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# Reports

## Ethnogeography and Resource Use among the Yanomami

### Toward a Model of “Reticular Space”

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Study of the spatial patterns of land use and forest resource exploitation by a Yanomami community in northern Amazonia (Brazil) combining high-resolution satellite imagery and global positioning system survey data with ethnogeographic fieldwork shows that its natural-resource use is configured in terms of “reticular space” rather than a set of discrete concentric exploitation “zones.” This model of reticular space has general relevance for the Yanomami and other Amazonian indigenous groups. The research reported demonstrates the value of a multidisciplinary methodology for gathering data on ethnogeographic practices and knowledge that are essential for the appropriate demarcation of indigenous protected areas and the long-term sustainable management of their environment in the Amazon and other tropical-forest environments.

The Yanomami occupy a vast area of tropical forest stretching from the Upper Orinoco River in Venezuela to the Upper Negro and Branco River basins in Brazil. They are the largest indigenous group in the Amazon to maintain a traditional system of production based on hunting, fishing, gathering, and swidden horticulture, and their use of natural resources in the tropical forest has been one of the most studied cases in the region over the past three decades. Despite a few narrow applications to Yanomami settlement patterns since the early '90s (Chagnon 1991, 1995; McGwire, Chagnon, and Brewer Carias 1996; Craig 1999; Craig and Chagnon 2000), researchers have not yet fully mobilized the potential of remote-sensing tools and geographical information systems for determining the precise spatial configurations of the land-use models underpinning indigenous systems of production. This article presents a new approach to the Yanomami system of forest use by taking advantage of current geographic tools such as high-resolution satellite imagery (Landsat-TM, EYM+, and SPOT-HRV) and Global Positioning System

(GPS) survey equipment. We used these tools to map paths and places and other relevant ethnographic data with a group of Yanomami research collaborators. [A detailed description of our methodology may be found in the electronic edition of this issue on the journal's website.] Our study was conducted between October 2003 and April 2005 among the Watoriki t<sup>h</sup>eripë,<sup>1</sup> members of a Yanomami community in the state of Amazonas in Brazil with whom the first author has conducted ethnographic fieldwork since the mid-1970s. All ethnogeographic information was elicited and discussed in the southeastern Yanomami language spoken by members of this community, Yanomae t<sup>h</sup>ëä (see Albert and Gomez 1997).

### Yanomami Forest Use: Concentric Zones or Interwoven Networks?

The spatial patterns of the Yanomami's use of forest natural resources have traditionally been described or represented by anthropologists as concentric zones of exploitation (gardening, hunting, and gathering) outlined by approximate contours. Numerous examples of this description can be found in the literature of the 1980s (e.g., Fuentes 1980, 30; Sponsel 1981, 226–29; Colchester 1982, 267; Lizot 1986, 39; Good 1989, 88), an interesting exception being a diagram offered by Lizot (1996 [1987], 754). Three types of concentric zones are usually distinguished: one close to the collective house, which includes the gardens, one for daily hunting, gathering, and harvesting, and, finally, one for long-distance collective hunting expeditions (*h<sup>h</sup>enimu*) and wild fruit gathering (*waimi huu, yanomoãi*). This anthropological “zonal model,” which lacks any indigenous cultural recognition, projects onto Yanomami productive activities an ethnocentric conception of successive “rings” of decreasing degrees of resource exploitation similar to the classic agricultural model proposed by J. H. von Thünen (Huriot 1994).<sup>2</sup>

The methodology we adopted, allowing a fine-grained record of the Yanomami's exploitation of natural resources, enabled us to produce a very different spatial model, this time structured by the collective knowledge and use of a web of identified forest paths (principal and secondary) tying together notable sites labeled by toponyms (hunting and gathering camps, former habitation and garden sites, groves of fruit trees, geographic features, and so on). In Yanomami cultural cartography, this complex network of paths and places is, moreover, closely interwoven with the intricate branching of the hydrographic network (made up of named rivers and streams), which constitutes another primary spatial reference.

From this new perspective, the Yanomami ethnogeographic organization of space appears to be reticular—structured by

1. Literally, “the inhabitants (t<sup>h</sup>eripë) of Windy Mountain (*Watoriki*).”

2. This “ring model” of resource use seems to have been an implicit convention in Amazonian studies since Carneiro's (1960) pioneering work on Kuikuru agriculture.

a crisscrossing network of sites (points) and routes (lines)—rather than zonal.<sup>3</sup> By taking into account this emic structuring of space based on networks, as opposed to the conventional etic perspective in anthropology and geography, we aim to contribute toward a spatial model of tropical-forest resource use through data that are both quantitatively more precise and qualitatively more compatible with Yanomami social practices and cultural concepts.

### Watorikí Village and Its Gardens

The Yanomami village of Watorikí, built in 1993, is located between the basins of the Upper Catrimani and Demini Rivers (the former a tributary of the Branco, the latter of the Negro) at the beginning of the lowlands that lie along the southern edge of the Parima mountain range, which defines the border between Brazil and Venezuela (fig. 1). Situated at an altitude of approximately 200 m, the village is flanked by a series of steep hills towering more than 700 m high. The soils are of the ferrallitic type common in tropical forests (Projeto RADAMBRASIL 1975) but finer and sandier in places where large stones or hills crop out from the surface. The region is covered with dense tropical forest, composed mainly of medium-sized trees overshadowed by a few protruding species (such as *Manikara huberi*, *Cedrelinga catenaeformis*, *Ceiba pentandra*, and *Hymenaea parvifolia*). The undergrowth is thin, except in ground depressions, where many species of

low trees and clusters of palms are found. In the hills the vegetation is sparser and lower because of the steep incline, which, along some peaks and ridges, is so extreme that the ground has become completely denuded.

The settlement is situated near an abandoned section of the Northern Perimetral Highway, now largely reclaimed by the forest, which was constructed in the southeastern portion of the Yanomami territory in 1973–76. A section of the road about 2.5 km from Watorikí was later turned into a landing strip, which offers the only outside access to the area, via small single-engine aircraft, from Boa Vista, capital of the state of Roraima, some 280 km away. Next to the airstrip lies the Demini Post, today a FUNAI control post as well as a health post of the Brazilian National Health Foundation (FUNASA). The Yanomami of Watorikí, who numbered 133 in October 2003 (Urihi 2003), live in a huge collective house, a doughnut-shaped structure about 70 m in diameter that encircles a central plaza (Milliken and Albert 1999, 58–72).

In January 2003 Watorikí's gardens (those that were productive, recently cleared, or planted) occupied a total area of 31.22 ha. This figure corresponds to 0.27 ha per inhabitant, which is higher than most published estimates: Smole (1976, 37) calculates 0.12–0.23 ha/inhabitant among the highland Yanomami, Lizot (1980, 30) suggests 0.0523 ha/inhabitant among the western Yanomami, and Colchester (1982, 248) estimates 0.0848 ha/inhabitant among the northern Yanomami. This indicates that, to the degree that Watorikí has become sedentarized since 1993, agricultural activities have been the focus of increasing efforts and attention.

If we take into account that each plot is cultivated for an average of three to four years, the annual increase in the amount

3. On the concept of reticular or reticulated space, see Bonnemaison (2005, 16–20, 96–97; 2005, 8–11, 84–85). See also Haesbaert (2004, 290) for an opposition between reticular and zonal “basic logics of territoriality” and Berque (1982, 119) on a similar contrast between “linear space” and “areolar space.”



Figure 1. Location of the research site and the Yanomami territory in Brazil.

of cultivated land in all the community's gardens should be between 7.8 and 10.1 ha. Our data show that after ten years of occupation (1993–2003) Watoriki had 31.22 ha of active gardens (*hutu kana*) and 40.23 ha of old garden plots (*hutu pata*), an expansion of an average of 7.14 ha per year. This figure is corroborated by our GPS survey of gardens begun during the 2002–3 dry season, which indicated a total of 7.57 ha. For the 2003–4 dry season, after 11 years of resource exploitation at the site, our data showed a much lower level of renewal (1.74 ha). The 2004–5 dry season confirmed this trend, since only 1.97 ha were opened, of which 0.75 ha were burned too late to be put in production.<sup>4</sup> Thus, only about a third of the total agricultural space was renewed over the last three years. In a context of increasing sedentarization, this signals a cumulative effect whereby gardens opened four to six years ago continue to produce, leading to an abundance of food<sup>5</sup> and encouraging conservative use of surrounding lands suitable for agriculture (this point being the topic of recurrent statements by our Yanomami research collaborators).

### Paths and Places: The Use of Forest Space

According to the ethnographic literature, Yanomami land use is spatially organized around a collective residential structure and adjacent gardens producing subsistence crops (mainly plantain and manioc [see Milliken and Albert 1999, 15–25]), which are complemented by the products of hunting, fishing, and gathering. As noted above, the Yanomami use of the forest has been conventionally described in terms of the regular or sporadic exploitation of a set of natural-resource zones, schematized as a series of progressively wider concentric domains surrounding the collective house. In this model, the complex web of Yanomami trails in the forest along which hunting, fishing, and gathering activities are conducted, if mentioned at all, is confined to a secondary level.

In contrast to this standard ring model, the spatial system currently in effect at Watoriki is organized as a reticular structure of crisscrossing webs of named paths and places spreading out from the collective house and its garden area (included in an approximate rectangle of 1.5 × 1 km). The forest space encompassed by this system, defined as *kami yamaki urhipë*, “our forest,” is structured by a series of three main networks, which, produced by individual and collective movements over time and subjected to landscape variables and the uneven distribution of natural resources, are quite irregular in shape.

4. We observed the same phenomenon in the dry season of 2003–4: 0.51 ha of a garden was established but not burned in time, and only 0.14 ha of it was planted in 2004. On the fluctuation of Yanomami agricultural production, see Lizot (1996[1986], 755–56).

5. In January 2005, the community held a *reahu* (intervillage funerary and alliance feast), during which its gardens supplied food for 300 people for seven days.

### Network of Nearby Sites for Gathering, Fishing, and Occasional Hunting

Departing from the house and adjacent gardens, the first network of notable spots refers to daily subsistence activities (gathering, fishing, and occasional hunting) (fig. 2). It is structured by three main routes, from which smaller paths branch off and lead to various sites where wild fruits are collected (in particular, those from palm trees such as *Euterpe precatoria*, *Jessenia pataua*, *Oenocarpus bacaba*, *Mauritia flexuosa*, and *Mauritiella armata* and those from other appreciated fruit trees such as *Caryocar villosum*, *Anacardium giganteum*, *Inga* spp., *Couma macrocarpa*, and *Spondias mombin*). Other sites are used for gathering crabs in small brooks, fishing, usually with fish-poisoning plants, in nearby streams and marshy areas (Milliken and Albert 1999, 51–54), occasional hunting in ponds (*Caiman crocodilus*) and riverine areas (*Hydrochaeris hydrochaeris*, *Agouti paca*), or collecting basketry materials in the forest (*Heteropsis flexuosa*).

The first main route leads to a river known as Apiahi uprapë u, situated about 2 km from the village. The second one, about 3.4 km in length, follows the path that connects the village with the Demini Post, going as far as the end of its airstrip, where the intersection of the former Northern Perimetral Highway with the Hawarihipi u River has created an especially good fishing site. The third route, only 1.1 km long, heads south and joins another part of the former highway, where graveled sections have turned into marshy areas. Independent of these three main routes, a dense network of paths (*periyo yo* or *māe*) in the immediate vicinity of the collective house provides access to water sites (*māu uka yo*), new and old gardens (*hutu yo* or *wamotima thëki māe*), and the like.

### Network of Daily Hunting Trips

Going farther yet from the village, a second network fans out, partially overlapping the first one but extending far beyond it (fig. 3). It consists of a set of hunting paths (*rama yo*) from which hunters go off into the forest in pursuit of game they sight or locate by animal tracks or calls and to which they always return. When conducting these hunts, usually individually or in pairs, men can cover long distances (up to 10 km from the village in linear distance), traveling, for example, as far as the rapids (*póra*) of the Maxahipi u River (where they can always find fish to avoid coming home empty-handed) or the area around the Pooxiki tire hehuopë u River.

Close to the village, the network of hunting paths consists of two main routes, superimposed on those leading to nearby gathering and fishing sites (fig. 2). The first hunting route branches off from the first one accessing nearby sites, going off on one side toward the south and meeting up with the Pata u River and on the other side toward the west in the direction of the Maxahipi u River. The second hunting route, called Warimahi praopë yo, is separate from any others, fol-

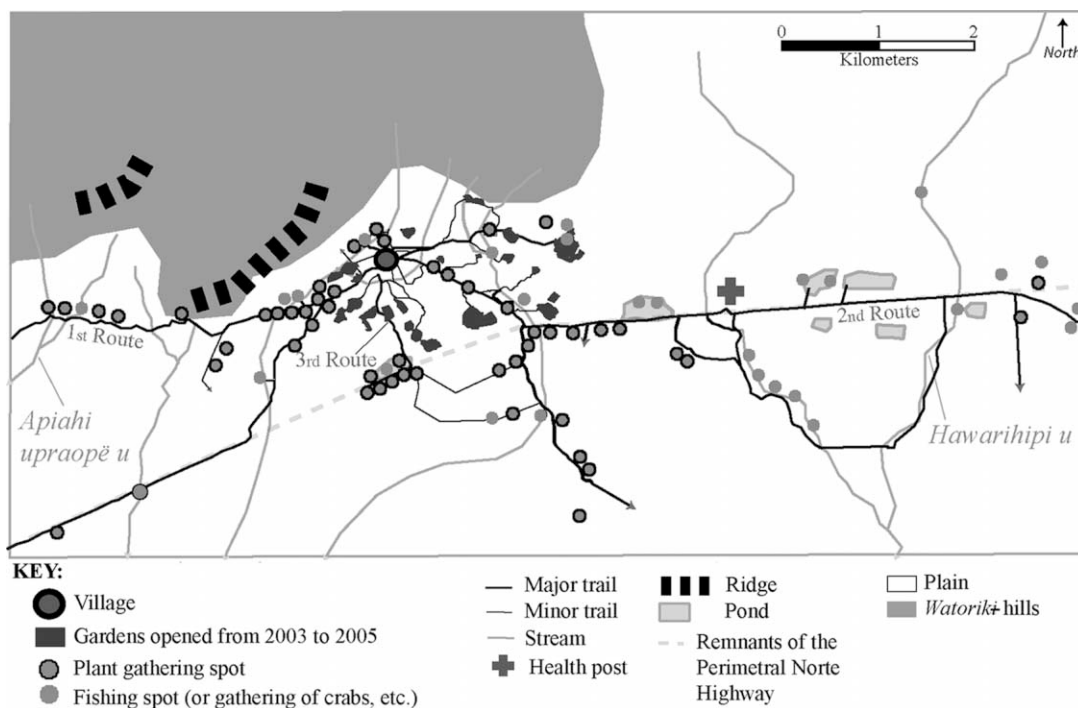


Figure 2. Network of nearby sites for gathering, fishing, and occasional hunting.

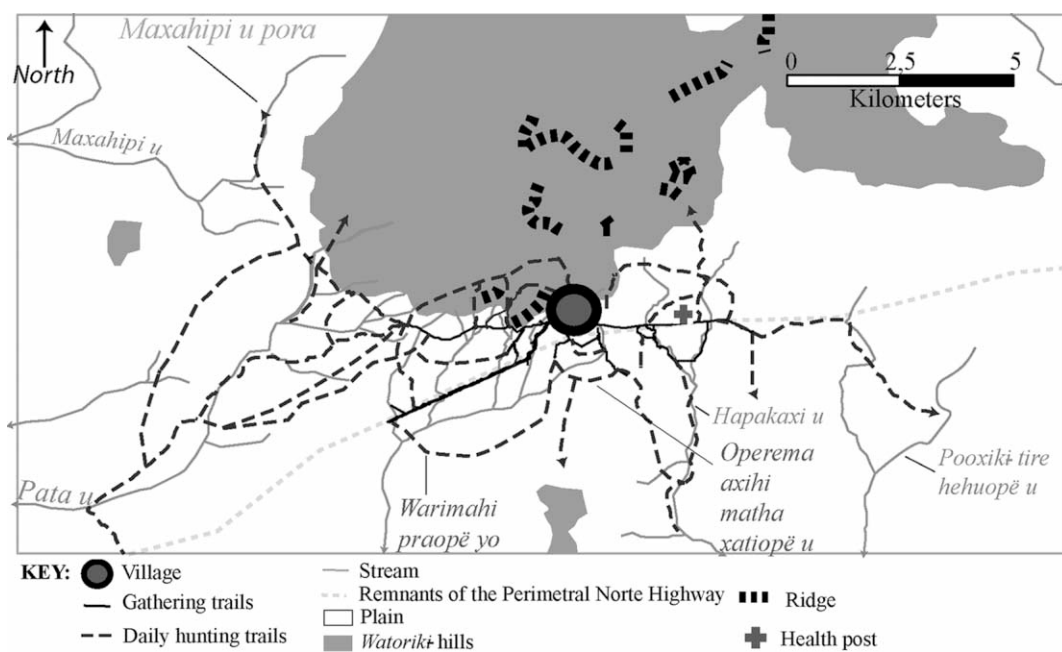


Figure 3. Network of daily hunting trips.

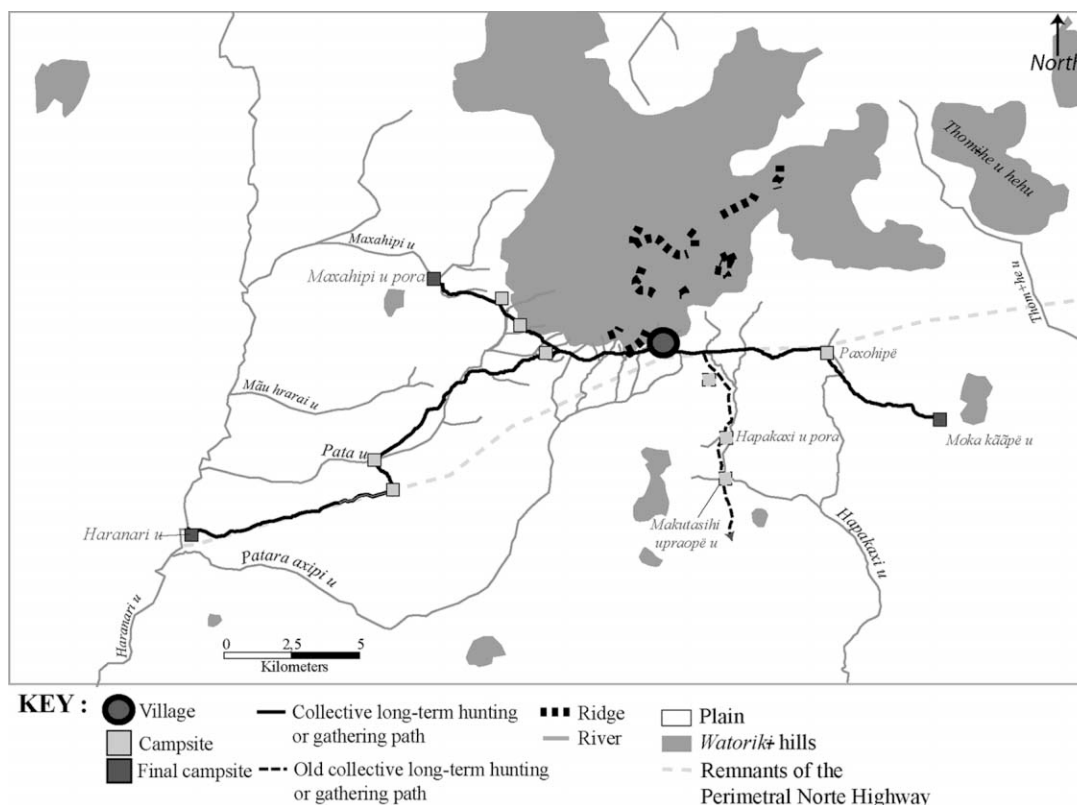


Figure 4. Network of long-distance collective hunting and gathering expeditions.

lowing the vestiges of the Northern Perimetral Highway for several kilometers and then heading off southeast. Some daily hunting paths branch off from these main routes, heading north to plunge into the mountainous formation of Watoriki, considered to be rich in game (particularly spider and howler monkeys), and tracing a wide loop about 10 km long around the northern side of village.

#### *Network of Long-Distance Collective Expeditions for Hunting and Gathering*

A third and final network is outlined by the routes used during collective expeditions for hunting (*hwenimona yo*) and gathering (*waimi yoa*) (fig. 4).<sup>6</sup> This network has two parts: the first includes a route leading from the village to temporary forest campsites (*naa nahipë*) that are chosen as the expedition's final destination, and the second is composed of paths looping around camps used by the hunters in search of game or leading to groves of trees from which fruits are gathered.

6. The inhabitants of Watoriki now pursue both activities at the same sites. Yanomami groups in the past used to spend between one-third and one-half of every year in these hunting and gathering camps, far from their main residence (Lizot 1986, 38–39; Good 1989, 89; 1995, 15).

When a new network of this kind is initiated, some of its geographic features—the destination campsite, the overnight sites used along the way to it, and especially the hunting loops that fan out from the camp—may be redefined over time, but our research shows that these elements are quickly settled after a few expeditions. The best camps<sup>7</sup> or overnight sites are regularly reused, and hunting loops that are productive and well known are often revisited, at least as long as the amount of game they yield is considered satisfactory. In several less sedentary Yanomami communities that we have studied recently, our data showed that, after some time, one of the preferred forest camps was generally chosen as the location for a new village.

At the time of our recent fieldwork, the community was using three long-distance hunting and gathering networks of this type: two of them, for which Moka Kããpë u and Maxahipi u campsites were the destinations, were situated at the farthest points of the area traversed on a daily basis by hunters (re-

7. These sites should have easy access to flowing water, allow a space to be cleared for temporary shelters, and, preferably, be located near valued vegetal resources.

spectively 8.5 km and 11 km, in linear distance, from Watorikì); the location of the third campsite, at Haranari u, was even farther away (19 km, in linear distance) on a large river (the Ananaliú or Haranari u) that is rich in big fish. In the case of hunting expeditions, the entire population of the village spends several days traveling to the destination camp, usually taking advantage of the same overnight sites from one expedition to the next. Once reaching the final campsite, the hunters depart each day, following circuits about 10–20 km long that bring them back to the campsite by late afternoon. Judging from information about sites located along these paths that are mentioned by the hunters and indicated on satellite images, we estimate that these hunting trips fanned out to a maximum to 6 km in linear distance.

## Discussion

### *Path Networks and “Empty Zones”*

Our field research showed that Yanomami ethnogeographic knowledge is organized by a rich toponymy consisting of an ensemble of sites tied together by interconnected paths (used for hunting, fishing, gathering, and traveling). The main routes forming the vertebrae of these networks (*hwii e yo pata*, “father path”) are also given names, and this complex system of paths and places is intermeshed with the local network of named rivers and streams. Furthermore, out-of-the-way forest spaces encompassed by the loops of crisscrossing trails or situated far outside the network of paths are labeled

by the generic term *urihi komi*, meaning “closed forest.” These spaces are essentially defined by the absence of any permanent human trail and by the possibility of bad encounters with *ně wāripě*, pathogenic “forest spirits” that hunt humans (Albert and Gomez 1997, 47, 103, 109). As “empty zones” (Bonne-maison 1997, 16) of unexploited forest left inside or outside the networks of hunting, gathering, and traveling routes, they probably play a significant ecological role as a game refuge areas.

It thus appears that the Yanomami conceptualization of space is indeed organized by reference to an ensemble of points and lines, corresponding to their practical use of the forest oriented by a web of sites and routes, rather than a set of roughly bounded areas (concentric or otherwise) characterized as zones of natural-resource exploitation. That this spatial organization includes culturally recognized empty zones of “closed forest” further confirms that we are witnessing a reticular system, since such a webbed structure of points and lines never completely fills the space through which it spreads.

This model of Yanomami ethnogeography (fig. 5) presents many similarities to those suggested by Collignon (1996) for the Inuit and by Bonne-maison (1997, 2004) for Vanaatu. Stimulating connections could even be made with very different domains of cultural-space studies, such as the cartographic depiction of ancient states and empires (Smith 2005) or the analysis of postmodern forms of territoriality (Haesbaert 2004, chap. 7).

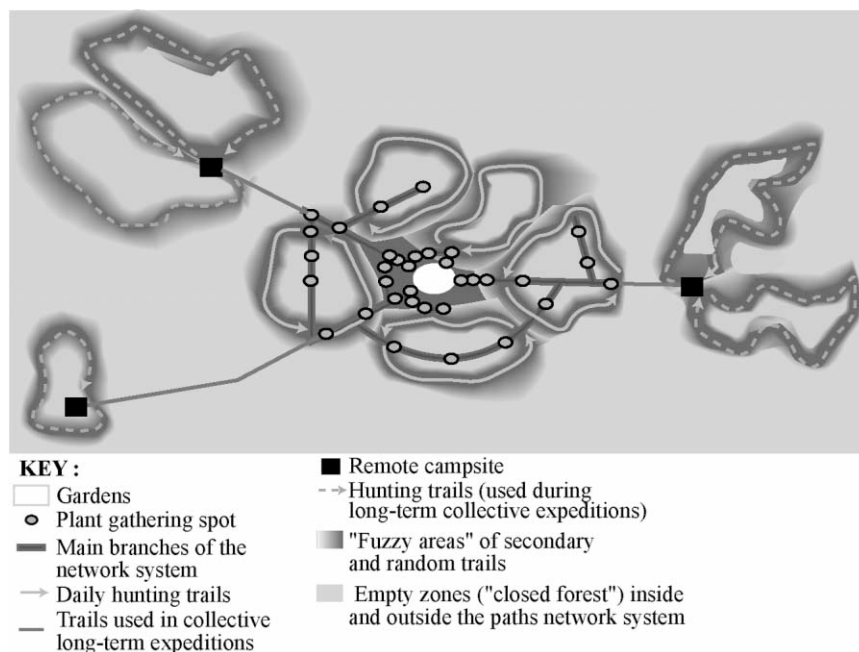


Figure 5. Model of reticular space in Yanomami forest use.

### *Peripheral Trails and "Fuzzy Areas"*

We have suggested that prior ethnographic representations of Yanomami economic space in terms of concentric zones have been construed, in large part, through the imposition of the etic perspective of anthropologists and geographers rather than through an effort to record the Yanomami's own cultural model of spatial organization. We should acknowledge, however, that this conceptual projection of a zonal logic onto the emic reticular space of the Yanomami is not completely groundless. Given the labile quality of the paths branching off from the network of main routes, the cumulative crisscrossing of these secondary trails and random hunting and gathering loops comes to nearly saturate some forest sectors over time (especially in more sedentary Yanomami communities like Watorikí). Thus, the gradual superimposing of less permanent and improvised and peripheral routes could end up configuring, from our own cultural-geographic perspective, what could be considered theoretical "fuzzy areas" (Costa Fonte and Lodwick 2004). In this context, such discontinuous areas, with their indefinite perimeters and limited extent, could be seen as embedded in the vertebral network, composed of named routes and sites, that structures Yanomami reticular space and the unlabeled "empty zones" mentioned above.

### *Calculating "Areas of Total Resource Endowment"*

From the point of view of either a zonal model or a reticular one, any calculation of the total surface area of the forest environment exploited by a local Yanomami group can only be based on approximate figures. The zonal model, based on the assumptions that a given community controls and exploits every part of its surrounding forest space—conceived almost like a kind of polygon joining the farthest points reached by its hunters—has, by definition, a bias toward overvaluation. The reticular model, based on a much more fine-grained record of the community's active use of forest space, deals with discontinuous, diffuse, and lacunary surfaces and is therefore bound to yield lower but more realistic figures for the total amount of surface area in the forest exploited by a particular group.

Smole (1976, 78) described for the Yanomami community of "Jorocoba-teri" in Venezuela an "area of total resource endowment" of 64,750 ha. Using the conventional zonal perspective,<sup>8</sup> he obtained his figure by drawing a line around the headwaters of three small rivers to define the "territorial base" of this local group. For the Watorikí community, we instead took as a basis for estimation a 1-km area around the three path networks actively used by community members at the time of our research plus another space with a 6-km radius (consistent with our data on the maximum distance covered in a one-day hunt) surrounding their three main campsites.

8. Although he clearly recognizes the fundamental structuring role of trail networks (1976, 76).

This calculation yields a total of about 37,300 ha, less than half Smole's figure. Although this method is more accurate than Smole's, it is less than satisfactory in that it still resorts to an approximate but traditional planimetric logic. Unfortunately, nothing more sophisticated can be offered at this point (but see Waters and Evans 2003 for interesting experiments on "fuzzy-area" mapping).

Finally, it should be noted that the distinction between "zonal territories" and "network territories" (Haesbaert 2004, 286) also represents a contrast between a timeless topography of closed surfaces and an open topology of changing webs (see Lévy and Lussault 2003, 607–9). This means that calculations of "areas of total resource endowment" based on a reticular model estimate the extent of a village spatial pattern of forest use at a specific time and that a more complete picture would require the successive recording of cumulative states of this pattern over a time.<sup>9</sup> For example, if we were to add to our estimation the recently abandoned southern Hapakaxi u hunting and gathering trail (shown as a dotted line in fig. 4), the "area of total resource endowment" of Watorikí would be 48,600 ha.

### *Reticular Space and Socioeconomic Changes*

Yanomami communities distant from any nonindigenous establishment formerly opened up a new agricultural site and built a new collective house within a radius of about 10 km every four or five years. Lizot (1980, 39) gives, for example, a maximum limit of five to seven years and Good (1989, 53) a minimum of two years.<sup>10</sup> The major difference in the land use system of the Watorikí the t<sup>h</sup>eripé is the long-term maintenance of its main residential structure and set of gardens at the same site. The community has occupied the same area since 1993, and, given the political choices and material investments associated with the construction of its collective house (Milliken and Albert 1999, 58–72), it is unlikely that the site will be abandoned in the near future. To cope with this sedentary situation, the Yanomami of Watorikí have begun to avoid using too much of the nearby forest that might be suitable for establishing new gardens (which is scarce because of topographical irregularities and the discontinuity of fertile soils). They are limiting the size of new clearings, using cultivated plots as long as possible, and returning some of the secondary forest to cultivation after a brief period of recuperation. As is shown by our data above, these new practices seem to have had a notable effect on Watorikí agriculture since 2003. After more than ten years of sedentarity, the com-

9. It should also be noted that Smole's calculation refers to a highland Yanomami community of the 1970s that was probably more mobile than that of today's Watorikí.

10. The harvest of manioc in a particular plot generally diminishes by 45–50% as early as the second year, while the decline in the productivity of plantains and bananas begins in the fourth year (Hames 1983, 23). Hunting productivity (kg/hunt) also diminishes rapidly over time, dropping 28% after two years (Good 1989, 95–96).



munity's alimentary conditions are excellent, and its gardens have not suffered from soil erosion or compaction.<sup>11</sup>

In response to socioeconomic changes, residents have made another major adaptation in hunting and gathering, an effort to maximize the use of the community's large territory (which they do not share with any other village, the closest being located several days' walk away). The group simultaneously maintains three main networks of forest campsites for protracted collective hunting and gathering expeditions (and fishing expeditions, as in the case of Haranari u). It rotates use of these networks during the year or from one year to the next and gradually renews them on a longer time scale, abandoning one and shifting to another in a different part of the forest.

In view of these adaptive strategies the question arises whether the spatial pattern of resource use recorded during our research is representative of Yanomami communities in general. In fact we have recorded data fully congruent with Watoriki's organization of space during comparative fieldwork in two other Yanomami regions in northern Brazil, one on the upper Demini River (Toototobi, lowlands) and the other on the Mucajai (Homoxi, highlands).

Watoriki, because its unusual location in a region devoid of other Yanomami villages since 1970, longer period of sedentarity, and rapidly expanding population,<sup>12</sup> displays certain distinctive features in relation to other communities, such as its wider, more complex and crystallized network of paths and its increased density of place-names. Nevertheless, these characteristics suggest that the spatial organization in Watoriki constitutes a more strongly marked, extended version of the basic Yanomami pattern of reticular space rather than one that is different or less zonal. Indeed, we argue that, precisely because of its specificity, the Watoriki case is an exemplary instance of a more general Yanomami model.

## Conclusion

The data presented in this article are intended to demonstrate the potential afforded by a new ethnogeographical approach for revitalizing a classic issue of lowland South America anthropology, namely, indigenous land and resource use in the Amazonian tropical forest. We believe that the multidisciplinary methodology used in this research on the spatial pattern of Watoriki resource use not only permits a revision of the conventional zonal model of previous Yanomami studies but also promises to shed new light on many other indigenous Amazonian systems of land use. This approach is capable of revealing the details of indigenous practices and knowledge

11. Some cumulative productive effects of old gardens (of which the accumulation of cultivable peach-palm, *Bactris gasipaes*, is the best example) and the composition of the local soils (mixed with sands derived from the breakdown of sandstone from the rocky ridges) probably contributed to this favorable situation.

12. In 1993, the population of Watoriki was 89, rising to 133 by 2003—an increase of almost 67% in ten years.

regarding natural-resource exploitation an understanding of which is essential for the appropriate demarcation of protected indigenous areas and the long-term sustainable management of their environment in the Amazon and elsewhere in the tropical-forest world.

The potential field for such ethnogeographical studies and their application is huge. Legally protected indigenous areas cover approximately 24% of the surface area of the Brazilian Amazon (Albert 2001); the "Yanomami Indigenous Land" alone, considered a priority region for the conservation of local biodiversity (Capobianco 2001, 398–99), represents almost 1% of the surface area of the world's remaining tropical forests. Given the vital but vulnerable nature of these regions, we recommend a serious consideration of these tools.

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