THE JOURNAL OF RAPTOR RESEARCH

A QUARTERLY PUBLICATION OF THE RAPTOR RESEARCH FOUNDATION, INC.

VOL. 25 SPRING 1991 NO. 1

J. Raptor Res. 25(1):1–8

ALTITUDINAL DISTRIBUTION AND CONSERVATION OF RAPTORS IN SOUTHWESTERN COLOMBIA

JEAN-MARC THIOLLAY

Laboratoire d'Ecologie, Ecole Normale Supérieure, 46 rue d'Ulm, 75230 Paris, Cedex 05, France

ABSTRACT.—Diurnal raptors were surveyed during four weeks along a gradient from sea level to 4000 m on the Pacific slopes of the Andes in southwestern Colombia. However, most of the work on habitat selection, density estimates and conservation problems was done within the subtropical level (1200–2400 m) in the 3200-ha forest reserve of La Planada and its surrounding mosaic of pastures, cultivated fields and disturbed forest. Twenty-two raptor species were recorded. Forest species richness does not change noticeably at successive levels between 0 and 1000 m, but this richness decreases rapidly above 1500 m. The number of open grassland species tends to increase with elevation. Extensive deforestation is a major threat to the survival of several forest raptors, including endemics from the humid western slope of the Andes. Some sufficiently large areas of relatively undisturbed forest, suitable for raptor conservation, still remain between 500 and 2000 m but very few can be found above or below this level.

Distribución y conservación de aves de rapiña en diversos niveles de altitud en el sudoeste de Colombia

EXTRACTO.—Raptoras diurnas fueron inspeccionadas durante 4 semanas a lo largo de una gradiente comprendida entre el nivel del mar y los 4000 metros, en las pendientes andinas del Pacífico en el sudoeste de Colombia. Sin embargo, la mayor parte del trabajo de selección de habitat, estimaciones de densidad y problemas de conservación, ha sido hecho dentro del nivel subtropical (1200–2400 m) en las 3200-ha. de la reserva forestal La Planada, y el mosaico de sus alrededores con pastos, campos cultivados y alterada floresta. 22 especies de aves de rapiña han sido registradas. La riqueza de las especies raptoras de floresta no cambia notablemente en los sucesivos niveles entre 0 y 1000 m, pero sí decrece rapidamente a partir de los 1500 m. El número de las especies de las áreas de pastos tiende a crecer con la elevación. La extensiva deforestación constituye el mayor peligro para la supervivencia de las aves raptoras de floresta; esto es cierto también para las especies de las húmedas pendientes occidentales de los Andes. Areas suficientemente grandes de floresta relativamente inalterada, apropiadas para la conservación de aves raptoras, aún se encuentran entre los 500 y los 2000 m, pero muy pocas pueden encontrarse por encima o por debajo de este nivel.

[Traducción de Eudoxio Paredes-Ruiz]

Colombia is ornithologically one of the richest countries in the world with at least 1695 species of birds reliably recorded, including 75 Falconiformes, as summarized by Hilty and Brown (1986). The extreme southwestern part of the country is among the least studied areas. Yet this Pacific slope of the Andes, called southern Choco, which extends into northwestern Ecuador, is both rich in endemic taxa and threatened throughout by rapid deforestation, especially in the lowlands. Moreover, diurnal raptors are usually poorly surveyed because specific survey methods are required to establish the presence, or to assess the relative abundance, of many species. These methods are time consuming and are often appropriate for only a particular subset of the raptor assemblage (Thiollay 1989a). The birds in this study area proved to be no exception.

The present study of the distribution of raptors along a gradient from sea level to 4000 m was of interest for several reasons. Little was known about the area and its endemic species; the gradient had a wide altitudinal range but within a relatively narrow

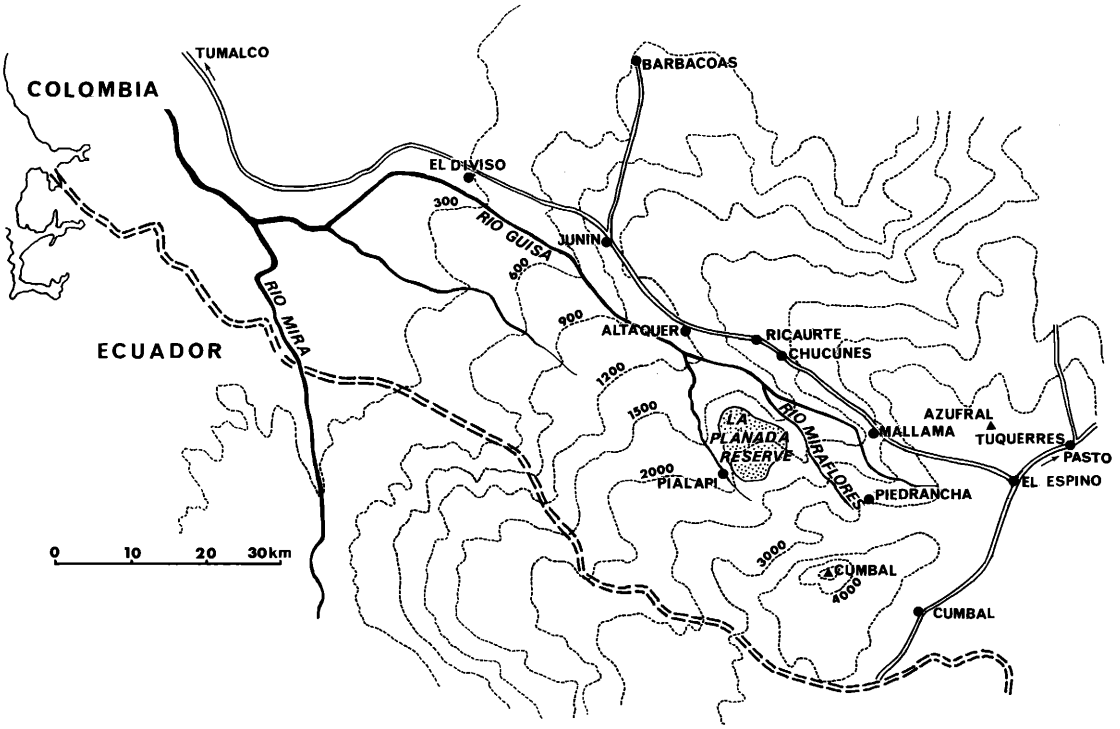

Figure 1. Map of the study area in southwestern Narino, Colombia. Dots represent villages or small towns and triangles the highest peaks (volcanoes).

strip; comparative data were drawn in 1987 from a personal survey of raptors in nearby northwestern Ecuador; this was among the first uses of raptors as sensitive indicators for the management of a Biosphere Reserve (UNESCO-MAB) proposed in the area; several species may soon become extinct because of the current high rate of deforestation.

STUDY AREA AND METHODS

The southwestern corner of Colombia (Narino), along the Ecuadorian border, provides a 115-km-wide gradient from the upper ridge of the western Andes, dominated by the Cumbal Volcano (4764 m), down to the Pacific coast. It is crossed by the Pasto-Tumaco road of which the El Espino-Altaquer section has been the most intensively surveyed during this study (Fig. 1).

This Pacific slope of the northern Andes (Choco) has the heaviest rainfall in the Americas (Hilty and Brown 1986), ranging from over 3000 mm on the coast to an average of 10 000 mm in the foothills (500–1000 m) and decreasing to about 4–5000 mm at the subtropical and montane levels. The heavy cloud cover tends to increase with altitude. The mean temperature drops by about 6°C with each 1000-meter increase in elevation.

The altitudinal gradient was divided into five main zones (Holdridge 1967). 1) The Paramo extends from the tree line (3200–3400 m) to the upper limit of vegetation (around 4500 m). The Rosette Shrub (*Espeletia* sp.) was characteristic of the lower part of this wet alpine grassland where some patches of low, dense *Polylepis* woodland still remained in the ravines. The upper part of the Paramo was dominated by grasslands. Strong winds, cool temperatures, moderate rains and extensive cloud cover occurred almost daily. 2) The temperate or montane forest was found mainly from 2500–3500 m between El Espino, Miraflores and Piedrancha. Trees were usually under 20 m tall and covered with epiphytes. Stunted trees and shrubs dominated a so-called elfin forest near the tree line. 3) From 2400 m down to 1200 m, a subtropical, humid or premontane forest was found. Many trees reached 25–30 m in height and were heavily covered by epiphytes (e.g., ferns, mosses, bromeliads). Trees were dominated by the genera *Cassia, Clusia, Ficus, Miconia,* as well as palms. The dense and wet undergrowth had many tree ferns. 4) From 1200 m to 500 m, in the Altaquer-Junin-Barbacoas-El Diviso area, the foothills bore a tropical wet forest (rain forest of Holdridge 1967). It was the elevation with the heaviest rainfall, covered by a dense, evergreen forest, with trees reaching 30–35 m. The highest tree species diversity may be found at this level (C. Samper, pers. comm.). 5) Below 500 m, the lowland wet forest was the tallest (35–45 m) with comparatively less undergrowth and still high tree species

richness. A wide belt of mangroves fringed the coast. All along the gradient, much of the original forest cover has been converted to cattle pastures and cultivated fields; shrubs predominated on lightly grazed or abandoned areas.

Most of my observations were made in and around La Planada Natural Reserve, within the subtropical zone. This 3200-ha reserve was at an altitude of 1500 to 2200 m and covered with primary forest. Over 200 ha were regenerating, after being either converted into pasture or logged for valuable timber 10–20 years ago. The mature forest was on average 20–30 m high with a dense, very wet undergrowth and a discontinuous canopy. Palms and tree ferns were numerous and epiphytes were omnipresent. Two hundred resident bird species have been identified (unpubl. list from numerous observers), including 25 Choco endemics. Mammals (squirrels, monkeys, carnivores) usually existed at low densities. The largest mammals were the Spectacled Bear, *Tremarctos ornatus* and the Brocket Deer, *Mazama americana.*

On the eastern border of the reserve, the deep valley of Pialapi was partly cleared for shifting cultivation and the remaining forest patches were often disturbed. Along the northeastern side, the slopes of the Rio Miraflores valley were used for cattle ranching, but substantial areas of forest still covered the upper slopes. The large valley of the Rio Guiza was densely populated and cultivated, with pastures on the upper slopes. Some patches of forest remained only on the steepest slopes, ridges and ravines. The lower and upper parts of the valley are here defined from the position of La Planada (at the level of Chucunes-Ricaurte) 25–30 km downstream to Altaquer and upstream to Mallama. The upper valley was more deforested but less cultivated than the lower section.

The entire area of La Planada-Pialapi and the valley from Altaquer to Mallama were surveyed on foot between 24 June and 26 July 1988. Three additional days were spent in the montane zone (around Cumbal and Azufral Volcanoes) and two days in the lowlands. Rain and fog were of almost daily occurrence and lowered the detectability of raptors. Using all available trails and roads, I searched the area for raptors from dawn to dusk, making intensive use of clear late morning hours. I spent more time in openings (treefall gaps, landslides, clearings, ridges) from where most raptors could be seen in flight. The secretive forest falcons (*Micrastur* sp.) were mostly located by their calls in early and late hours.

The data were expressed as the mean number of individuals recorded per hour spent under three different conditions affecting raptor detectability and defined as optimal, suboptimal and unsuitable. Based on prior experience (Thiollay 1989a), and according to the behavior of each species, these conditions included: habitat (i.e., inside or outside the forest), time of day and weather. A mean frequency of occurrence per hour was then calculated, using only optimal conditions. This index of abundance was comparable within a given species between different localities but not between species, which usually vary widely in their behavior and conspicuousness.

Most of La Planada Reserve was covered in this survey and all resident species are thought to have been recorded or confirmed by previous records. Conservative density estimates are presented based on the mapping of all observations and the behavior of adult birds monitored. This minimum number of pairs of each species is probably too low for the secretive small forest species but much more accurate for the conspicuous large soaring species. Pairs of displaying *Leucopternis* or *Leptodon* and even calling *Micrastur* were widely separated and thus easy to distinguish from each other without a complete mapping of their territory.

Around the 3000-ha forest of La Planada, an additional area of about 7000 ha of mixed pastures, cultivated fields, old clearings and disturbed forests was surveyed mainly for easily detectable (soaring) species. A minimum number of pairs was estimated for this total area of approximately 10 000 ha (see species status). The aim of the census was to provide some basic data about the ecological requirements of such species if their survival is to be considered in a future management plan for this part of the western Andes. More details about census are given elsewhere (Thiollay 1989a).

RESULTS

Altitudinal Distribution. The distribution of raptors along the altitudinal gradient is presented in Figure 2. It was not possible to give a more quantitative picture of the species' distribution because of the brevity of the survey in the foothills and lowlands. Table 1 emphasizes the relative abundance of species in the subtropical-temperate zone where most of the work was carried out. Below I describe the raptor assemblage in each successive altitudinal zone but species will be cited only in the upper level of their range and not repeated in each of the following ones (see Fig. 1). Especially in the least surveyed areas, some species may have been overlooked. This is why I mention the species that I have not seen but that have been recorded by J. Orejuela (pers. comm.) or that were known formerly and are still likely to exist at similar level in western Narino (Hilty and Brown 1986).

In the Paramo zone, the Carunculated Caracara (*Phalcoboenus carunculatus*) was still common and widespread in the highest grasslands and often came down to 3000 m or lower into ploughed fields. The Red-backed Hawk (*Buteo polyosoma*) was even more common, but was mostly associated with the lower paramo (up to 3800 m) and the montane grasslands down to 1800 m and even 1600 m in the La Planada area. Although considered merely a non-breeding migrant in Colombia by Hilty and Brown (1986), I found this species breeding on the slopes of the Azufral Volcano, above El Espino. An adult brought prey to a nest near the tree line at 3400 m on 7 July and another adult was followed by a calling, newly fledged young. Two Cinereous Harriers (*Circus ci-*

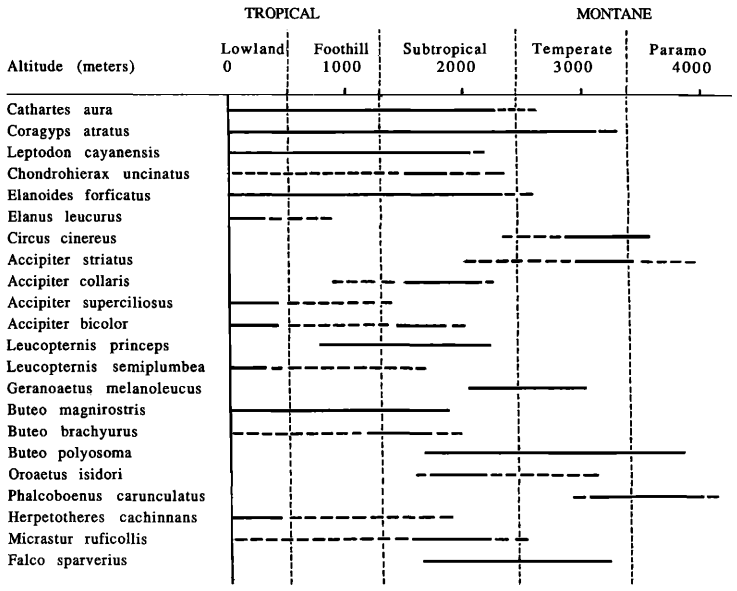

Figure 2. Altitudinal distribution of Falconiformes recorded in July 1988 along the Pacific slope of the Andes in southern Colombia. Solid lines represent regular observations. Dashed lines are ranges cited by Hilty and Brown (1986) but not confirmed during this study, or personal observations that are out of the known breeding level given by these authors. Fifteen additional species were formerly reported and are still likely to occur in the area, mainly in lowland forest.

Table 1. Raptor population of the subtropical zone in southwestern Narino, Colombia. Numbers represent the percentage of optimal detectability hours in which the species were recorded. Mean number of individuals seen per hr are in parentheses. The five habitats are arranged in increasing order of visually estimated deforestation. The total number of suitable census hrs ranged from 11–101.

	LA PLANADA RESERVE 1500–2200 m	PIALAPI VALLEY 1200–1900 m	RIO MIRAFLORES 1500–3300 m	LOWER RIO GUIZA 1200–1500 m	UPPER RIO GUIZA 1600–2500 m
Coragyps atratus		14 (2.0)	72 (4.2)	82 (4.1)	75 (5.3)
Cathartes aura		14 (1.0)	24 (1.0)	55 (1.8)	12 (4.0)
Leptodon cayanensis	28 (1.0)	20 (1.0)			
Chondrohierax uncinatus	20 (2.0)				
Elanoides forficatus	30 (1.0)	43 (6.7)	24 (5.6)	37 (18.3)	
Accipiter collaris	6 (1.0)	3 (1.0)			
Accipiter bicolor	4 (1.0)				
Leucopternis princeps	30 (1.5)	72 (1.8)	73 (2.2)		
Leucopternis semiplumbea	1 (1.0)				
Geranoaetus melanoleucus					25 (2.0)
Buteo magnirostris	14 (1.0)	57 (2.2)	79 (2.2)	45 (1.8)	12 (2.0)
Buteo brachyurus			9 (1.0)	12 (2.0)	
Buteo polyosoma			27 (1.3)		14 (1.0)
Oroaetus isidori	14 (1.0)				
Micrastur ruficollis	17 (1.1)				
Falco sparverius					38 (1.3)
Species richness	10	7	7	5	6
Diversity index (H')	2.150	1.376	1.582	1.143	1.106

nereus) were seen in the lower paramo and meadows of the same area. The Andean Condor (*Vultur gryphus*) formerly widespread (Goodfellow 1902), is now very rare in Narino (Orejuela, pers. comm.) and was not seen. It is still present in northern Ecuador (pers. obs.).

In the temperate montane zone, numerous Black Vultures (*Coragyps atratus*) were foraging in the cattle pastures and cultivated fields. They occurred up to 3300 m in the Cumbal-Espino-Tuquerres valley and were common in densely populated areas all along the gradient down to the coast. The American Kestrel (*Falco sparverius*) was locally common from 3200 m down to 1600 m. Two pairs of Black-chested Buzzard-Eagles (*Geranoaetus melanoleucus*) were located in the upper Rio Guiza valley around 2500 m and 2900 m. The nest of one of them, on a cliff ledge, contained a fully feathered fledgling on 17 July. I saw other pairs in similar grassy and rocky slopes near cliffs above El Pedregal and in the Rio Pasto Canyon near Chachagui. The only temperate forest raptor recorded was the Sharp-shinned Hawk (*Accipiter striatus*) between 3000 m and 3500 m. Three individuals, including one in dark phase, were hunting around a 200-ha forest remnant, along edges, shrubby areas, pastures and lower paramo at the foot of the Azufral Volcano. A feather was even found by C. Samper (pers. comm.) at 4000 m. The White-throated Hawk (*Buteo albigula*) which is a typical species of similar temperate forests in northern Ecuador, has not been observed here and is not cited from Narino (Hilty and Brown 1986).

In the subtropical zone, the Turkey Vulture (*Cathartes aura*), which was more common in the lowlands, extended here up to 2200 m and occasionally 2600 m but it was less numerous at this elevation than the Black Vulture. The Gray-headed Kite (*Leptodon cayanensis*) reached its upper limit at this level (2100–2200 m). It may breed up to 1900 m where a display flight was recorded, but it was more common in the coastal plain. The Hook-billed Kite (*Chondrohierax uncinatus*) which was seen at 1800–2000 m, may not be breeding at this upper limit of its range. The Swallow-tailed Kite (*Elanoides forficatus*) was seen commonly between 1200 and 2400 m, sometimes in flocks of 11 to 32 individuals. It was less abundant in the deforested lowlands. The little-known Semicollared Hawk (*Accipiter collaris*) and the much more conspicuous Barred Hawk (*Leucopternis princeps*) were the two most characteristic species of this altitudinal level and among the most frequent. I saw a pair of Barred Hawks down to 800 m below Junin. The Semi-collared Hawk is also known to extend down to the foothills (Hilty and Brown 1986). I observed both species up to 2200 m. The Bicolored Hawk (*Accipiter bicolor*) probably reaches its upper limit at La Planada Reserve where I recorded it several times around 1700 m. I saw it also in the lowlands and thus its range overlaps completely with that of *Accipiter superciliosus* and with most of that of *A. collaris*. The Roadside Hawk (*Buteo magnirostris*) was the most common hawk in the cleared semi-wooded areas, from sea level to 1900 m. It overlapped with the American Kestrel in the upper 200–300 m of its range. Individuals of the Short-tailed Hawk (*Buteo brachyurus*) were occasionally seen hunting up to 1900 m, but the highest established pair was recorded at 1300–1400 m. The White-rumped Hawk (*Buteo leucorrhous*) has been recorded in the La Planada area, but was not seen during this study. The Black-and-chestnut Eagle (*Oroaetus isidori*) is a rare, spottily distributed and threatened species, typically associated with the undisturbed, wet, subtropical forest of this level. I identified it six times, only in the La Planada area. The Barred-forest Falcon (*Micrastur ruficollis*) was the only common and widespread forest falcon, seen between 1500–2200 m, and may be the most abundant raptor in the natural forest undergrowth.

In the tropical foothills, no new species were recorded. However, two presumably rare Choco forest endemics, the Plumbeous Hawk (*Leucopternis plumbea*) and the Plumbeous Forest-falcon (*Micrastur plumbeus*) are known from this area, which several lowland species also may reach (Hilty and Brown 1986).

The lowlands were visited only briefly. This area was almost entirely deforested and devoted to cattle raising and cultivation. The only remaining forest patch was too small to include a representative sample of the natural raptor community. The species not previously recorded on the gradient were the Black-shouldered Kite (*Elanus leucurus*) and the Laughing Falcon (*Herpetotheres cachinnans*) in open pastures and secondary woodlands. Both may extend to 1000 m and more. The semiplumbeous Hawk (*Leucopternis semiplumbea*) and the Tiny Hawk (*Accipiter superciliosus*) were seen in and around forest fragments. I also recorded the former once at 1600 m in La Planada Reserve but it may not be resident at that altitude. Up to 10 additional forest species were known (Hilty and Brown 1986), and are still

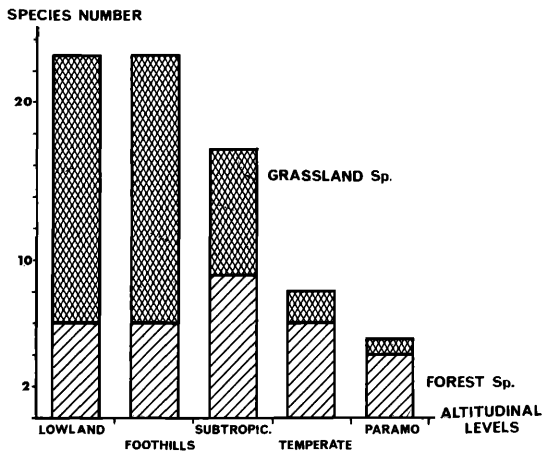

Figure 3. Highest number of primarily forest (hatched) and grassland or open-woodland species (cross-hatched) recorded in this study, or likely to occur (Hilty and Brown 1986), along the altitudinal gradient in SW Narino. All regular species are included, regardless of their abundance or breeding status. Occasional vagrants are excluded.

likely to occur in the coastal plain. These include the Double-toothed Kite (*Harpagus bidentatus*), Plumbeous Kite (*Ictinia plumbea*), Common Black Hawk (*Buteogallus anthracinus*), Crested Eagle (*Morphnus guianensis*), Black-and-white Hawk-eagle (*Spizastur melanoleucus*), Ornate Hawk-eagle (*Spizaetus ornatus*), Red-throated Caracara (*Daptrius americanus*), Slaty-backed Forest-falcon (*Micrastur mirandollei*), Collared Forest-falcon (*Micrastur semitorquatus*) and Bat Falcon (*Falco rufigularis*). Some of them may survive in the area but at least the eagles require large areas of relatively undisturbed forest (Thiollay 1989b) that may no longer exist at low elevation.

Habitat Selection in the La Planada Area. The raptors studied may be divided into several categories according to their natural habitat and their observed susceptibility to deforestation. Obligate forest species occur only in sufficiently large areas of primary or old secondary forest. *Micrastur ruficollis* has never been seen outside dense forest undergrowth. *Oroaetus isidori* was apparently hunting only over large tracts of forest, flying directly and high above clearings and second growth. Both species are likely to be the most sensitive to forest degradation or fragmentation.

Some primary forest species may hunt regularly along edges, in some openings, second growth and disturbed forest. *Leptodon cayanensis, Accipiter collaris, A. bicolor* and probably *Chondrohierax uncinatus* are representatives of this category. They may survive forest disturbance and fragmentation better than obligate forest species, but they do not take advantage of it and cannot persist in heavily deforested areas. Other forest species, such as *Leucopternis princeps,* are readily using, or even consistently associated with, natural or man-made openings inside the forest, including large wooded pastures along edges. *Elanoides forficatus* hunts for insects over the canopy of both unbroken and fragmented forest, as well as over open woodlands. They appear to benefit from a moderate amount of deforestation (at least *L. princeps* is rarer or absent in large unbroken tracts of forest) but they still avoid areas that are extensively cleared.

Originally nonforest species are still associated with partly wooded areas, forest edges and clearings (e.g., *Cathartes aura, Buteo magnirostris, B. brachyurus*). They increase their hunting and/or breeding range at least in the early stages of deforestation, since they readily colonize newly deforested areas. Most open grassland species invade formerly wooded areas in advanced stages of deforestation (Fig. 3). *Geranoaetus melanoleucus, Buteo polyosoma* and *Falco sparverius* were here typical representatives of the fauna replacing that of the former temperate forest.

The number of pairs of each species recorded during this one-month survey is probably too conservative. Some pairs may have been overlooked. However, the difference between the actual and observed densities cannot be great and is likely to provide a reasonable estimate of the current carrying capacity of the area. Two different pairs of *Leptodon cayanensis* were located on opposite sides of the 3000-ha La Planada Reserve. Their home ranges extended beyond the reserve's limits. An additional record may have represented a third pair within the 10 000-ha area. Only one pair of *Chondrohierax uncinatus* was seen flying over the reserve. One flock including 2 to 13 *Elanoides forficatus,* and sometimes additional isolated birds, were seen every day moving all over the area. The resident population within the 10 000 ha may not have exceeded 15 birds.

I made several observations within the reserve of *Accipiter collaris,* including individuals carrying prey. The existence of a minimum of two pairs can be assumed. This species was not seen outside the reserve. Similarly the presence of one pair of *Accipiter bicolor* was inferred from the spatial grouping of the six different records within the 3000-ha protected forest. However, these two secretive little hawks are

easily overlooked and their actual population may have been higher.

Leucopternis princeps was the only common large hawk. Six pairs were located on the 10 000-ha area. Three of the home ranges overlapped the limits of the 3000-ha reserve but probably none of them was completely included in it. At least seven pairs of *Buteo magnirostris* were identified, always associated with clearings. Only one pair was on the reserve. One pair of *Buteo polyosoma* with a fledged young was hunting regularly in the northern part of the study area, outside the reserve. One adult *Oroaetus isidori* was seen several times over the western and southwestern parts of the reserve, often ranging well outside the boundary of the protected area. It is unlikely that more than one pair of this rare eagle occurred within the 10 000-ha study area and the protected forest zone was apparently not large or suitable enough to meet all of its requirements.

At least, three well separated pairs of *Micrastur ruficollis* were located (direct observations and dawn or dusk calls), within the central part of the reserve. It was probably the most abundant forest raptor and the only one for which the 3000-ha reserve may be large enough to support a significant, if not self-sustainable, population.

DISCUSSION

Community Composition. Twenty-two raptor species were recorded and at least fourteen additional ones are expected. Altogether, two-thirds (24) are forest species, and only 12 are grassland or very open-woodland species. The marked succession and turnover of communities found along altitudinal gradients in the Andes (see Terborgh 1971, Terborgh and Walker 1975) were also found here, although the incomplete censuses at lower levels preclude a detailed analysis. Some species had narrow altitudinal distributions, replacing each other along the gradients while others had wider and overlapping distribution ranges (Figure 1). The genus *Accipiter* offers striking examples of three altitudinal specialists, with *A. superciliosus* under 1000 m, *A. collaris* between 1000 and 2500 m and *A. striatus* above 2500 m. The range of a larger species, *A. bicolor,* overlapped with that of *collaris* and *superciliosus.*

The total species richness, and the number of forest species, quickly decreased with altitude, but only above 1000 m (Figs. 2 and 3). At mid-level of the gradient (subtropical), the loss of forest species through deforestation was partly balanced by the invasion of species originating from grasslands and upper levels. At this elevation, the grassland community became richer than that of the forest alone. But the overall man-induced richness of the forest-grassland mosaic was still 26% lower than that of the tropical forest alone. At higher elevation, more raptor species were favored than were lost when the forest cover was destroyed. Conversely, below about 1500 m, many more species were lost than gained through large scale deforestation. The bird assemblages of small degraded patches of woodlands among fields and pastures were probably much poorer than those of the original forest. These patterns may be explained by the former rarity of open habitats below the temperate zone and the evolution of few species adapted to open areas in the humid lowlands. Moreover, apart from paramo specialists, most of grassland species benefiting from deforestation were geographically widespread and often common species, whereas the disappearing forest birds were potentially threatened everywhere and are therefore in more urgent need of conservation.

Conservation Problems. Raptors face a major threat from the extensive and rapid deforestation at all altitudinal levels, for cattle grazing more than for cultivation. Logging is now very important everywhere (first for valuable timber, then for fuelwood and charcoal) and it often precedes and prompts forest clearing. Erosion prevents regeneration and further aggravates deforestation. Pollution and hunting pressure seemed to have only a local and minor impact.

No comparable censuses, with statistically testable results, have been made in different forest types. However, at least within the best studied area, both abundance and diversity of forest raptors decreased with the reduction and degradation of forest patches (Table 1). A higher proportion of records per unit of time or distance covered was obtained from high primary forest in the reserve, on moderate slopes with deep, well-drained soils. Unfortunately these areas are also the most accessible and are said to be the most valuable for timber production and agriculture. Therefore they are the first to be logged and cleared. The remaining forest patches tend to be of the poorest type, i.e., on steep slopes, at high elevations, in ravines, on narrow ridges or swampy flats.

The wet Pacific slope of the Andes of Colombia and western Ecuador is well known for its numerous endemic bird species. Among the Falconiformes alone, several species have restricted ranges (*Micrastur*

plumbeus, and to a lesser extent, *Leucopternis plumbea* and *L. princeps*) or very scattered distributions (e.g., *Accipiter collaris, Oroaetus isidori*). Moreover, they are very little-known forest species whose long-term conservation may be dependent on national parks in Colombia and Ecuador which are currently in small number and understaffed.

Although the minimum size of a viable population of raptors is still debated, it can hardly be lower than several pairs. Thus the size of an isolated forest patch required for the long-term survival of a raptor population must be large. The 3200-ha reserve of La Planada harbors at best a few pairs of the most abundant species and not a single complete home range of the rarest ones. Fortunately, several species here use edges, clearings or secondary vegetation around the forest (all *Accipiter* and *Leucopternis* species) or can cross wide expanses of degraded woodlands between primary forest patches (*Oroaetus*). The small forest falcons (*Micrastur*), although restricted to forest undergrowth, may have small territories (under 100 ha) and reach relatively high densities (this study, Klein & Bierregaard 1988, Thiollay 1989b). These behavioral traits may reduce the area of forest reserves necessary for the survival of viable populations of these species.

Within the study area, both the lowland and the temperate zones are so deforested that there is little hope of preserving a viable natural community of forest raptors or even to afford the persistence of every forest species. In the La Planada-Pialapi area, significant expanses of suitable forest still remain. If deforestation can be stopped (e.g., through a management plan of the proposed Biosphere Reserve), the original raptor community may survive. However, the best prospects for conservation lie with the large tracts of little-disturbed forest that still remain on lower slopes (500–1000 m, notably the Junin-Barbacoas area). The very heavy rainfall may prevent large scale agricultural development and most of the easily accessible timber has already been logged. It is the last opportunity to take conservation measures in an area that probably harbors most of the species of the lower and upper levels, as well as endemics of its own.

ACKOWLEDGMENTS

The study was funded by the UNESCO-MAB project (Paris). It has been made possible thanks to the help and logistic support of the team of the La Planada Reserve, especially its director Jorge Orejuela and its manager Guillermo Cantillo. D. and B. Snow as well as C. Samper were also helpful both in the field and through their comments on a first draft of the manuscript, which was typed by F. Thiollay. To all of them, I am very grateful.

LITERATURE CITED

GOODFELLOW, W. 1902. Results of an ornithological journey through Colombia and Ecuador. *Ibis* 8:207–233.

HILTY, S.L. AND W.L. BROWN. 1986. A guide to the birds of Colombia. Princeton University Press, Princeton, NJ.

HOLDRIDGE, L.R. 1967. Life zone ecology. Tropical Science Center, San Jose, Costa Rica.

KLEIN, B.C. AND R.O. BIERREGAARD. 1988. Movement and calling behavior of the Lined Forest-Falcon (*Micrastur gilvicollis*) in the Brazilian Amazon. *Condor* 90. 497–499.

TERBORGH, J. 1971. Distribution on environmental gradients: theory and a preliminary interpretation of distributional patterns in the avifauna of the Cordillera Vilcabamba, Peru. *Ecology* 52:23–40.

——— AND J.S. WALKER. 1975. The role of competition in the distribution of Andean birds. *Ecology* 56:562–576.

THIOLLAY, J.M. 1989a. The census of diurnal raptors in a primary rain forest: comparative methods and species detectability. *J. Raptor Res.* 23:72–84.

———. 1989b. Area requirements for the conservation of rain forest raptors and game birds in French Guiana. *Conservation Biology* 3:128–137.

Received 19 May 1989; accepted 25 September 1990