This is an authorized facsimile, made from the microfilm master copy of the original dissertation or masters thesis published by UMI.

The bibliographic information for this thesis is contained in UMI's Dissertation Abstracts database, the only central source for accessing almost every doctoral dissertation accepted in North America since 1861.

U·M·I Dissertation Services

A Bell & Howell Company

300 N. Zeeb Road, Ann Arbor, Michigan 48106
1-800-521-0600 313-761-4700

Printed in 1993 by xerographic process on acid-free paper

3965

8302286

Picchi, Debra Sue

ENERGETICS MODELING IN DEVELOPMENT EVALUATION: THE CASE OF THE BAKAIRI INDIANS OF CENTRAL BRAZIL

The University of Florida PH.D. 1982

University
Microfilms
International 300 N. Zeeb Road, Ann Arbor, MI 48106

UNIVERSITY OF FLORIDA LIBRARIES

INFORMATION TO USERS

This reproduction was made from a copy of a document sent to us for microfilming. While the most advanced technology has been used to photograph and reproduce this document, the quality of the reproduction is heavily dependent upon the quality of the material submitted.

The following explanation of techniques is provided to help clarify markings or notations which may appear on this reproduction.

1. The sign or "target" for pages apparently lacking from the document photographed is "Missing Page(s)". If it was possible to obtain the missing page(s) or section, they are spliced into the film along with adjacent pages. This may have necessitated cutting through an image and duplicating adjacent pages to assure complete continuity.

2. When an image on the film is obliterated with a round black mark, it is an indication of either blurred copy because of movement during exposure, duplicate copy, or copyrighted materials that should not have been filmed. For blurred pages, a good image of the page can be found in the adjacent frame. If copyrighted materials were deleted, a target note will appear listing the pages in the adjacent frame.

3. When a map, drawing or chart, etc., is part of the material being photographed, a definite method of "sectioning" the material has been followed. It is customary to begin filming at the upper left hand corner of a large sheet and to continue from left to right in equal sections with small overlaps. If necessary, sectioning is continued again—beginning below the first row and continuing on until complete.

4. For illustrations that cannot be satisfactorily reproduced by xerographic means, photographic prints can be purchased at additional cost and inserted into your xerographic copy. These prints are available upon request from the Dissertations Customer Services Department.

5. Some pages in any document may have indistinct print. In all cases the best available copy has been filmed.

University Microfilms International

300 N. Zeeb Road
Ann Arbor, MI 48106

ENERGETICS MODELING IN DEVELOPMENT EVALUATION: THE CASE OF THE BAKAIRI INDIANS OF CENTRAL BRAZIL

By

DEBRA S. PICCHI

A DISSERTATION PRESENTED TO THE GRADUATE COUNCIL OF
THE UNIVERSITY OF FLORIDA
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE
DEGREE OF DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

1982

ACKNOWLEDGMENTS

This study describes the results of a research project which took place in central Brazil between October of 1979 and July of 1981. During the incipient stages of the project as well as during its realization, many individuals and organizations were extremely supportive and helpful.

The Bakairi Indians of P.I. Bakairi in Mato Grosso made this project a particularly pleasant and worthwhile piece of work to do. Their love of life and their incredible optimism about themselves and their future instilled in the researcher a deep sense of commitment to these people and their world. Anthropological fieldwork is often fraught with frustration and discouragement. However, in working with the Bakairi, these periods were kept to a minimum due to the Indians' ability to transform any obstacle into a game that would test the body and the mind. If feelings or intuition had any place in science, there would be no doubt in the researcher's mind that these Indians will survive in the face of whatever challenge they must confront.

Dr. Yu Chi Au of the Conselho Nacional de Desenvolvimento Cientifico e Tecnologico (CNPq) must be gratefully acknowledged for his patience, support, and understanding of problems foreign researchers have in Brazil. His ability to make the complex comprehendable to researchers faced with difficult bureaucratic procedures certainly marks him as an asset to that organization for which he works. In addition,

the obvious seriousness with which he approaches his work and the just as obvious commitment he has to those questions which scientists all over the world ask led to many fruitful exchanges between the researcher and him. The ideas generated during these discussions were instrumental in further refining the research project.

Sydney Possuello, Celio Horst, George Zarur, and Elizabeth Gameiro were those representatives of the Fundação Nacional do Indio (FUNAI) who facilitated the authorization process which is necessary for work among Brazilian Indians. They also strove to make the researcher's stay in Brasilia a pleasant and productive one. For this they must be acknowledged. In addition, Professor Roque de Barros Laraia of the University of Brasilia must be thanked for his assistance and support. Harold Midkiff of the Fulbright Commission in Brasilia and Pablo Barreyro, the American Consul in Brasilia, were also special sources of encouragement and practical advice.

In Cuiaba, those personnel of the Fifth District Regional Headquarters of FUNAI were always anxious to exchange ideas and information. Their dedication and professionalism were impressive, and they must be acknowledged for the help they gave to the researcher. Also in Cuiaba, Jean and Ed Barkman, Deanne and Dalton Noack, Jean and Wes Bell, Jacky Jackson, and Sheila Tremaine of the Summer Institute of Linguistics offered hospitality, assistance, and friendship to the researcher. Their generosity and kindness were extraordinary.

In the United States, many people assisted in the realization of this project. The researcher's doctoral committee provided comments,

suggestions, and critiques. Dr. Maxine Margolis, chairperson of the committee, was especially helpful. The time and concentrated effort she allocated to both the project in its formative stages and to the dissertation must be gratefully acknowledged. Dr. John Alexander must also be thanked for his patience and for the time he gave the researcher while she worked on the computer simulations. Drs. Daniel Gross, Leslie Lieberman, and Charles Wagley also provided useful comments and encouragement.

Other individuals who made suggestions and critiques include Charles Wood of the University of Florida whose understanding of demography was an enormous help, and Dorris Ragsdale and Greg Steinkraus of the New Hanover Memorial Hospital in North Carolina whose suggestions on the parasitology section were of great value. Robert Carneiro of the Museum of Natural History in New York advised the researcher on methodology. Alfredo Lopes at the Escola Superior de Agricultura de Lavras in Minas Gerais, Brazil, and Aimee Picchi at the Virginia Polytechnic Institute gave insight into soil analysis results. Robin Smith, Steve Dicks, Bob Wilson, and Marvin Smith at the University of Florida assisted in Landsat image analysis. Richard Fluck, also at the University of Florida, made many helpful suggestions on the mechanized agriculture project section of the study. Christ McCarty and Russell Bernard of the University of Florida patiently contributed time and support in the data analysis stages of the project.

The field project was funded by grants from the Fulbright-Hays Organization and from the Inter-American Foundation. Liz Veatch from the latter organization not only simplified time-consuming bureaucratic procedures but also provided a great deal of kind support.

It is clear that from this less than complete list of people who contributed to this project's realization that both the researcher and the field project have profited from the open discussion that has surrounded them during the past six years. Discussing, arguing, challenging, criticizing, and sharing have resulted in a study that is more than it would have been without the assistance of those listed above, and of many more who were not mentioned.

TABLE OF CONTENTS

Abstract of Dissertation Presented to the Graduate Council
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Doctor of Philosophy

ENERGETICS MODELING IN DEVELOPMENT EVALUATION:
THE CASE OF THE BAKAIRI INDIANS OF CENTRAL BRAZIL

By

Debra S. Picchi

August 1982

Chairperson: Maxine Margolis
Department: Anthropology

This dissertation evaluates the impact of a mechanized agriculture project on the traditional subsistence system and the health and nutritional status of the Bakairi Indians of Central Brazil. Until the present, the Bakairi depended upon slash-and-burn horticulture in the gallery forests along the rivers of their reservation. However, in 1980 the Brazilian Indian Foundation (Fundação Nacional do Indio) financed a project giving the Indians equipment, chemical fertilizers, and fuels to initiate industrial agriculture in the prairie areas of their reservation. Ecological anthropology theory is employed to describe the implications of this project. The indigenous system of production is defined within the parameters of the Bakairi reservation ecosystem. Then, the mechanized agriculture project is imposed on this system. This new subsistence system is evaluated in terms of the resulting cultural and ecological stresses and benefits.

These stresses and benefits are modeled using energy flow diagrams and energy circuit language. Interactions between the Bakairi and major components of their ecosystem are mathematically described. Then, the quantitative values of these interactions are varied over time through computer simulation. The results of these simulations indicate that reliance on only traditional subsistence methods or on traditional subsistence and limited industrial agriculture will eventually result in the the population growing exponentially, peaking, and then rapidly declining. On the other hand, increased reliance on mechanized agriculture results in exponential population growth with a higher peak which is supported by the greater amount of calories from the prairie rice fields. After the population peaks, rapid decline follows in this scenario.

CHAPTER 1
THE PROBLEM THE BAKAIRI INDIANS CONFRONT TODAY

Indians in Brazil, and indeed all over Latin America, have been subjected to assimilative pressures since the New World was discovered. In recent years, the nature of this process in Brazil has changed in that the national agency, which previously existed only to protect Indian groups, has concentrated its efforts on internal development of the individual reservations where the tribes are located. The objective of these new policies is to integrate the Indians into Brazilian society by teaching them skills that will allow them to participate in the national economy. These skills are related to the operation of high energy, or mechanized, agricultural systems. The national Indian Foundation (Fundação Nacional do Indio) argues that the Indians can utilize all the lands that they have been decreed in the form of reservations, if they are given equipment such as tractors and harvesters, as well as the know-how to run them. That is, instead of depending upon low-energy-investment subsistence methods where land is used extensively in the production process, the Indians will be able to utilize their lands intensively, producing more crops than they need, the surplus of which can be sold for cash. Once cash flows into the reservations on a regular basis, a feedback system will be generated. The Indians will put more land under intensive production in order to sell more cash crops outside of the reservation. The cash will give them the means with which to purchase more equipment for the production process as well as more consumer goods. The accumulation of consumer goods will, in turn, eventually allow life in the reservations to approximate life outside of them as cigarettes, radios, bicycles, guns, tee-shirts, and other such items become firmly entrenched in the Indians' world.

Assimilative pressures from the "outside" world are not the only forces which jeopardize the continuity of the traditional culture of Indians in Brazil today. Many groups, which have been isolated up to the twentieth century and then recently contacted, are undergoing rapid depopulation and concomitant cultural and physical deterioration (Davis 1977). These groups struggle to maintain some kind of an approximation of the only life they know as the world around them shifts. Other groups confront a different problem. They were contacted earlier, perhaps in the eighteenth or nineteenth century. Depopulation occurred prior to the twentieth century so that when the first Brazilian Indian Protection Service (Serviço Proteção aos Indios) was established during the 1920s, these groups, if they had survived, were ripe for reorientation within the new nation of which they were a part. These latter groups responded to the health and education programs offered to them by the Protection Agencies. As a result, their populations stabilized and in the latter part of the twentieth century, their numbers began to increase.

Upon recognition of this demographic trend, most social scientists and Foundation agents felt profound relief. The extinction of at least part of the aboriginal population of the lowlands had been successfully prevented. However, relief quickly gave way to anxiety as people realized that many of these groups had been placed on tiny reservations at the beginning to middle of the twentieth century when their population levels were extremely low. These reservations could not possibly support more than one or two small villages of Indians practicing traditional subsistence methods. As the possibility of population pressure on available resources in these reservations was defined, people began to cast about for solutions to the problem. The objective was, of course, to avoid a situation where the Indians, unable to make a living from their own lands, would leave their reservations and go to the cities where they would be forced to live in ghettos and to assume the most difficult kinds of life that a city has to offer.

Some social scientists and Foundation agents suggested that the population-land problem which Brazilian Indians confront could be solved by introducing the Indians to high-energy technology and methods of production. It was felt that if the small reservations that dot Brazil could be made to produce intensively, larger populations would be supported on the limited amounts of land available. Furthermore, a cash supply would enable them to purchase high-protein foods such as beans, salted beef, or even cattle herds which would supplement the reservations' animal food supply. If these production techniques could be successfully taught to the Indians, concern about indigenous migrations to the cities would be dispelled.

Like any solution to a difficult, if not impossible, problem, controversy at once surrounded the possibility of introducing non-traditional subsistence methods to Indians. On one hand, people objected to the Brazilian government funneling large amounts of money into Indian reservations. They claimed these reservations make up only a small part of Brazil, and that indigenous populations compose a disproportionally small amount of the nation's population. Why fund agricultural projects in Indian reservations when large numbers of rural Brazilians and urban poor need financial assistance even more? They also pointed out that these Indians do not know how to operate or maintain the machinery they are given. Nor do they understand seeding and fertilizers. In fact, they cannot add and subtract, or even read and write. How can they successfully participate in the national economy while they lack the most rudimentary of skills? Furthermore, why waste money on projects that are certainly doomed to failure? Instead of giving these Indian minorities special privileges, this group calls on the government to leave them to cope with the problems of poverty in the way the Brazilian poor are coping.

A second group of scientists and Indian Foundation representatives object to the government's endangering the traditional culture of the Indians. They see the initiation of mechanized agriculture on Indian reservations as the beginning of the final phase of contact which will end up only in genocide or total integration. They predict the end of Indian cultures in Brazil and call for the termination of these projects before it is too late. This group would minimize all contact between the Indian and non-Indian groups in an effort to both preserve the Indians' cultures and to prevent a disintegration of the tribal groups both as cultural units and as biological populations.

Some social scientists clearly recognize the impossibility of traveling backwards in time to a pre-contact point of history. They understand the difficulties associated with dealing with Indians who by and large greatly desire goods such as tractors and radios and who violently and jealously react when one Indian group receives an item when they do not. This subgroup also understands the dangers associated with the perceived underexploitation of Indian lands. As state and national legislators review the traditional subsistence methods of Indians, they conclude that Indians do not know how to efficiently use their lands. As a result, they are less likely to decree new Indian reservations when the rural and urban poor need the jobs these same lands could provide. As a result, the subgroup in question would like to initiate some kind of development project in the indigenous reservations; however, they advise against the implementation of mechanized agricultural projects for two main reasons.

In the first place, the world, in general, and Brazil, in particular, are undergoing an energy crisis. Products such as diesel fuel and fertilizer are subject to high inflation, and their cost in Brazil, especially, spirals upward on a weekly basis. Some see these high costs leading to the end of civilization as we now know it. They foresee the necessity of our reorienting our economies, indeed our lives, to a moderate energy, steady state strategy of existence from the high energy growth strategies that industrial nations now depend upon and that less developed countries try to emulate (Odum and Odum 1981). As nations all over the world work to accommodate themselves to this crisis and to evaluate what it means to their economies and the lives of their populations, some see the foisting of high-energy agricultural systems onto Indians as a serious miscalculation. They advise us that we are the ones that should be examining, and absorbing, lessons from indigenous, low-energy-investment, subsistence strategies. In addition, this group foresees serious problems emerging from agricultural projects on Indian lands. It is not that the implementation of a project is inimical to the Indians per se. Rather the operationalization of the projects, as well as their impact on the various aspects of the Indian culture, are problematic. Questions that are regularly raised concern the operation and maintenance of equipment, the transport and sale of crops in the distant cities, the distribution of crop surpluses in the Indian villages, etc. The list of potential problems is endless, and people fear the frustration, waste, and disruption that they are certain will ensue.

This brief outline of an enormously complex problem emphasizes the difficulties which Indians, as well as those concerned for them, are facing. The troublesome choices which have to be made coupled with attempts to minimize their deleterious effects currently plague Brazil. In order to better understand and evaluate the trends described above, it is helpful to focus on one group and examine the situation it confronts.

The Problem

The Bakairi Indians, who number 288 people, live on a small reservation in the state of Mato Grosso, central Brazil. The reservation was demarcated in the early part of the twentieth century when the indigenous population was estimated to be about 150 people or less. The Bakairi were given about 50,000 ha of land on which to subsist. Over the years, the interior of Mato Grosso, once so sparsely populated, saw a dramatic increase in its population. In the last thirty years ranchers have rapidly moved into the area surrounding the Bakairi reservation. As a result, they have been left with little maneuverability. The Indians can neither leave their traditional lands nor expand outward into the neighboring regions. The land which they now inhabit is all they have. (See Chapter 2 for further details.)

If the 50,000 ha allocated to the Indians were rich, fertile land, the situation would be a less problematic one. However, over 85 percent of the Bakairi reservation is composed of parched, unfertile _cerrado_. _Cerrado_ does not support the production of crops under the slash-and-burn methods traditionally employed by the Indians. Rather, it is used for extensive cattle raising and for some hunting. These areas can also be utilized for crop production if mechanized agricultural methods are employed. For example, on the nearby ranches, rice is grown for two or three years on the _cerrado_, and then cattle are introduced into the areas which, in time, are transformed into artificial pasture land. In contrast with the _cerrado_, gallery forest makes up under 14 percent of the reservation's land. These forests which line the rivers in the area are the location of the Indians' gardens. The soils there are rich and fertile, and the surrounding trees and vegetation provide shade from the burning sun and moisture for the growing crops. A great deal of gallery forest can be found in the vicinity of the Bakairi village. The Indians, with a great deal of foresight, made their settlement upon the banks of the Paranatinga River, a major headwater of the Tapajos River. At that particular site, the river makes a complete "S." In addition, it intersects with two other important rivers which are called the Azul and the Vermelho Rivers. As a result, the most concentrated mass of gallery forest is found there (see Chapter 3). However, the village has been located in this same site since the 1930s, and the forest around it has been used and reused several times. The Indians claim it is "tired land," and, consequently, each year they must travel farther from the village to make their gardens. In these recesses of the reservation, the forests are not so extensive as they are where the Paranatinga winds around, creating a huge reservoir of lush forest.

Land for cultivation purposes is only one problem the Indians face. Animal food supplies which provide complete proteins for the population represent a second important consideration. The Bakairi are primarily fishermen; however, they also hunt in the forests, and to some extent, on the cerrado where armadillos and anteaters are found. The most important source of fish in the region is clearly the Paranatinga River. However, a small but growing town was recently located upstream from the Bakairi reservation. In this town, the Brazilians fish with nets, inspite of the fact that they are outlawed in the state. The Indians now complain that no fish are left for them. In addition, the game in the vicinity of the village is totally hunted out, and the men must travel into the headwaters of the Azul and Kayapo Rivers to find animals. These areas are distantly located from the village, requiring the men to expend large amounts of time and energy to even find a place where hunting is viable (see Chapter 7).

Land and animal resource availability must always be discussed in relative terms. Factors which influence availability include population and technology. The Bakairi population stabilized around 1940 and since that time the Indians have been increasing in number. Although they still practice artificial population control in the form of abortion and infanticide, the natural rate of increase of the population is estimated to be 3.47 percent, and the population doubling time is 20 years (see Chapter 4). These rates are extremely high. In part, they are the result of the Indian Foundation's disease-control program which has been very successful in vaccinating the Indians and in treating them for such diseases as tuberculosis. As the population increases, more land is put under production. In addition, larger amounts of land accumulate in the nonproductive category of succession gardens where the forest is taking over, and rejuvenating, the old gardens. Population levels also affect the intensity of animal food exploitation. The amount of fish and game secured is, of course, partially dependent upon the population level.

Technology and subsistence strategies also affect resource availability. The Bakairi practice low-energy agricultural methods. They employ slash-and-burn horticulture in which they clear, and plant, small plots of land that support their households on an annual basis.

After approximately two years, they clear other plots and allow the original gardens to be taken over by the fast-growing forests. Rudimentary kinds of technology are employed. Although the men use steel axes and machetes for land clearing, digging sticks are still used for harvesting. Furthermore, no chemical fertilizers or mechanized equipment such as tractors are utilized in the production process. In hunting and fishing, some .22 rifles and lines and hooks are used. However, most men employ bows and arrows in both activities because the other types of technology are both difficult and expensive to secure (see Chapters 6 and 7).

Low-energy subsistence methods such as those employed by the Bakairi depend upon the natural ecosystem to perform most of the recycling of energy and minerals in the environment. All human populations accelerate this process to some extent; however, some groups subsidize natural ecological processes with fossil fuels in the form of pesticides, fertilizers, machinery, and fuels. Others tap into only a relatively small part of the total energy of the ecosystem and therefore they can depend upon the system itself to restabilize the components on which they impact. Yields of the ecosystem differ depending upon energy investment into the system. If human and solar energies are supplemented by machinery and high-quality energy in the agricultural process, the former are amplified by these other types of power, and agricultural yields are increased. However, if human and solar energies interact by themselves within the subsistence strategy, yields are relatively low (Odum and Odum 1981).

The Bakairi currently find themselves in a situation which is in part related to the ethnohistorical, environmental, demographic, and cultural factors outlined above. The central problem defined by these parameters is how can the Bakairi continue to survive, and grow, in their reserve using traditional modes of subsistence to provide them with adequate nutritional supplies? The traditional solution to this problem is for the village to fission. Part of the population would remain where it is now located, and part would migrate to a different section of the reservation. This would result in two or more settlements which would minimize the impact of the entire population on the ecological system. Some cultural features which characterize the Bakairi and which would facilitate this process include the following. There is an absence of any strong political leadership which could prevent the village from fissioning. A capitão, or leader who represents the Indian village to the non-Indians, does exist. However, he has no executive power and functions only to voice those decisions and questions which result from meetings of the household heads in the village. Several shamans, or curers, also live in the village. These men are very powerful in generating and channeling anxiety; however, they tend to manipulate factions in the village rather than the entire population. Furthermore, disputes over women, sex, and witchcraft accusations also characterize the functioning of the village and would facilitate fissioning. Issues that revolve around who is sleeping with whom and who cast a spell on whom cause serious conflicts which divide the village and result in a great deal of anger and long-lasting bitterness. The desire to avoid the contact and confrontations associated with meeting old enemies on a daily basis often results in a village splitting. Finally, the Bakairi unit of production and consumption is the household. An exchange of goods and labor flows between extended families; however, these small units are generally self-sufficient. Since there is little or no specialization among the Indians, no real economic need exists to unify the village.

Fissioning can be considered a traditional resource management strategy. Bakairi cultural institutions such as those discussed above make it possible and, indeed, encourage its occurrence. However, is this a viable solution for the Bakairi who do not live in an isolated or precontact state? For example, they do not have a limitless amount of land at their disposal. The location they currently inhabit is the finest in the entire reservation both in terms of the amount of land, albeit worn out, that is available to them for horticulture, and in terms of the fishing grounds in the Paranatinga River. The decision on the part of one group to leave this area and go inhabit another inferior part of the reservation would surely be problematic. Another factor which might influence their decision to fission involves the community wealth which the Indians have accumulated through their relations with the Indian Foundation. The Bakairi now have a truck and a cattle herd of about 400 head at their disposal. The Foundation technically owns these possessions; however, the Indians do have unlimited use of them. How will possessions of this kind be divided up equitably in this egalitarian society? Finally, the Indian Foundation itself actively discourages the Indians from splitting into two villages. In the 1930s they unified all the Bakairi in the reservation into one community in order to facilitate health care, education, and administrative control. The Foundation has also invested a great deal in the infrastructure which makes up the Indian post. Wells, a school, a clinic, a headquarters, and an airstrip comprise time and money spent on facilities which would be wasted if part, or all, of the Indians left their present settlement.

The traditional method of fissioning may have been put into effect if the Foundation had not moved to implement its new integrative policy in the form of mechanized agricultural projects. However, in 1980, the Foundation sent into the reservation a tractor and seeder along with fertilizers, rice, seeds, and fuels (see Chapter 8). This equipment adds to the village capital, in the form of a truck and cattle herd, which would have to be split up should the village divide. In addition, the anticipated cash flow from the sale of the rice harvests binds each and every household to the village so that it may enjoy its rightful share. Currently, despite the political conflicts and the complaints about land, game and fish shortages, few families discuss the real possibility of making a new settlement. The mechanized agricultural project, along with admonishments from the Foundation, have effectively squelched that option.

The central problem which the Bakairi confront today must be redefined. A new economic variable related to contact with non-Indians transforms the situation. The question already posed may still be asked.

The emphasis placed upon the demographic, technological, and nutritional aspects of the problem indicates it is an important subject to examine. However, the newly introduced technology and its impact upon the Bakairi must also be evaluated. In reference to this consideration, the costs and benefits of the adoption of the new technology will be examined. In terms of benefits, the nutritional and demographic aspects of the problem are given priority. For example, if it is determined that the traditional mode of subsistence cannot support the growing Bakairi population as time goes on, then the additional calories that the agricultural project provides both directly (in the form of rice) and indirectly (in the form of cash) must be evaluated. Will the supplementary energy allow the Indians to survive and to increase in numbers within the reservation beyond those levels allowed by the traditional subsistence mode? In terms of costs, the impact of the project on the economic and political organization of the community is examined. For example, will political infighting result from differential participation of the various factions in the project? How will the rice and cash be distributed in the village? How will the expenditure of time and energy on the project be allocated? Furthermore, will inflation in the Brazilian economy affect the project's chances for success? The Indians are to purchase more fuel, seeds, and fertilizer from the proceeds of the sale of the rice they harvested the previous year. If the tractor breaks down, they will be responsible for servicing it. However, as the price of equipment and high-energy products soars, the cost of rice rises steadily but does not keep up with the other goods.

Will the Bakairi be able to finance their project as the years pass, or will it fail due to those economic trends with which most countries are now trying to cope?

These are only some of the questions we can ask about the difficult situation in which the Bakairi find themselves. In defining these questions and in seeking answers to them, we hope to illuminate the complexity of the processes in operation in many of the indigenous reservations of Brazil.

Ecological Anthropology: A Theoretical Construct

A problem can be examined in several different ways. In the first place, it can be described in general terms. The situation in question is outlined as accurately as possible giving due attention to as many factors as affect the central issue. A second way to treat a problem is to focus upon certain questions and to seek the answers to them. When this occurs, a theoretical orientation is automatically implied. The resultant bias does not indicate that other theoretical constructs are not valid or meaningful. Rather, it signifies that the researcher has certain predilections or that upon reviewing the problem, it was determined that a particular theory might provide more valuable insight into the situation in question.

The problem the Bakairi, and many other indigenous groups, confront today is an important and controversial one. In order to examine, evaluate, and anticipate events that are taking place so rapidly in that area, the theoretical construct of ecological anthropology was chosen. It was selected for two reasons. In the first place, ecological anthropology assumes a systemic premise. The interrelationships between the components of the defined unit's ecological and cultural systems are stressed. In addition, the functioning of the entire system is given attention so that the model is both a dynamic, and explanatory, one. Furthermore, ecological anthropology focuses upon the relationships between human populations and their subsistence resources. This relationship is a key one in terms of the reproductive success of a group. The foci of this theory are such that its use gives important insight into the specific problem addressed by this thesis. For example, the Bakairi can be considered part of at least two different systems. In the first place, they are participants in the Brazilian cultural system. Although their links with the national society have been tenuous for many years, the Indians have had access to Brazilian towns where they have been treated for medical disorders or where they have made small purchases and sales. It has already been established that relations between the two societies, Indian and non-Indian, have been intensified now that a mechanized agricultural project has been initiated on Bakairi lands. However, the point is not that the linkages between the two societies are multiplying or that they are quantitatively different than they were in the past. Rather, the essential consideration here is that with this high-energy agricultural project, relations between the two cultural systems have qualitatively changed. That is, the subsistence base of the Bakairi is undergoing dramatic reorganization as non-Indian technologies, methods of production, and systems of labor organization are introduced to the Indians.

Flows of goods between the two systems will now play an indispensable role in Bakairi subsistence because fuel, fertilizer, and equipment parts will have to come from outside of the reservation, while rice from Indian lands must be sold in Brazilian towns in order to obtain the necessary cash for the purchase of the former items. The economic bases of the two disparate systems will become inextricably linked as time goes on.

The Bakairi are also part of another system. The reservation with its rivers, forests, and cerrado makes up an ecological system of which the indigenous population is an integral part. The animal, fish, and human populations interact together in a community where they all impact upon each other. In addition, each of these "consumers" interacts with the forests or the rivers or the prairies, or all three, as they subsist and reproduce within the huge and vital energy web they inhabit. If the Bakairi are defined as a population within an ecosystem, the introduction of the high-energy agriculture project represents a disturbance or perturbation in this system. The energy links between the living population and the producing subsystems in the overall ecosystem are transformed much in the same way that they were between the two cultural systems in question. Not only do quantitative differences immediately emerge in that energy and time expenditures into the forest-related subsistence activities may decrease, but new links between the Bakairi population and other parts of the ecological system are forged. For example, mechanized agriculture takes place in the cerrado where no crops have ever been grown by the Indians. With the project, the Bakairi began to set up an important energy relation with this part of their environment. Labor was expended upon that subsystem and energy yields in the form of rice were derived.

Ecological anthropology illuminates the Bakairi's problems of resource exploitation and management in a systemic and functional manner. In addition, it calls for the collection of data that can be quantified, analyzed, and presented to such organizations as the Indian Foundation for use in planning and evaluation. In the past, the complaints of this Foundation about anthropological research have centered on its esoteric nature. The Foundation personnel accuse anthropologists of providing them with information on kinship, mythology, and cognition which is interesting and useful for only those field representatives who have direct contact with Indians on a daily basis. However, few facts, as the Foundation defines them, are made available to those who work in the regional and national headquarters where policy originates. This is unfortunate because headquarters' policy formation, and not field representative feedback, initiates important changes, such as agricultural projects, in the indigenous reservations. The ecological anthropology approach provides data that Foundation personnel can examine and employ in developing their culture change programs and in evaluating these programs at a later date.

Ecological anthropology, as opposed to cultural ecology, was first defined by Vayda and Rappaport in 1968. In their seminal article, they called for a more unified approach in the study of the interrelations between living organisms and their environment. They criticized cultural ecology for isolating itself from general ecology and for restricting its studies to the examination of cultural factors. Vayda and Rappaport do not advise us to omit cultural institutions from consideration. However, they do establish the necessity for the analysis of the relationship between cultural traits and the balance between human populations and their subsistence resources. In their methodological statement, a tripartite operation is outlined. First, a unit of study is chosen. This unit can be a group of organisms sharing the same area, a community or a group of populations, or an entire ecosystem. If an ecosystem is defined as the unit under investigation, the relations between the living and the nonliving environment are examined. Those plants, animals, minerals, and nutrients which compose a food web, and which affect each other's chances for survival, are studied (Hardesty 1977:14).

Once a unit of study is defined, the capture of energy from, and the exchange of material with, the diverse components of the units are described in quantitative terms. The emphasis placed on energy exchange by Vayda and Rappaport is now considered problematic. For example, Hardesty agrees that many ecological problems can be understood by reducing the exchange of energy and matter between systemic components to a common denominator, such as calories. However, at the same time, other kinds of problems can be obfuscated by this same method (Hardesty 1977:65, 74). For example, living organisms tend to require energy in particular forms. Proteins, fats, carbohydrates, as well as certain kinds of minerals and vitamins can occur in limited amounts, thus restricting the exchange of energy within the ecosystem. Little and Morren add that a misconception has evolved from the adoption of this method due to the fact that much research has assumed that the task of subsistence systems is to cope with the problem of limited availability of nutritional energy (Little and Morren 1976:20). They contend that work by researchers such as Carneiro (1968) and Sahlins (1972) indicates that nutrition is not necessarily a limiting factor. Rather, utilization of available energy is controlled by a population's resource management strategies which act to maintain the flow of energy necessary for life support within that system (Little and Morren 1976:23).

Hardesty's point concerning the kinds of energy needed to maintain life is an important one. In addition, it is eminently applicable to studies in the lowland areas of South American where research has determined that calorie acquisition is not a serious problem but where adequate amounts of protein are thought to be more difficult to obtain (Gross 1975; Lathrap 1968; Denevan 1966). On the other hand, Little and Morren's contention that systemic strategies exist to prevent nutritional limiting factors from ever emerging makes the a priori assumption that a system actually controls those limiting factors which have an impact upon it. That is, they state that any natural system through which energy flows tends to change until a stable adjustment, with self-regulating mechanisms, is achieved (Little and Morren 1976:15). They put forth a hierarchy of responses available to living organisms subject to ecological stresses. These responses, originally outlined by Slobodkin (1968), assume that populations respond to limiting factors in the least costly way. Initially, behavioral reactions are employed. However, if these are not effective, in terms of enhancing or even maintaining reproductive success, then physiological adjustments are developed to cope with the perturbation. Finally, the most costly response, in energetics terms, is relied upon. Genetic adaptation, the slowest of the mechanisms available to organisms, comes into play. Recent research indicates that all three types of responses to a perturbation can occur simultaneously in a population.

Little and Morren are addressing two completely different problems here: that of the homeostatic responses of a system to a perturbation and that of a population's adjustment to stress in its environment. Their conceptualization of the latter is most certainly accurate as demonstrated by Baker and Little's (1976) study of the Andean Quechua and their behavioral and physiological adjustments as well as their genetic adaptations to high-altitude stress. However, with regard to the former topic, an ecosystem is not a population, nor even a community of populations. Nor can the responses of a population to a disturbance be assumed to apply to a system. Although Odum (1969) put forth a controversial model of ecosystems as characterized by "perturbation-resistant" features, little empirical data exist to support this contention (Richerson 1977:11).

Little and Morren's statement that an ecosystem adjusts to those flows of energy within it until they are regulated, thus negating the impact of any type of limiting factor on the overall system implies what Richerson calls the "fallacy of misplaced teleology" (Richerson

1977:4). Richerson posits that researchers such as Vayda and Rappaport (and Little and Morren we might add) assume teleological explanations for processes at inappropriate levels. That is, goal-oriented processes do not necessarily operate at all levels of biological organization. Natural selection, a particularly creative but costly form of adjustment, occurs at the base of the biological hierarchy. It operates at the individual level and, in turn, impacts on the population level as organisms maximize their genetic contribution to the population's gene pool. Teleological causation may clearly be assumed to exist here. However, those complex processes which occur in the higher levels of biological organization, such as in the population or ecosystem, are not necessarily related to any kind of goal-oriented behavior on the part of the population or system. Richerson suggests that such phenomena may be the result of the interaction between individuals in a population or between diverse populations in a community.

The complaint that some ecological researchers tend to erroneously assume the occurrence of teleological processes at the population, community, or ecosystem levels illustrates the point that both the social and biological sciences are currently confronting the same problem. How can one link the study of individual organisms, and the problem of natural selection, with the study of ecosystems? Richerson suggests that the study of ecological systems can be accomplished through the documentation of the complex phenomena which characterize them as well as through the functional analysis of the components which make up the system. Cultures, within an ecological context, can be subjected to a similar kind of investigation. At a later date, as theory improves at lower levels in the biological hierarchy, a linkup between the two areas may occur (Richerson 1977:21).

To return to Vayda and Rappaport's tripartite method of accomplishing an ecological anthropology study, the final phase of a piece of research consists of examining the cultural traits of a population in terms of their role in maintaining that group, or its flora-fauna resources, within an adaptive range. Due to the fact that anthropologists specialize in the study of culture, most of the critiques leveled against Vayda and Rappaport pertain to this statement. Three major criticisms can be discussed. The first one regards the concept of homeostasis, which in fact pertains to some of the systemic characteristics already discussed above. For instance, Brush (1975) contends that the ecological anthropology paradigm assumes that cultural institutions can be understood in terms of their homeostatic functions. That is, certain cultural features regulate population levels so that the carrying capacity of the ecosystem is not overreached, and land degradation is avoided (Brush 1975:804). Brush asks how culture change and cultural evolution can possibly be incorporated into this model since homeostasis is obviously favored. He claims that an a priori assumption is made by the paradigm. This assumption is that change is "maladaptive" while equilibrium is "adaptive." If this is true, then the model is reduced to a functional description which may be interesting, but not very important as an explanatory device (Brush 1975:804). On the other hand, Holling (1973) works from Odum's (1969) problematic premise that systems exhibit their own teleological behavior. He proposes a refinement for the ecological paradigm suggesting that two types of processes regulate the functioning of any system. The first is of a homeostatic nature. The system is kept in equilibrium so that uneven fluctuations of energy do not occur. The second kind of process concerns those that prevent the system from self-destructing and ensure its survival through time. These operations provide resilience for the system, and are characterized by a type of "fine-tuning" in response to the discordant factors which enter, and disturb, the system. Although Holling's refinement does answer Brush's criticism in that it provides for the incorporation of change, and evolution, it is best reserved for application to cultural systems rather than to ecological ones. The former are more responsive to behavioral adjustments which may take place in comparatively short spans of time, while the latter are so complex and so interrelated on a planetary basis that they are still poorly understood.

A second major criticism directed at the ecological paradigm concerns its emphasis upon rising population levels. Hardesty (1977) and Cowgill (1975) take issue with the assumption, originally put forth by Boserup (1965) that population growth is an inherent tendency in human populations. Boserup and the advocates of her theory posit that population growth is not a dependent variable controlled by agricultural productivity. Rather, increases in population are seen as a constant or an independent variable which in turn is a major factor in stimulating technological innovation (1965:11). Hardesty and Cowgill argue that the defintion of population growth as an independent variable dangerously simplifies a complex issue. They advise us to consider this factor as part of a set of variables which may include technology, environment, politics, economics, and other cultural institutions. According to Cowgill, all of these factors interact with each other in the definition of a cultural situation.

This theoretical question will be dealt with in more detail in Chapter 4. However, it should be established as a premise of this thesis that the Bakairi population is growing in size. This factor in combination with the technology employed by the indigenous group as well as the nature of the environment they inhabit has created a problematic situation. If Cowgill and Hardesty are correct, it is not useful to define one of these three variables as being more important than the other two. Indeed, they would have us include even more factors as critical considerations in the problem. However, if their advice is followed, we are left with an amorphous set of circumstances where everything, and nothing, is important to the problem we address. Rather than weighting each variable equally, emphasis will be placed on the economic base of the Bakairi in order to illuminate the technological and economic features which interact most closely with the ecological system (Harris 1979a). In doing so, a refined version of Boserup's theory is adopted. The premise of this version states that potential growth in human populations creates a continuing tension between populations and their food resources (Roosevelt 1980:73). Where environmental conditions allow, technological innovations, or adoptions as in the case of the Bakairi, will result from population pressure on strategic resources. A correlate is that when technoenvironmental conditions discourage the intensification of subsistence strategies, a variety of artificial population control mechanisms will restrict population growth. We shall see that these two processes can operate simultaneously.

The issue of population growth leads directly to the third and final area of contention surrounding the Vayda and Rappaport methodology, that of the concept of carrying capacity. Carrying capacity is defined as the theoretical limit to which a population can grow and still be supported by the environment. This theoretical construct is a very controversial one. It involves not only the assumption that population growth is an inherent human tendency but that environmental degradation, as well as technological exploitation of the environment in question, is absolute. Street (1969), Johnson (1974), and Sahlins (1972) argue that environmental degradation is difficult to define because it is a gradual and subtle process. They contend that anthropologists can rarely collect those sequences of data which would allow for the long-term assessment of the impact of a population on its environment. Johnson adds that it is possible that no such limit of threshold even exists but that the costs of subsistence gradually increase over time. Morren (1974) and Nietschman (1972) also consciously avoid the use of the concept of carrying capacity. They claim it does not take into consideration the importance of other scarce resources such as protein and is, thus, an inaccurate means for evaluating the presence of limiting factors.

The technology factor is also problematic. Street (1969) claims that the means of production employed by a population are not always readily identifiable. Groups are able to rapidly adopt new crops, tools, and techniques, thus automatically changing the definition of their carrying capacity. Furthermore, the subsistence data which are necessary for the definition of an area's carrying capacity are infrequently forthcoming in the field situation. Defining precisely how a people makes its living in terms of exploiting the huge variety of parts of its environment is extremely difficult. Brush (1975) adds that researchers are automatically forced to define a partial system selecting key components with which the population interacts most frequently. A researcher may approximate reality; however, the necessary selectivity skews the results of the study.

In 1976 and 1975, Vayda and Vayda and McCay provided some responses to those questions posed by their critics. However, in the process it is clear that their position on ecological anthropology has been redefined over the years. Their focus on the balance between populations and resources has shifted over to an examination of ecological perturbations or hazards and how they affect a group's survival. Equilibrium is no longer the issue. Rather the concept of change, and a system's response to it, have been incorporated into the study of homeostasis. Resilience and flexibility are key words applied to the adjustments a system makes in order to persist through time. Furthermore, the flow of energy is only one of the many possible problems which may affect a group's survival. Flooding, predation, water shortages, etc., are other hazards or stresses. Finally, Vayda (1976) goes so far as to disagree that carrying capacity is central to ecological anthropology. He contends that the analysis of how people respond to specific environmental problems can be accomplished without the calculations of carrying capacity.

Vayda's (1976) arguments clearly indicate that he has moved closer to a general ecological position. Although he continues to assume that societies, and populations, are involved in goal-oriented behavior and thus may still be accused of misapplying this biological model, those ecological factors which influence behavior are more numerous. Furthermore, the possible responses to these variables are conceptualized as being more labile and situational. Ecological anthropology no longer relies on the concept of carrying capacity. Rather the definition of a system, its components, the links between them, and the limiting factors or perturbations are more broadly and realistically interpreted.

The new ecological anthropology paradigm is eminently suitable for application to the Bakairi problem. The adoption of new technology and the opening of an entirely different part of their ecosystem for exploitation would call for a dramatic redefinition of their carrying capacity if this concept were going to be employed. Rather than focus upon that aspect of the construct, it would be more fruitful to view the high energy agriculture methods as a perturbation to which the Indian population will respond within a set of technological, ecological, and demographic parameters.

Methodology

The problem the Bakairi Indians confront has been defined. In addition, the theoretical construct employed to frame questions and to search for answers has also been discussed. In order to organize and analyze collected data and to draw pertinent conclusions about them, a computer simulation model will be employed. Upon cursory examination, it may appear that the use of computer simulation in anthropology is inappropriate. A reliance on equations, computer languages, and models which graphically represent a specific cultural reality seems to conflict with the anthropological position where the individual or society as a culture-carrying entity is stressed. It can be argued that this particular methodology represents reductionism to the extreme. However, if the problem is more closely examined, the apparent dichotomy between the two orientations disappears. For example, Dyke (1981) argues that all human perceptions of the world are selective. Cognitive processes create an abstract and simplified version of reality which is formalized into models used in the scientific method. This method devises reproductions of the real world which are unambiguous and replicable, and which have as few assumptions as possible. Computer simulation models are only one kind of scientific model which reduce the world to a set of specific attributes. In the necessary process of reductionism which accompanies the formation of any model certain limitations are built into the system from its inception. However, at the same time, the model is tailored to fit the problem in question, and the data used in the formation process are empirical. Thus, the simulations which result are considered approximations of the particular reality under examination.

In addition, each energy flow diagram is culture specific. That is, the components, and the links between them, are defined by the relationships between the particular culture in question and its environment. In the case of the Bakairi, who are horticulturalists, a close relationship between the gardens and the population exists. They are both represented in the diagram. Since the Indians employ slash-and-burn technology, gallery forest and succession gardens are also represented and connected directly or indirectly to each other in the model. The Indians also rely on both hunting and fishing for protein and calories so that the population energy tank is connected to the fish and game variables in the diagram. However, if the Bakairi were hunters and gatherers, the energetics diagram devised to represent their system would be completely different. For example, no garden or succession garden variable would be modeled. The Indian population would be linked directly to the forest, and those flows of energy between the two state variables would represent only hunting and collecting. If the Bakairi were horticultural fishermen and did not exploit game, then the hunting link between them and the forest would be eliminated.

The energetics diagram also reflects the social organization of the Indians to a certain extent. For example, the Bakairi are egalitarian. They do not have social classes as do state societies where a clear distinction exists between people on the basis of access to the means of production or an unequal distribution of wealth. Nor do they have moieties, age grades, or defined ritual groups as do certain Ge Indian societies. Due to the relative simplicity of Bakairi social organization, the Indians can be lumped into one state variable which is designated as the population. However, if social classes or moieties did exist in their culture, the population tank would be divided into subtanks representing the various social groupings. If class differences existed, unequal amounts of energy would flow into the subtanks. If ritual groups characterized their society, the nature of the relation between these subtanks would be diagrammed. For example, Wagley (1978) states that if the number of Tapirape Indians in a village falls below approximately 200 individuals, ritual activities cease to be held. The functioning of rituals is related to the representation of various ritual groups. Complete representation is, of course, culturally defined and would have to be diagrammed if a model of the Tapirape system were to be constructed.

The outlines of an energetics diagram are not only determined by the subsistence activities and social organization of a particular society. They also reflect the nature of the ecosystem which the society inhabits. For example, the Bakairi live in a reservation which is composed of mostly cerrado, or prairie. A small part of the land area is covered by gallery forest and rivers. Relative proportions of vegetation and the distinct fauna which are endemic to these vegetation types are determined and then incorporated into the model. Other Indian groups do not live on legally demarcated reservations. In these cases, the researcher employing the computer simulation method will have to determine the size of the territory within which the Indian groups subsist. Vegetation and fauna biomass will also surely differ. For example, some groups inhabit areas which are covered by tropical rain-forest. Others will inhabit desert regions and still others will occupy tundra. The actual composition of the ecosystem will differ, just as the subsistence methods and social organization will distinguish one model from another.

Finally, the perturbation introduced into the system will differ cross-culturally. The Bakairi are currently confronting the implementation of a mechanized agriculture project. However, other groups are coping with land invasions, epidemics, flooding, and reduced game and/or fish resources. The specific stress with which the indigenous population contends is modeled and then incorporated into the model at the appropriate position. In that way, the impact of the perturbation on the entire system can be evaluated.

We have established that computer simulation models are not inimical to anthropology. They reflect the specific culture under study as well as the interactions which exist between it and its environment. However, energetics diagramming is not only compatible with anthropology. Rather it can make a significant contribution to the field on a number of different levels. In general terms, modeling as an analytical tool clarifies such key processes as cultural adjustment in the face of change. Both the structures of the cultural and ecological systems, as well as their functions, are considered in the construction of the model. The dynamic variable, or change in the generic sense, is introduced and its impact, over time, is evaluated. Structure, function, cultural adjustment and change have been important issues in anthropology for many decades. Energetics diagramming allows for a more precise definition and a clear, graphic representation of these terms for the particular culture in question. It forces the researcher to focus on components of a system, their functions, and their interactions. Furthermore, this tool facilitates the incorporation of the diachronic aspect. In simulating the effects of a disturbance on a cultural and ecological system, the researcher is able to make certain predictions about the nature of this disturbance's impact on the various components of the system. Computer simulation cannot foresee cultural innovations and/or natural disasters unless they are initially modeled into the diagram. However, it can alert the researcher to certain dangers which the population will confront unless steps are taken to alleviate particular stresses. In the case of the indigenous groups which inhabit Brazil, the researcher can call the attention of the Indian Foundation to these potential problems so that they can be dealt with prior to their actual occurrence. In doing so, not only will structure, function, and change be better understood on a theoretical level, but human suffering may well be prevented.

Computer simulation and energetics diagramming do not only have general applicability in anthropology. They also have specific relevance to ecological anthropology. The thrust of their contribution lies in the emphasis placed by both constructs on subsistence resources and their relation to the human population which depends upon them.

Not only do they focus on the composition of ecosystems and the interactions which define their functioning, but they both consider disturbances of these systems. The dynamic and the diachronic perspectives are thus central to ecological anthropology and to energetics diagramming. However, computer simulation provides the means whereby these two factors can be better understood. While ecological anthropology may suggest that certain changes will take place in the future as the result of a particular perturbation, computer simulations, based on mathematical descriptions of components and interactions between them, can more precisely demonstrate how and why they occur, and when they might take place. Furthermore, during simulation, equations for each component in the diagram are simultaneously solved. This allows for the impact of any one perturbation on each of the componential units to be evaluated. While the researcher may be investigating one particular problem, computer simulation results will call his or her attention to other aspects of the system which are unexpectedly affected by the disturbance. This is a significant contribution in that simulations provide an objective and holistic framework that the researcher can refer to and then compare to reality.

Since the early 1960s, modeling has become increasingly popular so that two types of computer simulation models can now be defined. The first type is referred to as a theoretical model. It provides insight into the organization and operation of a system (Wiegert 1975: 313). The second type of model is called an empirical model. It does not attempt to explain the functioning of a system. Rather, it reproduces the behavior of the system under a variety of conditions. The original model is formulated upon the basis of data collected directly from the system. Parameters are set by the data, and a series of simulations is run according to the occurrence of specified perturbations which may affect the components of the model. These models are designed with the sole purpose of providing information on the possible behavior of the variables within defined parameters (Weigert 1975:313, 329). For example, the Bakairi's place in the ecosystem can be modeled. Those interactions which characterize the population's relations to its environment are described and quantified. The mechanized agriculture project is then diagrammed and overlaid upon this traditional subsistence pattern. The impact of the high-energy project is evaluated as its functioning is simulated for five, or twenty, years. However, if a small factory is built on Bakairi lands in the year 2000, this new perturbation must be modeled because the existent parameters do not automatically anticipate its occurrence.

The construction of any computer simulation model consists of several steps (Wiegert 1975:315-330). The first step is to perform an ecological survey in which the biotic and abiotic units of the ecosystem are described. Then, state variables, which are symbols that represent these components of the ecosystem, are chosen. The presence or absence of a variable in the model will reflect the importance of it to the problem. This process of survey and description is necessarily selective. In the second step, the model is condensed. Again, the issue under investigation will determine which parts of the model are developed with greater detail and which sections are streamlined. For example, in order to understand the effects of mechanized agriculture, it is not necessary to model in detail the termite population of the reservation.

The mathematical description of the componential interactions then follows. This is the most controversial step in the construction of a model mainly because of the paucity of data which exist on any one aspect of an ecosystem. In the case of the Bakairi, the researcher relied upon two different kinds of data. Primary data were collected over a 15-month period at P.I. Bakairi. The research documented the amount of energy expended by the population over a year's period as well as that energy produced and consumed by the group. The types of energy expenditures on which the researcher focused included gardening, fishing, hunting, and cattle raising, as well as that energy expended working on the agricultural project. The types of energy produced and consumed included game, fish, slaughtered cattle, garden products, purchased foodstuff, and rice from the project. Those specific methodologies associated with each kind of data collection are discussed in the appropriate chapters of this study. In addition to the primary data relied upon, the researcher also depended upon the literature in order to document those flows of energy through the various subecosystems which are described in Chapter 3.

The core of this study documents these three methodological steps. Each chapter addressed a different part of the Bakairi's ecosystem as well as their interaction with it. The areas are surveyed and described. Then state variables are chosen to represent the units in the system. Finally, the variables and the interactions between them are mathematically described.

Following the actual composition and evaluation of the model, equations which characterize the interactions between the components are written. Either linear or nonlinear equations can be used. In this case, nonlinear equations are relied upon because they more closely approximate the dynamic and continuous processes which characterize an ecosystem. A computer is then chosen. The choice between an analog or digital computer is usually made on the basis of availability. Although analog computers allow for rapid operator-machine interactions, digital computers with interactive terminals are increasingly available to the public. Furthermore, unit costs of using them are decreasing rapidly. For these two reasons, a digital computer was used in this project. A simulation language must also be selected. Mathematical statements describing the interactions between the components of the ecosystem are written in appropriate computer language. Many computer languages are available to researchers. FORTRAN and BASIC are two popular ones. However, DYNAMO was chosen over them. This language is able to translate and run models which are described in nonlinear or differential equations. It can be used by those who are "problem" rather than "computer" oriented (Pugh 1976:1). Furthermore, it has the added advantage of marking errors for the researcher. The above three steps are included in Appendix 1 where the interactional equations are rewritten in DYNAMO. Other interested parties can thus manipulate these equations to run their own scenarios if they desire.

The last step in constructing a model consists of validation. In empirical models, the simulation results are reviewed and compared to what is considered an accurate range. Validation may also be accomplished by returning to the field at a later date and collecting data which will indicate whether the predictions made in the simulations are indeed accurate. Many possible problems may emerge here. For example, the researcher may have inaccurately described the interaction between the Bakairi population and a part of the ecosystem. Exploitation of an area may have been under or overestimated. Furthermore, unforeseen developments which may interfere with the processes described by the model may evolve. For example, there is the possibility of invasion of Indian lands by the non-Indians. This is a frequent occurrence in Brazilian indigenous lands, and it would, of course, affect the mechanics of the model. Land available for exploitation would be effectively reduced.

In this chapter, the problem confronting the Bakairi Indians of Mato Grosso is outlined and explained, and the theoretical construct is discussed. Ecological anthropology was chosen because it concentrates, in a systemic manner, upon the relations between a population and its strategic resources. However, other cultural institutions may also be important. Rappaport's (1968) study of the Tsembaga of New Guinea demonstrates the importance of religion in the adaptation of a population to its environment. Finally, the methodology used in the research project is explained. The Bakairi are modeled within their ecosystem, and computer simulations allow for the introduction of mechanized agriculture as a perturbation as well as for the assessment of its impact on both the indigenous population and the ecosystem.

CHAPTER 2
BAKAIRI ETHNOHISTORY

The Bakairi Indians are a Carib-speaking group who are currently located in central Brazil (see Figure 2-1). They inhabit two reservations which lie approximately 300 km from each other. These reservations are called P.I. Santana and P.I. Bakairi. The latter was previously referred to as P.I. Simões Lopes; however, it has recently been renamed. The Indians in these reservations share a common language, although certain dialectical differences exist. They also share a common subsistence base; however, those Bakairi in P.I. Santana are oriented toward cattle raising and an extractive economy, and those in P.I. Bakairi depend more upon subsistence horticulture. Furthermore, they share a common history up to a point. However, as in the case of language and subsistence, differences emerge upon closer examination. In this chapter, the ethnohistory of the Bakairi who live at P.I. Bakairi will be investigated. To a certain extent, their history is, in fact, the history of Mato Grosso, the state in which they live. However, long periods of isolation coupled with at least two major migrations set them off from both the Indians at P.I. Santana and from their compatriots in Mato Grosso.

The Colonial Period and the Contact of the Bakairi (1700-1820)

The region now known as Mato Grosso was initially part of the Spanish empire. Jesuits moving north and west from Paraguay created

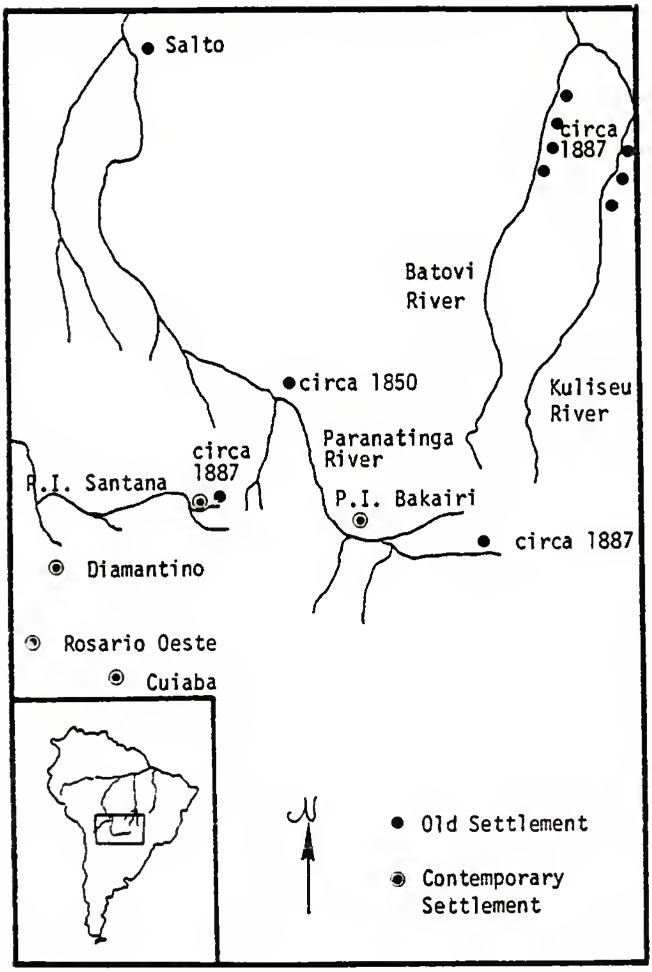


Figure 2-1. Bakairi settlements in central Brazil

the first settlements during the seventeenth century. From these areas, _bandeirantes paulistas_, or Portuguese explorers, radiated outward into the hinterlands in search of slaves, gold, and precious stones. In 1718, Antonio Pires de Campos and Pascoal Moreira Cabral penetrated the Coxipo-Mirim area where Cuiaba, the capital of Mato Grosso, is now located. Near Coxipo, gold was discovered. This news stimulated a gold rush of such magnitude that by 1728, the Portuguese governor of São Paulo established jurisdiction over the area in both an attempt to counter Spanish influence and to control the flow of gold.

The occupation of the territory proceeded rapidly. It was discovered that Mato Grosso could be reached from the Amazon River through the interior river systems which added to the ease with which the population grew. By 1748, only 30 years after the discovery of gold in Coxipo, the first Portuguese governor, Antonio Rolim de Moura, had arrived and established a seat on the banks of the Guapore River. From this administrative center, he tried to stabilize the region which by then had a population of about 40,000 people. During the next 70 years, the general area was characterized by demographic fluctuations, mineral exploitation, and open armed conflict between the Spanish and the Portuguese. However, by 1819, Mato Grosso entered into a period of decline. A mineral company created by the governor to develop the best possible mining techniques did not have the desired effects. Furthermore, military, civil, and ecclesiastic expenses rose. As a result, the government went into debt, and the population ceased to grow. In fact, by 1819, the population was estimated to be only 29,801 with 10,948 slaves.

During the initial occupation of the Mato Grosso region, the Bakairi are thought to have inhabited the general area between the Arinos River on the west, the Kuliseu River on the east, the Paranatinga on the south, and the elevated areas of the headwaters of the Verde River in the north (see Figure 2-1). It is difficult to pinpoint when contact between the Bakairi and the non-Indians occurred. However, the first recorded contact took place in 1723, when Antonio Pires de Campos met with the Indians on his way to gold mines located in the general vicinity (Campos 1862). In his report to the governor, he described the "Bacayris" as being located in the headwaters of the Amazon River, which was then referred to as the Maranhão. He also discusses their condition to some extent, explaining that the Indians were being abused by the bandeirantes who were in search of slaves. Campos's report was substantiated by the findings of Manoel Rodrigues Torres (1738) who mentions the Bakairi along with other Indian groups such as the Kayabi and Parecis, as being a possible threat to the governor's power. Apparently, by 1738, the Indians were still numerous enough to pose a danger to the still fragile Portuguese infrastructure. In addition, the treatment they had received in the hands of the non-Indian had not motivated them to establish an alliance with the Portuguese.

When further exploration of the region demonstrated the link between Mato Grosso, the Amazon River, and the Atlantic Ocean, the Bakairi became increasingly vulnerable to the influx of people who traveled up and down the Arinos and Paranatinga Rivers near which the Indians were located. These explorers and miners in search of slaves and minerals appeared in ever greater numbers.

Von den Steinen (1940) hypothesizes that an early as the eighteenth century, the Bakairi were living in two different locations. One group, the western Bakairi, occupied the headwaters of the Arinos River around which P.I. Santana is now located. This group was permanently contacted before the eastern Bakairi as the result of the radiation of miners from Diamantino, a village which was settled southwest of the already designated Bakairi territory in about 1745. However, contact with the eastern Bakairi on the Paranatinga River, on which P.I. Bakairi is now located, soon followed. In the mid-nineteenth century, a village for the eastern Bakairi was founded by a Portuguese man named Correia. This Indian settlement was made further downstream on the river than it is today. Correia used force or enticement to settle the Indians in this strategic area, which was located between the legendary gold mines of Martirios and the more heavily populated south. As a result, expeditions traveling through the area were able to use Bakairi canoes to cross the Paranatinga River.

During the Colonial Period, from the late seventeenth century to the early nineteenth century, the Bakairi were located in what is now the central part of Mato Grosso. They were initially contacted by miners and explorers who settled in the area as a result of the gold rush which began around 1718. Von den Steinen (1940) hypothesized that even then the Bakairi were divided into an eastern and a western group. The eastern group, settled on the Paranatinga River, were permanently contacted later than the western group. However, both were forced to come to terms with the non-Indians who penetrated the region. It is possible they were abused and/or used as slaves in the gold mines located in the area. It is certain that the non-Indians used them to serve their purposes as the Correia case demonstrates. Population figures for the Bakairi during the Colonial period are impossible to establish. We can only guess that initially they were more numerous than they are now. However, disease and assimilation probably decimated their population prior to the mid-nineteenth century.

Further Contact and Two Migrations (1820-1920)

Between 1820 and 1920, the economic base of Mato Grosso underwent a transformation. Gold mining declined in importance until, in 1844, even Diamantino's mines were exhausted. However, a new enterprise, cattle raising, replaced mining. Huge ranches emerged, and pasture lands reached even the headwaters of the Paranatinga River. At that time, the cattle were slaughtered in Diamantino and Rosario Oeste. This economic activity declined in importance toward the end of the nineteenth century. When von den Steinen (1940) passed through the area around 1885, he commented on the number of abandoned ranches.

At the same time, the Bakairi were being converted, after a fashion, to Christianity. In 1820, the famous Padre Lopes left Diamantino and traveled up the Arinos River. He was in search of gold, but along the way, he catechized as many Indians as he could. The Bakairi were only one of the groups subjected to Padre Lopes, and as a result, they went to war. During the violent confrontations that followed, many Bakairi were killed. However, after this period, during which the Indians were defeated, the Bakairi were considered Christian.

In fact, the first Bakairi baptism took place in Diamantino, and by 1849, the western Bakairi, at least, were selling artifacts in the town (von den Steinen 1940; Castelnau 1949).

Up to this point in our discussion, we have been able to lump the Bakairi into one group, commenting on only some of the superficial differences that distinguish their histories. However, now their development diverged in dramatically different ways. The western Bakairi on the Arinos River were absorbed into the cattle-raising economy as it spread east from the Diamantino-Rosario Oeste-Cuiaba triangle of settlements. They were considered Christians, worked on the ranches, and made and sold artifacts for cash in the cities. At least some of these Bakairi spoke Portuguese and used Brazilian names. When von den Steinen passed through Cuiaba in 1887, he met some western Bakairi in town selling rubber that they had extracted in their territory. They were from a settlement on the Arinos River. Six houses, two of the traditional elliptical style and four of the new wattle-and-daub style, made up the village. There were only 55 Indians living there, and 20 of them were children. During the twentieth century, the western Bakairi continued their participation in the Mato Grosso economy. They worked on ranches until they were expulsed in 1973 after conflicts between the ranch management and the Indians occurred. In addition, they extensively exploited the rubber in their territory, traveling frequently to nearby towns to sell it. Finally, they cultivated subsistence plots where they grew such staples as manioc and corn. They also hunted and fished.

Today, the western Bakairi live at P.I. Santana. Their population is estimated to be approximately 120. They have a school, and an

Indian Foundation agent lives with them on their lands which were officially demarcated in 1905. They were awarded a reservation made up of only 9,000 ha. Currently, they share this land with a rubber collecting firm, based in Cuiaba. The Indian Foundation is negotiating to have the firm removed; however, the various claims involved are complex, and the issue is not expected to be resolved in the near future.

The history of the so-called eastern Bakairi contrasts with that of the western Bakairi. In the first place, the two groups divided some time in the late eighteenth century, and perhaps even earlier. A group of Bakairi traveled northeast, up into the headwaters of the Xingu River, where they settled on the banks of the Batovi and Kuliseu Rivers. The reasons for this migration, as well as the way in which it took place, have now entered the realm of mythology for the Indians. We will probably never know for certain when or why they moved; however, a combination of non-Indian and other Indian population pressures, along with political infighting among the eastern Bakairi themselves probably lay at the root of the problem. The story that the eastern Bakairi tell is as follows. At one time, they lived at the Salto, or waterfall, where the Paranatinga and Verde Rivers flow close together. They lived there before the non-Indian penetrated the area. However, then the people began to plot against one another. As a result, one group decided to go on a long hunting trip. But what they actually did was travel to the headwater of the Xingu River where they cleared a large garden. After it was burned, they returned to the Salto where they kept their plans a secret going about their garden clearing, burning, and planting in that location in the usual fashion. After a few months had elapsed, they traveled once more to the Xingu where they planted corn and manioc in their new garden. Then they returned to the Salto to harvest the crops they had planted in their old village. When the harvests were completed, they packed up all of their belongings, which included only hammocks, fishing gear, and bows and arrows, and they traveled for the third and last time to the Xingu headwaters. There they remained. It was only after several years had passed that the other Bakairi who had remained at the Salto realized how they had been tricked (Barros 1977).

This legend raises a number of questions. For example, were the Bakairi in the Salto the same as those Indians known as the eastern Bakairi who later inhabited the Paranatinga River area? This interpretation would presuppose that the eastern and western Bakairi divided prior to the split between the former group and the Xingo-bound group. Or were the Indians at the Salto the eastern and western Bakairi combined? This would indicate that the remaining Indians split again after the Xinguano Bakairi departed. One group would have gone to the Arinos, where they were later contacted first by the non-Indians, while the second group went to the Paranatinga River. Von den Steinen (1940) suspects that the division of the eastern and western Bakairi preceded the splintering of the Xinguano Bakairi off from the eastern Bakairi. He posits that the eastern Bakairi had actually begun to move up the Paranatinga River before the fissioning process began. He supplies linguistic data to support this supposition. The eastern and western Bakairi speak the same language with little dialectical variation. The dialectical similarities indicate that the two groups separated fairly recently. Furthermore, von den Steinen (1940) was certain that the Xinguano Bakairi had had absolutely no contact with non-Indians prior to his visit to the area in 1884. His contention was supported by the fact that all their tools were of stone, rather than metal. This indicates that the Xinguano Bakairi split off from the eastern Bakairi before the non-Indians had penetrated as far as the Paranatinga River. This probably occurred after 1723, when Campos wrote of the Indians on his way to the gold mines, and before 1850, when Correia relocated the eastern Bakairi village. One could presuppose a pre-1723 migration to the Xingu, except for the linguistic factor.

Although the time sequence of the division of the Bakairi into three geographically distinct groups continues to present problems, it is known that by 1884, they were established in a west-east arc across Mato Grosso. [For pre-1884 information on the Bakairi, see Casal (1945), Coudreau (n.d.), and Leverger (1862).] The three clusters of Indians had contact with each other, and continue to have contact up to this day. However, in spite of the linguistic similarities and the communication between them, striking differences evolved. Of the three groups, the western Bakairi were the most acculturated. We have already discussed their participation in the extractive economy as well as their frequent journeys to such towns as Diamantino and Cuiaba where they sold rubber and artifacts. The eastern Bakairi were also quite acculturated by 1884. When von den Steinen (1940) passed through, only 22 people (10 men, 8 women, and 4 children) lived in a small village made up of seven houses. The gardens were located at a distance from the village, where such crops as manioc, beans, and sweet potatoes were cultivated. In addition to the subsistence plots, the eastern Bakairi also worked on some of the cattle ranches in the area.

The Xinguano Bakairi, on the other hand, were living on the Batovi and Kuliseu Rivers, which are headwaters of the Xingu River. Of the three groups of Bakairi, they were the least acculturated. In fact, as already mentioned, von den Steinen (1940) contends that they had not been contacted by non-Indians prior to his visits in 1884 and 1887. From data provided by von den Steinen, seven Bakairi villages were located in the Xingu. Four of them inhabited by 165 people were situated on the banks of the Batovi River. One village was referred to as Tapakuya. Von den Steinen did not supply the names of the other three villages. Three other villages were settled on the Kuliseu River. They were called Maigeri, Igueti, and Kuyaqualieti. A total of 326 Bakairi lived in the Xingu headwaters in 1887. They were not only closely bound to the eastern Bakairi who represented their only link to the outside world, but they also had close ties with the Nafuqua, Kalapalo, and Waura, other tribes who occupied the same region as they did. These connections continue up to this day. Kalapalo and Nafuqua fleeing from witchcraft accusations feel free to travel to P.I. Bakairi, the current location of the eastern Bakairi. In addition, the Bakairi refer to Nafuqua as their kinsmen and one of their ritual songs is composed of

Nafuqua lyrics. Not even the elders know what the words mean; however, the Indians continue to sing it.

In 1884 and 1887, the Bakairi in the Xingu still used only stone tools for gardening and bows and arrows for fishing. They relied on ceramics made by the Mehinaku, stone instruments manufactured by the Trumai, and clay dolls made by the Aweti. They lived in the traditional elliptical houses which are usually 10 meters by 20 meters in size (Levi-Strauss 1948:327). Several families shared each of these houses. In addition, the village also had a guest house in which von den Steinen and later Petrullo stayed. These guest houses were described as badly constructed and poorly kept. The guest house is also called the flute house or the men's house. One is still found in P.I. Bakairi.

The Xinguano Bakairi were fishermen and used canoes extensively both in fishing and traveling. Von den Steinen (1940) mentions that fish was offered to him so rarely and in such small portions that he assumed it was a very precious food. The Indians also consumed ants, manioc, maize, yams, squash, peanuts, peppers, and sweet potatoes. Both Levi-Strauss (1948) and von den Steinen (1940) wrote that the Indians hunted with bows and arrows and that food taboos seemed to be rare. However, fishing, which was practiced throughout the year, predominated.

After von den Steinen's visit to the headwaters of the Xingu River, other explorers and scientists also visited the area. For example, in 1895 Coudreau (n.d.) explored the Tapajos River for the governor of Para. He mentioned two groups of Bakairi in his report: the "mansos" or pacified Indians who inhabited the region around the

Paranatinga, and the "bravos" or wild Indians who had settled between the Kuluene and the Paranatinga Rivers. Ribeiro (1967) also discusses the Bakairi situation as it stood around the turn of the century. He claims that in 1900 the Bakairi on the Kuliseu were isolated, those on the Batovi River were in intermittent contact, and those on the Paranatinga River were in permanent contact. Interestingly enough, Ribeiro goes on to state that by 1957 the Batovi and Kuliseu River Bakairi were extinct while the Paranatinga River Indians were integrated. We shall see that he was mistaken in making his first statement and premature in making his second.

Between 1890 and 1920, the Xinguano Bakairi left the Xingu for the Paranatinga River settlement. They left the area gradually as the result of a combination of push and pull factors. On one hand, the Xingu headwater area was hit by a number of serious epidemics at the turn of the century. Many died, and those that lived began to flee the area for even more isolated recesses of the jungle, or in the case of the Bakairi, for more populated regions. On the other hand, an eastern Bakairi leader by the name of Antoninho attempted to build up a political power base among his own people by attracting the Xinguano Bakairi out of their settlements and into his own political orbit on the Paranatinga River. He was assisted in realizing this objective by Antonio Correa Dias, the then president of the Mato Grosso Province. Dias supplied Antoninho with guns and metal tools with which to entice the Bakairi. According to legend, Antoninho also threatened them saying that non-Indian soldiers were approaching the Xingu to kill them all.

By 1900-1901, when Schmidt visited the Xingu, only two of the three Kuliseu villages still existed (Schmidt 1947). Approximately 34 of the Bakairi had already moved to the Paranatinga River, and more were on the way. In 1927, Schmidt returned to the eastern Bakairi to find that 180 Xinguano Bakairi had left their villages on the Batovi and Kuliseu, and resettled on the Paranatinga River. The additional 140 which von den Steinen (1940) counted in 1884 and 1887 had either died in the epidemics or had been absorbed into other tribal groups which remained in the Xingu area.

The eastern Bakairi numbered 22 individuals when the Xinguano Bakairi began their migration. The former were inundated and finally absorbed by the large number of the latter who came from the Batovi and Kuliseu Rivers (Barros 1977). Initially, all of the Bakairi lived together peacefully but political infighting soon began. Antoninho quarreled with a rival named Jose Coroado. They established different villages in the same vicinity. Jose settled upstream on the Azul River while Antoninho settled on the Paranatinga River (see Figure 2-2). Later, groups of the Xinguano Bakairi argued with the eastern Bakairi. Kauto took a group of the former downstream on the Paranatinga where they settled some 8 km from the Antoninho village, and Pires, another Xinguano leader, took another group to settle on the Vermelho River. In 1918, a reservation of about 50,000 ha was decreed for the Bakairi by Resolution Number 761. In 1920, an Indian post named Simões Lopes was established between the villages of Jose Coroado and Pires. The Indian Protection Service (Serviço de Proteção aos Indios) soon sent a

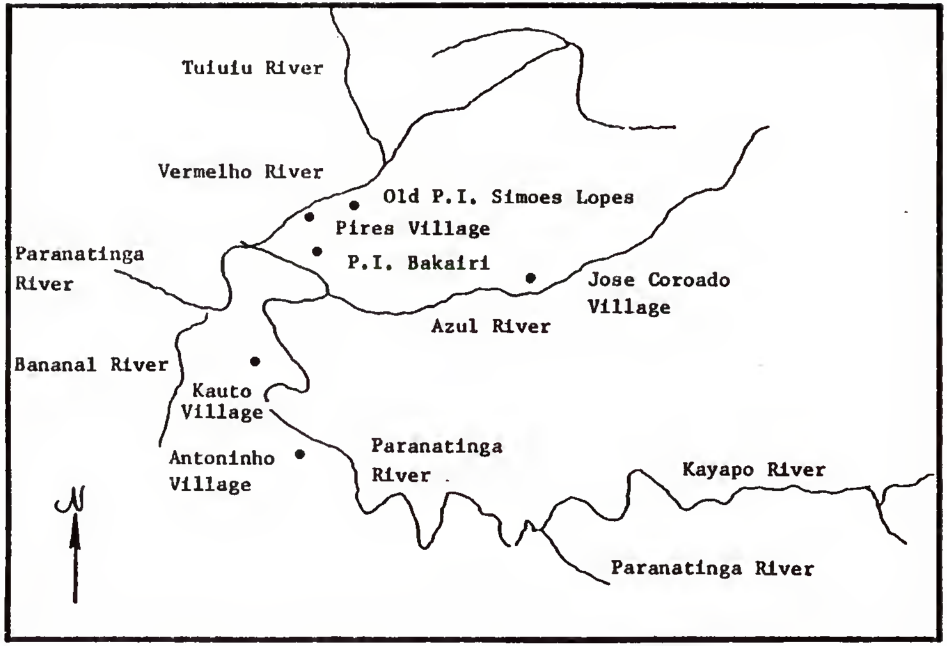


Figure 2-2. Twentieth-century eastern Bakairi settlements in the Bakairi reservation

representative to live at P.I. Simões Lopes from where the various groups of Bakairi could be administered.

As Mato Grosso changed its political status from province to state, and its economic base from mining to cattle raising, far-reaching political control and long-term economic infrastructure evolved and replaced those structures which had previously existed. The non-Indian in the nineteenth century was there to build a life. Unlike the miners in the eighteenth century who came to get rich quickly and then to leave, the ranchers of the nineteenth century came to stay. The Bakairi were both directly and indirectly affected by this trend. As the headwaters of the important rivers in the areas were penetrated by cattle-raisers trying to secure pasture land, important links between Indians and non-Indians were established. In addition, it became desirable from the point of view of the non-Indian to pacify and control as many Indians as possible. With them out of the way, concentrated and carefully controlled in such small reservations as P.I. Santana and P.I. Simões Lopes, vast areas previously occupied by the Indians could then be exploited by the non-Indian. This was one reason Dias supported Antoninho in his attempts to attract the Xinguano Bakairi to the Paranatinga River. After von den Steinen's visit to the Xingu, the government in Cuiaba was aware that a large number of Indians inhabited that area. It was highly desirable from a political and economic standpoint that the region be neutralized. By 1920, the Xinguano Bakairi were living on the Paranatinga River in a tiny reservation along with the eastern Bakairi. Their lands were officially demarcated, and an official stayed on their lands with them to prevent them from leaving the general vicinity.

The Bakairi on Their New Reservation (1920-1958)

From 1920 to 1958, cattle raising continued to dominate the economy of the northern part of Mato Grosso. Although the northwest railroad system was completed by 1910, the area in which the Bakairi lived remained sparsely populated. The lack of roads and developed communication networks, which present difficulties even today, plagued the region. In addition, the habitation of the area by the war-like Xavantes discouraged people from settling in the vicinity. Large numbers of these Ge-speaking peoples roamed the area attacking Indian and non-Indian alike. The Bakairi deny that the Xavantes ever frightened them. In fact, they demand credit for pacifying the Xavantes. The Bakairi did in fact participate in the expedition which attracted this Ge group. The expedition, organized in the mid-1950s by the famous Francisco Meirelles, resulted in the settlement of a large group of Xavante Indians in the northern part of the Bakairi reservation approximately 15 km from the Bakairi village. The Xavantes remained there until about 1974 when they were resettled on their own reservations further east of P.I. Bakairi. If the Bakairi are casual about their relationship with the Xavantes, they continue to be extraordinarily afraid of the Kayabi Indians. The elders in the Bakairi village still remember how the Kayabi would ambush and kill men from the village on their way to and from the gardens. They were also known to kidnap women and children, and to this day, the women discipline the children by threatening them with the Kayabi.

During this time, the Bakairi were living in four different villages in their reservation. In 1927, Schmidt (1947) visited P.I. Simões Lopes to find them all, Xinguano Bakairi included, dressed in European fashion. This was one of the first policy decisions implemented by the Indian Protection Service then in existence. Furthermore, traditional elliptical houses had been forbidden and the Indians were living in wattle-and-daub houses. By 1930, when Petrullo (1932) visited the area, the post had been moved to where it is currently located, on the banks of the Paranatinga River, between the Vermelho and Azul Rivers (see Figure 2-2). A small cattle herd had also been established, but the Indians did not participate in caring for it at that time. Petrullo added that malaria and syphilis had decimated a great deal of the population. Syphilis was probably the result of contact between the Indians and the non-Indians who lived in the area. However, malaria, which is not endemic in that particular part of the Paranatinga River, was probably brought from the Xingu region where it continues to be a serious problem. Currently, malaria does not pose a health danger at P.I. Bakairi.

In the 1930s, the Indian Protection Service made a concerted effort to draw the Indians out of their distinct settlements and to concentrate them in one organized group around the post (Barros 1977). This policy was the direct result of a decree which necessitated that indigenous posts become self-sufficient. Indian labor was needed in the production of rice, beans, corn, sugar cane, etc. The cattle herd was also increased in size until 5,000 heads grazed on the cerrado or prairie in the reservation. The Indian men were organized in groups and sent to the fields at the beginning of the week and brought back to their families at the end of the work week. A list was kept of the work done by each individual, and payment was made with cloth, tools, and other items not produced in the reservation. In addition, the Indians were required to maintain their own subsistence plots because those goods produced in the Post fields were harvested and sold outside the reservation to support the Post itself. Time to work these plots were scarce because even the women were busy at the Post headquarters processing manioc into flour and hulling rice as well as making hammocks for sale. Women also provided domestic services for the non-Indians living at the Post.

In a relatively short period, the Xinguano Bakairi passed from an isolated state into permanent contact. They were forced to adjust to innumerable changes which were foisted upon them in the new reservation. The net result was a decline in population, which became such a problem that, in 1943, the Indian Protection Service took steps to remedy the situation. They donated a heifer to every family which gave birth to a child. In addition, for every birthday up to five years of age, another heifer was awarded to the parents of the child. This policy was also implemented at the Bororo and Umutina reservations. The Bakairi responded to the Indian Protection Service's stimulation. As we will see in greater detail in Chapter 4, the long trend of depopulation among the Bakairi at P.I. Simões Lopes was broken in the mid-1940s. After that, their population steadily increased.

Between 1920 and 1958, Mato Grosso's economic base depended upon extensive cattle raising. This type of economic activity did not require intensive human labor. Thus, no need for Indian workers presented itself during that time. Furthermore, the cattle-raising industry was not as well developed as it is now. Part of this was the result of the underdeveloped road and communication network in Mato Grosso. Another factor was the large number of unpacified Indians, such as the still notorious Xavantes, who roamed the northern reaches of the state, discouraging new settlers from entering the area. During this time, the Bakairi Indians, fresh from their isolated state in the headwaters of the Xingu River, were subjected to new cultural pressures stemming from their relationship with the Indian Protection Service. They were encouraged to wear clothes and to use a new kind of housing. Later, when the Service tried to make its posts self-sufficient, the Indians were forced to work on Post lands producing crops which would be sold in the city. When their populations declined to a dangerous level, the Service encouraged them to reproduce by offering a heifer to each family that gave birth to a child. This policy was successful in that it reversed the long trend of depopulation of the Bakairi which had begun even prior to their migration to the Paranatinga River.

This phase of Bakairi history is remembered by many of the Indians who currently reside in P.I. Bakairi. Their impressions differ in many ways. For example, one group is incredibly bitter when they speak about the past. They remember, with shame and anger, how they worked on the land like slaves while the products of their labor were sold in the cities. One man said the history of the Bakairi is a history of robbery by the karaiwa or non-Indian. He claimed that never again would the non-Bakairi be trusted to have anything to do with Bakairi land, cattle, or women. As a result of this attitude, any non-Indian is regarded with deep and angry suspicion by these Indians. Another group remembers that time with pride. They describe how all the administrative buildings at the Post were filled with rice and corn and cane that they, the Bakairi, had produced. This group says that the Bakairi who now live in the village are lazy and weak, and that only the old timers knew how to take care of themselves. For them, the early to middle part of the twentieth century was a kind of golden period when much food as well as cloth and tools were available for the Indians. Life in contemporary times strikes them as being much poorer.

Development in the West Central States and Recent Bakairi History (1958-1980)

With the pacification of the Xavante Indians in the mid 1950s, the area surrounding the Bakairi reservation began to open up to settlers. More ranches were organized, and labor became a valuable commodity. Indians on nearby reserves were viewed as a perfect source of cheap labor, and as a result Indian men, such as the Bakairi, stopped working for the Indian Protection Service and began to leave the reservations for extended periods of time. Wives and families remained behind as the men traveled to ranches where they built fences, corrals, and other structures. They were paid little for their work; however, the Indians retained subsistence plots in the reservation where they raised rice, manioc, and corn for their own consumption. The ranch pay they received was used to purchase cloth, soap, tobacco, and alcoholic beverages which rapidly became a problem once the Indians left the reservation.

At the same time, the Indian Protection Service withdrew its representative from the reservation and replaced him with a female schoolteacher who remained in the Bakairi reservation until 1968. She acted as unofficial agent as well as teacher and was much respected by the Indians. In fact, she is probably the only non-Indian who has lived at P.I. Bakairi and never been accused of corrupt behavior by the Indians. When the Service withdrew its male representative, it also removed all but about 500 head of cattle, which were transferred to other indigenous reservations. Furthermore, organized labor in Post fields was abolished and the Indians were allowed to concentrate their efforts on their own subsistence plots and on work outside of the reservation. Violeta, the teacher, taught the Indians to speak, read, and write Portuguese as well as to do simple arithmetic. She also outlawed alcoholic beverages in the reservation and was strict in her application of this rule. Records of her letters of complaint about various "troublemakers" in the reservation are still on file at the Post. They were without exception people who were inebriated in public on a regular basis. Today, alcohol consumption is not a serious problem, although some Indian men occasionally drink when they go to the city. Those who drink in the reservation are the object of gossip, and one of the criterion parents use to chose husbands for their daughters is whether the man has the reputation of a drinker. Thus, social pressure and Indian Protection Service rules act together, in this case, to control a potentially serious problem. When the former fails to have effect, the

Service has been known to take steps. For example, as late as 1981, the son of a nearby rancher was found to be selling liquor to the youths in the Bakairi village. The Service representatitve spoke to the young man and then to his father. When that did not have the desired effect, the representative contacted Cuiaba headquarters, which wrote a letter to the rancher threatening him with two years in prison and a fine. It is now against the law to sell liquor to an Indian in Mato Grosso.

In about 1970, an official representative of the Indian Foundation was assigned to the Bakairi reservation. His name was Brauvin, and he remained there until 1975. Brauvin was the first of the Fundaçao Nacional do Indio (FUNAI) agents. FUNAI was the organization which replaced the former Indian Protection Service (SPI) in 1968 after allegations of corruption and abuse of Indians brought an end to it. Violeta and Brauvin worked together for a short time in the reservation. However, their interests conflicted. Violeta was in favor of rapidly integrating the Indians into national Brazilian society. She encouraged them to work outside the reservation, to discontinue their rituals, and to speak Portuguese. Brauvin, and the Indian Foundation, were suspicious of the assimilationist position. Their policy was to cut short the period of intense contact that the Indians had had with the non-Indians on the ranches surrounding the reservation since 1958. They continued Portuguese classes for the children; however, they began a decade-long fight to convince the Indians that they must remain in the reservations. Their goal was to prevent the Indians from moving to the cities where the women tended to become prostitutes and the men became involved with criminals or became alcoholics.

Not all of those people who work for the Indian Foundation hold this particular philosophy. Some still maintain that the Indian needs to be integrated into Brazilian society as rapidly as possible and that linguistic and religious differences only serve to perpetuate the alienation of the Indians. For example, in 1980 when a medical team arrived at the Bakairi reservation to innoculate and vaccinate the Indians, the driver of the Foundation's truck ridiculed the Indians' language and mask dance. The Indians were so furious that they complained to the doctor and nurse, and that particular driver was not allowed back in the reserve again.

This suggests another point. Since at least 1968, the Indians have been interacting with people who have stressed the value of their culture. Due to the support of the mass media in Brazil, this particular viewpoint is even spreading to the ranchers in the area. A great deal of idealism about the "noble savages" who live on indigenous reservations has been generated by the popular Brazilian soap opera, "Aritana," which was about the contact of a more isolated group of Indians, and by other movies and articles now popular in the cities of Brazil. In addition, the Xavantes and the Txukarramãe, tribes who also inhabit Mato Grosso, have recently been given a great deal of publicity. A certain amount of respect for Indian power now exists, and the Bakairi have sensed this growing sentiment. As a result, the Bakairi self-image is changing. In 1975, they revived the annual mask dance again which had been discontinued during the Indian Protection Service's administration. Also, the

Indians are more aggressive about their demands. They have been known to go to Brasilia to forcefully lobby for projects they want realized. But most important, the way in which they interact with the non-Indian has changed. Two incidents illustrate this point.

In 1980, the researcher and about 20 Indians traveled by truck to a small town located a day's journey away. As supplies were being purchased, an older non-Indian man, slightly drunk, came over to one of the Indians who was loading the truck. He was obviously in an antagonistic mood, and he told the Indian he had heard that Bakairi eat the penis of animals. This is an incredible insult to a Bakairi, and to a rural Brazilian for that matter. However, the Indian calmly approached the non-Indian and said slowly in Portuguse, "No, we eat only the penises of white men." The non-Indian backed off quickly without exchanging another word. A second example concerns the use of the formal versus the informal term for you in the Portuguese language. The application of the formal you in the rural areas is much more rigid than in the cities where people are becoming more and more casual about using it. In the past, non-Indians used the informal you, voce, when they addressed an Indian. This signified that the Indian was a social inferior. However, recently, the Bakairi demand the use of the formal you, o senhor or a senhora. The researcher heard one Bakairi male of about 40 years of age explain to a non-Indian that he too demanded "a little respect." The non-Indian complied and addressed him with the formal term.

When Violeta left the reservation in about 1971 after arguments with Brauvin about the direction in which the Bakairi were to go, she left a passive and well-behaved group of Indians for him to administer. It is, of course, possible that this demeanor was only superficial, as we will note when we discuss how Brauvin was run off of the reservation by the Indians in 1975. Suppressed rage may have existed below the passivity and the perfect manners which characterized the Bakairi during that period. However, by 1980, the Bakairi had ceased to represent the model Mato Grosso Indian group by anyone's standards. Although not as aggressive as the Xavantes, nor as violent as the Txukarramãe, they are better educated and more experienced in dealing with the non-Indian than the other two groups.

Violeta was partially responsible for this metamorphasis in that she taught the Bakairi Portuguese and arithmetic. Also, the experiences with the non-Indians that took place under her administration are currently being drawn upon. Brauvin was also partly responsible for their fledgling independence and new self-image. He began the process whereby the Indians were discouraged from working on the ranches in the area. Policy had determined that intensive contact between Indian and non-Indian was no longer in the best interests of the former. As a result he encouraged the Indians to remain in the reservation all year round. Furthermore, he blocked non-Indians from entering the reservation and trading with the Indians. Brauvin's actions in response to the new policy confused and initially displeased the Indians. They perceived him as trying to frustrate their attempts to earn money, with which they needed to buy soap and clothes. The Indians, accustomed to having certain consumer goods, were suddenly forbidden access to the means whereby they could secure those goods. Anger and hostility resulted, and the Indians attacked and pillaged the Post. Certain parts of the buildings were burned, but Brauvin managed to escape in the dark with his life.

In 1975, Idevar Jose Sardinha and his wife replaced Brauvin as official representatives of the Foundation. They entered the reservation with two goals. The first was to increase the value with which the Indians perceived their cultural heritage. The second objective was to provide them with the means whereby they could develop their resources in the reservation. This latter objective, first conceived of in general terms, would provide a cash income for the Bakairi village. In addition, it would teach them agricultural skills which are highly valued in the national society. Finally, it would raise the standard of living in the reservation so that, ultimately, life there would approximate life in the rural areas. In order to realize these objectives, Sardinha and the Bakairi men developed a proposal which concerned the funding of a mechanized agricultural project for the reservation. It called for the financing of a tractor, seeder, harvester, and diesel fuel to run the equipment. In addition, the proposal also requested fertilizer and seeds. The project was approved in late 1980, and in time the first Bakairi tractor arrived in the reservation. It was run by a Bakairi man who had been trained on a nearby ranch. About 50 ha of land in the cerrado were cleared and planted with rice. This crop, when harvested, would be sold outside the reservation for cash which in turn would be used to buy more seed, fertilizer, and oil from the next year.

Each year the Indians were to increase the amount of land under cultivation as well as the cash flow from it. In the process, they would learn about mechanized agriculture.

Sardinha, the principal author of the project, was not in the reservation to see the initiation of the project. In August of 1980, he was disciplined for spending too much time outside the reservation. The Cuiaban administrators suggested that he resign, reminding him that getting an agricultural project off of the ground in an Indian reservation was a full-time job. Sardinha complied and was replaced by another man from Rio Grande do Sul. He and his family moved to the reservation to oversee the realization of the project. In Chapter 5, we will see that his administration did not go very smoothly in its initial stages.

The final historical phase of the Bakairi examined in this chapter has two parts. The first part, beginning in 1958 with the pacification of the Xavantes, saw rapid growth of population in the area around the Bakairi reservation. Cattle ranchers moved into the region from the south and northeast of Brazil. As a result, the Bakairi entered a period of intense contact with these non-Indians as they provided cheap labor for the latter. At first the Indian Protection Service encouraged the Bakairi to interact with the non-Indians because rapid integration of the Indian was their goal at that time. Cultural traditions were neglected during this phase as the men spent the majority of the time outside of the reservation.

In about 1974, the economic profile of Mato Grosso shifted somewhat. Extensive cattle raising was replaced by a combination of rice production and more intensive cattle raising than previously seen. This refocusing was the result of the polar development strategy adopted by Brazil during the 1970s. The method observed during that time was to designate regional poles (Mato Grosso was part of the central pole) into which huge amounts of cash would be funneled through international and national banks in the form of low interest loans. These loans would be absorbed into the underdeveloped regions around the pole where they would finance the kinds of projects the central agency had designated as appropriate for that area. The money, and ultimately that infrastructure which would qualify the area to be called developed, would ripple outward in waves away from the pole until the entire area would be ripe for economic growth, a by-product of development.

Mechanized rice production and more specialized cattle raising was financed by such major banks as Banco Bradesco and Banco do Brasil. Corporate land holders moved into the area, buying up land owned by small farmers and controlling these large estates from Cuiaba and São Paulo. The dispossessed clustered in tiny villages along the dirt roads which crisscross the interior of Mato Grosso. Around the reservation, such towns as Paranatinga, Rancharia, Nova Brasilandia, and Peresopolis are filled with people who, at one time, had a small plot of land somewhere, but who currently work when and where they can. As land became concentrated in the hands of corporate landowners, the landless replaced the Indians as a source of cheap labor. The latter no longer provided a valuable commodity. Nor did the Indian Foundation encourage them to work outside of the reservation. The new policy was to reduce contact between the Indians and non-Indians in order to slow the process of integration. Foundation representatives during the 1970s attempted to prevent the Indians from leaving the reservation. However, in order to effect a gradual integration of the Indians as well as to raise the perceived low standard of living in the reservation, some new policy had to be developed to replace the older abandoned one.

The most logical solution to this problem was to replicate the national polar development strategy on a micro-level in the indigenous reservations. That is, mechanized agricultural and intensive cattle raising projects would be implemented in these reservations in order to stimulate development there. In addition, the Indians would be gradually assimilated into Brazilian society through the process. However, they would not be integrated as migrant workers, prostitutes, or criminals. Rather, in ideal terms, they would own their own agricultural cooperative with vested interests in land and equipment. The Bakairi agricultural project was part of this overall strategy. It was initiated in 1980, and in 1981 its first rice harvest was completed. Further discussion of the project is included in both Chapter 8 and Chapter 9.

The Bakairi Today

The Bakairi are currently being subjected to increasingly strong assimilative pressures. The extent to which they will incorporate those changes forced upon them is clearly an open question. In 1981, they still retained a great deal of their indigenous culture. They can be called Bakairi, rather than rural Brazilian, on the basis of the presence of a number of characteristics.

All of the Bakairi speak Bakairi, a Carib language. Most of the men speak at least some Portuguese, and approximately half of the women speak a little Portuguese. The children are taught Portuguese in the Indian Foundation school in the reservation. Later on, these young people will develop their bilingual skills in interactions with Brazilians either in nearby towns or on ranches. Men, of course, have more opportunity to learn the second language because they tend to travel outside the reserve more frequently than the women do. However, in the village Bakairi is spoken, and few people will initiate a conversation in Portuguese unless the presence of a non-Indian calls for it.

Bakairi social organization also distinguishes the Indians from their rural counterparts. For example, the kinship terminology system applied by an individual to those people in the first ascending generation is referred to as the bifurcate merging system. People lump their mothers and mothers' sisters into one category and refer to them as <u>seko</u>. Fathers and fathers' brothers are referred to as <u>shogo</u>. However, mothers' brothers and fathers' sisters are split off from this nucleus. The former are called <u>kugu</u>, and the latter are called <u>yupũri</u>. All grandparents are referred to as <u>tako</u>, if they are male, and <u>ningo</u>, if they are female. In the individual's generation, the Iroquois system is employed in the classification of kin. An individual's siblings are called <u>ko</u>, if they are female, and <u>paigo</u> or <u>kono</u>, if they are male. <u>Paigo</u> is a term reserved for older brothers and <u>kono</u> is used for younger brothers. The offspring of fathers' brothers and mothers' sisters are referred to by the same terms which are applied to the individual's siblings. However, offspring of fathers' sisters and mothers' brothers require the use of different terms which set them off from the other relations. Pama is the term used for the male offspring and iwiãpũ is used for the female offspring of father's sister and mother's brother.

The Bakairi can be considered village endogamous. That is, they prefer to marry someone from P.I. Bakairi. However, two other alternatives exist. The Indians can marry a non-Indian or they can marry a Bakairi from P.I. Santana. The Indian Foundation actively discourages the Bakairi from choosing the first alternative. The Indians were told that if they allowed marriages between their children and ranchers, for example, they would eventually lose their lands. Theoretically, upon marriage, the kin of the non-Indian spouse would have legal grounds for moving into the reservation and living with the Indian-Brazilian couple. The Indian Foundation claims that in time the reservation will be filled with non-Indians rather than with Indians. Two Bakairi women are married to non-Indian men. These men are both Brazilian orphans who were raised in the area and who live no differently than their indigenous counterparts. Both speak at least some Bakairi. The Bakairi at P.I. Bakairi can also marry other Bakairi from P.I. Santana. Several of these kinds of marriages have taken place; however, they are difficult unions to maintain because the couple, especially in their early years together, are forced to commute back and forth between reservations to visit their families.

The Bakairi are also exogamous in terms of the extended family. That is, one can marry one's cross-cousins, or those offspring of mothers' brothers or fathers' sisters. However, one cannot marry one's parallel cousins or siblings because they are part of one's extended family and lumped with one's siblings. Parents are normally responsible for the selection of a spouse for a child although the individual chooses those with whom he or she will have sexual relations.

Following marriage, the couple tends to reside with the woman's family for at least the first year unless the man is an only child. While observing matrilocal residence, the husband will go to great lengths to help his father-in-law in the fields. After the birth of the first child, the couple will build their own house and live there alone or with siblings of one of the spouses. Later, parents or aunts and uncles may join them when age or sickness prevent them from making a living on their own. The Bakairi do not have descent groups or lineages. Their geneologies are very shallow and many do not even remember who their grandparents were.

Several non-kinship based social groupings exist for males only. For example, one of the male rites of passage is the ear-piercing ceremony which takes place when the boys are between approximately 14 and 19 years of age. Those who pass through the ear-piercing ceremony together comprise an age-set. These men have few concrete responsibilities toward each other. However, the village recognizes them as a unit, and they tend to fraternize and hunt together. A second group consists of the mask dancers. About 25 masks exist in the village today. During the dry season, a number of specially selected men dance inside of these masks on a daily basis. These men spend a great deal of time in the men's house, which is a centrally located structure where the masks are hidden from the women and children. The men's house is not a square building made of wattle-and-daub as are the houses in the village. Rather it is elliptically shaped and covered with palm thatch. It resembles those long houses found in the Xingu culture area. In addition, it is said that if a woman enters the men's house, she will be gang raped by the youths in the village. This rule is also found in the Xingu culture area. Although all men have the right and the opportunity to frequent the men's house, those who dance with the masks have a special status in the village and are closely associated with this structure. Although these individuals are not necessarily related by blood, nor are they the same age, they are recognized as a ritual group which shares important responsibilities and privileges. The last non-kinship based group consists of soccer players. About 20 men of all ages are fond of playing soccer in a field nearby the village. These men play almost every day during the dry season and then go and bathe together in the river where they gossip and discuss important events. They represent a group of men who tend to take similar positions in the village political arena. Although their solidarity is sometimes temporarily affected by village disputes and rivalries, relationships between them continue to be strong and enduring over the long run. No secret societies or classes exist among the Bakairi.

In addition to their linguistic affiliation and the nature of their social organization, the presence of certain rites of passage also set the Bakairi off from their Brazilian compatriots. Upon the birth of a child, which is attended by the woman's family as well as some of the older women in the village, both of the parents observe certain food taboos. These taboos are rigorously adhered to the first month until the mother has completely discharged the lochia and until the remainder of the umbilical cord has fallen from the infant's navel. During this time, neither the woman nor the child leave the house because not only are they themselves in danger, but they represent a danger to the village. Foods avoided by both parents include fish and meat, sweet manioc, sweet potatoes, rice, squash, banana, and beans. Beans, squash, banana, and sweet manioc are considered very dangerous to the health of the mother and child. Foods eaten include bitter manioc pancakes and manioc soup. After the first month, the parents gradually begin to incorporate more and more foods into their diet. However, up to seven months after birth, certain meat avoidances may still be in effect.

After several months have passed the child is named. It is given two Indian names and may be given a Portuguese name as well. The Indian names are chosen by the wife's and the husband's parents. Both sets of parents normally choose names of dead relatives. If one of the child's grandparents is dead, that name will most likely be given to the child. The mother and father address and refer to the child by different names in order to avoid pronouncing the name of one of their in-laws. An avoidance of in-law names exists. Names may be changed several times during a person's life time. Depending upon the individual, they may choose new names as they pass through key life crises. For example, when a woman goes through menopause, she will select a new name.

As the child grows and approaches maturity, he or she will pass through a kind of puberty rite. When a female begins to menstruate, the entire village is informed by the mother who runs to all the houses shouting the news. She will also stop a short distance from the men's house, and without directly addressing the gathered men, she will call out so that they can hear. The adolescent is confined to her hammock for three to four days until the bleeding stops. A palm thatch partition is erected in the house to separate her from the rest of the family. She is not allowed to speak or to eat. A root drink is provided to quench her thirst, but she cannot drink water by itself. After the bleeding ceases, an old woman appears at the house before sunrise. The girl's entire body is scraped with fish teeth. The scraping is painful in that it draws blood. However, no scars are left. The girl can then go to the river to bathe and also go into the village and circulate once again. The individual female, rather than a group of girls, passes through this ritual.

After a woman begins to menstruate, she can begin to take lovers. As a result, a dramatic metamorphosis of her personality is evident. Whereas before the menses, she was a quiet, obedient, and even demure child, after it appears she becomes a loud, attention-attracting flirt. Due to the fact that this transformation occurs almost overnight, it is always somewhat startling to see. Her laugh, her shouting, and her obvious teasing of the men elicit a tremendous response from the males in the community. Her first sexual experience will most likely take place at dusk in her hammock. Her lover, a single or married man, will creep into the house while everyone pretends they do not notice. Afterwards, he will quickly leave with little delay. The missionary position is the preferred sexual position. Both male and female orgasms are recognized and expected. Little foreplay is relied upon, and after the male ejaculates, the female reaches for a cloth carefully left on the ground by the hammock with which she cleans herself and the male so that the hammock is not soiled. Affectionate behavior before and after intercourse is acceptable though lovers often have to leave the woman's house quickly and secretly.

Men also pass through a puberty rite. However, they do so in a group rather than individually. The ear piercing ceremony takes place inside of the men's house away from the women and children. Boys between the ages of 14 and 19 years are stretched out on a wooden platform. Amid chanting and singing, their ears are pierced with an animal bone. The process is supposedly very painful and some of the boys faint. Crying is not an acceptable reaction. After the ritual, the boys are confined to their hammocks for three to four days. It is a dangerous time for both them and for the community. In addition, since their necks and faces swell up as a result of the infection which invariably sets in, the period is also an uncomfortable one for the boys.

Men and women are allowed to mate as they please for a number of years before they marry. However, when the time comes for marriage, their parents choose their mates for them and negotiate with the in-laws. The marriage ceremony is brief. The old women of the village go to the house of the boy, take his hammock and secure him by the arms, and then herd him down to the house of his wife. There his hammock is slung over the hammock of his wife. The couple lie down while the two sets of parents announce to each other and to the crowd of visitors what the children's responsibilities to each other and to their families will be. The husband and wife are obviously embarrassed by the entire event. The following week the new couple may move back to the husband's house if his mother is a widow or if he is the only child. However, the couple usually remains in the wife's home until the birth of the first child.

The pregnancy of th : woman generates a great deal of interest and excitement in the village. The woman will act embarrassed and deny until the last possible moment that she is actually pregnant. She has three choices once she has actually confirmed her state. She can abort with herbs from the forest, have the child and kill it, or have the child and raise it. This subject will be discussed in detail in Chapter 4.

Divorce is acceptable to the Bakairi. Reasons for divorce do not usually include adultery. Most husbands and wives will take lovers during their marriages. However, a woman does have the option of divorcing, or leaving her husband if his lover becomes pregnant. She can also leave him if he is unnecessarily brutal and violent. Wife beating is common among the Bakairi and although most families feel that a woman must tolerate this kind of male behavior, everyone is very sympathetic to a woman if she feels she can no longer remain with an abusive husband. A man does not usually leave his wife. However, if he does it is because she will not cook for him or wash his clothes.

Females apply these two types of punishment in jealousy and anger, and the men are afraid of these weapons because it forces them to go into the village for food. When they have to do this, they lose face in front of their kinsmen and the rest of the village. If the woman resorts to this kind of behavior too frequently, the man can move back to his family's house.

Upon death, the individual is wrapped in his or her hammock and buried a short distance from the village. The body is not buried in the village plaza or inside the house. The grave is not marked, and it is not revisited after the actual burial occurs. In some households, a type of wake occurs where everyone visits the house of the dead person and wails and cries. Sometimes the wife or the mother of the dead will faint, and the men will blow into her hands in order to revive her. The Bakairi feel the death of even a child very deeply. Years after the demise of a loved one, they will cry when they talk about the person. However, at the time of the actual event, they force themselves to bury the person quickly and assume a normal routine as fast as possible. In this way, they hope to "forget the sadness."

One other aspect of Bakairi culture separates them from Brazilian society. This aspect concerns their world view or their sense of identity. Barros (1977) charts the cognitive map of the Bakairi. She posits that these Indians make a number of distinctions when they relate to other people. Three kinds of distinctions are of special interest. In the most general terms, the Bakairi distinguish between the Bakairi and the non-Indians. The Bakairi category includes the

Indians who live at P.I. Santana and those who live at P.I. Bakairi. The non-Indian category, the karaiwa, includes all non-Indian peoples, Brazilian and otherwise. Within the Bakairi category, the Bakairi of P.I. Bakairi distinguish between themselves, whom they call Xinguanos, and the Indians at P.I. Santana, whom they call Santaneiros. The Xinguanos claim that the Santaneiros are not really Bakairi any more. The latter are ashamed to speak the Bakairi language and only want to speak Portuguese. They prefer not to marry Indians but think that the rancher is their friend and want to live outside their reservation with Brazilians. Furthermore, Santaneiros do not like to walk but prefer to use cars. Nor do they help their fathers-in-law or share things like true Bakairi do.

On the other hand, the Santaneiros claim the Xinguanos at P.I. Baikairi are primitive. The Xinguanos supposedly do not like the non-Indian or want to live as he does. They only like the bakururu, or traditional Bakairi rituals. Moreover, they do not know Portuguese or even want to learn the language. The Santaneiros say that when the Xinguanos came from the Xingu culture area, they did not even have pots or clothing. They were a "hard-headed" people with whom the Santaneiros tried to work but failed. The Xinguanos say, with regret, that the Santaneiros are no longer Bakairi, while the Santaneiros bitterly accuse the Xinguanos of being wild or bravo.

The Baikari also distinguish two kinds of non-Indians, or karaiwa. Brazilians are generally referred to as Cuiabanos, or natives of Cuiaba, the capital of Mato Grosso. No matter where a Brazilian comes from or lives, the Indians will call him a Cuiabano. Non-Brazilians are called alemão, or German. French, American, Chinese, or otherwise are all lumped together into the alemão category.

The Bakairi are set apart from other Brazilians on the basis of their linguistic affiliation, their social organization, the rites of passage they recognize, and the nature of their sense of identity. Although they are more acculturated than those groups of Indians who currently inhabit the Xingu culture area, from where the Bakairi migrated some 60 years ago, they continue to perceive themselves as being different not only from the Brazilians but from the other Baikairi who live at P.I. Santana.

CHAPTER 3
THE PHYSICAL ENVIRONMENT

The Bakairi reservation is located in the municipality of Paranatinga in Mato Grosso, one of Brazil's west central states. The capital of Paranatinga is also called Paranatinga and is a small village founded in 1964. It was only in 1979 that Paranatinga became a separate municipality. Prior to that the Bakairi reservation was located in the municipality of Chapadas dos Guimarães, a large, sprawling area that has since been reduced by 50 percent. Mato Grosso's population is increasing; however, parts of the state are growing at different rates. The highest population densities are found in Mato Grosso do Sul (Mato Grosso was divided into two states, Mato Grosso and Mato Grosso do Sul in 1978). There are 5 persons/km^2 around Campo Grande, 10 persons/km^2 around Corumba, and 25 persons/km^2 around Dourados, the major cities of this state. These relatively densely concentrated areas can be contrasted with the northern part of Mato Grosso where the Bakairi are found. In the latter area there are still vast stretches of land which are scarcely inhabited. Population density has been estimated at .5 person/km^2 in this region. However, these low population densities will not remain low indefinitely. Small as well as corporate landholders are moving rapidly into northern Mato Grosso. Two major ranchers, and several minor ones, now surround the reservation. Currently, fairly good relations exist between the reservation and ranchers and their workers.

Communication with the world outside of the reservation grows easier every year. There are currently four ways to leave or enter the reservation (see Figure 3-1). The first method is by way of the Paranatinga River. In an extreme emergency, one can canoe up the Paranatinga to the capital of the municipality or down the river to a ranch. This option is not used frequently because of the time and effort it would require. The second option is by air; a small plane can be used to carry the sick from the reservation to medical facilities in Cuiaba, the capital of the state of Mato Grosso (unfortunately no medical facilities yet exist in Paranatinga). The Bakairi reservation has a grassy landing strip on which planes can land, and although its poor condition presents certain dangers, it is a viable alternative.

The third and fourth options are by land. During the dry season, one can travel by truck or jeep to the reservation over dirt roads. One can travel from Cuiaba to the southern bank of the Paranatinga River and then leave one's vehicle and canoe across the river to the village. Or one can travel from Cuiaba via Paranatinga to the village itself. The former method is generally superior to the latter except for the necessity of fording the river. It is a much shorter route, and the roads are somewhat better. Leaving the reservation from the south, one passes through several ranches. Then there is a section of wilderness where a range of hills is crossed. On the other side, a plain stretches out where the small village of Peresopolis is located. A little further on is the new town of Brazilandia which boasts a bar that serves chilled Coca-Cola, refrigerated in a generator-run ice box. Brazilandia as yet

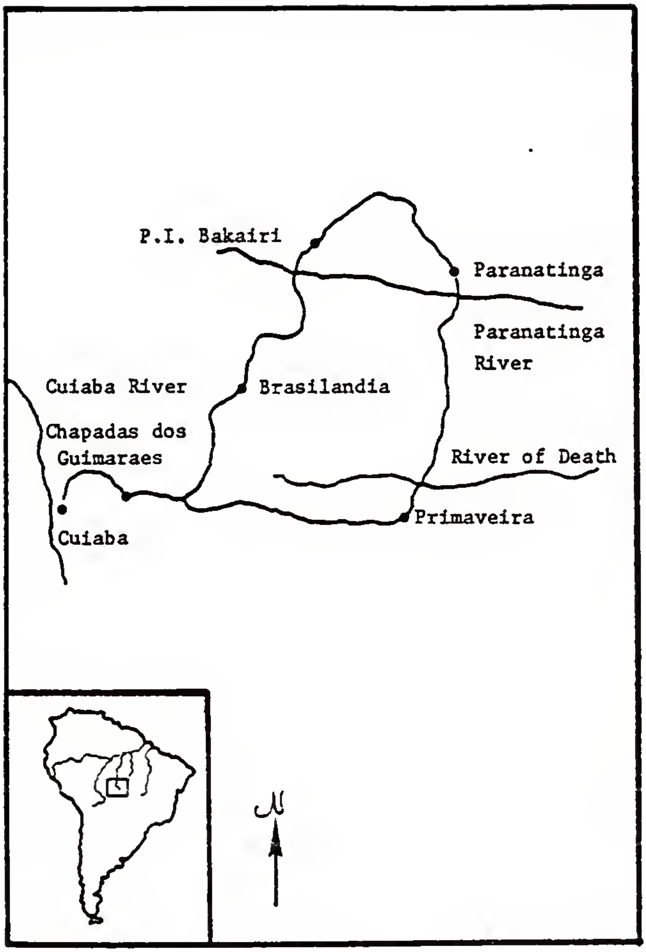


Figure 3-1. P.I. Bakairi located in Mato Grosso, Brazil

has no electricity or phones. After Brazilandia the roads improve and it is only 128 km to Chapadas dos Guimarães. In Chapadas, an hour from Cuiaba, one can pick up an asphalt road. Departing from the south of the reservation, the village lies 300 km or seven hours from Cuiaba. Average speed for the trip is 43 km/hour; however, on the stretch between the village and Brazilandia one can only travel 30 km/hour while from Brazilandia to Cuiaba one can accelerate to 55 km/hour. It should be reiterated that this applies only to the dry season. The rains either complicate the situation or make it an impossible journey. Most people in the area avoid traveling during the rainy season.

The last option is to leave the reservation from the north and travel to Paranatinga which lies 120 km away. The roads between the reservation and the town are quite poor, allowing for a maximum speed of 20 km/hour. Even traveling at this low speed, car repairs are invariably necessary and one normally is required to spend the night on the road. During the rainy season, it is realistic to allow two days for the journey, and some Indians even prefer to walk. From Paranatinga the road cuts south to Primaveira and then across the River of Death. The River of Death presents problems because the bridge that spans the river is constantly being washed out by the white water which characterizes this affluent. Often one is diverted upstream where the river can be crossed over a narrow gorge. After the River of Death one moves on to Chapadas dos Guimarães, and then to Cuiaba. Departing from the northern border of the reservation, the village lies 530 km from Cuiaba by this route. It can take from 18 hours to two days to make the journey during the dry season. It is not advisable to travel this route during the rains.

Topography, Vegetation, and Climate

In traveling between the reservation and the outside either by air or by land, certain features of the physical environment of the region are impressed upon the mind. The topography of the reservation and the surrounding area is characterized by undulating plateau formations. These plateaus are broken by ranges of hills to the north and the south of the reservation. Many rivers and streams which disappear during the dry season provide the reservation with an adequate water supply. These rivers actually constitute some of the natural boundaries of the reservation. For example, major rivers such as the Kayapo and the Paranatinga compose the southern and southeastern frontiers of the reservation (see Figure 2-2). Minor rivers which are greatly affected by the dry season serve as border points in the reserve. At the Bananal River, which lies in the southwestern corner of the reservation, the frontier of the reservation cuts north up to the Vermelho River and then northwest to the headwaters of the Tuiuiu River. From the Tuiuiu, the reservation border arcs to the east until it intersects with the Kayapo River once again.

The rivers as well as the hill ranges in the north and the south serve to isolate and protect the Bakairi from rapid encroachment by outsiders. The demographic characteristics of Mato Grosso also contribute to this isolation. Up until the early 1970s, the Bakairi reservation was relatively free from direct and regular contact with non-Indians, contact which has proven so difficult for other indigenous groups. Aerial photographs taken in 1972 reveal that no ranches existed anywhere near the reservation at that time. The closest ones were located south of the southern hill range. As a result of this isolation, the acculturation process, which is well underway in the reservation, has occurred more gradually than in other areas and has allowed the Bakairi the illusion of decision making in terms of how much and how frequently they interact with the non-Indian world (see Chapter 2). In 1980, a number of Bakairi had still never been outside of the reservation, and the Indian Foundation was encouraging the Bakairi chief to make arrangements for these people to visit Paranatinga where they could at least be exposed to some of the differences that exist between themselves and their non-Indian compatriots. In other Indian areas isolation and gradual acculturation have not been possible, and the results have been extremely detrimental to both the physical and cultural well-being of the indigenous groups in question.

Vegetation in the reservation and the surrounding region is composed of cerrado and gallery forest (Bezzera dos Santos 1977:62,72). The area in which the reservation is located lies on the natural border between Amazon Forest and cerrado vegetation types. However, the cerrado type of vegetation clearly dominates in the reservation. The cerrado consists of two distinct layers of vegetation. The first layer is made up of grasses that reach approximately one meter in height. The second layer consists of relatively short twisted trees that can reach up to 10 meters (1977:70). The grasses on the cerrado are continuous and are interrupted only sporadically by the trees and shrubs. They burn annually during the dry season (Murphy 1975:228). This adaptation to fire is beneficial to the renewal of the grasses. Thus fire represents a selective pressure which favors the growth of the grasses at the expense of the shrubs. It also decomposes organic matter and releases mineral nutrients from litter that has accumulated on the ground. Odum argues that fire increases the productivity of these areas by accelerating the recycling process (1975:117). The question of whether the cerrado is a natural vegetation type or a variation of the savannah vegetation type continues to be debated (Bezzara dos Santos 1977:69). Savannah vegetation is man-made. It is an artificial clearing of land that is the result of burning and degradation of the land. At one time the cerrado was classified as a type of savannah due to the wide open spaces, the grasses, and the stretches of gallery forest near the rivers that characterize it. However, Waibel (1948) and Beard (1949) introduced the idea that this vegetation type is totally distinct from both the savannah and gallery forest types. Waibel bases his conclusions on the nature of the leaves on the trees in the cerrado. They are unusually large and are not found anywhere in the intermingled forests. Beard supports Waibel's hypothesis, but criticizes him for not considering soil factors. He suggests that soil types are at the root of the kinds of vegetation found in the cerrado. He observes that natural drainage is the most important characteristic of tropical soils affecting the distribution of vegetation. The soils of the cerrado lack relief; that is, they are not well drained. Therefore, they are subject to unfavorable drainage conditions in the form of droughts during the dry season and water-logging during the rainy season. As a result of these edaphic characteristics, Beard concludes that the cerrado is a vegetation type distinct from gallery forest or, again, from savannah.

Research on the cerrado has usually addressed the problem of soil fertility and the possibility of successful agriculture. At one time, the cerrado, like the plains in temperate climates, were thought to be more fertile than the gallery forest areas. Then, the cerrado was thought to be completely unproductive and suitable for only livestock raising rather than plant cultivation. Currently, there is evidence that the cerrado can produce manioc, cotton, and rice if fertilizers and other high-energy agricultural techniques are employed. Most ranchers in northern Mato Grosso raise rice as a cash crop for one or two years, and then gradually introduce cattle into the ranch while at the same time phasing out the rice production. Rice is more energy intensive and thus more expensive to produce than cattle, especially if the grain must be repeatedly cultivated on the same piece of land. The Bakairi, on the other hand, have never cultivated crops in the cerrado. Rather they make their gardens in the gallery forest and reserve the cerrado for cattle raising where they now have, encouraged by the Indian Foundation, a herd of over 300 head. The Bakairi contention that the cerrado is unfit for plant cultivation will be discussed more completely in Chapter 5 where the results of soil analysis from the respective areas will be reviewed.

Gallery forest is the second type of vegetation found in the reservation. While the cerrado can be considered the core kind of vegetation, islands of gallery forest, a secondary vegetation type, surround the rivers that flow through the reservation and the general area (Bezzerra dos Santos et al. 1977:72). Gallery forest soils are considered to be the most productive lands in the region. They are composed of terra roxa which is red clay, rich in humus in the top layers with high water content (Waibel 1948). The forests with their three distinct layers grow on these soils. The first layer is the canopy with trees that reach between 20-30 meters. These trees shed their leaves during the dry season. Beneath the taller trees, shorter trees which grow up to 15 meters high, are found. They retain their leaves during the dry season. Shrubs and bushes compose the third layer. They grow to be one to two meters high and their leaves remain green during the dry season. The Bakairi invariably make their gardens in the gallery forests, cutting away the bush and the shorter trees with machetes before attempting to chop down the taller trees with axes. The absolute availability of the gallery forest in the reservation as well as the relative availability of forest near the village is both an important and worrisome factor for the Bakairi. Their perception of the situation is that the forest nearest to the village is worn out, and that each year they must go further from the village to make their gardens. This is undesirable from their point of view for several reasons. In the first place, it is time and energy consuming to commute long distances to the gardens. It is also inconvenient to transport harvests from the gardens to the village. Furthermore, if the garden is located at a distance, there is a greater chance of animals such as capybara and paca finding and ruining the crops before harvest time. In order to determine average distances of gardens from the village, a random sample of 36 (26 percent of the total number of gardens) was selected. The distance between these gardens and the village was measured employing Carneiro's method of estimating distances traveled on foot (Carneiro 1979, personal communication). Carneiro discourages the use of a pedometer due to the inaccuracies involved with using this piece of equipment. Rather he suggests using a method whereby one determines in advance how far one actually travels a minute at different rates of speed. Then during a hike, rates of walking at various intervals are recorded with the use of a stop watch. From the distance-per-rate-traveled figures and the actual-rate-traveled figures, one can calculate with reasonable accuracy the distance actually traveled on a hike. Average distance of gardens from the village was estimated to be 4 km, or a round-trip of 8 km (see Table 3-1). From the frequency table presented, a cluster of gardens surrounding the village and up to 4.5 km away can be clearly seen. However, the frequency of occurrence tapers off. No gardens are located further than 14 km from the village.

In order to examine more closely the availibility of gallery forest for crop production in the reservation, Landsat images from the EROS Data Center were secured. Photographs from the infrared band were ordered because in this band heavy vegetation, which reflects radiation, shows up in white. It is very easy to contrast heavy gallery forest with soil, open fields or water which have low reflectance and which show up as black or dark grey. Once the boundaries of the reservation

Table 3-1. Garden distance from village based on a random sample of 36 gardens (26% of total number of gardens)

Distance in Km	Frequency	Cumulative Frequency
0-.5	3 (8.3%)	2 (8.3%)
.6-1.0	1 (2.8%)	4 (11.1%)
1.1-1.5	3 (8.3%)	7 (19.4%)
1.6-2.0	8 (22.3%)	15 (41.7%)
2.1-2.5	2 (5.5%)	17 (47.2%)
2.6-3.0	1 (2.8%)	18 (50.0%)
3.1-3.5	3 (8.3%)	21 (58.3%)
3.6-4.0	3 (8.3%)	24 (66.6%)
4.1-4.5	2 (5.5%)	26 (72.1%)
4.6-5.0		
5.1-5.5		
5.6-6.0		
6.1-6.5	2 (5.5%)	28 (77.6%)
6.6-7.0		
7.1-7.5	6 (16.8%)	34 (94.4%)
7.6-8.0		
8.1-8.5		
8.6-9.0		
9.1-9.5		
9.6-10.0		
10.1-11.0		
10.6-11.0		

Table 3-1—Continued

Distance in Km	Frequency	Cumulative Frequency
11.1-11.5		
11.6-12.0	1 (2.8%)	35 (97.2%)
12.1-12.5		
12.6-13.0		
13.1-13.5		
13.6-14.0	1 (2.8%)	36 (100.0%)

were located and drawn using Indian Foundation maps, that part of the image was enlarged from the Landsat negative. Then the area was traced onto mylar for weighing purposes. Gallery forest, cerrado, and river areas were traced separately, cut out, and then weighed in order to determine ratios of these areas to the entire reservations area. According to the estimates based on the above calculations, gallery forest makes up 6.9014018×10^7 m^2, or 6,901 ha (13.8 percent) of the total reservation's land area. Cerrado covers 4.2604261×10^8 m^2, or 42,604 ha (85.2 percent) of the reservation. River area is estimated to be 4.83×10^6 m^2 (1.0 percent).

The climate of the area in which the Bakairi reservation is located is classified as hot and semi-humid (Nimer 1977:53). There are two markedly different seasons which characterize this type of climate: the rainy and the dry. The rainy season occurs between the months of November and March. Temperatures during this time average between 26° and 28°C (1977:38). In addition, rainfall and humidity are heavy. During the entire year some 1,750-2,000 mm of rainfall, and 70 percent of it falls during the rainy season with the heaviest precipitation occurring during December, January, and February. Nimer points out that rainfall in Mato Grosso is solely the function of air currents. Topography, or more specifically, high altitude areas, do not influence precipitation. The dry season occurs between the months of May and September. During this period, rainfall diminishes and temperatures drop. The coldest months are June and July when temperatures average 20°C. However, during the dry season friagens or cold spells also occur.

These spells last for two to three days and see temperatures as low as 2°C. Friagens take place on the average of three times a year (1977:41-44).

Energy in the Environment

In order to clarify some of the ecological processes that take place in the Bakairi reservation, key natural systems of the region can be represented by symbols and then arranged in an energy systems diagram. The borders of the reservation itself will constitute the boundaries of this energy system. As we will see, energy does flow between the outside and the interior of the reservation; however, generally speaking, the majority of the flows circulate within the reservation itself. The most important natural ecological systems that have been defined are the gallery forest, the cerrado, and the rivers. Production symbols will be assigned to these systems. The production symbol is used to indicate the processes, interactions, and storages that are involved in transforming dilute forms of energy, such as sunlight, into higher quality energy such as plant biomass (Odum 1981:13). These kinds of energy interactions characterize the above three ecological systems where photosynthesis occurs, and organic matter is produced.

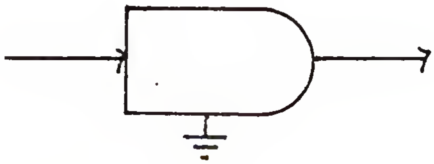


Figure 3-2. The production symbol

Fish and terrestrial animals also figure into the Bakairi ecosystem. Both kinds of organisms are consumed by the Indians, being important sources of calories and protein. They are also closely associated with the production systems that have been defined above. For example, fish subsist directly or indirectly off of the matter produced in the river system, and terrestrial animals consume, again directly or indirectly, the matter provided to them in the cerrado or gallery forest systems. Animal biomass will be assigned the consumer symbol which is hexagonal in shape (Odum 1981:13). This symbol is useful because it designates the utilization of high-quality energy, and contrasts with the production symbol where low-quality energy is converted or concentrated (1981:294). Although consumer and production symbols both represent self-maintaining systems, they indicate that the systems in question rely on different qualities of energy to subsist.

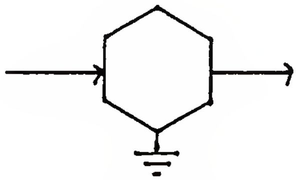


Figure 3-3. The consumer symbol

The production and consumer symbols can be given greater detail through the addition of the energy storage tank symbol. This symbol indicates a storage of energy within a system. It can be employed to represent the plant biomass in a forest system or the fish biomass in an aquatic system. When it is attached to an interaction symbol, or a pointed block, it means that two different kinds of energy are interacting in order to feed energy into the tank (Odum 1981:11-12). For example, sunlight, or another form of dilute energy, flows into a river production symbol.

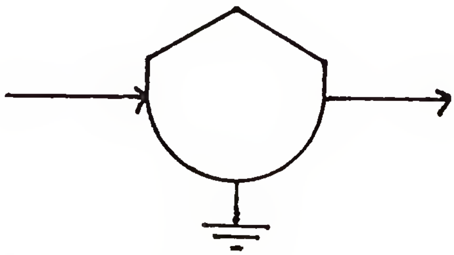


Figure 3-4. The storage tank symbol

Within this system it interacts with other kinds of energy in order to produce plant matter which is stored in the tank symbol. The lines attached to these symbols represent energy flows and the arrow pointed downward designates what is called a heat sink where energy is degraded and lost from the system. Heat sinks are required on all storage tanks and interaction symbols because energy is lost whenever a process, or work, takes place (Odum 1981:12) (see Figure 3-5).

One other energy symbol will be used in the Bakairi diagram: that of the energy source. The energy source is represented by a circle, and it indicates that some kind of energy is flowing from the outside into the system where it triggers various processes (Odum 1981:11).

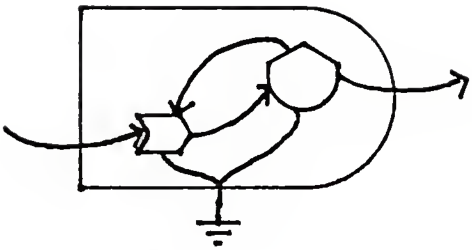


Figure 3-5. Interaction symbol combined with a storage tank symbol within a production symbol

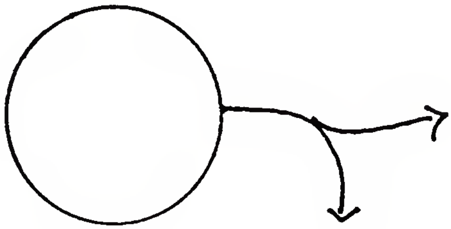


Figure 3-6. The energy source symbol

Sunlight is an example of a dilute form of energy which flows into the reservation where it interacts with the ecological systems to produce plant biomass. This symbol can also represent other outside sources of energy; however, for our purposes here, we will use it only for solar energy.

Prior to the actual construction of an energy diagram, it is useful to look closely at each one of the variables, or components, of the system, and at the energy that flows around these variables. We will begin by examining the solar energy source which lies outside the boundary of the Bakairi system. Then we will go on to define the producers, consumers, and storagers in the system, and the energy flows that represent the processes which occur within it.

Solar Radiation: An Outside Energy Source

Solar radiation provides 99.97 percent of the heat energy required for the physical processes which take place in the earth-atmosphere system. Each year the sun radiates 2.9 x 10^{30} kcal of heat (Sellers 1965:11). Of this huge amount of energy, the earth-atmosphere system intercepts very little. Only an average of 2.63 x 10^{6} kcal/m^{2}/year actually enter our planetary system. A certain percentage of this energy is reflected while the other part is absorbed and used in energy driven processes. Of the 2.63 x 10^{6} kcal/m^{2}/year which is intercepted by earth, 7.9 x 10^{5} kcal/m^{2}/year (30 percent) are reflected and scattered into space by the clouds and particles in the atmosphere. Another 4.5 x 10^{5} kcal/m^{2}/year (17 percent) are absorbed by clouds and atmospheric particles. The remainder of the energy is an average of 1.39 x 10^{6} kcal/m^{2}/year (53 percent). This energy actually reaches the earth's surface (1965:23).

However, the amount of heat-energy that strikes earth also varies according to latitude and month of the year. The Bakairi reservation is located at 14°S latitude 54°W longitude. If one averages insolation per month over a year's time for 14°S latitude, energy that actually reaches the earth's surface in this specific area increases to 1.56 x 10^6 kcal/m^2/year over the planet's average of 1.39 x 10^6 kcal/m^2/year (Sellers 1965:18,23). A part of this energy is reflected by the earth's surface itself. Depending upon the color and texture of the ground, the surface albedo, or reflected energy, will vary. The Bakairi reservation is mainly composed of grasslands or cerrado, and forests. Average albedo listed for these types of vegetation is 14.8-15.8 percent of total energy which leaves 1.32 x 10^6 kcal/m^2/year (1965: 29; Gates 1971:45).

Of the total amount of sunlight which remains after all important factors which affect insolation have been considered, only about 25 percent is of wavelengths that stimulate photosynthesis (Gates 1971:46). Only a fraction of this 25 percent is actually used by green plants in photosynthesis processes; however, the 25 percent, 3.3 x 10^5 kcal/m^2/year, enables us to estimate solar enregy input for the reservation. In Figure 3-7, the solar energy which lies outside of the boundary of the Bakairi system is presented. Flows of energy have been calculated on the basis of the above data for the reservation itself which is 49,989 ha in area.

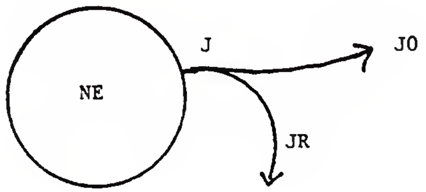


Figure 3-7. Solar energy source for the Bakairi reservation model

Table 3-2. Evaluation, name, and description of energy source and associated flows for the Bakairi model

Energy Flows and Source	Name of Flows and Source	Values (Kcal/Year)
E	Solar Energy	2.90×10^{30}
J	Insolation	6.57×10^{14}
JR	Albedo	4.53×10^{14}
JO	Solar Energy for Photosynthesis	1.65×10^{14}

Table 3-3. Net primary productivity figures for tropical forests

NPP	Source
2.30×10^3 g/m^2/year	Farnsworth and Golley 1974:81
2.16×10^3 g/m^2/year	Murphy 1975:227
2.00×10^3 g/m^2/year	Lieth 1975:205
2.20×10^3 g/m^2/year	Whittaker and Likens 1975:306

Producers Subsystems: Gallery Forest, Cerrado, and Rivers

When sunlight flows into the reservation, it provides energy for the photosynthetic processes which take place in the rivers, cerrado, and forests of the area. To understand the flow of energy through these production systems, each natural system will be examined separately. The gallery forests in the reservation comprise 13.8 percent of the total area involved. These forests are in a steady state. That is, the flows of energy into the system equal the flows of energy out so that the forests are no longer growing or spreading. They have reached an equilibirum. Energy processed in the forest is either expended in self-maintenance activities, in heat dissipation, or in supporting the wild-life that inhabit the area.

Net primary productivity, gross primary productivity, and autotrophic respiration are terms assigned to productive functions that occur in natural systems. Gross primary production is the total energy that flows into the system, or the actual rate of generation of products (Odum and Odum 1981:78; Whittaker and Marks 1975:98), while net primary production is that production which is observed: that is, the net gain in mass (Odum and Odum 1981:78; Whittaker and Mark 1975:56). Autotrophic respiration refers to plant metabolic processes. It is generally agreed in the literature that a great deal of needless confusion has arisen over these two terms due to the difficulties associated with determining actual gross and net productivity by different methodologies. This controversy will not be discussed here. Instead several generalizations on which most researchers agree will be set forth. In the first place, gross primary productivity may be estimated to equal net primary productivity plus autotrophic respiration of the plants in a fully mature climax community (Murphy 1975:227; Gates 1971:48). In addition, although world gross primary productivity is listed as twice net primary production (Whittaker and Likens 1975:310), Tropical Forest primary production is much higher than other less productive areas of the world, such as tundra or oceans. Thus, in Tropical Forests, gross primary productivity is equal to up to four times net primary production (1985:310; Gates 1971:48). Furthermore, autotrophic respiration rates for Tropical Forests are also quite high. Between 60 and 75 percent of total gross primary production has been estimated by some researchers (Whittaker and Likens 1975:310; Whittaker and Marks 1975:98-99). Respiration in these areas is high due to the high temperatures and the massiveness of the community structure, both of which raise respiration rates. These estimations provide the means wehreby a number of energetics calculations can be made. Using the below equations as well as data provided on net primary productivity, reasonable estimates for both gross primary productivity and autotrophic respiration may be derived.

$$GPP = NPP + Ra$$

$$GPP = 4(NPP)$$

$$Ra = .75(GPP) \text{ or } (.75)(4)(NPP)$$

Net primary productivity has been referred to as the net gain in mass in a community. In a young forest, this net gain may accumulate from year to year as the forest expands. However, in a mature climax forest, net primary productivity may be equaled by the death or loss of plant matter. Part of this loss occurs when food is made available to other organisms in the system (Odum 1975:65). In such a case it is possible for net primary productivity to be high while actual net ecosystem production to be zero (Whittaker and Marks 1975: 56). Data on net primary productivity for Tropical Forests have been compiled in Table 3-3.

By using an average figure taken from the above data (Table 3-3), 2.165×10^3 g/m^2/year, gross primary productivity as well as autotrophic respiration can be estimated and then used to calculate flows of energy in Figure 3-8.

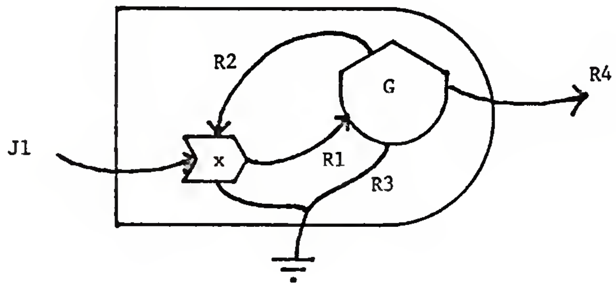


Figure 3-8. Gallery forest in the Bakairi reservation model

Inspite of the importance of the gallery forest in the reservation to the subsistence activities of the Bakairi, the area is still dominated by the <u>cerrado</u>. Over 85.2 percent of the reservation is composed of this type of vegetation. The <u>cerrado</u> natural system is similar to the gallery forest system in that it is in a steady state, and the flows of energy in are equaled to the flows of energy out. Thus, the equation GPP = NPP + Ra still holds true. However, net and gross primary productivity are lower in the cerrado than in the gallery forest due to the fact that the community structure is not as well developed as it is in the forest ecosystem. In addition, autotropic respiration is lower. Whittaker and Likens estimate that gross primary productivity is approximately 2.7 times that of net primary productivity. Moreover, autotrophic respiration in the cerrado drops to 63 percent of the gross primary productivity of the system (1975:310).

Net primary productivity of the cerrado is estimated to be 890 g/m^2/year (Murphy 1975:225). Standing biomass (dried matter) is set at 4 kg/m^2 (Whittaker and Likens 1975:306). Comparable figures for the gallery forest are 2.16 g/m^2/year and 4.5×10^4 g/m^2, which are considerably higher than the cerrado figures. In Table 3-5, estimates for the values associated with energy storages and flows in the cerrado are presented.

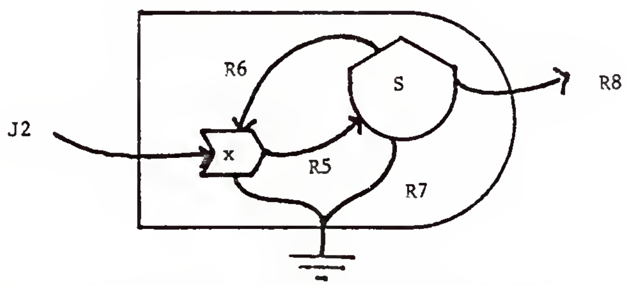


Figure 3-9. Cerrado in the Bakairi reservation model

Table 3-4. Evaluation, name, and description of the energy storage and flows associated with the gallery forest in the Bakairi reservation model

Energy Flows and Storage	Names of Flows and Storage	Values (Kcal/year)
G	Gallery Forest Biomass	1.32×10^{13}
J1	Sun on the Forest	2.30×10^{13}
R1	GPP	2.57×10^{12}
R2	Self-Maintenance	9.52×10^{11}
R3	Heat Sink	9.52×10^{11}
R4	NPP	6.35×10^{11}

Table 3-5. Evaluation, name, and description of the energy storage and flows of the cerrado in the Bakairi reservation model

Energy Flows and Storage	Names of Flows and Storage	Values (Kcal/Year)
S	Cerrado Biomass	7.24×10^{12}
J2	Sun on Cerrado	1.41×10^{14}
R5	GPP	4.35×10^{12}
R6	Self-Maintenance	1.37×10^{12}
R7	Heat Sink	1.37×10^{12}
R8	NPP	1.61×10^{12}

The rivers in the Bakairi reservation are the third ecological system we will examine. They are extremely important to Bakairi subsistence because the Indians are primarily fishermen and depend on fish as a major protein and calorie resource. Five rivers are located in the reservation; however, only one of these, the Paranatinga River, is of major importance for both gardening and fishing. This river is one of the headwaters of the Teles Pires which is a tributary of the Tapajos River. Over 45 km of the Paranatinga are to be found in the reservation. Its average width, according to Landsat images is 77.3 m. Other smaller rivers include the Tuiuiu, notable for its lush but distant gallery forests; the Azul, which also has much gallery forest and which serves as a secondary fishing area; the Vermelho; and the Kayapo which is the most distant of all the rivers from the village. Total river area is estimated to be about only 1 percent of the reservation's area.

River productivity, and indirectly fish productivity, are affected by a number of factors of which light penetration, temperature, oxygen content, and imported organic material are the most important. Light penetration depends upon the amount of suspended material in the water, which in turn is a factor of water turbidity and river bottom conditions. For example, rapids and soft bottoms will inhibit photosynthetic processes and primary productivity by limiting the amount of light that can penetrate the water. Temperature differences also affect the distribution of plant life. If temperature differences are great enough, cold water tends to remain on the bottom of the river, and the nutrients and oxygen in the water do not circulate evenly (Emmel 1973: 101). Imported organic matter is the result of dead leaves and branches which fall into the river from the surrounding forests. Rivers, which are considered "incomplete ecosystems," rely heavily upon adjacent terrestrial ecosystems for additional energy input. If a great deal of overhanging foliage exists, organic matter imports will be high (Odum 1975:72,178).

The Tapajos and its headwaters are classified as clear water. That is, the water itself seems a yellow to light-green color due to its transparent nature. Light penetration in these rivers is high. The river beds are normally of hard brown clays being part of the extension of the terra firme in Amazonia. Gallery forest surround the rivers, inhibiting soil erosion and, along with the clay bottoms, limiting sediment and nutrient supplies (Sioli 1975:285-286). Primary productivity in the Paranatinga River is limited as a result of low sediment levels but enhanced due to high light penetration. In the other secondary rivers, where a great deal of organic matter from gallery forests is imported, light penetration and primary productivity is decreased but debris provides nutrients for aquatic organisms. This debris is supplemented by organic supplies which result from annual flooding of the rivers. Then a river floods onto adjacent forest lands, fish follow the water and are rewarded by rich feeding grounds. When the river goes down, they may be trapped in small shallow lagoons where the Bakairi employ vegetable asphyxiants to facilitate spearing them with arrows.

Aquatic plant biomass contrasts with terrestrial plant biomass in that it has a short life span and small accumulation of mass. The ratio of biomass to net primary productivity is usually a fraction while ratios in terrestrial communities range from 50 upward. Aquatic plant biomass averages from less than .1 kg/m^2, and mean biomass is estimated to be .02 kg/m^2 (Whittaker and Likens 1975:306). Aquatic gross primary productivity is also smaller than that of terrestrial systems. Mean ratios of gross to net productivity are 1.5 for the seas (and slightly higher, 1.75 for streams) and 2.7 for continents (1975:310). Plant respiration in aquatic communities is also less than in terrestrial systems. It is estimated to be 25-50 percent of gross primary productivity with the higher levels being found in river water (1975:310). In Figure 3-10 and Table 3-6 estimates of the flow of energy in the Bakairi aquatic system are presented.

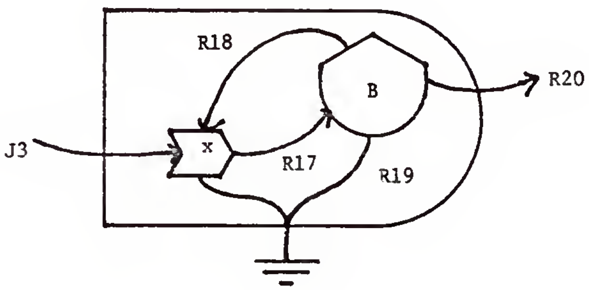


Figure 3-10. Rivers in the Bakairi reservation model

Table 3-6. Evaluation, name, and description of the energy storage and flows of energy in the rivers of the Bakairi reservation model

Energy Flows and Storage	Names of Flows and Storage	Values (Kcal/Year)
B	Aquatic Plant Biomass	4.11×10^{8}
J3	Sun on Rivers	1.65×10^{12}
R17	GPP	1.44×10^{10}
R18	Self-Maintenance	3.09×10^{9}
R19	Heat Sink	3.09×10^{9}
R20	NPP	8.22×10^{9}

Table 3-7. Comparison of area and net primary productivity of gallery forest, _cerrado_, and rivers in the Bakairi reservation model

Ecosystem	Area	% of Area	NPP (Kcal/Year)	% of NPP
Gallery Forest	6.90×10^{7} m^2	13.8	6.35×10^{11}	28.2
Cerrado	4.26×10^{8} m^2	85.2	$1.61\ 10^{12}$	71.4
Rivers	4.83×10^{6} m^2	1.0	8.22×10^{9}	0.4
Total	4.99×10^{8} m^2	100.0	2.25×10^{12}	100.0

The relative productivity of the three areas which have been examined differs according to the biomass in each system as well as to the amount of energy that circulates within each area. In Table 3-7, net primary productivity of gallery forest, cerrado, and rivers are compared to area proportions. Gallery forest productivity is over double the proportion of land area it occupies, while cerrado and river productivity is less. The relative and absolute amounts of energy that are pumped through any one ecosystem are of key importance to the consumers that depend upon these energy supplies for subsistence.

Nonhuman Consumers: Animals, Cattle, and Fish

Consumers in the Bakairi environment include the animals in the forest, the cattle and natural fauna in the cerrado, and the fish in the rivers. Although the Indians fish, hunt, and occasionally slaughter a steer, most of the terrestrial and aquatic animal biomass is left untouched and, therefore, remains in storage. In Table 3-8, a selective list of the terrestrial fauna available to the Bakairi is presented. In the fifth column, an X indicates whether or not a history exists of indigenous groups eating the organism in question. Bakairi consumption of the organism is indicated in the sixth column. Within the mammalian class, nine important orders are cited. Opossums, which are generally small, are unimportant as a source of food, except for *Didelphis* which is large and easy to capture. Bats and marmosets are considered to be either dangerous pests, in the case of the former, or potential pets, in the case of the latter. They do not constitute a

Table 3-8. Abbreviated list of fauna in the Bakairi terrestrial environment

Class[a]	Order	Family	Common Name	Indians Consume	Bakairi Consume
Mammals	Marsupilia	Didelphis	Opossum	X	—
	Chiroptera	10 families	Bats	—	—
	Primates	Cebidae	Monkeys	X	—
		Callithrichidae	Marmosets	—	—
	Endentata	Bradypodidae	Sloths	X	—
		Dasypodidae	Armadillos	X	X
		Myrmecophagidae	Anteaters	X	X
	Rodentia	Leporidae	Rabbits	X	—
		Erethizontidae	Porcupines	X	—
		Echimyidae	Bristle rat	X	—
		Dasyproctidae	Agoutis	X	—
		Caviidae	Capybara, paca, mara, cavy	X	—
	Carnivore	Procyonidae	Raccoons, quatis, coatimundis	X	—
		Mustelidae	Otter, lontras, nutrias, iraras	X	—
		Felidae	Jaguar, puma, ocelot	X	—
		Canidae	Fox	X	—
	Sirenia	Manatees	Manatees	X	—
	Perissodactyla	Tapiridae	Tapirs	X	X

Table 3-8—Continued

Class[a]	Order	Family	Common Name	Indians Consume	Bakairi Consume
	Artiodactyla	Tayassuidae	Peccary, wild pigs	X	X
		Cervidae	Deer	X	X
Aves	Rheiformes	Rheas	Emas	X	X
	Tinamiformes	Tinamidae	Tinamous	X	X
	Ciconiiformes	Ciconiidae	Herons, storks, flamingos	X	—
	Anseriformes	Anatidae	Ducks, geese	X	—
	Falconiformes	Catharitidae	Condors, buzzard	—	—
		Accipitridae	Hawks, vultures, harpy eagle	—	—
	Galliformes	Cracidae	Pheasants, quails	X	X
	Gruiformes	(various)	Seriemas	X	X
	Psittaciformes	(various)	Parrots, macaw, parakeets	—	—
	Piciformes	Ramphastidae	Toucans, wood-peckers	—	—
	Passeriformes	(various)	Song birds	—	—

Table 3-8—Continued

Class[a]	Order	Family	Common Name	Indians Consume	Bakairi Consume
Reptilia	Chelonia	(various)	Tortoises, turtles	X	X
	Crocodilia	(various)	Crocodilia, cayman	—	—
	Lacertilia	(various)	Lizards	X	X
Insecta	Orthoptera	(various)	Grasshoppers	X	—
	Isoptera	(various)	Termites	X	X
	Anopleura		Lice	X	X
	Siphonaptera		Fleas	—	—
	Diptera	(various)	Flies, mosquitos	—	—
	Hymenoptera	(various)	Wasps, bees, ants	X	X

[a]Information compiled from Gilmore (1950), Villas Boas (1976), von den Steinen (1940), and field notes.

food resource. Although monkeys are consumed by a great many indigenous groups, the Bakairi prefer not to eat them. The Indians claim they are too difficult to catch. The order Endentata which includes armadillos and anteaters represents an important food source for the Bakairi. Although the Indians do not consume sloths, the other two families, anteaters and armadillos, are extremely popular and eaten quite frequently. Rodentia is another important order. Although rabbits, porcupines, and rats are not consumed by the Bakairi, agoutis, capybara, and paca are an important source of food for the group. Capybara and paca are also considered obnoxious pests who raid the Indians' gardens so their elimination often has a dual purpose. The Carnivore order is interesting for several reasons. The Procyonidae, Mustelidae, Felidae, and Canidae families are all well represented in the reserve. Jaguar and fox tracks are regularly seen around the gardens and on the paths in the reservation. In addition, otters and iraras are often spotted on the rivers when the men are fishing. However, these animals are not hunted and never eaten by the Indians. The one time that a jaguar was accidentally killed during a community hunt and brought into the village where the men were going to skin it, a terrible uproar ensued. The elders of the community made it clear that the animal's carcass was to be taken out of the village immediately. The Perissodactyla and Artiodactyla orders, represented in the reservation by tapirs, peccaries, wild pigs, and deer, are highly desirable and eaten frequently by the people.

A large variety of birds inhabit the reservation. Emas are abundant and often eaten by the Indians as are tinamous which resemble partridges. Quails and seriemas are also eaten, but herons, storks, hawks, harpy eagles, and vultures are avoided. Parrots, parakeets, macaws, and toucans are kept as pets, and their feathers are used by the Indians for body and arrow decorations. It is interesting to note that bird as well as fish and bat motifs are employed by the Bakairi in the decoration of their ritual masks. During the dry season the Indians attired in palm and wood masks dance several times a day around the village. The Indians claim the dancing increases the fertility of the birds and fish, which suggests that these two types of organisms are of central dietary importance. No terrestrial animal motifs are employed in the decoration of ritual masks.

Reptiles and insects consumed by the Bakairi include turtles and turtle eggs, lizards, roasted termites, and honey from bees. Land tortoises, *Testudo tabulata*, are often captured and raised as pets before they are killed for their meat. River turtles, *Podocnemis expansa*, are mainly exploited for their eggs. When the water in the river is at its lowest, the adult females move to the sand bars and beaches of the river where they lay their eggs at night. Gilmore argues that they choose the beaches in the area for their fine texture of sand, high elevation but close proximity to the water, and the relative absence of enemies (1950:401). After about a month, the eggs hatch and the baby turtles make their way to the river water. Usually the exodus occurs during the night because predators are relatively scarce at that time. However, some eggs hatch during the following day when the turtles' chances for survival are poor. The Indians will depend solely on eggs, rice, and manioc for a month or so at the end of the dry season. August is usually a time of abundance of food in that the fish are plentiful since the water is low, and the women and children spend time on the beaches collecting the turtle eggs. Nonetheless, the Bakairi point out that the beaches where the turtles normally lay their eggs are not as plentiful as in past times. These areas are being covered by vines and other succession vegetation, which makes it increasingly difficult to find the egg areas. Cayman are plentiful in the area, but the Bakairi do not exploit them. Snakes are also common. Jararacas (Bothrops, sp.), rattlesnakes, bushmasters, boa constrictors, anacondas, and surucucu (Lachesis muta) are found in the reservations. However, the Indians kill and bury them rather than consume them. Lizards are represented by many species both large and small. The Bakairi will only occasionally trap and eat one; they are not considered highly desirable. Termites are also consumed irregularly. These insects live in arboreal nests which are composed of anal secretions or in surface nests of earth cemented with saliva. The insects are eaten roasted. Many other kinds of insects are commonly found in the reservation, but the only other ones of dietary importance are bees. Although honey is very desirable, the Indians consume it infrequently due to the difficulty associated with securing it.

The Bakairi diet, which will be discussed more fully in Chapter 5, is highly varied. However, it is selective in that it does not encompass all the organisms that inhabit the reservation. The Bakairi have their culinary preferences as do all other groups. Therefore, in order to estimate faunal biomass and energy utilization in the reservation for the Bakairi energetics model, it will be necessary to broaden the scope of our discussion. For example, although the Bakairi do not consume bats and carnivores, they are well represented in the reservation and play an important part in the functioning of the total ecosystem. Thus, they must be considered in the construction of the animal biomass consumer variable.

Documentation of available animal biomass in Tropical Rainforests has become a controversial subject in recent years (Gross 1975, n.d.; Divale and Harris 1976; Beckerman 1979, 1980; Chagnon and Hames 1979; Werner, Flowers, Ritter and Gross 1979; Diener, Moore and Mutaw 1980; Kiltie 1980; Ross 1978). The argument has its roots in the energetics principle that dilute energy can be concentrated through the degradation of energy, into high-quality energy capable of doing more work. Tropical Rainforests are a kind of dilute energy which is transformed into more concentrated energy by animals. Viewed from this perspective, the animal biomass in the Tropical Forest represents the efficiency of this particular natural system. Efficiency here is defined as the ratio of desired energy output to all energy input. In examining this problem of efficiency of the forest, researchers continue to analyze the foodbase or potential energy the forest can provide the fauna (Farnsworth and Golley 1974; Bourliere 1973; Fittkau and Klinge 1973). The conclusions that these researchers draw is that food availability for all animals, and especially for mammals and birds, is low. Bourliere (1973) discusses the subject in terms of vegetation layers in the forest. He argues that a large number of diverse habitats exist within the various layers that structure the forest ecosystem. The number of habitats, or niches, is high; however, each habitat is necessarily limited in area and thus, the amount of food it can provide any one genus. In addition, organic matter which seems plentiful is limited due to the rapidity with which it decomposes in the high temperatures and humidity that characterize the Tropical Forest. Farnsworth and Golley (1974) add that food for mammals is further limited in the forest because most of the above-ground plant mass is wood.

In this environment where food is scarce and unevenly distributed in time and space, fauna adapt in a variety of ways. Mammals, for example, have low reproductive rates (Farnsworth and Golley 1974) and, as a result, low population densities (Bourliere 1973). In addition, the majority of mammals are solitary with the exception of some rodents and primates. Furthermore, Bourliere estimates that 45 percent of nonvolant mammals are located in the canopy or the upper storey of the forest, rather than on the ground where food is less abundant. Eisenberg and Thorington (1973) found in their studies of the Barro Colorado Islands and of a site in Surinam that sloths and howler monkeys, both arboreal mammals, comprise some 71 percent of the nonvolant terrestrial mammal population of the former and 29 percent of the latter. Bats are also heavily represented. Although some researchers estimate that these flying mammals are equal to the biomass of all other mammals, Odum (1970) and Eisenberg and Thorington (1973) disagree. They estimate that bat biomass equals no more than 10 percent of total nonvolant mammalian biomass. The domination of these kinds of mammals in the Tropical Forest underlines the importance of relative food availability. Bats as well as certain families in the Endendata and Primate orders rely on diets which are based on ants, termites, and "browsing," all of which are stable food or energy resources in the Tropics. Thus, the species of these orders are more highly represented.

The high species diversity/low population density hypothesis is the result of energetics assumptions made on the basis of food availability in the myriad niches that comprise the Tropical Forest. It should be stressed here that the hypothesis, although well reasoned, is still tentative due to the absence of comprehensive data of total mammal fauna in Tropical Forests (Farnsworth and Golley 1974; Bourliere 1973). This paucity of data presents certain difficulties for the construction of the Bakairi animal biomass variables. We are forced to return to some of the estimates for fauna and mammal biomass that have been previously mentioned as well as to introduce some other research.

In 1970, Odum published the results of the Puerto Rico Tropical Forest study. In it he estimates that animal biomass in a Tropical Forest amounts to 11,800 kg/km^2 (dried matter) or 11.8 m^2. One percent of this, .118 g/m^2, consists of birds and mammals. Both Beckerman (1979) and Eisenberg and Thorington (1973) contend these figures are extremely low due to both historical and ecological factors. Fittkau and Klinge (1973) estimated total animal biomass of a Tropical Forest to be 20 g/m^2 (wet weight). However, a full 75 percent of this is made up of soil fauna and insects. Moreover, of the 5.0 g/m^2 remaining, only a percentage, perhaps 60 percent, is composed of mammals, reptiles, and birds. Beckerman (1979) argues that Fittkau and Klinge's site had been subjected to hunting pressures. However, since he argues within the context of the development of an historical construct whereby aboriginal population densities can be estimated, it seems that Fittkau and Klinge's estimate can be considered realistic assessments of biomass levels as they currently exist in many parts of the Tropics. Eisenberg and Thorington (1973) also present mammalian biomass figures. They draw on the previously mentioned studies of the Barro Colorado Islands and of Surinam. Nonvolant terrestrial mammal levels are set at 5.3 g/m^2 (wet weight) on the Islands and 3.1 g/m^2 (wet weight) in the Surinam site.

In order to estimate mammalian biomass for the Bakairi reservation, the Surinam figure of 3.1 g/m^2 (wet weight) will be employed. To this nonvolant mammal biomass figure, another 10 percent must be added for bat biomass (Eisenberg and Thorington 1973:155). Furthermore, avifauna biomass figures must be considered. Karr estimates standing bird biomass in the Neotropics to be .1317 g/m^2 (wet weight) (1975:165). The sum of these figures equals 3.67 g/m^2 (wet weight). The Surinam figure was chosen for a number of reasons. In the first place, Surinam is part of the South American mainland whereas Puerto Rico and the Barro Colorado Islands are enclosed systems subject to different ecological and historical factors not present on the main continent. Furthermore, Beckerman, and Eisenberg and Thorington, cite problems with these two island studies. In addition to the unusually low animal biomass figures Odum derived, which may be attributed to ecological factors, the Barro Colorado Island study also underrepresented tapirs and deer, important Bakairi food resources. Eisenberg and Thorington posit that poaching or isolation may have resulted in these low levels which do not exist in the Surinam data (1973:151). In addition, the Fittkau and Klinge estimate of 3 g/m^2 mammals and birds is relatively close to the 3.67 g/m^2 terrestrial animal-bird reading that the Surinam study evolved. Both areas are classified as previously hunted which matches the Bakairi situation.

In Figure 3-11, the mammal-bird consumer variable for the Bakairi energetics diagram is presented. Mammal-bird energy consumption is set at 3,500 kcal/ha/day as is estimated by Eisenberg and Thorington (1973: 159). This estimation is supported by Farnsworth and Golley (1974:86) and Odum (1975:66) who figure that animal biomass consumes less than 10 percent of energy available from primary production. Basal metabolic rate of these animals is represented by the heat sink of the variable, or Rate 11. Basal metabolic rate (BMR) is estimated to be 1,600 kcal/ha/day (Eisenberg and Thorington 1973:159). Rate 10 and Rate 12 are slightly more problematic. Odum estimates that in the food chain, available energy for the next higher level is reduced to 10-20 percent of the original amount of energy. Thus, Rate 12 would be approximately 15 percent of Rate 9 (Odum 1975:66). Then assuming that Bakairi hunting has little impact upon the animal population in the reserve and that the fauna can regenerate itself (see Chapter 5), Rate 10 is equal to the difference between Rate 9 and the sum of Rate 12 and Rate 11.

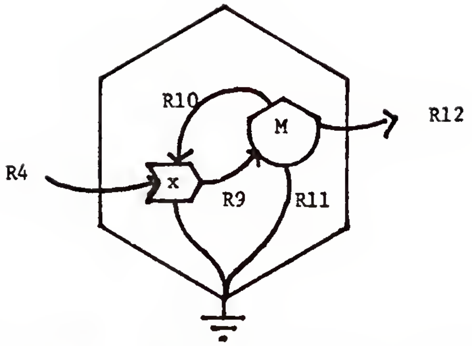


Figure 3-11. Forest mammals and birds in the Bakairi reservation model

The cerrado in the Bakairi reservation is inhabited by two kinds of animals: natural fauna and cattle. The natural faunal types include birds, snakes, amphibians, lizards, insects, and medium-sized mammals such as deer and rodents. Unlike in the grasslands of the African Tropics, no large mammals occupy the grasslands of the Neotropics. Fittkau comments on the faunal poverty of the cerrado. He suggests that this particular biotrope is not fully occupied indicating that these ecological areas are not as old as the Tropical Forest areas. They evolved too recently to have developed their own life-form types (Fittkau 1969:638-639). For example, 87 major genera occupy the forest areas while only 49 genera inhabit the cerrado areas (Olrog 1969:860). The most commonly found organisms in the latter are the deer, rhea, seriema, tinamous, parakeet, macaw, rattlesnake, and bushmaster.

Lamotte sets cerrado faunal biomass at 80 kg/ha (1975:217). Although her material is collected in the African Tropics, her estimations will be used here because her plant biomass figures, 6 kg/m^2,

Table 3-9. Evaluation, name, and description of the energy storage and flows associated with the forest mammals and birds in the Bakairi reservation model

Energy Flows and Storage	Names of Flows and Storage	Values (Kcal/Year)
M	Mammal Biomass	5.07×10^{8}
R4	NPP of Forest	6.35×10^{11}
R9	Biomass Consumption	9.70×10^{9}
R10	Population Feedback	3.81×10^{9}
R11	Biomass BMR	4.43×10^{9}
R12	Biomass Yield	1.46×10^{9}

Table 3.10. Evaluation, name, and description of the energy storage and flows associated with the *cerrado* animals in the Bakairi reservation model

Energy Flows and Storage	Names of Flows and Storage	Values (Kcal/Year)
D	*Cerrado* Faunal Biomass	1.89×10^{10}
R8	*Cerrado* NPP	1.61×10^{12}
R13	Consumption	3.62×10^{11}
R14	Population Feedback	1.63×10^{11}
R15	BMR	1.63×10^{11}
R16	*Cerrado* Fauna for Exploitation	3.62×10^{10}

are similar to the Whittaker and Likens figures, indicating that certain ecological features are shared by the two areas. Furthermore, large mammals, such as antelopes, buffalo, and elephant play an insignificant role in her study site (Lamotte (1975). If they had been present, it would have been imposible to use her biomass figure because these large mammals are, of course, absent in the Neotropics. Finally, her faunal biomass breakdown matches Mato Gross's so that the figure of 89 kg/ha or 8 g/m^2 can be used with relative confidence. For example, birds are estimated to represent .1075 g/m^2 (1975:196), snakes .00465 g/m^2 (1975: 197), amphibians .0035 g/m^2 (1975:197), lizards .0029 g/m^2, rodents .14 g/m^2, and termites .12 g/m^2 (1975:209). The last figure on termites is particularly interesting. The Bakairi roast and consume these insects principally during the rainy season when fish are scarce. (They also consume lizards during the rains suggesting that the cerrado becomes an important food resource area during the rainy season when the waters are high and the fish difficult to catch.) Lamotte states that in these grassland areas, 60 nests/ha inhabited by 1.3 million individuals on the average can be found (1975:209). This estimate of 1.2 kg/ha (dried weight) of termites indicates that there is some 51,100 kg of termites available in the reservation for exploitation purposes at any one time. That the Bakairi do not choose to consume these organisms any more frequently than they do underlines the importance of cultural food preferences in resource exploitation.

To the natural faunal biomass figure, cattle biomass must be added. The mid-year count of the Bakairi cattle was to 400 head. Two hundred twenty-nine adults at an average of 200 kg each, 50 immature cattle at 100 kg each, and 121 calves at an average of 50 kg forage off of the cerrado. In dried weight, 18,760 kg or .044 g/m^2 of cattle inhabit the reservation. This is lower than the medium-sized rodent readings for these grasslands, indicating that the Bakairi herd could be safely increased. Indeed, according to the Indian Foundation reports and to the Indians themselves, the 400 head herd is very small in comparison to what once existed in the area. The Bakairi have a long history of cattle raising due to the fact that the Indian Protection Service encouraged them to raise cattle. In 1921, only about 50 head of cattle existed; however, during the 1940s and 1950s, herds of up to 1,000 head of cattle inhabited the reservation. These cattle, as with today's herd, were not owned by the Indians. Rather the Indian Foundation technically owns and controls them so that the Indians are not allowed to slaughter or sell a head without permission from headquarters, In addition, when a Foundation representative is in the reservation, he is required to complete a monthly report on the state of the herd for Foundation files.

In order to estimate consumption and yield of the cerrado animals, Lamotte estimates that yield is some 10 to 11 percent of consumption (1975:198-199). This assumption is supported by Odum (1975: 66-67). However, the yield of cattle is extremely low in comparison to other organisms. The conversion rate of energy is equaled to 3 to 4 percent, although a net dietary gain for human populations is usually recorded because these animals are able to digest high cellulose materials that humans cannot consume (Janick, Noller, and Rhyherd 1976: 84). Consumption of cerrado fauna is estimated to be 2,000 kg/ha/year

(Lamotte 1975:216). Consumption of an adult cow is estimated to be 8,000 kcal/day (Odum 1971:109), or 27 kcal/kg/day. Energy expended on basal metabolism and population feedback is high. Odum estimates it to be 89-90 percent of total energy consumption. In Figure 3-12 and Table 3-10 estimations for the energy flows and storages in the cerrado subsystem are compiled. Of particular interest is the percentage of cerrado net primary productivity consumed by cerrado fauna compared to the corresponding organic material consumed by the gallery forest animals. Over 22 percent of the cerrado NPP is consumed by the fauna in that environment while only 1.5 percent of the gallery forest NPP is exploited by the forest organisms. Part of the explanation for this discrepancy lies in the fact that the gallery forest consumer variable does not include microorganisms and insects which constitute the bulk of terrestrial forest life. The cerrado consumer variable, on the other hand, is more inclusive in that it considers such insects as termites which the Bakairi gather. Faunal biomass figures also reflect this difference in definition. The discrepancy in consumption by the two consumers can also be attributed to the nature of the ecological systems themselves. Herviborous animals of the cerrado exploit a wider range of foods than do those in the forest due to the distinctive structure of the Tropical Forest (Farnsworth and Golley 1974:87).

Aquatic fauna is a very important resource for the Bakairi Indians, who are adapted to a riverine existence. They depend heavily upon a variety of fishes throughout the year although they tend to consume more fish during the dry season. The Bakairi fish in all of the rivers in the reservation; however, the Paranatinga, Azul, and Vermelho are the most important sources of aquatic wildlife. The Paranatinga River, because of its size and proximity to the village, is by far the most important source of all of them. It has already been established that the Paranatinga, a headwater of the Tapajos, is clear water, which suggests that although sediment and nutrient levels are low, light penetration is high. Thus, some phytoplankton is produced, and this material coupled with the organic matter from the surrounding forests, provides the food supply for the herbivores, and indirectly for the carnivores.

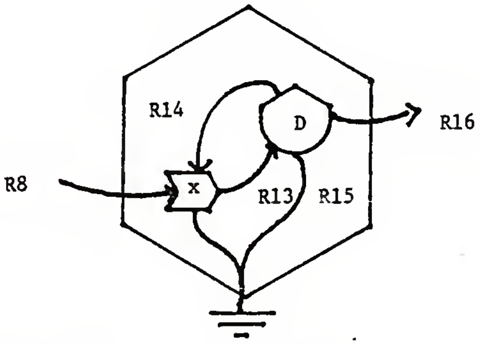


Figure 3-12. Cerrado animals in the Bakairi reservation model

In forest streams, such as the rivers in the Bakairi reservation, detritus amounts to approximately 1 kg/dried matter/meter of length/year (Hynes 1970:433). Depending upon the system, this debris can amount to 30-66 percent of the energy consumed by the aquatic organisms. In narrow streams, energy provided would be greater than in wider streams where the forest litter would have less of an impact.

Detritus input is estimated to be 5.47 x 10^8 kcal/year for the reservation area. This organic matter serves to feed invertebrates, insects, and vertebrates such as fish.

The determination of fish biomass and yield of fish on Tropical rivers has become a problematic subject. When Gross, based on estimates provided by Hickling (1971) and Cable (1971), suggested that Tropical rivers are capable of yielding 5,000 kg/km^2/year of fish (1975:528; n.d.:20), Beckerman criticized him for using data collected in United States fisheries and African lakes to derive figures which he considered to be undergenerous estimations of actual fish yields in Tropical rivers (1979:535). However, data on secondary production, in general, and on fish production, in particular, are extremely difficult to collect. Most of the quantitative research that has been done on streams deals with specific species present rather than total biomass and energy yield of all available fish. In addition, most of the study sites are located in the United States and in Europe (Hynes 1970:418-442,292-293). An exception to this is Patricks' (1964) work which examined numbers of species, rather than numbers and body weights of representatives per species, in the Amazon headquarters.

Work on tropical lakes is more common; however, a disproportionate amount of this research has come from the African continent. Farnsworth and Golley note that since there is no reason to anticipate radical ecological differences between the African and South American continents, reliance upon the African data is justified due to its relative completeness (1974:87). Hickling's data on African lakes indicate that fish productivity at these sites ranges from 8,000 kg/km^2/year to 16,500 kg/km^2/year (1975:42). The higher fish yields characterize the more shallow tropical lakes. However, fish productivity in lakes is generally higher than it is in streams where competition for a place in the ecosystem is fierce (Hynes 1970:442). Streams can be distinguishsed by, among other factors, current. Flowing water not only can carry the fish into unsuitable environments, but it also has the capacity to erode and modify the physical and chemical nature of the river habitat on which the fish depend (Reid and Wood 1976:391). Therefore, although Hickling's estimation of 8,000 kg/m^2/year for lake fish productivity may be considered the upper limit for stream productivity in a Tropical area, average figures for rivers will surely be lower than this.

Based on data provided by Odum's Silver Spring study, estimations of river fish yields have been made which are higher than Gross's figures but lower than the range put forth by Hickling and Beckerman. In Figure 3-13 and Table 3-11, details of consumer energy flows and storage are presented. Aquatic consumer biomass is estimated by Odum to be 53.6 g/m^2. This figure includes such herbivores as microfauna and such carnivores as leeches and insects. However, perhaps 20 percent of the biomass is carnivorous and top carnivorous fishes which people can catch and consume. Of the total amount of energy that flows from primary production in the river and from the detritus of the gallery forest, approximately 38 percent is actually consumed by the secondary consumers in the river. In turn about 65 percent or more is used in the metabolic processes, leaving some 34 or 35 percent of the energy left over. Of this net yield of energy only 6.35 percent, or 7.24 x 10^7 kcal/year or 7,489 kg/km^2/year. This pool of energy constitutes the major protein source of the Bakairi diet.

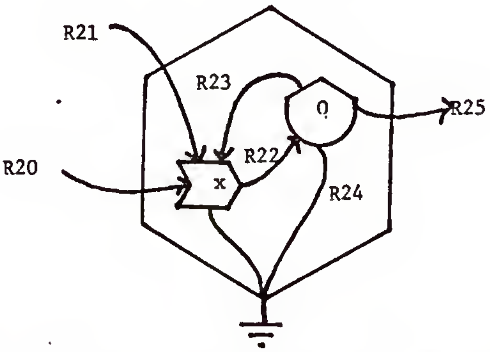


Figure 3-13. Aquatic consumers in the Bakairi reservation model

In this chapter, the microcosm of the Bakairi was introduced. Salient points made about their reservation include the unbalance between the amounts of land covered by gallery forest and cerrado, and the pressure from the outside world, in the form of surrounding ranchers, on the reservation preventing the Indians from expanding their territory. In addition, the Bakairi ecosystems was divided into subsystems on the basis of Bakairi exploitation of their environment. With the goal of ultimately understanding the Indians' method of exploitation of these subsystems, the energy flows within each area defined were discussed in detail.

Table 3-11. Evaluation, name, and description of the energy storage and flows associated with aquatic consumers in the Bakairi reservation model

Energy Flows and Storage	Names of Flows and Storage	Values (Kcal/Year)
Q	Aquatic Biomass	1.42×10^9
R20	NPP of Rivers	8.22×10^9
R21	Organic Imports	5.47×10^8
R22	Consumption	2.27×10^9
R23	Self-Maintenance	1.10×10^9
R24	BMR	1.10×10^9
R25	Fish Yield	7.24×10^7

CHAPTER 4
BAKAIRI DEMOGRAPHY AND NUTRITIONAL STATUS

The Bakairi reservation is inhabited by 288 Indians. Of these 288, 259 Bakairi live in the village, 12 individuals live approximately 1 km away from the village on the banks of the Azul River, 14 live some 10 km away in a distant set of gardens, and three live about 4 km away on the Paranatinga River. A total of 59 households make up the Bakairi community; however, only 54 of these households are located in the village proper. Two households are located on the Azul River, two are located in what the Bakairi refer to as the Paraisso, and one is located downstream on the Paranatinga River. The village is not laid out in an elliptical or circular pattern as are those villages found in the Xingu culture area. Rather, the main axes of the village make up a "T" shape, and the traditional men's house is found where the two axes intersect. Now that the Bakairi population is growing once again, households are springing up irregularly, filling up the spaces around the two axes and stretching down to the river banks. It was not always like this. The Bakairi speak often of the time when the village was only a short straight line of houses, and the very old still tell stories about when there was no village at all, but only houses attached to gardens scattered through the general area.

From the map below the general layout of the village is clear (see Figure 4-1). Two main parts constitute the community: the village

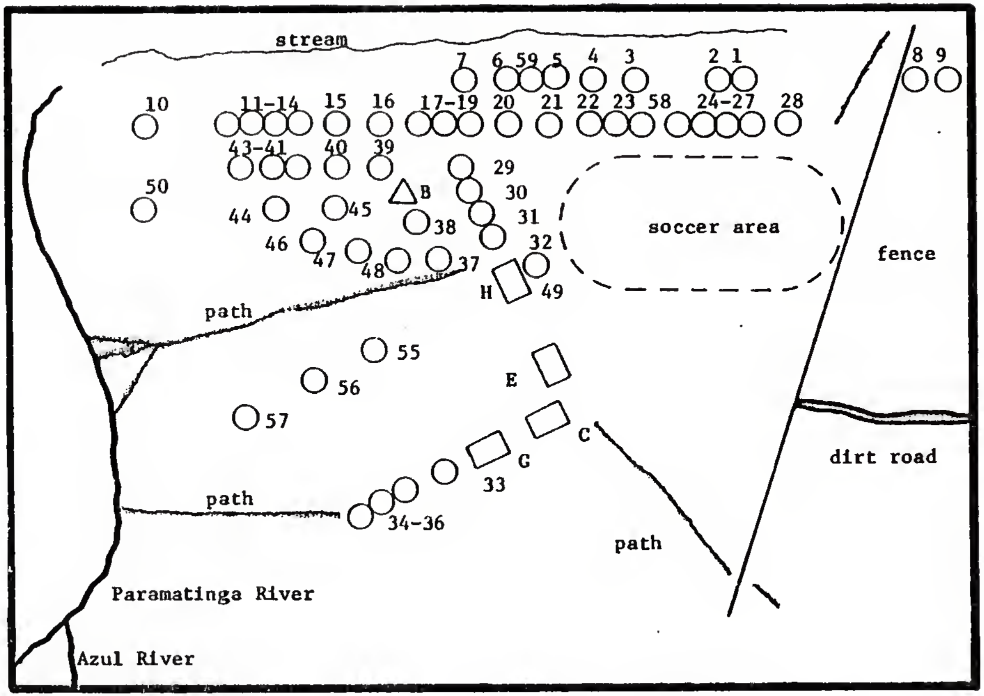


Figure 4-1. Bakairi village, P.I. Bakairi, Mato Grosso, Brazil

Table 4-1. Bakairi village by household

Household Number	Household Head
1	Chico Xerente
2	Timoteo
3	Jose Nunez
4	Zito
5	Euclides/Evaristo
6	Daniel
7	Macedonio
8	Braulio
9	Ubaldo
10	Tomas
11	Getulio
12	Carlos
13	Antonio Rondon
14	Felix/Roberto
15	Ramiro/Joaquim
16	Anisio
17	Militao
18	Empty
19	Bertino
20	Armando
21	Fernando Maiuka
22	Geraldina
23	Ademir

Table 4-1—Continued

Household Number	Household Head
24	Moises
25	Astrogilda
26	Severiano
27	Alcindo
28	Maria Makalo/Joel
29	Vitorino
30	Otavio
31	Euclides
32	Beatriz
33	Paulino
34	Florizel
35	Rafael Xerente
36	Aquilino
37	Juliano
38	Roldão
39	Felinto
40	Rachids
41	Itacy
42	Moacyr Mandakai
43	Laurinda
44	Armindo
45	Jose Kamiare
46	Gilson

Table 4-1—Continued

Household Number	Household Head
47	Moacyr
48	Verissimo
49	Laurival
50	Odil
55	Vincente
56	Jeremias
57	Belinho
58	Martinha
59	Manoel Kwigi
H	Hospital/Infirmary
B	Men's House—Casa Bakururu
C	Indian Protection Agent's House
E	School
G	Garage
Houses on the Azul River	
51	Rafael P.
52	Leonardo
Pariasso Households	
53	Estenio
54	Pedro
Downstream on the Paranatinga River	
60	Davi

itself with an adjacent field in which the Indians play soccer and the Indian Foundation post where the Foundation agent's house, the school, the garage, and the infirmary are located. The post area was constructed between 1940 and 1947 under the auspices of the Indian Protection Service. The Indians provided the labor, and the Indian Protection Service provided the raw materials with which to construct the buildings. The infirmary, schoolhouse, and Foundation agent's house as well as the garage are all made of cement on top of wood with tile roofs. The garage building is now used to house and repair the Bakairi truck; however, in the past it was used to store products from the Bakairi gardens that the agent would collect and sell outside the reservation. A large elevated water tank is located outside the infirmary. The Bakairi say that at one time it was filled with water. However, now it serves no purpose as there is no way to get water from the river or one of the two wells to the tank for storage. Water in the infirmary is not a real necessity at this time. The structure is abandoned except for bats and other pests, and the Indians refuse to go near the building when it is dark as they say the spirits of the dead inhabit the place. Apparently, during the 1950s and 1960s, the time of the great measles and tuberculosis epidemics, many Bakairi died in the infirmary, and their spirits remained there. The Bakairi _attendante_, or nurse's aide, does have a small room in the building. She attends clinic two hours in the morning and two hours in the afternoon, when it is still daylight. The schoolhouse and the quarters of the agent are closed up or used for storage of cattle materials and rice or corn seeds except when a school teacher or agent are in the reservation. Then, these structures are inhabited by non-Indians at least for a short while, and the Indians tend to visit that part of the village. Otherwise the outlying post area remains deserted except for people passing through on their way to the gardens and to the Azul River.

The second part of the village is composed of the 54 households and the men's house. The houses are made of clay, palm thatch, and wood. A house is constructed by a man and his male kinsmen erecting a wooden frame. Then a mutirão, or a communal labor effort, is organized, and all the men join together to help the household owner slap wet clay up on the walls of the house. After the clay has dried, the household owner cuts palm thatch in the forest and transports it to the village where the thatch is bent over long wooden slats in order to make a waterproof roof. Roofs are ideally erected at an acute vertical angle so that the water will run off the palm rather than drip into the house. Also if the roof is too flat, the water will remain in puddles and eventually saturate the thatch precipitating decomposition. The wooden and clay parts of a house can last up to seven years; but a roof must be replaced every five years.

Bakairi houses have a minimum of two internal divisions, two windows that can be shuttered, and two doors. Larger houses have three internal areas; however, this depends on the number of people living in the household. Kitchen areas can be located inside the houses or in a separate kitchen structure which is constructed in the back of the house. Cooking takes place over the fire although some

Bakairi are now arranging large stones around their cooking fires, giving the impression that a cooking platform exists. Food preparation takes place on the dirt floors. Cooking can be directly on the fire, when, for example, fish or game are roasted, or it can be in pans when, for example, fish are boiled into a soup or corn is boiled into a gruel. Inside the house, little furniture is found. The Indians sleep in hammocks at night, and during the day the hammocks are either raised above the rafters to make more space or used for chairs. Some families have makeshift shelves leaning against a wall; however, for the most part, people string line from one wall to another and hang their belongings from the lines. Both the line and the shelves serve to protect clothes and other objects from dust and pests such as cockroaches, spiders, and snakes. In front of each house there is a bench where people sit during the hottest part of the day or during the evening hours when visiting occurs. These benches can be traditionally carved pieces of wood or they can be pieces of plank nailed together. Dried skins are also used. During the day, the skins can also be pulled in front of the house for the children to play on or for adults to work upon.

Houses are cleaned every morning after the men have eaten and gone to the men's house to plan their day's activity. The women use thatch brush to sweep out the trash that has accumulated in the house, and to uncover a fresh layer of dirt. After sweeping, water is sprinkled on the floor to settle the dust. Rubbish is burned in back of the house or simply swept into the brush that borders the back area of the village. Some latrines have existed in the Bakairi reservation since 1976. The Indian Foundation encouraged the Indians to build these structures because of the growing number of people in the community. However, only some of the houses have this feature, and even where they exist, the children refuse to use them. In addition, the Indians believe that the latrines have attracted the large numbers of mosquitoes that now plague the village. Also, they fear the possibility of malaria which they know is associated with the insects and which is not endemic to their region. Thus, latrines are not as popular now as they were when the Indian Foundation first introduced them.

The Bakairi have three main water supplies. Of the three, the Paranatinga River located 800 meters from the village, is the most widely used all year round. The Indians descend to the banks of the river at least three times daily in order to bathe, socialize, and collect water which is carried up to the village in large buckets or cans by the women. The women also wash clothes at the river using the large smooth stones on the banks as wash boards. A second source of water is the stream that runs in back of the village (see Figure 4-1). The water in the stream dries up early in the dry season so that although it is closer than the river, it is not a constant source. A third source of water is the two wells that were dug by the Indian Protection Service in the 1940s. One of these wells dries up during the dry season but the other can be used all year round although its water becomes very muddy in mid-dry season. With regard to distance from the village, the wells are the closest and the river is the farthest away, so that we would expect to see the wells used most frequently for water collection. However, the wells are actually used the least frequently because the water has a great deal of sediment in it, especially as the dry season approaches. It also does not taste good according to the Bakairi. Finally, snakes live around the wells making it dangerous to approach the areas. On the other hand, although the village lies downstream from the minicipal capital on the Paranatinga River, the water there is still cleaner at least at this time. In addition, due to the fact that socializing, clothes washing, and bathing occur at the same time as water collection, the Indians tend to rely on the river more to accomplish a number of tasks at the same time.

Marriage and Household Composition

Bakairi households are small. In Table 4-2, it is clear that the majority of households are composed of between three and six individuals with a mode and median of four individuals. The mean is only slightly higher, 4.88 ± .478 people. In each household, a married male and female constitute the core. Children, young married couples, their children and the parents of one or both of the core male-female unit make up the peripheral individuals. Of the 59 Bakairi households 47 (80 percent) were made up of a single married core couple, six (10 percent) had two married couples living on the premises, and six (10 percent) were composed of a widow or widower core. In the six cases where two married couples lived together in one house, the situation was considered temporary in only two of the households. In these cases, the daughters of the core couple had just married and were awaiting the

Table 4-2. Bakairi household composition by number of individuals

Number of People in Household	Households		
	N	%	Cum. %
1	1	1.7	(1.7)
2	1	1.7	(3.4)
3	12	20.3	(23.7)
4	15	25.4	(49.1)
5	9	15.3	(64.4)
6	14	23.7	(88.1)
7	2	3.4	(91.5)
8	2	3.4	(94.4)
9	1	1.7	(96.6)
10	1	1.7	(98.3)
11	1	1.7	(100.0)
Total	59	100.0	(100.0)

birth of their first child before building and moving to their own homes. In the other four cases, aging parental couples lived with and were cared for by middle-aged daughters and their husbands.

Marriages among the Bakairi are fairly stable. Of the 99 menstruating or post-menopausal women in the village, 60 (61 percent) were married. One woman (1 percent) had been divorced and remarried, three (3 percent) were divorced and living with their families of orientation, seven (7 percent) were unremarried widows, and five (5 percent) were remarried widows. Twenty-nine marriageable women lived in the village (see Table 4-3).

Marriage among the Bakairi takes place early although women are marrying later now. Twenty years ago it was not unusual for a 13-year-old girl to be married, but now women wait until they are older. From Table 4-4, one can see that 8 (28 percent) of the 29 marriageable women are over 20 years of age, which is considered quite old by Bakairi standards. There is a good possibility that these women will never marry unless they are able to arrange a marriage with a widower. However, there is a surplus of females in relation to the pool of marriageable males which makes this possibility unlikely for the older unmarried women. This topic will be discussed in greater detail in the population section. At this point, it is sufficient to compare column 1 and column 2 in Table 4-4 to see that females (29) outnumber males (27). In addition, if one considers that males cannot marry until they are older than 15 years because the Bakairi do not consider them able to care for their own gardens and support a family until this age, the pool of marriageable males is still smaller (20 men to 29 women).

Table 4-3. Marriage among Bakairi women

	N	%
Married women	60	61
Divorced—remarried 1 (1%)		
Widowed—remarried 5 (5%)		
Married one time 54 (55%)		
Unremarried widows	7	7
Unremarried divorcees	3	3
Unmarried marriageable women	29	29
Total	99	100

Table 4-4. Marriageable Baikairi females and males according to age (divorced individuals are not included)

	Females			Males		
Age in Years	N	%	Cum. %	N	%	Cum. %
12	3	10.4	(10.4)	—	—	—
13	2	6.9	(17.3)	3	11.1	(11.1)
14	2	6.9	(24.2)	3	11.1	(22.2)
15	1	3.4	(27.6)	1	3.7	(25.9)
16	2	6.9	(34.5)	1	3.7	(29.6)
17	4	13.9	(48.4)	5	18.5	(48.1)
18	3	10.4	(58.8)	5	18.5	(66.6)
19	2	6.9	(65.7)	—	—	—
20	2	6.9	(72.6)	2	7.4	(74.0)
21	1	3.4	(76.0)	2	7.4	(81.4)
22	2	6.9	(82.9)	—	—	—
23	1	3.4	(86.3)	—	—	—
24	2	6.9	(93.2)	3	11.1	(92.5)
25	—	—	—	—	—	—
26	—	—	—	—	—	—
27	—	—	—	1	3.7	(96.2)
28	—	—	—	—	—	—
29	—	—	—	—	—	—
30	—	—	—	—	—	—
31	—	—	—	—	—	—
32	1	3.4	(96.6)	—	—	—
32	—	—	—	—	—	—

Table 4-4—Continued

	Females			Males		
Age in Years	N	%	Cum. %	N	%	Cum. %
34	1	3.4	(100.0)	—	—	—
35	—	—	—	—	—	—
Total	29	(100.0)		27	(99.9)	

Marriage is preceded by a great deal of experimental mating. As soon as a female passes through menses, she is a potential mate. Intercourse can take place in the gardens or forest, or in the girl's hammock. If it occurs in the girl's house, it takes place secretly and rapidly so that the couple will not be discovered. An affair can last for a week or several months. Reasons for termination of a relationship are parental objection, jealousy on the part of either the male or female, or pregnancy. In the case of pregnancy, the female has the option to abort using wild herbs, kill the child when it is born, or deliver and raise the child. Many unmarried women do not want to deliver and raise a child because of the economic burden and because caring for the child will remove them from the marriage pool for a critical two or three years, further reducing their chances for marriage. When a marriage is arranged, the parents of the couple meet and decide on the future of the couple, often without their knowing about it. In the typical case of Joel and Maria, the two widowed mothers arranged for their immediate union after they had been mating for only three days. The young couple was informed of the decision after the fact, and Joel moved his hammock to Maria's house within the week. Exceptions do occur. In the case of Odil and Inocencia, an elopement to a distant garden took place. Odil was married, and yet he convinced Inocencia to run way with him. They remained in the garden for three days waiting until Odil's wife moved back to her own home. Then the couple returned to the village.

Divorces are rare among the Bakairi. Only four divorced women, and no divorced men, live in the village. Marriages are normally very stable although physical abuse, adultery, and other problems occur. When divorce takes place, it is because the husband has taken a lover and she has become pregnant. Adultery is not grounds for divorce; however, a pregnancy is. When a married man impregnates a woman, his wife almost invariably leaves him. However, if the man does not marry his lover and if she, in turn, aborts or kills the child, the marriage between the original partners may resume.

Bakairi Weights and Heights Compared to General Standards

The unit of production and consumption in the Bakairi reservation is the household, which is usually made up of a core married male and female. This unit is responsible for providing sustenance and for dividing labor among all of its members. Food, goods, and labor flow outside of the household, especially to kinsmen; however, for the most part, they are concentrated within this unit of production-consumption. It is appropriate to ask at this time exactly how successful Bakairi households are in providing for their members.

In order to assess the nutritional status of a community, it is necessary to rely on a number of methods because each method in and of itself is imperfect and may be inaccurate. It is important not to overestimate the validity of the results of any one survey (Jelliffe 1966:170). Two types of investigations can be performed in order to assess nutritional status. The first type is referred to as a cross-sectional prevalence study. This investigation is undertaken for a short period of time in an effort to determine whether or not malnutrition exists in a population. Data collection in the form of anthropometric measurements, parasite infection, tuberculosis, and immunization records can be included. In a cross-sectional study, sampling is extremely important. Randomness and sample size must be carefully considered (Jelliffe 1966:142-143). The second type of survey is referred to as a longitudinal investigation. The results of this kind of study are included in this section. Data collection in basically the same areas as in the cross-sectional survey take place. Anthropometric measurements (height, weight, arm circumference, skinfold thickness), parasitology data, tuberculosis incidence, immunization records, and dietary histories are examined. However, in this type of survey, which lasts for at least one year, the annual incidence of malnutrition is determined while at the same time seasonal variations in community nutritional status may be distinguished. For example, longitudinal studies do not overestimate the impact of short-term diseases such as the Gillian Barre viral infection which occurred in the reservation and caused a short-term weight loss in children under two years of age, and weight loss and paralysis in some of the adults. However, they do determine the effects of long-term problems, such as beriberi, which are associated with poor nutritional status (Jeliffe 1966:134-135).

In this section, an examination of anthropometric measurements will be presented. A discussion of parasite infection, infectious disease, including tuberculosis and immunization, will be reserved for the following section. Analysis of diet will be included in Chapters 6 and 7. Results of anthropometric measurements will be reported in two ways: mathematically and in relation to standard references (Jelliffe 1966:167-168). Mathematical reporting will be given for each age group and sex as the mean plus or minus twice the standard error of mean. Measurements will also be compared to two standards: a general standard of reference and a local standard of reference. They will be reported in 10 percent categories below the standard. Moreover, problems associated with these standards will be discussed.

In Table 4-5 and Table 4-6 mean heights and weights of the Bakairi are presented. The people were weighted without shoes but with some light clothing. Weights are taken from the nearest half of kilogram and heights from the nearest half of centimeter. A Brazilian Fizola scale with a capacity toweigh up to 150 kg in 500 g intervals was used to weigh adults and a Fizola baby scale with a capacity to weigh up to 16 kg in 10 g intervals was used to weigh infants. In order to measure the length of small children as accurately as possible, they were stretched out on a table, with their pelvic and knee joints carefully extended, alongside of a measuring board which had been secured to the surface of the table.

In Tables 4-7 through 4-9, the Bakairi adult weight for height measurements are compared to general standards. These standards are adapted by Jelliffe (1966) according to frame size and nude measurements. They originally derive from tables prepared by the Society of the Actuaries. In Tables 4-10 through 4-15, the weight for height measurements of adolescents and children are included. These measurements are first compared to a general standard prepared by Jelliffe

Table 4-5. Mean weights of Bakairi Indians by sex and age group

Age in Years	N[a]	Mean Weight (kg)	2 X Standard Error of Mean
		Males	
0-3	15	8.0	±1.53
4-11	26	22.2	±2.90
12-19	23	51.0	±6.33
20-35	26	67.1	±3.51
36-50	19	66.2	±3.50
Over 50	11	57.9	±6.65
		Females	
0-3	17	7.6	±1.50
4-11	25	19.5	±2.52
12-19	29	43.9	±4.31
20-35	40	54.1	±2.21
36-50	19	55.4	±4.43
Over 50	12	49.7	±3.75

[a]Total number weighted is 262 or 91.0 percent of the population.

Table 4-6. Mean heights of Bakairi Indian by sex and age group

Age in Years	N[a]	Mean Height (cm)	2 X Standard Error of Mean
		Males	
0-3	15	67.0	±6.70
4-11	26	114.9	±5.66
12-19	23	152.4	±5.08
20-35	26	165.3	±2.02
36-50	19	162.5	±2.30
Over 50	11	160.6	±3.33
		Females	
0-3	17	69.3	±6.42
4-11	25	110.0	±5.63
12-19	29	144.0	±3.34
20-35	40	150.8	±1.22
36-40	19	150.6	±2.41
Over 50	12	148.8	±2.24

[a]Total number weighted is 262 or 91.0 percent of the population.

Table 4-7. Comparison of adult Bakairi male and female weights for heights to general standards (persons over 50 years of age)

% of Standard Weight for Height	Males		Females	
	N	Frequency	N	Frequency
70-79%	1	(9.1)	0	(0.0)
80-89%	2	(18.2)	1	(8.4)
90-99%	5	(45.4)	4	(33.3)
Standard	1	(9.1)	3	(25.0)
Over Standard	2	(18.2)	4	(33.3)
Total	11	(100.0)	12	(100.0)

Table 4-8. Comparison of adult Bakairi male and female weights for heights to general standards (persons between the ages of 36 and 50 years)

% of Standard Weight for Height	Males		Females	
	N	Frequency	N	Frequency
80-89%	1	(5.55)	2	(11.8)
90-99%	1	(5.55)	0	(0.0)
Standard	5	(27.8)	0	(0.0)
Over Standard	11	(61.1)	15	(88.2)
Total	18	(100.0)	17	(100.0)

Table 4-9. Comparison of adult Bakairi male and female weights for heights to general standards (persons between the ages of 20 and 35 years)

% of Standard Weight for Height	Males		Females	
	N	Frequency	N	Frequency
80-89%	2	(7.4)	0	(0.0)
90-99%	7	(25.9)	8	(20.5)
Standard	5	(18.5)	6	(15.4)
Over Standard	13	(48.2)	25	(64.1)
Total	27	(100.0)	39	(100.0)

Table 4-10. Comparison of male adolescent Bakairi weights for heights to general standards

Age in Years	N	Above Standard Weight for Height	Standard Weight for Height	90% Standard Weight for Height
12	2	1	0	1
13	4	4	0	0
14	3	3	0	0
15	2	2	0	0
16	1	1	0	0
17	6	6	0	0
18	5	5	0	0
19	0	0	0	0
Total	23 (100.0%)	22 (95.6%)	0 (0.0%)	1 (4.4%)

Table 4-10—Continued

Age in Years	N	Within Range of Predicted Weight/Height for Age	Below Range of Predicted Weight/Height for Age
12	2	2	0
13	4	4	0
14	3	3	0
15	2	2	0
16	1	0	1
17	6	5	1
18	5	4	1
19	0	0	0
Total	23 (100.0%)	20 (87.0%)	3 (13.0)

Table 4-11. Comparison of female adolescent Bakairi weights for heights to general standards

Age in Years	N	Above Standard Weight for Height	Standard Weight for Height
12	10	8	2
13	4	3	1
14	1	1	0
15	1	1	0
16	3	3	0
17	4	4	0
18	6	6	0
19	0	0	0
Total	29 (100.0%)	26 (89.7%)	3 (10.3%)

Table 4-11—Continued

Age in Years	N	Within Range of Predicted Weight for Height of Age	Below Range of Predicted Weight for Height of Age
12	10	9	1
13	4	1	3
14	1	1	0
15	1	1	0
16	3	3	0
17	4	2	2
18	6	2	4
19	0	0	0
Total	29 (100.0%)	19 (65.5%)	10 (34.5%)

Table 4-12. Comparison of male Bakairi children's weights for heights to general standards (persons between the ages of 4 and 11 years)

Age in Years	N	Above Standard Weight for Height	Standard Weight for Height	90% Standard Weight for Height
4	2	0	1	1
5	2	2	0	0
6	4	4	0	0
7	5	3	2	0
8	1	0	1	0
9	2	1	1	0
10	4	4	0	0
11	4	4	0	0
Total	24 (100.0%)	18 (75.0%)	5 (20.8%)	1 (4.2%)

Table 4.12—Continued

Age in Years	N	Within Range of Predicted Weight/Height for Age	Below Range of Predicted Weight/Height for Age
4	2	1	1
5	2	0	2
6	4	4	0
7	5	5	0
8	1	1	0
9	2	2	0
10	4	4	0
11	4	4	0
Total	24 (100.0%)	21 (87.5%)	3 (12.5)

Table 4-13. Comparison of female Bakairi children's weights for heights to general standards (persons between the ages of 4 and 11 years)

Age in Years	N	Above Standard Weight for Height	Standard Weight for Height	90% Standard Weight for Height	80% Standard Weight for Height
4	2	1	1	0	0
5	3	1	1	0	1
6	4	2	2	0	0
7	3	1	1	1	0
8	6	4	1	1	0
9	2	0	2	0	0
10	0	0	0	0	0
11	3	2	1	0	0
Total	23 (100.0%)	11 (47.8%)	9 (39.1%)	2 (8.7%)	1 (4.4%)

Table 4-13—Continued

Age in Years	N	Within Range of Predicted Weight for Height of Age	Below Range of Predicted Weight for Height of Age
4	2	0	2
5	3	0	3
6	4	2	2
7	3	2	1
8	6	5	1
9	2	2	0
10	0	0	0
11	3	2	1
Total	23 (100.0%)	13 (56.5%)	10 (43.5%)

Table 4-14. Comparison of Bakairi infants' weights by sex for heights to general standards (persons between the ages of 0 and 3 years)

Age in Years	N	Above Standard Weight for Height	Standard Weight for Height	90% Standard Weight for Height	80% Standard Weight for Height
			Males		
Less than 1	1	1	0	0	0
1	5	3	1	1	0
2	4	3	1	0	0
3	4	1	1	1	1
Total	14 (100.0%)	8 (57.1%)	3 (21.4%)	2 (14.3%)	1 (7.2%)
			Females		
Less than 1	0	0	0	0	0
1	4	0	1	3	0
2	7	1	3	2	1
3	4	1	1	2	0
Total	15 (100.0%)	2 (13.3%)	5 (33.3%)	7 (46.7%)	1 (6.7%)

Table 4-15. Comparison of Bakairi infants' weights for age to general standards (persons between the ages of 0 and 3 years)

Age in Months	N	Above Standard Weight for Age	Standard Weight for Age	90% Standard Weight for Age	80% Standard Weight for Age	70% Standard Weight for Age	60% Standard Weight for Age
				Males			
0-12	5	4	0	1	0	0	0
13-24	3	1	1	0	1	0	0
25-36	4	2	0	0	0	2	0
Total	12 (100.0%)	7 (58.4%)	1 (8.3%)	1 (8.3%)	1 (8.3%)	2 (16.7%)	0 (0.0%)
				Females			
0-12	4	4	0	0	0	0	0
13-24	7	0	2	2	2	0	1
25-36	3	1	0	1	1	0	0
Total	14 (100.0%)	5 (35.7%)	2 (14.3%)	3 (21.4%)	3 (21.4%)	0 (0.0%)	1 (7.2%)

and derived from the Stuart and Stevenson Harvard Standards. The measurements are also compared to weight for height for age standards translated and adapted by Jelliffe from the Baldwin-Wood tables. The standard represents the mean weight.

Bakairi male adults are classified into three age groups. The mean heights and weights of these men steadily decrease from the 20-35 age group to the over-50 age group. That is, men between the ages of 20 and 35 are on the average 2.8 cm taller and .9 kg heavier than men that are 36-50 years of age, and 4.7 cm taller and 9.2 kg heavier than men over 50. The range of variation within each age group also increases. More variation in both weight and height exists among men over 50 than among men between 20 and 35 years of age.

This same pattern, although less extreme, can be seen among the females. Females between the ages of 20 and 35 years of age are on the average .2 cm taller than women between 36 and 50 years. Weights are somewhat more complex. Women between the ages of 20 and 35 years are 1.3 kg lighter than women between the ages of 36 and 50. Moreover, women in the 36-50 age group are 5.7 kg heavier than women in the over-50 age category.

In the case of people over 50 years of age, a reduced workload in addition to illness may contribute to the reduced weight levels. For example, an older male or female who is not contributing to any great extent to the household food supply will not be allowed to eat as much as a person in their physical prime who does participate actively in the production process. In addition, illness reduces weight as a result of loss of appetite or food taboos which surround illnesses and decrease food intake. On the other hand, since the trend of lower heights for those in older age categories is evident over three age groups, the data may indicate increased availability of calories and protein. That is, there is not just a difference in the weights and heighs of the young and old. Rather, every twenty years, an increase in the heights and weights of the Indians is evident. Stini posits that human populations are able to make both short- and long-term adjustments to low protein and caloric intake (Stini 1971). Short-term adjustments include delays in skeletal growth and maturation, and lower statures. When the nutritional pressures on the population change, skeletal growth and stature increase within one generation.

When the weights for heights of Bakairi over 50 years of age are compared to general standards, only one male and no females fall below 80 percent of the standard weight for height levels. The adult male in question has a long history of tuberculosis. In addition, he has had two hernias which have weakened him considerably. No men or women in the other two age categories record weights for heights that fall below 80 percent of the standard weights for heights. The large number of adult Bakairi whose weights for heights are above the standard levels is notable. Some 46.4 percent of the adult males and 64.7 percent of the adult females are heavier than the standard ratios listed. This point is even more significant when one considers that the standards, although adapted by Jeliffe, are based on data collected on U.S. populations.

In examining the data on adolescents and children, it is important to consider the added dimension of weight for height for age. Weight for height ratios alone are not adequate for young populations because both heights and weights are reduced when chronic malnutrition occurs. When growth retardation takes place in a population, it is possible to distinguish its incidence only by investigation of weight for height for age ratios.

Over 95.0 percent of the weights for heights of the adolescent males are above the standard ratios. No male weights for heights fall below 80 percent of the standard. A comparison of weights for heights for age ratios indicate that 3 male adolescents (13.0 percent) fall below the range of predicted weight for height for age. No adolescent female weight for height measurements fall below the standards; however, 10 persons (34.5 percent) register weight for height for age ratios that fall below the predicted range. No Bakairi children between the ages of 4 and 11 years record weight for height ratios below 80 percent of the standard, and the weight for height ratios of 18 of the males (75.0 percent) and 11 of the females (47.8 percent) are above the standard levels. However, the weight for height for age ratios of 10 of the females (43.5 percent) and 3 of the males (12.5 percent) are below the predicted range.

In Table 4-14, weights for heights of children under 3 years of age are presented. One male infant (7.2 percent) and 1 female infant (6.7 percent) had ratios beneath 90 percent of the standard. Eight of the males (57.1 percent) and two of the females (13.3 percent) had weights for heights that were above the standard ratio. In Table 4-15, weights for age of children under 3 years are shown. Two male infants (16.7 percent) and one female infant (7.2 percent) are of weights for ages below the standard.

Anthropometric data on arm circumference, tricep skin-fold, and weight gain have been included for children between birth and 3 years of age as additional measures of nutritional status. Measurement of mid-upper arm is a useful and practical means for determining the incidence of protein-calorie malnutrition. This anatomical area is easily accessible and quickly measured to the nearest tenth of a centimeter with a flexible tape. The left arm is usually measured while it is hanging freely at the midpoint between the acromion and olecranon processes. The arm circumference measurement may be used by itself to determine the presence of malnutrition because the upper arm is much reduced in all more serious forms of malnutrition in early childhood. Or arm circumference and tricep skin-fold readings may be used to calculate the mid-arm muscle circumference which is one other measure of malnutrition. However, this is not necessary because arm circumference measurements have been shown to correlate well with the calculated muscle circumference (Jelliffe 1966:78). Tricep skin-fold readings are taken at the same point as the mid-upper arm circumference measurements. While the arm is hanging freely, the skin-fold is picked up by the thumb and forefinger of the left hand and pulled away from the underlying muscle. The calipers, held with the right hand, are applied about one centimeter below the fingers while the fold is still held securely. Two

Table 4-16. Comparison of Bakairi weights for heights to general standards (compiled)

Age in Years	N	Above Standard Weight for Height	Standard Weight for Height	90-99% Standard Weight for Height	80-89% Standard Weight for Height	70-79% Standard Weight for Height
			Males			
0-3	14	8	3	2	1	0
4-11	24	18	5	1	0	0
12-19	23	22	0	1	0	0
20-35	27	13	5	7	2	0
36-50	18	11	5	1	1	0
Over 50	11	2	1	5	2	1
Total	117 (100.0%)	74 (63.3%)	19 (16.2%)	17 (14.5%)	6 (5.1%)	1 (0.9%)

Table 4-16—Continued

Age in Years	N	Above Standard Weight for Height	Standard Weight for Height	90-99% Standard Weight for Height	80-89% Standard Weight for Height	70-79% Standard Weight for Height
			Females			
0-3	15	2	5	7	1	0
4-11	23	11	9	2	1	0
12-19	29	26	3	0	0	0
20-35	39	25	6	8	0	0
36-50	17	15	0	0	2	0
Over 50	12	4	3	4	1	0
Total	135 (100.0%)	83 (61.5%)	26 (19.3%)	21 (15.5%)	5 (3.7%)	0 (0.0%)

measurements are made and then the results are averaged. Tricep skin-fold measurements are especially useful in that they indicate the presence or depletion of subcutaneous fat stores in the child's body. In Tables 4-17 and 4-18, arm circumference and tricep skin-fold data have been compiled. The arm circumference of one male child (8.3 percent) and one female child (7.1 percent) were found to be below 80 percent of the standard measure. Tricep skin-fold measurement results show that 4 male infants (33.3 percent) and 4 female infants (28.6 percent) have fat reserves which are below 80 percent of the standard.

In Tables 4-19 and 4-20, weight gains of children under four years of age are described. These individuals were weighed every three months for a calendar year, and then their respective weight gains were compared to standard weight gains for their age (Jelliffe 1966:86). Around the second reading, during the end of the dry season, children generally lost weight, or registered inadequate weight gains. Since the dry season is usually a time of plenty in the village, this was somewhat unanticipated. However, it can be explained by the occurrence of the Gillian Barre viral infection in the village. This infection, diagnosed by the Indian Foundation, infected the Bakairi, causing sore throats and high fevers which lasted for about a week. Then the disease seemed to disappear, only to recur approximately three weeks to a month later. The same sore throats and high fevers afflicted the victims before the disease vanished once again. However, a month later, it reappeared for a third and last time but with more serious consequences for some. After the third session of fevers and sore throats began to

Table 4-17. Comparison of Bakairi infants' arm circumference to general standards (persons between the ages of 0 and 3 years)

Age in Months	N	Above Standard Arm Circumference	Standard Arm Circumference	90% Standard Arm Circumference	80% Standard Arm Circumference	70% Standard Arm Circumference
			Males			
0-12	5	4	1	0	0	0
13-24	3	0	1	1	1	0
25-36	4	1	1	1	0	1
Total	12 (100.0%)	5 (41.7%)	3 (25.0%)	2 (16.7%)	1 (8.3%)	1 (8.3%)
			Females			
0-12	4	3	1	0	0	0
13-24	7	0	2	4	1	0
25-36	3	0	1	1	0	1
Total	14 (100.0%)	3 (21.4%)	4 (28.7%)	5 (35.7%)	1 (7.1%)	1 (7.1%)

Table 4-18. Comparison of infants' tricep skin-fold measurements to general standards (persons between the ages of 0 and 3 years)

Age in Months	N	Above Standard Tricep Skin-fold Measure-ments	Standard Tricep Skin-fold Measure-ments	90% Standard Tricep Skin-fold Measure-ments	80% Standard Tricep Skin-fold Measure-ments	70% Standard Tricep Skin-fold Measure-ments	60% Standard Tricep Skin-fold Measure-ments
				Males			
0-12	5	1	0	0	3	0	1
13-24	3	0	0	0	1	0	2
25-36	4	0	0	3	0	0	1
Total	12 (100.0%)	1 (8.3%)	0 (0.0%)	3 (25.1%)	4 (33.3%)	0 (0.0%)	4 (33.3%)
				Females			
0-12	4	0	4	0	0	0	0
13-24	7	0	1	0	2	0	4
25-36	3	0	0	0	3	0	0
Total	14 (100.0%)	0 (0.0%)	5 (35.7%)	0 (0.0%)	5 (35.7%)	0 (0.0%)	4 (28.6%)

Table 4-19. Annual weight gain among Bakairi children under 4 years of age

Category	4/80-7/80	7/80-10/80	10/80-1/81	Total
Adequate Weight Gain	16 (61.5%)	15 (57.7%)	20 (76.9%)	51 (65.4%)
Inadequate Weight Gain	1 (3.9%)	6 (23.1%)	4 (15.3%)	11 (14.1%)
No Weight Gain	3 (11.5%)	1 (3.9%)	1 (3.9%)	5 (6.4%)
Weight Loss	6 (23.1%)	4 (15.3%)	1 (3.9%)	11 (14.1%)
Total	26 (100.0%)	26 (100.0%)	26 (100.0%)	78 (100.0%)

Table 4-20. Incidence of inadequate weight gain among Bakairi children under 4 years of age

	N	%
No Inadequate Weight Gain Readings	7	26.0
One inadequate Weight Gain Reading	11	42.3
Two Inadequate Weight Gain Readings	8	30.8
Three Inadequate Weight Gain Readings	0	0.0
Total	26	100.0

subside, three adults were paralyzed. In addition, their facial muscles were twisted and contorted. One man was evacuated but the other two said they preferred to die with their families and refused to leave the reservation. This was a very difficult time for the Bakairi. Most people were confined to their hammocks either suffering from a high fever or recovering from its enervating effects. People could not fish or go to the gardens for manioc, and they could barely walk to the river to carry water. In addition, when the paralysis appeared in the village, such a terrible anxiety was generated that it took an additional physical and mental toll.

During a difficult time such as this in an Indian village, the presence of the disease as well as the absence of anyone to secure food combine to physically weaken a group. Children are, of course, more vulnerable to these pressures so that it is not unusual for them to lose weight or to gain inadequate amounts of weight over a short period of time. The distinctive danger of the Barre virus was that the course of the disease was so lengthy. For over three months the village, in effect, came to a halt. One hesitates to classify the event as "unusual" and, thus, to discount its importance because past research experiences with the Nafuqua in the Xingu National Park indicate that if it was not the Gillian Barre infection, it could have been any other kind of influenza, cold, or common disease that would have had the same effect. Therefore, although one can explain the weight gain patterns of the children under four years around the second reading, one cannot label them or the conditions that caused them as unique.

Conclusions drawn from the above data concerning the nutritional status of the Bakairi are necessarily tentative. However, malnutrition does not appear to be a problem among adults, adolescents, and children over four years of age. Indeed, when comparing their weights for heights to standard weight for height ratios, the data suggest that at least some of the Bakairi may even be tending toward overweight. Inspite of the above resutls, the use of general standards based on European Caucasian populations is problematic. The critical question yet unresolved is whether or not all populations have the same growth potentials. Large differences exist between populations in height and weight, and it is not clear if these are the result of hereditary or environmental factors (Eveleth and Tanner 1976:1). Usually reliance upon general standards results in the classification of the majority of the population in the poorly nourished or malnourished category. These standards, derived from longitudinal studies of middle-class populations in industrial nations, set high height and weight values as their mean figures. For this reason, heights and weights are usually compared to local standards. This in effect equalizes some of the hereditary or environmental factors which may be reducing stature or weights in the population in question. Although this particular problem has not arisen with the Bakairi data in that so few people were found with weight/height ratios below even 80 percent of the standard, the data will now be compared to local standards.

Bakairi Weights on Heights Compared to Local Standards

Data on South American indigenous populations are scarce and incomplete. Some information on the Xavante, the Xinguano, the Kayapo, the Kaingang, and the Yanomami are available. However, problems are associated with each set of figures. For example, only heights are available for some groups, and only weights for other groups. Furthermore, no information is available for children, except for Neto's (1977) work on the Xingu which will be discussed later. Also some of the cited Indian groups are in the same geographic area (Xavante, Kayapo) but they are adapted in radically different ways to their environments than are the Bakairi. Both the Kayapo and the Xavante are Ge-speakers and rely on hunting and gathering, and horticulture as major subsistence activities in contrast to the Xinguanos and the Bakairi who are riverine Indians. Other groups such as the Kaingang, located in the south of Brazil and in contact for much longer than the other groups, and the Yanomami, located on the Brazilian-Venezuelan border, inhabit totally different environments than do the Bakairi. In addition, the former have been subjected to different social, ecological, and economic pressures than have the latter.

With these problems in mind, comparative data compiled in Table 4-21 may be examined. The Bakairi are on the average taller than the Xinguanos which is interesting since the Bakairi migrated from the Xingu area approximately 60 years ago. Xinguano male height, 160.0 cm, matches the heights of Bakairi males over 50 years of age, 160.6 cm.

Table 4-21. Comparison of Bakairi adult mean weights and heights by sex to other South American indigenous groups

Group	N	Age in Years	Mean Height (cm)	Mean Weight (kg)	Source[a]
			Males		
Bakairi	45	20-50	163.9	66.7	Field Notes
Xinguano	178	—	160.0	—	Eveleth et al. 1974
Kayapo	110	Over 15	165.4	61.4	Da Rocha and Salzano 1972
Kaingang	354	18-45	161.0	56.3	Keiter and Salzano 1963
Yanomami	316	19-24	153.2	48.3	Good 1982; Spielman et al. 1972
Xavante	42	—	170.2	69.8	Niswander et al. 1967
			Females		
Bakairi	59	20-50	150.7	54.8	Field Notes
Xinguano	183	20-50	149.4	—	Eveleth et al. 1974
Kayapo	156	Over 15	153.9	51.6	Da Rocha and Salzano 1972
Kaingang	219	—	149.1	50.0	Keiter and Salzano 1963

Table 4-21—Continued

Group	N	Age in Years	Mean Height (cm)	Mean Height (kg)	Source[a]
Yanomami	260	16-45	142.3	38.3	Good 1982; Spielman et al. 1972
Xavante	39	Over 18	156.3	57.9	Niswander et al. 1967

[a]Comparative data for this table are supplied by Eveleth and Tanner (1976:118-157; 366-370) and Good (1982, personal communication).

Bakairi female heights are greater than Xinguano female heights; however, Bakairi women over 50, measured at an average of 148.8, are shorter than the average Xinguano female who is 149.4 cm tall. This evidence once again suggests that the Bakairi are growing taller and heavier as time goes on. On the other hand, the Bakairi are on the average shorter than the Kayapo, and the Xavante, although they are heavier than the Kayapo. The greater availability of protein in the form of game and wild foods may be a contributing factor in the height of the two Ge-speaking groups. Finally, the Bakairi mean weights and heights are greater than both those of the Kaingang and the Yanomami. The Kaingang have had a difficult and long contact history, and this may constitute an important factor in their nutritional status. However, the Yanomami are hunter-gatherer-horticulturalists much like the Kayapo and Xavantes. Their comparatively low mean heights and weights may be explained by their dependence upon plantains as a staple crop rather than manioc and rice on which the Xavante and Kayapo depend. Limited protein may also be a factor.

The paucity of comparative data for indigenous children is unfortunate. Neto (1977), however, does provide anthropometric data on Xinguano children. He also employs the Jelliffe-Stuart and Stevenson general standards in order to classify 51 children between the ages of birth and five years into percentage-of-standard categories. He goes on to interpret these categories in the following ways. First, up to 10 percent below the standard weight for height can be considered normal, 10-20 percent below is "thin," 20-30 percent below is "very thin," and less than 30 percent below is "malnourished." A second way to classify the categories is to consider 10-20 percent below the standard weight for height as initially malnourished, 20-30 percent below the standard as moderately malnourished, and less than 30 percent as gravely malnourished (1977:71-73). In Table 4-22, the results of Neto's findings are compared to the Bakairi data. In both cases, over 90 percent of the children are classified as being in good health. However, 7.9 percent of the Bakairi children are considered initially malnourished or thin, depending on how one interprets the results, while only 3.9 percent of the Xinguano children sampled fall into the same category.

Neto suggests that the Xinguano results indicate that indigenous communities that preserve their traditional customs do not have to contend with serious nutritional problems. He links malnutrition with contact situations and with lower socioeconomic brackets where the unequal distribution of wealth is most keenly felt. This suggestion is supported by the 1970 World Health Organization report which examines the incidence of malnutrition of children under six years of age in 24 countries. Those gravely malnourished fall between .5 and 7.6 percent, and those either initially or moderately malnourished were estimated to equal 4.4 to 43.1 percent of the children tested. Batista Filho (1976) studied the incidence of malnutrition among chldren in a São Paulo favela. He found that 19 percent of the children tested were malnourished. Guitti's (1975) research in London ghettos provides comparable results in that 13.5 percent of the children tested were currently malnourished and 54.0 percent were chronically malnourished.

Table 4-22. Comparison of weight for height ratios to general standards among Xinguano and Bakairi children (persons) between the ages of 0 and 5 years)

		Good Health Standard—90%		Malnutrition					
				Initial[a]		Moderate[b]		Grave[c]	
Group	N	N	%	N	%	N	%	N	%
Xinguano[d]	51	49	96.1	2	3.9	0	0.0	0	0.0
Bakairi	38	35	92.1	3	7.9	0	0.0	0	0.0

[a]80-89%

[b]70-79%

[c]Less than 70%

[d]From Neto 1977:71

In general, the results of research on Bakairi children are in accordance with Neto's findings except for the low tricep skin-fold readings on eight (30.8 percent) of the children and the low weight gain readings for a percentage of the children. These low figures are worrisome because Jelliffe states that if tricep skin-fold measurements fall beneath 80 percent of the suggested standard, supplementary feeding, and even hospitalization, are suggested (Jelliffe 1966:86). It is possible that the impact of the Gillian Barre infection was greater on these children, or on their parents, than on the others in the village. Or it is possible that other factors are affecting the health of these children. We will now procede to investigate some of the other aspects of the nutritional status of a community. These include parasite infection, immunization histories, and infectious diseases.

Parasites

The effects of parasite infection on the nutritional status of an individual, or a population, have yet to be clearly defined. Solomons and Keusch (1981) agree that it is logical to assume that parasites interfere with the absorption of nutrients in the gastrointestinal tract of the host. The result of this interference is synergistic in that once the host is affected and nutrients are diverted from it, the impaired nutritional status further decreases the host's resistance to additional parasite infection. Impairment of nutritional status of the host can take place through six mechanisms: (1) reduction of enzymatic digestion, (2) impairment of mucosal absorption,

(3) competition for the host's nutrients, (4) gastrointestinal loss of the nutrients prior to absorption, (5) catabolic loss of nutrients, (6) possible conditioning of bacterial overgrowth in the gastrointestinal tract (Solomons and Keusch 1981:153). It is possible that parasites such as Ascaris can affect protein utilization (Layrisse and Vargas 1975) although recent studies in Korea and Guatemala failed to establish a correlation between the presence of these parasites and reduced capacity for nitrogen absorption (Jin Soon, Hwang, Rya, and Oh 1980; Schneider, Torun, Shiffman, Anderson, and Helms 1980). It has also been suggested that in giardiasis, steatorrhea, or the excessive discharge of fat in the feces, affects the host's capacity to absorb fat. Between 12 and 64 percent incidence of fat malabsorption has been cited in parasite victims (Solomons and Keusch 1981:154). Carbohydrate malabsorption is also suspected in parasite victims; however, results of studies on the documentation of this process have proven contradictory. More conclusive evidence for the effect of parasites on vitamin and mineral absorption exists. For example, it has been established that Ascaris and Giardia affect Vitamin A absorption. In addition, hookworms such as Necator americanus certainly cause blood loss and can result in iron deficiencies (1981:154-155). Parasite infection has been linked to retarded child growth in several studies (Hartong, Gourley, and Arvanitakis 1979; Kay, Barnes, and Townley 1977). Giardiasis and Ascaris infection have been correlated with low mean weight for height indices when compared to noninfected control groups. However, these correlations do not allow for the establishment of a

cause-and-effect relationship between parasite infection and slow growth in children. Other factors such as food consumption patterns, poor diet, etc., may be contributing problems in poor growth in these study groups.

In Table 4-23, the results of the examination of feces carried out in August of 1980 are tabulated. Laboratory analysis was made by Indian Foundation medical personnel in Cuiaba, Brazil. Necator americanus, a hookworm, occurs most frequently of all parasites in the Bakairi population. In its adult form, this worm lives in the small intestines passing its eggs in the feces of the host. Infection occurs when the larva penetrate the feet of a person who walks where infected feces are left. Necator absorbs blood from the intestinal tissue and, thus, causes anemia in the host. The anemia can be severe or insignificant depending upon the health of the host. Ascaris lumbricoides has the second highest incidence in the Bakairi village. Ascaris is a large roundworm which can grow to 9 inches in length. It occurs when sanitation is poor as eggs of the Ascaris worm are swallowed with food or drink that have been polluted by feces. Once in the body of the host, the roundworm inhabits the small intestines where it subsists off of the nutrients from the intestinal tract of the host. Ascaris infection is most serious in small children where symptoms include a protruding stomach and intestinal obstruction.

The amoeba is the third most frequently found parasite in the village. It, like Ascaris, is also correlated with poor sanitation as amoeba cysts can be transmitted through the agency of soiled hands or

Table 4-23. Results of fecal examinations of the Bakairi Indians

Group	N	Frequency
People Tested	265	100.0
People Uninfected	103	38.9
People Infected	162	61.1 (100.0%)
Infected with 1 Type	102	38.5 (62.9%)
Infected with 2 Types	56	21.5 (34.6%)
Infected with 3 Types	4	1.5 (2.5%)

Parasite	N	Frequency
Necator americanus	66	28.9
Ascaris lumbricoides	63	27.6
Entamoeba histolytica	48	21.1
Giardia intestinalis	32	14.0
E. coli	17	7.5
Trichurius trichura	2	0.9
Total Number of Cases	228	100.0

fly activity. Once swallowed, the cysts hatch and the amoeba inhabit the large intestine. Dysentery may result, and, in extreme cases, liver abscesses occur. Giardia intestinalis has the fourth highest incidence in the Bakairi village. This parasite is also common where sanitation is defective. It can cause vague digestive disorders which include diarrhea. Trichurius trichura, like Giardia, also does not cause gross pathology. It is a type of whip worm which is common in the Tropics. It resides in the upper large intestine and a heavy infestation may cause bloody diarrhea and anemia.

The high incidence of parasite infection in the Bakairi village suggests that a large number of calories on an annual basis are being siphoned off of the population. However, the results of investigations on the connection between parasite infection, and nutrient absorption and growth and development in children are yet inconclusive. As a result, it is difficult to demonstrate to what degree parasites actually affect the nutritional status of a population. Furthermore, it is even more difficult to estimate the number of calories parasites deflect from their hosts on an annual basis for the purpose of adding to the Bakairi energetics model. The only study found that attempted to precisely quantify this caloric loss concerned French sheep. Hubert, Kerboeuf, and Gruner (1979) slaughtered five lambs a month for nine months, noting weight and parasite infestation levels of each of the animals. They concluded that weight gain of infected animals was half that of healthy sheep. Some 50 percent of caloric intake was diverted by such parasites as strongyles. It is, of course, impossible to adopt the 50 percent figure for the Bakairi due to inexact information on degree of parasite infection among the Indians, differences in types of parasite infection, and most important, differences in the host organisms (human versus sheep).

In conclusion, no alternative exists except to agree with the general principle that a gap exists between calories consumed and calories absorbed and that parasites divert a proportion of the calories an individual consumes. In addition, the loss of calories per infected individual can affect the functioning of the population over time. Parasite infestation will weaken especially children to the extent that they will die before reaching reproductive age as the result of a relatively minor fever or an infectious disease. Parasitism, then, can constitute an artificial population control mechanism. It can be considered artificial, in the way that other diseases such as smallpox cannot, due to the social norms that control or at least affect its incidence (Alland 1969). Cultural traditions which affect the incidence of parasitism in the Bakairi reservation include drinking polluted waters, especially during the rainy season, defecation near houses where people walk and sit, permanent and close contact with animals such as dogs, lack of insect control, and preparation of food on dirt floors.

Infectious Disease and Causes of Death

Most infectious diseases which occur in the Bakairi village are a result of the Indians' contact with non-Indians. Measles, tuberculosis, venereal diseases, polio, smallpox, yellow fever, meningitis, whooping cough, diphtheria, and typhoid are only some of the Old World diseases which have decimated New World populations. Due to the Indian Foundation's awareness of this problem, the Bakairi are very well vaccinated against polio, smallpox, measles, typhoid, and whooping cough. In addition, while the researcher was in the field, yellow fever and meningitis caused the deaths of workers on nearby ranches. The ranch foremen in both cases had the presence of mind to radio the Indian Foundation so that within 24 hours of the first deaths, a plane with vaccination equipment had arrived at the Indian post. The only problem with the vaccination program is that the logistic conditions are so poor that oftentimes the serum is no longer effective once it reaches the Indian population. Extreme heat, absence of electricity and, thus, refrigeration, light penetration, jarring, and breakage all combine to reduce the efficacy of the Indian Foundation's program. In addition, once the medical personnel are in the reservation, all Indians do not cooperate. They can either be in the gardens working or on a hunting or fishing trip. Also political conflicts between the Bakairi nurse's aide and members of the community can be so serious as to discourage the people from taking advantage of the vaccine. Finally, the vaccine serum itself may be impotent. Problems either arise during the production of the vaccine, which takes place in São Paulo, or in transporting the vaccines to Cuiaba. Medical personnel cannot determine whether or not the serum has arrived safely, however, and only when an epidemic occurs in an indigenous area do they know for certain. For these varied reasons epidemics have been known to occur in populations that have already been vaccinated. (Note the Xingu National Park measles epidemic which occurred in 1981.) This is a serious problem; however, the Indian Foundation is constantly working to improve techniques.

In Table 4-24, causes of death among the Bakairi during a 30-year period have been tabulated. A large number of deaths, especially in the early years (from 1945-1950) are not attributed to any cause. Many times Indian Foundation agents are either not assigned to the Bakairi post or are not at their work site. This results in incomplete or vague records. However, of the 90 deaths listed and accounted for, 37 (41.1 percent) are the result of lung infections of one kind or the other. Tuberculosis has always been listed as a major killer of the Bakairi and the deaths that result from this disease are evenly distributed over the 30-year interval. Four cases of tuberculosis currently exist in the reservation. At various points in time, the individuals are taken from the reservation and treated in hospitals in Cuiaba. However, the treatments are not completely successful due to the resistance on the part of the Indians themselves. If the victim is a child, the parents do not want it to be away from home for the six months to a year usually required. In addition, once treatment is completed and the child is returned, a relapse is common because dairy products, such as milk, eggs, and butter required for a complete recovery of a tuberculosis victim, are absent in the reservation. When the parents see the relapse, they claim the treatment is ineffective and resist sending the child back to Cuiaba for further care. If the

Table 4-24. Causes of death of Bakairi Indians during the period of 1945-1975

Disease[a]	N		Frequency	
Lung Infections	37		44.1	
Tuberculosis		14		15.6
Whooping Cough		13		14.4
Pneumonia		10		11.1
Liver-Heart Disease	11		12.2	
Accidents	8		8.9	
Fevers	5		5.6	
Intestinal Disorders	2		2.2	
Measles	2		2.2	
No Reason Cited	25		27.8	
Totals	90		100.0	

[a]Information compiled from P.I. Bakairi health records

tuberculosis victim is an adult, problems are even more complicated. An absent wife cannot harvest gardens, cook, clean, wash dishes, or care for children. An absent husband cannot fish, hunt, and make gardens. In either case, the spouse of the victim can create such a disturbance that the victim is returned from Cuiaba long before the treatment has had any impact on the disease.

Whooping cough is a second lung disease that has affected the Bakairi. However, unlike tuberculosis, it occurred only once in the reservation and then disappeared. In 1960, when the Xavantes, having been pacified, were living a short distance from the Bakairi village, a whooping cough epidemic took place killing 10 Bakairi and 13 Xavante. After the epidemic passed, the disease did not reapper presumably because of the vaccination program. Pneumonia is a regular killer of small children in the reservation. Colds or fever can rapidly turn into pneumonia and result in death within very short periods if not carefully monitored.

Liver and heart diseases are the cited cause of death of 11 (12.2 percent) persons during a 30-year period. It is difficult to assess the accuracy of this particular diagnosis because symptoms of liver or heart disease can be easily confused by the layman, and no autopsies were performed in order to establish cause of death. Accidents such as burning, drowning, murder, suicide, and wounds killed eight (8.9 percent). Fevers and intestinal disorders caused the death of seven (7.8 percent). These infections tend to result in the death of young children more than adults. The Bakairi, like many other indigenous groups, have their own beliefs about caring for children with fevers and diarrhea. They dehydrate them, do not allow them to eat, bundle them up in clothes and blankets, and place them in a hammock over a smoldering fire. This treatment is to drive out the spirits that are causing the sickness; however, if the illness does not pass rapidly or if the child is weak from a parasite infection, for example, the actual treatment can be considered a contributing factor in the death of the child.

Jelliffe suggests that diarrhea is one of the major causes of death among young children in developing areas of the world. Its etiology is complicated but intestinal bacterial infections and protein-calorie malnutrition are probably the two main causes of the disease. In view of the relation between diarrhea and malnutrition, mortality attributable to this type of infection may constitute indirect evidence of poor nutrition in a community (Jelliffe 1966:105). Information of causes of death among the Bakairi suggest that diarrhea is not a principal threat to young children in the village. Rather, lung infections claim a much greater number of lives than do intestinal disorders.

Only one measles epidemic has occurred in the Bakairi reservation in the last 30 years. In 1962, directly after the whooping cough epidemic, a measles epidemic occurred in the reservation killing two Bakairi and 29 Xavantes. It is suspected that the Bakairi had been exposed to the disease at a previous time, and that is why it had such a small impact on their population.

In Table 4-25, deaths among the Bakairi are tabulated by sex and age. Over a 30-year period, slightly more females (51.1 percent)

Table 4-25. Deaths among the Bakairi Indians between 1945 and 1975 by sex and age

Total Number of Deaths 90 (100.0%)	Female Deaths 46 (51.1%)	Male Deaths 44 (48.9%)
Total Number of Deaths 90 (100.0%)	Child Deaths 48 (53.3%)	Adult Deaths 42 (46.7%)

Table 4-26. Bakairi population according to sex and age distribution

	Male		Female		Total	
Age in Years	N	%	N	%	N	%
0-12	43	(4.6)	52	(18.1)	95	(32.7)
13-20	23	(8.0)	24	(8.4)	47	(16.4)
21-35	31	(10.8)	38	(13.2)	69	(24.0)
36-50	21	(7.3)	19	(6.6)	40	(13.9)
51-70	14	(4.9)	12	(4.2)	26	(9.1)
Over 70	1	(0.4)	1	(0.4)	2	(0.8)
Unknown	4	(1.4)	5	(1.7)	9	(3.1)
Total	137	(47.4)	151	(52.6)	288	(100.0)

than males (48.9 percent) died; however, since the sex ratio in the reservation is, and has traditionally been, unbalanced in favor of females, this disproportionate number of female deaths can be accounted for by the actual sexual composition of the population. Moreover, more children (53.3 percent) than adults (46.7 percent) died during the same 30-year interval. This ratio can be accounted for in different ways and leads us to a discussion of some basic demographic problems among the Bakairi.

Demographic Interrelationships

Certain demographic measures of population composition and growth can be employed in order to understand more completely the dynamic qualities of the Bakairi population. These measures also allow for predictions to be made about the rate of natural increase of the Indian group and the impact of this increase on the energy resources available in the reservation.

In Table 4-26, the age and sex composition of the Bakairi population is outlined. One hundred thirty-seven (47.4) males and 151 (52.6 percent) females inhabit the reservation. The problems associated with this unbalanced sex ratio in terms of unequal marriage pools have already been mentioned. The distribution of the population across age cohorts is also of interest. The structure of the Bakairi population is extremely irregular in that it cannot be classified as an "old" age structure or a "young" age structure. That is, distinctly large proportions of old persons, as are found in industrialized countries, or young persons, as are found in Less Developed Countries, are absent. Instead, the shape of the population is rectangular, which may indicate that artificial population control mechanisms are in effect (C. Wood, 1981, personal communication). In addition, the structure is characterized by bulges and indentations which may reflect the impact of such epidemic diseases as measles and whooping cough.

In order to determine the rate of natural increase of the Bakairi, it is necessary to subtract the crude death rate from the crude birth rate. The latter two measures are usually shown per thousand individuals. For the Bakairi they are estimated to be 45.1 births per thousand inhabitants, and 10.4 deaths per thousand inhabitants. Therefore, the crude rate of natural increase is 3.47 percent. Doubling time of the population is calculated to be only 20 years. A crude birth rate of 45.1 births per thousand persons is obviously quite high compared to other populations. In order to provide more refined information on fertility among the Bakairi, age-specific fertility rates and total fertility rates have been calculated. Age-specific fertility rates provide information on reproductive levels of females in certain age groups. They are derived by dividing the total number of live children born by the number of women in the specific age group. In Table 4-27, age-specific fertility rates for women in seven age categories have been calculated. Total fertility rate is the average number of children any woman could be expected to have in her lifetime if she were subjected to age-specific fertility rates. This measure is calculated by adding up the age-specific fertility rates and then multiplying them by 5, the number of years an individual is in any one

Table 4-27. Age specific fertility rates and total fertility rates of Bakairi women

Age Group	N	Number of Children	ASPR
15-19	16	2	.125
20-24	11	4	.364
25-29	15	5	.333
30-34	13	0	.000
35-39	8	2	.250
40-44	6	0	.000
45-49	6	0	.000
Total	75	13	1.072
			X 5
Total Fertility Rate			5.362

age group. Total fertility rate is estimated to be 5.36 children for the Bakairi. That is, in a woman's lifetime she can be expected to give birth to five live children. It is interesting to note at this point that the Bakairi men themselves claim that an ideal number of children is five. The total fertility rate can be contrasted with the number of live births found in Table 4-28. The total fertility rate is calculated on the basis of data collected the previous two years, while the number of live births figure is calculated from interviews of all women all different ages. The discrepancy between the two values, five and three, indicates Bakairi families are growing larger.

Pregnancy, birth, and infant mortality among the Bakairi constitute an enormously complex problem. In the village, both abortions and infanticide are not only common but socially sanctioned. The question of how these two artificial population control mechanisms affect the natural rate of increase of the Bakairi is an important question. In addition, the infant mortality rate, estimated to be 10.4 per thousand, complicates matters even further. Scrimshaw (1978) and Dickeson (1975) both suggest that infanticide can take many forms. For example, blatant infanticide in the form of strangulation, suffocation, and burying alive occur in the village. However, what Scrimshaw refers to as underinvestment in a child also takes place. Inadequate feeding and neglect as well as child abuse are oftentimes linked to close birth spacing, high number of living children in the family, the marital status of the mother, and the sex of the child (Scrimshaw 1978:392). Thus, when a child dies, ostensibly of medical reasons, the inclusion of

Table 4-28. The results of fertility interviews of mature Bakairi women

Variable	N	Mean	Standard Deviation
Average Age of First Pregnancy	72	16.2	3.3
Number of Pregnancies	72	4.5	2.7
Number of Abortions	72	1.3	1.8
Number of Miscarriages	72	0.2	0.4
Number of Live Births	72	3.0	2.0
Number of Infanticides	72	0.1	0.3
Number of Dead Children	72	0.4	0.6
Number of Living Children	72	2.5	1.7

this figure in the infant mortality statistic may or may not be misleading. It is difficult to determine if its death is an example of benign infanticide or not.

In Table 4-28, results of fertility interviews are tabulated.[1] Eighty-six interviews were conducted. Of these 86 cases, 72 (83.7 percent) women had been pregnant at least once. In comparing average numbers of pregnancies, live children born, and actually living children, numbers steadily decrease. For example, the mean number of pregnancies is 4.5 $\pm$ .6 but the mean number of children born is 3.0 $\pm$ .5 and mean number of children living is 2.5 $\pm$ .4. The average number of abortions is high, 1.3, with a maximum value of ten in several of the older women. The average number of infanticides was .1 with a maximum value of 2. Average number of years between pregnancies is 3.8 but the average number of years between live children is 4.2. It should be noted at this point that six abortions that the researcher knew of took place during the calendar year that she was in the Bakairi village. Only one male infanticide, by burying alive, occurred.

Three definite cases of benign infanticide appeared to be in progress. One case concerned an older widow who had attempted to strangle her female child when she was born. The mother was convinced by her father to allow the child to live. However, in 1981, the little girl, 3 years of age, was so thin and small that she was not able to walk. When she attempted to nurse, the mother beat her. The second case concerned a 2-year-old girl whose mother was unhappily married. Once again the child was not allowed to eat, and over a period of a year she recorded a weight loss of 1.5 kg instead of a gain which would have been normal. The child began to walk but stopped after a few months. When the researcher left the field, the girl was two and a half years of age, extremely apathetic and very thin. Her grandmother was fond of saying that a good flu would carry the child off. The third little girl was a tuberculosis victim. Her parents did not expect her to live and refused to feed here. Toward the end of the field session, her hair began to fall out and huge sores appeared on her body.

In examining the impact of abortion and infanticide on population regulation, Scrimshaw and Dickeson among others agree with the Malthusian principle that human populations are constantly expanding and that high infant mortality rates are a response to high fertility. Infanticide and abortion are means whereby populations can be maintained beneath the carrying capacity of their environments (Dickeson 1975: 110-111; Alland 1970). Evidence from the Bakairi case suggests that these kinds of population control mechanisms may indeed be in operation. The rate of natural increase of the population has already been estimated to be 3.47 percent with a doubling time of 20 years. However, if we subtract infanticides from the death rate and add abortions to the birth rate, the rate of natural increase jumps to 5.9 percent, and doubling time of the population increases to 11.7 years. In a reservation of 50,000 ha, almost halving the population doubling time through artificial means is of critical importance.

However, a key question remains. The Bakairi have reduced the rate of natural increase of their population, yet has it been reduced enough in terms of the resources and technology that are available to the Indians? In Figure 4-2, the increase of their population is charted over a 27-year period. Since 1965, the population has steadily increased, and since 1977 it appears to be in exponential growth. Part of this phenomenon is related to the removal of external population controls in the form of infectious disease. The last epidemic was in 1962, and since that time the Indian Foundation has had tremendous success in controlling the occurrence of such diseases as measles, whooping cough, and yellow fever. Even the flu, colds, and diarrhea are taken extremely seriously by the Foundation representatives in order to prevent unnecessary deaths. Part of this situation can also be attributed to the Indians' perception of their relationship with the non-Indian. The Bakairi contend that if they were a large, powerful tribe like the Xavantes or the Xinguanos, whose diverse tribes they often lump into one unit, they would receive more economic benefits from the Indian Foundation. As a result, they would like to increase the number of people in their village so that the Indian Foundation will take more notice of their demands for material goods and assistance.

In this chapter, the Bakairi, living in their present village, are discussed. Such topics as marriage, household composition, nutritional status, and fertility are addressed. In addition, disease, causes of death, infant mortality, and crude death rate are also examined. The data presented allow for the calculation of the annual rate of increase and the doubling time of the Bakairi population.

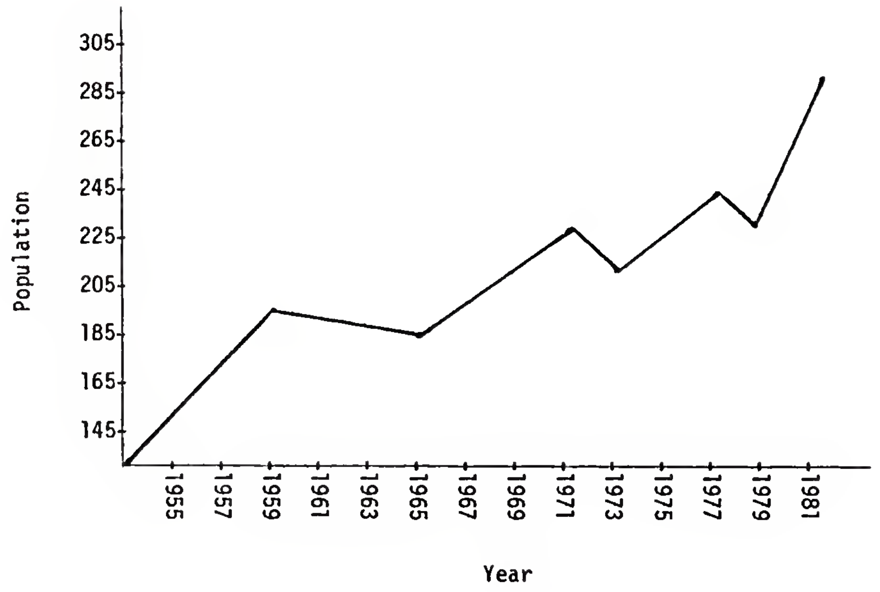


Figure 4-2. Bakairi Indian population increase over a 27-year period

Note

[1]Fertility data are notoriously difficult to collect. With Brazilian Indians, problems are compounded by community fears that the Indian Foundation will punish them for abortion and infanticide which the Foundation has outlawed. In addition, although some Indians understand the concept of western time, it is often difficult for them to calculate their ages and the ages of their children. Even more troublesome is for them to remember exactly when and how many times they were pregnant or when a child died. Therefore, the fertility data used in this chapter were collected in three ways. First, the individual women in the village were interviewed. In order to help them pinpoint times of pregnancies and deaths of children, they were asked how old the child would be if it had been born or if it had lived. For example, would the child be as old as Maisa, who was 3, or as old as Maiare, who was 20. This method had very good results as the children in the village are apparently lumped in groups based on proximity of age by the women. The second method of data collection was to interview the old women of the village. With the data from the interviews in hand, the old women of the village were then consulted. The materials were reviewed with their assistance, and they made corrections and suggestions. These additions were later checked with the younger women. Oftentimes, the older women could remember abortions or infanticides that the younger women either did not want to mention or that they had forgotten. However, when confronted with the information, they would admit that it was correct. The third method used was to refer to Indian Foundation death-birth records. These records are supposedly kept by the agents; however, since the Bakairi reservation has only sporadically had an agent in residence, the records are incomplete. Inspite of this problem, they did provide the researcher with some leads that could be checked with the help of the elders of the community.

CHAPTER 5
BAKAIRI ENERGY EXPENDITURE

Energy expenditure for a population can be determined in two different ways: the tables of recommended energy allowance method and the factorial method. In order to determine the number of calories expended by the Bakairi in the course of a year using the table method, a number of calculations were made. The Bakairi were first sorted by sex. Then they were divided into nine age groups according to calories required to maintain a kilogram of weight in that age group as recommended by the Food and Nutrition Board in 1974. The weights of the individuals in each age group were then summed and multiplied by recommended calorie allowances. The resulting figures, number of calories per age group per day, were added together and multiplied by 365 in order to determine number of calories required annually by the entire population; 210,591,817 kcal per year was the total number of kilocalories calculated using this method.

Assumptions and problems with the above calculations are as follows. The question of whether or not the Bakairi actually expend recommended daily allowances as set forth by the Food and Nutrition Board is raised. Analysis of nutritional status of the Bakairi has indicated that they are generally of standard weight for height, or standard weight for age, according to the standards used. These standards, normally applied to industrial nations, tend to stipulate higher nutritional levels than one would find in nonindustrial societies. However, even with the use of these tables, evidence suggests that the Bakairi diet maintains the populations at an acceptable level. Indeed, 62.3 percent of the population weighed more than the set standard weights for heights.

Lactation and pregnancy present a second problem. These biological processes require additional calories. During pregnancy, extra energy is needed for the growth of the fetus as well as for the placenta and other maternal tissues. Energy needs are also increased on the basis of the cost of moving a heavier mother. Moreover, basal metabolism increases by 20 percent in the last trimester of pregnancy (World Health Organization 1974:13). The Food and Nutrition Board considers 300 additional calories per day satisfactory for a pregnant woman (Food and Nutrition Board 1974:31). Lactation also requires additional energy. Fat reserves deposited during the course of pregnancy can be relied upon to a certain extent; however, even with these reserves, 500 kcal/day are suggested for lactating mothers. In the first three months of lactation, these calories will allow for physiological readjustments in the mother's body. If lactation continues after this, as it does in the Bakairi who nurse up to the child's fourth year, the calories will be used in the manufacture of milk (1974:32). To determine calories expended by pregnant or lactating Bakairi women, it was necessary to review each case individually. Those who were nursing were separated from those who were pregnant during the field session. The number of lactating mothers was multiplied by 500 kilocalories to

Table 5-1. Energy expenditure of the Bakairi according to the table method

Age in Years	N	Total Number of Kg in Group	Total Number of Kcal/Kg/ Age/Day[a]	Total Number of Kcal/Age Group Day
		Males		
0-1	6	32.4	113	3,661.2
2-3	9	88.4	100	8,840.0
4-6	10	155.0	90	13,950.0
7-10	12	287.5	80	23,000.0
11-14	13	463.0	64	29,632.0
15-18	14	846.0	49	41,454.0
19-22	7	487.1	45	21,919.5
23-50	51	3,381.7	39	131,886.3
51+	15	869.3	34	29,556.2
Total	137	6,610.4		303,899.2
		Females		
0-1	6	24.0	113	2,712.0
2-3	11	105.1	100	10,510.0
4-6	11	160.5	90	14,445.0
7-10	12	248.7	80	19,896.0
11-14	18	618.5	55	34,017.5
15-18	13	695.5	39	27,124.5
19-22	7	396.2	36	14,263.2
23-50	57	3,155.7	35	110,449.0

Table 5-1—Continued

Age in Years	N	Total Number of Kg in Group	Total Number of Kcal/Kg/ Age/Day[a]	Total Number of Kcal/Age Group/Day
51+	16	794.6	31	24,632.6
Total	161	6,198.8		258,050.3
Annual Total	288			205,111,567 kcal/yr
Lactation	(31)			4,960,000 kcal/yr
Pregnancy	(11)			520,250 kcal/yr
TOTAL	288			210,519,817 kcal/yr

[a]Food and Nutrition Board (1974)

derive additional energy needs for a day. This figure was then multiplied by 365 in order to determine calories required over the course of a year. The course of the pregnancy of each pregnant woman was reviewed. The number of days of pregnancy for each woman was multiplied by the number of additional calories needed to sustain pregnancy. Trimesters of pregnancy were also considered due to the fact that less energy is expended during the first trimester of pregnancy than during the final two trimesters. Caloric requirements of each of the 11 women were individually calculated for the year and then summed. The pregnancy and lactation figures were finally added to the subtotaled kilocalories for the total population calculated from age and weight in order to derive the grand total of kilocalories for a year.

Another problem concerns missing weight values. Weight/height data on 26 individuals, or 9 percent of the population, are absent. In these cases, mean weights of the individuals in the particular age/sex group were substituted for the missing value and added to the sums of the weights in that group. These numbers were then used in the energy calculations.

The last problem pertains to the method by which the National Research Council determines energy needs. These allowances are based on average male and female caloric expenditures and, therefore, cannot be applied to individuals, but only to populations. The Bakairi who have a population of only 288 present a rather small group. In addition, the table method does not take physical activity under consideration. It only presents energy needs per kilogram of weight per sex per age group. However, physical activity is the most variable factor in estimating the energy expenditure of a population. This problem remains a serious and unavoidable obstacle to the unqualified use of the table method for the calculations of energy expenditure.

A Comparison of the Table and Factorial Methods of Determining Energy Expenditure

In order to compare the total number of kilocalories expended by the Bakairi as determined by the table method, energy expenditure was recalculated with the use of the factorial method. To determine caloric expenditure using this method, four factors which influence this process must be considered: basal metabolism and sleep, the specific dynamic effect of food eaten, physical activity, and pregnancy and lactation. Basal metabolism is defined as the amount of heat given off by an individual at rest. It includes the amount of energy needed to carry on body processes by major organs and metabolic processes by the cells. Basal metablism does not include energy needed for physical activity or the specific effect of food (Wilson, Fisher, and Fuqua 1965:102). To calculate energy expenditure for basal metabolism, the formula 1 kg of weight x 1 kcal of energy x 1 hour was used. During sleep, the basal metabolic rate is reduced by 10 percent. Thus, the formula for sleep is given as 1 kg of weight x .9 kcal of energy x 1 hour (1965:103). The Bakairi normally sleep 8-9 hours per night so that 8 hours x 12,809.2 kg (total body weight of 288 Indians) x .9 kcal is equal to 92,226 kcal/day expended by the village in sleep. The other four hours of darkness are usually spent lying in a hammock with a drowsing child or chatting with friends. Few people go outside the house after the sun has set and it is not abnormal for a person to be asleep by 7 p.m. Most certainly, with children in every household, noise and activity are kept to the minimum. The basal metabolic rate for these four hours is calculated as 4 hours x 12,809 kg (total body weight in the village) x 1 kcal, or 51,237 kcal/day, expended by the village in minimal activities during the dark hours. When these two figures are summed and multiplied by 365 days/year, the subtotal is 52,363,995 kcal.

The specific dynamic effect is defined as the increased heat production that occurs as the result of food digestion. Energy expended in this process has been found in human experiments to be relatively small. An average estimate is 6 to 8 percent of the sum of energy expended in basal metabolic processes (Wilson, Fisher, and Fuqua 1965:114-115). An estimation of the specific dynamic effect of the food eaten by the Bakairi is .06 x 52,363,995 kcal which equals 3,141,840 kcal for the total village for 12 hours per day over a year.

The physical activities of the individuals in question is the third factor which must be considered in determining the number of calories expended by the population. The number of kilocalories used for an activity per unit of body weight per hour multiplied by the total number of kilograms of body weight and the number of hours of performance of activity give the energy expended for a particular physical activity. Kilocalories per kilogram of body weight for the population, or sex or age set, are used instead of average individuals in order to ensure more precise estimations. A number of charts describing energy expenditure by activity are available (Consolazio, Johnson, and Pecora 1963; Passmore and Durnin 1955; and Durnin and Passmore 1967). In order to determine the metabolic cost of activities performed by the Bakairi, the Consolazio et al. (1963) list was used. In order to convert kcal/minute to kcal/hour, the factor of 60 was multiplied by kcal/minute/kg body weight. Then the kcal/hour figure was multiplied by 12,809.2 kg or the total amount of weight in the village.

To determine the number of hours spent on each activity by the Bakairi, time allocation studies were performed over the course of a year. The time allocation methodology has been chosen over other methodologies because it allows for the systematic collection of data from a random sample. In addition, this method produces data which are representative of activities performed over an entire year's period. That is, variations which occur between times of day and months of the year are registered in the resultant data set. Factional variations between groups are also recorded. Another suggested methodology advocates following around a small group of individuals all day for several consecutive days. In this way, the exact duration of a particular activity can be determined. However, this method does not address the problem of how an entire group allocates its time; not is it sensitive to monthly or to seasonal variations in allocation.

Time allocation studies are based on the assumption that the proportion of observations of a given activity is the same as the proportion of time actually spent on that activity during the daily time period used (Werner et al. 1979:310). Following Johnson's (1975) and

Gross, Eiten, Flowers, Leoi, Ritter, and Werner's (1979) techniques, the field worker made 12 visits each week to houses randomly selected in the village. Days of the week as well as times of the day were also randomly chosen in order to systematically examine how the Indians allocated their daylight hours to various activities. The hours between 6 a.m. and 8 p.m. at 15-minute intervals were initially chosen; however, after a month the field worker stopped visiting houses after 6 p.m. for two reasons. In the first place, by entering a house full of sleeping people at 7 or 8 p.m. she became a disruptive force, capable of waking as many as ten dogs and three children, thus annoying large numbers of people. Second, although some Bakairi may hunt or fish at night, few actually do so. Normally everyone was home and in bed by 7 p.m. Thus, by visiting houses at times between 6 a.m. and 6 p.m., the researcher did not have reason to believe that she was missing important opportunities for data collection. Upon entering each of the households, the investigator noted the activities in which each member, or visitor, of the household was engaged. If members were absent, other individuals were questioned as to their whereabouts. Later in the day, the absent person was found and questioned in order to make certain that the information supplied was accurate.

During data analysis with the SAS computer system, a number of problems arose. In the first place, numbers of observations per month varied due to the researcher's absence from the field on two occasions or due to sicknesses in the village which left little time for the researcher's study. In order to correct for these variations, absolute values for each month were turned into percentages, and then averaged in order to determine proportions of time spent on activities. In this way, the absolute values were weighted.

In addition, on a number of occasions, the entire household was found to be spending an extended period of time in the garden. The Bakairi build palm thatch lean-tos in the gardens when the fields are located more than 8 km away. This saves them commuting time during peak horticultural seasons, examples of which are rice harvesting and underbrush-slashing and large tree-chopping periods. The Bakairi also go to the gardens for long visits when the gossip and political crises in the village reach unbearable proportions. At these times the village will empty as people go to their gardens for a cooling-off period. Commuting up to 14 km one way for every time allocation session was impossible. Thus, the researcher made it a point to spend several extended periods in the gardens with families. During these three- to four-day visits, she recorded activities performed by each member of the household at half-hour intervals. These data sets provided the researcher with information on which to draw when the families were absent from the village.

After total number of hours spent on each activity over the course of a year was calculated from analysis of the time allocation data set, the various figures were multiplied by kilocalories expended per hour per activity per total number of kilograms of body weight. Kilocalories per activity for the entire year by the Bakairi were then summed in order to determine energy expenditure for physical over the

12-month period. Approximately 139,961,000 kcal was the result (see Table 5-2).

The last factor to be considered in the factorial method for calculating energy expenditure is pregnancy and lactation. As in the table method, each individual case was examined in order to determine extra annual energy requiremenst; 5,480,250 kcal was the net result.

To determine total calorie expenditure of the Bakairi for a year, the four subtotaled figures for each factor considered were added together; 200,947,061 kcal was the sum. When the two methods for calculating energy requirements are compared, the results are similar (see Table 5-3). The kilocalorie difference between the two methods is equal to 9,644,756 kcal for a year, or 4.79 percent of the factorial method. The factorial or conservative method is chosen over the table method because of the various problems associated with the table method. Moreover, the factorial method more accurately assesses the physical activity level of the Bakairi, which varies greatly by population.

Energy Expenditure and the Bakairi Energetics Model

In Chapter 3, the physical environment of the Bakairi was divided into ecological subsystems. Each of these subsystems was represented by an energy symbol which indicated the processes and storages that characterized the functioning of the system. With the data provided by the weight/height study discussed in Chapter 4 and the time allocation study, the Bakairi can now be positioned within this energetics diagram. The Indians who live in the reserve are represented by a consumer symbol. However, in oder to provide additional details,

Table 5-2. Kilocalories expended by the Bakairi over the course of a year in the 12 hour day based on results of the time allocation study

Activity	Hours Spent on Activity per Year[a]	Kcal/Activity Hour/Kg Weight[b]	Kcal/Activity Year/Bakairi
Child-rearing	153.30	3.762	7,387,220.4
Domestic Animal Care	21.90	5.136	1,440,757.2
Eating	402.96	1.224	6,317,606.8
Food Preparation	183.96	2.136	5,033,145.6
Hygiene	219.00	3.396	9,526,500.0
Idle	2,093.64	1.614	43,283,913.0
Sick	30.66	1.170	459,501.4
Housework	127.02	3.990	6,491,865.1
Paid Labor	214.62	5.874	16,148,223.0
Manufacturing	135.78	3.084	5,363,853.0
Ritual Activity	144.54	3.672	6,798,438.9
Schoolwork	56.94	1.608	1,172,793.1
Transport/Travel	83.22	4.398	4,688,198.7
Other	179.58	3.084	7,094,128.0
Wildfood Acquisition			
Hunting	17.43	4.398	981,919.0
Fishing	64.17	2.646	2,174,913.8
Other	19.14	2.646	648,712.0

Table 5-2—Continued

Activity	Hours Spent on Activity per Year[a]	Kcal/Activity Hour/Kg Weight[b]	Kcal/Activity Year/Bakairi
Gardening			
Harvesting	59.20	5.172	3,921,941.0
Other	172.94	4.978	11,027,346.0
Total			139,960,976.0

[a]From the time allocation study

[b]Based on Consolazio et al. (1963)

Table 5-3. Comparison of the table and factorial methods for determining total energy expenditure of the Bakairi for a year

The Table Method

Adjustment made for nine age groups

Adjustments made for sex

Adjustments made for body weight of individuals

Subtotal: 205,111,597 kcal

Adjustments made for lactation and pregnancy

Subtotal: 5,480,250 kcal

Total: 210,591,817 kcal or 2.11×10^{8} kcal

The Factorial Method

Energy expenditure for basal metabolism (BM = 1 kg/1 kcal/1 hr

Energy expenditure for sleep (sleep = 1 kg/.9 kcal/1 hr)

Subtotal: 52,363,995 kcal

Energy expenditure for specific dynamic effect of food eaten (SDE = 6 percent of energy expenditure of BM)

Subtotal: 3,141,840 kcal

Energy expenditure for physical activities (PA = kcal/activity/hour x body weight x hrs/activity)

Subtotal: 139,960,976 kcal

Table 5-3—Continued

Energy expenditure for pregnancy and lactation	
(lactation = 500 kcal x days x no. of females)	
(pregnancy = 300 kcal x days x no. of females)	
Subtotal:	5,480,250
Total:	200,947,061 kcal or 2.01×10^8 kcal

an energy storage tank, P, and an interaction symbol occupy the space within the consumer hexagon. The interaction symbol is significant because of the diverse types of energy which flow into it from other energy storages (see Figure 5-1 and Table 5-4). These flows of energy are consumed and transformed by the Indians into high-quality outputs, both in terms of the human biological organisms which are supported and the sophisticated cultural system which the Bakairi produce and maintain. One main kind of energy which flows into the population tank is represented by Rates 42 and 43. Rate 43 flows from a food storage which is not quantified in Table 5-4. This storage and the two connected flows will be discussed in Chapter 7. However, for our purposes here, it is sufficient to note that kilocalories of food flow in from a food storage tank. This food biologically maintains the population. Rate 41, basal metabolism and the specific dynamic effect of food, represents that energy which is degraded in the biological processes.

For a population to survive, kilocalories of protein, fat, and carbohydrate are not the only necessities involved. A cultural infrastructure is required. This infrastructure, transmitted across generations through time, involves teaching the young how to make a living from the forests and rivers in the reserve. It also involves the coordination of subsistence activities through ritual and the distribution of products through kinship systems and economic transactions. The rhythm which characterizes an Indian village is very pronounced and in order to organize and maintain it, a great deal of energy is required. Rate 40, which has the largest value in the table, represents the

Table 5-4. The evaluation, name, and description of the energy storages and flows associated with the Bakairi Indian population

Flows and Storages	Names of Flows[a] and Storages[b]	Values (kcal/year)
P	Bakairi Population	2.47×10^7
H	Food Storage[c]	—
R34	Gardening	1.10×10^7
R35	Harvesting	3.92×10^6
R37	Fishing	2.18×10^6
R38	Hunting	9.82×10^5
R39	Cattle Care	1.44×10^6
R40	Cultural Feedback	1.20×10^8
R41	BMR and SDE	6.10×10^7
R42	Food Consumed[c]	—
R43	Food Prepared[c]	—

[a]Energy flow values taken from Table 5-2

[b]Storage derived from dried weights

[c]See Chapter 7 for evaluations and explanations

cultural feedback. Most of the energy expended by the Indians is not spent on harvesting or fishing, but rather, it is invested in maintaining the cultural structure which frames all activities.

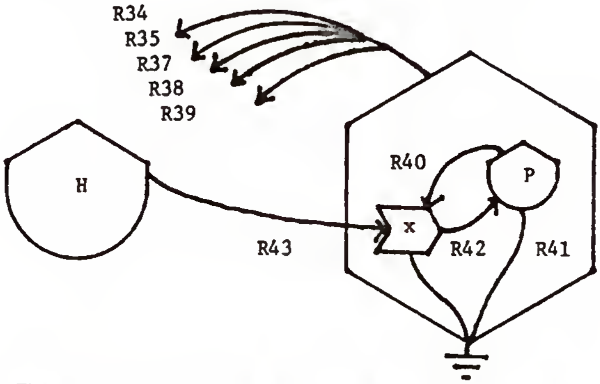


Figure 5-1. The Bakairi Indians and their energy expenditure

Rates 34, 35, 37, 38, and 39 represent that energy which is expended in subsistence activities. These expenditures have been broken down into separate flows because they interact with different ecological subsystems. For example, fishing expenditures intersect with aquatic biomass yields from the river in order to produce fish catches. Hunting expenditures intersect with gallery forest consumer yields to produce edible game. The separation of these expenditures also allows for the evaluation of energy investement into each of the ecological subsystems. The Bakairi invest 7.4 percent (1.49×10^7 kcal/yr) of their total energy expenditure into the gardens, while only 1.1 percent (2.18×10^6 kcal/yr) is invested in fishing, .7 percent (1.44×10^6 kcal/yr) in the care of cattle, and .5 percent (9.82×10^5 kcal/yr) in hunting. The comparatively small amounts of energy actually designated for subsistence activities is notable. Also of interest is the order of investment. Energy is expended in decreasing order on gardening, fishing, cattle care, and hunting. As a result, we would expect to see a comparably ordered return for this investment. That is, gardening and fishing should yield more calories than cattle care and hunting. In Chapters 6 and 7, gardening and protein acquisition will be examined in order to determine whether this supposition is correct.

Monthly Variation in Time Allocation

One of the advantages of using the time allocation methodology is that it allows for the registration of seasonal variations of time expenditures by a group. Over a year's period, the level of some actitivites remains constant. For example, the allocation of time for child care, eating, food preparation, and personal hygiene does not vary dramatically on a monthly basis. However, ritual, wild food procurement, gardening, idleness, and manufacturing are activities in which the Indians differentially participate depending upon the month. In Table 5-5, the numbers of data points for certain activities have been converted to proportions. In Figure 5-2, these percentages have been charted in order to show more clearly their annual fluctuation.

Participation in hunting and fishing activities vary greatly over the year. In December and January, which is the height of the rainy season, the Bakairi tend to avoid fishing in the swollen rivers and instead turn to the gallery forests where they hunt alone and in groups for peccary, deer, and other kinds of game. During the month of

Table 5-5. Monthly variation of time allocation for selected activities over a year's time (in percentages)

Activity	1	2	3	4	5	6	7	8	9	10	11	12	Total
Idleness	10.2	9.3	5.5	9.2	8.6	8.7	8.1	6.6	9.3	7.3	7.1	10.1	100.0
Gardening	9.6	5.2	4.3	8.6	5.5	5.5	2.3	9.0	14.3	11.4	11.2	13.1	100.0
Ritual	0.0	0.0	0.0	5.8	21.6	21.6	37.5	11.6	0.0	1.0	0.0	0.0	100.0
Ritual Dancing	0.0	0.0	0.0	11.8	25.3	17.5	12.2	10.5	5.7	15.3	1.7	0.0	100.0
Manufacturing	3.8	2.9	14.7	2.4	6.2	6.3	9.9	17.4	9.5	12.2	7.7	7.0	100.0
Hunting	26.2	0.0	0.0	6.9	3.4	3.5	0.0	0.0	0.0	12.0	0.0	48.0	100.0
Fishing	0.0	13.1	13.1	7.5	10.3	10.3	13.1	3.3	13.0	9.8	6.5	0.0	100.0

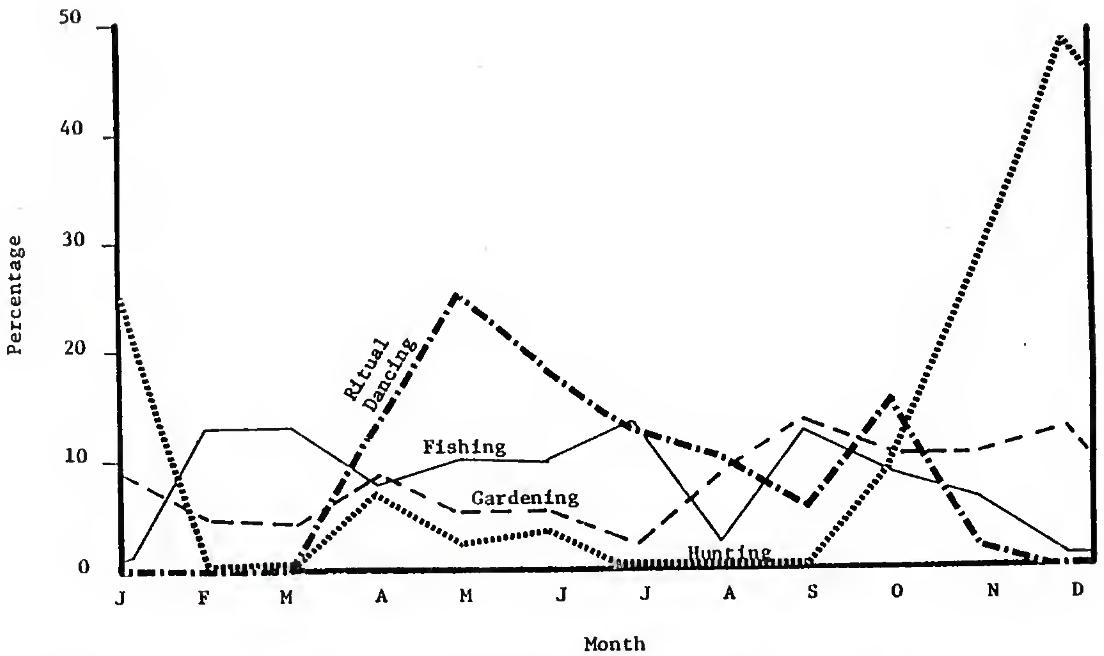


Figure 5-2. Monthly variation of time allocation for selected activities

February, after the corn-hunt festival, which will be discussed in more detail in Chapter 6, the Indians begin to fish again. However, a slight reduction in fishing levels, and an increase in hunting levels, are seen in April when the huge ritual masks begin to dance for the first time that year. For three days the men dance night and day, with only short intervals for rest, to introduce the newly painted masks to the community. During the festivities, game, fish, and manioc pancakes are distributed throughout the village from the men's house. After the festivities, participation in fishing gradually increases while at the same time hunting activities decrease.

During the months of July, August, and September, few people hunt. This is the height of the dry season when the rivers are low and the fish easy to catch. Fishing is popular with men and women during these months, and the yields are substantial. In August a temporary decrease in the allocation of time to fishing occurs. This decrease can be attributed to two main factors. In the first place men leave the reservation for short periods of time in order to earn some money working on nearby ranches. Ten-day to three-week journeys effectively reduce the number of hours men can spend on the river. Overlapping with this period, men finish up the garden clearing and prepare for the burning of the land. Long hours are spent in the gardens and although some men fish for a few hours from the banks of the river on which their gardens lie before returning home, most people depend upon reduced fish and game supplies during this time. Time spent fishing peaks for the year in September, when the rains begin, and then gradually falls off until February. Simultaneously, time allocated to hunting increases, peaks in January just as fishing allocation hits its low point, and then declines as time spent fishing once again increases.

Time spent gardening varies; however, in general, some sort of activity can always be performed in the gardens. In June and the beginning of July, the men slash and burn the forest. Then they wait for the sun to dry the vegetation, before setting fire to it in August. During the months of September through December, they clear the gardens of as much superfluous material as they can and begin to plant the crops. In December and January, a lull occurs before the corn, and then the rice, harvests are carried out. Rice harvesting peaks in April. This period of intense activity is followed by a second lull which ends with the slash-and-burn cycle being repeated. From Figure 5-2, it is clear that some sort of gardening activity is constantly in progress. This reflects manioc harvesting which is always occuring in the old gardens as well as weeding and cleaning which occur during November and February. The Bakairi differ in the time they allocate to weeding. Some do not consider it important. Others go so far as to completely weed and clean the old manioc gardens from the previous year. The latter is a back-breaking and unpleasant task because the forest reclaims the gardens so quickly that weeding requires hacking away at thick vines and bushes with a machete. If this is not performed, the manioc harvests in these gardens are reduced. In addition, harvesting turns into a very difficult task as one has to fight one's way into the garden in order to dig up the tubers.

Ritual dancing with the huge masks takes place early in the morning before the men go off to fish or work in the gardens and at sunset before people go home to sleep. On important festival days, the men dance all day and night using herbs to keep up their strength. In spite of precautions, however, a few of the dancers always collapse in the heat of the day when high temperatures, exhaustion, and hunger weaken them. When this happens, the people say that the mask has stolen the spirit of its dancer. Ritual dancing begins in March or April depending on the pattern of the rains. Time allocation to this activity peaks in May and then gradually declines during the months of July and August.

By the end of September when fishing activities decline, the women complain that they do not have enough food, or time to prepare the food, for the masked dancers. Thus, in November, when allocation of time to fishing spirals downward, a two-day festival occurs where the village bids goodbye to the masks. Unlike the corn-hunt festival which is distinguished by games and contests or the introduction of the mask festival which is characterized by the joy and satisfaction of seeing old masks resurrected after many months of absence, the farewell festival is a time of pain and grief. The women become frightened and tearful and the men exhausted and dazed as the days of the festival wear on. The children are subdued and the old, fearful they will never see the masks dance again, wail and chant. At the climax of the festival, the women hide themselves while the men destroy parts of the masks and the costumes, and throw the materials into the river. For several days following this period, the village is characterized by lethargy and an eerie silence. November, December, and January are considered sad months by the people because no masks dance and the weather is constantly rainy and dark. The ritual season begins once again in February with the corn-hunt festival.

In Table 5-5, percentages of time allocated to manufacturing and idleness are also included. Manufacturing of mask costumes, hammocks, and houses are part of this category. In March, people gather palm thatch from the forest and make mask costumes. These costumes are completed by April when the masks begin to dance. In July and August, another peak in manufacturing is evident when the men, who need to reroof their houses before the rains begin, concentrate on this activity. At the same time, the women prepare cotton for hammock and twine. Hammock making continues through the month of December, but in January and February, it is necessary to allocate more time to gardening activities. Therefore, manufacturing activities are curbed until the mask costumes need to be prepared.

Idleness is actually a partial misnomer as it can signify staring into space, swinging in a hammock, or sitting around talking. Conversation is, of course, essential for organizational, educational, and political purposes. During "idle" periods, men plan hunting expeditions and discuss gardening problems. They form and break political factions over issues that pertain to relations with ranchers, the Indian Foundation, and cattle raising. Women are involved in their own groups and are powerful in deciding who is participating in witchcraft activities, who is having an affair with whom, and when and how harvesting should take place. Although women tend to do their organizing down by the river while they wash clothes or collect wateer, they still manage to spare some time in the late afternoon, while the men are at the men's house, to sit quietly and talk about important village events. Thus, idleness is rather evenly distributed over a 12-month period; however, in March when rice harvesting is at its height or in August when people are burning their gardens and preparing their homes for the rainy season, it is more difficult to spare time for conversing and resting. On the other hand, in December and January during the worst part of the rainy season, people have more opportunity to rest and relax indoors.

Comparison of South American Indigenous Time Allocation Patterns

Allen Johnson (1974) and Werner et al. (1979) also supply information on how South American indigenous peoples allocate their time. Johnson worked with the Machiguenga Indians of Lowland Peru and Werner et al. provide data on the Mekranoti, Xavante, Bororo, and Kanela of Central Brazil. In Table 5-6, comparative data has been compiled in order to evaluate Bakairi time and energy expenditure patterns. The Bakairi in particular spend an inordinate amount of time in what is classified as nonwork activities. The greatest proportion of this, 53.4 percent, is spent in "idle conversation." This contrasts with the other groups who spend some 5 percent less time in "idleness" and proportionally more time involved in subsistence-related activities, such as hunting, fishing, and gardening and in nonsubsistence work,

Table 5-6. A comparison of time allocation among adults in six South American indigenous communities

Activity	Machiguenga[a] (%)	Mekranoti[b] (%)	Xavante[b] (%)	Bororo[b] (%)	Kanela[b] (%)	Bakairi[c] (%)
Wild Food Procurement	11.1	8.9	8.8	6.4	5.3	3.3
Gardening	12.6	8.7	14.9	10.2	17.7	7.5
Nonsubsistence Work[s]	27.4	34.3	28.2	28.6	28.8	35.8
Nonwork[e]	48.9	48.1	48.1	54.8	48.2	53.4
Total	100.0	100.0	100.0	100.0	100.0	100.0

[a]Information compiled from Johnson (1974:10)

[b]Information compiled from Werner et al. (1979:311)

[c]Information compiled from time allocation study data set.

[d]Nonsubsistence work includes child care, food preparation, housekeeping, tool manufacturing, the gathering of firewood, business transactions in community, domestic animal care, and market activities.

[e]Nonwork includes eating, ritual, hygiene, conversation, idleness, recreation, and visiting.

such as child care and food preparation. The Bororo constitute an exception to this rule; however, due to the lumping of such activities as ritual and conversation into the one nonwork category, it is impossible to comment on the Bororo case.

In order to explain why the Bakairi expend so much time and energy in nonwork activities, one could posit the hypothesis that they are lazier than the other groups as did Lizot (1977) when he attempted to account for differential time allocation for hunting in two Yanomami villages. Or we could assume that the Bakairi inhabit such a rich environment that both their caloric and protein requirements are met with so little trouble that they need not expend much time or energy in subsistence activities. With regard to the first proposition, Werner et al. (1979) and Harris (1979a) warn against drawing conclusions about the importance of personality variables in determining behavior. They do not deny that ideological or social structures can play important roles in ordering behavior; however, they suggest that economic and/or ecological variables may represent underlying reasons for the emergence of behavior patterns as well as the additional cultural infrastructures that support them (Werner et al. 1979:313; Harris 1979a:55-56).

To examine the second proposition, we refer to Chapter 3, where a description of the Bakairi environment was provided and to Chapter 4, where a discussion of the demographic situation was included. In those chapters, several important facts were introduced. First the dominance of the unfertile cerrado in the Bakairi was stressed. Over 80 percent of the total available land area cannot be cultivated by the Bakairi. The relatively small amount of forest available for gardening combined with an average of 8 km round trip in order to reach a garden is one result of this imbalance. In addition, it was established that cerrado game is scarce and that most hunting occurs in the gallery forest. Cattle raising, a relatively recent Bakairi activity does take place on these plains; however, the Bakairi do not own these herds. They represent Indian Foundation investment and wealth. Although some cattle can be slaughtered on an annual basis, the Foundation discourages this practice because its aim is build up the herd as much as possible. In Chapter 4, the rate of natural increase for the Bakairi was set at an extraordinarily high 3.47 percent. It was established that the Indians rely on artificial population control methods to curb the growth of their group; however, whether or not it has been adequately controlled is a problem that requires close examination.

A growing population and a deficiency of gallery forest suggest that the Bakairi do not live in such a fertile environment that it is not necessary for them to work as hard as other groups in order to make a living. In fact, we will see in Chapter 6, the Bakairi live in a much poorer environment than do the Mekanoti Indians who spend 5 percent less time in nonwork activities than do the Bakairi. What, then, is the explanation for the exceptionally large amount of time that the Bakairi spend in "idleness"?

The key to the answer to this problem lies in the definition of "idleness" which has already been described as a misnomer. "Idleness or nonwork is in effect conversation or politicking or organizing. In establishing that the Bakairi population, in general, spends approximately 54 percent of a 12-hour day in nonwork activities, we are in effect emphasizing the amount of time which they spend participating in political activities. These activities are of two types: blatant faction formation and defense, and subtle political maneuvering through witchcraft accusations. Faction formation, disintegration, and reformation occurs on a monthly and even daily basis in the Bakairi village; however, long-standing lines of antagonism have been drawn and are regularly observed in these conflicts. For example, the upper part of the village, organized around the old widow Makalo and her five powerful sons, is pitted against the lower part of the village, which is controlled by a wiley old widow named Laurinda. Both, however, react against two factions which are centralized in the east and west parts of the village. These are controlled by the current capitão, or Bakairi representative to the non-Indian world, and by the ex-capitão, Maiuka, who was displaced in the late 1970s. Other less powerful gropus also exist, one of which is headed by the most important Bakairi shaman, Paulino. He is an intelligent and difficult man who aligns his faction mostly with Maiuka's group; however, when the need arises he will support the current capitão. An endless number of permutations are the net result of the large number of groups that compose the Bakairi village. From day to day, the factions realign themselves depending upon the issue. These realignments require a great deal of energy and time both for the men and the women who participate in these activities with undisguised gusto.

In order to illustrate this point, a discussion of those conflicts which took place during a randomly selected three-month period in the village is provided. In December, the village was convulsed by a bitter conflict over the current capitão. One faction accused him of secretly selling cattle and pocketing the money. They also claimed he was ineffectual in dealing with the non-Indians. Calling him a thief, they swore that they would kill him if he did not step down. The capitão never directly defended himself. Instead he relied on intermediaries to establish the case that the old capitão was a corrupt and arrogant man who could not be trusted, but that he, the present capitão, was sensitive to their needs. At the same time that this was occurring, the latter mounted a campaign against the current Indian Foundation agent in order to distract the village and to reunite it behind him. The agent, rarely in the village, was an easy scapegoat. He was accused on stealing those funds allocated to the village by the Indian Foundation. His wife who was to teach the children Portuguese was also attacked for being lax in observing her obligations. By January, this conflict was fully developed and the capitão problem had been put to one side. The Indians organized a meeting in front of the men's house and everyone marked their sign on a paper which called for the removal of the agent from the reservation. This petition was then taken to the Foundation's headquarters in Cuiaba. Feelings ran so high that they planned to kill the agent and his family when and if they returned to the reservation. They threatened to chop off their heads and impale them on stakes to warn other non-Indians from entering their lands.

By February, the agent had still not returned to the reservation, and a third conflict emerged as the Indians turned inward, on themselves, once again. The Bakairi nurse's aide who treats people for minor medical problems was chosen this time. This aide is a 50-year-old, unmarried, childless woman who is somewhat physically deformed. She was accused by a faction of using witchcraft to cause the Gillian Barre epidemic described in Chapter 4. Laurinda's faction established this case in revenge because one of this widow's sons-in-law was completely paralyzed by the disease. In addition, while the son-in-law was in Cuiaba being treated, one of Makalo's sons, from the upper village faction, went to Cuiaba and told him that his wife, Laurinda's daughter, was sleeping with another man. The reaction of Laurinda's group to this piece of gossip was not to strike Makalo's faction directly, but to distract the village from the episode by attacking a third party, the west village faction, to which the aide is attached.

The turmoil which resulted from these fast-flying accusations was extraordinary. Few people left the village at all during those days for fear that the entire situation would change, leaving them in the middle, in the space of a few hours. A great deal of fear was also generated due to the fact that witchcraft is one certain motive for killing a person in an Indian village. Those who are accused of practicing this art flee, either temporariliy or permanently, or they rely upon swift and effective politicking in order to protect themselves. The nurse's aide and her ex-*capitão* faction chose the latter course. To protect themselves, they mobilized against the accusation by mounting a very serious offensive against Makalo's upper village party. It was a brilliant ploy because it effectively brought Laurinda into the fray on their side. They joined in accusing Makalo's people of using witchcraft to cause the epidemic and supporters of the nurse's aide circulated stores which documented the appearance of Makalo supporters, in spirit form, over their bodies while they were ill. Groups broke and recoalesced over the issue, until, in the final breakdown, Makalo was outnumbered and had to cut her losses. She resolved to sacrifice a peripheral supporter. This man, without substantial family to support him, was singled out as the witch who had caused the disease. He was killed.

The tragic consequences of this randomly chosen sequence of events which transpired in a three-month period underline the dangers of minimizing the nonwork activities in which the Bakairi participate. The conflicts are real and are serious in that they affect individual lives as well as the overall functioning of the village. However, if we have established why the Bakairi spend so much time in nonwork activities, and what this means in more precise terms, an explanation for this intense and dangerous political activity has yet to be offered.

The relationship between warfare and pressure on key ecological resources in the South American Lowlands has been well documented in the anthropological literature (Carneiro 1960; Siskind 1973; Divale and Harris 1976; Vayda 1976). One of the correlates of this theory is that before indigenous village populations increase to the point that they begin to impact upon the surrounding environment, witchcraft accusations, political infighting and violence escalate to the point that the village fissions. Results of this process include dispersion of settlements, and of populations, as well as reduced pressure on strategic resources. For example, Siskind (1973) discusses the relationship between game resources and successful hunting on one hand, and antagonism beteween the sexes and village fissioning on the other hand. Her study indicates that when game shortages occur, fewer men are successful when they hunt. As a result, the women in the village gravitate toward the more adept hunters, exchanging sexual favors for meat. When this occurs, the men in the village fight among themselves. The conflicts result in the fissioning of the village, and indirectly in a reduction of pressure on the game resources in the vicinity.

The frequency of the disturbances which wrack the Bakairi village in addition to the time and energy expended in controlling them suggest that the Bakairi may be undergoing a similar process. With a population of 288, their community puts pressure on strategic resources and results in an unequal distribution of the natural products. Men more successful in gardening or in hunting and fishing receive more attention from the women. The clandestine affairs cause conflicts between both the men and the women, straining the social relations which are essential to the functioning of the village.

In this chapter, Bakairi time and energy expenditures have been examined. Through the analysis of time allocation data, the energy flows from the Bakairi population tank were quantified. This enabled us to place the Bakairi in the energetics diagram which at this point includes key ecosystem components and the Indian population. In subsequent chapters, the documentation of the links between these two sections of the model will be investigated. Furthermore, an important question was raised. It was established that the Bakairi spend over 50 percent of their working day in nonwork activities. These activities were defined in terms of political organizing and conflict. The query posed concerned the reason for the large expenditure of energy on this type of activity. Tentatively linking energy expenditure on politicking with demographic and ecological variables, the suggestion that the Bakairi village is at a fissioning point was posited.

CHAPTER 6
BAKAIRI GARDENS AND THE FLOW OF ENERGY

The Bakairi depend upon their gardens to provide them with the bulk of the calories they consume. These gardens are located along the rivers in the gallery forest. Until fairly recently tropical soils were thought to be of low productivity. Researchers pointed to the low cation exchange capacity, a chemical property which affects the leaching of soil, and the lack of accumulation of humus, due to rapid decomposition of organic matter, as limiting factors in soil productivity (Janick, Noller, and Rhykerd 1976:79). In addition, it was theorized that people unable to use industrial agricultural technology employ slash-and-burn horticulture in response to the low nutrient levels of these soils. Currently, however, reseracher have found evidence which indicates that tropical soils cultivated by slash-and-burn subsistence methods are actually rich in such critical substances as organic matter and potassium. In addition, these soils have a high cation exchange capacity which is indispensible for successful agriculture (Moran 1979:267). Moreover, slash-and-burn technology is an important means whereby the fertility of topsoils used in cultivation is enhanced.

Soil Analysis Results

In order to evaluate in what kinds of soils the Bakairi make their gardens, soil samples were collected and then analyzed by the Soil

Science Department of the Escola Superior de Agricultura de Lavras in Minas Gerais. Samples were taken from four distinct areas: the forest, where the Indians make their gardens; the cerrado, which the Indians claim is unfertile; a newly burned garden; and an adjacent one-year garden. The four soil samples were each collected at a depth of 0 to 10 cm from 15 holes dug in a zigzag fashion across each designated area. The 15 holes were 1.5 m apart. From each hole 100 g of soil were removed, then mixed in a tarpaulin before 500 g were sieved and drawn. The samples were then air-dried and placed in a cloth bag for transport. The results of the analysis are included in Table 6-1.

The cation exchange capacity of soil refers to its capability to attract positively charged ions such as calcium, magnesium, and hydrogen to the particles that compose its mass. If the cation exchange capacity is low, soil nutrients can be easily leached from the soil. However, if the capacity is high, then these same nutrients can be held in reserve for later use by growing organisms. The cation exchange capacity depends on the amount of clay and humus, or organic matter, in the soil. Clays in general have a higher cation exchange capacity than silt or sand; however, depending on the composition of the clay, cation exchange capacities of clays can vary widely. Organic matter, on the other hand, has an overall high cation exchange capacity. For this reason, its presence is of critical importance for growing crops (Janick et al. 1976: 78-79). In Table 6-1, a low rating (3.558 meq/100 cc of soil) for the cation exchange capacity is given the cerrado, while the forest and two gardens are all given high ratings. The freshly burned garden has the

Table 6-1. Results of analysis of soils taken from new garden, one-year-old garden, adjacent forest, and *cerrado* in the Bakairi reservation

Chemical	*Cerrado*[c]	Forest[c]	First-year Garden[c]	New Garden[c]
Cation Exchange Capacity (meq/100 cc)[a]	3.558 (L)	6.335 (H)	7.412 (H)	9.316 (H)
Organic Matter	2.200 (M)	3.700 (H)	3.700 (H)	4.200 (H)
pH (in H_2O)	5.500	6.100	6.200	7.100
Phosphorus (ppm)[b]	3.000 (L)	12.000 (M)	17.000 (M)	160.000 (H)
Nitrogen	0.090 (M)	0.120 (M)	0.130 (M)	0.160 (H)
Potassium^{+} (meq/100 cc)[a]	0.258 (H)	0.235 (H)	0.312 (H)	0.716 (H)
Calcium^{++} and Magnesium^{++} (meq/100 cc)[a]	1.900 (L)	6.000 (H)	7.000 (H)	8.600 (H)
Aluminum^{+++} (meq/100 cc)[a]	1.400 (H)	0.100 (L)	0.100 (L)	0.000 (T)

[a] Meq/100 cc = milliequivalents per 100 cc of soil

[b] Ppm = parts per million

[c] T = trace; L = low; M = medium; H = high

highest level of cation exchange capacity (9.16 meq/100 cc). According to Moran, high temperatures which are the result of burning energize ions and make them available for plant utilization (1979:269). Thus, burning prior to planting actually increases overall CEC, and indirectly improves soil fertility.

Since the CEC of the cerrado is low, we would expect to also find low levels of organic matter since with a high level of humus, one would necessarily find a high CEC. The cerrado with 2.2 percent organic matter composition is given a medium rating while the forest and the two gardens receive high ratings. Although burning theoretically does not affect the percentage of organic matter, the Bakairi soil results register a slight increase in the amount of organic matter made available for plant growth through the burning process. This may be the result of an acceleration of the nutrient-cycling process which is triggered by burning.

The pH of soils has an important yet indirect effect on plant productivity. Very acid (pH 4 or below) or very alkaline (pH 9 or above) soils are of course toxic to roots. However, between pH 5 and 8, relative acid/alkaline levels affect fertility by increasing the proportion of ions bound to soil particles, thus reducing their availability to plants. For example, phosphorus becomes insoluable, and unavailable to plants, if the pH is too high or too low. In addition, high acidity inhibits nitrogen fixation (Janick et al. 1976:79). The pH of the cerrado soils was 5.5, medium-acid, while the pH of the forest and garden soils were weakly acidic or neutral, respectively. In the newly burned garden, the pH was 7.1 which indicates that the slash-and-burn procedures reduced the acidity of the forest soils. Moran states that the deposition of ashes is responsible for the overall decrease in soil acidity which is most marked in the top layers of the soil (1979:268-269).

Due to the acidic nature of the cerrado soils, one would expect to find lower levels of both phosphorus and nitrogen than in other areas of the reservation. Phosphorus is only needed in small quantities and its presence is stable so that leaching does not affect it. Nevertheless, it is necessary for plant growth, and soils are usually unable to supply enough phosphorus for maximum growth (Janick et al. 1976:81). Phosphorus levels of the cerrado soils were rated low (3.0 ppm) while the levels in the forest and one-year-old garden were medium (12.0 and 17.0 ppm, respectivley). The level of phosphorus in the new garden was extremely high (160.0 ppm). This dramatic increase in the availability of phosphorus is one of the more significant results of burning, which frees this nutrient for plant use (Moran 1979:260-270).

Availability of nitrogen also differs with area and changes with the burning process. Nitrogen levels in the cerrado, forest, and one-year-old garden are all rated medium; however, the cerrado and forest are lower than the one-year-old garden. This result is interesting because nitrogen is lost to plants through biological processes and when a crop is harvested, the loss is permanent. The Bakairi soil samples, taken after the first-year garden was harvested, indicate that although nitrogen levels are reduced with harvesting they are yet higher than the forest and the cerrado even after a year's growing season. The nitrogen level of the freshly burned garden is high (0.16 percent), which is in part related to the high organic matter level.

Potassium, calcium, and magnesium are also important for plant growth. While calcium and magnesium are rarely found to be deficient in soils, potassium is required in large amounts. Its precise role is poorly understood; however, it is agreed that potassium, like calcium and magnesium, must be available as an exchangeable ion (Janick et al. 1976:81-82). If the CEC is low, then the presence of these nutrients will be irrelevant. If the CEC is satisfactory, then relative amounts of especially potassium become significant. Potassium is found in large amounts in all four of the areas sampled. The area with the highest level of potassium was the new garden. High levels of calcium and magnesium were also found in the new and old gardens and in the forest. Low calcium and magnesium levels existed in the cerrado. However, the low CEC of the cerrado already discussed above indicates that the small amounts of magnesium and calcium found in the same area are probably unimportant from an agricultural standpoint.

The presence of high levels of aluminum ions is detrimental to crop production. In acid soils, aluminum toxicity can affect some plants. Aluminum ions were found at high levels in the cerrado and at low levels in the forest and first-year garden. Only traces were found in the first-year garden. Current research indicates that the effect of burning prior to planting is to decrease exchangeable aluminum and, thus, reduce the possibility of aluminum toxicity (Moran 1979:268-279).

The soil sample results support this hypothesis since although the forest aluminum levels are low, they are even lower in the first-year garden.

Soil analysis of samples from the Bakairi reservation suggests a number of points. The Bakairi distinction between the forest where they make their gardens and the _cerrado_ which is considered unproductive is supported scientifically. Low cation exchange capacity, medium organic matter levels, medium acidity, low levels of phosphorus, calcium, and magnesium, as well as high levels of aluminum ions are all characteristics of the _cerrado_ soils. These properties are unfavorable from an agricultural point of view. The gallery forests along the rivers and streams in the reservation contrast with the _cerrado_. The soils in these areas have such properties that allow for the successful cultivation of crops. In addition, the results of the Bakairi soil analysis can be added to the growing body of data that demonstrates the significance of the slash-and-burn process to successful horticulture in the Tropics (Gross et al. 1979:1046). Burning, especially, affects the soil nutrient content, thus ensuring high agricultural yields. The increases in cation exchange capacity, organic matter, phosphorus, nitrogen, potassium, calcium, and magnesium all contribute to higher soil fertility and are the result of burning. The reduction of acid and aluminum ion content are also important factors. Moran adds that burning eradicates seeds and growths that can lead to large crop of weeds. It also drives out animal and insect pests which affect overall crop yields (1979:270). Slash-and-burn techniques are not a primitive response to inferior soils where no other kinds of technology exist. Rather, they are part of a subsistence strategy that calls for low-energy input and that have the net result of increasing overall soil fertility.

Bakairi Garden Site Selection and Garden Size

Garden site selection on the part of the Bakairi depends on such factors as when the land was last cultivated, proximity to the village, the relative abundance of such pests as capybara, parakeets, and paca, and elevation of the land over the river. Pests, flooding, and worn land all reduce crop yields, and long distances from the village require unnecessary expenditures of time and energy for commuting to the gardens and for transporting harvests back to the village. Men begin their search for a garden site up to two years prior to the slashing season. They carefully check water levels during the height of the rainy season and discuss with the other men animal spottings in the vicinity of the desired area. The cultivation of crops in a new garden represents a two-year investment in that the second year garden is normally made adjacent to the first-year garden. Proximity of the two gardens facilitates garden care and manioc harvesting which usually stretches over a 12-month period. On the third year, a new site is located and the cycle is repeated. However, if a miscalculation has been made in that the river floods the gardens or animals consume the crops prior to harvest, the household head will move the garden to a new site the following year. The premature relocation of a garden site is considered undesirable by the Indians.

The Bakairi gardens are located on the Paranatinga, Azul, and Tuiuiu Rivers. It has already been established that these gardens lie on an average of 4 km away from the village. In order to determine average size of a garden, number of gardens, and total land under production, a random sample of 14 households (26 percent) was chosen to study intensively. From the data collected on gardening in the sample households over a 12-month period, a subsistence questionnaire was constructed which was then applied to each household head in the village at the termination of the field session. This questionnaire was used to check the results derived from the sample study. The households included in the sample were distributed geographically across the possible areas where gardens could be made. The vast majority of the gardens are found on the village side of the Paranatinga River; fewer are located on the other side. Only three gardens are located on the Azul River, where gallery forest is skimpy and wild animals abundant. Eight gardens are located on the Tuiuiu River which lies at least 10 km away. The 1980 community corn garden was made in this vicinity at a distance of 14 km. However, people complained so bitterly about the long distances involved that the leaders of the community resolved to move the next garden closer to the village. Measurement of the sample gardens was calculated by the pace method suggested by Gross (1979, personal communication) and Carneiro (1979, personal communication). Using a compass, colored ropes, and cloth flags, rectangular areas were cordoned and paced off. Odd areas not included in the original rectangle were then paced off using additional rope. Bakairi gardens are usually composed of a large rectangle and a smaller triangle attached either to the side or the base of the rectangle. The width of the rectangle, between 16 and 60 m, usually fits the width of the gallery forest that lines the river at that point. Lengths vary widely depending upon how much land the family wants to cultivate. After mapping the shape, and dimensions, of the gardens, areas were mathematically estimated using standard geometric formulas depending upon the shape in question.

Based on the above methodology, the average size of a 1979 garden is determined to be 4,058 $\pm$ 1,344 m^2. The average size of a 1980 garden is estimated to be 4,061 $\pm$ 1,481 m^2. In addition to these single household gardens, three multihousehold gardens existed, two large community gardens were cultivated, and seven corn capoeiras, or replanted gardents, were made (see Table 6-2). Ten households did not burn gardens in 1980 due to illnesses in the family or to community responsibilities. These people were forced to go hungry and/or to share the food of their kinsmen. Total land cleared in 1980 was estimated to be 23 ha. Total land under produciton was calculated as 44.5 ha.

Slash-and-Burn Technology and Planting

As already mentioned the Bakairi depend upon slash-and-burn technology to make their gardens. In June and July they slash away the underbrush in the new garden site using machetes and then chop down the largest trees with axes. Oftentimes the household will ask the men of the village to assist in this phase of garden making. The household head will hunt or fish the day before the community labor effort. Then

Table 6-2. Bakairi gardens

Type of Garden[a]	N	%	A (m^2)	%
1980 Single Household[b]	44	42.3	178,706	40.1
1980 Multi-Household[c]	3	2.9	27,546	6.2
1980 Community[c]	1	1.0	23,950	5.4
1980 Corn _Capoeiras_	7	6.7	18,564	4.2
1980 Community Corn _Capoeira_	1	1.0	2,652	.6
1979 Single Household	48	44.2	186,668	41.9
1978 Single Household	2	1.9	7,032	1.6
Total Land Cleared 1980	48	46.2	230,202	51.7
Total Land Under Production 1980-1981	104	100.0	445,118	100.0

[a]Ten households did not burn gardens in 1980.

[b]Of the 90 single household gardens, 32 (35.5 percent) were measured. Mean garden size was calculated to be 4,061 ± 1,481 m^2 for the 1980 gardens and 4,058 ± 1,344 m^2 for the 1979 gardens. Total number of gardens was then multiplied by mean size in order to estimate land area.

[c]All of these gardens were measured.

while the men are clearing the land, the women of the household will prepare a large feast for them to eat when they return to the village. June and July, then, are times of organized labor with the majority of the men moving together from one new garden site to the next. From the end of July to the end of August, the fields are allowed to dry in the sun. At the beginning of September, directly before the rains begin, the fields are burned. If they do not burn well, extra time must be spent reclearing and reburning. Bakairi gardens are not clean-cleared. Rather logs and stumps are left in the middle of the fields instead of being carried to the edge of the gardens. After the gardens are abandoned, the forest is able to recover, and rejuvenate, the land faster as a result of this practice (Clarke 1976:250).

In October and November, rice, corn, and manioc are planted. The rice and corn will be harvested during late February, March, and into April; however, the Bakairi will not begin to harvest the manioc until the following fall, a full year after it has been planted. Thus, two gardens are usually being gradually harvested simultaneously. The old garden provides manioc as well as banana, papaya, and sugar cane, if they were planted, while the new garden supplies rice, corn, melon, and squash. Continuous harvesting of this sort increases total harvest as the plants are given an opportunity to recover. Gradual harvesting also reduces the necessity for storage facilities which are absent. The fields in effect become storage sites which can be drawn upon as the need arises. Some parts of the old garden can also be reburned the following year. In these small plots, corn is planted. However, most

Bakairi do not consider this effort worthwhile as these capoeiras do not yield abundant harvests.

Intercropping is one of the hallmarks of slash-and-burn horticulture. Manioc, rice, melon, etc., are all cultivated together. However, 39.5 percent of the 1980 gardens did separate out corn into distinct growing areas. According to the owners, this separation prevents the trampling of the rice plants during the corn harvest. Corn is harvested several weeks before the rice matures. The majority of the Bakairi do not bother to do this, however, and intercrop their corn with the rice and manioc.

Gardens are in effect abandoned after the second year although those who have planted banana and sugar cane may, or may not, return to these sites to occasionally harvest these plants. Land is allowed to remain fallow at least ten years after it has been cultivated. Ten years, however, is not considered an ideal fallow period by the Indians. Rather 15 to 20 years is preferred although land around the village is rarely allowed to remain unused for this length of time.

Harvest Methodology

Ten important crops are cultivated by the Bakairi. They include, in order of importance, bitter and sweet manioc, rice, corn, sugar cane, banana, yams, melon, beans, papaya, and squash. In order to determine yields of crops the following methods were employed. To estimate manioc yields, a 10 x 10 m plot was cordoned off and harvested in three different gardens. The tubers were counted and weighed. Yields for these sample areas were averaged and then multiplied by the total area under manioc cultivation. Schwerin (1970) suggests that a 1:4 ratio exists between manioc tubers and manioc flour used in food preparation. Therefore, to estimate edible manioc mass, total yields were multiplied by .25. Rice yields were more easily estimated because the Indians harvest all of the rice at one time, thresh it in palm-thatch huts in the gardens, and then transport the rice to their houses by canoe. As a result, the researcher was able to count the number of bags of rice entering the village during the rice harvest period. Later, figures on this harvest were checked with the subsistence interview. In order to determine edible mass, total rice weight was multiplied by .66. Hulls are estimated to equal approximately one-third of total weight.

Corn harvests were difficult to estimate due to the large number of factors which influence corn yields. Gardens were first divided into categories: <u>capoeiras</u> (or land that has been recently cultivated), intercropped corn, separately cultivated corn, and community garden corn. Only eight corn <u>capoeiras</u> and one large community corn garden were planted in 1980 so that 10 x 10 m plots in each of these areas (two in the community garden) were roped off. Then the number of plants, stalks, and ears were counted in each plot. Yields per plot per garden were then multiplied by the area of the garden in question. A great deal of variation in plant density and plant yield was noted. For the intercropped and separately grown corn gardens, samples of six gardens per category were chosen from the random sample. Yields per category of garden were determined in the same way as in the <u>capoeiras</u> and the community garden. Then average yield per garden type was multiplied by total area of land under cultivation in that category. In order to estimate edible mass, the weight of the harvested ears of corn was multiplied by .8. Twenty percent of the weight of a corn ear is estimated to be inedible. In addition, the ratio of fresh corn to dry corn harvested was noted because dried corn has higher caloric value than does fresh. At least 57 percent, and possibly more, of the corn was allowed to dry in the sun prior to harvesting.

In order to estimate banana and sugar cane yields, number of mature shoots and plants in the sample gardens was counted. However, the subsistence interviews were relied upon to check the total number of plants actually cultivated in the gardens. Much of the yielding banana and sugar cane is found in the 1979 community garden. The plants and shoots located there were counted by the researcher. Cane and banana are alike in that after they yield their fruits, the harvested shoot is cut back and another plant will grow up in its place to be harvested the following year. A mature banana shoot will give one bunch of bananas per year. Mean weight of banana bunch is estimated to be 22.7 kg. Edible weight is 15 kg (Smole 1976:143). Only one-half of the cane in the gardens was harvested. The weight harvested was determined. This figure was then used to estimate the amount of sugar cane sap the Indians squeeze from the stalk. The Indian Foundation has given the Bakairi a small press which the cane is pushed through in order to squeeze out the juice. Cane is cut and pressed on special occasions throughout the year when the entire community can participate in the harvesting.

Squash, melon, and yam harvests were estimated by determining the number of vines that were planted and grown, the yield per vine, and then the total yield. Each family decides individually how many vines will be planted in their garden so that a great deal of variation per garden was noted. In addition, yields of melons and squash largely depend on how many fruits the wild animals will leave for the producers. These gourds present a special source of attraction for the forest animals who can consume up to 50 percent of a harvest. The Indians themselves will also leave some of the total crop unharvested due to the inconvenience of having to transport the heavy fruits back to the village. To a great extent, melon, especially, is actually consumed in the garden as a refreshing snack. Rarely will it be taken back to the village as are squash and yams which require cooking.

Beans are cultivated in only six gardens. Usually a capoeira is made for this purpose. Land under bean cultivation and yield per acre were determined. To estimate papaya yields number of mature trees were counted, and then fruits per tree harvested were estimated. As in the case of melons and squash, papaya fruits are not carefully harvested and tend to provide snacks for those working in the gardens.

Crop Yields

Two types of manioc are cultivated by the Bakairi: bitter (*Manihot utilissima*) and sweet (*Manihot dulcis*). The majority of people plant both kinds, dividing their gardens into half. Manioc is planted in mid-September. After seven to eight months, harvesting can begin although most people prefer to harvest all the manioc from the old gardens before starting on the new gardens. This delay allows the tubers to fully mature. Manioc is depended upon throughout the entire year while corn is enjoyed only during the spring, and rice is consumed for six to eight months depending on the individual's harvest. Yields for manioc are high, possibly because of the delay in harvesting. The consumption of rice in the early and middle months of the year allows the Bakairi to conserve more manioc than they otherwise might (see Table 6-3).

Rice (Oryza sativa) has not always been cultivated by the Bakairi. The Indians say that when they lived on the headwaters of the Xingu River, they did not cultivate the crop. During that time, and during the first decade of their settlement on the Paranatinga River, they depended solely upon manioc. However, in about 1935, the Indian Protection Service, which was at the height of its power, used the Bakairi as laborers to cultivate and harvest large rice fields. The rice was then sold outside of the reservation, and the Bakairi were left with new information which they used to begin their own rice gardens. Rice is now relatively popular with the Indians. Each year they slash and burn a new plot of land for rice cultivation because rice capoeiras do not yield well. The rice seeds were planted in December and harvested in March. By the following December, all the rice has been consumed and the people eat only manioc until the next harvest comes in. In 1980, 7 (14.9 percent) of those who made gardens decided not to plant rice. Another 10 (21.3 percent) suffered reduced harvests as a result of flooding and animal interferences. A great

Table 6-3. Manioc yields for the Bakairi over a 12-month period

Garden Type	N	Bitter Manioc		Sweet Manioc	
		Area (m^2)	Yield (kg)	Area (m^2)	Yield (kg)
Both Kinds Raised	32	72,665	127,613	72,665	127,613
Only Bitter Raised	10	40,615	71,328	—	—
Only Sweet Raised	2	—	—	8,123	14,266
Neither Raised	3	—	—	—	—
Total	47	113,280	198,941	80,788	141,879

Table 6-4. Rice yields for the Bakairi over a 12-month period

Garden Type	N	Area (m^2)	Yield (kg)
Rice Harvested	30	136,486	18,840
Reduced Harvests	10	41,336	540
No Rice Grown	7	—	—
Total	47	177,822	19,380

deal of annoyance resulted from these minimal harvests; however, these households still had manioc crops on which they could depend. In Table 6-4 figures on land area involved in rice cultivation indicate that less land is used in rice than in manioc cultivation. Yields are also lower than manioc harvests.

Corn (Zea mays) is a third major crop; however, as previously mentioned, it is only seasonally important. It is generally planted in October and harvested in February although some plant in December and harvest as late as April. The 1980 community where only corn was planted was not harvested until June of 1981. By that time the corn was dried and the people boiled it in water to make a kind of syrupy soup (see Table 6-5).

The first corn harvests are ritually marked by the Bakairi. These initial harvests and the rituals associated with them can also be correlated with the climax of the hunting season. At the end of January, most of the men go on a week-long hunting trip. Those men that do not go hunt during the day and return at night. At the same time, the women harvest part of the new corn and bring it to the village where they make soups and corn flour as well as prepare large numbers of manioc pancakes. At night they gather in a group, lock arms, and go from house to house singing and chanting. When the men return from the hunting trip with the game they have killed, a two-day festival takes place which involves both the women and the men forming separate circles and dancing from house to house. The scarification of the young children with fish teeth also occurs during this time. At odd

Table 6-5. Corn yields for the Bakairi over a 12-month period

Garden Type	N	Area (m^2)	Yield (kg)
Corn *Capoeira*[a]	8	21,217	2,050
Intercropped Corn[b]	23	97,453	3,306
Separately Grown Corn[b]	15	12,874[c]	1,842
Community Garden	1	23,950	9,492
No Corn Grown	9	—	—
Total	56	155,494	16,690

[a]Ten percent of these gardens harvested nothing.

[b]New gardens

[c]Separate corn areas approximately 18 percent of total garden area.

Table 6-6. Banana yields for the Bakairi over a 12-month period

Garden Type	N	Shoots	Yield[b] (kg)
Producing Bananas	15	1,223	27,762
Community Bananas	1	296	6,719
No Bananas Grown	33	—	—
Total[a]	49	1,519	34,481

[a]1978, 1979 gardens with producing banana shoots

[b]Based on Smole (1976:143)

hours during the festival the roasted meat and previously prepared corn and manioc foods are brought to the men's house where they are distributed to household heads. The end of the festival is marked by the anteater and armadillo games where men and women are organized into opposing groups. In the anteater game, the women form a chain-line and dance around the village making squeaking sounds. The leader of the chain holds a stick in front of her to protect her column of ants. The stray male, representing the anteater, also carries a stick. The object of the game is either for the male to knock the stick out of the leading woman's hands or for the women to break file when the male approaches too closely and knock him to the ground where he is pummeled. Roles are reversed; however, the male ants are generally too rough on the female anteaters, so that the elders call a halt to the game. The armadillo game is also played by men and women. The women are the armadillos, and the men are expected to stalk and capture them. This game, however, quickly grinds to a halt because all of the women hide too well for the men to find them. After the festival, corn harvesting is intensified and hunting drops off (see Chapter 5).

Banana (Musa sapientum) and sugar cane (Saccharum officinarum) are cultivated in single gardens; however, the largest concentrations are found in the 1979 cummunity garden. Over 575 sugar cane plants and 296 banan shoots had matured in this garden by fall of 1980. However, 320 banana plants had been planted the previous year which indicates a 7.5 percent crop failure occurred. Due to this large amount of food stuff not many families planted cane or banana in their new gardens.

Those that did were careful to plant the shoots prior to rice, corn, and manioc cultivation so not to disturb these crops after they are put into the ground (see Table 6-6).

Squash (Cucurbita maxima), melon (Cucumis sp.), and yams (Dioscorea sp.) are cultivated in many but not all of the gardens. They are always intercropped with the other cultigens so that their vines are found trailing along the ground alonside of the rice and corn. They are planted at random so that only the owner of the garden can find them once the other plants have grown up. This practice discourages visitors from entering the garden and consuming the fruits. Squash, melon, and yams are enjoyed only on a seasonal basis. Around March and April, an overabundance of these foods is available (see Table 6-7).

Papaya (Carica papaya) and beans (Phaseolus sp.) are cultivated by relatively few garden owners. Papaya is available all year round once the trees begin to produce. Beans, on the other hand, are harvested and consumed directly (see Table 6-8).

Bakairi garden yields are compiled in Table 6-9 in order of importance. Manioc, rice, and corn are most important in terms of kilocalories produced. Banana, sugar cane, and yams provide fewer calories but they make an important contribution to the diet of the people. Melon, beans, papaya, and squash play an even less significant role. However, in considering the impact of these cultigens on the diet of the Bakairi, the factor of seasonality must be considered. Since no means of storage or preservation exists, except in the fields themselves, when some crops are ripe for harvesting they must be consumed within a

Table 6-7. Squash, melon, and yam yields for the Bakairi over a 12-month period

Garden Type	Squash	Melon	Yams
Gardens That Planted	21	25.0	32.0
Gardens That Did Not Plant	26	22.0	15.0
Total Gardens	47	47.0	47.0
Yields (kg)	925	2,332.5	961.4

Table 6-8. Papaya and bean yields for the Bakairi over a 12-month period

Garden Type	Papaya	Beans
Gardens That Planted	26	6
Gardens That Did Not Plant	21	41
Total Gardens	47	47
Yields (kg)	910	220

Table 6-9. Gardening yields for the Bakairi over a 12-month period

Food Type	Harvested (kcal)	Edible[a] (kcal)
Manioc	3.75×10^8	2.86×10^8
Rice	7.42×10^7	4.62×10^7
Corn	6.31×10^7	4.54×10^7
Banana	5.26×10^7	2.51×10^7
Sugar Cane	3.41×10^7	2.86×10^6
Yams	1.27×10^6	8.65×10^5
Melon	6.00×10^6	4.52×10^5
Beans	—	4.01×10^5
Papaya	1.86×10^6	1.63×10^5
Squash	2.47×10^6	1.10×10^5
Total	6.11×10^8	4.08×10^8

[a]Kilocalorie values and some edible portions for specific foods taken from Leung (1961) and then multiplied by the harvest yields.

relatively short period. Thus, some of the calories provided by the foodstuff from the gardens are not spread out evenly over a year's time. Rather, they tend to be bunched together at specific peak times in the year when too much food is available and tends to go to waste. The Bakairi are actually forced to underharvest a great deal of what is produced; however, even with this tendency, such crops as manioc and banana, and to a lesser extent rice, provide constant sources of calories throughout the year.

In Table 6-10, crop exploitation is differentiated according to seasonality. The majority of cultigens are actually relied upon only during specific months of the year. These month include February, March, April, and part of May. They constitute the peak harvest time. We will see in Chapter 7 that the peak hunting time is December and January, the peak fishing time is June, July, and August, and the peak gathering time is September, October, November, and December. Thus, a rhythm exists in the village in that the population exploits one part of the ecological system for a short while prior to moving on to the next niche.

Gardening Energy Efficiency Ratio

Agricultural data have been used by some researchers to draw conclusions about the efficiency of the agricultural system in use by a people. One group of researchers has relied upon the efficiency ratio which was developed by Black (1971). (See also Carneiro 1970; Harris 1975.) This ratio is defined as the proportion of output energy, in the form of food produced, to input energy, in the form of human labor. The ratio may also be used to evaluate those systems which rely on fossil

Table 6-10. Seasonal versus year-round exploitation of crops

Food Type	Seasonal	Year-Round
Manioc		X
Rice	X	
Corn	X	
Banana		X
Sugar Cane		X
Squash	X	
Melon	X	
Yam	X	
Papaya		X
Beans	X	

Table 6-11. Resistance to Swiden (S) in five Brazilian indigenous communities

Community[a]	L	D	A	Y	L/Y	S
Mekranoti	61,410	0.512	0.333	1,078.6	56.1	9.71
Xavante	77,426	0.490	0.488	549.5	140.9	33.69
Bororo	34,203	0.375	0.333	53.0	645.3	80.59
Kanela	256,676	0.476	0.598	1,318.4	194.7	55.42
Bakairi	59,459	0.372	0.517	407.5	145.9	28.06

[a]The first four community results are taken from Gross et al. (1979: 1047). Bakairi data are from field notes.

fuels although in these cases, the limitations of this particular measure become apparent more rapidly. Norman (1978) states that nonindustrial agricultural systems must have energy efficiency ratios of at least one in order to survive. To assure the group of long-term survival, a ratio of at least 15 must be derived. Those peoples who produce manioc show some of the highest energy ratios in the world (Fluck and Baird 1980:48). Ratios of up to 70.0 have been found in these types of systems; however, an average of 13 to 30 is a more common range. Leach (1976) has compiled ratios for a variety of agricultural systems. In his article, he includes the !Kung Bushmen of the Kalahari (energy efficiency ratio of 7.8) and the Dodo of Uganda (energy efficiency ratio of 5.0) who are not horticulturalists. However, since it is necessary for them to expend energy in food collection, a ratio may be determined. Leach derived efficiency ratios of up to 65.0. The highest ratios were found among shifting cultivators while lower figures were characteristic of those groups that cultivated their land more intensively. Examples of the latter are found in China, India, and the Philippines.

To Leach's list, the Siona-Secoya of Ecuador, the Kuikuru of Brazil, and the Tsembaga of New Guinea may be added (Vickers 1976; Fluck and Baird 1980). Vickers determined the amount of time and kilocalories spent on gardening activities. He divided this into the number of kilocalories produced in a garden over a year. The energy efficiencey ratio that he derived was equal to 52.1 (Vickers 1976:91). Vickers goes on to calculate the energy efficiency ratio of the Kuikuru based on data provided by Carneiro. He derives a figure of 56.5 (1976:94), which is only somewhat higher than the Siona-Secoya's. The calculations for the Tsembaga of New Guinea are much lower. The energy efficiency ratio derived by Fluck and Baird from data provided by Rappaport is equal to 17.4 (Fluck and Baird 1980:12). Key differences which may explain the discrepancy include the Tsembaga's reliance on domestic pig meat for kilocalories and the domination of sweet potatoes and taro over manioc in their diet. Population density and environmental degration may also be factors.

In order to determine the energy efficiency ratio for the Bakairi gardens, kilocalories expended by the population in gardening activities are divided into those kilocalories produced in the gardens (see Chapter 5). About 6.11×10^8 kcal/year are harvested from the gardens. If this is divided by 1.492×10^7 kcal/year expended in gardening activities, the efficiency ratio derived is equal to 40.95. However, if one considers only the edible part of that which is produced in the gardens, then 4.08×10^8 kcal/year is divided by 1.492×10^7kcal/year, and the ratio which results is equal to 27.35. This ratio is well within the range of systems which produced manioc as described by Fluck and Baird (1980). However, it is one-half of the Siona-Secoya and Kuikuru ratios as calculated by Vickers (1976). In fact, it more closely approximates that ratio calculated by the Tsembaga.

The energy efficiency ratio provides researchers with a simple measure of agricultural production which can be used for cross-cultural comparative purposes. However, it has many limitations. In attempting to explain the causes for differences between ratios, we are left with few factors with which to work. Low-energy input on the part of a population can be linked to a large number of factors. In addition, low-energy yields by gardens can be related to such problems as ecological degradation, poor soils, limited land for cultivating purposes, etc. The efficiency ratio does not allow for the definition of any one of these factors as being dominant, or even present. Thus, as an explanatory device, it is unsatisfactory. Moreover, the efficiency ratio, by concentrating on only gardening activities, does not consider the wide range of energy expenditures which operate to keep the entire cultural system functioning. It atomizes horticulture without taking under consideration the cultural feedback loops which keep the horticultural aspect operating. These subsystems, in the form of animal husbandry, fishing, and hunting which often occur simultaneously with gardening, and even ritual which may act as a stimulus or a check on gardening, cannot be ignored when determining gardening efficiency.

Resistance to Swidden Formula

Gross et al. (1979) incorporate more factors into the evaluation of gardening efficiency with the resistance to swidden formula which is applied to four central Brazilian Indian groups. The resistance to swidden formula considers four important factors. They include, in addition to labor and yields which the efficiency ratio employs, the ratio of producers to dependents in a population and the ratio of land freshly cleared to the total amount of land under production. The mathematical combination of this formula produces a figure which can be used in comparative studies to determine relative pressure on resources (Gross et al. 1979:1048). The emphasis of this particular measure is on subsistence effort applied to gardening activities; however, environmental degradation is also considered as an important factors.

Gross and his colleagues derive resistance to swidden figures for four groups: the Mekranoti, the Xavantes of Pimentel Barbosa, the Bororo of Gomes Carneiro, and the Kanela or Ramkokamekra. They calculated L as the amount of time spent gardening by all village producers; D as the ratio of nonproducers of food to food producers; A as the ratio of land freshly cleared each year to the total area under production; and Y as the annual yield of all gardens. These factors are mathematically combined in the formula LDA/Y which is equal to S, or resistance to swidden (Gross et al. 1979:1047-1048). The Gross project results are compared to the Bakairi case in Table 6-11. The highest resistance figures are associated with the Bororo and the Kanela where the environment is considered degraded, soils poor, and crop yields, as a consequence, relatively low (1979:1048). The lowest resistance figures are found among the Mekranoti where the land is fertile and the crop yields high per unit of labor. The Bakairi and the Xavante occupy a middle range. Gross and his coworkers were surprised by the relatively close association between the Xavantes, on one hand, and the Bororo and Kanela, on the other. They had anticipated a better correlation between the Mekranoti and the Xavantes; however, they explain this discrepancy in terms of the Xavantes' reliance upon rice which is labor intensive.

The Bakairi also cultivate rice which may in part explain their high resistance value. However, in addition the Bakairi have a larger number of dependents to feed than do the other groups although the Xavante demographic characteristics are similar. This indicates that the growing Bakairi population requires producers to expend additional labor in order to produce adequate amounts of calories. In turn the resistance value is increased. Furthermore, the L/Y value for the Bakairi is high when compared to the Mekranoti. That is, yields for the Bakairi are relatively low when compared to this Ge group. This is particularly striking when one notes that Mekranoti labor expenditure (61,410 hours) is very similar to Bakairi labor expenditure (59,459 hours). However, yields differ dramatically ($1,078.6 \times 10^6$ kcal to 407.55×10^6 kcal). In part this can be explained by the domination of the cerrado in the Bakairi reservation which is absent in the Mekranoti area where evergreen tropical forests are ubiquitous. Moreover, it is possible that soil and vegetation degradation has occurred in the Bakairi reservation.

The resistance to swidden measurement provides researchers with a more sophisticated instrument with which to evaluate the efficiency of agricultural systems. The addition of the dependent and the freshly cleared land ratios provide some modifiers which adjust for those factors that may affect the overall functioning of the system. The A variable takes under consideration decreasing fertility in garden sites, and the D variable provides qualifications based on demographic characteristics of the group in question. However, at the same time, the resistance to swidden formula does not allow for the integration of change as a separate variable. The impact of changing conditions in the areas in question are not registered upon the formula. Gross and his coworkers address part of this problem when they state that the measure cannot make predictions about the additional labor that might be required to increase output (Gross et al. 1979:1048). The strength of this formula revolves around its use in synchronic cross-cultural comparisons. Its central weakness, on the other hand, concerns its inability to absorb dynamic factors which affect the overall functioning of the system over time. Therefore, predictions about a community cannot be offered if the resistance formula is relied upon. In addition, although the number of factors considered in the formula is greater than those encompassed by the efficiency ratio, the resistance formula is still limited as an explanatory tool. As yields, labor, and land under cultivation increase or decrease depending on the situation it is difficult to differentiate that aspect of the system which is impacting on the other parts. One is able to localize the variable within defined parameters of the formula; however, beyond this, it is difficult to go.

The Gardens and Energy

In order to develop the garden part of the Bakairi energetics model, three separate issues are considered. First, land under cultivation and land in fallow must be subtracted from the overall gallery forest available in the reservation. Then, energy flows associated with the fallow land and crop storages need to be developed. Finally, the flows of energy from the Bakairi population tank, in the form of energy expended in gardening, etc., and the flows of energy toward the population tank, in the form of food harvested, can be attached.

In Chapter 3, energy flows associated with the gallery forest were presented in Table 3-8. At that time, based on Landsat images, gallery forest area was determined to cover 6,901.4 ha in the 50,000 ha reservation. Of that 6,901.4 ha, producing gardens take 44.512 ha (see Table 6-2). Another category of land, which is neither gallery forest nor producing garden, is represented by the succession gardens, or the old gardens which are gradually returning to the forest. In order to estimate the amount of land in the succession garden category, a population/land use ratio was prepared. The amount of land cleared in 1980 was divided by the total Bakairi population. This figure, 799.3 m^2/person, was then multiplied by the total number of people in the Bakairi village during the ten-year interval prior to 1978. The results of this calculation are equal to 1,601,797 m^2. Land cleared in 1968 was estimated to equal 153,466 m^2. This land returns to the forest during the 1980-1981 year. Land cleared in 1978 was estimated to equal 198,226 m^2. This area is in transition between producing gardens and succession gardens during the 1980-1981 season. Land to be cleared in 1981 was estimated to be 238,191 m^2 based on a 3.47 percent population increase. (See Chapter 4.) This area is in transition between the forests and the producing gardens.

Two new storage tanks, one for crops and another for succession gardens, result from these estimates. The third tank, the gallery forest, must be revised in that the areas included in the two above tanks should be subtracted from it. In Figure 6-1, a diagram of the relationship between the three storages is presented.

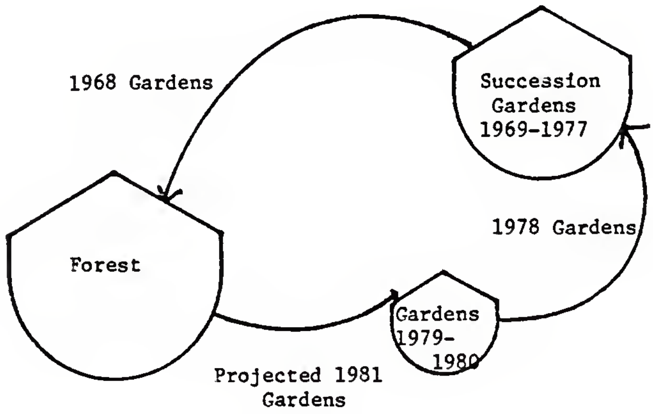


Figure 6-1. Gallery forest, succession gardens, and producing gardens in the Bakairi reservation model

To calculate the flows of energy around the succession garden tank, the biomass and heat sink of the storage will be considered. Biomass of a growing forest is of course much lower than that of a mature forest due to reduced mass. Whittaker and Likens (1975) estimate a biomass to be 10,395 g/m^2. In order to estimate heat sink, the autotrophic respiration rate of the young forest is estimated and then halved in order to distinguish this process from the feedback energy (Murphy 1975). The flow from the succession gardens to the forest, represented by the 1968 garden land, is estimated on the basis of mature forest biomass (Whittaker and Likens 1975). Energy from the gardens to the succession gardens, that is, the 1978 gardens, is calculated from young forest biomass. In Figure 6-2 and Table 6-12, details on these estimates are presented.

To calculate the flow of energy around the garden tank, a number of different types of energy are considered (see Figure 6-3 and Table 6-13). The interaction between the forest, garden, and succession gardens is accounted for by Rates 26 and 29. The internal functions of the crops in the gardens are described by Rates 30, 31, 32, and 33, and by variable Q2. Garden biomass is estimated on the basis of figures provided by Whittaker and Likens (1975). Mean biomass cited for cultivated land is approximately 1,000 g/m^2. Whittaker and Likens (1975) as well as Whittaker and Marks (1975) also discuss gross and net productivity of crops along with autotrophic respiration rates; NPP is calculated to equal 81 percent of GPP while autotrophic respiration is set at 19 percent. The proportion of NPP to GPP in crop cultivation is notably higher when compared to that ratio which characterizes mature forests or the cerrado. This is due to the fact that the crops are accumulating mass while the forest is in steady state.

The interaction between the Bakairi and the gardens are represented by Rates 34, 35, and 36. Rates 34 and 35 are based on estimates of the amount of energy the Bakairi expend on gardening activities and on harvesting (see Chapter 5). Note that Rate 35, harvesting, intersects Rate 33, signifying that the net primary productivity of the

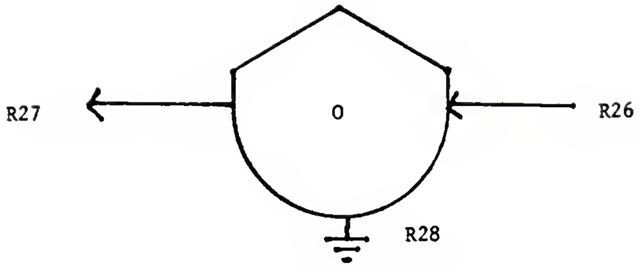


Figure 6-2. Succession gardens and flows of energy in the Bakairi reservation model

Table 6-12. Evaluation, name, and description of energy storage and flows associated with the succession gardens in the Bakairi reservation model

Energy Flows and Storage	Names of Flows and Storage	Values (Kcal/Year)
O	Succession Gardens	7.08×10^{10}
R26	1978 Gardens	8.76×10^{9}
R27	1968 Gardens	8.44×10^{9}
R28	Heat Sink	3.20×10^{8}

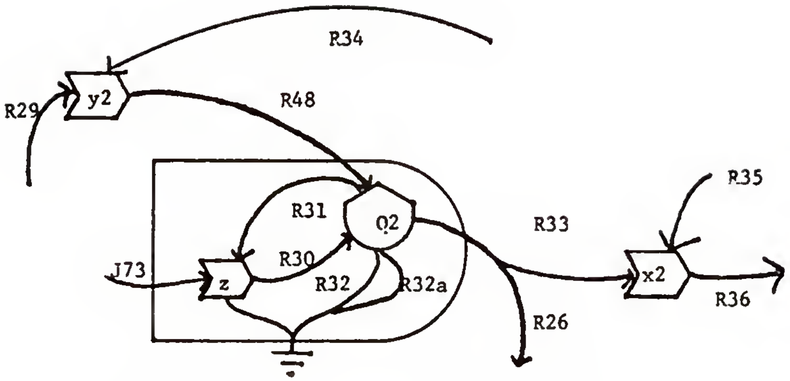


Figure 6-3. Gardens in the Bakairi reservation model

Table 6-13. Evaluation, name, and description of energy storage and flows associated with the gardens in the Bakairi reservation model

Energy Flows and Storage	Names of Flows and Storage	Values (Kcal/Year)
Q2	Garden Biomass	1.89×10^{9}
J73	Sun on Gardens	1.48×10^{11}
R26	1978 Gardens	8.76×10^{9}
R29	Land for New Gardens	4.41×10^{10}
R30	GPP	1.51×10^{9}
R31	Self-Maintenance	4.25×10^{8}
R32 + R32a	Heat Sink	4.25×10^{8}
R33	Garden NPP	1.23×10^{9}
R34	Gardening Activities	1.10×10^{7}
R35	Harvesting Activities	3.92×10^{6}
R36	Garden Harvests	6.11×10^{8}
R48	1981 Gardens	9.33×10^{9}

gardens is transformed into harvests through the expenditure of human energy. Rate 36 represents these harvests which are based on estimates compiled in Table 6-9 of this chapter. The discrepancy between Rates 33 and 36 signifies two things. In the first place, all of the energy labeled net primary productivity is not harvestable. Only approximately 30 percent of the NPP or cultivated land is usable (Whittaker and Marks 1975:100). The rest is either left in the fields to decompose or discarded in the village after initial food processing takes place. The rough estimate of 30 percent cited by Whittaker and Marks can be compared to the Bakairi harvests which are presented in Table 6-9. About 4.08×10^8 kcal/year is the estimate of edible portion of crop yields from Bakairi gardens. This number of kilocalories equals 33.2 percent of the NPP of the gardens, or 1.23×10^9 kcal/year. Thus, it appears that Bakairi yields match those general estimations provided by Whittaker and Marks. In the second place, the importance of human energy investment is underlined. The value of Rate 35, 3.92×10^6 kcal/year, is very small compared to the harvest yield, 6.11×10^8 kcal/year. Even if Rate 35 is added to Rate 34, or general gardening activities, the sum, 1.492×10^7 kcal/year, is still only equal to approximately 2.4 percent of the value of the food stuff harvested.

Finally, the gallery forest storage tank and associated flows of energy can be refined now that the impact of succession and producing gardens on the structure of the forest has been considered. In Figure 6-4 and Table 6-14, the gallery forest biomass as well as the surrounding flows of energy have been recalculated. Two additional flows have been

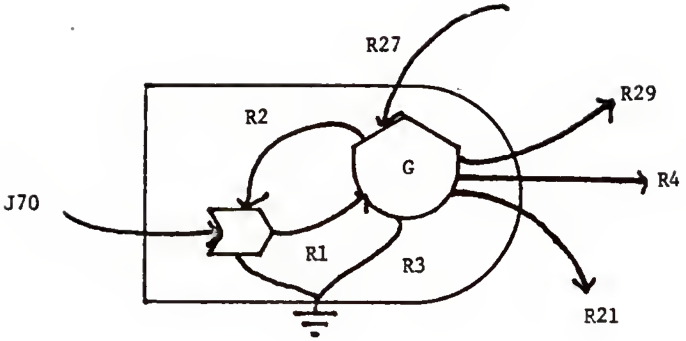


Figure 6-4. Refined version of the gallery forest in the Bakairi reservation model

Table 6-14. Evaluation, name, and description of energy storage and flows associated with the refined version of the gallery forest in the Bakairi reservation model

Energy Flows and Storage	Names of Flows and Storage	Values (Kcal/Year)
G	Gallery Forest Biomass	1.27×10^{13}
J70	Sunlight on Forest	2.21×10^{13}
R1	GPP	2.57×10^{12}
R2	Self-Maintenance	9.52×10^{11}
R3	Heat Sink	9.52×10^{11}
R4	NPP	6.35×10^{11}
R21	River Organic Imports	5.47×10^{8}
R27	1968 Gardens	8.44×10^{10}
R29	Land for New Gardens	4.41×10^{10}

attached to the diagram: the projected 1981 gardens and the 1968 gardens which return to the forest for later use by the Bakairi. The litter from the trees along the rivers has also been considered in the calculations. This version of the gallery forest more accurately approximates the reality of the reservation in that as the Bakairi population increases, more land is absorbed from the forest tank into the garden tank. Land made into gardens must pass through a succession garden stage prior to turning back into forest and becoming available for cultivation once again. This rejuvenation stage slows down the entire land-processing cycle. Furthermore, as the population increases, more land is cultivated and more land becomes caught in the succession garden stage. A build up of land in this processual stage results.

In this chapter, one of the most important links between the Bakairi and their environment has been documented. Both in terms of energy expenditure and caloric yields, the Indians depend more upon their gardens, made in the gallery forests along the rivers, than upon other parts of the ecosystem with which they interact. By tabulating crop yields and converting them to caloric values, the flow of energy from the gardens to the Bakairi population was established. In addition, quantifying the flows of energy between the forests, the succession gardens, and the producing gardens has allowed for the production of a more sophisticated version of that part of the Bakairi reservation.

Furthermore, various measures for interpreting the garden data were examined. Both the energy efficiency ratio and the resistance to swidden formula were reviewed. It was established that these formulas do provide us with the means whereby cross-cultural comparisons can be made. However, their limitations in terms of making predictions about changing agricultural conditions as well as defining the cultural variables which cause the discrepancies between cultures were underlined. In response to the need for implementing a tool for the evaluation of the impact of change upon both the Bakairi and their ecosystem, the construction of the energetics diagram continues.

CHAPTER 7
PROTEIN ACQUISITION BY THE BAKAIRI

The Bakairi Indians depend upon fishing, hunting, and cattle raising for the supply of animal protein they consume. Of these three activities, fishing in the most important in terms of both calories and grams of protein provided. The Bakairi fish in all of the rivers in the reservation except for the Kayapo which lies too far away from the village for easy access. The Paranatinga is the most frequently used. The Bakairi also depend upon lagoons for fish. These meadow lakes form on the _cerrado_ side of the gardens following the flooding of the rivers in the rainy season. Towards the end of the dry season these lagoons begin to dry up, and the Indians organize _timbo_ expeditions. When this occurs, the men go to a designated lagoon early in the morning where they beat thick stalks of _timbo_ in the water. After several hours, this herbal asphyxiant, released by the mashed stalks, takes effect, and the fish float to the top of the lagoon. The women and children coordinate their arrival with this event. They join the men in collecting the fish as they appear on the surface of the water. The children are especially helpful in digging the fish out of the armadillo holes where they often gather.

Fishing Technology

The Bakairi employ bows and arrows, which they manufacture themselves, in fishing. The bows are made of hard wood from the forests and cotton twine from the gardens. The arrows are made from palm. To shoot a fish with an arrow requires a great deal of skill. From an early age, small boys are encouraged to practice shooting birds and other small animals with their bows. A timbo expedition is often a perfect opportunity for these children to show the community how much progress they are making with the development of their skills. When a young boy spears a fish, both the women and the men take time to complement the child on his prowess. At the same time, they call to the other children that they are worth nothing because they have not yet caught a fish. Before a fishing expedition, the men subject themselves to the painful ordeal of fish-scraping. Their mothers or wives use fish teeth attached to a piece of wood to scrape the wrists and forearms of the men. After blood has been drawn, an astringent herbal solution is poured on the scratches to stop the bleeding and to give strength to the limbs. The Indians claim that fish-scraping steadies the arms so that when they fish they will be less prone to make mistakes.

The Bakairi also employ fishline and hooks in fishing. They either buy or trade these articles in the city, or they depend upon non-Indians met on nearby ranches for a supply. Hooks and line are very highly valued articles, and only infrequently are they loaned out or given away. Baskets are a third type of technology on which the Indians depend on fishing. Baskets of all different sizes and shapes are used by the women and children to collect minnows and other small fish. These articles are used in the lagoons and in the shallow parts of the rivers where the people bathe and collect water.

The last important kind of technology employed in Bakairi fishing is the canoe. The Bakairi have long been adapted to a riverine existence. Since their settlement of the Upper Xingu River during the last century, and possibly for even longer than that, they have depended on the river as a source of livelihood. They are expert canoe makers and women and children are also adept at handling the canoes on the water. It should be noted, however, that accidents do occur and can lead to drowning. Especially during the height of the rainy season, the Paranatinga's current is swift and dangerous, and white water rapids are evident both upstream and downstream from the village. As a result, canoes capsize, and the strong currents prevent the individuals from reaching the banks in time. As a result, the dangers associated with canoes and rivers are impressed upon the children's minds from a very early age. However, despite the cautionary advice, young boys, especially, are encouraged to develop their skills and strength on the river.

Two types of canoes are manufactured by the Indians. Those of solid wood are the first type. They are more difficult to control in the water; however, those of bark, a second type, have a shorter life-span. Groups of men will join together in constructing a canoe. Usually brothers or fathers and sons will make up a work unit. However, oftentimes a number of unrelated males will cooperate in this chore. The favor is expected to be returned at a later but indefinite date. In order to construct a canoe, a large tree is located and felled with an ax. Then, the bark is removed and either used to make the canoe or discarded if a dugout is to be made. Smoldering fires seal the inside of the canoe in order to make it riverworthy. Upon the completion of the canoe, it is secured to a tree near the village. Three areas for canoe storage exist. One of these is directly on the Paranatinga where the men bathe. Another is at the mouth of the Azul River where the women bathe. A third area is downstream from the other two at the curve of the Paranatinga River. The area chosen for storage depends upon the location of the household's garden since the majority of men rely on their canoes for transportation to their gardens. Using this means of transport instead of walking over land not only allows them to easily carry harvests back to the village, but it enables the men to fish on the way to or from the gardens.

Sometimes the use of a canoe will cause an argument between men. Each household has at least one canoe which is considered that household's property. If someone borrows a canoe without asking permission, the owners can be inconvenienced, or the canoe can be damaged. As a result, when someone finds their canoe missing, they consider themselves justified in losing their tempers and in speaking harshly to the man who borrowed it. Recently, the men in the village have been investing in locks and chains to secure their canoes to trunks of trees along the rivers. Although this development appears somewhat incongruous, the Indians perceive it as guarding against unnecessary unpleasantness.

Patterns of Fish Exploitation

The Bakairi depend on fish throughout the year; however, during the dry season they both expend more time and energy on the activity and enjoy greater success as a result of their investment. During the rainy season, the waters are high, and the fish are able to subsist on the organic matter which either fall into the rivers or which are covered by the rising waters. As a result, they are less prone to bite at the pieces of manioc and fruit which the Indians use as bait. Bakairi men fish any time of the day. They fish in the morning before going to the gardens, at noon upon returning from the gardens, in the afternoon before going to the men's house, or in the early evening when most people are visiting and relaxing. Fishing, then, constitutes not only a means of livelihood but a pleasant interlude during which a man may escape from the turmoil of village life.

In order to determine fishing yields, a random sample of 14 households (26 percent) was intensively studied for three months. Each evening, a household from the sample was randomly selected and visited. The household head was questioned as to whether anyone in the household had gone fishing that day, if he or she had fished alone or with others, how long they were gone, and waht the catch was. The fish caught that day were then examined and weighed. If part of the fish had already been eaten, the proportions were calculated and summed. In most cases, the questions were unnecessary. Since the researcher knew which household was to be visited that day, she could observe the members and actually note when and if anyone went fishing. In addition, wehn a member of that particular household arrived with a catch, the researcher was able to immediately, but casually, visit the household in order to weigh and count the fish. However, the ritual of questions at the end of the day continued because the men enjoyed describing their experiences on the river and were very proud of their abilities to catch fish.

According to extrapolations from the three-month fish study, the Bakairi participate in 998 fishing trips over the course of a year. Total yield of fish is estimated to equal to approximately 11,862 kg. The average length of a fishing trip was calculated to equal 4.2 hours. Average yield per fishing trip equaled 1.91 $\pm$ 1.3 kg of dressed fish. The large amount of variation evident in the mean is due to the fact that no fishing trip is ever a complete failure. Even a woman will avoid coming home with nothing. Thus, some of the tabulated yields amounted to as little as 500 g of minnows. These low yields contrasted sharply with those 6 kg yields registered for men who spent several hours out in a canoe on the Paranatinga River. However, regardless of the size of the fish brought in, the contributions were always consumed and appreciated.

In order to convert the 11,862 kg annual yield of fish into edible weight, the total was multiplied by .66 and then by 1.01 kcal/g (Leung 1961). The two-thirds ratio is a conservative estimate of the amount of edible mass available for consumption. It is based on the range of variation in disposable waste among various kinds and sizes of fish caught by the Indians. The kilocalorie value of 1.01 kcal/g is also an average figure since depending upon the fish, and the type of preparation, energy content can be as high as 2.00 kcal/g and as low as .75 kcal/g. Total edible energy yield of fish is estimated to be 7.91×10^6 kcal/year.

After the fish are brought into the house, the women are responsible for cleaning and cooking them. Small fish are boiled whole and then eaten with manioc or ice. Large fish are decapitated and roasted over a slow fire. They are consumed with manioc for the most part. The heads of large fish can be used in a fish-bone soup if so desired, or the fish waste can be thrown to the dogs.

The Exploitation of the Bakairi Cattle Head

The Bakairi cattle herd is the second most important source of animal protein for the Indians. It has already been established that this herd numbers about 400 head and that it grazes on the cerrado. The cattle are the responsibility of four men. Three of these men consider themselves professional vaqueiros or cowboys, and one is a young man in training. The four cowboys care for the cattle during the entire year. One of their most important chores is to spot check the herd as it grazes so that it does not wander and disappear into neighboring ranches. Occasionally, a stray head is stolen by a non-Indian, and in retaliation, the Indians steal one of the non-Indians' cattle. This kind of incident generates a great deal of anger and tension in the village and in the surrounding areas. For example, during a months's period in the dry season, sons of a neighboring rancher began to ride into the village fully armed in an attempt to intimidate the Bakairi because they had killed one of their herd. The Bakairi had a meeting and resolved to kill two of these men. The confrontations in the village at this time were extremely difficult. However, before violence erupted, the rancher himself decided that he was running the risk of losing his entire family which was settled 4 km from the village across the Vermelho River. If he pitted both his workers and his 13 children against the Indians, his group would still be completely outnumbered. As a result, he forbade his sons to enter the reservation, and he himself appeared at the capitão's house. The business at hand was never discussed openly; however, the fact that he had appeared alone and unarmed in a friendly fashion calmed the Indians to some extent.

The cattle are also a source of contention among the Indians, and between the Indians and the Indian Foundation. In Chapter 5, the cattle were cited as one of the factors in the conflicts between the capitão and the village. Since one of the cowboys is the brother-in-law of the capitão, the Indians speculate that the capitão's faction has the means and opportunity to secretly sell cattle to neighboring ranchers and to pocket the procedes. Other kinds of problems evolve between the cowboys themselves. For example, an ex-cowboy in the village once came to blows out on the range with one of the current cowboys who to this day sports a deep scar on his neck as one result of the fight. Apparently, they fought over the cattle although the details of the argument have been lost since the incident took place nearly ten years ago. However, what has not dissolved is the antagonism between the two men. Directly after the brawl, the ex-cowboy fled from the village and hid in the furthest recesses of the reservation. He and his family lived alone for nearly five years before returning to the village. Even now, they are somewhat alienated although some social intercourse does take place between the family and the other Indians. The cattle issue also causes problems between the Indians and the Indian Foundation. All three of the last Foundation agents who have been assinged to the reservation have been accused of stealing cattle by the Indians. It is extremely unlikely that this could occur due to the strict measures by which the Indian Foundation, both in Cuiaba and Brasilia, oversees the herds. However, the Indians regard non-Indians with such suspicion that they are convinced that theft commonly takes place. As a result, conflicts between the agents and the Indians periodically erupt. The agents normally deal with these situations by leaving the reservation for short periods of time to allow tempers to cool.

In considering all the controversies and problems which surround raising cattle, the question of why the Indians and the Indian Foundation bother to do so arises. The answer to this question lies partly in the nature of their interaction with the reservation's ecosystem. Cattle represent wealth because they can be sold to non-Indians in return for money which then can be used to purchase goods. Without the cattle, the Indians have little or no opportunity to accumulate large sums of money for investment purposes. In fact, as it has already been pointed out, the cattle are not actually owned by the Indians themselves, but are the property of the Indian Foundation. Any major sale must be authorized by the Brasilia headquarters. However, if the Bakairi want to make a major purchase they go to Cuiaba and Brasilia to lobby for their interests. This took place in 1976 when they wanted to buy a small truck. After much negotiation, the Foundation allowed the Indians to sell 100 head of cattle to raise the money for this project. The vehicle was purchased and is currently being used to transport the sick in and out of the reservation and to facilitate taking cattle medicine and salt into the area. The Bakairi truck driver is a 17-year-old boy who was taught to drive by a neighboring rancher. However, he was recently in an accident with the truck and since has no license, the police were somewhat annoyed. Currently, the Indian Foundation is encouraging one of the older men to learn how to drive the truck. The licensing of an Indian remains a difficult problem. Thus, the cattle represent a link with the non-Indian world in that the herds are valuable to both non-Indians, in terms of cash, and Indians, in terms of tangible goods. If the Bakairi can again build up the cattle herds to a certain level, they will be able to make another transaction which will result in a second major community purchase.

Cattle also occupy a very important position in the Bakairi's ecosystem. The Indians fish in the rivers, and hunt and garden in the gallery forests. However, the cerrado remains an underexploited area due to paucity of game located there and the unfertile nature of its soils. Since the cerrado covers over 80 percent of the reservation's land area, the problem of underexploitation is a serious one. However, in raising the cattle on this range, the cerrado ceases to represent a problem, and, instead, becomes an asset to the Indians. It enables them to raise large herds of animals which not only can be sold for cash, but which can be slaughtered and consumed at will. Very little time and energy is required to corral a head of cattle, herd it back to the reservation, slaughter it, and distribute some 150 kg of meat to the village. In contrast to hunting, comparatively little or no energy is expended in locating or stalking the animal. The meat need not be carried back to the village as the steer can be led there and then slaughtered in front of the men's house. Ammunition is not required to kill it because the Indians secure the animal to a tree and then cut its throat. Cattle, then, are not only an important source of calories and protein for the Indians; their inhabitation of an underused area in the reservation, as well as their cash value, increases their significance to the Indian adaptation of the area.

In order to determine the amount of beef that the Indians consume annually, the number of steers slaughtered were counted and then the pieces of the animal were weighed as it was cut up and distributed from the men's house. This was a relatively simple procedure since only 25 head were slaughtered during a 12-month period, and each time this occurred, it was considered to be an event. For example, the slaughter of the majority of the cattle killed corresponded with important village rituals or community labor efforts. The rationale offered by the Indians was that if everyone is busy working or participating in a ritual, no one has time to fish or hunt. Thus, in order to eat, a steer had to be sacrificed. Other times, a head was slaughtered when everyone in the village was too ill to participate in subsistence activities. In killing a steer, the village was assured of several days worth of beef which could be consumed with rice and manioc.

Twenty-five head of cattle were slaughtered in a year's time. The average weight per head was calculated to be 200 kg. Approximately 2,800 kg of the total 5,000 kg was edible. If one considers that these animals are thin range cattle, rather than grain-fed animals raised in enclosures, caloric value per gram of meat is estimated at 1.13 kcal/g (Leung 1961). Total edible energy yield of cattle is estimated to equal 3.16×10^6 kcal/year.

After the animal was slaughtered and butchered, part of the raw meat was sent to the various households via children and part of it was roasted in the capitão's house. The men eat first at the capitão's house. They gather around the roasting pits and cut off chunks of the meat which are wrapped within manioc pancakes brought from home. After eating there, they return to their homes where more meat has been prepared for the women and children. A household can subsist off of the meat distributed from one steer for up to three days. In order to prevent the meat from spoiling, it is hung in the sun or above the smoking fires.

Hunting in the Bakairi Reservation

Hunting is the third most important source of animal protein for the Bakairi. The Indians hunt in the gallery forests, and to a much lesser extent in the cerrado where they kill some armadillo and deer. In the forests, they commonly exploit such game as white-lipped and collared peccary, anteater, capybara, paca, and deer. The forests of the Tuiuiu and Kayapo Rivers are exploited heavily for their game. However, distant parts of the Paranatinga River are also depended upon.

Only the Vermelho River forests appear to be avoided. Two possible explanations for this are suggested. First, the Indians were settled on the Vermelho River, some 10 km from the current village, in 1920. During the period that they inhabited the area, the Bakairi could have hunted out the forests there. This hypothesis is problematic in that the Bakairi, immigrating from the Xinguano culture area, probably did not consume meat at that time, as its consumption is considered taboo by the Alto-Xingu groups. The avoidance of meat is recalled by the elders in the Bakairi village. Although they do eat meat now, they remember a time when they, and their families, only ate fish. Therefore, the Vermelho River region was probably not overexploited during the time the Bakairi were settled there. A more plausible explanation, supported by Landsat images, is that the Vermelho River forests are very thin indeed. It is suggested that these forests do not, and have not in the recent past, supported a great deal of game. Thus, the Indians are forced to travel long distances in order to hunt. In fact, the average length of a hunting trip is 7.15 hours. Most of this time is spent in reaching an area in which the hunting can successfully take place.

The Bakairi hunt alone, in pairs, and in groups. In a three-month hunting study, only 40.0 percent of the trips recorded were undertaken by single men. In contrast, 23.3 percent of the trips were participated in by two men, and 36.6 percent by groups. In Chapter 5, energy expenditure in hunting was found to be highest in the months of December and January. This tendency was correlated with low-energy expenditure in fishing activities as well as with the height of the rainy season when fish yields suffer a reduction. Many of the hunting trips in December and January occur as the result of large community hunts which precede the corn festival already described in Chapter 6. These hunting trips can include up to 40 men and have a duration of up to five days. When this occurs the men sleep in the forest for several nights eating only what they catch with the manioc pancakes they have brought from home. When the hunting trip is over, they carry the remaining meat back to the village where it is distributed from the men's house to the various households.

However, most hunting trips that occur are the result of one man, or a small group of men, leaving early in the morning and returning in the afternoon that same day. They may or may not take their dogs with them. Dogs are popular among the Bakairi men both because they go hunting with them and because they guard the houses. Ninety-five of them live in the village, and some households own up to five dogs. These animals are diseased, starved, abused, and vicious; however, notwithstanding, most of the men in the village appear to feel some affection for them. On the other hand, the women despise them, and the children are terrified of them. The animals often slash the legs of unwary people with their teeth, especially at night. In addition, they are aggressive scavengers who take food even as it is being prepared over the fire. The battle between the women and the dogs frequently results in the women tying them up and beating them, and on one occasion a dog was strung up and disemboweled for taking a piece of meat.

However, the dog population in the village is large and probably will remain large due to the need for protecting the households against uninvited visitors and thieves.

The Bakairi employ two types of technology in hunting. The first kind is the bow and arrow, which is also used in fishing. The second kind is the .22 rifle, which is either bought or traded. Fifteen rifles can be found in the village. Ammunition is also traded or given to the Indians by the Indian Foundation. In order to purchase weapons or ammunition in Mato Grosso at this time, a permit must be secured by the individual from the police. The Foundation makes small amounts of ammunition available to Indians at regular intervals so that they will not have to deal with the police bureaucracy. However, the supply is limited, and as a consequence, the Indians turn to nearby ranchers for additional sources.

In order to determine hunting yields, a random sample of 14 households (26 percent) was selected and intensively studied for three months. As in the fish study, one household was visited every day, and the members were quizzed on such subjects as who had been hunting, how long had they been gone, where had they gone and with whom, and how much game did they kill. The information gathered daily over this period was supplemented by data collected during the time allocation study in order to determine the variation of both hunting and fishing patterns, and yields, over a year's time. The average length of a hunting trip was determined to be 7.15 hours. Average yield of a trip was 1.74 kg (dressed meat). Total annual yield from hunting activities was estimated to be 2,600.41 kg. Only 1,764.35 kg of this was edible weight. The energy value of the various meats was calculated (Leung 1961), and total energy yield from hunting was estimated to equal 2.83×10^6 kcal/year.

After the meat has been distributed from the men's house to the village, if it is a community hunt, or taken directly to the hunter's home, if only one or two men have gone hunting, the women prepare the meat and roast it slowly over a fire. It is eaten with manioc, or less frequently, with rice. The meat can be divided and shared with kinsmen if there is too much of it to be smoked and dried. Another option available to the Indians is simply to prepare a large meal and then to call kinsmen in to eat with them. If the latter course is chosen, it signifies that not enough meat was available for actual distribution. However, since the gesture of sharing is extremely important, kinsmen were invited in to partake of what little there was.

Energy Efficiency Ratios of Fishing, Cattle Herding, and Hunting

In Chapter 5, Bakairi energy investments into the various subecosystems was calculated. Only .5 percent of the total energy expended by the Bakairi in the course of a 12-hour day was invested in hunting in the gallery forest, while .7 percent was spent in cattle raising on the cerrado, and 1.1 percent was invested in fishing on the rivers. It was suggested that the returns on these energy investments would be similarly ordered. That is, fishing would supply more calories than the other two activities, and cattle raising would provide more acloires than hunting. In Table 7-1, we find that this supposition is, in fact, correct. Fishing activities yield almost three times as much energy as do hunting activities. In addition, cattle raising results in over 10 percent more energy acquisition than does hunting. In comparisons of energy efficiency ratios, that is, the amount of energy captured divided by the amount of energy spent, fishing once again rates the highest of the three activities. With a 3.645 efficiency ratio, fishing requires less energy investment per unit yield than do both of the other activities. However, when hunting and cattle raising efficiency ratios are compared, the anticipated order of ratios is reversed. Despite the fact that cattle raising yields more energy than does hunting in absolute terms, proportions of energy yield and investment indicate that hunting, for the Bakairi, is a more efficient activity than is cattle raising.

The rationale for expending more energy in cattle raising than in hunting, despite the proportionally lower returns, pivots upon two conditions. The most important factor is reliability. While 71.4 percent of all hunting trips over a three-month period were successful in that at least some game was killed, 100 percent of all cattle slaughters were successful. That is, when a small group of men go out to lasso a steer, everyone in the village knows that they will return with an animal, and that every household will receive a substantial amount of meat. However, when men hunt, not only are they uncertain that they will be successful, but they are unsure of how much game will actually be captured. For example, high yields of

Table 7-1. Comparison of Bakairi energy investment and returns on protein acquisition activities over the course of a year

Activity	Edible Energy Value (kcal)	Proportion of Energy Value (%)	Energy Investments (kcal)	Proportion of Energy Investments (%)	Energy Efficiency Ratio
Fishing	7.91×10^6	56.9	2.17×10^6	47.3	3.645
Cattle Raising	3.16×10^6	22.7	1.44×10^6	31.4	2.194
Hunting	2.83×10^6	20.4	9.82×10^5	21.3	2.882
Total	1.39×10^7	100.0	4.59×10^6	100.0	3.028

81.65 kg were registered during the hunt study, but low yields of 1.0 kg of dressed land turtle were also tabulated. Nietschman describes a similar situation which exists among the Miskito Indians of Nicaragua. He found that although hunting provides more kilo-calories per hour than does turtle fishing, turtle fishing is a more important subsistence activity because it reduces the subsistence risk of meat getting (Nietschman 1972:58-59). Nietschman adds that turtle fishing also provides a higher protein return. The problem of protein will be reviewed later. At this point in our discussion, reliability and the avoidance of risk takingare underlined.

The second factor of renewability must also be considered. Wildlife supplies of any kind cannot be artificially increased by the Indians. That is, unless the Bakairi stop hunting for a certain number of years, the game levels in the reservation will not be raised. In fact as long as the Indians continue to regularly exploit the forests, chances are that game availability will decrease over time. On the other hand, the size of the cattle herds are directly controlled by the Indians. They are able to improve their herds by trading calves for fertile cows, cows for bulls, and old cows and steers for younger cattle as the need arises. They have the knowledge and training to vaccinate the cattle and to separate and treat those individuals who are ill. Moreover, the pruchase or sale of cattle can be effected as the community stipulates. Cattle, then, represent a renewable resource which can be increased or at least controlled with energy investments. Hunting contrasts with this activity in that no matter how much energy is expended, the level of animals in the forest will continue to drop until the point of diminishing returns is reached. After that, the only course to take is to avoid hunting altogether.

The hunting and cattle raising efficiency ratios are both low when compared to those of other groups. For example, Vickers derived a hunting efficiency ratio of 9.33 for the new village of the Siona-Secoy of Ecuador (1976:124). This figure is considerably higher than the Bakairi ratio of 2.882. However, if the Siona-Secoya hunting ratio calculated for the old village is compared to the Bakairi ratio, a different situation evolves. Vickers found that the hunting efficiency ratio in the old settlement was equal to 2.48, a figure much closer to the Bakairi efficiency ratio. No longitudinal hunting data for the Bakairi is available. This prevents us from conclusively demonstrating that Bakairi hunting efficiency ratios have declined over time and that the area which they inhabit is effectively being overexploited in the same way that the Siona-Secoya's first hunting territory was. However, the correlation of three factors allows us to put forth this hypothesis. The first factor concerns Bakairi ethnohistory. These Indians have inhabited the Paranatinga-Vermelho River area for over 50 years. During this period, they were not only, or even primarily, hunters. However, they have participated in some hunting activities in this general vicinity since at least 1930. Furthermore, the Bakairi hunting efficiency ratio is low both in absolute terms and when compared to the Siona-Secoya efficiency ratio in their new settlement. In addition, Bakairi yields per hour expended hunting are also lower than the Xavante and Mekranoti yields which are compared in Table 7-2. The Bakairi not only spend more time per hunting trip than all the other groups, but their yields per hour, .24 kg/hour, are lower than two of the groups listed.

These factors allow us to suggest that the area around the Bakairi village has been hunted out. If this hypothesis is correct, the implications for the Bakairi are serious. For example, the game in the region is scarce so that the Indians are forced to expend more time and energy in traveling long distances to find still viable hunting grounds. The time spent traveling and locating these areas pushes up the average number of hours per hunting trip recorded in Table 7-2. However, even when they arrive in these areas, they are not able to kill large amounts of game. This is not only reflected in the hunting efficiency ratio, it can also be seen in the average yield per hour ratio recorded in Table 7-2. Nor are the Indians always successful in their efforts. Over 25 percent of the time they return to the village empty handed. Other times, the men are only nominally successful in that they return with 1 to 2 kg of meat after a day's work.

One solution, to change village locations, has been chosen by such groups as the Siona-Secoya. Upon settlement relocation, hunting efficiency ratios rose dramatically. However, the Bakairi, although pulled in this direction, are also being pushed to remain exactly where they are. Not only does the Paranatinga River offer this group the most lush gallery forests for their gardens from which they derive

Table 7-2. Comparison of hunting productivity and hunting time expended in five Brazilian indigenous communities

Category	Mekranoti[a]	Xavante[a]	Bororo[a]	Kanela[a]	Bakairi[b]
Average Yield/Hunt	3.78 kg	2.78 kg	1.18 kg	.51 kg	1.74 kg
Average Number of Hours/Hunt	5.5 hr	7.0 hr	6.0 hr	4.8 hr	7.15 hr
Average Yield[c]/Hour	.69 kg	.40 kg	.20 kg	.11 kg	.24 kg
Number of Hours Spent/Day/Adult[d]	.87 hr	.47 hr	.09 hr	.55 hr	.08 hr

[a] Compiled from Werner et al. 1979:308

[b] Compiled from three-month hunt study

[c] Dressed weight

[d] From time allocation and hunt study

most of their calories, but it also provides them with the best fishing waters in the entire reservation. The Azul, Tuiuiu, and Vermelho Rivers are exploited to some extent, but they do not compare in length, depth, or width to the Paranatinga which is one of the major headwaters of the Tapajos River. Fishing is, of course, one of the most important subsistence activities in which the Bakairi participate. It supplies them with almost 50 percent of the animal food they consume. It is also a major protein resource which is indispensible in light of of the manioc and rice heavy diet on which they depend. To relocate the village on the Kayapo, Azul, or Tuiuiu River would leave the Indians with more game but less fish and gallery forest for gardening.

To move the settlement further east to a different location on the Paranatinga might be a viable alternative in that they would remain on the same river but would be closer to the Kayapo-Azul headwaters. However, two factors argue against this proposition. The Bakairi are currently located on a part of the Paranatinga River that curves in a giant S and then stretches out in a long undulating line until it it reaches the Kayapo River in the east (see Figure 2-2). This location places within easy reach the most concentrated mass of gallery forest to be found in the entire reservation. To reach any garden, one can either canoe down or up the river, or one can cross the river and take a short cut over land to the next section of the river as it curves around. This prime location in terms of available garden land argues against moving the village to the straight section of the Paranatinga where the people would be forced to make their gardens on either side of the village, stretching at indefinitely long distances in either direction.

A second factor concerns the Indian Foundation. In Chapter 4, the investment in infrastructure on the part of the Foundation was described. Not only have they financed the construction of a hospital, school, headquarters, and two wells, but they have also encouraged the Indians to clear and maintain, to some extent, an airstrip. Their interest is to concentration the Indians in one location where they can be easily taught to speak Portuguese, treated for disease, and communicated with in the event of dangerous conflict. If the village is relocated or if it splits, numerous difficulties for the Foundation would result.

At this point in time those forces acting to maintain the Bakairi in their current location are strong enough to prevent a relocation. As one consequence, the Indians are forced to tolerate low hunting efficiency ratios and to concentrate their energy on cattle raising which, although, less efficient than the former, is a renewable and reliable resource. In addition, cattle exploit the cerrado rather than the scarce gallery forest of the area. In fact, reliance on cattle as a major animal food will increase over time as the population grows, and game and fish resources shrink.

Animal versus Garden Foods

Bakairi energy input into such activities as hunting, fishing, and gardening have already been estimated. In addition, total energy yields of each of these three activities have been calculated and compared. However, one other measure may be employed to examine in greater detail the interaction between the Bakairi and their ecosystem. Yields from each of the subsystems can be converted into the basic food groups of protein, fat, and carbohydrate. The grams of each of these groups derived from the different subecosystems can then be compared. In Table 7-3, yields of energy as well as grams of protein, carbohydrate, and fat are compiled. The overall contribution of the gardens to the Bakairi diet is obvious. Not only do garden products provide over 96 percent of the energy produced annually, but they also supply the Indians with large amounts of the three basic food groups. In fact, over 62 percent of the protein available to the Bakairi is vegetable protein while only 37.7 percent is animal protein. The significance of this breakdown becomes clearer if we review some basic points pertaining to the subject of protein and its nutritive value.

Protein is a key organic substance in that it provides the body with amino acids for the manufacture and maintenance of tissues, enzymes, antibodies, and hormones. The various kinds of proteins differ in their nutritive value according to amino acid composition. Nutritionists classify proteins into two categories: low-quality proteins which neither maintain life nor support growth, and high-quality proteins which play an indispensible role in metabolism and growth processes (Wilson, Fisher, and Fuqua 1965:60). High-quality proteins contain nine essential amino acids. These amino acids must be supplied ready made in the diet because the body is unable to synthesize them as needed. These nine chemical compounds are a prerequisite in the diet of growing children; however, only eight of them are

Table 7-3. Breakdown of annual Bakairi diet by food category

Foods	Edible Portion			Protein		Carbohydrate		Fat	
	(g)	(kcal)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
Gardening									
Bitter Manioc Flour	4.97×10^7	1.59×10^8	37.7	8.45×10^5	12.3	4.03×10^7	41.0	2.49×10^6	31.4
Sweet Manioc Tubers	9.65×10^7	1.27×10^8	30.2	9.65×10^5	14.1	3.17×10^7	32.2	3.86×10^6	48.7
Rice	1.28×10^7	4.62×10^7	11.0	9.09×10^5	13.2	9.98×10^6	10.2	1.41×10^5	1.8
Dried Yellow Corn	9.49×10^6	3.43×10^7	8.1	8.92×10^5	13.0	7.06×10^6	7.2	4.08×10^5	5.2
Fresh Yellow Corn	7.20×10^6	1.11×10^7	2.6	2.52×10^5	3.7	2.29×10^6	2.3	1.37×10^5	1.7
Banana	2.28×10^7	2.51×10^7	6.0	3.19×10^5	4.6	5.75×10^6	5.9	4.56×10^5	5.8
Sugar Cane	8.17×10^5	2.86×10^6	0.7	3.27×10^4	0.5	7.40×10^5	0.8	4.09×10^4	0.5
Yams	8.65×10^5	8.65×10^5	0.2	1.73×10^4	0.3	2.10×10^5	0.2	1.73×10^3	0.0
Melon	1.03×10^6	4.52×10^5	0.1	6.18×10^3	0.1	1.14×10^5	0.1	3.09×10^3	0.1
Red Beans	1.10×10^5	3.61×10^5	0.1	2.51×10^4	0.4	6.39×10^4	0.1	1.65×10^3	0.0
Green Beans	1.10×10^5	3.96×10^4	0.0	2.20×10^3	0.0	7.26×10^3	0.0	2.20×10^2	0.0

Table 7-3—Continued

Foods	Edible Portion			Protein		Carbohydrate		Fat	
	(g)	(kcal)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
Papaya	5.10×10^5	1.63×10^5	0.0	2.55×10^3	0.0	4.23×10^4	0.0	5.10×10^2	0.0
Squash	3.70×10^5	1.10×10^5	0.0	6.29×10^3	0.1	6.66×10^3	0.0	7.40×10^2	0.0
Total	2.02×10^8	4.08×10^8	96.7	4.27×10^6	62.3	9.83×10^7	100.0	7.54×10^6	95.2
Fish[a]	7.83×10^6	7.91×10^6	1.9	1.53×10^6	22.3	—	0.0	1.33×10^5	1.7
Cattle (Beef)[b]	2.80×10^6	3.16×10^6	0.7	5.99×10^5	8.7	—	0.0	6.72×10^4	0.8
Game[c]	1.76×10^6	2.83×10^6	0.7	4.61×10^5	6.7	—	0.0	1.82×10^5	2.3
Total	2.14×10^8	4.22×10^8	100.0	6.86×10^6	100.0	9.83×10^7	100.0	7.92×10^6	100.0

[a]Average fish values used (Leung 1961)

[b]Thin range cattle values used (Leung 1961)

[c]Values calculated on the basis of various types of game killed (Leung 1961)

needed for the maintenance of life in adults (Wilson, Fisher, and Fuqua 1965:62). This does not mean that low-quality proteins lacking the essential amino acids are unnecessary in human diets. These proteins are, in fact, quite important, and research has determined that diets which supply only essential amino acids support slow growth rates.

As a general rule, animal proteins, such as those derived from meat, fish, milk, fowl, and eggs are high quality while vegetable proteins, unless eaten in combination, are low quality. If the amino acid content of various proteins is broken down and then compared, this distinction becomes clearer. Pyke compares the essential amino acid composition of a variety of foods to the composition of an egg which has a perfect protein score of 100 (Pyke 1970:24-25). Beef receives a score of 83, while fish is rated at 70, rice at 72, and manioc at a very low 22. The relatively low protein score of fish is slightly misleading because the proportion of the total energy value of fish flesh derived from the protein in it exceeds 90 percent whereas in lean meat it is only 60 percent (1970:35). Furthermore, animal foods contain greater percentages of protein when compared to vegetable foods. In Table 7-4, protein percentages of typical Bakairi foods have been compiled. Proportions of protein in the animal foods are greater than in the vegetable foods on the order of one. That is, in order to consume the same amount of protein, ten times as much manioc as fish would have to be eaten. However, it should be remembered that the quality of protein would still be unequal in terms of essential amino acid.

Table 7-4. Protein percentages of foods consumed by the Bakairi

Food	% of Protein[a]
Fish	19.6
Beef	21.4
Game	
Pork (Peccary)	12.4
Venison	29.5
Armadillo	29.0
Turtle	19.8
Bitter Manioc Flour	1.7
Rice (Home-pounded)	7.1
Corn (Dried)	9.4
Banana	1.2

[a]Values compiled from Leung (1961)

Evaluating Bakairi Protein Consumption

The problem of differential food values is important in any evaluation of a people's diet. For example, Beckerman (1979) makes a case for indigenous dependence upon vegetable and insect proteins which he claims could, and could have in the past, supported large aboriginal populations. Harris (1979b), on the other hand, argues that insects and other small invertebrates seldom constitute preferred sources of animal protein because they are poor "cost/benefit bargains" in that they are widely distributed over space, only seasonally available, and contain comparatively small amounts of protein per unit. In addition, Gross (n.d.) suggests that Beckerman's argument is weak because he supplies no data relating to actual Indian dependence upon vegetable or insect foods. Thus, the question of whether indigenous peoples could or would collect adequate supplies of fruits, nuts, vegetables, and insects to fulfill protein requirements remains a moot point.

The subject of protein requirements is another controversial topic in this problematic area. To date, minimal human protein needs have not been quantified by nutritionists. However, both the World Health Organization and the U.S. Food and Nutrition Board update on a regular basis their standards of recommended protein allowances. These allowances have been derived on the basis of population needs. They provide for individual differences in terms of both biological discrepancies and the differences in the quality of proteins in the diet. In other words, the allowances advanced are liberal due to the fact that they attempt to account for myriad situations.

The protein quality factor has already been discussed to some extent. Diets which include high proportions of vegetable proteins may or may not be deficient depending upon how the vegetable foods are consumed. (Note corn and beans eaten together.) However, they will certainly require that the population consume greater amounts of food stuff. Well-known exceptions to this rule include the Central American diet in which corn and beans are eaten together, thus providing all of the essential amino acids in the correct combination. Another example is the nut-concentrated diet which is relied upon by some Australian groups. Certain nuts contain large amounts of high-quality protein which supply all biological needs.

Individual differences are a second problem which must be considered in determining allowances. Factors which influence the nitrogen balance in the body include the physiological state of the person. For example, pregnancy and lactation increase the protein needs of a female. In addition, stress and injury also affect protein metabolism. Fat and carbohydrate consumption levels of the individual are a second factor which affect nitrogen levels in the body. If the non-protein consumption levels drop for a period of time, the body begins to metabolize protein in order to meet its energy needs. This is a wasted use of protein which should ideally be used for tissue manufacture and maintenance. Furthermore, if consumption levels remain low for a lengthy period, the body begins to break down the protein in the internal organs and glands to increase the energy supply. At a later date, this protein will have to be replaced. Finally, individuals differ in their capacity to adjust to protein intake levels. Biological mechanisms provide for the overconsumption of protein through the excretion process. When protein levels drop, excretion of protein theoretically ceases. However, some individuals continue to excrete needed protein even when consumption levels are low. This maladjustment obviously necessitates increased protein intake.

The recommended allowances advanced by the World Health Organization and the Food and Nutrition Board attempt to consider the range of variation in a population's protein consumption and metabolism. Their tables provide protein intake constants which allow for the determination of protein requirements based on age and body weight. Protein needs are closely related to lean body weight; however, in employing general body weight, the errors involved are not considered significant (Food and Nutrition Board 1974:5).

To determine protein needs for the Bakairi, body weight and age were considered. Total number of kilograms per age group were summed, and then multiplied by protein constants supplied by the allowance tables. In Table 7-5, protein needs for the Indians are compiled. Note that lactation and pregnancy are considered in the calculations. The total number of grams of protein annually needed to fulfill recommended allowances for the Bakairi population are estimated to be 4.31×10^6 g. We have already established that the Indians produce 6.86×10^6 g of protein per year. However, only 2.59×10^6 g (37.7 percent of total protein production) are high-quality animal protein. The remaining 62.3 percent is vegetable protein. If the Bakairi diet

Table 7-5. Protein needs of the Bakairi Indians calculated from general standards

Age Group in Years	N	Total kg in Group	Protein (g/kg/Day)	Protein (g/kg/Group/Day)
		Males		
0-1	6	32.4	2.10	68.04
2-3	9	88.4	1.80	159.12
4-6	10	155.0	1.50	232.50
7-10	12	287.5	1.20	345.00
11-14	13	463.0	1.00	463.00
15-18	14	846.0	.89	752.94
19-22	7	487.1	.80	389.68
23-50	51	3,381.7	.80	2,705.36
51+	15	869.3	.80	695.44
Total	137	6,610.4		5,811.08
				X 365 days/year
				2.12×10^6

Table 7-5—Continued

Age Group in Years	N	Total kg in Group	Protien (g/kg/Day)	Protein (g/kg/Group/Day)
		Females		
0-1	6	24.0	2.10	50.40
2-3	11	105.1	1.80	189.18
4-6	11	160.5	1.50	240.75
7-10	12	248.7	1.20	298.44
11-14	18	618.5	1.00	618.50
15-18	13	695.5	.89	618.99
19-22	7	396.2	.80	316.96
23-50	57	3,155.7	.80	2,524.56
51+	16	794.6	.80	635.68
Total	151	6,198.8		5,493.46
				X 365 days/year
				2.01×10^6
Pregnancy[b]	(11)		6.00	9,840
Lactation[b]	(31)		17.00	168,640
Total	288			4.31×10^6

[a]From Food and Nutrition Board (1974); World Health Organization (1974)

[b]From World Health Organization (1974)

included large amounts of beans and corn consumed together, there would be no problem. However, the Bakairi produce few beans, and those which are harvested are eaten with rice. Furthermore, corn is relied upon on a seasonal basis. On the other hand, manioc and rice are the most important staples. Both of these foods contain low-quality proteins, although Pyke has rated rice higher in quality than manioc. High-quality protein production by the Indians amounts to only 60.1 percent of the recommended protein allowance (2.59×10^6 g of 4.31×10^6 g). In terms of per capita consumption, this amounts to an average of 41.0 g/day. About 65.3 g/day is supplied by the Bakairi diet; however, only 24.6 g/day is hiqh-quality protein.

In Chapter 4, the nutritional status of the Bakairi was reviewed. No evidence of protein deficiency diseases such as Kwashiorkor was found. In addition, only 23.2 percent (29 of 125) of children under 20 years of age were determined to fall below designated height-for-age standards. That is, a small minority of the children may be stunted in growth, a condition that has been related to inadequate protein intake. However, the difficulties associated with relying upon general standards for height-for-age measures have previously been discussed. Currently, the relationship between height and genetic variables is poorly understood. In addition, other variables such as disease and underinvestment in children have also been linked to food consumption and to retarded growth rates.

The tangle of factors which influence protein intake affect the certainty with which Bakairi protein consumption levels may be evaluated. On one hand, relative protein quality and proportional amounts of vegetable and animal foods consumed complicate the situation from the production angle. If the Bakairi produce about 60 percent of their recommended protein allowances in terms of high-quality protein, are we justified in concluding that the standards are too liberal, or that the abundance of vegetable protein produced supplies the remaining 40 percent needed? On the other hand, the problems associated with using height-for-age standards as well as evaluating nutritional evidence in the light of artificial population control mechanisms complicate the situation from the consumption perspective. If we assume that 23.2 percent of the children under 20 are registering low height-for-age values, are we to understand that disease and underinvestment in children are taking their tolls? Are the general height-for-age standards even applicable to indigenous groups when the genetic component in human growth has not yet been clearly defined?

Despite the numerous difficulties pertaining to this subject, two tentative conclusions regarding Bakairi protein production and consumption are offered. In the first place, based upon nutritional evidence and protein production figures, we conclude that, at this point in time, Bakairi protein needs are being met. The amounts of high-quality protein, and the larger amounts of vegetable protein, being produced indicate that recommended protein allowances are available to the Indians. Furthermore, the minority of children registering low height-for-age ratios is not considered significant in light of the absence of both low height-for-weight ratios and other clinical signs of protein deficiency diseases.

Our second conclusion pertains to the vulnerability of the position in which the Bakairi currently find themselves. If high-quality protein production declines further, forcing the Indians to depend even more upon their vegetable protein supplies, the level of protein consumption may become problematic. In the discussion of fishing, hunting, and cattle-raising efficiency ratios, areas of concern were outlined. It was predicted that hunting efficiency ratios will drop and that the Indians will increase their energy investments as well as their returns from cattle raising. Fishing will continue to supply an important part of the Bakairi diet; however, the fishing energy efficiency ratio (3.645) is not that much higher than the hunting ratio (2.882). This ratio may drop even further as Paranatinga, the municipal capital, which unfortunately lies upstream from the reservation, grows in size. In the long run, larger non-Indian populations in the area, coupled with their use of nets in fishing will decrease the amount of fish made available to the Indians.

Protein Acquisition and Energy

In order to clarify the evaluation of the traditional Bakairi subsistence patterns, the construction of the energetics diagram continues. In Figure 7-1 and Table 7-6, the population tank is linked to the other subecosystems in the Bakairi environment. The flows of energy from the gardens, forest, cerrado, and rivers are intercepted by human labor and transformed into energy harvests. These harvests are channeled into variable A, the food storage tank. The size of A is relatively

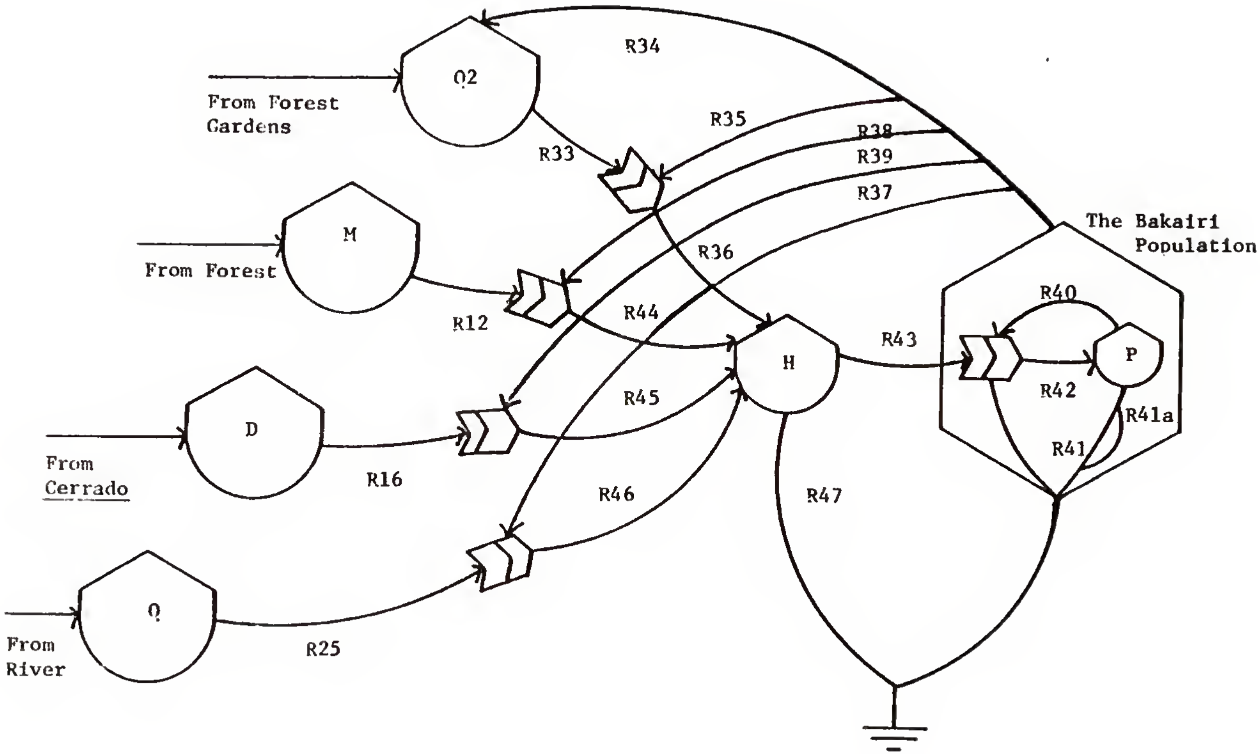


Figure 7-1. Links between the Bakairi and their ecosystem

Table 7-6. Evaluation, name, and description of the energy storage and flows associated with the links between the Bakairi and their ecosystem

Energy Flows and Storage	Names of Flows and Storage	Values (Kcal/Year)
P	Bakairi Population	2.47×10^{7}[a]
H	Food Storage	4.23×10^{8}
Flows to the Population Tank		
R42	Food Consumed	2.00×10^{8}
Flows from the Population Tank		
R34	Gardening	1.10×10^{7}[a]
R35	Harvesting	3.92×10^{6}[a]
R37	Fishing	2.18×10^{6}[a]
R38	Hunting	9.82×10^{5}[a]
R39	Cattle Care	1.44×10^{6}[a]
R40	Cultural Feedback	1.20×10^{8}[a]
R41 + R41a	BMR and SDE	6.10×10^{7}[a]
Flows to the Food Storage Tank		
R33	Garden NPP	1.23×10^{9}[c]
R12	Forest Biomass Yield	1.46×10^{9}[b]
R16	Cerrado Faunal Yield	3.62×10^{10}[b]
R25	Fish Yield	7.24×10^{7}[b]
R36	Garden Harvests	6.11×10^{8}[c]
R44	Game Caught	4.35×10^{6}

Table 7-6—Continued

Energy Flows and Storage	Names of Flows and Storage	Values (Kcal/Year)
R45	Cattle Slaughtered	7.15×10^6
R46	Fish Caught	1.52×10^7
Flows from the Food Storage Tank		
R43	Food Prepared	4.22×10^8
R47	Food Debris	2.16×10^8

[a]See Chapter 5.

[b]See Chapter 3.

[c]See Chapter 6.

small because means for food preservation and storage are underdeveloped among the Indians. The effects of this small storage can be serious. For example, during an epidemic or when gardens are flooded or exploited by wild animals, the Indians do not have food stores on which they can rely. As a result, the impact of adverse conditions on a household are quickly and dramatically felt. This was evident with the Gillian Barre epidemic during which children regularly showed weight loss which was only partially related to the effects of the disease itself. It was established that during this difficult time, household heads were unable to go to the gardens or to fish and hunt. As a result food consumption dropped, and people lost weight.

Rates 43 and 47 flow away from the food storage tank. Rate 47 represents the energy value of that material which is discarded during food preparation. This category includes corn cobs, rice husks, bones, and animal and plant skins. It is that debris which is harvested from the diverse ecosystems but which is not consumed by the Indians. Rate 43 is the food which is prepared. In Table 7-6, it is obvious that Rate 42 is different from Rate 43. In other words, what is consumed is less than what is actually prepared. In part, the loss is attributed to scavenging on the part of the dogs. Ninety-five dogs live in the village. If we estimate that their mean weight is equal to 11.3 kg and that it requires a minimum of 100 kcal/kg to maintain a dog on a daily basis, 3.92×10^7 kcal/year are channeled away from the Bakairi people to these animals. Approximately 3.83×10^8 kcal/year remain for the Indians to consume. In addition, waste, reduction through cooking, spoilage, and loss of food reduce Rate 42 even further to 2.00×10^8 kcal/year.

In this chapter, Bakairi exploitation of their environment has been examined in terms of protein acquisition. The yields and the efficiency of energy investment into the rivers, cerrado, and forests have been reviewed. The Indians' subsistence activities provide the population with a more than adequate supply of calories. This conclusion is further substantiated by the results of the weight-for-height study which were discussed in Chapter 4. Furthermore, their diet also supplies them with a greater number of grams of protein than general standards require. However, grams of animal protein provide only 60 percent of the population's needs. Whether or not the remaining 40 percent is actually supplied by the abundance of vegetable protein made available through gardening is an important point. Manioc, rice, and corn are considered incomplete proteins in that they do not contain all nine of the essential amino acids deemed necessary for life support.

The traditional subsistence system of the Bakairi was completed when the remaining energy links between the forests, rivers, and cerrado, and the Indian population were quantified and modeled. The completion of this section of the diagram will allow for long-term evaluations of this system based on any number of imaginary scenarios. For example, lower hunting and/or fishing efficiency ratios can be simulated, and their impact upon the population over a twenty-year period can be monitored. In addition, cattle-raising efficiencry ratios can be raised, and their effects determined. In Chapter 9, these possible scenarios will be investigated more thoroughly.

CHAPTER 8
CONTACT: THE FLOW OF ENERGY FROM OUTSIDE

Chapter 2 discussed the ethnohistory of the Bakairi Indians. It was established that they have been in contact since the early part of the twentieth century and that, during the 1950s, after the pacification of the Xavantes, interaction between the Bakairi and the non-Indians intensified. During a 20-year period, 1955 to 1975, the Indian men regularly left the reservation to work on nearby ranches to earn small amounts of cash which would enable them to purchase basic necessities such as clothes, soap, flashlights, line and hooks for fishing, etc. After 1975, the number of Indians working on ranches began to decline due to both the Indian Foundation's policy of discouraging them from leaving the reservation, and the concentration of ranches into large land holdings. These corporate holdings are organized along modern agro-business lines which call for reduced inputs of unskilled labor. Although some Indian men still leave the reservation to work on these ranches for short intervals, the tendency to do so continues to taper off.

Links between the Bakairi and the non-Indians have existed for some time. Cash has flowed into the reservation from a number of different sources, and it has moved out of the reservation as the Indians spent it in an effort to secure those products which they now consider essential to maintaining a particular lifestyle. With the advent of the industrial agriculture project, these links will continue to exist. However, new ones are also being forged. High-technology agricultural equipment has been purchased and donated to the Bakairi reservation by the Indian Foundation. This equipment facilitates opening up the cerrado area in the reservation for rice production. In order to operate and maintain this equipment, the Indians will have to sell the cerrado-cultivated rice and use the cash from its sale for the purchase of fuel, chemical fertilizers, and other products essential to the success of high-energy agriculture. The use of this equipment and the concomitant dependence upon the national economy for cash and goods which are a necessary part of the industrial agriculture project are changing the nature of the Bakairi's relation with the non-Indian.

Prior to the project, the national economy occupied a peripheral position in the Bakairi's subsistence system. Indigenous labor was expended outside the reservation for one to two months during the dry season, either before the gardens were cleared, or before the gardens were burned and planted. The men, in effect, earned cash on ranches when the rhythm of their own subsistence activities allowed them to do so. The cash that resulted from this expenditure was spent on nonsubsistence-related items which, should there be inadequate funds available, could be easily done without. With the initiation of the project, this situation has been transformed. Rice production is a subsistence activity and its success is directly dependent upon fuel for the tractor, which turns over the topsoil in the cerrado, as well as upon chemical fertilizer, which must be used on the relatively unfertile cerrado soils. In order to purchase these products, the Bakairi will have to sell part of the rice harvest in order to obtain cash. The bonds between the indigenous subsistence base and the national economy, as defined by the sale of rice and the purchase of industrial agricultural goods, will be strengthened as the Bakairi become accustomed to the additional flow of calories and cash stemming from the cerrado fields.

The Cash Flow into the Bakairi Reservation

Up until the Indian Foundation organized the agriculture project, three main sources of cash were tapped by the Bakairi. The most important of these three is the nearby ranches. Indian men travel to these ranches on foot or bicycle to ask the foreman if they have any work available for them to do. Or the foreman himself visits the reservation to encourage the men to go to work for him. On one occasion, a German rancher actually flew into the reservation and convinced two Bakairi to travel to his ranch to work for an extended period of time. The other men in the village, as well as the Indian Foundation, did not approve of this arrangement. The Indians thought the men who had traveled to the German ranch were foolish because they did not know what kind of food and living arrangements would be available for them there. In addition, once at the ranch, they would not be able to travel back by foot to the reservation to make sure their families were all right. They would be trapped in that distant area until the German rancher brought them home. Finally, no one knew this German.

The Indians are wary of strangers because they have had direct experience with physical abuse, and only infrequently will they put themselves in the hands of someone with whom they have not had previous dealings. The Indian Foundation was also against these two Indians accompanying the German rancher, and its officials were concerned about the potential violence inherent in the situation. Mato Grosso is currently the site of a great many skirmishes between Indians and non-Indians, and in order to control the raiding and ambushing that are taking place, the Foundation has tried to set up a buffer zone between the Brazilians and the indigenous populations.

In spite of the Foundation's warnings against leaving the reservation to work, the Indians do regularly visit those ranches where they know they will be well treated and where there are facilities provided for them. Sometimes they take their own food with them, other times they are provided with board. The Indians usually prefer to carry a week's supply of manioc and rice with them and then hunt and fish in the ranch area, as their needs dictate. This allows them to eat those foods to which they are accustomed in the quantities they so desire instead of being forced to consume standard rural Brazilian fare in those small portions which the foreman serves. Furthermore, if they eat the ranch's food, they receive less pay as their meals are deducted from their salaries. Since food is not a problem for the Bakairi, while cash is, they prefer to receive a full wage and make their own board arrangements. Finally, if the Indians carry only a week's supply of food with them, they have an excuse to leave the ranch, where they rapidly become bored and tired, and return to the village and visit their families. There, they make certain their wives are not having affairs, and their children and parents are in good health. Ranch work puts the greatest strain on Bakairi marriages because when some of the men are out of the reservation, the group of men which remains makes good use of the opportunity which has been afforded them. However, since there are no secrets in an Indian village, someone always discovers when an affair takes place and tells the traveling husband. Then he must deal with the situation before leaving once again to work on the ranch.

Permission to hunt and fish on ranch lands while working is part of the verbal contract established between the ranch foreman and the Indian workers. For example, a nearby ranch north of the reservation was purchased by a São Paulo corporation which installed a new foreman. Twenty Bakairi men and the researcher traveled to this ranch in order to investigate working conditions there. After discussing the situation in minute detail, the Indians decided not to remain there to work because the foreman, new to the area, would not allow them to fish and hunt on the land. The Indians claimed they would starve; the foreman said they could eat beans like everyone else. This was unacceptable to the Indians.

Once arrangements with those ranchers with reliable foreman and tolerable work conditions have been made, the Indians travel in small kinship-organized groups to these areas, where they will remain, commuting home on weekends, from anywhere from a week to three months. The

Indians are usually hired to do a particular job rather than paid to work by the hour or day. Some of the rural Brazilians realize that Indians have their own particular work pace and sense of labor organization. Thus, rather than cause trouble by imposing their own methods on the Indians, the Brazilians pay them by the job. The Indians feel comfortable with this arrangement. They organize themselves by kin relations working in small groups of up to six men. Fathers and sons or sons-in-law as well as brothers tend to organize into these small groups. It is unheard of for them to work alone because of the isolation and boredom which would ensue. It is also unheard of for them to work in a Brazilian team. Not only do labor patterns differ, but social discrimination exists. The Indians feel the Brazilian workers despise them, and the Brazilians are nervous around the Indians because the latter do not speak Portuguese unless absolutely necessary. Thus, the Brazilians are convinced the Indians are ridiculing them.

Tasks assigned to the Indian teams are of an unskilled nature. Building fences, clearing land for rice cultivation or cattle pasture, harvesting and sacking rice, or caring for cattle are kinds of work available to them. They are usually paid upon completion of the assignment, although if the foreman does not have cash available, the Indians will accept a delay. However, this is often a source of great annoyance to the Bakairi men because they are required to return again and again to the ranch to see if their money has arrived. Often funds do not come in for months and by that time the Indians are extremely impatient and vow never to work for that particular foreman again. When cash is available, the foreman pays the Indian who originally negotiated for the job. This man is considered the "owner" of the task. He will divide up the money among his kinsmen as he sees fit. For example, some men work less than others because they spend more time in the village. Thus, they receive a smaller share of the total amount. Other times, everyone works well together and the payment is divided up equally. In one season, a man working in a small team can earn up to Cr$7,000 or US$100. (Cr$70 equaled US$1 during the research period.) If he wants to work two different jobs in one session, he can double this amount, receiving, by Bakairi standards, a substantial amount of money. Between March of 1980 and March of 1981, 37 men left the Bakairi reservation at least once to work on ranches. Seven left the reservation twice that year. Altogether they brought approximately Cr$292,455 or US$4,177 into the reservation from the ranches. This money is well hidden in the houses until the family needs to use it to make a purchase.

The Bakairi are able to leave their homes and gardens for weeks at a time because they arrange to be absent during lulls in the subsistence cycle. The two most popular times to work on ranches are in May, following the rice and corn harvests and prior to the clearing of new garden plots, and in August and early September, after the plots have been cleared and before they are burned and planted for the next year. During these periods, the women continue to perform their garden-related tasks which consist of weeding and harvesting the manioc. As these jobs are definitely the women's responsibilities, the men are free to concentrate on fishing or on working on the ranches. Thus, the younger men leave the area, to return on weekends, and the older men remain to fish for the families.

During the last five to ten years, the Indians have traveled less frequently to the ranches. As previously explained, part of this trend is the result of the Indian Foundation's policy of discouraging them from doing so, and part is the result of the new technologically oriented ranches which make unskilled labor less necessary. However, one other factor deserves mention. The Indians themselves prefer not to leave the reservation now because they feel they are underpaid and overworked on the ranches. In addition, the political climate in the village is so dangerous that many do not want to leave, and return to find themselves a scapegoat for the occurrence of some disaster. Thus, during the 1981 dry season, fewer men than even the year before left the reservation for their annual work effort. Instead, groups of men remained in the village preparing ritual masks for sale to the Indian Foundation. The Foundation agreed to buy a certain number of these masks on an experimental basis to see if they could sell them in their Indian artifact shop in Cuiaba. By June of 1981, the Indians agreed that the experiment was not a great success. The Foundation could not sell the masks to non-Indians at the price the Bakairi were asking which was approximately Cr$3,000 to 5,000 or US$42 to 71. Furthermore, the Indians did not feel they could charge less for the masks because of the time and energy that went into manufacturing them and because they were trying to earn from the sale of the masks the equivalent of what they were giving up by not working on the ranches.

A second source of cash for the Bakairi is the Funrural payments which arrive every three months in the village. Funrural is a social-service organization which pays retired people or their widows an annual stipend. The Indian Foundation has been conscientious about signing all older Indian men and women up for these payments. Although it is not altogether clear which of the Bakairi is actually eligible for these stipends, the Foundation tends to give everyone the benefit of the doubt in order to receive maximum financial assistance for the Bakairi. The Foundation itself assumes responsibility for the paperwork and for collecting the money every three months which is then hand carried into the reservation by a responsible Foundation official. There, the stipends are distributed to the Bakairi recipients. Twenty-five Bakairi receive these payments on a regular basis. Total village income amounts to Cr$527,740 or US$7,539 which is nearly double that which the men earn on the ranches in a year.

The Funrural payments are obviously a windfall for the Bakairi. They expend no energy in order to receive these payments. Those households that receive them are a source of envy for all those who are not entitled to the stipend. Every household head regularly attempts to convince the Foundation personnel that his family is eligible to receive funds. Also, as soon as the money arrives in the village, relations and friends of the recipients visit the latter to see if they can borrow a portion of the money. Some lending does occur, but the Indians generally prefer to purchase small luxury items such as razors, kerosene, or candy with it. Another option they have is to give the money to a son or a grandson who perhaps wants a knife or a bicycle. The Bakairi elders are very indulgent towards their offspring and will sacrifice attending to their own needs in order to satisfy the whims of their children. It is no unusual to see a wizened old woman dressed in rags giving Cr$5,000 or about US$70 to her young grandson so that he can purchase bright red or blue shorts and a pair of running shoes. An old woman had a friend buy an extremely expensive ivory-handled knife for her in the city, which she then shyly presented to her grandson who was more than capable of working on a ranch to earn the money for the knife himself.

The last source of cash for the Bakairi is the Indian Foundation itself. Three Indians are employed by the Foundation to perform certain tasks in the village. Three others, who worked for the former Indian Protection Service, are retired and receive a monthly pension. The tasks performed by the currently employed individuals vary. Two men are responsible for maintaining the Post buildings. They repair the wells and the tile roofs on the schoolhouse, and they do a bit of carpentry, etc. Their responsibilities are few, and although they are supposed to work daily from 7:30 to 11:30 a.m. and from 1:30 to 4:30 p.m., they are rarely on the job for more than two hours a day. When a Foundation agent lives in the reservation, he usually tries to keep these men busy. However, when no one is there to oversee their work, they tend to disappear. These two men are despised by the Indians in the reservation because not only do they earn money for no reason the Bakairi can understand, but neither of them had gardens until fairly recently. They were considered lazy scavengers and were shunned and ridiculed by the villagers. One of these men now has a son who is 18. This year the boy made his own garden so that now the family will not have to depend on kinsmen and purchased food to eat. The other man, however, has only grown children who have their own families to support. Thus, he and his wife eat regularly in his son's house and then share the Foundation salary for purchasing consumer goods.

The third employee is an elderly woman who left the reservation for a three-month medical training program and then returned to assume the position of nurse's aide in the village. The Indian Foundation attempts, where possible, to train the Indians to man those medical and educational programs which have been established in the indigenous reservation. Many benefits have resulted from this policy. For example, no Indian, receiving a regular salary, will ever quit their job. Unlike non-Indians who can seldom tolerate the isolation of an Indian reservation for more than a short time, these indigenous employees provide continuity within the program. Furthermore, they speak the language of the Indians and can thus easily communicate with the women and children who barely speak Portuguese. However, the problems associated with the program are also numerous. For example, to try and train an Indian who barely reads and writes to use Western concepts of disease in coping with medical emergencies is an awesome task. The Bakairi nurse's aide deals with serious problems in two ways, which are not mutually exclusive. She will give an antibiotic injection, usually from an unsterilized needle, and then send the patient to the local shaman. The reasoning is that if one kind of treatment does not cure the disorder, the other kind definitely will. An additional problem revolves around the political atmosphere in the village. Due to the fact that the nurse's aide is an important member of one faction, she tends to ignore those people who belong to opposing groups. Thus, if an enemy is sick, she is less prone to give this person any attraction. Even more important, the enemy is reluctant to even visit the aide for advice. As a result of the political situation, an entire part of the population is cut off from the Foundation's medical program.

For the above reasons, it is difficult to evaluate the efficacy of the Bakairi medical program. Several times a year, the village tries to convince the Indian Foundation that the aide should be replaced. To date the Foundation has supported the aide, mainly because it has had no one with which to replace her. However, upon the researcher's departure from the field site, the Foundation had decided to move a qualified non-Indian nurse into the reservation from another indigenous area. Plans were to keep the Bakairi aide or as her assistant.

The three Foundation employees, in addition to the three retired employees, bring a total of Cr$523,680 or US$7,480 into the reservation on an annual basis. Unlike the Funrural recipients, they receive their money on a monthly basis. Delivering their salaries to them is a constant source of irritation for the Indian Foundation. Previously, the Indians went to Cuiaba to pick up their money at the Regional Headquarters. However, requiring these people to regularly make the brutal journey to this distant city was patently absurd. Thus, when the municipal capital of Paranatinga grew large enough to have a bank, and a police force to protect it, the Foundation arranged to have their salaries sent there where they were more accessible. Unfortunately, the bureaucracy involved in this transfer was too complex to be handled properly so that the salaries were effectively stopped for over four months. This created a certain amount of frustration and hardship in the village but eventually everything worked out.

In Table 8-1, the annual cash flow into the Bakairi reservation from the various sources is compiled. A total of Cr$1,343,875 or US$19,198 is made available to the Indians over a 12-month period. If we assume that during the 1980-1981 year, the average exchange for a US dollar was 70 cruzeiros, then approximately US$19,200 entered the reservation. This amounts to US$325 per household per year. In Table 8-2, those households with some kind of cash income are listed. Only 16.9 percent of the 59 households in the village do not have a direct income. However, this does not mean that they do not have access to cash. Kinship networks, political faction formation, and ritual all serve to redistribute whatever cash flows into the village. These leveling mechanisms will be discussed in greater detail in the following chapter.

<u>The Cash Flow out of the Bakairi Reservation</u>

That cash which is earned over the course of a year is spent that same year. Whatever saving exists takes the form of investment in bicycles, guns, expensive knives, and watches which can be sold later at

Table 8-1 Annual flow of cash into the Bakairi village

Source	Recipients (N)	Total Cash (Cr$)[a]
Funrural Payments	25	527,740
Retired Agency Employees	3	266,400
Current Agency Employees	3	257,280
Temporary Ranch Workers	37	292,455
Total	68	1,343,875
		(19,200 dollars)

[a]Cr$ 70 to US$1.

Table 8-2. Households with annual cash flow

Category	Households N	Households %
Cash Flow	49	83.1
No Cash Flow	10	16.9
Total	59	100.0

a loss. Inflation, rising Bakairi expectations, and the axiom that what one has one shares with kinsmen and friends force the Indians to spend what they make as rapidly as possible. The Bakairi either spend their money in the village or outside of the village when they travel to Paranatinga or Cuiaba.

A small percentage of what is earned is spent in the village general store. This store was originally started under the auspices of the resident Indian Foundation agent in 1975. During the period preceding that year, a person who needed soap or matches would have to travel five to six hours on foot to a ranch store in order to buy the item. The Foundation agent felt that the Indians were not only wasting a great deal of time and energy making these trips, but that they were being exploited in these small stores which charged outrageous prices for their products. The Foundation agent's request for a Bakairi store was approved, and the Foundation funded the stocking of a small shop which was located in the hospital. Initially, they planned to sell only essentials such as coffee, sugar, soap, kerosene, matches, etc. Later, after the capital invested in the store by the Foundation had been paid back, it would expand to sell fishing line, ammunition, cloth, etc. Even later, they anticipated turning the store into a type of "middle-man" operation. It would buy manioc and rice from the Indians and sell the products in the city. Essentially, the store would be a nonprofit organization existing only to fulfill the needs of the Indians. One man would be in charge; however, he would only facilitate the functioning of the operation. He would not earn anything.

Between 1975 and 1980, the store developed into something quite different. In the first place, the Indians initially assumed that the products in the shop would actually be given to them. They did not want to pay for the goods which they thought were overpriced anyway. Furthermore, they did not approve of a Bakairi being in charge and accused him of robbing the money earned by the store. The Indian Foundation agent removed one man and put another in charge. Then he removed him and chose a third man. Eventually, this third man took over the operation. He saved that money which he made working on the ranches and added it to the Funrural payments his mother- and father-in-law received. Then he slowly began buying goods in Cuiaba and stocking them in the little store for sale in the village. Finally, he moved the shop into his own house and now completely owns it as well as all the proceeds from it. Occasionally, the Indians complain that he charges too much for the goods he sells; however, it is easier to buy from him than to travel to a distant ranch. In addition, other men, learning from his method, often try to imitate him by using money they earn over the year to buy a stock of goods which they then sell from their houses. These temporary "stores" rarely succeed because the family involved either consumes the products or gives them away to relatives before they can be sold. It is reasonable to assume that the only reason the first store was a success was because it was originally organized and financed by the Indian Foundation. Only when the stock was built up and the clientele established did the owner move it into his own home. By that time, it was a solid business.

The Bakairi store is open daily from about 5:00 to 6:30 a.m. and from 5:00 to 6:00 p.m. These are the hours that the masks dance and that people go visiting. Many of the men drop by the store just to gossip and chat. Occasionally they will purchase some candy or cookies. However, the store is as much of a social club as a commercial enterprise. In fact, it rivals the men's house in social importance to the village. During the day, the owner of the store as well as everyone else is busy attending to their own tasks. As a result, the shop is securely locked up to prevent theft until the evening falls. Edible goods in the store include sugar, rice, flour, candy, spaghetti, coffee, and tea. Very infrequently, there will be cans of yeast and tomato extract for sale. Inedible goods include kerosene, soap, matches, razors, and batteries. Most of those products stocked and sold are of an edible nature. In Tables 8-3 and 8-4, the amounts of edible goods sold over a year's period in the village are tabulated. Money spent as well as calories derived are also estimated. It is clear that the Indians spend only a small percentage, 11.1 percent, of their annual income at the store. In addition, they derive even a smaller percentage, 4.6 percent, of the total number of kilocalories they consume in a year. Thus, although the shop occupies an important position in the village social network and provides an important service to the Indians, the Bakairi are not economically dependent upon the products sold there to survive.

We have established how the Indians dispose of about 10 percent of their annual income. Where does the other 90 percent go? Part of it

Table 8-3. Goods sold in the Bakairi village store over a year's period

Product	Amount (kg)	Cost (Cr$)[a]
Sugar	780	35,100
Rice	660	23,100
Flour	588	17,640
Candy	264	37,728
Spaghetti	204	6,120
Coffee	114	17,100
Cookies	108	3,780
Tomato Extract	34	7,392
Tea	17	1,680
Total	2,769	149,640
		(2,138 dollars)

[a]There are approximately Cr$70 to US$1.

Table B-4. Kilocalories derived annually from purchased goods in the Bakairi village

Product	Kilocalories
Sugar	2.925×10^6
Rice	2.38×10^6
Flour	2.14×10^6
Candy	1.11×10^6
Spaghetti	2.24×10^5
Coffee	—
Cookies	5.18×10^5
Tomato Extract	7.06×10^3
Tea	—
Total	9.30×10^6

is spent on major purchases such as bicycles, clothes, knives, and part of it is spent traveling to the cities to secure these goods. However, the Bakairi do not just go on a trip for a specific purpose. They are very fond of traveling for traveling's sake. Now that they have their own truck, they cause a great deal of consternation in the Indian Regional Headquarters by touring all over central Mato Grosso. They have painted a hugh Bakairi mask on their truck and are currently known at every tuck stop between the River of Oeath and the Cuiaba River. However, traveling is expensive. Everyone that rides on the truck is required to pay for a portion of the diesel fuel. Furthermore, in the cities, they either sleep in the truck or stay at hostels run especially for the Indians by Catholic priests. These hostels provide space for them to hang their hammocks and kitchen facilities where rice can be prepared for them. In addition, they go to bars where they get drunk, and they visit brothels. These two latter activities can be inordinately expensive because the Indians are an easy mark for thieves, and as a result, they are robbed quite frequently. One man lost Cr$15,000 or US$214 in a bar in Paranatinga. He was so drunk that he did not even discover his loss until he was back in the reservation. A second man was robbed in a brothel and was too afraid to go to the police to report the incident. The Indian Foundation tries to discourage the Indians from traveling without an important reason. However, it cannot actually prevent them from doing so as the Bakairi purchase their own gas and use their own truck.

In a 12-month period, the Indians made no less than 27 journeys. Eight of these trips were to Paranatinga and 19 of them were to Cuiaba.

Of the Cuiaba trips, 12 were ostensibly to pick up equipment and supplies for the agriculture project. However, as the Indian Foundation personnel pointedly commented, 20 Indians did not need to come along for the ride every time the truck left the reservation. The Indians would remain in the city for anywhere from three days to a week. Their return to the reservation would be precipitated by insufficient funds. When they had no more money to buy food, they would all start for the reservation once more. Oftentimes they would not even have enough cash to buy food for the three-day journey home.

A New Source of Cash and Technology

The Bakairi community development project was designed in early 1980 after five years of lobbying on the part of the Bakairi Indians and their Foundation agents. The stated objectives of the project are contradictory in nature. In the first place, they call for the gradual integration of the Bakairi into the Brazilian socioeconomic system through the introduction of mechanized rice production. The introduction of this new type of subsistence system entails teaching the Indians those technical skills which pertain to the intensive cultivation and sale of the crop in question. As they learn these new skills, increased participation in the Brazilian economic and social systems will follow. However, at the same time, the Indian Foundation hopes that the project will fix the Indians on their reservation so that they will be discouraged from working as day laborers on nearby ranches. Furthermore, the project will theoretically prevent the Indians from becoming dependent upon Brazilian society. The problem is clear. Integration is synonymous with dependence and cannot take place with the Indians remaining on their reservation in an independent and autonomous state. If the Foundation had genuinely desired the Indians to remain independent, they would have reduced, rather than increased, the number of links binding the Bakairi to the national society. Thus, it is fair to assume that the primary de facto objective of the project is to integrate the Indians by giving them the means whereby they can participate in the Brazilian economy.

The Foundation advised the Indians to initially clear 50 ha of land in the cerrado. Using communal labor, they were to plant this 50 ha with rice seed. In addition, they were to fertilize the land with chemical fertilizers, without which it would be impossible to grow crops in the cerrado soils. It was anticipated that the 50 ha would yield approximately 1,000 sacks or 55,000 kg of rice. In order to operationalize the project, the Indian Foundation planned to send to the Bakairi a complete set of farm equipment. They were not able to deliver everything they promised due to certain budget difficulties; however, those implements listed in Table 8-5 did arrive safely in the reservation.

The Indian Foundation originally planned also to fund the purchase of a harvester at the additional cost of Cr$450,000. However, they were not able to manage this major purchase. Personnel justified this decision on the basis of the small area under cultivation. They stated that 50 ha of rice did not warrant the expenditure of Cr$450,000 and that perhaps the harvester could be purchased at a later date when more land was put under production. In May of 1981, when the Indians

Table 8-5. Agricultural machinery and implements sent into the Bakairi reservation in 1980

Equipment	Cost (Cr$)[a]
Massey Ferguson 275 Diesel Tractor	459,090
Massey Ferguson 204 Disk Plow	46,688
Disk Harrow	71,390
Row Planter (Seeder, Fertilizer)	26,040
Insecticide Dispenser	66,400
Small Wagon	60,900
Tool Box	15,300
Total Cost	745,808
	(10,654 dollars)

[a]Cr$50 to US$1 at the time of purchase of the equipment.

were forced to begin harvesting, or lose the rice crop, they desperately tried to borrow a harvester from several of the nearby ranches. However, these landowners were either not able to loan out the equipment because of their own harvests or unwilling to lend the equipment because of the Indians' lack of experience with it. Thus, the Bakairi organized work groups which were composed of men, women, and children. They alternated working at a variety of tasks all of which the harvester could have done in a few days. A number of work groups cut the rice, several more bundled the rice stalks up and placed them in the truck, and one group drove the bundles to the school house and unloaded them. Once at the school house, a number of task groups divided the stalks into piles and commenced beating them on top of wooden platforms. The kernels of rice then fell beneath the wooden structures where they were shoveled into sacks and dragged to the hospital. There they were spread on the ground for drying. Ideally, the rice should have been baked outside in the sun; however, late rains made it necessary to dry the rice indoors. These unfortunate circumstances resulted in the rice sprouting which would lower the value of the harvest when the Bakairi sold the crop on the market.

The harvesting process was long and arduous. Over a month of intensive labor was required to harvest the rice fields; however, despite all the effort, a great deal of rice was still lost. This loss was due in part to the fact that the Indians had anticipated receiving a harvester when they planted the rice. The field had been divided into small sections and then planted in a staggered fashion in order to enable the Indians to harvest one section before the next one was ripe. If they had allowed for manual harvesting in their calculations, more time would have been left between the planting of the various rice subfields. However, as it turned out, the sections ripened before the rice could be cut and in spite of an incredible effort on the part of the population, some of the crop spoiled prior to harvesting. A second factor affecting the rice harvest pertained to the Indians' own rice gardens which ripened at the same time as the project's crop. The Bakairi, anticipating the arrival of the harvester which would have cut, threshed, and sacked the rice mechanically, had planted their own subsistence crops with the understanding that few men would be needed to harvest the project fields. Thus, when the machinery did not arrive, they attempted to harvest both their own gardens and the project rice. Discouragement, anger, and resentment resulted, and unfortunately, much of it was directed toward the Indian Foundation.

One additional point about the equipment should be mentioned. The clearing of _cerrado_ land is geneally not as time consuming as the clearing of gallery forest. The _cerrado_ is sparsely covered with small, twisted trees and tall grasses which were described in Chapter 3. On neighboring ranches, the method of clearing is to attach a long steel chain between two tractors which are spaced at a distance of approximately 20 feet. The tractors drive forward dragging the taut cable between them which, in turn, tears up the vegetation by the roots. Small parties of men then gather the bushes together in a pile where they are left to dry prior to burning. However, the Indians only received one tractor and no cable. Therefore, they had to borrow a clearing cable and at the same time try to borrow a second tractor. Once again, ranchers were unwilling to lend out this expensive equipment. The Bakairi ingeniously solved the problem by attaching one end of the cable to the largest tree in the area and the other end to the tractor which they then drove in a circle, pulling down the vegetation in a wide-sweeping arc. Although proud of the solution they found to the problem of clearing, they were annoyed that it had arisen in the first place.

In addition to the farm equipment sent into the Bakairi reservation, the Indian Foundation also purchased rice seeds, diesel fuel for the tractor, sacks for the anticipated rice harvest, and chemical fertilizer. Additional goods such as insecticide, engine oil, and corn and bean seeds were also proposed in the project budget; however, once again financial difficulties prevented a total realization of the plan. In Table 8-6 those items received by the Indians, rather than those proposed in the budget, are included.

To transport the materials into the reservation, several of the Bakairi drove the truck to Cuiaba to pick up the goods. Diesel fuel was transported in large barrels and the fertilizer and seeds arrived in 55 kg sacks. One special trip was made for the sacks which arrived only a week before the harvesting began. Another special trip was organized when someone remembered that thread and needles were needed to sew the sacks of rice shut. The most important problem associated with the above materials concerns the fertilizer. No soil analysis was done of the <u>cerrado</u> prior to planting. Furthermore, no agronomists were

Table 8-6. Agricultural products sent into the Bakairi reservation in 1980

Item	Amount	Cost (Cr$)[a]
Rice Seeds	2,500 kg	69,000
Tractor Oil	3,400 liters	68,000
Sacks	1,500 sacks	75,000
Chemical Fertilizer	11,000 kg	162,000
Total Cost		374,000
		(5,343 dollars)

[a]Cr$50 to US$1.

sent to oversee the mixing of the fertilizer and seeds at planting time. Thus, the Indians were at a complete loss when it came to determining the relative proportions of fertilizer needed to plant in the cerrado. They decided to plant each subsection of the rice field with a different amount of fertilizer in an attempt to determine the precise amount needed to fertilize the land without under- or overfertilizing the crop. THe problems with this experimental method are obvious in that a certain amount of the rice was indeed of poor quality because inadequate amounts of fertilizer were applied in some sections and too much in other sections. In addition, in those areas where the correct amount of fertilizer was used, the Indians generally assumed that the following year the could apply the same amount with similar results. The fact that the land would be less fertile as a result of the cultivation process, and, thus, would require additional fertilizer, was not understood.

In Table 8-7, the schedule of work activities associated with the agricultural project are outlined. The tractor arrived in the village on September 3, 1980, and within two weeks, the Indians had organized the land-clearing parties and chosen two tractor drivers who would be directly responsible for the plowing, harrowing, and planting. Intensive work on the project continued through October with the two tractor drivers and their teams working both day and night to get the crops in on time. From November to mid-March, a lull in working on the project occurred while the rice grew and ripened. However, from mid-March through April, another burst of activity, in which the entire

Table 8-7. Schedule of work activities associated with mechanized agriculture project

Activity	Dates
Agricultural Equipment Arrives	September 3, 1980
Measuring off 50 ha	September 25-October 12, 1980
Clearing the Land	September 14-October 1, 1980
Plowing[a]	October 1-October 13, 1980
Harrowing[a]	October 7-21, 1980
Planting[a]	October 22-30, 1980
Growth and Ripening of Crop	November 1, 1980-March 8, 1981
Rice Harvest	March 9-20, 1981
Threshing	March 10-21, 1981
Drying and Sacking	March 22-April 13, 1981
Storage for Sale	April 14-May 1, 1981

[a]Involves night and day work with two tractor teams composed of three men each.

village was involved, took place. During the latter period, a large number of the men and women gathered together to harvest and thresh the rice.

Energy expended on the agriculture project is difficult to estimate due to the number of diverse tasks involved and the varying participation of the population in producing the rice. In order to derive an approximate figure on energy expenditure, kinds of works, numbers of workers, and hours involved in each type of work were noted. Kilocalorie expenditures for the kinds of tasks were then multiplied by the estimated number of man hours involved. These subtotals were finally summed. In Table 8-8, the results of these calculations are compiled. It is estimated that the Bakairi expended 1.76×10^6 kcal on the agricultural project. This does not include the 12 trips that the Indians made to Cuiaba to pick up supplies. Since these journeys also served recreational, medical, and commercial purposes, it would not be justifiable to include the time and energy expended on them in the overall project figure.

The 50 ha of land in the cerrado yielded 450 sacks of rice instead of 1,000 sacks as anticipated. The Bakairi distributed 63 of the sacks in the village and sold the remaining 387 sacks. If the energy efficiency ratio for the project is calculated, the figure 36.53 is derived. This is considerably higher than the 27.35 ratio estimated for the Bakairi forest gardens. However, Fluck and Baird (1980) warn us against comparing products of different agricultural systems. Once fossil fuels, in the form of diesel oil and chemical fertilizers, are

Table 8-8. Time and energy expenditure associated with the mechanized agricultural project

Activity	Kilocalories
Measuring Land	6,785
Clearing Land	144,900
Plowing	102,720
Harrowing	71,904
Planting	35,952
Harvesting	1,035,000
Threshing	276,000
Drying and Sacking	86,250
Total	1,759,511 or 1.76×10^6

introduced into a system, it is no longer meaningful to make comparisons between that system and another system which is subsistence based. The energy expended processing the high-energy inputs would need to be calculated and then inserted into the efficiency equation. This would, of course, lower the energy efficiency ratio. However, the question of whether or not one can actually compare such dissimilar systems of production would remain. Fluck and Baird suggest that once fossil fuels are introduced into a production system, the exclusive use of caloric input-output ratios should be replaced with a broader range of criteria (1980:50).

The key consideration here is not which system is more productive. Rather, we need to ask whether the Bakairi will be able to continue employing the industrial system of production in the future. In addition to their lack of experience and technical know-how, they are saddled with two enormous, and interrelated, problems. The rising cost of energy and inflation in Brazil are two trends which will affect the success of the Bakairi project. The rising cost of energy has resulted in agricultural products becoming increasingly dependent upon enery costs, and less dependent upon nonenergy costs. Thus, the impact of any increase in the price of oil effects agricultural on two levels. In the first place, the increase is felt immediately in that the prices of fuel and chemical fertilizers rise as the price of oil goes up. The production of chemical fertilizer is energy intensive. It requires large amounts of fossil fuel to manufacture. Ammonia for nitrogen-based fertilizers is, in particular, heavily dependent upon natural gas. In addition, those involved in industrial agriculture are forced to secure the means for paying these rising prices because one-half to two-thirds of production of high-energy agriculuture is directly due to the use of chemical fertilizers (Fluck and Baird 1980:87). The relationship between the price of fuel and oil is clear. As the price of oil rises, so does the price of fuel and the impact is immediately felt. This is particularly true in Brazil where about 90 percent of the petroleum is imported. However, the price of oil affects industrial agriculture on a second level. The price and availability of high-technology equipment, such as tractors and harvesters, are affected over the long run by the increasingly high costs of fuel. Production of such equipment is not affected at once. Rather a delay of several years occurs. Maintenance and repair of equipment are also affected by this tendency. Thus, higher energy costs will result in increased production costs wherever industrial agriculture is found (1980:77).

Inflation is a second problem with which the Indians must cope. Inflation in Brazil is over 100 percent per year. It affects the price of everything; however, it results, particularly, in increasingly high costs of such items as fuel, fertilizers, and high-technology equipment. Part of this tendency is related to Brazil's efforts to encourage its population to conserve. If the high costs of oil are passed on directly and immediately to the consumer, the government hopes to see reliance on certain products curbed. For example, in a period of three months, the price of diesel oil rose 30 percent. The government anticipated fewer people using their own cars and depending more upon mass transit systems. If consumption of fuel decreases, then oil imports will decrease and Brazil's balance of payments will tip in its favor as its national debt increases. This same tendency can be seen in the rising price of high-technology equipment. Although Brazil has factories which manufacture such products as tractors and trucks, these industries are part of multinational corporations which have been seriously affected by rising production costs. As prices rise, these costs are passed on to the consumer in the specific nations. Once again, Brazil tries to continue development, which necessitates the purchase of high-technology equipment, and control its national debt, which necessitates the limiting of these purchases.

Brazilian Indians such as the Bakairi know nothing about these complex issues. They do, however, understand that the cost of agricultural production in Brazil has risen sharply these past few years. If the Indian Foundation did not exist to assist them absorb these high costs of production, the project would, without a doubt, fail. For example, the Bakairi sold 387 sacks of rice at Cr$850 or US$12 a sack, which is the seller's price. They made Cr$328,950 or US$4,699 off of the deal. This money is to be put toward production costs for the next year. However, these costs are much higher than that which the Indians earned in a year. If a minimum of four sacks of fertilizer are used for a hectare of rice production and the Bakairi double the amount of land under production as they have been advised by the Indian Foundation, fertilizer costs alone will equal a minimum of Cr$480,000, or US$6,857. If 60 liters of oil are used to plow, harrow, and plant a hectare of land, then Cr$156,000 or US$2,228 of oil will be needed for production. Since the cost of oil is rising rapidly and steadily, the Cr$156,000 or US$3,900 estimated is probably an optimistic one. An additional Cr$60,000 or US$857 for oil must be set aside for a minimum of 15 trips to Cuiaba. The rice must be transported to the city for sale, and more fertilizer, oil and seed must be brought back into the reservation for the new production season. Once again, this estimate presents the bare minimum. To this sum, Cr$120,000 or US$1,714 are added for rice seed. This results in a total of Cr$816,000 or US$11,657 of which the Cr$328,950 or US$4,699 earned from the sale of rice equals only 40 percent. However, tractor and truck repairs, a harvester, and miscellaneous needs which will surely develop will raise the Cr$816,000 figure to at least Cr$1,266,000 or US$18,085. That money earned by the Bakairi is only equal to 26 percent of this latter estimate.

The Indian Foundation has promised to lend an additional Cr$3,000,000 or US$42,857 for the 1981-1982 production year. If their budget allows for this contribution, the Bakairi will be able to continue the industrial project for another season. If not for the constantly rising cost of fossil fuel and inflation in Brazil, the project might in time gain momentum and be able to finance itself. However, if current trends continue, the Foundation will be forced to partially finance the project indefinitely.

The Bakairi have a relatively long history of contact. Prior to the initiation of the mechanized agriculture project, they were bringing into the reservation approximately Cr$1,343,875 or US$19,200 a year. They spent this money on traveling, on buying expensive items, such as bicycles and clothes, and inexpensive goods, such as candy and sugar, in the city, and on making small purchases in the village store. In 1980, a mechanized agriculture project was begun in the reservation. This project produced 450 sacks of rice the first year. The proceeds from the sale of the rice will only finance the purchase of a small part of those products needed for the second production season. The Indian Foundation will make up the difference in hopes of keeping the project running until it can completely finance itself. The chances of total independence occurring in the near future are slim due to the rising cost of fossil fuel which both directly and indirectly affects the project.

In Table 8-9 and Figure 8-1, the project is diagrammed. The rice fields, Q3, are connected to the cerrado, S, and the energy harvested from the fields flows into the food storage tank which we have already named H. Energy expended by the population flows from storage tank P to production functions W4 and W5, where diverse kinds of energy are transformed and upgraded. The most important point to be noted about this diagram is that in attaching Q3 to S (in the same way that the gardens are attached to the gallery forest), the energy on which the growing Bakairi population can draw from its environment is nearly doubled. We will see what this means to the Indians in the following chapter.

Table 8-9. Evaluation, name, and description of the energy storage and flows associated with the Bakairi agriculture project

Energy Flows and Storage	Description	Values (Kcal)
Q3	Rice Fields	2.125×10^9
R50	NPP of Cerrado	1.89×10^9
R51	GPP of Rice Fields	9.6411×10^8
R52	Self-Maintenance	4.77×10^8
R53	Heat Sink	2.388×10^8
R53a	Crowing	2.388×10^8
R54	Yield of Rice Fields	9.01×10^6
R55	Secured Yield of Rice	1.76×10^6
R56	Production of Rice	3.60×10^5
R56a	Harvesting of Rice	1.40×10^6

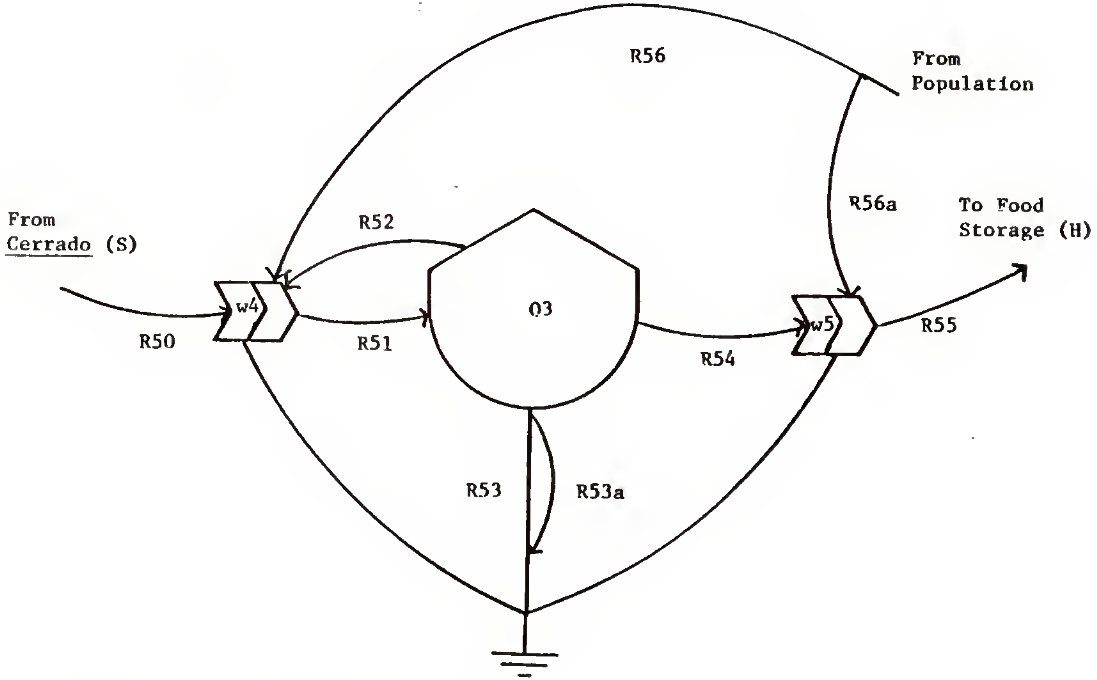


Figure 8-1. The Bakairi agriculture project

CHAPTER 9
CONCLUSIONS

The Bakairi maintain themselves through participation in three major subsistence activities. Each one of these activities is affected by environmental, historical, and cultural factors which tend to limit their efficacy (note table 9-1). Horticulture provides the bulk of the calories for the Bakairi population. Rice, manioc, and corn are the three most important staple crops produced in terms of energy yields. However, the relatively small supply of gallery forest and the abundance of unfertile cerrado, where the Bakairi do not make their gardens, could be an important limiting factor to Bakairi subsistence. A cultural factor, that of slash-and-burn horticultural technology, contributes to the problem. The value of slash-and-burn horticulture in the Tropics will not be debated here. It has already been established that this type of subsistence method increases soil fertility and crop yields. Rather the point is that the Bakairi live in a small reservation of 50,000 ha. They are surrounded by Brazilian ranches and constrained by national Brazilian society in general. As a result, they are unable to expand into the surrounding regions where they could slash and burn new areas.

In addition, their village has been set in the same area of the reservation for the last 60 years (between the Vermelho, Azul, and Paranatinga Rivers). Originally, the Indian Protection Service and,

Table 9-1. Bakairi subsistence activities and factors that influence them

Subsistence Activity	Environmental Factors	Historical Factors	Cultural Factors
Horticulture	*Cerrado* dominates region; gallery forest limited	Village in one area for 60 years; Indian Foundation discourages them from moving	Slash-and-burn methods practices
Fishing	Paranatinga River major fish supplier; problem of fish availability in secondary rivers	Settlement of Mato Grosso; fishing with nets by non-Indians	Fish preference of the Indians
Hunting	Depletion of game; gallery forest versus *cerrado* ratio	Rising cost of ammunition; Xavante Indians in reservation for 20 years	Underdeveloped hunting skills; fish preferred

later, the Indian Foundation, actively encouraged them to remain in this area—first through coercion, and later by offering the Indians incentives such as gifts, medical aid, education facilities, and now a mechanized agricultural project. This policy has discouraged the Bakairi from fissioning and/or from moving their village eastward to the gallery forests of the Kayapo River or northwestward to the fertile lands of the Tuiuiu River. As a result of these environmental, cultural, and historical factors, the Bakairi confront a serious problem. Depletion of soils around the village due to extended use of the land for the last 60 years combined with the inability to fission or to move the village to a new part of the reserve requires them to either commute longer distances to their gardens or to tolerate lower crop yields.

Moreover, demographic trends in the reservation indicate that the Bakairi population is increasing rapidly. The rate of natural increase of the population has been set at 5.9 percent per year which suggests that estimated doubling time is 11.7 years. Taking into consideration abortions and infanticides, both artificial population control mechanisms, the actual rate of natural increase of the population is 3.5 percent per year which indicates that the doubling time of the Bakairi village will be 20 years. We can now see the positive results associated with the Indian Foundation's immunization and tuberculosis-venereal disease control programs combined with their policy of responding to emergency calls from the reservation by flying in to pick up the sick Indians for immediate treatment. The Bakairi are growing in size. Resultant demographic pressure combined with the other factors already outlined suggest that the Bakairi will have to make some difficult choices in the near future. They will be forced to either fission, move their village back from the Paranatinga River, or rely more heavily on mechanized agriculture.

Factors in Consider in Choosing a Survival Strategy

Obviously each one of the above options is problematic. In order to assess the possible problems associated with moving or splitting the village, the objections of the Indian Foundation should not be the only consideration. It is true that they have invested a great deal in the airstrip and the infrastructural facilities that currently exist in the Post part of the village. However, even more important for the Bakairi, is the impact of moving the village on the other two important subsistence activities on which they depend. Fishing is the second most important source of calories for the Indians. It is important in terms of the quantity of calories that it provides, the amount of protein supplied (in which both manioc and rice are poor), and the Indians' cultural preference for fish. It has previously been established that the Bakairi prefer, and consume, more fish than game. The fact that they are more dependent upon this former resource is reiterated in order to underline the difficulties associated with moving the Bakairi village away from the Paranatinga River, which is the major supplier of fish in the reservation. It was not by chance that the Bakairi chose to settle on this river for the last half a century.

Indeed, the other rivers in the reservation including the Kayapo and the Tuiuiu are relatively small and narrow in comparison with the Paranatinga River. Moreover, these smaller secondary rivers are more seriously affected by the dry season. These factors affect the fish supply in a negative way so that it is suggested that the Bakairi would be unable to subsist off of the fish that they catch from these other rivers.

On the other hand, the Bakairi themselves contend that the fish supply in the Paranatinga River is shrinking due to the presence of non-Indian fishermen and their use of fishing nets which, although outlawed in Mato Grosso, are still widely used. In addition, the town of Paranatinga, still small but growing rapidly, lies upstream from the reserve. It is probable that even if the Bakairi are currently imagining the depletion of the fish resources, in the near future this depletion will be real. The dangers associated with moving the village to another part of the reservation in order to increase gallery forest availability, and perhaps to reduce pressure on the fish supply of the Paranatinga River, must be carefully considered alongside of the limited fish availability in the other secondary rivers of the reservation.

Hunting is the third subsistence activity which must be examined. It is a seasonably important source of protein and calories in the Bakairi diet. However, hunting is affected by the ratio of cerrado to gallery forest ratio. In addition, the Bakairi do not consider themselves to be competent hunters, an opinion that is shared by the Xavante and the Xerente who ridicule the Bakairi hunting abilities in the same way that the Bakairi joke about these peoples' lack of fishing acumen. Nor do the Bakairi enjoy game as much as they enjoy fish. During the rains when fish are difficult to secure they consume more meat than usual and complain bitterly about it. However, without game during the rains they would have negligible protein resources since the Bakairi do not gather wild foods such as palms or nuts which may be high in protein (Beckerman 1979:540-548).

Also, game availability in the reservation must be considered. When the Bakairi hunt they travel long distances to the headwaters of the Azul or Kayapo Rivers. It is only in these distant recesses of the rivers that they claim they find game. According to the Bakairi, the Xavante, who were pacified in the 1950s and settled into the reservation 15 km from the Bakairi village for some 20 years, are responsible for depleting the reservation's game. However, in an early Indian Protection Service report, the Xavantes agitated to return to their homelands near the Kuluene River because they themselves, proficient hunters, were not able to find game in the reservation even during that time.

Rising costs of ammunication and guns are also an important factor in hunting. In order to purchase guns and ammunition in Mato Grosso, it is necessary to secure a permit from the police or to buy on the black market. The Indian Foundation makes a small amount of ammunition available to the Indians so that they do not have to obtain permits; however, the cartridges go quickly in the reservation and the

Indians are forced to buy from acquaintances in the town or ranches where they pay high prices. Guns must also be purchased from acquaintances, and they are extremely expensive. There are only 15 .22 rifles and five revolvers, which are virtually useless for hunting purposes, in the reservation. Only 25 percent of the households have a rifle available, and even fewer are able to use theirs due to ammunition shortages.

Game resource depletion, gun and ammunition shortages, as well as a cultural preference for fish tend to limit Bakairi meat intake. Whether the Bakairi remain on the Paranatinga River or move to the Kayapo or Tuiuiu Rivers, meat consumption will probably remain low. However, energy expenditure on hunting will be reduced if the Bakairi move out to one of these rivers since less time and work will be involved in commuting to these areas for hunting purposes if the Indians are located nearby.

Fissioning or moving the Bakairi village are both traditional options available to Indians. The effect of these processes on gallery forest, on fish and game availability and the Indian Foundation's reaction to such a decision on the Indians' part, are all important factors to consider before recommending one of these options. Moreover, a nontraditional alternative has recently been made available to the Bakairi for solving their subsistence problems. The Indian Foundation is currently encouraging them to become involved in a mechanized agriculture project. By financing a project whereby energy-intensive methods of crop production in the <u>cerrado</u> will be employed, the Indian Foundation hopes to accomplish several goals.

First and foremost, it aims at further integrating the Bakairi into national Brazilian society. Agricultural and marketing skills as well as money handling are only some of the lessons that the Foundation hopes the Indians will learn through the project. In addition, the Foundation plans to raise the Bakairi standard of living by increasing the availability of food supplies and cash from the sale of a percentage of the crops raised. Indian cultures continue to be classified as underdeveloped and poverty stricken. The fact that Indian groups such as the Bakairi have maintained their population at adequate dietary intake levels, while employing traditional subsistence methods, is a consideration overriden by the need to integrate indigenous peoples into the mainstream society and to create a standard of living for them that will compare to Western society's. To subject the Bakairi to similar economic pressures that plague both the large and small landowners in the area is an inevitable result of this process. Inflation, high costs of gasoline and fertilizer, an unstable rice market, and transportation difficulties in and out of the reservation all increase the number of difficulties that the Bakairi will confront as they learn to use tractors, seeders, fertilizers, and harvesters.

However, this nontraditional option now open to the Bakairi does allow these Indians to open up lands previously unusued at a time when they are expanding and reaching the limits of the gallery forest available to them in the village vicinity. It will also provide them with cash funds to purchase meat and fish from neighboring ranch owners who are willing to sell it to the Indians at exorbitant prices or to regularly purchase vegetable protein sources, such as beans, in Paranatinga. They will be integrated and will no doubt have more consumer goods at their dispoal, but they will sacrifice their autonomy and their self-sufficiency. Environmental and demographic pressures will be at least temporarily relieved, but new economic pressures linked to the high costs associated with energy-intensive agriculture will be emerging obstacles. The problems are difficult ones, and the costs associated with their solutions are high.

Combining the Components of the Energetics Diagram

In order to examine more closely some of the long-term effects of the mechanized agriculture project on the Bakairi, the ecological energy storages and flows have been taken from the previous chapters, where they have already been defined and evaluated, and combined into an energetics diagram of the entire Bakairi ecosystem. In Figure 9-1, the broad outlines of the ecosystem are described. It can be divided into three main parts: the river, the *cerrado*, and the gallery forest. Energy from these three areas is captured by the Bakairi population. In addition, energy is degraded as the result of the many natural processes which occur within the large bullet-shaped modules, or producer units. This energy flows downward into the heat sink at the base of the diagram.

In Figure 9-2, more details are added to the simplified version of the ecosystem. The river may be viewed as being composed of flora and fauna storage tanks as well as an energy tank which represents the

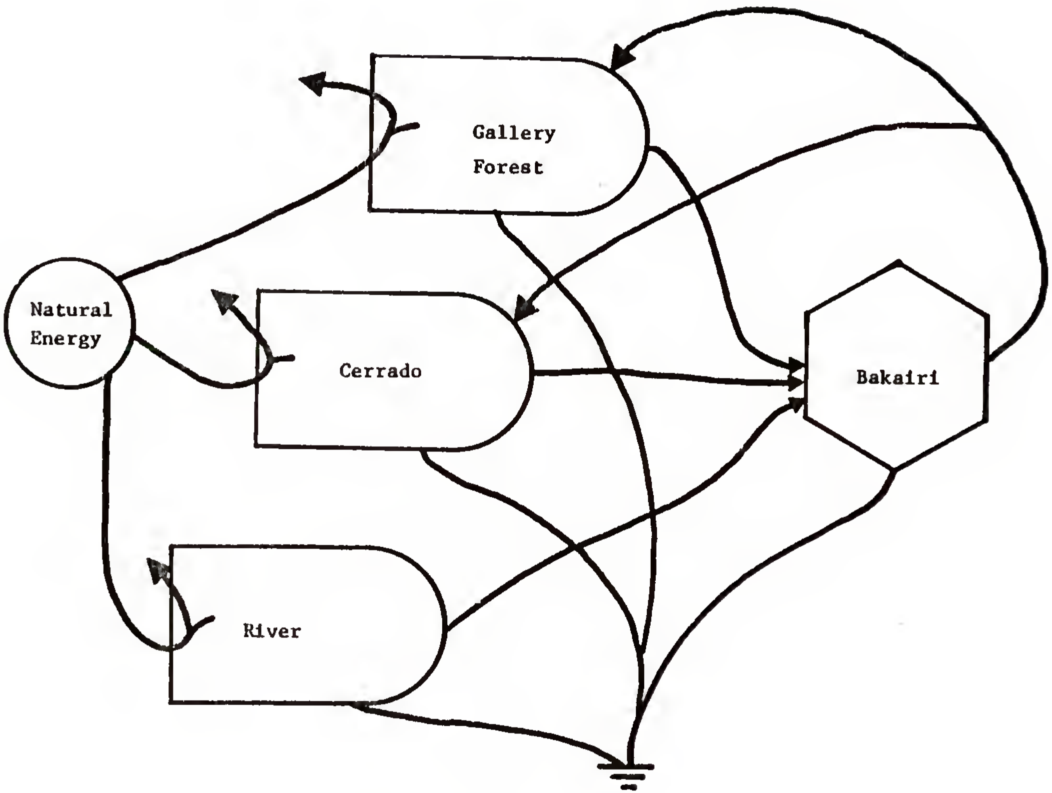


Figure 9-1. Simplified version of the Bakairi ecosystem

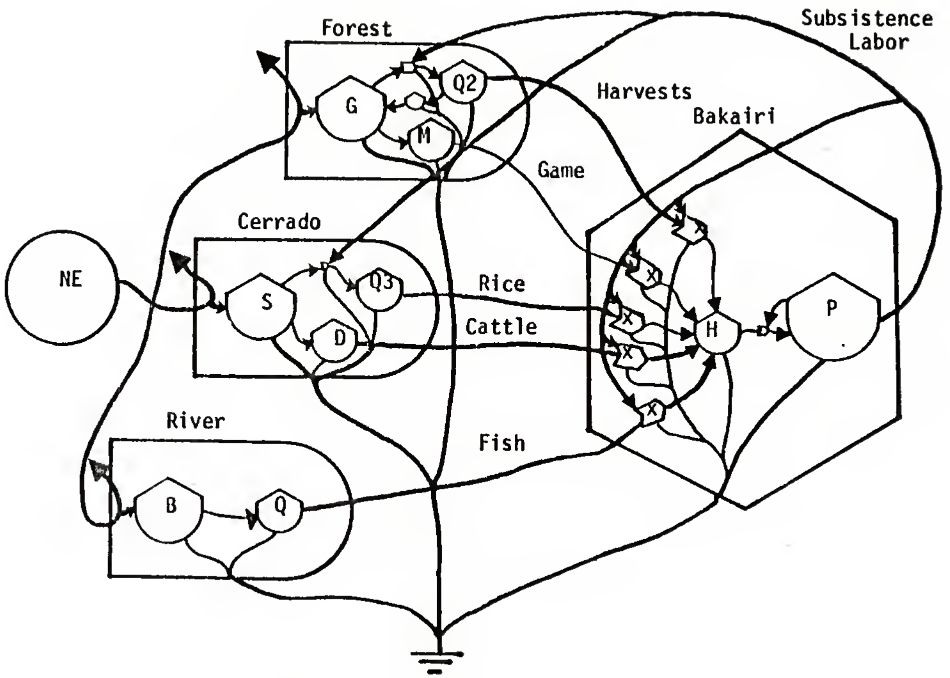


Figure 9-2. The Bakairi ecosystem with more details

project rice field. The gallery forest unit is even more complex. In it we find a flora storage tank, a fauna or game tank, a garden tank, and a succession garden tank. Energy flows from five storage tanks, which represent the five major sources of food for the Indians, to the Bakairi population tank. However, in this version of the ecosystem, the Bakairi are not viewed as a passive receptacle of energy. Rather, they expend energy in order to secure it. Fishing, project work, cattle raising, hunting, harvesting, and gardening all require expenditures of energy on the part of the people. In addition, energy is spent in cultural activities which maintain the entire infrastructure.

In Figures 9-3 through 9-6, even more details are added to the diagram. The addition of these details allows for the writing of differential equations which characterize the interactions between the components in the diagram. Then, these nonlinear equations are rewritten in DYNAMO (see Chapter 1 and the Appendix). Once the nonlinear equations have been programmed, the effects of changing certain variables in the Bakairi ecosystem can be simulated. What results from these simulations are certain specific projections about the Bakairi population and their subsistence resources. These projections must be differentiated from predictions. Predictions imply prophesy. They are statements about what will happen in the future. On the other hand, projections outline what will occur given that a certain set of parameters remain constant. In a projection, the parameters and variables, which interact within them, are emphasized, while in a prediction events are foretold.

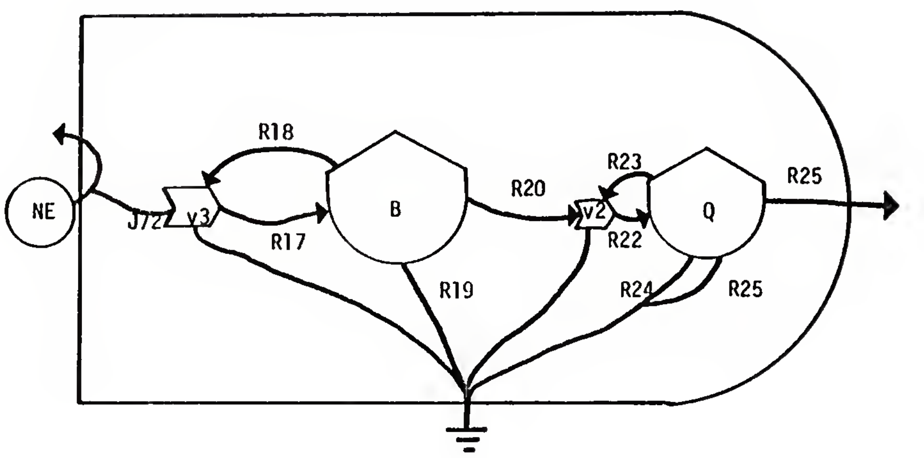


Figure 9-3. Detailed version of the river producer unit

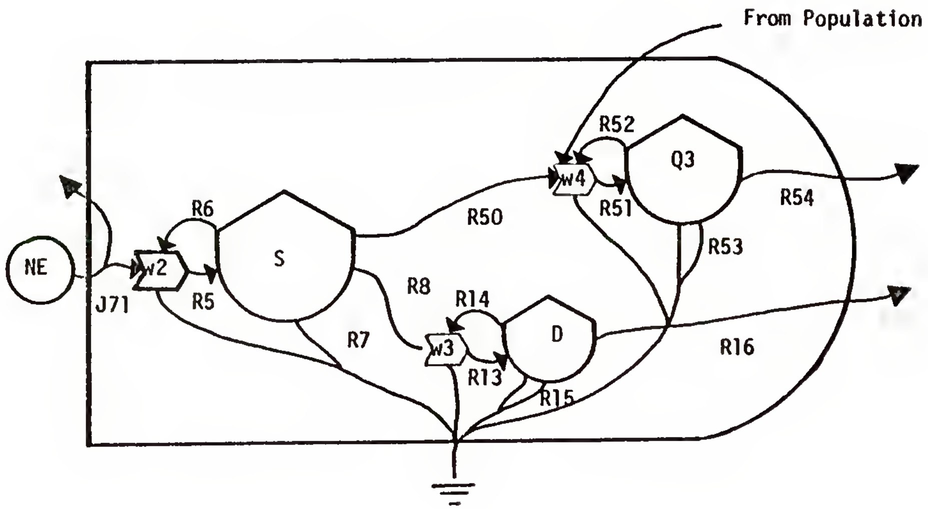


Figure 9-4. Detailed version of the <u>cerrado</u> producer unit

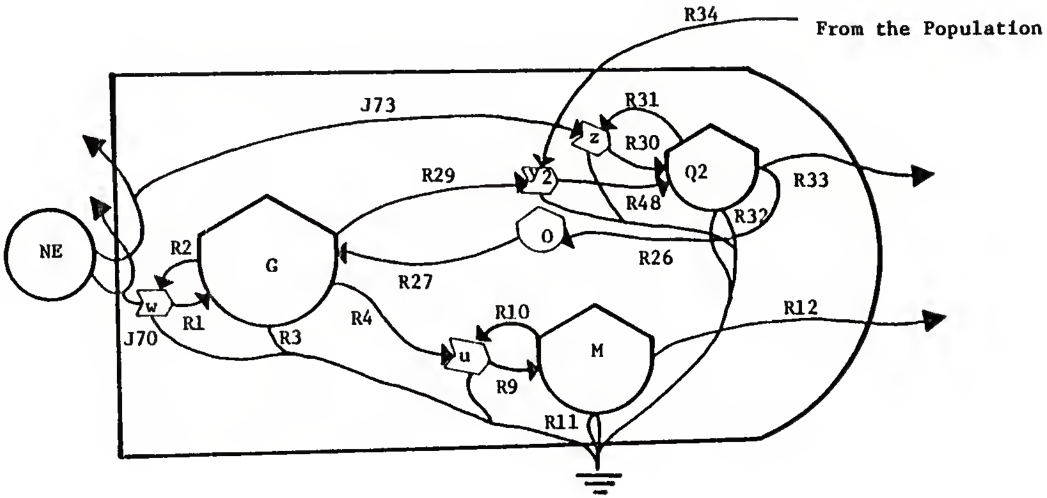


Figure 9-5. Detailed version of the gallery forest producer unit

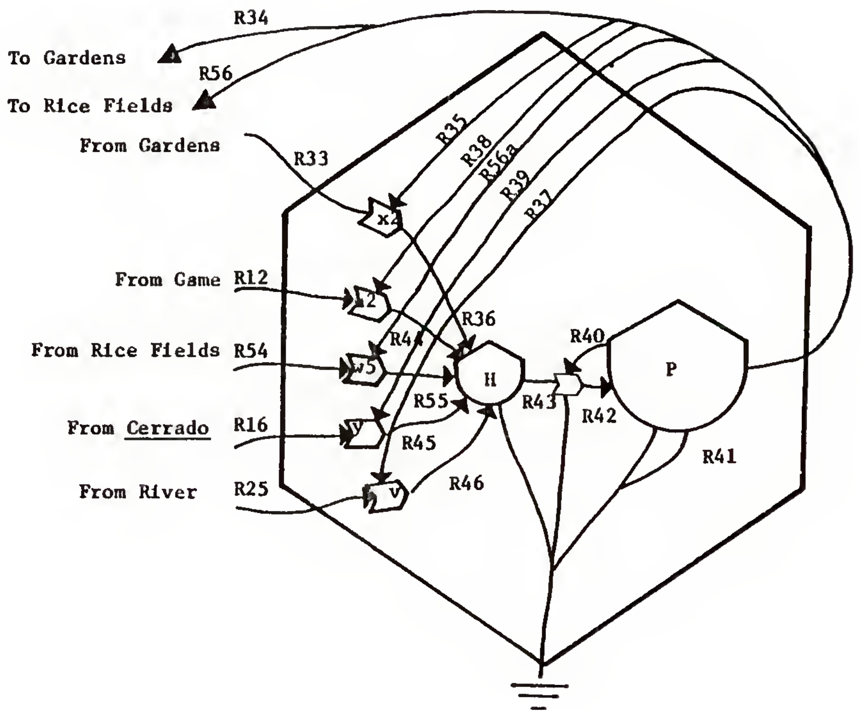


Figure 9-6. Detailed version of the Bakairi consumer unit

Table 9-2. Evaluation, name, and description of the major flows and storages of energy in the Bakairi reservation model

Energy Flows and Storage	Names of Flows and Storage	Values (kcal)
B	River	4.11×10^{8}
Q	Fish	1.42×10^{9}
S	Cerrado Vegetation	7.24×10^{12}
D	Cerrado Fauna	1.89×10^{10}
Q3	Rice Fields	2.125×10^{9}
G	Gallery Forest	1.32×10^{13}
M	Game	5.07×10^{8}
Q2	Crops	1.89×10^{9}
H	Food Storage	4.23×10^{8}
P	Bakairi Population	2.47×10^{7}
O	Succession Gardens	7.08×10^{10}
R17	River GPP	1.44×10^{10}
R18	River Feedback	3.09×10^{9}
R19	River Heat Sink	3.09×10^{9}
R20	River NPP	8.22×10^{9}
R22	Fish Consumption	2.27×10^{9}
R23	Fish Feedback	1.10×10^{9}
R24 + R24a	Fish BMR	1.10×10^{9}
R25	Fish Yield	7.24×10^{7}
R5	Cerrado GPP	4.35×10^{12}
R6	Cerrado Feedback	1.37×10^{12}
R7	Cerrado Heat Sink	1.37×10^{12}

Table 9-2—Continued

Energy Flows and Storage	Names of Flows and Storage	Values (Kcal)
R8	*Cerrado* NPP	1.61×10^{12}
R13	*Cerrado* Faunal Consumption	3.62×10^{11}
R14	*Cerrado* Faunal Feedback	1.63×10^{11}
R15 + R15a	*Cerrado* Faunal BMR	1.63×10^{11}
R16	*Cerrado* Faunal Yield	3.62×10^{10}
R50	*Cerrado* NPP	1.89×10^{9}
R51	GPP of Rice Fields	9.64×10^{8}
R52	Rice Fields Feedback	4.775×10^{8}
R53 + R53a	Rice Fields Heat Sink	4.776×10^{8}
R54	Rice Fields Yield	9.01×10^{6}
R56	Production of Rice	3.60×10^{5}
R56a	Harvesting of Rice	1.40×10^{6}
R1	Forest GPP	2.57×10^{12}
R2	Forest Feedback	9.52×10^{11}
R3	Forest Heat Sink	9.52×10^{11}
R4	Forest NPP	6.35×10^{11}
R9	Game Consumption	9.70×10^{9}
R10	Game Feedback	3.81×10^{9}
R11 + R11a	Game BMR	4.43×10^{9}
R12	Game Yield	1.46×10^{9}
R26	1978 Gardens	8.76×10^{9}
R27	1968 Gardens	8.44×10^{9}
R29	Land for New Gardens	8.41×10^{10}

Table 9-2—Continued

Energy Flows and Storage	Names of Flows and Storage	Values (kcal)
R28	Succession Gardens Heat Sink	3.20×10^9
R48	1981 Gardens	9.33×10^9
R30	Garden GPP	1.51×10^9
R31	Garden Feedback	4.25×10^8
R32 + R32a	Garden Heat Sink	4.25×10^8
R33	Garden NPP	1.23×10^9
R34	Gardening	1.10×10^7
R36	Garden Harvests	6.11×10^8
R44	Game Caught	4.35×10^6
R55	Secured Yield of Rice	1.76×10^6
R45	Cattle Slaughtered	7.15×10^6
R46	Fish Caught	1.52×10^7
R47	Food Debris	2.16×10^8
R43	Food Prepared	4.22×10^8
R42	Food Consumed	2.00×10^8
R40	Cultural Feedback	1.20×10^8
R41 + R41a	Bakairi BMR and SDE	6.10×10^7
R35	Harvesting	3.92×10^6
R39	Cattle Care	1.44×10^6
R37	Fishing	2.18×10^6
R38	Hunting	9.82×10^5

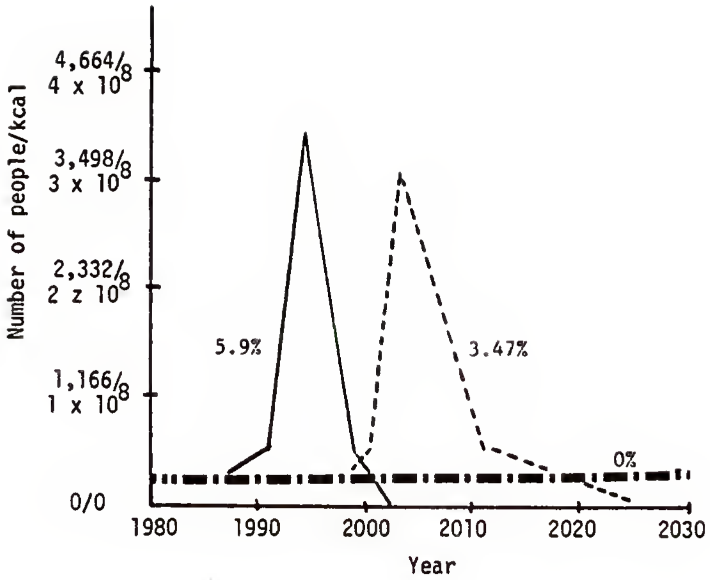
Three Sets of Simulations and Their Results

The first set of simulations pertains to the Bakairi as they relate to their ecosystem with only traditional subsistence methods. In the first simulation, no population growth whatsoever occurs. The population and the resources on which it depends are in steady state. Thus, no growth or decline in the energy values of the ten storages which have been diagrammed is evident (see Figures 9-7 through 9-20). The Bakairi can indefeinitely continue to exist in the reservation at current population levels, if they draw the same amount of energy in the future as they did during the year 1980-1981. Under these conditions, no long-term deleterious effects on the tripartite ecosystem would occur. In the second simulation, 3.47 percent annual population growth is registered. This is the actual rate of population increase among the Bakairi. This growth rate results in a 20-year doubling time for the Indians. In the third simulation, 5.90 percent annual population growth occurs. This is the natural rate of population increase. It equals the actual rate of increase plus infanticides and abortions (see Chapter 4). This rate results in the Bakair population doubling in 11.7 years. The results of these two simulations can be compared to each other and to the population steady-state simulation (see Figures 9-7 through 9-20).

The most important variable to consider is, of course, the population. In the simulations, the Bakairi population begins to grow exponentially, peaks between 3,500 and 3,900 people, and then rapidly declines. The time at which exponential growth begins varies. If the

Figure 9-7. Comparison of Bakairi population growth curves over a 50-year period with reliance on traditional subsistence methods: 0% annual growth, 3.47% annual growth, and 5.9% annual growth

Figure 9-8. Comparison of Bakairi population growth curves over a 50-year period with reliance on traditional subsistence and industrial agricultural methods: 0% annual growth, 3.47% annual growth, 5.9% annual growth


Number of people/kcal
4,664/4 x 10^8
3,498/3 x 10^8
2,332/2 z 10^8
1,166/1 x 10^8
0/0
5.9%
3.47%
0%
1980
1990
2000
2010
2020
2030
Year

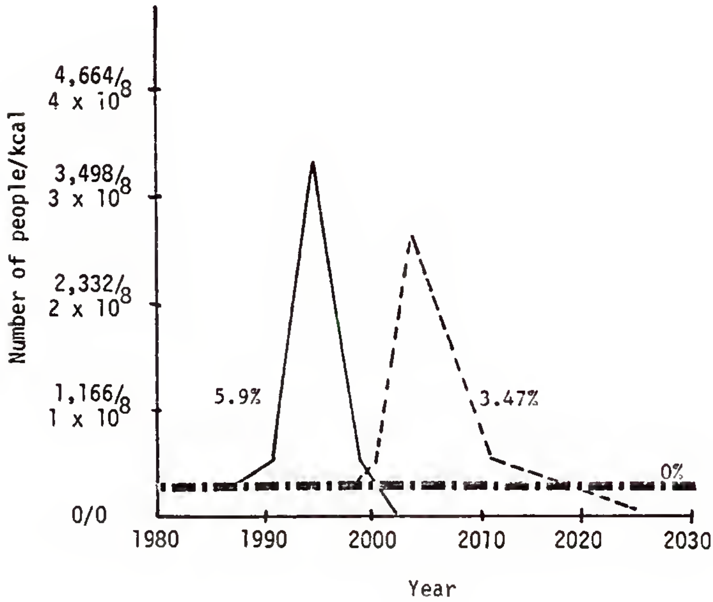
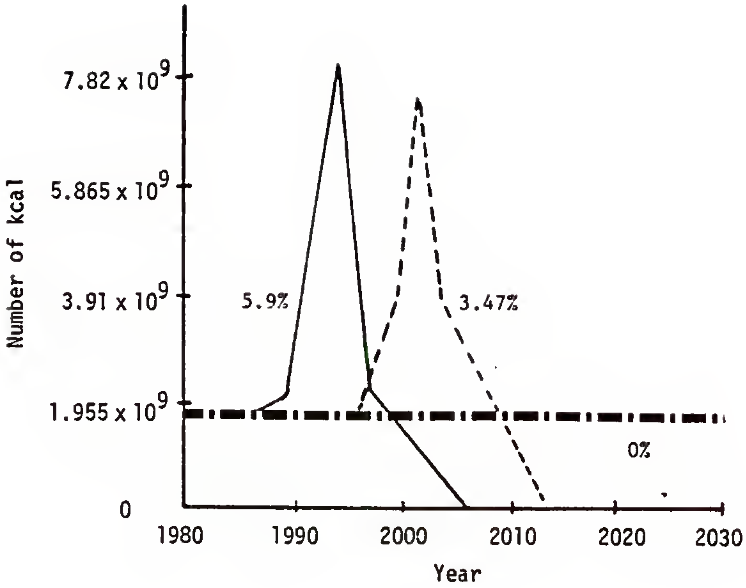

Number of people/kcal
4,664/4 x 10^8
3,498/3 x 10^8
2,332/2 x 10^8
1,166/1 x 10^8
0/0
5.9%
3.47%
0%
1980
1990
2000
2010
2020
2030
Year

Figure 9-9. Garden growth curves over a 50-year period resulting from population growth among the Bakairi; reliance on only traditional subsistence, and on both traditional subsistence and industrial agricultural methods: 0% annual population growth, 3.47% annual population growth, 5.9% annual population growth

Figure 9-10. Succession garden growth curves over a 50-year period resulting from population growth among the Bakairi; reliance on traditional subsistence methods: 0% annual population growth, 3.47% annual population growth, 5.9% annual population growth


7.82 x 10^9
5.865 x 10^9
3.91 x 10^9
1.955 x 10^9
0
Number of kcal
5.9%
3.47%
0%
1980
1990
2000
2010
2020
2030
Year

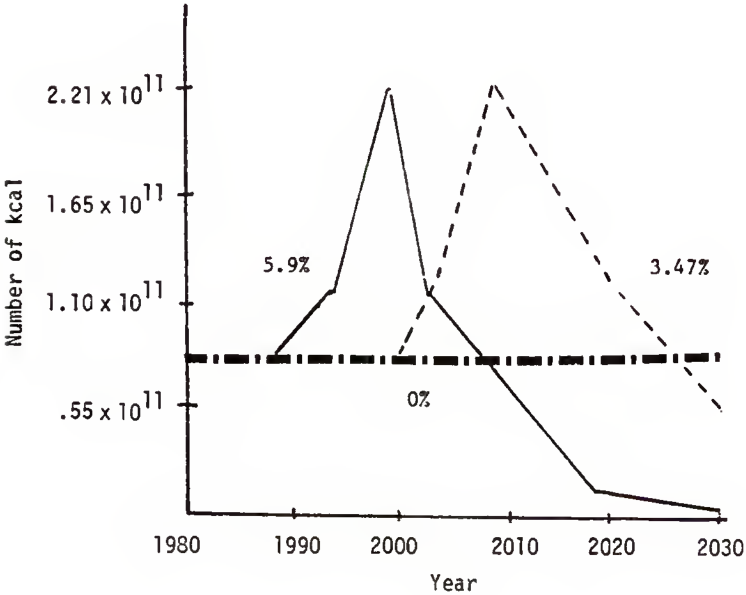
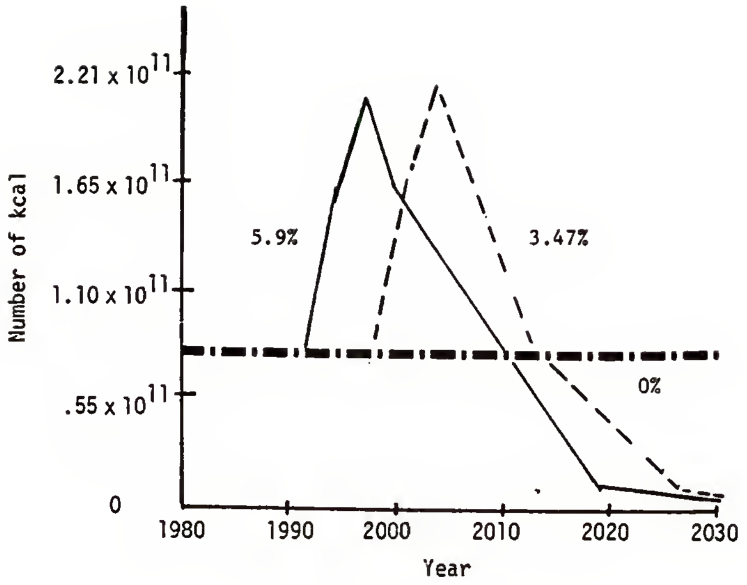

2.21 x 10^11
1.65 x 10^11
1.10 x 10^11
.55 x 10^11
Number of kcal
5.9%
3.47%
0%
1980
1990
2000
2010
2020
2030
Year

Figure 9-11. Succession garden growth curves over a 50-year period resulting from population growth among the Bakairi; reliance on both traditional subsistence and industrial agricultural methods: 0% annual population growth, 3.47% annual population growth, 5.9% annual population growth

Figure 9-12. Gallery forest growth curves over a 50-year period resulting from population growth among the Bakairi; reliance on traditional subsistence methods: 0% annual population growth, 3.47% annual population growth, 5.9% annual population growth


2.21 x 10^11
1.65 x 10^11
1.10 x 10^11
.55 x 10^11
0
Number of kcal
5.9%
3.47%
0%
1980
1990
2000
2010
2020
2030
Year

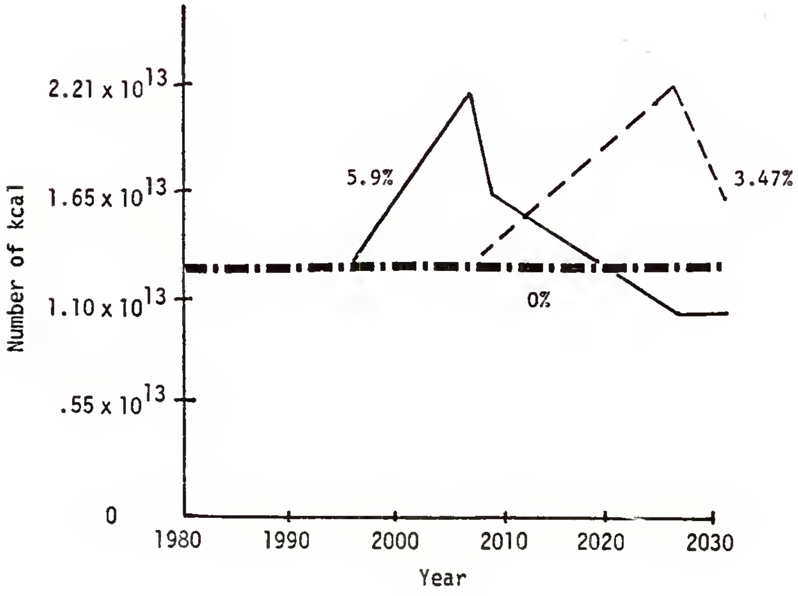
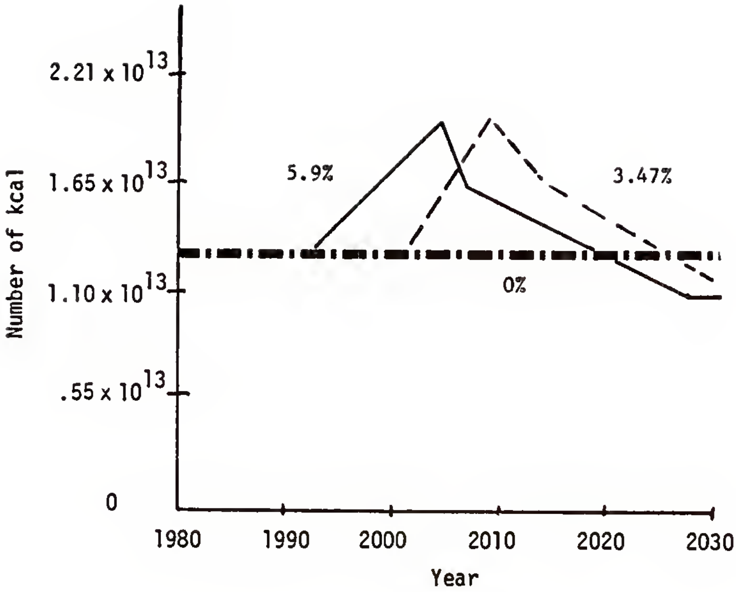

2.21 x 10^13
1.65 x 10^13
1.10 x 10^13
.55 x 10^13
0
Number of kcal
5.9%
3.47%
0%
1980
1990
2000
2010
2020
2030
Year

Figure 9-13. Gallery forest growth curves over a 50-year period resulting from population growth among the Bakairi; reliance on both traditional subsistence and industrial agricultural methods: 0% annual population growth, 3.47% annual population growth, 5.9% annual population growth

Figure 9-14. Cerrado growth curves over a 50-year period resulting from population growth among the Bakairi; reliance on traditional subsistence methods: 0% population growth, 3.47% population growth, 5.9% population growth


2.21 x 10^13
1.65 x 10^13
1.10 x 10^13
.55 x 10^13
0
Number of kcal
5.9%
3.47%
0%
1980
1990
2000
2010
2020
2030
Year

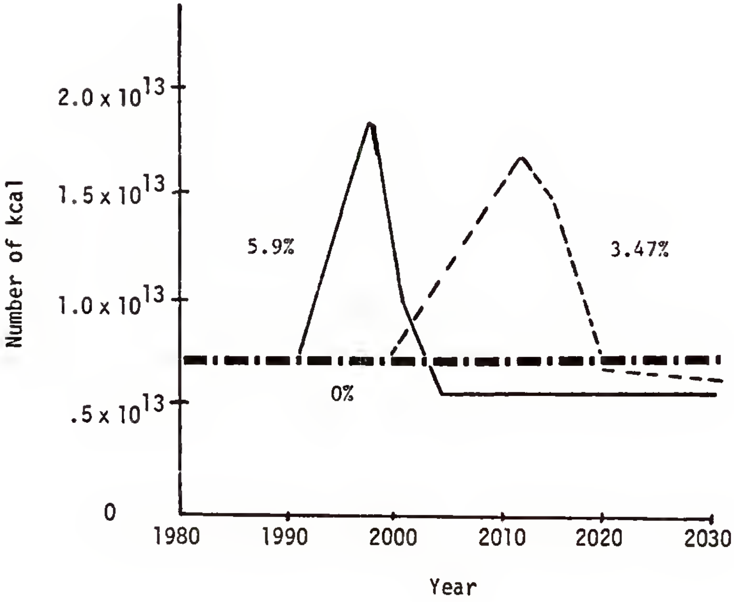
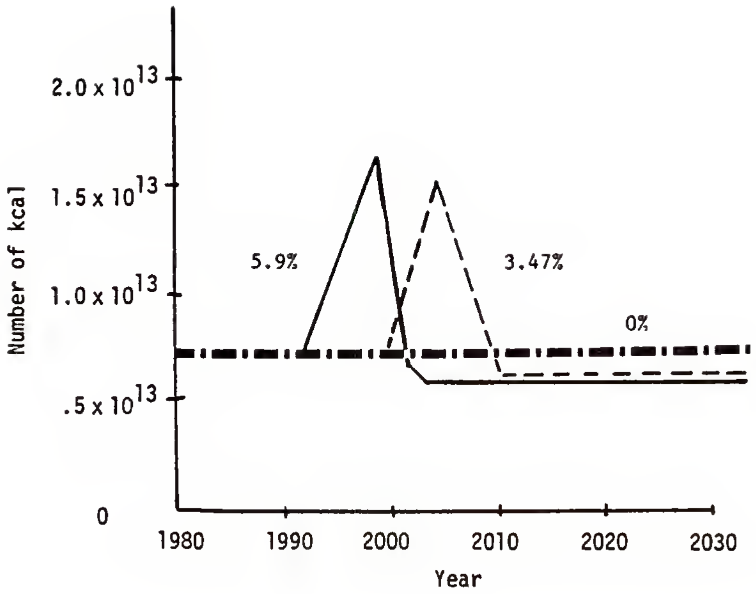

2.0 x 10^13
1.5 x 10^13
1.0 x 10^13
.5 x 10^13
0
Number of kcal
5.9%
3.47%
0%
1980
1990
2000
2010
2020
2030
Year

Figure 9-15. <u>Cerrado</u> growth curves over a 50-year period resulting from population growth among the Bakairi; reliance on both traditional subsistence and industrial agricultural methods: 0% annual population growth, 3.47% annual population growth, 5.9% annual population growth

Figure 9-16. <u>Cerrado</u> fauna growth curves over a 50-year period resulting from population growth among the Bakairi; reliance on traditional subsistence methods: 0% annual population growth, 3.47% annual population growth, 5.9% annual population growth


2.0 x 10^13
1.5 x 10^13
1.0 x 10^13
.5 x 10^13
0
Number of kcal
5.9%
3.47%
0%
1980
1990
2000
2010
2020
2030
Year

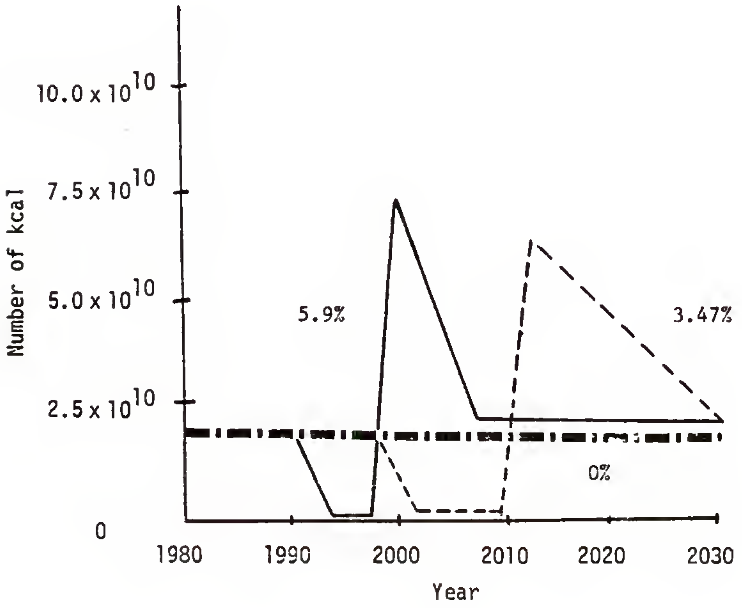
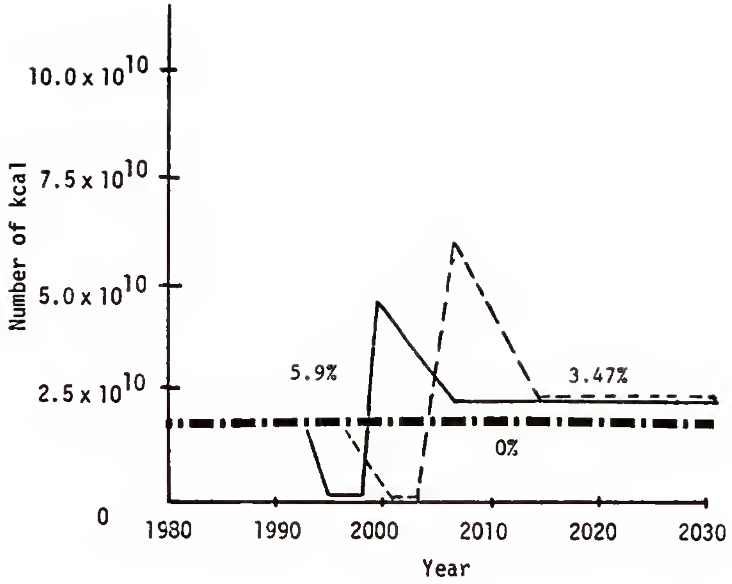

10.0 x 10^10
7.5 x 10^10
5.0 x 10^10
2.5 x 10^10
0
Number of kcal
5.9%
3.47%
0%
1980
1990
2000
2010
2020
2030
Year

Figure 9-17. *Cerrado* fauna growth curves over a 50-year period resulting from population growth among the Bakairi; reliance on traditional subsistence and industrial agricultural methods: 0% annual population growth, 3.47% annual population growth, 5.9% annual population growth

Figure 3-18. The decline in game over a 50-year period resulting from population growth among the Bakairi; reliance on only traditional subsistence, and both traditional subsistence and industrial agricultural methods: 0% annual population growth, 3.47% annual population growth, 5.9% annual population growth


10.0 x 10^10
7.5 x 10^10
5.0 x 10^10
2.5 x 10^10
0
Number of kcal
5.9%
3.47%
0%
1980
1990
2000
2010
2020
2030
Year

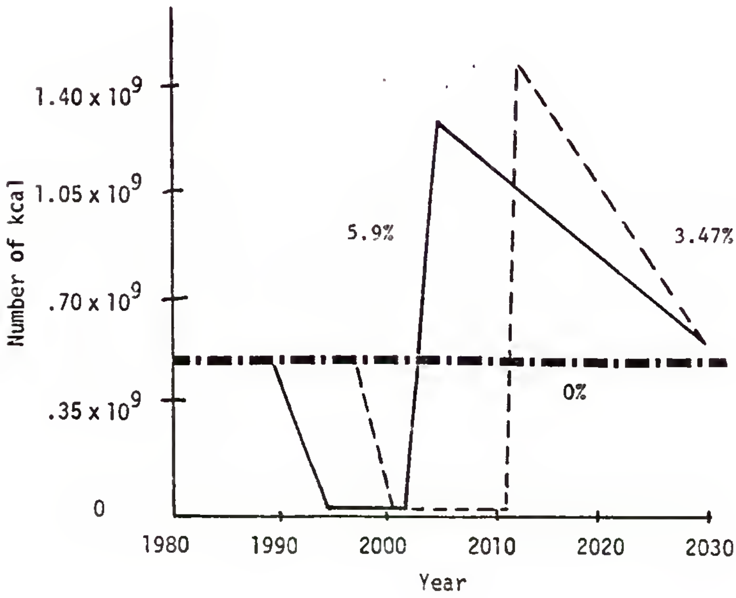
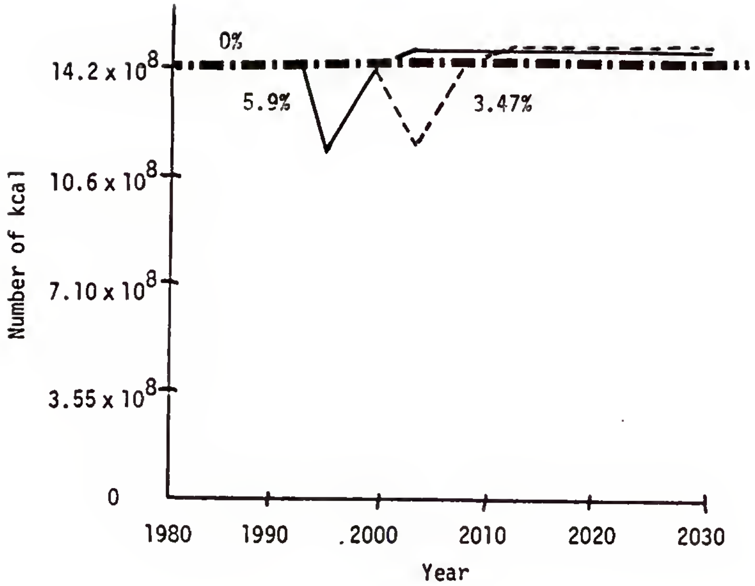
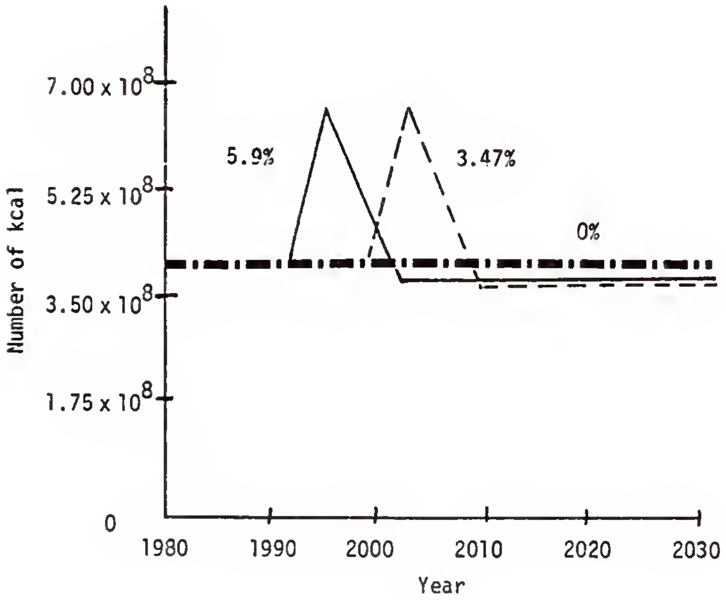

1.40 x 10^9
1.05 x 10^9
.70 x 10^9
.35 x 10^9
0
Number of kcal
5.9%
3.47%
0%
1980
1990
2000
2010
2020
2030
Year

Figure 9-19. The decline in fish over a 50-year period resulting from population growth among the Bakairi; reliance on only traditional subsistence, and on traditional subsistence and industrial agricultural methods: 0% annual population growth, 3.47% annual population growth, 5.9% annual population growth

Figure 9-20. River growth curves over a 50-year period resulting from population growth among the Bakairi Indians; reliance on only traditional subsistence, and on traditional subsistence and industrial agricultural methods: 0% annual population growth, 3.47% annual population growth, 5.9% annual population growth


0%
14.2 x 10^8
5.9%
3.47%
10.6 x 10^8
7.10 x 10^8
3.55 x 10^8
0
Number of kcal
1980
1990
.2000
2010
2020
2030
Year


7.00 x 10^8
5.9%
3.47%
5.25 x 10^8
0%
3.50 x 10^8
1.75 x 10^8
0
Number of kcal
1980
1990
2000
2010
2020
2030
Year

population annual grows at a rate of 5.9 percent, then exponential growth can be expected to occur between the years 1990 and 2000. However, if the annual rate of increase of the population is slower, for example 3.47 percent, then exponential growth will not be triggered until between the years 2000 and 2010. The slower the rate of population increase, the longer it will take for exponential growth to begin. Otherwise, the curve, its width, and the overall decline are similar.

It should be mentioned here that within this set of simulations, 15 different runs were made where the energy flow into the population tank was varied. Population doubling times of as low as five years were simulated. In each, the results indicated that under the traditional system of production, no more than 4,000 people, compared to the 288 that now live in the village, can be supported in the reservation before a decline begins. However, the rate of exponential growth and the rapidity of the decline do vary.

The decline from exponential growth of the Bakairi is initially triggered by the dramatic decline seen in the _cerrado_ fauna, the fish, and the forest game energy storages (see Figures 9-16, 9-18, and 9-19). The Bakairi draw on the energy flows from these three storage tanks to such an extent that they begin to decline or are emptied. After population pressure on these three resources is alleviated, they revive to steady-state levels.

The garden energy tank does not begin to decline until _after_ the population peaks and begins its own decline (see Figure 9-9). That is, when the Bakairi begin to decrease in number, they expend less energy on gardening than previously so that less land is drawn from the gallery forest and put under production. This does not indicate that productive land is not a limiting factor on population growth. Rather, it represents a secondary limiting factor which would eventually cause the population to peak and decline, although the peak levels would be higher and the decline would occur later than they are here registered. This issue will be addressed in more detail later.

The flora storages in the form of the aquatic plants, the _cerrado_ flora, and the forest remain surprisingly unaffected in the simulations (see Figures 9-12, 9-14, and 9-20). As the population increases exponentially and draws upon the fauna energy storages, the latter pull available energy from the natural energy sources into the flora tanks in order to increase productivity on which they can draw. The natural energy sources in the form of the sun, rain, and those productive processes which result from their interactions are limited in and of themselves. However, they can be classified as tertiary limiting factors. If the game and _cerrado_ fauna existed in unlimited supplies, and the garden land representing the secondary limiting factor was also unlimited, only then would those limits built into the natural floral subsystems take effect. The population would once again peak at an even higher level than it would operating within the set of secondary limiting factors. However, it would eventually be forced to decline in the same way as it did when controlled by the primary limiting factors.

The second set of simulations pertains to the Bakairi as they relate to their ecosystem with both the traditional subsistence and industrial agricultural methods. In these simulations, the flow of energy from the project's lands in the cerrado is equal to only that energy which is consumed by the people. This, of course, represents only 15 percent of all that was produced by the project, due to the fact that so much of the rice had to be sold on the market in order to raise cash to purchase supplies for the following year. In the first simulation, no population growth occurs. Once again, the population and the ecological subsystems are in a steady state. No changes in the energy storages or flows are evident. In the second simulation, the Bakairi population grows at a rate of 3.47 percent. In the third simulation, this rate is increased to 5.9 percent.

In Figure 9-7 through 9-20, the results of the two simulation sets (traditional versus traditional and mechanized systems of production) can be compared. The population increase to approximately the same level in the second simulation set as in the first. That is, when relying upon the project rice, the Bakairi population does not grow to any new high level when compared to those peaks registered under the traditional system simulations. The calories supplied by the project are so few, in comparison to the calories supplied by the traditional gardens and by hunting, fishing, and cattle raising, that the impact on the population is negligible. In addition, the population still goes into exponential growth, and then begins to decline, at the same points as it did when it relied only upon the traditional system or production. If the Bakairi continue to depend to a limited extent upon the mechanized agriculture project, their population's rate of increase, and decrease, will clearly remain unaffected.

Once again, the decline from exponential growth is triggered by the reduced energy levels in the fish, game, and cerrado fauna storage tanks (see Figures 9-17, 9-18, and 9-19). Directly before the population peak occurs, lower energy levels begin to appear in these three resource tanks. The reduced levels almost immediately begin to pull down the population energy levels, resulting in a spiraling effect. However, a few interesting differences are apparent if the behavior of the fish, and cerrado fauna storages are compared under traditional and mechanized conditions. For example, although the fish supply declines and rebounds at approximately the same time, the nadir of the traditional subsistence curve is lower, indicating that dependence upon fish is greater under the traditional production system than it is under the industrial agricultural system. Furthermore, the cerrado fauna supplies decline and then rise to a peak under both systems of production. However, the apex under the traditional production system is slightly higher than that which occurs under the combination of the two systems.

Two explanations can be offered for this phenomenon. In the first place, the Bakairi dependence upon the cerrado fauna may be greater under the traditional system. As a result the population draws more energy from this resource energy tank, forcing it, in turn, to draw more heavily on the flora energy tank. When the fauna energy levels can no longer rise any further, nor even maintain peak levels, then the storages decline rapidly. A second explanation, which is not mutually exclusive, is that under the mechanized agriculture system of production, both the fauna and the rice fields compete for the same land or energy storages. Thus, part of the energy which, under the traditional system of production flowed into the fauna tank, is rerouted into the project lands away from the animals. As a result, the faunal population levels cannot reach as high an apex as they previously did when only the traditional production system was in effect.

The simulation results indicate that the primary limiting factor, when the two systems of production are combined, continues to be the game, fish, and cerrado faunal energy storages. If the Bakairi are able to raise enough rice, and sell it on the market so that they can purchase adiitional food stuff or even consume the cerrado rice itself, then it is possible that the primary limiting factors may disappear. However, the secondary limiting factor, in the form of productive garden land, will then be put into effect. Under the second set of simulations, the garden storage rises, peaks, and declines at the same time, and in the same way as it did under the traditional production system. That is, only after the population reduces its energy input into the gardens do they, in turn, begin to decline. The rice project energy storages behave in a similar fashion. The storage in the project lands increases, peaks as the Bakairi population begins to spiral downward, and then decreases itself.

Energy levels in the aquatic storage tanks behave similarly under both systems of production. The river energy level curves upward, then peaks, and finally drops to a slightly lower than steady-state level, after the population pressure has been reduced. However, the gallery forest's behavior under simulation differs from that which is seen under the traditional production system. Under the traditional subsistence system, the energy levels in the gallery forest peak higher and later than they do when the traditional and industrial systems of production are combined. In the latter case, the dependence upon the gardens is reduced somewhat so that more net energy is derived from the cerrado subsystem, and concomitantly, proportionally less comes from the forest areas. The population, depending less on the forest gardens when using both production methods, pulls less on the garden storages which in turn pull less on the forest energy storages. Once again, the population never increases to such an extent that the tertiary limiting factors, in the form of natural energy, are activated. This same tendency can be seen in the succession garden energy tank. With the traditional system of production, more land accumulates in the succession garden storage so that energy levels in that tank peak higher before declining as the population decreases. On the other hand, when both systems of production are used, the storage levels in the succession garden tank peak of a lower level before declining. This, once again, reflects reduced dependence on the gallery forest gardens.

Under the combined production system, the cerrado floral energy storage rises in response to the growing population, peaks, and then declines after the Bakairi population is reduced. Once again, evidence indicates that the tertiary limiting factors are not activated by the Indian population levels reached in the simulations.

In the first two sets of simulations, primary, secondary, and tertiary limiting factors are defined. Under both the traditional and the traditional-mechanized subsistence systems, the game, fish and cerrado fauna resource levels began to decline, thus, causing the population level to peak and decline itself. These former energy storages represent the limiting factor in the Bakairi ecosystem. The secondary limiting factor of productive garden lands was also discussed. Simulation results indicate that if the entire mass of gallery forest in the reservation is considered to be at the disposal of the Bakairi, it will temporarily support it over ten times the number of people who now live in the reservation if the fallow period remains set at 10 years. Village relocation, fissioning, and dispersion of the population, or the simple expenditure of more time and energy in commuting to these lands located farther from the current village will allow for the population growth rates which are inherent in the current demographic sitaution.

The tertiary factors in the form of the natural sources of energy which fuel the floral storages were also discussed. Results indicate that these factors are not activated under the traditional or the combined systems of production. Rather, the primary and secondary factors act to limit growth prior to the population impacting upon the floral energy reserves. However, population levels of 10 times the current number of Indians cannot be tolerated indefinitely by the reservation's resources. If the Bakairi population does begin to grow exponentially at around the year 2000, within a decade it will begin to rapidly decline. How can the primary and secondary limiting factors be shortcircuited in order to prevent this occurrence?

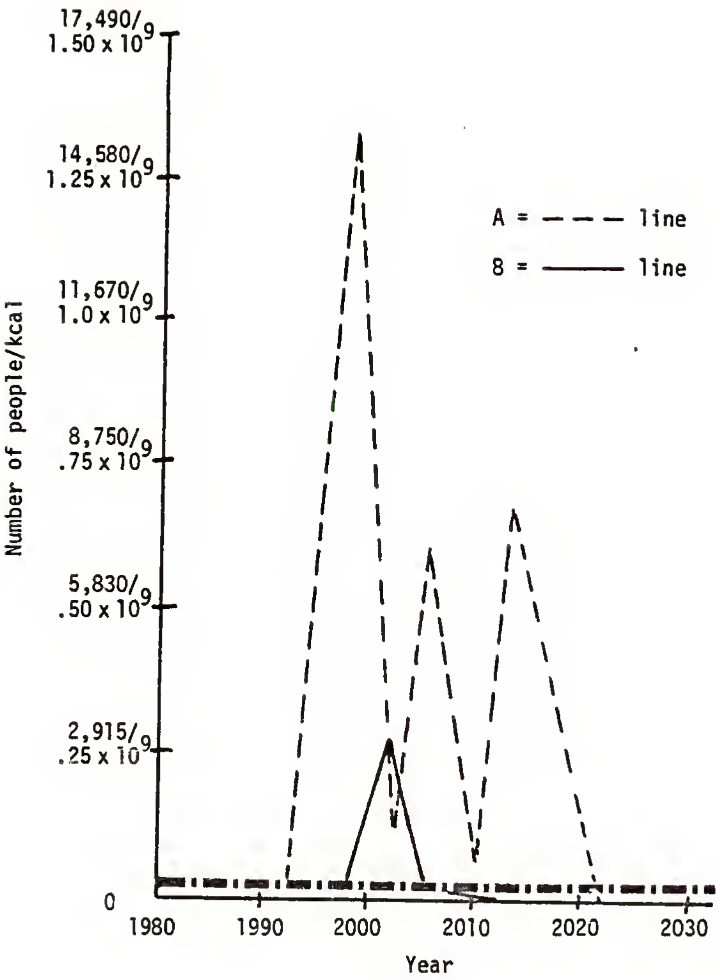
In the third set of stimulations, rice production in the _cerrado_ is increased. In addition, those flows of energy from these fields to the population are augmented. For example, if the Bakairi at least double the land under production in the _cerrado_ and are allowed to exploit the entire harvest, rather than just 15 percent of it, how will the population energy tank behave? Which of the limiting factors will be activated? In Figure 9-21, the results of this simulation are presented, and compared to the results of the first and second simulations. It is clear that the mechanized project in the _cerrado_ can support vast numbers of people. This statement must, of course, be qualified. It assumes, first, that the Bakairi will receive fuel and fertilizers free from the Indian Foundation; second, that the entire rice harvest will be kept for consumption purposes; and third, that additional protein supplies can be imported. If these three conditions are met, then the _cerrado_ can supply an adequate amount of kilocalories, or energy, to temporarily support as many as 15,000 people.

However, when those energy levels in the population storage tank are reached, the tertiary limiting factors are activated and precipitate rapid decline in the population. But the _cerrado_ and the gallery forst energy reserves begin to drop, and subsequently, the population storages peak and also decline. In effect, the primary and

Figure 9-21. Comparison of Bakairi population growth curves over a 50-year period

A represents the population growth curve resulting from increased reliance upon industrial agriculture methods

B represents the population growth curve resulting from reliance on only traditional subsistence methods or on both traditional subsistence and industrial agriculture methods


17,490/9
1.50 x 10^9
14,580/9
1.25 x 10^9
11,670/9
1.0 x 10^9
8,750/9
.75 x 10^9
5,830/9
.50 x 10^9
2,915/9
.25 x 10^9
0
Number of people/kcal
A = - - - line
8 = ——— line
1980
1990
2000
2010
2020
2030
Year

secondary limiting factors are circumvented, resulting in higher population energy levels. However, ultimately new limits to growth come into play and cause these levels to drop.

These simulations illustrate possible situations the Bakairi may confront over the next 50 years. The Indians can continue to rely only on traditional subsistence methods or they can rely primarily on traditional production methods and to a certain extent on mechanized methods of production. If either of these routes is followed, the Indian population will begin to grow exponentially and be forced to eventually confront rapid depopulation as the result of resource shortages. At that point, they will no doubt attempt to rely more heavily on the mechanized system of production which will allow the population to grow to new high levels, and, at the same time, stave off forced migration or depopulation. However, ultimately, the natural energy sources of the reservation, in the form of the floral energy storages, will force the Indians to reduce the rate of population increase or to confront the painful possibilities of migration or starvation and death of large numbers of people.

The Benefits of Adopting the Industrial Agriculture System

If the Indians adopt the new industrial agriculture system while retaining their own traditional gardens, they will gain a number of benefits. Most important, the harvest from the rice crops cultivated in the *cerrado* will supplement the flow of calories from the traditional gardens. The availability of an increased amount of calories could enable the Bakairi population to grow to a larger size than they would if they only depended upon those foods from their own forest gardens. Furthermore, they will be able to exploit the cerrado area, which covers over 80 percent of the reservation and which is currently underexploited. More efficient and productive use of these lands would justify the allocation of the area into the legal category of Indian lands available for non-Indian exploitation. It would be demonstrated to those detractors of Indian rights that indigenous populations need, and can utilize, those lands which the federal government has decreed for them.

Also, the cultivation of crops in the recesses of the cerrado will discourage non-Indians from invading the Bakairi reservation. At this time, two particulrly vulnerable points exist. Both the northwest and southeast corners of the reservation are considered open to attack. The Indian Foundation has advised the Bakairi to patrol these areas regularly; however, the distances involved are so great that the Indian men avoid touring the regions. Mechanized agriculture would force the Indians to have frequent contact with these areas, and the plowed fields, in and of themselves, might prevent unauthorized entrance of non-Indians into the region.

The employment of industrial agriculture will also require the Indians to learn new skills on which the non-Indian population places a great deal of value. The skillful and successful application of Western know-how will allow the Brazilians to apply standards to the Indians which they apply to themselves. Also the Bakairi will no longer find it necessary to provide cheap migrant labor for the surrounding ranches. They will indirectly control their own cash source as it will be their land and their fields that they are cultivating. The Indians will no longer be peons which the ranchers and even their rural workers patronized. Rather, the Bakairi will be awarded a more equitable status as the ranchers come to recognize them as producers, according to non-Indian definitions, rather than scavengers, as they are now perceived.

In addition to the increased amount of respect which the Bakairi will gain, the cash from the sale of the rice crops will allow them to purchase sewing machines, cloth, radios, clothes, bicycles, flashlights, batteries, soap, razors, etc. These products are now very important to the Indians, and their desire to own these items has led to a great deal of begging, petty theft, and angry demands on their part. This not only strains their relations with the non-Indians in the area, but it actually embarrasses the Indians who are, at this point, acculturated enough to know what is socially appropriate and what is not in the Brazilian world. Currently, simple desperation, resulting from a limited cash flow and rising expectations, forces the Bakairi adult to debase him- or herself in a way that the villagers themselves define as unacceptable.

Additional categories, more efficient use of the reservation, new skills, greater respect from the Brazilians, and an increased cash flow, which the Indians themselves control, must be counted as benefits of the mechanized agriculture project. However, central to the key problem discussed in this thesis is the population factor. Simulation results indicate that the project would allow the population to grow to higher levels than otherwise while retaining an adequate nutritional status. This does not only mean that additional calories must be made available to the people. Rather, it indicates that an adequate protein supply must also be produced. In Chapter 7, the various problems associated with the acquisition of animal foods were discussed. The energy efficiency ratios of hunting, fishing, and cattle raising were all estimated to equal approximately three. That is, for every calorie of energy expended in a protein-acquisition activity, three calories are secured. Compared to other groups, this is not a very high return. In addition, the efficiency ratios associated with hunting and fishing may drop even further in the future.

As the Bakairi population grows and the hunting and fishing efficiency ratios decline, the Indians will have two options. They can expend some of the cash flow from the sale of the rice harvests upon protein-rich foods purchased in the city. In this category, beans, dried meat, and canned fish and meat can be included. However, it should be mentioned that these foods are the most costly of all available foodstuff. The price of beans, in particular, rises monthly in Brazil. Or the Indians can build up the cattle herd in the reservation. As the number of cattle increases, the Bakairi will be able to siphon off for consumption those older cows and steers which are of little or no reproductive value. The animals can be regularly slaughtered and distributed in the village, thus augmenting the current protein supply. The direct increase of available calories, in the form of rice, and the indirect increase of available protein, in the form of purchased high-protein foods and domesticated animals, will buffer the growing Bakairi population from those constraints which their limited reservation area and traditional subsistence methods have placed on them.

One important point about the above scenario should be underlined. Traditional subsistence gardens must be retained as an integral part of the Bakairi subsistence system. Not only are the calories supplied by the crops from these plots of critical importance, but also the industrial agriculture project may fail in the near or distant future. In Chapter 8, the high costs of fuel and fertilizer were discussed. It was established that cash from the sale of the mechanized project's rice would not over necessary expenditures on these goods, which are essential to production in the cerrado. For now, the Indian Foundation has agreed to finance the industrial agriculture project for another year. However, can this continue indefinitely? If the project fails, the forest gardens will be all that stands between the Bakairi and starvation.

In 1971, Gross and Underwood published an article in which the effects of the adoption of sisal production on northeastern Brazilians were discussed. The transformation of subsistence-based agriculture to the production of crops for sale in a national and international market may initially raise the standard of living of a population, both in terms of cash availability and nutritional resources. However, if the market for the particular crop crashes, then the population is left with goods which cannot be sold.

This is extremely dangerous when the crop is inedible, as in the case of sisal. However, a similar danger may exist in the case of rice production by the Bakairi. Rice is, of course, edible; however, if the cost of such products as fuel and chemical fertilizers become prohibitive or if the tractor and other equipment break down and cannot be repaired or replaced, then production of rice in the _cerrado_ will grind to a halt. The _cerrado_ soils will not sustain the production of crops if only traditional Bakairi technology is employed. Turning over the topsoil with a plow and using chemical fertilizers are essential to the production process in these areas. Therefore, the total dependence upon this single crop produced with industrial technology in the _cerrado_ can only be to the detriment of the Indians. The Indian Foundation must be responsible for warning the Bakairi against this development. Subsistence gardens in the forest must be maintained at all costs.

The threat of abandonment of traditional technology by the Indians is not an idle one. When the tractor arrived in the Bakairi reservation, the Indians were extremely impressed and enthusiastic about the potential of the machinery. Within weeks, factions began to argue about what could, and could not be done by the equipment. One group called for the use of the tractor in making individual gardens in the forest. Since the equipment was the community's, they reasoned that each household could employ the tractor as they saw fit. They would choose the area in which they would make their gardens, and the tractor would travel to that spot to clear and plow the land. The reduction of labor in clearing and planting that would result was immediately perceived by this group of Indians. A second faction wanted to abandon their gardens in the forest altogether and create individual plots in the *cerrado* itself which would be larger and more productive than those small gardens in the forest. Seed, fertilizers, and fuel for the tractor would be borrowed from the Foundation supplies sent into the reservation and paid back at a later date when the sale of the individual rice crops took place. Each household would retain its own harvest as well as the cash from its sale. Men all over the village went out into the *cerrado* and began to divide up the land according to their needs.

The third faction reacted against both of the other groups. They were in the minority but these men had had more interaction with the Indian Foundation than the others, some of whom had never even left the Bakairi reservation. This group immediately perceived the difficulties associated with making gardens in the forest with the tractor or with creating individual plots in the *cerrado*. They contacted the head of the Fifth Regional Indian District, a colonel, who immediately flew into the reservation to brief the Bakairi on what they could expect to do with the machinery. He established that the tractor and supplementary equipment were to be used only for community projects on which everyone would work and from which everyone would gain. No individual plots in the forests or the *cerrado* could employ the tractor because the equipment would not tolerate being run from one end of the reservation to the other over the worst possible paths. If the Bakairi pushed the machinery to that extent, it would have a lifespan of a year at best. Furthermore, the expensive supplies could only be used for the community rice project. There was simply not enough for any other purpose. The colonel ended his speech on a positive note saying they were to continue making their own gardens and then the project's rice, and cash from its sale, could be considered a luxury with which they could purchase soap and bicycles.

As a result of the meeting with this colonel, most of the Indians did go ahead and make gardens in 1981. They seemed to have abandoned, at least for the time being, the idea of employing industrial agriculture techniques in household crop production. However, the fact that the three men most closely allied with the project did not make gardens in 1981 constitutes an ominous foreshadowing of what may be in store for the entire village. These men claimed that they had no time for making gardens and that, as a result, their share of the rice produced in the cerrado plot would be greater than the others. The disagreements and complaints which followed their announcement triggered an entire round of political infighting in the village, and eventually led to two of the men quitting the project. Those men who replaced them later claimed that their families became sick as a result of the witchcraft spells that the initial project participants put on them out of jealousy. Another round of infighting ensued.

The Costs of Adopting the Industrial Agriculture System

This leads us directly to a discussion of the costs associated with adopting the industrialized agricultural technology. Political infighting is definitely a real problem with which the Bakairi will have to cope. Who drives the tractor, who works on the equipment team, who assists in the clearing, planting, and harvesting phases of production, and who receives what kind of payment for their labor are all questions which deeply concern each household in the village. If men from one faction gain control of the tractor, the opposing faction reacts with witchcraft and violent altercations. If some people work harder than others in harvesting the rice, angry gossip is generated against the latter group. If one man receives a sack of rice for driving the tractor for a month, every other household wants equal payment claiming they are at least as deserving as he is. Examples of this sort could be listed indefinitely. However, it is clear even at this point that a great deal of turmoil lies ahead for the Bakairi. Whether they can unite in order to make this project work is an open and delicate question.

A second set of problems closely related to the above discussion concerns the distribution of rice and money from the sale of the crop. How will they be distributed? Before the rice seed was even planted in the _cerrado_, the Indians distributed a certain percentage of it in the village against the expressed orders of the Indian Foundation. It is safe to assume that the cash will be partially distributed in the village prior to the purchase of supplies such as fertilizer and diesel fuel for the following year's production season. Emergencies will come up, friends of those in control of the rice and cash will request favors, etc. Accusations of theft will result and probably an unequal distribution of the wealth derived from the project will also occur. This may affect the ultimate outcome of the project. If there is not enough fertilizer, crop yields will decline. If there is not enough fuel, the amount of land under production will drop. However, even more important is how the unequal distribution of the products of the project will affect the functioning of the village. In the long run, it may lead to concentration of wealth in the hands of certain factions. These people will probably never be able to control the means of production in the form of land and water. However, the accumulation of capital will certainly affect their social and political status and will also enable them to purchase labor, which will, in turn, allow for further concentration of wealth in their hands.

This is not as farfetched as it may seem to those who have worked with Brazilian indigenous groups. This situation already exists to a certain extent in the Bakairi village today. For example, the Bakairi nurse's aide earns a good salary. She also has a nephew whom she raised and who is old enough to make and care for a garden. However, sometimes he does not feel like working and in order to weed their manioc garden or complete a rice harvest, she pays a man in the village to attend to these tasks. This man works for about Cr$100/day, which is an extremely low wage even by ranchers' standards. However, he gains a bit of cash to buy a razor or candy, and her household continues to harvest the products of an entire garden with very little cash or energy output. In addition, the nurse's aide retains most of her salary with which she can do what she wants as most of her food requirements are met by her crop harvests.

Differentiation of wealth already exists in incipient form at P.I. Bakairi. As the project gains momentum, we can expect to see even more of an unequal distribution of capital in the village. Initially, cultural leveling mechanisms will act to limit the extent to which this maldistribution evolves. For example, the flow of goods within the kinship network is one way in which redistribution currently occurs in the Bakairi reservation. Those members of the family who are wealthier or who have better or larger harvests are expected to share everything that they have with their kin. Thus, goods which cluster at certain points in any one kinship network eventually flow away from that point towards other individuals who have less.

On a higher level of social integration, families bond together to form political factions. Within these factions, favors are exchanged in the form of labor, support, or trading. If wealth is concentrated in one extended family within the faction, other families in this same faction are able to tap the former's wealth in return for a political or economic pay-off. This is a frequent occurrence among the Bakairi. A good example would be the ex-capitão and one of the older capitaẽs, who have joined forces to oust the current capitão. These two families are very distantly related; however, they eat in each other's houses, share each other's belongings, and help each other in the gardens. In spite of the fact that the younger ex-capitão is wealthier in terms of food harvests and cash income from working on nearby ranches on a regular basis, he gladly divides everything he owns equally with the other man's family. This redistribution is the result of the ex-capitão's need for the older man's support in the village's political arena. The older man is highly respected by the people for his wisdom and his ability to participate in the mask dance. He knows all the songs of each of the masks and is the most admired of all the dancers. The exchange between these two men may seem uneven to the outsider; however, to the Bakairi it is equitable.

Concentrated wealth is also dispersed on the village level at P.I. Bakairi. This is accomplished through ritual. During the season in which the masks dance, men don masks which disguise their identities and visit the village's households three times a day in order to collect food and drink. They carry this food back to the men's house where they eat and drink their fill and then send the remainder of what they took to their own houses. What this in effect accomplishes is to gather together all the surplus food in the village for the day and redistribute it, evenly, to all the houses. That way, if someone was lucky enough to catch a great deal of fish that day, it will be divided and circulated so everyone in the village has a part of the catch. If one family expended time and energy harvesting and processing manioc, the fruits of the labor will be distributed.

In addition to the traditional Bakairi rituals, the Indians also participate in no less than six Brazilian festivals which they have adopted and tailored to their own specifications. These festivals, or religious holidays by Brazilian definition, are perceived by the Indians as a time during which they can dance, sing, eat, take lovers they normally would not have, get drunk, and, most important, redistribute concentrated wealth which exists in the village. The festival of Judas held around Easter in April is an obvious example. A group of men go from household to household carrying an effigy of Judas. In front of each house they sing a song about how Judas is lost and hungry and can someone spare him some food. Every household donates what it can in the form of rice, fish, oil, manioc, or sweets. When the entire village has been canvassed, the women gather together and prepare a large meal which everyone eats. What is particularly interesting about this festival is that during the entire period, wanton thievery is condoned. Anyone can steal anything and if they are discovered, they do not have to return the goods they took. Although everyone tries to hide, or at least fasten down, what they own during "Judas night," many items exchange hands.

Another example is the festival of Saint Benedict. This festival, which lasts for several days and nights, is sponsored by one family. Each year the responsibility of organizing and financing this festival is transferred to another household. However, the number of potential sponsors is limited to those who either have regular cash incomes (the Foundation employees, for example) or to those families which have a large number of grown children who can all contribute to financing the festival. Being a sponsor requires that a family assume many responsibilities. First, if the house of the sponsor is not large enough, the household head and his kinsmen must build an open structure where everyone can gather and dance. Firecrackers, coffee, sugar, sweets, and traditional foods must all be purchased, borrowed, or harvested, and then prepared for consumption. Two breakfasts, two lunches, and two dinners, in addition to coffee with a lot of sugar, are prepared for the entire community. Labor for oganizing this effort is drawn from the kinsmen of the sponsoring household. Manioc and rice are taken from their gardens. Money to purchase the firecrackers, sugar, and coffee is raised through the efforts of the male kinsmen. If they do not receive a regular salary or stipend from Funrural, then they have to leave the reservation and work on a nearby ranch until they earn the cash. Or they have the option of selling or trading a gun, a bicycle, or any other valuable possession for the necessary goods.

The time, effort, and money expended in sponsoring a festival is considered to be enormous. The Bakairi schoolteacher and Foundation representative are extremely critical of the tradition, claiming that the population is wasting its money and time on an ostentatious and short-lived display. They point out that these festivals are Brazilian by nature, and that the indigenous population does not even understand what the holidays commemorate. They interpret the Bakairi's adoption, and adaptation, of these festivals as just one more example of how Indians will find any excuse to get drunk.

What is more likely is that the celebration of these festivals is the direct result of the entrance of cash into this society. The Bakairi have not been in contact yet for a full century. Work on nearby ranches began even more recently. Funrural payments and Foundation salaries have complicated the economic situation in the village even further. Now, the agricultural project will create even greater discrepancies of wealth in this egalitarian soicety. In order to minimize these discrepancies and avoid the conflicts that accompany an unequal distribution of wealth, these festivals will grow in importance. They act to maintain the redistributive and reciprocal links that are so essential to the functioning of the Bakairi society.

One last cost associated with adopting the mechanized agriculture system should be mentioned. As the Bakairi become increasingly involved in the production of rice for sale on the national market, a dependency relation between the Indians and the national society will develop. This dependency will be different from anything they have previously known. For the first time in their history, they will rely on the non-Indian in order to produce food. At first this dependence will be partial because they will be able to continue crop cultivation in their own forest gardens. However, as the population increases and the calories and cash derived from the _cerrado_ rice fields grow more important to the survival of the group, the overall contribution of the forest gardens to subsistence will dwindle. As a result, inflation and fluctuations in the price of rice, fuel, and fertilizers will impact on the Bakairi in a way they have not yet experienced. At this time, if the price of candy or soap is too high, the Indians have the option of not purchasing the product. In the future, if the price of fuel or fertilizer becomes intolerable, they will have to raise the money somehow in order to continue production.

The benefits of participation in the industrial agriculture project are numerous and essential to the growth of the Bakairi population. However, the costs of adopting this system are equally as high.

The loss of autonomy, an increasingly marked maldistribution of wealth in the village, and the resultant infighting and conflict are all penalties which will be paid by the Indians. It has been said that upon adoption of the industrial agriculture project, the Bakairi as a people will cease to exist. That is, participation in the project will necessarily transform them into rural Brazilians. This is a real possibility. However, the other alternative is to allow the Indians to outgrow the means of production on their reservation, and as a result, either confront starvation, activate more stringent population control mechanisms, or migrate to the cities where they will live in ghettos. It seems that the Bakairi themselves have made their choice.

The data and the results of the simulations compiled in this dissertation are organized in such a way that they can be employed by the Brazilian Indian Foundation in order to develop policy, which results in those kinds of projects described here, and to evaluate the impact of these programs on the target population. Information about traditional indigenous subsistence patterns and industrial agriculture have been included. The ecological anthropology paradigm as put forth by Vayda (1976) has been used in an effort to comprehend those events which are currently taking place in the Bakairi reservation. The application of this theoretical construct to the problem addressed in this thesis has yielded fruitful results. Approaching those questions posed in Chapter 1 in a systemic manner, while stressing the industrial agriculture project as a perturbation within the Bakairi ecosystem has allowed for a more realistic assessment of what is occurring as well as an evaluation of what problems lie in store for the Bakairi.

APPENDIX
DYNAMO EQUATIONS FOR THE BAKAIRI RESERVATION MODEL

```
L S.K=S.J+DT*(R5.JK-R6.JK-R7.JK-R8.JK-R50.JK)
N S=SI
C SI=7.23E+12
A W2.K=(J1*S.K)/((K71.K*S.K)+1)
A W2I.K=(J1*SI)/((K71.K*SI)+1)
A K71.K=1.41E+14/(4.21E+14*SI)
R R5.KL=K5.K*W2.K
A K5.K=F5/W21.K
R R6.KL=K6.K*W2.K
A K6.K=F6/W21.K
C J1=5.62E+14
A W3.K=S.K*D.K
A W3I.K=SI*DI
R R7.KL=K7.K*S.K
A K7.K=F7/SI
R R8.KL=K8.K*W3.K
A K8.K=F8/W3I.K
L Q3.K=Q3.J+DT*(R51.JK-R52.JK-R53.JK-R53A.JK-R54.JK)
N Q3=Q31
C Q31=2.125E+9
A W4.K=S.K*Q3.K*P.K
A W4I.K=SI*Q3I*PI
A W5.K=Q3.K*P.K
A W5I.K=Q3I*PI
R R50.KL=K50.K*W4.K
A K50.K=1.89E+9/W4I.K
R R51.KL=K51.K*W4.K
A K51.K=9.6411E+8/W4I.K
R R52.KL=K52.K*W4.K
A K52.K=4.775E+8/W4I.K
```

```
R R53.KL=K53.K*Q3.K
A K53.K=2.388E+8/Q3I
R R53A.KL=K53A.K*Q3.K*Q3.K
A K53A.K=2.388E+8/(Q3I*Q3I)
R R54.KL=K54.K*W5.K
A K54.K=9.01E+6/W5I.K
R R55.KL=K55.K*W5.K
A K55.K=1.76E+6/W5I.K
R R56.KL=K56.K*W4.K+K56A.K*W5.K
A K56.K=3.60E+5/W4I.K
A K56A.K=1.40E+6/W5I.K
L D.K=D.J+DT*(R13.JK-R14.JK-R15.JK-R16.JK-R15A.JK)
N D=DI
C DI=1.89E+10
R R13.KL=K13.K*W3.K
A K13.K=F13/W3I.K
R R14.KL=K14.K*W3.K
A K14.K=F14/W3I.K
R R15.KL=K15.K*D.K
A K15.K=F15/DI
R R15A.KL=K15A.K*D.K*D.K
A K15A.K=8.15E+10/(DI*DI)
R R16.KL=K16.K*Y.K
A K16.K=F16/YI.K
C F5=4.35E+12
C F6=1.37E+12
C F7=1.37E+12
C F8=1.609E+12
C F14=1.63E+11
C F13=3.622E+11
C F15=8.15E+10
C F16=3.62E+10
L B.K=B.J+DT(R17.JK-R18.JK-R19.JK-R20.JK)
N B=BI
C BI=4.11E+8
```

```
A V3.K=(J2*B.K)/((K72.K*B.K)+1)
A V31.K=(J2*BI)/((K72.K*BI)+1)
R R17.KL=K17.K*V3.K
A K72.K=1.65E+12/(4.95E+12*BI)
A K17.K=F17/V3I.K
C F17=1.44E+10
C J2=6.60E+12
R R18.KL=K18.K*V3.K
A K18.K=F18/V3I.K
C F18=3.09E+9
R R19.KL=K19.K*B.K
A K19.K=3.09E+9/BI
R R20.KL=K20.K*V2.K
A K20.K=F20/V2I.K
C F20=3.22E+9
L Q.K=Q.J*DT*(R22.JK-R23.JK-R24.JK-R25.JK-R24A.JK)
N Q=QI
C QI=1.42E+9
R R22.KL=K22.K*V2.K
A K22.K=F22/V2I.K
C F22=2.2724E+9
R R23.KL=K23.K*V2.K
A K23.K=F23/V2I.K
C F23=1.10E+9
R R24.KL=K24.K*Q.K
A K24.K=F24/QI
C F24=5.5E+8
R R24A.KL=K24A.K*Q.K*Q.K
A K24A.K=5.5E+8/(QI*QI)
R R25.KL=K25.K*V.K
A K25.K=F25/VI.K
C F25=7.24E+7
A V2.K=B.K*Q.K
A V2I.K=BI*QI
L P.K=P.J+DT*(R42.JK-R35.JK-R37.JK-R34.JK-R38.JK-R56.JK-R40.JK-R41.JK)
N P=PI
```

```
C PI=2.47E+7
L H.K=H.J+DT*(R36.JK+R44.JK+R45.JK+R46.JK+R55.JK-R47.JK-R43.JK)
N H=HI
C HI=4.234E+8
A X.K=P.K*H.K
A XI.K=PI*HI
A X2.K=P.K*Q2.K
A X2I.K=PI*Q2I
A U2.K=P.K*M.K
A U2I.K=PI*MI
A Y.K=P.K*D.K
A YI.K=PI*DI
A V.K=P.K*Q.K
A VI.K=PI*QI
R R42.KL=K42.K*X.K
A K42.K=2.02282E+8/XI.K
R R35.KL=K35.K*X2.K
A K35.K=3.92E+6/X2I.K
R R37.KL=K37.K*V.K
A K37.K=2.18E+6/VI.K
R R34.KL=K34.K*Y2.K
A K34.K=1.10E+7/Y2I.K
R R38.KL=K38.K*U2.K+K39.K*Y.K
A K38.K=9.82E+5/U2I.K
A K39.K=1.44E+6/YI.K
R R40.KL=K40.K*X.K
A K40.K=1.20E+8/XI.K
R R41.KL=K41.K*P.K+K41A.K*P.K*P.K
A K41.K=3.05E+7/PI
A K41A.K=3.05E+7/(PI*PI)
R R36.KL=K36.K*X2.K
A K36.K=6.11E+8/X2I.K
R R44.KL=K44.K*U2.K
A K44.K=4.35E+6/U2I.K
R R45.KL=K45.K*Y.K
```

```
A K45.K=7.15E+6/YI.K
R R46.KL=K46.K*V.K
A K46.K=1.52E+7/VI.K
R R47.KL=K47.K*H.K
A K47.K=2.157E+8/HI
R R43.KL=K43.K*X.K
A K43.K=4.2376E+8/XI.K
L G.K=G.J+DT*(RI.JK+R27.JK-R2.JK-R3.JK-R4.JK-R29.JK)
N G=GI
C GI=1.32E+13
L Q2.K=Q2.J+DT*(R30.JK+R48.JK-R31.JK-R32.JK-R33.JK-R26.JK-R32A.JK)
N Q2=Q2I
C Q2I=1.89E+9
L O.K=O.J+DT*(R26.JK-R27.JK-R28.JK)
N O=OI
C OI=7.08E+10
A Y2.K=P.K*G.K
A Y2I.K=PI*GI
R R48.KL=K48.K*Y2.K
A K48.K=9.33E+9/Y2I.K
A W.K=(JO*G.K)/((K70.K*G.K)+1)
A WI.K=(JO*GI)/((K70.K*GI)+1)
A K70.K=2.21E+13/(GI*6.61E+13)
C JO=8.82E+13
A Z.K=(J3*Q2.K)/((K73.K*Q2.K)+1)
A ZI.K=(J3*Q2I)/((K73.K*Q2I)+1)
A K73.K=1.48E+11/(Q2I*4.43E+11)
C J3=5.91E+11
R R30.KL=K30.K*Z.K
A K30.K=1.51E+9/ZI.K
R R31.KL=K31.K*Z.K
A K31.K=4.25E+8/ZI.K
R R32.KL=K32.K*Q2.K
A K32.K=2.125E+8/Q2I
R R32A.KL=K32A.K*Q2.K*Q2.K
```

```
A K32A.K=2.125E+8/(Q2I*Q2I)
R R33.KL=K33.K*X2.K
A K33.K=1.23E+9/X2I.K
R R26.KL=K26.K*Q2.K*O.K
A K26.K=8.76E+9/(Q2I*OI)
R R27.KL=K27.K*O.K*G.K
A K27.K=8.44E+9/(OI*GI)
R R28.KL=K28.K*O.K
A K28.K=3.20E+8/OI
R R1.KL=K1.K*W.K
A K1.K=2.57466E+12/WI.K
R R2.KL=K2.K*W.K
A K2.K=9.52E+11/WI.K
R R3.KL=K3.K*G.K
A K3.K=9.52E+11/GI
R R4.KL=K4.K*U.K
A K4.K=6.35E+11/UI.K
R R29KL=K29.K*Y2.K
A K29.K=4.41E+10/Y21.K
L M.K=M.J+DT*(R9.JK-R10.JK-R11.JK-R12.JK-R11A.JK)
N M=MI
C MI=5.07E+8
A U.K=G.K*M.K
A UI.K=GI*MI
R R9.KL=K9.K*U.K
A K9.K=9.70E+9/UI.K
R R10.KL=K10.K*U.K
A K10.K=3.81E+9/UI.K
R R11.KL=K11.K*M.K
A K11.K=2.215E+9/MI
R R11A.KL=K11A.K*M.K*M.K
A K11A.K=2.215E+9/(MI*MI)
R R12.KL=K12.K*U2.K
A K12.K=1.46E+9/U2I.K
PRINT B,S,G,O,Q2,M,D,Q,H,P,Q3
```

```
PLOT B=B(0,7.00E+8)/S=S(0,2.00E+13)/D=D(0,1.89E+10)/Q=1(0,1.42E+9)
PLOT G=G(0,2.20E+13)/O=O(0,2.21E+11)/Q2=2(0,7.82E+9)/P=P(0,3.17E+8)
PLOT M=M(0,5.07E+8)/H=H(0,2.35E+9)
PLOT S=S(0,2.00E+13)/D=D(0,1.89E+10)/Q3=3(0,*)/P=P(0,3.17E+8)
SPEC DT=.01/LENGTH=50/PRTPER=1/PLTPER=1
RUN
```

REFERENCES CITED

Alland, A.
1969 Ecology and Adaptation to Parasitic Diseases. In Environment and Cultural Behavior. A. Vayda, ed. pp. 80-89. Garden City, N.Y.: Natural History.

1970 Adaptation in Cultural Evolution: An Approach to Medical Anthropology. New York: Columbia University.

Baker, P., and M. Little
1976 Man in the Andes: A Multi-Disciplinary Study of High-Altitude Quechua. Stroudsburg, Pa.: Dowden, Hutchinson and Ross. US/IBP Synthesis Series, No. 1

Barros, E. P.
1977 Kura Bakairi/Kura Karaiwa: dois mundos em confronto. Master's Thesis, Anthropology Department, University of Brasilia.

Batista Filho, R.
1976 Prevalencia e estagios da desnutriçao proteico-calorica em crianças de cidade de São Paulo. Master's Thesis, Public Health Department, University of São Paulo.

Beard, J. S.
1949 Brazilian Campo Cerrado: Fire Climax or Edaphic Climax. Geographic Record 39:664-666.

Beckerman, S.
1979 The Abundance of Protein in Amazonia: A Reply to Gross. American Anthropologist 81:533-560.

1980. More on Amazon Cultural Ecology. Current Anthropology 21: 540-541.

Bezerra dos Santos, L.
1977 Vegetação. In Geografia do Brasil: Região Centro-Oeste, Vol. 4. M. V. Galvão, gen. ed. pp. 59-84. Rio de Janeiro: Diretoria de Divulgação.

Black, J. N.
1971 Energy Relations in Crop Production: A Preliminary Survey. Ann. Applied Biology 67:272-278.

Boserup, E.
1965 The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure. Chicago: Aldine.

Bourliere, F.
1973 The Comparative Ecology of Rain Forest Mammals in Africa and Tropical America: Some Introductory Remarks. In Tropical Forest Ecosystems of Africa and South America: A Comparative Review. B. Meggers, E. Ayensu, and W. Ducksworth, eds. pp. 279-292. Washington, D.C.: Smithsonian.

Brush, S.
1975 The Concept of Carrying Capacity for Systems of Shifting Cultivation. American Anthropologist 77:799-811.

Cable, L. E.
1971 Inland Fisheries. In Our Changing Fisheries. S. Shapiro, ed. n.p. Washington, D.C.: U.S. Government Printing Office.

Campos, A. P.
1862 Breve noticias que da o capitão Antonio Pires de Campos do gentio barbaro que ha na derrota da viagem das minas do Cuyaba o seu reconcavo. Revista Trimensal do Instituto Historico, Geografico, e Etnografico do Brasil 25:437-449.

Carneiro, R. L.
1960 Slash and Burn Agriculture: A Closer Look at Its Implications for Settlement Patterns. In Men and Cultures. A. Wallace, ed. pp. 229-234. Philadelphia: University of Pennsylvania.

1968 Slash-and-Burn Cultivation among the Kuikuru and Its Implications for Cultural Development in the Amazon Basin. In Man in Adaptation: The Cultural Present. Y. Cohen, ed. pp. 131-145. Chicago: Aldine.

1970 The Transition from Hunting to Horticulture in the Amazon Basin. In Eighth Congress of Anthropological and Ethnological Sciences 3:243-251.

Casal, P. M.
1945 Corografia Brasilica. Imprensa Nacional, Vol. 1. Brazil: Ministry of Education and Health-National Institute of Books (Rare Books Collection).

Castelnau, F.
1949 Expedição as regiões centrais da America do Sul. In Brasiliana, serie 5, Vol. 266-A-Tomo II. São Paulo: Companhia Editora Nacional

Chagnon, N. A., and R. B. Hames
1979 Protein Deficiency and Tribal Warfare in Amazonia: New Data. Science 203(4383):910-912.

Clarke, W.
1976 Maintenance of Agricultural and Human Habitats within the Tropical Forest Ecosystem. Human Ecology 4(3):247-259.

Consolazio, C. F., R. E. Johnson, and L. J. Pecora
1963 Physiological Measurements of Metabolic Functions in Man. New York: McGraw-Hill.

Coudreau, H.
n.d. Viagem ao Tapajos (28 de julho de 1895 a 7 de janeiro de 1896). In Coleção Brasiliana, Serie 5-Vol. 208. São Paulo: Companhia Editora Nacional.

Cowgill, G. L.
1975 On Causes and Consequences of Ancient and Modern Population Changes. American Anthropologist 77:505-525.

Davis, S.
1977 Victims of the Miracle. New York: Cambridge University.

Denevan, W. M.
1966 The Cultural-Ecological View of Former Aboriginal Settlement in the Amazon Basin. The Professional Geographer 18:346-351.

Dickeman, M.
1975 Demographic Consequences of Infanticide in Man. In Annual Review of Ecology and Systematics, Vol. 6. R. E. Johnston, P. W. Frank, and C. D. Michener, eds. pp. 107-137. Palo Alto, Cal.: Annual Reviews.

Diener, P., K. Moore, and R. Mutaw
1980 Meat, Markets, and Mechanical Materialism: The Great Protein Fiasco in Anthropology. Dialectical Anthropology 5:171-192.

Divale, W., and M. Harris
1976 Population, Warfare and the Male Supremacist Complex. American Anthropologist 78:521-538.

Durnin, J. V., and R. T. Passmore
1967 Energy, Work and Leisure. London: Heineman and Educational Books.

Dyke, B.
1981 Computer Simulation in Anthropology. In Annual Review of Anthropology, Vol. 10. B. J. Siegel, A. R. Beals, and S. A. Tyler, eds. pp. 193-207. Palo Alto, Cal.: Annual Reviews.

Eisenberg, F., and R. Thorington, Jr.
1973 A Preliminary Analysis of Neotropical Mammal Fauna. Biotropica 5(3):150-161.

Emmel, T.
1973 An Introduction to Ecology and Population Biology. New York: W. W. Norton.

Eveleth, P. B., and J. M. Tanner
1976 Worldwide Variation in Human Growth. London: Cambridge University.

Farnsworth, E. G., and F. B. Golley, eds.
1974 Fragile Ecosystems: Evaluation of Research and Application in the Neotropics. New York: Springer-Verlag.

Fittkau, E. J.
1969 The Fauna of South America. In Biogeography and Ecology in South America. E. J. Fittkau, J. Illies, H. Klinge, and G. H. Schwabe, eds. pp. 624-658. The Hague: Dr. W. Junk N.V.

Fittkau, E. J., and H. Klinge
1973 On Biomass and Trophic Structure of the Central Amazonian Rain Forest Ecosystem. Biotropica 5(1):2-14.

Fluck, R. C., and C. D. Baird
1980 Agricultural Energetics. Westport, Conn.: Avi.

Food and Nutrition Board
1974 Recommended Dietary Allowances. Eighth Edition. Washington, D.C.: National Academy of Sciences.

Gates, D. M.
1971 The Flow of Energy in the Biosphere. In Energy and Power. Scientific American. pp. 43-52. San Francisco: W. H. Freeman.

Gilmore, R.
1950 Fauna and Ethnozoology of South America. In Handbook of South American Indians, Vol. 6. J. H. Steward, ed. pp. 345-464. Washington, D.C.: Smithsonian Institute.

Gross, D.
1975 Protein Capture and Cultural Development in the Amazon Basin. American Anthropologist 77:526-549.

n.d. Protein and Culture in Amazonia. Manuscript. Department of Anthropology. Hunter College-CUNY. New York.

Gross, D., G. Eiten, N. Flowers, F. Leoi, M. Ritter, and D. Werner
1979 Ecology and Acculturation among Native Peoples of Central Brazil. Science 206:1043-1050.

Gross, D., and B. Underwood
1971 Technological Change and Caloric Costs: Sisal Agriculture in Northeastern Brazil. American Anthropologist 73:725-740.

Guitti, J. C.
1975 Condição nutricional de crianças de zero a seis anos de idade na periferia da cidade de Londrina: Influencia de condição socioeconomica. Master's Thesis, Department of Health Sciences, London University.

Hardesty, D. L.
1977 Ecological Anthropology. New York: John Wiley.

Harris, M.
1975 Culture, People, and Nature. Second Edition. New York: Crowell.

1979a Cultural Materialism: The Struggle for a Science of Culture. New York: Random House.
1979b The Human Strategy: Our Pound of Flesh. Natural History 88(7):30-41.

Hartong, W. A., W. K. Gourley, and C. Arvanitakis
1979 Giardiasis: Clinical Spectrum and Functional-Structural Abnormalities of the Small Intestinal Mucosa. Gastroenterology 77:61-69.

Hickling, C. F.
1971 Fish Culture. Second Edition. London: Faber and Faber.

1975 Water as a Productive Environment. New York: St. Martin.

Holling, C. S.
1973 Resilience and Stability of Ecological Systems. Annual Review of Ecology and Systematics, Vol. 4. R. E. Johnston, P. W. Frank, and C. D. Michener, eds. pp. 1-23. Palo Alto, Cal.: Annual Reviews.

Hubert, J., D. Kerboeuf, and L. Gruner
1979 Study of Gastro-intestinal Strongylosis in a Sheep Flock on Permanent Pasture. Ann. Rech. Vet. 10(4):503-518.

Hynes, H. B. N.
1970 The Ecology of Running Waters. Toronto: University of Toronto.

Janick, J., C. Noller, and C. Rhykerd
1976 The Cycles of Plant and Animal Nutrition. Scientific American 235:75-86.

Jelliffe, D. B.
1966 The Assessment of the Nutritional Status of a Community. Geneva: World Health Organization.

Jin Soon, J., W. I. Hwang, T. G. Rya and S. H. Oh
1980 Report. Symposium on Protein and Energy Requirements. Cambridge, Mass.: United Nations University. May 19-23, 1980.

Johnson, Allen
1974 Carrying-Capacity in Amazonia: Problems in Theory and Method. Paper Read at the 73rd Annual Meeting of the American Anthropological Association, Mexico City, 1974.

Karr, J. R.
1975 Production, Energy Pathways, and Community Diversity in Forest Birds. In Tropical Ecological Systems: Trends in Terrestrial and Aquatic Research. F. B. Golley and E. Medina, eds. pp. 161-176. New York: Springer-Verlag.

Kay, R., B. L. Barnes, and R. R. Townley
1977 Giardia lamblia infestation in 154 children. Austr. Paediatr. Jour. 13:98-104.

Kiltie, R. A.
1980 More on Amazon Cultural Ecology. Current Anthropology 21: 541-544.

Lamotte, M.
1975 The Structure and Function of a Tropical Savannah Ecosystem. In Tropical Ecological Systems: Trends in Terrestrial and Aquatic Research. F. B. Golley and E. Medina, eds. pp. 179-222. New York: Springer-Verlag.

Lathrap, D.
1968 The "Hunting" Economies of the Tropical Forest Zone of South America: An Attempt at Historical Perspective. In Man the Hunter. R. B. Lee and I. DeVore, eds. pp. 23-29. Hawthorne, N.Y.: Aldine.

Leach, G.
1976 Energy and Food Production. Surrey, England: I.P.C. Science and Technology.

Leung, W. T. W.
1961 Food Composition Tables for Use in Latin America. Bethesda: National Institute of Health and the Institute of Nutrition of Central America and Panama.

Leverger, A.
1862 Observações sobre a carta de provincia de Mato Grosso. Revista Trimestral do Instituto Historico. Rio de Janeiro. Vol. 25:246.

Levi-Strauss, C.
1950 The Tribes of the Upper Xingu River. In Handbook of South American Indians, Vol. 8. J. Steward, ed. pp. 321-348. Washington, D.C.: Smithsonian Institute.

Little, M., and G. Morren
1976 Ecology, Energetics, and Human Variability. Dubuque, Iowa: Brown.

Lizot, J.
1977 Population, Resources, and Warfare among the Yanomami. S. Hoelgaard, transl. Man 12:497-517.

Moran, E.
1979 Human Adaptability: An Introduction to Ecological Anthropology. North Scituate, Mass.: Duxbury.

Morren, G.
1974 Settlement Strategies and Hunting in a New Guinea Society. Ph.D. dissertation, Department of Anthropology, Columbia University.

Murphy, P. G.
1975 Net Primary Productivity in Tropical Terrestrial Ecosystems. In Primary Productivity of the Biosphere. H. Lieth and R. Whittaker, eds. pp. 217-231. New York: Springer-Verlag.

Neto, U. F.
1977 Avaliação do estado nutricional das crianças indias do Alto-Xingu. Ph.D. dissertation, Department of Pediatrics, São Paulo School of Medicine.

Nietschmann, B.
1972 Hunting and Fishing Focus among the Miskito Indians, Eastern Nicaragua. Human Ecology 1(1):41-67.

Nimer, E.
1977 Clima. In Geografia do Brasil: Região Centro-Oeste, Vol. 4. M. V. Galvão, gen. ed. pp. 35-58. Rio de Janeiro: Diretoria de Divulgação.

Norman, M. J.
1978 Energy Inputs and Outputs of Subsistence Cropping Systems in the Tropics. Agro-Ecosystems 4(3):355-366.

Odum, E. P.
1969 The Strategy of Ecosystem Developement. Science 164:262-270.

1975 Ecology. Second Edition. New York: Holt, Rinehart, and Winston.

Odum, H. T.
1970 A Tropical Rainforest. Washington, D.C.: Division of Technical Information-U.S. Atomic Energy Commission.

1971 Environment, Power, and Society. New York: Wiley-Interscience.

Odum, H. T., and E. C. Odum
1981 Energy Basis for Man and Nature. Second Edition. New York: McGraw-Hill.

Olrog, C. C.
1969 Birds of South America. In Biogeography and Ecology in South America. E. J. Fittkau, J. Illies, H. Klinge, G. H. Schwabe, and H. Sioli, eds. pp. 849-878. The Hague: Dr. W. Junk N.V.

Passmore, R., and J. V. G. A. Durnin
1955 Human Energy Expenditure. Physiology Review 35:801.

Patrick, R.
1964 A Discussion of the Results of the Catherwood Expedition to the Peruvian Headwaters of the Amazon. Verh. int. Verein. theor. angew. Limnol. 15:1085-1090.

Petrullo, V. M.
1932 Primitive Peoples of Matto Grosso, Brazil. The Philadelphia Museum Journal 23(2):83-173.

Pugh, A. L.
1976 Dynamo User's Manual. Fifth Edition. Cambridge: M.I.T.

Pyke, M.
1970 Man and Food. New York: McGraw-Hill.

Rappaport, R.
1968 Pigs for the Ancestors: Ritual in the Ecology of a New Guinea People. New Haven: Yale University.

Reid, G. K., and R. D. Wood
1976 Ecology of Inland Waters and Estuaries. New York: D. Van Nostrand.

Ribeiro, D.
1967 Indigenous Cultures and Languages of Brazil. In Indians of Brazil in the Twentieth Century. J. Hopper, ed. pp. 77-165. Washington, D.C.: Institute for Cross-Cultural Research.

Richerson, P. J.
1977 Ecology and Human Ecology: A Comparison of Theories in the Biological and Social Sciences. American Ethnologist 4(1):1-26.

Roosevelt, A. C.
1980 Parmana: Prehistorical Maize and Manioc Subsistence along the Amazon and Orinoco. New York: Academic Press Studies in Archaeology.

Ross, E. B.
1978 Food Taboo, Diet, and Hunting Strategy: The Adaptation to Animals in Amazon Cultural Ecology. Current Anthropology 19(1): 1-36.

Sahlins, M.
1972 Stone Age Economics. Chicago: Aldine.

Schmidt, M.
1947 Os Bakairi. Revista do Museu Paulista, n.s. 1:11-58.

Schneider, R. E., B. Torun, M. Shiffman, C. Anderson, and R. Helms
1980 Report. Symposium on Protein and Energy Requirements. Cambridge, Mass.: United Nations University. May 19-23, 1980.

Schwerin, K. H.
1970 Apuntes sobre la yuca y sus origenes. Boletin Informativo de Antropologia 7:23-27.

Scrimshaw, S. C. M.
1978 Infant Mortality and Behavior in the Regulation of Family Size. Population and Development Review 4(3):383-403.

Sellers, W. D.
1965 Physical Climatology. Chicago: University of Chicago.

Sioli, H.
1975 Tropical Rivers as Expressions of Their Terrestrial Environments. In Tropical Ecological Systems: Trends in Terrestrial and Aquatic Research. F. B. Golley and E. Medina, eds. pp. 275-288. New York: Springer-Verlag.

Siskind, J.
1973 To Hunt in the Morning. New York: Oxford University Press.

Slobodkin, L. B.
1968 Toward a Predictive Theory of Evolution. In Population Biology and Evolution. R. C. Lewontin, ed. pp. 187-205. Syracuse: Syracuse University Press.

Smole, W.
1979 The Yanoamo Indians: A Cultural Geography. Austin: University of Texas.

Solomons, N., and K. Keusch
1981 Nutritional Implications of Parasitic Infections. Nutrition Reviews 39(4):149-161.

Stini, W.
1971 Evolutionary Implications of Changing Nutritional Patterns in Human Populations. American Anthropologist 73:1019-1030.

Street, J.
1969 An Evaluation of the Concept of Carrying Capacity. The Profesional Geographer 21:104-107.

Vayda, A.
1976 On the "New Ecology" Paradigm. American Anthropologist 78: 645-646.

Vayda, A., and B. McCay
1975 New Directions in Ecology and Ecological Anthropology. In Annual Review of Anthropology, Vol. 4. B. J. Siegel, A. R. Beals, and S. A. Tyler, eds. pp. 293-306. Palo Alto, Cal.: Annual Reviews.

Vayda, A., and R. Rappaport
1968 Ecology, Cultural and Noncultural. In Introduction to Cultural Anthropology: Essays in the Scope and Methods of the Science of Man. J. A. Clifton, ed. pp. 477-497. Boston: Houghton Mifflin.

Vickers, W.
1976 Cultural Adaptation to Amazonian Habitats: The Siona-Secoya of Eastern Ecuador. Ph.D. dissertation, Department of Anthropology, University of Florida.

Villas Boas, O., and C. Villas Boas
1976 Xingu: Os indios, seus mitos. Fourth Edition. Rio de Janeiro: Zarar Editores.

Von den Steinen, K.
1940 Entre os aborigenes do Brasil Central. São Paulo: Departamento de Cultura.

Wagley, C.
1978 Welcome of Tears. New York: Oxford University.

Waibel, L.
1948 Vegetation and Land Use in the Planalto Central of Brazil. Geographical Review 38:529-554.

Werner, D., N. Flowers, M. Ritter, and D. Gross
1979 Subsistence Productivity and Hunting Effort in Native South America. Human Ecology 7(4):303-315.

Whittaker, R. H., and G. E. Likens
1975 The Biosphere and Man. In Primary Productivity of the Biosphere. H. Lieth and R. H. Whittaker, eds. pp. 305-329. New York: Springer-Verlag.

Whittaker, R. H., and P. Marks
1975 Methods of Assessing Terrestrial Productivity. In Primary Productivity of the Biosphere. H. Lieth and R. H. Whittaker, eds. pp. 55-117. New York: Springer-Verlag.

Wiegert, R. G.
1975 Simulation Models of Ecosystems. In Annual Review of Ecology and Systematics, Vol. 6. R. E. Johnson, P. W. Frank, and C. D. Michener, eds. pp. 311-338. Palo Alto, Cal.: Annual Reviews.

Wilson, E. D., K. Fisher, and M. E. Fuqua
1965 Principles of Nutrition. Second Edition. New York: Wiley.

World Health Organization
1974 Handbook on Human Nutritional Requirements, Vol. 61. Geneva: World Health Organization.

BIOGRAPHICAL SKETCH

I was born on March 13, 1953. I attended the State University of New York at Buffalo between 1972 and 1975, where I studied anthropology. In 1976, I came to Gainesville and began graduate studies in the Department of Anthropology at the University of Florida. Major interests include Latin America, New World aboriginal populations, and resource utilization.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Maxine Margolis, Chairperson
Associate Professor
of Anthropology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

John Alexander, Jr.
Professor of
Urban and Regional Planning

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Daniel Gross
Professor of
Anthropology
Hunter College—CUNY

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Leslie Lieberman
Associate Professor
of Anthropology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Charles Wagley
Graduate Research Professor
of Anthropology

This dissertation was submitted to the Graduate Faculty of the Department of Anthropology in the College of Liberal Arts and Sciences and to the Graduate Council, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

August 1982

Dean for Graduate Studies and Research

UNIVERSITY OF FLORIDA
3 1262 08667 032 9