

Rufford Small Grant for Nature Conservation
– Final Report –



USING CAVITY-NESTERS TO INFORM SUSTAINABLE FORESTRY IN THE MONTANE FORESTS OF ARGENTINA

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Introduction

Protected areas are an essential tool for conservation, but because only a small fraction of lands can be set aside as reserves, it is essential to maintain biodiversity in areas subject to economic activities (Lindenmayer and Franklin 2002, Fischer et al. 2006). In particular, well managed forests can have an important role in biodiversity conservation (Johns 1985, Whitmore 1997). However, we have a limited understanding about how to sustainably manage tropical and subtropical forests to assure the conservation of biodiversity (Fimbel et al. 2001). This is particularly relevant because deforestation and degradation are currently the primary cause of biodiversity loss (Mace et al. 2005), with approximately 15 million ha of forest destroyed each year during the 1990s. There are few systematic studies on the effects of degradation and deforestation in Neotropical montane forests (Renjifo 1999, 2001) despite their biological importance and rapid disappearance (FAO 2001, Kappelle and Brown 2001). These forests are particularly important since they provide many ecosystem services (e.g., water for human consumption and agriculture irrigation), timber resources, and high levels of richness and endemism for several taxa (Grau and Brown 1993). Selective logging aimed at a few valuable timber species is the most common logging practice in the Neotropics. Most of the harvesting operations are conducted without an adequate management plan (Gomez-Pompa and Burley 1991), which eventually leads to degradation of the forest ecosystem. In economic terms, degraded forests cannot compete with other land uses, and the pressure to transform degraded forests increases (Schmidt 1991, Johns 1992).

Tree cavities play an important role in the life history of cavity-using species (Harestad and Keisker 1989, Steeger and Hitchcock 1998) and are an important structural feature of forests (Fischer and McClelland 1983, Raphael and White 1984, Spies et al. 1988, Spies and Franklin 1991, Lindenmayer et al. 1993, Newton 1994). However, many forest management practices can have a profound negative effect on cavity quantity and quality (Graves et al. 2000, Fan et al. 2004), and attention is needed to maintain cavity trees (Naylor et al. 1996). Furthermore, the

management of tree cavities is challenged by the dynamic nature of tree cavities; i.e., the cavity resource changes over time (Fan et al. 2003) as cavity-trees fall, new cavities are created, and cavities become unavailable through decay or changes in cavity structure (Raphael and Morrison 1987, Lindenmayer et al. 1993). Moreover, cavity development is a relatively uncommon process governed by stochastic processes that lead to tree injury, decay, or excavations by wildlife (Carey 1985, Fan et al. 2002, Holloway et al. 2007).

Many animal species use tree cavities for dens and roosts (Bull et al. 1992, Flemming et al. 1999, McComb 2007) because cavities offer shelter from weather and security from predators (Conner et al. 1975). Cavity nesters are particularly sensitive to timber harvesting (Gibbons and Lindenmayer 2001, Titus 1983), especially secondary cavity nesters; i.e., species that use cavities created by primary cavity nesters (species such as woodpeckers that excavate their own cavities) or by wood decay following damage to a tree (McComb 2007). To establish guidelines for maintaining cavity trees we need to understand the distribution of cavity trees and potential cavity trees at multiple spatial scales such as individual trees (species), stands, landscapes, and across forest regions (Cline et al. 1980, Raphael and Morrison 1987, Morrison and Raphael 1993, Gibbons 1994). Understanding the relationships between cavity availability and cavity nesters' requirements and selection is an important step toward understanding forest ecosystems, and thus a prerequisite for managing forests while maintaining their ecological integrity (Lawler 1999, Gibbons and Lindenmayer 1996).

Objectives

We examine the effect that current selective logging has on the bird community and cavity tree abundance. We develop models that can be used to predict the relative frequency of cavity trees, its availability over time, and the probability of occurrence of nests.

Study area

Most (estimates range from 50-90%: Brown et al. 2001; Brown and Malizia 2004, Brown et al. 2002) forest land in the piedmont region of northwestern Argentina has been transformed to agricultural fields. Piedmont lands are particularly good for transformation to agriculture due to the relatively flat terrain, good soil qualities, and proximity to urban areas. Remnant piedmont forests are subject to extensive selective logging, focusing basically on ten valuable timber species. The effect of selective logging was studied in an experiment that consisted of two treatments in piedmont: control forest and forest with harvesting activity for at least 30 years. We selected six sites (three controls, three harvested) of ca. 100 ha (Fig.1).

Methods

At each site 20 circular plots of 0.05 ha were randomly placed. Trees >10 cm diameter at breast height (DBH) were identified and DBH measured. Species identifications were made directly in the field. Snags (standing dead trees) of more than >10 cm DBH were counted and DBH measured.

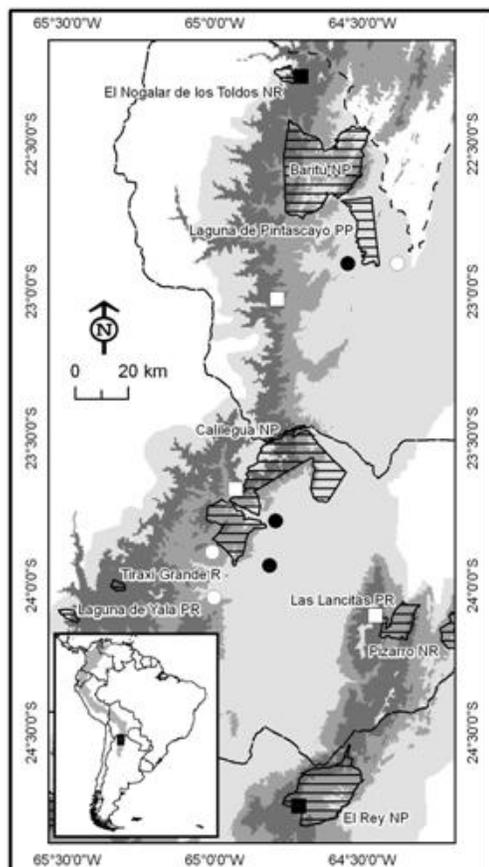


Figure 1. Location of study sites in the subtropical montane forests of the Andes. Lightest gray (almost white): piedmont forest; intermediate gray: montane forest of intermediate elevation that were not studied; darkest gray: cloud forest; filled symbols: control sites; open symbols: harvested sites. Left-bottom corner map shows in gray the distribution of subtropical and tropical montane forest of the Andes and box shows the study area. Hatched areas represent protected areas; NP: National Park; NR: National Reserve; PP: Provincial Park; PR: Provincial Reserve.

Bird data were collected using point-count surveys combined with distance estimation, which allows estimating bird population densities (Buckland et al. 2001, Bibby and Buckland 1987). Within each site we randomly allocated 40-points that were at least 200 m apart.

At each site we established 20 variable-width, 300-m long transects that were at least 150 m apart. We marked every cavity encountered that had a diameter entrance of more than 3 cm. Cavities were inspected with a camera system attached to an extensible pole of 15 m (Richardson et al. 1999) to determine if they were “usable” for avian cavity-nesters (i.e., hollow chambers surrounded by sound wood [not collapsing wood] accessed by entrance holes with a floor to harbor an incubation chamber, and a roof that provide adequate protection) or “non-

usable". We recorded: tree species, diameter at breast height, tree height, tree type (1: living with no signs of decay; 2: living with signs of decay; 3: dead), cavity height, tree diameter at cavity height (DBH), vertical and horizontal entrance diameter, diameter of the incubation chamber (Fig. 3.2), and origin of the cavity (i.e., excavated or decayed). We randomly selected one "usable" cavity on each transect and made it the center of a 0.05 ha circular plot in which we identified every tree species of more than 10 cm DBH, measured DBH, and determined tree type. Each cavity was revisited monthly during two breeding seasons. Active cavities trees were made the center of a 0.05 ha circular plot

Results

Control stands had significantly higher tree density and basal area than harvested stands, but no difference was found in mean DBH. The density-size distributions in all sites were reverse J shapes characteristic of uneven-aged forests (Fig. 2). The overall size distribution was different between treatments in the piedmont forest (Friedman test: $\chi^2=76.63$ $p<0.001$); small and intermediate sized trees (< 0.59 m dbh) were more abundant in control sites, whereas harvested sites had more large trees (> 0.70 m dbh). The same pattern characterized valuable timber species grouped in the piedmont forest (Fig. 2).

Harvested and control sites in the piedmont forest harbored distinct birds communities (Fig. 3). We detected a total of 21 avian cavity-nesting species, and these had significantly higher densities in the control treatments of both forest types than in harvested sites (Fig. 4).

The estimated density of all cavities was 13.62 ± 0.87 /ha in control sites and 3.24 ± 0.50 /ha in harvested sites, while the estimated density of usable cavities was much lower: 4.12 ± 0.61 and 0.51 ± 0.14 /ha in the control and harvested sites, respectively. In control sites, 42% of the usable cavities were encountered in *Calycophyllum multiflorum*, 25% in *Phyllostylon rhamnoides*, and 10% in snags. In harvested sites, *Calycophyllum multiflorum* harbored 60% of the usable cavities; *Phyllostylon rhamnoides* and snags each harbored 12%. Usable cavities in control sites were mainly in the 30-50 cm DBH class, while harvested sites had many usable cavities in trees > 50 cm. Usable cavities trees in both treatments of both forest types had a greater DBH (44.51 ± 22.64 in control and 50.56 ± 27.11 in harvested) than non-cavity trees (24.18 ± 9.40 and 19.76 ± 8.65 , respectively). Usable cavities had a significantly greater tree height in control sites (15.52 ± 5.13) than in harvested sites (12.63 ± 4.40) of both forest types. Tree-level characteristics (DBH, tree species, and tree type) were strong predictors of which trees harbored a usable cavity. The probability of occurrence of usable cavities increased with DBH across all tree species and types

In the control sites the average loss rate of usable cavities was 23 % per year (with a total decline of 44 % after the end of the second breeding season). The cavities in the 50-70 cm DBH were the most likely to remain available. In the harvested sites the loss of usable cavities was 40 % per year; the rate of loss was greatest in snags and as tree DBH increased. All tree-level characteristics (i.e., DBH, species, height, and type) were strong predictors of a cavity remaining available in the piedmont forest. Usable cavities in snags had a lower probability of remaining available, but the chance increased with DBH and tree height.

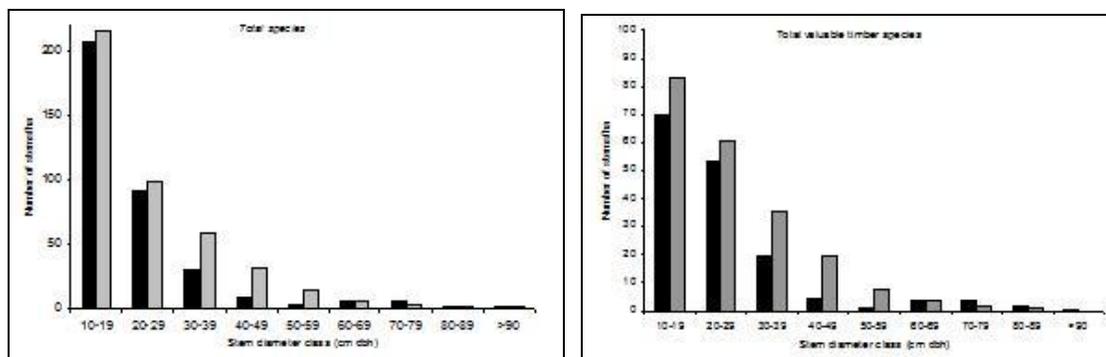


Figure 2. Tree diameter distribution in 10 cm intervals for piedmont forest of northwestern Argentina. Black bars represent harvested sites, and gray control sites.

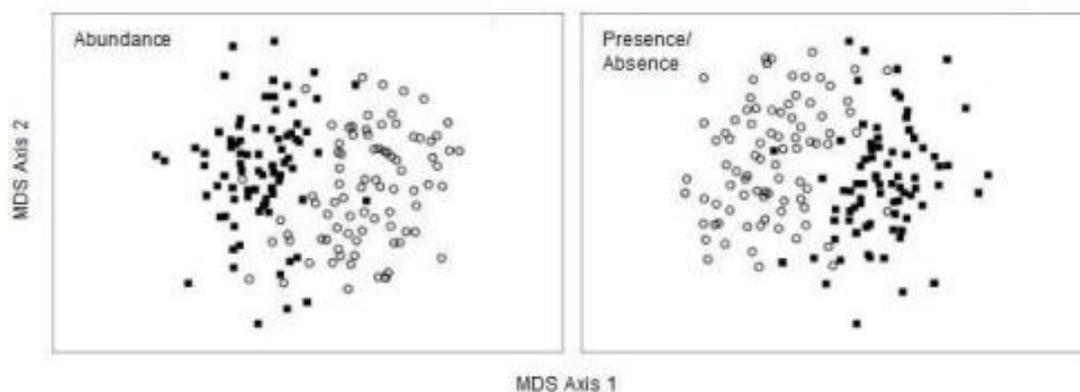


Figure 3. Nonmetric multidimensional scaling (MDS) ordinations for bird community in piedmont subtropical montane forest of the Andes. Open circles: control sites; filled squares: harvested sites. Ordinations are based on quantitative (abundance) and qualitative (presence or absence) similarity matrices.

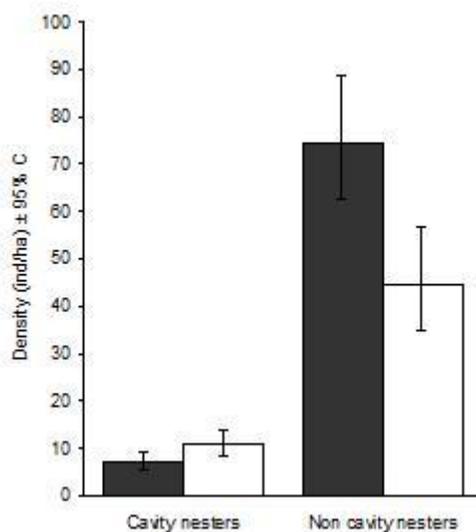


Figure 4. Comparative density analyses of bird species categorized by nesting guild in the subtropical montane forests of the Andes. Black bars: harvested; white bars: control.

A total of 192 cavities available for bird breeding (hereafter usable cavities) were identified in the piedmont and 31 of those had nests (16 %). Cavities occupied for breeding were, compared to usable cavities, significantly more frequently: found in *Calycophyllum multiflorum*, snags, and live trees with signs of decay; excavated; had north-facing entrances; were higher from the ground; and were located in plots with significantly greater mean tree DBH. The model that best predicted whether a cavity was used as a nest was based on the plot DBH and density. As the plot surrounding the cavity increased in mean DBH and stem density so did the probability of encountering a nest. At the cavity level the best model for predicting cavity use was based on cavity height and origin: cavities higher from the ground and excavated cavities were more likely to be used.

Discussion

Piedmont forest is characterized by mixed species composition (Connell and Lowman 1989, Hart et al. 1989, Malizia 2004) and common species are valuable timber trees. This provides an opportunity to conduct sustainable timber management. However two factors work play against the conservation of this forest (both economically and ecologically) (Brown and Grau 1993, Brown and Malizia 2004). First, almost flat terrain and short distances to paved roads make it relatively easy to exploit the forest. Second, land is leased to timber industries for short periods allowing loggers to deplete valuable timber stocks in a site then move to new areas with no effort to assure regeneration of valuable timber. As logging intensity increases rare and economically valuable species will be removed (e.g., *Amburana cearensis*, *Cordia trichotoma*) opening the way for less valuable species to increase their importance in harvested stands (e.g., *Trichilia hieronymi*, *Ceiba insignis*).

Cavity nesters are specialists that depend on mature or old-growth forest and are sensitive to forest disturbances (Grieser Johns 1996, McComb and Lindenmayer 1999), since they depend on the availability of cavities in large and old trees (Cornelius et al. 2008, Gibbons and Lindenmayer 2002, Grieser Johns 1997, Martin 1988). In the subtropical montane forest of the Andes, cavity nesters are probably sensitive to unsustainable timber harvesting, as indicated in this study by the greater density of cavity nesters in control sites (Fig. 4).

This study indicates that cavities are an uncommon feature in control sites of the montane forest of northwestern Argentina with only 13.62 ± 0.87 cavities/ha in the piedmont forest, representing 3 % of the total tree density. Even more uncommon are usable cavities for avian cavity-nesters (4.12 ± 0.61 usable cavities/ha) and these could be a limiting resource given the estimated density of 10 cavity-nesting birds/ha. Timber harvesting operations can significantly reduce the supply of cavities, especially of usable cavities (Kalina 1988, Dranzoa 1995, Grieser Johns 1997). In logged montane forests of northwestern Argentina 0.15 % of the trees have a usable cavity (0.51 ± 0.14 usable cavities/ha). The lower number of usable cavities in logged forest is not a simple function of the total number of stems extracted from the stand. For example, in control piedmont forests the tree density is 420 stems/ha and the usable cavity density is 4.12 /ha, and therefore in harvested piedmont forest, where the tree density is 340, one would expect to find 3.34 usable cavities/ha. However, one finds 0.51 usable cavities/ha or 6 times less than the expectation based on tree density. This greater decrease than expected could be explained by an overlap between those trees likely to harbor a usable cavity and those harvested. In particular, most harvested trees in the piedmont forest are in the intermediate (30-60 cm) DBH classes, which in this study were the most likely to harbor a usable cavity.

Even more striking is the high loss rate of usable cavities documented (from 23 - 40 %/year). Many usable cavities are available for short period of time due to cavity deterioration (Sedwick and Knopf 1991); for example, the cavity entrance becoming too large, or the cavity compartment decomposing. A high rate of usable cavity loss can be attributed to the high rates of wood decomposition in the tropics due to high temperatures and moisture (Jordan 1986). Cavities are an avenue for fungal and invertebrate invasion (Jackson and Jackson 2004) and decomposition can deteriorate a cavity within a few months or years. Interestingly, this study shows that rates of cavity loss differ between tree species and DBH classes. Snags are more likely than live trees to lose usable cavities.

Large, decaying *Calycophyllum multiflorum* have a relatively greater probability of having usable cavities. Snags are very likely to harbor a usable cavity. The importance of snags as a source of usable cavities has been long recognized (Rosenberg et al. 1988, Sedgwick and Knopf

1986, Adams and Morrison 1993, Bull and Holthausen 1993), and in many regions special management guidelines for this feature have been developed (i.e., Evans and Conner 1979, McComb 2008). Despite the fact that usable cavities are very likely to occur in snags, the majority occur in living trees because snags comprise a small portion (10 %) of all standing trees in the montane forest of northwestern Argentina, as in many other tropical regions (Gibbs et al. 1993). As a result, the supply of live cavity trees is a key management consideration, both as present habitat and as future snags when trees die.

This is the first study that addresses the nesting requirements of cavity nesters in the Andean forests. In this study cavities used for nesting were not simply a random subset of all available cavities. Birds are selective of cavities, thus rendering a proportion of apparently available cavities unsuitable (e.g. cavities low to the ground, low plot DBH). In the piedmont stand variables provided the greatest explanation of cavity nest presence. As basal area increased there was a greater probability of encountering a nest. The tree-level results show that cavities that were higher from the ground were more likely to be used.

In this study region cavities excavated by woodpeckers were used more often than expected according to their availability, highlighting the key role that woodpeckers have in providing preferred cavities. In many other forest ecosystems (Raphael and White 1984, Erskine and McLaren 1972, Dobkin and Wilcox 1986), primary cavity excavators often provide the bulk of cavities used by secondary cavity nesting birds, but in this forest woodpeckers provide a low percentage of the total cavities available (i.e., 12%). Tree condition may be an important factor in the selection of a potential nest tree by an excavator (Daily 1993, Conner et al. 1976, Hinds 1985). Trees with softer, rotten wood are often selected over healthier trees presumably for ease of excavation (Kilham 1971, Dobkin et al. 1995, Schepps et al. 1999, Harestad and Keisker 1989, Moore 1995). The use of particular tree species by avian cavity nesters was not random: piedmont avian cavity nesters species used *Calycophyllum multiflorum* far more often than would be expected according to the abundance of this tree species.

Forest management

Currently, the logging operations in the subtropical montane forests of the Andes are not planned and if logging continues without sustainable management then stocks of valuable timber species will probably become depleted and low-value species will increase. This study shows that selective logging changed the bird community in the subtropical montane forests of the Andes. Doubtlessly logging in northwestern Argentina has reduced suitable nesting habitat and availability of nest sites for cavity-nesting species. Therefore, current and proposed programs of selective logging in the subtropical montane forest of the Andes should address the conservation

of trees that provide suitable cavities. However, as shown in this study, solely retaining certain tree species of a particular DBH will not be sufficient and cavity retention decisions should also be made at the cavity level and stand level (e.g., retaining trees with highest cavities and stands with large basal area, respectively). In other words, forest management aimed at biodiversity conservation should encompass management at different scales, but foresters in Argentina usually manage forests at the tree-level, rarely taking into account stand or cavity-level attributes because no management guidelines are available at other scales.



Photo 1. *Piculus rubiginosus* inside a nest.



Photo 2. Subtropical montane forests of the Andes harbor a great biodiversity and provide many ecosystem services.



Photo 3. Forests that are not managed sustainable have a greater change to be transformed to other land uses, such as sugar cane fields as shown in this photo.



Photo 4. Selective harvesting without management recommendations in the subtropical montane forests of the Andes deplete forest stands of valuable timber.

Budget

Item	Budget	Spent
<i>Field expenses</i>		
Food	1392.00	1392.00
Miscellaneous (stove gas, batteries)	130.50	230.50
4-wheel vehicle rental	1044.00	1044.00
Vehicle fuel	417.60	467.60
Local transportation	348.00	348.00
Local guides	478.50	478.50
Camera service	227.52	267.52
<i>Management guidelines</i>		
Brochures	360.00	360.00
Posters	290.00	290.00
Talks	69.60	200.00
TOTAL	4995.61	5078.12