JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

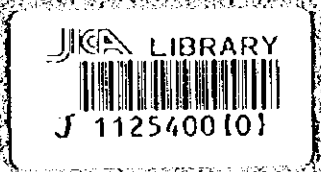
STATE SECRETARIAT OF PLANNING AND GENERAL COORDINATION,
PARANÁ STATE, THE FEDERATIVE REPUBLIC OF BRAZIL

THE MASTER PLAN STUDY ON THE UTILIZATION OF WATER RESOURCES IN PARANÁ STATE IN THE FEDERATIVE REPUBLIC OF BRAZIL

FINAL REPORT

SECTORAL REPORT VOLUME K

ECOLOGY



December, 1995

Yachiyo Engineering Co., Ltd.
Tokyo, Japan

and

Nippon Koei Co., Ltd.
Tokyo, Japan

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

STATE SECRETARIAT OF PLANNING AND GENERAL COORDINATION,
PARANÁ STATE, THE FEDERATIVE REPUBLIC OF BRAZIL

THE MASTER PLAN STUDY ON
THE UTILIZATION OF WATER RESOURCES IN PARANÁ STATE
IN
THE FEDERATIVE REPUBLIC OF BRAZIL

FINAL REPORT

SECTORAL REPORT VOLUME K

ECOLOGY

December, 1995

Yachiyo Engineering Co., Ltd.
Tokyo, Japan

and

Nippon Koei Co., Ltd.
Tokyo, Japan

Cost Estimate is Based
on The Price Level of August, 1994,
According to The Following Exchange Rate.

US$ 1.00 = ¥ 98.87
(as of August, 1994)

COMPOSITION OF FINAL REPORT

1. EXECUTIVE SUMMARY

2. MAIN REPORT
   - I. Strategy for Paraná State
   - II. Master Plan for Iguaçu River Basin
   - III. Master Plan for Tibagi River Basin

3. SECTORAL REPORT
   - A. Socio-economy
   - B. Meteorology, Hydrology and Surface Water Resources
   - C. Hydrogeology and Groundwater Resources
   - D. Domestic and Industrial Water
   - E. Agriculture
   - F. Hydroelectric Power Generation
   - G. Water Utilization Plan
   - H. Flood Control
   - I. Water Quality and Sewerage
   - J. Soil Erosion and Forest
   - K. Ecology
   - L. Water Environment Management
   - M. Institution
   - N. Cost Estimate, and Economic and Financial Assessment

4. DATA BOOK

THE MASTER PLAN STUDY

ON

THE UTILIZATION OF WATER RESOURCE IN PARANA STATE

IN

THE FEDERATIVE REPUBLIC OF BRAZIL

Sectoral Report Vol. K

Ecology

Table of Contents

List of Tables

<Chapter-2>

List of Figures

<Chapter-2>

APPENDICES

LITERATURE CITED

List of Abbreviation

ADB	: Asian Development Bank *Banco Asiático de Desenvolvimento*
APA	: Environmental Protection Area *Área de Proteção Ambiental*
CEPA	: State Comission for Agricultural Planning *Comissão Estadual de Planejamento Agrícola*
CIC	: Industrial District of Curitiba *: Cidade Industrial de Curitiba*
COMEC	: Coordination of the Metropolitan Area of Curitiba *Coordenação da Região Metropolitana de Curitiba*
CONAMA	: National Council for Environment *: Conselho Nacional do Meio Ambiente*
COPATI	: Inter Municipal Concessionaire for the Environmental Protection of the Tibagi River Basin *Consórcio Intermunicipal para a Proteção Ambiental da Bacia do Rio Tibagi*
COPEL	: Energy Company of the State of Paraná *Companhia Paranaense de Energia*
CORPRERI	: Permanent Regional Commission Against Floods in the Iguacu River *Comissão Regional Permanente Contra as Cheias do Rio Iguaçu*
DAGRI	: Agricultural Operation Department *Departamento Operacional da Agricultura*
DEPEC	: Livestock Department *Departamento de Pecuária*
DERAL	: Economy Department *Departamento de Economia*
DNAEE	: National Department of Water and Electric Energy *Departamento Nacional de Águas e Energia Elétrica*
EIA	: Environmental Impact Assessment *Estudo de Impacto Ambiental*
EMATER	: Paraná State Technical Assistance and Rural Extension Company *Empresa Paranaense de Assistência Técnica e Extensão Rural*

EMBRAPA	: Brazilian Agriculture and Livestock Research Company *Empresa Brasileira de Pesquisa Agropecuária*
FAO	: Food and Agriculture Organization *Fundo das Nações Unidas para Alimentação e Agricultura*
FAMEPAR	: Institute for Municipal Assistance of Paraná State *Instituto de Assistência aos Municípios do Estado do Paraná*
FUNAI	: Indian National Foundation *Fundação Nacional do Índio*
GTZ	: Deutsche Gesellschaft fur Technische Zusammenarbeit *Agência Alemã de Cooperação Internacional*
IAP	: Environmental Institute of Paraná *Instituto Ambiental do Paraná*
IAPAR	: Agricultural Research Institute of Paraná *Instituto Agronômico do Paraná*
IBAMA	: Brazilian Institute of Environment and Renewable Natural Resources *Instituto Brasileiro do Meio Ambiente e de Recursos Naturais Renováveis*
IBDF	: Brazilian Forest Development Institute (current IBAMA) *Instituto Brasileiro de Desenvolvimento Florestal*
IBGE	: Brazilian Institute of Geography and Statistic *Instituto Brasileiro deGeografia e Estatística*
IPARDES	: Economic and Social Development Institute of the State of Paraná *Instituto Paranaense de Desenvolvimento Econômico e Social*
ITCF	: Institute of Lands, Cartography and Forest *: Instituto de Terras, Cartografia e Florestas*
IUCN:	: International Union for the Conservation of Nature *: União Internacional para a Conservação da Natureza*
JICA	: Japan International Cooperation Agency *Agência de Cooperação Internacional do Japão*
MERCOSUL	: South Common Market in Brazil, Argentina, Uruguay and Paraguay *Mercado Comum do Sul*

MINEROPAR	: Paraná State Mineral Company *Minerais do Paraná S/A*
MSW	: Municipal Solid Waste *Resíduo Sólido Municipal*
NUPELIA	: Nucleus for Limnology, Ichthyology and Aquaculture Research - UEM *Núcleo de Pesquisa em Limnologia, Ictiologia e Aquacultura - UEM*
PIAB	: Program for Dam Environmental Impacts *Programa de Impactos Ambientais de Barragens*
PMISA	: Integrated Program for the Management of Soil and Water *Programa Integrado de Manejo de Solo e Água*
PROID	: Irrigation and Drainage Program *Programa de Irrigação e Drenagem*
PROSAM	: Environmental Sanitation Program *: Programa de Saneamento Ambiental*
SANEPAR	: Sanitation Company of the State of Paraná *Companhia de Saneamento do Paraná*
SEAB	: State Secretariat of Agriculture and Supply *Secretaria de Estado da Agricultura e do Abastecimento*
SEDU	: State Secretariat of Urban Development *Secretaria de Estado do Desenvolvimento Urbano*
SEMA	: State Secretariat of Environment *Secretaria de Estado do Meio Ambiente*
SEPL	: State Secretariat of Planning and General Coordination *Secretaria de Estado do Planejamento e Coordenação geral*
SETR	: State Secretariat of Transport *Secretaria de Estado dos Transportes*
SUCEAM	: Superintendency of Erosion Control and Environmental Sanitation *Superintendência do Controle de Erosão e Saneamento Ambiental*
SUREHMA	: Superintendency of Hydric Resources and Environment (former IAP) *: Superintendência de Recursos Hídricos e Meio Ambiente (antigo IAP)*
UEL	: State University of Londrina *: Universidade Estadual de Londrina*

UNDP	: United Nations Development Program *Programa das Nações Unidas para o Desenvolvimento*
URI	: University of Rhode Island *Universidade de Rhode Island*
USEPA	: United States Environmental Protection Agency : *Agência de Proteção Ambiental dos Estados Unidos*
WHO	: World Health Organization *Organização Mundial de Saúde*

SUMMARY

INTRODUCTION

Ecology in this Study should be understood as restricted to the aquatic environment, and within this context, mainly referred towards the aquatic biota.

The purpose is to discuss the main environmental issues related to the aquatic environment, and in the Iguaçu and Tibagi river basins as model areas, and to propose environmental preservation, rehabilitation, preventing and/or mitigating programs under the Study scope that will serve as models to other basins and similar conditions.

The present study was made by data and information supplied mainly from the IAP Limnological Laboratory, the Museum of Natural History of Parana, The Botanical Museum of Parana, the State University of Londrina, and COPATI.

BIOLOGICAL ENVIRONMENT

Flora

1) The original forest cover condition and deforestation process of Parana state is summarized under Table-2.20, Fig.2.12, and Fig.2.13.

2) The native forest cover area per river basin is summarized under Table-2.40, and Fig.2.1 through Fig.2.11. Percentage of cover area goes from 1.26% of the total basin area for Itarare river basin, up to 80.98% of the total basin area coverage for the Coastal river basin.

3) The historical deforestation process and agricultural expansion process has been summarized under section 3.1

4) 81.8% of the river basins of the state are considered to be under critical condition for native forest coverage.

5) Iguaçu river basin (14.6% of basin area with forest) is considered under dangerous condition.

6) Tibagi river basin (3.8% of basin area with forest) is considered under critical condition, with most of the flora under secondary vegetation, see Fig.2.3

7) The Coastal basin appears as a highly vegetated and preserved environment, Table-2.4 and Table-2.5 summarize the major tree species occurring in this basin, Fig.2.7 shows the percentage of existing vegetation cover in the basin.

8) There is no detailed information on the existing area still covered with river margin vegetation, section 7.3.2 and 7.5.2 summarize proposed programs for the identification and monitoring of the river margin vegetation in the Iguaçu and Tibagi river basins.

9) A summary of problems caused by microalgae in SANEPAR water intakes can be found under section 6.2.1 and 6.2.4.

10) As a consequence of the vegetation cover reduction, the related terrestrial and avian fauna have also diminished, Appendix-3 gives a list of reported endangered, rare or extinct animal species, and Appendix-2 gives a detailed list of endangered tree species per river basin.

Conservation Units

1) Table-2.8 through Table-2.18 summarize the existing conservation units per river basin and their management category. Table-2.41 summarizes the total area per river basin. The conservation area per river basin goes from 0.01% of the total basin area for the Piquiri river basin, up to 75.44% of the total basin area for the Coastal river basin.

2) Section 7.2.5, and section 7.4.4 propose the assessment of these units for the upgrading of their management plans, and the definition of their needs, Table-6.4 and Table-6.16 summarize the problems detected in these areas.

3) Main areas that should be considered as conservation units are discussed under section 6.2.4 and section 6.3.4. Specific programs for some of these areas can be found in section 7.2.6 and section 7.2.7

4) Developing of ecotourism and biotechnology are directly dependent on conservation areas, A general program layout for a biodiversity institute as baseline for biotechnology development is summarized under section 7.2.8

5) The proposed conservation area of Serra da Baitaca-Irai includes recreational, botanical, landscape, and endangered bird species values, and water supply areas of importance to the Curitiba metropolitan area. See section 6.2.4 and 7.2.6, Fig.6.2 for the vegetation types in the area.

6) The proposed conservation area of Corredeiras Eng. Bley (Fig.6.1) compromises the last sector of the Iguaçu river resembling the original river condition, and still well preserved vegetation including endangered orchids along the river margins, as shown in section 6.2.4 and 7.2.7

Terrestrial Fauna

1) Terrestrial fauna is heavily dependent on the forest, Parana state has 130 mammal species reported, and the Coastal basin is where the fauna is better preserved, Table-2.21 summarizes the fauna groups reported for this area.

2) Among the mammals, 16% are considered in the red list, Table-2.22 summarizes the fauna groups reported for the red list of the state.

3) A summary of the reported terrestrial fauna can be found in Table-2.42, and Appendix-3 shows the detailed red list of mammals, birds and reptiles reported in the state.

Aquatic Fauna

Extensive fish population studies involving complete river basins are scarce, the most comprehensive work has been carried out by IAP for Iguaçu river, by NUPELIA for the Parana river and the Salto Segredo reservoir, by the UEL for the Tibagi river, and by the Natural History Museum through the collection in different regions.

1) A summary of the reported fish fauna can be found in Table-2.43, and a detailed list of fish species reported per river basin can be found in Appendix-1.

2) The number of fish species found only in the Iguaçu river is very high (70%), making this river a unique habitat. Section 2.7.1 discusses these issues.

3) Significant areas of the Iguaçu river basin such as the Iguaçu National Park sector and main tributaries have not been sampled yet, section 7.2.1, and section 7.2.2 outline the programs to achieve this information, Fig.7.2 shows the areas to be covered.

4) Approximately 50% of the Iguaçu river length was modified by hydroelectric projects, Fig.6.7 shows the location of the major existing and planned hydroelectric projects, and Table-6.2 summarizes the fish species considered endangered in the Iguaçu river ichthyofauna.

5) Section 7.2.4 outlines a program for the study of fish and their environment in the Hydroelectric reservoirs. Its purpose is to define conservation and fish production strategies in the reservoirs.

6) Endangered, rare or commercially important species can be reproduced artificially for conservation and production purposes in reservoirs, rivers or aquaculture facilities, section 7.2.3 outlines this program.

7) The fish populations of the Tibagi river should be studied before major hydroelectric projects (Section 6.3.5) are installed, Section 7.3.2 and Section 7.3.3 propose fish inventory and population dynamics studies in this area.

8) Most abundant fish species reported for the Tibagi river can be found under Table-2.24 and Table-2.25, the location of these species can be found in Table-2.26, and a list of endangered fish species can be found under Table-6.9.

9) Migratory fish species reported for the Tibagi river can be found under Table-6.10, and commercial fish species can be found under Table-6.11

Benthos

Bottom dwelling organisms (benthos) are internationally considered as water quality and aquatic environment indicators by virtue of the number and type of species, and the presence of pollution indicator species.

Other organisms such as Daphnia magna (plankton) are used as control and monitoring species for toxic substances present in the water. This techniques are well known and used in Europe.

1) Section 7.3.1 and Section 7.5.1 suggest the plan outline to implement such biomonitoring in the Iguaçu and Tibagi river basin, Fig.7.3 and Fig.7.5 show some of the locations where the biomonitoring stations can be allocated. Fig.7.6 and Fig.7.7 outline schematic diagrams showing the biomonitor principle.

Bird Fauna

The avian fauna is the most affected species because of anthropic activities and environmental degradation. The extinction of these animals is attributed among others to reduced food supply and shelter due to deforestation, agrochemical pollution and insect biodiversity reduction.

1) Table-2.22 summarizes the number of species per animal group reported, among these, the birds have the highest number of species reported. Appendix-3 summarizes the list of endangered species, and Appendix-4 gives the list of aquatic birds reported for the state.

2) Habitat destruction is attributed to the drainage of periodically inundated lowlands along water courses for agricultural expansion, as discussed in section 6.2.3 and section 6.3.3

3) Main destruction of aquatic bird habitat is attributed to the Tibagi river basin's agricultural expansion. Table-2.30 summarizes the aquatic bird families in Parana state and Tibagi river basin.

4) Table-2.32 shows the aquatic habitats where little studied bird fauna is present, and Table-2.43 summarizes the reported aquatic fauna per river basin.

5) In the Iguaçu river basin, the Iguaçu Environmental Protection Area, important community of aquatic birds has been reported, including temporary resting populations of migratory birds.
Table-6.3 summarizes the reported bird species for these area.

6) Among the reported 10 migratory species, populations up to 600 individuals have been observed, also 6 rare species, and 2 endangered species, and 5 species known to depend on the lowland vegetation for shelter, nesting and food supply have been reported.

SIGNIFICANT AQUATIC HABITATS

Lowlands Along Watercourses

Alluvial floodplains adjacent to river courses have been subject to the Agricultural expansion, drainage, sand mining, and marginal human settlements in the urban periphery, originating social and sanitation problems.

1) Table-2.36 shows the most common plant species ideally found in this environments.

2) The high Iguaçu area has a significant potential for sand mining in its lowlands (varzeas), the abandoned mined areas are settled by low income people, or remain as pond holes. Main problems associated with these ponds are summarized under section 6.2.4

3) Section 6.2.4 discusses the Palmital river area as an urban occupation-problem model, Fig.6.1 and Fig.6.6 show the location and main areas of the Palmital river.

Marshes

Marshes and natural open fields subject to inundation are constituted by grasses, and in less extent by bushes and isolated trees. Typical vegetation of marshes and lagoons is shown in
Table-2.38 and Table-2.39.

1) In the proposed Irai reservoir area, the direct area of influence is composed of 4 botanical formations, among these, the natural open fields subject to inundation.

2) The highest percentage area to be inundated with the proposed Irai reservoir is dominated by natural fields subject to periodic inundation, this formation only occurs in the eastern part of Curitiba.

3) Section 6.2.4 summarizes the main ecological components of this area, and Fig.6.1 shows the approximate location of the area suggested for preservation. Section 7.2.6 summarizes the proposed program for the identification of the area to be preserved.

4) Tibagi river basin has 342,822 ha of lowlands, among these some 78.25% are considered with some restriction for agriculture by EMATER.

SOCIO-ECONOMIC ENVIRONMENT

Farming

In the 1930's the Northern Parana Land Company, of British capital acquired some 1 million hectares of land, which where subdivided into smaller parcels for further speculation. Each lot had a water source, lower lands and hilly areas.

1) Coffee crops where planted in the higher elevations, and grazing areas in the lower elevations.

2) Between the 1930's and 1960's the lower Tibagi region experienced the highest demographic density, and by the 1970's coffee crops declined because of frost's, intensive soil use, and low coffee prices.

3) From the 1970's onward the exodus of farmers to the metropolitan area became the origin of poverty belts.

4) Agricultural land moved from multiple culture and small-medium parcels to bigger monocultured areas eliminating forest remainders, and river margin vegetation, increasing erosion, water turbidity, and agrochemical pollution.

Fisheries

Fisheries of interest are located in the Parana river basin and Itaipu reservoir. The main species of commercial interest are restricted to 5 species, and generate an estimated 2,000 MT/year catch. Table-2.28 show the main species of fish with commercial interest in the Paranapanema river basin.

1) Fisheries in the Tibagi river are mainly sport fishing and artisanal fisheries composed of approximately 100 fishermen. Section 3.3 summarizes the main fishermen communities.

2) Table-6.11 show the reported fish species of commercial interest for the Tibagi river, from these, 50% are migratory, 27% are endangered, and only 15% are abundant. Section 6.3.2. discusses this issue.

3) No major hydroelectric project is yet installed in the Tibagi river, several projects are planned, as shown in section 6.3.5, Fig.6.5, and Fig.6.11 through Fig.6.17.

4) Major impacts expected from these projects are attributed to the fish populations with the damming of river sectors.

5) Section 7.4.1, 7.4.2, and 7.4.3 propose specific programs to evaluate the fish resource, and to establish the baseline data for restocking endangered species and commercial production of fish. Fig.6.3 shows the indicative location of areas to be studied.

Aquaculture

Aquaculture production is incipient, and represented by 14 aquaculture associations with 600-700 small individual producers, the majority of producers are located in the Parana, Piquiri and Iguaçu river basins.

1) Total estimated production area is 2,500 ha of ponds. Number of species being cultured is 8, and Table-3.2 summarizes the species and percentage area cultured by species. The estimated production for all species is found in Table-3.2

2) Aquaculture potential to be developed is foreseen as a possibility in the existing and planned hydroelectric reservoirs of Iguaçu and Tibagi river, section 7.2.3, section 7.2.4 and section 7.4.3 outline action programs in this direction.

Hydropower

1) Approximately 50% of the Iguaçu river stretch has been modified by hydroelectric projects, Table-6.6 summarizes the existing and planned hydroelectric projects in the Iguaçu river, and section 6.2.5 deals with he main environmental issues attributed to these projects.

2) The environmental impact study performed for Salto Caxias reflects a well structured and comprehensive study approach, including specific programs for the amelioration, prevention or rehabilitation of the impacts foreseen.

3) Hydroelectric projects proposed for the Tibagi river basin, and their major foreseen environmental impacts are considered under Section 6.3..5, Table-6.18 and Table-6.19 summarize the existing and planned hydroelectric projects in the basin, and Fig.6.11 shows the proposed location for the planned projects.

4) The projects proposed for Tibagi river basin are small scale, will inundate rather small areas, and most of the areas to be inundated are heavily altered by agricultural and anthropic activities, no mayor population is foreseen to be affected.

5) Apparently, significant forest resources are compromised in the Maua project, where some 57% of the 97.4 Km^2 to be inundated are covered with natural forest, see Fig.6.15

6) In the Sao Jeronimo project, further studies should evaluate the forest extension to be inundated, and the conflict that could arise with the indigenous population by the inundation of some 7 Km^2 of the reserve, see Fig.6.16

7) Representative area to be inundated and general condition of the adjacent environment for the Jataizinho, Santa Branca, Tibagi, Telemaco Borba, and Cebolao hydroelectric projects can be seen in Fig.6.5, and Fig.6.12 through Fig.6.14, and Fig.6.17

8) Basic knowledge of the limnology and fish population dynamics of fish in the Iguaçu river reservoirs and in the Tibagi river where projects are being planned are proposed under Sections 7.2.4, 7.4.1, and 7.4.2

Water Intake Locations

1) Reservoirs and water intake locations presenting detrimental environmental conditions according to SANEPAR limnological laboratory, are summarized under Section 6.2.5 for the Iguaçu river basin.

2) Main problems are attributed to organic pollution generating excessive microalgae growth and eventual oxygen depletion cycles.

3) Agrochemical runoff from fields located north of the Passauna reservoir, and effluent leaching from the abandoned Lamenha Pequena landfill, domestic sewerage disposal, industrial effluent from paper industry, and pig manure discharge are mentioned as problems being faced by the Passauna reservoir.

4) Water intake locations for the Tibagi river basin and main problems associated are summarized under Table-6.17, pollution problems are associated with domestic, industrial and agricultural effluent, and increased turbidity from erosion runoff.

5) Urban and industrial expansion tendency without adequate environmental studies towards the water supply areas in Arapongas, Ribeirao Jacutinga and Ibipora springs is a main concern for COPATI in the Tibagi river basin.

6) Biomonitoring of water intake locations through Daphnia magna and benthos are suggested under section 7.3.1 and section 7.5.1, the schematic concept of a biomonitor and the suggested integration of biomonitoring information are shown in Fig.7.6 and Fig.7.7

Landfills

1) The total estimated volume of solid waste per day generated in the Iguaçu river basin is estimated in 2,200 MT/day. The major urban centers, their estimated volume and disposal system is summarized in Table-6.7

2) Seven major urban centers generate 56% of the municipal solid waste in the Iguaçu basin, the remaining municipalities are estimated to generate some 970 MT (44%) of the total, the system used for disposal goes from open air disposal to municipal landfill.

3) Most of the municipalities have open air disposal except Curitiba with 1,000 MT/day, and 56% of the total solid waste volume of the basin is organic matter. Main problems related to landfills are discussed under section 6.2.5

4) The municipal solid waste of the Tibagi river basin is left in open dumps (30%), disposed of in sanitary landfills (65%) and 5% is recycled. Table-6.21, and section 6.3.5 summarize the municipal solid waste management system, population serviced, and respective municipality.

ASSESSMENT OF SIGNIFICATIVE ENVIRONMENTAL CONDITIONS

Flora

1) Disappearance of the river margin vegetation, and absence of monitoring and control methods to preserve the remaining of the resource.

2) Deforestation of 95% of the original forest cover of the state with the consequent soil and genetic material loss.

3) Anthropic pressure still existing on the remaining Araucaria forest estimated to be 2% of the original population.

4) 82% of the state river basins are considered under critical conditions respecting native forest coverage (0-10% basin area coverage)

Fauna

1) Agrochemical, industrial, and domestic sewerage effluent deteriorating aquatic environment and biota.

2) Hydroelectric and dam construction affecting fish population and insufficient knowledge on the fish population inventory and population dynamics to establish mitigating measures.

3) Loss of forest area originates the loss in terrestrial and bird biodiversity exemplified in the extensive list of endangered and rare species.

4) Mangrove destruction and estuary pollution by urban growth and improper sewerage and municipal solid waste disposal in Paranagua attempt against ecological balance of the estuary environment.

5) Depletion of lowlands subject to periodic inundation by agricultural expansion in Tibagi river basin and sand mining activities in the Iguaçu river basin have a direct effect on the aquatic biota including birds, and on the river energy flow and buffer zone areas.

6) Deterioration of the biotic index reported for benthic macroinvertebrates as a sign of aquatic environment deterioration in polluted areas such as in the Curitiba metropolitan area.

Conservation Units

1) Lack of adequate management plans or lack of implementation of the existing plans, fire risk, Inadequate infrastructure, the lack of it or deficient maintenance are some of the issues addressed.

2) Important areas to be preserved with endangered species of orchids, birds, and having recreational, cultural, botanical, landscape, and water preservation values are still unprotected, as is the case of the Serra da Baitaca and Corredeiras Engenheiro Bley in the Iguaçu river basin, see Fig.6.1, and section 6.2.4

MASTER PLAN FOR PILOT RIVER BASINS

The strategy implementation for the creation of a healthy water environment is oriented between conservation and monitoring programs, the set of these programs is the master plan, and the relationship between monitoring and preservation programs is shown in Fig.7.1

A summary of the proposed programs is as follows:

1) Iguaçu River Basin

   a) Program for the Inventory of Fish Populations :
   Mainly oriented in the areas of the Iguaçu Park and tributaries of the Iguaçu river, to complete the Iguaçu river fish inventory. See section 7.2.1 and Fig.7.2

   b) Program for the Assessment of the Fish Population Dynamics:
   Oriented to rare, endangered, migratory, and/or commercially important species, the purpose is to attain knowledge in the way these species eat, reproduce and about the habitat they occupy. See section 7.2.2

   c) Program for the Artificial Reproduction of Endemic Fish with Ecological and/or Economic Interest:
   For the massive production and repopulation and/or production of endangered or commercially viable species. These species will be selected from the previous programs, and will be reproduced in the commercial scale laboratory. See section 7.2.3

   d) Program for the Assessment of the Fish Fauna and Experimental Aquaculture in the Iguaçu River Hydroelectric Reservoirs:
   Oriented towards the inventory, population dynamics and limnology of the reservoirs, with the objective of conservation, mitigation, and eventually production of fish in the reservoirs. Basic studies will identify the adequate species for future fisheries and aquaculture development. See section 7.2.4 and Fig.6.8

e) Program for the Assessment of the Aquatic Environment through the use of Bioindicators:
Integrated monitoring approach using benthic organisms, zooplankton toxicity tests, and fish liver tissues to evaluate pollution effects, and correlate with chemical analysis is suggested to be implemented in water treatment plants and water intakes, as well as in industrially and agriculturally polluted areas to monitor water quality. See section 7.3.1, and Fig.7.3, Fig.7.6, and Fig.7.7

f) Program for the Upgrading of Management Plans for Existing Conservation Units:
To strengthen and improve the existing conservation areas, the program is geared towards ecotourism and conservation. See section 7.2.5, and Fig.6.10

g) Program for the Identification and Monitoring of the River Margin Vegetation and Lowlands Along Water Courses:
To define the existing area, and regularly monitor the resource degradation or improvement, See section 7.3.2

h) Program for the conservation of the Serra da Baitaca and the proposed Irai reservoir area:
Rare, endangered, and endemic species of plants and animals, genetic diversity typical and unique for the region, as well as scenic, recreational and landscape values, are some of the reasons to consider the preservation of this area. See Fig.6.1 and section 7.2.6

i) Program for the Geographic Definition and establishment of the Corredeiras Eng. Bley as a conservation unit:
Important scenic, touristic, and recreational values are being left without any conservation criteria in the planning process for this area. This river sector maybe the last one resembling the original Iguaçu river condition of rapids. See Fig.6.1, and section 7.2.7

j) Program for the Establishment of a Biodiversity Institute:
Resources available in the terrestrial vegetation, insects and other species not directly related with the aquatic environment could be a natural resource capital from which, significant developments in biotechnology and pharmaceutical can be developed generating income to support conservation and monitoring projects related to the water and terrestrial environment. See section 7.2.8

k) Program for the Control of Sandflies (Simulium sp) in the Iguaçu River Basin:
For the pest control and sanitary improvement of the population adjacent to the water environment, the sand fly Simulium sp inflicts bites, rashes and allergies to the adjacent populations, and it's considered a pest. See section 7.3.3 and Fig.7.4

l) Program for the Environmental Education of the Water Sources Development

The present program is oriented towards the integration of cultural, architectonic, historic, sanitation, and water environment values and components for the education and training of the population in the context and process of potable water source development.

2) Tibagi River Basin

a) Program for the Inventory of Fish Populations:
Seven hydroelectric projects are being sought for the Tibagi river between 2003 and 2010, fish population inventories are the first step to assess possible impacts on the resource. See Fig.6.3, Fig.6.11, and refer to section 7.4.1

b) Program for the Assessment of the Fish Population Dynamics:
The study of the fish population dynamics becomes highly desirable at the time when no dams, and no reservoirs have occurred yet in the river, this studies will give the baseline for future impact mitigation on the resource. Refer to section 7.4.2, and Fig.6.3

c) Program for the Artificial Reproduction of Endemic Fish with Ecological and/or Economic Interest:
The artificial reproduction of fish is a viable means of producing vast amounts of offspring for repopulation of endangered species, and/or economic fisheries purposes. Refer to section 7.4.3

d) Program for the Upgrading of Management Plans for Existing Conservation Units:
The present program is oriented towards the assessment of problems such as forest fires, excessive tourism, and solid waste disposal, which are reported to be common and require adequate solutions. refer to Section 7.4.4, and Fig.6.4

e) Program for the Assessment of the Aquatic Environment through the use of Bioindicators:
The use of bioindicators represents a fast and comprehensive method for the assessment of the aquatic ecosystem through monitoring of indicative river sectors subject to agricultural, municipal, and industrial pollution, and water intake locations. Refer to section 7.5.1, and Fig.7.5, Fig.7.6, and Fig.7.7

f) Program for the Identification and Monitoring of the River Margin Vegetation and Lowlands Along Water Courses:
Inventorying these environments before major hydroelectric project are installed will give the data base to identify extent and magnitude of environmental impacts upon these resource. Refer to section 7.5.2

g) Program for the Identification of the Periodically Inundated Lowlands Along the Butimirim River

The present program aims at the basic study to identify the botanical and the animal associations occurring in this habitat to provide the data base for the rehabilitation of degraded lowlands along the basin. Sections 6.2.1, 2.9.1, and 3.1.1 summarize the impacts, importance and historical reasons for the destruction of this habitat. Section 7.4.5 outlines the program to be implemented.

Summary of Program Objectives and Indicative Costs

The following table summarizes the area of influence of each one of the proposed projects:

Summary of Program Objectives and Indicative Costs

Program	Cost	Objectives			
	US$ x 1000	Conserve	Economic	Sanitation	Monitor
IGUAÇU RIVER BASIN					
Preservation Programs					
7.2.1	881	X			X
7.2.2	487	X	X		
7.2.3	493	X	X		
7.2.4	2'620	X	X		X
7.2.5	31	X	X		
7.2.6	585	X	X	X	
7.2.7	241	X	X		
7.2.8	Not Determined	X	X		X
Environmental Education Program					
7.2.9	860	X		X	
Monitoring Programs					
7.3.1	1'286	X		X	X
7.3.2	670	X		X	X
7.3.3	414			X	X
TIBAGI RIVER BASIN					
Preservation Programs					
7.4.1	664	X			X
7.4.2	487	X	X		
7.4.3	493	X	X		
7.4.4	51	X	X		
7.4.5	245	X			
Monitoring Programs					
7.5.1	1'096	X		X	X
7.5.2	670	X		X	X

NOTE: Notation of the programs is as follows:

1. Preservation Oriented Programs for Iguaçu River Basin
   - 7.2.1 Inventory of Fish Population
   - 7.2.2 Assessment of Fish population Dynamics
   - 7.2.3 Artificial Reproduction of Endemic Fish
   - 7.2.4 Assessment and Experimental Aquaculture in Reservoirs
   - 7.2.5 Upgrading Management Plans for Existing Conservation Units
   - 7.2.6 Establishment of Preservation Area in Serra da Baitaca
   - 7.2.7 Establishment of Preservation Area Corredeiras Eng. Bley
   - 7.2.8 Biodiversity Institute
   - 7.2.9 Environmental Education
2. Monitoring Programs for Iguaçu River Basin
   - 7.3.1 Monitoring of aquatic Environment through Bioindicators
   - 7.3.2 Monitoring of River Margin Vegetation Cover through Geographic Information System
   - 7.3.3 Monitoring and control of sandflies
3. Preservation Programs for Tibagi River Basin
   - 7.4.1 Inventory of Fish Population
   - 7.4.2 Assessment of Fish population Dynamics
   - 7.4.3 Artificial Reproduction of Endemic Fish
   - 7.4.4 Upgrading Management Plans for Existing Conservation Units
   - 7.4.5 Periodically inundated lowland (Varzea) study along the Bitumirim River
4. Monitoring Programs for Tibagi River Basin
   - 7.5.1 Monitoring of aquatic Environment through Bioindicators
   - 7.5.2 Monitoring of River Margin Vegetation Cover through Geographic Information System

Interrelationship between preservation and monitoring programs is summarized under Fig.7.1

7.7 Implementation Schedule

The following table summarizes the extent, frequency and implementation period for each program:

Implementation Schedule

Program Number	Extension in Years	Frequency	Implementation Period 1996 2000	2001 2005	2006 2010	2011 2015
7.2.1	4	2 years @ 3 months, 2 years lab. 14 years @ 5 years	X---------->			
7.2.2		2 years @ 3 months	X			
7.2.3	2	2 years research, then continuous		X---------->		
7.2.4	2	1 year @ month 2 years @ 3 months 15 years @ 5 years	X---------->			
7.2.5	0.6	CONTINUOUS	X---------->			
7.2.6	3	CONTINUOUS	X			
7.2.7	1	CONTINUOUS	X			
7.2.8	2	CONTINUOUS	X---------->			
7.2.9	3	CONTINUOUS	X---------->			
7.3.1	13	2 years @ 3 months	X			
		2 years @ 6 months	X			
		9 years @ year		X---------->		
7.3.2	13	0.8 years data base, then @ 5 years	X---------->			
7.3.3	1	1 year @ 2 months, then once a year	X---------->			
7.4.1	2	@ 3 months	X---------->			
7.4.2	2	@ 3 months	X			
7.4.3	2	2 years research, then continuous		X---------->		
7.4.4	0.6	CONTINUOUS	X---------->			
7.4.5	1	CONTINUOUS	X			
7.5.1	13	2 years @ 3 months	X			
		2 years @ 6 months	X			
		9 years @ year		X---------->		
7.5.2	0.8	0.8 years data base, then @ 5 years	X---------->			

NOTE: Notation of the programs is as follows:

1. Preservation Oriented Programs for Iguaçu River Basin
   - 7.2.1 Inventory of Fish Population
   - 7.2.2 Assessment of Fish population Dynamics
   - 7.2.3 Artificial Reproduction of Endemic Fish
   - 7.2.4 Assessment and Experimental Aquaculture in Reservoirs
   - 7.2.5 Upgrading Management Plans for Existing Conservation Units
   - 7.2.6 Establishment of Preservation Area in Serra da Baitaca
   - 7.2.7 Establishment of Preservation Area Corredeiras Eng. Bley
   - 7.2.8 Biodiversity Institute
   - 7.2.9 Environmental Education
2. Monitoring Programs for Iguaçu River Basin
   - 7.3.1 Monitoring of aquatic Environment through Bioindicators
   - 7.3.2 Monitoring of River Margin Vegetation Cover through Geographic Information System
   - 7.3.3 Monitoring and control of sandflies
3. Preservation Programs for Tibagi River Basin
   - 7.4.1 Inventory of Fish Population
   - 7.4.2 Assessment of Fish population Dynamics
   - 7.4.3 Artificial Reproduction of Endemic Fish
   - 7.4.4 Upgrading Management Plans for Existing Conservation Units
   - 7.4.5 Periodically Inundated Lowland (Varzea) Study Lowlands along the Bitumirim River
4. Monitoring Programs for Tibagi River Basin
   - 7.5.1 Monitoring of aquatic Environment through Bioindicators
   - 7.5.2 Monitoring of River Margin Vegetation Cover through Geographic Information System

CHAPTER 1 INTRODUCTION

The information contained in this Report was made possible mainly through the coordination of the IAP personnel of the limnological laboratory, and the Museum of Natural History of Parana State. The lack of data in this report owes to the lack of existing data in different organizations related, such as fish sampling in some of the basins, and detailed area coverage data for river margin vegetation. Some data such as aquatic bird populations by basin, and detailed fish specie list can be found in appendix 1 through Appendix 4 in this report.

Parana state has two main hydrographic complexes, delineated by the basin of the Ribeira river, and the basin of the Parana river. The Ribeira basin hydrographic complex has 14,674 Km^2 and drains in the Atlantic Ocean, and the Parana river has 186,312 Km^2, and is composed by rivers that flow inside the state and afterwards integrate the La Plata river basin.

The Iguaçu river basin has 69,373 Km^2 of drainage area, 80.4% of the area is located in the Parana state, 16.6% is located in the state of Santa Catarina, and 3% in the republic of Argentina. For descriptive purposes, the basin has been divided by DNAEE in 3 hydrographic areas, high, medium and lower Iguaçu.

The high Iguaçu area concentrates the highest urban and industrial population, generating the most critical conditions of the basin. The city of Curitiba, Uniao da Vitoria, Porto Uniao, Curitiba's industrial city.

The worst area in terms of water quality is the metropolitan region of Curitiba, this region shows the lowest indicators of water quality, and a decreasing tendency. These results are justified when this area is the most populated and industrialized of the state.

The best water quality indicator values (IQA) were found in the coastal basin, this basin is the most protected area of the state, with a high vegetation cover, and several preserved and environmentally regulated areas.

The state of Parana has unique scenic and landscape resources, mainly given its marked division between interior valleys, dividing rivers, waterfalls, and its coastal plain. It is considered that the interaction between the dynamics of the natural and social systems generates the landscape as we perceive it.

CHAPTER 2 BIOLOGICAL ENVIRONMENT

2.1 Terrestrial Flora

2.1.1 Iguaçu River Basin

The upper Iguaçu region presents a vegetation cover dominated by Araucaria sp. The vegetation is in advance state of devastation, given the agricultural and mining activity. The native flora is confined to reduced land extensions with accessibility problems or steep slopes. The existing associations of Podocarpus sp (Pinheirinho Bravo) with the Lauraceae family are very recent regeneration associations. See Fig.-2.1.

Twenty six families that include tree species have been reported with a total of 48 species reported for this area (21).

Open natural fields with grasses and coppices are typical of the area located northeast of the Curitiba Metropolitan Area and can also be found in the lower Iguaçu region between Serrinha and Porto Amazonas, adjacent to the Iguaçu river.

Fairly well preserved vegetation cover can still be found north of Colombo municipality, where important underground water resources are located.

The Iguaçu Park located in the lower Iguaçu basin is the biggest extension in the basinn with native forest cover. Table-2.19 shows the original vegetation cover of the state by 1890, and Table-2.20 shows the deforestation process of the state. A summary of the reported forest coverage per basin can be found in Table-2.41. Appendix 2 shows the list of reported endangered tree species.

The following table summarizes the tree species reported for the area :

Table-2.1 Tree Species Reported for Alto Iguaçu

Family	Species	Common Name
Araucariaceae	Araucaria angustifolia	Pinheiro
Podocarpaceae	Podocarpus lambertii	P. Bravo
Asteracea	Piptocarpha angustifolia	Vassourao
	P. rotundifolia	Cambara
Euphorbiacea	Sapium glandulatum	Leiteiro
Rutaceae	Bleaphorocalix salicifolius	Murta
	Fagara kelinii	Juveve
Rubiaceae	Guetarda uruguensis	Veludinho
	Psichotria sp	
Verbenaceae	Aegiphyla riedelina	Gaioleira
	Aegiphyla sp	Gaioleira
Bignoniaceae	Jacaranda sp	
	Tabebuia sp	Ipe-amarelo
Ulmaceae	Trema sp	
	Celtis triflora	
Ulmaceae	Trema sp	
Meliaceae	Cedrela fissilis	Cedro
Proteaceae	Roupala sp	Carvalho brasil
Rosaceae	Prunus sellowii	Pessegueiro
Lauraceae	Ocotea pretiosa	Canela sassafras
	Ocotea puberula	Canela guaiaca
	Ocotea pulchella	Canela lajeana
	Ocotea porosa	Imbuia
	Ocotea sp	Canela preta
	Nectandra megapotamica	
Sapindaceae	Salix humboldtiana	
Canalaceae	Capsicodendron dinisii	Pimenteira
Clethracea	Clethra scarba	Guarapere
Boraginaceae	Cordia trichotoma	Louro pardo
	Patagonula americana	Guajuvira
Anacardiaceae	Schinus terebentifolius	Aroeira
	Litraea brasiliensis	Bugueiro
Erythroxylaceae	Erythroxilum sp	Quina
Celastraceae	Maytenus ilicifolia	Espinheira
Aquifoliaceae	Ilex paraguiensis	Erva mate
	Ilex microdonta	Cauna
	Ilex sp	Cauna
Myrcinaceae	Rapanea umbellata	Capororocao
Mirtaceae	Eugenia involucrata	
	Eugenia uniflora	Pitanga
	Myrrinium loranhoides	
	Psidium sp	Araça
	Blepharocalix sp	Murta
	Britoa sp	Sete capotes
Leguminosae	Erythrina crista-galli	Corticeira
	Mimosa scabrela	Bracatinga
	Pletophorum dubium	Canafistula
Palmaceae	Syagrus romanzoffianum	Geriva

Source: SUREHMA, 1989 (21)

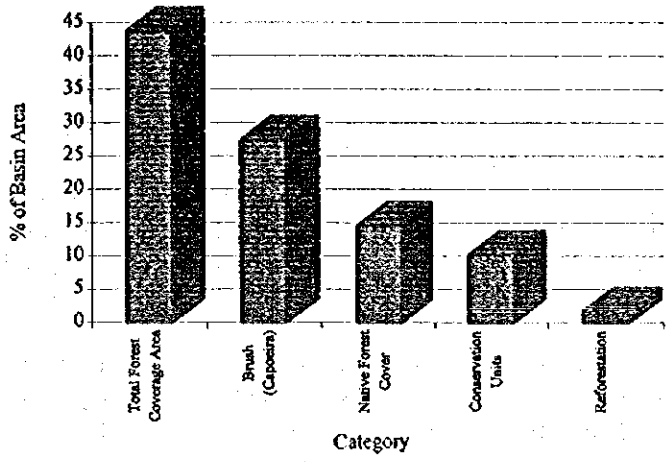


Figure-2.1 Reported Flora for Iguaçu River Basin
Source: IAP

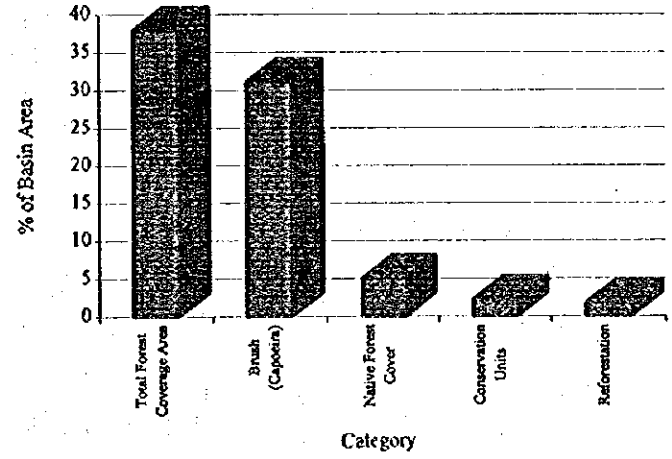


Figure-2.2 Reported Flora for Ivaí River Basin
Source: IAP

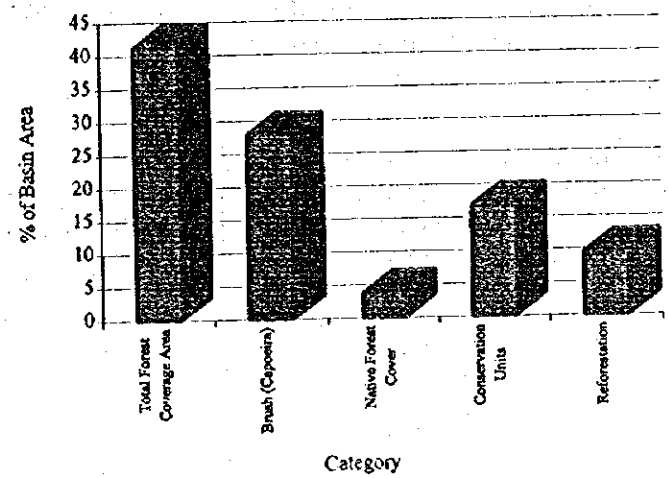


Figure-2.3 Reported Flora for Tibagi River Basin
Source: IAP

2.1.2 Ivai River Basin

According to information of the Instituto de Terras e Cartografias e Florestas (ITCF) of Paranavai, the municipality of Santa Cruz do Monte Castelo represented 4.02% of forest cover, Santa Isabel do Ivai 4.27%, Planaltina do Parana 3.33%, Querencia do Norte 3.18%, Amapora 3.12%, and Mirador 2.39% (20). See Fig.-2.2.

It is very probable that today this low forest coverage is still more reduced. At least 34 families that include tree species have been identified, along with 31 species of trees. The most abundant trees found in the area are the following:

Table-2.2 Most Abundant Tree Species in Lower Ivai

Family	Species	Common Name	% Abundance
Flacourtiaceae	Fagara sp	Guarita	6.01
Leguminosae	Gallesia gorarema	Pau de Oleo	6.01
Bignoniaceae	Tecoma chrysostricha		
	Piuna		31.18
		Vinhaco	8.91

Source : IAP, 1988 (20)

2.1.3 Tibagi River Basin

Most of the basin is absorbed by secondary vegetation, whether in the forest region or in the forests of Araucaria angustifolia, as well as in the subtropical pluvial forest in the northern area of the basin. According to COPATI (35), approximately 6,870 km^2 are occupied by secondary vegetation. See Fig-2.3.

In the left margin of the Tibagi river on the second plateau, dense forest of Araucaria still persist, when the river goes to the third plateau, we find the Subtropical Pluvial Forest of Parana-north, characterized by big size trees, rich in epiphytes, and in ancient times rich in palm trees (Arecaceae).

The arrangement of the flora in the region seems to follow the climatic regions, and it is estimated that less than 10% of the basin area still has an untouched native vegetative cover. Table-2.41 summarizes the vegetation type of coverage.

2.1.4 Piquiri River Basin

Given the intense human activity in the area, the original vegetation is very altered in it's floristic composition and in its limits, making it very difficult to reconstruct the originally existing vegetation (See Fig.-2.4). Very few studies deal with the subject. Species shown in Table-2.3 are considered typical of the area.

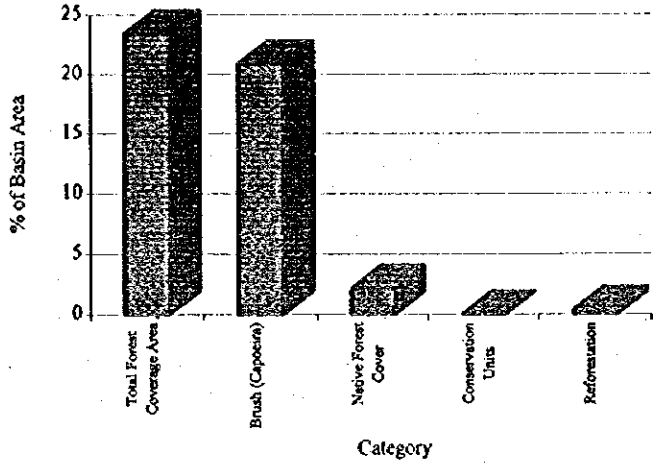


Figure-2.4 Reported Flora for Piquiri River Basin
Source: IAP

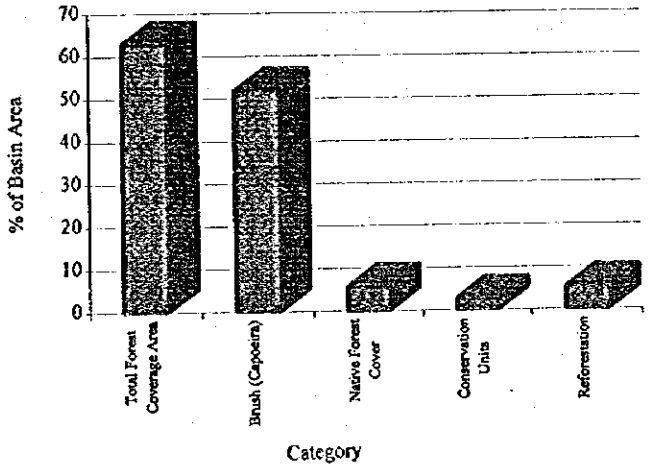


Figure-2.5 Reported Flora for Ribeira River Basin
Source: IAP

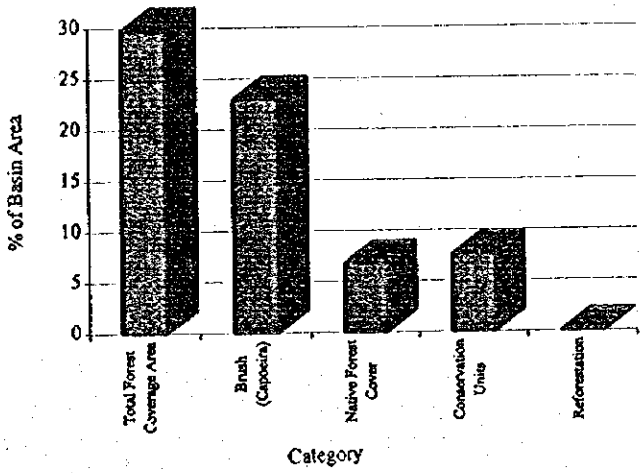


Figure-2.6 Reported Flora for Paraná River Basin
Source: IAP

Table-2.3 Typical Vegetation of the Piquiri River Basin

Scientific Name	Common Name
Euterpe edulis	Palmito
Gallezia garazema	Pau d'anta
Arrecastrum romanzoffianum	Jeriva
Acrocomia sclerocarpa	Macauba
Aspidosperma polyneuron	Peroba
Aspidosperma ramiflorum	Guatambu
Cedrella fissilis	Cedro vermelho
Cedrela sp	Cedro rosa
Ocotea sp	
Nectandra sp	
Cordia sp	
Terminalia australis	Amarelinho
Holocalux glaziovii	Alecrim
Machaerium sp	Jacaranda
Balfourodendron riedelianum	Pau-Marfim
Gallezia gorazema	Pau d'anta
Manilkara sp	Maçarandubas
Lucuma procera	Macaanduba
Araucaria sp	Pinheiro
Nectandra sp	
Ilex paraguaiensis	Erva mate
Dalbergia nigra	Jacaranda
Dikinsonia sellowiana	Xaxim-bugio
Cyatea schanschin	Samambaia-açu
Ocotea pretiosa	Sassafras
Mchaaerium sp	Caviuna
Podocarpus lambertii	Pinheiro bravo
Solanum verbascifolium	Fumo-bravo
Croton sp	Tapexingui

Source: IAP, 1988 (20)

2.1.5 Ribeira River Basin

The forest cover in this basin is very small and poor. The tropical forest covers some 2,500 Km^2, and some 500 Km^2 are colonized by conifers. (23). See Fig.-2.5.

2.1.6 Parana River Basin

The original vegetation is highly altered, even to the point where the reconstruction of it is very difficult. (22). See Fig.-2.6.

2.1.7 Coastal Basin

Part of the basin flat areas is covered with forests of different categories (See Fig.-2.7). The basin is bordered by the Serra do Mar, which receives the oceanic winds and the polar fronts, favoring a generous rainfall which in turns favors the development of the Atlantic rainy forest ecosystem. This forest cover has a maximum of 25-30 m height, the species diversity is high; the bush strata is dense, and the grass strata is rare. The most frequent tree species found shown on Table-2.4:

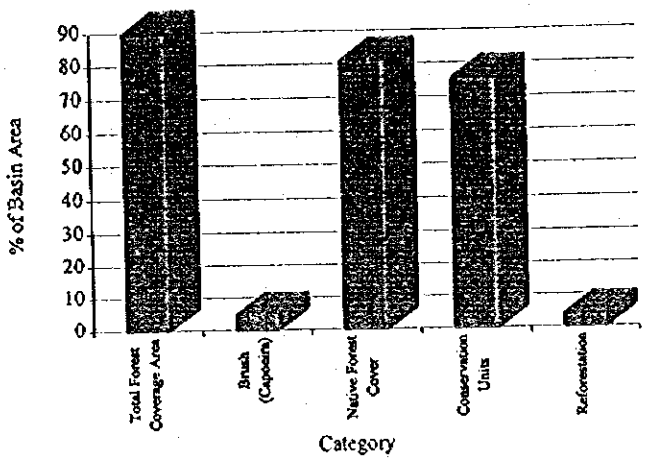


Figure-2.7 Reported Flora for Coastal Basin
Source: IAP

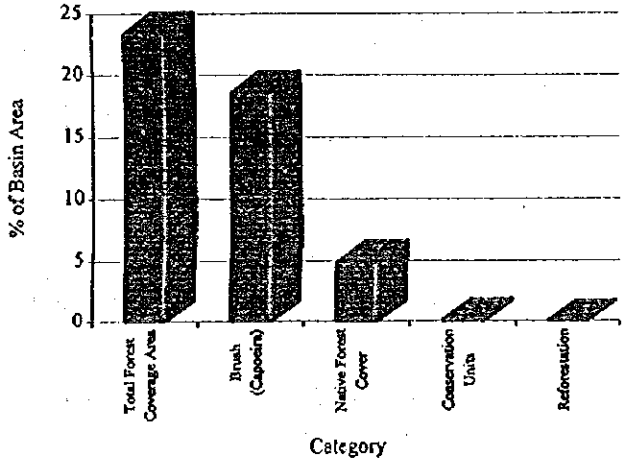


Figure-2.8 Reported Flora for Paranapanema River Basin
Source: IAP

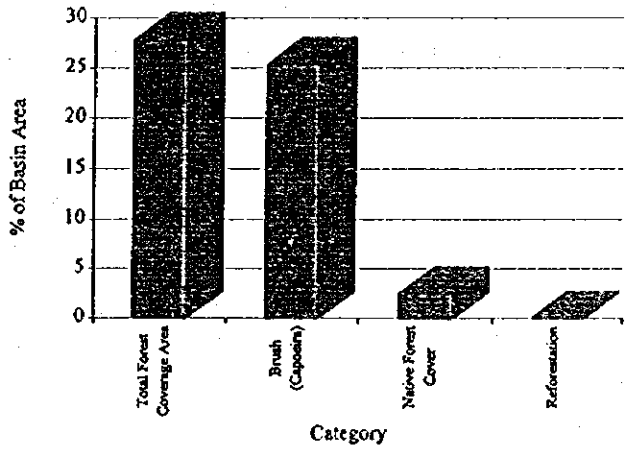


Figure-2.9 Reported Flora for Pirapó River Basin
Source: IAP

No data available for Conservation Units

Table-2.4 Most Frequent Species of Trees Found in the Coastal Basin

Scientific Name	Common Name
Calophyllum brasiliensis	Guanandi
Bombax sp	Embirucu
Schyzolobium parahyba	Guapiruvu
Tibouchina sp	Jacatirão
Marliera sp	Guaporanga
Aspidosperma sp	Peroba
Gallesia gorarema	Pau d'alho
Cedrela fissilis	Cedro

Source: Multiservice (14)

The superior strata is dominated by Ficus sp and Schyzolobium parabyba (Guapiruvu), in the river margins Cecropia sp (Embauba) is dominant. Palm trees are dominant in the ridges, major species are shown in Table-2.5.

Table-2.5 Major Species of Palm Trees Found in the Coastal Basin

Scientific Name	Common Name
Euterpe edulis	Palmito
Arecastrum sp	Geriva
Orbignia sp	Indaia

Source: Multiservice (14)

Epiphytes are abundant and common, in general, the Atlantic rainy forest is well preserved, except for minor patches that have been cleared for subsistence agriculture of bananas, sugar cane, beans, corn and papaya.

The difficult accessibility and the uncontrolled land tenure registration favored the preservation of the vegetation cover in this area.

2.1.8 Paranapanema River Basin

The original forest coverage is actually very much restricted to a few spots which are also very altered due to the extraction of commercial wood. During colonial times, this was one of the first areas to be deforested. (24). See Fig.-2.8.

Small patches of remaining forest have the following typical tree species:

Table-2.6 Typical Tree Species Found in Paranapanema River Basin

Scientific Name	Common Name
Sthryphnodendron barbatiman	Barba-timao
Piptadenia sp	Angico do campo
Aspidosperma tomentosa	Peroba do campo
Diplothenium campestre	Palmeira
Arecastrum romanzoffianum	Jeriva
Ocotea sp	Canelas
Ilex paraguaiensis	Erva mate
Cedrela sp	Cedro
Euterpe edulis	Palmito
Nectandra sp	Canelas
Pleptophorum sp	Canafistula

Source: SUREHMA, 1989 (24)

As for the vegetation adjacent to river margins, the predominant family is Leguminoseae, the vegetation is very much restricted to a few small areas, and these areas are found in a high degree of alteration due to the extraction of commercial wood.

2.1.9 Pirapo River Basin

Only 2.49 % of the basin area is estimated to be covered by native forest cover, along with 25.29% of the basin area covered by brush. No reforestation projects are reported for this basin. See Fig.-2.9.

2.1.10 Cinzas River Basin

In the southern part of the Cinzas basin there are reforestation areas next to isolated patches of native forest which has been highly altered by anthropic action. (24)

In general the native vegetation is highly altered given the wood extraction and agricultural development, isolated and altered patches are the only recipient of the original flora of the area (24). See Fig.2.10.

2.1.11 Itarare River Basin

Only 1.26 % of the basin area is estimated to covered by native forest, along with 20.03 % of the basin area by brush. It is estimated that 21.69 % of the basin area is under reforestation projects. See Fig.-2.11.

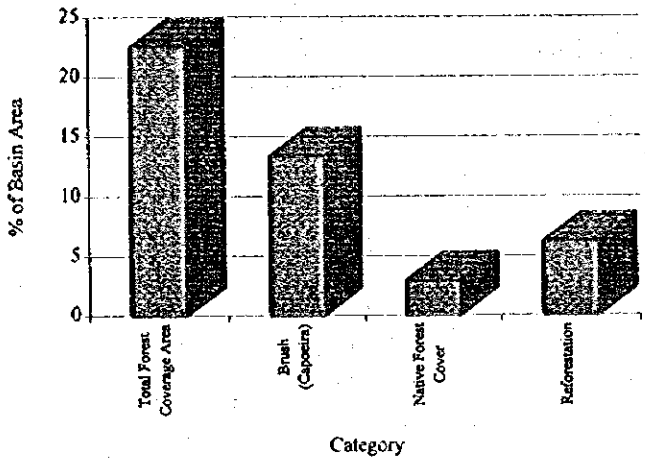


Figure-2.10 Reported Flora for Cinzas River Basin
Source: IAP

No data available for Conservation Units

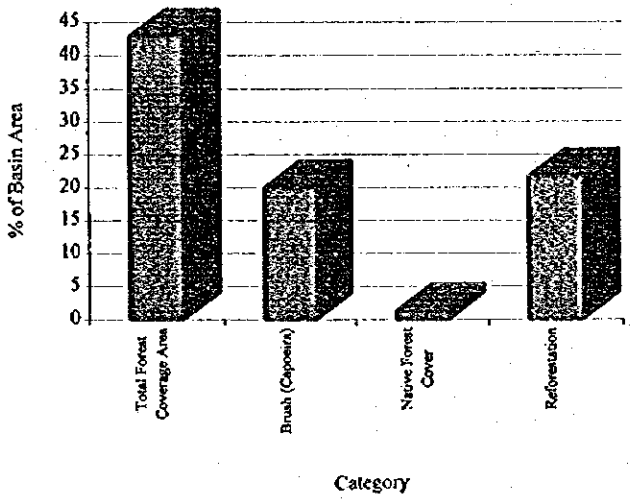


Figure-2.11 Reported Flora for Itararé River Basin
Source: IAP

No data available for Conservation Units

2.1.12 Urban Flora

The available data and project planning on urban flora is mostly related to the metropolitan area of Curitiba. The metropolitan area comprises 14 municipalities, and 8,454 Km^2, accounting for 4.5% of the total area of the state, and allocating approximately 1'968,880 inhabitants, out of which, roughly 2/3 are found in the municipality of Curitiba.

The predominant forest cover by 1980 was shrub (capoeira) coverage, representing 19.84% of the area, the native forest covered 18.3% of the area, and the Araucaria angustifolia forest covered 1.89% of the area.

The deforestation process reached almost 1/5 of the original forested area by 1980-1984. The deforestation process was mainly for fire wood procurement (97% of the volume)

The metropolitan area has a considerable number of water courses, and PROSAM has estimated that close to 60% of the regional space is considered as water producing areas for public supply of the metropolitan area, restricting settlement policies and land use criteria, for this reason, recuperation of forestry degraded areas in the metropolitan area have a significant importance. (25)

2.2 Aquatic Flora

Very little research and documentation is available for the aquatic plant population of the state. No major infestation problems are reported for Eichornia sp (water hyacinth) in the existing reservoirs, although a minor population was reported before the construction of the Itaipu project, further research revealed the extent of the Eichornia population was not significant, and so far the proliferation of this plant is not a problem.

IAP has identified problems occurring with Elodea sp, a submerged macrophyte anchored in the bottom and extending throughout the water column. This plant is found in the Passaúna reservoir, and in low flow periods, when the level of the reservoir resides, the exposed Elodea sp decomposes and eventually sinks, causing an influx of decomposing organic matter which has a detrimental effect in the water quality and fauna of the reservoir. Massive fish kills have been reported by IAP in 1983, after such condition of decomposition was observed.

A preliminary catalog of aquatic plant species, with 22 families, 28 genera, and 32 species has collected the available information from the Municipal Botanical Museum, and the Botanical Department of the Federal University of Parana. The following table summarizes the reported species of aquatic plants in the state.(26)

Table-2.7 Summary of Reported Aquatic Plants in Parana State

Scientific Name Family/Specie	Common Name
Alismataceae	
Echinodorus grandifolius	Chapeu-de-couro
Echinodorus paniculatus	
Araceae	
Pistia stratiotes	Erva de Santa Luzia
Campanulaceae	
Lobelia nummularioides	
Cruciferae	
Nasturtium officinale	Agrião
Bidens laevis	
Cyperaceae	
Cyperus giganteus	
Elocharis maculosa	
Scirpus californicus	
Eriocaulaceae	
Syngonanthus caulescens	Sempre-viva
S.caulescens(angustifolium)	Sempre viva
Gramineae	
Luziola peruviana	
Paspalum rapens	
Halorrhagaceae	
Myriophylum brasiliense	Pinheiro d'agua
Hydrocharitaceae	
Anacharis densa	
Otelia brasiliensis	
Lemnaceae	
Spirodela intermedia	
Wolffia papulifera	
Lentibulariaceae	
Uricalara foliosa	Violeta do brejo
Urticularia obtusa	Violeta do brejo
Menyanthaceae	
Nymphoides indica	
Nymphaeceae	
Nymphaea rudgeana	
Onagraceae	
Ludwigia uruguayensis	
Orchidaceae	
Cyrtopodium palodiscolum	
Polygonaceae	
Polygonum ferrugineum	Lambedor
Polygoneum stelligerum	
Pontederiaceae	
Eichornia azurea	
Eichornia crassipes	Jacinto d'agua
Pontedeira lanceolata	Rainha dos lagos
Potamogetonaceae	
Potamogeton polygonus	
Scheuchzeriaceae	
Triglochin striata	
Scrophulariaceae	
Bacopa monnierii	Hisopo d'agua
Umbeliferae	
Hydrocotyle ranunculoides	

Source: IAP, 1983 (26)

2.3 Endangered flora

The IAP and the German GTZ cooperation program are ready to publish the list of endangered species of the state of Parana by the end of 1994. The list comprehends the most critical situations, where the category falls into the red list of the IUCN: extinct, rare, endangered or vulnerable. Appendix 2 gives a list of the reported trees included in the red list for Parana state.

The botanical species include a total of 605 species, restricted to gymnosperms and angiosperms, grouped into families with an indication of botanical formation in which they occur. The high number of botanical species in the red list is a reflection of the actual diminution of the natural forest to only approximately 5% of the original covering as of today.

2.4 Natural Forest Areas and Status

2.4.1 Iguaçu River Basin

Table-2.8 Iguaçu River Basin Existing Conservation Units

Name	Locality	Basin	Area (ha)	Management Category
Metropolitana	Piraquara	Iguaçu	455.3	State Forest
Santana	Paulo Frontim	Iguaçu	60.50	ND
Independencia	Pato Branco	Iguaçu	84	Refuge
Pinhão	Pinhão	Iguaçu	196.8	Refuge
	Cel. Vivida	Iguaçu	9,000	Forest Reserve
Palmas	Palmas	Iguaçu	180.12	Ecological Situation
Serra Esperança	U. da Vitoria	Iguaçu	197,750	APA
Passa Dois	Lapa	Iguaçu	255	State Forest
Serra do Tigre	Mallet	Iguaçu	33	Refuge
Monge	Lapa	Iguaçu	362.17	State Park
Iguaçu	Foz do Iguaçu	Iguaçu	185,000	National Park
Açungui	Campo Largo	Iguaçu	4,300	National Forest
PN do Iguaçu	Foz do Iguaçu	Iguaçu	170,000	National Park (PN)
Total Area		Iguaçu	564,676	

Source: Francisco Gubert, Agronomic Engineer, IAP.

2.4.2 Ivai River Basin

Table-2.9 Ivai River Basin Existing Conservation Units

Name	Locality	Basin	Area (ha)	Management Category
Flora	Candido de Abreu	Ivai	48.68	ND
Amapora	Amapora	Ivai	204.57	Refuge
Vila Rica do Espirito Santo	Fenix	Ivai	353.86	State Park
Sao Domingos	Roncador	Ivai	100	State Forest
Secoes Figueira e Saltinho	Eng. Beltrão	Ivai	10	ND
APA do Rio Ivai			80,000	
TOTAL AREA			80,881	

Source: Francisco Gubert, Agronomic Engineer, IAP.

2.4.3 Tibagi River Basin

According to the National Forestry Inventory (IBDF-1984) for the Tibagi river basin, by 1980, only the south western corner of the Tibagi river basin known as the Colonia do Irati homogeneous microregion had a forest cover of 23.03% of the total area estimated in 765,500 ha, this is 176,314 ha of forest cover. This forest cover is an area with a good forest cover situation, as recommended by international organisms.

The following is a summary of the classification used by IBDF to describe homogeneous microregions:

Table-2.10 IBDF Criteria to Describe Forest Condition

Homogeneous Type	Microregion	Percentage (%) of Basin Area Coverage	Condition of Forest
HMR-1		0-10	Critical
HMR-2		10-15	Dangerous
HMR-3		15-20	Acceptable
HMR-4		>20%	Good

Source: IBDF, 1984

Homogeneous Micro Regions (HMR) located in the northern part of the state where by 1980 already in a critical situation, with a 0.44-6.44% of forest in their total area.

Homogeneous Micro Regions (HMR) located in Campos do Ponta Grossa has a significant forest coverage area induced by commercial forestry planting by Klabin paper industry, this area is approximately 200,000 ha, consisting of introduced species such as Eucalyptus and Pinus sp. in approximately 130,000 ha, and some 70,000 ha of native forest under forestry reserve conditions.

Table-2.11 Tibagi River Basin Existing Conservation Units

Name	Area (ha)	Municipality Name	Forest Type	Fauna Type	Uses
Caxambu (SP)	1,054	Castro	2.1-2.1 3.1	1	PR/RC CL/CF EC.
Vila Velha (SP)	3,425	P. Grossa	1.1	1	PR//RC CL/CF
Geraldo Russi (FR)	131	Tibagi	-	3	PR/RC
Saltinho (FR)	9	Tel. Borba	2.1-2.2	3	PR/RC CF
Ibipora (FR)	74	Ibipora	21.-2.2		PR/RC CF/EC
Corrego da Biquinha	25	Tibagi	2.2		PR/RC CF
Irati (NF)	3,495	Irati	-	-	-
Mata Godoy	675	Londrina	1.2	-	PR/RC
Caxambu	1,040	Castro			Forest Park
Penhasco Verde	302	São Jeronimo da Serra			State Park
Guartela	4,390	Tibagi			CL
Escarpa Devoniana	400,000	Tibagi			CL
Córrego Maria Flora	48,7	C. Abreu	-		SP
São Domingos	164	Roncador			SP
Cerrado	393	Jaguariaiva	-		SP
County Conservation Units	441				
Total Area	415,666				

Source: Agraria Engenharia Consultoria, 1989, & Gubert, 1994 & COPATI (35)

SP=State Park, NF=National Forest, FR=Forest Reserve, PR=Preservation, RC=Recreation, CL=Cultural, CF=Scientific, EC=Economic.
Fauna: 1)Diverse/abundant, 2)Some diversity/abundance, 3) Little diversity/abundance.
Forest Type: 1. Primary forest, 1.1 Pristine, 1.2 Little alteration, 1.3 Medium alteration, 1.4 Highly altered,
2. Secondary forest, 2.1 Original, 2.2 Pioneering, 3.Others
3.1 Wetland, 3.2 Marsh, 3.3 Mangrove.

2.4.4 Piquiri River Basin

Table-2.12 Piquiri River Basin Existing Conservation Units

Name	Locality	Basin Area	(ha)	Management Category (ha)
São Camilo	Palotina	Piquiri	385	Ecological Station

Source: Francisco Gubert, Agronomic Engineer, IAP

2.4.5 Ribeira River Basin

Table-2.13 Ribeira River Basin Existing Conservation Units

Name	Locality	Basin Area	(ha)	Management Category (ha)
Lauraceas	Adrianopolis	Ribeira	23,863	State Park
Campinhos	Bocaiuva Sul	Ribeira	208.11	State Park
Total Area			24,071	

Source: Francisco Gubert, Agronomic Engineer, IAP.

2.4.6 Parana River Basin

Table-2.14 Parana River Basin Existing Conservation Units

Name	Locality	Basin Area	(ha)	Management Category (ha)
Cabeça do Cachorro	Toledo	Parana	61	Wild life refuge
APA Ilha Grande	Vilha Alta	Parana 2	100,00	APA
Total Area			100,061	

Source: Francisco Gubert, Agronomic Engineer, IAP

2.4.7 Coastal Basin

The coastal basin is one of the better preserved areas in terms of its forest cover. This condition has been possible in the beginning because of the difficulty in accessing the area for natural resource exploitation, joined by the legal ownership system, which was not well defined for the registered properties in the area, and thus several "legal" owners owned a same piece of land.

After 1970, the legislation oriented towards the preservation of the natural resources implemented various protected, and of restricted use areas, avoiding the colonization of the area by predator entrepenours willing to exploit the resources.

Mangrove areas are present in the basin, and are discussed further. The preservation of the mangrove-terrestrial vegetation transition zone (restinga) has been also possible, given the inaccessibility to these areas in some parts of the coastal belt, other parts of this transition vegetation suffers the unplanned colonization and housing development, endangering the existence of this vegetation type.

The biggest area for this ecosystem is located in sloped areas, and between 500 and 1,200 m, the characteristic species for this and subsequent elevations is shown below:

Table-2.15 Typical Tree Species According to Elevation in the Coastal Basin

Elevation (m.a.s.l)	Characteristic Species	Common Name
500-1,200	Ocotea sp	Canelas
	Copaifera sp	Oleo
	Pterocarpus sp	Pau Sangue
1,200-1,400	Crinys sp	Catalia
Mata Nebular	Ilex sp	Cauna
	Weinmania sp	Gramimuha
> 1,400	Graminea associations	Grasses

Source: Multiservice (14)

Along the plains, where topographic conditions are favorable, the forest is very altered, and in many cases occupied by pasture lands and subsistence agriculture.

Table-2.16 Coastal Basin Existing Conservation Units

Name	Locality	Basin Area	(ha)	Management Category
Rio da Onça	Matinhos	Litoral	118.5	Forest Park, Wildlife Refuge
Ilha do Mel	Paranagua	Litoranea	2,240	Ecological Station
Agudo da Cutia	Antonina	Litoranea	1,009	State Park
Serra da Graciosa	Morretes	Litoranea	1,190	State Park
Pico do Marumbi	Morretes	Litoranea	2,342	State Park
Superagui	Guaraqueçaba	Litoranea	214,400	Environment Protection Area (APA)
Guaraqueçaba	Guaraqueçaba	Litoranea	13,638	Ecological Station
Ilhas do Pinheiro & Pineirinho	Guaraqueçaba	Litoranea	109	Area of Ecological Interest
APA Guaratuba	Guaratuba	Litoranea	200,000	Environm. Prot.Area
Total Area			435,046	

Source: Francisco Gubert, Agronomic Engineer, IAP.

2.4.8 Paranapanema River Basin

Table-2.17 Paranapanema River Basin Existing Conservation Units

Name	Locality	Basin Area	(ha)	Management Category
Jacarezinho	Jacarezinho	Paranapanema	96.27	Wild Life Refuge
Ibicatu	Centenario do Sul	Paranapanema	57.01	Wild Life Refuge
Diamante do Norte	Diamante do Norte	Paranapanema	1,427	Caiua Ecological Station
Total Area			1,580	

Source: Francisco Gubert, Agronomic Engineer, IAP

2.4.9 Pirapo River Basin

Table-2.18 Pirapo River Basin Existing Conservation Units

Name	Locality	Basin Area	(ha)	Management Category
Mandaguari	Mandaguari	Pirapo	21.53	ND

Source: Francisco Gubert, Agronomic Engineer, IAP

2.4.10 Cinzas River Basin

No conservation units are reported for this basin by IAP.

2.4.11 Itarare River Basin

No conservation units are reported for this basin by IAP.

2.4.12 Summary of the Flora

Before 1940, Parana state had 83% of its native forest coverage, out of which 43% where Araucaria forests. By 1940 this percentage decreased to 57%, and today there is only 5% left of the original forest coverage. The eastern side of the Serra do Mar reflect the influence of the Atlantic Ocean climate, with its warm Brazilian current, and favoring a tropical-sub-tropical vegetation peculiar to the coastal area. The areas to the west of the state are influenced by totally different vegetation forms.

The original forest cover composition of the State in 1890 is estimated by Maack, 1968 (7) and shown under Table-2.19 anf Fig.-2.12.

Table-2.19 Original Forest Cover Composition of Parana State in 1890

Formation Type	Coverage Area in Km^2	% of State Area
Rainy Forest	94,044	46.74
Araucaria Forest	73,780	36.66
Denuded Fields	30,534	15.17
Other Formations	2,847	1.41
Total	201,203	100

Source: Maack, 1968 (7)

The following data in Table-2.20 and Fig.-2.3 show the deforestation process, actual stage, and estimated future situation if actual tendencies continue.

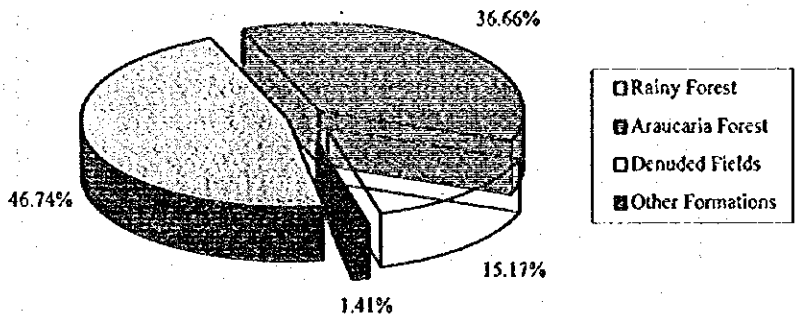


Figure-2.12 Original Forest Cover Composition of Paraná State in 1890
Source: Maack, 1968 (7)

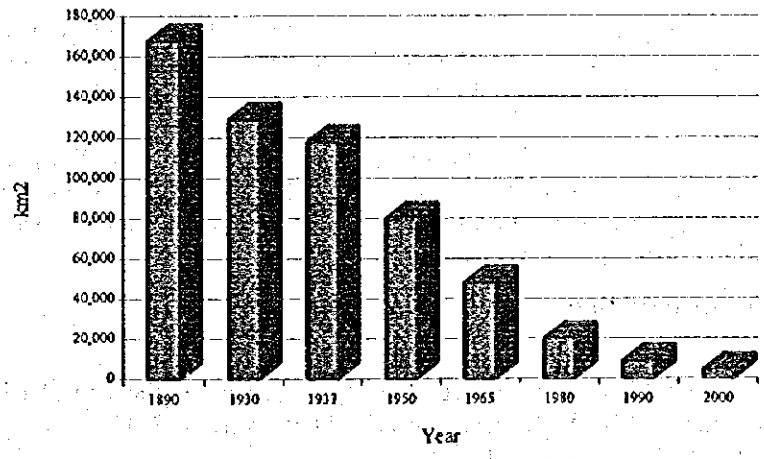


Figure-2.13 Deforestation Process in Paraná State
Source: F. Goubert, IAP 1994

Table-2.20 Deforestation Process in Parana State

Year	Forest Coverage in Km^2	Deforested Area in Km^2	Coverage in (%)	Reference
1890	167,824		83.41	Maack 1968
1930	129,024	38,800	64.12	Maack 1968
1937	118,002	49,801	28.65	Maack 1968
1950	79,834	87,990	39.67	Maack 1968
1965	48,136	119,668	23.92	Maack 1968
1980	19,971	147,853	11.90	IBDF
1990	8,726	159,098	5.20	Gubert, F.A.
2000	4,195	163,629	2.50	Gubert, F.A.

Source: F. Gubert, IAP.

Araucaria angustifolia (Pinheiro) is one of the most significant species of trees in the state, it is considered the state symbol, and is actually subject to extreme anthropic pressure for the supply of wood and seedlings for human consumption. by 1990 IAP estimated that only 150,000 ha of Araucaria forest still persist, this is approximately 2% of the original coverage area for this species.

A summary of the reported forest coverage in the state is given in Table-2-41, as estimated by the Geographic Information System department of IAP.

2.5 Proposed Conservation Units

2.5.1 Pinheiro Park

The IAP has proposed a State System of Conservation Units for Araucaria angustifolia. During the 1950's, the state of Parana had appointed 50,000 ha of idle lands for the creation of an Araucaria reserve, but the area was not delineated and it ended up being entitled to private owners for other uses. By 1960 the Pinheiro inventory survey recommended the establishment of a minimum of 1,000 ha of Araucaria forest as a reserve and state park to ensure the supply of seedlings and allow for further studies.

By 1990 only 2% of the original cover area was left in the state (150,000 ha). Today, the IAP forestry departments in Ponta Grossa, Irati, Uniao da Vitoria, Guarapuava and Pato Branco are proposing the above mentioned protection system.

The strategy of the proposal is to enable the protection of isolated patches of Araucaria in areas of 150-500 ha/each, and in representative regions where ecological stations are established, and to preserve endemic or in danger of extinction species like the associated species such as Ocotea porosa, Ocotea odorifera, Ocotea pretiosa, and Nectandra sp.

2.5.2 Metropolitan Conservation Areas

The Forestry Management Plan for the Integrated Development of the Curitiba Metropolitan Area, and being overtaken by PROSAM, has the following objectives:(23)
a) To guarantee the subsistence of natural forest coverage remains.
b) To induce recuperation of environmentally degraded areas.
c) To promote the socio-economic development of forestry activities, in accord with other productive activities

The project intends to protect aquifer areas, establish parks on the flood prone areas to avoid human settlements, and improve the urban quality of life creating recreational areas at the same time.

The recuperation of the riverain vegetation of the Belem river in the Municipality of Curitiba intends to reforest and improve the landscape potential of this area. The river has approximately 21 Km, and the most relevant problems are related to the sewerage effluent, industrial effluent, land occupation, and the consequent degradation of the vegetation.(27)

2.6 Terrestrial Fauna

The terrestrial fauna still existing is heavily dependent on the remaining forest vegetation of the state. Parana state has more than 160 species of mammals reported, and represented by 32 families.

The basin where the terrestrial fauna is better preserved, is the basin where the vegetation cover is also better preserved, this is the Coastal basin, where according to Multiservice (14), the following are some of the orders found:

Table-2.21 Terrestrial Fauna Reported for the Coastal River Basin

Order	Family	Common Name	Number of Species
Marsupialia	Didelphidae	Cuicas	12
Chiroptera	Molosidae	Morcegos	5
	Vespertilionidae		5
	Phyllostomidae		14
	Noctilionidae		1
	Desmodidae		3
Primates	Cebidae	Macacos	4
Edentata	Myrmecophagidae	Tamandua	1
	Bradipodidae	Preguica	1
	Dasypodidae	Tatu	4
Lagomorpha	Leporidae	Tapeti	1
Rodentia	Cricetidae	Rato	12
	Erethizontidae	Ourico	2
	Dasyproctidae	Cutia	2
	Agoutidae	Paca	1
	Caviidae	Prea	3
	Hydrochoeridae	Capivara	1
	Echymidae	Rato	1
	Capromidae	Ratao	1
Carnivora	Canidae	Cachorro	3
	Procyonidae	Quati	2
	Mustelidae	Furao	2
	Procinidae	Irara	1
	Felidae	Gato	7
Perissodactilya	Tapiridae	Tapir	1
Artiopdactyla	Tayasuidae	Porco	4

Source: Multiservice (14)

2.6.1 Endangered Species

The red list showing endangered, extinct, rare endangered or vulnerable species is being prepared for publication, and shows the following number of species present in the list:

Table-2.22 Summary of Species in the Red List for Parana State

Taxa	Number of Species in Red List
Mammals	21
Reptiles	12
Birds	117
Butterflies	17

Source: IAP

The most significant aquatic related mammal endangered so far is Lutra platensis (Lontra), which is found in the Coastal basin rivers among other basin rivers, and is considered an enemy by chicken and duck growers, as well as by the fishermen, and its skin is highly valued by hunters. A detailed list of endangered species is provided in Appendix 3.

The mos significant group affected by anthropic impacts on the environment are the birds. See Fig.-2.14.

2.6.2 Urban Fauna

The Curitiba Municipality project to populate the urban green areas with fauna species (Projeto Cutia/Serelepe) (28) is considering the following species for repopulation:

Table-2.23 Animal Species Considered for Repopulation of Urban Parks

Scientific Name	Common Name
Dasyprocta azarae	Cutia
Sciurus aestuans	Serelepe
Cairina moschata	Pato-do-mato
Amazonetta brasiliensis	Marreca-ananai
Dendrocygna bicolor	Marreca caneleira
Dendrocygna viduata	Marreca-irere

Source (28)

The project intends to populate the existing water areas with native duck species and the parks with small mammals to stimulate the appreciation of the regional fauna by the urban population, as well as to develop a conservationist concern, and provide educational and recreational opportunities.

A summary of the reported terrestrial fauna by river basin is can be found in Table-2.42.

2.6.3 Conservation Projects

(1) Fauna da Lapa Project, Passa Dois state forest area. The objective is to reproduce native fauna for re-introduction of species in the forest. presently reproducing Hydrochaeries hidrochaeris (capivara). Continuous monitoring of populations is being done.

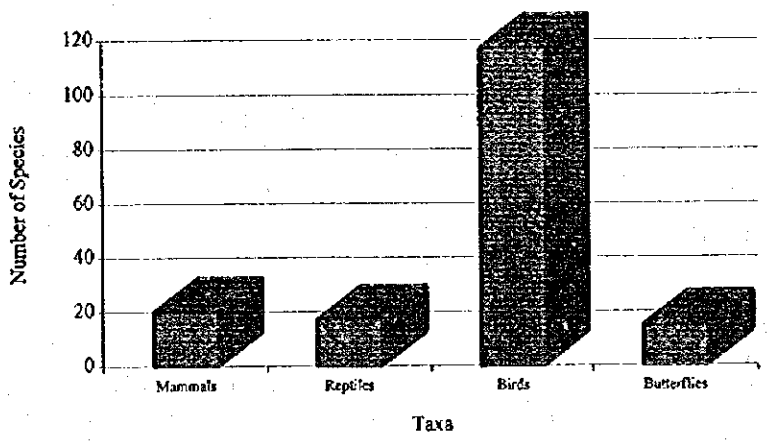


Figure-2.14 Species in the Red List for Paraná State
Source: IAP

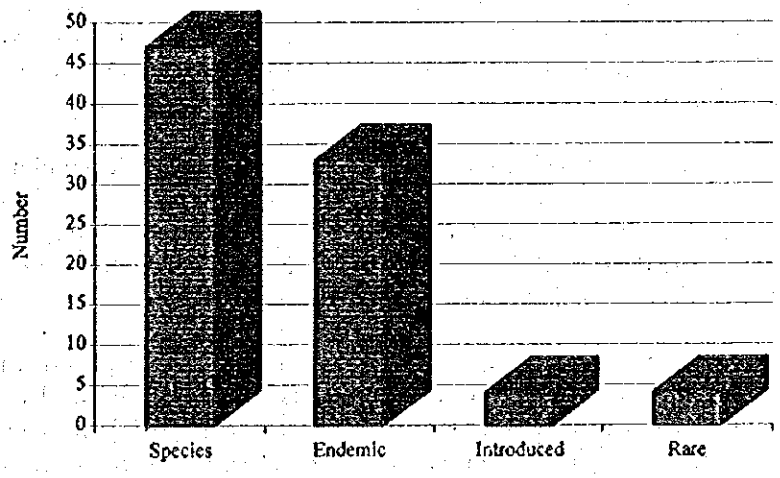


Figure-2.15 Reported Fish Fauna for Igauçu River Basin
Source: IAP/GTZ (1)

(2) Pomba-Amargosa Project, related to the Ivai, Tibagi, Cinzas, and Paranapanema. The objective of the project is to make conscience in the local population about the overpopulation problems caused by the pigeon Zenaida auriculata, which is becoming a pest in wheat and soy bean culture areas.

(3) Projeto Cutia-Serelepe, is a project intending to introduce small mammals in the urban green areas around the metropolitan area of Curitiba. The project includes the reproduction in captivity, releasing and population monitoring of the species. The purpose is to enhance environmental education and quality of life in the urban areas.

2.7 Aquatic Fauna

Extensive fish population studies involving all of a given river basin are scarce in the state, the most comprehensive works have been carried out by the German GTZ for Iguaçu river, by the University of Maringa and the environmental department of Itaipu Binacional for the Parana river, and by the University of Londrina for the Tibagi river basin, and by the Natural History Museum of Curitiba through the collection of specimens in different regions.

A summary of the reported fish fauna can be found in Table-2.43, and a detailed list of fish species reported per river basin can be found in Appendix 1.

2.7.1 Iguaçu River Basin

Endemic fish species occur in high degree at the Iguaçu river basin given its geomorphological characteristics and occurrence of natural barriers throughout the river course. A list of endemic species identified for this area can be found in Appendix 1.

For the Iguaçu river basin, studies carried out by the Instituto Ambiental do Parana, and the Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) under the Programa de Impactos Ambientais de Barragens (PIAB) have identified a significant number of fish species

The ichthyofauna of the Iguaçu river has suffered severe alterations given its geographical position, its proximity to Curitiba metropolitan area, and the construction of several reservoirs along its river course. Several waterfalls isolate sectors of the river acting as a natural barrier and enhancing biodiversity and endemism of fish species in this river.

The Iguaçu river was always considered a poor river in terms of fish populations, although with a high degree of endemic species (species only found in that area) given its irregular topography favoring natural isolation. Given the occurrence of the Iguaçu waterfalls, the Iguaçu river was isolated from the Parana river, where the fish population and species composition is very rich, comprising more than 150 species of fish.

The composition of the fish population of the Iguaçu river is not well known, the present knowledge of the fish population indicates that it is composed of at least 47 species, distributed in 35 genera and 15 families. Out of these, 33 species (70%) and 2 genera (6%) are only found in this river (endemic), 11 (23%) are common to other river basins, and 3 (6%) are exotic i.e.: Tilapia sp, Cyprinus carpio, and Micropterus salmoides These are cultured in local fish farming operations within the river basin, and have escaped into the free running waters of the river. See Fig.-2.15.

A list of species identified for the Iguaçu river basin is presented in Appendix 1.

2.7.2 Ivai River Basin

Non systematic collections of fish at Ivai river by NUPELIA show the occurrence of at least 39 species. Similarity index applied to the ichthyofauna of this river shows a high degree of similarity (59.2%) with the Parana river ichthyofauna, and low similarity (39%) with the Piquiri river ichthyofauna.

Main fish species found to be associated with flood areas along the river are Prochilodus scrofa (Curimbata), and Pseudoplatystoma corruscans (Pintado).

The Museum of Natural History list of species is presented in Appendix 1.

2.7.3 Tibagi River Basin

Fish species reported for the Tibagi river basin through studies carried out by the University of Londrina, account for 63 species identified, and the percentage of occurrence of the different taxa is shown as follows:

Table-2.24 Most Abundant Fish Groups Reported for the Tibagi River Basin

Classification (Order)	Occurrence (%)
Characiforms	55.1
Siluriforms	34.7
Perciforms	10.2

Source: UEL, 1993

According to NUPELIA, in the neotropical ichthyofauna there is a dominance of Characiforms and Siluriform groups, that are responsible for 80% of the species in South America.

From the species analyzed, 8 performed more than 50% of the whole individual number obtained, this means 61.8 % of them, the following list shows the appearance percentage by specie:

Table-2.25 Most Abundant Fish Species Reported for the Tibagi River Basin

Scientific Name Species	Percentage of Individuals Collected (%)	Number
Hypostomus sp	13.07	(1)
Astyanax bimaculatus	12.07	(2)
Steindachnerina insculpta	9.33	(3)
Astyanax sp	7.80	(4)
Acestrorhynchus lacustris	5.54	(5)
Schizodon borelii	5.06	(6)
Pimelodus maculatus	4.53	(7)
Apareiodon piracicabae	4.38	(8)
Others	38.22	

Source: NUPELIA

Main species found at the different geographical areas are shown in the following table:

Table-2.26 Location of the Most Abundant Fish Species Reported for the Tibagi River Basin

Location	Most Frequent Species
Sertanopolis	(2), (6), (5), (3)
Londrina	(1), (3), (2), (7)
Sapopema	Apareiodon affinis
	Astyanax eigenmanniorum
	Leporellus vittatus (exclusive)
Telemaco Borba	(1)
	Geophagus brasiliensis
Ipiranga	(4), (2)
	Hoplias malabaricus

Source: UEL (5)

A list of species reported by the Museum of Natural History is presented in Appendix 1.

In general, the species identified for the Tibagi river do not vary much along the length of the river, the main variation found is the frequency of occurrence.

2.7.4 Piquiri River Basin

Sampling done by NUPELIA 1986 shows at least the presence of 50 species of fish. Appendix 1 shows the list of reported species by the Museum of Natural History.

2.7.5 Ribeira River Basin

The ichthyofauna of this basin has not been well studied, fish registers started to take place in 1983, and only 38 species of fish have been reported by the Museum of Natural History.

2.7.6 Parana River Basin

In studies of the Parana river basin for 2 years, NUPELIA has registered by means of sampling 94 species, 88% of them where from the Characiform and Siluriform groups. Appendix 1 shows the list for reported fish in the Parana river. Latest samplings account for 170 species identified in the area.

The most important fisheries occur in this basin. Commercial fisheries will be further discussed under section 2.7.13 of this report.

2.7.7 Coastal Basin

According to the Museum of Natural History collections, and Multiservice (14), the fish species that can be found in the basin are listed in Appendix 1.

The majority of the species mentioned have a commercial value.

2.7.8 Paranapanema River Basin

A low fisheries catch is reported, and it is assumed to be because of the disappearance of the riverain vegetation, and agrochemical and sewerage pollution. Seven (7) species are considered commercial, and only 15 species are frequently found, out of 63 species reported by Torloni in 1988 (24).

The following table shows the most common reported genera of fish for Paranapanema I.

Table-2.27 Most Commonly Reported Fish Species for Paranapanema I

Genera	Number of Species
Astyanax	6
Schizodon	5
Leporinus	18
Pseudocurimbata	3
Serrasalmus	3
Pimelodus	3
Loricaria	3
Plecostomus	3
Ageneiosus	3

Source: Torloni, C.E.C. (24)

2.7.9 Pirapo River Basin

Actually 36 species of fish are reported, belonging to 16 families.

2.7.10 Cinzas River Basin

Fish species collected for the Cinzas river where collected in the downstream of the confluence of the Paranapanema and the Cinzas rivers, reporting a total of 63 species, being only 15 species the most observed today. Fisheries in this region has also diminished in the catch per effort.(24)

2.7.11 Itarare River Basin

No specific data on the Itarare river basin ichthyofauna was found to be reported.

2.7.12 Endangered Fish Species

Endangered species of fish are mostly related to the disappearance of the riverain vegetation and eradication of fruit trees, industrial, urban and agricultural pollution, and overfishing of certain areas.

One of the reported species disappearing from the sampling is the fruit eating Piracanjuba (Brycon sp), which is also a seed distributor for the riverain fruit bearing vegetation.

Preservation and mitigating activities will be further discussed under section 7.2 and 7.3 of this report.

2.7.13 Species of Commercial Interest

Main fish species of commercial interest are located in the Parana river basin and Itaipu reservoir, where the commercial fresh water fisheries is restricted. The main species of commercial interest are the following:

Table-2.28 Main Fish Species of Commercial Interest in the Paranapanema River Basin

Common Name	Scientific Name	Catch Location
Sardela	Apareiodon sp	Itaipu reservoir
Curvina	Plagioscion quamosissimus	Foz do Iguaçu
		Santa Helena
		Porto Mendez
Armado	Pinirampus pirinampu	Guaira
		Oliveira Castro
Curimba	Prochilodus scrofa	Porto Mendez
		Oliveira Castro
Cascudo Preto	Rhinelepis aspera	Guaira

Source: Jornal do Pescador NUPELIA

2.7.14 Migratory Species

Population dynamics studies are not abundant in the state, COPEL and NUPELIA (University of Maringa) are conducting studies in the main hydroelectric project reservoirs if the Iguaçu river, and the UEL has done some research in the Tibagi river in this respect. The available information is scattered and punctual.

Section 7.2 of this report discusses the need to implement a systematic study on this area.

Table-2.29 Migratory Species of Fish from the Tibagi River

Scientific Name	Common Name
Prochilodus lineatus	Curimbata
Leporinus elongatus	Piapara
Salminus maxillosus	Dourado

Source: UEL

2.7.15 Species of Scientific Interest

According to the Museum of Natural History of Parana, the studies carried out on the fresh water fish population of the state are restricted to the following areas:

(1) Parana river basin, studies carried out by the limnological department of the Maringa University.

(2) Iguaçu river basin, studies carried out by the Instituto Ambiental do Parana, and the Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) under the Programa de Impactos Ambientais de Barragens (PIAB)

(3) Tibagi river basin, studies carried out by the limnological department of the Londrina University.

(4) Other studies are punctual, scattered throughout the state, and at this point they do not offer significant conclusions on the ichthyofauna of the remaining basins.

2.7.16 Benthic Fauna

Water quality assessment techniques in rivers have heavily relied on physical-chemical analysis, furnishing a punctual and momentary situation. The use of living organisms (benthic macroinvertebrates) as indicators offers a more comprehensive assessment of the water quality

condition in a given area, by virtue of the presence, absence, and abundance of specific populations directly related to given physical-chemical conditions of the water body.

Monitoring costs are less expensive, and a wider area can be evaluated in less time and cost, while the organisms evaluated persist as the living memory of the overall ecological conditions of the habitat. The IAP has been developing the methodology, with the objective of mapping the water quality condition in the rivers, and has achieved preliminary mapping of the rivers water quality in most of the metropolitan area of Curitiba.

Results of this evaluation can be seen in Table-4.2, summarizing the benthic macroinvertebrate biodiversity found in the river basins researched so far.

2.8 Other Species of Interest

2.8.1 Avian Fauna

The avian fauna of the Tibagi river basin is located in 2 zoogeographic provinces: the region comprehending the rivers draining in the Atlantic Ocean; and the region located west of the Serra do Mar. The mosaic formed by the remaining forest patches has a reduced biodiversity, maintains a unique genetic bank.

Studies undertaken by Agraria Engenharia Consultora in 1989 show that the avian fauna is composed at least by 249 species belonging to 48 families. The following table shows the families with a high representativeness:

Table-2.30 Most Commom Bird Families of the Tibagi River Basin

Family	Number of Species	Habits	Common Names
Tinamidae	7	Terrestrial	Inambu
Ardeidae	9	Aquatic	Garças
Accipitridae	12	Various	Falcões
Rallidae	9	Bordering Rivers	-
Scolopacidae	6	Bordering Rivers	-
Columbidae	11	Forest dweling	-
Psittacidae	7	-	Papagaios
Cuculidae	7	Wetlands	Anu-preto-grande
Strigidae	8	Nocturnal	Corujas
Trochilidae	7	Gallery forest	-
Picidae	71		Tucanos
Ramphastidae	-	Forest Dwelers	
Formicariidae	-	Medium forest strata	
Tyranidae	-	Medium forest strata	
Emberizidae	-	Medium forest strata	
Trochilidae	-	Medium forest strata	
Furnaridae		Upper medium forest strata	
Dendrocolaptidae		Upper medium forest strata	
Cotingidae		Upper forest Strata	

Source: Agraria Engenharia (10)

Avian fauna of fresh water aquatic habits in the state of Parana is reported to have at least 156 species belonging to 28 families. For the Tibagi river basin 56 species are reported, this is 35.8% of the reported species for the state. The following table shows the families of birds with aquatic habits identified for the state, and for Tibagi river basin:

Table-2.31 Bird Families with Aquatic Habits in Parana State and Tibagi River Basin

Family	Number of Species in Parana	Number of Species in Tibagi	Percent Present in Tibagi
Podicipedidae	05	02	40
Phalacrocoracidae	01	01	100
Anhingidae	01	-	-
Ardeidae	16	09	56.3
Ciconiidae	03	02	66.6
Threskiornithidae	07	03	42.8
Anhimidae	02	-	-
Anatidae	18	05	27.7
Aramidae	01	01	100
Rallidae	22	09	40.9
Helliornithidae	01	-	-
Jacanidea	01	01	100
Rostratulidae	01	-	-
Haematopodidae	01	-	-
Recurvirostridae	01	01	100
Craradiidae	04	02	50
Scolopacidae	11	06	54.5
Phalaropodidae	03	-	-
Sternidae	02	-	-
Caprimulgidae	01	-	-
Alcedinidae	05	03	60
Furnariidae	01	01	100
Tyraniidae	07	05	71
Hirundinidae	03	03	100
Emberizidae	03	06	50
Mimidae	01	01	100
Icteridae	05	02	40
Parulidae	02	02	100

Source: Agraria Engenharia (10)

Recent sampling (1990) in the Piquiri river basin showed the existence of at least 101 bird species, equivalent to 13.46% of the total number of bird species of the state, the most representative orders and families are shown by percentage in the following table:

Table-2.32 Most Representative Orders and Families of Birds in the Piquiri River Basin

Taxa	Percentage of the Sample
Passeriformes	67.33
Tyranidae	20.79
Emberizidae	17.82

Source: (12)

The Serra do Mar in the Coastal basin has 290 species of birds reported belonging to 49 families. This is the area where the highest diversity of bird species occur, since the vegetation cover still existing is abundant (14). A summary of reported aquatic bird fauna can be found in

Table-2.44, and a list of aquatic birds can be found in Appendix 4. Fig.-2.16 shows the reported number of aquatic birds per river basin and Fig.-2-17 shows the reported number of aquatic bird species in different aquatic environments for Tibagi river basin.

The Museum of Natural History has classified 5 types of aquatic habitats where little studied avian fauna is present, the following classification for aquatic habitats is used:

Table-2.33 Aquatic Habitats where Little Studied Bird Fauna is Present

Class Type	Geomorphology	Bird Types
1	Ponds, lagoons, shallow water, low aquatic vegetation	Ducks, Jacanas, Kingfishers, Herons
2	Rivers, lakes, depths of >3 m, with bordering vegetation	Kinfishers, gulls, others
3	Wetlands adjacent to rivers, with dense vegetation, tree size plants like Erythrina sp	Herons among other species
4	Herbaceous vegetation	Donacobilus sp, Curtie sp, Certhiaxis sp, Pseudolistes sp.
5	Inland wetlands	Pigeons among other species

Source: Engenharia e Consultoria Agraria (10)

The following table shows the occurrence of these species in Tibagi river basin according to the different habitats:

Table-2.34 Reported Quantity of Bird Species Occurring in Each Class of Aquatic Environment in the Tibagi River Basin

Class	1	2	3	4	5
Species	33	18	28	30	14
% Total	59	32	50	53	25

Source: Engenharia e Consultoria Agraria (10)

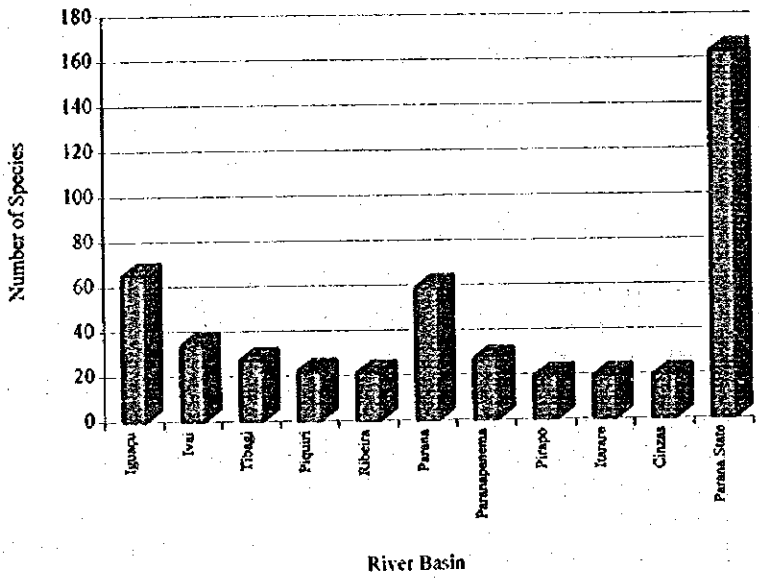


Figure-2.16 Reported Number of Aquatic Birds per River Basin
Source: Museum Natural History

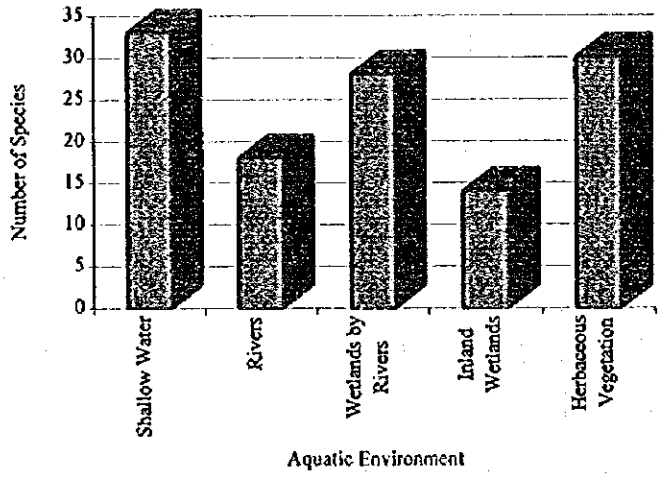


Figure-2.17 Reported Number of Aquatic Bird Species Occuring in Each Class of Aquatic Environment in the Tibagi River Basin
Source: Engenharia e Consultoria Agrária (10)

2.9 Significant Aquatic Habitats

2.9.1 Low Lands Along Water Courses

Existing studies on low lands along river margins subject to flood are scarce, particularly in the Parana river basin area.

In general, these areas are heavily influenced by river peak flows and the consequent flooding of the areas. The existing organic matter promotes the development of a food chain in these areas, and the production of biomass of different species of plants and animals.

It is estimated that 60% of the fish biomass from the floodable areas is constituted by Prochilodus platensis (Curimbata), and studies carried out by NUPELIA in 1987 revealed that in these habitats, Curimbata (Prochilodus sp) and Pintado (Pseudoplatystoma sp) spend their first years (20)

The destruction of these areas while being reclaimed for agricultural purposes, and the extraction of the border riverain vegetation has reduced the existence of fauna corridors between inland vegetation patches, and has favored the water quality deterioration in the river waters increasing turbidity and agrochemical runoff.

In the Coastal basin the areas of lowlands along watercourses correspond to 21,683 ha, where 6,205 are used in agriculture. The total lowland areas by municipality are shown below:

Table-2.35 Area of Lowlands along Watercourses (Varzeas) Reported in the Coastal Basin by Municipality

Municipality	Area in ha
Antonina	4,020.63
Guaratuba	7,947.73
Morretes	3,280.26
Paranagua	6,4343.31
Total	21,683

Source: Multiservice (14)

Low lands along watercourses, have been the most exploited by men, and thus the most modified areas in the botanical aspect, in the coastal basin. This vegetation reaches some 15-20 m in height, and the most frequent species found are summarized below:

Table-2.36 Most Frequent Plant Species Found in the Lowland Varzeas

Scientific Name	Common Name
Bambusa sp	Taquaras
Merostachys sp	Taquaras
Ludwigia sp	Cruz de Malta
Reussia sp	Aguapa rastreiro
Diodia sp	Erva de lagarto
Potamogeton sp	
With moderate draining soils:	
Ficus sp	Figueira
Manilkara subserica	Macaranduba
Colophyllum brasiliensis	Guarandi
Tabebuia umbellata	Ipe do Brejo
Arecastrum romanzoffianum	Geriva
Euterpe edulis	Palmito

Source: Multiservice (14)

For the Tibagi river basin, data available from Agraria Engenharia e Consultoria (10), and surveys done by EMATER in 1981, show an area of approximately 342,822 ha of wetlands, including 268,260 ha with some type of restriction such as conservation, restricted soil aptitude, flood area etc. More recent data from derived from the irrigation and drainage program PROID, show that by 1989 approximately 9,387 ha of wetlands had been incorporated into the production program.

The areas are mainly in the municipalities of Castro, Ponta Grossa, Palmeira, with more than 65% of the areas. The use of drained wetlands is being directed towards the agriculture of rice, corn, soy bean, beans and pasture.

According to Projeto Agua Limpa (IAP) there is no reliable data on the remaining area or state of the river margin vegetation. Section 7.2 of this report suggests the need for such assessment.

2.9.2 Mangroves

Mangroves are existing at the ocean-land interface in the coastal basin, this habitat covers significant areas in the Guaratuba, Paranagua, Antonina, and Guaraqueçaba bays, giving nursery conditions for the avian, fish, mollusc and crustacean species of economic, scientific, touristic interest. Representative species of this habitat are:

Table-2.37 Representative Species of Mangrove in the Coastal Area

Scientific Name	Common Name
Laguncularia racemosa	Mangue branco
Rhizophora mangle	Mangue vermelho
Aviscenia tomentosa	Mangue siriuba

2.9.3 Marshes

Marshes are also present over alluvial extensions, constituted by Herbaceous communities, and less commonly, by bushes and trees. The areas are adjacent to rivers, and are subject to flooding. Morretes alluvial plane is an example of this environment. Typical vegetation of these areas is shown below:

Table-2.38 Typical Vegetation of the Marshes

Scientific Name	Common Name
Cyperus princeps	Periperi
Cyperus sp	Tiririca
Gynerium sagittatum	Uba
Panicum elephantipes	Grama boiadeira
Paspulum sp	Capim das rocas
Digitaria sp	
Baccharis penningtonii	
Bidens laevis	
Poligonum acuminatum	Erva de Bicho
Hydrocotyle sp	
Centella biflora	Pé de Cavalo
Typha sp	Taboa

Source: Multiservice (14)

The marsh vegetation covers about 80 Km^2 (8,000 ha) of the coastal basin, and is not inhabited.

Small lagoons and narrow lakes are also observed in the sandy valleys, where macrophites are found, the main species found in these areas are:

Table-2.39 Typical Vegetation of Lagoons

Scientific Name	Common Name
Azolla sp	Murere
Pistia stratioides	Repolho d'agua
Nymphea sp	Lirio d'agua
Eicchornia azurea	Aguape
Eiccchornia crassipes	Aguape
Camboba australis	Camboba
Pontedeira lanceolata	Aguape
Salvinia sp	Salvinia

Source: Multiservice (14)

2.9.4 Sand Dunes

Sand dunes mark the border between ocean and land, important sediment retention vegetation and dune stabilizing vegetation is present in this area, the most significant species occurring are:

Table-2.40 Typical Vegetation of Sand Dunes

Scientific Name	Common Name
Remirea maritima	Barba de boi
Sporolobus virginicus	Grama de praia
Ipomoea espaprae	Salsa da praia
Acicarpha spathulata	Picão da praia
Polygala cyparissias	Pinheirinho
Canavalia obtusifolia	
Sofhra tomentosa	

Source: Multiservice (14)

Table-2.41 Summary of Reported Forest Coverage

	Iguaçu river basin	Ivai river basin	Tibagi river basin	Piquiri river basin	Ribeira river basin	Parana river basin	Coastal river basin	Parana-panema river basin	Pirapo river basin	Itarare river basin	Cinzas river basin
Native Forest Cover (%) of basin area	14.56	5.05	3.80	2.17	5.69	6.75	80.98	4.86	2.49	1.26	2.92
(ha) x 1000	805.40	181.18	93.60	53.60	51.94	88.80	466.93	47.61	12.46	6.54	27.12
Brush (%) of basin area (capoeira)	27.42	31.08	27.84	20.90	51.93	23.00	4.68	18.56	25.29	20.03	13.36
(ha) x 1000	1517.00	1115.00	685.80	516.40	474.10	302.60	26.98	181.83	126.59	104.11	124.12
Reforestation (%) of basin area	1.72	1.80	9.54	0.35	5.34	0.02	3.97	0.00	0.00	21.69	6.21
(ha) x 1000	95.14	64.58	235.00	8.64	48.75	0.26	22.89	0.00	0.00	112.74	57.69
Total Forest coverage area (%) of basin area	43.70	37.93	41.18	23.42	62.95	29.77	89.63	23.42	27.78	42.89	22.49
(ha x 1000)	2417.40	1360.90	1014.40	578.60	574.80	391.60	516.80	229.44	139.06	223.40	208.94
Endangered Species (E, NR,NE)	E	E	E	E	E	E	E	E	E	E	E
Conservation Units (ha) x 1000	565.00	80.00	415.67	0.38	24.00	100.00	435.00	1.58	ND	ND	ND
% of Basin Area	10.21	2.22	16.87	0.01	2.62	7.60	75.44	0.16	ND	ND	ND
Total Area (ha x 1000)	5531.80	3587.89	2463.47	2470.80	912.93	1315.63	576.60	979.70	500.59	519.79	929.07

SOURCE:. Williams Mendoza, Remote Sensing/IAP, Gubert,F. Forestry/IAP.1994 and Ziller, S. Forestry/IAP
E= existing, NE= Non Existing, NR= Non reported, ND= No Data

Table-2.42 Summary of Reported Terrestrial Fauna

	Iguaçu river basin	Ivai river basin	Tibagi river basin	Piquiri river basin	Ribeira river basin	Parana river basin	Coastal river basin	Parana-panema river basin	Pirapo river basin	Itarare river basin	Cinzas river basin
Family (number of)	11	13	16	4	7	5	11	15	13	18	17
Genera (number of)	12	16	21	5	9	7	13	17	19	18	16
Species (number of)	17	19	23	8	12	9	14	17	16	17	19
Cultural (number of species)	10	8	12	6	8	7	7	6	7	7	7
Common (number of species)	9	10	9	3	4	3	10	12	11	11	11
Exotic (number of species)	ND	1	2	ND	ND	ND	ND	NR	NR	NR	1
Scientific (number of)	5	4	6	ND	ND	ND	3	1	2	1	1
Commercial (number of species)	3	ND	3	ND	ND	ND	1	2	1	3	3
Migratory (number of species)	ND	1	1	ND	ND	ND	ND	1	NR	1	1

SOURCE: Dr. Mauro M. Britto Zoologist/IAP/DITEC
E= existing, NE= Non Existing, NR= Non reported, ND= No Data

Table-2.43 Summary of Reported Fish Fauna

	Iguaçu river basin	Ivai river basin	Tibagi river basin	Piquiri river basin	Ribeira river basin	Parana river basin	Coastal river basin	Parana-panema river basin	Pirapo river basin	Itarare river basin	Cinzas river basin
Family (number of)	15	18	9	13	12	25	12	6	16	NR	NR
Genera (number of)	35	33	36	30	39	66	40	14	31	NR	NR
Species (number of)	47	43	42	43	64	170	NR	15	36	NR	NR
Endemic (number of species)	33	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
percent	70	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
introduced (number of species)	4	1	ND	ND	ND	NR	ND	ND	1	ND	ND
percent	8.51	2.32	ND	ND	ND	ND	ND	ND	2.7	ND	ND
Rare (number of species)	4	ND	ND	ND	ND	ND	ND	NR	NR	NR	NR
percent	8.51	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endangered (number of species)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Commercial(number of species)	NR	NR	NR	NR	NR	8	NR	NR	ND	ND	ND
migratory (number of species)	NR	NR	NR	NR	NR	NR	NR	NR	ND	ND	ND

SOURCE: Museum of Natural History of Parana State
E= existing, NE= Non Existing, NR= Non reported, ND= No Data

Table-2.44 Summary of Reported Aquatic Bird Fauna

	Iguaçu river basin	Ivai river basin	Tibagi river basin	Piquiri river basin	Ribeira river basin	Parana river basin	Coastal river basin	Parana-panema river basin	Pirapo river basin	Itarare river basin	Cinzas river basin	Parana State
Family (number of)	15	14	9	10	8	17	ND	13	8	8	8	31
Order (number of)	8	7	6	6	6	7	ND	6	6	6	6	10
Species (number of)	65	34	27	22	21	59	ND	27	19	19	19	163
Endangered (number of species)	5	2	0	0	1	7	ND	1	0	0	0	12

SOURCE: Museum of Natural History of Parana State
E= existing, NE= Non Existing, NR= Non reported, ND= No Data

Table-2.45 Terrestrial Fauna of Scientific, Commercial and Cultural Interest

Species	Common Name	Taxonomic Group	Class	River Basin
Didelphis albiventris	Gamba	Marsupialia	CUL/SPC	1-2-3-4-5-6-7
Tamandua tetradactila	Tamanduá	Edentata	SPC	3
Dasypus novencinctos	Tatu-galinha	Dasypodidae	CUL/SPC	1-2-3-4-5-6-7
Cebus apella	Macaco-prego	Primates		
Chrysocyon brachiurus	Lobo-guará	Carnivora	SCI/SPC	1-2-3-4-5-6-7
Nasua nasua	Coati	Procyonidae	SPC	2-7
Procyon cancrivorus	Mão-pelada		SPC	
Eira barbara	Irara	Mustelidae	SPC	2-3-5-7
Lutra longicaudis	Lontra		CUL	
Felis concolor	Puma	Felidae	SPC/SCI	1-2-3
Felis pardalis	Jaguatirica	Felidae	SPC/SCI/CUL	1
Panthera onça	Onça-pintada	Felidae	SCI/CUL	1
Tapirus terrestris	Anta	Perissodactyla	CUL	1
Tayassu tajacu	Cateto	Tayassuidae	COM/SPC	1-2
Mazama americana	Veado-mateiro	Cervidae	SPC	1
M. rufina	Veado-bororó		SCI	1
M. guazoubira	Veado-catinga		SPC/SCI	1
Cavia aperea	Preá	Rodentia	SPC	3
Coendou vilosus	Ouriço	Erethizontidae	SPC	
Hydrochares sp	Capivara	Hydrochaeridae	SPC/COM.CUL	1-2-3-7
Dasyprocta azarae	Cutia	Dasyproctidae	CUL/SPC	1-2-3-7
Agouti paca	Paca			
Zenaida auriculata	Amargosa	Aves Columbidae	SCI	3
Tupinambis teguixin	Teiu	Teiidae	SPC	2
Caiman latirostris	Jacaré	Alligaotridae	SCI/COM	3-7
Sus scrofa	Javali	Artiodactyla	COM	3
Lepus capensis	Lerão	Lagomorpha	SCI	3
Bothrops sp	Jararaca	Viperidae	CUL	1
Crotalus sp	Cascavel	Crotalidae	CUL	2-4-5-6-7
Crypturellus obsoletus	Inambu	Tinamidae	CUL	3
Penelope sp	Jacu	Cracidae	CUL	3

Source: Britto, M. Mauro IAP/DITEC. 1994.

1) Iguaçu River Basin, 2) Ivaí River Basin, 3) Tibagi River Basin, 4) Piquiri River Basin, 5) Ribeira River Basin, 6) Paraná River Basin, 7) Coastal River Basin, 8) Paranapanema River Basin, 9) Pirapó River Basin, 10) Itararé River Basin, 11) Cinzas River Basin.

SCI= Scientific, COM= Commercial, CUL= Cultural, SPC= Common Species

CHAPTER 3 SOCIO-ECONOMIC ENVIRONMENT

3.1 Farming

3.1.1 Tibagi River Basin

Since 1930, two distinct pioneer fronts occurred in the state, a front that reached the north of the state (lower Tibagi in Londrina area), and a front that reached the south-southwest, composed of colonizers of European origin. The news regarding the good soils prevailing in northern Parana promoted the colonizing of rural estate companies, and significant numbers of people from Sao Paulo and Minas Gerais started to immigrate to this area.

The Northern Parana land Company, of British capital acquired some one million hectares, which where subdivided in lots for further speculation. Each lot would have some source of water, and a percentage of land would be placed in higher elevations. These characters will help understand the distribution of activities in each state.

Coffee crops where installed in the higher elevation lots and grazing areas where installed in the lower elevation lots, along with pig pens, agriculture and housing. Coffee activities substituted the forest and agriculture of corn, rice, beans, among others, covered the valleys. Coffee farms developed housing and parcels for the worker to live and produce subsistence agriculture for its own use. Between the 30's and the 60's, the lower Tibagi region experienced its highest demographic density.

Coffee crops declined due to the intensive soil use, inadequate soil management, competitive international market and frosts. These events climaxed in the 70's (1975, last great frost), and thousands of coffee plants where eliminated. This issue favored the regions greater exodus, then machinery substituted manual labor.

The rural exodus climaxed in the poverty belts around the urban centers, with the consequent problem generation of solid waste, open sewers, school deficit and worsening of health conditions, and worsening of environmental conditions. The change from a permanent culture to a rotative crop system with soy, beans, corn, rice, and other staples brought serious environmental problems, causing an increase in erosion of good soil, and excessive use of pesticides.

The majority of small owners sold their land and favored the creation of big properties which were dedicated to rotational cultures, eliminating the multiple use of the land common in the coffee plantations, displacing the farm workers and their parcels and animals. Thus, from the 70's on, the lower Tibagi region gradually loses its initial small state model and acquires the extensive farm (Latifundio) model. The urban areas are invaded by non qualified labor and people in need of basic services, which in turn promote the environmental degradation of the urban environment.

The rural mode of production is then geared towards the monoculture, where maximum use of the land is foreseen, irrespecting previous practices and areas such as steep slopes, small grazing areas, and borders of water courses. These practices favored erosion, soil leaching, border vegetation eradication, and affected the water quality of rivers.

The colonization process of medium Tibagi promoted and maintained the land rotation practices, the forest was not cut because the lack of roads made difficult the commercialization of timber. The soil in this region is acid and less fertile, topography offers less accessibility to machinery, and the climate is inadequate for coffee crops. Slash and burn practices were common, and thus soil exhaustion was common.

Fern areas, bushlands and secondary woods gave place to livestock which in turn favored the introduction of exotic grass species.

Today, agriculture is characterized by highly technified producers, and lower technology operations with a subsistence operation, a very advanced center for grain storage is available, and the cities of Ponta Grossa and Londrina, which are the main industrial poles in the basin and the state.

According to the agricultural census of 1985, 86% of the basin is under agricultural activities with an average farm size of 50 ha.

3.1.2 Piquiri River Basin

The main crop being grown in the area is soy bean, introduced in the 70's with the agriculture modernization process of Parana, where the rural industrialization acted as a concentration of land in less and bigger farms for the culture of soy bean and wheat demanding such areas. By 1985, the farms with more than 100 ha increased from 51.3 to 69.2 %, this fact went along with a change in the working relationship, increasing the number of people receiving a salary and diminishing the number of owners.

The consequences of the introduction of soy bean culture and mechanization did not have so dramatic consequences to the rural population as in other areas of the state, in fact the total number of people working in agriculture increased approximately 11% between 1970 and 1980. Non the less the urban population growth of Cascavel grew 12.6%, and the urban construction rate increased by 37% in 1980.

Cascavel became a service center, with 69.7 % of the employment dedicated to the service area. According to IBGE, by 1980, 47.8% of the population of Cascavel municipality didn't have an income.

3.1.3 Coastal Basin

It can be said that in the coastal basin virtually there is no agricultural tradition. the existing agriculture is of subsistence type, and mechanization is minimum. The main products are bananas, manioc, hart of palm, rice and horticulture. The total agricultural area is estimated in approximately 2,024 ha.

3. 2 Urban Development

3.2.1 Tibagi River Basin

The basin is composed of 41 cities, 15 of them have their whole area inside the basin, out of all the cities in the basin, the ones with the major areas are the following:

Table-3.1 Major Urban Centers in the Tibagi River Basin

City	Area in Km^2	Percentage of the Basin Area (%)
Tibagi	3,213.7	12.7
Castro	2,116.8	8.4
Londrina	2,068.63	8.2
Ortigueira	1,708.56	6.8
Telemaco Borba	1,689.16	6.7
Ponta Grossa	1,686,51	6.7

Source: Engenharia e Consultoria Agrária (10)

3.2.2 Iguaçu River Basin

The main urban development is given by the city of Curitiba, where roughly 1.5 million people live, with an estimated population growth rate of 3%. The first traces of urban planning can be located around 1946, when the French planning strategy of centralization was popular throughout Latin America, and basically consisted in centralizing services, infrastructure, and administration in a unique center where the satellite population would come and go to and from the center to the periphery.

With the agricultural change caused by the frosts that eliminated the coffee activity in the 1970's, Curitiba urban area started receiving inmigrants from the agricultural areas, mainly from the northern and southwestern part of the state, and more recently from Sao Paulo, where urban violence and big city problems has driven immigrants out looking for a better urban environment.

Immigrants in their vast majority are not qualified for jobs in the city, have low or no capital and opportunities, and end up creating the poverty belts (favelizacao) around the city, where land is cheaper, and in some cases subject to flooding, and where no public services are available for sewerage, potable water, electricity and others. Such case is evident in the vicinity of Villa Amelia, in the eastern sector of the Curitiba urban area, where more than 100,000 people live ascinated. The exisitng conditions ot thte river margins of the Palmital river will be further discussed under section 6.2.4 of this report as a model area of this condition.

It is estimated by the COMEC/PROSAN environmental program that at least 1,500 families in this condition are to be relocated from their actual location in the vicinity of potable water springs being used today by the city of Curitiba.

The expansion of Curitiba metropolitan area is considered a crucial issue for future planning, since surrounding areas are rich in water resources to supply actual and future needs of the population.

3.2.3 Coastal River Basin

It was estimated in 1989 by Multiservice (14), that in the municipality of Antonina 70% of the population didn't have a stable income, migration is common among the young population, and urban expansion was not foreseen.

The urban development of Antonina has been linear, along the railway (Avenida Matarazzo). The economy is turned towards the tourist activity, the fluctuating population in the Guaratuba municipality is estimated in 150,000 - 200,000 during summer, being only 25,000 the total estimated resident population. This condition has been favoring the unplanned urban development, although specific zoning and parceling legislation exists. Expansion is mainly along the BR-277 highway, and not towards the rural areas, affecting the landscape and coastal area attractiveness.

Matinhos municipality is considered the one of major tourist attraction with a floating population of 400,000 people during the summer season. This condition exerts a stress over the reduced area of 98 km^2 .

Morretes municipality has a development oriented towards the municipality of Paranagua, along the BR-277, and without any regulation for land occupation. Solid waste deposited in the rivers of the area are prejudicial to the tourist activity and to the quality of life of the population.

The Paranagua municipality is the most developed one economically among the coastal area, the urban expansion is occurring along the BR-277 and towards the district of Alexandra, endangering the urbanization of the rural area, and the agriculture activity of the area.

The future expansion of Paranagua attempts towards the destruction of mangrove forest bordering Paranagua bay, a fragile environment necessary for the larval development of commercially important aquatic species.

3.3 Fishing

Fresh water fisheries of commercial interest are restricted to the western boundary of the state of Parana, along the Parana river and the Itaipu reservoir, in the Parana river basin. There are 6 fishermen aggregations or colonies along this river i.e.:

(1) Bandeirantes, at the Paranapanema river, northeast of the state. Fisheries catch is considered low in this area.

(2) Porto Rico, at the Parana river, northwest of the state.

(3) Guaira, at the Parana river, close to the Itaipu reservoir. This area is considered one of the most important fishing colonies along the river, generating approximately 32-34% of the catch coming from the Itaipu reservoir.

(4) Candido Rondon, located south of Guaira.

(5) Sta Helena, located south of Candido Rondon. This region provides the major portion of the fisheries catch coming out of the Iguaçu reservoir, this is between 51-56% of the reservoirs catch.

(6) Foz do Iguaçu, fishing activities in his area include catches from the Iguaçu and Parana rivers. This colony is considered the main distribution point for fisheries products to the rest of the state, Argentina, and Paraguay.

Fisheries in Tibagi river are mainly sport fishing, although a minor level of commercial fishing still takes place. COPATI estimates approximately 100 commercial fishermen operating along the 550 Km of river. Catch per effort has diminished according to interviews with local fishermen, as well as individual size of fish.

Reduction of fisheries is mainly attributed to deforestation practices inducing erosion, siltation, pesticide use and runoff, and destruction of the boundary vegetation in rivers, which supported fish species belonging to the initial stages of the food chain, i.e.: fruit eating fish.

3.3.1 Fisheries Production

The estimated production is 2,000 MT/year, all of it coming from the Parana river basin, and mainly from the Itaipu reservoir is estimated between 126 and 144 MT/month, for the period between 1987-1991.

3.4 Aquaculture

Aquaculture production is incipient in Parana state, although significant water resources are available. The aquaculture activity is mainly concentrated in the western part of the state, and includes 14 aquaculture associations, with an estimated 600-700 small producers associated. The majority of the small producers are located in the Parana, Piquiri and Iguaçu river basins.

3.4.1 Aquaculture Production

The total estimated area by the Secretaria do Agricultura for aquaculture production is 2,500 ha, out of these, 2,000 ha (80%) is located in the western part of the state, along the basins previously mentioned. The species cultured are the following:

Table-3.2 Fish Species Being Cultured in Parana State, Potential Production per Species and Culture Volume Percentage

Common Name	Scientific Name	Pot. Production in kg/ha/year	Percentage Cultured
Tilapia	Tilapia nilotica	10,000	30.88
Pacu	Piaractus sp	4,500	5.88
Bagre africano	Clarias gariepinus	10,000	2.94
Curimbata	Prochilodus sp	NR	1.47
Carpa	Cyprinus sp	NR	47.04
Lambari		NR	4.41
Taira	Hoplias sp	NR	2.94
Others			4.44
Total			100.00

Source: Silvestre, Danilo.Secretaria de Agricultura-DEPEC.

In the Tibagi river basin, approximately 150 ha of fish ponds are found in the neighbor area of Londrina, individual farms are 1-12 ha in size, and the following species are cultured:

Table-3.3 Fish Species Cultured in the Tibagi River Basin

Scientific Name	Common Name
Piaractus mesopotamicus	Pacu
Cyprinus sp	Carpa
Prochilodus lineatus	Curimbata
Leporinus sp	Piapara

Source: Londrina University Aquaculture Station.

Estimated production for each of the species mentioned is showed in the following table:

Table-3.4 Potential Production of Cultured Fish Species in the Tibagi River Basin

Scientific Name	Individual Weight at Harvest (kg)	Production Ton/ha year
Piaractus mesopotamicus	1.5	1-3
Cyprinus sp	1.0	1-3
Prochilodus lineatus	0.4	1-3
Leporinus sp	0.4	1-3

Source: Silvestre, Danilo Secretaria de Agricultura-DEPEC.

Fingerlings are supplied at production cost ($25/1000) by the aquaculture station of the Londrina University, which has a production capacity of 400,000 fingerlings/year.

Fish aquaculture is carried out in earthen ponds, in areas where clay soils are available for water retention. No cage culture of fish has been reported in the reservoirs. Ponds have an average depth of 1.0 m, fish are fed pelleted dry feeds on a daily basis, and water exchange is kept at a minimum to save on pumping costs and maintain the primary productivity of the pond. The estimated water use is 10% per day, so the total water use for the aquaculture industry of the state is roughly estimated as follows:

Total area submerged: 2,500 ha

Average depth of pond: 1.0 m

Water volume /ha : 10,000 m^3

Total m^3 /day :10,000 m^3/ha X 2,500 ha X 0.10 = 2'500,000 m^3

Production systems vary from extensive to intensive, passing through semi-intensive systems, documentation and statistics are scarce, as well as the state budget for the agencies in charge of promoting the activity.

The fingerling production is estimated to surpass 30 million for 30 producers reported to the Secretaria do Estado da Agricultura. There are 12 state producing centers, and 18 reported private producers. Out of the 30 million produced, the state consumes 50%, and the rest is exported outside of the state.

There are 3 feed plants for fish located in Parana and Piquiri areas. Production practices in Tibagi river basin can be summarized as follows:

Table-3.5 Fish Production Parameters in the Tibagi River Basin

Species Cultured	Stocking Density per m^2	Production Cost $/kg	Sale Price $/kg
Piaractus mesopotamicus	0.3-0.5	0.60	1.5
Cyprinus sp	0.3-0.4	1.00	1.5
Prochilodus lineatus	0.1-0.2	0.50	1.5
Leporinus sp	0.1-0.2	1.20	2.0
Tilapia nilotica	1.0-2.0	0.60	1.5

Source: Londrina University Aquaculture Station.

Initial investment for the operation is estimated in $1000-3000/ha

3.4.2 Aquaculture Potential

Although incipient, the fish aquaculture activity is estimated to have a promising future and a significative potential given the water resources of the state, and the market opportunities for the product.

Demand mainly for Tilapia is considered to be high, and it's been now marketed as file, and in fast food restaurants as fish burgers. Production coming from rivers is considered to have achieved its sustainable yield according to information given by the Secretary of Agriculture, Aquaculture Department. So, future fish production increase can only come from fish culture practices.

Increase in fish consumption by the population could be achieved through marketing of the product, the actual consumption per capita in the state is below the national average consumption, so it is believed that there is room for an increase in the production. Average consumption of fish per person is shown below:

Table-3.6 Average Consumption of Fish Per Capita in Brazil

Location	Average Consumption in kg /person/year
Brazil	6.5
Amazon basin	20.0
Parana	2.0

Source: Silvestre, Danilo (DEPEC)

In 1994, approximately 500 MT of cultured fish where marketed in supermarkets, weekly fairs, and on the farm site. A considerable amount of cultured fish is marketed outside the state.

In the western region of the state, 3 enterprises are dedicated to the industrialization of fish, these processing plants have a capacity for processing 10 MT/day of file.

3.4.3 Aquaculture Subsidies

Integrated Program for the Management of Soil and Water (PMISA), with the subsidy of 30-50% of the value for heavy equipment rental, up to 20 hours per producer.

Panela Cheia program, for the subsidy of heavy equipment rental cost for pond construction, and a loan for the purchasing of 2,000 bags of corn, and 3 years of grace to pay.

Pro-Litoral program, supporting fishermen and aquaculturists, with a subsidy of up to 50% of the investment.

3.5 Hydropower

3.5.1 Iguaçu River Basin

The Iguaçu river, in the Iguaçu river basin has suffered along the last 20 years a considerable alteration of its course with the construction of dams for hydroelectric generation. Along its main river course, four major dams have been constructed:

a) Bento Munhoz da Rocha Neto (Foz do Areia), with 148.2 km^2 of submerged area.

b) Segredo, with 83.0 km^2 of submerged area.

c) Salto Santiago, with 230 km^2 of submerged area.

d) Salto Osorio, with 62.9 km^2 of submerged area.

The installation of Salto Caxias generation facility is planned for this century, with 124 km^2 of surface area, with the installation of this facility The Iguaçu river will have approximately 50% of its longitude dammed.

Severe environmental impact is estimated to be caused upon the river biota. The modification of the natural conditions and its effects on the fish population will be further discussed in this report.

3.5.2 Tibagi River Basin

The following table shows the hydroelectric power projects installed and projected in the Tibagi river basin until 1989:

Table-3.7 Hydroelectric Power Projects Installed in the Tibagi River Basin

Name	Organization	River	Drainage Area (km^2)
INSTALLED PROJECTS UNTIL 1989:			
Sao Jorge	COPEL	Pitangui	520
Pitangui	COPEL	Pitangui	606
Pres. Vargas	Klabin	Tibagi	15,100
P.Apucaraninha	P.Apucaraninha	Apucarana	-
Apucaraninha	COPEL	Apucaraninha	580
Tres Bocas	COPEL	Tres Bocas	468
Mecano Fabril	M Fabril	Congonhas	-
Caratuva	COPEL	Caratuva	-
PLANNED PROJECTS:			
Maua		-	114
Jataizinho		-	31.7
Cebolao		-	25.7
Sao Jeronimo		-	96.5

Source: Agraria Engenharia Consultora, 1989 (10)

Major hydroelectric projects not yet installed in the Tibagi river will require a comprehensive environmental impact study mainly directed towards the fish resource and the river margin vegetation to be affected.

CHAPTER 4 ASSESSMENT OF SIGNIFICATIVE ENVIRONMENTAL CONDITIONS

Major impacts in the environment have been identified when related to the water environment, both in the socio-economic and natural environments.

4.1 Socio-Economic Environment

The following itemized impacts have been identified for the socio-economic environment:

(1) Deterioration of the quality of life in populated areas adjacent to polluted waterways.

(2) Increased operational cost of water treatment plants because of increased suspended solid concentration in the water.

(3) Increased flood damage in lands adjacent to waterways, because of the lack of river margin vegetation that could act as a barrier.

(4) Irregular river flow regime affecting operation of hydropower projects.

(5) Loss of inter-state supply of endemic wood, favoring importation of this material.

(6) Poverty belts around urban areas.

Centralized planning model, and concentration of main economic activities together with agricultural modernization, promoted migration from the rural areas to low cost lands adjacent to urban areas. These lands are usually flood prone areas, with little or no public services. Human settlement in this areas affect and is affected by detrimental environmental conditions.

4.2 Natural Environment

4.2.1 Terrestrial Flora

(1) Disappearance of the river margin vegetation.

Agricultural use of river margins has depleted this community, disrupting flow of nutrients, fruits, and nuts into the waterways, and reduced shelter, and reproductive habitat for margin dueling species.

Major effects assessed are the reduction or disappearance of fruit eating fish, like Brycon sp, which is not appearing any more in the Tibagi river captures.

(2) Reduction of 95% of the original forest cover of the state.

Forest cover reduction has favored soil losses of at least 20 ton/ha/year, according to EMATER. Turbidity has become one of the main parameters to evaluate water quality deterioration by SUREHMA (15). No data is available to evaluate past and present aquifer recharge with and without forest.

(3) Anthropic pressure over remaining Araucaria forest

Human pressure on Araucaria is related to the use of wood, and the cultural trait of consuming the seedlings as food, remaining population of Araucaria is estimated in 2% of the original.

4.2.2 Terrestrial Fauna

(1) Biodiversity deterioration of the original fauna is directly proportional to the loss of vegetation and forest habitat.

4.2.3 Aquatic Flora & Fauna

(1) Water quality deterioration in rivers (see table-4.1).

Water quality deterioration could be attributed mainly to he following sources:

1) Deforestation increasing turbidity

2) Sand extraction increasing turbidity

3) Raw sewerage water and incompletely treated sewerage

4) Industrial polluting effluent of various sorts

5) Solid waste disposal in rivers

(2) Potentially polluting industries located in the upper northeastern corner of the Iguaçu river basin, and bordering the Curitiba metropolitan area, are the most concentrated pollution foci affecting the aquatic biota of the Iguaçu river basin.

(3) Interception of natural river flow by dam constructions.The high degree of fish species endemism reported in the Iguaçu river, and probably occurring in the other Parana state rivers, could be affected by dam construction projects where the natural history of the fishes is not taken into account.

(4) Introduction of detrimental exotic species of fish for aquaculture purposes.

Commonly used aquaculture species have escaped commercial farms, and can be now found in several of the state rivers.The exotic African catfish Clarias gariepinus, of carnivore habits, could specially have a detrimental effect on young fish of endemic origin.

(5) Mangrove destruction by urban growth.

Space constraints in the urban growth of Paranagua have promoted the invasion of mangrove areas to expand the city and port facilities.

(6) Raw sewerage effluent discharged in the Paranagua bay. Unexistent sewerage treatment system in Paranagua is discharged in neighbor rivers flowing towards the bay. Low depth, and low water exchange rate make of Paranagua bay a fragile environment to pollution accumulation.

(7) Planned road between Paranagua and Pontal do Sul could promote mangrove destruction.

The 14 Km planned road will have to go across mangrove areas, and could promote colonization of adjacent lands.

(8) Change in the use of the land from wetland (known as Varzea) into agricultural areas is depleting a rich environment used as nursery ground for a multitude of species. Most of this wetlands (65%) are located in the municipalities of Castro, Ponta Grossa, and Palmeira.

Table-4.1 Summary of Massive Fresh Water Fish Mortality Records in Parana Rivers and Reservoirs

Date	Water Body Affected	River Basin	Closest Urban Center	Cause of Death
May/90	Pond	Iguaçu	Piraquara	Low D.O.
May/90	River	Coastal	Paranaguá	Toxic Substance
Aug/90	Pond	Iguaçu	Guarapuava	Toxic Substance
Aug/90	Iguaçu River	Iguaçu	Porto Vitória	Toxic Substance
Sep/90	River	Coastal	São José dos Pinhais	Unknown
Dec/90	River	Iguaçu	General Lucio	Low D. O.
Jan/91	Pond	Iguaçu	Tijucas do Sul	Low D. O.
Feb/91	Lake	Iguaçu	Mandirituba	Low D. O.
Mar/91	River	Coastal	São José dos Pinhais	Toxic Substance
Mar/91	ND	Cinzas	Quatigua	Toxic Substance
Mar/91	River	Iguaçu	Irati	Low D. O.
Mar/91	Pond	Iguaçu	Curitiba	Low D. O.
Mar/91	Pond	Coastal	Paranaguá	Low D. O.
May/91	Pond	Iguaçu	Almirante Tamandaré	Toxic Substance
June/91	Lake	Iguaçu	Curitiba	Toxic Substance
Sept/91	ND	Ribeira	Bocaiúva	Toxic Substance
Sept/91	Pond	Iguaçu	Curitiba	Low D. O.
Sept/91	Lake	Iguaçu	Lapa	Toxic Substance
Sept/91	River	Igauçu	Curitiba	Unknown
Sept/91	Lake	Iguaçu	Curitiba	Low D. O.
Oct/91	River	Iguaçu	Mandirituba	Toxic Substance
Nov/91	ND	Iguaçu	Almirante Tamandaré	Toxic Substance
Dec/91	Lake	Iguaçu	Curitiba	Low D. O.
May/92	ND	Iguaçu	Guarapuava	Unknown
May/92	Reservoir	Iguaçu	Curitiba	Toxic Substance
June/92	Pond	Iguaçu	Araucária	Low D. O.
July/92	Pond	Iguaçu	Cachimba	Low D. O.
Sept/92	Dam Site	Iguaçu	São Mateus do Sul	Toxic Substance
Nov/92	Pond	Iguaçu	São José dos Pinhais	Toxic Substance
Dec/92	ND	Iguaçu	Campina Grande do Sul	Toxic Substance
Feb/93	Pond	Iguaçu	Campina Grande do Sul	Low D. O.
Feb/93	Pond	Coastal	São José dos Pinhais	Low D. O.
Aprl/93	River	Iguaçu	Quatro Barras	Toxic Substance
May/93	River	Iguaçu	Campina Grande do Sul	Toxic Substance
Dec/93	Lake	Iguaçu	Curitiba	Low D. O.
Mar/94	River	Coastal	Paranaguá	Toxic Substance
Jul/94	Pond	Iguaçu	São José dos Pinhais	Toxic Substance

Source: Merlin, E./IAP-Limnology. 1994

4.2.4 Benthos

(1) Deterioration of the biotic index for the macroinvertebrate population in the waterways benthos is evident when less number of species and increased number of individuals per specie is present. This condition is specially evident in waterways affected by pollutant effluents, such as those adjacent to the Curitiba metropolitan area. See Table-4.2.

4.3 Water Requirements for Conservation of River Ecosystem

The present section deals mainly with the aquatic environment, and within this, fish as the main occurring species, and representative fauna such as macroinvertebrates, which can be used as bioindicators of water quality conditions.

There are several water quality criteria as shown below:

Water quality criteria established by CONAMA resolution number 20 for the preservation of aquatic communities and their natural balance, and the one for the preservation of fresh water aquatic life, and established by the United States Environmental Protection Agency USEPA, and published in the Federal register.

In reference to requirements of water quantity for the conservation of the aquatic ecosystem, DNAEE stipulates in its rule 02 for the approval of Hydropower Generation Studies for public Service item 3.7, that:

"*During the working out of the studies and the basic project conception one must take into consideration that the remaining flow in the water course downstream the dam shall not be less than 80% of the monthly mean minimal flow, characterized with base on the historical series of natural flows comprising at east 10 years. The cases for which the criteria above mentioned are not applicable and the reservoirs in cascade will be examined by DNAEE*".

Table-4.2 Benthonic Macroinvertabrates as Water Quality Indicators

	River Basin						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Family (number of)	61	NR	NR	NR	35	73	59
Genera (number of)	59	NR	NR	Nr	46	101	70
Species (number of)	03	NR	NR	NR	02	06	02
Endemic (number of)	01	NR	NR	NR	01	01	NR
Bioindicators (number of species)	20	NR	NR	NR	13	18	13

Source: Toniolo, V. IAP/Limnology Laboratory. 1994.

1) Iguaçu River Basin, 2) Ivaí River Basin, 3) Tibagi River Basin, 4) Piquiri River Basin, 5) Riveira River Basin, 6) Paraná River Basin,
7) Coastal River Basin, 8) Paranapanema River Basin, 9) Pirapó River Basin, 10) Itararé River Basin, 11) Cinzas River Basin.
E= Existing, NE= Non existing, NR= Non reported.

CHAPTER 5 STRATEGY FOR ECOLOGICAL IMPROVEMENT

Water quality deterioration by anthropic activities has a direct effect on aquatic biota, the determination of a Biotic Index based on samples of aquatic macroinvertebrate communities provides a simple, low cost, reliable and practical approach to evaluate aquatic ecosystem deterioration. Present studies are being carried out by IAP, and should be continued throughout the state.

Main sources of water quality deterioration are attributed to untreated sewerage (>75% of the total volume), industrial effluent, and turbidity caused by deforestation-erosion. Enforcement of effluent discharge legislation, and regular monitoring of effluent discharges, as well as afforestation and soil conservation projects should have environmental priority in the state.

Limnological studies and fish population studies should be comprehensive in the existing rivers and reservoirs to preserve and avoid detrimental impacts by man made projects upon the rich endemism of the resource.

5.1 Desirable Conditions of Aquatic Ecosystem in Parana State in the Future

Conditions of aquatic ecosystem in Parana state in the future should improve in the following aspects:

(1) Reduction of pollutant effluent discharge from industrial activity, raw sewerage disposal, solid waste, and suspended solid load originating from soil erosion.

(2) Increased re-vegetation of the waterways borders, to enhance survival of fruit eating fish species, and reduce sediment arrival to the waterways.

(3) The existing ichthyofauna should be preserved, or in the best case re-established to the condition when river margin vegetation supported other fish species which are being depleted today.

(4) The benthic fauna should show a biodiversity index indicator of a healthier environment through increased species diversity in todays polluted waterways.

(5) The river maintenance flow to be allowed in projects dealing with water use should implement DNAEE rule 02, or in the best case consider the endemic ichthyofauna and its natural history, in order to procure a suitable maintenance flow for the perpetuation of the fish species.

(6) The protection of the periodically inundated areas known as Varzeas should limit the change in the use of the land into agricultural areas, since these areas are known to play an important role in the nursing of different species.

(7) The mangrove and estuarine areas should be fully protected from urban encroachment, wood extraction, overfishing and pollutant discharges which hamper their crucial role as nursery areas for the coastal fisheries.

5.2 Objective of Preservation of Ecosystem Library in Parana

The objective of the ecosystem library in Parana is to establish an inventory and data base center, where the biodiversity status of the state can be assessed and recorded, as well as the different ecosystems status at present.

Some of the specific objectives of the center are the following:

(1) Establish a species catalog for aquatic and terrestrial organisms, which will be readily accessible for research and development.

(2) The data base center will be the reference point to evaluate present and future ecosystem status and its relative deterioration or improvement.

(3) The data base center will be a source of information for the research and development of new biotechnology such as medicinal plant extracts, and other pharmaceuticals with economic potential for development.

(4) The data base center will provide the information to assess the location and status of natural seed banks for the regeneration of degraded ecosystems where species diversity has been deteriorated.

(5) The data base center will provide updated lists of threatened, endangered and endemic aquatic, terrestrial and avian species.

(6) The data base center will develop an ecotoxicological and hazardous chemical and agrochemical catalog supported by macroinvertebrate monitoring and bio-toxicity tests.

5.3 Proposed Structural-Non Structural Measures in 2005 and 2015

5.3.1 Structural Measures

(1) Start the planning and construction of sewerage treatment plants.

(2) Start the planning and allocation of solid waste disposal areas for recycling, composting and landfilling.

(3) Start design and construction of water treatment plants for various industries.

(4) Continue with the establishment of urban green areas and parks, specially in lowlands subject to flood and low income people settlement.

(5) Continue with the introduction of fauna into the green belts of the urban area as an environmental education program.

(6) Allocate resources, area and laboratory equipment for the establishment of a centralized aquatic ecology laboratory which will deal with ecotoxicology, ichthyology, aquatic birds, and limnology of Parana state.

(7) Allocate resources, area and laboratory equipment for the establishment of an endemic fish species reproduction facility for the state.

5.3.2 Structural Measures 2006 to 2015

(1) Complete construction of sewerage treatment plants for all urban areas of the state.

(2) Complete allocation of solid waste disposal areas for recycling, composting and landfilling for all urban areas of the state.

(3) complete implementation of water treatment plants for the various industries of the state.

(4) Linkage of the green urban areas of the Curitiba metropolitan area with adjacent preserved areas to establish a corridor for flora and fauna linking urban areas and preserved areas.

(5) Continue with the introduction of fauna into the green belts of the urban area as an environmental education program.

(6) Centralized aquatic ecology laboratory in full operation and providing data base information, monitoring, guidelines and standards for the preservation and maintenance of the aquatic ecosystem.

(7) Laboratory for the reproduction of endemic fish species at full operational scale.

5.3.3 Non-Structural Measures Present to 2005

(1) To continue with the ongoing projects for the monitoring and assessment of water quality through benthic community analyses of macroinvertebrate populations in the rivers of the state.

(2) To continue with the ongoing project for ecotoxicological classification of agrochemicals being used and introduced in Parana state.

(3) To continue the fish population inventory for the different rivers of Parana state.

(4) To enforce Environmental legislation for the industrial sector to properly treat their effluents.

(5) To plan for the de-centralization of the urban services and promote alternative development poles to avoid population encroachment and massive growth of the main urban areas.

(6) To continue the research project for the study of the reproductive cycle of endemic fish species.

(7) To enhance environmental education programs to broaden up the concept of sustained development in the population.

(8) To enforce mangrove protection legislation and avoid destruction of existing ecosystem.

(9) To declare periodically inundated areas (Varzeas) of interest as protected areas, to minimize change in the use of these lands into agricultural lands.

(10) To enhance the existing re-cycling programs and policies to minimize solid waste disposal in waterways.

(11) To promote regulations, programs and policies that will stimulate reforestation of endemic species as a business activity, in order to move the private sector to invest in this activity.

(12) To promote regulations and legislation to limit the importation of wood from other states, and through this measure enhance reforestation efforts in the state.

(13) To develop a screening mechanism to regulate the entrance of exotic aquaculture species that could be deleterious to the endemic population of fish.

(14) To enforce reproductive and migratory studies of the fish population by new projects dealing with the use of the water environment, and to enforce regulations for these projects to procure mitigation and prevention of deleterious impacts on the ichthyofauna.

(15) To organize and centralize scattered information from the pertinent organisms and institutions to develop the data base bank for the ecological data base center.

5.3.4Non Structural Measures 2006 to 2015

(1) To continue with the ongoing projects for the monitoring and assessment of water quality through benthic community analyses of macroinvertebrate populations in the rivers of the state. To feedback on agencies and organisms related to pollution control enforcement to act accordingly.

(2) To continue with the ongoing project for ecotoxicological classification of agrochemicals being used and introduced in Parana state. To feedback on agencies and organisms related to pollution control enforcement to act accordingly.

(3) To continue the fish population inventory for the different rivers of Parana state. To feedback to programs related to fish reproduction and evaluate re-stocking of endemic species.

(4) To review, evaluate, modify, and adapt the environmental pollution legislation to the existing conditions, and according to the past 10 year experience.

(5) To continue the development of alternative development poles to avoid population encroachment and massive growth of the main urban areas, and to develop sub-centers for data base collection and processing in the main development poles, interlinked by information networks between development centers.

(6) To continue the research project for the study of the reproductive cycle of endemic fish species and to evaluate re-stocking of endemic species in the rivers.

(7) To continue with advanced environmental education programs to expand the possibilities of sustained development in the state.

(8) To continue to enforce mangrove protection legislation and avoid destruction of existing ecosystem.

(9) To continue to enforce periodically inundated areas (Varzeas) as of public interest and protected areas, to minimize change in the use of these lands into agricultural lands.

(10) To review, adapt and enhance the existing re-cycling programs and policies to minimize solid waste disposal in waterways.

(11) To review, adapt and promote regulations, programs and policies that will stimulate reforestation of endemic species as a business activity, in order to move the private sector to invest in this activity.

(12) To review and continue promoting regulations and legislation to limit the importation of wood from other states, and through this measure enhance reforestation efforts in the state.

(13) To continue implementing a screening mechanism to regulate the entrance of exotic aquaculture species that could be deleterious to the endemic population of fish.

(14) To enforce reproductive and migratory studies of the fish population by new projects dealing with the use of the water environment, and to enforce regulations for these projects to procure mitigation and prevention of deleterious impacts on the ichthyofauna, and to evaluate the past 10 year experiences to adapt and modify regulations and mechanisms.

5.4 Proposed List of Monitoring Items in Ecology

5.4.1 First Stage and Second Stages

- Water quality items for environmental protection laws.
- Water quality and quantity items for ecosystem preservation.
- Fish population of endemic, introduced, threatened and endangered species.
- Macroinvertebrate population and benthic community in waterways adjacent to urban areas.
- Primary and altered forest and wetland area extension.
- Reforested area and river margin vegetation extension.
- Aquatic bird population and its geographic distribution.

5.5 Summary Evaluation of Environmental Deterioration

A) ENVIRONMENTAL RESOURCE	EXISTING ENVIRONMENTAL STATUS	EXISTING SERIOUS CAUSES OF ENVIRONMENT DEGRADATION
1-NATURAL RESOURCES		
1.1-FOREST/WILDLIFE	1.1-Only 5% of original forest cover remains.	1.1-Agriculture & grazing
1.2-River border vegetation	1.2-Almost inexistent	1.2-Agriculture & grazing
1.3-Fish population	1.3-Disrupter of food chain, overfishing, man made barriers (dams), reduction of biodiversity, disappearance of some species	1.3-Elimination of border vegetation, dam encroachment, fishing, introduction of exotic species, pollution. Lotic/lentic environment disrupted.
1.4-Soils	1.4-High erosion rate, loss of top soil by rains, subject to monocultures.	1.4-Agriculture practices, loss of forest cover, absence of soil conservation practices.
1.5-Wetlands	1.5-Looked upon as possible agriculture areas if drained	1.5-Increase of agricultural frontier, lack of environment protection.
1.6-Mangroves	1.6-In the way of urban expansion.	1.6-Urban growth in coastal cities.
URBAN ENVIRONMENT		
1.7-Sewage/Excreta management	1.7-Only 23.5% of the urban population has sewerage collection, no treatment in rural areas.	1.7-Raw sewerage arriving to the receptor rivers, increasing coliform count.
1.8-Water supply	1.8-Inadequate treatment system, specially in rural areas.	1.8-Non-automatic control system in treatment plants & no treatment in rural areas.
1.9-Industrial liquid waste management	1.9-Little control over existing regulations, pollution in rivers adjacent to water sources.	1.9-Diminishing biodiversity in river areas associated to industrial effluent discharge. Deterioration of water quality.
1.10-River/Flood control	1.10-Lowlands adjacent to urban areas are subject to flood, affecting low income dwellers living in such areas.	1.10-Colonization of lower lands given low cost, and excessive deforestation in upper watershed increasing runoff and reducing infiltration of rain water.
1.11-Slums/housing	1.11-Occupying lowlands subject to flooding.	1.11-same as
1.12-Urban green areas	1.12-Used successfully in Curitiba as flood until control mechanism, recreation area, boundary for urban expansion, and slum/ housing construction avoidance.	1.12-Areas not considered now as potential urban green areas could be incorporated, enlarging the mentioned benefits to flood areas occupied by low income housing.
1.13-Agriculture	1.13-Expanding and covering river margins, enhancing erosion of soil, using agrochemicals, monoculture type.	1.13-Severe erosion of soil, destruction of river margin vegetation affecting herbivorous fish, increase river turbidity, deteriorating water quality.
1.14-Aquaculture	1.14-Incipient industry, using endemic/exotic species.	1.14-Exotic species may affect local fish populations habitat.
1.15-Fishing	1.15-Catch declining in rivers, controlled in some reservoirs.	1.15-Overfishing, agrochemical runoff, increase turbidity, industrial pollution.
1.16-Sand	1.16-Being extracted from river margins, leaving considerable areas as ponds, leaching clay and increasing water turbidity.	1.16-Lack of control and regulations over the activity.