BIRD ECOLOGY, CONSERVATION, AND COMMUNITY RESPONSES TO LOGGING IN THE NORTHERN PERUVIAN AMAZON

by

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(Under the Direction of Robert J. Cooper)

ABSTRACT

Understanding the responses of wildlife communities to logging and other human impacts in tropical forests is critical to the conservation of global biodiversity. I examined understory forest bird community responses to different intensities of non-mechanized commercial logging in two areas of the northern Peruvian Amazon: white-sand forest in the Allpahuayo-Mishana Reserve, and humid tropical forest in the Cordillera de Colán. I quantified vegetation structure using a modified circular plot method. I sampled birds using mist nets at a total of 21 lowland forest stands, comparing birds in logged forests 1, 5, and 9 years postharvest with those in unlogged forests using a sample effort of 4439 net-hours. I assumed not all species were detected and used sampling data to generate estimates of bird species richness and local extinction and turnover probabilities. During the course of fieldwork, I also made a preliminary inventory of birds in the northwest Cordillera de Colán and incidental observations of new nest and distributional records as well as threats and conservation measures for birds in the region.

In both study areas, canopy cover was significantly higher in unlogged forest stands compared to logged forest stands. In Allpahuayo-Mishana, estimated bird species richness was highest in unlogged forest and lowest in forest regenerating 1-2 years post-logging. An estimated

24-80% of bird species in unlogged forest were absent from logged forest stands between 1 and 10 years postharvest. Ten years after logging, bird species richness remained significantly lower in logged forest compared to unlogged forest. In the Cordillera de Colán, estimated bird species richness was similar between unlogged forest and logged forest stands, but logged forests 4-5 years postharvest had a significantly greater estimated number of species than logged forest 1-2 years postharvest. An estimated 28-30% of unlogged forest understory bird species were absent from logged forest between 1 and 5 years postharvest. These results suggest that even where logging is carried out without the use of heavy equipment and logged stands are interspersed in large tracts of unlogged forest, it is associated with moderately low to high rates of local extinction of unlogged forest understory bird species.

INDEX WORDS: selective logging, tropical forest, white-sand forest, understory, birds, species richness, community dynamics, jackknife estimator, COMDYN4, endangered species, distributions, indigenous communities, Aguaruna-Jívaro, Cordillera de Colán, Allpahuayo-Mishana, Peru, Amazonia, conservation

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For Pwiat
and for Bióloga
and everything they loved
in celebration

In our next lives, we’ll remember
not to be human.
We’ll be a pair of wild geese
flying high into the sky
And from that distance,
we’ll look down
on the world’s blinding snows
its oceans, waters, hills,
clouds and red dust
as if we had never fallen.

- Nguyen Khac-Hieu

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We need another and a wiser and perhaps a more mystical concept of animals. Remote from universal nature, and living by complicated artifice, man in civilization surveys the creature through the glass of his knowledge and sees thereby a feather magnified and the whole image in distortion. We patronize them for their incompleteness, for their tragic fate of having taken form so far below ourselves. And therein we err, and greatly err. For the animal shall not be measured by man. In a world older and more complete than ours they move finished and complete, gifted with extensions of the senses we have lost or never attained, living by voices we shall never hear. They are not brethren, they are not underlings; they are other nations, caught with ourselves in the net of life and time, fellow prisoners of the splendor and travail of the earth.

- Henry Beston

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CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

Understanding how birds respond to logging is a critical part of developing integrated forest management plans that mitigate logging damage and support the long-term protection of wildlife. In this project, I examined bird ecology, conservation, and community responses to selective logging in western Amazonia through studies in the Allpahuayo-Mishana Reserve, dept. Loreto, and the Cordillera de Colán, dept. Amazonas, northern Peru. Peru is one of the most biologically diverse countries on earth and is host to nearly 20% of the world's bird species (Schulenberg *et al.* 2007). This spectacular avifauna is one of the largest on earth in a single country and includes a number of recently discovered species in the northern Peruvian Amazon (Graves 1981; Graves and Parker 1983; Schulenberg and Williams 1982; O'Neill and Parker 1997; Johnson and Jones 2001; Alvarez Alonso and Whitney 2003). Much of the regional fauna and flora in the northern Peruvian Amazon remains undocumented and poorly known (Rodriguez and Young 2000), such that research for this study contributes not only to understanding birds' responses to selective logging, but also to knowledge of baseline avian ecology, conservation and threats in the region.

Selective logging opens the forest canopy and allows light to reach the forest floor, making the understory hotter and drier and its vegetation denser than that of unlogged forest. Too few studies have examined how selective logging impacts biodiversity to predict how any taxonomic group might respond to different intensities of selective logging (Whitman et al. 1998; White and Tutin 2001). Birds may be appropriate biological indicators of forest logging damage because of their wide ranges, interactions with other organisms, and sensitivity to landscape-scale disturbances (Furness and Greenwood 1993). Birds play critical roles in forest structure and function as pollinators, predators, seed dispersers, and prey for other animals. With their high visibility and aesthetic appeal, birds have also helped garner popular support for conservation worldwide.

Few studies in the Neotropics have evaluated the effects of logging on birds (Mason and Thiollay 2001), and none has taken place in Peru. Research elsewhere in the tropics has shown that selective logging has major impacts on primary forest bird communities, especially those that forage and breed in forest understory, and that many understory bird species decline dramatically or disappear altogether following selective logging (Wong 1985, Lambert 1992; Thiollay 1992, Johns 1996, Mason 1996, Dranzoa 1998, Marsden 1998, Dale et al. 2000, Mason and Thiollay 2001, Plumptre *et al.* 2001). Because understory birds are particularly sensitive to alteration in forest structure due to logging, they may serve as reliable indicators of forest regeneration (Wong 1985; Whitman et al. 1998).

Most studies of the impacts of selective logging on biodiversity have examined mechanized selective logging (e.g., Wong 1985, Thiollay 1992, Mason 1996, Dranzoa 1998, Marsden 1998, White and Tutin 2001, Sekercioglu 2002). Mechanized selective logging typically results in the destruction of about 50% of all trees present before logging, most of which is incidental damage due to timber felling and skidding (Johns 1988, White 1994). By contrast, I examined selectively logged forest stands where trees have been harvested without the use of heavy equipment. I evaluated the effects non-mechanized logging has on forest structure and understory birds, identified bird species and groups particularly vulnerable to logging damage, and contributed to baseline ecological research towards improved planning for conservation in the region.

Background and Justification

Case study 1: Allpahuayo-Mishana Reserve, Loreto Department. As the first case study in this project, I examined the effects of selective logging on understory birds in low elevation (~125 m a.s.l.) moist tropical forest in the Allpahuayo-Mishana Reserve, Loreto. Allpahuayo-Mishana is in an area of extraordinarily high habitat heterogeneity and high species endemism; previous studies have established that the area hosts some of the highest diversity of flora in the world, but few studies on fauna ecology in the area have been conducted (Alvarez Alonso 2002, Alvarez Alonso and Whitney 2003).

In 1999, the Peruvian government created the 57,600 ha Allpahuayo-Mishana Reserve, in part to protect a number of recently discovered endemic bird species apparently restricted to white-sand forests in the Nanay River basin (Alvarez Alonso 2002, Alvarez Alonso and Whitney 2003). The reserve includes over 400 bird species and is located 22 km southwest of Iquitos, the largest city in the Peruvian Amazon with a population of 300,000 (Juvonen and Alvarez Alonso 2003). The reserve's proximity to a large and growing urban center has placed increasing demands on its resources. Although commercial logging is prohibited in the reserve, illegal logging is widespread and uncontrolled (Whitney and Alvarez 2005), and is among the main threats to its protection (Juvonen and Alvarez Alonso 2003). Local people selectively log the endemic tree, *Caraipa utilis*, from white-sand forests for sale as construction material in the nearby city of Iquitos; this species makes up about 70% of the wood used to build houses (Vasquez 1991). Successfully addressing this and other threats will involve working with communities within the reserve to involve them in conservation efforts, conducting environmental education and developing alternative uses such as sustainable ecotourism (Juvonen and Alvarez Alonso 2003).

Research for this project took place in October–November 2005. Legal commercial logging took place in Allpahuayo-Mishana until the reserve was designated in 1999, where 30-40 trees were extracted from a single area and transported by road or river to Iquitos (J. Díaz Alvan, pers. comm.). Despite laws prohibiting most commercial extraction, clandestine logging operations persist in the reserve, which appears to result in the removal of a similar volume of timber removal, or approximately 30-40 stems per logged stand.

Case Study 2: Cordillera de Colán, Amazonas Department. As the second case study in this project, I examined the effects of selective logging on understory birds in mid-low elevation (550–750 m a.s.l.) humid tropical forest in the northern Cordillera de Colán, dept. Amazonas (Figure 7.1). The Cordillera de Colán is an isolated mountain range that forms part of the Tropical Andes biodiversity hotspot identified by Conservation International as a global priority for conservation, due to its high concentration of endemic species and severe environmental degradation (Myers *et al*. 2000). BirdLife International divides the Cordillera de Colán into four Endemic Bird Areas: the Peruvian Cordilleras, which includes the eastern Andes from 5-10º south of the equator; the Andean Ridge Forests, which includes ridge top elfin forest; the Marañón Valley, which includes low altitude dry deciduous forest; and the Ecuador-Peru East Andes, which includes humid forests on foothills and lower mountain slopes (Davies *et al.* 1997).

In 2002 Peru established the 64,115 ha Cordillera de Colán Reserve as part of a national initiative to promote biodiversity conservation. The new reserve is designed to protect a number of rare and endemic species, including the endangered Royal Sunangel (*Heliangelus regalis*), Ochre-fronted Antpitta (*Grallaricula ochraceifrons*), Russet-mantled Softtail (*Thripophaga berlepschii*), and Long-whiskered Owlet *(Xenoglaux loweryi*) (BirdLife International 2008).

Peruvian legislation recognizes a number of management categories for protected areas, and the new reserve now needs to be categorized based on studies of its wildlife in consultation with local communities (Davies et al. 1997). The Peruvian government has stated a particular need to increase participation of indigenous people in protected area management (World Bank 2000).

No published studies of any kind appear to exist for the northern part of the Cordillera de Colán. The only published survey of birds in the Cordillera de Colán took place 11 years ago in the southern part of the mountain range, approximately 40 km southwest of what is now the reserve (Davies *et al.* 1997). At that time, researchers observed rapid, large-scale deforestation due to logging and burning for agriculture by recent colonists in the area from other parts of Peru; more recent surveys have confirmed that habitat destruction in the area continues unabated (BirdLife International 2008; pers. obs. 2004). The reserve, which was created in part due to research and recommendations by Davies *et al.* (1997), is located in an extremely remote, high altitude region that remains virtually inaccessible and uninhabited by people. No roads or paths to the reserve appear to exist, and no studies appear to have been carried out within the reserve itself.

Research took place in the northern part of the Cordillera de Colán between August 2003 and March 2005, in forest located approximately 30 km north of the new reserve. The northern part of the Cordillera de Colán is part of a large semi-autonomous indigenous territory inhabited by two Jívaro-speaking native American groups, the Aguaruna and Huambisa, who traditionally hunt a wide range of birds and exhibit substantial knowledge of bird species identification, behavior and habitat (Berlin and Berlin 1983). Aguaruna communities in the northern Cordillera de Colán practice single-tree selective logging, primarily for the timber species *tornillo* (*Cedrelinga cateniformis*). Commericial logging in the study area is carried out without the use of heavy machinery or vehicles. Boards are cut at the timber harvest site, carried to the main river, and floated to a central location for processing; once processed, they are floated a further 5 km downstream to the nearest road crossing for commercial pickup.

Study Objectives and Implementation

My research objectives were to: 1) quantify and compare the forest understory bird communities at unlogged and logging forest stands at varying times since logging; 2) quantify vegetation structure at these logged and unlogged forest stands; 3) investigate whether time since logging or any measures of vegetation structure correlate with understory bird community parameters or abundance of forest bird species; and 4) use research findings to make conservation recommendations that involve local communities.

Further objectives in the Cordillera de Colán were to: 1) generate an inventory of area avifauna, which may be used in setting up monitoring programs; and 2) determine the presence or absence of populations of endangered bird species in the study area. This has already been accomplished at the Allpahuayo-Mishana Reserve (J. Díaz Alvan, pers. comm.), and so was not necessary to carry out at this location.

Objectives were met by sampling understory bird communities using mist nets at multiple study plots in unlogged and logged forests, and by quantifying forest structure at different stages of regeneration after selective logging. Preliminary work involved conducting general bird surveys and training local collaborators in bird field research. The research team in the Corillera de Colán included: Anika Mahoney, Agustín Tsamajain Yagkaug, Oscar Tsamajain Shiwig, Segundo Tsamajain Yagkaug, Roberto Jeremías Wampush, and Enrique Tsamajain Chumpi. The research team in Allpahuayo-Mishana included: Joel Holzman, Julio Sánchez Indama, Eneas Perez Walter, and Alimber Amasifuen Amasifuen.

Research for this project was carried out in partnership with local communities at the study sites. Project objectives, methods, results, and recommendations were presented and discussed in community meetings to solicit community input and promote community participation in conservation action. Research reports and publications have been submitted on an ongoing basis to the Asociación Peruana para la Conservación de la Naturaleza (APECO), Conservation International, the American Bird Conservancy, the Instituto de Investigaciones de la Amazonía Peruana (IIAP), the Instituto Nacional de Recursos Naturales (INRENA), the Unión Ornitológica del Perú (UNOP) and other relevant institutions to be used in promoting sustainable resource management practices and environmental education programs that promote the inclusion of local people in the conservation and management and of forests and wildlife in and adjacent to the Cordillera de Colán and Allpahuayo-Mishana Reserves in northern Peru.

Chapter Organization

This dissertation includes six manuscripts based on the research described above at various stages from in preparation to in print. The manuscripts are preceded by an introduction and literature review, and are followed by a brief conclusion that highlights major findings, conservation implications, and recommendations based on this study. Recommendations focus on applying research results to develop and implement conservation strategies for bird species affected by current logging practices. The manuscripts are organized in chapters as follows:

1) Chapter 2, "Bird community responses to selective logging in white-sand forests of western Amazonia," examines the effects of non-mechanized selective logging on white-sand forest understory bird communities in the Allpahuayo-Mishana National Reserve; it is in preparation for submission to *Forest Ecology and Management*.

2) Chapter 3, “Bird community responses to non-mechanized logging in humid tropical forest in the Cordillera de Colán, Peru,” examines the effects of non-mechanized, single-tree selective logging on humid Neotropical forest understory bird communities; it is in preparation for submission to *Conservation Biology*.

3) Chapter 4, “Birds of the north-west Cordillera de Colán, Peru, with range extensions for some birds in western Amazonia,” presents taxonomic and new distributional findings based on bird surveys and sampling in the same study area; it is in preparation for submission to *Ornitologia Neotropical*.

4) Chapter 5, “First description of the nest of the Brown Nunlet *Nonnola brunnea*,” is a contribution to our knowledge of the breeding ecology of a species in the family Bucconidae (puffbirds), for which such information is generally poorly known; it was published in *Cotinga*.

5) Chapter 6, “A new location and altitude for the Royal Sunangel *Heliangelus regalis*,” includes a geographical and elevational range extension and contribution to knowledge of breeding ecology of an endangered hummingbird species endemic to Peru; it has been accepted in *Cotinga*.

6) Chapter 7, “Bird conservation in Aguaruna-Jívaro communities in the Cordillera de Colán, Peru,” highlights some ongoing conservation threats and strategies in the first of my two study areas in the northern Peruvian Amazon; it was published in *Ornitologia Neotropical*.

Two additional collaborative manuscripts are mentioned here because of their subject relevance, but are not included in the dissertation because I was a contributing author rather than first author. These include: “An avian assessment of the Pongos basin, dept. Amazonas, Peru,” by D. M. Brooks, J. P. O’Neill, M. S. Foster, T. Mark, N. Dauphiné, and I. Franke, which is in press in the *Wilson Journal of Ornithology,* and “Aguaruna-Jívaro knowledge of bird foraging ecology: A comparison with scientific data," by K. Jernigan and N. Dauphiné, which is in press in *Ethnobotany Research and Applications*.

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CHAPTER 2

BIRD COMMUNITY RESPONSES TO LOGGING IN WHITE-SAND FORESTS OF WESTERN AMAZONIA[1]

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ABSTRACT. We examined the responses of understory bird communities to non-mechanized selective logging in western Amazonia through a case study in Allpahuayo-Mishana National Reserve, Peru. Allpahuayo-Mishana is in an area of high habitat heterogeneity and species endemism that hosts a number of recently discovered bird species associated with its rare Amazonian white-sand forests. Most logging is illegal in Allpahuayo-Mishana, but clandestine logging operations persist and are thought to pose one of the main threats to biodiversity in the reserve. We used mist nets to sample birds at 12 study stands in unlogged forest and forest regenerating between 1 and 10 years after selective logging. We detected a total of 54 bird species in 16 taxonomic families. We assumed not all species were detected and used sampling data to generate estimates of bird species richness and local extinction and turnover probabilities. Estimated bird species richness was highest in unlogged forest and lowest in forest regenerating 1-2 years post-logging. Canopy cover was significantly higher in unlogged forest stands compared to logged forest stands. Ten years after logging, bird species richness and canopy cover remained significantly lower in logged forest than in unlogged forest. Our results suggest that logging activities may threaten the reserve's white-sand forest flora and fauna, which includes many endemic and range-restricted species.

INTRODUCTION

Logging and other human impacts now affect most of the world's tropical forests, and all remaining unprotected forests are expected to be logged within the next 15 years (White 1994). Half of the world's remaining tropical forests are in Latin America (Mason and Thiollay 2001), and logging operations have been recently expanding dramatically in the Amazon region (Barlow *et al.* 2006). An estimated 80% of all logging operations in the Amazon region are illegal and poorly executed (Laurance 1998). Too few studies have examined how selective logging impacts biodiversity to predict how any taxonomic group might respond to different intensities of selective logging (Whitman *et al.* 1998; White and Tutin 2001).

Selective logging causes forest fragmentation and fragment isolation and alters the structure, composition, and microclimate of forests, all of which can affect bird communities (Mason and Thiollay 2001). Species associated with gaps and edges or those that are adapted to disturbance may increase after logging and become dominant, and species restricted to forest interior may decline or disappear. Moreover, logged forests are more vulnerable both to commercial hunting and poaching and to wildfires, which can quickly decimate wildlife populations (Wilkie *et al*. 2001; Barlow *et al.* 2006).

Few studies in the Neotropics have evaluated the effects of logging on birds (Mason and Thiollay 2001). Research to date has shown that selective logging may have major impacts on primary forest bird communities in the tropics, especially those that forage and breed in forest understory, and that many understory bird species decline dramatically or disappear altogether following selective logging (Wong 1985; Lambert 1992; Thiollay 1992; Johns 1996; Mason 1996; Dranzoa 1998; Marsden 1998; Dale et al. 2000; Mason and Thiollay 2001; Plumptre *et al.* 2001).

Understanding how birds respond to logging is a critical part of developing forest management plans that support the long-term protection of wildlife. Birds may be appropriate biological indicators of forest logging damage because of their wide ranges, interactions with other organisms, and sensitivity to landscape-scale disturbances (Furness and Greenwood 1993). Birds play critical roles in forest structure and function as pollinators, predators, seed dispersers, and prey for other animals. Because understory birds are particularly sensitive to forest structure damage due to logging, they may serve as reliable indicators of forest regeneration (Wong 1985;

Whitman *et al.* 1998). With their high visibility and aesthetic appeal, birds have also helped garner popular support for conservation worldwide.

We examined the effects of non-mechanized selective logging on understory birds in low elevation (116-148 m a.s.l.) humid tropical white-sand forests in the Allpahuayo-Mishana National Reserve, Loreto department, northern Peru. Our research objectives were to: 1) quantify and compare the forest structure and understory bird communities at study sites in unlogged and logged forests, 2) investigate whether any measures of vegetation structure are associated with differences in understory bird communities; and 3) use research findings to make appropriate conservation and management recommendations.

METHODS

Study area. Forests growing on white sands are patchy and local in Peru, covering less than 0.1% of the Peruvian Amazon region (Shany *et al.* 2007). White-sand forests tend to be lower in stature and have reduced bird species richness compared to other Amazonian forests in Peru, but they are rich in endemic and range-restricted species (Schulenberg *et al.* 2007). Álvarez Alonso (2002) has described characteristic birds of white-sand forests in the northern Peruvian Amazon in detail. Vásquez Martínez (1997) has described the flora of these forests, which include over 1900 species of which 110 are range-restricted or endemic to white-sand forests. Distinctive features of white-sand forests include high tree density, low frequency of large emergent trees, lianas or herbs, and a thick humus layer due to low decomposition rates. There is a tendency towards dominance by one or a few tree species, and trees tend to exhibit adaptations to nutrient-poor soils, including long-lived leaves protected by chemical defenses and physical toughness such as a waxy cuticle that appear to minimize the leaching of nutrients by rain (Álvarez Alonso 2002).

White-sand forest is patchily distributed and restricted to a few areas in the northern Peruvian Amazon, one of largest areas of which occurs on the north bank of the Amazon near its confluence with the Nanay River (Shany *et al.* 2007). In 1999, the Peruvian government created the 57,600 ha Allpahuayo-Mishana Reserve (henceforth referred to as Allpahuayo-Mishana) in this area, in part to protect a number of recently discovered endemic bird species apparently restricted to white-sand forests in the Nanay River basin (Álvarez Alonso 2002; Álvarez Alonso and Whitney 2003). Nearly 500 species of birds have been recorded in Allpahuayo-Mishana, of which 32 species in 13 families have some degree of specialization on white-sand forests (Álvarez Alonso 2002). This avifauna also comprises a number of recently discovered species, including the Critically Endangered Iquitos Gnatcatcher (*Polioptila clementsi*), which has been adopted as the official bird of the nearby city of Iquitos (Whitney and Álvarez Alonso 2005).

Dominant trees, including *Caraipa tereticaulis* and *C. utilis*, have long straight trunks that are locally in great demand for construction material, firewood and charcoal (Whitney and Álvarez Alonso 2005; Indama Sánchez, pers. obs.). Although logging is prohibited in the reserve, the laws protecting the reserve are difficult to enforce as there is only one government-salaried staff member of the reserve, who is aided by one of four volunteer park rangers who take turns manning the only guard post in the reserve at km 28 on the Iquitos-Nauta highway. Thus, illegal logging continues in white-sand forests inside the reserve and is among the main threats to its protection (Juvonen and Alvarez Alonso 2003; Whitney and Álvarez Alonso 2005). We studies the effects of logging on birds in the humid white-sand forest type locally known as *varillal*, which is typically characterized by 10-25 m tall trees that form a canopy and a well-developed understory including palms such as *Euterpe catanga* (Shany *et al.* 2007).

Sampling techniques. In October and November 2005, we used constant-effort mist netting to sample birds in forest stands logged approximately 1, 5, and 9 years previously and unlogged forest stands as a control. We conducted fieldwork inside the protected area near field camps located at the reserve guard post 28 km from Iquitos (S03º58, W73º26) and the settlement of Nueva Esperanza (S03º54, W73º25) (Figure 2.1). We selected three replicate stands in each of four forest treatments, for a total of 12 stands: forest stands one year post-logging (L1), forest stands four to five years post-logging (L5), forest stands 8-10 years post-logging (L9), and unlogged forest (U). Study plots were approximately 0.5 ha in area and all logged forest stands were surrounded by unlogged forest.

We used a sample effort of 2495 mist net hours (mean = 207.9 ± 6.2 net hours/stand).At each stand, 10 mist nets (10 m by 3 m, 35 mm mesh) were placed in a straight, continuous 100 m long line, opened by dawn, checked every 15-20 minutes, and closed at approximately 1400 hours. Nets were operated for two to three consecutive days at each site, and then transferred to a new location. Captured birds were identified, weighed, measured, photographed, and marked before being released at the site of capture (Ralph *et al.* 2004). Birds were marked by clipping 1 cm off the tip of the third right outer tail feather (C. J. Ralph, pers. comm.). Recaptured birds were released immediately and excluded from subsequent count data. Capture rates decline after the each day of net operation because the proportion of the population captured increases with each passing day, and captured birds avoid mist nets after being caught (Karr 1980; Karr 1981; Bierregaard 1990; Remsen and Good 1996; Dranzoa 1998; Faaborg *et al.* 2004; Whitman 2004).

Mist netting has a number of advantages over other methods and is considered especially important for surveying birds in tropical forests (Terborgh and Weske 1969; Karr 1981; Bierregaard 1990; Mason 1996; Remsen and Good 1996). Mist nets provide a large amount of quantitatively reliable information in a relatively short period, and the results are repeatable (Karr 1981; Mason 1996). Mist nets are a powerful tool for detecting understory bird species, particularly secretive species or those that vocalize infrequently (Terborgh and Weske 1969; Mason 1996; Remsen and Good 1996; Bibby *et al.* 2000). Using mist nets avoids the obvious biases of survey methods that rely on the visual and auditory ability of human observers (Karr 1981; Remsen and Good 1996; Bibby *et al.* 2000; Whitman 2004). Mist nets are especially useful in areas with high species richness and where the avifauna is not well studied (Karr 1981).

We quantified vegetation structure using a modified circular plot method (James and Shugart 1970; Shahabiddin and Kumar 2007). We randomly selected a 10 m diameter circle at each plot and used a convex mirror densitometer and ocular observations to estimate percent vegetation cover at four levels: canopy, subcanopy, breast-height, and ground cover. We measured basal area (frequency and diameter) for all trees > 10 cm dbh in each study plot.

Statistical analysis. We assumed that not all understory bird species were captured and used the bootstrap approach described by Nichols *et al.* (1998) and implemented in program COMDYN4 (Hines *et al.* 1999) to estimate community parameters from the empirical species abundance curves generated by our capture data. COMDYN4 employs the jackknife estimator described by Burnham and Overton (1978, 1979) via program CAPTURE (Rexstad and Burnham 1991) to generate estimates of species richness, variance, local extinction probability, local species turnover, and number of local colonizing species. In addition, COMDYN4 incorporates Pollock's (1982) robust design to deal with heterogeneous capture probabilities and performs a χ^2 test of equal detection probabilities between all sampling treatments being compared. Its design is based on capture-recapture methodology, where the sampled community is considered as "closed" to local extinction and colonization during the period of time over which species presence-absence data are collected.

We tested differences in forest structure variables between forest treatments with one-way ANOVA using the programming language Python (Python Software Foundation). For species exhibiting sufficient sample sizes, we also used one-way ANOVA to test whether there was a species-specific response to forest treatment in the form of differences in relative abundance.

We made comparisons between bird communities in different forest treatments using the definitions for parameters provided by Williams *et al.* (2002). In this case, the rate of change in species richness (λ) is defined as the ratio of estimated number of species present in the second forest treatment compared with the estimated number of species present in the first. Local extinction probability ($1 - \varphi$) is defined as the probability that a species present in the community during the first treatment being compared is not present in the second treatment being compared. Local species turnover ($1 - \psi$) is the probability that a species selected at random from the second treatment being compared is a "new" species, i.e. a species not present in the first treatment. The number of local colonizing species is related to species turnover, and is the estimated number of species not present in an area in the first treatment, which colonize the second treatment; this is analogous to the recruitment parameter in population models.

RESULTS

Excluding recaptures, we made a total of 348 captures of 54 species belonging to 16 taxonomic families in five simplified feeding guilds (Gray *et al.* 2007) (Table 2.1). The Thamnophilidae (typical antbirds) was the best-represented family in our sample, with 13 species. The three most commonly captured species accounted for 34.4% of our total captures:

Wedge-billed Woodcreeper (*Glyphorynchus spirurus*) (n = 69), Scale-backed Antbird (*Hylophylax peocilinotus*) (n = 29), and White-plumed Antbird (*Pithys albifrons*) (n = 22). Rare species, which were defined as those comprising less than 2% of total captures, made up the majority (74.1%) of captures. Twenty-eight of the total 54 species (51.9%) were represented by only one or two captures. We captured two Nearctic-Neotropical migrant species: Gray-cheeked Thrush (*Catharus minimus)* and Swainson's Thrush (*Catharus ustulatus*). Nine species (16.7% of the total) were captured only in primary forest, while eight species (14.8% of the total) were captured only in logged forest (Table 2.2).

In all cases, our data fit the heterogeneity model M_h that accounts for differences in capture probability between species. In three of the four forest treatments we found evidence that not all understory bird species were captured, and estimated that actual species richness exceeded the number of species detected in our sampling data. In forest 1-2 years post-logging, we estimated that there were 26 species based on the abundance curves for the 19 bird species we captured, but the 95% confidence interval included 19 (19 – 35). In forest 8-10 years post-logging, we estimated there was a minimum of 1 species more than the number of species we actually captured, up to an upper limit of the 95% confidence interval of 20 species more than we captured (n = 25 species detected, R = 35 species estimated with 95% CI 26 – 46). In most cases we found no evidence of differences in capture probabilities among treatments ($P > 0.05$). However, differences in capture probabilities in comparisons between primary forest and forest 1-2 years post-logging and primary forest and forest 8-10 years post-logging approached significance ($\chi^2 = 4.75$, df = 2, $P = 0.09$ and $\chi^2 = 5.43$, df = 2, $P = 0.07$, respectively),

Estimated bird species richness differed significantly between unlogged and logged forest treatments (Figure 2.2). Species richness in unlogged forest and forest 4-5 years post-logging was significantly higher than that in forest 1-2 years and 8-10 years post-logging. Estimated bird species richness in unlogged forest stands (64) was more than two times the estimated number of species in forest stands 1-2 years post-logging (26). Estimated species richness in forest 4-5 years post-logging (56) was similar to that in unlogged forest. Estimated species richness in forest stands 8-10 years post-logging (35) was significantly lower than in unlogged forest or logged forest 4-5 years postharvest.

Unlogged forest bird species had a moderately high (67%) probability of local extinction compared to logged forest 1-2 years postharvest and a moderately low (30% and 32%, respectively) probability of local extinction in logged forest 4-5 years postharvest and 8-10 years postharvest. Unlogged forest contained a high estimated number of species (43) not found in logged forest 1-2 years postlogging, a low number of species (13) not found in logged forest 4-5 years postlogging, and a moderate number of species (28) not found in logged forest 8-10 years postlogging.

Birds captured only in unlogged forest may be among those especially vulnerable to forest logging damage; these are listed in Table 2.2, along with all other bird species captured in only one forest treatment. All of these species are categorized as rare in the context of this study. Some or all may have life history characteristics that prevent them from persisting in logged forests, at least for the first 10 years after logging at the intensities examined in this study. While some bird species from unlogged forest were able to persist in logged forest stands, unlogged forest stands consistently harbored a higher estimated number of species than any logged forest stand. By contrast, Table 2.3 lists the estimated numbers of species shared between treatments.

Of the vegetation structure variables measured, only canopy cover differed significantly among different forest treatments (Figure 2.3). Canopy cover in unlogged forest was significantly higher than in logged forest (F = 7.5, df = 2, P = 0.01). Because most or all of the logging that took place in our study area was illegal, it was not possible to obtain figures on the exact volume of timber extracted from the forest stands we studied. However, scientists familiar with the reserve estimate that operations typically cut 30-40 trees from a single forest stand and transport them by footpath, river or road for sale in Iquitos (J. Díaz Alván, pers. comm.). Because most logging operations extract all mature *Caraipa sp.* trees in a given area, we have no reason to assume the volume of timber varied significantly over the time since logging covered in this study.

Twelve species (denoted with an asterix in Table 2.1) were captured with sufficient sample sizes (N > 10) to enable one-way ANOVAs comparing capture frequency between sites. The capture frequency of these species did not show significant differences in abundance (P > 0.05) between logged and unlogged forest. Thus, the 12 most commonly captured species did not appear to respond to forest damage due to logging in the form of significant changes in relative abundance. These species may possess life history traits that make them less vulnerable to logging damage than some other species.

DISCUSSION

Assuming that our forest treatments present an accurate temporal gradient of post-logging changes in understory bird communities, our results show that bird species richness significantly declined within 1-2 years after selective logging, temporarily appeared to rebound within 4-5 years after selective logging, and then declined again 8-10 years after selective logging. We speculate that the temporary rebound in species richness in logged forest approximately 5 years postharvest can be at least partially explained by an increase in edge and gap-associated species at this time, in response to increased fruiting and flowering stimulated by the canopy opening caused by logging. In this scenario, as floristic productivity declines and canopy cover has not yet recovered sufficiently to resemble that in unlogged forest, edge and gap-associated species move elsewhere.

Although species richness in unlogged forest and logged forest 4-5 years postharvest was similar, the understory bird communities were not the same. An estimated 20% (13/64) of unlogged forest understory bird species were absent from logged forest 4-5 years postharvest, and up to 67% of unlogged forest understory bird species were absent from other logged forest stands. Presumably the loss of these species is offset by colonizing species, such that although species richness is temporarily restored 4-5 years post-logging, the community composition is not, and many bird species found in unlogged forest stands are lost from logged forest.

In the short- to mid-term following logging we found significant declines in bird species richness in logged forests and significant local extinction probabilities of primary forest bird species in logged forest patches. Local extinction probability of unlogged forest bird species in logged forest stands ranged from 30-68%, and remained at a minimum of 30% even when species richness was similar to unlogged forest, indicating that forest-dependent species were replaced by colonizing species in logged forest stands. Longer term effects of selective logging on bird communities remain to be seen.

Whitney and Álvarez Alonso (2005) have speculated that white-sand forests and associated biodiversity may in fact not be able to fully regenerate following logging, due to the extremely nutrient-poor edaphic conditions characteristic of these forests. Our estimates of forest damage caused by logging may be taken conservatively, as logged forest patches in this study were small and surrounded by unlogged primary forest. If larger stands of forest were logged, if logged forest was not surrounded by unlogged forest, or if most forest stands are logged over time, the probability of survival of those bird species restricted to unlogged forest and associated with the higher canopy cover it host would be expected to decline. As it is, our results show that there is a high probability of local extinction of primary forest bird species following logging, and 8-10 years post-logging forest patches continue to host lower bird species richness compared to unlogged forest.

These results suggest that selective logging has significant negative effects on white-sand forest canopy cover and primary forest understory bird communities in Allpahuayo-Mishana National Reserve that persist for at least a decade after a logging event. The time to the full recovery of unlogged forest understory bird community or forest canopy is not known. Logging activities in white-sand forests may therefore threaten the reserve's endemic and range-restricted species. In order to promote the effective long-time protection of birds in the Allpahuayo-Mishana, we recommend that appropriate agencies take urgent action to work with local residents in the reserve to reduce illegal logging, and increase efforts to enforce laws in place to control logging in the reserve.

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Table 2.1: Bird species (n = 54) and guilds captured in white-sand forests of Allpahuayo-Mishana National Reserve, Peru, 2005. Taxonomy follows that of the South American Classification Committee of the American Ornithologists' Union (www.museum.lsu.edu/~Remsen/SACCBaseline.html) (* denotes n > 10).

No.	Guild[1]	Family	Species	Common name
1	F	Columbidae	*Geotrygon montana*	Ruddy Quail-Dove
2	N	Trochilidae	*Glaucis hirsutus*	Rufous-breasted Hermit
3	N	Trochilidae	*Threnetes niger*	Pale-tailed Barbthroat
4	N	Trochilidae	*Phaethornis superciliosus*	Long-tailed Hermit*
5	N	Trochilidae	*Phaethornis ruber*	Reddish Hermit
6	N	Trochilidae	*Phaethornis bourcieri*	Straight-billed Hermit*
7	N	Trochilidae	*Florisuga mellivora*	White-necked Jacobin
8	N	Trochilidae	*Doryfera ludovicae*	Fork-tailed Woodnymph
9	O	Motmotidae	*Momotus aequatroialis*	Blue-crowned Motmot
10	I	Bucconidae	*Malacoptila fusca*	White-chested Puffbird
11	I	Picidae	*Celeus elegans*	Chestnut Woodpecker
12	I	Dendrocolaptidae	*Glyphorynchus spirurus*	Wedge-billed Woodcreeper*
13	I	Dendrocolaptidae	*Dendrocincla fulginosa*	Plain-brown Woodcreeper
14	I	Dendrocolaptidae	*Dendrocincla merula*	White-chinned Woodcreeper
15	I	Dendrocolaptidae	*Xiphorhynchus guttatus*	Buff-throated Woodcreeper
16	I	Dendrocolaptidae	*Dendrocolaptes picumnus*	Amazonian Barred-Woodcreeper
17	I	Dendrocolaptidae	*Xiphorhynchus promeropirhynchus*	Straight-billed Woodcreeper
18	I	Dendrocolaptidae	*Xiphorhynchus ocellatus*	Ocellated Woodcreeper
19	I	Furnariidae	*Hyloctistes subulatus*	Ruddy Spinetail
20	I	Furnariidae	*Automolus ochralaemus*	Buff-throated Foliage-Gleaner
21	I	Furnariidae	*Sclerurus rufigularis*	Short-billed Leaftosser
22	I	Furnariidae	*Xenops minutus*	Plain Xenops
23	I	Thamnophilidae	*Megastictus margaritatus*	Pearly Antshrike
24	I	Thamnophilidae	*Thamnomanes caesius*	Cinerous Antshrike
25	I	Thamnophilidae	*Mymotherula haematonota*	Stipple-throated Antwren
26	I	Thamnophilidae	*Myrmotherula axillaris*	White-flanked Antwren*
27	I	Thamnophilidae	*Hypocnemis hypozantha*	Yellow-browed Antbird
28	I	Thamnophilidae	*Hypocnemis cantator*	Warbling Antbird
29	I	Thamnophilidae	*Mymoborus mytherinus*	Black-faced Antbird
30	I	Thamnophilidae	*Myrmeciza castanea*	Zimmer's Antbird
31	I	Thamnophilidae	*Phelgopsis erythroptera*	Reddish-winged Bare-eye
32	I	Thamnophilidae	*Gymnopithys leucaspis*	Bicolored Antbird*
33	I	Thamnophilidae	*Pithys albifrons*	White-plumed Antbird*
34	I	Thamnophilidae	*Pygiptila stellaris*	Scale-backed Antbird*
35	I	Thamnophilidae	*Myrmotherula hauxwelli*	Plain-throated Antwren*
36	I	Tyrannidae	*Mionectes oleagineus*	Ochre-bellied Flycatcher*
37	I	Tyrannidae	*Corythopis torquata*	Ringed Antpipit
38	I	Tyrannidae	*Terenotriccus erythrurus*	Ruddy-tailed Flycatcher
39	I	Tyrannidae	*Lathrotriccus euleri*	Euler's Flycatcher
40	I	Tyrannidae	*Attila spadiceus*	Bright-rumped Attila

41	I	Tyrannidae	*Attila bolivianus*	White-eyed (Dull-capped) Attila
42	I	Tyrannidae?	*Schiffornis turdina*	Thrush-like Schiffornis
43	F	Cotingidae	*Lipaugus vociferans*	Screaming Piha
44	F	Pipridae	*Machaeropterus regulus*	Striped Manakin
45	I	Pipridae	*Tyranneutes stolzmanni*	Dwarf Tyrant-Manakin
46	I	Pipridae	*Chiroxiphia pareola*	Saffron-crested Tyrant-Manakin
47	F	Pipridae	*Dixiphia pipira*	White-crowned Manakin*
48	F	Pipridae	*Lepidotrhix coronata*	Blue-crowned Manakin*
49	F	Pipridae	*Pipra erythrocephala*	Golden-headed Manakin
50	I	Troglodytidae	*Microcerculus marginatus*	Nightingale Wren
51	I	Turdidae	*Catharus minimus*	Gray-cheeked Thrush
52	I	Turdidae	*Catharus ustulatus*	Swainson's Thrush
53	I	Vireonidae	*Hylophilus hypoxanthus*	Dusky-capped Greenlet
54	G	Cardinalidae	*Cyanocompsa cyanoides*	Blue-black Grosbeak

[1] Simplified feeding guild categories (after Gray *et al.* 2007): F = frugivore, fruit eater; G = granivore, seed eater; I = insectivore, ant follower, bark/foliage gleaner, woodpecker; N = nectarivore, pollen eater; O = omnivore, any species spanning two or more guilds.

Table 2.2. Bird species captured in only one forest treatment

Forest treatment	**Bird species**
Primary (n=9)	Amazonian Barred-Woodcreeper (*Dendrocolaptes picumnus)*
	Short-billed Leaftosser (*Sclerurus rufigularis)*
	Zimmer's Antbird (*Myrmeciza castanea)*
	Reddish-winged Bare-eye (*Phelgopsis erythroptera)*
	Ringed Antpipit (*Corythopis torquata)*
	Warbling Antbird (*Hypocnemis cantator)*
	Stipple-throated Antwren (*Mymotherula haematonota)*
	White-eyed Attila (*Attila bolivianus)*
	Screaming Piha (*Lipaugus vociferans)*
Forest regenerating 1-2 years post-logging (n=1)	Bright-rumped Attila (*Attila spadiceus)*
Forest regenerating 4-5 years post-logging (n=6)	White-necked Jacobin (*Florisuga mellivora)*
	Blue-crowned Motmot (*Momotus aequatroialis)*
	Chestnut Woodpecker (*Celeus elegans)*
	Buff-throated Woodcreeper (*Xiphorhynchus guttatus)*
	Yellow-browed Antbird (*Hypocnemis hypozantha)*
	Dwarf Tyrant-Manakin (*Tyranneutes stolzmanni)*
Forest regenerating 8-10 years post-logging (n=1)	Dusky-capped Greenlet (*Hylophilus hypoxanthus)*

Table 2.3. Number of shared species estimated in unlogged and logged forest stands in Allpahuayo-Mishana National Reserve, Peru, 2005

Number of species present in

Also present in

	U	**L1**	**L5**	**L9**
U	----	12	25	25
L1	15	----	19	11
L5	32	17	----	23
L9	26*	12	23	----

U = unlogged forest, L1 = logged forest 1-2 years postharvest, L5 = logged forest 4-5 years postharvest, L9 = logged forest 8-10 years postharvest.

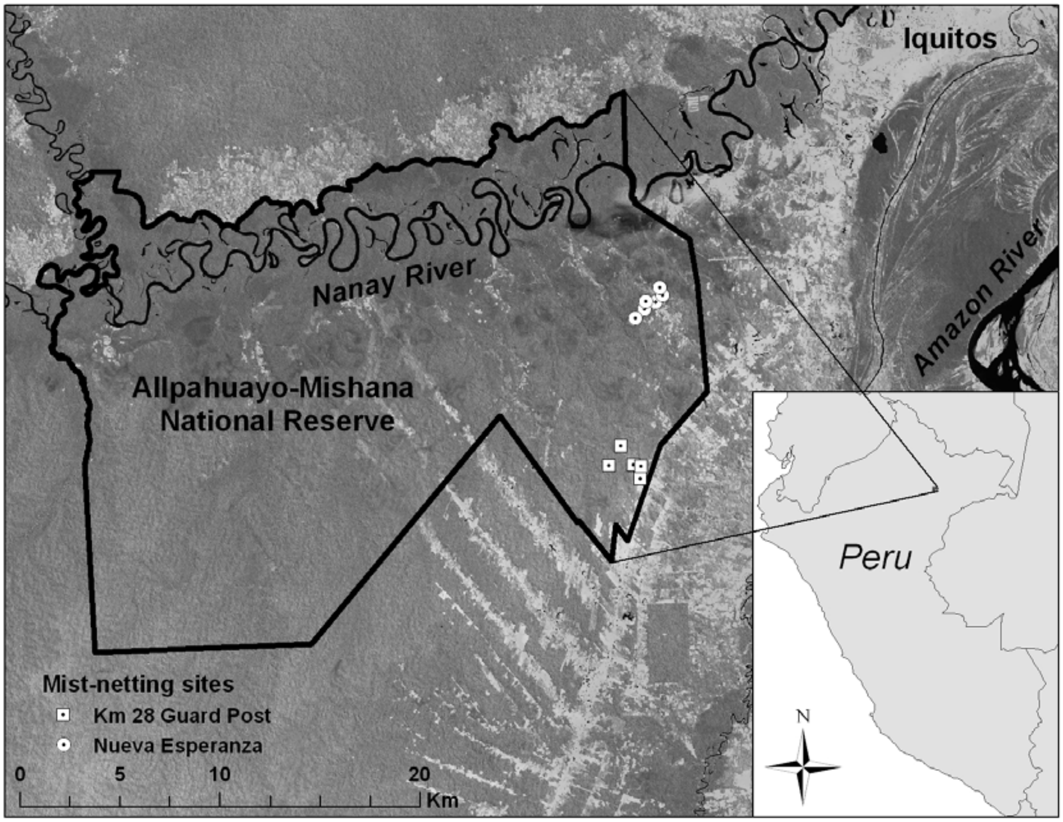

Figure 2.1. Map showing location of study area and mist netting sites in Allpahuayo-Mishana National Reserve, Peru, 2005.

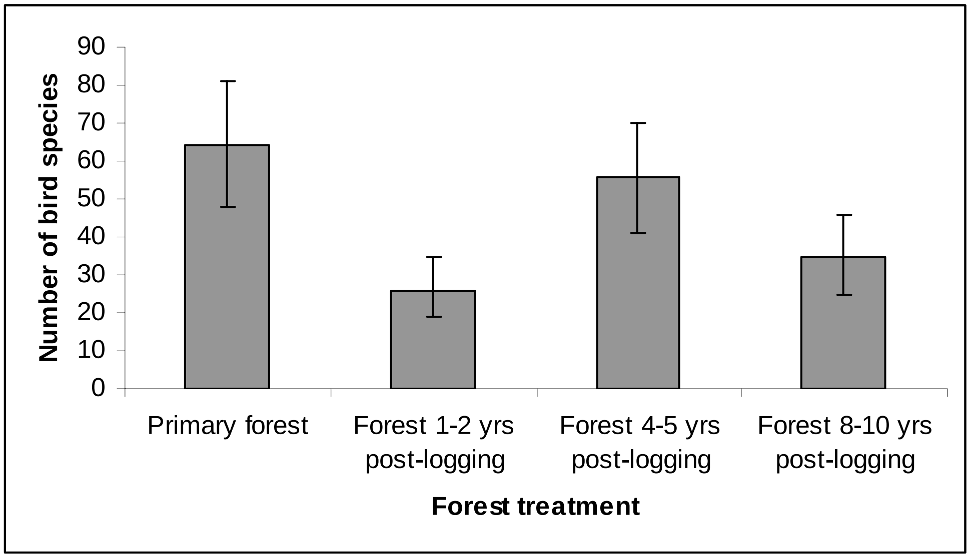

Figure 2.2. Estimated bird species richness and 95% confidence intervals in relation to forest treatment in Allpahuayo-Mishana National Reserve, Peru, 2005.

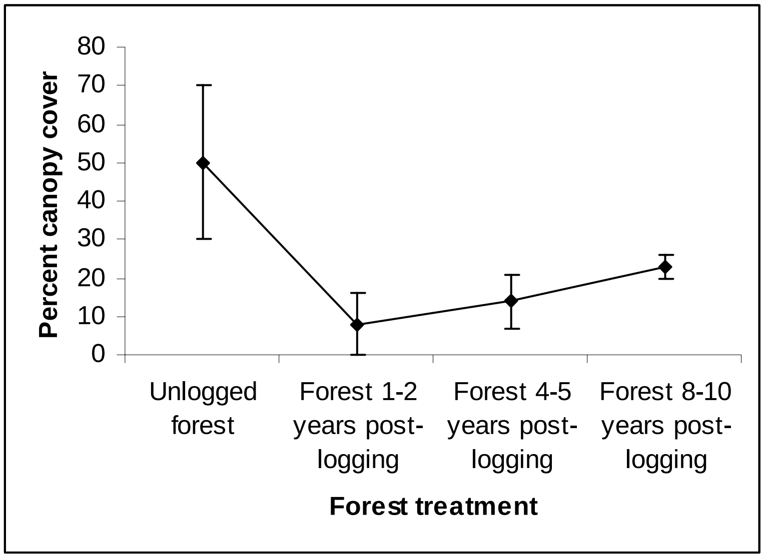

Figure 2.3. Percent canopy cover (± s) by forest treatment in Allpahuayo-Mishana National Reserve, Peru, 2005.

CHAPTER 3

BIRD COMMUNITY RESPONSES TO NON-MECHANIZED LOGGING IN HUMID TROPICAL FOREST IN THE CORDILLERA DE COLÁN, PERU[1]

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[1] N. Dauphiné, O. Tsamajain Shiwig, and R. J. Cooper. To be submitted to *Conservation Biology*.

ABSTRACT. Timber harvest methods employed by Aguaruna-Jívaro communities in the northern Cordillera de Colán appear to be the lowest impact commercial logging practices on record. We compared understory bird communities in unlogged humid tropical forest with those in logged forest stands between 1 and 5 years postharvest. We estimated species richness and related community parameters adjusted for differing capture probabilities of different species. Logged forests 4-5 years postharvest had a significantly greater estimated number of species (118) compared to logged forest 1-2 years postharvest (74), while there was no significant difference between the number of species in primary forest (89) and that in either logged forest treatment. However, we estimated that 28-30% of unlogged forest understory bird species were absent from logged forest between 1 and 5 years postharvest. This loss in species was offset by an influx of colonizing species that made up an estimated 22-36% of total species logged forest and increased with time since logging. Thus, while logging did not result in overall declines in species richness in the short to mid-term period after logging, it did result in differences in species composition between primary and logged forest stands, suggesting that a long term recovery period is necessary for many primary forest bird species to repopulate logged forest, even when reduced-impact logging methods are used. This study provides a working example of reduced impact timber harvest methods in humid tropical forest, and also demonstrates some important and lasting effects logging practices may have on tropical forest understory birds, even when reduced impact methods are used and logged stands are surrounded by large tracts of unlogged forest.

INTRODUCTION

Wildlife plays a critical part in maintaining tropical forests, where up to 90% of plant species are dependent on animals for pollination or dispersal (Fimbel *et al.* 2001). Birds in particular play critical roles in forest structure and function as pollinators, predators, seed dispersers, and prey for other animals, and in turn, approximately 30% of the world's bird species are sufficiently dependent on tropical forest for either year-round or wintering habitat that they would become extinct if these forests were lost (Myers 1992). Because most tropical forests are in low-income countries, incentives to gain income through logging are especially high. Unfortunately, conversion of tropical forests in Peru, one of the lowest-income Latin American countries, to agriculture and non-sustainable harvest practices may result in the disappearance of many forest areas and associated biodiversity within a few decades (Hartshorn 1995). Understanding the effect of resource extraction on the structure and function of tropical forest communities is, therefore, critical to conserve global biodiversity.

The most common forestry practice in the tropics is selective logging, where most stems of an economically valuable species above a certain diameter are harvested in a specific area; harvests in such systems tend to take place at 20 to 40 year intervals (Fimbel *et al.* 2001). Logging and other human impacts now affect most of the world's tropical forests, and all remaining unprotected forests are expected to be logged within the next 15 years (White 1994). Half of the world's remaining tropical forests are in Latin America (Mason and Thiollay 2001), and logging operations have been recently expanding dramatically in the Amazon region (Barlow *et al.* 2006). An estimated 80% of all logging operations in the Amazon region are illegal and poorly executed (Laurance 1998).

Intensive logging and other unsustainable practices within tropical forests have negative impacts on biodiversity by destroying or modifying habitat, decreasing species richness, and causing genetic erosion at the species and community level (O'Neill *et al.* 2001). Species associated with gaps and edges or those that are adapted to disturbance may increase after logging and become dominant, and species restricted to forest interior may decline or disappear following logging. Logging directly impacts forest wildlife through the destruction or degradation of habitat and the disruption of movements of and interactions between organisms. Even low-intensity cutting (<3 trees/ hectare) can have relatively high impacts when poorly managed, possibly resulting in declines or elimination of mature forest-dependent species.

Too few studies have examined how selective logging affects biodiversity to predict how any taxonomic group might respond to different intensities of selective logging (Whitman *et al.* 1998; White and Tutin 2001). Few studies in the Neotropics have evaluated the effects of logging on birds (Mason and Thiollay 2001), and none has taken place in Peru. To our knowledge, all published studies of the impacts of selective logging on biodiversity have examined mechanized selective logging (e.g., Wong 1985, Thiollay 1992, Mason 1996, Dranzoa 1998, Marsden 1998, White and Tutin 2001, Sekercioglu 2002). Mechanized selective logging typically results in the destruction of about 50% of all trees present before logging, most of which is incidental damage due to timber felling and skidding (Johns 1988, White 1994). Such research has shown that selective logging has major impacts on primary forest bird communities, especially those that forage and breed in forest understory, and that many understory bird species decline dramatically or disappear altogether following selective logging (Wong 1985, Lambert 1992; Thiollay 1992, Johns 1996, Mason 1996, Dranzoa 1998, Marsden 1998, Dale et al. 2000, Mason and Thiollay 2001, Plumptre *et al.* 2001).

By contrast, native Amazonian Aguaruna-Jívaro communities in the Cordillera de Colán, Peru, appear to use the lowest-impact commercial tropical logging practices that have been documented and/or quantitatively studied. Aguaruna communities in the northern Cordillera de Colán harvest trees by non-mechanized, single-tree selection for timber species including *tornillo*

(*Cedrelinga cateniformis*), which occurs locally at a density of approximately 4 mature trees per hectare. Trees are harvested without the use of roads or heavy machinery, greatly reducing incidental damage to forest that in mechanized systems accounts for the majority of forest damage. The only mechanized equipment is a hand-held chain saw, and boards, which are cut on-side, are transported manually and by river for processing and pickup. Harvested trees are rough sawn into thick boards on site and then transported for processing and pickup via the local river, quebrada Wawas. The village receives about $180 U.S. for each tree harvested. While this is a substantial value locally, given that the average annual income in Peru is $480, this represents a fraction of the tree's current market value at $344 to $352 per m^3 sawn wood (Global Wood 2006).

In order to be considered sustainable, non-mechanized, single-tree selective logging should be performed so as to mimic natural forest gap-phase dynamics as closely as possible. When reduced-impact logging is widely interspersed and harvested areas are allowed to regenerate, we would expect negative impacts to species richness are minimal. On the other hand, even reduced-impact logging methods are additive to natural forest disturbance (Wunderle *et al.* 2006) and have impacts on forest wildlife. Logged forests cannot conserve every species that occurs in unlogged forest. Ideally, however, production forests could play a complementary role to protected areas in the tropics. For this to happen, they must be managed sustainably – that is, in such a way that maintains their biodiversity, productivity, regeneration capacity, vitality, and their potential to provide ecological, economic, and social functions without causing long-term damage to the ecosystem (Fimbel *et al.* 2001).

Native Amazonians should ideally play a formal role in biodiversity conservation (Redford and Steadman 1993, Adrade and Rubio-Torgler 1994, World Bank 2002). At the same time, indigenous people in Peru rely on timber harvest as a primary source of income (O'Neill *et al.* 2001). Because understory birds are particularly sensitive to alteration in forest structure due to logging, they may serve as reliable indicators of forest regeneration (Wong 1985; Whitman et al. 1998). Understanding how birds respond to logging is a critical part of developing integrated forest management plans that support the long-term protection of wildlife. In this study, we evaluated the effects non-mechanized logging has on forest structure and understory bird communities, identified some bird species particularly vulnerable to logging damage, and contributed to baseline ecological research towards improved planning for conservation in the region.

Study area. We studied understory bird community responses to logging in two adjacent indigenous Aguaruna-Jívaro communities comprising a total of about 10,000 ha of humid tropical forest in the north-west Cordillera de Colán, Peru (Figure 3.1). The Cordillera de Colán is an isolated mountain range in the Andean foothills of the northern Peruvian Amazon. The fauna and flora in this region remain poorly-known (Davies *et al.* 1997; Rodriguez and Young 2000), and, with the exception of our own work, no published studies of any kind appear to exist for the area of the Cordillera de Colán. The Cordillera de Colán forms part of the Tropical Andes biodiversity hotspot identified by Conservation International as a global priority for conservation, due to its high concentration of endemic species and severe environmental degradation (Myers *et al.* 2000). The mountain range occurs just east of the North Peruvian Low created by the arid Marañón valley, which is considered one of the major barriers to dispersal of bird restricted to humid montane forests (Parker *et al.* 1985). Biogeography in this region is extremely complex and bird species diversity correspondingly high (Cracraft 1985); four Endemic Bird Areas (EBAs) intersect on the Cordillera de Colán (EBAs) (Davies *et al.* 1997). In

2002 Peru established the 64,115 ha Zona Reservada Cordillera de Colán to protect a number of threatened, rare and endemic species.

We conducted fieldwork in low and mid-altitude tropical moist montane forest and elfin forest in the north-western part of the mountain range, south of the confluence of the Marañon and Chiriaco rivers. We carried out surveys in and adjacent to EBA047 (Andean ridge top forests), an urgent priority due to moderate habitat loss and poor knowledge of its ecology, which is considered to be one of the most biologically important but least protected EBAs in the Americas (BirdLife International 2008).

The Zona Reservada Cordillera de Colán is located in a remote, high altitude region of the northern Cordillera de Colán that is uninhabited and that appears to remain largely inaccessible. No biological surveys appear to have been carried out within the reserve itself or in the areas beyond its northern boundary. At its northern perimeter the reserve borders Aguaruna-Jívaro territories.

We carried out field surveys for birds in collaboration with the Aguaruna communities of Wichim and Alto Wawas, 10–20 km north of the new reserve. The Comunidad Nativa de Wawas, Anexo Wichim (5.16ºS 78.20ºW) is an Aguaruna community of *c.* 120 people on the east bank of the Wawas River between two mountains featuring ridge top elfin forest. Elevation ranges from 400–1000 m a.s.l. and vegetation is dominated by cloud forest with very steep slopes and frequent fast-running streams, within which are scattered agricultural fields and patches of secondary forest. The Comunidad Nativa de Alto Wawas (5.19ºS 78.20ºW) is an uninhabited Aguaruna territory managed by residents of neighboring communities. The southern limit of Alto Wawas borders the Zona Reservada Cordillera de Colán. Elevations range from 550-1000 m a.s.l. and vegetation in Alto Wawas is dominated by low to mid elevation primary cloud forest, within which two small huts are the only structures. Further descriptive details on this and the surrounding area are provided in Dauphiné *et al.* (2008).

METHODS

Field Sampling. We mist netted understory birds at nine locations (550 – 750 meters a.s.l.) during February and March 2005 (Figure 3.2). Mist nets (8 x 10 m by 3 m, 36 mm mesh) were opened by dawn, checked every 15-20 minutes, and closed at approximately 1400 hours. Sites were categorized by level of forest disturbance based on logging history: logged forest 1-2 years postharvest (L1), logged forest 4-5 years postharvest (L5), and unlogged forest (U) as a control. There were 3 replicates of each treatment in stands of between 0.2 and 0.6 hectare in size (i.e., 9 total stands with mean = 0.33 ha). Treatments were interspersed to the extent possible given the many logistical constraints of working in the area.

We quantified vegetation structure using a modified circular plot method (James and Shugart, 1970; Shahabiddin and Kumar, 2007). We randomly selected a 10 m diameter circle at each plot and used a convex mirror densiometer and ocular observations to estimate percent vegetation cover at four levels: canopy, subcanopy, breast-height, and ground cover. We measured tree basal area (frequency and diameter) for all trees > 10 cm dbh in each study plot. In the absence of any data on forest flora species composition in the study area, comparing forest flora species composition between treatments was beyond the scope of this study, with the exception of noting the absence of mature tornillo trees in logged forest patches.

Study sites were of similar size, mist-netting effort was similar for all sites (mean: 229 net-hours), sampling was conducted during the same time-period, and habitat measurements were similar for all study sites. Captured birds were identified (Clements and Shany 2001; Schulenberg *et al.* 2007) and released at the site of capture. Nets were generally operated for two to three consecutive days at each site, and then transferred to a new location. Capture rates decline after each day of net operation because the proportion of the population captured increases with each passing day, and captured birds tend to avoid mist nets after being caught (Karr 1980; Karr 1981; Bierregaard 1990, Remsen and Good 1996; Dranzoa 1998; Faaborg et al. 2004; Whitman 2004).

Mist netting has a number of advantages over other methods and is considered especially important for surveying birds in tropical forests (Terborgh and Weske 1969; Karr 1981; Bierregaard 1990; Mason 1996; Remsen and Good 1996). Mist nets provide a large amount of quantitatively reliable information in a relatively short period, and the results are repeatable (Karr 1981; Mason 1996). Mist nets are a powerful tool for detecting understory bird species, particularly secretive species or those that vocalize infrequently (Terborgh and Weske 1969; Mason 1996; Remsen and Good 1996; Bibby et al. 2000). Using mist nets avoids the obvious biases of survey methods that rely on the visual and auditory ability of human observers (Karr 1981; Remsen and Good 1996; Bibby et al. 2000; Whitman 2004). A primary advantage of nets is that they do not require extensive familiarity with bird vocalizations and field marks; they are especially useful in areas with high species richness and where the avifauna is not well studied (Karr 1981).

Statistical analysis. Most literature based on mist net studies has assumed that differences in numbers of bird captured are determined primarily by relative abundance and has therefore equated capture frequency with relative abundance of a species; this assumption, however, is not generally valid. Birds exhibit capture heterogeneity due to spatial movement patterns, flight behavior, activity level at a given period of time, and other factors influencing their catchability (Remsen and Good 1996). Unequal detection probabilities produce a negative bias, i.e.

underestimate the true number of species (Boulinier *et al.* 1998, Williams *et al.* 2001). For these reasons, we used a limiting form of the jackknife method (Burnham and Overton 1979) that incorporates capture heterogeneity in order to estimate actual species richness based on our empirical data. We used the bootstrap approach described in Nichols *et al.* (1998) and implemented in program COMDYN4 (Hines *et al.* 1999) to estimated comparative bird community parameters between different forest treatments, based on summary statistics calculated from our sampling data.

We tested whether there were differences in the forest structure variables we measured using one-way ANOVA using the programming language Python (Python Software Foundation). For the 16 most commonly captured species, we also tested for differences in capture frequency between forest treatments using one-way ANOVA.

RESULTS

Sampling effort for this study totaled 2064 mist net-hours. We made 723 captures of 98 species belonging to 19 families (Table 3.1). Three species made up 34% of all captures: Wedge-billed Woodcreeper (*Glyphorynchus spirurus*) (n = 118), Koepcke's Hermit (*Phaethornis koepckeae*) (n = 50) and Long-tailed Hermit (*Phaethornis superciliosus*) (n = 48). Rare species, defined as those comprising less than 2% of total captures, made up the majority (87%) of captures. In all cases we found evidence that not all species were detected, and estimated that actual species richness exceeded the number of species detected in our sampling data. Goodness of fit tests indicated that all data fit the heterogeneity model M_h ($P > 0.05$) that accounts for differences in detectability, or in this case, "catchability."

We found no evidence of differences in capture probabilities between forest treatments ($P > 0.05$). The probability of capturing a species was similarly moderate in all forest treatments (p

(U) = 0.61, 95% CI = 0.49 – 0.77; p (L1) = 0.65, 95% CI = 0.53 – 0.82; p (L5) = 0.61, 95% CI = 0.51 – 0.73). We therefore used raw species counts to compute relative species richness (λ) of unlogged and logged forests. In doing so, we found that there were 12% (55/49) more species in unlogged forest than logged forest 1-2 years postharvest, 31% (72/55) more species in logged forest 4-5 years postharvest than in unlogged forest, and 47% (72/49) more species in logged forest 4-5 years postharvest than in logged forest 1-2 years postharvest.

In unlogged forest, estimated species richness (*R*) was 89 (95% CI = 70.8 – 109.8) based on 55 species captured. In logged forest 1-2 years postharvest, we estimated 74 species (95% CI = 59.09 – 90.37) based on 49 species captured. In forest 4-5 years post-logging, we estimated 118 species (95% CI = 98.17 – 140.94), based on 72 species captured. Estimated bird species richness did not differ significantly between unlogged and logged forest treatments ($\chi_2^2 = 1.06$, P = 0.59; $\chi_2^2 = 0.73$, P = 0.69; $\chi_2^2 = 3.23$, P = 0.20); however, species richness in forest 4-5 years post-logging was significantly lower than that in forest 1-2 years post-logging (Figure 3.2).

The estimated extinction probability of birds in unlogged forest occurring in logged forest 1-2 years postharvest was high ($\varphi = 0.86$; 95% CI = 0.57 – 1.00), while the estimated extinction probability of birds in unlogged forest birds in logged forest 4-5 years postharvest was moderate ($\varphi = 0.52$; 95% CI = 0.37 – 0.72).

The number of “new” species occurring in logged forests, i.e., species that did not occur in unlogged forests (B), increased with time since logging, with an estimated 15 colonizing species in logged forests 1-2 years postharvest and an estimated 43 colonizing species in logged forests 4-5 years postharvest.

Although estimated species richness in logged forests 4-5 years postharvest was higher than in unlogged forest, this estimate incorporates colonizing species that offset a high estimated loss of unlogged forest species. An estimated 25 species in unlogged forest did not persist in logged forest 1-2 years postharvest, and an estimated 28 species in logged forest did not persist in logged forest 4-5 years postharvest. Thus, nearly one-third (31%) of unlogged forest understory bird species were locally extinct in logged forest patches 4-5 years after logging. We captured 16 species only in unlogged forest (Table 3.2), which were mainly insectivores.

We estimated a 0.89 rate of change in species richness from primary forest to logged forest 1-2 years postharvest. We estimated a 1.31 rate of change in species richness from primary forest to logged forest 4-5 years postharvest. We estimated a 1.47 rate of change from logged forest between 1-2 years postharvest and 4-5 years postharvest. Bird species in logged forest 1-2 years postharvest had a zero probability of extinction in logged forest 4-5 years postharvest, which gained an estimated 44 colonizing species.

Of the forest habitat structure variables we measured, the only one that approached significant differences between forest treatments was canopy cover ($F_2 = 4.9$, $P = 0.05$), with unlogged forest having a greater degree of forest cover (mean = 87%) compared to logged forest (mean = 60% in L1, 73% in L5). Logged forest stands differed from unlogged forest stands by the absence of mature *Cedrelinga cateniformis* trees. Assessing other possible differences in floristic species composition was beyond the scope of this study, but would ideally be incorporated in future studies. None of the 16 most frequently captured species (n > 10, Table 3.3) exhibited differences in capture rates across forest treatment using ANOVA.

DISCUSSION

The logging practices examined here did not result in a decline in species richness in response to logging, and in fact appeared to stimulate an increase in species richness following logging. If we consider that we cannot expect logged forest to conserve all species present in unlogged forest, we can view these results optimistically as not causing overall declines in forest understory species that have been documented in studies of mechanized logging. In addition, the suite of most commonly captured species, which was dominated by understory insectivores, a guild known to be sensitive to logging damage, did not appear to respond negatively to forest damage by logging in terms of their relative abundance. We may consider that this group of species is resilient to the forestry practices used in this particular system of logging.

On the other hand, a large proportion of primary forest bird species were absent from logged forest patches five years following low-intensity logging, even in logged forest patches surrounded by contiguous forest with minimal disturbance. Thus, a significant fraction of primary forest birds were sufficiently sensitive to forest logging damage that they did not appear to persist in logged patches at least five years following logging. Further empirical research is needed to determine whether or not these understory bird species would tolerate non-mechanized tree harvest in the long-term, and if so, how long it would take them to recover. Local extinction probability of primary forest birds in logged forests decreased from 0.86 in forest patches 1-2 years after logging to 0.52 in forest patches 4-5 years after logging.

The logging methods used in this study did not appear to significantly influence forest structure variables such as subcanopy cover, understory cover, ground cover, and tree-basal area between 1 and 5 years after logging. We found some evidence that they reduced canopy cover during the same period of time, and they also obviously resulted in the systematic removal of many mature specimens of economically valuable timber species. Further research on forest flora composition and understory bird ecology along with longer-term data on bird responses to forest damage due to logging would help pinpoint drivers of local extinction and colonization in logged forests.

Although structural damage to logged forest appeared to be minimal in this system, especially when compared to damage sustained in mechanized logging operations that are typical of the region, forest understory bird communities appeared to exhibit a strong response in terms of local extinction and colonization. We interpret this as highlighting the principle that even low-impact logging methods cannot conserve all bird species present in primary forest understory. The Aguaruna communities in this area have placed a moratorium on any logging in the 7000 ha territory of Alto Wawas in 2002 (S. Tsamajain Yagkuag, pers. comm.), which, if maintained, would ideally help conserve regional forest-restricted bird species that are most sensitive to forest damage.

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Table 3.1. Bird species captured in forest understory in the Cordillera de Colán, Peru, 2005

Guild*	Family	Species	Common name
UF	Columbidae	Geotrygon montana	Ruddy Quail-Dove
UN	Trochilidae	Eutoxeres condamini	Buff-tailed Sicklebill
UN	Trochilidae	Threnetes niger	Pale-tailed Barbthroat
UN	Trochilidae	Phaethornis superciliosus	Long-tailed Hermit
UN	Trochilidae	Phaethornis koepckeae	Koepcke's Hermit
UN	Trochilidae	Phaethornis ruber	Reddish Hermit
UN	Trochilidae	Doryfera ludovicae	Green-fronted Lancebill
UN	Trochilidae	Doryfera johannae	Blue-fronted Lancebill
UN	Trochilidae	Campylopterus largipennis	Gray-breasted Sabrewing
UN	Trochilidae	Thalurania furcata	Fork-tailed Woodnymph
UN	Trochilidae	Chrysuronia oenone	Golden-tailed Sapphire
UN	Trochilidae	Heliodoxa aurescens	Gould's Jewelfront
UN	Trochilidae	Heliodoxa schreibersii	Black-throated Brilliant
UN	Trochilidae	Heliodoxa gularis	Pink-throated Brilliant
UI	Galbulidae	Galbula albirostris	Yellow-billed Jacamar
CF	Ramphastidae	Pteroglossus azara mariae	Ivory-billed Aracari
BI	Picidae	Celeus grammicus	Scaly-breasted Woodpecker
BI	Furnariidae	Xenops tenuirostris	Slender-billed Xenops
UI	Furnariidae	Hyloctistes subulatus	Striped Woodhaunter
UI	Furnariidae	Ancistrops strigilatus	Chestnut-winged Hookbill
UI	Furnariidae	Automolus ochralaemus	Buff-throated Foliage-Gleaner
UI	Furnariidae	Philydor pyrrhodes	Cinnamon-rumped Foliage-Gleaner
UI	Furnariidae	Automolus infuscatus	Olive-backed Foliage-Gleaner
UI	Furnariidae	Automolus rubiginosus	Ruddy Foliage-Gleaner
UI	Furnariidae	Sclerurus mexicanus	Tawny-throated Leaftosser
UI	Furnariidae	Sclerurus caudacutus	Black-tailed Leaftosser
BI	Dendrocolaptidae	Glyphorynchus spirurus	Wedge-billed Woodcreeper
BI	Dendrocolaptidae	Dendrexetastes rufigula	Cinnamon-throated Woodcreeper
BI	Dendrocolaptidae	Xiphorhynchus promeropirhynchus	Strong-billed Woodcreeper
BI	Dendrocolaptidae	Xiphorhynchus obsoletus	Striped Woodcreeper
BI	Dendrocolaptidae	Xiphorhynchus ocellatus	Ocellated Woodcreeper
UI	Thamnophilidae	Thamnophilus cryptoleucus	Castelnau's Antshrike
UI	Thamnophilidae	Thamnophilus schistaceus	Plain-winged Antshrike
UI	Thamnophilidae	Thamnomanes ardesiacus	Dusky-throated Antshrike
UI	Thamnophilidae	Thamnomanes caesius	Cinereous Antshrike
UI	Thamnophilidae	Thamnomanes schistogynus	Bluish-slate Antshrike
UI	Thamnophilidae	Myrmotherula hauxwelli	Plain-throated Antwren
UI	Thamnophilidae	Pygiptila stellaris	Spot-winged Antshrike
UI	Thamnophilidae	Dysithamnus mentalis	Plain Antvireo
UI	Thamnophilidae	Mymotherula haematonota	Stipple-throated Antwren
UI	Thamnophilidae	Myrmotherula erythrura	Rufous-tailed Antwren
UI	Thamnophilidae	Myrmotherula multostriata	White-flanked Antwren
UI	Thamnophilidae	Myromotherula shisticolor	Slaty Antwren
UI	Thamnophilidae	Myrmotherula longipennis	Long-winged Antwren
UI	Thamnophilidae	Cercomacra nigrescens	Blackish Antbird*
UI	Thamnophilidae	Myrmoborus myotherinus	Black-faced Antbird
UI	Thamnophilidae	Hypocnemis cantator	Warbling Antbird
UI	Thamnophilidae	Myrmeciza hemimelaena	Chestnut-tailed Antbird
AFI	Thamnophilidae	Percnostola leucostigma	Spot-winged Antbird
AFI	Thamnophilidae	Pernostola lophotes	White-lined Antbird

AFI	Thamnophilidae	Pithys albifrons	White-plumed Antbird
AFI	Thamnophilidae	Gymnopithys leucaspis	Bicolored Antbird
AFI	Thamnophilidae	Gymnopithys salvini	White-throated Antbird
AFI	Thamnophilidae	Rhegmatorhina melanosticta	Hairy-crested Antbird
AFI	Thamnophilidae	Hylophylax naevia	Spot-backed Antbird
AFI	Thamnophilidae	Hylophylax poecilinota	Scale-backed Antbird
UI	Formicariidae	Grallaricula ferrugineipectus	Rusty-breasted Antpitta
UFI	Pipridae	Chlrorpipo holochlora	Green Manakin
UFI	Pipridae	Chiroxiphia pareola	Blue-backed Manakin
UFI	Pipridae	Pipra coronata	Blue-crowned Manakin
UFI	Pipridae	Pipra erythrocephala	Golden-headed Manakin
UFI	Pipridae	Machaeropterus regulus	Striped Manakin
UFI	Pipridae	Tyranneutes stolzmanni	Dwarf Tyrant-Manakin
UFI	Pipridae	Piprites chloris	Wing-barred Piprites
UFI	Tyrannidae	Mionectes olivaceus	Olive-striped Flycatcher
UFI	Tyrannidae	Mionectes oleagineus	Ochre-bellied Flycatcher
UI	Tyrannidae	Hemitriccus zosterops	White-eyed Tody-tyrant
UI	Tyrannidae	Corythopis torquata	Ringed Antpipit
UI	Tyrannidae	Rhynchocyclus olivaceus	Olivaceous Flatbill
UI	Tyrannidae	Platyrinchus coronatus	Golden-crowned Spadebill
UI	Tyrannidae	Platyrinchus platyrhinchos	White-crested Spadebill
UI	Tyrannidae	Terenotriccus erythrurus	Ruddy-tailed Flycatcher
UI	Tyrannidae	Myiobius villosus	Tawny-breasted Flycatcher
UFI	Tyrannidae	Attila spadiceus	Bright-rumped Attila
UI	Troglodytidae	Thryothorus coraya	Coraya Wren
UI	Troglodytidae	Thryothorus leucotis	Buff-breasted Wren
UI	Troglodytidae	Henicorhina leucosticta	White-breasted Wood-Wren
UI	Troglodytidae	Microcerculus marginatus	Nightingale Wren
UI	Troglodytidae	Cyphorhinus aradus	Musician Wren
UFI	Turdidae	Cichlopsis leucogenys	Rufous-brown Solitaire
UFI	Turdidae	Catharus ustulatus	Swainson's Thrush
UFI	Turdidae	Turdus albicollis	White-necked Thrush
UI	Polioptilidae	Mixrobates cinereiventris	Tawny-faced Gnatwren
UI	Vireonidae	Hylophilus ochraceiceps	Tawny-crowned Greenlet
UI	Parulidae	Wilsonia canadensis	Canada Warbler
UI	Parulidae	Basileuterus fulvicauda	Buff-rumped Warbler
CFI	Thraupidae	Creurgops verticalis	Rufous-crested Tanager
CFI	Thraupidae	Tachyphonus surinamus	Fulvous-crested Tanager
UFI	Thraupidae	Habia rubica	Red-crowned Ant-Tanager
CF	Thraupidae	Euphonia mesochrysa	Bronze-green Euphonia
CF	Thraupidae	Euphonia xanthogaster	Orange-bellied Euphonia
CFI	Thraupidae	Tangara schrankii	Green-and-Gold Tanager
CN	Thraupidae	Cyanerpes caeruleus	Purple Honeycreeper
UF	Emberizidae	Oryzoborus angolensis	Chestnut-bellied Seed-Finch
UF	Emberizidae	Arremon aurantiirostris	Orange-billed Sparrow
UFI	Cardinalidae	Saltator maximus	Buff-throated Saltator
UFI	Cardinalidae	Saltator grossus	Slate-colored Grosbeak
UF	Cardinalidae	Cyanocompsa cyanoides	Blue-black Grosbeak

*Feeding guild categories: AFI = Ant-following insectivore; BI = Bark-gleaning insectivore; CF = Canopy frugivore; CN = Canopy nectarivore; UF = Understory frugivore; UI = Understory insectivore; UN = Understory nectarivore.

Table 3.2. Bird species captured only in unlogged forest (n = 16).

Guild	Family	Species	Common name
N	Trochilidae	Heliodoxa schreibersii	Black-throated Brilliant
O	Ramphastidae	Pteroglossus azara mariae	Ivory-billed Aracari
I	Picidae	Celeus grammicus	Scaly-breasted Woodpecker
I	Furnariidae	Xenops tenuirostris	Slender-billed Xenops
I	Furnariidae	Philydor pyrrhodes	Cinnamon-rumped Foliage-Gleaner
I	Furnariidae	Automolus infuscatus	Olive-backed Foliage-Gleaner
I	Furnariidae	Automolus rubiginosus	Ruddy Foliage-Gleaner
I	Dendrocolaptidae	Dendrexetastes rufigula	Cinnamon-throated Woodcreeper
I	Dendrocolaptidae	Xiphorhynchus obsoletus	Striped Woodcreeper
I	Tyrannidae	Hemitriccus zosterops	White-eyed Tody-tyrant
I	Tyrannidae	Corythopis torquata	Ringed Antpipit
I	Tyrannidae	Platyrinchus platyrhinchos	White-crested Spadebill
I	Tyrannidae	Myiobius villosus	Tawny-breasted Flycatcher
FI	Turdidae	Turdus albicollis	White-necked Thrush
FI	Thraupidae	Tachyphonus surinamus	Fulvous-crested Tanager
N	Thraupidae	Cyanerpes caeruleus	Purple Honeycreeper

Simplified guilds: FI = Frugivore-insectivore, I = insectivore, N = Nectarivore, O = Omnivore.

Table 3.3. Most frequently captured understory bird species (n = 16) in the Cordillera de Colán, Peru, 2005.

Species	n
Bicolored Antbird	11
Tawny-faced Gnatwren	12
Spot-backed Antbird	13
Fork-tailed Woodnymph	15
Ochre-bellied Flycatcher	16
Golden-headed Manakin	17
Scale-backed Antbird	27
Orange-billed Sparrow	28
Pale-tailed Barbthroat	30
Blue-crowned Manakin	31
Black-faced Antbird	35
Green Manakin	37
White-plumed Antbird	41
Long-tailed Hermit	48
Koepcke's Hermit	50
Wedge-billed Woodcreeper	118

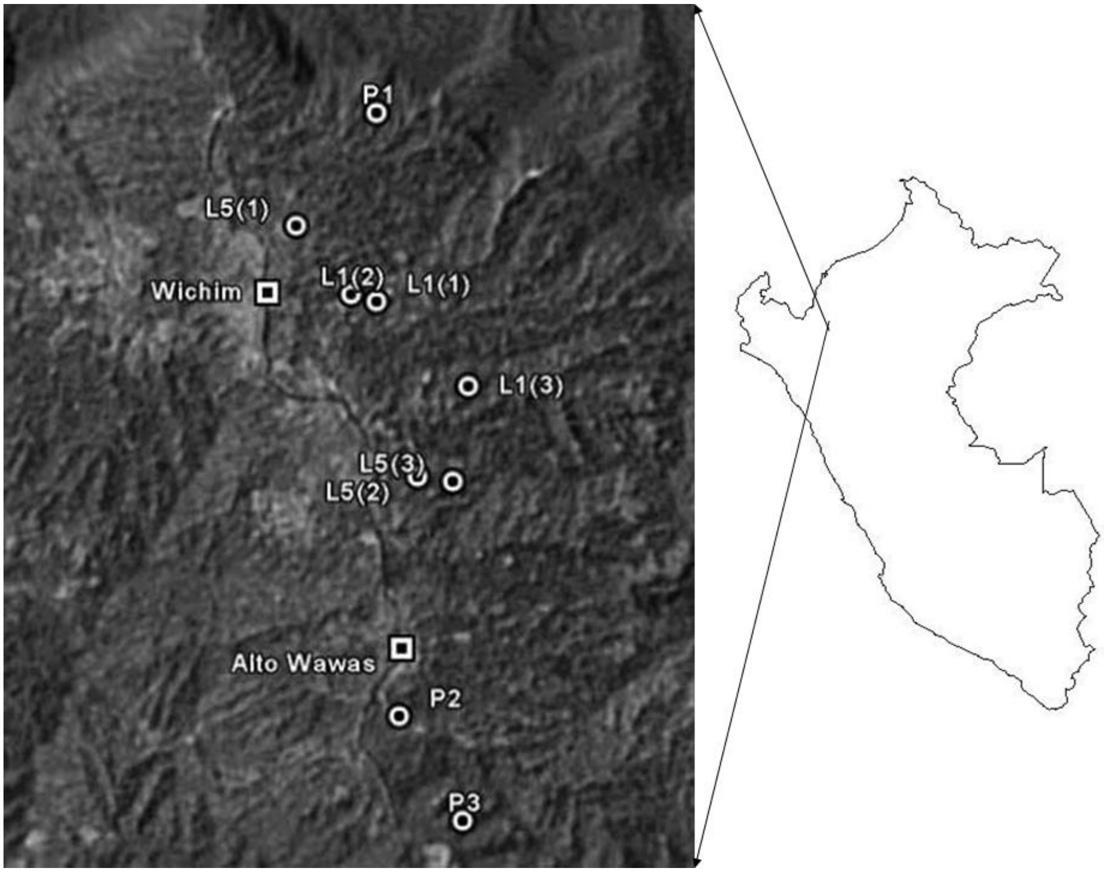

Figure 3.1. Mist net locations in the Cordillera de Colán, Peru, 2005. L5 = logged forest 4-5 years postharvest; L1 = logged forest 1-2 years postharvest; P = unlogged forest.

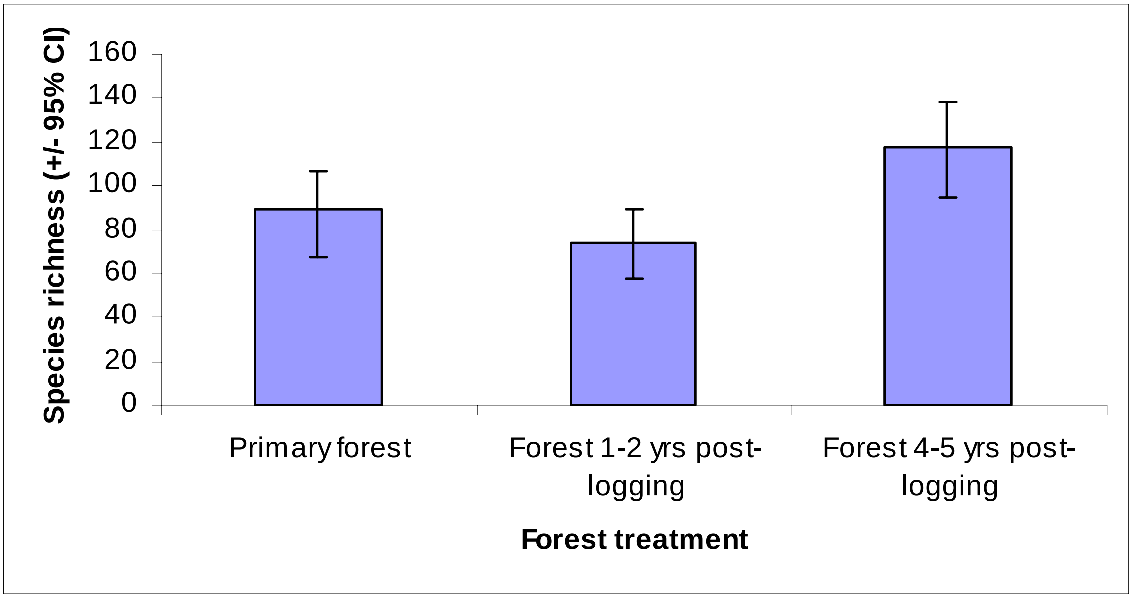

Figure 3.2. Species richness estimates and 95% confidence intervals by forest treatment in the Cordillera de Colán, Peru, 2005.

CHAPTER 4

BIRDS OF THE NORTH-WEST CORDILLERA DE COLÁN, PERU, WITH NEW LOCATIONS AND NEST RECORDS FOR BIRDS IN WESTERN AMAZONIA[1]

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[1] N. Dauphiné, A. Tsamajain Yagkuag, S. Tsamajain Yagkuag, and R. J. Cooper. To be submitted to *Ornitologia Neotropical*.

ABSTRACT. We present the first survey of birds found in the north-west Cordillera de Colán, dept. Amazonas, northern Peru. During 12 weeks of field surveys and mist net sampling in 2004 and 2005, we documented a total of 306 species, including 7 wintering Nearctic migrants. Findings represent new locations and/or range extensions for a number species known from elsewhere in western Amazonia. Records of juveniles and active nests of some species represent evidence of breeding for some species whose breeding ecology is poorly known. Our surveys were not exhaustive, such that our findings represent only a partial list of birds expected to be present in the region, and future surveys should detect additional species. Surveys took place within two adjacent indigenous Aguaruna-Jívaro territories, Wichim and Alto Wawas, which are largely composed of humid tropical forest with elfin forest on some outlying ridges. Theses communities are currently protected from most human immigration and associated large-scale habitat destruction.

INTRODUCTION

Between July 2004 and March 2005, we surveyed an area in the north-western Cordillera de Colán, Amazonas department, Peru, south of the confluence of the Marañón and Chiriaco rivers. Surveys took place in low and mid-altitude montane and elfin forest, primarily in the Aguaruna communties of Wichim and Alto Wawas, which comprise part of a large native Amazonian territory that borders the northern edge of a recently established protected area, the Zona Reservada Cordillera de Colán. We observed a low rate of deforestation in titled Aguaruna territories, and a high rate of forest clearance in areas recently colonized by immigrants from elsewhere in Peru.

The Cordillera de Colán (Figure 1) is an isolated mountain range in Amazonas department, northern Peru, that forms part of the Tropical Andes biodiversity hotspot identified by Conservation International as a global priority for conservation, due to its high concentration of endemic species and severe environmental degradation (Myers *et al*. 2000). The mountain range occurs just east of the North Peruvian Low created by the arid Marañón valley, which is considered one of the major barriers to dispersal of bird restricted to humid montane forests (Parker *et al.* 1985). Biogeography in this region is extremely complex and bird species diversity correspondingly high (Cracraft 1985). In 2002 Peru established the 64,115 ha Zona Reservada Cordillera de Colán to protect a number of threatened, rare and endemic species.

Fieldwork has been limited at elevations in the upper tropical zone (*c.* 700–1500 m), and only a few localities within this altitudinal range in Peru have been thoroughly surveyed (Davis 1986). Davies *et al.* (1997) conducted bird surveys in the southern Cordillera de Colán in 1994 and reported rapid, large-scale deforestation due to logging and burning for agriculture by recent settlers in that area. We conducted fieldwork in the north-western part of the mountain range, south of the confluence of the Marañon and Chiriaco rivers, where forests appear to remain largely intact.

STUDY AREA AND METHODS

The Zona Reservada Cordillera de Colán is located in a remote, high altitude region of the northern Cordillera de Colán that uninhabited and that appears to remain largely inaccessible. We carried out field surveys in the Aguaruna communities of Wichim and Alto Wawas, 10–20 km north of the recently designated reserve (Figure 4.1). Wichim (5º16’S, 78º20’W) is an Aguaruna community of c. 120 people, located c. 95 road and trail km northeast of Bagua Chica. Alto Wawas (5º19’S, 78º20’W) is an uninhabited Aguaruna territory managed by residents of the neighboring communities of Wichim and Sukutín in the Comunidad Nativa de Wawas (S. Tsamajain Yagkaug, pers. com.). We conducted a total of 329 field hours of surveys and 2064 net hours of mist net (10 x 10 m by 3 m, 36 mm mesh) sampling for birds, mainly in humid tropical montane forest, but also in elfin forest, secondary forest, and agricultural habitats.

As a group, Aguaruna residents tend to be exceptional local collaborators in ecological field research, as they exhibit substantial knowledge of bird taxonomy, ecology and behavior, and their knowledge corresponds strongly to scientific taxonomy and findings on bird ecology and behavior (Berlin *et al.* 1983, Boster *et al.* 1986, Berlin 1993, Jernigan and Dauphiné, in press). In this study, Aguaruna names were provided by ATY, STY, Roberto Jeremías Wampush, Enrique Tsamajain Chumpi, and Nestor Réategui. In some cases two or more taxonomic species may share the same Aguaruna name, and in some cases our Aguaruna informants were not aware of an Aguaruna name. Our informants suggested that some of the Aguaruna taxonomic knowledge of birds is being lost, and the most knowledgeable authority in Wichim was c. 80 years old and partially blind. Local Aguaruna knowledge of avian ecology is presented elsewhere (Jernigan and Dauphiné, in press).

RESULTS

We recorded a total of 306 bird species, which includes birds seen, heard, and mist netted by the authors and field collaborators including Roberto Jeremías Wampush and Enrique Tsamajain Chumpi. Voucher photographs were made of some mist-netted species before they were released at the site of capture, and a single collection was made of a bird found dead in a road of unknown causes. We present bird species names together with their English and Aguaruna common names in order to facilitate their location in the field (Appendix 4.1).

Species recorded belong to 44 families of birds, of which c. 98% are permanent residents and 2% are wintering Nearctic migrants. The tyrant flycatcher (Tyrannidae) family showed the highest species richness (45 species), followed by the typical antbirds (Thamnophilidae) (39 species). Seven wintering Nearctic migrant species included: Spotted Sandpiper (*Actitis macularia*), Olive-sided Flycatcher (*Contopus cooperi*) Swainson's Thrush (*Catharus ustulatus*), American Redstart (*Setophaga ruticilla*), Canada Warbler (*Wilsonia canadensis*), Summer Tanager (*Piranga rubra*), and Scarlet Tanager (*Piranga olivacea*).

The presence of a number of birds classified as globally threatened or near-threatened, including Koepke's Hermit (*Phaethornis koepckeae*), Royal Sunangel (*Heliangelus regalis)*, Orange-throated Tanager (*Wetmorethraupis sterropteron)*, and Olive-sided Flycatcher (*Contopus cooperi*), (BirdLife International 2008) highlights the conservation value of the area.

The north-west Cordillera de Colán represents a new location for a number of species in western Amazonia. Species accounts for some noteworthy records, including new locations, range extensions, and nesting records are presented below. The north-west Cordillera de Colán represents a new location for the globally endangered endemic hummingbird Royal Sunangel (Heliangelus regalis), and is the site of the first documented nest of Brown Nunlet (Nonnola brunnea), the details of which are respectively presented elsewhere (Dauphiné *et al.*, in press, Dauphiné *et al.* 2007).

Species Accounts

Wavy-breasted Parakeet (Pyrrhura peruviana). This is a newly recognized species that was until recently considered conspecific with *P. roseifrons*, which was considered a subspecies of *P. picta* (Ribas *et al.* 2006). Ribas *et al.* (2006) used genetic techniques to diagnose it as a separate species, and it is treated as such by Schulenberg *et al.* (2007). It is very poorly known from two disjunct locations in northern and central Peru. We observed a single individual on 26 October 2004, which had been reportedly captured at a clay lick in the Aguaruna community of Sukutín c. 10 km south of Wichim a day or so earlier and was being kept on a leash as a pet by an Aguaruna resident of Wichim. This individual reportedly escaped from captivity within several days. We did not observe any individuals of this species in the wild, but Aguaruna residents reported it was locally common in Sukutín.

Bronze-winged Parrot (Pionus chalcopterus). The closest location in Peru where this species had previously been recorded in dept. Piura, c. 280 km north-west of our study area (Schulenberg *et al.* 2007). We made one sighting of a single individual of this species on 30 July 2004 in humid montane forest in Wichim at *c.* 800 m a.s.l. Because we only observed one individual, its status in the study area is not clear. It is possible that this individual was an escaped captive bird, but Aguaruna residents stated that they were familiar with this species and that is was a rare resident of higher altitudes in the study area.

Rufous Nightjar (Camprimulgus rufus). The closest location in Peru where this species had previously been recorded is in dept. San Martín, approximately 100 km southeast of our study area (Schulenberg *et al.* 2007). We made one sighting of a roosting pair that we inadvertently disturbed at close range on 3 August 2004 on a ledge at the base of a sheer cliff face in montane-elfin transitional forest at c. 950 m a.s.l. in Wichim. This is *c.* 90 km east of its closest previously recorded location in the río Marañón drainage just north of the Ecuador-Peru border at 700 – 1100 m a.s.l. (Ridgely and Greenfield 2001). According to Aguaruna residents, this species is a rare resident in higher altitudes of the study area.

Koepcke's Hermit (Phaethornis koepckeae). This Peruvian endemic species is listed as near-threatened by the World Conservation Union (IUCN) (BirdLife International 2008) and locally common but very patchily distributed in Peru (Schulenberg *et al.* 2007). We made three sightings of Koepcke's Hermit in 2004 and captured 50 individuals in humid montane forest understory between 550 – 800 m a.s.l. in February and March 2005. We obtained photographs of mist-netted individuals. We found this species to be locally common in the study area.

Pink-throated Brilliant (Heliodoxa gularis). This species is listed as near-threatened by the IUCN (BirdLife International 2008) and rare and poorly known with few records in Peru (Schulenberg *et al.* 2007). We made one sighting of this species on 26 October 2004 and captured three individuals in humid montane forest understory in 2005 between 550 – 800 m a.s.l. in February and March 2005. We obtained photographs of mist-netted individuals (Figure 4.2). We found the species to be rare in the study area, which is c. 50 km south of the nearest previously recorded location of this species in the southern foothills of the Cordillera del Condor (Schulenberg *et al.* 2007)

Castelnau's Antshrike (Thamnophilus cryptoleucus). This species is listed as uncommon to locally fairly common in dense *Cecropia*-dominated undergrowth on river islands and similar mainland habitats (Schulenberg *et al.* 2007). We mist-netted and obtained photographs of a single male individual of this species in March 2005 in humid montane forest at c. 600 m a.s.l. (Figure 4.3). This location is c. 130 km southwest of its closest previously known location on the west bank of the río Santiago (Schulenberg *et al.* 2007).

White-plumed Antbird (Pithys albifrons). This species is fairly common in northern and western Amazonia. On 17 February 2005, we found an active nest of White-plumed Antbird in humid montane primary forest (c.05°16'S 78°20'W, elevation c. 600 m) in Wichim (Figure 4.4).

While nests of this species are known from northeastern South America (Hilty and Brown 1986), this nest appears to be the first record from Peru and in western Amazonia. We found the nest, which was being incubated by an adult, on the ground at the base of a small sapling. The nest was constructed of dried leaves and other forest fibers and contained two pinkish white eggs with wreath of reddish brown dots at larger end (Figure 4.5). The nest cup was 95.8 mm deep by 67.4 mm, and the egg (Figure 3) measured 22.4 mm by 22.0 mm. We made 5 sightings of this species in 2004 and mist netted 41 individuals (both adults and juveniles) in 2005.

Tawny-faced Gnatwren (Microbates cinereiventris). This species is listed as uncommon and patchily distributed in Peru (Schulenberg *et al.* 2007). We made four sightings of this species in 2004 and mist-netted 12 individuals in 2005. We found this species to be uncommon in the study area, which is c. 60 km southwest of the nearest previously recorded location of this species in the río Cenepa basin (Schulenberg *et al.* 2007).

Orange-throated Tanager (Wetmorethraupis sterrhopteron). This species is listed as vulnerable by the IUCN (BirdLife International 2008) and uncommon and local in Peru (Schulenberg *et al.* 2007). We documented more than 20 records of Orange-throated Tanagers during fieldwork in Alto Wawas at 700–800 m elevation. We heard and tape-recorded three songs and multiple calls of a lone individual perched 10 m high in cloud forest understory on 16 October 2004. While mist netting in Alto Wawas in ridge top cloud forest (5.19ºS 78.20ºW) at 750 m elevation on 19, 20, 25, and 26 March 2005, we daily heard this species' dawn song from *c.* 0600–0620 and its full song sporadically and regularly throughout the day. During this time, we made multiple sightings of groups of 5–6 individuals throughout the day as they foraged in the nearby canopy of fruiting trees adjacent to a tree fall gap in mixed species flocks of about 20 birds including Swainson's Thrush *Catharus ustulatus*. Aguaruna residents recognize this species as locally common in Alto Wawas, which is approximately 50 km southwest of its closest previously recorded location near the confluence of the ríos Cenepa and Marañón (Schulenberg *et al.* 2007, van Oosten *et al.* 2007).

Olive-sided Flycatcher (Contopus cooperi). The Olive-sided Flycatcher is a Nearctic migrant that is a rare winter visitor to eastern Andean forests in Peru (Clements and Shany 2001). The population of this species has dropped by 67% over the past 40 years, and habitat loss in its wintering grounds is thought to play a role in its continuing decline (BirdLife 2008; Cornell 2005). We made one sighting of an individual Olive-sided Flycatcher on 23 October 2004 as it perched on an exposed snag and sallied for insects at the edge of an agricultural field adjacent to cloud forest in Wichim at *c.* 600 m elevation; it made several sallies and returned to the same perch over a 10-minute period. Further surveys are required to assess the status of this species in this area, which could be conducted as part of a larger study proposed to determine its range and status on its wintering grounds by the American bird conservation network Partners in Flight (Rich *et al.* 2004).

Canada Warbler (Wilsonia canadensis). Canada Wabler, a Nearctic migrant that winters in the study area, is listed as a species of national conservation concern in the United States by Partners in Flight (Rich *et al.* 2004). We made numerous sighting of this species in forest canopy in 2004 and 2005 and mist netted a single individual in forest understory in 2005. We found this species to be locally common in the study area.

Buff-rumped Warbler (Phaeothlypis fulvicauda). This species is fairly common and widespread in Amazonia, and our study site is located at the western edge of its range (Schulenberg *et al.* 2007). On 20 October 2004, we found an active nest of Buff-rumped Warbler hidden in a rocky cleft at ground level along a trail on the west bank of the quebrada Wawas; an adult was incubating two whitish eggs. While the nests of this species are known from other regions (Hilty and Brown 1986), this nest may represent the first records for Peru. We made multiple sightings of individuals of this species in 2004 and mist netted two individuals in 2005. We found this species to be uncommon along quebrada Wawas in our study area.

Buff-throated Saltator (Saltator maximus).This species is fairly common and widespread in Amazonia, and specializes in gaps and edges in humid tropical forest (Schulenberg *et al.* 2007); our study area is located at the western edge of its range. On 22 October 2004, we found an active nest of Buff-throated Saltator (*Saltator maximus*) c. 2 m high near a trail in humid montane forest at c. 700 m a.s.l.. The nest contained two pale blue eggs. While the nests of these species are known from other regions (Hilty and Brown 1986), this nests may represent the first record for Peru. We made four sight records of this species in 2004 and mist netted two individuals in 2005, and found this species to be locally uncommon in our study area

We searched for but did not find Black-and-chestnut Eagle (*Oroaetus isidori*). Davies *et al.* (1997) recorded a breeding pair in the southern Cordillera de Colán, where they reported that locals persecuted the species as a livestock pest. During our surveys in 2004 and 2005, neither Aguaruna nor colonist residents reported recognizing this species from photographs or color plates. It is possible that continued persecution has caused this species to become locally extinct, but further searches are necessary to determine this species' status in the area.

DISCUSSION

Our surveys were not exhaustive, and we estimate that our findings represent only a partial list of birds present in the region, and future surveys should detect additional species. To our knowledge, however, no systematic surveys of fauna have been carried out in the north-west Cordillera de Colán or any other land under Aguaruna control, with the exception of our own work. This is probably partly due to the region's remoteness and partly due to the fact that the Aguaruna as a cultural group have a history of sensitive relations with settlers and visitors to the region (Stap 1990, Jernigan 2006). Aguaruna people also have a history of involvement in the Peruvian indigenous rights movement (Jernigan 2006), and exert an unusually high level of control over their land compared to other indigenous groups in the Western Hemisphere. Biodiversity conservation on their lands to a large extent appears to be a byproduct of their success in keeping their autonomy during the colonization

Despite a superior level of forest protection compared to, birds in the northern Cordillera de Colán are threatened by habitat loss and over hunting in recently colonized areas. Specific conservation threats and possible mitigating strategies are discussed elsewhere (Dauphiné *et al.* 2008). Briefly, however, forest and wildlife management measures put in place by Aguaruna communities in Wichim and Alto Wawas in general appear to offer a higher measure of biodiversity protection to resource use in the same region by recent colonists. Because they appear to be particularly motivated conservationists, we recommend that adjacent Aguaruna communities participate in the management of the Zona Reservada Cordillera de Colán. We hope that the present study will help facilitate further collaborations in the region between scientists and indigenous people.

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Appendix 4.1. Systematic list of birds detected in the north-west Cordillera de Colán, Peru, 2003-2005 (n=306). Taxonomy follows that of the South American Classification Committee of the American Ornithologists' Union (www.museum.lsu.edu/~Remsen/SACCBaseline.html).

Genus	**species**	**English name**	**Aguaruna name**
Nothocercus	*nigrocapillus*	Hooded Tinamou	wága
Tinamus	*major*	Great Tinamou	wága
Crypturellus	*soui*	Little Tinamou	tsúwam
Crypturellus	*undulatus*	Undulated Tinamou	
Crypturellus	*tataupa*	Tataupa Tinamou	wagkúsh
Chamaepetes	*goudotii*	Sickle-winged Guan	Pitsa
Ortalis	*guttata*	Speckled Chachalaca	Crakas
Odontophorus	*stellatus*	Starred Wood-Quail	push
Butorides	*striata*	Striated Heron	
Cathartes	*aura*	Turkey Vulture	chuwág
Elanoides	*forficatus*	Swallow-tailed Kite	
Ictinia	*plumbea*	Plumbeous Kite	
Accipiter	*superciliosus*	Tiny Hawk	
Accipiter	*striatus*	Sharp-shinned Hawk	
Leucopternis	*albicollis*	White Hawk	sai pínchu
Leucopternis	*schistaceus*	Plumbeous Hawk	
Buteo	*magnirostris*	Roadside Hawk	chígkiwi
Buteo	*brachyurus*	Short-tailed Hawk	
Buteo	*albonotatus*	Zone-tailed Hawk	
Micrastur	*ruficollis*	Barred Forest-Falcon	bakantáu
Daptrius	*ater*	Black Caracara	shánashna
Falco	*rufigularis*	Bat Falcon	téuteu
Falco	*deiroleucus*	Orange-breasted Falcon	chíijai, káuta
Anurolimnas	*castaneiceps*	Chestnut-headed Crake	pitjuak
Eurypyga	*helias*	Sunbittern	piyái
Actitis	*macularius*	Spotted Sandpiper	tiígkig
Claravis	*pretiosa*	Blue Ground-Dove	
Patagioenas	*fasciata*	Band-tailed Pigeon	paúm
Patagioenas	*speciosa*	Scaled Pigeon	shímpa
Patagioenas	*plumbea*	Plumbeous Pigeon	yápagkam
Patagioenas	*subvinacea*	Ruddy Pigeon	yápagkam
Geotrygon	*montana*	Ruddy Quail-Dove	tsabau yámpits
Leptotila	*rufaxilla*	Gray-fronted Dove	yaúch
Ara	*severus*	Chestnut-fronted Macaw	wácha/ shamak
Pyrrhura	*peruviana*	Wavy-breasted Parakeet	magstet
Pionus	*menstruus*	Blue-headed Parrot	tuwísh
Pionus	*chalcopterus*	Bronze-winged Parrot	chawaít
Coccycua	*minuta*	Little Cuckoo	tututág
Piaya	*cayana*	Squirrel Cuckoo	ikáncham
Piaya	*melanogaster*	Black-bellied Cuckoo	tejés ikáncham
Crotophaga	*ani*	Smooth-billed Ani	baít
Pulsatrix	*perspicillata*	Spectacled Owl	
Bubo	*virginianus*	Great Horned Owl	púmpuk
Steatornis	*caripensis*	Oilbird	táyu
Lurocalis	*rufiventris*	Rufous-bellied Nighthawk	díigshap
Nyctidromus	*albicollis*	Common Pauraque	taakén

Caprimulgus	*anthonyi*	Scrub Nightjar	téuteu
Eutoxeres	*condamini*	Buff-tailed Sicklebill	jémpechau
Glaucis	*hirsutus*	Rufous-breasted Hermit	
Threnetes	*leucurus*	Pale-tailed Barbthroat	yegkitkig jémpeji
Phaethornis	*ruber*	Reddish Hermit	ipák jémpe
Phaethornis	*koepckeae*	Koepcke's Hermit	yugkipkin jémpe
Phaethornis	*bourcieri*	Straight-billed Hermit	
Phaethornis	*superciliosus*	Long-tailed Hermit	
Phaethornis	*malaris*	Great-billed Hermit	
Doryfera	*ludovicae*	Green-fronted Lancebill	mujaya jémpe
Doryfera	*johannae*	Blue-fronted Lancebill	mujaya jémpe
Heliothryx	*auritus*	Black-eared Fairy	pujúpat
Heliangelus	*regalis*	Royal Sunangel	
Coeligena	*torquata*	Collared Inca	
Heliodoxa	*gularis*	Pink-throated Brilliant	
Heliodoxa	*schreibersii*	Black-throated Brilliant	
Heliodoxa	*aurescens*	Gould's Jewelfront	
Heliodoxa	*leadbeateri*	Violet-fronted Brilliant	
Klais	*guimeti*	Violet-headed Hummingbird	
Campylopterus	*largipennis*	Gray-breasted Sabrewing	
Thalurania	*furcata*	Fork-tailed Woodnymph	
Amazilia	*fimbriata*	Glittering-throated Emerald	
Chrysuronia	*oenone*	Golden-tailed Sapphire	
Trogon	*viridis*	White-tailed Trogon	
Trogon	*violaceus*	Violaceous Trogon	táwai
Megaceryle	*torquata*	Ringed Kingfisher	cháji
Electron	*platyrhynchum*	Broad-billed Motmot	esátyukúju
Baryphthengus	*martii*	Rufous Motmot	yukúju
Brachygalba	*lugubris*	Brown Jacamar	kuimish
Galbula	*albirostris*	Yellow-billed Jacamar	jémpeemu
Galbula	*cyanescens*	Bluish-fronted Jacamar	jémpeemu
Galbula	*chalcothorax*	Purplish Jacamar	jémpeemu
Bucco	*macrodactylus*	Chestnut-capped Puffbird	
Bucco	*capensis*	Collared Puffbird	apapájua
Malacoptila	*fusca*	White-chested Puffbird	mujáya shiík
Malacoptila	*fulvogularis*	Black-streaked Puffbird	
Nonnula	*brunnea*	Brown Nunlet	
Monasa	*morphoeus*	White-fronted Nunbird	tíiju
Capito	*auratus*	Gilded Barbet	takáikit
Ramphastos	*vitellinus*	Channel-billed Toucan	tsukagká
Aulacorhynchus	*prasinus*	Emerald Toucanet	ikáuk
Aulacorhynchus	*derbianus*	Chestnut-tipped Toucanet	ikáuk
Selenidera	*reinwardtii*	Golden-collared Toucanet	kajúntsam
Pteroglossus	*azara*	Ivory-billed Aracari	pinísh
Picumnus	*lafresnayi*	Lafresnaye's Piculet	dái
Melanerpes	*cruentatus*	Yellow-tufted Woodpecker	tegashá
Veniliornis	*passerinus*	Little Woodpecker	samake
Piculus	*leucolaemus*	White-throated Woodpecker	samake
Colaptes	*rubiginosus*	Golden-olive Woodpecker	samake
Celeus	*grammicus*	Scale-breasted Woodpecker	
Celeus	*elegans*	Chestnut Woodpecker	
Celeus	*torquatus*	Ringed Woodpecker	
Dryocopus	*lineatus*	Lineated Woodpecker	tátasham

Campephilus	*melanoleucos*	Crimson-crested Woodpecker	tátasham kiakia
Sclerurus	*mexicanus*	Tawny-throated Leaftosser	yasag
Sclerurus	*caudacutus*	Black-tailed Leaftosser	tagtag
Synallaxis	*maranonica*	Marañon Spinetail	
Metopothrix	*aurantiaca*	Orange-fronted Plushcrown	
Xenerpestes	*singularis*	Equatorial Graytail	
Premnornis	*gutturigera*	Rusty-winged Barbtail	
Ancistrops	*strigilatus*	Chestnut-winged Hookbill	
Hyloctistes	*subulatus*	Striped Woodhaunter	
Philydor	*pyrrhodes*	Cinnamon-rumped Foliage-gleaner	ekemin kuíntam
Thripadectes	*holostictus*	Striped Treehunter	
Automolus	*ochrolaemus*	Buff-throated Foliage-gleaner	ekemin kuíntam
Automolus	*infuscatus*	Olive-backed Foliage-gleaner	ekemin kuíntam
Automolus	*rubiginosus*	Ruddy Foliage-gleaner	ekemin kuíntam
Automolus	*rufipileatus*	Chestnut-crowned Foliage-gleaner	ekemin kuíntam
Xenops	*tenuirostris*	Slender-billed Xenops	
Xenops	*rutilans*	Streaked Xenops	
Dendrocincla	*fulginosa*	Plain-brown Woodcreeper	kuíntam
Glyphorynchus	*spirurus*	Wedge-billed Woodcreeper	tushím
Dendrexetastes	*rufigula*	Cinnamon-throated Woodcreeper	kuíntam
Xiphocolaptes	*promeropirhynchus*	Strong-billed Woodcreeper	apu kuíntam
Dendrocolaptes	*picumnus*	Black-banded Woodcreeper	kuíntam
Xiphorhynchus	*ocellatus*	Ocellated Woodcreeper	kuíntam
Xiphorhynchus	*guttatus*	Buff-throated Woodcreeper	kuíntam
Xiphorhynchus	*triangularis*	Olive-backed Woodcreeper	kuíntam
Lepidocolaptes	*lacrymiger*	Montane Woodcreeper	kuíntam
Lepidocolaptes	*albolineatus*	Lineated Woodcreeper	kuíntam
Cymbilaimus	*lineatus*	Fasciated Antshrike	tsejechík
Taraba	*major*	Great Antshrike	aénts págka
Thamnophilus	*schistaceus*	Plain-winged Antshrike	págka
Thamnophilus	*cryptoleucus*	Castelnau's Antshrike	
Thamnophilus	*caerulescens*	Variable Antshrike	
Thamnophilus	*unicolor*	Uniform Antshrike	págka
Dysithamnus	*mentalis*	Plain Antvireo	
Thamnomanes	*ardesiacus*	Dusky-throated Antshrike	
Thamnomanes	*caesius*	Cinereous Antshrike	
Pygiptila	*stellaris*	Spot-winged Antshrike	
Epinecrophylla	*haematonota*	Stipple-throated Antwren	
Epinecrophylla	*spodionota*	Foothill Antwren	
Epinecrophylla	*erythrura*	Rufous-tailed Antwren	
Myrmotherula	*brachyura*	Pygmy Antwren	chunchuíkit
Myrmotherula	*hauxwelli*	Plain-throated Antwren	
Myrmotherula	*axillaris*	White-flanked Antwren	kunchácham
Myrmotherula	*schisticolor*	Slaty Antwren	
Myrmotherula	*longipennis*	Long-winged Antwren	ujushkutam
Hypocnemis	*peruviana*	Peruvian Warbling-Antbird	wáakiam
Cercomacra	*cinerascens*	Gray Antbird	
Cercomacra	*nigrescens*	Blackish Antbird	kunchácham

Cercomacra	*serva*	Black Antbird	
Pyriglena	*leuconota*	White-backed Fire-eye	
Myrmoborus	*myotherinus*	Black-faced Antbird	ujikíach
Myrmochanes	*hemileucus*	Black-and-white Antbird	
Schistocichla	*leucostigma*	Spot-winged Antbird	chíjikiau
Myrmeciza	*hemimelaena*	Chestnut-tailed Antbird	mujaya chíjikiau
Myrmeciza	*atrothorax*	Black-throated Antbird	
Myrmeciza	*melanoceps*	White-shouldered Antbird	
Myrmeciza	*hyperythra*	Plumbeous Antbird	
Pithys	*albifrons*	White-plumed Antbird	kuncháu
Pithys	*castaneus*	White-masked Antbird	
Gymnopithys	*leucaspis*	Bicolored Antbird	kuncháu
Rhegmatorhina	*melanosticta*	Hairy-crested Antbird	
Hylophylax	*naevius*	Spot-backed Antbird	
Willisornis	*poecilinotus*	Scale-backed Antbird	
Grallaricula	*flavirostris*	Ochre-breasted Antpitta	
Grallaricula	*ferrugineipectus*	Rusty-breasted Antpitta	
Phyllomyias	*cinereiceps*	Ashy-headed Tyrannulet	
Myiopagis	*caniceps*	Gray Elaenia	
Elaenia	*flavogaster*	Yellow-bellied Elaenia	
Elaenia	*albiceps*	White-crested Elaenia	
Ornithion	*inerme*	White-lored Tyrannulet	
Mecocerculus	*poecilocercus*	White-tailed Tyrannulet	
Serpophaga	*cinerea*	Torrent Tyrannulet	
Phaeomyias	*murina*	Mouse-colored Tyrannulet	pakitagtag
Pseudotriccus	*pelzelni*	Bronze-olive Pygmy-Tyrant	
Corythopis	*torquatus*	Ringed Antpipit	
Phylloscartes	*ophthalmicus*	Marble-faced Bristle-Tyrant	
Phylloscartes	*ventralis*	Mottle-cheeked Tyrannulet	
Mionectes	*olivaceus*	Olive-striped Flycatcher	
Mionectes	*oleagineus*	Ochre-bellied Flycatcher	
Myiornis	*albiventris*	White-bellied Pygmy-Tyrant	
Myiornis	*ecaudatus*	Short-tailed Pygmy-Tyrant	pakitagtag
Hemitriccus	*zosterops*	White-eyed Tody-Tyrant	
Todirostrum	*cinereum*	Common Tody-Flycatcher	
Todirostrum	*chrysocrotaphum*	Yellow-browed Tody-Flycatcher	timpemush
Rhynchocyclus	*olivaceus*	Olivaceous Flatbill	
Platyrinchus	*mystaceus*	White-throated Spadebill	
Platyrinchus	*coronatus*	Golden-crowned Spadebill	
Platyrinchus	*platyrhynchos*	White-crested Spadebill	
Myiophobus	*fasciatus*	Bran-colored Flycatcher	
Myiobius	*villosus*	Tawny-breasted Flycatcher	
Myiobius	*atricaudus*	Black-tailed Flycatcher	tagkuík
Terenotriccus	*erythrurus*	Ruddy-tailed Flycatcher	
Neopipo	*cinnamomea*	Cinnamon Manakin-Tyrant	jinimcham
Lathrotriccus	*griseipectus*	Gray-breasted Flycatcher	
Contopus	*cooperi*	Olive-sided Flycatcher	
Contopus	*fumigatus*	Smoke-colored Pewee	piasha
Contopus	*nigrescens*	Blackish Pewee	
Sayornis	*nigricans*	Black Phoebe	bishkig

Myiotheretes	*striaticollis*	Streak-throated Bush-Tyrant	
Myiozetetes	*similis*	Social Flycatcher	
Myiozetetes	*luteiventris*	Dusky-chested Flycatcher	
Pitangus	*sulphuratus*	Great Kiskadee	kántut, kistun
Pitangus	*lictor*	Lesser Kiskadee	
Myiodynastes	*maculatus*	Streaked Flycatcher	
Tyrannus	*melancholicus*	Tropical Kingbird	suiwiwi
Sirystes	*sibilator*	Sirystes	
Attila	*spadiceus*	Bright-rumped Attila	
Pipreola	*frontalis*	Scarlet-breasted Fruiteater	
Pipreola	*chlorolepidota*	Fiery-throated Fruiteater	
Rupicola	*peruvianus*	Andean Cock-of-the-rock	súgka
Lipaugus	*vociferans*	Screaming Piha	paípainch
Rhytipterna	*simplex*	Grayish Mourner	
Xipholena	*punicea*	Pompadour Cotinga	
Cephalopterus	*ornatus*	Amazonian Umbrellabird	unkumsúgka
Tyranneutes	*stolzmanni*	Dwarf Tyrant-Manakin	wiíshamaw
Machaeropterus	*regulus*	Striped Manakin	pinchínam
Lepidothrix	*coronata*	Blue-crowned Manakin	shítagkui
Manacus	*manacus*	White-bearded Manakin	tashíjim
Chiroxiphia	*pareola*	Blue-backed Manakin	
Xenopipo	*holochlora*	Green Manakin	apu wiísham
Pipra	*pipra*	White-crowned Manakin	
Pipra	*erythrocephala*	Golden-headed Manakin	achayáap
Tityra	*semifasciata*	Masked Tityra	étsa
Laniocera	*hypopyrra*	Cinereous Mourner	
Pachyramphus	*polychopterus*	White-winged Becard	
Piprites	*chloris*	Wing-barred Piprites	
Hylophilus	*ochraceiceps*	Tawny-crowned Greenlet	
Hylophilus	*hypoxanthus*	Dusky-capped Greenlet	
Cyanocorax	*violaceus*	Violaceous Jay	kíjuancham
Tachycineta	*albinenter*	White-winged Swallow	kayashuhimpit
Microcerculus	*marginatus*	Nightingale Wren	tiigkísh
Troglodytes	*aedon*	House Wren	kúshukush
Thryothorus	*coraya*	Coraya Wren	
Thryothorus	*leucotis*	Buff-breasted Wren	
Henicorhina	*leucosticta*	White-breasted Wood-Wren	chuíchuig
Cyphorhinus	*arada*	Musician Wren	
Microbates	*cinereiventris*	Tawny-faced Gnatwren	tsanchíim
Ramphocaenus	*melanurus*	Long-billed Gnatwren	tsanchíim
Polioptila	*plumbea*	Tropical Gnatcatcher	
Myadestes	*ralloides*	Andean Solitaire	
Catharus	*ustulatus*	Swainson's Thrush	kúpi
Entomodestes	*leucotis*	White-eared Solitaire	
Cichlopsis	*leucogenys*	Rufous-brown Solitaire	
Turdus	*leucops*	Pale-eyed Thrush	
Turdus	*ignobilis*	Black-billed Thrush	yaukupau
Turdus	*maranonicus*	Marañon Thrush	
Turdus	*albicollis*	White-necked Thrush	
Schistochlamys	*melanopis*	Black-faced Tanager	
Schistochlamys	*ruficapillus*	Cinnamon Tanager	
Cissopis	*leverianus*	Magpie Tanager	píshi

Creurgops	*verticalis*	Rufous-crested Tanager	
Trichothraupis	*melanops*	Black-goggled Tanager	
Tachyphonus	*cristatus*	Flame-crested Tanager	
Tachyphonus	*surinamus*	Fulvous-crested Tanager	wampagkít
Tachyphonus	*luctuosus*	White-shouldered Tanager	wampagkít
Tachyphonus	*rufus*	White-lined Tanager	
Lanio	*fulvus*	Fulvous Shrike-Tanager	sechai
Ramphocelus	*nigrogularis*	Masked Crimson Tanager	chágke
Ramphocelus	*carbo*	Silver-beaked Tanager	kanampúsh
Thraupis	*episcopus*	Blue-gray Tanager	suísh
Thraupis	*palmarum*	Palm Tanager	
Calochaetes	*coccineus*	Vermilion Tanager	
Wetmorethraupis	*sterrhopteron*	Orange-throated Tanager	inchítuch
Iridosornis	*reinhardti*	Yellow-scarfed Tanager	
Tangara	*nigrocincta*	Masked Tanager	tsánu
Tangara	*cyanicollis*	Blue-necked Tanager	
Tangara	*xanthogastra*	Yellow-bellied Tanager	dashípkit
Tangara	*chilensis*	Paradise Tanager	semanchúk
Tangara	*gyrola*	Bay-headed Tanager	písumanch
Tangara	*schrankii*	Green-and-gold Tanager	bakakít
Tersina	*viridis*	Swallow Tanager	chaís
Dacnis	*lineata*	Black-faced Dacnis	tsejémna
Dacnis	*flaviventer*	Yellow-bellied Dacnis	
Dacnis	*cayana*	Blue Dacnis	
Cyanerpes	*caeruleus*	Purple Honeycreeper	jémpekit
Chlorophanes	*spiza*	Green Honeycreeper	ukúshkit
Hemithraupis	*flavicollis*	Yellow-backed Tanager	makuikuishi
Conirostrum	*sitticolor*	Blue-backed Conebill	
Conirostrum	*albifrons*	Capped Conebill	
Diglossa	*mystacalis*	Moustached Flowerpiercer	
Diglossa	*albilatera*	White-sided Flowerpiercer	págka
Saltator	*grossus*	Slate-colored Grosbeak	wichikaut
Saltator	*maximus*	Buff-throated Saltator	tsayag
Ammodramus	*aurifrons*	Yellow-browed Sparrow	
Sporophila	*murallae*	Caqueta Seedeater	nagchijam
Oryzoborus	*angolensis*	Chestnut-bellied Seed-Finch	
Arremon	*aurantiirostris*	Orange-billed Sparrow	bashukit
Piranga	*flava*	Hepatic Tanager	
Piranga	*rubra*	Summer Tanager	pichukít
Piranga	*olivacea*	Scarlet Tanager	
Habia	*rubica*	Red-crowned Ant-Tanager	
Cyanocompsa	*cyanoides*	Blue-black Grosbeak	
Parula	*pitiayumi*	Tropical Parula	
Setophaga	*ruticilla*	American Redstart	
Geothlypis	*aequinoctialis*	Masked Yellowthroat	
Wilsonia	*canadensis*	Canada Warbler	chichakaim
Basileuterus	*luteoviridis*	Citrine Warbler	
Phaeothlypis	*fulvicauda*	Buff-rumped Warbler	bijankísh
Psarocolius	*decumanus*	Crested Oropendola	
Cacicus	*cela*	Yellow-rumped Cacique	teesh
Icterus	*mesomelas*	Yellow-tailed Oriole	
Icterus	*chrysocephalus*	Moriche Oriole	
Euphonia	*laniirostris*	Thick-billed Euphonia	

Euphonia	*mesochrysa*	Bronze-green Euphonia	táma
Euphonia	*minuta*	White-vented Euphonia	táma
Euphonia	*xanthogaster*	Orange-bellied Euphonia	
Euphonia	*rufiventris*	Rufous-bellied Euphonia	kanaritsáka

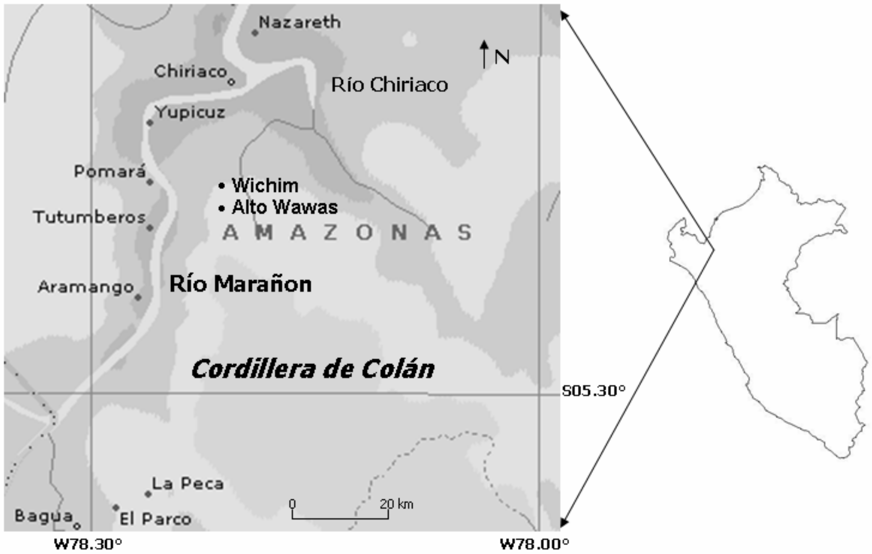

Figure 4.1. Map of study area in the north-west Cordillera de Colán, Peru.

Figure 4.2. Pink-throated Brilliant (*Heliodoxa gularis*), March 2005.

Figure 4.3. Castelnau’s Antshrike (*Thamnophilus cryptoleucus*), March 2005.

Figure 4.4. Active nest of White-plumed Antbird (*Pithys albifrons)*, 17 February 2005

Figure 4.5. Egg of White-plumed Antbird (*Pithys albifrons)*, 17 February 2005.

CHAPTER 5

FIRST DESCRIPTION OF THE NEST OF BROWN NUNLET *NONNULA BRUNNEA*[1]

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[1] N. Dauphiné, A. Tsamajain Yagkuag, and R. J. Coooper. 2007. Cotinga 28: 78-79. Reprinted here with permission of the publisher, 4/16/08.

The Brown Nunlet *Nonnula brunnea* occurs in humid lowland forest east of the Andes, from south-east Colombia to northern Peru[3]. Whilst this species is not classed as threatened by BirdLife International, it appears to be rare throughout its range[1,2,3,5.] On 21 October 2004, we found a nest of Brown Nunlet near quebrada Wawas (c.05°18'S 78°20'W; elevation c.550 m), a shallow, fast-running river that drains into the río Chiricao, dpto. Amazonas, northern Peru. Whilst walking a trail near the west bank of the river, we observed an adult Brown Nunlet flush silently from below the spiked prop roots of a c.6 m palm in dense primary forest understorey, to a branch c.10 m up in a tree c.10 m distant. We then discovered its nest in a shallow burrow at the base of the palm, hidden amongst the stilt root mass (Figure 5.1). A horizontal tunnel underneath the decayed leaf litter, c.25 cm long and 8 cm wide, led to the nest cavity; the tunnel entrance was partially hidden by dead leaves (Figure 5.2). The bottom of the burrow was lined with decayed leaf litter and contained an unmarked white oval egg that we visually estimated at 25 × 20 mm and a young nestling, its eye-slit beginning to open and its skin grey covered with white down. Burrow height above the nest cup was 54.3 mm, and the nest cup measured 69.1 mm deep by 77.7 mm wide. Following an inspection of > 2 minutes, we replaced the leaf litter over the tunnel. We then observed that the adult, still on its perch watching us silently, had been joined by another, perched c.50 cm away on the same branch, which we assumed was its mate. We returned on 25 October 2004, and briefly checked the nest whilst the adults were absent; the unhatched egg was still present and the nestling had grown larger, its pin-feathers were beginning to break through their sheaths and its eyes were partially open. When we returned on 2 March 2005, we found the nest empty but still intact.

Nothing is known of the breeding biology of the Brown Nunlet, one of six species in a genus of small, inconspicuous puffbirds (Bucconidae)[4]. Breeding data for many Bucconidae appear to be unavailable; however, other described nests were also in burrows in the ground or in arboreal termitaria, and other known eggs are white[4].

ACKNOWLEDGEMENTS

Daniel M. Brooks alerted us to the lack of any nest description for this species. We are grateful for research funding provided by Conservation International, the University of Georgia, the Georgia Ornithological Society, the Tinker Foundation and the Warnell School of Forestry and Natural Resources. We thank the Comunidad Nativa de Wawas, Anexo Wichim, for hosting fieldwork and the Instituto Nacional de Recursos Naturales (INRENA) for permission to conduct research. For additional support, we thank Anika Mahoney, Oscar Beingolea, Segundo Tsamajain Yagkuag, Oscar Tsamajain Shiwig, Miguel & Wilfredo Aguilar Torres, Flor Idiáquez Acevedo, Flor & Jaso Angulo, José Lirio, Juan Díaz Alván and José Alvarez Alonso. Finally, we thank a Harold Greeney for his valuable comments on the manuscript.

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Figure 5.1. Entrance tunnel to burrow nest of Brown Nunlet; entrance is visible in center foreground (Nico Dauphiné)

Figure 5.2. Inactive nest of Brown Nunlet, photographed after removal of the entrance tunnel (Nico Dauphiné)

CHAPTER 6

A NEW LOCATION AND ALTITUDE FOR ROYAL SUNANGEL *HELIANGELUS REGALIS* [1]

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[1] Dauphiné, N., A. Tsamajain Yagkuag and R. J. Cooper. Accepted by *Cotinga*. Reprinted here with permission of the publisher, 4/16/08.

Royal Sunangel *Heliangelus regalis* was previously known from five localities in northern Peru, in a very small range where suitable habitat is declining[1–4]. It is consequently classified as Endangered on the IUCN Red List by BirdLife International[1]. Records are from forest-edge shrubbery, typically on sandy soils, in humid elfin scrub at 1,350–2,200 m[2]. We conducted intermittent searches for Royal Sunangel between July 2004 and March 2005 in the north-west Cordillera de Colán, dpto. Amazonas, northern Peru, in conjunction with a project to survey regional birds[5]. Vegetation in the north-west Cordillera de Colán is mainly characterised by low to mid-altitude humid tropical cloud forest interspersed with scattered agricultural fields, with elfin forest on some exposed ridges (Figure 6.1).

We conducted a total of 49 field-hours of searches for Royal Sunangel over c. 25 km of trails in two locations in the north-west Cordillera de Colán that were determined to host elfin forest[5]. We made a total 16 sightings of at least five male Royal Sunangels on six different days between 3 August 2004 and 23 February 2005 at both survey locations. We recorded the locations of our sightings using a global positioning system (GPS). Sightings took place about 80 km from the nearest previously published location for this species in the south-east Cordillera de Colán[4]. Sightings were of individuals and groups of 2–3 males at altitudes from 550 m up to 700 m a.s.l.. This is a significant expansion of its previously known altitudinal range, indicating this species may be less restricted to mid and high altitudes than previously thought.

Fourteen of our 16 Royal Sunangel sightings occurred in cloud-elfin transitional forest above the rural settlement of Duran (05º15'S 78º22'W), on 20 and 26–28 October 2004. We observed individuals in flight, briefly perching in trees and vines on rocky outcrops c.10 m above the ground, foraging on flowers <10 m off the ground. They fed on at least two flowering plants, one of them matching the description of the flowering melastome *Brachyotum quinquenerve*[3], whilst the other was a thin liana reaching c.10 m, with horizontal pinkish-violet tubular flowers. Sunangels were also observed sallying for insects from exposed perches on rocky outcrops, returning repeatedly to the same perch, and several male–male chases were observed near favoured perches. One male gave a series of high-pitched calls on returning to a perch after approaching us and hovering for several seconds at eye-level at a distance of c.2 m.

We made two additional sightings of individual male Royal Sunangels in edge habitat between cloud-elfin transitional forest and agricultural clearings in Wichim (05º16'S 78º20'W), about 7 trail km from our sighting locations in Duran, on 3 August 2004 and 23 February 2005. Single males were seen approaching, hovering and flying away in edge habitat between cloud-elfin transitional forest and agricultural clearings, at c.600–700 m.

Our sightings on 27 October included at least one individual that appeared to be a juvenile male, as indicated by iridescent dark green feathers on the throat and belly[3]. This is consistent with previous records that suggest the breeding season of this species takes place between July and September[1,6]. We did not detect any Royal Sunangels on a return visit on 7 March 2005, when the foodplants were not in flower. Males may prefer higher altitudes and different nectar sources than females, at least seasonally[4]. No females of this species were detected during our surveys.

The habitat of Royal Sunangel in Wichim is relatively well-protected by Aguaruna-Jívaro residents from colonization by new immigrants and associated forest destruction[5]. Its habitat in Duran (Figures 1 and 2), however, is potentially threatened by forest clearing for agriculture and pasture. Protection of this location would benefit this species as well as an Oilbird *Steatornis caripensis* colony near where the Royal Sunangels were found.

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Figures 6.1. Elfin forest in Duran near where Royal Sunangel was found. This area is threatened by clearing for pasture and agriculture (Nico Dauphiné).

CHAPTER 7

BIRD CONSERVATION IN AGUARUNA-JÍVARO COMMUNITIES IN THE CORDILLERA DE COLÁN, PERU[1]

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[1] Dauphiné, N., S. Tsamajain Yagkuag and R. J. Cooper. *Ornitologia Neotropical* 19 (Suppl.): 587-594. Reprinted here with permission of the publisher, 4/24/08.

ABSTRACT. During July 2003 and March 2005 we conducted field research on birds in the Cordillera de Colán in collaboration with two indigenous Aguaruna-Jívaro communities in an area previously unexplored by ornithologists, using field surveys, mist net sampling, and interviews with local residents. We detected 315 bird species, including the globally threatened and near-threatened species Royal Sunangel (*Heliangelus regalis*), Orange-throated Tanager (*Wetmorethraupis sterrhopteron*), and Olive-sided Flycatcher (*Contopus cooperi*). Aguaruna collaborators exhibited substantial knowledge of bird taxonomy, ecology, and behavior. We observed a low rate of deforestation in Aguaruna communities and a high rate of forest clearance in adjacent areas recently colonized by immigrants from elsewhere in Peru. Forest within Aguaruna territories currently appears to be protected from large-scale destruction by existing management practices and a general prohibition on immigration. We expect that extensive deforestation and overhunting in recently colonized areas elsewhere in the Cordillera de Colán will continue in the absence of effective conservation action. Conservation initiatives by Aguaruna communities include a moratorium on hunting a number of bird species whose populations were perceived to be in decline due to overexploitation, and the designation of a 7000 ha reserve where logging, forest clearance, and human settlement is prohibited. Aguaruna residents of the Cordillera de Colán appear to be motivated conservationists of forest birds, due in part to their concern with long-term forest protection and to the high cultural value traditionally placed on birds.

INTRODUCTION

An isolated mountain range in northern Peru, the Cordillera de Colán (Fig. 1) is one of the most important centers of bird endemism in Peru and a global priority area for bird conservation (Davies *et al.* 1997, Myers *et al.* 2000, BirdLife International 2005). The northern

Cordillera de Colán is part of a semi-autonomous territory controlled by Aguaruna-Jívaro residents who are its indigenous inhabitants. The Cordillera de Colán is located just east of the arid Marañón river valley, which is a major barrier to dispersal of birds restricted to humid montane forests (Parker *et al.* 1985). Biogeography in this region is extremely complex and bird species diversity correspondingly high (Cracraft 1985). Four Endemic Bird Areas (EBAs) intersect on the Cordillera de Colán, including the Andean Ridge-top Forests where the majority of our fieldwork took place (Davies *et al.* 1997, BirdLife Interantional 2005). In 2002 the government of Peru established the 64,115 ha Zona Reservada Cordillera de Colán to protect a number of threatened, range-restricted and endemic species in a remote, high altitude region of the northern Cordillera de Colán that remains uninhabited and largely inaccessible by people. (APECO 2005).

Despite field expeditions to adjacent areas (Fitzpatrick *et al.* 1977, Berlin & Prance 1978, Parker *et al.* 1985, Davis 1986, Hornbuckle 1999), the ecology of the Cordillera de Colán remains poorly known (Davies *et al.* 1997, Rodriguez & Young 2000). Prior ornithological research has focused on high altitudes in the southern part of the mountain range, which has been colonized by agrarian settlers (cf. Weske & Terborgh 1977, Schulenberg & Williams 1982, Graves *et al.* 1983, Davies *et al.* 1997, Johnson & Jones 2001). During the past several decades, these colonists have implemented rapid, large-scale deforestation, which appears to continue unabated (Davies *et al.* 1997, BirdLife International 2005).

To our knowledge, no systematic ecological surveys have been carried out in the reserve, or, until now, in the northern Cordillera de Colán or any other land under Aguaruna control. This is probably partly due to its remoteness and partly due to the fact that the Aguaruna as a cultural group have a reputation for fierceness and indomitability and a history of sensitive relations with settlers and visitors to the region (cf. Larson & Dodds 1985, Stap 1990). On the other hand, Aguaruna residents tend to be exceptional local collaborators in ecological field research, as they exhibit substantial knowledge of bird taxonomy, ecology and behavior, and their knowledge corresponds strongly to scientific taxonomy and findings on bird ecology and behavior (Berlin *et al.* 1983, Boster *et al.* 1986, Berlin 1993, Jernigan & Dauphiné in prep., N. Dauphiné, pers. observ.). Birds occupy a prominent position in traditional Aguaruna culture as central figures in folklore. Birds are described as having had human form before they became birds, and men are described as having been able to fly (Chumap Lucía & García Rendueles 1979). Many folk tales demonstrate Aguaruna traditional knowledge of bird ecology; an example is a story where a toucan (*Ramphastos sp.*), a secondary cavity-nester, requests and is given a home by a woodpecker (*Campephilus sp.*) (Chumap Lucía & García Rendueles 1979). Birds are also highly valued for their use in subsistence and traditional ornamentation (Berlin & Berlin 1983, Berlin 1993).

The Aguaruna occupy one of the many remote areas in the world where insufficient scientific information currently exists to formulate wildlife management decisions. Our premise is that in this situation, Aguaruna ecological knowledge can serve as a useful, complementary data source to current scientific knowledge of the region (Huntington 2000, Gilchrist *et al.* 2005). Our purpose in documenting Aguaruna ecological knowledge in this context is to bring to light and apply an additional source of reliable data to contribute to more informed decisions for conservation in the region (Gilchrist & Mallory 2007).

Traditional ecological knowledge, which may resemble adaptive management in its emphasis on dynamic responses to change, can make significant contributions to the understanding and conservation of biodiversity by scientists and resource managers (Gadgil *et al.*

1993, Berkes *et al.* 2000). Particularly in remote areas, indigenous knowledge can surpass scientific knowledge, such as in the case of Bedouin people in Syria who demonstrated that a bird species thought extinct by scientists did in fact persist in the wild (Serra 2003). However, according to one survey, only 0.1% of recently published ornithological or wildlife management articles incorporated ecological knowledge (Gilchrist & Mallory 2007). We find this doubly unfortunate, if potentially valuable contributions to our knowledge of ecological systems in remote areas are being neglected together with valuable opportunities to collaborate with the people who make decisions that affect conservation on the ground. Our aim in this paper is to present Aguaruna ecological knowledge of an area virtually unknown to science to complement scientific data collection, as well as to enhance opportunities for collaboration with the Aguaruna people adjacent to a new protected area in its future management and monitoring.

METHODS

Between 30 July 2003 and 26 March 2005, we conducted bird surveys in collaboration with two Aguaruna communities, the Comunidades Nativas de Wawas–Anexo Wichim and Alto Wawas (hereafter, Wichim and Alto Wawas, respectively), located 10–20 km north of the Zona Reservada Cordillera de Colán. We surveyed birds in and adjacent to the Andean Ridge-top Forests EBA, named as an urgent priority for conservation and research due to moderate habitat loss and poor knowledge of its ecology (BirdLife International 2005) Fieldwork was focused in low and mid-altitude tropical moist montane forest and elfin forest in the north-western part of the mountain range, south of the confluence of the Marañon and Chiriaco rivers. We made additional surveys in the adjacent areas of Duran and La Peca, which are controlled by agrarian colonists. During the course of surveys, we made incidental observations on land-use patterns, regional harvest pressure and other local threats and/or conservation efforts directed toward regional birds. We also conducted group and individual interviews with residents about the presence of particular bird species in the study area, their habitat, ecology, and behavior, population trends, land-use patterns, awareness of the new protected area in the area, and attitudes towards conservation and any actions taken for the pupose of conservation. We had in-depth interviews with 11 individuals, nine of whom were men between the ages of 32 and 84 (six of them Aguaruna and three of them mestizo) and two of whom were women (one Aguaruna and one mestizo), and briefly interviewed several dozen Aguaruna and mestizo residents of the area during the course of our travel and fieldwork.*Study design*. Table 7.1 summarizes survey and sampling efforts made during four expeditions to the Cordillera de Colán between 31 July 2003 and 26 March 2005. Over 12 weeks of fieldwork at five sites, we conducted a total of 349 field hours of surveys and 2064 net hours of mist net (10 x 10 m by 3 m, 36 mm mesh) sampling for birds in cloud forest, elfin forest, secondary forest, and agricultural habitats. A field hour is defined as one hour of field observation carried out by one or more people; a net hour is defined as the operation of a single mist net for one hour. Areas surveyed included elfin forest and humid montane forest on foothills and lower mountain slopes. Surveys were primarily diurnal.

Study sites. La Peca (5.36ºS 78.26ºW) is a rural settlement of several thousand people, mainly recent Andean colonists, located c. 15 road km northeast of Bagua (5º38'S, 78º32'W). Wichim (5º16'S, 78º20'W) is an Aguaruna community of c. 120 people, located c. 95 road and trail km northeast of Bagua. Alto Wawas (5º19'S, 78º20'W) is an uninhabited Aguaruna territory managed by residents of the neighboring communities of Wichim and Sukutin in the Comunidad Nativa de Wawas (S. Tsamajain Yagkaug, pers. com.). Duran is a settlement of several hundred colonists immediately west of Wichim; elfin forest (hereafter, Duran Elfin Forest) occurs on the mountain at Duran's eastern boundary on the west bank of the Wawas river at 5º15'S, 78º22'W.

Elfin forest also occurs on an uninhabited mountain northeast of Wichim (hereafter, Wichim Elfin Forest) at 5º15'S 78º19'W up to a summit of c. 1200 m a.s.l. (N. Dauphiné, pers. observ.).

RESULTS AND DISCUSSION

We detected a total of 315 bird species during our surveys, including including the globally threatened and near-threatened species Royal Sunangel (*Heliangelus regalis*), Orange-throated Tanager (*Wetmorethraupis sterrhopteron*), and Olive-sided Flycatcher (*Contopus cooperi*), and informants reported the presence of a number of additional species not detected in our surveys. The complete species list is presented elsewhere (Dauphiné *et al.* in prep.) and is also available from corresponding author upon request. We found large areas of intact low to mid altitude tropical moist montane and elfin forest in Aguaruna territories in the northern Cordillera de Colán, and large areas of extensively deforested mid altitude montane and elfin forest in land occupied by recent immigrants to the region. The intact forest within Aguaruna territories currently appears to be effectively protected from large-scale deforestation by existing management practices. We expect that extensive habitat loss in recently colonized areas of the Cordillera de Colán will continue in the absence of effective conservation action.

In contrast to the lack of harvest pressure on birds reported by Davies *et al.* (1997), we found direct and anecdotal evidence of extensive human predation on birds in the Cordillera de Colán. Birds commonly hunted by Aguaruna residents for subsistence include species of Tinamidae, Cracidae, Columbidae, Psittacidae, and Ramphastidae (N. Dauphiné, pers. observ.). Aguaruna residents are known to harvest Spotted Sandpiper (*Actitis maculari*), Amazonian Oropendula *Gymnostinops bifasciatus*, and some species of Trochilidae and their eggs (Larson & Dodos 1985, K. Jernigan pers. com.). Both Aguaruna and colonist residents reported observing declines in some bird populations including species of Cracidae and Psittacidae, which they attributed to overhunting. There are no protective measures for the majority of harvested bird species in the Cordillera de Colán. While colonist residents reported observing the decline and disappearance of a number of bird species due to overhunting and habitat destruction, no conservation action appeared to have been taken to attempt to mitigate these trends. By contrast, Aguaruna authorities recently prohibited the hunting of some birds, including Andean Cock-of-the-Rock (*Rupicola peruana*), Blue-headed Parrot (*Pionus menstruus*) and other species of Psittacidae, in response to perceived population declines due to overhunting; they have also designated a 7000 ha nature reserve in Alto Wawas where logging, forest clearance, and human settlement is prohibited (S. Tsamajain Yagkuag, pers. com.).

An Oilbird (*Steatornis caripensis*) colony in Duran Elfin Forest is under intense harvest pressure by local people and appears to be threatened with extirpation. Oilbirds are widespread in the Neotropics, but are extremely vulnerable to human predation and habitat destruction (Roca 1994). The Oilbird colony in Duran is located on land that previously belonged to Aguaruna people but that was claimed by the state of Peru c. the 1960s and opened for colonization shortly thereafter. In the past, Aguaruna people regularly harvested juvenile birds during the end of the breeding season (March–May); now settlers also harvest nestlings, increasing the harvest pressure on the colony, and the encroaching deforestation and influx of new immigrants pose an increasing threat to this Oilbird population (A. Tsamajain Yagkuag, pers. observ.). According to Aguaruna residents, local people now harvest every juvenile from every nest that may be reached. The number of nests that remain inaccessible to human predation is unknown, but appears to be the only factor limiting the complete reproductive failure of this colony. While Holyoak and Woodcock (2001) report that protection exists or is planned for Oilbird colonies in

Peru, the local Oilbird colony remains entirely unprotected from intensive exploitation and appears likely to decline or disappear in the near future (A. Tsamajain Yagkuag, pers. observ.).

Birds are also locally hunted in Aguaruna communities for use in ornamentation, traditional medicine, and the pet trade. Birds used in traditional ornamentation include Andean Cock-of-the-Rock, Paradise Tanager (*Tangara chilensis*) and other species of Thraupidae, and species of Ramphastidae, among many others. Birds locally harvested for use in traditional medicines include Sunbittern *Eurypyga helias* and Slate-colored Grosbeak *Saltator grossus* (A. Tsamajain Yagkuag pers. observ.). Birds locally harvested for the pet trade include Yellow-tufted Woodpecker (*Melanerpes cruentatus*) and other species of Picidae, Shiny Cowbird (*Molothrus bonariensis*), Painted Parakeet (*Pyrrhura picta*) and other species of Psittacidae, and species of Columbidae and Ramphastidae; parrots may be trapped at a clay lick in the neighboring community of Sukutin (N. Dauphiné pers. observ.). Hunting for the pet trade appears to be uncommon in Wichim and Alto Wawas, and very few Aguaruna residents of these communities appear to keep birds as pets; however, we observed many wild-caught bird kept as pets by colonist residents in the adjacent areas of Duran, Imaza and Bagua.

While all the Aguaruna people we interviewed were aware of the Zona Reservada Cordillera de Colán, residents we interviewed in the surrounding colonist settlements, almost without exception, did not appear to be aware of its existence (N. Dauphiné, pers. observ.). The designation and categorization of the Zona Reservada Cordillera de Colán is an important conservation step, but does not in itself guarantee protection of the wildlife or habitat within its limits. An investment in local environmental education and management will be necessary to ensure that the reserve will achieve a real measure of protection.

The Peruvian government has a stated objective of increasing participation of indigenous people in protected area management (World Bank 2000). Such efforts should ideally include further documenting Aguaruna knowledge of regional bird taxonomy and ecology, and investigating local populations of and effecting conservation measures for globally threatened species such as Royal Sunangel and Orange-throated Tanager, as well as locally threatened species, such as Oilbird. Effective conservation in the Cordillera de Colán will require investing in reserve staff and infrastructure, educating local settlers about the value of the new reserve and of protecting area biodiversity, and researching and promoting sustainable alternatives to resource management practices that currently threaten the unique cultural and biological heritage of this region. Aguaruna residents, with their demonstrated competence as both field ecologists and land managers, have great potential to make valuable contributions as partners in any regional conservation efforts.

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TABLE 7.1. Survey and sampling effort in the Cordillera de Colán

Site	Dates	Field h	Net h	Elevation (m a.s.l)
La Peca	22–26 July 2004	20	–	900–1400
Wichim	30 July–2 August 2003, 29 July–7 August 2004, 12–31 October 2004, 4 February–22 March 2005	197	1548	400–900
Alto Wawas	2–6 August 2004, 13–30 October 2004, 20 February–26 March 2005	83	516	550–1000
Duran Elfin Forest	20–30 October 2004, 7 March 2005	33	–	500–1000
Wichim Elfin Forest	3 August 2004, 13 February–16 March 2005	16	–	600 –1200

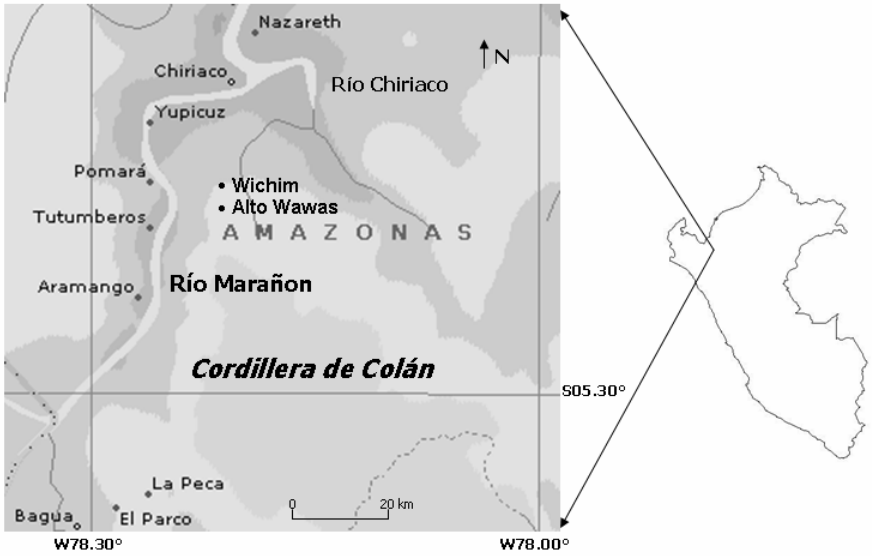

Figure 7.1. Map of the study region in the Cordillera de Colán

CHAPTER 8

CONCLUSIONS AND CONSERVATION RECOMMENDATIONS

Birds may serve as catalysts for conservation because they act as umbrella species, whose protection may benefit a wide range of less visible coexisting species, and as flagship species, whose aesthetic and ecotourism appeal help garner popular interest. This examination of birds' responses to logging in northern Peru is intended to contribute both to science and to the development of policies for protected areas and conservation planning. Recommendations based on this research should benefit not only the regional bird species most affected by logging, but also the host of other organisms with which they interact, the forests they support, and the people who depend on them. A very brief summary of findings and recommendations appears below.

What are the short to mid-term responses of white-sand forest understory birds to non-mechanized logging? In Allpahuayo-Mishana National Reserve, Peru, I used a capture total of 54 bird species in 16 taxonomic families to estimate community responses to logging. Estimated bird species richness was highest in unlogged forest and lowest in forest regenerating 1-2 years post-logging. Canopy cover was significantly higher in unlogged forest stands compared to logged forest stands. Ten years after logging, bird species richness and canopy cover remained significantly lower in logged forest than in unlogged forest. Since laws are already in place that prohibit commercial logging in the reserve, I recommend that the appropriate authorities in Peru act to step up law enforcement by hiring and training additional protected area personnel to patrol and enforce laws in the reserve. Unless they do, I expect that logging activities will continue to threaten the reserve’s white-sand forest flora and fauna, which includes many endemic and range-restricted species.

What are the short-term responses of white-sand forest understory birds to non-mechanized logging? Timber harvest methods employed by Aguaruna-Jívaro communities in the northern Cordillera de Colán appear to be the lowest impact commercial logging practices on record. Logged forests 4-5 years postharvest had a significantly greater estimated number of species (118) compared to logged forest 1-2 years postharvest (74), while there was no significant difference between the number of species in primary forest (89) and that in either logged forest treatment. However, I estimated that 28-30% of unlogged forest understory bird species were absent from logged forest between 1 and 5 years postharvest. This loss in species was offset by an influx of colonizing species that made up an estimated 22-36% of total species logged forest and increased with time since logging. Thus, while logging did not result in overall declines in species richness in the short to mid-term period after logging, it did result in differences in species composition between primary and logged forest stands, suggesting that a long term recovery period is necessary for many primary forest bird species to repopulate logged forest, even when reduced-impact logging methods are used. This study provides a working example of reduced impact timber harvest methods in humid tropical forest, and also demonstrates some important and lasting effects logging practices may have on tropical forest understory birds, even when reduced impact methods are used and logged stands are surrounded by large tracts of unlogged forest.

What are the results of bird surveys and incidental observations of threats and opportunities for bird conservation in the north-west Cordillera de Colán, dept. Amazonas, northern Peru? During 12 weeks of field surveys and mist net sampling in 2004 and 2005, I documented a total of 306 species, including 7 wintering Nearctic migrants. Surveys took place within two adjacent indigenous Aguaruna-Jívaro territories, Wichim and Alto Wawas, which are largely composed of humid tropical forest with elfin forest on some outlying ridges. Theses communities currently appear to be protected from most human immigration and associated large-scale habitat destruction. Findings represent new locations and/or range extensions for a number species known from elsewhere in western Amazonia. Records of juveniles and active nests of some species represent evidence of breeding for some species whose breeding ecology is poorly known. My surveys were not exhaustive, such that these findings represent only a partial list of birds expected to be present in the region, and future surveys should detect additional species, particularly of noctural and rare birds. I recommend that Aguaruna residents of these communities play a role in managing the recently designated protected area, the Zona Reservada Cordillera de Colán. Their extensive knowledge of biodiversity and effective management practices should benefit conservation in the reserve, and they should benefit from increased engagement with formal conservation efforts in Peru.