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PART I

Local Peoples and Community Management

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Conceptual Basis for the Selection of Wildlife Management Strategies by the Embera People in Utría National Park, Chocó, Colombia

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The depletion of natural resources and the consequent deterioration in quality of life for humans have in recent decades generated the urgent need to rethink the relationship between human groups and nature. Conservation strategies and actions directed toward natural resource management—especially game animals—are now subjects of interest to governments, to nongovernmental organizations (NGOs), to biologists and anthropologists, and of course, to local peoples.

One frequently used tool for conservation is the creation of protected areas. These areas, however, can be a source of conflict in cases when they are superimposed on the lands of local peoples because they bring a normative structure that regulates local peoples' use of their principal economic base—natural resources such as game animals. Different game management strategies have been attempted, many of them developed by NGOs and academic scientists working jointly with local peoples. Governments have also initiated efforts to support resource management strategies, especially those forms of management that include a wide range of options and rely on methodologies that stimulate participation.

Despite these efforts, it remains a priority to understand the relationship of local people to their land and to conservation areas in order to generate long-term management strategies that are guided by an interdisciplinary and intercultural vision that in turn facilitates their implementation with local communities. Wildlife management strategies aimed at sites where protected and human-use areas overlap will only be effective if they harmonize the use and management of resources with the local inhabitants and if they include plans to recover local resources and encourage the sustainable use of species that are of cultural and ecological interest.

In Colombia there are eighteen protected areas that overlap with indigenous territories, in particular with the legal figure of indigenous reserves, or *resgurado* (in Colombia, resguardos are lands to which indigenous communities hold legal collective title). Just as in other countries, many of these conservation areas were created without taking into account the social and cultural characteristics of the people and without seeking their participation. Furthermore, in many cases local peoples have been marginalized by the areas' management system. However, the Colombian Ministry of Environment is investing considerable effort to change the situation.

Article 7 of Law 622 recognizes as a legal land category the overlap zones between national parks and indigenous reserves in Colombia, implying a mandate for joint, participatory management of these areas. This study describes a long-term effort to develop a management strategy for one such overlap zone. The project relied on the historical and cultural relationships of Embera indigenous people with their natural resources to create a strategy that is consonant with recent state level conservation goals and culturally as well as ecologically viable. Following a brief summary of the overall scope of the project, this paper focuses on the process of selecting and reaching an agreement on wildlife management strategies in the national park-indigenous reserve overlap zone. Detailed explanations of the various phases of the project and the participatory methodologies used have been published in Campos, Ulloa, and Rubio 1996; Ulloa et al. 1996; Rubio-Torgler et al. 1998; Rubio-Torgler, Ulloa, and Campos-Rozo 2000; and Campos-Rozo, Rubio-Torgler, and Ulloa 2001.

ISSUES IN RESOURCE USE AND CONSERVATION BY THE EMBERA

There are eight conservation areas in the Chocó Biogeographic Province: seven National Natural Parks and one Flora and Fauna Sanctuary. The 53,200-ha Utría National Natural Park (UNNP) was created in 1987. Eighty-five percent of its land surface area overlaps with three Embera Indigenous Reserves, and this overlap zone supports four communities with a joint population of 600 people (fig. 2.1).

This project arose out of certain conditions existing in the overlap zone: (a) the interaction between two conceptualizations of wildlife management, that of the Embera and that of the national society, which are based on different logics and ways of thinking; (b) the implications of state and local politics and projects related to land and resource management; (c) the process of interaction with other societies in which the Embera communities are immersed, and (d) a reduction in game populations in general and of large primates in particular (howler monkeys, *Alouatta palliata*, and spider monkeys, *Ateles fuscipes*); the extinction of the tapir (*Tapirus bairdii*); and the near-disappearance of the white-lipped peccary (*Tayassu pecari*). The latter two species are of great symbolic, dietary, and ecological importance for the Embera.

These conditions stimulated the search for commonalities to be used in the joint management of the overlap area, generating an intercultural, consensus-building process that combined Embera and Western approaches to wildlife management,

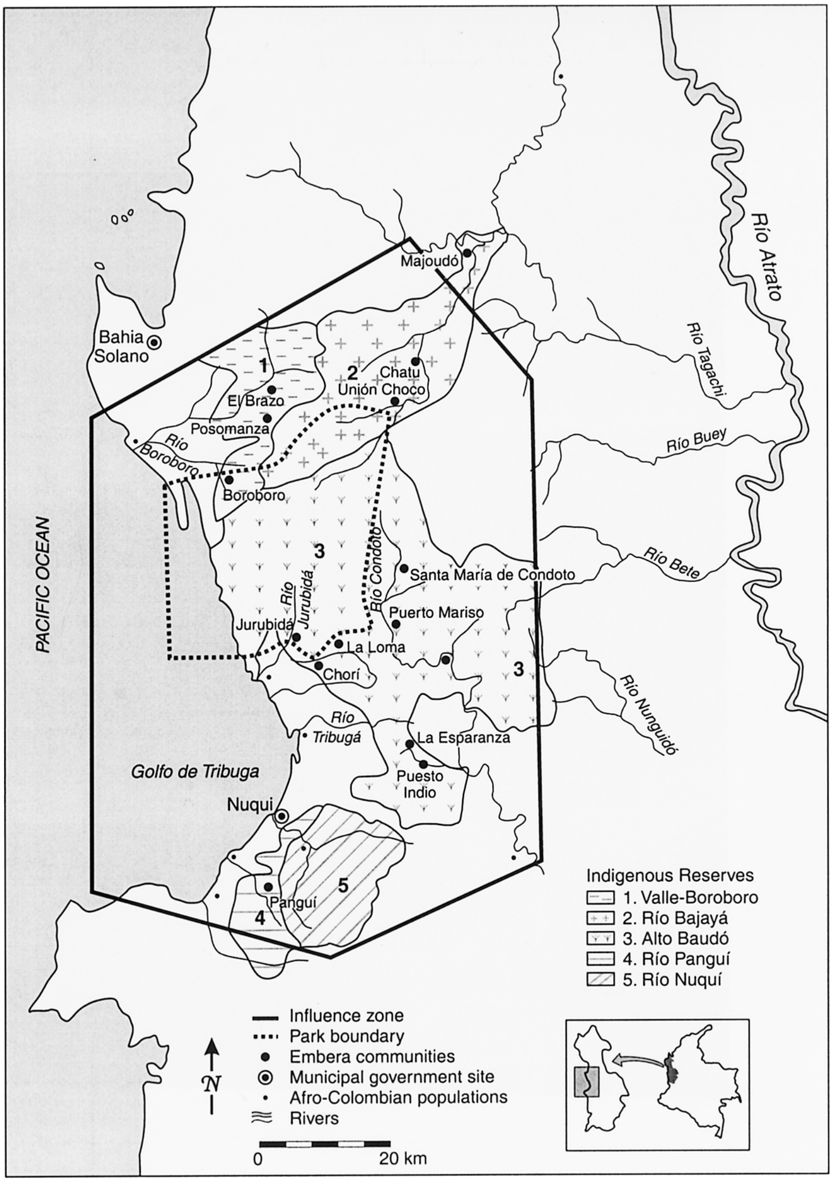

FIGURE 2.1 Location of Utría National Park (small polygon), the indigenous reserves (resguardos), numbered 1 through 5, and the Embera communities falling within the park's influence zone (large polygon).

and their visions of the relationship between humans and nature, in order to arrive at a site-specific intercultural and interdisciplinary management strategy. This effort arose as a social decision rather than as a state imposition and relied on the participation of members of sixteen communities, indigenous researchers, the indigenous organization OREWA (Embera Wounan Regional Organization), a state institution (UAESPNN, in the Ministry of the Environment), an NGO (Fundación Natura-Colombia), and several organizations that provided technical support (Colombian Institute for Anthropology and History-ICANH) and funding (The Wildlife Conservation Society, Conservation Food and Health, and the Organization of Ibero-American States). This was one of the first formal attempts in Colombia to arrive at joint wildlife management between an indigenous organization, an NGO, and a governmental institution for a park-reserve overlap area. The objectives were

1. to improve the relationship between the state and local peoples,
2. to increase the level of participation of local peoples and the OREWA in the management of the area, taking into account their social processes and cultural practices,
3. to counteract the scarcity of game caused by the impact of recent hunting practices and by the hunting of species with small, at-risk populations or of species vulnerable to anthropic processes, given that a severe impact on wildlife in the area would both reduce the quality of life of the indigenous population and alter ecological processes,
4. to rescue or give voice to the Embera's interests and proposals for wildlife management by linking them to those of the national society,
5. to have an impact on wildlife management policies in national parks and indigenous reserves in Colombia in general.

THE EMBERA

The Embera live in rain forest territories where they maintain symbolic, productive and social exchanges with other Embera communities, with other worlds for which they conceive the existence of different beings, and with other cultures. The Embera have traditionally settled in river headwaters in accordance with family linkages and today are concentrated in villages. Currently 70,000 Embera people are distributed primarily in the upper and middle headwaters of the many rivers that drain to the Colombian Pacific or along the Atrato River in the Chocó, Cauca, and Valle Departments. Some Embera also live in Córdoba and in the mountainous and foothill regions of the Cordillera Occidental in Antioquia, Caldas, Risaralda, and Caquetá. Embera economy is currently based on hunting, fishing, gathering, diversified agricultural production, and husbandry of small domestic species. The Embera also market a small agricultural surplus.

For the Embera the universe is structured into three worlds, inhabited by different beings with which humans interact by means of concepts, representations, and practices (fig. 2.2). In the upper world live the creator (*dachizeze*), the spirits of the dead, and the primordial beings. In the lower world live some *jai* (vital principles of all beings), *wuandras* (the mothers of the species), and other entities. The middle world is inhabited by humans, animals, plants, and diverse entities with human and/or animal appearance. Natural resources and their use are underpinned by the concept of wuandra or mothers of the plants and animals. The most important mother is that of the white-lipped peccary, because it determines the abundance or scarcity of species and allows humans to maintain access to and exchange relationships with nature by means of individual practices and the practices of the *jaibaná* or shaman. The jaibaná is a man or woman who after a long learning process ac-

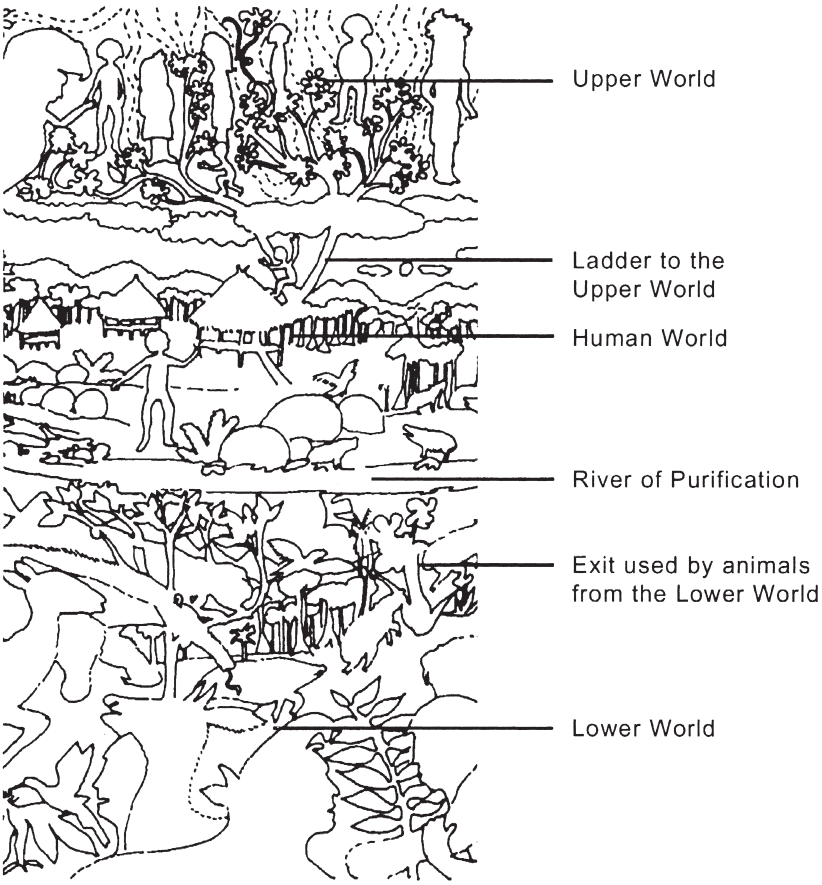

FIGURE 2.2 Schematic of the Embera conceptualization of the Universe. Labels read from top to bottom: Upper World, Ladder to the Upper World, Human World, River of Purification, Exit used by animals from the Lower World, and Lower World.

quires knowledge vital to Embera culture and mediates the interactions between humans and nature.

The Embera's complex body of knowledge of the environment arises from their long historic-cultural process and their relationship with the territory. This knowledge is expressed in their strategies for the management of nature and of resources and in their symbolic, productive, and social activities. Embera wildlife management integrates the human and the nonhuman in a process of reciprocal relationships. Relationships with animals are established by means of (a) the jaibaná, who regulates hunting by designating territories and species as sacred and/or forbidden; (b) selective hunting; (c) interactions among spaces assigned to different uses (shifting agriculture, semi-nomadic, or rotational hunting); (d) diversified production (relationships between hunting, fishing, agriculture, and gathering); and (e) cycles of production associated with seasonal species that provide varied sources of animal and plant proteins.

Game scarcity (see next section) has affected the Embera diet because meat that previously came from now-scarce species, especially white-lipped peccaries, is now provided by smaller species, which formerly were not preferred. Similarly, the symbolic importance of the white-lipped peccary—on which a large part of Embera culture is based—means that game scarcity affects Embera culture as well as their diet. Today, the Embera have several explanations for game scarcity, including the activities of the jaibaná, human population increase, increased demand for game meat, the introduction of firearms, the more frequent use of nonselective hunting with dogs, and forest fragmentation.

BRIEF PROJECT DESCRIPTION

The first phase of the project, which extended from 1990 to 1992, had as its two main objectives to determine the way in which the Embera use wildlife, including hunting practices and use of space, and to promote the implementation of a management agreement for the overlap zone between the communities, the OREWA, and the state government. From June 1990 to November 1991, participatory methods were used to gather data among the four communities in the overlap zone (Rubio-Torgler 1992). Two of the communities are relatively isolated from contact with the national society, while the other two communities are close to Afro-Colombian populations on the coast. In consequence, the latter two communities interact more with the national society than the former, and their lands are impacted by nonindigenous peoples.

In each community one trained participant recorded data on every hunted animal brought into the village, writing down species, weight, sex, location of kill, and method used to hunt the prey. Hunting locations were recorded using participatory mapping methods. Throughout the study period, during their visits to the communities, researchers used observational methods to record Embera perceptions of hunting and of animal ecology (Rubio-Torgler 1992).

Over an 18-month period, the four communities hunted a total of 1,079 animals of 5 reptilian, 6 avian, and 18 mammalian species, representing a biomass of 9,015 kg. Seventy-eight percent of individuals hunted belonged to 5 species: *Dasyprocta punctata* (269 individuals), *Agouti paca* (230), *Dasypus novemcintus* (135), *Tayassu tajacu* (112), and *Mazama americana* (95). Seventy-five percent of the biomass came from the same species, with *Tayassu tajacu* contributing the greatest amount and *Dasypus novemcinctus* the smallest. No tapirs or white-lipped peccaries were killed, and community members reported that these species had not been seen for a long time. Large primates also were rarely encountered and killed by hunters. The isolated communities hunted more animals overall and more individuals of the larger species than the communities near the coast. This difference is probably due to a combination of game depletion, spurred by economic booms and trade, and cultural change, which alters activity budgets in the communities near the coast (Rubio-Torgler 1992).

As a result of game depletion, the Embera in these communities hunt smaller animals than they did 15 years ago. They want to protect the populations of large species to increase their abundance, but have no interested in protecting "pest" species such as jaguars. Their culture does not contain the concept of biological extinction, and they believe that the jaibaná hides away the animals either as punishment for overhunting by humans or out of malice. However, they are willing to use both traditional and Western scientific methods to lead to the recovery of game animal populations.

The second phase of the project (1994 to 1996) built consensus on alternative strategies for wildlife management among members of sixteen Embera communities located in the influence zone of Utría National Park and representatives of the OREWA, all of whom were part of the project's core team and participated in research, coordination, evaluation, and budget management. During this stage project participants concentrated on exploring with the indigenous communities the strategies used by the Embera and the national society (both government and civil society) to achieve sustainable wildlife management, identifying social, cultural, and biological aspects that needed to be considered in order to assess the feasibility of each strategy. Project participants also continued the effort to understand Embera conceptualizations and practices related to wildlife, and inquired into systems of perception and representation and the social processes involved in decision making about wildlife. Finally, project participants carried out a feasibility analysis of the different wildlife management strategies that were proposed for the five communities that would be directly or indirectly involved with the implemented strategies and that expressed interest in participating in the management plan. These communities were Alto Bojayá, Alto Baudó, and Boroboro-Valle (direct involvement), as well as Nuquí and Paguí (indirect involvement).

In the third phase of the project, from 1997 thorough the present, the Embera people have been implementing some of the selected wildlife management strategies within their territories. Unfortunately, because of political problems among the OREWA, Fundación Natura, and the Ministry of Environment, as well as social and political problems at both regional and national scales, these actions have not yet been articulated at a regional level.

CONCEPTUAL FOCUS OF THE PROJECT

This project was conceived as a new approach to wildlife management in protected areas inhabited by local peoples and was based on consensus building and the participation of all stakeholders. Its conceptual focus is based on seven key premises:

1. Long-term conservation is feasible if it is taken up as a social decision in which local stakeholders put forth their own solutions, rather than having them imposed by the state.
2. Natural resource management strategies must be planned and implemented in a joint manner, taking into account the wildlife management solutions of the local people, of Western science, and of state policies.
3. The interaction between western scientific and local knowledge should be pursued and explored.
4. Management strategies cannot be exported wholesale from one region to another.
5. The construction of wildlife management strategies must be carried out with an interdisciplinary and intercultural vision.
6. Different management options must be integrated, with special emphasis on cultural, conservationist, and productive elements.
7. The conceptualizations, cultural practices, and social and political organization of the local people must always be taken into account to ensure that decision making is autonomous and that there is full participation in the planning, diagnosis, evaluation, analysis, and implementation of conservation actions.

The above premises emerge from the framework provided by the dialogue between local indigenous knowledge and Western knowledge, by the interaction of the disciplines of biology and anthropology, and by state policies (fig. 2.3).

Local indigenous knowledge was defined as the conceptualization and perception of the world by the Embera, with emphasis on their concept of territory and of the relationships between humans and territory and between humans and animals. This knowledge gives rise to particular social activities and practices involved in decision making and in the use and management of productive, social, and symbolic spaces, all of which were considered in the definition of indigenous knowledge.

The interdisciplinary and intercultural dialogue included contributions from biologists, anthropologists, and individuals specialized in other disciplines who participated at specific points in the project. From the anthropological perspective, we set out to understand the stage upon which the interacting actors develop a way of constructing the relationship between humans and nature. This was done primarily by observing the transformations generated by the development and presentation of conservation solutions, mediated by the definitions and cultural practices partic-

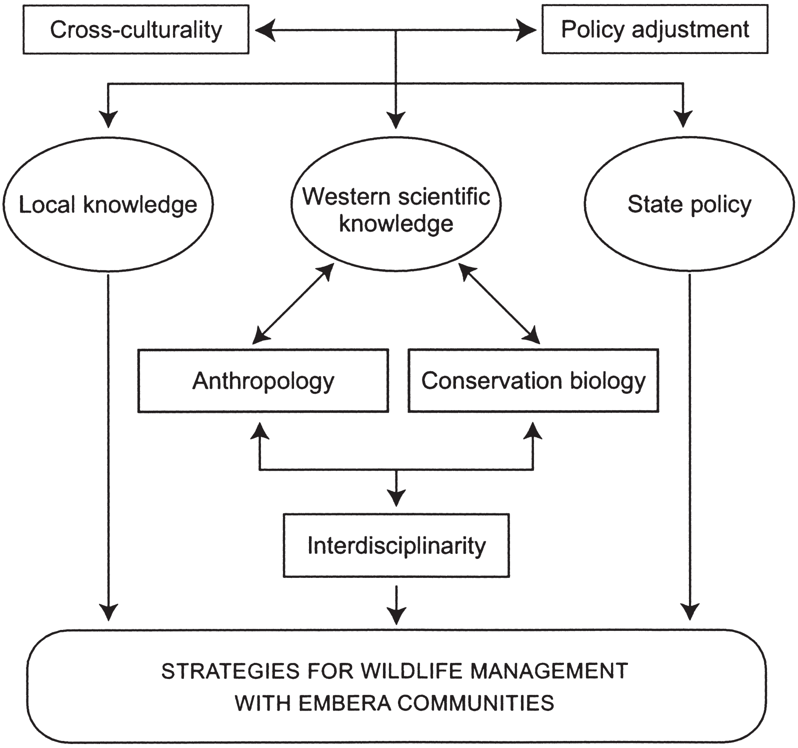

FIGURE 2.3 Framework for wildlife management with Embera indigenous communities.

ular to each actor. This understanding was facilitated by the concept of culture as a permanent process of restructuring meaning, in which society is constantly being reinterpreted, elaborated, and constructed, with structuring categories at the symbolic level that permit the continuity of culture as a dynamic process (García Canclini 1982). In this case one aspect of reality is constructed on the basis of the interests of the local peoples, of an indigenous organization, of a government organization, of an NGO, and of biology and anthropology researchers. In addition, researchers act as mediators that link the relationships proposed by the different actors, because their knowledge of different situations and practices can help the actors to interact under conditions where the political equality of all actors is recognized.

The goals of conservation biology are to research human impacts on biological diversity and to develop practical means to prevent the extinction of species (Soulé and Wilcox 1980; Wilson 1988; Primack 1993). The project strove to accomplish these two main goals through the diagnosis of hunting and its impact on wildlife and through the generation of strategies to protect species, always reconciling the needs of animal species with the needs of the people. In this particular case we strove for the conservation of species that have great symbolic and dietary importance for local indigenous peoples as well as of species of great ecological importance.

The indigenous researchers that participated in the core team were members of the indigenous communities and representatives of the OREWA. Each group carried out research on their own reality, based on their own ways of approaching their world, always maintaining interchange with the biologists and anthropologists in order to find solutions to problems. Diverse peoples from the communities also participated in this exchange of knowledge.

METHODOLOGICAL APPROACH

Initially conceived as a participatory process, the project methodology gradually developed into what we term interactive participation. This concept brings together several elements:

1. *Participation* promotes the presence of, as well as the giving of opinion by and the action on the part of, all actors during the entire process. Participation is based on respect for differences and considers local people as key actors in the process.
2. *Autonomy* proposes decision making and action by the local inhabitants with respect to the use of their territory and wildlife.
3. *Equity* works toward equality of political conditions based on the differences between each of the actors, thus generating a respectful dialogue.
4. *Interculturality* facilitates the exchange of knowledge, logics, and ways of acting between the two cultures.
5. *Interdisciplinarity* seeks a joint vision by the social and natural sciences of the problem and its solutions.
6. *Communication* explores the different systems of perception and representation of the two cultures. Communications were complemented by various materials used to socialize information—pamphlets, tapes, maps, calendars, posters, guides, and others.
7. *Continuity* proposes a long-term process that can be adjusted according to political, social, cultural and environmental conditions.

In order to develop the methodology and include each of the above elements, we took into account cultural aspects of the Embera:

1. social organization (nuclear family and kinship networks);
2. mechanisms of social control and cohesion, such as head of kin, the jaibaná, traditional leaders, the new categories of leaders, and the OREWA;
3. the traditional system for reaching consensus and for decision making (majority);
4. traditional systems of representation (oral, graphical, musical, and others);
5. traditional (oral) and new (schooling) ways of socializing information;
6. perceptions and explanation for the decrease and extinction of game (e.g., the actions of the jaibaná);

7. cultural strategies for game managementm such as rotational hunting;
8. traditional classification systems for animals (e.g., by habitat or behavior);
9. values and attitudes with respect to wildlife, that is, the absence of the concept of extinction.

Similarly, we also considered the proposals that the communities have for their own future and development, to avoid the external imposition of projects alien to the local cultural or environmental reality, and to allow instead projects to be constructed at the local level in a decentralized fashion. In this way the local inhabitants would make their own decisions about the planning, diagnosis of, implementation of, and follow-up on all aspects of the project that impinge on their territory.

We also took into account parallel aspects in the national society: (a) control mechanisms (e.g., environmental legislation); (b) national policy with respect to other ethnic groups; (c) national policies for participation and the opportunities/ mechanisms available for participation; (d) representational systems (oral and written) and mechanisms for socializing these systems (written materials, maps, and data bases); (e) perceptions and explanations for the decrease and extinction of wildlife from the Western perspective (anthropic and environmental factors); (f) legal wildlife management strategies (hunting seasons, wildlife refuges, captive breeding, and others); (g) biological systems of classification; (h) values and attitudes toward wildlife (conservation); and i) wildlife management policies inherent to each of the participating institutions.

CONSENSUS-BUILDING AND SELECTION OF WILDLIFE MANAGEMENT ALTERNATIVES

A basic step required to initiate consensus building among the above mentioned actors, a step that although obvious is often ignored, was to recognize that two different conceptualizations and ways of thinking were interacting with each other. The management strategies to be considered were therefore defined while taking into consideration six elements, that are linked together by means of the project's interactive participation methodology:

1. a study of the Embera population and their use of the territory and wildlife;
2. Embera wildlife management strategies;
3. national and legal strategies;
4. interests and requirements of the communities that live in the park;
5. environmental policies of the NGO and the government;
6. historical, cultural, and ecological context at the local, regional, national, and global scale.

The three indigenous reserves that overlap with the park participated in the process through representatives from fourteen of their communities. Representatives from two communities from nearby reserves also participated because the proposed solutions would affect not only the overlap zone but also the surrounding populations for political, sociocultural, and environmental reasons. The Embera, through the OREWA, have always proposed solutions that apply not only to one isolated case but that can be extended to all communities. According to their conception, all Embera have access to the territory. Additionally, if the communities from reserves that do not fall within the park were ignored, the project would be overlooking the reality of kinship and social relationships that link these groups directly to the park. Another factor was biological: the movement of animals links spaces and ecosystems. Finally, conservation actions must involve the greatest number of people and institutions possible, as such involvement gives these actions the regional recognition required to make them viable.

The participation of indigenous researchers facilitated not only the interactions among the various actors and institutions but also the construction of a common language. The perceptions of the OREWA and the indigenous researchers were key in guiding the dynamic of a communication process adjusted to Embera parameters. This dynamic was established at two levels: encounters and the preparation of materials.

Encounters are defined as interactive opportunities for reflection and included meetings, workshops, and committees. As the point where collective analysis leading to decision making was initiated, these encounters became the focal element of the dynamic. Two social processes took place during these encounters: participation / consensus building / decision making and exchange of knowledge and feedback.

Workshops were open opportunities for consensus building and participation and were based on the traditional form of agreement, that is, decision by majority. They were complemented by various materials used to socialize information—pamphlets, tapes, maps, calendars, posters, guides, and others. Since encounters are brief, time-limited events, these printed and taped materials gave continuity to the process of reflection. They also served to incorporate into the process other community members who were not present at the workshops.

Elaboration of materials took into account several variables, both thematic and representational in nature, and relied on the communication strategies most appropriate to Embera culture. Graphic and oral materials were best accepted by the communities because they fit into traditional forms of representation. Community members expressed interest in understanding the problems of game scarcity from the Western perspective and the solutions proposed by the national society. Therefore references to these concepts and perspectives were included in the representational materials.

PRESELECTION OF ALTERNATIVE MANAGEMENT STRATEGIES

We carried out a preselection of potentially appropriate management strategies, taking into account our survey of Embera use of territory and wildlife; Embera management strategies; legal strategies; the interests and needs of the communities; the environmental policies of the OREWA, Fundación Natura, and the Ministry of Environment; and the territorial and environmental contexts of the park-reserve overlap zone. We established basic principles to be used as guidelines in this preselection, principles which would enable the long-term continuity of Embera culture as well as that of the ecosystem in which it occurs. Based on an eventual analysis of their social and biological viability, a final set of alternatives would be chosen for implementation by the communities from this pool of preselected alternatives.

PRINCIPLES TO BE CONSIDERED: CULTURAL,CONSERVATIONIST, AND PRODUCTIVE

The cultural principle demands a consideration of the conceptions and knowledge of the human-nature relationship, values and meanings of nature, social practices, productive processes, and processes of interaction with other societies, taking into account the role played by nonhuman nature in all of these factors The relationship between humans and nature is in most indigenous cultures a continuous process of reciprocal relations, and must be viewed in an integral way, so that one does not consider only the resource. Similarly, one must consider the knowledge of and interest in nonhuman species and the practices, innovations, and cultural strategies that refer to resource management in general and game animals in particular. The cultural principle also implies a recovery and consolidation of local knowledge and management strategies (e.g., culturally restricted territories, agreement on use of animals with the mothers or owners of the animals, and identification of protein sources other than hunted animals). It further implies a need to understand and incorporate Embera explanations for the scarcity of animals, thus adjusting the management alternatives to Embera cultural parameters. Additionally, one must consider the impact of national, regional and local policies and development plans on culture.

The conservationist principle demands a consideration of the environmental conditions, an evaluation of supply and demand of natural resources, biological characteristics of the species, extinction processes, and the environmental carrying capacity. The goal of the conservation element of the strategies is sustainable use of wildlife or at least long-term sustained harvest, attaining the maximum production for human consumption that will not deplete wildlife populations or make them vulnerable to local extinction. Implicit in this principle is management with and for people because long-term conservation is viable only when local practices and knowledge and ethnic rights are considered along with the scientific knowledge of the biological and social sciences.

The productive principle calls for technical improvements in the management of traditional or new resources (introduced species or those that are not regularly used) in order to achieve greater productivity of animal or plant protein, a process that can help reduce pressure on game animals. This principle aims at generating strategies that ensure food quality and security for local inhabitants.

CATEGORIES OF WILDLIFE MANAGEMENT

In accordance with the above principles, four types of management were proposed. They were categorized according to their influence on wildlife by a social group.

Direct management occurs when a human group takes action to control and/or conserve species or groups of species by means of actions that directly affect them or their habitat:

1. Symbolic practices are based on hunting restrictions or prohibitions associated with symbolic criteria and specific ritual practices; they generate actions and allow control of animals by a group or people or an individual. They derive from cultural conceptualizations and generate social practices.
2. Conservationist practices are those that most human groups use to maintain equilibrium between supply and demand of natural resources used for a variety of purposes, such as food, symbolic, aesthetic or spiritual, among others. These practices may allow the increase of animal populations, for example, when they are released from hunting pressure at certain times or places.

Indirect management occurs when a human group carries out productive practices that provide food security and that decrease pressure on wildlife populations. There are several distinct forms of indirect management:

1. Extensive practices apply traditional economic practices to resources that are not traditionally used. In order to be considered extensive, the resource must be congruent with the cosmology of the social group. It must further be easily attained, and techniques for its use must be easily acquired. Also, it must be near to the territory used by the community, and it must be acceptable in the diet.
2. Technical improvement practices increase the quantity or quality of a resource by improving the technical level of traditional productive practices.
3. Cultural change practices require the modification of the relationship between humans and nature both at the symbolic and the daily use level in order to allow access to a resource. Use of this type of practice requires the acquisition of new knowledge about the resource at the ecological and technological level, and this new knowledge implies sociocultural changes.

EMBERA AND NATIONAL SOCIETY WILDLIFE MANAGEMENT STRATEGIES

Once the ground rules for reaching concordance on any suggested wildlife management strategy had been set, the project proceeded to revisit those strategies of the Embera and national societies that ensure the continuity of both Embera culture and species conservation and that provide an optional source of animal protein (table 2.1). By opening up a discussion with the Embera communities about their own management strategies, we were also able to discuss other management op-

TABLE 2.1 Types of Wildlife Management and Alternatives Preselected for Analysis by the Embera

EMBERA WILDLIFE MANAGEMENT	NATIONAL SOCIETY (LEGAL AND CIVIL) WILDLIFE MANAGEMENT	PRESELECTED ALTERNATIVES
Symbolic reciprocity relationship with animals		Control by the Jaibaná
—Practices of the Jaibaná		
Symbolic reciprocity relationship with animals	Protected areas	Game refuges
—Practices of the Jaibaná	Areas with use restrictions	
—Diversified production	—Fauna reserve	
	—Hunting reserves	
Natural history knowledge	Game Source areas	
	Communal reserves	
Interrelated use areas	Rotation of hunting areas	
Rotation of hunting areas		
Rotational agriculture		
Rotational hunting		
Selective hunting	Regulation of wildlife use	Selective hunting or hunting bans
Diversified production		—Ban during reproductive season
	Hunting bans	—Ban by sex
Symbolic reciprocity relationship with animals		—Ban by age
Practices of the Jaibaná		—Total bans
Natural history knowledge		
Natural history knowledge	Substituting protein sources	Use of new resources
		—Marine fisheries
Diversified production		
—Broadening the resource base		
Diversified production	Substituting protein sources	Improved techniques for small animal husbandry
Natural history knowledge		—pigs and chickens
Symbolic reciprocity relationship with animals	Captive wildlife production	Captive wildlife production
—Practices of the Jaibaná	—repopulation	—Food source
	—commerce	
Raising pets	—food source	

tions, as viewed from the perspective of their culture. This approach ensured that the proposals would actually be developed and implemented.

Embera wildlife management strategies include the diversified use of wildlife, diversified sources of vegetable and animal protein, symbolic reciprocity relations with animals, diversified production (explicit links between hunting, fishing, agriculture, and gathering activities), productive cycles associated with seasonal species, and interaction of spaces designated for different uses (by means of shifting agriculture, seminomadic or rotational hunting, and selective hunting). Currently, the Embera's ability to use the full range of strategies is limited by social, environmental, and territorial changes. These limitations dictate the need for agreement on new strategies, which although based on traditional Embera practices, have a new connotation due to the Embera's current situation.

We also took into consideration the dynamic nature of Embera society, a society that has experienced a series of interactions that have contributed to the introduction—or rather imposition—of new social structures within the communities and of new ways of organization. These new ways have persisted in some situations because, paradoxically, they serve to retain cultural identity. This means that day-to-day new knowledge and social processes arise that must or will be appropriated, transformed, or given new meaning.

At the same time we also took into account governmental proposals for in situ (protected areas, establishment of restricted use areas, regulations on wildlife use, and reintroduction and repopulation of species) and ex situ (captive breeding) wildlife protection. Parallel to these legally accepted strategies we also included proposals from the civil society with articulate conservation actions that take into account the interests of local peoples, such as community reserves, protection of wildlife sources, protection of water bodies, substitution of protein sources, and rotation of hunting zones, among others.

Multiple indirect strategies for wildlife management exist, such as ecotourism, craft sales, photo safaris, collection of vegetable ivory, agroforestry, pisciculture, and use of such pest species as pigeons. Project participants preferred, however, to search for solutions to wildlife scarcity that were based on traditional Embera strategies, solutions that would directly or indirectly advance wildlife conservation.

PRESELECTED ALTERNATIVES

Taking into account cultural, conservationist, and productive principles, along with the kinds of management strategies available, project participants preselected the following alternatives: control of animals by the jaibaná, wildlife refuges, selective hunting and hunting bans (total or by reproductive season, age, or sex), use of marine fisheries, breeding of smaller domestic species, and captive breeding of native species. The alternatives in the final proposal are expressed in Western terminology. Conceptually, however, with the exception of captive breeding, they are based on Embera ideas and strategies that legitimize the people's knowledge and their relationship with the environment (table 2.1).

Control of Animals by the Jaibaná The jaibaná sustains the relationship of symbolic reciprocity between animals and the Embera. In order for any management alternative to be viable, control of animals by the jaibaná must be proposed as a vital element that articulates Embera cosmology and that is the starting point from which other alternatives can then be proposed. Control of animals by the jaibaná occurs when the jaibaná interacts with the mothers of the species in order to lock up the white-lipped peccary in the underworld or to uncover the underworld to release the white-lipped peccary. This control causes the abundance of game animals to increase or decrease. The Embera believe that the disappearance of species from their territories is caused by the actions of the jaibaná.

Wildlife Refuges The concept of wildlife refuges encompasses practices such as restrictions on a territory by a jaibaná, rotational and seminomadic hunting, diversified production, diversified protein sources, and interaction among spaces designated for different uses. All of these practices remove pressure from a portion of land and also make available protein from different plant and animal sources. These Embera strategies are related to national society strategies, such as protected areas, restricted use areas (faunal refuges and hunting reserves), faunal source areas, communal reserves and rotation of hunting areas, all of which also have the goal of leaving an area free of pressure.

Based on the conceptual congruence between Embera and national society strategies, we reached consensus on the definition of wildlife refuges as portions of land where a human group decides to stop hunting and extracting animals for a predetermined time in order to allow animal populations to maintain themselves or to increase. These refuges also function as sources of animals that disperse into hunting areas. In setting the boundaries of a refuge, one must consider spaces available for the productive, social, and symbolic activities of the human group as well as the occurrence of habitats used by the animals of interest.

Selective Hunting or Hunting Bans This concept encompasses Embera practices such as selective hunting, diversified production, symbolic reciprocity relationship with animals, and practices of the jaibaná associated with restrictions placed on some species. These strategies coincide at the conceptual level with such national society strategies as regulation of the use of wildlife and hunting bans. Therefore we reached consensus on the definition of selective hunting and hunting bans as occurring when a group of people decide to use or hunt in a selective way one or more animal species during a predetermined time with the objective of allowing the populations of these species to increase or be maintained so that they may be sustainably hunted.

Use of New Resources The concept of use of new resources encompasses both Embera practices of diversified production and the national society's strategy of the substitution of protein sources. We therefore define the use of new resources as the use of an animal species (new to the area or new to use) in a sustainable manner within a local productive practice, with the consequent reduction of pressure on wildlife by means of protein substitution.

Improvement of Animal Husbandry This concept encompasses Embera practices of diversified production, which in turn is related to such national society strategies as substitution of protein sources. Given this congruence in the strategies, the project reached consensus on the use of livestock, defining improvement in small animal husbandry as an increase in the quality and quantity of production associated with small domesticated species in order to decrease pressure on wildlife populations. In this project, chickens and pigs were chosen as target species for increased production.

Captive Breeding for Food The concept of captive breeding brings together the Embera concepts of symbolic reciprocity with animals by the jaibaná, the keeping of pets, and of diversified production with the national society concept of captive breeding. We define captive breeding for food as the rearing and reproduction of wild species in captive or semi-captive conditions that achieves stable productivity, which in the long term serves as a protein option for local peoples.

DEFINING SOCIOCULTURAL AND BIOLOGICAL VIABILITY OF THE PRESELECTED ALTERNATIVE STRATEGIES

Once a set of potential alternative management strategies had been preselected, the project needed to analyze the viability of each one. We defined viability as the ability to sustain traditional practices, to increase the amount of meat available to each individual, and to improve health and nutrition levels, thus ensuring food security to the Embera as well as the recovery or maintenance of game populations. Project participants determined the minimum sociocultural and biological concepts and elements to be taken into account to accurately gauge the viability of each of the alternatives. These factors are not always easy to approach or identify because of limited basic information about the area and the short amount of time available for research afforded by the real need to make timely decisions about management. Nevertheless, these concepts and elements serve as guides to infer the feasibility of the strategies.

SOCIOCULTURAL CONCEPTS AND ELEMENTS USED TO DEFINE THE VIABILITY OF WILDLIFE MANAGEMENT STRATEGIES

To be socioculturally viable, it is not enough for an alternative to provide an optional protein source and result in long-term management of resources. It must also (a) derive from the people's own strategies, (b) be accepted by a group that is representative of the community in terms of numbers, social rank, and gender, (c) not obstruct any cultural, political, or economic processes, and (d) not generate pro-

TABLE 2.2 General Factors for Evaluating the Sociocultural Viability of Wildlife Management Alternatives

Conceptualization and knowledge of the universe
- a. Interacting time scales
- b. Spaces in which these time scales act

Territory
- a. Capacity for cultural reproduction
- b. Ability to sustain the population
- c. Boundaries
- d. Relationship among use spaces
- e. Resource use processes
- f. Regulation and access
- g. History of sociocultural and environmental processes

Relationship between humans and nature
- a. Entities that make up the universe
- b. Relationships with the entities
- c. Clasification of animals
- d. Strategies for use and management
- e. Perceptions and values of abundance and scarcity

Socialization
- a. Systems of perception and presentation
- b. Socialization processes

Organization, cohesion, control, and social regulation
- a. Internal systems for social regulation and authority

Intercultural relationships and transformations at conceptual, social, and cultural levels
- a. Conceptualized
- b. Socialized
- c. In organization, cohesion, and social control
- d. In productive activities

cesses that cannot be culturally assumed due to cultural concepts or daily practices. Viability analyses must therefore take into account forms of social organization, processes of socialization, and cultural interrelations, along with a people's conceptualization and knowledge of the universe and of their territory and their ideas about the relationship between humans and nonhuman nature (table 2.2).

BIOLOGICAL ASPECTS AND ELEMENTS USED TO DEFINE THE VIABILITY OF WILDLIFE MANAGEMENT STRATEGIES

An alternative is considered biologically viable if it helps wildlife populations to increase and if it allows extraction without affecting population viability. The factors that help to define the biological viability of the alternatives can be determined by studies of how the people use their territory and wildlife, by evaluations of population density, and through theoretical analyses. Other biological aspects such as resilience and resistance of ecosystems and communities are also important in determining the biological viability of wildlife management strategies. However, given the immediate need for conservation of wildlife populations of economic importance to the local people, in this respect i was impossible to carry out the complex, long-term, and expensive studies necessary to evaluate these aspects of the biology of the system).

SOCIOCULTURAL AND BIOLOGICAL FEASIBILITY OF EACH OF THE ALTERNATIVE MANAGEMENT STRATEGIES PRESELECTED FOR THE PARK-RESERVE OVERLAP ZONE

Between 1994 and 1996, the period of analysis, eight workshops were carried out, one for each preselected alternative, in conjunction with local meetings and other consensus-building processes headed by the indigenous researchers at the local level. These local meetings gave continuity to the reflection process started in the workshops.

In the workshops the social, political, and environmental processes that could result from specific management strategies were discussed. Discussions were based on factors previously identified by the researchers. The dynamic consisted in exercises that generated reflection, carried out in Embera language with the support of the indigenous researchers (for example, analyzing changes in gender-specific daily practices that would result from captive breeding). The information was socialized following the perceptional and representational systems of the Embera, that is, using graphical (face and body painting), oral and musical traditions, and other traditions of the material culture.

SELECTION OF THE ALTERNATIVES BY THE COMMUNITIES

After two years (1994–1996) of consensus-building exercises among all the stakeholders and based on the preselected alternatives, five final strategies were selected (table 2.3). These strategies blended cultural, conservationist, and productive elements and consolidated and strengthened Embera knowledge.

Captive breeding was considered to have low social feasibility and was eliminated from the list of preselected alternatives. More specifically, captive breeding was not deemed a valid alternative because in Embera conceptualizations animals are cared for by their wuandras, or mothers, and are under the control of the jaibaná. Therefore wild animals do not require any additional care. Implementation of captive breeding would imply a conceptual change in which humans would replace the wuandras and would have to take care of the animals without mediation by the jaibaná. Additionally, captive breeding would imply changes in daily practices due to the maintenance requirements of the captive animals.

Although the final proposal was formulated in Western terminology, its alterna-

TABLE 2.3 Selected Wildlife Management Strategies

MANAGEMENT TYPE	PRACTICES	ALTERNATIVE	VIABILITY
Direct Management	Symbolic practices	Control of animals by the *jaibaná*	High
	Conservationist practices	Refuges	High
		Selective hunting or bans	Medium
Indirect Management	Extensive practices	Marine fisheries	High
	Practices to improve husbandry techniques	Raising pigs and chickens	High

tives respond directly to Embera ideas and practices and sought legitimacy in their knowledge and ways of relating to nature. To illustrate the sociocultural and biological feasibility analysis carried out for each alternative, we describe below the decisions taken with respect to the establishment of wildlife refuges.

THE WILDLIFE REFUGES

/ TATSIRÂ EMBERA EJUA ANIMARA GUACAUATA / LAND FOR TAKING CARE OF THE ANIMALS WITHIN THE TERRITORY /

The Embera from the park-reserve overlap zone communities chose to establish refuges that would allow the recovery of white-lipped peccaries, collared peccaries, red brocket deer, spider monkeys, howler monkeys, white-faced capuchin monkeys, armadillos, pacas, and agoutis, all species valued for their size, taste, and multiple uses. Additionally, it was noted that refuges would help the recovery of the white-lipped peccary population should these animals return to the region. The area of the refuges was chosen by the communities themselves, guaranteeing that these refuges will be viable in the long term because local people rather than planners unfamiliar with local realities will generate, manage, and assume responsibility for refuges.

Of the 42,300 ha of land surface area in the overlap zone, 14,952 (35.34%) were proposed as refuges, using geographical boundaries that make them easy to locate both on maps and by the local people. The community of Santa María de Condoto selected 3,456 ha; Unión Chocó, 8,271 ha; Boroboro, 1,725 ha; and Jurubidá, 1,500 ha. According to Posada (1991), only 4.8% of the overlap zone is anthropogenically disturbed, while an additional 10.9% is in some way influenced by human activities. These numbers probably have not varied much in the last few years, given the stability of demographic and socioeconomic conditions in the area. This means that approximately 84.3%, that is, 35,658.9 ha, of the overlap zone supports little disturbed forests.

In the diagnosis of use of territory, spaces used for living, agriculture, and hunting by the four communities were determined. Based on these data one can see that the refuges do not overlap with areas used for productive activities such as agriculture, where hunting would also be practiced on a sporadic basis. Similarly, they do not overlap with communal productive areas where activities such as gathering take place and that can experience intensive use by hunters. Furthermore, the eventual expansion of the boundaries of productive activities, especially agriculture, will not interfere with the refuges in the long term because topographical boundaries limit such expansion.

Likewise, based on the Embera vision of the territory, conceptual concordances with refuges were also established. In the proposed refuges, the sites through which animals are locked up and the sites where the animals come out into the world (caves, ponds, and ritual sites) coincide with physical sites in the world inhabited by humans. The fact that there are specific places where these two sites coincide makes it possible for the animals to return through these sites and allows them to disperse among refuges. In Santa María there are also places that have already been protected as refuges by the practices of the jaibaná. Such a site is the mouth of the Omando river, where according to oral tradition, more than thirty years ago the jaibaná Ventura placed a monster as a guardian so that nobody would hunt in the area. Also, in Unión Chocó, at the headwaters of the Bojayá River, there are caves that provide access to the underworld, and from which animals can therefore emerge.

The refuges also coincide with the dwelling place of the *nusi*, or giant fish, of the *pakore*, or grandmother of the animals, and with the exit sites of the wuandras, all vital beings in Embera thought. Since these sacred spaces overlap with the refuges, a relationship is established with the animals by means of the symbolic human-animal reciprocity, and the management alternative becomes quite feasible. Refuge viability is also strengthened by the fact that the relations, classifications, perceptions of abundance and scarcity, and expectations of the Embera coincide for the most part with the biological expectation of increase of animal populations, i.e., whether they are vulnerable, threatened, or common species (table 2.4).

Based on Embera knowledge and by means of surveys of the proposed refuge areas, we observed that the forest is in good conservation shape, that it is composed of a mosaic of habitats, and that the vegetation is not undergoing high levels of intervention. These observations indicate that the habitat should provide the necessary resources for the species of interest. Additionally, the refuges are located toward the center of the overlap zone, and between them there is a continuum of forest that experiences sporadic use for hunting and gathering of plant products, providing a habitat corridor between the refuges. Additionally, relatively undisturbed forests are located to the north and east of the overlap zone. These factors increase the potential for protection of species with large home ranges or migratory habits. They also prevent the fragmentation of the populations as a whole into smaller populations that would be more vulnerable to extinction, and they may maintain genetic variability by permitting the exchange of individuals among subpopulations. Finally,

TABLE 2.4 Species of Interest to Conservation from the Biological and Embera Perspectives

SPECIES THAT THE EMBERA WISH TO RECOVER	LOCAL CATEGORY	BIOLOGICAL EXPECTATION OF RECOVERY*
White-lipped peccary (*Tayassu pecari*)	In the process of extinction	Low
Collared peccary (*Tayassu tajacu*)	Threatened/common	Medium
Brocket deer (*Mazama americana*)	Threatened/common	Medium
Spider monkey (*Ateles fuscipces*)	Threatened	Medium
Howler monkey (*Allouatta palliata*)	Threatened	Medium
White-faced capuchin (*Cebus capucinus*)	Threatened	Medium
Armadillo (*Dasypus novemcinctus*)	Common	High
Paca (*Agouti paca*)	Common	High
Agouti (*Dasyprocta punctata*)	Common	High

*Biological expectation of recovery: refers to the feasibility of recovery or maintenance of the populations; it is defined by taking into account only the intrinsic characteristics of the species, excluding anthropic pressure that is absent in a refuge.

the shape of the refuges is delimited by geographic features and tends to be oval or round so that the borders tend to be distant from the center and edge effects are minimized.

Theoretical analyses that incorporate home range, size of the overlap area, and reproductive rates and that were used to predict the number of individuals or groups that could be sustained by each refuge indicate that the protection of spider monkeys, howler monkeys, and capuchins is feasible (H. Rubio-Torgler unpublished data). Of course, their recovery must be linked to hunting bans because these three species are locally threatened. The numbers of collared peccaries and brocket deer will vary in the refuges, given that their abundances already vary over the entire overlap zone: they are more common in the interior than in the coastal zones where they are threatened (H. Rubio-Torgler unpublished data). For the white-lipped peccary, on the other hand, it is unlikely that the refuges will protect several groups, in as much that the species may currently be undergoing local extinction. Therefore, for threatened populations of all species to recover and disperse throughout the hunting zone, the refuges must be left without hunting for an extensive period of time. Although the decision of when to end the refuge strategy is a social one, it has been suggested by the indigenous people that one of the refuges could be temporarily opened if considered necessary or that use of the refuges for hunting could be rotated based on the recovery of the populations in them.

By proposing refuges linked to the control of animals by the jaibaná and by basing management on culturally established strategies, a process is generated that, although requiring input of new information, contributes to Embera cultural continuity and facilitates the development of the strategy in the long term. Another element to be considered is the fact that conceptually the structure of the refuge is present in the mind of the Embera as a space regulated by productive practices and by the control of the jaibaná.

Nevertheless, as a new form of management, refuges require periodic evaluations of their effectiveness. Monitoring allows one to know whether populations are increasing or whether individuals are dispersing toward hunting zones. Monitoring also implies consensus with people from other surrounding communities, Embera as well as Afro-Colombian and mestizo. Therefore specific individuals must be charged with evaluation of the biological and social effectiveness of the refuges.

Since there are no local mechanisms for evaluating the effectiveness of the refuges, the Embera must determine whether they need outsiders to measure changes in population abundance or whether they can do it by means of traditional roles, such as tongueros (persons who can see the spiritual world by drinking hallucinatory plants), yerbateros (individuals who use plants to cure different illness), and expert hunters. Given these alternatives, the Embera have suggested control by means of traditional and nontraditional forms, such as establishment of a system of regulations, including forms of access to the refuges, and of biological monitoring. At this point it is best not to create new hierarchies of individuals that do not fit into traditional hierarchies or roles. Otherwise, a desire for power could be created among the individuals elected to carry out the control and monitoring, since responsibility would be centered on them. Thus, the implementation process will have to be assumed by all members of the community rather than assigned to a few individuals.

The above factors all suggest that wildlife refuges can become sources of game animals for hunters of the four Embera communities and that they represent a viable form of land use. Currently, wildlife refuges exist in the four communities located in the overlap zone. However, in order for the process to be viable, information about the refuges must be socialized. The most important topics that must be socialized and monitored are minimum area requirements for animal reproduction, population sizes, space used by animals, population growth rates, diet, reproductive behavior, social structure of some of the species, population monitoring methods, and long-term monitoring. In order for the refuges to be viable, they must be implemented in parallel with other alternative strategies of protein procurement and strengthened with hunting bans. In other words, the three basic principles initially proposed must be kept in mind: cultural, conservationist, and productive.

FACTORS THAT AFFECT THE CONTINUITY AND SUCCESS OF THE PROJECT

For continuity to be guaranteed, the process of reaching consensus on wildlife management alternatives must count on the political support and will of all the stakeholders during implementation and follow-up. Among the actions that must be implemented and that must be monitored to ensure continuity are the promotion of activities that will improve the procurement of protein from nonhunting sources, analysis of cultural changes generated by the process, strengthening of intercultural relations, and appropriate application of the communication mechanisms that generate better intercultural relationships and that allow the communities to continue with research and dissemination of results.

However, success and management continuity also depend on two other key factors: cultural continuity and strengthening of participatory processes. Wildlife management based on the conceptualizations of the local people necessarily implies guaranteeing the basic conditions that support the cultural continuity of this human group and of their territory, and recognizing the rights that all communities have to make use of their environment in accordance with their traditional practices. These grant the people the autonomy to decide, under the forms and mechanisms of organization established by their own culture, what actions to take toward management. At the same time the participatory process requires that all stakeholders remain engaged. Such engagement is necessary not only for communities, indigenous organizations, and the State that are directly involved and are the ones immediately affected by the decisions taken about their territories, but also for other human groups, NGOs, etc. indirectly involved and that are members of civil society. Furthermore, the participatory process must encourage decentralization of State actions, so that real management based on local autonomy can take place. This decentralization implies presenting and assuming the issue of wildlife management as the responsibility of both the local inhabitants and of the State.

Diverse other cultural, ecological, economic, political, and participatory factors and basic conditions affect the success of any consensus and implementation process for long-term wildlife management. These factors can and should be taken into account because they can influence the process depending on the context or level at which they occur (local, regional, national, or transnational). Examples of these factors include development programs instituted at the national or transnational level. While it is clearly necessary to articulate local plans with the nation's reality, it must also be recognized that these two visions are often in conflict because the interests of the nation do not always coincide with the interests of indigenous peoples. A contributing problem in Colombia is that the policies of the Ministry of Environment change depending on the identity of the officials in power, and these changes can accelerate, delay, or otherwise affect the wildlife management process. Finally, social conditions, i.e., the presence of paramilitaries and guerillas, means that consensus-building processes are threatened by violence. Environmental priorities are placed on the back burner because the social conditions necessary for the implementation of a program based on participation and consensus are lacking.

It is therefore not surprising that not all the wildlife management strategies selected by the project have been implemented in the overlap zone. This delay and decoupling of the strategies is also due in part to a lack of interinstitutional coordination and to the political problems existing between the indigenous organization, the National Park, and the NGO Fundación Natura. Additionally, at the local level a series of infrastructure development and tourism projects have been established that will eventually affect the area and its inhabitants. Despite these factors, since 1997 members of the four communities in the overlap zone and several of the neighboring communities have implemented at the local level several conservationist wildlife management strategies: refuges, bans, and reliance on marine fisheries.

3

Bridging the Gap Between Western Scientific and Traditional Indigenous Wildlife Management

THE XAVANTE OF RIO DAS MORTES INDIGENOUS RESERVE, MATO GROSSO, BRAZIL

KIRSTEN M. SILVIUS

Several authors have suggested that indigenous lands in the Neotropics function or could function as important conservation units (Redford and Stearman 1993; Peres 1994; Peres and Terborgh 1995; Redford and Mansour 1996). In the Amazon there are approximately 250 indigenous reserves, representing 44% of government-managed land area (Peres and Terborgh 1995). Twenty percent of the Brazilian Amazon alone is indigenous land. On the basis of land area and of documented levels of species diversity in Amazonia, these lands hold within their boundaries a high proportion of the world's biodiversity, most of it as yet unstudied. Hunting, however, can locally reduce or eliminate vertebrate populations on indigenous lands, especially during the transition from subsistence to market economies, from nomadic to sedentary settlement patterns and from traditional hunting technologies to the use of guns (Bodmer, Fang, and Moya 1988a; Robinson and Redford 1991; Vickers 1991 Redford and Stearman 1993; Peres 1994; Bodmer, Eisenberg, and Redford 1997; Auzel and Wilkie 2000; Eaves and Ruggiero 2000; Fragoso, Silvius, and Prada 2000; Hill and Padwe 2000; Leeuwenberg and Robinson 2000; Mena et al. 2000; Robinson and Bennett 2000a; Yost and Kelley 1983). The fact that hunting is an integral part of indigenous cultures in the Amazon thus brings into question the value of indigenous lands for the conservation of large vertebrates. If indigenous reserves are to play a role in national and regional conservation strategies, the causes of game depletion by indigenous people must be understood and remedied through appropriate management. At stake is not only the biodiversity supported by vast expanses of forest and savanna ecosystems encompassed by indigenous lands, but also the traditional cultures of the region.

In response to game declines on their reserves and the resultant impact on diet quality and traditional livelihoods, several Neotropical indigenous communities have initiated collaborations with biologists to develop sustainable wildlife use practices (Ulloa, Rubio-Torgler, and Campos-Rozo 1996; Leeuwenberg and Robinson 2000; Souza-Mazurek et al. 2000; Townsend 2000b; Townsend et al. 2001; Noss and Painter this volume.) As highlighted by Ulloa, Rubio-Torgler, and Campos-Rozo (this volume), biologists working with indigenous peoples must balance the ecological rules under which wildlife populations operate with the cultural rules under which indigenous populations operate. A similar situation is experienced by health workers seeking to balance indigenous views of disease with the knowledge of Western medicine (Albert and Gomez 1997). Often, the traditional management practices of the indigenous group in question offer the best means of approximating the management prescriptions of Western science, with the added advantage that traditional practices are more likely to be adhered to than alien practices that do not have a basis in the indigenous world view.

In this article I explore ways in which biologists and indigenous peoples can reach consensus on game management plans by reviewing the motivations, dynamics, and management outcomes of the Xavante Wildlife Management project, which has been under way in central Brazil since 1990 (Leeuwenberg 1997a,b; Fragoso, Silvius, and Prada 2000; Graham 2000; Leeuwenberg and Robinson 2000). I focus on aspects of the Xavante culture and of the project itself that may have influenced the final management decisions made by the community. I then review the findings of biologists and anthropologists working on other indigenous hunting studies and in the process develop a set of loose guidelines for biologists working with indigenous peoples in South and Central America. These guidelines summarize some of the common factors found to affect hunting practices and game depletion in several indigenous reserves.

THE XAVANTE PROJECT

The Xavante people have traditionally lived in the savannas and woodlands of central Brazil's cerrado ecosystem. Their once extensive range and population is now reduced to approximately 9,000 people living on five reserves in Mato Grosso state (Graham 2000). Hunting is a key element of Xavante culture (Maybury-Lewis 1967). Despite extensive contact with Brazilian national society, Eteñitepa, the dominant community in the 330,000-ha Rio das Mortes Reserve, maintains a highly traditional life style. When community members noted a decline in their hunting yields in the late 1980s, they sought advice from World Wildlife Fund (WWF)-Brazil. From 1991 to 1993 wildlife biologist Frans Leeuwneberg worked with the Xavante to collect basic data on hunting effort, hunting areas, sex ratios, and age structure of hunted animals (Leeuwenberg 1997a,b; Leeuwenberg and Robinson 2000), all of which are required to assess the status of wildlife populations on the reserve and to determine the sustainability of the communities hunting practices (Bodmer and Robinson this volume).

After three years of data collection, Leeuwenberg concluded that tapirs (*Tapirus terrestris*) were being hunted unsustainably. He based his conclusion on a comparison of actual harvest rates with potential productivity. Age structure analyses for pampas (*Ozotoceros bezoarcticus*) and marsh deer (*Blastoceros dichotomus*) suggested these species too were overhunted, even though very low numbers of pampas deer were being killed. The situation for giant anteaters (*Myrmecophaga tridactyla*) was less obvious, as adequate data on carrying capacity and productivity were not available for the area. However, these animals were being hunted at such a high rate that there was a good probability that they were being overhunted (Leeuwenberg 1994; Leeuwenberg 1997a,b; Leeuwenberg and Robinson 2000). The same indices showed that other regularly hunted species of concern, including brocket deer (*Mazama americana*), collared peccaries (*Tayassu tajacu*), and white-lipped peccaries (*Tayassu pecari*), were being sustainably hunted.

From 1995 to1997 wildlife biologist José M. V. Fragoso designed a continuous monitoring system and an adaptive management plan, based on data already collected by Leeuwenberg and on new, track-based indices of animal population abundances (Fragoso, Silvius, and Prada 2000). Because most sedentary indigenous groups have a limited hunting radius, Fragoso's design used tracks to assess the relative abundances of key game species at three incremental distances from the village. The rationale was that when areas are left undisturbed for long periods of time due to low hunting pressure far from a village, a source-sink dynamic may be created if the reserve is large and continuous. As long as production is high in the distant areas, animals may move into the hunted areas near the village, in effect maintaining a constant, though low, supply of game. The effect will vary with both the biological parameters of the species and the degree of preference the hunters show for the species. The situation may be stable and sustainable, as it appears to be for a fox-hunting system in the Argentine pampas (Novaro this volume). Because the Rio das Mortes Reserve is a relatively large area, it is possible for source-sink dynamics to be operating within it rather than between the reserve and outside areas, as suggested by Townsend (1995a) for the Sirionó in Bolivia.

On the basis of the combined analyses by Fragoso and Leeuwenberg, management recommendations were made to the community. The community then took several months to consider the recommendations and to reach consensus on a management strategy. In 1997 the community signed an agreement with WWF-Brazil to implement the monitoring and management plan they had chosen. Management has been in place for four years now, and the data from the first two years are being analyzed (R. Lemos de Sá pers. comm.). However, there were key differences between the management strategy recommended by biologists and the strategy chosen by the Xavante community, differences which may be at least partially rooted in cultural perceptions of wildlife.

MANAGEMENT RECOMMENDATIONS AND XAVANTE CHOICES

The analyses by Fragoso, Silvius, and Prada (2000) and by Leeuwenberg and Robinson (2000) indicated that five species were threatened by or vulnerable to overhunting: giant anteater (considered to be overhunted everywhere, with equal abundances at all distances from village, and a source probably outside the reserve), pampas deer (overhunted everywhere, no source in the reserve), giant armadillo (*Priodontes giganteus*, overhunted, low abundances everywhere, unknown natural history), marsh deer (vulnerable or threatened, but potential source area within the reserve), and tapir (vulnerable or threatened, populations low, but higher abundances at greater distances from village). All other species, including collared peccary and white-lipped peccary, showed the expected pattern of low track counts near the village and high track counts far away, suggesting that they have source populations within the reserve. Sample sizes for brocket deer (*M. americana* and *M. gouazoubira*) were very low; however, they actually appeared to have higher abundances near the village than far from it, perhaps because of their ability to use disturbed habitats. Pacas (*Agouti paca*) and agoutis (*Dasyprocta agouti*) were not hunted frequently and had equal abundances at all distances from the village, and so there was no reason to assume that their populations were threatened by any other factors (Fragoso, Silvius, and Villa-Lobos 2000).

SUGGESTED MANAGEMENT SCENARIO BASED ON BIOLOGICAL CONSIDERATIONS

On the basis of the assessments described in the previous section, the following management recommendations were made to the Xavante of the Rio das Mortes Reserve (although the Eteñitepa community retained leadership of the project, WWF-Brazil required that the other communities in the reserve participate in the management plan):

1. Do not hunt giant armadillo and giant anteater in the reserve until populations recover or monitoring indicates that population levels are not likely to become higher and until their biology, including reproductive potential, has been studied.
2. Do not hunt pampas deer in the reserve until their populations recover because population levels appear to be unusually low.
3. Only hunt marsh deer, tapir, and white-lipped peccaries at locations distant from the village in order to allow populations to recover in other areas. Once other areas recover, hunting can be shifted there. In this way, a source-sink system will be maintained not by distance from the village but by design in certain areas, irrespective of distance from the village.
4. Hunt collared peccary, brocket deer, and smaller species at current or higher levels in all areas of the reserve.

XAVANTE MANAGEMENT DECISION

Using their traditional process of achieving consensus through long discussions at the men's council, the Xavante developed a very specific management plan that included well-defined refuge areas and specific hunting periods for species in each area. However, the species they prioritized for protection differed from those recommended by the biologists. The Xavante placed 96,000 ha of the reserve into three different wildlife refuges. These area were chosen not on the basis of distance from village but rather on the basis of geographical boundaries, location of villages, a perceived need to protect reserve boundaries, and interpretation of the areas as "production zones" for species of concern (F. Leeuwenberg pers. comm.). Animal abundances would be monitored using the track-sampling method, and when abundances increased in an area, hunting would intensify there and decrease in areas where monitoring showed tracks were decreasing. A ban on hunting of tapir and marsh deer, however, would continue in some areas even after they were opened to hunting of other species. The decision to eventually hunt these two species would be made on the basis of track monitoring. Thus, the Xavante preferred to manage species on the basis of refuges rather than on the basis of hunting bans, a decision similar to that of the Embera in Colombia (Ulloa, Rubio-Torgler, and Campos-Rozo 1996, this volume). During the first part of the study, Leeuwenberg (1994) also recommended a ban on two species of concern, the pampas and marsh deer. The Xavante men's council decided against this recommendation, preferring to leave an area unhunted rather than to eliminate the hunting of a particular species altogether.

RATIONALE BEHIND THE MANAGEMENT CHOICES BY THE XAVANTE

To test the hypothesis that the difference between the biologically recommended plan and the Xavante choice lay in culture, tradition, and different interpretation of biological facts given by a very different world view/system of explanation, I searched the anthropological literature for references to use of the different game species by the Xavante. None of the studies carried out by anthropologists at the Eteñitepa community adequately quantified hunting returns, but I have deduced overall patterns from their descriptions of hunting. Maybury-Lewis (1967) gives a qualitative description of the importance of different game species, while Flowers (1983a) monitored meat intake by two households during three days on four occasions representing different seasons. Maybury-Lewis states that peccaries, tapir, and deer were the most prized animals in 1958, describing them in that order. Based on common name roots, he indicates that tapir are classed with peccaries. All deer share the same name root except for marsh deer, which is classed separately. He has little to say about the giant anteater, except that it was abundant and was hunted. Today, this species is the third most frequently captured.

The animals noted by Flowers for twenty-four hunts in 1976 and 1977 are twelve white-lipped peccaries, five brocket deer, eight tapir, and three pacas. She comments that men hunt paca at night in the gardens and that by this time this species had become a much more important aspect of community life and food production than it was during the Maybury-Lewis study. Even though her sample size is small, if giant anteaters were being captured at the same frequency as they are today, they should have appeared on her list. The high frequency of tapir captured during Flowers's study is also surprising since today tapir are not brought in any more frequently than the larger deer species, which do not appear on Flowers's list. Still, since different hunters tend to specialize in specific animals, it is difficult to interpret Flowers's small sample size.

Leeuwenberg (1994) comments that primates were never eaten during his study, although they were during Maybury-Lewis's survey. This absence may reflect the influence of white prejudice against primate meat or the fact that currently the Xavante do no like to hunt in forested areas. Community members informed Leeuwenberg that during a past time of low-game availability, capybara, boas, and foxes were also eaten, although they are not used today (Leeuwenberg and Robinson 2000).

These early changes in hunting parallel the change to a sedentary life style and a greater economic reliance on agriculture. The community has been undergoing constant change since first contact with whites in the 1700s, their retreat from white contact in the mid to late 1800s and their subsequent establishment in their current homeland. When they arrived at their current location (1850 to 1940), the ancestors of the current community members were seminomadic. In the late 1960s they still trekked for most of the year (Maybury-Lewis 1967). By the late seventies, however, they trekked only a few weeks on the year (Flowers 1983a,b). By the early 1990s they relied little on communal hunts or large long-distance fire hunts (Leeuwenberg 1994).

In conclusion, the anthropological literature suggests that the list of preferred species hunted by the Xavante has changed in parallel with (a) changes in game populations, (b) an increasingly sedentary life, (c) an increased emphasis on gardens, and (d) a more recent reclamation of a traditional hunting culture. Thus the reasons for the differences between the management recommendations of the biologists and the final Xavante choice are practical and biological rather than cultural.

The work by Maybury-Lewis (1967) and Flowers (1983a,b) suggests that tapir were either more abundant in the past or were hunted more intensively. The Xavante may be aware of a decline in tapir populations during the last thirty years that cannot be picked up by the short-term study carried out here. It is possible that the population has stabilized at a lower level than at some past time, as has occurred with hunted ungulate populations in the temperate/arctic zones (Caughley and Sinclair 1994). Anteaters, on the other hand, seem never to have been a preferred or culturally important species. The current intensive use of anteaters is probably recent, suggesting that the Xavante are substituting anteater for other preferred species. This use could be a response to an overall decline in availability of other species or a consequence of hunting near the village. In either case there may not have been time for a reciprocity or respect bond to be established with the species or even for accurate knowledge of its natural history, carrying capacity, or population characteristics to accumulate. The special concern for the marsh deer and the lesser concern for the pampas deer are difficult to explain from either a biological or cultural point of view and may be due to a simple preference for pampas deer meat.

Despite the lack of evidence for a cultural or spiritual basis for the Xavante's management decisions in this study, other studies do point to the importance of spiritual practices in determining how indigenous peoples interact with game (Albert 1985; Anderson 1996; Colding and Folke 1997). These attitudes are based to an unknown degree on knowledge of natural history and an understanding of the explicit need to manage resources. We do not have sufficient information on the relationship of the Xavante and other indigenous groups with animals at the spiritual level so as to understand how their decisions are made and to predict how decisions will be made in the future. Partly this lack of information is due to the unwillingness of some groups to discuss cosmological issues with outsiders, and biologists must respect and work around this desire for cultural privacy. However, Ulloa, Rubio-Torgler, and Campos-Rozo (this volume) show how a participatory process can successfully allow a community to make management decisions consonant with their world view without the need for an in-depth study of the cultural aspects of hunting.

DYNAMICS ASSOCIATED WITH THE IMPACT OF WESTERN CULTURE ON INDIGENOUS COMMUNITIES

Researchers have identified and, in some cases, studied in detail the aspects of Western culture that can alter indigenous cultures and lead to the overexploitation of game animals. These factors will be operating in all but the most intact indigenous cultures and must be addressed during the elaboration of management plans.

TRANSITION FROM A SEMINOMADIC TO A SEDENTARY LIFE

The most effective factor preventing extreme game depletion may be the traditional seminomadic life of most Amazonian indigenous groups at the time of contact (Vickers 1991; Townsend 1995a; Ulloa, Rubio-Torgler, and Campos-Rozo 1996; Fragoso, Silvius, and Villa-Lobos 2000; Robinson and Bennett 2000b; Stearman 2000). This system creates a shifting impact on game populations over the landscape in time and space. Game populations probably always declined locally to the point at which they were not efficiently hunted with bows and arrows, contributing to the decision to move the village site or to undertake an extended trek. The impact, however, was probably never sufficient to cause local extinction of an animal population. Following contact, many national governments pursued a policy of settling indigenous communities and limiting their ability to practice seminomadic hunting. Limits to reserve size, presence of permanent health posts, and agricultural or livestock projects all lead to sedentarianism. With communities remaining in the same location, sometimes for decades, local game depletion becomes chronic. Game populations may be endangered if they are also under pressure from forces external to the reserve.

The transition to a sedentary life includes not only remaining at a fixed village for more than the two to four years typical of precontact times but also the degree of reluctance to temporarily trek away from this village. The importance of the village versus trekking will vary from community to community. Even historically, the Xavante were likely to have a fixed village site, but they were not there very often (Maybury-Lewis 1967). The Yanomami of northern Brazil and southern Venezuela, on the other hand, both shift the village site and trek extensively (Good 1989).

Currently, the Xavante of Eteñitepa maintain a fixed village and do not trek. This way of life has a negative impact on culture but may have a positive impact on game populations: if no hunting occurs away from the village, then there is little reduction of game populations and areas distant from the village may in fact become source populations that can be included in the management plan (Fragoso, Silvius, and Prada 2000; Novaro, Redford, and Bodmer 2000). However, with access to motorized vehicles, some sedentary communities are now able to hunt distant locations without moving the village site or trekking (Fragoso, Silvius, and Prada 2000; Souza-Mazurek et al. 2000). Without an explicit rotational hunting scheme, the overall impact can be heavier than before: the home site is given no chance to recover, and the distant areas are also hunted

INCORPORATION TO MARKET ECONOMIES

Participation in market economies is considered to be one of the primary contributors to the loss of traditional practices by indigenous groups because such participation brings access to new technologies, shifts traditional power hierarchies in a community, favors sedentarianism, and removes both men and women from traditional practices such as hunting and gardening in favor of seasonal or permanent wage labor. There have been several individual studies of the dynamics within individual communities that lead to participation in market economies and promote overhunting or overfishing (e.g., Gross et al. 1979; Yost and Kelley 1983; Stearman 1990; Stearman and Redford 1992; Godoy, Brokaw, and Wilkie 1995; Godoy, Wilkie, and Franks 1997; Santos et al. 1997; Fragoso, Silvius, and Prada 2000; Townsend 2000b; Godoy, Kirby, and Wilkie 2001).

POPULATION GROWTH

When a community becomes sedentary near a health post, human population is likely to increase due to reduced mortality. Management plans must be able to predict growth on the basis of demographic and cultural factors and to determine how such growth can be prevented from affecting wildlife populations. While management can potentially increase the game yields by keeping populations at the most productive level through cropping, the potential is limited and dangerous (Caughley and Sinclair 1994; Bodmer and Robinson this volume). Therefore alternate resources will need to be used unless the community controls its population growth. In the case of the Xavante, population increase in one site may have been traditionally mitigated by village fissioning. Community division can be detrimental to current management plans, however, by spreading the impact on wildlife population into source areas and by making it difficult for agreement to be reached among communities that have split along hostile faction lines.

HABITAT FRAGMENTATION

Because of increasing land conversion to pasture and agriculture, indigenous reserves like national parks are often isolated from contiguous natural habitats that still support healthy wildlife populations. Management plans must assess the vulnerability of fragmented wildlife populations and look for ways of interconnecting reserves with any other territory. In the case of the Xavante, some wildlife species appear to have population sources outside of the reserve (Fragoso, Silvius, and Villa-Lobos 2000). Here the importance that Ulloa, Rubio-Torgler, and Campos Rozo (this volume) assign to the meshing of local, state, national, and international goals becomes a key issue. To the extent that state and national governments are charged with biodiversity protection, indigenous reserves with a good management plan can provide this function and therefore could receive govermental benefits, such as the guarantee of inviolate borders, in exchange for this service.

TRADITIONAL FORMS OF MANAGEMENT AND PATTERNS OF RESOURCE USE

Traditional management practices, such as food taboos, protection of sacred sites, explicit management by shamans and elders, the concept of "owners" of the game, and others, persist in many communities and exert bottom-up pressure for resource protection. These practices open up the potential for effective, innovative resource management by indigenous peoples if they are integrated with, and in some cases substituted for, Western scientific precepts for management. Because these practices and cosmological factors are in some cases the same or similar for several indigenous groups, they are worth examining as focal points in the elaboration of indigenous management plans.

WHITE-LIPPED PECCARIES

In terms of biomass the white-lipped peccary is usually one the most important sources of protein for Neotropical indigenous peoples (Good 1989; Stearman 1995; Mena et al. 2000; Townsend 2000b). It also figures prominently in spiritual or reciprocity systems (Ulloa, Rubio-Torgler, and Campos-Rozo; R. dos Santos pers. comm.; J. Fragoso pers. comm.). The status of white-lip populations and of the traditions associated with the species may serve as indicators of the health of both wildlife and culture, and the species may be a good focus for educational campaigns and management plans. In cases where the white-lipped peccary is not a common animal or is not commonly hunted, another species may substitute it—e.g., marsh deer in the case of the Xavante (Fragoso, Silvius, and Prada 2000; Leeuwenberg and Robinson 2000) or rheas in the case of the Izoceño-Guaraní (Noss and Painter this volume).

EXISTENCE OF SACRED AREAS

Many cultures have traditional reserve systems, sacred sites in which hunting is prohibited because of their cosmological significance (Ventocilla 1992; Ulloa, Rubio-Torlger, and Campos-Rozo 1996; Fragoso, Silvius, and Villa-Lobos 2000). This system provides a population source area for animals and in some cases is recognized as such by the communities themselves (Fragoso, Silvius, and Villa-Lobos 2000). With the loss of traditional cosmology and values, such sites are no longer protected.

Sacred areas or other areas with special status should be assessed for their value in protecting biodiversity and be involved in management plans, either directly as actual refuges, as in the case of the Xavante and the Embera, or as a conceptual tool to explain Western systems of protected areas. If an area has spiritual as well as natural value, it is more likely to be protected in the long term, and its protection will also serve to reinforce cultural values.

HUNTING LARGE ANIMALS FOR RITUALS

Many groups use small mammals daily but focus on white-lipped peccaries and other large mammals for rituals, such as when members of other communities are invited as guests or when weddings, funerals, or rites of passage are celebrated. If this pattern can be reinforced, it may be a good management tool, increasing pressure on small mammal species with healthy populations and high reproductive potential (Bodmer 1995b; Bodmer, Eisenberg, and Redford 1997) and reserving large species for special occasions. The availability of shotguns, which make hunters more likely to pursue large game, and of motorized vehicles, which make it easier for large game to be carried back to the village, currently works against this tradition (Hill and Hawkes 1983; Peres 1990; Souza-Mazurek et al. 2000).

HUNTING IN GARDENS

Hunting in gardens occurs to some extent in all communities but seems to be more common in the more acculturated ones. The Xavante currently reject this option (F. Leeuwenberg pers. comm.), but it seems that twenty years ago they may have used it (Flowers 1983b). It needs to be seriously considered, as it will put pressure on smaller animals whose populations can sustain higher harvest rates (Bodmer, Eisenberg, and Redford 1997).

SHAMANS

Among many indigenous peoples certain older hunters and shamans hold the role of "owners of the game" (Fragoso, Silvius, and Prada 2000). These men have extensive knowledge of the natural history of a particular species and are believed to be in spiritual contact with either the animals or the spirits that represent or mediate for the animals. They can decide whether or not a particular species should be hunted at a particular time and how many individuals should be taken (Ulloa, Rubio-Torgler, and Campos-Rozo 1996; Rubio-Torgler 1997; Fragoso, Silvius, and Prada 2000; Leeuwenberg and Robinson 2000; R. dos Santos pers. comm.). Like taboos, these practices are lost when younger men with access to money, education, and market goods and communication with the national society gain authority and power in the community (Stearman 1995; Fragoso, Silvius, and Prada 2000).

Flowers (1983a,b) and Leeuwenberg (per. comm.) both describe the practice of "owner of the game" among the Xavante, where one man is responsible for directing the hunting of a particular species. The amount of control the person has in determining when and how many individuals of a species should be hunted is not known; the practice may not be comparable to hunting decisions made by shamans in other tribes or to the controlling power ascribed to them by the community (Ulloa, Rubio-Torgler, and Campos-Rozo 1996, D. Yanomami pers. comm.). In the case of the Xavante, such decisions are made by the entire men's council, and it is unclear how much influence one person, the "owner" of a particular game species, might have.

Projects aimed at developing management plans for indigenous areas should ascertain the degree of respect accorded to the shaman or to the equivalent person. The shaman can be a focus for management if he/she has been traditionally viewed as a manager. As described by Ulloa, Rubio-Torgler, and Campos-Rozo (this volume), the Embera stated that shamans should be given decision-making control over animal management because that is how their traditional role is now perceived. The translation between the spiritual control originally attributed to the shaman (covering and uncovering the entrance from the underworld from which animals emerge) and the biological management necessary today is unclear. It is best to make use of this strategy by viewing the shaman as a knowledgeable person who can lead a community in coherent game use in accordance with biological requirements.

TABOOS

For many Amazonian indigenous groups, taboos prevent seasonal or complete use of certain animal species (MacDonald 1977; Ross 1978; Colding and Folke 1997) and may thus decrease hunting pressure on animals, including those that are vulnerable to local extinction (Colding and Folke 1997). However, taboos are rapidly lost following contact: the Huaorani of Ecuador shifted their target species over a fifteen-year period once certain species became amenable to hunting with guns or were valued in the market (Mena et al. 2000). Ulloa, Rubio-Torgler, and Campos-Rozo (1996) also indicate that there has been considerable breakdown of taboos in the Embera society, probably due to the extreme reduction in animal populations. Leeuwenberg (1994) mentions that the Xavante have taboos on armadillo, brocket deer, and peccaries, which cannot be eaten by parents for the six months after the birth of a child. The author does not comment on how strictly these partial prohibitions are adhered to. He also indicates that the use of capybara, fox, and large snakes in the past was restricted by a partial taboo to elderly people and that even today the lesser anteater (tamandua) is eaten primarily by elderly people (F. Leeuwenberg pers. comm.).

Because taboos are flexible and situation-specific, they may or may not function as an adequate management tool. Projects should assess the degree to which traditional taboos are followed. If adherence is lax, then game populations are probably in trouble, and commerce in game meat may be important.

ROLE OF FISHING

Fishing is easily incorporated into and accepted by traditional societies. The reasons for this easy acceptance may be because fishing is similar to hunting (killing a large animal that requires stalking and other skills), although not as strenuous, and because fishing has always been used to some degree. Both the Xavante and the Embera chose an increased emphasis on fishing as a preferred management tool (Fragoso, Silvius, and Prada 2000; Ulloa, Rubio-Torgler, and Campos-Rozo this volume).

However, if there is pressure on fish stocks from human populations outside the reserve or by illegal incursion into the reserve, then the alternative may not be viable, or it may lead to conflict between ethnic groups. Management of the fish stocks will also be necessary to prevent overfishing, especially if the group does not have a fishing tradition with culture-specific management practices. This is of special concern given the ease with which fish populations are driven to extinction by the use of traditional fishing methods such as poison and such introduced methods as gill nets, dynamite, and bleach. Fishing is thus best incorporated into a seasonal shift in resource use, as a complementary diet source rather than as an absolute substitue.

Projects should always assess the willingness of the community to use alternate protein sources rather than introducing a source that is not already acceptable, such as domestic animals, because such acceptance is likely to weaken the traditional culture (Ulloa, Rubio-Torgler, and Campos-Rozo this volume). For example, when missionaries provided domestic chickens to the Yanomami of the Catrimani area as an alternative protein source to hunting, community members simply left the animals to starve in their cages when they went on trek because they had no tradition of or philosophical basis for domestic animal husbandry (P. Guillerme pers. comm.)

CONCLUSION

The above factors serve both as indicators of health of game animals in indigenous areas and as management tools for a community. Traditional reserves can work as well or better than reserves chosen for purely ecological reason because the community will already respect their boundaries. Management for white-lipped peccaries will automatically protect large areas or habitat mosaics that are key to smaller species, at least in a forested habitat. Strengthening the traditional role of shamans will also strengthen the importance given to traditional natural history observations and management systems such as hunting or burning seasons (Fragoso, Silvius, and Prada 2000). Managers or management plan designers should survey the status of the above factors to determine the context in which the management plan will take place. They could focus wildlife management and education on key species in which the hunters have a traditional interest, using these animals as conceptual as well as ecological umbrella species. The type of analysis used by Ulloa, Rubio-Torgler, and Campos-Rozo (this volume) if included from the start of the study will increase the study's coherence and facilitate decision making.

4

Increasing Local Stakeholder Participation in Wildlife Management Projects with Rural Communities

LESSONS FROM BOLIVIA

WENDY R. TOWNSEND

Conservation professionals must consider how to improve their ability to promote wildlife management as a viable development alternative in Latin America. Although not all countries have the same socioeconomic situation as Bolivia, we can probably all agree that natural resource management implies more than just extraction. In legal terms (e.g., Forestry Law #1700 of Bolivia), commercial harvest should require an indication of sustainability documented in the form of a management plan. To produce a management plan, it is essential to have a clear view of the social reality within which wildlife management is to be carried out. For many people, especially for indigenous peoples, wildlife resources make survival possible in the marginalized informal economy they experience in the countryside. For this reason a wildlife management plan requires the participation of local game users to achieve success in a way that a timber management plan may not. The challenge for wildlife managers is to promote biodiversity conservation while recognizing the dignity of the local people, decreasing poverty, and promoting self-administration. These needs imply the participation of local people at all stages of planning and implementation.

Subsistence hunting is a daily activity for rural people in Bolivia and other regions of Latin America. Hunters are naturally interested in wildlife issues and are therefore easily involved in wildlife management. It is particularly important that hunters participate because they make the decisions as to what animals to hunt and when, although sometimes this decision is instantaneous. That moment of decision during a (usually) solitary activity is important, and one that needs to be adequately understood in order to reinforce the behavioral changes needed for sustainable management of wildlife resources. With these considerations in mind, we must examine both the social and legal contexts in which rural inhabitants live because increasing the hunters' involvement will help make them responsible for the management of their wildlife resources. This article offers some ideas for achieving this goal by describing some participatory management techniques, along with their limitations.

DEFINING PARTICIPATION AND PARTICIPATORY

Participation is a very popular concept in many projects, especially in Bolivia, where it is also guaranteed and regulated by legislation. Given that wildlife management requires that hunters participate, it is interesting to contemplate what such participation implies. In the Larousse Spanish Dictionary (García-Pelayo and Gross 1979), we find three interpretations of the word:

1. "Act of participating and its result";
2. "Notice, warning";
3. "System by means of which the employees of a firm are linked to its profits and eventually to its administration."

These definitions accurately reflect the different levels of participation that are found in natural resource management. According to the second definition, for example, only the giving of information is required, while the third definition leads to self-motivated management.

Participation in natural resource projects is carried out in many different ways and to different degrees. In Ecuador, The Nature Conservancy (TNC) designed a system of categories to evaluate participation in its PALOMAP project in the Cayembe-Coca Ecological Reserve (B. Ulfelder pers. comm.). I use the ideas here because they are useful in helping wildlife managers develop their approach to community management plans. In figure 4.1, these categories are represented in

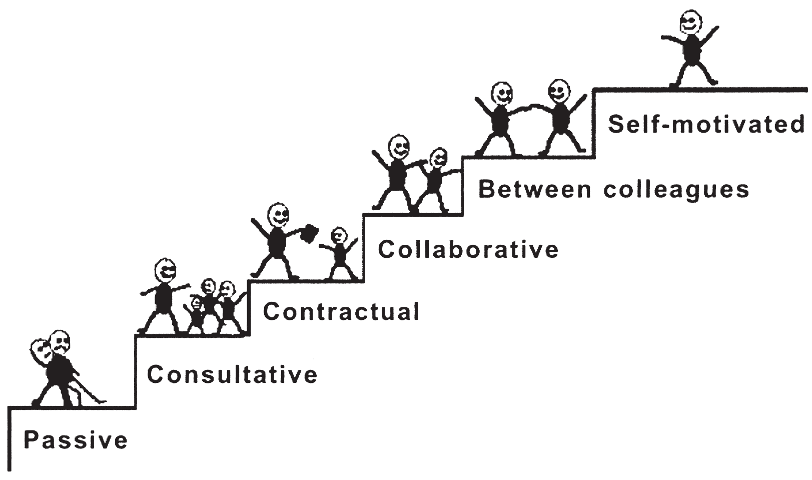

FIGURE 4.1 Stairway to self-motivated participation in resource management.

the form of a ladder, with the steps leading toward increasing participation until the most desired outcome, autonomous and self-motivated management, is reached. The categories that represent the different levels of community participation are described below.

PASSIVE

Passive participation occurs when plans are produced in an office without consultation or intervention by stakeholders. From the point of view of conservation, passive participation is not very useful because it usually does not consider the local reality and thus does not seek, nor does it achieve, consensus with local people. Additionally, this method can lead to serious conflicts because of misunderstandings among local stakeholders, managers, and institutions.

CONTRACTUAL

Contractual participation implies that local people are contracted to carry out a project that was developed by others on behalf of the community. It is akin to paying local people to manage their park but without giving them any power of decision over park management. To a certain extent this participation is analogous to the situation that occurs when logging companies pay for standing wood (in indigenous territories) and take charge of management plans, permits, and administration without any local participation.

CONSULTATIVE

In consultative participation, the institution comes to the community to present its ideas and objectives, but it provides little room for an exchange of ideas. Often, a language of exclusion is used, which relies on technical words and which might even require the use of translators. Consultation may occur unexpectedly without sufficient advance warning for the community to reflect on the topic. Sometimes consultation is carried out independently with different segments of society, typically with men and women as separate focal groups, in an misguided attempt to be "gender sensitive." A consultation meeting may end in an agreement that is not well understood by all the participants. The agreement may easily be forgotten by the time the project reaches the implementation phase. A participatory consultation process can be very useful for gathering initial information, but attempts should be made to ensure that there is information sharing as well as information extraction.

BETWEEN COLLEAGUES

Participation between colleagues requires information to flow horizontally and bidirectionally. It implies the building of a true process of communication with the community during the planning and implementation stages. Achieving this level of communication may require a change in professionals' attitudes and in particular in the technical language they have become accustomed to use. This level of participation also requires mutual respect from the professional and the local people, with each participant listening, attempting to understand, and fulfilling the role they must play in the management plan.

SELF-MOTIVATED

The most complete type of participation is self-motivated, and is attained when the community invests its own effort in participating, exercising its power of decision, seeking information about its own problems, and implementing possible solutions. At this point the community is autonomous in its management decisions. Such autonomy does not mean that community members can or will wish to perform all the tasks necessary for management actions by themselves, but rather that they are prepared and able to make the management decisions that they are convinced are necessary.

COMMUNITY PARTICIPATION AND THE CHALLENGE OF ACHIEVING SELF-MOTIVATION

The real challenge is to attain self-motivated participation by communities in wildlife management plans. We know that wildlife issues are able to attract the attention of stakeholders. For example, in the United States hunters supported levying taxes on themselves from gun and ammunition sales to fund game management (Lacy Act). Although similar initiatives might also be possible in some Latin American countries, most rural subsistence hunters do not have the wherewithal to pay taxes. Perhaps by taxing adventure tourism and other nature-seeking tourists, a fund could be developed, but for most Latin American countries, it would be irresponsible to even dream that taxes could lead to wildlife conservation and the timely protection of critical wildlife populations. For wildlife professionals in rural South America, it should be clear that the people who use the game must be responsible for the sustainability of their resource use. It is our challenge as professionals to provide them with the tools to facilitate the process.

Achieving stakeholder-motivated participation, although an attainable goal, faces many difficulties, especially those based in human limitations. First, there is the diversity of personalities involved—not all biologists have a vocation for working with people. On the contrary, some biologists chose their field of study because they prefer animals to humans! Nevertheless, professionals can educate themselves and become more sensitive to participatory issues, and local people can start to demand mutual respect for their right to participate. Each professional must recognize his or her own strengths, abilities, skills, weaknesses, and, limitations. Most importantly, they must honestly evaluate their own commitment as a colleague with community members. This is the only way in which professionals will be able to stimulate community participation through the processes of information gathering and informed decision making.

Another constraint on achieving self-motivated participation in natural resource management is time. Community processes tend to occur slowly, although occasionally communities can be stimulated to take major actions quickly. It can be difficult to obtain funding for long-term programs because funding agencies prefer three-year projects. Therefore community-level processes run the risk of being pressured and thus distorted by professionals in order complete the logical framework and to ensure financing for the following phases. It is extremely important that funding agencies begin to consider the amount of time required for true community-level processes.

Even though most wildlife management concepts are intuitive and logical and have long been observed by rural people with their domestic animals, the language used to express the concepts can be one of the primary obstacles to participation. Not only can Spanish sometimes be the second language of the participants, there is also an exclusionary effect due to the use of technical terminology. Professionals tend to use technical terms as though they were a part of daily language. These words can frighten or confuse rural listeners, and as a consequence, they are rarely inclined to ask for clarification. The result is insufficient informed participation and the inability to attain a good consultation.

Thus it is very important to create dictionaries and glossaries to explain the terminology in each local language so that professionals and technicians can stimulate participation through use of a people's own language to explain technical concepts. The need for translations between two kinds of knowledge—academic and local—becomes even more obvious when we try to achieve self-management because local people will need to integrate all the information from all sources in order to make sound management decisions.

PROMOTING COMMUNITY PARTICIPATION IN WILDLIFE MANAGEMENT

To increase community participation in wildlife management, one must move up the ladder, converting consultation into self-motivated management (fig. 4.1). There are certain attitudes, techniques, and actions that broaden participation:

1. Return all work done with the community back to the community in a permanent way that they will understand. This is the primary complaint of indigenous peoples. They point out that others have studied them for many years, but the majority of this information has not been returned to them. Libraries in Europe and the United States sometimes contain more information about Latin American indigenous peoples than libraries in the region itself. Fortunately, the internet is increasing access to information, but this source of information is not available to most of these communities. The use of workshops to return information is only one step; it is important that communities be left with a written record of the work accomplished.

2. Dialog must be multidirectional: All the actors, at all levels, must be included in the dialog. Professionals must learn to listen and read the message between the lines. Sometimes, with the opening of discussion, conflict arises. This conflict may have existed prior to the dialog, but previously it would have surfaced in ways and at moments that were unfavorable for reaching resolution. By promoting discussion among stakeholders, conservation professionals can guide the search for solutions before wildlife populations reach a critical point. During a recent round table discussion on wildlife management, the question arose of "What do indigenous peoples want the professionals to do?" This is a very difficult question for indigenous people to answer because most of them do not understand what skills or services we have to offer. We need to open the dialog and thus become informed of each other's roles in order to reach a mutual understanding of the necessary steps toward productive community wildlife management. It is our obligation to explain the ways in which our knowledge is useful and to describe the tools we bring with wildlife management. For their part local communities can contribute considerable specific information about the local environment, which can be crucial to the success of management efforts.

Local knowledge is a truly valuable source of secondary information and one that can serve as a baseline for future research. In some localities there still exists local knowledge, accumulated over centuries, with details about distributions, diets, behavior, and other factors necessary for the elaboration of wildlife management plans.

However, not all representatives of a culture know every detail, as there are usually specialists on the subject of wildlife. Hunters are the main group of specialists, but there can be others who transfer their knowledge in the oral history (alternatively called mythology). This has been my own experience with the Murui of the Caquetá river (Townsend, Nuñez, and Macuritofe 1984; Townsend 1995b) with respect to primates in the area of Araracuara, Amazonas, Colombia. When that research was done, there was very little acceptance by the academic community of the utility of indigenous knowledge except with respect to medicinal plants (Posey 1985; Posey and Balée 1989; Clay 1988). The oral history of the Murui is almost an instruction manual of natural history because it includes information about food species, activity patterns, and other details important for wildlife management (Townsend, Nuñez, and Macuritofe 1984). When the information obtained from the Murui expert Vicente Macuritofe Ramirez was compared with that published in the scientific literature, there was a 97% agreement rate (Townsend 1995b). But this information was obtained through interview work with a culturally known specialist of the Murui, not through a participatory meeting.

It is important to understand that there are analytical limitations to the information obtained through participatory meetings and interviews. The first key point is that the information comes from opinion and memory and therefore requires different analytical methods than those used for direct measurements with which we, as biologists, are more familiar. For example, a numerical value agreed upon during a participatory meeting is not an average, as it has no range of values. Therefore it cannot be statistically described unless it is compared to numerical values agreed upon in other meetings, the value at each meeting being the unit of analysis.

Similarly, participatory meetings and interviews should not be used to determine the amount of wildlife harvested for the management plan. Although the people may have a good idea about how much they use, the frailties of human memory and character make it risky to quantify game use in this way for the development of a management plan. Other, more reliable, techniques are available to evaluate wildlife harvest levels to improve management efficiency.

Participatory meetings can facilitate reaching consensus about specific wildlife issues and the information gathered. Although sometimes these meetings are dominated by a few participants, if guided properly, they can provide the opportunity to gather basic information, such as fruiting cycles of wildlife food species. Participatory meetings have produced lists of wildlife food species and of their availability cycles in several places, including the Izozog, Ibiato, TIPNIS, Pilón Lajas, Madidi, and Lomerío where workshop participants identified more than sixty species (Townsend 1995a, 1996; Ino, Kudrenecky, and Townsend 2001; Townsend 2002). Other important points that can be researched during participatory meetings and interviews are the areas and resources critical for wildlife. This information is imperative for any wildlife management plan (Townsend 1996a).

Participatory meetings are also good communication spaces for registering the local names of habitat types in the area. Community maps developed in these meetings facilitate the naming and the distinguishing of these habitats. This work can provide a baseline for communication between professionals and local hunters because it stimulates the interchange of technical descriptions and local knowledge. In this way local people become involved in data collection for management plans for all their resources, including wildlife. Local knowledge is subject to confirmation by observations, and local peoples have shown themselves to be excellent at making these observations. If given the tools, local people can collect data on resource extraction, resource availability, and phenology, as well as other parameters critical to monitoring sustainable natural resource management.

One tool that has been especially useful in promoting participation in data collection for wildlife management has been for hunters to self-monitor their game harvest. In Bolivia this system has had moderate success in promoting community participation but as yet has not led to a self-motivated management system. For example, the Yuracaré of San Pablo, Territorio Indigena Isiboro Secure, registered the use of five classes of resources during one year without much oversight by an NGO (Z. Lehm pers. comm.). Seven families in San Pablo registered their hunting, fishing, fruit collection, garden produce, and the trees that they cut during more than one year. They stated that they believed this information to be important for community planning. There are various experiences with game harvest monitoring by hunters from a variety of indigenous groups: Chiquitano (Lomerio: Guinart 1997), Sirionó: (Ibiato: Townsend 1997), Guaraní (Izozog: Noss and Painter this volume) and 'Tsimane (Pilon Lajas: Townsend 2002).

The key to achieving self-monitoring success is to create the mechanism in conjunction with the community. For example, one may invent a way in which hunters can easily report their harvest without affecting their cultural habits by, for instance, the collecting of the skulls of hunted animals. Alternatively, more detailed information can be reported on participatory data sheets. Data sheets have been most successful when they have been designed together with the hunters, thus giving them the opportunity to learn why each piece of information is important. Hunters are more likely to collect the information and use the data sheets if they understand how the information will add to their management plan.

In Bolivia people have responded to this process in a very positive way. The Chiquitanos, for example, insisted on writing the questions on the data sheet in their own language for their children and in Spanish for the hunters (figure 4.2). Linguists have refined the Chiquitano alphabet to the point that some hunters actually have problems reading with the new alphabet, but since the school children use the new way, the hunters wanted it on their form (Townsend 1996a). Some Sirionó have registered their game harvest for more than five years (F. Billon pers. comm.). The 'Tsimane Indians of Pilón Lajas Biosphere Reserve and Indigenous Territory have voluntarily registered their game for two years, and the results have generated community discussions on protecting some areas as reserves and for ecotourism (Townsend 2002). Experiences in Bolivia have also shown that hunters

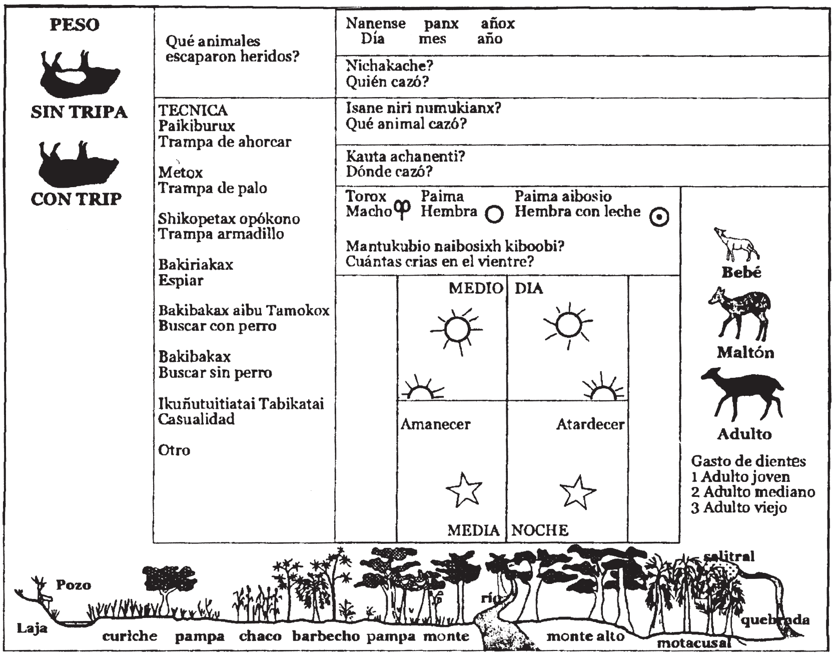

FIGURE 4.2 Self-Monitoring game harvest form designed with Chiquitano hunters of Lomerío.

who know how to write appreciate the opportunity to use this skill. Professionals need to be creative in looking for the ways to explain the utility of the information and in making the data sheets attractive and even fun to use. The information gathered must always be summarized in consultation with the hunters, who then are the first to know what their hunting totals are.

The success of self-monitoring of resource use and availability lies in its twofold utility—first as an impact on the process of community development and second in its ability to obtain the needed data to formulate a management plan. When participatory research tools are given to the resource users, these users also receive the power to inform themselves as a community about the state of their natural resources (Ino, Kudrenecky, and Townsend 2001; Salvatierra et al. 2001). This process may not function in all communities or in all situations where it is attempted. However, the results can be surprising in terms of the assumption of responsibility by the communities (Townsend et al. 2001; Ellis 2002; Townsend 2002). Participatory research allows communities to feel they are the owners of the process and of the information gathered. The sense of ownership of the process is a large step toward self-motivated wildlife management.

5

Community-Based Wildlife Management in the Gran Chaco, Bolivia

ANDREW J. NOSS AND MICHAEL D. PAINTER

Since 1991 the Wildlife Conservation Society (WCS) and the Capitanía de Alto y Bajo Izozog (CABI) have collaborated in the design and implementation of a community wildlife management program in the Bolivian Chaco. WCS is an international conservation organization that works to conserve wild areas and wildlife and carries out research on wildlife species and ecology. CABI is the indigenous organization that represents approximately 9,000 Izoceño-Guaraní inhabitants of twenty-threee communities of the Izozog along the Parapetí river south of the Bañados de Izozog wetlands (declared a RAMSAR site in 2001). This article examines the collaboration between WCS and CABI through the present time, emphasizing activities at the regional and local levels as well as at the institutional and biodiversity levels.

REGIONAL AND INSTITUTIONAL CONCERNS

At the beginning of their collaboration, the interests that governed the respective positions of WCS and CABI for conservation in the Chaco were fundamentally different. On the basis of extensive field research in the Gran Chaco of Argentina, Paraguay, and Bolivia (Taber 1991; Taber et al. 1993, 1994, 1997), WCS became concerned that Bolivia was the only country in the region where large expanses of Chacoan ecosystems and habitats remained relatively intact, and perceived the creation of a protected area as a first step toward conservation of the region. Dry forests are the most threatened ecosystems in lowland Bolivia (Taber, Navarro, and Arribas 1997), while tropical dry forests represent one of the most endangered biomes globally (Janzen 1988; Redford, Taber, and Simonetti 1990).

CABI, as political representative of the Izoceño communities, began its fight for land rights in the 1940s as the Izoceños sought to recover from the devastating Chaco war. Following protest marches to La Paz, the Izoceños received their first land titles in 1948 but promptly saw the titles nullified by the agrarian reform of 1953. Forced to start over, not until 1986 did they once again receive land titles totalling 65,000 hectares. This grant was an important landmark but nevertheless of greater symbolic than real value: the area was insufficient to assure the long-term survival of the Izoceño people because it covered only a part of the land occupied at the time by the Izoceño communities. The land grant also failed to provide for population growth.

CABI therefore began to seek alternative mechanisms to consolidate territory in order to guarantee the long-term survival and security of the Izoceño people and to stop the expanding agricultural frontier. At the same time, CABI sought to identify alternate means of livelihood for the Izoceño people, which did not include the negative environmental, socioeconomic, or cultural impacts associated with the forms of farming and ranching that fueled Santa Cruz's agroindustrial growth since the 1950s. Independently of WCS, CABI leaders reached the conclusion that a protected area would provide the legal basis for halting the expanding agricultural frontier, as well as a focal point for defining new production alternatives.

On the basis of these complementary interests, different but convergent with respect to the future of the Bolivian Chaco, CABI and WCS began to work together in the region in 1991. In the case of the Bolivian Chaco, WCS considered collaboration with and participation by CABI and the Izoceño communities to be the best and only option for long-term biodiversity conservation.

The key success of the collaboration between CABI and WCS was the creation of the Kaa-Iya del Gran Chaco National Park and Integrated Management Area (KINP) in September 1995 (fig. 5.1). CABI presented the proposal for the creation of the park to the government of Bolivia. WCS provided CABI with technical assistance in preparing the proposal and assisted CABI through the review process. Following the creation of the park, CABI was named its coadministrator (together with the National Park Service SERNAP). Covering 3,440,000 hectares, the KINP is Bolivia's largest protected area and the largest tropical dry forest protected area in the world (Taber, Navarro, and Arribas 1997). It is also the only national park in the Americas created as a result of the initiative of an indigenous people and the only one in which a Native American organization shares fundamental administrative responsabilities with the national government.

In addition to the national park, CABI pursued a second and complementary path to safeguard Izoceño interests as a people. During 1996 CABI played a leading role in the successful effort of lowland indigenous peoples to include the concept of indigenous territory in Bolivia's new agrarian reform law (Ley de Reforma Agraria, Ley 1715, 1996). Called Tierra Comunitaria de Origen (TCO) in Bolivia, the concept refers to territorial rights as defined under International Labor Organization (ILO) Convention 169 on the rights of indigenous people. These rights are based on the historical occupation or use of an area and on the spatial requirements of a people needed to satisfy its subsistence requirements in a manner con-

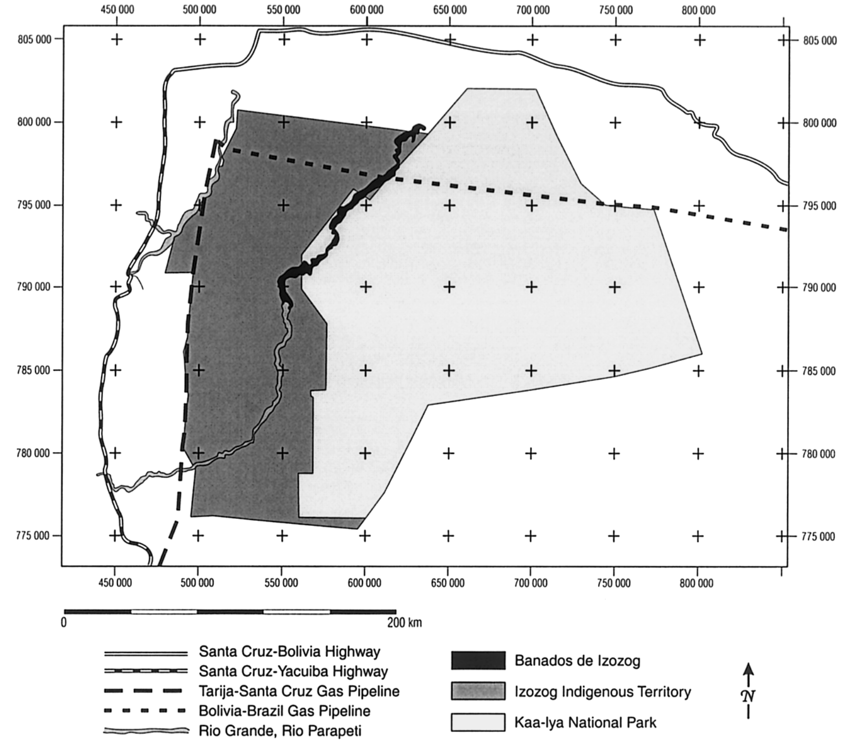

FIGURE 5.1 Map of Kaa-Iya National Park, Izozog Indigenous Terrritory, showing the major highways and gas pipelines.

sistent with its culture and way of life. In early 1997, taking advantage of the stipulations of the new law, CABI presented a demand for a TCO totalling 1,900,000 hectares (fig. 5.1) that adjoins, but does not overlap with, the KINP.

Although many other indigenous peoples also presented territorial demands at about the same time, CABI's case was unique because the territorial demand, like the proposal for the creation and administration of the KINP, derived from a vision of establishing an area in the Chaco that would safeguard the survival of the Izoceños as a people. As a result, contrary to other cases in Bolivia where protected areas and indigenous territories overlap and generate mutually exclusive land use and ownership conflicts, CABI's vision created the opportunity to manage 5,300,000 hectares of Bolivian Chaco—an area nearly the size of Costa Rica—under principles of conservation and sustainable use of wildlife and other natural resources.

The creation of the KINP, together with CABI's role as coadministrator, opened the door for a more extensive community conservation effort. In 1995 USAID/Bolivia joined the CABI-WCS association and began to provide financial assistance that will continue through 2003. WCS and USAID technical and financial assistance through the Kaa-Iya Project concentrates on four important areas: (a) institutional strengthening of the technical arm of CABI, the Ivi-Iyambae Foundation, (b) participatory research on wildlife populations and ecology and development of wildlife management practices, (c) planning and environmental monitoring, and (d) environmental education (Painter and Noss 2000; Painter et al. in press).

The beginning of the project coincided with a rapid expansion of the hydrocarbon industry in Bolivia, in particular with the construction of the Bolivia-Brazil gas pipeline that crosses or borders the KINP for 250 kilometers. Among other things the agreement provided $1,500,000 for titling indigenous territories in the pipeline's area of influence. CABI subsequently proposed a methodology for working together with the Instituto Nacional de Reforma Agraria (INRA), the Bolivian government agency responsible for land titling. Using this methodology, the agreement permitted the titling of the Ayoreo TCO demand for a territory north and east of the KINP. Although other donors, especially the Danish Aid Agency DANIDA and the World Bank, had been working on land titling for several years and had been investing greater sums of money, the Ayoreo TCO was the first indigenous territory to be titled in Bolivia. The Izoceño TCO is being surveyed and third-party claims are being addressed under a process that produced the first title in September 2001 for 160,000 hectares. Delivery of the final title in 2003 will complete the full 1,900,000 ha. Additional funds of approximately $4,000,000 under the agreement with the pipeline consortium included $1,000,000 to start a trust fund that will provide a source of permanent income for the KINP, funds to cover the costs of monitoring the construction of the pipeline within the KINP, and funds for research on flora and fauna that may be affected by the pipeline's construction and use.

As coadministrator of the KINP, CABI has played a crucial role in generating the funds necessary to cover its basic operating budget. During the period 1998 to 2000, the Bolivian government was unable to meet its obligations, and CABI covered over 51% of the operating budget. This allowed the KINP to continue functioning through the government's financial crisis and demonstrated to all the potential importance of the coadministration mechanism for the long-term viability of Bolivia's national parks.

When the TCO titling process is complete, CABI must present a TCO management plan to the government. This plan will include (a) a land use plan, based on a zonification according to the potential of the land and (b) an investment plan defining ways to finance productive activities defined in the plan. CABI's intention is that the zonification of the TCO be an extension of the zonification exercise completed for the KINP, using the same biological and socioeconomic criteria, though obviously with a greater emphasis in the TCO on productive activities as opposed to conservation.

In 2002 CABI was faced again with challenges from further hydrocarbon and other large-scale infrastructure developments. These developments included highway projects connecting Santa Cruz with Brazil and Argentina and gas pipeline projects parallel to both highways (see fig. 5.1). CABI played a leadership role in negotiating the first agreement with the consortium backing the Bolivia-Brazil gas pipeline. This agreement provided the precedent for a subsequent environmental and socioeconomic impact package negotiated by a group of conservation organizations with the consortium building the second Bolivia-Brazil gas pipeline through the Chiquitano forest, and for negotiations by municipalities and indigenous organizations with the donors supporting the bioceanic highway corridor project. These experiences were again the basis for negotiations underway in 2002 between an alliance of seven CABI-led Guaraní TCOs with the consortium building the second pipeline, which will connect the gas fields in southern Bolivia with the principal Bolivia-Brazil pipeline. This pipeline runs along the western edge of the Izoceño TCO for 150 km. Separate negotiations got underway with the consortia building pumping stations and the second gas pipeline to Brazil, which passes through or alongside the KINP for 250 km and the Izoceño TCO for 80 km. One pumping station is within the KINP, and another is on its border. Reflecting the interests of CABI and WCS, and the general objectives of their institutional collaboration, all of these agreements include funds for development and natural resource management activities, for biodiversity research and environmental monitoring and for land titling processes.

Although these types of activities may appear to lie outside the scope of a conservation project like the Kaa-Iya Project or outside the mandate of a conservation organization like WCS, upon careful consideration it becomes evident that they are critical to long-term conservation in the region. CABI and WCS must address these enabling factors (land titling and institutional strengthening) and regional threats (hydrocarbon development and highway construction) for long-term community conservation efforts to succeed. An unwillingness or inability to address issues at the regional scale doom local efforts to failure. Success in addressing these issues has strengthened CABI as a regional actor in conservation, generated important funds and funding mechanisms for conservation efforts and has provided models—for relations between indigenous groups on the one hand and government, private companies, and NGOs on the other—that strengthen conservation efforts far beyond the Izozog and the Bolivian Chaco.

LOCAL AND WILDLIFE CONCERNS

Parallel to the activities at the regional and institutional scales described above, the Kaa-Iya Project simultaneously pursues a series of local activities focusing on wildlife and community-based management practices, seeking to integrate tradition with science. Like other indigenous groups, the Izoceños emphasize their role as protectors of nature with traditions of sustainable use that maintain forests and wildlife populations (COICA 1989; Kleymeyer 1994; Robinson and Bennett 2000b). Guaraní culture emphasizes a set of spiritual relations with the environment: the “Tumpa” is a superhuman celestial being that represents a wildlife species and guarantees that the species will always exist on earth. Thus the armadillo-Tumpa protects armadillos, the fox-Tumpa protects foxes, and so on. The principal Tumpa is the rhea (*Rhea americana*), Ñandú, which governs all other animals. Ñandú-Tumpa appears as a constellation in the Milky Way and sends animals to Earth for the benefit of hunters. On Earth the "kaa-iya" or spirit guardian is the immediate keeper of wildlife, the superior of humans, and responsible for ensuring that wildlife is not destroyed or mistreated.

The hunter therefore must request permission of the kaa-iya and the Tumpa before entering the forest to hunt. If he behaves appropriately, he will be rewarded and must then thank the spirit guardians for providing meat and safety. Hunters must not kill for pleasure or cause harm or injury to any wild animal, and they must only take what they need to supply their families. An injured animal will complain to its guardian, who will punish the hunter by not sending him more game, by causing him to become lost in the forest, or even with death (Riester 1984; Combès et al. 1998).

These traditions and their contribution to sustainable use and conservation, again similar to other examples of indigenous peoples, have been undermined by socioeconomic changes over the past decades (Vickers 1994; Brandon 1996; Stearman 1999; Robinson and Bennett 2000b; Stearman 2000):

1. New hunting technologies (firearms and nylon fish nets, along with horses and dogs) and changes in employment patterns with seasonal emigration to sugar cane and cotton harvests. Although migrants do not exploit wildlife in the Izozog during part of the year, upon their return they may depend on wildlife more than do their neighbors, who as permanent residents can maintain livestock. In addition, seasonal migration disrupts community solidarity and the implementation of long-term community projects including wildlife management (Beneria-Surkin 1998; Noss and Cuéllar 2001).
2. Reduction of the area accessible to Izoceño hunters with the installation of private cattle ranches and Mennonite colonies on "fiscal land" now being claimed as part of the Izoceño indigenous territory.
3. A growing population that has tripled since 1930 (Combès 1999), reaching a current level of 9,000 inhabitants in twenty-three communities of the Izozog and a population density of 2.8/km^2 in the actively exploited hunting range.
4. Rise in the actual standard of living, creating new expectations in terms of basic needs (health and education) as well as material welfare. Wildlife exploitation can provide important economic benefits either directly through the sale of skins and pets or indirectly because wildlife meat consumption allows Izoceño hunters and fishers to save domestic animals (chickens, goats, and cattle) for sale.

Through the Kaa-Iya Project, CABI and WCS sought to address these issues in the context of the regional and institutional frameworks described above. In order to ensure full participation in all aspects of planning and implementation, CABI and WCS formed a technical team composed of non-Izoceño biologists working together with Izoceño "parabiologists." The parabiologists were selected by CABI and their communities for their interests and abilities, though they lacked formal academic training beyond the high school level and in biology. In addition to the technical team, the Project has emphasized scientific research that actively involves local hunters in research and in community discussions in order to collectively design and implement community wildlife management activities in the Izozog (Cuéllar 1999; Noss 1999; Ayala 2000; Leaños and Cuéllar 2000; Painter and Noss 2000; Noss and Cuéllar 2001).

Research focuses on the two sides of the sustainable use equation: the exploitation of the resources on one hand and the availability and productivity of the resources on the other. Research also emphasizes such aspects of the biology of exploited species as population densities, population structure, reproduction, diet, and health . An understanding of the biology could help improve the sustainability of current exploitation patterns through appropriate management plans.

HUNTER SELF-MONITORING

Beginning in 1996, the team established a self-monitoring program with hunters in all Izoceño communities (Townsend 1996c, 2000a). The purpose of the self-monitoring was to identify the principal prey species (for subsistence as well as commercial purposes) on which to focus subsequent biological research in both hunted and nonhunted areas. The comparative information, combined with the mapping of over 300 hunting locations listed by hunters, permits an evaluation of the sustainability of current hunting patterns and pressure and elicits recommendations for management practices that can further promote sustainable use (Noss 2000; Noss and Cuéllar 2001).

Together, the team and the hunters developed, tested, and revised data sheets that hunters could carry with them on hunting trips to record information on hunted animals (appendix 5.1). Hunters also provide specimens from hunted animals: skulls for age classification, stomach contents for diet studies, and fetuses for reproductive studies. Although all hunters participate on a voluntary basis, in 1997 the project hired individuals in eleven communities who are responsible for providing materials to hunters—data sheets, tape measures, and spring scales—and who collect information from hunters once a month. These monitors were selected by their communities and by CABI.

Over 700 Izoceño hunters have provided data on hunting activities to date. Although some provided information on only a single recorded kill, others have recorded more than 100 hunted animals. In total they have reported over 5,000 mammals (31 species), 3,000 birds (15 identified species), and 280 reptiles (5 identified species) (E. Cuéllar 1999; Noss 1999; R. L. Cuéllar 2000c; Leaños and Cuéllar 2000; E. Cuéllar in press). The most important species for subsistence purposes are mammals: ungulates, i.e., gray brocket deer (*Mazama gouazoupira*), collared peccary (*Tayassu tajacu*), white-lipped peccary (*Tayassu pecari*), and tapir (*Tapirus terrestris*), and armadillos: nine-banded (*Dasypus novemcinctus*), three-banded (*Tolypeutes matacus*), large hairy (*Chaetophractus villosus*), small hairy (*C. vellerosus*), and yellow (*Euphractus sexcinctus*). Birds are also consumed, in particular doves (*Zenaida auriculata*, *Columbina picui*, *Columba picazuro*, and *Leptotila verrauxi*) and the only local cracid, the Chaco chachalaca (*Ortalis canicollis*) (Mamani 2000, 2001).

Hunters rarely recorded data on animals hunted for commercial, medicinal, or artisanal purposes, and the team obtained details of these uses through interviews (R. L. Cuéllar 2000a, 2000b) and focused studies. Most important are the commercial harvests of the three abundant psittacids—blue-fronted Amazon (A*mazona aestiva*), blue-fronted parakeet (*Aratinga acuticaudata*), and monk parakeet (*Myiopsitta monachus*) sold as pets (Guerrero et al. 2000; Guerrero and Arambiza 2001; Saavedra 2000)—and the red tegu lizard (*Tupinambis rufescens*), whose skin is marketed (Montaño 2000, 2001).

BIOLOGICAL RESEARCH: HUNTERS AND MONITORS

Parallel to hunting self-monitoring, the team has established several lines of research activities, focused on the species most important for subsistence and trade. A first set of studies depended on specimens of hunted animals voluntarily provided by hunters. Community wildlife monitors collect, prepare, and superficially analyze the specimens. More detailed analyses are performed by undergraduate or graduate biology students at laboratory facilities in Santa Cruz.

AGE STRUCTURE

Wildlife monitors clean and dry skulls provided by hunters, then classify each ungulate skull into three to four age categories according to molar growth and wear (Townsend 1996b). A more accurate age analysis involves counting dental annuli on cross-sections of incisors extracted from the same skulls (Maffei and Becerra 2000; Maffei 2001 in press).

DIET

Wildlife monitors record the common names of plants and other items encountered in the stomach contents of ungulates, then wash and dry the specimens and store them in formalin for laboratory analysis in Santa Cruz (Caballero and Noss 2000; Lama 2000). Armadillo stomach contents are stored directly in formalin for laboratory analysis (Bruno and Cuéllar 2000).

REPRODUCTION

Wildlife monitors record number, biometrics, and characteristics of fetuses collected by hunters. These permit estimates of fecundity (proportion of females that are reproducing), seasonality of reproduction, and number of young per female (Chávez 1999; Rojas 2001).

HEALTH

Hunters have also collected digestive tracts from armadillos for laboratory analysis of parasites. Additional research on wildlife and domestic animal health, carried out in conjunction with the WCS Field Veterinary Program, has focused on samples (serum, tissue, ectoparasites, and feces) collected while accompanying hunters during their normal subsistence hunting excursions (Villarroel 2000; Parada and Villarroel 2001; Deem et al. in press a, in press b).

BIOLOGICAL RESEARCH: MONITORS AND PARABIOLOGISTS

A second set of research activities is conducted at a nonhunted site on the boundary of the Izoceño TCO and the KINP using a system of twenty 5-km transects opened throughout the Izozog hunting area. The field camp also opened a system of trails in a rectangle roughly 4 km wide by 12 km long.

TELEMETRY

In order to determine home ranges, activity patterns, and habitat use, the team captured and attached radio transmitters externally (in the case of tapir, brocket deer, collared peccary, and red-legged tortoise [*Geochelone carbonaria*] or internally (in the case of tegu lizard and three-banded armadillo). Tracking ungulates consisted of standard telemetry triangulation procedure. Compass bearings toward the signal from three fixed points (marked every 100 m along study trails) were taken each hour on the hour. Locations were recorded throughout the 24-hour daily cycle, from 8 hours per week to 8 hours per day depending on the number of animals being tracked and the number of parabioligists avialable for as long as the animal and transmitter permitted (Barrientos and Maffei 2000; Ayala 2002; Miserendino 2002; Barrientos and Maffei in press). In the case of the reptiles and armadillos, parabiologists tracked the signal directly to the animal or its burrow and recorded the location directly using a GPS receiver (Soria, Mendoza, and Ayala 2001; Mendoza and Noss in press; Soria and Cuéllar in press).

Tapirs were tracked for over 2 years (N=5), brocket deer for 6 to 24 months (N=2), collared peccaries for 2 to 24 months (N=9), tortoises from 6 to 20 months (N=8), tegu lizards from 2 to 18 months (N=10), and armadillos from 6 to 12 months (N=2). By combining telemetry data on home range and overlap with group size, it was possible to estimate density at a nonhunted Chaco site.

LINE TRANSECT CENSUSES

The monitors and parabiologists respectively conducted weekly line transect censuses along the transects near the communities and at the field camp respectively.

They used standard methods of walking at a pace of 1 to 1.5 km per hour and recording perpendicular distances from the trail to any animal sighted. In 2001 the team abandoned the method, finding it inappropriate for estimating densities of mammals in the Chaco, given the poor visibility and study of animals that are small, cryptic, solitary, burrowing, and/or nocturnal (Ayala and Noss 2000).

TRACK COUNTS

Along the same study trails, the monitors and parabiologists established 1 x 2 m track plots every 200 m in order to estimate relative abundance from track counts. Track plots were cleared one day then checked the following day for new tracks, with all track plots cleared and checked every week or two weeks (Noss and Cuéllar 2000; R. L. Cuéllar in press). An alternative track-based method involved sweeping 5 km or more stretches of trails and roads and checking for new tracks on the following day. This was done daily during 10-day periods (Cuéllar and Noss 1997). Despite biases in the layout of the transects, the track counts at both hunted and nonhunted sites permited comparisons of relative abundance in order to evalute the impacts of hunting and livestock near the Izoceño communities.

DRIVE COUNTS

With the participation of hunters and community members, the team conducted drives to estimate brocket deer density both near Izoceño communities and at Cerro Cortado field camp. For each drive the group of beaters walked from the trail or road approximately 200 m into the forest and formed a line roughly 200 m long and parallel to the trail. Then they began shouting and beating while walking back to the trail and the waiting observers. All deer crossing among the observers or beaters were recorded at the end of each drive (Noss, Cuéllar, and Ayala in press).

PLANT REPRODUCTIVE AND VEGETATIVE PHENOLOGY

Using ten of the same trails in the hunting area near the communities, and two trails at Cerro Cortado, the monitors and parabiologists marked five individuals, separated by 100 m or more, of thirty fruiting plant species important for game species in the area. The plant species were selected during a field course with Izoceño hunters and by examining stomach contents of hunted animals. Each month the plants are checked, with the availability and development of fruits, flowers, and leaves according to a scale of 0–4 (R. L. Cuéllar 2000a; Martínez and Cuéllar in press).

Not all biological research supported by the Kaa-Iya Project has direct management implications, for example fruiting plant phenology, tortoise telemetry, and diet, but it is nevertheless valuable in at least two important ways. It provides baseline data on little-known species and ecosystems, and it supplies training opportunities to local technicians who can later apply their skills in research design, investigation, and data analysis to the full range of natural resource management and environmental monitoring scenarios that CABI faces.

SOCIOECONOMIC RESEARCH

A third and complementary set of research activities depends on interviews and surveys in the Izoceño communities. These interviews are conducted by monitors, parabiologists, and biologists.

MEAT CONSUMPTION

In order to evaluate the relative importance of domestic versus wild sources of meat, a parabiologist conducted a set of surveys. She either administered the survey directly or demonstrated it to a member of the household who then assumed responsibility for recording on a daily basis whether meat was consumed in the household and, if so, what type of meat. Results confirm the importance of wildlife and fish for Izoceño communities: one-third of meat consumed in Izoceño households derives from wild game, one-third from fish, and one-third from domestic animals (Parada and Guerrero 2000).

ACTIVITY PATTERNS

In order to determine the importance of hunting relative to other activities (wage labor, farming, etc.) and the participation rate in the self-monitoring program, the monitors maintain a monthly activity record for all potential hunters (men and boys) in their community. Roughly one-fourth of potential hunters (all teen-age boys and men) actively hunt and fish during any given month of the year, again confirming the importance of these activities for Izoceños.

NATURAL RESOURCE CONSUMPTION

Focusing in particular on firewood consumption, a further survey involved daily visits by monitors in five communities to between eighteen and twenty-five households. This survey recorded the type and quantity of firewood, construction materials, fish, game, honey, etc., brought into the household that day. Information on consumption was compared with data on productivity to determine whether firewood use is sustainable (by species and by habitat type) and to propose management measures (Navarro 1999).

COMMUNITY MEETINGS

In the context of the Kaa-Iya Project, community meetings serve a variety of purposes, through oral presentations in Spanish and Guaraní as well as slide presentations. In part they serve to inform and educate community members with respect to research activities and objectives, legislation, the park management plan, and the TCO management plan, among others. They also serve to train the Izoceño technicians (monitors, parabiologists, and hunters) who have been directly involved in activities by giving them the opportunity to explain what they do and why to their communities.

Finally, the meetings serve to engage the communities in a discussion of the issues described above, particularly wildlife and natural resource management issues. For example, in January and February 1998 the team posed several questions intended to elicit opinions and beliefs regarding wildlife and wildlife management: (a) what activities do you pursue? (b) what purpose does wildlife serve? (c) what problems does wildlife cause? and (d) is it possible to care for wildlife? The team did not provide any options beforehand and recorded all community responses. In response to the final question, the team compiled a list of management proposals:

1. establish hunting zones or a hunting rotation system;
2. hunt only adult animals;
3. hunt only male animals when females are pregnant;
4. hunt only what the family needs without exaggerating;
5. hunt animals that are abundant and protect those that are rare;
6. conserve plants that are important food sources for wildlife;
7. prohibit hunting in the Izozog by outsiders.

Supported by considerable data from the field research, the round of meetings in November and December 1999 reviewed the wildlife management ideas proposed by the communities in the earlier meetings. For each proposal the team provided concrete examples from our experience with Izoceño hunters and from our field research on the game species of what the management idea meant in practice and how it could be applied. In each community the team asked which of these ideas were valuable and which were feasible in that hunters were willing to implement them, recording for each proposal the community's overall response. Responses generally favored the development of management plans but ranged from outright rejection as impossible or irrelevant (proposals 2, 3 , 4, 5), explanations of how current hunting practices in fact represent management (proposals 1, 3, 4, 5, 6), and full acceptance (7). Communities with a stronger tradition of livestock use and with less participation in seasonal emigration to the sugar cane harvest tend to favor active scientific management, whereas other communities emphasized traditional belief systems wherein supernatural forces ensure that wildlife resources will not be depleted (Noss and Cuéllar 2001).

More specific community meetings were also held to unite individuals and community representatives interested in the hunting of a particular species, such as parrots, tegu lizards, and peccaries, in order to discuss and develop conservation or management plans for those species. On the basis of the extensive research described above on wildlife as well as on hunting practices and traditions, the Kaa-Iya Project has developed conservation or management plans for subsistence as well as commercial use, including the following elements depending on the species: annual harvest quotas, age class or sex-based harvest quotas, distribution of quotas among interested hunters and communities, hunting seasons, and hunting methods. Data suggest that the principal prey species persist under current hunting pressure, with the exception of tapir and white-lipped peccary.

The framework of a general management plan for the TCO, together with a zonification of the TCO, was based on the following: delimitation of livestock, hunting, conservation areas; livestock management and veterinary care; prohibition of hunting by outsiders; and the strict conservation of the endangered guanaco (*Lama guanicoe*) and Chacoan peccary (*Catagonus wagneri*). The species and TCO management plans have been presented to the Izoceño General Assembly for a decision on how CABI wishes to proceed (Noss 2000), although formal implementation depends on the titling of the TCO, which is needed to provide the legal framework for any management plans.

TRAINING

In addition to the community meetings described above, practical experience is also an important training method, particularly for parabiologists and monitors, but also for community members participating in hunting self-monitoring as well as in other field activities. Furthermore, the Kaa-Iya Project has provided a series of formal field courses for parabiologists, monitors, community members, and Kaa-Iya National Park guards (table 5.1). Most courses have taken place in Izoceño communities or at the field camp. Aside from the specific technical content of the training courses, the emphasis on research design and the ability of each course participant to develop and carry out his or her own research project, based on the schoolyard ecology methodology (Feinsinger, Margutti, and Oviedo 1997), has been fundamental to the training program. As a result, all of the Izoceño parabiologists and monitors have participated in meetings with other ethnic groups in Bolivia (Chiquitano and Tsimane) and have presented papers, which are based on research projects they themselves have designed and/or implemented, at national and international wildlife management conferences. The participation in international congresses has been particularly motivating for Izoceño technicians, helping build confidence in themselves and in CABI and helping establish professional contacts with others working on similar issues in different contexts across Latin America. In 2002 several individuals assumed positions of responsibility for natural resource management projects undertaken by CABI within the TCO: guanaco conservation, parrot conservation, honey production by native stingless bees, and commercial harvest of tegu lizards and peccaries.

ENVIRONMENTAL EDUCATION MATERIALS

A further means to encourage discussion and implementation of natural resource management issues in the Izozog has been a strong environmental education program directed at both the formal education system and at community members

TABLE 5.1 Training Courses for Parabiologists, Wildlife Monitors, Hunters, and Park Guards

TOPIC	DATE	LOCATION
Field methods in biology I	August 1996	Yapiroa,Izozog
Field methods in biology II	August 1997	Ibasiriri, Izozog
Phenology	November 1997	Iyobi, Izozog
Radiotelemetry	April 1998	Cerro Cortado
Driver training	1998–2000	Santa Cruz
Data analysis	May 1998	Santa Cruz
First aid	May 1998	Santa Cruz
Necropsy and wildlife health	September 1998	Kuarirenda, Izozog
Herpetology	December 1998	Kopere Brecha, Izozog
Wildlife capture and handling	January 1999	Cerro Cortado
Basic administrative management	March–July 1999	Santa Cruz
Ornithology	April 1999	Karaparí, Izozog
Biology and ecology	February–March 2000	La Brecha, Izozog
Research design	April 2000	La Brecha, Izozog
Environmental impact assessment	October 2000	Tucavaca, Kaa-Iya
Herpetology	January 2001	Ravelo, Kaa-Iya
Research design	March 2001	Natividad, Chiquitanía
Protected area management	September 2001	OTS, Costa Rica
Research design	February 2002	Tucavaca, Kaa-Iya

and the public in general. The formal environmental education program includes a curriculum that has been implemented in all schools in the Izoceño communities (Combès et al. 1997) as well as a pair of teachers' guides to plants of the Chaco (Bourdy 2001, 2002) and a guide to wildlife of the Izozog (Cuéllar et al. 1998). The curriculum is currently being extended to the municipal school district. Nonformal education materials derive from Kaa-Iya research activities and include bulletins for general distribution on the following topics: armadillos; uses of wildlife; parrots and parakeets; guanacos; wildlife research at Cerro Cortado; jaguar (*Panthera onca*) and puma (*Puma concolor*) predation on livestock; Izoceño folk tales (Kaa-Iya Project 2000); wildlife health; and fishing in the Izozog. Additional written materials include billboards, posters and leaflets promoting conservation of the guanaco, while a series of radio broadcasts in Spanish and Guaraní have addressed guanaco conservation as well as broader natural resource management issues in the TCO.

The environmental education program emphasizes drawing upon and systematizing Izoceño environmental knowledge and fits in with CABI's efforts to ensure that Izoceño values and lifeways are not implicitly associated by the formal education system with backwardness and other negative characteristics. In addition, the concepts and information help prepare future generations of leaders to assume the technical and administrative challenges of managing this large area that includes the TCO and National Park.

CONCLUSION

The CABI-WCS experience in the Bolivian Chaco suggests that community-based conservation can be an important mechanism to ensure long-term biodiversity conservation. However, the CABI-WCS relationship is based on the explicit understanding that conservation and development are not synonymous and on an explicit definition of the specific interests and objectives guiding each institution's actions. The result is a relationship with clear and limited objectives, minimizing erroneous expectations or perceptions that could destabilize the relationship. At the same time, each institution's interests complement the other's in unexpected ways. CABI's interest in the KINP is not as a territory that Izoceños can occupy but principally as a buffer for the TCO from external pressures. The demand for the TCO itself is a public declaration by an indigenous people of its right to pursue an alternative development path, consistent with its culture and values, and that improvements in quality of life cannot be reduced to economic growth. Thus, CABI supports conservation objectives both in the KINP and the TCO. Meanwhile, WCS sees institutional strengthening and training as fundamental to CABI's long-term ability to effectively manage the KINP and the TCO land titling as the basis for any sustainable resource management. The same institutions, trained personnel, and land titles are essential elements for any development scenarios CABI wishes to pursue.

In order for the relationship to be successful, it must simultaneously address issues on regional and local scales and focus on institutional as well as biodiversity concerns. In fact, all are cross-cutting: for example, community meetings and training at the local level strengthen institutions for regional level action. Likewise, biodiversity concerns cannot only be addressed on a local scale through community management plans for particular species but also depend on landscape scale activities such as the establishment and defense of protected areas. The following lessons derived from the Bolivia experience can provide guidelines for community-based conservation efforts elsewhere in Latin America, including areas much smaller than the enormous expanse of the Bolivian Chaco (Painter et al. in press).

1. The project created a vision of territory as a space for the long-term survival of a people. Here, protected areas and indigenous territories are complementary—not overlapping—elements. The principle of complementarity that is implicit in the vision becomes real in terms of management practice through the participatory approach to preparing the zoning proposal.
2. The project provided a strategic vision that united communities or indigenous groups. It also allowed consideration of long-term regional (including protected

areas, indigenous territories, and their surroundings) environmental and socioeconomic impacts as a basis for negotiation with government and private institutions responsible for development policies and programs.

3. The project required long-term financing mechanisms, such as trust and development funds, that were independent and complementary to government or short-term project funds.
4. The project strengthened community organizations that were responsible for the management of supracommunal territories and resulted in an emphasis on transparency and accountability in the distribution of benefits and internal control.
5. The project promoted strategic relations with important neighbors, such as municipalities and other government agencies, as well as forestry and hydrocarbon concessions.
6. The project required a multidisciplinary focus that addressed not only the biological aspects of conservation but also the socioeconomic needs of local actors.
7. The project demonstrated that conservation actions and ventures must derive from the communities or these enterprises will be doomed to failure.

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APPENDIX 5.1

Hunter self-monitoring data sheet with English translation

CACERIA Comunidad ______________________________
Quienes salieron? ______________________________
____
Cuántas horas o días duró la salida ______________________________
Dónde cazó? ______________ Clima ______________________________
Qué cazó? ______________________________
No. de etiqueta ______________________________
Fecha ________Hora________Tipo de monte ______________________________
Cómo lo consiguió? Montados_______Cuántos perros ______________________________
Con qué arma ______________________________
Sexo: Macho_______Hembra_______Tiene leche ______________________________
Cuántas crías en la barriga ______________________________
Peso: Con tripas______________Sin tripas ______________________________
Medidas: Total_____Cola_____Pata trasera_____Oreja ______________________________
Edad: Juvenil________________Adulto ______________________________
Animales heridos pero no cazados: ______________________________
____
Otros animales encontrados pero no cazados ______________________________
____
Por qué? ______________________________
Observaciones: ______________________________
____

HUNTING Comunity ______________________________
Who hunted? ______________________________
____
How many hours or days did the trip last? ______________________________
Where did you hunt?________________Weather ______________________________
What did you hunt? ______________________________
Specimen no. ______________________________
Date_________Hour________Habitat type ______________________________
How did you hunt? Horseback_______no. of dogs ______________________________
With what weapon? ______________________________
Sex: Male_______Female_______Lactating ______________________________
Number of fetuses ______________________________
Weight: Whole ______________Cleaned ______________________________
Measurements: Total____Tail____Hindlimb _____Ear ______________________________
Age: Juvenile________________Adult ______________________________
Animals injured but not captured: ______________________________
____
Other animals encountered but not hunted ______________________________
____
Why? ______________________________
Observations: ______________________________
____

6

Fisheries in the Amazon Várzea

HISTORICAL TRENDS, CURRENT STATUS, AND FACTORS AFFECTING SUSTAINABILITY

WILLIAM G. R. CRAMPTON, LEANDRO CASTELLO,
AND JOÃO PAULO VIANA

The várzea floodplain flanking the sediment-rich whitewater rivers of the Amazon basin is a mosaic of seasonally inundated rain forests, lakes, and winding channels. This ecosystem is exceptionally productive and species rich, with a large proportion of endemic taxa adapted to the prolonged annual floods. Várzea floodplains cover about 180,000 km^2, or approximately 2.6%, of the 7 million-km^2 area of the Amazon basin (Bayley and Petrere 1989). This figure does not include the less productive floodplains of nutrient impoverished blackwater and clearwater rivers. Junk (1997) estimated that the total area of seasonal floodplains in the Brazilian Amazon basin is 307,300 km^2, of which 40% (106,000 km^2) is typical whitewater várzea (Bayley and Petrere 1989). An additional one million km^2 of the Brazilian Amazon's terra firme forest (above the seasonal floodplain) are periodically inundated by the flash flooding of streams (Junk 1997).

Várzeas support an astonishingly diverse fish fauna (Henderson, Hamilton, and Crampton 1998) and highly productive fisheries (Goulding, Smith, and Mahar 1996). Fish are unquestionably the most economically important of all natural resources in the várzea (Batista 1998; Queiroz and Crampton 1999a). They provide the main source of income for the rural settlers (*ribeirinhos*), underpin entire regional economies, and provide the main source of protein for the Amazon's rural and urban population. The fisheries of the Brazilian Amazon currently employ around 25,000 professional and 70,000 subsistence fishermen (Batista 1998). In the early 1990s fishing in the Central Amazon generated profits exceeding US$ 200 million/year (Batista 1998). The main theme of this article is that with appropriate management, várzea fisheries could provide a major contribution to economic growth and rural development in the Amazon basin, as well as a powerful incentive to conserve the habitats that várzea fishes rely upon.

Although there is growing evidence for the overfishing of some species (Bayley and Petrere 1989; Goulding, Smith, and Mahar 1996; Araujo-Lima and Goulding 1997; Barthem and Goulding 1997; Crampton 1999a, 2001), studies suggest that the overall fish productivity of intact Amazonian várzeas can comfortably support contemporary levels of exploitation (Bayley and Petrere 1989; Crampton and Viana 1999). The main threat to the fish stocks of the várzea is not overfishing but habitat loss (Goulding 1999). Floodplain fishes depend upon flooded forests and floating meadows for sustenance, refuge, and breeding sites (Goulding 1980; Crampton 1999b). Because the alluvial soils of the várzea support outstanding agricultural production in comparison to terra firme forests, most of the natural várzea forests and meadows of the middle to lower course of the Amazon have already been cleared or severely degraded by livestock ranching, agriculture, and predatory logging (Smith 1999). More than 70% of várzea forests may have already disappeared (Alexander 1994), whereas the loss of Amazonian terra firme rain forest is estimated at 10 to 14% (Ayres and Fonseca 1997; Schwartz 2000). Relatively intact várzea forests and meadows are still found in the Upper Amazon regions of Brazil and Peru, but their future is uncertain (Laurance 2000).

A major challenge to fisheries management in the várzea is restricting access and economic benefits to independent groups of fishermen. The federal government owns all the várzeas of the Brazilian Amazon. Fishing is permitted in any water body accessible by boat, and there are no formal regulations defining exclusive fisheries rights for any group of stakeholders, including the local populations (McGrath et al. 1999). The only exceptions to this situation occur in some conservation units and in a rising number of local lake-protection schemes that have received official recognition by Brazil's Institute for the Environment and Renewable Resources, IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis). For the most part, fisheries legislation in the Brazilian Amazon comprises state-imposed restrictions that are so poorly enforced as to be effectively nonexistent (Isaac, Rocha, and Mota 1993; Crampton and Viana 1999; McGrath et al. 1999). These conditions of almost unrestricted access and impotent regulation define the fish stocks of várzeas as a typical "open access resource," meaning that few stakeholders have exclusive rights of access or the incentive to control their own activities.

Following the collapse of several major fisheries around the world (McGoodwin 1990), planners are losing faith in state-imposed regulation and devoting serious attention to community-based models of fisheries management (Anderson 1986; Berkes 1989). In some ways várzea fisheries are ideally suited to community-based management. First, várzea settlers have evolved a semicommunal organization with cooperative labor (Lima 1999). Second, the outstanding economic value of floodplain fisheries provides the incentive for fishermen to defend their resources and undertake management. Third, várzea settlements are often located at strategic positions such as the entrance to lake systems. Finally, várzea fishermen have an excellent understanding of fish ecology.

In other ways várzea fisheries are less amenable to management. Many species of várzea fishes have complex migratory life histories, and their abundance in any given location is primarily a function of exploitation levels elsewhere. Local management has negligible effects on the stocks of these migratory species.

Self-motivated lake vigilance schemes began to appear spontaneously around the Amazon basin in the mid-1970s in response to invasions of predatory fishing fleets from the growing cities. These schemes had limited success, mainly because of political weakness and lack of infrastructure (Lima 1999). More recently, many self-motivated social movements (e.g., lake-protection schemes and rubber-tapping syndicates) have formed alliances with state or nongovernmental conservation organizations. Such alliances are intended to strengthen community projects by providing funding, training, and technical cooperation (Lima 1999). These kinds of partnerships may represent the most promising direction for fisheries management in the várzea (Ruffino and Isaac 1994; McGrath et al. 1999; Ruffino 1999).

This article brings together information from a variety of disciplines to provide a broad review of the history and status of várzea fisheries in the Brazilian territories of the Amazon. We emphasize the polarization of contemporary management strategies toward (1) government-based regulation and (2) community-based lake-management schemes, including those working in alliance with government authorities or NGOs.

VÁRZEAS: A LONG HISTORY OF HUMAN SETTLEMENT

The reports of early expeditions (Fritz 1922; Acuña 1942; Hemming 1978) and the abundance of archaeological sites along the Amazon suggest that a large indigenous population existed before European colonization (Palmatary 1939; Lathrap 1970; Smith 1980; Porro 1981; Meggers and Evans 1983; Porro 1983; Costa et al. 1986; Roosevelt 1987, 1991; Denevan 1996; Roosevelt 1999). Smith (1999) speculated that there might have been as many as fifteen million Amerindians in the basin before Europeans arrived. Archaeological studies reveal a pattern of large settlements closely spaced along the Amazon and located mostly on terra firme bluffs near várzea (Lathrap 1970; Denevan 1996; Roosevelt 1999). Here, Amerindians benefited from the resources of both várzea and terra firme ecosystems but avoided the flooding and biting insects of the várzea. We do not know when humans first arrived in the Amazon, but there is evidence for settlements near várzeas dating back to 11,000 or perhaps even 16,000 years ago (Roosevelt et al. 1991; Roosevelt 1999; Roosevelt et al. 1996).

How did várzeas provide such a large indigenous population with a sustainable supply of protein? The answer seems to be that several protein sources were exploited, with fish being less important than today. Roosevelt (1999) described the preponderance of turtle carapace fragments at sites dating from 11,200 to 9,800 years near Santarém, Pará. Roosevelt (1999) also found the bones of many fish species, including small characiforms, catfishes, and the pirarucu (*Arapaima gigas*), at paleo-indian sites (from 11,200 to 8,000 years ago) and in more recent pre-

Colombian sites. Roosevelt et al. (1991) reported that freshwater mussels were an important food source near várzeas of the Central and Lower Amazon.

Accounts of travelers and naturalists until the beginning of this century suggest that turtles provided the main protein supply for Indians along the Amazon (Spix and Martius 1822–1831; Wallace 1853; Bates 1863; Coutinho 1868; Fontes 1966; Ferreira 1971, 1972). The most important species at the time was the giant turtle (*Podocnemis expansa*), which emerges onto nesting beaches at low water. Indians harvested turtles for meat and collected eggs to make lard and lamp oil. Manatees (*Trichechus inunguis*) were also abundant before mass slaughters occurred in the seventeenth century (Vieira 1925–1928) and perhaps also represented a significant food supply.

Soon after the arrival of Europeans, the indigenous population of the Amazon suffered a massive decline, mainly because of lack of resistance to Old World diseases (Hemming 1978). Few European immigrants took their place and for the next two centuries much of the basin became almost devoid of human population and commerce. Verissimo (1895) reviewed fishing in the Amazon between the sixteenth and eighteenth centuries. From 1667 until 1827 the imperial administration established Royal Fisheries for commerce in the states of Amazonas, Pará, and Maranhão. It is clear from Verissimo's accounts that fishing pressure in the Amazon was generally low during this period. However, during the late nineteenth and early twentieth centuries, turtles were exploited recklessly for the manufacture and export of an oil made from the eggs. The populations of *P. expansa* and some other species were almost obliterated (Sternberg 1995), and today turtles form a negligible (although prized) component of the Amazonian diet. In the late twentieth century caiman, which were previously abundant in várzeas, were reduced drastically by skin hunters. The black caiman (*Melanosuchus niger*) was particularly affected. However, hunting restrictions have since resulted in a wide-scale recovery of populations (R. da Silveira, INPA, pers. comm.).

The rubber boom from the 1870s to the 1920s (and a minor boom after World War II) brought a wave of immigrants into the Amazon, but most of the latex tapping took place in terra firme forests or in seasonally inundated blackwater igapó forests away from the várzeas. Following the final collapse of the rubber boom in the 1920s, many unemployed workers settled in várzea floodplains. Settlements grew around the outposts of the patrons who controlled trade in the area through the aviamento system of debt bondage. The major economic activities in the early twentieth century were the cutting of firewood for steam ships and the commercial extraction of pirarucu, manatees, and turtles. During the 1940s and into the 1970s, jute growing provided a substantial source of income in the várzea and, along with agriculture and fishing, attracted even more rural Amazonians away from the less productive blackwater and terra firme systems (Goulding, Smith, and Mahar 1996).

By the late 1960s the rural population of the Amazon had grown steadily but was still low in comparison to the estimated pre-Columbian population (Smith 1999). The cities of the Amazon were only just beginning to grow rapidly, and the pressure on várzea fisheries was still light. However, most of the Amazon's rural population had become concentrated in várzea floodplains. As the jute industry collapsed in the early 1970s and as the urban market for fish began to grow at about the same time, many várzea farmers turned to fishing (McGrath, Silva, and Crossa 1998; Smith 1999). With turtle, manatee, and caiman populations almost extirpated, fish remained as the only major natural source of protein. In the next chapter of Amazonian history—the explosive growth of the urban population—várzeas and their fish stocks were poised to play a new and central role in the regional economy.

OPERATION AMAZÔNIA: URBANIZATION AND COMMERCIAL FISHING

The status of várzea fisheries changed radically with the implementation of Operação Amazônia in 1966. In just three decades this package of resettlement and development projects resulted in more changes to the ecological fabric of the Amazon than in all previous human history (Kohlhepp 1984; Goulding, Smith, and Mahar 1996). The human population of the Brazilian portion of the Amazon basin (considering Acre, Amapá, Amazonas, Pará, Rondônia, Roraima, and Tocantins) increased from 1.8 million in 1960 (Costa 1992) to 9.2 million in 1991 (IBGE 1991) and to 12.9 million in 2000 (IBGE 2001). Most of the growth occurred in urban areas. Manaus grew from just 320,000 in 1970 (Costa 1992) to 1.4 million in 2000 (IBGE 2001) and continues to grow by 6% per year (Costa 1992). In Amazonas, 74.8% (2.10 million) of the total population (2.81 million) lives in towns with over 800 inhabitants (IBGE 1991).

In the 1970s and early 1980s fish represented the primary protein source for people in large Amazonian cities. Estimates of average per capita fish consumption of Manaus at this time varied from 102 g/day (Amoroso 1981) to 155 g (Shrimpton and Giugliano 1979). These figures represent fish consumption of between four and seven times the world average. The dominance of fish continues to prevail in the towns of the Upper Amazon, although in Manaus fish is declining in importance because of imports of cheap poultry and meat from Southern Brazil.

Rapid urban growth and dependence upon fish protein in the 1970s and 1980s created a demand for fish above that supplied by rural fishermen. The response was the development of commercial fishing fleets. Cheap credit and engines were easily available at the time, and the number of (inboard) motorized boats in the Amazonas interior increased from around 70 to 1,700 between 1970 and 1988 (Costa 1992). In 1995 the commercial fishing fleet of the Central Brazilian Amazon (encompassing the Amazon and its tributaries from Tabatinga, Amazonas, to Ilha Tupinambarana, Pará) comprised around 2,500 fishing vessels with inboard engines (Batista 1998).

Until the 1970s salting and the production of a fishmeal called *piracui* were the main preservation methods for fish. The wide scale introduction of ice not only shifted the market toward fresh fish but also allowed fishing to occur at much greater distances from port. The modern fleet of *geleiras* (boats with ice holds) can travel to fisheries hundreds of kilometers away. Várzea lakes were targeted from the onset due to the ease with which tambaqui (*Colossoma macropomum*), pirarucu, and other premium quality fish could be harvested using seine and gill nets. These techniques can be devastatingly indiscriminate, and the geleira crews often discard the lower-value species. The expansion of predatory commercial fishing practices throughout the várzeas of the Brazilian Amazon introduced not only unprecedented pressure on key commercial species but also a new era of conflicts over fishing rights with the local ribeirinho communities.

FISHERIES OF THE MODERN VÁRZEA

The commercial and subsistence fisheries of várzeas and adjacent whitewater river channels are multispecific, seasonal, and dependent on several types of equipment (Meschkat 1961; Batista 1998). They focus on three ecological categories of fishes:

Resident várzea species spend their entire life cycle inside the várzea. They include pirarucu, aruanã (*Osteoglossum bicirrhosum*), tucunaré (*Cichla* spp.), many other cichlids, and some armored catfishes (Loricariidae) (Crampton 1999b).

Migratory characiforms undertake most or at least the initial part of their growth phase in várzea floodplains and then disperse upstream to colonize whitewater and low-nutrient floodplain systems up to several hundred kilometers away. These fishes stay upstream and eventually spawn along the edge of whitewater river channels. Their juveniles are recruited into várzea floodplains adjacent to and downstream of the spawning sites (Goulding 1980). Commercial species with this type of complex migratory life history include tambaqui, pirapitinga (*Piaractus brachypomus*), pacus (Myleinae), curimatá (*Prochilodus nigricans*), jaraquis (*Semaprochilodus* spp.), aracus (Anostomidae), and the matrinch's (*Brycon* spp.).

Migratory catfishes of the family Pimelodidae (*peixe-liso*) undertake long-distance migrations up the Amazon's main whitewater rivers. At least two species, the dourada (*Brachyplatystoma flavicans*) and the piramutaba (*B. vaillantii*), migrate from the Amazon's estuary to headwater tributaries thousands of kilometers away (Barthem and Goulding 1997). Other species such as the surubim (*Pseudoplatystoma fasciatum*) and the caparari (*P. tigrinum*) are thought to undertake shorter migrations, but the distances involved are unknown (Goulding, Smith, and Mahar 1996).

The capture of characiform fishes and catfishes in the main river channels is undertaken on an almost completely commercial basis. Fishermen distinguish between the long-distance upstream movement of migratory characiform fishes, the *arribação*, the timing of which varies among species, and local spawning runs, the *piracema*, which occur during the rising water period. Piracemas usually involve movements out of whitewater or black/clear water floodplains into spawning grounds along whitewater river margins. Migrating characiform fishes are sold to urban fish markets, while catfishes from the main rivers and their side branches (*paranás*) are mostly sold to *frigoríficos* (freezer storage plants) for export to Colombia, Southern Brazil, and Peru. Fishing within the floodplain is undertaken both by visiting professional fishermen and by ribeirinhos for subsistence and local sale. Falabella (1994) and Batista (1998) describe fishing methods in the Amazon, updating earlier accounts by Petrere (1978 a,b), Goulding (1979), and Smith (1979).

MODELS OF FISHING SUSTAINABILITY IN THE AMAZON VÁRZEA

Várzea floodplains, because of their relatively nutrient-rich waters and annual deposits of alluvium, are much more productive than the floodplains of nutrient-impoverished blackwaters and clearwaters (Schmidt 1973a,b; Fittkau et al. 1975; Schmidt 1976; Goulding, Carvalho, and Ferreira 1988; Henderson and Crampton 1997; Saint-Paul et al. 2000). Few studies have attempted to quantify the fish productivity of Amazon floodplains. Using carbon flow-analysis in várzeas near Manaus, Bayley (1989) estimated that around 1% of the carbon fixed annually by photosynthesis is assimilated by fishes, representing a total fish biomass production of between 174,000 and 523,000 kg/km^2/year. Bayley (1980) previously calculated a maximum fishing yield of 12,000 kg/km^2/year for the same area—around 17% of total annual fish production.

Bayley and Petrere (1989) reviewed potential yield estimates from tropical floodplains and concluded that a conservative sustainable yield of fish from typical whitewater floodplains is probably closer to 5,000 kg/km^2/year. This is within Welcomme's 1979 estimated range of sustainable tropical floodplain fish yields of from 4,000 to 6,000 kg/km^2/year. Quantitative estimates of actual yields for várzeas include 2,000 kg/km^2/year near Manaus in the late 1970s (Bayley and Petrere 1989) and 1,800 kg/km^2/year near Iquitos, Peru, in 1981 (Bayley et al. 1992).

The total area of whitewater floodplain in the Brazilian Amazon basin is an estimated 106,400 km^2 (Bayley and Petrere 1989). Assuming a minimum production of 4,000 kg/km^2/year, a per diem consumption of 100 g of fish biomass by the entire population, and a conservative estimate that half of this fish biomass is edible (Batista 1998), the whitewater várzeas of Brazilian territory should theoretically be able to provide 11.7 million people (almost the entire population of the Brazilian Amazon) with the World Health Organization recommended minimum daily protein requirement of 50 g.

However, fishing pressure is not evenly applied to standing fish biomass. Of the estimated 2,500 or more species of fishes in the Amazon basin (Val and Almeida-Val 1995), of which perhaps around 700 frequent várzeas, only a few dozen are eaten in appreciable quantities. Fewer than ten species provide more than three-quarters of the fish biomass extracted from várzeas by commercial fishing (Goulding 1979; Smith 1979b; Gerrits and Baas 1997; Barthem 1999a). Today's várzea fisheries are characterized by the overexploitation of a very small number of key species.

There is no evidence of overexploitation for the majority of other species (Crampton and Viana 1999).

Goulding, Smith, and Mahar (1996) speculated that urban centers with more than 5,000 inhabitants account for more than three-quarters of the total fish consumption of the Amazon basin. However, Batista (1998) argues that, even though rural Amazonians are a minority, they eat so much more fish than urban Amazonians that they create a greater overall demand. Batista (1988) reported per capita/day fish consumption in several Amazonian towns: Manacapuru (34 to 104 g), Itacoatiara (160 g), Parintins (60 g), and Santarém (28 g). Batista (1998) and Cerdeira, Ruffino, and Isaac (1997) recorded per capita/day fish consumption of from 400 to 800 g in rural settlements or small towns (less than 5,000 people) in Pará and Amazonas. Batista's argument for a larger rural consumption of fish seems compelling when one considers the following calculations. In the states of Amazonas and Pará combined, 44% (4.01 million) of the total population (9.00 million) lives in rural settlements with fewer than 800 inhabitants (IBGE 2001). Assuming a maximum per capita daily consumption of 100 g for the urban population and a minimum per capita daily consumption of 400 g for the rural population, rural Amazonians consume at least 3.2 times more fish than urban Amazonians. Although commercial fishing fleets are driven by the demands of urban Amazonians, rural Amazonians seem to make the greatest demands on fish biomass. This overlooked consideration is important for the planning of fisheries. It implies, for example, that as much as two-thirds of the total fish landings of the Brazilian Amazon cannot be assessed or monitored using the standard method of monitoring market landings.

CONTEMPORARY STATUS OF FISH STOCKS

MAJOR SPECIES

Pirarucu was exploited throughout the colonial period as a substitute for sun-dried salted codfish. Records show a stable supply to Manaus and Belém from 1885 to 1920, with landings exceeding 1,000 tons/year (Fontenele 1948). Following the collapse of the rubber boom in the 1920s, many workers settled in várzeas and took to pirarucu fishing. Landings started to decline during the 1930s (Fontenele 1948), and by the late 1940s only around 300 tons/year were landed in Belém (Menezes 1951). Until the 1970s, pirarucus were mostly harpooned. Now, commercial fishermen employ gill nets, which are far more effective. Few quantitative data are available on the overall status of pirarucu in the Amazon basin, but two trends are clear. The first is that the size structure of pirarucu populations has changed over the last three decades in all but the most remote areas. Pirarucus up to 3 m long were once common but specimens over 2.5 m long are now rare. The second trend is that in some areas pirarucu have reportedly been depleted to the point of commercial extinction (Goulding, Smith, and Mahar 1996).

Tambaqui was once a staple food species. It accounted for around 50% of the total fish catch in the Manaus fish market during the 1970s (Goulding, Smith, and Mahar 1996) and was not considered overexploited until the mid-1980s (Petrere 1983). Merona and Bittencourt (1988) reported declining tambaqui landings in Manaus during the late 1980s. Today, large adults (over 70 cm) are rare throughout most of the Amazon, and the majority of marketed fish are undersized (Goulding, Smith, and Mahar 1996). Evidence for overexploitation of tambaqui has been reported around Tefé (Costa et al. 1999), Manaus (Ribeiro and Petrere 1990; Batista 1998), and Santarém (Isaac and Ruffino 1996).

Pimelodid catfishes are captured in huge numbers along the entire course of the Amazon, mostly for the frigorifico market. Pimelodid catfishes are usually captured during their upstream migrations. The piramutaba is the most important of all fish species exported from the Amazon basin since the 1970s (Goulding, Smith, and Mahar 1996). In the late 1970s 22,000 tons were landed annually in the Amazon estuary, of which three-quarters were exported. By 1990 the harvest had halved. Due to declining yields, the value of the harvest dropped from a peak of US$ 13 million in 1980 to around US $ 3 million in 1986 (Barthem and Petrere 1992). The dourada also appears to be overfished in the Amazon estuary, with the Belém market now dominated by juveniles (Goulding, Smith, and Mahar 1996). Goulding, Smith, and Mahar (1996) predicted that the industrial-scale exploitation of estuarine dourada and piramutaba populations would eventually precipitate a collapse of the inland fisheries of these species. Gerrits and Baas (1997) have already reported declining landings of piramutaba in the Óbidos area of Pará, some 600 km inland. On the basis of market landing data, Isaac, Ruffino, and McGrath (1998) reported overfishing of surubim and caparari in the lower Amazon region of Santarém. The status of other pimelodid catfishes is unknown.

OTHER MAJOR COMMERCIAL SPECIES

In terms of biomass the detritivorous curimatá and jaraquis (Prochilodontidae) are probably now the dominant food fishes in Amazon markets (Batista 1998; Barthem 1999a,b). There is, as yet, no firm evidence for overexploitation, although Batista (pers. comm.) has observed a reduction in jaraqui sizes at Manaus markets over the last decade. Detritus constitutes a major proportion of the biomass of Amazonian aquatic systems (Araujo-Lima et al. 1986; Bayley 1989), perhaps explaining the enormous productivity of these fishes. Likewise, the abundance of newly recruited fishes in várzeas means that the exclusively piscivorous tucunarés represent a direct trophic conversion of a vast but unmarketed protein resource. Goulding, Smith, and Mahar (1996) speculate that this explains the apparent resistance of tucunarés to intense fishing pressure. Several characiform fishes, such as matrinch's, pacus, and the sardinhas (*Triportheus* spp.), are omnivorous, eating seeds, fruit, insects, and other fish in floodplain forests. The generalist nature of these fishes may account for their continued abundance, despite heavy fishing pressure.

MINOR SPECIES

In addition to the fish groups discussed above, some 150 other várzea fish species are eaten (Goulding 1979; Smith 1979b; Barthem 1999a; Crampton and Viana 1999; Crampton et al. this volume). Some of the previously less popular food species, such as piranhas (*Serrasalmus* and *Pygocentrus*), are now marketed in increasing quantities to compensate for shortages of other fishes.

MONITORING FISH LANDINGS

The assessment of fish stocks in the Amazon basin is based almost entirely on market landing data. The regional planning of várzea fisheries is limited by the paucity of such data. It is impossible to tell, for example, what the current total landings of fish are in the Brazilian Amazon. The markets of Manaus were monitored from 1976 to 1978 (Petrere 1978b) for a few years in the early 1980s (Merona and Bittencourt 1988) and then from 1993 to date (Batista 1998). Landing data have been collected at Tefé by the IDSM (Instituto de Desenvolvimento Sustentável Mamirauá) since 1992 (Barthem 1999a) and at Santarém since 1994 by Instituto Iara (Instituto Amazônico de Manejo Sustentável de Recursos Naturais, e.g., Amazon Institute for Sustainable Resource Management) (Ruffino, Isaac, and Milstein 1998; Ruffino 1999). Short-term landing data were collected in the late 1970s at Porto Velho (Goulding 1979) and Itacoatiara (Smith 1979b). Data from these studies and some governmental statistics from Manaus and Belém constitute just about all that is known about fish landings in the Brazilian Amazon.

Even the best market surveys are only partially informative about total landings. In the first place two-thirds or more of fish consumption may be on a subsistence basis (see above). Also, the trade in controlled species (such as pirarucu) and undersized or closed-season catches is usually diverted from public markets. Finally, the sale of large catfishes to frigorificos and the transport of fish to distant markets via passenger boats are notoriously hard to monitor. Despite these difficulties, landing data probably represent a more realistic means of assessing the (relative) status of stocks of Amazonian fishes than direct stock assessments from wild populations. Researchers from the University of Amazonas, the Federal University of Pará, the Mamirauá Sustainable Development Institute (IDSM), the Iara Institute, and Projeto Várzea in Santarém are joining forces with IBAMA to form a linked web of data collectors throughout the Brazilian Amazon.

ALTERNATIVE PROTEIN SUPPLIES

The management of wild fish stocks should continue to be a regional priority, but the protein demands of the Amazon's expanding population will inevitably need to be met by other forms of production. Cattle and water buffalo ranching are ecologically unacceptable forms of protein production in várzeas (Goulding, Smith, and Mahar 1996). Promising and more acceptable options are fish and poultry farming. Several species of Amazonian fishes, in particular pirarucu and tambaqui, respond well to domestication, and fish farming is now becoming lucrative business in the Amazon and in southern Brazil (Cerri 1995; Smith 1999). Cerri (1995) reports that farmed pirarucu and tambaqui can yield up to 4,560 kg/ha/year and 2,800 kg/ha/year respectively of marketable flesh. This compares very favorably with the production of water buffalo (225 kg/ha/year), cattle (203 kg/ha/year), and sheep (144 kg/ha/year) (Cerri 1995).

Chicken is cheaper than all premium quality fishes and represents a growing supply of animal protein in the Brazilian Amazon. Most is imported frozen from Southern Brazil, but the Amazonas State Livestock Development Institute, IDAM (Instituto de Desenvolvimento Agropecuário do Estado do Amazonas), is promoting poultry production in Amazonas state (E. Nunes de Sá, IDAM, pers. comm.). The captive production of Amazonian turtles is also expanding, and tagged and IBAMA-certified captive-raised turtles are now sold in some Manaus supermarkets. Smith (1999) describes other options for forest-friendly livestock production, including pigs, ducks, and such domesticated game as capybara.

ACCESS RIGHTS AND FISHERIES LEGISLATION IN THE VÁRZEA

All seasonally flooded land in the Brazilian Amazon is owned by the state. In fact, the semiaquatic nature of várzea places it under the juridical responsibility of the Brazilian Navy. Although the state can concede rights of use to individuals or companies, as it has done in some parts of Pará, várzeas cannot be privately owned (McGrath et al. 1999). Many ranchers and ribeirinhos in várzeas of the lower Amazon hold title deeds that routinely change hands, but these documents have no legal standing. The poorly defined status of land tenure is a major barrier to defining management plans for várzea fisheries.

The formulation and enforcement of inland fisheries legislation in Brazil is the direct responsibility of IBAMA. By law, fishermen are permitted unrestricted access to all waterways under the control of the state (i.e., all várzeas) except those within reserves and national parks. Streams and ponds in the terra firme surrounded by private land are recognized as private property but do not support substantial fisheries.

RESTRICTIVE REGULATIONS

IBAMA policy for inland fisheries regulation is based on a series of legally binding restrictions on fishing activities. The early framework was devised in the late 1960s and covers restrictions on equipment, minimum sizes, and closed seasons. These restrictions were based on fisheries research from southern Brazil and in many cases were inappropriate for Amazonian waters (Isaac, Rocha, and Mota 1993). Closed seasons for pirarucu (fig. 6.1), however, were based on regional studies. Three categories of fishing were defined by this early legislation: commercial, scientific, and sport fishing (although not, to universal surprise, subsistence) (Fischer, Chagas, and Dornelles 1992). In recent years there have been extensive modifications and additions to the laws, including minimum size limits, closed seasons for additional species, and a list of 175 fish species that can be legally exported for the aquarium

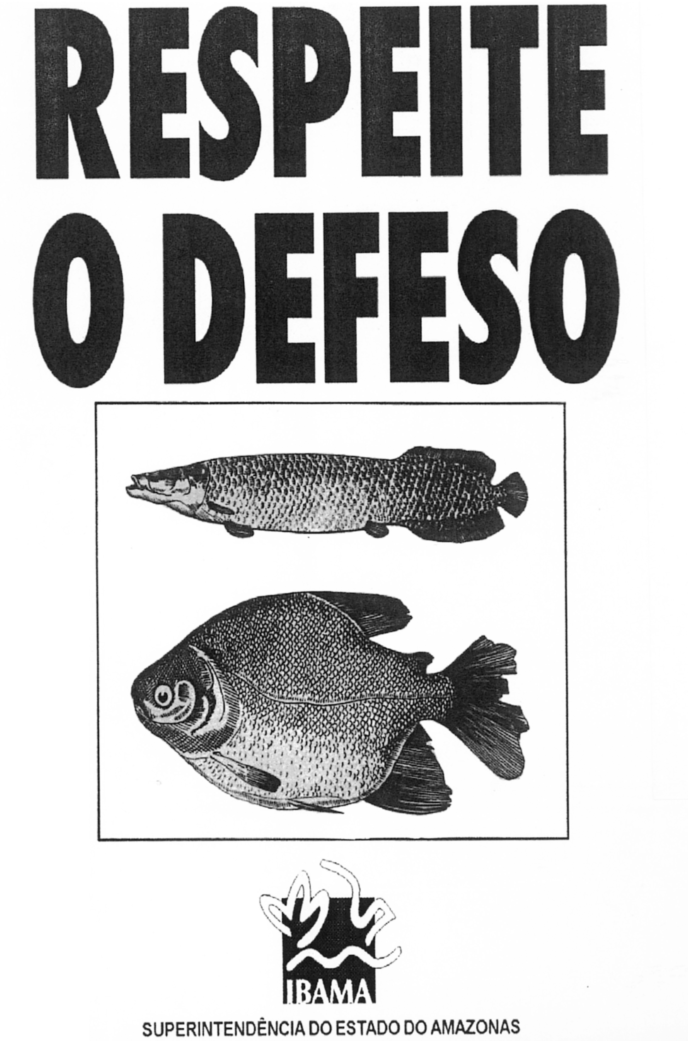

FIGURE 6.1 1995 IBAMA notice posted in ports and fish markets to remind fishermen of the closed season (defeso) for pirarucu (above) and tambaqui (below).

trade (IBAMA 1996). Some IBAMA regulations are highly restrictive. On the grounds that pirarucu had reached an "advanced stage of over-exploitation," IBAMA-Amazonas declared a statewide ban on the capture and commercialization of pirarucu in 1996. This ban has been extended without interruption and was still in effect as of July 2002.

An important law in 1994 recognized the authority and competence of regional IBAMA superintendents to enact temporary fishing regulations or closed seasons of up to two months in response to information concerning overexploitation. For instance, a 1997 decree introduced measures to control the total number of commercial fishing boats in Lake Tefé, Amazonas (L. McCulloch, IBAMA, pers. comm.). The devolution of decisions to the heads of regional IBAMA posts is part of a trend toward combating local problems through tactical response rather than a fixed global strategy. Nonetheless, each decision must still be codified as a formal decree (*portaria*) and published in the government's official gazette (*Díario Oficial*) before it can be enacted. These decrees can be subject to long delays, and it is not unknown for them to disappear in a sea of paperwork.

Another advance in IBAMA policy is the recognition of the potential of lake-protection schemes set up by ribeirinhos. Many fishing accords developed by communities around the Amazon have been granted legal backing by IBAMA decrees. IBAMA posts encourage communities to submit management plans prepared by regional fishing councils (Conselhos Regionais de Pesca). Proposals that make provisions for reconciling rights of access with commercial fishermen are supposedly favored. Nonetheless, IBAMA-supported lake-protection schemes are unpopular with commercial fishermen. They argue that IBAMA is awarding privileges to communities, marginalizing professional fishermen, and ignoring the question of how both parties could benefit from joint management (Batista 1998).

THE CHALLENGES OF ENFORCEMENT

Many of IBAMA's restrictive regulations are believed to be both unrealistic and based on insufficient research. Isaac, Rocha, and Mota (1993) provide a critique of the main problems of contemporary fisheries regulations. One recurring criticism refers to the protection of fish during their migrations, when in fact they are often more vulnerable during the lowest water period (Goulding, Smith, and Mahar 1996). Moreover, IBAMA is unable to enforce most of the wide range of measures intended to control fishing in the Brazilian Amazon. IBAMA posts are widely spaced, underfunded, and operated by staffs that are historically undermotivated. Consequently, most of the Amazon basin receives only superficial vigilance (Goulding, Smith, and Mahar 1996; Isaac, Ruffino, and McGrath 1998; Ruffino, Silva, and Castro 1998b; Crampton and Viana 1999; McGrath et al. 1999). Manifestations of IBAMA's failure to enforce regulations include the continued trade in pirarucu following its 1996 suspension in Amazonas and the ubiquitous marketing of undersized tambaqui.

IBAMA REFORM

In response to the difficulties discussed above, IBAMA is currently undergoing considerable reform, including the employment of a new generation of staff (Anon. 2000) and the aforementioned devolution of management decisions to regional offices. One of IBAMA's most innovative recent initiatives is the training of Voluntary Environmental Agents (AAVs), who are expected to complement the activities of IBAMA's field agents and to take responsibility for environmental education in local schools and village meetings (Crampton et al. this volume). IBAMA has also for some time been contemplating the potential for schemes of integrated fisheries management that operate at a regional level (Fischer, Chagas, and Dornelles 1992). The IBAMA-supported Instituto Iara in várzeas near Santarém, Pará, was the first working example of this kind of scheme (Ruffino 1999) and is described later.

These initiatives typify IBAMA's general trend toward decentralized administration and comanagement with the public sector. A seminal internal report (IBAMA 1997) conceded that resource management in the Amazon cannot be resolved through the straightforward enforcement of rules (instructive management). Instead, IBAMA instigated a policy of forging new institutional cooperation and consultation with a wide range of stakeholders (consultative management), such as municipal authorities, fishing and extractive syndicates, environmental NGOs, research institutes, and universities.

COMMUNITY-BASED FISHERY MANAGEMENT

MANAGEMENT PROCEDURES

Várzea communities have practiced basic fishery management techniques for at least the last four decades (Lima 1999). Lakes are usually divided informally into protection, subsistence, and commercialization categories, with the latter often located further away from the community. Subsistence lakes are managed with frequent, low-intensity harvesting and selective fishing techniques. Commercialization lakes are fished infrequently but intensively with less selective techniques (such as. gill netting) and are often left for a period of fallow before being refished. Studies have demonstrated that fish production of várzea lakes increases under community management schemes (IPAM 2000a). McGrath, Castro, and Futemma (1994) demonstrated that a várzea lake near Santarém under community management produced up to double the yield of an unmanaged lake for some commercial species. Crampton et al. (this volume) and Viana et al. (this volume) describe community lake-management schemes in the Mamirauá Sustainable Development Reserve, RDSM (Reserva de Desenvolvimento Sustentável Mamirauá).

Floodplain communities regard commercialization and protection lakes as economic security. During times of difficulty, for example when crops fail due to an unusually protracted flood, the bumper yields of commercialization lakes can provide much needed cash. For the same reasons many families in the várzea like to keep a few head of cattle that can be sold in times of difficulty.

MIGRATORY FISH STOCKS: MANAGEMENT DIFFICULTIES

The migratory life history of many characiform fishes means that their recruitment in any given várzea is primarily a function of exploitation conditions elsewhere. Species like tambaqui are therefore less amenable to in situ management than are resident species like pirarucu. Ribeirinho communities make no attempt to protect or manage the migratory pimelodid catfish stocks of whitewater rivers. The main channels of the Amazon are considered by ribeirinhos to be free for all. Moreover, local management would have negligible effects on their stocks.

CONFLICTS AND VIGILANCE

In the early 1980s campaigns for the defense of community lakes sprung up in várzeas along the Amazon basin. This came chiefly as a response to the growth of predatory fishing by commercial fleets. The early stages involved assistance from the Catholic Church through its Pastoral Land Commission, the Comissão Pastoral de Terra (CPT), and provided some empowerment for communities to expel commercial fishermen (CPT 1992; Lima 1999; McGrath et al. 1999). Around this time villages began to use the term *comunidade* (community) with hierarchical levels of organization and a village committee. These early lake-protection schemes met with some success, but the campaigns were blighted by intercommunity disputes, the weak legal status of várzea residency, and transport or communication difficulties. Moreover, government authorities never endorsed these early lake-protection schemes.

ECOLOGICAL PARTNERSHIPS

Escalating concern about environmental degradation and inequitable development stimulated a recent increase in the number of Brazilian and international conservation-oriented NGOs operating in the Brazilian Amazon. At the same time the growing recognition of the importance of involving local people in biodiversity conservation has encouraged many conservation and development projects to forge partnerships with previously existing social movements (Lima 1999). These alliances can greatly strengthen self-motivated movements by providing the funding, the legal support, and the technical cooperation necessary to formulate management plans, enhance production efficiency, or pursue alternative economic activities. Many ecological partnerships involve programs of environmental education, which seek to increase the general ecological awareness of rural people (Hall 1997). Environmental education programs usually also work with government educational authorities to improve basic educational standards. Illiteracy and innumeracy are perhaps the greatest constraints to the economic independence and self-confidence of rural people.

Many conservation alliances between local people of the Brazilian Amazon and either NGOs or government agencies concentrate on extractive forest products or timber and are based in areas where fishing is not a major economic activity (Lima 1999). There are currently only three projects in the Brazilian várzea that are based on community participation and that have a substantial fisheries component.

PROJETO VÁRZEA

Located at Santarém, Projeto Várzea promotes the sustainable exploitation of fisheries and other natural resources in várzeas of the Middle Amazon (fig. 6.2). This project is run by the (nongovernmental) Institute for Amazonian Environmental Research, IPAM (Instituto de Pesquisa Ambiental da Amazônia), in partnership with local communities and other stakeholders in the Santarém region. The project lists six goals (IPAM 2000b): to develop and strengthen community lake-management programs, to diversify the management strategies of várzea communities, to develop a program of environmental education, to study economic and ecological trends in the fisheries sector, to develop regional fisheries policies, and to provide management and marketing training to local fisheries organizations.

Projeto Várzea is working with várzea communities and the commercial fishing syndicate of Santarém to consolidate a framework for rights of access and regional

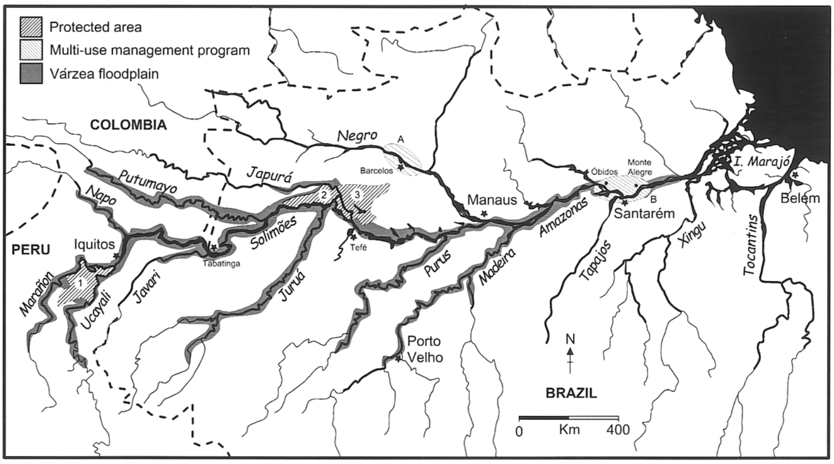

FIGURE 6.2 Location of major fisheries conservation and management programs in the Amazon basin: Pacaya-Samiria National Reserve, Loreto, Peru (1); Mamirauá Sustainable Development Reserve (2); Amanã Sustainable Development Reserve (3); ornamental fish catching initiatives directed by Projeto Piaba (A); and multiple-use fishery management initiatives directed by Projeto Várzea and Instituto Iara (B).

fisheries management. It is also working with communities to promote agricultural activities that reduce the destruction of levee forest and floating meadows and to restore floating meadows damaged by buffalo and cattle ranching (M. Crossa, Projeto Várzea pers. comm.). McGrath, Castro, and Futemma (1994) and McGrath et al. (1994, 1999) review the fisheries management activities at Projeto Várzea.

INSTITUTO IARA

Also based at Santarém, Instituto Iara (previously Projeto Iara) is responsible for the administration of fisheries resources in the Middle Amazon. The Institute's acronym, Iara, is a mythical nymphlike apparition in Amazonian folklore (Smith 1996). Since 1996 Instituto Iara has been "developing, testing and consolidating institutional measures for the sustainable use of fisheries resources in the Middle Amazon that are compatible with the interests and needs of local populations and of the regional and national economy and society" (IBAMA 2000). Instituto Iara is based on technical and financial cooperation between IBAMA and the German technical cooperation agency, GTZ (Deutsche Gessellschaft für Technische Zusammenarbeit). It also involves cooperation with several Brazilian academic institutions. Through a multidisciplinary program of research, training, environmental education, and monitoring, Instituto Iara is working closely with the full spectrum of stakeholders involved in fishing in the Middle Amazon region to define rights of access to fisheries resources and to develop management plans for sustainable use. The training of Voluntary Environmental Agents from local communities and from Santarém's fishing cooperative (Colônia de Pescadores-Z20) forms an important part of these initiatives. Instituto Iara's sphere of influence affects around 250,000 people living in várzeas along a 200-km stretch of the Rio Amazonas between Óbidos and Monte Alegre (fig. 6.2) (M. Ruffino, Instituto Iara, pers. comm.). Many of the activities and results of Projeto Iara are described by Fischer (1995) and Ruffino (1999).

THE MAMIRAUÁ AND AMANÃ SUSTAINABLE DEVELOPMENT RESERVES (RDSM/RDSA)

The RDSM is an 11,240-km^2 area of várzea located at the confluence of the Rios Solimões and Japurá. This Reserve was originally established in 1990 and was given Sustainable Development Reserve (SDR) status in 1996. Here, local people in partnership with the Mamirauá Sustainable Development Institute (IDSM) are mounting an integrated sustainable resource use program. Crampton et al. (this volume) and Viana et al. (this volume) provide a detailed overview of fisheries management in the RDSM. This reserve constituted the first of a new category of Brazilian conservation unit that permits the presence of traditional peoples and allows them exclusive rights of access to the natural resources of the area. In 1999 a second SDR, the 23,500-km^2 Amanã Sustainable Development Reserve (RDSA) was inaugurated (fig. 6.2). This reserve is also administered by IDSM and was established to form a contiguous corridor between the RDSM and the Jaú National Park on the west bank of the Rio Negro. Fisheries management in the RDSA is planned for the future and will follow the RDSM model.

OTHER PROJECTS

The only major conservation and development projects in a várzea floodplain outside Brazilian territory are being developed in the Reserva Nacional Pacaya-Samiria in Peru (see Tello this volume). This 21,508-km^2 state-administrated reserve located at the confluence of the Rios Ucayali and Marañon (fig. 6.2) has an active fisheries management program built around community participation and a multiple-use zoning system (COREPASA 1986; Bayley et al. 1992; Durand and McCaffrey 1999).

One other fisheries-dominated project in the Brazilian Amazon deserves a mention although it is not based in várzea floodplains. Projeto Piaba is based in the town of Barcelos on the blackwater Rio Negro (fig. 6.2) and has investigated the biological and economic sustainability of ornamental fish catching in the area (Chao et al. 2001). The ornamental fish trade involves around 1,600 part-time fishermen in the area and contributes to more than 60% of the economy of the municipality of Barcelos. Commercial food fishing is relatively unimportant in the nutrient-poor blackwaters of the middle Rio Negro. Chao et al. (2001) concluded that current extraction levels of ornamental fishes, including the heavily exploited cardinal tetra (*Paracheirodon axelrodi*), are sustainable. They argue that the trade encourages habitat conservation and contributes positively to local economies and livelihoods. In addition to research Projeto Piaba is developing a program to improve the production and marketing efficiency of rural fishermen.

HABITAT CONSERVATION

Several authorities on Amazonian conservation have stressed that habitat loss through the deforestation of floodplains and river margins or through the construction of hydroelectric dams has a far more devastating and irreversible effect on fish stocks and diversity than does overfishing (Goulding 1983; Leite 1991; Ribeiro, Petrere, and Juras 1995). The two most important fish habitats in the várzea are seasonally flooded forests (Goulding 1980) and floating meadows (Junk 1973, 1983; Crampton 1999b; Henderson and Crampton 1997). Both provide seasonal refuge and sustenance for a huge diversity of fishes. The meadows have an especially important role as nurseries for juveniles of many commercially important species (Crampton 1999b). Of the various types of forest in várzea floodplains (Prance 1979; Ayres 1993) the tall restinga forests found on the higher levees host the highest terrestrial and arboreal biodiversity and provide much of the sustenance for commercially important fruit- and seed-eating fishes, such as tambaqui and pacu (Goulding 1980).

The destruction of levee forest by ranching, agriculture, and predatory logging, as well as the trampling and grazing of floating meadows by livestock, have detrimental effects not just on overall biodiversity of várzeas but also on fisheries production (Goulding, Smith, and Mahar 1996). Although any commercial fishermen in the Amazon will tell you that degraded várzeas offer poor fishing for key commercial species in comparison to intact ones, there is little quantitative data to substantiate this. Ruffino and Isaac (2000) report average catch per unit effort (CPUE) estimates of around 10 to 20 kg/fisherman/day in the Santarém area. Batista (pers.comm.) reports around 20 kg/fisherman/day in the Manaus area. Viana (pers. obs.), on the other hand, estimates that the average CPUE in the Tefé region is from 50 to 80 kg/fisherman/day. The extent to which these discrepancies reflect the diminished and fragmented forest cover in the lower reaches of the Amazon (Santarém and Manaus) versus higher fishing pressure is unknown.

DISCUSSION

Fisheries management in the Brazilian várzea has polarized toward two approaches: state (IBAMA)-imposed restrictive regulations at one end of the spectrum and self-motivated community lake-management programs at the other. The first of these approaches is not working. Like fisheries agencies around the world, IBAMA is unable to adequately enforce its regulations. The second approach, community management, is often extolled as a miracle solution. However, proponents of community management place a great deal of faith in the abilities of rural people to manage and defend resources. We argue that community management is unlikely to work unless five provisos are satisfied:

1. A single group of users is awarded guaranteed rights of access.
2. There are strong economic incentives for defending and managing fish stocks.
3. The users have a general ecological awareness and understand the concepts of resource depletion and management.
4. Management is based on sound scientific grounds and/or traditional ecological knowledge.
5. There are concerted efforts to preserve the intricate mosaic of flooded forests and floating meadows upon which many várzea fish depend.

A worldwide analysis of community-based management programs by Barret et al. (2001) concluded that the capacity of communities to manage resources has been overemphasized and that the success of these programs rarely matches the fanfare. Without financial, legal, and scientific support, local fishing communities are unlikely to be able to satisfy the five provisos above. Alliances between self-motivated social movements and conservation/development-oriented external agencies (governmental or nongovernmental) probably represent the most promising direction for fisheries management in várzeas.

Of the three such alliances with a strong várzea fisheries component currently being developed in the Brazilian Amazon, all approach the challenges of management in different ways. The RDSM is the only one to undertake fisheries management in the context of a protected area in which local people enjoy legally binding rights of access. Projeto Várzea and Instituto Iara operate in the normal context of state-owned várzea. These three projects also differ in their emphasis on habitat conservation, geographical coverage, and the extent to which the interests of the entire spectrum of stakeholders are included.

HABITAT CONSERVATION

The long-term health of várzea fisheries is ultimately dependent upon the conservation of relatively intact forests and floating meadows. The RDSM is unique in prioritizing habitat protection. The reserve effectively compensates for a closed zone of complete biodiversity protection by offering local people a surrounding sustainable use zone. Here, integrated fisheries and forest management, along with a package of economic incentives, promote sustainable exploitation and encourage economically favorable alternatives to such destructive land use as livestock ranching (Crampton et al. this volume; Viana et al. this volume). The RDSM contains a considerable proportion of Brazil's remaining areas of relatively intact várzea floodplain habitats. Assuming two-thirds of the estimated 106,000 km^2 of Brazilian várzeas (Bayley and Petrere 1989) have already been severely degraded (Alexander 1994), around 32% of the remaining, relatively intact area lies within the RDSM, including its Subsidiary Area (7% within the Focal Area alone).

Instituto Iara is solely concerned with fisheries management. It focuses on the important issues of access rights and market incentives but does not directly address habitat preservation. Projeto Várzea is attempting to promote sustainable forest management and to encourage forms of livestock production and agriculture that are less damaging to várzea habitats. However, it does not emphasize the need for completely protected areas of forest. In fact, there are very few undamaged forests left to protect in the lower Amazon region, making habitat restoration, rather than conservation, the main concern.

GEOGRAPHICAL COVERAGE

Fisheries projects operating on a regional scale are arguably better suited to the management of migratory fish stocks and better prepared for managing the full range of economic concerns and conflicts that decide the fate of management. Instituto Iara is the most expansive fisheries project in Brazil, operating over a 200-km stretch of the axis of the Rio Amazonas and encompassing around 3,000 km^2 of várzea. This initiative was originally projected to affect around 600,000 people in an area extending from Itacoatiara in Amazonas downstream 1,000 km to Almeirim in Pará. However, this area was subsequently considered to be too large to be effectively managed with available resources. Likewise, because of logistic difficulties and funding limitations, management activities in the 11,240-km^2 RDSM have been restricted to an area of 2,600 km^2. The difficulties the Mamirauá and Iara initiatives have experienced in expanding the geographical scale of their operations indicates that single fisheries management programs are unlikely to be effective over areas much larger than 3,000 km^2 unless they are spectacularly well funded.

STAKEHOLDER INCLUSION

Due to their larger, regional nature, both Instituto Iara and Projeto Várzea seek to reconcile the needs of both várzea residents and commercial fishermen. These projects provide a forum for negotiating mutually acceptable divisions of fishing rights and provide technical cooperation for the production of management plans. For example, the commercial fishing syndicate of Santarém contains many associates who are from the communities of the surrounding várzeas, allowing a balanced forum for discussing fishing agreements and a consolidated front for excluding fishermen from outside the region (e.g., from Belém). Likewise, IBAMA's training program for Voluntary Environmental Agents is providing training for community representatives from both local communities and the urban fishing fleet (M. Ruffino pers. comm.).

In the Upper Amazon region of Tefé, there has always been a much greater separation between várzea fishing communities and the urban fishing fleets of the local towns (Lima 1992). This separation is probably in part a historical consequence of the fact that the rural population of the state of Amazonas is smaller and younger than that of Pará. The rural fishermen of the lower Amazon have for some time been a more forceful political force and have developed a more integrated and mutually beneficial relationship with commercial fishermen.

The fishermen of the RDSM are especially divergent in organization and interests from the nearby urban fishing syndicate of Tefé. Under the area's legal status as an SDR, the resident and user communities are awarded exclusive rights of access to the natural resources of the region. The RDSM is criticized by commercial fishermen from Tefé for providing access rights to 6,000 ribeirinhos while at the same time restricting access rights to almost everybody else in the area. The situation was aggravated by the demarcation of the Amanã Sustainable Development Reserve, which contains large areas of várzea to the east of the RDSM (fig. 6.2). With the formal closure of both the RDSM and RDSA, the Tefé commercial fishing syndicate argues that it has been left with almost no viable fishing grounds. Likewise, ribeirinhos in the remaining unprotected várzeas of the Tefé region are indignant that their lakes are now under much greater pressure.

Anticipating the necessity to concede some access rights to the commercial fishing syndicate of Tefé, the reserve's 1996 management plan made provisions for communities to concede temporary access rights to some lakes for visiting commercial fishermen. However, most communities of the reserve subsequently opted not to provide such concessions (see Crampton et al. this volume). This deadlock has provoked serious debate. How can the managers of a protected area justify developing one part of a regional rural economy at the expense of another?

Protected Areas Act as Fish Supply Areas and Restocking Nuclei The Mamirauá Sustainable Development Institute has argued that managed fisheries and the protection of core no-use zones in the RDSM should, in time, guarantee not only a permanent supply of reasonably priced premium quality fish for the urban markets of the region but also generate surplus stock that will replenish surrounding fisheries (Queiroz and Crampton 1999a). Skeptics argue that there is no evidence that protected areas have the capacity to generate surplus stock and that local communities are in any case likely to maximize harvesting for their own gain. The reluctance of the residents of the RDSM to negotiate fishing concessions with commercial fishermen no doubt fuels this skepticism. So far there is no scientific evidence that the RDSM (or any other protected fishing ground in the Amazon) is restocking adjacent areas. There is evidence, however, for significant increases in the stocks of pirarucu, tambaqui, and caiman in the core protection zone of the RDSM (Crampton et al. this volume; Viana et al. this volume).

The Value of Intact Biodiversity Intact várzea floodplains are among the most diverse and yet threatened ecosystems on earth. The human population is rapidly growing in the Upper Amazon regions where most of the remaining intact várzeas are located (Cincotta, Wisnewksi, and Engelman 2000). Some proponents of biodiversity conservation argue that the economic marginalization of some stakeholders through lost rights of access to protected areas like the RDSM is an unfortunate but necessary price paid by societies that place value on conserving their ecological and genetic heritage (Pimm et al. 2001).

CONCLUSION

Fisheries management is conventionally about providing people with a sustainable supply of fish protein. However, in the Amazon basin the issues are complicated by the multiple interfaces between fish stocks, habitats, and livelihoods. Fisheries managers in the Amazon are concerned with habitat preservation, with sustainable use and development, and with resolving social conflicts.

Of the three contemporary community-based fisheries management models described in this article, all are experimental in nature. They are also young, and results indicating their successes and failures are only just emerging. These three models all have attendant theoretical merits and shortcomings, and strategies for the management of várzea fisheries will in the future probably need to incorporate features of all three. For example, protected areas like the RDSM may in the future need to concede larger areas of várzea for access to outside commercial fishing fleets. Likewise, some areas of the regional fishing grounds in the middle Amazon region may need to include zones of protection. We argue that an increase in the number of fisheries management initiatives would be more effective than expanding the geographical range of existing reserves or multiple-use management programs to much more than around 3,000 km^2, which seems to be about the upper limit for effective administration.

Goulding, Smith, and Mahar (1996) proposed a chain of reserves for "fish forests" and "fish meadows" along the axis of the Amazon River and an integrated regional management program. We envisage a similar model that combines features of contemporary fisheries management schemes by including multi-use regional fisheries management programs and Sustainable Development Reserves, which would need to be arranged in a constellation along the major whitewater rivers of the Amazon (Amazon, Juruá, Purus, Madeira, etc.). Each initiative could be independently managed but coordinated within an overall scheme for national fisheries management within Brazil and Peru (and internationally between the two countries). The administration of such a chain of fishery management initiatives would need to involve the entire spectrum of stakeholders, including communities, businesses, the environmental authorities, commercial fishing syndicates, conservation organizations, and research institutions. Institutional cooperation between the Amazonian countries of Brazil, Peru, Bolivia, Colombia, and Ecuador would also be necessary to formulate management plans for the some migratory catfishes.

Finally, a word of warning: in the drive to establish integrated, socially appropriate models of management, it is important not to forget the biology of the fish. Scientific studies are still needed to define the migratory ranges of commercially important characiform fishes and catfishes, as well as the minimum size of single blocks of várzea necessary to sustain viable populations of commercial fish species.

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7

Fisheries Management in the Mamirauá Sustainable Development Reserve

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Fisheries management in the Brazilian Amazon has polarized toward state-imposed regulations at one extreme and community-based management at the other (Crampton, Castello, and Viana this volume). At present there is no overall government fisheries conservation policy for Amazônia, and existing state fisheries restrictions are almost completely ineffective (Hall 1997; Crampton and Viana 1999). Since the 1970s fishing has become an increasingly important source of income for the ribeirinho people of the whitewater várzea floodplain and a growing number of várzea communities have set up lake reserves (reservas de lagos de várzea) to manage fish stocks and to guard them from predatory fishing by the commercial fleets of major towns. The Pastoral Land Commission, Comissão Pastoral da Terra (CPT), of the Catholic Church supported many of these initiatives and reports that up to 15% of all major lakes in Amazonas are inside such reserves (Hall 1997). These self-motivated lake-vigilance schemes met with only limited success due to political weakness, poor infrastructure, and lack of recognition by the state authorities (Hall 1997; Lima 1999). Alliances between local social movements and state or nongovernmental organizations can greatly strengthen the former by providing funding, training, and technical or legal support. These kinds of alliances represent one of the most promising directions for the management of Amazonian fisheries (McGrath et al. 1999; Ruffino 1999; Crampton, Castello, and Viana this volume).

At present, three partnerships between NGOs and local people of Brazilian várzeas involve a substantial fishery component. Projeto Várzea and the Iara Institute (Instituto Amazônico de Manejo Sustentável dos Recursos Naturais) are two multidisciplinary projects designed to promote sustainable fishing at the regional level in the state of Pará (Crampton, Castello, and Viana this volume). These projects seek to reconcile the needs of várzea communities, commercial fishermen, and other stakeholders. The third such alliance, which is the subject of this article, involves a partnership between the people of the Mamirauá Sustainable Development Reserve (or RDSM), Amazonas, and its supporting NGO, the Mamirauá Sustainable Development Institute (Instituto de Desenvolvimento Sustentável Mamirauá, or IDSM).

Crampton, Castello, and Viana (this volume) defined five provisos for successful community-based fishery management:

1. Access rights are restricted to an economically independent group of users.
2. The users understand the concepts of resource depletion and management.
3. Management is accompanied by conservation of the habitats that sustain fish populations.
4. Profits accrued from fish marketing are sufficient to provide economic motives for long-term management and vigilance.
5. Management is based on sound scientific and/or traditional ecological knowledge.

In this article we describe general strategies for fisheries management in the RDSM and how these interlink with biodiversity conservation and the sustainable management of other resources. We emphasize community participation, access rights, restrictive fishing regulations, and the conservation of habitats. These issues correspond to the first three provisos above. Viana et al. (this volume) go on to emphasize the last two of the provisos above by describing an experimental Fish Commercialization Program in the RDSM. We evaluate the progress of ongoing fisheries management activities in the RDSM and conclude with a discussion of the applicability of the RDSM program to general models of fisheries management in the Amazon.

THE MAMIRAUÁ RESERVE

The RDSM encompasses 11,240 km^2 of várzea floodplain and represents the largest contiguous block of reasonably intact várzea forest left in the Brazilian Amazon (Ayres et al. 1999). Unlike the situation in the Lower Amazon, the várzeas of the Tefé region have not suffered large-scale deforestation or degradation (Goulding, Smith, and Mahar 1996; Goulding, 1999). Research and community-participation in the RDSM have concentrated on a 2,600 km^2 Focal Area delimited by the Rios Solimões, Japurá, and the Paraná Aranapu (figs. 7.1 and 7.2). Unless otherwise stated, Mamirauá Reserve, RDSM, or just the reserve will henceforth refer specifically to this Focal Area. In 2001 the RDSM contained 1,585 people (0.61 people/km^2) who live mostly in twenty-one communities. A further 4,401 people lived in forty-two villages outside the reserve that are classified as user communities because of their dependence on resources from within the RDSM (SCM 1996).

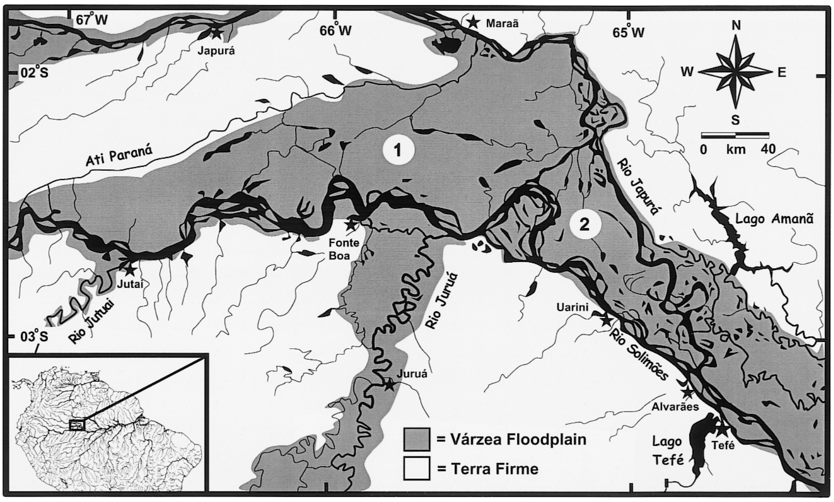

FIGURE 7.1 Map of the Upper Amazon region showing the Subsidiary (1) and Focal (2) areas of the Mamirauá Sustainable Development Reserve. Also shown are regional municipal centers and the extent of the várzea floodplain.

THE FISHERIES STATUS OF THE RDSM AND TEFÉ REGION

The fisheries of the reserve underpin the local economy, contributing at least 79% of the market value of resources extracted from the area (table 7.1). The commercial yield of the Focal Area of the reserve from resident and user communities was estimated at around 320 tons/year in the period 1991–1994, of which 58% was fresh fish, 40% dried and salted fish, and 2% pickled fish (SCM 1996). Commercial fishing boats from the towns of Tefé and Alvarães extracted a further 220 tons/year from the Focal Area of the reserve during the period 1991–1994 (Barthem 1999a). Most commercial fishing is undertaken during the low-water season when fish are concentrated in lakes and river channels (Barthem 1999b; Queiroz 1999). Subsistence fishing, which does not figure in table 7.1, provides around 80% of local animal protein requirements (Howard et al. 1995; Santos 1996). Caiman, game, and turtles provide the rest (Santos 1996). The per capita consumption of fish in the RDSM is as high as 500 g/diem (Queiroz 1999). Ayres et al. (1999) estimated that the total annual subsistence demand for fish in the RDSM was between 240 and 300 tons in the early 1990s.

Added together, the total annual yield of subsistence and commercialization for the RDSM in the early 1990s was in the order of approximately 840 tons/year. This is equivalent to an average extraction of approximately323 kg/km^2/year (840,000/2,600). Although probably somewhat of an underestimatation, this figure is still an order of magnitude below Bayley and Petrere's 1989 estimated maximum sustain-

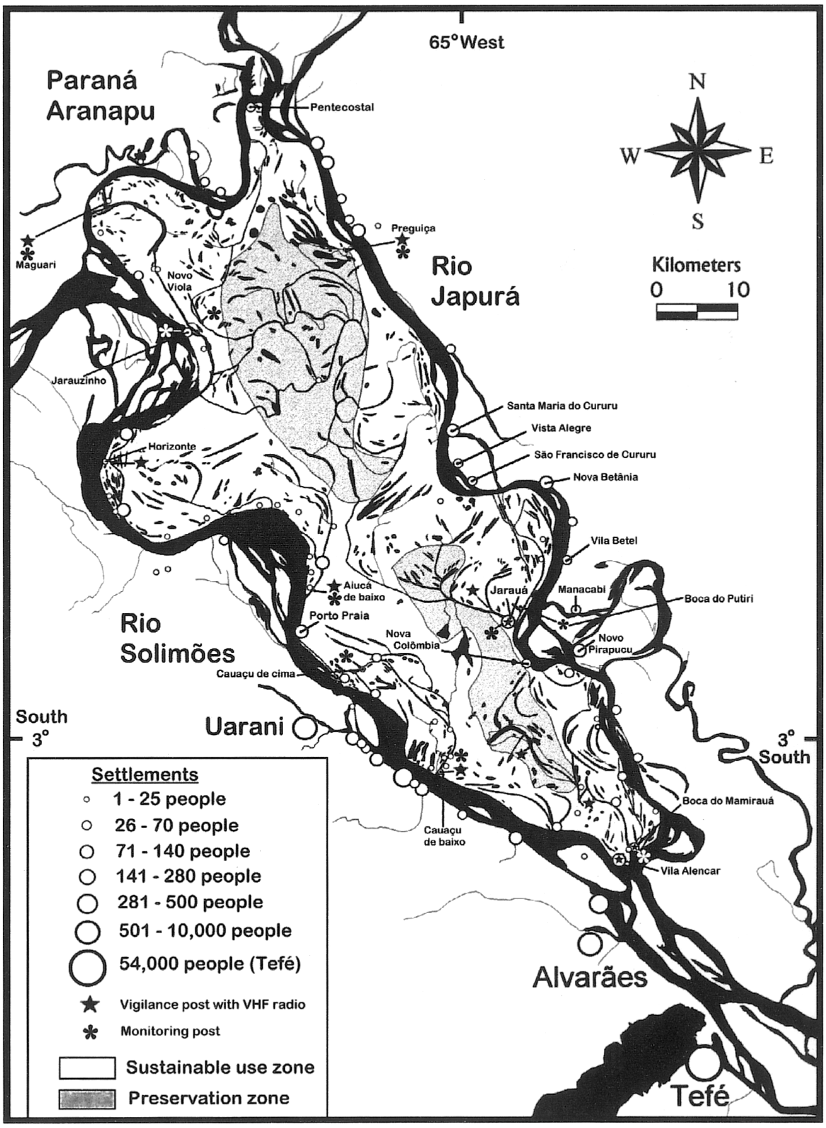

FIGURE 7.2 Map of the Focal Area of the Mamirauá Sustainable Development Reserve showing the core zones of total protection and communities.

able annual yield for Amazonian várzeas of 5,000 kg/km^2/year. It is also well below documented levels of production in other Amazonian várzeas (1,800 to 2,000 kg/km^2/year) (Bayley and Petrere 1989; Bayley et al. 1992). These calculations imply that in general terms the fish resources of the RDSM are harvested at levels below those that would deplete them. However, as is the pattern throughout the Amazon

TABLE 7.1 Estimated Annual Economic Value of the Principal Natural Resources of the Focal Area of the Mamirauá Sustainable Development Reserve

RESOURCE	MARKET VALUE
Fisheries	
External fishermen (multispecies)	US $867,000
Internal fishermen	
—Pirarucu (*Arapaima gigas*)	US $329,000
—Tambaqui (*Colossoma macropomum*)	US $240,000
—Other species	US $417,000
Timber and Firewood	US $ 107,000
Agricultural Products (manioc, banana, citrus, etc.)	US $157,000
Hunting (mostly caiman)	US $64,000
Other Resources	US $185,000
Total:	US $2,336,000

Source: Mamirauá Management Plan (SCM, 1996)
Note: Fisheries data is averaged over the period 1993–1995 and exclude the direct sale of large tambaqui to Manaus via commercial passenger boats and the sale of catfishes to *frigorificos* (freezer stations).

basin (Crampton, Castello, and Viana this volume), commercial fishing in the Tefé region is biased toward only a few species.

There are around 600 species of fishes in the Tefé area (Crampton 1999b; W. Crampton pers. obs.). Of these, around 100 are used for subsistence or commercialization and around fifty regularly appear in the Tefé market (table 7.2). Three species alone constitute more than half of the annual biomass of fish landed from RDSM and sold in the Tefé market, and the top ten species represent 84% of the catch (table 7.3). For brevity, scientific names of all fish species mentioned in this article are listed in table 7.2.

Research prior to 1995 suggested that three species were being overfished in the RDSM. Based on size -class and life-table analyses of 1995–1996 data, Queiroz and Sardinha (1999) concluded that levels of pirarucu exploitation exceeded the maximum sustainable yield. They predicted a halving of stocks within six years in the absence of management. Costa, Barthem, and Correa (1999) reported overfishing of tambaqui in the RDSM and documented that 93.5% of tambaqui in the Tefé market during the low water of 1993 were below the legal minimum length of 55 cm. Crampton (1999b,c) described overfishing of discus in the RDSM by visiting ornamental fish catchers. There is no evidence for overfishing of aruanã, curimatá, tucunaré, or any of the other species that are heavily commercialized in the Tefé area (table 7.3).

TABLE 7.2 Fish Species Consumed by the Rural and Urban Population of the Tefé Region

Clupeiformes	
Pellonidae	
—*Pellona castelnaeana*	Apapa-amarela *3
—*Pellona flavipinnis*	Sardinhão
Osteoglossiformes	
Arapaimidae	
—*Arapaima gigas*	Pirarucu *1
Osteoglossidae	
—*Osteoglossum bicirrhosum*	Aruanã, Sulamba *3
Characiformes	
Erythrinidae	
—*Hoplias malabaricus*	Traira *3
—*Hoploerythrinus unitaeniatus*	Jeju *3
Anostomidae	
—*Leporinus friderici*	Aracu-piau
—*Leporinus fasciatus*	Aracu-flamengo *3
—*Rhytiodus microlepis*	Aracu
—*Rhytiodus argenteofuscus*	Aracu
—*Schizodon fasciatum*	Aracu-comum *3
Hemiodontidae	
—*Anodus elongates*	Charuto *3
—*Anodus melanopogon*	Charuto
—*Hemiodopsis immaculatus*	Orana-branca *3
—*Hemiodopsis microlepis*	Orana-flecheira *3
—*Hemiodus unimaculatus*	Orana *3
Curimatidae	
—*Curimata vittatus*	Chorona
—*Curimatella alburnus*	Chorona
—*Potamorhina latior*	Branquinha *3
—*Potamorhina altamazonica*	Branquinha *3
—*Potamorhina pristigaster*	Branquinha *3
—*Psectrogaster rutiloides*	Chorona *3
—*Psectrogaster amazonica*	Chorona *3
Prochilodontidae	
—*Prochilodus nigricans*	Curimatá *2
—*Semaprochilodus insignis*	Jaraqui esc. –grossa *2
—*Semaprochilodus taeniurus*	Jaraqui escama-fina *2
—*Semaprochilodus theraponura*	Jaraqui esc. –grossa *2
Acestrorhynchidae	
—*Acestrorhynchus falcatus*	Peixe-agulhão
Cynodontidae	
—*Cynodon gibbus*	Peixe-cachorro
—*Hydrolycus scomberoides*	Peixe-cachorro
—*Rhaphiodon vulpinus*	Peixe-cachorro *3

TABLE 7.2 Continued

Characidae (Characinae)	
—*Brycon melanopterus*	Jatuarana *
—*Brycon cf. cephalus*	Matrinchã *2
—*Triportheus angulatus*	Sardinha-chata *3
Triportheus elongates	Sardinha-comprida *2
Characidae (Serrasalminae)	
—*Colossoma macropomum*	Tambaqui *1
—*Myleus rubripinnis*	Pacu-galo *3
—*Myleus torquatus*	Pacu
—*Mylossoma duriventre*	Pacu-comum *3
—*Mylossoma aureum*	Pacu-manteiga *3
—*Piaractus brachypomus*	Pirapitinga *3
—*Pygocentrus nattereri*	Piranha-caju *3
—*Serrasalmus elongates*	Piranha-mucura
—*Serrasalmus spilopleura*	Piranha-jirda
—*Serrasalmus rhombeus*	Piranha-preta *3
Gymnotiformes	
Rhamphichthyidae	
—*Rhamphichthys cf. rostratus*	Sarapó
Siluriformes	
Doradidae	
—*Centrodoras brachiatus*	Reque-reque
—*Lithodoras dorsalis*	Bacu-pedra *3
—*Megalodoras uranoscopus*	Rebeca *3
—*Pseudodoras niger*	Cuiu-cuiu *3
—*Pterodoras lentiginosus*	Bacu-liso *3
Auchenipteridae	
—*Trachelyopterichthys taeniatus*	Cangati
—*Trachycorystes trachycorystes*	Cangati
Pimelodidae	
—*Brachyplatystoma filamentosum*	Filhote, Piraiba *2†
—*Brachyplatystoma flavicans*	Dourada *2†
—*Brachyplatystoma vaillantii*	Piramutaba *2†
—*Goslinia platynema*	Babão *
—*Hemisorubim platyrhynchos*	Braço-de-moça *3
—*Hypophthalmus edentatus*	Mapará *3
—*Hypophthalmus fimbriatus*	Mapará *3
—*Hypophthalmus marginatus*	Mapará **3
—*Leiarius marmoratus*	Jandiá *3
—*Paulicea luetkeni*	Jau, Pacamum †
—*Phractocephalus hemioliopterus*	Pirarara *3†
—*Pimelodina flavipinnis*	Mandi *3
—*Pinirampus pirinampu*	Barba-chata *3
—*Platynematichthys notatus*	Mandi

TABLE 7.2 Continued

—*Platynematichthys sturio*	Mandi
—*Pseudoplatystoma fasciatum*	Surubim *2†
—*Pseudoplatystoma tigrinum*	Caparari *2†
—*Sorubim lima*	Bico-de-pato *3
—*Sorubimichthys planiceps*	Peixe-lenha *3
Ageneiosidae	
—*Ageneiosus brevifilis*	Mandubé *3
Callichthyidae	
—*Hoplosternum littorale*	Tamoatá *3‡
—*Megalechis thoracata*	Tamoatá *3‡
Loricariidae	
—*Glyptoperichthys gibbiceps*	Bodó *3‡
—*Hypostomus carinatus*	Bodó
—*Hypostomus cf. emarginatus*	Bodó
—*Liposarcus pardalis*	Bodó *3‡
Perciformes	
Sciaenidae	
—*Plagioscion squamosissimus*	Pescada *3
—*Plagioscion* sp.	Pescada *3
Cichlidae	
—*Astronotus ocellatus*	Acará-açu *2
—*Chaetobranchus semifasciatus*	Acará-tucunaré *3
—*Chaetobranchus flavescens*	Acará-branco *3
—*Cichla monoculus*	Tucunaré *2
—*Crenicichla gr. lugubris*	Jacundá-vermelho *3
—*Geophagus proximus*	Acará roe-roe *3
—*Heros appendiculatus*	Acará-roxo *3
—*Hypselecara temporalis*Acará	
—*Satanoperca jurupari*	Acará-garrafa
—*Symphysodon aequifasciatus*	Acará-disco *3
—*Uaru amphiacanthoides*	Acará-bararuá *3
Pleuronectiformes	
Soleidae	
—*Achirus* sp.	Soia, Solha
Rajiformes	
Potamotrygonidae	
—*Potamotrygon constellata*	Arraia
—*Potamotrygon hystrix*	Arraia
—*Potamotrygon motoro*	Arraia

Note: Species marked * appear regularly in urban fish markets and are classed by price as 1 (premium quality), 2 (medium quality), and 3 (low quality); † are sold to *frigorificos* (freezer stations) at Tefé and Alvarães; and ‡ are sold alive. Unmarked species are eaten commonly only in the rural interior.

TABLE 7.3 Average Annual Landings of the Thirty Most Common Species/Groups of Species Originating from the Mamirauá Reserve at the Tefé Market

LOCAL NAME	SCIENTIFIC NAME	WEIGHT (KG)	%	CUMULATIVE %
1. Aruanã	*Osteoglossum bicirrhosum*	38,261	22.3	22.3
2. Curimatá	*Prochilodus nigricans*	28,875	16.8	39.2
3. Tucunaré	*Cichla monoculus*	18,374	10.7	49.9
4. Tambaqui	*Colossoma macropomum*	12,875	7.5	57.4
5. Pacu comum	*Mylossoma duriventre*	10,372	6.0	63.4
6. Pirapitinga	*Piaractus brachypomus*	8,741	5.1	68.5
7. Jaraqui escama grossa	*Semaprochilodus insignis*	7,970	4.6	73.2
8. Jaraqui escama fina	*Semaprochilodus taeniurus*	6,881	4.0	77.2
9. Acará-açu	*Astronotus ocellatus*	5,811	3.4	80.6
10. Matrinchã	*Brycon cf. cephalus*	3,073	3.3	83.8
11. "Salada"	—	5,159	3.0	86.8
12. Branquinha peito-de-aço	*Potamorhina latior*	3,062	1.8	88.6
13. Sardinha comprida	*Triportheus elongatus*	3,046	1.8	90.4
14. Caparari	*Pseudoplatystoma tigrinum*	2,678	1.6	92.0
15. Bodó	*Liposarcus/Glyptoperichthys*	2,313	1.3	93.3
16. Pacu galo	*Myleus rubripinnis*	2,098	1.2	94.5
17. Piranha caju	*Pygocentrus nattereri*	2,021	1.2	95.7
18. Acará-tucunaré	*Chaetobranchus semifasciatus*	1,675	1.0	96.7
19. Branquinha comum	*Potamorhina altamazonica*	1,263	0.7	97.4
20. Pescada	*Plagioscion* spp.	1,016	0.6	98.0
21. Cuiu-cuiu	*Pseudodoras niger*	998	0.6	98.6
22. Pirarucu	*Arapaima gigas*	628	0.4	99.0
23. Sardinha chata	*Triportheus angulatus*	408	0.2	99.2
24. Surubim	*Pseudoplatystoma fasciatum*	403	0.2	99.4
25. Dourada	*Brachyplatystoma flavicans*	206	0.1	99.5
26. Aracu comum	*Schizodon fasciatum*	205	0.1	99.7
27. Jatuarana	*Brycon melanopterus*	158	0.1	99.8
28. Orana	*Hemiodopsis/Hemiodus* spp.	154	0.1	99.9
29. Sardinhão	*Pellona castelnaeana*	141	0.1	99.9
30. Charuto (cubiu)	*Anodus melanopogon*	116	0.1	100.0
Total:		168,975		

Source: Summarized from Barthem (1999a).
Note: Data is averaged over the period 1991–1994. "*Salada*" refers to a mixed catch for which the market data collectors were unable to separate the species by weight. Data are absent or only partial for the following: (1) salted and sun-dried pirarucu, (2) fresh pirarucu since 1996 when IBAMA introduced an indefinite ban on all pirarucu commercialization, (3) large tambaqui that are transported to Manaus, and (4) large catfishes that are sold to *frigorificos* (freezer stations) for export to Peru or Colombia.

THE EARLY STAGES OF THE MAMIRAUÁ RESERVE

In the early 1980s a local group, the Movement for Grass-Roots Education, Movimento de Educação e Base (MEB), began to train community leaders in the Tefé region and build upon the CPT's campaign to assist lake-protection schemes (Hall 1997). During the late 1980s the primatologist José Márcio Ayres and the anthropologist Deborah Lima conducted pioneering studies in várzea floodplains at the confluence of the Rios Japurá and Solimões and recognized the outstanding conservation importance of the area. In addition to its relatively intact forest, this region contains a rich fauna and flora, including rare and endemic taxa, such as the white uakari monkey (*Cacajao calvus calvus*) (Ayres 1986). Ayres's and Lima's work led to a proposal for a conservation unit in the area to be established on a philosophy of community participation and to be built on the foundation of existing community-based lake protection schemes in the area.

The Mamirauá Reserve, named after a prominent lake in the area, began in 1990 under the interim status of Ecological Station, a conservation category in which the presence of people and the use of resources for purposes other than scientific research are illegal. Despite these restrictions, early work encouraged the communities of the area to consolidate an organizational structure based on the CPT model in which clusters of nearby communities regularly convene to discuss issues of mutual concern. Nine such clusters, or political sectors, were founded in the reserve. To resolve the irregular status of the Mamirauá Ecological Station and to guarantee defined rights of access for the local people necessitated lobbying for a revision of national conservation policy (Ayres et al. 1999). This was finally achieved in 1996 with the transformation of the Ecological Station into a Sustainable Development Reserve, the first of a new category of Brazilian conservation unit (Amazonas state decree 2.411 of July 16, 1996). The transformation provided local residents with defined access rights and represented a milestone in the inclusion of local people in some protected areas of Brazil. The overall goal of the Mamirauá Reserve is to reconcile biodiversity protection with long-term improvements in the living standard of the local people through three processes:

1. empowering and educating local people to defend the resources of the area from outside interests;
2. encouraging economically motivated sustainable management of these resources;
3. conducting a program of applied research on biodiversity and key natural resources (Ayres et al. 1999; Lima 1999).

RESEARCH AND EXTENSION ACTIVITIES IN THE RDSM

In 1992 Projeto Mamirauá was launched from headquarters in Tefé. Its goals were to formulate a management plan for the sustainable use of natural resources in the area that would become the RDSM and to catalog biodiversity. An international team of biological and socioeconomic researchers and a basic infrastructure of boats and floating research stations were funded by government and overseas aid. This first phase of the Mamirauá Project culminated with the production of the Mamirauá Management Plan (MMP) (SCM 1996) and supporting technical reports (Queiroz and Crampton 1999b). Implementation of the integrated management program outlined in the MMP began in 1997. The program emphasizes the shifting and seasonal nature of resource exploitation in the RDSM and, in addition to fisheries management, covers alternative agricultural practices, timber extraction, and caiman, turtle, and game hunting. (Queiroz and Crampton 1999a).

The Instituto de Desenvolvimento Sustentável Mamirauá (IDSM) was created by presidential decree in 1999 and charged with a mission to expand activities in the RDSM and to develop general models for the sustainable management of tropical forest ecosystems. By 2001 the IDSM hosted around twenty-five professional staff, seventy support staff, twenty interns, and several teams of visiting researchers. This involved an infrastructure comprising six boats, sixteen floating houses, fifty motorized aluminum canoes, and three vehicles. In 2001 the IDSM operated with a core annual budget of US$ 1.3 million, two-thirds of which came from the Brazilian government and the remainder from the U.K. Department for International Development. IDSM is currently expanding a multidisciplinary extension and research program in fisheries, forestry, agriculture, environmental education, and ecotourism. IDSM also runs a microcredit program that provides small loans for residents and users of the RDSM. Limited health and sanitation support beyond the obligations of the municipal authorities are also provided by IDSM. Regularly held meetings, including an annual General Assembly, provide a negotiating forum for the communities of the reserve and for other stakeholders in the region. The IDSM also produces a biweekly radio show and a quarterly newsletter.

BASIC AND ENVIRONMENTAL EDUCATION

Although researchers and extension workers in the IDSM constantly strive to explain the concepts of management to *ribeirinhos* (rural river-dwelling people), a baseline ecological awareness is essential for such concepts to be assimilated. Most fishermen are aware that some fish stocks are under pressure and that the need for preservation and management exists. Nonetheless, it is sometimes difficult for them to appreciate the long-term issues of management. The IDSM runs an environmental education program in which itinerant teachers and guest researchers run practical courses for both adults and children. The IDSM is due to inaugurate a moving (floating) center for environmental and scientific education in 2002 in order to intensify this program and deepen its impact on the young generation of ribeirinhos in the RDSM (E. Moura; IDSM, pers. comm.).

Illiteracy and innumeracy are the archenemies of economic independence and self-confidence in rural people. Just about every aspect of resource management requires a good standard of literacy. Participating in training courses, dealing with the environmental authorities, organizing community associations, and marketing produce, for example, all require reading and writing skills. The proportion of illiterate people over fifteen years old within the RDSM declined from 38% to 31% between 1996 and 2001. However, 55% of people over the age of ten in the RDSM either cannot read or read except with difficulty (E. Moura pers. comm.). As is the case in most várzeas, schools in the RDSM are small, usually run by just one part-time teacher, and offer education only to around the fourth grade. Thirty-two percent of people who migrate to urban centers from the RDSM do so to continue their schooling. The environmental education team of the IDSM is working closely with the state education authorities to raise standards of reading, writing, and arithmetic in the reserve for both children and adults. In addition to assisting with teacher training, the IDSM is also contributing to the schooling infrastructure, for example by donating solar panels and lights that allow classes to continue into the night (E. Moura pers. comm.).

ACCESS RIGHTS TO THE RDSM

The people of the Brazilian várzea floodplains do not possess exclusive rights of access to fisheries resources. This lack usually represents a major obstacle to the development of community-based fisheries management. Under the legislation supporting the demarcation of Mamirauá as a Sustainable Development Reserve (SDR), the residents are entitled to exclusive access to the natural resources of the reserve, even though they are still not the legal landowners. Therefore, it is illegal for commercial fishing boats to operate inside the RDSM without permission from the residents. If invading fishermen ignore requests to leave the reserve, the residents can request the intervention of agents of the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA) or the police. The powers and willingness of these authorities to support the population of the RDSM is discussed later. The status of a SDR effectively provides the preconditions for a community property regime in which rights to resources are held by a distinct group of users who exclude outsiders (McGrath et al. 1999).

ZONING IN THE RDSM

In addition to defining general rights of access to the reserve, a system of zoning was implemented. This system divides lakes and forests into areas of no use and sustainable use.

PROTECTION ZONE

A zone of total protection where fishing and all other forms of exploitation are unconditionally prohibited was demarcated in the central areas of the RDSM (fig.

7.2). This demarcation provides, in theory, a refuge for fish stocks, nursery grounds for many resident and migratory species (Crampton, Castello, and Viana this volume), and an area in which the habitats and biodiversity of the ecosystem are preserved intact. The boundaries of protection zone evolved during five years of negotiations with the reserve's residents and were designed to include: (a) substantial areas of all the major lake systems, (b) a variety of relatively intact forest ecosystems, and (c) acceptable divisions of territory between the organizational sectors of the reserve.

SUSTAINABLE USE ZONE

A sustainable use zone designated for multiple resource management by the resident and user communities of the reserve surrounds the protection zone (fig. 7.2). Lakes in this zone are divided into two categories: community lakes (*lagos comunitários*) and town lakes (*lagos de sede*).

Community lakes are reserved for the resident and user communities of the RDSM but closed to fishermen from outside. Each community has a territory of lakes and forest, the boundaries of which are negotiated with neighboring communities. The use of these lakes is left to the discretion of each community, but as described later, systems of active management are being implemented or encouraged. Basic management involves the division of community lakes into three categories: (a) subsistence lakes (*lagos de subsistência*), designated for supplying food; (b) commercialization lakes (*lagos de comercialização*), reserved for commercial operations; and (c) preservation lakes (*lagos de preservação*), set aside for permanent preservation or very occasional use (not to be confused with lakes in the zone of total protection). In the first phase of the Mamirauá Project, many conflicts were precipitated by neighborly incursions into community lakes. Most communities have since agreed on mutually satisfactory territorial borders. However, a considerable proportion of the Mamirauá Institute's efforts and resources were and continue to be expended in appeasing a wide range of these internal conflicts.

Town lakes form a category designated in the MMP for exclusive access by commercial fishing boats from the main towns of the area (Tefé, Alvarães, Uarani, Fonte Boa, and Maraã) but not from distant cities, such as Manacapuru, Manaus, and Itacoatiara. The original idea was that this concession was necessary to secure the cooperation of local urban fishing fleets after the closure of lakes within the RDSM. During the first years of the Mamirauá Project, attempts to provide controlled fishing rights in the RDSM for boats from Tefé's commercial fishing syndicate floundered. Commercial fishermen refused to acknowledge the limitation of fishing rights in what were previously more or less free-for-all areas. They refused to negotiate a settlement and vowed to continue invading the reserve (even with the threat of arrests by IBAMA following the 1990 transformation of the area into a conservation unit). In response, the communities of the RDSM reached a unanimous decision in the 1997 General Assembly to close all lakes to outside users.

Dialog between representatives of the Tefé fishing syndicate and RDSM fishermen was reopened tentatively in 1998 but achieved nothing until a small but symbolic agreement was reached in January 2000. The communities of Maguari and Barroso established three lakes as town lakes. Here, fishing was opened to associates of the Tefé fishing syndicate with stipulations that the communities would receive a share of the fishing profits in the form of fuel (which is used by the communities for lake vigilance). This agreement represented the first step toward establishing good faith between the antagonists of a decade-long deadlock. Reconciling the needs of urban fishermen with the needs of the population of the RDSM continues to be one of the Mamirauá Institute's central concerns.

VIGILANCE

The system of zoning and exclusive access rights described above would be weakened without an accompanying system of vigilance—the desire and motivation for which should ultimately come from the local communities. In the lake-protection schemes that preceded the implementation of the Mamirauá Reserve, the traditional procedure was for communities to intercept invading boats and request that they leave. These requests were usually ignored. To take advantage of the new legal status of the reserve and to strengthen the position of local fishermen, the IDSM is working closely with federal authorities and supports the training of voluntary environmental agents by IBAMA. When invading fishermen refuse to respect requests to leave the reserve, a network of VHF radios installed at strategic locations of the reserve is used to call the IDSM headquarters in Tefé. A formal denunciation is then delivered to the local IBAMA office. IDSM deals not just with incidents involving fishermen from outside the RDSM but also infractions by residents and users of the reserve (e.g., fishing illegally in the protection zone or in another sector's fishing grounds). When necessary, two or three authorized IBAMA agents are sent to resolve the incident, sometimes with the support of a police officer. IBAMA agents have the authority to make arrests and expel fishermen from the reserve. They can also confiscate equipment and illegal catches if they are intercepted in flagrante delicto.

A quantitative system of monitoring invasions of the RDSM by fishing boats was implemented in 1999 by the IDSM. Voluntary agents at the ten monitoring stations marked in figure 7.2 record the origin and motives of each attempted invasion. During the period February to December 1999, 94% of 304 attempted invasions by boats were by fishermen, 5% by professional hunters, and just 1% by timber extractors. Most of the invasions occurred during the peak fishing season at low water (Reis and Souza 2000). During eight IBAMA missions to the RDSM in 1999, 5 canoes, 1.9 tons of salted and sun-dried pirarucu flanks, and 178 tambaqui were confiscated (L. McCulloch, IBAMA-Tefé, pers. comm.). Following a violent encounter between community and commercial fishermen in which one community member was seriously injured, media attention led to Operação Mamirauá. This large-scale mission involved a sweep through the reserve in the peak fishing period preceding Christmas 1999 and was undertaken by a team of IBAMA agents from Manaus and Tefé in collaboration with officers of the federal and local police. Twenty-four illegal fishermen, three boats, sixteen wooden canoes, three motorized canoes, and ninety gillnets were apprehended during the operation. The list of confiscated catches included 6,755 kg of fish, 40 kg of game and 560 live turtles. A total of 17,200 Brazilian Reais in fines were applied (Pantoja 2000).

Similar but smaller scale operations were conducted through the low water season of 2000 as a partnership between the IDSM, voluntary agents from the RDSM, the Amazonas State Institute for Environmental Protection, IPAM (Instituto de Proteção Ambiental do Amazonas), IBAMA, the Tefé police force, and the army. Between August and November around 35,000 kg of fish and over 650 kg of game were apprehended along the margins of the RDSM. Over 330,000 Reais of fines were applied. These operations gave some indication of the scale of clandestine activity in the RDSM and surrounding areas.

Enforcement, however, is often difficult. The Tefé IBAMA post is responsible for an area of 251,000 km^2 and yet is staffed by just eight field agents. Until 1999 it did not even possess a boat. To address the paucity of field agents throughout the Amazon, IBAMA recently began training Voluntary Environmental Agents (Agente Ambiental Voluntário, or AAV). With additional support from the Catholic Church, a total of 330 voluntary AAVs have already been trained to operate in the Tefé region (Reis and Souza 2000). By August 2001 eighty-five AAVs from the RDSM had been trained and thirty-seven were active (P. Souza, Mamirauá Institute, pers. comm.). The AAVs assume a largely educational role and are trained to give courses in environmental education at schools and village meetings. They are also trained to guard lakes from intercommunity invasions by fishermen of the reserve itself and to confront invaders from outside. AAVs in the RDSM receive small stipends and rations of gasoline and are issued with a field kit including a flashlight and a jacket emblazoned with an AAV logo in IBAMA livery.

LOGISTIC AND INFRASTRUCTURE SUPPORT FOR VIGILANCE

Most of the 500 or so lakes in the RDSM are accessible to large boats only via channels effectively guarded by the presence of communities (fig. 7.2). However, illegal fishermen can easily carry canoes along trails that lead to some lakes. The Mamirauá Institute is strengthening the vigilance of lake systems by expanding a network of floating or fixed houses equipped with VHF radios. These posts also serve as bases for research, monitoring, and extension activities (fig. 7.2). The reserve currently has fifteen floating and two fixed posts equipped with radios. Voluntary agents conduct routine nocturnal forays during the low-water season. By 2001 seven organizational sectors of the RDSM had been provided with speedboats and rations of fuel to conduct these forays. The IDSM contributes 50% of the maintenance costs of the engines (P. Souza pers. comm.).

PARTICIPATORY MANAGEMENT

LAKE MANAGEMENT PROTOCOLS

Subsistence lakes are usually located near communities. Fishing is traditionally controlled in these lakes by using species-specific techniques (table 7.4) and by limiting effort to small and frequent catches. Commercialization lakes are fished infrequently but with a much greater effort and using generalist techniques, usually gill nets, for maximum yield. Similar patterns of gear use and catch frequency/intensity have been observed in várzeas of the Lower Amazon (McGrath, Silva, and Crossa 1998) and Central Amazon (Smith 1981; Merona 1990).

Commercialization lakes in the RDSM are often far from the communities, and camps are set up for fishing expeditions that last two or more days per lake. The management of commercialization lakes involves a *rodízio* (rotation) system of leaving the lakes to fallow for a period of four to six years between exploitation (McGrath et al. 1999). The logic of the fallow period is twofold. First, it encourages the reproduction and recruitment of species that breed within the várzea (see Crampton, Castello, and Viana this volume). Second, the lack of disturbance encourages all fishes, including those that breed outside (e.g., tambaqui and matrinchã), to take low-water refuge in fallow lakes over successive years. Communities suspend fishing and disruptive activities like logging in or near the entrances to favorite fallow lakes during the flood ebb period, a time when fishes move into lakes to seek low-water refuge. Rather than being formally preplanned, the timing of fallow periods and the total catches of these lake rotation schemes usually depend upon community needs and the abundance of fish in a given year.

MANAGEMENT SUPPORT FROM SCIENTIFIC RESEARCH

Scientific research at the Mamirauá Institute is beginning to strengthen traditional management by defining conservative sustainable yields for commercial species. One example of cooperative planning between researchers and fishermen is a community management and stock assessment system for pirarucu. This forms part of the experimental Fish Commercialization Program described by Viana et al. (this volume). A separate management plan for tambaqui included provisions for the protection of spawning sites along the Rio Solimões (Costa, Barthem, and Correa 1999). Nonetheless, in situ management of this species is unlikely to be effective because tambaqui undertake long upriver migrations from their natal sites before colonizing other floodplain areas. A management plan was also prepared for the exploitation of discus for the ornamental fish trade (Crampton 1999c).

RESTRICTIVE FISHERIES REGULATIONS

The fisheries component of the MMP (SCM 1996) included a series of restrictive regulations. These regulations were circumscribed by current IBAMA legislation,

TABLE 7.4 Selective, Semiselective, and General Fishing Techniques Used in Floodplain Lakes and Flooded Forests Within the Mamirauá Reserve

SELECTIVE TECHNIQUES	SPECIES
Arpão (robust single-head harpoon)	Pirarucu
Flecha/Flechão (small single-point harpoon launched from a bow or attached to a spear, usually used by day for fish swimming near the surface)	Aruanã, Tucunaré, Acará-açu, Pirapitinga, Jatuarana Matrinchã, Traira, Surubim, etc.
Zagaia (spear with a trident head, used with a head lamp or oil lantern for night fishing)	(As above)
Caniço/Caponga (The caniço is a rod and line with, in this case, a hook baited with a seed such as from a latex tree. The caponga is a rod and line with a seed or weight tied onto the end of the line that is splashed onto the water surface to mimic seeds falling from overhead branches.)	Tambaqui, Pirapitinga, Pacus
Espinhel (multihook longline baited with fruit)	Tambaqui, Pirapitinga, Pacus
Currico (hand line with retrievable metallic lure or dead bait)	Tucunaré, Pirapitinga, Aruanã
Pinauaca (rod and line with red cloth attached to hook as a lure)	Tucunaré, Pirapitinga, Jatuarana
SEMISELECTIVE TECHNIQUES	**SPECIES**
Tarrafa (throw net)	Bodó, Tamoatá, various characiform fishes
Caniço (rod and line with hook baited with berries, insects, cubes of fish, etc.)	Sardinha, Traira, Jeju Piranha, Jatuarana, Matrinchã, Pirapitinga, Acará-açu, etc.
Espinhel (multihook longline baited with insects, frogs, meat, etc.)	Aruanã, Acará-açu, Piranha, Traira, Jatuarana, Matrinchã, Sardinha, etc.
GENERAL TECHNIQUES	**SPECIES**
Small *malhadeira* or *miqueira* (gill net with monofilament netting, set in flooded forest or along lake edges)	Most small and medium-sized fishes
Large *malhadeira* (gill net with multifilament netting, set passively in lakes. Large fishes such as pirarucu and tambaqui are often driven into gill nets by batição [beating] in the manner of a driven game shoot.)	All large fishes. Small size classes are avoided by using large mesh.

Note: See Barthem et al. (1997) for additional techniques used exclusively in whitewater river channels and paranás.

but extra rules and recommendations were incorporated to accommodate local ecological and economic factors (Queiroz and Crampton 1999a). The following section describes fisheries restrictions in the MMP and how they have changed during the period 1996–2001. The Mamirauá Institute sympathizes with the fact that rural fishermen are often driven by economic circumstances to disobey restrictions and zoning regulations. Some tolerance is exercised in the case of subsistence fishing, but fishing for economic gain is enforced as carefully as possible. IBAMA regulations on size limits are reiterated in the MMP, and extra regulations are included for specific fisheries (Queiroz and Sardinha 1999; Viana et al. this volume).

TACKLE RESTRICTIONS

Gill Nets The MMP banned the use of gill nets throughout the reserve for pirarucu and recommended banning all other kinds of gill netting during low water. These restrictions were lifted through unanimous agreement in the 1997 General Assembly because it was agreed that gill nets are appropriate for the rotation harvesting of commercialization lakes in a well-run management program.

Seine Nets IBAMA laws include complex rules on which types of seines can be deployed in different habitats. The main types (purse and beach seines) were unconditionally banned in the MMP because they cause large-scale mortality of nontarget species (Barthem 1999a). This ban has been maintained and well respected since its imposition; very few residents of the reserve own seine nets.

CLOSED SEASONS

Pirarucu The MMP prohibited pirarucu fishing during the period December 1 to May 31. This prohibition is a reiteration or IBAMA policy before pirarucu fishing was indefinitely banned in 1996. This closed season is still applied to pirarucu harvested with special IBAMA authorization by the Fish Commercialization Program (Viana et al. this volume).

Tambaqui IBAMA's closed season for tambaqui usually extends from December to February (dates vary from year to year) and corresponds to the spawning period. The MMP recommended extending the closed season to begin earlier on October 1, which corresponds to the beginning of the low-water season when tambaqui are sensitive to exploitation. However, this recommendation was never approved by the general assemblies of the RDSM because of the economic value of this species.

HABITAT PROTECTION

The intimate dependence of floodplain fishes on seasonally flooded forests and floating meadows (Goulding 1980, 1993; Pires 1996; Henderson and Crampton

1997; Crampton 1999b) means that fisheries management can only work in the long term if integrated with habitat conservation. Floating meadows act as nursery grounds for a variety of commercially important species and provide low-water refuge for almost all fishes (Junk 1984; Crampton 1999b). Of the forest ecosystems, *restinga alta* forest growing on the high levees supports the highest diversity of trees and richest terrestrial and arboreal biota (Goulding, Smith, and Mahar 1996). It is also an important source of sustenance for seed- and fruit-eating commercial species, such as tambaqui, pirapitinga, and pacu. Levee forests are flooded by one to three meters of water for up to four months each year (Ayres 1993) and cover around 12% of the RDSM. A further 50% of the reserve is made up of transitional *restinga baixa* forests, the back-slopes from high levees down to low-lying pioneer chavascal forest (Ayres et al. 1999). Flooded chavascal forests support enormous areas of floating meadows during the high-water season.

At present there are no immediate threats to floating meadow habitats in the RDSM. However, restinga forests are threatened by the clearing of *roças* (gardens) for manioc and banana production. The high levees are always chosen for roças because they remain inundated for less time than lower-lying land. The greatest threat to the várzea habitats of the Amazon is unquestionably large-scale cattle or water buffalo ranching. which involves the complete destruction of várzea forests and the degradation and trampling of floating meadows. Ranching has begun in the Tefé region but does not occur in the RDSM, in part because there are no terra firme areas into which livestock can be driven during the high-water period. A major priority of the Mamirauá Institute is to provide the population of the RDSM with ecologically and economically acceptable alternatives to ranching. Profitable fisheries, integrated with forest management and forest-friendly agricultural activities, provide local communities with strong economic incentives to preserve restinga forests and floating meadows. Effective fisheries management should in this sense promote a self-reinforcing cycle in which habitat conservation and fisheries management are reciprocally beneficial.

FOREST-FRIENDLY AGRICULTURE

Researchers at the Mamirauá Institute are introducing new seed stock and teaching techniques for the cultivation of beans, corns, rice, peanuts, and melons on exposed beaches (J. Inuma, Mamirauá Institute, pers. comm.). These crops have no impact at all on the forest ecosystems of the várzea. Methods for extending the duration of roças or using secondary-growth roças instead of new forest are also being explored. Finally, the cultivation of understory trees for agro-forestry production is being evaluated. Cacao (*Theobroma cacao*), *açai* palm (*Euterpe oleracea*), and some other species already grow naturally in the várzea but are not very economically attractive. One promising species for commercialization is the camu-camu tree (*Myrciaria dubia*), the fruits of which are used to make a vitamin C-rich juice (SCM 1996).

FORESTRY

Várzea forests have outstanding economic potential due to the fast growth rates of a variety of commercially important trees, low harvesting costs (logs can be floated to the market), and constant market demand (Albernaz and Ayres 1999). With careful management, restinga forests (where most of the valuable timber grows) have the potential to provide a long-term supply of timber, the economic value of which exceeds that of agricultural production. With low harvest rates (approximately 5 trees/ha/year) and selective felling of trees, managed restinga forests are expected to retain most of their biodiversity and continue to sustain fish stocks during the high-water period (J. Bampton, DFID, pers. comm.). A forest management program at the IDSM is building the capacity of local communities to undertake sustainable management and to market wood through the formation of formal community associations. As with fisheries the definition of rights of exclusive access to timber resources is fundamental.

DISCUSSION

The primary aim of the Mamirauá Reserve is to reconcile wildlife conservation with long-term improvements in the living standards of the local people. So far, after almost ten years of activities, the partnership between MSDI and local people continues to be expanded with great enthusiasm by the resident and user population of the RDSM. The spending power of many communities has increased, and some indices of general standard of living such as infant mortality, literacy, and parasite infestation levels have improved over the last decade (IDSM 2001; E. Moura pers. comm.). Moreover, the results from the Fish Commercialization Program described by Viana et al. (this volume) give a clear indication of the magnitude of financial benefits that can accrue from sustainable fisheries management.

Is there evidence that participatory management, community vigilance, and zoning are also having the desired effects of restricting access rights to local users and promoting the conservation of resources? Below, we summarize some lines of evidence to suggest that for fish resources the answer in both cases seems to be yes:

MONITORING LANDINGS

Fish landings from the Focal Area of the RDSM have been monitored at the Tefé market since October 1991 (fig. 7.3) (Barthem 1999a,b). Although much of the variation in landings illustrated in figure 7.3 is related to seasonal effects, mean monthly landings from the Focal Area of the RDSM are 58% lower in the second half of the time series (5.40 tons, SD 4.14) than in the first half (12.74 tons, SD 8.87). This disparity is strongly significant (two-tailed t-test, $n = 51$, $T = 5.35$, P 0.001). Comparing the same periods, there was a smaller but significant decline (14%) in mean monthly landings from outside the Focal Area of the reserve from 159.25 tons (SD

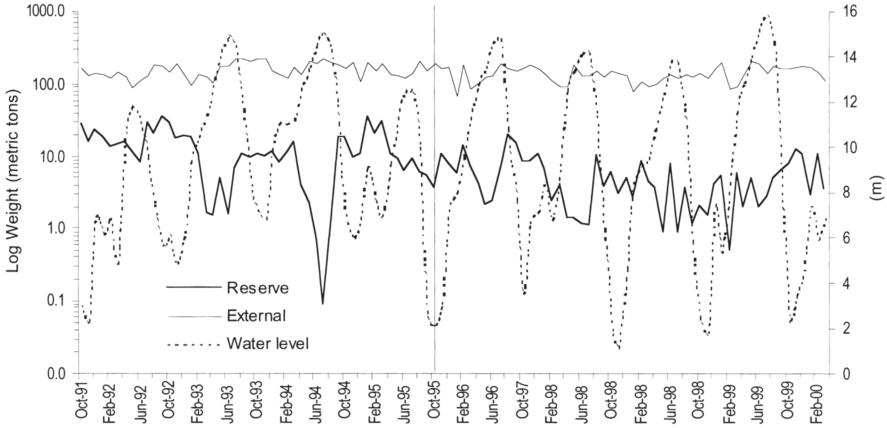

FIGURE 7.3 Commercial landings of fish at the Tefé fish market originating from inside and outside the Mamirauá Sustainable Development Reserve. Left axis shows landings on logarithmic scale. Right axis shows water level measured near Tefé at the beginning of each month. The datum at 10 m corresponds to the point at which high levee forest of the várzea become flooded. The vertical solid line divides the time series in half. The data excludes or is incomplete for the categories of fish listed in table 7.3. "Reserve" refers to the Focal Area of the RDSM (Mamirauá Sustainable Development Reserve) where fisheries management and vigilance are undertaken. "External" refers to the sum of three categories of data: (1) Subsidiary Area of RDSM (Mamirauá Sustainable Development Reserve), (2) outside the reserve, and (3) without information. The without information category represents 3.4% of the total data set and refers primarily to landings from outside the reserve.

36.94) to 136.99 tons (SD 34.01) (two-tailed t-test, n = 51, T = 3.17, P 0.005). These analyses indicate a substantial decline in the proportion of fish landings deriving from the Focal Area of the RDSM.

Landings from different classes of fishing boat were also discriminated (fig. 7.4). Fish brought to Tefé from the RDSM in canoes with long-shaft (*rabeta*) engines belong almost exclusively to residents and users of the reserve. On the other hand, commercial boats with inboard engines and with or without fixed iceboxes are exclusively owned by fishermen outside the RDSM and mostly belong to the urban fleet of Tefé. Between 1991 and 2000 there was a clear decline in (invasive) fishing in the RDSM from the most important category of commercial fishing boat—those with fixed iceboxes. At the same time there was a distinct rise in the proportions of landings at Tefé by the rabeta canoes.

Our feeling is that, despite some shortcomings, these data and observations indicate a decline in invasive fishing in the Focal Area of the RDSM and a concomitant increase in landings from residents and users. On a smaller scale, a similar trend was also observed in várzeas of the Amanã Sustainable Development Re-

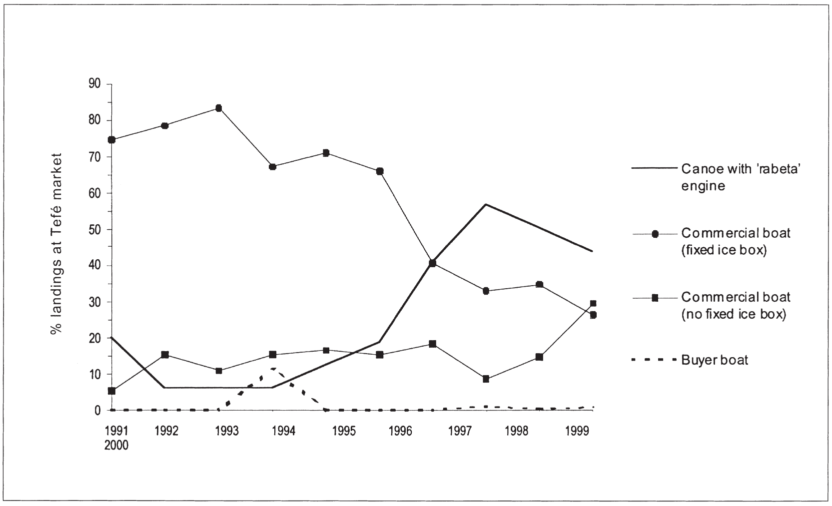

FIGURE 7.4 Proportional contribution of different categories of fishing boats to the commercial landings of fish at the Tefé fish market that originate from the Focal Area of the RDSM (Mamirauá Sustainable Development Reserve).

serve, a new protected area created in 1999, and in várzeas along the Rio Solimões within 50 km of Tefé. Both of these areas developed self-motivated community vigilance schemes over the last decade with support from the Tefé-based Preservation and Development Group (Grupo de Preservação e Desenvolvimento, or GPD) and from MEB of the Catholic Church (Hall 1997). Ongoing work at IDSM is attempting to describe more precisely who is fishing in the Tefé region and when.

INVASIONS BY THE *GELEIRA* FLEETS

One of the Mamirauá Reserve's most resounding successes has been the almost complete elimination of commercial *geleira* boats (with large ice holds) originating from the cities of Manaus, Manacapuru, and Itacoatiara (Ayres et al. 1999). The evidence for this elimination comes mostly from the reports of fishermen who recall a series of conflicts with geleira crews in the years preceding the designation of the area as a reserve. The geleira boats travel over distances of up to 700 km, and the closure of the Mamirauá Reserve affected only a small proportion of their potential fishing grounds. In contrast, a substantial portion of the fishing grounds of the Tefé commercial fishing fleet has been affected. This difference probably explains why there has been a more marked reduction in invasions by the geleira boats than by commercial boats from the Tefé fleet.

PERCEPTIONS OF LOCAL FISHERMEN

Interviews with thirty-eight fishing families from ten communities in the RDSM documented a general observation of increasing stocks for several commercial species (table 7.5).

POPULATION GROWTH OF KEY COMMERCIAL SPECIES

There is mounting evidence that populations of several key commercial species are increasing in the protection zone of the MSDR. Pirarucu populations are higher in the protection zone of the Jarauá Sector than in the surrounding sustainable use zone (Viana et al. this volume). Costa, Barthem, and Correa (1999) recorded consistently higher densities of tambaqui in protection-zone lakes of the RDSM than in lakes used for community subsistence or commercialization. The population of black caiman (*Melanosuchus niger*) has also increased dramatically within the protected zone of the Mamirauá Sector since the early 1990s (Ronis da Silveira, INPA—National Institute for Amazonian Research, pers. comm.).

OVERVIEW

The results above provide early evidence for the growth of key commercial species within the core protection zones of the MSDR and for a decline in invasions by outside users. The extent to which the two are linked is impossible to quantify, but

TABLE 7.5 Results of Interviews with Thirty-eight Fishermen in the RDSM to Characterize Perceived Changes in the Abundance of Key Fish Stocks

	NUMBER OF REPLIES				
SPECIES	Major Decrease	Minor Decrease	No Change	Minor Increase	Major Increase
Pirarucu	3	4	7	16	8
Tambaqui	2	2	8	13	13
Tucunaré	0	3	6	14	15
Aruanã	0	6	1	10	21
Pimelodid catfishes	4	8	13	8	5
Discus	2	2	17	8	9

Note: The interviews were conducted in September 2000 using a multiple-choice questionnaire. All of the communities are located on or near the banks of the Rio Japurá within twenty kilometers of the Jarauá community (fig. 7.2). The ten communities are Jarauá (4 fishermen interviewed), Santa Maria do Cururu (4), Vista Alegre (4), São Francisco do Cururu (4), Nova Betânia (3), Nossa Senhora da Fátima (4), Vila Betel (3), Manacabi (4), Novo Pirapucu (4), and Nova Colômbia (4).

presumably there has been an overall decline in pressure on key resources within the reserve (and especially within the core protection zones) that is promoting the recovery and growth of previously overexploited species. Community management and vigilance are presumably the main explanations for these patterns. Nonetheless, anecdotal evidence suggests that the mere presence of scientists and extension workers of the IDSM has an appreciable effect on the extent to which local users are likely to break zoning rules and on the extent to which outsiders are likely to invade.

Despite the incomplete and early nature of results emerging from the Mamirauá Reserve, it is evident that the kind of partnership between local people and a supporting NGO that is being developed in the RDSM can create the conditions for successful management, vigilance, and economic gain that are required to set up a self-reinforcing cycle of sustainable management.

These emerging results are welcome, especially because just five years ago it was unclear as to whether the substantial costs of establishing a Sustainable Development Reserve would be rewarded with any evidence for simultaneous improvements in ecosystem health, livelihoods, and access rights. Crampton, Castello, and Viana (this volume) suggest that future models for fisheries management in the Amazon basin will need to look carefully at the early results of contemporary experiences in fisheries management—both in the zoned reserve context of the RDSM and in the open multiuse context currently being developed by the Instituto Iara and Projeto Várzea in the lower Amazon. The early successes of the RDSM indicate that zoned reserve nuclei offer a tangible and potentially effective means of reconciling the conservation of fish stocks and habitats with sustained economic growth. The model offered by Crampton, Castello, and Viana (this volume) proposes a chain of such nuclei within regional zones of multiuse management. Each one of these nuclei will require the intervention and support of outside agencies or NGOs like the IDSM. Whether funding and expertise will be available for this proposal stands as one of the major challenges for environmentalists and politicians of the coming century.

ACKNOWLEDGMENTS

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8

Hunting Effort as a Tool for Community-Based Wildlife Management in Amazonia

PABLO E. PUERTAS AND RICHARD E. BODMER

Wildlife hunting is a major activity of Amazonian inhabitants, both in seasonally flooded várzea forest and nonflooded tierra firme forest (Beckerman 1994; Bodmer 1994). Local people in Amazonia preferentially exploit large and mid-sized mammals as sources of protein and cash income through meat sales (Redford and Robinson 1991; Bodmer et al. 1997b). In the western Amazon, hunting patterns are strongly influenced by meat values, and wildlife conservation strategies must incorporate local people's needs for wildlife meat. Community-based wildlife management allows people to obtain subsistence and cash benefits from hunting, while at the same time promoting conservation. Community-based strategies are apparently successful at conserving wildlife species in western Amazonia, in large part because human populations are relatively low (less than 1 person/km^2) and because an intact habitat is still abundant.

In a community-based system local people must make management decisions about access rights and levels of hunting. Thus, local communities must have a mechanism to evaluate the impact of hunting on wildlife species. Most models that evaluate the impact of hunting combine information on hunting pressure and some estimation of species populations (Bodmer and Robinson this volume). Information on hunting pressure is relatively easy for local communities to collect since hunters usually bring back animals to villages. However, information on animal populations requires great effort and in the Neotropics usually involves line transect censuses. These censuses are very time consuming and require methods that use unhunted trails with no hunting activity being conducted during censuses (Rabinowitz 1993). Local people must take time away from such other important activities as small scale farming, fishing, or subsistence hunting to do censuses. These other demans make it difficult for local people to carry out line transect censuses, especially if they do not receive financial incentives from outsiders.

Catch per unit effort (CPUE) analysis is an alternative method that can be used to evaluate the abundance of wildlife species and to measure trends in wildlife populations. CPUE is assumed to indicate whether a species is overhunted or not overhunted. A decrease in the CPUE would suggest overuse (a decreasing population), a constant CPUE would suggest a stable population, and an increase in CPUE would suggest an increasing population (Vickers 1991).

CPUE methods do not interfere with the activities of local people since they do not compromise other work, and CPUE data are relatively easy for community members to collect. Further, unlike line transects, CPUE is also relatively easy to analyze and can potentially be analyzed by local people. In turn, local people can make management decisions using CPUE.

This study evaluated the effectiveness of CPUE as a tool for community-based wildlife conservation. First, we determined whether CPUE could be used in Amazonia to evaluate wildlife species abundances. We did this by comparing CPUE with an independent measure of abundance using line transect censuses. Next, we determined whether CPUE data could be collected easily by local people, and could be used as a tool for community-based wildlife management.

The effectiveness of CPUE as a community-based wildlife management strategy was studied in the Tamshiyacu-Tahuayo Community Reserve (Reserva Comunal Tamshiyacu-Tahuayo, or RCTT) in northeastern Peru. Community-appointed wildlife inspectors collected data on CPUE. These inspectors were community members who were responsible for the vigilance of hunting, and they formed part of the community-based wildlife management program of the reserve. This inspection system was already in place prior to the start of the project. CPUE data were collected during 1994, 1995, and 1996 in the Tamshiyacu-Tahuayo community reserve. It examines the relationships between effort and yield, and in this case the relationship is presented as animal per hunter-days.

We evaluated changes in CPUE both annually and seasonally and compared differences in CPUE inside and outside the reserve. The comparison between seasons allowed us to test CPUE against an independent measure of abundance and to test whether CPUE reflects abundance. The comparison of CPUE inside and outside of the reserve showed us what species are appropriate for CPUE analysis and why CPUE analysis does not work for certain species. The comparison between years was used to test whether CPUE could be used as a measure of the sustainability of hunting.

STUDY AREA AND METHODS

THE RESERVA COMUNAL TAMSHIYACU-TAHUAYO

The RCTT, located in the northeastern Peruvian Amazon, comprises 322,500 ha of continuous, predominantly upland forest (75%) with a lesser amount of flooded forest (Bodmer et al. 1997b). (fig. 8.1). The city closest to the reserve is Iquitos, located

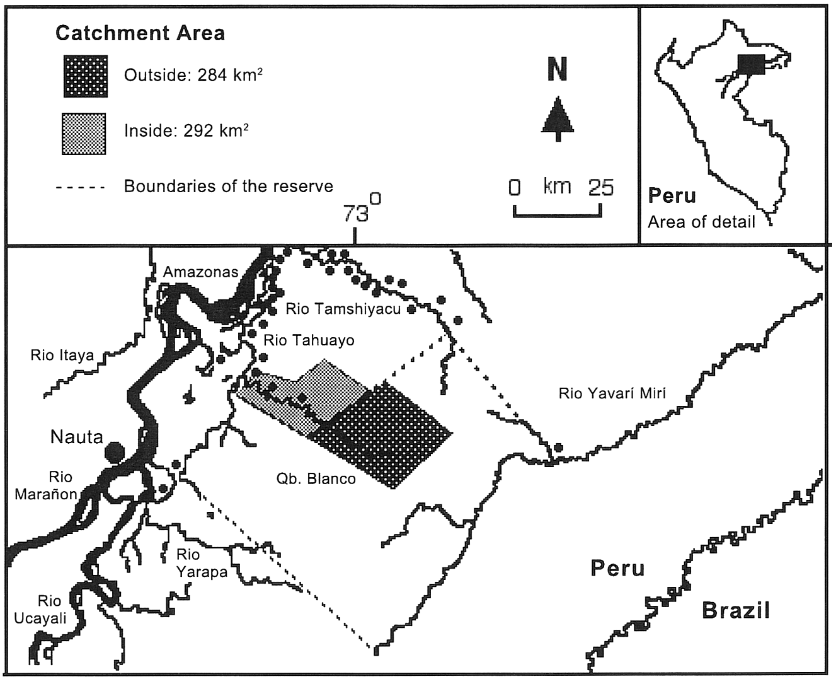

FIGURE 8.1 Location of the study area in the Reserva Comunal Tamshiyacu-Tahuayo, northeastern Peru, showing the catchment areas inside and outside the reserve.

about 100 kilometers northwest of the reserve, with a population of approximately 400,000 inhabitants. The reserve is bordered to the west by the upper Tahuayo and Blanco rivers, to the south by the upper Yarapa River, to the east by the upper Yavarí Mirí River, and to the north by the upper Tamshiyacu River.

The RCTT is divided into three distinct land use zones: (a) a protected source area of approximately 160,000 ha, (b) a zone of subsistence use of approximately 160,000 ha, and (c) an area of permanent human settlement that has no defined boundaries (Bodmer et al. 1997b). The subsistence use and source areas are within the official limits of the reserve and have no people living inside them. The area of subsistence use is for extraction of natural resources by local residents of the permanent settlement zone. Residents cannot set up houses or clear land for agricultural uses within the boundaries of the subsistence use or source areas. The area used for permanent settlements along the Tamshiyacu, Tahuayo, Yarapa, and Yavarí Mirí rivers is adjacent to the reserve. This area includes villages and is for intensive land use, such as agriculture. The human settlement zone was not officially included in the reserve in order to avoid conflict over land-use practices, but it is an important part of the RCTT management plans (Bodmer et al. 1997b).

The RCTT has an extraordinarily high diversity of faunal and floral groups (Castro 1991; Puertas and Bodmer 1993), due in part to the juxtaposition of tierra firme (upland) forest with rich soils and várzea (flooded) habitats and to its location in a biogeographic region of high species diversity in western Amazonia (Gentry 1988). At least fourteen species of primates are found in the RCTT, the greatest diversity of primates reported for any protected area in Peru (Puertas and Bodmer 1993).

The majority of rural inhabitants who use the reserve are nonindigenous people known as *ribereños* (Bodmer et al. 1997b). The major economic activities of these people include fishing, agricultural production, game hunting, small-scale lumber extraction, and collection of minor forest products, such as fruits, nuts, and fibers (Coomes 1992). Ribereños, like Amazonian Indians, have a great knowledge of forest plants, agriculture techniques, and hunting and fishing methods. Many have only recently abandoned their indigenous heritage in order to claim themselves as Peruvians. Ribereños have an intricate involvement in the market on both regional and international levels and harvest products, such as spices, rubber, and furs, that have traditionally been marketed in European countries and North America. These rural Amazonians are renowned for their ability to switch harvest patterns as markets change, a reason for their wide geographic mobility (Padoch 1988).

DATA COLLECTION, SAMPLING, AND HUNTING

Information on CPUE was collected from hunters who live in the middle and upper sections of the Blanco river and who use both the human settlement and subsistence areas of the Reserva Comunal Tamshiyacu-Tahuayo (fig. 8.1). The forests that hunters used in the human settlement area cover 284 km^2 and will be referred to as the "human settlement catchment area" or the "area outside the reserve." The forests that hunters used in the subsistence area are 292 km^2 and will be referred to as the "subsistence catchment area" or the "area inside the reserve."

Information on CPUE was collected from both direct observations and through hunting registers. Hunters began registering harvests in 1991 as part of the participatory involvement of community-based comanagement. Hunter participation relies on building interest in community-based wildlife management by having researchers work with hunters when evaluating the impact of harvests (Bodmer and Puertas 2000). Hunting registers involve hunters and their family in data collection. This participatory method helps researchers, extension workers, and hunters find common ground to discuss wildlife issues. These registers also provide information on CPUE and can be analyzed as the number of kills per person-day of hunting per year. Hunting registers were analyzed for this article using data from 1994, 1995, and 1996.

Three hunters and their families were trained as recorders for the registers in 1993. However, only two families collaborated effectively with the project, and we only used their data. The recorders' homes were strategically located along the banks of the Blanco river (Quebrada Blanco) so that they could easily note which hunters went up or came down the river. Hunting registers were checked continually during the first six months of the study to evaluate their accuracy and to make adjustments. Later, registers were checked monthly and compared for uniformity. Recorders' wives continued to register hunting activity when their husbands were away hunting or went to Iquitos to sell products. If hunters were not registered immediately after their return from the forest, they were registered indirectly through information provided by other local inhabitants.

Hunting registers included information about the number of animals hunted, the species, sex, and location of the kill, and dates of departure and return of the hunter. This last item was used to determine effort. The majority of the animals were identified by direct observation. In some cases, identification was made by comparison with specimens at the Zoology Museum of the National University of the Peruvian Amazon or the Peruvian Primate Project Manuel Moro Sommo in the city of Iquitos.

Line transects censuses were used as an independent measure of animal abundance. While over 3,000 km of line transects have been conducted in the area, we only used a portion of the data set to compare CPUE with abundance. We used data from 1997 collected during the low- and high-water seasons from the upper Qb. Blanco site inside the reserve. A total of 92 km of census was used for the low-water season and 170 km for the high-water season. The encounter rates of animal groups were used as a measure of abundance since individuals are not independent in social species.

RESULTS

COMPARISON BETWEEN SEASONS

There was no observed difference in CPUE between the high- and low-water seasons from 1994 to 1996 in the subsistence area inside the reserve (one-way Anova, $F = 0.009$, $p = 0.931$, $df = 1$) (fig. 8.2a). Likewise, there was no difference in the abundance of animal groups sighted on line transect censuses between the high- and low-water seasons when all species are considered together (Kruskal-Wallis, $p = 0.1$; $df = 7$) (fig. 8.3). The total harvest was greater in the high-water seasons than in the low-water (one-way Anova $F = 10.443$, $p = 0.032$, $df = 1$) (fig. 8.2b). This finding reflects a difference in access to the hunting zones between seasons. Hunters can reach the subsistence area inside the reserve more easily in the high-water season since high-water levels facilitate access with canoes and small boats. This access was reflected in a greater number of hunter-days in the high-water season than in the low-water.

There was no observed seasonal difference in CPUE between the high- and low-water seasons from 1994 to 1996 in the human settlement area (one-way Anova, $F = 0.168$, $p = 0.703$, $df = 1$) (fig. 8.4a). Thus, the collective abundance of species was similar during both seasons in the human settlement area. In addition, there

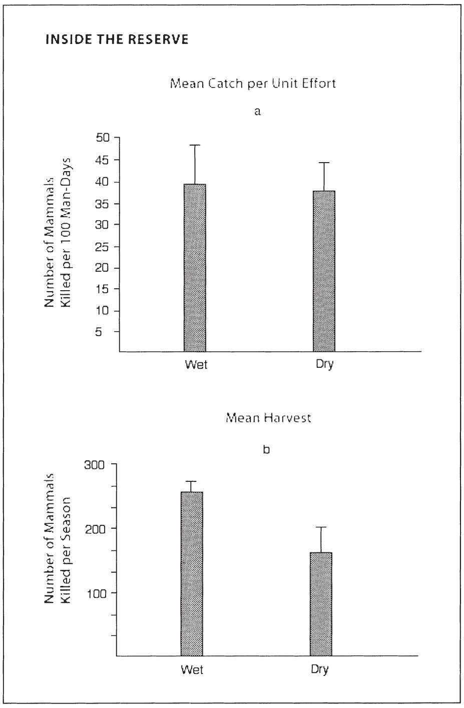

FIGURE 8.2 Mean (SD) CPUE (catch per unit effort) and hunting pressure inside the reserve between the high/(wet)-water and low/(dry)-water seasons.

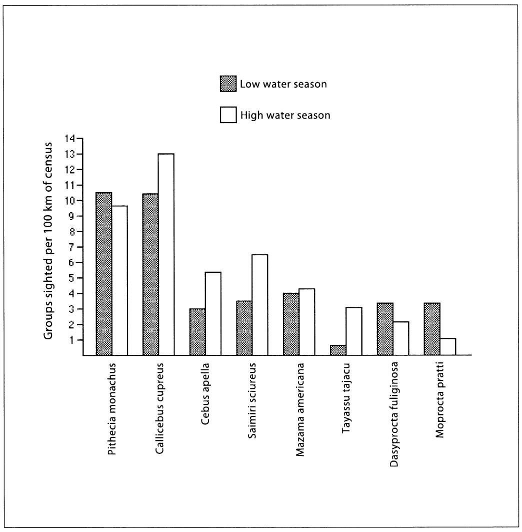

FIGURE 8.3 Relative abundance of large mammals between the high- and low-water seasons in the Tamshiyacu-Tahuayo Community Reserve in 1997.

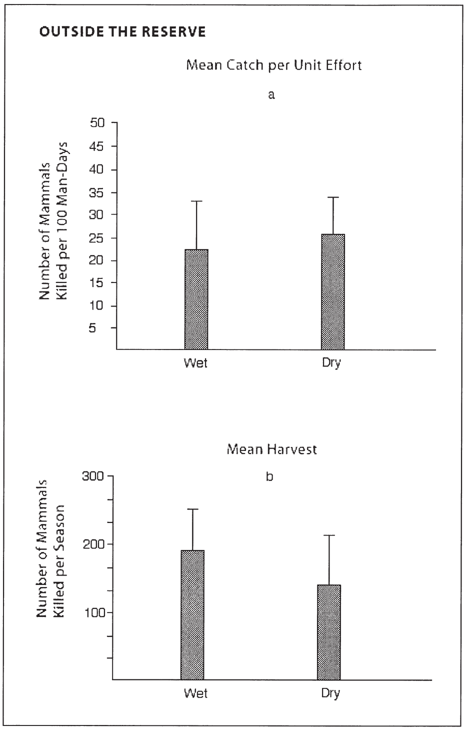

FIGURE 8.4 Mean (SD) CPUE (catch per unit effort) and hunting pressure outside the reserve between the wet and dry seasons.

was no observed difference in the harvests of mammals between the seasons (one-way Anova F = 0.748, p = 0.436, df = 1) (fig. 8.4b).

COMPARISON BETWEEN HUNTING AREAS

A total of 3,358 man-days of hunting were recorded during 1994, 1995, and 1996 in the subsistence area inside the reserve. On a few occasions, hunting dogs were observed accompanying novice hunters inside the reserve (table 8.1A). Artiodactyls, rodents, perissodactyls, primates, and edentates were the most important orders for local people hunting in the reserve. The ten most commonly hunted species, in order of importance, were: *T. pecari*, *T. tajacu*, *A. paca*, *M. americana*, *D. fuliginosa*, *T. terrestris*, *D. novemcinctus*, *P. monachus*, *M. gouazoubira*, and *Tamandua tetradactyla*.

A total of 4,200 person-days of hunting were recorded during 1994, 1995, and 1996 in the human settlement area outside the reserve. People were not observed using dogs when hunting in the human settlement area. Artiodactyls, rodents, primates, carnivores, and perissodactyls were the most important orders for local peo-

TABLE 8.1 Number of Individuals Hunted

	A	B	C	D	E	F
Species	**In (SD)**	**Out (SD)**	**In (SD)**	**Out (SD)**	**In (SD)**	**Out (SD)**
Tayassu pecari	42 (2.1)	21 (5.9)	11.3 (1.5)	4.3 (1.5)	3.46 (0.69)	1.393 (0.472)
Tayassu tajacu	30 (3.8)	14 (1.5)	7.7 (1.5)	2.7 (2.1)	2.037 (0.343)	0.727 (0.487)
Mazama americana	9 (1.5)	8 (0.6)	2.3 (0.6)	1.8 (1.9)	0.73 (0.115)	0.6 (0.575)
Mazama gouazoubira	2 (0.6)	2 (0.6)	0.5 (0.1)	0.1 (0.1)	0.097 (0.029)	0.107 (0.006)
Tapirus terrestris	3 (2.0)	3 (1.5)	0.7 (0.4)	0.7 (0.3)	1.123 (0.544)	0.6 (0.575)
Pithecia monachus	2 (2.0)	6 (5.0)	0.5 (0.5)	1.1 (0.9)	0.01 (0.01)	0.026 (0.022)
Callicebus cupreus	1 (0.2)	6 (1.2)	0.2 (0.1)	1.0 (0.1)	0.002 (0.001)	0.01 (0.0001)
Lagothrix lagothricha	1 (1.0)	2 (1.0)	0.5 (0.2)	0.4 (0.1)	0.053 (0.025)	0.043 (0.012)
Cebus apella	1 (1.4)	1 (1.4)	0.2 (0.1)	0.3 (0.1)	0.007 (0.004)	0.01 (0.009)
Cebus albifrons	1 (0.5)	2 (0.6)	0.2 (0.2)	0.5 (0.2)	0.005 (0.005)	0.016 (0.006)
Ateles paniscus	0.3 (0.6)	0.3 (0.2)	0.1 (0.2)	0.1 (0.1)	0.01 (0.017)	0.004 (0.004)
Cacajao calvus	0.4 (0.2)	0.5 (0.2)	0.1 (0.1)	0.1 (0.1)	0.005 (0.001)	0.004 (0.001)
Alouatta seniculus	0.7 (0.4)	0.8 (0.3)	0.2 (0.1)	0.2 (0.1)	0.016 (0.012)	0.016 (0.008)
Saimiri spp.	0	2 (1.3)	0	0.4 (0.3)	0	0.003 (0.002)
Aotus nancymae	0	0.1 (0.2)	0	0.02 (0.05)	0	0.0002 (0.0003)
Saguinus spp.	0	0.5 (0.5)	0	0.09 (0.1)	0	0.0004 (0.0005)
Agouti paca	44 (12.2)	22 (12.9)	17.0 (4.0)	4.7 (2.9)	1.137 (0.189)	0.393 (0.257)
Dasyprocta fuliginosa	4 (2.1)	8 (5.3)	1.1 (0.8)	1.8 (1.3)	0.057 (0.02)	0.083 (0.056)
Myoprocta pratti	0	2 (2.3)	0	0.5 (0.5)	0	0.004 (0.004)
Hydrochaeris hydrochaeris	0	0.1 (0.2)	0	0.03 (0.5)	0	0.01 (0.017)
Coendou bicolor	0	0.1 (0.2)	0	0.1 (0.1)	0	0.003 (0.005)
Sciurus spp.	0.2 (0.2)	4 (0.1)	0.1 (0.05)	0.1 (0.1)	0	0.0002 (0.0003)
Dasypus novemcinctus	2 (2.1)	3 (3.3)	3 (4.4)	0.5 (0.5)	0.047 (0.015)	0.039 (0.037)
Tamandua tetradactyla	1 (0.6)	2 (2.4)	0.4 (0.1)	0.5 (0.5)	0.017 (0.007)	0.022 (0.024)
Myrmecophaga tridactyla	*0.1 (0.2)*	*0.9 (0.9)*	*0.03 (0.1)*	*0.2 (0.2)*	*0.01 (0.017)*	*0.057 (0.064)*
Priodontes maximus	0	0.3 (0.2)	0	0.05 (0.04)	0	0.01 (0.012)
Didelphis marsupialis	0	0.1 (0.2)	0	0.03 (0.05)	0	0.0002 (0.006)
Chironectes minimus	0.1 (0.2)	0	0.03 (0.05)	0	0.002 (0.003)	0
Puma concolor	0.2 (0.4)	0	0.05 (0.04)	0	0.063 (0.065)	0
Nasua nasua	0.5 (0.4)	5 (3.0)	0.1 (0.1)	1.1 (0.9)	0.159 (0.27)	0.033 (0.021)
Leopardus spp.	0.3 (0.1)	0.6 (0.3)	0.1 (0.01)	0.1 (0.1)	0.007 (0.003)	0.01 (0.009)
Eira barbara	0	0.5 (0.5)	0	0.1 (0.1)	0	0.004 (0.005)
Potos flavus	0.1 (0.2)	0.4 (0.1)	0.03 (0.05)	0.1 (0.01)	0	0.002 (0.0006)
Total	150 (34.7)	115 (54.3)	46.4 (15.3)	23.7 (15.85)		

Note: (A) Annual mean number of individuals hunted in the subsistence area inside the reserve (In) and (B) in the human settlement area outside the reserve (Out); (C) CPUE (per 100 person-days) of mammals hunted in the subsistence area (In) and (D) in the human settlement area (Out); (E) CPUE (per 100 person-days) of mammalian biomass extracted in the subsistence area (In) and (F) in the human settlement area (Out). Values are for 1994, 1995, and 1996, and provided with (SD).

ple hunting outside the reserve. The ten most frequently harvested species, in order of importance, were: *Tayassu pecari*, *T. tajacu*, *Agouti paca*, *Mazama americana*, *Dasyprocta fuliginosa*, *Pithecia monachus*, *Callicebus cupreus*, *Nasua nasua*, *Tapirus terrestris*, and *Dasypus novemcintus* (table 8.1B).

Registries of hunters were greater in the subsistence area than in the human settlement area of the reserve (one-way Anova $F = 663.1$, $p < 0.001$, $df = 1$). Hunters living in communities close to the reserve did most of the hunting, while people living further from the reserve hunted less. Hunters living in communities further from the reserve tended to use the subsistence area inside the reserve. In contrast, hunters living in the communities closest to the reserve hunted more frequently in the human settlement area.

CPUE was greater in the subsistence area of the reserve than the human settlement area outside the reserve (one-way Anova, $F = 7.708$, $p = 0.037$, $df = 1$) (fig. 8.5). This finding suggests that animals are more abundant inside the reserve than outside.

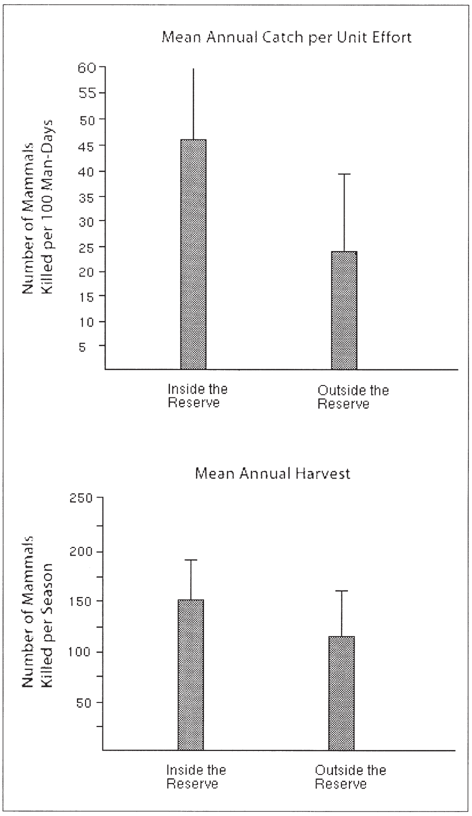

FIGURE 8.5 Mean (SD) annual CPUE (catch per unit effort) and hunting pressure inside and outside the reserve.

CPUE was greater in the subsistence area than the human settlement area for economically valuable species, such as *Tayassu pecari* (one-way Anova, $F = 31.5$, $p = 0.005$, $df = 1$) and *T. tajacu* (one-way Anova, $F = 11.25$, $p = 0.028$, $df = 1$), reflecting a greater abundance of peccaries inside the reserve. However, for such smaller, noneconomically valuable species as the titi monkey (*Callicebus cupreus*). CPUE was greater in the human settlement area than the subsistence area (one-way Anova, $F = 700$, $p < .0001$) (table 8.1C and D). Interestingly, noneconomically valuable species are used for household food and are usually hunted close to the villages. In contrast, hunting in the subsistence area focuses more on large animals whose meat can be used for subsistence or sold to purchase other basic subsistence goods (Bodmer et al. 1997b).

CPUE can also be analyzed using measures of biomass extracted;, such an analysis looks at the amount of meat hunted from an area. The species that had the greatest biomass extracted included *T. pecari*, *T. tajacu*, *Tapirus terrestris*, and *Agouti paca*. Total CPUE of biomass extracted differed between the subsistence and human settlement areas (one-way Anova, $F = 9.296$, $p = 0.038$, $df = 1$) (table 8.1E and F). *T. pecari* (one-way Anova, $F = 17.59$, $p = 0.014$), *T. tajacu* (one-way Anova, $F = 14.52$, $p = 0.019$, $df = 1$), and *Agouti paca* (one-way Anova, $F = 16.24$, $p = 0.016$, $df = 1$) had greater CPUE inside the reserve than outside, suggesting greater abundance of these species in the subsistence use area than in the human settlement area. These species are also the ones with the greatest economic value for people who hunt in the subsistence area.

In contrast, *Callicebus cupreus* (one-way Anova, $F = 53$, $p < .0001$) and *Potos flavus* (one-way Anova, $F = 49$, $p = 0.002$, $df = 1$) had greater CPUE of biomass extracted in the human settlement area than the subsistence area. Smaller species like *Callicebus* and *Potos* are exclusively hunted for household use and have little economic value.

These results show that CPUE should be divided among species. The effort for nonpreferred species is lower than for the preferred species in some sites, and CPUE analyses should be partitioned per species. For example, a low CPUE for agouti may be false if very little time was actually spent on hunting agouti at a site. If more time was then spent on hunting agouti at another site, then CPUE is not comparable for agouti. Thus, one can only really compare CPUE between sites for preferred species or for overall hunting yields, without a division into species.

COMPARISON OF CPUE BETWEEN YEARS

Comparing the annual values of total CPUE suggests that the animal populations are increasing in both hunting areas, although more data are needed to demonstrate this statistically (fig. 8.6). Overall, CPUE is showing similar trends between the subsistence area inside the reserve and the human settlement area outside the reserve. This positive trend in CPUE suggests that the community-based comanagement of wildlife is working for the conservation of most species. However, some

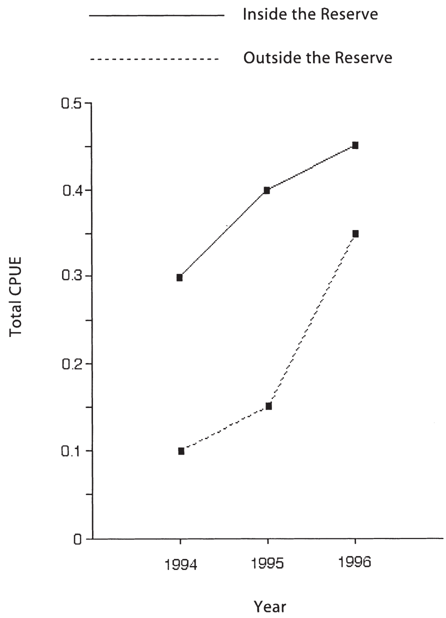

FIGURE 8.6 Trend in the total CPUE (catch per unit effort) per year inside and outside the reserve.

species of carnivores, primates, and edentates had decreasing CPUE over the years, indicating a decrease in their abundance.

CPUE AND COMMUNITY-BASED WILDLIFE MANAGEMENT

CPUE appears to be a reliable method for assessing the populations of wildlife in the Tamshiyacu-Tahuayo community reserve. Results show that, when independently comparing each hunting area, there are no statistically significant differences between high- and low-water seasons. This constant CPUE suggests that the abundance of species was similar between seasons both inside and outside the reserve. This similarity provides evidence of CPUE being an accurate measurement of mammal abundance since one would not expect changes in densities between seasons in Amazonian mammals that are found in upland (tierra firme) forests and that generally do not migrate.

One weaknesses of using CPUE as a comparative index of abundance between sites is that it only works well with economically important species, such as peccaries, deer, tapir, and large-bodied rodents. These mammals are hunted whenever they are encountered, either in the human settlement area or the subsistence area. However, with nonpreferred species, such as *Callicebus* and *Potos*, hunters really only kill these animals in the settlement area close to their homes since they are used almost exclusively for household consumption. These smaller, nonpreferred species are rarely hunted in the subsistence area since hunters visit the subsistence area for economically important species. Thus, the higher CPUE of *Callicebus* and *Potos* in the human settlement area compared to the subsistence area does not necessarily reflect a difference in abundance. Rather, it reflects a difference in hunter preference.

Community-based conservation is potentially a very important means of achieving conservation in tropical regions because people living in tropical forests often need to use resources for subsistence and market sale. If they are involved with managing those resources through community-based mechanisms, then there is potential for sustainable use and, in turn, conservation.

For community-based resource management to be truly participatory, local people must have a means of evaluating the impact of their resource use. For wildlife hunting this need means local people must have some way of evaluating the status of animal populations. Most simple population models that have been used to evaluate hunting in tropical forests rely on abundance or density estimates, usually using line transect counts. Abundance or density estimates are then entered into the models.

Line transect counts involve visual, auditory, or indirect counts (tracks) along trails that have been cut in the forest. Line transects only work well if trails are not used by hunters and if no hunting is occurring during censuses. For many tropical forest species, approximately 1,000 km need to be censused per site to obtain appropriate sample sizes. People conducting the censuses should walk at an average speed of 1 km/hour. It would then take an estimated 1,000 hours to conduct line transects or 125 person/days (using 8 hours/day), not taking into consideration the time it takes to open unhunted trails.

The effort needed for local people to conduct appropriate line transects as part of a participatory wildlife management program is likely to be impractical. People would need to take considerable time away from other activities to conduct line transects. If these transects were not financed it would be difficult for most local people to participate in wildlife censuses.

Alternative ways are therefore required for people to evaluate the impact of hunting that do not involve line transects. One of these might be using age structure analysis. Skulls of animals can be collected easily by local people, especially if they cook skull-brain soup, which is often the case in Amazonia. The animal skulls can then be used to assess the age of individuals, often using simple techniques such as tooth wear. These age data can be easily plotted into age structures. The problem of using age structure as a measure of hunting impact is in the interpretation of the results. Age structures of a hunted sample from randomly hunted populations might not differ significantly between slightly hunted and overhunted populations. Thus, using age structure of a hunted sample might give a false impression of sustainability when in fact the population is heading toward extirpation.

Another alternative is using CPUE as a measure of animal abundance and then using comparative abundances as a way of evaluating the impact of hunting. For example, in this study the annual values of total CPU were increasing for each hunting area. Preliminary results indicate that the overall wildlife population in both study areas was healthy and that the populations were not declining. The increase in the CPU between 1994 and 1996 might be due to the comanagement programs in the reserve. However, this finding does not apply for the specific species of carnivores, primates, and edentates. The results of this study suggest that wildlife is more abundant inside the reserve than outside and that the reserve zone conserves wildlife populations.

One great advantage of CPUE is that it agrees with the activities of local people and does not take much time away from other activities. Local people in the Tamshiyacu-Tahuayo community reserve were able to collect CPUE data easily by setting up a system of wildlife inspectors. Hunters would record the number of animals hunted and the time they spent hunting upon their return to the villages. This system meant that they could continue their resource use activities and collect the CPUE information at the same time. Similar to skull collections, CPUE information is compatible with community-based management systems. It is also more reliable than age structure analysis in the interpretation of the results, and it gives a clearer picture of the impact of hunting. Indeed, local hunters can evaluate CPUE results with minimal assistance from wildlife extensionists. This ability makes CPUE particularly valuable as a community-based technique. Furthermore, hunters could potentially work out abundances and see if animal populations are increasing, stable, or decreasing in their hunting areas. Local hunters could then make management decisions on hunting according to the CPUE results.

For CPUE to be reliable, hunting technology must be constant during the monitoring period. If technology changes then the CPUE does not give accurate results. In the Neotropics there are examples of indigenous groups converting from bow and arrows to shotguns (Hames 1980; Yost and Kelly 1983). This type of drastic change will influence the effort needed to hunt and, in turn, will make comparisons of CPUE between technologies difficult to interpret.

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