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Ethnoecology as Applied Anthropology in Amazonian Development

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Social and ecological devastation in Amazônia necessitates alternative strategies for sustained, ecologically sound development. The study of indigenous ecological knowledge (ethnoecology) is shown to offer the bases for these new strategies. Six categories of folk knowledge are explored: gathered products, game, aquaculture, agriculture, resource units and cosmology. A set of recommendations for systematic ethnoecological research is offered, the application of which will not only identify new categories of resources, but also offer alternative resource management strategies to bring the benefits of development to all residents of Amazônia.

Key words: ethnoecology, economic development, subsistence strategies, Amazônia

To find alternative paths for the development of hinterland regions that lead to greater human riches for more people, we need to begin with a less arrogant view of the superiority of our world of shiny hardware, a greater appreciation of the wisdom—and the potential power—of the villagers we would teach and guide (Keesing 1980:6).

AMAZÔNIA (SEE FIGURE 1) IS CONSIDERED to be one of the last terrestrial frontiers of the planet. Tremendous ecological and social devastation has followed in the wake of recent attempts to "develop" this region (Davis 1977; Denevan 1973, 1981; Foweraker 1981; Sioli 1980; Smith 1982). The early history of economic exploitation in Amazônia was characterized by enterprises based upon the promotion of simple technology, de-centralized, extractive activities that relied upon the knowledge and labor of indigenous peoples who were most often subjected to a system of "quasi-slavery" (Barbira-Scazzocchio 1980:xv; Reis 1974: 34). Little natural environmental degradation occurred, although the indigenous population appears to have been devastated (Denevan 1970; Dobyns 1966; Morey 1978; T. P. Myers 1978). Gradually, however, changes in world market demand, the structure of capital investment and returns, and general social, economic, and political developments resulted in two problems that, by the 1970s, were commonly shared by the South American countries whose national territories encompass portions of Amazônia. First, these nations had all become net food importers (World Bank 1980); and secondly, they all had developed severe balance of payment deficits (Hecht 1981:62, Table 1). In order to rectify these problems, these nations turned to their Amazonian hinterlands with a variety of developmental goals. These goals were:

> . . . 1) to increase basic food production; 2) to expand exports; 3) to alleviate population and political pressures in non-Amazon regions of the countries; 4) to improve access to non-agricultural resources such as timber, minerals, hydropower, etc.; 5) to promote economic integration; and 6) to secure national boundaries. (Hecht 1981:63).

To achieve these goals, the Amazonian countries instigated large-scale development projects such as road-building, colonization programs, monocrop agriculture, cattle ranching, and mining in their Amazon territories.

From a purely economic viewpoint, the performance of these development projects in Amazônia has been poor. Highly proclaimed commercial forest schemes, like the Jari Project, have proven unprofitable (Hecht 1981:78). Cattle ranching, the major vector for development funds and enterprise in the Brazilian Amazon during the last decade (Goodland 1980:18), has similarly failed to generate long-term, fiscally sound development (Hecht 1982:27–28). For example, in the Brazilian Amazon approximately 95% of all cleared land is used for cattle ranching; yet, in the Paragominas region of Para alone, 85% of the recently established cattle ranches are now unproductive due to pasture degradation (Hecht 1981:96).

From a social standpoint, the results of development projects in the Amazon are equally poor. Indigenous populations in Amazônia have suffered significantly from efforts to develop and "conquer" the region. Entire groups have been eliminated (Davis 1977; Indigena 1974). At least 87 Amerindian societies have become extinct in the Brazilian Amazon alone over the past 75 years (Ribeiro 1970:238). *Caboclos*

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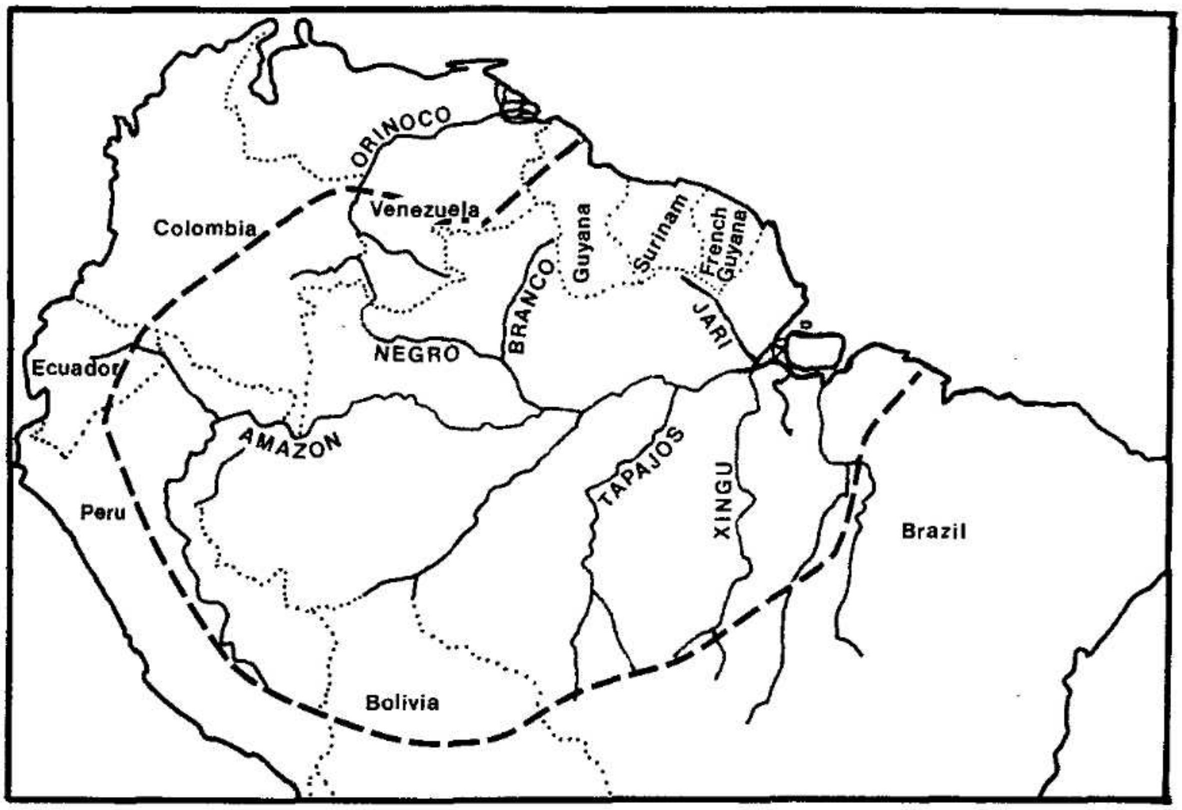

FIGURE 1. APPROXIMATE LIMITS OF AMAZONIA

and *colonos*[1] have fared little better even though one of the major justifications for varied development projects in Amazônia has been the provision of new lands for settlement and small-holder farming which would contribute to relieve population pressure, poverty, and unemployment (Bunker 1981; Schmink 1981). However, colonization projects from the Tocantins to the Trans-Amazon Highway have abysmal social success records (Moran 1981; Smith 1982).

Development projects are also accelerating rates of deforestation, soil destruction, and desertification in Amazônia (Cultural Survival Inc. 1982; Fearnside 1979). Amazônia constitutes the largest tract of tropical rain forest in the world, over 55 million hectares. Despite controversy over the current amount of deforestation in Amazônia (see Fearnside 1982; Hecht 1981:65–66), authorities agree that land clearing is occurring at an alarming rate that threatens the viability of the entire region. Deforestation destroys the ecosystem nutrient cycle, and inevitably and rapidly leads to leeching, soil compaction, soil erosion, and flooding (Goodland and Irwin 1975:23–36; Sioli 1980). This is followed by water pollution, changes in water turbidity, and changes in pH that reduce or destroy aquatic life (Lovejoy and Schubart 1980: 23–24; Schubart 1977). It is estimated that continued deforestation in the Amazonian rain forests, one of the most species-diverse regions in the world (Goodland and Irwin 1975:78–111; Sioli 1980:264–265), will push to extinction up to 90% of the natural inventory of organisms before even basic taxonomic descriptions, much less scientific evaluations of their value, can be made (Gottlieb 1981:23).

Largely because of poor economic performance, and partially due to the adverse environmental and social effects of large scale developments, Brazil (the country with sovereignty over the largest section of Amazônia) has reduced the rapid pace of some forms of Amazonian development (Goodland 1980:22). Formulation of a new policy of development in the Brazilian Amazon was supposed to begin in 1979 (Goodland 1980:9). However, Brazilian Amazonian development still appears to be directed towards large-scale projects (currently concentrating upon mining and hydroelectric dam construction) that retain many of the unsound ecological and social aspects associated with the development projects of the last two decades (Wright 1983).

Failure of the bulk of Amazonian development projects underscores the necessity for radically different strategies if development is to be humane, productive, and ecologically sound. This paper argues that indigenous systems of resource perception, utilization, and management can contribute significantly to these alternative strategies and are the logical products of applied ethnoecological research.

It must be noted, however, that a critical aspect of alternative strategy development as proposed herein is the formulation and implementation of equitable indigenous rights policies throughout Amazônia. Respect for the cultural integrity of Amazonian indigenous and peasant populations has been growing. In reality, many Amazonian nations already have laws guaranteeing indigenous populations rights to their lands and to the retention of their particular cultural practices (for example, for Brazil see Ramos 1980:228; and for Venezuela see Frechione 1981:139–142). Generally these laws have been ignored or have been difficult to enforce due to the remoteness of Amazônia within the infrastructure of the region's nations. The continuing integration of Amazônia into national and international systems has made it more difficult for these laws to be ignored, or for negligence to escape attention.

In addition, indigenous and folk societies are now organizing themselves into political and economic interest groups with the power to represent their interests within the regional, national, and international systems (Barbira-Scazzocchio 1980:xv). The Shuar Federation in Ecuador (Salazar 1981) and the Union Makiritare del Alto Ventuari in Venezuela (UMAV) (Frechione 1981) are examples of such successful movements. Groups are becoming politicized and are knowledgeable of the potential value of their ethnoecological expertise and the natural resources of their territories. In some areas, they are attempting to limit exploitation in their territories without their participation, or the assurance of equitable recompense (UMAV 1978, personal communication).

In this paper we do not suggest a policy of isolation for Amazonian populations or a complete "hands off" policy for the development of the area in general, but rather a cooperative strategy for the formulation of development planning based upon a combination of indigenous ethnoecological knowledge and western scientific knowledge that is fostered by the Amazonian nations and by the international community.

Indigenous Roots

Ethnoecology may be defined as indigenous perceptions of "natural" divisions in the biological world and plant-animal-human relationships within each division. These cognitively defined ecological categories do not exist in isolation; thus ethnoecology must also deal with the perceptions of interrelatedness between natural divisions (Posey 1981). The diversity of indigenous strategies aimed at the integrated utilization of natural resources is witness to the complexity and richness of Amazonian ecosystems. The strategies themselves are interrelated, forming an overall cultural system inextricably wrapped in myth, ceremony, kinship, and politics (Posey 1981). For purposes of clarity in this paper, however, we divide the text into six sub-headings with suggestions for the incorporation of indigenous ideas into new development strategies. These six areas of consideration are: (1) gathered products, (2) game, (3) aquaculture, (4) agriculture, (5) resource units, and (6) cosmology.

Gathered Products

Gathering refers to procurement of wild plants, animals and animal products, and various inert elements for food, materials or medicines. The array of wild plants collected by Amazonian Indians is known to be extensive, but taxonomic, pharmacological, and nutritional data remain scanty. A limited number of wild food sources have been described in detail (e.g., Cavalcante 1972, 1974). Gathered plants are used for cordage, thatch, oils, waxes, fuels, ointments, tools, ornaments, perfumes, timber, pigments, dyes, gums, resins, and fibers, to name a few (e.g., Prance et al. 1977; Steward 1948; Verdoorn 1945). Many plants also have medicinal value (cf. Kreig 1964; Poblete 1969), but ethnopharmacology is a regrettably underemphasized field of research. Table 1 lists some representative plants gathered by Amazonian Indians and the uses of these plants (see also Fidalgo and Prance 1976, Prance et al. 1977).

Insects are another major gathered product (Ruddle 1973). Entomophagy, insect eating, is widely reported (cf. Beckerman 1979:538–539; Posey 1980; Smole 1976:163–167) but not systematically studied in the Amazon. However, substantial evidence now documents the importance of bees (*Apidae*) and bee products (resin, wax, honey, pollen) to indigenous groups (see Posey 1981, 1982b). Table 2 lists a number of species of bees that are exploited by the Kayapó Indians of Brazil.

The initial developmental value of indigenous and folk knowledge concerning gathered products is likely to be based on the identification of products having pharmacological and industrial applications within the Western system. Indigenous knowledge of wild plants has already made significant contributions to modern pharmacology (see, for example, Kreig 1964). Generally, the indigenous peoples have not benefited from this application of their knowledge. An equitable system of remuneration is required if this type of development is to be successful both economically and ethically.

Gathering could also be part of an integrated development plan with the collection and marketing of already important wild forest products (e.g., Brazil nuts and rubber) taking place during the appropriate season. When given the opportunity, Amazonian Indians have proven themselves quite capable of successfully directing such enterprises. For example, the Gaviões of central Brazil now profitably collect and market Brazil nuts in their area. This is due in large part to their having taken control over the production, transport, and marketing of their products (Ramos 1980). In this case, it is important to note that in some areas of Amazônia a dense stand of Brazil nut trees "... generates more revenue than an equivalent area of pasture" (Bunker 1981:56) devoted to cattle herding.

Indigenous ethnoentomological knowledge is being utilized in southern Venezuela where a group of Sanema (Yanomamo) Indians have established bee hives with plans to market the honey (UMAV 1982, personal communication).

Some potentially valuable wild plants may also be suitable for more controlled production. For instance, *Calathea lutea*, a tall herb that grows wild in swamps in the Amazon Basin, produces a wax similar to carnauba. This plant is easy to cultivate and harvest, and could provide jobs and income while exploiting otherwise unusable swampy areas in the region (National Academy of Sciences 1975:137–140)

These brief examples indicate that indigenous knowledge of gathered products has potential for inclusion in development planning for Amazônia.

Game

Indigenous inhabitants of Amazônia hunt many forms of mammals and birds (see Table 3 for an example of game species hunted by the Yekuana of southern Venezuela). The

TABLE 1. REPRESENTATIVE GATHERED PLANTS OF THE TROPICAL FOREST AND THEIR USES (BASED UPON LOWIE 1948:7–10).

Common name(s)	Scientific name	Use
	Drugs and poisons	
Assacu, possumwood, sandbox tree	*Hurs crepitans*	fish drug
Ayahuasca, cayapi, yage, huni	*Banisteriopsis* spp.	hallucinogenic drug
Cunambi	*Clibadium surinamense*	fish drug
Curare, curari	*Strychnos toxifera*	hunting poison
Curupa	*Mimosa aracioides*	cathartic drug
Floripondia, campa, datura	*Datura arborea*	hallucinogenic drug
Guayusa	*Ilex* sp.	anesthetic agent
Parica, yupa, niopo	*Mimosa acacioides*	hallucinogenic drug
Timbo	*Paullinea pinnata*	fish drug
Yoco	*Paullinia yoco*	hallucinogenic drug
	Foods and manufactures	
Almecega	*Tetragastris balsamifera*	resin used for fuel
Ambaiba	*Cercropia* sp.	various products
Anaja, palm	*Maximiliana regia*	fiber used in basketry
Andirobá, Brazilian mahogany	*Carapa guianensis*	oil used for fuel
Angelim	*Andira* sp.	wood for canoes
Aratazeiro	*Anonaceae* sp.	wood for bows
Arrow reed	*Gynerium saccharoides*	arrow shafts
Assaí palm	*Euterpe oleracea*	fruit eaten
Palm	*Attalea humboldtiana*	fruit eaten
Palm	*Attalea spectabilis*	fruit eaten
Pine tree	*Araucaria brasiliensis*	nut eaten
Babassú palm	*Orbignya speciosa*	oil and fruit eaten
Bacaba palm	*Oenocarpus bacaba*	oil for cooking
Bactrix marajá, palm	?	fruit eaten
Brazil nut, Pará nut	*Bertholetia excelsa*	nut eaten
Buriti, muriti, achua, palm	*Mauritia flexuosa*	numerous products
Bussú palm	*Manicaria saccifera*	leaves for thatch
Cabacinho	*Theobroma* sp.	pith eaten
Cajú, Cajueiro	*Anacardium occidentale*	fruit eaten
Camayuva cane	*Guadua* sp.	arrow shafts
Carayuru	*Bignonia chico*	pigment from leaves
?	*Carludovica trigona*	material for baskets
Castanha, Brazil nut	*Bertholletia excelsa*	nut eaten
Cedar	*Cedrela angustifolia*	wood for canoes
Cumarú	*Coumarouna odorata*	condiment from bean
Cupuassú	*Theobroma grandiflorum*	pith eaten, oil from seeds
Curauá	?	fiber for cordage
Curuá piranga	*Attalea monosparma*	leaves for thatch
Embira	*Couratari* sp.	fiber for cordage
Palm	*Euterpe oleracea*	fruit eaten
Greenheart	*Nectandra rodioei*	seeds eaten
Guaraná	*Paullinia sorbilis*	medicine and condiment
?	*Hymenaca courbaril*	resin used as glaze
Iacareva	*Calophyllum* sp.	wood for canoes
Itauba	*Ocotea megaphylla*	wood for canoes
Itauba	*Silvia itauba*	wood for canoes
Itauba	*Silvia duckei*	wood for canoes
Jabotá	*Cassia blancheti*	bark for canoes
Jatahy	?	bark for canoes
Jauary	*Astrocaryum jauary*	various products
Jerimú, jerimum	?	fruit eaten
Manga, mango	*Mangifera indica*	fruit eaten
Masaranduba	*Mimusops excelsa*	fruit eaten
?	*Moronobea coccinea*	gum used for glue
Nibi	*Carludovica* sp.	vine used in basketry
?	*Oenocarpus* sp.	fruit eaten
Palo de balsa	*Ochroma* sp.	wood for rafts
Pau d'arco	*Tecoma* sp.	wood for bows

TABLE 1. CONTINUED.

Common name(s)	Scientific name	Use
Paxiuba, pashiuba palm	*Iriartea ventricosa*	materials for houses
Leopardwood	*Brosimum aubletii*	wood for bows
Pequí, pequiá	*Caryocar villosum*	seeds for oil and food
?	*Pratium heptaphyllum*	resin used for fuel
Siriva palm	*Cocos* sp.	wood for clubs
Tucumã	*Acrocomia officinalis*	cordage and edible fruit
Tucumã	*Bactris setosa*	cordage and edible fruit
Tucumã	*Astrocaryum tucuma*	cordage and edible fruit
Urucurí palm	*Attalea excelsa*	resin used as glaze

Jivaro have knowledge of the significant details of animal behavior, including cries and calls, preferred foods, types of excrement, scents, teeth marks on fruit, and so forth (McDonald 1977; Ross 1978). According to Hames (1979: 7–8, 20), some Yekuana and Yanomamo alternate hunting activities among a number of hunting zones to benefit from the increased fauna produced by an "edge effect" linked to numerous overlapping biotopes of the hunting zones. Reichel-Dolmatoff (1978:286) states that Desana shamans continually inventory resources and game to channel group exploitative activity. These represent indigenous attempts at resource management.

Game animals are efficient in use of available food, with high protein-to-fat ratios and resistance to diseases (de Voss 1977; Sternberg 1973; Surujbally 1977). Some game animals could potentially be cropped in a form of "semi-domestication" in abandoned garden sites (see section on Natural and Human-Made Resource Units below) or in an integrated management system combining the animals with plantations of fruit-bearing trees favored by the animals and to which they are attracted (Smith 1977). This "game farm" strategy has been suggested as a viable system for sustained Amazonian development (Goodland and Bookman 1977; Goodland et al. 1978; Smith 1977; Vasey 1979).

The immediate application of game farming would be to improve the subsistence methods of small farmers (Goodland 1980:17) and their diet. It is also important to note that some small animals, such as the agouti (*Dasyprocta* sp.) and capybara (*Hydrocherus hydrochaeris*), and birds, like the currasow, might be susceptible to "semi-domestication" in enclosed areas (fenced, abandoned garden sites or areas adjacent to household gardens) for significant surplus production and sale.

Aquaculture

One of the most promising strategies of aboriginal resource utilization with potential for large-scale development is aquaculture, or systems of water resource management (Goodland 1980:14). Indigenous populations in Amazônia make use of numerous species of fish, reptiles, and water mammals, as well as some forms of riverine and lacustrine vegetation. Amazônia contains the most diverse freshwater fish fauna in the world (Smith 1981:18).[2] Fish provide substantial portions of protein for most indigenous groups (Ross 1978; Sternberg 1973). Fish also have high quantities of essential amino acids (Bell and Canterbury 1976) and are superior to meat animals in terms of feed/protein conversion ratios as illustrated in Table 4.

During the past two decades, commercial fishing in Amazônia has become a profitable industry. However, little is actually known of the life cycles of even the most important commercial fish species (Smith 1981:121), and commercial exploitation appears to be drastically reducing the populations of these fishes (Goulding 1980:154).

Turtles are also efficient in meat/protein production (Smith 1974:85). Turtle meat is a delicacy in many parts of the world, and would be a highly exportable and valuable commodity. Since aboriginal times, Indians have corralled turtle-breeding groups for year-round cropping of their meat and eggs (Smith 1974:85; Sternberg 1973:258).

Caimans (various species) may prove important in large-scale aquaculture because they too can be bred in captivity (Montague 1981). They can provide both meat for local consumption and skins for export. They also play an important role in nutrient cycling in Amazonian waters (Fittkau 1973).

The manatee (*Trichechus inongrus*) can also be managed to produce meat while at the same time contributing to the larger aquacultural system by keeping waterways clear of vegetation and releasing large amounts of nutrients into the water to stimulate primary fish production (Myers 1979:178; Spurgeon 1974:239).

Lacustrine and riverine vegetation do not appear to have been directly exploited to any great degree by indigenous groups in Amazônia. However, some groups in the Xingu River area did make a kind of salt by burning the leaves of the water hyacinth (*Eichhornia crassiper*). Nonetheless, this vegetation shows considerable potential for inclusion in a highly productive aquaculture. Water hyacinth (*Eichhornia crassiper*) purifies water (⅓ hectare can purify one ton of sewage per day) and filters out toxic heavy metals (Myers 1979:78). A variety of other water plants that form familiar "floating meadows" generate as much as seven tons of biomass per hectare per day (Myers 1979:78). These floating meadows provide food for numerous invertebrates which in turn are consumed by fish (Smith 1981:13).

Detailed studies of Amazonian aquatic ecosystems and their relationship to terrestrial environments are only now being undertaken (Goulding 1980; Smith 1981). These studies suggest that the clearing of várzea forest, a process related to some types of development projects, appears to have a

TABLE 2. PRINCIPAL SPECIES OF APIDAE UTILIZED BY THE KAYAPÓ.

Kayapó designation	Scientific designation	Wax use[1]			Honey availability		Other uses[2]				Aggressiveness[3]	Distinctive traits
		U	C	M	Season	Amount	LE	PE	POE	RU		
ngài-pêrê-ỳ	*Apia melligera*	+	+		all year	very much			+		A	honey taken during New Moon
ngài-ñy-tỳk-ti	*M. semiligra*	+	+	+	dry	average					B	bee parts used for hunting magic
ngài-kumrenx	*M. rufiventris*	+	+	+	all year	average						
ngài-re	*M. compressipes*	+	+	+	all year	much						markings like tapir
ngài-kàk-ñy	*Partamona* sp.											wax used in magic
mykrwàt	*Frieseomelitta* sp.	+	+	+	all year	average	+	+	+			
udjỳ	*T. amlthea*				dry	average				+		bee parts used for hunting magic
kukraire	*T. dallatorreana*				all year	much			+		C	break off limb with nest and run to expel bees
mehnôrà-kamrek	*T. cilipes*			+	all year	little				+		eyes like jaguar
mehnôrà-tỳk	*Scaura longula*			+	all year	little				+		used for jaguar hunting magic
kangàrà-krà-kamrek	*O. tataira*	+	+	+	all year	average	+	+	+		A	cut tree to take honey
kangàrà-krà-tyk	*Oxytrigona* sp.	+	+	+	all year	average	+	+	+		B	bee causes blisters on skin
kangàrà-udja-ti	*Oxytrigona* sp.	+	+	+	all year	average	+	+	+		A	used in hunting magic
kangàrà-ti	*Oxytrigona* sp.	+	+	+	all year	average	+	+	+		A	
mỳre	*T. pallena*	+	+	+	all year	average					C	sometimes fell tree
ngôi-tênk	*Trigona* sp.		+		all year	average						live in termite nests
djô	*T. fuscipennis*	+	+	+	all year	little						live in termite hills
imrê-ti-re	*T. clinnchamayoensis*				all year	little	+	+	+			live in ant nests
kukoire-kà	*Partamona* sp.				all year	average					C	nests in termite nests
d'i	*Tetragona* sp.				dry	little						very acidic honey; fell tree
tôn-mỳ	*Tetragona* sp.	+	+	+	dry	average				+		fell tree
rì	*Tetragona* sp.	+	+	+	all year	much				+		bees thought to be "stupid" and weak
mehr-xi-we'i	*Tetragona goettie*	+	+	+	all year	average						found only in Xingu
mènire-udgà	*T. quandrangula*	+	+	+	all year	average						opening of nest like a vagina
mehnôdjành	*F. varia*				dry	little				+		smoke from wax used for curing
mehñykamrek	*T. apinnipea*	+	+	+	dry	little	+	+	+		C	burn wax; smoke causes dizziness
mehñy-tyk	*T. banneri*	+	+	+	dry	little					C	
pyka-kam	*T. fulvivintria*	+	+	+	dry	little				+	C	bee deposits drops of resin on skin

[1] U = Utilitarian, C = Ceremonial, M = Medicinal.
[2] LE = larvae eaten, PE = pupae eaten, POE = pollen eaten, RU = resin used.
[3] Nests of aggressive bees are raided using smoke and fire to expel bees first. A = very aggressive, B = moderately aggressive, C = slightly aggressive.

direct, adverse effect upon aquatic fauna (Goulding 1980: 252–253; Smith 1981:125–127). These data support the ethnoecological knowledge of indigenous groups who are well aware of the interrelationship between the forest and aquatic fauna (see, for example, Chernela 1982).

As noted above, some aquatic faunal and floral species appear to present possibilities for surplus production within an integrated system of management. The potential for implementing aquatic management systems is an area requiring considerably more study. As Goulding (1980:254) points out, ". . . a better understanding of the natural fisheries and their proper management will be the best method for assuring a continual supply of fish to the Amazon region for years to come." Those persons possessing the best understanding of the natural fisheries in Amazônia are the indigenous populations who have successfully exploited these resources for millenia.

Agriculture

The domesticated plant inventories of the indigenous populations of Amazônia are extensive, yet their potential for

TABLE 3. GAME ANIMALS MOST FREQUENTLY HUNTED BY THE YEKUANA OF SOUTHERN VENEZUELA (FROM FRECHIONE 1981:50).

Scientific name	Common name
Birds	
Ahinga ahinga	Heron
Ara macao	Macaw
Cairina moschata	Duck
Colinus cristatus sonnini	Quail
Columba cayenninsis	Forest dove
Columba subvinacea purpureotineta	White-tipped dove
Cripturellus soni soni	Ponchita
Cripturellus undulatus	Forest chicken
Leptolila verreauxi	Ruddy pigeon
Mitu tomentosa	Crestless currasow
Neochen jubata	Duck
Odonthophorus gujanesis	Wood quail
Ortalis motmot motmot	Guacharaca
Pauxi pauxi	Black currasow
Penelope granti	Guan
Penelope marail	Forest turkey
Rhamphastos sulfuratus	Toucan
Tinamus major serratus	Great tinamou
Monkeys	
Alouatta seniculus	Howler monkey
Ateles belzebuth	Spider monkey
Cebus apella fatuellus	White monkey
Callicebus torquatus lugens	Window monkey
Pithecia chiropes	Saki
Terrestrial mammals	
Cuniculus paca	Lapa
Dasyprocta aguti lunaris	Agouti
Dasyprocta fuliginosa	Picure
Dasypus novemcintus	Armadillo
Hydrochoerus hydrochoerus	Capybara
Mazama nemoriaga	Brocket deer
Tapirus terrestrius	Tapir
Tayassu pecari	White-lipped peccary
Tayassu tacaju	Collared peccary

consumption and industrial uses is poorly evaluated and largely ignored by development planners. An exemplary list of some major cultivars is provided in Table 5. Some of the aboriginal domesticates are well-known and form an impressive list of New World inventions (Ucko and Dimbleby 1969). Many other cultivars remain unknown, or if known are seldom utilized in Western agriculture (Kerr et al. 1978).

Numerous Amazonian domesticates demonstrate a great economic potential and lend themselves to large-scale exploitation (National Academy of Sciences 1975; Williams 1960). Indigenous uses of these plants include more than just foodstuffs; plants are frequently used as medicinals, insect repellants, dyes, and raw materials for production. Indigenous varieties of cultivars attest to the great diversity of genetic stock and afford the opportunity for scientific experimentation in crop adaptations to various tropical soils and environmental factors.

The Western approach to agricultural development has been to eliminate complexity and impose a limited and controlled range of specific cash crop monocultures. In the process, the local natural environment has been destroyed, perhaps irretrievably in light of predictions about the effects of the current rate of deforestation (Denevan 1981; Myers 1981). The genetic diversity and economic utility of local wild and domesticated plants is being lost (Gottlieb 1981). The attempt to impose mid-latitude agricultural practices in Amazônia has resulted in soil erosion, soil compaction, leaching, and the outbreak of epizootic pests and diseases, with concomitant rapidly decreasing agricultural yields (Lovejoy and Schubart 1980; Sioli 1980).

TABLE 4. FEED CONVERSION RATIOS (FROM ACKEFORS AND ROSEN 1979).

	Dry weight feed: live weight	Dry weight feed: shredded weight (flesh)
Cow	7.5:1	12.6:1
Pig	3.25:1	4.2:1
Chicken	2.25:1	3.0:1
Rainbow trout	1.5:1	1.8:1

Justification for the imposition of mid-latitude agricultural methods traditionally has been that the shifting cultivation systems of the indigenous populations are primitive and inefficient. However, scientists now recognize that the range of indigenous agricultural systems is more complicated and, generally, better adapted to tropical conditions than was previously assumed (Conklin 1969; Dickinson 1972; Frechione 1981; Geertz 1963; Lovejoy and Schubart 1980).

Indigenous agriculture depends heavily upon native plants which demonstrate an adaptation to localized climatic conditions (Alvim 1972, 1980; Lathrap 1970:37–38). They have also been found to be more efficient in their utilization of micro-nutrients and less dependent upon nutrients considered essential for good soil fertility in the mid-latitudes (Hecht 1981, personal communication). Indigenous farmers act upon their knowledge of the localized adaptation of certain domesticates by developing what might be termed intra-garden microzonal planting patterns which match specific cultivar varieties with soils, drainage patterns, and other climatic features (Frechione 1981:55; Hames 1980:20–21; Johnson 1974; Leeds 1961:19; Smole 1976:132–135).

Indigenous agricultural systems generally result in positive soil conservation effects. For example, aboriginal field utilization practices minimize the time that soils are exposed to the destructive impact of direct sunlight and tropical rains. Vegetative cover is maintained at various heights to deflect the impact of tropical rainfall and provide sufficient shade, thus helping to prevent rapid erosion and leaching.

Indigenous horticulturalists usually rely on small, dispersed garden sites. Garden dispersal contributes to the maintenance of the ecosystem and the success of native horticulture. The spatial dispersal minimizes the epizootic growth of insect pests and plant diseases (Pimental et al. 1978; Posey 1979; Stocks 1980), thus eliminating the need for expensive and environmentally dangerous pesticides. Garden dispersal also stimulates the growth of wildlife populations (Hames 1979; Linares 1976; Ross 1978). Perhaps most important, indigenous agricultural systems always include "natural corridors" between garden sites. These natural corridors form valuable ecological refuges for plant and animal species (Gomez-Pompa et al. 1972; Lovejoy and Schubart 1980).

TABLE 5. COMMONLY CULTIVATED FOOD PLANTS OF AMAZÔNIA (BASED PRINCIPALLY UPON LOWIE 1948:3–5 AND DENEVAN 1974:101).

Common name	Family	Scientific name
Tubers		
Arracacha	Umbelliferae	*Arracacia xanthorrhiza* Bancr.
Achira	Cannaceae	*Canna edulis* Ker.
Dali-dali	Marantaceae	*Calathea allouia* (Aubl.) Lindl.
Cupa	Vitaceae	*Cissus* sp.
Taro*	Araceae	*Colocasia esculenta* (L.) Schott
Yam*	Dioscoreaceae	*Dioscorea alata* L.
Yam	Dioscoreaceae	*Dioscorea trifida* L.
Sweet potato	Convolvulaceae	*Ipomoea batatas* (L.) Lam.
Manioc	Euphorbiaceae	*Manihot esculenta* Crantz
Arrowroot	Marantaceae	*Maranta arundincacea* L.
Yam bean	Leguminosae	*Pachyrrhizus tuberosus* (Lam.) Spreng.
Potato	Solanaceae	*Solanum tuberosum* L.
Tania	Araceae	*Xanthosoma sagittifolium* (L.) Schott
Fruits and seeds		
Bacaiuva palm	Palmae	*Acrocomia* sp.
Cashew	Anacardiaceae	*Anacardium occidentale* L.
Pineapple	Bromeliaceae	*Ananas comosus* (L.) Merr.
Peanut	Leguminosae	*Arachis hypogaea* L.
Pigeon pea*	Leguminosae	*Cajanus cajan* (L.) Millsp.
Jack bean	Leguminosae	*Canavalia ensiformis* (L.) DC.
Chili pepper	Solanaceae	*Capsicum* spp.
Papaya	Caricaceae	*Carica papaya* L.
Piqui	Caryocaraceae	*Caryocar* spp.
Star apple	Sapotaceae	*Chrysophyllum cainito* L.
Watermelon*	Cucurbitaceae	*Citrullus lanatus* (Thunb.) Mansf.
Lemon*	Rutaceae	*Citrus limon* (L.) Burm. f.
Orange*	Rutaceae	*Citrus* sp.
Squash	Cucurbitaceae	*Cucurbita* spp.
Hyacinth bean*	Leguminosae	*Dolichos lablab* L.
Surinam cherry	Myrtaceae	*Eugenia unifora* L.
Peach palm	Palmae	*Guilielma gasipaes* (HBK.) Bailey
Mangabeira	Apocynaceae	*Hancornia speciosa* Gomes
?	Leguminosae	*Inga* spp.
Bottle gourd	Cucurbitaceae	*Lagenaria* sp.
?	Sapotaceae	*Lucuma* sp.
Mango*	Anacardiaceae	*Mangifera indica* L.
Plantain, Banana*	Musaceae	*Musa × paradisiaca* L.
Granadilla	Passifloraceae	*Passiflora ligularius* Juss.
Avocado	Lauraceae	*Persea americana* Mill.
Lima bean	Leguminosae	*Phaseolus lunatus* L.
Kidney bean	Leguminosae	*Phaseolus vulgaris* L.
Guava	Myrtaceae	*Psidium guajava* L.
Sicana	Cucurbitaceae	*Sicana odorifera* (Vell.) Naud.
Frutas de lobo	Solanaceae	*Solanum lycocarpum*
Pepino	Solanaceae	*Solanum muricatum* Ait.
Cocona	Solanaceae	*Solanum quitoense* Lam.
Topiro	Solanaceae	*Solanum topiro*
Cacao	Steculiaceae	*Theobroma cacao* L.
Corn	Gramineae	*Zea mays* L.
Other		
Sugar cane	Gramineae	*Saccharum officınarum* L.

* Post-Columbian introduction.

Therefore, species are not only protected from extinction but are reserved close at hand for re-establishment in the "abandoned fields."

Shifting cultivation gardens are highly productive in terms of yields per unit of labor expended (Carneiro 1961:53; Harris 1972:247) and yield per unit of land actually under cultivation (Carneiro 1961:52–53). Manioc and plantain, for example, are especially productive relative to the yield of calories per hectare. The Barafiri Yanoama are capable of producing 23.16 tons of plantain per hectare, yielding 15.6

TABLE 6. REPRESENTATIVE PLANTS COMMONLY FOUND IN REFORESTATION SEQUENCE OF "ABANDONED" KAYAPÔ FIELDS AND ANIMALS ASSOCIATED WITH EACH (BASED UPON POSEY 1982a).

Plant	Kayapó name	Associated animal*	Use of plant	
			Man	Animal
Humeria balsamifera	bà-rerek	A, B, C, D, E	eat fruit	eat fruit
Psidium guinaensis	kamokâtytx	F	eat fruit	eat fruit/leaves
Zinziberaceae	madn-tu	F	tea from leaves	eat leaves
Paschieria sp.	pita-teka		use for paint	
Cataset sp.	pitu		medicinal	
Bignoniaceae	ngra-kanê	C, F	medicinal	eat leaves
Cisampelus sp.	tep-kanê	C, D	fish bait	eat fruit
Piperaceae	màkrê-kanê	A, B, C, D	fish bait	eat fruit
Amasonia sp.	pidjô-râ		prophylaxis	
Oenocarpus distichus	kamêrê	A, B, C, D	eat fruit	eat fruit
Macrostaychia sp.	kukrytmka	F	use wood	?
Monotagima sp.	kûryre	F	eat leaves/roots	eat leaves/roots
Myrsia sp.	kônôkô	A, C, D, F	eat fruit	eat fruit/leaves
Cecropia leucocoma	atwŷra'ô'	H, F		eat fruit/leaves
Paulipodiaceae	tôn-kanê		medicinal	
Clarisia ilicifolia	pidgô-nirê	F	medicinal	eat leaves
Centrosema carajaense	akrô		fish poison	
Cassia hoffmanseggii	pidjô-kakrit	C, D, F	medicinal	eat fruit/leaves

* Animals: A—white-lipped peccary, B—white paca, C—agouti, D—tortoise, E—red paca, F—red agouti, G—deer, H—tapir.

million calories per hectare from the edible portion of the fruit (Smole 1976:150). The Yekuana of southern Venezuela have produced as much as 30 tons of manioc per hectare, yielding 23.8 million calories from the raw tubers, and approximately 6 million calories per hectare from processed manioc products (Frechione 1981:101).

The idea that indigenous shifting cultivators of Amazônia are incapable of producing significant crop surpluses is no longer generally accepted (Carneiro 1961; see also Allen and Tizon 1973; Kloos 1971:38–39; Smole 1976:192–193). Recent research also indicates that properly managed monozoned and basically monocultural gardens planted in native cultigens are no more deleterious to the forest ecosystem than are polycultural gardens (Frechione 1981:102–105; Harris 1971).

Tropical forest cultivators can produce surpluses through shifting cultivation with a minimal amount of labor expended, but they generally lack the necessary economic and political stimuli to do so (Allen and Tizon 1973; Carneiro 1961: 54). As early as 1930, Nimuendaju (1974:115–116) noted that the Ramkokamekra were capable of producing surplus manioc flour, but were deterred from doing so consistently because they lacked the means of transporting this surplus to the marketplace.

Thus, although shifting cultivation is usually discounted as a focus of possible development in Amazônia (Goodland 1980:14–15), it is suggested here that it does have developmental potential. Marketable surpluses of native cultigens can be produced immediately under long-fallow systems in areas where population pressure is low. However, it is usually these areas that lack the transportation facilities and stable markets necessary to encourage such development.

Shifting cultivation can also serve as the basis for the development of ecologically sound and profitable models for agricultural development (see, for example, Dickinson 1972; Janzen 1973; and Sioli 1980:266–269), and as an initial stage in an integrated agro-forestry system (Denevan et al. 1982).

Natural and Human-Made Resource Units

A further manifestation of sophisticated and ecologically sound adaptations to tropical forest ecosystems by the indigenous populations of Amazônia is their recognition and utilization of "resource units," both natural and human-manipulated. The procurement of resources from these units tends to overlap the measurable or statistically quantifiable neat boundaries of hunting, gathering, and horticulture, thereby making it difficult for Western science to recognize or measure the effects of the use of such areas (Posey 1981, 1982a).

Resource units are intimately known and periodically visited to harvest produce (Posey 1982a). Some are the result of naturally occurring concentrations of trees, plants, and animals. Others are artificially induced. For example, the Kayapó Indians systematically gather a variety of forest plants and replant them near camps and major trails to produce artificial resource concentrations that may be denoted as "forest fields" (Posey 1982a). There are at least 54 species of plants[3] used in these "forest fields," including several types of wild manioc, three varieties of wild yams, a type of bush bean, and three or more wild varieties of cupa. This transplanting of wild plants into human-made, higher density forest fields intimates a transitional process of plant semi-domestication (Posey, in preparation) and a type of ecological strategy largely overlooked by Western science.

Abandoned garden sites could be considered yet another type of resource unit. Although the principal agricultural production from shifting cultivation gardens culminates in two to three years, the sites are not totally abandoned after this period (cf. Basso 1973:34–35; Bergmann 1974:147–148; Hames 1980:9; Smole 1976:152–156). In addition, indigenous populations gather a range of plants which appear in abandoned sites as part of the natural reforestation process (Denevan et al. 1982; Posey 1982a; Yde 1965:28, 54). A representative inventory of these plants for the Kayapó are listed in Table 6.

Abandoned garden sites also produce a variety of foods which attract wild animals such as wild pig, coati, paca, agouti, deer, and others (Gross 1975:536; Ross 1978:10), as illustrated in Table 6. Many birds, particularly sparrows, macaws, and parrots, are attracted to these areas and are hunted by the Amerinds (Ross 1978:10). The Kayapó are aware of the attractiveness of these abandoned garden sites to wildlife populations, and in dispersing their fields great distances from their villages maximize the area they can efficiently manage. This large-scale management strategy produces forest reserves where game is attracted in artificially high densities, thereby improving yields from hunting efforts.

Resource units should be identified, initially preserved and studied, and then evaluated on the basis of their potential economic value vis-à-vis alternative development schemes that might eliminate these units. Study of indigenous knowledge of these units also provides invaluable information on ecosystemic relationships.

Cosmology

Further information concerning the complex ecosystems of Amazônia and the various ways in which they can be exploited may be found expressed, directly and indirectly, in the cosmologies, myths, and rituals of the indigenous groups of the region. These concepts influence, and to varying degrees are influenced by, perceptions about the ecosystems with which the indigenous populations interact, and provide important information on ecological interrelationships critical to the functioning of micro-ecosystems.

McDonald (1977) and Ross (1978) have suggested the possible operation of myth-based food taboos in preventing the over-exploitation of various fauna. Reichel-Dolmatoff (1976, 1978) has discussed the Desana shaman's attempts to manage the group's use of natural resources by using sanctions and cosmological constructs which promote the maintenance of balance in a closed system of economic, social, and spiritual forces. Posey (1983) has sketched the function of Kayapó ceremonial cycles in dispersing knowledge concerning the systematic utilization of renewable resources. Furthermore, myth has been shown to encode intricate ecological relationships between the human and natural worlds (Berlin and Berlin 1979; Chernela 1982; Posey 1983).

Conclusions

Development projects for Amazônia have been based upon the imposition of mid-latitude technology and methodology which promotes large-scale forest clearing for ranching and the production of monocultures of a limited number of cash crops. On the whole, these projects have resulted in ecological, economic, and social failures. This paper has suggested the need for systematic study of indigenous systems of knowledge and utilization of the Amazonian ecosystems. It appears that such study can contribute to the formulation of ecologically sound, efficiently productive, profitable, labor-intensive, and integrated management systems of agriculture, aquaculture, and the cropping of wild and semi-domesticated plants, mammals, fish, reptiles, birds, and insects. Besides being commercially productive, such systems would blend with the natural Amazonian ecosystems, thereby preserving the diverse natural genetic stock with its unknown potential for commodities with nutritional, medicinal, and industrial use.

Indigenous knowledge of Amazonian ecosystems is sophisticated and extensive. Amerindians perceive a myriad of ecological zones, the elements composing these zones, and the interrelationships within and between such zones. They discern associations between soils, plants, animals, topography, drainage, and so forth, and rely upon a complex understanding of animal and insect behavior. They manipulate various semi-domesticated and wild floral and faunal species and depend upon long-term use of abandoned garden sites and resource concentrations.

In order to change the nature of development in Amazônia towards one promoting ecologically and socially sound long-term sustained yield systems based upon indigenous knowledge, it is necessary for the international community to sponsor and support appropriate research in a timely manner. National and local governments within Amazônia must allow scientists access to Amerind groups and indigenous areas. Experimental stations need to be established to test the productivity and commercial viability of various integrated management systems. Nutritional, medicinal and industrial values of commodities derived from native Amazonian plants also need testing.

Special emphasis should be given to the study of:

1. Folk ecological zones and their complexity—e.g., the floral, faunal, edaphic and climatic associations within zones as perceived by indigenous populations.
2. Forms of shifting cultivation—e.g., the special adaptations of native plants, the function of vegetative cover and the importance of spacial distribution of crops within gardens for pest and weed control and optimal production.
3. Natural corridors and their role in the preservation of biological diversity and facilitation of reforestation.
4. Manipulation of semi-domesticated plants and animals in "abandoned fields" and "resource units."
5. Sustained yield aquaculture focused upon the integrated and controlled cropping of riverine and lacustrine flora and fauna.
6. Large-scale management of animals and forests to develop "forest-game reserves."

Finally, indigenous societies of Amazônia are in rapid decline. There are a few aboriginal cultures still relatively intact, but little time remains to salvage the valuable information resulting from millenia of accumulated ecological knowledge. Anthropology offers the mechanisms for investigating ethnoecological knowledge, the application of which offers new strategies for ecologically and socially sound sustained yield development strategies for Amazônia.

NOTES

[1] The term *caboclo* is used differently in different parts of Brazil. Here the term refers to those persons who have lived for generations on small farms or in small villages in Amazônia. The true *caboclo* has roots in indigenous cultures and is the intellectual inheritor of indigenous ecological knowledge in many areas. Much of what is said in this paper concerning the ethnoecological knowledge of Indians also applies to *caboclos*. *Colonos* are considered more recent immigrants to Amazônia, and often know little about the ecology of the region. *Colonos* are often confused with *caboclos* in the literature.

[2] For examples of some of the most commonly exploited fish species in the central area of Amazônia, see Goulding (1980) and Smith (1981:140–143).

[3] Dr. Posey is currently undertaking research in the Kayapó area to provide detailed identifications of these plants.

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