

# 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](http://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 Sieguayo 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 Ccucono 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 Ccucono (see below), above the headwaters of the Candoe.

##### Ccucono 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 Ccucono 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 Ccucono.

Once at the Ccucono 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 Ccucono River. The plant and mammal group followed the Ccangopacho down to its junction with the Smaller Ccucono and camped on the open beaches of the river itself.

Very little of the present-day landscape in the Ccucono 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 Ccucono 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 Ccucono, 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-Ccucono 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 Ccucono 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.

*Ccucono 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 Ccucono 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**

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**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-Chinchipec, 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 (Ccuconco) 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<sup>2</sup> 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 Ccuconco River basin we visited. Indeed, the epicenters of these quakes have been traced to directly beneath the Ccuconco 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 Ericaceae 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 Ccucono 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 bracceliniae* (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. glycyarpa* (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 northernmost 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 Ccucono 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 Ccuconco, 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), *Podandrogynne 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 glycyarpa* (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 (*Compsoeura ulei*, *Otoba glycyarpa*, and *Virola* sp.) made up 20%

(7%, 7%, and 6%, respectively). And on the sloping ridge above Ccuconco 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 neubertii* (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 Ccuconco 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 Ccuconco. 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 *Compsoeura 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 Ccuconco 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* (Melastomataceae) 9%, and the *Geonoma* sp. (Araceae) 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-Chinchi 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.

**Mountain summits** – 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 *Calyptanthes* (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 *Hesteria* (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-Yáñez 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-Yáñez 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* (*Crematosperma 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), *ttet-teccu'cho* (*Grias neuberthii*, Lecythidaceae), *tssinimbo 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 Sofia (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 Ccucono River are a few small campsites, but human use seems minimal. Any human impacts in the bottom of the Ccucono 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-occurring 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<sup>2</sup>) 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 *Calypttranthes* (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 *Calypttranthes 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 Ccucono 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, particularly *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 Sucumbios. 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 Ccucono—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 *Rhombophryne* (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 Cuccono watershed. Similarly, we found perfectly good habitat for *Colostethus* cf. *marchesianus* in the forest below our Shishicho campsite and in the vicinity of our Cuccono 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 Cuccono 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 Sucumbios. 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 Cuccono/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 Cuccono 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* (Carmioli'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 Sucumbios 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 ruficularis* (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 gualaquiza* (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 gualaquiza*) 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 Sucumbios). 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), *Haplophedia aureliae* (Greenish Puffleg), *Agelaiocercus 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 gualaquiza*, *Hemitriccus ruficularis*, 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 *Gymnophithys 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 *Campylorhamphus 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-Chinchipec). 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.

#### Ccucono and Sinangoe

I spent the nights of 11-14 August at Ccucono, 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 Ccucono camp back towards the Sinangoe station, down to elevations of about 900 m. On 14 August I

descended from the camp to the Ccucono 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 Ccucono, 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 Ccucono, and also from the station down the Sieguyo River towards the Aguarico River.

Ccucono 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 Ccucono, but it has a limited geographic distribution encompassing a few localities from extreme southern Colombia south to extreme northern Peru. Another noteworthy observation at Ccucono 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 geoffroyi* at this swarm.

Several large, empty, cup-shaped nests were noted on the face of a small cliff near a stream feeding into the Ccucono 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 stictopectera* (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 ruficularis*. 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 gualaquiza*, and *Hemitriccus ruficularis*. 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 Ccuconco 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 Ccuconco 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.