

# TECHNICAL REPORT

## OVERVIEW OF SITES SAMPLED

For intensive, on-the-ground inventories, we accessed the northern Cordillera Azul at three points (Figures 2 and 3): one in the watershed of the upper Río Pauya (at Pauya Campamento Principal); the second ca. 65 kilometers to the south, along the Río Pisqui (at Pisqui Campamento Planicie); and the third (Pisqui Campamento Playa), 5–6 kilometers upstream and southwest of the first Pisqui site, from where we gained easier access to the mountains.

Helicopter access to the Pauya site was possible because of the labor of J. P. O'Neill and colleagues on the LSUMZ/MUSM ornithological expedition, who prepared and used a heliport just prior to our rapid biological inventory. Rocky, dry-season beaches along the Río Pisqui (Figure 4C) provided access to the other sites, along with a heliport prepared with local Shipibo residents. In addition to several hours of helicopter overflights in transit to our sampling sites, we had 10 additional hours of flight time in small planes, which allowed us to examine other, remote areas of the huge, northern Cordillera Azul. We indicate the most notable of these areas in Figures 2 and 3.

Below, we provide general descriptions of the three major study sites (the Pauya and Pisqui “macrosites”) and the distinct subsites and trails studied within each. These descriptions also apply to the LSUMZ/MUSM expedition to the upper Río Pauya in 2000. For description of the LSUMZ/MUSM study sites in the upper Río Cushabatay, see the Technical Report: Birds, and O'Neill et al. (2000). The range of values in seconds of latitude and longitude reflect the variability of our GPS readings at each study site.

## UPPER RIO PAUYA MACROSITE

Although the Río Pauya eventually runs into the eastern lowlands, its headwaters drain the northwestern peaks of the Cordillera Azul. This uppermost reach of the Río Pauya is roughly parallel to the lower portion of the Río Biabo, though the Biabo runs north and the Pauya runs south. As the Río Pauya continues

downstream, it carves a broad U-turn around a high mountain range ("Serrania del Pauya"), where our access point was located (at Pauya Campamento Principal). The access point was on the west flank of this north-south mountain range. Our sampling ranged from a narrow floodplain at ca. 350 m to mountain ridges at over 1700 m; other parts of the Serrania del Pauya reach 2000 m. Beyond our study sites, the Río Pauya curves northwards, penetrates the western-curving front escarpment of the Cordillera through a narrow opening, and in the lowlands soon joins the Río Cushabatay.

Members of the rapid biological inventory team visited these Pauya sites between 23 and 31 August 2000. We often worked in teams that were sorted by focal organisms. In the technical reports we note the specific dates of visitation by these field teams to the particular subsites.

#### Pauya Campamento Principal

(07°35'09.9–16.7"S, 75°56'00.6–01.6"W, ca. 420 m elevation)

Our main camp in the Pauya watershed, this was also the main camp of the O'Neill LSUMZ/MUSM ornithological expedition that immediately preceded us into the area; they called this Campamento 2. The site was a lowland forest on an alluvial fan, adjacent to a small stream (Quebrada John, after John O'Neill), which flowed to the upper Río Pauya. It was from the heliport and camp that we accessed all other Pauya sites on foot, by trails cut for the LSUMZ/MUSM expedition. One study trail headed west-northwest of camp for several kilometers and met the Río Pauya at about 07°36'02.2"S, 75°57'09.0"W. Two additional trails left the Campamento Principal en route to the next four sites listed below.

#### Pauya Campamento Orilla del Río

(07°36'17.0–22.5"S, 75°56'26.3–28.0"W, ca. 360 m)

This study site was several kilometers southwest of the main camp, in alluvial fan and terrace habitats on the shore of the Río Pauya at the point of its convergence with Quebrada John. The LSUMZ/MUSM expedition called this site Campamento 1.

#### Pauya Campamento Ladera

(07°33'36.1–40.0"S, 75°54'54.5–58.0"W, ca. 1100 m)

The trail running northeast from the Campamento Principal, roughly parallel to the Quebrada John and rising gently but steadily, bifurcated at ca. 510 m elevation (07°34'45.4"S, 75°55'08.1"W). The dominance of palms in the understory decreased steadily as the trail ascended from the lowlands. The left fork of the trail junction climbed to Campamento Ladera. Both the rapid inventory and the O'Neill expeditions used this satellite camp; the O'Neill expedition called it Campamento 4. The camp itself was on a flat ridgetop of tall *Cedrelinga* forest. Above this camp, the trail rose steeply through the spongy, short forest into the shrubland and elfin forest at the ridgecrests, from 1300–1450 m (07°33'21.1"S, 75°54'39.6"W).

#### Pauya Campamento Torrente

(ca. 07°34'15"S, 75°54'40"W; 600 m)

The right fork of the bifurcation mentioned above cuts across several kilometers of lowland forest on hills and intervening alluvial fans and stream beds, until it follows the upper Quebrada John to this temporary camp at streamside, used primarily by the ichthyologists. Approximately 200 meters upstream from this camp, the Quebrada John divides into two smaller streams. The ichthyologists ascended and sampled the east branch ("Torrente Este") for 1.5 kilometers, until they reached 700 m altitude.

#### Pauya Campamento Cumbre

(07°34'00.0–07.5"S, 75°53'31.7"W, 1400–1440 m)

From the Campamento Torrente, the trail climbed steeply upwards for several more kilometers through slope forests along the ridges. The camp was on a sharp ridge in spongy, short forest adjacent to a richer, more humid ravine. The trail then continued along a steep ridge above camp, through landslides into elfin forest and shrublands on the crest, at ca. 1700 m.

### THE UPPER RIO PISQUI MACROSITES

Most of the water entering the southeast drainage of the northern Cordillera Azul finds its way into the Río

Pisqui. The Pisqui and its tributaries, the Quebrada Nucane and the Río Shaypayá, drain the highest part of the front escarpment, the spectacular Serranía de Manashahuemana (meaning “turtle” in the Shipibo indigenous language, see Figure 5A), whose peaks line up like turtles on a log. The upper Río Pisqui is a larger river than the upper Río Pauya and, being closer to its mountain sources, is faster moving. Because of this faster flow, the beaches are mostly covered with stones and small boulders, even though the meanders are larger than those of the Pauya. Our base camps (Campamento Planicie and Campamento Playa) were just below rapids difficult enough to impede navigation by boat. This proximity to higher lands near the river gave us access (from the lower Campamento Planicie macrosite) to high floodplains, various river terraces of different age, and tertiary hills; and (from the higher, Campamento Playa macrosite) to the highest ridges of the small mountain range that separates the Pisqui from the Aguaytía drainage. At Campamento Planicie, our sampling ranged from 220 m to 340 m, between the river and the tertiary hills on the west side (Trocha Huangana). On the east side of the Pisqui, we sampled habitats along Trocha 6 km and Trocha Hacia Apua, from 220 m to 500 m across hills and ancient terraces, and into the watershed of the Río Aguaytía and its tributary, Quebrada Apua. From the upstream camp, Pisqui Campamento Playa, our sampling included transects along the Trochas a las Colinas, from 230 to 600 m on the high hills of the west side, and 230 to 1300 m to the mountain crest on the east side (see Campamentos Quebrada, Subcresta, and Cresta, below). The habitats of the upper Pisqui were all wetter than their counterparts on the upper Pauya.

#### Pisqui Campamento Planicie

(08°24'15.5–22.7"S, 75°42'05.2–06.2"W; ca. 200 m)

This main camp at our second macrosite was on a high, young river terrace with tall, widely spaced, emergent, floodplain trees separated by a lower canopy with many palms and viney thickets. Shipibo hunters have used this as a camp in the past, and we could see evidence of palm and timber harvest locally.

#### Pisqui Trocha Huangana

This 3-km long, newly cut trail ran northwest from our Pisqui Campamento Planicie for 1.9 km, through a high but poorly drained floodplain with a very open canopy, thick with vine tangles (at ca. 200 m) and then ascended to 340 m into low hills with *Cedrelinga* forest.

#### Pisqui Trocha 6 km

This newly cut trail originated on the east side of the Río Pisqui, directly across from Pisqui Campamento Planicie, and ran 6 km due south. The first 3 km of the trail ran through high forest on the young river terrace, and across several small ravines, all between 200 and 280 m elevation. The second half of the trail climbed into low hills and old terraces.

#### Pisqui Trocha Hacia Apua

This path is a route actively used by the Shipibo for travel between the Río Pisqui (which it departs just below the first difficult rapids) and the Quebrada Apua, in the separate watershed of the Río Aguaytía. The path intersects the northern portion of our “Trocha 6 km” very near the river (Pisqui) and soon climbs out of the young floodplain to over 500 m in the hills and sandy, ancient terraces, then descending to meet the Quebrada Apua at ca. 245 m, 08°26'12.2"S, 75°40'49.7"W.

#### Pisqui Campamento Playa

(08°25'57.8"S, 75°43'43.2"W, ca. 260 m)

This main camp was the hub of our third macrosite. It was perched on a slightly raised island of the floodplain between a broad, dry, rocky, seasonal beach of the Pisqui and a small stream. Tall, floodplain forest, early-successional forest, and the vegetation of rocky and sandy beaches and rocky riverbanks surrounded the camp. This camp was ca. 2 km above the point where the Quebrada Nucane joins the Río Pisqui, on the opposite river bank.

#### Pisqui Campamento Quebrada

(estimated as 08°27'15"S, 75°43'46"W, too dense for a GPS reading; 310–320 m)

This satellite camp was adjacent to a small, swiftly flowing stream along the newly cut trail running from

Campamento Playa on the river up to the mountain crests. The hill forest here was a mixture of elements from the floodplain and hills above (see Vegetation and Flora in Overview and Technical Reports for more detail).

#### Pisqui Campamento Subcresta

(ca. 08°28'35"S, 75°43'49" W, 1150–1170 m)

A camp in short, spongy forest on a narrow ridge, ca. 30 minutes (nearly vertical) walk below the crest of the mountain.

#### Pisqui Campamento Cresta

(08°28'45.6"S, 75°43'52.1" W, ca. 1220 m)

This terminus of the newly cut trail from Campamento Playa was in moist, very mossy, elfin forest with scattered, larger trees, on the exposed crest of the mountain ridge that sits southeast of the point at which the Río Pisqui emerges from the mountains.

#### Pisqui Trochas a las Colinas

There were two trails on the west side of the Pisqui, both upstream from our Campamento Playa. The first was a poorly marked trail that leaves the Río Pisqui at ca. 265 m and 08°26'26.6"S, 75°44'21.7" W (at the limit of navigation, from a bank of solid rock), and runs up the surrounding hills. The trail is used only occasionally by hunters and itinerant loggers. Tall, lowland forest at riverside becomes slightly drier, and more frequently disturbed on the ridges, which are separated by shallow, humid valleys. We reached ca. 510 m on this trail, at which point it faded away. The second trail, newly cut, was further downstream across from the Pisqui Campamento Playa and crossed old river terraces and high hills, along with several streams, until reaching a sharp drop-off at 600 m. Continuing in the same direction, one would soon encounter the main escarpment of the Cordillera.

## GENERAL PHYSIOGRAPHY, GEOCHEMISTRY, AND CLIMATE

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### PHYSIOGRAPHY

The northern Cordillera Azul encompasses a complex of smaller mountain ranges and represents the easternmost outlier of the Andes at this latitude, except possibly for the much lower Serrania de Contamana, just east of the Río Ucayali, which remains poorly known and may be geologically distinct. Each range is a separate, uplifted block of mostly Jurassic and Cretaceous strata, which predominate in the northeastern Peruvian Andes south of the Río Marañón. Most of these uplifted, tilted blocks are oriented north and south, but some curve to run east and west. The easternmost uplift, the most recent of all, is a long, remarkably uniform, sinuous ridge system, which seen in the satellite images resembles the shape of a mammalian spinal column (Figure 2). This eastern escarpment of the Cordillera forms a sheer wall blocking access to the southern two-thirds of the northern Cordillera Azul from the eastern lowlands. Only the Ríos Pauya, Shaypaya, and Pisqui penetrate this formidable wall of mountains (towering 1800 m above the adjacent lowlands) through a few narrow openings. To the north, this escarpment curves westward and smashes into the north-south running escarpment that terminates at the Río Pauya (just north of our upper Río Pauya study sites).

In the northeasternmost part of the Cordillera Azul, a similar but lower escarpment faces northeast and is bisected by the Río Huallaga to the north. In the broad gap between this steep, northeastern wall and the main escarpment to the south, the Río Cushabatay penetrates into two low, broad, ridge-filled basins. Northward, these basins constrict into narrow necks, separated by a high north-south running mountain range with peaks of 1700 m and higher. The broader, western basin is an extraordinary geological formation with long, low, flat, anvil shaped ridges sloping to the south and a virtually flat-bottomed center (elevation 450 m) with dozens of emerging small, steep ridges up

to 400 m. Nested within this strange landscape is a large, isolated blackwater lake. A tributary of the Río Chipuruna drains this northern part of the basin, then plunges through a narrow canyon in the eastern wall and finally runs north to merge with the Río Huallaga.

In the central portion of the northern Cordillera Azul, the eastern slopes of the peaks (to 2400 m) drain down narrow openings to the Río Ucayali. The west slopes of these peaks drain into the straight, northward flowing valleys of the Río Biabo, and eventually to the Huallaga. Just south of the upper Río Pauya, an eastern branch of the Río Biabo drainage comes right up to the west slope of the east wall. In the southernmost portion of the northern Cordillera Azul, a small river passes through high-elevation swamps and into the upper Huallaga to the southwest. These high swamps (at 1400 m elevation) are an unexpected feature in such close proximity to steep mountains. A newer uplift of very hard rock presumably formed these unusual swamps by blocking the drainage of a valley.

A distinctive geological feature, the “Vivian formations”—rows of giant, flat, sloping triangles of rock up to 7 km broad at the base and 4 km from the base to the tip (but usually smaller), resembling “zig-zags” (Figures 7E, 11)—are well developed and almost perfectly symmetrical in two areas of the northern Cordillera Azul. One is a 50-km row of Vivians along the east slope of the mountains running north of our study sites on the upper Río Pauya. The other is a 20-km stretch of smaller, 2–3 km broad Vivians running east-west from the main eastern escarpment, just south of the “U-curve” formed by the Río Pauya (Figure 2). Smaller versions of similar, sloping rock triangles occur in other ranges in the Cordillera. Recent uplift of very erosion-resistant rock, such as quartzite, and concurrent erosion of much softer rock beneath it, presumably created these Vivian formations. Drainage from the higher mountain valleys above the Vivian formations continues to carve gaps between the segments, often resulting in spectacular waterfalls. North of the Río Pauya are higher and presumably older rows of Vivians that are more eroded, but still maintain their basic “zig-zag” form.

The high range of hills in the forestry concessions between the Río Ucayali and the eastern escarpment of the northern Cordillera Azul appear to be the beginning of the uplift of the next mountain range, as the Nazca Plate at the bottom of the Pacific Ocean continues to slide eastwards under the South American continent. This uplift will take a while, but this phenomenon emphasizes the unstable and geologically dynamic nature of the eastern slopes of the Andes. The area shows considerable indication of old seismic activity, with ridge systems displaced along fault lines and recent activity, as evidenced by massive simultaneous landslides in several areas. One of these earthquakes occurred within the last few years, in the mountain range just north of the Río Cushabatay: a “huaico” mudslide, from the merged landslides, damaged a wide swath along a northern tributary of the Cushabatay, the Río Inahuaya (Figure 8A).

#### GENERAL GEOCHEMISTRY

The Jurassic and Cretaceous strata that make up most of the Cordillera Azul are formed from a mixture of mostly very acidic, continental and marine sediments. The area has more surface coverage by acidic types of rock than any other reserve in the Andes. Neither the Bahuaja-Sonene park, nor the Manu, Vilcabamba, Yanachaga, or Abiseo reserves have such extensive nutrient-poor rock formations within their mountains. This rock appears to be mainly soft sandstones, but may include harder quartzites or granites and other rock that creates acid soils. In Peru, only the top mesa of the Cordillera Condor and the Tabaconas Namballe reserve north of the Río Marañón have large extensions of sandstone, but they represent less extensive coverage of the mountainous areas.

In contrast to the nutrient-poor strata that dominate the mountains, the less extensive lower slopes and lowlands of the northern Cordillera Azul have considerable exposure of rich strata such as limestones and rich alluvial terraces. These slopes date to the Cretaceous-Tertiary boundary and more recent Tertiary and Quaternary sources. They are sometimes interlaced

with pockets of acid soil, usually displaced from above, just as there are some strata of more basic soil perched higher on the mountains. The recent (Tertiary) hills extending from the mountains eastwards are mostly intermediate in acidity.

## CLIMATE

This region is subject to the southern-hemisphere pattern of drier periods from June/July to October/November. These periods of drought are likely not as severe or prolonged as they are to the south, in Madre de Dios, but from our observations they are clearly more pronounced than the weak dry-periods that the Iquitos area experiences around August. The prevailing winds during these drier periods bring moisture northwards from Argentina and Bolivia with the frontal systems locally known as “friaje.” The highest mountains of the northern Cordillera Azul are in the south, and pose a barrier to this northward flow of moisture. The eastern wall of the Cordillera, in turn, blocks moisture arriving across the Amazonian plains to the east. As a consequence, the northwest part of the northern Cordillera Azul appears to be driest at all elevations. We predict that the two broad basins in the northeasternmost portion of the proposed Parque Nacional Cordillera Azul Biabo get more rainfall and cloud moisture in the dry period than does the upper Río Pauya region, because of the gap in the east wall and subsequent funneling of clouds to the northwest, into these basins.

## FLORA AND VEGETATION

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**Conservation targets:** 1) all plant community types (floodplain forests, alluvial terraces, hill forests and lower slopes; short, spongy forests; elfin forests; shrublands and meadows on upper slopes and crests; swamps at middle and high elevations; isolated lakes); 2) plant species commonly overexploited (*Swietenia macrophylla*, *Cedrela odorata*, *Cedrelinga catenaeformis*, *Amburana cearensis*); and 3) new and rare species.

## METHODS

### Flora Sampling

***Collections:*** Abiding by INRENA’s decision, we were unable to make botanical collections during the expedition.

***Photographs:*** We photographed plants for documentation and possible later identification and verification, as well as to create color field guides to the species of the area. We took an estimated 1000 pictures of 500 species.

***Species notes:*** In the field and during overflights, we noted easily recognizable species, or species not accessible for photographs.

### Vegetation Sampling

***Transects:*** We used variable transects (Foster et al. ms., [www.fmnh.org/rbi](http://www.fmnh.org/rbi)) to sample composition and relative abundance of different classes of plants. For emergent trees (>60 cm DBH) and canopy trees (>30 cm DBH), we recorded all individuals encountered along 20-m wide strips. For medium, subcanopy trees (10–30 cm DBH), we used 5-m wide strips. For shrubs (1–10 cm DBH) 1-m wide strips, and for herbs we used 1 x 5 m segments with each species represented once per segment (because most herbaceous forest plants are clonal). In sum, we conducted 16 transects in 6 areas, with 1660 individuals sampled.

***Vegetation Notes:*** We made anecdotal observations during overflights and on the ground, noting differences in composition between lowland, slope, and crest forests; canopy and understory plants; successional versus older stands; frequency of open versus closed canopy; patchiness of species; forest dynamics including regeneration from windthrow, landslide, and fire.

## RESULTS

The outline below lists the physiographic habitats we recorded within the northern Cordillera Azul. Some of these we documented only from overflights. Later in this section (under Pauya and Pisqui study sites), we describe in more detail the habitats that we were able to examine closely.

## Lowlands

### River floodplain

#### Periodically flooded

- Active beaches
- Shrub and vine thickets
- Early-successional forest (*Cecropia*, *Ochroma*,  
*Guazuma*)

#### Tall floodplain forest

#### Stable alluvium

#### Eroding banks

#### Rocky-river-margin

#### Oxbow lakes

#### Swamps

#### Non-flooded, recent (Quaternary) terraces

#### Rock and gravel terraces

#### Sandy terraces

#### Clay terraces

#### Swampy terraces

### Foothills

#### Alluvial fans

#### Stream edges

#### Well-drained soils

#### Disturbed areas (landslides, washouts, human activity)

#### Very acid alluvial soils

#### Tertiary hills and ancient terraces

#### Limestone hills

#### Semi-acid hills

#### Sandy terraces

#### Stream edges

#### Disturbed areas

## Mountains

### Slopes

#### Basic or semi-acid rock

#### Valleys

#### Ridge slopes

#### Landslides

#### Very acid rock substrates

#### Valleys

#### Ridge slopes

#### Narrow, horizontal ridges

#### Vivian formations

#### Landslides and sheer rock walls

#### High Crests (the highest peaks and ridges that are frequently cloaked by clouds)

#### Basic or semi-acidic rock

#### Broad summits

#### Narrow summits

#### Small, high-altitude streams

#### Landslides

#### Very acid rock

#### Broad summits

#### Narrow summits

#### Small, high-altitude streams

#### Landslides and sheer rock walls

### High marshlands and swamps

#### Open water

#### Water with floating vegetation

#### Shrub thickets

#### Bamboo groves

#### Palm stands

## FLORISTIC RICHNESS, COMPOSITION, AND DOMINANCE

In our brief visit to the northern Cordillera Azul, we were able to distinguish 1616 different species of plants. We identified 566 of these to the species level; most of the remaining 1050 species will not be identified, because we were not permitted to collect voucher specimens. With only three weeks to survey the northern Cordillera Azul, we did not intensively study the lianas or epiphytes, such as orchids. We estimate that the flora in the proposed Parque Nacional Cordillera Azul Biabo has between 4000 and 6000 species of vascular plants.

## VEGETATION AND FLORA OF THE PAUYA MACROSITES

### Lowlands: Floodplains

The upper Río Pauya floodplain, narrow and meandering, leaves a few small ox-bow lakes and a very short series of levees covered by successional bands of vegetation. The narrow beaches are silty, with scattered stones, and the successional strip closest to the river is usually a band of *Gynerium* (caña brava). When these levees age and stabilize, other successional species emerge, also typical of Amazon floodplains: *Cecropia membranacea*, *Guazuma crinita*, *Triplaris americana*, *Acacia lorentensis*—but only occasional *Ficus insipida*. Whatever *Cedrela odorata* may once have been on these older levees is now gone. Dense tangles of vines, and extensive, understory stands of the stemless *Phytelephas macrocarpa* palms—mixed mainly with *Astrocaryum* and *Attalea*—cover some poorly drained floodplains. *Phytelephas* also occurs in scattered patches in the hills and other unflooded areas, but never in such large stands. These poorly drained areas along the Río Pauya may be flooded only infrequently. They show abundant evidence of frequent use by herds of white-lipped peccaries. *Petiveria alliacea* shrubs are very abundant here, and their seeds are probably dispersed by attaching themselves to the peccaries. Old floodplain forest or high terraces seem absent; they may be obliterated by frequent landslides and washouts (huaicos) on the alluvial fans.

### Lowlands: Alluvial Fans and Dry Hills

A scattering of very low hills separates the mountains from the floodplain of the Río Pauya. The shallow corridors between the hills have allowed extensive development of alluvial fans of sediment—filled with rocky boulders—spreading out in a gradual slope from the base of the mountains to the river. The rock underlying the soils on the hills appeared to be limestone or some similar, non-acidic rock. Forest canopies with a high frequency of deciduous species, along with understories dominated by palms (Figure 4D), characterize the alluvial fans and dry hills. There is considerable floristic

overlap between these two habitat types. The emergent deciduous species are largely genera of Bombacaceae (such as *Matisia*, *Pachira*, and *Ceiba*, as well as *Hura crepitans*, *Gallesia integrifolia*, *Apeiba membranacea*) and several Fabaceae (*Apuleia leiocarpa*, *Dipteryx micrantha*, and *Amburana cearensis*). These are mixed mainly with evergreen species of Moraceae (with conspicuous, truly enormous individuals of *Ficus schultesii*), Sapotaceae, Chrysobalanaceae, and other Fabaceae. Many or most of these species would occur in old floodplain terraces if these habitats existed along the Río Pauya. The understory of alluvial fans and dry hills has a mixture of palms, but is heavily dominated by *Attalea phalerata* and *Astrocaryum murumuru*, which are also characteristic species of old floodplains.

Low hills and alluvial fans, which are closely juxtaposed, differ primarily in that the hills have a less dense canopy but higher diversity of trees, and an obviously greater density and diversity of lianas (often with large tangles of lianas), shrubs, juvenile palms, and ephemeral herbs. The hills also have large patches of the terrestrial bromeliad, *Pitcairnia*, which spreads vegetatively. On the alluvial fans, the deep-rooted palms probably have greater access to underground water than do those on the hills. This may permit denser packing of these palm species and subsequent shade inhibition of the establishment of lianas, shrubs, herbs, and other tree species. The herbs on the alluvial fan are dominated by a few, vegetatively spreading species. The age of the forest also may be relevant to this difference between the hill and alluvial-fan forests. Large segments of the alluvial fans are typically formed during a single, major disturbance, such as a major mud and rockslide that covers an area and wipes out most of the existing trees. Such an event generates a relatively uniform successional development on the mud, sand, and rocks that are deposited—much like the development on floodplain beaches.

We crudely estimate that the age of what appears to be successional forest on the alluvial fan at our Pauya Campamento Principal is about 200 years. We base this estimate on the size of individuals of

different species, their estimated growth rates, and the composition of other successional tropical forests of known age. The alluvial-fan forest probably has not had as much time to accumulate species as has the hill forest, nor have the alluvial fans had as many large treefalls that would allow lianas and other understory species to become established.

Likewise, because of their presumably recent origin, and perhaps also because of their seasonal instability and canopy cover, the small streams that run through these alluvial fans have only a few plant species associated with their banks, such as *Ochroma*, *Cecropia*, *Croton lechleri*, *Condaminea corymbosa*, *Banara guianensis*, *Vernonia megaphylla*, *Urera laciniata*, *Liabum* sp., and the grass *Arundinaria berteroniana*.

As is true in most semideciduous forests, epiphytes are only occasional in the hill and alluvial-fan forests. The most unusual and conspicuous epiphyte in these lowlands is the staghorn fern, *Platynerium andinum* (Figure 9E). The few other localities in Peru and Bolivia where this fern occurs are low Andean valleys with dry deciduous or semideciduous forest, but with a distinct climatic feature: the valley bottoms consistently form a low cloud or fog layer at night during the dry season, which does not dissipate until mid-morning. From our experience (and that of John O'Neill, pers. comm.), such fog is present almost every morning in the upper Río Pauya valley, covering most of the lowlands. It is reasonable to expect that some other species of epiphytes, especially orchids, also occur in this valley because this unusual climatic phenomenon allows them to absorb moisture and survive the dry season, despite being stuck to the sides of dry trees. In most dry forests, the only epiphytes that survive are those that basically shut down during the dry season.

These dry conditions change dramatically closer to the base of the mountains, where the surrounding slopes and hills increasingly crowd the streambeds. Here, humidity is high even during the dry season. Species found downstream, in drier habitats, also occur here, but these moist banks are much richer in species, have an abundance of *Siparuna* and *Myriocarpa*, have more

epiphytes on tree trunks, and are richer in herb species (especially ferns, aroids, and *Peperomia*). The canopy over the adjacent, alluvial slopes is also more evergreen and richer in species. The large palm, *Iriartea deltoidea*, which is so common in most of the upper Amazon floodplain and hill forest, finally makes its appearance here. The understory is more speciose, but with few and different palms, and with occasional aggregations of single species such as the large-seeded *Patinoa* (Bombacaceae). Overall, the hills adjacent to the mountains are not so different from the hills closer to the river. They have dry soils, frequent vine tangles, and much the same flora (including the palms) that make up so much of the alluvial-fan forests downslope. The floras of the hills and recent alluvial fans converge in composition when closer to the river but diverge when closer to the mountains, apparently because the humidity and/or soil moisture in the dry season are more constant on the hills than on the lower-lying alluvium.

### Mountains: Slope Forests

Because our trails up the mountains of necessity followed the ridges and not the valleys, this description of vegetation is confined mostly to ridge slopes. As in mountains everywhere, the vegetation of lower elevations typically reaches a higher elevation in the valleys than it does on the ridge slopes.

*Dark-brown clay forest* – The vegetation of the ridge slopes, from ca. 600 to 900 m, is evergreen and grows mostly on dark-brown, slippery clays. These clays appear to be rich, basic soils and are slippery in part because the plant roots embed themselves in the clay rather than form a superficial mat (as occurs on the more acidic soils), and also because such rich soils usually support a slick, superficial growth of algae.

The flora on these dark-clay soils mostly consists of species found in rich-soil lowland forests, especially those in moist areas such as near the mountains. Few of the deciduous species of the lowlands are here. A large, herbaceous fern, *Metaxya rostrata*, covers much of the steep slopes. One area of understory was

dominated by a rare genus of small trees, *Sanango* (Buddlejaceae, Loganiaceae, or Gesneriaceae).

*Cedrelinga forest* – On some, but not all of the ridge slopes, between 900–1100 m or higher, are areas with semi-acid soil and a vegetation remarkably similar to that of the semi-acid Tertiary hills in the lowlands (Figure 7A). These relatively flat areas, perched halfway up the mountainsides, have a moderate amount of surface roots. The forest canopies are dominated by huge *Cedrelinga catenaeformis* (tornillo), as well as by large *Brosimum utile*, *Tachigali vasquezii*, *Protium*, and *Attalea maripa*. Species such as *Wettinia augusta*, *Faramea capilipes*, and *Palicourea punicea* dominate the understories. All these species usually occur on lowland hills, at elevations of 200 to 400 m. Some kind of older rock, or mixture of rocks, has apparently given rise to a soil that nearly duplicates that of the common Tertiary sediments and these plant species have managed to disperse up to the higher elevations. An analagous situation occurs on the limestone strata of the upper Río Pisqui slopes (see below).

A few abundant species in these forests, such as the common *Protium* and some of the *Geonoma* palms, occur also in the short, spongy, forest above, and sometimes in the dark-clay forest below. Where *Cedrelinga* forest is missing on the mountain slopes, several of its species occur in the short transition between the dark-clay soils and the higher, spongy forest over sandstone. A few species not seen elsewhere, e.g. a terrestrial *Anthurium* and a terrestrial *Elaphoglossum*, are also noticeable on these transitions.

*Short, spongy forest* – During our overflights, we observed that the ridge slopes above 900 m, and often lower, usually are covered with a distinctive forest of reduced stature. This forest is short, usually about 10 m tall, and covers an acidic, soft, pink sandstone. The soils on these ridges are apparently so lacking in nutrients that plant roots are almost entirely on the surface, where they catch what nutrients come their way in rain- and litter-fall. This creates a deep mat of roots and other organic matter that, when stepped on, sinks down and bounces back with a “spongy” feel. The analogy probably holds,

in that this root mat probably holds water on or near the surface of the soil much as a sponge would.

This short, spongy forest is not as rich in woody plant species as are forests lower down the upper Pauya slopes, but it appears to have a high number of epiphyte species. The dominant trees are a large-leaved *Pouteria*, a *Bonnetia paniculata*, and three species of capsulate *Graffenrieda* (Melastomataceae). These are mixed with a couple dozen other species of small-tree genera, such as *Clusia*, *Miconia*, *Schefflera*, *Alchornea*, as well as *Dictyocaryum* palms and genera of Myrtaceae and Lauraceae. The common *Pouteria* also occurs in the semi-acid soils of the *Cedrelinga* forest, lower on the slopes. Meanwhile, the *Bonnetia* and the *Graffenrieda* species, among others, also occur in the shrublands of the high mountain crests, but with smaller stature.

The understory of this short, spongy forest frequently has small bamboos such as *Chusquea*; common understory herbs include *Schizaea elegans*, *Lindsaea*, and *Trichomanes*. The commonest vines are species of *Mikania*, *Piptocarpha*, *Dioscorea*, *Gnetum*, the climbing ferns *Sticherus* and *Dicranopteris*, and an occasional, climbing Ericaceae. Parasitic Loranthaceae are conspicuous.

Species with small, wind-dispersed seeds dominate the flora of the short, spongy forests and of the higher, elfin forests and shrublands, all of which are underlain by acid rock. While several genera of Melastomataceae, Rubiaceae, Myrtaceae, and Araliaceae, in addition to the *Pouteria* species produce animal-dispersed fruit in these habitats, most of these were not fruiting during the dry season. This is important, considering how much of the northern Cordillera Azul is covered with this kind of forest. These areas probably support local migrations of frugivorous birds and mammals in the wet season, rather than having resident populations year-round.

Colonization of steep landslides in this habitat is variable but usually includes a white-leaved *Guettarda*, *Tibouchina*, *Oreocallis*, several species of the crawling ferns *Sticherus* and *Lycopodiella*, and several Asteraceae and Cyperaceae.

The wet ravines and small valleys we were able to inspect at the higher elevations seemed richer in species and had a radically different flora from the ridgetops, as well as being totally different from the stream margins at the base of the mountains. In the ravine near our Pauya Campamento Cumbre, at ca. 1400 m, we did observe a large-fruited *Capparis*, as well as *Chrysochlamys*, *Aegiphila*, and the unexpected *Chaetocarpus echinocarpus* (see below). But our observations were insufficient to generalize about what was common in these habitats.

### Mountains: High Crests

The crestlines of the mountaintops and the highest ridges are often horizontal or gently sloping surfaces, exposed to wind, lightning, and frequent mist, as well as to occasional, severe droughts.

*Shrublands and elfin forest* – The crests of the mountains above the Río Pauya, as well as in most of the northern Cordillera Azul, are underlain by very acid, hard rock that has resisted erosion. The plants that live in such areas are usually slow-growing species, often with high concentrations of polyphenolic compounds, which make them vulnerable to fire during extreme drought. We have no evidence that these fires are very frequent on the mountain and ridgetops, but they appear to be frequent enough to have caused the formation of dense shrublands at elevations one normally would expect to find forest (Figures 7E, 7F). Such fires need not occur more than once every one or two centuries to suppress the forest and maintain a shrubland. It is not unreasonable to expect that something like the El Niño/La Niña phenomenon could, at rare intervals, cause extreme drought in the drier parts of the northern Cordillera Azul, and that this would make the crests and ridges vulnerable to lightning fires over small areas.

On both high crests we visited in the Pauya, a high, flat ridgetop at 1400 m and the mountain crestline at 1700 m, the shrubland (2 to 3 m tall) has many species in common with the short, spongy forest lower on the ridge slopes. The same tree species are present, but stunted and separated enough that a large number

of other shrubby species, which do not occur with any regularity in the short forest, also survive here. Common shrubs that are mostly restricted to these mountain crests are several Rubiaceae, such as *Retiniphyllum* and *Pagamea*, the dwarf palm *Euterpe catinga*, *Purdiaea nutans* (Cyrillaceae), *Macrocarpaea* (Gentianaceae), and a few Myrtaceae and Myrsinaceae. It is not clear that epiphytes are any more numerous or diverse here than in the short forest, but they are more often noticeable at eye level. Many of the large bromeliad species are both epiphytic or terrestrial.

The shrublands are interspersed with wet depressions or small ravines that bear a slightly taller, elfin-forest vegetation, usually 4–9 m tall. This elfin forest appears to be a shorter version of the short, spongy forest, mixed with the species of wet ravines and of the shrubland itself. As such, the elfin forest, a mixture of plants from different habitats—a three-way ecotone—is extremely rich in species. A sample of all vascular plants in a very small, 20 m by 1 m, strip through flat elfin forest at 1400 m contained a remarkable 47 species. Many of the rare and new plants we found in the northern Cordillera Azul were in this mosaic of vegetation. The *Parkia*, *Talauma*, *Stenopadus* were all emergents in the shrubland and not seen elsewhere, although *Talauma*, found along a tiny streamlet, might be present as well in the high ravines, which we did not investigate. The tiny fern *Schizaea poeppigiana*, known previously from a single collection made 170 years ago, was in an open section of low shrubland, growing out of a mat of *Sphagnum* moss and *Cladonia* lichen.

## VEGETATION AND FLORA OF THE PISQUI MACROSITE

### Lowlands: Floodplains

The floodplain of the upper Río Pisqui rapidly broadens after the river emerges from the canyon at the base of the mountains. Much of this floodplain is elevated, however, and only becomes inundated in the highest of floods, perhaps not annually. Thus, this stretch of the river course is analogous to an alluvial fan, confined by high terraces or hills on either side. The river meanders

and splits mostly by large leaps of position, which create broad strips of nearly even-aged successional forest along the floodplain.

The floodplain we studied intensively was just below the first serious rapids of the Pisqui, and the gradient was already shallow enough that there was poor drainage throughout. The result is a fairly high terrace but with open, semi-swampy vegetation over most of it; it was lowest and wettest where the floodplain meets the hills. We saw similar floodplains in our overflights of many parts of the upper Río Pisqui and other rivers east of the Cordillera. These poorly drained floodplains are unpleasant places for humans, though the white-lipped peccaries have a great affinity for them (presumably due to the abundance of palm fruits). The forest was thick with vine tangles, spiny and urticating plants, and the greatest concentration of stinging and biting ants that we have ever seen.

The better-drained pockets of the floodplain had many of the typical large floodplain trees, such as *Ceiba pentandra*, *Dipteryx micrantha*, *Matisia cordata* and *M. bicolor* (both also abundant in the smaller size classes), *Clarisia biflora*, and *Ampelocera ruizii*. The high density of *Sterculia apetala*, a species usually not very abundant, was surprising. The wetter, more-frequently flooded areas of the floodplain, when not devoid of canopy trees, had an abundance of *Mauritia flexuosa* palms, the conspicuous, orange-red flowered *Erythrina poeppigiana*, *Ficus insipida* and *F. maxima*, and *Acacia lorentensis*.

The conspicuous medium-sized trees of the floodplain were mainly the palms *Astrocaryum murumuru*, *Iriartea deltoidea*, and *Socratea exorrhiza*, but also abundant were *Dendropanax arboreus*, *Chrysochlamys ulei*, *Lonchocarpus spiciflorus*, *Pleurothyrium* sp., *Otoba parvifolia*, *Leonia crassifolia*, and various species of *Pourouma*, *Inga*, and *Guarea*. No single species in the shrub class was particularly common, and a large proportion of them were juvenile trees. The herbs, in contrast, were dominated by a *Calathea*, a *Pariana*, and a tiny *Psychotria*.

The stony beaches along the Río Pisqui are colonized frequently by *Baccharis salicifolia*, *Calliandra*

*angustifolia*, and several herbs, but these stands seem to be ephemeral; a successional sequence to *Gynerium*, *Cecropia*, and *Ochroma* does not seem to occur until sand and clay has accumulated. Where the river meets the bedrock of the hills, a different, more stable riparian vegetation is established, dominated by overhanging trees of *Zygia longifolia*; shrubs of *Ardisia*, *Eugenia*, *Psychotria carthaginensis*, and a small *Acalypha*; and a specialized set of small herbs clinging to the rock: *Matelea rivularis*, and a *Justicia*, *Ruellia*, *Spigelia*, and a species of *Cuphea*.

#### Lowlands: Terraces and Hills

The relatively recent (Quaternary) terraces on either side of the upper Río Pisqui are mostly 5–25 m above the river level in the dry season, and the adjacent hills are 50–200 m above that. The terraces, which are essentially old floodplain, have many species in common with the younger floodplain. However, there is an almost continuous gradient of species into the flora of the adjacent hills. The forest composition varies considerably from place to place within these species-rich habitats, and it is difficult to recognize distinct communities. Mostly, the hills are very dissected, steep, and with frequent landslides.

Dense stands of single species are common in the understory of the hills. Among the most conspicuous are areas dominated by the herbaceous *Danaea* spp., *Clidemia heterophylla*, *Spathiphyllum*, *Calathea wallisii*, and *Calathea altissima*; or shrubs and small trees belonging to *Hippotis*, *Rinorea*, and *Galipea*. We did not sample sufficiently to compare the hills on opposite of the river, but did notice dense stands of *Rinorea viridifolia* and *Esenbeckia amazonica* on the hillslopes of the west side of the river but not on the east.

The following, distinct habitat types are exceptions to the general heterogeneity of the hills:

*Cedrelinga forest* – This distinctive community is associated with the semi-acid, reddish sandy clays on the Tertiary-age hills. Such hills are less eroded than the other hills and usually gently sloping, with tall closed-canopy forest and a conspicuous presence of

large *Cedrelinga catenaeformis* (now mostly as stumps). The most common understory shrub is usually *Tabernaemontana undulata*.

Ancient sandy terraces – Along the top of the broad system of hills (ca. 500 m) that separate the upper Río Pisqui from the Río Aguaytía drainage (along the Trocha Hacia Apua trail), there are extensive flat terraces of very sandy, brown soil. Though not as extreme as the white-sand soils of the Iquitos region, these terraces have a distinctive understory composition with a high density of two pole-like, long-branched treelet species of Flacourtiaceae (*Neoptychocarpus killipii* and *Ryania speciosa*) and small *Iriartella stenocarpa* palms, with a high frequency of *Rapatea* among the herbs (Figure 4E). These terraces are dotted with poorly drained depressions, some at least a hectare in size, with mono-dominant stands of a small-leaved species of *Zygia* trees.

#### Mountains: Upland Slopes

The slopes of the upper Pisqui Mountains, below 500 m elevation, did not differ noticeably from the high hill-forests. They appeared to have semi-acid, clay soils rather than any basic, dark-brown soils as found on the lower slopes of the upper Río Pauya. But higher on the slopes were two distinctive plant communities.

Limestone forest – Slope forests between 500 and 600 m along the trail connecting the Pisqui Campamento Quebrada and Pisqui Campamento Subcresta had a distinct stratum of exposed limestone and slippery, derived soils. This resulted in a rather stunning band of tree and understory species from the floodplain and low alluvial fans, perched atop the mountainside. Even the typical lowland cedro, *Cedrela odorata*, was here rather than the typical hill species, *Cedrela fissilis*. Floodplain tree species found in this limestone band included *Stryphnodendron*, *Lunania parviflora*, *Garcinia madruno*, *Patinoa*, *Matisia cordata*, *Cedrela odorata*, *Schizolobium parahybum*, *Tetragastris altissima*, *Guarea pterorhachis*, *Zizyphus cinnamomum*, *Caryodaphnopsis fosteri*, *Quararibea wittii*, *Theobroma cacao*, *Otoba parvifolia*, *Clarisia racemosa*, *Triplaris*

*poepigiana*, *Ceiba pentandra*, *Posoqueria latifolia*, and *Astrocaryum murumuru*. Shrubby floodplain species present were *Tabernaemontana sananho*, *Randia armata*, 2 *Clavija* spp., *Piper reticulatum*, *Pentagonia*, *Sanchezia*, *Urera baccifera* and *U. caracasana*, *Pachystachys*, *Ixora peruviana*, *Calyptanthes longifolia*, *Calycolpus*, and *Acalypha macrostachya*. Finally, also present were the floodplain climbers *Monstera obliqua*, *Omphalea diandra*, and *Anomospermum grandifolium*; and floodplain herbs *Tectaria incisa*, *Cyclopeltis semicordata*, and *Pariana* sp.

Horizontal ridges of small palms and rubiaceaceous trees – At approximately 750 m altitude, and at intervals above that, the ridges our trails followed flattened out over what appeared to be a much sandier, erosion-resistant rock. Two of the conspicuous understory plants of the ancient Tertiary, sandy terraces—*Iriartella stenocarpa* and a *Rapatea* sp.—are abundant here. But this time they were mixed with dense stands of several other palm species, such as *Geonoma maxima*, another *Geonoma* sp., a *Bactris* sp., and *Wettinia augusta* in the understory, with an overstory largely composed of several arboreal species of Rubiaceae with capsulate fruits and wind-dispersed seeds. Lacking abundance of fleshy fruits and edible seeds, these are not likely to be popular areas for vertebrates, except for the few that take advantage of small, hard palm fruits.

Though quite exceptional, neither the limestone forest nor this flat-ridge forest was easily recognizable from the air, except that the limestone forests had a greater frequency of deciduous trees and more vine tangles than surrounding forests on semi-acid soil. The forest on the ridgeslopes apart from these two habitats was less distinct.

The forest on the ridge slopes outside the distinctive limestone and horizontal ridge communities was very rich in species, not easy to characterize, and highly variable in composition from place to place. From 600 to 1150 m, there seemed to be an uneven but gradual transition from semi-acid clays to sandier soils, with forests of 40-m tall trees dwindling to 20-m tall trees, and roots becoming more prominent on the surface.

On these upper slopes, plants characteristic of the semi-acid Tertiary hills and short, spongy forest were mixed with many species not seen before, but no group of species seemed dominant. *Cedrelinga* was absent. *Brosimum utile*, and the common *Pouteria* and *Micropholis* of the upper Pauya mountains, were only occasional. Many species of Melastomataceae were abundant in the understory in addition to the occasional *Graffenrieda* sp. (previously seen in the slopes above the Río Pauya). One of the most conspicuous of these Melastomes, not seen elsewhere, is the unusual *Florbella*. Many species of Rubiaceae, Lauraceae, and *Inga* also occur here. Some lowland gap species of semi-acid soils, such as *Psychotria poeppigiana* and *Warszewiczia coccinea* were surprisingly abundant at the higher elevations (over 1000 m) and rarely seen elsewhere, perhaps because of the increasing frequency of landslides higher on the ridges.

#### Mountains: High Crests

The high, gently sloping crests of the Pisqui (at 1250 to 1300 m), are covered with an extremely wet forest over a moss-laden, spongy ground layer (Figure 7D). This forest includes many of the same species that we saw on the mountain crests of the upper Río Pauya. In contrast, only a very few, small areas here could be considered shrubland, perhaps because of more persistent moisture and less frequent fires.

The commonest trees were a large-leaved *Schefflera*, a large pink-leaved *Clusia*, *Clethra*, *Ternstroemia*, *Bonnetia paniculata*, a *Graffenrieda*, 2 capsulate Rubiaceae trees, and a distichous *Wettinia*. Common shrubs were *Pagamea*, *Miconia*, an Ericaceae, *Stenospermation*, *Cybianthus*, *Retiniphyllum fuchsioides*, and 3 Myrtaceae. Epiphytes were common, including a conspicuous, new species of fern vine (*Solanopteris*, see below and Figure 9D), with its tuberous formicaria lining the branches of the *Schefflera* spp. Other common epiphytes included 2 Bromeliaceae, a tiny *Peperomia*, 2 *Trichomanes*, *Sphaeradenia*, *Cavendishia*, and a large, yellowish *Phoradendron*. The cliffs seemed to have a

few species specifically associated with them, notably the rare *Godoya* (Ochnaceae).

#### COMPARISON OF FORESTS IN THE PAUYA AND PISQUI SITES

The floodplain of the upper Río Pauya is too small to be directly comparable with that of the upper Río Pisqui, and the flora of the former appears to be a small subset of the latter. In contrast, the differences are considerable in the predominant species of shrubs, small palms, and herbs between the mountains of the two areas. This may be due in part to the contrasts in dry-season moisture—the upper Pisqui drainage remaining much moister. However, marked differences in the understory flora over short distances is not uncommon in other tropical forests, even when the habitats have similar moisture and soil regimes. This phenomenon is likely due to the limited range of seed dispersal by understory plants, which creates a “pioneer effect,” in which the first colonizers of a local area maintain their dominance for many years, while latecomers are recruited only gradually.

The appearance of the forests in the lowlands and lower-mountain slopes is similar at both macrosites, except for a greater frequency of epiphytes and trunk climbers in the wetter Pisqui sites, and a greater frequency of deciduous canopy tree species at the drier, Pauya sites. This difference in moisture between the two macrosites also was manifested in another way. In the Pauya watershed, there was a great contrast between the vegetation on dry hills and the intervening, moister valleys. In the Pisqui watershed, the generally moister hills and adjacent valleys were not so different from each other.

Many of the tree species appear to be the same in the upper-mountain habitats of the two macrosites. However, on the mountaintops and high ridge crests, the difference in the moisture regimes of the Pauya and Pisqui macrosites is dramatic. The short, spongy forest and shrublands of the wetter mountains of the Pisqui watershed have deep layers of moss and perched

organic material on the ground and on leaning stems and branches. This ground surface is a serious hazard for the unwary trying to walk through it; a wrong step plunges one waist-deep into a mass of roots, moss, and litter duff. Each stem that emerges is covered with moss, giving it a false diameter that is often many times greater than the actual diameter. In contrast, the drier, short, spongy forest and shrublands of the mountain crests of the Pauya watershed have little moss on the ground and on upright stems. At both sites, the density of vascular epiphytes, such as orchids and bromeliads, appears to diminish in areas of dense moss, probably because establishment of a firm foothold on the host plant is more difficult for the tiny seedlings when a dense covering of moss is present. Some of these epiphytes may require a micro-disturbance to create a bare stem for colonization.

#### OTHER VEGETATION TYPES REGISTERED FROM OVERFLIGHTS

We spent approximately ten hours in small planes or helicopters over the huge expanse of the proposed Parque Nacional Cordillera Azul Biabo. From this privileged perspective, we viewed a number of important habitats that we were unable to access and examine on foot, including the following:

- extensive, kaleidoscopically diverse, high-elevation (1400 m) wetland complexes, with open water, extensive floating vegetation, swamp forest with large monospecific stands of a tree species that we couldn't identify from the air, dense palm stands of *Euterpe*, large areas of rooted, herbaceous vegetation (Cyperaceae?), bamboo, and vine-laden forests (Figures 8E, 8F);
- meadows on the highest peaks (2000–2500 m), with a dense, puna-like low, grassy, vegetation, which had a high density of terrestrial bromeliads—not unlike some of the vegetation on top of the Cordillera del Condor in northern Peru, but more sloping and not interrupted with shrub thickets or matorrales;
- odd mixtures of seemingly short forest and river floodplain forest at low elevations along the Río Biabo;

- broad expanses of short, dry forest on the sloping, massive backs of Vivian formations (Figure 7E); and
- unusual, eroding red hills from which huge sheets of vegetation routinely slough off, either due to frequent earthquakes, unstable plates of soil or rock, or both (Figure 8C).

We also overflowed several lakes deeply hidden within the Cordillera that probably have been visited rarely, if ever, by humans (Figure 8D).

An assessment of the diversity of these communities, and of the many additional, new species of plants that likely occur there, awaits the next expedition.

#### PALMS

The northern Cordillera Azul stands out as a center of palm species diversity and abundance. Peru has 105 known species of palms (Henderson, Galeano, and Bernal 1995). In our brief visit, we encountered 45 species within the proposed park, equivalent to 43% of the total for all of Peru. Of these, at least 2 are either new species or new records for the country. Although palms are encountered with frequency throughout the area, from lowland floodplain to the dense shrublands at high elevations, they are especially dominant in certain areas: the understory of the alluvial fans and of low foothills (Figure 4D), the understory of flat acidic ridges at mid-elevations, and the more common lowland palm swamps (aguajales) with *Mauritia* and *Mauritiella*. In a transect on the alluvial fan near our Pauya Campamento Principal site, of 60 mid-size trees (10–30 cm DBH), 4 species of palms constituted 73% of the individuals. At mid-elevations (750 m) above the upper Pisqui, in a very different flora of small palms (1–10 cm DBH), 5 species constituted a similar percentage of the individuals.

The high diversity of palms is attributable to the high diversity of habitats in the northern Cordillera Azul, especially with soils varying from highly acidic to highly basic, across a range of elevations and moisture regimes. Palm species are almost evenly split between those more frequently encountered on poor soils (mostly in the mountains) and those more common on richer soils

(mostly in the lowlands). The reasons for the striking dominance of palms in particular areas are less clear.

High density of palms on alluvial fans spreading out from the mountains might be a secondary effect of the more widely spaced crowns of the canopy trees in these areas and the higher frequency of deciduous trees, both of which contribute to more light in the understory. The density of understory palms in these lowland areas is readily visible from overflights due to the openness of the canopy. In contrast, palm-dominated forests at mid-elevation in the Cordillera are barely noticeable from the air. An explanation for their occurrence is not obvious, though it presumably has something to do with the underlying soil conditions. Forests on both the alluvial fans and mid-elevation slopes have well-drained soils, yet palms are not very tolerant of conditions that will dry out their roots.

In contrast, palm swamps are well known and widespread in the neotropics. In the northern Cordillera Azul, they are scattered in poorly drained areas, but are not a dominant feature of the landscape as they are in other, large areas of the Amazon lowlands. Why the dominance by *Mauritia* in such areas has not been broken up by more species of trees adapted to swamp conditions remains a mystery.

In the unusual, high-elevation swamps (at 1400 m) in the southwest corner of the northern Cordillera Azul, the dense patches of multi-stemmed *Euterpe* in standing water were a big surprise. This is a species very similar in form to *Euterpe oleracea* known from the Chocó region of Colombia, from lowland wet areas such as tidal swamps near the sea, and from swamps along the coast of Guiana and the mouth of the Amazon River. The discovery, high in the eastern Andes of Peru, of an important economic palm (hearts-of-palm) or, perhaps, a similar but new species of palm, was totally unexpected. This *Euterpe* species could be quite economically valuable: it may serve directly as a genetic resource, or for hybridization with other species to provide continual production of hearts-of-palm and the edible fruits. The clustered, multiple stems of this species may allow sustainable harvest of the apical meristems

(hearts-of-palm) without killing the entire palm, as is now the case in Peru.

#### NEW SPECIES, NEW RECORDS, UNUSUAL PLANTS

We observed at least 12 species of plants during our field work in the northern Cordillera Azul that appear to be new to science, several more that are likely new records for Peru, and hundreds that may be new records for the Department of Loreto.

Expeditions to large, remote regions like the northern Cordillera Azul, which have not been explored scientifically, often lead to the discovery of new species in large genera, such as *Psychotria*, *Inga*, *Guarea*, *Pouteria*, *Ocotea*, *Paullinia*, *Calathea*, *Ischnosiphon*, *Schefflera*, and *Dendropanax*. Yet, even experts who study these specific groups (when such experts exist) have trouble determining if a species is new while in the field. Such determinations require comparative examination of dried specimens. In the northern Cordillera Azul, we saw many species in these groups that none of us had ever seen before, which are likely species new to science. Unfortunately, these cannot be formally described and given scientific names without voucher specimens.

Recognition of new species, while in the field, is more feasible for smaller genera that are better known. Yet, even these new species cannot receive scientific names without voucher specimens. Among the more conspicuous of these species in the northern Cordillera Azul are:

- A small tree in the tribe Mutisiae of the Asteraceae, genus *Stenopadus*, mainly known from the Guianas and not known from Peru. We encountered a single tree of this undescribed species in flower at 1700 m on the ridge at the upper Pauya (Figure 9F).
- *Parkia*, a pantropical genus of the Fabaceae, which consists mainly of large lowland trees (usually 30–50 m tall) having distinctive leaves and inflorescences. We encountered a small patch of dwarf trees (less than 5 m tall), with erect inflorescences and short fruit at 1400–1450 m, on a ridge above our Pauya Campamento Ladera. In addition to being new, this species sets an altitudinal record for the genus.

- *Solanopteris*, a neotropical fern genus with only 4 species that bears enlarged, ball-like structures inhabited by ants. We encountered a species of *Solanopteris* (or perhaps a new genus)—also with ants in swollen structures, but with fertile fronds completely different from the known species (Figure 9D). We first found this fern on the highest ridges of the Pauya site (above 1400 m), but it was very abundant on the ridge at the Pisqui Campamento Cresta (1250–1300 m), where it covered the branches of most individuals of the common *Schefflera*.
- *Zamia*, a genus of Cycads (“primitive,” cone-bearing plants), of which only 3 species are known from Peru. Large-stemmed species of *Zamia* are typically endemic with very restricted distributions. We encountered 2 individuals of a large-stemmed species on the wet hills (ca. 500 m elevation) along the Trocha a las Colinas, upper Pisqui.
- *Gnetum*, another “primitive” genus of seed plants, has only 2 known species in Peru, both from the lowlands. We encountered a distinctive species on the high, acid ridges and slopes of the upper Pisqui: it is 2-meters tall, has large leaves, and is unlike other large-leaved species in the genus (Figure 9G).
- *Geonoma*, a large genus of small palms. One (and possibly 2) of the 11 species we encountered does not match the descriptions in the recent books on palms (e.g., Henderson, Galeano, and Bernal 1995).
- *Euterpe*, an economically important palm (hearts-of-palm). During our overflights, we saw a possibly new, multi-stemmed species in the high-elevation swamps (see above, under Palms).
- *Wettinia*, a palm genus with 4 of its 21 species known from Peru. We encountered 2 species that do not match any of the 4; they are possibly also new to science.

The large quantity of new records for the Department of Loreto is not surprising, since only small parts of western Loreto have high mountains, mostly in areas fairly inaccessible like this one, which are not frequently inventoried. Most of these montane species are probably known from the adjacent department of San Martín. Examples of these and some of the other

unusual plants we encountered include:

- *Godoya*, a small genus of trees in the Ochnaceae, not represented in the Herbario Nacional, with large yellow flowers and small leaves. We encountered 2 large *G. obovata* in flower near the top of the ridge (ca. 1200 m) at our Pisqui Campamento Subcresta.
- *Platyserium andinum* (“cuerno de ciervo”), a strange-looking fern that is popular as a houseplant (Figure 9E). All species of the genus, except this one, occur in Asia. This species is known only from a few sites in Peru and Bolivia (Parker and Bailey 1991). During this trip we encountered the first record for Loreto; it is relatively abundant in the lowlands of the upper Río Pauya, within the Zona Reservada.
- *Talauma*, a genus closely related to *Magnolia*, a group of flowering trees mostly known from the Northern Hemisphere. We encountered 3 individuals in flower at the top of the 1700 m ridge above our Pauya Campamento Cumbre.
- *Pentaplaris*, a genus of trees historically placed in the family Tiliaceae, but now known to be a basal lineage of the core group comprised by traditional Malvaceae. Until recently, it was known only from Costa Rica, but 2 additional species were described in 1999 from Bolivia, Ecuador, and Peru. Interestingly, one of these new species, *P. davidsmithii* Dorr & C. Bayer was called *Reevesia smithii* A. H. Gentry in the report from the first RAP in 1990, but was never published. We frequently encountered this same species, with long narrow buttresses, in the lowlands of the Río Pauya.
- *Schizaea poeppigiana*, a tiny fern we encountered in the shrublands on the acid ridges of the upper Pauya. It had been collected only once before, in 1829.
- *Chaetocarpus echinocarpus*, a small tree in the Euphorbiaceae, only recently added to the flora of Peru from a collection in the Santuario de Pampas del Heath. We saw one individual in fruit in a high, wet ravine, at 1400 m near our Pauya Campamento Ladera.
- *Phyllonoma fuscifolia*, a rarely collected shrub of the Grossulariaceae, with flowers that emerge from the edges of the leaves. We encountered it on the high, steep slope ridges around our Pauya Campamento Ladera.

- *Sciaphila purpurea*, a rarely collected, achlorophyllous saprophyte, or parasite, in the poorly known family Triuridaceae. We encountered this species several times on the high, steep-slope ridges around Pisqui Campamento Cresta, always growing out of terrestrial termite mounds.
- *Florbella*, a recent segregate of the Melastome genus *Conostegia*, rarely collected and unusual in the family in having a large flower with hundreds of pink stamens. We found a possibly new species of *Florbella*, high on the ridge above the Rio Pisqui, with a huge calyptrate calyx that turns red and at anthesis is flipped to one side of the flower and adds to pollinator attraction, presumably hummingbirds.
- *Retiniphyllum*, a genus of Rubiaceae associated with acid soils, mainly in the Guiana Highlands. Only 2 species are known from Peru. We found one, *R. fuschioides*, on the upper ridges of the upper Pauya and the upper Pisqui. A second, more common species on these ridges is not known from Peru.

Other plant species are of particular interest not because of their rarity, but because of some unusual biological feature or behavior. These include more than 20 species in the northern Cordillera Azul that have obligate mutualisms with ants: *Cordia alliodora* and *C. nodosa* (Boraginaceae), *Duroia hirsuta* (Rubiaceae) *Ocotea javitensis* and *Pleurothyrium* spp. (Lauraceae), *Triplaris americana* and *T. poeppigiana* (Polygonaceae), *Maieta guianensis* and *M. poeppigiana*, *Tococa guianensis* and 5 other *Tococa* spp., and 3 species of *Clidemia* (Melastomataceae), *Lonchocarpus spiciflorus* and 3 species of *Tachigali* (Fabaceae), 6 species of *Cecropia* (Cecropiaceae), *Streptocalyx* sp. (Bromeliaceae), as well as *Peperomia macrostachya* (Piperaceae) and a species of *Philodendron* (Araceae).

We encountered 5 species of trees in the genus *Tachigali*, some with and others without ant associations. All show evidence of monocarpy, i.e., flowering only once in their life, then dispersing seed and dying.

In an area of mountains and lowlands, most plants have some restrictions in their habitat, especially with regard to soil. However, a few species seem to be able to occupy a whole range of habitats. These are plants with no apparent ecological niche or with a universal niche, in spite of competition from thousands of other plant species. Species with such broad ecological amplitudes are worthy of much more study to understand their success. Two examples from this region are the large herb, *Cyclanthus bipartitus* (Cyclanthaceae) and the small tree, *Tovomita weddelliana* (Clusiaceae) both of which can be found in the northern Cordillera Azul from fertile lowland forests all the way up to the most acidic ridgetop shrublands. These also have broad geographic distributions, from Central America to Bolivia.

Finally, several montane forest genera that are common and characteristic throughout the Andes (but mainly on richer soils) have not yet been encountered in the Cordillera Azul. These include *Hedyosmum*, *Saurauia*, and *Alzatea*. Even *Weinmannia* and large *Clusia* trees, usually the dominants of high montane forest, are few and far between in this Cordillera.

#### STATUS OF COMMERCIALY VALUABLE SPECIES

Mahogany (caoba, *Swietenia macrophylla*) is rare and has nearly vanished, already, from the alluvial fans of the mountains and the river floodplains of the northern Cordillera Azul. Likewise, tropical cedar (cedro blanco, *Cedrela odorata*) is uncommon and mostly gone from the river floodplain and limestone strata. *Cedrela fissilis* (cedro colorado) is uncommon and has been mostly removed from the hill forest. *Cedrelinga catenaeformis* (tornillo) is still fairly frequent but being cut out from hill forests and old river terraces. *Amburana cearensis* (ishpingo) has not yet been cut, and is frequent on well-drained alluvial deposits. There are also many robust individuals of *Cordia alliodora* along the rivers.

The medicinal vine, *Uncaria tomentosa* (uña de gato), is harvested but remains fairly frequent in lowlands; in any case, it is a fast-growing species of secondary habitats and is not of great conservation concern. Small populations of *Croton lechleri* (sangre

de grado) remain intact along the margins of streams and landslides. The palm, *Phytelephas macrocarpa* (tagua), is still abundant on poorly drained river terraces and *Euterpe precatoria* (huasai) is infrequently seen but is not much cut. Other palms are mostly abundant and uncut except in local sites along the major rivers.

The northern Cordillera Azul is rich in orchid species but not in orchid abundance. It is also rich in ornamentals—especially very showy Acanthaceae and ferns, including the rare neotropical *Platyserium* staghornfern (see above), with moderate numbers of showy Bromeliaceae, Marantaceae, Rubiaceae, Melastomataceae (especially *Tibouchina*), and a few *Heliconia*, but few Gesneriaceae.

#### INFERRED HISTORY OF HUMAN IMPACT

Humans have greatly reduced the abundance of the most valuable timber species within a few kilometers of the major rivers in the northern Cordillera Azul but have had little impact on other plant communities or species. The sheer inaccessibility of much of the Cordillera has discouraged human visitation and rendered uneconomic the extraction of other commercial resources.

#### FISHES

**Participants/Authors:** Max Hidalgo, Patrick de Rham, and Hernan Ortega

**Conservation targets:** The fish communities of the Biabo Cordillera Azul headwaters, in particular, species adapted to fast-running water and species of the main river-channels.

#### METHODS

We conducted our inventory at 3 sites within the watersheds of the upper Río Pauya and at 16 points in the upper Río Pisqui. All inventory work took place between 27 August and 13 September 2000.

We focused on all types of water bodies and used several means for sampling, including netting by hand, netting with 6 x 2 m and 2 x 1 m dragnets, targeted fishing with hook and line, and direct observation while diving and snorkeling. Many of our

observations were *in situ* because the water was completely transparent. We deposited the fish collections at the Museo de Historia Natural de la Universidad Nacional Mayor de San Marcos (MUSM), in Lima, under collection numbers of the MUSM.

Across all sites, we recorded 93 species of fish, of which 10 appear to be new to science (Figure 9A). At least 22 of these are new records for Peru.

The fish community was particularly rich in species of Characiformes and Siluriformes. At all sites, we registered endemic species, and species showing conspicuous adaptations to life in clean, fast-flowing water (Figure 9B). We also frequently registered large individuals of fish species that are commonly exploited for human consumption.

#### RESULTS

Pauya Campamentos Principal, Llanura Del Río, and Torrente

In the upper Pauya watershed, from 27–30 August, we sampled many points across the following 3 main sites: (1) the lower portion of Quebrada John (named after the ornithologist John O'Neill), close to its mouth on the upper Río Pauya, where the trail to Campamento Orilla del Río crosses the stream; (2) in the pool, at the level of the Pauya Campamento Principal; and (3) around the Campamento Torrente (below, at the level, and above the Campamento), following the northeast fork of the Quebrada (“Torrente Este”) to an altitude of 700 m. We also collected a few Loricariids (carachamas) under driftwood in the upper Río Pauya, at the level of Campamento Orilla del Río (Figure 4B), and further upstream, where the west-northwest trail from the Pauya Campamento Principal reaches the river.

Overall, we observed 20 species within the Río Pauya and Quebrada John, of which we collected 16. The collections were dominated by Characiformes of small and medium size (commonly named mojaritas, mojaras, sardinas—9 species) and Siluriformes (bagres and carachamas, 6 spp.). Three of the fishes appear to be undescribed species, and an additional 5 are new records for Peru.

The fish community appears intact and is rich in unique forms. Particularly notable were the specially adapted forms of *Astroblepus* spp., *Trichomycterus* sp., a large *Characidium* sp., and a *Creagrutus* sp. (with a band on the anal fin). These fishes are probably new species to science, belonging to the genera adapted to torrent conditions. Because these genera are restricted to the cool, well-oxygenated headwaters, they are likely to develop endemic populations and species. The small catfishes of the genus *Astroblepus*, which extend along the Andes from Bolivia to Panama, can rightly be considered the most torrent-adapted fishes of the world: they can ascend waterfalls by clinging with their strong, sucker mouth to vertical and even overhanging rock. Although *Trichomycterus* and *Characidium* have no such device, we also found them in the waterfall-studded east fork, Torrente Este, of the Quebrada John. In this watershed, *Astroblepus* and *Trichomycterus* most likely climb to the highest elevations, followed by *Characidium*, and a bit lower *Creagrutus*. Both *Creagrutus* (see Vari 1998, Vari and Harold 1998) and *Astroblepus* probably have unique species in each watershed where they occur. *Trichomycterus*, a genus of small Siluriformes of fast-flowing waters, has special feeding adaptations.

The upper Pauya watershed is an important element for the conservation of fish diversity. The watershed harbors an intact fish community with distinct altitudinal gradients and the fish fauna includes marked evolutionary specializations. The upper Pauya sites also offer a remarkable opportunity (especially along the relatively accessible Quebrada John) to study a pristine, lotic community of fishes, as it changes over a short distance according to slope gradient and altitude. The torrent-adapted genera also deserve research focus, both in taxonomy and geographic distribution. Although some of these groups have undergone recent taxonomic revisions, these genera are prone to speciate in their isolated headwater habitats, and many regions rich in such habitats are still unexplored in Peru.

## Pisqui Campamento Planicie

From 1–6 September, we sampled 9 points both in the Río Pisqui itself and in small, tributary streams within approximately 3 km of this riverside camp. The river itself was well oxygenated (>7 ppm) and had a high conductivity (>600 microsims/cm), the latter probably due to salt deposits near its sources in the mountains. Other limnological data for the river and other water-courses in the region appear in Appendix 2.

The river averaged 50-m wide here, and was generally shallow (less than 5 m). Few areas were more than 2-m deep, such as the base of steep banks and the exterior bank of river bends. The bed was composed of sand or loose stones and rocks from 10 to 100 cm in diameter. The stretches with conspicuous drop-offs and strong currents (“cachuelas”) ran over loose rocks. During our stay at Campamento Planicie the river water was clear, transparent to 2 m depth, and when seen from a distance (e.g., from the overflights; Figure 4C), aquamarine in color.

The larger streams feeding the Río Pisqui at this point are relatively open (not strongly shaded by overhanging canopy) and averaged about 5 m in width. Their water was completely transparent, slightly greenish in color, and shallow (no more than 1-m deep). It ran over sand and clay in the slow-flowing stretches, and over loose rocks and gravel in the rapids.

The small streams in the area, densely shaded by forest canopy, were 2 m or less in width, no more than 30 cm in depth (at the time of our dry-season visit), and often steep and with small waterfalls. Some had clear water, while a few others had “black” water—stained by organic matter. Some small streams had rock beds, often with large rocks and boulders. But others had a predominantly mud or sand bottom, such as those in the low alluvial terrace of the upper Río Pisqui’s west bank.

Within these habitats, we recorded 53 species, of which 40 were collected. For practical reasons, we did not preserve specimens of large Characiformes or Siluriformes, but we measured, weighed, and photographed them for documentation.

We found considerable species richness in the upper Pisqui, likely due to the great quantity of different microhabitats. Four species that we collected around the Campamento Planicie appear to be new to science and another 8 are new records for Peru. Characiformes and Siluriformes fishes dominated, with 30 and 20 species, respectively. We observed only 2 species of Cichlids, *Crenicichla sedentaria* (añashua) and a *Bujurquina* sp. (bujurqui).

Small fish (<5 cm long), adapted to shallow water, dominate the streams. A *Rivulus* sp. was common in the smallest streams of the east bank of the upper Río Pisqui, where they were often the only fish present. Strangely, we found no *Rivulus* in the west alluvial bank streams, at the level of Campamento Pisqui Planicie.

Especially interesting species collected at this site were small, unidentified catfishes (Pimelodidae), Glandulocaudinae (Characidae), and some Loricariidae. Also worth special mention are the large individuals that the Shipibo caught of species commonly harvested as food. The large sizes indicate that the stocks of these edible species are still largely untapped and that the fish community of the upper Pisqui is in near-pristine condition. Especially outstanding was an extremely large (>50 cm) specimen of an unidentified *Panaque* sp., Loricariidae (carachama gigante).

### Pisqui Campamento Playa

From our second camp on the Río Pisqui, about 5 km upstream from Campamento Planicie, we sampled aquatic habitats at 7 points, between 260–400 m in elevation, from 9 to 13 September 2000. At this site, the Río Pisqui has a large, boulder-strewn bottom and strong current. Moreover, shortly after our arrival, brief but heavy rains resulted in the river becoming completely turbid, with a reddish color. Because of these adverse conditions and lack of time, we attempted no collecting in the main river at this site. The rapid increase of sediment load of the upper Pisqui—a watershed free of human activity in this upper portion—after a heavy, but short rain episode, indicates that strong natural erosion takes place in this tectonically

young area. It also indicates that the Río Piqui must be turbid during much of the year, becoming clear only at the peak of the dry season.

Our sampling included lentic habitats such as relictual pools—filled by streams or seeps—with brownish-green water on the east side of the Río Pisqui's dry bed, which were up to 2-m deep, with sandy, muddy, or occasionally rocky bottoms. The larger of the 2 main pools we sampled had an extension of a few hundred meters.

We also examined larger feeder streams that averaged about 5-m wide, with shallow (to 1 m), completely transparent, slightly green-tinted water flowing over sand and clay (where the water current was slow) or gravel and loose rocks (where the current was strong). The smaller streams were similar to those near the Campamento Planicie (described above), although we found no slow-moving, small streams (as those on the west alluvial bank, behind Campamento Planicie) at this site.

In the vicinity of the Campamento Playa, we recorded 39 species of fish, of which 26 were collected and 13 were documented by other means. Of these, 3 were new to science and an additional 6 are new records for Peru. As at the other Pisqui sites, Characiformes (15 species) and Siluriformes (7 species) dominated the species richness.

Of special scientific interest was a *Crossoloricaria* sp. (Loricariidae)—probably a fourth, undescribed species of this genus, closely related to, but different from, *C. rhami*, which is endemic to the Río Aguaytía basin, to the south. The small fishes of the subfamily Glandulocaudinae (Characidae) are also worthy of attention. They represent a group of several genera that are presently the object of detailed research because of their special sexual apparatus and peculiar reproductive biology (internal fertilization). These minute fishes, many colorful, often are collected as aquarium fishes. The samples of the genera *Scopaecharax* and *Chryssobrycon*, collected at this site and down stream, are likely to include new species.

As in the downstream study site, our Shipibo assistants caught several large individuals of species commonly fished by local people, which confirmed that the upper Río Pisqui is still little exploited and that the fish community here is largely intact. Similarly, the fish fauna is diverse and appears to contain several endemic species with marked specializations for life in torrential currents. This portion of the upper Río Pisqui also serves as a migration route for many fish species, including several of the most desirable for human consumption.

We found few species in common in the Pauya and the Pisqui sites. However, this may be due, in part, to the special characteristics of the Quebrada John (strong gradient, fairly high altitude). No such streams were available close to the Pisqui study sites. Also, had we collected more thoroughly in the Río Pauya, the number of species common to both watersheds would very likely have been higher.

#### THREATS AND RECOMMENDATIONS

The upper Pauya and Pisqui watersheds are in excellent condition and are critical habitat for the fish community of the northern Cordillera Azul and adjacent lowlands. They offer the rare opportunity to protect virtually entire watersheds. The Río Pisqui itself is lightly fished by transient timber-cutters and native Shipibo, but not yet to the degree where the fish community is threatened. With increased human pressure, however—as would result from influx in colonization with the opening of roads for logging concessions, or as could result from the steady demographic growth of the native community of Nuevo Edén—this could change rapidly. At low water levels, the Río Pisqui is shallow and transparent, and the large adult individuals that ensure the bulk of reproduction of their species are vulnerable to spear and castnet fishing, as practiced by the Shipibo. Naturally, a large-scale timber operation (as opposed to the current, single-tree poaching at low levels) would not only greatly disturb and impoverish terrestrial ecosystems, but would have similar consequences in aquatic ecosystems, as erosion and sedimentation in all water bodies would increase rapidly. Conversion of terrestrial habitats

to the cultivation of crops or cattle ranches would have an even more dramatic impact on all natural ecosystems of the area, severely reducing the diversity and productivity of fish communities. To maintain the current level of species diversity, and to protect the specialized forms, we recommend that appropriate measures be instituted now—before degradation sets in—to conserve the watershed (and especially the headwaters) against deforestation. We also recommend that fishing activities be monitored, and if necessary regulated, to avoid over-exploitation of food-fish stocks. It will be especially important to keep fishing in the region open for local consumption only and not for wide commercialization.

The aquatic habitats of the upper Pisqui are very important because they provide breeding habitat for the many migratory species of fish, especially species commonly harvested for human consumption, such as *Colossoma macropomum* (gamitana), *Piaractus brachypomum* (paco), *Prochilodus nigricans* (boquichico), *Brycon cephalus* (sabalo cola roja), *Brycon melanopterum* (sabalo cola negra), *Salminus affinis* (sabalo macho), *Pseudoplatystoma fasciatum* (doncella), *Zungaro zungaro* (zúngaro), large Loricariids (carachamas), *Potamotrygon* spp. (rayas), and others.

These habitats also harbor a myriad of small fishes, many of which are endemic species with distinctive morphological adaptations to life in shallow water and/or strong current. The role of these small species in the overall functioning of forest ecosystems is little known, but available studies show that the small fishes living in forest-shaded creeks feed mainly on alloctonous materials that fall or wash down from the canopy, such as ants and other arthropods. These fishes also feed on plant material, such as pollen, seeds, and leaves; they are likely to play an important role in the recycling of nutrient-rich organic matter. In more open situations, where light can penetrate to the bottom of the stream allowing primary production to take place, many small fishes appear to feed mainly on periphyton and algae filaments found in shallow areas, on stones, or submerged wood. Of course, in such situations the invertebrate fauna—aquatic insects, crustaceans,

mollusks—are also an important food source. We found freshwater crabs and shrimps to be plentiful in the upper Pauya and upper Pisqui watersheds, with shrimps present and often numerous in even the tiniest of forest creeks, ascending often to higher elevations than fishes. As a further example of interrelations between forest and aquatic ecosystems, some Loricariid species (carachamas) are able to feed on dead wood on submerged fallen tree parts that they rasp with their specialized mouth and teeth. Some, like the *Panaque* species, feed on dead wood exclusively. Like the insects that feed on wood, these fishes probably have symbiotic microorganisms in their guts, enabling them to break down and assimilate cellulose. The amount of wood falling into Amazonian water bodies is enormous, and Loricariids can be locally very abundant, as we observed under driftwood in the upper Pisqui, upstream from Campamento Planicie. These fishes may well play the same function, and have an equivalent importance in the aquatic ecosystem, as termites have on land.

The above examples amply show that the preservation of the large and topographically diverse area of the northern Cordillera Azul would not only protect a huge diversity of terrestrial and aquatic living beings, but also would preserve the complex and vital interrelationships between the terrestrial and aquatic biomes.

## AMPHIBIANS AND REPTILES

**Participants/Authors:** Lily O. Rodríguez, José Pérez Z., and H. Bradley Shaffer

**Conservation targets:** High-altitude species: *Bufo* of the *B. typhonius* group, *Colostethus* spp., *Bolitoglossa* salamander, species that live in mosses and terrestrial bromeliads (*Syncope* sp.), *Atelopus andinus*. Lowland species: *Epipedobates* spp., *Eleutherodactylus* of the *E. conspicillatus* group, *Geochelone denticulata*, *Podocnemis* spp., and caiman species (*Caiman*, *Paleosuchus*; also *Melanosuchus*, if present)

## METHODS

Our data are based on visual and auditory observations, along transects that followed available trails through a wide array of habitats, from lowland to elfin forests.

Because of the affinity of amphibians for moist and wet habitats, we paid particular attention to streams, especially at higher elevation slopes and ridgecrests.

We collected up to 4 individuals per species when this was necessary to supplement the preliminary identifications we made in the field; these specimens are deposited at the Museo de Historia Natural de la Universidad Nacional Mayor de San Marcos (MUSM). We also made tape recordings of the majority of the species that were difficult to identify in the field; we will analyze these sonographically and deposit the tapes at the American Museum of Natural History (AMNH, New York, USA).

We typically made our observations and collections from mid-afternoon (3 pm on) into the early hours of the night, when amphibians are most active. However, we took advantage of any opportunity, day or night, to document the herpetofauna, such as when we were moving between camps.

We noted relative abundance in qualitative terms, using auditory and visual records to rank species as abundant when they were commonly seen or heard; as common when they were present, but only in restricted habitats; and as rare when we only had a single record per macrosite.

We did not attempt to obtain a complete list of the species of amphibians and reptiles present at the study sites; the limited amount of time available for fieldwork prevented this. Instead, we targeted taxonomic groups that would best characterize the type and uniqueness of the herpetofauna in the northern Cordillera Azul. We therefore focused our inventories on Anurans, particularly on the *Eleutherodactylus* (Leptodactylidae) and Dendrobatidae. We selected *Eleutherodactylus* because of its high species diversity, the restricted ranges but high local abundance of many of its species, and the independence of its species from water for reproduction (all species have direct development). Dendrobatidae, on the other hand, consists of diurnal species with distributions closely associated with drainage systems and elevation; they have distinct, conspicuous calls, making them ideal for rapid inventories. *Eleutherodactylus* and

dendrobatids also have a tendency to show differences in species composition and abundance between habitats and even among sites.

We also gathered data on the Centrolenidae. This diverse and interesting group of Anurans is restricted to fast streams and adjacent, very moist areas. As such, they cannot serve as a broad basis of comparison among sites.

Reptiles generally occur at low densities (for example, one snake per 7 km of transect—Zimmerman and Rodrigues 1990), have wide distributions, and are less conspicuous than Anurans. We did not specifically search for reptiles on this rapid inventory.

## RESULTS OF THE HERPETOLOGICAL SURVEY

At the Pauya study sites, we (LR, BS, and JP) found 31 species of amphibians and 11 reptiles over 90 person-hours of searching during 6 days. In the Pisqui study sites, we (LR and JP) encountered 35 species of amphibians and 17 reptiles during 102 person-hours of searching over a 14-day period.

Overall, we recorded a total of 58 amphibian species, sampled over 20 days. This total suggests that the herpetofauna of the zone is quite rich, especially given that we sampled during the dry season (when a large number of the species were not breeding and therefore less conspicuous). Inaccessibility prevented us from sampling several swamps and marshes, prime habitats for Hyloid frogs (which are represented poorly in our samples).

Our most significant record was a species of salamander (*Bolitoglossa* sp.), which is likely new to science. Prior to this sighting, only 3 species of salamanders were known from Peru and these were all below 1700 m. We now need to determine whether this specimen is conspecific with an individual collected from the Río Shaypaya, at 200 m, in the lowland watershed of the Río Pisqui (RAP 1999).

We found 14 species of amphibians on the upper slopes and crests around the Río Pauya and 9 on the upper slopes and crests of the Río Pisqui, well within the range of species richness expected for these

altitudes. Nevertheless, the exposed, seasonally dry vegetation of these crests is by no means optimal habitat for amphibians.

The overall species composition we found in the northern Cordillera Azul is a good representation of the herpetofauna of montane and lowland forests of northern and central Peru, with 4 species of Centrolenidae, 12 of *Eleutherodactylus* (Leptodactylidae), and 13 of Dendrobatidae, including several species of *Colostethus*, *Epipedobates*, and *Dendrobates*. This exceptionally high number of Dendrobatids highlights the importance of the northern Cordillera Azul for the diversity of this group in the region of the Central Andes.

There may be endemic species of *Eleutherodactylus* in our collections from the northern Cordillera Azul; we need further comparative work with museum specimens for a definitive answer. We found several species of the *E. conspicillatus* group and they do not seem to correspond to other collections made east of the Río Huallaga. We also registered several species of the *Bufo typhonius* group, although in our lists we include only the 2 species for which we tape recorded calls. This group definitely needs further studies.

With regard to the Dendrobatidae, the presence of *Epipedobates trivittatus* was significant: it was the most abundant frog in both the upper Pauya and the upper Pisqui watersheds. The call notes and coloration of *E. femoralis* were notably different than those of populations of presumably the same species in the Río Lullapichis area, to the southeast. We also observed several forms of *Epipedobates pictus* group (e.g., *E. hanheli* and *E. rubriventris*, the latter endemic to the Cordillera Azul). We found 3 species of small *Colostethus* in the lowlands of both watersheds (all forms of the *C. marchesianus/trilineatus* complex) and 2 species of *Colostethus*—that appear to be new to science—in the highlands, at the top of the ridges at both the Pauya and the Pisqui.

The greater abundance of streamside habitats that we visited in the upper elevations of the Pauya, compared to the Pisqui, probably explains the better representation of Centrolenidae in the Pauya.

The herpetofauna of several sites in the general vicinity of the northern Cordillera Azul has received some inventory attention. These sites include Panguana (Río Lullapichis) and the Cordillera del Sira, along the Pucallpa-Tingo María highway; the zone of the Huallaga, which has been surveyed for Dendrobatid frogs (Schulte 1999); and a short expedition in 1999 to the Ríos Pisqui and Shaypaya in the northern Cordillera Azul (RAP 1999). Some older collections reside at the AMNH in New York. From those records, we know some of the endemic species to the area: *Atelopus andinus* (Bufonidae), *Epipedobates rubriventris* (Dendrobatidae), and *Neusticurus strangulatus* (Teiidae). Yet, despite this previous work, we encountered several species that are likely new to science: *Colostethus* spp., and *Epipedobates* sp. (Dendrobatidae); 3 *Eleutherodactylus* spp.; *Adenomera* sp. (Leptodactylidae), and *Bolitoglossa* sp. (Plethodontidae).

Perhaps because we sampled at higher elevations in the Pauya than in the Pisqui, the herpetofauna we found at the Pauya is slightly more similar to that of montane forests of the Huallaga river valley, while the herpetofauna at the Pisqui is more like that of lowland forests of the Ríos Ucayali and Amazonas and has more southern biogeographic elements. Overall, the herpetofauna at the northern Cordillera Azul is a biogeographic mix that includes species complementary to, and not yet included in, the habitats protected within the Sistema Nacional de Areas Naturales Protegidas por el Estado (SINANPE).

Through casual observations at both the upper Pauya and upper Pisqui watersheds, we registered the presence of lizards, geckos, and snakes usually common in the habitats surveyed. We found a few differences between the watersheds; for example, *Anolis* lizards, so typical of lowland forests, were almost absent from the Río Pauya sites but were relatively common in the Pisqui watershed. The presence in the Pauya of the snakes *Imantodes lentiferus* and *Dipsas indica* was of note, because these species are relatively rare in more intensively sampled lowlands elsewhere.

Residents along the Pisqui regularly harvest aquatic turtles, especially *Podocnemis unifilis*. This species requires focused management and monitoring efforts, to ensure that populations remain stable. The yellow-footed tortoise (motelo, *Geochelone denticulata*), on the other hand, seems to tolerate current levels of harvest (which appear to be low) in both the upper Pauya and upper Pisqui watersheds.

Observations made at the Shaypaya in 1999, and at the upper Pisqui during this expedition, report the presence of the white caiman (*Caiman sclerops*) in the region. Based on the 1996 LSUMZ/MUSM expedition and reports from Shipibo residents, the smaller caiman, a species of *Paleosuchus*, also occurs within the northern Cordillera Azul. However, there are no current records of the black caiman (*Melanosuchus niger*). Further field studies should focus on the status of the populations of these conservation targets.

#### Pauya Campamento Principal and Trail to Campamento Torrente

Each of us surveyed the terraces and low hills around the main Pauya camp for 10 hours (day and evening) between 29–30 August (for a total of 30 person-hours). We also spent several daytime hours walking between Pauya Campamento Quebrada and Campamento Principal, on 26 August.

We found frog species typical of lowland forests, including *Chiasmocleis bassleri*, a Microhylidae; a large number of Dendrobatidae; and *Bufo* of the *B. typhonius* group. The dendrobatids included several unusual records: the red *Epipedobates cainarachi*, known from the other side of the Río Huallaga (Lamas region); possibly a new morph of *E. cf. hanheli*; and variations in *E. cf. femoralis* and *E. trivitattus*, which were both very common in the sites we surveyed. These frogs showed differences from known populations either in call (*E. cf. femoralis*), or in color pattern (*E. trivitattus*—we found differences even between the Pisqui and Pauya morphs). We also collected a possibly new species of *Adenomera*, which reproduces in masses of foam on the forest floor, and

whose call is distinct from the other two known species in the genus.

During our brief period in the area, we encountered at least two individuals of *Geochelone denticulata*—a species heavily harvested through most of its range.

#### Pauya Campamento Ladera

We examined habitats around a stream at 1400 m, elfin forest on the ridge tops, forested slopes, and tank bromeliads along the trails, for 10 hours during 24–25 August; and during ca. 5 hours of travel to lower elevations while returning to Campamento Principal on 26 August (for a total of ca. 15 person-hours).

Despite the small size of this high-elevation stream, we found unexpected records, including some elements of lower elevation forests, such as *Neusticurus* cf. *ecpleopus* and a *Bufo* (*B. typhonius* group, collected at 1100 m), which may be a new species. Two species of *Cochranella* (one green, one spotted) were common along the highest portions of the stream. The dwarf forests of upper elevations, with their terrestrial bromeliads and mosses, provide microhabitats and refuges for frogs. The habitat seems particularly favorable to *Syncope* sp., a very small microhylid that reproduces in bromeliads, laying few but large eggs that hatch into nonfeeding tadpoles (as reported previously from the Serranía del Sira, between the Pachitea and Ucayali Rivers, where the same species has been recorded—Krügel 1993).

#### Pauya Campamento Cumbre

We surveyed a stream at 1700 m, and forest habitats (especially bromeliads) along the ridges for 10 hours on 27–29 August (total of 30 person-hours). At this highest site that we inventoried in the northern Cordillera Azul, we found 17 highland species, with good taxonomic diversity of frogs, salamanders, and lizards. The forest on the ridge crest was very short in stature and seemed to be a somewhat dry habitat (see Flora and Vegetation). However, the forests on the slopes just below the crest

provided good habitat for many species of herpetofauna. The valleys on the slopes were the best habitats for amphibians and reptiles, probably because they were sheltered from sun and wind.

Our most significant record, as mentioned above, was a species of salamander (*Bolitoglossa* sp.), which is likely new for Peru and possibly new to science. Other interesting findings include *Atelopus andinus*, a poorly known species endemic to the Cordillera Azul; *Colostethus* sp., a typical montane species and very aquatic; and a more terrestrial and smaller *Colostethus* sp. that belongs to a group restricted to montane forests. Both of these *Colostethus* appear to be new species (although we still need to do further comparative work with museum collections). We also found a *Neusticurus* (*strangulatus?*, species still to be determined), a group restricted to montane forests, and a *Centrolene* that needs further work for identification.

#### Pisqui Campamento Planicie and Trocha Huangana

We surveyed habitats in alluvial forest along the Río Pisqui, a sand-bottomed stream, low-forested hills, and small streams, for 18 hours during 1–3 and 6 September (36 person-hours).

Of all sites examined in the northern Cordillera Azul, the herpetofauna here most resembled that of the lowland forests of northern Peru. Within the area, some species showed high fidelity to particular habitats, e.g., the frogs *Colostethus* cf. *trilineatus* and *Epipedobates* cf. *petersi* occurred only in the hills that were above the seasonal floodplain, and *Osteocephalus* cf. *leprieurii* was abundant in these same non-flooded habitats. The tortoise, *Geochelone denticulata* was present, despite regular visits to the area by local hunters (in fact, our Campamento Planicie was an old hunting camp, complete with cultivated papayas and peppers).

We found several significant records for frogs of the genera *Bufo*, *Cochranella*, *Epipedobates*, *Eleutherodactylus*, and *Physalaemus* in this area. For example, a population of *Epipedobates* cf. *petersi* may represent a new species in that its ventral coloration

ranges from turquoise to greenish yellow, almost without spots, and its back is coffee-colored with green dorsolateral stripes bordered with black. We found a *Cochranella* species in a wooded stream; it may be a species of calm waters. A *Bufo* from the *typhonius* group here had a different call (to be compared with the other records from this expedition and from the Ucayali). We found only one *Physalaemus petersi*, a species normally very common in seasonally flooded forests.

#### Pisqui Trocha 6 km

We spent a total of 9 hours (18 person-hours) searching along this newly cut trail on 4 and 5 September, in habitats along small rocky streams and the Río Pisqui itself, as well as in high forests on the raised alluvial terrace and low hills.

The most notable find here was *Dendrobates* cf. *lamasi*, a species previously known from adjacent southern areas of the Cordillera Azul (Huánuco and Junín). The herpetofauna of the terrace differed from that of the seasonally inundated areas on the other side of the river (i.e., along most of Trocha Huangana). For example, *Colostethus* cf. *trilineatus* was a very common species in this habitat. We also found *Osteocephalus* cf. *leprieurii* (a species that needs thorough revision, as several related species are currently been described from northern and southern regions—Iquitos and Manu, respectively). Given the location of its calls, we believe that this species nests in tree cavities, which is unusual for hylid frogs.

#### Pisqui Campamento Playa, Campamento Quebrada, and Trail Between the Two Camps

We spent 14 person-hours running transects along streams and trails on old river-terraces and low hills covered with lowland forest, on 8–9 and 11 September.

These habitats were moister than the other lowland Pisqui sites and appeared to be in a good state of conservation. Our most notable record in this area was a second unidentified species of *Colostethus* cf. *C. marchesianus*, which inhabited the highest river terrace

at ca. 300 m. We found several individuals of the snake *Xenodon severus*. However, we encountered no tortoises (*Geochelone denticulata*).

#### Pisqui Campamento Subcresta

We sampled forest habitats on the slopes around the camp at ca. 1150 m for 8 person-hours on 9 and 10 September. These forests are quite exposed to winds. Several species of *Eleutherodactylus* and *Hemiphractus johnsoni* are representatives of this area.

On the slopes towards this camp, in the forest at ca. 700 m, we observed *Dendrobates variabilis*, one of the most attractive species in the region. We found a pair of eggs of this species developing in a knothole of a tree at 280 m, suggesting that it belongs to the lowland rather than the montane fauna.

#### Pisqui Campamento Cresta

For 10 person-hours during 9 and 10 September, we inventoried mossy, short forests between 1150 and 1250 m, above Pisqui Campamento Subcresta. This was the highest forest that we surveyed in the Pisqui and the most humid. It is heavily covered with mosses and has dense root-mats over sterile, coarsely sandy rock (see Flora and Vegetation for further description). The trees on the ridgetop were higher in stature than the ridge-top forests of the Pauya.

Our most notable record was a probably new species of *Colostethus*, also recorded at Pauya Campamento Cumbre.

#### Pisqui Trocha a Las Colinas

We spent 10 person-hours at this site on 12 September, walking old, logging trails that crossed old river terraces and hills, as well as sampling the habitats along a stream near the end of the trail.

We encountered a species of *Epipedobates* (*E.* cf. *petersi*)—with a unique ventral pattern—that was very abundant in this area; it may represent a new species to science. *E. trivittatus* was uncommon here, in contrast to other sites that we visited. Likewise, it was

striking that *Colostethus* was totally absent from the forest on the old river terrace (possibly due to the drying winds from the nearby hills).

## THREATS

Overall, the amphibian fauna of the northern Cordillera Azul seems remarkably rich and intact at present, offering a tremendous opportunity for conservation and for further research. The most immediate, direct threat to this fauna seems to be habitat destruction, especially alteration of habitat structure. Logging seems imminent in the areas adjacent to the proposed national park. We do not yet understand the full impact that timber production will have on the herpetofauna due to alterations of microhabitats by selective logging and to construction of roads that could fragment the amphibian populations (given their limited capacity for dispersal).

Conditions also are good at present for reptiles, with the exception of a few species—especially aquatic turtles, caimans, yellow-footed tortoise, and perhaps boas—that already are, or may soon be affected by harvest for food by local residents. Sensible management plans, especially for aquatic turtles, will be critical.

## RECOMMENDATIONS

The higher slopes and crest forests of the northern Cordillera Azul merit special protection. These isolated habitats are critical for the diversity of montane amphibians and for protection and integrity of unique natural processes, such as frequent landslides. Of special interest to the herpetofauna are the small, upper elevation streams and ravines. These vulnerable elements provide good habitats for several species, such as the new salamander and centrolenid frogs.

The northern Cordillera Azul region harbors an interesting confluence of herpetofauna. Further studies of the complex biogeography of these amphibians and reptiles would provide a better understanding of the origins of this fauna. In particular, the following taxa merit further research: *Colostethus*, *Bufo typhonius* group, *Epipedobates pictus* group, *Eleutherodactylus*

*conspicillatus* group. More detailed studies on the fidelity of anurans to particular habitats and on different modes of reproduction also are important to obtain adequate information on the vulnerability of these populations to different degrees of habitat conversion.

We recommend more complete inventories of the herpetofauna in the region, especially of the high, isolated habitats (e.g., the mountains north of the Río Cushabatay, the mountains between the Ríos Pisqui and Chupichotal, the highest peaks in northern Cordillera Azul), and of other habitats that we did not have the opportunity to inventory (e.g., high-elevation swamps and marshes, isolated lakes) or that we inventoried insufficiently (e.g., streams and forests along the whole altitudinal gradient).

Dedicated research on selected turtles (especially *Podocnemis* and *Geochelone*) and caimans will help determine tolerable levels of harvest for local consumption. These species, as well as other game animals, should be the targets of adaptive management plans, to ensure their continued survival.

Field guides with photographs of the common amphibians and reptiles in the region could become great aids for ecotourism: these animals are gorgeous, common through much of the area, and easy to observe.

## BIRDS

**Participants/Authors:** Thomas S. Schulenberg, John P. O'Neill, Daniel F. Lane, Thomas Valqui, Christian Albújar

**Conservation targets:** Bird communities of hill, cloud, and short, spongy forests; endemic and elevation-restricted birds; large parrots; large gamebirds.

## METHODS

Participants on the rapid biological inventory team (August–September 2000) were Thomas S. Schulenberg and Christian Albújar, with supplemental observations from Debra K. Moskovits and other members of the survey team. In this report, we also include results from two expeditions—by the Louisiana State University Museum of Natural Science (LSUMZ) and the Museo de

Historia Natural de la Universidad Nacional Mayor de San Marcos (MUSM)—to the upper Río Cushabatay (June–August 1996) and to the upper Río Pauya (June–August 2000).

The basic protocol for the rapid surveys involved walking trails through the forest to locate and identify birds. Each observer was in the field from first light (or very shortly thereafter). Depending on the length of the trail, an observer might be in the field until late afternoon; those who did return for lunch were in the field again from early afternoon until dusk. We made an effort to survey all habitats in the area. Ornithologists usually walked the trails separately, and, when possible, walked different trails on different days. Schulenberg and Albújar, and several members of the LSUMZ/MUSM expeditions carried portable cassette tape recorders and directional microphones to make sound recordings of bird species. The sound recordings will be deposited at the Library of Natural Sounds, Cornell Laboratory of Ornithology (LNS). We did not conduct transects or point counts, but Schulenberg and Albújar tallied the number of individuals observed daily, for each bird species, to aid in the assessment of relative abundances. The LSUMZ/MUSM expeditions used long lines of mistnets for bird capture. Voucher specimens obtained by the LSUMZ/MUSM expeditions are deposited in both the Museo de Historia Natural de la Universidad Nacional Mayor de San Marcos (Lima, Peru), and the Louisiana State University Museum of Natural Science (Baton Rouge, Louisiana, U.S.A.).

## RESULTS OF THE BIRD SURVEYS

The rapid biological survey team recorded a total of 375 species during the three weeks in the field in the Pauya and Pisqui drainages, with 227 species recorded in the Pauya basin and 328 species in the Pisqui. The higher total that we observed in the Pisqui reflects at least two main factors, namely (1) that we spent more time overall in the Pisqui drainage (two weeks instead of one week), and (2) that we made more extensive observations at the lower (and more species-rich) elevations in the Pisqui. The 2000 LSUMZ/MUSM

expedition to the Pauya registered almost 400 species during the more intensive studies, suggesting that the two watersheds have similar diversities. In addition, the 1996 LSUMZ/MUSM expedition to the high ridges north of the Río Cushabatay reported 386 species (with an additional 54 species observed only along the Río Cushabatay itself, from the field camp downstream to Pampa Hermosa). Of this total, 40 species were not found in the Pauya or Pisqui study sites. The number of bird species currently known from the Cordillera Azul is 520.

Broadly speaking, we divide the forest birds into three components or macrohabitats: (1) those restricted to lowland forests, including floodplain forests (along rivers and large streams) and old river terraces, at elevations below 300–500 m (depending upon local topography); (2) slope forests, including those that occur on the hills and ridges from ca. 300 m up to 1000–1100 m; and (3) crest forests, namely, those found in cloud forests; mossy, short, spongy forest; elfin forests; and high-elevation shrublands (ca. 1100–1200 m and higher).

## Birds of the Lowland (Floodplain and Terrace) Forests

We expect the greatest species richness—for birds as well as for all other organisms—to be in the lowland (floodplain/terrace) and hill forests. That said, the bird diversity of such forests throughout the northern Cordillera Azul is relatively low compared to many other parts of Peru. For example, even relatively lengthy surveys, such as the 2000 LSUMZ/MUSM expedition to the upper Pauya, resulted in only 14 species of ovenbirds (Furnariidae) in the lower-elevation forests, while extensive floodplain forests at other sites in eastern Peru may support up to 20 or 25 species (T. A. Parker unpub., Terborgh et al. 1984, Foster et al. 1994). Admittedly, a better comparison would be other rainforest sites in central Peru, but very few localities in the Ucayali valley have been surveyed well. Furthermore, the relative densities of many of the “expected” species of the lowland rainforests of the northern Cordillera Azul seemed lower than at other sites with which we are familiar.

The avifauna of the floodplain and terrace forests of the northern Cordillera Azul represents an area of faunal mixing, with elements of what often are considered “north [Amazon] bank” and “south bank” avifaunas. This north-south dichotomy, however, is too simple, given that many so-called “north bank” taxa occur on the south bank of the Amazon in the valley of the Río Huallaga, or between the mouths of the Ríos Huallaga and Ucayali (Haffer 1978). Species present in the northern Cordillera Azul that conform to the “north bank” distributional pattern include Black-headed Parrot (*Pionites melanocephala*), Yellow-billed Jacamar (*Galbula albirostris*), White-chested Puffbird (*Malacoptila fusca*), Short-billed Antwren (*Myrmotherula obscura*), White-plumed Antbird (*Pithys albifrons*), and Nightingale Wren (*Microcerculus marginatus*, northern song type). Species representative of the “south bank” include Razor-billed Curassow (*Crax tuberosa*), Pale-winged Trumpeter (*Psophia leucoptera*), White-throated Jacamar (*Brachygalba albogularis*), Lemon-throated Barbet (*Eubucco richardsoni aurantiicollis*), Brown-mandibled Aracari (*Pteroglossus azara mariae*), White-winged Shrike-Tanager (*Lanio versicolor*), and Red-billed Pied Tanager (*Lamprospiza melanoleuca*).

Beyond this general pattern of faunal mixing, we observe specific instances in which two closely related taxa apparently replace one another over short distances in or near the Cordillera Azul. For example, at Sarayacu, a site in the Río Ucayali floodplain just to the northeast of the Cordillera Azul, the following species are reported: Blue-cheeked Jacamar (*Galbula cyanicollis*), Rufous-necked Puffbird (*Malacoptila rufa*), Saturnine Antshrike (*Thamnomanes saturninus*), and Wire-tailed Manakin (*Pipra filicauda*) (Sclater and Salvin 1873; Zimmer 1931, 1932; Haffer 1974). Each of these species is replaced by a sister taxon at our study sites on the Río Cushabatay, ca. 80 km to the southwest—Yellow-billed Jacamar (*Galbula albirostris*), White-chested Puffbird (*Malacoptila fusca*), Dusky-throated Antshrike (*Thamnomanes ardesiacus*), and Band-tailed Manakin (*Pipra fasciicauda*). Within the northern

Cordillera Azul, we recorded Moriche Oriole (*Icterus chryscephalus*, a “north bank” species) on the Río Cushabatay, whereas we saw this species *and* its (“south bank”) congener Epaulet Oriole (*Icterus cayanensis*) along the Río Pauya. Meanwhile, we encountered only the “south bank” *I. cayanensis* on the Río Pisqui. Most of our observations are sight records only (i.e., not documented with specimens), so subtle signs of introgression might not be apparent; nonetheless, it appears that these two species geographically replace one another over a distance of only ca. 70 km. Two species of *Thamnomanes* antshrikes present a complicated scenario. The LSUMZ/MUSM expedition collected the Cinereous Antshrike (*T. caesius*) along the Río Cushabatay, whereas the southern Bluish-slate Antshrike (*T. schistogynus*) has been collected at Sarayacu (to the northeast of the Río Cushabatay; Zimmer 1932), and we found it along the Río Pisqui (to the south of the Cushabatay). At a more local level of faunal turnover, the populations of the Paradise Tanager (*Tangara chilensis*) from the Río Cushabatay sites belong to the nominate subspecies (*chilensis*), which is widespread through much of western and southern Amazonia. However, at the Río Pauya sites we collected a wide range of individuals, some with plumage characters of the nominate subspecies (*chilensis*), others with characters of the subspecies *chlorocorys* (known from the Río Huallaga valley), and still others intermediate between these two.

The first specimen records for Peru of the Purple-breasted Cotinga (*Cotinga cotinga*) come from the LSUMZ/MUSM expedition to the Río Pauya. This species, which has a primarily Guianan distribution, was known in Peru only from sight records (T. Schulenberg, B. Walker, and others) from one locality in San Martín, east of Moyobamba, at Jesús del Monte. The San Martín site, like the northern Cordillera Azul, also is an area with outcrops of sandy soil (Davis 1986).

Despite the relatively low species richness of the lowland forests in the northern Cordillera Azul, the floodplains and terraces represent an area of conservation interest both because of the transition in faunal

elements and because of the relatively large populations of game birds: Spix's Guan (*Penelope jacquacu*), Blue-throated Piping-Guan (*Pipile cumanensis*), and, most importantly, Razor-billed Curassow (*Crax tuberosa*). We know that the chain-saw loggers who work the upper Río Pauya hunt these birds for food, as do the Shipibo communities in the upper Río Pisqui. Nonetheless, we saw these large game birds almost daily at both the Pauya and the Pisqui macrosites, suggesting that the region harbors substantial populations of these species. Macaws and large parrots (*Amazona*) were not abundant at the study sites; however, we did see these birds daily, in reasonable numbers, in the upper Río Pisqui and on the Río Cushabatay. Populations of these species (especially of macaws) have declined greatly in many parts of Amazonian Peru, due to the combined pressures of habitat destruction and capture for the pet trade.

#### Birds of the Slope Forests (to 1200 meters)

Typically, a large portion of the avifauna of the floodplain and old terraces ascends the lowermost hills of the Andes. In the low hills of the northern Cordillera Azul, however, the first elements of the Andean avifauna appear at elevations as low as 300 m. As one ascends the hills and the mountain slopes, more and more Andean species appear and at ca. 1200 m the Amazonian species have dropped out, being replaced by a purely Andean avifauna. The overall species richness in the northern Cordillera Azul is high: we estimate the total for the region to reach or perhaps exceed 800 species.

Several hill- and slope- forest birds characteristically have narrow elevational distributions. These very elevational bands often are prime targets for agriculture (e.g., coffee, cereals), putting these birds at risk of extinction. The hill and slope forests and their biological communities are therefore important targets for conservation in the northern Cordillera Azul. As yet untouched by agriculture, we had expected these forests of the northern Cordillera Azul to present an exceptional opportunity for the conservation of this threatened avifauna. We were surprised to find that some of the most characteristic birds of the hill and slope forests

appeared to be entirely absent from the region, e.g., Blue-rumped Manakin (*Lepidothrix isidorei*) and Ornate Flycatcher (*Myiobrycon ornatus*), or present only in low numbers and not found at all sites surveyed, e.g., Thrush-like Manakin (*Schiffornis turdinus*), and Carmiol's Tanager (*Chlorothraupis carmioli*). On the other hand, some of the more poorly known and elevationally constricted, hill- and slope-forest species were present at one or more of the sites investigated, e.g., Buff-throated Tody-Tyrant (*Hemitriccus rufigularis*), Scaled Fruiteater (*Ampelioides tchudii*), Gray-tailed Piha (*Lipaugus subalaris*), and Sharpbill (*Oxyruncus cristatus*). We also found Blackish Pewee (*Contopus nigrescens*), a bird of this elevational zone that is known from only a handful of other localities in Peru.

The hill and slope forests in the Cushabatay and the upper Pauya are the only sites at which two taxa previously known only from northeastern South America—"Golden-chested" Manakin (*Machaeropterus regulus aureopectus*) and Dotted Tanager (*Tangara varia*)—have been recorded in Peru. We first found these birds in the upper Cushabatay and then recorded them again in the upper Pauya. Albújar observed *Tangara varia* in the upper Pisqui, but we have no records of the *Machaeropterus* from that basin.

#### Birds of the Upper Slope and Crest Forests

Above ca. 1200 m, the forest turns more humid and mossy and the ground very spongy (see short, spongy forests, in Flora and Vegetation). At the uppermost ridges of the upper Pauya and Pisqui basins, we found stunted forests, and from our overflights it was clear that this stunted vegetation seems to be the rule along the crests of northern Cordillera Azul (see Flora and Vegetation). Our only encounter with tall, cloud forest was along the crest of one ridge on the upper Cushabatay, in 1996 (LSUMZ/MUSM expedition). Comparing the three upper-elevation forest areas we sampled (Cushabatay: relatively extensive area, well sampled, tall forest, to 1500 m; Pauya: relatively extensive area, well sampled, forest of low stature, to 1650 m; Pisqui: relatively extensive area, lightly

sampled, largely forest of low stature, to 1250 m), we find that the upper-elevation avifauna changes considerably from one ridge or crest to the next. Each study site contains a common set of species, supplemented by species not known from either of the two other sites. Most of these montane forest species are widespread and common in the main Andes, but two elements stand out as faunal elements of considerable interest and of conservation importance. The first of these is an endemic species of tall cloud forest in the northern Cordillera Azul, the Scarlet-banded Barbet (*Capito wallacei*). Based on our overflights and from what we could see of other ridges from our study sites, suitable habitat for this species is restricted to a relatively small number of ridge crests within the Cordillera. Given the low levels of human activity in the region, especially at the higher elevations, this species is not threatened at present, but it nonetheless must have one of the most geographically restricted ranges of any Andean bird. The other component of interest and conservation importance encompasses two species that are restricted to the stunted forest along the crests of the ridges: Royal Sunangel (*Heliangelus regalis*) and Bar-winged Wood-Wren (*Henicorhina leucoptera*). Both species are known from only a few other sites in the Andes, and in what seem to be small, isolated populations; the *Heliangelus* has been considered to be “vulnerable” to extinction (Collar et al. 1994). In the northern Cordillera Azul, however, the habitat occupied by both of these species appears to be the dominant plant community at the higher elevations throughout the Cordillera. Cordillera Azul could be the center of abundance for both of these species (and these species may be less threatened than previously thought). The northern Cordillera Azul forests also hold sizeable populations of Wattled Guan (*Aburria aburri*), another large game species that is declining with increasing hunting pressure and habitat loss (Ortiz and O’Neill 1997).

## UPPER RÍO CUSHABATAY

(John P. O’Neill, Daniel F. Lane)

An expedition from the Louisiana State University Museum of Natural Science (LSUMZ) and from the Museo de Historia Natural de la Universidad Nacional Mayor de San Marcos (MUSM) surveyed birds in the upper Río Cushabatay from June to August 1996. Ornithologists on this expedition were John P. O’Neill, Leticia A. Alamía, Angelo P. Capparella, Andrew W. Kratter, Daniel F. Lane, and Cecilia Fox. We inventoried the birds with mistnets and general observations, and obtained vouchers (specimens and tape recordings) for the majority of the species registered during the trip. Specimens are deposited at LSUMZ and MUSM, and the tape recordings will be deposited at Cornell Laboratory of Ornithology (Library of Natural Sounds).

Our aim was to survey the avifauna of the tallest peaks accessible from the Río Cushabatay. We established camp at about 200 meters near the river. From here we cut a trail that generally headed northeast, and established a series of field camps along the route. Eventually, the expedition reached the summit of a tall (ca 1540 m) ridge at 7°05’S, 75°39’W. Locations of the Cushabatay field camps were: Camp I at 7°09’S, 75°44’W, 200 m; Camp II at 7°08’S, 75°41’W, 350 m, and Camp III at 7°05’S, 75°39’W, 1000 m.

The vegetation along the trail from the river to the top of the peak was extremely variable; unfortunately, time constraints did not allow us to survey adequately many of the vegetation types that we encountered. The area immediately around the base camp on the banks of the river was not typical of the lowland forests of eastern Peru with which we are familiar. The understory was full of palms and viney growth (see also Flora and Vegetation). There was a *cocha*-like swampy area about 0.5 km inland from the river with a *Mauritia* palm swamp at one end. We spent little time exploring these two habitats and doubtless overlooked some species specializing in them. The forest was not overly tall, with a canopy that rarely exceeded 30 m. The forest on the first small hills contained a large number of palms, but diversity and size of trees

seemed to be more typical of the rainforests of eastern Peru, with the canopy reaching approximately 40 m in height. Certain birds typical of lowland forest, such as greenlets (*Hylophilus*), all *Turdus* thrushes (except White-necked Thrush, *T. albicollis*) and most species of manakins were rare or absent in the riverine forest. In the hill forest, we found most typical lowland species, but often not in large numbers, especially in comparison to equivalent forests in southeastern Peru. Bamboo was essentially absent from the whole transect, being found only on the second ridge and consisting of a small area of *Chusquea* and two plants of *Guadua*. Despite this almost total lack of bamboo habitat, however, we did encounter 2 individuals of the Rufous-headed Woodpecker (*Ceelus spectabilis*), a near-obligate bamboo specialist (Kratzer 1997).

The forest at the second camp was fairly typical of lowland hill forest, with tall trees, few buttress roots, a “normal” quantity of palms, and emergent trees with a canopy over 40 m tall. The soil here was mostly sandy. The avifauna was typical of lowland hill-forest, and most waders and other riverine or swamp-forest species dropped out, e.g. all herons, Variable Chachalaca (*Ortalis motmot*), Pale-vented Pigeon (*Columba cayennensis*), White-tipped Dove (*Leptotila verreauxi*), Chestnut-fronted Macaw (*Ara severa*), Dusky-headed Parakeet (*Aratinga weddellii*), Canary-winged Parakeet (*Brotogeris versicolurus*), Swallow-winged Puffbird (*Chelidoptera tenebrosa*), Little Woodpecker (*Veniliornis passerinus*), and Yellow-bellied Elaenia (*Elaenia flavogaster*).

The most interesting species we encountered on a ridge above Camp II was an adult male White-bellied Dacnis (*Dacnis albiventris*). This is one of the few lowland forest species that truly seems to be rare, or at least to exhibit an extremely patchy distribution; we know of only about 3 other specimens from Peru.

The crests of most ridges were composed of sandy or rocky soils, probably from block faulting followed by erosion and the breakdown of exposed rock. These ridges support a dense, stunted vegetation with lots of Melastomataceae (especially *Miconia*), an

understory of shrubs, ferns, and some terrestrial Bromeliaceae, and ground cover of *Selaginella* and mosses (quite dry and shriveled at the time of our visit). In several places on most ridges we found ourselves walking along the upper edge of landslides, and in some areas we crossed fairly large rockslides that were just beginning to develop new vegetation. The canopy on most ridges was in the range of 4–10 m. As these ridges were located between the field camps, we did not survey them adequately for birds. It was in such forest, however, that Lane sighted the only record for the seemingly rare and patchily distributed Cinnamon Manakin (*Neopipo cinnamomea*). Another manakin species, the Striped Manakin (*Machaeropterus regulus*), was not confined to the stunted forest, but seemed to reach its peak abundance there. The form we found in the Cushabatay closely matches specimens of the subspecies *M. r. aureopectus*, previously known only from the Guianan Shield area of southern Venezuela and northern Brazil. *Aureopectus* typically occurs at elevations of 400 m or higher. The elevational distribution of *aureopectus* (i.e., restricted to relatively high elevations) and its disjunct occurrence in the Cordillera Azul and in Roraima suggest that this taxon is a biological species. Our specimens show consistent differences when compared to Roraiman specimens of *M. r. aureopectus*, and we suspect that the Cushabatay birds represent an undescribed subspecies, closely allied to the Guianan taxon. We further suspect that members of the *aureopectus* group are patchily distributed in poor-soil vegetation in areas of more than 500 m elevation. The bird should be looked for in suitable habitat in the areas of southeastern Colombia, eastern Ecuador, and northwestern Brazil that lie between Venezuela and Peru.

Another habitat that we did not adequately sample was the tall, very humid forest in the deep, narrow canyons between ridges. In such forest, near the saddle between ridges “4” and “5,” we found the Gray-tailed Piha (*Lipaugus subalaris*). Its congener, the Olivaceous Piha (*L. cryptolophus*), was an uncommon resident of the cloud forest above 1300 m. Although the 2 may replace each other elevationally, this is the

first instance in which they have been found at the same locality.

The trail continued up to a small water seep where two hills came together, at a ridge of 1000 m, the site of Camp III. Above Camp III is where the expedition first collected the Dotted Tanager (*Tangara varia*), the first record of this species for Peru. It previously was known from northeastern South America, primarily from the Guianan region. We found it as low as 400 m on Ridge 1; it usually seems to be associated with poor-soil vegetation.

Some of the tallest humid forest was on the steep slopes of the main peak (1000–1300 m range), with a canopy height of approximately 45 m. Here foraging flocks were common and noisy, and contained birds typical of those elevations, such as Bay-headed Tanager (*Tangara gyrola*) and Carmiol's Tanager (*Chlorothraupis carmioli*).

The most abrupt and dramatic vegetational change came at approximately 1250 m, where, on most days, the lower level of the cloudbanks hangs over the mountain. At this point, trees and forest floor went from having few epiphytes to having surfaces festooned with bromeliads, orchids, mosses, bryophytes, ferns, small tree seedlings, and other vegetation (Figure 7B). As the trail reached the upper ridge-top and began to level out, the vegetation once again became scrubby and was composed mainly of *Miconia*, *Clusia* and other poor-soil plants. At the peak, we cleared a small area that allowed a 360° view of the surrounding lowlands. When the weather was clear, we were able to see southeast as far as the banks of the Río Ucayali (ca. 120 km away), west to the mountains in the upper Río Pauya drainage (ca. 70 km distant), and north to the next high peaks (ca. 25 km away). Most of the areas to the east, west, and south were hilly and forested. But to the north was one of the most incredible views O'Neill has ever witnessed in his 40 years of Peruvian travel. There were huge canyons; tall, block-faulted mountains with 300–500 m cliff faces on their east-facing sides, and mountains of 800–1000 m that rolled off into the distance with no end in sight. In the entire 360° view

there was no sign of human disturbance except for a smoky haze that comes as people burn small plots that they clear in the dry season.

The avifauna of the cloud forest (the wet, epiphyte-laden forest from 1250 m to the 1540 m summit) was the main focus of our expedition. This may be the most isolated cloud forest in Peru and in the continent. The most exciting find was a spectacular, brilliantly colored new species of barbet, the Scarlet-banded Barbet (*Capito wallacei*, O'Neill et al. 2000; Figure 1). Aside from the barbet, the overall avifauna of the cloud forest was quite strange in composition. Most notable was the total lack of *Tangara* tanagers, a group that normally typifies the lower elevation cloud forests of the Andes. At the other extreme, we certainly did not expect to encounter the Wattled Guan (*Aburria aburri*), a large bird that would not seem to be able to maintain a population in such a small area of forest. Present were a number of predictable species such as the Green Hermit (*Phaethornis guy*), Versicolored Barbet (*Eubucco versicolor*), Slaty Antwren (*Myrmotherula schisticolor*), Scaled Antpitta (*Grallaria guatemalensis*), Slaty-capped Flycatcher (*Leptopogon superciliaris*), Green Jay (*Cyanocorax yncas*), Slate-throated Redstart (*Myioborus miniatus*), and White-winged Tanager (*Piranga leucoptera*). Other surprises included the prominence of Blue-winged Mountain-Tanager (*Anisognathus somptuosus*) as the common tanager in mixed species flocks, and the presence of a *Scytalopus* tapaculo in such an isolated forest. In several cases, the “expected” species of hill forest species was absent, but was replaced by a congener, e.g. the (lowland) Blue-crowned Manakin (*Lepidothrix coronata*) went all the way to the summit instead of being replaced in the cloud forest by Blue-rumped Manakin (*L. isidorei*), and the Chestnut-tipped Toucanet (*Aulacorhynchus derbianus*) was common in the cloud forest, but we did not encounter its lower hill-forest replacement, the Emerald Toucanet (*A. prasinus*).

The peculiarities of the avifaunal composition of this cloud forest probably reflect several factors, including the unusual nature of the sandy-soil substrate

of these ridges, the long period of isolation of these cloud forests, and the relatively small, overall size of the forest area (ca. 5 x 5 km). Aside from the peaks to the north, we estimate our study site to be at least 60 km away from another such area of cloud forest. The extent of forest may be greater on the peak to the north, where two high peaks seem to be joined by a long saddle.

The only signs of humans we encountered away from the river were two trees near our second camp, which had been tapped by rubber workers, one bearing a date of 1965. Mammals were fairly common, but it was obvious that lumbermen and rubber-tappers had hunted in the area for some time: animals were quite wary near the river, but from Camp II up, monkeys and other mammals were fairly tame. Game is easily hunted only in the flatter areas near the river, and we did not see Brazil nuts in the area. Aside from logging, there seems to be little reason for humans to enter the region except for subsistence hunting in the lowland forests along the river.

#### UPPER PAUYA BASIN

(Thomas S. Schulenberg, John P. O'Neill, Daniel F. Lane, Thomas Valqui, Christian Albújar)

An expedition from the Museum of Natural Science, Louisiana State University and the Museo de Historia Natural, Universidad Nacional Mayor de San Marcos surveyed this area from 11 June until 15 August 2000. This team established 4 camps in the upper Pauya watershed: Campamento Pauya Orilla del Río (O'Neill Camp 1), Campamento Principal (O'Neill Camp 2), Campamento Cresta (O'Neill Camp 4), and Campamento Ladera (O'Neill Camp 3). See Overview of Sites Sampled (in this Technical Report) for further information about these localities. The rapid biological survey team was at these upper Pauya Basin sites from 23–31 August 2000.

The LSUMZ/MUSM team collected the first specimens for Peru of the Purple-breasted Cotinga (*Cotinga cotinga*) from an emergent tree directly over the campsite at Campamento Principal. Razor-billed Curassow (*Crax tuberosa*) regularly frequented this

region, although illegal loggers had worked in the area and presumably had hunted *Crax* for food. White-breasted Pygmy-Tyrant (*Myiornis albiventris*) was common in the forest on the slopes of the ridges from 700 to 1200 m; this species previously was known north only to southern Huánuco, although it was tape recorded by Lane on the Río Cushabatay (400–600 m), and by Valqui at Jesús del Monte, east of Moyobamba in San Martín.

The most notable records in the Pauya macrosite were the birds of cloud forests. The Scarlet-banded Barbet (*Capito wallacei*) was not found, perhaps because only very small patches of its habitat—tall cloud forest—occurred at this site. This species may well be on another ridge, just to the northwest, which (as seen from a distance) seemed to have an extensive area of suitable, tall forest along its crest. Two locally distributed species associated with stunted forests on sandy soil outcroppings, the Royal Sunangel (*Heliangelus regalis*) and Bar-winged Wood-Wren (*Henicorhina leucoptera*), were common in this habitat above the two higher camps. Curiously, although the forests on the crests of the Pauya ridges generally were of lower stature than the forests (at 1300–1500 m) on the Río Cushabatay, the Pauya localities had a large number of cloud-forest species that were not detected along the Cushabatay; among these are Buff-fronted Owl (*Aegolius harrisi*), Rufous-webbed Brilliant (*Heliangelus branickii*), Bronzy Inca (*Coeligena coeligena*), Booted Raquettail (*Ocreatus underwoodii*), Crested Quetzal (*Pharomachrus antisianus*), Brown-billed Scythebill (*Campylorhamphus pusillus*, previously known with certainty south only to the headwaters of the Río Mayo, in San Martín, although it probably also was seen by Kratter at the Río Cushabatay), Streaked Tuftedcheek (*Pseudocolaptes boissonneautii*), Variable Antshrike (*Thamnophilus caeruleus*), Chestnut-crowned Gnatcatcher (*Conopophaga castaneiceps*), Chestnut-crested Cotinga (*Ampelion rufaxilla*), Scarlet-breasted Fruiteater (*Pipreola frontalis*), Andean Cock-of-the-Rock (*Rupicola peruviana*), Glossy-black Thrush (*Turdus serranus*), and Tricolored Brush-Finch (*Atlapetes*

*tricolor*). Also of interest was the presence of White-capped Dipper (*Cinclus leucocephalus*) along the stream below Campamento Cresta, and once along Quebrada John (at Campamento Torrente). As we noted on the Río Cushabatay, we also found here sizeable populations of Wattled Guans (*Aburria aburri*) in taller forests at the higher elevations.

#### UPPER PISQUI MACROSITES

(Thomas S. Schulenberg, Christian Albújar)

We surveyed two sites within the upper Río Pisqui basin, each for one week. At Pisqui Campamento Planicie (31 August to 8 September 2000), on the west bank of the upper Río Pisqui, we had a limited number of trails available, all of which were through areas at relatively low elevations. Pisqui Trocha Huangana headed directly northwest from the camp. Two trails were accessible on the east bank of the Río Pisqui, opposite camp. The first of these, Pisqui Trocha 6 Km, headed due south, and initially was parallel to the river. We only worked the northern 3 km or so of this trail. On two occasions we also surveyed Pisqui Trocha Hacia Apua.

At the second macrosite on the upper Río Pisqui (8–14 September), in contrast, we were able to spend more time investigating the ridges on the southeast bank of the river. We spent three nights (9–11 September) at Pisqui Campamento Subcresta, at 1150 m, just below the crest of the ridge. From here we surveyed for birds both in the moderately tall forest along the ridge, in the vicinity of camp, and in the stunted forest at the crest, above camp (at about 1200 m). We (primarily Albújar) spent a limited amount of time surveying birds in hill forests near Pisqui Campamento Quebrada and along some of the Pisqui Trochas a las Colinas, on the northwest bank of the Río Pisqui.

It was at Pisqui Campamento Planicie that we recorded *Thamnomanes schistogynus* and *Icterus cayanensis*, 2 species that seem to “replace” congeners found in the Pauya drainage, to the north. As along the upper Río Pauya sites, we found large game birds such as *Pipile cumanensis* and *Crax tuberosa* to be fairly

common. We observed the highest densities of large parrots (macaws and Amazon parrots) along the Pisqui. One curious habit we observed was large numbers of parrots descending to the ground, very early in the morning, on the banks of the upper Río Pisqui, primarily where small side tributaries emptied into the river and rivulets of water flowed around the small rocks that formed the riverbanks. These congregations of parrots had the appearance of the concentrations that gather at *colpas* (“salt” licks) elsewhere, although the parrots on the Pisqui gave the impression of being attracted by the water. Also of interest was that the common (and possibly only?) Amazon parrot observed in the upper Pisqui drainage was the Yellow-headed Parrot (*Amazona ochrocephala*), while the only Amazon we found in the upper Pauya drainage was the Mealy Parrot (*A. farinosa*).

Although the vegetation along the crest of the ridge, at 1200 m, is floristically similar in species to the ridge crests of the Pauya basin, we did not record the two most interesting birds, *Heliangelus regalis* and *Henicorhina leucoptera*, which were found in the Pauya. On the other hand, although the highest ridge on the south bank of the upper Río Pisqui reaches only 1200 m (in contrast to almost 1700 m on the upper Pauya, and 1500 m on the Río Cushabatay), we recorded several lower montane species here that we did not find at the higher sites. Among these species are White-backed Fire-eye (*Pyriglena leuconota*), Rufous-breasted Antthrush (*Formicarius rufipectus*), Scaled Fruiteater (*Ampelioides tschudii*), and Scarlet-rumped Cacique (*Cacicus uropygialis*).

#### THREATS AND PRELIMINARY RECOMMENDATIONS

Currently, we see little threat to the higher elevations of the northern Cordillera Azul. However, the forests of the floodplain, terraces, and hills are vulnerable to logging and subsistence hunting. We do not know what effect the removal of selected species of commercial trees would have on the bird community, but subsistence hunting by seasonal loggers will lower the local populations of

game birds (and of large mammals as well). From the east, at least, the rapids (pongos) on the rivers that drain this region of the Cordillera provide good protection from human colonization, but encroachment from the northwest (and perhaps eventually from the west) is a real possibility and threat.

The northern Cordillera Azul is a region of impressive habitat heterogeneity. Only a few of these habitats have been surveyed for birds. A priority for further inventory is to confirm our suspicions that areas containing what looks to be similar vegetation on different ridges indeed support the same or similar bird communities. The differences among the different cloud-forest sites leave us cautious about extrapolating too greatly from one ridge to another. In any event, what looks from the air to be the same or similar vegetation is found from 2000 m down to 300 m; we imagine that the bird community could change considerably over this large elevational range, so this habitat type should be surveyed at several different elevations. The forests of the Vivian formations along the front range of the Cordillera Azul warrant investigation. Also of interest would be the avifauna of the high elevation swamps (*pantanos*) in the southern portion of the northern Cordillera Azul. During the overflight we saw Horned Screamer (*Anhima cornuta*), normally a bird of lowland rivers and cochas (oxbow lakes), in these *pantanos* at the extraordinary elevation of 1400 m.

The combination of large populations of game birds, the presence of endemic species, the presence of species of restricted elevational and/or geographic distribution, and the almost total absence of a permanent human presence in the Cordillera Azul make the region a prime target for conservation. The value of the Cordillera Azul as a site for conservation action further is highlighted by the fact that the high cordilleras that line this region on almost all sides help form protective, natural boundaries.

## MAMMALS

**Participants/Authors:** Victor Pacheco and Lily Arias

**Conservation targets:** Mammals classified as CITES I (threatened with extinction) and CITES II (potentially threatened if no action is taken), including *Ateles chamek*, *Lagothrix lagotricha*, *Lontra longicaudis*, *Myrmecophaga tridactyla*, *Panthera onca*, *Pithecia monachus*, *Priodontes maximus*, *Pteronura brasiliensis*, *Speothos venaticus*, *Tapirus terrestris*, *Tayassu pecari*, and *Tremarctos ornatus*; also, rare mammals (*Atelocynus microtis* and *Chironectes minimus*), and seed-dispersers and seed-predators. Names generally follow Emmons and Feer 1997.

## METHODS

The protocols we used to evaluate the species richness of mammals within the northern Cordillera Azul consisted of both visual sightings and trapping. Sightings included direct observations, complemented with tape recording of vocalizations, and indirect evidence (e.g., tracks, dung). For non-lethal trapping, we used 12-m mistnets for bats and Tomahawk and Sherman traps for non-flying mammals. We also interviewed indigenous Shipibo working with us as guides and trailcutters. For both visual and trapping protocols, we attempted to include the diverse array of habitat types present, for example floodplains, terraces, hills, and lower and upper slopes. Our observations occurred during daytime and nighttime hours along existing trails, and along riverbanks (there were no roads in the region we surveyed). Daytime observations spanned 0630 and 1700 hours and nighttime observations were from 1900 to 2200 (i.e., we did not limit our observations to the period of peak activity). We walked at a pace of approximately 1–1.5 km/hour, scanning from understory to canopy and focusing on any movement or noise. When necessary, we followed the animals until we could obtain positive identification. For each sighting, we noted the time of day, location, elevation, habitat type, number of individuals, height in the vegetation, and distance from the trail. INRENA did not give us permits to collect specimens, so we were unable properly to document our findings of small mammals and bats. Also because of restrictions on collecting, we were unable to use certain traps (e.g., snap traps), which are usually more efficient

in the capture of small mammals in the lowlands. We therefore concentrated on bats and large mammals. We also documented our records photographically, when possible. The photographs and tape recordings remain with V. Pacheco at the Museo de Historia Natural de la Universidad Nacional Mayor de San Marcos (MUSM), in Lima. Our records also include observations from other members of the rapid inventory team, especially from Thomas S. Schulenberg, Debra K. Moskovits, and Christian Albújar, as well as from the O'Neill expeditions (LSUMZ/MUSM).

## RESULTS OF THE MAMMAL SURVEY

We recorded 71 mammal species in our inventories at the Pauya and Pisqui macrosites, including 31 species for the upper Río Pauya watershed and 61 species for the upper Río Pisqui. The greater number of species for the Pisqui primarily reflects the information that we obtained from the Shipibo residents. Among the most notable records are 10 species of primates (Appendix 6), tapirs (*Tapirus terrestris*), 2 species of peccary (*Pecari tajacu*, *Tayassu pecari*), 4 cats (*Leopardus pardalis*, *Panthera onca*, *Puma concolor*, and *Herpailurus yagouaroundi*), 2 dogs (*Speothos venaticus* and *Atelocynus microtis*), and the spectacled bear (*Tremarctos ornatus*). Our low number of bat and rodent species is almost certainly due to the restrictions on collecting (see above). Nevertheless, our records of the larger mammals indicate that the mammal fauna is intact. We encountered many CITES I and II species. These species, which are often rare or missing in other natural areas, were strikingly abundant in the sites we surveyed. We saw large numbers of monkeys (*Pithecia monachus*, *Lagothrix lagotricha*, *Ateles chamek*) and large herds of white-lipped peccaries (*Tayassu pecari*). These large populations reflect virtually no hunting pressure and habitats in good condition.

Our most significant find was a dark, small squirrel, no larger than *Microsciurus flaviventris*, which was present both at the upper Pauya and upper Pisqui sites. This species is probably new to science, and here we call it *Microsciurus* "oscura." We also

observed several lowland species high up on the slopes. Among the more noteworthy records are the altitudinal range-extension for saki monkeys (*Pithecia monachus*), at 1000 m, and frequent observations of large, tame groups of woolly monkeys (*Lagothrix lagotricha*).

Our initial results suggest great similarity in the mammal fauna of the upper Pauya and upper Pisqui watersheds. As expected, we found differences between the lowland and highland (above 900 m) fauna, with more species in the lowlands than in the highlands. We registered 6 species of monkeys in the higher slopes, versus 10 species in the lowlands. We found most of the other large species (e.g., deer, peccaries, dogs) only in the lowlands.

### Pauya Orilla Del Rio

The ornithological (LSUMZ/MUSM) group that visited the upper Río Pauya just prior to our arrival recorded *Callicebus cupreus* along the river, *vide* Daniel Lane. We did not observe this species during our weeklong stay in the Pauya, although we did record it at the Pisqui sites.

### Pauya Campamento Principal

We surveyed the terraces and low hills around our main camp on the upper Río Pauya and encountered 29 individual mammals, representing 18 species. Especially notable were *Ateles chamek*, *Lagothrix lagotricha*, *Pithecia monachus*, *Tapirus terrestris*, *Lontra longicaudis*, *Tayassu pecari*, and the water opossum, *Chironectes minimus*. The O'Neill expedition also registered *Myrmecophaga tridactyla* at this site. Primates, with 9 species (including the previous observations by the O'Neill expedition of *Saimiri sciureus* and *Saguinus fuscicollis*), are the dominant component of the mammal fauna at this subsite. We found a large group of at least 14 individual woolly monkeys (*Lagothrix lagotricha*) spread over an area of ca. 100 m, separated about 300 m from a group of another 6 individuals, all of which were moving in the same direction and were likely part of the same group. The groups of spider monkeys (*Ateles chamek*) were smaller (2 groups

of 2 and one sighting of 1 individual). We saw saki monkeys (*Pithecia monachus*) only once. These 3 species forage in the higher layers of the canopy, usually above 20 m. We also noted medium and large rocks in the terrain that formed refuges for bats, including *Diphylla ecaudata* (seen hopping on the ground, under large rocks) and *Tonatia sylvicola* (found inside a cavity of a fallen tree). We encountered a large group of white-lipped peccaries (*Tayassu pecari*) foraging in the same site during our entire stay, probably attracted by the large quantities of palm nuts. V. Pacheco counted at least 65 individuals on one occasion, but estimates more than 100 individuals in the group, based on the calls and grunts of more distant animals.

This subsite is a priority for conservation of mammals because of the diversity and abundance of primates and other threatened species that occur here, including tapirs, white-lipped peccaries, and nutrias.

#### Pauya Campamento Ladera

We surveyed forests on the lower slopes (900 to 1200 m altitude) to the north of our main camp on the upper Río Pauya, including records from other members of the inventory team who ascended to 1700 m. We encountered 25 mammals, representing 16 species. Among the most interesting records is a small squirrel, uniformly black, and of a size similar to *Microsciurus flaviventer*. This little squirrel may be an undescribed species and we called it *Microsciurus* “oscura.” We also recorded an altitudinal range extension for the saki monkey (*Pithecia monachus*), which was known to occur only to 600 m (Emmons and Feer 1997). Also notable for their frequent occurrence at high elevations were *Lagothrix lagotricha* (800 to 1100 m). We saw 4 groups during our few days at this site, with 4 to 12 individuals per group.

#### Pisqui Campamento Planicie and Trocha Huangana

We surveyed the alluvial habitats of both of these subsites from 1 to 8 September 2000, and registered 30 mammals, representing 22 species. The most commonly encountered mammals at this site were frugivorous bats. We also encountered 5 species of monkeys (*Ateles chamek*, *Lagothrix lagotricha*, *Pithecia monachus*, *Saguinus fuscicollis* and *Saimiri sciureus*), with *Ateles* common. The name of the trail is due to the frequent presence of a large herd of white-lipped peccaries, *Tayassu pecari*, with at least 80 individuals. The large mammals were very tame at this site. We captured and released 11 species of bats in mistnets (see Appendix 6), and in the Tomahawk traps, we captured one *Didelphis marsupialis* female with young, and one *Proechimys* cf. *simonsi*.

#### Pisqui Trocha 6 km

At this site, we walked along a recently cut trail—across alluvial plain, river terrace, and into surrounding hills—recording all mammals seen or heard. We observed 28 individuals, representing 11 species. Especially notable at this subsite were *Speothos venaticus* (the only record from our inventory, by V. Pacheco) and *Tapirus terrestris*. We also recorded *Saguinus fuscicollis* and *Callicebus cupreus*, sometimes in mixed groups. We did not trap along this trail.

#### Pisqui Trocha Hacia Apua

We sampled terraces and hills along this well-established Shipibo trail on 5–6 September. *Pithecia monachus* and *Tapirus terrestris* were present, as were 7 other species of mammal. We encountered a very tame pair of coati, *Nasua nasua*, who continued to climb and descend trees less than 10 m away from us. We did not trap along this trail.

### Pisqui Campamentos Playa y Quebrada

We used traps, nets, and visual and auditory observations to survey mammals in the alluvial plain and terraces at this subsite, from 9 to 13 September.

We had 11 individuals representing 8 species, among which were *Panthera onca* and *Pithecia monachus*.

In the Sherman traps, we caught *Oryzomys* cf. *megacephalus* and *Proechimys* sp., and we caught 3 species of bats in our mistnets.

### Pisqui Campamentos Subcresta

We also used traps and nets, in addition to visual and auditory observations, to examine these generally north-facing slopes from 8 to 12 September. We had 28 encounters representing 17 species, of which the most significant was another sighting of the “new” squirrel, *Microsciurus* “oscura.” We saw tapirs (*Tapirus terrestris*) and a large number of woolly monkeys (*Lagothrix lagotricha*). We also found *Microsciurus flaviventer* at this site, so the two small squirrels are sympatric. At the higher reaches of the mountain, at 1200 m, we found several species of bats and night sightings of the night monkey (*Aotus* sp.) and kinkajou, *Potos flavus* (both species foraging close to camp). We also had daily sightings of white-fronted capuchin monkey, *Cebus albifrons*. The abundance of monkeys in this region was notable and makes it a high priority for conservation.

### Pisqui Trochas a Las Colinas

Finally, we surveyed terraces along the Río Pisqui, recording 7 species in 10 events on 12 and 13 September. Conservation targets present in this area included *Ateles chamek*, *Pithecia monachus*, and *Lagothrix lagotricha*. The area is significant because of the abundance of primates (all of which were extremely tame). We saw 6 species of primates in the two days, with two groups of woolly monkey (*Lagothrix lagotricha*), one with 30 and the other with 4 individuals, a group of 12 *Ateles chamek*, a group of 4 *Pithecia monachus*, and a group of about 10 *Cebus albifrons*.

## THREATS AND

## PRELIMINARY RECOMMENDATIONS

We recommend further inventory work in the Pauya and Pisqui watersheds, along with additional inventories at other sites in the northern Cordillera Azul, with adequate and appropriate collection permits to document the diversity of small mammals. A careful inventory of the flying and non-flying small mammals can easily double the total number of species we recorded. The Pauya Campamento Ladera and Pisqui Campamento Subcresta sites should be revisited to collect specimens of the small, dark squirrel (*Microsciurus* “oscura”), to determine whether it is a species new to science, and to document it appropriately. The Pisqui Trocha 6 km subsite would be a good site to evaluate the population and conservation status of *Speothos venaticus*.

The northern Cordillera Azul contains an unusually high richness of large mammal species, with high estimated densities, indicating an intact and healthy condition of the forests. The rarity or absence of these species at other sites highlights the importance of designating the highest degree of protection to this area, that is, the creation of the proposed Parque Nacional Cordillera Azul Biabo. At areas closer or more accessible to resident human populations, careful restrictions on hunting, with allowance for subsistence only, under sensible management, will guarantee the continued survival of such mammalian richness.