Conference : The development of Amazonia in seven countries

Cambridge, 23-26th September 1979

Development planning in Rondônia based on naturally renewable resource surveys

Peter A. Furley
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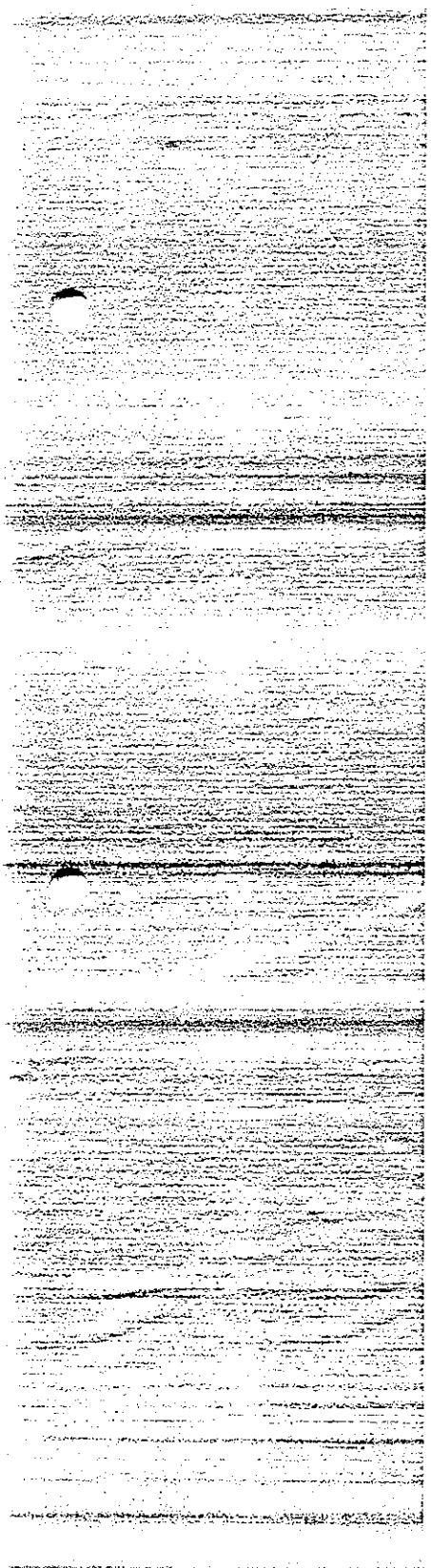
Introduction

The Federal Territory of Rondônia occupies an area of around 243,000 square kilometers out of a total area of approximately $5\frac{3}{4}$ million square kilometers for the Brazilian sector of the Amazon Basin. Despite being only in the order of 5% of the Brazilian Amazon, the area is still large enough to be approximately equal to that of West Germany, and has the advantage of a wide diversity of environments, plant communities and soil groups and, at present, a low population of about a quarter of a million.

Although the Territory is undergoing a rapid transformation, the actual area of disturbance is relatively small and is largely confined to the margins of the major roads and banks of the main rivers. There is still an opportunity therefore, to produce a development plan which takes into account the concerns of ecologists and anthropologists whilst at the same time satisfying the pressures for agricultural colonisation and meeting the political demand for the occupation of all national lands.

So much conflicting advice is offered to local planning officials that it is hardly suprising that they appear to follow simply 'ad hoc' policies. At times the arguments of the more conservationist ecologists (for example Sioli 1977, Golley 1974, Goodland and Irwin 1975,1977,Janzen 1970) and the justifiably sceptical views about government concern for the environment (as expressed in Sternberg 1975), are so different in conception from the more optimistic scientists (Alvim 1978), particularly agronomists (such as Condurú 1974, Sanchez 1977) that it is difficult at times to appreciate that they are referring to the same area. There seem to be two main difficulties at the Territory planning level - one being to formulate clear objectives for development out of the multitude of local and national pressures, and the other being to distinguish between the arguments of the various parties involved. For example 'development' is frequently seen to be equated with clear felling of the forest and the replacement of trees by monoculture; further,the advocacy of one particular type of land use is often taken to refer to the whole area without reference to scale or multiple use. In fact when the arguments of apparantly opposing factions are brought together, they can often be seen to be complementary - supporting the fairly obvious principle that each local area should be treated on its merits, and that objective land evaluation which picks out the most potentially useful soils for agricultural development should also point to those areas where agriculture should not be attempted.



If this reasoning is accepted, then the initial issue would seem to be the quality of the land evaluation followed by interpretation of the results according to long term and sustainable objectives. The present discussion attempts to show how this is being achieved within the area.

Naturally renewable resources

The resources may be considered under the headings of environmental components comprising climate. topography, ground and surface water, and biological components including plant communities, wildlife and, for the present discussion at least, the upper horizons of soils. No attempt will be made here to enter the dialectic as to whether any or all of these components are truly renewable, although most have been questioned (for instance Gomez Pampa 1977 on the non-renewable nature of tropical rainforest or Van Wambeke 1978 on a similar theme for tropical soils). These resources are not distributed evenly over the Territory any more than they are for the Amazon Basin as a whole. Consequently there are some areas of considerable promise for a variety of types of development, and there are large areas where the potential is so low and the risks so high that development should be precluded until there is a better understanding of the nature of the resources.

Up until the last two or three years, insufficient evidence was available, even at a reconnaissance scale, to permit an adequate evaluation of the resources (along for instance, the lines recommended by UNESCO 1974). A reasonably accurate but generalised picture derived from the limited sources available but inadequate for detailed planning, had been prepared by Embrapa (1975) at a scale of 1 to 5 million, and a useful summary of existing knowledge was prepared for the Atlas of Rondônia (IBGE 1975) at a scale of 1 to 2½ million. No systematic account of the total area was available until the surveys of Projeto Radam (Ministério de Minas e Energia -DNPM) at a published scale of 1 to 1 million.

There are several comments which can be made concerning the renewable resources of the Territory, although there is not space here to cover more than a brief outline of their characteristics. The climatic resources are generally favourable for plant growth - high solar radiation (Porto Velho : 10.7 $MJm^{-2}day^{-1}$ in January to 13.4 $MJm^{-2}day^{-1}$ in August), adequate growing temperatures throughout the year (average annual temperature ca.25°C), adequate precipitation (over 2000mm pa) for most of the year (where there is a short dry season, June to August, with a marked air saturation deficit, it is arguably an advantage for agriculture and accessibility), giving a moderate (70%) to high (over 80%) humidity depending upon the season, and moderate to low winds (Johnson 1978). The topography is varied, much of the 'terra firme' being sufficiently sloping

to provide adequate drainage, with a backbone of upland ridges and tabular surfaces (Chapada dos Parecis, Sa.dos Pacaás Novos) and extensive hilly topography with isolated inselbergs throughout the centre of the Territory (IBGE 1975, 1977 and the publications of Projeto Radam). The water resources contained both in surface streams and also in groundwater are generally adequate, with the possible exception of the upper plateau areas to the south-east covered by cerrado (savanna). Periodic flooding and poor drainage characterise the várzea on the margins of small streams and more extensively within the river basin of the Madeira-Mamoré-Guaporé. The biological resources are rich and varied. The scant information concerning the wildlife reveals a diverse fauna (Raw and Alho 1979; Wetterberg, pers.comm; Gifford, pers.comm); it is not considered however, that the area formed one of the Quaternary refuges identified elsewhere (Prance 1978, Myers 1979), the nearest being to the east in Aripuaná. The aquatic resources are also believed to be considerable with scope for fishery development (Bastos 1979) and probably aquatic plants. The vegetation is also diverse. In general terms the area lies just outside the perennial rainforest typical of Amazonas to the north, and is dominated by semi-deciduous forest over the lowlands, with grassland (campo limpo) and savanna (cerrado plus gallery forest) over the upper land surfaces, and grass or forest on the predominantly flooded várzea lands (Gifford 1979). In addition there are representatives of most of the major Brazilian Amazon soil groups (Falesi 1974, van Wambeke 1978) more or less related at a very broad scale to the vegetation cover. Even where the vegetation is not precisely related to the soils beneath, the plants are very well adapted to the broad characteristics such as the low base status and the high exchangeable aluminium and hydrogen. Since the nature of the soils reflects both the environmental and biological factors in its genesis, it is fundamental to the position of agriculture, and is therefore one of the more contentious issues for development and will now be discussed in greater detail.

The major soil groups and their characteristics

Several recent publications have indicated that there exists within the Territory, a relatively greater proportion of more promising soils for development than may be found within the Amazon Basin as a whole (eg Ceplac 1973-77, Falesi 1974, Embrapa 1975, F.João Pinheiro 1975, Projeto Radam, MME-DNPM 1976-). Evaluations of these soils by the latest and most detailed surveys (Radambrasil), have concluded that of the 17 major groups indicated in Figure 1, several are promising for both annual and perennial crops at various management levels, as well as being equally promising for pasture or for forestry. These are well drained soils (non-hydromorphic) with finer textures in the subsoil (textural B horizon). They include most of the red-yellow eutrophic podzols, some of the dystrophic red-yellow podzols and the terra roxa soils. A brief summary of their properties and the American Soil Taxonomy equivalents are included in Table 1.

Figure 1 : Legend

RONDÔNIA : TENTATIVE SOIL MAP

LEGEND

1 NON-HYDROMORPHIC LATOSOLS

- YELLOW LATOSOL, DYSTROPHIC AND ALLIC VARIETIES
- RED-YELLOW LATOSOL, ALLIC
- DARK RED LATOSOL, DYSTROPHIC AND ALLIC VARIETIES

2 NON HYDROMORPHIC SOILS WITH A TEXTURAL B HORIZON

- RED-YELLOW PODZOL, EUTROPHIC
- RED-YELLOW PODZOL, DYSTROPHIC
- RED-YELLOW PODZOL, ALLIC
- TERRA ROXA SOILS, DYSTROPHIC
- REDDISH BRUNIZEM SOILS

3 HYDROMORPHIC SOILS WITH GLEY OR PLINTHITE HORIZONS

- HYDROMORPHIC LATERITE, ALLIC
- HYDROMORPHIC PODZOL
- GLEYED HYDROMORPHIC SOILS, MOSTLY ALLIC
- QUARTZ-SAND HYDROMORPHIC SOILS, ALLIC

4 NON-HYDROMORPHIC QUARTZ-SAND SOILS

- QUARTZ SAND SOILS, DYSTROPHIC AND ALLIC VARIETIES

5 POORLY DEVELOPED SHALLOW SOILS

- LITHOSOLS, EUTROPHIC
- LITHOSOLS, DYSTROPHIC AND ALLIC VARIETIES
- ALLUVIAL SOILS, DYSTROPHIC AND ALLIC VARIETIES
- CAMBISOLS, EUTROPHIC, DYSTROPHIC AND ALLIC VARIETIES
- ROCKY OUTCROPS

modified from PROJETO RADAMBRASIL, sheets SC 19, SC 20, SD 20

Figure 1

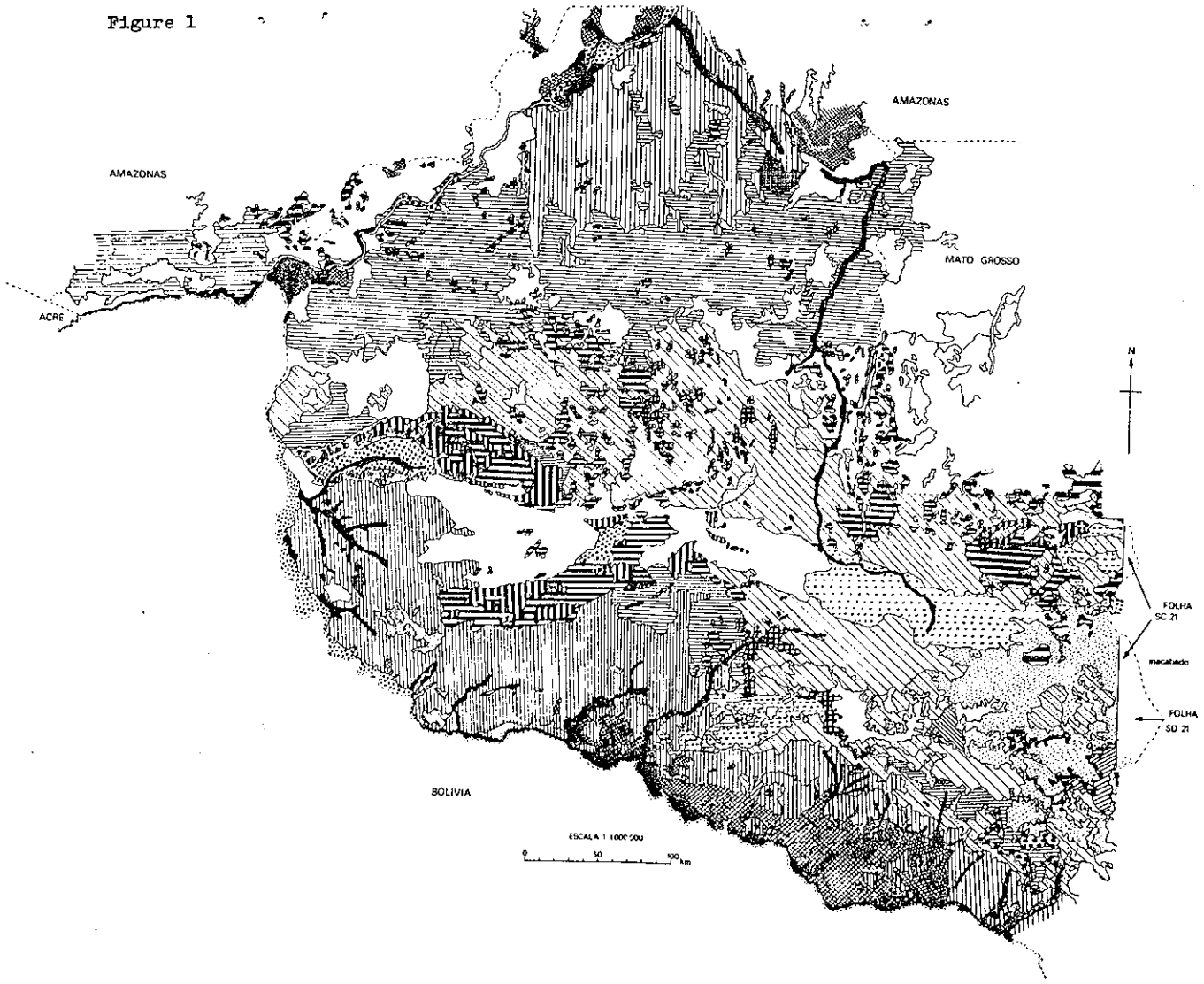

AMAZONAS
AMAZONAS
MATO GROSSO
ACRE
N
FOLHA
SC 21
FOLHA
SD 21
BOLIVIA
ESCALA 1:1000 000
0
50
100 km

Table 1. Principal soil groups and their potential for development

(American equivalent - Soil Taxonomy 1975)

1. Non-hydromorphic Latosols: deep well drained soils usually of rapid permeability generally on elevated land; loam to clay textures with little difference between horizons; weakly susceptible to erosion; low to very low nutrient reserves.
   - 1a Yellow Latosols; dystrophic and allic varieties
     (Haplorthex and Acrorthox groups)
     $\alpha b^1 c^1/pS$
   - 1b Red-Yellow Latosols; allic.
     (Haplorthox and Acrorthox groups)
     $\alpha b^1 c^1/pS$
   - 1c Dark-Red Latosols; dystrophic and allic varieties
     (Haplorthox, Umbriorthox and Acrorthox groups)
     $\alpha b^3 c^3/\pi\sigma$ to $\alpha b^1 c^1/pS$

2. Non-hydromorphic soils with a textural β horizon: medium depth moderately drained soils of moderately rapid permeability on elevated land; loam to clay textures with either a concentration of finer material in the subsurface horizon or clay-rich textures throughout the profile; moderately to strongly susceptible to erosion; very variable nutrient reserves.
   - 2ai Red-Yellow Podzols, eutrophic
     (Tropudalf and Rhodustalf groups)
     ABC/PS to $a^3 b^3 i^3/\pi\sigma$
   - 2aii Red-Yellow Podzols, dystrophic and allic varieties
     (Haplustult, Paleustult and, Tropudult groups)
     a^1BC/PS to $\alpha b^3 i^3/\pi\sigma$ (dystrophic)
     $\alpha b^1 c^1/pS$ to $\alpha\beta^2 c^3/ps$ (allic)
   - 2b Terra Roxa, Eutrophic and dystrophic varieties
     (Tropudalf, Palendult, Rhodustult, Paleustoll, Rhodustalf, and Paleustalf groups)
     ABC/PS to α^4ii/PS
   - 2c Reddish Brunizem
     (Palenstoll and Argiustoll groups)
     $a^1 b^1$ ^{2}/PS to $\alpha^2\beta^2 i^3$/PS

3. Hydromorphic soils with gley or plinthite horizons: typical of varzea situations usually shallow with a high water table; variable permeability and restricted drainage - wet or waterlogged for considerable periods.
   - 3a Hydromorphic laterite, allic
     (Paleudult, Plinthaquult and Plinthaquox groups)
     ii $^4/\pi\sigma$ to iii $/\pi i$
   - 3b Hydromorphic Podzols
     (Tropaquod group)
     iii/ii
   - 3c Gleyed Hydromorphic soils, eutrophic, dystrophic and allic varieties
     (Tropaquept and Dystropept groups)
     $a^4\beta^4 i/pi$ to $iii/\pi i$
   - 3d Quartz-sand Hydromorphic soils, allic
     (Psammaquent group)
     iii/ii

Table 1 cont.

4. Non-Hydromorphic Sandy Soils (quartz sands)): very deep soils extremely sandy throughout the profile found at varied elevations; excessively drained with very rapid permeability; strongly susceptible to erosion; very poor nutrient reserves.
   4. Quartz sand soils, dystrophic and allic varieties
      (Quartzipsamment and Troporthent groups)
      iii/iσtto iii/ii

5. Poorly developed shallow soils: young soils developing on varied consoldiated and unconsolidated parent materials on elevated land; varied textures usually well drained with moderate to rapid permeability; stongly to very strongly susceptible to erosion.
   5a Lithozols, eutrophic, dystrophic and allic varieties
      (Troporthent group)
      iii/πσ to iii/ii
   5b Alluvial soils, dystrophic and allic varieties
      (Dystropept group)
      iii/πi
   5c Cambisols, eutrophic, dystrophic and allic varieties
      (Haplustoll and Dystropept groups)
      $a^3b^3c^3/\pi\sigma$ to iii/ii
   5d Rocky outcrops
      (Troporthent group)
      iii/ii

(for a key to the land potential symbols, see Table 2)

Areas of várzea, which have been shown to have agricultural potential in other parts of the Amazon where they occur on neutral, alluvial soils, are found in Rondônia mostly associated with acid alluvium or with low humic, aluminium-affected gleys, acid sands or concretionary (lateritic) soils (MME-DNPm and NCRA 1979)-Groups 3 & 4, Table 1, and are therefore of relatively little value for agriculture. The better soils possess physical and chemical characteristics which make them suitable for carefully managed agriculture - such as an inherent fertility(high base status and an ability to retain nutrients and water), a resistance to erosion together with conditions amenable to mechanisation. No assessment of possible improvements by engineering works has yet been made and no account is taken of any potential following large scale drainage.

The area covered by the more promising soils is distributed east-westwards across the middle of the Territory, with outliers to the south-east towards the state of Mato Grosso (Figure 2).The principal restrictions to the moderate level of development so far have been the inadequate access to much of the area and the difficulties of obtaining land titles.

At the other extreme,there exists a much larger group of soils whose properties exhibit so many limitations to development that they have not been utilised so far and furthermore, are unlikely to be used in the near future (excepting the possibilty of major drainage engineering works). Figure 3. Between these extremes lie soil groups whose properties may be appropriate for a more restricted range of uses - for example silviculture, possibly pasture, and perennial as opposed to annual crops, all with different potentials at different management levels. These soils of intermediate value are likely to be exploited in the future, even though it is more advisable to try to prevent colonisation, and great care will be required to ensure that the best use is made of them, since they all possess limitations of one form or another and mismanagement could cause permanent damage (although this process is not nearly as well documented as is commonly supposed: see for example Bourne 1978).

Land evaluations based on soil resource surveys

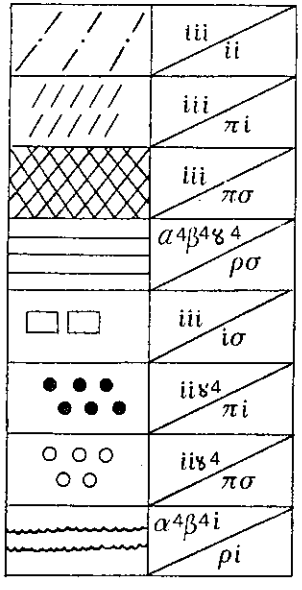
Although the details of the methodology have been modified since the inception of Projeto Radam, there is a consistent pattern adopted by both Embrapa and DNPM. The Projeto Radam surveys at 1 to 1 million based on radar imagery at 1 :250,000, cover most of Rondônia, although they are not all published. The reports commence with descriptions of geology and geomorphology, climate and vegetation, soils and agricultural potential and then go on to a wider evaluation of land use involving socio-economic issues and ultimately producing a framework for land development. The scheme for evaluation is constantly being upgraded in conjunction with technical aid from FAO. and the

Figure 2 Legend

RONDONIA : MAP SHOWING AREAS WITH SOILS UNSUITED TO DEVELOPMENT FOR AGRICULTURE, AND RESTRICTED OR UNSUITED TO PASTURE AND SILVICULTURE

LEGEND

 symbol includes the following soil groups



(modified from PROJETO RADAMBRASIL, sheets SC 19, SC 20, SD 20)

Figure 2

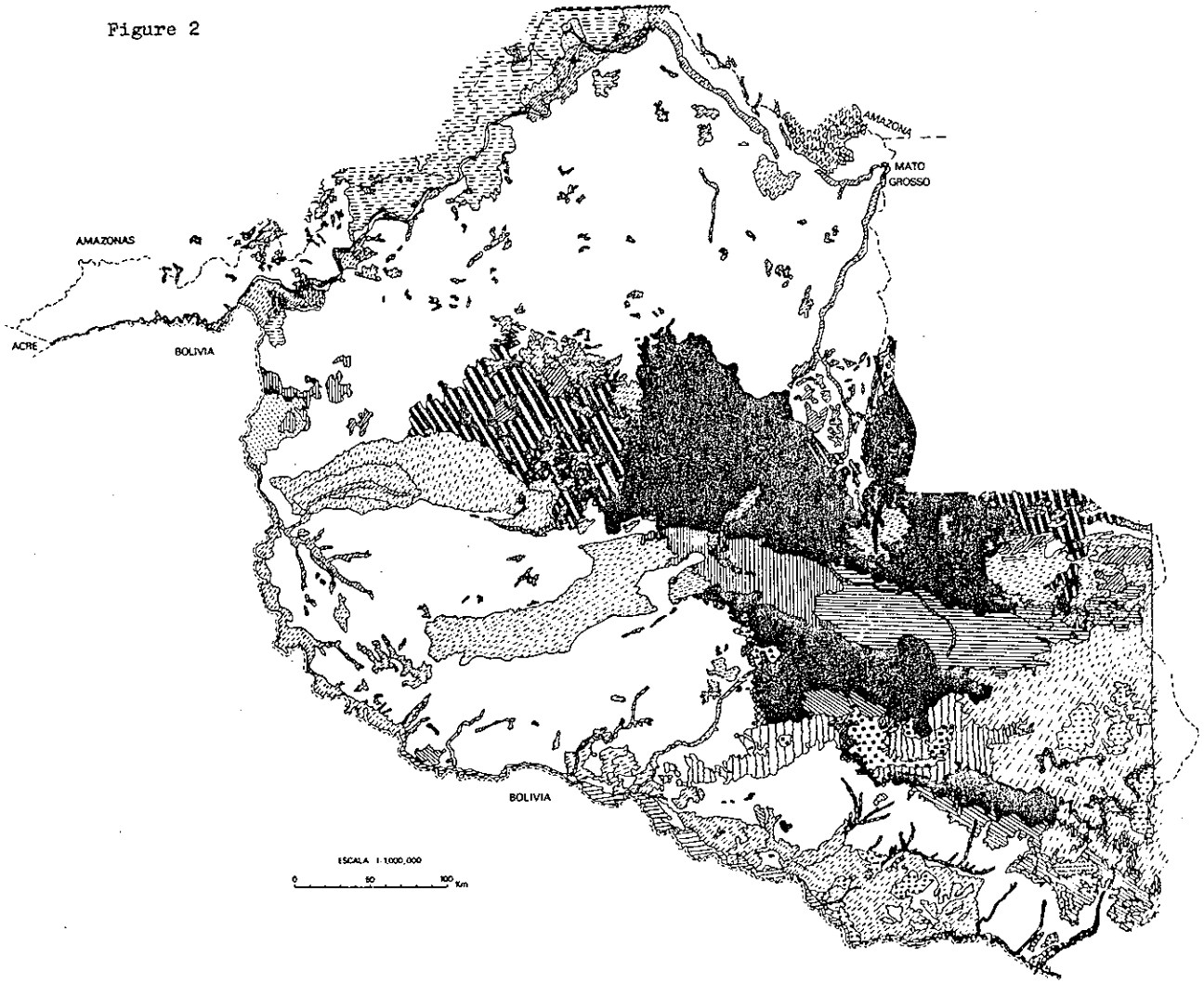

AMAZONAS
ACRE
BOLIVIA
AMAZONA
MATO
GROSSO
BOLIVIA
ESCALA 1:1.000.000
0
50
100 Km

Figure 3 Legend

MAP SHOWING THE MOST PROMISING SOILS FOR DEVELOPMENT

LEGEND

1 Good potential for all forms of agriculture under any level of management good potential for pasture and silviculture

2 Good potential for all forms of agriculture with a reasonable level of technical knowledge (management system B) and for perennial agriculture with traditional methods (system A) good potential for pasture and silviculture

3 Good potential for agriculture using traditional methods (system A) and for perennial crops with more advanced technology (systems B and C), good potential for pasture and silviculture

4 Good potential for agriculture with perennial crops under all forms of management, good potential for pasture and silviculture

modified from PROJETO RADAMBRASIL sheets SC19, SC20, SD20

most recent include further categories of land use and notably include conservation (Ramalho Filho et al. 1977).

Following the practice of the work so far achieved by Projeto Radam in the Territory, each soil group is evaluated according to limitations to development. These are characterised as (i) excesses and (ii) deficiencies of water, (iii) infertility, (iv) susceptibility to erosion and (v) a lack of suitability for mechanisation. A fourfold scale of 'good', 'standard','restricted', or 'unsuitable is then applied to a number of possible uses:

(a) annual or perennial crops under traditional or subsistence levels of management (system A)

(b) annual or perennial crops under simple management practices characterised by the modest application of capital and technology and normally employing manual labour (system B)

(c) annual or perennial crops under advanced management practices with a high technological level (system C)

(d) pasture

(e) silviculture

A series of conventions describe the 'aptitude'of each soil to each possible land use (Table 2):

Table 2 Land use potentials based upon soil properties

Class of aptitude	Agriculture (annual crops) (i)system A	(ii) system B	(iii)system C	Pasture (iv)	Silviculture (v)
1. Good	A	B	C	P	S
2. Standard	a	b	c	p	s
3. Restricted	α	β	γ	π	σ
4. Unsuitable	i	i	i	i	i

Where the potential for perennial crops is different from that for annual crops, an additional number is given under the conventional symbols for agriculture (eg α would indicate a restricted use for annual crops under management system A, but α^1 would indicate a good aptitude for perennial crops under the same system). The fraction usedto present this data is given in the form:(i),(ii),(iii)/(iv),(v). A tentative aptitude map for the Territory has been prepared following these conventions (Figure 4).

At a later stage in the Radam survey, a wider perspective of potential land use is postulated, involving not only ecological and environmental but socio-economic considerations (Subsídios ao Planejamento Regional). At present evidence is available for an area to the west (Rio Branco sheet), the northern half (Porto Velho sheet) and in draft form only,the southern half (Guaporé sheet). Land has been classified into five divisions for planning purposes, ranging from the most promising areas (A) to the least promising (E). Table 3.

Figure 4 Legend

RONDÔNIA : TENTATIVE MAP OF THE AGRICULTURAL POTENTIAL OF THE MAJOR SOIL GROUPS

LEGEND

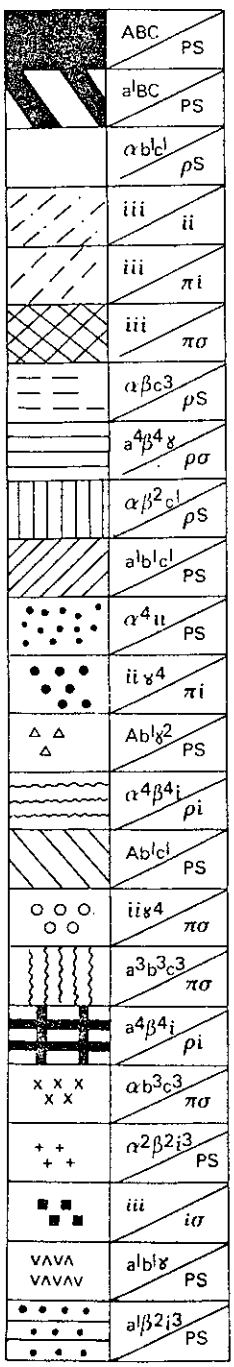


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Figure 4

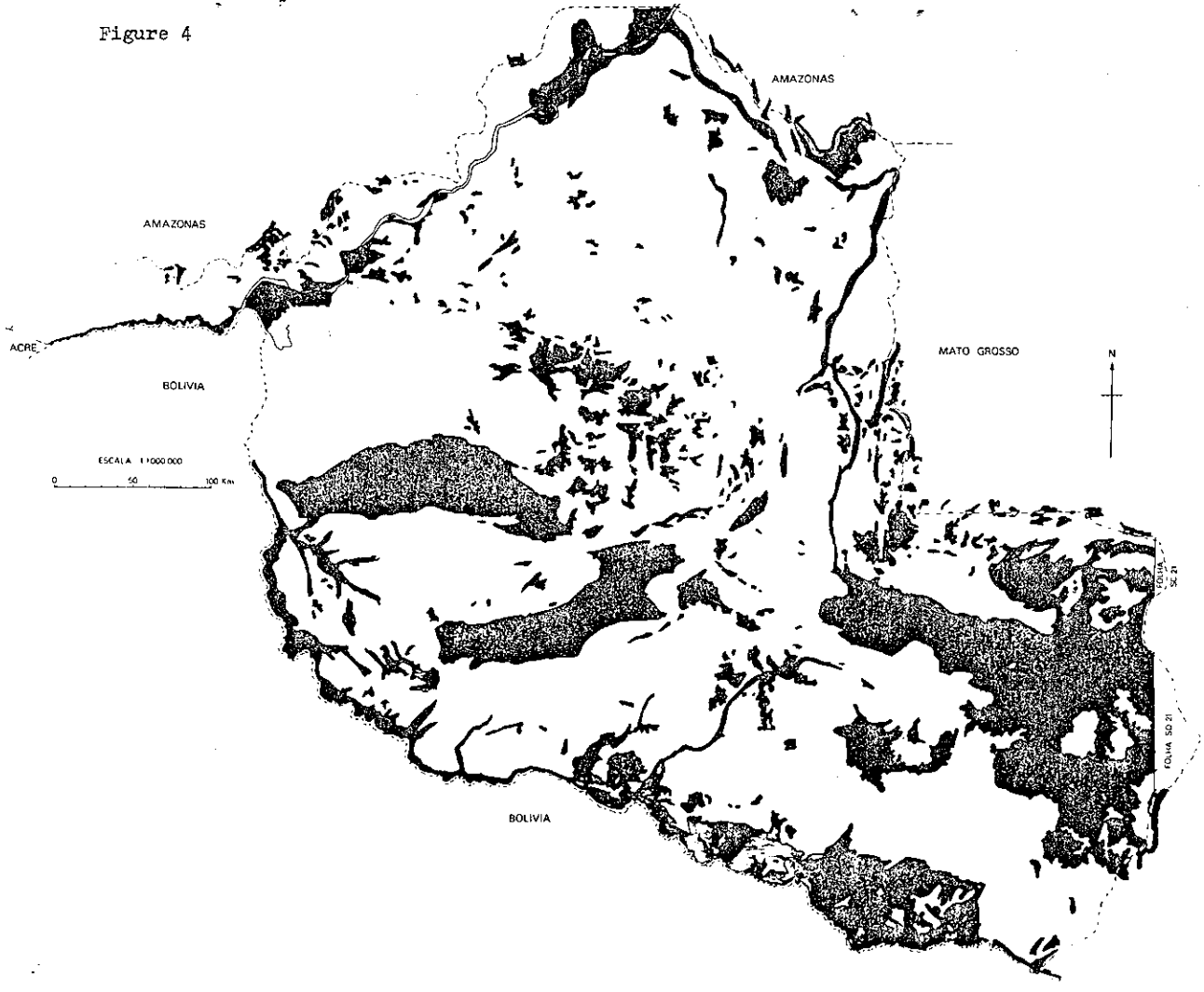
AMAZONAS
AMAZONAS
ACRE
BOLIVIA
MATO GROSSO
N
ESCALA 1:1000.000
0
50
100 Km
FOLHA SC.21
FOLHA SD.21
BOLIVIA

Table 3. The areas and types of development recommended following reconnaissance surveys (based on Projeto Radam)

A. Suitable for controlled colonisation and the establishment of small and medium enterprises for diversified annual and perennial crops (around 2% of the area).
B. Suitable for controlled colonisation and the establishment of varied size enterprises with annual and perennial crops and intensive dairy farming (around 7% of the area)
C. Vulnerable to flooding but suitable for spontaneous occupation in the form of subsistence agriculture or limited commercial agriculture on a small scale (around 3% of the area)
D. Suitable for government encouraged medium and large scale timber, beef cattle and commercial agricultural developments with associated small scale supporting enterprises (around 41% of the area)
E. Not suitable for utilisation at present (around 47% of the area)

These figures are still tentative and no attempt has been made to map the distributions for the Territory.

Discussion

Four aspects are worth amplification in this discussion - the objectives of development planning, the scale of enquiry, the development alternatives and the role of government.

(i) The objectives underlying the occupation of Rondônia are far from explicit and their clarification would undoubtedly help in the planning process. The general aims encompass political, social and economic motives. The political drive to occupy all the national territory either for security or strategic reasons or simply to demonstrate effective occupancy is difficult to make more precise in planning terms. It results in a pressure to settle - particularly along border areas. Social motives also lead to colonisation, in this case in government stimulated and spontaneous settlement of landless farm workers, most of whom come from minifundia and overcrowded areas to the south (Paraná and Rio Grande do Sul). These pressures are manifest in the flood of migrants at the Vilhena border post, where the arrival of 600 families per month in the dry season has been reported (Bourne 1978, based on Incra figures), and in the overall increase in population which was in the order of sixfold between 1970 and 1976 (IBGE, Porto Velho), with the bulk of the increase occuring in the new towns along the BR 364 particularly in the fertile soils of the central section (Cy-Paraná or Vila Rondônia). Evaluation of the economic motives are more straightforward in the sense that the strict criteria of surplus for export

and profitability can be readily measured. With the imbalance presented by the number of small scale holdings, the lack of middle sized farms and the lack of development on large holdings together with the very weak service and transport infrastructure, it is not suprising that the economic potential is failing to materialise. Furthermore much of the history of development in the area has been tied up with land speculations and the end result of these moves has been a low rate of income on which to base regional development. The most promising silvicultural, pastoral or agricultural schemes are those depending upon 'energy subsidies' and financial aid from outside - notably the Ceplac and Incra (Ouro Preto) enterprises. This is not to say that a number of different land uses are not viable in the long term and could generate a sustained profit sufficient to provide the momentum for development. The small scale, traditional forms of agriculture and probably the medium scale low capital enterprises do not seem to be profitable in the present economic climate of the Territory. Development of these sectors will depend upon much more intensive government aid to become soundly established, and they raise the question of whether the objectives are truly economic.

(ii) It should be remembered that our present day understanding of the soil potential is based upon a scale of 1 to 1 million reduced from drafts at 1 ; 250,000. Consequently it is extremely unlikely that all the area indicated in Figure 2 is of high potential, or conversely that none of the remainder of the Territory contains any promising soils for agricultural development. It is obvious that the excellent reconnaissance surveys will have to be supplemented by more detailed investigations before long term plans can be formulated at a local level, and this is emphasised by the Radam reports.

A further point is that the interpretations have been based upon criteria which are not equally applicable to all areas (we are considering here the vast area so far surveyed by Projeto Radam in the Amazon Basin). The evaluations offered to the planners at present do not take into account drainage or irrigation possibilities and the recommended uses and crops are not based upon detailed or long term field trials (with the exception of research in Pará by CPATU (IPEAN) such as Falesi's 1976 summary of pasture establishment). In addition much of the land most suitable for development has already been occupied legally or illegally. Larger scale investigations are therefore required as a matter of urgency particularly to discover the extent of the most fertile soils and to initiate trials on the principal soil groups. Both SUPLAN ('Subsecretaria de Planejamento e Orcamento') of the Ministry of Agriculture, and University research is working on these lines. The basic point is that the landscapes are not homogeneous and should not be approached in mono-use terms. Development will need to be sufficiently varied to take account of the advantages and limitations of each individual area - even down to the scale of the

100 ha colonisation plot where appropriate. The recognition of a need for looking at detailed components of the landscape has been growing (eg Eden's 'compartment model' 1978, Furley 1978, van Wambeke 1978).

(iii) The issues of development objectives and the scale of operation lead to the question of devlopment alternatives. Goodland and Irwin (1977) and van Wambeke (1978) amongst others have reviewed a number of the most important single alternatives and offer views on the sustainable nature of each (Table 4)

Table 4 Alternative strategies for development

Undisturbed forest	: National Parks, Environmental protection, Scientific research, Tourism and recreation, Indian Reserves, Hunting, gathering and tapping
Disturbed forest	: Shelterwood forestry, Selective felling and other forms of cutting, Regeneration
Artificial Plantations	: Mixed species products, Monoculture products
Agriculture with Silviculture	: Intercropping, Rotation with animals and crops as well as trees
Agriculture	: Subsistence annuals and perennials, Cash crop annuals and perennials, Pasture

(Sustained yield strategies at the top of the list are preferable to the more exploitative strategies at the bottom on all but the best soils)

However, as Condurú (1974) has remarked, the question of raising productivity per unit area has not received much attention in the Amazon where the easiest solution has been to increase the area rather than production. Consequently it is difficult to compare the alternatives either within the Amazon area or with similar production elsewhere. Without discussing each possibilty in detail, some of which are covered in Mueller's review of the current position in the Territory (1978), it is apparant from experience in other tropical areas, that a combination of these alternatives, in the form of multiple land use and mixed farming (involving intercropping and rotations with animals and forest) is more lokely to be ecologically stable and therefore more acceptable. Despite criticism, it has been shown thatcareful manual cutting of the forest plus controlled burning can lead to successful pasture (Falesi 1976) or cultivation (Seubert 1977, Sanchez 1977), although insufficient time has elapsed to verify the long term productivity of these trials. Certainly, as Alvim (1978) has commented, there is a place for intensive agriculture given the right conditions.

(iv) The role of government in this development is crucial. Without clear guidance, planning officials at the local level cannot be expected to implement the controls which will be essential. It is also apparant that there are insufficient officials in the various organisations such as INCRA or BDF to offer adequate supervision (Mueller 1978, Bourne 1978). This also applies to the whole area of marketing and services and to agronomic advice to farmers. Both the expansion of agriculture on a sustainable basis and the conservation of areas which should be

excluded from development at present will require greater government involvement, with a larger number of technicians working within the area.

The only long term research into agriculture and land use underway in the Territory, at all comparable with detailed work elsewhere, is that being carried out at Ouro Preto (INCRA colonisation scheme) and at the CEPLAC (cocoa research) station, together with a modest programme at the Porto Velho agricultural research station. If the vehement critics of agricultural development are to be shown to have exaggerated, much more detailed research into sustainable production at varying scales of enterprise and different systems of management will be needed.

Conclusions

1. The long term objectives for development need clarification as a pre-requisite to the choice of alternatives.

2. More detailed information on the renewable resources is necessary, probably at a scale of around 1 to 10,000, indicating the extent of variation within the established soil groups, but concentrating upon the most promising soils. There is also an urgent need to initiate research into the most acceptable land use solutions including trees, animals, perennial and annual crops at different management intensities.

3. Middle scale enterprises are lacking in the area which has made current development rather imbalanced. The smaller plots (100 ha or less) even when managed expertly, are not likely to result in much of a surplus. On the other hand, the larger holdings of 5 or 10,000 ha or more, have not yet developed sufficiently to establish whether they are speculative (with nearly all of the profits siphoned out of the Territory) or a serious contribution to long term economic stability.

4. If one of the principal objectives of development is to generate profit-making primary activities leading to sufficient internal growth to justify moving from the position of a Federal Territory to that of a Federal State (see Convênio FUB/SUDECO, Ministério do Interior, in press), then there is a need for further government intervention. This is especially true in the fields of (a) financial credits, (b) markets and guaranteed prices, (c) controls on immigration and settlement, (d) advisory help - not just seeds, fertilisers, pesticides, herbicides and technical methodology but in the pragmatic business of day to day land management. The older style tax and loan incentives no longer seem appropriate.

5. The ecological arguments for the conservation of the forest are

reasonably well known (see Bourne 1978, Goodland and Irwin 1975,1977) and the delicate nature of the soil-plant relationships is tolerably understood (see Herrera et al. 1978), but few people seem familiar with the most recent agricultural research in analogous environments (viz Sanchez 1977 and the work of the North Carolina team in Peru or even in the work of CPATU mostly in Pará).

6. Soil potential has been used as one of the major criteria in development planning and will continue to be of importance along with other related data on renewable resources. A limited number of the soils in Rondônia are fertile by Amazon standards, but most have either been developed already or are likely to be exploited by deliberate or spontaneous colonisation in the near future. Over large areas the soils are very poor and should not be used for any type of cultivation and probably not for pasture, until there is a greater understanding of their management problems. On the basis of the Projeto Radam recommendations (Table 3), there are no plans to develop the poorer soils which may occupy around 50% of the Territory and there are recognided limitations to the use of the slightly better soils which occupy a further 40% (Furley 1979). Use of these areas should be restricted (the upper part of the list given in Table 4), and the principal difficulty will be the supervision and control of spontaneous forest clearance and settlement.

7. With the limitations to development in the rainforest well known, and with the knowledge that field trials are necessary over a long period (at least 15 to 20 years), there is much sense in the suggestion that farming enterprises shoul d be encouraged elsewhere. The extensive cerrado (savanna) area is still underutilised and productivity could be increased more rapidly and with less risk (see CPAC and CIAT reports) than the forest. Such an admittedly difficult political move would buy the time necessary to avoid the most serious errors and still allow for slower, more controlled development from the more fertile nuclei - as found in central Rondonia.

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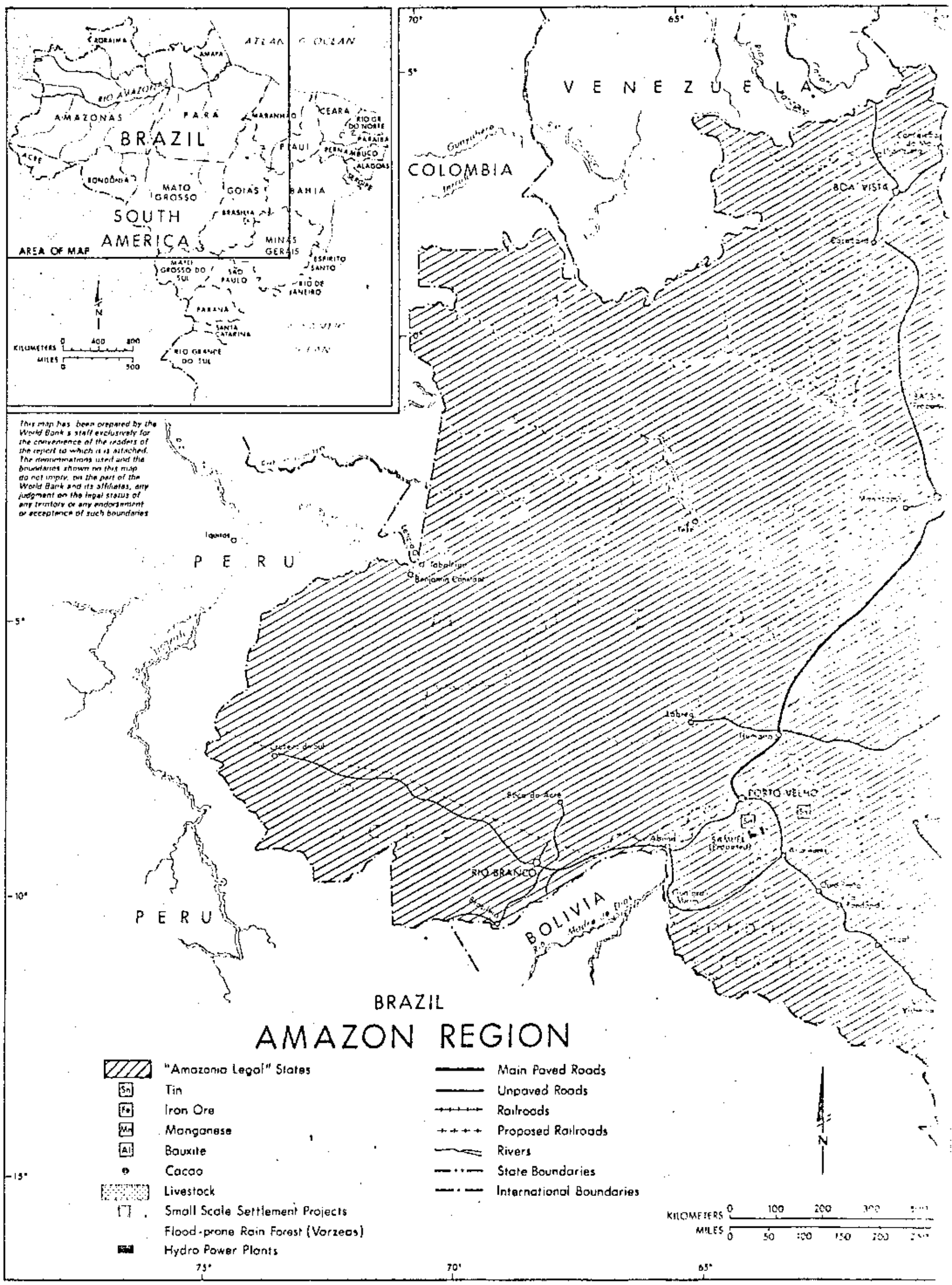
ATLANTIC OCEAN
RORAIMA
AMAPA
RIO AMAZONAS
AMAZONAS
PARA
MARANHÃO
CEARA
RIO GR. DO NORTE
PARAIBA
PERNAMBUCO
ALAGOAS
SERGIPE
BRAZIL
PIAUI
ACRE
RONDÔNIA
MATO GROSSO
GOIAS
BAHIA
BRASILIA
SOUTH AMERICA
MINAS GERAIS
ESPIRITO SANTO
AREA OF MAP
MATO GROSSO DO SUL
SÃO PAULO
RIO DE JANEIRO
PARANA
SANTA CATARINA
RIO GRANDE DO SUL
KILOMETERS 0 400 800
MILES 0 500
This map has been prepared by the World Bank's staff exclusively for the convenience of the readers of the report to which it is attached. The denominations used and the boundaries shown on this map do not imply, on the part of the World Bank and its affiliates, any judgment on the legal status of any territory or any endorsement or acceptance of such boundaries
V E N E Z U E L A
COLOMBIA
BOA VISTA
P E R U
Iquitos
Tabatinga
Benjamin Constant
Labrea
Cruzeiro do Sul
Boca do Acre
PORTO VELHO
SAMUEL (Proposed)
Abuna
RIO BRANCO
BOLIVIA
P E R U
BRAZIL
AMAZON REGION
"Amazonia Legal" States
Tin
Iron Ore
Manganese
Bauxite
Cacao
Livestock
Small Scale Settlement Projects
Flood-prone Rain Forest (Varzeas)
Hydro Power Plants
Main Paved Roads
Unpaved Roads
Railroads
Proposed Railroads
Rivers
State Boundaries
International Boundaries
KILOMETERS 0 100 200
MILES 0 50 100 150
N
70°
65°
5°
10°
15°
75°

18

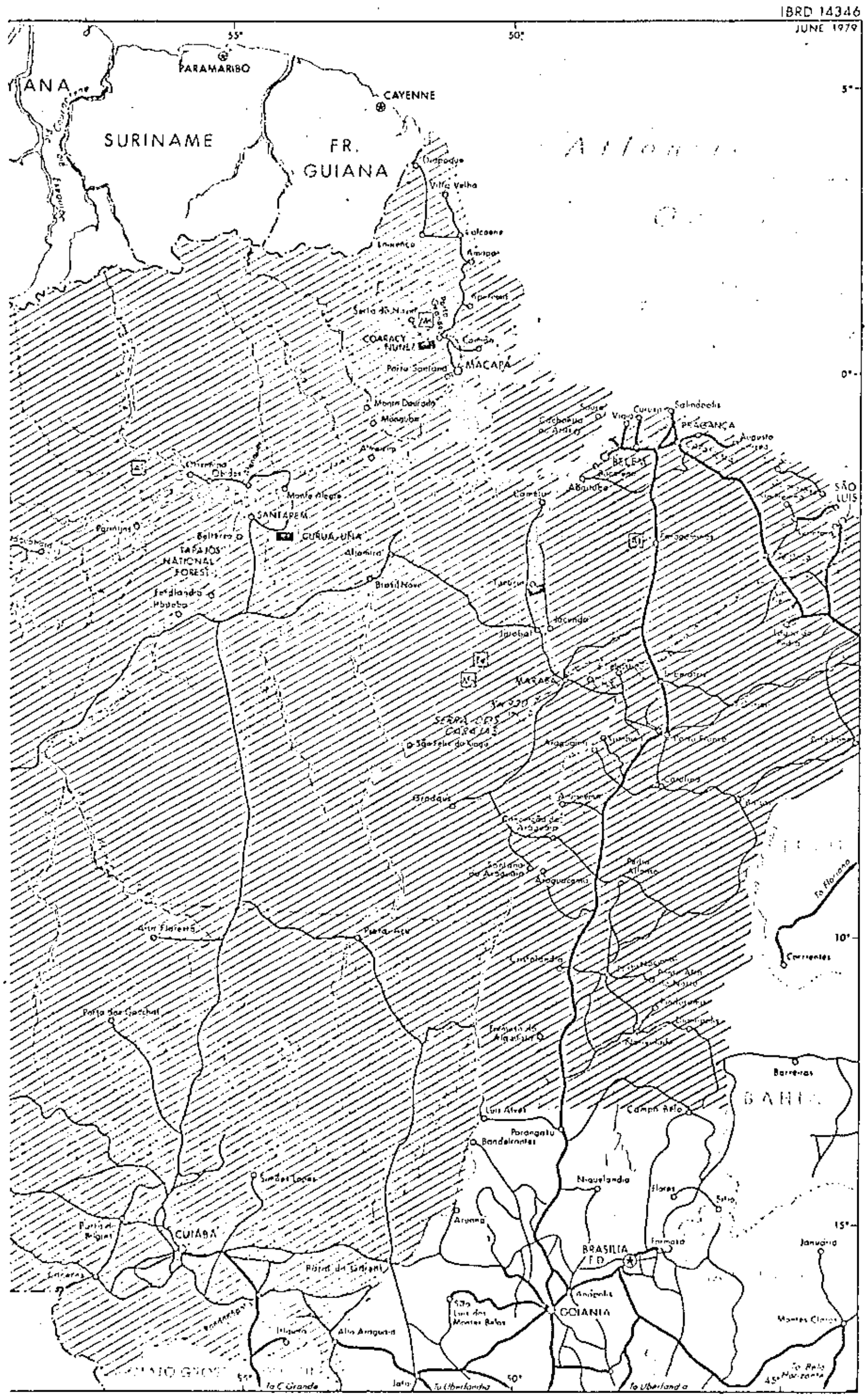

FIGURE 8

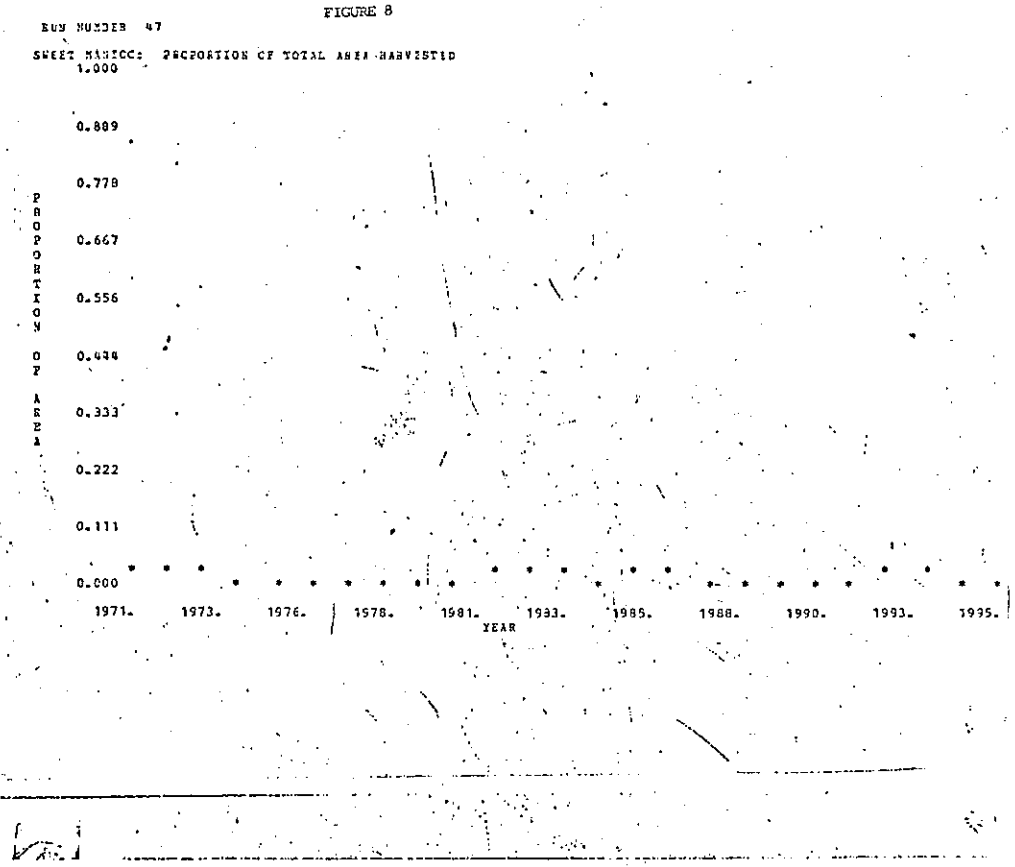

FIGURE 7