Gauging the Ecological Health of a Costa Rican Cloud Forest: Birds as Bio-Indicators

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Summary

As deforestation and fragmentation pose a constant threat to rainforests and the biodiversity they harbor, conservation and preservation are of the utmost importance. To evaluate the overall ecological well-being of an ecosystem and by extension its conservation priority, the degree of disturbance and fragmentation should be determined. One way of examining the disturbance status of an area is to examine the local avifauna using birds as bioindicators. The overall ecological state of the Costa Rican tropical cloud forest in which the Savegre Lodge is situated can be inferred by examining the avifauna cataloged through mist netting and observation during one week studies in March of 2003 and 2005. Because this area is a rainforest preserve which relies heavily on ecotourism, it is hypothesized that the biodiversity and health of the ecosystem have been preserved, as disturbance is kept to a minimum. Of the 116 species cataloged, 34 species were caught in the mist nets. Nine of the catalogued species are considered rare or uncommon and 13 are highly sensitive to human disturbance. The presence of a number of rare and/or highly disturbance-sensitive species at Savegre, in addition to the plethora of common species, suggests that this habitat has not been disturbed or significantly fragmented and points to the overall good health of the environment. The area around the Savegre Lodge stands as an example of a well managed reserve where biodiversity remains intact even in the presence of ecotourism.

Introduction

Deforestation and fragmentation have become issues of ever-increasing importance in tropical forests as human encroachment breaks up large tracts of forests into smaller areas. Within these smaller areas, multifaceted changes take place which affect community composition and structure. The variety of plant and animal interactions differ at the edges of fragments from the interior of the forest and some species cannot survive under edge conditions (Hagan et al. 1996).

There are a number of mechanisms behind species loss due to fragmentation. One of the most apparent of these mechanisms is the restriction of population size. This leads to a number of problems that can result in the local extinction of a species. Local extinction occurs when the reduced species population size decreases the genetic viability of the species because genetic drift and inbreeding reduce genetic variation and increase homozygosity (Turner 1996, Hagan et al. 1996). A significant population reduction could plunge the species below some minimum size needed for recovery, resulting in the local extinction of that species (Terborgh 1992).

Fragmentation also prevents or reduces immigration of new individuals into an area, which places more strain on an already reduced gene-pool, and increases the immigration of exotic species (Turner 1996, Terborgh 1992). Alien species often dominate the fragmented landscape and overwhelm native species because the native species are not tolerant of the new conditions (Turner 1996). This invasion of alien species is part of what is called the edge effect. Edge effect changes in microclimate can reduce inhabitable fragment size even more for some species (Turner 1996). Deforestation related disturbances, such as felled trees, altered water courses, and the introduction of smoke and fire into the forest, as well as higher order effects which change the dynamic of interspecies interaction, also have negative effects on biodiversity (Turner 1996, Terborgh 1992).

Therefore, in order to gauge the ecological well-being of an overall ecosystem, the degree of disturbance and fragmentation should be determined. One way of examining the overall health and disturbance status of an area is to examine the local avifauna. Birds are often used as a bioindicator because they are easy to quantify and a number of studies have outlined the effects of disturbance on tropical bird populations (Turner 1996, Terborgh 1977). The overall ecological state of the Costa Rican tropical cloud forest in which the Savegre Lodge is situated can be inferred by examining the avifauna cataloged through mist netting and observation during one week studies in March of 2003 and 2005. By examining the milieu of species composing the bird community, their abundance and distribution, one can determine if this area has suffered the effects of fragmentation. Because this area is a rainforest preserve that relies heavily on ecotourism, it is hypothesized that the biodiversity and health of the ecosystem have been preserved as disturbance is kept to a minimum.

Results

A total of 116 bird species were cataloged which represent 17 families (Table 1). Approximately thirty-eight percent of the species recorded were members of 4 families—Tyrannidae (Flycatchers), represented by 15 species; Parulidae (Warblers), represented by 11 species; Thraupidae (Tanagers and Honeycreepers), represented by 9 species; and Emberizidae (New World Sparrows, Finches, and Grosbeaks), represented by 9 species.

The majority of the cataloged species were classified by Stiles and Skutch (1989) as common or abundant with 93% of the species falling loosely into one of these categories (Table 1). Comprising the remainder of the species, however, were nine uncommon to rare species including: the Chestnut-capped Brush-finch (Atlapetes brunneinucha), the Summer Tanager (Piranga rubra), the Mountain Elaenia

1 This paper was written based on original scholarship conducted in BIO380 Tropical Ecology and Conservation, taught by Dr. Caleb Gordon.
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<td></td>
<td>Vermivora</td>
<td>chrysoptera</td>
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<td></td>
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<td></td>
<td>Breeds Alaska and Canada,</td>
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<tr>
<td></td>
<td></td>
<td>peregrina</td>
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<td></td>
<td></td>
<td>Winters S Mexico to Venezuela</td>
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<tr>
<td></td>
<td>Parula</td>
<td>gutturalis**</td>
<td>4 Medium</td>
<td></td>
<td></td>
<td>Costa Rica to W Panama</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
<td>Breeds Canada and E US,</td>
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<tr>
<td></td>
<td>Dendroica</td>
<td>virens</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>Breeds Alaska to NW US, Winters</td>
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<tr>
<td></td>
<td>Seiurus</td>
<td>motacilla</td>
<td>4 Medium</td>
<td></td>
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<td>California to Costa Rica</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Breeds Canada and US, Winters</td>
</tr>
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**Order**: Order of birds.  
**Family**: Family of birds.  
**Genus**: Genus of birds.  
**Species**: Species of birds.  
**CP**: Code of protection.  
**Sensitivity**: Level of sensitivity.  
**Geographic Range**: Geographic range of birds.
Buff-Fronted Quail-Dove (*Geotrygon costaricensis*), the Ochraceous Pewee (*Contopus ochraceus*), the Streaked Xenops (*Xenops tibialis*), the Barred Becard (*Pachyramphus versicolor*), the Buffy Tuffedcheek (*Pseudocolaptes lawrencii*), the Red-tailed Hawk (*Buteo jamaicensis*) and the Warbling Vireo (*Vireo gilvus*). All of these species, save the Warbling Vireo which is migratory, have a limited area of natural habitat ranging from Costa Rica to as far South as Northwest Amazonian Brazil.

According to the classification system of Stotz, et al. (1996), 13 of the cataloged species, representing 11% of the total number of species, are highly sensitive to human disturbance (Table 1). Sixty-seven, or 58%, of the cataloged species are moderately vulnerable to human disturbance and 36 species, or 31%, were considered to have a low sensitivity to human disturbance (Table 1). Twelve species were given a Conservation Priority rating of 3 or Medium, indicating that they are vulnerable to endangerment or extinction if present trends in habitat destruction continue. The remaining 104 species were classified with a Conservation priority reading of 4 or Low, meaning that their current population status is not at risk (Stotz, 1996). Five of the highly sensitive species—the Black Guan (*Chamaepetes uniclor*), the Buff-Fronted Quail-Dove (*Geotrygon costaricensis*), the Red-Fronted Parrotlet (*Touit costaricensis*), the Streaked-Breasted Treehunter (*Thripadectes rufobrunneus*), and the Ochraceous Pewee (*Contopus ochraceus*)—were also given a Conservation Priority rating of 3 or Medium.

Of the 116 cataloged species, 34 were netted in at least one of the netting sites—streamside, hillside, primary, or secondary forest (Table 2). The majority of the netted species are geographically distributed in the area from Southern Mexico to Peru. Only three species, the Louisiana Waterthrush (*Seiurus motacilla*), the Hairy Woodpecker (*Picoides villosus*), and the Wilson’s Warbler (*Wilsonia pusilla*) were migratory species with wide geographical distribution. Seventeen species were netted at the primary forest site, 19 at the secondary forest site, 13 at the hillside site, and 23 at the streamside site (Table 2).

**Discussion**

In previous research, relatively rare species were found to occupy fewer forest fragments than relatively common species, suggesting that rarer species are more vulnerable to local extinction than relatively common ones (Newmark 1991, Turner 1996). The presence of a number of rare and/or highly

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**Table 1**: Species observed and/or netted March 8-15, 2003 and March 8-15, 2005 in the tropical cloud forest in Costa Rica between 1500 and 3324 meters above sea-level. *Indicates species classified as uncommon or rare by Stiles and Skutch (1989). Sensitivity and Conservation Priority (CP) [1=Urgent, 2=Hight, 3=Medium, 4=Low] classified according to Stotz et al. (1996) ** Indicates species not classified in this source.

<table>
<thead>
<tr>
<th>Order</th>
<th>Family</th>
<th>Genus</th>
<th>Species</th>
<th>CP</th>
<th>Sensitivity</th>
<th>Geographic Range</th>
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<tr>
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<td>Wilsonia</td>
<td>pusilla</td>
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<td></td>
<td></td>
<td>Myioborus</td>
<td>torquatus</td>
<td>4</td>
<td>Medium</td>
<td>Winters S US to C Panama</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Basileuterus</td>
<td>melanogenys</td>
<td>4</td>
<td>Medium</td>
<td>Costa Rica to W Panama</td>
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<tr>
<td></td>
<td></td>
<td>Zeledonia</td>
<td>coronata</td>
<td>4</td>
<td>Medium</td>
<td>Costa Rica to Panama</td>
</tr>
<tr>
<td>Icteridae</td>
<td>Thraupidae</td>
<td>Amblycercus</td>
<td>holosericeus</td>
<td>4</td>
<td>Medium</td>
<td>C Mexico to NW Peru and N Bolivia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Icterus</td>
<td>gaitulia</td>
<td>3</td>
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<td>Breeds SE Canada and E US,</td>
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<td></td>
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<td>Chlorophonia</td>
<td>callophrys</td>
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<td>Tangara</td>
<td>icterocephala</td>
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<td>Thraupis</td>
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<td>Amazonian Brazil</td>
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<td></td>
<td></td>
<td>Piranga</td>
<td>rubra*</td>
<td>4</td>
<td>Low</td>
<td>Mexico to Amazonian Brazil</td>
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<tr>
<td></td>
<td></td>
<td>Chlorosspingus</td>
<td>ophthalmicus</td>
<td>4</td>
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<td>Costa Rica to W Panama</td>
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<tr>
<td></td>
<td></td>
<td>Emberizidae</td>
<td>Pheucticus</td>
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<tr>
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<td></td>
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<td>tbilialis</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>ludovicianus</td>
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<td>Medium</td>
<td>Mexico to Venezuela and Peru</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>olivea</td>
<td>4</td>
<td>Low</td>
<td>Bolivia, NW Brazil</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>bidentata</td>
<td>4</td>
<td>Medium</td>
<td>NW Mexico to W Panama</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>pileatus</td>
<td>4</td>
<td>Medium</td>
<td>Costa Rica to W Panama</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>carduelis</td>
<td>4</td>
<td>Medium</td>
<td>Costa Rica to W Panama</td>
</tr>
<tr>
<td>Fringillidae</td>
<td>Emberizidae</td>
<td>Altapetes</td>
<td>brunneinucha*</td>
<td>4</td>
<td>Low</td>
<td>Costa Rica to N Colombia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zonotrichia</td>
<td>capensis</td>
<td>4</td>
<td>Low</td>
<td>SE Mexico to Tierra del Fuego</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>xanthogastra</td>
<td>4</td>
<td>Low</td>
<td>Costa Rica to SW Ecuador and C Bolivia</td>
</tr>
</tbody>
</table>

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**Notes**

1. *Geotrygon costaricensis*—Breeds Alaska and Canada, Winters S US to C Panama
2. *Myioborus torquatus*—Medium, Costa Rica to W Panama
3. *Basileuterus melanogenys*—Medium, Costa Rica to W Panama
4. *Zeledonia coronata*—Medium, Costa Rica to Panama
5. *Amblycercus holosericeus*—Medium, C Mexico to NW Peru and N Bolivia
6. *Icterus gaitulia*—3, Medium, Breeds SE Canada and E US, Winters C Mexico to N SA
7. *Chlorophonia callophrys*—Medium, Costa Rica to W Panama
8. *Tangara icterocephala*—Medium, Costa Rica to W Ecuador
9. *Thraupis episicus*—Low, Costa Rica to W Panama
10. *Piranga rubra*—Low, Amazonian Brazil
11. *Chlorosspingus ophthalmicus*—Medium, Costa Rica to E Panama
12. *Emberizidae Pheucticus tbilialis*—Medium, Costa Rica to W Panama
14. *Emberizidae Pheucticus olivea*—Low, Bolivia, NW Brazil
15. *Emberizidae Pheucticus bidentata*—Medium, NW Mexico to W Panama
16. *Emberizidae Pheucticus pileatus*—Medium, Costa Rica to W Panama
17. *Emberizidae Pheucticus carduelis*—Medium, Costa Rica to W Panama
18. *Zonotrichia capensis*—Low, Costa Rica to W Panama
19. *Altapetes brunneinucha*—Low, Costa Rica to Panama
20. *Propyrrhopterus xanthogastra*—Low, Costa Rica to Panama

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**New Year’s Resolution**

In the new year, the Costa Rica Bird Conservation Program aims to continue its efforts in protecting and restoring the country’s unique avian biodiversity. The program focuses on several key areas:

1. **Habitat Conservation**
   - Continue to support conservation efforts in key habitats such as the cloud forest and wetlands.
   - Collaborate with local communities to promote sustainable land use practices.

2. **Species Monitoring**
   - Expand the monitoring of rare and threatened species through citizen science initiatives.
   - Collaborate with universities and research institutions to conduct more comprehensive biodiversity assessments.

3. **Education and Outreach**
   - Enhance public awareness through educational programs and workshops for both adults and children.
   - Collaborate with schools and universities to integrate bird conservation into their curricula.

4. **Policy Advocacy**
   - Advocate for policies that protect wildlife and habitats at both the national and international levels.
   - Collaborate with other conservation organizations to strengthen collective efforts.

5. **Economic Incentives**
   - Implement economic incentives to support local communities in adopting conservation-friendly practices.
   - Collaborate with the private sector to invest in conservation projects.

The Costa Rica Bird Conservation Program looks forward to partnering with other organizations and individuals to achieve these goals and ensure the survival of Costa Rica's unique avian diversity for future generations.
Table 2: Habitat distribution of netted species.

* Indicates species with a brood patch at the time of capture.

Disturbance-sensitive species at Savegre suggests that this habitat has not been disturbed to the point that fragmentation and edge effects have led to local extinction of vulnerable species. This also points to the overall good health of the forest environment there (Stotz et al., 1996). As Beier et al. (2002) concluded that species richness was conversely related to patch size, meaning that the larger the forest patch, the more diverse its avifauna, it appears that the fragment created by the PanAmerican highway remains large enough to compensate for the break.

Another indication of the lack of fragmentation and edge effects is the presence of many local species. Research indicates that in disturbed areas, alien species overwhelm and dominate the native species because the native species are not tolerant of the new conditions (Turner 1996). While 'weedy' and migratory area tolerant species, such as the Turkey Vulture (Cathartes aura), the Clay-colored Robin (Turdus grayi), and the Wilson's Warbler (Wilsonia pusilla) to name a few, are present, they are found in the same area with low tolerance, native species found only in wet, mountain forests such as the

<table>
<thead>
<tr>
<th>Species</th>
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<td>Colibri thalassinus</td>
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<td>Contopus ochraceus*</td>
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<tr>
<td>Diglossa plumbea</td>
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</tr>
<tr>
<td>Eiaenia frantzii*</td>
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<td>Empidonax flavescens</td>
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<tr>
<td>Eugenes fulgens</td>
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<tr>
<td>Henicorhina leucophrys</td>
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<td>Lampornis cinereicauda</td>
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<td>Lepidocolaptes affinis</td>
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<td>Margarornis rubiginosus</td>
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<td>Mionectes olivaceus</td>
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<tr>
<td>Mitrephanes phaeocercus</td>
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<tr>
<td>Myadestes melanops</td>
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<td>Myioborus torquatus</td>
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<td>Parula gutturalis</td>
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<td>Pezopetes capitalis</td>
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<td>Picoides villosus</td>
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<td>Premnoplex brunnescens</td>
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<td>Pselliophorus tibialis</td>
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<td>Selasphorus flammula</td>
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<td>Tangara dowii</td>
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<td>Thripadeutes rufobrunneus</td>
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<tr>
<td>Turdus plebeus</td>
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<td>Wilsonia pusilla</td>
<td>14</td>
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<td>Zeledonia coronata</td>
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</tbody>
</table>

Table 2: Habitat distribution of netted species.
Barred Forest-falcon (Micrastur ruficollis), the Dark Pewee (Contopus lugubris), and the Ochraceous Wren (Troglodytes aedon). Though some might say the presence of ‘weedy’ species is indicative of disturbance, the presence of rare species contradicts this notion. Perhaps it is the mild disturbance presented by the clearing of the lodge that provides increased species diversity, following the assertion that species diversity is greatest in areas of moderate disturbance (Connell 1978).

While most of the netted species were common, the majority prefer mountain habitat in higher elevations. The uncommon or rare netted species were the Chestnut-capped Brush-finch (Atlapetes bruneinucha), the Ochraceous Pewee (Contopus ochraceus), the Mountain Elaenia (Elaenia frantzii), and the Streaked-breasted Treehunter (Thripadectes rufobrunneus). The netting of these rare species is indicative of their local residency. In order to be netted, birds had to be present in the forest understory which means the area of the net was likely part of their home range. This indicates that these rare species are members of the forest community around Savegre and not merely passing through as could be the case with birds only observed.

The slightly higher species diversity of the streamside community perhaps reflects the greater microhabitat variation provided by the stream itself. Greater variation in microhabitat ultimately results in the presence of a greater number of niches which will ultimate be filled by a greater number of species. The Louisiana Waterthrush (Seiurus motacilla) was netted at only the streamside site because its habitat is restricted to rocky streams in forested areas (Stiles and Skutch 1989). Therefore, it is a habitat specialist species, most likely incapable of surviving in an alternate habitat in the presence of edge effects and fragmentation, as it requires forest and does not live in open areas. The presence of such specialists indicates that this ecosystem is undisturbed enough to suit such habitat specific species.

If the avifauna species cataloged during 2003 and 2005 in the Costa Rican tropical cloud forest are taken to be indicative of the overall ecological wellness, the rainforest around the Savegre Lodge can indeed be considered undisturbed and representative of optimum species diversity and forest composition. The presence of both common and rare species as well as the diversity of habitat and distribution of these birds indicates that fragmentation and edge effects have not had an impact on this forest community. Therefore, Savegre can be examined as an example of a successful conservation effort where proper management has allowed ecotourism to flourish while maintaining the health of the ecosystem.

This study gives the researchers and monitors responsible for the upkeep and conservation in the Savegre Preserve baseline data with which they can compare future species counts. Clearly, if the avifauna species diversity decreases over time, it may be the result of fragmentation, as the Beier et. al. (2002), Newmark (1991), and Hagan (1996) experiments confirm. If avifauna species diversity falls, it might indicate decreased biodiversity of the forest as a whole. Such continued species composition and diversity monitoring is a way of evaluating fragmentation and edge effects on the whole forest over time, a valuable tool when considering conservation strategies and necessities.

Materials and Methods

The study area near the Savegre Lodge, situated closely to San Gerando de Dota, Costa Rica (9 34’N; 81 43’W), lies in the northern region of the Cordillera de Talamanca, a volcanic mountain range that stretches from central Costa Rica to western Panama (Wolf et al., 1976). This site is composed of montane cloud forest and harbors vegetation that is both primary and secondary forest growth; there are mainly oak forests with both bamboo and shrubs. The site is nine kilometers West of the PanAmerican Highway and the clearing and orchard of Savegre Lodge transects and interrupts the continuity of this habitat.

Four mist netting stations, each consisting of fifteen, 12x3 meter mist nets, were established at four locations ranging from 2300-2500 meters in elevation. Two, five hour periods were spent at each station. Stations were chosen as examples of specific habitats—hillside, streamside (both in primary forest), old growth primary forest, and second growth forest. Netted bird species as well as species observed from March 8th and 15th of 2003 and March 8th to March 12th, 2005 by experienced ornithologists were cataloged.

Acknowledgments

I would like to thank my student colleagues for their never-ending support, encouragement, and feedback in the research and writing of this study and Caleb Gordon and Jeff Sundberg for their guidance in the classroom and the field. I am also infinitely grateful for the hospitality and assistance of the Savegre community in Costa Rica.

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References


