Composition and abundance of birds in Andean alder (Alnus acuminata) patches with past and present harvest in Bolivia

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ABSTRACT

We compared species richness and abundance of birds between five patches under selective Alnus exploitation and five patches that have not been harvested for at least 10 years prior to our study, during the early dry season (April–July 2001), in Cotapata National Park. Using “point counts” we recorded birds and their distribution in two (<1.5 m and >1.5 m) forest layers. Simultaneously we evaluated the floristic structure (size [dbh] distribution, basal area, tree density, tree height, and vegetation cover) and composition (diversity) on three transects placed within each Alnus patch. Both bird diversity and vegetation cover were significantly higher in not presently used patches but only for the higher layer of the forest, whereas plant diversity was higher in presently used patches. Lack of differences between the two types of Alnus patches in any of the vegetation parameters measured in the lower layer was coupled with an indistinct avifauna. Small changes in habitat characteristics following a perturbation like selective logging have the potential to affect richness and abundance of birds, at least within the habitats directly affected by the perturbation.

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1. Introduction

Selective logging is the most common timber extraction method in tropical regions (Macedo and Anderson, 1993; Mason, 1996; Putz et al., 2001; Uhl and Guimaraes, 1989), where this activity is considered potentially sustainable and economically viable (Lewis, 2001). In Bolivia, approximately 50% of the national territory is covered with tropical forest subject to selective harvest (Fredericksen, 2001).

The primary impacts of selective logging are changes in forest structure, in particular changes can be observed in: diametric (DBH) distribution, increased gap areas (and a related decrease in cover), and more heterogeneous habitats (Johns, 1985; Fredericksen, 2001). These changes may be similar to those produced by natural disturbances that allow the maintenance of primary forest species richness, in fact disturbance can be a major contributor to species enrichment through the maintenance of a diversity of microhabitats and associated taxa (Thiollay, 1992; Flores et al., 2000). However, when the intensity of wood extraction is high, it may result in ecosystem changes where fauna is often the most affected (Halffer, 1983; Lima and Gascon, 1999). Depending on a variety of factors related to the intensities of logging, spatial scales, forest intervention modes, and the characteristics of the focal taxa, the effects of forestry activities might be more or less similar to natural disturbances (Putz et al., 2000). It is clear that selective logging induces structural changes that are accompanied
both by drastic population changes for a variety of taxa and, in some cases, the natural biodiversity may not be main-
tained (Guariguata, 1998).

Birds are commonly the first group of vertebrates to show a response to selective logging (Johns, 1988). Changes in hab-
itat may affect the birds' reproductive processes, with result-
ing changes in demographic parameters such as rates of birth, death, migration, and extinction (Riffell et al., 1996). Species diversity changes of birds have been reported in sev-
eral studies, with higher species richness in primary as op-
posed to selectively logged forests (Johns, 1985, 1991; Thiiollay, 1992; Mason, 1996; Riffell et al., 1996; Marsden, 1997; Raman et al., 1998, 2001). Some studies report that nei-
erth all species nor assemblages of birds respond in the same 
way to changes in vegetation structure: their response is rel-
nated to the natural history of the species and to both the type 
and intensity of the changes in habitat (Johns, 1985; Hansen 
et al., 1993). Even low intensity logging may significantly af-
fect understory bird assemblages (see Barlow et al., 2006 for a review). Changes in an historic assemblage of birds should be strongly related to significant changes in vegetation com-
position and structure because vegetation changes mean a 
reduction in both foraging space and resource availability 
(Bierregard, 1990; Johns, 1991; Thiiollay, 1995; Putz et al., 
2000). In spite of the many studies reporting the effect of 
selective logging on birds, we are aware of none that deals 
with this problem for tropical montane forests.

In the humid montane forests (Yungas) of Bolivia, a com-
mon disturbance is selective logging (Ribera-Arismendi, 1995). Selective logging occurs on both private lands and in 
protected areas, such as Cotapata National Park. It is impor-
tant to note that most protected areas in Bolivia harbour hu-
man populations who are entitled to traditional schemes of 
natural resource use. However, most of these activities are 
not currently monitored and their ecological consequences 
are not known. Andean alder (Alnus acuminata, Betulaceae) 
is among the preferred species by local people within Cota-
pata National Park and its wood is used mainly for the man-
ual elaboration of handles for agricultural tools. Andean alder 
is a fast growing tree and colonizer of riverside, landslide, 
landslide, and secondary vegetation sites (Halloy, 1996). Wood 
is extracted with axes, and finished handles are transported 
on llamas and horses to the city of La Paz, where they are sold 
in seasonal markets (González and Hinojosa, 1999). Local 
users indicate that most patches of Andean alder (Alnus here-
after) can be harvested at intervals of ≥ 10 years, and that 
probably most, if not all, Alnus patches within Cotapata Na-
tional Park have been exploited at some time in the past. 
Therefore, a quantitative evaluation of the effect of harvest-
ing would have to be based on the comparison of presently 
exploited patches with those not presently exploited but 
exploited in the past, at least 10 years prior to our study.

Our study addressed the following question: What differ-
ces exist in the richness and abundance of birds between 
Alnus patches currently under selective exploitation and 
patches that have not been harvested for at least 10 years 
in Cotapata National Park? Given that Alnus harvesting af-
facts vegetation structure, we predicted that structural 
changes should result in presently exploited patches having 
lower bird species richness, and that changes in the abun-
dance of bird species should be related to each species nat-
ural history.

2. Methods

2.1. Study area

The study was carried out in cloud forests within the “Parque 
Nacional y Área Natural de Manejo Integrado Cotapata” (Cotapata 
National Park and Natural Area of Integrated Management, 
Cotapata NP hereafter) Bolivia; 68°02'S–16°20'W, 68°03'S– 
16°05'W, 63°43'–16'10'NE and 67°47'–16'18'SW. Cloud forests 
within Cotapata NP are found between 3600 and 2400 m above 
sea level and are characterized by fog, rain, and frequent driz-
zles (Ribera-Arismendi, 1995). Mean annual temperatures 
range between 11 and 12 °C. Plant diversity is high, dominated 
by gnailed trees, usually covered by mosses, lichens, and other 
epiphytes. Common families include Melastomataceae, Rosae-
ceae, Compositae, and Fieraceae. Canopy height ranges be-
tween 10 and 15 m, with emergent trees up to 30 m. The 
understory is very dense and rich in lianas, bamboo (Chusquea 
sp.), grasses, bromeliads, and orchids (Ribera-Aris-
smendi, 1995).

Alnus patches are poor in terms of species numbers and 
most of the ground herbs and shrubs are widely distributed 
weedy species. The reason for this low diversity is not clear, 
but the young age of the forest patches may play a role. Alnus 
acuminata is an ideal component in silvopastoral systems as 
the nitrogen fixed by the bacteria in root nodules help to 
maintain soil fertility, and the young, protein rich leaves serve 
as fodder for animals. Decomposing leaves collected in an-
dean alder forest serve as fertiliser for crops and as growth 
substrate in plant nurseries. The most important product 
from Alnus is its wood (Stahl et al., 1997).

Alnus in Cotapata NP is distributed between 2000 and 
3200 m, mostly occupying old landslide or fire disturbance 
areas, where it is the dominant tree species. Undergrowth 
of these patches is relatively open compared to the surround-
ing high diversity old-growth cloud forest. Due to thin foliage 
in Alnus stands, light conditions are favorable for an under-
growth community typically dominated by 1–2 m tall herbs 
and bushes of Liabum sp., Eupatorium sp., Viguiera sp., 
Baccharis primera y Bidens andicola, Cuphea sp., Tillandsia sp., 
Chusquea permacoee, Anthurium sp., Epidendrum sp., Oxalis sp., 
Hydrocotyle acuminata, Lycopodium sp. However, the epiphytes tend to 
be poorly developed. Altogether, these features made the vis-
ibility of birds easy within Alnus patches.

Alnus comprise an average of 70% of the individual trees of 
these patches, other tree species present were Gaultheria sp., 
Vaccinium sp., Cauendishia sp., Piperr elongatum, Miconia sp., Myr-
sine sp., Clethra sp., Collaea speciosa, Peperomia galoideos, Dioscorea 
sp., Prymoria sp., Adiantum sp., Smilax sp. Most trees at our study 
sites, including Alnus, were covered by lichens (mainly Usnea 
sp.) and mosses. Canopy height ranged between 4 and 8 m, 
with a few emergent trees up to 12 m. For the purposes of this 
study, we defined two different layers in the Alnus patches: a 
lower layer (less than 1.5 m), and higher layer (above 1.5 m).

Bird diversity of cloud forests in the Cotapata NP include 
285 registered species, and includes endemic species of Bolivia 
such as Coeligena torquata inca, Coeligena violifor violifer, Ochtho-
eca frontalis boliviana, Myioborus melanocephalus bolivianus,
Chlorospingus ophthalmicus bolivianus, Iridosornis yelskii boliviana and Diglossa mystacalis mystacalis. (Martínez, 1999). Alnus patches in other countries in South America harbor between 48 and 65 bird species (Vides, 1985; Poulsen, 1996; Fjeldsa and Krabbe, 1997). We recorded 55 species at our study sites, including the endemics C. torquata, C. viioljfer, M. melanocephalus, and C. ophthalmicus. These patches may be considered rich given the small proportion (probably less than 5%) of this type of habitat within cloud forests at Cotapata NP.

For the study, 10 Alnus patches were selected in the Chucura-Tiquimani region, close to the center of the Cotapata NP. Five patches were under selective exploitation at the time of our study (presently used patches = PU), whereas the other five patches had not been harvested for at least 10 years prior to our study (not presently used patches = NPU). Selected patches had similar topography (slopes between 30° and 45°), and elevation (2600–2800 m). All patches faced to the northeast and did not differ significantly in size (range 2–7 ha; \( U = -1.048; n = 10; p > 0.3 \)). Study patches were selected during a preliminary visit in February 2001 and observations were made in the early dry season during 10 days per month in the same year. Tree density did not change during the study because local people agreed not to cut any trees within that interval.

2.3. Bird species diversity and abundance

The vegetation structure in the Alnus patches was based on bibliographical information on birds’ diet (Fjeldsa and Krabbe, 1990; Martínez, 1999; Stotz et al., 1996). These results are illustrated only in graphic form, given the low number of replicates to run an ANOVA. Finally, we assessed the differences between presently used patches (PU) and not presently used (NPU) patches in both abundance of birds separating the higher layer (>1.5 m) and lower layer (<1.5 m). Observations were made at one hour intervals between 07:00 and 11:00 hours, and only under good environmental conditions, avoiding continuous rains, fast winds, and fog. We did not record passing birds due to the unknown relationship between these birds and the Alnus patches. Neither crepuscular nor nocturnal birds were considered.

Although abundance was recorded for each bird species we did not run a statistical comparison for each species, to avoid increasing the \( x \) levels. To assess the differences in abundance of birds (absolute counts) between treatments, we used a Sign test (Siegel and Castellan, 1995). To further illustrate differences, we used rank-abundance graphs. First we calculated a proportion of each species for each patch type at forest layer: \( p_i = n_i/n \), where: \( n_i = \) number of individuals of species “i” in sample, and \( n = \) total number of individuals in sample. Then we calculated the logarithm of each \( p_i \) value. The abscissa is “rank of species from most to least abundant”. The ordinate is \( log_{10} p_i \). With rank-abundance graphs we can compare all biologically important aspects of species diversity among samples (Feinsinger, 2001). In our study we compared lower layer birds between PU and NPU and also higher layer birds between PU and NPU.

We also compared the guild composition between PU and NPU based on bibliographical information on birds’ diet (Fjeldsa and Krabbe, 1990; Martínez, 1999; Stotz et al., 1996). These results are illustrated only in graphic form, given the low number of replicates to run an ANOVA. Finally, we assessed the differences between presently used patches (PU) and not presently used (NPU) patches in both abundance of birds separating them by their sensitivity to habitat disturbances (high, medium, and low) following Stotz et al. (1996).

3. Results

3.1. Vegetation characterization

Plant diversity in the higher layer was significantly greater in PU (median of \( H’ \) index = 3.06; range = 2.7–3.4) than in NPU patches (median = 2.37; range = 1.37–2.73, \( U = -2.193, n = 10, p < 0.05 \)). For lower layer plants, diversity did not differ between PU (median = 2.1, range = 1.6–2.7) and NPU patches (median = 1.7, range = 1.6–1.9, \( U = -1.061, n = 10, p = 0.3 \)). The vegetation structure in the Alnus patches did not differ between PU and NPU, for any of the other variables measured (Table 1 and Fig. 1), except for vegetation cover at the higher layer, which was greater for NPU patches (Table 1 and Fig. 2).
3.2. Bird species diversity and abundance

A total of 1180 individual birds of 55 species (18 families) were recorded during the study (Table 2). Birds were observed using different kinds of resources, but more frequently were observed foraging either within Alnus foliage, lichens of Alnus trunks, and at Alnus’ inflorescences. Some birds used Alnus patches as perching or nesting sites. More (62.4%) individuals were counted within NPU patches, where the number of species (52, median = 27, range = 23–29) was also significantly greater than in PU patches (36 species, median = 19, range = 13–22, \( U = 2.611, n = 10, p < 0.01 \)). Thirty three species (60%) were common to both NPU and PU patches; only three species were exclusively recorded in PU patches, whereas 19 species were recorded only in NPU patches. Considering vegetation strata, only five species were exclusively recorded in the lower layer, whereas 25 species were exclusively recorded in the higher layer, and 20 species were common to both layers (Table 2).

### Table 1 - Vegetation diversity and structure in presently used (PU) and not presently used (NPU) Alnus patches in the Cotapata National Park, Bolivia

<table>
<thead>
<tr>
<th>Vegetation structure</th>
<th>PU (n = 5)</th>
<th>NPU (n = 5)</th>
<th>Mann–Whitney test</th>
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<tr>
<td></td>
<td>Median</td>
<td>Range</td>
<td>Median</td>
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<td><strong>H’ diversity (higher layer)</strong></td>
<td>3.1</td>
<td>2.7–3.4</td>
<td>2.4</td>
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<td><strong>H’ diversity (lower layer)</strong></td>
<td>2.1</td>
<td>1.6–2.7</td>
<td>1.7</td>
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<tr>
<td>Higher layer cover (%)</td>
<td>59.1</td>
<td>23.5–69.5</td>
<td>65.7</td>
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<tr>
<td>Lower layer cover (%)</td>
<td>54.4</td>
<td>18.8–57.7</td>
<td>50.5</td>
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<td>Density (ind/m²)</td>
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<td>0.10–0.13</td>
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<td>Height (m)</td>
<td>5.3</td>
<td>2.5–10.0</td>
<td>4.8</td>
</tr>
<tr>
<td>DAP (cm)</td>
<td>11.8</td>
<td>2.9–33.2</td>
<td>10.3</td>
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<tr>
<td>Basal area (cm²/m²)</td>
<td>2.7</td>
<td>1.6–14.7</td>
<td>3.2</td>
</tr>
</tbody>
</table>

Fig. 1 – Diametric distribution (DBH) of trees in presently used (PU) and not presently used (NPU) Alnus patches in the Cotapata National Park.

Fig. 2 – Higher layer species vegetation cover (%) at: (a) higher and lower layer, and (b) Alnus vs. other species cover at higher layer in presently used (PU) and not presently used (NPU) Alnus patches in the Cotapata National Park.
Table 2 – Relative abundance, diet (by Fjeldsa and Krabbe, 1990; Martínez, 1999), sensibility (by Stotz et al., 1996) of bird species registered in presently used (PU) and not presently used (NPU) Alnus patches in the Cotapata NP, Bolivia

<table>
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<th>Sensibility</th>
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<th>Higher layer</th>
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<tr>
<td>Parulidae</td>
<td>Basiluterus signatus</td>
<td>i</td>
<td>l</td>
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<td>Total</td>
<td></td>
<td></td>
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i: insectivore; f: frugivore; n: nectarivore; h: higher; m: medium; l: lower.

A total of 292 individual birds of 25 species were recorded during the study in the lower layer (Table 2). Seventeen species were common to both NPU and PU patches. Five species (Metallura tyrannithina, Margarornis squamiger, Scytalopus parvirostris, Mionectes striaticollis, and Anisognathus igniventris) were exclusively recorded in PU patches and only three species (Colibri serrirostris, Catamblyrhynchus diadema, and Basileuterus signatus) were exclusively recorded in NPU patches. Bird species diversity did not differ for the lower layer between NPU (median S-W index = 0.89, range = 0.77–1.24) and PU patches (median SW index = 0.84, range = 0.77–1.01, U = –0.83, p = 0.40). Similarly, bird species richness for the lower layer did not differ between NPU, where 20 species were recorded (median = 9, range = 8–13), and PU patches, where 22 species were recorded (median = 10, range = 9–12, U = –1.01, n = 10, p = 0.314). Individual species absolute counts show no differences between Alnus patches, where 12 species were more frequently recorded in PU, 11 species were more frequently recorded in NPU, and two species were equally abundant in both types of patches (Sign test, p = 1.00; Fig. 3a).

3.2.2. Higher layer birds
A total of 888 individual birds of 50 species were recorded in the higher layer of the Alnus forest patches (Table 2). Twenty seven species were common to both NPU and PU patches, 21 species were exclusively recorded in NPU patches, while just two species were recorded only in PU patches. Bird diversity (H’ index) was slightly lower at PU (median = 1.01, range = 0.79–1.06) than at NPU patches (median = 1.16, range = 0.97–1.25; U = –1.886; n = 10; p = 0.05). Bird species richness was also higher in NPU patches, where 48 species (median = 26, range = 22–27) were recorded against 29 species (median = 16, range = 9–19; n = 10, U = –2.627, p < 0.01).

Fig. 3 – Rank–abundance curves of birds in presently used (PU) and not presently used (NPU) Alnus patches at (a) lower <1.5 m and (b) higher >1.5 m layers. (ai: Anisognathus igniventris; am: Adelomyia melanogenys; ar: Atlapetes rufinucha; as: Anisognathus somptuosus; bs: Basileuterus luteoviridis; bt: Buarremon torquatus; ca: Conirostrum albifrons; cd: Catamblyrhynchus diadema; cf: Columba fasciata; cg: Coeligena violifera; ch: Chlorospingus ophthalmicus; cm: Contopus fumigatus; co: Coeligena torquata; cr: Chlorornis riefferii; cs: Colibri serrirostris; ct: Colibri thalassinus; cv: Cyanolyca viridicauda; dc: Delothraupis castaneoventris; dg: Diglossa caerulescens; dy: Diglossa cyanea; e: Elaenia sp.; ea: Elaenia albiceps; eg: Eriocnemis glaucopoides; eo: Elaenia obscura; hc: Hemispingus calophrus; hm: Hemispingus melanotis; hs: Hemispingus superciliiarius; ll: Lepidocolaptes lacrymiger; mb: Myioborus brunneiceps; mh: Mecocerculus hellmayri; ml: Mionectes striaticollis; m: Mecocerculus leucophyds; mn: Myioborus melanocephalus; ms: Margarornis squamiger; mt: Metallura tyrannithina; or: Ochthoeca rufimaculata; ot: Ochthoeca thoracica; pa: Pipreola arcurva; pb: Pseudocolaptes boissonneaultii; pc: Pterophanes cyanopterus; pm: Penelope montagnii; pn: Pyrrhomyias cinzamomea; pr: Piculus rufiloli; ps: Premnoplex brunnescens; sa: Synallaxis azarae; sp: Scytalopus parvirostris; tc: Thraupis cyanopechula; tf: Turdus fuscater; tn: Tangara nigroviridis; tp: Trogon personatus; tr: Thlypopsis ruficeps; ts: Troglodytes solstitialis; tv: Tangara vassorii; tx: Tangara xanthocephala).
in PU patches. Species absolute counts were generally greater in NPU patches (40 species), while only seven species had absolute counts higher in PU, and three species were recorded similar number of times (Sign test = -4.668, p < 0.01, Fig. 3b).

3.2.3. Composition of guilds and birds’ sensitivity to disturbance
We have identified seven guilds occurring in Alnus patch: frugivores, frugivores–insectivores, frugivores–nectarivores, insectivores, insectivores–frugivores, nectarivores and ±1.96*Std. Err.

Mean

Fig. 4 – Number of individuals by guild in (a) higher (>1.5 m) and (b) lower (<1.5 m) forest layers at presently used (PU) and not presently used (NP) Alnus patches in Cotapata National Park.

±1.96*Std. Err.

Mean

Fig. 5 – Number of bird species with high, medium and low sensibility to habitat disturbance in (a) higher (>1.5 m) and (b) lower (<1.5 m) forest layers at presently used (PU) and not presently used (NP) Alnus patches in Cotapata National Park.
nectarivores–insectivores. Most (78%) of the birds recorded at Alnus patches have partially or totally insectivorous diets, and these birds were the most clearly affected by selective logging (Fig. 4). Most of the bird species recorded have medium sensitivity to disturbance, and our observations suggest that this group is the most affected by wood harvesting activities (Fig. 5).

4. Discussion

Our study, with five replicates per treatment, temporal and spatial subsampling for each replicate, and controlling for potentially confounding factors (elevation, slope, and exposition) suggest that differences in plant diversity and vegetation cover between presently used (PU) and not presently used (NPU) patches can be attributed to selective logging. This assumption is further supported by the fact that differences in bird species richness and abundance between PU and NPU patches were found only for the higher layer, where differences in vegetation diversity and structure were also evident, whereas undifferentiated lower layer harbour indistinct assemblages of birds.

It is somewhat puzzling why presently used Alnus patches did not differ from those not presently used in attributes such as size (DBH) structure, basal area, height and density of trees. Although statistically significant differences between PU and NPU patches were absent, it is worthwhile considering that absolute measurements for the biomass-related parameters tree density and basal area were consistently larger in NPU than PU (see Table 1). This allows us to speculate that biomass is actually affected by harvesting of Alnus although such differences where not detected by the study, probably because of a small effect size for the power of our test, related to the small sample size. An additional, non-excluding explanation is that more evident effects of harvesting may be detected as harvesting itself continues. No data were available about either the duration or intensity of the harvesting within presently used patches.

Although the effects of selective harvesting on both Alnus density and vegetation structure seem to be rather low, the consequences on the bird community appear very clear. This may be due to the tight relationship between the birds’ communities and the floristic structure and composition of their habitats (Pearson, 1977), which may be influenced by changes in the vegetation following a perturbation. These authors point out that bird diversity is positively correlated to availability of resources. Therefore, it is possible that selective harvesting of Alnus results in a reduced availability of resources for birds, affecting in this way their diversity and abundance. The fact that most of the affected birds (absent from – or decreased abundance in – PU patches) were insectivorous coincides with this explanation. Although the higher plant diversity found within PU patches might result in a higher diversity of insects, the reduction in vegetation cover probably leads to a decreased abundance of insects, producing a shortage of food resources for insectivorous birds. Furthermore, it is reasonable that most bird species using Alnus patches have insectivorous diets because these habitats are highly dominated by Alnus trees, which provide neither edible fruits nor nectar for birds. In fact, there is an important group of invertebrates, mainly Lepidoptera, Hemiptera, Diptera, Hymenoptera, Coleoptera, Arachnida, living associated to Alnus trees (Vides, 1985).

Our study also supports earlier observations that contend that most forest bird species persist in logged forests, although often in reduced numbers (Johns, 1985, 1991; Thiol-lay, 1992; Mason, 1996; Riffell et al., 1996; Marsden, 1997; Ram-an et al., 1998, 2001). However, previous studies found that changes in both the bird assemblage and the vegetation characteristics as a consequence of logging occur mainly in the lower (understory) layer (Levey, 1988; Mason, 1996; Marsden, 1997), which is opposite to what we report here. It has been argued that selective logging generally reduces the forest’s basal area and opens the higher layer, allowing light to reach the forest floor. This results in a lower layer which is hotter, drier, and denser than higher layers of the forest. Our results suggest that selective logging in Alnus patches affects vegetation cover and plant diversity only at the higher level and those changes are determinant factors influencing the bird assemblage. As explained above, changes in the bird assemblage may be due to changes in resource availability. Any change in resource availability forces a response in bird populations according to their habitat requirements, as was observed in tropical as well as temperate sites (Johns, 1991; Tobalske et al., 1991). In a recent study, Soh et al. (2006) found that montane forest birds in Malaysia are highly sensitive to canopy cover reductions, which is similar to our findings.

Clearly, not all species respond in the same way to changes in vegetation structure following a perturbation and their responses will be conditioned by their natural history and the type of changes suffered in the landscape (Hansen et al., 1993). Therefore, it is important to consider the species’ sensitivity to perturbations of the environment. A literature review suggests that differences in the fragility of forest bird–faunas may be related to the long-term stability of the respective areas (Fjelds and Krabbe, 1997). For example, it is suggestive that species considered “in risk of extinction”, such as Hemispingus calophrys (Rocha and Quiroga, 1996), or highly sensitive to anthropogenic changes, such as Trogon personatus and Penelope montagnii (Lambert, 1992), were not recorded in presently exploited Alnus patches. On the other hand, those species that were more frequently recorded in presently exploited patches are considered flexible to perturbation of their habitats or frequent inhabitants of disturbed habitats, such as Columba fasciata (Stotz et al., 1996). That most species affected by logging in our study were actually categorized as of medium sensitivity to disturbance only highlights that the habitat under observation is not prime habitat for all bird species of the cloud forest. This seems an obvious outcome given that Alnus patches are an early successional phase of the forest.

The most common response of birds to environmental changes following selective logging is an alteration in their abundance (Canaday, 1997; Marsden, 1997). It has been suggested that species abundance patterns in communities are a useful indicator of forest disturbance (Fjelds and Kessler, 1999). This is supported by our finding that most (75%) of the species common to both types of patches, were more frequently recorded in those not presently exploited. Birds more frequently recorded at the NPU, such as Premnoplex
brunnescens, Pseudocolaptes boissonneautii, Mecocerculus hellmayri, Buarramon torquatus, Catamblyrhynchus diadema, and Hemispingus calophrys, are highly sensitive to perturbations (Stotz et al., 1996), and usually occur in primary forest (Fjeldså and Krabbe, 1990). On the other hand, some species recorded in both types of Alnus patches, such as Colibri thalassinus, Synallaxis azarae, Atlapetes rufinucha, and Thylogypsis ruficeps, are very common in montane forest and less sensitive to perturbations (Stotz et al., 1996; Fjeldså and Krabbe, 1990), but were recorded more frequently in NPU patches, suggesting that even generalist species may be affected by selective logging. Loiselle and Blake (1992) point that the variation in the abundance of birds in a community depends on the species’ capacity to cope with changes following habitat perturbations. The fact that many species were less frequently recorded in presently exploited Alnus patches coincides with this view. In any event, it is important to emphasize that a small change in habitat characteristics associated with selective Alnus logging appears to result in large differences in bird species diversity and abundance.

The landscape or regional effect of the changes occurring within Alnus patches are impossible to assess with our data. However, some possible scenarios can be drawn from other studies. Putz et al. (2000) point out that numerous key ecological processes, such as pollination, herbivory, seed dispersal, and predation, are all probably affected by logging. Birds participate in all of these ecological processes; thus, changes in the assemblage of birds probably affect all of them, with probable strong effects on the community structure and succession pathways within Alnus patches. Of course, it is possible that bird species richness remains unchanged at the landscape or regional levels, despite changes within Alnus patches. However, it is also possible that ecological functioning of those bird species most affected by changes within the Alnus patches are affected at the landscape or regional levels as well. Effects of the loss of animal species on vegetation structure have been predicted (Redford, 1992; Redford and Feinsinger, 2001) and studied (Dirzo and Miranda, 1991; Pacheco and Simonetti, 1998; Pacheco and Simonetti, 2000; Roldán and Simonettij, 2001), with special reference to mammals. We do not know of any such studies for birds.

Whatever the effects at the landscape or regional levels are, our study shows that small changes in habitat characteristics following a perturbation such as selective logging, can influence the diversity and abundance of birds, at least within the habitats directly affected by the perturbation. Natural history knowledge is the key to understand and predict the different responses of birds to those changes.

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