rapid biological inventories : 03

Ecuador: Serranías Cofán Bermejo, Sinangoe

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Cofán Survival Fund

The Cofán Survival Fund (CSF) is a non-profit organization dedicated to the survival of the Cofán indigenous culture and its rainforest environment. Together with its Ecuadorian counterpart, the Fundación para la Sobrevivencia del Pueblo Cofán, the CSF supports an array of conservation and ecologically compatible development work in all seven Cofán communities in the Ecuadorian Amazon. The Fund's current projects are focused on biodiversity conservation and research, procuring legal rights and protection for traditional Cofán territory, the development of environmentally sound economic alternatives, and educational opportunities for young Cofán students.

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Federación Indígena de la Nacionalidad Cofán del Ecuador (FEINCE)

The Indigenous Federation of the Cofán Nation in Ecuador is the political arm of the Ecuadorian Cofán, representing the five legalized communities in the country—Chandia Na'e, Doreno, Dovuno, Sinangoe, and Zábalo—at the national level. FEINCE works to defend the human rights of the Ecuadorian Cofán, is a member of the larger umbrella groups supporting indigenous groups in Ecuador, the Confederation of the Indigenous Nationalities of Ecuador (CONAIE), and the Confederation of the Indigenous Nationalities of the Ecuadorian Amazon (CONFENIAE). The Federation is directed by a board of officers elected by the Cofán community every three years.

Lago Agrio, Ecuador

National Herbarium of Ecuador

The National Herbarium of Ecuador is a section of the Ecuadorian Museum of Natural Sciences, a government institution founded in 1978. The National Herbarium carries out programs of inventory, research and conservation of the Ecuadorian flora and vegetation, and houses a collection of 160,000 plant specimens and a botanical library of 2,000 volumes. The Herbarium serves as the national center for information on the flora and vegetation of Ecuador, with broad public access, and is among the principal scientific and cultural institutions of the country. It provides a public service to scientists, natural resource managers and students, and makes its voice heard in nationwide forums dealing with environmental and biodiversity issues. In the past two decades the Herbarium has provided training for hundreds of young Ecuadorian botanists, and carried out dozens of intensive botanical inventories throughout Ecuador.

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REPORT AT A GLANCE

Dates of field work:	24 July–16 August 2001
Region surveyed:	Three areas in the eastern foothills of the Ecuadorian Andes, between 450 and 2,341 m elevation: the headwaters of the Bermejo and Chandia Na'e Rivers, including the Sur Pax ridge complex; Cerro Shishicho and the forests at its base, near the Cofán community of Sinangoe; and the Ccuccono River basin (Figure 2).
Organisms surveyed:	Vascular plants, reptiles and amphibians, birds, and large mammals

Highlight of results:

The rapid biological inventory team identified significant opportunities for conservation in the Bermejo and Sinangoe region: large expanses of endangered foothill forests that stretch unbroken from the Amazonian lowlands to above 2,300 m in the Andes. The forests we inventoried contained a spectacularly diverse mix of lowland and montane biota, including a large number of undescribed and endemic species protected nowhere else. Historically under the *de facto* management and protection of small Cofán communities who have inhabited the region for centuries, these forests now face fragmentation and clearing as streams of colonists spread out from the new Interoceanic Highway.

During our three weeks in the field, the inventory team registered many rare or geographically restricted species in the four groups of organisms sampled. Several of the species are new to science, others are new for Ecuador, and many are apparently endemic to the area. A brief summary of results follows.

Vegetation and flora: Extremely wet, diverse forests on clay soils ascend from 400 to more than 2,300 m in elevation. The region is a crossroads for the lowland Amazonian and montane Andean floras, with a conspicuous shift between the two at 1,500 m. A distinct, slightly stunted vegetation grows on scattered outcrops of acidic rock throughout the region. Regenerating forest of varying ages covers large areas subject to repeated landslides, especially along the Bermejo River and in the eastern half of the Sinangoe area.

The team identified 800 species of plants, collected 1,000 herbarium specimens, photographed 600 species, and sampled nearly 1,000 trees and shrubs in transects. We estimate the region's flora to contain 2,000 to 3,000 species. Ten new plant species already have been confirmed; we expect at least ten others. One new bromeliad species, apparently a favorite food plant of spectacled bears, carpeted whole sections of the higher ridges of Cerro Sur Pax (Figure 4B). The region appears to be the world center of diversity for the coffee family, Rubiaceae, with more than 39 genera and 129 species present. It is also exceptionally rich in Orchidaceae, Gesneriaceae, Sapotaceae, and pteridophytes (ferns and their relatives). Many of these species are narrowly endemic to this section of the Andes. Half of all the palm species known from eastern Ecuador were recorded in the area.

REPORT AT A GLANCE

Large mammals: The team registered 42 species of large mammals during the inventory, eight of which are listed in CITES Appendix I (globally threatened species); 17 others are listed in Appendix II (potentially threatened). At least 12 primate species inhabit these forests, as do large populations of spectacled bear and lowland tapir. We observed what may be a new species of squirrel, and local reports suggest that other undescribed mammal species—including an opossum and a miniature woolly monkey—might occur in the area.

Birds: We found a surprisingly rich bird community in the upper hill forests of the region, including large populations of many species that are rare or threatened elsewhere in the Andes. The team recorded 399 bird species out of an estimated regional total of 700 and registered several significant range extensions. One species on the list is new for Ecuador (*Tinamus osgoodi*, the Black Tinamou), and another was known previously from only three sites (*Myiopagis olallai*, the Foothill Elaenia).

Amphibians and reptiles: Our herpetological survey was confined to the Sinangoe area, where we documented 31 species. The list includes 17 frogs and toads, six snakes, five lizards (including what is likely a new species in the genus *Dactyloa*, Figure 5E), a caecilian, and a salamander. We expect that several additional new species await discovery in the higher-elevation forests of the region.

Main threats:

The new Interoceanic Highway, connecting Tulcán with Lago Agrio (Figure 2A), has bisected this once continuous stretch of foothill forests, and waves of invading colonists are rapidly clearing and fragmenting the area. Commercial logging interests have begun to cut hardwoods along the road, and incursions into the Cayambe-Coca Ecological Reserve for illegal hunting and fishing are intensifying. The most immediate threat is that spreading, disorganized development will reach the intact forests to the east and south of the road.

Current status:

The Bermejo area has minimal legal protection, mostly under Patrimonio Forestal status, but that designation is too weak to provide an effective defense against the spreading colonization. As this report was being written, Ecuador's Ministry of the Environment expressed their intent to establish a new, 50,000 ha ecological reserve in the Bermejo area (Reserva Ecológica Cofán de Bermejo) to be declared officially in January 2002. Cerro Shishicho and the Ccuccono River are currently within the boundaries of the Cayambe-Coca Ecological Reserve (Figure 2), and are managed in part by the Sinangoe Cofán community under a *convenio* with the Ministry of the Environment.

REPORT AT A GLANCE

Principal recommendations for protection and management:	1) *In the Bermejo area, designate formal conservation status for the intact forests in the headwaters of the Bermejo, Chandia Na'e, and San Miguel Rivers and throughout the Sur Pax ridge complex.* Modify the current borders of the Cayambe-Coca Ecological Reserve to include a new 50,000-ha annex in the Bermejo area as a Cofán-administered "community reserve" (Reserva Comunitaria Cofán), managed in collaboration with the Ministry of the Environment (Figure 2; see also Current Status). 2) *Establish a high-profile, effective conservation presence in the Bermejo region, with clear delimitation and posting of the new reserve.* Train a small team of Cofán guards to patrol the area, especially along the proposed western border, closest to new settlements along the Interoceanic Highway. 3) *In the Sinangoe region, strengthen the existing collaboration between the Ministry of the Environment and the Cofán community.* Expand the management authority of Cofán park guards to prevent incursions into the Cayambe-Coca Ecological Reserve along the Aguarico, Cofanes, and Due Rivers. Increase patrolling of the area and construct new, strategically placed trails and guard stations. Post prominent signs at access trails along the borders of the reserve, with clear reminders of the area's conservation status and regulations. 4) *Establish a biological corridor to connect the proposed Bermejo annex with the rest of the Cayambe-Coca Ecological Reserve.* Extend the current northern border of the park to the vicinity of La Sofía and La Bonita, in cooperation with the local communities and the authorities of Sucumbíos Canton (Figure 2).
Long-term conservation benefits:	1) A globally important new conservation area linking protected montane forests from Colombia to central Peru 2) A model of successful, science-based conservation stewardship of ancestral lands by an indigenous community 3) Effective protection of a newly vulnerable sector of the Cayambe-Coca Ecological Reserve, one of the largest conservation areas in Ecuador 4) Preservation of the major watersheds in the Sucumbíos region

Why the Serranías Cofán?

Follow the equator westwards across the Amazon basin to the foothills of the Andes, where the most diverse mountain range in the world rises out of the richest lowland forest on Earth. Here, thunderstorms coming off the wet lowlands run head-on into the Andean massif, carving deep mountain gorges where Amazonian rivers begin their lives as white-water torrents. Twisted ridges and isolated peaks steam on the landscape like a geological train-wreck, and everywhere are reminders of the mountain-building in progress: smoldering volcanoes on the horizon, mountainsides swept clean by avalanches, and active faultlines beneath your feet.

These are the Serranías Cofán, rising up from the Amazonian lowlands in a complex tangle of topography and biodiversity. We were drawn to them because the distinctive climate and geology of their transitional forests—intermediate between the snowcapped peaks to the west and the hot Amazonian plains to the east—have fostered unique biological communities, where plant and animal communities from the lowland forests rub shoulders with the Andean flora and fauna, in the company of hundreds of endemic and undescribed taxa. In a day's climb here, a biologist can eat breakfast in an Amazonian forest and dinner in an Andean one, stopping for lunch in the narrow, mid-elevation ribbon where two of the world's most diverse biotas overlap briefly in a mix of species found nowhere else on Earth.

But the situation in these foothills is increasingly critical. A new highway, opened in August 2000, has split the formerly contiguous forests of Bermejo and Sinangoe in two. Colonization, small-scale clearing, and logging are gaining momentum in the adjacent forests, and the front has already reached the Bermejo Valley. Even at the highest point we surveyed, the 2,275-m summit just south of Cerro Sur Pax, we could hear chainsaws working in the colonist clearings below. Our explorations, collections, and recommendations for action were all spurred on by the recognition that some of these forests are months away from destruction.

Overview of Results

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ECOLOGICAL PROFILE

Seen from space on satellite images, the forests around Bermejo and Sinangoe—in the Andean foothills of northeastern Ecuador—look like uninhabited wilderness. But the picture is misleading. These forests have been inhabited for centuries by the indigenous Cofán people, who now live in four small communities along the Aguarico, Bermejo, and Chandia Na'e Rivers. For three weeks in July and August 2001, our inventory team, which included several Cofán naturalists, focused on the plants and animals at three sites in these foothills: (1) the headwaters of the Bermejo River, rising from the 450-m valley floor to the summit of 2,341-m Cerro Sur Pax, near the Colombian border; (2) the Shishicho ridgeline, near the confluence of the Cofanes and Aguarico Rivers, and the forests at its base; and (3) the watershed of the Ccuccono River (Figure 2). Our goal was not a comprehensive inventory of the area—impossible in such a short time—but instead a portrait of its biological communities detailed enough to allow us to assess their conservation value for Ecuador and the world.

Much of what we saw was unmapped terrain for scientists—who never before had visited Cerro Sur Pax, Cerro Shishicho, or the Ccuccono River drainage—but it has been familiar to local Cofán inhabitants for years. The team documented at least 1,000 species of plants out of an estimated regional flora of 2,000 to 3,000, sighted 399 species of birds out of an estimated regional avifauna of 700, and registered 42 of the 46 species of large mammals expected for the region. In such a poorly studied landscape, we were not surprised to find that a large proportion of the species we encountered were new to Ecuador or totally unknown to science. Even at this early stage, before the bulk of our plant specimens have been identified, at least ten of them have been confirmed by taxonomic specialists as new to science; at least one represents a genus never before collected in Ecuador. We registered a new species of bird for Ecuador, an undescribed species of lizard, and large populations of mammal species that have been hunted nearly to extinction in large areas of eastern Ecuador. A large number of the bird and mammal species we documented are rare or threatened elsewhere in their ranges, and many were more abundant in the Serranías Cofán than we had seen anywhere else.

In the following sections we summarize the principal results of our survey and outline our recommendations for conservation action. In most respects this is an abridged version of the technical report, which begins on page 114. We begin this overview with the caveat that the landscape described here is in a constant state of renewal, and is subject to change at any moment. Located in an active earthquake zone, adjacent to one of the eastern Andes' liveliest volcanoes, swept periodically by massive landslides and flooding events, the forests here are probably more dynamic at a large scale than most other sites in the Neotropics. As recently as 1987, a massive earthquake stripped all of the forest from several thousand square kilometers of terrain just south of the foothills region. Satellite images of the area are dotted with the scars of recent landslides and collapsing cliffs (Figure 2), and in some areas tangled young forest recovering from recent washouts covers a significant portion of the landscape.

LOCAL COFÁN COMMUNITIES

These foothill forests have been inhabited by the Cofán people for as long as records have existed, and probably for several centuries prior to the arrival of Europeans. Spanish conquistadors scouting the area in the 16th century came into contact with the Cofán as early as 1536, as described in Juan de Velasco's *Historia del Reino de Quito*. Almost exactly 400 years later, when oil companies initiated large-scale drilling in northeastern Ecuador, the Cofán were still the predominant indigenous group in the area.

Also known as the A'i, the Cofán people are indigenous to the Aguarico and San Miguel watersheds of northeastern Ecuador and southern Colombia. The Cofán language is linguistically unique, with no close living relative, though it shares some features with the Chibchan languages of central Colombia and western Ecuador. Now one of eight indigenous groups living in Amazonian Ecuador, the Ecuadorian Cofán number about 1,000 native speakers in seven isolated communities in the Andean foothills and Amazonian lowlands. Nearly a third of these—about 320 people—live in four communities in the area visited by the rapid inventory team in 2001. Given the tiny "footprint" of these four communities and the immensity of the forests surrounding them, most of the foothills remains wilderness, with a regional population density of less than half a person per square kilometer. The Cofán's knowledge, use, and historical residence of the area, and their growing involvement in conservation initiatives (see Appendix 5), however, make them critical players in the long-term conservation of the region.

The largest and most accessible Cofán community in the region is Sinangoe, where approximately 150 people live on the south bank of the Aguarico, between the mouths of the Candue and the Sieguyo Rivers, and just across the river from the new Interoceanic Highway (Figure 2A). Because the community lies inside the Cayambe-Coca Ecological Reserve, it has long attracted the interest of biologists and conservationists (Cerón et al. 1994, Altamirano and Quiguango 1997, Mena 1997). Cofán park guards patrol a large segment of the reserve, under an agreement with the Ecuadorian Ministry of the Environment. The Sinangoe community is working on a management plan that balances its aspirations with the common, long-term goal of protecting the reserve. We based part of our inventory of this region at a field station that the Cofán built recently—for research and surveillance—at the mouth of the Sieguyo River (Figure 6C).

Most of the day-to-day activity in Sinangoe is still devoted to small-scale agriculture, hunting, fishing, and craft-making for tourism. Similar activities occupy the three smaller Cofán communities in the Bermejo River valley, where they are complemented by the harvest of medicinal forest products like *uña de gato* (the liana *Uncaria tomentosa*, Rubiaceae) and *sangre de drago* (the tree *Croton lechleri*, Euphorbiaceae). We did not visit the two communities in the lower half of the basin (Chandia Na'e and Tayosu Canqque, each with about 80 people and visible on satellite images as tiny clearings surrounded by forest; Figure 2). We did visit Alto Bermejo, a village of just 12 people near the headwaters of the Bermejo River, basing the first stage of our inventory at the new field station recently constructed there.

VEGETATION AND FLORA

The greatest botanical surprise upon arriving in the Cofán foothills—so close to major cities like Lago Agrio and Tulcán, and bordered by two major highways—was to find it an essentially untouched wilderness. These forests have remained exceptionally well-preserved despite a long history of Cofán occupation, and they have not yet been cut off from large adjacent wilderness areas in the Andes and Amazonia. From the vantage point of our 1,200m campsite, overlooking the Bermejo valley, we had a spectacular view of forest stretching unbroken to the horizon. It is only along the new Interoceanic Highway that one sees the forest degradation and fragmentation that are so common elsewhere in the tropics (Figure 2A).

Two of the largest floras on Earth—the Amazonian and the Andean—come together here to produce an extremely diverse and complex plant community. We registered at least 1,000 species out of a regional flora we estimate at between 2,000 and 3,000 (Appendix 1). For the purpose of this report, we divide the landscape into three major forest types: one at lower elevations (mostly Amazonian taxa), one at the highest elevations (mostly Andean taxa), and one at intermediate elevations (a complicated mixture of the two). This altitudinal zonation appears to be driven more by climate than other factors. The most conspicuous transitions between lowland and upland floras occur between 950 and 1,500 m at the elevations where cloud cover persists almost year-round, rainfall is highest (OAS 1987), and sunlight becomes a scarce commodity. We did observe some significant heterogeneity in forest composition and structure within each of these major divisions (i.e., from site to site in the same elevational band), but those differences were usually not pronounced. This is probably because there are few instances of "extreme" geological or soil conditions in the region, like those seen, for example, in the Cordillera del Cóndor (Schulenberg and Awbrey 1997).

LOWER HILL FOREST (400-950 m)

The lowest-elevation forests in these foothills are an extension of the famously diverse lowland forests of eastern Ecuador. Nearly all of the plant families and genera found here are shared with Amazonian forests a few kilometers to the east, like Yasuní National Park and the Cuyabeno Wildlife Reserve. Most individual species also are shared, though several taxa do show a strong preference for the wetter climate at the base of the Andes. As in the rest of eastern Ecuador, local diversity of trees and lianas here is among the highest on Earth. In one of our canopy tree transects in the lower hill forest, we recorded nearly 60 different species in a sample of 100 trees. As a result of this diversity, most individual tree and liana species grow at infinitesimal densities. Palms are a dominant family, along with legumes, Myristicaceae, Vochysiaceae, Meliaceae, and several others. The most common tree here, as in most of eastern Ecuador, is the palm *Iriartea deltoidea* (Figure 3E).

Already evident at this elevation is a feature that sets apart the Cofán foothills flora from any other forests we have seen: an astonishing diversity of species in the coffee family, Rubiaceae. It is hard to find a place in this forest—whatever the elevation—where one is not in sight of a dozen different species of rubiaceous shrubs, treelets, and trees. Overall we recorded more than 129 species of this family, in at least 39 different genera. Many of these are unknown to science. Seventeen percent of the *Psychotria* species we collected during a trip to this region in 2000, for example, have since been confirmed as new species.

The high, red clay escarpments that are such a dramatic feature of the Bermejo River valley also appear to support a distinctive plant community along their clifftops. Soil and climate conditions on these ridgelines are quite different from those elsewhere in the lower foothills forest: trees at the top of the escarpment intercept much of the moist air blowing up the valley, and the constant erosion may mean that acidic outcrops are especially close to the surface. We found several intriguing species here and nowhere else, including the tree *Humiriastrum diguense* (Humiriaceae), characteristic of acidic soils, and a beautiful, unidentified wildflower in the Gentianaceae.

UPPER HILL FOREST (950-1,500 m)

At higher elevations, community composition begins a gradual, though dramatic, shift. Tree richness progressively declines, while the diversity of terrestrial herbs and epiphytes explodes. It is here, too, that one starts to record species turnover along the elevational gradient. Every step on an ascending trail at these elevations appears to cross the boundary of some species' range—lowland species vanish one by one, while exclusively highland taxa begin to appear. In Bermejo, as much as 20% of the canopy at these higher elevations was taken up by *Billia rosea* (Hippocastanaceae), a large-seeded, mostly montane tree that is frequent in the region at least southwards to Sumaco (Figure 4D). In contrast, the dominant tree in Ccuccono, accounting for 26% of our transect and visible for kilometers around because of its distinctive orange flushing leaves, was *Dacryodes olivifera* (Burseraceae).

Several of the ridges we visited in the higher portions of the upper hill forest—especially in the Sinangoe area—were topped with slightly stunted vegetation. The flora on these ridgetops is characteristic of acidic soils, probably because rocky outcrops are exposed here. On one such site in Bermejo, we collected *Purdiaea nutans* (Cyrillaceae), a treelet whose distribution in Ecuador was previously restricted to the acidic mountains in the southern provinces. On the Shishicho ridgeline, we collected the giant herb *Symbolanthus calygonus* (Gentianaceae), similarly known in Ecuador only from the southern provinces, and the shrub *Basistemon* (Scrophulariaceae), the first record of this genus in Ecuador (Jørgensen and León-Yánez 1999). Also on Shishicho, just under the highest summit, we found a new species of terrestrial bromeliad in the genus *Pitcairnia* (J. M. Manzanares, pers. comm.). As additional collections from these ridges are identified, we anticipate several other such range extensions and new species to emerge.

MONTANE FORESTS (ABOVE 1,500 m)

In the highest forest type, the flora shifts definitively from mainly lowland genera to mainly montane genera. High-elevation families like Podocarpaceae, Brunelliaceae, Cunoniaceae, and Clethraceae make their appearance in the canopy, though *Billia rosea* remained dominant in a transect on the 1,900-m ridge below Cerro Sur Pax. The forest canopy is noticeably lower and wetter than at lesser elevations; epiphytes weigh down the branches and filmy ferns and mosses carpet the forest floor. This same transect registered only 24 species in a sample of 100 trees.

This declining diversity in the tree canopy is richly compensated by an explosion of diversity in terrestrial and epiphytic herbs. On the narrow ridge just below Sur Pax we collected at least a dozen species of bromeliads; the most common of these, a terrestrial *Guzmania* that practically carpeted some sections of the trail, is new to science (J. M. Manzanares, pers. comm.; Figure 4B). Orchids, ferns, and aroids are also very abundant and very diverse at these elevations. The rich herbaceous community is especially apparent on the 2,275-m summit just south of Sur Pax, where the low, open, and disturbed forest—punished repeatedly by lightning strikes—is practically buried under an extravagance of epiphytic mosses and wildflowers.

ENDEMIC PLANTS

Observations in the field and experience from adjacent regions indicate that a large proportion of these herbaceous species, particularly in the families Orchidaceae, Bromeliaceae, Araceae, and Gesneraceae, are endemic (geographically restricted) to this section of the Andes. More than 100 plant species in the Cayambe-Coca Ecological Reserve, for example, have never been collected outside of Ecuador. At least 15 of the plant species we registered during this inventory are also endemic to the country, and this number will probably soar past 100 as additional identifications are made. Perhaps the best example of a species with a very restricted range in the Cofán foothills is a shrub we collected in the guava family (Myrtaceae). This species, currently being described as *Calyptranthes ishoaquinico*, was previously used by Cofán communities for coming-of-age ceremonies, and the Cofán confirmed that the plant had never been found anywhere but a small area in the vicinity of the new Sinangoe field station (Figure 4A).

AMPHIBIANS AND REPTILES

The forests we studied are 20 km to the west of the richest herpetofauna locality ever documented—Santa Cecilia, Ecuador (Duellman 1978, 1988). The reptile and amphibian community at Bermejo and Sinangoe may be comparably diverse, if not more diverse, as it combines most elements of the lowland fauna at Santa Cecilia with a different suite of higher-elevation species restricted to the Andean foothills. In addition, the Serranías Cofán protect many of the species that became locally extinct at Santa Cecilia when the last of its forests were destroyed in the 1990s. (Their disappearance is documented chillingly in the paired satellite images in Figure 7.)

Although the herpetological team worked only in the Sinangoe area and did not survey the Bermejo foothills, we registered 31 species during the trip (Appendix 2). The list includes 17 frogs and toads, six species of snakes, a caecilian (photographed by the team in Bermejo), a salamander, and six lizards, including an apparently undescribed species in the genus *Dactyloa* (Figure 5E). Of these, three snakes, two lizards, a frog, and the salamander are apparently restricted to the upper hill forests. One of these, the lizard *Cercosaura ocellata*, is a species never before recorded in Ecuador. Elevations above 1,500 m are almost certain to harbor herpetological communities different from those we were able to sample, and we expect that several additional new species await discovery there.

As in other amphibian communities around the world, population declines and disappearances have been recorded just south of the Serranías Cofán and may be spreading through the apparently pristine areas we visited. The situation appears particularly critical for several species of glass frogs (Centrolenidae) and poison-arrow frogs in the genus *Colostethus*, which have disappeared from some streams and waterfalls in the Cayambe-Coca Ecological Reserve over the last decade (F. Campos, pers. obs.). We encountered only one species in this group.

BIRDS

Our brief ornithological survey of the forests around Bermejo and Sinangoe indicates that they should be considered one of the most important bird conservation areas in eastern Ecuador. The upper elevations in particular appear to be a refuge for many birds considered rare or threatened elsewhere in the Andes. We registered significant range extensions, both elevational and geographic, for many species, and many rare birds were gratifyingly frequent and abundant in the area. For example, never before had we seen such large populations of *Campylopterus villaviscensio* (Napo Sabrewing), *Phylloscartes gualaquizae* (Ecuadorian Tyrannulet), and *Snowornis subalaris* (Gray-tailed Piha).

We recorded 399 bird species and estimate a regional total of 700 (Appendix 3). The avifauna of the upper hill forest was especially remarkable for its completeness; in just a few days there we encountered nearly all of the species expected at this latitude and these elevations. In other words, an ornithologist hiking up from the valley floor in Bermejo can pass from a complete lowland Amazonian bird community into a complete hill forest avifauna in a matter of hours—an increasingly rare experience elsewhere in the Andes.

Perhaps our most notable sighting was of the Foothill Elaenia, *Myiopagis olallai*, a bird described so recently by scientists (Coopmans and Krabbe 2000) that it does not even appear in the new volume *The Birds of Ecuador* (Ridgely and Greenfield 2001). Although *M. olallai* had been known from just three localities in Ecuador and Peru, this new register, less than 10 km from the Colombian border, almost guarantees that the species eventually will be recorded in that country as well. Just as significant was our sighting of the Black Tinamou, *Tinamus osgoodi*, previously known only from one site in Colombia and another in southern Peru. Although ornithologists never had recorded this species in Ecuador before we saw and heard it on the Shishicho ridge, the Cofán accompanying us reported having seen the same species as far south as the San Rafael falls.

Throughout the area, and particularly at higher elevations, we encountered relatively large populations of showy bird species that are typically vulnerable to hunting, including the Military Macaw (*Ara militaris*), Salvin's Curassow (*Crax salvini*), and the Wattled Guan (*Aburria aburri*). The implication is that the Cofán foothills may be an important sanctuary for species whose populations are declining over large areas elsewhere in eastern Ecuador.

LARGE MAMMALS

We were able to carry out an intensive inventory of large mammals during the trip, partly because several Cofán with decades of experience tracking animals in these forests accompanied the team in the field. We found a very diverse, intact mammalian fauna, including 12 species of monkeys and large populations of several globally threatened species. Perhaps the most significant individual sighting was of the rare Short-eared Dog, *Atelocynus microtis*, seen here at the highest elevation (1,200 m) recorded for the species.

We confirmed the presence of 42 species of large mammals in the area, more than half of these globally threatened or rare (see Appendix 4). Twenty-five species on the list are included in CITES Appendices I (globally threatened) or II (potentially threatened), including the 12 species of monkeys. As with the bird community (see above), many of these vulnerable species are abundant in the area. Especially common were spectacled bears (*Tremarctos ornatus*, Figure 1), tapirs (*Tapirus terrestris*), woolly monkeys (*Lagothrix lagothricha*), and collared peccaries (*Tayassu tajacu*). On the Shishicho ridge, just across the river from the new Interoceanic Highway and a few kilometers from the town of Puerto Libre, we encountered groups of monkeys daily.

We were unable to confirm persistent reports of a new species of miniature woolly monkey from the high-elevation forests around Cerro Sur Pax. We did find evidence, however, of other potentially undescribed mammal species in the region, especially a large, gray squirrel. It is worth noting, as an example of how poorly known the area remains, that one of the favorite food plants of the spectacled bear on Cerro Sur Pax, a terrestrial bromeliad it strips for the tender leaf bases, is itself an undescribed species (Figure 4B).

THREATS

As in most tropical forests around the world, the biological communities of the Cofán foothills face a bewildering array of threats. The situation in these forests has grown increasingly ominous since they were bisected by the Interoceanic Highway, completed in August 2000 (Figure 2A). This major road, the first paved connection between Andean Ecuador and lowland Amazonia, is likely to be a heavily traveled route for decades to come. For conservationists in the region, the immediate challenge is to confine the coming flood of human activity to a narrow corridor of land bordering the highway, where it will not endanger biological communities in adjacent Cofán lands and the nearby Cayambe-Coca Ecological Reserve.

Historically, most forest destruction along new roads in Ecuador has resulted from rapid, disorganized colonization and small-scale forest clearing by farmers and cooperatives. Figure 7, adapted from a study by Sierra (2000), demonstrates just how quickly this sort of devastation has taken place just a few kilometers to the east of Bermejo, in the Lago Agrio-Coca-Shushufindi area. Along the new Interoceanic Highway, colonists have already begun to clear forest for cattle ranching, crop land, and small-scale timber harvesting. The whine of chainsaws was audible even at our highest-elevation campsite, which looked down on newly felled plots along the Chingual River. Between Puerto Libre and La Bonita, large areas have been cleared for the cultivation of *naranjilla* fruit (*Solanum quitoense*, Solanaceae). This crop is notoriously susceptible to attack by root-knot nematodes; in most cases farmers must choose between applying large amounts of pesticides and abandoning the crop after a few harvests (National Research Council 1989). Once the marginal agricultural capacity of these areas has been exhausted, the deforested lands—many of them on remarkably steep slopes—will pose a great danger to the entire Aguarico watershed (and to the new highway) for many years to come. The bare, quickly eroding clay slopes will only exacerbate the region's natural tendency for massive landslides and flooding.

Mixed in with the flood of small-scale colonization come threats associated with larger commercial interests. For example, since the new road provides a quick route to timber mills in the Andes, logging companies already have begun to harvest high-value hardwoods in the adjacent forests. Cable-cars ferrying loads of lumber from forested hills down to the road are now a common sight in the region. We predict that most of the valuable hardwoods within a kilometer of the road will have been cut down by the end of 2002. Once that happens, both small- and large-scale logging operations will move deeper into the forest, via an ever-spreading network of small logging roads throughout the zone.

Even in places far from the new highway, where forests remain standing, the influx of hunters and fishermen can seriously compromise the integrity of biological communities. Commercial hunting of deer, paca, and tapir appears to be on the rise. Even rather small-scale hunting—whether for food (peccaries, large monkeys, tapirs, curassows and other large birds, deer), protection of livestock (jaguars and pumas, birds of prey), or for sale (jaguar pelts, parrot feathers)—can cause serious imbalances in the area's animal populations, leading to long-term disruptions of the regional ecosystem. For example, removing most of the large, fruit-eating birds and monkeys from otherwise intact forest could eventually lead to a serious collapse in regional tree diversity. The resulting breakdown in the forest's seed-dispersal mechanism makes it much harder for seeds and seedlings to escape herbivores and diseases (Janzen-Connell effects) concentrated around their parents (Janzen 1970, Connell 1971, Terborgh et al. in press).

Indigenous communities are just as capable of overhunting as more recent colonists, and this is a major threat in other Amazonian forests (Peres and Zimmerman 2001). A well-documented example from eastern Ecuador is Mena et al.'s (1997) description of the unsustainably high woolly monkey harvests in forests around Huaorani communities. Likewise, a decline in piping guan populations around the Cofán community of Zábalo recently led hunters there to implement a strict program of seasons and limits (R. Borman, pers. obs.). Given the small population density in the Cofán community of Bermejo and the small footprint of the community of Sinangoe, overhunting by indigenous inhabitants does not appear to be a severe threat at this time, but it may become one as the communities continue to grow and change.

In Bermejo, the long-term conservation outlook depends greatly on the development plans of the oil company that operates the oilfields just a few kilometers southeast of the Alto Bermejo community. Tecpecuador, a subsidiary of the Argentinian company Tecpetrol, produces 7,700 barrels of petroleum a day in the Bermejo field and holds a concession (permission to explore and develop petroleum resources) that extends throughout the lower Bermejo River valley, as far as the Cofán community of Chandia Na'e. A large-scale expansion of oil operations in the future would bring with it many of the same problems associated with the new Interoceanic Highway, in addition to the potential for oil spills and chemical leaks like those that have poisoned huge areas of ancestral Cofán forests around Lago Agrio and Cuyabeno over the last 40 years. Since the completion of the new Interoceanic Highway, colonization and forest clearing have intensified along the roads in the Bermejo oilfield. Large stretches of forest were cleared in the six months leading up to our inventory (February-August 2001); stacks of recently cut timber dot the roadside. It is not clear at this point whether oil company operations will expand in the region, what form that expansion might take, or which areas would be most affected, but this is clearly an important threat to monitor.

In the Sinangoe region, the greatest threat is an intensification of existing pressures along the eastern border of the Cayambe-Coca Ecological Reserve. Unauthorized hunting and fishing expeditions into the reserve by colonists are common at present, though they are probably still too small and infrequent to pose much danger to the animal communities there. One exception is the occasional use of dynamite and poison to harvest fish in the Ccuccono and Cofanes Rivers, which can be devastating even on a small scale. These incursions threaten to become much more severe in the near future, especially as game becomes scarce along the new highway. If, as we recommend below, a new protected area is established in the highlands north of the Bermejo River valley, similar incursions will be a major threat there: much of the newly claimed land along the highway is only a short hike from the proposed western border.

Small-scale mining is another occasional activity in the Cayambe-Coca reserve, mostly along the rocky sandbars of the Cofanes River. During our inventory we met one colonist family traversing the Shishicho ridge on a week-long mining trip. The activity is probably too scattered and infrequent at present to pose a real threat, but a large strike could set off a flurry of activity, or even attract the interest of commercial mining companies, with very dangerous consequences for the forests in and around Cayambe-Coca. Commercial mining companies have shown intermittent interest in the mineral resources of both the Bermejo and Sinangoe regions for several years, especially when the market value of precious metals is high (R. Borman, pers. obs.).

Augmenting these hazards to the region's forests is the civil war across the border in Colombia, with great potential for disrupting long-term plans in Ecuadorian frontier communities. Satellite images of the border area make heartbreakingly clear how grim the conflict has been for Colombia's biological communities (Figure 2). Approximately 80% of the lowland forests north of the border have vanished under a sea of coca plantations, many of these now defoliated by the Plan Colombia initiative. If history had placed the Colombian border some 25 km south of its present position, much of the forest we describe in this report would have been totally destroyed by now.

CONSERVATION TARGETS

The following species and communities are of primary focus for conservation within the Cofán foothills region because of their: 1) global or regional rarity, 2) influence on community dynamics, and/or 3) importance in ecosystem processes, like watershed protection.

Organism Group	Conservation Targets
Biological communities	Low-stature ridgeline forests and unique plant communities growing on exposed acidic rock Upper hill forests and montane forests, with high concentrations of restricted-range species Streams and rivulets (important habitats for fishes, amphibians, and reptiles) Diverse lowland tree communities with populations of *Cedrelinga* (*tornillo*), *Cedrela* (*cedro*), and other valuable and overharvested timber species Isolated paramo in the Cordillera Murallas, west of Bermejo (Figure 2) Functional, representative samples of all habitat types; stretches of contiguous forest types spanning the entire elevational gradient
Plants	*Cedrela odorata* and *C. fissilis* (*cedro*, Meliaceae) *Cedrelinga cateniformis* (*tornillo*, Mimosaceae) *Dacryodes olivifera* (*copal*, Burseraceae) *Billia rosea* (Hippocastanaceae) Endemic taxa (plant species unique to Ecuador or with restricted geographic ranges), especially in the families Orchidaceae, Bromeliaceae, Gesneriaceae, and Araceae
Reptiles and amphibians	*Enyalioides cofanorum* and other lowland species formerly shared with Santa Cecilia but now extinct there Centrolenidae (glass frogs) and *Colostethus* (poison-arrow frogs) species potentially experiencing population declines Herpetological communities at higher elevations
Birds	Bird communities of upper hill forests Endemic and elevation-restricted birds Large gamebirds (e.g., *Crax, Aburria*) Large parrots, especially *Ara militaris*
Mammals	Primates (particularly *Lagothrix lagothricha* and *Ateles belzebuth*) Seed dispersers and seed predators *Atelocynus microtis* (short-eared dog; rare) Other CITES I and CITES II species: *Lontra longicaudis* (neotropical otter), *Panthera onca* (jaguar), *Priodontes maximus* (giant armadillo), *Speothos venaticus* (bush dog), *Tapirus terrestris* (tapir), *Tayassu pecari* (white-lipped peccary), *Tremarctos ornatus* (spectacled bear)

Even the short time we spent in the field was sufficient to demonstrate that the forests around Bermejo and Sinangoe have outstanding biological value and merit long-term protection. Beyond protecting important conservation targets (see above), the Serranías Cofán offer the rare opportunity to conserve intact biological communities along a 2,000-m elevational gradient.

A strong new reserve here would also protect unique Colombian-centered biota—not found anywhere else in Ecuador—that have been obliterated by deforestation and coca fields to the north of the international border. Following, we highlight some of the long-term benefits that conservation of this region will bring to Ecuador and the world.

1) **A globally important new conservation area in Ecuador, linking protected montane forests from Colombia to central Peru.** The wet slopes of the eastern Andes—stretching from Venezuela to Bolivia—pack unique species and assemblages of plants and animals along their entire length. Many Andean species are limited to one segment of the cordillera: if that block or elevational band is eliminated, so are the biological communities that exist nowhere else. Conservation of the Serranías Cofán will add a vital link to the chain of protected areas connecting these distinct communities along the Andes.

2) **Effective protection of a newly vulnerable sector of the Cayambe-Coca Ecological Reserve, one of the largest conservation areas in Ecuador.** The ecological reserve, already facing an array of challenges, is confronting intense new pressure along the recently completed Interoceanic Highway (Figure 2A). Strong interest from the resident Cofán community to participate in conservation and patrolling activities—and the possibility of the reserve's expansion to the north and west (Anexo 2 in Figure 2; Appendix 6)—would effectively safeguard one of Ecuador's primary conservation areas.

3) **Protection of the major watersheds in the Sucumbíos region.** Sucumbíos already is experiencing greater floods because of deforestation along river margins. Preservation of the headwaters will prevent huge fluctuations along with their devastating consequences to the province.

4) **Preservation of important reservoirs of wet forest habitat.** As global warming accelerates in the next century, the Amazon Basin will become increasingly drier. Areas close to the base of the Andes, especially those near the equator where seasonal changes are least severe, will be increasingly important reservoirs of moist habitat. These areas will become safe havens for populations of species that may otherwise vanish during extreme droughts.

5) **A model of successful, science-based conservation stewardship of ancestral lands by an indigenous community.** A Cofán-operated conservation center will provide resident-based protection to this highly vulnerable region and will form a nucleus for long-term management rooted in rigorous science and cultural tradition.

The conservation future we envision for the region—one in which small Cofán communities at once protect and benefit from the wilderness surrounding them—is not dramatically different from the current state of the landscape. Achieving this vision will require action, however, because of imminent and long-term threats. Here we outline some preliminary recommendations for (1) protection and management to confront immediate dangers, (2) conservation planning for the medium term and future, and (3) information to sharpen conservation goals and strategies. To be successful, these actions will require coordinated financial planning and sustained funding.

Protection and management: Bermejo

1) **Designate formal, legal conservation status for the forests in the headwaters of the Bermejo, Chandia Na'e, and San Miguel Rivers, and throughout the Sur Pax ridge complex.** Rapid protection is crucial; otherwise, the active colonization front along the new Interoceanic Highway will overtake these intact forests. We recommend the immediate modification of the borders of the Cayambe-Coca Ecological Reserve to include much of the Bermejo area as a new annex, administered jointly with the Cofán (Anexo 1 in Figure 2). The proposed annex, measuring ca. 50,000 ha, will protect forests from the Colombian border in the north to the Bermejo River valley in the south, and from the Chingual River watershed in the west to the Amazonian lowlands in the east. Once the annex is in place, we recommend reclassifying the existing Bosque Protector Bermejo south of the Bermejo River (now degraded by colonization and petroleum operations) as a buffer zone.

2) **Negotiate a written, legally binding agreement (*convenio legal*) between the Cofán Federation (FEINCE) and the Ecuadorian Ministry of the Environment to ensure the long-term conservation of biological communities in the area.** The Ministry would promote conservation interest in the reserve at national and international levels, and would provide legal and institutional support for preventing misuse within its borders or large-scale incursions of settlers or commercial interests. For their part, the Cofán Federation and local Cofán communities would commit to a science-based management plan ensuring that 85-90% of the new reserve is maintained in perpetuity as conservation land, combining wildlands with ecologically compatible human use around existing settlements. The cooperative relationship between the Cofán community of Zábalo and the Cuyabeno Wildlife Reserve could be a model for similar management of the Bermejo area.

3) **Establish a biological corridor between the new Bermejo annex and the Cayambe-Coca Ecological Reserve.** Because the land separating the two is itself wilderness of high biological value (especially the isolated paramo of the Cordillera Murallas, a logical solution would be to extend current reserve boundaries northward, to include the natural areas surrounding the towns of La Sofía and La Bonita (Anexo 2 in Figure 2). To be successful, this modification must have the support of local communities and regional authorities. We recommend that conservation planning in the region build on the excellent work of the La Bonita–Sucumbíos Foundation. This local nongovernmental group, based in La Bonita, has carried out biological inventories, drawn up a detailed map of the area, and begun conservation planning with local communities throughout the zone (Appendix 6). It would be an appropriate coordinator of conservation efforts in this region.

4) **Protect the forests of La Ranchería, across the Colombian border from the proposed annex and contiguous to it.** Other than La Corota (an 8-ha reserve 80 km from the international border), this 25,000-ha tract of forest managed by the Cofán is the only protected area in this region of Colombia. As soon as politically feasible, we recommend that the Colombian Ministry of the Environment and the Cofán of Colombia take conservation action for the long-term preservation of La Ranchería's forests. A long-term goal could be the declaration of the joint Bermejo and La Ranchería reserves as a multinational park, managed by Ecuador, Colombia, and the Cofán.

5) **Map, mark, and publicize the boundaries of the new Bermejo reserve.** Especially important will be well-marked borders (*linderos*) and signs posted at access trails along the western border of the new reserve, closest to settlements along the Interoceanic Highway. The signs will be a clear reminder of the area's conservation status and of the regulations to be observed within its boundaries.

6) **Establish a high-profile conservation presence in the areas most vulnerable to incursions, particularly along the western border of the proposed reserve.** A small team of Cofán park guards should patrol the border and nearby trails from a well-placed Cofán guard station. We envision an arrangement similar to those in the Cofán communities of Zábalo (with the Cuyabeno Wildlife Reserve) and Sinangoe (with the Cayambe-Coca Ecological Reserve). To be effective protectors of biodiversity, these guards must have authority to enforce regulations.

7) **Develop conservation programs with the Cofán communities of Alto Bermejo, Chandia Na'e, and Tayuso Canqque, based on biological values, regional threats, and local needs.** To be successful, these programs must balance new responsibilities (e.g., patrolling the new reserve, enforcing limits and seasons for hunting large game) with environmentally sensitive economic alternatives to meet the communities' needs. Outreach activities, led by the local Cofán communities, should engage neighboring colonists in conservation work along protected area borders.

8) **Manage harvests of gamebird, large-mammal, and large-fish populations around Cofán communities inside the proposed protected area.** Until a more detailed system of seasons, limits, and zoning can be developed, our recommendation is to keep fishing and hunting pressures at current levels (i.e., for subsistence by local residents only).

Protection and management: Sinangoe

1) **Establish an agreement between the Ecuadorian Ministry of the Environment and the Cofán Federation that outlines a clear conservation strategy for the traditional Cofán territories within the Cayambe-Coca Ecological Reserve** (Figure 2). This should expand on the existing agreement between the Cofán community of Sinangoe and the Ministry of the Environment and respond to the intensifying threats to the region, using the *convenio* between the Cofán community of Zábalo and the Ministry of the Environment as a model. One key feature of the relationship should be regular meetings to review current conservation threats and opportunities, and to coordinate action.

2) **Establish a long-term, high-profile conservation presence along the northern and eastern borders of the ecological reserve.** Regular, frequent patrols by Cofán park guards should concentrate on areas where hunting or colonization pressure is most severe. These patrols will require some infrastructure, in the form of three or four additional guard stations in strategic locations between the Aguarico and Due Rivers, and a trail system linking them.

3) **Post signs at access trails along the eastern border of the Cayambe-Coca Reserve.** These markers should be clear reminders of the area's conservation status and of the regulations to be observed within its boundaries.

4) **Remove the cable car that allows easy access across the Aguarico River from Puerto Libre to the undisturbed forests of Cayambe-Coca.** Its removal will immediately diminish incursions by unauthorized hunters and fishers.

5) **Prevent construction of roads or logging infrastructure within the ecological reserve.** Monitoring similar activity on the western and southern edges of the new Interoceanic Highway (see Monitoring, below) will complement this goal.

Information management: Bermejo and Sinangoe

1) **Initiate and maintain a map-referenced database of the region's physical, biological, and political features.** This geographical information system (GIS) should incorporate basic geographic and political features, as well as information derived from monitoring programs. By renewing and analyzing layers of information in this database, reserve managers will be able to develop and revise management strategies, identify and update threats to the reserve, and better understand its communities, both human and nonhuman.

2) **Establish a network for data sharing among stakeholders.**

Further inventory: Bermejo and Sinangoe

1) **Carry out an inventory of physical features not included in the rapid biological inventory**. Among the needs identified during our field work are:

   a. **A survey of water and soil quality in watersheds at risk from petroleum, mining, or logging activities.** Prominent among these are the lower Bermejo River valley and the Cofanes River and its tributaries. This inventory will provide the baseline data against which to measure effects of increased road-building or large-scale extractive activities in the region.

   b. **An inventory of the area's surface geology.** This information, to be incorporated into the regional GIS, is vital for identifying unique or vulnerable plant and animal communities and for protecting the area against mining incursions.

2) **Fill the most prominent gaps in the geographic and taxonomic coverage of inventories to date:**

a. **Inventories of ecosystems that remain poorly explored, especially at higher elevations.** In the Bermejo region these areas include the high ridges and valleys between the Pax and Sur Pax mountains (Figure 3A); the isolated valley that forms the headwaters of the Chandia Na'e River; and the ridgeline of the exposed escarpments on the northern banks of the Bermejo River. In Sinangoe, the areas of immediate interest are the high ridges in the western section of the Ccuccono River drainage (especially the 2,686-m high point of that ridge and a peak taller than 3,100 m on a different ridge system to the south); and the peaks to the west of the Shishicho ridge, especially a mountain indicated on the IGM topographic map as the Cerro de Cal (Limestone Mountain). These sites are described in more detail in the Overview of Inventory Sites section of the Technical Report, below.

b. **An expanded program of botanical exploration and collection, focusing on times, places, and taxa not covered well to date.** Needs include botanical collections throughout the year (especially in January and February), at higher elevations, and of small, herbaceous, epiphytic plants.

c. **Inventories of the Bermejo herpetofauna, at both high and low elevations.** Complete surveys of the frog taxa possibly undergoing population declines (Centrolenidae and *Colostethus*) are also of highest priority (see below).

d. **A short, focused expedition to Cerro Sur Pax to assess reports of a new primate species.** Reports of other unusual mammal species in the Bermejo region should also be investigated.

Research: Bermejo and Sinangoe

1) **Determine the effects of large-scale threats on forest dynamics and inhabitants.** Colonization and illegal incursions, road building, and wholesale deforestation are among the most obvious threats at this scale. Information from frequent patrols by Cofán park guards would contribute strongly to this research. Analysis in the regional GIS would identify problem areas and emerging threats.

2) **Assess the region's carrying capacity for fishing and hunting.** Peccaries, tapirs, monkeys, and cracids are the game animals that appear to be under greatest pressure.

3) **Investigate the causes of apparent population declines and fluctuations among the region's amphibians.** Of special concern are glass frogs (Centrolenidae) and poison-arrow frogs in the genus *Colostethus* (Dendrobatidae). This long-term research may require studies of biogeography, habitat preferences, and reproductive schedules.

4) **Promote the use of existing field stations as sites for long-term studies in conservation biology.** Unlike many other biodiversity-rich, remote sites in the Andean foothills, these forests are accessible and have a resident community ready and willing to participate in gathering information. We particularly recommend exploration of:

a. **The composition, structure, and function of communities (plants, birds, and amphibians) on multiple ridge systems, along the whole elevational gradient.** These studies would provide information on the distribution, population sizes, and conservation status of rare or geographically restricted species.

b. **The interaction between plant species and their seed dispersers.** Research in other parts of the tropics has revealed that alterations in the community of animal seed dispersers can degrade otherwise intact plant communities, and details of this relationship are critically important for effective management and conservation of inhabited forests.

Monitoring: Bermejo and Sinangoe

1) **Measure the effectiveness of conservation strategies in reaching goals.** Variables to be measured might include the effect of boundary marking and patrols on incursions and resource misuse, the outcome of conservation education and outreach programs in local communities, and the popularity, percent implementation, and effectiveness of hunting and fishing regulations, among many others. Participation of community residents in planning and implementing these monitoring projects will be crucial to success.

2) **Monitor amphibian populations through regular censuses.** Special attention should be given to taxa for which declines have been observed in nearby areas, e.g., glass frogs (Centrolenidae) and poison-arrow frogs in the genus *Colostethus* (Dendrobatidae), and to species around streams and waterfalls.

Technical Report

OVERVIEW OF INVENTORY SITES

The 2001 biological inventory team based its exploration of the Bermejo and Sinangoe regions out of six main campsites. Two of these were wooden houses built over the last year by the local Cofán communities and intended as permanent bases for scientific researchers and park guards; the other four were temporary forest camps. In this section we summarize the salient features of each of these sites and the trails we explored in their vicinity. We also include a brief description of the areas visited in a preliminary plant-collecting trip in July 2000.

Many of the trails, campsites, ridges, and streams described here were unnamed at the time of our visit, and have been newly christened to make future exploration of the area easier. Spelling of traditional Cofán names may differ in some cases from that on maps of the area. Additional information about visiting or carrying out research at the Bermejo or Sinangoe field stations is available from the Cofán Survival Fund (www.cofan.org).

BERMEJO

Bermejo field station

(00°14’44.7”N, 77°23’04.9”W, ca. 450 m)

This house in the Cofán community of Alto Bermejo was the starting point and base camp for our exploration of the Bermejo River valley. We reached it via a four-hour hike from the nearest road, a trailhead at Pozo Dos (Wellsite Two) in the Bermejo oilfield. The trail in makes a long, gradual descent some 200 m into the valley, passing through mostly mature lowland forest and traversing two major ridges and creeks.

The Alto Bermejo community consists of half a dozen scattered houses and crop clearings on a low terrace on the southern banks of the Bermejo River. On satellite images it is visible as a tiny speck in a sea of forest (Figure 2). The station house stands in a small clearing surrounded by primary and secondary forest and neighboring crop gardens. The forest around the community is criss-crossed by dozens of trails, three of which we explored:

Pozo Seco trail – This trail leads away from the river, climbing up the southern side of the valley towards an abandoned wellsite, Pozo Seco (Dry Well). The first kilometer of the trail passes through a dense population of the understory palm *Chelyocarpus ulei*; in the higher portions huge old *Cedrelinga* and *Parkia* trees are common. The trail traverses tall, upper and lower hill forests, crossing deep ravines before climbing a long, steep ridge to ca. 1,100 m and then descending again to the dry well, at ca. 600 m. The strenuous climb is amply rewarded with gorgeous vistas from several outlooks.

Escarpment trail – Beginning on the northern side of the Bermejo River, this trail leads up a long, steep, forested slope, before following the edge of the tall, red clay escarpments that are such a striking feature of the northern banks of the Bermejo. Most of the forest along the trail is structurally and floristically similar to that in the vicinity of the station, though this trail also passes through large areas of successional forest growing on old landslides.

River trails – We explored a number of semi-permanent trails that lead along the Bermejo River. The river itself was low enough and its banks were broad enough that it was possible to hike up and down its bed, lined by overhanging *Inga ruiziana* (Mimosaceae) trees. Other trails ran along the edge of the woods, across the steep slopes and occasional strips of floodplain forest that border the river. Most of these trails appear to be very old, and have been used by Cofán for generations. Populations of most game animals were present but wary in the forest close to the community. Only the woolly monkey and some cracids seem to have been hunted out of the immediate area.

Bermejo Vista camp

(00°18’13.8”N, 77°24’32.0”W, ca. 1,200 m)

This was our mid-elevation base in Bermejo, reached by a five-hour climb from the community below. The trail up from the Bermejo field station, on the floor of the valley, follows a tributary of the Bermejo (the Sisipa) for the first hour, then ascends steeply to the meseta that forms the top of the escarpments on the northern banks of the Bermejo River. The vegetation on top of this meseta is very similar to the lowland forest around the station, with only a scattering of montane tree species. It is only after the long traverse of the meseta, interrupted by occasional ravines, that the trail climbs up to a wet shelf where montane tree species are more frequent.

We made camp on this wet shelf, where a hectare-sized clearing 800 m above the floor of the valley gives a commanding view of the surrounding landscape. To the east the Amazonian lowlands stretch to the horizon; to the south one looks across the valley to the Bermejo oilfields on the opposite ridge and the volcanoes Reventador and Sumaco on the horizon; and to the north one looks up at a near-vertical southern flank of the Sur Pax mountain complex, marked by the long waterfalls of the descending Ttonoe River. From this perspective the forests of the region appear essentially undisturbed in every direction. The only obvious signs of human presence are the nighttime flickering of the Bermejo oilfield gas flares, a bright beacon at the Colombian border, and the lights of the small Amazonian cities on the horizon.

Chandia Na’e trail – This trail leads east from the camp clearing, sloping down to meet the Chandia Na’e River. The one- to two-hour hike to the river descends ca. 200-300 m in elevation along a narrow forested ridge dotted to either side with successional forest on recent landslides. The trail emerges at the junction of the Chandia Na’e with the smaller Ttonoe River. The narrow Chandia Na’e tumbles down a steep gradient of huge white quartzite boulders, giving it an appearance that is strikingly different from most of the other streams we saw in the Bermejo area. Note that this river is marked on maps of the area as the Zarayacu or Sarayacu; because that rather recent Quichua name is barely familiar to the inhabitants of the area, in this report we use the traditional Cofán name.

Chingual trail – To the west of the Vista camp, a trail descends steeply westwards, crossing the upper reaches of the Bermejo River and leading to the colonist farms along the Chingual River. We did not explore this trail, but it will be a key route for park guards to patrol when a reserve is established in this area. Under good conditions, the walk to the road takes roughly eight hours.

Bermejo Bear Ridge camp

(00°19'17.7"N, 77°25'10.0"W, ca. 1,920 m)

This was the highest campsite of the expedition, accessed by a steep climb up from the Vista camp and a hike along an ascending ridge through very wet, low, and tangled forest. Camp was established on a thin ridge an hour's walk below Sur Pax. The low forest around camp appears to grow on a tangle of moss-covered roots, with no rocks or mineral soil visible on the surface and a near-permanent drip from the constant cloud and fog cover (Figure 3C). Another feature of the area is a persistent cool breeze cutting across the ridge, periodically switching from easterly to westerly. A small lookout at the camp clearing looks steeply down on the Shishicho ridge and the Sinangoe field station to the south (see description below) and on the Chingual River and the new Interoceanic Highway to the west.

Bear Ridge trail – The main trail from this campsite continued north along an ascending ridge, passing through the same very wet and tangled forest type that surrounds the campsite. As elevation increases the forest becomes lower in stature, with the vegetation around the summit reaching only 10-20 m above the trail. After an hour's climb the trail reaches a 2,275-m summit just southeast of Cerro Sur Pax proper (summit coordinates: 00°19'54.5"N, 77°25'25.4"W). An impassable ravine prohibited us from reaching Sur Pax itself from this direction, though it was clearly visible and would have been a mere half-hour's walk away if a trail had existed. A large, eastward-looking clearing at the 2,275-m summit allowed a clear view of the high, horseshoe-shaped ridgeline surrounding the upper reaches of the Chandia Na'e River. The highest points of that ridge appeared to support a forest type that we saw nowhere else—stunted, shrubby vegetation much lower than that on Sur Pax. There is no doubt that extending the trail northwards (or cutting a new one up from the Chingual River) to reach more of the high-elevation ridges north of Sur Pax will allow biologists access to entire biological communities that we missed on this survey (Figure 3A).

Ttonoe trail – This trail was our attempt to reach an intriguing feature on topographic maps of the Sur Pax area—a broad-bottomed valley ca. 3 km to the east of the peak. The valley is especially interesting because it is very deep (more than a vertical kilometer below the summit of Sur Pax); it is effectively cut off from similar-elevation forest by steep slopes on all four sides; and it has a curiously broad, flat floodplain that is very unlike the V-shaped ravines that characterize most valleys in the area. The access trail, which stopped short of this valley, cuts steeply downhill to the east of the main trail between the camp and Sur Pax. It eventually crosses the boulders of the rushing Ttonoe River, which forms the waterfalls visible from the Vista camp (see above) and ends after traversing one more ridge. The forest along the Ttonoe, in contrast to that of the ridge, is characterized by tall old trees growing on relatively gentle slopes. It was here that one member of the team saw a spectacled bear.

SINANGOE

Sinangoe field station

(00°10'49.4"N, 77°29'50.0"W, ca. 600 m)

In July 2000 the Sinangoe community constructed a small house near the junction of the Sieguyo and Aguarico Rivers, directly across the Aguarico River from the town of Puerto Libre (Figures 2, 6C). The station's proximity to Puerto Libre and the new Interoceanic Highway—just a two-minute canoe trip across the Aguarico—made it an ideal base camp for our inventories in the Sinangoe region. The station is close to the start of the two major trails in the area, one accessing the Ccuccono River system to the west and the other leading north, up and over the Shishicho ridge complex and thence to the Cofanes River (see descriptions of these areas below). Because of its strategic location on the border of the Cayambe-Coca Ecological Reserve (the Aguarico forms the park border in this area), park guards operating out of the field station can play a major role in preventing the rapid colonization along the new highway from spilling over into the reserve.

Station loop trail – The forest in the vicinity of the Sinangoe station is compositionally similar to the lower hill forest of the Bermejo River valley, though drier and with a much stronger secondary element. Significant areas here are dominated by mature old trees in the pioneer family Cecropiaceae. Unlike in Bermejo, where most of the successional forest is clearly related to old landslide patches, the abundance of pioneer species around Sinangoe is something of a mystery. A small fraction of the succession is taking place on abandoned clearings and homesites (the station clearing itself was once a rice field), and some other patches may correspond to much older settlements. The rest appears to be the consequence of a large natural disturbance, perhaps a large-scale windstorm or flooding episode in the last 100 years.

Botanical trails – During the 2000 and 2001 trips, Robin Foster, Roberto Aguinda, and José Omenda identified more than 300 plant species along trails close to the Sinangoe field station. These plants have been marked with laminated labels that give both the scientific and Cofán names, so that visiting botanists can learn Cofán plant names, Cofán botanists can learn scientific (Linnaean) names, and other visiting researchers can teach themselves how to identify some of the more common plant species in the area (Figure 6D).

Candoe trail – This trail leads west-southwest from the Sinangoe station, crossing the Fetsavoe River before ascending a broad, gently sloping ridge to about 1,000 m. It then circles around the headwaters of the Fetsavoe, narrowing to a knife-edge ridge that separates the Fetsavoe from the Candoe. Recent landslides tangled with young regrowth alternate with old *Dacryodes* forests. We were especially interested in visiting this area because Cofán hunting is permitted here under the Sinangoe management plan. We found little difference in occurrence of wildlife or in the wariness of individual animals encountered, indicating low usage of the region. This trail eventually connects with one linking the station to Ccuccono (see below), above the headwaters of the Candoe.

Ccuccono Beach and Ridge camps

(00°07'48.5"N, 77°33'19.9"W, ca. 940 m, and 00°08'09.0"N, 77°32'48.1"W, ca. 980 m)

To reach the Ccuccono River drainage, we hiked five hours west from the Sinangoe field station, along a gradually ascending ridge that peaks at ca. 1,100 m and then drops rapidly down into the watershed. The trail passes through old successional forest for the first several kilometers, before the high canopy of old pioneer trees in the family Cecropiaceae eventually gives way to a much more mature forest. We also noted an apparent moisture gradient along this ridgeline, with the drier, epiphyte-poor lower forest near the station giving way to a much wetter, epiphyte-laden, higher forest dominated by huge old hardwoods closer to the Ccuccono.

Once at the Ccuccono watershed, the bird and herpetofauna team established a base in the *Dacryodes* forest on a low ridge just above the Ccangopacho Stream (Figure 3D), a tributary of the Smaller Ccuccono River. The plant and mammal group followed the Ccangopacho down to its junction with the Smaller Ccuccono and camped on the open beaches of the river itself.

Very little of the present-day landscape in the Ccuccono drainage can be understood without reference to a massive earthquake that struck the area in March 1987, triggering simultaneous landslides across several thousand square kilometers of forest. As the temporary dams formed by these landslides were breached, a series of towering flash floods—high enough to wash out the Lumbaqui bridge more than 15 km downstream—scoured the valley clean of vegetation at least 20 m above the current river level, leaving mature forest only on the high ridges along the river. Indeed, present-day satellite images of the area show as much as half of some areas of the watershed in the same stage of regeneration (Figure 2). Given the unstable geology of the region, the frequency of earthquakes, and the proximity of active volcanoes, we expect that catastrophes of this kind are a relatively frequent feature of the Ccuccono landscape, at least on ecological and geological time scales.

The river in the vicinity of our beach camp still showed clear evidence of the 1987 damage. Cofán team members who had camped at the same site before the earthquake were surprised to find the rather narrow, pretty river they remembered now open to the sky at least 50 m across, littered with boulder fields, sandbars, and weedy islands to either side of the modest (ca. 5 m wide) current. Even along the smaller tributaries of the Smaller Ccuccono, like the Ccangopacho Stream, large stretches of riverbank that would traditionally be covered with tall gallery forest were still buried under a tangled mess of vines and weedy low trees. This was especially noticeable in the inside bends of the rivers, where flashflood scouring would have been most destructive.

Apart from the station-to-Ccuccono trail, we investigated a variety of small tributaries and ridge systems around our two campsites, and describe the most interesting of these below:

Ccopaye Fensi (Oilbird) Stream trail – This is a minor tributary that empties into the Smaller Ccuccono just opposite our beach campsite, from which it extends back ca. 200 m through flat, mostly successional forest to a waterfall. One of the most interesting features of this small stream is a small overhanging cliff on which three or four birds—most likely cocks-of-the-rock but possibly oil birds—have nested at eye-level.

Ccuccono Ridge trail – This trail, beginning just upstream from and on the opposite bank of our beach campsite, ascends the ridge dividing the two major branches of the Ccuccono River. Unlike most of the ridges in the vicinity of our camps, which barely exceed 1,500 m, this one climbs to 1,800 m within a few kilometers. We were able to explore this trail only partially, following tapir and bear tracks up to 1,500 m, but it continues westwards to an unnamed and isolated peak of nearly 2,700 m, 12 km to the west of our beach campsite. This totally unexplored ridgeline—almost as high as the city of Quito—is likely to contain a large number of endemic plant species and should be a high priority for future expeditions to the region.

Shishicho camp

(00°12’01.3”N, 77°31’54.3”W, ca. 1,020 m)

This camp is a two-hour hike uphill from the Sinangoe field station, climbing about 400 m to the base of the steep, eastern face of Cerro Shishicho. Forest in the vicinity of camp and around the trail from the station is typical mature hill forest, dominated by common lowland tree species (particularly Myristicaceae) and interspersed with small patches of bamboo or successional forest. A few temporary trails lead downhill in different directions from the campsite, through forest very similar to that on the main trail. Just above camp is a several-hectare patch of secondary forest from an old landslide.

Shishicho ridgeline trail – From camp the trail continues directly up the near-vertical slope of Shishicho, gaining almost 400 m in elevation before reaching a crest just below the main peak. This section of the trail is often rocky underfoot, with patches of loose shale and outcrops of the same material dotting the route. The redeeming feature of this difficult climb is the profusion of spectacular lookouts along the way, which give a panoramic view of the Aguarico River valley (Figure 2B).

Once the peak of Shishicho is reached, the trail levels off and begins to follow the main ridgeline, which curves towards the north as it continues to gain gradually in elevation. Vegetation here is a mixture of surprisingly tall old trees in the lower sections of the ridge and shorter, more heavily epiphyte-laden trees on the higher sections, and some successional forest in areas of past disturbance. An hour’s climb from the first crest, one reaches the highest point of the ridge at 1,570 m. As in the Sur Pax summit forest, the trees at this summit are relatively short (to 10 m tall) and the ground disappears under a tangle of moss-covered tree roots. The tree flora here loses most of the lowland elements that are frequent on the lower parts of the ridge and takes on a more obviously montane character, with genera like *Viburnum*, *Brunellia*, *Tibouchina*, and *Clusia* dominating, and carpets of *Sphagnum* and other mosses underfoot. The summit forest also appears to be in a rather early successional stage, though it is not clear whether this is chiefly due to wind and storm damage, lightning strikes, or the Cofán habit of felling a few trees in high points for lookouts.

The trail forks at this summit. Both branches continue down to the Cofanes River; one follows the main ridgeline to the north and the other follows a different ridge to the northwest. As is the case on most of the Shishicho ridgeline, the northern trail passes through a rather dry forest, exposed to desiccating winds sweeping up the Aguarico Valley. The northwest trail, which is apparently lower and so sheltered from the winds, makes its way through a tangle of much denser and wetter vegetation.

INTEROCEANIC HIGHWAY

(between Lumbaqui and La Bonita, ca. 500-1,000 m)

In July 2000, Robin Foster, Roberto Aguinda, Margaret Metz, Terra Theim, and several members of the Sinangoe community made a preliminary floristic survey of plant communities along the new highway that bisects the formerly continuous forest of Bermejo and Sinangoe (Figure 2A). Because at the time of our visit the highway was still under construction and large-scale colonization of the land along its margin had not yet taken place, the trip gave us rare easy access to intact, botanically unexplored forest. Now that the highway has opened, colonization in the adjacent forest is advancing rapidly. By the time this report is published, most of the forest we explored in 2000 probably will have vanished.

GEOLOGY, PHYSIOGRAPHY, AND CLIMATE

Authors: Nigel Pitman and Robin Foster

BASIC GEOLOGY AND PHYSIOGRAPHY

The landscape around Bermejo and Sinangoe is a jumble of different rock types and geological formations, and for good reason. For the last ten million years, throughout the Andean mountain-building, huge slabs of rock of different ages and materials have been snapped in two and wrenched upwards here, buckled and folded around each other, and then subjected to extreme weathering. Much of the uplifted rock is of Cretaceous age (65-146 million years old), but older Jurassic and even Pre-Cambrian formations also dot the landscape (Baldock 1982, Nieto 1991). To complicate the picture further, these different rock groups include individual strata that vary from shales to conglomerates to limestones to sandstones. Each of these are different in the effect they have on the soils derived from them, leaving one to guess at the edaphic characters of any particular site.

At a larger scale, the geological setting is more similar to the non-volcanic southern Ecuadorian provinces of Morona-Santiago, Zamora-Chinchipe, and Loja than to adjacent areas in central Ecuador. The reason is that the Serranías Cofán lie just to the north of the zone of young, active volcanoes from Sangay to Reventador. Though their southern portion is affected by Reventador’s activity (see below), the northern portion may be more closely affiliated with the non-volcanic eastern cordillera of Colombia, and the non-volcanic provinces in southern Ecuador.

Topography in the area is just as varied as geology, and is generally determined by the tilt and composition of the uplifted formations. In the lowlands, most geological blocks have been uplifted without much tilting, resulting in the flat-topped terraces just north of the Bermejo and Aguarico Rivers. Closer to the main body of the Andes, where the geological history is much more complex, steeply tilted and twisted formations, weathered for millions of years, have given rise to the sheer-walled cliffs and gorges around Cerro Sur Pax and the Cofanes River.

CATASTROPHIC DISTURBANCE

Just as important as a picture of the region's surface geology is the recognition that all of it is subject to change at any moment. Immense natural disasters have reworked the landscape around Bermejo and Sinangoe with unsettling frequency, stripping away successive layers of surface material during earthquakes, volcanic eruptions, floods, and landslides. Because the area is already a jumble of different rock strata, the consequence of this constant building up and tearing down of the landscape is that the particular rock group and soil chemistry under a given patch of forest may change greatly in only a few decades or centuries, as different layers of rock are exposed.

Just 10 km south of the southernmost site we visited (Ccuccono) sits one of the most active volcanoes in the eastern Andes: the 3,562-m Reventador. This stratovolcano has erupted at least 24 times since 1541, littering the landscape around it with tons of ash and lava, periodically building itself up and then exploding. During the 20th century, the volcano erupted continuously from 1900 to 1906, then again in 1912, 1926, 1929, 1936, 1944, 1955, 1958, 1960, 1972, 1973-1974, and 1976. The implication of all this activity, which dates back at least to the Pliocene, is that the southern portion of the Cofán foothills have been blanketed with ashfalls and peppered with pyroclastic bombs from Reventador on a regular basis for at least the last 2 million years (Nieto 1991).

The area is also intersected by a spiderweb of fault lines, along which the landscape shifts occasionally, and with great violence, as part of the ongoing Andean orogeny. On the night of March 5, 1987, back-to-back earthquakes measuring 6.1 and 6.9 on the Richter scale struck the foothills region. The quakes, which were preceded by heavy rains, caused an estimated 100 million cubic meters of soil to peel away from the steep slopes in avalanches of mud and forest, leaving thousands of square kilometers stripped to the bedrock. Aerial photos taken after the disaster indicate that an area of at least 2,500 km^2 lost 75-100% of its forests to landslides. An area at least three times larger lost 25-75% of its forest cover (Nieto et al. 1991).

These massive landslides temporarily dammed a large number of rivers in the area; a few kilometers downriver from the epicenter, the bed of the Coca River dried up entirely for several hours following the quakes (Nieto et al. 1991). The breaching of these dams triggered towering flood surges that scoured clean (or buried under debris) the floodplain forests along most rivers in the area, including those throughout the portion of the Ccuccono River basin we visited. Indeed, the epicenters of these quakes have been traced to directly beneath the Ccuccono watershed, and almost exactly below the campsites we used during the rapid biological inventory (Espinosa et al. 1991).

Even when the landscape is not being torn apart at the seams by catastrophic physical processes, a large proportion of it is quietly collapsing in a less dramatic fashion. The Bermejo Valley basin is encircled by a ring of eroding cliffs that slip into the river with such frequency that the water of the Bermejo has a permanently reddish color. Satellite images of the area are dotted with the scars of landslips large and small, recent and old (Figure 2). These slides are so frequent at the very base of the Andes that they form a nearly continuous line tracing the first line of foothills. Not coincidentally, it is at these elevations (roughly 1,000 m) that the precipitation is heaviest in this part of the Andes (OAS 1987).

Large-scale flooding events are also frequent phenomena in the Serranías, and probably have been so ever since the Andes began to rise some 10 million years ago. The community of Alto Bermejo was destroyed by a flood within the last decade. Stories of other catastrophic floods are a mainstay of Cofán legends. Quaternary pollen gathered a few kilometers to the east have led paleoecologists to suggest that a massive, prolonged flooding episode reworked the eastern Ecuadorian landscape as recently as 800-1,300 years ago (Colinvaux et al. 1988). Huge quartzite boulders like those currently lining the banks of the Aguarico River also dot the terraces nearby, providing a reminder of past washouts.

CLIMATE AND PHENOLOGY

Climate in the Cofán foothills is unrelentingly wet, because the prevailing winds on the equator—blowing from east to west—collect evaporation over the Amazonian lowlands and drop it as rain when they hit the Andes. Annual rainfall at the three closest weather stations (Reventador, El Chaco, and Santa Cecilia) ranges from 2.5 m to more than 6 m, and the heavy epiphyte load and moss density at Bermejo and Sinangoe suggest that the sites we visited fall at the high end of this range (OAS 1987). Even in this relatively small area, however, the amount of precipitation that a given site receives may vary dramatically across the landscape. Intermediate elevations receive more rain than higher or lower ones (with the peak at 1,000 m; OAS 1987), and sites at the same elevation but in different drainages may receive dramatically different amounts of moisture, because the complicated topography generates a complex pattern of rain shadows.

Rain here falls year-round, punctuated by weak dry seasons of short duration. The driest time seems to be January-February, which corresponds to the Northern Hemisphere dry season (not unexpected given the latitude here just north of the equator; OAS 1987). Short, unpredictable dry periods can occur at any time of year, but with a greater probability in August, which corresponds to the Southern Hemisphere dry season. These droughts are probably most severely felt on ridges that are low enough to fall below the cloudline but exposed enough to be swept by desiccating winds. At elevations over 950 m, where the vegetation is frequently enveloped in clouds, condensation probably adds significantly to the total amount of precipitation landing on the ground.

Temperature in the Serranías varies linearly with elevation, due to adiabatic cooling. In the lower hill forest, temperatures average around 25° C year-round; at 1,000 m, the average drops to ca. 20° C; and at 2,000 m, to ca. 15° C (OAS 1987).

In spite of the general lack of seasonality and minimal change in daylength throughout the year, many plant species seem to be roughly synchronized in their reproductive and leaf-flushing behavior. This synchrony is probably triggered for most species by the usual, but not reliable, short dry period in January and February. For some it may be the sudden drop in temperature accompanying a specific rainstorm, or a few days of drought stress coming at any time of year. An example is one species of *Faramea* (Rubiaceae), a shrub in which all the individuals came into flower and finished during one week of our trip. Another is the common tree *Dacryodes olivifera* (Burseraceae), in which all the adult trees seemed to be flushing new leaves during our stay.

A somewhat smaller set of species had flowering, fruiting, or leaf-flushing individuals mixed in the same population, or even on the same individual tree. These asynchronous species may either be responding to repeated signals throughout the year, or merely responding to internal signals of the nutrient status of the tree or branch. An example is the common tree *Billia rosea* (Hippocastanaceae), which we found sometimes with flowers, sometimes with ripe fruit (Figure 4D), and sometimes with neither but flushing new leaves. The wild cherry at upper elevations, *Prunus herthae* (Rosaceae), was unusual in that all the individuals observed on the slopes above Bermejo were in fruiting condition, whereas on the high ridges of Sinangoe they were all in flower. The most likely explanation for this is some local climatic event that affected one side of the Aguarico and Chingual Valleys but not the other.

FLORA AND VEGETATION

Participants/Authors: Robin Foster, Nigel Pitman, and Roberto Aguinda

Conservation targets: Upper and lower hill forests; montane forests; stunted ridgeline and summit forests; plant communities on acidic outcrops; lowland forests with commonly overexploited trees

METHODS

This was a short, fast-moving survey of a large region, with the goal of sketching a quick portrait of the area's vegetation. During our three weeks in the field we were constantly on the move, hiking from one site to another in an attempt to cover as much terrain and visit as many habitats as possible. We used a variety of formal and informal sampling techniques, and drew whenever possible from the lifelong experience of the Cofán naturalists who inhabit the area.

The groundwork for our exploration of the Bermejo and Sinangoe area was laid by the excellent earlier work of Carlos Cerón and colleagues (1994) from Ecuador's Universidad Central. Some of the observations here also draw on previous visits of RF, RA, M. Metz, T. Theim, and G. Baker to Sinangoe and the new Interoceanic Highway in June 1999 and July 2000. No quantitative sampling was carried out during those visits, but several hundred plants were collected or photographed.

Throughout the 2001 inventory we continued to collect and photograph as many unrecognized species as possible, and kept a running list of species identified in the field but not collected. The database now includes more than 1,000 herbarium specimens representing at least 800 species, and 1,400 photographs of at least 700 species. The preliminary list, given in Appendix 1, incorporates and updates the inventory of Cerón et al. (1994) in the vicinity of the Sinangoe community. This obviously is not a complete catalog of the flora, just as our ecological work is an initial overview to stimulate additional research in the area's plant communities.

We also gathered quantitative data along transects in several of the major habitat types, sampling 969 trees and shrubs in total. Transects were established as opportunity permitted (i.e., adequate time without rain), with priority given to canopy trees and the shrub layer. Sampling followed the rationale of Foster et al. (unpublished manuscript) for variable transects laid out along existing trails. We sampled canopy trees in single, continuous transects of 100 individuals, or fewer if time ran out. Tree transects were 20 m wide (10 m on either side of the observer) and included all trees with a trunk diameter measuring greater than 30 cm at breast height (DBH; ca. 1.3 m from the ground). Species identifications, often to temporary "morphospecies," were made using binocular observations of the canopy, fallen leaves, and cuts in the bark. Trees with insufficient visible leaf material were ignored. The shrub layer was sampled separately, in "interrupted" transects incorporating 100 to 200 free-standing stems measuring 1-10 cm dbh. These transects were 1 m wide on one side of the trail, with subsamples of 20 individuals each separated by 100-m intervals. Vouchers were collected for most fertile morphospecies and for the most abundant morphospecies. We collected and made observations on plants in all habitats, but concentrated our quantitative sampling in upper hill forest, with additional transects in mountain ridge forest and lower hill forest. We did not establish transects in the mountain summit or slope vegetation, or in the riverine plant communities.

These data were supplemented with qualitative observations on vegetation dynamics, habitat composition, and other aspects of plant ecology. In addition, because one of us (RA) speaks the Cofán language, we were able to record the indigenous names and uses of several plants by interviewing Cofán elders in the communities of Alto Bermejo and Sinangoe.

Collections were preserved in alcohol in the field and subsequently dried in Quito. Fertile specimens were deposited at the National Herbarium of Ecuador (QCNE), with additional duplicates sent when available to the Field Museum (F), to family specialists, and to the Catholic University of Ecuador (QCA).

FLORISTIC RICHNESS, COMPOSITION, AND DOMINANCE

Our preliminary vascular plant list (see Appendix 1) lists 1,596 species. Based on field observations to date and on our experience in better-known areas of the Neotropics, we estimate a total vascular flora of 2,000 to 3,000 species for the Bermejo and Sinangoe area. This is obviously a broad approximation, and the true number will depend on how one draws the boundaries of the area (i.e., how much of adjacent lowland and Andean forests is included). As in other Andean forests, a good estimate of the area's floristic diversity will depend on a good estimate of its orchid diversity; that family typically accounts for a major part of the flora in forests this wet.

Both the regional- and local-scale diversity in the Cofán foothills seem typical of eastern Andean forests—extremely high, especially in the families Orchidaceae, Melastomataceae, Rubiaceae, Piperaceae, and Bromeliaceae. The diversity at intermediate spatial scales (i.e., one to several hundred square kilometers) may be lower than in other parts of the Ecuadorean Andean slopes, which have more geological or microclimatic extremes.

The obvious exception in the Serranías Cofán is the astonishing concentration of species in the coffee family, Rubiaceae. We encountered at least 39 genera and over 129 species in the family in a relatively short time of observation and collection. This family has the largest number of species of woody plants in the Neotropical lowlands and is usually abundant in the understory of Neotropical forests. In our experience, however, no other area of Ecuador, South America, or the world has as great a concentration of Rubiaceae as found in the area we visited during this inventory.

The Pacific slopes of Ecuador and Colombia have long been recognized by botanists as a center of diversity for the families Gesneriaceae, Araceae, and Ericaceae. For the Gesneriaceae (41 species encountered) and *Anthurium* (the largest genus of Araceae; 38 species encountered), the species richness around Bermejo and Sinangoe probably rivals that of a similar-sized area on the Pacific slope, and is certainly higher than in any other forests we have studied at the eastern base of the Andes. For the Ericaceace and the rest of the Araceae, on the other hand, the area does not seem especially diverse. The presence of at least a dozen treefern species (mostly *Cyathea*) in the area seems high to us by comparison with any area south of the Marañón River, but may be shared with the Cordillera del Cóndor and north into the Putumayo drainage.

FOREST TYPES AND VEGETATION

The diversity of habitats and plant communities in the Bermejo-Sinangoe region is typical for the base of the Andes. While the region is a jumble of different geological formations, it does not have as many extremes in underlying rock chemistry as some areas, such as the Cordillera del Cóndor (Schulenberg and Awbrey 1997). In that sense it is not as rich in habitats, and there are also no extreme differences in moisture availability at any given elevation. But there is a magnificent, undisturbed transition up the southern slopes of the Cerro Sur Pax complex, from lowland forest habitats up to cloud forests, including all the smaller-scale habitats of ridges, slopes, ravines, and landslides. Such intact elevational transects are becoming increasingly rare on the slopes of the Andes, and this one provides an outstanding outdoor laboratory to study the changes in plant populations and communities along an altitudinal gradient.

Here we use the general term "hill forest" for most of the forest in the Serranías Cofán, distinguishing for the purposes of this report three broad habitat types: lower hill forest, upper hill forest, and forest on mountain ridges and summits. Within each of these we have identified a few obvious smaller-scale habitats such as stream margins, successional forest on landslides, and vegetation on acidic outcrops. All such classifications are subjective, especially in areas like this, where species distributions are very patchy and most vegetation change is gradual. Our major categories reflect altitudinal differences in species presence, species relative abundance, and structure of the vegetation.

Lower Hill Forest (400-950 m)

This forest type covers much of the Bermejo River valley, and the low ridges and uplifted, sloping terraces between the Ccuccono River and the Sinangoe community. Our best opportunities to study lower hill forests were in the vicinity of the Bermejo and Sinangoe field stations, and on the walks to and from the Bermejo Vista camp and the Shishicho camp. The forest at these elevations is a somewhat less diverse extension of the Amazonian lowland forest just a few kilometers to the east. Like the plant communities around Yasuní National Park and the Cuyabeno Wildlife Refuge, this is tall, closed-canopy forest, where the local diversity of trees is among the highest on Earth and most species are rare. Species composition in these forests can vary dramatically from one small area to another in a way that remains poorly understood by ecologists, while at the same time a small group of species occurs fairly consistently, albeit at low densities, across the landscape.

As in the lowland forests farther to the east, the most common canopy tree across the lower hill forest is the ubiquitous palm *Iriartea deltoidea* (Figure 3E). Palms in general are frequent on the landscape, sharing dominance with the families Myristicaceae, Fabaceae *s.l.*, Meliaceae, Euphorbiaceae, Melastomataceae, Rubiaceae, Vochysiaceae, and Moraceae. In a transect of 100 canopy trees on the moderately steep ridges south of Bermejo, at 500-600 m, the most common species were *Minquartia guianensis* (Olacaceae) and *Vochysia braceliniae* (Vochysiaceae), though neither of them made up more than 10% of the trees. One consequence of this lack of canopy dominants—so characteristic of Ecuador's Amazonian forests—is that these are extremely diverse tree communities. Of the 100 canopy trees sampled in our transect, we recorded 59 different species. Cerón et al. (1994) report similarly high diversity for trees and shrubs in four plots established in low hill forest around Sinangoe.

The high density of very tall trees (40-45 m) was another conspicuous feature of the lower hill forest on the ridge we sampled. Prominent among these were several giant legumes, including *Cedrelinga cateniformis*, several species in the genus *Parkia*, and what is possibly the world's largest Melastomataceae: a 50-m tall *Tessmannianthus heterostemon* with a stem diameter of 1 m. We were surprised to encounter a "cannonball tree," *Couroupita guianensis* (Lecythidaceae), on the ridge, since it is usually encountered on floodplains. Other conspicuous trees of the low hill forest canopy are the various *Sterculia* (Sterculiaceae) species with their large roundish leaves, and in the case of *S. apeibophylla*, large, round fruit littering the forest floor beneath them. Both *Otoba parvifolia* and *O. glycycarpa* (Myristicaceae) are common in the canopy, along with several species of *Virola*. The lower hill forests on the small ridges around Sinangoe appear to have similar canopy composition (Cerón et al. 1994).

At somewhat higher elevations in the lower hill forest, on top of the flat terrace north of Bermejo at 800-900 m, the forest appeared considerably wetter. The canopy here was 30-35 m tall and with few large-diameter trees, but diversity was just as impressive, with 41 species recorded in a transect of 70 canopy trees. Again, the legumes and the Myristicaceae were the dominant families of canopy trees. The most abundant smaller species was *Matisia bracteolosa s.l.* (Bombacaceae), which accounted for 13% of the trees. The subcanopy tree *Tovomita weddelliana* (Clusiaceae)—perhaps the most common small tree in the region, and abundant across a broad altitudinal zone—was conspicuously more abundant in the understory here than in other areas of lower hill forest. The shrub layer (plants up to 5 m tall) was dense with Rubiaceae and Melastomataceae, along with a relatively high abundance of treeferns—all of these characteristic as well at higher elevations in the Serranías. Terrestrial ferns, especially species of *Danaea*, probably account for half the herbaceous ground cover here (Figure 4C), while dense stands of the aroid *Dieffenbachia harlingii* were almost invariably present in wetter depressions. The long-leaved Marantaceae, *Ctenanthe ericae*, is the dominant herb species, covering most of the slopes in the lower hill forest of Sinangoe, up to about 900 m. *Ctenanthe* is completely missing, however, from the Bermejo area.

An understory fan-palm, *Chelyocarpus ulei*, is the most abundant and conspicuous small tree over several square kilometers in the vicinity of the Alto Bermejo community, but was not seen anywhere else in the region. It appears abruptly on the trail from Pozo Dos to Bermejo, becoming almost immediately common a few small streams west of the Rayo River, on the south side of the Bermejo River. The population extends upslope to the south for about a kilometer on the trail to Pozo Seco, but does not appear to cross to the north side of the Bermejo River—somewhat strangely, for a species with a small, bird-dispersed fruit. We have observed a similar large patch of *C. ulei* in the lowland forests of Yasuní National Park, similarly unrelated to any obvious edaphic or topographic features. The population we encountered in Bermejo is the northern-most known in South America.

While these lower hill forests do share most elements with Amazonian forests to the east, we were surprised to note some conspicuous absences. Several species that are common in the lowlands were not registered here at all, including *Spondias mombin* and *Astronium graveolens* (Anacardiaceae); *Astrocaryum chambira* and *Geonoma deversa* (Arecaceae); *Hevea guianensis*, *Omphalea diandra*, and *Pausandra trianae* (Euphorbiaceae); *Casearia aculeata* and *C. sylvestris* (Flacourtiaceae); and *Swartzia arborescens* (Fabaceae), *Ficus paraensis* (Moraceae), *Palicourea guianensis* (Rubiaceae), and *Rinorea lindeniana* (Violaceae). Ant-gardens, the ant nests with characteristic plant species cultivated and protected by the ants, are noticeably rare here and consist of little more than the bromeliad *Aechmea longifolia* and the herb *Codonanthe* (Gesneriaceae), rather than the more diverse assortment of species found farther from the Andes.

Other taxa, though present, are noticeably scarcer here, including *Attalea* and *Bactris* (Arecaceae); *Brownea* and *Hymenaea* (Caesalpiniaceae); *Brosimum* and *Naucleopsis* (Moraceae); *Hamelia patens* and *Geophila* (Rubiaceae); and *Anaxagorea* (Annonaceae), *Cordia nodosa* (Boraginaceae), *Hirtella* (Chrysobalanaceae), *Heliconia velutina* (Heliconiaceae), *Gustavia* (Lecythidaceae), *Mouriri* (Melastomataceae), *Zygia* (Mimosaceae), *Ouratea* (Ochnaceae), *Chrysophyllum* (Sapotaceae), and *Petrea* (Verbenaceae). Presumably all these taxa prefer somewhat drier soils than are found in this area.

River and Stream Margins

Floodplain forest is very rare in the Cofán foothills. In some cases this is because the valleys are too young and steep to have developed any alluvial plains, with slopes right down to the rocky river beds (as along the Bermejo and Sieguyo Rivers). In other cases—particularly in the flatter Ccuccono Valley—it is because huge areas of floodplain forest have been destroyed by a major recent washout (flash flooding associated with major landslides; see Overview of Inventory Sites).

The vegetation associated with rivers and streams, while showing some variation with respect to the size and substrate of the watercourse, was fairly regular in composition throughout the region, even though individual streams were almost always distinguished by a few locally abundant species not common elsewhere. Along all the rivers, large and small, is *Blakea repens* (Melastomataceae), which occurs as either a hemi-epiphyte on the lower trunk of a riverbank tree, spreading into the sun out over the river, or growing on rocks or fallen trunks. This same species grows frequently in the forest away from the river as a hemi-epiphyte, but it is only along tree-lined rivers that it is conspicuous as a dominant. Other characteristic riverbank species are *Trophis caucana* (Moraceae), *Myriocarpa stipitata* (Urticaceae), *Bauhinia tarapotensis* (Caesalpiniaceae), and *Calliandra trinervia* (Mimosaceae).

The larger rivers and occasionally the smaller ones have developed some areas of meander, with relatively stable sand or gravel beaches. The most common tree on older parts of these areas is *Inga* *ruiziana* (Mimosaceae), a characteristic floodplain species of the upper Amazon. On the stable gravel banks grow dense stands of a probably undescribed cane species in the genus *Gynerium* (Poaceae). This species is similar to, but clearly distinct from, the robust and cosmopolitan *caña brava*, *Gynerium sagittatum*; we observed the two taxa growing together without any evidence of intermediate forms. While the smaller cane is so far considered by grass taxonomists as nothing more than a form of *G. sagittatum*, the taxon clearly deserves recognition as a distinct species.

Other beach strand species, less predictable in their occurrence, include *Brugmansia candida* and *Solanum* spp. (both Solanaceae), *Cleome* sp. (Capparidaceae), *Tovaria pendula* (Tovariaceae), *Tessaria integrifolia* and *Mikania micrantha* (both Asteraceae), *Commelina erecta* (Commelinaceae), and even an occasional *Bocconia integrifolia* (Papaveraceae). On one tributary stream of the Ccuccono, the abundance of *Canna jaegeri* (Cannaceae)—a species widely cultivated by the Cofán and other Amazonian communities for its seeds, which are used as the principal small bead in their necklaces—suggests former human occupation in the area.

On the rocks lining most of these rivers grow a set of shrublets and perennial herbs that can survive frequent flooding. The most cosmopolitan of these is a pale, medium-sized *Cuphea* (Lythraceae), found along all rivers and streams with enough sunlight exposure. Other common members of this rock community include a smaller species of *Cuphea*, two species of *Justicia* (Acanthaceae), *Liabum amplexicaule* (Asteraceae), *Thelypteris angustifolia* (Pteridophyta), and, on the sides of large stable rocks, the elegant lady-slipper orchid *Phragmipedium pearcei*. Another important herbaceous community grows on the branches of riverside trees, and many of these also seem to be characteristic of stream habitats. These especially include ferns, but also orchids, *Peperomia* (Piperaceae), and bromeliads.

Most other plant species along the riverbanks are species characteristic of disturbance regeneration, typically found growing in disturbed patches on the slopes of the hill forest following landslides or major windthrow. It is only along the rivers and streams that their “patch” is a long linear one. These include two species of *Sanchezia* (Acanthaceae); *Acalypha* sp., *Croton lechleri*, and *Mabea* sp. (Euphorbiaceae); *Guettarda crispiflora* and *Isertia laevis* (Rubiaceae); and *Saurauia* cf. *herthae* (Actinidiaceae), *Eirmocephala megaphylla* (Asteraceae), *Ochroma pyramidale* (Bombacaceae), *Senna ruiziana* (Caesalpiniaceae), *Podandrogyne brachycarpa* (Capparidaceae), *Cecropia putumayonis* (Cecropiaceae), *Banara guianensis* (Flacourtiaceae), *Piper umbellatum* (Piperaceae), *Triplaris americana* (Polygonaceae), and *Trema micrantha* (Ulmaceae).

Missing or rare on these riverbanks are the tree *Zygia longifolia* (Mimosaceae) and the shrubs *Calliandra angustifolia* (Mimosaceae) and *Adenaria floribunda* (Lythraceae), so characteristic of riparian vegetation along other small rivers of the upper Amazon. It may be that the clay banks and rocky borders of these rivers are too unstable to support them, but it then is difficult to explain how they are stable enough to support *Inga ruiziana*.

Smaller but permanent streams, partly shaded and rocky, often had a distinctive set of species associated with them. These usually included the herb *Dicranopygium* (Cyclanthaceae), various species of *Pilea* (Urticaceae), and the shrubs *Urera baccifera* (Urticaceae) and *Hoffmannia* (Rubiaceae). On some of the small tributaries of the Bermejo, we found a couple of unusual species strictly associated with the stream banks: *Calathea gandersii* (Marantaceae), which until recently was known only from the type collection near Tena, and an apparently new variety of one of the Neotropics’ best-known and most widespread herbaceous species, *Cyclanthus bipartitus* (Cyclanthaceae; see below in species notes).

Upper Hill Forest (950-1,500 m)

We were able to sample this altitudinal range more thoroughly than any other, as we set three of our campsites between 950 and 1,200 m. The physical characteristics of forests at this elevation are not greatly different from those of the lower hill forest. The trees are on average not quite as large in height or girth, and the trunks have greater densities of epiphytes, though the bark is still mostly exposed.

Although there is still considerable overlap in species composition with lower elevations, it is in this range that one begins to see abrupt limits to species distributions, apparently associated with elevation. Many plant species seem to appear only above ca. 950 m, while other species suddenly drop out at this elevation. A bright-red-flowered *Aphelandra* (Acanthaceae), for example, appeared at roughly this elevation at all three sites, while the common herb *Ctenanthe ericae* (Marantaceae) disappeared from the two Sinangoe sites (the species was absent in the Bermejo area). We did not notice any turnover of this kind at lower elevations, but it would require thorough investigation to establish that fact. There is also turnover in the flora *within* this band of upper hill forest, e.g., species that grow only above 1,300 m or species that grow no higher than 1,200 m, but the landscape variation in climate and geology makes it unlikely that these limits would remain constant across the region.

As expected, in our samples of canopy trees in the upper hill forest we found somewhat lower species diversity and more dominance by a few species than in the lower hill forest. We also noted considerable variation in the dominant trees from one site to another. On the steep ridge below the Bermejo Vista camp, a transect of 100 canopy trees contained 47 species (compared to 59 for the comparable lowland transect; see above). Nearly a third of the trees belonged to only two species: *Billia rosea* (Hippocastanaceae; 18% of the sample) and *Otoba glycycarpa* (Myristicaceae; 12%). On the sloping ridge below Shishicho camp, our 100-tree transect contained 50 species. *Minquartia guianensis* (Olacaceae) accounted for 12% of the trees, while three species of Myristicaceae (*Compsoneura ulei*, *Otoba glycycarpa*, and *Virola* sp.) made up 20% (7%, 7%, and 6%, respectively). And on the sloping ridge above Ccuccono Ridge camp, an 80-tree transect contained 37 species. Here the dominants were *Dacryodes olivifera* (Burseraceae; 26% of the total), *Billia rosea* (9%), and two euphorbs (*Conceveiba* sp. and *Hyeronima macrocarpa*; 8% and 6%, respectively). Other tree species that are conspicuously abundant at these elevations, though not in the transects, are the large emergent *Ficus coerulescens* (Moraceae), and the subcanopy *Grias neuberthii* (Lecythidaceae) and *Wettinia anomala* (Arecaceae).

The dominance of individual species is very patchy, and this patchiness is apparent from the smallest to the largest spatial scales. On one long stretch of the Ccuccono trail ridge, for instance, nearly half of the shrub layer stems appear to be *Psychotria deflexa* (Rubiaceae), while on two other stretches of the same ridge the dominants are an *Alibertia* sp. (Rubiaceae) and a *Miconia* sp. (Melastomataceae), respectively. At a larger scale, the most common understory species in our Shishicho camp transect, the palm *Hyospathe elegans*, is missing or rare only a couple of kilometers away, on the ridge from the Sinangoe station leading down to Ccuccono. But this species is common again on the Bermejo Vista camp ridge many kilometers away. Some of this variation in dominant species reflects small-scale heterogeneity or dispersal limitation within a site, while some variation represents large-scale environmental differences across the landscape. For example, although *Dacryodes olivifera* and *Compsoneura ulei* were absent from our Bermejo Vista camp transect, they were both fairly abundant just above camp, from 1,200 to 1,300 m. By contrast, there is no question that *Dacryodes* was exceptionally abundant throughout the Ccuccono area, since large patches of its newly flushed, orangish leaves were visible on all the surrounding ridges.

Our only transect sample of the shrub layer in upper hill forest was from the Shishicho camp, from 950 to 1,000 m. The 200 stems sampled contained 90 species, with the most common taxa the small palm *Hyospathe elegans* (11% of the stems) and the shrub

Psychotria bertieroides (Rubiaceae; 7%). At the family level, Rubiaceae (18 species) and Melastomataceae (14 species) were dominant. These two families account for more than a third of the species in this transect, which supports our casual observations that they dominate the shrub layer of the hill forests throughout this region. In addition to the many *Psychotria*, the common Rubiaceae include various species of *Faramea*, *Coussarea*, *Rudgea*, and a widespread small tree of *Chomelia*. The common Melastomataceae include many *Miconia*, as well as various species of *Ossaea* and *Clidemia*.

Acid ridges in upper hill forest – All the narrow ridgetops in the Sinangoe area above 1,350 m, including the Shishicho ridgeline, seem to be characterized by a stunted vegetation and a flora indicating highly acid soils. Where exposed by landslide, the parent material here is a very hard rock, probably quartzite. The areas we visited had characteristically short forest (ca. 10-15 m tall) and trees with small crowns, a solid mat of roots covering the soil, frequent clumps or carpets of *Sphagnum* and other mosses on the ground, but little moss cover or other epiphytes on the tree trunks. Except for its stature, this vegetation is very different from that on the higher-elevation mountain summits of the Cerro Sur Pax complex (described below).

This distinctive vegetation grows very narrowly along the spines of the ridges in this "roller coaster" terrain. This is probably because both the acidic soils and the dry conditions caused by the exposure to wind are confined to a very narrow ribbon of forest running along the highest points of the ridges. On the major saddles between the ridgetops and on the slopes flanking them, the soil is once again a dark clay, the trunk-epiphyte load and moss cover is almost as dense as on any of the wetter ridges, and the vegetation is much more like that of typical upper hill forest, with species such as *Tovomita weddelliana* again prominent in the understory. In traversing the ridgeline, one passes in and out of the acid ridge vegetation.

One of the most distinctive components of this vegetation, in addition to *Sphagnum*, is *Trichomanes cristatum*, an erect, terrestrial filmy-fern with orangish hairs. Other conspicuous and characteristic taxa are *Graffenrieda* and *Tibouchina* (Melastomataceae), *Guzmania squarrosa* and *Racinaea undulifolia* (Bromeliaceae), and *Sphaeradenia* (Cyclanthaceae). Also apparent here are taxa characteristic of the higher mountains but known to reach lower elevations on acid soils. These include genera such as *Brunellia* (Brunelliaceae), *Symbolanthus* (Gentianaceae), *Weinmannia* (Cunoniaceae), *Prunus* (Rosaceae), *Centronia* (Melastomataceae), and *Myrsine* (Myrsinaceae). Also common here are *Miconia* (Melastomataceae), *Cybianthus* (Myrsinaceae), *Palicourea* (but not *Psychotria*; Rubiaceae), *Vochysia* (Vochysiaceae), Ericaceae, Myrtaceae, Sapotaceae, and Chrysobalanaceae. Legumes are uncommon, except for one distinctive *Inga* that we could not identify with the recent field guide for Ecuadorian *Ingas* (Pennington and Revelo 1997). The most common palm on the Shishicho ridgeline was a small *Geonoma* that we encountered in Bermejo only above 1,700 m, on the mountain ridge south of Cerro Sur Pax.

In a transect of the shrub layer on the acid ridges, a small-leaved *Myrsine* (Myrsinaceae) accounted for 11% of the individuals, a *Miconia* (Melatomataceae) 9%, and the *Geonoma* sp. (Aracaeae) 8%. Out of 120 stems there were 49 species. In a mixed-habitat transect of canopy trees that included some of the acid-ridge as well as the adjacent clay-soil slopes and saddles, a *Pouteria* (Sapotaceae) made up 14% of the individuals, *Macrolobium* sp. nov. (Caesalpiniaceae) 10%, *Vochysia* sp. (Vochysiaceae) 8%, a *Licania* (Chrysobalanaceae) 6%, another *Pouteria* 5%, and a new *Conceveiba* (Euphorbiaceae) for Ecuador 5%. Out of 99 trees there were 39 species. The same *Macrolobium* was also abundant in patches in the typical upper hill forest at 1,300 m on the southern slopes of the Cerro Sur Pax complex. The *Vochysia*, although similar in appearance to *V. braceliniae* of the lowlands, is probably a distinct species.

In the Bermejo area, there seems to be very little exposure of acidic rock, except perhaps on the highest summits. At lower elevations, quartzite is mostly evident as sheer cliffs. Only on the edges or faces of such cliffs did we find characteristic acidophilic species. The lip of the escarpments directly north of the Bermejo River was the only site where we encountered the tree *Humiriastrum diguense* (Humiriaceae), a taxon characteristic of acid soils, and an unidentified purple-flowered Gentianaceae. On the edge of a higher cliff at ca. 1,700 m on the Sur Pax complex, we encountered several individuals of *Purdiaea nutans* (Cyrillaceae), a species known from the acid-rock mountains in the southern provinces of Zamora-Chinchipe and Morona-Santiago, but never collected north of there in Ecuador.

Mountain Ridges and Summits (1,500-2,300 m)

Mountain ridges – The major break in floristic composition with elevation occurs at approximately 1,500 m. At this height the flora shifts from one of mainly lowland genera to mainly montane genera. On our route up the southern slopes of Cerro Sur Pax, the transition happened to coincide with the presence of a steep cliff at 1,500 m. The abrupt change in flora there may have been due, in part, to a change in the rock and soil chemistry above and below the cliff, but it is more likely the result of an elevational transition in cloud and moisture conditions. The 1,500-m mark appears to be the lower limit of the cloudline here—the elevation where the clouds hit these mountains with greatest frequency, especially in the dry season.

Above 1,500 m the canopy is mostly 20-30 m tall and the leaves noticeably thicker than at lower elevations. Tree trunks here are dense with filmy-ferns and other vascular epiphytes, as well as a relatively thin and patchy layer of different mosses. Also characteristic is a high frequency of large hemi-epiphytes such as *Clusia* (Clusiaceae), *Schefflera* (Araliaceae), and *Blakea* or *Topobea* (Melastomataceae) growing from the crotches of trees; many large trees with prop-roots and a high frequency of resprouted stems; a high density of succulent shrubs such as Gesneriaceae and terrestrial bromeliads (mainly *Guzmania* and *Pitcairnia*); relatively more stumps serving as "nurse logs" (platforms for the germination and establishment of tree seedlings) than in the lower elevation forests; and more organic material and moss (rarely *Sphagnum*) on the ground.

There are many fewer species of trees on the mountain ridges than in the hill forest, but the flora here is by no means impoverished. In our canopy-tree transect on the ridge ascending Cerro Sur Pax from the south (at 1,900-2,100 m), the 100 trees we sampled represented 24 species. *Billia rosea* (Hippocastanaceae) made up 17% of the trees, *Calatola* sp. 15% (Icacinaceae; identification in doubt but *Calatola* fruits found under one of the trees), a freestanding species of *Clusia* (Clusiaceae) 10%, *Tovomita weddelliana* (Clusiaceae) 9%, *Myrsine* sp. (Myrsinaceae) 8%, *Weinmannia* cf. *pinnata* (Cunoniaceae) 7%, and *Clethra revoluta* (Clethraceae) 5%. The transect included mostly montane genera, such as *Podocarpus* (Podocarpaceae), *Ilex* (Aquifoliaceae), *Prunus* (Rosaceae), and *Cinchona* (Rubiaceae). Other, smaller, mostly montane genera in the sample included *Meriania* (Melastomataceae), *Hedyosmum* (Chloranthaceae), *Ruagea* (Meliaceae), and *Monnina* (Polygalaceae). The aroid *Stenospermation*, generally a trunk epiphyte at lower elevations, appeared here as a shrubby terrestrial plant.

Except for *Disterigma* and *Sphaerospermum*, Ericaceae are not particularly abundant on these high mountain ridges, especially in comparison with the acid ridges we visited in Sinangoe. Rubiaceae are frequently encountered here as trees rather than shrubs, though the most common species is a small-leaved, orange-flowered *Palicourea*. Also common are an *Eschweilera* (Lecythidaceae) treelet with recurved leaves, three species of *Guatteria* (Annonaceae), and several short treeferns and *Geonoma* palms. Bromeliads are also more conspicuous here as understory epiphytes, in addition to the usual high diversity of Araceae and

Pteridophytes. One *Burmeistera* (Campanulaceae) is an exceptionally common climber on tree trunks. The only bamboo we encountered at these elevations was an infrequent, skinny, clambering *Chusquea* (Poaceae), and the only legume a large tree, *Abarema killipii*.

Along much of the Andean slopes, like in the Salado River drainage to the south of the Sinangoe area, the palm *Dictyocaryum lamarckianum* replaces *Iriartea* above 1,500 m, but not here. While *Iriartea* drops out at these elevations, only a few juvenile *Dictyocaryum* were seen in the understory, and a couple of emergent individuals were spotted on the ridges to the north and east of Sur Pax. It may be that *Dictyocaryum* is more adapted to the acid soils that are scattered and rare in the Bermejo area. Probably this species will show up in abundance in the higher southern part of the Sinangoe area, not far from the Salado River drainage. Two tall understory palms of *Wettinia*, a genus also related to *Iriartea*, are similarly abundant in the Cofán foothills. *Wettinia maynensis* is common in the lower hill forest, and *Wettinia anomala* is common in the upper hill forest and extends into the mountain ridge forest. The transition between the two species is not well-marked, but may occur at roughly 1,000 m.

The most frequent colonists of landslides and treefall gaps at these elevations are a lobed-leaved species of *Croton* (Euphorbiaceae), similar in habit to *Croton lechleri* but replacing it at these elevations, an orange-leaved *Vismia* (Clusiaceae), and various *Miconia* (Melastomataceae) species. Rarely there are patches of a large white-leaved species of *Cecropia* (Cecropiaceae), the kind easily spotted from above on a clear day, but these are not as conspicuous an element here as on the western slopes of the Andes at this latitude.

<u>Mountain summits</u> – The southern peak of Cerro Sur Pax (2,275 m), the highest point we reached in this survey, has a much lower and more open canopy than the ridges below it. Most of the species here also grow along the lower mountain ridgecrests, but the stature of the canopy trees is reduced to 10-20 m, the bark of trees more covered in moss and other trunk epiphytes, species associated with disturbance more frequent, and canopy epiphytes more visible and accessible.

The explanation for the low stature and apparently active disturbance regime seems revealed in the clusters of dead snags scattered over the summit. These are symptoms of frequent lightning strikes that usually hit the tallest trees, especially those with monopodial (Christmas tree–like) growth, but also kill many of the adjacent smaller stems when the lightning heats their sap to the boiling point. The cool temperatures and near-permanent cloud cover may also reduce growth rates of the trees. Both factors probably also explain the great accumulation of dead trunks, branches, moss, and other organic material on the surface, which makes walking precarious here.

The northern peak of Sur Pax, which is only slightly higher (2,341 m) than the southern peak we visited, appears to have very similar vegetation. But along the ridge to the east of Sur Pax, on a series of high summits forming the northern wall of the Chandia Na'e River headwaters, the plant community is somewhat different. These summits, which we were unable to visit, mostly have much shorter, shrubby vegetation. They are also flanked by steep, recent landslides, which have exposed large areas of flat rock close to the summit. This is a sharp contrast to the open and tangled forest on the slopes of Sur Pax, which, though subject to landslides, show very little exposed rock. It is not clear whether there is a different type of rock underlying these shrubby summits, whether the rock strata there are tilted at such a steep angle that forest never develops, or whether there is simply a greater frequency of lightning on the northern headwall of the valley. The presence there (seen through binoculars) of a few isolated emergent individuals of the palm *Dictyocaryum lamarckianum* (see previous section) suggests that the stunted vegetation on these eastern ridges may be largely the result of a distinct soil chemistry related to a different underlying rock.

Natural Disturbance on Slopes and Ridges

Satellite images show as much as a quarter of the Cofán foothills covered by early successional forest growing on recent landslides. Some of these are tiny patches of less than a hectare; others cover square kilometers. One horseshoe-shaped landslide west of Sinangoe is as large as the entire Shishicho ridge system (Figure 2). The pattern of disturbance on ridges throughout area, whether large-scale or small, is basically the same. As streams erode and undermine the slopes, landslides or lateral slumps wipe out whole sections of vegetation, leaving large expanses of mineral soil exposed to sunlight. These open areas are eventually filled with a succession of pioneer species. On the upper slopes of the landslides, where rock is exposed or the soil is very shallow and unstable, the process is slow. Small herbs, vines, and shrubs may persist for a long time, but trees colonize very slowly. Toward the bottom of the landslide, where deep piles of mixed debris are deposited, the regrowth is rapid, with giant herbs and fast-growing trees shooting up to form a closed-canopy forest. The large bamboo, *Guadua angustifolia*, is frequently found in dense patches associated with old disturbance, but it is not a consistent member of the regeneration community.

In contrast to the ridges, some of the gradual slopes have a very different disturbance regime. These are subject to continuous lateral sliding of the soil and underlying soft rock. The consequence is that large areas of these unstable sloping terraces (sometimes several square kilometers of forest) are in a state of constant disturbance as the soil buckles and slides downhill. Much of the vegetation survives this slippage—a bit downhill from where it was and often with considerable root damage, and now interspersed with a mosaic of breaks in the soil and canopy, where pioneer species can colonize among the mature-forest species. Lianas and vines also benefit from these slips, by virtue of a highly flexible system for establishing new rooting points (as well as taking advantage of the old ones), quickly expanding into the breaks and up and over damaged trees. Thus a large portion of these unstable slips are covered with a disorganized tangle of plants that is very difficult to penetrate. The local Cofán residents in both areas describe these slopes as having always been in this condition of flux, not the result of an earthquake.

NEW SPECIES AND OTHER SIGNIFICANT RECORDS

Although most of the plants we collected during the inventory have not yet been identified, many collections have already been confirmed as new species. Of the 23 species of *Psychotria* (Rubiaceae) we collected in the Sinangoe region in our preliminary trip in 2000, four (17%) have been confirmed as new to science (C. Taylor, pers. comm.). At least two terrestrial bromeliads—one collected on the southern slopes of Sur Pax (Figure 4B) and the other collected on the Shishicho ridgeline—are undescribed (J. M. Manzanares, pers. comm.). One of the few Myrtaceae we collected in reproductive condition is currently being described as a new species of *Calyptranthes* (M. L. Kawasaki, pers. comm.; see Figure 4A and a more complete description of the plant below). One species of *Calathea* (Marantaceae) has been confirmed as new, and two others are probably new as well (H. Kennedy, pers. comm.; Figure 4E).

Several other taxa we suspect to be new await confirmation. The most common *Inga* on the acid ridges at Shishicho is different from any of those described and illustrated in a recent monograph of *Inga* in Ecuador (Pennington and Revelo 1997). Other taxa that appear to be new species include an *Heisteria* (Olacaceae) with strikingly tiny leaves, a *Gynerium* (Poaceae), and a *Cyclanthus* (Cyclanthaceae).

Many species on our list are not present in the new *Catalogue of the Vascular Plants of Ecuador* (Jørgensen and León-Yánez 1999), and at least one, a yellow-flowered shrub in *Basistemon* (Scrophulariaceae), represents a new genus for Ecuador. In some cases, these species may already have been collected in Ecuador but the specimens were either not fertile or not seen by a specialist working on the catalogue. But for other species these are clearly the first specimens known from the country. An example is *Conceveiba* sp. (Euphorbiaceae), one of the most common trees in both the upper hill forest and mountain ridge forest, but quite distinct from the two species of *Conceveiba* listed for Ecuador. Other species represent significant range extensions. For example, *Cassia grandis* (Caesalpiniaceae), although known from the Pacific coast of Ecuador, had never before been found in the Ecuadorian Amazon.

We estimate that at least 75% of the species we collected on Sur Pax and Shishicho have never been reported from the province of Sucumbíos. This is because the mountainous, western part of Sucumbíos has had very few visits from botanists. A recent map of plant collection localities in Ecuador shows a gaping hole around the Bermejo area (Jørgensen and León-Yánez 1999).

PLANTS IMPORTANT TO WILDLIFE

Virtually all the dominant trees in the Bermejo-Sinangoe area have animal-dispersed fruit, as do most of the other canopy species. Many of these, such as the dominants *Billia* and *Dacryodes* and the subcanopy *Grias*, produce big nuts, which are a rich resource for many terrestrial mammals such as deer and peccaries but are probably dispersed only by rodents such as agoutis, pacas, and squirrels. Other dominant trees such as *Minquartia, Tapirira, Otoba, Virola, Pouteria*, the many *Inga* and Lauraceae, and the scattered giant *Ficus*, have fruit that attract large birds, monkeys, and terrestrial mammals. Observations of tapir activity in the Ccuccono Valley suggest that the soft sweet fruit of the common successional melastome tree, *Bellucia pentamera*, is a favored food (R. Borman, pers. comm.). In the understory, the preponderance of bird-dispersed shrubs and treelets in the Rubiaceae, Melastomataceae, Myrtaceae, and other families is partly responsible for the region's rich avifauna.

The mammal team's observations on the mountain ridges of the Cerro Sur Pax complex indicate that spectacled bears there eat the tender leaf bases of dense stands of terrestrial bromeliads (*Guzmania* and *Pitcairnia*) and the "hearts" of small *Geonoma* palms. Whether these are really preferred foods, or just abundant edible resources where mountain bamboo species are in short supply, is not clear. It is interesting that of the two bromeliads most eaten, one is an undescribed species and the other may be new to Ecuador.

PLANTS COMMONLY USED BY THE LOCAL COFÁN COMMUNITIES

(Roberto Aguinda and Robin Foster)

As with most native communities somewhat isolated from western culture, there is considerable knowledge and use of the native plants in the daily lives of the region's Cofán residents. Especially in the community of Alto Bermejo, which has very limited contact with the outside, botanical knowledge appears to exceed that found among elders of the other Cofán communities. Even species of small, inconspicuous plants that go largely ignored or forgotten in the forests around other Cofán villages are readily distinguished from each other in Bermejo and have names in current use.

An ongoing project among the Cofán is to catalog the names and uses of these plants before more information is lost, and to link Cofán taxonomy to specimen collections and Linnaean names. This effort builds on the already published work of Cerón and colleagues (1994) for the area around the Sinangoe community; Cerón (1986, 1988, 1995), for the area around the Cofán community of Doreno; and a database of collections and images of plants (Aguinda and Foster, unpublished) for the area around the Cofán community of Zábalo. The following is a brief summary of the plants that the Cofán foothill communities use most frequently, according to interviews and observations.

For house construction, the underlying posts are usually made of the very durable *seña'mba quinicco* (*Minquartia guianensis*, Olacaceae), the floors from split trunks of the common palm *bom'bo*

(*Iriartea deltoidea*, Arecaceae), and the cross beams of strong but flexible small trees, often in the Annonaceae, especially *tsao quini'cco* (*Cremastosperma gracilipes*). In Bermejo, with its dense stands of the small fan-palm *tananácco* (*Chelyocarpus ulei*), this is the preferred roofing material with a very long life-span. In other areas, *uttuvo* (*Carludovica palmata*, Cyclanthaceae), found along the lowland streams, is the next best material for roofs. These plants are not readily available to the downriver Cofán, who usually use *Geonoma* and *Attalea* palms (or metal) for roofing.

The larger canoes are usually made from *cuticho* (*Cedrelinga cateniformis*, Mimosaceae; *chuncho* in Ecuadorian Spanish). When older canoes are no longer serviceable, they are recycled into seats and benches and become the principal source of furniture. The large stems of the riverside grass *upe caufa* (*Gynerium sagittatum*, Poaceae) are used as canoeing poles, or *palancas*. Harpoons for fishing are usually made from split trunks of *ccu'ye* (*Wettinia* palms) or on the spur of the moment from the small, perhaps undescribed species of *Gynerium* common along riverbanks (see the section on river and stream margins above). Rope comes primarily from hanging roots of a large *Philodendron* (Araceae), rather than *Heteropsis*, which is commonly used elsewhere, and strapping is largely from the bark of *Sterculia* (Sterculiaceae) trees. Leaves of *nijon'cho* (*Oenocarpus bataua*) are one source of the elegant backpacks woven together quickly for carrying heavy loads; aerial roots also are used (Figure 6A-B).

Although clothing is now all imported, decorative collars of seeds are made from the flexible leaf rachises of the small spiny *Aiphanes* palms. The *tuinfa* palm (*Astrocaryum chambira)* used for fiber in the Cofán communities downriver is missing here. For perfume and deodorant, the fragrant *patisa'cco* (*Ammandra dasyneura*, Arecaceae) and *Hedyosmum* (Chloranthaceae) from the mountain ridges are used. The resinous gums from Burseraceae trees (mostly the genera *Protium, Dacryodes*, and *Trattinnickia*) are used commonly for starting camp fires and as candles.

As in most of Amazonia, the thorny prop-roots of the palm *Socratea exorrhiza* are used for grating plantains or sweet potatoes (*Ipomoea*, Convolvulaceae). *Cecropia* (Cecropiaceae) leaves are used in the fermentation process to produce the important chicha drinks derived from mashed plantains (principally) and yuca. Wild edible fruits are varied, but commonly used ones include all the grapelike wild *bocha tsa'ja* (*Pourouma* spp., Cecropiaceae), *fiño* (*Inga* spp., Mimosaceae), *ttetteccu'cho* (*Grias neuberthii*, Lecythidaceae), *tssinímbo suvu* (*Brosimum* spp., Moraceae), *Ammandra dasyneura* (Arecaceae), and *Oenocarpus bataua* (Arecaceae), from which a sweet drink is made.

The important drug plants include the famous stimulant *yaje* (*Banisteriopsis caapi*, Malpighiaceae), and the more locally known *yoco* (*Paullinia yoco*, Sapindaceae). *Conguju* (*Senna ruiziana*, Caesalpiniaceae) is commonly used for headache; *avune'cho* (*Begonia rossmanniae*, Begoniaceae) to reduce swelling, redness, and pain; *shendu* (*Tournefortia*, Boraginaceae) for pain and infections; *Croton lechleri* (Euphorbiaceae) for wound healing; and both *Triolena pileoides* (Melastomataceae) and *ya'picho* (*Antrophium cajenense*, Pteridophyta) for throat infections. The shamans of course have many other plants in their repertoire.

ADDITIONAL SPECIES NOTES

- *Miconia calvescens* (Melastomataceae), with its large, roundish leaves, usually red below when newly emerged, was occasional on stream margins and other disturbed sites, mostly at middle elevations above 800 m. What makes this species important is that it has somehow arrived on Hawaii, Samoa, and many other islands of the Pacific Ocean, and has become one of the principal invasive pests in that region, pushing out the native flora. In this region of Ecuador, it seems to suffer frequent damage from insect herbivores eating holes in the leaves, something not seen on the Pacific islands. The key to controlling this species elsewhere might be found among its natural pests in Ecuador.
- *Piper* (Piperaceae) is a large genus of shrubs characterized by long skinny spikes of tiny flowers and

fruits, known to be dispersed mostly by bats (mainly the genus *Carollia*). The bats remove the entire ripe spike while in flight and consume it later while perched. At higher elevations we encountered in the understory a high frequency of several species of *Piper* with very short inflorescences, as well as *Piper piluliferum*, a species with an orbicular inflorescence. Although at least one such species occurred in the lowlands, and a few of the long-spiked species occur on the mountain ridges, the abundance of such *Piper* species in the mountains suggests that there is a different spectrum of seed-dispersers (or pollinators) available.

- In the Bermejo area we collected a small variety of *Cyclanthus bipartitus* (Cyclanthaceae), associated with the banks of several of the small shaded streams but also on the north bank of the Bermejo River. In the view of the senior author, this variety will likely be shown to be a new, cryptic species distinct from the usual *Cyclanthus*, which is now considered a monotypic genus. The new "variety" is found in dense stands along the watercourses, either on rocks or solid banks, and is smaller (<1 m), narrower, darker, shinier, and with a smaller inflorescence than the common variety. Although difficult to distinguish from the juveniles of the typical variety, it is not found along many of the streams, even when the typical, much larger variety is present.
- The understory palm *Hyospathe elegans* frequently forms dense patches in the upper hill forest from 950 to 1,300 m, although it is only scattered in the lower hill forest. Although *H. elegans* is considered to be a highly variable species, the purple-flowered variety with consistently narrow leaflets and more persistent spathe, encountered only in the mountain ridge forest, appears to be sufficiently distinct to merit recognition as a separate species.
- Low shrubs of certain melastomes, such as *Clidemia heterophylla* and *Tococa guianensis*, are often found in dense patches associated with abandoned nests of *Atta* (leaf-cutter) ant colonies. In creating their underground colonies, the *Atta* place subsoil from their excavations onto the surface, creating a nearly water-impermeable roof over the nest. Once the colonies are abandoned, few plants seem to be able to colonize these areas, but there is little competition for those that can. The ant-associations of these two species, with large formicaria (myrmecodomatia) at the base of their leaf blades, may also play a part in allowing the plants to establish while the *Atta* colony is still active.
- Another ant-plant, the small tree *Duroia hirsuta* (Rubiaceae), has other species associated with the clearings created by the ants around its stems. Two of the most frequent associates are the low shrublet *Psychotria polyphlebia* (Rubiaceae), and the shrub *Ossaea boliviensis* (Melastomataceae). The latter is also occasionally found on the abandoned *Atta* nests, although not harboring ants itself.

INFERRED HISTORY OF HUMAN USE

Alto Bermejo

The Bermejo community shows the usual patchwork of currently cultivated plots and regenerating old ones. Human impact beyond this is barely noticeable. Even a short distance away on the trails, valuable timber species such as *Cedrelinga cateniformis* (Mimosaceae) are abundant. Palms and other species important for house construction are harvested nearby, but on a small scale.

Given the tiny footprint of the Bermejo community, it is not surprising that as we walked the several kilometers of trail to ascend from 450 to 2,300 m we passed little sign of human impact. The exceptions are a few small campsites, near streams or on promontories such as our Vista camp, and a small clearing at 1,600-1,700 m on the southern slopes of Sur Pax, made ten years ago in an attempt to cultivate potatoes. This clearing has now regenerated into a 10-m tall forest dominated by *Croton* and *Vismia*. It is also interesting to note that peach palm (*Bactris gasipaes*) is frequent along the riverside trails near the community. The local residents also describe finding *caimito* (*Pouteria*, Sapotaceae), *achiote* (*Bixa orellana*, Bixaceae), tobacco, and other frequently cultivated plants growing wild in these sites. All indications point towards a long-term human presence in the area, perhaps with a much higher population density than at present.

Sinangoe

The Sinangoe field station above the Sieguyo River, our base of operations for this region, is built on a small flat terrace that was cleared for rice cultivation roughly 30 years ago. Other nearby areas to the east appear to have been cleared around the same time. Prior to being cut again for the present station in 2000, the regrowth on this terrace consisted mainly of medium-sized *Jacaranda copaia* (Bignoniaceae) and *Cecropia sciadophylla* (Cecropiaceae) trees. Closer to the confluence of the Sieguyo and Aguarico Rivers, there are many small abandoned clearings from colonization attempts during the last decade. All of the failed colonization lends additional support to the impression that the area is poorly suited to agriculture (OAS 1987).

Just north of the Sinangoe field station, the trail to Shishicho passes a large stump of what appears to be a *cedro* (*Cedrela fissilis*, Meliaceae), cut into boards with a chainsaw. It seems likely that most of the mature *cedro* this close to Puerto Libre has already been cut. However, even far from human settlements *cedro* are only encountered sporadically, leading us to conclude that it has probably never been an important timber resource for the area. It is apparently more common in the vicinity of La Sofía (L. Narvaez, pers. comm.). This trail to Shishicho partly follows an old path, so well-used in the past that it is now marked in places by deep erosion gullies. Scattered on the trail to the Ccuccono River are a few small campsites, but human use seems minimal. Any human impacts in the bottom of the Ccuccono Valley would have been obliterated in the massive washouts following the earthquake of 1987.

ENDEMIC PLANTS

Participants/Authors: Nigel Pitman, Robin Foster, and Roberto Aguinda

Conservation targets: restricted-range species, especially pleurothallid orchids, terrestrial bromeliads, aroids, and other herbaceous wildflowers

INTRODUCTION

The foothills of tropical mountain ranges around the world are celebrated for their extravagant levels of plant endemism, meaning that forests there contain large numbers of plant species not known to occur anywhere else (Gentry 1992). In the Cofán foothills, lying at the crossroads of two of the world's most diverse bioregions and bisected by the equatorial line, the expectation is of enormous numbers of endemic plants.

That expectation is borne out in nearby plant communities just a few kilometers to the south. Nearly 20% of the 4,011 plant species currently considered endemic to Ecuador have been collected in the thin strip of Andean forest stretching from the town of Tena in the south to the Colombian border in the north—an area constituting just 3-4% of the country's territory (Valencia et al. 2000). On a smaller scale, the narrow triangle of forest between the Sumaco and Reventador volcanoes and the Cordillera de los Guacamayos is swarming with endemics. More than 100 plant species endemic to Ecuador have been collected so far in the Cayambe-Coca Ecological Reserve, and more than 90 have been collected in the Sumaco-Napo-Galeras National Park; these numbers will double, at least, as the area is explored further.

The list of endemics for these protected areas is dominated by small, herbaceous plants, especially epiphytes in the families Orchidaceae, Gesneriaceae, Araceae, and Bromeliaceae. At least 21 orchid species and eight species of bromeliads endemic to Ecuador have been registered in Sumaco-Napo-Galeras, and inventories of other areas of the Ecuadorian Andes suggest that dozens more are waiting to be discovered there. The new reserve we propose for the Bermejo region would protect a large number of these species.

That is critically important, because plants with restricted ranges face an elevated risk of extinction. In the recently published *Red Book of the Endemic Plants of Ecuador*, Valencia et al. (2000) outline the precarious conservation status of the country's endemic flora. Fully 36% of all Ecuadorian endemics are known from a single population, 75% have never been registered within a protected area, and 83% qualify as threatened with extinction under World Conservation Union (IUCN) guidelines.

Here we present some initial observations on plant endemism in the Cofán foothills. It is still too early to draw precise conclusions about endemism in this poorly explored region, and we have tried to avoid the trap of thinking that all the strikingly unfamiliar plants we observed in the field were endemic species. Instead, our aim is to open the discussion with some preliminary observations from the field and the herbarium, and to suggest some avenues for further study. Considering the profusion of endemic taxa in adjacent areas of the eastern Andes, our caution will probably prove unwarranted. A large proportion of the plants we registered are most certainly unique to the area.

REGIONAL-SCALE ENDEMISM

The preliminary list of plants assembled for the Bermejo and Sinangoe region (see Appendix 1 and the preceding chapter) contains at least 15 species currently believed to be endemic to Ecuador. Since most of the plants on our checklist for the region have not yet been identified to species (and since widespread species are often identified first), we predict that the actual number of endemics is at least ten times higher. Ironically, the discovery of these species in the Cofán foothills almost guarantees that most of them will eventually lose their endemic status, because our collection sites are just a few kilometers from the Colombian border. As plant-collecting programs continue in the eastern Andes of Colombia (especially along the Pasto-to-Mocoa road), a large number of species currently considered endemic to Ecuador, and many of those present in our area, will probably be crossed off the list.

The evidence suggests, however, that many of those will prove endemic to a small stretch of the eastern Andean slopes (i.e., a few degrees of latitude). Botanists working along the length of the Andes have documented thousands of plant species that appear to be restricted to very narrow sections of the cordillera (e.g., Henshold 1999, Valencia et al. 2000), and it is unlikely that all of these are artifacts of a scanty collection record.

Prominent among the confirmed Ecuadorian endemics in the Cofán foothills list—and in the list of endemics expected to occur there—are epiphytic orchids and bromeliads. The two undescribed species of bromeliads we collected around Cerro Sur Pax and the Shishicho ridgeline probably have narrowly restricted ranges as well (J. M. Manzanares, pers. comm.). By contrast, we found an oddly meager diversity and abundance of micro-orchids in the tribe Pleurothallinae, and especially in the genus *Lepanthes*, which contains hundreds of species endemic to the Ecuadorian Andes. In the Pastaza River valley alone, L. Jost has recently documented 90 co-occuring species of *Lepanthes*; 25-30 of these can occur together on a single mountain covering the same elevational range as Cerro Sur Pax (L. Jost, pers. comm.). But the only site where we found species of *Lepanthes* during the survey was on the upper-most slopes of Sur Pax, between 1,900 and 2,275 m. Even there, methodical searches of the understory and canopy during our three days of collecting only turned up seven or eight individual plants, of mostly the same species. We may have spent too little time or covered too little ground in the higher-elevation forests that these taxa prefer. Or we may simply have overlooked dozens of these notoriously inconspicuous plants (Endara and Jost 2000).

SMALL-SCALE ENDEMISM

Botanists working on the opposite side of the Ecuadorian Andes have suggested that levels of "micro-endemism" among plants in the western foothills may be astronomically high. The idea is that a large number of the species endemic to forests of western Ecuador might, in addition, be restricted to a single ridge, valley, or mountaintop. In Gentry's (1986) famous description of the Centinela ridge, just south of Santo Domingo, he hypothesized that several dozen plant species might not occur anywhere else in the world but that small hill (5-10 km^2) at the base of the Andes. Although Gentry's report has proven somewhat premature—most of the putative Centinela endemics have now been collected elsewhere in coastal Ecuador, and only five species are still known only from that mountain (Valencia et al. 2000)—the idea of this single, rather unremarkable ridge harboring five unique plant species is itself astonishing (Dodson and Gentry 1991). If confirmed, the Centinela hypothesis would imply the existence of hundreds of micro-endemics in the Cofán foothills.

The most intriguing example of this sort of endemism that we encountered in the rapid inventory was an undescribed shrub in the genus *Calyptranthes* (Myrtaceae, the guava family; Figure 4A). This shrub was well known to the Cofán members of the team as *ishoaquinico*, a plant Cofán communities used, until very recently, in coming-of-age ceremonies for young men. The species was abundant along trails in the vicinity of the Sinangoe station and present on the lower portion of the trail up to the Shishicho campsite, but we did not encounter it anywhere else in the region. Indeed, the Cofán apparently used to make long expeditions to this area of Sinangoe to collect the plant, because they had never found it anywhere else. The species is currently being described as *Calyptranthes ishoaquinico* sp. nov. by M. L. Kawasaki, a specialist in the taxonomy of Myrtaceae.

We also collected a pair of very similar *Calathea* species that may illustrate this pattern. One of them, a striking herb with purple flowers and pink bracts (Figure 4E), was a common sight along the trail leading from the Bermejo Vista camp up the southern slopes of Cerro Sur Pax. At the same elevation on the Shishicho ridge, 10 km to the south, we encountered a superficially similar plant that, on closer inspection, proved distinct in several respects. Whether these taxa are still in the process of speciation or simply replacing each other in alternate drainages remains to be determined. In the meantime, it is interesting to note that the closest taxon to these in the *Flora of Ecuador* is a species that was first collected on the Centinela ridge by Al Gentry (Kennedy et al. 1988).

OTHER ENDEMICS OF INTEREST

- *Passiflora popenovii* (Passifloraceae), a vine endemic to Ecuador but apparently extinct in the wild (Jørgensen 2000), is cultivated along the new road from La Bonita to Puerto Libre (P. Fuentes and X. Aguirre, pers. comm.). The La Bonita–Sucumbíos Foundation in the town of La Bonita is now developing a program to prepare preserves from the fruits.
- The bromeliad *Werauhia haltonii* was known from just one other population in the Cordillera de los Guacamayos (more than 100 km to the south) before we found it growing on the 2,275-m summit just south of Cerro Sur Pax.

THREATS AND RECOMMENDATIONS

These patterns of endemism are important for conservationists because species with small geographic ranges will be the first to go extinct as habitat loss and climate change intensifies. In the case of micro-endemics, even moderate forest clearing on isolated mountaintops and ridgelines, where endemics may persist in tiny remnant populations, can potentially result in global extinctions (Dodson and Gentry 1991). On the larger scale, restricted-range species are protected by fewer parks and reserves than more common species. Plant species endemic to the San Miguel or Bermejo watersheds—like, apparently, the new species of *Guzmania* we discovered on Cerro Sur Pax—are not currently protected by any Ecuadorian or Colombian park there, and do not fall within the present borders of the Cayambe-Coca Ecological Reserve.

Measuring the precise number of species endemic to this area—and to any particular section of the Andean range—is still beyond the reach of scientists. Considering how critical the project is for the effective conservation of the Andean flora, we are astonished that it has attracted so little research attention to date. Within the Cofán foothills, the first step would be to sample systematically ridgetops throughout the region, focusing on taxa with a propensity for endemism (i.e., orchids, bromeliads, Gesneriaceae, etc.). Carefully designed and carried out, such an effort would produce invaluable data for conservationists and biologists alike.

AMPHIBIANS AND REPTILES

Participants/Authors: Lily O. Rodríguez (field) and Felipe Campos (museum)

Conservation targets: species with restricted ranges; species of higher elevations (*Hyla phyllognatha, Liophis epinephelus, Neusticurus cochranae, Chironius monticola*); taxa with declining populations, e.g., glass frogs (Centrolenidae) and poison-arrow frogs in the genus *Colostethus* (Dendrobatidae); *Enyalioides cofanorum* and other lowland species now extinct at Santa Cecilia (Figure 5A).

METHODS

This report combines L. Rodríguez's fieldwork around Sinangoe during the inventory with longer-term observations of the region's herpetological communities by F. Campos (who was not able to join us in the field). Supplemental observations were made by other members of the rapid inventory team, in the form of photographs taken at Bermejo. Fieldwork was restricted to the lower and upper hill forests around Sinangoe, at elevations between 800 and 1,450 m.

During my (LR) 11 days in the field, I spent 78 hours actively searching for amphibians and reptiles, mostly around the Ccuccono Ridge camp and the Shishicho camp. Sampling consisted of visual and auditory observations during walks on existing trails, both during the day and at night. I focused my searches on the taxa that are less common and widespread and that best characterize the type and condition of different habitats (e.g., Anurans, particulary *Eleutherodactylus* and Dendrobatidae). I also paid special attention to the stream habitats preferred by many species. I recorded some songs in the field, to compare later with published records. I collected ten species that I could not identify in the field (one specimen apiece) and deposited all specimens in the collections of the zoological museum of the Pontificia Universidad Católica del Ecuador (QCAZ). Two species on the list correspond to photographs taken by other team members in the Bermejo region.

Little prior fieldwork has been done in this mountainous region of Sucumbíos. The study conducted by Altamirano and Quiguango (1997) in Sinangoe focused on reptiles and amphibians between 565 and 670 m elevation. Not surprisingly, the species registered in their 34-day inventory (using transects and plots) were all lowland taxa shared with earlier lists from Santa Cecilia, with the exception of *Eleutherodactylus* cf. *incomptus*. Campos et al. (2001) inventoried herpetological communities around La Bonita (between 1,700 and 2,000 m) and Rosa Florida (1,400 m), and their results are summarized in Appendix 6 of this report.

RESULTS OF THE HERPETOLOGICAL SURVEY

We observed 85 amphibians and reptiles (excluding tadpoles) during the rapid biological inventory, corresponding to 31 different species. The list includes six species of snake, six lizards, 17 frogs and toads, a salamander, and a caecilian (Appendix 2). Among the most notable records are a new lizard species in the genus *Dactyloa* (Figure 5E), and the first Ecuadorian record for the lizard *Cercosaura ocellata*. We expect that a more complete survey, especially at higher elevations, would reveal several additional undescribed species and extend the altitudinal ranges of many known species.

The Cofán foothills lie just 20 km to the west of Santa Cecilia, whose forests held the world record for amphibian diversity until they were destroyed in the 1980s (Duellman 1988; see also Figure 7). The implication is that the lowest elevations of our study site—particularly the floor of the Bermejo River valley, at ca. 450 m—also harbor very diverse communities, including most of the species that were extirpated over the last two decades at Santa Cecilia; see Figure 5A.

Species richness drops significantly as elevation increases, though our data are not sufficient to give a clear picture of how the diversity of this region compares with similar-sized areas elsewhere in the Andes. Between 900 to 1,200 m in the Andes, one typically expects to find 30 or fewer amphibian species (Duellman 1988; species records for Cordillera del Cóndor and Cordillera del Cutucú in Ecuador, and the foothills of Manu in Peru). In just 11 days in the field, I recorded half this number, probably indicating that species richness in the region is high. By contrast, endemism is low. Most of the species in this region are shared with foothill forests in neighboring Colombia or with lowland forests in western Amazonia (Lynch et al. 1997).

Not surprisingly, the herpetological community in the Cofán foothills is a complex overlap of Amazonian- and Andean-centered fauna. Most of the species we observed in the field have altitudinal ranges rising from the base of the Andes to approximately 2,000 m elevation, and many are mostly known from the adjacent Amazonian lowlands. For example, the black-banded robber frog, *Eleutherodactylus nigrovittatus*, and at least seven other amphibian species on our list have been collected in Santa Cecilia (Duellman 1978), Yasuní National Park (Ron 2000), and lowland forests farther to the east (Lynch et al. 1997). (As usual in these forests, the small, hard-to-identify frogs in the genus *Eleutherodactylus* made up a disproportionate number of the species I registered in the field. We list nine in the checklist, though at least four others were seen and not identified.)

Other taxa are more characteristic of montane forest. Among the amphibians, for example, the montane species *Hyla phyllognatha* (Figure 5C) ranges widely in the Andes from Colombia to Bolivia, always between 600 and 1,700 m. (It is worth noting, however, that the different populations of *H. phyllognatha* might eventually prove to be distinct species; the songs we heard in this survey were different from the typical songs of this species in southeastern Peru [pers. obs.] and from the Ecuador recordings published in Duellman 1972.) It would appear that the herpetological communities in the Andean foothills near the equator have somewhat broader elevational ranges (though similar diversity) compared to foothill communities at higher latitudes, like those in Peru's Manu National Park. This will require more detailed studies to confirm. On the other hand, none of the species in our list that I consider to be taxa of montane forests (*Hyla phyllognatha, Liophis epinephelus, Neusticurus cochranae, Chironius monticola*) were reported by Altamirano and Quiguango (1997) at their lower-elevation study site around Sinangoe.

While much of the herpetofauna we registered in the Serranías Cofán is shared with lowland sites like Santa Cecilia, most species possess particular adaptations for the steep foothills landscape, where swampy areas are rare and most water is in the form of rushing streams. Thus *Eleutherodactylus* juveniles hatch directly from eggs, while *H. phyllognatha* and *Cochranella midas* reproduce in rushing streams.

Reptiles are rarely informative in rapid biological surveys because their population densities are so low as to make observations sporadic. I was surprised, then, to find considerable reptile populations during the survey, registering six snake species without any special effort. One of these was a bushmaster (*Lachesis muta*) coiled next to one of our tents at the Shishicho campsite (Figure 5B). At least two other snakes—*Liophis epinephelus* in Shishicho, and *Chironius* cf. *monticola* in Ccuccono—appear to be restricted to higher-elevation forest. We also identified six different species of lizards. *Neusticurus cochranae*—a lizard known only from the eastern slopes of the Ecuadorian Andes, where it can reach 1,300 m—appears to be common in the region. We found it in both the Cuccono and Shishicho camps, close to streams, at ca. 1,000 m. Of all *Neusticurus*, this species seems to be the least aquatic (Uzzell 1966).

While the density of amphibians fell within a typical range for forests of this kind, the animals did not appear to be in a particularly active season. The large number of juvenile animals we saw and the scarcity of singing males suggest that our survey may have coincided with the end of the mating season. While Crump (1974) and Duellman (1978) pinpoint the beginning of the mating season at Santa Cecilia (350 m) in August and September, it may be that the reproductive schedule and activity of the species shared with that site is different here due to the higher altitude. This sort of altitudinal variation in the mating schedule of a single species has been documented for amphibians and for forest birds in southeastern Peru.

Notable for their absence in the survey were species in the genera *Colostethus* (Dendrobatidae), *Bufo* and *Rhamphophryne* (Bufonidae), and *Hemiphractus* (Hylidae), as well as glass frogs (Centrolenidae), all of which are normally present in forests at this altitude. These absences may be related to the alarming declines observed elsewhere in the Cayambe-Coca Ecological Reserve (see below and Appendix 6). Yet the presence of *Hyla phyllognatha, Cochranella midas*, and other species in the streams around our campsites suggests that these absences were not related to environmental quality. More intensive surveys may eventually register the missing species, at low population densities. It is also possible that microhylid frogs like *Syncope antenori* are present in the moss-covered Shishicho ridge, or in the common epiphytic bromeliads in the Ccuccono watershed. Similarly, we found perfectly good habitat for *Colostethus* cf. *marchesianus* in the forest below our Shishicho campsite and in the vicinity of our Ccuccono Ridge camp, but not the frog itself. I heard (but was not able to record) songs that may have been this species; the species may simply have escaped detection.

Even after such a short time in the field (four days at each site), simple abundance patterns and differences between sites are fairly clear. *Eleutherodactylus nigrovittatus* was the most common amphibian species in Shishicho, while *Bolitoglossa peruviana* dominated in Ccuccono and *Epipedobates femoralis* in Sinangoe. Of the three, *E. nigrovittatus* appears to have the broadest local distribution, as it was recorded at all three sites. The dominant species in an earlier survey at Sinangoe (*Eleutherodactylus lanthanites;* Altamirano and Quiguango 1997) was only moderately abundant in our survey, and the most common amphibian at Santa Cecilia (*Eleutherodactylus variabilis*; Duellman 1978) was not even recorded. This sort of temporal and spatial variability points to habitat differences among sites, but the details are not at all understood.

THREATS AND RECOMMENDATIONS

Some alarming but poorly understood declines have been observed among amphibian populations in this part of Ecuador, particularly at higher elevations in the Cayambe-Coca Ecological Reserve (see also Appendix 6). Most notably, several species in the families Centrolenidae (glass frogs) and Dendrobatidae (poison-arrow frogs; especially the genus *Colostethus*) that were previously common at elevations between 1,000 and 2,000 m have shown dramatic fluctuations in the past 10-15 years. Most of the species in these groups were once frequently encountered along streams and waterfalls but have now largely vanished, with the sole (and puzzling) exception of *Colostethus bocagei*.

Uncovering the factors responsible for these population declines (or fluctuations) is an immediate priority for conservation in the area. If, as has happened in amphibian communities worldwide, these declines eventually spread to other taxa in the region, effective conservation action will require baseline information on (1) the distribution and abundance of individual species at different elevations and in different habitats throughout the Bermejo and Cayambe-Coca forests, and (2) the seasonality of reproduction of individual species. Neither set of information currently exists.

BIRDS

Participant/Author: Thomas S. Schulenberg

Conservation targets: Bird communities of hill forests; range- and elevation-restricted birds; large gamebirds; *Ara militaris.*

METHODS

The principal ornithologist on the rapid biological inventory team (July-August 2001) was Thomas S. Schulenberg. Supplemental observations were made by other members of the survey team, but primarily by Debra K. Moskovits and Randy Borman. In addition, our records from Bermejo are supplemented by the list of species recorded there by Douglas F. Stotz, Moskovits, and Jennifer M. Shopland during a short visit from 7 to 9 November 1998.

The basic protocol for the rapid surveys involved walking trails through the forest to locate and identify birds. I attempted to be in the field from first light (or very shortly thereafter), although early morning rains sometimes resulted in a later start. Usually I would remain in the field until late afternoon or dusk. I made an effort to survey all habitats in the area, but focused most of my efforts on closed-canopy forest. I carried a portable cassette tape recorder and directional microphone to make sound recordings of bird species. These sound recordings will be deposited at the Macaulay Library of Natural Sounds in the Laboratory of Ornithology at Cornell University. I did not conduct transects or point counts, but tallied the number of individuals observed for each bird species daily, to aid in the assessment of relative abundances.

RESULTS OF THE BIRD SURVEYS

The team recorded a total of 350 species during the three weeks in the field in the Serranías Cofán, and an additional 49 species were recorded in the Bermejo area by Stotz and others in November 1998. The avifauna documented by us to date totals 399 species (see Appendix 3).

Very little prior field work had been done in this region of Sucumbíos. The Academy of Natural Sciences of Philadelphia (ANSP) conducted a short ornithological survey from 11 to 17 March 1993 at 850-1,000 m in the Bermejo oil fields, at a site about 12-13 km south-southeast of the Cofán community of Alto Bermejo (M. Robbins, pers. comm.; the field team was Mark B. Robbins, Francisco Sornoza M., and Marco Jacome). Separately, Mena (1997) reported on the birds observed at the Cofán community of Sinangoe, and at two sites about 8 km to the southwest of Sinangoe. His list includes around 70 species not recorded by our rapid inventories. On the basis of the species listed by Mena (discounting the few apparent misidentifications, e.g., *Heliodoxa jacula*, a species of the western cordillera) as well as on a more general consideration of Ecuadorian bird distribution (Ridgely and Greenfield 2001), I estimate that the total number of bird species found in the Serranías Cofán may exceed 700 species. This would represent an essentially “complete” avifauna for the elevational range found in this area.

Of the 399 bird species recorded during the rapid biological inventory and Stotz’s earlier visit, fully 85% (339 species) were observed in the Bermejo region. In contrast, our totals for Shishicho (135 species; 34% of the total) and Ccuccono/Sinangoe (209 species; 52% of the total) are notably lower. There are several reasons for these disparities. The list for Bermejo reflects in part the more intensive coverage that this site received (all or part of 13 days during the rapid biological survey, plus three days by Stotz, as compared to all or part of five days for Shishicho and all or part of ten days for Ccuccono and Sinangoe). Bermejo also has been visited during different seasons (July and August during the rapid biological inventory, and November by Stotz), so the list for that region reflects seasonal variations in the bird community that are not documented at the two other sites. Finally, the Bermejo valley encompasses the greatest range of elevations of any of the study sites (440-2,250 m), and for that reason alone would be expected to have the greatest bird species diversity. Indeed, we no doubt would have recorded many more species around Bermejo were it not for the periods of rain on 3-4 August.

In the Serranías Cofán, the avifauna of the Amazonian lowlands overlaps with, and at higher elevations is replaced by, an Andean avifauna. In the forests from 400 m up to about 900 or 1,000 m (referred to throughout this report as lower hill forest), the avifauna is primarily lowland in composition, with only a few Andean species present where the hills first emerge from the Amazonian floodplain at about 400 m. At higher elevations, typically above 1,000-1,100 m, virtually all of the Amazonian species have dropped out, and the bird community is primarily Andean in character (upper hill forest). This bird community, in turn, is replaced at higher elevations by a different suite of Andean bird species, representative of what might be called mountain forest or cloud forest. Elements of this cloud forest community occur on the higher peaks that we visited in the Serranías Cofán, including several species with very limited distribution within Ecuador, or with globally small, threatened populations. I review the bird communities of these forest types in the following sections.

Birds of the Lower Hill Forest (400 to 900-1,000 m)

The extensive lower hill forests in the Serranías Cofán are where the greatest species richness is expected, because of that forest type's similarity to the adjacent, and extremely diverse, lowlands. Endemism, on the other hand, is low here, with most of the species widely distributed. Although my best opportunities to study this avifauna were cut short by rain (especially at Bermejo), we did record some species of interest.

One interesting discovery was *Hemitriccus zosterops* (White-eyed Tody-Tyrant), an Amazonian species that was of regular occurrence in lower hill forest throughout the Serranías Cofán. This species previously was known in Ecuador only from areas south of the Napo River (Ridgely and Greenfield 2001), although Mena (1997) also recorded *H. zosterops* at all of his study sites near Sinangoe, and there are a few records for *H. zosterops* in adjacent Amazonian Colombia (Hilty and Brown 1986). Our records both extend the distribution of the species in Ecuador and help to "fill in" what had been an anomalous hole in its distribution.

Relatively few truly Andean bird species are found in the lower hill forests of the Serranías Cofán, but among these are several of particular interest. *Chlorothraupis carmioli* (Carmiol's Tanager) is known in Ecuador primarily from Sucumbíos. The narrow distribution of this species in Ecuador is something of a surprise, as farther south (in southern Peru and Bolivia) *C. carmioli* is very widespread and common in lower hill forest. In contrast, *Snowornis subalaris* (Gray-tailed Piha), a bird of the hill forests that is known from rather few localities within its geographic distribution, occurred all the way down to around 450 m near Bermejo, perhaps the lowest elevation at which this species has been found.

It was in the lower hill forest, at the Sinangoe field station, that I had very good looks at a rare and poorly known swift, *Cypseloides lemosi* (White-chested Swift). I suspected the presence of this species over the Bermejo station as well, but was never able to confirm it there. Until recently, *Cypseloides lemosi* was only recorded from southwestern Colombia, but in recent years there have been records from several sites in eastern Ecuador and at one site in Peru (Schulenberg et al. 1997). This bird does not use the lower hill forest itself, but it presumably roosts, and perhaps even breeds, in the cliffs and waterfalls at higher elevations of the Serranías. Other, even lesser-known swifts, such as *C. cryptus* (White-chinned Swift) and *C. cherriei* (Spot-fronted Swift), also may occur in the Serranías Cofán. Due to the great similarities among all *Cypseloides*, and especially between *C. cryptus* and *C. cherriei*, their presence in the region would be very difficult to confirm. Attention should be paid, however, to the possible presence of these species near waterfalls and other likely nesting sites.

We recorded *Crax salvini* (Salvin's Curassow) at the uppermost elevations in the lower hill forest (900 to 1,000 or 1,100 m) at all three of our study sites. This large gamebird is primarily a lowland species, and is known only from parts of the northwestern Amazon basin, from southern Colombia across eastern Ecuador and south into northwestern Peru. The *Crax* is heavily hunted, and already has been exterminated from many areas within its range (especially in Ecuador). Although it was encouraging to find this species still widely distributed within the Serranías Cofán, the fact that the curassow seemed to be much more common in, or even restricted to, the uppermost elevations of lower hill forest within the region may be a telling indication of the hunting pressure it faces, even in an area with a relatively low human population.

We had no records during our brief inventory of *Heliodoxa gularis* (Pink-throated Brilliant), a hummingbird that is regarded as globally near-threatened (BirdLife International 2000) or threatened (vulnerable; Ridgely and Greenfield 2001). This rare species was found, however, at the ANSP study site southeast of Bermejo, and also along the Due River (Ridgely and Greenfield 2001). The ANSP survey also recorded another near-threatened species, *Pipreola chlorolepidota* (Fiery-throated Fruiteater). Both of these species surely occur at or close to our study sites.

Although not recorded during our 2001 survey, *Falco deiroleucus* (Orange-breasted Falcon) was observed by Stotz during his earlier visit to Bermejo. This falcon is a widespread species that is nonetheless scarce throughout its range. Other interesting species recorded by Stotz include *Tinamus tao* (Gray Tinamou) and *Touit purpurata* (Sapphire-rumped Parrotlet), two species with wide geographic distributions that are known in Ecuador from only a few records each (Ridgely and Greenfield 2001).

Birds of the Upper Hill Forest (1,000-1,100 to 1,500 m)

The upper hill forest, a narrow and fragile ribbon of habitat running the length of the Andes, has one of the most poorly studied avifaunas in South America. Although some elements of this region's bird communities are widely distributed, it also is characterized by a large number of bird species that occupy very restricted geographic or elevational ranges. Historically, the bird communities of the upper hill forest in Ecuador were best known from the Sumaco region, perhaps because this area was visited repeatedly, over many years, by collectors, ornithologists, and birdwatchers. Some of the rarer bird species of that region have since been discovered at additional localities in eastern Ecuador, but even these still are known, in most cases, from only a very few locations each. The avifauna of the upper hill forest in Sucumbíos province in particular seems to have been almost unknown prior to our visit.

Even during the short period of our rapid biological inventory, and though we visited only a few sites, we encountered some of the least-known and most geographically restricted bird species of the upper hill forest. The most important of these may be *Myiopagis olallai* (Foothill Elaenia), a species that was discovered only very recently (Coopmans and Krabbe 2000). This small flycatcher previously was known from only three localities: Sumaco and the valley of the Bombuscaro River in eastern Ecuador, and from a site in south-central Peru. We expected that this poorly known bird would be discovered eventually at additional localities; our record from the Serranías Cofán, however, is also a significant range extension.

Another major discovery was the first record for Ecuador of *Tinamus osgoodi* (Black Tinamou). This rare bird previously was known from only two small regions, in the head of the Magdalena valley in southern Colombia and in the Andes east of Cusco in southern Peru. It may be more widespread in Ecuador, however: birds believed to be this species have been seen as far south as Coca Falls (R. Borman, pers. comm.). *Tinamus osgoodi* is regarded as globally threatened (vulnerable; BirdLife International 2000).

Other highlights among the species of the upper hill forest include *Hylophilus semibrunneus*

(Rufous-naped Greenlet), which prior to our inventory was known in Ecuador only from Sumaco and the adjacent Archidona road; *Hemitriccus rufigularis* (Buff-throated Tody-Tyrant), previously registered at only three sites within Ecuador (and not known from Colombia); and *Phlogophilus hemileucurus* (Ecuadorian Piedtail), a small hummingbird known previously in Ecuador from only five sites (and elsewhere from only a single site in Colombia, and two sites in northern Peru).

Two important aspects of the bird community of upper hill forests in the Serranías Cofán are that many of these species—even those that are considered among the rarest and most locally distributed—were found (1) at all of our study sites and (2) on a regular basis. For example, *Campylopterus villaviscensio* (Napo Sabrewing), *Phylloscartes gualaquizae* (Ecuadorian Tyrannulet), and *Snowornis subalaris* all seemed much more common in the Serranías Cofán than at any other site where I have encountered them. The high relative abundance of these species is particularly important because two of them (*Campylopterus villaviscensio* and *Phylloscartes gualaquizae*) are, like the *Phlogophilus* hummingbird, entirely restricted to a small area of the Andes between Colombia or eastern Ecuador to the north, and northernmost Peru to the south, and these species typically occupy only a narrow elevational band within this region.

Also present in the Serranías Cofán is a population of *Ara militaris* (Military Macaw). Although this species has a wide distribution, it is decreasing in abundance throughout its range, its populations are increasingly fragmented, and the species is regarded as globally threatened (vulnerable; BirdLife International 2000). Within Ecuador, *A. militaris* previously was known from only six sites (none of them in the province of Sucumbíos). Since we encountered the species at all of our study sites (although always in small numbers), the Serranías Cofán may be an important refuge in Ecuador for this spectacular parrot.

We recorded *Aburria aburri* (Wattled Guan) at several of our sites. *Aburria* has a relatively large geographic distribution, but populations are declining and the species is considered to be globally near-threatened (BirdLife International 2000). We did not encounter *Chamaepetes goudotii* (Sickle-winged Guan) during our short visit, although it is reported to be present in the area (R. Borman, pers. comm.). *Chamaepetes* remains relatively common in Ecuador, but *Aburria* is generally uncommon in this part of its range and may be vulnerable to hunting pressure.

We have a little data on the presence in the Serranías Cofán of nearctic migrants (bird species that breed in the Northern Hemisphere and spend the northern winter in tropical latitudes), thanks to Stotz's visit to Bermejo in November 1998. During the three days that he was present in the region, Stotz recorded eight species of nearctic migrants, which is about half the number of migrant passerine species that would be expected to occur in forested habitats of the Serranía. *Dendroica cerulea* (Cerulean Warbler) was not recorded by Stotz, but the ANSP survey team found it southeast of Bermejo in March (M. Robbins, pers. comm.). Populations of *D. cerulea* are experiencing sharp declines in their North American breeding grounds, and this is a species of conservation concern (Robbins et al. 1992).

Birds of the Mountain Forests (1,500 to 2,300 m)

Given the relatively small area of mountain forest habitat at the crest of the ridges of Cerro Sur Pax, it was something of a surprise to encounter as many montane bird species there as we did. Among the numerous birds characteristic of higher elevations but present on Sur Pax were several species with extremely limited distributions within Ecuador. Perhaps the most significant of these is *Grallaria alleni* (Moustached Antpitta). This species currently is considered to be globally threatened (endangered; BirdLife International 2000). Until recently it was known only from two specimens from Colombia, but now has been found at additional sites in Ecuador (Krabbe and Coopmans 2000). Though *G. alleni* remains a poorly known bird recorded at only a few places within a limited geographic area, a ranking of "endangered" may overstate the level of threat. Also of interest were *Eriocnemis alinae* (Emerald-bellied Puffleg), a small hummingbird previously known from only three other sites in Ecuador, and *Campylorhamphus pucherani* (Greater Scythebill), a scarce species that previously had been recorded at only six sites in Ecuador.

Other clearly montane species observed on Cerro Sur Pax include *Adelomyia melanogenys* (Speckled Hummingbird), *Coeligena torquata* (Collared Inca), *Haplophaedia aureliae* (Greenish Puffleg), *Aglaiocercus kingi* (Long-tailed Sylph), *Trogon personatus* (Masked Trogon), *Andigena nigrirostris* (Black-billed Mountain-Toucan), *Dendrocincla tyrannina* (Tyrannine Wood-creeper), *Xiphorhynchus triangularis* (Olive-backed Woodcreeper), *Pseudocolaptes boissonneautii* (Streaked Tuftedcheek), *Thamnophilus unicolor* (Uniform Antshrike), *Scytalopus spillmanni* (Spillmann's Tapaculo), *Mecocerculus minor* (Sulphur-bellied Tyrannulet), *Leptopogon rufipectus* (Rufous-breasted Flycatcher), *Pseudotriccus ruficeps* (Rufous-headed Pygmy-Tyrant), *Hemitriccus granadensis* (Black-throated Tody-Tyrant), *Myiophobus pulcher* (Handsome Flycatcher), *Ochthoeca diadema* (Yellow-bellied Chat-Tyrant), *Pipreola riefferii* (Green-and-black Fruiteater), *Snowornis cryptolophus* (Olivaceous Piha), *Cinnycerthia olivascens* (Sharpe's Wren), *Cyphorhinus thoracicus* (Chestnut-breasted Wren), *Basileuterus luteoviridis* (Citrine Warbler), *Chlorornis riefferii* (Grass-green Tanager), and *Chlorospingus ophthalmicus* (Common Bush-Tanager).

We also were surprised to find evidence of species turnover at the higher elevations, with some congeneric replacements occurring even between the Bear Ridge camp and the ridgeline just below the crest of Cerro Sur Pax. *Coeligena coeligena* (Bronzy Inca), for example, reached the elevation of our ridgeline camp at 1,900 m, but was replaced just above, at 2,100 m, by *Coeligena torquata*.

Bermejo

We surveyed three sites in the Bermejo area, between 24 July and 5 August 2001. Our base was the Bermejo field station (440 m), where I spent the nights of 24 July and 2-4 August. I made casual observations along the trail to Pozo Dos as I entered (24 July) and left (5 August) the Bermejo area, both on days with remarkably clear weather. In addition, I spent parts of 3-4 August investigating the trail to Pozo Seco, but frequent rains both days hampered field work. The nights of 25-26 July and 30 July-1 August I spent at the Bermejo Vista camp (1,200 m). At this site I surveyed the lower part of the trail from the Vista camp towards the Bear Ridge camp, back down the main trail towards Bermejo (to about 850 m), and down the trail to the Chandia Na'e River, to about 900 m. We spent only three nights (27-29 July) at the Bear Ridge (Sur Pax) camp at 1,900 m. From here, I surveyed the trail from the camp up to the summit at 2,275 m, and, on one occasion, back down the trail towards the Vista camp, to about 1,700 m.

The Bermejo station was notable for the presence, at such a low elevation, of *Snowornis subalaris*, a species of the hill forest that is known from only a small number of sites within its geographic range. I also was impressed at Bermejo by the relatively high abundance of *Frederickena unduligera* (Undulated Antshrike), an Amazonian species with a wide distribution, but which usually is very scarce.

The area around the Vista camp was where I had my first indications that the Serranías Cofán contained a significant number of hill forest bird species that are elevationally or geographically restricted. Among these were a few species that, during our survey, were noted only at Bermejo, such as *Myiopagis olallai* and *Ampelioides tschudii* (Scaled Fruiteater). Most of the species found at Bermejo, however, later were noted at our other sites as well, such as *Campylopterus villaviscensio, Heliodoxa schriebersii* (Black-throated Brilliant), *Phylloscartes gualaquizae, Hemitriccus rufigularis*, and *Snowornis subalaris*. Another such species, *Phlogophilus hemileucurus*, not observed by us in the Bermejo region, was found by Stotz at about 900 m on a ridge between Pozo Seco and the community of Bermejo.

Army ants were active around Bermejo to the surprisingly high elevation of 1,400 m, and we observed a large number of obligate and regular ant-following birds, generally considered to be lowland species, as high as 1,200 m: *Neomorphus geoffroyi* (Rufous-vented Ground-Cuckoo), *Myrmeciza fortis* (Sooty Antbird), *Pithys albifrons* (White-plumed Antbird), and *Gymnopithys leucaspis* (Bicolored Antbird). Also notable at this site was a family group (two adults and two juveniles) of *Aramides calopterus* (Rufous-winged Wood-Rail), a widespread but scarce species that has been reported only a few times in Ecuador.

Our brief visit to the crest of Sur Pax was our only investigation of the higher areas of the Serranías Cofán (those above ca. 1,500 m). The ridges that we surveyed in the Serranías Cofán only barely reach the elevation at which the avifauna of the upper hill forest typically is replaced, in part, by a montane bird community. Often in such situations most or all of the expected higher-elevation bird species are lacking (presumably because the area of suitable habitat on top of the ridge is too small), and the bird species of lower elevations may extend their distributions up to higher altitudes than would be the case on higher ridges. In the Serranías Cofán, however, we found a significant degree of turnover in the bird community at the crests of the highest ridges.

In view of the tiny extent of these mountain forests on the ridges that we surveyed, I was somewhat surprised to find some species with extremely limited distributions within Ecuador. The most significant were the rare *Grallaria alleni*, the near-threatened *Campyloramphus pucherani*, and the scarce and local *Eriocnemis alinae*.

Shishicho

I was present at the Shishicho camp (1,000 m) during the nights of 6-9 August. Casual observations were made along the trail between the Sinangoe field station and Shishicho during the ascent (6 August) and descent (10 August). From Shishicho, I primarily explored the higher elevations along the ridge farther out the trail (7, 9 August), to about 1,500 m. The day of 8 August, however, I spent at elevations of 900-1,000 m along the trail between Shishicho and the Sinangoe station.

The most important discovery at Shishicho was of the poorly known tinamou *Tinamus osgoodi*, previously known only from two isolated populations, one in southern Colombia and one in southern Peru. A single bird was seen well at 1,400 m on 7 August, and I heard a tinamou song that I assume to belong to this species at rare intervals at comparable elevations both on 7 and 9 August.

Among other species noted only at Shishicho were the scarce hummingbird *Colibri delphinae* (Brown Violetear), feeding on a blue-flowered *Palicourea* tree; *Pipreola frontalis* (Scarlet-breasted Fruiteater), a cotinga that has not been recorded in Colombia (previously known north only to the Sumaco region); and *Piranga flava* (Hepatic Tanager), a species that is widespread in the Andes but not known from the eastern Andes of Colombia (the few prior records for eastern Ecuador all are from the south, in the provinces of Morona-Santiago and Zamora-Chinchipe). Also interesting was an unidentified *Knipolegus* flycatcher seen once at 1,450 m; this individual differed from the expected species, *K. poecilurus* (Rufous-tailed Tyrant), by having a brown (not reddish) iris and appearing medium brown (not pale gray or grayish brown) above, with the upper tail coverts more rufescent than the back, buffy wing bars, and blurry streaking on buffy brown underparts.

Ccuccono and Sinangoe

I spent the nights of 11-14 August at Ccuccono, on a ridge above the river, at 1,000 m. The days of 12 and 14 August I worked northeast along the trail from the Ccuccono camp back towards the Sinangoe station, down to elevations of about 900 m. On 14 August I descended from the camp to the Ccuccono River, and worked areas along the Ccangopacho and Ccopaye Fensi streams as well. I stayed at the Sinangoe station the nights of 5, 10, and 15-16 August. During most of these visits, we were en route to another site such as Shishicho or Ccuccono, and I made only casual observations around the station. Much of 16 August, however, I spent investigating trails near the station, primarily the lower part of the trail towards Ccuccono, and also from the station down the Sieguyo River towards the Aguarico River.

Ccuccono was the only site where I saw *Phlogophilus hemileucurus* during the rapid inventory. It was registered in the Bermejo area, however, by both Stotz and the ANSP team, and seems to be widespread in the region. This small hummingbird can be locally common, as it was at Ccuccono, but it has a limited geographic distribution encompassing a few localities from extreme southern Colombia south to extreme northern Peru. Another noteworthy observation at Ccuccono was an army ant swarm noted at 1,000 m. This was not attended by obligate ant-following antbirds, but on two successive days I observed a *Neomorphus geoffryoi* at this swarm.

Several large, empty, cup-shaped nests were noted on the face of a small cliff near a stream feeding into the Ccuccono River. Piles of palm seeds and germinating palm seedlings were present beneath these nests, at the base of the cliff. The initial identification of these as Oilbird (*Steatornis caripensis*) nests led the team to name the adjacent stream Ccopaye Fensi ("Oilbird Creek" in Cofán), but the substantial size of the nest cups suggests that they may have been nests of another species (*Rupicola peruviana*, Andean Cock-of-the-Rock) instead.

CONSERVATION IMPORTANCE

Even our brief survey of the Serranías Cofán was sufficient to establish the presence of a rich hill forest bird community, especially in the upper hill forest. Two features of this bird community make it of special importance for conservation: the presence of a significant number of species that are endemic to a small geographic area of the Andes, or which have been recorded at only a few locations; and the fact that most of these species were encountered at most or all of our study sites, indicating that the Serranías are an important center of population for these species. Among these are birds that are considered to be globally threatened, such as *Tinamus osgoodi*, *Touit stictoptera* (Spot-winged Parrotlet, considered vulnerable; BirdLife International 2000), and *Grallaria alleni* (but see my note on this last species above), as well as several species that are regarded as near-threatened, such as *Aburria aburri*, *Campylopterus villaviscensio*, *Phlogophilus hemileucurus*, *Campylorhamphus pucherani*, and *Hemitriccus rufigularis*. Indeed, the number of threatened and near-threatened bird species recorded from even this brief survey of the Serranías Cofán are sufficient to make this region one of the most important sites for bird conservation in eastern Ecuador (Wege and Long 1995).

Other species of special conservation interest include birds known from relatively few sites or with constricted distributions, such as *Myiopagis olallai*, *Phylloscartes gualaquizae*, and *Hemitriccus rufigularis*. More intensive surveys almost surely would discover the presence of additional range-restricted species within the Serranías.

THREATS AND RECOMMENDATIONS

The Serranías Cofán are an important refuge for populations of large, vulnerable birds, like the parrot *Ara militaris* and the large cracids *Crax salvini* and *Aburria aburri*. *Ara militaris* is considered globally threatened (BirdLife International 2000). Both *Crax salvini* and *Aburria aburri* are declining in Ecuador, and *Aburria* is considered to be globally near-threatened. These cracids are threatened not only by habitat loss (deforestation), but also by hunting, as they commonly are shot for food. It is not known what level of hunting pressure these gamebirds can sustain, but hunting within the Serranías will need to be strictly regulated to maintain stable populations for the long term.

The Cofán community at Zábalo has implemented a community-based regulation of hunting loads and initiated a program of wildlife censusing (R. Borman, pers. comm.) that is a good model for Cofán residents in this area.

Most, if not all, of the region's bird species that are of conservation importance are restricted to relatively undisturbed habitats. Consequently, this avifauna is at risk from the colonization currently taking place along the Interoceanic Highway from Tulcán to Lago Agrio (Figure 2A). Species that are hunted for food (such as the guans and curassows) will be particularly vulnerable to the growing human presence, and even to relatively transient impacts (e.g., miners who enter the region only for short periods).

Additional surveys of the avifauna of the Serranías Cofán undoubtedly will increase the total number of species known from the region. Particular species that would be expected to occur in these foothills, and that should be targets of future investigations, include two threatened species that are regarded as vulnerable (BirdLife International 2000), *Galbula pastazae* (Coppery-chested Jacamar) and *Dysithamnus occidentalis* (Bicolored Antvireo), as well as several near-threatened bird species: *Heliodoxa gularis*, *Xenerpestes singularis* (Equatorial Graytail), *Pipreola chlorolepidota*, and *Chloropipo flavicapilla* (Yellow-headed Manakin).

LARGE MAMMALS

Participant/Author: Randall Borman A.

Conservation targets: Mammals classified as CITES I (threatened with extinction) and CITES II (potentially threatened if no action is taken), including *Alouatta seniculus, Aotus vociferans, Ateles belzebuth, Callicebus moloch cupreus, Callicebus torquatus, Cebuella pygmaea, Cebus albifrons, Cebus apella, Herpailurus yaguarondi, Lagothrix lagothricha humboldtii, Leopardus pardalis, Leopardus wiedii, Lontra longicaudis, Myrmecophaga tridactyla, Panthera onca, Pithecia monachus, Priodontes maximus, Puma concolor, Saimiri sciureus, Sanguinus nigricollis, Speothos venaticus, Tapirus terrestris, Tayassu pecari, Tayassu tajacu*, and *Tremarctos ornatus*; also, rare mammals (*Atelocynus microtis*), and seed dispersers and seed predators. Names generally follow Emmons and Feer (1997).

METHODS

The large-mammal fauna of the Serranías Cofán was a blank spot on the map for biologists at the time of this inventory, though it has been well-known for centuries to the Cofán hunters and naturalists inhabiting the area. Because I grew up within the Cofán culture, speak the language, and have hunted and fished with Cofán for most of my life, it was easy to draw up a checklist of expected species. The challenge during the inventory was to confirm the presence of the species already known to the Cofán inhabitants, and to estimate their local abundances, over the course of our 24 days in the field.

We first compiled a list of 46 expected mammal species, spanning six orders and 14 families, based on the taxonomic literature, personal experience, and interviews with Cofán who live in the Bermejo and Sinangoe areas. We excluded bats, marsupials, and most small rodents from the list, because inventorying these groups effectively in such a quick survey is next to impossible. Instead, we concentrated on species that are either important to the Cofán inhabitants as game animals or provide a good indication of the ecological health of the region.

In the field, I tried to cover as much ground and as many habitats as possible in each area we visited, often following unmarked paths or animal trails away from the main trails. I remained alert for visual sightings, but also recorded identifiable tracks, scat, smells, and feeding sites. I also kept a record of all mammals sighted by others during the rapid inventory—both by the members of the scientific team and by the more than 30 Cofán who assisted us in the field. From these data, supplemented by conversations with local Cofán and by my own prior experience in the area, I derived estimates of population size for each species.

RESULTS OF THE MAMMAL SURVEY

Of the 46 species of large mammals expected to occur in the area, 42 were confirmed and 32 directly detected during the inventory (see Appendix 4 for the species list and abundance estimates). The tally includes 12 species of primates, nine of which were detected in our 24 days in the field. We also found dozens of records of tapirs and peccaries throughout the area, indicating a rich and largely intact mammal community, despite the small-scale hunting by the local residents. Another ten species are confirmed by local Cofán inhabitants, leaving four species unverified (*Mazama rufina*, *Nasuella olivacea*, *Tapirus pinchaque*, and *Aotus lemurinus*). These are all montane species that are similar to lowland species and could easily be confused by local residents.

Several of the mammal species confirmed for the Serranías Cofán are extremely rare or considered globally threatened by the World Conservation Union (IUCN). Eight species are listed in CITES Appendix I, 17 in Appendix II, and six in Appendix III. The recently published *Libro Rojo de Mamíferos de Ecuador* (Tirira 2001) lists six of our 42 confirmed species as threatened, with one of these classified as endangered (*Priodontes maximus*) and five as vulnerable. Two of the four unconfirmed species are listed in CITES Appendices I or II; the first of these qualifies as endangered (*Tapirus pinchaque*), while the second is considered vulnerable (*Aotus lemurinus*). Several additional species we recorded, like the short-eared dog, *Atelocynus microtis*, are so rare that their conservation status is entirely unknown but potentially critical.

During the field work we were unable to validate reports from local Cofán hunters of a miniature woolly monkey said to inhabit the higher elevation forests of Bermejo. The animal has reportedly been spotted several times and hunted twice by Cofán, who insist that it is different not only in size but in habits, sounds, and color patterns from the more common *Lagothrix lagothricha*. Note that the Cofán hunters I accompanied on an earlier trip to Cerro Sur Pax had never before seen the brown capuchin monkey, *Cebus apella*, that we collected there, and it may be that the Bermejo region's unusually dark and thickly haired individuals of that species are the basis for the stories of the small woolly. On the other hand, when confronted with the unfamiliar *C. apella* specimen, the Cofán hunters immediately stated that it was not the small woolly they had collected. There remains some possibility that a new species or subspecies of *Lagothrix* inhabits these forests, and resolving the issue is a high priority for mammal studies in the area.

We were likewise unable to verify reports of several other unusual mammals in the region. Bermejo hunters, for example, claim to have seen a smallish blonde bear in the high-elevation forests we investigated around Cerro Sur Pax. In previous visits to Bermejo, I have observed two different opossums—one a captive juvenile and the other a wild adult—that I have been unable to identify. One of the most common squirrels in Bermejo and Sinangoe, a large gray animal with a white underside, appears to be an undescribed species. For the time being, all of these apparent novelties await confirmation.

The large-mammal communities of Bermejo and Sinangoe are very similar in composition, but animal densities appear to be substantially higher in Sinangoe. I suspect that these differences are driven by higher productivity in the Sinangoe forests. An alternative hypothesis, given that Cofán communities hunt for food in both forests, is that the Bermejo community is harvesting animals more intensively than the Sinangoe community. This hypothesis can probably be rejected, however. Sinangoe's Cofán population is ten times larger than Bermejo's, and the Sinangoe forest is also occasionally hunted by outsiders, suggesting that animals are being harvested much more intensively there than in Bermejo. It is true that hunters in Bermejo range more widely and hunt more aggressively than those in Sinangoe, but I suspect that this is a consequence of low animal densities, not their cause. The real cause of the discrepancy probably lies in richer soils leading to higher fruit production, coupled with a better distribution of habitat types in the Sinangoe region.

Bermejo

My initial assessment of Bermejo's large-mammal community divides the region into three important sub-regions, distinguished by differences in elevation and productivity: (1) rather unproductive lowlands; (2) more productive mid-elevation forest; and (3) steep slopes and ridges of the higher-elevation forest.

Much of the lower-elevation forest in the Bermejo River valley—at elevations of 400-1,000 m—grows on hills of soft red silt that are very unstable and constantly eroding. Sizeable landslides seem to occur with every rain, giving the Bermejo River its distinctive reddish color, and the waterlogged, nutrient-poor soils are probably as unproductive for wild fruit crops as they are for agriculture. As a result, natural forests in this subregion are dotted with patches of successional forest choked with vines and brush. Deer, armadillos, and the larger forest rodents thrive in this landscape, but collared peccaries (*Tayassu tajacu*), which usually adapt well to secondary forests and easily resist hunting pressure, were surprisingly scarce.

Collared peccaries were far more common in the more mature forests of the second sub-region, from 1,000 m up to 1,200 m. This sub-region is characterized by dark organic soils that seem to provide far larger fruit crops than the reddish, unstable soils around Bermejo. Landslides are still common here, but the relative areas of mature forests, old successional forest, and recent successional scrub are more evenly distributed, providing mammals with several large habitats. Collared peccaries, tapirs (*Tapirus terrestris*), woolly monkeys (*Lagothrix lagothricha*), howler monkeys (*Alouatta seniculus*), and other smaller mammals were all abundant in this rich region. Spectacled bears (*Tremarctos ornatus*) were also present, though not as frequent as at higher elevations. We had multiple records of white-fronted capuchins (*Cebus albifrons*) and squirrel monkeys (*Saimiri sciureus*) here, but neither seemed to climb above 1,200 m. Cat signs likewise cease here. The lowland deer (*Mazama americana* and *M. gouazoubira*) are common throughout this region.

The third sub-region corresponds to the relatively steep slopes and ridges of the Cerro Sur Pax mountain complex, above 1,200 m. Quartzite boulders and deep organic mud are the surface characteristics, with tall forests growing increasingly moss- and epiphyte-laden as one climbs. Woolly monkeys, howler monkeys, deer, and tapir all range along the lower slopes, but drop out at higher elevations, starting with deer and tapir (1,200 m), followed by howler monkeys (1,350 m) and woolly monkeys (1,500 m). The brown capuchin (*Cebus apella*) and the white-bellied spider monkey (*Ateles belzebuth*) appear near the crest, at 1,600 m and upwards. At some point on these slopes we began to register an unidentified species of coati with light red fur and an unringed tail (perhaps not *Nasuella olivacea*), apparently native to the higher-elevation forests. Spectacled bears are common throughout this region, and we frequently encountered heavily traveled trails and large feeding areas.
Small deer prints at the 1,800-m mark are probably indications of the little red brocket, *Mazama rufina*.

The stunted, moss-laden forests that grow along the ridges between 1,600 and 2,200 m are often so narrow as to give the impression that they are not an important habitat for mammals. However, both bears and brown capuchin monkeys occur there, probably attracted to the bromeliads that grow abundantly along the ridges. The unidentified coati also uses this habitat. This was also the area where we had our most frequent sightings of the unidentified large grey squirrel. Notable for its absence was *Tapirus pinchaque*, which is common above 2,000 m elsewhere in the eastern Andes. It should be present in the higher-elevation areas north of Cerro Sur Pax.

Sinangoe

The Sinangoe landscape appears far simpler than Bermejo in its geology and habitat heterogeneity, in part because it lacks the poor red soils that dominate much of the lower-elevation forest in Bermejo. Distribution of important habitats for mammals is much more even, and species distributions less patchy. For instance, the two major sub-regions in the Sinangoe area—the huge, mostly flat alluvial plain between the Ccuccono and Aguarico Rivers, and the more mountainous and rugged landscape to the north and west—show few differences in mammal composition, apart from some predictable turnover related to elevation.

One of the few differences we noted between the mammals of the two sub-regions was the surprising absence of most large primate species from the alluvial plain. We sampled this region on three different occasions, and discussed its fauna at length with the Sinangoe community. Remarkably, and in spite of a great deal of available habitat, the only common large primate here is the howler monkey. Interviews with older Cofán inhabitants confirmed that while spider monkeys have occasionally been seen in the region, woolly monkeys have never been sighted. This is puzzling, especially given that hunting pressures have been quite low for at least a century and that we spotted several groups of woolly monkeys in the adjacent Cerro Shishicho. It may be that one of the catastrophic geological events that seem to be a common occurrence in the Ccuccono River drainage (e.g., earthquakes, floods, volcanic eruptions) eliminated woolly monkey populations in the recent past, and that subsequent recolonization is occurring at a slow pace.

Species notes:

Cebus apella (Brown Capuchin Monkey)
We encountered this species only once during the inventory, at 2,100 m on the southern slopes of Cerro Sur Pax. I have seen it on at least three separate occasions in the same area, between 1,800 and 2,000 m, over the last two years. The abundance of partially eaten fruits and sucked bromeliad leaves bearing tooth marks that correspond to *C. apella* dentition suggest that the species is common at these elevations—up to 600 m higher than the upper elevational limit of 1,500 m suggested by Emmons and Feer (1997).

I believe that the two specimens I hunted here in 1999 constitute the only confirmed records of *C. apella* north of the Pastaza River watershed in Ecuador. My own decades of field experience in Ecuadorian Amazonia and numerous conversations with Cofán, Secoya, Siona, Quichua, and Huaorani hunters have failed to turn up any indications of the species' presence in the Napo and Aguarico watersheds. Reports of *C. apella* from Cuyabeno and Yasuní have generally been made by scientists unfamiliar with *C. apella* populations in other regions, and in most cases I believe they can be attributed to confusion with the large, dark, and thickly haired *C. albifrons* males. Adding to the confusion is the fact that indigenous hunters in lowland Amazonia often have a distinct name for these males.

Ateles belzebuth (White-bellied Spider Monkey)
This species does not appear to be common in the Bermejo region. Cofán hunters reported only one encounter, nearly a decade old, near Cerro Sur Pax. We located only one group in Bermejo, of more than ten individuals, also near Sur Pax. The monkeys were very tame and curious, coming over to investigate the noise of our trail construction. Two days later, we encountered a single individual much lower, at 1,600 m. The low density of spider monkeys in the area—and their apparent restriction to high-elevation forests, along with *C. apella*—may be a result of low food availability. Human hunting does not seem to be responsible for these patterns, as only one individual spider monkey is known to have been killed in the area over the last generation.

In sharp contrast to the situation in Bermejo, *A. belzebuth* was common in the Sinangoe region. Once again, it seems to be confined to fairly high altitudes, overlapping only narrowly with *Lagothrix lagothricha* (see below). Groups were detected on five separate occasions on Cerro Shishicho, always above 1,300 m. The monkeys there were tame and curious, in spite of the fact that the Shishicho trail has been used heavily by colonists and indigenous people for at least the past century. This is partly because Shishicho is now off-limits to Cofán hunters (see below).

Lagothrix lagothricha humboldtii (Woolly Monkey)
Although no woolly monkeys were sighted by the team during our Bermejo inventory, the Bermejo residents encountered at least four groups in hunting trips during the same time. All four encounters were in the relatively productive area on the meseta below the Bermejo Vista camp, between 600 and 900 m. Cofán familiar with woolly monkeys in eastern Ecuador were surprised by the robustness of the individuals at Bermejo.

In the Sinangoe region, the distribution of *L. lagothricha* shows several interesting patterns. Farther downstream, the Aguarico River forms the border between the subspecies *humboldtii* (to the north) and *papaegi* (to the south). In the headwaters of the Aguarico, this border follows the Due River, a major and wide-channeled tributary of the Aguarico. It appears *humboldtii* was able to cross the upper Aguarico tributaries (the Chingual and Cofanes) but not the Due. Just as interesting is the patchy distribution of woolly monkeys between the Due and the Aguarico (see discussion in Sinangoe section above).

The fact that healthy populations of *Ateles* and *Lagothrix* seem to occur around Cerro Shishicho, a region designated off limits to hunting by the Sinangoe community, suggests that these populations will be viable and stable for the long term if colonist incursions can be minimized. They can then serve as "seed" populations to recolonize adjacent areas.

Tremarctos ornatus (Spectacled Bear)
On the basis of indirect evidence, spectacled bears are common in both the Bermejo and Sinangoe regions; one member of the 2001 inventory team sighted one briefly near Cerro Sur Pax. Bear trails, torn-apart bromeliads and palms, and other signs are obvious and ubiquitous at higher elevations throughout the region, and in Bermejo I registered signs for spectacled bear as low as 450 m.

Atelocynus microtis (Short-eared Dog)
This animal, perhaps the most elusive and least-studied carnivore in the Amazon basin, was sighted in Bermejo by D. Moskovits. At 4:30 PM on a rainy afternoon, she observed a solitary dog trotting towards her along a heavily used trail in mature forest near the Bermejo Vista camp, just above 1,200 m elevation. Apparently oblivious to her presence, the animal passed within ca. 30 cm of her before disappearing into the undergrowth. This is the highest elevation at which *Atelocynus* has ever been recorded (Leite and Williams in press).

THREATS AND PRELIMINARY RECOMMENDATIONS

Developing appropriate management plans for these forests will require studies on current hunting practices and their effects. The Sinangoe community has already implemented some simple rules for hunters, mostly by establishing some areas that are off-limits and others that are fair game. Our observations of dense animal communities at both Shishicho (off-limits) and the Candue (fair game) suggest that management in those areas is on the right track, at least for the time being. In Bermejo, on the other hand, no attempts have been made to manage game populations, and the apparent abundance of monkeys there is a simple consequence of the small population of hunters. Establishing simple hunting rules for Cofán hunters in Bermejo, and reinforcing the rules in Sinangoe, should be one of the highest priorities for the conservation and management of the area's wildlife. Initially, a system of zoning will probably give the best results, with further management tools being developed in tune with the community's ethic and needs. Engaging local Cofán residents in wildlife censusing programs will provide important data on population dynamics and hunting levels, and these will help construct a sensible management plan.

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