rapid biological inventories 11

Perú: Yavarí

Nigel Pitman, Corine Vriesendorp,
Debra Moskovits, editores/editors
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The Field Museum

The Field Museum is a collections-based research and educational institution devoted to natural and cultural diversity. Combining the fields of Anthropology, Botany, Geology, Zoology, and Conservation Biology, museum scientists research issues in evolution, environmental biology, and cultural anthropology. Environmental and Conservation Programs (ECP) is the branch of the museum dedicated to translating science into action that creates and supports lasting conservation. ECP works with the Museum's Center for Cultural Understanding and Change (CCUC) to involve local residents in long-term conservation of the lands that surround and sustain them. With losses of natural diversity accelerating worldwide, ECP's mission is to direct the museum's resources—scientific expertise, worldwide collections, innovative education programs—to the immediate needs of conservation at local, national, and international levels.

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Durrell Institute of Conservation and Ecology

DICE, the Durrell Institute of Conservation and Ecology, is dedicated to building capacity and undertaking research necessary to conserve biodiversity and the functioning ecosystems upon which people depend. DICE was established in 1989 as Britain's first research and postgraduate training center in conservation science, and named in honor of Gerald Durrell. Consequently, DICE seeks to integrate conservation and development sustainably; transfer capacity from developed to developing countries; and design and promote incentives to conserve biodiversity. In support of its mission, DICE has now trained postgraduates from over 70 different countries, and many occupy increasingly influential positions in conservation. DICE research is recognized internationally for its excellence and practical applications.

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Museum of Natural History of the Universidad Nacional Mayor de San Marcos

Founded in 1918, the Museum of Natural History is the principal source of information on the Peruvian flora and fauna. Its permanent exhibits are visited each year by 50,000 students, while its scientific collections—housing a million and a half plant, bird, mammal, fish, amphibian, reptile, fossil, and mineral specimens—are an invaluable resource for hundreds of Peruvian and foreign researchers. The museum's mission is to be a center of conservation, education and research on Peru's biodiversity, highlighting the fact that Peru is one of the most biologically diverse countries on the planet, and that its economic progress depends on the conservation and sustainable use of its natural riches. The museum is part of the Universidad Nacional Mayor de San Marcos, founded in 1551.

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The goal of rapid biological and social inventories is to catalyze effective action for conservation in threatened regions of high biological diversity and uniqueness.

Approach

During rapid biological inventories, scientific teams focus primarily on groups of organisms that indicate habitat type and condition and that can be surveyed quickly and accurately. These inventories do not attempt to produce an exhaustive list of species or higher taxa. Rather, the rapid surveys 1) identify the important biological communities in the site or region of interest, and 2) determine whether these communities are of outstanding quality and significance in a regional or global context.

During social asset inventories, scientists and local communities collaborate to identify patterns of social organization and opportunities for capacity building. The teams use participant observation and semi-structured interviews quickly to evaluate the assets of these communities that can serve as points of engagement for long-term participation in conservation.

In-country scientists are central to the field teams. The experience of local experts is crucial for understanding areas with little or no history of scientific exploration. After the inventories, protection of natural communities and engagement of social networks rely on initiatives from host-country scientists and conservationists.

Once these rapid inventories have been completed (typically within a month), the teams relay the survey information to local and international decision-makers who set priorities and guide conservation action in the host country.

REPORT AT A GLANCE	
Dates of field work	25 March–13 April 2003 (biological), 17 March–15 April 2003 (social)
Region	The Yavarí and Yavarí Mirín river valleys in the Amazonian lowlands of north-eastern Peru (Figure 2), where a 1.1 million-ha area has been proposed as a Zona Reservada, a first step towards formal protection. The area stretches from the Peru-Brazil border in the east to the Reserva Comunal Tamshiyacu-Tahuayo (which it includes) in the west. Its western border is 60 km south of the city of Iquitos.
Sites surveyed	Four sites along the Yavarí River, between the town of Angamos and the mouth of the Yavarí Mirín. At each site we surveyed a mix of forest types and microhabitats, both in the hilly uplands and on the Yavarí's broad floodplain. Upland forests at the first site grow on steep hills with relatively poor soils, while those at the second and third sites cover rolling terrain with richer soils. At the fourth site, an old alluvial terrace overlooks a mosaic of flooded forests and oxbow lakes near the mouth of the Yavarí Mirín.
Organisms surveyed	Vascular plants, fishes, reptiles and amphibians, birds, large mammals, and bats
Highlights of results	This region of Peru holds world records for tree and mammal species richness, and every group of organisms we studied was exceedingly diverse. Despite the area's extensive use during the rubber boom—attested to by thousands of scarred rubber trees still standing throughout the area—plant and animal communities appear fully recovered and essentially indistinguishable from those in famously intact regions of Amazonian Peru, like Manu National Park. **Plants:** The team registered more than 1,650 plant species in the field, of an estimated regional flora of 2,500–3,500 species. Forests along the Yavarí are floristically similar to those around Iquitos (but lack white sand soils) and are probably a good approximation of what the Iquitos area looked like many years ago. Even so, many common plant species here appear to be new records for Loreto or Peru. Upland forests are extremely diverse and heterogeneous, especially in poorer-soil areas, where tree species composition appears to turn over with soils on a very small scale. **Fishes:** Despite floodwaters that prevented sampling in the Yavarí itself, the ichthyologists recorded a much richer fish fauna than expected—240 species—in the mixed-water lakes and tributaries of the Yavarí. At least ten of the species collected are new to science and about 20 others are new to Peru. Most of the new species are small, showy fish with potential as ornamentals. More than 400 fish species are expected in the region.

REPORT AT A GLANCE

Highlights of results

Reptiles and amphibians: The herpetological team recorded 77 amphibian and 43 reptile species during the inventory, and estimate a combined total of 215 species. Five amphibians appear to be new to science, including a black frog speckled with vivid yellow and white spots that belongs to a formerly monotypic genus never before collected in Peru (*Allophryne*). Apart from river turtles and caiman, which are not common along the Yavarí and may be recovering from hunting pressure, the herpetofauna appears healthy and intact.

Birds: We recorded 400 bird species in just three weeks and estimate a regional avifauna of 550 species. The Red-fan Parrot (*Deroptyus accipitrinus*, Figure 6B), known in Peru from a single record and not reported in the country for half a century, was spotted several times in the Yavarí floodplain. Many other records, like the Elusive Antpitta (*Grallaria eludens*), represent significant range extensions. During the inventory we witnessed a large-scale migration event—a curious mix of boreal, austral, and within-Amazonia migrants—that suggests the area may be an important flyway for Amazonian birds.

Large mammals: Censuses reconfirmed what a decade's worth of mammal work in the area has documented in detail: world-record diversity and robust populations of many mammals globally threatened with extinction. Thirteen species of primate have been found inside the proposed Reserved Zone; two others occur just outside its borders. At least 11 populations of the threatened red uakari monkey—*Cacajao calvus*, protected nowhere else in Peru—occur in the area, and some of these contain more than 200 individuals. During the brief inventory we sighted several rare Amazonian mammals, including jaguar, tapir, giant anteater, short-eared dog, and giant otter.

Human communities

Despite the region's proximity to Iquitos, no settlements exist inside the 1.1 million-ha proposed Reserved Zone. The *ribereño* village of Nueva Esperanza (Figure 2), with 179 inhabitants, borders the proposed area to the northeast. Several other communities that settled in the region over the last four decades have since left, largely because of endemic, chloroquine-resistant malaria and poor access to markets in Leticia and Iquitos. The social team found strong interest in the surrounding *ribereño* settlements, and in the nearby Matsés indigenous territories farther up the Yavarí, for conservation that involves and benefits local communities. The Reserva Comunal Tamshiyacu-Tahuayo, which is included in the proposed Reserved Zone, has been successfully managed for 12 years by local communities on the Tahuayo and Blanco rivers (Figure 2).

REPORT AT A GLANCE

Main threats	The area is remarkably untouched at present, but two major threats are on the horizon. In the north, a segment of the proposed Reserved Zone overlaps with forestry concessions that may go into auction this year. Other forest concessions border the proposed Reserved Zone to the north, along the Esperanza and the lower Yavarí Mirín rivers. At the same time, communities on the lower Yavarí are discussing large-scale immigration projects into unoccupied areas along the Yavarí Mirín.
Current status	INRENA, the Peruvian service for protected areas, is supportive of the establishment of a Zona Reservada in Yavarí. However, a large area in the north of the proposed Zona Reservada (Figure 8)—a region of extreme biological importance and part of an AIDESEP (Asociación Interétnica de Desarrollo de la Selva Peruana) proposal to protect a non-contacted indigenous group—remains designated for logging concessions.
Principal recommendations for protection and management	01 ***Provide long-term protection for forests in the proposed Reserved Zone*** in association with surrounding communities, including strict protection for the upper Yavarí Mirín watershed and ecologically compatible use in buffer areas. 02 ***Remove or minimize the impacts of soon-to-open forestry concessions*** in the crucial "three headwaters" area between the Esperanza and Yavarí Mirín rivers. 03 ***Upgrade the Reserva Comunal Tamshiyacu-Tahuayo*** to a Reserva Comunal at the national level, within the Peruvian protected areas system (SINANPE).
Long-term conservation benefits	01 ***A new conservation area of global importance,*** protecting species and communities not present in conservation areas elsewhere in Amazonia and attracting conservation investments and ecotourism to Loreto and Peru. 02 ***Permanent preservation of a source area*** for commercially important fish and large mammal populations vital to the rural economy of Loreto. 03 ***Watershed protection*** for at least six major rivers in Loreto. 04 ***Participation of local* ribereño *populations in the management of the region's natural resources,*** as stakeholders in and beneficiaries of the long-term protection and sustainable use of the greater Yavarí valley.

Why Yavarí?

The world-famous forests around Iquitos, their animal communities exhausted by decades of hunting, stand eerily quiet. But just across the Amazon River, 60 km south of the city, the forests rustle with life. Here, where the Yavarí Mirín and six other rivers are born in the low hills of the Iquitos Arch, jaguar, tapir, and vast herds of white-lipped peccary roam a million-hectare wilderness with a human population density close to zero. Nowhere else in the tropics can one find such a vast back-country so close to a major urban area. Geography explains the paradox. A fisherman on the upper Yavarí Mirín, less than 100 km from Iquitos, must travel a twisting, 600-km route, skirting the Brazilian and Colombian borders and paddling up the main current of the Amazon, to sell his catch in the city.

Skimming above the mosaic of swamps and flooded forests in these headwaters, our overflights startled so many macaws and smaller parrots that for six hours we were rarely out of sight of them. On the ground, long-term inventories in the Yavarí Mirín valley have recorded healthy populations of mammals threatened by extinction nearly everywhere else in Amazonia, including 13 species of primates and the large game species that supply the rural economy in this part of Peru. For the many other groups of organisms that had never been studied in detail in the Yavarí valley—plants, fishes, amphibians and reptiles, birds, bats—our inventory provided a first glimpse at the riot of Amazonian diversity four degrees south of the equator.

Once bustling with traders drawn by its abundant natural rubber, the Yavarí region is all but deserted today. Only the occasional scarred rubber tree stands as a reminder of its working past. Yet as the Yavarí's forests grow wilder, people are planning their return. Logging concessions along the lower Yavarí Mirín are slated to become active this year, and large-scale immigration is creeping up the lower Yavarí. But a promising local alternative is at hand. Extending the success of the Reserva Comunal Tamshiyacu-Tahuayo (Figure 2)—which combines community-based management with scientific research to benefit forests and livelihoods—into the Yavarí Mirín valley will preserve a critically important area of Loreto, Peru and Amazonia for future generations.

Overview of Results

LANDSCAPE AND SITES VISITED

The rapid biological inventory team surveyed upland and floodplain forests, lakes, rivers, and swamps along a 125-km stretch of the upper Yavarí River, where it forms the Peru-Brazil border and the southeastern boundary of the 1.1 million-ha proposed Yavarí Reserved Zone (Figure 2). Over three weeks, we worked at four sites between the town of Angamos and the mouth of the Yavarí Mirín, a region previously unvisited by biologists. As the bulk of the team explored forests away from the river, the ichthyological team visited various aquatic habitats along the Yavarí and its tributaries, and the social team visited communities in the area of influence of the proposed Reserved Zone.

This area of Peru—the broad interfluvium bordered by the Ucayali, Amazon, and Yavarí rivers—is relatively homogeneous in geology and climate but a complex jumble of topography, soils, and forest types. Much of this variability is attributable to an uplifted geological structure here, the Iquitos Arch, in whose hills six major rivers—the Blanco, Tamshiyacu, Maniti, Orosa, Esperanza and Yavarí Mirín—have their headwaters. The Yavarí Mirín forms the heart of the proposed Reserved Zone, and its course follows the major abiotic gradient in the area, from the steep, less fertile hills in the south to the rolling, more fertile hills in the north.

VEGETATION AND FLORA

The most diverse tree communities in the world grow in the vicinity of Iquitos, and the number of trees and shrub species alone in the proposed Reserved Zone probably exceeds 2,000. Such an overwhelming diversity of species, most of them rare and patchily distributed, and many of them responding to small-scale variation in topography and drainage, made it a challenge for us to explore the region's vegetation effectively during such a short inventory. Though the botanical team collected >2,500 plants and carried out quantitative surveys of >1,700 trees in the field, we were left with the recognition of having only scratched the surface.

The ~1,650 species of plants we registered during the trip represent maybe half of the flora of the proposed Reserved Zone. This is a rough estimate,

but based on our experience elsewhere in Amazonia and on botanical surveys in the vicinity of Iquitos, we estimate the total flora of the proposed reserve at 2,500–3,500 species. The great majority of these are trees, shrubs, and lianas; epiphytic and terrestrial herbs seem only moderately diverse by Amazonian standards. Aquatic plants are notably underrepresented, perhaps because of the nutrient-poor black waters that dominate the region's lakes.

Most of the plant specimens collected during the rapid biological inventory have not yet been reviewed by specialists, so it is not yet possible to say how many of the taxa are new records for Peru, new to science, or globally threatened. At the family and genus level, the composition of these forests is essentially identical to those around Iquitos, with the exception of a few white-sand specialists present in Iquitos and absent in the Yavarí. A surprising number of the most common species we collected along the Yavarí, however, could not be matched to material in the Iquitos herbarium, and our expectation is that several dozen collections are new to Loreto and Peru.

Upland forests in Yavarí are structurally typical of the wet tropics, with a dense shrub and pole layer, a mostly closed canopy at 25 m, and scattered giant emergents exceeding 40 m. Local diversity of upland tree communities is terrifically high. In our poorer-soil tree plot, the first 50 trees ≥10 cm dbh we looked at represented 45 species. As around Iquitos, the most important tree family here is Myristicaceae, represented primarily by *Iryanthera* and *Virola* in the poorer-soil sites, these joined by *Otoba* in the richer-soil sites. Together, Myristicaceae, Sapotaceae, and Lecythidaceae account for more than a quarter of all the trees surveyed in the upland tree plots. At the species level, compositional differences between different soil types are especially noticeable at the poorer-soil site, where near-complete compositional turnovers are sometimes apparent on single hilltops. The most common tree species throughout the uplands are the palm *Astrocaryum murumuru*, natural rubber (*Hevea* sp., Euphorbiaceae), *Senefeldera inclinata* (Euphorbiaceae), *Iryanthera macrophylla*, *I. juruensis*, *Virola pavonis*, and *Osteophloeum platyspermum* (all Myristicaceae).

Very few plants were fruiting or flowering inside the forest at this season, with the exception of some areas of the floodplain, where we found an explosion of fruiting and carpets of recently germinated seedlings. Here the common trees are *Virola surinamensis* (Myristicaceae), *Maquira coriacea* (Moraceae), and *Pseudobombax munguba* (Bombacaceae), as well as the palms *Socratea exorrhiza*, *Euterpe precatoria* and *Astrocaryum murumuru*.

Swamp forests are mostly mixed-species, relatively diverse but palm-dominated stands intergrading with other types of flooded forest. In our swamp tree plot, just three plant families—palms, Clusiaceae, and Lepidobotryaceae—accounted for 53% of the trees. Apart from the well-known *Mauritia flexuosa* (*aguaje*), common elements of area swamps include *Symphonia globulifera* (Clusiaceae), *Ruptiliocarpon caracolito* (Lepidobotryaceae), *Virola surinamensis* (Myristicaceae), and the palms *Euterpe precatoria*, *Socratea exorrhiza* and *Attalea butyracea*.

FISHES

Apart from the Yavarí River itself, which was in full flood during the inventory, the ichthyological team covered the full spectrum of aquatic habitats, collecting standardized samples at 24 stations. The team visited six oxbow lakes and twelve large tributaries along the Yavarí, three smaller tributaries far inland and away from the river, two flooded forest sites, and a swamp. Fourteen of these sites were classified as primarily blackwater habitats, seven as primarily whitewater habitats, and three as primarily clearwater habitats.

We recorded 240 species of fish in the inventory and we estimate between 450 and 500 species in the proposed Reserved Zone. The very high diversity of fish communities along the Yavarí and the marked compositional differences between blackwater and whitewater habitats are illustrated by the low proportion

of species shared by the first three sites we visited: a mere 22%.

Roughly every one in ten fish species collected on the Yavarí during the rapid biological inventory is a new record for Peru. Ten species are likely new to science, including undescribed taxa in *Characidium*, *Moenkhausia*, *Tatia*, *Ernstichthys*, *Otocinclus*, Glandulocaudinae, and Trichomycteridae. Many of the species probably new to science are small, showy fish with high potential as ornamentals.

Another important result of the rapid biological inventory was the discovery of a large number of economically important species, including *Arapaima gigas* (*paiche*), *Osteoglossum bicirrhosum* (*arahuana*), and the large catfish *Brachyplatystoma flavicans* (*dorado*), *Pseudoplatystoma fasciatum* (*doncella*), *P. tigrinum* (*tigre zúngaro*), and *Phractocephalus hemioliopterus* (*peje torre*). Many of these were found as juveniles in the flooded forest, suggesting that the extensive seasonally flooded aquatic habitats along the Yavarí and the Yavarí Mirín are important breeding grounds in the life cycles of larger migratory fish.

AMPHIBIANS AND REPTILES

Our inventory was at the height of the rainy season, and reptiles and amphibians were abundant in the leaf litter in most habitats. In only 20 field-days, the herpetological team registered more than 70 amphibian and nearly 45 reptile species, including 15 snakes. We estimate respective regional totals at 115 and 100, including some 60 species of snake.

The composition of the Yavarí herpetofauna is typical of the hyperdiverse amphibian and reptile communities of upper Amazonian terra firme sites. Even so, it differed in many respects from the closest well-known herpetofauna, at Jenaro Herrera. We registered all but four of the 18 species of *Eleutherodactylus* expected here and all but eight of the expected lizards, undoubtedly some of the highest diversities for these groups ever recorded in the Peruvian lowlands. By contrast, the single species of microhylid, three of *Phyllomedusa*, three gekkos, and relatively few *Hyla* recorded in Yavarí indicate an absence of typical *várzea* habitats and floating aquatic vegetation. Arboreal species and amphibians with explosive reproduction were also less diverse than expected, perhaps because of poorly understood seasonal variation in their activity.

Perhaps the most important find among the amphibians—undoubtedly the most striking—was a small black frog speckled with yellow and white spots (Figure 5C), collected along a stream at Lago Preto. Initially field-identified as an undescribed species of *Hyla*, the specimen has since been classified as an undescribed species of a formerly monotypic genus known primarily from Venezuela and never before collected in Peru (*Allophryne*). We also registered at least one *Scinax* new for Peru and at least four other species probably new to science, in the genera *Scinax*, *Hyla*, *Hyalinobatrachium* and *Bufo*.

Reptiles are difficult to sample well during rapid inventories, because of their low densities and secretive lifestyles. But Yavarí was exceptionally rich in arboreal lizards (*Anolis*, *Enyaloides*) and streamside lizards, and the rarely encountered snake *Porthidium hyoprorus* was sighted on two occasions. Terrestrial tortoises (*Geochelone denticulata*) seem to have healthy populations here, with individuals spotted in the first three sites. By contrast, taricayas (*Podocnemis unifilis*), charapas (*Podocnemis expansa*, Figure 5H) and spectacled caimans (*Caiman crocodilus*), commonly hunted for food along major rivers, are rare along the Yavarí and its tributaries, and will require special attention in the protected area.

BIRDS

Despite its proximity to Iquitos, the interfluvium among the Ucayali, Amazon, and Yavarí rivers has been understudied by ornithologists. The few sites surveyed to date suggest that the region's avifauna is a unique mix of species with strong affinities to the avifauna of

southeastern Peru and southwestern Brazil, but complemented by some other species typical of the north bank of the Amazon. The sites we visited along the upper Yavarí during the rapid biological inventory are distant from any locality studied extensively by ornithologists, and provide further insight into the distribution of the avifauna of this interfluvium. We found some species pairs of closely related birds that turn over between the northern and southern parts of the interfluvium, where the Amazon and Juruá watersheds meet.

During the three-week inventory we recorded 400 birds, of a likely regional avifauna of 550 species. Particularly important was the discovery of the second-known Peruvian population of *Deroptyus accipitrinus* (Red-fan Parrot, Figure 6B). Other novelties included the northernmost Peruvian records for *Grallaria eludens* (Elusive Antpitta) and *Hylexetastes stresemanni* (Bar-bellied Woodcreeper). We also discovered what appears to be the boundary between the geographic ranges of two closely related puffbirds: *Malacoptila semicincta* (Semicollared Puffbird) and *Malacoptila rufa* (Rufous-necked Puffbird).

Important habitats for birds within the proposed Reserved Zone include terra firme and seasonally flooded forest, stands of aguaje palms (*Mauritia flexuosa*), lakes, streams, and riparian habitats along the Yavarí as well as the smaller Yavarí Mirín. The aquatic habitats along the Yavarí are unusual within south-bank forests of the Peruvian Amazon in their blackwater components, which influence the composition of the local avifauna. This results in the presence of some species not regularly found elsewhere in other south-bank Amazonian forests, such as *Hemitriccus minimus* (Zimmer's Tody-Tyrant) and *Conopias parva* (Yellow-throated Flycatcher).

During the first week of fieldwork, we witnessed an impressive migration event in which thousands of birds—a mixture of boreal, austral, and within-Amazon migrants—passed northward over the Yavarí River. Among the migrants were nighthawks, swifts, swallows, and tyrant flycatchers. Some of the species are poorly known from the Peruvian Amazon, and some were not known to be migratory, including *Cypseloides lemosi* (White-chested Swift).

Commercially important species like large macaws, parrots, and cracids seem to be present here in healthy populations. Though it was not encountered during the inventory, there is evidence that the endangered *Crax globulosa* (Wattled Curassow) occurs along the Yavarí. Should this species be found within the boundaries of the proposed Reserve Zone, it would become only the second protected area in Peru to harbor the species.

MAMMALS

In contrast to the site's poorly known avifauna, mammal communities of the Yavarí valley are among the best-studied in Amazonia. Richard Bodmer and colleagues from WCS-Perú and DICE have been carrying out mammal research in the Yavarí Mirín valley since 1990. Their work has focused on the population dynamics of economically important game species, like peccary, deer, primates, and tapir, and has relied on extensive collaboration with local hunters, who register hunting pressure and collect skulls from harvested animals. A focus of recent work has been to understand how and why mammal composition and density vary from place to place in the greater Yavarí valley, both between different forest types and under different hunting regimes.

One key result of this work, described in detail in this report (see "Use and Sustainability of Wildlife Hunting in and around the Proposed Yavarí Reserved Zone"), derives from a careful comparison of the sustainability of hunting inside and outside the proposed Reserved Zone. The results indicate that all of the animals that are hunted near or above sustainable levels in the outskirts of the proposed Reserved Zone are hunted below sustainable levels within it. The Yavarí Mirín valley thus functions as a source area for large mammals, with population excess migrating into and bolstering populations in adjacent overhunted sink areas. Because the trade in wildlife meat accounts for some

25% of the rural economy in this area of Peru, the Yavarí Mirín's production of large mammals is key for the long-term stability of the rural economy in the area.

During the rapid biological inventory, the mammal team censused more than 500 km of trails at the first three sites along the Yavarí River. This area had never been censused for large mammals before, and one goal of the work was to assess the health of populations in this region, presumably impacted by hunters traveling along the Yavarí. The censuses revealed that the area's large mammal populations are at very healthy densities, with little sign of hunting impact. Most species' population densities are within the ranges documented inside the more remote and less-hunted Yavarí Mirín valley. Tapir and white-lipped peccary are less common along the Yavarí, but woolly monkeys and black spider monkeys are more common.

We registered 39 large terrestrial mammal species during the rapid biological inventory. Based on more extensive work in the adjacent Quebrada Blanco, just outside the proposed Reserved Zone (Figure 2), we estimate that approximately 150 mammal species, including bats and small terrestrial mammals, are present in the area, making it a strong contender for the world's most diverse mammal community.

The proposed Reserved Zone is a safe haven for a large number of mammal species threatened with extinction elsewhere in their ranges. Twenty-four species confirmed or expected in the area are listed as threatened by the IUCN or in the appendices of the CITES convention. Globally threatened mammal species present in the Yavarí valley include giant river otter, bush dog, lowland tapir, giant armadillo, giant anteater, and the red uakari monkey. A large number of mammal species currently listed as data deficient by the IUCN also have healthy populations here.

Of the 13 primate species present in the proposed Reserved Zone, the red uakari (*Cacajo calvus*) is of keen interest for research and conservation. Groups sighted in the Yavarí Mirín to date are some of the largest ever seen for these species, containing up to 200 individuals. This species is of key conservation importance for several reasons. First, half of the known populations within the proposed Reserved Zone occur in areas currently slated for logging concessions, and will be in severe danger of hunting when operations begin, potentially within a matter of months (Figure 8). Second, the species is ecologically restricted to a small proportion of this vast landscape—the swamps where its principal food tree, the *Mauritia* palm, grows. Third, the species is distributed in a peculiarly patchy fashion across the area, with a small number of apparently disjunct populations scattered along the Yavarí and Yavarí Mirín rivers and the Quebrada Blanco (Figure 8). Fourth, the species is not protected anywhere else in the Peruvian network of protected areas. On the basis of this species alone, the Yavarí Mirín valley merits strict, long-term protection.

In addition to the large mammal censuses, we conducted a preliminary bat survey during the rapid biological inventory. For ten nights, two mist nets in both upland and flooded forest, at ground level and in the mid-story, caught 20 species of an expected bat fauna of 60.

HUMAN COMMUNITIES

The proposed Reserved Zone is practically unoccupied by people, and the surrounding region is sparsely populated as well. This has not always been the case. From the late 19th century until the collapse of the rubber industry in the 1920s, the area was thick with rubber tappers and traders, and steamships plied the Yavarí and Yavarí Mirín regularly. As recently as the 1960s, some 1,000 people lived along the upper and lower Yavarí Mirín, in the heart of the proposed Reserved Zone, harvesting *palo de rosa* and other timber species and hunting commerically. Over the next few decades there was a gradual exodus from the region, as epidemics of chloroquine-resistant malaria and the difficulty of getting products to market made life increasingly strenuous.

Today, the last remnant of this formerly more extensive population is the small community of Nueva Esperanza, home to 179 people, which would be immediately adjacent to the protected area (see map in

Figure 2). Most of Nueva Esperanza's inhabitants are not indigenous, but rather *ribereño* settlers with a long history in the region (Figure 9H). The economy is a mix of subsistence agriculture and commercial trade in wildlife meat and skins (principally peccary), which are sold in the distant markets of Leticia, Benjamín Constant, and Tabatinga. Malaria continues to be a problem, with more than 340 cases registered in 2001 and 2002; during the social team's visit a dangerous epidemic was underway.

Apart from the settled population, there are persistent rumors that an uncontacted indigenous group may inhabit some of the proposed Reserved Zone. AIDESEP has requested protection of the northwestern sector, north of the Yavarí Mirín, as a refuge for this population.

The human population within 20 km of the proposed Reserved Zone's borders is larger and more heterogeneous, probably numbering between 1,000 and 2,000 people. The largest settlements are the border town of Angamos and the nearby Matsés indigenous communities to the south of the proposed Reserved Zone, and along the Tamshiyacu and Tahuayo rivers to the west, where a large proportion of the proposed reserve has been successfully managed by local communities as the Reserva Comunal Tamshiyacu-Tahuayo since 1991 (Figure 2). The social team visited some 11 communities here, and conducted interviews and town meetings to gauge social organization and opportunities for collaboration with a new protected area (Figure 9G).

THREATS

The threats facing forests in the Yavarí valley are the same that haunt forests across Amazonia: uncontrolled colonization and land-clearing, poorly managed commercial logging, and the unsustainable hunting that commonly accompanies them. All of these threats are insubstantial for the time being in Yavarí, in part because the region's human population is so small and in part because the proposed logging concessions along the Yavarí Mirín are not yet active. But all three factors could become enormous threats in a matter of months, given the episodic history of immigration, timber extraction and commercial hunting on both sides of the Peru-Brazil border.

Logging is the most immediate threat. A large area of forest along the northern border of the proposed Reserved Zone has been slated by the government for logging concessions. Some of the proposed concessions overlap with the proposed Reserved Zone, on nearly 300,000 ha of forest between the Esperanza and Yavarí Mirín rivers (Figure 8). This area of overlap, which represents more than a quarter of the proposed Reserved Zone, is particularly unsuited to logging, and even well managed concessions could lead to significant ecological impacts. The area's strategic location, along more than half of the Yavarí Mirín, provides easy access to the entire watershed, the heart of the proposed Reserved Zone. More than half of the known populations of the threatened red uakari monkey in the proposed Reserved Zone occur here (Figure 8). It includes the headwaters of three major rivers—the Orosa, Maniti and Esperanza—and key breeding habitat for economically important fish and mammal species. Finally, the area's endemic malaria and remoteness from major markets will make cost-efficient, environmentally sensitive logging operations exceedingly difficult.

The threat of large-scale immigration is harder to quantify, in part because the potential immigrants are part of a religious sect, locally known as "Israelitas," whom we did not interview during our visit to the region. The sect has formed several communities on the lower Yavarí, near Islandia, and is rumored to be seeking locations for new communities on the upper Yavarí and the Yavarí Mirín.

The threat of hunting is relatively easy to quantify, thanks to the long-term detailed studies of mammal densities and current hunting levels at a regional level (see "Use and Sustainability of Wildlife Hunting in and around the Proposed Yavarí Reserved Zone"). What these analyses make clear is that an uncontrolled influx of new hunters into the region would quickly tip mammal harvests towards the unsustainable.

CONSERVATION TARGETS

The following table highlights species, forest types, and ecosystems in and around the proposed Yavarí Reserved Zone that are of special importance to conservation. Some are important because they are threatened or rare elsewhere in Peru or in Amazonia; others are unique to this area of Amazonia, key to ecosystem function, important to the local economy, or important for effective long-term management.

ORGANISM GROUP	CONSERVATION TARGETS
Biological Communities	Megadiverse plant and animal communities fully recovered from historical impacts of rubber harvesting and human occupation. Mosaics of intact flooded forest and swamp along the broad floodplains of the Yavarí, of a kind not protected elsewhere in Loreto. Seasonally flooded aquatic habitats, important in the reproductive cycles of the regional fish fauna.
Vascular Plants	Upland tree and shrub communities, perhaps the most diverse in the world. Intact floodplain and swamp forests along the Yavarí and Yavarí Mirín rivers. Populations of commercial tree species decimated elsewhere in Amazonia.
Fishes	A diverse, intact ichthyofauna in a wide variety of well-preserved aquatic habitats. Populations of commercially valuable fish species, including *paiche (Arapaima gigas)*. Spawning grounds in the headwaters of the six major rivers in the region.
Reptiles and Amphibians	Exceptionally rich communities of *Eleutherodactylus* and arboreal lizards. Nearly half a dozen undescribed amphibians, including a new frog in the genus *Allophryne*. Black caiman (*Melanosuchus niger*) and turtle (*Podocnemis* spp.) populations.
Birds	Large tracts of forest and riparian habitat that represent an important corridor for boreal, austral, and trans-Amazonian migrants. *Deroptyus accipitrinus* (Red-fan Parrot) and other bird species threatened in Peru. The globally vulnerable *Crax globulosa* (Wattled Curassow), not confirmed for the area but known to occur lower on the Yavarí River.
Mammals	The globally vulnerable red uakari monkey, *Cacajao calvus* (Figure 1). 24 other globally threatened mammal species (see Appendix 6). A source area for economically important large mammals commonly overhunted elsewhere in Amazonian Peru, such as white-lipped peccaries (*Tayassu pecari*) and tapirs (*Tapirus terrestris*).

CONSERVATION TARGETS

Human Communities	Long-term community experience in protected area and large-mammal management in communities around the Reserva Comunal Tamshiyacu-Tahuayo.
	Local practices to rotate areas of forest for hunting and for the recovery of game species; traditional low-impact fishing techniques.
	Rotation of small-scale agriculture and reforestation of plots with fruit trees.

The conservation landscape we propose for the Yavarí region will provide **long-term protection for some of Peru's most diverse forests**, hundreds of species not protected elsewhere in the country's parks network and **dozens of globally threatened species**. There is a wealth of additional reasons—economic, cultural, and political—why the establishment of a conservation landscape in the region will benefit Loreto and Peru for the long term, including:

01 **Permanent protection and long-term monitoring of a source area for game animals**—especially peccaries, tapir, and large fish—that form the basis of Loreto's rural economy.

02 **Economic opportunities for isolated rural communities** and local control of the area's natural resources.

03 **Highest protection for lands that may be inhabited by indigenous groups who prefer to remain uncontacted.**

04 **Increased international conservation investment in Loreto,** and a windfall for Loreto's ecotourism industry—with a new, globally important tourist attraction just 60 km from Iquitos.

05 **Binational collaboration with Brazil** in conservation, management and sustainable development in the border region.

RECOMMENDATIONS

Our long-term vision of the Yavarí landscape is of a harmonious blend of land-use categories that can sustain healthy ecosystems and healthy local communities. Some areas should be set aside for the strict protection of the area's megadiverse flora and economically important fauna; others should be designated for the sustainable use of natural resources; and both should be overseen by local communities. This is not a new vision, but one pioneered—and put into practice—by the local communities that have managed the Tamshiyacu-Tahuayo Communal Reserve for a decade. Here we offer some preliminary recommendations for extending this vision to the Yavarí Mirín and Yavarí river valleys, including specific notes on protection and management, further inventory, research, and monitoring.

Protection and management

01 **Establish the proposed Zona Reservada del Yavarí inside the boundaries outlined in Figure 2.** These bear slight modifications to the boundaries proposed in the January 2003 *expediente técnico* submitted to the Peruvian parks service (INRENA), to exclude the town of Nueva Esperanza and the proposed research station at Lago Preto.

02 **Elevate the status of the Tamshiyacu-Tahuayo Communal Reserve (Figure 2) from regional to national level,** and ensure that management of the reserve remains in the hands of the communities that have managed it successfully for more than a decade. Search for sustainable funding that will provide the technical and financial assistance requested by those communities to improve the effectiveness and long-term viability of their efforts (see addendum in "Human Communities" and "An Overview of the Tamshiyacu-Tahuayo Communal Reserve").

03 **Provide strict, long-term protection for the remainder of the proposed Zona Reservada, by establishing a new national park (Figure 2).** This area merits the strongest possible protection under Peruvian law, based on its exceptional biological richness, its large and intact expanses of forest, its remoteness, and its apparent lack of human inhabitants. At present, less than one half of one percent of Loreto's megadiverse lowland forests are strictly protected. Increasing this number by just 2%—the size of the national park we propose here—will provide long-term protection for thousands of currently unprotected species in Peru's richest forests. This proposal for strict protection is consistent with recommendations made by AIDESEP (the Asociación Interétnica de Desarrollo de la Selva Peruana) to protect the uncontacted indigenous communities believed to inhabit the remote reaches of the Yavarí Mirín (see below).

04 **Involve local communities in the management of the new protected area, so that local people benefit directly and indirectly from it.** Work with communities and local authorities in and around the reserve—principally those around Nueva Esperanza, those close to the Tamshiyacu-Tahuayo Communal Reserve, Angamos,

and the Matsés communities near Angamos—to ensure that they are involved in the categorization of the new protected area, in its management and protection over the long term, and in the design and management of compatible local uses inside and outside of its boundaries. Provide local residents with strong programs and educational materials, and hire park personnel from nearby towns.

05 **Relocate logging concessions planned for the forests between the Yavarí Mirín and Esperanza rivers (Figure 8).** This area is critical for the viable conservation of the entire area because it provides access to forests throughout the Yavarí Mirín watershed; constitutes a crucial source area for game meat and fish important to the rural communities of Loreto; includes the headwaters of three important rivers (the Manití, Orosa and Esperanza); and harbors half of the known populations of the threatened red uakari monkey (*Cacajao calvus*) in the region.

06 **Minimize impacts in logging concessions and other areas adjacent to the new protected area.** Provide technical assistance to minimize direct and indirect impacts of logging, to monitor those impacts, and to adjust practices, as needed. Seek options for the long-term protection of forests northeast of the Yavarí Mirín and Esperanza, including eventual inclusion in the protected area, to facilitate conservation of the entire Yavarí Mirín watershed. Work with the Centro de Desarrollo del Indígena Amazónica (CEDIA) to establish the proposed Reserva Comunal Matsés (Matsés Communal Reserve), southwest of the proposed Zona Reservada.

07 **Prohibit logging, hunting, and fishing along a significant stretch of intact floodplain forests on the Yavarí River between Angamos and the mouth of the Yavarí Mirín.** Intact floodplain forests along large rivers are increasingly rare in Loreto and upper Amazonia. Similar protection should be given to flooded forests in the headwaters of the six rivers that originate in the area. These are critical breeding grounds for migratory and economically important fish species.

08 **Minimize impacts to the old alluvial terraces overlooking some stretches of the Yavarí and the Yavarí Mirín.** These small patches on the landscape are attractive areas for human settlement but may harbor plants and animals found nowhere else in the region.

09 **Minimize illegal incursions into the new protected area by maintaining close collaboration with local communities.** Establish park guard stations and regular patrols, and post signs at key entry points along the borders. The participation of local residents as park guards, managers, and educators in environmental education programs is essential to maximize protection of the new area.

RECOMMENDATIONS

10 **Determine the status of the uncontacted indigenous group** believed to live along the Yavarí Mirín. A management plan for the area should contain recommendations made in this respect by AIDESEP, including measures to avoid involuntary contact and a contingency plan for voluntary contact.

11 **Establish contact with the Israelita communities on the lower Yavarí** to discuss and adjust plans for settlement in the region.

12 **Promote binational conservation action,** through collaboration with Brazilian government authorities (including INPA, FUNAI, and the Brazilian army), communities, researchers and non-governmental organizations. What makes cross-border cooperation especially important in this region is that the Brazilian army bases along the Yavarí are the only authorities currently monitoring resource extraction in the area, through mandatory checks of boats that pass on the Yavarí.

Further inventory

01 **Continue basic plant and animal inventories in the heart of the proposed Reserved Zone,** where the rapid biological inventory team did not visit. Focus on forest types not well sampled by the rapid biological inventory, including the old alluvial terraces along the Yavarí and Yavarí Mirín and above Lago Preto.

02 **Conduct basic inventories during the drier months of June-September,** focusing on the habitats we could not sample satisfactorily during the rapid biological inventory because of high water levels. Carry out ichthyological collections in the main current and lateral habitats of the Yavarí River, as well as in the Yavarí Mirín and Lago Preto, which have never been visited by ichthyologists.

03 **Conduct binational inventories in association with Brazilian researchers** to assess similarities and differences between forests on the Peruvian and Brazilian banks of the Yavarí and to investigate opportunities for cross-border conservation.

04 **Confirm the presence or absence of potentially occurring species of special conservation interest,** such as the threatened game bird *Crax globulosa* and the CITES II-listed longleaf mahogany, *Swietenia macrophylla*.

05 **Continue systematic analyses of satellite imagery of the Yavarí** region to help put local inventories in a larger regional perspective and to identify areas in need of further inventory. These analyses are currently underway for much of the Yavarí Mirín drainage (K. Salovaara et al., unpublished analyses).

RECOMMENDATIONS

Research

01 **Design an integrated research program to examine relationships between plant and large-mammal communities.** Peccaries, deer, and tapir consume a huge proportion of seeds and seedlings in Amazonian forests, and the densities and behavior of these animal populations can greatly influence the composition and structure of plant communities. Because densities of large mammal have been measured continuously for nearly a decade in the Yavarí valley (see "Use and Sustainability of Wildlife Hunting in and around the Proposed Yavarí Reserved Zone"), there is a great opportunity for integrated research that can clarify the links between plant and animal conservation in these forests.

02 **Carry out additional studies on local resource use and management,** focusing on poorly studied aspects like plant use, fishing, and economically viable extractive alternatives to timber.

03 **Bring floristic data to bear on poorly understood mammal distributions in the Yavarí valley.** Two high priorities are determining whether the red uakari's patchy distribution is caused by variation in the floristic composition of regional swamp forests (or alternatively, by chance and history), and which plants in terra firme forests contribute to the predictably different mammal densities observed on different soils and topographic conditions (see "Diversity and Abundance of Mammals").

04 **Combine spatial and temporal data on flooding dynamics, tree phenology, and animal densities in floodplain forests** for a better understanding of how and when animals use flooded forests, and how and why floristic composition varies across the flooded landscape.

Monitoring

01 **Continue the long-term monitoring of hunting effort and harvest in the region,** to ensure that current uses are sustainable and to modify management, as needed, to maintain them so (see "Use and Sustainability of Wildlife Hunting in and around the Proposed Yavarí Reserved Zone").

02 **Monitor the direct and indirect impacts of logging concessions** bordering the proposed protected area to the north; adjust practices to minimize negative impact (see recommendation 6 in protection and management).

Technical Report

OVERVIEW OF INVENTORY SITES

The rapid biological inventory in March–April 2003 focused on three sites along a 125-km stretch of the Yavarí River, where it flows northeast from the town of Angamos to the mouth of the Yavarí Mirín River, forming the Peru-Brazil border. A few members of the team visited a fourth site at the mouth of the Yavarí Mirín towards the end of the inventory. In this section we give a brief description of each site visited by the rapid biological inventory team, as well as a basic overview of important physical features of the Yavarí and Yavarí Mirín drainages. Detailed descriptions of the vegetation and animal communities surveyed at each site are given in the following chapters.

GEOLOGY, CLIMATE, AND HYDROLOGY

The geology of the Yavarí valley has not been studied in detail, but it is thought to be relatively uncomplicated. Maps published by Peru's Instituto Geológico, Minero y Metalúrgico show the entire area dominated by the geological formation that covers much of northeastern Peru: the Pebas formation, a thick slab of clays and sands deposited in ancient lakes and rivers (Räsänen et al. 1998, Sánchez et al. 1999, de la Cruz et al. 1999). All of the proposed Reserved Zone, but especially the southern sector close to Angamos, is associated with an uplifted geological structure known as the Iquitos Arch, which stretches hundreds of kilometers across Loreto and into Colombia. From the air and in satellite images, much of the Iquitos Arch is identifiable as a band of steep topography extending northwest of Angamos.

Soils are more variable than the simple geology would suggest (Figure 3A). Because the Pebas formation is a jumble of deposits ranging from primarily sand to primarily clay, basic soil texture can vary dramatically over small spatial scales. This was especially obvious at the first site we visited, where the conspicuous "cicada towers" scattered around the forest floor—miniature towers built with topsoil—ranged in color from orange to grey to purple. Despite this variability, most soils in the proposed Reserved Zone, as throughout this region of Peru, are very acid, low in nutrients and high in elements toxic to plants, such as aluminum. Soils in the highest hills of the Iquitos Arch are

generally older and sandier than those in the lower, rolling hills away from the arch.

Weather data do not exist for the proposed Reserved Zone, but a close approximation is given by nearby records from Jenaro Herrera (Gautier and Spichiger 1986), Angamos (ONERN 1976), and stations in and around around Iquitos (Marengo 1998). This is a technically aseasonal climate, with significant rainfall year-round and an annual total precipitation between 2000 and 3000 mm. Even so, pronounced seasonal variation in rainfall is evident. The driest months are May, June, July, and August, during which monthly rainfall falls to 30% of that in the wettest months, and monthly minima sometimes dip below 100 mm. Mean temperatures are between 24 and 26° C, but cold spells in the drier months produce minima as low as 10° C.

Water levels in the region's rivers and streams rise and fall seasonally, but neither the basic dynamics nor the mechanisms driving them are well understood. Rivers are at their lowest during the drier months, exposing large white sand beaches on point bars, and at their highest during the rainier months, covering nearly all the beaches and flooding some of the floodplain forest for extended periods, suggesting that water levels are mostly determined by rainfall in the Yavarí watershed. On the other hand, the seasonally high water in the Amazon around April and May must also play a role in flooding dynamics on the Yavarí, by reducing the elevational gradient of the Yavarí and backing up its current.

What seems clear is that rivers in the Yavarí valley are intermediate between central and upper Amazonian rivers in their flooding dynamics. These are not the central Amazonian rivers whose entire floodplains are famously underwater for months on end, though some of the Yavarí floodplain does seem to be flooded for much of the rainy season. But water level on the Yavarí does give the appearance of being more stable than that of most other rivers its size in the Peruvian Amazon, especially those closer to the Andes, where water level is mostly driven by local rainfall and flooding is restricted to a few days, or occasionally weeks, during especially rainy periods.

SITES VISITED

We selected the three main inventory sites (Figure 2) by searching satellite images for areas that allowed quick access to a variety of different forest types, streams, lakes, and other landscape features from the Yavarí River. The team traveled from site to site and stayed on the research boats *Lobo de Río* (Figure 10) and *Nutria*, operated by DICE and WCS-Peru. At each site the boats were tied up for five to seven days at a bluff that provided access to upland forest. During the day (and some of the night for the herpetology and bat teams), most of the team explored ~15 km of temporary trails at each site, while the ichthyologists visited nearby lakes, rivers, streams, and swamps. To sample a greater area undisturbed by other researchers, the mammal team established an additional trail system a short boat ride downriver at each of the three sites. In the evening we returned to the boats to discuss what we had seen, prepare collections, and make plans for the following day.

Because this stretch of the Yavarí is essentially uninhabited, the social team focused their work in the larger communities near the first and last inventory sites. The social team worked a week in the small border town of Angamos and various Matsés communities southwest of that town on the Gálvez River, then surveyed the few scattered houses between Angamos and the mouth of the Yavarí Mirín, and spent six days at the *ribereño* communities of Carolina and Nueva Esperanza.

Quebrada Curacinha
(5°03'05"S, 72°43'42"W, ~95–190 m elev.)

This was the first site we visited during the rapid biological inventory, roughly 20 km down the Yavarí from Angamos. For six days the boats were docked to a steep forested bluff on the outside bend of the river, where three trails totalling >20 km crisscrossed a complex of steep hills and valleys. This was the steepest terrain we encountered during the inventory, associated with the uplifted formation known as the Iquitos Arch (see geology section above).

Soils at this site were extremely variable in color and texture even on the same hill, ranging from orange, purple and white clays to brownish, sandier material.

A small deposit of pure white sand was exposed in the bluff where the boat was docked, but we did not see this anywhere else in the uplands. In general, soils at this site appeared nutrient-poor and badly-drained, and on many hilltops one had to cut through a dense tangle of fine roots ~4–5 cm thick to reach the underlying soils.

These hills are drained by a large number of streams (Figure 2E) with rather narrow floodplains and associated vegetation (locally called *bajiales*). A typical trail, rising and falling as it headed north from the boat site, crossed streams 21 times in the first 2.5 km. As the trails got farther from the river, the hills became higher and higher—reaching nearly 100 m above river level at their highest point—though the constant up-and-down of the trails made this hard to appreciate in the field.

To the southwest of the docking point, another trail followed the hills down into a progressively swampier floodplain forest. Near the adjacent terra firme, soils were saturated but not flooded, small pools stood here and there, and the vegetation was similar to that of occasionally flooded forest along the Yavarí. As the trail continued on, dropping imperceptibly in elevation, the soils became wetter and the forest progressively more dominated by swamp specialists like the palm *Mauritia flexuosa* (locally known as *aguaje*) and *Symphonia globulifera* (Clusiaceae), until one was up to one's knees (or waist) in water. Even where the water was deepest, *Mauritia flexuosa* did not form the pure stands (*aguajales*) commonly associated with this species (Figure 2F).

The river level was relatively high when we arrived at this site, dropping gradually and then rising again as the days went on. Much of the floodplain forest of the Yavarí was underwater during our work here. Even so, large areas of floodplain forest were not flooded, and the botanical team found an explosion of fruiting and germination there, in contrast to the relatively fruit-poor uplands (see "Flora and Vegetation").

Quebrada Buenavista
(4°50'04"S, 72°23'25"W, ~90–150 m elev.)

Following the work at Quebrada Curacinha, we continued approximately 45 km downriver to dock for seven days at another terra firme bluff overlooking the Yavarí, roughly equidistant between Angamos and the mouth of the Yavarí Mirín. Here there was more evidence of earlier human habitation than at the first site, though most of it was within ~200 m of the river. Close to the docking point were several patches of secondary forest 80–100 years old and thus dating roughly to the years of the rubber boom. Given that the name Buenavista ("Pleasant View" in Spanish) appears on modern maps of this area, it seems clear that a small community of that name, since abandoned, occupied the area some time in the last century.

At this site the upland terrain was much gentler than at the first, with mostly rolling hills under 150 m. Soils seemed less variable from place to place, had a higher clay content and were more fertile, and mostly lacked the thick layer of fine roots at Quebrada Curacinha. Consequently, the composition of the upland vegetation here was strikingly different in some aspects from that of the first site (see "Flora and Vegetation"). It was also interesting that, while streams dissected the uplands to the same degree as at the previous site, most streams had beds of reddish clay, rather than the white sand streambeds at Quebrada Curacinha. All of these changes are related to an important shift in the underlying geology, as we moved farther from the older hills of the Iquitos Arch and farther into the depositional basin it borders. Only to the northwest, where a curious long, thin strip of hilly terrain extended perpendicular to the Yavarí, did we find a few of the steep hills characteristic of the previous site.

Another feature that distinguished this site from the first was its much broader, more extensive *bajiales*. In contrast to the first site, where it was often possible to look across a stream and see terra firme on the opposite side, the floodplain of the Quebrada Buenavista at the second site was hundreds of meters wide and even fairly distinct on satellite images.

A kilometer to the southwest of the docking point, a huge swamp, measuring some 7 km^2, covered a large proportion of the Yavarí floodplain. We only explored its margins, but what we saw in the field, in the

overflights, and in the satellite images of the area suggest that most of this swamp is a complicated mix of permanently flooded and occasionally flooded forests, similar to the one we visited at Quebrada Curacinha. Here too, we did not see pure *aguajales*, but mixed-species forest with a characteristically high proportion of palms.

Quebrada Limera
(4°30'53"S, 71°54'03"W, ~90–150 m elev.)

The third site was some 65 km farther downriver from Quebrada Buenavista, at a place where the last terra firme bluffs overlook the Yavarí River before its junction with the Yavarí Mirín. Most of the team spent four and a half days exploring this area, in the vicinity of the Quebrada Limera, while one member each of the botanical, herpetological, and mammal teams continued a few kilometers downriver and surveyed forests around Lago Preto (see description below), and the social team visited the communities of Carolina and Nueva Esperanza.

The upland terrain at this site, now well inside the depositional basin of the Iquitos Arch, had much more in common with the rolling, richer-soil landscape of the second site than with the steeper, poorer-soil landscape of the first. Upland vegetation, too, was similar in many respects to the second site. Many of the dominant trees, shrubs and ferns here are well-known components of richer clay soil forests in upper Amazonia.

One consequence of the gentler topography was that terra firme was dotted with natural salt licks and mud baths visited by peccaries and other mammals. Between the hills, a large number of streams with narrow channels but broad floodplains drained the landscape. In heavy rains these streams flood a very large area of inland floodplain, perhaps as much as 20% of the landscape. The Quebrada Limera, which crossed all three of our main trails, overflowed its banks during our first day at this site, and we were only able to cross it and see forests on the other side of it two days later. Three days after that flood, the Limera's very broad floodplain, >600 m wide in places and easily visible on satellite images, was still pooled with standing water.

There were no large swamps near the docking site, but just upstream was a long meander point of floodplain forest along the Yavarí. Here we encountered a low-diversity forest on waterlogged soils, with the same vine tangles and fruit and seedling boom we saw in the similar floodplain forest at Quebrada Curacinha.

Human impacts were more evident at this site than anywhere else on the trip. A group of Brazilians was hunting and fishing along the Quebrada Limera when we arrived, and a hunting camp built by a different party had been abandoned recently on the same quebrada. A short walk from the docking point, a large tropical cedar (*Cedrela* sp.) had been felled for timber, apparently two or three years earlier. In floodplain forest upriver from our docking site, we found several shotgun shells, two large trees felled for timber, and several smaller trees felled for temporary shelters.

Lago Preto
(4°28'S, 71°46'W, ~90 m elev.)

Some members of the mammal, plant, and herpetological teams visited this site for four days towards the end of the inventory. Lago Preto is one of a dozen abandoned river channels, or oxbow lakes, that dot the floodplain forests of the Yavarí River just below its junction with the Yavarí Mirín. Students and researchers from DICE have made the area a base for field expeditions in recent years, and studies to date have focused on large animals, particularly caiman and the locally abundant red uakari monkey (*Cacajao calvus*; see Figure 1). The area is a four-hour walk from the community of Carolina, where local residents are working with DICE to minimize human impacts to the plant and animal communities in the lake's vicinity.

The name Lago Preto ("Black Lake" in Portuguese) refers to the blackish water, low in nutrients and suspended sediments, which drains into the lake from the surrounding floodplain and the poor-soil upland terraces overlooking it. The area is especially attractive to researchers because it presents several different forest types—forests flooded when the Yavarí is high, swamp forests that are saturated year-round, and upland terra firme—in a relatively small area. These forest types are described in more detail in the vegetation section of this report. For more information on

the Lago Preto site visit www.kent.ac.uk/anthropology/dice/lagopreto/index.html.

OVERFLIGHTS

In October 2002 we spent six hours flying over the proposed Reserved Zone and its buffer areas. The objectives were to "sky-truth" satellite images of the area, to look for appropriate sites for the ground inventory, and to assess impacts from logging and other activities visible from the air. We first surveyed forests along the Tamshiyacu, Esperanza, Yavarí Mirín, and Yavarí rivers, and then forests around Angamos, Jenaro Herrera, and Quebrada Blanco. Perhaps the most striking aspect of these overflights was the near-total absence of signs of large-scale extractive activity in the area—a heartening contrast to many other similarly remote areas in the Peruvian Amazon.

FLORA AND VEGETATION

Participants/Authors: Nigel Pitman, Hamilton Beltrán, Robin Foster, Roosevelt García, Corine Vriesendorp and Manuel Ahuite

Conservation targets: Megadiverse upland floras growing on a small-scale soils mosaic; intact floodplain and swamp forests along the Yavarí and Yavarí Mirín rivers; populations of commercially valuable timber species threatened elsewhere in Amazonian Peru

INTRODUCTION

The vegetation of the Yavarí valley and the adjacent Yavarí Mirín drainage is poorly known today, but that has not always been the case. During the rubber boom, tappers and traders explored these forests creek by creek in their search for natural rubber. Before them, the area was occupied by indigenous groups that undoubtedly knew and used hundreds of plant species on a regular basis. During our brief inventory, every rubber tree scarred by old tapping (Figure 2D) reminded us of the plant explorers who once knew this area far better than we, and whose knowledge is lost to science.

The only formal botanical expeditions to the area we know of are brief collecting trips in the 1970s by Gentry, Revilla, Prance, and Lleras, mostly along the lower Yavarí; a 1986 forestry survey and collecting trip on the lower Yavarí Mirín (Zapater Carlín 1986; R. Vásquez, pers. comm.); and a recent survey of ferns along the Yavarí Mirín (K. Salovaara and G. Cárdenas, unpublished data). This last study represents the only botanical work actually carried out inside the proposed Zona Reservada.

While forests in the Yavarí valley have only begun to be studied, forests in the surrounding region, especially in the vicinity of nearby Iquitos, are increasingly well known. Our work suggests that upland vegetation in Yavarí is compositionally and ecologically similar to those forests. Thus botanical studies in the vicinity of Iquitos (Vásquez-Martínez 1997), on the eastern bank of the Ucayali (Ruokolainen and Tuomisto 1998), and even at Jenaro Herrera (Spichiger et al. 1989, 1996) provide a better approximation of the area's plant life than those from Brazilian forests farther to the east.

METHODS

During our three weeks in the field, the botanical team's aim was to cover as much terrain and to explore as many different kinds of forest as possible. We used a range of techniques to characterize the flora, from quantitative inventories to general collections to field observations. R. Foster took some 1,500 photographs of plants, to be included in a preliminary field guide to plants of the area. R. García, H. Beltrán, C. Vriesendorp, M. Ahuite and N. Pitman inventoried >1,700 trees ≥10 cm diameter at breast height (dbh) in four tree plots at the three sites, as well as several hundred others in informal transects along the trails. C. Vriesendorp and R. Foster carried out quantitative inventories of understory plants and C. Vriesendorp made observations on seedlings and germination biology. K. Salovaara did a quantitative sample of the fern community in the tree plot at Quebrada Buenavista. Altogether we collected some 2,500 plant specimens, now deposited in the Iquitos herbarium (AMAZ), the Museum of Natural History in Lima (USM), and the Field Museum (F).

FLORISTIC RICHNESS AND ENDEMISM

A preliminary list of plant species for the Yavarí valley is given in Appendix 1. It includes plants that were identified in the field but not collected, plants that were collected or photographed in the field and identified later in herbaria, as well as some plants collected on earlier expeditions to the same area. The ~1,675 species of plants we registered during the trip represent maybe half of the flora of the proposed reserve. This is a rough estimate, but based on our experience elsewhere in Amazonia and on botanical surveys in the vicinity of Iquitos (Vásquez-Martínez 1997), we estimate a total flora of the proposed reserve at 2,500–3,500 species.

Local diversity—the number of plant species that grow together within a small area of forest—is astronomical for woody plants in both the canopy and the understory at the sites we visited, and at the high end of the gradient for this famously diverse region of Peru (Vásquez-Martínez and Phillips 2000). The first 50 trees (≥10 cm dbh) we examined in transects at the first, poorer-soil site belonged to 45 different species. The tree inventory at the second, richer-soil site proved to be even richer in species, representing one of the highest recorded diversities to date in a hectare of tropical forest. Herbarium work to date suggests this richer plot contains 27 species of Sapotaceae, 19 species of free-standing trees in the fig family (Moraceae), and 11 species of Sterculiaceae. Local diversity of woody plants in the understory was similarly high. In a terra firme transect at Quebrada Limera, 100 free-standing plants 1–10 cm dbh were sorted to 80 different species.

Family and genus level composition of forests along the Yavarí are typical of that of most of the wet Neotropics, but certain groups stood out as particularly diverse or uncharacteristically species-poor. The families Sapotaceae, Myristicaceae, Lecythidaceae are especially diverse (and abundant) in tree communities at both the richer- and poorer-soil sites, accounting for 27% of all trees in the upland inventories. Marantaceae, *Guarea*, and *Pourouma* are extraordinarily diverse at all sites. The families Lauraceae and Fabaceae and the genus *Piper* seemed under-represented at the poorer-soil site, while Bignoniaceae seemed poorly represented at all sites.

Canopy and understory epiphytes and hemi-epiphytes are not particularly diverse or abundant, as is usual in the Amazonian lowlands, and are even less apparent at the poorer-soil site. Lianas (woody vines) are perhaps less diverse than expected, due to the uncharacteristically modest representation of Bignoniaceae, of which we saw only ~12 species. Important in the liana community are Hippocrateaceae, Malpighiaceae, Sapindaceae, Dilleniaceae (especially *Doliocarpus*), *Petrea* (Verbenaceae), *Bauhinia* (Fabaceae), and several species of *Machaerium* (Fabaceae). Aquatic plants are scarce in the streams and oxbow lakes (cochas) along the Yavarí, probably because of low nutrient levels.

Levels of endemism—the proportion of plant species that occur here and nowhere else in the world—are not well understood for the Yavarí valley, because the area has been so poorly explored to date that any endemic species are undescribed and so unrecognized in the field and herbarium. But given that weather and soils like those in Yavarí extend over the large interfluvium between the Amazon and the Yavarí (and eastward into Brazil), it is unlikely that this area will prove an important center of endemism for plants.

FOREST TYPES AND VEGETATION

Our inventory began in the midst of the geological formation known as the Iquitos Arch and moved progressively farther from it, and into the depositional basin it defines (see "Overview of Inventory Sites"). This change in the underlying geology seemed to make little difference to the composition of the flooded forest vegetation along the Yavarí, but produced a very marked change in the uplands. As we moved down the Yavarí from Angamos we seemed to be moving along a gradient from higher hills and less-fertile soils at the first site to lower hills and more fertile soils at the second and third sites. Here we focus on describing individual forest types, with notes on the sometimes significant site-to-site variation we observed in them.

Upland (terra firme) forest

The astronomical diversity and great extension of upland forests in the Yavarí valley made them the most challenging forest type we surveyed during the trip. Given that 80–90% of the region is uplands (Figure 2), that the vast majority of the regional flora grows there, and that small-scale heterogeneity in soils and vegetation can be extreme (Figure 3A), our description here is basic. Our impression is that more detailed studies of edaphic and floristic heterogeneity around Iquitos (e.g., Ruokolainen and Tuomisto 1998) are probably a good approximation of the patterns we observed in the Yavarí area, though we did not find white sand forests. The poorer-soil forests along the Yavarí seem more similar in composition to forests on the brown sands of Allpahuayo Mishana, while the richer forests resemble those on clay soils at the Explorama Lodge and Explornapo Camp near Iquitos, as well as sites much closer to the Andes, like Manu National Park in southeastern Peru and Yasuni National Park in eastern Ecuador.

In Yavarí these soil changes are broadly indicated by some large palms, with *Oenocarpus bataua* and *Astrocaryum chambira* more frequent on poorer soils and *Iriartea deltoidea* and *Euterpe precatoria* more frequent on the richer soils. Tree species relatively indifferent to soil changes and easy to find anywhere in the region include the palm *Astrocaryum murumuru*, natural rubber (*Hevea* sp., Euphorbiaceae [Figure 2D]), *Senefeldera inclinata* (Euphorbiaceae), *Iryanthera macrophylla*, *I. juruensis*, *Virola pavonis*, and *Osteophloeum platyspermum* (all Myristicaceae).

Poorer-soil upland forest (Quebrada Curacinha)

Forests on these steep hills are variable in composition and structure at small spatial scales. Hiking up one of the long, steep hills common here, one often began in a richer soil forest at the base of the hill, where a relatively open understory is shaded by giant trees and tall palms, climbed a steep incline dotted with thin, pole-like stems, and came out on a hilltop where the understory was dense with the shrubby palm *Lepidocaryum tenue*, the forest floor covered with a mat of roots, and the canopy lower and broken. Some lower hills have tall, closed-canopy forest with enormous trees, few lianas, and an open understory; others have a broken canopy of scattered, smaller trees tangled in vines and lianas. On one anomalous hill at Quebrada Curacinha we found a suite of richer-soil taxa, including the fern *Didymochlaena truncatula*, the palm *Iriartea deltoidea*, and several species typical of floodplain forests.

Documenting tree turnover between soil patches at the species level is difficult, in part because the community is so fantastically diverse, and in part because family- and genus-level (but not species-level) composition are rather consistent from patch to patch. Nearly 15% of the trees in these forests are Myristicaceae, mostly the genera *Iryanthera* and *Virola*, and half of the trees in our one-hectare sample belong to the families Myristicaceae, Sapotaceae, Moraceae, Euphorbiaceae, Lecythidaceae and Fabaceae. In our 1-ha tree sample, the most common tree species were *Senefeldera inclinata* (Euphorbiaceae), *Rinorea racemosa* (Violaceae), *Oenocarpus bataua* (Arecaceae), *Ecclinusa* cf. *lanceolata* (Sapotaceae), *Iryanthera macrophylla*, *Virola pavonis*, and *Iryanthera tricornis* (all Myristicaceae).

Turnover in the understory is more immediately obvious, because shrubs and herbs in these forests are relatively species-poor. Large areas of the understory are dominated by patches of single species, these mostly shade-tolerant ferns and grasses, some of them surely clonal. Among the locally common and widespread understory species are a low purple grass (*Pariana*), a terrestrial fern in the genus *Adiantum*, the treelet *Mouriri grandiflora* (Memecylaceae), and at least three species of *Guarea* (Meliaceae) which reach maturity as unbranched shrubs under 1.5 m tall.

Richer-soil upland forest
(Quebrada Buenavista and Quebrada Limera)

In contrast to the high, steep hills of the poorer-soil site, forests here grow on low, rolling hills that rise up only slightly between the broad *bajiales* or lowlands separating them. Soils are mostly white and orange clays, lack a root mat, and are often exposed where rainstorms sweep hillsides clean of leaf litter.

Tree communities here are dominated by many of the same families important at the poorer-soil site, but with a much higher representation of richer-soil families like Meliaceae, Annonaceae, and palms. Myristicaceae is still the most abundant family, still strongly represented by *Virola* and *Iryanthera*, but also by the rich-soil genus *Otoba*. Other fertile-soil genera important here are *Inga*, *Guarea* and *Trichilia*. The most common trees in our one-hectare sample at Quebrada Buenavista are the palms *Astrocaryum murumuru* and *Iriartea deltoidea*, *Anaueria* cf. *brasiliensis* (Lauraceae), *Nealchornea japurensis* (Euphorbiaceae), *Otoba parvifolia* and *O. glycycarpa* (Myristicaceae), *Pseudolmedia laevis* (Moraceae), *Eschweilera* cf. *coriacea* (Lecythidaceae), and *Iryanthera laevis* and *I. juruensis* (Myristicaceae). Despite some obvious compositional differences, at least a quarter of the species in this plot we also recorded in the poorer-soil plot, and at least a third of the trees belong to shared species.

Understory vegetation is denser and more diverse here, with monodominant patches much reduced and especially high diversity in Marantaceae and Rubiaceae. *Didymochlaena truncatula* and *Adiantum pulverulentum* were among the most frequently encountered ferns. All the fern species collected in the 1-ha tree plot in Buenavista are indicators of rich or intermediately rich clay soils (Tuomisto and Poulsen 1996), suggesting that the site may be exceptionally nutrient-rich for Loreto. Like the tree flora, the fern flora here resembles that of richer-soil sites in, for example, Yasuní National Park in Ecuador (Tuomisto et al. 2002).

The two richer-soil sites (Quebrada Limera and Buenavista) are much more similar to each other than to the poorer-soil site (Quebrada Curacinha), but they are far from identical. At Limera but not Buenavista, we found several typically floodplain species—including *Calycophyllum spruceanum* (Rubiaceae)—growing on hilltops in terra firme. The shrub *Psychotria iodotricha* (Rubiaceae), rare at Curacinha and Buenavista, numbered in the thousands along trails at Limera. *Hybanthus prunifolius* (Violaceae), an explosively dehiscent shrub and the most common species on Barro Colorado Island, Panama, covered several hectares of the understory at Quebrada Buenavista, but not at the other sites. A subshrub in the genus *Besleria* with glabrous orange flowers that was common at the first two sites was absent at the third, where it was replaced by a very similar congener with pubescent yellow flowers.

Old alluvial terraces (Lago Preto)

While the rest of the botanical team was at Quebrada Limera, R. García visited this site. The forests he explored near Lago Preto represent a formation we did not get a chance to explore anywhere else—upland forest growing on old alluvial terraces visible on satellite images as scattered patches overlooking the floodplain forest to both sides of the Yavarí and the Yavarí Mirín. At Lago Preto, these terraces are drained by (and eroding into) deep ravines. Soils appear to be mostly clay, poor in nutrients, covered with a thick root mat, and poorly drained, collecting pools of water after heavy rains.

Large stands of the understory palm *Lepidocaryum tenue* grow on these terraces, together with the small palms *Iriartella setigera*, *Bactris killipii*, and *Itaya amicorum*. The fern community is dominated by the family Hymenophyllaceae. The canopy composition is similar to that at the poorer-soil site, Quebrada Curacinha. The families Myristicaceae, Lecythidaceae, Fabaceae, Euphorbiaceae, and Sapotaceae account for half of the trees in our small tree plot in this site. Common trees include *Iryanthera tricornis* and *Virola elongata* (Myristicaceae), the palms *Oenocarpus bataua* and *Astrocaryum chambira*, *Hevea* cf. *brasiliensis* (Euphorbiaceae), *Eschweilera* cf. *coriacea* (Lecythidaceae), *Parkia igneiflora* (Fabaceae), and *Cespedezia spathulata* (Ochnaceae). A small number of genera (e.g., *Ilex*, Aquifoliaceae) and even one family (Anisophylleaceae) that we did not see in terra firme elsewhere occur here. Given their patchy occurrence on the landscape and their unique soil properties, these old alluvial terraces merit more attention.

Flooded forests

There are many floristically different kinds of flooded forests along the Yavarí and its tributaries, and these grade into each other in a way that makes classification

difficult. Complicating the situation further is the profusion of local terms used in Peru and Brazil, often inconsistently, to describe different kinds of flooded forests. Much of the flooded forest along the Yavarí is locally called *várzea* or *igapó*, but both terms describe rather extreme forest types not commonly found in this region. In this section we briefly describe the composition and structure of the most distinct flooded forest types we saw during the rapid biological inventory.

Successional forests along the Yavarí

The Yavarí is an actively meandering river, but it lacks the clear successional sequences that are so obvious on other such rivers in the Peruvian Amazon, where newly formed point bars are colonized by a predictable series of species that stand out in cross-section as one travels along the river. On the Yavarí, a fairly regular sequence of shrubby vegetation is apparent close to the waterline, starting with *Alchornea castanaefolia* (Euphorbiaceae) or in some places *Adenaria floribunda* (Lythraceae), then proceeding to monodominant stands of shrubby *Tabernaemontana siphilitica* (Apocynaceae), the low treelet *Annona hypoglauca* (Annonaceae), and *Margaritaria nobilis* (Euphorbiaceae). This vegetation, reaching 2–3 m in height, is followed by *Cecropia latiloba* (Cecropiaceae), *Triplaris weigeltiana* (Polygonaceae), and *Acacia* sp. (Fabaceae). The first large tree to emerge is *Maquira coriacea* (Moraceae), which sometimes forms nearly uniform stands behind the earlier successional species. Behind the *Maquira* it is not easy to pick out a next stage of succession, but rather a relatively stable, diverse mix of tree species, apparently dominated by *Virola surinamensis* (Myristicaceae).

It is not clear why successional sequences are vague on the Yavarí, but it is probably a consequence of the flooding dynamics of the river. A comparison of 1979 maps with 2002 satellite images suggest that the Yavarí meanders relatively slowly, since most of the bends and oxbow lakes mapped in 1979 are essentially identical after 23 years. This would not be the case in many other meandering rivers in Amazonian Peru, where lateral migrations of dozens of meters per year produce new point bars at a much quicker pace.

Periodically flooded forests along the Yavarí

Our limited observations in the field suggest that only a small proportion of the floodplain forests along the Yavarí are underwater for months on end, during the high-water season. Most of the periodically flooded forests appear to be underwater for a few days at a time, during especially high storm surges, as is typical of floodplains along rivers of this size in upper Amazonia.

We studied these forests from the boat as we traveled down the Yavarí from site to site, and on foot at Quebrada Curacinha and Limera. Components obvious from the boat included the palms *Socratea exorrhiza* and *Euterpe precatoria* (as well as clonal stands of *Astrocaryum jauari*), *Virola surinamensis* (Myristicaceae), and *Pseudobombax munguba* (Bombacaceae). On one stretch of the river between Quebrada Curacinha and Quebrada Buenavista, an unidentified *Tachigali* growing at the water's edge formed an almost monodominant stand extending several kilometers. We did not see the distinctive slick-barked *Calycophyllum spruceanum* (Rubiaceae), typically common and conspicuous in floodplain forests of upper Amazonia.

The composition and structure of the floodplain forests we explored on foot varied, as is typical, with minute changes in elevation. In the higher areas, structure and composition were similar to the uplands; as the ground sloped lower and lower, the canopy became lower and more uneven, and large areas were dense with vine tangles and treelets. In the higher areas the common trees were *Vochysia* sp. (Vochysiaceae), a bullate-leaved *Sterculia* sp. (Sterculiaceae), *Virola surinamensis* (Myristicaceae), *Hevea* cf. *brasiliensis* (Euphorbiaceae), *Socratea exorrhiza* (Arecaceae), and *Astrocaryum murumuru* (Arecaceae). As the ground sloped lower large palms gradually disappeared and species restricted to aquatic habitats began to appear, like *Vatairea guianensis* (Fabaceae), *Crudia glaberrima* (Fabaceae), and *Pseudobombax munguba* (Bombacaceae).

Periodically flooded forests along tributaries

Deep inside the terra firme hills and far from the influence of the Yavarí, ribbons of periodically flooded

forest line the streams and small tributaries draining the landscape. These forests, briefly inundated during storm surges, range from strips a few meters wide to broad belts hundreds of meters to each side of the stream channel. At the hillier, poorer-soil site, these inland floodplains are generally narrow, and the most obvious components of their vegetation the trees *Pourouma* spp., *Astrocaryum murumuru*, *Iriartea deltoidea*, and the common terrestrial fern *Thelypteris macrophylla*.

At Quebrada Buenavista and Quebrada Limera we found much more extensive floodplains and a more distinct forest type. Some of these forests are dominated by palms to an amazing extent, with nearly half of the trees accounted for by *Astrocaryum murumuru*, *Iriartea deltoidea*, and *Socratea exorrhiza*. Also common here are typical floodplain species like *Spondias* cf. *mombin* (Anacardiaceae) and *Ficus insipida* (Moraceae). This was the only place we found the important timber tree *Cedrela odorata* (Meliaceae).

Swamp forests

Forests with permanently saturated soils cover less than 10% of the regional landscape, but 25–50% of the floodplains of the Yavarí and Yavarí Mirín rivers. Swamps are critical for conservation in this area, because they are the only place on the landscape where the globally threatened red uakari monkey's chief food, the fruits of the palm *Mauritia flexuosa*, is available (see "Diversity and Abundance of Mammals").

Most swamps here are not pure stands of *Mauritia*, but mixed forests whose floristic composition and structure are determined by variation in elevation and flooding dynamics (Figure 2F). Given the complicated patchwork of these inundated forest types, it is hard to know how typical the half-hectare tree inventory we did in the large swamp at Quebrada Buenavista is of the area's swamps. But because diversity is low in swamp forests and we were able to identify many of the dominant species during the overflights (nearly all the palms, plus *Symphonia globulifera* [Clusiaceae, Figure 2A], which was in flower), we are fairly confident that the important species in the Buenavista swamp plot are important throughout the region's swamps, and probably represent more than three-quarters of all the trees growing there. These include, in order of decreasing abundance, *Symphonia globulifera*, *Ruptiliocarpon* cf. *caracolito* (Lepidobotryaceae), *Euterpe precatoria* (Arecaceae), *Mauritia flexuosa* (Arecaceae), *Virola surinamensis* (Myristicaceae), *Attalea butyracea* (Arecaceae), *Eriotheca macrophylla* (Bombacaceae), *Ilex* sp. (Aquifoliaceae), *Campsiandra* cf. *angustifolia* (Fabaceae), *Guatteria* aff. *multivenia* (Annonaceae), *Socratea exorrhiza* (Arecaceae), and *Buchenavia* sp. (Combretaceae). Although *Mauritia* was relatively rare (only 8% of trees), this did not result in an especially diverse swamp; the half-hectare swamp plot contained only 52 species. Palms, Fabaceae, Clusiaceae, and Myristicaceae alone accounted for 56% of the species and 70% of the trees. As in temporarily flooded forest, several species in area swamps can also be found, often at much lower densities, in upland forest.

PHENOLOGY AND SEEDLING BIOLOGY

(Corine Vriesendorp)

Because few botanists have explored the Yavarí area, this expedition provided an opportunity to encounter poorly collected species and to explore general patterns in fruiting, flowering, and seedling germination. We found few species flowering in any forested habitat, suggesting that the bulk of the forest flowering is concentrated in drier periods (June to September), which are presumably more favorable for pollinator activity. However, flowers were abundant and obvious along the river, including a white morning glory (*Ipomoea*, Convolvulaceae), a scrambling Cucurbitaceae, and a dusty yellow *Acacia* (Fabaceae). Although we found few species flowering inside the forest, some notable exceptions included a *Palmorchis* (Orchidaceae) with delicate white flowers, a *Dracontium* (Araceae) spadix encased in a smoky purple spathe, and the big raucous pink and yellow flowers of *Caryodendron* (Euphorbiaceae). Along one of the slopes at Quebrada Limera we were surprised to find *Stachyococcus adinanthus*, a rare monotypic genus in the coffee family (Rubiaceae), with tubular white flowers protruding from a spicate inflorescence (Figure 3F).

Other forest flowering records reflected species with smaller inconspicuous flowers or lone individuals flowering out of synchrony with the rest of the population.

At a community level, we found distinctly higher levels of fruit and seedling production in flooded sites than in terra firme sites. Typically we encountered flooded forests full of species with immature green and recently dropped fruits. In contrast, in terra firme forests we found few fruits on the ground, although the rotting woody capsules of *Eschweilera* and *Cariniana* (Lecythidaceae) indicated that fruiting had occurred within the last three months, at least in these species.

In flooded sites we encountered many fruiting midlevel canopy species (1–10 cm dbh), such as *Perebea* (Moraceae), *Coussarea* (Rubiaceae), *Swartzia* (Fabaceae), *Neea* (Nyctaginaceae), and *Tovomita* (Clusiaceae), compared to the few Violaceae (*Leonia* and *Gloeospermum* spp.) and Rubiaceae (*Palicourea* and *Psychotria* spp.) species fruiting in this strata of the terra firme forest.

In the flooded forest, the water had receded leaving behind extensive seedling carpets, with a single species often covering more than a 5 x 10 m area. We encountered large patches of *Simarouba amara* (Simaroubaceae) seedlings, as well as those of other animal-dispersed species including *Virola surinamensis* (Myristicaceae), *Bauhinia guianensis* (Caesalpiniaceae), *Carapa guianensis* (Meliaceae), and *Tapura* sp. (Dichapetalaceae).

Seedling species with larger, water-dispersed fruits occurred in sparser clumps than animal-dispersed ones but were encountered more consistently over a large area. The enormous spongy seed of *Vatairea guianensis* (Fabaceae) was commonly found floating in standing pools of water, and the seedling measured more than a meter in height after initial leaf expansion. Incredibly, all other species of *Vatairea* have winged samara fruits, markedly different from their large (8 x 10 cm) water-dispersed congener. In a parallel situation, we found a swamp species in the primarily wind-dispersed genus *Machaerium* with a nearly non-existent wing, certainly not substantial enough to support the weight of the large seed in the air. These observations suggest that evolving water-dispersed fruits from wind-dispersed ones could be a common evolutionary trajectory, at least within the Fabaceae. As in other flooded sites in the Amazon basin, in addition to passive dispersal by water, many of these plant species may be fish-dispersed (Goulding 1990).

Of the many poorly known species we collected, perhaps the most important fertile collection was along the banks of the Yavarí. We were fortunate to encounter several fruiting individuals of *Froesia diffusa* (Quiinaceae), a rare species that exists in few herbaria, either sterile or fertile (Figure 3H). We prepared nearly 30 collections of the meter-long compound leaves, and the spectacular three-carpellate red fruits, for distribution to herbaria worldwide.

FISHES

Participants/Authors: Hernán Ortega, Max Hidalgo and Gerardo Bértiz

Conservation targets: Commercially valuable and evolutionarily significant species like *Arapaima gigas* (*paiche*) and *Osteoglossum bicirrhosum* (*arahuana*); commercially valuable migratory species over-fished elsewhere in Amazonia, like *Pseudoplatystoma fasciatum* (*doncella*) and *P. tigrinum* (*tigre zúngaro*); a very diverse community of ornamental fish, including *Corydoras* spp. (*shirui*), *Hyphessobrycon*, *Hemigrammus*, *Thayeria* (tetras), *Otocinclus*, *Oxyropsis* (*carachamitas*) and several other small and colorful species that may include new records for Peru and undescribed taxa

INTRODUCTION

The Amazon basin is an extensive river network that serves as a source of fresh food and water, and a highway for transportation and communication. Amazonia is home to an immense variety of aquatic animals, including as many as 8,000 fish species (Schaefer 1998). At least 750 of these have been recorded to date in the Peruvian Amazon, but a conservative estimate of the regional total may exceed 1,100 species (Chang and Ortega 1995, Ortega and Chang 1998). Fish communities in many medium-sized and smaller drainages in the region, like

the Yavarí River, shared with Brazil, remain poorly explored (Ortega and Vari 1986).

This study was carried out between 25 March and 12 April 2003, at three sites along a 150-km stretch of the Yavarí River between Angamos and the mouth of the Yavarí Mirín River. The inventory included lakes (cochas), swamps and tributaries of the Yavarí, all in Peruvian territory on the western side of the river. The chief goal of the study was to collect basic information on an interesting region whose fish communities are very poorly known.

DESCRIPTION OF THE STUDY SITES

The Yavarí is a whitewater river that originates in the hills east of Contamana and traces a winding, 1,050-km course, along which its principal tributary on the Peruvian side is the Yavarí Mirín. On the stretch we studied, the Yavarí meanders dramatically and varies in width from 80 to 150 m. Most of the river is less than 100 m above sea level, resulting in a very gentle gradient and a slow current.

During the rapid biological inventory the Yavarí was in full flood, with very high water levels in most aquatic habitats and much of the floodplain forest underwater. These conditions made it difficult to collect fish, because neither shoreline nor beaches were easily apparent, and as a result we made no collections in the Yavarí River itself.

We identified the most representative aquatic habitats (lakes and streams) at each site by reviewing satellite images and topographic maps at a scale of 1:100,000. We were able to sample most of the habitats identified in this way, but a few proved impossible to reach in the field.

The aquatic habitats we studied can be classified into lentic habitats (lakes and flooded forest) and lotic habitats (streams and rivers), all of them influenced by the Yavarí River. The most common aquatic habitats had still, black water. The next most common habitats were those with running white water, and the least common were those with mixed water or clear water (Appendix 2).

All of the lakes were characterized by black water, but in a few this was mixed with white. Lake water was slightly acid (between 6 and 6.5), its transparency approximately 30 cm, and its temperature between 22 and 23° C. Lake bottoms were generally clay, sand, and organic matter. In none of the lakes did we find aquatic plants like *Pistia* (Araceae) or *Eichhornia* (Pontederiaceae), which are abundant in similar habitats in the Reserva Nacional Pacaya-Samiria, but some of the streams had very small patches of *Lemna* (Lemnaceae).

Streams were generally white water and also slightly acidic. Their clay and sand streambeds had less organic matter than the lakes, because of the current. On their lower stretches many streams resembled lentic black-water habitats, because the high-water level of the Yavarí backed up their currents.

Two of our collection sites were temporary pools in periodically flooded forest in the floodplain of the Yavarí (locally called *tahuampa*). The average depth in some areas of these flooded forests exceeded 3 m.

METHODS

We sampled eight stations at each of the three sites (Figure 4A), for a total of 24. At each station we recorded metadata and basic characteristics of the aquatic habitat. Of the 24 stations, six were lakes, 12 were streams more than 2 m wide, three were streams less than 2 m wide, two were flooded forest or *tahuampas* and one was a palm swamp. Fourteen of the stations were black water, seven white water, and three clear water.

To sample fish communities we used dragnets measuring 5 x 1.5 m and 15 x 2 m, with mesh of 2 and 7 mm respectively. We continued sampling at each station until the sample appeared representative to our eyes. Occasionally we used a fixed net measuring 30 x 2 m and a mesh of 5 cm, as well as hooks and lines, to capture larger species and food species.

Collected fish were fixed immediately in a 10% formol solution for a minimum of 24 hours, and then placed in a 70% ethyl alcohol solution. We made preliminary identifications in the field using basic keys (Géry 1977, Eigenmann and Allen 1942) and based on

our experience from other collecting trips in the Peruvian Amazon. A large number of the collected specimens were identified to species, especially those that are common to the neighboring drainages of Loreto, Ucayali, and Madre de Dios. Nevertheless, some of the specimens were only identified to genus and provisionally sorted to morphospecies, as is standard in such inventories (Chernoff 1997). We are currently carrying out a more in-depth identification of the material in the Ichthyology Department at the Museo de Historia Natural (UNMSM), where the specimens have been deposited.

RESULTS

During the rapid biological inventory we collected roughly 4,500 fish specimens. The preliminary species list from this material includes 240 species belonging to 134 genera, 33 families and ten orders (Appendix 3). At the first site, Quebrada Curacinha, we registered 148 species; at the second, Quebrada Buenavista, 141 species; and at the third, Quebrada Limera, 116 species.

The most diverse habitats were white water streams, lakes, and areas flooded by streams. Forests flooded by the Yavarí River were also very diverse in fish, and it was in one of these *bajiales* that our highest diversity station was located (49 species, Quebrada Limera). Apparently, these temporarily flooded habitats represent important habitats for the reproductive and juvenile stages of many fish species. Most of the specimens we collected (roughly 65%) measured less than 10 cm in both adult and juvenile stages (Figure 4D). The season allowed us to detect juveniles of large food fish (*Phractocephalus hemioliopterus*, *Mylossoma* spp., *Leporinus* spp., *Acestrorhynchus* spp., *Hoplias malabaricus*, *Aequidens tetramerus*, *Bujurquina* spp., etc.).

The most diverse orders in the inventory were Characiformes (fish with scales; 154 species and 64% of the total) and Siluriformes (catfish with smooth skin or plates; 53 species and 22% of the total). The most diverse families in the Characiformes were Characidae (112 species), Anostomidae (13), and Curimatidae (8). Of the Siluriformes, the most diverse families were Loricariidae (17), Pimelodidae (12) and Callichthyidae (8). The family Cichlidae, in the order Perciformes (spiny-finned fish) was represented by 16 species.

Twenty-two percent of the species registered during the rapid biological inventory (53 species) were found at all three sites, while 53% (128 species) were found at just one site (31 in Q. Curacinha, 43 in Q. Buenavista and 54 in Q. Limera). The percentage of species shared between Q. Curacinha and Q. Buenavista, and by Q. Buenavista and Q. Limera, was 38%. Thirty-four percent of species were shared by Q. Curacinha and Q. Limera.

Incorporating results from previous studies of the Yavarí River (Ortega 1983, Sánchez 2002) brings the list to 301 species, 168 genera, 36 families, and ten orders, for the Peruvian half of the Yavarí drainage (Appendix 3). Characiformes remains the most diverse order, with 175 species (58% of the total), followed by Siluriformes, with 82 species (27%). Likewise, the most diverse families in Characiformes are Characidae (121 species), Anostomidae (15) and Curimatidae (12). In Siluriformes, the most diverse families are Pimelodidae (25 species), Loricariidae (20) and Callichthyidae (14). The family Cichlidae (Perciformes) is represented by 21 species.

If we also include an inventory from the Orosa River (Graham 2000), whose headwaters form part of the proposed Zona Reservada, the species list increases to 394 species (Appendix 3), which represents 53% of the valid fish names for the Peruvian Amazon. Of this total, 211 species belong to Characiformes (54% of the total), 116 to Siluriformes (29%) and 67 to other orders (14%).

NEW OR IMPORTANT RECORDS

- New records for Peru (probably 10% of the species we registered), and among them approximately ten species new to science (*Characidium* spp., *Moenkhausia* spp., *Tatia* spp., Glandulocaudinae, *Ernstichthys*, *Otocinclus*, Trichomycteridae).
- Large, commercially important catfish, including *Brachyplatystoma flavicans* (*dorado*), *Pseudoplatystoma fasciatum* (*doncella*), *P. tigrinum*

(*tigre zúngaro*), and *Phractocephalus hemioliopterus* (*peje torre*).

- A large number of ornamental species in the families Characidae (*Chalceus* [tetras]), Anostomidae (*lisas*), Callichthyidae (*Corydoras* [*shiruis*]), and Loricariidae (*carachamas* and *shitaris*), among others.
- Relict species (living fossils) like *Arapaima gigas* (*paiche*) and *Osteoglossum bicirrhosum* (*arahuana*), of commercial, ecological, and evolutionary importance.

DISCUSSION

The Yavarí region has a very diverse ichthyofauna (Figure 4D) that merits conservation attention, particularly the headwaters and the floodplains. Many of the aquatic habitats we studied are seasonally flooded and very important in the reproductive cycles and juvenile stages of many commercially important species. For that reason, floodplain forests along the Yavarí River are of interest to conservation and in the future should be managed by establishing seasons and areas off-limits for fishing.

A total of 240 species for an area smaller than 60 km^2 constitutes a very diverse fish community, especially considering that the high water in the Yavarí River prevented us from sampling the river itself. A similar inventory on the Pastaza River in August 1999 registered 292 species, but the sampling effort was higher, with 38 stations (14 more than in this study; Chernoff et al., in press). An inventory in the Putumayo watershed (Ortega and Mojica 2002) reported 310 fish species, including previous collections deposited in the Museum of Natural History in Lima (UNMSM) and collections on the Colombian side of the river. When results from the present study are combined with those of earlier inventories (Ortega 1983, Graham 2000, Sánchez 2002), the total fish diversity reaches 301 for the Yavarí watershed and 394 for the proposed Reserved Zone. The latter number represents 53% of the valid names registered in the entire Peruvian Amazon to date. Were fish communities of the entire Yavarí watershed to be studied in depth, there is no doubt that the final tally would exceed 400 species.

CURRENT AND POTENTIAL USE, AND THREATS

Threats to the fish communities of the Yavarí region are minimal, considering the vast size and almost pristine state of the ecosystem, exemplified by the abundance of large fish here. One potential threat is the traditional use of toxic plant substances to poison fish, like *barbasco* (*Lonchocarpus* spp.) and *huaca* (Solanaceae). This fishing technique, while very effective at harvesting food fish, also poisons many species undesired for eating and juveniles of food fishes. Another potential threat is the large-scale extraction of fishes carried out by commercial fishermen based near the mouth of the Yavarí, in Leticia and Tabatinga. Timber extraction may also impact aquatic resources by reducing microhabitat and food for fish and increasing erosion.

Among the *ribereño* communities on the Yavarí River, some 30 fish species are regularly caught for food or for commerce (Figure 4F). The best-known species are *paiche* (*Arapaima gigas*), *arahuana* (*Osteoglossum bicirrhosum*), *paco* (*Piaractus brachypomum*), *gamitana* (*Colossoma macropomum*), *lisa* (*Leporinus* spp.), *corvina* (*Plagioscion squamossissimus*), *acarahuazú* (*Astronotus ocellatus*) and *tucunaré* (*Cichla monoculus*).

Several additional fish species could potentially be used locally for food. A much larger number of ornamental fish in the area, which we recorded in lakes and streams during the rapid biological inventory, have potential commercial use (Figure 4E). We estimate that the number of potentially useful ornamental species in the area could be twice that of the potentially useful food species. The uses of local fish species are given in Appendix 3.

AMPHIBIANS AND REPTILES

Participants/Authors: Lily O. Rodríguez and Guillermo Knell

Conservation targets: Complex communities of hilly upland forest, floodplain forest, and flooded lowlands; a diverse community of sympatric dendrobatids (especially the genera *Colostethus* and *Dendrobates*); an undescribed species of *Allophryne*, the only representative of its genus in Peru; commercially valuable species like turtles and caiman; the black caiman (*Melanosuchus niger*)

INTRODUCTION

The Amazonian plain is one of the most diverse ecosystems on the planet, and the cataloguing of its biodiversity continues to occupy researchers, who advance a little year by year. The Yavarí region is a good example of the work that remains to be done. Although some preliminary studies of the herpetofauna have been carried out in nearby sites (Dixon and Soini 1986, Lamar 1998, L. Rodríguez, unpublished data), herpetologists still consider the Yavarí basin a blank spot on the map. This impression is only reinforced by the fact that in just 20 days in the field during this rapid biological inventory, we found several species new to science, as well as some new records—including a new genus—for Peru.

METHODS

For 20 days we recorded all the amphibians and reptiles found on day- and night-time walks at four sites on the Peruvian side of the Yavarí River, between Angamos and the mouth of the Yavarí Mirín River. We sampled between eight and ten hours per day in the first week and between eight and fourteen hours per day in the second and third weeks, for a total of more than 200 hours of field work. The majority of the specimens were photographed alive and released. To ensure accurate identifications, we collected 77 voucher specimens that will be deposited in the Natural History Museum in Lima.

At each site we made an effort to cover all of the available habitats. The three first sites were dominated by diverse, heterogeneous hilly upland forest with many streams, where important microhabitats included seasonal pools in low-lying areas inside the forest, tree fall gaps, leaf litter, the bases of buttressed trees, and old palm leaves. In Quebrada Curacinha and Quebrada Buenavista we also visited small patches of palm swamp (*aguajales*) mixed with other plant communities. The fourth site, in very homogeneous flooded forest around Lago Preto, presented a very different set of interesting habitats, as it was a mix of black and white waters. At this fourth site most of our observations were made from a canoe.

Most of the information presented here comes from the herpetological team, but other members of the rapid biological inventory team provided complementary data and observations.

RESULTS AND DISCUSSION

Herpetological diversity

Although the interfluvium between the Yavarí, Tapiche, Ucayali, and Amazon rivers appears rather homogeneous on satellite images, with some hillier areas near Angamos, field work revealed a magnificent mosaic of habitats and microhabitats, which was reflected in the diversity and distributions of amphibians and reptiles. During the rapid biological inventory we recorded 77 species of amphibians and 43 species of reptiles. Of the amphibians, 76 species were anurans and one was a salamander. Of the reptiles, 22 species were lizards, 15 were snakes, four were turtles, and one was a caiman. For the full species list see Appendix 4.

Given our limited time in the field, these preliminary results indicate very high levels of amphibian and reptile diversity in the Yavarí watershed. As more studies are carried out, more habitats are explored, and more work is done during the dry season, the list will undoubtedly lengthen. In the greater Iquitos region, some 115 species of anurans (Rodríguez and Duellman 1994) and 194 species of reptiles (Lamar 1998) are known. For the four sites we sampled along the Yavarí River during the rapid biological inventory, which seem slightly less heterogeneous in their habitats than the Iquitos region, we estimate between 100 and 115 species of anurans and roughly 100 species of reptiles.

New species and other records of special interest

Just two and a half months after returning from the field, taxonomic specialists had confirmed five of the amphibian species collected during the rapid biological inventory—three hylids, a bufonid, and a centrolenid—as new to science. At least one other species, a dendrobatid, may also turn out to be undescribed.

The most striking new species is a black hylid speckled with yellow and white spots, which belongs to the genus *Allophryne* (Figure 5C). This genus had never before been collected in Peru and was believed to be monotypic, represented only by *A. ruthveni*, endemic to the Guiana Shield in Surinam and Brazil (Hoogmoed 1969, M. Hoogmoed, pers. comm.). The new Peruvian record, from flooded forest around Lago Preto, extends the distribution of this genus significantly to the southwest. *Allophryne* is a poorly understood genus from a phylogenetic standpoint. It has been tentatively assigned to the family Hylidae, but Lynch and Freeman (1966) have suggested a relationship with Dendrobatidae.

Another undescribed hylid collected during the rapid biological inventory belongs to the genus *Scinax* (W. Duellman and J. Faivovich, pers. comm.). This species, with a characteristic yellow vocal sac, was discovered with two other species of the same genus in a low, flooded area at the Quebrada Buenavista site.

The third undescribed hylid is a blue-legged frog in the genus *Hyla* (Figure 5E). One of us (LR) recorded this species previously in Jenaro Herrera, and it is currently being described. On the Yavarí trip it was observed mating at the first two sites.

We recorded at least three species in the *Bufo typhonius* complex, including what may be *Bufo margaritifer*. A fourth species, resembling *B. dapsilis*, is new to science and currently being described by M. Hoogmoed (pers. comm.). This taxon (*Bufo* sp. nov. "Pinocchio"), remarkable for its velvety skin and long "nose", was one of the most common amphibians at the Quebrada Buenavista site (Figure 5B).

A species in the genus *Hyalinobatrachium*, collected by the ichthyological team during a daytime excursion at the Quebrada Buenavista site, has also turned out to be undescribed (J. Lynch, pers. comm.; Figure 5D). The same taxon has also been collected in Colombia.

Dendrobatids are an important group in Yavarí, with nine species registered overall. Three of these are in the genus *Colostethus*, and two of these—*C. melanolaemus* and *C.* cf. *trilineatus*—appear to share the same habitat or neighboring habitats. The sighting of *Colostethus melanolaemus* in Yavarí is only the second for the species, which was described recently from a specimen collected close to the mouth of the Napo River. Until now it was not known in which direction its geographic range was most likely to extend, whether to the north or south of the Amazon River. This new record makes it likely that the species also occurs in Brazil, unless the Yavarí River serves as a geographic barrier.

The Yavarí list includes three *Dendrobates* in the *ventrimaculatus* group, one of which may be undescribed. This taxon, which we found at the first three sites, has a distinctive dorsal pattern, with fine red lines on the head fading distally to gold. We also registered *D. tinctorius igneus*, recuperating an old name from Melin (1941) for this morphospecies discovered at the Quebrada Curacinha site; and *D. flavovittatus*, or another taxon similar to *D. imitator*, a spotted species known only from the Tahuayo River, which was observed but not collected far from the river at the Buenavista site (D. Moskovits, pers. comm.).

Among the most important reptiles we collected was the viper *Porthidium hyoporus*. Although this snake is generally reported as very rare (Schleser and Roberts 1998), it was spotted twice during the rapid biological inventory, at both Quebrada Curacinha and Quebrada Buenavista. We also registered *Micrurus putumayensis*, a rare, two-toned coral snake known from the Aucayacu, Tahuayo, and Orosa rivers, as well as the southern bank of the Amazon and the mouth of the Yavarí (P. Soini, pers. comm.; Figure 5G). The type is known from the southern bank of the Putumayo River. An interesting record among the lizards we registered was *Stenocercus fimbriatus*, known from the Juruá, Purús, and Manu drainages, and from the Itaya and Nanay rivers near Iquitos (Figure 5A).

Quebrada Curacinha

Field work at this first site lasted seven days. We visited all the surrounding habitats during the day and at night. The principal habitats were hilly upland forests, drained by clear or slightly turbid creeks, and the mixed palm swamps (*aguajales*) 4 km from the docking point.

The most common amphibians at this site were two leptodactylids (*Leptodactylus rhodomystax* and *Ischnonema quixensis*), a dendrobatid (*Epipedobates hanheli*) and the *Bufo typhonius* complex. Species found most frequently in or near water were *Leptodactylus petersi* in seasonal pools and small hylids, like *Hyla granosa*, *Hyla brevifrons* sp.1 and an unidentified *Hyla*, in the palm swamp.

Quebrada Buenavista

We spent a week at this site, sampling habitats similar to those at Quebrada Curacinha but with gentler hills. The flooded areas were larger here, the seasonal pools had more water, and the *Duroia* (*supay chacra*) clearings were larger, warmer and brighter.

The most common species at this site were toads in the Bufonidae, especially *Bufo* sp. nov. "Pinocchio"(Figure 5B), which was observed both during the day and at night, sleeping on understory plants more than a meter above the ground. We also found various individuals of the salamander *Bolitoglossa peruviana*, several individuals of the dendrobatids *Epipedobates femoralis* and *E. hanheli*, and three species in the genus *Scinax*, one of them new to science, all in a single flooded site. In the uplands here the most common species was *Osteocephalus planiceps*. Many *Anolis trachyderma* lizards were seen in the understory vegetation during walks at this site.

In several places here we detected the call of *Eleutherodactylus toftae* during the day. This represents a range extension for a species previously known from southeastern Peru, only as far north as the Purús drainage. A similar case is *Eleutherodactylus buccinator*, a species in the *conspicillatus* group that was very common here and at Quebrada Limera.

Quebrada Limera

We sampled forests at the third site for four days, exploring no more than 2 km inland. A hundred meters to the east of our docking point, a swamp associated with streams contained populations of *Hyla calcarata*, *Bufo typhonius*, *Scinax garbei* and *Hyla brevifrons*.

The most remarkable records at this site were *Colostethus melanolaemus* and *Colostethus* cf. *trilineatus*, in part because *C. melanolaemus* was previously known only from the Napo River, and in part because it was believed that the two species did not co-occur. *Dendrobates* "*amazonicus*" was present here along all the trails, and *Osteocephalus* "verde" was common, especially near streams. Individuals of the latter were seen calling from relatively low vegetation (2 m) rather than from tree trunks as is usual in this genus.

Dendrophriniscus minutus was common here, especially in riparian sites. Adults of an undescribed *Bufo* species (*Bufo* sp. nov. "Pinocchio") were also frequently encountered (Figure 5B). We observed two male tortoises at this site, together in the forest, and a spectacled caiman.

Lago Preto

We sampled forests at this site for four days. Because this is a floodplain forest that was a mostly inundated complex of lakes and swamps during our visit, we took a different approach to sampling here. From the banks of the Yavarí we paddled by canoe until reaching the unflooded section of the floodplain. From here, we explored the forest on foot, along a trail that leads to the community of Carolina. These forests are very different in composition from the others we visited along the Yavarí, dominated by understory palms, much more poorly drained, and more homogeneous. We concentrated sampling mostly in the flooded forest and in vegetation along the blackwater lakes.

The most frequently recorded species at this site were the hylids *Hyla geographica*, *Hyla leali* and *Scinax garbei*. On several occasions we found a species in the genus *Adenomera* in the wet leaf litter of the forest. Various individuals of *Caiman crocodylus* were spotted at this site. The most remarkable record here was a spotted frog in the genus *Allophryne*, a new species

to science and a new genus for Peru (see above and Figure 5C).

THREATS AND RECOMMENDATIONS

Amphibian and reptile diversity are closely related to habitat and microhabitat diversity, and the top conservation goal for this group is simply the preservation of undisturbed forest. Smaller reptile species and amphibians would likely be threatened by poorly managed timber extraction, as a result of habitat and microhabitat destruction. Timber extraction in the Yavarí area would probably also result in more hunting, with direct consequences for terrestrial and aquatic tortoises.

The long-term conservation of commercially valuable reptiles like tortoises and caimans requires some preliminary research with local communities to get a better understanding of their current status and the hunting pressure they face. One potential threat, in addition to the hunting of adults, is the over-harvest of tortoise eggs. We recommend carrying out surveys during the dry season, which is the nesting season for the globally threatened South American river turtle (*Podocnemis expansa*; Figure 5H) and the yellow-spotted Amazon River turtle (*Podocnemis unifilis*), to assess their population status and the impact of egg harvesting by local communities.

Another priority is documenting the population status of caimans (especially the black caiman, *Melanosuchus niger*, which was not observed during this inventory), for a better understanding of historical trends and the impacts of historical and current (if any) harvest of caiman skins. If the caiman community is found to be in decline, management plans should include special measures for the species, including community-based initiatives like those underway in the Pacaya-Samiria National Reserve.

BIRDS

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Conservation targets: Intact bird communities of terra firme and flooded forest; range-restricted species (e.g., *Hylexetastes stresemanni*, *Grallaria eludens*); *Deroptyus accipitrinus*; large gamebirds; *Harpia harpyja*; *Crax globulosa*

INTRODUCTION

Little ornithological work has been conducted along the Río Yavarí or elsewhere in the interfluvium between the Yavarí, Amazon and Ucayali rivers. Castelnau and Deville collected specimens at "Rio Javarri" for the Paris museum in 1846, but it is unclear how far upstream they ventured (Stevens and Traylor 1983, T. Schulenberg, pers. comm.). Bates deposited a collection in the British Museum made on the "Rio Javari" in 1857 and 1858; these specimens probably came from the mouth of the river (Stevens and Traylor 1983, T. Schulenberg, pers. comm.). On the Yavarí Mirín, a small ornithological collection was made by Kalinowski in 1957 (Stevens and Traylor 1983). Finally, Hidasi made a collection at the Brazilian town of Estirão do Equador between 1959 and 1961 (Paynter and Traylor 1991).

Elsewhere on the interfluvium, the Olallas collected birds along the Amazonas at Orosa in 1926, and various collectors have visited Quebrada Vainilla (Powlison in 1966 and 1967, and Louisiana State University in 1983) and the nearby Río Manití (Academy of Natural Sciences in 1987). Along the Ucayali, other collections have been made near Contamana (Schunke in 1947 and Hocking in the 1960s–80s) and the Río Shesha (Louisiana State University in 1987).

More recently, in 1998, A. Begazo (pers. comm.) conducted surveys in the Reserva Comunal Tamshiyacu-Tahuayo and on the Yavarí and Yavarí Mirín rivers. Finally, several ornithologists have contributed to a bird list for the new Palmarí Lodge, on the Brazilian bank of the Yavarí near its mouth (A. Whittaker, B. Whitney, K. Zimmer, et al.). Records reported here from Palmarí or the lower Yavarí are those of Whitney unless otherwise credited.

METHODS

We conducted surveys along the temporary trail system at each site, starting about an hour predawn (weather permitting) and continuing through at least mid-day. We used sound recording equipment to document species and to conduct playback for confirmation of identification. Recordings will be deposited at the Macauley Library for Natural Sounds at the Cornell Laboratory of Ornithology. During the mornings, we visited all accessible habitats at each site, including hilly and low terra firme (upland) forest, streams, flooded forest, and oxbow lakes. In the afternoons we conducted occasional sky watches from the riverside. We did not perform point counts (standardized censuses), but estimated the numbers of individuals we saw of each species each day, noted habitats in which they were encountered, and later converted these into approximate abundance and habitat preference data (Appendix 5). We have augmented our own records with sightings by other members of the RBI team, particularly Alvaro del Campo and Kati Salovaara.

RESULTS

Diversity and geographic patterns

During our three weeks in the field we observed approximately 400 species of birds, and estimate perhaps 550 species for the proposed protected area—a particularly rich avifauna for a lowland region (see Cohn-Haft et al. 1997). Based on the satellite images of the area, we had expected to encounter a relatively homogeneous forest; instead, we were surprised to discover substantial habitat heterogeneity. This heterogeneity generates patchy species distributions and elevates the overall species richness of the area. Of the several forest types we surveyed, terra firme forests had the highest species richness.

We recorded between 248 and 314 bird species at each of the three inventory sites. There was relatively high turnover of species between camps, either because many shared species were missed due to imperfect sampling, or because real changes in microhabitat from site to site caused species to drop out in some places.

The avifauna of the interfluvium between the Ucayali, Amazon, and Yavarí rivers comprises a mixure of elements from different regions of Amazonia. With few exceptions, the overall avifauna we encountered is typical of Amazonian Peru and adjacent Brazil. But bird distributions in Amazonia are not broad-brush, and many species occupy ranges in only one portion of the basin. Various authors have noted that many bird species have their distributions limited by large Amazonian rivers (e.g., Haffer 1969, 1974; Cracraft 1985; Capparella 1988, 1991). In many cases, species occur only on the north or south bank of the Marañon-Amazon-Solimões River, or are replaced on the opposite bank by a closely related species that probably occupies the same niche. One example in the Yavarí area is *Galbula cyanescens* (Bluish-fronted Jacamar), a "south-bank" species replaced on the north bank of the Río Amazonas by *G. tombacea* (White-chinned Jacamar; Haffer 1974). Another example is the Bluish-cheeked Jacamar (*G. cyanicollis*), replaced to the west of the Río Ucayali, as well as to the north of the Amazon, by the Yellow-billed Jacamar (*G. albirostris*; Haffer 1974). Thus, it is suspected by some that the rivers have created breaks in the gene flow of related forms, allowing them to speciate (Capparella 1988, 1991).

However, there are species pairs with distributions that suggest that rivers are not the ultimate cause of the current distributional patterns of Amazonian birds. In the Yavarí area species pairs that break the river-barrier pattern include *Pipra filicauda* (Wire-tailed Manakin) and *Attila citriniventris* (Citron-bellied Attila). These two species are replaced farther south in the same interfluvium by related species: *Pipra fasciicauda* (Band-tailed Manakin) and *Attila bolivianum* (Dull-capped Attila; Haffer 1997). What serves as the distributional boundary between these two pairs of species, and where that boundary lies, is not clear. Further fieldwork is needed to determine if both species turn over in the same area, suggesting some common physical barrier, either current or historical. At least one pair of closely related species, *Malacoptila semicincta* (Semicollared Puffbird) and *M. rufa* (Rufous-necked

Puffbird) seems to turn over within the stretch of the Yavarí we visited (see below).

Several areas of endemism have been identified within Amazonian South America, with the Yavarí watershed encompassed by the Inambarí area of endemism (Cracraft 1985). Some bird species characteristic of the Inambarí area are rather widespread in southwestern and western Amazonia, such as *Psophia leucoptera* (Pale-winged Trumpeter), *Galbula cyanescens* (Bluish-fronted Jacamar), *Pteroglossus beauharnaesii* (Curl-crested Aracari), *Hylexetastes stesemanni* (Bar-bellied Woodcreeper), and *Tachyphonus rufiventer* (Fulvous-crested Tanager; Haffer 1974, Cracraft 1985). Other species, including *Phaethornis philippi* (Needle-billed Hermit), *Brachygalba albogularis* (White-throated Jacamar), and *Grallaria eludens* (Elusive Antpitta), all of which we encountered at our Yavarí sites, are more restricted to the heart of this center of endemism, apparently located in southeastern Peru and adjacent Brazil and Bolivia (Haffer 1974, Cracraft 1985).

With one exception, there seem to be no species with a distribution limited by the Río Yavarí. At Palmarí Lodge, on the Brazilian side of the river, *Thryothorus griseus* (Gray Wren) inhabits vine tangles in floodplain forest. Despite Whitney's searches in those habitats on the Peruvian side of the river near Palmarí, and our own searches at the rapid inventory sites, there is still no Peruvian record for the species. The habitat used by *Thryothorus griseus*, and the relatively small width of the river, suggest that the species should also occur on the Peruvian bank. With more effort, it may yet be found there.

Migration

Migration was especially extensive and conspicuous during our first week of fieldwork, but throughout the trip we observed migrant species actively moving overhead or foraging. On the evening of 28 March, immediately after a large electrical storm had passed over, we witnessed an impressive migration event over the Yavarí. Nearly a thousand birds were observed flying roughly south to north, from the Brazilian side of the river to the Peruvian, in the space of two hours. Some species, particularly swallows and kingbirds, rested briefly in riverside vegetation before departing to the north, whereas others, most notably swifts, flew by at rather high altitudes. The bulk of the individuals included *Chordeiles minor*, *Cypseloides lemosi*, two different unidentified *Cypseloides* spp., an unidentified *Chaetura* sp., *Tyrannus savanna*, *Tyrannus tyrannus*, *Tyrannus melancholicus*, *Hirundo rustica*, *Riparia riparia*, *Notiochelidon cyanoleuca*, *Progne modesta*, *Progne tapera*, and *Tachycineta albiventer*. On the following days we saw smaller numbers of swifts and swallows, but nothing matching the huge movement of 28 March. *Tyrannus savanna*, in particular, was moving in large numbers from our arrival on 25 March through 31 March. The species was nearly absent afterwards, suggesting that its migration period had ended and that there are few or no locally wintering populations.

The migrants we observed were not all moving between the same areas. Austral migrants returning from breeding grounds in the south were mixed with boreal migrants departing for North America. Other species' movements are very poorly known, but several appear to be intra-tropical migrants within Amazonia or at least within South America. The migrating species we observed in the Yavarí can be categorized as follows:

<u>*Austral migrants*</u>

Myiodynastes maculatus solitarius (Streaked Flycatcher), *Empidonomus varius* (Variegated Flycatcher), *Empidonomus aurantioatrocristatus* (Crowned Slaty Flycatcher), *Tyrannus savanna* (Fork-tailed Flycatcher), *Tyrannus melancholicus* (Tropical Kingbird), *Notiochelidon cyanoleuca* (Blue-and-white Swallow), *Progne modesta* (Southern Martin), and *Progne tapera fusca* (Brown-chested Martin).

<u>*Boreal migrants*</u>

Pandion haliaetus (Osprey), *Falco peregrinus* (Peregrine Falcon), *Actitis macularia* (Spotted Sandpiper), *Coccyzus americanus* (Yellow-billed Cuckoo), *Chordeiles minor* (Common Nighthawk), *Contopus virens* (Eastern Wood Pewee), *Myiodynastes luteiventris* (Sulfur-bellied Flycatcher), *Tyrannus tyrannus* (Eastern Kingbird),

Pterochelidon pyrrhonota (Cliff Swallow), *Hirundo rustica* (Barn Swallow), and *Riparia riparia* (Bank Swallow).

Intra-tropical migrants

Cypseloides lemosi (White-chested Swift), *Cypseloides* sp. (short-tailed), *Cypseloides* sp. (long-tailed), *Chaetura* sp., and *Tachycineta albiventer* (White-winged Swallow).

Other patterns

Several species normally widespread and/or more common in western Amazonia were surprisingly scarce in our inventory. We encountered some only once or twice, while others appeared to be missing altogether. Perhaps absences can be explained by the lack of appropriate microhabitat, or perhaps some species move seasonally within Amazonia. Whatever the reason, we cannot provide a solid explanation for the scarcity of species like *Elanoides forficatus* (Swallow-tailed Kite), *Ara chloropterus* (Red-and-Green Macaw), *Heliornis fulica* (Sungrebe), *Columba cayennensis* (Pale-vented Pigeon), *Brotogeris versicolurus* (Canary-winged Parakeet), *Cotinga cayana* (Spangled Cotinga), *Todirostrum chrysocrotaphum* (Yellow-browed Tody-Flycatcher), and *Campylorhynchus turdinus* (Thrush-like Wren). Both the botanical and ornithological teams noted a dearth of fruiting and flowering, potentially explaining the low density and relatively poor species richness of hummingbirds and tanagers in the area. Most likely, these species undertake local movements tracking seasonally and patchily distributed food sources.

Sites visited

Quebrada Curacinha

We spent seven days at this site and tallied 314 species. It was here that we witnessed the impressive migration event described above. Among the migrants observed, *Chordeiles minor* (Common Nighthawk) and *Cypseloides lemosi* (White-chested Swift) are both poorly known in Peru. The former is known to migrate along the coast and in Amazonian Peru, but its movements are not well documented. *Cypseloides lemosi* is one of several species of large swift which are extremely poorly known overall. It was originally recorded only from Colombia (Hilty and Brown 1986), but has since been found in Ecuador and northern Peru (Collar et al. 1992, Ridgely and Greenfield 2001, Schulenberg 2002), and at the lower Yavarí near Palmarí Lodge over both Peru and Brazil. Thus our observations are not entirely unexpected, but they may be the first to suggest that the species is an intra-tropical migrant.

We did not conclusively identify other swifts we saw migrating, but they represent records of interest nonetheless. Of the two large *Cypseloides*-like species we recorded, one with a short tail could represent *Cypseloides cryptus* (White-chinned Swift), which is not known to occur such a long distance from the Andes, although there have been large unidentified *Cypseloides* swift sightings from Palmarí Lodge thought to be *C. cryptus*. The second, longer-tailed species could have been one of several species: *Cypseloides niger*, *C. fumigatus*, *C. rothschildi*, or *Streptoprocne rutila*, none of which are known from lowland Amazonian Peru nor nearby Brazil.

Presumed migrant *Chaetura* swifts we observed were larger than the local species, *C. egregia* (Pale-rumped Swift) and *C. brachyura* (Short-tailed Swift), and seemed darker on the rump and paler on the throat and breast. This description seems to agree most with *Chaetura meridionalis* (Sick's Swift), but other large *Chaetura* species such as *C. pelagica* (Chimney Swift) and *C. viridipennis* (Amazonian Swift) cannot be ruled out (see Marín 1997). B. Whitney (pers. comm.) reported *Chaetura meridionalis* from along the Yavarí near Palmarí in early August 2000, the first record of the species in Peru.

At Curacinha, we encountered several species whose status in Peru is only becoming understood over the last decade or so. Among these were two flyover *Touit purpurata* (Sapphire-rumped Parrotlet) that we heard, but did not tape record, on our first two days at the site. This species is known from several areas in northeastern Peru, mostly from the Iquitos area west to Ecuador, and has been observed on the Brazilian bank of the lower Yavarí at Palmarí Lodge (Ridgely and Greenfield 2001; J. V. Remsen, Jr., B. Whitney, and

T. Schulenberg, pers. comm.). The species has been previously encountered in the proposed reserve area by A. Begazo (pers. comm.). Similarly, *Hemitriccus minimus* (Zimmer's Tody-Tyrant) is also known from several areas in northeastern Peru (Álvarez and Whitney, in press). This small tyrannid was frequently encountered on ridgetop terra firme, and occasionally in low terra firme forest nearby. It has been encountered previously in the Reserva Comunal Tamshiyacu-Tahuayo (A. Begazo and J. Álvarez, pers. comm.).

Our sight record of *Malacoptila semicincta* (Semi-collared Puffbird) is the northernmost of the species in Peru, and suggests that it and *Malacoptila rufa* (Rufous-necked Puffbird) may replace one another along the stretch of the Yavarí we visited. Along lake edges at this site we encountered *Myrmotherula assimilis* (Leaden Antwren), a species normally associated with river islands (Ridgely and Tudor 1994). It appears that the middle-lower Yavarí is the only area of this species' range where it has been found to be common away from river islands (B. Whitney, pers. comm.). *Nyctiprogne leucopyga* (Band-tailed Nighthawk), a poorly known nightjar that is very local in its Peruvian distribution, was encountered along the main Yavarí several times en route to or from nearby lakes and streams. It is also common along the lower Yavarí near Palmarí Lodge. Finally, our record of *Thripophaga fusciceps* (Plain Softtail) from Curacinha, and A. Begazo's earlier record from the area (pers. comm.), are quite distant from other published localities for the species—the middle and upper Río Napo in Peru and Ecuador, Madre de Díos in south-eastern Peru, and central Amazonian Brazil (Ridgely and Tudor 1994, Ridgely and Greenfield 2001). What subspecies our population represents is not clear. It may be *dimorpha*, of western Amazonia, or *obidensis*, known only from central Amazonian Brazil.

Quebrada Buenavista

We spent seven days at this site and tallied 304 species. Buenavista had the highest within-site habitat heterogeneity of the three sites visited, including hilly and low terra firme forest, seasonally flooded forest, mixed *Mauritia* swamps, and lake and streamside habitats.

Particularly startling here was our discovery of *Deroptyus accipitrinus* (Red-fan Parrot; Figure 6B), a species known in Peru from only one specimen from the Río Pastaza nearly at the Ecuadorian border (Ridgely and Greenfield 2001). Our new record, most likely representing the subspecies *fuscifrons*, is quite distant from any other known population. The species is known primarily from northeastern South America west to Colombia, with an isolated population in the Pastaza area of Ecuador and Peru and another in Brazil south of the Amazonas and east of the Rio Madeira. Thus our record, along with another previously unreported sighting from the junction of the Yavarí and Yavarí Mirín (A. Begazo, pers. comm.), indicates a very isolated population along the Yavarí. In Ecuador this species appears to be associated with blackwater lakes, much as we found it to be here (B. Whitney, pers. comm.).

We heard another blackwater forest indicator species, *Conopias parva* (Yellow-throated Flycatcher), once at Buenavista. This species is considerably more widespread in Amazonia than is apparent from the literature, but has a highly patchy distribution restricted to blackwater drainages (Álvarez and Whitney in press). It too has been reported from Palmarí Lodge (K. Zimmer, pers. comm.).

At this site we also registered the northernmost Peruvian record of *Grallaria eludens* (Elusive Antpitta), a species described in 1969 (Lowery and O'Neill 1969) and known from fewer than ten sites worldwide. The nearest records are from Benjamin Constant, Brazil (M. Cohn-Haft, pers. comm.), and the Río Shesha, Peru (J. O'Neill et al., unpub. data; Isler and Whitney 2002), the former just east of our Yavarí sites. Another northernmost Peruvian record, and probably only the sixth for the country, is our observation of two individuals of *Hylexetastes stresemanni* (Bar-bellied Woodcreeper). This species is rare and poorly known throughout its distribution. It has been reported from the Brazilian side of the lower Yavarí.

Malacoptila rufa (Rufous-necked Puffbird) was found at this site, including a pair with a recently fledged chick, suggesting that either this species is

sympatric with *M. semicincta* along the Yavarí, or that we crossed a boundary of parapatry between Curacinha and Buenavista across which one species replaces the other. However, the fact that both species were encountered in terra firme forest, rather than one in terra firme and the other in *várzea* (as has been noted at other sites where two *Malacoptila* occur together; D. Lane, pers. obs.), suggests that the first option is more likely. Perhaps the Iquitos Arch acts as a boundary between the two species (see Patton and Nazareth F. da Silva 1998). At Buenavista we also encountered species of particular interest that we first noted at Curacinha (see above): *Chordeiles minor*, *Nyctiprogne leucopyga*, and *Myrmotherula assimilis*.

Quebrada Limera

We spent five days at this site, tallying 248 species. Due to inclement weather and high water levels, we had less field time and poorer access to local habitats here than at the previous two sites. Most of the notable records were additional reports of species already noted at the previous sites (see above): *Deroptyus accipitrinus*, *Chordeiles minor*, *Nyctiprogne leucopyga*, and *Myrmotherula assimilis*.

Here we found our only pair of *Synallaxis gujanensis* (Plain-crowned Spinetail) of the inventory. This population seems to have a two-note song, as described in the species account for *gujanensis* of Ridgely and Tudor (1994), but quite different from the three-note song given by populations from the lower Río Marañon, from the middle Río Huallaga area in San Martín, from Madre de Díos, and from Santa Cruz, Bolivia (D. Lane, pers. obs.), which is more like the description of the voice of *S. albilora* (White-lored Spinetail) in Ridgely and Tudor (1994). This observation is at odds with Ridgely and Tudor's argument to maintain *albilora* as a species distinct from *gujanensis* (see also Remsen 2003). It appears that the break in vocal types occurs within Amazonian populations of the latter species, not between *gujanensis* and *albilora*.

Other important sightings came from other members of the RBI team and from local inhabitants. They suggest the presence of such rare and poorly-known species as *Harpia harpyja* (Harpy Eagle), *Morphnus guianensis* (Crested Eagle), *Geotrygon saphirina* (Sapphire Quail-Dove), and *Neomorphus* sp. (ground-cuckoos) in the Yavarí basin. In the case of *Neomorphus*, the observer was certain that both *N. geoffroyi* and *N. pucheranii* occur in the area. If true, this would be a rare case of sympatry in the genus (see also Ridgely and Greenfield 2001). Furthermore, A. del Campo encountered captive individuals of *Amazona festiva* (Festive Parrot), *Brotogeris versicolurus* (Canary-winged Parakeet), and *B. sanctithomae* (Tui Parakeet) in the towns of Nueva Esperanza and Carolina on the Río Yavarí Mirín. All of these species probably occur in the region, although none were observed by the ornithological team.

CONSERVATION IMPORTANCE

Several species observed during our surveys along the Río Yavarí, or reliably reported to us by others, are of particular conservation interest. We found several species that are poorly known in western Amazonia or have restricted global distributions: *Touit purpurata*, *Nyctiprogne leucopyga*, *Cypseloides lemosi*, *Hylexetastes stresemanni*, *Thripophaga fusciceps*, and *Grallaria eludens*. Cracids, often among the first species to feel the effects of hunting, seem to have relatively healthy populations here, particularly the large *Mitu tuberosa* (Razor-billed Curassow). We did not find *Crax globulosa* (Wattled Curassow), listed as Vulnerable by BirdLife International (2000), but it has been recorded along the lower Yavarí (J. V. Remsen, Jr., pers. comm.) and may occur in flooded forests within the proposed protected area. Found almost exclusively in flooded forest along western Amazonian rivers, where it is easily found by hunters, *Crax globulosa* is particularly vulnerable to hunting pressure. If this magnificent curassow proves to be present in the area, the Yavarí protected zone would be only the second in Peru to harbor the species, and as such would be critically important to its long-term persistence in the country.

Local inhabitants in the towns of Carolina and Nueva Esperanza assured us that *Harpia harpyja* (Harpy Eagle) occurs in the area, and with the incredible

densities of primates we saw during the inventory, we see no reason to doubt this. This rare species needs large tracts of pristine forest to support its prey base.

Habitat loss and capture for the pet trade have strong impacts on the populations of large parrots and macaws. Of particular interest is the newly-discovered population of *Deroptyus accipitrinus* (Red-fan Parrot; Figure 6B) which is extremely restricted in its distribution in western Amazonia. This parrot does not appear to be particularly common in the commercial pet trade, but may be captured for pets by locals.

THREATS AND RECOMMENDATIONS

The Yavarí and Yavarí Mirín basins are under immediate pressure from commercial logging operations, immigration, and even a projected road-building project. If timber extraction proceeds, the effects will be more far-reaching than the simple removal of trees. Degradation of the pristine forest and aquatic habitats will result in the local extinction of various bird species and hunting will cause population declines of slowly reproducing game species such as large cracids and some tinamous. Should the edges of the proposed protected area be opened to human use, the river margins of the Yavarí and Yavarí Mirín should have particular restrictions on hunting of large cracids and settling and clearing of seasonally flooded forest.

To complement our rapid inventory, a longer, more comprehensive inventorying trip is necessary in the Yavarí and Yavarí Mirín watersheds. Especially important is survey work in flooded forest habitats to determine the status of *Crax globulosa* in the region. Finally, the status of other restricted-range and poorly known species likely in the area should be determined, particularly *Hemitriccus minor* and *Thryothorus griseus*. The latter species has yet to be confirmed in Peru, despite its presence on the Brazilian bank of the Yavarí.

DIVERSITY AND ABUNDANCE OF MAMMALS

Participants/Authors: Kati Salovaara, Richard Bodmer, Maribel Recharte, and Cesar Reyes F.

Conservation targets: World-record mammal diversity; numerous endangered and rare species at relatively high frequencies; dense populations of large-bodied game species that have been overharvested in other parts of Peruvian Amazonia; intact habitat mosaic

INTRODUCTION

The vast expanses of upland forest between the Amazon, Ucayali and Yavarí rivers, like other relatively aseasonal western Amazonian sites, harbor extremely diverse mammal communities. Two previous inventories from this region of Peru, carried out within 100 km of the sites we visited in the rapid biological inventory, have confirmed 79 (Fleck and Harder 2000) and 84 (Valqui 2001) species of nonvolant mammals to date. Valqui's list is probably the longest ever reported for such a small area sampled (ca. 125 km^2), making the Yavarí valley one of the mammalian diversity hotspots in Peru, Amazonia and indeed the world.

Numerous studies on the ecology and use of large mammals have been conducted to date inside the proposed Yavarí Reserved Zone. Much of this work has focused on the Yavarí Mirín river basin at the heart of the region, where data on the density and biomass of large mammal species have been collected for many years (Bodmer et al. 1997a, 1997b). Because no such work had been carried out in the forests we visited during the rapid biological inventory, along the upper Yavarí, our first goal was to gather comparable density data for that region.

In this chapter we present the results of those inventories, discuss their relevance for conservation, and compare these new data with existing data from the Yavarí Mirín river. The aim is a better understanding of how and why the abundances, densities, and biomass of large mammals vary from site to site within the proposed Reserved Zone. This information can be used to evaluate the conservation importance of the different areas surveyed, because large mammals are sensitive to hunting and human presence and their densities are an index of human impact. The among-site comparisons

also provide baseline information for wildlife management. In Amazonia, large mammals, especially ungulates and primates, are an important economic resource for the local inhabitants, and their populations are vulnerable to overexploitation (see "Use and Sustainability of Wildlife Hunting in and around the Proposed Yavarí Reserved Zone"). For conservation and management planning it is important to analyze the variation in wildlife densities between areas with differing hunting intensities (Robinson and Bodmer 1999).

METHODS

We censused large mammal communities (ungulates, primates, rodents >1 kg body weight, edentates, and carnivores) along the trail systems established in the first three study sites of the upper Yavarí River. We used the DISTANCE sampling method (Buckland et al. 1993) and conducted the surveys between 7 AM and 3 PM. Groups of one or two observers walked the transects at a pace of ca. 1.5 km/h. We censused a total of 507.2 km in the three sites. When a group of animals was encountered, we recorded the number of individuals and measured the perpendicular distance from the trail to the first individual sighted. We analyzed the data using DISTANCE 4.0 software. We did not calculate density for species with fewer than eight observations; instead, we substituted a measure of abundance (number of individuals observed/100 km censused). Although the number of observations was sometimes small, the model fit was generally good and density estimates should be reliable.

Large mammal density data for the Yavarí Mirín come from previous surveys conducted with the same methodology along 1,827 km of trails during the years 1992–1999. For the comparative analyses, we divided the Yavarí Mirín data into lower and upper regions, with the Quebrada Panguana serving as a midpoint. The lower Yavarí Mirín is an area of light hunting pressure, while the upper Yavarí Mirín has virtually no hunting pressure, with wildlife populations reaching relatively natural equilibrium densities. This allowed us to assess hunting pressure in the upper Yavarí sites, which are more accessible to people and may be more impacted from resource use, though habitat differences between the three areas may also influence wildlife densities.

We used additional mammal observations made by the rest of the rapid biological inventory team, together with the census data, to compile a species list for the sites along the upper Yavarí. We used data from previous censuses along the Yavarí Mirín and from skulls collected by local hunters (deposited in the museum of the Universidad Nacional de la Amazonía Peruana, Iquitos) to compile a species list for the Yavarí Mirín basin. In presenting these lists we also include results of a more complete inventory from the nearby site of San Pedro (Quebrada Blanco, just outside the Reserva Comunal Tamshiyacu-Tahuayo; Valqui 1999, 2001), because it represents a list of species likely to be found within the Yavarí and Yavarí Mirín basins.

Information on globally threatened species was taken from the 2002 IUCN Red List of Threatened Species website (www.redlist.org). Information on CITES appendices was taken from the CITES website, updated 13 February 2003 (www.cites.org).

RESULTS

Species observed

The censuses on the upper Yavarí and previous studies on the Yavarí Mirín show a very high diversity of nonvolant mammals (Appendix 6). We registered 39 species during the inventory on the upper Yavarí; 50 have been recorded along the Yavarí Mirín. All 39 species recorded on the upper Yavarí are also present on the Yavarí Mirín, and it is likely that the 11 additional species found on the Yavarí Mirín will be registered along the upper Yavarí river once a more complete inventory is possible.

All species encountered at both sites are present in Valqui's (1999, 2001) list from Quebrada Blanco and in Fleck and Harder's (2000) list from the Gálvez river. We believe that most species in Valqui's list are present in Yavarí and Yavarí Mirín, with at least two notable exceptions. Two primate species that have been observed in nearby sites do not seem to occur in the areas studied to date within the proposed Yavarí Reserved Zone. Goeldi's monkey (*Callimico goeldii*) has been observed

on the Gálvez river (Fleck and Harder 2000), and a second species of squirrel monkey (*Saimiri boliviensis*) has been observed on the Tahuayo River (Valqui 2001). Neither species has been observed in the upper Yavarí or Yavarí Mirín sites during the 2,300 km of censuses. Despite their absence, these sites still have very high species richness of primates (13 species).

Sloths (Bradypodidae) and Amazonian manatee (*Trichechus inunguis*) have not been recorded inside the proposed Reserved Zone, but both are reported by locals and probably occur at low densities. Sloths prefer regularly inundated forests along whitewater rivers, where mammal censuses have not been extensive. Both the Yavarí and Yavarí Mirín rivers have a mixture of black and white waters, and the two sloth species on Valqui's (2001) list are likely present in very low numbers along both rivers. Confirmation of manatees in the area would require extensive sampling along the lakes and smaller rivers, because the area has little aquatic vegetation (see "Flora and Vegetation") and does not seem to offer much obvious manatee habitat. If the species is present, it is likely to be spottily distributed and rare.

Rare and threatened species encountered

Many mammals found or expected in the region are considered globally rare or threatened. Twenty-four species included in the Red Data Book of the IUCN (2002) are potentially found in the area (Valqui 2001), and 15 of these species have been recorded in the upper Yavarí and Yavarí Mirín sites (Appendix 6). The major threats to these species at a global scale, mainly habitat degradation and hunting, are weak or absent in the Yavarí and Yavarí Mirín basins, and this makes the area extremely valuable for conservation.

The only primate species in the Yavarí valley listed by the IUCN is the red uakari monkey (*Cacajao calvus*), which is considered vulnerable due to severe hunting across its range (see Figure 1). This species is one of the flagship species for conservation in the Yavarí valley, with a healthy population but a peculiar disjunct distribution inside the proposed Reserved Zone (see Figure 8). There are large populations in the Lago Preto area close to the mouth of the Yavarí Mirín, but elsewhere in the area group size seems to be smaller and the species less abundant. Red uakari monkeys have also been observed along the middle Yavarí Mirín, on the northern side of the river, and at Quebrada Blanco, just outside the Reserva Comunal Tamshiyacu-Tahuayo. For some reason, the species is absent from all but one site on the southern side of the Yavarí Mirín river, an observation which has also been confirmed by the local people. During this inventory we encountered red uakari at Quebrada Curacinha, close to Colonia Angamos, but not at the other two sites of the upper Yavarí. The patchy distribution makes the species vulnerable to overhunting, although at the moment hunting pressure is low on the Yavarí Mirín (see "Use and Sustainability of Wildlife Hunting in and around the Proposed Yavarí Reserved Zone").

Although not listed as threatened, other large-bodied primates currently have very low densities in much of the Peruvian Amazon due to heavy hunting, and their low reproductive rates make them vulnerable to overharvesting (Bodmer et al. 1997a). The upper Yavarí and Yavarí Mirín river basins have healthy populations of black spider monkeys (*Ateles paniscus*) and woolly monkeys (*Lagothrix lagothricha*), whose populations have been severely depleted closer to Iquitos and other larger towns.

Despite the relatively short study period in the upper Yavarí sites, there were sightings of rare and threatened carnivores, such as the poorly known short-eared dog (*Atelocynus microtis*) and the near threatened jaguar (*Panthera onca*). Jaguar seem to be common in the region based on footprints and claw markings on trees (Wales 2002), and local people report that there are signs of population recovery following more intense hunting in the past. Jaguars are still occasionally hunted by local people, but along the upper Yavarí and the Yavarí Mirín rivers this may partly be compensated for by the abundance of prey, especially ungulates (*Mazama* spp., *Tayassu* spp.) and capybara (*Hydrochaeris hydrochaeris*), which are the main food resource for jaguars. The vulnerable bush dog (*Speothos venaticus*) has been observed in Yavarí Mirín, but its status in the region is not well known.

The endangered giant river otter (*Pteronura brasiliensis*) was observed three times during the inventory, first on the Quebrada Curacinha on the upper Yavarí, later at Lago Preto, and again close to the village of Carolina on the Yavarí Mirín. Isola and Benavides (2001) conducted an inventory of giant river otter on the Yavarí Mirín, where they found a healthy number of family groups and solitary individuals throughout the basin. Local people report that giant otters are increasing in numbers and are concerned about their adverse impact on fish populations; they occasionally kill them close to villages. The southern river otter (*Lutra longicaudis*) was also observed in the upper Yavarí sites, and seems to be common on the Yavarí Mirín.

The lowland tapir (*Tapirus terrestris*; Figure 7A) is considered globally vulnerable due to habitat loss through deforestation and hunting for meat. Tapir is one of the main game species in the area and vulnerable to overhunting due to its low reproductive rate (Bodmer et al. 1997a). It is likely not overhunted on the Yavarí Mirín (see "Use and Sustainability of Wildlife Hunting in and around the Proposed Yavarí Reserved Zone"), but was very rarely sighted in the upper Yavarí sites. However, tapir are difficult to observe during diurnal censuses, and based on the abundant tracks observed it seems to be quite common at all sites. Its population may best be monitored using track counts or other suitable methods. On the Yavarí Mirín, tapir populations are quite healthy, and they can often be observed visiting natural salt licks (O. Montenegro, pers. comm.).

Red and gray brocket deer (*Mazama americana* and *M. gouazoubira*) are both listed by the IUCN because there is deficient data on their populations. They are preferred game for hunters, but even so seem to have healthy populations in the region. In the upper Yavarí sites the sighting rate of brocket deer was high, as it was along sections of the Yavarí Mirín.

The giant armadillo (*Priodontes maximus*) is listed by the IUCN as endangered and the giant anteater (*Myrmecophaga tridactyla*) as vulnerable, both from habitat loss and hunting. Giant armadillo and giant anteater have been regularly sighted in the region, and there is a healthy population of giant armadillos in the Lago Preto region of the upper Yavarí (Drage 2003). These species are rarely hunted in the region, and their populations are probably at natural equilibrium levels. Emilia's short tailed opossum (*Monodelphis emiliae*) is considered globally vulnerable by the IUCN due to human-induced habitat loss. The team saw this marsupial being eaten by a pitviper (Figure 7D); its status in the proposed reserve merits further study.

The Amazonian manatee (*Trichechus inunguis*) may be present in the area, and is considered vulnerable. It was heavily hunted in the past, and is still killed occasionally. If still present in the area this species is very rare, and will require special attention. Both grey and pink river dolphins (*Sotalia fluviatilis* and *Inia geoffrensis*) are very common in both the Yavarí and the Yavarí Mirín and there are no current threats to their populations in the area.

Three species of endangered rodents are potentially found in the area. A spiny mouse, *Scolomys ucayalensis*, is considered endangered, and two echinomyid rodents near threatened or data deficient. The distribution of these species is poorly known, and their presence and status in the area require further study.

Density variation in large mammals

Census results for ten species of primates, five ungulates, and three rodents from the upper Yavarí, the lower Yavarí Mirín, and the upper Yavarí Mirín indicate high mammal density and rather low hunting pressure for the upper Yavarí (Table 1).

Primate densities on the upper Yavarí are within the range found in the Yavarí Mirín sites, except for the two larger species, woolly monkey and black spider monkey, whose densities are 1.3 and 2.6 times higher on the upper Yavarí than on the Yavarí Mirín, respectively. These large-bodied species are the most hunted primates in the region, and their populations are vulnerable to overexploitation due to their low reproductive rate. Spider monkeys were especially abundant in the second site on the upper Yavarí and in the middle part of the Yavarí Mirín (between Quebrada Panguana and Quebrada Miricillo), both of which have rather rich soils.

Table 1. Density, abundance and biomass comparisons for the most common large mammals along the Yavarí, lower Yavarí Mirín, and upper Yavarí Mirín rivers.

	Density (ind./km²)			Abundance (ind./100 km)		
	Yavarí	Lower Mirín	Upper Mirín	Yavarí	Lower Mirín	Upper Mirín
PRIMATES						
Ateles paniscus	4.06	n/a	1.58	28.39	1.24	7.24
Lagothrix lagothricha	32.68	27.61	24.50	181.78	114.26	28.31
Alouatta seniculus	n/a	0.77	0.76	1.77	3.83	3.94
Cebus apella	4.01	5.01	10.20	22.85	25.56	35.78
Cebus albifrons	2.63	2.23	5.58	19.47	13.40	28.43
Cacajao calvus	n/a	4.94	n/a	14.79	47.33	6.07
Pithecia monachus	7.18	4.41	10.51	23.86	23.76	33.12
Callicebus	11.84	5.08	11.72	23.85	12.72	23.55
Saimiri	18.63	33.07	45.90	54.23	199.05	192.96
Saguinus mystax/*S. fuscicollis*	30.49	22.63	28.52	97.60	70.15	80.10
Subtotal						
UNGULATES						
Tapirus terrestris	n/a	0.31	0.31	0.20	1.35	1.17
Tayassu pecari	n/a	15.19	14.59	0.02	151.90	72.94
Tayassu tajacu	9.10	2.13	8.54	16.59	10.70	15.76
Mazama americana	0.70	1.05	0.96	2.37	2.59	2.13
Mazama gouazoubira	0.43	n/a	n/a	2.17	0.24	0.51
Subtotal						
RODENTS						
Dasyprocta fuliginosa	1.71	1.24	2.91	5.12	4.60	5.95
Myoprocta spp.	0.90	0.79	3.95	1.97	1.35	3.94
Sciurus spp.	5.22	3.11	6.70	8.08	6.64	10.44
Subtotal						
TOTAL						

This suggests variation in productivity as another possible explanation for the differences in densities of the larger primates.

The only primates whose densities are somewhat lower on the upper Yavarí than in the Yavarí Mirín sites are squirrel monkeys (*Saimiri sciureus*) and black-fronted capuchins (*Cebus apella*). Both of these species prefer inundated riverside forests, and the low densities may be because sampling on the upper Yavarí was more focused on upland forests than sampling on the Yavarí Mirín.

Compared to areas closer to Iquitos, all the Yavarí and Yavarí Mirín regions have healthy populations of ungulates. The tapir sighting rate was lower on the upper Yavarí than in the Yavarí Mirín sites, but this may be due to chance variation. Diurnal censuses may not be the best method for estimating relative abundance of this species, which is mostly active at night. Tapir tracks were common on the upper Yavarí, especially at the second and third field sites, and outside the censuses the species was observed at all sites. White-lipped peccaries (*Tayassu pecari*) were also sighted rarely during the census walks on the upper Yavarí, which together with atypically small group size resulted in an extremely low sighting rate. By contrast, the species is common on the Yavarí Mirín. Collared peccaries (*Tayassu tajacu*) were equally common on the upper Yavarí and upper Yavarí Mirín, but less common on the lower Yavarí Mirín. Red and grey brocket deer

	Body weight (kg)	Biomass (kg/km²)			Metabolic biomass (BW 0.7/km²)		
		Yavarí	Lower Mirín	Upper Mirín	Yavarí	Lower Mirín	Upper Mirín
	11.0	44.6	n/a	17.4	22.3	n/a	8.7
	8.0	261.5	220.9	196.0	143.1	120.8	107.2
	7.8	n/a	n/a	5.9	n/a	n/a	3.3
	3.5	14.0	17.5	35.7	9.8	12.2	24.8
	3.0	7.9	6.7	16.7	5.7	4.9	12.2
	3.0	n/a	14.8	n/a	n/a	10.8	n/a
	2.0	14.4	8.8	21.0	11.7	7.2	17.2
	1.0	11.8	5.1	11.7	11.8	5.1	11.7
	0.8	14.9	26.5	36.7	15.9	28.2	39.2
	0.5	15.2	11.3	14.3	18.6	13.8	17.4
		384.3	**311.6**	**355.5**	**238.9**	**203.0**	**241.7**
	160.0	n/a	48.9	50.0	n/a	11.22	11.48
	33.0	n/a	501.3	481.5	n/a	181.86	174.66
	25.0	227.5	53.3	213.4	89.4	21.0	83.9
	33.0	23.0	34.6	31.6	8.3	12.5	11.5
	15.0	6.5	n/a	n/a	2.97	n/a	n/a
		256.9	**638.1**	**776.5**	**100.7**	**226.6**	**281.5**
	5.0	8.5	6.2	14.5	5.4	3.9	9.1
	1.0	0.9	0.8	3.9	0.9	0.8	3.9
	0.8	4.2	2.5	5.4	4.5	2.7	5.7
		13.6	**9.5**	**23.9**	**10.7**	**7.3**	**18.8**
		654.9	**959.2**	**1155.8**	**350.3**	**436.9**	**542.0**

(*Mazama americana* and *M. gouazoubira*) were especially abundant in the upper Yavarí sites.

Of the three rodent species compared, black agoutis (*Dasyprocta fuliginosa*) were about equally common in all three regions, whereas agouchies (*Myoprocta* sp.) and red squirrels (*Sciurus igniventris* and/or *S. spadiceus*) were most abundant on the upper Yavarí Mirín. These species are rarely hunted, and the variation in densities is probably due to habitat differences between the regions.

Biomass and metabolic biomass

The importance of large mammals in an ecosystem can be determined through analyses of crude biomass and metabolic biomass, and these were calculated for the most abundant herbivore species in the upper Yavarí and Yavarí Mirín sites (Table 1). All these species are highly frugivorous, although they include varying degrees of leaves, other plant material (such as flowers) and animal matter in their diets.

Crude biomass accounts for the variation in body size between the different species and measures how much energy the species or community makes available for the next trophic level, i.e., carnivores and humans. Metabolic biomass (calculated as body weight$^{0.71}$ x density) gives an indication of relative energy expenditure by each species and is a measure of how much of the primary production in the ecosystem is used by each species. Metabolic biomass corrects for the

effects of body size, because larger species need relatively less energy per kg body weight than the smaller species.

Overall, the upper Yavarí Mirín appears to have the greatest productivity of large mammals, followed by the lower Yavarí Mirín and lastly, the upper Yavarí. This suggests that the habitats of the upper Yavarí Mirín have a combination of attributes that make them particularly productive for large-bodied mammals.

Throughout the sites, primates account for almost 40% of the crude biomass and over 50% of the metabolic biomass in the community. However, two thirds of primate biomass is accounted for by a single species, the woolly monkey. The next most important primates in terms of biomass and energy consumption are spider and squirrel monkeys.

Large terrestrial frugivores, such as tapirs, peccaries and deer, rely on the fruits that are not consumed by arboreal species and fall to the forest floor. Their share of the crude biomass and metabolic biomass in the community is approximately 60% and 46%, respectively. Peccaries are by far the most important consumers of energy among terrestrial frugivores. In the Yavarí Mirín sites they make up about 85% of the terrestrial crude biomass and metabolic biomass, with the majority being white-lipped peccaries in the Yavarí Mirín sites. The crude and metabolic biomass of the white-lipped peccary is much lower in the upper Yavarí sites. Tapir and red brocket deer are about equal in terms of their crude and metabolic biomass. The three rodent species included in the analysis have only a small share (less than 3%) of the crude and metabolic biomass in the community.

DISCUSSION

Current status of wildlife populations in the Yavarí and Yavarí Mirín basins

The proposed Yavarí Reserved Zone may have the highest diversity of mammal species in the world. Although small mammals and bats have not been studied in detail (but see "Bats"), it is likely that the total number of mammals will reach approximately 150 species. The proposed Reserved Zone still maintains its original mammal species richness (i.e., it has not suffered any local extinctions), although several of the species are now globally endangered (see above).

Population densities of large-bodied mammals in the upper Yavarí and Yavarí Mirín river basins are relatively high in comparison to areas with higher human population and hunting pressure. This suggests that the human impact on wildlife and wildlife habitat in the area is currently marginal. Permanent hunting is restricted to areas close to the communities in the lower Yavarí Mirín area, and in other areas hunting is occasional and mainly occurs close to the major rivers. The total area of cultivated or young secondary vegetation within the region probably remains less than 0.5%. At the moment, the small resident population and the few outsiders entering the area to fish and hunt are apparently not causing major threats to wildlife populations.

The situation may change drastically if the local population grows or timber operations commence in the area. It has been shown repeatedly that timber operations are accompanied by heavy wildlife hunting (Bodmer et al. 1988). Timber companies rely on hunting for subsistence and financial income, and employees of timber companies are encouraged to hunt in order to offset the debts incurred by the companies until they are able to sell their lumber. Indeed, in areas of timber extraction the majority of hunting is done by lumbermen. Since financial gain is an important driving force for timber companies, lumbermen often hunt the large primates for subsistence and sell the tapir, deer and peccary meat to city markets. Timber operations are often also involved in the illegal sale of jaguar and giant otter pelts. Thus, the impact of hunting from timber operations is often drastic and causes rapid declines in the populations of large mammals most vulnerable to overhunting, like primates and tapirs. Even limited logging could cause hunting pressure to increase to unsustainable levels within a short period of time.

For most species, the regional variation in density is probably influenced more by habitat quality than by hunting pressure. Habitat quality may vary according to soil fertility, site productivity and tree species

composition. Understanding this variation in wildlife-habitat interactions is vital not only for the animals, but also for ecosystem functioning, because healthy populations of seed dispersers and predators are important for sustaining the natural dynamics and diversity of forest vegetation. The metabolic biomass analysis indicates the special importance of large primates and peccaries in the maintenance of these intact forests.

Importance of the area for wildlife conservation

The Yavarí and Yavarí Mirín basins offer an opportunity to protect a basically intact primary rainforest landscape with healthy, highly diverse mammal communities. The landscape itself is a diverse mosaic varying from nutrient-poor sandy soils to relatively nutrient-rich clay soils in the upland forests (Figure 3A), and several types of inundated forests along the rivers and streams. Maintaining the landscape's integrity would ensure the existence of all the habitats and species necessary for the survival of the mammal populations, because the area is large enough to maintain viable populations of most species even if surrounding areas are altered in the future. The only existing conservation unit protecting the extremely high mammal diversity in the region is the Tamshiyacu-Tahuayo Community Reserve, whose strictly protected zone does not offer a sufficiently extensive area for large mammal populations.

Many globally threatened species live in the proposed Yavarí Reserved Zone. The Yavarí and Yavarí Mirín region is one of the few areas in the Peruvian Amazon where the threats facing these species worldwide—habitat loss and hunting—are at a minimum. Few opportunities exist for their conservation in areas with a higher human impact closer to the Ucayali river. Especially for red uakari monkey, jaguar, giant river otter and other carnivores, this area would offer the large, intact, and continuous landscape necessary for long-term viability. For example, the red uakari monkey occurs patchily and at low densities (see Figures 1 and 8). For the long-term survival of the species, it will not be sufficient to protect the patches where the species is found, since subpopulations would then be isolated from one another.

One especially important area for conservation is the middle part of Yavarí Mirín on the northern side of the river (Figure 8). There are especially high densities of large mammals, e.g., spider monkeys and deer, here, perhaps owing to fertile soils and high productivity (K. Salovaara, unpublished data). This is also a key area for giant river otter (Isola and Benavides 2001) and red uakari monkey, and offers connectivity between red uakari populations west and east of the Yavarí Mirín river. If the narrow corridor between the Yavarí Mirín, Orosa and Tamshiyacu rivers became uninhabitable for red uakaris, it would split the known distribution of the species into two separate subpopulations. Thus, this area is important for the population connectivity and long-term survival of the red uakari not just regionally, but globally.

RECOMMENDATIONS

We recommend conserving the whole Yavarí Mirín basin, including the Esperanza River, to secure the long-term survival of the area's mammal species and communities. Although the area is largely intact today, it faces many potential threats that could best be controlled within a conservation unit. Protecting the entire proposed area is important because several species have restricted distributions within the region, and would only persist within a large continuous tract of forest.

The status of many large mammals is already well known in the area, but there is also a need for further inventories and ecological studies. For example, several threatened large mammals have been observed in the area but their population sizes are not known. These species include carnivores, giant anteater, and sloths. Also, small mammals and bats are still practically unstudied (see "Bats"), and many larger species are still not recorded although likely present. Many endangered species still require confirmation, such as manatee, two-toed sloth and several marsupials and small rodents.

For management and conservation of large mammals it is vital to continue collaboration with local communities in the Yavarí Mirín basin and to monitor their wildlife use. Wildlife use is currently monitored in

collaboration with the local communities, but additional monitoring of population trends would be beneficial for red uakari monkey, giant river otter, jaguars and lowland tapir. Local people should have an active role in conservation and management programs. This would include, among other things, monitoring hunters who enter the region from outside, mainly by boats from the lower Yavarí, but also by land, crossing from the Tamshiyacu river to the upper Yavarí Mirín.

Extension and education work in the communities must be continued to support other conservation efforts. For example, giant otters are not currently hunted for pelts or meat, but local people dislike them and occasionally kill them in the areas close to the villages. To prevent conflicts in the future it would be beneficial to undertake more environmental education programs in the local communities.

At the moment local inhabitants have a positive attitude towards conservation, and expect it to bring benefits to their remote communities, where even basic education and health services are lacking. Their participation in conservation and management programs is essential. If the communities grow or change their resource use patterns in the future, it will be necessary to manage and redirect their resource extraction. This will be easier if the inhabitants recognize the importance of their environment for their well-being as well as for conservation objectives in a larger context.

BATS

Author: Mario Escobedo

Conservation targets: IUCN redlisted species, including *Tonatia carrekeri* (Vulnerable), *Artibeus obscurus* and *Sturnira magna* (both Near Threatened); seed dispersers of ecologically and economically important plants, like *Carollia perspicillata* (disperser of *Piper* and *Cecropia* spp.), *Artibeus jamaicensis* (disperser of *Ficus insipida*) and *S. magna* (disperser of *Cecropia* spp., *Ficus* spp., and *Psidium guajaba* [Loja 1997])

INTRODUCTION

One hundred and fifty-two bat species are known to occur in Peru (Hutson et al. 2001). The conservation status and distributions of the great majority of these are poorly known, and there are still large areas of the country where the bat fauna has never been studied. Such is the case for the sites we visited during the rapid biological inventory on the Yavarí River, and for the entire proposed Zona Reservada del Yavarí.

Nevertheless, intensive bat inventories have been carried out in at least three nearby sites. Fleck et al. (2002) reported 57 species in the Matsés community of Nuevo San Juan on the Gálvez River, to the southwest of the proposed Reserved Zone. Gorchov et al. (1995) reported the same number of species, in seven families, from Jenaro Herrera. Cevallos (1968) reported 15 species for the Orosa River (at Quebrada Esperanza), but his list is problematic as it includes some species with mostly Andean distributions, like *Vampyressa thyone* and *Micronycteris brosseti*. On the other side of the Ucayali and Amazon rivers, 39 bat species have been registered to date in the Reserva Nacional Pacaya-Samiria and 49 species in the Zona Reservada Allpahuayo-Mishana (Escobedo 2002).

METHODS

For ten days during the rapid biological inventory I captured bats with two 12-m mist nets. I set up the nets in a single line or in the form of a "T" inside the forest between 5 and 9 PM, and checked for bats every ten minutes during peak hours (from 6 to 8 PM) and otherwise every 15 minutes.

Before setting up the nets, I recorded the forest type, dominant vegetation, and other landscape characters of the collecting locale. Most of the sites were in upland (terra firme) forest, but a few were in forest that is periodically flooded by streams. Nearly all the sites were within 500 m of the Yavarí River. I set up the nets in potential flightpaths for bats, like natural clearings, streams, and along the trails. To capture high-flying bats, I used poles to raise the mist nets to a height of 10–12 m near flowering or fruiting trees, which included *Cecropia* spp. and *Ficus insipida*. Because our time in the field was limited, I did not sample several important habitats, including palm swamps, lakes, and hilltops in upland forest.

For all captured individuals, I recorded total length, forearm length, color, presence or absence of a tail, etc. I identified *in situ* frequently captured and easily-recognized species. Bats that could not be identified in the field were taken in cloth sacks back to camp, where I identified them with the keys in Pacheco and Solari (1997). Once the measurements and identifications were complete, all captured specimens were marked with white paint and released.

RESULTS

I registered 51 individual bats belonging to three families, three subfamilies, and 20 species (see Appendix 7). Apart from captured species, the list includes a few species that were observed in the field but not captured. For example, I observed the insectivorous bats *Rhynchonycterix naso* and *Saccopterix biliniata* sleeping in their roosts in branches of a *Cecropia* tree hanging over the river, and a species in the genus *Noctilio* flying over the Yavarí River in the early afternoon at the Quebrada Buenavista camp.

This preliminary list contains a mix of habitat generalists and specialists. Among the generalists are *Phyllostomus elongatus*, *Carollia perspicillata* (Figure 7B), and *Artibeus jamaicensis*. Among the specialists are *Trachops cirrhosus*, a frog-eating bat that prefers habitats close to lakes, streams, and rivers. *Artibeus hartii* and *Vampyressa brocki* are typically high-flying species, captured 10 m above the ground near a fruiting fig tree (*Ficus insipida*).

THREATS AND RECOMMENDATIONS

The three main threats facing Amazonian bats are intensive agriculture, the eutrophication of lakes and rivers, and erosion along riverbanks. Given the lack of human activity in the Yavarí area, none of these were observed in the sites we visited during the rapid biological inventory. The most serious threat in the near future is probably the opening of forestry concessions, because logging will have an immediate impact on many tree species important to the diet of bats.

More intensive studies are needed to understand bat communities in the Yavarí watershed and the proposed Zona Reservada, especially long-term studies that can reveal the true value of the ecological services carried out by bats, like seed dispersal and insect control.

HUMAN COMMUNITIES

Participants/Authors: Hilary del Campo, Zina Valverde, Arsenio Calle, and Alaka Wali

Conservation Targets: Traditional fishing techniques; rotation of hunting grounds; reforestation of agricultural plots with fruit trees

INTRODUCTION

The proposed Yavarí Reserved Zone is located in a remote, almost entirely unpopulated area near the Peru-Brazil border. The *ribereño* community of Nueva Esperanza, located just outside the proposed reserve's northeast border and home to 179 people, is the closest human settlement. According to residents of Nueva Esperanza and researchers who know the area, there is also a tiny, five-person outpost called Pavaico (or sometimes San Francisco de las Mercedes) inside the proposed reserve on the Yavarí Mirín River. The region's tiny population is a relatively recent phenomenon (see "A Brief History of the Yavarí Valley"); previous settlers left because of poor access to markets and healthcare and the high incidence of chloroquine-resistant malaria.

The outskirts of the proposed reserve have a similarly low human population. We estimate that 1,000–2,000 people live within 20 km of the limits of the proposed Reserved Zone. This population is concentrated in approximately ten settlements, as well as military bases and scattered homesteads. The population is heterogeneous, consisting of Matsés (Mayoruna) indigenous people, *ribereño* settlers, and more recent colonists. We were unable to confirm rumors of uncontacted Matsés in or near the proposed reserve, but these should be investigated more completely to guarantee appropriate zoning in a new protected area.

In order to outline the economic, social, and political features of these communities, we carried out a rapid inventory that focused on their social assets, skills,

and natural resource use. We gathered data on history, demography, economy, social organization and institutions, and natural resource use. Based on these data, we identified and analyzed communities' strengths, local attitudes towards the environment and place, threats to local livelihood patterns, local activities compatible with conservation efforts, and conservation targets.

METHODS

Our social research in the Yavarí region took place over three weeks, in 11 communities. Subsequently, we made a two-day visit to communities west of the proposed reserve along the Tahuayo and Blanco rivers. The methods we used included systematic observation and participation in community activities, interviews with community members, local authorities, leaders and other key individuals, as well as focus groups, community assemblies, and visits to agricultural plots. We also used bird and mammal guides to document local knowledge on the area's fauna, as well as questionnaires to collect data on hunting, fishing, and resource use.

RESULTS

Yavarí sector: eight communities, ~1,210 residents

Between March 21 and 31, we conducted intensive research in the town of Angamos (Figure 9A) and five Matsés communities: Fray Pedro, Las Malvinas, San José de Añushi, Paujil and Jorge Chávez. We also visited and/or conducted interviews at the Palmeiras military base, which has a civilian population, and the Manihuari Pinches family settlement, both of these on the Brazilian side of the Yavarí River. During our time on the Yavarí River, we interviewed passing fishermen and hunters when possible to gain a better understanding of resource use on both sides of the river.

Angamos

The largest settlement in the district of Yaquirana, Angamos is a town and military base with just under 1,000 inhabitants. Two thirds of the population are military personnel and their families. Other residents of Angamos appear to have arrived within the last ten years to work in timber extraction. The town is fairly well established and is physically divided between the military base and the civilian population.

Angamos exhibits the typical settlement pattern of small Peruvian towns, with houses lined along paved walkways and a central plaza. Households are formed by nuclear families. In addition to kinship ties, the town's social organization is structured around civil and social institutions. Three female political authorities are key leaders in Angamos: the justice of the peace, the mayor, and the governor. These individuals form the political base and help maintain socioeconomic links with Iquitos and the district municipality. In addition, the municipal government of Angamos, three evangelical churches, the military base, a health center, the *Subregión* of Yaquirana, and primary, secondary and occupational schools play integral roles in the community structure. Angamos also has associations such as the *Comité de Agricultores de Angamos* (Committee of Farmers of Angamos), the *Frente Patriótico de Yaquirana* (Patriotic Front of Yaquirana), soccer and volleyball teams, and government programs such as the *Club de Madres* (Mothers' Club) and *Vaso de Leche* (Glass of Milk), both of which are national programs that promote family health.

Currently, Angamos is an important commercial center for surrounding communities, and has strong economic and social links to Iquitos. Residents told us that between 1990 and 1996, logging of hardwoods like tropical cedar (*Cedrela* spp.) and mahogany (*Swietenia macrophylla*) dominated the region. This attracted people from outside the region and resulted in an increased population and improved infrastructure. Because a logging ban was implemented by INRENA in 1996, the town now depends on government institutions like the military base, the municipal and subregional governments, and INRENA for employment. Other sources of work include hunting, fishing, small-scale agriculture, and small commercial enterprises such as restaurants and stores.

Much of the town's economy depends on commercial flights between Angamos and Iquitos, which

transport animal skins, meat and ornamental fish to markets in Iquitos approximately eight times per month. A cargo ship brings commercial products from Iquitos roughly once a month, but its arrival is unpredictable and often delayed. Due to the town's remoteness, the prices of basic goods in town are highly inflated (250% during our visit). Nevertheless, all of the residents we spoke with expected the economic situation to improve in the near future, and the majority of them have decided to remain in the town despite current economic hardships.

Matsés communities

The Matsés indigenous peoples, known as the Mayoruna in prior studies, are the original inhabitants of the region. According to Romanoff (1984), the Matsés had sporadic contact with rubber tappers between 1920 and 1930, and before that it is probable that their population was decimated and forced to live in *reducciones* (towns established by Spanish missionaries who arrived with the conquistadors). According to current residents, between 1980 and 1990 many Matsés moved from the community of Buenas Lomas along the Chobayacu River to the Gálvez River in search of improved health care and access to the market in Angamos. The legal titling of the Matsés Native Community, an area of 452,735 ha, occurred in 1993 with the support from the Centro de Desarrollo del Indígena Amazónica (CEDIA, the Center for the Development of the Indigenous Amazonian). At present, the Matsés communities are proposing the creation of a Matsés Communal Reserve adjacent to their titled territory, also with the support of CEDIA.

Today, the Matsés represent 70% of the population of the district of Yaquirana in the department of Loreto. The titled Matsés territory contains more than 2,100 people in 12 communities, as well as two that are in process of becoming established. We visited five communities within 20 km of the limits of the proposed Reserve Zone. Three of these are located within the titled Matsés territory along the banks of the Gálvez River: Paujil (with ~45 people), San José de Añushi (~55), and Jorge Chávez (~40). The two untitled communities we visited are Fray Pedro (~40) and Las Malvinas (~50), both close to Angamos. All these communities have medical centers, schools, and sidewalks and several have community meeting houses constructed by the regional government.

Life in the Matsés communities is primarily based on small-scale subsistence agriculture, and each family cultivates a small farm plot on a slash-and-burn cycle. People depend on selling game meat in Angamos to buy basic products like kerosene, soap, and salt, and this is done approximately once a week, depending on the distance of the community to Angamos. Economic activities are managed at the household level, not by the community.

All of the Matsés communities we visited are concentrated settlements with extended families living in each household. Community and household structure are dominated by kinship rules, which have been thoroughly addressed in prior research (Fields and Merrifield 1980, Romanoff 1976). The Matsés are organized patrilineally, and many men have more than one wife. Newly married couples live with the bride's or groom's family. Each Matsés community has a leader, and an elected president has jurisdiction over all the titled Matsés land. The communities maintain strong links with each other, also based on kinship.

The Matsés who live near Angamos have strong social ties with the town and visit it for healthcare. For both the Matsés and the residents of Angamos, religion is an important aspect of social life and services are conducted three times a week. Since the time of contact between missionaries from the Summer Institute of Linguistics and the Matsés in 1969 (Vivar 1975), for example, evangelical services are regarded as important community events. In addition, soccer teams and government programs such as *Vaso de Leche* ("Glass of Milk") are important to community members.

Yavarí Mirín sector: three communities, ~214 residents

Between April 8 and 13, the social team visited three *ribereño* communities on the Yavarí Mirín River: Nueva Esperanza, San Felipe and Carolina. All three communities are legally recognized by the government, although they do not hold title to their land (*personería jurídica*). Nueva Esperana is the largest of the three,

with 179 residents and approximately 7,500 ha (75 km^2) of land, which includes the outskirts occupied by residents' farm plots (Figure 2). San Felipe is home to 18 people and Carolina 17, not including seven policemen who staff a post on the banks of the river.

The area surrounding the Yavarí Mirín River is part of the Matsés ancestral territory, but the current inhabitants are descendents of the Yagua and Cocama peoples. The majority of these communities were established by people who left settlements farther up the Yavarí Mirín River in the 1970s because of their isolation and high incidence of malaria. Today, economic and political isolation, as well as a high mortality rate, continue to be salient concerns for the communities. In Nueva Esperanza, 347 cases of malaria were registered in the 179 inhabitants between 2001 and 2002. Resistance to choloroquine treatment appears to be a problem in the region, and during our stay there were several advanced malaria cases. Malaria incidence is highest during the rainy season (December–April).

The people of the Yavarí Mirín sector practice a subsistence-based lifestyle of hunting, fishing, and small-scale agriculture. Nueva Esperanza's principle subsistence activity is hunting. The local economy is driven by three villagers who purchase the meat and skins of peccaries to sell them in the trinational markets of Peru, Brazil and Colombia, located three days' continuous travel down the Yavarí River in a *peque-peque* (16 hp outboard motor) canoe. Other skins are sold to a man who has a partnership with a buyer in Angamos. Hunting small animals and primates for consumption is generally regarded as wasteful because it does not compensate the cost of shotgun shells. Fishing is generally practiced with hooks, bow and arrow, and spears, though large nets are used to catch larger species of fish, such as *zúngaro* (*Pseudoplatystoma tigrinum*), *doncella* (*Pseudoplatystoma fasciatum*), *paiche* (*Arapaima gigas*) and *gamitana* (*Colossoma macropomum*). These large fish are also sold in the trinational markets. All residents have the right to hunt and fish in the forests, rivers and lakes in the region, but individual fishing and hunting zones are established by informal agreements.

Unlike hunting and fishing, agricultural plots are cultivated primarily for household consumption. We were told that one individual was extracting commercial timber, but community members generally extract wood for the sole purpose of building houses. INRENA is investigating reports of illegal wood extraction along the Pavaico, a tributary of the upper Yavarí Mirín, but we have few details of these reports.

The key economic problem for these communities is the enormous distance they must travel to reach markets, where they may not even sell all of their products. Since their lifestyle is primarily based on subsistence, barter is a standard form of exchange in the communities. For example, pet monkeys, peccaries, achunis, turtles, and wild birds such as parrots, pinshas, trompeteros and other species are commonly traded with other community members or with the occasional visitor in exchange for goods.

All of the communities are nuclear settlements with extended families in the household. Communities interact during sporting events (soccer and volleyball), community anniversaries, and birthdays. Furthermore, communities are bound by commerce and education. For example, the children of San Felipe study in Nueva Esperanza until the end of the school year, at which time they return to their communities.

Carolina and Nueva Esperanza are politically independent. San Felipe's proximity to Nueva Esperanza precludes the need for community authorities. Carolina has a *teniente gobernador* (local government representative) and an *agente municipal* (municipal representative). Because public schools do not operate in this area, some parents are inclined to send their children to study in Pelotão, Brazil. Nueva Esperanza has a government representative, a community president, and a municipal representative, a president of the Asociación del Padre de la Familia (Association of Fathers of Families), a president of the Club de Madres (Mothers' Club), and a president of the local soccer team. Nueva Esperanza also has a medical center, pre-elementary and elementary schools, a radiophone, a church, a government office, a community meeting house and an agrarian office branch.

ASSETS, THREATS AND CONSERVATION TARGETS

Assets

Based on our work in the field, we identified several primary assets in the three sectors: a strong social organization, local practices aligned with conservation efforts, and the desire to improve quality of life in the long-term. Each of these is developed in further detail below.

- **Social organization: The communities maintain a strong community identity and take pride in maintaining their cultural values and practices.**

  In the three sectors we visited, residents are choosing to remain in the region to maintain their traditions, customs and kinship networks despite the problems associated with life in an isolated region, including a dearth of commercial activity, weak political representation, and in some cases lack of adequate healthcare and educational services. Through people's links with government institutions and their own informal organizations and social networks, the communities possess capable, effective leadership which maintains strong community organization.

  In the Matsés communities and the communities on the Yavarí Mirín, inhabitants possess a great deal of knowledge about their natural surroundings. Furthermore, the Matsés take pride in their history and identity. This pride is manifested in their knowledge of natural resources, which surfaces in the Matsés language. Finally, both young and old utilize Matsés as their first language, and it appears that living closer to Angamos does not lead to a preference for Spanish or a loss of the Matsés language.

- **Subsistence practices that are compatible with the conservation of the ecosystem**

  Since the majority of the communities practice a subsistence-based lifestyle, the people depend upon the health of the surrounding ecosystem. Their practices and traditions are completely interconnected with local knowledge systems pertaining to natural resources. For example, people maintain the practice of fishing with bow and arrow, spears, and hooks. These customs have their roots in cultural values and have a low impact on aquatic life.

  Recent studies have suggested a strong link between the maintenance of native languages and the conservation of biodiversity. Knowledge of the ecosystem is preserved in indigenous languages, both in the names of species as well as in myths, legends and taboos. This knowledge includes an intimate familiarity with the diversity of flora and fauna, animal behavior, and the ways in which seasonal variations affect the ecosystem. For these reasons, the maintenance of indigenous languages is an extremely important asset for conservation.

- **Local practices in favor of conservation: Throughout the area people are taking steps to protect the regional flora and fauna.**

  Residents of the communities we visited recognize that their actions and those of others can lead to the overexploitation of the region's natural resources, and they are already taking steps to monitor and diversify areas at risk. We identified two specific measures that are conservation targets: the rotation of hunting areas, which allows animal populations to recover after hunting, and the reforestation of agricultural plots with fruit trees.

  In the Matsés communities we visited, residents are concerned about the decline in the populations of important game animals. As a result, hunters enforce restrictions in certain areas, leaving the area undisturbed for eight months. This local management plan is implemented by majority vote when community members perceive a decline in local fauna. In Angamos, residents voted to protect a nearby lake due to its abundance of ornamental fish. Nueva Esperanza has taken similar measures to protect local wildlife populations by establishing a local "reserved zone" near the Esperanza stream, where wildlife populations are especially robust. In addition, hunters informed us that they consider the forests that border their agricultural plots as "buffer zones" where hunting is restricted so that animals have space to reproduce.

People prefer to hunt animals that are attracted to the fruit and crops inside their agricultural plots.

In the communities along the Yavarí and Yavarí Mirín rivers, community members cultivate fruit trees, such as papaya (*Carica papaya*), guayaba (*Psidium guajava*), caimito (*Pouteria* spp.) and pijuayo (*Bactris gasipaes*), among others, alongside a diverse array of other crops including corn (*Zea mays*), manioc (*Manihot esculenta*) and banana (*Musa* spp.). This strategy helps reforest agricultural land after the soil no longer supports other crops.

In the Yavarí Mirín sector, local communities are participating in wildlife management research with the Wildlife Conservation Society (WCS) and the Durrell Institute of Ecology and Conservation at the University of Kent, England. These studies provide an opportunity for local people to evaluate and reflect upon their resource use, and serve as a base for future participatory management and conservation partnerships.

- **Interest in improving quality of life: Local residents are eager to work with outside organizations to manage and conserve their natural resources, with the long-term objective of improving their quality of life.**

Because of their long-term presence in the region and desire to uphold their communities, local residents are natural allies of conservation efforts. They are eager to protect their natural surroundings and maintain their customs over the long-term. Given their concern over the long-term sustainability of these forests, we found the communities eager to work with and receive support from conservation organizations. In the Yavarí and Yavarí Mirín sectors, 88% of residents interviewed stated they would be interested in working together with and creating sustainable management plans with outside groups like conservation organizations.

One opportunity for collaborative conservation work is with the Matsés people, who are very concerned about excessive hunting in their territory. They attribute this to two factors: the low value of agricultural products, such as bananas, manioc, corn and rice, which has forced them to sell more game meat; and a growing demand for game meat in Angamos since the increase in the town's population during the 1990s. Their desire to manage their resources in a sustainable manner represents an opportunity for conservation collaboration and the development of local management plans.

Threats

In community meetings and interviews, regional authorities and local residents listed the following threats to local lifestyle practices:

01 **Medium- and large-scale logging**, which may soon return to the region (see "Threats" in "Overview"). Logging interferes with people's subsistence activities because it restricts their hunting zones, among other impacts. One of the immediate goals of the people of Nueva Esperanza, for example, is to acquire legal title to their land as well as a government-authorized protected area for the region, because they fear that INRENA and the regional government could grant logging concessions in the near future.

02 The **immigration** to the region of outsiders and the arrival with them of agricultural practices that are incompatible with local natural resources. For example, the members of a religious sect, colloquially referred to as the "Israelitas", have settled on the lower Yavarí River, and appear to be expanding their colonist territories.

03 The **irregular provision of basic services** (such as medicines for the health center and education, since schoolteachers sometimes do not arrive when the school year begins) impacts the communities on the Yavarí Mirín and endangers people's ability to organize in defense of their lands and lifestyle. Furthermore, the high incidence of malaria in these communities could cause future migration inside the region, spreading the impact of human settlements on the surrounding forest.

04 In the area surrounding Angamos, **over-hunting** is a problem that may be caused by the depressed value of agricultural products like banana, manioc, corn

and rice, forcing community members to hunt and sell more game meat (see above). Over-hunting could also reflect an increased demand for game meat in Angamos, associated with the increase in population during the 1990s.

To conclude, we found that local residents are actively involved in the management of natural resources and have designed strategies to maintain their lifestyle and quality of life in ways that minimize the degradation of natural resources. Communities maintain contact with government authorities through internal political institutions, and carry out community work and other activities in a collective manner that reinforces community identity. Interviews and community meetings revealed that a prime threat to subsistence practices is the reemergence of medium- and large-scale extractive activities, especially logging and high-impact agriculture practiced by new settlers.

ADDENDUM: VISIT TO THE TAHUAYO REGION

After completing the social assessment in the Yavarí region, two members of the social group (Hilary del Campo and Alaka Wali), visited two communities on the Tahuayo River, within the buffer zone of the Reserva Comunal Tamshiyacu-Tahuayo (RCTT) and the buffer zone of the proposed Reserved Zone. The objective of the two day (April 13–14) visit was to observe the efforts of the Rainforest Conservation Fund (RCF) to both organize the communities to manage their resources and to provide technical assistance in agroforestry projects. Accompanied by David Meyer (president) and Gerardo Bértiz (extension agent) of the RCF and Pablo Puertas of the Wildlife Conservation Society (WCS), we held community meetings, visited and spoke with school children and their teachers, and conversed informally with people in Chino (on the Tahuayo River) and San Pedro (on the Quebrada Blanco). In Chino, we also visited the nearby fields of two community residents to observe the agroforestry project. We also visited a tourist installation, the A&E lodge, located within the bounds of the community of Chino and interviewed the agent.

These two communities and potentially the others in the region involved with the protection of the RCTT represent an important asset to the proposed Reserved Zone for several reasons. First, these communities will be adjacent to the proposed area and a significant part of its buffer zone. Second, these communities have already demonstrated the capacity to organize to protect habitats and wildlife through their successful efforts to create the RCTT, their ongoing vigilance of the RCTT and their participation in the agroforestry projects supported by RCF. Third, these communities have considerable experience participating in the research projects on resource use that are being conducted by scientists associated with the University of Florida, Gainesville, the Wildlife Conservation Society, and the Durrell Institute for Conservation Ecology at the University of Kent. All of these experiences as well as their approach to resource management and protection of the RCTT can provide valuable models for the communities in the Yavarí region.

In addition to these communities, the work of the scientists mentioned above as well as the work of RCF can also be considered assets. The scientific research, conducted in a participatory manner, provides insights into patterns of natural resource use and levels of sustainability. The RCF-supported projects are providing communities with options for sustainable sources of livelihood that may ultimately reduce their dependence on wildlife harvesting.

In the community meetings, we discussed with residents and leaders their perceptions of the current status of their efforts to protect the RCTT and their own habitats. A major concern they expressed was their difficulty in maintaining vigilance and protection on their own. They stated that they felt that the regional authorities were not providing sufficient support and they would like to seek support on a national level. They would like reinforcement for their efforts to control excessive fishing and hunting in the zone. In this, they received support from the administration of the tourist lodge, which also expressed a great interest in having renewed vigilance and protection efforts.

History and Previous Work in the Region

A BRIEF HISTORY OF THE YAVARÍ VALLEY

Authors: Richard Bodmer and Pablo Puertas

The Yavarí River flows through western Amazonia, forming the border between Brazil and Peru. Although sparsely inhabited and rarely visited today, the Yavarí River valley has a long and colorful history, with written accounts of its indigenous inhabitants and natural resources dating back more than 300 years. As on many Amazonian rivers, recorded history along the Yavarí involves conflicts with indigenous people, disease, and a century of natural resource extraction. In the following pages we describe some key points in the history of this fascinating river.

The Yavarí was first described during the expedition of Don Pedro de Texeira, documented by Padre Christopher D'Acuna (1698), in the mid-seventeenth century. Texeira's chief interests were finding El Dorado, "The Lake of Gold," and the "Amazons," a warlike tribe of women that reportedly used men only for their reproductive functions. Fortunately, Padre D'Acuna was a keen naturalist and described the manners of the people and their use of forest products and agriculture in amazing detail. Writing about the Yavarí, he noted the vast natural resources and the abundance of wildlife.

During the 1800s, the Yavarí was described by two major scientific expeditions: a French team led by F. Castelnau (1850–51) and an Austrian team led by Spix and Martius (1823–31). As with D'Acuna, these 19th century explorers noted both the variety of animals and plants of the Yavarí valley and the indigenous tribes there, dominated by the Mayorunas, also known as the Matís (Matsés). F. Castelnau was the first scientist to describe in detail the red uakari monkey (see Figure 1), and reported on the geographic division between the red and white forms. Spix and Martius described in some detail the Mayoruna nation, and its vast expanse through the Yavarí valley. They noted the ferocity of this tribe and reported that Portuguese could not enter the Yavarí River for fear of attacks. The Austrian explorers described how the Mayoruna would hide in the forest as Portuguese canoes ascended the currents, and then attack them with arrows, spears and clubs.

The Mayoruna were one of the major indigenous nations of Loreto. In the map published by A. Raimondi (ca. 1888) one can see that they inhabited the entire Yavarí valley, covering most of northeastern Loreto, from Pebas to Contamana to

Tabatinga. Other groups, including the Ticunas, Chirabos and Marubos, also inhabited the region at the end of the 19th century. The Mayoruna were known for their skills as hunters, not as farmers or fishermen. This is undoubtedly related to the abundant production of large mammals in the Yavarí valley relative to other Amazonian sites (see "Diversity and Abundance of Mammals"). Indeed, the abundance of game mammals in the Yavarí valley still makes it one of the most important areas for wild meat hunting in Loreto (see "Use and Sustainability of Wildlife Hunting in and around the Proposed Yavarí Reserved Zone").

The Yavarí River has played an important part in diplomatic relations between Peru and Brazil (Maúrtua 1907). In 1777, the two colonies signed the treaty of San Ildefonso to settle the border between the Spanish and Portuguese crowns, including the division between Leticia and Tabatinga and the Yavarí River (Public document 1777). But the fear of Brazilian expansion continued, despite the Ildefonso agreement. Francisco Requena, responsible for the frontier region of Loreto during the end of the colonial period, was so concerned about Brazilian expansion across the Yavarí valley and into the Ucayali basin that he established the town of Requena along the Ucayali River as a means of protecting Peruvian territory (Martín Rubio 1991).

In 1866, the Republic of Peru and the Emperor of Brazil agreed on a joint expedition to the unknown regions of the upper Yavarí, both for the enhancement of scientific knowledge and to determine the true limits between the two nations (Raimondi 1874–79). The joint expedition was led by the secretaries of state for both countries, Dr. Manuel Rouaud y Paz-Soldán from Peru, and Dr. João Soares Pinto from Brazil. The expedition ascended the Yavarí in the steamship *Napo* after leaving Tabatinga on the 5th of August 1866. On the 23rd day of the expedition they passed the Curuzao River and five days later passed the mouth of the Yavarí Mirín; from this confluence the river was referred to as the Yaquirana. On the 8th of September, the joint commission reached another division in the river, and as instructed, they followed the larger tributary to determine the international border. The smaller tributary was named Río Gálvez by Paz-Soldán, in memory of the famous Peruvian officer who lost his life in the war with Chile.

As the river narrowed Paz-Soldán and Pinto eventually had to leave the larger steamship and continue their explorations in canoes. As they ascended the headwaters of the Yaquirana, they frequently noticed signs of indigenous people, whom they called Matapis. On the 10th of October, the commission was attacked by indigenous warriors who hid in the forest and shot arrows at the canoes. The commission retreated to a beach to aid the wounded and rapidly returned downstream. On one of the numerous bends of the river the expedition was attacked again, this time by over 100 indigenous men and women, naked and painted, who rained down arrows on the defenseless expedition. Pinto was killed by three arrows to his chest, and Paz-Soldán escaped in a small canoe, leaving behind the log books, scientific equipment, and food. Four days later, the survivors arrived at the steamship and promptly returned to Tabatinga. Paz-Soldán lost one of his legs from an injury sustained during the attack.

It was not the brilliant gold of El Dorado that brought riches to the Yavarí, as Texeira had hoped, but the "black gold" of smoked rubber (Figure 2D). During the end of the 19th and the start of the 20th century the rubber boom engulfed the region. People from Europe, North America, and the Peruvian Andes immigrated to the Amazon in search of rubber. The Yavarí valley, rich in natural rubber, was a prime target for the newly arrived rubber tappers. The importance of the Yavarí as a source of this newly found treasure resulted in its declaration as a province of Loreto in 1906, with the districts of Caballococha, Yavarí and Yaquirana. The capital of Yavarí was Nazaret (now known as Amelia) and the capital of Yaquirana was Esperanza, a prominent rubber estate on the upper Yavarí (Fuentes 1908).

In 1903 there were 55 rubber estates along the Peruvian side of the Yavarí, with a total of 1,358 *estradas* (trails), and in 1905 the rubber harvest totaled 600,000 kg. The river was booming with activity and fluvial travel. In 1905, 22 steamships and 107 smaller

steamboats collected rubber in the Yavarí for delivery to Caballococha and Iquitos (Larrabure y Correa 1905–09).

The indigenous inhabitants of the Yavarí did not fare well during the incursions of rubber tappers. The Mayoruna, once a great nation, were pushed back into the upper reaches of the Yavarí and reduced to small isolated villages. Other tribes experienced a similar fate as the rubber tappers set up their posts and *estradas*.

But life was often equally hard for the rubber tappers. The Yavarí was famous for its terrible, often fatal, fevers. Dr. Pesce described these fevers as malignant and abnormal, likely caused by a strain of "tifo-malaria" (Fuentes 1908). But fevers were not the rubber tappers' only concerns, as conflicts with the indigenous inhabitants continued through the rubber boom. Algot Lange, in his fascinating 1912 book on the Yavarí, describes witnessing a group of warriors from the Yavarí attack 20 Peruvian rubber tappers, killing the lot with blowguns, arrows, spears and clubs, dismembering the bodies, and eating them with their wives and children (Lange 1912).

One of the villages on the Yavarí Mirín, San Felipe, was the base of a small Brazilian rubber baron. He was patron to the rubber tappers of the Yavarí Mirín and supplied them from this outpost. One day a group of warriors attacked and killed everybody in the post, leaving behind all the rubber tappers' goods. Today, one can still find 90 year-old beer bottles, bricks from Pará, medicine bottles imported from New York, and the remains of an iron boat, complete with its rusted engine.

The boom ended by the 1920s, when cheaper rubber from the Malaysian plantations out-competed Amazonian rubber. The decline in the Amazonian rubber business was clearly documented in the Yavarí. In 1905, the commercial export of rubber from the Yavarí was calculated at S/.1,500,000, equivalent to £300,000. Two years later it had declined to S/.143,000, and by 1917 it amounted to only S/. 2,000.

But the exploitation of the Yavarí continued. Timber, rosewood oil, and animal pelts were among the products extracted from the Yavarí valley following the rubber boom, as people continued to look for ways of making it rich from the natural products of this great river.

By the 1940s and 1950s, the population of the Yavarí River was once again booming on both the Peruvian and Brazilian sides. In 1942, the military base of Angamos was created to secure the Peruvian borders after the war with Ecuador. The number of families rose to 710 and in 1978 the civil community of Angamos was formed, with Sr. Francisco Dámaso Portal as its first municipal leader. In 1981, Angamos was formally organized with its first major and in 1984 it received its first presidential visit by Alan García Pérez. Currently, the population of Angamos is at ~1,000 inhabitants, in 300 families.

The Yavarí Mirín saw a similar rise in its population as natural resource extraction expanded. In the 1950s, Joaquín Abenzur Panaifo entered the Yavarí Mirín and constructed an industrial plant for the extraction of rosewood oil. The cement and iron remains of this plant can still be found on the upper Yavarí Mirín. Sr. Abenzur used Petrópolis, at the mouth of the Yavarí, as a base for his timber operations, as it was the mid-point between the Yavarí Mirín and Iquitos. Other people also began to extract natural resources from the Yavarí Mirín, such as Sr. Victoriano López, who hired people to collect timber and rosewood oil from the region.

With increasing conflicts between the indigenous inhabitants and commercial operations, the government of Peru established the military base of Barros in the upper Yavarí Mirín to protect the economic interests. The population of the Yavarí Mirín was booming, with families living on every bend of the river and villages such as Buen Jardin having over 300 inhabitants. It is said that over 1,000 people were living and working along the Yavarí Mirín in the 1960s.

But the problems with the indigenous people continued. The Mayoruna were notorious for kidnapping women from villages and towns, and taking them as wives. We had the privilege to meet one of these women and hear the story of her kidnapping. She had gone to the Yavarí to accompany her young husband, who was working lumber. He would go off into the forest for several days at a time, while she watched their small hut and newborn child. One day, when she went out to feed

the chickens, five Mayoruna men descended on her and carried her off into the forest. The men kept her restrained and disoriented, and walked for over a week. When they arrived at the indigenous village, she was kept in the large communal house known as a *maloca*, whose door was guarded day and night. Other kidnapped women were also there. The woman was then "married" to the chief's son, and soon bore children. When her new husband had enough confidence in her, she was allowed to go outside the *maloca*, bathe in the streams and collect vegetables from the gardens. She loved her children, became integrated in the tribe, and soon lost interest in escaping. Some of her fellow kidnapped women, however, were never content to become Mayoruna and kept trying to escape. Eventually, after numerous attempts, they were beaten to death.

One day the missionaries arrived, flying over in their hydroplane and dropping blankets, pots, pans, machetes, beads, and the like. Some time later they landed, and long-bearded men got out of the plane and approached the Mayoruna chief. There was much discussion among the Mayoruna, as to whether they should kill these men or accept them. The latter was decided and the missionaries started their work. The efforts of the military and missionaries eventually stopped the kidnapping, with the last reported cases being in the late 1960s.

Resource extraction in the Yavarí peaked in the 1970s and then began a slow decline. The rosewood oil was exhausted, the professional pelt hunting officially ended in 1973 as Peru entered CITES, and the valuable *Cedrela* timber was becoming scarce close to the rivers. In 1990, when we first started working in the Yavarí Mirín, there were five villages and three timber operations and a population of around 400 inhabitants. The timber operations were finding it increasingly difficult to extract lumber, sometimes taking up to three years to float the timber out of the small upland forest streams. Indeed, the timber operations relied more on income from hunting of wild game meat than they did on timber extraction.

Then, in 1995, a deadly outbreak of cerebral malaria hit the region. One village on the upper Yavarí Mirín, San Francisco de las Mercedes, lost almost half of its inhabitants to the epidemic. Other villages were hit equally hard. The timber companies left the Yavarí Mirín and the villages began to look for governmental support. However, the district capital of Islandia could not provide support to all the communities and advised people that they would only support the largest community of Nueva Esperanza, a *ribereño* village founded in 1971. The Yagua community of San Felipe decided to move their entire village closer to Islandia on the lower Yavarí in order to maintain their traditional society. The village of Buen Jardin broke up and the village of San Francisco de las Mercedes disintegrated and only two families remained.

Today, the Yavarí Mirín is probably at its lowest population levels since the beginning of the rubber boom. At present there are 179 inhabitants in Nueva Esperanza, 18 inhabitants in San Felipe (who moved down from Buen Jardin), 17 inhabitants and seven policemen in Carolina, close to the mouth of the Yavarí Mirín, and five people who remain in San Francisco de las Mercedes, on the upper Yavarí Mirín.

A similar trend in human population decline also occurred on the Brazilian side of the Yavarí. Fifty years ago, José Candido de Melo Carvalho (1955) noted inhabitants along every bend of the Itacoaí, a tributary of the Yavarí, with 77 different houses and settlements. Today, the same river is part of the Javarí indigenous reserve and is almost void of settlements. In fact, uncontacted indigenous groups have moved back into the area, now that the *caboclos* have left the region.

The upper Yavarí River is equally desolate. Once, the area between the mouth of the Yavarí Mirín and Angamos was teeming with resource extraction. Large villages were abundant and fluvial navigation was regular, with ships traveling weekly from Iquitos to Angamos. Resources were sold to ships travelling up and down the Yavarí and people had a regular economic income. Today, there are no villages left in this long stretch of the river, and only patches of secondary forest remain. Ships from Iquitos rarely travel up the Yavarí, at most once every three months, and Angamos is supplied by commercial planes rather than fluvial transport.

Since the early 1990s, the villages of the Yavarí Mirín have been involved with participatory conservation activities led by the Wildlife Conservation Society-Peru and the Durrell Institute of Conservation and Ecology (DICE). Local people have taken part in conservation education programs and community-based wildlife management. The communities have a strong sense of conservation responsibility and have shown sincere interest in community-based conservation, including signed agreements demonstrating their intentions.

The Yavarí and Yavarí Mirín rivers have seen a century of resource extraction. The forests, especially those close to the rivers, are not pristine untouched wilderness. They are forests that have been used to supply firewood for steamships, rubber to Iquitos and Manaus, rosewood oil for perfume, jaguar, otter and peccary pelts for North America and Europe, and timber for fine grade furniture. But today, once again, the forests are quiet from the bustle of human activity. The animals are returning to pre-rubber boom numbers and the few people who continue to use the forest resources are doing so more at subsistence than commercial levels.

As we traveled up the Yavarí to meet the helicopter that was bringing the remainder of the rapid inventory team, we could only think about the secrets that this great river holds. As our boats penetrated the misty morning fog, the forests looked as they did 100 years ago, when the first steamships pushed up the Yavarí to collect black gold. The Yavarí feels as if it is lost in time, and has once again returned to its natural splendor.

AN OVERVIEW OF THE TAMSHIYACU-TAHUAYO COMMUNAL RESERVE

Authors: David Meyer and James Penn

For the last twelve years, a large section of the forest inside the limits recently proposed as the Zona Reservada del Yavarí—322,500 ha in the upper Tamshiyacu, Tahuayo, and Yavarí Mirín watersheds—has been managed as a community reserve by the *ribereño* villagers of the upper Tahuayo and Blanco rivers (see map in Figure 2). This area, the Tamshiyacu-Tahuayo Communal Reserve (RCTT), was created in June 1991 by the regional government of Loreto, in response to the combined efforts of local communities and researchers who had been working in the area for more than a decade.

The reserve's creation was prompted by a confluence of biological and socioeconomic factors: the extraordinary biodiversity of the region; the desire of local communities to gain legal title to their lands; increasing incursions of commercial logging and hunting teams from outside the region; and the recognition of local communities that their own hunting and agricultural practices (especially the destructive harvest of *aguaje* [*Mauritia flexuosa*] palms) were putting the region's abundant natural resources at risk. Based on their work with the communities of Esperanza, Chino, and Buena Vista, a group of interested individuals, many involved with the Peruvian Primate Project research in the Quebrada Blanco area, formed a non-governmental organization, the Amazon Conservation Fund (ACF). Together with community leaders and lawyers, ACF succeeded in obtaining legal communal title for the land which the communities occupied, as well as establishing the community-run reserve, in which portions of the reserve were accessible to the communities for managed hunting, logging and other uses, and other portions were strictly protected.

Now one of the largest and best-known community reserves in South America, the RCTT has been community-managed from its inception. The regional government of Loreto has not actively participated in managing or protecting the reserve. Those tasks are carried out by the communities themselves, with assistance from the ACF and the Rainforest Conservation Fund (RCF), a non-governmental organization based in Chicago, USA, that assumed the principal role of funding ACF in 1992. (In 1995 ACF merged its operations with RCF; from this point on in the chapter the organizations will be referred to as RCF.) The Wildlife Conservation Society-Peru (WCS) and the Durrell Institute of Conservation Ecology (DICE) have also provided

long-term assistance in the management of the reserve, with a special focus on helping local communities to monitor populations of large, commercially important mammal species, and to devise management plans to keep wildlife harvests sustainable.

Following the declaration of the RCTT, RCF's two broad goals were: to serve as a "watchdog" organization that could help protect the reserve and promote it within Peru and internationally, and to help the local communities defend their interests, meet their economic and cultural needs, and keep outsiders from extracting resources (lumber, fruits, animals, etc.) from the reserve and its buffer zone. RCF hired social workers, many of whom had extensive experience in Iquitos neighborhoods, to begin strengthening relationships with the communities. After helping interested communities evaluate their goals and needs, RCF helped organize and fund a variety of short- and long-term activities, including various agroforestry projects, community management plans to regulate hunting, the formation of "watch groups" to deter outsiders interested in extracting timber, game or other forest products, and projects to provide alternative food sources, including the construction of fish ponds and assistance in raising chickens.

Through legal action, RCF and the RCTT removed large-scale squatters who had illegally taken over thousands of acres of community property for raising cattle. They also obtained governmental support to remove police who were abusing their authority to extract timber and other resources illegally. RCF provided a variety of services to the communities in times of emergency, such as fumigation during malarial outbreaks and motorized river transportation for villagers in medical emergencies.

The agroforestry projects have had an especially positive impact, both on the local economies and organization of these communities and on the long-term prospects for the RCTT. For example, a large percentage of local families have implemented clearing, planting and harvesting practices which have increased production of more than 40 plant species. Many of these are commercially valuable and ecologically important species which would otherwise be extracted from the forest.

Perhaps the most encouraging agroforestry project to date in the communities of the RCTT concerns the *aguaje* palm. The sustainable management of this species was a long-term concern in the Tahuayo and Blanco region that predated the creation of the reserve, since the palms—whose fruits are an important source of food for people and wildlife—were cut down each year by the hundreds, rather than harvested sustainably. Since 1993, the communities and RCF have planted several thousand aguaje palms, which are today beginning to bear fruit. Fruit from these palms, which is highly valued in markets in Iquitos, will be a significant and long-term source of income for the communities. Similar programs are now underway for other economically and ecologically important palms and other plants.

In spite of past and continuing efforts, the RCTT remains threatened by illegal extraction of timber, animals and other resources. Poverty is also a persistent problem which contributes to pressure for both small- and large-scale extraction. The local villagers receive little assistance from the government to prevent aggressive incursions, and RCF's funding is not sufficient to combat the continuing pressures and provide all of the extension work necessary to meet the needs of the communities. Nevertheless, most villagers in the adjacent communities are supportive of the RCTT and recognize the role it plays in maintaining a rich supply of forest resources upon which they depend. They are well aware of the threats to their economic viability and way of life.

RCF strongly supports the proposal to incorporate the RCTT into the national-level protected area proposed for the Yavarí region (see "Recommendations"), if a) community reserve status is maintained for what is now the RCTT; b) rights of the communities are clearly articulated; and c) management includes active participation by a consortium of involved organizations including RCF and WCS. Additional information regarding the RCF and the RCTT is available at the website <www.rainforestconservation.org>.

USE AND SUSTAINABILITY OF WILDLIFE HUNTING IN AND AROUND THE PROPOSED YAVARÍ RESERVED ZONE

Participants/Authors: Richard Bodmer, Pablo Puertas and Miguel Antúnez

IMPORTANT CONSERVATION ISSUES

01 Economic arguments should be a key reason for the creation of a new protected area in the Yavarí Mirín valley.

02 Game meat use from the headwaters of the Orosa, Maniti, Tamshiyacu, Tahuayo, Yarapa, Gálvez and Yaquirana rivers in the Yavarí valley is an important subsistence and economic activity for the rural populations of about 25% of the department of Loreto.

03 Game meat extracted from these headwaters in the Yavarí valley supplies many rural communities with an important source of protein, and economic income through the legal sale of game meat in the towns of Islandia, Angamos, Caballococha, Tamshiyacu, Pebas, San Pablo, Nauta, Santa Rosa and Requena.

04 Previous studies have shown that the illegal sale of game meat in Iquitos only accounts for around 6% of the total number of animals hunted in Loreto, and it is the use of game meat in the rural communities and towns that is of major economic importance.

05 The proposed Yavarí Reserved Zone is a major source area for animals hunted in the headwaters of the Orosa, Maniti, Tamshiyacu, Tahuayo, Yarapa, Gálvez and Yaquirana rivers (Figure 8). To guarantee the long-term benefits of wildlife use for rural people in the greater Yavarí valley of Loreto, this source area must be protected.

06 The sustainability of wildlife use in the headwater regions and within the Yavarí Mirín valley must be understood to determine the relationships between animal populations, hunting, and the economics of wildlife use.

INTRODUCTION

The long-term conservation of the Amazon will require a combination of landscape strategies that balance the socio-economic needs of rural and urban populations with the conservation of biodiversity. Protected areas play an important role in biodiversity conservation. However, throughout Amazonia there are numerous examples where the rural population is in conflict with protected area management, because the needs of local people are not considered appropriately within protected area management. In contrast, there are also many cases where the protected areas are managed in a way that incorporates both the needs of rural people and the biological requirements of biodiversity (Bodmer 2000). Sustainable use is key in finding conservation solutions that not only incorporate rural people in conservation, but have rural communities actually promoting conservation initiatives (Freese 1997).

One of the important resources that rural people use from Amazonian forests is wildlife meat (Robinson and Bodmer 1999). Interestingly, hunting of wildlife in and around protected areas can either be full of conflicts, or on the other hand quite harmonious. For example, rural people who live in the vast expanses of western Amazonia naturally recognize the value of setting aside non-hunted areas, because they understand that these areas will help guarantee the long-term use of their wildlife resources. Protected areas that set aside non-hunted areas to benefit the long-term wildlife use of rural people will have the full support of the local people and will promote more harmonious conservation strategies between the protected area and the rural communities. These non-hunted areas effectively preserve the entire complement of biodiversity, but are more sustainable in the long term than areas set aside chiefly to preserve biodiversity.

Meat obtained from wildlife, especially large-bodied mammals, is an important resource for rural people in the Peruvian Amazon. Around 113,000 mammals are estimated to be hunted annually in the department of Loreto, with an annual value for the rural population of around US$1,132,000 (Bodmer and Pezo

2001). The majority of wildlife meat, 94%, is used legally in the rural villages and towns of Loreto, and only 6% is sold illegally in the city of Iquitos.

The socio-economic importance of wildlife meat for subsistence and financial income is unquestionable. However, the long-term benefits that people gain from wildlife meat will only be realized if hunting is maintained at sustainable levels. In rural Loreto this is particularly important, since economic alternatives are limited. If wildlife hunting is unsustainable, the consequences will be significant for the rural economy. Thus, to maintain the long-term benefits of wildlife meat it is necessary to set up management systems that ensure sustainable use throughout most of Loreto.

Source-sink management systems are important landuse strategies that help secure the long-term sustainable use of wildlife (McCullough 1996). Source areas are non-hunted or slightly hunted areas that have a surplus of wildlife production. Sink areas are places where wildlife is hunted more intensively. In turn, source areas help maintain viable wildlife populations in sink areas (Figure 8).

The Yavarí valley is a major area of wildlife production for rural Loreto. Large quantities of wildlife meat are extracted annually from the Orosa, Maniti, Tamshiyacu, Tahuayo, Yarapa, Gálvez and Yaquirana rivers. Approximately 25% of the wildlife hunted in Loreto is estimated to come from these headwater rivers (Verdi, pers. comm.). Wildlife meat obtained from these rivers is used in the rural villages and in the towns of Islandia, Angamos, Caballococha, Tamshiyacu, Pebas, San Pablo, Nauta, Santa Rosa, and Requena. Some of the wildlife meat obtained from these headwater rivers is also sold in the markets of Iquitos.

The Yavarí Mirín valley is an important source area for the headwater rivers. The sustainability of wildlife hunting in the Orosa, Maniti, Tamshiyacu, Tahuayo, Yarapa, Gálvez and Yaquirana rivers will depend on the maintenance of the Yavarí Mirín source area. Thus, for the socio-economics of rural Loreto it is imperative that the Yavarí Mirín valley is set aside as a protected area with non-hunted and slightly hunted zones that act as wildlife sources for the headwater rivers outside the proposed protected area.

This chapter will analyze the use, economics and sustainability of wildlife hunting within the Yavarí Mirín valley, and a representative site within the adjacent headwater river region, the Quebrada Blanco of the Tahuayo river. This analysis will evaluate the importance of the Yavarí Mirín valley as a source area for the headwater rivers and help guide management recommendations for the proposed protected area. The analysis will also allow us better to understand the relationships between animal populations, hunting, sustainability and economics in the Greater Yavarí valley.

METHODS

Analysis of sustainability of hunting requires data on hunting pressure, catch-per-unit-effort, animal densities in hunted and non-hunted areas, and reproductive rates of species in hunted sites. These data have been collected in the Yavarí Mirín and Quebrada Blanco for over a decade.

We collected hunting pressure data in the Yavarí Mirín and Quebrada Blanco by involving hunters in the study, through community meetings, educational presentations, and informal interviews. This participatory approach has several advantages over non-participatory methods: 1) it permits researchers to collect direct information on hunting pressure; 2) it allows researchers and hunters to work together and understand each other's needs; 3) it sets the stage for local involvement in future management of wildlife resources; 4) it teaches hunters how to collect data so that in the future they will be directly involved with analysing the sustainability of their own hunting; and 5) hunters can easily collect animal parts such as skulls and reproductive tracts. The participatory approach was instrumental in getting hunters thinking about wildlife management and for them to learn about hunting registers (Bodmer and Puertas 2000).

In the Yavarí Mirín valley and the Quebrada Blanco the participatory hunting studies have been used to collect data on hunting pressure, catch-per-unit-effort, catchment area, age structure from skulls, and reproduc-

tive tracts of female animals that were harvested. This one method allows many types of data to be collected, while at the same time involving hunters in the initiation of management and the analysis of data. It is for those reasons that this method becomes so vital in evaluating the sustainability of hunting and initiating management practices to convert unsustainable hunting to more sustainable hunting.

In the Yavarí Mirín valley and the Quebrada Blanco, we collected catch-per-unit-effort data using hunting registers (Puertas 1999). Hunters recorded the number, species, and sex of animals they hunted in written registers that the community wildlife inspector administered. The village designated one or two wildlife inspectors responsible for coordinating the community wildlife efforts, including vigilance patrols and hunting registers.

The one type of data that usually requires non-participatory approaches is estimating animal density. While some projects have involved hunters in censuses, many hunters find that the extra work involved in collecting census data is an additional task that cannot be assimilated easily into their lives. Local hunters are often employed as assistants in censuses, but this is more of paid service than local participation.

Sustainability models were used to evaluate the impact of hunting and the potential for the Yavarí Mirín valley as a source area for the headwater rivers. These models include catch-per-unit-effort analysis, harvest models, and unified harvest models.

RESULTS

Use and economic importance of wildlife hunting

The economic importance of wildlife derives mostly from larger mammal species in both the Yavarí Mirín and in the Quebrada Blanco.

Hunting pressure in the Quebrada Blanco is almost 500% greater than hunting pressure in the Yavarí Mirín, in terms of individual mammals hunted.

In the Yavarí Mirín the most frequently hunted mammals are the white-lipped peccary, collared peccary, and to a lesser extent, the lowland tapir and red brocket deer. All of the other species, including large primate, large rodent, edentate, marsupial, and carnivore species are rarely hunted in the Yavarí Mirín (Table 2).

The most frequently hunted mammals in the Quebrada Blanco are the paca, white-lipped peccary, collared peccary, agouti, titi monkey, red brocket deer, woolly monkey and saki monkey. In contrast to the Yavarí Mirín, hunters in the Quebrada Blanco frequently hunt large primate, large rodent, edentate, marsupial, and carnivore species. Indeed, the number of species hunted in the Quebrada Blanco is considerably greater than that in the Yavarí Mirín.

The economic value of wildlife hunting, in terms of both subsistence and financial values, is almost 300% greater in the Quebrada Blanco than in the Yavarí Mirín. In the Quebrada Blanco the estimated economic value of wildlife hunting is around US$5,000 per 100 km^2 of catchment area per year, whereas the economic value in the Yavarí Mirín is around US$1,600 per 100 km^2 of catchment area per year.

Catch-per-unit-effort analysis

We used hunting registers to obtain hunting offtakes and effort (time spent hunting), to develop catch-per-unit-effort (CPUE) relationships in the Yavarí Mirín and Quebrada Blanco. CPUE reflects the relative abundance of species, since areas where animals are more abundant are easier to hunt and have higher CPUE than areas that have fewer animals. CPUE can also be used to assess the relative sustainability of hunting between sites. Areas with higher CPUE are deemed more sustainable than those with lower CPUE. However, CPUE only works for species that are preferred by hunters. Non-preferred species will always have low CPUE, irrespective of their densities (Puertas 1999).

The Yavarí Mirín region has much greater CPUE of preferred species than the Quebrada Blanco region (Table 3). This is especially true for white-lipped and collared peccaries, which are the preferred species on the Yavarí Mirín. These results suggest that hunting in the Yavarí Mirín region is considerably more sustainable than hunting in the Quebrada Blanco region.

Table 2. Number of mammals hunted in the Quebrada Blanco and Yavarí Mirín. Values are in individuals hunted per 100 km^2 per year.

Latin Names	Common Names		
		Quebrada Blanco	Yavarí Mirín
Artiodactyls			
Tayassu pecari	white-lipped peccary	33.2	20.8
Tayassu tajacu	collared peccary	33	12.8
Mazama americana	red brocket deer	12	2.4
Mazama gouazoubira	grey brocket deer	5.6	0
Perissodactyls			
Tapirus terrestris	lowland tapir	7.6	2.4
Primates			
Callicebus cupreus	titi monkey	15.2	0.1
Cebus albifrons	white capuchin	4	0
Cebus apella	brown capuchin	9.2	0.6
Alouatta seniculus	howler monkey	4.4	1.5
Lagothrix lagothricha	woolly monkey	11.6	6.4
Ateles paniscus	spider monkey	1.6	1
Pithecia monachus	saki monkey	11.4	0.4
Cacajao calvus	uakari monkey	4.6	1.6
Saimiri spp.	squirrel monkey	1.8	0.4
Aotus nancymae	night monkey	0.8	0
Saguinus spp.	tamarin	2.2	0
Rodents			
Coendou bicolor	bicolored porcupine	1.6	0
Hydrochaeris hydrochaeris	capybara	2	0.4
Agouti paca	paca	34.8	0.6
Myoprocta pratti	acouchy	2.6	0
Dasyprocta fuliginosa	agouti	19.4	0.6
Sciurus spp.	Amazon squirrel	3	0
Marsupials and edentates			
Didelphidae	opossums	5	0
Dasypus novemcinctus	armadillo	3.8	0
Bradypus variegatus	three-toed sloth	0.8	0
Myrmecophaga tridactyla	giant anteater	1	0
Priodontes maximus	giant armadillo	0.2	0
Tamandua tetradactyla	collared anteater	3.4	0
Carnivores			
Canidae	dogs	0.4	0
Felis spp.	ocelot/margay	5	0.4
Potos flavus	kinkajou	0.8	0
Panthera onca	jaguar	0	0.1
Puma concolor	puma	0.6	0.1
Eira barbara	tayra	2.8	0
Nasua nasua	coati	9.8	1.1
Lutra longicaudis	southern river otter	0.2	0
TOTAL		**255.4**	**53.7**

Table 3. Results of catch-per-unit-effort analysis of species commonly hunted in the Quebrada Blanco and Yavarí Mirín. Units are in number of individuals hunted per 100 man-days. The abbreviation "np" denotes "not preferred" and indicates species that are not appropriate for CPUE analysis.

Species	Quebrada Blanco	Yavarí Mirín
White-lipped peccary	11.3	64.6
Collared peccary	7.7	23.4
Red brocket deer	2.3	5.1
Lowland tapir	0.7	8.2
Agouti	1.1	np
Paca	17	np
Woolly monkey	0.5	7
Saki monkey	0.5	np
Brown capuchin	0.2	np
White capuchin	0.2	np
Total for all hunted species	**46**	**122**

Harvest model

The impact of hunting can be evaluated using the harvest model, which examines the relationship between production and harvest. This model evaluates the sustainability of hunting by comparing the actual production at the population size being harvested. The harvest can then be compared to production to obtain a measure of the percent of production harvested, and whether this percent is within sustainable limits.

The harvest model uses production estimates that are derived from reproductive productivity and population density. We determined reproductive productivity from data on reproductive activity of females, along with information on litter size and gross reproductive productivity (the number of young per number of females examined). We determined population density from field censuses of wildlife species. We then multiplied animal densities by reproductive productivity to yield an estimate of production, measured as individuals produced per km^2, as:

$$P= (0.5D)(Y*g),$$

where Y is the number of young recorded per female (or as gross production, which is the total number of young per total number of females), g is the average number of gestations per year, and D is the population density (discounted by 50% under the assumption that the population sex ratio is 1:1).

Whether the population is being overhunted can then be determined by comparing harvest with production. The percentage of production that can be harvested sustainably is estimated using the average lifespan of a species, which can be used as an index of the number of animals that would have died in the absence of human hunting (Robinson and Redford 1991). These estimates suggest that hunters can take 60% of the production of very short-lived animals (those whose age of last reproduction is less than five years), 40% of the production of short-lived animals (those whose age of last reproduction is between five and ten years), and 20% of the production of long-lived animals (those whose age of last reproduction is greater than ten years).

In the Yavarí Mirín the results from the harvest model suggest that all of the species hunted were within sustainable levels, including the lowland tapir. The peccaries and deer were hunted well within sustainable limits, with a small fraction of their production being harvested. The lowland tapir was closer to the sustainable limits, with 16% of their production being harvested in the catchment area (Table 4).

Table 4. Results of the harvest model analysis for Quebrada Blanco and Yavarí Mirín. Units are in percent of production hunted.

Species	% of production hunted	
	Quebrada Blanco	Yavarí Mirín
White-lipped peccary	11	3.5
Collared peccary	31	7.8
Red brocket deer	38	5
Lowland tapir	140	16
Agouti	8	0.3
Brown capuchin	21	0.5
White capuchin	15	0
Woolly monkey	28	6
Saki monkey	16	1.1

In contrast, in the Quebrada Blanco the peccaries and deer were much closer to sustainable limits. The lowland tapir and many of the primates were being harvested above sustainable limits and are clearly overhunted in the catchment area (Table 4).

Unified harvest model

The unified harvest model combines the percent of production of a harvested population with its position relative to maximum sustainable yield (MSY) to give both a measure of the current sustainability and the long-term riskiness of the harvest. This can be very useful, since it can all be represented by a single line, which indicates both the percent of production harvested in relation to the sustainable yield (SY) line and relative to the species' MSY.

The unified harvest model uses a modified population growth curve, where the horizontal axis is the population size from extirpation (0) to carrying capacity (K) and the vertical axis is the sustainable limit of exploitation expressed as SY (Caughley 1997). The SY mirrors the growth of the population, dN/dt, and has a maximum point of growth or a maximum sustainable yield (MSY). The SY line is in fact the 20%, 40%, or 60% limits of the percent of production that can be harvested.

The unified harvest model also analyzes the riskiness of the harvests in terms of the potential for long-term sustainability by incorporating a stock-recruitment analysis. This is done by determining the proximity of the current harvest to carrying capacity (K) and to the MSY. A safe harvest is one that occurs to the right of the MSY point. MSY is species-specific and is predicted to be at 50% for very short-lived species, 60% for short-lived species and 80% for long-lived species. The unified harvest model can be used to evaluate whether a harvest level is risky or safe depending on the population size relative to the predicted MSY.

The unified harvest model is a practical way to evaluate the sustainability of hunting. The information that needs to be collected for the unified harvest model is hunting pressure, reproductive productivity, and density at hunted and non-hunted sites. The density at hunted sites is used to calculate the species proximity to MSY and as an important variable in estimating production. The density in non-hunted sites is used to estimate the K and in turn the MSY. We used data on reproduction, such as gross productivity, to calculate production, and harvest pressure to calculate the percent of production harvested.

In the Yavarí Mirín site, the species with greater than 2% of production harvested were analyzed. The white-lipped peccary, red brocket deer, lowland tapir, and woolly monkey were all harvested at sustainable levels, both in terms of their current harvests and potential for long-term sustainability (see figures in Appendix 8). The collared peccary was the only species that had a population density less than its MSY. In terms of long-term sustainability, the collared peccary densities should be allowed to increase in the catchment area of the Yavarí Mirín. However, the percent of production harvested was well within sustainable limits with only 7.8 percent of production being harvested. It could be that habitat differences are responsible for the variance in density of collared peccaries between the hunted and non-hunted sites and that this is confounding the results. Further studies are needed to determine the actual long-term sustainability of collared peccary in the catchment area of the Yavarí Mirín.

In the Quebrada Blanco site, only collared peccary, red brocket deer and agouti were hunted sustainably in terms of both current harvests and potential for long term sustainability. White-lipped peccary, white-capuchin, and saki monkey were hunted sustainably in terms of their percent of production harvested; however, their base populations should be increased above the predicted MSY for long-term sustainability. Lowland tapir, woolly monkey, and brown capuchin were all hunted unsustainably, both in terms of the production harvested and for long-term sustainability (see figures in Appendix 8).

Overall, the unified harvest model clearly shows that the hunting in the Yavarí Mirín site is much more sustainable than the hunting in the Quebrada Blanco site. The overhunting in Quebrada Blanco is particularly evident with slow reproducing species such

as the lowland tapir and large primates, and agrees with previous analyses on the vulnerability of mammals to overhunting in Amazonia (Bodmer et al. 1997a).

Source-sink analysis

If animals are overhunted in sink areas adjacent to sources, the larger source-sink area might be sustainably used, since animals from the source area can replenish the sink area. Source areas should be incorporated into sustainable hunting strategies as a way to guarantee long-term sustainable hunting (Novaro et al. 2000). Sink areas that are sustainably used should be adjacent to source areas that can replenish animals as populations go through fluctuations and for periods become overhunted. Source areas should not be used to sustain overhunting.

The harvest model can incorporate source and sink areas by estimating the percent of production harvested and the riskiness of harvests in heavily hunted sinks, slightly hunted sources and non-hunted sources. In non-hunted sources the percent of production harvested is zero. It is then possible to combine source and sink areas to get an approximation of the percent of production harvested and the riskiness of the harvest throughout the entire source-sink area.

The Yavarí Mirín and Quebrada Blanco sites demonstrate how source-sink analysis can incorporate the harvest model. The Quebrada Blanco site is a persistently hunted area of 1,700 km^2, and the Yavarí Mirín site can be divided into two hunting zones: 1) a slightly hunted area totalling 4,000 km^2, and 2) a non-hunted area totalling 5,300 km^2. The non-hunted and slightly hunted areas are potential source populations for the persistently hunted area. We estimated the size of hunting zones from data on harvests and catchment area.

We examined the effectiveness of the source-sink strategy for lowland tapir, peccary and deer populations. The harvest model showed that in the persistently hunted Quebrada Blanco site 140% of lowland tapir production was hunted, and the harvest was risky. This is clearly a sink area for lowland tapir. The slightly hunted site had an estimated 16% of lowland tapir production hunted, which is below the 20% limit, and the hunting was deemed safe. Thus, the slightly hunted Yavarí Mirín site can be considered part of the source area. The non-hunted site had 0% of production hunted, and the slightly hunted plus non-hunted site together made up the aggregate source area. Hunters were taking an estimated 8% of the lowland tapir production from this aggregate source area, which is within sustainable levels. Within the entire source-sink area including the persistently hunted, slightly hunted and non-hunted sites hunters were taking an estimated 18% of lowland tapir production. This suggests that hunting of lowland tapir in the entire source-sink area appears to be sustainable and the sustainability of hunting in the persistently hunted area depends largely on immigration (or replenishment) from adjoining source areas. However, overhunting of tapir in the persistently hunted area should be remedied and regional sustainability should not rely solely on the source areas.

Currently, there is some limited information on lowland tapir moving between the hunting zones. First, the continued persistence of tapir in the Quebrada Blanco site suggests that recruitment by immigration from the source area is important. Second, tapir populations in the Quebrada Blanco site are considerably younger than tapir populations in the slightly hunted area, which suggests that younger animals are moving from the source to the sink.

The effectiveness of the source-sink strategy was also examined with peccary and deer populations (Table 5). The risky hunting levels of white-lipped peccary harvests in the Quebrada Blanco, and the proximity of collared peccary and brocket deer harvests to the sustainable limits, suggest that these animals

Table 5. Results of the harvest model for ungulates in source and sink areas in and around the proposed Yavarí Reserved Zone. Sink areas are adjacent to the Yavarí valley, such as the Quebrada Blanco, and source areas are in the Yavarí Mirín.

Species	% of production harvested		
	Sink	Source	Sink and Source
Lowland tapir	140.0	8.0	18.0
Collared peccary	31.0	3.3	6.0
White-lipped peccary	11.0	1.5	2.3
Red brocket deer	38.0	2.1	9.0

might be at risk of overhunting during some years. However, if a management strategy includes the slightly hunted and non-hunted source areas, this strategy is less risky, because source areas could replenish overhunting of the persistently hunted populations if necessary.

DISCUSSION

Economic arguments for establishing a new protected area in the Yavarí Mirín area are essential for the region of Loreto. New protected areas should be considered in light of the economic realities of the region. The economic benefits of the proposed Reserved Zone are clear in terms of the long-term sustainability of wildlife use in the Greater Yavarí valley and the importance of the proposed protected area as a source that allows for more sustainable use.

The economic consequences of *not* protecting the Yavarí Mirín valley are also clear. The economic value provided through sustainable use will disappear, and overhunting in many headwater rivers will not be compensated for by production of a source area. The department of Loreto will lose about 25% of its current benefits from wildlife use. Rural people will need to find other, often more destructive, uses of the forest to maintain their subsistence and livelihoods.

Sustainable use of wildlife is a strong argument for biodiversity conservation. If rural people appreciate the benefits provided through the sustainable use of wildlife, then they will want to maintain wildlife habitats in order not to lose those benefits. This has been shown repeatedly throughout tropical regions of the world (Freese 1997). If people conserve wildlife habitats then they also conserve the entire complement of biodiversity of those habitats.

The results of this chapter show that the Yavarí Mirín valley is acting as a source area for the many rivers whose headwaters are contiguous to it (Figure 8). The wildlife production of the Yavarí Mirín valley is buffering overhunting, or potential overhunting, in adjacent areas. Protecting the Yavarí Mirín valley would agree with the current wildlife use practices of the people living in the Orosa, Maniti, Tamshiyacu, Tahuayo, Yarapa, Gálvez and Yaquirana rivers. With appropriate management, these communities and others in the region will clearly see the economic benefits of protecting the Yavarí Mirín valley for the long term and will support conservation efforts.

Lowland tapir is one species that requires further conservation and management actions with regard to hunting. The species is particularly vulnerable to overhunting, because of its large body size and slow reproduction. Hunters will usually take lowland tapirs they encounter, since the large body size provides a significant amount of meat. Unfortunately, the slow reproductive rates of lowland tapir make them very vulnerable to overhunting and their populations rapidly decline under persistent hunting pressure. One important management recommendation is the reduction of lowland tapir hunting in the headwater rivers outside the proposed protected area.

Whilst the large primates are equally vulnerable to overhunting as the lowland tapir, in terms of their slow reproductive rates, they are easier to manage because of their smaller body size. Hunters are more willing to reduce hunting of large primates, since they do not provide as much meat and are not nearly as economically important as the lowland tapir. Indeed, community-based programs in the Reserva Comunal Tamshiyacu-Tahuayo have resulted in a significant decrease in primate hunting (Bodmer and Puertas 2000).