People in Nature

WILDLIFE CONSERVATION IN SOUTH AND CENTRAL AMERICA

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COLUMBIA UNIVERSITY PRESS / NEW YORK

COLUMBIA UNIVERSITY PRESS
Publishers Since 1893
New York Chichester, West Sussex

Library of Congress Cataloging-in-Publication Data
People in nature : wildlife conservation in South and Central America / Kirsten M. Silvius, Richard E. Bodmer, and José M. V. Fragoso, editors.
p. cm.
Includes bibliographical references (p.).
ISBN 0–231–12782–0 (cloth : alk. paper) —ISBN 0–231–12783–9 (paper : alk. paper)
1. Wildlife management—South America. 2. Wildlife management—Central America. I. Silvius, Kirsten M. II. Bodmer, Richard E. III. Fragoso, José M. V.

SK479.P46 2004
333.954'16'098—dc22

2003069649

Columbia University Press books are printed on permanent and durable acid-free paper.

Printed in the United States of America

c 10 9 8 7 6 5 4 3 2 1
p 10 9 8 7 6 5 4 3 2 1

To José Márcio Ayres, 1954–2003

That this book is dedicated to Marcio Ayres is powerfully appropriate, in that Marcio touched the lives and the intellects of so many of the authors. Marcio influenced the course of conservation in the Amazon probably more than any other single person in recent memory, and community-based management was at the heart of everything that he did.

Marcio will be forever associated with the creation of the Mamirauá and Amanã Reserves, two huge protected areas in central Amazonia that involve local communities in their management and development. In 1996, when the first was gazetted, Marcio helped introduce a new concept—the "sustainable development reserve." As opposed to a national park, which in Brazil called for the removal of local people from the reserve, the sustainable development reserve actively involved local inhabitants in management. Brazil's President Fernando Henrique Cardoso would later call Mamirauá "a living example of how it is possible to create positive coexistence between the inhabitants of a region and the preservation of that region." This was not empty rhetoric. Marcio had realized early on that in the absence of strong governmental institutions in the Amazon, local people driven by their own self-interest could become the guardians of nature and natural resources. Mamirauá, situated in the flooded forests, contains important wildlife, timber, and especially fish resources. The management plan granted usufruct rights to the local people, allowing them with the help of government agencies to exclude nonresidents from fishing in the reserve. The result was one of those rare "win-win" situations: the average income of local fishermen rose from R$320 in 1999 to R$845 in 2001, based largely on an increase in fish production from management lakes from 6.2 to 15 tons, while at the same time populations of pirarucu (*Arapaima*), the most important fisheries species, tripled in density. And local people have seen a dramatic rise in their educational achievement and health.

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.

ACKNOWLEDGMENTS

We thank several authorities cited by personal communication. J. Bampton, S. Gillingham, and G. Watkins commented on the manuscript. The authors were funded by CNPq and DFID.

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).

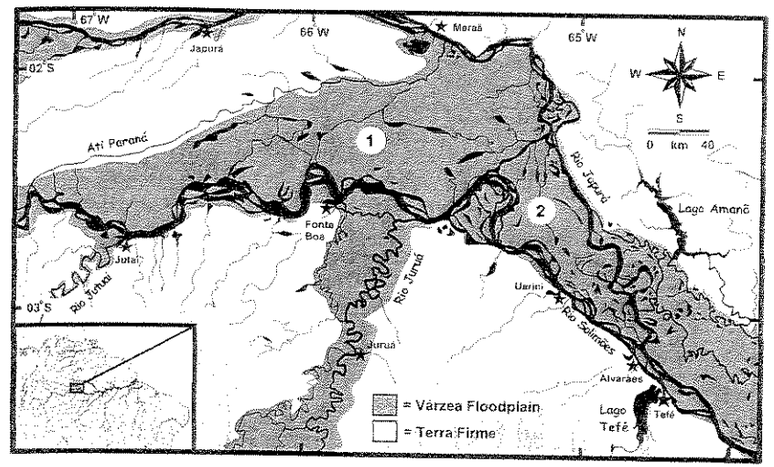

FIGURE 7.1 Map of the Upper Amazon region showing the Subsidiary (1) and Focal (2) areas of the Mamirauá Sustainable Development Reserve. Also shown are regional municipal centers and the extent of the várzea floodplain.

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 approximately 323 kg/km^2/year (840,000/2,600). Although probably somewhat of an underestimation, this figure is still an order of magnitude below Bayley and Petrere's 1989 estimated maximum sustain-

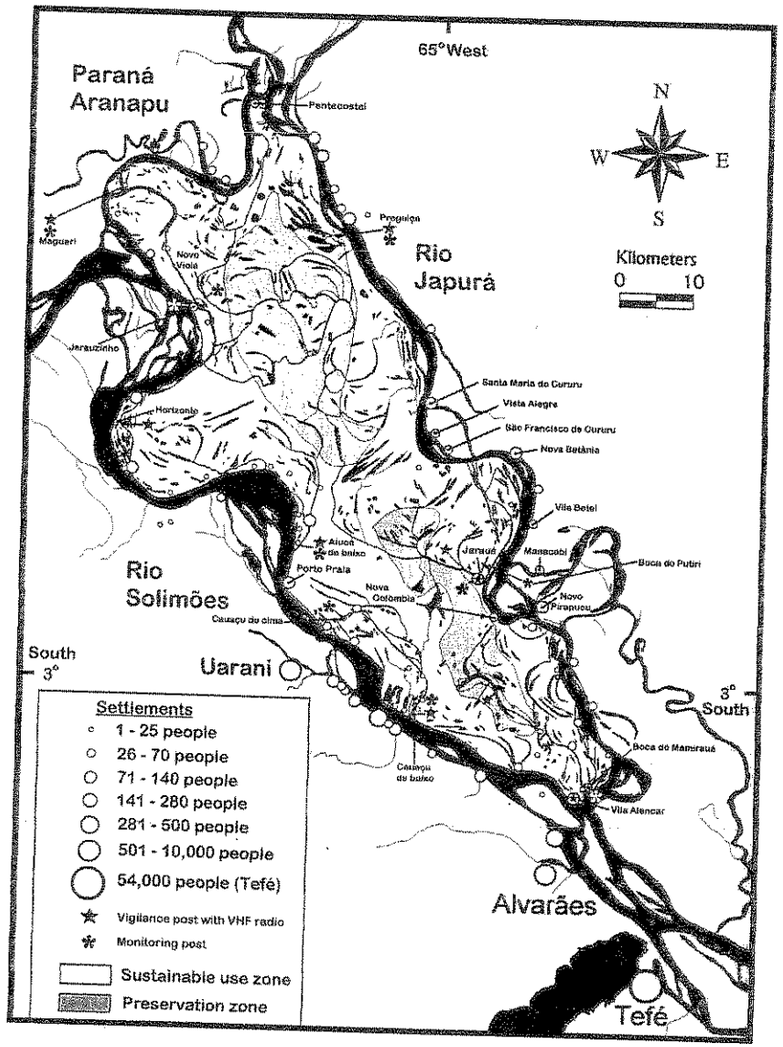

FIGURE 7.2 Map of the Focal Area of the Mamirauá Sustainable Development Reserve showing the core zones of total protection and communities.

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*	Traíra *3
—*Hoplocrythrinus 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 elongatus*	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
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 elongatus	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 elongatus*	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 *frigoríficos* (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 *frigoríficos* (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 re-

quires 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 of 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

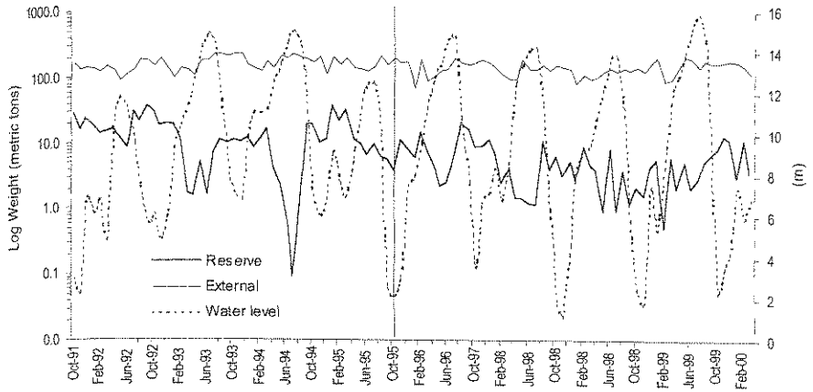

FIGURE 7.3 Commercial landings of fish at the Tefé fish market originating from inside and outside the Mamirauá Sustainable Development Reserve. Left axis shows landings on logarithmic scale. Right axis shows water level measured near Tefé at the beginning of each month. The datum at 10 m corresponds 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-

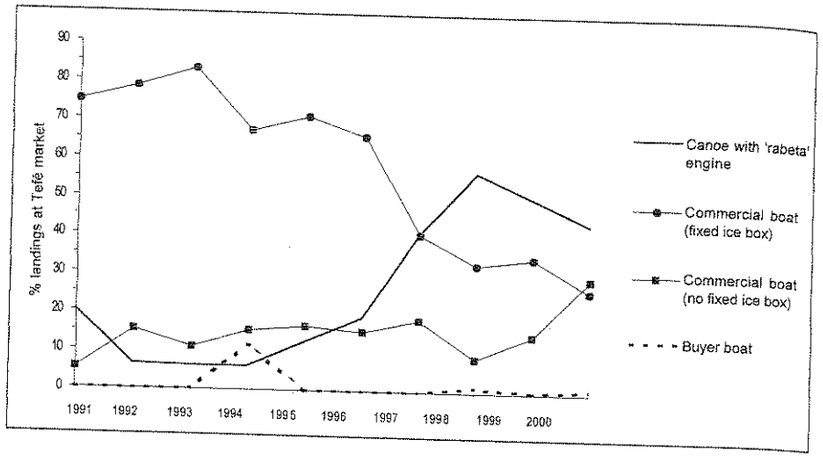

FIGURE 7.4 Proportional contribution of different categories of fishing boats to the commercial landings of fish at the Tefé fish market that originate from the Focal Area of the RDSM (Mamirauá Sustainable Development Reserve).

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

We thank J. M. Ayres and the staff of the Instituto de Desenvolvimento Sustentável Mamirauá. J. Bampton, G. Castro, M. Harrison, and S. Gillingham commented on the manuscript. The authors were funded by CNPq and DFID.

8

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

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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.