

NATURAL HISTORY OBSERVATIONS AND ECOLOGICAL EVALUATION OF THE LA SELVA PROTECTION ZONE, COSTA RICA

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ABSTRACT

An Organization for Tropical Studies (OTS) expedition in the La Selva Protection Zone (ZP), Heredia Province, Costa Rica, forms the basis for ecological commentary on land use, hydrology, ecological life zones, and aspects of the flora and fauna of the ZP. Primary forest covers 73 percent of the 7,368 ha that extends from 36 to 850 m elevation. The 1,208 ha of pasture do not yet appear to have seriously affected movements of large animals and birds within the protection zone.

Two ecological life zones plus two transitional zones support four distinctive forest communities. We estimate that the ZP contains approximately 650 species of trees and 400 species of birds, as well as providing critical habitats for at least 75 species of trees and 50 bird species. Expedition members discovered at least 28 new plant species, plus 12 plant species previously not known for Costa Rica. At least 35 bird species use these forests for altitudinal migrations. In addition, 17 species of frogs and toads, 27 species of reptiles, and 18 species of mammals were recorded from the ZP. These included monkeys, tapir, large carnivores, 3 species of herps not known to occur at La Selva, and several rare taxa.

The 2,870 m altitudinal transect from the top of Volcán Barba (2,906 m) to the La Selva Biological Station, over a linear distance of 35 km, offers a topographic gradient of primary forests and rivers that is unmatched in Central America. Together, Braulio Carrillo National Park and the La Selva Protection Zone are estimated to harbor 80 percent of Costa Rica's landbird avifauna and 40 percent of the tree species.

The La Selva Protection Zone (ZP) is a narrow corridor of land on the Caribbean slope of Costa Rica that comprises part of the last altitudinal transect of primary tropical rainforests remaining in Central America. The 7,368 ha ZP lies between the Río Peje and Río Guácimo. It stretches from the La Selva Biological Station at the confluence of the Río Sarapiquí and Río Puerto Viejo at 36 m elevation, south by southwest to about 850 m elevation (Fig. 1). The upper boundary contacts an 8 km wide stretch of Forest Reserve that connects with the northern border of Braulio Carrillo National Park (PNBC) extending to 2,906 m elevation.

The maximum length of the ZP is about 18 km. Its greatest width of 6 km is at the southern boundary of La Selva; the narrowest width of 3 km occurs in the vicinity of the present National Park Service (SPN) guardhouse near the origin of the Quebrada El Salto. The two principal north-south boundaries occur 300 m beyond the Peje and Guácimo rivers, thereby protecting the riparian forests and river gorges.

The ZP was created on 28 April 1982 by presidential decree No. 13495--A with two principal objectives: 1) to protect forest lands adjoining the 1,336 ha La Selva Biological Station and 2) to maintain an altitudinal corridor of primary forest, and its attendant flora and fauna, between lowland La Selva and the highlands in the 32,000 ha Braulio Carrillo National Park. "Protection zone" in Costa Rica is a legal designation generally assigned to small areas that are critical to development or in need of protection. Control of land use in protection zones is normally administered through the Forest Service (DGF); however, through an intra-ministerial agreement, the National Parks Service (SPN) has primary responsibility for the ZP. Designation as a protection zone means that land owners can continue with existing farming practices, but conversion or alteration of forest is prohibited. Protection zone status does not require expropriation of titled land or payment for improvements such as forest clearing, but this measure is viewed as a holding action while seeking funds to incorporate the lands into a national park. The SPN is actively evaluating the possibilities for converting the ZP into an extension of Braulio Carrillo. The private National Parks Foundation (FPN) of Costa Rica is seeking funds to consolidate the ZP as part of PNBC with the assistance of the OTS, World Wildlife Fund (US), and The Nature Conservancy.

Present Land Use

Interpretation of actual land use in the ZP is based on aerial photos (1:20,000) taken in January 1983 (Fig. 2). Of a total area slightly less than 74 km (about 19,200 acres), 73 percent is still in primary forest and the rest in various states of disturbance (Table 1).

All of the ZP is either legally titled as private land or is contested and claimed by squatters. The Agrarian Development Institute (IDA) collaborated with the SPN on mapping and evaluating private holdings and claims in the ZP. The 50 or so land holders in the ZP have accepted the current freeze on land use; however, the pres-

sure mounts with delays in government expropriation. Privately held land within established national parks and equivalent reserves is the paramount obstacle to the consolidation of the Costa Rican National Parks System (Hartshorn 1983). Government funds to buy out private holdings have been depleted by the worst economic crisis in the country's history.

Ecological Reconnaissance

Nine scientists under the auspices of OTS conducted a two-week expedition into the ZP in January 1983. The accounts that follow present a glimpse of an altitudinal transect with exceptional biological diversity that is a unique remnant on the extensively deforested Caribbean slopes of Central America. The importance of such areas to the hydrology and natural resources of the tropics argues persuasively for their preservation. We hope that this report will stimulate additional research in the ZP and encourage a concerted international effort to convert the ZP into an extension of Braulio Carrillo National Park.

Hydrology

The ZP is drained by two well-developed stream valley systems: the Peje and the Guácimo (Fig. 2). The Río Peje system [Quebrada Cascante, Q. Las Juntas (Q. Toño, Q. Zoncho, Q. Cathy)] drains western-central portions of the ZP, with the Peje itself cutting a deep gorge almost the entire length of the western ZP boundary. The Río Guácimo is a small creek in its upper watershed, forming a deep gorge only below 250 m elevation. The Guácimo and its western tributaries [Río Sardinalito (Q. Cavalonga, Q. Carvajal, Q. Gómez), Q. Cantarrana (Q. La Negra, Q. José María) and Q. La Gata (Q. La Gemela)] drain the eastern-central portions of the ZP. The northern third of the ZP is drained by the Q. El Surá and Q. El Salto directly to the Río Puerto Viejo, plus the Q. Esquina into the Q. Sábalo; the latter is an unusual branch of the lower Río Guácimo.

Virtually the entire watersheds of the Peje and Guácimo rivers lie within the ZP and the forest reserve (Fig. 1). The insured protection of the vegetative cover of these drainages is hydrologically crucial for groundwater stabilization in coastal plain areas such as La Selva. The Peje and Guácimo rivers constitute examples of high-gradient, tropical river systems—dropping from 1600 m to near sea level in less than 25 km.

The watersheds of the ZP are underlain by volcanic basalt with low solubility, and are therefore generally poor in dissolved compounds. The erosive potential of rivers in the ZP also warrants emphasis. During the rainy season high discharge in streams draining the ZP and PNBC have resulted in water levels 9 m above normal at La Selva. The Quebrada Sábalo (a branch of the Guácimo) has been observed to rise precipitously from .3 to 10 m and exhibit current velocities greater than 116 cm/

sec (Stout 1979). Heavy precipitation (ca. 4000–5000 mm/yr), coupled with the high gradient drainage systems and shallow soil profiles of the ZP, contribute to the fragility of the overall drainage system. In similar areas where rainforest has been converted to pasture, an estimated 400–800 tons of soil/ha/yr are lost (Hartshorn *et al.* 1982).

Ecological Life Zones and Forests

Altitudinal distribution patterns of certain tree species indicate that two ecological life zones (Holdridge *et al.* 1971) and two transitional areas occur in the ZP. The La Selva Biological Station area is classified bioclimatically as Tropical wet forest (mean annual rainfall 4000 mm). Near the south end of La Selva, Tropical wet forest-cool transition begins at 100–125 m elevation. This transition area is similar floristically and structurally to La Selva, with forest dominance by *Pentaclethra maculosa* (Mimosaceae); however, tree species more typical of higher elevations occur sporadically in this cool transition, e.g., *Calatola costaricensis* (Icacinaceae), *Guatteria recurvisepala* (Annonaceae), *Sloanea* sp. (Elaeocarpaceae). Other tree species such as *Minquartia guianensis* (Olacaceae), *Calophyllum brasiliense* (Guttiferae), and *Pithecellobium pedicellare* (Mimosaceae) are more abundant in the cool transition than at La Selva.

The transitional Tropical Premontane rain forest-perhumid life zone begins at 250–300 m elevation. This ecological change is exemplified by the fairly abruptly reduced abundance of *Pentaclethra maculosa*, to the point where it is no longer dominant. *Carapa guianensis* (Meliaceae), *Terminalia amazonia* (Combretaceae), and many canopy *Pouteria* spp. (Sapotaceae) are characteristic of this perhumid transition. The abundance of *Carapa* on the steep hillsides is a good indication that this area receives appreciably more rainfall than La Selva, possibly averaging as much as 4500 mm/yr.

Non-transitional Tropical Premontane rain forest life zone begins at 500–600 m. Numerous species of Lauraceae and Sapotaceae are prominent in the canopy along with *Laplacea semiserrata* (Theaceae), *Roupala complicata* (Proteaceae) and *Alchornea latifolia* (Euphorbiaceae). This life zone extends considerably beyond the southern, upper limit of the ZP.

The two transitions between Tropical wet forest and Tropical Premontane rain forest are not well represented in other conservation units on the Caribbean slope of Costa Rica. Although the enormous La Amistad National Park descends to about 300 m on the Caribbean side, this minimum elevation is in a river gorge and the park contains only a modest amount of forest below 500 m elevation. Similarly, the Hitoy-Cerere Biological Reserve also extends down to about 300 m elevation in the Talamanca foothills, but virtually all lowland primary forest in this area has been cut. The lower elevation limit of Braulio Carrillo National Park is about 500 m. Tortuguero National Park is a vast area of Tropical wet forest life zone, but it is entirely isolated from any upland areas.

Approximately 200 tree species were identified during the expedition. This number probably constitutes less than one-third the number of tree species to be expected in the 74 km² ZP. Since the La Selva tree flora contains 450 species (Hartshorn and Hammel 1982), the higher and wetter ecological life zone (Tropical Premontane rain) should add at least another 200 species of trees. Although no information is available on the tree flora of PNBC, it is not unreasonable for the extensive area of Tropical Lower Montane rain forest and minor areas of Tropical Montane rain forest in the national park to contain another 150 tree species. The 2,870 m altitudinal transect from the top of Volcán Barba to La Selva, a linear distance of only 35 km, could include some 800 tree species, or 40 percent of the number of tree species estimated for the entire country.

There are at least 69 tree species in the ZP that do not occur in Tortuguero National Park (too low and swampy), Braulio Carrillo National Park (top high) or La Amistad (too high and not as wet at low elevations). Several other tree species have good populations in the ZP, but are rare in Costa Rican national parks, including Corcovado. The ZP forests are critical habitat for at least 75 tree species including: *Alchorneopsis floribunda* (Euphorbiaceae), *Ampelocera hottlei* (Ulmaceae), *Anaxagorea phaeocarpa* (Annonaceae), *Ardisia granatensis* (Myrsinaceae), *Byrsonima aerugo* (Malpighiaceae), *Cespedesia macrophylla* (Ochnaceae), *Dalbergia tucurensis* (Fabaceae), *Dichapetalum bullatum* (Dichapetalaceae), *Dipteryx panamensis* (Fabaceae), *Dystovomita pittieri* (Guttiferae), *Eschweilera costaricensis* (Lecythidaceae), *Ferdinandusa panamensis* (Rubiaceae), *Guatteria recurvisepala* (Annonaceae), *Hippotis albiflora* (Rubiaceae), *Hymenolobium pulcherrimum* (Fabaceae), *Ilex skutchii* (Aquifoliaceae), *Lecointea* sp. (Fabaceae), *Lecythis ampla* (Lecythidaceae), *Macrobium* sp. nov., *M. costaricense* (Caesalpiniaceae), *Micropholis crotonoides* (Sapotaceae), *Ormosia macrocalyx* (Fabaceae), *Pithecellobium pedicellare* (Mimosaceae), *Posoqueria* sp. nov. (Rubiaceae), *Pouteria* sp. nov. (Sapotaceae), *Quararibea ochrocalyx* (Bombacaceae), *Richeria dressleri* (Euphorbiaceae), *Sloanea fragrans* and *S. latifolia* (Elaeocarpaceae), *Symplocos* sp. nov. (Symplocaceae), *Tabebuia guayacan* (Bignoniaceae), *Virola minutiflora* (Myristicaceae), *Vouarana* sp. nov. (Sapindaceae), and *Xylopia bocatorena* (Annonaceae).

Herbaceous and Understory Plants

Due to the limited time and specialized interests, plant collections were biased towards pteridophytes and the angiosperm families Araceae, Palmae, Cyclanthaceae, Piperaceae and Annonaceae. Some plant groups are species rich at lower elevations (e.g., Melastomataceae and Rubiaceae, and the genus *Piper*), whereas others (e.g., Sapotaceae, *Peperomia*) are more diverse at higher elevations. Other groups do not change perceptibly in diversity over the altitudinal gradient, or else it was not possible to assess changes in species composition, with the limited collections. Since the distribution of plants on the Atlantic watersheds of Costa Rica is so poorly known, the range of some species cannot be assessed at this time.

The following species are less common at La Selva than in the ZP. Species known from only one or a few collections at La Selva are marked by an asterisk (*). *Selaginella bombycina* Spring, *Danaea cuspidata* Liebm. (*), *Trichomanes diversifrons* (Bory) Mett. (*), *T. elegans* L. C. Rich., *Asplenium holophlebium* Bak., *A. cf. pteropus* Kaulf. (*), *Dennstaedtia dissecta* (Sw.) Moore, *Diplazium cf. cristatum* (Desv.) Alston (*), *Lindsaea lancea* (L.) Bedd. (*), *Oleandra articulata* (Sw.) Presl., *Tectaria brauniana* (Karst.) C. Chr., *T. plantaginea* (Jacq.) Maxon, *Thelypteris descussata* (L.) Proctor, *T. gigantea* (Mett.) Morton, *Anthurium lancifolium* Schott (*), *A. ochranthum* C. Koch, *A. ravenii* Croat & Baker, *Dieffenbachia cf. leopoldii* Bull., *D. longevaginata* Croat & Grayum sp. ined., *Homalomena hammeliana* Croat & Grayum sp. ined. (*), *Monstera lechleriana* Schott (*), *Philodendron davidsonii* Croat, *P. fragrantissimum* (Hook.) Kunth, *P. sagittifolium* Liebm. (*), *P. tenue* C. Koch & August., *Syngonium schottianum* Wendl. ex Schott, *Xanthosoma robustum* Schott (*), *Sphaeradenia carrilloana* Grayum & Hammel (*), *Calathea cleistantha* Standl., *C. cuneata* H. Kennedy, *Justicia sarapiquensis* McDade, *Paradrymonia decurrens* (Morton) Wiehler, *Canavalia* sp. (*), *Ardisia auriculata* Donn. Sm., *Passiflora nitida* H.B.K. (*), *Peperomia distachya* (L.) A. Dietr. (*), *P. emarginella* C. DC. (*), *P. hernandiifolia* (Vahl) A. Dietr., *P. montecristana* Trel., *Piper cf. euryphyllum* C. DC. (*), and *Psychotria polyphlebia* Donn. Sm.

Documented rarities occurring in the ZP and definitely in need of protection include: *Metaxya rostrata* (H.B.K.) Presl, *Tectaria brauniana* (Karst.) C. Chr., *Syngonium schottianum* Wendl. ex Schott, *Asplundia uncinata* Harl., *Potalia amara* Aubl., *Xylopiya bocatorena* Standl., *Philodendron aff. platypetiolatum* Madison, *P. rigidifolium* Krause, and the recently described *Asplundia ferruginea*, *A. sleeperae*, *Sphaeradenia carrilloana* (Grayum & Hammel, 1982) and *Justicia sarapiquensis* (McDade, 1982). Some of these species are also known from La Selva, but are otherwise unknown or seldom collected in Costa Rica.

The following species are rare in Costa Rica and unknown from La Selva: *Lycopodium callitrichaefolium* Mett., *Danaea carrillensis* Christ, *D. crispa* (Enders) Reichb. f., *D. plicata* Christ, *Trichomanes ankersii* Hook. & Grev.; several mid-elevation species of *Peperomia* (*P. ebingeri* Yuncker, *P. cf. quapilesiana* Trel., *P. lancifolioidea* W. Burger, etc.), *Hylaeanthus hoffmannii* (Schum.) Jonk. & Jonk., *Anthurium wendlingeri* Barroso, as well as the recently described *A. lentii*, *A. prolatum*, *A. amethystinum* (Croat & Baker 1979), *Heliconia lophocarpa*, *H. deflexa* (Daniels & Stiles 1979) and *Thelypteris pseudoaspidioides* (Gómez 1982).

Some of the more outstanding botanical findings of the expedition are detailed below.

Thelypteris valdepilosa (Baker) Reed, a rare fern known previously only from Colombia and a single Costa Rican specimen lacking good locality data (A. R. Smith, pers. comm.), was rediscovered in the ZP at about 800 m.

Mapania pycnocephala (Benth.) Benth. was also rediscovered, making only the second time it has been collected in Costa Rica, and the first time this Century (J. Gómez-Laurito, pers. comm.).

Geonoma epetiolata H. E. Moore, a distinctive palm recently described from two collections from Panama (Moore 1980), is rather common in the ZP above 200 m (G3098).

Syngonium armigerum (Standl. & L. O. Wms.) Croat, heretofore known only from the type collection in Cartago Province, was rediscovered on this expedition.

Monstera deliciosa Liebm., described by Madison (1977) as "rare in the wild", occurs sparingly in the ZP between 400–600 m. We have not seen any other wild collections of this economically important species from Costa Rica. A cultivar of this species is the source of an edible multiple fruit, "ceriman", and the preservation of wild genetic types might be of great significance to future breeding programs.

A fair number of apparently undescribed species were also collected or encountered in the ZP. Many of these are already known from La Selva, including *Anthurium llanoense* Croat sp. ined. (also known from Panama), *Philodendron mediacostatum* Croat & Grayum sp. ined., *P. aromaticum* Croat & Grayum sp. ined., *P. brunneicaule* Croat & Grayum sp. ined., *P. nitidum* Croat & Grayum sp. ined., *P. cretosum* Croat & Grayum sp. ined., *Syngonium sarapiquense* Croat & Grayum sp. ined., *Dieffenbachia beachiana* Croat & Grayum sp. ined., *Homalomena hammelii* Croat & Grayum sp. ined., *Ravnia* sp. nov., *Ctenanthe villosa* H. Kennedy sp. ined., and *Quararibea* sp. ined.

The following collections are believed to represent new taxa not known from La Selva or elsewhere: *Anthurium* sp.; two *Monstera* spp.; one and perhaps two *Pteris* spp.; *Peperomia* sp.; a spectacular dioecious, arborescent *Euphorbia* sp. in subsect. *Laurifoliae*; a bizarre understory treelet, possibly a new *Eugenia* sp., however the family determination is not even certain at this point; and a remarkable new *Unonopsis* sp. was also collected recently near Virgen del Socorro by Barry Hammel. One of the more exciting discoveries is an understory annonaceous treelet, seen only on a single slope. This specimen may represent a second species of the supposedly monotypic genus *Reedrollinsia*, now known only from southern Mexico. Many other unidentified collections from the ZP must await critical examination by specialists.

Mid-elevation forests between 300 and 1000 m on the Atlantic slope of Costa Rica have been poorly collected and are less well known than the adjacent lowland forests. As has been shown, a large number of rare and undescribed species exist in these forests. Several species of economic importance, or closely related to economic species, grow wild in the ZP, including *Monstera deliciosa*, *Vanilla* sp., at least two species of *Theobroma* (cacao) and several genera of palms valued for their "palmito" (heart of palm) —especially *Euterpe*. Perhaps of greater significance is

the unrealized potential value of this poorly known flora, not only as a source of food and timber, but also of pharmaceutical products, ornamentals and all of the other applications that accrue from such tremendous genetic diversity.

Avifauna

During the ZP expedition, we recorded 221 species of birds. It is estimated that the ZP avifauna comprises roughly 400 species including latitudinal and altitudinal migrants, plus accidentals. Inclusion of PNBC adds around another 100 species; thus the Volcán Barba—La Selva altitudinal transect includes 75–80 percent of Costa Rica's landbird avifauna (Stiles 1983). Observations were made during a period in which virtually no birds except hummingbirds were nesting. Therefore, information on breeding distributions in the ZP is largely indirect and inferential, or based on data from other areas (e.g., Carrillo). Furthermore, the strong "temporal" during the first week of the expedition may have provoked some altitudinal movements. Since altitudinal movements of many species are much more pronounced in some areas than others, elevation limits cited here are approximations of a dynamic situation.

The ZP spans an elevational band in which many mid-elevation species typical of PNBC and many lowland species typical of La Selva drop out of the local avifauna community. The lower limit of one such "Carrillo belt" species, *Myrmeciza laemosticta*, was pinpointed at 330 m along with approximate lower limits at 300–450 m for another 14 species, some of which had been recorded from La Selva in the past as accidental visitors (Stiles 1983). Approximate upper limits were defined for 30 species and at least 25–30 other species appear to be approaching their upper limits at 500 m. The ZP thus encompasses the upper or lower altitudinal limits for at least 60 (and probably as many as 100–120) species of birds.

Species reaching their upper limits in the ZP include *Malacoptila panamensis* (white-whiskered Puffbird), *Carpodectes nitidus* (Snowy Cotinga), and *Geotrygon veraguensis* (Olive-backed Quail-dove); at their lower limit in the ZP are *Leucopternis princeps* (Black-chested Hawk), *Lophotriccus pileatus* (Scale-crested Pygmy-tyrant), *Tangara florida* (Emerald Tanager), and *Fornicarius nigricapillus* (black-headed Ant Thrush), among others. Perhaps the most interesting ornithological discovery of the ZP expedition was a sizeable population of *Rhynchortyx cinctus* (Tawny-faced Quail), one of the rarest and least-known birds of Central America. The entire altitudinal range of this colorful little quail may be encompassed by the ZP.

The river gorges within the ZP are relatively unaffected by deforestation and thus serve as effective corridors for the movement of many forest birds. A number of bird species extend their distributions downward in the Río Peje gorge. Such birds include *Tigrisoma fasciatum* (Fasciated Tiger-heron), *Serpophaga cinerea* (Torrent Tyrannulet), raptors such as *Leucopternis princeps*, tanagers, and ovenbirds. Unusually dense populations of *Eurypyga helias* (Sunbittern) were also observed here.

This spectacular species, placed in its own monotypic family, is a rare visitor to La Selva.

Several bird species with declining populations at La Selva were found to have robust populations in the central ZP. These include *Ciccaba nigrolineata* (Black-and-white Owl), *Selenidera spectabilis* (Yellow-eared Toucanet), *Lanio leucothorax* (White-throated Shrike-tanager), *Leucopternis albicollis* (White Hawk), *Phaenostictus mcleannani* (Ocellated Antbird), *Shiffornis turdinus* (Thrushlike Manakin), *Spizaetus ornatus* (Ornate Hawk-eagle), and *Thamnistes anabatinus* (Russet Antshrike). Population declines of these species at La Selva are probably attributable to increasing isolation of the station from the surrounding primary forest. These species could potentially become more numerous again at La Selva should protection be afforded the ZP, including regeneration of areas presently in pasture and young secondary forest.

At least 33 bird species are known to use the ZP during seasonal altitudinal migrations between the mid-elevation PNBC and the lowland ZP or La Selva forests. Altitudinal migrants include *Aulacorhynchus prasinus* (Emerald Toucanet), *Cephalopterus glabricollis* (Bare-throated Umbrellabird), *Colibri delphinae* (Brown Violetear), *Corapipo alera* (White-ruffed Manakin), *Dacnis venusta* (Scarlet-thighed Dacnis), *Microchera albocoronata* (Snowcap), *Myadestes melanops* (Black-faced Solitaire), *Phaethornis guy* (Green Hermit), *Popelairia conversii* (Green Thorntail), *Procnias tricarunculata* (Three-wattled Bellbird), *Selenidera spectabilis* (Yellow-eared Toucanet), *Tangara gyrola* (Bay-headed Bananager), *Tangara icterocephala* (Silver-throated Tanager) and *Turdus obsoletus* (Pale-vented Robin). Since these altitudinal migrants may spend several months in lowland forests, deforestation would seriously threaten their survival.

A number of other species of higher elevations normally migrate to lower mid-elevations and rarely reach the lowlands. *Heliodoxa jacula* (Green-crowned Brilliant), *Lampornis hemileucus* (White-bellied Mountaingem) and *Myrmeciza immaculata* (Immaculate Antbird) are some examples of upper to mid-elevation migrants. Conversely, some lowland species migrate seasonally upslope, e.g., *Florisuga mellivora* (White-necked Jacobin), and *Thalurea colombica* (Crowned Woodnymph). Finally, a number of species, notably hawks and eagles, move altitudinally on a daily or sporadic basis. These migrants include such spectacular species as *Elanoides forficatus* (Swallow-tailed Kite), *Harpyhalietus solitarius* (Solitary Eagle) and *Leucopternis principis* (Black-chested Hawk). For all of these species the ZP forests represent essential habitat.

Of the approximately 400 species of birds known for La Selva, about 125 are restricted to interior, primary forest. If La Selva's 961 ha of primary forest were to be surrounded by pasture, over 75 percent of these primary forest interior species would eventually be lost from the reserve, including at least 30 taxa within 40 years following isolation (Stiles 1984). Clearly, the protection of the ZP forests is absolutely critical to the survival of the majority of the La Selva forest avifauna.

Mammals, Reptiles and Amphibians

Sightings and signs of 18 species of mammals were recorded. Monkeys were frequently heard and seen during the expedition, including *Alouatta palliata* (howler), *Ateles geoffroyi* (spider), and *Cebus capucinus* (white-face). A *Tamandua mexicana* (arboreal anteater), and a *Dasypus novemcinctus* (armadillo) were seen on the trail east of the Quebrada Cantarrana base camp. Marsupial observations were restricted to a *Chironectes minimus* (water opossum) and a *Didelphis marsupialis* (opossum), both observed at or near base camp.

Rodents appeared to be abundant in the ZP. We repeatedly saw tracks of *Agouti paca* (paca), and once found a hunters' blind with paca hair beneath it on a ridge above the Río Sardinalito. *Dasyprocta punctata* (agouti) and *Microsciurus alfarri* (dwarf squirrel) were sighted in the forest, and we found hair of *Proechimys semispinosus* (spiny rat) beside a tributary of the Quebrada Cantarrana. *Sylvilagus brasiliensis* (cottontail rabbit) were occasionally seen in grass along the trail east of base camp.

Carnivore sightings include *Potos flavus* (kinkajou) and *Nasua narica* (coati). We repeatedly encountered tracks of *Felis onca* (jaguar) throughout the ZP, and a fresh scat was observed on the trail east of the base camp.

We saw tracks of peccaries (*Tayassu*), deer (*Mazama americana*), and tapir (*Tapirus bairdii*) in the ZP, the latter both in forest and on a trail passing through the large finca of Bernardo Gómez, located at the southern end of the ZP (ca. 700 m). Local people told us that white-lipped peccaries (*T. pecari*) were especially vulnerable to overhunting because of large herd size and aggressive temperament, and that this species is now very rare or absent in the ZP. It seems likely that the tracks we saw were those of collared peccaries, *T. tayacu*.

Despite the occurrence of pasture (16%) in the ZP, our observations point to an abundance of native biota. Pastures are patchy and do not extend continuously across the ZP. Most pastures conform to the north-south physiography of the uplands and the widest is only 1,200 m. Thus, the existing clearings should not function as a permanent barrier to north-south movement of fauna.

Tropical herpetological communities are notoriously difficult to sample in short periods (e.g., Myers and Rand 1969), and our efforts were sometimes hampered by weather and the necessity of covering as much rugged terrain as possible in a few days. Nevertheless, we recorded 17 species of frogs and toads, a turtle, 11 species of lizards, and 15 species of snakes in the ZP. Most of these amphibians and reptiles are among the 125 taxa known from La Selva. Of the exceptions, *Atelopus varius*, a harlequin frog, and *Bufo melanochloris*, a toad, are typically found at higher elevations than La Selva (Savage 1972, 1980). The presence of these anurans in the ZP is correlated with greater topographic relief and indicative of a significant change in faunal composition that is undoubtedly underestimated, perhaps greatly, by our

brief reconnaissance. We obtained a single *Drymobius melanotropis*, perhaps one of the rarest moderate-sized colubrid snakes in Middle America, and endemic to southern Nicaragua and Costa Rica. Scott (1969) considered this green racer characteristic of middle elevations, but it has subsequently been recorded twice in the hillier southern portions of La Selva (Wilson 1975; Green & Donnelly, in prep.).

Anolis frenatus, a giant anole lizard, and *Smilisca sordida*, a tree frog, are known elsewhere from comparatively low elevations; our specimen of the former is the first record from Heredia Province (Savage and Talbot 1978). The apparent absence of these taxa from La Selva might reflect real distributional limits or simply the difficulty of locating arboreal herps. In any case, our collections and published data on salamanders (Wake and Lynch 1976) and frogs (Duellman 1970) make it clear that the altitudinal transect from La Selva to PNBC harbors a very rich and extremely interesting faunal gradient.

We did not encounter bushmasters (*Lachesis muta*) in the ZP, but local people repeatedly assured us that they occur there. This species, the largest living viper, is of special concern because it is restricted to lowland moist forest (Vial and Jiménez-Porras 1967), is apparently nowhere common, is very poorly known (Greene and Santana 1983), and potentially very vulnerable to human persecution and habitat destruction.

Like many other faunal components, the species richness of vertebrate predators is extremely high in northeastern Costa Rica. More than 100 species of snakes, birds and mammals that feed largely or entirely on vertebrates inhabit the La Selva reserve, whereas ca. 70 species of vertebrate predators occur in the entire state of California (Greene, MS). Considerations of small population size, social behavioral characteristics, and potential for human exploitation suggest that large vertebrate carnivores and herbivores are likely to disappear within a few years with the isolation of even moderately large patches of tropical forest (Frankel and Soule 1981). Observations of faunal change on Barro Colorado Island, Panama, during this century strongly support this expectation (Terborgh and Winter 1980). Field observations and experiments at a number of New World sites indicate further serious consequences of the disappearance of large predators. These include increases in smaller predators (e.g., *Dasypus*, *Nasua*), increased mortality on ground nesting birds and other prey, disappearance of substantial parts of the litter microfauna, increased number of arboreal folivores, and changes in crown structure and other aspects of forest ecology (Leopold 1959; Janzen 1978; Eisenberg 1980; Terborgh and Winter 1980; Loiselle and Hoppes; Greene *et al.* MS).

Lepidoptera

In spite of the foul weather of the first week, some 175 species of butterflies (excluding skippers) were recorded, including a number of very rare and little-known, and/or spectacular species, like *Papilio birchalli*, *Eurytides pausanias*, *Hypna clyte-*

mnestra, *Consul jansonii*, *Baeotus baeotus*, *Heliconius eleuchia*, *Eryphanis polyxena*, *Caerois gertrudis*, and *Morpho cypris* (one of five species of spectacular *Morpho* butterflies!). Rather few species of the families Lycaenidae and Riodinidae were recorded: these butterflies are highly seasonal and a longer period of observation would be required to assess their diversity. In general, the butterfly fauna of the ZP is characteristic of the 'foothill belt', an extremely rich zone for butterflies extending along the base of the Atlantic side of the mountains, the length of Costa Rica, in the transition from Tropical wet to Premontane rain forest.

In 1-1/2 nights of black-lighting we obtained 36 species of sphinx moths (Sphingidae) and 13 species of giant silkworm moths (Saturniidae), as well as many other species of at least 10 other families, especially the Arctiidae. Several very rare species were obtained, notably the sphingid *Xylophanes libya* (at least 30 individuals seen!) and the spectacular long-tailed saturniid *Copiopteryx semiramis*. The giant sphingid *Amphimoe walkeri*, with its foot-long proboscis, was also more numerous than at any other site we know.

Conclusions

The ecological reconnaissance into the La Selva Protection Zone (ZP) set out to document the plant and animal life and to assess its overall biological importance in maintaining species diversity along an altitudinal gradient. Through our brief excursion into this rugged area, we have identified many species of interest to man and science. It is our collective opinion that the ZP should be protected by the Costa Rican government with the following recommendations.

1. The La Selva Protection Zone (ZP) should be upgraded to national park status as an extension of Braulio Carrillo National Park (PNBC). The legal upgrading from protection zone to national park status is clearly justified by the restricted occurrence of more than 100 plant and bird species, critical habitat for altitudinal migrants, healthy populations of several large mammal and bird species and a preponderance of primary forest that is not protected elsewhere on the Caribbean slope of Costa Rica.
2. The 8 km hiatus of forest reserve between the ZP and PNBC must be included in the PNBC extension. The western ZP boundary should be continued due south along the Río Peje. The eastern boundary should extend from the southeast corner of the ZP (E529900; N251400) directly southeast to connect with PNBC where the Río Puerto Viejo leaves the Park (E542750; N246750) (Fig. 1). This appreciable widening from the south boundary of the ZP is justified because the Río Guácimo boundary constitutes a small and inconspicuous creek; virtually all of the forest reserve between the ZP and PNBC is still in primary forest. Continuing the ZP due south as a narrow corridor would permit deforestation southeast of the ZP, possibly creating a disjunction between the northeast corner of PNBC and the lowland forests of the ZP.

3. The northern boundary of the PNBC extension should be coincident with the south boundary of La Selva. At the southwest corner of La Selva the boundary could be extended due west to the Río Peje. On the northeast the extension boundary should follow Quebrada Esquina downstream along southeast La Selva to its confluence with the Quebrada Sábalo, then follow Quebrada Sábalo upstream to its origin at the Río Guácimo. The exclusion of La Selva from the PNBC extension is justified on the basis that OTS is doing an excellent job of protecting the northern end of the ZP and the need for experimental research on the Sarapiquí annex should not be hindered by national park status.
4. More detailed floral and faunistic surveys are needed within the ZP in the immediate future. High priority should be given to endangered or threatened species, as well as seasonal changes in abundance and distribution of known or suspected altitudinal migrants. Similarly, emphasis should be placed on groups of organisms (e.g., salamanders, frogs, bats) that frequently show altitudinal zonation and local endemism. Further studies on the ecology of large and poorly known terrestrial vertebrates, particularly predators, are also important to the successful long-term protection and management of the area.

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Resumen

Una expedición a la Zona Protectora La Selva (ZP), Provincia de Heredia, Costa Rica, auspiciada por la Organización para Estudios Tropicales (OTS), sirve como base para este comentario ecológico sobre uso de la tierra, hidrología, zonas de vida, y aspectos de la flora y fauna de la ZP. Bosques primarios cubren 73 por ciento del área de 7,368 ha que se extiende desde 36 m.s.n.m. a 850 m.s.n.m. Las 1,208 ha de potreros no parecen haber restringido hasta ahora a los movimientos de animales grandes y aves dentro de la zona protectora.

Dos zonas de vida más dos transiciones soportan cuatro comunidades distintas de bosques. Estimamos que la ZP contiene alrededor de 650 especies arbóreas y 400 especies de aves, además de proveer habitat crítica para por lo menos 75 especies de árboles y 50 de aves. Los miembros de la expedición descubrieron 28 especies nuevas de plantas, más 12 especies de plantas que no habían sido recolectados previamente en Costa Rica. Un mínimo de 35 especies de aves usan los bosques de la ZP para sus migraciones altitudinales. Además, se recordaron 17 especies de sapos, 27 especies de reptiles y 18 especies mamíferas, incluyendo monos, dantas y carnívoros grandes. Varias especies de la herpetofauna son poco conocidas, de las cuales tres especies no ocurren en La Selva.

El transecto altitudinal de 2.870 m desde la cumbre del volcán Barba (2.906 m.s.n.m.) a la estación biológica La Selva, en una distancia recta de apenas 35 km, ofrece un gradiente topográfico de bosques primarios y ríos sin igual en América Central. Juntos, se estima que el Parque Nacional Braulio Carrillo y la Zona Protectora La Selva albergan 80 por ciento de la avifauna y 40 por ciento de las especies arbóreas del país.

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Table 1. Land use in the La Selva Protection Zone, January 1983.

Land use	Hectares	%
Primary Forest	5,398	73
Pasture	1,208	16
Young Second Growth	440	6
Secondary Forest	248	3
Permanent Crops	74	1
TOTAL	7,368	100

Fig. 1. Location of Braulio Carrillo National Park, La Selva Protection Zone and the La Selva Biological Station in Costa Rica.

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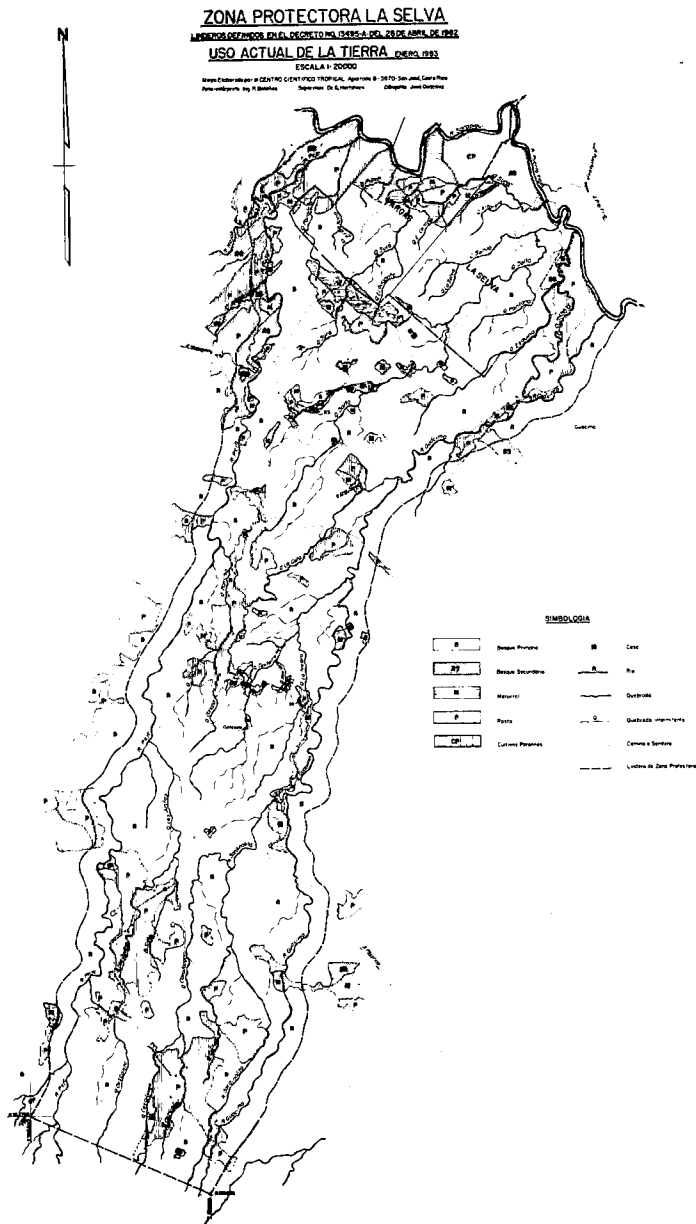


Fig. 2. Actual Land Use in the La Selva Protection Zone, Costa Rica, as of January 1983.