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Indigenous management of tropical forest ecosystems: the case of the Kayapó indians of the Brazilian Amazon[1]

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Abstract. The Kayapó Indians of Brazil's Amazon Basin are described as effective managers of tropical forest, utilizing an extensive inventory of useful native plants that are concentrated by human activity in special forest areas (resource islands, forest fields, forest openings, tuber gardens, agricultural plots, old fields, and trailsides). Long-term transplanting and selection of plants suggest semi-domestication of many species. The overall management strategies of forest also includes many manipulated animal species (birds, fish, bees, mammals) utilized as food and game. Forest patches (*apêtê*) are created by Indians from campo/cerrado using planting zones made from termite and ant nests mixed with mulch: formation and development of these is briefly discussed, including the implications for new ideas concerning reforestation and campo management. Finally an integrative cognitive model is presented showing the relationships between variants of forest and savanna recognized by the Kayapó. Indigenous knowledge of subtle similarities between conceptually distinct ecological units in the model allows for the interchange of botanical material between microclimates to increase biological diversity in managed areas. It is suggested that indigenous knowledge is extremely important in developing new strategies for forest and campo/cerrado conservation, while improving productiveness of these ecological systems. Such knowledge is not only applicable for Amazônian Indians, but also has far-reaching implications for human populations throughout the humid tropics.

Introduction

Indigenous societies have been living in Amazônia for unknown millenia, during which time they developed their own strategies for management of forests and campo/cerrados. Serious investigation of indigenous ethnobiological/ethnoecological knowledge is rare, but recent studies (Alcorn, 1981; Carneiro, 1983; Denevan et al., 1984; Frechione, 1981; Hames, 1979, 1980; Kerr and Posey, 1984; Parker et al., 1983; and others) show that indigenous knowledge of ecological zones, natural resources, agriculture,

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aquaculture, forest and game management, to be far more sophisticated than previously assumed. Furthermore, this knowledge offers new models for development that are both ecologically and socially sound (Posey, 1983a; Posey, et al., 1984).

This paper presents a general outline of management strategies of the Kayapó Indians of the Brazilian Amazon to illustrate how they utilize, conserve, and even create tropical forest patches (*apêtê*) in campo/cerrado. Secondary forest management is also important, employing their knowledge of conceptually similar ecological zones to concentrate transplanted (and possibly semi-domesticated) and planted (principally domesticated) species close to population centers or areas of need. It becomes clear that the Kayapó view forest management as an integrated system of plant communities rather than individual species; likewise, manipulated wildlife and even semi-domesticated bees figure into the overall management strategies. The long-term management strategies of the Kayapó, which actually increase biological diversity, offer many fundamental principles that shoul guide development throughout the humic tropics along a path that is both ecologically and socially sound.

Examples in this paper are taken from the Indian Post of Gorotire (7°48′S, 54°46′W), which is the largest of the Northern Kayapó villages (approximately 600 Indians). The author has conducted ethnobiological research in the village since 1977 and is currently coordinating an inter-disciplinary team project to investigate in depth various aspects of biological and ecological knowledge by the Indians. This paper is a preliminary report on integrated forest and campo/cerrado management by the Kayapó.

I. Management and use of campo/cerrado

Little is known of indigenous and cerrado management, although the ecological diversity of these ecological systems provides a wealth of natural resources for Indians like the Kayapó (Posey, 1984b).

The Kayapó classify campo/cerrado (*kapôt*) into a variety of folk ecological zones or 'ecozones'. The term 'ecozone' is used in this paper to refer to ecological zones recognized by indigenous peoples, i.e., cognitive or *emic* categories. The following typology is of principal ecozones:

kapôt kêin: 'clean' campo with few trees

kapôt kumrenx: open campo with many forest patches

kapôt mêtx: low, grassy and open campo

kapôt punu: closed campo with scrub (campo fechado)

kapôt jajôre: open campo with small scrub patches

kapôt imôk krê pôk re: small open areas surrounded by scrub forest near large campos

kapôt kam imô: seasonally inundated campo

kapôt imõ nôi pôk: campo openings on tops of mountains

kapôt krã nhi môk: campo rupestre

The Kayapó also recognize the following transitional types of cerrado/campo:

krã nhinon ã kapôt: campo at top of mountains

krã nhi kratx ã kapôt: campo at base of mountains

kapôt nô kà: transition zones between savanna and forest

pô'ê kô: cane breaks

pô'ê te: very closed forest with cane

Of specific interest is the Kayapó classification of forest 'islands' (*apêtê*) that occur in campo/cerrado and are frequently managed and exploited by the Indians. Typological classification is based on size, form and dominant species in the *apêtê*, although full criteria have not yet been fully worked out. Principal *apêtê* types are:

apêtê-nu: newly formed vegetative clumps

apêt: small, low vegetative patches

apêt kryre: larger forest patch, with small trees and shrubs

apêtê ngri: forest plot with some trees and large shrubs

apêtê (kumrenx): 'real apêtê' with shade from tall trees

apêti: large forest islands with many tall trees (2+ HA)

apêti poire: oblong apêti

apêti rhynh: long corridors of forest (for defense)

In the vicinity of the Kayapó village of Gorotire, a notable increase in the number of *apêtê* forest patches/islands is apparently found in comparison to campo areas distant from the village. This is the direct effect of indigenous influence. Although cursory examination appears to show these *apêtê* to be natural, closer scrutiny reveals that a sizeable percentage (as much as 75%) are indeed man-made.

A preliminary study of *apêtê* made with Dr. Anthony Anderson (Museu Paraense Emilio Goeldi) in November 1983 shows that of the 140 different plant species collected, only two were *not* considered useful by the Kayapó. Equally astonishing is that approximately 85% of the plants collected in ten samples forest 'islands' were actually claimed to have been planted by the Indians (Anderson and Posey, 1985).

This amazing fact requires that we rethink what has been previously considered 'natural' in campo/cerrado environments where there are indigenous populations. Even in areas where Indians have long since disappeared, the hand of human manipulation and management may still be evident.

It is impossible to know the true extent of Indian influence in forest and campo. Kayapó villages today are only remnants of ancient villages that were once linked by sizeable and extensive trails (Posey, 1983b). Old villages and campsites dot the vast area between the Araguaia and Tapajos Rivers that was the Kayapó domain. It is probable that campo/cerrado management was once widespread in other tribes throughout Brazil.

Creation of *apêtê* is in itself an interesting process. Compost heaps are prepared in existing *apêtê* from sticks, limbs, and leaves. These are allowed to rot, then are beaten with sticks to produce a mulch. This mulch is subsequently taken to a selected spot in the campo and piled onto the ground. Slight depressions in the surface are usually sought out because they are more likely to retain moisture. These depressions are filled with the mulch, which is mixed with soil from the mounds of a termite (*Nasutitermes*) called *rorote*, and smashed up bits of the nest of an ant called *mrum kudjà* (*Azteca* sp.). Living ants and termites are included in the mixture. The resulting mounds of earth, called *apêtê-nu*, are generally one to two meters in diameter and 50 to 60 cm. deep. The *apêtê-nu* are usually formed in August and September during the first rains of the wet season and then nurtured by the Indians as they pass along the savanna trails to their gardens (*puru-nu*). Over the years, the *apêtê-nu* 'grow' into large *apê-ti* (see Figure 1). How long this process requires is still under study. Perhaps as much as 1 HA per ten years is possible since there are *apê-ti* of 4HA in Gorotire, that has known to have been permanently inhabited for at least 40 years. This figure may be high, however, because Gorotire was an ancient campsite long before it became a permanent village.

The Kayapó create *apêtê* for a variety of reasons. Until fairly recent times, the Kayapó were still at war with other Kayapó and non-Kayapó (principally Shavante, Carajas, Tapirapé and Brazilian) groups. Their post-contact history seemed to be punctuated daily by wars, raids, and disease epidemics. The Kayapó prefer village sites in campos: *kapôt* is considered to be 'healthier' than forest (*bà*) because there are fewer diseases. Campo villages, however, are hard to hide and defend. *Apêtê* are utilized as disaster shelters in cases of raids or epidemics when it is safer to temporarily abandon the village. The ideal apêtê, therefore, is one in which all the necessities of life are close at hand to afford self-sufficiency to families dispersed from their homes during times of emergencies. Since epidemics and periods of warfare could be prolonged, *apêtê* are a valuable resource and security to the Gorotire family. *Apêtê* have been observed being used as refuges during the threat of a measles epidemic as recently as April 1983.

Plants found in Gorotire *apêtê* are used as food (tubers, roots, fruits, nuts), medicines (for fevers, bleeding, diarrhea, body aches, dizziness, headaches, toothaches, abortives, and anti-conceptuals), materials for daily life (for baskets, cords, needles to open wounds, bow and arrow wood, insect repellents), firewood, ceremonial items (wrist bands, ear spools, lip plugs), body paint, poisons, shade, and leaves for containers and wrappings. Certain trees (eg., *Alibertia edulis, Anonna crassiflora, Byrsonima crassifolia, Caryocar villosum,* and *Solanum paniculatum*) are even planted to attract game and birds. Palms (such as *Astrocaryum tucuma, Mauritia vinifera, Maximiliana regia, Oenocarpus bacaba,* and *Orbygnia martiana*) figure prominently in the inventory because of the variety of uses they afford. Shade

trees are also highly valued, and even vines that produce drinkable water are transplanted to and replanted in *apêtê*.

Apêtê also serve as barriers, parapets, and lines of defense for the village. Warriors could hide in the bush, await their enemies, and then surprise them from their verdant palisades. *Apêti-poire* and *apêti-rhynh* are specificially used for these purposes. *Apêti-poire* are manmade forest corridors formed by uniting a chain of *apêtê*.

In peace time, *apêtê* are used as places of rest, to pass the hottest time of the day, to paint bodies of relatives with urucú (*Bixa orellana*) or genipapo (*Genipa americana*), or for supervised play for children. They are also a favored spot for sexual intercourse. Perhaps because of the latter reason, combined with the concentration of valuable resources in the *apêtê*, children are discouraged from entering along into these forest patches. They are told that ghosts (*karon*) hide there and that balls of light of powerful shamans (*wayanga karon*) appear there in the night. These stories serve to protect the *apêtê* and are enhanced and perpetuated by the shamans, who frequently have their medicinal gardens hidden in large *apê-ti*.

Fire is important in the management of *apêtê*, but contrary to existing theory, fire for the Kayapó is used to protect and encourage the forest patches rather than create larger campos. Campos (*kapôt*) in range of Gorotire are burned annually. The Indians say the fires produce beautiful effects in the night skies (*kaiwka metx, metire*) and have practical effects: they decrease the population of snakes and scorpions and prevent the excessive growth of grasses and thorny vines that make walking and hunting in *kapôt* difficult. Burning is not random. The time for burning is decided by the old people (*mebengêt*) and announced by the chiefs (*benadjwyrà*). Burning occurs before the 'birth' of the August moon (*muturwa katôrô nu*) and before the buds of the piquí tree (*Caryocar villosum*) are too developed. If burning occurs after this time, the highly prized fruit of the piquí (*prĩ*) will not be abundant. Not all *kapôt* are burned on the same day, nor even during the same week. When selected *kapôt* are designated to be burned, the 'owners' of the *apêtê* of out to cut dried grasses and shrubs around their *apêtê* to produce a fire barrier. They then set the fires and await with branches of palms and banana ɔ.aha (*Ravenala guyanensis*) to beat out any flames that come too close.

Not all *apêtê*, however, are protected from fire in this manner. The Indians recognize a group of plants that are actually stimulated by burning. These are plants that are said to 'like' fire (*xêt okin*) and produce more fruit as a result. These include *Alibertia edulis, Byrsonima crassifolia, Astrocaryum tucuma,* and *Alibertia* sp2. Only *apêtê* that have an abundance of these trees are allowed to be burned.

Azteca sp. ants (*mrum kudjà*) are not only used to create soil for the *apêtê-nu* but are also highly prized for their abilities to repel saúva leaf-cutting ants (*Atta spp., mrum-krã-ti*). The *Azteca* has a pungent smell that

distinguishes it to the Kayapó and is apparently the same smell responsible for repelling the saúva. Colonies of the *mrum kudjà* are broken into small pieces and carried to bits of forests where no colony exists. This transplanted colony will then begin to replicate and spread their natural protection against leaf-cutter ants.

Management of campo/cerrado is more complicated than we yet understand. A study of planting sequences and the process of maturation of *apêtê* is forthcoming. But with available data, it is obvious that our ideas of 'natural' campo/cerrado and forest must be re-evaluated with an eye toward the possiblity of widespread aboriginal management and manipulation of these ecosystems. Perhaps the most exciting aspect of these new data is the implication for reforestation. The Indian example not only provides new ideas about how to build forests 'from scratch', but also how to successfully manage what has been considered to be infertile campo/cerrado.

II. Management and use of secondary forest

(1) 'Anything-but-abandoned fields'

Contrary to persistent beliefs about indigenous slash/ burn agriculture, fields are not abandoned after a few years from initial clearing and planting. Recent studies show that, on the contrary, old fields offer an important concentration of highly diverse natural resources long after primary cultivars have disappeared (Carneiro, 1961; Alcorn, 1981; Denevan, et al., 1984).

Kayapó 'new fields' (*puru nu*) peak in production of principal domesticated crops in two or three years but continue to bear produce for many years; e.g. sweet potatoes for four to five years, yams and taro for five to six years, manioc for four to six years, and papaya for five or more years. Some banana varieties continue to bear fruit for 15 to 20 years, urucú (*Bixa orellana*) for 25 years, and cupá (*Cissus gongyloides*) for 40 years. The Kayapó consistently revisit old fields seeking these lingering riches.

Fields take on new life as plants in the natural reforestation sequence begin to appear in maturing fields (*puru-tum*). These plants soon constitute a type of forest called *ibê* (mature old fields) and provide a wide range of useful products, including: food and medicine, fish and bird baits, thatch, packaging, paints, oils, insect repellents, construction materials, fibers for ropes and cords, body cleansers, and products for craft production – to name but a few.

Old fields are perhaps most important for their concentrations of medicinal plants. In a recent survey of plants found in *puru tum* and *ibê*, and 94% of the 368 plants collected were of medicinal significance.

Old fields also attract wildlife to their abundant, low, leafy plants (Linares, 1976; Hames, 1979). High forests, in contrast, are sparse in game. Intentional dispersal of old fields by Indians and management of these by systematic

Table 1. A partial list of tree species planted by the Kayapo indians

Scientific name	Portuguese name	Kayapó name	Planted for			Attract	
			Food	Misc.	Use	Game	Fish
Allagoptera cf. pseudocalyx	piaçaba	ngra djàre	X				
Alibertia edulis A. Rich	marmelada (lisa)	motu	X			X	
Alibertia sp.	marmelada do campo	roi-krãti	X			X	
Anonna crassiflora Mart.	Araticum	ongrê	X				
Atrocarpus integrifolia L.f.	jacá	jacá	X				
Astrocaryum tucuma Mart.	tucum (2 varieties)	roi-ti (mrà)	X	salt			
Astrocaryum vulgare Mart.	tucumã	woti	X	oil			
Bertholletia excelsa Humb. & Bonpl.	castanha do Pará	pi'ỳ	X				
Bixa orellana L.	urucú (4 varieties)	pỳ kumrenx pỳ pot ti pỹ krã re pỳ jabiê		body	paint		
Byrsonima crassifolia H.B.K.	muruci	kutenk	X				
Caryocar villosum (Aubl.) Pers.	piqui (3 varieties)	prĩ kà ti prĩ krã ti prĩ kumrenx	X X X			X	
Citrus aurantifolia (Christm.) Swingle	lima	pidgô ngrã ngrã	X				

Table 1. (Continued)

Scientific name	Portuguese name	Kayapó name	Planted for			Attract	
			Food	Misc.	Use	Game	Fish
Citrus aurantium L.	laranja	pidgô ti	X				
Citrus limonia Osbeck.	limão	pidgô poi re	X				
Coffea arabica	café	kapê					
Cordia sp.	cereja Kayapó	kudjà redjô	X			X	
Endopleura uchi	uxi	kremp	X				
Eugenia jambos L.	jambo	pidgô nore	X			X	
Euterpe oleracea Mart.	açai (2 varieties)	kamere kàk (kamere kàk ti)	X			X	
Genipa americana L.	genipapo (2 varieties)	mroti, mrotire	X	body	paint		
Hancornia speciosa Gomez	mangaba	pi-ô-tire	X				
Hymenaea courbaril L.	jatobá	moi (motx)	X			X	
Inga sp.	inga	kohnjô-kô tire, ngrängrã, tyk	X			X	
Lecythis usitata Ledoux	sapucaia	kromu	X				
Lecythis usitata Miers, var. parensis (Ducke) Knuth	sapucaia	pi'ỳ tê krê ti	X				
Mangifera indica L.	manga	Kuben poi re	X				
Manilkara huberi (Ducke) Stand.	massaranduba	krwya no kamrek				X	X
Mauritia martiana Spruce	buritirana	ngrwa ràre	X				
Mauritia vinifera Mart.	buruti	ngrwa	X				

Table 1. (Continued)

Scientific name	Portuguese name	Kayapó name	Planted for			Attract	
			Food	Misc.	Use	Game	Fish
Maximiliana maripa	inajá	rikre	X	salt			
Oenocarpus bacaba Mart.	bacabá	kamere	X			X	
Orgygnia martiana	babassú	rõ	X	oil,	salt		
Parinari montana Aubl.	pariri	kamô	X			X	
Persea americana Mill.	abacate	kaprã	X				
Platonia insignis Mart.	bacurí	pĩ pannê ka tire	X			X	
Pourouma cecropiae-folia Mart.	imbaúbarana	atwỳrà krã krê	X			X	
Pouteria macro-phylla (Lam.) Eyma	tuturubã	kamokô	X			X	
Psidium grayava L.	goiaba	pidgô kamrek	X				
Ravenata guyanensis	banana brava	tytyti djô	X				
Rollinia mucosa Baill.	biribá	biri	X				
Solanum pani-culatum L.	jurubeba	miêchet ti	X			X	X
Spondias lutea L.	Cajá		X				
Spondias lutea L. (S. mombim L.)	taperabá	bàrere-krã-kryre	X				
Theobroma cacao L.	cacau	kuben krã ti	X			X	
Theobroma grandi-florum K. Schum.	cupaçú	bàri-djô	X				

Identifications primarily based upon Cavalcante (1972, 1974, 1979) from comparisons with common names of the region; systematic specimen collection is now underway.

hunting extends the human influence over the forest by providing, in effect, large 'game farms' near human population concentrations. A delicate balance is necessary to manage these old fields. Game populations that are too dense can cause severe damage to crops; thus hunting provides meat for food while protecting new fields from excessive destruction. In the Kayapó division of labor, the women work in the fields while their husbands hunt in the surrounding forests.

Game animals are particularly attracted to fruit trees planted by the Kayapó in new and old fields, as well as along trails (see Table 1). Tree plantings illustrate long-term planning and forest management since many of the trees require many years to bear fruit; castanha do Pará (Brazil nut), for example, does not produce its first nuts for 12–20 years. In addition to attracting game, fruit and nut-producing trees are also planted to attract birds and even fish during high water river and igarapé cycles. Most of these trees also provide food important in human subsistence. Thus old fields should perhaps be called 'game-farm orchards' to emphasize their diverse resources (Smith, 1977; Posey et al., 1984).

(2) Semi-domesticates in old fields

Old fields serve as important repositories of 'semi-domesticated' or manipulated plants. The term 'semi-domesticate' is used to indicate plants that are intentionally manipulated by the Indians, who knowingly modify the plant's habitat to stimulate growth. The genetic consequences of this process are still unknown but merit serious study (Kerr and Posey, 1984).

Relatively open forests are given special names (*bà-ràràrà* and *bà-epti*) and are known refuges for light-loving plants that also grow well in old fields. Gathering trips to primary and secondary forests are frequently made to collect appropriate plants for transplanting into old fields.

The Kayapó also see forest areas disturbed by either natural or man-made events as habitats that approximate field clearings. Forest openings (*bà-krê-ti*) caused by trees that have fallen through natural processes (old age and storms) or that have been felled by Indians to raid bee hives create micro-environmental conditions similar to those of field clearings (Posey, 1984a). Likewise, openings due to abandoned camp and village sites, or wide swaths left by trails, are also reserves for plants that thrive in old fields. These areas are visited on gathering trips with the goal of transplanting forest plants to old fields or *apêtê*, thereby making needed forest products more readily available.

(3) 'Forest-fields'

The Kayapó custom of transplanting is only part of a much broader system that has been described (Posey, 1982, 1983a) as 'nomadic agriculture' and was undoubtedly once widespread in Amazonian tribes. Until recently, Kayapó groups travelled extensively in the vast areas between the east-west

boundaries of the Tocantins and Araguaya Rivers and the north-south limits of the Planalto and the Amazon River. Today the Kayapó still carry out several month-long treks per year, although much of the old network of trails and campsites is now abandoned.

Food and utensils, because of their bulk and weight, are not carried out by the Indians on treks. Food gathering for 150 to 200 people cannot, however, be left solely to chance. Thus gathered plants are transplanted into concentrated spots near trails and campsites to produce 'forest fields' that make readily available to future passersby the necessities of life, including: food, cleansing agents, hair and body oils, insect repellents, leaves for cooking, vines that supply drinkable water, house construction materials, and especially medicinals.

Forest-fields intentionally replicate naturally occurring 'resource islands' (*kô*), which are areas where specific concentrations of useful plants are found. These resource islands include: Brazil nut groves, fruit tree stands, palmito and nut sources, cane breaks, etc.

Dependency on naturally occurring 'resource islands' and their man-made 'forest-field' counterparts allow Kayapó groups to travel months at a time and great distances without need of domesticated garden produce. Today only remnants of this once vast system remain.

(4) Trailside plantings

In addition to the 'forest-fields' near campsites and trails, the sides of trails (*pry kôt*) themselves are planting zones for the Kayapó. It is not uncommon to find trails composed of four-meter-wide cleared strips of forest. It is hard to estimate the extensiveness of aboriginal trails that interconnected distant Kayapó villages; conservative estimate of existing trials associated with Gorotire (one of 11 modern Kayapó villages) yields 500 km of trails that average 2.5 m wide. Trailsides are planted with numerous varieties of yams, sweet potatoes, Marantaceae, *Cissus,* Zingiberaceae, Araceae, and other as yet unidentified edible tubers. Hundreds of medicinal plants and fruit trees also increase the diversity of the planted flora.

In a survey of a three-kilometer trail leading from Gorotire to a nearby garden, the following were observed: (1) 185 planted trees representing at least 15 different species; (2) approximately 1,500 medicinal plants of an undetermined number of species; and (3) approximately 5,500 food-producing plants of an undetermined number of species.

The immediate one- to four-meter wide swath provided by trail clearing is *not* the entire effective distance of human activity. An additional factor is the distance away from the trail that the Kayapó choose for defecation/urination, I have measured the average distance, a rather culturally fixed proxemic unit, at five meters (or 14 m in width, considering both sides of the trail and the trail itself).

While squatting to defecate, the Kayapó often plant tubers, seeds, or nuts

they have collected during the day and stored in a fiber pouch or bag. This activity, combined with the natural process of seed transportation through fecal material, makes the overall distance near trails under human influence even more extensive and significant. The effect is further accentuated by the age of the trails: some are uncounted centuries old.

(5) Plantations in forest openings

For the Kayapó, openings in the primary forest are called *bà-krê-ti* and are seen as natural prototypes for gardens. As mentioned, there are two types of *bà-krê-ti*: (1) openings caused by trees or limbs that fall due to old age or storms; and (2) openings that are man-made by felling large trees to take honey from bees (Posey, 1983c). Both types of forest openings create new micro-habitats and planting zones due to light reaching the forest floor and creating conditions similar to those of garden plots. The idea for planting gardens may have come from the Indian's study and use of *bà-krê-ti* or may be a logical extension of their management of such forest openings.

Bà-krê-ti are used to transplant domesticates and semi-domesticates like varieties of manioc, taro, cupá, yams, sweet potatoes, beans, and arrowroot. These thrive in such habitats and according to Kayapó agriculturalists, their productivity is significantly increased as the result of this transplantation.

(6) Hill gardens

Another form of agriculture that is related to *bà krê ti* plantations is the *krãi kam puru* or 'hill garden'. Tuberous plants, like Zingiberaceae, Araceae, and Marantaceae varieties, are planted in these well-drained, hillside plots. These fields are principally reserved as food sources in case of floods or of crop disasters and are considered as very valuable plant 'banks' or reserves. Hill gardens are exclusively kept by old women (*mẽ-begnet*) under the direction of the Kayagp female chief (*menire-nhõ-benadjwỳrà*), the highest ranking female authority. To form the plantations, old fields of eight to ten years of fallow are cleared of underbrush. Pieces of tuber stock are then planted in shallow holes in fertile pockets of soil when the new rains have soaked the soils in September. Little care, other than cutting back of competing vegetation, is required to maintain these fields. Harvest occurs at the onset of the dry season (June), although representative plants are always left behind to preserve the tuber 'bank' (reserve).

(7) Plant communities and microzonal planting

Another interesting aspect of Kayapó agriculture is based upon management of plant communities associated with bananas. As banana trees grow in maturing fields, they produce shading and modify soil conditions that produce a specialized microenvironment. The Kayapó know approximately two dozen varieties of edible tubers and numerous medicinal plants that thrive under these conditions and are planted in the banana plantation (*tytyti-kô*). These

plants are called 'companions of the banana' (*tytyti-kotam*) and continue to grow together with the banana until the height of the secondary forest is no longer conductive to the growth of the plant community. When this occurs, shoots of old bananas are transferred to new fields, while the 'companions' are transplanted to already established plantations of bananas in other maturing fields.

This illustrates not only how Indians exploit the properties of fields in transition between new and old (*puru* to *ibê*) but also shows how micro-environmental planting zones are created to modify effects of secondary forest growth. Equally significant is the indigenous conceptualization of plant communities, rather than individual species, as the basis for ecological management. Other plant companions are under investigation for papaya, genipapo, and urucú, all of which are viewed as foci of other managed plant communities and produce their own unique mircrozones for planting.

(8) 'Quintal' management

'Quintal' is a Portuguese word that describes areas adjacent to homes that are generally planted with useful or decorative plants. The idea is more ancient than the European introduction, since the Kayapó too rely on areas near their homes (*ki krê bum*) to grow useful plants. A partial *ki krê bum* survey has produced 86 species (estimate based on tentative identification) of food plants and dozens of additional medicinal plants.

The practice of medicine is highly elaborated for the Kayapó. Almost every household has its complement of common medicinal plants, many of which are domesticates or semi-domesticates. Shamans (*wayanga*) specialize in different disease treatments, each of which requires specific plants. Dozens of 'medicine knowers' (*pidjà mari*) also effect minor cures with their own array of medicinals. Medicinal plants are often kept in secret forest plantations since their use forms part of the private knowledge of the curer; others are overtly grown in the quintal and only their use is secret. Thus each quintal reflects the medicinal knowledge and specialization (or lack thereof) of its owner.

A major result of quintal management is the formation of topsoil. Some of the richest and most productive soils in Amazônia are those called 'terra preta dos índios', produced by Indian manipulation of generally poor Amazonian soils (Smith, 1980).

(9) Ken-po-ti ('Rock Gardens')

One of the most unusual ecozones manipulated by the Kayapó is the *ken-po-ti*, which is a basaltic outcropping transformed into a special 'rock garden'. These outcroppings frequently occur in the middle of forests. The area of exposed rock creates open spaces within the forest that become hot and dry when heated by the tropical sun. Environmental conditions in parts of *ken-po-ti* resemble those of campo/cerrado (*kapôt*), yet their margins are shaded

by the encompassing forest and water seepage is common from aquafer cracks. Thus a variety of microclimates are available for exploitation by the Indians, who concentrate plant resources in *ken-po-ti* through plantings and transplantings from a variety of other ecozones. Frequently forest mulch and rich soils are carried to the outcroppings and placed in existing cracks in the rocks or piled high between stones arranged to form planting containers. Piles of the planting medium provide productive plots for the raising of plants requiring special care and growth conditions. A managed *ken-po-ti*, in sharp contrast to its barren unmanaged couterpart, looks like a lush Japanese garden. For the Kayapó, stone out-croppings have special significance because they have special cosmic energies and are associated with powerful spiritual forces. Only shamans do not fear these forces. Thus *ken-po-ti* are mostly used by shamans, who plant some of their most powerful and important medicinals there.

An indigenous model of cognitive integration

In studies of the Kayapó Indian classification, overlapping sets have been described as being in contiguous 'sequences' that form 'continua' between polar types (Posey, 1983a). That is, members of classification units frequently share diagnostic characteristics with members of other contiguous units. Each unit as a 'focal' or 'ideal' type, which is the member that is most characteristic of the set. The greater any set member differs in characteristics from the ideal type, the more likely that member will co-occur in other sets. Extremes or poles of the continuum represent the maximal divergence possible within the domain and thereby define the parameters of the higher taxonomic grouping.

One of the most salient of the taxonomic continua in the Kayapó system is that between forest (*bà*) and campo/cerrado (*kapôt*). The ideal or 'focal' type of forest is *bà-kumrenx* ('true forest'), which is the most productive of the forest types. Trees of at least eight meters in height provide many edible fruits, nuts and seeds, and well as useful woods and fibers. A herbaceous understory is rich in medicinal plants.

The 'focal' *kapôt* type is *kapôt-kumrenx* ('true campo'), which is open land with knee-high grasses. The landscape is also dotted with patches of forest-like vegetation called *apêtê*.

Apêtê are the link between the poles of the *bà-kapôt* continuum (see Figure 2). They are composed of many sun-tolerant, heat-resistent species that survive in the demanding climate of the campo/cerrado, yet also have many forest species. Thus they unite diagnostic elements of both poles of the continuum.

Different planting zones are found within *apêtê* as represented in Figure 1. *Apêtê-nu* consist of only one planting zone. *Apêtx* (an intermediary form between *apêtê-nu* and *apêtê*) have a relatively shady center (*nhi-pôk*), with a

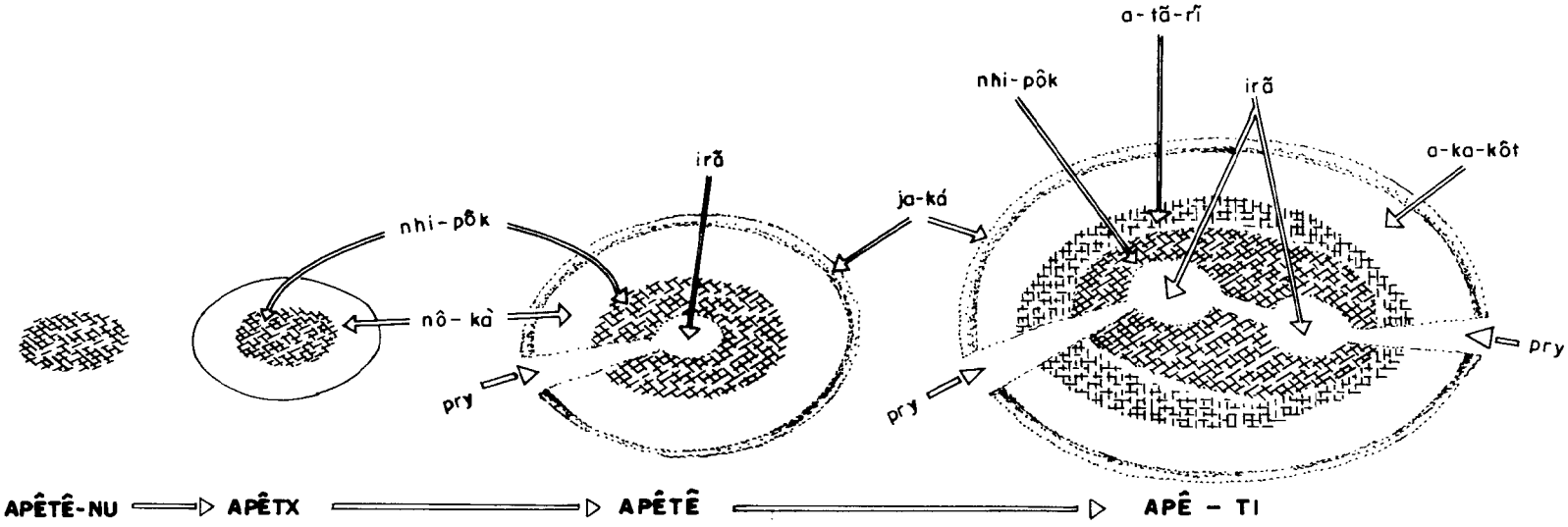

Figure 1. Apêtê formation: planting zones.

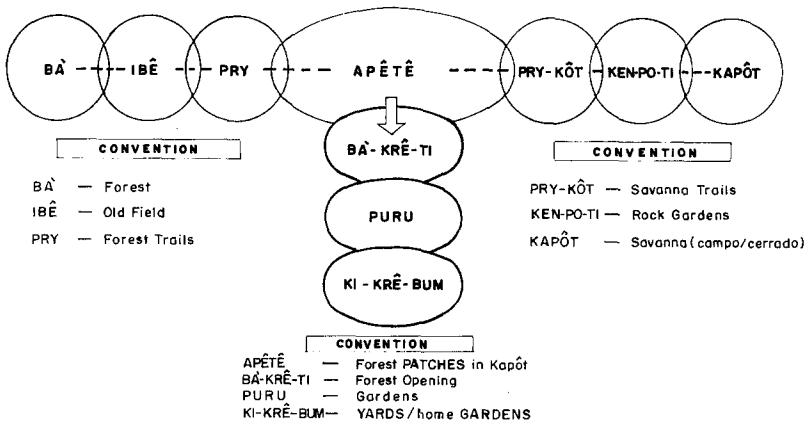

Figure 2. Ethno ecological units on the bà-kapôt continuum.

sunnier edge (*nô-kà*). True *apêtê* have a shady center area (*nhi-pôk*), an outer edge (*nô-kà*), and an additional shadow zone (*ja-kà*) formed by higher vegetation that shields the zone from morning or evening sun. Note that in the center of the *apêtê* is an opening where light penetrates. This is called the *irã* and functions to preserve the 'patchiness' of the *apêtê* to maximize micro-environmental variation. Patchiness helps preserve the biological heterogeneity of larger *apêtê*. *Irã* are usually connected to the open *kapôt* by trails (*pry-kôt*).

Large *apêtê*, or *apê-ti*, have all the planting zones found in an *apêtê*, plus a darker, middle zone where less light can penetrate (*a-tã-rĩ*). *Irã* may be numerous to maintain patchiness and light penetration. Large *irã* are ringed by a bright zone called the *irã-nô-kà* which is good all-purpose planting zone. Trails (*pry*) connect *irã* and the *kapôt* and are frequently wide enough to provide a light margin (*pry-kôt*) that also serves as a planting strip.

Variations in planting zones, therefore, seem to be based principally upon variations of shade and light, plus associated variations in temperature and moisture. Planting zones in *apêtê* are matched with ecological types recognized by the Indians in the forest (see Table 2). Plants that grow well in certain forest environments can be predicted to do well in *apêtê* zonal counterparts. For example, plants found in the dark, damp forest (*bà-tyk*) are likely to do well in the *a-tã-rĩ* or the *nhi-pôk* of an *apê-ti*. Plants that thrive in the light-penetrating forest (*bà-ràràrà*) would be planted *no-kà* or *a-kà-kôt*. Species found at the margins of the forest or the edges of other *apêtê* would be transferred to the *ja-kà* or *a-kà-kôt*.

Plant species are said by the Indians to have been brought for planting or transplanting in Gorotire *apêtê* from very distant areas. Most species encountered in *apêtê* are common campo species, but the Kayapó say that certain varieties have specific desired qualities (taste for food, texture for

Table 2. *Apêtê* planting zones in relation to corresponding ecological units

Apêtê planting zones[1]	Corresponding ecological units[2]
nhi-pôk	bà-ràràrà, bà-kamrek, bà-krê-ti
nô-kà	bà-kôt, bà-ràràrà, bà-krê-ti
ja-kà	kapôt, bà-kôt
irã-nô-kà	bà-ràràrà, bà-kamrek, bà-krê-ti
a-tã-rĩ	bà-tyk, bà-kamrek
a-kà-kôt	bà-ràràrà, bà-kumrenx

[1]*Apêtê zones: nhi-pok,* shady center; *nô-kà*, sunny edge; *ja-ka*, shadow zone; *irã-nô-kà*, edge of open center; *a-tã-ri*, darker middle zone; *a-ka-kôt*, light-penetrating margin.

[2]*Forest units: bà-kamrek,* gallery or riverine forest; *bà-ràràrà*, forest in which light penetrates to the forest floor; *bà-krê-ti,* forest openings; *bà-kôt*, forest edge; *kapôt*, campo/cerrado; *bà-tyk*, high dark forest; *bà-kumrenx,* forest with large trees and a herbaceous lower level.

wood or fiber, medicinal properties, etc.) and were acquired from Indian groups such as the Tapirape, Karaja, Mundrucu, Assurini, Shavante, Canela, Gavião and Sororo. Thus if stated origins of plant varieties are accepted, Gorotire *apêtê* are composed of a concentration of plant varieties brought from an area the size of Europe. Origins and processes of planting and transplanting are now under study.

Conceptually *apêtê* are related to other human-made ecological zones described in this paper, such as trail sides (*pry-kôt*) and field gardens (*puru*), since all are planted with many of the same varieties of useful herbs and fruit trees. Furthermore, old fields are managed in much the same way as *apêtê*, since long-term management of plant and animal communities is fundamental to the exploitation strategies of both. Old fields (*ibê*) for the Kayapó are like *apêtê* surrounded by forest rather than campo.

Other zones that are conceptually linked with *apêtê* are: (1) *bà-krê-ti*[1] (forest openings). (2) *ken-po-ti* (rock gardens); and (3) *ki-krê-bum* (quintal or yard).

Given the various ecological zones recognized by the Kayapó, it is possible to construct a more generalized pattern of cognitive relatedness on the *bà-kapôt* continuum. Figure 2 represents the overlapping sets of *bà, ibê, puru tum, apêtê* (and related cognates), *pry, ken-po-ti*, and *kapôt*. Sets with more savanna elements are placed closer to the *kapôt* pole; sets with more forest elements are placed closer to *bà*.

In this scheme, *apêtê* are intermediary between poles. Cognitive variants of *apêtê, puru* and *bà-krê-ti*, occupy the same classification space. That is, *puru* (fields) are considered as types of *bà-krê-ti*, which in turn are inverse models of *apêtê*. *Ki-krê-bum* (quintais) are likewise related since they unite elements of all ecological zones.

For the Kayapó the most productive ecological systems are those in secondary forest created through human activity. Whether *apêtê* forest patches in the campo, or *ibê* forest resulting from management of old fields, the Kayapó system is built upon the maintenance—or actual increase – in

biological diversity. Forest 'patchiness' is the principal mechanism for the preservation of diversity, both in the creation of *irã* in *apêtê* and *bà-krê-ti* in the forest. Kayapó resource management, therefore, focuses upon the intermediary forms (*apêtê, bà-krê-ti, quintal, pry*, etc.) between the polar forest and campo/cerrado types because it is in these zones that maximal biological diversity occurs. To put such a statement in more ecological terms, the Indians not only recognize the richness of 'ecotones', they create them.

Concluding remarks

Recognition of diagnostic similarities within a contrast continuum of forest (*bà*) and campo/cerrado (*kapôt*) allows the Kayapó Indians to manipulate a variety of ecological zones and micro-climates through the exchange of botanical materials between units perceived as similar. Fundamental to indigenous management is the reliance upon a wide range of plant and animal resources integrated into long-term exploitation of secondary forest areas and specially created concentrations of resources near areas of need (forest fields, forest openings, rock outcroppings, old fields, trailsides, agricultural plots, and hill gardens). Forest patches (*apêtê*) created by the Indians in cerrado/campo also provide dense concentrations of useful species. Maintenance, or more usually increase, in biological diversity is the key to successful indigenous conservation and exploitation.

The Kayapó example teaches us that sophisticated management must be based upon recognition of likeness between ecological units: contrast should never obscure similarity in ecological typologies. Furthermore, that secondary forest can, indeed, be maximally productive without endangering the long-term survival of native species nor ecological systems.

Creation of *apêtê* is likewise of great potential in understanding more about campo/cerrado utilization. Indigenous management of *apêtê* has far-reaching implications for the study of forestation in savanna areas and reforestation in areas denuded by deforestation.

Presence of extensively managed areas by indigenous peoples emphasizes the extensively manged areas by indigenous peoples emphasizes the necessity for the re-evaluation of concepts about the natural landscape. 'Naturalness' of ecological communities can never be assumed without investigating the human history of the area.

This paper has merely attempted to outline some of the major principles of Kayapó forest management in an effort to show how indigenous knowledge can help generate alternative philosophies for a more rational system of resource management in the humid tropics. The Kayapó are only one of many small enclaves of native peoples located in remote parts of the world, but the lessons they have learned through millenia of accumulated experience and survival are invaluable to a modern world in much need of rediscovering its ecological and humanistic roots.

Note

1. It is interesting to speculate that *bà-krê-ti* and *puru* are cognitive inverses of *apêtê*. They form relatively open, sun-penetrating patches of forest, whereas *apêtê* are relatively shady areas in the campo. The result is the same: areas of concentrated plant diversity in ecologically similar conditions. Gardens clearly show zonation (Kerr and Posey, 1984), albeit an inside-out version of *apêtê* planting zones.

References

Alcorn J (1981) Huastic noncrop resource management: Implications for prehistoric rain forest management. Human Ecology 9 (4): 395–417

Anthony A and Posey DA (1985) Manejo do Campo e Cerrado pelos índios Kayapó. Boletim do Museu Goeldi (Botânica) (in press)

Carneiro RL (1961) Slash-and-burn cultivation among the Kuikuru and its implications for cultural development in the Amazon Basin. In: The Evolution of Horticultural Systems in Native South America: Causes and Consequences, A Symposium. J Wilbert, ed, pp 47–67. Caracas: Antropologica Supplement No 2

Carneiro RL (1983) The cultivation of manioc among the Kuikuru of the Upper Xingú. In: Adaptive Responses of Native Amazonians. R Hames and W Vickers, eds Academic Press

Denevan W, Treacy J and Alcorn J (1984) Indigenous agroforestry in the Peruvian Amazon: The example of Bora utilization of swidden fallows. In: Change in the Amazon Basin. J Hemming, ed. Manchester, England, University of Manchester

Frechione J (1981) Economic self-development by Yekuana Amerinds in southern Venezuela. Ph D dissertation (Department of Anthropology), University of Pittsburgh, Pittsburgh, Pennsylvania

Hames RB (1979) Game depletion and hunting zone rotation among the Ye'Kuana and Yanomamo of Amazônias, Venezuela. Paper presented at the XLIII International Congress of Americanists, Vancouver, B.C.

Hames RB (1980) Monoculture, polyculture, and polyvariety in tropical forest swidden cultivation. Paper read at the 79th Annual Meeting of the American Anthropological Association, Washington, DC

Kerr WE and Posey DA (1984) Notas sobre a agricultura dos índios Kayapó. Interciência 9(6): 392–400

Linares O (1976) Garden hunting in the American tropics. Human Ecology 4(4): 331–349

Parker E, Posey DA, Frechione J and da Silva LF Resource exploitation in Amazônia: Ethnoecological examples from four populations. Annals of Carnegie Museum, Vol 52, Article 8: 163–203

Posey DA (1982) Keepers of the forest. New York Botanical Garden Magazine 6(1): 18–24

Posey DA (1983a) Indigenous ecological knowledge and development of the Amazon. In: The dilemma of Amazonian development. E Moran, ed. Boulder, Colorado, Westview Press

Posey DA (1983b) Indigenous knowledge and development: An ideological bridge to the future. Ciência e Cultura 35(7): 877–894

Posey DA (1983c) Keeping of stingless bees by the Kayapó Indians of Brazil. Journal of Ethnobiology 3(1): 63–73

Posey DA (1984a) A preliminary report on diversified management of tropical forest by the Kayapó Indians of the Brazilian Amazon. Advances in Economic Botany 1: 112–126

Posey DA (1984b) Keepers of the campo. New York Botanical Garden Magazine 8(6): 8 ff

Posey DA, Frechione J, Eddins J and da Silva LF (1984) Ethnoecology as applied anthropology in Amazonian development. Human Organization 43(2): 95–107

Smith N (1977) Human exploitation of terra firma fauna in Amazônia. Ciência e cultura 30(1); 17–23

Smith N (1980) Anthrosols and human carrying capacity in Amazônia. Annals of the Association of American Geographers 70(4): 553–566