Avaliação e Identificação de Ações Prioritárias para a Conservação, Utilização Sustentável e Repartição de Benefícios da Biodiversidade da Floresta Amazônica

PROVÍNCIAS BIOGEOGRÁFICAS DA AMAZÔNIA

Extraído do documento "Evaluation of the current status of Federal Conservation Areas in the Tropical Rain Forest of the Brazilian Amazon"

Elaborado por Anthony B. Rylands - Conservation International do Brasil; Coordenador do meio biótico do subprojeto "Avaliação e Ações Prioritárias para Conservação do Bioma Floresta Amazônica"

Biogeographical Provinces

There have been numerous schemes proposed for the classification and categorizations of the world's biotic provinces. These are reviewed by Udvardy (1975), who by request from the International Union for Conservation of Nature and Natural Resources (IUCN), devised yet another scheme with the aim of defining a satisfactory classification specifically for conservation purposes. Udvardy's synthesis is based to a large extent on two previous reports, also published by IUCN, with the same aim (Dassmann, 1973a. 1973b), but differing in some important respects, not only in the terminology used but also in terms of the taxonomy and the limits of the defined areas.

The classification of Udvardy (1975) was adopted by IUCN and consists of just two hierarchical taxa defined as follows:

Biogeographical Realm. The highest taxon. A continent or subcontinent-sized area with unifying features of geography and fauna/flora/vegetation. This rank more or less corresponds to the "kingdom" used especially in phytogeography and "region" used by zoogeographers.

Biogeographical Province. Ecosystematic or biotic subdivisions of the above realms. These correspond more or less to "regions" in phytogeography and "faunal provinces" of the zoogeographer, and especially to the "biotic province" of Dice (1943).

Udvardy (1975) accepts the division of realms into subrealms, as well as provinces into subprovinces, districts and subdistricts, but argues that these are beyond the scope of his analysis, would only add contraversy in their delimitation, and that their elaboration is the task of regional experts. Although Udvardy (1975) divided Amazonia into several provinces (Fig.9, and see below), these do not correspond to the Amazonian phytogeographical regions. These are reviewed below (see also Daly and Prance, 1988). Prance (1977) argued for the importance of considering phytogeographic regions for the rationalization of an Amazonian parks system, and they were duly given priority by Wetterberg et al. (1976) in the document "An Analysis of Nature Conservation Priorities in Amazonia", as well as in this analysis, but no such similar subdivision has been adopted for the fauna.

Udvardy (1975) also considered 14 biome types, the first 11 of which correspond to major ecosystem groups including all except what he refers to as azonal formation classes (for example, lakes, rivers, marshes, and other wetlands, salt pans, and caves). Numbers 12 and 13 are composites of several vegetation zones and their biota, and the last, number 14, is the only aquatic biome - lakes.

Amazonia is included in the Neotropical Realm (8) and is divided into eight provinces as follows (see Fig.9):

8.4.1	Guyanan
8.5.1	Amazonian
8.6.1	Madeiran
8.28.10	Campos Limpos
8.29.10	Babacu
8.30.10	Campos Cerrados
8.34.12	Colombian Montane
8.35.12	Yungas

Table 9. The National Parks (N.P.), Biological Reserves (B.R.) and Ecological Stations (E.S.) and Reserves (E.R.) in the Biogeographical Provinces of Udvardy (1975).

8.4.1 Guyanan
N.P.Cabo Orange
B.R.Rio Trombetas
B.R.Lago Piratuba
E.S.Jari
E.S.Maraca-Jipioca

8.5.1.Amazonian
N.P.Pico da Neblina
N.P.Jau
N.P.Serra do Divisor
B.R.Abufari
B.R.Uatuma
E.S.Anavilhanas
E.S.Rio Acre
E.S.Juami-Japura
E.R.Jutai-Solimoes
E.R.Sauim-Castanheiras

Transition 8.5.1 Amazonian/8.6.1 Madeiran
P.N.Amazonia

8.6.1 Madeiran
B.R.Jaru
B.R.Tapirape
E.S.Cunia

Transition 8.6.1.Madeiran/8.28.10 Campos Limpos
E.S.Caracarai
E.S.Niquia

Transition 8.6.1 Madeiran/8.29.10 Babacu
B.R.Gurupi

Transition 8.6.1 Madeiran/8.30.10 Campos Cerrados
N.P.Araguaia
N.P.Pacaas Novos
B.R.Guapore
E.S.Coco-Javaes
E.S.Ique

8.28.10 Campos Limpos
N.P.Monte Roraima
E.S.Maraca

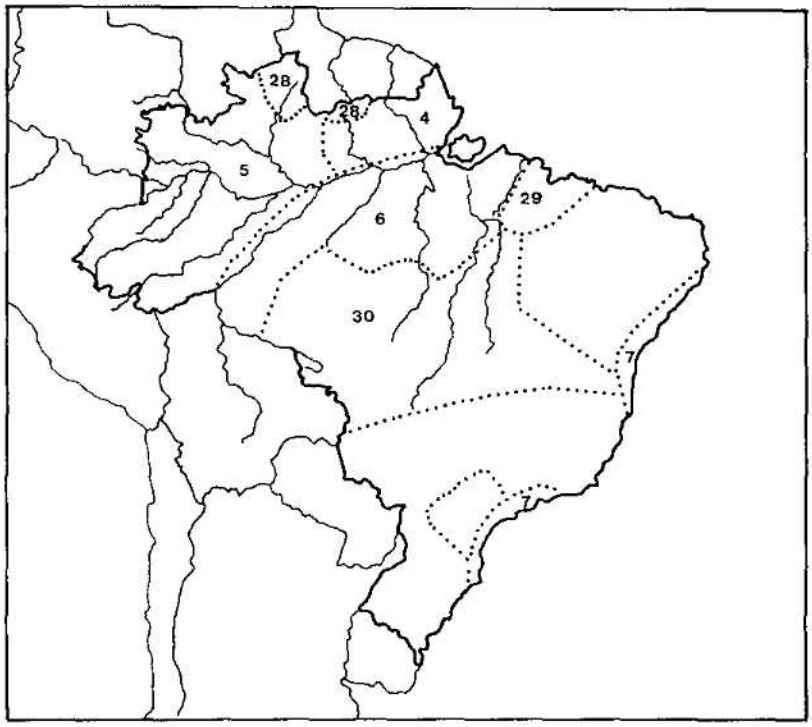

Figure 9. The Biogeographical Provinces in the Brazilian Amazon (Udvardy, 1975). 4 = 8.4.1 Guyanan; 5 = 8.5.1 Amazonian; 6 = 8.6.1 Madeiran; 28 = 8.28.10 Campos Limpos; 29 = 8.29.10 Babacu; 30 = 8.30.10 Campos Cerrados.

The first number in this scheme corresponds to the realm, the second to the province, and the third to the dominant biome type, which here includes Tropical Humid Forests (1), Tropical Grasslands and Savannas (10) and Mixed Mountain and highland systems with Complex Zonation (12). All but the Colombian Montane and Yungas Provinces occur within Brazilian Amazonia.

Since 1975, Udvardy's scheme has been undergoing revision, especially concerning the Neotropical Realm and Amazonia. Udvardy (1984) lists 13 provinces for Amazonia, which are evidently based in large part on the phytogeographical regions of Prance (1977), but they remain as yet unmapped and are, therefore, not applied in this study. The revised scheme includes the following provinces:

8.4.1	Atlantic Coastal
8.5.1	Rio Negro
8.7.1	Manaus
8.8.1	Guyanan Rainforest
8.8.1	Solimoes
8.10.1	SW.Amazonas
8.11.1	Madeiran Rainforest
8.31.10	Campos Limpos Savanna
8.32.10	Pantepui
8.33.10	Babacu
8.34.10	Campos Cerrados Savanna
8.41.12	Colombian Montane
8.42.12	Yungas Montane

The Colombian Montane and the Yungas Montane Provinces do not extend into the Brazilian Amazon, leaving 11 provinces to be considered for the region. However, a map of these divisions is not available and the listing of the occurrence of federal conservation units within each is restricted to Udvardy's scheme of 1975 (Table 9).

7.Geochemical Provinces

Fittkau (1971) divided the Amazon basin into three major geochemical provinces (Fig.10).

1. **Western peripheral region** (Andean and pre-Andean) with its associated alluvial formations which penetrate east. The waters and soils are relatively rich in nutrients.
2. **Northern and southern peripheral regions** of the ancient Brazilian and Guianan shields, with soils and waters relatively poor in nutrients.
3. **Central Amazon region**, of extreme geochemical poverty, covered with Tertiary sediments of fluvial and lacustrine origin.

Table 10. The occurrence of Brazilian National Parks (N.P.), Biological Reserves (B.R.), and Ecological Stations (E.S.) and Reserves (E.R.) in the four geochemical provinces identified by Fittkau (1971).

Geochemical Province	Area (ha)
Central Amazon	
N.P.Amazonia (part)	994,000
N.P.Jau	2,272,000
B.R.Uatuma (part)	560,000
E.S.Anavilhanas	350,018
E.R.Sauim-Castanheiras	109
Northern Peripheral Region	
N.P.Pico da Neblina	2,200,000
N.P.Monte Roraima	116,000
B.R.Rio Trombetas	385,000
B.R.Uatuma (part)	450,000
E.S.Maraca	101,312
E.S.Caracarai	400,560
E.S.Niquia	286,600
E.S.Jari	227,116
Southern Peripheral Region	
N.P.Araguaia	562,312
N.P.Amazonia (part)	994,000
N.P.Pacaas Novos	764,801
B.R.Jaru	268,150
B.R.Guapore	600,000
B.R.Tapirape	103,000
E.S.Ique	200,000
E.S.Coco-Javaes	37,000
Western Peripheral Region	
N.P.Cabo Orange	619,000
N.P.Serra do Divisor	605,000
B.R.Lago Piratuba	357,000
B.R.Abufari	288,000
E.S.Rio Acre	77,500
E.S.Maraca-Jipioca	72,000
E.S.Cunia	104,000
E.S.Juami-Japura	745,830
E.R.Jutai-Solimoes	284,285

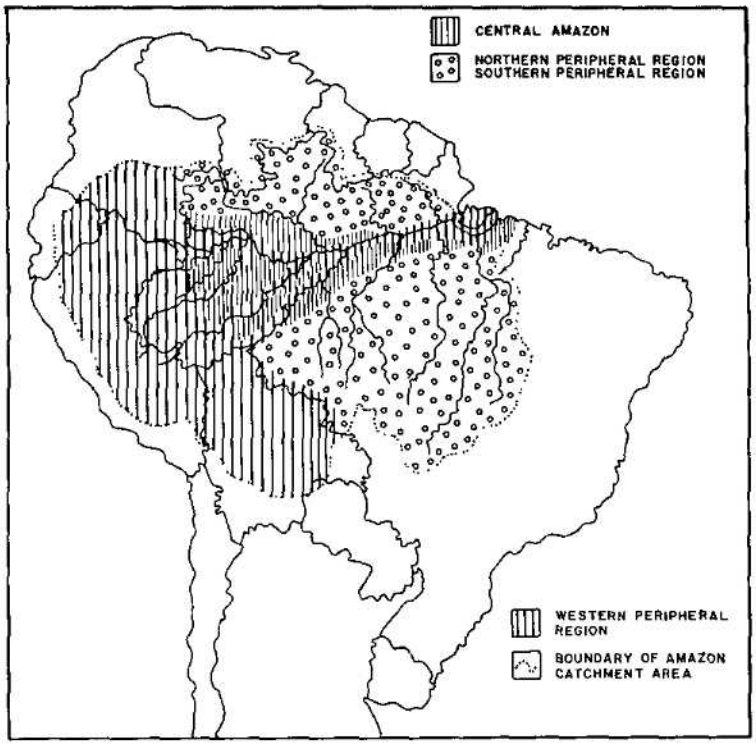

Figure 10. Geochemical Provinces of Amazonia (Fittkau 1971).

40x

Table 10 shows the distribution of conservation units within these four regions.

8.Amazonian Vegetation Types

There is a considerable literature dealing with the highly varied vegetation types in Amazonia. The classic work is that of Ducke and Black (1953, 1954). Wetterberg et al. (1976) based their analysis of the protection afforded to the Amazonian vegetation types on the classification of Pires (1974). Although providing modifications and refinements, more recent reviews maintain his basic system (Prance 1978; Braga 1979; Pires and Prance 1985; Rylands 1987; Rizzini et al. 1989). Brown and Prance (1987) provide a vegetation map based on the RADAM Project surveys of Brazilian Amazonia, which used side-looking airborne radar, aerial photographs and ground checks (see Fig.11).

The following summary is based on Brown and Prance (1987) who divided the Amazonian vegetation types into Amazonian savanna, transition forests, terra firme rain forest, white sand formations, inundated forests, gallery forests and montane forests. Another category, secondary forest and agricultural areas, occurs to a greater or lesser extent throughout Amazonia and is not included here. The classification of these vegetation types is based mainly on topography, physiognomy, climate, soil types, drainage, and floristic communities, including plant species endemicity and diversity. It is important to emphasize that many of these vegetation types may themselves be sub-divided, not only on a regional-geographical basis, depending on distance and geographical barriers (such as the Rio Amazonas itself), but also according to small-scale variations in the above mentioned parameters (Rylands 1987). Table 11 lists vegetation types in each of the Federal Conservation Units.

1. **Amazonian Savanna.** **Terra firme savannas** are open grasslands, often containing gallery forest and semi-deciduous forest patches, scattered throughout the Amazonian region, but concentrated in drier and more seasonal regions, with annual rainfall being 2000 mm or less. They have floristic affinities with the cerrado of central Brazil, but occur predominantly in lowland areas, have less local endemism and species diversity, and less tortuous trees. It is possible to distinguish six major terra firme savanna or campo areas: coastal Amapa (extending into French Guiana); Cachimbo-Cururu (southern Para); Madeira; Roraima-Rupununi or Gran Sabana (extending into Venezuela); Trombetas-Paru; Sipaliwini (extending into Surinam); and Marajo (the eastern part of the island). These vary greatly in their botanical diversity and degrees

of endemism. Notable in this respect is the sandstone savanna of Cachimbo-Cururu, and, for example, the archipelago of white sand savannas of the Orinoco-Amazonas drainage. The latter have an extremely specialized flora, strongly related to that of the mountain tops of the Guayana highlands, but each savanna island has well-defined and differing plant communities and a high degree of endemism (Huber 1982, 1987).

The Amapa savanna has the best coverage in terms of protected areas (Table 11). The Monte Roraima National Park is the most important area protecting the Roraima savanna, but small areas are also included in a number of other reserves. Two small and separate patches of the Madeira savannas are protected in the Amazonas National Park and the Cunia Ecological Station. Part of the Trombetas-Paru savanna complex is protected in the Rio Trombetas Biological Reserve. Plans exist to increase the size of this reserve as a compensatory measure for the construction of the Cachoeira Porteira hydroelectric dam on its north-west corner, which my increase the area of savanna protected. The Marajo, Sipaliwini and Cachimbo-Caruru savannas remain without any protected areas. The majority of the Brazilian part of the Sipaliwini savanna is within the Tumucumaque Indian Park. A number of other reserves occur on the southern border of Amazonia where transition forests form mosaics with savanna vegetation which forms part of the cerrado of central Brazil.

Inundated savannas or campos de varzea are similar to the terra firme savannas but are periodically inundated. They occur along the white-water rivers, and the largest expanse of this type of vegetation is found on the east of the island of Marajo. Seven reserves include variations of this type of vegetation, but none occur along the Rio Amazonas-Solimoes, between the Rios Xingu and Tapajos where it is especially common (Table 11).

2. Transition forests. This category includes: semideciduous forest, babassu palm forest, mixed forest with palms, liana forest, bamboo forest, and floodplain open mixed forest. These forest types predominate in the transition zones between savanna areas and high forest. In some cases they are semi-deciduous, and they have a lower biomass than the Amazonian terra firme rain forest. **Semi-deciduous forests** occur mainly along the southern border of Amazonia but are also common along the more seasonal and drier belt running south-east to north-west through the lower Rio Madeira. The **babassu palm forests** occur along the southeastern border of Amazonia, in the states of Tocantins, Para and Maranhao. This forest type has a low species diversity and few endemics, and is believed to

have been more widespread during periods of drier and more seasonal climates. **Liana forest** is an open forest, dense in lianas and vines, but sparse in epiphytes. Species diversity is low in this forest type. It occurs mainly in southern Para and northern Mato Grosso, between the upper Rios Xingu, Tapajos and Tocantins. Liana forest has elements of both Amazonian and Atlantic forest floras, as well as that of the cerrado, and islands of cerrado are common. **Bamboo forests** are an open forest formation, with very dense understoreys and a predominance of bamboo species which form part of the canopy. They occur mainly in the state of Acre, extending into Bolivia and the state of Rondonia.

3. **Amazonian rain forests on terra firme.** The most widespread forest type (estimated to occupy 51% of the Amazonian region), occurs in areas where seasonality is not marked with annual rainfall exceeding 2000 mm. Biomass and species diversity are very high. The canopy is closed, understoreys are sparse and the number of lianas is limited in comparison to liana forest. Although physiognomically uniform, the floristic composition varies considerably (see section on phytogeographic regions). The RADAM Survey Project distinguished two types of terra firme rain forest. The first is **lowland forest**, occurring on Tertiary sediments at altitudes below 250 m. The canopy is relatively closed, and is usually around 30 m, with emergents reaching 50 m. The second is **hill forest** , which replaces lowland forest above 250 m altitude. It is less uniform physiognomically, generally lower, with a more open canopy, and has differences in species composition.

4. **Vegetation on white sand soils.** This category includes campinas (or caatinga baixa), campinarana (caatinga alta), campina rupestre (vegetation on sandstone rock outcrops) and coastal restinga (beach forest). The sandy soils are nutrient deficient and support distinctive floristic communities. The vegetation is more or less scleromorphic but there is otherwise considerable diversity in forest structure and physiognomy. **Campinarana** is a tall forest of intermediate biomass, with an open canopy, and extremely rich in endemic plant species and epiphytes. It occurs throughout the basin, but is predominant in the region of the upper Rio Negro (see Rodrigues 1961; Pires and Rodrigues 1964; Lisboa 1975; Anderson 1981). The Pico da Neblina National Park is significant for its protection of this vegetation type. **Campina** is considerably lower and more open, abundant in epiphytes, lichens, blue-green algae and has many endemic species. Campinas occur in smaller islands around the lower Rio Negro (the Jau National Park, the Uatuma Biological Reserve and the Anavilhanas Ecological

Station), the Serra do Cachimbo, Para (Lleras and Kirkbride 1978), the Chapada dos Parecis in Rondonia, and northwest of Cruzeiro do Sul, between the Rios Moa and Ipixuna in Acre (the Serra do Divisor National Park). **Campina rupestre** is a campina-like vegetation occurring on sandstone outcrops. It occurs particularly in the tepui region of northern Amazonia (the Pico da Neblina and Monte Roraima National Parks) and also in the Serra do Cachimbo, Para. This formation is also protected in the Serra do Araca State Park, decreed in 1990. **Restinga** is a low coastal scrub, occurring along a narrow strip eastwards from near the Amazon delta in northern Para and Maranhao.

5. **Inundated forests.** Brown and Prance (1987) divide this category into seven types, the most important of which are seasonal varzea and igapo. **Seasonal varzea** is periodically flooded by white-water rivers and has a lower plant species diversity than terra firme rain forest. It has a broken canopy, a higher tree density and fewer epiphytes than seasonal igapo forest and the two formations share very few plant species. **Seasonal igapo** is a very variable formation, occuring along black-water (for example, the Rio Negro) or clear-water rivers (for example, the Rio Tapajos). It is usually on sandy soil and has a lower plant species diversity, a more even and closed canopy and lower tree density than seasonal varzea. Leaves are frequently scleromorphic. Varzeas are threatened because of their importance for agriculture and the facility of transporting timber (floating logs out during high water). Relatively few reserves contain extensive areas of this vegetation type, the most important being the Mamiraua State Ecological Station and the Jutai-Solimoes Ecological Station. Only one reserve, the Anavilhanas Ecological Station, protects a significant area of igapo. Its occurrence in the other areas is limited. **Permanently flooded varzea and igapo** are swamp forests on humic gleys, and often take the form of palm forests, dominated by Mauritia or Euterpe. They occur along water courses throughout the basin. **Tidal varzea** is similar to the other varzea formations, but is subjected to twice daily floods. It occurs in the delta region, up to 100 km inland. **Floodplain forest** is flooded by irregular heavy rainfall. It is similar to seasonal varzea but contains many more terra firme forest elements. **Mangrove forests**, flooded by salt-water and brackish-water, are typical of the coastal areas of Amapa and the Amazon delta.

6. **Gallery forests.** All the savanna areas contain gallery forests, which occur along major water courses and remain evergreen because of the high water table. Acting as corridors, these forests have undoubtedly played an important role in the past in determining forest species'

Table 11. The occurrence of different vegetation types and aquatic ecosystems in the National Parks, Biological Reserves, and Ecological Stations and Reserves in Brazilian Amazonia (see text for descriptions).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
National Parks																
Araguaia							+		+							
Amazonia				+						+	+		+			
Pacaas Novos							+		+				+			
Pico da Neblina													+		+	
Cabo Orange	+							+				+				+
Jau							+					+			+	
Serra do Divisor											+	+				
Monte Roraima			+								+	+				
Biological Reserves																
Rio Trombetas					+			+				+	+			
Jaru									+			+	+			
Lago Piratuba	+							+				+				+
Abufari												+				
Guapore							+	+	+				+			
Gurupi									+			+	+			
Tapirape												+	+			
Uatuma												+	+		+	
Ecological Stations																
Anavilhanas												+			+	
Ique									+				+			
Maraca			+				+						+			
Rio Acre											+	+	+			
Maraca-Jipioca	+							+								
Cunia				+					+			+				
Caracarai			+										+			
Jari												+	+			
Juami-Japura								+				+				
Coco-Javaes							+		+				+			
Niquia			+									+	+			
Ecological Reserves																
Jutai-Solimoes								+				+				
Sauim-Castanheira																

	17	18	19	20	21	22	23	24	25	26	27	28	29	30
National Parks														
Araguaia	+				+								+	
Amazonia	+	+											+	
Pacaas Novos					+	+	+	+	+	+				
Pico da Neblina		+				+	+	+	+	+	+			
Cabo Orange				+	+								+	
Jau		+												
Serra do Divisor	+					+	+	+	+	+				
Monte Roraima					+	+	+	+	+	+				
Biological Reserves														
Rio Trombetas	+		+										+	+
Jaru	+												+	
Lago Piratuba				+	+								+	
Abufari	+												+	
Guapore	+				+								+	
Gurupi														
Tapirape														
Uatuma		+								+			+	+
Ecological Stations														
Anavilhanas		+											+	
Ique														
Maraca	+									+				
Rio Acre	+									+			+	
Maraca-Jipioca				+	+									
Cunia	+	+											+	
Caracarai					+							+		
Jari	+													
Juami-Japura	+												+	
Coco-Javaes	+				+								+	
Niquia					+							+		
Ecological Reserves														
Jutai-Solimoes	+												+	
Sauim-Castanheiras														

Key:
1. Savanna - Amapa
2. Savanna - Cachimbo-Caruru
3. Savanna - Roraima
4. Savanna - Madeira
5. Savanna - Trombetas-Paru
6. Savanna - Marajo
7. Other savannas
8. Campos de varzea
9. Semi-deciduous transition forest
10. Liana forest
11. Bamboo forest
12. Lowland terra firme forest
13. Upland terra firme forest
14. White-sand forest (caatinga alta)
15. White-sand forest (campina)
16. Coastal scrub (restinga)
17. Seasonal varzea
18. Seasonal igapo
19. Tidal varzea
20. Mangrove swamp
21. Gallery forest
22. Lower montane forest
23. Upper montane forest
24. Subalpine vegetation
25. Rocky outcrops
26. Waterfalls and cataracts
27. Deep closed lakes
28. Shallow closed lakes
29. Shallow open lakes
30. Artificial lakes

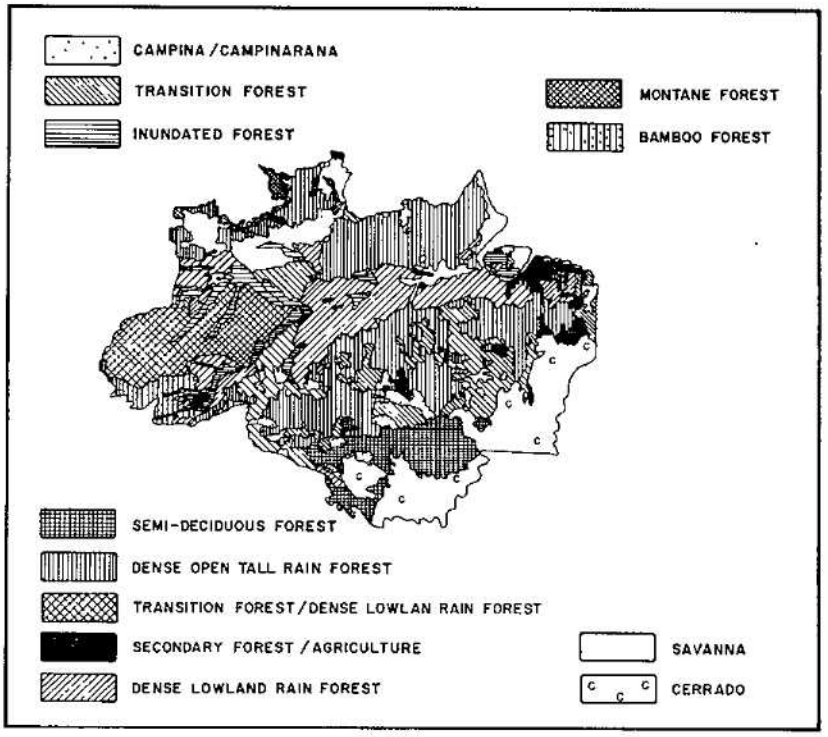

Figure 11. Vegetation types in Amazonia (from Brown and Prance 1987).

distributions during drier and cooler climates and the expansion of savanna or dry transition forest in the past.

7. **Montane forests.** These are low forests occurring above 700 m altitude, mainly on the northern and southern borders of the basin. Brown and Prance (1987) divide this category into **lower montane rainforest** (below 1000 m) and **upper montane rainforest**, or cloud forest or elfin forest. Lowland species are generally absent in the upper montane forest. Shrubby savanna, or **subalpine vegetation** occurs at higher altitudes, notably in the Guayana highlands and the eastern slopes of the Andes. **Rocky outcrops** have a specialized vegetation, including plants adapted to withstand seasonal drought. There are four main conservation units protecting these types of vegetation, the National Parks of Monte Roraima, Pico da Neblina and Serra do Divisor and the State Park of Serra do Araca on the Rio Demini.

9.Aquatic Ecosystems

The variety of aquatic ecosystems was first emphasized by Sioli (1950, 1968, 1984). His division of three water types according to their colours (black, clear and white), following Wallace (1853a), is still maintained, and corresponds well not only to their chemical properties but also their biology and productivity (Junk, 1983a, 1983b). However, considerable research is necessary to examine the more subtle but significant biological and chemical differences within and between each type (Junk and Furch 1985; Furch 1984; Sioli 1984). The chemical characteristics are largely dependant on the geological, geochemical and petrographic properties of the drainage basins of each river system (Fittkau 1971; Furch 1984), and are evidently an important factor determining primary and secondary productivity and, hence, the biological communities they contain. However, as pointed out by Junk (1983a) and Gery (1984), a characterization of water bodies by key organisms is not yet possible, and the classification of Amazonian aquatic habitats described below, following Junk (1983a, 1983b), is based on their morphological and hydrobiological characteristics.

1. Rivers. As already mentioned, rivers can be subdivided into white-water, clear-water and black-water. The morphological, biological and chemical properties of the different river systems are reviewed by Sioli (1950, 1984), Junk (1983a, 1983b), Furch (1984) and Junk and Furch (1985). Although as yet poorly documented, the biological communities evidently differ between the large rivers and also between affluents of the same river (fishes, Goulding et al. 1988; aquatic insects, V.Py-Daniel, pers.comm.). The

occurrence of conservation units in the major river basins of Amazonia is shown in Table 12. The Rio Amazonas-Solimoes is very poorly represented, only by the Jutai-Solimoes Ecological Station near Colombia. The Rios Xingu, Ica and Nhamunda have no federal reserves along their main courses or tributaries. Rivers act as barriers to the geographical distributions of numerous plant and animal species (Ducke and Black 1953; Sick 1967; Hershkovitz 1977; Ayres 1986). It is important to note that only four reserves span a major river; the Abufari Biological Reserve includes both banks of the Rio Purus, the Amazonia National Park includes a buffer zone on the east side of the Rio Tapajos, the Lago Piratuba Biological Reserve includes both sides of the lower Rio Araguari and the Cabo Orange National Park includes both sides of the Rio Cassipore.

2. **Creeks.** The differences in the biological and chemical properties of forest streams and creeks, or igarapes, is at least as large as between the major rivers. Ecological differences evidently exist between perennial and temporary creeks. The fish fauna of creeks with rapids is quite different from that of slow running creeks in the lowlands, and in both they are extremely diverse (Junk, 1983a). Junk (1983a) proposes that creeks may be classified hydrochemically in relation to the geology of their catchment areas. The ecology of forest streams is reviewed by Walker (1987).

3. **Waterfalls and cataracts.** Waterfalls are very specialized habitats and may act as barriers to the dispersal of many insect and fish species. They are found mostly in the area of the archaic shields of Central Brazil and the Guianas and the Andes. The three National Parks, Pico da Neblina, Monte Roraima and Serra do Divisor, in mountainous areas are significant for theor protection of these habitats.

4. **Deep closed lakes.** These are accumulating systems with physical, chemical and biological stratification and are generally inducive to the evolution of an endemic fauna. They are rare in Amazonia, but include terra firme or ria lakes, either clear- or black-water, which, however, are not considered true lakes in geological terms, but rather part of river systems with the more or less well-developed characteristics of a true lake. The only true lakes known to occur in the Brazilian Amazon are those of the Morro dos Seis Lagos, north of the upper Rio Negro, part of the Pico da Neblina National Park and the Serra dos Carajas, Para.

5. **Closed shallow lakes.** These are common in the savanna area of Roraima. They are rounded, generally oligotrophic and part perennial, part temporary, and believed to have arisen through wind erosion. Swampy and

Table 12. The occurrence of National Parks (N.P.), Biological Reserves (B.R.), Ecological Stations (E.S.) and Reserves (E.R.) on the main rivers systems in the Amazon basin of Brazil.

River	Area (ha)
Rio Amazonas-Solimoes (white)	
E.R.Jutai-Solimoes	284,285
Rio Gurupi	
B.R.Gurupi	341.650
Rio Tocantins-Araguaia (clear)	
N.P.Araguaia	562,312
B.R.Tapirape (tributary)	103,000
E.S.Coco-Javaes (tributary)	37,000
Rio Xingu (clear)	
None	
Rio Tapajos (clear)	
N.P.Amazonia	994,000
E.S.Ique (tributary)	200,000
Rio Madeira (white)[1]	
E.S.Cunia	104,000
N.P.Pacaas Novos (tributary)	764,801
B.R.Guapore (tributary)	600,000
Rio Purus (white)	
B.R.Abufari	288,000
E.S.Rio Acre (tributary)	77,500
Rio Jurua (white)	
N.P.Serra do Divisor	605,000
Rio Jutai (white)	
E.R.Jutai-Solimoes	284,285
Rio Ica (white)	
None	
Rio Japura (white)[2]	
E.S.Juami-Japura	745,830
Rio Negro (black)[3]	
N.P.Pico da Neblina	2,200,000
N.P.Jau (tributary)	2,272,000
E.S.Anavilhanas	350,018
Rio Branco (clear/white)	
E.S.Caracarai	400,560
E.S.Niquia	286,600
N.P.Monte Roraima (tributary)	116,000
E.S.Maraca (tributary)	101,312

Contd.

Table 12 contd.

Rio Uatuma	
B.R.Uatuma	560,000
Rio Nhamunda[4]	
None	
Rio Trombetas (clear)	
B.R.Rio Trombetas	385,000
Rio Jari (clear)	
E.S.Jari	227,116
Rio Araguari	
B.R.Lago Piratuba	357,000
Rio Cassipore	
N.P.Cabo Orange	619,000

[1] Also the Samuel State Reserve of 20,865 ha on the Rio Jamari, a right bank tributary of the Rio Madeira.
[2] Also the Mamiraua State Ecological Station of 1,124,000 ha between the Rio Japura and Rio Solimoes.
[3] Also the Araca State Park of 1,818,700 ha on the Rio Demini, a northern tributary of the Rio Negro.
[4] Nhamunda State Park (28,370 ha).

eutrophic lakes also occur there, which are important habitats for water birds. The fish fauna of these lakes is generally poor because of their temporary nature.

6. **Open shallow lakes.** These are floodplain or fluvial lakes, and involve a continuous or seasonal exchange of water with their rivers. They include ox-bow lakes, lateral levee lakes, lakes in abandoned channels and lakes in depressions formed by the uneven deposition of sediments during floods. They are subject to high water level fluctuations. Most Amazonian lakes are of this type (Junk, 1980). The limnology of floodplain lakes has been relatively well studied (see Junk, 1983a).

7. **Floodplains.** This refers to the aquatic phase of the inundated forest, both varzea and igapo, and differs only from lakes in that they are partly terrestrial. Junk (1980, 1983a) emphasizes their extreme importance, both in terms of their area, estimated to be more than 100,000 km^2 , and their significance, for example, for the fish fauna of the basin (Goulding, 1980). Adis (1984) and Junk (1980, 1984) provide the most recent reviews of the ecology of this aquatic/terrestrial system. As noted above, three reserves are of special significance for the protection of large floodplain areas, the Anavilhanas, Jutai-Solimoes and Mamiraua Ecological Stations.

8. **Swamps.** Swamps occur where the water table is permanently at or near the surface. They are common in Central Amazonia, along creeks and small rivers, and are often characterized by Mauritia palms. The Juami-Japura Ecological Station includes large expanses of Mauritia palm swamp forest.

9. **Permanent and temporary small water bodies.** These include small pools and phytotelmes which are widespread through the terra firme forest and most important as microhabitats for numerous animal species.

10. **Brackish coastal waters.** Junk (1983a) emphasizes that the coastal brackish waters of the Amazon delta, dominated by mangrove forests, are highly susceptible to changes in the hydrological and hydrochemical regime of the Rio Amazonas. The Amapa reserves are the only ones protecting this habitat.

11. **Artificial water bodies.** These include man-made lakes, fish ponds, rice paddies, and artificial pools and wastewater arising from road construction, for example. The large artificial lakes resulting from hydroelectric dams include, to date, Paredao (Amapa), Curua-Una (Para), Tucurui (Para), Balbina (Amazonas) and Samuel (Rondonia). The Uatuma Biological Reserve surrounds the Balbina reservoir, and the Samuel State Reserve includes part of the lake formed by the dam of the same name.

The preservation of aquatic ecosystems and their fauna and flora have to date been given little attention. The scheme of Wetterberg et al. (1976) was criticized by Junk (1979) for this reason. Junk argued that conservation units should be created to protect some part of all the major river systems in the basin, choosing areas where semi-aquatic and aquatic fauna are still reasonably abundant. Bayley and Petrere (in press) emphasized the importance of flooded forests, especially varzea, and discussed various options regarding the preservation and management of important commercial fish stocks, one of which is periodic prohibition of all but local fishing activities in each basin ("pulse fishing").

10. Phytogeographical Regions

The four principal attempts to establish the limits of phytogeographically distinct regions in the Amazon are reviewed by Daly and Prance (1988). All are based to a greater or lesser extent on the first of these, that of Ducke and Black (1953). Ducke and Black dealt with the distributions of more than 500 plant species and defined 10 regions (Fig.12). Rodrigues (1979) indexed the taxa used by Ducke and Black and updated the taxonomic nomenclature of some of the species. Specific criteria used by Ducke and Black included: 1) the presence of endemic families, genera and species; 2) physiognomy; 3) the presence of "characteristic" but not necessarily endemic species; 4) predominant vegetation and soil types and topography, soils and climate, especially rainfall patterns; 5) the existence of identifiable centres of diversity or endemism; and 6) distributional limits. They argued that it was not possible to establish subregions because of the paucity of collections from interfluves; uplands between navigable rivers. Since then, however, the construction of highways has to some extent remedied this dilemma, and more than 200,000 collections have been made since Ducke and Black's pioneer treatise (Daly and Prance 1988). Regarding groups with Amazonian centres of diversity, of special significance for identifying phytogeographic regions and subregions, Daly and Prance (1988) point out that species distributions are a primary tool and appeal to taxonomists to analyse distribution data with care, along the lines of the recent publications of Prance (1973) dealing with Caryocaraceae, Chrysobalancaeae, Dichapetalaceae and Lecythidaceae, and Gentry (1979) who analysed the phytogeographic implications of the distribution patterns of the Neotropical Bignoniaceae.

Further problems regarding the phytogeographic subdivision of Amazonia include the fact that there is little supra-specific endemism. In addition, species pairs occurring in Amazonia and the cerrado and between adjacent regions confuse the boundaries (Daly and Prance 1988).

Ten years after Ducke and Black, Rizzini (1963), using similar criteria, used Braun-Blanquet's (1932) system for defining phytogeographic units and came up with four subprovinces and, in one of them, five sectors (Fig.13). Hueck and Seibert (1981) produced what Daly and Prance (1988) considered to be one of the best vegetation maps for Amazonia, and Hueck (1966, 1972) revised the scheme of Ducke and Black (1953) using more recent field work and bibliography. The most recent revision is provided by Prance (1973, 1977), again building on the basic scheme of Ducke and Black (1953), but including revisions based on the (limited) distribution patterns of terra firme forest trees of four families (see above). He specifically ignored widespread species, gallery forest species and taxa restricted to rare and edaphically unusual habitats.

The phytogeographic regions of Ducke and Black (1953)

In their classic paper of 1953, Ducke and Black outlined the characteristic vegetation types of the Amazon, defining the area in terms of the distribution of the genus Hevea (Euphorbiaceae), the rubber trees. They divided the Amazon basin into 10 phytogeographical regions as follows (Fig.12):

Atlantic Sector. The estuary of the Rio Amazonas, including the Island of Marajo. This region comprises part of the alluvions of the seacoast, which are characterized by mangrove swamps and, inland, salty marshes with herbaceous vegetation and low campos, predominant on the eastern half of the Island of Marajo and coastal Amapa. The flora is extra-hylaean, being related to that of the entire South American coast. All other authors except Prance (1973, 1977) delimit a similar region. Hueck (1966) excluded the Guianas and northern coastal Amapa. Prance extended this region to the entire coastal area of the Guianas, Amapa and Para, extending well inland to the mouth of the Rio Jari and including the major part of the Rios Tocantins and Araguaia.

Northeastern Hylaea. This region includes the Guianas, north to the Rio Essequibo, and the Rios Jari, Paru de Oeste and Trombetas, north of the Rio Amazonas. The lowest courses of the rivers are subject to tidal influences and frequently contain mangrove swamps. According to Ducke and Black, the floristic composition of the terra firme forests

are remarkably homogeneous, and the Amazonas and Tocantins estuaries do not interrupt very similar floras from Maranhao to the Guianas. Having stated this, however, Ducke and Black insist that the two sides of the lower Amazonas are sufficiently distinct to warrant separation into the North-east and South-east regions. Prance (1973, 1977) did not separate them. The vegetation of the hilly North-east Region is very heterogeneous, high rain forest being substituted by what they refer to as summer-dry forests of lower tress, shrubland (campos cobertos) or more or less open campos with grasses and other herbs, resembling the cerrado of Central Brazil. The brazil nut tree, Bertholletia, reaches its northeastern limit. The northern margin of the lower Amazon (between the towns of Monte Alegre and Almeirim) characteristically contains hill campos; islands of deciduous forest which contain many possibly endemic species with a flora "foreign" to the true hylaean forests.

Southeastern Hylaea. This region includes the basin of the lower Tocantins and Araguaia, south as far as the undetermined limits of the distribution of Hevea. Very little was known of the flora of this region but Ducke and Black indicate that the flora may not be so rich in in species as it is in the Northeastern Hylaea, but may be rich in botanical novelties due to its being little explored. Bertholettia is abundant in this region. Both the Northeastern and Southeastern Hylaea mark the distributional limits of many species common throughout the Atlantic zone of the basin.

Northern Hylaea. This comprises the basin of the Rio Negro, excepting the upper Rio Branco and Rio Uraricoera, the basin of the upper Rio Orinoco, the upper reaches of the western tributaries of the Rio Trombetas and the basin of the Rio Japura-Caqueta. Ducke and Black indicate that this region is the richest in numbers of genera and species and endemism. Rainfall is very high the upper Rio Negro and Rio Uaupes have annual precipitation of up to 3,000 mm and are almost aseasonal. The trees are generally not so large,, the leaves are smaller and darker and the flowers frequently more showy than in other regions. Ducke and Black cite the forests along the rapids of the Rios Uaupes and Curicurari as typical in this respect, and provide numerous examples of species, genera and families which are characteristic of the region. The considerable variety of the flora of the Rio Negro basinis believed to be related to the variability of ecological conditions, greater than in any other part of the Hylaea. In the far north, high mountains and tepuis provide

a wide range of altitudinal variation in climate and soil, resulting in low montane forests, shrublands and savannas as well as high forests (see Steyermark 1986). The flora of the middle reaches of the Rio Japura-Caqueta is related to that of the upper Rio Negro, but containing many species of its own. The most characteristic vegetation type, however, for this region is the white sand forest, a continuum of forest types ranging from savanna-like shrubby vegetation with small trees (campina and caatinga baixa) to tall forest (campinarana and caatinga alta) (see section on vegetation types). These occur particularly along the middle and upper Rio Negro and such tributaries as the Icana, Uaupes and Curicuriari. Numerous small islands of campina also occur on the lower reaches of the Rio Negro basin. The only other locality cited by Ducke and Black where similar forests are known is in the region of Sao Paulo de Olivenca on the upper Solimoes near the Colombian border, although small patches or islands of campina, surrounded by the taller campinarana are quite numerous throughout the upper parts of the Amazon basin (Daly and Prance 1988; pers.obs.). Ducke and Black indicate that there are floristic differences between the caatinga of the upper basin and campina of the lower, notably in the absence of Rosaceae and epiphytic orchids in the former. These formations have no close affinity with any other type of forest, nor with the open shrubland and campos.

Southern Hylaea. This region includes the entire Tapajos basin and the majority of the Madeira basin, excepting its extreme south and the Andean south-west. It also includes the Rio Purus, up to the mouth of the Rio Acre, and the intervening southern tributaries of the Rio Solimoes as far west as the Rio Tefe. This region approaches the Northern Hylaea in species richness, especially on the middle reaches of the Rio Tapajos and a large number of plants are common to both. Several species widely distributed over the Eastern Hylaea reach their western limits in this region. Amongst the many characteristic species listed, Ducke and Black cite two trees which they indicate are very characteristic of the region, Physocalymma scaberrimum (Lythraceae) and Martusia elata (Leguminosae).

Flooded Forest (Varzea). The northern half of the Amazon basin is, except in the estuary, separated from the southern half by a broad belt of varzea or seasonally flooded forest, which has a flora which is less species rich and distinct from the terra firme forest. The varzea is more species rich in the upper Amazon than the lower reaches (below the mouth of the Rio Negro), but a large number of species occur

throughout this region. The eastern half of the varzea also contains large tracts of campos de varzea; open, seasonally flooded grasslands, where the rainfall is is less than in any other part of the Hylaea, with marked dry seasons and strong daily east winds. The varzea forests extend up a number of the Amazon tributaries. It is important to note that Ducke and Black did not distinguish varzea from igapo, the latter now being restricted to blackwater flooded forest, typically the Rio Negro, and the former to whitewater flooded forest, typically the Rio Amazonas-Solimoes (Prance 1979; see section on vegetation types).

Western Hylaea. An immense plain occupying both sides of the Rios Solimoes and Maranon (above the mouth of the Rio Huallaga), extending east as far as the Rios Tefe and Japura and as far west as the Andean foothills in Peru, and including the lower basin of the southern tributaries of the Solimoes, such as the Rios Javari and Jutai (neither of which have rapids). Little was known of this region. Ducke and Black affirm, however, that the flora of both sides of the lower Rio Amazonas is more akin to that of the middle reaches than that of the Western Hylaea, and there is no evidence of the upper part of the basin separating distinct floras as it does on the lower. In this region, the terra firme forests are not so easily distinguished in their floristic composition from the varzea as they are down river. The varzea includes many islands of higher, rarely flooded, restingas, where the typical varzea forest is mixed with variable numbers of terra firme species. In contrast to the eastern parts of the Hylaea, characterized by continuous upland interrupted only by forest streams, the terra firme of this region is a more undulating terrain where strips of upland alternate with depresson which are often marshy and floode by rain water. The most striking feature of the flora of this region, emphasized by Ducke and Black, is the abundance of Musaceae, Zingiberacaee and Marantaceae, typical of the terra firme forests and the restingas. Palms are extremely common, including very large tracts of buritizais, Mauritia sp., in the swampy depressions (pers.obs.), and the richness of the orchid flora is second only to that of the Northern Hylaea. This region is the distribution centre for Myristicacae. The brazil nut tree extends west in this region only as far as the Rio Jutai. Notable in this region, is the area of caatinga, similar to those of the Northern Hylaea, a sandy plateau rising 90 metres above the river, which extends southwest from the town of Sao Paulo de Olivenca.

Northwestern Hylaea. This comprises the upper courses of the Rios Caqueta, Uaupes, Icana, Guainia and Vichada. The flora of this region belongs entirely to Colmobia along with the partly mountainous transition zone of the middle Orinoco.

Southwestern Hylaea. This is represented by the State of Acre, encompassing the uppermost reaches of the Rios Purus, and Jurua and the Rio Acre, and includes a mixture of hylaean and extra-Amazonian elements in its flora. Notable is the abundance of rubber trees, Hevea, brazil nut trees, Bertholletia (except in the Jurua basin), and mahogany, Swietenia. This region is also characterized by bamboo forests.

Subandine Belt. This region belongs to Bolivia, Peru, Ecuador and Colombia and may extend into Brazil only along the Serra da Contamana (frontier of Brazil and Peru). The flora is a mixture of Andean, southern extra-Amazonian and Amazonian elements.

The phytogeographic regions of Rizzini (1963, 1979)

Rizzini (1963, 1977b) followed Braun-Blanquet's (1932) scheme of recognizing four phytogeographic units. Brazilian Amazonia lies within the Tropical American Region and the Amazon Hylaea is regarded as one of three distinct Brazilian Provinces, along with the Central Province and the Atlantic Province. Rizzini lists 16 genera which he refers to as notable for the Amazonian Province including Gnetum and Hevea which serve to delimit the area. The role of Hevea in this respect was also recognized by Ducke and Black (1953, see above). Within the Amazonian Province, Rizzini recognized four Sub-provinces: Upper Rio Branco, Jari-Trombetas, Tertiary Plain, and the Rio Negro. The Tertiary Plain was further divided into five sectors: Oceanic, South-east, South, West, and South-west/Acre (Fig.13). It is important to note that his scheme is limited to the Brazilian Amazon.

Amazonian Province (III). This is defined as the Amazon forest and the savannas of the upper Rio Branco in Roraima.

Upper Rio Branco Sub-province (IIIA). The non-forested portion of the upper Rio Branco. A mixed flora. This very restricted area was not separated out by any of the other authors, although Ducke and Black (1953) excluded it from their scheme.

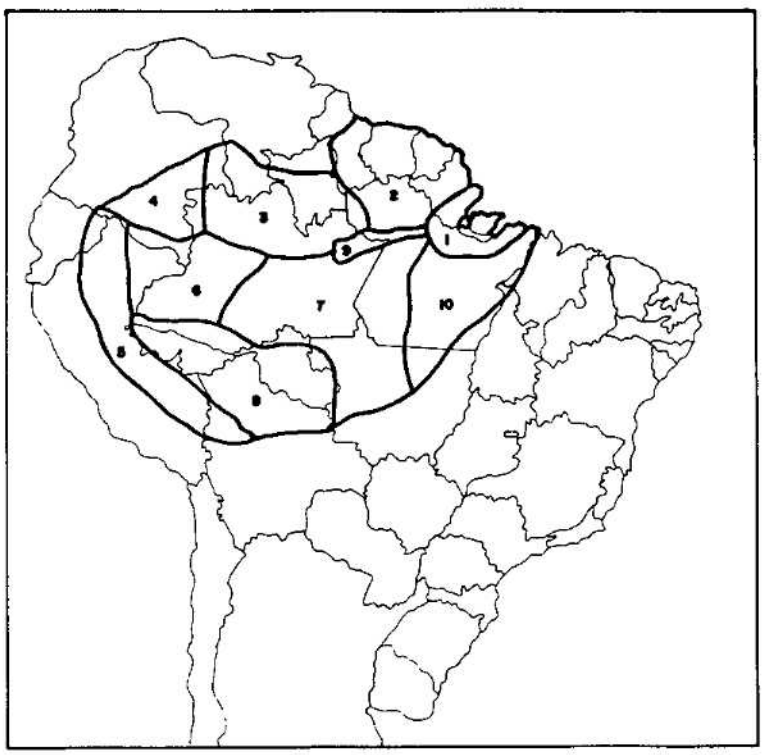

Figure 12. Phytogeographic Regions proposed by Ducke and Black (1953). 1 = Atlantic Sector; 2 = Northeastern Hylaea; 3 = Northern Hylaea; 4 = Northwestern Hylaea; 5 = Subandine Sector; 6 = Western Hylaea; 7 = Southern Hylaea; 8 = Southwestern Hylaea; 9 = Flooded forests; 10 = Southeastern Hylaea.

Jari-Trombetas Sub-province (IIIB). This is between the mouth of Rio Jari and extending east to the lowland coastal savanna region of Amapa and west to the middle reaches of the Rio Trombetas, north of the Rio Amazonas. It is a mountainous region on the crystalline rock formations of the Guayana shield. The vegetation is heteregeneous and includes semi-deciduous forest and cerrado. This sub-province corresponds roughly to the Northeastern Hylaea of Ducke and Black (1953), the North-east Sector of Hueck (1966) and the Jari-Trombetas Sector of Prance (1973, 1977).

Tertiary Plain Sub-province (IIIC). This includes the entire area south of the Rio Amazonas-Solimoes and Rio Japura. It is divided into five sectors, the delimitation of which is less distinct due to a relatively homogeneous vegetation and floristic composition.

Oceanic Sector (IIIC-1). The estuary region of the Rio Amazonas, extending north to along coastal and inland savannas of Amapa. This sector corresponds roughly to Ducke and Black's Atlantic Sector, and to Hueck's (1966) Amazon Delta, but both exclude the more northerly extension along the coast of Amapa. Prance (1973, 1977) on the other hand expanded this region to a wide belt extending north along the coast of Amapa and the Guianas to the Orinoco delta and extending south and east along the Para coast to the area of the Rio Guripi and the lower reaches of the Tocantins and Araguaia.

South-east Sector (IIIC-2). This sector takes in coastal Para to the south-east of the Amazon delta as far as the mouths of the Rios Guripi and Pindare, extending inland to the Rio Araguaia and Tocantins and the middle reaches of the Rio Xingu. It corresponds with the northern half of the Southeastern Hylaea of Ducke and Black (1953), and the Tocantins-Gurupi Sector of Hueck (1966) and the southern third of the Atlantic coastal region of Prance (1973, 1977). In the last two cases, however, the regions are limited to the Tocantins-Araguaia basin and do not extend west to the Rio Xingu.

South Sector (IIIC-3). The largest of the subdivisions, the South Sector takes in the entire southern part of the basin as far west the left bank of the Rio Purus, but exluding the state of Acre and of course excluding the previous two sectors. It covers the Southern Hylaea and the eastern part of the Southwestern Hylaea of Ducke and Black (1953); the mid-lower Xingu-Tapajos, the Madeira-Purus and the eastern half of the Acre, Beni, Mamore, Guapore

regions of Hueck (1966); and the Xingu-Madeira and the western half of the South-west Sector of Prance (1973, 1977).

West Sector (IIIC-4). The south of the Rio Japura, from its mouth, to the state border of Amazonas with Acre. This corresponds to the Western Hylaea of Ducke and Black (1953); the southern part of the West Sector and the northern part of the Acre, Beni, Mamore, Guapore regions of Hueck (1966); and the southern part of the Solimoes-Amazonas West nd the northern part of the South-west Sectors of Prance (1973, 1977).

South-west Sector (IIIC-5). The state of Acre, covered by: the Southwestern Hylaea of Ducke and Black (1953); the Acre, Beni, Mamore, Guapore region of Hueck (1966); and the South-west Sector of Prance (1973, 1977).

Rio Negro Subprovince (IIID). The basins of the Rio Negro, upper Rio Orinoco, the right banks of the Rios Japura and Solimoes, east as far the upper Rio Trombetas. This sub-rpvince is mostly on the crystaline rock of the Guayana Shield and includes most notably the white-sand forests, caatingas, which Rizzini describes as the vegetation type which is richest in endemism in the entire Hylaea. It corresponds roughly to: the Northern and Northwestern Hylaea of Ducke and Black (1953); the Guyana Venezuelanica and Western Guiana, the Northwest, and the Caqueta, Vaupes, Guainia regions of Hueck (1966); and the Manaus, Roraima and North-west Sectors of Prance (1973, 1977).

The phytogeographic regions of Hueck (1966, 1972)

Hueck (1966, 1972) divided the entire South American continent into phytogeographic regions. He divided the northern forests of the Amazonas and Orinoco basins into 14 regions. He defined tropical rain forests as those occurring under a rainfall regime of more than 1,800-2,000 mm per year, lacking in accentuated dry seasons and where the temperature is relatively constant at 25 to 28° C, with a minimum of 20-22° C. The Amazonian phytogeographic regions are based on those of Ducke and Black (1953) and are only described briefly here (Fig.14).

1.Rio Amazonas Delta. The estuary of the Rio Amazonas, lower Rio Tocantins, and smaller affluents flowing into the Marajo bay. It extends west to the mouths of the Rios Jari (to the north of the Rio Amazonas) and the Rio Xingu (to the south of the Rio Amazonas). The parts of the rivers

Figure 13. Phytogeographic Regions proposed by Rizzini (1963). 1 = Oceanic Sector, 2 = Jari-Trombetas, 3 = Alto Rio Branco Subprovince, 4 = Rio Negro Subprovince, 5 = West Sector, 6 = South-west Sector, 7 = South Sector, 8 = South-east Sector.

602

included in this region suffer influence from the daily tides and some have at least temporarily brackish water. The region is very flat or just slightly undulating, with large areas of campos, especially the eastern half of the Island of Marajo. Rainfall seasonality is not marked and there are no months with less than 100 mm. Principal vegetation types include: terra firme forest, swamp forest, mangrove forest, and campos.

2. North-east Amazonas. The southern part of the crystaline Guyana Shield, including the left bank of the Rio Amazonas, north to the Serra de Tumucumaque on the frontier with the Guianas and extending west as faras the Rio Trombetas basin. The coastal savanna region of Amapa is not included. In the east of the region, the rainfall regime is similar to that of the Amazonas Delta, but in the west it is drier, having less rainfall and more marked dry seasons. At Obidos, at the mouth of the Rio Trombetas, annual rainfall is reduced to 1,680 mm and monthly rainfall in August and September is as low as 23 to 28 mm. Like Ducke and Black (1953), Hueck emphasizes the heterogeneity of the vegetation. Tropical rain forest is interrupted by highly seasonal, low, dry forests, lowland and upland savannas, and seasonally flooded forests (igapo and varzea). Local soil variation is extremely important in determining these vegetation types (see, for example, Lescure and Boulet 1985). The region corresponds roughly to the southern half of the Northeastern Hylaea of Ducke and Black (1953), and to the Jari-Trombetas Sub-province and Region of Rizzini (1963) and Prance (1973, 1977), respectively.

3. Tocantins-Gurupi. This regon includes the mouth of the Rio Tocantins as far south as its confluence with the Rio Araguaia and west to the basin of the Rio Gurupi and the Rio Mearim in the state of Maranhao. The entire region marks the irregular transition between the Amazonian rain forest and the cerrado. The rain forest penetrates the cerrado in the form of extensive gallery forests. Climatic conditions are similar to those of the Amazonas Delta, but become drier in the east. Principal vegetation types include terra firme forest, varzea and igapo forests, campo cerrado with gallery forests in the south, and Hueck also makes mention upland campos or cangas in the region of the Serra dos Carajas. Hueck also points out the abundance of brazil nut trees and mahogany in this region. This region overlaps with the northern part of the Southeastern Hylaea of Ducke and Black (1953), the South-east Sector (Tertiary Plain Sub-province) of Rizzini (1963) and the southern most

section of the Atlantic Coastal Region of Prance (1973, 1977).

4. **Mid-lower Xingu and Tapajos.** This region comprises the major part of the basins of these two rivers. The region is poorly known. It corresponds to the southern half of a drier south-east to north-west belt extending diagonally across the basin and which also covers part of the Rio Trombetas (see North-east Amazonas Region) and into Roraima and part of the Guianas. The principal vegetation types include terra firme forest, cerrado incursions in the south and cerrado islands between the rivers, Amazonian savannas, and seasonally flooded forests (both the Tapajos and Xingu are clearwater rivers draining the Brazilian Shield). The region corresponds to the eastern parts of the Southern Hylaea of Ducke and Black (1953), the South Sector (Tertiary Plain Sub-province) of Rizzini (1963) and the Xingu-Madeira Region of Prance (1973, 1977).

5. **Madeira-Purus.** This region includes the basin of the Rio Medeira (except the Mamore-Guapore), and the middle and lower Rio Purus. The principal vegetation types include terra firme forest, varzea, and flooded and terra firme campos (especially in the regions of Humaita and Labrea between the Rios Madeira and Purus. The region is considered less rich in species than the Mid-lower Xingu and Tapajos, but many are common to both. It corresponds to the western part of the Southern Hylaea of Ducke and Black (1953), the northwestern part of the South Sector (Tertiary Plain Sub-province) of Rizzini (1963) and the western part of the Xingu-Madeira and the northeastern part of the South-west Regions of Prance (1973, 1977).

6. **Western Hylaea.** A slightly undulating plain, both sides of the Rio Solimoes from the mouths of the Rios Japura and Tefe, west to the Andean foothills. It includes the lower reaches of the Rios Jurua and Javari, besides the Maranon, Ucayali and Huallaga which form the Rio Amazonas-Solimoes. The rainfall is high in this region, always above 2000 mm, and the dry season is accentuated. The principal vegetation types include terra firme forest, varzea, igapo, and, in the region of Sao Paulo de Olivenca, white sand forest. The region corresponds to the Western Hylaea of Ducke and Black (1953), the West Sector (Tertiary Plain Sub-province) of Rizzini (1963) and the Solimoes-Amazonas West Region of Prance (1973, 1977).

7. **North-west Hylaea.** The Rio Negro basin (excluding the savannas of the upper Rio Branco) and the western part of

the Rio Trombetas basin, north of the Amazonas-Solimoes. The region is an immense plain, interrupted by granitic outcrops in the north part which forms the southern part of the Guiana Shield. In the upper Rio Negro, rainfall is extremely high (more than 3,000 mm per year) and there is no evident dry season. Hueck describes the white sand forests and also lists igapo, and terra firme rain forest, as characterizing the region. It corresponds to the Northern Hylaea of Ducke and Black (1953), the Rio Negro Sub-province of Rizzini (1963), and the Manaus Region, the southerly part of the Roraima Region, the northeastern tip of the Solimoes-Amazon West Region and the southeastern tip of the North-west Region of Prance (1973, 1977).

8. Varzea and Campos de Varzea of the Rio Amazonas and the lower Rio Madeira. These inundation formations form a strip along the Rio Amazonas from the Delta Region to the lower Rio Madeira. This region separates distinct floras south and north of the Rio Amazonas. The inundation area may reach up to 100 km in width, and even along the narrow reach near Santarem, the varzeas are 20 km wide. The sedimentation processes along this stretch of the Rio Amazonas result in the formation of numerous irregularly shaped islands which contrast with the lens shaped islands of the black waters, notably the Anavilhanas Archipelago. Only Ducke and Black (1953) included this formation as a separate region.

9. Acre, Beni, Mamore, Guapore. An undulating plain coveirng the nuumerous headwaters which give rise to the Rios Purus and Jurua, but excluding the uppermost reaches of the Rios Mamore and Guapore and the headwaters of other Rio Madeira affluents which arise in the Andean foothills (10). In the northern and western part of this region, the dry season is not marked but becomes more accentuated further south in the areas of the Rios Beni and Guapore. The principal vegetation types in this region include terra firme forest and flooded and dry savanna, including palm savanna, with the terra firme forest extending along the waterways as gallery forest. The region corresponds to the Southwestern Hylaea (although extending slightly further north) of Ducke and Black (1953) and the South-west Sector and the western part of the West Sector and South Sector (all of the Tertiary Plain Sub-province) of Rizzini (1963), and is entirely covered by the South-west Region of Prance (1973, 1977).

10. Andean Foothills. This region accompanies the eastern foothills and cordilleras of the Andes from Ecuador,

south through Peru and into northwest Bolivia. It does not extend in to Brazil. Rainfall in this region is very high and the principal vegetation type is tropical terra firme rain forest. This region corresponds to the Subandine Belt of Ducke and Black (1953), but is included as part of the South-west Region of Prance (1973, 1977). It was not considered by Rizzini (1963).

11. Caqueta, Vaupes, Guainia. This region has close affinities with the North-west Region of Rio Negro basin. It includes the upper reaches of such major rivers as the Caqueta, Vaupes, Icana, Guiania, Guaviare and Vichada, forming the Colombian Amazon. The principal vegetation types include terra firme rain forest, with some caatinga and black-water inundated forests (igapo). This region corresponds with the Northwestern Hylaea of Ducke and Black (1953) and the North-west Region of Prance (1973, 1977), although the latter extends rather further east.

12. Right bank affluents of the Rio Orinoco (Venezuelan Guiana). This includes the rain forests of the fluvial systems of the upper Rio Orinoco and the Rios Cassiquiare, Ventuari, Caura and Caroni. The terrain is generally weakly undulating but includes granitic and sandstone outcrops, the tafelbergs and tepui mountains of northernmost Brazil, the Guianas and south and south-east Venezuela. The terra firme forests of this region eventually grade into the llanos and gallery forests of Venezuela and include many savanna patches, Amazonian caatinga and, in the mountainous regions, submontane forests. Only the southernmost part of this region is included in the Northern Hylaea of Ducke and Black (1953). It covers the Upper Rio Branco Sub-province and the northern part of the Rio Negro Sub-province of Rizzini (1963) and the Roraima Region and the northeastern part of the North-west Region of Prance (1973, 1977).

13. Guyana, French Guiana and Suriname. The forests of this region are closely related to those of the Venezuelan Guiana (12), although it is notable that all four schemes separate them. The region is mountainous, with heavy annual rainfall and short but distinct, and in some twice-yearly , dry seasons. In that it includes the coasts, the typical vegetation types include coastal savanna and mangrove forests and swamps, as well as terra firme tropical rainforest and upland savannas and submontane forests. Hueck describes eight vegetation types identified by Davis and Richards (1933-1934) from the Rio Essequibo valley in Guyana. This region includes the northern part of the Northeastern Hylaea of Ducke and Black (1953) and the

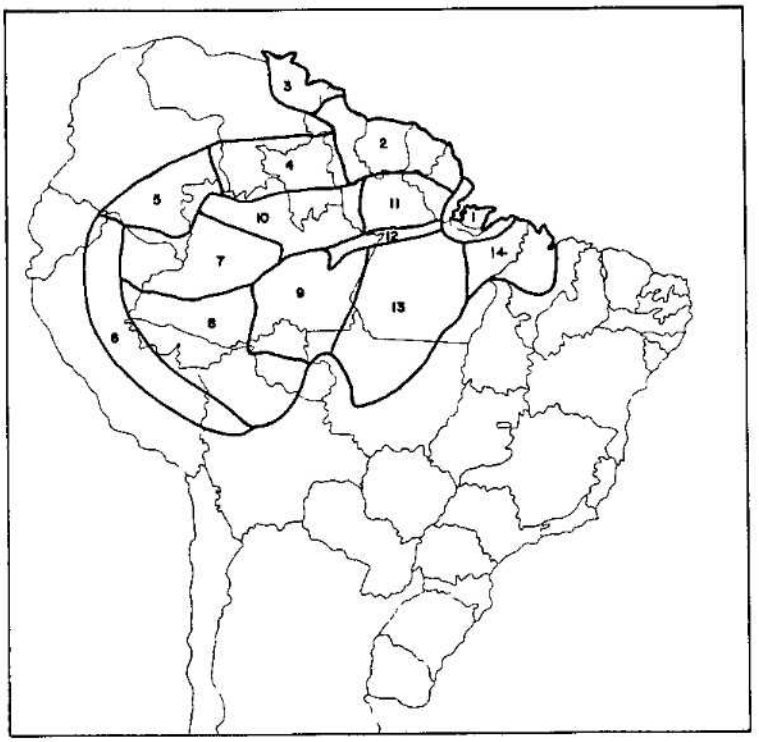

Figure 14. Phytogeographic Regions proposed by Hueck (1966). 1 = Amazon Delta; 2 = Guiana, French Guiana, Suriname, 3 = Orinoco Delta; 4 = Guiana Venzuelanica, western Guyana; 5 = Caqueta, Vaupes, Guainia; 6 = Andean foothills; 7 = West Sector; 8 = Acre, Beni, Mamore, Guapore; 9 = Madeira-Purus; 10 = North-west Sector; 11 = North-east Sector; 12 = Varzeas; 13 = Mid-lower Xingu-Tapajos; 14 = Tocantins-Gurupi.

northern part of the Jari-Trombetas Region with the Guiana section of the Atlantic Coastal Region of Prance (1973, 1977). Rizzini's (1963) treatment was restricted to the Brazilian Amazon.

14. Orinoco Delta. This is equivalent to the Amazonas Delta Region, with extensive savanna and mangrove forests. Hueck identifies two ecologically distinct areas: the north part which is geologically older and with islands containing savanna, and the south and east part of the delta which is more recent and still in formation. To the north of the region, tropical and extensively swampy rain forests, with wet and dry savannas. To the south of the delta are low swamp forests and on the coastal areas, mangroves. Ducke and Black (1953) and Rizzini (1963, 1979b) did not extend their consideration to this region, but Prance (1973, 1977) found no reason to separate it from the Atlantic Coastal Region which takes in the entire coast from the Orinoco to the Rio Gurupi in the state of Maranhao.

The Phytogeographic Regions of Prance (1973, 1977).

Following the somewhat complex divisions of both Ducke and Black (1953) and especially Hueck (1966, 1972), Prance (1977) provided a simplified system of seven major regions, one with two subregions (Fig.15). These regions were identified by detailed studies of the distribution patterns of five families of terra firme forest trees:

1. Chrysobalanaceae. This family has its distribution centre in Amazonia. Particular attention was given to the genera Licania (160 species, with 75 in Amazonia) and Couepia (58 species, with 29 in Amazonia).
2. Caryocaraceae. A small, predominantly Amazonian, family 23 species of two genera.
3. Dichapetalaceae. Two of three genera of this family occur in Amazonia. Tapura has 17 American species, 10 of which occur in Amazonia. Dichapetalum has 15 American species with eight in Amazonia.
4. Connaraceae. A pantropical family. Prance (1977) used the data of Forero (1976).
5. Lecythidaceae. This family has its distribution centre in Amazonia and is extremely well represented in the Amazonian terra firme forests. Prance et al. (1976) found 74 trees of this family in one hectare of forest near to Manaus, representing 21% of the total of 350 trees surveyed (with 15 cm or more DBH).

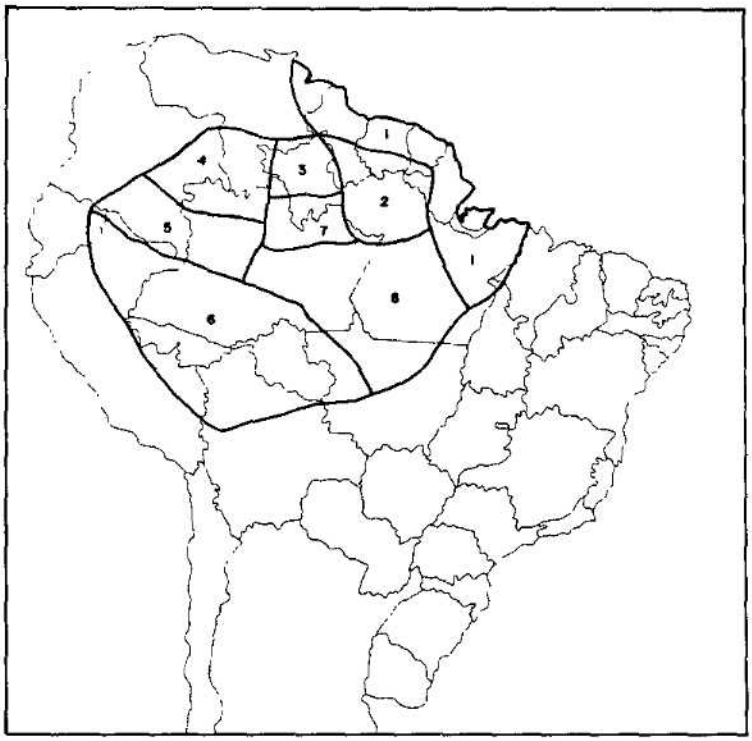

Figure 15. Phytogeographic regions proposed by (Prance 1973). 1 = Atlantic Coastal; 2 = Jari-Trombetas; 3 = Roraima; 4 = North-west Sector; 5 = Solimoes-Amazon West; 6 = South-west Sector; 7 = Manaus; 8 = Xingu-Madeira.

The phytogeographical regions which Prance identified, based on Ducke and Black (1953) and his findings regarding the distributions of members of these families, are summarized in his 1977 paper as follows:

1. Atlantic Coastal Region. From the Orinoco delta, south through the northern halves of the Guianas to the eastern limits of Amazonia in the state of Maranhao and (south of the Rio Amazonas), west to the Rio Xingu.

2. Jari-Trombetas Region. Bordered by the Rio Jari to the east, the boundary of the states of Amazonas and Para to the west, and the Rio Amazonas to the south. This region was also identified by Ducke and Black (1953) and Rizzini (1963, 1979b). It is hilly and contains savannas and savanna forests with a high degree of endemism.

3. Xingu-Madeira Region. The south of the Rio Amazonas-Solimoes, west as far as the Rio Tefe and the basin of the Rio Purus (south to the town of Labrea), limited to the south by the cerrado of central Brazil, and in the east by the Rio Xingu.

4. Roraima-Manaus Region. This region is subdivided to distinguish the savannas of Roraima that extend into Guyana, and to distinguish the break division between the ancient Guiana Shield (Roraima) of the upper Rio Negro and the Tertiary sediments of the lower basin (Manaus).

a. Roraima. The forest bordering the savannas is different from that further south (Manaus), though the two sub-regions have many species in common.

b. Manaus. An area of high endemism, taking in the lower Rio Negro, east to the western limits of the Rio Trombetas basin.

5. North-west, Upper Rio Negro Region. The basin of the Rio Negro, west of the town of Barcelos to the limits of Amazonia in Colombia and Venezuela.

6. Solimoes-Amazonas West Region. The basins of the Rios Solimoes, Japura-Caqueta and Ica-Putumayo.

7. South-west Region. The Rio Amazonas of Peru, west to the Andes, the upper reaches of the Rios Purus and Jurua, the state of Acre and the state of Rondonia, east to the Rios Roosevelt and Aripuana (tributaries of the Rio Madeira).

Table 13. Occurrence of National Parks (N.P.), Biological Reserves (B.R.), Ecological Stations (E.S.) and Ecological Reserves (E.R.) in the Phytogeographic Regions of Prance (1973).

Phytogeographic Region	Area (ha)
1. Atlantic coastal	
N.P.Cabo Orange	619,000
B.R.Lago Piratuba	395,000
E.S.Maraca-Jipioca	72,000
Total 3	1,086,000
2. Jari-Trombetas	
B.R.Trombetas	385,000
E.S.Jari	227,116
Total 2	612,116
3. Xingu-Madeira	
N.P.Amazonia	994,000
B.R.Tapirape	103,000
B.R.Abufari	288,000
Total 3	1,385,000
4a.Roraima	
N.P.Monte Roraima	116,000
E.S.Maraca	101,312
E.S.Caracarai	400,560
E.S.Niquia	286,600
Total 4	904,472
4b.Manaus	
N.P.Jau	2,272,000
B.R.Uatuma	560,000
E.S.Anavilhanas	350,012
E.R.Sauim-Castanheira	109
Total 4	3,182,121
5. North-west sector	
N.P.Pico da Neblina	2,200,000
Total 1	2,200,000

Cont.

Table 13 contd.

6. Solimoes-Amazonas	
E.S.Juami-Japura	745,830
E.R.Jutai-Solimoes	284,285
Total 4	**1,030,115**
7. South-west sector	
N.P.Pacaas Novos	605,000
N.P.Serra do Divisor	700,000
B.R.Guapore	600,000
B.R.Jaru	268,150
E.S.Rio Acre	77,500
E.S.Cunia	104,000
E.S.Ique	200,000
Total 7	**2,554,650**

The following reserves lie outside the phytogeographical regions defined by Prance (1973): N.P.Araguaia, B.R.Gurupi and E.S.Coco-Javaes.

Summary: Comparison of the Phytogeographical Regions

As stated above, the schemes of Rizzini, Hueck and Prance are based on the first major thesis of Ducke and Black (1953, 1954). Both Rizzini and Hueck were "splitters" regarding their modifications whereas Prance was a "lumper". However it is possible to point out a number of regions which, although changing somewhat in their exact boundaries, are basically common to all four systems. The Amazonas Delta is clearly distinct, but Prance extended the region to the entire Atlantic/Amazon coastal area. The Jari-Trombetas region is unanimously defined, as is the Rio Negro, with all authors, except Ducke and Black, identifying a separation of the floras of the northern and southern halves of the Rio Negro. The upper part of the Amazon basin is divided into at least three major regions in all four systems; these being the North-west Region, Solimoes-Amazonas West Region and part of the South-west Region of Prance. Prance did not, however, recognize the Andean belt of Ducke and Black and Hueck as separate from the rest of the upper and south-west parts of the basin. The Tertiary Plain Sub-province of Rizzini is perhaps the most disputed, although all authors seprated the eastern region encompassing the lower Tocantins/Araguaia and Gurupi in Maranhao, and there is a consistent recognition of the Southwestern Hylaea of Ducke and Black, a region of tertiary sediments, as separate from the Xingu Complex of crystaline rocks of the Brazilian Highlands which enter the basin from the south principally in the north of the state of Mato Grosso, the state of Rondonia and the south of the state of Para, up to the Tocantins/Araguaia confluence. In addition, all four systems recognize the importance of the lower Amazonas as a phytogeographical limit, but not the upper reaches of the river. Daly and Prance (1988) indicate that this may be because of higher sea levels in the past which significantly increased the width of the river in the lower reaches but not in the upper reaches. Under any circumstances, rivers are important barriers to dispersal and are evidently important in delimiting the phytogeographical regions. Daly and Prance (1988) indicate that this may be because less collections have been carried out in interfluves, but also because of barriers to dispersal and because of the chemical differences between rivers, resulting from their geologically distinct drainage basins.

Daly and Prance (1988) conclude that edaphic and climatic factors affect vegetation types more than they do phytogeograhic regions. Some regions have characteristic vegetation types (for example, the white sand forests of the Rio Negro basin, and the <u>varzea</u> regions of Ducke and Black

and Hueck), but none are exclusive to one region. Although Benson (1982) argues that existing edaphic factors are important to explain centres of endemism and speciation processes in the Amazon, an important historical factor is that of the cool, dry glacial periods of the Pleistocene which resulted in contractions of the Amazonian forests into islands surrounded by non-forest (probably largely savanna) vegetation. This is considered below.

11.Centres of Endemism and Pleistocene Refuges

Biogeographical research on plants (Prance 1973, 1977, 1982b, 1987), butterflies (Brown 1975, 1977a, 1977b, 1982a, 1982b, 1987a), and birds (Haffer 1969, 1987) has demonstrated the existence of numerous centres of endemism within the Brazilian Amazonian rain forest. These centres of endemism are believed by these authors to have resulted from changes in climate and the vegetational cover during the Pleistocene and early Holocene, which resulted in a fragmentation of the forest into islands in open vegetation, thorn scrub or poor transition forest (for review see Prance 1982a; 1985; Whitmore and Prance 1987). This explanation is somewhat controversial (Endler 1982; Connor 1986; see also Brown 1987b), and Nelson et al. (1990) argued that, at least for plants, the geography of collecting localities might be influencing the identification of endemism centres. Nelson et al. showed that a considerable number of species are rare and liable to be recorded only in sites where prolonged and intensive collections are made. He sites the example of the collection of Chrysobalanaceae (one of the families used for the identification of the plant refuge areas) at the herbarium of the National Institute for Amazon Research (INPA). Of 1,971 specimens of 156 species, 32 (20.5%) were collected only once and 105 (67%) were collected less than 10 times. Nelson et al. also analysed the distribution and intensity of collecting of Inga spp. and found that, of the seven plant refuges located entirely within Brazil, only that of Sao Paulo de Olivenca was not associated with what he refers to as a "collecting island". Alternative explanations for unequal distributions and "centres of endemism" include edaphic factors and parapatric speciation processes (Benson 1982; Nelson et al. 1990). Whatever the reason for the "centres of endemism", it would seem that areas of high numbers of local and restricted species are a most important guide for the siting of conservation units (Brown 1987b).

Prance (1973, 1985) identified 14 forest refugia in Amazonia, on the basis of the distribution of four woody, predominantly rain forest families: Caryocaraceae,

Table 14. The occurrence of Brazilian National Parks (N.P.), Biological Reserves (B.R.), and Ecological Stations (E.S.) and Reserves (E.R) in the 10 Pleistocene forest identified by Prance (1973, 1982b).

Forest refuges	Area (ha)
11. East Guiana	
None	
12. Imeri	
N.P.Pico da Neblina	2,200,000
14. Sao Paulo de Olivenca	
None	
15. Tefe	
E.R.Jutai-Solimoes	284,285
16. Manaus	
B.R.Uatuma	560,000
E.S.Anavilhanas	350,018
E.R.Sauim-Castanheiras	109
17. Trombetas	
B.R.Rio Trombetas	385,000
18. Belem-Gurupi	
B.R.Gurupi	341,650
B.R.Tapirape	103,000
19. Tapajos	
None	
20. Aripuana	
B.R.Jaru	268,150
21. East Peru/Acre	
N.P.Serra do Divisor	605,000
E.S.Rio Acre	77,500

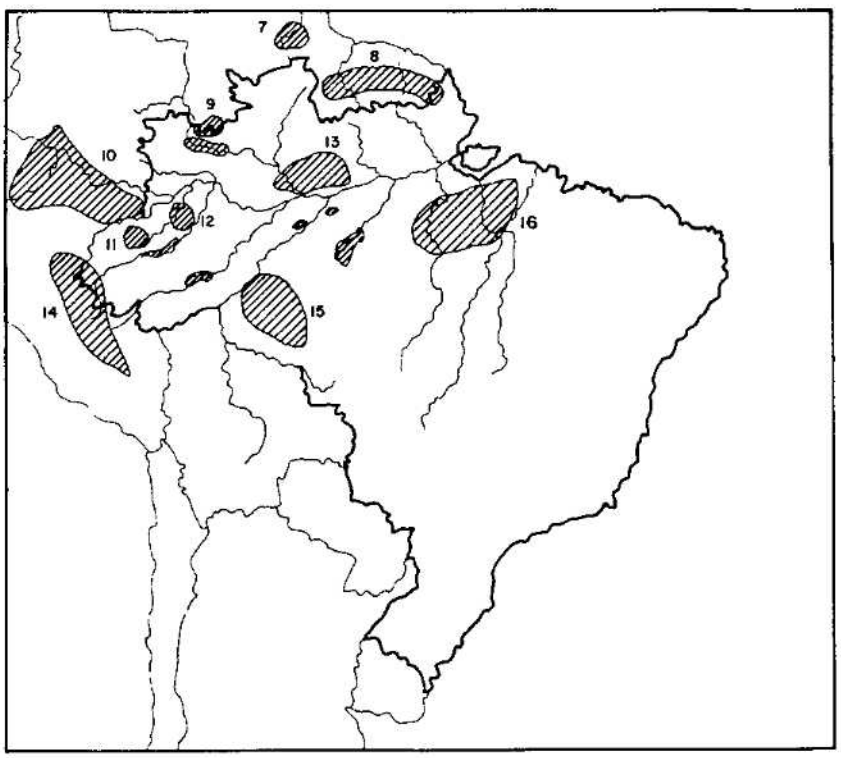

Figure 16. Pleistocene forest refuges for plants (Prance 1973). 7 = Imataca; 8 = Guiana; 9 = Imeri; 10 = Napo; 11 = Olivenca; 12 = Tefe; 13 = Manaus; 14 = East Peru; 15 = Rondonia-Aripuana; 16 = Belem-Xingu. Numbering follows Prance (1973).

Table 15. The occurrence of Brazilian National Parks (N.P.), Biological Reserves (B.R.), Ecological Stations and (E.S.) and Reserves (E.R) in 16 centres of endemism identified for butterflies in Brazilian Amazonia by Brown (1982, 1987b).

		Area (ha)
Be.	Belem centre	
	B.R.Gurupi	341,650
Mj.	Marajo centre	
	None	
Oy.	Oyapock centre	
	N.P.Cabo Orange	619,000
	B.R.Lago Piratuba	357,000
MG/JT.	Manaus/Guiana, Jari-Trombetas centre	
	B.R.Rio Trombetas	385,000
	B.R.Uatuma	560,000
	E.S.Anavilhanas	350,018
	E.S.Jari	227,116
	E.R.Sauim-Castanheiras	109
Ro.	Roraima centre	
	E.S.Maraca	101,312
	E.S.Caracarai	400,560
	E.S.Niquia	286,600
Pn.	Pantepui centre	
	None	
Ir.	Imeri centre	
	N.P.Pico da Neblina	2,200,000
Lo.	Loreto centre	
	None	
Tf.	Tefe centre	
	E.S.Juami-Japura	745,830
	E.S.Mamiraua	215,000
U.	Ucayali centre	
	N.P.Serra do Divisor	605,000
In.	Inambari centre	
	E.S.Rio Acre	77,500
Md.	Madeira centre	
	R.B.Abufari	288,000
Ro.	Rondonia centre	
	P.N.Pacaas Novos (part)	764,801
	R.B.Guapore (part)	600,000
	R.B.Jaru	268,150
	E.S.Ique	200,000

Contd.

Table 15 contd.

Gp.	Guapore centre	
	P.N.Pacaas Novos (part)	764,801
	R.B.Guapore (part)	600,000
Tp.	Tapajos centre	
	N.P.Amazonia	994,000
Ar.	Araguaia centre	
	N.P.Araguaia	563,312
	E.S.Coco-Javaes	37,000

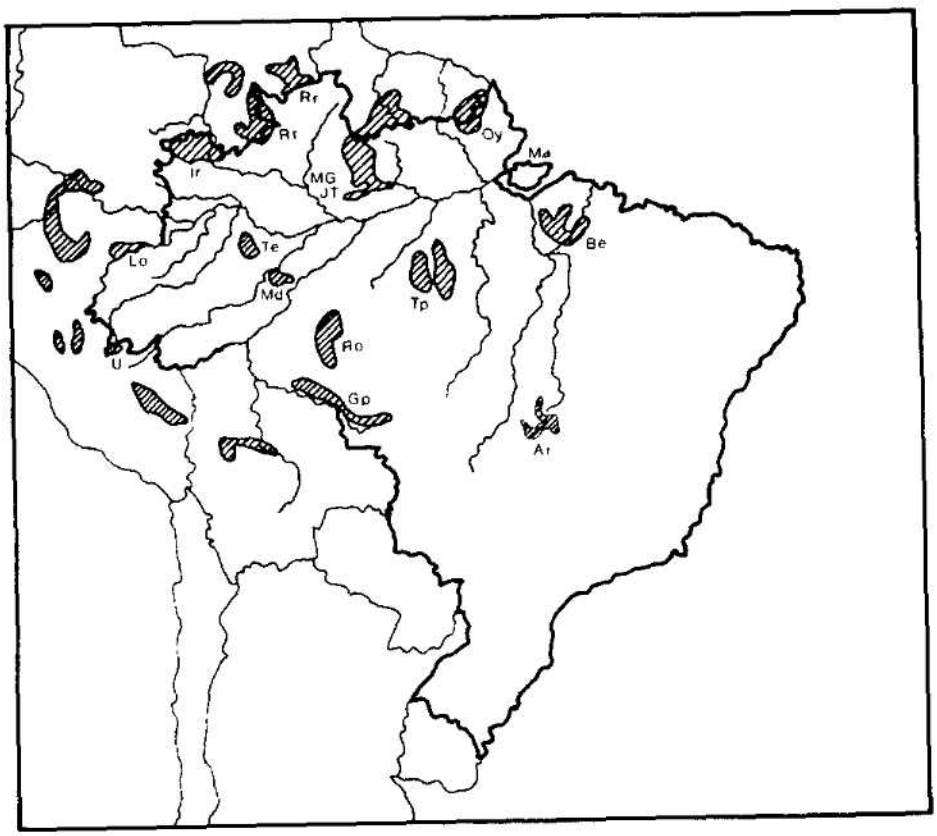

Figure 17. Pleistocene forest refuges for butterflies (Brown 1977b). Ma = Marajo; Oy = Oyapock; MG = Manaus-Guiana; JT = Jari-Trombetas; Rr = Roraima; Ir = Imeri; Lo = Loreto; U = Ucayali; Te = Tefe; Md = Madeira; Ro = Rondonia; Gp = Guapore; Ar = Araguaia; Tp = Tapajos; Be = Belem.

Table 16. The occurrence of National Parks (N.P.), Biological Reserves (B.R.), and Ecological Stations (E.S.) and Reserves (E.R.) in the 17 Pleistocene refuge areas identified by Haffer (1969) in Brazilian Amazonia .

Refuge Area	Area (ha)
4. Imeri	
N.P.Pico da Neblina	2,200,000
6. East Peruvian	
N.P.Serra do Divisor	605,000
7. Madeira-Tapajos Refuge	
None	
8. Belem	
B.R.Gurupi	341,650
9. Guiana	
None	
Unnamed (west of lower Rio Negro)	
N.P.Jau	2,272,000
Unnamed (mouth of Rio Ica)	
E.R.Jutai-Solimoes	284,285
Unnamed (Sao Paulo de Olivenca/Tabatinga)	
None	
Unnamed (upper Rio Jutai)	
None	
Unnamed (middle Rio Jurua)	
None	
Unnamed (middle Rio Purus)	
None	
Unnamed (middle Rio Xingu)	
None	
Unnamed (lower Rio Xingu)	
None	

[1] Haffer (1969) named only nine forest refuges. Those listed here as unnamed are described by him as additional smaller forest refuges along the major river courses, on the slopes of isolated mountains and in extensive lowlands between the upper Rio Madeira and the Rio Maranon.

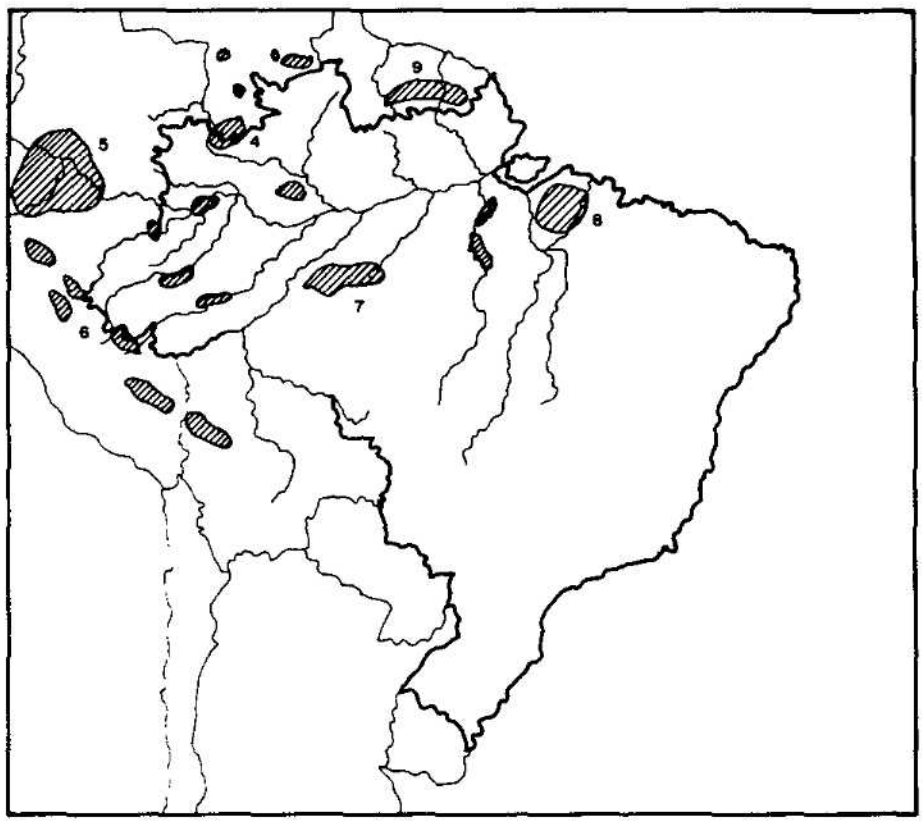

Figure 18. Pleistocene forest refuges for birds (Haffer 1969). 4 = Imeri; 5 = Napo; 6 = East Peruvian; 7 = Madeira-Tapajos; 8 = Belem. Numbering follows Haffer (1969).

Table 17. The occurrence of Brazilian National Parks (N.P.), Biological Reserves (B.R.) and Ecological Stations (E.S.) and Reserves (E.R.) in the 30 priority refuge areas identified by Wetterberg et al. (1976).

	Area (ha)
1. Bacia do Capim	
None	
2. Oiapoque	
None	
3. Cabo Orange	
N.P.Cabo Orange	619,000
4. Cabo Norte	
B.R.Lago Piratuba	357,000
5. Maraba	
None	
6. Guiana	
None	
7. Ponta do Flechal	
None	
8. Altamira	
None	
9. Caxinduba	
None	
10. Alto Xingu	
None	
11. Jau	
P.N.Jau	2,272,000
12. Jatapu	
B.R. Rio Trombetas	385,000
13. Pico da Neblina	
N.P.Pico da Neblina (part)	2,200,000
14. Cuxiauia	
N.P.Pico da Nelbina (part)	2,200,000
15. Cutuiaia	
E.R.Jutai-Solimoes	284,285
16. Loreto	
None	
18. Panaua[1]	
None	

Contd.

Table 17 contd.

20. Javari	
None	
22. Serra do Divisor	
P.N.Serra do Divisor[2]	605,000
23. Ucayali	
None	
26. Eirunepe	
None	
27. Purus	
None	
28. Marmelos	
None	
29. Serra das Oncas	
None	
30. Parecis	
P.N.Pacaas Novos (part)	764,801
R.B.Guapore	600,000
Total (9 reserves)	**8,087,086**

The following priority areas recommended by Wetterberg et al. (1976) do not lie within Brazilian Territory: Napo do Norte (17), Napo do Sul (19), Huallaga (21), Inambari (24), and Yungas (25). The following priority areas were placed outside of Brazil by Wetterberg et al. (1976) but, being on the Brazilian border, it is presumed that their influence extends into Brazil and they are included in this analysis: Loreto (16), Javari (20), Serra do Divisor (22), and Ucayali (23).

[1] The Mamiraua State Ecological Station decreed in 1990 (1,124,000 ha) covers this refuge.

[2] The description of this refuge provided by Wetterberg et al. (1976) includes the Brazilian part of the Serra do Divisor.

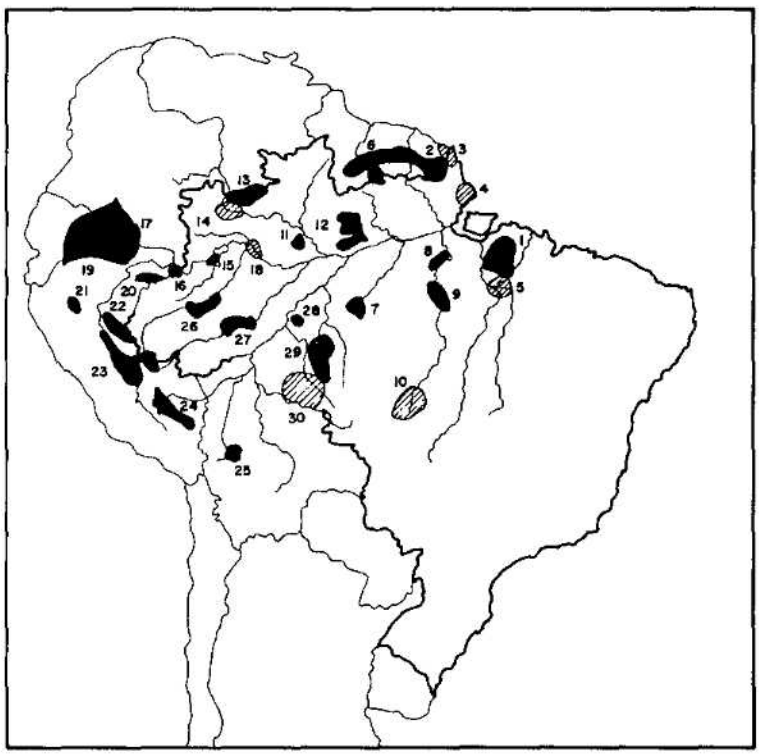

Figure 19. Priority areas for conservation in Amazonia proposed Wetterberg et al. (1976). 1 = Bacia do Capim; 2 = Oiapoque; 3 = Cabo Orange; 4 = Cabo Norte; 5 = Maraba; 6 = Guiana; 7 = Ponta do Flechal; 8 = Altamira; 9 = Caxinduba; 10 = Alto Xingu; 11 = Jau; 12 = Jatapu; 13 = Pico da Neblina; 14 = Cuxiauia; 15 = Cutiuaia; 16 = Loreto; 17 = Norte Napo; 18 = Panaua; 19 = Napo do Sul; 20 = Javari; 21 = Huallaga; 22 = Serra do Divisor; 23 = Ucayali; 24 = Inambari; 25 = Yungas; 26 = Eirunepe; 27 = Purus; 28 = Marmelos; 29 = Serra das Oncas; 30 = Parecis. Numbering follows Wetterberg et al. (1976).

Chrysobalanacae, Dichapetalaceae and Lecythidaceae. Ten of these are within Brazil , seven of which contain reserves (Table 14, Fig.16). Brown (1987a) dealt with two groups of nymphalid butterflies: Heliconiini and Ithomiinae and identified 16 centres of endemism for the region, 13 of which contain reserves (Table 15, Fig.17). Haffer (1969) proposed 13 refuge areas in the Brazilian Amazon based on the distribution and speciation patterns of a number of bird species groups, including Rhamphastidae, Cracidae and Cotingidae, amongst others (Fig.18). Only five of these contain reserves (Table 16). The early papers of these authors were used by Wetterberg et al. (1976) as the basis for their recommendations for the siting of new conservation units in Amazonia (Fig.19). Wetterberg et al. identified 30 priority areas, only nine of which contain federal conservation units (Table 17). The recently decreed Mamiraua State Ecological Station (1,124,000 ha) covers a tenth priority area identified by Wetterberg et al. (1976) - the Panaua refuge.

12.Zoogeographic Regions

The current state of knowledge of the biogeography of the Amazon basin is reviewed by Brown (1987b). Brown emphasizes that neotropical biogeography is still in its infancy, with scanty information as yet available on distributions, biosystematics, ecological interactions and evolutionary trends of both plants and animals. Space does not allow for a full analysis of species' distributions in relation to the Brazilian Amazon parks system which will, therefore, be restricted to recent reviews of certain groups for which faunistic regions, distributions, or centres of endemism have been identified. These are: fish (faunistic regions), Gery 1984; anurans (rain forest units), Lynch 1979, modified by Duellman 1982; turtles (distributions), Iverson 1986; birds (areas of endemism), Cracraft 1985; and primates (zoogeographical regions), Rylands and Bernardes in press).

12.1 Faunistic Regions for Fish

Gery (1984) reviewed the geographic distributions of fish in South America, with emphasis on the Amazonian fauna and its endemism. He provided a tentative sub-division of Amazonia, identifying five regions, on the basis of more or less distinct groupings of genera and species. The limits to regions are not mapped and are defined rather vaguely as follows:

1. **Lower Amazon.** The northern part of the state of Para, with the western limits near Obidos and Santarem. The region has affinities with the Upper Amazon, and is also

influenced by the Guiana region (northern) and Central Amazon.

2. **Central Amazon.** The section of the Rio Amazonas-Solimoes from Santarem to the Rio Ica. West of this, the fauna changes gradually to that of the upper Amazon.

3. **Upper Amazon.** The largest region, including the Rios Maranon and Ucayali and all of the eastern Andean tributaries. An apparantly extremely rich fauna, because of the numerous biotopes, but evidently quite homogeneous within the region. Affinities with the lower Amazon.

4. **Northern region.** Can be divided into two sub-regions: eastern, influenced by the eastern Guianas; and the Rio Negro-Orinoco, influenced by Guyana (via the Rio Branco).

5. **Southern region.** Can be divided into two sub-regions: western, including the Rio Madeira basin (affinities with the Upper Amazon); and an eastern part, coinciding with the Brazilian Shield (affinities with the Guianas).

The distribution of reserves in these faunistic regions are shown in Table 18.

12.2 Rain Forest Units for Anurans

Duellman (1982) analysed the frog faunas of one of the four South American lowland tropical forest regions of Lynch (1979); the Central Cis-Andean region, of Amazonia and the Guianas. Lynch (1979) identified 202 species in the region, 182 (90%) of which are endemic. Duellman (1982) found that frogs were unevenly distributed in the Amazon, and divided the Central Cis-Andean region into seven subregions or rain forest units. These are shown in Figure 20. High species richness and endemism are especially pronounced in the western part of the basin and the Guianan region. Table 19 lists the reserves occurring in each of these rain forest units.

12.3 Distributions of Turtles

Turtles have been included in this analysis because of their commercial importance and the need to protect turtle nesting beaches (see Mittermeier 1978; Smith 1979; Alho 1985). Alho (1985) and Mittermeier (1978) reported that the most heavily exploited species are Podocnemis expansa, P.unifilis and Kinosternon scorpiodes (in Para), but all Podocnemis species are exploited to some degree. Iverson (1986) analysed the known distributional data for Amazonian turtles.

Table 20 lists the reserves within the known distributions of 12 turtle species. Alfinito (1978)

catalogued the major turtle nesting beaches over a large area of the basin, and those within or nearby parks and reserves are shown in Table 21. Certain reserves are notable for their protection of turtle nesting beaches, particularly for Podocnemis expansa; the Amazonia National Park, and the Abufari, Rio Trombetas, Lago Piratuba and Guapore Biological Reserves. However, the most significant nesting beaches identified for P.expansa by Alfinito are found in the following rivers: Purus, Jurua, Guapore, Branco, Tapajos, Xingu and Trombetas (see also Alho, 1985) and the large majority remain unprotected.

12.4 Areas of Endemism for Birds

Cracraft (1985) postulated 33 areas of endemism for the South American avifauna, nine of which cover the Brazilian Amazon (Table 21, Fig.22). The areas of endemism are regions defined by distributional congruence of constituent taxa. Cracraft proposed that the pre-Pleistocene physiographic evolution of South America was probably as important as the refuges proposed by Haffer (1969, 1987) in determining the geographical patterns of endemism.

12.5 Zoogeographical Regions for Primates

Rylands and Bernardes (in press) divided Amazonia into three major regions defined by the Rio Solimoes-Amazonas, the Rio Negro and the Rio Madeira (Fig.22). This division was recognized by Wallace (1853b) and is useful in defining three major groupings of primate species and subspecies (see also Ayres and Best 1979; Ayres 1986). The richest area for primate species is the upper Amazon, which has the fewest reserves, and, excluding the Jau National Park of 2,200,000 ha, has the most inadequate coverage in terms of area. Two reserves, the Amazonia National Park and the Abufari Biological Reserve, have high numbers of species and subspecies within their boundaries because they cover both sides of rivers which delimit the primate distributions. Rylands and Bernardes (in press) identified two important areas for the siting new reserves and parks. They are the entire upper Amazon, especially from the Rio Japura south to the Rio Madeira, and the lower reaches of the southern affluents of the Rio Amazonas, east of the Rio Madeira. The primates occurring in the federal parks and reserves are listed in Table 23. Nineteen subspecies of primates do not occur any of the federal conservation units or the Mamiraua State Ecological Station (Table 24). Seven of these are on the I988 IUCN Red Data List and the Brazilian List of Threatened Species, and twelve are endemic to the Brazilian Amazon, including all those in Region 3.

Table 18. The occurrence of Brazilian National Parks (N.P.), Biological Reserves (B.R.), and Ecological Stations (E.S.) and Reserves (E.R.) in the five Amazonian faunistic regions for fish (Gery 1984).

Faunistic Region	Area (ha)
1. Lower Amazon	
N.P.Amazonia (transition with Central Amazon)	994,000
B.R.Rio Trombetas	385,000
B.R.Tapirape	103,000
E.S.Jari	227,116
2. Central Amazon	
N.P.Amazonia (transition with Lower Amazon)	994,000
B.R.Uatuma	560,000
E.S.Anavilhanas (transition with Rio Negro-Orinoco subregion)	350,018
E.S.Juami-Japura	745,830
E.R.Jutai-Solimoes (transition with Upper Amazon)	245,285
E.R.Sauim-Castanheiras	109
3. Upper Amazon	
N.P.Serra do Divisor	605,000
B.R.Abufari	288,000
E.S.Rio Acre	77,500
E.R.Jutai-Solimoes (transition with Central Amazon)	245,285
4a.Northern Region - Guyana subregion	
P.N.Monte Roraima (transition with Rio Negro-Orinoco subregion)	116,000
E.S.Maraca (transition with Rio Negro-Orinoco subregion)	101,312
4b.Northern Region - Rio Negro-Orinoco subregion	
P.N.Pico da Neblina	2,200,000
P.N.Jau	2,272,000
E.S.Anavilhanas (transition with Central Region)	350,018
E.S.Caracarai (influenced by Guyana subregion)	400,560
E.S.Niquia (influenced by Guyana subregion)	286,600
5a.Southern Region - Western subregion	
P.N.Pacaas Novos	764,801
B.R.Jaru	268,150
B.R.Guapore	600,000
E.S.Cunia	104,000
E.S.Ique	200,000
5b.Southern Region - Eastern subregion	
P.N.Araguaia	562,312
B.R.Tapirape	103,000
E.S.Coco-Javaes	37,000

Table 19. The occurrence of National Parks (N.P.), Biological Reserves (B.R.), and Ecological Stations (E.S.) and Reserves (E.R.) in the Central Cis-Andean rain forest units of Brazilian Amazonia (Duellman 1982).

Rain Forest Unit	Area (ha)
Para	
B.R.Gurupi	341,650
Guiana	
N.P.Cabo Orange	619,000
N.P.Monte Roraima (transition with Venezuelan Guiana)	116,000
B.R.Lago Piratuba	357,000
E.S.Maraca-Jipioca	72,000
Venezuelan Guiana	
None	
Savanna transition between Guiana, Venezuelan Guiana and Supra Amazon	
N.P.Monte Roraima	116,000
E.S.Maraca	101,312
E.S.Caracarai	400,560
E.S.Niquia	286,600
Supra-Amazon	
N.P.Pico da Neblina	2,200,000
N.P.Jau	2,272,000
B.R.Rio Trombetas	385,000
B.R.Uatuma	560,000
E.S.Anavilhanas	350,018
E.R.Sauim-Castanheiras	109
E.S.Jari	227,116
E.S.Juami-Japura	745,830
Napo-Ucayali	
P.N.Serra do Divisor	605,000
E.S.Rio Acre	77,500
E.R.Jutai-Solimoes	284,285
Bolivia	
B.R.Guapore (transition with Madeira-Tapajos)	600,000
Madeira-Tapajos	
N.P.Amazonia	994,000
N.P.Pacaas Novos	764,801
B.R.Jaru	268,150
B.R.Abufari	288,000
B.R.Guapore (transition with Bolivia)	600,000
B.R.Tapirape	103,000
E.S.Igue	200,000
E.E.Cunia	104,000

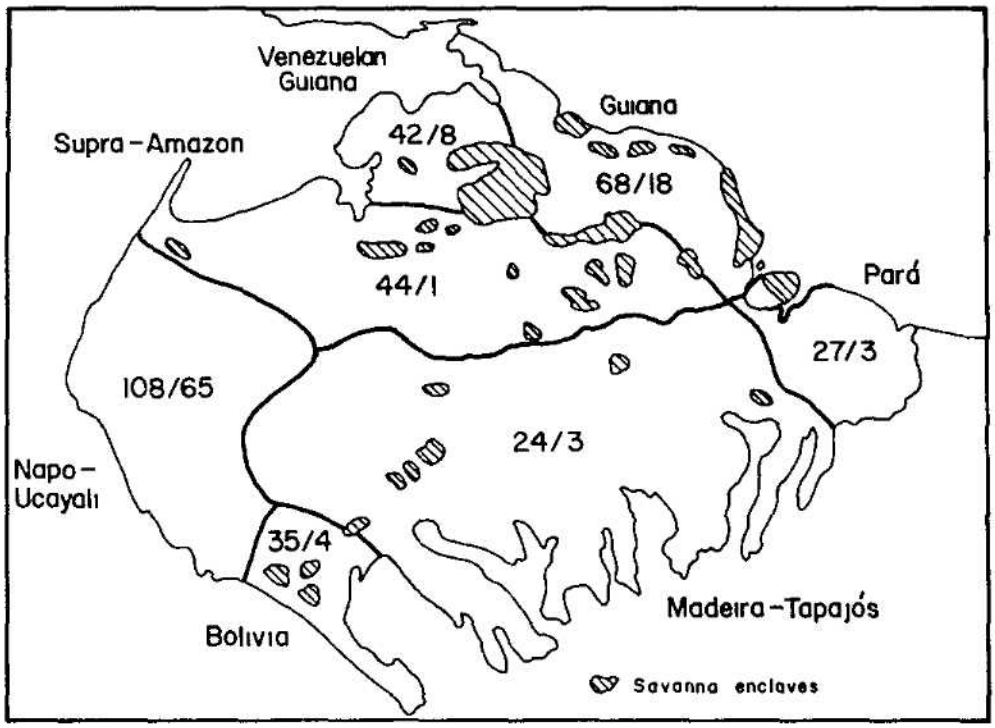

Figure 20. Rain forest units for frogs proposed by Duellman 1982). Species/endemic species.

8/2

Table 20. The occurrence of National Parks (N.P.), Biological Reserves (B.R.), and Ecological Stations (E.S.) and Reserves (R.E.) within the distributions of 12 species of turtles (Iverson, 1986).[1]

Species	Area (ha)
Podocemis expansa	
N.P.Amazonia *	994,000
B.R.Trombetas *	385,000
B.R.Abufari *	288,000
+ all others (28)	
Podocnemis unifilis	
N.P.Araguaia *	563,312
N.P.Amazonia *	994,000
N.P.Trombetas *	385,000
N.P.Abufari *	288,000
B.R.Guapore *	600,000
+ all others (26)	
Podocnemis sextuberculata	
N.P.Amazonia	994,000
N.P.Pico da Neblina	2,200,000
N.P.Jau	2,272,000
B.R.Trombetas	385,000
B.R.Uatuma	560,000
B.R.Abufari	288,000
E.S.Anavilhanas	350,018
E.S.Cunia	104,000
E.S.Jari	227,116
E.S.Juami-Japura	745,830
E.R.Jutai-Solimoes	284,285
Podocnemis erythrocephala	
N.P.Amazonia	994,000
N.P.Pico da Neblina	2,200,000
N.P.Jau	2,272,000
B.R.Uatuma	560,000
E.S.Anavilhanas	350,018
Rhynoclemys punctularia	
N.P.Cabo Orange	619,000
R.B.Trombetas	385,000
B.R.Lago Piratuba	357,000
B.R.Gurupi	341,650

Cont.

Table 20 contd.

B.R.Uatuma	560,000
E.S.Anavilhanas	350,018
E.S.Maraca	101,312
E.S.Caracarai	400,560
E.S.Jari	227,116
E.S.Niquia	286,600
Kinosternon scorpiodes	
N.P.Amazonia	994,000
N.P.Cabo Orange	619,000
N.P.Trombetas	385,000
B.R.Lago Piratuba	357,000
B.R.Gurupi	341,650
B.R.Tapirape	103,000
B.R.Jari	227,116
Peltocephalus dumeriliana	
N.P.Amazonia	994,000
N.P.Cabo Orange	619,000
N.P.Pico da Neblina	2,200,000
N.P.Jau	2,272,000
B.R.Trombetas	385,000
B.R.Abufari	288,000
B.R.Uatuma	560,000
B.R.Lago Piratuba	357,000
E.S.Anavilhanas	350,018
E.S.Jari	227,116
E.S.Caracarai	400,560
E.S.Niquia	286,600
E.S.Juami-Japura	745,830
E.R.Jutai-Solimoes	284,285
Chelus fimbriatus	
All (30) except R.B.Gurupi	
Platemys platycephala	
All (31)	
Phrynops gibbus	
N.P.Pico da Neblina	2,200,000
N.P.Cabo Orange	619,000
N.P.Serra do Divisor	605,000
N.P.Monte Roraima	116,000
E.S.Rio Acre	77,500
E.S.Caracarai	400,560
E.S.Niquia	286,600
E.R.Jutai-Solimoes	284,285

Contd.

Table 20 contd.

Phrynops rufipes	
N.P.Pico da Neblina	2,200,000
N.P.Jau	2,272,000
B.R.Uatuma	560,000
E.S.Anavilhanas	350,018
E.S.Juami-Japura	745,830
E.R.Jutai-Solimoes	284,285
Phrynops nasutus	
N.P.Amazonia	994,000
N.P.Pico da Neblina	2,200,000
N.P.Jau	2,272,000
N.P.Pacaas Novos	764,801
N.P.Serra do Divisor	605,000
B.R.Trombetas (?)	385,000
B.R.Jaru	268,150
B.R.Abufari	288,000
B.R.Guapore	600,000
B.R.Uatuma	560,000
E.S.Anavilhanas	350,018
E.S.Ique (?)	200,000
E.S.Rio Acre	77,500
E.S.Cunia	104,000
E.S.Juami-Japura	745,830
E.R.Jutai-Solimoes	284,285

[1] Note that this table indicates the conservation units within the known geographical distribution of each species but does not necessarily mean that they occur within them.

Table 21. The occurrence of turtle nesting beaches identified by Alfinito (1978) in the National Parks, Biological Reserves, and Ecological Stations in Brazilian Legal Amazonia.

National Parks	
Araguaia	Not included in survey.
Amazonia	Rolino and Monte Cristo just downstream of park - Rio Tapajos.
Pacaas Novos	Not included in survey.
Pico da Neblina	Not included in survey.
Cabo Orange	Not included in survey.
Jau	Not included in survey.
Serra do Divisor	Not included in survey.
Monte Roraima	Not included in survey.
Biological Reserves	
Rio Trombetas	Gaivota, Praia Rasa, Abui Grande, Janari, Silvana, Jacare, Faria, Leonardo - Rio Trombetas.
Jaru	Not included in survey.
Lago Piratuba	Praia do Acai, Praia do Munguba, Campinho, Ilha dos Anjos, Ilha and Praia das Tabocas and various others upstream of the reserve - Rio Araguari.
Abufari	Abufari - Rio Purus.
Guapore	Sao Miguel, Cobra and numerous others both and downstream of the reserve - Rio Guapore.
Gurupi	Not included in survey.
Tapirape	Not included in survey.
Uatuma	Three beaches downstream of the reserve, above the Rio Jatapu - Rio Uatuma.
Ecological Stations	
Anavilhanas	Three beaches upstream of the Reserve, near Barcelos - Rio Negro.
Ique	Not included in survey.
Maraca	Not included in survey.

Cont.

Table 21 contd.

Rio Acre	Not included in survey.
Maraca-Jipioca	Not included in survey.
Cunia	Praia do Periquito and Praia de Iracema just outside reserve boundaries - Rio Madeira.
Caracarai	Ten beaches identified downstream of the reserve, near the confluence of the Rio Catrimani - Rio Branco.
Jari	Not included in survey.
Juami-Japura	Not included in survey.
Niquia	Ten beaches identified downstream of the reserve, near the confluence of the Rio Catrimani - Rio Branco.
Coco-Javaes	Not included in survey.

Table 22. The occurrence of Brazilian National Parks (N.P.), Biological Reserves (B.R.), and Ecological Stations (E.S.) and Reserves (E.R.) in the nine centres of endemism identified for forest birds in Brazilian Amazonia by Cracraft (1985).

	Area (ha)
10A. Pantepui centre-Gran Sabana subcentre	
N.P.Monte Roraima	116,000
10B. Pantepui centre-Duida subcentre	
N.P.Pico da Neblina (part)	2,200,000
17. Guyanan centre	
N.P.Cabo Orange	619,000
B.R.Lago Piratuba	357,000
B.R.Trombetas	385,000
B.R.Uatuma	560,000
E.S.Anavilhanas	350,018
E.S.Maraca-Jipioca	72,000
E.S.Caracarai	400,560
E.S.Niquia	286,600
E.S.Jari	227,116
E.R.Sauim-Castanheiras	109
18. Imeri centre	
N.P.Pico da Neblina (part)	2,200,000
19. North Amazon (Napo) centre	
E.S.Juami-Japura	745,830
20. South Amazon (Inambari) centre	
N.P.Serra do Divisor	605,000
B.R.Abufari	288,000
E.S.Rio Acre	77,500
E.R.Jutai-Solimoes	284,285
21. Rondonia centre	
N.P.Amazonia	994,000
N.P.Pacaas Novos	764,801
B.R.Jaru	268,150
B.R.Guapore	600,000
22. Para centre	
B.R.Tapirape	103,000
23. Belem (Maranhao) centre	
B.R.Gurupi	341,650

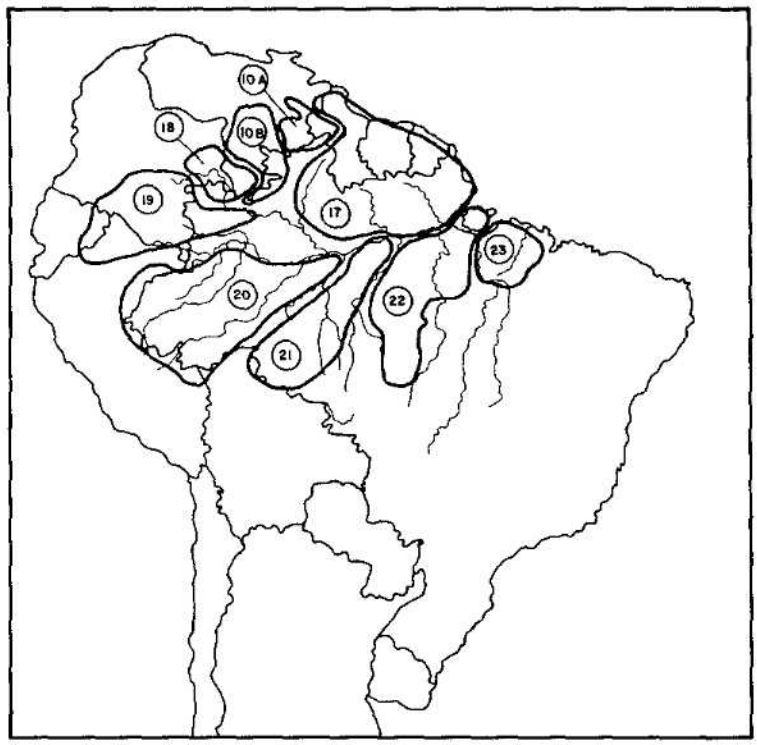

Figure 21. Centres of endemism proposed for birds by Cracraft (1985). 10A = Gran Sabana Subcentre of Pantepui Centre; 10B = Duida Subcentre of Pantepui Centre; 17 = Guyanan Centre; 18 = Imeri Centre; 19 = North Amazon (Napo) Centre; 20 = South Amazon (Inambari) Centre; 21 = Rondonia Centre; 22 = Para Centre; 23 = Belem (Maranhao) Centre. Numbering follows Cracraft (1985).

872

Table 23. Primates occurring in the National Parks, Biological Reserves, Ecological Stations and Reserves and State Ecological Stations in three regions in Brazilian Amazonia (Fig.22), according to their known or supposed distributions. Taxonomy follows Mittermeier et al. (1988) except for the genus Callicebus which follows Hershkovitz (1988). * Species and subspecies which are restricted to just one reserve.

Region 1 - National Parks

Cabo Orange

Saguinus midas midas
Saimiri sciureus sciureus
Cebus apella apella
Cebus olivaceus
Pithecia pithecia pithecia
Chiropotes satanas chiropotes
Alouatta seniculus
Ateles paniscus paniscus ?
Total 8

Pico da Neblina

Saguinus midas midas ?
Saimiri sciureus cassiquiarensis
Aotus trivirgatus
Callicebus torquatus lugens
Cebus apella apella
Cebus albifrons unicolor
Pithecia pithecia pithecia ?
Chiropotes satanas chiropotes
Cacajao melanocephalus ouakary
Alouatta seniculus
Ateles belzebuth belzebuth
Lagothrix lagotricha lagotricha
Total: 12

Region 1 - Biolgogical Reserves

Rio Trombetas

Saguinus bicolor martinsi *
Saguinus midas midas
Saimiri sciureus sciureus
Cebus apella apella

Cont.

Table 23 cont.

Cebus olivaceus
Pithecia pithecia chrysocephala
Chiropotes satanas chiropotes
Alouatta seniculus
Ateles paniscus paniscus
Total 9

Lago Piratuba

Saguinus midas midas
Saimiri sciureus sciureus
Cebus apella apella
Cebus olivaceus
Pithecia pithecia pithecia
Chiropotes satanas chiropotes
Alouatta seniculus
Ateles paniscus paniscus ?
Total 8

Uatuma

Saguinus midas midas
Saimiri sciureus sciureus
Aotus trivirgatus
Cebus apella apella
Cebus olivaceus
Pithecia pithecia chrysocephala
Chiropotes satanas chiropotes
Alouatta seniculus
Ateles paniscus paniscus
Total: 9

Region 1 - Ecological Stations

Anavilhanas

Saguinus midas midas ?
Saimiri sciureus sciureus
Aotus trivirgatus
Cebus apella apella
Cebus olivaceus
Pithecia pithecia chrysocephala
Chiropotes satanas chiropotes
Alouatta seniculus

Cont.

Table 23 cont.

Ateles paniscus paniscus
Total: 9

Maraca

Saguinus midas midas ?
Saimiri sciureus sciureus
Aotus trivirgatus
Callicebus torquatus lugens
Cebus apella apella
Cebus olivaceus
Alouatta seniculus
Pithecia pithecia chrysocephala ?
Chiropotes satanas chiropotes ?
Ateles belzebuth belzebuth
Total: 10

Caracarai

Saguinus midas midas ?
Saimiri sciureus sciureus
Aotus trivirgatus
Callicebus torquatus lugens
Cebus apella apella
Cebus olivaceus
Pithecia pithecia chrysocephala ?
Chiropotes satanas chiropotes
Alouatta seniculus
Ateles belzebuth belzebuth
Total: 10

Jari

Saguinus midas midas
Saimiri sciureus sciureus
Cebus apella apella
Cebus olivaceus
Pithecia pithecia chrysocephala
Chiropotes satanas chiropotes
Alouatta seniculus
Ateles paniscus paniscus
Total: 8

Cont.

Table 23 cont.

Niquia

Saguinus midas midas ?
Saimiri sciureus sciureus
Aotus trivirgatus
Callicebus torquatus lugens
Cebus apella apella
Cebus olivaceus
Pithecia pithecia chrysocephala ?
Chiropotes satanas chiropotes
Alouatta seniculus
Ateles belzebuth belzebuth
Total: 10

Maraca-Jipioca

Saimiri sciureus sciureus
Cebus apella apella
Total: 2

Region 1 - Ecological Reserves

Sauim-Castanheiras

Saguinus bicolor bicolor *
Saimiri sciureus sciureus
Aotus trivirgatus
Cebus apella apella
Pithecia pithecia chrysocephala
Alouatta seniculus
Total: 6

Region 2 - National Parks

Jau

Saguinus inustus ? *
Saimiri sciureus cassiquiarensis
Aotus vociferans
Callicebus torquatus torquatus (southern part)
Callicebus torquatus lugens (northern part)
Cebus apella apella
Cebus albifrons unicolor
Pithecia pithecia chrysocephala ?

Cont.

Table 23 cont.

Cacajao melanocephalus ouakary
Alouatta seniculus
Total: 10

Serra do Divisor

Cacajao calvus ucayali ? (although restricted by Hershkovitz (1987) to the west of the Rio Javari in Peru) *
Saimiri boliviensis peruviensis ? *
Saguinus fuscicollis spp. (Subspecies not identified by Hershkovitz (1977), but a likely candidate is S.f.fuscicollis)
Saguinus mystax mystax
Callimico goeldii
Saimiri sp. (Hershkovitz (1984) does not identify the squirrel monkey on the left bank of the Rio Jurua in this region; S.b.peruviensis or S.sciureus macrodon are candidates)
Callicebus cupreus cupreus
Callicebus caligatus
Aotus nigriceps
Cebus apella apella
Cebus albifrons unicolor
Pithecia monachus monachus
Lagothrix lagotricha poeppigii
Ateles paniscus chamek
Alouatta seniculus
Total: 13 (excluding Cacajao)

Region 2 - Biological Reserves

Abufari

Saguinus fuscicollis avilapiresi (left bank) *
Saguinus mystax pileatus (left bank) *
Saguinus mystax pluto or Saguinus labiatus labiatus (right bank) *
Saimiri boliviensis (jaburuensis ?) (left bank) *
Callicebus torquatus purinus (left bank) *
Callicebus dubius (right bank) *
Pithecia albicans (left bank) *
Cebuella pygmaea ? (left bank)
Saguinus fuscicollis weddelli (right bank)
Saimiri ustus (right bank)

Cont.

Table 23 cont.

Aotus nigriceps
Callicebus caligatus
Callicebus cupreus cupreus (left bank)
Cebus apella apella
Cebus albifrons unicolor
Pithecia irrorata irrorata (right bank)
Alouatta seniculus
Ateles paniscus chamek ?
Lagothrix lagotricha cana
Total: 19
Region 2 - Ecological Stations
Rio Acre
Saguinus imperator imperator *
Saimiri boliviensis boliviensis *
Cebuella pygmaea
Callimico goeldii
Saguinus fuscicollis weddelli
Aotus nigriceps
Callicebus cupreus cupreus
Callicebus caligatus
Cebus apella apella
Cebus albifrons unicolor
Pithecia irrorata irrorata
Alouatta seniculus
Ateles paniscus chamek
Lagothrix lagotricha cana
Total: 14
Juami-Japura
Cebuella pygmaea ?
Saguinus fuscicollis fuscus
Saimiri sciureus macrodon
Aotus vociferans
Callicebus torquatus lucifer
Cebus apella apella
Cebus albifrons unicolor
Pithecia monachus monachus
Cacajao calvus rubicundus ?
Alouatta seniculus

Cont.

Table 23 cont.

Ateles paniscus chamek or Ateles belzebuth belzebuth
Lagothrix lagotricha lagotricha
Total: 13
Cunia
Saguinus fuscicollis weddelli
Saguinus mystax pluto
Saimiri ustus
Aotus nigriceps
Callicebus brunneus
Cebus apella apella
Cebus albifrons unicolor
Pithecia irrorata irrorata
Alouatta seniculus
Ateles paniscus chamek
Lagothrix lagotricha cana
Total: 11
Region 2 - Ecological Reserves
Jutai-Solimoes
Saguinus fuscicollis fuscicollis *
Aotus nancymai *
Callicebus torquatus regulus *
Cebuella pygmaea
Saguinus mystax mystax
Saimiri sciureus macrodon
Aotus nigriceps ?
Callicebus cupreus cupreus
Callicebus caligatus
Cebus apella apella
Cebus albifrons unicolor
Pithecia monachus monachus
Cacajao calvus rubicundus ?
Alouatta seniculus
Lagothrix lagotricha poeppigii
Ateles paniscus chamek
Total: 16

Cont.

Table 23 cont.

Region 2 - State Ecological Reserve

Mamiraua

Saguinus labiatus thomasi *
Saimiri boliviensis vanzolinii *
Cacajao calvus calvus *
Cebuella pygmaea ?
Saguinus fuscicollis fuscus
Aotus vociferans
Callicebus torquatus lucifer
Cebus apella apella
Cebus albifrons unicolor
Pithecia monachus monachus
Alouatta seniculus
Ateles paniscus chamek
Lagothrix lagotricha lagotricha
Total: 13

Region 3 - National Parks

Amazonia

Callithrix argentata leucippe (buffer zone) *
Callithrix humeralifer humeralifer (left bank) *
Callicebus hoffmannsi hoffmannsi (left bank) *
Alouatta belzebul nigerrima (left bank) *
Ateles belzebuth marginatus (buffer zone) *
Saimiri ustus (buffer zone)
Aotus nigriceps (left bank)
Aotus infulatus (buffer zone)
Callicebus moloch (buffer zone)
Cebus apella apella
Cebus albifrons unicolor (left bank)
Pithecia irrorata irrorata (left bank)
Chiropotes albinasus
Alouatta belzebul discolor (buffer zone)
Ateles paniscus chamek (left bank)
Lagothrix lagotricha cana ? (left bank)
Total: 16

Pacaas Novos

Callithrix emiliae
Saimiri ustus

Cont.

Table 23 cont.

Aotus nigriceps
Callicebus brunneus
Cebus apella apella
Cebus albifrons unicolor
Pithecia irrorata irrorata
Chiropotes albinasus
Alouatta seniculus
Ateles paniscus chamek
Lagothrix lagotricha cana
Total: 12

Araguaia

Aotus infulatus
Cebus apella apella
Alouatta belzebul discolor
Total: 3

Region 3 - Biological Reserves

Jaru

Callithrix emiliae
Saimiri ustus
Aotus nigriceps
Callicebus brunneus
Cebus apella apella
Cebus albifrons unicolor
Pithecia irrorata irrorata
Chiropotes albinasus
Alouatta seniculus
Ateles paniscus chamek
Lagothrix lagotricha cana
Total: 11

Guapore

Callithrix emiliae
Saimiri ustus
Aotus nigriceps ?
Callicebus brunneus
Cebus apella apella
Cebus albifrons unicolor
Pithecia irrorata irrorata
Chiropotes albinasus
Alouatta seniculus

Cont.

Table 23 cont.

Ateles paniscus chamek
Total: 11

Gurupi

Chiropotes satanas satanas *
Alouatta belzebul belzebul *
Saguinus midas niger ?
Saimiri sciureus sciureus
Aotus infulatus ?
Cebus apella apella
Total: 6

Tapirape

Chiropotes satanas utahicki *
Saguinus midas niger
Saimiri sciureus sciureus
Aotus infulatus
Callicebus moloch
Cebus apella apella
Alouatta belzebul discolor
Total: 7

Region 3 - Ecological Stations

Ique

Callithrix argentata melanura ? *
Callicebus cinerascens *
Callithrix emiliae or Callithrix argentata melanura
Saimiri ustus
Aotus nigriceps
Cebus apella apella
Pithecia irrorata irrorata
Chiropotes albinasus
Alouatta seniculus
Ateles paniscus chamek
Lagothrix lagotricha cana
Total: 11

Coco-Javaes

Aotus infulatus
Cebus apella apella
Alouatta belzebul discolor
Total: 3

Table 24. Primates not known to occur in any Federal Protected Areas in the Brazilian Amazon. Endemic = endemic to the Brazilian Amazon, RDB = 1988 IUCN Red Data List, BR = Brazilian List of Threatened Species

Region 1		
Saguinus bicolor ochraceus	Endemic	RDB/BR
Cacajao melanocephalus melanocaphalus		RDB/BR
Region 2		
Saguinus nigricollis nigricollis		
Saguinus fuscicollis acrensis	Endemic	
Saguinus fuscicollis melanoleucus	Endemic	
Saguinus fuscicollis primitivus	Endemic	
Saguinus fuscicollis crandalli	Distrib.unknown	
Saguinus fuscicollis cruzlimai	Distrib.unknown	
Saguinus imperator subgrisescens		RDB/BR
Saimiri boliviensis pluvialis	Endemic	
Cebus albifrons cuscinus		
Pithecia irrorata vanzolinii	Endemic	
Cacajao calvus novaesi	Endemic	RDB/BR
Cacajao calvus ucayali		RDB/BR
Region 3		
Callithrix argentata argentata	Endemic	
Callithrix humeralifer intermedius	Endemic	RDB/BR
Callithrix humeralifer chrysoleuca	Endemic	RDB/BR
Callicebus hoffmannsi baptista	Endemic	
Alouatta belzebul ululata	Endemic	

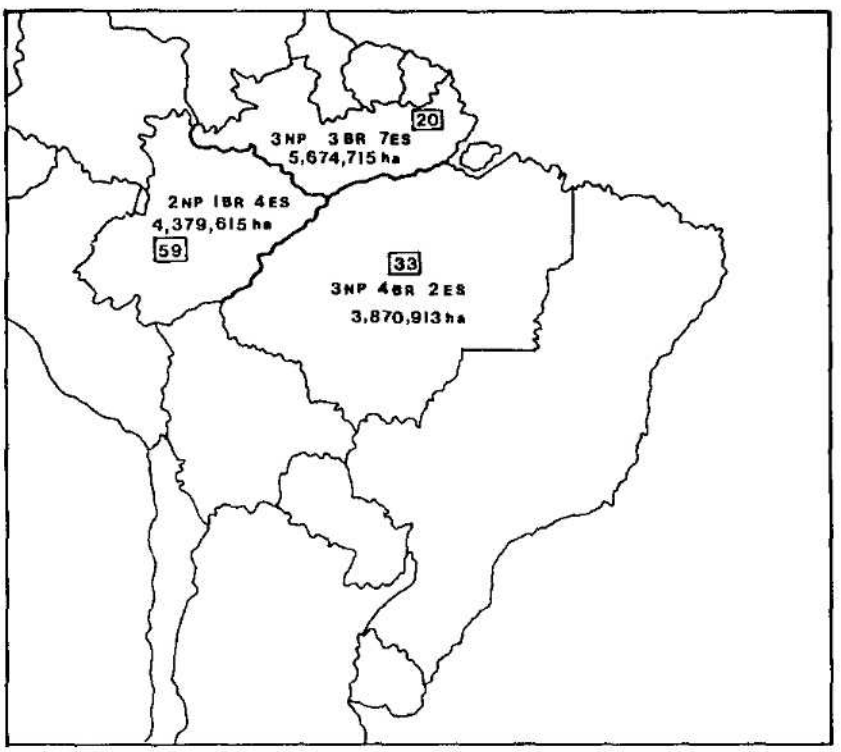

Figure 22. Zoogeographic regions for primates (adapted from Rylands and Bernardes (in press). The number in the box is the number of species and subspecies. Also shown are the number of National Parks (NP), Biological Reserves (BR), Ecological Stations (ES) and State Reserves (SR) and the area of conservation units in each region.