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INSTITUTO FLORESTAL

THE AVIFAUNA AND THE VEGETATION STRUCTURE OF A MATURE ARAUCARIA PLANTATION IN SÃO PAULO, BRAZIL

Série Registros

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SUMÁRIO/CONTENTS

THE AVIFAUNA AND THE VEGETATION STRUCTURE OF A MATURE *ARAUCARIA* PLANTATION IN SÃO PAULO, BRAZIL.*

Douglas J. GRAHAM**

ABSTRACT

The research reported on here evaluated the impact of an exotic plantation of *Araucaria angustifolia* on the indigenous bird fauna by comparing a plantation to the adjacent natural forest. Almost no such studies have been done in Brazil, so it was considered of importance to develop a methodology which could conveniently be used in similar studies. The vegetation structure was primarily described through the use of an original "foliage volume profile". Birds were sampled with mist nets and by fixed radius point counts. The bird data were analyzed in terms of "guilds": groups of species which shared a foraging height and food resources (e.g., "canopy insectivores"). There was little apparent difference between the two areas in terms of numbers of bird species but the natural forest sites had significantly more birds than the *Araucaria* sites. The guild level analysis of the data revealed that it was particularly the mid-level and canopy guilds which were more abundant in the natural forest. The ground level and understory guilds showed similar, but inconsistent trends. Other guilds showed no preference for either area. It was concluded that the study quite convincingly related the bird distribution differences to the presence of the *Araucaria* foliage in the mid-levels and canopy. The understory vegetation of the plantation and the natural forest was very similar. This study made no attempt to document the mechanisms by which the presence of *Araucaria* may affect bird faunas, but it allowed the impact to be quite specifically related to particular groups of birds and particular aspects of the vegetation structure. A similar approach in other studies will add to the understanding of how exotic plantations impact on indigenous faunas and should lead eventually to useful proposals for measures of mitigation.

RÉSUMÉ

La présente recherche évalue l'impact d'une plantation exotique d'*Araucaria angustifolia* sur la faune avienne indigène en comparant une plantation à la forêt naturelle. Il était considéré important de développer une méthodologie applicable à des études subséquentes puisque peu de travaux du genre avaient été réalisés auparavant au Brésil. La structure de la végétation fut principalement décrite à partir d'une méthode inédite de "profil volumétrique du feuillage". Les oiseaux furent échantillonnés à l'aide de filets japonais et de "comptes ponctuels à rayon fixe". Ces données furent analysées en termes de "guildes": groupes s'alimentant à la même hauteur et partageant les mêmes ressources d'espéces alimentaires (p. ex., "insectivores des cîmes"). Il y avait peu de différences apparentes entre les deux aires en terme de nombre d'oiseaux mais les sites en forêt naturelle montraient, de façon significative, plus d'oiseaux que les sites a *Araucaria.* L'analyse des données a révélé que les guildes des strates des niveaux moyens et des cîmes comptaient plus de représentants dans la forêt naturelle. La même tendance était remarquée pour les strates du sol et du sous-bois mais de façon inconsistante. Aucune préférence, en faveur d'une aire, n'a pu être attribuée aux autres guildes. Il fut conclu que l'étude démontre de façon convaincante que la différence dans la distribution des oiseaux est reliée à la présence du feuillage d'*Araucaria* dans les strates moyennes et des cîmes. Le sous-bois de la plantation présentait une végétation similaire à celle de la forêt naturelle. Cette recherche ne se veut pas une étude des mécanismes par lesquels la présence d'*Araucaria* peut affecter l'avifaune mais permet de relier, de façon spécifique, l'impact à des groupes d'oiseaux ou des aspects de la végétation en particulier. Une approche similaire dans d'autres études pourra ajouter à la compréhension de la manière par laquelle les plantations exotiques génèrent un impact sur la faune indigène et devrait mener, éventuellement, à d'intéressantes propositions pour des mesures de mitigation.

(*) Aceito para publicação em setembro de 1988.
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RESUMO

A pesquisa descrita no presente relatório avalia o impacto de uma área reflorestada com *Araucaria angustifolia* sobre a avifauna nativa através de uma comparação entre uma plantação e a mata natural adjacente. Em razão da escassez de estudos semelhantes no Brasil, foi considerado importante o desenvolvimento de uma metodologia que poderá ser utilizada em trabalhos posteriores. A estrutura da vegetação foi descrita de modo original por meio de um "perfil volumétrico da folhagem". Para amostragem das aves foram empregadas redes de neblina e "contagens pontuais a raio fixo", tendo os dados obtidos sido analisados em termos de "guildas", grupos de espécies se alimentando a uma mesma altura de mata e utilizando dos mesmos recursos alimentares (por exemplo, insetívoros de cimeira). A mata natural apresentou um número significativamente maior de aves, embora não tenham sido observadas muitas diferenças aparentes quanto ao número de espécies nas duas áreas. A análise dos dados demonstrou que as guildas dos estratos médio e superior da mata natural possuíam maior população, tendência igualmente observada nas guildas dos estratos inferiores, embora de forma incoerente. Nenhuma preferência em favor de uma determinada área pôde ser atribuída às outras guildas. Neste estudo é demonstrado de maneira convincente que a diferença na distribuição das aves relacionada à presença da folhagem da *Araucaria* nos estratos médio e superior. Os estratos inferiores da área reflorestada apresentavam uma vegetação similar à da mata natural. Este trabalho não visa explicar os mecanismos pelos quais a presença da *Araucaria* afeta a avifauna mas sobretudo relacioanar de maneira específica seu impacto sobre grupos de aves ou aspectos da vegetação em particular. Uma abordagem semelhante em outros estudos poderá aumentar a compreensão do modo pelo qual tais plantações causam um impacto sobre a fauna nativa e deverá finalmente conduzir a proposições interessantes para mitigação.

1 INTRODUCTION

From any prominent location in the Serra da Cantareira, one can look out over the 15 million people of São Paulo, the largest city in South America. Paradoxically, the forests of the Serra, a State Forest Reserve, are home to a startling diversity of flora and fauna and are one of the few remaining areas of natural vegetation in the state of São Paulo (FIGURE 1). In the centre of the Reserve, a plantation of the conifer *Araucaria angustifolia* interrupts an otherwise continuous area of over 5000 ha of forest. The research reported on here was undertaken to compare the avifauna and vegetation structure of that plantation to the surrounding forest. In addition to providing some basic ornithological data on the little known avifauna of the devastated and fragmented Atlantic Coastal Forest, this research improves the knowledge of the impact of exotic tree plantations on the natural bird fauna of S.E. Brazil and of how that impact can be evaluated.

The State of São Paulo originally had a forest cover of 20.5 million ha (81.8 % of the state's area). Widespread deforestation was well underway in the late 1800's and today, less than 5 % of the State is forested (representing about 1.25 million ha). It is expected that by the year 2000, only about 3 % of the original forest cover will remain (BARRETO, 1985).

In a wider view, the fate of the Atlantic Coastal Forest of Brazil is even more alarming. This area of humid tropical forest, which originally extended along the Brazilian coast from extreme N.E. Brazil to the southeastern border of the country, has close biogeographical affinities to the Amazonian forest, yet it has a distinct fauna and a very high rate of endemism. Perhaps only 1 % of the original Atlantic Coastal Forest remains (FONSECA, 1985).

Reforestation programmes in the state of São Paulo have restored some forest cover. In a

1972/1973 study (Instituto Florestal, 1980) it was estimated that about 640 000 ha had been reforested. Virtually the total area consisted of plantations of exotic trees (especially *Pinus* and *Eucalyptus*). *Araucaria angustifolia* has also been fairly widely planted. In São Paulo State, this species is native to highland areas of the Serra da Mantiqueira (FIGURE 1) but is exotic elsewhere.

1.1 The Avifauna of Exotic Tree Plantations

The widescale planting of exotic tree species in the tropics has lad to increasing concern among ecologists as to their adverse impact on indigenous faunas. Pine plantations in particular have a reputation as being "biological deserts". SICK (1985) poignantly refers to them as "matas de silêncio". Other arguments against monospecific exotic tree plantation can be cited: exhaustion of soils (RUSSELL, 1983) and increased susceptibility to fungal diseases and insect predators. The reduction in bird diversity and numbers accentuates problems with insect pests. Despite these preoccupations, a quick survey of the forestry literature reveals that wildlife concerns are rarely considered in tropical forestry studies. In part, this can be attributed to a paucity of studies that have carefully evaluated the impact of exotic plantations on natural faunas.

The avifaunas of exotic plantations have received more attention in temperate areas: e.g., CHILDERS, et alii (1986) in the U.S. and ADAMS & EDINGTON (1973) in England. Studies of more relevance to tropical areas are however few indeed (HAVEL, 1980). A comprehensive review of the recent literature revealed that the majority of studies, concerning the impact of exotic plantations on tropical bird faunas, have been carried out in the Australian Region. PAWSEY (1966), DISNEY & STOKES (1976) and DRISCOLL (1977) all looked at birds in exotic pine forests of Australia. The latter author, who discusses similar results from the previous studies, found that the plantations had similar numbers of birds as indigenous forests but that species diversities were lower (especially in young plantations). The research of CLOUT & GAZE (1984) in New Zealand pine forests can be cited as one of the most thorough studies in this subject area. Other papers from the Australasian Region have considered exotic plantations of non-coniferous species (BELL, 1979; YORKE, 1983).

A study in Kenya (CARLSON, 1986) compared small patches of pine forest to primary forest and found lower densities and species diversities in the coniferous forests. He also showed that "forest specialist species" (restricted to the primary montane forest habitat) were more adversely affected than forest generalist species.

Apart from the Brazilian studies discussed below, no study on birds of exotic plantations seems to have been published from a tropical area of the New World. Although SICK (1985) stated that there have been almost no such studies in Brazil, a few have been recently published. ALMEIDA & ALVES (1982), in a study on the integrated control of leafcutter ants, investigated the avifauna of a *Eucalyptus* plantation. Birds in the plantation and a nearby natural forest area were sampled with mist nets. Foliage densisities were measured, but no methods were explained in the paper, nor were any results provided for the natural forest area. Although the authors found that there were more species in the *Eucalyptus* plots, their conclusions must be considered tentative since sample sizes were very small, and possibly the mist netting effort was not equivalent in each study area.

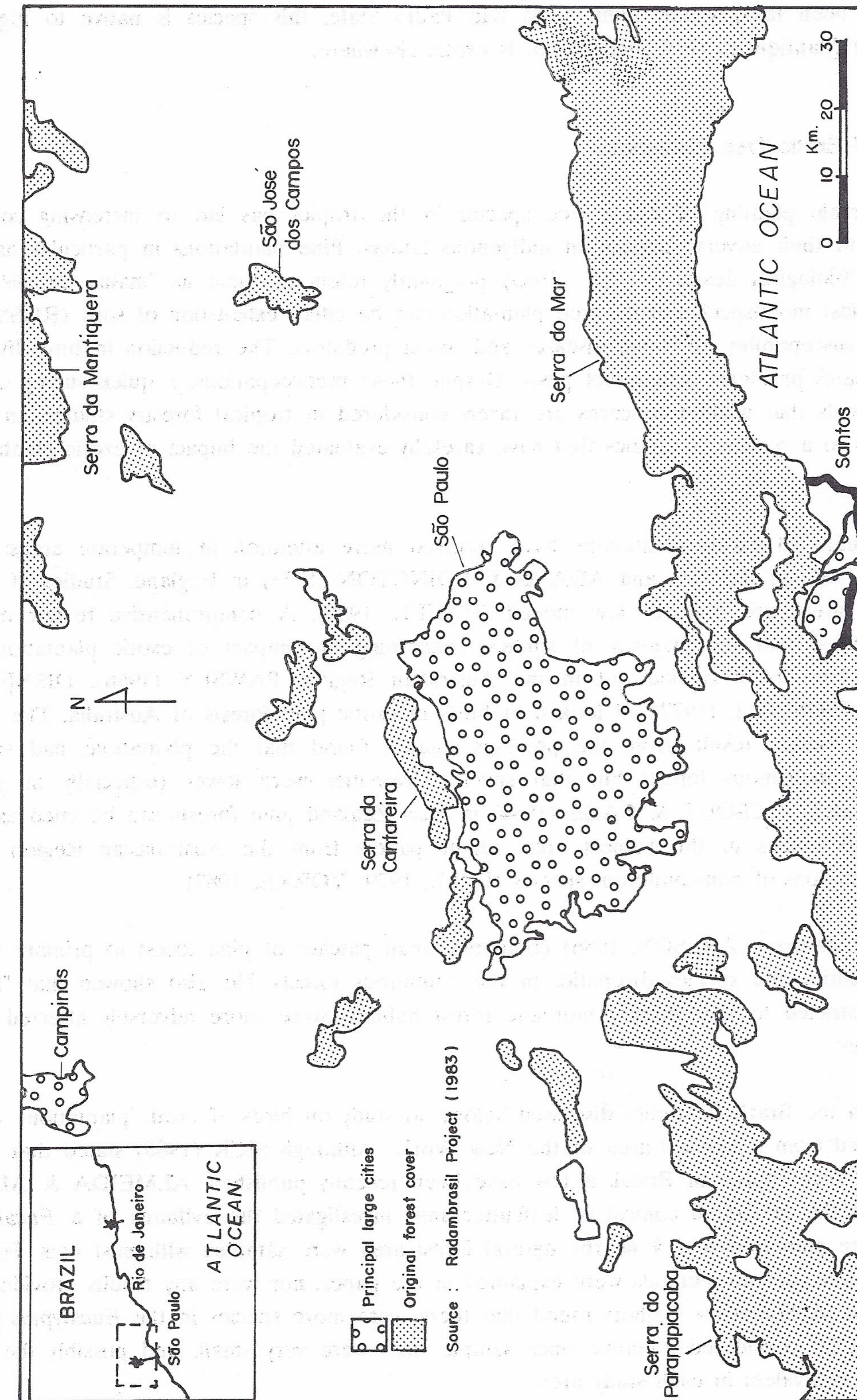

FIGURE 1 - Location of the "Serra da Cantareira".

ALMEIDA (1979), in similar study of *Pinus* plantations and natural forest areas, concluded that there were significant differences between the bird communities of the two areas. This study's results are however compromised by small sample sizes (a total of 189 birds were captured in 9 different study areas) and an absence of information on the number of net-hours or vegetation structure.

The only published study on the avifauna of an exotic *Araucaria* plantations* is that of RODRIGUES et alii (1981) in the state of Paraná. Their comparison of the *Araucaria* plantations's avifauna with that of a natural *Araucaria* forest, concluded that here was virtually no avifaunal differences between the study areas. The only substantial difference between the study areas understory but no details were provided in the paper on how that conclusion was reached.

2 DESCRIPTION OF THE SERRA DA CANTAREIRA

The Serra da Cantareira (23° 22' S, 46° 36' W) is located on the northern border of the city of São Paulo ("serra" being the Portuguese word for a small range of hills). Virtually all of the Serra is included in the State Forest Reserve of Cantareira. A 1974 management plan contains an overview of information on the Cantareira Reserve (NEGREIROS et alii, 1974).

The "Reserva Estadual da Cantareira" is administered by the INSTITUTO FLORESTAL of São Paulo. This government organization, responsible for all state parks and reserves, has its headquarters in the "Parque Estadual da Capital", a 174 ha state park contiguous with the Cantareira Reserve. It is planned to eventually combine the two as a state park, which will ensure the long-term protection of the Serra da Cantareira. The Reserve is currently closed to the public, with visitors only allowed under restricted circumstances. Plans to make the Reserve more accessible to the São Paulo public (NEGREIROS et alii, 1974) have not yet been implemented.

The majority of the Serra da Cantareira was deforested in the last century to make way for coffee and tea plantations. Due to the importance of the Serra for the water supply of the growing city of São Paulo, it was declared a protected forest reserve in 1896. The forest cover has subsequently regenerated naturally and today, the Reserve is almost completely forested.

The bulk of the Reserve's forest is therefore actually secondary forest, which is however virtually indistinguishable from the remaining remnants of primary forest. At about the same time that the Reserve was established, a small area in the centre of the reserve was planted with *Araucaria angustifolia*. In subsequent years, a few other small plots of exotic conifers were established in the same area.

2.1 Climate

Metereological data were collected at the Serra da Cantareira (in the Parque Estadual da Capital) from 1944 to 1981. The mean monthly values for temperature and preciptation from this period

(*) Graham (1986b) is a published abstract of a presentation given by the author, on this study, at the 13th Congresso Brasileiro de Zoologia in Cuiabá, Mato Grosso in February, 1986.

(INSTITUTO FLORESTAL, s.d.) were adapted by the author to produce the climate graphic shown in FIGURE 2. Based on the data for this 38 year period, the month with the highest mean temperature is February, with a mean of 21.3°C. The lowest temperaures are recorded in July, with a mean temperature of 14.7°C. During the 38 years of data collection, a slight and unexplained rise in temperature of 0.3°C per decade has been a consistent trend, with an overall rise of 1.1°C.

Total annual precipitation is subject to little variation from year to year, generally being from 1500 to 1600 mm with a mean value of 1570 mm. As can be seen from FIGURE 2, a well pronounced rainy season occurs in the summer from October to March. The greatest amount of precipitation falls in January, with a mean of 256.4 mm (with rain on a mean of 61 % of the days). The least precipitation occurs in August with a mean of 42.2 mm (rain on 23 % of the days). Summer rains are generally abrupt and heavy, while rains in the winter tend to be prolonged, yet intermittent (NEGREIROS et alii, 1974). It should be noted that the year of this study was considerably drier than average but unfortunately, no metereological data were available at the time of writing.

The number of "dry days" (PROJETO RADAMBRASIL, 1983) is the number of days on which the precipitation values*, fall below the temperature values. The Serra da Cantareira has 0 dry days and is therefore not considered to have a dry season.

2.2 Geology and Pedology

The geology and pedology of Southeastern Brazil are considered in some detail by the PROJETO RADAMBRASIL (1983). We will be limited hear to a very brief summary of that part of their findings relevant to the Serra da Cantareira.

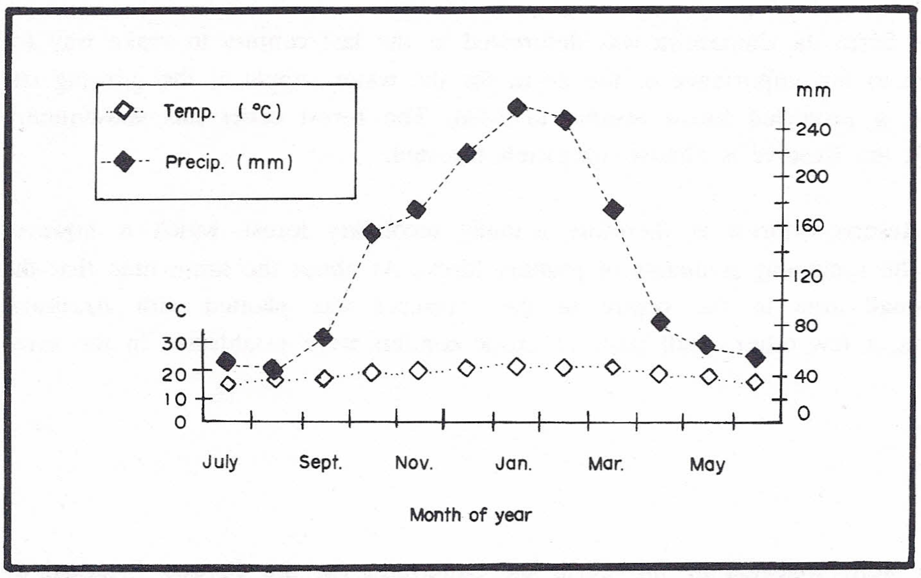

FIGURE 2 - Climate graph for the Serra da Cantareira.

(*) For "dry day" calculations, all values must be graphed in a standard format, such as in FIGURE 2, where 10°C on one vertical axis is equal to 20 mm of precipitation on the other vertical axis.

The name Serra da Cantareira is generally used synonymously with the State Reserve of Cantareira but, properly speaking the eastern portion of the reserve (east of the highway BR-381) is the Serra da Pirucaia. The Serra da Pirucaia belongs geologically to the Açungui quartzite formation. In this formation, the quartzite varies from coarze and feldspathic to fine and quartzose and possesses a rather heterogeneous granulation and recrystallisation along the planes of tectonic movement. The Serra da Cantareira proper, belongs to the Três Córregos intrusive granite formation. The granites of this formation are characterized as post-tectonic with rosaceous porphyries in a coarse, granodioritic to tonalitic matrix. Its contact with the Serra da Pirucaia is characterized by an intercalation of the to rock types.

The soils of the Cantareira Reserve are all classified as Alic Red-Yellow Podzols. They are characterized as non-hydromorphic, quite deep (about 1 m deep according to NEGREIROS et alii, 1974), well drained and with A, B, and C horizons. The A horizon has a texture considered clayey to very clayey. The B horizon, generally a red-yellow colour, has a sandy, coarse to fine texture.

2.3 Vegetation

The vegetation of Serra da Cantareira is classified by the PROJETO RADAMBRASIL (1983) as falling within the "Dense Ombrophile Forest" phytoecological region, the category that includes the rain forests of the Atlantic Coastal Forest. More specifically, the Serra is included with the "Montane Forest Sub-region". Before the intervention of man, all areas within at least 60 kilometres of the Serra (with the exception of small isolated patches of savanna or "cerrado") were in the same phytoecological region. As can be seen from FIGURE 1, there are few remaining areas of forest today.

The "Dense Ombrophile Forest Region" is, according to the PROJETO RADAMBRASIL (1983), characterized by regions with 0-60 dry days and therefore without a well-marked dry season. Annual precipitation values showed be about 1500 mm. The Serra da Cantareira, as discussed above, has no dry days and a mean annual precipitation of 1570 mm.

Within this phytoecological region, the "Montane Forest Sub-region" is found at altitudes from 500 to 1500 m. The Serra da Cantareira has a mean altitude of 850 m and a maximum altitude of 1200 m. The vegetation of this sub-region typically has a dominant stratum at a height of about 25 m, characterized by genera such as *Vochysia*, *Talauma*, *Cariniana*, *Clethra*, *Ocotea* and *Nectandra*. Lower strata are characterized by diverse species of the families Rubiaceae, Myrtaceae, Melastomataceae and Palmae as well as by Pteridophytes and a large number of epiphytes and lianas.

The Serra da Cantareira is, phytoecologically speaking, extremely similar to the nearby Serra do Paranapiacaba (FIGURE 1) and to the inland portions of the coastal Serra do Mar (within which, different sub-regions are found where altitudes approach sea level). The author found no evidence to support the hypothesis suggested in NEGREIROS et alii (1974) that, because of its intermediate geographic position, the Serra da Cantareira contains forest types typical of the Serra do Mar and of the Serra da Mantiqueira. The former forest is described as a humid tropical broadleaf forest and the second as a high altitude forest with a canopy height of 6-8 m and composed of gnarled moss-covered trees. No such forest exists in the Serra da Cantareira.

No phytoecological studies have been published for the Serra da Cantareira, although

NEGREIROS et alii (1974), provided a list of 55 plant species that had been identified in the Reserve's forest and BAITELLO & AGUIAR (1982) provided a more complete list of identified trees and shrubs. The species composition and vegetation structure of the sites chosen for this study are further described in subsequent sections.

2.4 Avifauna

Despite its proximity to the city of São Paulo, the Serra da Cantareira's avifauna was virtually unknown when this study was initiated. From 1897 to 1965, about 250 specimens (representing about 80 species) where collected in the Serra da Cantareira and are currently located in the Museu de Zoologia de São Paulo. Most of these specimens where listed in PINTO's (1938, 1944) catalogues. NEGREIROS et alii (1954) included a list of some 25 species but these were only species of "probable occurrence". Nothing else has been published on birds of the Cantareira Reserve.

In conjunction with the research discussed in this report, a general survey of the Serra's avifauna was carried out. A checklist of the Reserve's birds (GRAHAM, 1986a) includes 215 species that have definitely been recorded in the Reserve and a further 11 species of hypothetical status. A copy of the Checklist is appended to this report (Appendix 3). With further work in the Serra, the complete avifaunal list should eventually include about 300 species.

A more complete analysis of the avifauna of the Serra da Cantareira will be reported on elsewhere (GRAHAM, **in prep.**) but a few general remarks can be made here. The available evidence would suggest that the local avifauna is very similar to the avifauna of the nearby Serra do Mar or to forested tracts in the inland part of the state (WILLIS, 1979; WILLIS & ONIKI, 1981). The avifauna of the State Park of Campos do Jordão, in the Serra da Mantiqueira is distinguished by many species which rarely occur elsewhere in the state* (WILLIS & ONIKI, 1981; and BARBOSA, 1988) and shares no particular affinities with the Serra da Cantareira. The Serra da Mantiqueira is the nearest area to the Serra da Cantareira where *Araucaria angustifolia* occurs naturally.

There are probably no forest species in the Serra da Cantareira which do not occur in other similar forests of the state. The Serra's avifauna, as listed by GRAHAM (1986a) does include about 40 species that are native to the more open "cerrado" areas of the dry interior of São Paulo. Their presence is anthropogenic and related to the widescale deforestation of surrounding areas. These species are restricted to semi-open areas in the Reserve and did not occur in the heavily forested study sites of this research.

Many of the species that must have originally inhabited this area are no longer present. This would be due in part to the fact that a large proportion of the Serra was deforested in the late 1800's. TERBORGH & WESKE (1969) noted in Peru that secondary vegetation, although with foliage height profiles similar to the original forest cover, was relatively impoverished in terms of the number of bird species. The relatively small size of the Reserve is perhaps also a limiting factor for some birds with very

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(*) An example is the Araucaria Tit-Spinetail Leptasthenura setaria, the only species in São Paulo that occurs exclusively in Araucaria forests.

large territory requirements such as certain eagle species. Finally, the present day isolation of the Serra da Cantareira probably is responsible for the abscence of some species which might otherwise have recolonized it. The enormous urban sprawl of São Paulo effectively creates a 40 km barrier from the Serra do Mar, the single largest remnant of Atlantic Coastal Forest in Brazil (FIGURE 1). Some of the birds that have presumably been lost from the Serra's avifauna include the large raptors, all the large parrot and macaw species, the large canopy frugivores and other species depend on large tracts of undisturbed forest or particularly sensitive to the human presence. In his interesting study of remnant woodlots in São Paulo, WILLIS (1979) came to similar conclusions.

3 DESCRIPTION OF THE STUDY SITES

The Cantareira Forest Reserve is almost entirely covered with natural forest except for a small area of 127 ha, locally known as the "Chapada", located in the western half of the Reserve (FIGURES 3 and 4). In addition to 78 ha of *Araucaria angustifolia*, there are 17 ha of stands of other exotic conifers: primarily *Pinus* spp but also *Cunninghamia* sp, *Cryptomeria elegans*, *C. japonica* and *Araucaria excelsa*. The "Chapada" area also includes 32 ha of low scrub. The families of five Reserve workers live in the area. Natural forest completely surrounds the "Chapada" and extends to the border of the Reserve (FIGURE 3). The map of FIGURE 3 is adapted from NEGREIROS et alii (1974). The map for FIGURE 4 is original and based on aerial photographs (1:10.500) of the Reserve taken in the mid-1970's. All features shown on the map were ground-proofed in the field and modified accordingly. Areas were calculated with a planimeter.

Several roads extend to the "Chapada" and there is a small number of paths through the surrounding area (FIGURE 4). Human activity in the area was minimal. The public is excluded from the Reserve and on no occasion during 6-7 months of field work, was a person ever encountered in the vicinity of the study sites.

Two study sites were chosen in the *Araucaria* plantations and two study sites in the adjacent natural forest. The two sites from each vegetation type were intended to be eventually grouped, if it could be shown that they have statistically similar bird communities and vegetation structure.

3.1 *Araucaria* Study Sites

From a distance, the plantations of *Araucaria angustifolia* were quite homogeneous in appearance, seeming to be exclusively composed of *Araucaria* which completely dominated the upper stratum of the forest. When within these plantations, the impression of monospecificity was much less marked, since the understory and lower strata appeared to be no different from those of the natural forest. The *Araucaria* were not planted in regular rows and the stands did not at all give the impression of being artificial plantations. No exact date could be obtained for these plantations, but they were planted at about the turn of the century. Virtually all the trees are now 22-28 m high, with a very few individuals reaching heights of 30 m. Essentially no regeneration of *Araucaria* is occurring; young trees were extremely rare within the plantations and were never seen in any nearby area of forest*.

(*) AUBRÉVILLE (1965) considered the Araucariaceae incapable of regenerating under forest canopy by virtue of their light demanding nature.

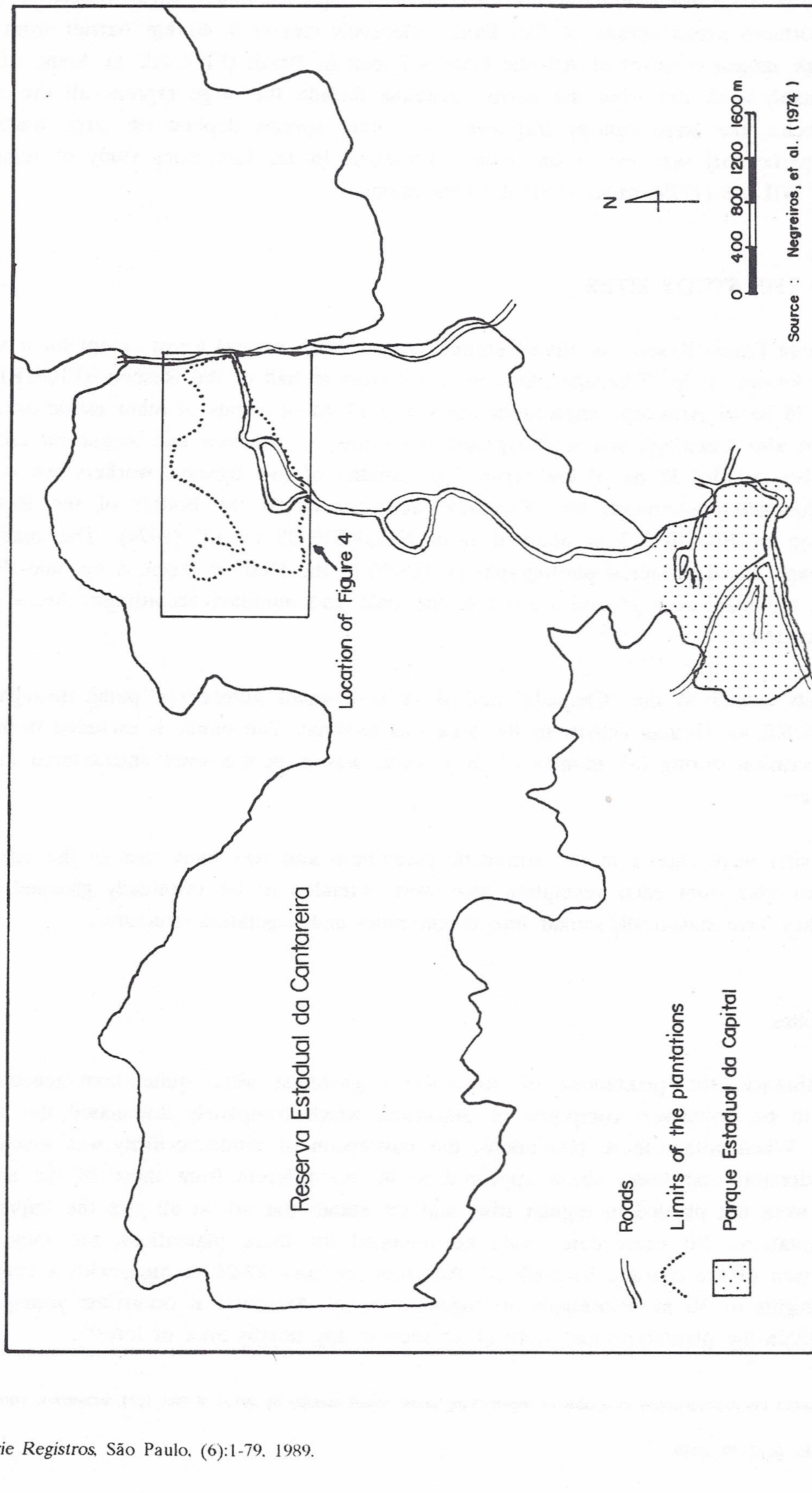


FIGURE 3 - Western half of the Cantareira Forest Reserve showing the location of the study area.

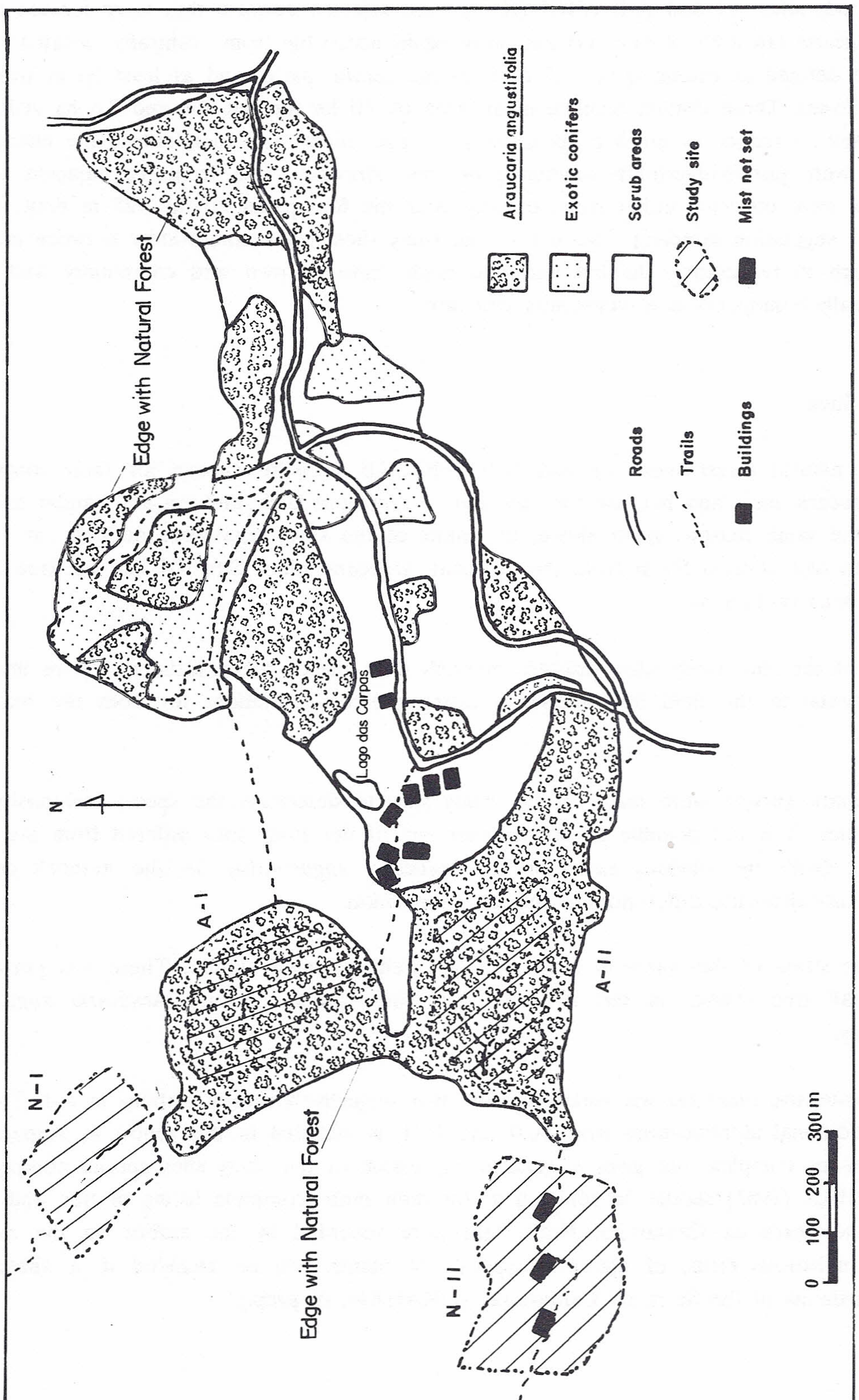


FIGURE 4 - Location of the study sites and mist net sets.

The two study sites A-I and A-II (FIGURE 4) were selected because they were located in the largest patch of *Araucaria* (an area of 41.6 ha) and were easily accessible from centrally located trails. The study sites were defined as extending to 125 m from the central paths, and as least 50 m from the edge of the natural forest. These criteria resulted in an area of 7.0 ha for site A-I and 8.6 ha A-II. The 50 m limit was chosen to reduce as much as possible any "edge effect" and to minimize the chances of recording birds that were just inadvertently wandering into the *Araucaria* sites from the adjacent natural forest. The bird data were collected either from, or very near the foot paths, so the 125 m limit was of relevance only to the vegetation sampling. The size of the study sites was a compromise between an area that was large enough to represent a habitat unit that might have its own bird community, and small enough to be essentially homogeneous in vegetation structure.

3.2 Natural Forest Sites

The two natural forest sites N-I and N-II (FIGURE 4) were chosen for their convenient proximity to the *Araucaria* plots and because they seemed to represent fairly uniform and similar areas of natural forest. For the same reasons given above, the limits of the study sites were defined as being 125 m from the path and at least 50 m from the adjacent *Araucaria* plots. Site N-I had an area of 6.6 ha and site N-II an area of 11.8 ha.

At each of the four study sites, distance markers were placed along trails at 100 m intervals. These were instrumental in the field for precisely locating pre-chosen stations for both the bird and vegetation sampling.

No systematic surveys were made of the study sites to determine the species composition of their plant communities. It is not possible to say whether any of the study sites differed from the other sites in this respect (with the obvious exception of *Araucaria angustifolia*). In the author's opinion however, there were no distinctive differences in species composition.

The lower strata of the forest at each site appeared extremely similar. There was perhaps a smaller variety of tall tree species in the A-I and A-II sites, simply because *Araucaria angustifolia* dominated the canopy.

A fairly extensive plant list was obtained from two subjectively chosen stations in A-I. The list, as well as a few additional identifications from A-II and N-II, is included in this report as Appendix 4. The list is by no means complete but gives a general impression of the study sites species composition. BAITELLO & AGUIAR (1982) should be referred to for their more complete listing of tree and shrub species known of the Serra da Cantareira. Notes that were recorded by the author on the use, by nectarivorous and frugivorous birds, of about 30 species of plants, will be included in a subsequent publication on the avifauna of the Serra da Cantareira (GRAHAM, **in prep.**).

4 METHODS

4.1 Vegetation Sampling

A variety of vegetation sampling methods were employed to quantify the structure and density of the forest vegetation. The most important of the sampling techniques was an original approach that yields a "foliage volume profile". The "point-centred quadrat" method of COTTAM & CURTIS (1956) was employed to obtain data on the density of the shrub and tree layers. This method also provided a means of randomly choosing tree and shrub samples for the foliage volume calculations. The characteristics of the foliage are described with a method adapted from the "Universal system for recording vegetation" of DANSERAU et alii (1966). Finally, data on the foliage density near ground level were collected separately with a "coverboard". Each of the four studies sites was sampled at ten stations except for site A-II which was inadvertently only sampled at nine stations. The sampling procedure required about one and a half hours at each station.

4.1.1 Location of the Sampling Stations

In order to randomly locate the sampling stations, a grid was laid over a map of the study sites with the grid lines 25 m apart. Each intersection point on the grid was marked on the map as a potential sampling point and numbered. These stations were thus located at a maximum distance of 125 m from the trail. A minimum distance of 25 m from the trail was chosen to avoid the sampling of areas that were near the paths. The number of potential sample stations ranged from 85 at site A-I to 169 at N-II. Ten stations were then chosen in each of the four areas using a randon number table.

To allow location of the chosen stations in the field, the map was used to predetermine a starting point on the trail (always at a precisely located distance marker), a compass direction to follow and an exact distance to pace out. The exact location of the station was marked with a stake.

4.1.2. Tree and Shrub Densities

As detailed by COTTAM & CURTIS (1956), the chosen sampling point was the centre for four imaginary "quadrats", as defined by the four compass directions. Within each quadrat, the distance was measured to the nearest shrub and the nearest tree. In this study, shrubs and trees were considered separately so as to provide more complete information on the upper forest levels. A "shrub" is defined here as any woody plant which has a height from 0.5 m to 8.0 m. This arbitrary choice was principally one of convenience, since the data from the shrub and tree categories are combined in the data analysis. If the shrub and tree categories had not been separated in the field, the relative abundance of shrubs would have simply reduced the proportion of data pertinent to the upper forest levels.

The mean distance to the nearest tree or shrub in each quadrat (this distance the fined as D) provides an indirect measure of density as it can be demonstrated that the reciprocal of D squared is equal to the density. The density of the shrub and tree categories at each sampling station were used in the foliage volume profile calculations as described below. The mean densities were also calculated for each study site.

4.1.3. Foliage Volume Profiles

In order to calculate the foliage volume, the parameters listed below were considered for every shrub and tree that was selected for the density calculations. Four shrubs and four trees were thus sampled at each station.

Height: The height was estimated by eye, as it was discovered that other conventional measurement techniques (requiring sighting of the top of the tree while fairly distant from it) were extremely difficult to use in the dense tropical forest. My height estimations were regularly "calibrated" against known heights.

Crown depth: The depth of each individual's crown was the difference between the overall height and the estimated height of the lowest part of the crown.

Crown diameter: This value was determined by measuring, on the ground, the linear distance through the area over which the crown projected.

Crown shape: The crown shape was described by choosing a geometric shape which most closely approached its true configuration FIGURE 5 illustrates the four basic geometric shapes which were used and describes three variants then.

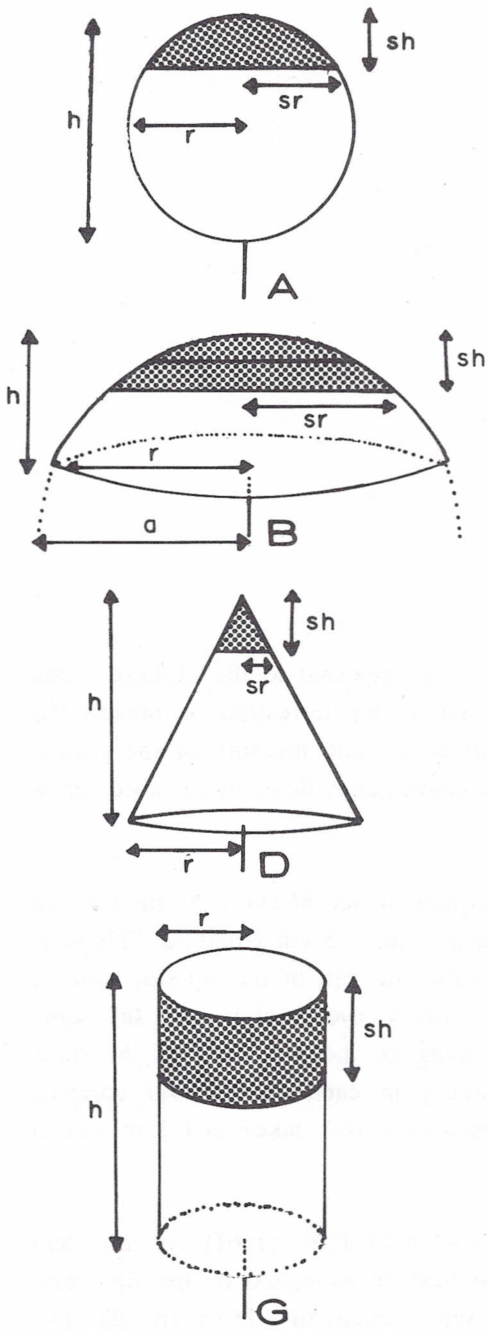
The calculation of the crown volume for each individual took into account all the above values and was based on the volume formulas given in FIGURE 5. The determination of a foliage volume profile requires that a number of height classes be arbitrarily defined. Four-metre intervals were chosen (the lowest interval was only 3.5 m since it started at 0.5 m above ground) as it was found that using finer division, such as of two or three metres substantially increased the variability of the results*. The formulas for açrown slice", also given in FIGURE 5, were used to calculate that part of the crown's volume in each of the height classes.

A computer programme was written which, for every individual tree and shrub, calculated the volume of foliage in each height class. The value thus obtained were, for each individual, the m^3 of foliage/height class. These values were then subsequently divided by the depth of height class and multiplied by the appropriate density value of the station (depending on whether the individual was a shrub or a tree) to give the m^3 of foliage $m^3$of each height class. The eight values for each station were summed and averaged and considered one independent datum. The foliage volume profile for the study site was drawn using the mean values of each height class.

4.1.4. Characteristics of the Foliage

The size and shape of the leaves of each sampled individual were summarily described using the vegetation recording system of DANSEREAU et alii (1966). That part of their classification which was

(*) The height classes were thus: 0.5 - 4.0 m, 4.0 - 8.0 m, 8.0 - 12.0 m, 12.0 - 16.0 m - 16.0 - 20.0 m, 20.0 - 24.0 m and 24.0 - 28.0 m.



Total crown volume	Volume of crown slice (shaded)

Shape A: Sphere

$V = \dfrac{4 \pi r^3}{3}$

$V = \dfrac{\pi sh^2}{3} (3 sr - sh)$

where $sr = \sqrt{2r\ sh - sh^2}$

Shape B: Partial Sphere

$V = \dfrac{\pi h^2}{3} (3r - h)$

As above but where r is replaced by a where

$a = \dfrac{r^2 + h^2}{2h}$

Shape C is an inverted partial sphere.

Shape D: Upright cone

$V = \dfrac{\pi r^2 h}{3}$

$V = \dfrac{\pi sr^2\ sh}{3}$

where $sr = \dfrac{r\ sh}{h}$

Shape E is an inverted cone and shape F is equal to an upright cone and an inverted cone placed end to end (a spindle shape).

Shape G: Cylinder

$V = \pi r^2 h$

$V = \pi r^2 sh$

Note:

h = crown depth estimated in field
r = crown radius estimated in field
sh = depth of the crown slice (thus a defined value)
sr = radius of the crown slice (if not known, this value can be calculated from known values)

FIGURE 5 - Crown shapes and volume.

adopted is defined below. Their "medium" category of leaf size was divided into two finer categories: "small" and "medium" (their "small" becomes my "very small").

Leaf shapes

o Leafless
n Needle, spine, scale or subulate
g Narrow (defined here, as at least twice as long as broad)
h Broad (less than twice as long as broad)
q Thalloid ("an amorphous outline")
v Compound

Leaf sizes
r Very small: < 2.25 cm^2 (= 1.5 cm squared)
t Small: 2.25 to 20.25 cm^2 (= 4.5 cm squared)
m Medium: 20.25 to 182.25 cm^2 (= 13.5 cm squared)
u Large: 182.25 to 1640.25 cm^2 (= 40.5 cm square)
y Very large: > 1640.25 cm^2

4.1.5. Foliage Density Near Ground Level

The measurements of foliage volume described above were only relevant to the foliage found at heights above 0.5 m. Many species of birds in tropical forests are either terrestrial or inhabit the vegetation layers very close to the ground so it was thought useful to have some measure of the ground level foliage density. Direct measurements of foliage density could be conveniently done by an absenver at ground level.

Foliage density was measured by using a "coverboard", a square panel 30 cm x 30 cm covered by a checkerboard pattern of black and white squares which were each 5 cm x 5 cm (MACARTHUR & MACARTHUR , 1961). The distance (D) from the coverboard, at which one half of the squares were at least partially obscured by vegetation, was measured by an observer whose eye level was at the same height as the middle of the board. The coverboard was successively hung on the four sides of the stake that marked the exact location of the sampling station (facing directly in each of the four compass directions) allowing four measures at each sampling point. A set of measures were taken at 0.3 m and at 1.5 m from the ground.

As explained in more detail by MACARTHUR & MACARTHUR (1961), n, the leaf silhouette per unit of board area (unit size itself is unimportant), can best be estimated by the first term of a Poisson distribution such that n = 1n 2. The foliage density it self is equal to n/D or 1n 2/D. The density is measured as m>of leaf silhouette/m^3.

An interpretation of how many squares are covered by vegetation can be quite subjetive and there would probably beconsiderable variation between individual observers. To minimize this factor, the author made all the coverboard measurements.

The four measures from each station were averaged to give one independent measure of the foliage density at each of the two heights. Overall mean values of density for the study sites are the means of all station values.

4.2 Bird Sampling with Mist Nets

KARR (1981a) provides an excellent summary of information about mist netting in the tropics. Most of the methods he suggests were followed quite closely in this study.

Each netting session consisted of a linear deployment of five nets end to end. The four-shelved, black mesh, nylon mist nets had a mesh width of 38 mm, a height of 2.1 m and a length of 9.1 m. The nets were set as close to the ground as possible since previous studies in the tropics have shown that a disproportionate number of bird captures are made very near the ground (TERBORGH & WESKE, 1969).

Many factors are known to have an influence on netting results (KARR, 1981a). Important sources of variation, excluding those attributable to different habitat types, are: time of day, time of year, weather and the number of days nets are opened in any given location. As detailed below, all of these factors were kept as uniform as possible between the study sites, since the variation of interest in this study was precisely that due to habitat differences.

No netting was ever conducted during periods of precipitation, heavy fog or strong winds. Weather conditions were therefore essentially quite uniform for all netting periods. The only weather variable that was recorded during netting was the percentage of cloud cover.

Each of the four study sites, was sampled with three different lines (FIGURE 4). At each site, the net sets were labelled as the a, b and c lines. Lines a and b were each run for two days, and line c for three days, giving a total of seven days at each site.

The a lines were sampled in the period from 14 November to 13 December 1985 and b lines from 13 to 30 January 1986. The a and b lines were both set parallel to, and at the edge of the paths. Their location within each study site was subjective: approximately 75 m from each end of the study site both with their exact locations chosen to minimize local variations in relief. These nets were run from about 6:30* (shortly after sunrise) till about 11:30. The two days of netting were often, both not always, on consecutive days. It is only after three days of consecutive netting in any one location that capture rates start to decline significantly (KARR, 1981a; personal experience).

The c lines were placed perpendicular to the path, and set back about 15 m so that the entire length of the set was in undisturbed forest. These lines were run during the period from 25 February to 27 March 1986. The nets were opened on three different days before being dismantled and moved to the next site but on no occasion were they opened on three consecutive days. Nets for this

(*) Daylight saving times in effect after 14 March have been adjusted to agree with the clock settings in effect during the summer. All times are by the 24 hour clock.

final group of sites were opened from about 7:30 till 15:00 or 16:00. One might certainly expect that different species or different numbers of birds would be captured when netting away from the paths; since each area was sampled similarly, this should not have caused differences between study sites.

It was considered particularly important that each time period of the day be sampled equally since it is perhaps this factor that most strongly influences capture rates. TABLE 1 below shows the distribution of sampling efforts among the four study sites for each time period of the day. One net-hour is an hour of mist netting with a single net. Since five nets were always used for this study, an hour of mist netting was equivalent to five net-hours. The total number of net-hours differed only very slightly between study sites and this was largely a consequence of differences in numbers of net-hours in the afternoon - a period when very few birds were captured. For the purposes of comparing numbers of captured birds, the sampling effort is considered equal at each site.

The nets were usually checked every 60 to 90 minutes, with a minimum period between checks of about two hours. For the purposes of this study, the only information of interest was the number and identity of each species. Additional information was however recorded for each bird such as sex, age, the moulting pattern (if any) of remiges and rectrices and the extent of moult of body feathers. This information will be considered elsewhere (GRAHAM, **in prep.**). No birds were banded, but in order to approximately determine the recapture rate, all birds had a unique combination of one or two rectrices of remiges clipped neatly at the end of the feather. This method provides only an approximate recapture rate because of feather loss and moulting patterns. Definite recaptures, of which there were very few, were considered no differently from new, unmarked birds. KARR (1981a) recommends this approach if one's objective is simple to define activity levels. On three occasions a bird was recaptured on the same day. These individuals were not reconted.

TABLE 1 - Mist netting effort (numbers of net-hours) at each study site.

Time period	A-I	A-II	N-I	N-II	Total
6:00 - 8:00	39.4	38.6	36.6	32.8	147.4
8:01 - 10:00	69.2	69.2	69.2	69.3	276.9
10:01 - 12:00	58.6	59.3	58.2	59.8	235.9
12:01 - 14:00	29.8	29.7	29.8	29.7	119.0
14:01 - 16:00	28.6	29.8	26.1	29.7	114.2
16:01 - 18:00	6.2	5.0		12..5	23.7
Total	231.8	231.6	219.9	233.8	917.1

4.3 Bird Censusing with Fixed-ratius Point Counts

The survey method that was used in this study, to complement the mist netting, involved fixed-ratius point counts. This counting technique yields a measure of relative densities.

Each count was of a duration of 20 minutes, and involved the recording of every bird seen or heard within a radius of 25 m of the stationary observer. All counts were conducted along one of the paths that passed through the middle of the study site. The 25 m radius was chosen as it represented the approximate limit of visibility under these conditions. A certain error was involved in estimating the 25 m radius, but the observer's perception of this distance was frequently checked against known distances and was usually very accurate. Variable-radius point counts (and most other couting techniques that measure absolute densities) require that a distance by estimated to each recorded bird. This approach undoubtedly involves more estimation error than that in which the observer needs only to be able to estimate a single, constant difference.

Birds that were seen flying over the forest were not included in the counts because it was not considered that such wide-ranging individuals could be truly considered as associated with the habitat being surveyed. Birds thus excluded were swallows, swifts, vultures and most hawks and parrots. Any bird that flew by within the canopy was counted. Unidentified species were noted as being on or near the ground, in the understory (approximately to 5 m), in the mid-levels (5 - 20 m) or in the canopy (20+ m). Detailed notes were made on all unknown birds and calls, and some of these proved to be subsequently identifiable.

On any given day of survey at a study site, anywhere from one to four consecutive counts were made. Each count was at least 100 m from the previous count to minimize the possibilities that the same birds would be counted twice. It is possible that a very few wide-ranging birds were nevertheless included on successive counts, but this never obviously ocurred. When arriving at the location of the point count, the observer first remained very quiet for a period of exactly four minutes before initiating the count. It was anticipated that very shy species might be more likely to be subsequently counted. All counts were done unassisted by the author.

On each day of censusing, the count locations were determined before going in the field. They were chosen so that, at any given time, the completed counts would be uniformly spread along the path of the study site. Given that a relatively small length of trail was being surveyed, it was inevitable that some individuals would be included on different counts. The approach adopted minimized recounting as much as possible. A random selection of count locations, resulting in unequal spacing between counts, could have led to more birds being counted twice (either because counts would be too close to each other on any given day or because, on different days, there would be a higher probability of recounting resident birds on their territories.)

The counts were conducted in two different groups: afternoon counts and morning counts. The above criteria for spacing the counts were applied separately to each group. The afternoon counts were conducted from 24 September to 11 November 1985. On every day of afternoon censusing, four consecutive counts were done at a single study site: always at 15:40, 16:10, 16:40 and at 17:10. A total of 12 counts were done at each study site.

With the initiation of mist netting activities in December, it proved impractical to continue the afternoon point counts. It was however possible to conduct point counts between mist net checks. The morning counts were thus not done at set times nor in set numbers, but locations of any possible point counts were always predetermined as outlined above. Point counts were never done at the same study site at which netting was being conducted. The morning counts were all done in the period from 11 December to 29 March 1986. Starting times for the counts were restricted to the time period from 07:00

to 10:00. Sixteen morning counts were done in each area.

5 RESULTS

5.1 Vegetation Sampling

Because of their voluminous nature, only summaries of the vegetation sampling data are presented here. Full printouts of the vegetation data (and of the bird data) are available from the author.

5.1.1 Tree and Shrub Densities

TABLE 2 gives the mean density values for the shrub and tree categories of each study site. Although the densities are based on a total of 36 or 40 measurements, the number of independent measurements (n) is only equal to the number of sampling stations (9 or 10). Within each study site, there was a considerable variability among the various stations as concerns the density of both the shrub and tree layers. This variability is reflected by the high standard deviations of the means and the correspondingly large 95 % confidence intervals of the means.

TABLE 2 - Tree and shrub densities as calculated by the point centred quadrat method.

Study site	Mean density (no./m^2) ± 95 % Conf. limit	Standard Deviation	n
Shrubs (≤=8 m)			
A-I	1.46 ± 1.44	2.02	10
A-II	0.69 ± 0.36	0.46	9
N-I	0.83 ± 0.28	0.39	10
N-II	1.18 ± 0.62	0.86	10
Trees (>8 m)			
A-I	0.10 ± 0.04	0.06	10
A-II	0.13 ± 0.08	0.10	9
N-I	0.10 ± 0.05	0.07	10
N-II	0.12 ± 0.05	0.08	10

For both the shrub and tree categories, the study site means were compared with each other through the use of unpaired two sample t-tests. In no case could it be concluded, at a 95 % confidence level, that any two study sites had significantly different mean densities. The high shrub density value at A- I was largely the result of a single, unusually dense station. The exclusion of this one datum would give a new mean of 0.80, resulting in fairly uniform densities at A-I, A-II and N-I compared to a higher density at N-II.

5.1.2 Foliage Volume Profiles

TABLE 3 gives mean foliage volume for each height class and for each study site. In addition to the total foliage volume, the part of this total that was represented only by *Araucaria angustifolia*, at the study sites A-I and A-II, is also shown. FIGURE 6 is a graphic representation of the foliage volume profiles for each site. It should be noted that the values are m^3 of foliage/m^3 of space within each height class.

The standard deviations of the mean values of foliage volume are very high, indicating a great variability among stations. No further statistical testing would be justified, and in fact, little reliability can be accorded the apparent strata of some of the study site profiles. Overall, it can be only stated that no consistent stratification is apparent in either the *Araucaria* study sites nor in the natural forest sites. Impressions in the field would support an apparent abscence of strong stratification.

One important difference between the two groups of study areas is however immediately apparent from FIGURE 6. The two *Araucaria* study sites had a considerable volume of foliage in the 24.0 - 28.0 m height class whereas the two natural forest study sites had virtually no foliage in this height class. This heights of 25 to 28 m whereas in the natural forest areas, few trees where so tall. This volume, at A-I and A-II, was almost entirely formed by *Araucaria*. The total amount of foliage in the rate classes from 12.0 to 24.0 m appears to be similar at all study sites, but it is of interest to note, that at sites A-I and A-II, an important proportion of this foliage is represented by *Araucaria* (not below 16.0 m at site A-II). Since the foliage of *Araucaria* must represented a very different microenvironment for forest birds, it can be expected that this difference is of some biological interest.

TABLE 3 - Foliage volumes by height classes (m^3 of foliage/m^3)

Height classes (m)	Means of all stations	Standard deviations	*Araucaria* only (means)	n
A-I				
0.5 - 4.0	0.124	0.290		10
4.0 - 8.0	0.183	0.234		10
8.0 - 12.0	0.153	0.145	0.050	10
12.0 - 16.0	0.296	0.606	0.124	10
16.0 - 20.0	0.226	0.249	0.075	10
20.0 - 24.0	0.268	0.328	0.180	10
24.0 - 28.0	0.089	0.157	0.080	10
A-II				
0.5 - 4.0	0.143	0.226		9
4.0 - 8.0	0.266	0.389		9
8.0 - 12.0	0.158	0.128		9

continuation

cont. TABLE 3

Height classes (m)	Means of all stations	Standard deviations	*Araucaria* only (means)	n
12.0 - 16.0	0.074	0.119		9
16.0 - 20.0	0.053	0.125	0.046	9
20.0 - 24.0	0.205	0.331	0.185	9
24.0 - 28.0	0.058	0.173	0.052	9
N-I				
0.5 - 4.0	0.162	0.241		10
4.0 - 8.0	0.137	0.165		10
8.0 - 12.0	0.124	0.148		10
12.0 - 16.0	0.388	0.297		10
16.0 - 20.0	0.234	0.247		10
20.0 - 24.0	0.097	0.178		10
24.0 - 28.0	0.006	0.016		10
N-II				
0.5 - 4.0	0.099	0.103		10
4.0 - 8.0	0.056	0.056		10
8.0 - 12.0	0.165	0.210		10
12.0 - 16.0	0.167	0.227		10
16.0 - 20.0	0.167	0.240		10
20.0 - 24.0	0.142	0.251		10
24.0 - 28.0	0.003	0.011		10

5.1.3 Charcteristics of the Foliage

The data in TABLE 4 provide information on the leaf shapes and sizes of the foliage at each study site. Data are provided for all height classes combined.

The principal points of interest that emerge from an examination of these data, is once again the preponderance of *Araucaria* at sites A-I and A-II. The proportion of the total amount of foliage that is accounted for by this species (which exclusively represents all needle shaped leaves and all "very small" leaves), is 39.2 % at A-I and 34.0 % at A-II. Two other trends of interest can be pointed out, but it is doubtful if much statistical significance could be attached to them. Site N-II seems to have a relatively greater proportion of its foliage in the "medium" size category. Secondly, the *Araucaria* sites are distinguished by having a small proportion of their foliage accounted for by "large" and "very large" leaves which were not sampled at all at the natural forest sites. The large-leaved species were *Bathysa australis*, *Alchornea* spp and arborescent ferns (probably *Dicksonia* sp).

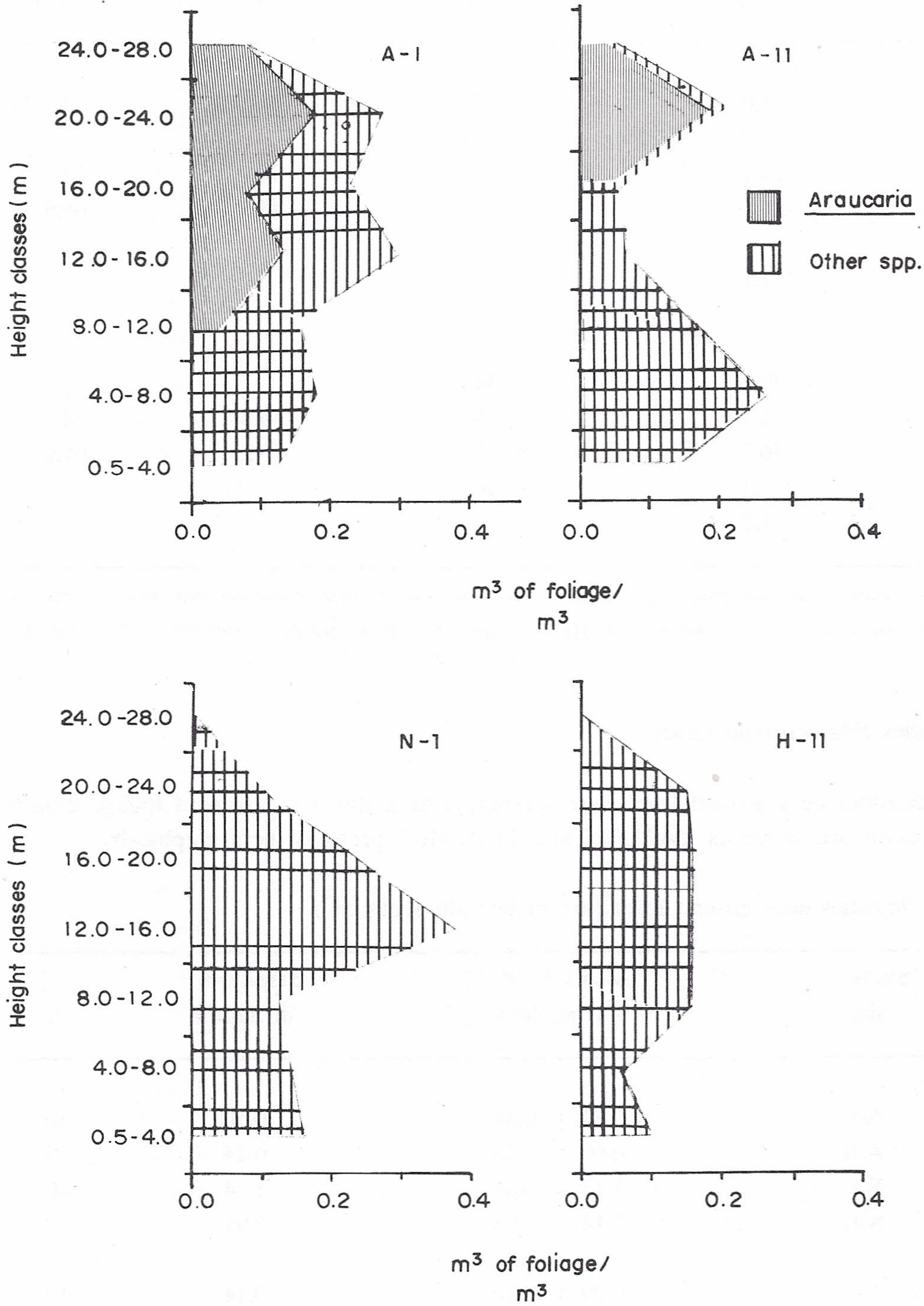


FIGURE 6 - Foliage volume profiles for each study site.

TABLE 4 - Characteristics of the foliage at each study site[a].

Leaf characteristic	Study site A-I	A-II	N-I	N-II
Leaf shapes				
Leafless	5.0 %		4.2 %	2.5 %
Needle	30.2	34.0		
Narrow	24.1	9.0	54.2	34.1
Broad	34.6	57.0	45.8	65.9
Thalloid				
Compound	2.1			
Leaf sizes				
Very small	39.2	34.0		
Small	2.7	19.1	64.8	34.4
Medium	16.3	30.6	35.2	65.6
Large	7.3	16.3		
Very large	1.7			

(a) Values for the leafless category are the percentages of the total number of sampled individuals that were leafless. All other values represent percentages of the total volume of foliage. See text for a more complete definition of the shape and sizes categories.

5.1.4 Foliage Densities Near Ground Level

Foliage densities near ground level were quantified by a direct measure of foliage density with a coverboard. The results are shown in TABLE 5 and FIGURE 7 presents them graphically.

TABLE 5 - Foliage densities near ground level (m^2 of leaf silhouette/m^3).

	Study site	Mean ± 95 % conf. limit	Standard deviation	n
At 0.3 m				
	A-I	0.62 ± 0.36	0.50	10
	A-II	0.60 ± 0.19	0.24	9
	N-I	1.13 ± 0.88	1.24	10
	N-II	2.14 ± 2.08	2.91	10
At 1.5 m				
	A-I	0.29 ± 0.10	0.14	10
	A-II	1.48 ± 1.72	2.24	9
	N-I	0.77 ± 0.80	1.13	10
	N-II	0.47 ± 0.27	0.38	10

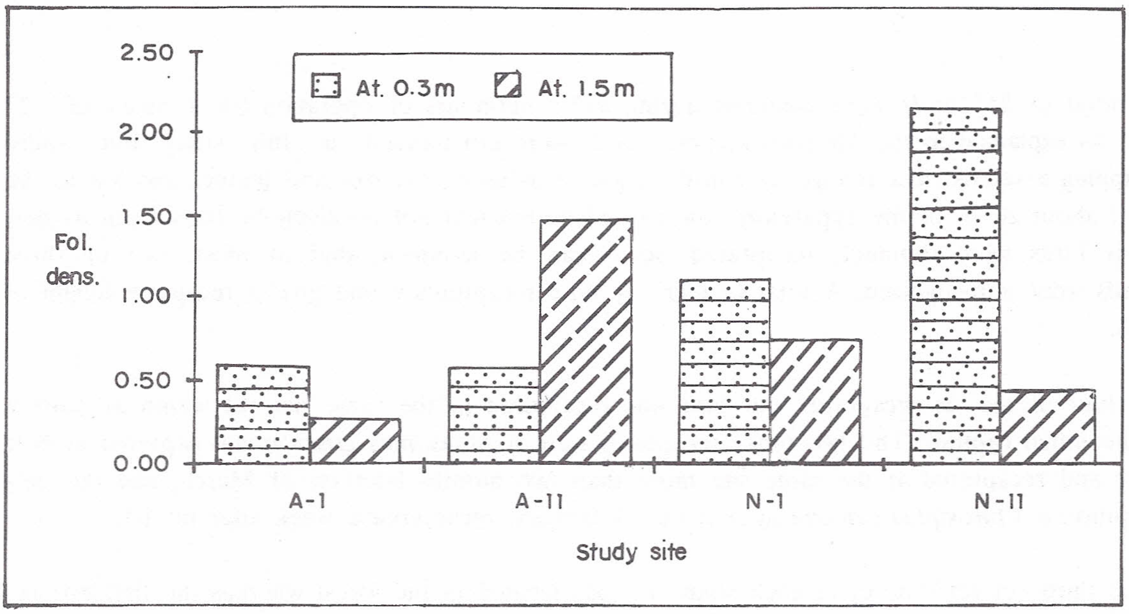


FIGURE 7 - Foliage densities (m^2 of leaf silhouette/m^3) near ground level.

Once again, high statistical variability does not inspire much confidence in these data. The particularly high foliage density at 0.3 m for N-II is though noteworthy. This site had however a low foliage density at 1.5 m; although not impossible that such a difference could exist between the two rates, this seems somewhat unlikely. Area A-I had a consistently low foliage density at both heights.

5.2 Bird Sampling Results

The data are not provided here on the results of every netting session and every point count, but the nettting and count totals for each species and each study site are included in Appendix 1. This appendix also includes the English names of birds species referred to in the main text. Before beginning the atual analysis of the bird communities*, the section that follow provide a general résumé of the bird sampling results.

(*) See the DISCUSSION section for an explanation of the sense in which the term "bird community" is employed.

5.2.1 General Results

Mist netting

A total of 247 birds were captured during 917.1 net-hours of operation for a mean of 0.27 birds/net-hour. As explained in the Methods section, birds were not banded in this study but where marked by clipping a rectrix or a remige. A consideration of moulting patterns and feather loss led to the calculation that about 20 % of the apparently non-marked birds could not positively be considered as new birds. Only six birds were definitely recaptured, so it can be assumed, that at most, two or three recaptured birds went unrecognized. A total of eight or nine recaptures would give a recapture height of only 3 to 4 %.

In four of the six recaptures, the bird was recaptured in the same net set within at most a few days of the initial capture. The two other recaptures were a *Sittasomus griseicapillus* captured at N-II on 13 January and recaptured at the same site more than two months later on 21 March, and the only inter-site recapture, a *Chiroxiphia caudata* in A-II on 15 January, recaptured a week later in A-I.

The third net set (line c) at each study site was located in the forest whereas the first two net sets (a and b) were set beside and parallel to the path. The c lines remained open until later in the day and for three days rather than two; both factors would have depressed the overall mean capture heights. To evaluate the effect of net location, I compared lines a and b to the first two days of netting and only for netting periods up till noon of the c lines. A mean number of 0.27 birds/net-hour was captured in the forest sets and 0.34 birds/net-hour in the path sets. The results would suggest that many birds preferentially occur along the paths, presumably exploiting the edge habitat for foraging or for local movements (the latter being obviously the case for hummingbirds which were frequently to be seen flying up and down the paths).

Point counts

The 16 morning and 12 afternoon counts are combined in the analysis of the following sections but the differences between these two groups are of interest. Grouping all the study sites together, the mean number of birds/count was 8.4 for the morning counts (n=64) and 5.5 for the afternoon counts (n=48). The mean number of species was, respectively, 7.0 and 4.5.

Unidentified birds represented 18 % of the total number of 801 birds recorded (unidentified hummingbirds accounted in turn for a quarter of this total). The percentage of unidentified birds was 25 % for the afternoon n counts, and 15 % for the morning counts, reflecting simply the improvement in the author's field identification skills: the afternoon counts were done in September and November 1985 and the morning counts from mid-December 1985 to March 1986. The percentage of records that was only auditory was 58.1 % (65 % for unidentified birds).

Of anedoctal interest is the proportion of point counts on which monkeys were recorded (within about 100 m). The Brown Howler Monkey *Alouatta fusca* was recorded on no less than 22 % of all counts. It can be noted in passing, that on a few occasions, their deafening howling at close quarters surely affected the observer's ability to hear birds. The lovely Titi Monkey *Callicebus personatus* was recorded on one point count. The two other species of monkey that occur in the Serra da Cantareira were both recorded on the study sites: the Tufted Capuchin Monkey *Cebus apella* was commonly noted feeding on the fruits of *Araucaria* in March while the Buffy Tufeted-ear Marmoset *Callithrix aurita* was only rarely seen.

Effects on cloud cover

None of the bird work was ever done under any extreme weather condition. The only weather factor that did vary to any important degree was the percentage cloud cover: recorded for all netting and point count work as < 50 %, > 50 % or 100 % cover. The results (data not presented) indicated no effect whatsoever due to cloud cover. This conclusion was further supported by similar data from about 370 birds that I mist netted in the Parque Estadual da Capital in work not related to this research (unpublished data). ROBBINS (1981) looked at the effect of cloud cover on Breeding Bird Survey results from North America and came to similar conclusions.

Time of day and year

The influence on counts due to the time of day was substantial and expected. FIGURE 8 shows the trends that resulted from the point count sampling. The mist netting results showed similar trends with a steady decline in capture rates from early morning till late afternoon. No effect could be demonstrated for the time of the year (data not presented) indicating an absence of any strong trends in bird abundance or activity during the study period.

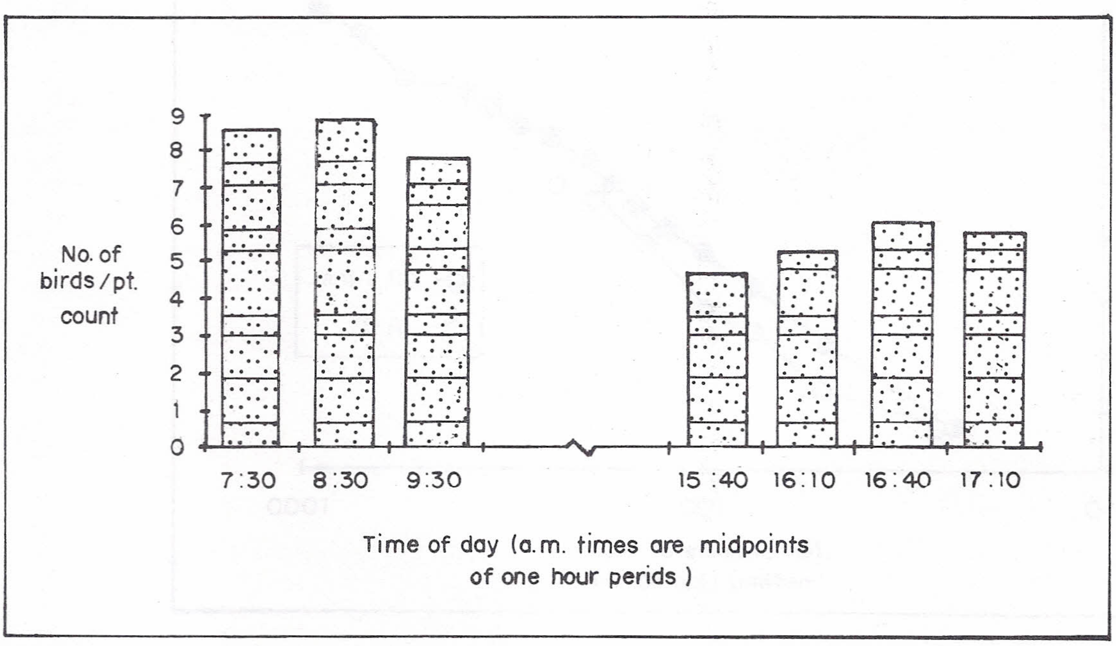


FIGURE 8 - Effect of the time of day on the mean number of birds/point count.

Number of bird species versus effort

A graph of the cumulative number of species versus the cumulative effort is of considerable interest since it provides information on the number of species in the study area, and on the completeness of the sampling programme. A number of mathematical equations have been proposed to represent this relationship. DAWSON (1981) stated that a plot of the number of species versus the logarithm of the effort should result in a straight line. This semilogarithmic relationship can be mathematically expressed as $s_n = s_1 + a \log n$, where S is the number of species, a is a coefficient that describes the rate of increase with increasing effort and n is the measure of effort. The coefficient a is estimated by: $a = (S_t - S_1)/\log t$, where t is the total effort that was expended (DAWSON, 1981).

FIGURE 9 is a graph of this semi-logarithmic relationship for the mist netting. The data for all sites combined are plotted, as well as an example of one of the study sites. Plots of the other study sites were similar. The number of species that would have been captured if the mist netting effort was very extensive, should approximate the total number of species that could conceivably be netted. These values and the coefficient a were calculated where n = 2300 hours (approximately 100 mornings of mist netting which would result in capture of about 620 birds) for each site and for all sites combined. The number of species to be expected would be 40, 53, 43 and 51 for A-I, A-II, N-I and N-II, respectively. The actual number of species recorded at each site varied from 51 % to 60 % of these totals. For all study sites combined, 54 spp. would be expected and 45 were in fact captured (83 %).

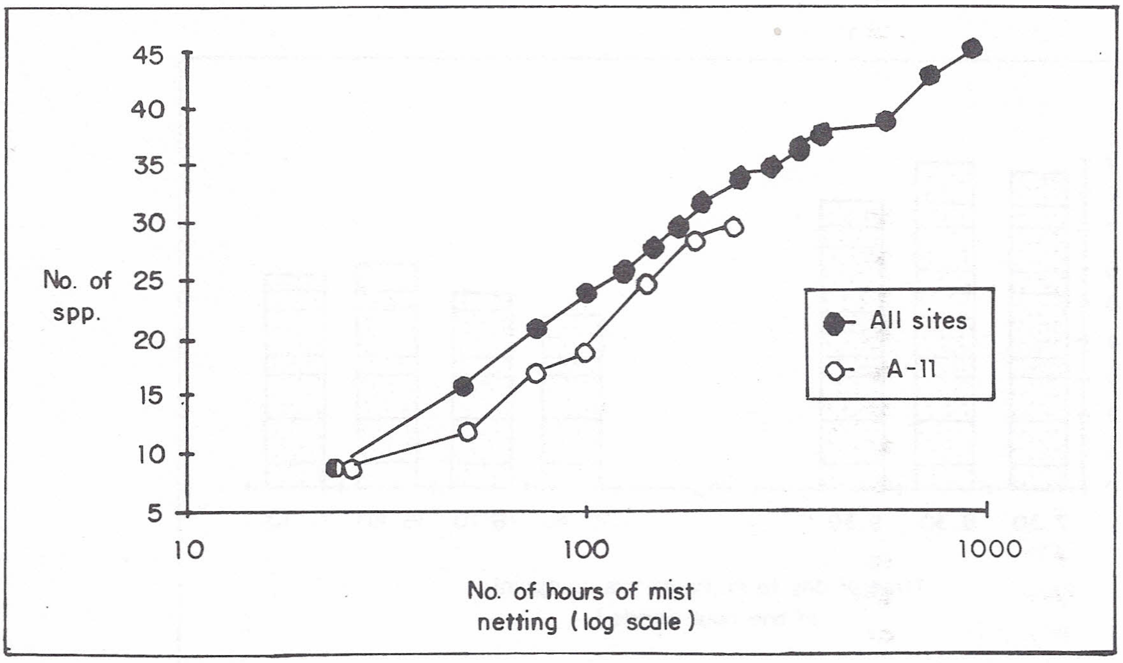


FIGURE 9 - Cumulative number of species versus mist netting effort.

The point count data for all sites combined, and again for a single study site, are presented in FIGURE 10. As indicated on the graph, the initiation of morning counts resulted in a noticeable change in the value of the coefficient a making an interpretation of the results difficult. The 64 morning counts (representing 59 of the 69 spp. recorded on all counts) were therefore considered alone. There was no apparent levelling off of the number of new species after 64 counts. The semi-logarithmic plot is therefore not linear although a logarithmic plot is almost perfectly so (data not presented).

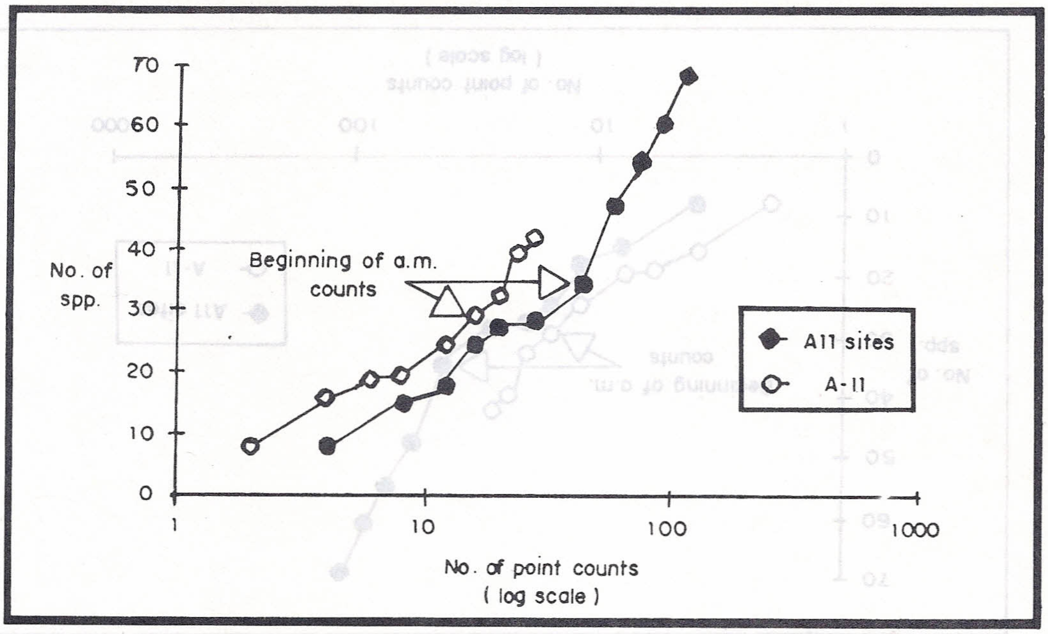


FIGURE 10 - Cumulative number of species versus number of point counts.

The linearity of the logarithmic plot would suggest that the value of the coefficient a was itself increasing at a regular rate. The obvious explanation of this trend, not evident in the mist netting, is that the point counts were done by an observer who was continually improving his field identification skills. An extrapolation of the total number of species cannot be made from the logarithmic plot, since it would cease to be linear as soon as a plateau was reached in field identification skills.

The number of "recordable" species can not be reliably calculated, but it can be noted that from the list of all species known from the study sites (Appendix 1), about 100 could reasonably be expected on a point count. It would seem that the point count effort, during which 64 species were noted, recorded a relatively smaller proportion of possible species than the mist netting.

5.2.2 Community Level Analysis

The bird communities associated with each study site are compared in the following sections at three successively finer levels of interpretation: i) community level (total numbers of birds, species diversity), ii) guild level and iii) species level.

TABLE 6 presents an overview of the community level results. The species diversity of the bird community at each study site is measured by the Shannon-Wiener Information Theory function

(KREBS, 1985): $H = -\Sigma (p_i)(\log p_i)$, where p is the proportion of the i^{th} species. These results are graphed on FIGURES 11 and 12.

TABLE 6 - Community level analysis of total bird numbers and species diversity.

	Study site				
	A-I	A-II	N-I	N-II	Total
Point counts					
Number of birds	124	170	139	224	656
Number of species	32	42	36	40	69
Species diversity (H)	1.32	1.40	1.35	1.40	1.49
No. of point counts	28	28	28	28	112
Mist netting					
Number of birds	58	69	41	79	247
Number of species	24	30	22	30	45
Species diversity (H)	1.27	1.32	1.27	1.38	1.46
No. of net-hours	231.8	231.6	219.9	233.8	917.1
Total number of species	40	55	47	50	80

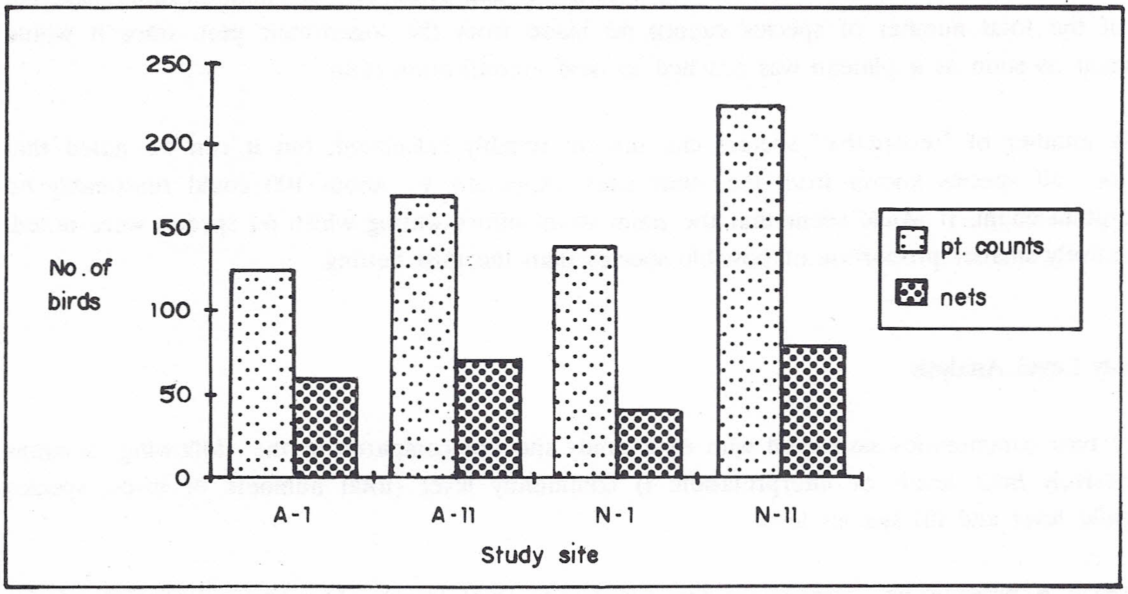


FIGURE 11 - Total bird numbers for point counts and mist netting at each study site.

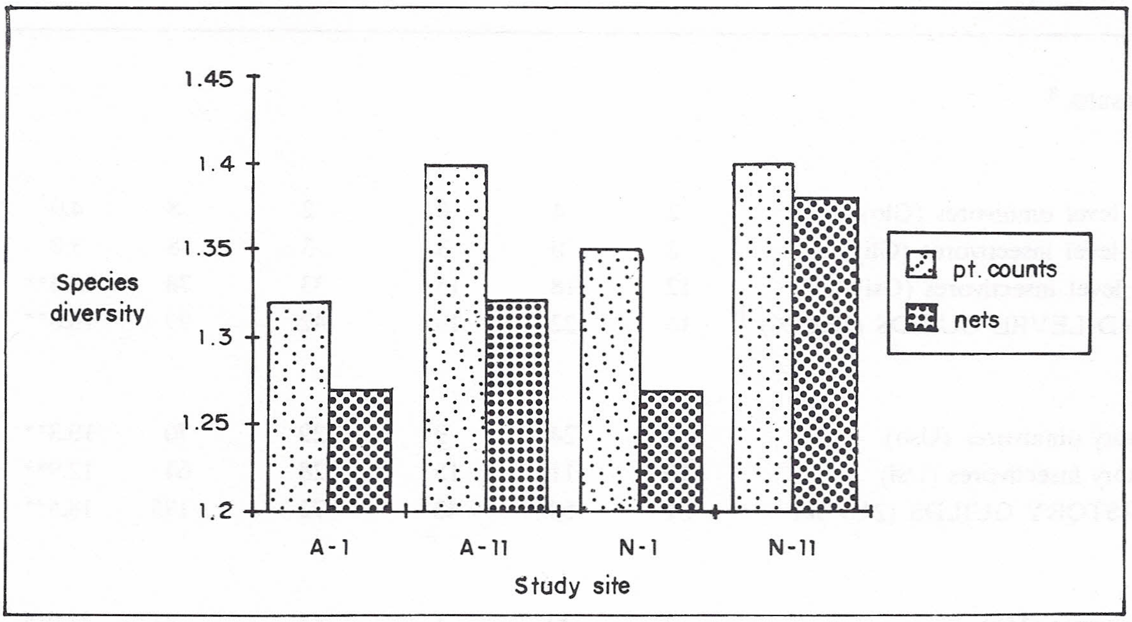


FIGURE 12 - Species diversity for point counts and mist netting at each study site.

The differences between the study sites are consistent, but surprising, and not the results that were expected. Site N-II in the natural forest has the highest numbers of birds and highest species diversities followed by A-II (which however has the highest combined number of species), N-I and then A-I. The effort at each study site was equal for all bird sampling so, if there were no inter-site differences at the bird community level, equal numbers of birds should have been recorded at each site. This hypothesis can be simply tested with the Chi*f* statistic. For both the point counts and the mist netting, the Chi*f* value (see TABLE 7 in the next section) is highly significant (p .01). The fact that two very different survey techniques resulted in such consistent and statistically significant differences is compelling evidence of real differences in these bird communities. The species diversity results show the same trends as for the total numbers data.

5.2.3 Guild and Species Level Analysis

Given the significance of these trends in the data, it becomes of particular interest to determine which components of the bird community contributed to these differences. An analysis at the guild level, supported by data from the most commonly recorded species, will serve that purpose.

TABLE 7 - Guild level analysis of the point count and mist netting data.

Guild (guild code)	Study site A-I	A-II	N-I	N-II	Total	Chi^2c
Point count results [a]						
Large ground level omnivores (Glo)	2	4	0	2	8	4.0
Large ground level insectivores (Gli)	2	0	3	3	8	3.0
Small ground level insectivores (Gsi)	12	18	15	33	78	13.4**
ALL GROUND LEVEL GUILDS (12.4 %) [b]	16	22	19	42	99	16.8**
Small understory omnivores (Uso)	8	24	9	29	70	19.3**
Small understory insectivores (Usi)	10	11	15	28	64	12.9**
ALL UNDERSTORY GUILDS (24.3 %)	31	50	42	72	195	18.5**
Mid-level omnivores (Mo)	2	20	4	15	41	21.9**
Mid-level insectivores (Mi)	30	33	39	51	153	6.8*
ALL MID-LEVEL GUILDS (28.6 %)	36	58	55	80	229	17.0**
Large canopy omnivores (Clo)	4	5	10	5	24	3.7
Small canopy omnivores (Cso)	5	4	10	12	31	5.8
Canopy insectivores (Ci)	12	13	10	4	39	5.0
ALL CANOPY GUILDS (13.0 %)	24	23	34	23	104	3.3
Diurnal carnivores (dc) (0.4 %)	1	0	0	2	3	3.7
Trunk and twig insectivores (Tti)(9.1 %)	17	17	18	21	73	0.6
Nectarivores (Nec) (12.2 %)	27	28	19	24	98	2.0
TOTAL	152	198	187	264	801	32.8**

cont. TABLE 7

continuation TABLE 7

Guild (guild code)	Study site A-I	A-II	N-I	N-II	Total	Chi²c
Mist netting Results						
Large ground omnivores (Glo)	1	0	2	0	3	3.7
Large ground level insectivores (Gli)	2	2	2	4	10	1.2
Small ground level insectivores (Gsi)	5	5	9	13	32	5.5
ALL GROUND LEVEL GUILDS (18.2 %)	8	7	13	17	45	5.8
Small understory omnivores (Uso)	22	28	10	18	78	8.8*
Small understory insectivores (Usi)	8	8	8	16	40	4.8
ALL UNDERSTORY GUILDS (47.8 %)	30	36	18	34	118	6.6
Mid-level omnivores (Mo)	2	2	0	0	4	4.0
Mid-level insectivores (Mi)	3	2	2	9	16	8.5*
ALL MID-LEVEL GUILDS (8.1 %)	5	4	2	9	20	5.2
Large canopy omnivores (Clo)	0	0	0	0	0	
Small canopy omnivores (Cso)	0	0	0	2	2	6.0
Canopy insectivores (Ci)	0	4	0	1	5	8.6*
ALL CANOPY GUILDS (2.8 %)	0	4	0	3	7	7.3
Diurnal carnivores (Dc) (0.8 %)	2	0	0	0	2	6.0
Trunk and twig insectivores (Tti) (11.7 %)	5	8	5	11	29	3.4
Nectarivores (Nec) (10.5 %)	8	10	3	5	26	4.5
TOTAL	58	69	41	79	247	12.9**

(a) Values for point counts are the total number of birds recorded at each study site. Values for the mist netting are the total number of birds netted.

(b) The value in parentheses is the percentage of the total number of birds from all study sites.

(c) An * indicates a significant value ($p \leq .05$) of the Chi square statistic and ** indicates a highly significant value ($p \leq .01$).

A guild is rather loosely defined here, as a group of birds preferentially occurring at about the same height in the forest, of about the same size and with the same feeding preferences. The concept is considered in more detail in the DISCUSSION section. Since birds in tropical forests tend to be quite specifically associated with certain heights, it is reasonable to use this as a first defining character in a guild classification. An initial division into four major height groups (ground level, understory, mid-level and canopy) corresponds well with published and personal observations for height preferences of the species involved in this study. Within each overall height group, two to three guilds are distinguished based on size and feeding preferences: omnivore (= frugivore/insectivore) or insectivore.

WILLIS (1979) classified many of the forest birds of São Paulo into 20 groupings of ecologically similar species (he did not employ the term guild). Although somewhat modified, his classification is adopted here. His original 20 categories, as well as the guilds proposed for this study, are detailed in Appendix 2.

The changes that have been made from the classification of WILLIS (1979) are: i) species belonging to his category "Forest birds eating large fruit and insects" are divided into two groups defined by height preferences: "Mid-level omnivores" and "Large canopy omnivores"; ii) the few species recorded in this study that belong to one of the three edge categories are assigned to some other appropriate group, since, at my sites at least, these species were a part of the regular forest avifauna and not associated with any extensive edge habitat; iii) the single species (*Myiornis auricularis*) in the category "Insectivores of bamboo or forest tangles" is added to the guild "Small understory insectivores" since my observations did not suggest that this species was particularly associated with thick tangles, an uncommon microhabitat on the study sites; iv) three species are considered to be primarily associated with a different height than that indicated by WILLIS (1979): *Cranioleuca pallida, Thamnophilus caerulescens* and *Basileuterus culicivorus* (all these species are further discussed below). The 15 species of this study not included by WILLIS (1979) are classified into an appropriate guild according to published information and personal observations in the Serra da Cantareira.

An additional seven categories of WILLIS (1979) are termed here "specialist guilds" since they are not generally associated with any special height in the forest but do share some distinctive resource base. Three of these groups were sampled in this study: diurnal carnivores, trunk and twig insectivores and nectarivores. The four other groups were either nocturnal or specifically excluded: carrion eaters, aerial insectivores and nocturnal carnivores and insectivores.

TABLE 7 gives the results of a guild level analysis of the point count and mist netting data. To test if there were significant differences between study sites, the Chi^2 test was used. Excluding for the moment the specialist guilds, the data were first examined at the level of groups of guilds of similar height preferences (ground level, understory, mid-levels and canopy) and subsequently at the individual guild level. The former approach has the advantage of allowing the incorporation of all the point count data on unidentified birds since all such records were assigned, in the field, to one of the four height levels.

To aid the interpretation of the guild level results, the most commonly recorded species from the point counts and from the netting are also considered. TABLE 8 includes the relevant data for the 15 most commonly netted species (from a total of 45). These species represent 73.3 % of all captures. TABLE 9 similarly summarizes the data for the 16 most common point count species out of the total of 69. These species account for 64.2 % of all the records and 78.2 % of all the identified birds. For the mist netting data, the Chi^2 statistic was used to test the hypothesis that, for each species, an equal number of birds occurred at all study sites. The point count results were analyzed (HUTTO, et alii, 1986) with a Kruskal-Wallis one-way ANOVA: a non-parametric rank test (SOKAL & ROHLF, 1981). In this test, birds which tend to occur in monospecific groups will influence the results less than the Chi^2 test which only takes into account total numbers of birds. The results for the point count species were also tested with the Chi^2 statistic which gave very similar results. The few differences are discussed below under the relevant species.

TABLE 8 - The 15 most common species recorded from the mist netting.

Species (guild code)	Study site A-I	A-II	N-I	N-II	Total	% of Total	Chi^{2}a
Sittasomus griseicapillus (Tti)	4	7	5	7	23	9.3	1.2
Schiffornis virescens (Uso)	6	6	3	8	23	9.3	2.2
Trichothraupis melanops (Uso)	6	11	2	0	19	7.7	14.9**
Basileuterus leucoblepharus (Gsi)	4	3	4	6	17	6.9	1.1
Chiroxiphia caudata (Uso)	4	3	0	6	13	5.3	5.8
Haplospiza unicolor (Uso)	5	4	2	1	12	4.9	3.3
Phaethornis eurynome (Nec)	2	6	1	1	10	4.0	6.8
Thalurania glaucopis (Nec)	1	3	2	3	9	3.6	1.2
Dysithamnus mentalis (Usi)	0	2	2	5	9	3.6	5.7
Conopophaga lineata (Gsi)	1	1	4	3	9	3.6	3.0
Platyrinchus mystaceus (Usi)	2	1	4	3	9	3.6	1.2
Pyriglena leucoptera (Gli)	1	2	2	3	8	3.2	1.0
Lathotriccus euleri (Usi)	6	1	0	1	8	3.2	11.0*
Thamnophilus caerulescens (Mi)	1	1	1	3	6	2.4	2.0
Basileuterus culicivorus (Mi)	1	1	1	3	6	2.4	2.0

(a) An * indicates a significant value (p $\leq$.05) of the Chi square statistic and ** indicates a highly significant value (p $\leq$.01).

TABLE 9 - The 16 most common species recorded from the point counts.

Species (guild code)	Study site A-I	A-II	N-I	N-II	Total	% of Total	H(Kruskal-Wallis)a
Basileuterus culicivorus (Mi)	23	23	25	27	98	12.2	0.5
Sittasomus griseicapillus (Tti)	13	11	15	16	55	6.9	2.1
Synallaxis ruficapilla (Gsi)	8	13	8	7	36	4.5	3.1
Phaethornis eurynome (Nec)	8	10	4	11	33	4.1	4.3
Thamnophilus caerulescens (Mi)	5	3	8	16	32	4.0	11.1*
Dysithamnus mentalis (Usi)	2	7	10	13	32	4.0	8.4*
Chiroxiphia caudata (Uso)	6	13	3	10	32	4.0	6.3
Tangara desmaresti (Mo)	0	17	0	13	30	3.7	5.6
Basileuterus leucoblepharus (Gsi)	2	3	4	19	28	3.5	30.3**
Vireo olivaceus (Cso)	4	3	6	8	21	2.6	3.6
Thalurania glaucopis (Nec)	2	5	1	6	19	2.4	4.1
Cranioleuca pallida (Ci)	5	10	0	1	16	2.0	15.6**
Lathotriccus euleri (Usi)	5	3	1	6	15	1.9	3.1
Amazilia versicolor (Nec)	4	3	3	2	12	1.5	1.0
Platyrinchus mystaceus (Usi)	2	1	4	5	12	1.5	3.7
Habia rubica (Uso)	0	0	0	12	12	1.5	18.9**

(a) Significant values of the Kruskal-Wallis H (p $\leq$ .1) are shown an * and highly significant values (p $\leq$ .01) are shown with **.

5.2.3.1 Ground Level Guilds

For the point count results, differences between the study sites are highly significant (p .01) for all ground level guilds combined (TABLE 7). The differences are however almost entirely attributable to the guild of "Small ground level insectivores" (Gsi). The other two guilds, "Large ground level insectivores" (Gli) and "Large ground level omnivores" (Glo) are both poorly represented in the data. Almost twice as many members of the "Small ground level insectivores" guild were recorded at N-II as at any other site. The same tendencies are evident for the mist netting results but the differences are not statistically significant.

Four members of the "Small ground level insectivores" guild were common enough to be included on TABLES 8 and 9 but only one of these species showed statistically significant differences in numbers between the study sites. The distribution of *Basileuterus leucoblepharus*, a ground-inhabiting warbler, had a highly significant (p .01) preponderance of point count records from N-II. This species alone accounts for the statistical differences at the guild level, but interestingly, the mist netting results indicated no such differences between the study sites.

In summary, differences between the study sites for ground level guilds essentially are based on high numbers of *B. leucoblepharus* at N-II, a distribution not substantiated by the mist netting data. The exclusion of this species from the point count data for this guild would result in very nearly equal numbers at each site (Chi^2 = 1.4).

5.2.3.2 Understory Guilds

The results from the point counts are generally in agreement with those noted at the boardest community level: high numbers at N-II and, less markedly, at A-II. Differences between sites for both the understory guilds and for the two of them combined are highly significant. A quarter of all point count records were from this height group. The mist netting data are of special relevance to this group of guilds, since almost half of all the captures were members of understory guilds. Overall, differences between the study sites are not significant although a significant difference for "Small understory omnivores" (Uso) results from high numbers at both of the *Araucaria* sites and low numbers at N-I.

Five species of "Small understory omnivores" are recorded on TABLES 8 and 9. The unusual distribution of this guild in the mist netting data (high numbers at the *Araucaria* sites) results almost entirely from the distribution of the Black-goggled Tanager *Trichothraupis melanops*. It was not frequently recorded in the point counts but of nine birds, only four were recorded at the *Araucaria* sites, thus not supporting this apparent distribution pattern. The only other "Small understory omnivore" with a significant distribution was the tanager *Habia rubica*. In the point counts, it was absent at all sites except N-II where no less than 12 were recorded (on 6 different counts). Although highly significant according to the Kruskal-Wallis test, the few mist netting results do not support this distribution pattern. Only a total of three birds were netted: one at each site, except N-II!

Three species of "Small understory insectivores" (Usi) were common in the mist nets but of these, only the flycatcher *Lathotriccus euleri** was not evenly distributed between study areas. It was significantly more common at A-I but the sample size is very small (total of six birds from all sites). No significant differences were noted for this species in the point count data. Of the two "Small understory insectivores" from the point count data of TABLE 9, only the ant-vireo *Dysithamnus mentalis* had significantly different numbers between the various sites. Particulary high numbers were recorded at the natural forest sites and relatively few at A-I. The mist netting trends for this species, although not significant, were similar.

In summary, the understory guilds generally followed the same distribution patterns noted for the bird community overall: highest numbers at N-II and A-II. This pattern was highly significant for the point counts but not significant in the mist netting. If the two species *Trichothraupis melanops* and *Habia rubica*, both of which show strange and inconsistent distribution patterns, are removed from the data, these same general trends are also evidenced by the guild of "Small understory omnivores". The trend would be significant only for the point count data. Numbers at each site would become: point counts - 8, 20, 6 and 15 (Chi^2 value = 10.2*) and mist netting - 15, 20, 7 and 18 (Chi^2 value = 6.5).

5.2.3.3 Mid-level Guilds

Only 8 % of the mist netting records were of members of mid-level guilds. The inter-site distribution pattern for "Mid-level insectivores" (Mi) was significant, with higher numbers at N-II. For the point counts, over one quarter of all records were of members of mid-level guilds. Differences were highly significant for "Mid-level omnivores" (Mo) with greatest numbers at A-II and N-II. Differences were significant for "Mid-level insectivores" with greatest numbers at N-II and similarly, for all mid-level guilds combined.

Only two mid-level species, *Basileuterus culicivorus* and *Thamnophilus caerulescens*, were commonly netted (TABLE 8). These two were both considered understory species by WILLIS (1979). Both of these common species occur throughout the different heights of the forest, but my observations suggested they were most common at about 5-15 m. This is supported by the data presented here: both species were among the five most commonly recorded during point counts but near the ground, were relatively infrequently netted (both ranked as 14th most common). Individually, neither species shows significant inter-site differences for the netting data but together, they account for the significance at the guild level. In the point counts, again only these two species were common among the "Mid-level insectivores". The warbler *B. culicivorus* was by far the commonest species recorded on point counts and very likely, the commonest forest species in the Serra da Cantareira. It showed a uniform distribution between the study areas with only slightly higher numbers in the natural forest sites. The ant-shrike *T. caerulescens* was commonest at N-II (inter-site difference considered significant by the Kruskal-Wallis test and highly significant by the Chi^2 test).

Only a single "Mid-level omnivore" was common enough to be recorded on either TABLE 8 or 9. The beautiful Brassy-breasted Tanager *Tangara desmaresti* was the only species in this study that

(*) The generic name Lathotriccus is used in preference to Empidomax following LANYON & LANYON (1986).

occurred commonly in monospecific flocks and is thus not appropriately considered in terms of total numbers per study site. Only five observations accounted for all 30 birds recorded. The high numbers at A-II and N-II of this species cannot be considered meaningful. These values had contributed to the significance of the distribution pattern of "Mid-level omnivores".

In summary, among mid-level guilds, only the inter-site distribution pattern of "Mid-level insectivores" can reliably be interpreted as significant. This guild was most strongly represented at N-II (and less so at N-I). This pattern was significant for both the point counts and for the mist netting. If the infrequently recorded *Tangara desmaresti* is excluded from the data for "Mid-level omnivores", no trends would be apparent for this guild.

5.2.3.4 Canopy Guilds

Canopy species, as would be expected, accounted for only a small fraction of the mist netted birds (2.8 %) resulting in sample sizes too small to be considered further. Members of canopy guilds accounted for 13 % of all the point count records. In the point counts, no guild showed a significant inter-site distribution pattern.

Two species were fairly commonly noted in the point counts. The Red-eyed Vireo *Vireo olivaceus*, was slightly more common, but not significantly so, at the natural forest sites. The spinetail *Cranioleuca pallida* had an inter-site distribution pattern that was highly significant, being restricted almost entirely to the *Araucaria* sites A-I and A-II. Observations in the field fully supported this distribution pattern. It was commonly to be seen in the crowns of *Araucaria* (both on the study sites and in small plantations in the Parque Estadual da Capital) but was extremely rare in natural forest areas. SICK (1985) recorded that it occurs in the forest crowns and is particularly partial to planted conifers. WILLIS (1979) recorded it as a "Mid-level insectivore".

If *Cranioleuca pallida* is excluded from the point count data, no one of the three canopy guilds shows significant inter-site differences. For the canopy guilds combined however, there are significantly more birds at the natural forest sites (especially at N-I). The new canopy guild totals, for all sites combined, would become: 19, 13, 34 and 23 (Chi^2 value = 10.6*).

5.2.3.5 Specialist guilds

Diurnal carnivores

The forest-dwelling hawks and falcons recorded in this study were extremely secretive species, which were only rarely recorded on point counts. Two species, *Buteo magnirostris* and *Micrastur ruficollis*, each once became caught in the mist nets while they were attacking captured birds.

Trunk and twig insectivores

This guild is comprised of the various woodpeckers, woodcreepers, and a few specialized

Furnariids that primarily feed along trunks and branches. As a whole, this guild accounted for about 10 % of both point count and mist netting records. This was almost entirely due to the Olivaceous Woodcreeper *Sittasomus griseicapillus*, the other members of the guild were all relatively rare. *S. griseicapillus* was, along with the manakin *Schiffornis virescens*, the most commonly netted bird. It was the second most commonly recorded species during point counts. Its distribution pattern among sites revealed no apparent preferences.

Nectarivores

Except for a single example of the Bananaquit *Coereba flaveola* during a point count, this guild was entirely represented by hummingbirds (the family Trochilidae). The inclusion of unidentified hummingbirds in the guild total is important, since they accounted for about a third of the nectarivore records. The guild comprised about 10 % of all records in both the point counts and mist netting. They were quite evenly distributed among the study sites.

Six species of hummingbirds were recorded of which the two most important were *Phaethornis eurynome* and *Thalurania glaucopis*. The first species, the Scale-throated Hermit, was the fourth most common species in point counts and, in addition, probably accounted for most of the unidentified Trochilids.

This study's findings that trunk and twig insectivores and nectarivores were the least affected groups of species contrasts sharply with the results of CLOUT & GAZE (1984). The latter authors found that in exotic conifer forests of New Zealand, the most affected groups were frugivores, nectar-feeders and hole-nesting species (which would include all woodpeckers).

5.2.4 Summary of the Bird Sampling Results

The total numbers of birds at the various sites originally indicated a highly significant inter-site distribution pattern: unusually high numbers at the natural forest site N-II and, somewhat less so, at the *Araucaria* site A-II. The guild and species level analysis permitted some interesting insights into this pattern and a somewhat different interpretation of the data.

As a first step, the removal of five "aberrant" species from the analysis simplifies the interpretation of the data. *Cranioleuca pallida* has a preference for planted conifers and can be removed as a known source of bias. The data for *Tangara desmaresti* are highly clumped, since it is a flocking species and is represented by so few records, thus it can also be excluded. Three other species (*Basileuterus leucoblepharus*, *Trichothraupis melanops* and *Habia rubica*) have distribution patterns that are totally inconsistent between the mist netting and point count data and are excluded on that basis. Of these three species, only *B. leucoblepharus* is particularly common, and its inclusion would only further support the conclusions proposed below.

The numbers of birds by guild and by site are shown in TABLE 10 after the exclusion of these species from the data. A different interpretation of the data immediately presents itself. For the point counts, there are significantly ($p \leq 0.01$) more birds at the two natural forest sites combined, than at the *Araucaria* sites. It should be noted that, before the exclusion of the aberrant species, the same two-group comparison would have similarly yielded a highly significant difference. That would be however, in spite of the fact that A-II had higher bird numbers than N-I, an anomaly that did not previously justify the grouping of the *Araucaria* sites versus the natural forest sites. The point count data of TABLE 10 further reveal that all the major guild groupings (the "Specialist guilds" excluded) contribute to this tendency but the difference is significant ($p \leq 0.1$) for the canopy guilds and highly significant ($p \leq 0.01$) for the mid-level guilds. The mist netting data also show higher numbers at the natural forest study sites but the difference is not significant for all birds combined nor for any guild grouping except for the ground level guilds.

TABLE 10 - Bird numbers at each site after exclusion of 5 "aberrant" species[a]

Guild category	*Araucaria* A-I+A-II= **Total**	Nat.Forest N-I+N-II= **Total**	Chi^2[b]
Ground-level guilds			
Point counts:	14 + 19= **33**	15 + 23= **38**	0.4
Mist netting:	4 + 4= **8**	9 + 11= **20**	4.9*
Understory guilds			
Point counts:	31 + 46= **77**	39 + 58= **97**	2.3
Mist netting:	23 + 24= **47**	15 + 34= **49**	0.4
Mid-level guilds[c]			
Point counts:	36 + 41= **77**	55 + 67= **122**	10.2**
Canopy guilds			
Point counts:	19 + 13= **32**	34 + 22= **56**	6.5*
All birds			
Point counts:	145 + 164= **309**	180 + 217= **397**	11.0**
Mist netting:	45 + 53= **98**	34 + 73= **107**	0.4

(a) The five excluded species are discussed in the text.

(b) Significant values ($p \leq 0.1$) are shown by * and highly significant values ($p \leq 0.01$) by **. The Chi^2 values are based on the two total values.

(c) Mist netting records from the the mid-level and canopy guilds are not included because of small sample sizes.

In conclusion, an analysis of the data after removal of the five species discussed above, reveals that the specialist guilds showed no inter-site preferences. The canopy and mid-level guilds were significantly more abundant at the natural forest sites. The results are less consistent for the other guild groupings. The understory guilds show the same tendency (not significant) but, particularly for the point counts, continue to show high numbers at N-II and A-II. For the ground-level guilds, there were more birds in the natural forest sites, but this is significant only for the mist netting (the inclusion of *Basileuterus leucoblepharus* would however result in highly significant numbers at N-II for the point counts).

6 DISCUSSION

Before discussing the relationship between the vegetation structure and birds, it will be valuable to pause, and elucidate what is intended by the term "bird community" in this study. Such a definition will be useful in clarifying what exactly was being measured by the bird surveys. Subsequent sections of the DISCUSSION will present some reflections on the methods used in this study and some possible means of improving them.

6.1 The Bird "Community" at Each Site

The Results section clearly showed that there were significant and consistent inter-site differences as concerns the bird communities. It is more problematic however, to describe what exactly was being measured at each site. The term "community" has been used in this study to describe the population of birds that was being sampled at each site. The use of the term community was not intended to be too literally interpreted, since the pretension cannot be made that any of the study sites supported a unique bird population. The sites were small, close together, and, except for structural features of the canopy, quite similar in vegetation structure. It would in fact be reasonable to assume that a single community of birds occurred in the whole study area, and that there was considerable interchange between the study sites. This study did presuppose though, that certain species, or groups of species, would preferentially frequent or avoid one or other of the sites, and it was the sum of these preferences that defines the bird "community" of each site.

It was not initially expected that any one species would be exclusively restricted to just one or two study sites. Nevertheless, one third of all the species were recorded from only a single site but since species lists were considered to be only about 50-60 % complete, this statistic means little. A single sure exception is the spinetail *Cranioleuca pallida*, which has a known preference for planted conifers and in this study was almost exclusively recorded from the *Araucaria* study sites.

It is evident that, as defined here, there were different communities at the *Araucaria* sites versus the natural forest sites. It must now be asked whether the experimental set-up allowed the impact of an *Araucaria* plantation to be fully manifested and measured. Unless an area of *Araucaria* was very large, the "interference" from the adjacent natural forest habitat will artificially minimize the perceived tendencies of birds to either avoid or frequent the *Araucaria*.

MORRISON et alii (1981) have suggested that 20 ha is the minimum size of a habitat unit that can be considered a relatively continuous area not overly subject to influences from the avifauna of adjacent habitats. In evaluating the impact of an *Araucaria* plantation, it must be clearly understood however that two phenomena are involved: avoidance of the *Araucaria* by some birds and the choice of *Araucaria* as a preferred habitat by others. The phenomenon of avoidance is only partially dependent on the size of the plantation, as even a very small area of unsuitable habitat can be avoided by birds (KARR [1981a] discussed studies that show that some forest species show a significant avoidance of such tiny microhabitats as a treefall gap). Of course, the larger the area, the more the avoidance phenomenon will be clearly apparent, since there will be less probability that a bird will wander a considerable distance into an "undesirable" habitat. In this study, no bird observations were made at a distance of less than 50 m from the adjacent habitat. Such a difference should have been sufficient for an avoidance tendency to be manifested, although certainly a larger margin, if it had been possible, would have been preferable.

The size of the plantation is critical though when we are discussing the phenomenon of "choice". Unless the area is simply a preferred feeding area, it must be large enough to support a breeding population of the species (or spp.) in question. It would presumably be in this context, that MORRISON et alii (1981) provided their guess of 20 ha. Again, a larger plantation of *Araucaria* would have been preferable, but as it was, the *Araucaria* plantation was certain sufficiently large to satisfy the 20 ha size criterion. The size of the patch of *Araucaria* in which study sites A-I and A-II were located was 41.6 ha. Although continuous in extent, it was partially split in half by a narrow tongue of natural forest (FIGURE 4) which extended along the course of a small stream. On the other hand, the total area of *Araucaria* plantations in the immediate area of the study sites, was 78.4 ha although this was divided up into several patches. One final point, which suggests that the size of the *Araucaria* plantation was sufficient for the purposes of this study, is that it obviously supported a unique population of at least one species: the example of *Cranioleuca pallida* was discussed above.

In summary, "interference" from the adjacent natural forest habitat must have, to some extent, caused an underestimation of the true impact of an *Araucaria* plantation. Several arguments are presented however which suggest that any such effect would have been minimal. The exact degree of underestimation could only be determined by further studies.

6.2 Role of the Vegetation Structure

Before addressing the role of the vegetation structure in determining the nature of the bird communities, it will be useful to summarize the results of the vegetation structure sampling. There were no consistent differences between the sites, as concerns the density of the shrub and tree categories, nor in any apparent stratification of the foliage profile itself. The data for foliage densities near ground level were tentatively considered to reveal a high foliage density at 0.3 m for N-II, and low densities for A-I at 0.3 m and 1.5 m. The two *Araucaria* sites were distinguished by having more foliage in the 24.0 - 28.0 m height category and of course, by having the upper strata dominated by *Araucaria*. Area A-I had 39.2 % of all its foliage above 0.5 composed of *Araucaria* while this figure was 34.0 % for A-II (TABLE 4).

The measure of vegetation structure that has been most commonly related to bird community structure is the Foliage Height Diversity index (F.H.D.) of MACARTHUR & MACARTHUR (1961). This measure deserves to be reviewed here in some detail.

MACARTHUR & MACARTHUR (1961) found a very high correlation between F.H.D. and species diversity and their results have been supported by many subsequent studies (KARR & ROTH, 1971; WILLSON, 1974; but compare ROTH, 1976). The F.H.D. uses the same information theory formula generally used for species diversity, but rather than the proportion of the i^{th} species, p_i represents the proportion of foliage in the i^{th} layer. MACARTHUR & MACARTHUR (1961) used the layers 0'- 2', 2' - 25' and 25' + (0 - 0.6 m, 0.6 - 7.6 m and 7.6 m+) as this combination gave the best correlation with the species diversity values. The correlation can essentially be interpreted as indicating that as additional vegetation strata are added (as the vertical diversity increases), species diversity increases correspondingly.

The foliage measure that was used for their F.H.D. calculations was the "square feet of leaf silhouette per cubic foot of space". In their original paper, and in several subsequent ones (MACARTHUR et alii, 1962; MACARTHUR, 1964), the area of leaf silhouette was measured with a coverboard as described in the methods for the present study. It is not mentioned how horizontal measurements were made at higher heights, although it is mentioned that: "the measurements are less accurate [above 15' since] the techniques of measurement (...) are most accurate in practice where one can stand on the ground" (MACARTHUR et alii, 1964). TERBORGH & WESKE (1969) reported that they used the method of MACARTHUR & MACARTHUR (1961) to calculate the foliage profile for their study sites in Peru, but they provided no details as to how horizontal measurements could have been made at canopy heights ranging to 50 m! Perhaps they in fact, used the method of MACARTHUR & HORN (1969) who proposed a measure of foliage profile through the use of vertical sightings from the ground. This method uses fairly sophisticated equipment to make accurate measurements from many random points to the height of the first leaf above each point. This technique is less conveniently used when working in forests with high and dense canopies, as relatively fewer measures will be made of leaves in the upper strata. This newer method measured the square feet of leaf surface per cubic foot as determined from the vertical leaf silhouettes rather than the horizontal leaf silhouettes. MACARTHUR & HORN (1969) stated that, in practice, the two measures are very similar. The method I have proposed in this study, measures instead the m^3 of foliage/m^3. From a "bird's eye view", it would be problematic indeed to determine which measure is more biologically meaningful. It can however be similarly used to draw up a foliage profile and to calculate a F.H.D.

To calculate a F.H.D. in this study, I used the same vegetation layers that were considered as being of importance in defining the bird guilds: an understory layer from 0.5 - 4.0 m (4 m is used rather than 5 m, as the former values are conveniently available on TABLE 3); a mid-level layer from 4.0 to 20.0 m and a canopy layer of 20.0 m+. The F.H.D. values for the two *Araucaria* sites are 0.36 and 0.41, and for the two natural forest sites, are 0.29 and 0.35. The slightly higher values of F.H.D. for the former sites reflect the extra layer of *Araucaria* foliage in the upper canopy.

Species diversity values for the four study sites were given in TABLE 6. No correlation between species diversity and F.H.D. is evident, but there are too few data to definitively reach a conclusion. It would provide an attractive explanation for the high species diversity of A-II (highest species diversity and highest foliage diversity) but at the same time, A-I, with the second highest F.H.D., has the lowest species diversity.

It is certainly not true that an increased F.H.D. results in higher levels of bird activity: the two *Araucaria* plots had the lowest bird numbers. It should not be surprising, if generally, the F.H.D. measure proves to be of little use in studies evaluating the impact of exotic tree plantations. The measure, as used in published studies, is related to structure of plots of natural vegetation. The addition of an extra layer of foliage, when that foliage is of a type exotic to the local bird fauna, should not be expected to result in an increase in bird diversity nor in bird numbers.

An important result of this study therefore, even if somewhat obvious, is that the traditional measure of F.H.D. cannot be used in studies involving exotic plant species. In their original paper, MACARTHUR & MACARTHUR (1961) had stressed that species diversity can be solely accounted for by vegetation structure, without any consideration of plant species composition. In fact, the addition of an extra layer of "exotic foliage" could perhaps even be expected to occasionally depress the species diversity of a forest. A different approach to evaluating the vegetation structure is necessary. The measure below, that very simply takes into account the presence of the exotic vegetation, is perhaps sufficient.

For the mid-level guilds, the number of point count birds* versus the percentage of natural foliage in the 4.0 - 20.0 m zone is: A-I: 36 (71 %); A-II: 41 (91.7 %); N-I: 55 (100 %) and N-II: 67 (100 %). For the canopy guilds, the same values, but for the 20 m+ zone yields: A-II: 13 (10 %): A-I: 19 (27 %); N-I: 34 (100 %) and N-II: 22 (100 %). In all cases, the higher the proportion of natural foliage, the higher the bird numbers. These tendencies however are not strongly correlated; an attempt to graph these values as a linear regression clearly showed a linear trend but indicated no significance at a 95 % confidence level.

No *Araucaria* foliage was present in the understory and ground level habitats, and, for the point counts at least, the number of birds at these height levels in the *Araucaria* sites, did not significantly differ from numbers at the natural forest sites. These conclusions are however tentative since the mist netting showed significantly more birds in the natural forest and the inclusion of *Basileuterus leucoblepharus* in the data would mean that the point counts would similarly show higher numbers. If indeed, numbers in these guilds were higher in the natural forest, the presence of the *Araucaria* trees may have depressed activity levels or abundance through some other unknown mechanism. The apparently denser foliage very near the ground at N-II, may have been somehow related to higher bird numbers at the site. Similarly, what may have been much less dense foliage near ground level at A-I, may partially explain the particularly low bird numbers at that site.

The structure of the foliage thus offers a reasonable and simple explanation for explaining differences between an artificial plantation of *Araucaria* and areas of natural forest. The structural feature of importance is not the vertical of the foliage (F.H.D.), but rather a direct measure of the presence of the *Araucaria*. That other considerations are also involved, is however indicated by the fact that no strong correlation could be shown for this effect. The use of a guild level approach allowed these differences to be most convincingly demonstrated for those areas were *Araucaria* foliage was present: the mid-level and canopy strata. Interestingly, DRISCOLL (1977) noted, anecdotally, that the species missing from exotic pine forests were those characteristic of high foliage and branches of native forest rather than ground level species.

(*) The bird data used in this section are from TABLE 10.

As a final point, it should be noted that even when vegetation structure is strongly implicated as "regulating" bird communities, the reality will be much more complex. If birds respond to vegetation structure directly, it will only be because other environmental variables are themselves related to vegetation structure (perhaps most importantly, food and nest site availability). For example, CLOUT & GAZE (1984), in their study of pine plantations in New Zealand, concluded that the principal factor that affected bird distribution was the availability of food such as fruit but that for some species, vegetation structure and nest site availability were important.

It would be beyond the scope of this report to consider other possible environmental parameters that regulate bird communities. Two other useful measures of vegetation structure can just be noted in passing: percent vegetation cover (KARR & ROTH, 1971; WILLSON, 1974) and horizontal heterogeneity or "patchiness" (ROTH, 1976). CODY (1985) can be referred to as a recent and comprehensive example of the vast literature on "habitat choice" in birds.

6.3 Reflections on the Proposed Methods

Foliage volume profile

The use of the foliage volume profile method, proposed in this study, has been discussed in previous sections. It allows the calculation of a F.H.D. and can easily be adapted to quantify other measures of vegetation structure. One advantage of the foliage volume method over the methods traditionally used, is that it requires no special equipment at all and is easy to use in the field. In this study, crown height and depth were estimated in the field but of course, more accurate measurements with surveying equipment would improve the accuracy of the profile.

Canopy volumes have been used in studies of habitat choice in birds but not, to the author's knowledge, through the calculation of volumes for defined height classes. STURMAN (1968) calculated the total canopy volume of individual trees and found high correlations with chickadee abundance (*Parus* spp.). He however defined the canopy of a tree as being the "living foliage of the tree", in effect, an outer shell of foliage around an inner space, the "subcanopy". I did not feel such a distinction was justified nor even necessarily true -- few trees have a "subcanopy" devoid of foliage. STURMAN (1968) used a cone formula for all conifers and a "half-ellipsoid" formula for all deciduous trees. His latter formula is misleading since the volume of a half-ellipsoid actually depends on the curvature of its outer surface and cannot be calculated simply knowing the radius and depth of the crown. The volume of his illustrated figure of a "half-ellipsoid" (actually a partial sphere atop a cylinder) would be about 20 % greater than the volume given by his formula.

The use of the additional shapes proposed in this study allow more precise volume calculations. It is suggested however that crown shapes intermediate between a cone and a partial sphere (i.e., half-ellipsoids), be described in the field as being composed of shapes whose volumes are easily calculable. Alternatively, if the width of the half-ellipsoid was known at several different heights, the curvature of the outer surface could be mathematically described and the crown volume calculated through the use of the calculus.

It was found in this study that the statistical variability of the vegetation data was very high, and this caused some doubt as to the usefulness of the data. Only 10 stations were sampled at each site, and it remains to be determined how many samples would be needed to reduce the variability to more acceptable levels.

At the same time that the crown volumes of each tree and shrub were measured, the leaf size and shape were characterized using criteria developed by DANSEREAU et alii (1966). A fruitful avenue for exploring bird diversity in tropical forests would perhaps be a further development of these measures, in conjunction with the foliage volume profile. The vegetation and bird data from this study are not considered sufficiently extensive to attempt the development of such a measure. It would be reasonable however to expect that some sort of combined index of foliage volume/leaf shape/leaf size, either for the forest as a whole, or for individual strata, would be strongly related to various characteristics of the bird community. The computer programme that was written to calculate foliage volumes could very easily be adjusted to calculate the foliage volume of any desired leaf type, and at any desired height range.

Fixed-radius point counts

Field studies of bird communities in the tropics have usually relied heavily on data from netting. This is due in part to the problems that beset every tropical ornithologist: field identification problems, great species richness, high proportion of rare species, inhospitable terrain and the general insuitability of censusing techniques developed in temperate areas (KARR, 1981b). Mist netting provides one of the best ways to obtain an unbiased sample of a part of the avifauna and it of course obviates the necessity for any field identification experience with the study area. KARR (1981b) concludes that it is the best all-around method for censusing birds in tropical forests.

It of course has been frequently noted that mist nets sample only a small part of the avifauna: essentially only those birds that occur within 2 m of the ground*. Tropical forests differ from temperate forests by having many more species with restricted vertical foraging ranges. TERBORGH & WESKE (1969) found that extensive mist netting captured only about 40 % of the forest land birds known to be present in area of rain forest in Peru, but they cite a study where mist netting captured all species known to be present in a Maryland forest. It was predicted, in the present study, that the number of species that could have been captured in 100 days of mist netting would have been about 55 whereas at least a 100 species were known to be present on the study sites. In order to effectively sample the major part of a tropical forest avifauna, other field censusing techniques must be employed.

A vast array of methods are currently available for estimating absolute bird densities (RALPH AND SCOTT [1981] is a useful compendium). The validity of many have been brought into serious question because of the violation of assumptions that underly their use. Their utilization may be even more questionable in tropical areas where many species have "unusual" breeding systems and are not easily censused by methods designed to survey temperate species (KARR, 1981b).

(*) Mist netting at higher heights, or in the canopy, is logistically difficult and may involve substantial damage to the vegetation to allow the raising and lowering of the nets (pers. comm. with field personnel of the WWF/INPA project at Manaus).

In many cases, a knowledge of relative densities is sufficient to answer the research questions being posed and the relevant techniques may often be simpler and more reliable. DAWSON & BULL (1975) described a transect count method that yielded measures of relative densities. Another well known technique is the French I.P.A. (*Indice Ponctuel d'Abondance)* point count method (BLONDEL et alii, 1981). It is conducted over a period of 20 minutes and is a count of all birds recorded by a stationary observer with an unlimited radius of observation. Jacques Vielliard (pers. comm.) of Campinas, São Paulo, has been studying for several years the use of I.P.A. counts in São Paulo forests. KARR (1981b) noted that point counts have rarely been used in tropical forests but he suggested that their use should be more seriously considered.

This study employed a fixed-radius point count method, which differs from the I.P.A. count in that birds are only counted if recorded within a certain distance of the count centre. Fixed-radius point counts have apparently received almost no attention from researchers. In his assessment of counting techniques, VERNER (1985) reported that he found no reference at all to their use. It is interesting to note that HUTTO et alii (1986), working in tropical forests in Mexico, proposed a field methodology that is virtually identical with the one reported here.

It is suggested that a fixed-radius point count enjoys several important advantages over unlimited-radius I.P.A. counts. The principal advantage is that a fixed-radius count requires less field expertise with birds. An unlimited-radius count requires that the observer has a very good knowledge of all local bird calls as the great majority of records will be auditory and many will be faint and distant. A fixed-radius point count involves a smaller number of birds, which simplifies the count, and a higher proportion of the records are visual and thus more easily identified (and less likely to be misidentified). For example, in 95 twenty minute I.P.A. counts, Vielliard* recorded a mean of 19.9 birds/count and of these, 9.2 % were visual records (pers. comm.). The comparable statistics from this study, are 8.4 birds/count (for morning counts) and 42 % (all counts combined). A disadvantage of the smaller sample sizes is that more counts must be done to reach the same degree of statistical reliability.

It is recommended that all point counts be done during a fixed period of 3-4 hours in the morning to avoid the analytical problems caused, in this study, by having afternoon and morning counts taken at quite different levels of bird activity.

HUTTO et alii (1986) suggested that 25-30 counts per site would give reasonable estimates of density and species richness: 25 counts produced from 72 % to 86 % of the species eventually recorded in a much larger number of counts. In this study, I found that after 64 morning counts (all sites combined), there was no levelling off of the cumulative number of species curve. It was concluded (Section 5.2.1), that this was attributable in part to gradually improving field ability of the observer. But, for the morning counts combined, 85 % of all records were identified, so this cannot entirely account for the trend. HUTTO et alii (1986) were working in areas that probably had fewer species than the Serra da Cantareira. In rich tropical forests, considerably more than 30 counts appear to be required in order to census most of the species present. Further use of this counting technique in tropical forests should clarify the question.

(*) It can be noted that Dr. Vielliard, as Director of Brazil's only ornithological bioacoustics laboratory, is particularly well qualified for conducting such counts.

Guild level analysis of the bird data

One of the objectives of this study was to develop a simple analytical tool for the description of differences between bird communities of two forest types. Such a methodology would be useful in other studies of exotic tree plantations. In describing bird communities, many studies rely on a few broad parameters such as total bird numbers and species diversity or investigate differences at the species level. The guild analysis method used in this study offers certain advantages over these approaches.

If differences between two communities are simply indicated by a broad overall community parameter such as species diversity, no information is provided as to the nature of this difference. Such would be the case for the community level test used by HUTTO et alii (1986): a log-linear model approach to analyzing a three-way contingency table (species by site by presence/absence). An apparent similarity may also be misleading, since important differences between communities at a finer level of discrimination may exist, but effectively "cancel" each other out. An analysis of differences at a species level can lead to important insights into community structure if sample sizes are very large. In tropical forests however, most species are rare and there will always be relatively few species well represented in field studies. A major problem that arises from working at the species level is that the population of a given species will be related to its environment in enormously complex ways that cannot easily be unravelled in a short-term field study.

A guild is a group of species which exploit a common resource base in a similar fashion (KREBS, 1985). The guild concept has been explored in ecological studies in ornithology (e.g., FEISINGER, 1976) but has only occasionally been used as a practical tool in field studies. For example, WILLSON (1974) used a carefully conceived guild system based on primary food habits, foraging stratum and foraging behaviour. BELL (1979) defined his guilds based only on their feeding preferences. A recent paper by EMLEN et alii (1986) uses a number of "trophic categories" which are very similar to the guilds used here. The use of a guild approach seemed particularly appropriate for the comparison of an exotic plantation with a natural forest, since the distinctive and discrete differences between two such forest types would be expected to affect whole groups of similar species rather than just individual species.

If differences are indicated by some of the broad community level parameters, an analysis at a guild level should identify which groups of birds are responsible, and in turn, which features of the environment are particularly critical in determining community structure. A guild analysis may also be superior to analyses of individual species by overcoming the problems, mentioned above, of small sample sizes and great ecological complexity at the species level. A grouping of several species into a guild may result in a statistically interesting sample size, which may not have been the case for the individual members. The problem of complexity at a species level can be illustrated by an example of a guild such as "canopy insectivores". Individual members of the guild will have complex environmental requirements (related to nesting areas, predator avoidance, foraging strategies, etc.) which will only partially be related to their preferred microhabitat: the canopy. As a group however, theoretically sharing in common, only the characteristic of being canopy insectivores, they should be sensitive to major changes in the canopy environment. In some cases though, lumping species in a guild may only increase the overall level of complexity rather than reducing it. This may be the case with guilds whose perceived "common thread" is a tenuous reality. "Nectarivores" or "diurnal carnivores" may be good examples.

In this study, sample sizes were too small to allow a consideration of the specific composition of individual guilds. The supposition had been made that the total number of birds in a given guild would be related to structural features of the forest environment but the specific composition would depend on phenomena such as mutual exclusion or competition. An analysis of the specific composition of guilds could reveal interesting insights into their structure.

Further field studies using this approach will be helpful in finetuning it as a tool for the analysis of bird communities in tropical forests. In particular, field studies of microhabitat preferences of individual species should allow a more rigorous definition of guilds (perhaps using one of a number of powerful cluster analysis techniques now available). It is suggested that, during a field procedure such as point counts, the height and foraging behaviour of every bird observed be recorded to eventually allow better guild definitions. The guilds used in this study were based primarily on perceived similarites between species that may prove to be misleading in some cases*. In studies with carefully defined guilds and with extensive data bases, multivariate analysis techniques, such as discriminant analysis, could be suitably employed for detecting each guild's contribution to overall differences between communities.

7 CONCLUSION

7.1 General Considerations Regarding Exotic Plantations

Previous studies in Brazil, on the impact of exotic plantations, have relied exclusively on mist netting, broad overall parameters of the bird community such as the number of species, and have paid little attention to vegetation structure. The results from this study show that alternative approaches are necessary for evaluating the true impact of an exotic plantation.

Firstly, a reliance on mist netting will always seriously underestimate the true extent of differences, since understory layers of vegetation, the almost exclusive habitat for birds that are mist netted, will generally show the least habitat alteration. This will be especially true in more mature plantations. Birds from upper height layers in the forest can only be conveniently sampled by field censusing. The point count method gives relative estimates of density which are quite adequate for comparative studies. Census methods that measure absolute density have been little tested in tropical forests and would introduce an unneeded level of complexity. The use of the fixed-radius point count method, as developed for this study, was shown to have some advantages over unlimited-radius point counts. Its use is particularly advantageous for observers without the field identification expertise necessary for the latter type of counts.

Secondly, a guild level analysis of the bird data will allow a much better understanding of which components of the bird community are being adversely affected (or are benefiting from) the exotic plantation. Such an approach was successfully used in this study, but many suggestions were made for refinements and these should be carefully considered.

(*) That first impressions may be misleading, is illustrated by the woodcreeper Dendrocolaptes platyrostris, which is not classed as a "Trunk and twig insectivore", as are all the other woodcreeper species. Following Willis (1979), it was considered here as a "Large ground level insectivore" because of its association with army ant swarms.

Finally, a quantitative description of the vegetation structure is instrumental to fully responding to the question of the impact of exotic plantations. In this study, vegetation structure was shown to largely account for the differences in the bird communities. In other studies, other factors may have to be evaluated (especially when working at the species level), but the role of vegetation structure must always first be considered as the most likely primary explanation for bird community differences.

7.2 Considerations Regarding *Araucaria* Plantations

As indicated in the introduction, *Pinus* and *Eucalyptus* are by far the species of choice in São Paulo for reforestation programmes. Field studies on plantations of these exotic species should be a priority in Brazil because of their ubiquity and, because they are, due to their completely exotic origin, potentially the least beneficial for indigenous bird faunas.

A few words are necessary on the rather special situation of *Araucaria angustifolia* in Brazil. This species is native to large areas of southern Brazil and even in parts of São Paulo, so it can be expected that indigenous bird faunas will adapt more easily to its presence. In fact, it would not be surprising if some bird species prefer the *Araucaria* plantations. The example of *Cranioleuca pallida* has been discussed above. This study was unfortunately terminated at the end of March, just as the *Araucaria* fruit were ripening. It is possible, that at that time, some large frugivorous species may even have been moving into the plantations to exploit this rich food source. For example, it was noted above, that in March, the Tufted Capuchin Monkey was commonly noted feeding on the as yet unripe fruit. The parrot *Pionus maximiliani* seemed to be also incresing in abundance at this time in the *Araucaria* plantations (personal observation) and they may also have been feeding on the fruit.*

Nevertheless, the overall results of this study indicated an important avoidance of the *Araucaria* plantations by at least some components of the local avifauna. A better understanding of these phenomena will be necesssary before, ecologically speaking, reforestation programmes with *Araucaria angustifolia* can be fully endorsed for areas where it was not historically present.

In the state of São Paulo, as elsewhere in the tropics, it is a reality that economic considerations will continue to be uppermost in reforestation planning. The short-term economic benefits of planting exotic tree species will ensure that they will continue, in the conceivable future, to represent the species of choice for foresters.

A concern in Brazil about the adverse effects on bird faunas of such plantations (e.g., SICK, 1985), has not yet resulted in careful field investigation of the problem. Research similar to the present study will allow a better understanding of the precise nature of such adverse effects. The importance of such data cannot be overemphasized: a sound knowledge of adverse consequences inherent to exotic tree plantations should lead to more consideration of the use of indigenous tree species in reforestation

(*) It is possible that the jay Cyanocorax caeruleus moves into the Reserve to feed on the Araucaria fruit. The author could find however no conclusive proof of its presence. A few museum specimens that were shot in the Reserve may have been released birds.

programmes. At the very least, the formulation of mitigation measures will be facilitated and based on sound data, as is currently so rarely the case.

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LITERATURE CITED

ADAMS, M. W. & EDINGTON, J. M. 1973. A comparison of song-bird populations in mature coniferous and broad-leaved woods. *Forestry*, London, *46*:191-202.

ALMEIDA, A. F. de. 1979. Influência do tipo de vegetação nas populações de aves em uma floresta implantada de *Pinus* spp, na região de Agudos, SP. *IPEF*, Piracicaba, 18:59-77.

_______. & ALVES, J. E. M. 1982. *Controle integrado de saúvas na Aracruz Florestal*. Paraná, Aracruz Florestal. 72p.

AMERICAN ORNITHOLOGISTS' UNION. 1983. *Check-list of North American birds*. 6th ed. Washington, American Ornithologists' Union. 877p.

AUBREVILLE, A. 1965. Les fôrets tropicales denses australiennes et leurs coniféres. *Bois et Fôrets des Tropiques*, France, *104*:3-16.

BAITELLO, J. B. & AGUIAR, O. T. DE. 1982. Flora arbórea da Serra da Cantareira (São Paulo). In: CONGRESSO NACIONAL SOBRE ESSÊNCIAS NATIVAS, Campos do Jordão - SP, set. 12-18, 1982. Anais... *Silvicultura em São Paulo*, São Paulo, *16-A*:582-590. pt. 1 (Edição Especial)

BARBOSA, A. F. 1988. Avifauna do Parque Estadual de Campos do Jordão. *Boletim Técnico IF*, São

Paulo, *42*(único): 33-56, maio.

BARRETO, F. V. de B. 1985. *Áreas naturais do Estado de São Paulo..* São Paulo, Conselho Estadual do Meio Ambiente. 16p.

BELL, H. L. 1979. The effects on rain-forest birds of plantings of teak, *Tectona grandis*, in Papua New Guinea. *Australian Wildlife Research*, Victoria, *6*:305-318.

BLONDEL, J.; FERRY, C. & FROCHOT, B. 1981. Point counts with unlimited distance. *Studies in Avian Biology*, 6:414-420.

CARLSON, A. 1986. A comparison of birds inhabiting pine plantations and indigenous forest patches in a tropical mountain area. *Biological Conservation*, England, *35*:195-204.

CHILDERS, E. L.; SHARIK, T. L. & ADKISSON, C. S. 1986. Effects of loblolly pine plantations on songbird dynamics in the Virginia Piedmont. *Journal of Wildlife Management*, Wisconsin, *50*:406-413.

CLOUT, M. N. & GAZE, P. D. 1984. Effects of plantation forestry on birds in New Zealand. *Journal of Applied Ecology*, *21*:795-815.

CODY, M. L., ed. 1985. *Habitat selection in birds.* New York, Academic Press. 558p.

COTTAM, G. & CURTIS, J. T. 1956. The use of distance measures in phytosociological sampling. *Ecology*, San Diego, *37*:451-460.

DANSEREAU, P.; BUELL, P. F. & DAGON, R. 1966. A universal system for recording vegetation. II. A methodological critique and an experiment. *Sarracenia*, Montréal, *10*: 1-74.

DAWSON, D. G. 1981. Experimental design when counting birds. *Studies in Avian Biology*, *6*:392-398.

_______ & BULL, P. C. 1975. Counting birds in New Zealand forests. *Nofornis*, 22:101-109.

DISNEY, H. J. de S. & STOKES, A. 1976. Birds in pine and native forests. *Emu*, *76*:133-138.

DRISCOLL, P. V. 1977. Comparison of bird counts from pine forests and indigenous vegetation. *Australian Wildlife Research*, Victoria, *4*:281-288.

EMLEN, J. T. et alii. 1986. Density trends and range boundary constraints of forest birds along a latitudinal gradient. *The Auk*, *103*:791-803.

FEINSINGER, P. 1976. Organization of a tropical guild of nectarivorous birds. *Ecological Monographs*, North Carolina, *46*:257-291.

FONSECA, G. A. B. 1985. The vanishing Brazilian Atlantic forest. *Biological Conservation, England*, *34*:17-34.

GRAHAM, D. J. 1986a. *Lista das aves da Reserva Estadual da Cantareira.* São Paulo, Instituto Florestal. 11p.

_______. 1986b. A comparison of the avifaunas of an *Araucaria* plantation and an area of natural forest. In: CONGRESSO BRASILEIRO DE ZOOLOGIA, 13, Cuiabá-MT, fev. 2-7, 1986, *resumos...* Cuiabá, Universidade Federal de Mato Grosso. p. 204

HAVEL, J. J. 1980. Application of fundamental synecological knowledge to practical problems in forest management. *Forest Ecology and Management*, Amsterdam, *3*:81-111.

HUTTO, R. L.; PLETSCHET, S. M. & HENDRICKS, P. 1986. A fixed-radius point count method for nonbreeding and breeding season use. *The Auk*, *103*:593-602.

INSTITUTO FLORESTAL. s.d. *Análise climatológica dos parâmetros de temperatura e precipitação do período de 1944 a 1981.* São Paulo, Instituto Florestal. 2p. (Documento interno não publicado)

_______. 1980. *Instituto Florestal, São Paulo, Brasil.* São Paulo, Instituto Florestal. 32p.

KARR, J. R. 1981a. Surveying birds with mist nets. *Studies in Avian Biology*, *6*:62-67.

_______. 1981b. Surveying birds in the tropics. *Studies in Avian Biology*, *6*:548-553.

_______. & ROTH, R. R. 1971. Vegetation structure and avian diversity in several New World areas. *The American Naturalist*, *105*:423-435.

KREBS, C. J. 1985. *Ecology; the experimental analysis of distribution and abundance.* New York, Harper & Row. 800p.

LANYON, W. E. & LANYON, S. M. 1986. Generic status of Euler's Flycatcher: a morphological and biochemical study. *The Auk, 103*:341-350.

MACARTHUR, R. H. 1964. Environmental factors affecting bird species diversity. *The American Naturalist, 98*:387-397.

_______ & HORN, H. S. 1969. Foliage profile by vertical measurements. *Ecology*, San Diego, *50* :802-804.

_______. & MACARTHUR, J. W. 1961. On birds species diversity. *Ecology*, San Diego, 42:594-598.

_______; MACARTHUR, J. W. & PREER, J. 1962. On bird species diversity. II. Prediction of bird census from habitat measurements. *The American Naturalist, 96*:167-174.

MEYER DE SCHAUENSEE, R. 1982. *A guide to the birds of South America.* Washington, International Council for Bird Preservation. 498p.

MORRISON, M. L.; MANNAN, R. W. & DORSEY, G. L. 1981. Effects of number of circular plots on estimates of avian density and species richness. *Studies in Avian Biology, 6*:405-408.

NEGREIROS, O. C. de; CARVALHO, C. T. de; CESAR, S. F.; DUARTE, F. R.; DESHLER, W. O. & THEZEN, K. D. 1974. *Plano de manejo para o Parque Estadual da Cantareira.* São Paulo, Instituto Florestal. 58p.

PAWSEY, C. K. 1966. Birds in relation to the pine forests of the south east of South Australia. *S. Aust. Ornithol.*, Australia, *24*:93-95.

PINTO, O. 1938. Catálogo das aves do Brasil: 1ª parte. *Revista do Museu Paulista*, São Paulo, *22*:1-566.

_______. 1944. *Catálogo das aves do Brasil: 2ª parte.* São Paulo, Secretaria da Agricultura, Indústria e Comércio - Departamento de Zoologia. 700p.

PROJETO RADAMBRASIL. 1983. *Levantamento de recursos naturais.* Rio de Janeiro, Ministério das Minas e Energia - Secretaria Geral. 780p. (Folhas SF 23/24, v. 32)

RALPH, C. J. & SCOTT, J. M., ed. 1981. Estimating numbers of terrestrial birds. *Studies in Avian Biology, 6*:1-630.

ROBBINS, C. S. 1981. Bird activity levels related to weather. *Studies in Avian Biology, 6*:301-310.

RODRIGUES, L. C.; ALMEIDA, A. F. de; KIKUTI, P. & SPELTZ, R. M. 1981. Estudo comparativo da avifauna em mata natural e em plantio homogêneo de *Araucaria angustifolia* (Bert) O. Ktze. Piracicaba, Instituto de Pesquisas e Estudos Florestais. 7p. (IPEF Circular Técnica, 132)

ROTH, R. R. 1976. Spatial heterogeneity and bird species diversity. *Ecology*, San Diego, *57*:773-782.

RUSSEL, C. E. 1983. *Nutrient cycling and productivity of native and plantation forests at Jari Florestal, Pará, Brazil.* Georgia, University of Georgia. 146p. (Dissertation, Ph. D.)

SICK, H. 1985. *Ornitologia brasileira, uma introdução.* Brasília, Ed. Universidade de Brasília. 827p. 2v.

SOKAL, R. R. & ROHLF, F. J. 1981. *Biometry.* 2nd ed. San Francisco, W. H. Freeman & Co.

STURMAN, W. A. 1968. Description and analysis of breeding habitats of the chickadees, *Parus atricapillus* and *P. rufescens*. *Ecology*, San Diego, *49*:418-428.

TERBORGH, J. & WESKE, J. S. 1969. Colonization of secondary habitats by Peruvian birds. *Ecology*, San Diego, *50*(5):765-782.

VERNER, J. 1985. Assessment of counting techniques. In: JOHNSTON, R. F., ed. *Current ornithology.* New York, Plenum Press. p. 247-302.

WILLIS, E. O. 1979. The composition of avian communities in remanescent woodlots in Southern Brazil. *Papéis Avulsos de Zoologia*, São Paulo, *33*(1):1-25.

WILLIS, E. O. & ONIKI, Y. 1981. Levantamento preliminar de aves em treze áreas do Estado de São Paulo. *Revista Brasileira de Biologia*, Rio de Janeiro, *41*:121-135.

WILLSON, M. F. 1974. Avian community organization and habitat structure. *Ecology*, San Diego, *55*:1017-1029.

YORKE, C. D. 1983. *Avian ecology in a Malaysian rubber tree plantation*. Arkansas, University of Arkansas. 222p. (Dissertation, Ph. D.)

APPENDIX 1

Summary of bird records at each site

Figures in parentheses refer to numbers of birds mist netted and unenclosed figures type refer to numbers recorded in the point counts. English and scientific names closely follow the AMERICAN ORNITHOLOGISTS' UNION (1983). For species beyond the geographic coverage of the Checklist, a variety of recent publications were consulted; MEYER DE SCHAUENSEE (1982) and SICK (1985) were particularly useful.

		Study Site				
Scientific name	English name (Guild code)	A-I	A-II	N-I	N-II	Total
Crypturellus obsoletus	Brown Tinamu (Glo)	2	3		2	7
Harpagus diodon	Rufous-thighed Kite (Dc)				1	1
Buteo magnirostris	Roadside Hawk (Dc)	1(1)				1(1)
Micrastur ruficollis	Barred Forest-Falcon(Dc)	(1)			1	1(1)
Odontophorus capueira	Spot-winged Wood-Quail(Glo)			(1)		(1)
Columba plumbea	Plumbeous Pigeon (Clo)			4	1	5
Leptotila rufaxilla	Gray-fronted Dove (Glo)	(1)	1	(1)		1(2)
Pyrrhura frontalis	Reddish-bellied Parakeet (Clo)	1	1			2
Pionus maximiliani	Scaly-headed Parrot (Clo)	3	1	4		8
Coccyzus americanus	Yellow-billed Cuckoo (Mi)	1				1
Piaya cayana	Squirrel Cuckoo (Mi)			2	2	4
Phaethornis eurynome	Scale-throated Hermit (Nec)	8(2)	10(6)	4(1)	11(1)	33(10)
Thalurania glaucopis	Violet-capped Woodnymph(Nec)	7(1)	5(3)	1(2)	6(3)	19(9)
Leucochloris albicollis	White-throated Hummingbird (Nec)	(2)	(1)			(3)
Amazilia versicolor	Versicolored Emerald (Nec)	4(3)	3	3	2(1)	12(4)
A. lactea	Sapphire-spangled E. (Nec)		1			1
Clytolaema rubricauda	Brazilian Ruby (Nec)		1			1
Trogon surrucura	Surucua Trogon (Mo)	2	1	2	2	7
Veniliornis spilogaster	White-spotted Woodpecker (Tti)	2	3	1	3	9
Piculus aurulentus	White-browed Woodpecker (Tti)	1	1			2
Dryocopus lineatus	Lineated Woodpecker (Tti)		1			1
Synallaxis ruficapilla	Rufous-capped Spinetail(Gsi)	8	13(1)	8(1)	7(1)	36(3)
Cranioleuca pallida	Pallidi Spinetail (Ci)	5	10(1)		1	16(1)
Anabazenops fuscus	White-collared Foliage-Gleaner (Mi)				(1)	(1)
Syndactyla rufosuperciliata	Buff-browed F.-G.(Mi)		3	1	1(2)	5(2)
Anabacerthia amaurotis	White-browed F.-G.(Usi)	(1)	(1)	(2)	(4)	
Philydor atricapillus	Black-capped F.-G.(Usi)		(1)	(1)	(1)	(3)
P. rufus	Buff-fronted F.-G.(Mi)			1	1	
Heliobletus contaminatus	Sharp-billed Treehunter (Tti)	1(1)	(1)			1(2)
Xenops rutilans	Streaked Xenops (Tti)		1			1

App.1 (cont.)

Scientific name	English name (Guild code)	Study Site				
		A-I	A-II	N-I	N-II	Total
Sclerurus scansor	Rufous-breasted Leaf-tosser (Gli)			1		1
Sittamosus griseicapillus	Olivaceous Woodcreeper (Tti)	13(4)	11(7)	15(5)	16(7)	55(23)
Dendrocolaptes platyrostris	Planalto Woodcreeper (Gli)			1		1
Lepidocolaptes fuscus	Lesser Woodcreeper (Tti)				2(4)	2(4)
Thamnophilus caerulescens	Variable Antshrike (Mi)	5(1)	3(1)	8(1)	16(3)	32(6)
Dysithamnus mentalis	Plain Antvireo (Usi)	2	7(2)	10(2)	13(5)	32(9)
Myrmotherula gularis	Star-throated Antwren (Gsi)	2	2		(2)	4(2)
Herpsilochmus rufimarginatus	Rufous-winged Antwren (Mi)				1	1
Pyriglena leucoptera	White-shouldered Fire-eye (Gli)	1(1)	(2)	(2)	(3)	1(8)
Myrmeciza loricata	White-bibbed Antbird (Gsi)			3	7(1)	10(1)
Chamaeza campanisona	Short-tailed Antthrush (Gli)	1(1)		2	2(1)	5(2)
Conopophaga lineata	Rufous Gnateater (Gsi)	(1)	(1)	(4)	(3)	(9)
Elaenia mesoleuca	Olivaceous Elaenia (Mi)	1(1)				1(1)
Mionectes rufiventris	Gray-hooded Flycatcher (Uso)		2(1)	(1)	(2)	2(4)
Leptopogon amaurocephalus	Sepia-capped Flycatcher (Usi)		(1)			(1)
Phylloscartes ventralis	Mottle-cheeked Tyrannulet (Ci)	3	1			4
Myiornis auricularis	Eared Pygmy-Tyrant (Usi)	1	4			5
Hemitriccus nidipendulum	Hangnest Tody-Tyrant (Usi)				(1)	(1)
H. orbitatum	Eye-ringed Tody-Tyrant (Usi)		(1)	(1)	(3)	(5)
Tomomyias sulphurescens	Yellow-olive Flycatcher (Mi)		4	2	3	9
Platyrinchus mystaceus	White-throated Spadebill (Usi)	2(2)	1(1)	4(3)	5(3)	12(9)
Lathotriccus euleri	Euler's Flycatcher (Usi)	5(6)	3(1)	1	6(1)	15(8)
Attila rufus	Gray-hooded Attila (Mi)			1		1
Myiarchus swainsoni	Swainson's Flycatcher (Ci)		1(1)	1	(1)	2(2)
Myiodynastes maculatus	Streaked Flycatcher (Mo)		2			2
Pachyramphus polychopterus	White-winged Becard (Ci)		(2)	1		1(2)
P. validus	Plain Becard (Ci)			4		4
Tityra cayana	Black-tailed Tityra (Clo)			5		5
Pyroderus scutatus	Red-ruffed Fruitcrow (Clo)		1	1		2
Schiffornis virescens	Greenish Manakin (Uso)	2(6)	2(6)	3(3)	2(8)	9(23)

App. 1 (cont.)

Scientific name	English name (Guild code)	Study Site A-I	A-II	N-I	N-II	Total
Ilicura militaris	Pin-tailed Manakin (Uso)		1			1
Chiroxiphia caudata	Swallow-tailed Manakin (Uso)	6(4)	13(3)	3	10(6)	32(13)
Oxyruncus cristatus	Sharpbill (Cso)			1		1
Platycichla flavipes	Yellow-legged Thrush (Mo)		(1)	1		1(1)
Turdus albicollis	White-necked Robin (Uso)		2(2)	(1)	3(1)	5(4)
Vireo olivaceus	Red-eyed Vireo (Cso)	4	3	6	8(2)	21(2)
Cyclarhis gujanensis	Rufous-browed Pepper-shrike (Ci)	4	1	4	2	11
Basileuterus culicivorus	Golden-crowned Warbler (Mi)	23(1)	23(1)	25(1)	27(3)	98(6)
B. leucoblepharus	White-browed Warbler (Gsi)	2(4)	3(3)	4(4)	19(6)	28(17)
Coereba flaveola	Bananaquit (Nec)		1			1
Conirostrum speciosum	Chestnut-vented Conebill (Ci)			1		1
Tangara desmaresti	Brassy-breasted Tanager (Mo)	(2)	17		13	30(2)
Dacnis cayana	Blue Dacnis (Cso)			2	2	4
Pipraeidea melanonota	Fawn-breasted Tanager (Cso)	1	1	1	2	5
Trichothraupis melanops	Black-goggled Tanager (Uso)	(6)	4(11)	3(2)	2	9(19)
Habia rubica	Red-crowned Ant-Tanager (Uso)	(1)	(1)	(1)	12	12(3)
Saltator similis	Green-winged Saltator (Mo)		(1)	1		1(1)
Haplospiza unicolor	Uniform Finch (Uso)	(5)	(4)	(2)	(1)	(12)
Cacicus chrysopterus	Golden-winged Cacique (Clo)		2			2
	Unid. woodpeckers (Tti)			2		2
	Unid. hummingbirds (Nec)	8	7	11	5	31
	Unid. ground level spp.			1	4	5
	Unid. understory spp.	13	15	18	15	61
	Unid. mid-level spp.	4	5	12	14	35
	Unid. canopy spp.	3	1	4	2	10
	Total	152 (58)	198 (69)	187 (41)	264 (79)	801 (247)

App. 1 (cont.)

The following species were recorded on at least one of the study sites but were neither mist netted nor recorded during a point count. See also Appendix 3 for a complete listing of all forest species known from the Serra da Cantareira.

Tinamus solitarius	Solitary Tinamou
Coragyps atratus	Black Vulture
Leptodon cayanensis	Gray-headed Kite

Milyago chimachima	Yellow-headed Caracara
Micrastur semitorquatus	Collared Forest-Falcon
Penelope obscura	Dusky-legged Guan
Geotrygon montana	Ruddy Quail-Dove
Coccyzus euleri	Pearly-breasted Cuckoo
Chaetura andrei	Ashy-tailed Swift
Malacoptila striata	Crescent-chested Puffbird
Baillonius bailloni	Saffron Toucanet
Ramphastos dicolorus	Red-breasted Toucan
Picumnus temminckii	Ochre-collared Piculet
Celeus flavescens	Blond-crested Woodpecker
Automolus leucophthalmus	White-eyed Foliage-Gleaner
Xiphocolaptes albicollis	White-throated Woodcreeper
Drymophila ferruginea	Ferruginous Antbird
Grallaria varia	Variegated Antpitta
Todirostrum plumbeiceps	Ochre-faced Tody-Flycatcher
Pitangus sulphuratus	Great Kiskadee
Pygochelidon cyanoleuca	Blue-and-white Swallow
Hylophilus poicilotis	Rufous-crowned Greenlet
Euphonia pectoralis	Chestnut-bellied Euphonia

APPENDIX 2

Proposed guild classification with a list of each guild's members

The groupings proposed by WILLIS (1979) were:

1. Forest birds eating large fruit and insects
2. Small canopy omnivores
3. Small understory omnivores
4. Edge omnivores or frugivores
5. Large ground frugivores
6. Large nocturnal carnivores
7. Diurnal carnivores
8. Carrion eaters
9. Trunk and twig insectivores
10. Understory birds eating large ground arthropods
11. Understory birds eating small ground arthropods
12. Understory birds eating small foliage arthropods
13. Insectivores of bamboo or forest tangles
14. Midlevel insectivores
15. Small treetop insectivores
16. Edge insectivores
17. Aerial insectivores
18. Nocturnal insectivores
19. Nectar and insect eaters
20. Edge seedeaters

The following is the guild classification proposed for this study. If the species was included by WILLIS (1979), his classification is noted in brackets. A mnemonic code for each guild is included in parentheses.

Ground level guilds

Members of these guilds are either terrestrial or are largely restricted to foliage very near the ground.

LARGE GROUND LEVEL OMNIVORES (Glo)

Crypturellus obsoletus [5]
Odontophorus capueira [5]
Leptotila rufaxilla [5]

LARGE GROUND LEVEL INSECTIVORES (Gli)

Sclerurus scansor [10]
Dendrocolaptes platyrostris [10]
Pyriglena leucoptera [10]
Chamaeza campanisona [10]

SMALL GROUND LEVEL INSECTIVORES (Gsi)

Synallaxis ruficapilla [11]
Myrmotherula gularis
Myrmeciza loricata [11]
Conopophaga lineata [11]
Basileuterus leucoblepharus [11]

UNDERSTORY GUILDS

Members of these guilds occur with greatest frequency at the lower heights of the forest (generally < 5 m) but are not closely associated with the ground.

SMALL UNDERSTORY OMNIVORES (Uso)

Mionectes rufiventris [3]
Schiffornis virescens [3]
Ilicura militaris
Chiroxiphia caudata [3]
Turdus albicollis [3]
Trichothraupis melanops [3]
Habia rubica [3]
Haplospiza unicolor [20]

SMALL UNDERSTORY INSECTIVORES (Usi)

Anabacerthia amaurotis
Philydor atricapillus [12]
Dysithamnus mentalis [12]
Leptopogon amaurocephalus [12]
Myiornis auricularis [13]
Hemitriccus nidipendulum [16]
H. orbitatum [12]
Platyrinchus mystaceus [12]
Lathotriccus euleri [12]

Mid-level guilds

Bird species that are classified in these guilds preferentially frequent mid-levels of the forest (roughly defined as from 5 to 20 m).

MID-LEVEL OMNIVORES (Mo)

Trogon surrucura [1]
Myiodynastes maculatus [4]
Platycichla flavipes [4]
Tangara desmaresti
Saltator similis [4]

MID-LEVEL INSECTIVORES (Mi)

Coccyzus americanus
Piaya cayana [14]
Anabazenopos fuscus
Syndactyla rufosuperciliata
Philydor rufus
Thamnophilus caerulescens [12]
Herpsilochmus rufimarginatus [14]
Elaenia mesoleuca
Tolmomyias sulphurescens [14]
Attila rufus [14]
Basileuterus culicivorus [12]

Canopy guilds

Bird species which are assigned to these guilds occur preferentially in the uppermost levels of the forest: generally at 20^{+}m.

LARGE CANOPY OMNIVORES (Clo)

Columba plumbea
Pyrrhura frontalis [1]
Pionus maximiliani [1]
Tityra cayana [1]
Pyroderus scutatus [1]
Cacicus chrysopterus

SMALL CANOPY OMNIVORES (Cso)

Oxyruncus cristatus [2]
Vireo olivaceus [2]
Dacnis cayana [2]

Pipraeidea melanonota [2]

CANOPY INSECTIVORES (Ci)

Cranioleuca pallida [14]
Phylloscartes ventralis
Myiarchus swainsoni [15]
Pachyramphus polychopterus [15]
P. validus [15]
Cyclarhis gujanensis [15]
Conirostrum speciosum [15]

Specialist guilds

DIURNAL CARNIVORES (Dc)

Harpagus diodon [7]
Buteo magnirostris [7]
Micrastur ruficollis [7]

TRUNK AND TWIG INSECTIVORES (Tti)

Veniliornis spilogaster [9]
Piculus aurulentus
Dryocopus lineatus [9]
Heliobletus contaminatus
Xenops rutilans [9]
Sittasomus griseicapillus [9]
Lepidocolaptes fuscus [9]

NECTARIVORES (Nec)

Phaethornis eurynome
Thalurania glaucopis [19]
Leucochloris albicollis [19]
Amazilia versicolor [19]
A. lactea [19]
Clytolaema rubricauda
Coereba flaveola [19]

APPENDIX 3

Checklist of the birds of the State Reserve of Cantareira

This appendix is based on GRAHAM (1986a) -- a checklist in Portuguese of the birds of the State Reserve of Cantareira that was produced under the auspices of the Instituto Florestal. A translation from the Portuguese is provided for the checklist's introduction. The manakin *Neopelma aurifrons* (Pipridae) was omitted from the original list. It is probably a permanent resident.

STATUS

r permanent resident
v summer resident
n breeding confirmed
m migrant
o occasional visitor
i introduced species
h status hypothetical

HABITAT

forest primary and secondary forest; virtually the totality of the Reserve's area

semi-open shrub, grassy areas and areas near habitations; principally in the vicinity of the Headquarters of the Instituto Florestal [in the Parque Estadual da Capital], semi-open areas of Chapada and Cabuçu and at the forest edge

aquatic ponds and reservoirs

ABUNDANCE

The abundance classifications are approximate and should be considered preliminary. In the following definitions, an excursion is defined as a period of observation of 4-5 hours by a competent observer, in the usual habitat of the species in question, and during an appropriate period of the day and the year.

xxxx **common:** species observed or heard during virtually all excursions

xxx **fairly common:** observed or heard during the majority of excursions

xx **uncommon:** observed or heard on less than half of excursions

x **rare:** observed or heard on less than a tenth of the excursions

? insuficient information

APPENDIX 4
Lista das aves da Reserva Estadual da Cantareira

1 INTRODUÇÃO

De uma elevada localização na Serra da Cantareira, pode-se observar cerca de 15 milhões de pessoas em São Paulo, a maior cidade da América do Sul. Paradoxalmente, a floresta da Serra da Cantareira, uma Reserva Estadual, abriga uma surpreendente diversidade de flora e fauna e são umas das poucas áreas remanescentes de vegetação natural no Estado de São Paulo (FIGURA 1). Por outro lado, no centro da Reserva, uma plantação de coníferas *Araucaria angustifolia* interrompe uma área contínua de mata de cerca de 5000 ha. A pesquisa relatada aqui foi realizada a fim de comparar a avifauna e a estrutura da vegetação desta plantação com a floresta circundante. Adicionando alguns dados básicos de ornitologia desta avifauna pouco conhecida e da devastada e fragmentada Mata Atlântica. Essa pesquisa incrementa o conhecimento do impacto da plantação de árvores exóticas na fauna natural de aves do Sudeste do Brasil e como este impacto pode ser avaliado.

O Estado de São Paulo originalmente apresentava uma cobertura vegetal de cerca de 20.5 milhões ha (81,8 % da área do Estado). Extenso desmatamento se iniciou no final de 1800 e hoje, menos de 5 % do Estado é coberto por floresta (o que representa cerca de 1.25 milhões de ha). É esperado para o ano 2000 que permaneça somente cerca de 3 % da floresta original (BARRETO, 12985).

Numa visão mais abrangente o destino da Mata Atlântica Brasil é ainda mais alarmante. Essa área de Floresta Tropical úmida, a qual originariamente se extendia ao longo da costa brasileira do extremo Nordeste do Brasil para a fronteira do Sudeste do país, apresenta estreita afirmidade biogeográfica com a Floresta Amazônica, ainda que com distinta fauna e alto grau de endemismo. Talvez somente 1 % da Floresta Atlântica original ainda exista (FONSECA, 1985).

Programas de reflorestamento no Estado de São Paulo tem restaurado alguma cobertura vegetal. Estudos de 1972/1973 (INSTITUTO FLORESTAL, 1980) estimou-se cerca de 640.000 ha total consistia de plantações de árvores exóticas (especialmente *Pinus* e *Eucalyptus*). *Araucaria angustifolia* tem também sido moderadamente plantada. No Estado de São Paulo, essa espécie é nativa de áreas altas da Serra da Mantiqueira (FIGURA 1), mas é exótica em outros lugares.

CATEGORIA

r residente permanente
v residente somente durante o verão
n nidificação confirmada
m migrante, visitante regular
o visitante ocasional
i espécie introduzida
h espécie de presença hipotética

HABITAT

mata: mata primária e secundária; quase a totalidade da área da reserva da Cantareira.

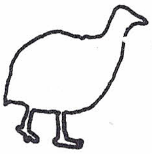
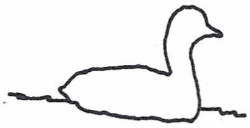
semi-aberto: campos sujos, áreas gramadas ou áreas cerca de habitações; principalmente nos arredores da Sede do Instituto Florestal, nas áreas semi-abertas da Chapada, Cabuçu e na beira da mata

aquático: brejos e represas

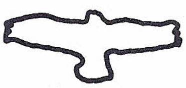
FREQÜÊNCIA

As classificações de freqüência são aproximativas e devem ser consideradas preliminares. Nas definições seguintes, um passeio é definido como uma excursão feita por um observador competente durante 4-5 horas, no habitat característico da espécie e num período apropriado do dia e do ano.

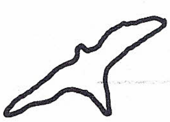
xxxx **comum:** espécie observada ou ouvida em quase todos os passeios
xxx **razoavelmente comum:** observada ou ouvida na maioria dos passeios
xx **incomum:** observada ou ouvida em menos da metade dos passeios
x **rara:** observada ou ouvida em menos de um décimo dos passeios
? informações insuficientes

Nome científico	Nome popular	Categoria	Habitat mata	Habitat semi-aberto	Habitat aquático
 **Familia Tinamidae**					
Tinamus solitarius	macuco	r,n	xxx		
Crypturellus obsoletus	inhambu-guaçu	r,n	xxxx		
C. parvirostris	inhambu-chororó	r		x?	
C. tataupa	inhambu-xintã	r	xx?		
 **Família Podicipedidae**					
Tachybaptus dominicus	mergulhão-pequeno	r			xx
 **Família Ardeidae**					
Casmerodius albus	garça-branca-grande	o			x
Butorides striatus	socozinho	r,n			xxx
Nycticorax nycticorax	savacu	r			xx
 **Família Cathartidae**					
Coragyps atratus	urubu-comum, urubu-de-cabeça-preta	r,n	xxxx	xxxx	
Cathartes aura	urubu-de-cabeça-vermelha	o		x	

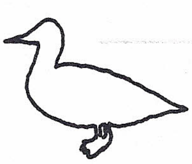
Nome científico	Nome popular	Categoria	Habitat: mata	Habitat: semi-aberto	Habitat: aquático



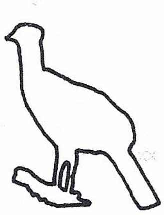
Família Accipitridae					
Leptodon cayanensis	gavião-de-cabeça-cinza	r	xx		
Chondrohierax uncinatus	caracoleiro	r?	x		
(*Elanus caeruleus*)	peneira	h		x	
Harpagus diodon	gavião-bombachinha	r	x		
Accipiter striatus	gaviãozinho, gavião-papa-pinto	r?	x		
Leucopternis lacernulata	gavião-pomba	o?	x		
Parabuteo unicinctus	gavião-asa-de-telha	o		x	
Buteo magnirostris	gavião-carijó	r	xxx	xxx	
B. brachyurus	gavião-de-curta-curta	o		x	



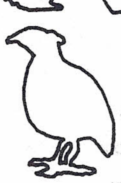
Família Falconidae					
Polyborus plancus	caracará	o		x	
Milvago chimachima	carrapateiro	r	xxx	x	
Micrastur ruficollis	gavião-caburé	r	x?		
M. semitorquatus	gavião-relógio	r	xx		



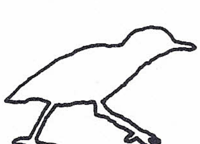
Família Anatidae					
Dendrocygna viduata	irerê	v?			xxx
Amazonetta brasiliensis	pé-vermelho, marreca-ananaí	o?			x



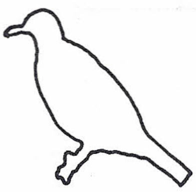
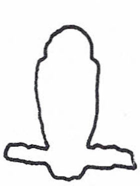
Família Cracidae					
Penelope obscura	jacuguaçu	r,n	xx		

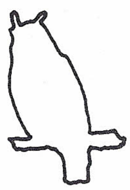
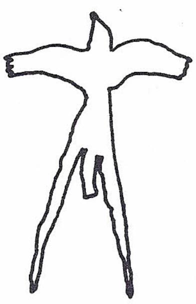
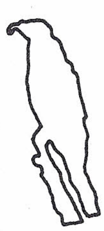
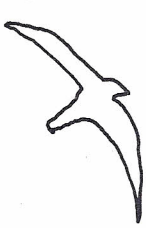
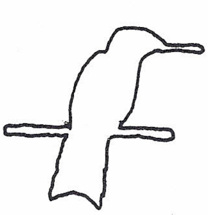


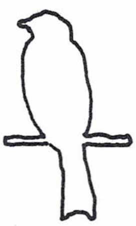
Família Phasianidae					
Odontophorus capueira	uru	r,n	xxxx		

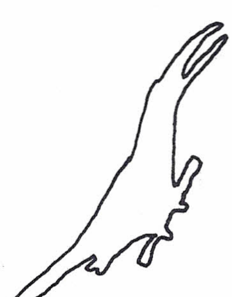


Família Rallidae					
Laterallus melanophaius	pinto d'água-comum	r			x?
(*Rallus nigricans*)	saracura-saña	h			x
Aramides saracura	saracura-do-mato	r,n	?	xx	xx
Gallinula chloropus	frango-d'água-comum	r,n			xxx

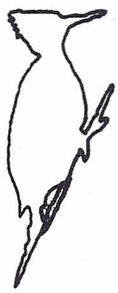
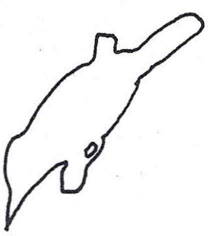
Nome científico	Nome popular	Categoria	Habitat mata	Habitat semi-aberto	Habitat aquático
 **Família Columbidae**					
Columba livia	pombo-doméstico	r,i		xxxx	
C. plumbea	pomba-amargosa, caçaroba	r	xxxx		
Columbina squammata	fogo-apagou	r		xxx	
C. talpacoti	rolinha	r		xxxx	
Claravis godefrida	pararu, pomba-espelho	r	x		
Leptotila rufaxilla	gemedeira, juriti	r,n	xxx	x	
Geotrygon montana	pariri	r	xx		
 **Família Psittacidae**					
Pyrrhura frontalis	tiriba-de-testa-vermelha	r,n	xx	x	
Forpus xanthopterygius	tuim	r?	x		
Brotogeris tirica	periquito-rico	r,n	x	xxx	
Pionus maximiliani	maitaca-bronzeada	r,n	xx	xx	
 **Família Cuculidae**					
Coccyzus melacoryphus	papa-lagarta	r		x	
C. americanus	papa-lagarta-norte-americano	m	x		
C. euleri	papa-lagarta-de-Euler	r	x		
Piaya cayana	alma-de-gato	r,n	xx	xx	
Tapera naevia	saci, sem-fim	r		x?	
Crotophaga ani	anu-preto	r		xxxx	
Guira guira	anu-branco	r?		xx	
 **Família Tytonidae**					
Tyto alba	suindara	r		xx	

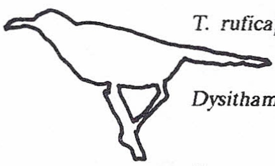
Nome científico	Nome popular	Categoria	mata	Habitat semi-aberto	aquático
 **Família Strigidae**					
Otus choliba	corujinha-do-mato	r	x	xx	
Pulsatrix koeniswaldiana	murucututu-de-barriga-amarela	r,n	xx		
Athene cunicularia	buraqueira, caburé-do-campo	r,n		xx	
Ciccaba virgata	coruja-do-mato	r	x?		
Rhinoptynx clamator	coruja-orelhuda	r		x	
 **Família Caprimulgidae**					
Lurocalis semitorquatus	tuju, curiango	r	xx	xx	
Chordeiles sp.	bacurau	m(r?)		xx	
Nyctidromus albicollis	curiango, bacurau	r	x?		
Hydropsalis brasiliana	bacurau-tesoura, curiango-tesoura	r	x?		
Macropsalis creagra	bacurau-tesoura-gigante	r	x?		
 **Família Nyctibiidae**					
Nyctibius griseus	mão-de-lua, urutau	r	xx		
 **Família Apodidae**					
(*Streptoprocne zonaris*)	andorinhão-de-coleira	h	x		
Chaetura andrei	andorinhão-do-temporal	v	xxx	xxxx	
 **Família Trochilidae**					
Phaethornis eurynome	rabo-branco-de-garganta rajada	r	xxxx	xx	
P. pretrei	rabo-branco-de-sobre-amarelo	o?		x?	
Eupetonema macroura	tesourão	v?		xxx	
Melanotrochilus fuscus	beija-flor-preto-e-branco	v?,n	x	xxx	
Lophornis chalybea	tufinho-verde	o?		x	

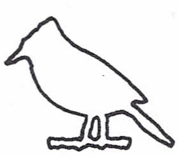


Nome científico	Nome popular	Categoria	Habitat mata	Habitat semi-aberto	Habitat aquático
Chlorostilbon aureoventris	besourinho-de-bico-vermelho	r		x	
Thalurania glaucopis	tesoura-de-fronte-violeta	r,n	xxxx	xx	
Leuchochloris albicollis	papo-branco	r	xx	xx	
Amazilia versicolor	beija-flor-de-banda-branca	r	xx	x	
A.lactea	beija-flor-de-peito-azul	r	x	xxx	
Aphantochroa cirrhochloris	beija-flor-cinza	r?		x	
Clytolaema rubricauda	beija-flor-rubi	r	xx		
Família Trogonidae					
Trogon surrucura	surucuá-de-peito-azul	r,n	xxx		
Família Alcedinidae					
Ceryle torquata	martim-pescador-grande	r?			xx
Chloroceryle amazona	martim-pescador-verde	r			xx
C.americana	martim-pescador-pequeno	r			xxx
Família Bucconidae					
Malacoptila striata	joão-barbudo	r	x		
Família Ramphastidae					
Selenidera maculirostris	araçari-poca	r?	x		
Baillonius bailloni	araçari-banana	r	x		
Ramphastos dicolorus	tucano-de-bico-verde	r	x		

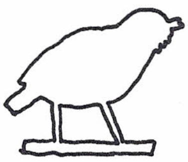
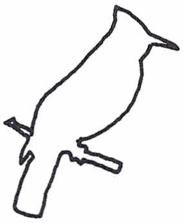
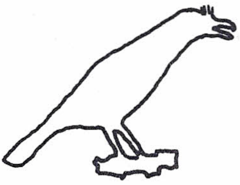
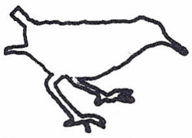
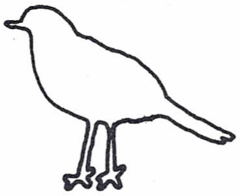
Nome científico	Nome popular	Categoria	Habitat mata	 semi-aberto	 aquático
 **Família Picidae**					
Picumnus temminckii	pica-pau-anão-de-coleira	r	xx		
Melanerpes flavifrons	benedito-de-testa-amarela	o?		x?	
Veniliornis spilogaster	pica-pauzinho-verde-carijó	r	xxx		
Piculus aurulentus	pica-pau-dourado	r	xx		
Colaptes campestris	pica-pau-do-campo	r		xx	
Celeus flavescens	pica-pau-de-cabeça-amarela	r	x		
Dryocopus lineatus	pica-pau-de-banda-branca	r	xx		
 **Família Furnariidae**					
Furnarius rufus	joão-de-barro	r,n		xxx	
Synallaxis spixi	joão-teneném	r		xxxx	
S. ruficapilla	pichororé	r,n	xxxx		
S. cinerascens	joão-teneném-de-mata	r	x?		
Certhiaxis cinnamomea	curutié	r,n			xxx
Cranioleuca pallida	arredio-pálido	r,n	xxx		
Anabazenops fuscus	trepador-coleira	r	x		
Syndactyla rufosuperciliata	trepador-quiete	r	xx		
Anabacerthia amaurotis	limpa-folha-miúda	r	x		
Philydor atricapillus	limpa-folha-coroada	r	xx		
P. rufus	limpa-folha-testa-baia	r	xx		
Automolus leucophthalmus	barranqueiro-olho-branco	r	x		
Heliobletus contaminatus	trepadorzinho	r	xx		
Xenops rutilans	bico-virado-carijó	r	xx		
Sclerurus scansor	vira-folhas	r	xx		
Lochmias nematura	joão-porca	r			xx?
 **Família Dendrocalaptidae**					
Sittasomus griseicapillus	arapaçu-verde	r,n	xxxx		
Xiphocolaptes albicollis	arapaçu-de-garganta-branca	r,n	x		
Dendrocolaptes platyrostris	arapaçu-grande	r	xx		
Lepidocolaptes fuscus	arapaçu-rajado	r	xxx		

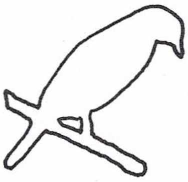


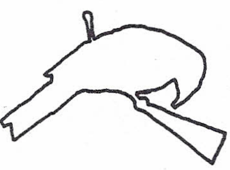


Nome científico	Nome popular	Categoria	Habitat		
			mata	semi-aberto	aquático
Família Formicariidae					
Thamnophilus caerulescens	choca-de-mata	r	xxxx		
T. ruficapilla	choca-de-chapéu-vermelho	r		xx	
Dysithamnus stictothorax	choquinha-de-peito-pintado	r?	x		
D. mentalis	choquinha-lisa	r,n	xxxx		
Myrmotherula gularis	choquinha-de-garganta pintada	r	xxx		
Herpsilochmus rufimarginatus	chororozinho-de-asa-vermelha	r	x		
Drymophila ferruginea	trovóada	r	x		
Pyriglena leucoptera	borralhara	r	xxx		
Myrmeciza loricata squamosa	papa-formigas-de-grota	r	xx		
Chamaeza campanisona	tovaca-campainha	r	xxxx		
Grallaria varia	tovacuçu	r	xxx		
Conopophaga lineata	chupa-dente	r	xx		
Família Tyrannidae					
Sub-família Elaeniinae					
Phyllomyias fasciatus	piolinho	r,n	x		
Camptostoma obsoletum	risadinha	r,n		xx	
Elaenia flavogaster	guaracava-de-barriga-amarela	r,n		xx	
E. mesoleuca	tuque	v?,n	xxx		
E. sp		v?	xx		
Serpophaga subcristata	alegrinho	r		xx	
Mionectes rufiventris	abre-asas-barriga-vermelha	r	xxx		
Leptopogon amaurocephalus	cabeçudo	r,n	xx		
Phylloscartes eximius	barbudinho	r	x		
P. ventralis	borboletinha-do-mato	r	xx		
Myiornis auricularis	miudinho	r	xxx		
Todirostrum poliocephalum	teque-teque	r	xx		
T. plumbeiceps	ferreirinho-de-cara-canela	r	x	x	
Hemitriccus nidipendulum	tachuri-campainha	r	x		
H. orbitatum	tiririzinho-do-mato	r	xx		
Tolmomyias sulphurescens	bico-chato-orelha-preta	r	xxx		
Platyrinchus mystaceus	patinho	r	xxx		

Nome científico	Nome popular	Categoria	Habitat mata	Habitat semi-aberto	Habitat aquático
Sub-família Fluvicolinae					
Myiophobus fascinatus	filipe	r		xx	
Contopus cinereus	papa-moscas-cinzento	r	xx		
Lathotriccus euleri	enferrujado	r	xxxx		
Cnemotriccus fuscatus	guaracavaçu	r	x		
Fluvicola pica	lavadeira-de-cara-branca	r?			xx
Colonia colonus	viuvinha	v?	x		
Knipolegus cyanirostris	maria-preta-de-bico-azulado	v?		x	
Hymenops perspicillata	viuvinha-de-óculos	o?			x
Machetornis rixosus	bem-te-vi-do-gado	r		xx	
Sub-família Tyranninae					
Attila rufus	capitão-de-saíra	r	xx		
Myiarchus ferox	maria-cavaleira	r?		x?	
M. tyrannulus	maria-cavaleira-de-rabo-enferruajado	v?		x	
M. swainsoni	irrê	v?,n	xxx		
Pitangus sulphuratus	bem-te-vi	r,n		xxxx	
Megarhynchus pitangua	bem-te-vi-de-bico-chato	v?	x	x	
Myiozetetes similis	bem-te-vi-pequeno	v?,n		xxx	
Myiodynastes maculatus	bem-te-vi-rajado	v	xxx	xx	
Legatus leucophaius	bem-te-vi-pirata	r?	x		
Empidonomus varius	peitica	v	x	xx	
Tyrannus melancholicus	suiriri	v	x	xxxx	
T. savana	tesoura	v		xx	
Sub-família Tityrinae					
Pachyramphus castaneus	caneleirinho	r,n		xx	
P. polychopterus	caneleirinho-preto	r,n	xx		
P. validus	caneleiro-de-chapéu-negro	r,n	xx		
Tityra cayana	anambé-branco-de-rabo-preto	r,n	xx		
Família Cotingidae					
Pyroderus scutatus	pavão-do-mato	r	xx		
Procnias nudicollis	araponga	r	x?		

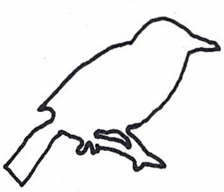
Nome científico	Nome popular	Categoria	mata	Habitat semi-aberto	aquático
 **Família Pipridae**					
Schiffornis virescens	flautim	r	xxx		
Manacus manacus	rendeira	r	x		
(Ilicura militaris)	tangarazinho	h	x		
Chiroxiphia caudata	tangará, dançador	r,n	xxxx		
 **Família Oxyruncidae**					
Oxyruncus cristatus	arapongo-do-horto	r,n	x		
 **Família Hirundinidae**					
Pygochelidon cyanoleuca	andorinha-pequena-de-casa	r,n	xxx	xxxx	
Stelgidopteryx ruficollis	andorinha-serrador	v?,n		xx	
 **Família Corvidae**					
(Cyanocorax caeruleus)	gralha-azul	h	x		
 **Família Troglodytidae**					
Troglodytes aedon	corruíra, cambaxirra	r		xx	
 **Família Muscicapidae**					
Sub-família Sylviinae					
Polioptila dumicola	balança-rabo-de-máscara	o		x	
Sub-família Turdinae					
Platycichla flavipes	sabiaúna	r,n	xxx	x	
Turdus rufiventris	sabiá-laranjeira	r,n	xx	xxxx	
T. leucomelas	sabiá-barranco	r		x	
T. amauroschalinus	sabiapoca	r,n		xx	
T. albicollis	sabiá-coleira	r	xxx		
 **Familia Mimidae**					
Mimus saturninus	sabiá-do-campo, galo-do- campo	r,n		xxx	

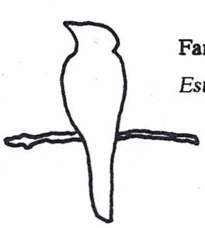




Nome científico	Nome popular	Categoria	mata	Habitat semi-aberto	aquático
Família Vireonidae					
Vireo olivaceus	juruviara	r,n	xxxx		
Hylophilus poicilotis	verdinho-coroado	r,n	xx		
Cyclarhis gujanensis	pitiguari	r	xxx		
Família Emberizidae					
Sub-Família Parulinae					
Parula pitiayumi	mariquita	r	x	xx	
Geothlypis aequinoctialis	pia-cobra	r		xx	
Basileuterus culicivorus	pula-pula	r,n	xxxx		
B. leucoblepharus	pula-pula-assoviador	r	xxxx		
Sub-família Coerebinae					
Coereba flaveola	sebinho, cambacica	r,n	xx	xxxx	
Sub-família Thraupinae					
Conirostrum speciosum	figuinha-de-rabo-castanho	r	xx		
Tangara seledon	sete-cores	r?	x		
T. desmaresti	saíra-lagarta	r,n	xxx		
T. cayana	saíra-amarela	r		xx	
Dacnis cayana	saí-azul	r	xxx	x	
Pipraeidea melanonota	viúva	r	xx	x	
Euphonia pectoralis	ferro-velho	r	x		
E. sp.	gaturamo	r?	x?	x	
Thraupis sayaca	sanhaço-cinzento	r,n	x	xxxx	
T. palmarum	sanhaço-de-coqueiro	r		xx	
Tachyphonus coronatus	tié-preto,gurundi	r	x	xxx	
Trichothraupis melanops	tié-de-topete	r,n	xxx	x	
Habia rubica	tié-do-mato-grosso	r,n	xxx		
Thlypopsis sordida	canário-sapé	r,n	x	xxx	
Orchesticus abeillei	sanhaço-pardo	r	x	x	
Hemithraupis ruficapilla	saíra-da-mata	r	x		
Schistoclamys ruficapillus	bico-de-veludo	r		x	
Tersina viridis	saí-andorinha	r	x		
Sub-família Cardinalinae					
Saltator similis	trinca-ferro-verdadeiro, pixarro	r,n	xxx	xxxx	
(*Cyanocompsa brissonii*)	azulão	h		?	
Sub-família Emberizinae					
Arremon taciturnus	tico-tico-do-mato-de-bico-preto	r	x?		
Volatinia jacarina	tiziu	r		xxx	

Nome científico	Nome popular	Categoria	Habitat mata	 semi-aberto	 aquático
Sporophila caerulescens	coleirinho, papa-capim	v		xxx	
(*Sporophila* sp.)		h	?		
(*Oryzoborus angolensis*)	curió	h		?	
Haplospiza unicolor	cigarra-bambu	r,n	xx		
(*Sicalis flaveola*)	canário-de-terra-verdadeiro	h		?	
(*Coryphosphingus cucullatus*)	tico-tico-rei	h		?	
Zonotrichia capensis	tico-tico	r,n		xxxx	
Sub-família Icterinae					
Agelaius ruficapillus	garibaldi	r?			x?
Molothrus bonariensis	chopim	v?,n		xxxx	
(*Gnorimopsar chopi*)	melro, graúna	h		?	
Cacicus chrysopterus	soldado	r,n	xx		
Família Fringillidae					
Sub-família Carduelinae					
Carduelis magellanicus	pintassilgo	r		xx	
Família Passeridae					
Passer domesticus	pardal	r,i,n		xxxx	
Família Estrildidae					
Estrilda astrild	bico-de-lacre	r,i,n		xxxx	





Total: 216 espécies + 11 espécies de presença hipotética

Douglas J. Graham
Seção das Reservas da Capital
Instituto Florestal
São Paulo
julho 1986

APPENDIX 5
Plant species recorded from the study sites

The following is a list of plant species that were recorded on 8 March 1986, at two subjectively chosen stations of the study site A-I. Identifications were made by Dr. Regis Guillaumon and Dr. Osny Tadeu de Aguiar. Dr. Pierre Dansereau reviewed an earlier draft of this appendix. The description as common or uncommon was based on observations at the two stations. Species that were more characteristic of the open path area are included separately.

Herbs (0.0 - 0.5 m)

COMMON SPECIES

Cyathea sp. (Cyathaceae)
Dichorisandria sp. (Commelinaceae)
Marantha sp. (Marantaceae)
Philodendron sp. (Araceae)
Serjanica sp. (Sapindaceae)
Bamboo sp. (Graminae)
Ferns spp.

UNCOMMON SPECIES

Jacobinea sp. (Acanthaceae)
Urtica sp. (Urticaceae)

A number of herb species were noted only along the foot paths:

COMMON SPECIES

Impatiens sp. (Balsaminaceae)
Ludwigia sp. (Onagraceae)
Phyllanthus sp. (Euphorbiaceae)
Selaginella sp. (Selaginellaceae)
Sida sp. (Malvaceae)
Grass spp. (Graminae)
Composite sp. (Compositae)

UNCOMMON SPECIES

Blechnum sp. (Polypodiaceae)
Cyperus sp. (Cyperaceae)
Tibouchina sp. (Melastomataceae)

Shrubs and small trees (0.5 - 8.0 m)

COMMON SPECIES

Bathysa australis (Rubiaceae)
Mollinedia sp. (Monimiaceae)
Pilocarpus sp. (Rutaceae)
Psychotria suterella (Rubiaceae)
Sorocea ilicifolia (Moraceae)
Bamboo sp. (Graminae)
Unid sp. (Solanaceae)
Arborescent fern sp. (*Dicksonia* sp.?)

UNCOMMON SPECIES

Alchornea triplinervea (Euphorbiaceae)
Aspidosperma olivaceum (Apocynaceae)
Begonia sp. (Begoniaceae)
Cariniana estrellensis (Lecythidaceae)
Cedrela fissilis (Meliaceae)
Cinnamomum sp. (Lauraceae)
Cupania oblongifolia (Sapindaceae)
Endlicheria paniculata (Lauraceae)
Euplassa cantareirae (Proteaceae)
Heliconia sp. (Musaceae)
Jaracatia sp. (Caricaceae)
Leandra sp. (Melastomataceae)
Miconia spp. (")
Tabebuia sp. (Bignoniaceae)
Unid. spp. (Commelinaceae, Myrtaceae, Sapindaceae, Sapotaceae, Rubiaceae)

A number of shrub and small tree species were noted only along the foot paths:

COMMON SPECIES

Alchornea sidaefolia (Euphorbiaceae)

UNCOMMON SPECIES

Bactris sp. (Palmae)
Croton floribundum (Euphorbiaceae)
Inga sessilis (Leguminosae)
Miconia sp. (Melastomataceae)
Sida sp. (Malvaceae)
Unid. spp. (Araliaceae, Curcurbitaceae, Leguminosae, Malastomataceae, Myrtaceae, Rubiaceae)

Trees (8.0+ m)

COMMON SPECIES

Alchornea triplinervea (Euphorbiaceae)
Araucaria angustifolia (Araucariaceae)

UNCOMMON SPECIES

Alchornea sidaefolia (Euphorbiaceae)
Cangerana sp. (Meliaceae)
Cedrela fissilis (")
Didymopanax sp. (Araliaceae)
Inga sessilis (Euphorbiaceae)
Nectandra sp. (Lauraceae)
Ocotea sp. (")
Unid. sp. (Solanaceae)

Epiphytes and lianas

EPIPHYTES

Bromelia spp. (Bromeliaceae)
Philodendron sp (Araceae)
Rhipsalis spp. (Cactaceae)
Tillandsia sp. (Bromeliaceae)
Ferns. spp.
Unid. spp. (Bromeliaceae, Cactaceae, Orchidaceae)

LIANAS

Philodendron sp. (Araceae)
Unid. spp. (Sapindaceae, etc.)

Sites A-II and N-II

On the 26 March 1986, study sites A-II and N-II were briefly visited with Osny Tadeu de Aguiar. Most of the species that were identified appear on the above list. Those that had not been previosly noted are recorded below.

SITE A-I

The following species are all trees or small trees (life form unknown for *Ouratea* sp.)

Casearia sylvestris (Flacourtiaceae)

Cestrum sp. (Solanaceae)
Picramnia sp. (Simarubaceae)
Ouratea sp. (Ochnaceae)

SITE N-II

The following species are all trees:

Cabralea sp. (Meliaceae)
Cassia multijuga (Leguminosae)
Croton salutaris (Euphorbiaceae)
Cryptocarya sp. (Lauraceae)
Mouriri chamissoana (Memecylaceae)
Ocotea catharinensis (Lauraceae)

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