Air temperatures in Central Amazonia

II - The effect of near-surface temperatures on land-use in the Tertiary region of Central Amazonia

W.L.F. BRINKMANN
M.N. GÓES RIBEIRO
Instituto Nacional de Pesquisas
da Amazônia

ABSTRACT

Maximum and minimum air temperatures were taken weekley at 10 different sites about 2 cm above ground level during the period of June 15th, 1968 to January 26th, 1970. Three temperature types were observed each of which has a specific ecological effect on land-use in Central Amazonia.

INTRODUCTION

Air temperatures near the ground have a profound effect on biosphere and pedosphere. To a certain extent, they also influence the variety and abundance of photosynthetic and non-photosynthetic micro-organisms of the air-soil boundary layer, and the chemical and biological dynamics of the decomposition of organic matter in the forests.

They hold a key position in the control of plant growth, as far as seedlings are concerned especially on cleared and naturally open areas such as: campinas, etc. It is already known, that various tree species in the early state of growth have a specific heat tolerance range, so near ground temperatures partly control the natural forest regeneration on cleared areas.

MATERIAL AND METHODS

Maximum and minimum air temperatures were read weekly at 10 different sites at about 2 cm above ground. These measurements were taken the time from June 15 th, 1968 to January 26 th, 1970. Maximum and minimum temperatures were recorded by the common mercury-filled thermometer with a support and protected against direct radiation input by means of a specially designed hardwood shield. These shields differ from the commonly used metal shields in heat transfer and this should be kept in mind, when these data are compared with equivalent measurements in the tropics.

The sites were as follows: (see Figure 1).

site. 1 The terra firme rain forest (Ducke Forest Reserve).

The forest community under study is a typical climax forest of the Tertiary region along the Manaus-Itacoatiara Road. This forest is closely correlated with the area distribution of yellow latosols. Dominant tree species are: *Eschweilera* spp (8,2 trees/a) and *Scleronema micranthum* Ducke (3.5 trees/ha) (Aubréville, 1961). Canopy heights range from 25m to 35m. The three canopy strata which are poorly defined, form quite a dense natural protection against direct radiation. The shrub stratum consists of palms and various saplings. The ground stratum is formed by numerous seedlings, a few herbs and stemless palms. The forest floor is covered with a perenial litter layer. Decomposition losses are restored every year, primarily during the dry season (June to October) (see Figure 1 — graph 1).

site. 2 Twelve years ago, a part of the terra firme rain forest of the chapada at Ducke Forest Reserve was cut down and preserved for a natural forest regeneration scheme. Today the site is covered with a dense secondary

(1) — Granted by Banco National de Desenvolvimento Econômico under contract INPA/FUNTEC 89/70.

forest, locally known as capoeira. The capoeira is 10 - 12 m high and consists mainly of Imbaúbas (*Cecropia* spp) No defined canopy strata were observed. The ground is covered with a thick litter layer, several trunks in the state of decomposition and a few seedlings and herbs. Saplings, 3 m - 5 m high, are abundant (see Figure 1 — graph 2).

site. 3 Another part of cleared terra firme rain forest plot (see site 2) was preserved clean, and planted with a short, but dense grass cover. Since 1965, this area served for the climatological station — Ducke Forest Reserve (see Figure 1 — graph 7).

site. 4 About 5 years ago, a tropical climax forest on white sand layers was cut down opposite Ducke Forest Reserve (Km 26 — AM 1). The area was burned and pineapples were cultivated. There are charcoal particles mixed with the white sand which is totally exposed to radiation. (see Figure 1 — graph 9).

sites 5 — 10 Maximum and minimum air temperatures were also measured near Km 18 of the Manaus-Itacoatiara Road. A large cleared area was chosen

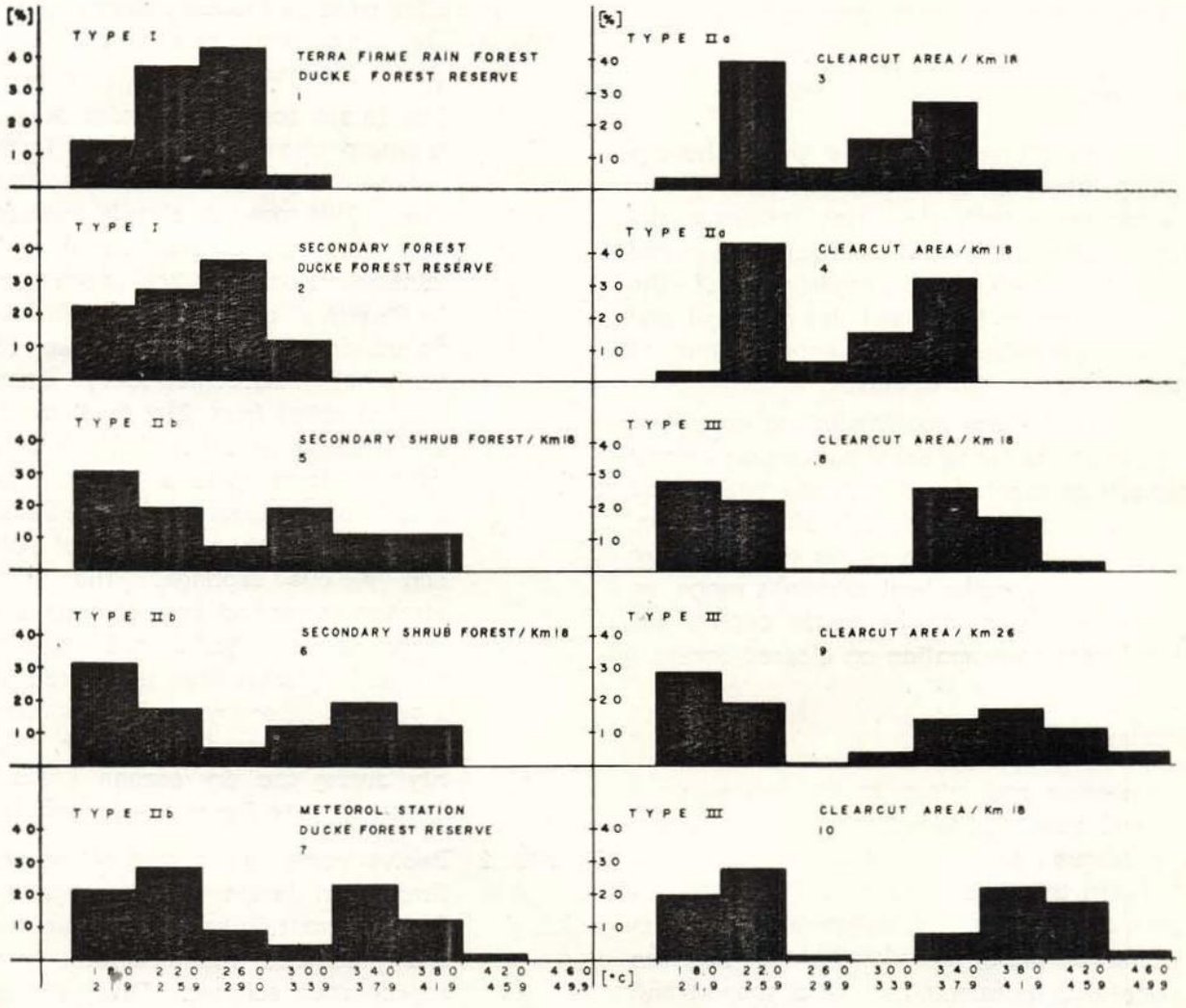

Figure I — Relative frequency distribution of weekly maximum/minimum air temperature (2 cm above ground at various sites of the Tertiary region near Manaus — central Amazonia (period: June 15 th, 1968 to January 26 th, 1970).

for the climatological survey. About 4 years earlier, the natural climax forest on poor white sands was slashed and burned. There was some pineapple cultivation, but the agricultural effort failed. Two years ago, coco palms were planted. The plantation produces extremely poorly. Today, the hill slope is covered completely with a secondary forest, which is dominated by 2 m to 4 m high Imbaúbas (*Cecropia* spp) and Jurubébas (*Solanum* sp.). Soils were classified as deep white sand layers somewhat similar to giant podzols, described for a nearby area (Klinge, 1965). The surface layer is impregnated with charcoal particles as a result of the previous burning.

sites 5 and 6 Maximum and minimum thermometers were set up in the secondary forest on a hill-top (Figure 1 — graph 6) and at the bottom of the valley (Figure 1 — graph 5). The sites have similar vegetation cover and vegetation density, but they differ in exposure to radiation. The valley site received direct solar radiation until 5 o'clock pm, while the hill top site was exposed to radiation about 12 hours a day.

sites 7 and 8 Maximum and minimum thermometers were set up at approximately the middle of the slope. The site was exposed about 12 hours a day to direct solar radiation. Site 7 (Figure 1 — graph 3) was installed on a small plot of white sand without any vegetation present, and site 8 (Figure 1 — graph 4) had a sparse grass cover.

sites 9 and 10 Maximum and minimum thermometers were set up on large vegetation — free white sand plots on the hill — top (Figure 1 — graph 10) and at the bottom of the valley (Figure 1 — graph 8). The sites had similar soil, and both lacked vegetation cover, but they differed in exposure to direct solar radiation as mentioned above for sites 5 and 6.

Results

When the data from all ten sites were collected the maximum and minimum air temperature readings revealed that the sites could be grouped according to their exposure to direct solar radiation and their vegetation cover.

According to maximum and minimum air temperatures near the ground, three temperature types were indicated. The temperature types were as follows:

Type I — The one peak type (Figure 1 — graphs 1 and 2).
The maximum and minimum temperature readings obtained must be considered "normal" for all sites, covered with natural climax forest (except campinas) or dense secondary forest. The temperature type is representative for about 90 percent of the Tertiary region along the Manaus-Itacoatiara Road and is independent of the type of soil.

Type II — The overlapping two peak type (Figure 1 — graphs 3, 4, 5, 6 and 7). This type has to be split into two sub-types, because of the weight and position of the peaks.
Type II a. (Figure 1 — graphs 3 and 4).
Type II b. (Figure 1 — graphs 5, 6 and 7).
In general, both types report intermediate air temperature conditions near the ground between type I and type III. With respect to tropical agriculture, they demonstrate to better (type II b) and poorer (type II a) conditions.

Type III — The two peak type (Figure 1 — graphs 8, 9 and 10).
This maximum and minimum temperature type must be considered limiting to various silvicultural or agricultural activities.

Conclusions

Reforestation, agriculture and cattle breeding in the Tertiary region of central Amazonia along the Manaus-Itacoatiara Road, are

primarily based on slash and burn. Not counting the unfavorable effects of this particular land-use system on soil water balance, nutrient cycling, microbial life, etc., the near-surface temperatures are affected as follows :

Slash and burn applied :

I — 1) *Reforestation on sandy soils* (Podzols, Regosols).

Near-surface maximum and minimum air temperature distribution chain is : Type I (Figure 1 — graph 1) —→ destroyed —→ type III (Figure 1 — graphs 8, 9 and 10) —→ type II a (Figure 1 — graph 4).

High near ground surface temperatures are extremely harmful to the seedlings of a great variety of tropical tree species of economic value. Reforestation will be affected by these high temperatures, as the number of tropical tree species plantable is greatly reduced (selection) and a proportion of the seedlings will be stunted or die, and have to be replanted. Type II b (Figure 1 — graphs 6 and 7) is not desirable (shadow effect), because the secondary growth, (especially *Cecropia* spp and *Solanum* sp) will raise serious root competition problems.

I — 2) *Agriculture on sandy soils* (Podzols, Regosols).

Near-surface maximum and minimum air temperature distribution chain is : Type I (Figure 1 — graph 1) —→ destroyed —→ type III (Figure 1 — graphs 8, 9 and 10).

High near-surface temperatures are harmful to almost all vegetables and some other cultivated plants. Natural shadowing (type II b — Figure 1 — graphs 6 and 7) is not desirable, because of serious root competion. Artificial shadowing has to be applied, i.e. the farmed plots are limited to a very minimum. The selective effect of near-surface temperatures, as one factor out of many others, conditions monocultures of pineapple and manihoc.

I — 3) *Cattle breeding on sandy soils* (Podzols, Regosols).

Near-surface maximum and minimum air temperature distribution chain is : Type I (Figure 1 — graph 1) —→ destroyed —→ type III (Figure 1 — graphs 8, 9 and 10) —→ type II b (Figure 1 — graph 7).

High near-surface temperatures will act selectively on grass species and native fodder plants. They are harmful in the early stages of growth. A dense grass cover will not be obtained owing to other limiting factors. During dry periods, the sparse grass cover dries up and raises serious fodder problems.

Neithef reforestation, agricultural efforts nor cattle breeding can be recommended for sandy soils. These areas (about 5 - 6 percent of the Tertiary region) should be conserved, in their natural state as only the natural forest cover supplies the best environmental conditions.

Slash and burn applied :

II — 1) *Reforestation on latosols.*

Near-surface maximum and minimum air temperature distribution chain is : Type I (Figure 1 — graph 1) —→ destroyed —→ type III (Figure 1 — graphs 8, 9 and 10, but less extreme) —→ type II b (Figure 1 — graphs 5 and 6) —→ type I (Figure 1 — graph 2)

High near-surface temperatures will affect reforestation under type III — conditions. While other limiting factors (soil water balance, nutrients available, etc.) are less pronounced, the situation is less serious. Nevertheless silvicultural efforts have to be restricted to a few tropical tree species of economic value, when large scale reforestation schemes are considered.

II — 2) *Agriculture on latosols.*

Near-surface maximum and minimum air temperature distribution chain is :

Type I (Figure 1 — graph 1) ——➤ destroyed ——➤ type III (Figure 1 — graphs 8, 9 and 10, but less extreme) ——➤ type II b (Figure 1 — graph 7). High near-surface temperatures will affect almost all vegetables and a series of other cultivated plants. As soil moisture problems, nutrient availability, etc. are less delicate, the variety of plantable crops is less restricted but monocultures (peper plantations, etc.) are not desirable, because, of the potential dangers of plant diseases.

II — 3) *Cattle breeding on latosols.*

Near-surface maximum and minimum air temperature distribution chain is : Type I (Figura 1 — graph 1) ——➤ destroyed ——➤ type III (Figure 1 — graphs 8, 9 and 10, but less extreme) ——➤ type II b (Figure 1 — graph 7). As stated above, high near-surface temperatures are harmful to grass species and fodder plants in the early state of growth, i.e. a negative selection of the wide variety of the available native fodder plants will take place. During serious droughts, and for several months after the grass cover dries up as a result of direct solar radiation and water deficiency. Serious droughts in central Amazonia occur at roughly 3 - 5 year intervals, so they are bound to affect all long term projects of cattle breeding. Latosols are the representative soil type for at least 85 percent of the Tertiary region along the Manaus-Itacoatiara Road. Large scale reforestation and agricultural efforts including cattle breeding cannot be recommended unconditionally on these soils, because of near-surface temperatures, and many other limiting factors such as cycling plant nutrients (Brinkmann, W. L. F. and A. dos Santos, 1971 a, 1971 b; Stark, N., 1971), nutrient leaching (Nascimento, J. C. de and W. L. F. Brinkmann, 1972), soil water balance, etc.

It seems to the authors, that the near-surface maximum and minimum air temperature distribution for an ideal agricultural or cattle breeding scheme should be in a position between temperature conditions shown in Figure 1 — graph 2 and graph 6. Futhermore the following guide — lines are proposed when large scale silvicultural or agricultural schemes are being planned :

1) All areas such as deep white sand areas (tropical podzol soils and regozols) which are known to be worthless for silvicultural or agricultural large scale schemes, should be conserved, as the existing climax forest matches best these very tight ecosystems.

2) Large scale slash and burn methods have to be avoided, because of their detrimental effects on mezo — and microclimate, humus content, nitrogen and other plant nutrients present, and on the soil — water balance of the area.

The Laboratories of Environmental Sciences and the Center of Forestry Research of INPA, developed a joint scientific program to clarify the basic needs and preservation rules of silvicultural and agricultural development of the Tertiary region of central Amazonia. The results which will be available in the near future, will provide governmental agencies, farmers and ranchers with the data necessary for a better understanding of the ecodynamics of the Tertiary region, and consequently should lead to viser development schemes.

ACKNOWLEDGEMENT

The senior author is indebted to the Max Planck Institute for Limnology, Department of Tropical Ecology, Plön, Germany for supplying facilities for these investigations.

RESUMO

Temperaturas máximas e mínimas do ar foram medidas em dez locais diferentes na Amazônia Central, a uma altura de 2 cm acima da superfície do solo. Como resultado destas medidas foram determinadas três tipos de temperatura, sendo que cada um dos três tipos apresentam influências específicas para a agricultura, silvicultura e pecuária em relação aos tipos de solos

Estas investigações foram realizadas em latossolos e solos arenosos, visto que, êsses dois tipos cobrem aproximadamente 90% dos solos da Estrada Manaus - Itacoatiara.

Nos latossolos, os resultados obtidos demonstram que sem considerar outros fatôres limitantes, as queimadas em grande escala prejudicam até certo ponto o desenvolvimento da agricultura, silvicultura e pecuária, havendo por isso mesmo urgentes necessidades de modificar o sistema de exploração.

Sem dúvida alguma, as áreas com areias brancas, não podem ser utilizadas por longo prazo para agricultura, silvicultura e pecuária em grande escala por sofrerem fortes influências da temperatura sem levar em consideração outros fatores limitantes. Essas áreas no momento são usadas para monoculturas (mandioca e abacaxí) porém em futuro elas devem permanecer conservadas.

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