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GAME DEPLETION AND HUNTING ZONE ROTATION  
AMONG THE YE'KWANA AND YANOMAMÖ OF AMAZONAS, VENEZUELA <sup>1</sup>

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### Introduction

Locational analyses of land use patterns among lowland Amazonian populations have been attempted infrequently, but when they have, they have proved crucial for deciding debates on the nature of indigenous adaptation to the Amazonian ecosystem. For example, Carneiro (1960, 1961), through a careful analysis of Kuikuru shifting cultivation in relation to productivity, fallowing, and available horticultural land, was able to demonstrate convincingly that shifting cultivation was not an impediment to the establishment of large and permanent villages in Amazonia. Recently, it has been suggested (Harris, 1974; Gross, 1975; Ross, 1978) that low animal biomass in the Amazon is an important adaptive variable for some Amazonian populations and that warfare, territoriality, low population density, and small nomadic village populations are responses to the problems of game depletion. Recent research (Chagnon and Hames, 1979; Lizot, 1978) has indicated that inadequate protein consumption cannot account for patterns of warfare in one Amazonian population, the Yanomamö, and the protein hypothesis is an unlikely explanation in a number of other populations on which we have adequate data. However, this paper will not comment directly on the relationship between warfare and protein capture and consumption but rather how native Amazonian hunters respond to the problem of declining hunting efficiency.

The aim of this paper is to show, through a locational analysis of hunting input and output, and their interrelationship, how the members of two Amazonian populations, the Ye'kwana and the Yanomamö, respond to game depletion in segments or zones of their environment. The research reported here suggests that Amazonian shifting

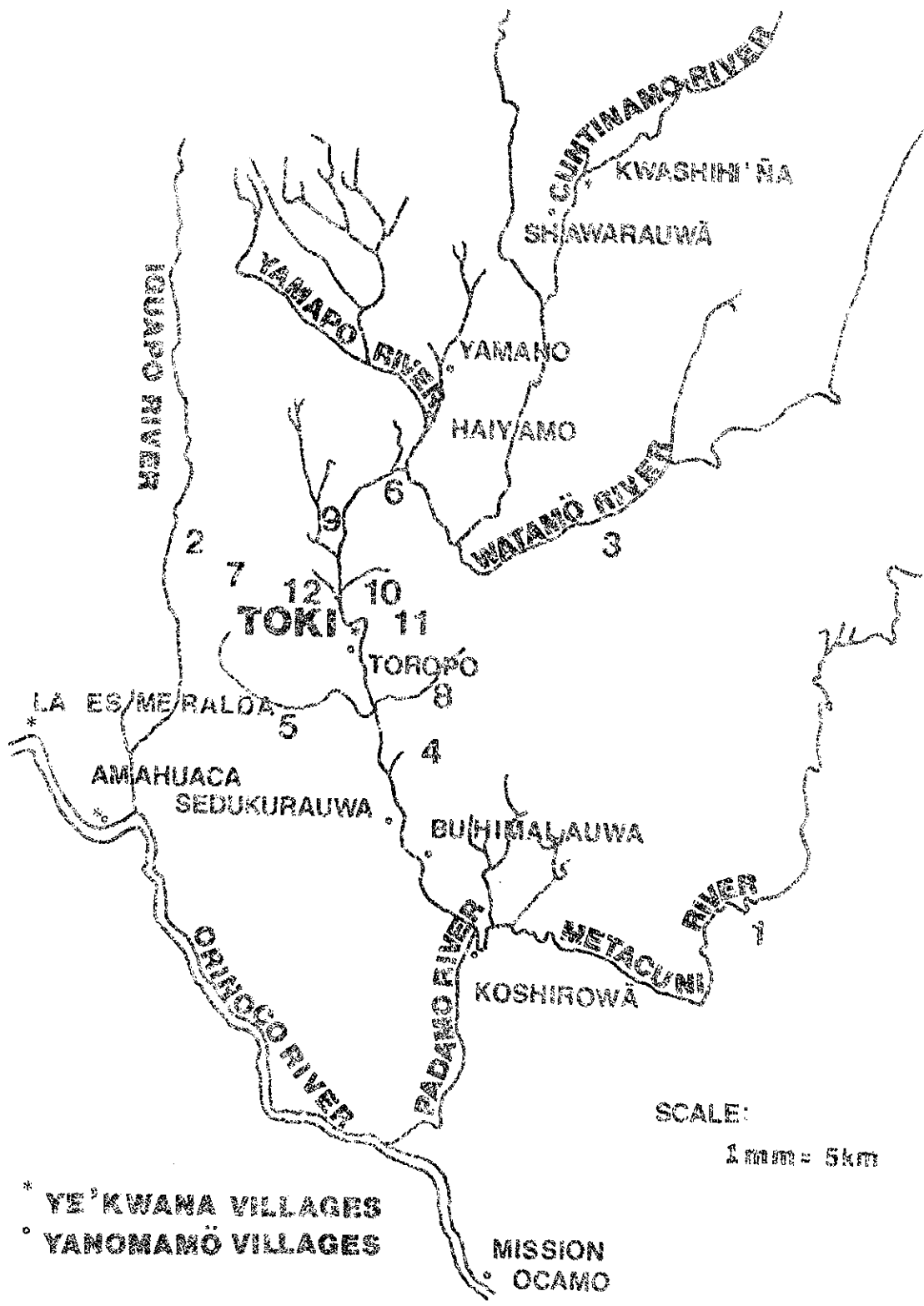
horticulturalists who depend on game for the bulk of their protein consumption deal with local game depletion through the rotation of hunting zones and that game depletion is not an important cause of village movement.

### The Setting

The Ye'kwana and Yānomamö Indians are rather typical neotropical shifting horticulturalists inhabiting the Upper Orinoco River Basin of southern Venezuela, with significant segments of the Yānomamö population spilling over into adjacent portions of northern Brazil. Arvelo-Jimenez (1971) estimates that there are some 1,600 Ye'kwana living in villages of from 20 to 120 people each, mainly along large tributaries of the Orinoco such as the Padamo, Cunucunuma, Ventuari, and Caura. Chagnon (1974) estimates that there are approximately 18,000 Yānomamö in 140 villages ranging in size from 40 to 250 people, with most villages located in the deep forest and away from large navigable rivers. Population density for both populations is less than one person per square mile.

While sustained contact with westerners was not attained until 1954 for the Yānomamö, and many villages still remain uncontacted, the Ye'kwana have sustained intermittent contact since the end of the 18th century, largely as a result of their wide-ranging water-borne trading activities. Missionary activities among the more accessible downriver Ye'kwana villages over the last 25 years, coupled with ties to the national economy through limited cash cropping, have culturally transformed some Ye'kwana villages. Nevertheless, most of traditional Ye'kwana culture persists with the exception of shamanism and some

# PADAMO RIVER BASIN



MAP I

aboriginal technology. By comparison, the Yānomamö culture is one of the most vigorous aboriginal cultures in lowland South America, and even those villages that have been heavily subject to missionary activities have only superficially changed by their acceptance of some manufactured goods, apart from demographic trends due to introduced diseases.

Both groups depend on shifting cultivation for about 75% to 80% of their total caloric intake (Hames, 1978; Lizot, 1978), with hunting, gathering, and fishing making up the balance. Ye'kwana gardens are dominated by manioc and Yānomamö gardens by plantains, cultigens with only 1%-2% protein content. Both populations depend on hunting and fishing for 75% to 80% of their protein requirements, with hunting and fishing supplying about 80% and 15% of Yānomamö animal protein, respectively, and 68% and 25% for the Ye'kwana (Lizot, 1978; Chagnon and Hames, 1979). The Ye'kwana's greater dependence on fishing is a result of their villages being located on the banks of rivers, while the smaller importance of fishing in Yānomamö protein consumption is due to their settlement in interfluvial areas where fish resources are low.

#### Area of Study

The general area of study among the Ye'kwana and Yānomamö populations is the Padamo River Basin, a border area delimiting the easternmost extent of the Ye'kwana and the westernmost extent of the Yānomamö population. Intensive research on hunting practices took place in the Ye'kwana village of Toki (Map I) and the adjoining satellite Yānomamö village of Toropo-teri. Toki contains a permanent Ye'kwana population of 76 with 18 Yānomamö adopted into Ye'kwana households. One section

of the village houses 20 Yanomamö who occupy two separate dwellings, while another Yanomamö house, occupied by 15 people, is located 10 minutes away from the main village. In this area Yanomamö are motivated to reside near Ye'kwana primarily to gain access to trade goods. Ye'kwana villages with satellite Yanomamö (including Sanumá) villages occur extensively throughout the Yanomamö/Ye'kwana border area (Arvelo-Jimenez, 1971; Ramos, 1972, 1978).

#### Environment, Climate, and Plant Formation

Given Toki's 2,280 mm of rain per year, elevation of 250 m, and mean annual temperature of 24 degrees centigrade, the biome around Toki could be classified as moist to wet tropical forest, according to Holdridge's natural life zone typology (Holdridge, 1967). The terrain immediately around Toki is flat to gently undulating with small hills of 50 to 75 m irregularly dotting the vista. Approximately 4 km to the east of Toki is a short range of hills about 10 to 12 km in length and 100 to 200 m in elevation. From 10 to 30 km upstream and inland on the Padamo are the giant Inselberg mountains of Duida, Huachumacari, and Marahuaca which attain heights up to 3,000 m, making them the largest mountains in all the Guiana Highlands.

Rainfall was recorded from September 1975 through May 1976. Rainfall exceeded 100 mm in all months except for November, January, and February. These three "dry season" months are important economically because trees felled in the garden-making process must have adequate time to dry to insure a good burn. Peak rainfall occurred in March, April, and May, averaging 350 mm per month.

As Nietschmann (1972, 1973) has shown for the Miskito Indians of coastal Nicaragua, biotopes and their associated forest vegetation types strongly correlate with hunting success and the distribution of important game animals. However, for Amazonia there is very little information as to the distribution and density of game animals across biotopes. Furthermore, there is a great deal of confusion and inconsistency over the classification of biotopes in Amazonia. Below, I will list the major biotopes surrounding Toki according to the schema developed by Prance (1978) and list some of the more important game animals found.

Terra firme forest. This is forest on high ground containing large trees with closed canopies and very sparse ground cover. Although its biomass is among the greatest of any terrestrial ecosystem in the world, very little of it is available to ground-dwelling animals, so 40-70% of the mammalian biomass exploiting this biotope is aboreal (Eisenberg and Thorington, 1973). Although no measurements were made, I estimate that this biotope covers at least 80% of the hunting zones frequented by Ye'kwana and Yanomamö hunters. Important game animals found there appear to be deer, tapir, white-lipped peccaries, monkeys, anteaters, and large game birds.

Seasonal várzea forest. (This biotope is similar to what Meggers [1971] calls Igapó.) This is forest behind natural levees of rivers or large streams which is inundated for 1 to 3 months per year during the period of heaviest rains (March, April, and May). Species diversity and biomass are less than terra firme forest. Letouzey (1978: 106) describes it as having ". . . an abundance of medium sized trees with silt roots, many buttressed trees with pneumatophores, an abundance of



lianas, and a poorly developed understory." This biotope is frequently dominated by water tolerant palms, heliconias, cecropias, cedar, silk floss, and bamboos (Guadua sp.). Animals commonly found are caviomorph rodents (capybara, agouti, acure, and picture), collared peccary, tapir, and water fowl. Caiman, naturally, are present along the margins of rivers and in the várzea when it is inundated.

Swamp forest. Poorly drained areas near the mouths of streams or basins behind river banks are rare in the Padamo but are important in hunting because deer and many of the large semi-aquatic fauna found in the várzea are also found here, but in denser concentrations. The vegetation is similar to that found in seasonal várzea forest but trees tend to be shorter and the canopy less complete.

Anthropogenic formations. This refers to any plant formation which has formed as a result of human activity. The forms are quite variable and range from producing gardens, rastrojos (Sp., Venezuela), or gardens abandoned for five to seven years, and to secondary forest in various stages of succession. Anthropogenic biotopes are dominated by softwoods (especially species of the genus Cecropia in riverine areas), usually less than 35 m in height with very narrow canopies. The small canopy allows a great deal of light to penetrate the forest floor, stimulating growth of dense ground cover, which in some areas is impassable. Anthropogenic biotopes surround the vicinity of Toki and the abandoned village sites of Shanama'ña and Nosamo'ña (see Map I). Deer, caviomorph rodents, and sloths are abundant in these areas.

### Hunting Zones

Among the Ye'kwana and the Yãnomãö nearly all hunting occurs in named and explicitly known hunting zones, with each zone characterized by one or more of the plant formations outlined above. A hunting zone can be best described as a drainage basin having a linked series of trails with the largest of these trails paralleling the stream or river which serves as the nexus of the drainage. And all but one of the twelve regularly used zones (see Map I and Table I) are named after the largest stream or river which drains them.

The fact that the main hunting trail in each zone parallels the largest streams is not without ecological significance. The Ye'kwana and the Yãnomãö believe that game animals tend to be more abundant around riparian habitats whether they be large rivers or small streams (especially during the short "dry season"). This native belief of animal abundance in riparian areas is perhaps explicable in terms of the ecological concept of the ecotone. An ecotone is defined as an area of transition between two biotopes or plant formations. Most rivers and streams of the tropical forest tend to have a riverine forest (Port., restinga) on their banks, and, if the bank is low enough to permit flooding during the height of the rainy season, a seasonal várzea forest is located behind the restinga. Invariably, a terra firme forest is found behind the restinga or the várzea. Therefore, main hunting trails tend to run through two to three biotopes more or less continuously with the areas of transition between each biotope serving as ecotones. Ecologists (e.g. Odum, 1959; Lamprey, 1963) have argued that ecotones typically have heavier concentrations and greater diversity of animals than either of the biotopes divided by

the ecotone. This fact is known as the "edge effect" and it is assumed that animals are more plentiful and diverse here because ecotones are able to supply alternate nutritional needs of animals owing to their ecological complexity (cf. Hickerson, 1962).

Thus far I have purposely avoided the term hunting "territory" to refer to specific areas in which hunting is done or the general area a village population exploits. This is because a territory is commonly defined as "an area occupied more or less exclusively by an animal or group of animals by means of repulsion through overt defense or advertisement" (Wilson, 1975:597), and this definition does not entirely fit the Ye'kwana or the Yānomamö. However, Harris has speculated for the Yānomamö (1975:103) and Ross has observed for the Jivaro (1978) that these Amazonian populations have rather discrete hunting territories at the village level and, importantly, the edges of such territories serve as buffer zones or no-man's-land between neighboring hostile villages. Lizot (1978) countered Harris' speculation by stating that the Yānomamö have a limited sense of territoriality which is based on a village's regular use of an area of land for hunting. Unfortunately, Lizot's observation brings up more questions than it answers.<sup>2</sup>

Locational analysis of Ye'kwana and Yānomamö hunting patterns indicates that the inhabitants of Toki actively share four of their twelve hunting zones (Cúa, Manguera, Sedukurawā, and Igupo; see Map I and Table I) with the neighboring Yānomamö villages of Sedukurawā-teri, Buhimalawā-teri, Haiyamo-teri, and the Ye'kwana village of Amahuaca'ña. However, these shared zones are 4-6 km from the neighboring villages and, according to Ye'kwana and Yānomamö informants,

hunters will not usually hunt any nearer unless they are in hot pursuit of game.

There are a number of political, economic, and ecological considerations which deter Yānomamö hunters from hunting closer than 4 to 6 km from neighboring villages and which permit the partial overlapping of hunting zones. The Yānomamö, due to shifting political alliances, do not fully trust the intentions of neighboring hunting parties when they come in close proximity to their village because these areas are frequently exploited by groups of women in their gathering, fishing, and gardening activities. Yānomamö men and women fear that neighboring hunting parties might be tempted to abduct these women, even at the cost of breaking an alliance. Economically, there is no rational reason to hunt near a neighboring village. This is because game resources are depleted near a village (see Table I and discussion below) and since neighboring villages are usually one-half to one day's walk apart, it would make no economic sense to travel such a great distance to hunt in a game depleted area when superior alternate areas could be reached more easily. And finally, as suggested by ecological studies of animal territoriality, territories are defended when the costs of defense are exceeded by the benefits conferred by being territorial (Brown, 1964; Covich, 1977). Furthermore, ecological theory suggests, as outlined by R. Dyson-Hudson and E. A. Smith (1979) for human societies, that territoriality is most likely to be adaptive (i.e. the benefits will exceed the costs) when resources are densely distributed and predictable in occurrence spatially and temporally. However, neotropical game animals are thinly distributed and spatially unpredictable (i.e. patchily distributed) but temporally

predictable. R. Kiltie, who has studied the behavior of white-lipped peccaries which are the most important game animals for the majority of neotropical hunters, has documented that these animals are unpredictably distributed both spatially and temporally (1979). Therefore, ecological theory and the biobehavioral characteristics of neotropical game suggest that territoriality probably would not be adaptive for Amazonian hunters.

Hunters from the various villages in the lower Padamo realize that they share overlapping hunting zones, but as Lizot (1978) points out, hunting zones are never the source of disputes. Smole (1976) who made a cultural geographic study of the Parima Yanocama, notes the existence of overlapping hunting zones and that land is never a source of disputes. The Yanomamö do have territories up to approximately 6 km from the village which are vigorously defended, and are maintained to prevent the abduction of women and, to a lesser extent, to safeguard crops (especially, the desired peach palm) in semiabandoned gardens and some gathering areas. Beyond this 6-km limit the disposition to defend areas of forest in which most hunting is done becomes attenuated with increasing distance from the village, until areas of overlapping exploitation are reached. As hunters pass through overlapping areas and near neighboring villages they feel themselves to be in another's hunting domain. However, they rarely transgress these zones of overlap, unless in hot pursuit of game, because they realize the closer they come to a neighboring village, the less likely they are to encounter game. The costs and benefits of hunting in various zones is the major mechanism that patterns hunting behavior and partitions hunting zones between villages.<sup>3</sup> For the Ye'kwana and Yanomamö of the Padamo, it is best to consider most of the land which

hunters exploit as part of their home range and not as a territory (cf. Brown, 1975:61, for a discussion of home range in relation to territory). Patterns of areal exploitation in other portions of the Yanomamö tribal distribution may differ as they are determined by local environmental, demographic, and political conditions.

### Methods

The variables of hunting labor input, output of captured game, and hunting zone characteristics are the crucial factors to be interrelated in the argument of this report. Therefore, in this section they will be defined and the methods used to measure them will be described.

Data on hunting input were gathered through an observational technique, known as "instantaneous scan sampling" by primatologists (Altmann, 1974) and "spot checks" by ethnographers (Johnson, 1975), and it has also been widely used in industrial time-motion studies (Mundel, 1978). The method consists of making randomized observations of all individuals in a population and noting what each individual under study is doing at the time of observation. After a sufficient number of observations have been made on individuals in a population, it is possible to make estimates of time allocated to each activity.

Gathering data on hunting activities employing the above method has some limitations. If an individual was out in the forest hunting, then it was always impossible to observe his activity directly. Therefore, sometimes I had to gain such information by relying on verbal statements about an individual's hunting activities from his kin (this also occurred for some gathering, fishing, and gardening activities which took place outside of the village). However, I

devoted a considerable amount of time to testing the reliability of informant's statement concerning the activities of others by comparing them to interviews of hunters after they returned home. With very few exceptions, informant's statements and hunter interviews corresponded in great detail.

Data on hunting time input was gathered over a period of 216 days divided into segments of 76, 62, and 78 days. Of the full-time Ye'kwana and Yqnomamö hunters, a total of approximately 8,000 observations were made of which 900 were scored as hunting. When an observation was made the following information was included on a FORTRAN computer coding sheet: (1) name, (2) time, (3) date, (4) location, (5) activity, and (6) interaction (this was only scored when the individual under observation was interacting with someone). Variable #4 is of particular importance in this study because it indicated the hunting zone in which the individual hunted.

Sampling of hunting outputs occurred simultaneously in the same time sample period as hunting input. All hearths in the village were visited several times a day. If a kill had been made, the following information was noted: (1) name of hunter, (2) day, (3) species of animal killed, (4) weight of animal, (5) weapon used, and (6) hunting zone where the kill was made.

All hunting zones were visited at least twice in order to determine their distance from the village, plant formations, travel time, topography, and size. In addition, hunters were interviewed in order to determine how long the zone had been exploited, animals characteristic of the zone, and other factors which influence hunting. Unfortunately, the area was first accurately mapped in 1971 with side-beam

radar at a scale of 1:250,000 and this technique and scale does not permit any interpretations of ecological or topographic characteristics of the area, save the location of major environmental features.

#### Hunting Input

Table I and Figure I reveal a number of differences and similarities in Ye'kwana and Yānomamö hunting input for each of the hunting zones. In general, these patterns are determined by the distance of a zone from the village, relative game abundance, hunting method, and technology (see Hames, 1979, for a discussion of the effect of modern hunting technology on Ye'kwana and Yānomamö hunting practices).

The most immediately visible differences between Ye'kwana and Yānomamö hunting zone time allocation is the fact that some zones are used exclusively or nearly exclusively by the Ye'kwana or by the Yānomamö. Yānomamö hunters do little or no hunting in the zones of Metacuni, Cúa, Watamo, and Sedukurawä because these areas are too difficult or distant to reach without the aid of outboard motors. The hunting they did in these areas occurred only in the company of a Ye'kwana hunting party using an outboard motor. Ye'kwana hunters, on the other hand, hunted in these areas frequently, owing to their possession of outboards. The Yānomamö could have hunted in the above-named zones during overnight hunting expeditions but instead preferred to devote time to this kind of hunting solely to Iguapo because the Ye'kwana did not hunt there and, as a consequence, game was subject to less hunting pressure. The Ye'kwana spent little or no time hunting



TABLE I. Hunting Input, Output, and Input/Output by Hunting Zone

Zone	Map Location #	Hours Hunted		Game		Input/Output		Distance (km)
		Ye'k.	Yano.	Ye'k.	Yano.	Ye'k.	Yano.	
Metacuni	1	302.0	0.0	1645.0	0.0	5.43	0.0	33.0
Iguapo	2	0.0	1137.0	0.0	900.0	0.0	0.79	14.0
Watamu	3	408.0	50.9	1385.0	73.2	3.39	1.43	13.0
Sedukurawā	4	224.9	0.0	526.6	5.2	2.34	0.0	9.5
Manguera	5	38.9	457.5	0.0	343.7	0.0	0.75	8.0
Cúa	6	398.9	49.2	386.5	0.0	0.96	0.0	7.5
Makanahama	7	140.1	720.0	142.6	340.0	1.01	0.47	7.2
O'doiyenadu	8	325.9	854.5	261.3	358.4	0.80	0.42	6.0
Shanama'na	9	329.8	71.9	685.5	37.8	2.07	0.53	5.5
Wohokuha	10	98.5	52.5	95.5	15.0	0.96	0.28	3.0
Audāha emadi	11	168.3	105.1	20.0	31.5	0.12	0.30	2.5
Gardens	12	272.4	245.6	164.0	74.0	0.62	0.30	1.5
Totals		2708.0	3604.0	5311.0	2179.0	1.96	0.604	

in the zones of Manguera and Iguapo because these zones are deeply inland and cannot be reached by outboard motor.

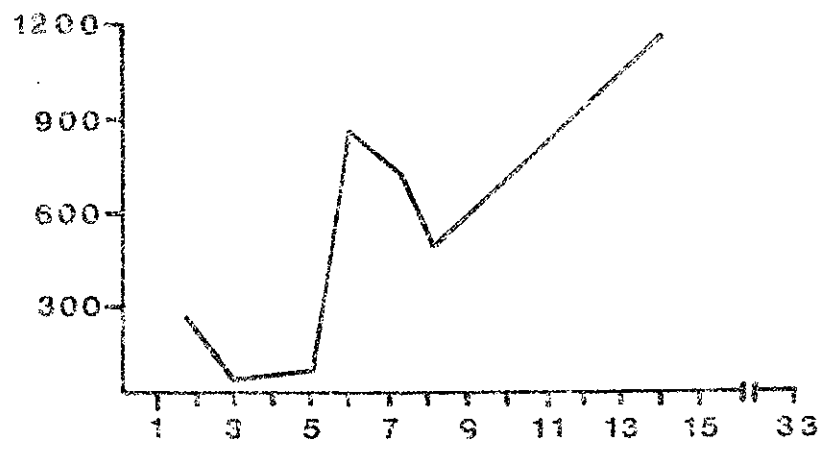
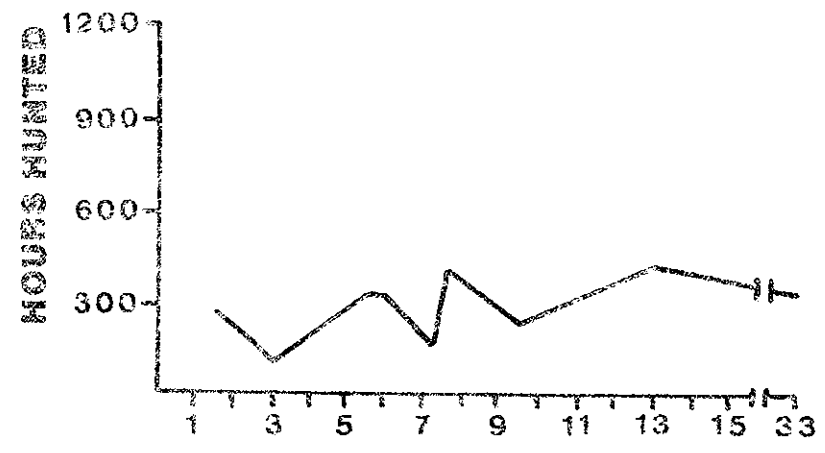
Due to their possession of the outboard motor, the Ye'kwana could exploit easily any hunting zone utilized by the neighboring Yānomamö villages of Koshirowä-teri, Sedukurawä-teri, Buihimalawä-teri, Haiyamo-teri, and Yamaho-teri (see Map I). However, as Map I indicates, the Ye'kwana do not hunt closer than 4-6 km from these villages. As mentioned previously, this is due to the fact that zones near a village are depleted of game and it not worth the effort to make a long hunting trip only to hunt in game-depleted areas.

The relation between hunting input and distance displayed in Figure I and Table II corresponds to the basic kind of hunts of the Ye'kwana and the Yānomamö. Both distinguish between morning and evening hunts, day hunts, and expedition or overnight hunts. Morning and evening hunts occur within a radius of up to 4 km of the village, last no more than two or three hours, and are for the purpose of adding meat to the morning and evening meals. They occur most frequently during seasons when time must be allocated to more pressing activities (e.g. felling gardens). Also, a large proportion of these hunts are made by youths who are honing their hunting skills and who do not have the ability to hunt in more distant zones. Day hunts occur between 3 and 9 km of the village, last for six to nine hours, and are the most common kind of hunt. Expedition hunting occurs beyond 9 km of the village, lasts for two days or longer, and is done to acquire large quantities of game for local consumption or for Ye'kwana wasai or Yānomamö reahu inter-village feasting.

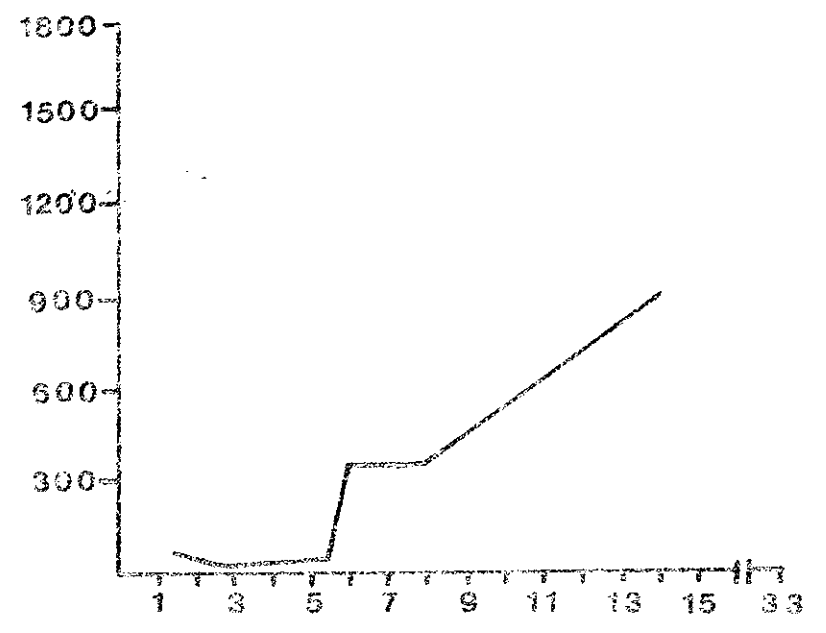
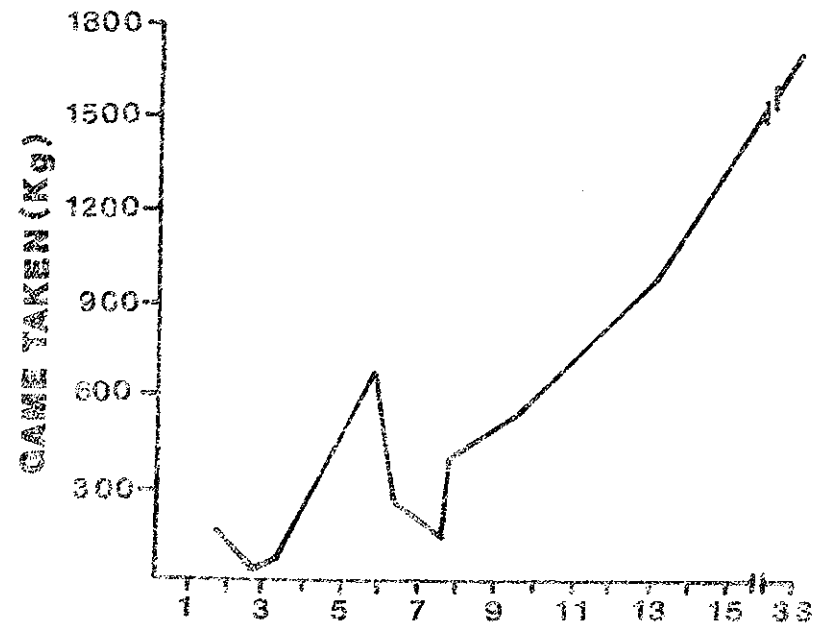
**YE KWANA**

**YANO NAMO**

**FIGURE I**



**FIGURE II**



**DISTANCE FROM VILLAGE (Km)**

Table II. Hunting Time Allocation (%)\*

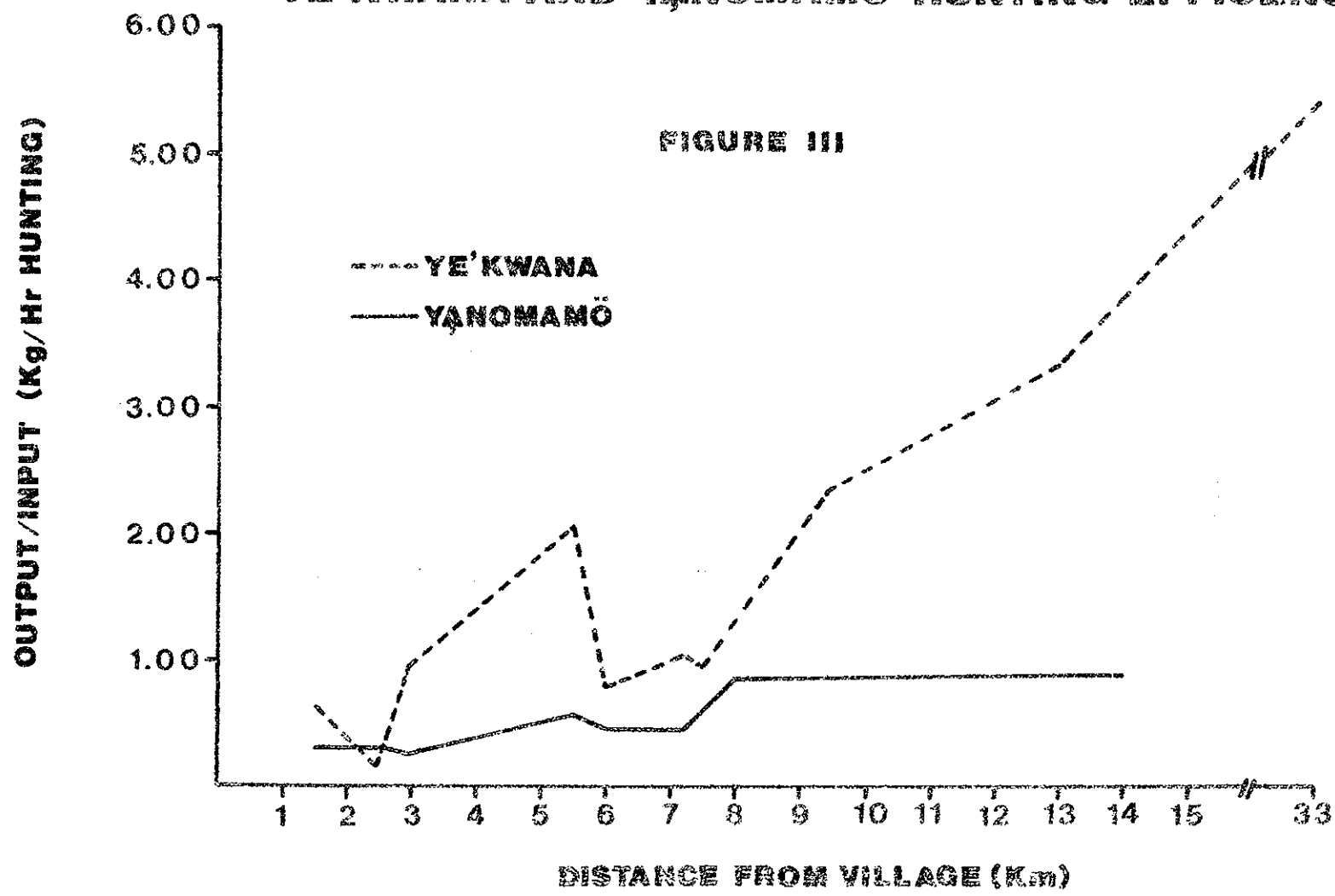
Hunt Type	Ye'kwana	Yanomamö
Morning/Evening (0-4 km)	20%	11%
Day (5-9 km)	53%	56%
Expedition (9+ km)	26%	33%

\*Derived from Table I.

#### Hunting Output

The amount of game taken from each hunting zone is obviously a function of the quantity of faunal biomass and amount of time spent hunting in each zone, which in turn is determined by the dominant biotope and the length of time the zone has been exploited. Figure II, which plots the amount of game taken from each zone against the distance of the zone from the village (distance is a fair index of the history and frequency of exploitation and hence the quantity of animal biomass for each zone). It indicates that, if we exclude hunting zones in which the Ye'kwana or the Yanomamö do little hunting, there is a fairly good positive relationship between distance from village and quantity of game. That is, the further the zone from the village, the greater the amount of game taken.<sup>4</sup> Distant hunting zones are important in the hunting economy of the Ye'kwana and the Yanomamö: 57% and 41% of all game taken by the Ye'kwana and the Yanomamö, respectively, was taken from distant hunting zones (Iguapo, Watamo, and Metacuni) which are the foci of expedition hunting.

# YE'KWANA AND YANONAMÖ HUNTING EFFICIENCY



The productivity of each hunting zone makes for an interesting comparison with the data published by Nietschmann (1973:173) on the Miskito Indians of Nicaragua. Nietschmann noted that the relationship between distance and hunting yield was not linear but that it was more akin to a normal distribution (i.e., yields were low far and near to the village and peaked over the middle range). Nietschmann implies that variability over distance is largely a function of the variable distribution of biotopes throughout the Miskito hunting area. The difference between the Ye'kwana and Yānomamö data and the Miskito data is probably attributable to the fact that Amazonian habitats are not as complex and diverse as the habitats of coastal Nicaragua.

#### Hunting Output/Input

The data on hunting input and output, alone, are insufficient measures of the quality of each hunting zone. By combining input and output data for each zone into output/input ratio (kilograms of game per hour of hunting) the quality of each hunting zone and the abundance of animals therein can be evaluated. Table I and Figure III indicate that there is a positive linear correlation between distance of a hunting zone from the village and its output/input ratio. Furthermore, if one were able to delete the added time necessary to travel to distant hunting zones then the relationship would be stronger and perhaps curvilinear.<sup>5</sup>

Actually, the real determinant of hunting success--measured by output/input--is not the distance of a zone from the village but rather the degree to which the zone has been exploited. Distance of a zone from the village is merely a useful index, in most cases, of its

history and intensity of exploitation. In a real sense, output/input ratios in hunting zones behave in much the same way as output/input ratios in horticultural plots which have been cropped for varying lengths of time; and, as will be argued later, Ye'kwana and Yanomamö hunters rotate or shift hunting zones in much the same way and for the same reasons they shift horticultural plots.

Earlier it was suggested that biotope could influence the abundance of game in each hunting zone. However, it was noted that for most zones the effect of biotope type is masked because most zones are about 80% terra firme and in practice it was very difficult to determine the proportion of other biotopes in each zone. Nevertheless, one can make a strong argument that biotope type strongly influences hunting success in the hunting zone of Shanama'ña. Figure III reveals that hunting success for the Ye'kwana is much higher in Shanama'ña than it should be given its proximity to Toki and its long history of exploitation. This zone has been exploited continually for at least 25 years and was once a village site, between 1965 and 1969, for the Ye'kwana and the Yanomamö of Toki. The high continued productivity of Shanama'ña is most probably related to its degree of ecological complexity and numerous ecotones. Instead of being dominated by the terra firme biotope, Shanama'ña contains large areas of swamp forest, seasonal várzea forest, and a variety of anthropogenic formations, as well as some terra firme forest. The juxtaposition of so many biotopes suggests large ecotonal areas.

The higher productivity of garden land and abandoned gardens immediately around Toki in comparison to the two nearby terra firme hunting zones of Audáha emadi and Wohokuha also attests to the role that biotope plays in hunting success. Gardens, abandoned gardens,

and secondary forest provide a large amount of edible biomass for terrestrial, as well as arboreal and volant, animals. Linares (1976) and others have already pointed out that garden hunting is relatively efficient even though such areas are often subject to long-term exploitation.

Since there is an implicit assumption in this study that hunters attempt to maximize the amount of game captured in relation to the amount of time spent hunting, one may legitimately ask why hunters bother to hunt in zones near the village which are least profitable and why they do not allocate more time hunting in distant zones which are most profitable. (This is also a perplexing problem in optimal feeding theory in relation to optimal patch [here, zone] choice, cf. Pyke et al., 1977; Krebs, 1978).<sup>6</sup> Time constraints for the Ye'kwana and the Yānomamö and gasoline cost and scarcity for the Ye'kwana are the major factors which may explain this deviance from the expected. As pointed out above, hunting near the village, which is the least efficient type of hunting, most commonly occurs during periods of the year when other necessary economic tasks, such as garden clearance, dominate Ye'kwana and Yānomamö time budgets. Similarly, long-distance hunting is limited to times when hunters can devote exclusively two to five days to hunting, and this hunting, especially for the Yānomamö, is best done during the short "dry" season when it is easiest to travel in the forest. The cost and scarcity of gasoline for outboard motors limits the amount of time the Ye'kwana can hunt in the rich zones of Watamu and Metacuni. Finally, the restricted seasonality of night hunting, which is the most profitable of all hunting, partially explains why Ye'kwana hunters did not spend more time hunting in Shanama'ña which is an unusually rich night hunting zone.



Discussion

A locational analysis of Ye'kwana and Yanomamö hunting patterns has a number of implications concerning aboriginal use of faunal resources in the neotropics, as well as the role of hunting and protein procurement in relation to successful adaptation to the Amazon.

Briefly, the Ye'kwana and the Yanomamö utilize hunting zones so as to maximize game yield while minimizing hunting effort and this pattern of areal exploitation is suggestive of a semi-sedentary settlement adaptation.

During the first few years of a village's existence the hunting zones immediately around the village are exploited intensively because game is abundant and effort expended is low. As game becomes depleted (in the sense that the output/input ratio declines in nearby hunting zones), more distant zones are opened if the added travel time is repaid by higher rates of return in comparison to nearby zones. Table I reveals that this process has occurred already in Toki because the two nearest hunting zones (aside from the garden zone), Audäha emadi and Wohokuha, are the least frequented hunting zones that the Ye'kwana and the Yanomamö exploit. This is not to suggest that the hunters of Toki are obeying some conservation ethic to preserve animals from local extinction, but rather, as the output/input ratios indicate, these areas give the lowest rates of return of all zones. Relaxation of hunting pressure in low-yielding zones allows game populations to rebuild and this will eventually enhance hunting success in such zones. However, I would not argue that the aim of relaxation of hunting pressure in depleted zones is to permit local game populations to rebound, although it is one of the effects (cf. Williams,

1966, p. 8 ff., for a discussion of adaptation and fortitious effects). The aim of taking pressure off the game-depleted zones is to maximize hunting efficiency by exploiting more profitable zones. This process has been well established for Athabaskan hunter-gatherers (Felt, 1973; Jarvenpa, 1977).

The utilization of hunting zones among the Ye'kwana and the Yānomamö is analogous to their utilization of garden land. Through time intensively cropped hunting and garden lands lose their fertility (as measured by declining output/input ratios). When this occurs to a particular degree, land is abandoned and new land is opened for exploitation. While the new land is exploited, heavily cropped land regains its fertility and later it can again be cropped effectively. Conklin (1957) has devised a well-accepted typology of shifting cultivation based on the length of time cultivated land is allowed to fallow before recultivation. Adopting this typology for neotropical forest hunters, one might classify groups like the Amahauca (Carneiro, 1970) as "pioneering hunters" because they abandon their settlement after one or two years, when game immediately around the village becomes depleted, in order to establish a village where game is more abundant. The Ye'kwana and the Yānomamö might be classified as "integral hunters" because of their practice of rotating hunting zones. The factors which determine the kind of hunting strategy utilized are undoubtedly complex: population density, political environment, settlement size, and the quantity and seasonality of fish and game resources are the most important factors.

The numerous and intensive studies of shifting cultivation in the tropics have provided a great deal of information regarding how long a

plot of garden land may be cultivated, how long it must be fallowed prior to recultivation, and the factors which determine this process. The primary aim of this paper has been to demonstrate that some neotropical hunters utilize their hunting land in much the same way as shifting cultivators. However, as the data presented here indicate, this process of hunting zone rotation is only vaguely understood, and it is not exactly known whether this form of hunting adaptation occurs among other neotropical horticulturalists who depend on hunting for a major portion of their protein intake. Given the rapid encroachment of criollo settlers into Amerind land in the Amazon and the creation of national Indian parks (especially the planned Yanomamö Indian Park near the Brazilian-Venezuelan border, cf. Ramos and Taylor, 1979), it is crucial that ecologically oriented researchers gain some idea of the extent to which Amerinds utilize their hunting land and what their needs are. The remainder of this paper will be devoted to accessing one part of that problem: that is, the rate of recovery of a hunting zone.

In order to assess the rate of recovery for hunting zones, the examples of Cúa, Watamo, and Metacuni will be used (see Map I and Table I). When the Ye'kwana and the Yanomamö arrived in Toki in 1969 none of these hunting zones were used. Initially game was locally abundant in Toki and there was no need to travel to these distant spots to hunt successfully. According to Ye'kwana and Yanomamö informants, Metacuni had been hunted intensively between 1920 and 1955 by the Yanomamö inhabitants of Koshirowä-teri, Buhimalawä-teri, and Sedukurawä-teri; Cúa was hunted intensively between 1945 and 1969 and then lightly from 1970-1974 by the villages of Haiyamo-teri and

Namaho-teri; and Watamo between 1940 and 1955 by the Toropo-teri and the Ye'kwana when they lived at Nosamo'ña. If we assume that all these zones were exploited until their output/input ratios were similar to Audäha emadi and Wohokuha (see Map I and Table I) and if we know that Watamo was reopened in 1973, Cúa in 1975, and Metacuni in 1975, then the following table (Table II) may be constructed:

Table II

Zone	Length of Fallow	Output/Input Ratio (kg/hr)
Cúa	6 years	0.98
Watamo	17 years	3.39
Metacuni	20 years	5.34

The table above suggests quite obviously that the longer a zone is not hunted the greater the hunting success when it is reopened. The findings here are consonant with those of Vickers (1976, 1979) in his study of the Siona-Secoya of the Ecuadorian Amazon. At the start of Vickers' study the Siona-Secoya moved their village into an area which had not been exploited for 20 years and they killed game at a rate of 2.82 kilograms (eviscerated weight) per hour of hunting during their first year of residence. During their second year of occupation, Siona-Secoya hunting yields dropped by 40% to around 2.0 kg/hr hunting. Vickers points out that the adaptive responses were to hunt smaller animals which were overlooked when large animals were abundant during the first year of settlement and to exploit increasingly zones

distant from the village. Partial analysis of animal types by hunting zone for the Ye'kwana and Yānomamö also indicate that small animals were more frequently taken in hunting zones near the village.

Furthermore, studies of optimal diet choice in a variety of animal species (cf. summaries in Schoener, 1971; Pyke et al. 1977; Krebs, 1978) have demonstrated repeatedly that as large prey (or prey which yields the highest net rate of return) becomes scarce, predators switch to small prey which had been ignored when large game was abundant (cf. also Winterhalder, 1979). In other words, predators switch from being specialists to generalists with changes in density of large and small game, by broadening their diet breadth.

Lathrap (1968) and Meggers (1971) suggest that interfluvial populations such as the Yānomamö must shift residence frequently due to local game depletion. While some Amazonian populations such as the Amahuaca of the Peruvian Montaña appear to fit this model, the Yānomamö of the Padamo do not. Although the Padamo Yānomamö are currently a fluvial population, they have become so only in the last 30 years. Ethnohistorical research on this population reveals that in over 30 village moves spanning a period of 90 years none, according to informants, were made because of declining game yields, even after they were pointedly queried about the relationship between game depletion and village movement. Research by Chagnon on the largely interfluvial Namowel-teri and Shamatari population blocs (Chagnon, 1974) with a sample of over 300 residential shifts over a period of more than 100 years also indicates that informants never rationalized such movement in terms of game depletion, although lack of easily accessible garden land was not infrequently cited (Chagnon, personal

communication). This is not to say that game depletion is not, or cannot be, a cause of residential shifts, but merely that we have been unable to document it.

Chagnon (1973) has shown that the Yanomamö shift residences for two general reasons. The first, which he terms a "micro-move," occurs when garden land immediately around the village becomes sufficiently distant productive gardens in order to shorten walking time. Such moves are also precipitated by general village structural decay (e.g. rotted roof thatch) and environmental health problems (e.g. increasing chigger and cockroach populations). These moves range from 100 m to 1 km of the former village site. The second kind of move is termed a "macro-move" and occurs when a village must put a great deal of distance between itself and a more powerful enemy village for reasons of safety.

### Conclusion

It appears that there are several major adaptive responses to declining game yields in Amazonia. The first might be called pioneering hunting. This response occurs among interfluvial populations with low population densities, small settlements, and little or no dependence upon fish, such as the Amahuaca (Carneiro, 1970). Such communities exploit the game immediately around the village for a period of one to two years and then abandon the settlement when game becomes difficult to acquire. The second form might be called integral hunting and is manifested by such groups as the Ye'kwana and Yanomamö through the rotation of hunting zones. The widening of diet breadth, which has been documented by Vickers (1976, 1979) for the Siona-Secoya, and which

occurs among the Ye'kwana and Yanomamö also, is another adaptive response for integral hunters and takes place in concert with hunting zone rotation. However, it is still too early to tell whether this simple dichotomy is adequate to cope with the various strategies for dealing with local game depletion. Johnson (1975) has suggested that the Machiguenga of the Peruvian Montaña have responded to game depletion by growing a greater number of protein-rich crops such as maize and beans instead of relying on protein-poor crops such as manioc and plantains, staples of the lowlands where fish and game are more abundant. Indeed, game depletion may provide the key for understanding the distribution of crop complexes in Amazonia. It is clear that

✓ further research is needed to determine the range of responses by Amazonian native populations to diminishing game yields and the demographic and ecological processes which underlie them.



Footnotes

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2. In regards to hunting territories Lizot asserts, "In fact each Yanomamö community has its own hunting territories. These territories are exclusive and determined by use alone, and they are never the object of disputes. Since neither game nor space is scarce, there is no competition for resources and the community is sovereign" (1978:507). Since the concept of territoriality is defined commonly as a defended area of exclusive use one must assume--implicitly at least--that the Yanomamö in Lizot's area of study are defending their right to monopolize game resources wherever they hunt. It is paradoxical that a settlement would have hunting territories if, in Lizot's words, neither game nor space is scarce. Perhaps Lizot really means to say that they have a home range or an undefended exclusive area (cf. Brown, 1975:58-70, 124-150, for a discussion of these and other concepts of animal spacing systems). However, overlapping or non-exclusive hunting zones between Yanomamö villages have been reported by Smole (1976:78-79) and suggested by A. and N. Lhermillier (1975).
3. Charnov, Orians, and Hyatt (1976:256-257) suggest that a kind of passive territoriality, which appears to be identical to Brown's concept of an undefended exclusive area, may evolve among conspecific predators due either to exploitative or behavioral or microhabitat depression of game animals. For human hunters B. Winterhalder has suggested (personal communication) that this might occur in environments where prey are well concealed, exist at low density, and are relatively sedentary and slow to recover from predation (this is a good typification of neotropical rain forests). In such environments intruders are at a disadvantage because they are ignorant of hunting depression levels caused by predators which regularly use the area. It is conceivable that this is true for Yanomamö and Ye'kwana hunters and it provides a further rationale for hunters spending little time in zones exploited heavily by neighboring villages.
4. Since the founding of the village of Toki in 1969-70 the distant hunting zones of Metacuni, Watamo, and Iguapo have been subject to the least hunting pressure of all zones, although their rate of exploitation, according to informants, has increased in recent years. Therefore, distant zones have a greater amount of total game biomass compared to near zones. But the greater yield of distant hunting zones is not so much a function of greater total biomass but rather the higher proportion of large game (white-lipped peccary, tapir, caiman, etc.) in the total game biomass. A preliminary analysis of the hunting data indicates that the average weight of a kill (kilograms of game divided by number of individuals taken) in distant zones is approximately double of that in near zones. A fuller analysis of this sort is being prepared and will be compared with W. Vickers' data on the Siona-Secoya (Hames and Vickers, in preparation) and related to the issues of optimal diet breadth (Charnov, 1976a) and hunting focus or image.



5. Charnov's marginal value theorem (Charnov, 1976b) would predict that hunting efficiency (or the net rate of energetic return) should be equalized over all patches (here, zones) of a hunter's habitat because a hunter should leave a patch when its marginal rate of return is equal to or less than the marginal rates of alternate patches. In other words, a hunter should not remain in a patch when his rate of return can be increased by travelling to another patch. The measure of hunting efficiency used here (kilograms of game per hour of hunting) are marginal values since travel, search, and return time are combined for the measure hunting input. To some extent Yanomamö hunting efficiency does confirm Charnov's marginal value theorem because even though hunting efficiency does increase with distance from the village it does so only slightly (cf. figure II). However, the same curve for the Ye'kwana does not bear out Charnov's prediction because hunting efficiency increased dramatically with distance from the village.

It should be noted that humans are central place foragers and Charnov's model applies to non-central place foraging, which, according to Orians and Pearson (1979), is a special case of central place foraging. Nevertheless, in central place foraging equality of net rates of return for each patch may never occur. This is because when a hunter travels to a desired patch he sometimes travels through a number of other patches on his way out and on his way back in which he intends to do no hunting. If suitable game is found en route then it will be taken (cf. Hamilton and Watt, 1970; on trampled zones and refuging). Also, as discussed on page 18, time constraints disallow equality of net rates of return for all hunting zones.

6. Theoreticians of optimal foraging theory frequently attempt to explain deviations from the expected as do to complicating factors such as an organism's desire to minimize variance of intake, to monitor food resources in a rapidly changing environment, and a host of other factors: for a discussion of the role of these factors see Pyke et al. (1976) and Krebs (1979).

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