Adaptive Responses of Native Amazonians

edited by

Raymond B. Hames
William T. Vickers

Studies in Anthropology

Adaptive Responses of Native Amazonians

This is a volume in

STUDIES IN ANTHROPOLOGY

Under the consulting editorship of
E. A. Hammel, University of California, Berkeley

A complete list of titles appears at the end of this volume.

Adaptive Responses of Native Amazonians

EDITED BY

Raymond B. Hames
Department of Anthropology
University of Nebraska
Lincoln, Nebraska

William T. Vickers
Department of Sociology and Anthropology
Florida International University
Miami, Florida

1983

ACADEMIC PRESS
A Subsidiary of Harcourt Brace Jovanovich, Publishers
New York London
Paris San Diego San Francisco São Paulo Sydney Tokyo Toronto

ACADEMIC PRESS, INC.
111 Fifth Avenue, New York, New York 10003

United Kingdom Edition published by
ACADEMIC PRESS, INC. (LONDON) LTD.
24/28 Oval Road, London NW1 7DX

Library of Congress Cataloging in Publication Data

Main entry under title:

Adaptive responses of native Amazonians.

(Studies in anthropology)
Bibliography: p.
Includes index.
1. Indians of South America--Amazon River Valley--Social conditions--Addresses, essays, lectures.
2. Indians of South America--Amazon River Valley--Social life and customs--Addresses, essays, lectures.
3. Human ecology--Amazon River Valley--Addresses, essays, lectures. 4. Amazon River Valley--Social conditions--Addresses, essays, lectures. I. Hames, Raymond B. II. Vickers, William T. III. Series: Studies in anthropology (Academic Press)
F2230.1.S68A3 1982 305.8'98'0811 82-18399
ISBN 0-12-321250-2

PRINTED IN THE UNITED STATES OF AMERICA

83 84 85 86 9 8 7 6 5 4 3 2 1

Contents

IV. SETTLEMENT PATTERN

This page intentionally left blank

Contributors

Numbers in parentheses indicate the pages on which the authors' contributions begin.

Stephen Beckerman (269), Department of Anthropology, Pennsylvania State University, University Park, Pennsylvania 16802

Brent Berlin (301), Department of Anthropology, University of California, Berkeley, California 94720

Elois Ann Berlin (301), Division of Family Medicine, Department of Family, Community and Preventive Medicine, Stanford University, School of Medicine, Stanford, California 94305

Robert L. Carneiro (65), Department of Anthropology, American Museum of Natural History, New York, New York 10024

Darna L. Dufour[1] (329), The Institute of Physiology, The University, Glasgow, G12 8QQ, Scotland

Nancy M. Flowers (357), Department of Anthropology, City University of New York, New York, New York 10021

Daniel R. Gross (429), Department of Anthropology, Hunter College of the City University of New York, New York, New York 10021

Raymond B. Hames (1, 393), Department of Anthropology, University of Nebraska, Lincoln, Nebraska 68588

Kristen Hawkes (139), Department of Anthropology, University of Utah, Salt Lake City, Utah 84112

Jonathan Hill (113), Department of Anthropology, Indiana University, Bloomington, Indiana 47405

Kim Hill (139), Department of Anthropology, University of Utah, Salt Lake City, Utah 84112

[1]Present address: Department of Anthropology, University of Colorado, Boulder, Colorado 80309.

Allen Johnson (29), Department of Anthropology, University of California, Los Angeles, California 90024

Patricia M. Kelley (189), International Linguistics Center, Summer Institute of Linguistics, Dallas, Texas 75236

Emilio F. Moran (113), Department of Anthropology, Indiana University, Bloomington, Indiana 47405

Anthony Stocks (239), Department of Sociology, Anthropology, and Social Work, Idaho State University, Pocatello, Idaho 83209

William T. Vickers (1, 451), Department of Sociology and Anthropology, Florida International University, Miami, Florida 33199

Dennis Werner (225), Pos-Graduačao em Ciências Sociais, Universidade Federal de Santa Catarina, Florianópolis, Santa Catarina 88.000, Brazil

James A. Yost (189), International Linguistics Center, Summer Institute of Linguistics, Dallas, Texas 75236

Preface

Amazonia is a region that has always had an aura of mystery and intrigue about it. The sprawling expanses of forests, rivers, and savannas that form the Amazon Basin have frustrated would-be rulers of the Inca, Spanish, and Portuguese empires, as well as countless explorers searching for El Dorado, lost cities in the jungles, and human, animal, and plant exotica. Yet today Amazonia is no longer terra incognita, as eight nations strive to develop their holdings within the basin. Paralleling this process is an explosion of scientific research on Amazonia. This volume focuses on such research from the ecological perspective within anthropology.

The native societies of Amazonia hold a certain fascination for many anthropologists. Much of this interest stems from the endemic warfare of many Amazonian people and the associated traits of cannibalism, shrunken heads, and other forms of human trophy-taking, along with Amazonian societies' rich cosmologies, varied social structures, and apparent lack of state-level political organization. Because the shifting cultivation and foraging economies of Amazonian peoples bring them into intimate association with their environments, serious students of ethnology have often turned to ecological analysis when attempting to understand and explain the foundation of Amazonian cultural dynamics. At one time or another, soil quality, protein availability, population regulation, and sexual competition have all been proposed as key influences on native adaptation. Through the mid-1950s much of the debate concerning environmental influences on Amazonian societies was frankly speculative. But in 1957 Robert L. Carneiro completed a doctoral dissertation at the University of Michigan that has had seminal impact; his *Subsistence and Social Structure: An Ecological Study of the Kuikuru Indians* was the first community-based quantitative analysis of the subsistence ecology of an Amazonian people. Since that event, both the quantity and quality of problem-oriented field investigations into the human ecology of native Amazonian societies have been impressive. This volume is based on our belief that the ecological approach to the understanding of aboriginal Amazonia is indeed a powerful perspective, and on our desire to present a collection of empirical studies that are representative of recent trends within ecological anthropology. It was conceived in the course of informal conversations at the 1979 Annual Meeting of the American Anthropological Association in Cincinnati, Ohio. Both of us were concerned about the sometimes polemic nature of the debates concerning Amazonian human ecology. At the same time, we were encouraged by the new wave of empirical research being carried out by younger scholars; we believed that a source book featuring up-to-date research of this type would be most useful for specialists and for anyone else interested in the general fields of human ecology, South American ethnology, and tropical studies. This volume was prepared with these goals in mind.

The essays presented in this book are organized into sections dealing with the major modes of Amazonian subsistence (cultivation, and hunting and fishing), nutrition, and settlement pattern. These topical headings relate to major aspects of human articulation with the environment and represent a logical order that emerged from the papers submitted by our contributors. But the individual chapters frequently transcend any static categorization and make points that apply across many aspects of human ecological analysis. Because we wanted a source book that would represent original and innovative research, we did not attempt to straitjacket our contributors into a single ecological theory. All of the authors approach their subject matter from an ecological perspective, but the reader will find studies representing the major contending theories of cultural ecology, cultural materialism, evolutionary ecology, and ethnoecology. We believe that the proponents of each of these theories have something to say and that our readers should have the opportunity to evaluate their data as well as their interpretations.

As editors, we do not seek to promote mere eclecticism, but wish to engage our readers in an interactive process of exposure to data and analytical judgment and debate. As scientists, we do have our theoretical preferences; our arguments are made in the introductory chapter and in our individually authored chapters. As scholars, we believe that the general field of Amazonian studies has made great strides in recent years, and that ecologically oriented anthropologists have been among the most vitally active of all Amazonian researchers in presenting new data and in formulating and testing theory. Yet, all who work in this area agree that much remains to be done. This volume is in large measure dedicated to the evaluation of where we are and where we should be heading as we seek to understand the complex interrelationships between man, environment, and culture in Amazonia.

We would like to thank a number of people for their assistance in this project as well as those contributors who rapidly responded to our queries concerning their manuscripts. Raymond Hames would like to thank Nina Cuèllar for compiling and editing the consolidated bibliography, Ilene Hames for editorial advice, Dorothy McEwen for under-the-gun typing, and Peter Bleed, chairman of the Department of Anthropology of the University of Nebraska, for allocation of departmental resources to the project, and Allan Osborn for encouragement. A Summer Faculty Fellowship from the Research Council of the University of Nebraska greatly facilitated Raymond Hames's work on this volume. William Vickers would like to express his appreciation to William E. Carter and Charles Wagley, who encouraged him to pursue ecological and Amazonian studies, and those at Florida International University who gave support in various phases of his work on the manuscript. The latter include Mark B. Rosenberg, director of the Latin American and Caribbean Center, James A. Mau, dean of the College of Arts and Sciences, Anthony P. Maingot, chairman of the Department of Sociology and Anthropology, Michelle Lamarre, Betty Jo Sargent, and Linda Miller. We would like to thank the editors at Academic Press for their initial faith in the project and for their understanding and patience during the longer-than-anticipated process of bringing together this research collection.

This page intentionally left blank

CHAPTER 1

Introduction

Raymond B. Hames and William T. Vickers

Introduction

For centuries Amazonia has captured the imaginations of many throughout the world as a mysterious and forbidding jungle inhabited by untamed savages. Perceptions such as these were largely based on ignorance, and were fueled by stories of ferocious animals, cannibalistic tribes, female warriors, and fantastic plant forms. Without a doubt, these perceptions contained kernels of truth, for the Amazon was remote and held a rich variety of life forms and cultures that were unusual from a European, temperate-zone perspective. From a scientific point of view, however, there is nothing about the Amazonian environment that is potentially unknowable. As scientific studies in the region have increased, our knowledge of Amazonia has expanded dramatically. Yet we have only begun to scratch the surface in our attempts to understand this vast geographical and culture area. The purpose of this volume is to bring together a selection of recent studies that are representative of the ecological approach to the study of aboriginal human adaptation in Amazonia. It is based on our belief that the ecological approach offers powerful tools for the analysis of sociocultural phenomena. Recent decades have witnessed an ever-escalating debate among anthropologists and other specialists concerning the significance of man–nature relationships in lowland South America, but the level of this discussion has suffered from a paucity of rigorous studies based on carefully executed research, and from a scantiness of empirical data. This volume addresses these problems by providing a collection of

ISBN 0-12-321250-2

chapters that contribute a wealth of new data on human adaptation in the tropical forests of South America. The analyses of major human ecological topics include (1) availability of vital natural resources, and the strategies used to exploit them through hunting, fishing, and horticulture; (2) how such procurement strategies in turn influence nutrition, settlement pattern, and population dynamics; and (3) the complex interplay between ecological adaptation and social institutions. Although all of the contributors are agreed on the utility of an ecological perspective, they place differing emphases on specific theoretical approaches such as cultural ecology, cultural materialism, ethnoecology, and evolutionary ecology. Hence, many of our contributors disagree on certain theoretical assumptions and specific points of interpretation, but we feel that this is healthy because it represents the current state of research and model building.

Some Characteristics of Amazonian Ecosystems

Amazonia is defined by the world's greatest river system; a basin encompassing 6 million km^2 and supplying approximately 20% of the fluvial discharge on this planet. For purposes of anthropological analysis, *Amazonia* often is defined broadly to include adjacent lowland tropical areas (such as the Orinoco River basin) because of environmental and cultural similarities to the Amazon Basin proper. The chapters by Beckerman, by Hames, and by Hill and Hawkes in this volume deal with peoples who are technically outside of the Amazon drainage, but who are located in adjacent tropical lowland areas, so they are eminently relevant to the focus of the book.

The present-day land mass comprising Amazonia has a long and complex geological history. During the Archeozoic era it consisted of two land masses that were separate bodies within the Atlantic Ocean. These Archaic massifs are today referred to as the Guyana and Brazilian shields. During the Miocene, geological forces raised the Andes range to the west and a mediterranean sea was created between these new mountains and the more ancient massifs. Gradually the area occupied by this sea was reduced through sedimentation, and the continuing formation of the Andes in the west produced the eastward flowing rivers of the Amazon Basin. As a consequence of this history, the major geomorphic regions of Amazonia include the highly weathered and crystalline uplands of the Guyana and Brazilian shields (to the north and the south of the basin, respectively), the young and rugged slopes of the eastern Andes of the upper Amazon (in the western and southwestern portions of the basin), a lowland plateau of Tertiary lake bed running across the center of the basin (bisecting the

Guyana and Brazilian shields), and the *várzea*, or modern-day flood plain, which comprises an estimated 3% of the basin (Pires and Prance 1977).

Although the soils of the Amazon have often been characterized as *lateritic* (i.e., containing plinthite or "ironstone"), and as having low agricultural potential (e.g., see Meggers 1954), recent research indicates that this is an oversimplification. In an important paper published in 1974, Falesi identified no fewer than 20 soil types in the Brazilian Amazon (Falesi 1974:202). Wambeke also emphasizes the diversity of soils in the Amazon Basin and correlates soil types with the degree of weathering to which the materials have been exposed.

> Soils exhibit differing degrees of weathering due to the interaction of many environmental variables and the chemical composition of the rocks from which the soils derive . . . plinthite, often wrongly described as a major barrier to agricultural development in the Amazon, is in fact only found to be a problem in 2% of the soils. . . . The diversity of soils . . . is also landscape specific. Topography favors particular vegetation and soil types. The greatest diversity of soils and land use potentials can occur within an average of 89 meters of altitude differential between rivers and the plateaus they divide [1978:233].

Wambeke also emphasizes that it is necessary to conduct fine-grained surveys to determine fully the distribution of soil types because of the considerable variability in distributions at the local level (1978:234).

Cochrane and Sanchez (in press, cited in Hecht 1981) indicate that the major soil orders of tropical South America are Oxisols, Ultisols, and Entisols (covering an estimated 45.5, 29.4, and 14.9% of the Amazon, respectively). *Oxisols* have physical characteristics that are favorable for cultivation, but are acidic, low in nutrients, and may have toxic levels of aluminum compounds (Hecht 1981:70). *Ultisols* are similar to Oxisols but have less-favorable structures. *Entisols* are often alluvial and offer better nutrient status in many cases. Additional, but less common, soil orders are also found and some of these have good to excellent characteristics (e.g., see N. Smith 1980).

Sioli's well-known limnological work in the Amazon has contributed another set of ecological contrasts in which white-water, black-water, and clear-water rivers have been described as having different optical qualities, pH, flow patterns, and loads of suspended solids (1975a). These variations in riverine conditions are attributed to differences in the geomorphological characteristics of the catchment area within which each river originates. Such factors significantly influence the rates of primary and secondary production in these rivers, as well as other processes such as the rates of erosion and siltation.

White-water rivers such as the Amazon proper and some of its tributaries (e.g., the Napo) derive their designations from the sediments they carry. These sediments are eroded materials from the Andean headwaters and they contribute to the formation and maintenance of the *várzea* floodplain.

Such rivers are rich in nutrients, but their turbulence and opacity limit the primary production of phytoplankton. *Black-water rivers* such as the Rio Negro (see Hill and Moran, this volume) are said to originate in areas where white sand soils are covered by *caatinga* (a type of forest that is lower and more open than tropical rainforest). Although dark due to dissolved humic matter, these waters are relatively transparent due to a lack of inorganic suspended particles. They are also nutrient-poor and acidic (Sioli 1975a:284). *Clear-water rivers* such as the Tapajós and Xingú derive from forest-covered zones of flat or mild elevation where erosion is minimal. They are poor in nutrients, like the black-water rivers, but lack the humic coloration.

Goulding has argued that Sioli's classification system "will eventually have to be tested in terms of ecological and biogeographical consequences, which themselves will demand better and more extensive hydrochemical studies" (1980:17). He finds, for example, that there is little difference in the fish species present in the lower Rio Machado (clear-water) and the lower Rio Negro (black-water), and postulates that the most significant ecological distinction is that between the white-water and the nonwhite-water rivers.

The predominant morphological forms for Amazonian rivers are braided, meandering, and channelized (Goulding 1980:17). The Amazon proper is of the *braided* type, with many secondary channels, lenticular islands, and associated bodies of water that are periodically flooded or drained by the shifting water levels of the channel. Fittkau *et al.* (1975) found that phytoplankton production is highest in decanted white waters (due to improved light transmission) and in mixed waters that receive a white-water input. Clear waters have a moderate phytoplankton density due to their low nutrient content, but overall production is relatively high due to their light transmission properties. Black-water rivers have very low production due to their poor nutrient status and poor light transmission. *Channelized* rivers tend to be relatively young and fast flowing, and have more narrow floodplains cut through the Andes or the archaic Brazilian and Guyana massifs. *Meandering* rivers are often found in association with relatively wide floodplains that are often covered with swamp forest. Numerous cutoffs or oxbow lakes straddle these rivers and provide good fishing grounds (see Stocks, this volume), particularly during periods of low water when fish become trapped in them and the volume of water is reduced.

The Amazon Basin has one of the wettest rainfall regimes in the world. Its major source of water is the Atlantic Ocean, although it is estimated that over 50% of the rainfall derives from water that is recycled within the region (Marques *et al.* 1977, cited in Salati *et al.* 1978:202). Precipitation generally increases as one moves from east to west; at Marajó Island at the mouth of the Amazon the mean annual rainfall is 2600 mm, whereas it is 3600 mm in the Vaupés region. To the north of the equator, maximum rains occur around June, and to the south, around January. Salati *et al.* (1978:205) identify four hydraulic regimes for the Amazon. North of the equator, from the Atlantic to 60° west longitude, the period of heaviest rainfall is from November through June with somewhat elevated values due to the ocean's proximity. South of the equator, from the eastern extent of the Amazon Basin to 65° west longitude, the wet and dry seasons are reversed. In the western portions of the Amazon Basin (north and south of the equator), the annual rainfall increases and the wet and dry season variations are less pronounced.

Water levels on the mid- and lower Amazon are at their lowest in October, but begin rising in November and reach their peak in June (Sternberg 1975:22). The mean annual fluctuation is 10 m at Manaus, 6–7 m at Santarem (downstream from Manaus), and only 4 m near the mouth of the Amazon (Sioli 1975b, cited in N. Smith 1981a:11). This annual rising and falling of the river is of great ecological importance as it is the mechanism by which silt is deposited in the floodplain and nutrients are infused into the *várzea* lakes. This process of enrichment enhances both the floodplain's aquatic and terrestrial productivity.

Temperatures in the Amazon are remarkably stable throughout the annual cycle, and the warm conditions, high levels of solar radiation, and high humidity create ideal conditions for plant growth. As a consequence, Amazonia is one of the most floristically complex regions of the world. Pires (1978:611), for example, identified 224 plant species in 136 genera and 52 families in a 5-ha area of *terra firme* forest near Belém. Overall, it is estimated that the Amazon has at least 50,000 species of vascular plants (Myers 1979:23). The distributions of these plants are not homogeneous. Prance, for example, proposes eight vegetation types for Amazonia (1978:212):

1. Forest on *terra firme* (nonflooded) with eight subtypes
2. Forest on inundated areas with two subtypes further broken into six categories
3. Savanna on *terra firme* (nonflooded) with eight locational categories
4. *Várzea* savannas (flooded)
5. *Campina* (low vegetation on white sand)
6. Montane vegetation on the fringes of Amazonia
7. Littoral vegetation (coastal dunes, etc.)
8. River beaches

The various subtypes of *terra firme* forest are estimated to cover about 85% of the Amazon Basin. They include high forest (with high biomass), liana forest, low forest (with reduced biomass), *campina* or *caatinga* forest (on sandy soil), dry forest (in transitional areas), montane and cloud forest (in elevated areas), bamboo forests (such as in Acre), and miscellaneous types of low, sparse forest. So the Amazon is not only complex in terms of its floristic composition, but also in terms of its varied associations that are influenced by differences in rainfall, soils, drainage, elevation, and proximity to the sea.

South America as a whole has an extremely high diversity of animal forms and is notable for its large number of archaic endemic species. Gilmore (1950:348) attributes this endemism and richness to the continent's (1) large area, (2) diverse environments, (3) isolation during the Tertiary period, (4) good stock of animals prior to this isolation, and (5) peripheral position to the Holoarctic land mass. In the lowland tropics the arboreal and aquatic forms are particularly notable and those of Amazonia are the most diverse on the planet. The Amazon is also notable for its many edentates (sloths, armadillos, and anteaters), primates, and reptiles. For some time, zoologists have recognized that the tropical forest regions of the world tend to have a somewhat lower biomass of terrestrial mammals than temperate regions, and relatively few species of large ungulates (Bourliere 1963; Eisenberg and Thorington 1973). The fact that the tropical rainforest represents a climax association with the bulk of the biomass tied up in the wood of trees limits the availability of nutrients to terrestrial herbivores. Arboreal hervibores such as sloths and monkeys comprise much of the mammalian biomass. There is an abundance of rodent forms in Amazonia, and their densities may be comparable to rodent densities in temperate zones (Fleming 1971, cited in UNESCO 1978:163).

Most of the terrestrial mammals of Amazonia have solitary or paired habits. A notable exception is the white-lipped peccary (*Tayassu pecari*), which organizes into nomadic herds of a hundred or more individuals (Kiltie 1980). Monkeys display both family and troop types of social organization. The population densities and structures of many mammal and bird populations vary according to the temporal and spatial availabilities of food in the environment.

Only about half of the estimated 2500–3000 fish species of Amazonia have been described scientifically. Approximately 80% of the species are characins and siluroids (Goulding 1980). As with the terrestrial and arboreal animals, there are a number of archaic endemic forms, including the *paiche*, or *pirarucu* (*Arapaima gigas*), which reaches weights in excess of 100 kg. The interesting adaptations of many fish species to Amazonian conditions include feeding on the fruits and seeds of terrestrial plants that have fallen into the water, and seasonal migrations related to feeding and reproductive behavior (Goulding 1980). Overall, the fishes of Amazonia represent all of the major trophic levels since they include planktivores, frugivores, carnivores, and detritivores (Goulding 1980:30). Turtles (and their eggs), caimans, and manatees are additional aquatic animals that are significant sources of food for aboriginal peoples.

Research of recent years indicates that the ecology of the Amazon is far more heterogeneous than previously supposed. As we have just outlined, new work by soil scientists, botanists, zoologists, and other scientists is presenting us with new data. These data indicate that Amazonia really consists of a highly complex and variable series of habitat types whose outlines and dynamics are only beginning to be recognized and understood. This is one reason why Amazonia is such an exciting place for scientific investigation, and also why many researchers feel a strong sense of urgency in their work as the region undergoes development. It seems certain that as these studies continue, many of our assumptions and generalizations about Amazonian environments and cultures will be modified and improved upon.

For example, Denevan (1976) has proposed a classification of habitat types for analyzing aboriginal demographic patterns that is similar to, if somewhat simpler than, Prance's classification of vegetation types (described earlier). Denevan's seven human habitat types are Floodplain, Brazilian Coast, Lowland Savanna, Upland Forest, Upland Savanna, Lowland Forest, and Uninhabitable. Even Denevan's classification probably does not indicate the true degree of variability in Amazonian habitats. Furthermore, it is highly likely that specific Amazonian communities exploit a range of biotopes in much the same manner as Nietschmann has described for the Miskito of Nicaragua (1973). As Vayda and Rappaport (1968) point out, the proper starting point in the detailed analysis of human ecological adaptation is the community and the activities of its members within a defined space. It is within this context that anthropologists can survey resources, quantify inputs and outputs, study demographic trends, and investigate historical circumstances. As we describe subsequently, the paucity of such community-based ecological studies has been a weakness that has plagued the debate on the constraints on aboriginal adaptation in Amazonia. In a large measure this volume developed out of a sense that this gap needed to be addressed. However, we would like to stress that our goal is not to particularize Amazonian human ecology. The point of studying individual communities is not to show that each represents a unique repertoire of behaviors adapted to a unique complement of biotopes. Instead, community and regional studies are employed to test hypotheses concerning general adaptive processes in Amazonian societies.

Environmental Models of Amazonian Sociocultural Evolution

Ever since Julian Steward's masterful editorship of the *Handbook of South American Indians* (seven volumes, 1944–1949) the Amazonian habitat has been cited by cultural ecologists as a prime example of how the environment determines and limits sociocultural evolution. Lowie, one of Steward's collaborators on the handbook, stated in his summary chapter on the social and political organization of tropical forest tribes: "In the Tropical Forest area there is almost every type of social structure, yet the variations in economic activities are trifling" (Lowie 1949:331). Lowie had in mind the relationships among rather specific aspects of social organization such as postmarital residence rules and conceptions of descent. However, Steward's approach was much more general—that is, he focused on the relationship between (1) core elements of culture and levels of sociocultural integration, and (2) technology and gross environmental factors (Steward 1955:34). Steward (1949:677,698) suggested that environmentally richer riverine and coastal habitats permitted large and socially stratified settlements to form. These settlements could be integrated on a large scale due to the ease of water transportation. However, the tropical forest *terra firme* horticulturalists and the so-called marginal foot nomads of Amazonia could not evolve socially because either no surplus could be produced or food could be obtained only in limited amounts (Steward 1949:669).

Steward developed his position more fully in *Native Peoples of South America* (1959), authored with Faron. They divided the societies of the Amazon into three different sociocultural types, each associated with a particular environmental regime: (1) small single-lineage villages with populations less than 100 were located near small streams and away from large rivers; (2) large multilineage villages of more than 1000 inhabitants were found along the Amazon and its major tributaries; and finally, (3) the marginal foot nomads (Steward and Faron 1959:373,424) lived in small groups of 25–50 individuals, were organized as composite or family bands, and occupied "regions that were economically marginal, inferior, or relatively unproductive" (Steward and Faron 1959:374). Steward and Faron postulated that chiefdom or state-level societies could not easily evolve in Amazonia because of poor soils, sparse faunal resources, lack of efficient transportation, and isolation from the main centers of cultural invention (e.g., the Andean region). In their framework, poor soils led to shifting cultivation that did not allow dense, permanent, or aggregated populations. Furthermore, shifting cultivation did not allow a surplus of food to be produced to support a stratified society (Steward and Faron 1959:61). They did recognize that root crop cultivation was somewhat productive, but noted: "These crops, however, provide predominantly starchy foods, and while no adequate analysis has ever been made of the diet, there is little doubt that the people had a need for protein foods which were obtained principally by hunting and fishing" (Steward and Faron 1959:291). Interestingly, regarding the cultural and physiological determinants of behavior, they noted that "when cultivated foods provide a badly unbalanced diet for which hunting and fishing can compensate it is quite possible that the craving for meat, rather than mere tradition led men to hunt" (Steward and Faron 1959:292). Steward and Faron believed that the marginal foot nomads could not achieve even the modest levels of egalitarian organization of the *terra firme* populations because they "barely met minimum subsistence needs and often fell far short of them" (1959:60), and all of their time was spent in the food quest, which allowed them little time for nonsubsistence activities.

The paradigm developed by Steward has served as the basic model for nearly all subsequent ecological theorizing on Amazonian societies. As we shall show, Steward's rather vague model has been more fully developed by detailed ethnographic research and greater knowledge of neotropical ecology. However, his basic observations on soil and protein problems and their relation to *várzea* (or fluvial) and *terra firme* (or interfluvial) populations are still central. Steward's model forced him to assume much that was not known concerning subsistence adaptation in Amazonia. For him, low levels of sociocultural integration and low population density were proof of either an unproductive environment, inefficient technology, or both. Refinements of Steward's model, examined subsequently, still face this problem of scarce empirical research. Recent cultural ecological theory has tended to stress one of the two main components of Steward's model: poor soils (Meggers 1954, 1957, 1971; Oberg 1973; Roosevelt 1980) or protein problems (Carneiro 1970a; Gross 1975; Lathrap 1968; Ross 1978).

Oberg's (1955) explanation for differential cultural evolution in Amazonia emphasizes one of Steward's environmental factors—quality of soil for horticulture. Amazonian societies are divided into homogeneous and segmented tribes, which parallel Steward's lineal and multilineal tribes, respectively. He argues that good soil leads to the production of a surplus, which supports greater population aggregations and stratification, and which leads to an increase in leisure time for culture building (Oberg 1955). Additionally, in a rather haphazard fashion, he alludes to subsidiary factors, such as a diverse environment and a varied crop inventory (Oberg 1955), that promote aggregation and cultural evolution. These other factors, along with good soil, account for chiefdoms and higher levels of sociocultural integration outside of Amazonia.

Meggers takes up the theme of environmental determinism in a series of important publications (1954, 1957, 1971). In a much clearer fashion than Steward or Oberg, she divides Amazonia into two basic habitats, *várzea* and *terra firme* (Meggers 1957), and argues that silt-rich *várzea* soils enabled denser and more advanced societies to develop compared to *terra firme* soils. Her major theoretical contribution to Amazonian human ecology came in 1971 with the publication of *Amazonia: Man and Culture in a Counterfeit Paradise*. For the first time, the soil poverty hypothesis was systematically tested using higher quality data than Steward or Oberg had at their disposal. Data on social organization, village size, population density, and village permanence are cited to evaluate her thesis. Significantly, she uses the concepts of carrying capacity and environmental equilibrium to account for a number of cultural practices such as warfare, infanticide, and sorcery, which are argued to be adaptive responses to environmental problems (Meggers 1971:106). On occasion she implies that protein shortage may be an adaptive constraint (e.g., Meggers 1971:26–27), but its role never emerges clearly.

We are indebted to Carneiro for the first thoroughly modern cultural ecological study of an Amazonian society (1957) and the first critical and quantitative examination of the soil poverty hypothesis (1960, 1961). Carneiro (1960) developed a measure of agricultural carrying capacity to determine how large a permanent village could grow without irreversibly depleting soil resources. By doing so he was able to demonstrate forcefully that something other than agricultural soil limited the size, permanence, and hence cultural evolution of Amazonian societies. Carneiro later answered his own question in terms of the effects of protein needs (1970a) and circumscription (1970b). In his characteristic style Carneiro developed quantitative indexes of sedentariness and subsistence and tested the relationship on a sample of seven Amazonian societies. He concluded that a high dependence on fishing and agriculture led to larger and more permanent village aggregations whereas a high dependence on hunting and gathering led to smaller and more mobile villages. The rich fisheries found in large rivers emerged as the main factor that led to large and complex societies because it lessened dependence on dispersive hunting and gathering.

Early on, Steward (1949:665) remarked, "One has the impression, however, that vast regions of potentially arable land were never utilized and that the population may have been expanding at the time of conquest"; and "many other tribes similarly failed to achieve comparable size which their economy would have permitted." This observation presages Carneiro's (1970b) theory of environmental circumscription. One of the reasons tropical forest settlements in the *terra firme* habitat never became large or permanent was that they were not bound by geographic barriers. And, as a result, they could adapt by expanding into virgin environments that permitted them to maintain an extensive subsistence base rather than selecting an intensive one. Carneiro argues that sociocultural evolution frequently occurs when a population is boxed into a restricted habitat and is forced to intensify subsistence through a variety of social and economic mechanisms. In Amazonia the narrow *várzea* floodplain represents such a circumscribed habitat, whereas the vast open *terra firme* habitat (occupying approximately 97% of Amazonia) is relatively uncircumscribed. In integrating Carneiro's resource concentration model (1970a) and circumscription model (1970b), we find that larger and more complex settlements arose in the *várzea* because it contained concentrated aquatic resources and was circumscribed by the *terra firme* habitat, which was relatively impoverished of protein resources. *Terra firme* societies, on the other hand, remained small because they could adapt to resource depletion by simple geographic expansion (Hames, this volume).