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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. Another branch, the Center for Cultural Understanding and Change, works closely with ECP to ensure that local communities are involved in conservation in positive ways that build on their existing strengths. 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.

The Field Museum
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Gobierno Regional de Loreto (GOREL)

The Regional Government of Loreto (GOREL) is a judiciary entity representing the will of the public. It has political, economic and administrative autonomy and receives a designated budget as established in Article 191 of the Peruvian Constitution and Article 2 of Law 27867. The scope of its jurisdiction is delineated by the current boundaries of the department of Loreto and its headquarters are in the city of Iquitos.

GOREL's mission is to govern democratically and achieve an integrated development in the region, in agreement with national, sectorial, and regional policies. Together with other public institutions and private investments, GOREL implements and promotes programs, projects, and action towards the goal of generating economic well-being and to improve the living standards of the population.

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Organizacion Regional AIDESEP-Iquitos (ORAI)

The Regional Organization AIDESEP-Iquitos (ORAI) is registered publicly in Iquitos, Loreto. This institution consists of 13 indigenous federations, and represents 16 ethnic groups located along the Putumayo, Algodón, Ampiyacu, Amazonas, Nanay, Tigre, Corrientes, Marañón, Samiria, Ucayali, Yavarí, and Tapiche Rivers in the Loreto region.

The mission of ORAI is to ensure communal rights, to protect indigenous lands, and to promote an autonomous economic development based on the values and traditional knowledge that characterize indigenous society. In addition, ORAI works on gender issues, developing activities that promote more balanced roles and motivate the participation of women in the communal organization. ORAI actively participates in land titling of native communities, as well as in working groups with governmental institutions and the civil society for the development and conservation of the natural resources in the Loreto region.

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Herbario Amazonense de la Universidad Nacional de la Amazonía Peruana

The Herbario Amazonense (AMAZ) is situated in Iquitos, Peru, and forms part of the Universidad Nacional de la Amazonía Peruana (UNAP). It was founded in 1972 as an educational and research institution focused on the flora of the Peruvian Amazon. In addition to housing collections from several countries, the bulk of the collections showcase representative specimens of the Amazonian flora of Peru, considered one of the most diverse floras on the planet. These collections serve as a valuable resource for understanding the classification, distribution, phenology, and habitat preferences of plants in the Pteridophyta, Gymnospermae, and Angiospermae. Local and international students, docents, and researchers use these collections to teach, study, identify, and research the flora, and in this way the Herbario Amazonense contributes to the conservation of the diverse Amazonian flora.

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Museo de Historia Natural de la
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Founded in 1918, the Museo de Historia Natural 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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ACKNOWLEDGMENTS

Our inventories are a massive collaborative effort, and we extend our deepest gratitude to everyone who helped us make the inventory in Nanay-Mazán-Arabela a great success. This was our fourth inventory in Loreto, and our first collaboration directly with Loreto's regional government (GOREL). We deeply thank Nélida Barbagelata for inviting us to do the inventory and for her profound commitment to conservation in Loreto. Similarly, we are extremely grateful to José "Pepe" Álvarez for his tireless conservation efforts in Peru, and his work in launching the regional conservation program in Loreto. Without Nélida, Pepe, and GOREL, this inventory would have been impossible.

Within GOREL, we extend our thanks to then-President Robinson Rivadeneyra and Vice-President Mariela Van Heurck. We were honored to be part of the historic agreement signed by GOREL and The Field Museum in Iquitos in early August 2006, and we are impressed with the current GOREL administration, especially the commitment Iván Vásquez and Víctor Montreuil have shown to the regional conservation initiatives. The work in Loreto will almost certainly inspire other regions in Peru and South America.

Logistically, this inventory was an enormous challenge. Our deepest gratitude goes to the Peruvian National Police (PNP), and especially Coronel Dario "Apache" Hurtado, Suboficial Roger "Checoni" Conislla, and Comandante Oscar "Orca" Roca. Over the last five years, the PNP has been instrumental in our inventories in Peru, getting us to remote corners in their helicopters. We also received generous help from the Ejército Peruano. We extend our deepest thanks to General Miranda and Mayor Pimentel from Lima, and Comandante Alva and Mayor Nacarino in Curaray, who went above and beyond to help us in our transportation needs.

Our advance team had to overcome several obstacles. Ítalo Mesones, Álvaro del Campo, and Marcos Ramírez led different teams into the field and established three campsites and trail systems. The teams rallied hard to pull the inventory together, and it is thanks to their dedication and hard work that the biological and social teams were able to be effective in the field. Ítalo Mesones deserves special recognition for persevering against incredible odds and establishing not one, but two full campsites and getting us exactly where we needed to be to visit the drainage divide and explore the highest reaches of the headwaters.

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Before the inventory began, we had an unexpected georeferencing crisis. We could not have solved this problem without the technical support of Hannah Anderson, Futurity Inc, and Roxana Otárola Prado and Willy Llactayo of CIMA. We are deeply grateful for all of their help and hard work. Without them we would not have had accurate maps in the field.

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The ornithologists are grateful to Pepe Álvarez for helpful discussions on the white-sand avifauna.

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First and foremost, the social inventory team is grateful to the residents of the eleven communities we visited for their generous hospitality and willingness to share their knowledge and experiences with us. We also thank the members of the sub-sector of the Regional Government in Santa Clotilde for their logistical support during the inventory, including the use of their motor boat. We thank the Fathers of the Santa Clotilde Vicariate for their warm hospitality and their insights on the region's economic and political context. We are grateful to the Parroquia of Santa Rosa de Mazán for housing us at the parrish, for accompanying us on our visits to the Mazán communities, and for facilitating contacts with members of AIDEPEMPROFORMA. Abel and Norma Chávez of AIDEPEMPROFORMA accompanied us on our visits and patiently shared the history of their organization's efforts. In Iquitos we received great assistance from the Regional Government's technical departments as well as the Defensoría del Pueblo, the National Statistics Institute, and the Ministry of Agriculture.

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Finally, we extend our gratitude to the Gordon and Betty Moore Foundation for financial support of the inventory.

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 to evaluate quickly 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 decisionmakers who set priorities and guide conservation action in the host country.

REPORT AT A GLANCE

Dates of Field Work	Biological Team:	15–30 August 2006
	Social Team:	15–29 August 2006

Region

Province of Loreto, northwestern Peruvian Amazon, near the border with Ecuador. Nanay-Mazán-Arabela (N-M-A) Headwaters lie south of the Curaray and Arabela rivers and north of the Tigre and Pucacuro rivers. A mosaic of land-uses surrounds the area: the Pucacuro Reserve Zone to the south and southwest, the proposed Territorial Reserve Napo-Tigre to the west, the proposed Comunal Reserve Napo-Curaray to the north, and forestry concessions to the east.

Fig. i. Map of the region showing original and current proposals for Nanay-Mazán-Arabela Headwaters.

All of the data and summaries for the biological inventory reflect the original proposal of 136,005 ha (Fig. 2A, i); therefore, the biological results represent a conservative measure of the diversity in the current proposal of 747,855 ha (Fig. 2A). The social inventory results are relevant for both proposals, irrespective of their size.

Inventories

Biological focus: Geology, hydrology, vascular plants, fishes, reptiles and amphibians, birds, large mammals, and bats.

The biological team visited 3 sites, one in each watershed (Mazán, Nanay, Arabela).

- Mazán: Alto Mazán, 15–20 August 2006
- Nanay: Alto Nanay, 21–24 August 2006
- Arabela: Panguana, 25–30 August 2006

Social focus: Cultural and social assets including organizational strengths and resource use and management.

The social team visited 11 communities in three watersheds (Arabela, Curaray, Mazán).

- Arabela (2 communities): Flor de Coco and Buena Vista, 18–19 August 2006
- Curaray (5 communities): Bolivar, San Rafael, Santa Clotilde, Shapajal, and Soledad, 16–17 and 20–24 August 2006
- Mazán (4 communities): Puerto Alegre, Santa Cruz, Libertad, and Mazán, 29 August 2006

Principal biological results

N-M-A Headwaters are spectacularly diverse (Table 1). Habitats vary broadly across the landscape, and range from white sand patches to hilly areas that represent the eastern most extension of the Ecuadorian Andes. The highest of these hills (270 m) is a drainage divide for three regionally important rivers: Nanay, Mazán, and Arabela. Below we summarize the biological highlights.

Table 1. Species richness in each inventory site for all organisms surveyed; total richness across inventory sites; and richness estimates for the Nanay-Mazán-Arabela Headwaters region.

Organismal group	Alto Mazán	Alto Nanay	Panguana	Inventory total	Regional richness
Plants	600	800	1000	1200	3000–3500
Fishes	92	78	56	154	240
Amphibians	25	26	31	53	80–100
Reptiles	20	12	26	36	60–80
Birds	271	221	297	372	500
Large Mammals*	29	17	31	35	59

* Bats (20 species found during the inventory) not included.

REPORT AT A GLANCE

Principal biological results
(continued)

Geology and Hydrology: Three formations (Pevas, Unit B, Unit C) meet in the N-M-A Headwaters region, creating a rich geological mosaic. Natural erosion is extensive along river and stream edges. Any artificial increase in erosion (deforestation, mining, intensive agriculture, oil extraction) would result in a catastrophic impact with heavy sedimentation throughout the watershed.

Vegetation: Vegetation varies broadly across the region, from stunted trees growing on white sands to tall forests growing on clay hills. In the Arabela headwaters, we found floodplain species growing on hilltops (Fig. 5E), an odd locale for species that colonize open areas. We speculate that these pioneer species may have colonized hilltops after agriculture was abandoned 400–500 years ago. Natural disturbances (tree-fall gaps, erosion) appear to be more common here than elsewhere in Amazonia.

Plants: Botanists found ~1,200 species, including 3 new plant species for Peru, and 5 species almost certainly new to science. Valuable timber species are nearly absent from the region. However, lesser-known timber species are abundant, and if markets for these species expand, the resulting deforestation would be immense (60% of forest cover).

Fishes: The region's 154 species include fishes that are new to science or new for Peru (13), rare or range-restricted (6), valuable as ornamentals (10), or important in local food markets (5). Headwater areas are a critical source of nutrients for downstream aquatic communities; any disturbance upstream will cascade through the food web.

Amphibians and Reptiles: Herpetologists registered 53 species of amphibians, including 2 species new to science, 3 rare species, and an abundant population of an *Atelopus* frog (Fig. 7C) critically threatened elsewhere. Reptiles were similarly diverse (36 species) and included a new record for Loreto and a species potentially new to science. Local drought and sedimentation, provoked by deforestation, would reduce stream quality and availability and severely impact the majority of the herpetofauna.

Birds: The region's diverse bird community (372 species) is dominated by terra firme species. Highlights include a specialist avifauna (12 species) associated with rare, white-sand habitats, and 6 foothill species typically associated with the Andes. Guans (*Penelope* and *Crax*) are abundant, suggesting the area provides an important refuge for game birds.

Mammals: Regional primate diversity (11 species) is high, and includes a range-restricted species of monk-saki (*Pithecia*, Fig. 9C). Currently, commercial hunting threatens mammal populations in the upper Mazán River, as evidenced by hunting parties traveling along the river (Fig. 4C), lower mammal densities at this site, and apprehensive behavior in observed animals. In contrast, the upper reaches

of the Nanay and Arabela rivers appear to provide an important refuge for local fauna. Human settlements along the Mazán, Arabela, and Curaray rivers are small communities (70–300 inhabitants) with a subsistence lifestyle that relies on forest resources, small-scale agriculture, and local commerce (Fig.10D). We found great social strengths and responsible natural resource use within these human communities, providing promising avenues for local management and conservation (Table 2).

Table 2. Overview of social assets and natural resource use in 11 communities visited during the social inventory in the Mazán, Arabela, and Curaray watersheds.

Watersheds	Mazán	Arabela	Curaray
Communities	Puerto Alegre Libertad Santa Cruz Mazán	CN* Buena Vista CN Flor de Coco CN Soledad CN San Rafael Santa Clotilde	CN Shapajal CN Bolívar
Overview	▪ A self-sufficient lifestyle predominates, largely compatible with environmental conservation. ▪ However, the last decade has seen greatly increased integration into commercial markets (timber as well as others) by native communities in the Arabela and Curaray rivers as well as the *ribereño* (riverine) communities along the Mazán River.		
Social assets	▪ A work ethic based on communal values ▪ Barter economy ▪ Organizations dedicated to management of natural resources ▪ Links between parish and communities that facilitate communication and management ▪ Family networks that support social cohesion ▪ River-based flows of information, commerce, and health care among communities ▪ Revitalization of cultural identity (including indigenous languages)		
Natural resource use	▪ Subsistence economy with relatively low levels of extraction ▪ Small semi-diversified agricultural plots (on average, 0.5–1 ha) ▪ Medicinal plant knowledge and use ▪ Some communities regulate commercial extractive use by outsiders		

Note: Communities on the Nanay River, although not visited during the social inventory, are involved in integrated management efforts in collaboration with the Instituto de Investigaciones de la Amazonía Peruana (IIAP) in Iquitos. The collaborative work along the Nanay would provide a model for working with local communities in the rest of the region.

*CN = Comunidad Nativa

REPORT AT A GLANCE

Principal threats

Although N-M-A Headwaters is in a remote corner of Peru, rivers provide access to the entire area. Without a coherent plan for local conservation and management of the area, the biological and human communities will become increasingly threatened (Figs. 4A–C).

Biological communities are threatened by:

01 **Commercial activities that increase erosion.** Deforestation created by extractive industries (timber, oil, mining), coupled with the already high natural levels of erosion in N-M-A Headwaters, would drastically increase river sedimentation within the entire watershed.

02 **Intensive commercial hunting and fishing.** Unregulated, large-scale hunting and fishing is not sustainable in the long term. Demand in Iquitos overwhelmingly drives the bushmeat trade.

03 **Contamination.** Mining and oil operations pose an enormous threat to water quality for local residents and local fauna, especially fishes.

Human communities are threatened by:

01 **Commercial activities that create social upheaval.** Historically, commercial resource extraction in Amazonia (e.g., rubber, gold, oil) follows a boom and bust cycle. These cycles destabilize local social networks and accelerate cultural erosion.

02 **Incomplete information during negotiations with commercial interests.** Communities are uninformed about their rights vis-à-vis commercial industries interested in extracting resources from their territories. Often, this leads to skewed decision-making. Moreover, commercial industries will negotiate directly with individuals in rural and indigenous communities, creating internal conflict and division.

03 **Excessive extraction.** Commercial hunting and fishing deplete game species that local people depend on for subsistence.

04 **Lack of a regional land-use plan.** N-M-A Headwaters harbor great biological diversity and are surrounded by communities motivated to conserve this diversity and their own livelihoods. However, oil concessions cover most of Loreto, including N-M-A Headwaters. A land-use plan would balance the importance of preserving biological and cultural diversity with the demand for large-scale resource extraction. These issues must be resolved at a regional scale.

Antecedents and current status	In March 2004, Loreto's regional government (Gobierno Regional de Loreto, GOREL) excluded 24 timber concessions from the Mazán headwaters (Regional Ordinance 003-2004-CR/GRL; 136,005 ha, Fig. 2A). In March 2006, GOREL invited The Field Museum to lead a rapid biological and social inventory to provide technical support for protecting this fragile region. All of the biological results reflect the original proposal of 136,005 ha (Fig. i). After the inventory in August 2006, the team presented preliminary results to GOREL in Iquitos. Based on the inventory results, GOREL proposed to protect the entire N-M-A Headwaters—including the Nanay headwaters—within the new regional conservation system managed by a new program (Programa de Conservación, Gestión, y Uso Sostenible de la Biodiversidad Biológica de la Región Loreto, PROCREL). The proposal (747,855 ha, Fig. 2A) is now awaiting review and approval by the Board of Ministers (Consejo de Ministros).
Principal recommendations for protection and management	01 **Establish a Regional Conservation Area (Área de Conservación Regional) of 747,855 ha that includes the upper Nanay River (Fig. 2A).** The area should be implemented and managed by PROCREL, and coordinated with the adjacent protected area (Zona Reservada Pucacuro) and adjacent, proposed protected areas (Reserva Territorial Napo-Tigre, Reserva Comunal Napo-Curaray). 02 **Restrict intensive commercial use in the fragile N-M-A Headwaters.** 03 **Support the proposed Nanay-Pucacuro Corridor.** The proposed Regional Conservation Area Nanay-Mazán-Arabela is a key piece of this corridor. 04 **Fully integrate local residents and appropriate local organizations in the protection of the area.** 05 **Create a buffer zone for the proposed Regional Conservation Area.** 06 **Create a zoning plan for the proposed Regional Conservation Area and its buffer zone.** 07 **Implement capacity-building, environmental education, and communication programs for local residents.**
Long-term conservation benefits	01 **Guaranteed water quality and supply** for rural and urban populations (including Iquitos) 02 **Integrity of the river network** (Nanay, Mazán, Napo) that supports regional transit and commerce 03 **Protection of fundamental resources** (waterways, forests) that are critical to maintaining stable fish populations (including economically valuable species)

REPORT AT A GLANCE

Long-term conservation benefits
(continued)

04 **Established refuge** in Loreto, to mitigate fauna and flora depletion elsewhere

05 **Ensured well-being of communities** along the Nanay, Mazán, Arabela, and Curaray rivers in their subsistence lifestyles

Why Nanay-Mazán-Arabela Headwaters?

Close to the border with Ecuador, a group of headwater streams originate along a small divide in the lowlands. These headwaters give rise to three of the most important rivers in Loreto—the Arabela, Mazán, and Nanay—and provide clean water for the more than 400,000 residents of the capital city of Iquitos. This is the area (747,855 ha) we call "Nanay-Mazán-Arabela Headwaters."

The three watersheds are characterized by distinct geologies, with elements of the ancient Pevas formation occurring alongside Andean formations. The geological diversity begets a tremendous biological diversity that ranges from stunted forest growing on white sands to tall, rich forests growing on clay hills, and includes rare and range-restricted species as well as species better known from the Andes.

The headwaters form part of the proposed biological corridor Nanay-Pucacuro, an area harboring spectacular biodiversity and rich in endemic species. In its entirety, this corridor protects a representative sample of Loreto's diversity, ensures habitat connectivity for migratory species or species with large home ranges, provides a refuge for flora and fauna threatened in areas with more intensive use in Loreto, and engenders source populations of flora and fauna for adjacent areas where resources are used more intensively by local residents.

Local indigenous and riverine populations rely on a barter economy with small-scale extraction of natural resources. Several organizations already exist that promote sustainability and limit excessive extraction by outsiders. With appropriate guidelines, current levels of use could be compatible with conservation of the area.

In the Arabela River and its tributaries, there is substantial evidence of indigenous people living in voluntary isolation. These people represent essential elements of the cultural patrimony of Peru, and their populations are extremely sensitive to disturbance and disease.

N-M-A Headwaters is highly susceptible to disturbances, with its soils currently experiencing nearly continuous natural erosion. Any activity that increases erosion rates would drastically increase river sedimentation, destroying aquatic habitats and fisheries, and damaging water quality within the entire watershed.

The headwaters of nearly all other important rivers in Loreto originate in Ecuador or Colombia, such that decisions in these countries dictate the fate of most of Loreto's watersheds. In contrast, the headwaters of the Nanay, Mazán, and Arabela rivers originate in Peru, creating a singular opportunity for the *Gobierno Regional de Loreto* (GOREL) to manage the area in an integrated manner, ensuring the sustainability of water, timber, and fish resources in the watershed, and the well-being of the region.

Conservation Targets

The following species, forest types, and ecosystems are of particular conservation concern in Nanay-Mazán-Arabela Headwaters. 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.

Biological and Geological Communities	▪ Complex geology and associated poor-to-rich soils developed within the only large headwater region north of the Amazon and outside of the Andes ▪ A unique combination of soils and elevations over 200 m that resemble Andean foothills, but are isolated from the Andes by intervening valleys and at least 300 km ▪ A mosaic of poor, intermediate, and rich soils that span a nearly complete gradient of soil fertilities and that represent habitats not protected within national (SINANPE) or regional protected areas ▪ Aquatic habitats, especially streams including the headwaters themselves, that provide reproductive sites and food resources for fauna (e.g., frogs and fishes)
Vascular Plants	▪ The westernmost extent of the poor-soil Central Amazonian flora ▪ Tiny populations of valuable timber species (e.g., *Cedrela fissilis* and *C. odorata*, Meliaceae; *Cedrelinga cateniformis*, Fabaceae) logged at unsustainable levels elsewhere in Amazonia ▪ Large populations of timber species of lesser value (*Virola* spp., Myristicaceae; various species of Lecythidaceae, Lauraceae, and Fabaceae; *Calophyllum brasiliense*, Clusiaceae; *Simarouba amara*,

	Vascular Plants (continued)	Simaroubaceae) that are increasingly exploited as higher value timber species become extinct ▪ 5–10 plant species potentially new to science
	Fishes	▪ Communities of species adapted to the headwaters, sensitive to the effects of deforestation, and probably endemic to the region (*Creagrutus, Imparfinis, Characidium, Hemibrycon, Bujurquina*) ▪ Species that are probably new to science (*Imparfinis, Cetopsorhamdia, Bujurquina*) ▪ Species of high value in the ornamental fish trade (*Monocirrhus, Nannostomus, Hemigrammus, Hyphessobrycon, Otocinclus, Apistogramma, Crenicara*)
	Reptiles and Amphibians	▪ An abundant population of *Atelopus* sp. (Fig. 7C), a new species within the harlequin frog genus, a genus considered threatened by extinction throughout its geographic range ▪ Two frogs that are new to science, the *Atelopus* sp. and an *Eleutherodactylus* sp. (Fig. 7A). ▪ Species with commercial value such as turtles (*Geochelone denticulata*) and caimans (*Caiman crocodilus*), especially in riparian forests and oxbow lakes along the upper reaches of the Arabela and Mazan rivers
	Birds	▪ A dozen bird species restricted to white-sand forests, which are rare habitats within Peru and Amazonia ▪ Game birds, e.g., Salvin's Curassow (*Crax salvini*), under considerable hunting pressure in other parts of their range, especially in Loreto ▪ Populations of foothill species, isolated from the Andes

	Mammals	▪ Abundant, intact populations of mammals, especially in the Arabela headwaters, threatened elsewhere in Amazonia ▪ Substantial populations of equatorial saki monkey (*Pithecia aequatorialis*, Fig. 9C), a range-restricted primate occurring in Peru only on the left bank of the Marañón River between the Napo and Tigre rivers ▪ Populations of primates that are important seed dispersers but threatened by commercial hunting, especially the white-bellied spider monkey (*Ateles belzebuth*) listed as Vulnerable (IUCN), the red howler monkey (*Alouatta seniculus*), and the common woolly monkey (*Lagothrix poeppigii*) ▪ Populations of giant armadillo (*Priodontes maximus*), listed as Vulnerable (IUCN) and Threatened (CITES) ▪ Top predators, e.g., jaguar (*Panthera onca*) and puma (*Puma concolor*), that are important in regulating prey populations ▪ Populations of Brazilian tapir (*Tapirus terrestris*), an important dispersal agent, especially of large seeds, listed as Vulnerable (CITES, IUCN) ▪ Three bat species (*Artibeus obscurus, Vampyriscus bidens*, and *Diphylla ecaudata*, Fig. 9B) considered Lower Risk/Near Threatened (IUCN)
	Human Communities	▪ Indigenous populations living in voluntarily isolation in the headwaters of the Arabela River ▪ Social behaviors and patterns (e.g., communal work, barter economy) that can buffer villagers from the uncertainties inherent in living in isolated parts of the Amazon ▪ Villagers practicing a self-sufficient lifestyle that is compatible with environmental conservation

RECOMMENDATIONS

Below we highlight a series of recommendations to secure effective conservation of the area and ensure the integrity of the watersheds in the long-term.

Protection and management

01 **Establish a Regional Conservation Area of 747,855 ha that includes the upper Nanay drainage (Fig.2A).** The Nanay is an important river for Loreto, especially Iquitos, and like other key rivers in Loreto, it provides a source of food, water, and transport. Currently, the Nanay headwaters have no formal protection. The Regional Government of Loreto achieved tremendous success with two ordinances—prohibiting dredging machinery and restricting commercial fishing. A similarly successful project was led by the Instituto de Investigación de la Amazonía Peruana (IIAP) in the mid- and lower Nanay where, with legal and technical support, the local residents are organized and recuperating their natural resources. The headwaters of the Nanay should be protected to ensure the continued success of existing projects and the quality of life of residents in the entire watershed. The regional conservation proposal captures the intent of an earlier initiative by IIAP to create a Communal Reserve in the mid- and upper Nanay, now reformulated to protect the headwaters.

02 **Categorize the Regional Conservation Area as "Área de Protección Ambiental Cabeceras Nanay-Mazán-Arabela," managed by PROCREL.** In Loreto, PROCREL represents a tremendous opportunity for regional conservation and is likely the most appropriate entity to manage the area. To guarantee the long-term benefits of these watersheds for Loreto, activities in the region should be carefully zoned and limited to subsistence practices by adjacent communities and uncontacted indigenous people. Management of this new conservation area should be coordinated with neighboring areas: the Zona Reservada Pucacuro, the proposed Reserva Territorial Napo-Tigre, and the proposed Reserva Comunal Napo-Curaray.

03 **Restrict intensive commercial use in Nanay-Mazán-Arabela Headwaters.** The headwaters, which provide essential ecosystem services to a large part of Loreto and supply water to Iquitos, are extremely fragile. The area's soft substrates and steep gradients are subjected to an almost continuous natural erosion, making the headwaters extremely vulnerable to any activity that increases the rate of erosion—timber extraction, oil extraction, mining, or large-scale agriculture. Excluding the timber concessions from the region is critical; however, this alone is not sufficient to protect the headwaters. If other intensive use is permitted in the area, the increase in erosion will trigger heavy sedimentation in the three watersheds, resulting in economic, biological, and social losses for Loreto.

RECOMMENDATIONS

Protection and Management (continued)

04 **Strengthen the proposed corridor Nanay-Pucacuro. The "Nanay-Mazán-Arabela Headwaters Area of Environmental Protection" is part of this corridor.** The corridor will protect the richest biological communities on Earth, unite the megadiverse forests of Peru and Ecuador, and conserve the characteristic richness of Loreto.

05 **Determine the roles of the principal actors in each of the three watersheds, once the Regional Conservation Area is established and under management by PROCREL.** Successful protection of the area will depend on a concerted and united effort by everyone, and should play to existing strengths found in neighboring communities, local authorities, and the national and regional institutions protecting the area. The key actors include GOREL, via PROCREL; local communities, via their management committees and their relevant organizations and representatives in each watershed; local governments, via the relevant legal norms; indigenous federations and *campesino* organizations; and other supporting entities (e.g., forest management committees, NGOs, state institutions).

06 **Involve local people in protection of the area, and strengthen and regulate existing initiatives in the region.** Managing a protected area is much more effective when local residents are integral participants. In Nanay-Mazán-Arabela Headwaters, the role of local people is even more critical because rivers provide such easy access to the region. In the Nanay and Arabela rivers, there are successful local initiatives to control entry into the area by outsiders. We recommend strengthening and regulating these activities and exporting these initiatives to all of the vulnerable entry points in the region. In addition, we recommend empowering local communities in the three watersheds by training voluntary park guards to eradicate illegal hunting, fishing, and logging in their watersheds, and by creating entry fees for outsiders visiting the region.

07 **Establish zoning for uses of varying intensitites in the Regional Conservation Area and its buffer zone, in accordance with the fragility of the soils and ecosystems.** Sustainable use of the area will ensure the well-being of both the uncontacted indigenous people living within N-M-A Headwaters and the communities that live outside of its borders. To ensure successful integrated management and sustainable use of the area, the buffer zone should include part of the Curaray watershed.

08 **Design and implement training, environmental education, and awareness programs.** In the region there is a lack of information about various topics, including the environmental impact of resource extraction in such a fragile area, and how to mitigate these impacts to restore the area. Technical assistance, training,

	environmental education, and awareness are key elements in allowing local communities to make informed management decisions about their watersheds. 09 **Avoid promoting agricultural and livestock programs and prevent invasion by exotic species, as the headwaters are incredibly fragile.** In particular, buffaloes cause enormous damage, destroying habitats and disrupting watersheds.
Further inventory	01 **Map the geology of the region.** There are no previous descriptions of the area's geology. We recommend conducting additional inventories that measure stream water chemistry, describe major landforms, characterize soils, and evaluate water quality. The results can be integrated into a preliminary geological map. 02 **Continue basic plant and animal surveys, focusing on other seasons and other sites.** Survey priorities include the hills inland from the Mazan River, the high terraces and low hills dominated by dead Tachigali trees (easily visible from the air, Fig. 3D), the Arabela River and associated lakes, and the flat region in the Tigre basin, south of Panguana and to the west of the Nanay. For amphibians, reptiles, and fishes, it will be important to do additional surveys during the wet season from October to March. 03 **Conduct longer inventories that can focus on small mammals and bats.** Mammal diversity is highest in smaller-bodied taxa such as rodents and bats, and our inventory was not long enough to adequately sample these groups. 04 **Inventory white-sand areas in the upper Nanay basin.** White-sand areas are rare habitats with low diversity overall, but high levels of endemism. Additional surveys should focus on plant and bird communities. One priority is searching for populations of *Polioptila clementsii*, an endemic bird known only from several dozen breeding pairs in white-sand habitats in the Reserva Nacional Allpahuayo-Mishana near Iquitos.
Research	01 **Evaluate the impact of local fishing and hunting on game populations (fish, birds, mammals).** Use participatory research methods to work with community members and determine which species are most commonly captured, the relative abundances of these species, and the sites most often used for hunting. These data will provide a baseline for long-term monitoring and local management decisions. 02 **Investigate whether large catfishes spawning in the headwaters.** These data will be critical elements in any regional plans for conserving and managing the most important fish resources. 03 **Conduct studies on *Pithecia* monkeys in N-M-A Headwaters.** We are not certain whether we observed one species with great variation in pelage, or two

RECOMMENDATIONS

Research (continued)	species (Fig. 9C). We recommend a revision of the genus, based on the collection of new specimens, behavioral observations, molecular analyses, and a detailed revision of existing museum specimens. 04 **Investigate the archeology of the Panguana region.** Floodplain trees growing on hilltops in Panguana (Fig. 5E) suggest that people may have cleared the rich-soil hills for small-scale agriculture in the last 400-500 years. There may be ceramics or other evidence corroborating past human presence.
Monitor and/or Survey	01 **Establish baseline data on water quality, sedimentation loads, and erosion rates.** Headwater areas are critical for preserving the water quality in the region. Increases in sedimentation and contamination can place local residents at risk, and these data will alert scientists and decision-makers to emerging threats. 02 **Create a practical monitoring plan that measures progress towards conservation goals established in the management plan for the region.** Integral participation of local communities is critical in the design, implementation, and revision of the management plan. 03 **Document illegal incursions into the area.** Priorities include understanding the magnitude of commercial hunting and illegal logging in the area, especially along the Mazan River. 04 **Monitor populations of *Atelopus* frogs, a new species found in Alto Nanay (Fig. 7C).** Currently, Alto Nanay harbors an abundant population. However, other frogs in the genus are experiencing a severe extinction crisis, and it will be important to track the fate of the Alto Nanay population, as well as any additional populations identified in the N-M-A Headwaters.