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EFFECTS OF FIRE ON BIRDS IN PARAMO HABITAT OF NORTHERN ECUADOR

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Abstract. We studied the effects of fire on the species richness and abundance of birds in paramo habitat at the Cotacachi-Cayapas Ecological Reserve and Lake Mojanda region, Imbabura, Ecuador. We conducted monthly point counts over a 1-year period starting December 1996 in three areas that had been burned at different amounts of time prior to the start of the study: a) 2-months, b) 3-years, and c) 8-years. We identified 40 species of birds and found the greatest number of species in the 3-year and 8-year-old burns. The Giant Hummingbird (*Patagona gigas*), Azara's Spinetail (*Synallaxis azarae*), and Red-crested Cotinga (*Ampelion rubrocristatus*) were found only on the 8-year burn area. Relative abundance increased with time after a burn for half of the species found in all three habitat types. Only one species, the Paramo Pipit (*Anthus bogetensis*), decreased in abundance with increasing time after a fire. The remaining species did not differ in abundance in any of the fire treatments. Although fire generally decreases species richness and abundance for paramo bird species, species richness on a regional scale may benefit from a mosaic habitat pattern that includes fire disturbance. *Accepted 13 August 1999.*

Key words: Paramo, grasslands, Andes, Ecuador, high altitude.

INTRODUCTION

Paramos in Ecuador cover approximately 25,000 ha (Josse & Anhalzer 1996) or about 2% of the country's landcover; much of it is under heavy human pressures related to agriculture, intensive livestock management, and tourism (Caberle *et al.* 1989). Many areas are burned every 1–3 years to perpetuate early seral conditions that are favorable to cattle grazing (Laegard 1992, Pels & Verweij 1992). In addition, accidental fires are common in areas visited by humans and lightning fires may occur at unknown intervals (Ramsay & Oxley 1996).

Vegetation response to paramo fires has been well documented. Repeated burning is known to reduce plant species diversity and allow grasses to dominate (Miller & Silander 1991). Shrubs and tree patches tend to shrink in size as tussock grasses assume local dominance after repeated burns every 1–2 years (Miller & Silander 1991). Herbs and shrubs are slow to recover (Horn 1989). Tussock biomass in disturbed areas may recover to pre-fire levels within 3–5 years while previously undisturbed vegetation may recover to pre-fire conditions in more than 5 years (Ramsay & Oxley 1996). A study by Williamson *et al.* (1986) suggests that up to 10–20 years may be needed for shrub recovery depending on frequency of fire.

Vuilleumier & Simberloff (1980) documented 60 species of birds in paramo habitat

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and believed that 29 were paramo specialists. Stotz *et al.* (1996) reported 53 species in paramos. There is a paucity of information in the literature, however, on the effects of fire on bird populations in paramo habitat. Population trend data is not available and the status of many birds found in paramos or the effects of habitat loss due to fires is unknown. This study was developed to measure impacts of fires on bird populations in paramo habitat and to determine the time interval needed for bird populations to recover to pre-fire conditions.

STUDY AREA

We conducted point counts along transects through paramo habitat in the Andes of Ecuador. Four census transects were located in the paramos near Lake Cuicocha of the Cotacachi-Cayapas Ecological Reserve (CCER), Cotacachi, Ecuador (00°25'N, 78°20'W). The CCER was established in 1969 and covers over 200,000 ha that range from 100 m to nearly 5000 m above sea level. The Lake Cuicocha area receives approximately 100,000 visitors annually of which nearly 5% hike through the paramo around the lake. Two additional census transects were located adjacent to Lake Mojanda, Otavalo, Ecuador (00°08'N, 78°17'W). The Lake Mojanda region is a proposed National Recreational Area (Caberle *et al.* 1989) and is used extensively by fisherman and hikers.

Both areas fall within the Western Cordillera of the Imbabura Province, Ecuador, and are classified as Moist Subparamo according to the Holdrige life zones (Cruz 1983). Moist subparamos are an equatorial alpine grassland ecosystem. Cattle and horses have been noted on the study sites but the areas are principally used for tourism. The elevation of the study area ranges from 3500 m to 4000 m. Fire is a major disturbance factor in the area and is attributed to vandalism, ranching practices, and the result of land clearing activities outside of the study areas.

The paramos in our study area were dominated by bunchgrasses (*Festuca* sp.), shrubs (*Polylepis incana, Brachyotum alpinum, B. ledifolium, Chuquiraga jussieui, Valeriana microphylla*), small ground-level plants (*Huperzia crassa, Valeriana rigida, Lupinus* sp.) and giant rosette-plants (*Puya* sp.) (Josse & Anhalzar 1996, Luteyn *et al.* 1992). Mean temperature is 8°C and two rainy seasons occur from February to May and from October to November. Total annual rainfall ranges between 900 mm and 2600 mm (Josse & Anhalzar 1996).

METHODS

We conducted extensive point counts along six transects in three habitat types that differed in the amount of time since they were last burned. All transects were similar with respect to elevation, slope and exposure. Each transect included nine point counts. Two transects were established in an area where > 600 ha burned in November 1996 in the CCER (2-month burn; N = 18 points). Two transects were placed through paramo at Lake Mojanda that had not been burned in the previous 3 years (3-year burn; N = 18 points). A third set of transects were established through paramo in CCER that had not been burned in approximately 8-years (8-year burn; N = 18 points). Time since last burn was determined by asking local inhabitants and INEFAN (Instituto Ecuatoriano Forestal y de Areas Naturales y Vida Silvestre) Park Rangers who knew the area well.

Point counts were placed at least 250 m apart along existing trails or tertiary roads through paramos that were located at least 500 m from a major different habitat type such as a forest or lake. Counts were conducted monthly along each transect starting in December 1996 and ending in November 1997; this effectively increased our sample to

216 point counts per habitat type. Point counts were randomly assigned every month to one of the two authors, each of whom had similar experience with local bird communities. To standardize detectability of birds, we did not analyze data collected on days with winds > 20 kph or during rain.

During each 10-min point count, all birds heard and seen were registered. Relative abundance comparisons among burn sites were limited to data collected within a 50-m radius due to the hilly terrain (Ralph *et al.* 1995). Counts were conducted between 0.5 and 4.5 h after sunrise. We assumed that all birds of a species had equal detection probabilities among the treatments.

We estimated bare ground and vegetation cover to relate the changes in avian species richness and relative abundance to differences in vegetation. Ocular estimates of vegetative cover were made 6 months after the beginning of the study. All estimates were made by using gridded 1-m squares (Higgins *et al.* 1994) placed 10 m from point counts in one preselected cardinal direction. Amount of vegetation cover and bare ground was categorized in the following percent classes: 0–5, 6–25, 26–50, 51–75, 76–95, and 96–100. One measurement of the tallest grass or woody vegetation was made at each estimate.

We compared mean bird species richness among burned test plots and vegetation height with one-way ANOVA and Tukey post-hoc tests. We added all data for each census point to increase the independence of the data and to avoid pseudoreplication. The Kruskal-Wallis test was used to compare abundance within species among treatments because count data were not normally distributed (Sokal & Rohlf 1981). If these were significant ($P < 0.05$), we conducted pairwise comparisons using Mann-Whitney *U*-tests. All statistical analyses were run with SYSTAT 5.2 statistical software (Wilkinson *et al.* 1992). Nomenclature follows Ridgely *et al.* (1998).

RESULTS

Species richness. After we removed data from poor survey conditions, we analyzed results from 189 point counts in the 2-month burn, 192 point counts in the 3-year burn, and 221 point counts in the 8-year burn. We recorded 40 avian species in the high-elevation grasslands (Table 1). We removed 10 species from our data because they were not counted within 50-m of the point or had wandering habits. Of the remaining 30 species, 19 were found on the 2-month old burn, 23 were on the 3-year, and 24 on the 8-year burn (Table 2). Likewise, more species were found on average on the 3-year burn ($P = 0.0078$) and the 8-year burn ($P = 0.0078$) than on the 2-month burn site.

Thirteen (42%) species were found on all three burn sites. Three (10%) were found only on the 8-year burn and four (13%) were found on the two older burns. Four (13%) species were found only on the 3-year burn and two (6%) species occupied only the two younger burns. No species were found only on the 2-month burn. Four (13%) species were found on the younger and older burn sites but were not seen on the intermediate burn site.

We also examined the amount of time required for species recorded on the 2-month burn site to return after the fire. Of the 19 species recorded on the 2-month burn site, Many-striped Canasteros (*Asthenes flammulata*), Tawny Antpittas (*Grallaria quitensis*), and Paramo Pipits (*Anthus bogotensis)* were recorded within 2 months of the fire. In addition, Paramo Pipits were noted within 2 weeks of a fire on a burned site outside of the study area. By the third month, we recorded the Bar-winged Cinclodes (*Cinclodes fuscus),* Great Thrush (*Turdus fuscater)*, Grass Wren (*Cistothorus platensis)*, and Plumbeous Sierra-Finch (*Phrygilus unicolor*). The Brown-backed Chat-Tyrant (*Ochthoeca fumicolor)*, Plain-capped

TABLE 1. Mean number of birds heard and seen within 50-m of point counts in different aged burn areas[1]. Means followed by the same letter are not statistically different, $P > 0.05$.

Species	2-month burn	3-year burn	8-year burn
Snipe (*Gallinago* sp.)	0.01	0.01	—
Ecuadorian Hillstar (*Oreotrochilus chimborazo*)	0.01	—	0.02
Giant Hummingbird (*Patagona gigas*)	—	—	0.01
Shining sunbeam (*Aglaeactis cupripennis*)	0.00^{a}	0.07^{ab}	0.11^{b}
Great Sapphirewing (*Pterophanes cyanopterus*)	—	0.02	—
Black-tailed Trainbearer (*Lesbia victoriae*)	0.00^{a}	0.03^{ab}	0.05^{b}
Purple-backed Thornbill (*Ramphomicron microrhynchum*)	—	0.03	—
Tyrian Metaltail (*Metallura tyrianthina*)	—	0.03	—
Bar-winged Cinclodes (*Cinclodes fuscus*)	0.10^{a}	0.02^{a}	0.09^{a}
Andean Tit-Spinetail (*Leptasthenura andicola*)	0.01	0.01	—
Azara's Spinetail (*Synallaxis azarae*)	—	—	0.02
Streak-backed Canastero (*Asthenes wyatti*)	—	0.01	—
Many-striped Canastero (*Asthenes flammulata*)	0.07^{a}	0.19^{b}	0.05^{a}
Tawny Antpitta (*Grallaria quitensis*)	0.06^{a}	0.11^{a}	0.26^{b}
Tufted Tit-Tyrant (*Anairetes parulus*)	—	0.01	0.01
Brown-backed Chat-Tyrant (*Ochthoeca fumicolor*)	0.03^{a}	0.07^{a}	0.02^{a}
Black-billed Shrike-Tyrant (*Agriornis montana*)	0.01	—	0.01
Plain-capped Ground-Tyrant (*Muscisaxicola alpina*)	0.04	—	0.02
Red-crested Cotinga (*Ampelion rubrocristatus*)	—	—	0.01
Great Thrush (*Turdus fuscater*)	0.03^{a}	0.06^{ab}	0.19^{b}
Grass Wren (*Cistothorus platensis*)	0.06^{a}	0.70^{b}	0.51^{b}
Paramo Pipit (*Anthus bogotensis*)	0.21^{a}	0.22^{a}	0.02^{b}
Cinereous Conebill (*Conirostrum cinereum*)	—	0.10	0.02
Masked Flowerpiercer (*Diglossa cyanea*)	0.01^{a}	0.01^{a}	0.02^{a}
Black Flowerpiercer (*Diglossa humeralis*)	0.01^{a}	0.34^{a}	0.81^{c}
Scarlet-bellied Mountain-Tanager (*Anisognathus igniventris*)	—	0.05	0.01
Plain-colored Seedeater (*Catamenia inornata*)	0.02^{a}	0.47^{b}	0.21^{b}
Plumbeous Sirrra-Finch (*Phrygilus unicolor*)	0.14^{a}	0.08^{a}	0.16^{a}
Rufous-naped Brush-Finch (*Atlapetes rufinucha*)	—	0.01	0.03
Hooded Siskin (*Carduelis magellanicus*)	0.02	—	0.01

[1]Species recorded but not included in analysis because located > 50 m from points or due to their wandering habits: Andean Condor (*Vultur gryphus*), Black-chested Buzzard-Eagle (*Geranoaetus melanoleucus*), Red-backed Hawk (*Buteo polyosoma*), Carunculated Caracara (*Phalcoboenus carunculatus*), Andean Gull (*Larus serra-*

TABLE 2. Average and total number of species encountered per count period on each burn area. Means followed by the same letter are not statistically different ($P > 0.05$).

	2-month burn	3-year burn	8-year burn
Average	5.33[a]	9.41[b]	9.41[b]
Total	19	23	24

Ground-Tyrant (*Muscisaxicola alpina*), and Hooded Siskin (*Carduelis magellanicus*) were present within 6 months of the fire (Fig. 1).

Abundance. Of the 13 species documented on the three burn sites, four (30%) expressed no significant ($P > 0.05$) differences in abundance among the sites (Table 1). Significant abundance increased from 2-month burn to 3-year burn sites for four species including the Many-striped Canastero ($P = 0.0037$), Grass Wren ($P = 0.0001$), Black Flowerpiercer (*Diglossa humeralis*; $P = 0.0086$), and Plain-colored Seedeater (*Catamenia inornata;* $P = 0.0020$). Abundance continued to increase from the 3-year burn to the 8-year burn areas only for the Black Flowerpiercer ($P = 0.0016$). Abundances were unchanged on the 2-month and 3-year burns but increased between the 3-year and 8-year burn for the Tawny Antpitta ($P = 0.0210$). A comparison of the 2-month and 8-year burn revealed an increase or relative abundance for the Shining Sunbeam (*Aglaeactis cupripennis*; $P = 0.0064$), Black-tailed Trainbearer (Lesbia victoriae; $P = 0.0063$), and the Great Thrush ($P = 0.0084$). In contrast, the Paramo Pipit had similar abundance for the two recent burn areas but decreased from the 3-year burn to the 8-year burn ($P = 0.0002$). Similarly, the Many-striped Canastero decreased in abundance from the 3-year to the 8-year burns ($P = 0.0003$) after its initial increase.

Vegetative cover. The 2-month burn had a greater percentage of exposed ground and less grass cover than the 3-year and 8-year burn areas (Table 3). In addition, grass height was significantly lower on the 2-month burn than on the 3-year ($P = 0.0073$) and the 8-year burn areas ($P = 0.0002$). Grass height did not differ significantly between the 3-year and the 8-year burn. The percent cover of woody vegetation increased with time and height was significantly greater on the 8-year burn than on the 2-month ($P = 0.0010$) and 3-year burn ($P = 0.0434$).

DISCUSSION

Although paramo has been considered a natural type of vegetation in the high elevation areas of the Andes, its lower limits have often been extended downslope through human intervention. The true climax vegetation type of many paramo areas would be forest, but for generations it has been cleared, burned, and replaced by grassland (Ellenberg 1979, Laegaard 1992). Even near our study area, remnant forest patches remain at 4000 m in elevation. Several fires during the study period burned into the forest edges, replacing it with grass. Luteyn (1992), however, notes that regardless of origin, paramos now cover much more area than in earlier times.

Grasslands, including paramo, have relatively low avian biodiversity compared to

nus), Band-tailed Pigeon (*Columba fasciata*), Barn Owl (*Tyto alba*), White-collared Swift (*Streptoprocne zonaris*), Brown-bellied Swallow (*Notiochelidon murina*), and Streak-throated Bush-Tyrant (*Myiotheretes striaticollis*).

TABLE 3. Percent cover classes for each study site. Average grass height (cm) noted in parentheses; means followed by the same letter are not statistically different ($P > 0.05$)

	2-month burn	3-year burn	8-year burn
Bare ground	26–50	0–5	0–5
Grass	26–50 (22^a cm)	51–75 (52^b cm)	51–75 (65^b cm)
Sedge	0–5	0–5	0–5
Forb	0–5	0–5	0–5
Woody	0–5 (0^a cm)	0–5 (32^a cm)	6-25 (89^b cm)

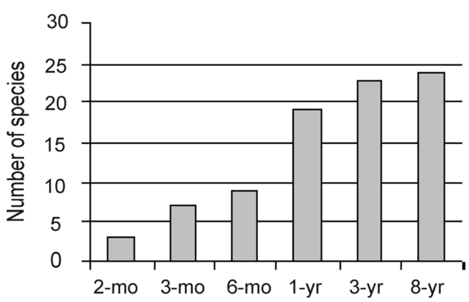

FIG. 1. Number of bird species recorded at different time intervals after a fire in paramo habitat, Ecuador.

other terrestrial habitats in the neotropics (Stotz *et al.* 1996). The distribution of birds in paramo habitat, however, is strongly influenced by fire disturbance. Our study documented changes in the bird populations after fires and we found more bird species on the older burn areas than in recently burned areas (Fig. 1). Within 6 months of burning, bird species richness was only half that on the 3-year and 8-year burn areas. After 1 year, the species richness was still substantially less than on the two older burn areas. Three years after a fire, however, the number of species nearly equaled the more mature 8-year burn site. Recovery, however, was still not fully realized after 3 years. A number of species were found only on the 8-year burn. The vegetation surveys show an increase in woody vegetation on the 8-year burn that may be required by certain species including the Giant Hummingbird (*Patagona gigas),* Red-crested Cotinga (*Ampelion rubrocristatus*), and Azara's Spinetail (*Synallaxis azarae*) which were found only on the 8-year burn.

The slow recovery of bird populations to paramo habitat is supported by the gradual increase in their relative abundance after a fire. Over 60% of the bird species recorded in all burn areas had higher abundances in the more mature paramo habitats than in the 2-month burn area. The abundance of half of these species increased most dramatically during the first 3 years after a fire. The abundance of at least one species, the Black Flowerpiercer, continued to increase significantly even after the 3-years post burn. Only four species, the Bar-winged Cinclodes, Brown-backed Chat-Tyrant, Masked Flowerpiercer (*Diglossa cyanea*), and the Plumbeous Sierra-Finch, appeared to recover within the first year and had equal abundance on all burn areas.

Although the recovery of species richness and abundance is slow for most species, we noted that two species may benefit or require fire disturbed areas. The Paramo Pipit, for example, appeared to specialize in areas that burned recently; they were not noted frequently in the 8-year burn areas with heavy growth even though one would expect their song to be readily apparent. The Many-striped Canastero also appeared to specialize in areas that are intermediate between recent fire disturbance and prolonged non-disturbance (Table 1).

In addition to overall differences in species richness and relative abundance, our study found that some species appear very localized in their distribution. The Purple-backed Thornbill (*Ramphomicron microrhynchum*), for example, was found regularly at only one count station throughout the study. The Ecuadorian Hillstar (*Oreotrochilus chimborazo*), Giant Hummingbird, Great Sapphirewing (*Pterophanes cyanopterus*), Black-billed Shrike-Tyrant (*Agriornis montana)*, Plain-capped Ground Tyrant, and Hooded Siskin were recorded repeatedly at just a few count stations. Patchy distribution patterns of birds in paramo habitat were also noted by Creswell *et al.* (1999) and Vuilleumier & Simberloff (1980). The species in our study with patchy distributions occurred in all study areas. The birds may be dependent upon micro habitats within the paramo that were not identified by the study and fire may play a key role in perpetuating that habitat.

Catastrophic impacts of fire on paramo bird populations are likely to be small due to lack of specific breeding periods. Similar to Smith (1969), we noted breeding evidence (active nests, food carries, or nesting material carries) during every month of the study. We did not encounter a peak of activity during the annual survey to suggest a distinct breeding period in the paramo. Even altitudinal migration, as reported by O'Neill & Parker (1978) and Fjeldså (1991), was not noted during our study. Only the Band-tailed Pigeon (*Columba fasciata*) formed large flocks consisting of more than several hundred individuals during one encounter in September 1997. The evidence of year round breeding, however, suggests that the effects of a catastrophic event such as a fire may be minimal on breeding birds because lost nests could be recouped throughout the rest of the year if appropriate habitat is available.

The results of this study show that fires in paramos can have varying effects on existing bird communities. Most species appear to fare better in undisturbed habitats and only the Paramo Pipit and Many-striped Canastero appear to prosper in recent post fire areas. Successional changes from paramo to forest may continue (Williamson *et al.* 1986) and further influence bird population changes in areas older than 8-years. Only 10 species in our study were considered paramo specialists by Vuilleumier & Simberloff (1980) and the rest are species that may depend on these later successional stages.

Much of the paramo near the study area and northern Ecuador is burned every 2–3 years (pers. observ.). While long term data is lacking, birds associated with the Andean grassland appear to be common and not in danger of becoming threatened (Fjeldså 1988). Extensive burning, however, reduces habitat for bird species that are associated with the less disturbed areas. Management activities that can increase the amount of time between fires may greatly benefit the birds in paramos that require less disturbed areas. Information on bird population trends and available habitat will be helpful to determine the need for specific conservation measures. Further paramo studies should also look at larger landscape patterns including patch sizes of recently burned areas and clearly identify the source and sink habitats (Dias 1996) for the different species. Studies examining even less disturbed paramo habitat are needed to determine if species richness and abundance continues to increase after 8-years post burn.

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