THE CONSERVATION AND UTILIZATION OF THE AMAZON RAIN FOREST

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INTRODUCCION

The Amazon Basin with its vast expanse of forest is the world's largest tropical rainforest. The forested lowland parts alone cover an area equal to the United States east of the Rockies. If separated as a nation, the Amazon Basin would be the world's ninth largest nation. The Amazon River is responsible for the drainage into the sea of one fifth of all the freshawater in the world. It is also biologically the most species-rich area of the world, containing over 50,000 species of higher plants, at least an equal number of fungi, a fifth of all the birds on earth, at least 3000 species of fishes, amounting to 10 times the number of fish species in all the rivers of Europe, and insect species numbering in the uncounted millions.

The Amazon forest contains a vast array of fascinating and record-beating plants and insects. The world's largest snake, the anaconda, graces the river banks of Amazonia, and the world's largest insect, the goliath beetle, flies through is forests. A host of useful products of worldwide importance have come from the forests of Amazonia, including cacao (the source of chocolate), rubber, quinine, Brazil nuts, and chicle or chewing gum.

Between the years 1600 and 1900 humankind eliminated about 75 known species worldwide, almost all of them mammals and birds (Myers 1979). During the present century, however, extinction has increased at an alarming pace, especially in the tropical rainforest. There are many causes of tropical extinctions, but they are all related to the extensive local endemism of species. And destruction is now on such a large scale in certain regions that it covers more than the entire range of these endemic or localized species. The Volkswagen Motor Company, for example, holds a concession on 1,400 square kilometers of forest, much of which is turning into cattle pasture. The Jari forestry proyect, founded by Daniel K. Ludwig, covers an area of one million hectares. Major tributaries of the Amazon, such as the Tocantins River, are being dammed to produce hydroelectricity, completely distrupting the life of fishes and other aquatic organisms, and flooding vast areas of riverine forest. Thus we have cause for concern about extinction in Amazonia, a region where not just individual species, but whole habitats are disappearing rapidly.

As we shall see destruction of the forest is not necessarily producing sustainable systems of land-use. Many of the destroyed areas are abandoned after a few years. It is therefore vital for us to be concerned about the creation of long-term sustainable uses of rainforest areas and to follow the excellent norms of 'the World Conservation Strategy' (IUCN, UNEP, WWF 1980) that present an excellent balance between conservation and utilization. In this paper I want to first draw attention to the alarming destruction in Amazonia and then some comments on why it is hard to creat sustainable use systems and finally I will address the issues of utilization and conservation, and the contributions that botanists can make on these issues.

THE DESTRUCTION OF AMAZONIA

The accelerated destruction of the Amazon rainforest really began in 1970 when President Médici of Brazil visited the drought and poverty stricken northeast of his country. He was so impressed by the poor estate of his subjects that for the best of humanitarian reasons he decided that the only solution was to develop the Amazon region and thus to open a large area of settlement for

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the northeasterners. They would be moved in great numbers from their arid land to the rain-filled paradise, the Amazon. The horror-stricken President Médici made a moving appeal to the Brazilian Congress on June 6, 1970. Only ten days later a National Intergration Plan (PIN) was formulated which included the construction of the Transamazon highway, the first leg of which was to cut across the Amazon region from east to west about 500 miles south of the River Amazon. The plan also included an elaborate colonization plan along the length of the highway. Bids for the highway construction were already out by June 18, and the construction began on September 1, 1970, an indication of the priority and urgency of the president's plan. This was the beginning of a particularly destructive phase in the history of the Amazon region. At the same time, Presidente Fernando Belaunde Terry of Peru, who had been dreaming for many years of building a north-south road around the western fringe of the Amazon, was designing plans to develop the Peruvian Amazon, and the discovery of oil in the Ecuadorian and Peruvian Amazon began to change things there too.

Although construction began only sixteen years ago, the Transamazon highway is now history. This road and other Amazonian highways are built and, for the most part, functional, but the colonization plan has been a failure and even parts of the main highway are impassable. The Brazilian plan to relocate one million northeasterners actually moved less than twenty thousand people. Even if it had moved the one million as planned, that is less than the annual population increase of northeastern Brazil.

The plan was unsuccessful largely because of poor soils, the failure of the initial rice harvests, and inadequate agricultural advice to the settlers. Many people ended up returning to their area of origin. Only a few of the settlers have succeeded: some by luck, some by hard work, and some by having enough local knowledge to have chosen one of the few areas along the highway that is more suitable for agriculture. Today as one drives along the highway, one is most impressed by the quantity of abandoned land full of regenerating *Cecropoia* trees and of degenerated, weed-filled cattle pastures.

Because the colonization plan for the highway failed, the next president of Brazil, Ernesto Geisel, concluded that the Amazon was not suitable for colonization by the small farmer, and that capital-intensive development was needed. Accordingly, he created hugh tax incentives for companies and rich individuals to invest in enormous tracts of land. The development passed from the phase of *minifundarios* to that of *latifundarios.* Vast areas of forest were felled, burned, or treated with herbicide to be replaced with cattle pastures in a region that is not suitable for cattle raising. Many of the areas cleared for such ranches have now been abandoned. Frequently the owners didn't care if they failed because the tax incentives insured they could have no economic loss. In many cases it takes about 1 1/2 hectares or more to sustain a single cow. This cow lives on an area that could have had over 700 individual trees of about 200 species, and many other plant and animal species as well. An enormous natural biomass with much greater productivity and value than that offered by the skinny, malnourished cow that now wanders around the weed infested pastures which replaced the forest. The failure of many ranches has led to a slowdown in the rate of deforestation for that purpose.

The state of Rondônia on the western frontier of Brazil provides another alarming chapter in the destruction of Amazonia. This area, which for a long time experienced only a moderate disturbance from tin mining and the construction of the famous Madeira-Mamoré railroad, has now become the development frontier of the Amazon region. When it was discovered in 1974 that, unlike the region of the Transamazon highway, there are rather large areas of the rich *terra roxa* soils, and that the terrain is flatter and more suitable for agriculture, what can only be described as a "land rush" of enormous proportions began along highway BR-364 between Cuiabá, in Mato Grosso state, and Porto Velho, the booming capital of Rondônia.

Up to 1969, the human population of Rondônia was sparse (2 individuals per km^2) and concentrated in the northern part of the state, in those nuclei which resulted from the building of the Madeira-Mamoré railroad. The economy of what was then the territory of Guaporé was based on the extraction of rubber and Brazil nuts. Subsistence-level food was obtained from the environment, by hunting, fishing and collecting forest plants. This did not affect the forest environment seriously. Itinerant farming during that period was insignificant.

With the completion of highway BR-364 in the sities, linking Rondônia with the south of Brazil. the wave of migration into the state of Rondônia began. Thousands of people from all over Brazil, but especially from the south-central region, moved into Rondônia. This accelerated, unorganized occupation of Rondônia continued until 1967 when INCRA (The Colonization and Agrarian Reform Institute) began its efforts to control the distribution of immigrants (Modesto, 1982).

Today, in addition to the state government and INCRA, the Polamazonia and Polonoroeste development programs contribute to the colonization process indirectly through the thousands of people who are attracted to the region by the unexploited "fertile" lands available for agriculture, cattle raising, timber extraction, etc. The traditional extraction of rubber, brazil-nuts, game and minerals, such as gold and cassiterite, continues to draw people to the state.

The population of Rondônia has grown exponentially since the late sixties. It grew from 111,000 in 1970 to 191.084 in 1975 to more than 500,000 in 1978. The rate of growth has remained high and continues to swell since the recent paving of the highway from Porto Velho to Cuiabá in Mato Grosso. Rapid deforestation is following this growth in population. Inhabitants are constantly practicing slash and burn techniques, destroying great areas of forest which have barely been studied. According to Fearnside's (1982) exponential projections, if the annual rate of deforestation continues, the state of Rondônia will be completely free of forest by 1988 (Fearnside and Salati 1985).

Today's aerial photos of Randônia compared with those of a few year ago show a vast network of new roads intersecting BR-364, and enormous areas of decimated forest. The only difference between BR-364 and the Transamazon highway is that, in the former case, many of the resulting farms work, for two reasons. First, the soil is better, and secondly, a diversity of crops has been grown. With less government control, success was not based on the single crop, rice, that was emphasized in the Transamazon colonization. The diversity of crops that the Rondônia settlers used has meant that, although some failed, others succeeded. Often when one farmer experienced a crop failure, another member of the family had a successful crop on his land and carried his relatives through the hard time. In addition, many settlers in Rondônia have concentrated on woody perennial crops such as cacao, *(Theobroma cacao)*, which is less destructive to the soil than most annuals. Consequently, the settlement of Rondônia is a cirious mixture of unplanned deforestation and species loss, and an interesting and often successful experimental laboratory in ways of using the land.

But the real tragedy of Rondônia is that it was one of the most important centers of species diversity in Amazonia. The same reasons that make the region useful, such as its richer soils, also made it the home of an extraordinarily high number of endemic species of plants and animals.

Rondônia is thought to have remained forest-covered during the drier periods of the Pleistocene glaciations, thus providing a haven for many forest species (See Brown 1979). Such forest refugia are the most important places to conserve the genetic diversity of Amazonia. The one national park in Rondônia, Jau, covers only a small part of the Rondônia refugium, and its borders have already been invaded. Less uncontrolled, but equally devastating deforestation is taking place further west in the state of Acre, the new frontier; the story promises to be the same.

The Amazon forest is disappearing for many other reasons, but the rush for land and agricultural settlement are certainly the most immediately destructive and the most alarming. Other projects that are changing the region to a desvastated fragment of its former splendor include forestry projects, hydroelectric dams, and mining enterprises.

The vast Tucuruí dam, slated to produce 8000 megawatts of electricity, was closed in 1984 and has created an enormous 160 km-long lake on the Tocantins River. Much research was carried out in the area of the lake before the dam was closed. The commendable scientific work of the Museu Goeldi in Belém and the National Amazon Research Institute (INPA) in Manaus, has meant that a lot was learned about this region before the flood. Fortunately it is not one of the centers of biological diversity, so that loss of terrestrial species there will not be great. Even so, the dam has caused many problems. The efforts to remove the stadyng crop of timber from the area to be flooded was a chapter of disasters that led to the bankruptcy of the military pension scheme. In spite of contracts to both the pension scheme and a French company for removal of the timber, the timber was never cleared and the lake has flooded much of the forest. The company, CAPEMI, had no logging experience and went bankrupt after clearing only one tenth of the contracted area. They also used the highly toxic chemical defoliant PCP (sodium pentachlorophenol), containers of which may have been left in the area to be flooded. The danger from the decomposition of the forest biomass will only become apparent with time. The lake also floods a small stretch of the Transamazon highway, which it was necessary to relocate.

The serious effects of the Tucuruí dam are minimal compared with the devastating potential of the extraordinary plan of the Hudson Institute (Panero, 1967), which proposed damming the main river to produce a vast inland sea! But even without the Hudson Institute's dam, the hydroelectric dams are one of the contributing causes of habitat destruction and extinction in Amazonia. Unlike Tucuruí, the Balbina dam, north of the city of Manaus will be an environmental disaster. It will flood an area larger than that of Tucuruí with an average lake depth of only two meters yet only one tenth of the energy of Tucuruí. It displaces two tribes of Indians, the Atroaris-Waimari and will flood a vast area of stanfing foreast.

There are many mining projects scattered around Amazonia. Some have been more destructive than others, but until recently they have destroyed comparatively small areas of forest. The gold mine at Serra Pelada in the south of Pará has drawn much attention because a whole hill has been dismantled to remove one of the richest gold deposits ever discovered. The mining project that is likely to cause the most damage because of its size is that of Serra Carajás in Pará, the world's largest iron deposit. The project will use energy from the Tucuruí dam to power its work, and a new railroad has been built from Carajás to the coastal part of São

Luís in Maranhão. The summit of Serra Carajás contains various endemic species of plants confined to the ironstone Canga formation. These may be condemned to extinction by this operation. The Carajás project, however, is one of the best monitored in terms of environmental controls. The environmental department of the Carajás project, however, is one of the best monitored in terms of environmental controls. The environmental department of the Carajás mining project has been well funded and is a fin example of what can be done. The work of its director, Maria de Lourdes Davis de Freitas, is helping to avoid the disaster that could have happened. The government has much broader plans for the development of the Carajás region (Projeto Grande Carajás), and this is likely to cause the vast deforestation and species loss, not the work of the iron mine. Some other mines have instituted interesting environmental projects. For example, the bauxite mines of the Trombetas River have employed an ecologist, John Knowles, to work on the rehabilitation, using native species of trees, of areas destroyed by their open-cast mining. Tree nurseries are growing many native trees for replanting after the mining is finished. The same bauxite mines in the Trombetas region began by polluting the river and severly affecting its fisheries with mine tailings, but proper pollution controls were installed later.

There have been several instances of deforestation for large forestry projects in which large tracts of rainforest were cut down to grow a single species. The first one was Henry Ford's Fordlândia near the Tapajós River. This vast rubber plantation was started in 1924 to reestablish rubber as an important crop of its native region. Ford built a whole, town, a railroad, and a plantation of over a million trees. The multimillion dollar project failed because the rubber trees were attacked by a fungus, and because riverine, flooded forest varieties were planted on the upland *terra firme*. The leaf rust fungus *(Microcyclus ulei)* is also a native species of Amazonia that has evolved over the years with the native rubber trees. In the forest, however, rubber trees are usually spaced 50-100 meters from their nearest neighbor, lost in a diversity of other tree species. In this natural situation the fungal spores are not often carried from one tree to another, and so the disease is of little consequence. Put a lot of trees next to one another, and the spores can be carried from rubber tree to rubber tree, devastating a plantation. For this reason Henry Ford gave up his rubber plantation in 1946, after investing 30 million dollars. In tropical Asia where the fungus does not exist, rubber plantations work well.

The losses of Henry Ford were small compared with those of Daniel K. Ludwig and his Jari forest project. In 1967 Ludwig began a vast plantation in the region of the Jari river which divides the state of Pará and the Territory of Amapá. He planned to plant a "miracle", fast-growing timber tree, *Gmelina arborea*, in his one million hectare estate. Mistakes were made early in the project, such as clearing with bulldozers and removing topsoil. Land had to be cleared by hand, and the gmelina trees planted among the debris. They also planted on sandy soils unsuitable for gmelina, and had to abandon large areas because their property runs through the boundary of the lowland Amazon alluvial clay soil, and the sandy soil of the Guiana Shield. Eventually they planted pine trees on the sandy soils, gmelina on the richest soils, and eucalyptus in intermediate areas. Ludwig's project is probably best known because it floated a 200-million-dollar, 17-stories-high paper mill from Japan to Jari, as well as an equally large power plant. The mill is one of the most modern in the world. It's amazing to enter the control room in the middle of the Amazon jungle and see the vast array of computer equipment that allows only six men to control the entire operation. Ludwig's investment was well over a billion dollars, but in 1982 he sold out to a consortium of Brazilian companies for $ 400 million and the assumption of his debt on the mill. With Ludwig's $ 600 million loss, the Jari project can hardly be called a success even if it becomes profitable to the present owners. The pulp mill continues to function and to produce much pulp for its new owners.

These examples demonstrate that the Amazon rainforest is being lost at a rapidly increasing rate. It is a cause for alarm for those who are concerned with the preservation of the genetic resources of the world, the stability of world climate, and the stewardship of soils of our planet. The official Brazilian government claim that only 1.55 percent of the Amazon forest had been felled is definitely untrue. It is based on interpretations of satellite images that do not distinguish the vast areas of secondary forest. Fearnside (1982) pointed out that the Bragantina zone of Pará which has been cleared since the late nineteenth century is, itself, larger than the official figures of devastation! Yet, all the other projects described above exist as well.

These examples are only from the Brazilian Amazon. Although at a less rapid rate, some deforestation is occurring in other Amazonian countries. We could also consider the effects of oil fields in the Peruvian and Ecudorian Amazon or of the road into the Peruvian Amazon and subsequent installation of cattle pastures and coca plantations there. The forests of Amazonian Bolivia are likewise being cut at an increasing rate to make way for cattle.

Another aspect which I have only touched upon briefly is the effect of the deforestation on the Indian peoples of the region. Some of the projects already described have had a largely destructive impact on the Indians, particulary the tribes whose territory will be flooded by the Tucuruí and Balbina hydroelectric dams, or the Nhambiquara Indians who have the misfortune to live near BR-364, the road across Rondônia which encroaches on some of their sacred sites. The Auca (Waorani) Indians of Ecuador were unfortunately situated in a region where oil was discovered, and uranium deposits have been discovered in the Yanomamí area. Some tribes are being acculturated, others are going extinct. The loss of these human cultures is not only a moral and ethical tragedy, but means the loss of a whole body of information that might have taught us how to create sustainable-use systems in the region.

SPECIES DESTRUCTION

So far we have considered mainly large-scale projects that destroy whole habitats, and consequently whole cohorts of species. Projects such as the Tucuruí dam, the colonization of Rondônia, and the Jari forestry project devastate entirse habitats. We could equally well look at the fate of a large number of individual species that have suffered and become threatened and endangered as a result of the modern developments in Amazonia. A few examples are given below.

A tragic loss of that of the Amazon manatee *(Trichechus inunguis)* or sea cow, one of the most important components of aquatic ecosystems because of the vast quantities of vegetation which they eat. These animals have been overhunted for their delicious meat and oil. They are now severely endangered, and very few individuals remain. Their only hope is that they have been the focus of a research program of the National Amazon Research Institute (INPA) in Manaus, which is making great efforts to learn about their ecology and physiology so they can breed them. Experiments have included trying to populate at least one lake behind a hydroelectric dam (Curuá-una) with manatees.

The giant otter (*Pteroneura brasiliensis*) is the largest otter in the world. No one can forget meeting a pack of these curious animals swimming in a river as they pop up beside one's canoe and bark. I will never forget the three times I have been fortunate enough to have had this inccreasingly rare experience. Their very curiosity makes them a sitting target for the hunter in search of their valuable fur.

Several of the Amazon side-necked turtle species are endangered because of excess exploitation. These creatures do not stand a chance, because people prey on both grown turtles and their eggs laid in the sand of river beaches during the dry season. The giant river turtle (*Podocnemis expansa),* once present in uncounted numbers, is near extinction.

The various species of crocodilians, large cats such as the jaguar, and large constricting snakes are all sought after for their skins or fur. Although Brazil's laws protect these animals, the control of hunting in a region as extensive as Amazonia is impossible, and many pelts are smuggled out through such countries as Bolivia where there is no protective legislation.

The over-exploitation is not confined to animal species. Useful species of trees are subject to such "mining." A good example is rosewood *(Aniba rosaeodora),* which is the source of rosewood oil. Small mobile distilleries are set up in the forest, and cutters are sent out to fell every tree around. Once all rosewood trees have been eliminated locally, the stills move on to other locations to continue the extermination of this species. Yet this kind of destructive explotation is totally unnecessary, Rosewood can be grown in plantations, as has been demostrated by INPA. It is also possible to harvest oil from leaves and small branches without destroying the tree Moreover, there are other sources of the essential oil, linalol, including a common weedy species of secondary forest tree, *Croton cajucara*.

Trees of the species of sôrva *(Couma)* are cut down to extract latex which is used in chewing gum. Again sôrva cutters are penetrating remote areas of otherwise little-disturbed forest to systematically fell all the trees of *Couma*. A visit to one of the processing factories of this latex in Manaus reveals the enormous numbers of *Couma* trees that are being cut down without being replaced. The massaranduba tree *(Manilkara huberi).* another species that is felled for its latex, is undergoing similar fate. The Brazilian cherry *Amburana acreana* (Ducke) A. C. Smith and the mahogany *(Swietenia macrophylla* King) have also been systematically removed from the forests. The individual trees that remain today were left because they have crooked trunks or hollow boles. This genetic erosion is occurring and the least usable material remains for the future rather than the capture of germ plasm from the most productive and best trees.

Ironically, those species that are most threatened with extinction are also some of the most useful. They are threatened because they are being mined and not managed. In many cases it is possible to farm or cultivate these most useful of Amazon species. It can only be hoped that efforts of the various research institutions such as INPA in Brazil and INVIC in Venezuela will help solve basic management problems in time to prevent the disappearance of these valuable species from the Amazon forests.

In spite of all the destruction that has been recounted above, there do remain a vast wealth of relatively undisturbed forest and of biological species in Amazonia, and a remnant of the Indian population. There is still much forest to save, and many species-including some whose resource value will add to the ways in which we can, with prudence, use the Amazon region in the future. The challenge for us today is not to lament over the existing destruction but to think of creative ways in which we may work out more rational systems of utilization and conservation of the vast array of Amazonian species.

The continued plundering of Amazonia will begin to seriously affect the physical environment that sustains the forest. It will not change the world's oxygen balance as has so often been misstated; instead it will produce other equally grave effects. To cut down the Amazon forest will add to the atmospheric carbon dioxide and the possibility of a warming world climate through the so-called "greenhouse effect". Knowing that that fifty percent of the rainfall in Amazonia comes from the transpiration of the trees, themselves, points to another consequence of deforestation (Salati et. al. 1983; Salati & Vose 1984). If you replace the forest with grassland, with a much reduced leaf area, then the rainfall will be greatly reduced. With such a reduction, the amount of savanna and other arid vegetation types will increase.

I have presented a gloomy picture of mismanagement of a priceless resource, the Amazon rainforest, but fortunately on the other side in several Amazon countries, significant things are occurring both in the conservation of natural areas and the creation of sustainable systems of land use. Peru, for example, has set up the large Manu National Park in its Amazon region, Venezuela, the vast Canaima National Park, and Brazil, the Tapajós National Park as well as several Ecological Reserves belonging to SEMA, the environmental secretariat. This is an excellent start for the conservation of Amazonia (Wetterberg et al. 1981), but the present system of parks doesn't cover nearly enough area to avoid species extinction on a large scale. Furthermore, many declared parks and reserves exist only on paper and confer no actual protection on the site. We must build on the firm foundation that has begun, to produce a network of conserved areas that protects enough area of forest and as varied a range of vegetation types and local habitats as is possible.

Similarly, there are at least some efforts already underway in most Amazon countries to study and produce sustainable yield systems of agroforestry and other continuous systems such as the seasonal use of nutrient-rich flood plains for agriculture. This knowledge is coming about both through ecological studies of indigenous peoples, (Deneven et al 1984; Kerr & Posey 1984) and through well-planned agroforestry programs, especially in Peru and Brazil. Some crops have been relatively successful in Amazonia, including jute *(Corchorus capsularis)* and malva *(Urena lobata)* grown for fiber on the floodplains of Brazil, and black pepper grown in conjunction with chicken farming which produces manure fertilizer. Although both these examples were successfully introduced by Japanese farmers, such crops are not without their problems. The task of retting the jute water is an unhealthy, hazardous occupation, as is work in the jute factories where there is no adequate protection from the dust. In the case of black pepper crop disease caused by *Fusarium* has rendered many areas unproductive. The indigenous experience and modern research is showing that polyculture agroforestry systems are most likely to succeed, rather than any type of monoculture, wheter it be *Gmelina* trees or the pasture grass *Brachiaria.*

THE SPECIES DIVERSITY OF AMAZONIA

Without doubt the most important reason we should be concerned about the destruction of Amazonian forests is because of the vast number of species they contain. The threat of extinction is so great in the Amazon because so many species live as specialists adapted to particular habitats, and so many exist in a limited range.

In the Amazon region there is a rich variety of species of each general type of organism that's unmatched in other places in the world. Henry Bates, who spent 11 years in the Amazon region from 1848 to 1859, described 8,000 new species from his 14.712 collections (Fleming 1969). Today, still only a small percentage of the insects have been named. A single hectare of forest which I examined in detail near Manaus, Brazil contained 179 species of trees of 15 cm. diameter or more and 236 species of 5 cm. diameter or more (Prance et al. 1976). Many similar studies have shown that the species diversity of forest trees is high throughout the region, varying a bit according to the local rainfall (Gentry 1982).

The various factors causing this enormous species diversity are well-known to members of this audience and I do not need to detail them here, but an equally important aspect for conservation and utilization considerations is the interactions between species. With such a diversity the interactions are also extremely diverse. In order to manage or to conserve the rainforest ecosystem we must be aware of pollination, dispersal, mycorrhizae, predator defense mechanisms and many other interactions between the different organisms.

BALANCE OF CONSERVATION AND UTILIZATION

Do we have to let the destruction continue? Or can we preserve the species diversity of Amazonia and still support a reasonable population density in Amazonia? I have shown that many, but not all of the projects that are causing deforestation are for replacement systems that we can, with some justification, call ecologically unsound. The sustenance, for example, of one cow on one and a half hectares, instead of over 1,200 individuals of 200 species of trees, or the destruction of a hectare of forest to remove a single mahogany tree. The answer to the present destruction, therefore, is not to create a vast biological reserve as a playground for naturalists and rich tourists from more developed countries. A viable can only be attained through a balance of conservation and utilization. Too often these two words are at opposite extremes. On a worldwide basis this is beginning to change, especially since the production of "World Conservation Strategy" by, the International Union fot the Conservation of Nature and Natural Resources (IUCN), the World Wildlife Fund (WWF), and the United Nations Environment Program (UNEP) in collaboration with the Food and Agricultural Organization of the United Nations (FAO) (IUCN, UNEP, WWF 1980).

The World Conservation Strategy expounded well the need for a balance between conservation and utilization. This is certainly the most logical step for the future of Amazonia. We need to remember the large size of the indigenous population which the region sustained before it was conquered by Westemers (Meggers 1971). We therefore need to learn as much as we can from what is left of these indigenous cultures, which means that ethnobotanical and especially ethnoecological studies of the Amazonian Indians are an urgent priority.

Recent quantitative studies of Amazon Indians (Boom 1985; Balée 1986) have shown the phenomenal number of rainforest species used by the forest Indians. For the first time we have a quantitative idea of how much of the forest is used by the Indians (Table 1). These data are a spectacular tool for conservation. However, ethnoecological studies can equally well be the pointer to more prudent utilization. Studies of various indigenous agricultural systems are showing highly productive systems that sustain a reasonable population. Good examples include those studies of the Huastec by Alcorn (1984), the Bora Indians (Denevan and Padoch in press) and the Kayapo Indians (Posey 1982, 1984).

It is also urgent to inventory and discover the useful plants and animals of the Amazon and of tropical rainforests of other parts of the world. It is among these unknown and underexploited species that we will find ones more suitable for the region than cattle or the gmelina tree. Many of the most successful crops in the tropics are growing on the opposite side of the world from their origin. We should not be afraid of the exchange of germ plasm with, for example, Malaysia or Indonesia. It is no coincidence that the main emphases of the newly formed Institute of Economic Botany of the New York Botanical Garden are the study of indigenous agricultural systems and the search for new food and fuel plants from the tropical forest. That is why we have investigators studying the fruit trees of the Peruvian Amazon, the agroforestry systems of

TABLE 1. Utilization of Inventory Trees ≥ 10 cm dbh by the Chácobo and Tembé Indians (by category) after Brian Boom, and William Balée.

A. CHACOBO

No. Species-117 — *No. individuals-499*

Category	*No. species (%)*	*No. Individuals (%)*
1. edible	44 (37.6%)	155 (31.3%)
2. edible for game	110 (94.0%)	484 (97.4%)
3. construction material	28 (23.9%)	160 (32.1%)
4. technological	21 (18 %)	228 (45.8%)
5. medicinal	24 (20.5%)	228 (45.8%)
6. fuel	96 (82.1%)	397 (79.8%)
7. other	8 (6.8%)	67 (13.5%)

B. TEMBE

No. Species-138 — *No. individuals-525*

Category	*No. species (%)*	*No. individuals (%*
1 edible	35 (25.4%)	122 (26.8%)
2. edible for game	118 (85.5%)	405 (88.8%)
3. construction material	52 (37.7%)	223 (48.9%)
4. technological	28 (20.3%)	105 (20.0%)
5. medicinal	16 (11.6%)	90 (19.7%)
6. fuel	126 (91.3%)	432 (94.7%)
7 other	21 (15.2%)	90 (20.1%)

the Amuesha nation in Peru, the ethnobotany of the Chácobo Indians in Bolivia, the economic plants of the Ecuadorean Amazon, and the economics and botany of the babassu oil palm in Brazil. But this is only a beginning. There is desperate need for a basic inventory of all the plants of Amazonia, not just those of known economic potential.

Experience has shown than in most of Amazonia it is difficult to make permanent cattle pasture. We must develop sustained yield systems that continue to support people through the years. The future should be much more with trees and perennial crops than with open clearing and exposure of the fragile soil to grassland or annual crops.

Why use the cow, an animal that does not belong in the rainforest habitat? Unlike the drier African grasslands which are suitable for large browsing animals, the Amazon does not have a heritage of many such animals. There are no wild herds of elephants, giraffes, wild beast, zebras, or cape buffa-

TABLE 2. A comparison of the use of capybaras and cows in the conditions of the Pantanal of Mato Grosso, Brazil (from Dourojeanni, 1985).

	Individuals for 3 hectares	*Age at harvest (years)*	*Weight at harvest (Kg)*	*Medium weight gained (g/day)*	*Medium weight gained/3 ha (g/day)*
Species					
Cow	1	4.5	490	283	283
Capybara	18	1.5	35	63	1,134

loes roaming the Amazon region. Instead there are only tapir and a few deer. Nature is telling us something. Large browsers have not evolved in Amazonia, and we should follow nature's hint. Use the Amazon primarily to produce trees, not beef but other meat producing animals more suitable for the region. Already water buffalo have been successful in the Amazon delta region, especially on the Switzerland-sized Marajó island at the mouth of the Amazon. Venezuela is experimenting with the commercial production of capybara, the world's largest rodent *(Hydrochoerus hydrochaeris),* and an Amazonian native (see Ojasti, 1973, Dourojeanni 1985 and Table 2). Capybara meat is highly esteemed. Turtle farming is underway in Belém. Brazil could produce turtle meat without depleting the wild stock of these severly endangered animals. We should also experiment with the local species of deer, tapir, agoutis, and other native animals that might be farmed in a less destructive way than cattle.

The lesson from Rondônia, mentioned above as an example of destruction, is that some uses of the rainforest area are working. Conservationists need to examine some of the successful agricultural projects of Rondônia and see the number of people who have been successfully settled there before they condemn every deforestation project out of hand. In a recent visit to Rondônia, in late 1984, I was impressed by some of the cacao plantations, rice cultivation projects, and even a few of the cattle ranches among many others that were obvious disastrous failures. Those of us who are concerned about deforestation and the conservation of the genetic resources of Amazonia are quick to mention the faitures like Fordlândia and the Transamazon colonization, but slow to acknowledge that some projects that have replaced primary forest are in fact working and providing a good living for their owners. These projects are in a minority, but they do demonstrate that some people have mastered techniques to use the fragile Amazon soil. One of the tragedies of rainforest conservation is the gap between conservationist and the agronomist or forester. We need at least need to examine what they have to say to begin planning with them. We must keep informed about which development projects are working, as well as the ones that are not.

The extremists on either side are not helping the eventual cause of either conservation or prudent utilization of resources. Each side needs to begin to learn from the other so that we encourage the wide use of Amazon soils, and strongly discourage the many wasteful and ecologically unsound practices that are now prevalent. At the same time we should create adequate and scientifically planned conservation areas.

As with examples of destruction, a long list of constructive programs could be called to attention; again only a few examples can be cited to indicate the direction in which future development of the Amazon region is more likely to succeed.

The residents of the small town of Tamshiyacu in the Peruvian Amazon, mostly of Indian extraction, have developed an agroforestry system based on a wide diversity of crops and products. An approximately thirty-five year cutting cycle of trees is followed (Denevan et al. 1984; Paitan, in press; Padoch, in press). As a result, these people are extremely well-off in comparison to most rural Amazonians. Their largest crop, the umari *(Poraqueiba),* is a fruit tree that yields throughout most of the cycle but is finally sacrificed as a source of firewood. The Brazil nut trees, which take much longer to grow and yield, are one of the other tress interspersed into the system. They are successfully pollinated in such a mixed forestry system, and they also obtain sufficient nutrients from the soil in this managed forest. Eventually they yield a high quality timber as well. One of the keys to the Tamshiyacu success is a diversity of crops rather than a plantation of one species, something that is much more similar to the natural Amazon ecosystem.

The original indigenous populations on the Amazon were largely riverine floodplain-based cultures, such as the Omagua and Tapajós Indians described by Meggers (1971). They cultivated between the floods, had elaborate storage techniques for preserving food through the flood season, and used the fisheries resources for the river. The riverside soils along white water rivers are different from those of the *terra firme* because of the effect of

TABLE 3. Comparison of flood plain and *terra firme* soils near Manaus, Brazil (Data from F. Magnani based on analysis made at INPA, 18 Nov. 1982).

	Sample Habitat	*pH*	*P (ppm)*	*K (ppm)*	*Ca*	*Mg*	*Al*
	FLOODPLAIN						
401	Ariau-Várzea Floodplain	5.3	70	45	7.0	2.4	0.3
402	Ariau-Várzea Floodplain	5.3	85	62	8.5	2.3	0.3
409	Curuá-Una Floodplain Forest	6.6	65	46	4.5	0.8	0.8
	CATTLE PASTURE ON TERRA FIRME						
403	T. Loureiro Cattle Pasture	4.0	2	12	0.3	0.1	2.0
404	T. Loureiro Cattle Pasture	4.0	3	20	0.5	0.2	2.0
	WHITE SAND						
405	INPA White Sand Campina	4.7	2	8	0.4	0.2	0.7
	TERRA FIRME						
407	INPA Terra Firme Forest (KM45)	3.5	1	8	0.3	0.1	2.8
	INPA Terra Firme Forest (KM45)	3.5	1	12	0.3	0.1	3.0

For comparison the average agricultural requirements for Amazonian soils are given below:

K low = 10	high = 30
P low = 46.8	high = 117
Ca low = 2.0	high = 5.0
Mg low = 0.5	high = 1.0

Al: Above 0.5 is often toxic to plants.

annual flooding, with its deposition of nutrients from the alluvial matter. Table 3 shows a comparison of soils in two areas of floodplains and *terra firme*. The riverside soil is much more appropriate for continued agriculture and is even less acidic.

Recently, various agricultural projects have been established on floodplain areas, following a suggestion made years ago by one of the sages of Amazon development, Felisberto Camargo (1951). The city of Manaus used to have problems with the production of lettuce, chives, and other green vegetables. A continuous production now comes from the floodplain near Iranduba and other similar areas. This is in marked contrast to the complete failure of a city government project on *terra firme* at Iranduba. The Iranduba projects give us a good example of the contrast between production from the floodplain or Várzea and that of *terra firme*.

There are problems with floodplain agriculture, however, and one is the damage to fisheries. Recent work, especially by Goulding (1980) has revealed the large number of Amazonian fishes that are fruit and leaf-eating which mainly take their nourishment in the flood season by swimming through the flooded forest. Because the fishery is one of the other priceless resources of the Amazon, floodplain agriculture must not be allowed to interfere with the life cycle of some of the most appetizing of all Amazon fishes, by clearing the forest upon which they depend. Consequently, when advocating the use of the floodplain, one must also ensure preservation of adequate areas of forest for the fishes, or even the interspersing of agricultural areas with tree crops that bear fruit eaten by fishes. An analysis of the fruits which the fishes eat shows that many are from trees of considerable utility, such as the rubber tree *(Hevea)*, the andiroba *(Carapa guianensis)*, a source of timber and medicinal oil, and the jauari palm *(Astrocaryum jauari)*, a source of thatching material and fiber. Fields where lettuce is grown interspersed with rubber and andiroba trees will be far less damaging to the fisheries than open fields without trees.

The challenge of the future is to design and ensure implementation of these constructive systems rather than the more destructive ones more often selected. This should involve much more forestry and much less agriculture than is currently being practiced. If some of the region can be rendered productive on a long-term basis to sustain the nourishment and livelihood of the Amazon region, then other large areas can be conserved in their pristine state for the preservation of the species pool of the region, the maintenance of the fragile soils, and the continuation of the high annual rainfall that is so largely dependent upon the transpiration of the forest.

The type of sustainable use systems mentioned above should be the concern of economic botanists, ethnobotanists, foresters and agronomists among our audience. But all of us can use our discipline in some way to contribute data for the conservation and wise utilization of Amazonia. The systemtists should be pointing out the rare and endangered species, discovering the clusters of local endemics and working out species distributions and frequencies so that informed conservation be carried out. Many of the reserves and National Parks of South America have been set aside because they are areas for which no one has found a use rather then by the use of scientific data. Notable exceptions are the Manú Park in Peru and the reserves in Brazil based on the study by Wetterberg et al., (1976) who analysed centers of endemism of birds (Haffer 1969), butterflies (Brown, 1979) and plants (Prance, 1982).

It is not enough to hide our very interesting data in systematic journals like Brittonia, Caldasia, Revista Brasileira de Botânnica or Acta Botânica Venezuelano. We must see that these data are made available to the efforts of local and international conservation organizations and especially to the politicians who ultimately decide on land use matters. The last two decades have seen a great advance in plant systematics in the rainforest countries of South America. Such projects as Flora Neotropica, Flora de Colombia, Flora de Venezuela, The Flora of Ecuador, Projeto Flora Amazônica and the Flora of the Guianas have all been initiated or made significant progress. These are providing the data we need for prudent conservation.

In addition much progress has been made in the understanding of plant-animal interactions and other biological factors which we must undestand to present viable plans of conservation (see for example; Bonson, 1985 for Amazon and plants, Goulding, 1980 for fish; Prance, 1985 for pollination; St. John 1985 for mycorrhizae and Terborgh 1985 for primates). More of these types of studies should be encouraged and I hope that we will leave this congress really to gather more data which will convince the world that it is vital to preserve the diversity of species of the Amazon rainforest in such a way that they can still interact and maintain a viable system.

Irrevocable loss *can* be averted in the Amazon region, but every year we get nearer to the brink of losing what will soon be the world's last rainforest paradise. We must use every influence we have as biologists to help in a constructive way to use, but not abuse, one of the greatest resources of the world, the Amazon rainforest.

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POSTLUDE

One of the most exciting aspects of the IV Congreso Latino Americano de Botánica is the obvious growing interest in both conservation and its sustainable use systems. The fact that so many young biologists of the region are taking up research projects and interest in these fields means that there is hope for some of the remaining rainforests of Amazonia and the diversity of species which they contain. It was not only exciting to see a "sesión técnica" of the congress devoted to conservation on the program but to find out that is was well attended by participants and that a lively discussion of the papers took place. It also contained a wide range of topics showing that conservation is no longer the realm of a few "eco freaks" but is the subject of serious scientific research, well designed programs of such organizations at IUCN/WWF and Nature Conservancy, and considerable computerized data banks.

Sustainable use systems featured throughout the congress program, some especially interesting and promising examples were presented from México and Brazil (Zizumbo; Contreras et al.; Sanabria-Diago; Gispert and Gomez; Anderson and Gély). These papers indicate the value of detailed studies of indigenous ecology and management techniques and their superiority to many of the systems that contemporary culture is imposing on the region. What can learn from such indigenous agroforestry techweniques is much more likely to lead to a locally designed technology that is much more appropriate for tropical rainforest areas. There is a desperate need for land use systems that yield continually cut new areas of forest each year. I am sure that the congress will encourage greater emphasis on research in both conservation and utilization, and hope that those interested in both areas will collaborate closely. Equally important is the publicity of this work to legislatures, the financial community and other influential people.

Nota del Editor: El autor de esta conferencia, Dr. G. T. Prance, envió este anexo en el cual incluye algunos comentarios resultantes de su participación en el Congreso. Los anexamos con gusto dado su importante contenido.

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