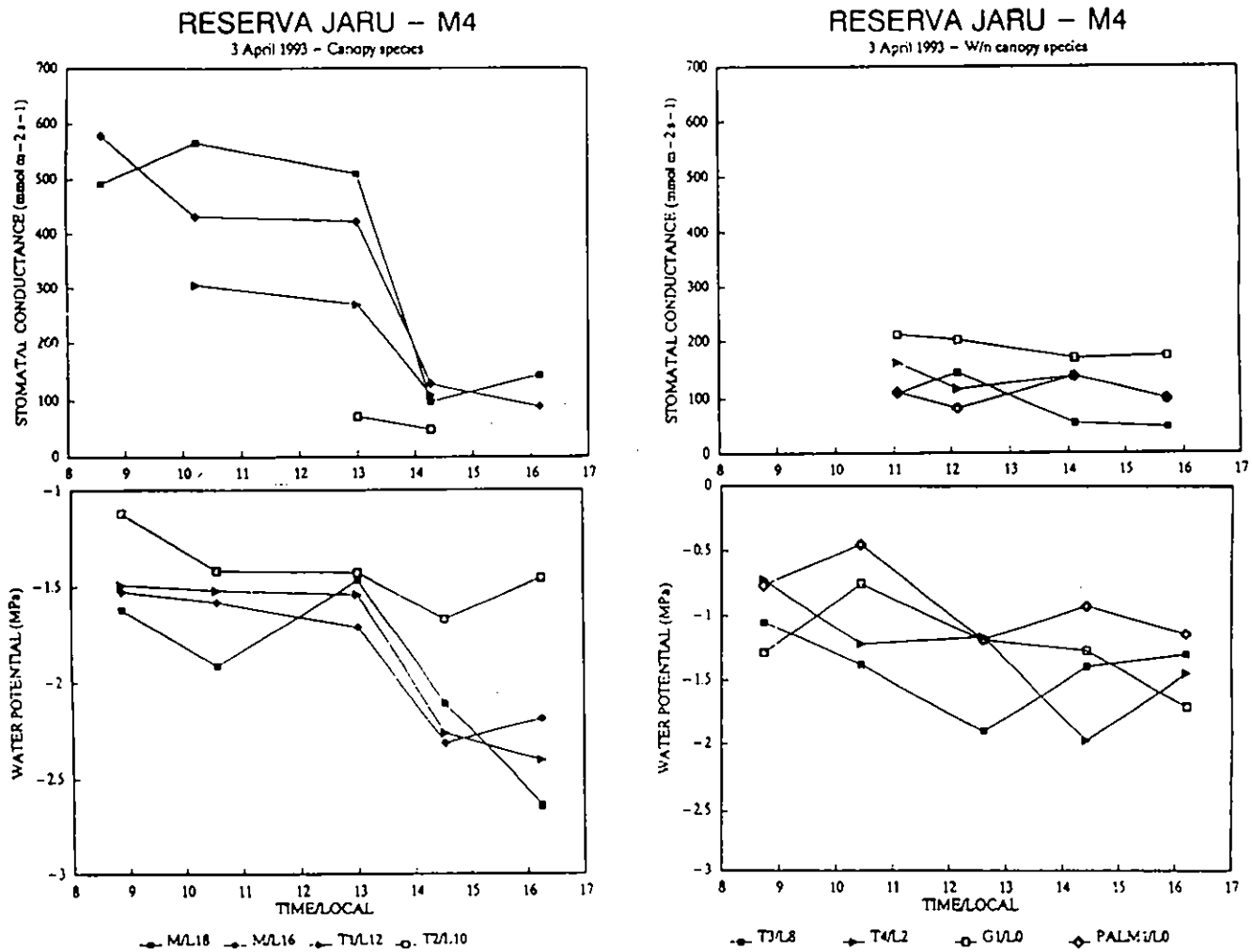

Figure 2.3.3 Stomatal conductance and leaf water potential of upper- and within-canopy species in the wet season of 1993.

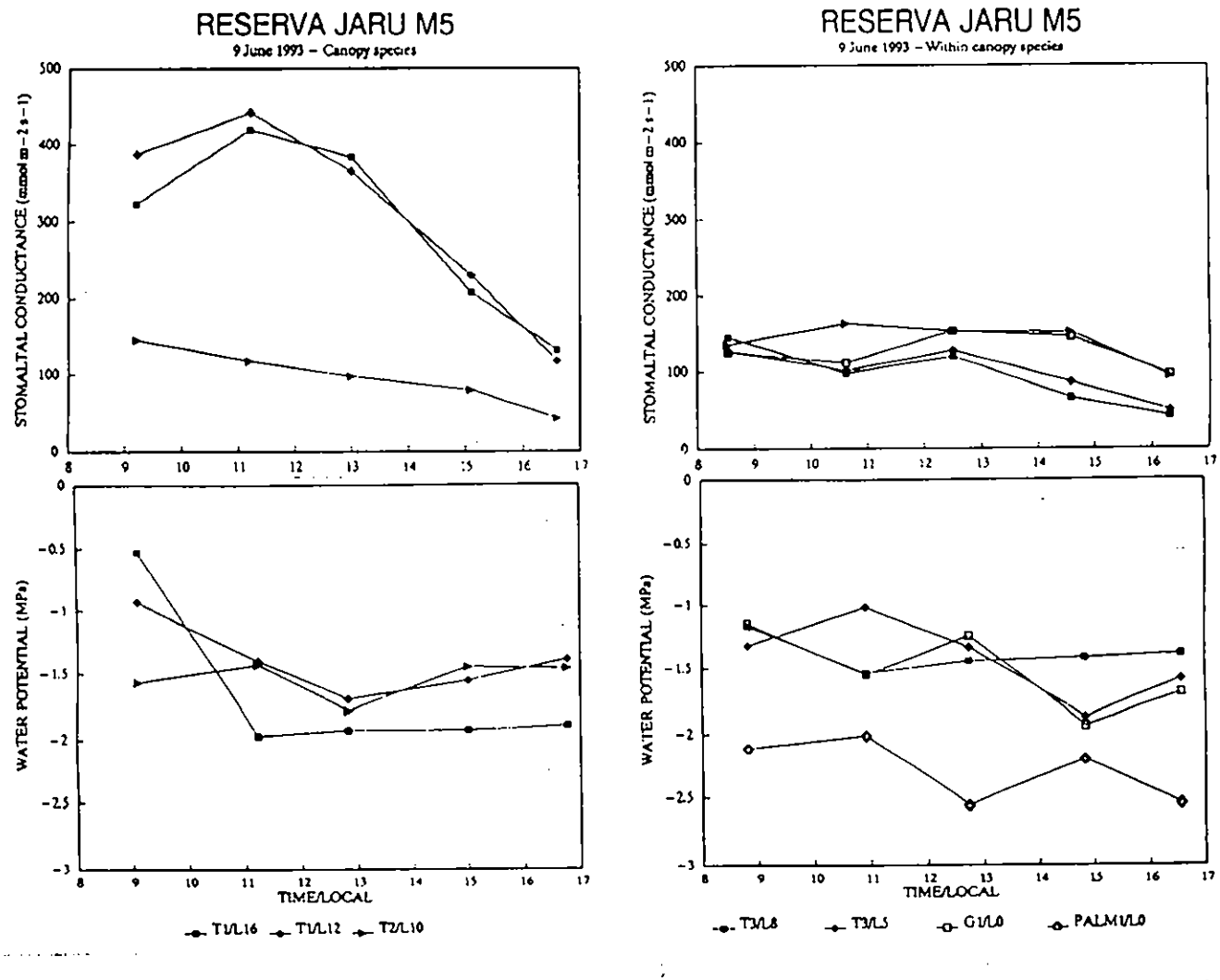

Figure 2.3.4 *Stomatal conductance and leaf water potential of upper and within canopy species in the dry season of 1993. Reserva Jaru, Ji-Paraná, Rondonia.*

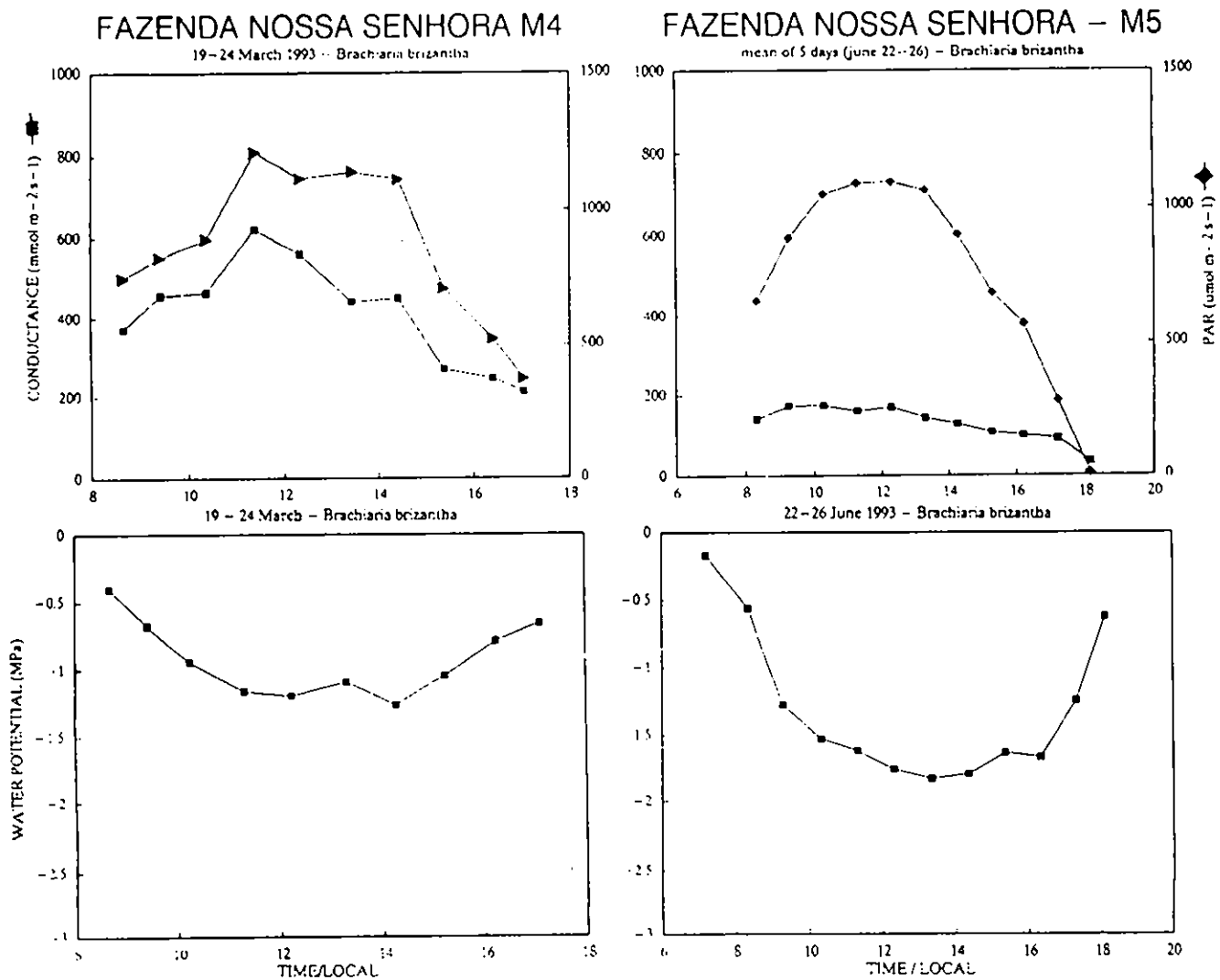

Figure 2.3.5 *Stomatal conductance and leaf water potential of Brachiaria brizantha in the dry season (19-24 March 1993) and wet season (22-26 June 1993) at the pasture site, Fazenda Nossa Senhora, Ji-Paraná, Rondonia.*

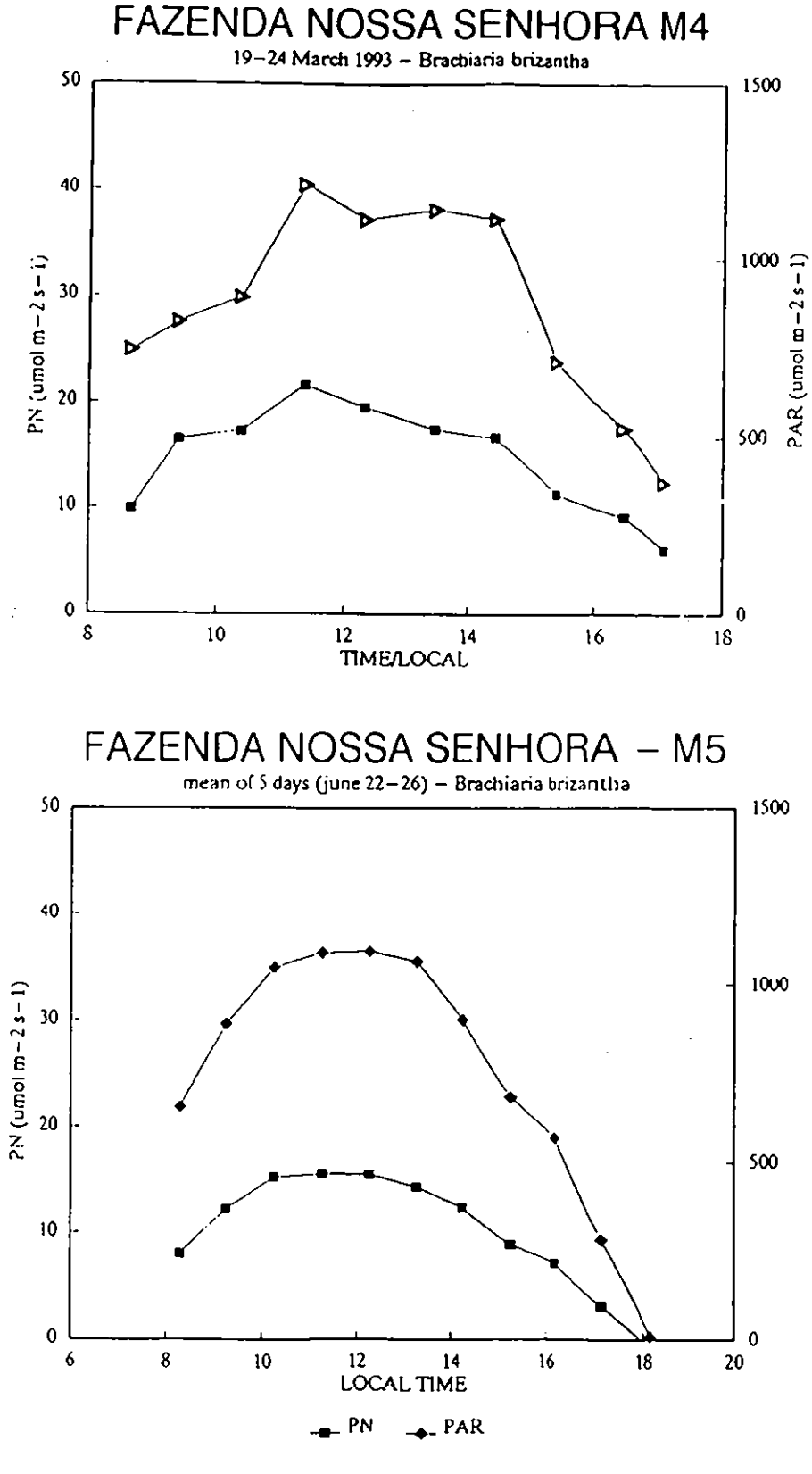

Figure 2.3.6 *Net photosynthesis of Brachiara brizantha and associated photosynthetically active radiation in the wet season (19-24 March 1993) and dry season (22-26 June 1993) at the pasture site, Fazenda Nossa Senhora, Ji-Paraná, Rondonia.*

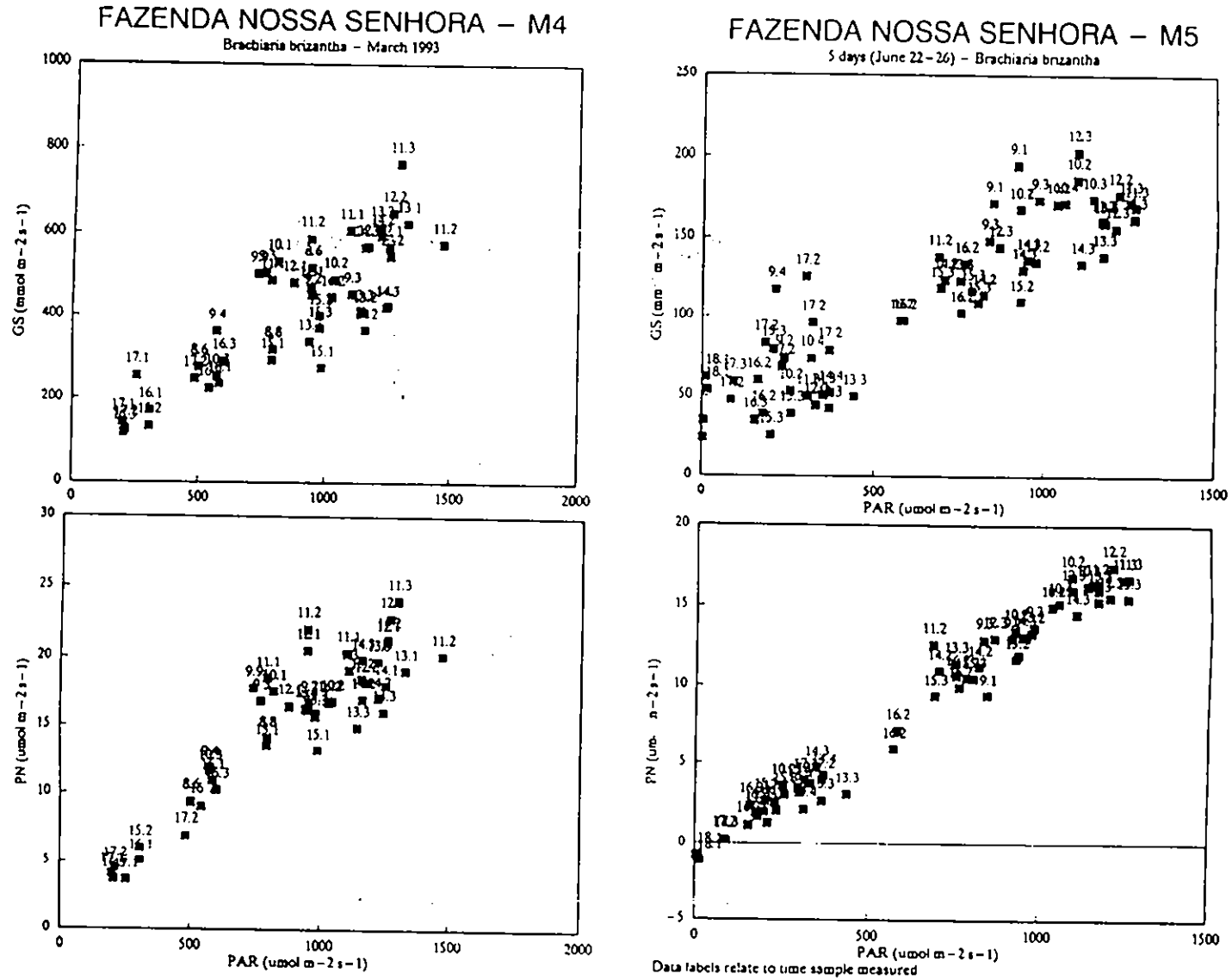

Figure 2.3.7 *Relationships between stomatal conductance and net photosynthesis with photosynthetically active radiation in the dry season (March, 1993) and in the wet season (June, 1993) at the pasture site Fazenda Nossa Senhora, Ji-Paraná, Rondonia.*

Table 2.3.1

PLOT	GRASS HT cm	% GRASS	LAI	SAI	PAI	DRY BIOMASS Leaf t ha^{-1}	Stem t ha^{-1}	Dry t ha^{-1}	Total t ha^{-1}	SLA cm^2 g^{-1}
8 August 1992										
MEAN	47		1.31	0.25	1.55	0.95	0.88	7.13	8.96	137.5
STD	12		0.60	0.14	0.72	0.48	0.44	2.49	3.20	28.0
21 September 1992										
MEAN	53		1.44	0.23	1.66	0.94	0.79	5.86	7.47	152.8
STD	12		0.49	0.09	0.57	0.33	0.26	1.42	2.01	28.4
9 April 1993										
MEAN	58		3.15	0.54	3.69	2.26	2.05	4.63	8.94	139.6
STD	11		1.07	0.21	1.27	0.77	0.80	1.27	2.46	-
18 June 1993										
MEAN	62	65	2.14	0.41	2.55	1.64	1.84	7.89	11.37	128.6
STD	14	16	0.75	0.10	0.82	0.44	0.41	1.90	2.24	15.2

LEAF AREA INDEX, GRASS HEIGHT AND BIOMASS - M3, M4 & M5

Twelve 0.5 m^2 plots (M3) and ten 0.5 m^2 (M4 & M5) were sampled for measurements of leaf area index and biomass. Leaf and stem area indices for M4 were estimated from average specific leaf & stem areas from M3 & M5.

LAI = leaf area index, SAI = stem area index, PAI = plant area index, SLA = specific leaf area.

2.4 SOIL MOISTURE STUDIES

Weekly measurements of soil moisture content measured with neutron probe and soil matric potential using tensiometers have been maintained at all ABRACOS sites and quality control and processing of these data is well advanced. At the Institute of Hydrology a new version of the Soil Water Information Processing System (SuperSWIPS) is now used for the processing. Dr Cathy Holwill is spending some time assisting Martin Hodnett to complete data processing and quality control. It is envisaged that a short familiarization course on the use of the SuperSWIPS will be held at IH in the current year for a small number of Brazilian scientists who are closely involved with soil water content data collection or processing in ABRACOS (c.f Section 4.3).

2.4.1 Ji-Paraná

Figure 2.4.1 shows the seasonal changes in total profile soil water storage at the Ji-Paraná forest and pasture sites from the beginning of data collection in October 1991 up to the present. Much larger changes in soil water storage are observed in the forest and although initially the rate of depletion of the soil water store at the end of both wet season is similar in both forest and pasture the rate falls off in the pasture but is sustained by the forest. The start of the period of depletion is different for the two vegetation types with the decline of the forest profile soil water content beginning later than in the pasture. This response might be a function of local rainfall differences or the influence of a high water table at those times in the forest which is adjacent to the Rio Machado. Undisturbed soil samples were obtained for the forest and pasture sites and *ex situ* determinations of hydraulic conductivity will be made on them.

2.4.2 Marabá

Figure 2.4.2 shows the seasonal changes in total profile soil water storage at the Marabá forest and pasture sites from the start of measurement in September 1991 to the present. At the forest site (Reserva Vale do Rio Doce) even larger differences in soil water storage compared to the pasture site (Fazenda Boa Sorte) are observed compared to the forest and pasture sites in Ji Paraná. Also, at Marabá there is substantially year to year variation in the behaviour of soil water content changes in the Forest. Unlike the previous wet season the wet season 1992-1993 failed to replenish the soil water reservoir. However physiological studies made at the forest and pasture sites at the end of the 1993 dry season indicated that stomatal conductance and therefore transpiration was not substantially different from to the levels observed at the end of the dry seasons of 1991 and 1992. At the end of the dry season in 1993 the change in total soil profile moisture storage in the forest is levelling off (Figure 2.4.2) suggesting that transpiration must be sustained from below the lowest measurement depth (3.75 m) measured in the neutron probe access tubes.

2.4.3 Manaus

In addition to routine measurements of soil water content and matric potential being maintained at the forest and pasture sites at Manaus detailed *in situ* measurements have been made of saturated and unsaturated hydraulic conductivity. Figure 2.4.3a shows saturated hydraulic conductivity measured in situ with a CSIRO permeameter. In the surface and upper

soil layer (30 cm) the range of saturated conductivity is large and is a function of the more abundant presence and size range of fissures and root channels compared to deeper in the soil profile (105 cm).

Figure 2.4.3b shows results from the "instantaneous profile" method for determining unsaturated hydraulic conductivity at two soil depths (30 and 105 cm). An important result from this study is the much sharper change of hydraulic conductivity with soil matric potential in the upper soil layers compared to deeper in the soil profile. This means that in the upper soil layers soil moisture availability to plant roots may be critically reduced even at relatively moderate soil matric potentials while deeper in the soil higher hydraulic conductivity is maintained over a much wider span of matric potential.

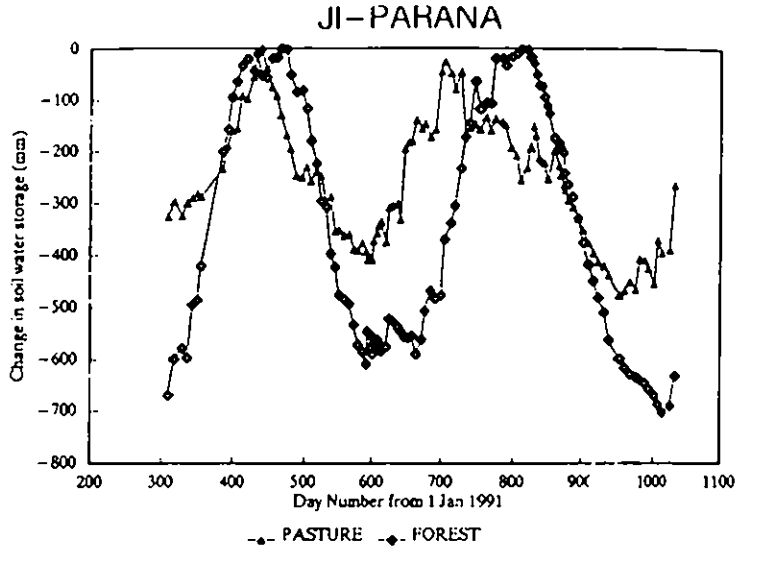

Figure 2.4.1 *Changes in profile water storage in the pasture (Fazenda Nossa Senhora) and the forest site (Reserva Jaru) at Ji-Paraná, Rondonia since October 1991.*

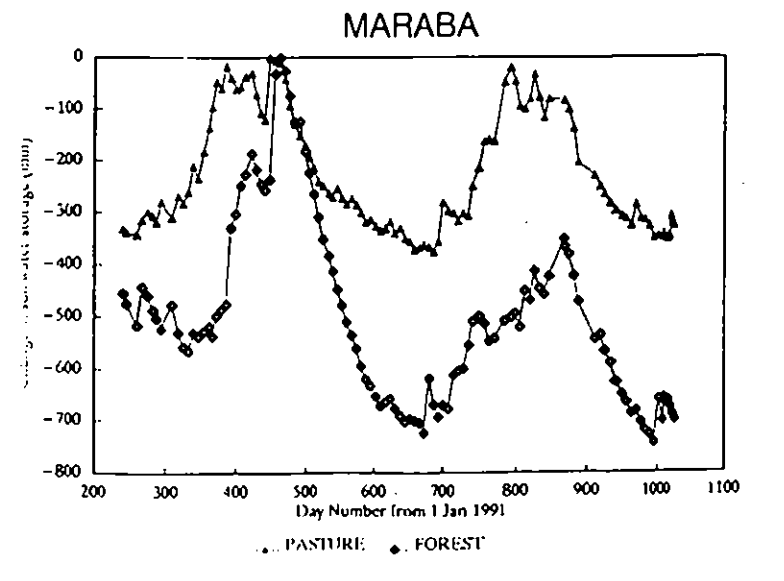

Figure 2.4.2 *Changes in profile water storage in the pasture (Fazenda Boa Sorte) and the forest site (Reserva Vale do Rio Doce) at Marabá since September 1991.*

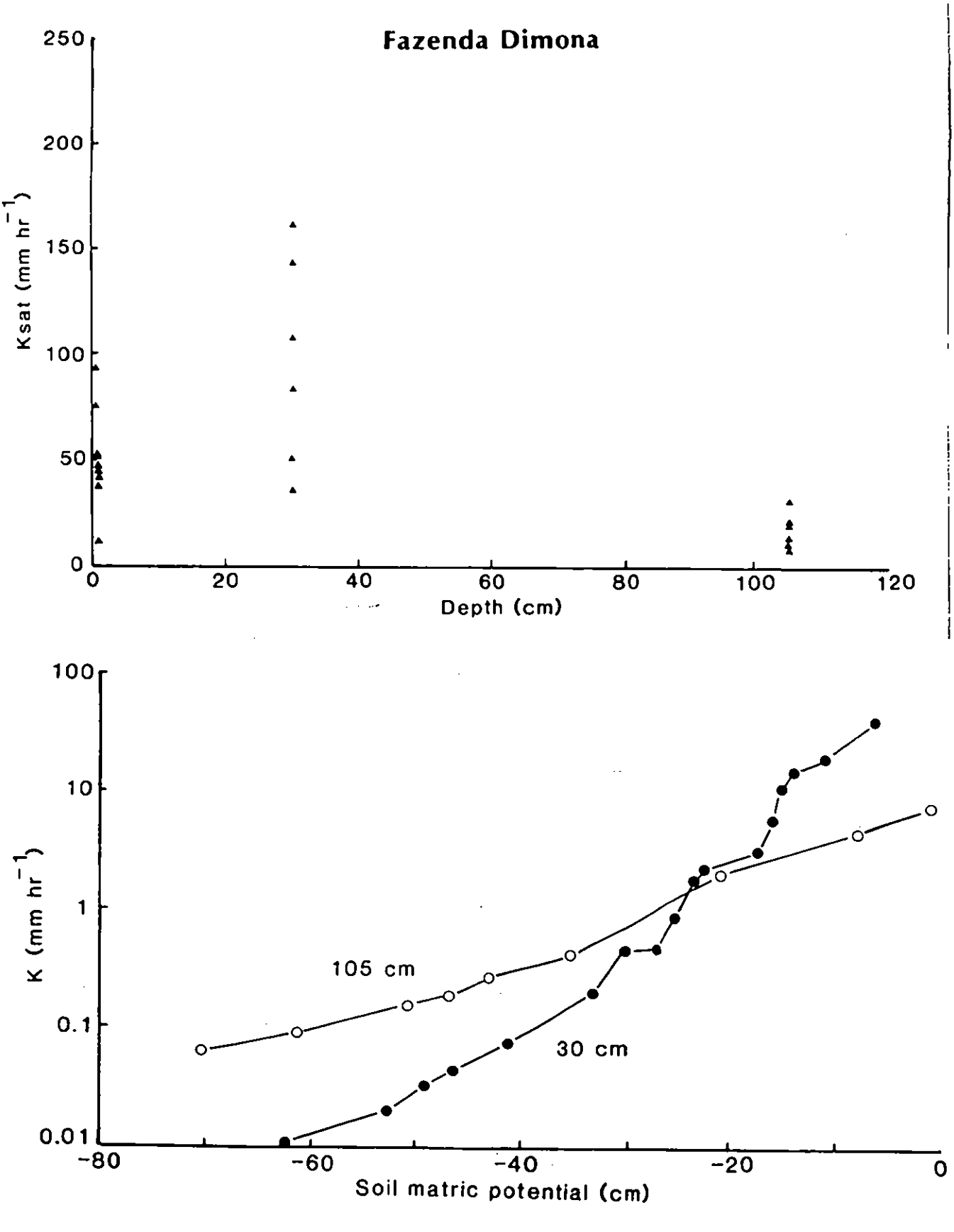

Figure 2.4.3 *(a) Measurements of saturated hydraulic conductivity made at three depths at the pasture site, Fazenda Dimona, Manaus. (b) Measurements of hydraulic conductivity made at 30 cm and 105 cm depth with the instantaneous profile method at the pasture site, Fazenda Dimona, Manaus.*

2.5 ISOTOPE STUDIES

Sr Aristides Ribeiro is a post-graduate student with Dr Reynaldo Victoria, Centro de Energia Nuclear na Agricultura (CENA) in Piricicaba, Sao Paulo. Sr Ribeiro has been examining the concentration of the stable isotopes of hydrogen and oxygen in water (gross and net rainfall) and vapour samples (four positions in the forest profile namely forest floor, 10m and 20 metres from the forest floor and above the canopy) taken at the three ABRACOS forest sites. One approach of the studies is an examination of the diurnal vatiation in isotopic composition of vapour above the forest and the contribution to changes in it which can be traced to contributions from the soil and other layers in the forest based on information from the isotopic signals identified for the different strata.

2.6 COORDINATION

A coordination meeting was held at IH in September. Results from the Missions 4 and 5 were discussed.

3. Publications

Bastable, H.G., Shuttleworth, W.J., Dallarosa, R.L.G., Fisch, G. and Nobre, C.A. (1993). Observations of climate, albedo, and surface radiation over cleared and undisturbed Amazonian forest. International Journal of Climatology, 13, 783-796.

Roberts, J.M. and Cabral O.M.R. (1994). ABRACOS: a comparison of climate, soil moisture and physiological properties of forests and pastures in the Amazon Basin. Commonwealth Forestry Review, 73 (in press). This paper was presented at the 14th Commonwealth Forestry Conference, Kuala Lumpur, September 1993.

Fisch, G., Wright, I.R. and Bastable, H.G. (1994). Albedo of tropical grass: a case study of pre- and post-burning. International Journal of Climatology, 14, 103-107.

4. Training

4.1 SR OSVALDO CABRAL

Sr Osvaldo Cabral of EMBRAPA, Manaus completed his training visit which was very productive. Detailed analysis was carried out on the interrelationships between values of specific humidity deficit and temperature above tropical forest and values within the forest. Consistent correlations were obtained between above and within-canopy values which will

form the basis of equations to use single point values from above or outside forest to generate within-canopy profiles. Within canopy profiles are essential for the function of the CLATTER model and normally data would derive from detailed and expensive studies such as those carried out in the ABRACOS missions.

4.2 SR GILBERTO FISCH

Sr Gilberto Fisch of CTA spent five months at IH working with Alistair Culf and Ivan Wright on the data taken from tethered and free-flight balloons during the Rondonia Boundary Layer Experiment (RBLE) in July 1993. This work forms part of Sr Fisch Ph.D programme. He also contributed to the forest and pasture albedo analysis referred to in Section 2.2.

4.3 FUTURE VISITS

It is planned that future visitors under the training programme will include Sr Javier Tomasella (IPH, Porto Alegre), Sr Vinicius Ubarana (INPE, São Jose dos Campos) and Dr Ari Marques (INPA, Manaus). The plans for the visit of Sr Tomasella are advanced, he will arrive in early January 1994 and analyse saturated and unsaturated hydraulic conductivity data taken in a intensive study at Manaus with Martin Hodnett of IH. During the coming twelve months it is also planned that at least two Brazilian scientists will spend short periods at IH to familiarize themselves with the software for the soil water information processing system (Super SWIPS). These scientists will be ones closely involved with ABRACOS soil moisture data collection and processing within Brazil and after their training at IH should be regarded as foci for problem-solving related to soil water data in Brazil.

5. Vehicles

The Land Rovers at all sites continued to function effectively needing only routine servicing and a moderate amount of expenditure on non-service repairs. The Marabá vehicle passed 100,000 km after little more than two years from new.

6. Future plans

6.1 CONTINUATION OF THE AWS AND SOIL MOISTURE NETWORK

Approval has been given for a reallocation of funds to maintain the AWS and soil moisture network beyond 31 December 1993.
A short intensive course will be held on the use of the latest IH software to process soil moisture data - SuperSWIPS. The course will be for a small number of Brazilian counterpart staff who have direct responsibility for soil moisture data collection, processing and quality control at the ABRACOS sites. This training is important for maintaining efficient management of soil water data thereby contributing to the success of studies initiated in ABRACOS beyond the lifetime of the project.

6.2 DATA ANALYSIS AND DISSEMINATION OF RESULTS

With the completion of all intensive field missions the activities in the remaining twelve months of the project will focus on the following:

6.2.1 Completion of data analysis and quality control of data

6.2.2 Incorporation of parameters into GCM formulations at the several modelling centres

6.2.3 Dissemination of quality controlled data sets on CD-ROM discs

6.2.4 ABRACOS Seminar

Dissemination of information derived from ABRACOS to the scientific community in the form of a seminar to be held in Brasilia in September 1994. The seminar will comprise 20 to 25 papers from the ABRACOS results and also four invited papers from acknowledged experts in subject areas central to the ABRACOS programme. The seminar proceedings will be peer reviewed prior to publication either as a special issue of an international journal or a book. Associated with the seminar there will be display material suitable for peer, press and public viewing. This display will also be the focal point of presentations to press and public at Manaus and Belem following the seminar at Brasilia.

6.2.5 Popular science articles

There will also be a dissemination of the ABRACOS results in the wide-circulation popular science press both in the UK and Brazil.

7. Modelling Studies

There has been considerable activity in preparing for the Hadley Centre GCM deforestation simulation experiment. As part of the work carried out under the (separate) IH-Hadley Centre MITRE project the Penman-Monteith equation has now been implemented in the Hadely Centre GCM. The surface conductance in that equation has been calibrated against the ABRACOS data, as have the roughness parameters, rooting depths and albedos. The experiment is currently underway at the Hadley Centre, the control (forested) run has been completed and two, out of ten, years of the deforested simulation have been completed. It is too early to give definite answers on the outcome of this experiment.

8. Public Dissemination of results

8.1 PUBLIC LECTURE

Dr Carlos Nobre, the Brazilian coordinator of ABRACOS, presented a public lecture entitled "Rainforests and the Global Water Balance" in a session on Tropical Rainforests at the British Association Annual Science Festival at Keele University in August. The theme of the Keele meeting was "Science for Life".

8.2 BRAZILIAN PRESS

Dr John Roberts of IH was contracted by ODA to supervise construction of a forest observation tower at the new Caxiuanã Forest Research Station for the Museu Goeldi, Belem. A journalist from the wide-circulation Brazilian colour weekly 'Veja' was present for the inauguration of the research station and interviewed Dr Roberts about the work of ABRACOS in Amazonia.

8.3 "FOLHA DA FLORESTA"

The ODA team conducting the mid term review in July 1993 were impressed by the involvement of large numbers of participants in ABRACOS from all over Brazil. Mechanisms to maintain an information network amongst the participants were discussed and one initiative was the launching of "Folha da Floresta" at the end of 1993 (in portuguese folha may mean a leaf or a newspaper). This issue was edited by Dr Alistair Culf (IH) and Sr Gilberto Fisch (CTA) and distributed to all participants in ABRACOS. A copy of the first issue is annexed to this report.

8.4 ENCYCLOPEDIA ENTRY

A contribution titled "Tropical Forests: Hydrology and Climate" has been written for "The Encyclopedia of Agriculture" to be published by Academic Press. The contribution was

written jointly by J.H.C.Gash and A.J.Dolman (of the Staring Centre, Wageningen, The Netherlands).

8.5 PILPS

PILPS is the Project for Intercomparison of Land-Surface Parameterization Schemes whose objective is to compare and validate the various land-surface schemes available for use in GCMs. It is an initiative of the WMO and GEWEX falling under the Working Group on Numerical Experimentation (WGNE) and GEWEX Continental-scale International Project (GCIP). Currently some 25 modelling groups are taking part.

PILPS has requested access to the ABRACOS data and the data for Missions 1 and 2, together with the first year's climate and soil moisture data from Fazenda Dimona have now been submitted. Submitting data to PILPS in this way will ensure that the results of ABRACOS are used as widely as possible within the climate modelling community.

9. Financial overview

9.1 SUMMARY

Following the instructions given in the Mid-term Review a revised budget has been prepared. This has made some savings in the previous budget and requests further funds to allow the long term measurements to be extended by a further year. This revised budget is presented here.

Rolling project budget (in £k) Revised to incorporate continuation of network to end of calendar year 1995

		Year 1 89/90	Year 2 90/91	Year 3 91/92	Year 4 92/93	Year 5 93/94 revised	Year 6 94/95 revised	Year 7 95/96 revised	Total revised
1	CAPITAL COSTS								
1.1	Hardware associated with Phase 2								
1.1.1	Micrometeorological equipment	0.5	43.2	10.4	11.5	35.5	9.0		110.1
1.1.2	Plant physiological equipment		71.8	10.7					82.5
1.1.3	Soil moisture equipment	1.3	13.4						14.7
1.2	Hardware associated with Phase 3								
1.2.1	Climatological equipment		77.5	42.3	10.4	1.2	9.0		140.4
1.2.2	Soil moisture equipment		38.7	1.3	1.1	3.9			45.0
1.3	Transport and site facilities								
1.3.1	Forest towers		62.7	5.7		0.0			68.4
1.3.2A	Transport (Op. & Maint)		6.4	8.2	8.8	10.2	11.0	8.3	52.9
1.3.2B	Transport (Purchase)		88.0						88.0
1.3.3	Site facilities		4.1	21.3	4.8	1.3			31.5
1.3.4	Site computers						10.5		10.5
1.4	UK based hardware facilities								
1.4.1	Computers		24.0	0.3					24.3
	TOTAL CAPITAL	1.8	429.8	100.2	36.6	52.1	39.5	8.3	668.3

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2. RECURRENT COSTS
(other than vehicle support)

		Year 1 89/90	Year 2 90/91	Year 3 91/92	Year 4 92/93	Year 5 93/94 revised	Year 6 94/95 revised	Year 7 95/96 revised	Total revised
2.1	Sundry scientific supplies		24.6	15.9	32.0	14.5	27.5	6.0	120.5
2.1A	Exhibition & publication						18.9		
2.2	Freight charges		27.8	25.1	9.6	3.5	5.0	2.0	73.0
2.3	Counterpart travel (scientific)		21.1	25.0	32.2	17.0	8.0	6.0	109.3
2.4A	Counterpart travel (project man)	0.2	4.6	5.4	3.9	4.0	4.0		22.1
2.4B	Short term training in UK			6.3	7.0	18.0	28.0		59.3
2.4C	English Language Training				13.0	0.0	2.0		15.0
2.4D	Dissemination of results						24.6		24.6
2.5	IH travel costs		71.0	80.2	89.6	62.4	55.8	4.5	363.5
2.6	IH consultant	0.5	9.3	8.7	6.1	10.8	5.5		40.9
2.7	IH staff costs	34.4	233.1	260.9	272.9	273.7	243.7	13.6	1332.3
2.8	Mid-term review					30.0			30.0
	TOTAL RECURRENT	35.1	391.5	427.5	466.3	433.9	423.0	32.1	2209.4
	TOTAL PER YEAR	36.9	821.3	527.7	502.9	486.0	462.5	40.4	2877.7
	New financial limit (including contingency)								3057.7

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FOLHA da FLORESTA

Number 1 January 1994

Editorial

Uma vez que o nosso projeto está iniciando a fase de análise dos dados coletados, nós achamos que há necessidade de aprofundar a comunicação entre os cientistas participantes. Este jornal tentará auxiliar neste processo, através de um meio informal de comunicação entre nós. Por favor, sinta-se livre para enviar seus artigos, comentários ou resultados preliminares.

As our project is entering the analysis phase we feel that we need to improve the communications between the participating scientists. This newsletter will try to help this process. It is intended to be an informal medium for communication amongst us. Please feel free to send your articles, comments or preliminary results.

Muito Obrigado

Gilberto/Alistair

ODA Completes Mid-Term Review
Avaliação Meio-Termo da ODA é completada

All major ODA projects have a Mid-Term Review. The ABRACOS review took place in June and July last year. Mr J.B. Warren a retired ODA advisor, Dr J.B.Williams from the UK Natural Resources Institute, and Dr A.C.M.Beljaars from the European Centre for Medium-Range Weather Forecasts reviewed all aspects of the project. They were able to visit all three ABRACOS sites and managed to meet the great majority of project scientists.

There is a copy of the full report at IH and INPE. The team gave the project a generally favourable report stating that the progress had been very good and that the project was on target to achieve its objectives. Recommendations made by the review team include putting much greater emphasis on dissemination of the results of the research, particularly to non-specialists. The climate stations and soil moisture measurements were recommended to be kept running for at least a further 12 months.

Todos os grandes projetos financiados pela ODA passam por uma avaliação durante o seu decorrer. A avaliação do Projeto ABRACOS foi feita em junho e julho último por um comitê composto pelodo Sr. J.B.Warren (consultor aposentado da ODA) e pelos Drs. J.B. Williams (do UK Natural Resources Institute) e A.C.M. Beljaars (do ECMWF), que avaliou todos os aspectos do Projeto. Este comitê teve a oportunidade de visitar todos os sítios experimentais do ABRACOS e conhecer uma grande parte dos cientistas envolvidos no projeto.

A opinião geral deste comitê foi favorável, elogiando o desenvolvimento até agora e reconhecendo que estamos no caminho certo para alcançar os objetivos previstos. Uma das recomendações feita pelo comitê foi a incentivar a disseminação dos resultados da pesquisa, particularmente para a comunidade não-especialista. Além disso, foi sugerido que a coleta de dados das estações meteorológicas automáticas e de água no solo continuem, pelo menos, por mais 12 meses. Existem cópias desse relatório no IH e no INPE, à disposição dos interessados.

Returning from their visit to the forest tower at Reserva Jaru in Rondonia. Mr J.B. Warren and Dr J.B. Williams of the ODA review team along with project scientists Dr John Roberts, Dr Anna McWilliam, Ivanildo Alves Tindade and local field observer Eduardo de Lacerda. *Retornando de sua visita à torre micrometeorológica na Reserva Jaru em Rondonia, participantes do grupo revisão da ODA (Sr. J.B. Warren e Dr. J.B. Williams) juntamente com membros do Projeto ABRACOS: Dr John Roberts, Dra Anna McWilliam, Sr. Ivanildo Alves Trindade e do observador local Sr. Eduardo de Lacerda.*

End of Project Seminar
Seminário ao Término do Projeto

Current plans are to have an end of project seminar in Brasilia starting on 19 September 1994. We hope to include a display and exhibition with receptions in the evening to explain our work to invited politicians, government officials, representatives of NGOs and the press. The exhibition may then go onto other cities, probably Manaus and Belém. Please note the date in your diary.

Está em fase de discussão a realização de um seminário ao término do projeto, a ser realizado em Brasília, durante a semana do dia 19 de Setembro de 1994. Espera-se que este evento possa apresentar painéis com resultados científicos e exibição de videos, explicando qual foi o trabalho e quais os resultados alcançados. Serão convidados autoridades do governo federal, políticos, representantes das ONGs e imprensa de forma geral. É possivel que o seminário seja repetido em algumas cidades, como Belém e Manaus. Por favor, anote a data em sua agenda.

Encerramento das Camanhas de Campo
Final Field Missions

As campanhas intensiva de campo do Projeto ABRACOS terminaram, com a superposição das missões 4 (época chuvosa) e 5 (época seca). Fluxos turbulentos de umidade e calor foram medidos continuamente entre os meses de abril e julho, em ambos os sítios experimentais de floresta e pastagem em Rondônia. A Reserva Jaru situa-se 5 horas de barco de Ji-Paraná, representando um desafio logístico para a manutenção do experimento; entretanto, esta longa missão foi um sucesso. O controle de qualidade dos dados está sendo realizado no IH, e comporão um excelente conjunto de dados. O conjunto total dos dados deverá estar disponíveis a todos participantes no início de 1994. Pesquisadores da Universidade de Edimburgo (Escócia), liderados pelo Prof. John Grace, também tomaram parte nestas missões, medindo fluxos turbulentos de CO2 assimilado pela floresta.

The final ABRACOS intensive field missions took place earlier this year in Ji-Parana. Fluxes of heat and water vapour were measured continuously throughout the period from April to July at the forest and the clearing sites in Rondônia. The Reserva Jaru forest site is a five hour boat trip from Ji-Parana and so the site presents a large logistical challenge for running a field experiment. However, despite the potential problems the longest field mission of the experiment was sucessfull. The data is currently being quality controlled at IH and should be an excellent dataset. The entire dataset should be available to all participants early in 1994. A team from Edinburgh University in Scotland lead by Professor John Grace also took part in the mission measuring fluxes of carbon dioxide at both sites.

RBLE

A segunda campanha de coleta de dados do experimento brasileiro RBLE (Rondônia Boundary Layer Experiment) foi realizada durante o mês de julho/93, em Ji-Paraná, com a participação de pesquisadores e estudantes do INPE, UFPA, CTA/IAE, UFAL e UFRO. O experimento consistiu de lançamento de radiossondagens e içamentos com balão cativo nos dois sítios experimentais do ABRACOS: Rebio Jaru e Fazenda N.S.Aparecida. Conforme já havia ocorrido no RBLE1, o experimento contou com a colaboração dos colegas britânicos (Ivan Wright e Alistair Culf) na manutenção do equipamento de medidas de fluxos turbulentos HYDRA. Os primeiros resultados deverão aparecer logo, uma vez que está sendo produzido um artigo geral para ser submetido ao Boletim da American Meteorological Society. Para o próximo ano, já está sendo discutida a possibilidade da realização do RBLE 3, novamente durante a época sêca em Ji-Paraná. Neste missão futura, espera-se realizar o experimento de forma simulatânea (nas áreas de pastagem e floresta), com a finalidade de observar como a camada limite atmosférica responde aos diferentes fluxos de superfície. Maiores informações podem ser obtidas com o coordenador Carlos Nobre (INPE).

As you are probably aware, the Brazilian community (INPE, UFPA, CTA/IAE, UFAL and UFRO) have carried out the Rondonia Boundary Layer Experiment (Phase 2) during July 1993 in Ji-Paraná. The experiment consisted of launching rawinsondes and tethered balloons at the two ABRACOS sites: Rebio Jaru and Fazenda Nossa Senhora da Aparecida. As in RBLE 1 we had the collaboration of British scientists (Ivan Wright and Alistair Culf) to run the Hydra eddy correlation equipment. The first results will appear very soon and it is planned to submit an overview paper of RBLE 1 and 2 to the Bulletin of the American Met Soc. For more information please contact the coordinator: Carlos Nobre (INPE). For next year we are discussing the possibility of running RBLE 3, again during the dry season. In Phase 3 we hope to have both experimental sites running simultaneously to compare how the boundary layer responds to different surface fluxes.

Gilberto's visit to IH
A visita de Gilberto ao Instituto de Hidrologia

Gilberto Fisch (CTA) está de volta ao IH para

analisar os dados coletados durante o experimento RBLE 2. Ele está trabalhando em estreita colaboração com Alistair Culf, no sentido de entender os mecanismos que controlam o desenvolvimento da camada limite atmosférica sobre as áreas de pastagem e floresta. Este estudo faz parte do programa de doutoramento de Gilberto Fisch e esta visita está sendo financiada por uma bolsa da CAPES-MEC.

Gilberto Fisch (CTA) has returned to IH to analyse the data collected during RBLE 2. He is working closely with Alistair Culf to try to understand the mechanisms controlling the development of the atmospheric boundary layer over forest and pasture. This study is part of his PhD programme and the visit has been funded by a scholarship from CAPES. Gilberto will return to Brazil at Christmas.

Brazilians visiting IH
Participantes Brasileiros visitam o Instituto de Hidrologia

Up to now seven Brazilian scientists have visited IH for training periods averaging 3 months. This training is fully sponsored by ABRACOS and is one of the main goals of the project. The first person to visit IH under this program was Pedro Rubens Carvalho (INPE), who came to IH to develop instrumentation software. One year later Gilberto Fisch (CTA) came to work on the AWS dataset. During his stay he completed a short paper in collaboration with Ivan Wright and Heidi Bastable, which should appear very soon in the International Journal of Climatology. The next visitor was Lucienne Pimentel (COPPE) who came to work on soil moisture data, assisting Martin Hodnett with the quality control. Later that year Gilda Maitelli (UFMT) visited IH for two months and worked closely with Ivan Wright on the AWS dataset. Gilda is writing a paper on the urban climate of Manaus which should be ready very soon. At the beginning of 1993, Tatiana Sa (EMBRAPA-CPATU) came to do some analysis on plant physiology data collected in Maraba, in collaboration with John Roberts. The most recent visitor was Osvaldo Cabral (EMBRAPA-CPAA) who came to work on the relationship of the climate above the forest to conditions within the canopy.

Até o momento, já são em 7 o número de brasileiros que visitaram o IH, com duração média de 3 meses cada um. Estes treinamentos são custeados pelo Projeto ABRACOS e fazem parte dos objetivos mais importantes do projeto (intercâmbio científico). O primeiro brasileiro a visitar o IH foi Pedro Rubens Carvalho (INPE), em 1991, com o objetivo de desenvolver software para os instrumentos utilizados. O próximo visitante, após um ano, foi Gilberto Fisch (CTA), que trabalhou com os dados coletados pelas estações automáticas. Durante sua estada, Gilberto Fisch produziu um pequeno artigo em colaboração com Ivan Wright e Heidi Bastable, que deve aparecer logo em periódico científico. A seguir, foi a vez de Lucienne Pimentel (UFRJ), que visitou o IH com objetivo de analisar os dados de água no solo, ajudando Martin Hodnett no controle de qualidade dos dados. Mais para o final do mesmo ano (1992), Gilda Maitelli (UFMT) esteve em visita ao IH por dois meses e trabalhou em colaboração com Ivan Wright nos dados das estações automáticas. Gilda está escrevendo um artigo sobre clima urbano de Manaus, o qual logo deverá estar concluído. No início de 1993, Tatiana Sá (CPATU-EMBRAPA) visitou o IH para realizar análises de dados de fisiologia vegetal coletados em Marabá, em colaboração com John Roberts. O último visitante foi Osvaldo Cabral (CPAA-EMBRAPA), que realizou estudos de correlação entre condições microclimáticas acima e dentro da copa florestada. Maiores informações sobre este estágio podem ser obtidas com o coordenador brasileiro (Carlos Nobre, INPE).

Team Armadillo
Equipe Tatu

July 1993 found the "Armadillo Team" in Manaus to investigate the hydraulic properties of the soil at the pasture site. An armadillo is a small burrowing animal, common in Brazil, and its aptitude for making holes has given the team its name! The line up for this mission was: Martin Hodnett, Javier Tomasella from IPH, Renato Cruz Senna and his team from INPA, Manaus. The most striking holes were the circular trenches used to isolate soil columns 1.5m diameter and 1.4m deep for the "instantaneous profile method" (IPM). The trenching was an adaptation of the normal method and was a first for the team and for the mystified labourer who dug them!! Isolating the column eliminated the need for a wide irrigated border zone around the instrumented plot and reduced the water required for the experiment by 80%. The IPM was run on 2 plots and conductivities were determined at 0.3, 0.5, 0.75 and 1.05 m over the potential range from near saturation to -8 kPa. Saturated conductivities decreased from over 100 mm h^{-1} at 0.3 m depth to 22 mm h^{-1} at 1.05 m depth. At all depths, the conductivity decreased very rapidly as the matric potential decreased. At a matric potential of -8 kPa , the conductivity at 0.3 m had decreased to 0.004 mm h^{-1} and at 1.05 m, to 0.14 mm h^{-1}. The very high conductivities at potentials close to saturation allow the soil to drain very rapidly. As an example, the soil profile was observed to drain to its pre-irrigated condition within 14 hours of an irrigation of 100 mm in 1 hour! The results are looking very good and will be examined in more detail over the 3 month period from January to March 1994, when Javier Tomasella visits IH to work on the data.

Em julho de 1993, o "Equipe Tatu" se reuniu em Manaus para investigar as propriedades hidraúlicas do solo na pastagem. Tatu é um pequeno animal especialista em fazer buracos. A equipe formada por

Martin Hodnett, do IH, Javier Tomasella do IPH, Renato Cruz Senna e seu time do INPA ganho esse nome pelas características de seu trabalho: fazer baracos. Os buracos mais difíceis foram as trincheiras circulares usadas para isolar a coluna do solo com 1.5 m de diâmetro e 1.4 m de profundidade para o método do perfil instântaneo (IPM). A trincheira foi uma adaptação do método normal e foi o primeiro a ser feito pela Equipe Tatu. Através deste isolamento, eliminou-se a necessidade de uma zona de fronteira irrigada ao redor do plot e também reduziu as necessidades de água do experimento em 80%. O IPM foi simulado em 2 plots e a condutividade foi determinada a 0.3, 0.5. 0.75 e 1.05 m de profundidade sobre um potencial do solo próximo a saturação ate -8 kPa. Condutividade em situações de saturação diminuíram de mais de 100 mm.h a 0.3 de profundidade até 22 mm.h em 1.05 m. Em todos os níveis, a condutividade diminui muito rapidamente conforme o potencial matricial decresce. Para um potencial matricial de -8 kPa, a condutividade a 0.3 m já havia diminuído para 0.004 mm.h e 0.14 mm.h em 1.05 m. As altas condutividades em potencial próximos a saturação permitem ao solo possuir uma drenagem rápida. Como exemplo, o perfil do solo submetido a uma irrigação de 100 m em 1 h, levou 14 horas para recuperar o valor pré-irrigado. Estes resultados serão examinados com mais detalhes durante a visita de Javier Tomasella (IPH) ao IH, de janeiro a março de 1994.

New Forest Tower
Torre Florestal Nova

Laercio Donato da Silva, Antônio Carlos Lola da Costa and John Roberts have built a new forest tower for the Museu Goeldi in the Caxiuanã Forest in Pará. The Museu Goeldi have established an impressive new research facility at Caxiuanã and the tower, close to the centre, is for observation of flora and fauna. It would also make an appropriate climatological tower, but probably needs four more sections to be ideal. The building of the tower was accomplished with the help of five employees of Amazontec who constructed the research site and was completed in just over five days, a new record - but for how long ? (John Roberts currently holds the world record for the number of towers constructed in Amazonia, this one being his fifth).

Laércio Donato da Silva, Antônio Carlos Lola da Costa e John Roberts construíram uma nova torre micrometeorológica para o Museu Gueldi (Belém,PA) na Reserva Florestal Caxiuanã. O Museu Gueldi está montando um centro de pesquisas nesta Reserva e a torre servirá para estudos da flora e fauna. Com relação a meteorologia, a torre ainda precisa de mais 4 seções para poder coletar os dados de forma adequada. A torre foi construída com ajuda de 5 empregados da Amazontec, que é responsável pela instalação deste novo centro. A torre micrometeorológica foi instalada em 5 dias (um novo recorde) e coloca John Roberts no livro Guiness: 5 torres construídas na Amazônia.

Humberto Rocha moves to USP
Humberto Rocha vai para a USP

Humberto, who has acted as Brazilian assistant coordinator for ABRACOS is about to leave IPE. He is moving to the department of Atmospheric Sciences, USP. However, he is not leaving ABRACOS. He plans to continue his long envolvment with the project. He is spending two months in early 1994 at the Goddard Space Flight Center (GSFC), NASA, Greenbelt, MD, USA. During that period a calibration of the newest version of SiB (SiB-2C with carbon assimilation) is to be carried out using ABRACOS data. The work is being conducted jointly with Dr. Piers Sellers. Humberto will be replaced in his capacity as assistant coordinator to the project by Vinícius da Nóbrega Ubarana.

Humberto Rocha, que por todos esses anos tem atuado como coorenador do ABRACOS, este deixando o INPE. Ele esta indo para o Departamento de Ciências Atmosféicas, da USP; mas não está, no entanto, deixando o ABRACOS. Ele planeja dar sequência ao seu longo envolvimento com o Projeto. Agora, no começo de 1994, ele estará passando dois meses no "Goddard Space Flight Center (GSFC), na NASA (Greenbelt, MD, EUA). Nesse período deve ser realivada uma calibração da mais nova versão do SiB (SiB-2C com assimilação de carbono), usando os dados do ABRACOS. O trablho estásendo desenvolvido juntamente com o Dr. Piers Sellers. Humberto será substituído por Vinícius da Nóbrega Ubarana no cargo de coordenador assistente do Projeto ABRACOS.

Folha da Floresta

FOLHA DA FLORESTA is an occasional newsletter to the ABRACOS research community. It aims to keep participants informed of project activities and up to date with current results and data availability. Short articles on any aspect of ABRACOS or associated projects are welcomed from anyone involved. Articles, which can be in English or Portuguese should be send to Dr Alistair Culf, Institute of Hydrology, Wallingford, Oxon, UK or to Gilberto Fisch, CTA/IAE, Av Nelson D'Avila s/n, CP 6019, 12001 Sao José dos Campos, SP, Brazil.

FOLHA DA FLORESTA é um jornal informativo para a comunidade do Projeto ABRACOS. O objetivo deste é manter todos os participantes informados das atividades atuais, dos resultados alcançados e da disponibilidade dos dados coletados. Artigos sobre qualquer aspecto do ABRACOS e/ou dos projetos associados são bemvindos e podem ser escritos na língua portuguêsa ou inglêsa. Os referidos artigos devem ser enviados para Dr. Alistair Culf, Intitute of Hydrology, Wallingford, OX10 8BB, United Kingdom ou para Gilberto Fisch, CTA/IAE, Av. Nelson D'Avila, s/n, CxP 6019, CEP 12228-904, São José dos Campos-SP-Brasil.


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