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CHAPTER 64

MANAGING AMAZONIAN VARIABILITY WITH INDIGENOUS KNOWLEDGE

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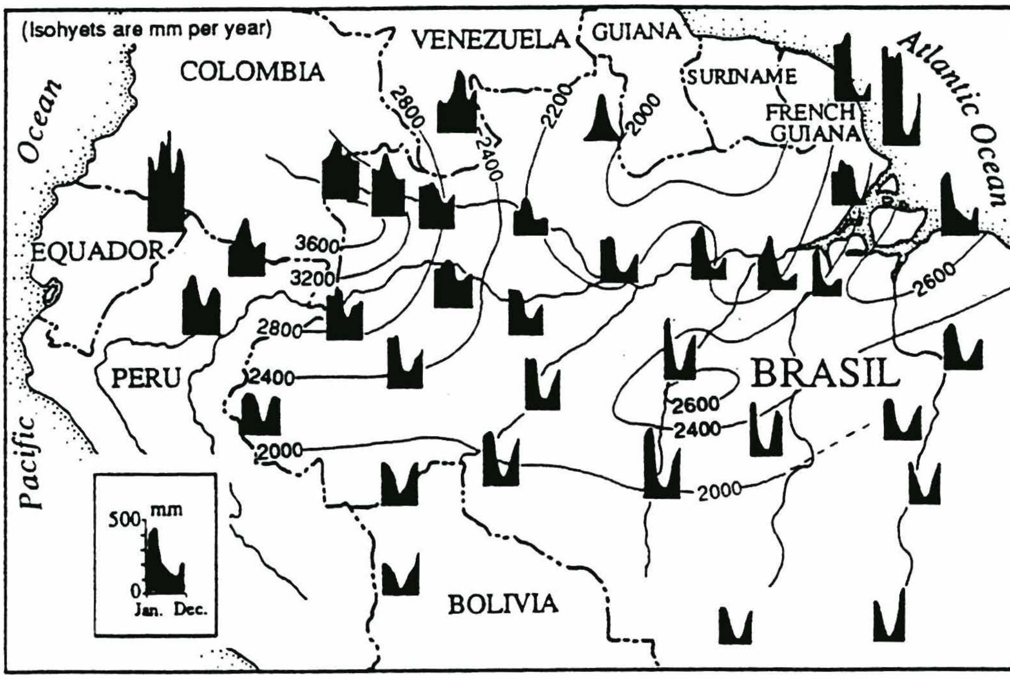
INTRODUCTION

The Amazon has the capacity to feed sizeable populations but for this potential to be achieved, current forms of resource use and development will have to change so that a broad array of food sources are exploited rather than a narrow range. It will be necessary also to recognize that the Amazon is not homogenous. It is neither Green Hell nor Paradise. The Amazon Basin is an ecological mosaic where one finds a rich variety of flora and fauna, soils of all kinds, and significant climatic differences. The native populations of Amazonia recognized this heterogeneity long ago, and contemporary populations need comprehend the difference that such a recognition can make to how we think about and treat this vast region.

The Amazon Basin is neither a demographic nor a cultural vacuum. Living in this green space are Indian and mixed populations that have grown familiar with the special character of their local habitats (Posey and Balée, 1989; Morán, 1990). If we are to contribute to balancing the use and conservation of this habitat, we need to begin by appreciating the knowledge that these local populations have about their environment. The Amazon includes a very large number of ecosystems, each one related to the other, each one having a distinct natural history, unique geophysical and chemical characteristics, and human populations that differ in their history, demography, social and political organization and in their view of nature. These differences are in part the result of the process of adaptation of individuals in these populations to the variability present within Amazonia, and in part from differences in their cultural histories. Human beings are embedded in a historical context and their future is shaped by these particular experiences.



Source: Salati et al. 1978: 204

Figure 64.1 Rainfall variability in the Amazon

The Amazon is far more diverse than the dichotomy made between *terra firme* (uplands) and *varzea* (floodplains) would suggest. We can usefully contrast today well-drained and poorly-drained savannas. We can compare mature upland forests with anthropogenic forests that look "virgin" but which have been shaped by prolonged indigenous management. We can compare species-diverse forests with species-dominant forests, and evergreen forests with seasonal forests. Each ecosystem offers opportunities, as well as limitations. Each one has unique characteristics that can be either used advantageously or resisted. Native peoples not only adjust to the environment but also actively modify the environment to enhance features that result in greater long-term value to them. The view that native peoples of Amazonia are "backward" (a view common in national government circles) must be replaced by appreciation of their stewardship of that region. The view that they are "noble savages" is no less off the mark. They vary a great deal amongst themselves. They do not agree about how to treat nature, no more than we do. Nevertheless, the imprint they have left on the forests has been far less destructive than ours despite their use of the region for millenia, compared to the impact we have had in a comparatively small number of years.

AMAZONIAN ECOSYSTEMS

The Amazon shares with the rest of the humid tropics a high solar radiation, uniformly high temperatures, high rainfall and humidity, and rich species diversity. Indeed, the Amazon is so different from the temperate and subtropical regions from which most scientists and bureaucrats come that it is not surprising that to them it is all hyperhumid, hot and luxuriously green. If any distinction is made, the tendency has been to over-rely on a simple but dramatic dichotomy between floodplains and upland interfluves. This dual distinction fails to distinguish between very fragile regions within the *terra firme* and regions with greater resilience, between areas with relatively high plant and animal biomass productivity and areas much more limited. The floodplains amount to about 2% of the Basin, while the upland interfluves amount to 98% .

Evidence for the diversity of Amazonian ecosystems has only begun to be available in the past decade or two. At the level of climatic differentiation, there are important differences in the seasonality of rainfall within this vast Basin (Figure 64.1). In the areas orographically affected by the Andes, rainfall can be as high as 5000 mm annually with virtually no dry season. By contrast, the eastern Amazon receives as little as 1700 mm, has a dry season of about 4 months, and supports evergreen moist forests and seasonal forests (Morán, 1991; Salati, 1985). The soils of the region, long-thought to be uniformly poor and acidic, are now known to range across the full spectrum of soil types and fertilities (Table 64.1). This is evident both at the level of the soil sample, and at the level of the watershed (Junk and Furch, 1985) where the various soils produce three distinct types of rivers: whitewater, clearwater and blackwater (Sioli, 1951; 1984; Sternberg, 1975). The common view, most recently expressed by Bailey *et al.* (1989; 1991), that the tropical rain forest is depauparate and its rivers blackwater applies only to a small proportion of the Basin, drained by the Rio Negro with large areas of nutrient-poor white sands or spodosols (Morán, 1991; Jordan, 1985; Clark and Uhl, 1987; Goulding *et al.*, 1988). The extreme poverty of these areas is atypical of the Basin as a whole. Smith (1979) has noted that blackwater lakes have a fish productivity 15 to 19 times lower than lakes fed by whitewater rivers. Blackwater rivers are poor in total fish biomass but they are rich in number of species (Goulding *et al.*, 1988).

The floodplain needs to be differentiated into at least three distinct habitats: the estuary, the lower floodplain, and the upper floodplain. The estuary is less rich in plant species than most of the Basin, but it is rich in net yield to human populations. Traditional populations have taken advantage of these regions by favoring palms that cope well with the cycles of daily tides. While the estuary is restricted in total surface area, it has very high carrying capacity when properly managed. Research has found contemporary popula-

Table 64.1 Distribution of soils in the Amazon

Order	Suborder	Great Group	Million hectares	% of Amazon
Oxisols			219.9	45.5
	Orthox	Haplorthox	137.8	28.5
		Acrorthox	67.5	14.0
		Euthorthox	0.3	0.1
	Ustox	Acrusthox	6.6	1.4
		Haplusthox	4.8	1.0
		Eutrosthox	2.0	0.4
	Aquox	Plinthaquox	0.9	0.2
Ultisols			141.7	29.4
	Udults	Tropudults	83.6	17.3
		Paleoudults	29.9	6.2
		Plinthudults	7.6	1.6
	Aquults	Plinthaquults	12.2	2.5
		Tropaquults	7.1	1.5
		Paleoquults	0.7	0.1
		Albaquults	0.1	0.1
	Ustults	Rhodustults	0.5	0.1
Entisols			72.0	14.9
	Aquents	Fluvaquents	44.8	9.3
		Tropaquents	6.7	1.4
		Psammaquents	2.8	0.6
		Hydraquents	0.6	0.1
	Orthents	Troporthents	6.9	1.4
	Psamments	Quartzipsamments	5.5	1.1
	Fluvents	Tropfluvents	4.7	1.0
Alfisols			19.8	4.1
	Udalfs	Tropudalfs	16.5	3.4
	Aqualfs	Tropaqualfs	3.3	0.7
Inceptisols			16.0	3.3
	Aquepts	Tropaquepts	10.6	2.2
		Humaquepts	0.5	0.1
	Tropepts	Eutropepts	4.3	0.9
		Dystropepts	0.6	0.1
Spodosols			10.5	2.2
Mollisols			3.5	0.8
	Udolls	Argiudolls	2.8	0.6
	Aquolls	Haplaquolls	0.9	0.2
Vertisols			0.5	0.1

Source: After Cochrane and Sanchez, 1982:152-153

tions at a density of up to 48 persons km^{-2}, with considerably higher incomes than elsewhere in the region due to the proximity of urban markets and high demand for palm fruits. However, it would be a mistake to think that the extractivist system found here can be replicated in non-estuary portions of the floodplain or in *terra firme* (Anderson and Ioris, 1989).

Table 64.2 Complex use of biotopes by local populations in an areaof the Peruvian upper Amazon

Biotope	Characteristics	Products
Levee Top	Not subject to inundation, sandy and silt-loam soils	Bananas, manioc, sweet potatoes *Vigna*, pineapple, guava, fruit trees.
High Levee	Infrequent flooding, sandy and silt-loam soils	Manioc, plantains, peanut and rice after floods.
Upper Levee	Rarely flooded clay soils	Manioc, plantains, sugar cane
Low Levee	Annual inundation, sandy to loamy soils	rice, corn, *Vigna*
Beaches	sand to loam banks	*Vigna* on sandy soils, peanuts on loamy
Backswamp	Shallow depressions between levees	Construction materials
Cochas	Ox-bow lakes	Fish and game meat
Aguajales	Shallow swamps dominated by *Mauritia flexuosa* palms	Palm fruit

Source: Hiraoka, 1985

A second type of floodplain occurs upstream and is known as the lower Amazon. This is the commonly thought of Amazon floodplain: rich in deposited alluvium from the Andes, with pH near neutral, and a high fish biomass (Junk, 1984: 215). It supported large prehistoric populations, such as the Omagua (Myers, 1989; Porro, 1989). However, following the devastating depopulation of the Basin with contact, the ecosystem has been underexploited and mismanaged. The highly variable annual flood levels make control of the water system difficult and costly in both terms of labour and capital. This region occupies about 1.6% of the Basin or 64 000 km^{-2}. The most promising populations to learn from are the *caboclos* or *riberenos*, riverine populations that have lived here for long periods of time (e.g. Frechione *et al.*, 1989; Wagley, 1953).

The third kind of floodplain is known as the upper Amazon and is highly variable, depending on the geological areas from which its sediment is derived. Some are highly acidic, some are near neutral. Their potential varies accordingly for human populations in terms of food production potential. These variations have not been noted in most ethnographic reports and thus it is unclear what the productivity of this mosaic-like ecosystems are. There are still sizeable native populations of indigenous peoples (e.g. Shipibo) and of non-indigenous communities from whom one can study the alternatives for managing the region (Table 64.2).

The 98% of the Basin which is terra firme contains a broad array of vegetations. We could begin by distinguishing minimally between *caatingas*, liana forests, palm forests, bamboo forests, seasonal forests, and savannas (Table 64.3 for a recent classification of types of vegetation in Amazonia). *Caatingas amazonicas* or *campinaranas* are a type of xeromorphic vegeta-

Table 64.3 Types of vegetation in Amazonia

Upland forests of *terra firme*	a. dense forest
	b. open forest
	c. liana forest
	d. *caatinga* or *campina* over spodosols
	e. bamboo forest
	f. palm forest
	g. dry forest
	h. pre-montane forest
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 vegetation	a. mangroves
	b. levees
	c. *buriti* or *aguajal* dominated areas (*Mauritia*).

Source: Adapted from Prance 1978 and Pires and Prance 1985: 113.

tion present in the blackwater basin of the Rio Negro (Jordan and Herrera, 1981). Rainfall is high with little seasonality, soils are extremely poor spodosols of near-pure quartz, plants have a high prevalence of secondary toxic compounds that reduce herbivore pressure, a high proportion of total biomass is in the root component, and many have sclerophylous leaves. Native peoples did not attempt cultivation of these oligotrophic areas but restricted cultivation to patches of upland tropical moist and rain forest on patches of oxisols (Hill and Morán, 1983). It is here we find the most elaborate, as well as effective, responses to environmental limitations in Amazonia. Here we find dependence on bitter manioc in horticultural activity and a near-absence of sweet varieties in contrast to areas like the western Amazon where mainly sweet varieties are cultivated (see discussions in Dufour; McKey and Beckerman, this volume). Unlike other regions of Amazonia, in this area one finds inherited control of riverfronts, with rights vested in patrilineal sibs. Unlike elsewhere in Amazonia, some communities delegate hunting to populations who are held in low esteem by the dominant fishing and farming populations. The system is supported by cultural homo-

Table 64.4 Ecological characteristics of types of forest

	Bana and *Caatinga*	Rio Negro Upland forest	Other moist and rain forest
Number of tree species >10 cm dbh ha^{-1}	18-69	80-100	80-100
Number of individual trees >10 cm dbh ha^{-1}	39-173	650-800	600
Canopy height (m)	6-20	25-30	30-50
Basal area for trees >10 cm dbh (km^{-2} ha^{-1})	0.15-22	25-30.	40-50
Above ground biomass (metric tons ha^{-1})	170-335	320-340	400-700
Root biomass (%)	34-87	20-38	20

Source: Modified from Klinge 1982 and Uhl and Murphy 1981

geneity among groups of diverse language families, by geographically far-reaching marriage systems, and by a system of interdependent rank classes (cf. Morán, 1991).

There are important differences and similarities between *caatingas* and proximate tropical rain forest on oxisols and between both of these and the averages for other tropical rain forests in Amazonia (Table 64.4). Of special note is the substantial increase in species diversity when moving from *bana/caatinga* to upland forests in the Rio Negro, which in turn is very much like that of tropical moist forests elsewhere. However, the Rio Negro forests have a shorter canopy, a considerably smaller basal area, lower-above ground biomass, and a higher proportion of total biomass in roots. As agricultural areas, these are areas to be avoided and their harvesting limited to the extraction of secondary compounds for pharmacological use and for environmental protection of their rich species diversity (Schultes and Raffauf, 1991).

Liana forests occcur throughout the Basin and are estimated to cover up to 100 000 km^{-2} (Pires and Prance, 1985). They tend to be associated with outcroppings of high base status parent materials and patches of high fertility soils and anthropogenic soils. These are the forests referred to by Herrera (1985) as eutrophic, as compared with the oligotrophic forests discussed above. Agriculture can be sustained for longer time periods here, given the higher initial soil fertility and higher pH. Field abandonment in these areas is likely to be an escape from the onus of weeding, rather than due to fertility decline (Sanchez, 1976). There is some evidence that these forests may be wholly, or in part, the result of the activities of prehistoric populations of Amazonia which over time concentrated plants of economic interest in these favoured soils (Balée, 1989). It is these areas which suggest intensive and

Table 64.5 Soils and vegetation of the savanna

Soil property	*Campo limpo*	*Campo cerrado*	*Cerrado*	*Cerradao*
Organic Matter %	2.21	2.33	2.35	2.32
Potassium (meq 100 ml^{-1})	0.08	0.10	0.11	0.13
Calcium (meq 100 ml^{-1})	0.20	0.33	0.45	0.69
Magnesium (meq 100 ml^{-1})	0.06	0.13	0.21	0.38
Zinc (ppm)	0.58	0.61	0.66	0.67
Copper (ppm)	0.60	0.79	0.94	1.32
Iron (ppm)	35.7	33.9	33.0	27.1

Source: Lopes, 1975

sustainable strategies for resource use in Amazonia – although what works here may not necessarily work elsewhere.

Palms are very good indicators of prehistoric occupation when found in unusual densities. *Pupunha* (*Bactris gassipaes*), *inaja* (*Maximiliana maripa*) and *buriti* (*Mauritia flexuosa*) have been used by ethnobotanists as indicative of past occupation. *Tucuma* (*Astrocarium vulgare*) is also associated with secondary growth: The Urubu Ka'apor of Maranhao, Brazil, consider the fruits of this palm attractive to small game and tapir, a relationship which probably encouraged them to promote its growth to increase the value of "hunting gardens" (Linares, 1976; Balée, 1989). The best known and most intensively managed palm is probably *babaçu* (*Orbignya phalerata*). Forests of this palm extend for over 196 370 km^{-2} in the Brazilian Amazon (May *et al.*, 1985: 115). Balée has observed *babaçu* forests of up to three hectares (Balée, 1984). The fruit is valued for protein and calories, while the leaves are prime thatching material.

Bamboo forests (*Guadua glomerata*) are important to indigenous peoples. In the Brazilian Amazon they cover about 85 000 km^{-2} (Braga, 1979) and indicate past indigenous occupation (Sombroek, 1966). Brazil nut forests (*Bertholletia excelsa*) occupy large areas in the eastern Amazon in the lower Tocantins (about 8000 km^{-2}) and are largely unmapped in the rest of the Basin. The Kayapo Gorotire have been observed planting Brazil nut trees because of their importance in attracting game and for their food value (and now market value) (Anderson and Posey, 1985; Posey, 1985). Brazil nut trees are among the most long-lived trees in the forest, which makes their current destruction by cattle ranchers is all the more tragic.

Savanna vegetations in the Amazon Basin are often overlooked due to the attention showered on forests despite their surface area and are not insignificant. At least five distinct types of vegetation along a gradient may be noted: *campo limpo* is characterized by the absence of trees and shrubs and the dominance of grasses; *campo sujo* refers to a vegetation where trees of less than 3 m high may be found at good distances one from another; *campo cerrado* refers to an area with discontinuous trees and shrubs averaging four metres in height; *cerrado, sensu stricto*, is an area with considerable tree vegetation of about six metres in height; and *cerradao* is an intermediate type of savanna and forest with trees averaging nine m in height and having sometimes three distinct strata (Ferri, 1977). Eiten (1972) proposed a sixth category, called *campo umido* such as occur in poorly-drained areas where *buriti* (*Mauritia flexuosa*) thrives. Table 64.5 summarizes the soils and vegetation characteristics of the South American savannas. The savannas of central Brazil have much in common with the savannas of the north such as those in Roraima. Plant biomass is less in general in the llanos of Colombia and Venezuela than in the Brazilian savannas.

MANAGING VARIABILITY

The systems of management observed in the floodplain and estuary suggest that care must be taken if fisheries are to be sustainable. Local populations avoid clearing the flooded forests and understand its importance for the fisheries as a hatchery and a place where the fish gain much of their weight. We also learn from them the importance of cultivating the alluvial beaches, levees and other areas which are enriched by sedimentation during floods. This potential can only be achieved by maintaining the local criteria for predicting the rise and fall of rivers – which, in turn, relies on long-term observation of the behavior of the local fauna and the development of ethnoecological clues. In the estuary, the potential is very high for extraction from fast growing fruit-producing plants that can handle the flood conditions, such as several palms.

In the upland forests, one finds a cornucopia of management practices. On the better soils one finds anthropogenic forests which concentrate species of economic value without excessive simplification of species in the ecosystem so much so that for a long time we thought of them as "virgin" forests. Palm forests, bamboo forests, and Brazil nut forests could also be further developed by observing the ways to do so used by native peoples.

The restoration of forested areas converted to pasture could benefit from the expertise of peoples like the Kayapo, in transitional areas of forest and savanna. There is evidence of native reforestation of savannas (Posey, 1985) and which species are able to support each other in such situations. In poorly-drained savannas, like those in Llanos de Mojos, Bolivia and Marajo island at the mouth of the Amazon, the restoration of drainage canals and reconstruction of raised fields could return those portions of Amazonia to their prehistoric productivity and enhance regional self-reliance and incomes. However, these labour intensive activities are unlikely to last at low

Table 64.6 Summary of management strategies

Estuary: Fast-growing fruit producing palms; other extractive products, limited agriculture usually on raised fields; lower species diversity, high productivity strategies especially near urban centers.
Lower floodplain: Fast-growing annual crops, irrigation management; fishery and hatchery development; truck farming; ecotourism.
Upper floodplain: Lake fisheries development; in low acidity areas rice and other cereals; palm management in swampy areas.
Blackwater uplands: Agroforestry focused on medicinal plants; extensive agriculture focused on bitter manioc; extensive fisheries to reduce potential for overexploitation; high species-diversity but low productivity.
Non-blackwater uplands: Agroforestry development according to local environmental conditions: palm forests, bamboo forests, Brazil nut forests, rubber, and fruit and oil-producing trees; in better endowed areas, intensive cultivation with high value crops and organic matter management.
Savannas: Towards the centre of the region, production of cereals with intensive fertilization; restoration of edge areas back to forest and agroforestry uses.

population density and unfavourable factor prices. In short, attention to the ways in which indigenous peoples use Amazonian resources suggests that there is a great deal that be learned by anyone who wants to enter the region and to use its resources intelligently.

A MATTER OF METHOD

To manage Amazonian variability in the ways discussed above will depend on the application of the methods of ethnoecology to the study of plant and animal productivity in tropical forests. The preoccupation of scientists with maximizing commodity production sometimes correlates with a neglect of the impact of such production priorities on the welfare of farming populations. This will have to be corrected as the quality of life declines in cities, and as it becomes more important to have sustainable systems of production nurtured by greater labour rather than capital inputs (Freudenberger, 1988). In short, a growing number of people are demanding a globally-aware, regenerative, and nationally self-reliant food system. This cannot be achieved by giving priority to the relative efficiency of some places to grow staples, while relegating all other areas to the production of non-staple commodities that wildly fluctuate in price. Food is too basic an item to be subjected to the speculative decisions of a few large-scale producers, or to the random fortunes of weather or prices. National and regional policies will have to favour food security, and in so doing restore the value of nurturing the earth that is often associated with small and medium scale food producers.

A regenerative food production system will need to break the stranglehold that large scale grain producers currently have on local production systems. Each nation would need to favour its own farming populations to maintain and enhance the fertility of its agricultural lands, while producing enough food to meet the basic needs of its people. Such a strategy will require that we find ways to maintain and enhance the biological processes that recycle nutrients, build up organic matter, conserve water (in arid areas) or move water (in hyperhumid areas) effectively and at low cost. In short, what we need are better mimics of the complexity and diversity of natural systems. We need to move towards a biologically-intensive, rather than fossil fuel or capital-intensive, foodproduction system (Freudenberger, 1988). It will be a food production system which calls for micro-management of plants and inputs, that incorporates many new plants into the consumption system, and that unlocks the unexploited potential of many plants and animals.

The food production system of the future looks a lot like the system known already to many indigenous peoples of Amazonia. While they may not currently share our concern with "efficiency" this may simply be a product of the dislocations and resettlement that have profoundly affected them since colonial times. Not all native populations have very extensive knowledge of the biological processes around them, due to these dislocations, but many do and working with them it will be possible to find interconnections in biological process that reduce the chances of failure that have so often plagued past efforts at increasing food production in the tropics. For example, why invest scarce capital in planting *Phaseolus* beans in the humid tropics of Amazonia when there is ample evidence of difficulty controlling *Fusarium* infestation of the bean plants. Why not, instead, allocate more effort to manioc production, processing and marketing? Why introduce sweet varieties to areas that grow bitter varieties of manioc almost exclusively? why plant cotton for the worldmarket if the country or the region cannot feed itself? How often do we ask local people why they plant something? The immediate answer, "because we like it" may not be the entire answer. Behind that like may lie a more profound truth: we have tried x, y and z and they failed to give acceptable returns and thus they have focused on this crop because of its reliable returns. Reliability in food supply may be ultimately more important to farmers – and to us all. Ask any farmer, or the population of Cuba or Russia.

Length of residence in the immediate area is the best proxy for expertise when it comes to farming knowledge. As a rule of thumb, no less than one generation in the area of study is necessary before one can expect accuracy in the folk system. A natural starting point is to talk about the soils of the region. A series of questions geated at identifying the major domains can be a start: are there good soils for agriculture around here? how can you tell good soils from bad soils? are some good for some crops and not others? do some need more inputs than others? In areas where the farmers make numerous discriminations and hierarchical ones, it may be necessary to go into greater detail: are there soils around here that are better for corn? for bananas? for cocoa? how does one find such soils? Such questions are best asked in the field, where it is possible to point to particular soils and discuss them.

How can the native terms for local soils and plants help an agronomist? A native distinction that indicates that soils under certain vegetation are no good for bananas would suggest a method for identifying a common nutrient deficiency (probably potassium or phosphorus) in that soil and allow immediate attention to be directed to what levels of fertilization may be needed and whether it would be cost effective to plant that crop, or one with comparable nutrient requirements. In short, it can serve as a shortcut to test plots focusing on all macronutrients.

Farmer practices can be put in experimental plots and results compared between test plot and farmer fields to discover the value of certain crop associations. This has been amply done over the years for the association between corn and beans, for example— but on very few other associations that surely merit examination.

The field practices of native Amazonians constitute a compendium of experimental knowledge which we can learn from and attempt to reproduce experimentally to get at the basic processes which are being used. The ability to isolate the biological principles behind the complex practices may very well determine whether our future is bright or bleak.

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