ARBOREAL FLORA OF THE GODOY FOREST STATE PARK, LONDRINA, PR. BRAZIL*

F. DAS CHAGAS E SILVA† & L. H. SOARES-SILVA‡

The floristic and ecological aspects of the tree vegetation of a remnant forest in the Godoy Forest State Park were studied. Two hundred and six native species of the region occur in the park. Comments on ecological aspects, such as dispersion, structure of vegetation and succession of these species, are provided. An analysis of the ecological parameters indicated that the occurrence of late secondary and climax species (55.8%) was greater than that of pioneer (6.8%) and early secondary species (34.5%). This seems to indicate a predominant dependence of biotic factors on the abiotic factors and an advanced stage of succession.

Keywords. Brazil, flora, floristic, forest, Godoy Forest State Park, Paraná State.

INTRODUCTION

Forest originally covered 83.4% of the total area of Paraná state in Brazil (Maack, 1968). This area has now been reduced to about 5% of the original total. The situation is most serious in the northern region, where there are counties where the original forest cover has been reduced to an alarming level, for example, to 1% in Maringá and 0.8% in Assai (Ipardes, 1986).

According to Hueck (1972) and Klein (1983) the north Paraná forests were part of the evergreen subtropical forest which covered large areas of the Paraná and Uruguai River basins. This type of forest stretched from Rio Grande do Sul as far north as Minas Gerais, through the states of Santa Catarina, Paraná and São Paulo, predominating throughout the warm band of the temperate zone where climatic and edaphic conditions favoured its development (Hueck, 1972). In Paraná it covered all the west and the north of the state, especially where there is 'Terra Roxa', a eutrophic structured soil formed from the meteorisation (weathering) of basic eruptive rocks in the trapp-spilling, São Bento group, from the Jurassic-Cretaceous period (Maack, 1968).

The forest is characterised by trees of up to 40m in height forming a discontinuous upper canopy which, combined with the presence of semideciduous and deciduous species, allows a great deal of sunlight to penetrate, permitting the development of a vigorous lower stratum.

It is a common practice among authors on succession in tropical forests to group species ecologically based on their regeneration strategies, e.g. Watt (1947),

* Paper presented to the 25th Argentinas Botanical Congress, Mendoza, Argentina, 17–22 November 1996.

† Jardim Botânico de Brasília. SMDB, Conj. 12, Lago Sul. 71.680–120, Brasília-DF.

‡ Departamento de Botânica-Universidade de Brasília. C. Postal. 04457, CEP 70.919–970, Brasília-DF.

Budowski (1965), Denslow (1980) and Whitmore (1989, 1993). These authors established, in different ways, that the success or failure of species in establishment and survival depends on their ability to germinate either in full sunlight (r strategists) or in the shade (K strategists) (Toledo, 1979).

According to Whitmore (1993) tropical tree species are divided into two distinct ecological groups, shade tolerant and shade intolerant. The intolerant are those unable to reach full development under shade conditions, needing higher levels of sunlight to mature. The shade tolerant reach maturity, flower and bear fruit under the canopy and are components of the understorey, or remain there until a canopy opening allows them to reach the higher strata of the forest.

This study provides information about the arboreal floristic composition of the Godoy Forest State Park and classifies the species into ecological categories. It is hoped that this information may help in the future recuperation of disturbed and/or degraded areas, seedling production and in environmental education programmes.

CHARACTERISTICS OF THE AREA

The Godoy State Park was created in 1989 and is administered by the Paraná Environmental Institute (IAP) in the county of Londrina. It is of 680ha and has its headquarters centre at 23°27′S, 51°15′W, 18km south of the city of Londrina (Fig. 1). Altitude ranges from 500m in the lowest valley to 650m on the highest ridge.

The topography is fairly even, with a smooth plain in the northern part and five parallel hills with moderate slopes in the south. The Apertados stream, a permanent watercourse 10m wide and 1m deep in the dry season, forms the southern boundary of the Park.

The park is an 'island', surrounded by agricultural lands, with crops such as soybean, wheat, maize and coffee.

The climate, according to the Köppen (1948) classification, is the Cfa-mesothermic type, characterised by hot summers, no defined dry season and an average temperature of above 22°C in the warmest month. There is appreciable rainfall in all months with a total of over 1600mm rainfall per annum. Soares-Silva & Barroso (1992) recorded weather data for Londrina county over a 10-year period from 1979 to 1988 and reported a mean temperature of 21°C, with an absolute maximum of 39°C and an absolute minimum of 0.6°C. The mean annual rainfall was 1631.7mm; December, the wettest month, had 233.4mm, while the driest month, August, had 51.7mm.

METHODS

Collections of trees and shrubs $\geqslant$5m were made throughout the Park from 1988 to 1996. In the northern part, the most intense collecting was sampled along three transects of 1100m each and also during walks along the access road. In the central and southern region, trails were opened, totalling 6000m, making walking and collecting easier in areas where access was difficult before.

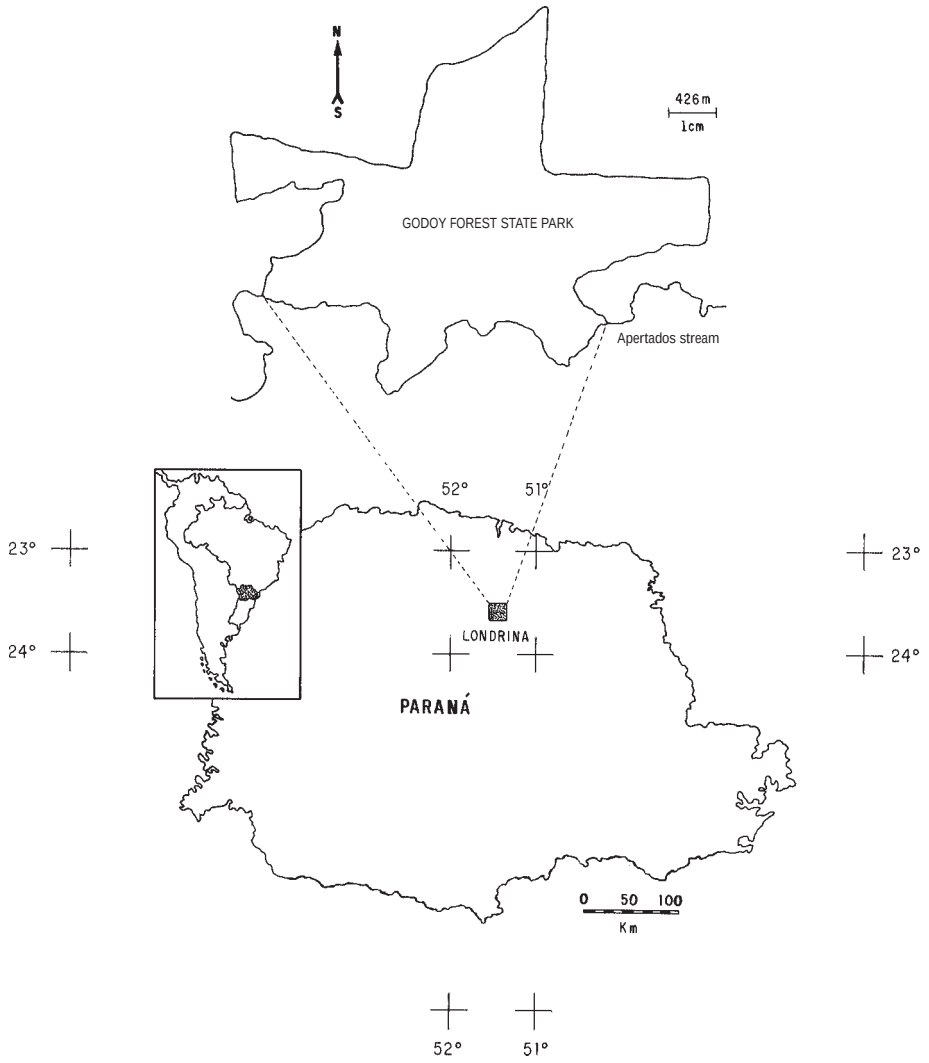

FIG. 1. Location of the Godoy Forest State Park, County of Londrina, Paraná State.

Specimens from the reserve, were lodged in the herbarium (FUEL), at State University of Londrina, and in the herbarium of the Royal Botanic Garden Edinburgh (E). Most of the identifications were made by the authors themselves, but in cases of doubt, specialists were consulted.

It is natural to find areas in different stages of development because of the size of the park and the differences in topography and soils. These stages determine mosaics in the forest (Denslow, 1980), which are distinct in flora, depending on the degree of tree-fall gap formation and closing. Stretches of mature forest are found in the north and central regions, while in the western region, because of slope and soil

depth, large canopy gaps are formed successively, forming a typical composition of successional stages. A similar situation is found along the nearby fringes and man-made clearings.

The species were placed in successional categories according to the classification suggested by Budowski (1965) and also considered by Whitmore (1993), that is, in the four traditional categories: pioneer, initial secondary, late secondary, and climax. The criteria established by Swaine & Whitmore (1988) were also used in this classification.

Species which develop in full sunlight areas, i.e. in large canopy gaps and at the forest edge, were considered as pioneers in accordance with the criteria established by Gómez-Pompa & Vázquez-Yañes (1979), Kageyama & Viana (1989) and Whitmore (1993). They are dependent upon conditions of greater sunlight for seed germination, and early in their lives produce a large quantity of small seeds that are dispersed by animals over long distances. Their life cycle is short and their wood is of low density. The initial secondary plants are species that even under the canopy have a low growth rate, medium-density wood and medium-size seeds produced in smaller numbers than the pioneers. Their fruits and seeds are dispersed by wind and animals. In the third category are the late secondaries, species which germinate and grow in the shade, but which also depend on direct sunlight to complete their life cycle (Gómez-Pompa & Vázquez-Yañes, 1979). The seeds of these species are medium- to large-sized, and are usually wind dispersed. Their growth is slow, the wood hard and dark; they have a long life span and their first reproduction occurs after 10 to 15 years. Species of this category are also known as small gap specialists. Species that geminate and grow slowly and reproduce in the shade are in the fourth and climax category; they have large seeds (the reserves feed the seedling until it is established), and they are dispersed by animals, wind, or even, in some cases, rainwater. They have a long life span and their wood is dense and dark.

The grouping of the species in ecological categories was based on field observations, mainly taking into account the presence of the species in the seedling bank and the development of individuals in diverse sunlight situations, as well as information from the available bibliography.

RESULTS AND DISCUSSION

General aspects of the forest

The vertical forest structure has individuals in three 'strata', called here understorey, canopy and emergent. The classic division into strata is however not easy to distinguish and is obscured by the presence of young trees of intermediate height occurring between levels. The emergent species are those which at their maximum development may reach 40m, such as *Aspidosperma polyneuron* (peroba-rosa-peroba), *Balfourodendron riedelianum* (pau-marfim), *Cariniana estrellensis* (jequitibá mirim), and *Pentapanax warmingianum* (authorities for species are given in Table 1).

TABLE 1. Floristic composition of the Godoy Forest State Park. No. FUEL, Herbarium registration number. EC, ecological classification: C, climax; I, initial secondary; P, pioneer; T, late secondary. DS, dispersal syndrome: An, wind; Au, autodispersal; Ba, rainwater; Zo, animal-dispersal. ST, stratum: Ca, canopy; Em, emergent; Un, understorey

FAMILY/scientific name	No. FUEL	EC	DS	ST
ACANTHACEAE				
Justicia brasiliana Roth.	11.897	I	Au	Un
ACHATHOCARPACEAE				
Achatocarpus pubescens C.H. Wright	9.400	C	Zo	Un
ANACARDIACEAE				
Astronium graveolens Jacq.	8.990	T	An	Em
Schinus terebinthifolius Radd.	7.972	I	Zo	Un
ANNONACEAE				
Annona cacans Warm.	12.311	T	Zo	Ca
Duguetia lanceolata St.Hil.	11.330	T	Zo	Ca
Rollinia sylvatica (St.Hil.) Mart.	8.857	I	Zo	Un
APOCYNACEAE				
Aspidosperma polyneuron Muell. Arg.	11.388	T	An	Em
Peschiera australis (Muell. Arg.) Miers	2.213	P	Zo	Un
Rauwolfia sellowii Muell. Arg.	8.859	T	Zo	Ca
AQUIFOLIACEAE				
Ilex brevicuspis Reiss.	11.900	T	Zo	Ca
ARALIACEAE				
Pentapanax warmingianum (March.) Harms	10.239	T	Zo	Em
Schefflera morototoni Dcne & Planch.	5.436	I	Zo	Ca
ARECACEAE				
Euterpe edulis Mart.	9.421	C	Zo	Ca
Geonoma schottiana Mart.	1.900	C	Zo	Un
Syagrus romanzoffiana (Scham.) Glassm.	8.187	T	Zo	Ca
ASTERACEAE				
Vernonia petiolaris DC.	9.402	I	An	Ca
Vernonia sp	9.379	I	An	Un
Baccharis sp	15.021	I	An	Un
BIGNONIACEAE				
Jacaranda puberula Cham.	11.824	I	An	Ca
Tabebuia alba (Cham.) Sandw.	9.403	T	An	Em
Zeyheria tuberculosa (Vell.) Bur.	9.481	T	An	Ca
BOMBACACEAE				
Chorisia speciosa St.Hil.	19.822	T	An	Ca
Pseudobombax grandiflorum (Cav.)A.Robyns	9.061	T	An	Ca
BORAGINACEAE				
Cordia ecalyculata Vell.	8.633	I	Zo	Un
C. trichotoma (Vell.) Arrab.ex Steud.	2.195	T	An	Ca
Patagonula americana L.	9.396	T	An	Em
CARICACEAE				
Jacaratia spinosa (Aubl.) DC.	8.997	T	Zo	Ca
CECROPIACEAE				
Cecropia pachystachya Trec.	17.166	P	Zo	Un

TABLE 1. Continued

Cecropia sp	11.798	P	Zo	Un
CELASTRACEAE				
Maytenus ilicifolia Mart. ex Reiss.	11.151	I	Zo	Un
COMBRETACEAE				
Terminalia triflora Lillo	9.394	T	An	Ca
T. reitzii Exell.	12.581	T	An	Ca
ELAEOCARPACEAE				
Sloanea monosperma Vell.	8.869	T	Zo/Au	Ca
ERYTHROXYLACEAE				
Erytrhroxylum cuneifolium (Mart.)Schultz.	11.392	I	Zo	Un
EUPHORBIACEAE				
Actinostemon concolor (Spreng.) Muell. Arg.	11.154	C	Au	Un
Alchornea glandulosa Poepp.	8.865	I	Zo	Ca
A. triplinervia (Spreng.) Muell. Arg.	2.178	I	Zo	Ca
Croton floribundus Spreng.	9.038	I	Au	Ca
Manihot grahami Hook.	11.339	I	Au	Un
Margaritaria nobilis L.F.	11.138	T	Zo/Au	Em
Pachystroma longifolium (Nees.) I.M. Jntm.	1.104	T	Au	Ca
Pera obovata Baillon	9.437	T	Au	Ca
Sapium glandulatum (Vell.) Pax	9.434	I	Au	Un
Sebastiania brasiliensis Spreng.	13.189	I	Au	Un
S. commersoniana (Baill.)Smith&Downs	9.381	I	Au	Un
Tetrochidium rubrivenium Poepp. & Endl.	9.074	T/I	Zo	Ca
FLACOURTIACEAE				
Banara tomentosa Clos.	9.480	T	Zo	Un
Casearia decandra Jacq.	8.587	T	Zo	Un
C. gossypiosperma Brig.	9.091	T	An	Ca
C. lasiophylla Eichl.	5.898	T	Zo	Un
C. obliqua Spreng.	9.039	T	Zo	Ca
C. sylvestris Sw.	2.287	I	Zo	Un
Prockia crucis L.	11.739	T	Zo	Un
Xylosma ciliatifolium (Clos.) Eichl.	13.405	I	Zo	Un
X. pseudosalzmannii Sleum.	11.929	I	Zo	Un
ICACINACEAE				
Citronella megaphylla (Miers) Howard	11.264	T	Zo	Ca
LAURACEAE				
Cinnamomum sellowianum (Nees. & Mart.) Kost.	8.864	T	Zo	Ca
Endlicheria paniculata (Spreng.) Macbr.	9.050	C	Zo	Un
Nectandra lanceolata Nees. & Mart.	11.382	T	Zo	Ca
N. megapotamica Mez.	11.329	T	Zo	Ca
N. saligna Nees et Mart. ex Nees.	2.318	T	Zo	Ca
Ocotea diospyrifolia (Meissn.) Mez	9.406	T	Zo	Ca
O. elegans Mez	8.960	I	Zo	Ca
O. indecora Schott.	9.925	I	Zo	Un
O. puberula (Rich.) Nees.	9.372	T	Zo	Ca
O. pulchella Mart.		T	Zo	Ca
O. silvestris Vatt.	9.517	T	Zo	Ca

TABLE 1. Continued

LOGANIACEAE				
Strychnos brasiliensis (Spreng.) Mart.	11.338	I	Zo	Un
LECYTHIDACEAE				
Cariniana estrellensis (Raddi) Kuntze	17.830	T	Au	Em
LEGUMINOSAE – Caesalpinioideae				
Apuleia leiocarpa (Vog.) Macbr.	12.133	T	An	Em
Bauhinia forficata Link	9.518	I	Au	Un
Bauhinia longifolia D.Dietr.	11.116	I	Au	Un
Cassia sp	11.125	I	Au	Un
Exostyles sp	10.720	T	Zo	Ca
Holocalyx balansae Mich.	12.130	C	Zo	Ca
Peltophorum dubium (Spreng.) Taub.	4.455	I	An	Ca
LEGUMINOSAE – Faboideae				
Dalbergia frutescens (Vell.) Britt.	2.184	I	An	Un
Erythrina falcata Benth.	8.851	T	Zo/Au	Em
Lonchocarpus campestris Mart. & Benth.	9.450	I	An	Ca
L. guilleminianus (Tul.) Malme	11.355	I/T	An	Ca
L. muehlbergianus Hassl.	9.042	I	An	Em
L. subglaucescens Benth.	1.943	T	An	Ca
Machaerium aculeatum Raddi	10.830	I	An	Ca
M. hatschbachii Rudd.	8.826	I/T	An	Em
M. nictitans (Vell.) Benth.	11.133	I/T	An	Ca
M. paraguariense Hass.	8.964	T	An	Ca
M. stipitatum Vog.	862	I/T	An	Ca
Machaerium sp		I	An	Ca
Myrocarpus frondosus Fr. Allem.	8.842	T	An	Ca
Pterocarpus rohrii Vahl.	9.132	I/T	An	Ca
LEGUMINOSAE – Mimosoideae				
Acacia polyphylla DC.	5.531	I	Zo/Au	Ca
Albizia austrobrasilica A. Burk.	9.407	T	Au	Ca
A. polycephala (H.B. & K.) Killip	9.438	T	An	Ca
Anadenanthera colubrina (Vell.) Brenan	7.044	T	Au	Em
Enterolobium contortisiliquum (Vell.) Morong	5.438	T	Zo	Em
Inga marginata Willd.	2.332	I	Zo	Un
I. sessilis (Vell.) Mart.	8.861	I	Zo	Ca
I. striata Benth.	2.337	T	Zo	Ca
I. virescens Benth.		I	Zo	Ca
Parapiptadenia rigida (Benth.) Brenan	9.433	T	Au	Em
MALPIGHIACEAE				
Bunchosia pallescens Skott.	11.334	T	An	Un
MALVACEAE				
Bastardiopsis densiflora (Hook. & arn.)Hassl.	9.373	T	An	Ca
MELASTOMATACEAE				
Leandra scabra Cogn.	8.868	P	Zo	Un
Miconia discolor var. *concolor* DC.	11.163	P	Zo	Un
M. discolor var. *subconcolor* Cogn.	2.359	I	Zo	Un

TABLE 1. Continued

M. minutiflora (Bonpl.) DC.	9.063	P	Zo	Un
M. tristis L.	3.381	P	Zo	Un
MELIACEAE				
Cabralea canjerana (Vell.) Mart.	9.081	I	Zo	Ca
Cedrela fissilis Vell.	11.942	T	An	Ca
Guarea kunthiana A.Juss.	9.439	C	Zo	Un
G. macrophylla Vahl.	8.554	C	Zo	Un
Trichilia casaretti C.DC.	8.873	C	Zo	Un
T. catigua A.Juss.	8.993	C	Zo	Un
T. claussenii C.DC.	2.365	C	Zo	Un
T. elegans A.Juss.	2.369	C	Zo	Un
T. pallens C.DC.	9.073	C	Zo	Un
T. pallida Swartz.	10.747	C	Zo	Un
MONIMIACEAE				
Mollinedia clavigera Tul.	2.379	C	Zo	Un
MORACEAE				
Ficus glabra Vell.	12.704	T	Zo	Em
F. guaranitica Chodat. ex Chodat.& Vischer	11.168	I	Zo	Ca
F. insipida Willd.	11.407	I	Zo	Em
F. monckii Hassl.	9.386	T	Zo	Ca
F. trigonata L.	13.255	T	Zo	Ca
F. organensis (Miq.) Miq.	9.454	T	Zo	Ca
Maclura tinctoria (L.) Don	11.343	T	Zo	Ca
Sorocea bonplandii (Baill.) Burger, Lanjow & Boer	9.065	C	Zo	Un
MYRSINACEAE				
Rapanea ferruginea (R. & P.) Mez.	2.375	I	Zo	Un
R. intermedia Mez.	11.907	I	Zo	Un
R. umbellata (Mart. ex A.DC.) Mez.	9.047	I	Zo	Un
MYRTACEAE				
Calyptranthes concinna DC.	11.331	C	Zo	Un
C. grandifolia Berg.	13.332	T	Zo	Ca
Campomanesia guaviroba (A.P.DC.) Kiaersk.	8.259	T	Zo	Ca
C. guazumifolia Camb.	9.408	C	Zo	Un
C. xanthocarpa Berg.	13.849	T	Zo	Ca
Eugenia burkartiana (Lerg.) Legr.	9.071	C	Zo	Un
E. cicliantha Legr.	17.042	C	Zo	Un
E. florida DC.	11.162	C	Zo	Un
E. handroana Legr.	17.093	C	Zo	Un
E. hyemalis Camb.	14.954	C	Zo	Un
E. moraviana Berg.	9.052	C	Zo	Un
E. neoverrucosa (Legr.) Sobral	9.313	C	Zo	Un
E. ramboi Legr.	9.455	T	Zo	Un
E. sulcata Spr. Ex Mart.	9.071	C	Zo	Un
E. uniflora L.	8.823	T	Zo	Un
Hexaclamys italiaiensis Mattos	11.910	T	Zo	Ca
Myrceugenia miersiana (Gard.) Legr. et Kausel	8.793	C	Zo	Un
Myrcia laruotteana Camb. var. *paraguayensis* Berg	11.901	I	Zo	Un

TABLE 1. Continued

Myrcianthes pungens (Berg.) Legr.	11.312	I	Zo	Un
Myrciaria delicatula (DC.) Berg	8.831	T	Zo	Em
M. floribunda (West. ex Willd.) Berg.	11.117	I	Zo	Un
Neomitranthes glomerata (Legr.) Legr.	2.380	C	Zo	Un
Plinia rivularis (Camb.) Rotman	2.382	C	Zo	Un
P. trunciflora (Berg.) Rot.	8.962	C	Zo	Un
NYCTAGINACEAE				
Bougainvillea spectabilis Willd.	9.041	T	An	Ca
Guapira opposita (Vell.) Reitz.	8.832	I	Zo	Un
Pisonia ambigua Heimerl.	2.386	T	An	Un
OLACACEAE				
Schoepfia brasiliensis A.DC.	9.389	T	Zo	Ca
PHYTOLACCACEAE				
Galesia integrifolia (Spreng.) Harms.	2.186	T	An	Em
Phytolacca dioica L.	9.387	I	Zo	Ca
POLYGONACEAE				
Ruprechtia laxiflora Meissn.	10.241	I	An	Ca
Ruprechtia sp.1	9.449	I	An	Ca
PROTEACEAE				
Roupala brasiliensis Klotz.	11.896	T	An	Ca
RHAMNACEAE				
Colubrina glandulosa Perkins	2.166	I	Au	Ca
ROSACEAE				
Prunus sellowii Koehne	9.055	I	Zo	Ca
RUBIACEAE				
Alseis floribunda Schott.	2.258	I	An	Ca
Coutarea hexandra (Jacq.) Schum.	9.764	I	Zo	Un
Faramea porophylla (Vell.) Muell. Arg.	9.453	I	Zo	Un
Randia armata DC.	9.435	I	Zo	Un
Rudgea jasminoides (Cham.) M.Arg.	8.815	C	Zo	Un
Simira corumbaensis Standl.	9.456	T	Zo	Un
RUTACEAE				
Balfourodendron riedelianum (Engl.) Engl.	9.424	T	An	Em
Esenbeckia febrifuga (St.Hil.) A.Juss.	13.213	I	Au	Un
E. grandiflora Mart.	13.214	T	Au	Un
Zanthoxylum hyemale St.Hil.	9.478	T	Zo	Ca
Z. petiolaris Griseb.	9.441	T	Zo	Ca
Z. rhoifolium Lam.	9.478	I	Zo	Ca
Z. rugosum St.Hil & Tul.	13.217	T	Zo	Ca
SAPINDACEAE				
Allophylus edulis (St. Hill.) Radlk.		I	Zo	Un
A. guaraniticus (St.Hil.) Radlk.	8.844	I	Zo	Un
Cupania vernalis Camb.	9.384	T	Zo	Ca
Diatenopteryx sorbifolia Radlk.	8.785	T	An	Ca
Matayba elaeagnoides Radlk.	5.805	T	Zo	Ca
SAPOTACEAE				
Chrysophyllum gonocarpum (Mart. & Eichl.) Engl.	2.376	T	Zo	Ca

TABLE 1. Continued

C. marginatum (H. & A.) Radlk.	2.191	T	Zo	Ca
Pouteria beaurepairei (Glaz. & Raunk.) Baehni	11.363	I	Zo	Un
SIMAROUBACEAE				
Picramnia ramiflora Planch.	2.177	C	Zo	Un
SOLANACEAE				
Cestrum calycinum Willd.	11.146	P	Zo	Un
Cestrum intermedium Sendtn.	9.051	I	Zo	Un
Cyphomandra patrum Smith & Downs	9.364	P	Zo	Un
Solanum argenteum Dun.	2.444	I	Zo	Un
S. mauritianum Willd. ex Roth.	11.142	P	Zo	Un
S. reitzii Smith & Downs	9.382	I		Un
S. rantonetii Carr.	9.360	P	Zo	Un
S. Sanctae-catharinae Dun.	9.374	I	Zo	Un
STYRACACEAE				
Styrax acuminatus Pohl.	8.852	T	Zo	Ca
S. leprosum Hook. et Arn	11.337	I	Zo	Ca
SYMPLOCACEAE				
Symplocos celastrinea Mart.	11.148	T	Zo	Un
TILIACEAE				
Heliocarpus americanus L.	9.528	I	An	Un
Luehea divaricata Willd.	9.446	I	An	Ca
ULMACEAE				
Trema micrantha (L.) Blume	11.342	P	Zo	Un
URTICACEAE				
Boehmeria caudata Sw.	9.513	P	Zo	Un
Urera baccifera (L.) Gaud.	1.875	P	Zo	Un
VERBENACEAE				
Aegiphila mediterranea Vell.	9.404	I	Zo	Un
Aloysia virgata (R.& P.) A, Jus.	11.165	I	Zo	Un
Vitex magapotamica (Spr.) Mold.	11.336	T	Zo	Ca

Individuals this size have long thick boles up to 2m in diameter and an irregular crown, with few widely spaced boughs.

The canopy is the level where the crowns touch and there are only occasional openings, particularly in the tree-fall gaps. This stratum varies from 16 to 20m in height and among its most characteristic components are species of *Lauraceae*, *Leguminosae* and *Myrtaceae*. *Nectandra*, *Ocotea*, *Lonchocarpus*, *Machaerium*, *Inga*, *Eugenia*, *Campomanesia* and *Myrciaria* are some of the well-represented genera. About 80% of the species in the canopy are evergreens, so that deep shade is cast throughout the year.

Small trees and shrubs make up the understorey, 8–10m in height, where characteristic species pass all their life-cycle in the shade of the canopy. Common species in the area studied are *Actinostemon concolor*, *Sorocea bonplandii*, *Guarea macrophylla*, *Guarea kunthiana*, *Mollinedia clavigera*, and six species of *Trichilia*, amongst others.

Table 1 lists all species registered with their ecological classification. There are 206

species belonging to 132 genera and 52 families. *Leguminosae* have the greatest number of species, 31 (15% of the total), while *Myrtaceae* with 24 species (11.6%) are second, *Euphorbiaceae* third with 12 species (5.8%) and *Lauraceae* fourth with 11 species (5.3%).

The floristic importance of these families in the Brazilian flora has been emphasised many times by various authors. Some families, such as the first two and also the *Lauraceae* stand out in surveys all over the country, with many characteristic species in each region. Some species encountered have a wider distribution, such as *Eugenia florida* and *Cordia trichotoma*, found from the Amazon to the south of the country.

A striking aspect of the type of forest is the small number of epiphytes, especially *Bromeliaceae* and *Orchidaceae*, when compared with more typical tropical forests, e.g. the Brazilian coastal forests. Lianas, however, are abundant in quantity and diversity; several families are represented, the most important being *Bignoniaceae*, *Leguminosae* and *Apocynaceae*.

In this type of forest, litter decomposition is rapid and takes place from October to March, after the drier part of the year, when high temperatures and humidity favour the development of soil microfauna. Under these conditions the accumulation of dead biological material on top of the soil is practically non-existent; only the thicker stems and branches from dead trees remain on the forest floor.

Ecological aspects

Authors such as Gómez-Pompa & Várquez-Yañes (1979) and Kageyama & Viana (1989) show various other traits in addition to those already mentioned, which separate the pioneer and secondary species. Traits for the secondary species include low nutritional demands, absence of mycorrhizas, a dense root system, strong resistance to herbivores, large seed size, and animal dispersion. In practice, however, the placing of species in a successional data category has not been an easy task (Gómez-Pompa & Vázquez-Yañes, 1979).

The difficulties are felt especially when determining secondary species, which is usually possible only after reporting environmental factors and the floristic and structural vegetation variations (Goldsmith & Harrison, 1976). These difficulties increase when the study area is made up of vegetation with areas at different successional stages, such as primary forest, man-made clearings, margins, hillsides, etc. This is a situation inherent in forests in tropical countries, and often makes it difficult to recognise the successional category of some species. Thus Gandolfi (1991) and Silveira (1993) placed the category 'without characterisation' for some species in their studies.

Fourteen of the species in our study (6.8%) were classified as pioneers, while 154 (74.7%) belonged to the secondary category. Of these, 71 (34.5%) are initial secondary and 83 (40.3%) are late secondaries. The 32 remaining (15.5%) belong to the climax category.

Attempts were made in as far as the information allowed to place all the species

into the four categories considered, in spite of some falling in rather intermediate positions. This happened with some (six) very rare species (very often there was only a single recorded individual) which did not provide sufficient information for accurate categorisation.

Silveira (1993) reported 67 species in a stretch of the same park and grouped them as, 12 pioneers (19%), 21 opportunists (31%), 26 tolerant (38%) and eight species (12%) not allocated, using Denslow's (1980) classification. The number of pioneers reported is close to that found in this study but the percentage is very different, when the number of species reported in each study is taken into account. There is also a significant difference in the percentage of secondary and opportunist species and the climax/tolerant. These differences can be attributed to the criteria used for classification.

Differences in geology and topography, together with continual formation and closing of gaps, cause much variation over the area of the forest. In some areas, such as the northern region of the Park, there are few natural gaps and thus few pioneers. In others, such as the margins and that studied by Silveira (1993), the situation is the reverse and pioneers and initial secondary species predominate. Stretches of fringe forest in the same Park may be considered mature under the present categories.

An analysis of the remaining forest includes a series of five hills in its southern region; here some of the slopes have more open areas, i.e. big clearings. In the rest of the park, covering about four-fifths of its total area, there was vegetation with emergent trees reaching over 30m in height. Clearings were also observed at different successional stages, making up a mosaic of vegetation. The biggest clearing in the south-west region is due mainly to the broken terrain and factors such as rain and wind, with no indication of catastrophic human disturbance being responsible. The forest in general is in an excellent primeval state and may be considered a mature climax at many points.

When dispersion modes are analysed, the animal syndrome predominates (67% of the species). Of the rest, 21.8% are wind-borne, 9.2% self-dispersed and 1.9% mixed animal-/auto-dispersal. In studies carried out in forests in Rio Grande do Sul, Santa Catarina, São Paulo and Espírito Santo, authors such as Matthes (1980), Rossi (1987), Costa *et al.* (1992) and Tabarelli (1992), found animals as the most important dispersal agents, corroborating the observations made here. This agrees with the prediction that the majority of tropical species show an animal-dispersal syndrome.

In 1991 the Paraná Environmental Institute carried out reforestation of a 90ha stretch of the Park adjacent to the forest, planting on a 3×3m pattern. Five species were used: *Peltophorum dubium* (Canafístula, *Leguminosae*/*Caesalpinioideae*), *Colubrina glandulosa* (Sombreiro, *Rhamnaceae*), *Parapiptadenia rigida* (Gurucaia, *Leguminosae*/*Mimosoideae*), *Tabebuia impetiginosa* (Ipê-roxo, *Bignoniaceae*), and *Cordia trichothoma* (Louro-pardo, *Boraginaceae*). Although *Aspidosperma polyneuron* (Peroba-rosa, *Apocynaceae*), was not amongst the main species used, it was included marginally in the reforestation, and was thus assessed with the others.

Differences in growth and vigour amongst the species were observed over the first five years. These were individuals of 'Canafístula' and 'Sombreiro' over 5m tall, and the latter bore fruit in the third year. Almost all the 'Gurucaia' and Ípê-roxo' specimens that were in full sunlight were weak with burnt leaves and heights less than 2m. 'Gurucaia', besides suffering from excessive sun, was also eaten by tapirs (*Tapirus terrestris*), which appreciate the tips and thus damage development. Individuals of this tree species that were shaded by other trees and not attacked by the animals developed very well to a height of about 4.5m and with excellent vigour.

'Canafistula' and 'Sombreiro were classified in the initial secondary category with fast growth, preference for full sunlight, and early reproduction. Such species are shade tolerant in more advanced forest development phases and develop well in open areas. *Croton floribundus, Luehea divaricata* and *Lonchocarpus muehlenbergianus* and others mentioned in Table 1 behave similarly. The remaining planted species are late secondaries, characterised by germination and initial development in the shade and the need for diffuse sunlight to complete their life cycle. Some of them may be more or less tolerant of shorts periods of direct sunlight.

CONCLUSIONS

The area studied was shown to be a formation in advanced successional stages, as late species prevailed over the others and the majority had an animal-dispersal syndrome (67%) which indicates predominance of dependence on biotic agents over abiotic agents.

About 56% of the species belong to the late and climax secondaries; the pioneers have a limited representation of 6.8% and even so are mainly restricted to the edges of the forest or in larger gaps on the hillsides. The initial secondaries (34.5%), are represented by species such as *Croton floribundus*, *Aegiphila mediterranea*, *Solanum reitzii* and *Miconia discolor*, and are found in small gaps, or in larger gaps at more advanced successional stages.

As the forest studied is an island, surrounded by agricultural land, the border effects are real and visible. Protection can be afforded by reforestation of the band of land lying outside the forest. Establishment of a buffer zone of this type has commenced in the north-eastern region of the park. Another measure which could be taken to protect the forest margins would be to allow natural regeneration under the trees, instead of clearing it as is done at present. These measures are important to assure more protection for the rare species that make up 60–70% of the floristic composition of the forest.

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Received 6 October 1998; accepted with revision 22 June 1999