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Minimum Data for Comparative Human Ecological Studies: Examples from Studies in Amazonia

E. F. Moran

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Anthropological Center for Training and Research on Global Environmental Change
Indiana University, Student Building 331, 701 E. Kirkwood Ave., 47405-7100, U.S.A.
Phone: (812) 855-6181, Fax: (812) 855-3000, Email: act@indiana.edu, internet: www.Indiana.edu/~act

MINIMUM DATA FOR COMPARATIVE HUMAN ECOLOGICAL STUDIES:
EXAMPLES FROM STUDIES IN AMAZONIA

Emilio F. Moran

ABSTRACT

The proliferation of approaches to human ecology provides a rare opportunity to explore a range of problem-oriented methods that disciplinary-based methods no longer permit. This positive scenario has some potentially negative risks. If comparison between different human ecological settings is to be workable, it will be necessary to agree on minimal data sets that ought to be collected, if there are to be comparable data in human ecology. This paper proposes criteria for minimum data that are consistent with the research goals of several types of human ecology. The criteria are developed from the kinds of questions posed by researchers working in rural settings (about climate, soils, flora, and fauna), some of which may prove generally applicable in human ecological studies (of social organization, demographic structure, health, and nutrition). This is done in the context of the ecology of Amazonian populations to provide a demonstration of how such minima may fit in with larger questions asked by researchers. These minima are not intended to reduce our current diversity in methods but, rather, to ensure that our data can contribute to the comparative understanding of the human condition on this planet.

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INTRODUCTION

For the past 40 years, the Amazon Basin has been a testing ground for human ecological theories, and it is likely to remain so in the foreseeable future. The reasons why are worth examining, as well as how we might be able to advance the quality of hypothesis testing and generalizations coming from research in this part of the world. Initial interest in the area was rooted in its vast lushness, and extremes of opinion were expressed by early travellers to the region: some argued that the region was undoubtedly "a rich realm of nature," while others asserted that the lush greenness was a cover-up for a depauparate landscape.

One of the central points of discussion has been the quality of the soils in the region. Amazonian soils have been a point of controversy for a good part of this century. Late-nineteenth-century travellers' opinion that the soils of the region must be very rich given the lushness of the vegetation were followed by severe criticisms suggesting they were so poor that they could not support complex cultures or intensive cultivation. No one stated this view more coherently and firmly than Betty Meggers (1954). In a now classic article, she set out to demonstrate that the poor and acidic soils could only support small-scale societies living by swidden cultivation, because soil fertility could only be sustained from the nutrients released by burning the forest, and these would be leached by the second or third year of cultivation. It did not take long for critics of this view to appear. Carneiro (1957) suggested that the Kuikuru of the Upper Xingu could sustain populations of up to 2,000 people over the long term without requiring village movement. For him, the limiting factor was not the fertility of the soils but weed invasion. His suggestion has turned out to be correct—for very rich soils only. In alfisols, for example, the vigor of weed invasion is greater than in acid, nutrient-poor soils, where soil fertility becomes a limiting factor first (Sanchez, Bandy, Villachica, and Nicholaides 1982). Ferdon (1959) added the point that the notion of static carrying capacity overlooks human capabilities for modifying the environment and changing the limiting conditions to cultural development. He provided examples from several Asian civilizations in the humid tropics as evidence of the human capacity for overcoming limiting constraints. Recent studies tend to emphasize that the soils of the Amazon are among the richest and the poorest in the world, with many soils along the middle of such a fertility continuum. Thus, future research in the area will need to include an understanding of the soil patchiness present in order to give due attention to the variability present in human uses of variable soil resources.

In this paper, I hope to briefly show that some of the obstacles to improved understanding of the region may be related to the persistent dependence on a simple dichotomous environmental distinction between floodplain and upland ecosystems. I also suggest a couple of ways in which it might be possible to develop future research in ways that go beyond trying to answer the simple question, "Can complex social systems develop in humid tropical environments?" While useful as a broad breakdown of the region, it is necessary at this stage in scientific development to move beyond distinguishing floodplains from upland ecosystems and use more elaborate classes to characterize areas being studied. Some of these classes of environments are discussed. Moreover, if comparison among regions is to be viable, it will be necessary to arrive at some agreement on the minimal data sets that ought to be collected at most study sites to create an accumulation of comparable data in categories generally relevant to human ecological study. This minimum data may also prove useful in areas other than the humid tropics and if this is the case, comparisons could be extended more generally in human ecological studies.

In comparative terms, the area occupied by the Amazon is equivalent to the continental United States of America, or to both Eastern and Western Europe combined (without the Soviet Union), or about 6 million square kilometers. The Amazon is a region not only of rain forests. It also has semi-evergreen forests, flooded forests, savannas of various types, montane forests, and palm forests. The rivers have very distinct qualities, with some having clear, limpid waters, and others having a muddy appearance, reflecting important differences in the amount and quality of alluvium they transport.

Recent evidence contradicts many of the views espoused until recently that only small, politically disconnected settlements may be present in Amazonia. It now seems that the ancestors of contemporary indigenous peoples have inhabited the Amazon Basin for at least 12,000 years (Roosevelt 1989, p. 3). They may be among the first to have produced ceramics in the New World, 6,000 to 8,000 years ago (Roosevelt 1987). By 5,000 years ago, they seem to have had a set of domesticated crops and art forms very similar to those of contemporary indigenous populations (Roosevelt 1987). By 2,000 years ago, there is evidence of the rise of larger settlements with more complex political organization and art forms such as polychrome pottery. These seem to have been more common in the more fertile areas of the floodplain and to have been supported by the cultivation not only of manioc but also of cereals such as corn (Roosevelt 1987).

The heterogeneity of the populations that inhabit the Amazon reflects the diversity of the physical environment and their diverse historical experiences (Oliveira 1988, p. 66). The European explorers of the sixteenth-century found an Amazon with large populations inhabiting the riverbanks of the larger rivers, capable of organizing themselves in self-defense and of conquering territory (Roosevelt 1989; Porro 1989; Whitehead 1989). Chroniclers of the time described the existence of chiefdoms capable of mobilizing thousands of warriors and of offering an abundance of food to visitors, with towns extending for hundreds of kilometers along the riverbanks (Herrera 1856; Simon 1861; Porro 1989; Myers 1989; Whitehead 1989). According to ethnohistoric sources, the land of the Omagua in the sixteenth century included between 23 and 34 villages along a 700 km continuous stretch of riverfront, from the lower Napo river to the mouth of the Javarí and Içá rivers (Myers 1989, p. 6). Some of these villages have been estimated to have had at least 8,000 inhabitants (Porro 1989, p. 7). The Omagua population persisted until the seventeenth-century, although its numbers declined and its settlements covered by then only 300 kilometers of riverfront (Porro 1989; Myers 1989). There is evidence, too, for pre-Columbian chiefdoms in the upland forests of the Amazon which Whitehead (1989, p. 9) suggests depended more on control over regional commerce than on local habitat productivity to sustain their complex polities.

In the sixteenth- and seventeenth-centuries, the principal impact felt by the indigenous people came from epidemic diseases, the presence of missionaries, and the wars of conquest along the major rivers (Fritz 1922; Figueroa 1904; Uriarte 1952; Hemming 1978). By the beginning of the Rubber Era, which began in the middle of the nineteenth-century, the native peoples were already a minority. It is by this time that there appear the beginnings of the more detailed ethnographic reports upon which many of our views have been based. What was observed were the shreds and patches of past societies, small populations seeking to escape from the arm of the state and its deleterious influence on their health and well-being. The mad search for rubber led to the violent expulsion of native peoples from their territories. Instead of being a necessary, even essential, labor force, as they had been up to this point, the Indians began to be seen as an obstacle to the region's development, and outside labor was brought in to take on productive tasks (Weinstein 1983; Oliveira 1988, p. 68). Today, only 220 ethnic groups survive with a total population of about 230,000, 60% of them living in the Amazon (Gomes 1988, p. 24).

One of the important objectives of human ecology is to discover strategies of resource use that permit conservation (Denevan and Padoch 1988). The adaptive strategies of indigenous and folk Amazonian populations constitute riches that human ecology, and non-Amazonian societies, ought to value since they offer solutions to the dilemma of how to obtain resources and yet preserve the biotic diversity of Amazonia.

THE ECOSYSTEMS OF THE AMAZON BASIN

Despite the explosion of research in the Amazon in the past 20 years, which has shown just how variable the habitats can be, comparative studies persist in the aggregating of results. Findings from one site are viewed as generalizable to the entire region or, conversely, treated as site-specific. Most people accept the dichotomy between uplands (*terra firme*) and floodplain (*várzea*) as adequately separating the important differences present in this vast region, which is equivalent to the continental United States in area. The distinction between uplands and floodplains glosses over important ecological differences,

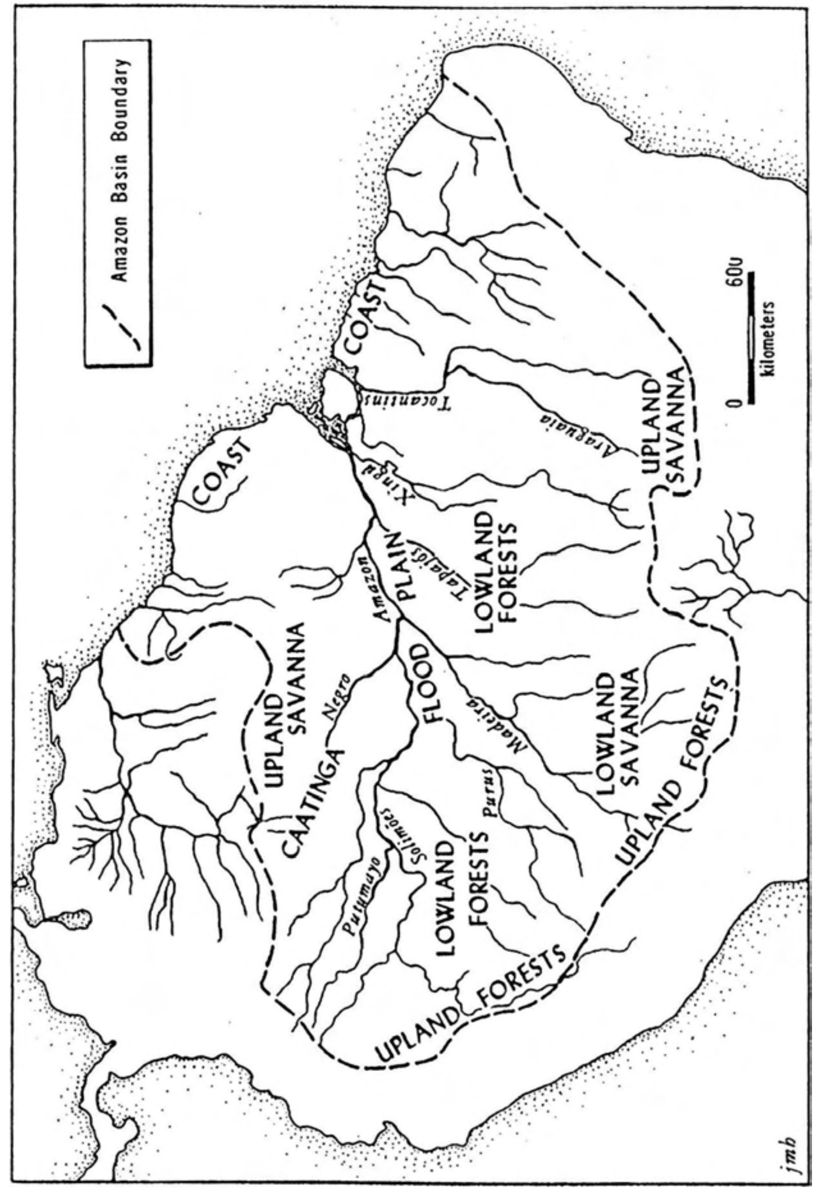


Figure Amazon Basin Habitats

Table 1. Types of Vegetation in Amazonia

Upland Forests of Terra Firme	
a. dense forest	b. open forest
c. liana forest	d. bamboo forest
e. caatinga on spodosols	f. palm forests
g. dry forests	h. pre-montane forests
Floodplains and Flooded Forests	
a. forests over clay soils	
b. floodplain forests of the lower Amazon	
c. floodplain forests of the upper Amazon	
d. forests of the estuary	
e. pantanal of the Rio Branco	
f. flooded forests in blackwater rivers	
Upland Savannas of Terra Firme	
a. campo sujo	b. campo cerrado
c. cerrado	d. cerradao
e. campo rupestre	f. savanna of Roraima
g. coastal savanna	h. flooded savannas
Restricted Vegetations	
a. mangroves	
b. levees	
c. buriti-dominated areas (*Mauritia sp.*)	

Sources: Adapted from Prance (1978) and Pires and Prance (1985).

as we shall see below. The dependence of scholars on this dichotomous distinction is no accident. It is broad enough to speak across the biological and social sciences, allowing the integration of findings from each. It has considerable value in distinguishing areas enriched by Andean sediments and having highly productive fisheries from areas less well endowed (Lathrap 1970).

The floodplains of the Amazon are not homogenous but need to be differentiated further into at least three distinct habitats: the estuary, the lower floodplain, and the upper floodplain. The estuary of the Amazon differs from the lower floodplain by the important role played by the daily fluctuations of the tides. Here we do not find the once-a-year rise of 10 to 20 meters for several months that exists further upriver, but a twice daily rise and fall. The estuary runs from the mouth of the Xingú river to the island of Marajó at the mouth of the Amazon river. This type of floodplain is associated with clayish soils on which grow an abundance of palms adapted to the estuary's cycles. The estuary resembles a system experiencing constant early secondary succession, thrown back constantly to earlier stages of succession by the dynamic action of the river system. Carrying capacity is high when properly managed. It may be better managed by sustained-yield extractive activities than by intensive farming (Lima 1956; Anderson and Ioris 1989). These were the

areas that supported large Amazonian populations before the Europeans' arrival, and which experienced the most devastating depopulation during the first century of contact. Only in recent years, with the growth of cities, have these areas once again become centers of intensive economic activity, due to the growth of nearby urban populations.

A second type of floodplain occurs upstream from the estuary, and is known as the lower floodplain or lower Amazon. This is the area described most often as typical of the floodplain as a whole—with annual deposition of alluvium rich in nutrients from the Andes, with pH near neutral, and with rich and varied fish populations (Junk 1984, p. 215). Despite the high potential it offers—it supported large pre-Columbian populations, such as the Omagua (Myers 1989)—its potential has not been fully exploited for several centuries. The highly variable annual flood levels make water control difficult and costly. Although it covers only 64,000 square kilometers or 1.6% of the Basin, its significance is many times greater. This is an area of dynamic morphology, where rivers continuously cut and modify the landscape, annually carrying whole river banks to be deposited downstream as sediment (Sternberg 1975, pp. 17-18).

The third kind of floodplain, known as the upper floodplain or upper Amazon, is the most internally diverse. Depending on the geological formations it may be acid or basic, rich or poor. Soils with headwaters in the eastern Peruvian Cordillera (e.g., the Rio Mayo) are generally nutrient rich, with pH values between 6.5 and 8.5. Those developing in sediments eroded from the calcareous sedimentary deposits of the Andean foothills of Ecuador and Peru (e.g., the drainage area of the Rio Cashiboya) tend to be slightly acidic, with pH between 5.0 and 6.5, but have no serious chemical deficiencies. By contrast, upper floodplain alluvial soils (usually thought to be uniformly excellent) originating in the eastern portion of the Peruvian Basin (e.g., the Rio Yavarí watershed) tend to be strongly acidic. Some of them may be blackwater watersheds, with pH of 4.0 to 5.0, and have toxic levels of aluminum saturation exceeding 85% (Hoag, Buol and Pérez 1987, pp. 78-79). Thus, it is necessary to approach all floodplains with considerable care in establishing their physical characteristics and the human strategies for dealing with and modifying those physical differences.

The uplands, an area constituting 98% of the Basin, contain a diverse array of habitats. We can minimally distinguish between blackwater river watersheds, lowland savannas, montane forests, and upland forests.

Lowland savannas are characterized by a marked dry and wet season, highly acid soils deficient in phosphorus, and patches of richer gallery forests along riverbanks. Until very recently, agriculture was very uncertain and of relatively low productivity. The lowland savannas were areas favored for human occupation because of the ease of hunting in this grassland habitat, the proximity to forested areas for other resources, and the abundance of ecotones for different resources (Gross, Eiten, Flowers, Leoi, Ritter, and Werner 1979; Posey 1985; Anderson and Posey 1985). Some are poorly drained (such as the Llanos de Mojos in Bolivia and Marajó Island at the mouth of the Amazon river), while others are well-drained, such as the cerrado of Brazil. The former are quite extensive in Amazonia and are believed to have supported large prehistoric populations that practiced intensive agricultural techniques, such as raised fields (Denevan 1966; Erickson 1988).

Blackwater watersheds were labelled very early as "rivers of hunger," given their sparser vegetation which resembles a semi-arid scrub forest more than an Amazonian landscape. From the viewpoint of nutrients, these are the most limited and fragile regions of the Amazon (Jordan and Herrera 1981). Rainfall is high, and soils are white sands of near-pure quartz that are extremely acid and devoid of nutrients. Plants have a high content of secondary compounds that serve to reduce herbivory and, thus, loss of nutrients. Plants have adaptations to drought (e.g., sclerophylly) as well as to flood (e.g., above ground fine roots). Many of the allusions to the perfection of nutrient cyclying in Amazonia refer to the processes found in this region—and not found in better endowed areas of Amazonia. Human populations lived in these extremely poor habitats by depending on highly toxic cultivated plants like bitter manioc varieties and by profound knowledge of local habitats ensured by territorial control over prime fishing areas and patches of slightly better soils for horticulture (Moran 1991).

Upland forests remain to this day a catchall category that includes a wide variety of habitats. In this region, we find what appear to be anthropogenic vegetations such as liana or vine forests, bamboo forests, palm forests, and brazilnut forests (Balée 1989). The vine or liana forests alone cover over 100,000 square kilometers of the Basin and are found near or on sizable outcroppings of high base status soils, in areas with a characteristic dry season and associated often with anthropogenic black earths.

The montane forests of the western Amazon have been the focus of many studies. They are different in having lower tree biomass but more epiphytes. There is a noticeably lower animal biomass but better soils in some watersheds. The lowland populations depended on trade relations with the Andean highlands with which they maintained regular interactions. This area has been profoundly affected by oil exploration in Ecuador and Peru, and more recently by the activities of cocaine interests.

In short, what this brief outline of the differences to be found in the uplands and the floodplains suggests is that the ecosystems of Amazonia are far more diverse than people have been willing to admit. In the process of human ecological study or in the efforts at ecosystem protection and conservation, it is important that the goal be not to conserve some vague notion of floodplain habitat and upland habitat but the much richer biotic and human variation present in this vast region. To preserve this cultural and biotic richness, it is

important to rely on the native peoples of the region, whose knowledge reflects the regular use of such resources. A fuller discussion of native uses of Amazonian ecosystems can be found in *The Human Ecology of Amazonian Populations* (Moran 1990, 1993).

MINIMUM HUMAN ECOLOGICAL DATA

Which variables of an ecosystem are the object of a human ecological study will depend on the objectives. Therefore, it is impossible to be all-inclusive about which data ought to be collected. If this is the case, is it ever possible to collect data that is systematic enough to permit rigorous comparison across sites? One possible way to proceed is by developing generally agreed-upon minimum data of such fundamental importance to the understanding of human ecologic relations that its collection does not detract from the more specific goals of a particular study but, in fact, provides a necessary basis for any generalization that may be made.

In studying human ecological processes, attention needs to be paid both to human perception of the environment and individual human behavior towards environment. Our perception of the environment is as influential as the physical reality of the environment. Ethnoecological data collection focuses attention on dimensions that we might overlook if we presumed that a population has the same perceptions as we have. Of interest, too, should be the fit between those perceptions and some measurable behavioral treatment of the environment. The perception of environment is influenced by other components of an individual's social experience, such as the population's demographic structure, social organization, health and nutritional status, and historical experience in a region, and thus does not stand alone and unrelated to the feedback processes experienced by individuals. Whether one begins with collecting data on perception or on behavior is less important than ensuring that both dimensions are studied and compared.

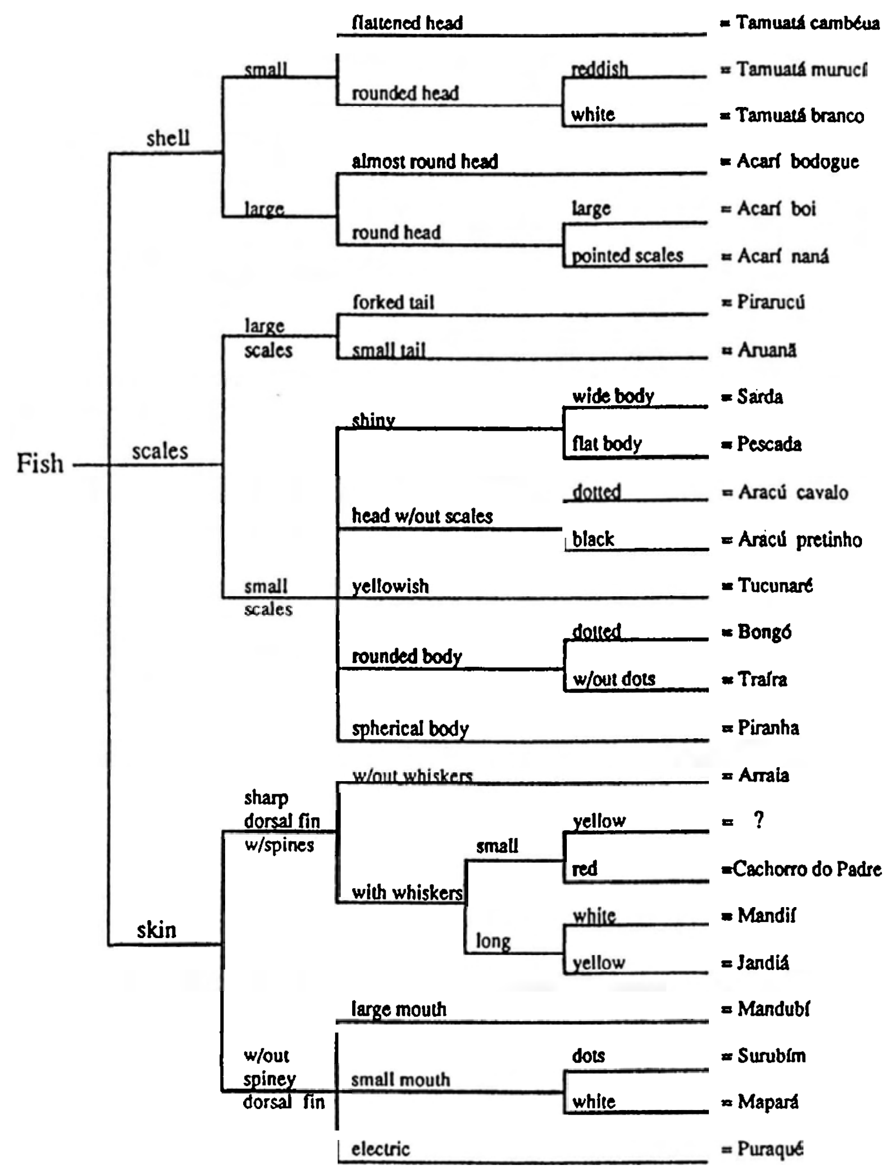
In ethnoecology, the investigation begins by asking about what names a population gives to items in a given domain of importance to it—for example, "fish" among a population where fishing is a major occupation. Thus, one would ask the informant: "How many kinds of fish are there around here?" He or she might respond by saying: "Well, there are many... there are acarí, tamuatá, bacú, pirarucú, traíra, arraia, puraqué, mandubí...." For each of these type of fish, one would subsequently ask, "Are there several kinds of, for example, acarí?" For each fish named, one would seek to arrive at the maximum number of named distinctions made by the informant. After that, one would proceed one-by-one and compare each one with the other, asking: "How can one tell an acarí boi from an acarí naná?" This process gradually leads to the definition of distinctive criteria used in making such discriminations. For example, while they both have a roundish head, Acarí naná has distinctively pointy scales and Acarí boi does not (having instead a larger head than Acarí naná). Table 2 illustrates one such ethnoecological classification collected among fishermen in the central part of Marajó Island, at the mouth of the Amazon Basin. Sometimes an important criterion will be differences in color, which tend to suggest age differences rather than species or variety differences. Such a distinction might be indicative of the importance of age discrimination to fishermen in how and when they catch fish. This possibility would have to be investigated by other means, such as detailed interviews and observation of use. From these cognitive dimensions of environment, it is possible to move to the collection of other social and environmental data that permit discussion of the ecosystem.

The strategy of human ecology is a complex one that relies on methods from a large number of disciplines. In the subsections that follow, a brief discussion of some minima that can be used in human ecological assessment is presented. The goal is to begin the process of dialogue among human ecologists so that some minimum standards in data collection might be agreed upon in the near future to enhance efforts in comparative human ecological studies. This discussion uses examples from Amazonia to give specificity to the discussion and to highlight problems that are present in data collection, in what is generally considered one of the most poorly understood regions of the world from both an environmental and cultural perspective.

Climate

One of the basic parameters in the understanding of ecosystem structure and function is climate. Climate affects organic decomposition, nutrient cycling, seasonality, and so forth. Amazonian climate was cited for some time as one of the reasons for the region's underdevelopment. It still looms as one of the alleged "problems" posed by the region to outsiders (i.e., hot and humid). Given how complex climate research can be, it is necessary to select some indices that can be productively used. The most necessary information for human ecological study is to know the *daily precipitation and maximum and minimum daily temperature* in the area of interest (Wilken 1988). With this data, it is possible to estimate other indices, such as number of days of continuous rain, evapotranspiration rates, (Bordne and McGuinness 1973), and indices of available soil moisture (Baier, Chaput, Russelo, and Sharp 1972), among others. Monthly or annual means are insufficient for an adequate assessment of the role of climate on local ecosystems. The above data should represent a 20-year time-series, minimally, if they are to have any chance of reflecting the effects of year-to-year fluctuations. At present, the number of climatological stations in Amazonia is insufficient, and more attention to the collection of climate data is needed, if we are ever to be able to take proper account of

Table 2. Fish Ethnoecology (Marajó Island)



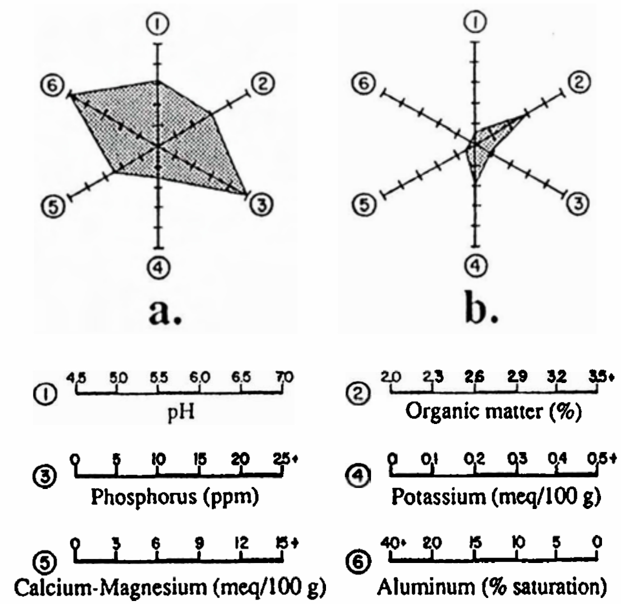
Source: Fábio de Castro and Emilio Moran, Field notes, 1989 the role of climate in human decisions. Until such time as more inclusive data is available for the immediate area under study, it may be wise to collect the folk systems of climate prediction (i.e., the ethnoclimatology, if you will) that represent long-term observations by local people (cf. Stigter 1986), and to take with a dose of skepticism the data from climatological stations of only a few years' duration.

Soils

Ecosystem characterization cannot go far without a description of the variation in soil types in an area. In the Amazon, it is rare to find soil maps at a scale appropriate for management decisions at the level of the farm (i.e., 1:10,000). Most maps are at the FAO scale of 1:5,000,000 or at best at 1:1,000,000 (Radam 1974-1979). To get around this limitation, most investigators may need to take soil samples. To be able to integrate this data into human ecological investigation, it is ideal to begin by collecting the local population's means of classifying soils (see the earlier discussion of ethnoecology). By asking, for example, "How many kinds of soils do you name?," it is possible to begin to construct a taxonomy that reflects locally important criteria. This might be followed by collecting the indicators used by the population to locate each type of soil. Figure 2 illustrates the good and bad soils in the area near Altamira, along the Transamazon Highway of Brazil, using vegetation indicators recognized by local Amazon peasants. This system of illustrating soil fertility is an effective way of visualizing the degree of fertility in tropical soils (Alvim and Cabala 1974) and has broad applicability. To construct such a summary view of a soil's fertility, it is necessary to have soil samples. In general, one soil sample is composed of 10-15 cores taken randomly from a homogenous field at a depth of 0-20 centimeters. In some cases, it may be useful to take deeper soil samples if the use of the land involves rooting processes at deeper levels in the soil profile or if the goal is to classify soils in a formal fashion, rather than simply to assess their potential fertility. The nutrients illustrated in Figure 2 are commonly the most telling in Amazonian soils.

Flora

The composition of a forested area is commonly sampled using transects, commonly of areas of 100 or 200 square meters. Another method is to sample the vegetation 5 meters to the right and left of a 50 meter tape placed on the forest floor until one arrives at 100 individuals. The manual of Nueller-Dumbois and Ellenberg (1974) is considered the standard (cf. Cain and Castro 1959) for work in the tropics. Other, often more sophisticated, manuals are available for temperate zones, given their better-studied status and less diverse



a. Forest Vegetation Indicative of Good Agricultural Soils

Local Term	Scientific Name
Pau d'arco or ipé (yellow variety)	*Tabebuia serratifolia*
Pau d'arco or ipé (purple variety)	*Tabebuia vilaceae*
Faveira	*Piptadenia* spp.
Mororó	*Bauhinia* spp.
Maxarimbé	*Emmotum* spp.
Pinheiro preto	(unidentified)
Babaçú	*Orbignya martiana*
Açaí	*Euterpe oleraceea*

b. Forest Vegetation Indicative of Poor Agricultural Soils

Local Term	Scientific Name
Acapú	*Vouacapoua americana*
Jarana	*Holopyxidium jarana*
Sumaúma	*Ceiba pentandra*
Melancieira	*Alexa grandiflora*
Sapucaia	*Lecythis paraensis*
Piquí	*Caryocar microcarpum*
Cajú-Açú	*Anacardium giganteum*
Massaranduba	*Manilkara huberi* (or *Mimusops huberi*)

Source: Moran (1977).

Figure 2. Soil Selective Using Vegetarian Criteria

species array. Biomass production is estimated most often by placing about 10 one-meter-square screens to catch leaf fall, placed randomly in the area of forest to be studied. Leaf fall must be collected every one or two weeks to avoid losing the collection to the natural process of decomposition. Most human ecologists also collect floral specimens given the richness of the flora of Amazonia and the importance of identifying new species. Leaves, flowers, and fruits are necessary for accurate identification by systematists working with major collections such as are found, for example, at the New York Botanical Gardens, Kew Gardens (United Kingdom), the Missouri Botanical Gardens, the Goeldi Museum in Belem, Brazil, and the National Institute for Amazonian Research in Manaus, Brazil.

Fauna

Some scholars have argued that it was not soil quality but the availability of game that kept the size of settlements small in Amazonia (Lathrap 1968). Gross (1975) suggested that the consumption of animal protein varied between 15 and 63 grams per capita per day, and that to maintain such levels it was necessary to relocate settlements often. Implicated in this process of village mobility was the taboo against hunting some of the larger mammals, as noted by Ross (1978), because their incidence was so low that it was more effective to focus cultural attention on smaller game than on the large animals. A whole generation tried to prove or disprove this proposition, each one arguing based upon their single study site the rightness or correctness of the formulation (e.g., Gross 1975; Beckerman 1979; Chagnon and Hames, 1980; Hames, 1980; Vickers 1979).

Despite a now considerable body of information, we still do not have systematic studies of animal biomass in Amazonia. One of the most detailed studies pointed out that it was precisely the meat yield of tapir and peccaries that accounted for the bulk of the meat hunted in the western Amazon (Vickers 1984), and that taboos are specific to ethnic groups and need to be explained in microecological rather than regional terms. Vickers also noted that the meat yields drop in tropical forests beyond 600 meters altitude above sea level, as would be expected in montane forests, and that yields are higher in the lowland forests. One careful analysis suggests what may be behind the assumption of low faunal availability: of the 41 most hunted species, 39% were of less than 5 kilograms total weight, 73% were nocturnal, 54% were solitary, and 44% were arboreal (Sponsel 1981). The lack of long-term studies continues to limit human ecological formulations of how people use faunal resources. In small-scale populations, the data for a single year may represent an outlying point in a long-term average, and the average may not be estimable from that single year. To this day, there is an excessive dependence on the two studies made in the neotropics: one in Barro Colorado, Panama (Eisenberg and Thorington 1973) and the other near Manaus, Brazil (Fittkau and Klinge 1973). The study by Fittkau and Klinge, for example, is beginning to be seen as having seriously underestimated animal biomass (Eisenberg and Redford 1979; Eisenberg, O'Connell and August 1979; Emons 1984).

Faunal data collectors must ask hunters about the various kinds of habitats used in hunting, and about sampling from each habitat used in hunting, as well as those that have been abandoned. The most common method is to scan an area of 100 square meters for visual accounting (Eberhardt 1978; Brower and Zar 1984; Seber 1986). To determine the efficiency of hunting, data should be obtained from hunters about the distance travelled, how many animals were seen, how many killed, how much meat was consumed on the spot and how much brought back, together with data reporting basic morphometric measurements that permit the sex and age determinations of animals the hunted (Redford and Robinson 1987).

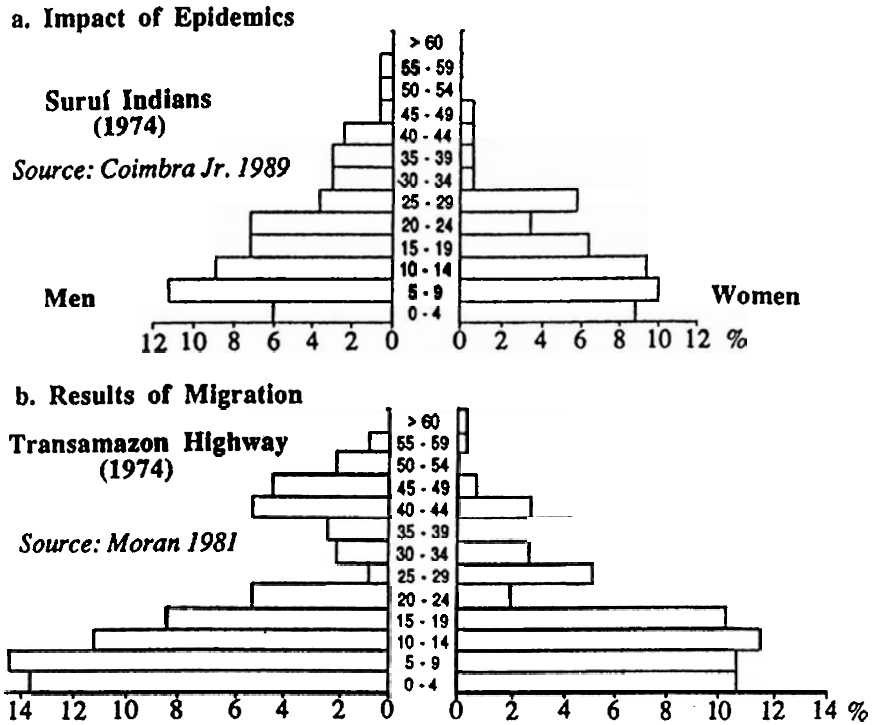
Social Organization

Human beings, as social animals, organize in ways that permit them to effectively obtain needed resources. Their social organization, especially among populations depending on the immediate physical environment, often reflects solutions to problems presented by those environments. Among the basic dimensions (adapted from Netting, Stone, and Stone 1988) that need to be described are the activities associated with resource use, the calendar of activities, and the local forms of organizing labor. One can begin by informal interviews about goods produced, including a list of cultivated plants, domesticated animals, fish caught, and wild food sources obtained. Then one can inquire into the seasonal division of labor in the various activities. The utilization of products for subsistence, exchange, sale, and the proportions going to each kind of use need to be accounted for, as does the nature of these activities (i.e., their names, the technologies used, and the relationship between the technology management and the resource).

Who participates in the subsistence activities is important basic data, and includes the division of labor by sex, age and status, the units of production (household, clan, phratry, etc.), types of mutual obligation created, the role of wage labor, sharecroppers, and so forth. The existing residential subsistence units may be isomorphic in many cases, but there may be important contrasts between work units and kin units. Finally, the problems perceived by the population, such as seasonal problems with climate, with crops, with getting enough labor, and with transportation give a baseline of what constraints the population may face that affects its forms of organization for subsistence.

Demographic Structure

As part of the collection of data on environmental perception and social organization, it is often necessary to do a census. A census permits the collection

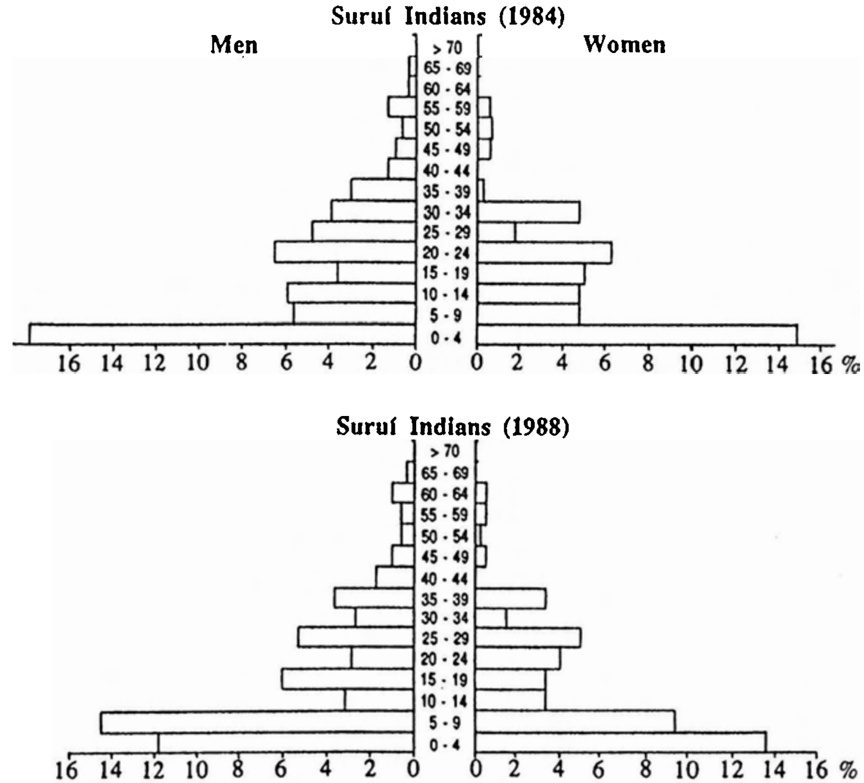


Sources: For panel a, Coimbra (1989); for panel b, Moran (1981).

Figure 3. Impact of Epidemics and Migration on Age-Sex Distribution

of demographic data and an estimate of the population's fecundity, mortality, and other changes. Getting a census down in size is always difficult, and the following suggestions may help. The most telling demographic indicator is the age-sex distribution illustrated commonly in the form of a pyramid. A sex-age pyramid serves as a synthesis of a population's history. A young population will have a broad base, while an aging one will be almost rectangular. If a significant gap exists in a given sex or age group, it suggests the occurrence of some notable event that led to the loss of population—for example, outmigration or epidemic deaths. Figure 3 illustrates the impact of epidemic disease on the Suruí Indians of Rondônia. During epidemics, not only is there high mortality but there is also a fall in fecundity (Coimbra 1989; Feldman 1977, p. 29; Peters 1980; Netter and Lambert 1981), confounding the demographic collapse and crimping the pyramid in telling ways.

Following a major decline in fecundity, a population may experience periods of catch-up fertility, which Coimbra (1989) observed among the Suruí. Figure 4



Source: Coimbra (1989).

Figure 4. Catch-up Fertility After Epidemic

illustrates the rapid increase in the number of children in the 1984(4a) and 1988(4b) censuses. Between these two censuses, the population grew at an annual rate of 5.6%, a rate that would permit it to double every 14 years. Given that they are recovering from a 75% mortality from the first decade of epidemics, such rates are entirely justified to ensure their biological survival.

Because of the difficulties in studying fertility in populations with high child mortality, one of the useful indices that can be used is the ratio between the total number of children aged 0-4 to the number of women of reproductive age (15-45). The child/woman ratio has a high correlation with more traditional indices such as the gross rate of fecundity ($p = 0.961$), the general rate of fecundity ($p = 0.975$) and the rate of total fecundity ($p = 0.970$), and can be used as a rapid assessment measure of a population's fecundity.

Another useful demographic measure is the infant mortality rate. This index refers to the number of deaths in the 0-1 years age group per 1,000 births. At present, the rates of infant mortality among many Amazonian indigenous groups are extremely high, due in large part to the lack of medical assistance and neglect of their needs. A rate of more than 100 per 1,000 births is considered very high, from 50 to 100 is considered high, 25 to 50 is considered mid-level, and below 25 is considered low. Among the Suruí of Rondônia, for example, recent rates have been 232.2 per 1,000 births (Coimbra 1989). This means that 23.2% of all children die in their first year of life! The rate among the Xavante in the 1980s was 242 per thousand (Flowers 1983). It has been noted to be 97.5 per thousand among the Shipibo of the Peruvian Amazon (Hern 1977, p. 360), suggesting that access to health care may be more precarious in the Brazilian than in the Peruvian Amazon.

Health and Nutrition

There is a close relationship between a population's demographic structure and its health and nutritional status. Native Amazonians' health status is generally good before contact, with high prevalence but low levels of morbidity and mortality. Following contact with national society, they experience epidemic mortality, which eventually stabilizes itself at a low level, and then they increase their numbers. With greater integration into national society, indigenous societies become increasingly affected by metabolic and chronic diseases rather than infectious or epidemic diseases.

Nutritional status can take any number of directions, depending on the degree of dislocation and transformation felt by the population's food production system. Signs of undernutrition increase with the intensification of contact. During periods of high mortality, there is a near total abandonment of farm work because of the loss of organization for production brought about by high adult mortality. The subsidies provided by government agencies and missionaries during this stage lead gradually to the population's loss of autonomy and to their growing dependence on subsidies. The contribution of these new sources of nutrition has rarely been positive. Most often, the products made available include refined sugar, table salt, and alcoholic drinks (associated with chronic and metabolic disorders such as goiter (Vieira Filho 1981) and diabetes (Vieira Filho 1977). Efforts to sedentarize Amazonian populations, without improving their access to better medical attention, could result in the spread of serious diseases such as Chagas' disease, which has never been reported for lowland South America but is endemic in the Andean region. Coimbra (1989) suggests that freedom from Chagas may be tied to the pattern of mobility and the type of housing materials used, which do not provide a favorable environment to the vector of the disease. This could change as they are restricted in their mobility and forced to sedentarize. Given the presence of the vector in their environment, the situation could become critical very quickly.

The most accurate and efficient measurements of the nutritional status of a population are obtained by body measurements or anthropometry. The minimum data to be collected are the height, weight, and age of each person (especially children under 12). Anthropometric measurements address the two principal causes of undernutrition: nutritional deficiencies and infection. Three indices are commonly used: height-for-age, weight-for-age, and weight-for-height. In general, a *chronic* deficiency of adequate nutrition will be reflected in height-for-age (i.e., stunting). Acute deficiencies may be reflected in below normal weight-for-age, but it may be hard to separate these from the effects of chronic undernutrition. For monitoring populations, the age-dependent indices are very sensitive to chronic deficiencies. When weight-for-height is abnormally low, we have a sensitive index to individuals in emergecy need of supplements due to *acute* forms of malnutrition (i.e., wasting) (Martorell 1982; Coimbra 1989). These indices can be supplemented with the measurement of subcutaneous fat using calipers. Most often used are the triceps skinfold and the subscapular skinfold. To estimate the muscular area and the fat-to-muscle proportion, the skinfold measurements are related to the circumference of the upper arm.

CONCLUSIONS

The object of study in human ecology is the interactive behavior of people toward their surroundings. The orientation is essentially interdisciplinary, concerned not only with people but also with the characteristics of the physical environment with which people interact. Both behavior and perception need to be studied in their context.

To explain human ecological relations, we need to account for a large number of possible implicated factors. The effective environment of an individual or a population is all-encompassing, and the effective pressures may come just as easily from the physical as from the political environment. Each population of Amazonia has a unique historical experience that makes it different from all others; each has suffered a specific impact from epidemic contact with outsiders that has resulted in a distinctive yet patterned age-sex distribution; each has been exploited by outsiders in particular ways; each has a given set of resources in their territory that they exploit in ways that reflect their seasonal availability and conflicting demands on the populations's time. They find themselves today in a particular situation that reflects all of these experiences. The solutions that each population, and individuals within the population, finds will also reflect all of these experiences, and some will be more effective than others.

The interdisciplinary approach of human ecology constitutes a first step in rethinking research and action towards our relations with the physical environment. I hope that the suggestions on minimum data will prove useful in coming to grips with the need to produce comparable data without regard to which specific disciplines our human ecology derives from. I hope that these minima prove useful not only to other Amazonian human ecologists but to others working in very different ecosystems. Although we can live without standards, we also need them—to ensure consistency in quality, fairness in evaluating various work produced, and to allow comparisons over time. Standards do not prevent innovation. In fact, it can be argued that standards promote change, by setting up a clear canon against which to match the gifts of individuals who are challenged to best the current standard. There is plenty of room in these minima for creativity and imagination. Human ecology, because of its disparate definitions and multidisciplinary foundations, is in particular need of seeking a common ground. Various efforts have been attempted at the level of theory, with mixed results. Perhaps a no less profitable avenue may be offered by agreement at the level of method and baseline data in what could be called human ecological minima.

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