THE FOREST RESOURCES MANAGEMENT STUDY IN BIO BIO AND ARAUCANIA IN THE REPUBLIC OF CHILE

INTERIM REPORT

MARCH, 1992

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

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CHAPTER 1 OUTLINE OF THE STUDY

1-1 Background of the Study

The Forestry Statistics published by the INFOR in Chile put the country's area of native forest and man-made forests at approximately 7.62 million ha and 1.46 million ha respectively as of 1990. While forest resources have been making an important contribution to the development of the national economy in recent years to meet both the domestic and foreign demand for Chilean wood, concern has been expressed in regard to the depletion of these resources, particularly native forests, from the viewpoint of forest conservation as well as environmental protection.

Against this background, and in the face of the rapid increase of new plantations using exotic species, the Government of Chile has adopted the fundamental principle of maintaining a balance between forest conservation and resource development and has introduced various forestry measures to sustain forest resources based on native species.

The relevant measures include the strict administrative guidance through an approval system for suitable sites for forestry and forest management plans relating to felling and afforestation activities. In reality, however, the stipulated checking mechanism does not properly function in certain circumstances and the conversion of forest by small landholders to grazing land and the planting of Radiata pine (*Pinus radiata*) in cut-over native forest sites have been observed in many places.

While upholding the fundamental principle described above, the Government of Chile recognizes that full understanding of the present conditions of forest resources and, based on it, the establishment of an appropriate forest management plan with a long term view is essential before any further exploitation of forest resources. However, currently a forest management plan which can reflect the forestry policy of the country is lacking. Therefore, the Government of Chile made a request to the Government of Japan in December, 1987 for cooperation for a study to prepare a forest management plan for specific areas in Region VIII and Region IX.

Following receipt of this request, the Japan International Cooperation Agency (JICA) dispatched the Preliminary Study Team to Chile in April, 1990 to investigate the background of the request, to confirm the implementation arrangements and to discuss the expected study contents and conclud the Scope of Work (S/W).

1-2 Purpose of the Study

In accordance with the request made by the Government of Chile, the purpose of the Study is to conduct aerial photography in the Study Area of approximately 550,000 ha in Region VIII and Region IX, to carry out a forest resources survey and to prepare a forest management plan for model areas of approximately 64,000ha within the Study Area. The provision of a technology transfer seminar on forest resources survey methods and forest management planning is also planned as part of the Study process.

1-3 Study Area

The Study Area stretches north-south to the west of the Andes Mountains from the southern border of Region VIII (Bio Bio Region) to Region IX (Araucania Region) and is located between the following longitudinal and latitudinal lines, covering some 550,000 ha.

37° 55' S	71° 35' W
39° 05' S	72° 00' W

Inside the Study Area 2 Model Areas have been set up, i.e. the North Model Area of some 38,000ha and the South Model Area of some 26,000ha, totalling some 64,000ha.

Fig. 1-3-1 shows the locations of the Study Area and Model Areas.

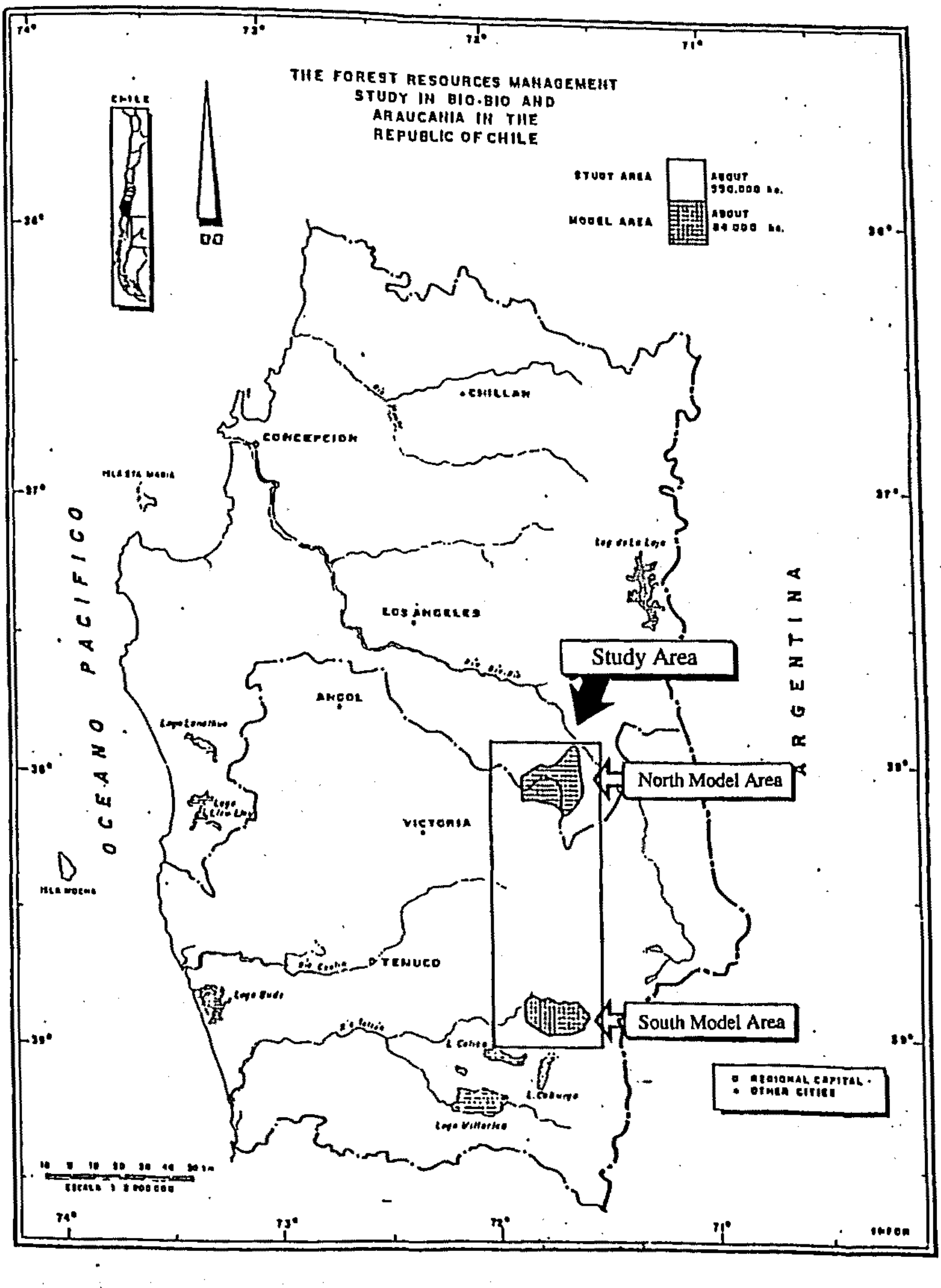


Fig. 1-3-1 Study Area and Model Areas

1-4 Outline of Study Schedule

The Study will be implemented over a period of 3 fiscal years (Japanese fiscal year begins on 1 April and ends on 31 March of the following year) and the study contents for each fiscal year are outlined below.

(1) First Year (Fiscal 1990)

① Preparation of the Inception Report

② Aerial photography (scale: 1/20,000) of the Study Area.

③ Confirmation of existing control points in and around the Study Area through field surveys and collection of data on control points.

④ Examination of existing volume tables and preparation of new volume tables for Roble *(Nothofagus obliqua)* and Rauli *(Nothofagus alpina)* in secondary forests.

⑤ Collection and analysis of existing data on forest resources, forest management plans, socioeconomic conditions and natural environment conditions, etc.

⑥ Preparation of the Progress Report.

(2) Second Year (Fiscal 1991)

① Implementation of control point survey in the Model Areas.

② Preparation of forest base maps (scale: 1/20,000) for the Model Areas.

③ Implementation of forest inventory, natural regeneration survey etc. in the Model Areas.

④ Interpretation of land use, vegetation and forest types in the Model Areas using aerial photographs (scale: 1/20,000).

⑤ Implementation of forest operation and land use/vegetation surveys in the Model Areas in connection with proposed forest management plan.

⑥ Implementation of surveys on socioeconomic and natural environment conditions in the Model Areas.

⑦ Preparation of the Interim Report.

(3) Third Year (Fiscal 1992)

① Preparation of the Forest Management Plan

② Preparation of land use/vegetation maps (scale: 1/20,000), forest type maps (scale: 1/20,000) and forest inventory books for the Model Areas.

③ Implementation of surveys to supplement the field surveys conducted in the second year and of the survey to verify the results of the analysis conducted in Japan.

④ Preparation of the forest management plan map (scale: 1/20,000).

⑤ Implementation of environment assessment.

⑥ Provision of the technology transfer seminar.

⑦ Preparation of the Draft Final Report and explanation of its contents to the Chilean side.

⑧ Preparation of the Final Report.

Fig. 1-4-1 is a flow chart illustrating the entire processes of the Study and their relationship.

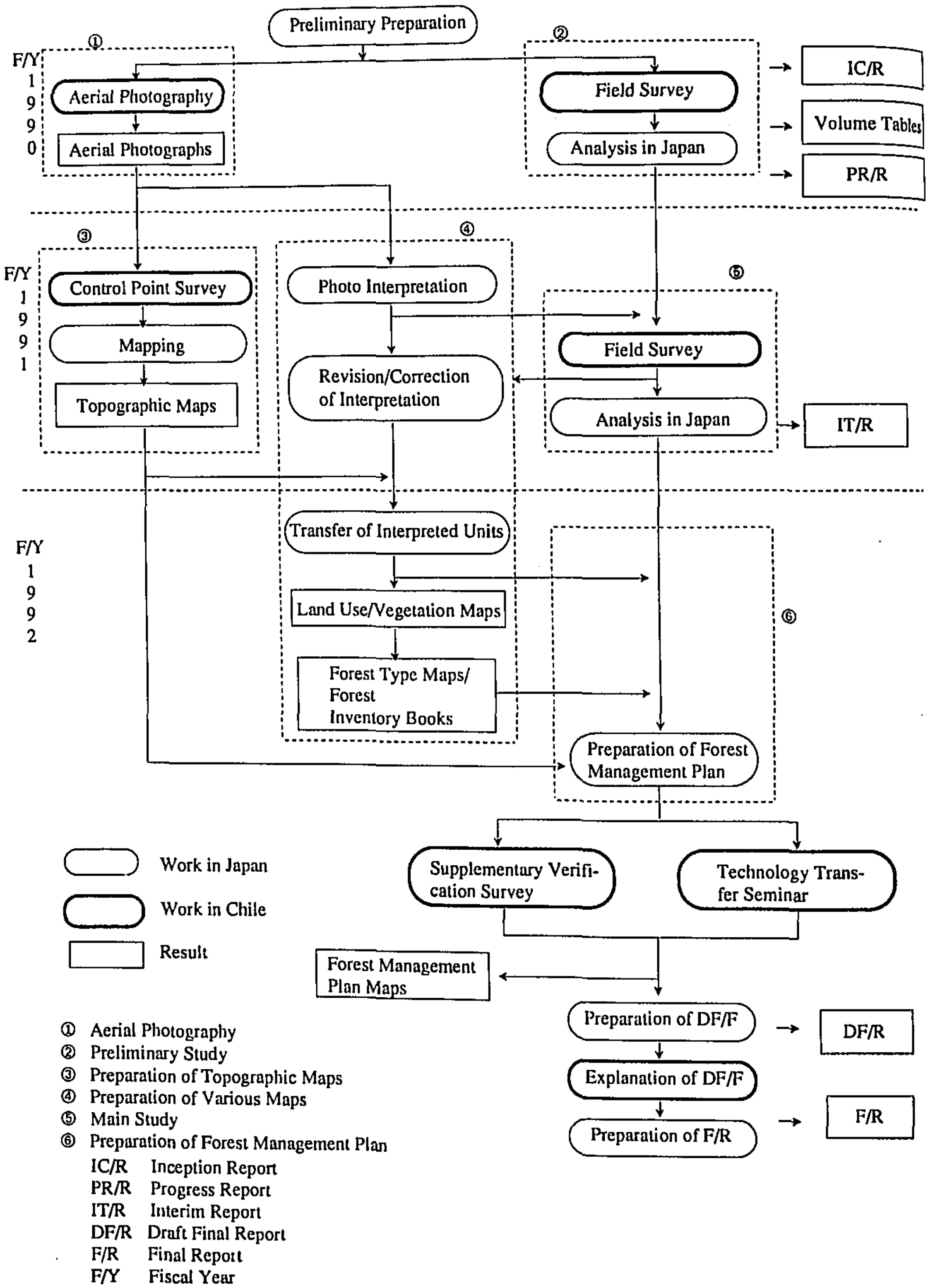


Fig. 1-4-1 Study Flow

CHAPTER 2 PREPARATION OF FOREST BASE MAPS

The progress of the work during the 2 year program is shown on Figure 2-1-1

2-1 Aerial Photography

2-1-1 Contract of Aerial Photography

A contracting agreement was made with the SAF (Servicio Aerofotogramétrico de Chile), the suitable organization in Chile capable of conducting the aerial photography, based on the first year field works. The specifications of the agreement are given next.

2-1-2 Photography Work

- Photographic Area .... approximately 550,000ha
- Photographic Scale 1/20,000
- Flight Height .... approximately 3,200m
- Flight Courses .... 12 courses in the north-south direction 865 photographs
- Overlap .... 60% for course direction and 30% between neighboring courses
- Aircraft .... Rear-Jet
- Camera .... RC-10 wide-angle camera (f = 15 cm)
- Result .... Photo indexmap (Fig. 2-1-2), Number of Photo (Table 2-1-1)

2-1-3 Supervision of Aerial Photography

The process control and quality control of the work was conducted by a Japanese supervisor and the resulting aerial photographs were deemed satisfactory. Santiago was used as the base in view of fuel supply and aircraft maintenance.

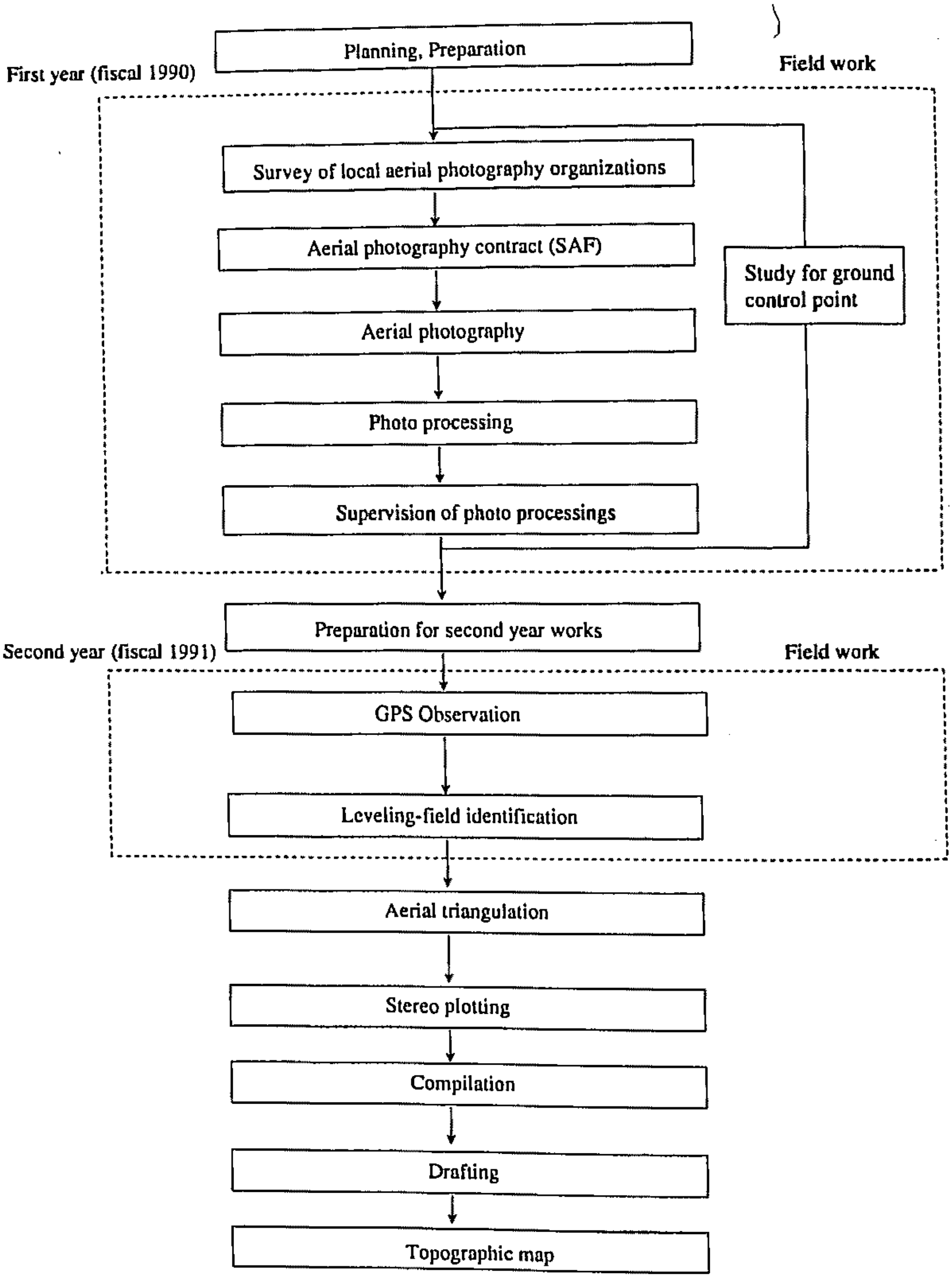
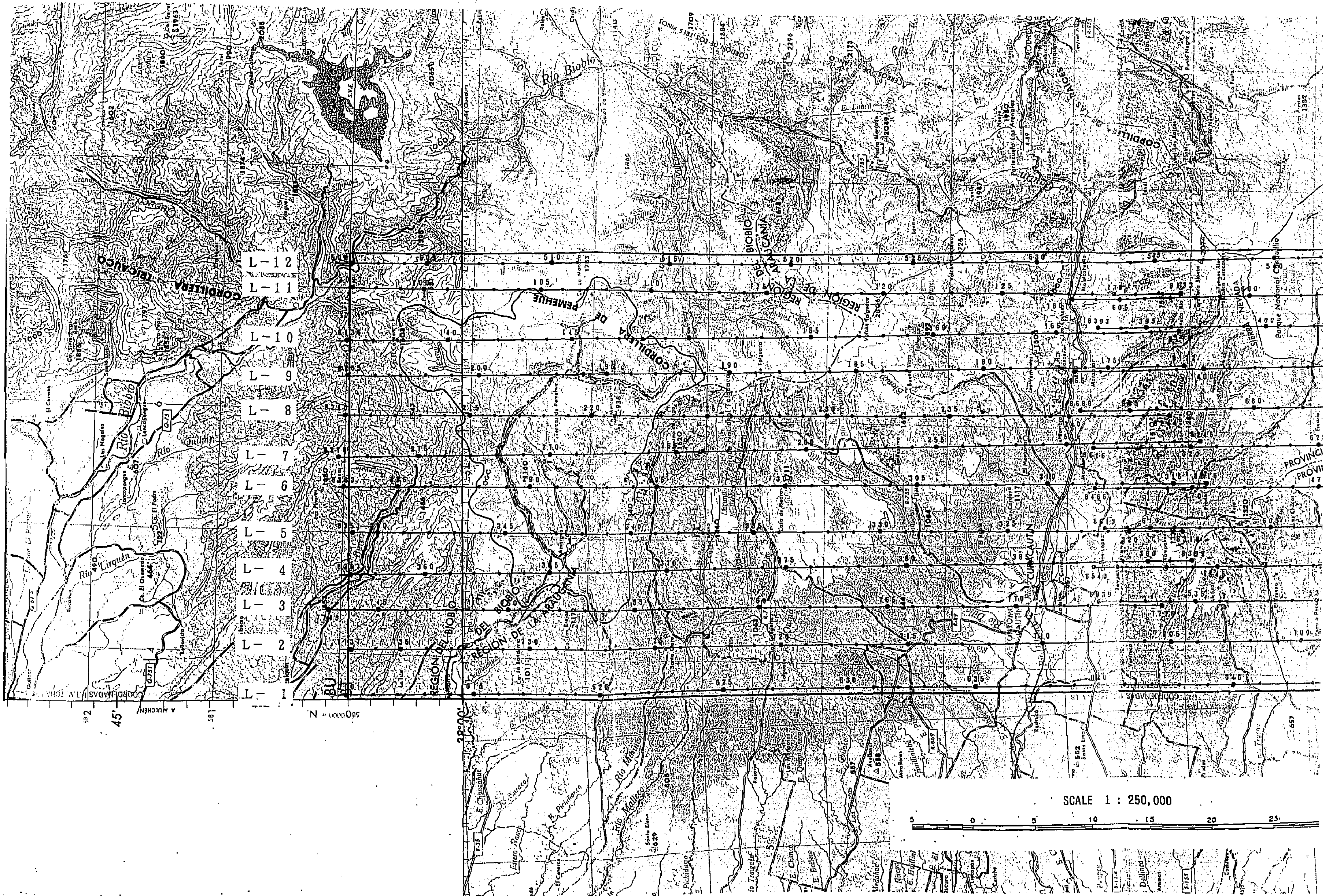


Fig. 2-1-1 Flowchart of forest base map preparation



L-12
L-11
L-10
L- 9
L- 8
L- 7
L- 6
L- 5
L- 4
L- 3
L- 2
L- 1
CORDILLERA TRICAUCO
CORDILLERA DE PEMEHUE
Río Biobío
REGION DEL BIOBIO
REGION DE LA ARAUCANIA
SCALE 1 : 250,000
5 0 5 10 15 20 25

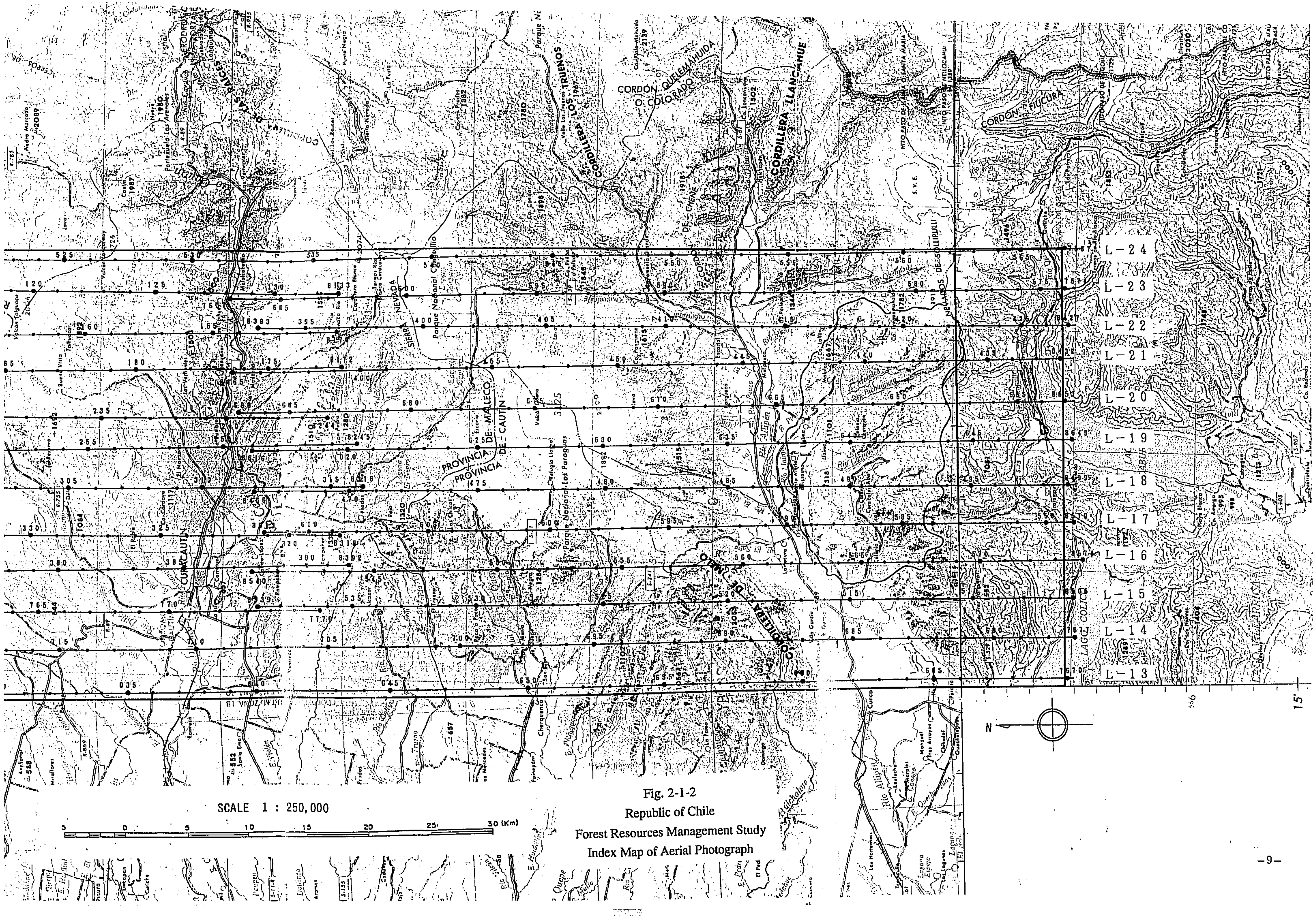


Fig. 2-1-2
Republic of Chile
Forest Resources Management Study
Index Map of Aerial Photograph

Table 2-1-1 Number of Diapositives and Contact Prints

Course No.	Photo No.		Total
1	237608	237641	34
2	237706	237740	35
3	237742	237776	35
4	238392	238355	38
5	238318	238354	37
6	238316	238281	36
7	238245	238279	35
8	238208	238244	37
9	238172	238207	36
10	238134	238170	37
11	238133	238095	39
12	237534	237500	35
13	237642	237672	31
14	237674	237705	32
15	238503	238539	37
16	238576	238540	37
17	238613	238577	37
18	238466	238501	36
19	238614	238650	37
20	238688	238651	38
21	238430	238465	36
22	238393	238429	37
23	237571	237607	37
24	237535	237570	36
		Grand Total	865

2-1-4 Photo Processing

The films were immediately developed by the SAF. A Japanese supervisor examined the developed films and sorted them into those requiring rephotographing and those to be forwarded to the contact print and positive film preparation processes.

2-2 Ground Control Point Survey

2-2-1 Confirmation of Existing Control Points

Existing control points were confirmed based on point description of the Instituto Geográfico Militar. Result of field investigations were as follows.

Item	Surveyed Points	Existing Point
Triangulation point	8	5
Bench Mark	15	8

According to the field investigation, some control points are missing (loss, destruction). This is why the study team planned the following control point survey.

Item	Amount of Survey Works
Triangulation point	3 existing points to be used
Bench Mark	12 points* to be established
Leveling	To cover 100 km

* North Model Area 6 points, South Model Area 5 points, Middle of the Study Area 1 point

2-2-2 Ground Control Point Survey

The control point survey which was essential for the aerial triangulation, in turn required for the preparation of a topographical map of the Model Areas, was conducted using GPS (Global Positioning System) in the following manner.

(1) Selection of Control Points

The 12 control points required for the angle of elevation 15° were selected in the area. Those points were selected in consideration of road access for the purpose of synchronized observation.

(2) Obtaining of Geodetic Satellite Data

In general, 3 optional points must be simultaneously observed and data from at least 4 satellites are required for reliable results. As data from 5 satellites were obtained, the resulting accuracy was sufficiently reliable.

(3) GPS Double Reference Positioning

Using double reference positioning analysis software, the simultaneously observed data were plotted to the three dimensional coordinates (x, y, z) on the WGS-84 ellipsoid and the geodetic coordinates (B, L, H) were calculated. Furthermore, conversion to the geodetic coordinates (B, L, H) on the International ellipsoid used by Chile and to the UTM Zone 19 System (a plane rectangular coordinate system) was conducted.

Geodetic data are as follows:

DATUM	:	PSAD-56
ELIPSOIDE	:	INTERNATIONAL 1924
PROJECTION	:	U.T.M Zone 19 (69° W)

Point name	Class	Latitude	Longitude	Elevation (m)
LONCO PANGUE	3	S 37° 45' 40.0440"	E71° 47' 01.2980"	606.80
LA ISLA	3	S 38° 27' 02.3370"	E71° 54' 23.4360"	657.15
LA LOMA	3	S 38° 50' 04.8550"	E71°44' 38.4880"	522.36

(4) Pricking

The selected control points have to be identified on the contact prints of aerial triangulation purposes. The control points selected on the basis of aerial photograph interpretation were pricked in such points as single trees and buildings on the aerial photographs.

2-2-3 Levelling

Levelling was carried out covering 100km in the Model Areas where no Chile leveling point exists. Observation was made at the error of closure less than 6cm $\sqrt{s}$. All results were confirmed as good and acceptable.

Results of ground control point survey an levelling are shown on Table 2-2 and Fig. 2-3.

2-2-4 Field Identification

The names of the places, rivers and roads, etc. to be entered on the maps were determined by interviews with local residents and based on existing data and used for mapping.

2-2-5 Main Equipment

•	GPS Receiver	Trimble 4000SL	3
•	Analysis-Related Equipment	Laptop Computers	2
		Printers	2
•	Level	Nikon Auto Level	4

Table 2-2-1 Results of Ground Control Point Survey and Leveling

NAME	LATITUDE (S)			LONGITUDE (W)			X COORDINAME (N)	X COORDINAME (E)	ELEVATION (M)
1 LA LOMA	38	50	4.92747	71	44	38.52720	5697915.915	261806.955	
2 LA ISLA	38	27	2.30707	71	54	23.45718	5740109.791	246348.865	
3 LONCOPAN	37	45	40.00323	71	47	1.23832	5816970.973	254774.596	
4 GPS 1	37	53	34.19899	71	36	58.30589	5802778.627	269941.014	453.259
5 GPS 2	38	4	29.93715	71	53	42.89381	5781836.367	246026.493	488.151
6 GPS 3	38	1	54.43356	71	46	55.14242	5786934.405	255820.452	534.887
3 GPS 4	38	4	54.56283	71	41	54.34815	5781597.417	263316.810	743.001
4 GPS 5	38	8	40.33853	71	49	38.60593	5774299.891	252215.519	677.917
5 GPS 6	38	13	50.99243	71	43	33.05343	5764989.009	261397.954	1153.799
6 GPS 7	38	40	51.73745	72	0	7.17502	5714268.218	238850.985	
7 GPS 8	38	55	26.77534	71	47	42.03410	5687858.016	257685.552	871.996
8 GPS 9	38	55	43.39930	71	36	28.77863	5687826.194	273916.060	856.571
9 GPS 10	39	3	14.49331	71	42	40.41539	5673656.196	265379.998	736.924
10 GPS 11	39	2	32.94496	71	49	44.56431	5674626.434	255142.774	387.548
11 GPS 12	38	54	34.35669	71	55	50.30319	5689104.796	245872.923	384.553
12 GPS 1043	38	51	52.83803	71	50	22.91733	5694334.674	253605.037	405.948

DATUM : PSAD-56
ELIPSIODE : INTERNATIONAL 1924
PROJECTION : U.T.M Zone 19 (69° W)
ELEVATION : South Model Area was based on the existing bench marks.
North Model Area was based on the GPS height.

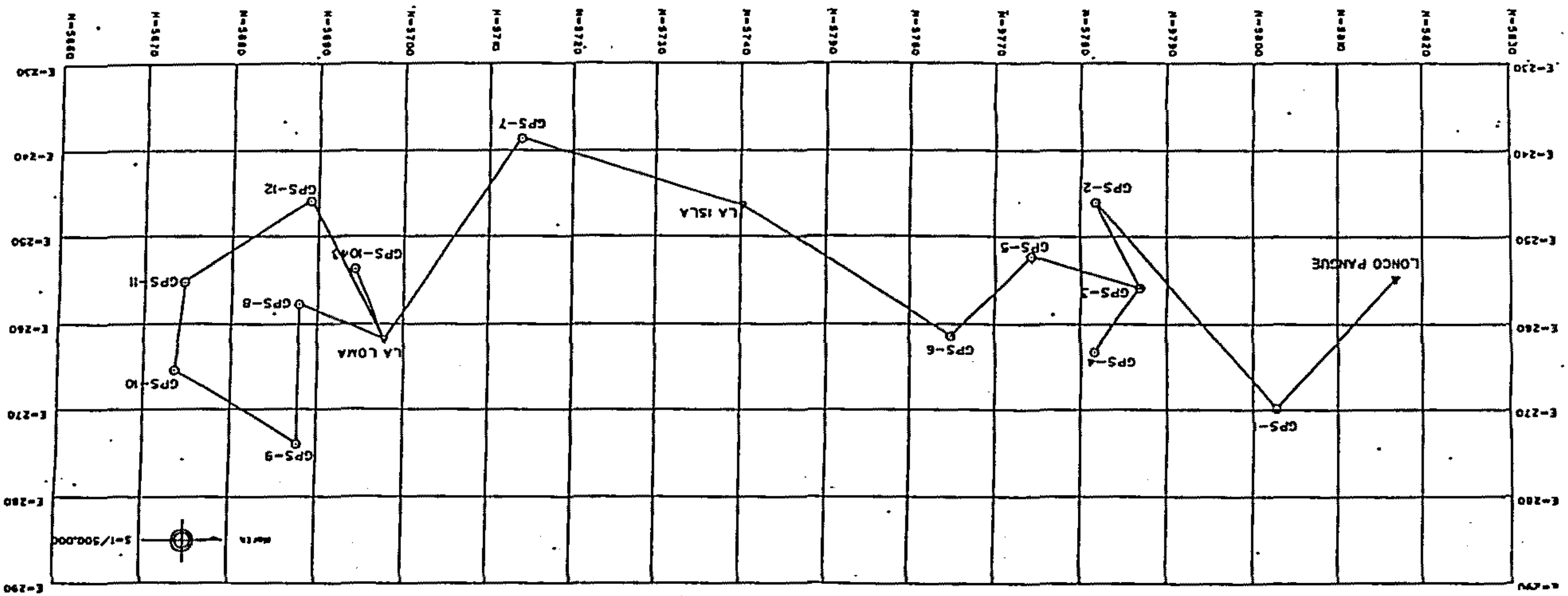


Fig. 2-2-2 Control Point Survey by GPS

2-3 Topograhic Mapping

2-3-1 Aerial Triangulation

(1) Outline of Work

Aerial triangulation was conducted to obtain geodetic coordinates of pass and tie points necessary for stereo plotting based on results of the ground control points and leveling points.

a) Specifications

Photo scale	:	1:20,000
Number of courses	:	9 courses
Number of models	:	196 models (North Model Area 87 models, South Model Area 109 models)
Adjustment computation	:	Block adjustment method (Independent model)

b) Main instruments

Pricking device	:	PUG-II (WILD)
Stereo comparator	:	STECOMETER (ZEISS JENA)
Computer	:	FACOM M-760 (FUJITSU)

(2) Point Selection and Pricking

Selection of pass points, tie points, etc. was conducted using contact prints. In consideration of block adjustment by independent model method, 6 pass points were selected per model and 1 tie point per model was selected in the area overlapped with the adjacent course. Positions of pass points and tie points were enclosed with red circles (diameter: approx. 7 mm) on the contact prints.

Pricking device (PUG-II) was used for transferring the points on diapositives and marking was conducted on diapositives with red circles of approx. 7 mm diameter. Transfer of control points were conducted on diapositives using pricking device stereoscopically according to description sheets of ground control points, leveling points.

(3) Measurement of Photo Coordinates

Coordinate measurement of fiducial marks at the four corners of the photo, control points, pass points and tie points was conducted at the measuring unit of 1μ using the Stecometer.

(4) Inner Orientation

Residual of the fiducial marks were transformed to the coordinate system whose origin was the project center of the camera, and measurement of the fiducial marks of 4 corners was conducted by using the Hermert's transformation.

(5) Relative Orientation

Relative orientation was conducted by using all pricked points of model.

(6) Successive Orientation

Successive orientation was conducted using all pass points included in the common area with the adjacent model.

(7) Adjustment Computation

Simultaneous adjustment computation, forming the two Model Areas, was carried out on planimetry and height by the independent model method. All points, without any neglects of control point, were used for the adjustment computation.

2-3-2 Stereo Plotting

1) Outline of Work

Stereo plotting was conducted by stereo plotter based on results of the aerial triangulation, the field identification, etc.

2) Specifications

Plotting scale	:	1:20,000
Coverage	:	North Model Area 370km^2
		South Model Area 270km^2

Restitution instrument	:	STEREO METROGRAPH
Projection	:	UTM
Neat lines	:	20 km x 16 km (100 cm x 80 cm)
Sheet index	:	Code numbers and sheet names are shown in Fig. 2-3-1 and 2-3-2.
Sheet materials	:	Plotting sheet polyester base #300
Plotting of control points	:	Automatic drafting machine XYNETICS
Accuracy	:	Planimetry Class C Height Class C
Measuring interval for spot height	:	in every 5 cm on the map
Contour line	:	20m intermediate contour line intervals, 10m half interval contour line

3) Stereo Plotting

(1) Plotting of control points, etc.

Automatic drafting machine was used for plotting the sheet lines, control points, pass points, tie points, etc. on the plotting sheets with a plotting, error of less than 0.2 mm on the map.

(2) Orientation

The relative orientation was carried out by using 6 pass points. Results of the relative orientation residual parallax were not exceeding 0.02 mm on diapositives.

The absolute orientation was conducted by using pass points, tie points, control points, leveling points.

(3) Plotting

a) Technical instructions regarding specification for plotting were given to machine operators and explanation was made with respect to application of the symbols and specifications, practical method of the plotting and the

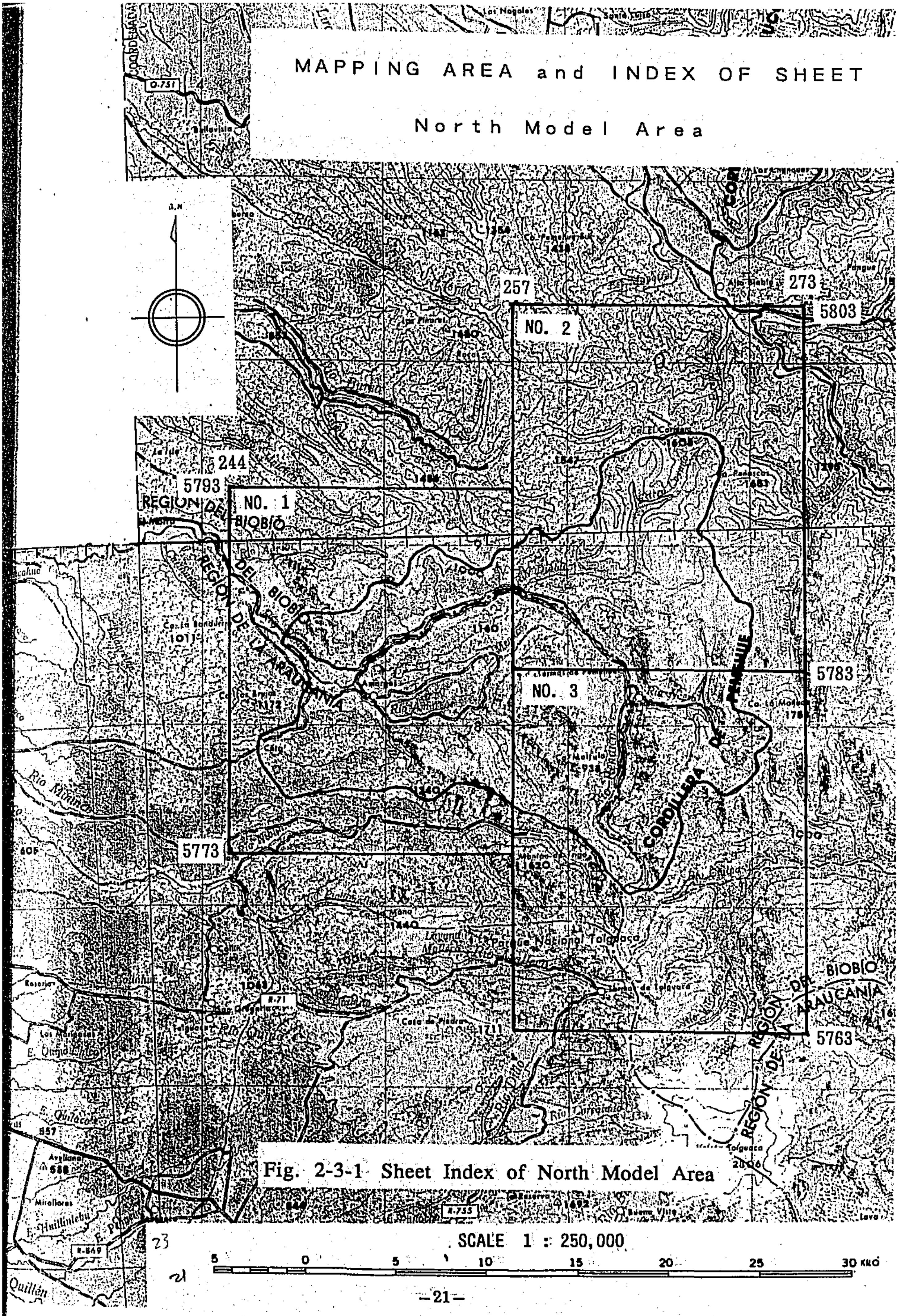


Fig. 2-3-1 Sheet Index of North Model Area

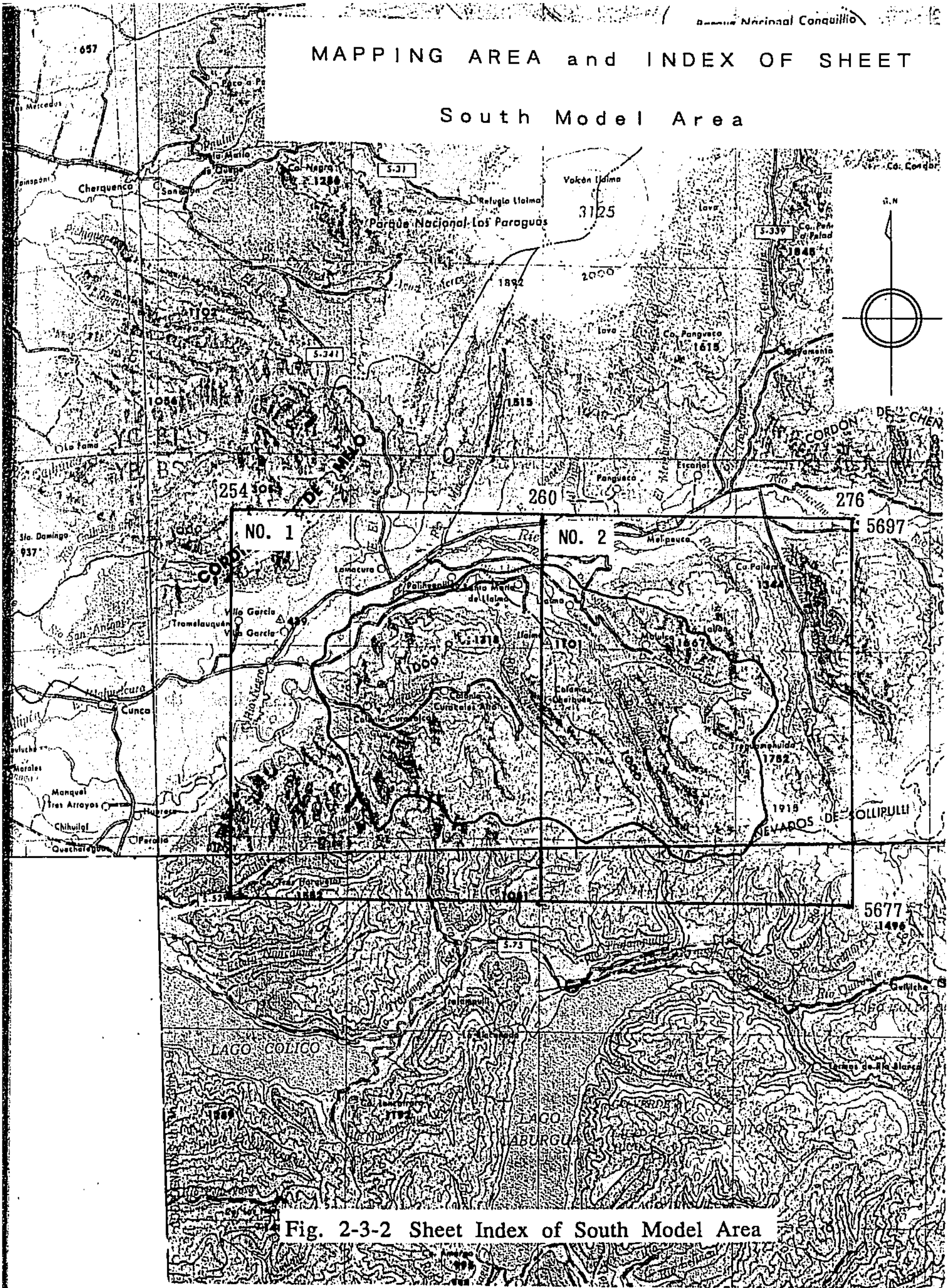


Fig. 2-3-2 Sheet Index of South Model Area

SCALE 1 : 250,000

5 0 5 10 15 20 25 30 KILO

matching, etc. so as to attain unified and homogeneous results among the operators work.

b) Plotting, based on the symbol and specifications, was carried out using the field identification results in the order of linear features (roads, rivers, etc.), buildings, vegetation and contour lines.

c) Color assignment for plotting was as follows:

Black	:	Roads compiled in true width, buildings
Red	:	Roads compiled in exaggerated width, points indicating direction , small objects, revetment
Green	:	Vegetation boundaries, vegetation symbols
Orange	:	contour lines
Violet	:	Rivers, lakes

d) In the delineation of contour lines, attention was paid so as not to sacrifice the elevation accuracy and not to deform the presentation of topography.

e) Spot heights were measured twice independently and the mean was adopted. The measuring unit of 0.1m was specified. The measuring interval for spot height was approx. 5 cm on the map including control point. The spot heights were selected according to the following principles.

- Main fork of roads
- Junction of rivers
- High points or depressions in the area
- Other points indispensable for clear topographic presentation

f) Consistency between spot height and contour line was checked.

g) Matching of sheets was made not by tie-strip but direct matching.

4) Inspection

After the completion of stereo plotting, the plotting manuscripts were checked by comparing with the aerial photos used of field identification, the data collected, the symbol and specifications, etc. Errors and omissions were corrected and supplemented respectively.

2-3-3 Compilation

(1) Outline of the work

The compilation was conducted by using the plotting manuscripts, the field identification results, etc. according to the symbols and specifications.

a) Papers

Shrink - proof papers were used for the compilation as follows:
Compilation manuscripts: Polyester base #300

b) Mechanical plotting

Neat lines, ground control points, etc. were plotted by automatic plotting machine. Discrepancy of neat lines and diagonal lines in length were limited less than 0.3 mm and 0.4 mm respectively.

(2) Compilation work

a) The compilation manuscripts were made in accordance with the JICA specifications for Overseas Surveying as well as with the symbols and specifications which were discussed and agreed between Japan and Chile. In view of the uniformity of map presentation, operational instructions were prepared for the unified compilation work.

b) The compilation was made by overlay method, and planimetric features and contoured lines were drawn on the same sheets.

c) The color assignment for the compilation was defined as follows:

Black	:	Roads compiled in true width, buildings, spot heights
Red	:	Roads compiled in exaggerated width, small features
Green	:	Vegetation boundaries, vegetation
Orange	:	Contour lines
Violet	:	Water body such as rivers, lakes, and ponds

d) The compilation was carefully carried out so as not to make any mistakes or omissions.

(3) Inspection

After the completion of the compilation work, the compilation manuscripts were checked and corrected on overlaid sheets paying attentions to the collation with the field identification photos and data, the relation between contour lines and spot heights, the conformity with the symbols and specifications, etc.

2-3-4 Drafting

(1) Outline of Work

The drafting was carried out by the inking method based on the original manuscripts of the 1:20,000 topographic map and according to its symbols and specifications which were agreed between Japan and Chile.

(2) Specifications

Scale	:	1:20,000
Number of sheets	:	5 sheets
Coverage	:	640 km^2
Neat lines	:	20 km x 16 km (100cm x 80 cm)
Drafting method	:	Inking

Materials used

Final drafting sheets : Polyester base (#500)

(3) Details of the drafting

a) The drafting of topography and planimetric features was conducted so as not to make any discrepancies in planimetry and indistinct presentation of lines.

b) Attention was paid so as to keep even density of inking for the delineation of lines.

c) For the determination of positions of annotations, attention was also paid so as not to spoil the surrounding planimetric features and grid crosses.

(4) Inspection

After the completion of the drafting, errors and omissions were then corrected and supplemented respectively.

CHAPTER 3 FOREST RESOURCES SURVEY

3-1 Interpretation of Aerial Photographs

3-1-1 Land Use and Vegetation Interpretation Criteria

The general conditions of forests and land use in each catchment in the Model Areas were examined and the preliminary interpretation of the land use and vegetation categories was conducted using aerial photographs. Table 3-1-1 gives the land use and vegetation interpretation criteria taking the need for coordination with the New Decree Law 701 on Forestry Development and the Supplementary Regulations to Legislative Decree No. 701 (Year 1974) on Forestry Development, both currently in force (and hereinafter referred to the Forestry Decrees), into consideration.

Table 3-1-1 Land Use and Vegetation Interpretation Criteria

Category			Symbol	Criteria
Forest	Natural Forest	Araucaria Forest	A	• dark tone with small round shape & uniform crown • high tree height
		Roble-Rauli-Coigue Forest	H	• irregular large crown for over-mature forest • regular shape, small crown for secondary forest
		Evergreen Forest	J	• distributed along valleys • dark tone with large & irregular shape crown • high tree height
	Man-Made Forest		F	• afforestation site with Radiata pine, Oregon pine or Eucalypts • dark tone with regular shape crown for pines • bright tone with small crown for Eucalypts
	Shrub		Vb	• Nirre forest near timber line • shrub at former forest fire site
	Treeless Land		D	• white tone, impossible to interpretate • bare land, cut-over land and rock outcrops, etc.
Non-Forest	Farmland		C	• land encircled by fences near housing
	Grassland/Bare Land		G	• white tone covering large area
	Settlement		P	• white tone mass of square shape spots
	Water bodies		L	• whitish tone of belt shape

3-1-2 Forest Type and Forest Physiognomy

3-1-2-1 Forest Type Interpretation Criteria

Most forests in the Model Areas are native forests. Araucaria forests are distributed mainly along ridges of EL 1,000m or more while over-mature Lenga (*Nothofagus pumilio*) and Coigue (*Nothofagus dombeyi*) forests are found between mid-slope and valley areas. Secondary Roble (*Nothofagus obliqua*), Rauli (*Nothofagus alpina*) and Coigue forests are widely distributed in areas below EL 1,000m.

Man-made forests of different sizes, mainly consisting of Radiata pine, are distributed around villages and are surrounded by pasture.

1) Native Forests

(1) Present Classification Used in Chile

The Forestry Decrees list 12 forest types as shown in Table 3-1-2 and stipulate the specific management method for each type of forest. The following 3 forest types were identified in the Model Areas.

a) Araucaria Forest

This is a stand where at least one Araucaria (*Araucaria araucana*) tree is observed per ha. It is found in areas of EL 1,000m or more and forms an upper storey of some 30m high, mostly in ridge areas. Lenga or Coigue is often mixed in the middle storey or understorey.

b) Roble-Rauli-Coigue Forest

This is a stand where either Roble, Rauli or Coigue or a mixture of these accounts for 50% or more of the stand area. It is generally either a young secondary forest of Roble and Rauli which is commonly seen in the North Model Area or an over-mature Coigue forest which is frequently seen in the hinterland of the South Model Area.

While Roble and Rauli are very seldom found in an over-mature Coigue forest, they are sometimes mixed in the North Model Area. In general, Roble is said to grow in lowlands with relatively good soil conditions, Rauli on slopes with a higher elevation than the area of Roble growth while Coigue is found in valleys. It is claimed that the forest composition varies depending on the slope direction but there is no clear evidence to support this claim.

Table 3-1-2 Forest Types and Main Species

Forest Type	Main Species
a) Alerce	*Fitzroya cupressoides*
b) Araucaria	*Araucaria araucana* (At least one *Araucaria araucana* per ha)
c) Ciprés de la Cordillera	*Austrocedrus chilensis*
d) Ciprés de las Guaitecas	*Pilgerodendron uvifera*
e) Coigue de Magallanes	*Nothofagus betuloides*
f) Coigue-Rauli-Tepa	*Nothofagus dombeyi, Nothofagus alpina, Laurelia philippiana* (Coigue or Rauli accounts for less than 50% of the total number of trees)
g) Lenga	*Nothofagus pumilio*
h) Roble-Rauli-Coigue	*Nothofagus obliqua, Nothofagus alpina, Nothofagus dombeyi* (One of these species accounts for 50% or more of the total number of trees of diameter 10cm or over)
i) Roble-Haulo	*Nothofagus obliqua, Nothofagus glauca* (Roble and Hualo combined accounts for 50% or more of the total number of trees)
j) Evergreen (Siempreverde)	*Nothofagus dombeyi, Nothofagus nitida, Nothofagus betuloides, Eucryphia cordifolie, Weinmannia trichosperma, Laurelia philippiana, Aextoxicon punctataum, Drymis winteri, Podocarpus nubigenus, Saxegothaea conspicua, Ammomyrtus luma, Ammomyrtus meli, Myrceugenia planipes*
k) Schlerophyllous (Escleróflio)	*Quillaja saponaria, Lithraea caustica, Cryptocaria alba, Acacia caven, Maytenus boaria, Prosopis chilensis, Beilschmiedia miersii, Peumus boldus, Kageneckia oblonga, Schinus latifolius*, others of similar geographic distribution
l) Palma chilena	*Jubaea chilensis*

Source: Supplementary Regulations to Legislative Decree No.701 (year 1974) on Forestry Development

c) Evergreen Forest (Siempreverde)

Several species normally constituting an evergreen forest were found in some valleys in the Model Areas. In general, this forest type is distributed along the west coast or in piedmont areas between Latitude 37°/38°S and 47°S.

(2) Sub-Divisions of Forest Types

In view of dealing with native forests in the Model Areas in the future, the forest types pursuant to the Forestry Decrees were further divided.

a) Araucaria Forests

Araucaria forests are classified into the following 2 sub- divisions.

① Araucaria Forest

This is a stand where Araucaria is dominant (dominant in this report means that the same species accounts for 60% or more of the crown area of the subject stand identified on the aerial photograph). In the Model Areas, this type of stand is mainly distributed along ridges at EL 1,000m or more and shows as a dark tone with, small, round, regular-shape crown on an aerial photograph image.

② Araucaria-Lenga-Coigue Forest

This is an Araucaria forest other than ① above and is mixed with Lenga and/or Coigue.

b) Roble-Rauli-Coigue Forests

4 sub-divisions were introduced for Roble-Rauli-Coigue forests.

① Secondary Roble-Rauli Forest

This is a stand with a high mixture ratio of Roble and Rauli and is dominantly a secondary forest. This type is widely distributed in areas lower than EL 1,000m, mainly in the North Model Area, and on aerial photograph shows a characteristic darkish tone crown of small and regular shape.

② Over-Mature Coigue Forest

This is a stand where Coigue is dominant and, in connection with elevation, is distributed between Roble-Rauli forest and Araucaria forest in the North Model Area and below Araucaria forest in the South Model Area. As over-mature trees are dominant, the tone is dark with an irregular crown.

③ Secondary Coigue Forest

This stand is mainly observed around over-mature Coigue forests in the South Model Area. The tone is dark with a small, irregular crown.

④ Mixed Roble-Rauli-Coigue Forest

This is a Roble-Rauli-Coigue forest other than ①, ② or ③ above and has a mixture of Roble, Rauli and Coigue. This type is widely seen in valleys and the aerial photograph shows a small, regular-shape crown.

2) Man-Made Forests

These are an afforestation area with Radiata pine, Oregon pine (*Pseudotsuga menziesii*) or Eucalypts. In the Model Areas, they occupy small sites near villages in addition to occupying a large commercial afforestation site at the western end of the North Model Area. On aerial photographs the tone of pines is dark with an irregular crown while the tone of Eucalypts is bright with a small crown.

3) Shrub

This category consists of Nirre (*Nothofagus antarctica*) forests distributed near the timber line and low shrub forests at former forest fire sites frequently observed in the South Model Area.

4) Treeless Land

This category includes bare land, cut-over land and rock outcrops, etc. and registers a white image within a forest and is difficult to interpretate.

Table 3-1-3 gives the forest type interpretation criteria taking the aforegoing forest descriptions into consideration.

Table 3-1-3 Forest Type Interpretation Criteria

Category	Forest Type by Forestry Decrees	Sub-Division	Symbol	Criteria
Native Forest	Araucaria Forest	Araucaria Forest	AP	• araucaria dominated stand • high tree height • dark tone with small, round, regular-shape crown
		Araucaria-Lenga-Coigue Forest	Am	• mixed stand with Araucaria, Lenga and Coigue • small crown and high tree height for Araucaria • Large, irregular-shape crown for Lenga and Coigue
	Roble-Rauli-Coigue Forest	Secondary Roble-Rauli Forest	HrR	• dark tone with small, regular-shape crown
		Over-Mature Coigue Forest	HC	• distributed below an Araucaria forest • high tree height • dark tone with large irregular-shape crown
		Secondary Coigue Forest	HcR	• distributed around an over-mature Coigue forest • dark tone with small, regular-shape crown
		Mixed Roble-Rauli-Coigue Forest	Hm	• mixed stand with Roble, Rauli and Coigue • small, regular-shape crown
	Evergreen Forest		NJ	• distributed in valleys • high tree height • dark tone with large irregular-shape crown
Man-Made Forest			F	• afforestation site with Radiata pine, Oregon pine or Eucalypts • dark tone with regular-shape crown for pines • bright tone with small crown for Eucalypts
Shrub			Vb	• Nirre forest near timber line • shrub at former forest fire site
Treeless Land			D	• white image in a forest which is impossible to interpretate • bare land, cut-over land and rocky land, etc.

3-1-2-2 Forest Physiognomy Interpretation Criteria

Forest physiognomy classification was introduced to be able to interpretate and estimate the stand composition and stand volume of natural forests in the Model Areas which are described in 3-1-2-1.

1) Height Classes

The height classes currently in use by the CONAF are as follows.

①	4m	-	8m
②	8m	-	12m
③	12m	-	20m
④	20m	or	higher

The tree height of widely distributed native forests in the Model Areas is more than 20m in the case of an Araucaria forest or an over-mature Coigue forest and 13-20m in the case of a secondary forest where Roble and Rauli are dominant, making height classes 2) and 3) above relatively meaningless. As a result, it was agreed with the CONAF that these 2 classes would be combined to make 3 classes instead of 4.

2) Crown Density

In the case of the crown density, the classes used by the CONAF were adopted with no change to introduce 4 classes for upper storey trees, i.e. dense, medium, sparse and very sparse.
The Forest physiognomy interpretation criteria based on the examination results in (1) and (2) above are given in Table 3-1-4.

Table 3-1-4 Forest Physiognomy Interpretation Criteria

Category	Class	Description	Symbol
Tree Height	High	20m or more	A3
	Medium	from 8m to under 20m	A2
	Low	under 8m	A1
Crown Density	Dense	75% or more	D4
	Medium	from 50% to under 75%	D3
	Sparse	from 25% to under 50%	D2
	Very Sparse	under 25%	D1

3-1-3 Interpretation of Aerial Photographs

Using the newly taken aerial photographs (January, 1991) of the scale 1/20,000, the preliminary interpretation was conducted on the land use and vegetation, forest type and forest physiognomy based on the respective criteria. The classification results based on this preliminary interpretation were verified by the field survey and the necessary alterations were made to the land use and vegetation interpretation criteria.

With regard to forest areas, the results of the inventory survey were used to revise the forest types and forest physiognomy in order to improve the interpretation accuracy.

3-2 Volume Table Preparation

3-2-1 Guidelines for Volume Table Preparation

① With regard to such exotic species at Radiata pine and Eucalypts, existing volume tables are used.

② Information on existing volume tables of native species are shown in Appendix 3.

It was agreed during discussions with the Chilean side that the existing volume tables will be used for those trees with a DBH of 50cm or more. With regard to trees with a DBH ranging between 10cm and 50cm, the existing volume tables of Roble, Rauli and Coigue will be examined with a view to preparing new volume tables if such tables are deemed necessary because of the high proportion of existing secondary forests in the Model Areas and the likelihood that the demand for small diameter trees will increase in the future as suggested by the past wood demand trend.

3-2-2 Sample Tree Survey

A survey was conducted in the Model Areas to measure sample trees with a view to collecting the data required to examine the suitability of the existing volume tables.

3-2-2-1 General Conditions of Survey Sites

In view of the conditions of the existing forest resources, availability of permission to fell trees and access conditions, etc., the following 5 sites, mainly national reserve forests in the North Model Area, were selected for the sample tree survey (see Fig. 3-2-1).

(1) Prado Menuco I

This area contains mixed native forest of Coigue, Roble and Rauli (more than 52 years old) and is located at a northern mountainside with an elevation of 320m and a gradient of 12°-27°. Roble and Rauli sample trees were measured in this site.

(2) Prado Menuco II

A mixed native forest of Roble, Rauli and Coigue (34-182 years old) exists in this site which is located at an eastern slope at the upper part of the divide between the Renaico river basin and the Amargo river basin with an elevation of 965-1,005m and a gradient of 3°-23°. Many Rauli sample trees were measured here because of the high mixture ratio of Rauli. Roble and Coigue sample trees were also measured in this site.

(3) Los Helechos

The forest in this area is composed of a mixed secondary forest of Roble and Rauli (28-37 years old). It is located at a northern mountainside with an elevation of 740m and a gradient of 16°-34°. In this area only Roble sample trees were measured.

(4) Rucue

This site has a mixed secondary forest of Coigue, Roble and Rauli (45-51 years old) and is located on a gentle slope at the lower part of a valley with an elevation of 1,000m and a gradient of 6°-8°. Coigue sample trees were measured in this site.

(5) Prado Escondido

There exist a mixed secondary forest of Coigue, Rauli and Roble (38-47 years old) in this site which is located at a southwestern slope with an elevation of 950m and a gradient of 10°-20° as part of the lowland along the Prado Escondido River, a tributary of the Amargo River. Coigue sample trees were measured here.

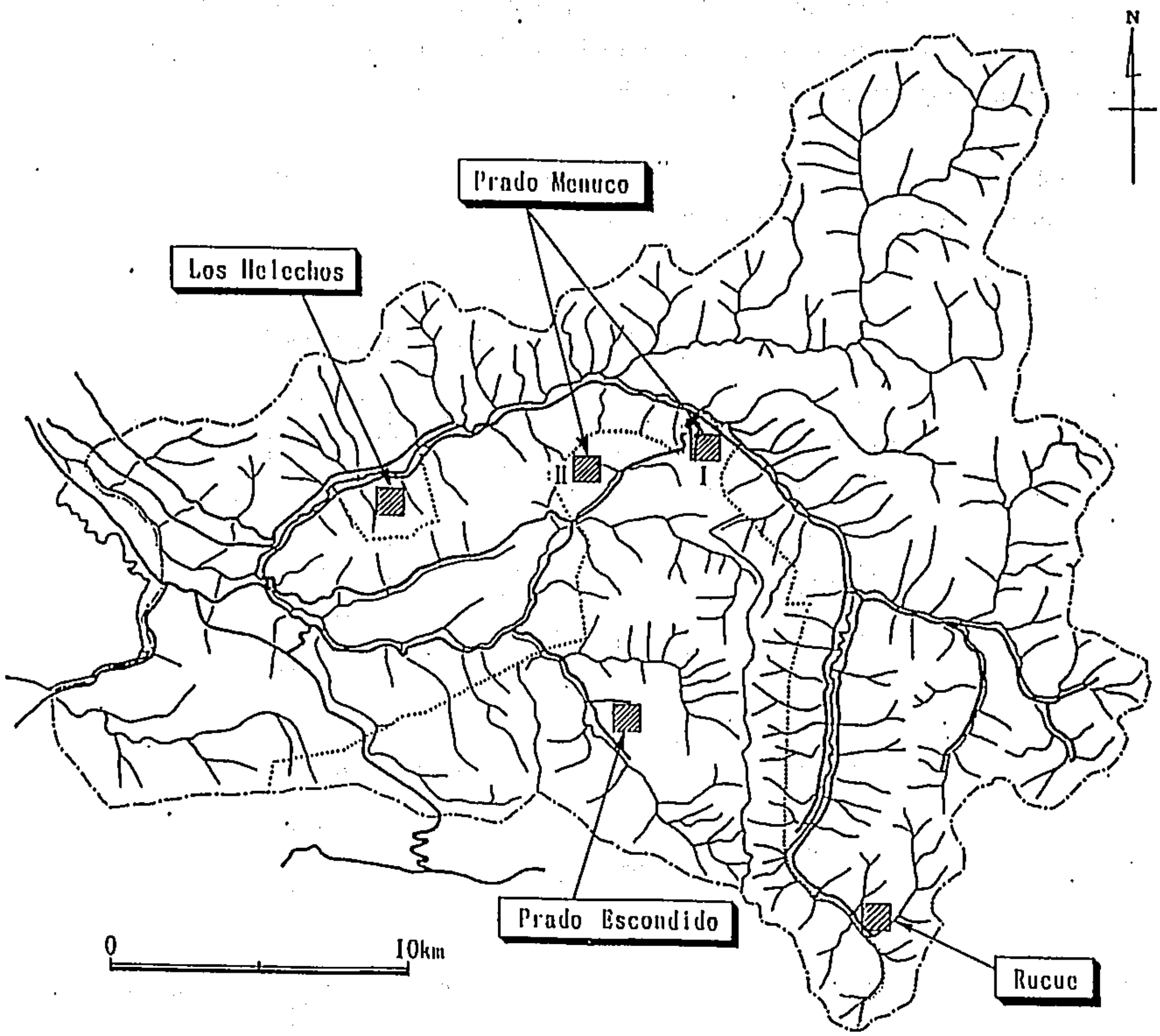


Fig. 3-2-1 Sample Tree Survey Sites

3-2-2-2 Selection of Sample Trees

The subject trees for measurement were those with a DBH of between 10cm and 50cm. As many of the existing volume tables deal with trees with a DBH of 25cm or more, conscious efforts were made to select trees with a DBH of less than 25cm to meet the purpose of the Study, i.e. emphasis placed on the selection of small diameter trees.

Table 3-2-1 gives the number of sample trees for each survey site while Table 3-2-2 gives the number of sample trees for each DBH class.

Table 3-2-1 Number of Sample Trees by Survey Site

Site	Rauli	Roble	Coigue
Prado Menuco I	14	5	3
Prado Menuco II	103	30	
Los Helechos		71	
Rucue			2
Prado Escondido			5
Total	117	106	10

Table 3-2-2 Number of Sample Trees by DBH Class

DBH Class (cm)	Rauli	Roble	Coigue
10~15	24	21	2
16~20	21	18	—
21~25	24	20	—
26~30	11	13	2
31~35	14	12	—
36~40	10	12	2
41~45	6	6	2
46~50	5	2	2
51~55	2	2	—
Total	117	106	10

3-2-2-3 Measurement Method

After felling, the DBH and tree height of each sample tree were directly measured. Table 3-2-3 below lists all the survey items.

Table 3-2-3 Sample Tree Survey Items

Survey Item	Unit	Description
1. Location	—	—
2. Species	—	—
3. Felling Height	m	uniformly set at 0.3m above the ground
4. Effective Height	m	length between felling height to point where steam diameter is 10cm
5. Total Tree Height	m	
6. Felling Height Diameter	cm	tree diameter at felling height
7. DBH	cm	tree diameter at 1.3m above the ground
8. Diameter every 4m above Felling Height	cm	tree diameter outside bark measured by diameter tape
9. Bark Thickness every 4m above Felling Height	cm	

Note: Height, diameter and bark thickness were measured to one-tenth of the basic unit.

3-2-3 Volume Table Preparation

The calculations required for volume table preparation were conducted in accordance with the flow shown in Fig. 3-2-2.

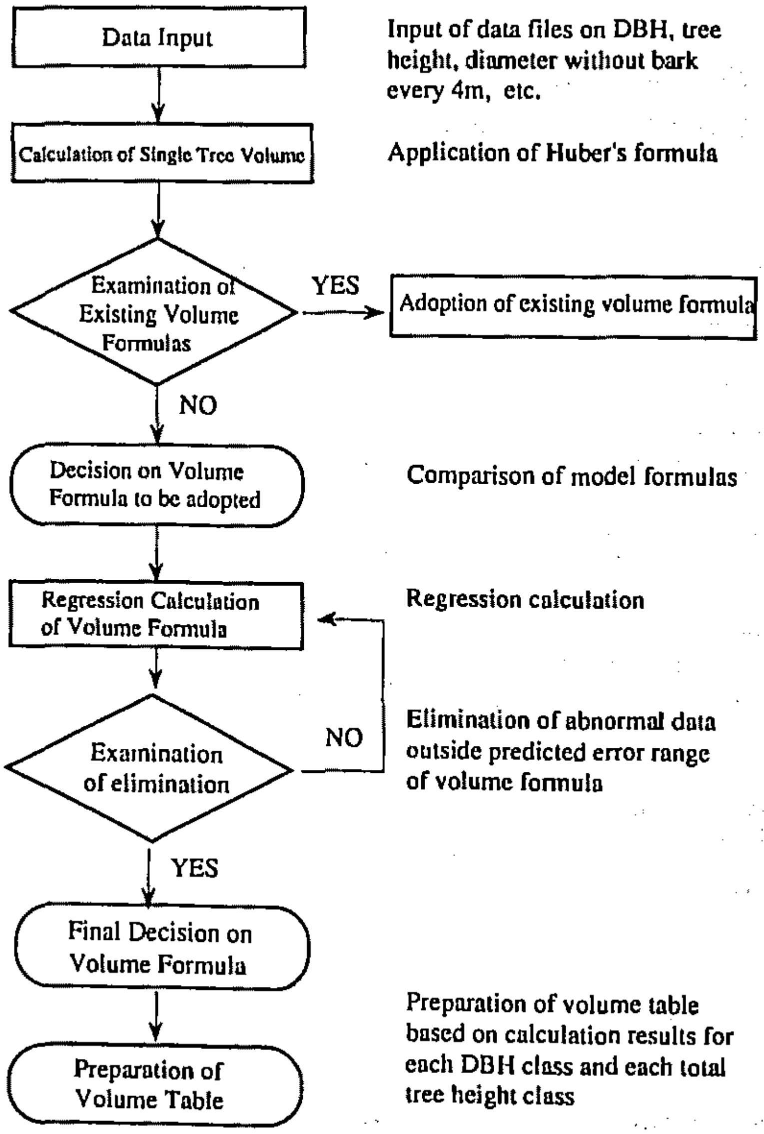


Fig. 3-2-2 Volume Table Preparation Flow

3-2-3-1 Examination of Existing Volume Formulas

The volume formulas used for compilation of the existing volume tables were examined using the sample tree data obtained in this survey.

(1) Existing Volume Formulas

The volume formulas for examination were the total stem volume formulas shown in Table 3-2-4 which were selected from various volume formulas for secondary forests of Rauli, Roble, Coigue and Tepa prepared by Dr. Hans Grosse and others of the INFOR in 1990.

Table 3-2-4 Existing Volume Formulas

Species	Volume Formulas
Rauli	$V = 0.00762 + 0.000028017D^2H$
Roble	$V = 0.02582821 + 0.000028502D^2H$
Coigue	$V = 0.01210478 + 0.000029462D^2H$

The rational for selecting these formulas is explained below.

a) Rauli Volume Formulas

There are 2 types of existing formulas for small diameter Rauli trees as shown in Appendix 3, i.e. total stem volume formula and merchantable volume formula to indicate the log volume for every 2m section of the stem. In fact, there are a total of 6 total stem formulas, i.e. one formula for each of the 5 sites in the Study Area and its surroundings (Neltume, Jauja, Melipeuco, Llancacura and Maquehua) and one general formula covering all sample trees in these 5 sites.

For the present examination of the existing volume formulas, the general formula is selected in view of the application of the examination results to the entire Study Area.

b) Roble Volume Formulas

As in the case of Rauli, there are 2 types of volume formulas for small diameter Roble trees, i.e. total stem volume formula and merchantable volume formula.

Since only one total stem formula based on sample trees in Neltume is available, this formula is selected for Roble.

c) Coigue Volume Formula

As in the case of Roble, there is only one total stem formula based on sample trees in Neltume and this formula is selected for examination purposes.

(2) Examination of Volume Formulas

a) Rauli Volume Formula

Examination of the existing volume formula was conducted to check the difference between the actual volume (VA) obtained by sectional measurement of the sample trees and the estimated volume (VE) obtained by applying the sample tree data to the existing volume formula. As the diameter of the sample trees when the existing volume formula was made was 10-40cm, the latest data were grouped into 2 diameter classes, i.e. 10-40cm and 10-50cm, for examination of the existing volume formula. Table 3-2-5 gives the examination results.

Because of $Fo > F^{1}_{n-1}(\alpha=0.01)$ for all diameter classes, the assumption that there was no significant difference between the VA and VE values with a 1% level of significance was rejected. Consequently, the existing volume formula was found to be inapplicable for the volume estimate of sample trees in the present study.

Table 3-2-5 Examination Results of Rauli Volume Formula

Item \ Diameter Class	10-50cm	10-40cm
Average of (VA-VE)	0.06800	0.05583
Unbiased Variance (U^2)	0.00861	0.00408
Number of Sample Trees (n)	117	105
Fo	62.8	80.2
$F^{1}_{n-1}(\alpha=0.01)$	6.859	6.885

b) Roble Volume Formula

The examination results of the existing Roble volume formula are given in the table below.

Table 3-2-6 Examination Results of Roble Volume Formula

Item \ Diameter Class	10-50cm	10-40cm
Average of (VA-VE)	0.03657	0.02779
Unbiased Variance (U^2)	0.00818	0.00498
Number of Sample Trees (n)	106	96
Fo	17.3	14.9
$F^1 n\text{-}1(\alpha=0.01)$	6.883	6.910

As in the case of the Rauli volume formula, the assumption that there was no significant difference between the VA and VE values with a 1% level of significance was rejected (because of $Fo>F^1 n\text{-}1(\alpha=0.01)$ for all diameter class). The existing Roble volume table was, therefore, found to be inapplicable for the volume estimate of sample trees in the present Study.

c) Coigue Volume Formula

All Coigue sample trees (in the diameter class of 10-40cm) were subject to the volume formula examination in the same way as Rauli and Roble trees. The examination results are given in the table below.

Table 3-2-7 Examination Results of Coigue Volume Formula

Item	Diameter Class (10-40cm)
Average of (VA-VE)	0.09937
Unbiased Variance (U^2)	0.009687
Number of Sample Trees (n)	7
Fo	7.14
$F^1{}_6(\alpha=0.01)$	13.7

Because of $Fo<F^1_6(\alpha=0.01)$, the assumption that there was no significant difference between the VA and VE values with a 1% level of significance could not be rejected. The existing Coigue volume formula was, therefore, found to be applicable for the volume estimate of sample trees in the present Study.

(3) Conclusion

Based on the findings described in (2) above, it was decided to prepare new volume formulas for small diameter trees of Roble and Rauli and to use the existing total stem formula for small diameter trees of Coigue.

3-2-3-2 Decision on Formulas to be Adopted

In deciding the volume formulas to be adopted, the collected data on Roble and Rauli sample trees were plotted on graphs to examine the relation between 3 factors, i.e. volume (V), DBH (D) and total tree height (H). It was found that the relation between V and D and between V and H was similar to that of a quadratic curve and proportional relation respectively for both species. It was inferred from this result that there was a strong correlation between V and the square of D and between V and the product of D and H.

As the H-D distribution chart indicated a distribution of the values of H over a wide area even with a constant D value, the adoption of a volume formula to use the product of D and H was preferable. As a result, the following 2 volume formulas were suggested.

(Formula 1) $V = a + bD^2H$

(Formula 2) $\log V = a + b \log D + c \log H$

3-2-3-3 Regression Calculation of Volume Formulas

Regression analysis of the 2 formulas suggested in 3-2-3-2 was conducted using the sample tree data for Roble and Rauli. The constant of each formula and the calculation results on the (multiple) correlation coefficient ((m)cc) and standard deviation of residuals (sd) are shown below.

Case of Rauli (*Nothofagus alpina*)

(Formula 1) $V = -0.00217 + 0.31771D^2H$
cc: 0.990152
sd: 0.07327

(Formula 2) $\log V = -4.86055 + 2.18916 \log D + 1.06172 \log H$
mcc: 0.983642
sd: 0.08845

Case of Roble (*Nothofagus obliqua*)

(Formula 1) $V = -0.00312 + 0.31722D^2H$
cc: 0.989127
sd: 0.07719

(Formula 2) $\log V = -4.79283 + 2.22167 \log D + 1.97116 \log H$
mcc: 0.986835
sd: 0.08181

In the above regression analysis, the (multiple) correlation coefficient and standard deviation of residuals were calculated using real figures for Formula 1 and logarithmic figures for Formula 2. To allow comparison of the 2 formulas, the calculation results of Formula 2 were changed to real figures to conduct another regression calculation and the following results were obtained.

Case of Rauli (*Nothofagus alpina*)

(Formula 1) cc: 0.990152 sd: 0.07327
(Formula 2) cc: 0.989696 sd: 0.07494

Case of Roble (*Nothofagus obliqua*)

(Formula 1) cc: 0.989127 sd: 0.07719

(Formula 2) cc: 0.987785 sd: 0.08178

As Formula 1, where the cc value is higher and the sd value is lower than those of Formula 2, was found to be more suitable for the present purposes, it was decided to use the formula 1, i.e. $V = a + bD^2H$.

It was also decided to eliminate abnormal data in the preparation of the preferable volume formula. All data were used for the regression calculation to check whether or not there was any extreme difference between the estimated value obtained by inserting measured data to the volume formula and the actual value. Data which resulted in the creation of an abnormal value were then eliminated.

3-2-3-4 Final Decision on Volume Formula

The results of the regression analysis using the data remaining following the elimination of abnormal data are as follows.

Rauli : $V = -0.00170 + 0.31623\ D^2\ H$
cc: 0.997417
sd: 0.0303
standard error ratio (%): 6.7
number of sample trees: 105

Roble : $V = -0.00729 + 0.31460\ D^2\ H$
c: 0.997552
sd: 0.03064
standard error ratio (%): 7.8
number of sample trees: 89

where V (m^3): stem volume without bark for section between stump height (0.3m above the ground) and top end diameter of 10cm
D (m): DBH (1.3m above the ground)
H (m): total tree height

3-2-3-5 Combined Volume Table for Rauli and Roble

Rauli and Roble are generally similar in size and are often mixed in the same stand. If there is no significant difference between the respective volume formulas for these 2 species, it is possible and preferable to introduce a common volume table to improve the efficiency of a forest inventory.

Based on the above understanding, any significant differance between the 2 regression formulas mentioned earlier was examined and the results are given in Table 3-2-8.

Table 3-2-8 Verification of Significant Difference Between Rauli and Roble Volume Formulas

	Degree of Freedom	Σx^2	Σxy	Σy^2	Residuals Degree of Freedom	Residuals Sum of Squares	Residuals Mean Square	F
Rauli	104	182.5173	57.716861	18.3463	103	0.094670		
Roble	88	167.8865	52.816703	16.6977	87	0.081671		
				Total	190	0.176341	0.000928	
				Difference of Coefficient	1	0.000288	0.000288	0.3103
Sum	192	350.4038	110.533564	35.0440	191	0.176629	0.000925	
				Difference of Constant	1	0.002834	0.002834	3.0638
Pooled	193	351.7025	111.004766	35.2149	192	0.179463		

Note: $x = D^2H$

$y = VA$

As no significant difference between the regression coefficient and regression constant of the 2 volume formulas was found, it was decided to prepare a common volume formula for Rauli and Roble as given below.

$V = -0.00416 + 0.31545\ D^2H$

cc = 0.9951

standard error = $0.0305m^3$

standard error ratio = 7.20%

Table 3-2-9 shows the volume table prepared based on the above formula.

Table 3-2-9 Common Volume Table for Rauli and Roble

VOLUMEN COBICO (m³S. S. C) DIAMETRO MENOR (C. C) ≧ 10cm

UNIT : CU. [illegible]

Height Class (M)

DBH Class	8	10	12	14	16	18	20	22	24	26	28	30	32	[illegible]
10	0.021	0.027	0.034	0.040	0.046	0.053	0.059	0.065	0.072	0.078	0.084	0.090	0.097	[illegible]
12	0.032	0.041	0.050	0.059	0.069	0.078	0.087	0.096	0.105	0.114	0.123	0.132	0.141	[illegible]
14	0.045	0.058	0.070	0.082	0.095	0.107	0.119	0.132	0.144	0.157	0.169	0.181	0.194	[illegible]
16	0.060	0.077	0.093	0.109	0.125	0.141	0.157	0.174	0.190	0.206	0.222	0.238	0.254	[illegible]
18	0.078	0.098	0.118	0.139	0.159	0.180	0.200	0.221	0.241	0.262	0.282	0.302	0.323	[illegible]
20	0.097	0.122	0.147	0.172	0.198	0.223	0.248	0.273	0.299	0.324	0.349	0.374	0.400	[illegible]
22	0.118	0.149	0.179	0.210	0.240	0.271	0.301	0.332	0.362	0.393	0.423	0.454	0.484	[illegible]
24	0.141	0.178	0.214	0.250	0.287	0.323	0.359	0.396	0.432	0.468	0.505	0.541	0.577	[illegible]
26	0.166	0.209	0.252	0.294	0.337	0.380	0.422	0.465	0.508	0.550	0.593	0.636	0.678	[illegible]
28	0.194	0.243	0.293	0.342	0.392	0.441	0.490	0.540	0.589	0.639	0.888	0.738	0.787	[illegible]
30	0.223	0.280	0.337	0.393	0.450	0.507	0.564	0.620	0.677	0.734	0.791	0.848	0.904	[illegible]
32	0.254	0.319	0.383	0.448	0.513	0.577	0.642	0.706	0.771	0.836	0.900	0.965	1.030	[illegible]
34	0.288	0.361	0.433	0.506	0.579	0.652	0.725	0.798	0.871	0.944	1.017	1.090	1.163	[illegible]
36	0.323	0.405	0.486	0.568	0.850	0.732	0.813	0.895	0.977	1.059	1.141	1.222	1.304	[illegible]
38	0.360	0.451	0.542	0.634	0.725	0.816	0.907	0.998	1.089	1.180	1.271	1.362	1.453	[illegible]
40	0.400	0.501	0.602	0.702	0.803	0.904	1.005	1.108	1.207	1.308	1.409	1.510	1.811	[illegible]
42	0.441	0.552	0.664	0.775	0.880	0.997	1.109	1.220	1.331	1.443	1.554	1.886	1.778	[illegible]
44	0.484	0.807	0.729	0.861	0.973	1.085	1.217	1.339	1.462	1.584	1.706	1.828	1.950	[illegible]
46	0.530	0.863	0.797	0.930	1.064	1.197	1.331	1.464	1.598	1.731	1.865	1.998	2.132	[illegible]
48	0.577	0.723	0.868	1.013	1.159	1.304	1.449	1.595	1.740	1.886	2.031	2.176	2.322	[illegible]
50	0.827	0.784	0.942	1.100	1.258	1.415	1.573	1.731	1.889	2.046	2.204	2.362	2.519	[illegible]

Notes: a) Without bark upto a stem diameter of 10cm.
b) Areas circled by a dotted line indicate the DBH and tree height distribution area of the sample trees used for the preparation of this volume table.

3-2-4 Preparation of Branch Volume Percent Table

1) Purpose

Data on the branch volume percent of native species are unavailable in Chile, mainly because the use of tree species found in native forests is mainly confined to the stem to produce logs of a certain diameter class or higher. Consequently, stems of a small diameter size and branches are hardly used.

However, it is necessary to identify the entire resource volume to facilitate the efficient use of wood resources to counter the decline of native forest resources. The likely

produce logs of a certain diameter class or higher. Consequently, stems of a small diameter size and branches are hardly used.
However, it is necessary to identify the entire resource volume to facilitate the efficient use of wood resources to counter the decline of native forest resources. The likely demand increase for chips in the future also necessitates accurate assessment of the entire resource volume.
As the first step, it was decided to prepare a provisional branch volume percent table for tree species in native forests using sample trees in the Model Areas in order to obtain the basic data required for the preparation of a forest management plan in the future.

2) Result

The branch volume percent vis-a-vis the stem volume was calculated based on data on 48 sample trees of Rauli, Roble and Coigue in the North Model Area using single regression analysis.

The branch volume was the volume of branches with a minimum diameter of 10cm while the stem volume was the volume of stems with a minimum diameter of 10cm providing a DBH of upto 50cm. In the case of a DBH exceeding 50cm, the minimum stem diameter to be calculated was set at 25cm. Based on a series of calculations, the following formula was obtained to indicate the relation between the branch volume and stem volume.

$y = -10.40270 + 0.41744\ x$
where y: branch volume percent (%)
x: DBH
cc: 0.86
number of sample trees: 48

By inserting the median of each 5cm unit diameter class into the above formula, the branch volume percent table shown in Table 3-2-10 was obtained. In those cases where the calculation result gave a negative value, the corresponding branch volume percent was set at zero %.

Table 3-2-10 Branch Volume Percent Table

DBH (cm)	Branch Volume Percent (%)	DBH (cm)	Branch Volume Percent (%)
10 ~ 15	0.000	111 ~ 115	36.559
16 ~ 20	0.000	116 ~ 120	38.646
21 ~ 25	0.000	121 ~ 125	40.734
26 ~ 30	1.077	126 ~ 130	42.821
31 ~ 35	3.164	131 ~ 135	44.908
36 ~ 40	5.251	136 ~ 140	46.995
41 ~ 45	7.339	141 ~ 145	49.082
46 ~ 50	9.426	146 ~ 150	51.170
51 ~ 55	11.513	151 ~ 155	53.257
56 ~ 60	13.600	156 ~ 160	55.344
61 ~ 65	15.687	161 ~ 165	57.431
66 ~ 70	17.775	166 ~ 170	59.518
71 ~ 75	19.862	171 ~ 175	61.606
76 ~ 80	21.949	176 ~ 180	63.693
81 ~ 85	24.036	181 ~ 185	65.780
86 ~ 90	26.123	186 ~ 190	67.867
91 ~ 95	28.211	191 ~ 195	69.955
96~ 100	30.298	196 ~ 200	72.042
101~ 105	32.385	201 ~ 205	74.129
106~ 110	34.472		

3-3 Forest Inventory

3-3-1 Preliminary Survey

3-3-1-1 Plot Survey

The forest inventory was conducted in the Model Areas to obtain basic data for the sampling design.

1) Survey Method

9 inventory plots were established in the Model Areas and every-tree-measurment was conducted in each plot. The minimum DBH of the subject trees was set at 10cm and the survey items were as follows.

- species
- DBH
- tree height
- effective height (height from ground upto point where tree diameter is 10cm)
- quality
- storey category
- ground conditions
- stand conditions
- topographical conditions
- plot location
- stand composition sketch

2) Survey Results

(1) Inventory Plot Shape and Size

As the Model Areas consist of mountain forests with many slopes, it was decided to adopt rectangular shape inventory plots stretching from upper part of the slope to the lower part of the slope so that each plot could represent the subject stand. The time schedule survey (explained later) found that the approach time to the plots was long because of poor access conditions. Taking this time factor into consideration, it was decided that the area of each inventory plot would be 1,000m^2 (0.1ha) in a 50m x 20m rectangular shape.

(2) Coefficient of Variation

Using the volume calculation results for the 9 inventory plots where every-tree-measurement was conducted, the coefficient of variation (C) was found to be 0.49.

$$C = \frac{S}{\overline{X}} = \frac{224.09}{458.54} = 0.49$$

where C: coefficient of variation

S: standard deviation

$\overline{X}$: mean value

3-3-1-2 Work Components Survey

The work components survey was conducted with reference to the possible survey base facilities, access conditions to the plots and possible time schedule to reach the plots.

1) Survey Base

In the North Model Area, a CONAF office and accommodation facilities are located at Los Guindos and it was found that these could be used as the survey base facilities. In the South Model Area, the accommodation facilities at Melipeuco were found to be able to serve as the survey base facilities. Consequently, it was decided that these facilities would be used as the survey base in each Model Area and that a forward base would be introduce where deemed necessary.

2) Access to Inventory Plots

Although there is a road network (hereinafter referred to as forest roads) in both Model Areas, use of the roads is extremely difficult during rain due to the soil being volcanic ash. The road surface has been eroded in many places and there are many steep slopes in the hinterland, making passage even in summer impossible for all but 4 wheel drive vehicles. These forest roads are mainly used for log transportation. Many have had no repair work since they were first opened and, therefore, only limited sections are passable by vehicles. Such road conditions mean that the survey team must travel by vehicle from the base to the nearest passable point to the inventory plot and then travel the rest of the way on foot.

3) Time Schedule Survey

The time required to gain access to each inventory plot is compiled in Appendix 4. The time schedule survey to obtain these times was conducted by dividing the entire passage into the following sections.

① Survey Base - Getting Off Point
vehicle transportation section
② Getting Off Point - Starting Point of Surveying (Access Point: AP)
section on foot to reach the clear point where pricking on the aerial photographs is possible
③ AP - Starting Point of inventory Plot (SP)
section where clearing of the vegetation which limits the eye site and surveying work will be conducted, starting from AP to SP
④ Inventory Plot Set-Up Work
⑤ Tree Measuring Work in Plot

The required time to complete an inventory plot survey largely varies depending on the access conditions, distance required for clearing the vegetation and surveying, conditions of undergrowth, topographical conditions and number of survey team members, etc. The average time spent to complete a survey in one inventory plot was 6.7 hours (with 10 survey team members), consisting of 3.6 hours (54%) for access, 1.3 hours (19%) for vegetation clearing, surveying and plot set-up work, 1 hour (15%) for tree measuring and 0.8 hours (12%) for regeneration survey. The most time consuming component was access to the plot.

As the plots selected this time are located in areas with relatively good access, the plot survey time will be much longer for plots located in the hinterland, necessitating the introduction of forward bases to shorten the access time.

In short, the inventory plot survey completion rate will be 1 or 1.5 inventory plots/day based on 8 hours work/day and taking the necessary set-up time for a forward base and unexpected constraints due to weather conditions, etc. into consideration.

3-3-2 Sampling Design

With regard to the plot sampling method to estimate the total stand volume of the native forests in the Model Areas, a simple random sampling method was adopted to calculate the number of required inventory plots using preliminary survey results. These plots were then distributed for each forest type. Details of the method used are given below.

1) Target accuracy
   Confidence level : 95%
   Acceptable sampling error : below 15%
2) Number of inventory plots
   Minimum required : 84

$$n = \left(\frac{tcs}{E}\right)^2 = \left(\frac{2x0.49x1.4}{0.15}\right)^2$$

$$= 83.66$$

$$\fallingdotseq 84$$

n : number of inventory plots
t : confidence coefficient (2, confidence level 95%)
c : coefficient of variation (0.49)
E : acceptable sampling error (15%)
s : safety factor (40%)

3) Inventory Plot Distribution

A simple forest type map was prepared based on the provisional forest type boundaries interpretated from the aerial photographs as a forest base map (scale: 1/20,000) is not yet available. A grid was overlaid on this simple forest type map and nodal points (intersection points) were used to set up the plot locations. The locations of the nodal points were decided using the table of random sampling and the total number of nodal points for each forest type was in principle the same as the required number of plots, in turn decided based on the relative area of each forest type. However, the total number of nodal points selected was 92 to include reserve points as it was assumed that the survey may not be feasible at some of the selected sites due to impossible access or other reasons.

4) Marking of Inventory Plots on Aerial Photographs

Prior to the field survey, the selected plot sites indicated by the relevant nodal points and access points from which the approach to the selected plot sites would be made were marked on the aerial photographs and the surveying routes and the distances between the access points and the plots were analysed.

3-3-3 Field Survey

(1) Field Reconnaissance

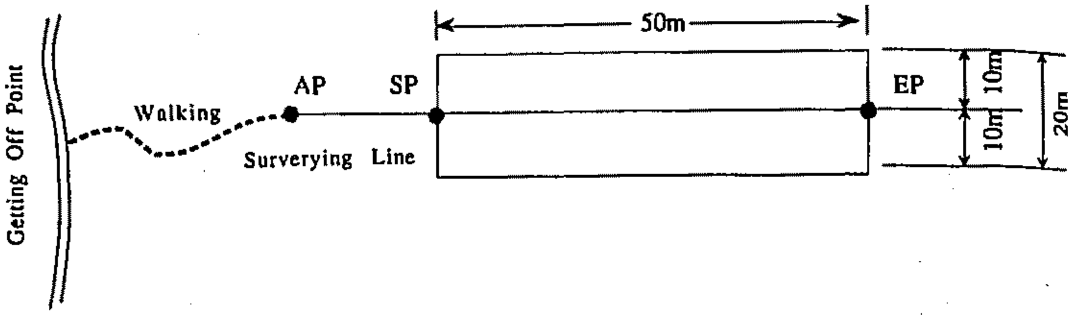
Field reconnaissance was conducted as part of the inventory plot survey to check the base location, prospect of smooth material procurement, possibility of locally employing workers, access conditions and plot locations.

(2) Inventory Plot Survey

a) Setting-Up of inventory Plots

In accordance with the sampling design contents, 92 rectangular inventory plots of 0.1ha each were set up following appropriate surveying of the planned locations and further confirmation of the locations using aerial photographs.

A post inscribed with such necessary information as the inventory plot number was erected at each of the APs, SPs and EPs shown in Fig. 3-3-1.



AP (Acess Point) ... : point from which acess to the inventory plot is possible

SP (Starting Point) ... : point from which the inventory plot starts

EP (End Point) ... : point from which the inventory plot ends

__________ ...... : surveying line

• ...... : post location

Fig. 3-3-1 Setting-Up of Inventory Plot

b) Plot Survey

The items recorded and surveyed and method of the plot survey are as follows.

1. Inventory Plot Number
2. Survey Date
3. Aerial Photograph Number
4. Place Name
5. Forest Type and Forest Physiognomy
6. Fieldnote Recording Person's Name
7. Ground Conditions

- Elevation : average elevation of plot
- Gradient : average gradient of slope where plot is located
- Bearing : slope bearing expressed in 8 directions

8. Ground Sketch Map
9. Stand Profile
10. Stand Conditions (Every-Tree-Measurement Data)

- Species : common names (local names) of observed species
- DBH : minimum DBH 10cm, measured 1.3m from the ground to nearest 2cm using a calliper or diameter tape
- Total Tree Heigh : height from ground to tree top to nearest metre measured using a hypsometer
- Effective Height : height from ground to point where trunk diameter is 25cm of those trees of which DBH is 50cm or more to nearest metre
- Quality : classified into one of following 3 groups, mainly based on tree form
  ① straight, healthy tree with no faults
  ② usable tree despite some faults
  ③ unusable tree because of faults
- Storey Classification : based on comparison result with trees in surrounding areas
- Regeneration : either natural seeding or coppicing to be determined for each tree

The findings of the above survey items were recorded in the corresponding columns of the Plot Survey Fieldnotes shown in Figs. 3-3-2 and 3-3-3.

FOREST INVENTORY FIELD NOTE

(Plot Size 20m x 50m)

Parcela No. ____. Fecha ____________. Area Modelo: Sur ☐ , Norte ☐

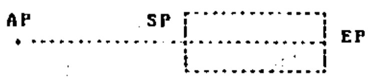
Foto Aérea No.________________________. Lugar______________________________.

Tipo de Bosque____________. Responsabilidad______________________________.

Elevación _______m. Tipo de Regeneración: Semilla ☐ , Retoño ☐

Pendiente _____grado. Exposición_______.

Descripción de parcela(localización y topografía)



Perfil de vegetación(sección a lo largo de parcela)

Fig. 3-3-2 Forest Inventory Fieldnote (1)

FOREST INVENTORY FIELD NOTE

Fecha__________. Parcela No. _____. Area Modelo: Norte ☐ , Sur ☐

No.	Arb. No.	Especie	DAP (cm)	Altura (m)		Calidad 1~3	Piso		Origen reg.		Volumen	Observación
				Comer. hasta ϕ 25cm	Total		Su	If	S	R		
1												
2												
3												
4												
5												
6												
7												
8												
9												
0												
1												
2												
3												
4												
5												
6												
7												
8												
9												
0												

1) Clase de calidad; 1. Sin ningún defecto con forma recta y cilíndrica.
2. Con defecto parcial y/o su forma moderadamente torcida
3. Con defecto generalizado y/o pronunciadamente torcida
2) Piso; If. Inferior, Su, Superior
3) Origen de regerenación; S. Semilla, R. Retoño

Fig. 3-3-3 Forest Inventory Fieldnote (2)

3-3-4 Inventory Plot Survey Results

1) Number of Inventory Plots and Their Locations

Based on the field survey results, 92 inventory plots were established and their breakdown by forest type is shown in Table 3-3-1.

Table 3-3-1 Number of Inventory Plots by Forest Type

Forest Type as Defined by Forestry Decrees	Sub-Division	Symbol	No.of Plots
Araucaria Forest	Araucaria Forest	AP	4
	Araucaria-Lenga-Coigue Forest	Am	2
Roble-Rauli-Coigue Forest	Secondary Roble-Rauli Forest	HrR	33
	Over-Mature Coigue Forest	HC	27
	Secondary Coigue Forest	HcR	9
	Mixed Roble-Rauli-Coigue Forest	Hm	15
Evergreen Forest		NJ	2
Total			92

Location of inventory plots in the North and South Model Areas are shown in figures 3-3-4 and 3-3-5 respectively.

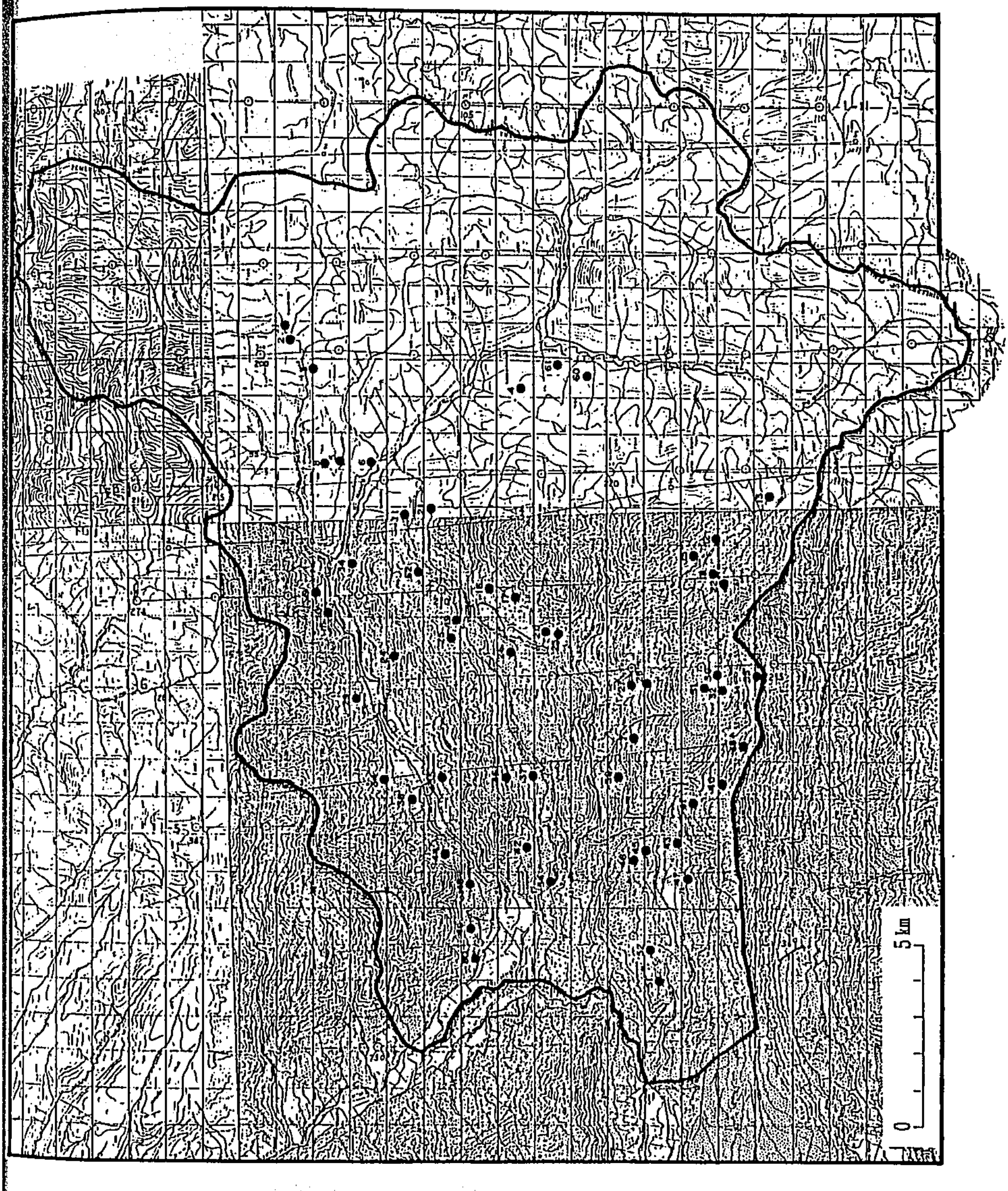


Fig. 3-3-4 Inventory Plot Locations in North Model Area

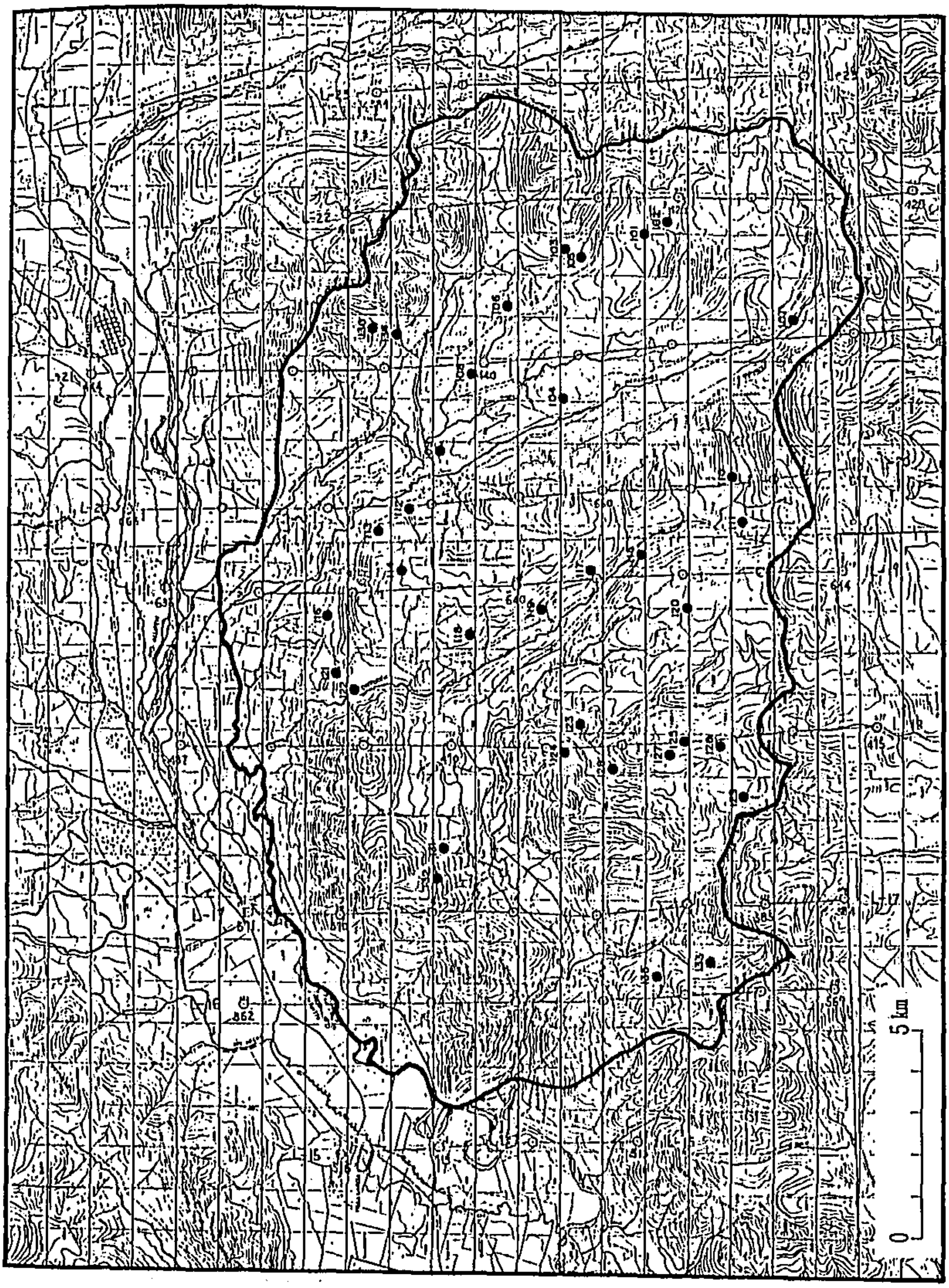


Fig. 3-3-5 Inventory Plot Locations in South Model Area

2) Inventory Plot Survey Result Tables

Tables 3-3-2/3 show the inventory plot survey results on the average DBH, average tree height, number of trees/ha and volume/ha for each plot.

Table 3-3-2 Inventory Plot Survey Results (North Model Area)

PLOT NO.	FOREST TYPE	OVERSTOREY N/ha*	OVERSTOREY Ave. DBH (cm)	OVERSTOREY Ave. HEIGHT (m)	OVERSTOREY VOLUME (cu.m/ha)	UNDERSTOREY N/ha*	UNDERSTOREY Ave. DBH (cm)	UNDERSTOREY Ave. HEIGHT (m)	UNDERSTOREY VOLUME (cu.m/ha)	TOTAL N/ha*	TOTAL VOLUME (cu.m/ha)
1	HrR A2D3	390	17.7	15.1	62.27	910	11.2	8.0	40.22	1300	102.49
2	HrR A2D3	470	16.0	12.3	49.73	520	11.1	8.6	17.74	990	67.47
3	HrR A2D4	570	19.5	15.4	124.15	1210	12.3	8.2	65.54	1780	189.69
4	HrR A1D2	200	18.0	7.7	17.21	140	12.1	5.8	4.40	340	21.61
5	HrR A2D4	1140	17.7	14.1	190.91	1010	12.4	9.2	56.14	2150	247.05
6	Hm A2D4	200	25.2	15.3	77.89	1250	14.7	9.2	106.07	1450	183.96
7	Hc A3D3	50	105.2	24.6	437.20	340	15.5	7.5	30.12	390	467.32
8	Hm A2D4	670	22.6	17.9	179.39	700	12.5	11.2	44.21	1370	223.60
9	Hm A2D4	410	23.9	17.2	134.57	1340	13.1	10.0	97.30	1750	231.87
10	HcR A2D4	330	23.8	16.2	135.40	1040	11.1	10.4	55.55	1370	190.95
11	HrR A3D4	220	50.4	20.8	335.90	930	14.9	8.6	68.19	1150	404.09
12	Hm A2D3	40	51.0	16.7	54.35	840	14.4	10.3	67.69	880	122.04
13	Hc A3D4	200	59.1	23.3	473.23	70	23.1	14.3	28.13	270	501.36
14	HrR A2D2	270	16.9	11.3	31.06	550	11.3	8.2	19.55	820	50.61
15	HrR A2D4	570	21.6	15.2	150.23	510	13.6	12.5	38.61	1080	188.84
16	Hc A3D3	50	80.8	28.6	278.90	650	15.9	8.5	63.46	700	342.36
17	HrR A2D4	480	27.6	17.4	217.97	490	17.2	13.2	68.60	970	286.57
18	Hc A3D4	190	57.5	24.6	539.58	70	22.6	9.6	11.97	260	551.55
19	HrR A2D4	850	16.2	13.0	94.67	400	11.9	10.4	20.04	1250	114.71
20	HrR A2D3	130	37.8	14.0	109.49	900	13.0	7.2	41.29	1030	150.78
21	HrR A2D4	200	43.3	18.7	216.02	470	14.3	7.6	35.02	670	251.04
22	HcR A2D3	460	26.4	14.4	161.01	480	14.5	10.2	38.40	920	199.41
23	HrR A2D2	530	11.7	8.7	19.53	30	10.0	5.3	0.87	560	20.40
24	HrR A2D3	540	14.1	12.0	44.05	1300	11.7	7.8	58.61	1840	102.66
25	Hm A2D3	120	31.7	19.0	76.21	530	12.5	8.3	27.38	650	103.59
26	Hm A2D4	620	24.8	19.1	260.38	350	14.1	12.1	31.05	970	291.43
27	HrR A2D3	90	47.1	17.5	118.43	550	13.3	7.3	28.36	640	146.79
28	Hc A3D3	60	79.3	22.7	251.23	430	17.7	7.2	77.54	490	328.77
29	HrR A2D4	600	21.1	15.8	152.26	300	14.5	10.3	24.06	900	176.32
30	A A2D2	90	61.7	13.5	145.31	250	25.6	5.9	42.76	340	188.07
31	A A2D4	200	55.9	12.7	241.97	700	17.5	6.3	69.46	900	311.43
32	Am A2D3	200	42.1	14.9	205.91	70	31.7	7.7	26.20	270	232.11
33	Hc A3D3	170	66.5	20.8	583.68	300	16.8	10.5	36.85	470	620.53
34	HrR A2D4	610	19.1	15.1	121.90	890	11.9	10.1	44.77	1500	166.67
35	HrR A2D2	370	14.3	10.6	26.97	190	11.2	8.0	5.42	560	32.39
36	HrR A2D3	330	20.6	14.6	70.67	190	12.8	10.1	11.98	520	82.65
37	HrR A2D4	850	16.0	15.6	118.31	690	10.8	9.1	30.13	1540	148.44
38	HrR A2D3	180	29.3	14.4	60.13	1250	12.4	7.4	85.19	1430	145.32
39	HrR A2D3	320	17.2	14.8	50.76	500	11.8	7.7	20.48	820	71.24
40	Hc A2D4	210	46.7	16.7	466.82	420	12.0	8.0	19.91	630	486.73
41	HrR A2D3	340	16.3	10.7	58.04	470	12.1	6.9	16.85	810	74.89
42	HrR A2D4	450	16.5	13.5	73.86	760	11.6	8.9	34.32	1210	108.18
43	Hc A2D3	50	61.2	19.6	154.96	540	22.1	8.7	117.09	590	272.05
44	Hm A2D4	800	21.7	12.9	185.30	1090	14.3	7.6	72.39	1890	257.69
45	HcR A2D3	170	31.8	15.5	198.57	690	14.7	9.2	58.32	860	254.89
46	HrR A2D4	850	14.2	11.8	71.70	380	11.7	9.4	15.18	1230	86.88
47	Hc A3D4	90	85.6	23.8	546.13	730	14.4	7.7	52.28	820	598.41
48	HrR A2D4	710	20.9	14.3	158.55	730	12.6	8.5	38.34	1440	196.89
49	HrR A2D3	490	20.4	15.1	102.34	260	12.3	8.8	21.30	750	123.64
50	HrR A2D3	190	28.2	19.8	84.26	170	12.7	9.6	10.48	360	94.74
51	HrR A2D3	110	48.0	19.0	131.29	70	34.0	12.0	35.24	180	166.53
52	Hm A3D3	230	32.3	22.0	266.59	930	14.8	9.0	80.02	1160	346.61
53	A A3D4	120	85.3	27.0	503.50	300	30.8	12.0	132.89	420	636.39
54	HcR A3D4	400	31.0	24.8	321.99	550	17.1	12.9	86.97	950	408.96
60	Hm A1D3	730	11.9	7.7	31.52	140	11.7	4.9	5.17	870	36.69
61	Hm A2D4	790	14.4	9.0	47.37	880	11.6	4.0	34.69	1670	82.06
62	Hc A3D3	110	53.1	21.2	220.76	600	15.1	9.3	56.44	710	277.20

*N/ha : Number of trees/ha

Table 3-3-3 Inventory Plot Survey Results (South Model Area)

PLOT NO.	FOREST TYPE	OVERSTOREY				UNDERSTOREY				TOTAL	
		N/ha*	Ave. DBH (cm)	Ave. HEIGHT (m)	VOLUME (cu.m/ha)	N/ha*	Ave. DBH (cm)	Ave. HEIGHT (m)	VOLUME (cu.m/ha)	N/ha*	VOLUME (cu.m/ha)
101	Am A3D4	330	42.0	23.5	477.90	170	14.7	7.8	11.18	500	489.08
102	A A3D4	110	77.8	20.2	498.83	250	20.6	9.8	50.32	360	549.15
103	Hc A3D3	60	96.3	27.2	373.96	80	32.7	10.7	36.63	140	410.59
104	HcR A2D3	660	21.1	16.0	180.15	440	12.4	9.7	24.95	1100	205.10
105	Hc A2D3	100	55.6	19.2	309.50	270	18.2	9.1	79.48	370	388.98
106	HrR A2D4	540	26.7	18.7	241.88	390	13.1	11.9	27.56	930	269.44
107	Hc A3D3	50	84.0	23.4	274.16	190	39.7	11.1	119.34	240	393.50
108	Hm A2D3	500	14.6	10.3	48.85	140	10.4	7.1	5.14	640	53.99
109	Hm A2D4	190	37.1	16.1	190.56	620	14.0	8.8	46.78	810	237.34
110	HcR A2D4	1270	15.8	11.4	163.41	540	11.8	3.0	26.67	1810	190.08
111	Hc A3D2	30	46.0	24.0	29.81	260	25.4	8.8	73.74	290	103.55
112	Hm A2D2	140	17.7	11.4	23.85	550	11.7	6.5	20.92	690	44.77
113	Hm A2D3	340	21.4	11.5	64.64	980	15.1	6.7	65.24	1320	129.88
114	Hc A3D4	140	92.8	27.6	759.04	50	22.0	7.8	15.41	190	774.45
115	Hc A3D4	90	59.7	25.1	245.06	490	25.8	11.7	206.84	580	451.90
116	HrR A2D2	130	27.7	13.1	47.27	60	15.3	6.5	4.08	190	51.35
117	Hc A3D4	60	96.0	28.5	400.91	250	43.4	16.2	244.90	310	645.81
118	Hc A3D4	40	127.5	29.7	463.62	600	22.0	8.4	123.18	640	586.80
119	HcR A2D4	1710	13.0	10.5	117.81	750	11.2	8.2	32.56	2460	150.37
120	Hc A3D4	110	67.8	24.8	308.73	40	43.0	13.3	28.75	150	337.48
121	HrR A2D4	270	35.0	19.1	198.34	350	16.6	10.0	37.67	620	236.01
122	Hm A2D3	600	17.6	10.5	87.47	800	12.2	7.4	39.13	1400	126.60
123	Hc A2D4	120	54.5	19.3	219.40	640	21.6	10.1	142.66	760	362.06
124	NJ A2D2	70	52.6	13.3	83.47	220	15.6	6.0	16.59	290	100.06
125	Hc A3D4	40	118.5	21.5	321.15	270	27.0	8.7	99.32	310	420.47
126	Hc A3D4	60	120.6	25.1	610.21	490	24.0	9.8	147.75	550	757.96
127	Hc A3D4	140	78.4	20.6	507.39	90	32.7	12.3	49.34	230	556.73
128	HcR A2D4	1560	15.8	13.4	221.57	810	11.1	9.9	41.19	2370	262.76
129	Hc A3D3	50	97.2	24.0	274.81	140	28.7	10.1	50.63	190	325.44
130	Hc A3D4	90	86.2	22.3	369.58	190	17.7	7.4	23.02	280	392.60
131	NJ A3D3	30	102.0	23.3	190.37	470	21.4	8.6	123.49	500	313.86
132	Hc A2D4	180	56.2	17.2	272.66	440	23.5	9.2	98.53	620	371.19
133	HcR A2D4	1800	15.6	10.4	177.41	640	11.4	7.2	26.45	2440	203.86
134	HrR A3D4	720	27.2	20.6	374.36	710	14.6	14.8	75.60	1430	449.96
135	Hc A3D4	50	102.0	27.4	457.38	150	35.3	11.7	84.79	200	542.17

*N/ha : Number of trees/ha

3) Tree Species

A total of 21 tree species were identified by the inventory plot surveys as shown in Table 3-3-4. Table 3-3-5 shows the distribution of the identified tree species by forest type.

Table 3-3-4 Identified Tree Species

No.	Tree Species	
	Local Name	Scientific Name
1	Araucaria	*Araucaria araucana*
2	Arrayán	*Luma apiculata*
3	Avellano	*Gevuina avellana*
4	Azara	*Azara sp.*
5	Canelo	*Drymis winteri var.andina*
6	Coigue	*Nothofagus dombeyi*
7	Corcolén	*Azara lanceolata*
8	Lenga	*Nothofagus pumilio*
9	Lingue	*Persea Lingue*
10	Maitén	*Maytenus disticha* or *Maytenus magellanica*
11	Mañío	*Saxegothaea conspicua*
12	Notro	*Embothrium coccineum*
13	Olivillo	*Aextoxicon punctatum*
14	Peumo	*Cryptocarya alba*
15	Piñol	*Lomatia dentata*
16	Radal	*Lomatia hirsuta*
17	Raulí	*Nothofagus alpina*
18	Roble	*Nothofagus obliqua*
19	Tepa	*Laurelia philippiana*
20	Tineo	*Weinmannia trichosperma*
21	Trevo	*Dasyphyllum diacanthoides*

Table 3-3-5 Distribution of Tree Species by Forest Type

No.	Species (Local Name)	Forest Type						
		AP	Am	HrR	Hc	HcR	Hm	NJ
1	Araucaria	+	+					
2	Arrayán			+	+			
3	Avellano			+	+	+	+	
4	Azara			+	+		+	
5	Canelo				+		+	
6	Coigue	+		+	+	+	+	+
7	Corcolén			+			+	
8	Lenga	+	+		+			
9	Lingue			+	+	+	+	
10	Maitén			+	+			
11	Mañío				+	+		+
12	Notro			+				
13	Olivillo			+	+	+	+	
14	Peumo						+	
15	Piñol			+	+	+	+	
16	Radal			+	+	+	+	
17	Raulí			+	+	+	+	
18	Roble			+	+	+	+	
19	Tepa			+	+	+	+	+
20	Tineo				+			
21	Trevo			+	+		+	+

4) Inventory Plot Survey Results by Forest Type

The survey results on the average DBH, average tree height, number of trees/ha and volume/ha by forest type are shown in Tables 3-3-6/12.

Table 3-3-6 Inventory Plot Survey Results for AP Type (Number of Plots: 4)

SPECIES	OVERSTOREY				UNDERSTOREY				TOTAL	
	Number of Trees per Ha	Ave. DBH (cm)	Ave. Height (m)	Volume (m^3/ha)	Number of Trees per Ha	Ave. DBH (cm)	Ave. Height (m)	Volume (m^3/ha)	Number of Trees per Ha	Volume (m^3/ha)
ARAUCARIA	108	73.4	18.7	331.77	207	20.3	6.7	27.35	315	359.12
ARRAYAN										
AVELLANO										
AZARA										
CANELO										
COIGUE	10	62.0	13.3	10.92	85	26.1	9.7	29.26	95	40.18
CORCOLEN										
LENGA	13	30.0	13.2	4.72	82	22.3	9.4	17.24	95	21.96
LINGUE										
MAITEN										
MAÑIO										
NOTRO										
OLIVILLO										
PEUMO										
PIÑOL										
RADAL										
RAULI										
ROBLE										
TEPA										
TINEO										
TREVO										
TOTAL	131	68.3	17.7	347.41	374	22.0	8.0	73.85	505	421.26

Table 3-3-7　Inventory Plot Survey Results for Am Type (Number of Plots: 2)

SPECIES	OVERSTOREY				UNDERSTOREY				TOTAL	
	Number of Trees per Ha	Ave. DBH (cm)	Ave. Height (m)	Volume (m³/ha)	Number of Trees per Ha	Ave. DBH (cm)	Ave. Height (m)	Volume (m³/ha)	Number of Trees per Ha	Volume (m³/ha)
ARAUCARIA	20	94.0	23.3	104.21	45	19.6	4.0	3.51	65	107.72
ARRAYAN										
AVELLANO										
AZARA										
CANELO										
COIGUE										
CORCOLEN										
LENGA	245	37.8	20.0	237.70	75	19.7	10.0	15.18	320	252.88
LINGUE										
MAITEN										
MAÑIO										
NOTRO										
OLIVILLO										
PEUMO										
PIÑOL										
RADAL										
RAULI										
ROBLE										
TEPA										
TINEO										
TREVO										
TOTAL	265	42.0	20.2	341.91	120	19.7	7.8	18.69	385	360.60

Table 3-3-8　Inventory Plot Survey Results for HrR Type (Number of Plots: 33)

SPECIES	OVERSTOREY				UNDERSTOREY				TOTAL	
	Number of Trees per Ha	Ave. DBH (cm)	Ave. Height (m)	Volume (m³/ha)	Number of Trees per Ha	Ave. DBH (cm)	Ave. Height (m)	Volume (m³/ha)	Number of Trees per Ha	Volume (m³/ha)
ARAUCARIA										
ARRAYAN					1	12.0	4.0	0.01	1	0.01
AVELLANO	2	50.0	13.4	0.59	121	12.1	7.2	6.19	123	6.78
AZARA					1	10.0	5.5	0.02	1	0.02
CANELO										
COIGUE	5	25.3	14.6	1.63	6	13.5	9.8	0.46	11	2.09
CORCOLEN					1	14.0	6.0	0.01	1	0.01
LENGA										
LINGUE	12	13.1	11.9	1.50	113	12.3	8.3	6.44	125	7.94
MAITEN					1	12.0	7.0	0.03	1	0.03
MAÑIO										
NOTRO					1	14.0	8.0	0.02	1	0.02
OLIVILLO					2	20.0	8.0	0.36	2	0.36
PEUMO										
PIÑOL					16	11.4	6.6	0.71	16	0.71
RADAL	2	16.0	9.0	0.18	28	12.3	6.8	1.38	30	1.56
RAULI	282	20.0	14.6	68.16	152	13.3	11.2	10.44	434	78.60
ROBLE	138	22.3	15.0	46.20	71	12.9	9.2	3.70	209	49.90
TEPA	5	20.2	14.4	1.26	28	14.0	9.1	2.28	33	3.54
TINEO										
TREVO					12	14.9	6.2	0.74	12	0.74
TOTAL	446	20.7	14.6	119.52	554	12.7	8.8	32.79	1,000	152.31

Table 3-3-9 Inventory Plot Survey Results for Hc Type (Number of Plots: 27)

SPECIES	OVERSTOREY				UNDERSTOREY				TOTAL	
	Number of Trees per Ha	Ave. DBH (cm)	Ave. Height (m)	Volume (m³/ha)	Number of Trees per Ha	Ave. DBH (cm)	Ave. Height (m)	Volume (m³/ha)	Number of Trees per Ha	Volume (m³/ha)
ARAUCARIA										
ARRAYAN					1	34.0	10.0	0.14	1	0.14
AVELLANO					56	14.9	7.9	4.40	56	4.40
AZARA					1	11.0	5.5	0.05	1	0.05
CANELO					1	12.0	6.0	0.01	1	0.01
COIGUE	57	86.9	25.0	323.26	27	20.0	10.2	5.69	84	328.95
CORCOLEN										
LENGA	3	50.0	22.1	3.39	3	46.6	14.0	2.37	6	5.76
LINGUE					1	16.7	8.7	0.10	1	0.10
MAITEN					1	13.0	4.5	0.06	1	0.06
MAÑIO	7	68.9	18.6	14.52	102	28.9	10.3	42.05	109	56.57
NOTRO										
OLIVILLO	1	42.0	13.0	0.27	9	13.4	8.2	1.45	10	1.72
PEUMO										
PIÑOL					10	14.4	7.7	0.81	10	0.81
RADAL					1	11.0	5.5	0.03	1	0.03
RAULI	16	37.0	17.3	12.63	37	16.2	10.4	4.87	53	17.50
ROBLE	6	45.2	22.0	8.26	2	26.4	8.6	0.39	8	8.65
TEPA	6	60.7	17.4	11.39	53	20.9	9.2	11.81	59	23.20
TINEO	1	64.0	19.5	2.20	5	23.6	10.8	3.04	6	5.24
TREVO					14	15.7	6.3	1.18	14	1.18
TOTAL	97	71.6	22.5	375.92	324	21.6	9.3	78.45	421	454.37

Table 3-3-10 Inventory Plot Survey Results for HcR Type (Number of Plots: 9)

SPECIES	OVERSTOREY				UNDERSTOREY				TOTAL	
	Number of Trees per Ha	Ave. DBH (cm)	Ave. Height (m)	Volume (m³/ha)	Number of Trees per Ha	Ave. DBH (cm)	Ave. Height (m)	Volume (m³/ha)	Number of Trees per Ha	Volume (m³/ha)
ARAUCARIA										
ARRAYAN										
AVELLANO					39	11.3	8.7	1.92	39	1.92
AZARA										
CANELO										
COIGUE	909	17.3	12.8	177.27	474	12.4	8.9	30.40	1,383	207.67
CORCOLEN										
LENGA										
LINGUE					62	13.4	9.7	4.69	62	4.69
MAITEN										
MAÑIO	1	56.0	13.0	0.89					1	0.89
NOTRO										
OLIVILLO					9	17.8	8.6	0.92	9	0.92
PEUMO										
PIÑOL					7	12.7	6.8	0.33	7	0.33
RADAL					2	10.0	8.0	0.08	2	0.08
RAULI	18	27.4	15.6	8.02	42	14.3	10.4	3.83	60	11.85
ROBLE	1	26.0	10.0	0.18	15	12.2	9.9	0.66	16	0.84
TEPA					8	11.4	9.1	0.41	8	0.41
TINEO										
TREVO										
TOTAL	929	17.6	12.9	186.36	658	12.6	9.1	43.24	1,587	229.60

Table 3-3-11 Inventory Plot Survey Results for Hm Type (Number of Plots: 15)

SPECIES	OVERSTOREY				UNDERSTOREY				T O T A L	
	Number of Trees per Ha	Ave. D B H (cm)	Ave. Height (m)	Volume (m³/ha)	Number of Trees per Ha	Ave. D B H (cm)	Ave. Height (m)	Volume (m³/ha)	Number of Trees per Ha	Volume (m³/ha)
ARAUCARIA										
ARRAYAN										
AVELLANO	13	14.7	9.3	1.04	231	12.8	7.7	13.11	244	14.15
AZARA					2	10.0	5.3	0.06	2	0.06
CANELO	13	15.9	8.4	1.12	9	13.3	6.9	0.48	22	1.60
COIGUE	108	22.2	14.1	41.25	55	14.7	10.3	5.36	163	46.61
CORCOLEN	1	12.0	8.0	0.03	2	12.0	6.5	0.13	3	0.16
LENGA										
LINGUE	55	17.8	11.5	7.36	112	14.3	8.6	8.64	167	16.00
MAITEN										
MAÑIO										
NOTRO										
OLIVILLO	11	13.1	3.9	0.68	30	11.5	7.2	1.36	41	2.04
PEUMO					1	13.0	7.0	0.07	1	0.07
PIÑOL	2	10.7	9.3	0.09	29	11.8	6.9	1.22	31	1.31
RADAL	6	20.1	10.8	1.11	35	13.2	8.0	2.23	41	3.34
RAULI	137	19.9	14.1	33.93	88	14.1	11.6	7.15	225	41.08
ROBLE	64	24.5	15.8	25.65	37	14.5	11.6	2.99	101	28.64
TEPA	8	18.2	10.1	1.10	30	12.5	8.2	1.67	38	2.77
TINEO										
TREVO	9	24.4	9.1	1.91	80	14.9	6.3	5.07	89	6.98
TOTAL	427	20.5	13.3	115.27	741	13.5	8.5	49.54	1,168	164.81

Table 3-3-12 Inventory Plot Survey Results for NJ Type (Number of Plots: 2)

SPECIES	OVERSTOREY				UNDERSTOREY				T O T A L	
	Number of Trees per Ha	Ave. D B H (cm)	Ave. Height (m)	Volume (m³/ha)	Number of Trees per Ha	Ave. D B H (cm)	Ave. Height (m)	Volume (m³/ha)	Number of Trees per Ha	Volume (m³/ha)
ARAUCARIA										
ARRAYAN										
AVELLANO										
AZARA										
CANELO										
COIGUE					30	11.7	5.7	1.05	30	1.05
CORCOLEN										
LENGA										
LINGUE										
MAITEN										
MAÑIO	25	71.2	18.0	75.27	70	38.4	10.8	44.18	95	119.45
NOTRO										
OLIVILLO										
PEUMO										
PIÑOL										
RADAL										
RAULI										
ROBLE										
TEPA	20	49.5	11.5	21.04	190	15.9	7.4	22.30	210	43.34
TINEO										
TREVO	5	120.0	27.0	40.61	55	12.5	6.1	2.51	60	43.12
TOTAL	50	67.4	16.3	136.92	345	19.6	7.7	70.04	395	206.96

3-4 Natural Regeneration Survey

In order to obtain a regeneral picture of the regeneration of *Nothofagus spp.* which is widely found in the Study Area, a survey was conducted on the number of regenerated seedlings and the relation between regeneration and the light environment.

3-4-1 Survey on Number of Seedlings

1) Survey Method

A natural regeneration survey sub-plot (1m x 1m) (hereinafter referred to as a sub-plot) was established at the 4 corners of each inventory plot in both Model Areas. In principle, one sub-plot showing evidence of the regeneration of *Nothofagus spp.* and another sub-plot showing no such evidence were selected and the number of seedlings in each sub-plot showing evidence of the regeneration was counted. The species subject to counting were all woody plants and were classified into 4 sizes for each species as shown in Table 3-4-1. With regard to herbs identified in the sub-plots, the types, height and coverage were recorded for each dominant species and co-dominant species. Fig. 3-4-1 shows the format of the fieldnote used for natural regeneration survey.

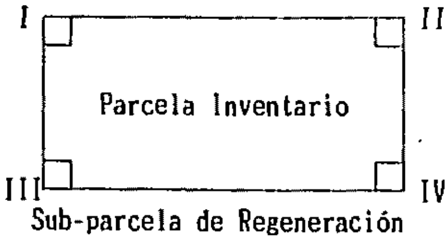
Table 3-4-1 Seedling Size Categories

Symbol	Height (h)	Diameter (d)
A	h≤0.3m	—
B	0.3m<h≤1.3m	—
C	1.3m<h	d<5cm
D	1.3m<h	5cm≤d<10cm

REGENERATION SURVEY FIELD NOTE

Plot size 1m x 1m

Parcela Inventario No.____. Fecha___/__/___. Area Modelo: Norte ☐, Sur ☐



Herbaceas	Especie	Alt.(cm)	Cubrimiento(%)
Dominantes			
Co-dominantes			

Sub parcela No	Especie	Arboreas forestales (cm)				Arb. no forestal	Observaciones
		Alt.≤30	30<Alt. <130	Altura ≧130		Cubrimiento(%)	
				DAP<5	5≤D.<10		

Fig. 3-4-1 Fieldnote for Natural Regeneration Survey

2) Stand Type

In compiling the regeneration survey results, the sub-plots were classified into the following 3 stand types depending on the dominant species.

Stand Type	Dominant Species	Forest Type by Forest Inventory
I	Araucaria	AP, Am
II	Roble-Rauli	HrR, part of Hm
III	Coigue	Hc, HcR, NJ, part of Hm

Stand Type I indicates the dominance of Araucaria and corresponds to forest types AP and Am. Stand Type II has dominant Roble and/or Rauli in the upper-storey and corresponds to forest types HrR and part of Hm where Roble and Rauli have a dominant volume ratio. Stand Type III has dominant Coigue in the upper-storey and corresponds to forest types Hc, HcR, NJ and part of Hm where Coigue has a dominant volume ratio.

3) Survey Results

The natural regeneration survey was conducted at all 92 inventory plots and the total number of sub-plots was 186, of which 12 were of Stand Type I, 87 of Stand Type II and 87 of Stand Type III. Ordinarily 2 regeneration sub-plots were selected in each inventory plot. However, only in 2 inventory plots where favourable regeneration was observed 3 regeneration sub-plots were selected.

(1) Identified Wooden Species

Some 40 wooden species were identified in the total 186 sub-plots. Table 3-4-2 shows the frequency of appearance by stand type.

11 wooden species were identified in Stand Type I with Araucaria being the most frequently appearing wooden species (number of plots in which it was identified), followed by Lenga. Such shrubs as Maitén, Canelo and Azara, etc. were also identified at a high frequency.

In the case of Stand Type II, 28 wooden species were identified with Avellano being the most frequently appearing wooden pecies, followed by Piñol, Chaura, Lingue, Roble, Rauli, Maqui and Mayú.

Although 28 wooden species were identified in Stand Type III, Coigue was by far the most frequently appearing, followed by Chaura, Tepa, Avellano, Corcolén and Piñol in that order.

Table 3-4-2 Natural Regeneration Survey: Appearance of Seedlings

No.	Species		Stand Type		
	Local Name	Scientific Name	I	II	III
1	Olivillo	*Aextoxicon punctatum*	-	+	+
2	Luma	*Amomyrtus luma*	-	-	+
3	Araucaria	*Araucaria araucana*	+	-	-
4	Maqui	*Aristotelia chilensis*	-	+	+
5	Corcolén	*Azara lanceolata*	-	+	+
6	Azara	*Azara sp.*	+	+	+
7	Michay	*Berberis spp.*	-	+	+
8	Peumo	*Cryptocarya alba*	-	+	-
9	Trevo	*Dasyphyllum diacanthoides*	-	+	+
10	Taique	*Desfontainia spinosa*	-	-	+
11	Canelillo or Canelo	*Drymis Winteri var.enana* or *var.andina*	+	-	+
12	Notro	*Embothrium coccineum*	+	+	+
13	Avellano	*Gevuina avellana*	-	+	+
14	Huallo or Huayo	*Kageneckia oblonga*	-	+	-
15	Tepa	*Laurelia philippiana*	-	+	+
16	Piñol or Avellanillo	*Lomatia dentata*	-	+	+
17	Radal	*Lomatia hirsuta*	-	+	+
18	Arrayán	*Luma apiculata*	-	+	-
19	Maitén	*Maytenus disticha*	+	+	+
20	Maitén	*Maytenus magellanica*	+	+	-
21	Myrtoides	*Myrtoides sp.*	+	-	-
22	Raulí	*Nothofagus alpina*	-	+	+
23	Coigue	*Nothofagus dombeyi*	+	+	+
24	Roble	*Nothofagus obliqua*	-	+	+
25	Lenga	*Nothofagus pumilio*	+	-	+
26	Chaura or Murtilla	*Pernettya mucronata*	-	+	+
27	Lingue	*Persea lingue*	-	+	+
28	Sauco	*Pseudopanax laetevirens*	-	+	+
29	Espino negro	*Rhaphitamnus spinosus*	-	-	+
30	Zarzaparilla	*Ribes sp.*	-	+	+
31	Rosa mosqueta(Coralillo)	*Rosa moschata*	-	+	-
32	Mañío	*Saxegothaea conspicua*	-	-	+
33	Mayú or Sophora	*Sophora macrocarpa*	-	+	+
34	Pelú	*Sophora microphylla*	-	+	-
35	Tineo	*Weinmannia trichosperma*	-	-	-
36	Lumilla	Unconfirmed	+	-	+
37	Murralla	Unconfirmed	-	+	-
38	Orites	Unconfirmed	+	-	-
39	Pilpilvoqui (Orocoy)	Unconfirmed	-	+	-
40	Unidentified	Unconfirmed	-	-	+

Note: - indicates no appearance of the species concerned.

+ indicates the appearance of the species concerned.

(2) Number of Wooden Species Identified

The numbers of identified trees of the same species in the sub-plots were added according to size for each stand type and the average number of identified trees/sub-plots was calculated (Table 3-4-3/5). The seedling sizes given in Table 3-4-1 were also used for Tables 3-4-3/5.

The most frequently identified wooden species for Stand Type I was Lenga, most of which were less than 30cm in height. Taking the relative height into consideration, Araucaria was found to be the most dominant wooden species in terms of regeneration. Araucaria was identified in 8 while Lenga was identified in 5 of the 12 sub-plots. The respective number of seedlings/sub-plot was 1-25 in the case of the former and 2-27 in the case of the latter.

In the case of Stand Type II, Roble were identified in 19, Rauli in 16 and Coigue in 1 of the 87 sub-plots. The number of seedlings/sub-plot ranged from 1-39 for Roble and Rauli and 1 for Coigue. The number of seedlings in most sub-plots was 5 or less.

In the case of Stand Type III, Coigue was identified in 28, Roble in 3, Rauli in 8 and Lenga in 3 of the 87 sub-plots. The number of seedlings/sub-plot was 1-25 for Coigue, 1-16 for Roble, 1-7 for Rauli and 3-8 for Lenga. The number of seedlings was 5 or less in more than half of the 28 sub-plots where Coigue was identified.

Table 3-4-3 Average Number of Seedlings/Sub-plot: Stand Type I (12 Sub-plots)

(Unit: No. of Seedlings/m^2)

Species \ Size	A	B	C	D	Total
Araucaria	4.75	0.83	0.17	—	5.75
Lenga	6.17	—	0.16	—	6.33
Coigue	0.42	—	—	—	0.42
Others	2.16	1.17	—	—	3.33
Total	13.50	2.00	0.33	—	15.83

Table 3-4-4 Average Number of Seedlings/Sub-plot: Stand Type II (87 Sub-plots)

(Unit: No. of Seedlings/m^2)

Size / Species	A	B	C	D	Total
Roble	0.91	0.07	0.03	0.02	1.03
Rauli	0.68	0.03	0.05	0.01	0.77
Coigue	-	0.01	—	—	0.01
Others	5.01	1.55	0.71	0.03	7.30
Total	6.60	1.66	0.79	0.06	9.11

Table 3-4-5 Average Number of Seedlings/Sub-plot: Stand Type III (87 Sub-plots)

(Unit: No. of Seedlings/m^2)

Size / Species	A	B	C	D	Total
Coigue	1.28	0.32	0.12	0.03	1.75
Roble	0.23	0.01	—	—	0.24
Rauli	0.14	0.01	0.09	0.02	0.26
Lenga	0.17	—	—	—	0.17
Others	3.29	2.13	0.45	0.04	5.91
Total	5.11	2.47	0.66	0.09	8.33

3-4-2 Relation Between Regeneration and Light

In view of the main survey objective being the regeneration of *Nothofagus spp.*, analysis of the relation between regeneration and light was only conducted for the Stand Type II and Stand Type III sub-plots, totalling 174 sub-plots. The subject seedlings were those upto 30cm in height which were assumed to be most affected by the light environment.

1) Openness Grade of Canopy

A hemispherical photograph was taken from the ground for all sub-plots where the number of seedlings was counted and the ratio of the canopy opening area on the black and white photograph was measured to obtain the openness grade of canopy for each sub-plot. Details of the method to measure the openness grade of canopy are given in the Appendix-5. Table 3-4-6 gives the number of sub-plots by openness grade of canopy category.

Table 3-4-6 Number of Sub-plots by Openness Grade of Canopy

Openness Grade of Canopy (OGC) (%)	Number of Sub-plots
0<OGC≤10	20
10<OGC≤20	57
20<OGC≤30	56
30<OGC≤40	22
40<OGC≤50	14
50<OGC	5

It is generally said that the light environment cannot be accurately expressed by the openness grade of canopy when the value of the openness grade of canopy is large because of a weak relation between the openness grade of canopy and the light environment. For the present survey, those sub-plots with an openness grade of canopy of more than 50% were omitted, partly because of the above general understanding and partly because of the small number of only 5 of the total 174.

2) Openness Grade of Canopy and Appearance of Seedlings

The ratio of sub-plots where seedlings of upto 30cm in height were observed vis-a-vis the total number of sub-plots of the same category (i.e. frequency of appearance) is shown in Fig. 3-4-2. The frequency of appearance is approximately 80% for each openness grade of canopy category. This means that as long as all species of woody plants are taken together, the appearance of seedlings has no relation to the actual openness grade of canopy.

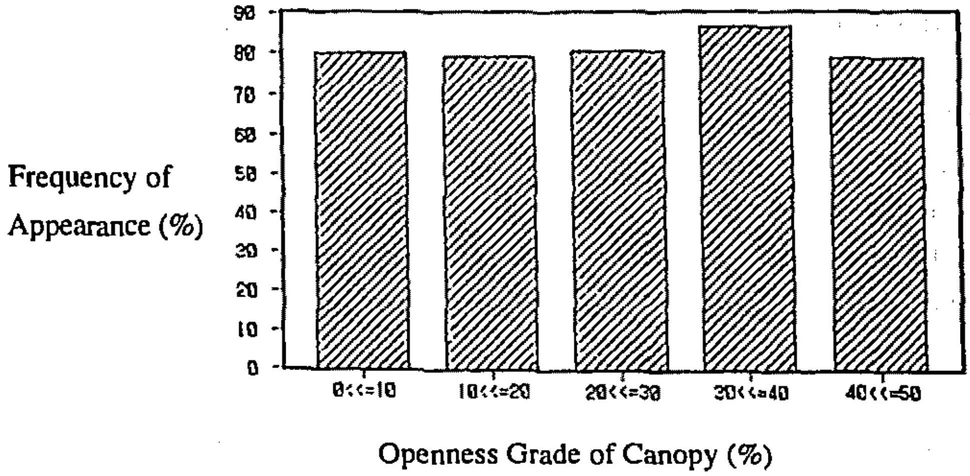


Fig. 3-4-2 Openness Grade of Canopy and Frequency of Seedling Appearance (All Species)

When analysed in terms of the stand type and type of species, the frequency of appearance was found to be high for an openness grade of canopy of between 30% and 40%. Fig. 3-4-3 shows the frequency of appearance of Roble and Rauli seedlings in Stand Type II sub-plots while Fig. 3-4-4 shows the frequency of appearance of Coigue seedlings in Stand Type III sub-plots.

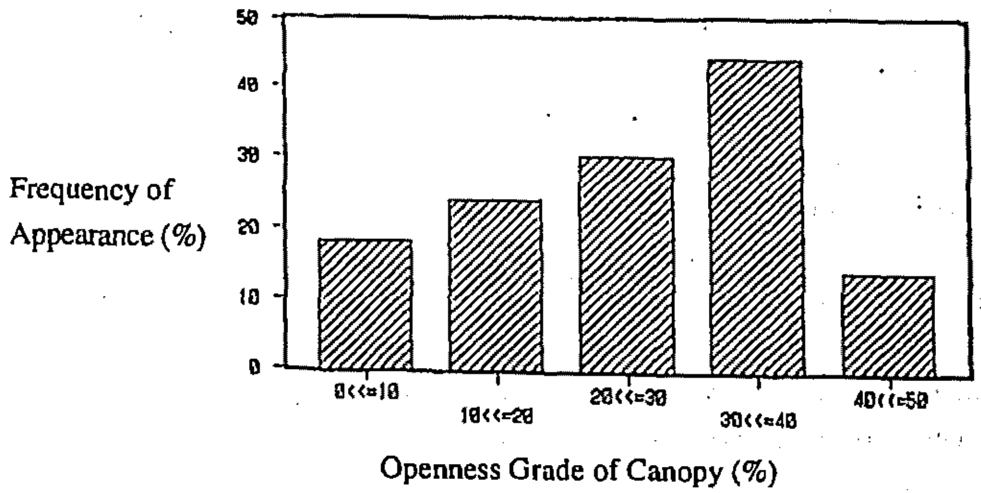


Fig. 3-4-3 Openness Grade of Canopy and Frequency of Appearance of Roble and Rauli Seedlings (Stand Type II)

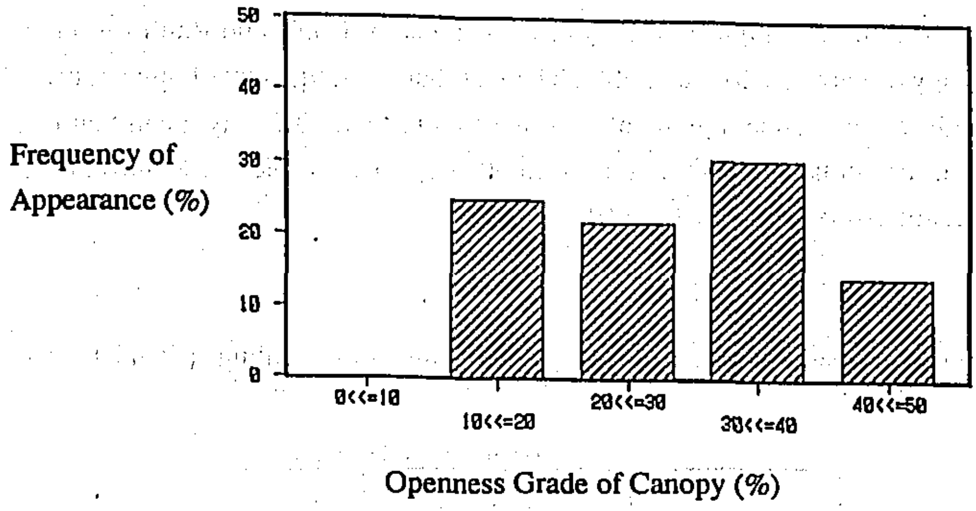


Fig. 3-4-4 Openness Grade of Canopy and Frequency of Appearance of Coigue Seedlings (Stand Type III)

3) Openness Grade of Canopy and Number of Seedlings

The possible relation between the openness grade of canopy and the number of seedlings was analysed. Table 3-4-7 shows the average number of seedlings/m^2 for Stand Type II, obtained by dividing the total number of seedlings in each size category by the number of sub-plots in that category.

Table 3-4-7 Openness Grade of Canopy and Number of Seedlings (Stand Type II)

(Unit: No. of Seedlings/m^2)

Species / OGC	Roble	Rauli	Sub-Total	Others	Total
0<OGC≤10	–	0.18	0.18	4.91	5.09
10<OGC≤20	0.40	0.04	0.44	3.72	4.16
20<OGC≤30	1.79	1.54	3.33	4.21	7.54
30<OGC≤40	1.11	0.33	1.44	5.89	7.33
40<OGC≤50	—	0.28	0.28	6.43	6.71

Table 3-4-7 shows a high frequency of appearance of Roble and Rauli for an openness grade of canopy of between 20% and 30%. The fact that the frequency of appearance of other species is high for an openness grade of canopy of more than 30% may mean that Roble and Rauli seedlings are subject to competition from other species. Table 3-4-8 shows the average number of seedlings/m² for Stand Type III.

Table 3-4-8 Openness Grade of Canopy and Number of Seedlings (Stand Type III)

(Unit: No. of Seedlings/m^2)

Species / OGC	Coigue	Others	Total
0<OGC≤10	–	2.56	2.56
10<OGC≤20	1.16	2.37	3.53
20<OGC≤30	1.52	3.48	5.00
30<OGC≤40	2.31	7.00	9.31
40<OGC≤50	1.00	7.71	8.71

The frequency of appearance of Coigue seedlings is the highest in the openness grade of canopy category of between 30% and 40%.

4) Conclusion

Natural regeneration is generally said to be affected by many factors, including topographical and soil conditions, seed dispersal, light environment and conditions of under-storey vegetation. The appearance of seedlings of *Nothofagus spp.* (Roble, Rauli, Coigue and Lenga), which are currently used for commercial purposes, was confirmed in 74 sub-plots, some 40% of 186 sub-plots.

Of the various factors mentioned above, the light environment (expressed in terms of openness grade of canopy) was selected and its relation with regeneration was analysed.

In the case of stands where Roble and Rauli are dominant, the frequency of appearance of their seedlings was the highest for an openness grade of canopy of 30-40% while the number of seedlings was the highest for an openness grade of canopy of 20-30%, indicating that an openness grade of canopy of 20-40% is favourable for the regeneration of seedlings of *Nothofagus spp.*

This survey results, however, is only applicable to the appearance of seedlings, which is only one stage of natural regeneration. As the required light environment after the initial stage of growth may well be different, a follow-up survey must be conducted to identify the relation between growth and light throughout the life-cycle of each species. A survey to measure the intensity of illumination and to clarify the relation between the openness grade of canopy and the relative intensity of illumination is required as objective data for forest operation.

Moreover, the development of reliable natural regeneration technologies will require further research on artificially controllable factors, including such ground treatment as soil preparation and the removal of under-storey vegetation and alteration of the upper-storey crown cover.

3-5 Increment Survey

(1) Survey Objective

Data on the increment is needed in order to be able to infer the possible trend of forest growth which is to be used as the basis for the possible felling volume calculation. However, currently very little information exist on the increment condition of native broad-leaf forests in the Model Areas. Therefore, an increment survey to graps the increment condition of Rauli, Roble and Coigue was conducted.

(2) Survey Method

Since hardly any increment data on native broad-leaf forests are available as described in (1), it was decided to adopt a simple estimation method to roughly determine the increment rate. The time-consuming stem analysis method was not applied because of the time constraints of the Study. Following discussions with the counterparts, it was decided to prepare an increment rate table based on the Prodan (a German) method which was used to determine the increment of broad-leaf trees in Europe by means of counting the number of latest annual rings of trees in 1cm core samples.

In this study, the increment cores were collected from 55 trees with a DBH ranging from 12cm to 80cm (18 Rauli, 15 Roble and 24 Coigue) in or near the inventory plots in the North Model Area. Two cores were collected from each tree at the breast height; one each from the valley side and mountain side of the trees. The number of annual rings within 1cm of each core was then counted and recorded. Finally, the average number of these annual rings was calculated.

(3) Calculation of Increment Rate

The data obtained in (2) were charted to see if there was any correlation between the DBH and the number of latest annual rings. As the results showed the same tendency for all the three species, it was decided to treat the obtained data as collective data disregarding the species.

Considering those trees from which cores were collected as sample trees, the following formula was obtained using the Least Square Method to express the relation between the DBH of the sample trees and the number of annual rings.

$$
\begin{aligned}
y &= a + bx \\
&= 4.193 + 0.02398x
\end{aligned}
$$

where, y: number of annual rings within 1cm core sample
x: DBH (cm)

The volume increment rate for each diameter class shown in Table 3-5-1 was then calculated by applying the number of annual rings, obtained by inserting the DBH value of every 2cm to the above formula, to the Prodan's volume increment table.

Table 3-5-1 Volume Increment Table

DBH (cm)	Volume Increment Rate (%)	DBH (cm)	Volume Increment Rate (%)
10	13.04	50	1.78
12	10.24	52	1.70
14	9.38	54	1.62
16	6.93	56	1.54
18	6.75	58	1.46
20	5.66	60	1.39
22	7.23	62	1.32
24	4.49	64	1.25
26	4.02	66	1.18
28	3.64	68	1.11
30	3.27	70	1.04
32	3.07	72	1.01
34	2.88	74	0.99
36	2.70	76	0.96
38	2.52	78	0.93
40	2.35	80	0.90
42	2.21		
44	2.08		
46	1.97		
48	1.88		

3-6 Soil Survey

(1) Objective

The soil survey was conducted to identify the main characteristics of the soil and overall condition of soil distribution in the Model Areas.

(2) Method

The soil profile survey was conducted at sample sites which were determined based on the topographical conditions, elevation and vegetation, etc. to describe soil horizons and to check such items as, thickness and conditions of horizons, conditions of A horizon, colour, existing quantity of humus, texture, structure, presence of gravel, hardness, moisture condition, evidense of leaching and accumulation, mycorrhiza and mycelium, root system and pH, etc.

Soil type units that are mentioned in the Soil Map of the World published by the FAO-Unesco were used. While the American Soil Taxonomy System could have been used instead of this FAO-Unesco classification system, it was found difficult to apply to steep slopes in the Model Areas as it was mainly developed to deal with flat farmland. The facts that the FAO-Unesco method can be used even by persons who are not soil specialists and that the method is expected to become the standard international system for soil comparison and reference contributed to this decision.

(3) Survey Findings

Both Model Areas have a thick volcanic ash cover and Andosols are the dominant soil type throughout. The only exception is Lithosols which lie with a thickness of less than 10cm on top of the rock outcrops around mountain ridges.

Andosols are a fairly young soil with a base material of volcanic ash. The base saturation is low and it is hardly crystalised. The clay content is light and lacks cohesion with a prominent presence of allophane. Andosols are often associated with mountain slopes and widely found in the Andes Mountains.

① Humic Andosols (Th)

This soil type is mainly found in cool and wet areas and is distributed in the middle or lower part of slopes in the Model Areas. It has an Umbric A horizon and a Cambric B horizon. The soil texture upto 100cm in depth from the ground surface is dominantly silty loam. A crumb or blocky structure is often clearly observed in the upper part of the A or B horizon.

② Ochric Andosols (To)

This soil type is distinguished by the Th soil type by the presence of an A horizon which has a higher colour value and chroma than the Umbric A horizon. It has an Ochric A horizon and a Cambric B horizon and the soil texture upto 100cm in depth from the ground surface is mainly silty loam.

③ Vitric Andosols (Tv)

This soil type is often observed in relatively dry areas and, in the Model Areas, is mainly distributed on convex slopes and ridges which tend to become dry. It is a relatively new soil containing vitric volcanic ash and the soil texture upto 100cm in depth from the ground surface is mainly loam or loam with a relatively high sand content. A granular or nutty structure is well developed in the A horizon and becomes very hard when dry. As the sand content tends to be higher in the South Model Area than the North Model Area, this soil type is found more frequently in the former.

In general, Andosols are vesicular, can absorb a large quantity of water, have a high positive ion exchange capacity, contain much organic matter and enjoy high natural fertility. Consequently, Andosols are suitable for farming, particularly when originating from intermediate or basic volcanic ash.

The Andosols found in the Model Areas are less vesicular and each horizon shows a relatively high hardness. Some profiles showed a high degree of compaction. The humus content is generally high, however, and the pH shows an almost neutral value of 6.8-6.9. Soil horizons are generally thick of more than 100cm although they are 40-50cm thick in some areas. The root systems of trees and Quila generally reach some 70-80cm below the ground surface. The relation between soil type and vegetation in the Model Areas is not clearly established but forests of different physiognomy and type, including secondary Roble-Rauli forests and old growth Coigue forests, and grassland are observed. Consequently, while the Andosols in the Model Areas are not the best soil for plant growth, they do not have any problematic factor vis-a-vis forest management.

However, it is worth noting that Andosols at sloping land differ from Andosols at flat land. In the case of the Model Areas for example, soil with an extraordinary black A horizon and massive structure is observed at the flat tops of plateaus and in valley bottoms, presumably because of the anaerobic decomposition of organic matter under excessive humidity. These places are now wet grassland containing plants of Cyperaceae family. The soil here is classified as Andosols but is not as fertile as Andosols found at sloping land because of poor drainage.

The Lithosols distributed around rock outcrops near mountain tops cannot be expected to have high productivity as the soil is shallow with hard rock right beneath it. At present,

Araucaria forests appear to have been naturally regenerating, implying that afforestation using Araucaria (but not Roble, Rauli or Coigue) is feasible.
The correspondence between the Andosol types and categories employed by the US Soil Taxonomy (USDA) is given below.

Ochric Andosols	-	Typic Dystrandept
Humic Andosols	-	Hydric Dystrandept
Vitric Andosols	-	Umbric Vitrandept

Andosols are described as being either Humic Allophane soil or Trumao soil by the Chilean soil classification system. In Japan, Andosols are classified as part black soil and brown forest soil.

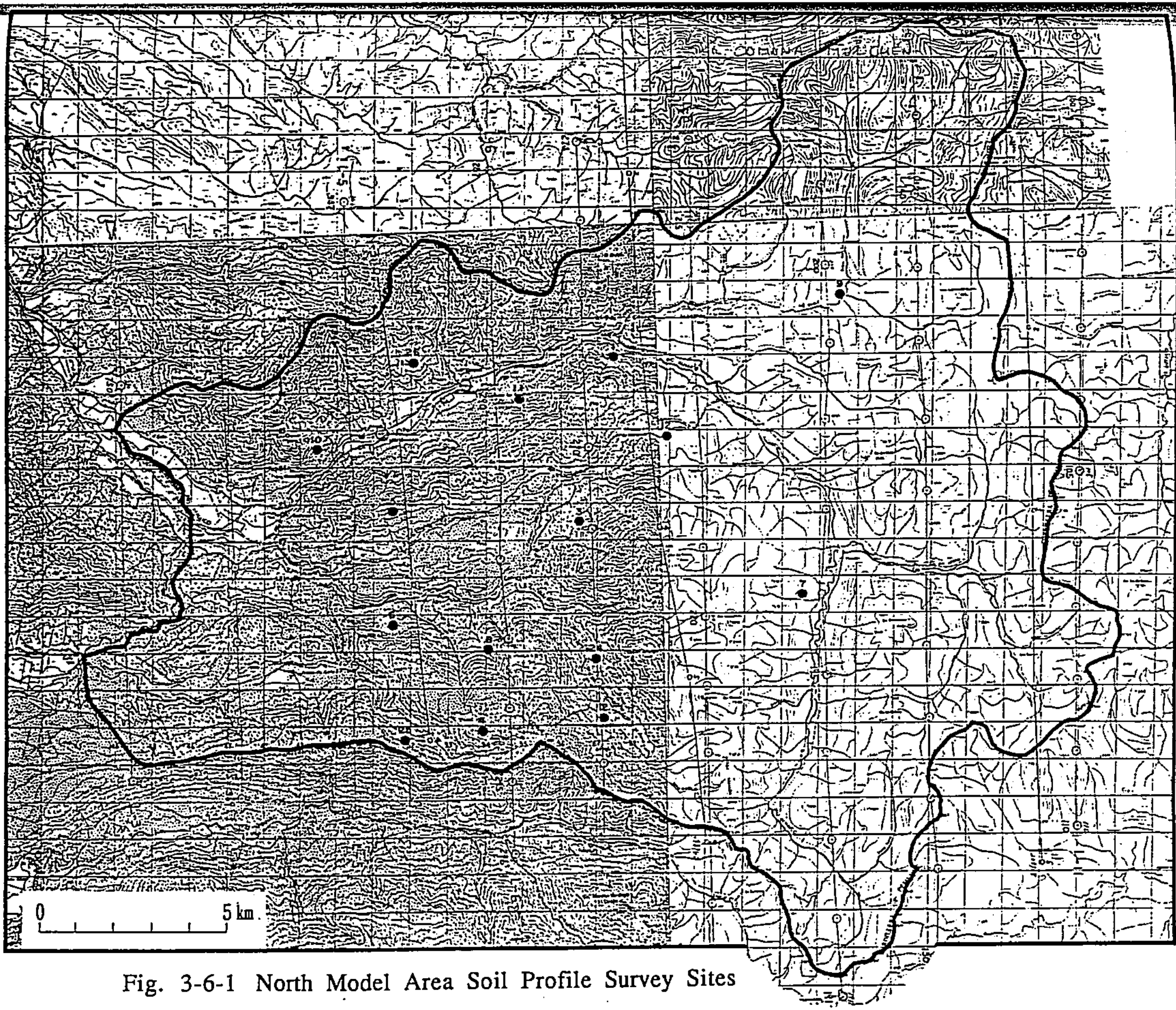


Fig. 3-6-1 North Model Area Soil Profile Survey Sites

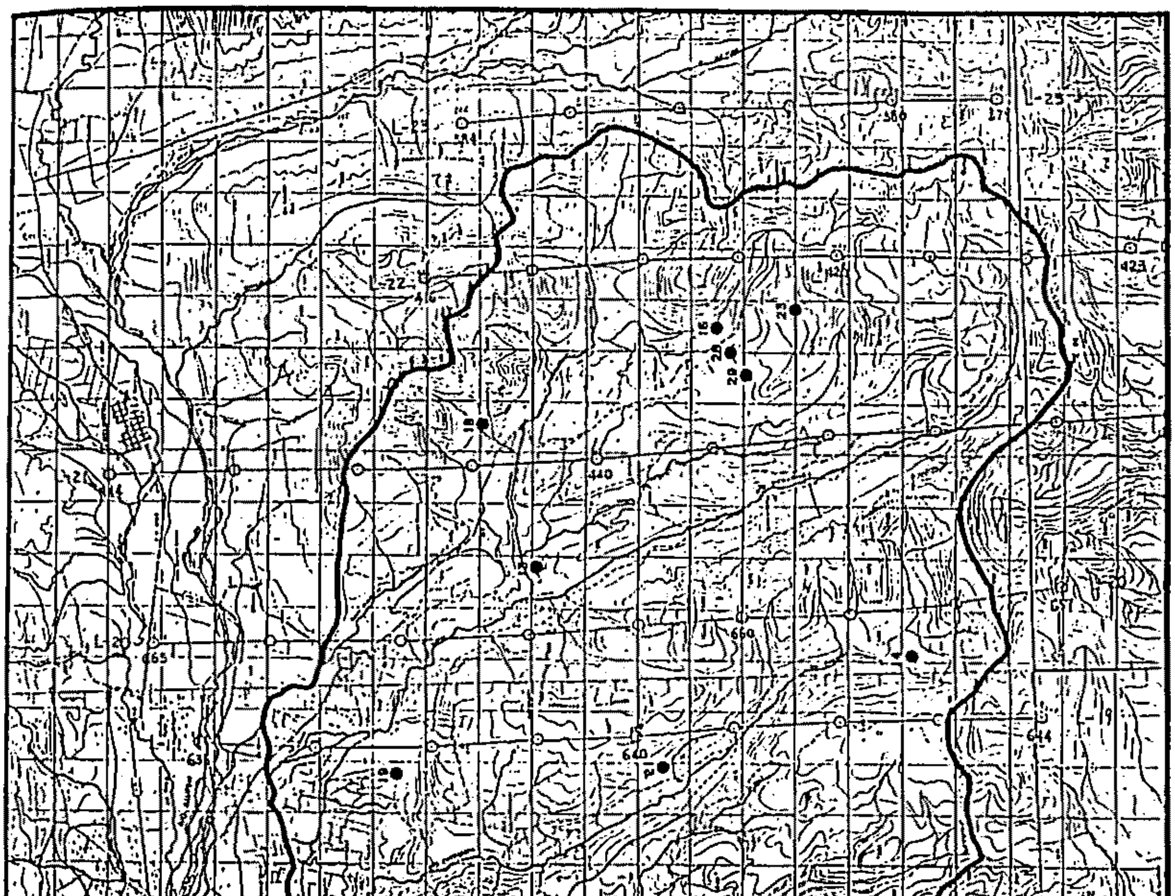


Fig. 3-6-2 South Model Area Soil Profile Survey Sites

Table 3-6-1 Soil Profile Survey Results

No	Location/Topography	Gradient (degree)	Soil Type	A Horizon Thickness (cm)	Soil Colour	Humus	Soil Texture	Structure	Gravel and Stone Size • From • Weathering Condition • Content	Hardness (mm)	Moisture condition	Leaching/ Accumulation	Mycorrhiza/ Mycelium	Root	Remarks
1	Mid-Slope, Straight	27	Th	30	7.5YR 3/2-3/4	Abundant	Loam - Silty Loam	Crumb Blocky	—	7-17	Moist	-	Found	Many	Roots deeper than 1m
2	Lower-Slope, Straight	10	To	12	5YR2/2-7.5YR3/3	Abundant	Silty Loam - Loam	Granular Blocky	Fine gravel • Sub-angular • Weathered • Very Few	16-25	Moist	-	-	Many	Roots upto 70cm deep
3	Mid-Slope, Straight	17	Tv	36	7.5YR2/2-3/4	Abundant	Loam	Crumb Granular Blocky	—	10-20	Moist	-	Found	Many	
4	Gentle Slope at Ridge	10	To	10	7.5YR2/1-3/4	Abundant	Loam	Granular	Fine gravel • Sub-angular • Weathered • Few	13-28	Moist	-	Found	Many	Roots deeper than 70cm
5	Mid- Slope, Straight	23	Tv	30	7.5YR3/3-3/4	Common	Loam	Crumb	Fine gravel • Sub-angular-Rounded • Strongly Weathered • Very Few	10-16	Moist	-	-	Common	
6	Lower Slope, Straight	24	Tv	53	7.5YR2/2-3/4	Abundant	Loam	Granular Blocky	—	15-20	Moist	-	Found	Common	
7	Lower Slope, Straight	44	To	18	7.5YR3/3-4/4	Common	Loam	Blocky Platy	Fine gravel• Angular- Rounded • Weathered • Very Few	8-26	Moist	-	-	Common	Rock layer after 86cm deep
8	Lower Slope, Straight	14	Th	59	7.5YR2/3-4/6	Abundant	Loam - Silty Loam	Crumb Blocky	Fine gravel • Sub-angular-Rounded • Weathered • Frequent	13-20	Moist	-	-	Many	
9	Lower Slope, Convex	14	To	11	7.5YR2/1-4/4	Abundant	Loam - Silty Clayey Loam	Crumb Blocky	Fine gravel • Sub-angular- Rounded • Weathered • Very Few	14-15	Moist	-	-	Many	Roots deeper than 85cm
10	Upper Slope, Convex	30	To	8	7.5YR3/3-4/6	Common	Loam	Granular Blocky	Fine gravel - Coarse• Angular-Sub-angular • Weathered • Few	14-20	Moist	-	-	Many	
11	Mid- Slope , Convex	16	Tv	30	7.5YR3/2-5YR3/4	Abundant	Loam	Granular Blocky	Fine gravel • Rounded • Weathered • Very Few	10-21	Moist	-	-	Common	Roots deeper than 90cm
12	Flat Plateau	2	Th	35	7.5YR2/1-3/4	Abundant	Loam - Silty Clayey Loam	Granular Massive	Fine gravel -Coarse • Sub-angular • Weathered • Very Few	13-24	Moist	-	-	Many	Roots upto 50cm deep
13	Upper Slope, Straight	8	Tv	30	5YR2/2-7.5YR3/3	Abundant	Loam	Crumb Blocky	—	14-20	Moist	-	-	Many	
14	Lower Slope, Convex	12	Th	37	5YR2/3-7.5YR3.5/4.5	Abundant	Loam - Silty Clayey Loam	Crumb	—	16-22	Moist	-	-	Many	Roots upto 30cm deep
15	Lower Slope, Convex	20	To	20	5YR3/3-7.5YR4/4	Common	Loam	Crumb Blocky	Fine gravel • Angular • Strongly Weathered • Very Few	8-21	Moist	-	-	Many	
16	Sediment Deposition Area of Mountain Foot	10	Th	25	7.5YR3/3.5-4/5	Common	Loam - Sandy Clayey Loam	Crumb Blocky	—	14-23	Moist	-	-	Common	
17	Flat Plateau	0	Th	35	7.5YR2/2-3/4	Abundant	Loam - Clayey Loam	Nutty Granular	Fine gravel • Rounded-Sub-angular • Weathered • Very Few	17-23	Moist	-	-	Common	
18	Lower Slope, Convex	28	Tv	32	7.5YR2/2-3.5/5	Abundant	Sandy Loam - Loam	Crumb Blocky	—	11-18	Moist	-	-	Many	Roots deeper than 80cm
19	Lower Slope, Straight	20	Th	67	7.5YR3/3-4/5	Common	Loam - Silty Loam	Crumb Blocky	Coarse - small stone• Angular • Fresh • Few	15-21	Slightly Dry	-	-	Common	
20	Upper Slope, Convex	18	Th	35	7.5YR2/2-3/4	Abundant	Loam - Clayey Loam	Crumb Granular	—	16-19	Moist	-	-	Many	Roots upto 70cm deep
21	Upper Slope, Convex	20	Tv	20	7.5YR2/3-4/4	Common	Sandy loam - Sandy Clayey Loam	Common	Fine gravel - Coarse • Sub-angular • Weathered • Few	13-22	Moist	-	-	Many	Gravel layer after 50cm deep
22	Lower Slope, Straight	6	Th	24	7.5YR2/2-10YR4/3	Common	Loam - Sandy Clayey Loam	Crumb Blocky	Fine gravel-Coarse • Sub-angular • Weathered • Very Few	6-19	Moderately Wet	-	Found	Common	
23	Flat Plateau	0	Tv	32	7.5YR2/2-10YR3/4	Common	Loam	Crumb	—	16-25	Moist	-	-	Many	
24	Mid-Slope, Straight	18	To	10	10YR2/3-3/4	Abundant	Loam	Massive	—	8-11	Moist	-	-	Many	pH 6.8-6.9
25	Lower Slope, Concave	17	To	25	10YR4/3-4/6	Scanty	Loam - Silty Loam	Granular	Fine gravel • Sub-angular • Weathered • Very Few	15-25	Moist	-	-	Many	pH 6.8
26	Lower Slope, Straight	9	To	62	10YR4/3-4/4	Common	Silty Loam	Granular	Fine gravel-Coarse • Sub-angular-Rounded • Weathered • Very Few	18-23	Slightly Dry	-	-	Many	pH 6.9
27	Mid- Slope, Convex	17	To	7	7.5YR4/3-4/6	Scanty	Loam - Silty Loam	Granular	—	6-21	Slightly Dry	-	-	Many	Rock layer after 40cm deep
28	Mid- Slope, Straight	18	To	20	10YR3/4-4/6	Common	Silty Loam - Clayey Loam	Granular Massive	Fine gravel • Sub-angular • Weathered • Very Few	11-21	Moderately Wet	-	-	Common	
29	Gentle Slope at Mountain Ridge	5	To	40	10YR3/4-4/4	Common	Silty Loam - Clay	Crumb Massive	—	18-25	Slightly Dry	-	-	Many	pH 6.8-6.9

Table 4-1-2 Production of Pulpwood by Species

(Unit: 1,000m³)

Year \ Species	Radiata pine	Others	Total
1985	3,270 (96)	136 (4)	3,406 (100)
1990	3,058 (56)	2,365 (44)	5,423 (100)

Source : INFOR
Note : Figures in brackets are relative percentages for each year.

Table 4-1-3 Sawn Wood Production Volume

(Unit: 1,000m³)

Year \ Region	Nation Wide	Region VIII	Region XI
1980	2,249 (100)	1,203 (53)	320 (14)
1985	2,191 (100)	1,176 (54)	309 (14)
1990	3,327 (100)	1,784 (54)	400 (12)

Source : INFOR
Note : Figures in brackets are relative percentages for each year.

Concerning the timber supply by species in Chile Radiata pine is the single largest sawn timber supply source in the country as shown in Table 4-1-4.

Radiata pine appears to suit the climate of Chile and grows rapidly. The final felling of around 16 years old trees to produce pulpwood is possible. The final felling of 20-25 years old trees to provide sawn timber is also considered possible, making investment in this species very attractive.

Table 4-1-4 Production of Sawn Timber by Species

(Unit: 1,000m^3)

Year	Species / Production	Alamo	Eucalypts	Radiata pine	Coigue	Laurel	Lenga	Rauli	Roble	Tepa	Others	Total
1985	Volume	25	22	1,871	49	4	35	20	40	53	72	2,191
	%	1.1	1.0	85.4	2.3	0.2	1.6	0.9	1.8	2.4	3.3	100.0
1990	Volume	26	41	2,889	74	4	53	34	62	56	88	3,327
	%	0.8	1.2	86.8	2.2	0.1	1.6	1.0	1.9	1.7	2.7	100.0

4-1-2 Forestry Activities in Model Areas

1) General Condition

Forests in the Model Areas are owned by either the state (central government), private companies or private individuals (small land owners). Private companies owning large forest areas are actively investing in forestry activities, including felling and planting. There are 3 major companies with large forest holdings in the North Model Area and 2 in the South Model Area. Private individuals own small forest areas and conduct felling for cash income. The forestry activities of the above 5 major companies and of the private individuals are outlined below.

(1) Company A

This company owns some 4,500ha of native forests and 120ha of man-made forests. It conducts selective felling with a rotation of 85~90 years in secondary forests.When conducting thinning, the company leaves fine trees for the future.

(2) Company B

This company owns some 6,000ha of man-made forests, mainly consisting of Radiata pine and Eucalypts, and some 25,000ha of secondary Roble, Rauli, Coigue and other forests. The rotation for man-made forests for pulpwood production is 12-20 years. In the case of secondary forests, thinning is conducted in stands where the ratio of fine trees is relatively high with a view to creating stands for timber production. In contrast, clear felling is employed in stands with a low fine tree ratio to create man-made forests. In the case of the latter, the company hopes to create man-made forests of native species, Rauli if possible.

(3) Company C

This company owns some 38,300ha of man-made forests, mainly consisting of Radiata pine, and some 2,600ha of native forests consisting of native broad-leaf species. Man-made forests are used for the production of pulpwood and timber. While thinning is conducted in secondary forests, the company appears to be eager to conduct man-made forestry activities using exotic species and is willing to expand its man-made forest area through the purchase of new land and the conversion of secondary forests.

(4) Company D

This company owns some 2,000ha of man-made forests, mainly consisting of Radiata pine, some 3,800ha of native forests and some 3,900ha of pasture. Man-made forests are used for the production of pulpwood and timber and the total area has been increasing in recent years. With regard to forestry activities in native forests, it is said that in the past the company conducted selective felling and undertook active enrichment efforts in Araucaria forests. Thinning is conducted in secondary forests to produce chip wood. Also, the company hopes to expand the use of thinned wood to pallet and furniture in the future.

(5) Company E

This company owns some 60,000ha of man-made forests, mainly consisting of Radiata pine, and some 12,000ha of native forests (of which 1,500ha are secondary forests of Rauli and other species). Man-made forests are used for the production of pulpwood and timber with a rotation of 20 years for the former and 25 years for the latter. Forestry activities are conducted in native forests with a high productivity. The company hopes to convert natural stands with a low productivity to man-made forests of exotic species, including Radiata pine.

(6) Small Landowners

A questionnaire survey on forestry activities conducted with settlers in the Model Areas (to be described in further detail later) found that many want to preserve the present native forests for the production and sale of forest products and to use them for the grazing of domestic animals to support their livelihoods but are generally unable to conduct systematic forestry activities.

2) Felling, Bucking and Yarding

Any forest owner who intends to fell trees must have his forestry activities plan officially approved by the CONAF prior to felling.

Since the access conditions in the Model Areas are poor in winter because of heavy snow and rain, felling is usually conducted between November and March. Some small owners, however, conduct felling in winter to prevent decay spreading from cut faces.

Felling of those trees where decay or the existence of a cavity caused by decay is suspected is abandoned from the viewpoint of profitability.

When the felling of large diameter trees is conducted in a native forest, all branches and parts of the stem which are not of commercial diameter are simply left in the stand in most cases. This must be viewed as a waste of resources.

Yarding over a general distance of 200-600m to a temporary sawmill or loading yard to trucks is conducted using oxen (small owners). Private companies use a tractor. As the use of oxen means the dragging of logs along the same tracks over several years, it often results in soil erosion of the stand concerned.

3) Wood Transportation

Wood is transported from the forest site to processing and consumption areas in the form of either logs or sawn timber using medium and large size trucks.

4) Forest Roads

The concept of forest roads does not exist in Chile. There are, however, roads in the forest areas which include those temporarily constructed for the yarding of wood from native forests and roads used for travelling by local inhabitants and for wood transportation (these roads are described as forest roads hereinafter).

Apart from forest roads maintained by some private companies, maintenance work is almost non-existent for most forest roads except when absolutely necessary for the yarding/transportation of wood or when the roads become impassable. Particularly serious aspects of these roads are their steepness, very narrow width and the small radius at bends. The absence of gravel paving and side ditches means erosion of the surface soil (volcanic ash) by rain or melted snow. Ruts on the road surface due to ground logging using oxen are the prime cause of such land erosion.

The improvement of forest roads must be given high priority in view of achieving the efficient use of wood resources, conducting appropriate forest management and securing a vital means of transportation for local inhabitants.

4-1-3 Processing, Use and Distribution of Wood

1) Processing Facilities

There are mobile temporary sawmills, each equipped with one large band saw and one circular saw for cutting into samller pieces and with around 8 workers, near the felling sites in the Model Areas. Sawing work is commissioned to the owners of these sawmills who are paid in some 30-40% of the product volume or sale incomes. Left-over wood and inferior wood which is unsuitable for sawing is simply abandoned around the sawmills.

There are many sawmills in the lowland in and around the Model Areas, including sawmills at Collipulli, Cunco, Temuco, Los Angeles, Mulchen and Nacimiento. The equipment in use varies from one band saw and one circular saw for cutting into smaller pieces at small-scale sawmills to modern, automated equipment at large-scale sawmills. The sawing yield generally appears to be in the range of 40-60%.

There are many chip mills in and around the Model Areas, including mills at Collipulli, Cunco, Temuco and Los Angeles, to cater for the increasing chip demand in recent years.

There are a total of 8 pulp plants in Chile, of which 5 are located in Region VIII and Region IX. Moreover, 6 of the 7 fibre board plants in Chile are located in these 2 regions. A pulp plant using Eucalypts became operational in Santa Fe in 1991.

2) Wood Use

The general fields of use for each species are shown in Table 4-1-5 based on information obtained from existing documents.

Some 30% of Radiata pine is said to be used as pulpwood. There appear to be varying opinions on the use value of native species. Some say that native species are superior to Radiata pine and Eucalypt in terms of both product quality and cost performance while others say that the existing markets, except the pulpwood market, are too small and unreliable to achieve efficient forest activities. Others also say that they would use any wood for pulp production except that of extremely high quality because of unestablished drying technologies and the diversity of species.

With regard to the form classes in use, the minimum diameter appears to be 16cm for Radiata pine and 40cm for native species for timber production. In the case of pulp production, the minimum diameter appears to be 10-35cm for all species. No reliable data was obtained in regard to the log production yield of standing trees. One private company put the figure at some 25% because of many defects, including decay and bending. It is true that many over-mature forests show signs of decay but the actual extent of decay has yet to be surveyed.

Determination of the total stem volume of standing trees as part of the basic quantitative data on forest resources is very important. However, a total stem volume table is unavailable for large diameter trees and the preparation of this table should be given urgent attention in the future.

Table 4-1-5 Fields of Use of Main Species in Study Area

Species	Main Field of Use			
	Building	Boards	Carpentry,etc	Others
Araucaria (*Araucaria arcucana*)	building structures, bridges, floors, roofs, pillars, beams	veneers, plywood, particle boards	packages, boxes, furniture	vehicle bodies, ships, mine timbers
Coigue (*Nothofagus dombeyi*)	building structures, bridges, silos, linings, stairs	plywood board, particle boards	furniture, toys, barrels, handles for tools	mine timbers, electric poles, sleepers, ships, fuel wood
Rauli (*N. alpina*)	linings, floors, ceiling, doors, windows, roof tiles	veneers, plywood boards	cabinets, furniture, barrels, stairs	bent wood, pulp ships
Roble (*N. obligua*)	bridges, building structures, roofs, tiles, lining, doors and window frames	veneers, plywood boards	furniture	ships, sleepers, electric poles, mine timber, pulp
Tepa (*Laurelia philippiana*)	forms for concrete, windows, ceilings	veneers, plywood boards	furniture, packages, containers, turnery toys, shoe soles	charcoal
Lenga (*N. pumilio*)	floors, doors, windows,lining	veneers, plywood boards	furniture, containers	
Radiata pine	ceilings, forms for concrete	particle boards, fibers boards, plywood	packages, furniture	fences, electric poles, pulp, resin oleo

3) Distribution

Most wood produced in the North Model Area is transported to sawmills at Collipulli and Los Angeles, etc. while wood produced in the South Model Area is similarly transported to sawmills at Cunco and Temuco, etc. to be processed into sawn timber or chips. The sawn timber and chips are then transported to the surrounding areas, ports for export, such as Concepcion and Santiago, and final processing plants.

Those pulp plants and sawmills with their own production forests directly transport the wood from the forests to the plants or sawmills.

Some large companies have separated the log supply operation from the log processing operation.

As shown in Table 4-1-1, exports accounted for some 11% of the total demand in 1990 and, in terms of volume, exports have increased by some 50% in 10 years, indicating the strong impact of the overseas market demand on wood consumption (production) in Chile. Radiata pine accounts for 100% of the exported sawn timber and some 40% of the exported pulpwood.

Trade prices are largely kept a business secret. However, the examples shown in Table 4-1-6 were obtained.

Table 4-1-6 Examples of Log Trade Prices

Purpose	Radiata pine	Native Species	Remarks
Sawn Timber	\$19,400 /m^3	\$17,000~34,000 /m^3	Price fluctuates depending on quality
Pulpwood	\$4,000~5,700 /m^3	\$2,400~4,800 /m^3 (\$2,400~3,000 /m^3)	Figures inside brackets indicate spot sale prices

Note: 1 US\$ roughly equals to 360 Chilean Peso \$ (1991 exchange rate)

4-2 Afforestation

4-2-1 Man-Made Forest Activities

1) Current Conditions of Man-Made Forests

Afforestation activities, mainly involving Radiata pine, are very evident in Chile as shown in Table 4-2-1.

Table 4-2-1 Man-Made Forest Area by Species (as of 1990)

Species	Radiata pine	Eucalypt	Atriplex	Tamarugo	Pino oregon	Alamo	Algarrobo	Others	Total
Area (1,000ha)	1,243,293	101,700	37,878	20,600	11,343	3,526	3,201	38,989	1,460,530

Source : INFOR

Table 4-2-2 shows the area of Radiata pine man-made forests by age class, indicating a rapid increase of this type forest in the last 15 years.

Table 4-2-2 Radiata Pine Man-Made Forest Area by Age Class (as of 1990)

(Unit: 1,000ha)

Age Class	0	1~5	6~10	11~15	16~20	21~25	26~30	31~	Total
Nationwide	61	326	344	310	142	40	10	10	1,243
(%)	(4.9)	(26.2)	(27.7)	(24.9)	(11.5)	(3.2)	(0.8)	(0.8)	(100)
Regions	36	189	218	213	91	35	6	3	791
VIII and IX (%)	(4.6)	(23.8)	(27.6)	(26.9)	(11.5)	(4.4)	(0.8)	(0.4)	(100)

Source : INFOR

In 1990, some 94,000ha of new afforestation areas were added nationwide to the man-made forest areas, of which some 55,000ha were recorded in Region VIII and Region IX, indicating very active afforestation activities in these 2 regions. Pasture and farmland have been included in the sites subject to afforestation in recent years.

The most common afforestation practice is uniform afforestation using the same species. Although the exact figure for the man-made forest area consisting of native species is unavailable, one estimate puts it at some 1,600ha. In fact, there are few man-made forests using native species in the Model Areas.

Appendix 6 gives an example of a man-made forest located at El Morro near the North Model Area which is owned by a private company and which consists of Rauli.

2) Outline of Afforestation Work

Afforestation work in the Study Area is outlined in this section using concrete examples.

Afforestation work is mainly conducted by those owning substantial land/forests and the annual area of afforestation is as extensive as upto 10,000ha. In comparison, small landowners do not regularly conduct afforestation and the afforestation area each time is fairly small.

In the case of large-scale afforestation, the actual planting is conducted by contractors working for large landowners. The necessary manpower is provided by the local workforce and is organized into work groups. In the case of afforestation by small landowners, self planting is a common feature. Afforestation usually consists of the following processes.

(1) Planting

The planting density for Radiata pine is 1,600-2,000 seedlings/ ha. The density is reduced when the production of timber is aimed at. In the case of Eucalypts which is mainly planted to obtain pulpwood, the normal planting density is some 1,600 seedlings/ha. The planting density for native species varies from 1,100 to 2,500 seedlings/ha. The survival rate is as high as 95% for Radiata pine and some 60% for Rauli. The planting season is from May to August for Radiata pine, from August to September for Eucalypts and from May to June for native species.

(2) Pruning

The common practice in the production of timber appears to be for pruning to be conducted when the trees are 5 years old, followed by a second pruning at 7 years old.

(3) Thinning

In the case of the production of timber thinning is conducted twice before the trees reach the felling age of 25 years old with a final tree density of 300-350 trees/ ha.

The CONAF publishes the standard afforestation costs each year to provide the basis for afforestation subsidy calculation. The published standard afforestation costs in 1992 are shown in Appendix 7 by species, by type of seedling and by region.

4-2-2 Native Forest Activitics

1) Current Conditions of Native Forests

Chile has a native forest area of some 7.62 million ha, of which some 83% are distributed in Regions X, XI and XII in the south. Together with some 14% distribution in Region VIII and Region IX, almost all Chile's native forests are distributed in and to the south of Region VIII.

Native forests in the Model Areas mainly consist of Araucaria, Lenga, Coigue, Rauli, Roble, Tepa and Lingue. Coigue, Roble and Rauli forests are classified as either over-mature forests (estimated to be 150-300 years old) or secondary forests (estimated to be around 40 years old). Most of the secondary forests are said to have regenerated either by coppicing or seeding at the former sites of forest fires which used to frequently occur.

Many of the old, large diameter trees, specially large Coigue trees, are dying or suffering from dead tree tops or decay of the stem, reducing the prospect of their use for wood. This is a problem any plan for native forest activities in the future must carefully consider.

2) Regeneration Condition of Native Forests

The field survey results on the regeneration of Roble, Rauli and Coigue by means of coppicing or natural seeding are described below.

(1) Effect of Quila on Regeneration by Natural Seeding

One of the largest obstacles to forest regeneration by natural seeding in the Model Areas is believed to be the existence of Quila (*Chusquea culeou*) which has a fast and vigorous growth and which grows as tall as 5m or more with a stem diameter of approx. 3cm. It usually likes sunlight and rapidly propagates to form clumps wherever space is created in a forest. With a further increase in the clump density, it may block seeding or sunlight. On some occasions, even if the germination occurs, growth is prevented due to competition from Quila. The lack of natural regeneration because of densely grown Quila can be observed in many places in the Model Areas.

Table 4-2-3 shows the effect of Quila density on natural regeneration. Plot 1 and Plot 2 have trees of 15 years old or so (based on the annual ring count results). With regard to Plot 3, the tree age is not quite confirmed but is believed to be younger than that of the other 2 plots. Given the fact that the site conditions are not much different for all the plots, it is inferred that Quila density is a critical factor in the regeneration of Coigue.

(2) Regeneration by Coppicing

Vigorous regeneration by coppicing from stumps in addition to natural seeding is much in evidence in the case of Roble and Rauli. For Roble and Rauli, coppices may emerge in the same year as felling depending on when felling takes place and as many as 5~6 coppices and in some case upto a couple of dozen of coppices may emerge from a single stump. Table 4-2-4 shows regeneration by coppicing after 2 years of felling near inventory Plots 17 and 50 in the North Model Area.

Table 4-2-3 Natural Regeneration as Affected by Quila

(Plot Size = 10m x 10m)

Plot No.	Location	Species	No. of Seedlings/ha	Quila Cover Ratio (%)	Regeneration Method	Possible Seed Trees		Remarks
						Number	Distance from Survey Site (m)	
1	Pino Huacho mid-slope SW direction	Coigue	400	70	Seeding	7	80 ~ 90	El : 1300 m Dm : 90 ~ 100 cm HQ : 0.9 ~ 1.8 m DQ : 28 ~ 38 DR : 3.0 ~ 16.0 cm HR : 2.5 ~ 7.0 m
2	Pino Huacho upper slope SW direction	Coigue	1100	60	Seeding	2	60 ~ 70	El : 1300 m Dm : 90 ~ 100 cm HQ : 0.5 ~ 2.0 m DQ : 27 ~ 42 DR : 3.0 ~ 20.0 cm HR : 2.0 ~ 6.0 m
3	Pino Huacho lower slope NE direction	Coigue Rauli	132,000	10	Seeding	5	10 ~ 30	El : 1100 m Dm : 90 ~ 120 cm HQ : 4.0 ~ 5.0 m DQ : 10 ~ 15 DR : 0.5 ~ 4.0 cm HR : 1.0 ~ 8.0 m

Note: El (Elevation), Dm (Diameter Breast Height), HQ (Quila Height), DQ (Number of Quila/m2)
DR (Diameter of Seedling), HR (Height of Seedling)

Table 4-2-4 Condition of Coppice Regeneration in 2 Sites in the North Model Area

Area	Species	Stump		Coppice			Remarks
		Diameter (cm)	Height from the ground surface (cm)	Number	Height (cm)	Damage by Cattle	
Near Inventory Plot 17	Roble	17	25	21	40	Terminal shoots eaten	stumps damaged by fire as site has changed to pasture due to burning
	Roble	15	20	26	40	Terminal shoots eaten	
	Rauli	10	14	48	65	Terminal shoots eaten	
Near Inventory Plot 50	Roble	22	80	5	100	none	
	Rauli	32	20	11	92	none	

Small forest owners in the Model Areas appear to be exercising control on the number of coppices to obtain firewood and pulp wood. Some examples observed were 4-7 trees of 20-30 years in age with a DBH of 20-25cm from the same stump.

3) Outline of Current Activities

The felling of Araucaria is currently prohibited except for trees which are dead. The present administrative set-up requires any forest owner wishing to fell trees to submit a management plan stipulating the scale of felling, regeneration method and forest protection measures to the competent agency to obtain a permit prior to actual felling.

In the case of selective felling, unless the prospect of natural regeneration after felling is excellent, some of the existing species of the stand in question must be planted to compensate for the loss by selective felling. In the case of clear felling, some of the existing species of the stand in question must be planted within 3 years of felling to encourage the quick recovery of the stand.

The actual application process for a forest owner for selective felling in a native forest in Region IX is outlined below.

- Advance Application for Permit for Forest Activities Received May 29, 1990
- Permit Issued August 3, 1990
- Contents of Application

(Felling Plan)

Forest Type: Araucaria				Area: 64.6ha		Timing: 1990		Slope Gradient: 20°	
Stand Conditions	DBH Class (cm)	Araucaria		Coigue		Lenga		Total	
		Number of Trees/ha	Basal Area (m^2/ha)	Number of Trees/ha	Basal Area (m^2/ha)	Number of Trees/ha	Basal Area (m^2/ha)	Number of Trees/ha	Basal Area (m^2/ha)
Present (A)	15-115	4	3.173	112	47.375	60	9.126	176	59.674
Selective Felling (B)	65-115	—	—	30	16.367	—	—	30	16.367
B/A								0.17	0.27

(Replanting Plan)

Area (ha)	Timing	Species	No.of Seedlings/ha	Remarks
64.6	1991	Coigue	300	To be implemented when natural regeneration is not secured.

Examples of the final felling and thinning of secondary forests are given below.

Example 1: Los Laureles

The subject forest is 40-50 years old and is a privately owned, secondary Rauli forest. Final felling is being conducted at a stand where the DBH, tree height and density are 18-60cm, 30m (maximum:35m) and 677 trees/ha respectively. Some 80 trees/ha of good quality are left untouched in the hope that they will act as seed trees for natural regeneration by seeding. These trees are also expected to protect the seedlings which appear as the result of natural regeneration. However, it has not yet been decided whether these trees will be felled immediately after successful regeneration, at the time of the next final felling or will be left as seed trees throughout their life-time.

Example 2: Pemehue

The subject forest is 30-40 years old and is a privately owned, secondary Rauli-Roble-Coigue forest. The plan involves 3 thinning operations with a view to selecting trees with superior genetic quality in order to creating a selection forest with a rotation of 85~90 years in the future. The first thinning is aimed at adjusting the density while the second thinning is aimed at removing damaged and/or defective trees. The third and final thinning is aimed at reserving plus trees (including small diameter trees of excellent quality). Pruning will be conducted for the purpose of producing nodeless wood when the DBH reaches 10cm.

Example 3: El Morro

The subject forest is 46 years old and is a privately owned, secondary mixed Rauli and Roble forest. Thinning is planned in the near future and the relevant data, including the rate of thinning, are given in Table 4-2-5.

Table 4-2-5 Selection of Trees for Thinning

(Survey Area: 20m x 50m)

DBH (cm)	Present Trees		Trees Subject to Thinning		Rate of Thinning	
	Number of Trees (a)	Basal Area (m^2) (b)	Number (a')	Basal Area (m^2) (b')	By Number (a')/(a)	By Basal Area (b')/(b)
10	30	0.235	30	0.235	1.00	
12	23	0.260	23	0.260	1.00	
14	20	0.308	18	0.277	0.90	
16	17	0.342	14	0.281	0.82	
18	13	0.330	9	0.165	0.69	
20	6	0.188	3	0.094	0.50	
22	9	0.342	7	0.266	0.78	
24	9	0.407	5	0.226	0.55	
26	7	0.371	4	0.212	0.57	
28	2	0.123	0	0	0	
30	4	0.283	1	0.071	0.25	
32	1	0.080	0	0	0	
34	—	—	—	—	—	
36	2	0.203	1	0.101	0.50	
38	—	—	—	—	—	
40	—	—	—	—	—	
42	1	0.138	0	0	0	
Total	144	3.610	115	2.188	0.80	0.61
per ha	1,440		1,150			

Species: Rauli and Roble

4-3 Nurseries

There are a total of 363 nurseries in Chile, the majority of which are located in the area between Region IV and Region X. 167 nurseries are actually located in Region VIII and Region IX. 2 permanent nurseries inside the North Model Area and 3 permanent nurseries outside it in the surrounding areas were surveyed.

1) Obtainment of Seeds

The surveyed nurseries obtain seeds from their own forests, private companies, the Seed Centre of the CONAF or from foreign sources. The Seed Centre of the CONAF is the only public organization of its kind in Chile and was established in 1974 to collect and supply high quality seeds. It is said to be capable of supplying a sufficient amount of seeds to meet the demand for seeds of such native species as Roble and Rauli. Table 4-3-1 shows the characteristics of the seeds handled by the Seed Centre.

Table 4-3-1 Characteristics of Seeds Handled by Seed Centre

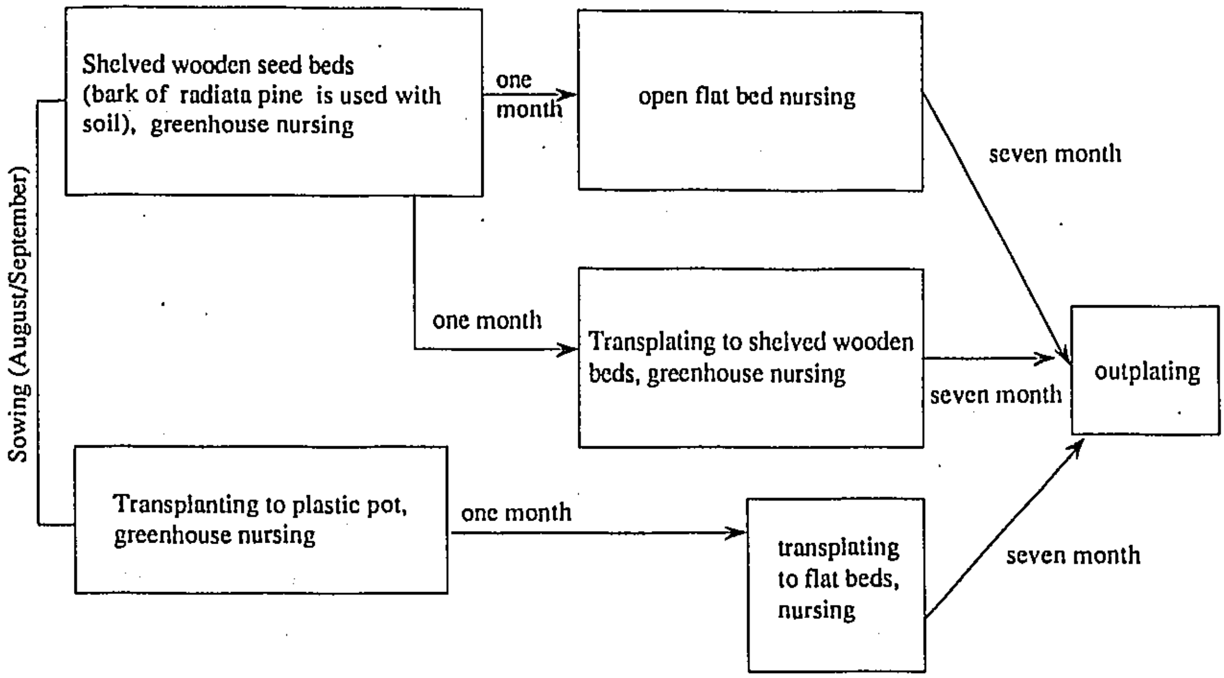
Item / Species	Seed Bearing Cycle (years)	Tree Age to Produce Good Seeds	No. of Seeds/kg	Germination Rate (%)
Rauli	3	35	80,000 ~ 90,000 (1)	40~50
Roble	1	30~35	100,000	20~40
Coigue	1	40~45	150,000 (2)	5~6
Araucaria	2	—	280	90
Radiata pine	1	18~29	30,000	80~90

Notes : (1) Number depends on provenance.
(2) Number of good seeds is small.

2) Nursery Operation

The survey on several privately owned nurseries found that the nursery practices for exotic species are similar. In comparison, however, the nurserys practices for native species vary from one nursery to another, probably because there are no established practices for these species. An example of nursery practices at a nursery is given below.

The seeds of Radiata pine are sown in beds of 1.2m x 100m in September or October and the seedlings are shipped for outplanting after some 8 months. The seeds of Eucalypts are sown in beds in October or November, transplanted to pots after one month and the seedlings are shipped for outplanting after an additional 7 months of nursing. This nursery has begun the nursing of Rauli and Roble seeds in the following manner.



3) Damage by Disease and Insects

Diseases occurring at nurseries for both exotic and native species are said to be root rot and damping-off. Fumigants and other agents are used to prevent damage by such diseases. Damage by cutworm is also reported, indicating the importance of introducing rotation and weeding.

4) Seed Storage and Germination Rate

The general conditions of seed storage and germination rate in Chile are outlined below based on data made available by the Seed Centre.

With regard to the seeds of such broad-leaf trees as Rauli and Roble, Radiata pine, *Picea sp.* and *Larix sp.*, etc., it is possible to store them for upto around 5 years with no negative effect on germination if they are kept in linen bags, in turn stored in sealed plastic bags, under conditions of a relative humidity of 6-8% and a temperature of 2°C.

The same storage conditions apply to the seeds of *Abies sp.*, *Cupressus sp.* and *Tsuga sp.*, etc. except that the relative humidity is increased to 8-10% to obtain the same storage performance.

In the case of Araucaria seeds, the relative humidity must be higher than for other seeds, making storage difficult without negatively affecting the germination rate.

5) Seeding Production

The nurseries owned by the companies A and C listed in Table 4-3-2 above (as mentioned in 4-1-1-2) have from 3 to 15 years experience in the mass production of seedlings. They have particular expertise in the raising of Radiata pine and Eucalypt seedlings. In contrast, however, the raising of native species only commenced recently and, with the absence of established nursery techniques, each company appears to adopt its own nursery practices.

Table 4-3-2 Seedling Production in the Nurseries Surveyed

(Unit: 1,000)

Nursery Affiliation	Nursery Area (ha)	Year of Establishment	Seedling Production				
			Species	Years Produced			
				1988	1989	1990	1991
Company A	2.5	1976	Radiata pine	1,000	1,000	1,000	(unknown)
			Eucalypts	—	—	116	
			Rauli	—	—85	—	
Company C	4.0	1989	Radiata pine	—	90	—	800
			Eucalypts	—	700	1,460	500
			Roble, Rauli	—	—	—	200

4-4 Forest Protection

4-4-1 Forest Fires

1) Recent Trends of Forest Fires

Table 4-4-1 shows the number of forest fires and damaged area in recent years. The number of forest fires shows an increasing trend while the annual figure fluctuates. The damaged area is also on the increase but the damaged area/forest fire is declining.

Table 4-4-1 Recent Trends of Forest Fires

Period	Average No. of Forest Fires/Year		Average Damaged Area/Year (ha)		Average Damaged Area/Fire (ha)	
	Nationwide	Regions VIII & IX	Nation wide	Regions VIII & IX	Nation wide	Regions VIII & IX
1971~1974	1,070	470	38,274	3,604	35	8
1985~1990	5,008	2,425	54,346	24,145	11	10

Source: CONAF

Major causes of forest fire are shown in Table 4-4-2. The biggest cause is cigarettes which are thrown away by passersby.

Table 4-4-2 Causes of Forest Fire (1988-1989)

Cause	Ratio (%)
Forestry Activities	5.6
Agricultural Work	5.6
Outdoor Recreational Activities and Sports	2.6
Playing with Fire	8.5
Passersby in Forest Areas	41.9
Other Activities in Forest Areas	1.7
Arson	18.7
Others	1.5
Unknown	13.9
Total	100.0

Source: CONAF

2) Forest Fire Prevention and Fire-Fighting Systems

There is a prior notification system for prescribed burning in forests and burning is prohibited during the day-time in the dry season.

The fire-fighting system includes the provision of small aircraft and helicopters by the CONAF in high risk areas and airborne patrols during the high risk season. When a fire breaks out, this aircraft is used to transport fire-fighting teams and water. Private companies owning large forest areas are also trying to consolidate their fire-fighting systems by basing helicopters and full-time fire-fighting teams.

4-4-2 Pests, Diseases and Animals

1) Pests

Common harmful insects to man-made forests include *Rhiacioria buoriana* which eats the terminal buds of Radiata pine, *Ormiscodes cinnamomea* which eats the leaves of Radiata pine and Chicharra which eats the stems of Eucalypts. In the case of man-made forests of the *Nothofagus spp.*, a group of larvae of 2 different types was observed eating the leaves of Roble during the field survey. However, the identities were not confirmed.

2) Diseases

Commonly known harmful micro-organisms include Diguenes (*Cyttarias espinosae, Cyttarias berteroi*) and *Cyttarias darwini* (mainly damage Lenga). Many decaying are reported but a relevant survey was not conducted during the field survey.

3) Animals

(1) Damage by Grazing Animals

Damage to man-made Radiata pine forests is said to be caused by trampling of animals. In regard to forests of the *Nothofagus spp.*, the field observation confirmed that young branches upto 2m from the ground are often eaten in naturally regenerated stands and that young trees upto 40-50cm in height are damaged by the feet of animals. Since cattle grazing is common throughout native forests in the Model Areas, measures are required to ensure successful natural or artificial regeneration without damage inflicted by cattle.

(2) Damage by Wild Animals

Terminal buds and the bark of planted *Nothofagus spp.* are often eaten by wild rabbits (*Oryctolagus sp.*). No special measures are taken apart from the setting of traps to prevent this. Damage to bark by wild rats (*Orthodom bridgessi*) is also reported.

4) Climatic Damage

There is the opinion that forests of native species, regenerated by coppicing, are vulnerable to wind damage due to the generally high density. Frost damage is said to occur in man-made Radiata pine stands with an elevation of more than 800m.

4-4-3 Soil Erosion

1) Past Erosion

Based on the field observation results and information provided by people familiar with the local forest conditions, it is reasonable to assume that vegetation cover protecting the soil in both Model Areas has been partially or totally removed at least once in the past 40-50 years because of forest fires, the clearing of stands to create ranches or farmland and/or felling to establish man-made forests.

Based on the above assumption and taking the topographical condition of the areas into consideration, various types of soil erosion, particularly surface erosion, may have taken place in the past in areas where vegetation cover had been removed. The intensity of past erosion in the areas concerned depends on the degree of vegetation cover lost, length of the site remaining bare, topography of the site, rainfall intensity during the period of the land being bare and stock raising/farming intensity.

Currently, in the sites where vegetation cover has been re-established evidence of significant erosion taking place was not observed. But in those ranches where stock raising has been continuing without improvement measures being applied and where vegetation cover has not been restored, soil erosion of different degrees and scales that started in the past has been continuing up to now.

2) Current State of Soil Erosion

Soil erosion in the Model Areas could be classified as 1) surface erosion (micro collapse, gully erosion and sheet wash); 2) Landslide.

(1) Surface Erosion

Surface erosion (particularly micro collapse and gully erosion) is often seen at ranches located on steep slopes (mostly with a gradient of more than 25°) where intensive stock raising has left barely any grass cover. Mainly cattle are raised and the intensity of cattle raising has resulted in the formation of cattle tracks of 10-20cm deep and from 40 to over 100cm wide. The field observation confirmed the occurrence of micro collapse at the edges of these tracks following the passage of cattle.

Most gullies are found to have developed at such micro collapse sites. Most gullies observed were active and were eroding headwards as well as downwards.

Gully erosion is also taking place at logging roads which are neither paved nor repaired and which lack drainage facilities due to ground yarding and the wheels of oxen-driven carts transporting wood and other goods. The field observation confirmed that gullies (1.0-1.2m deep and 1.5-2.0m wide) are in the process of development on some of the severely affected logging roads, with gully head expanding up-slope. Sheet wash can be said to be occuring on steep land laid bare by the burning of branches and other organic debris following felling.

A survey was conducted at 2 severely eroded ranches (400m^2 and 10,000m^2) in the South Model Area. This was to estimate roughly soil loss and ratio of the area affected by ongoing erosion in a severely eroded site.

Table 4-4-3 gives the survey results for the 10,000m^2 sample plot. As the table shows, more than 20% of the surface area of the plot has been affected by erosion. Assuming that felling was conducted some 50 years ago to establish the ranch and that erosion began some 10 years later, the soil loss volume can be estimated to be some 22 tons/ha/year. It must be noted here that this figure only represents the soil loss from gully erosion and does not include soil loss caused by other types of erosion. As data on soil loss for ranches and forests in the Model Areas are unavailable, the soil loss tolerance rate for farmland which is generally 2-12 tons/ha/ year, (widely used to determine the need for the introduction of soil erosion prevention measures for farmland) has been used as a general reference in comparison to which the severity of erosion in the sample plot could be evaluated. As can be seen, the amount of soil loss in the surveyed plot is approximately twice as high as the maximum limit of the soil loss tolerance rate mentioned above.

Table 4-4-3 State of Erosion at a Severely Eroded Ranch Located on Northeastern Slope of Nevados de Sollipulli in Upperstream of a South Tributary of Rio Curacalco (South Model Area)

(Plot Size: 100m x 100m, Slope Gradient: 27°, Elevation: 1,250m)

Type of Erosion	Volume of Erosion (tons)	Land Area Affected (m^2)	Ratio of Affected Area to Total Sample Area(%)
Gully	10.37	22.60	0.22
Gully	15.16	72.80	0.73
Gully	2.80	16.80	0.17
Gully	9.33	35.00	0.35
Gully	550.00	1,100.00	11.00
Gully	138.66	416.00	4.16
Gully	93.33	224.00	2.24
Gully	31.00	124.00	1.24
Gully	29.88	89.95	0.90
Sub-Total	880.63	2,101.15	21.01
Micro Collapse	—	12.60	0.12
Micro Collapse	—	19.08	0.20
Micro Collapse	—	10.14	0.10
Micro Collapse	—	26.25	0.26
Micro Collapse	—	22.41	0.22
Micro Collapse	—	20.09	0.20
Sub-Total	—	110.57	1.10
Total	880.63	2,211.72	22.11

(2) Landslide

One of the most recent landslides occurred in January, 1991 near Amargos. The landslide section was approx. 40m wide and 150m long. It started at the fragile road shoulder where waste soil from a newly constructed forest road had been dumped and the fallen sediment destroyed part of a house. Several naturally occurred landslides sites were observed in the Model Areas during the field survey but the details of these sites were not studied.

4-5 Land Ownership Boundaries

The CIREN has been preparing cadastral maps and cadastral registers throughout the country. The only established data at present, however, are data on urban areas and farmland and no cadastral data on forest areas are currently available.

Land ownership is under the jurisdiction of the National Tax Agency and the Agency supplies the CIREN with cadastral data. The interview survey in the Model Areas, however, revealed that many small landowners are not registered with the National Tax Agency and, partly due to this fact, the field survey failed to collect information and data on the boundaries of privately owned land.

CHAPTER 5 SOCIOECONOMIC SURVEY

Interview surveys were conducted mainly on local inhabitants in the Model Areas to identify the local socioeconomic conditions.

5-1 North Model Area

Land in the North Model Area is owned by local small landowners (settlers), by 3 large land-owners (private forestry companies) and by the central government. 16 households were selected from the settlers for the interview survey, the findings of which are compiled in Appendix 8.

Based on these findings and information obtained from private companies and the CONAF, the current socioeconomic conditions and problems facing local inhabitants are compiled in Table 5-1-1.

Table 5-1-1 Socioeconomic Conditions & Problems in North Model Area

Survey Item	Current Conditions	Problems & Requests Expressed by Inhabitants	Problems for Forest Management
Administrative Zone	• Mulchen District, Bio Bio Province, Region VIII & Collipulli District, Malleco Province, Region IX		
Village	• Village of 13 households at Amargo • Mostly sparsely located houses along the road		
Transport & Communications	• Unpaved 67km road between Collipulli (located along national Route 5) and Los Guindos • Unpaved 72km road between Mulchen (located along national Route 5) and Los Guindos • Distance between Los Guindos and the nearest airport (Temuco): 162km • Distance between Los Guindos and the nearest port (Talcahuano): 302km • Regular bus service between Collipulli & Los Guindos (one service/day on weekdays) • Twice weekly bus service between Collipulli & Pemehue in summer (December-February) • Main transportation means in the area: foot, horse, oxcart • Provision of one seasonal bridge to allow vehicles to cross Rio Rinaico in summer, suspension foot bridges available • Maintenance of unpaved road between Collipulli & Pemuhue in summer conducted by private forestry company • Radio communication equipment available at National Reserved Forest management office at Los Guindos & private company offices	• Many roads are unusable in winter or after rain • More than one days' travel to procure commodities for daily life (mainly at Collipulli) • Lack of telephone facilities, reliance on regular bus services or wireless communication equipment owned by CONAF or other organizations for emergency communication • Priority should be given to road improvement.	• Transport of forest products limited to summer • Forest management, including patrols & fire-fighting, hindered by poorly maintained roads in national forests • Minimum 2 days' travel from national forest management office at Los Guindos to CONAF's provincial office at Angol, making achievement of swift administrative activities impossible

Table 5-1-1 (Continued)

Survey Item	Current Conditions	Problems & Requests Expressed by Inhabitants	Problems for Forest Management
Households & Population	• Total of 125 households with 625 inhabitants • Average of 5 people/household • No population change in area for some time • 2-3 children/household since 1980's • Emigration of young women from the area		
Land Ownership	• 10-180ha of national land/ household (average: 70ha) were given free of charge in 1960's • Further compartmentation of original blocks of land in progress due to inheritance & other reasons • Caretakers appointed by absentee landowners living in Los Angeles & Collipulli, etc.	• Backlog in land registration to ascertain divided land due to inheritance & other reasons	• Decreasing unit size of forest operations due to compartmentation of original blocks of land • Unclear land boundaries even on official maps
Agriculture	• Cultivation of wheat, rye & oats, etc. for own consumption over 0.5-2.0ha of cleared land in native forests • *Cultivation of potatoes, beans, maize &* vegetables for own consumption over some 0.5ha of land near house (site is called Chacra) • Wheat cultivated in April for harvest in following January/February • Wheat yield: 900- 1,800kg/ha • Wheat cultivation is combined with grass, potatoes, rye & oats, etc.to avoid repeated cultivation • Wheat cultivation sites are rested for 5-10 years after harvest	• Wheat productivity in the area much lower than Chilean average of 3,007kg/ha (FAO, 1988), resulting in low wheat self-sufficiency rate • *Application for felling in native forests* to create farmland is impossible because of land registration backlog	• Reduction of forests due to expansion of farmland • Occurrence of forest fires due to burning to create farmland

Table 5-1-1 (Continued)

Survey Item	Current Conditions	Problems & Requests Expressed by Inhabitants	Problems for Forest Management
Stock Raising	• Domesticated animals: cattle, horses, sheep, pigs, goats, chickens, ducks, etc. • 2-15 head of cattle/household (average: 7.8 head) • 1.5-40.2ha of natural grazing land (average: 15.1 ha) • Cattle graizing in native forests all over the year. • Use of dry feed to supplement diet in winter (April-October) • Sales price of oxen: 60,000-150,000 pesos/head (360 pesos=1US$) • 0.1-4.0ha of man-made grazing land/house-hold to grow Ovillo, Trebol, Pesto & Alfalfa, etc.	• Obtainment of bull with superior qualities & numerical increase of cattle both difficult • Provision of assistance in terms of seeds, fertiliser & barbed wire, etc. to improve & expand grazing land & to practice intensive stock raising • Restoration of stock raising rights within national forests which was once permitted • Shortage of feed in winter	• Incomplete fencing of national land permitting invasion by settlers' cattle • Systematic stock raising not practiced with absence of designated grazing areas • Damage to natural forests due to eating by & trampling of cattle
Forestry/Forest Products Industry	• 6.5-121.1ha of native forest area/household (average:52.3ha) • 50% of interviewees (16 persons) engaged in timber production & 70% in production of logs as chip material • 6 mobile sawmills in the area to conduct sawing on contract with forest owners • Sawing in summer (November-March) at daily production volume of 11.8-16.5m^3 • Prices of sawn timber/m^3: 25,000-34,000 pesos for Rauli, 17,000-30,000 pesos for Roble & Coigue & 19,500 pesos for radiata pine • Spot-sale price of chip materials: 2,400-3,000 pesos/m^3 • Collection of firewood for own consumption from native forests • Production of charcoal & honey by some settlers • Man-made forests mainly consisting of radiata pine at 0.5-3.0ha/household (average: 3.3ha)	• Implementation of chip materials production and such forestry operations as thinning in secondary forests • Speedy processing of applications for permission for forestry activities • Negative response to prospect of afforestation using native species due to lack of technical experience • Inferior position as sellers vis-a-vis buyers of forestry products due to lack of a sellers' organization	• Illegal felling • Planted trees eaten by wild rabbits • Very low wood utilisation ratio

Table 5-1-1 (Continued)

Survey Item	Current Conditions	Problems & Requests Expressed by Inhabitants	Problems for Forest Management
Income	• 45% of cash income originating from local wage work & caretaking of absentee owners' land, 37% from sale of forest products & rest from sale of cattle & other animals • Annual household income from half million to 1.8 million pesos (average: 0.6 million pesos)		
Employment	• Large forestry companies in & around the area provide important employment opportunities • 170 people employed by 2 companies	• Most of those who finish secondary education prefer to become forest workers employed by private companies	
Public Facilities	• 3 primary schools in the area (number of pupils ranging from 18 to 38) • Clinic capable of conducting emergency treatment at Amargo • CONAF's National Reserved Forest management office at Los Guindos • *Junta de Vecinos (Neighbors Council)* acts as residents' organization to assist public works & school education • Hot spring owned by Collipulli District at Pemehue	• Some children unable to attend school because of distance • Less than 50% receive secondary education • Present clinic inadequate to treat serious patients who are transported to hospital at *Collipulli, some 70km away*	• Shortage of manpower & vehicles at CONAF's national forest management office
Electricity & Drinking Water	• Electricity mainly self-generated • Hydropower generation in some areas • Water sources: spring water or small streams near house	• minor pollution of water sources by animals	

5-2 South Model Area

As in the case of the North Model Area, land in the South Model Area is owned by either local small landowners (settlers), large landowners which are private companies and the central government. An interview survey was conducted on 8 selected households and the survey findings are compiled in Appendix 9.

Based on these findings and information obtained from private companies and the CONAF, the current socioeconomic conditions and problems facing local inhabitants are compiled in Table 5-2-1.

Table 5-2-1 Socioeconomic Conditions & Problems in South Model Area

Survey Item	Current Conditions	Problems & Requests Expressed by Inhabitants	Problems for Forest Management
Administrative Zone	• Cunco District & Melipeuco District, Cautin Province, Region IX		
Village	• Area around Santa Maria de Llaima with relatively high population density		
Transport & Communications	• 75km road between Temuco & Melipeuco usable throughout the year, providing good transport facility in the area • Regular bus service through LLaima between Cunco & Melipeuco . • Inhabitants in Curacalco catchment area have strong economic & social ties with Cunco while those in Cherquen & Llaima catchment areas have strong *economic & social ties with Melipeuco* • Main transportation means in the area: horse & oxcart • Telephone exchange at Cunco & Melipeuco (none in the Model Area) • Wireless communication equipment owned by large landowners	• Many roads are unusable in winter or after rain • Road improvement is one of the priority tasks in the area	• Transport of forest products limited to summer

Table 5-2-1 (Continued)

Survey Item	Current Conditions	Problems & Requests Expressed by Inhabitants	Problems for Forest Management
Households & Population	• Total of 230 households with 1,260 inhabitants • Average of 5.5 people/household • Emigration to Argentina to seek jobs • 72% of the population in Melipeuco District are descendants of natives but highly integrated to Chilean society with advancement of racial mixture		
Land Ownership	• 0.5-10ha/household around settlements in the northern parts of the area • 50ha or more/household in deep southern part of the area • Purchase of land by large owners in progress in some parts of the area		• No clear land boundaries shown on official maps
Agriculture	• Cultivation of wheat, rye, potatoes, beans & vegetables in some 3ha of land for own consumption (observed near settlements in the northern parts of the area) • Sowing of wheat in April or May, sowing of grass in September. After harvest of wheat (February), grass is produced in the land for some 2 years • Wheat yield: 690-1,000kg/ha • Cultivation for own consumption not conducted in deep southern parts of the area because of poor soil productivity	• Poor soil productivity resulted in deep southern part of the area due to continuous grazing • New development of farmland difficult due to refusal of felling • Lack of funds to buy fertilizers	• Reduction of forests due to creation of new farmland for wheat cultivation • Occurrence of forest fires caused by burning to create farmland

Table 5-2-1 (Continued)

Survey Item	Current Conditions	Problems & Requests Expressed by Inhabitants	Problems for Forest Management
Stock Raising	• Domesticated animals: cattle, horses, sheep, pigs, goats, chickens, ducks, etc. • 3-44 head of cattle/house-hold (average: 12.2 head) • *Grazing conducted mainly on natural* grassland (6-60ha/household, average: 25ha) • Cattle raising in native forests throughout year. Mountain grazing land may be rented in summer • 0.5-4ha/household (average:2.3ha) of man-made grazing land near settlements to grow Trebol (*Trifolium sp*), Ovillo (*Dactylis glomerata L.*) & Fomental (*Arrhenatherum elatis Beauv*), etc. • Sales price of oxen:100,000-160,000 pesos/head (calves: 30,000-70,000 pesos/head) • Cattle grazing density:0.05-0.08 head/ha • Systematic stock raising in designated grazing areas practiced by large land-owners with grazing density of 0.5 head/ha. • Feed consumption in winter (June-September) of large landowner: 10kg/head/day	• Numerical increase of cattle by 2-20 head • Grass growth is slow in mountain areas due to repeated grazing & short sunshine hours • *High death ratio among cattle in winter* due to insufficient feeding (May-October) • Hope for improvement & expansion of grazing land dashed due to lack of land purchasing funds & long period required to obtain felling permit for native forests • Lack of money to erect fences & gates to implement systematic stock raising • Improvement & recovery of low productivity grazing land in deep mountain areas difficult	• Reduction of forests due to expansion of grazing land • Damage to native forests due to eating by & trampling of cattle • Change of forests to grazing land *through clear felling extending to steep* slopes • Systematic stock raising not practiced with absence of designated grazing land

Table 5-2-1 (Continued)

Survey Item	Current Conditions	Problems & Requests Expressed by Inhabitants	Problems for Forest Management
Forestry/Forest Products Industry	• Main products: sawn timber & sleepers • Sawing conducted by mobile sawmill (capacity: 17-24 m^3/day) based on contract with landowner or families • Production of both sawn timber & sleepers confined to summer (December-April) • Highest sleeper production figure in the area: 1,800 pieces/year • Price of sawn timber: 25,000 pesos/m^3 for Roble (29,000-34,000 pesos/m^3 for Coigue) • Price of sleepers: 1,100 pesos/piece (25cm x 15cm x 180cm) or 2,400 pesos/piece (25cm x 15cm x 275cm) • Roof tile (10cm x 1.8cm x 40cm) produced in some areas with production rate of 2,000-3,000 tiles/day • Collection of firewood for own consumption from native forests • Beekeeping by some settlers	• Absence of sales routes for small diameter trees for chip production • Formulation & enforcement of new forest decree (No.701) (opinion of large forest owners) • Forest operations in native forests impossible due to prohibitive cost (opinion of large forest owners) • Inhabitants in northern parts of the area are interested in silviculture of native forests • Inhabitants in deep southern parts of the area are more interested in obtaining benefits from forests without active tending	• Extremely low yield of log & sawn timber production, slash thrown away at stand • Absence of systematic forest road construction, temporary roads made for yarding
Income	• Average household income: 450,000 pesos/year • 52% of cash income originating from sale of forest products & 34% from sale of cattle		

Table 5-2-1 (Continued)

Survey Item	Current Conditions	Problems & Requests Expressed by Inhabitants	Problems for Forest Management
Employment	• 160 people employed by large forest owners in the area • Emigration to Argentina for work		
Public Facilities	• 7 primary schools in the area (3 public & 4 private) • Number of pupils at public schools ranging from 12 to 20 • Clinic capable of conducting emergency treatment at Llaima • *Also monthly-travelling-clinic* • Junta de Vecinos (Neighbours Council) acts as residents' organization		
Electricity & Drinking Water	• Electricity mainly self-generated • Water sources: spring water or small streams		

CHAPTER 6 NATURAL ENVIRONMENT SURVEY

The survey was conducted to identify the basic characteristics of the natural environment in the Model Areas and to collect data on the conservation of the natural environment.

6-1 Current State of Environmental Conservation

6-1-1 Legal Framework

The conservation of wildlife by legal measures in Chile goes back as far as the late 19th century and a series of measures have since been introduced. The current legal framework related to the conservation of nature consists of the following laws and decrees.

(1) Supreme Decree 4363
Stipulates forestry activities in relation to soil and water conservation and the introduction of national parks and reserve forests on national land.

(2) Law 15020
Stipulates conservation measures for areas affected by erosion and the prohibition of felling of trees in natural landscapes in touristic sites.

(3) Supreme Decree 531
Stipulates genuine nature reserves and natural monuments to be strictly protected and managed.

(4) New Decree Law 701
Stipulates the prior permission system for forestry activities to be controlled by the CONAF and requires that a protection programme should be annexed to each forest management programme.

(5) Supreme Decree 141
Declaring Araucaria as natural monument.

6-1-2 Government Stance on Wildlife Conservation

The CONAF recently sponsored the "The Symposium on Threatened Chilean Native Tree and Shrub Flora" and The Symposium "Conservation Status of Chilean Terrestrial Vertebrate Fauna", the results of which were compiled in respective reports, i.e. "Red List of Chilean Terrestrial Flora" (CONAF, 1989) and "Red List of Chilean Terrestrial Vertebrates" (CONAF, 1988). The Chilean stance on wildlife conservation can be understood through these reports.

1) Red List of Wild Flora and Fauna

The reports mentioned above contain lists of rare wild flora and fauna, prepared pursuant to criteria set by the World Conservation Strategy (WCS). The red lists for Region VIII and Region IX are given in Tables 6-1-1, 6-1-2 and 6-1-3.

Table 6-1-1 Red List of Wild Flora in Region VIII

A. Species to be Protected at a National Level

Endangered Species	Vulnerable Species	Rare Species
Beilschmiedia berteroana	*Araucaria araucana*	*Citronella mucronata*
Berberidopsis corallina	*Austrocedrus chilensis*	*Eucryphia glutinosa*
Gomortega keule	*Laretia acaulis*	*Maytenus chubutensis*
Pitavia punctata	*Legrandia concinna*	*Myrceugenia correaefolia*
	Nothofagus glauca	*Myrceugenia leptospermoides*
	Nothofagus leonii	*Myrceugenia pinifolia*
		Orites myrtoidea
		Prumnopytis andina
		Ribes integrifolium
		Scutellaria valdiviana

B. Species Not Included in Table A But to be Protected at a Regional Level

Endangered Species	Vulnerable Species	Rare Species
NONE	NONE	*Eucryphia cordifolia*
		Caldcluvia paniculata
		Kageneckia oblonga
		Maytenus magellanica
		Senecio cymosus
		Laurelia philippiana
		Escallonia myrtoidea
		Corynabutilon vitifolium

Source: Red List of Chilean Terrestrial Flora, CONAF, 1989

Table 6-1-2 Red List of Wild Flora in Region IX

A. Species to be Protected at a National Level

Endangered Species	Vulnerable Species	Rare Species
Pitavia punctata	*Astrocedrus chilensis*	*Citronella mucronata*
Berberidopsis corallina	*Araucaria araucana*	*Corynabutilon ochsenii*
	Laretia acaulis	*Eucryphia glutinosa*
		Maytenus chubutensis
		Myrceugenia colchaguensis
		Myrceugenia leptospermoides
		Myrceugenia pinifolia
		Orites myrtoidea
		Prumnopytis andina
		Ribes integrifolium
		Satureja multiflora
		Scutellaria valdiviana

B. Species Not Included in Table A But to be Protected at a Regional Level

Endangered Species	Vulnerable Species	Rare Species
	Persea lingue	*Podocarpus nubigena*
	Laurelia philippiana	*Cryptocarya alba*
	Nothofagus alpina	

Source: Red List of Chilean Terrestrial Flora, CONAF, 1989

Table 6-1-3 Red List of Wild Fauna in Regions VIII and IX

Scientific Name	Red List Category		
	National	Region VIII	Region IX
MAMMALS			
Hippocamelus bisulcus	E	E	Ex
Lagidium viscacia	V	E	E
Lutra felina	V	-	E
Lutra provocax	E	Ex	E
Felis guigna	E	E	E
Lama guanicoe	V	Ex	E
Galictis cuja	V	V	V
Felis concolor	V	V	V
Pudu pudu	V	V	V
Geoxus valdivianus	R	-	R
Canis fulvipes	V	-	R
Lyncodon patagonicus	R	-	R
Euneomys sp.	K	K	K
Canis culpaeus	K	K	K
Canis griseus	K	K	K
Myocastor coypus	O	O	O
Conepatus chinga	O	O	O
Otaria flavescens	O	O	O
Felis colocola	E	E	-
Octodon bridgesi	V	V	-
Euphractus pichiy	V	R	-
Abrocoma bennetti	I	I	-
Abrothrix longipilis	K	K	-
BIRDS			
Plegadis chihi	E	E	E
Cygnus melancoryphus	V	E	E
Falco peregrinus analum	E	E	E
Nycticryphes semicollaris	E	E	E
Puffinus creatopus	V	V	V
Pelecanoides garnotii	V	V	V
Phalacrocorax bougainvillii	V	V	V
Pandion haliaetus	V	V	V
Gallinago gallinago	V	V	V
Larosterna inca	V	V	V
Columba araucana	V	V	V
Campephilus magellanicus	V	E	V
Ixobrychus involucris	R	R	R
Ardea cocoi	R	R	R
Phoenicopterus chilensis	V	R	R
Anas bahamensis	R	R	R
Heteronetta atricapilla	R	R	R
Vultur gryphus	V	R	R
Accipiter bicolor	R	R	R
Buteo ventralis	R	R	R
Buteo albigula	R	-	R
Attagis gayi	R	R	R
Larus serranus	R	R	R
Larus modestus	V	R	R
Spheniscus humboldti	V	K	K
Sula variegata	K	K	K
Phalacrocorax gaimardi	K	K	K
Tachyeres patachonicus	K	K	K
Anas platalea	K	K	K
Falco peregrinus cassini	K	K	K
Laterallus jamaicensis	K	K	K
Enicognathus leptorhynchus	V	E	K
Strix rufipes	K	K	K
Asio flammeus	K	K	K
Pseudocolopteryx flaviventris	K	K	K
Theristicus caudatus	V	V	O
Chloephaga melanoptera	V	R	-
REPTILES			
Philodryas chamisonis	V	V	X
Tachymenis chilensis	V	X	X
Liolaemus chilensis	V	X	X
Centrura flagelifera	V	X	-
Liolaemus nitidus	V	X	-
Liolaemus lemniscatus	V	X	-
AMPHIBIANS			
Bufo rubropunctatus	V	V	V
Rhinoderma darwini	V	V	V
Insuetophrynus acarpicus	E	R	R
Alsodes barrioi	R	-	R
Telmatobufo bullocki	R	-	R
Bufo spinulosus	V	V	K
Bufo chilensis	V	K	K
Bufo variegatus	K	-	K
Caudiverbera caudiverbera	V	E	K
Batrachyla taeniata	V	X	X
Alsodes vanzolinii	V	V	-
Telmatobufo venustus	R	E	-
Rhinoderma rufum	E	X	-
FISHES			
Austromenidia laticlavia	V	X	X
Geotria australis	V	E	-
Mordacia lapicida	E	X	X
Brachygalaxias bullocki	V	X	X
Galaxias maculatus	V	X	X
Galaxias platei	V	-	X
Aplochiton zebra	V	X	X
Aplochiton taeniatus	E	-	X
Cheirodon galusdae	V	X	X
Diplomystes chilensis	E	X	X
Trichomycterus areolatus	V	X	X
Bullockia maldonadoi	V	X	X
Nematogenys inermis	E	X	X
Percichthys trucha	V	X	X
Percilia gillissi	V	X	X
Cauque mauleanum	V	X	X
Genus cauque (under revision)	V	X	X
Basilichthys australis	V	X	X
Eleginops maclovinus	V	X	X
Mugil sp.	V	X	X
Leptonotus blainvillianus	E	X	X
Micropogon manni	E	-	X
Cheirodon pisciulus	V	X	-
Diplomystes nahuelbutensis	E	E	-
Trichomycterus chiltoni	E	E	-
Percichthys melanopus	E	X	-
Percilia irwini	E	E	-

Source: Red List of Chilean Terrestrial Vertebrates, CONAF, 1988

The red list categories used are conservation categories proposed by the International Union for the Conservation of Nature and Natural Resources (IUCN) and the definition of each category is given below.

EX (Extinct)
Flora and fauna of which an individual has not been found in a wildlife area for the last 50 years.

E (Endangered)
Taxa facing extinction unless factors causing the reduction of individuals are removed. Includes those taxa which have sometimes been found in the last 50 years but which are assumed to have become extinct by now.

V (Vulnerable)
Taxa which are likely to be classified as "endangered" in the near future unless factors causing the reduction of individuals are removed. Includes those taxa of which the number has drastically declined due to excessive use or large-scale destruction of habitats, those of which a conspicuous decrease in individuals may lead to extinction and those which are numerous at present but whose habitats are facing danger.

R (Rare)
Taxa which cannot be classified as endangered or vulnerable species but which are worthy of attention because of the small number of individuals. Includes those taxa whose habitats are confined to extremely small areas or are thinly scattered over a more extensive range.

I (Indeterminate)
Taxa which should be classified as E, V or R but for which classification is not possible due to insufficient data.

K (Insufficiently Known)
Taxa which may be classified as E, V or R but for which sufficient data is unavailable.

O (Out of Danger)
Taxa facing no danger of extinction.

X (Conservation Status Not Defined)
Taxa for which the conservation status cannot be currently defined.

2) Wildlife Conservation Programmes

The CONAF is implementing the following conservation programmes in response to the red lists mentioned earlier.

(1) Wild Fauna Conservation Programmes
These include the attempt to clarify those species in danger, promotion of studies on species with a high conservation priority, a campaign to boost funds for conservation activities and a campaign to demand legal protection for endangered species.

(2) Wild Flora Conservation Programmes
These include a study to determine the conservation priority order of endangered species, compilation of existing data, collection of field data, collection of seeds, fostering of seedlings and planting on national land.

6-1-3 Designation of Wildlife Reserves

Wildlife reserves are classified as national parks, reserve forests and natural monument forests. Table 6-1-4 shows the existing reserves in Regions VIII and IX.

Table 6-1-4 National Wildlife Reserves in Regions VIII and IX

Section		Region IX		Region VIII	
		Name	Area (ha)	Name	Area (ha)
Study Area	National Park	Tolhuaca Conguillio	6,374 46,000		
	Reserve Forest	Nalcas Malalcahuello Malleco China Muerta Hualalafquen	13,775 29,530 17,371 11,168 43,263		
Outside Study Area	National Park	Nahuelbuta Villarrica Huerquehue	5,415 61,000 12,500	Laguna del Laja	11,889
	Reserve Forest	Alto Bio Bio	35,000	Isla Mocha Ralco Nuble	2,369 12,421 71,790
	Natural Monument	Cerro Nielol	86	Contulmo	82
Total	National Park Reserve Forest Natural Monument Total	....	131,289 150,107 86 281,482	....	11,889 86,580 82 98,551

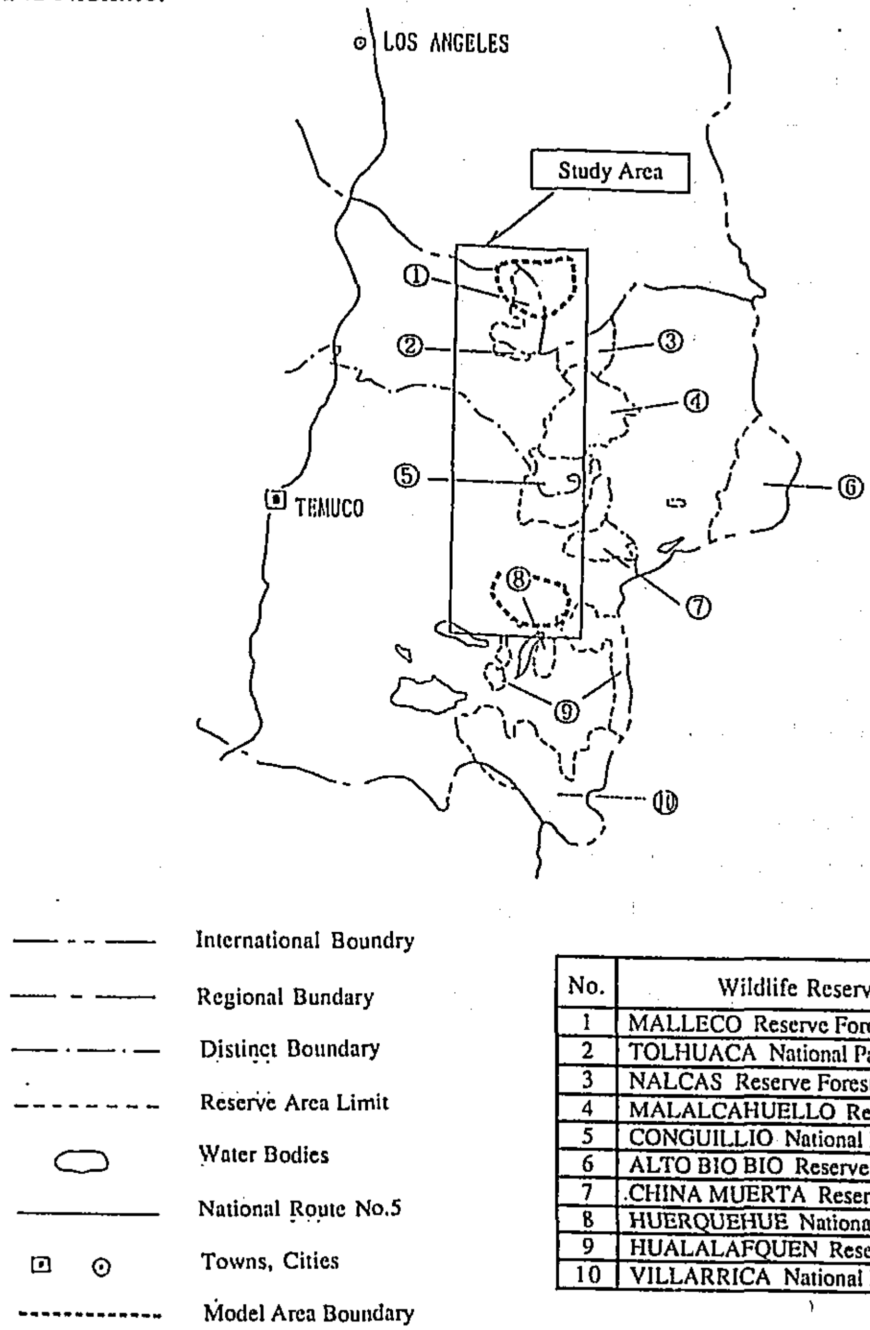
Source: Geografia de Chile Tomo XIV, IGM, 1985 and CONAF VIII Region, 1991

The reserves which are located in and around the Study Area are shown in Fig. 6-1-1. The Malleco Reserve Forest is situated in the North Model Area while part of the Hualalafquen Reserve Forest is situated in the South Model Area.

The Malleco Reserve Forest is divided into the following 5 areas.

I. Niblinto
II. Renaico
III. Menuco
IV. Pino Huacho
V. Prado 18

3 areas, i.e. II, III and IV, are situated in the North Model Area. Area IV is further divided into the enclave (IVa) near Los Guindos also along the Renaico River and the area (IVb) in the Amargo river basin. These areas are managed by the local CONAF offices located at Los Guindos and Niblinto.



No.	Wildlife Reserves
1	MALLECO Reserve Forest
2	TOLHUACA National Park
3	NALCAS Reserve Forest
4	MALALCAHUELLO Reserve Forest
5	CONGUILLIO National Park
6	ALTO BIO BIO Reserve Forest
7	CHINA MUERTA Reserve Forest
8	HUERQUEHUE National Park
9	HUALALAFQUEN Reserve Forest
10	VILLARRICA National Park

Fig. 6-1-1 Reserves in and Around Study Area

6-1-4 Environmental Conservation Activities

1) Research Project for Bio Bio River Basin Management (Gestion de Los Recursos Hidricos de la Cuenca del Rio Bio Bio y del Area Marina Costera Adyacente)

The North Model Area is the source of the Renaico River, a tributary of the Bio Bio River which is the largest river in Chile with a catchment area of 2,400km^2 but which is suffering from serious water pollution, particularly near the estuary. The University of Concepcion jointly established the Environmental Science Research and Education Centre with universities in Europe and Latin America in 1984 for environmental conservation along the Bio Bio River, including the river itself, and launched the Research Project in 1990.

The subject fields of research are (1) ocean pollution at the estuary, (2) river environment, (3) socioeconomic conditions in the Bio Bio river basin and (4) wildlife in the basin. In addition, research on the lives of natives living in the basin is in progress as a special research theme.

The Study Team obtained the following information from the Centre.

① The Bio Bio River serves as an important source of irrigation water in Region VIII and also as an important source of domestic water for Concepcion.

② The lowerstream of the Bio Bio River is abound with fish.

③ Some 80-90% of the natives in Chile live in an area between 1,200m and 1,800m above sea-level in the Bio Bio river basin. These natives raise livestock in natural forests with a high elevation (1,600m-1,800m) in summer and move to lower elevation areas (around 1,200m) in winter. While they seasonally migrate, the main areas of residence are (1) Rio Queuco river basin, (2) around Lake Gualletue and (3) around Lake Icalma. Above area (1) is near the North Model Area while area (3) is near the South Model Area.

④ The nut of the *Araucaria araucana* is the traditional food of the natives.

2) Region IX Environment Commission (Comision Regional del Medio Ambiente; CORAMA)

Environment commissions are established at different administrative levels, ranging from the national CONAMA (Comision National del Medio Ambiente) to regional CORAMAs and further to provincial COCOMAs (Comision Comunal del Medio Ambiente). CORAMAs are organized by the CONAF, university groups, the Ministry of National Land and the Nature Conservation Association with the CONAF playing the leading role. The CORAMA in Region IX is currently dealing with environmental problems in the region while referring to environmental issues compiled by the CONAMA.

6-2 Basic Characteristics of Natural Environment

1) Topography

The Study Area spreads along the outlying Andes Mountains to the west of the Andes Mountains and is characterised by mountainous topography with many slopes.

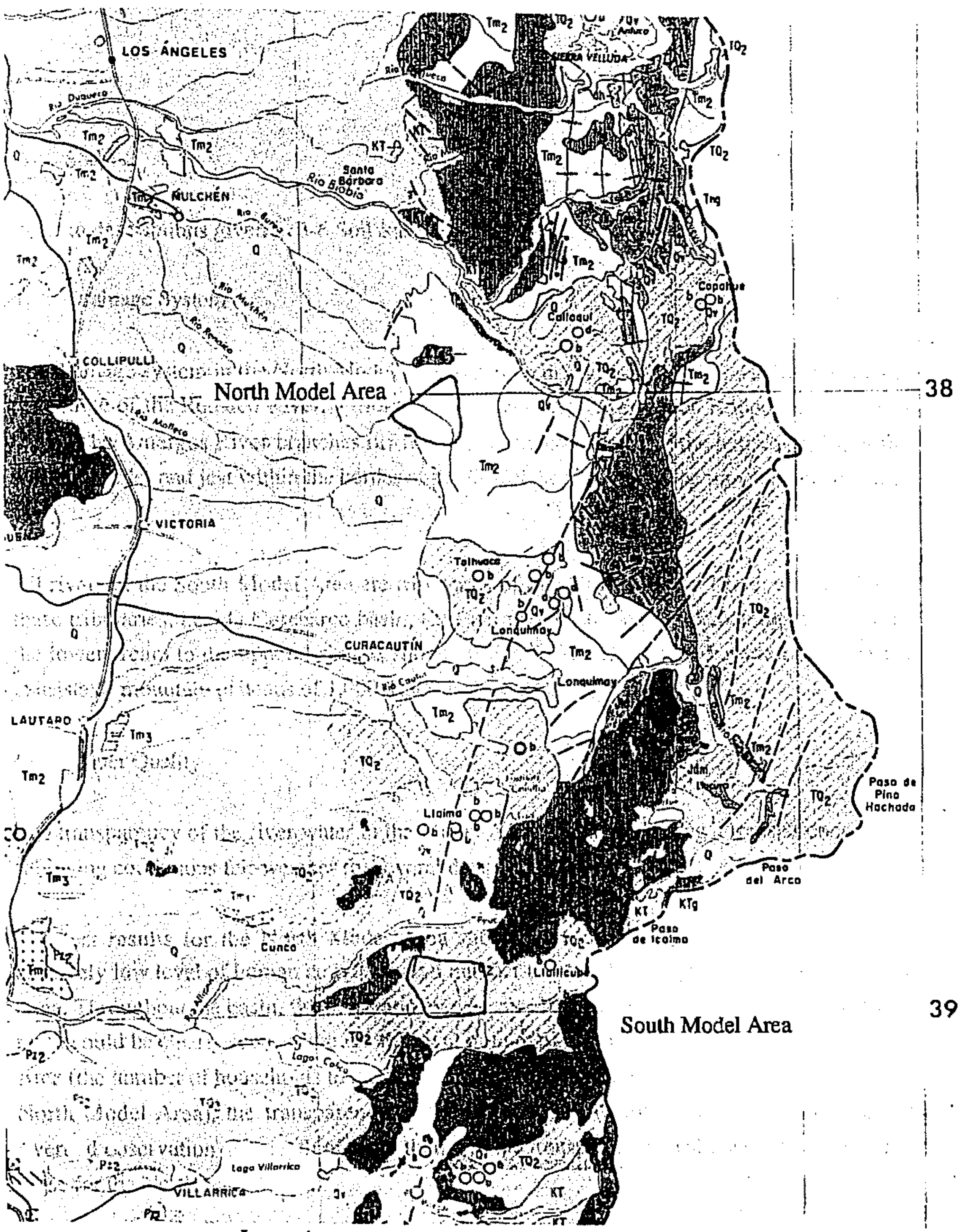
The North Model Area is a basin which spreads from an area of some 400m above sea-level along the Renaico River flowing in the west of the Model Area to the 1,500m class Cordillera de Pemehue Mountains which are the source of the Renaico River. Several rocky mountains of 1,200-1,900m above sea-level are scattered in the centre of the basin, forming a watershed between the Renaico River and its tributary, the Amargos River. These mountains are part of the Sierra Verruda Mountains which run from north to south.

The South Model Area is a basin which spreads from an area of some 400m above sea-level along the Allipen River flowing in the northwest of the Model Area to the Nevados de Sollipulli Mountains (elevation 1200m~1500m) which is the upstream of Curacalco River, Cherguen River and Llalma River.

In both Model Areas, steep slopes are very noticeable along torrents while areas along the main stream are mainly gentle slopes and flat land. There are many plateaus in the mountainous area at the centre of each Model Area.

2) Geology

Volcanic materials are dominant in both Model Areas. Fig. 6-2-1 shows the geological classification of these volcanic materials. Volcanic materials from the Miocene period (shown under TM_2 in Fig. 6-2-1) are distributed in the North Model Area while those from the Pliocene period and Plaistocene period (shown under TQ_2 in Fig.6-2-1) are distributed in the South Model Area.



Legend

MIOCENO-Volcánico.

PLIOCENO-PLEISTO-CENO-Volcánico.

: Model Area

Scale 1:1,000,000) .

Fig. 6-2-1 Geology of Model Areas

3) Soil

Refer to descriptions given in 3-6 Soil Survey.

4) Drainage System

The drainage system in the North Model Area is shown in Fig. 6-2-2. The North Model Area is the source of the Renaico River, a tributary of the Bio Bio River which is the largest river in Chile. The Amargos River branches off from the Renaico River near the halfway point of the western border and just within the border of the Model Area, dividing the upperstream area into two.

All rivers in the South Model Area are tributaries of the Allipen River. There are 3 basins of these tributaries, i.e. (1) Curacarco basin, (2) Cherguen basin and (3) Pichapinga basin, from the lowerstream to the upperstream as shown in Fig. 6-2-3. The divide between these basins consists of mountain plateaus of 1,000-1,500m above sea-level.

5) Water Quality

The transparency of the river water in the Model Areas was tested using a transparency meter following continuous fair weather for several days.

The test results for the North Model Area showed no turbidity probably because of the relatively low level of human activity (small number of households approximately 125) in the Area. Throughout the basin, the transparency was very high as the riverbed at a depth of 1m or more could be clearly seen. Although the level of human activity increases in the South Model Area (the number of households in the South Model Area is some 230, nearly double that in the North Model Area), the transparency meter did not indicate any turbidity. In the case of riverbed observation at a depth of more than 1m, the transparency results were not as good as those for the North Model Area.

During the interview survey conducted at 17 sites in the North Model Area (see Fig. 6-2-2) to check turbidity, local inhabitants said that the water of the Renaico River becomes clear one or two days after rain.

During a similar survey conducted at 6 sites in the South Model Area (see Fig. 6-2-3), local inhabitants said that any turbidity caused by rain in the lowerstream of the 3 tributaries clears up within 2-3 days.

The results of the daily measurements on river water temperature, conducted at the No. 5 site in Fig. 6-2-2 in view of collecting reference data, are given in Table 6-2-1.

Table 6-2-1 Water Temperature at Mainstream of Renaico River

Date (1991)	Time	Air Temperature (°C)	Water Temperature(°C)	Weather
Nov. 1	17:30	20.7	13.0	Fair
2	15:30	14.2	10.5	Drizzle
3	15:30	13.8	10.3	Drizzle
4	16:30	19.5	11.5	Fair
Nov. 10	08:00	9.8	10.2	Fine
	12:00	19.8	12.8	Fine
	14:00	20.8	14.0	Fine
	19:00	19.2	13.5	Fine

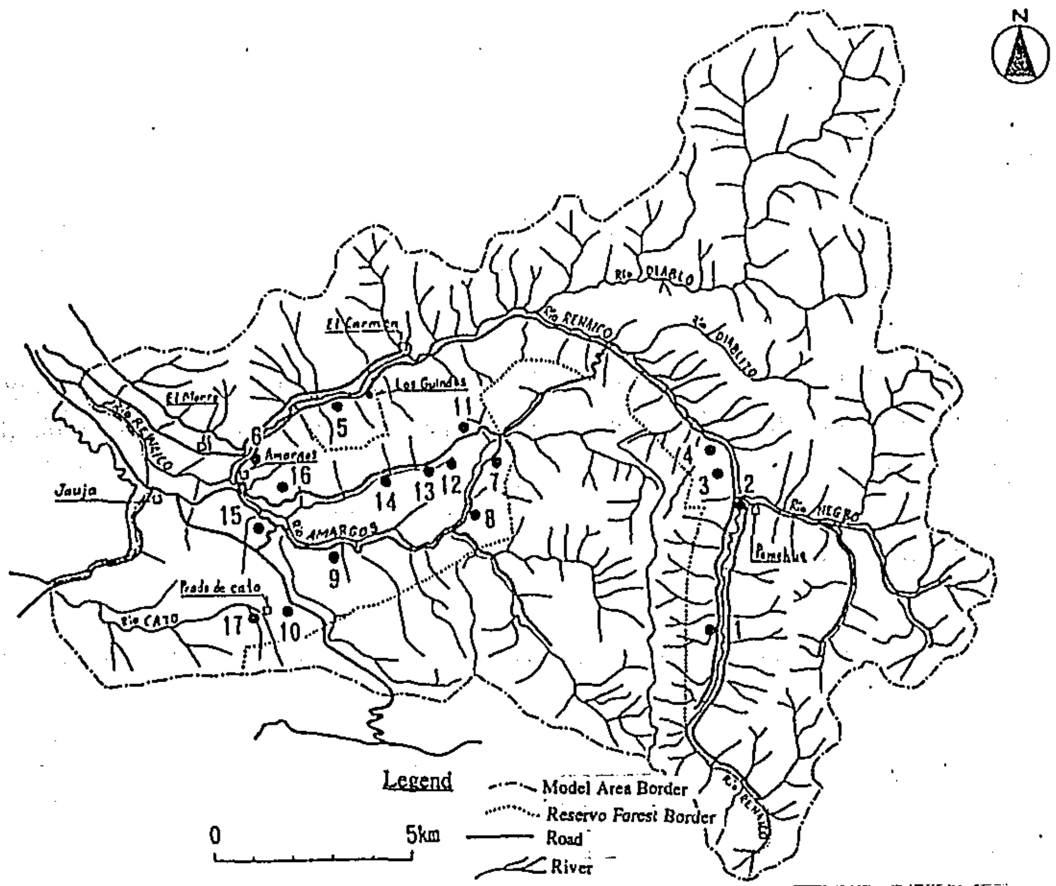


Fig. 6-2-2 Drainage System and Environmental Survey Sites in North Model Area

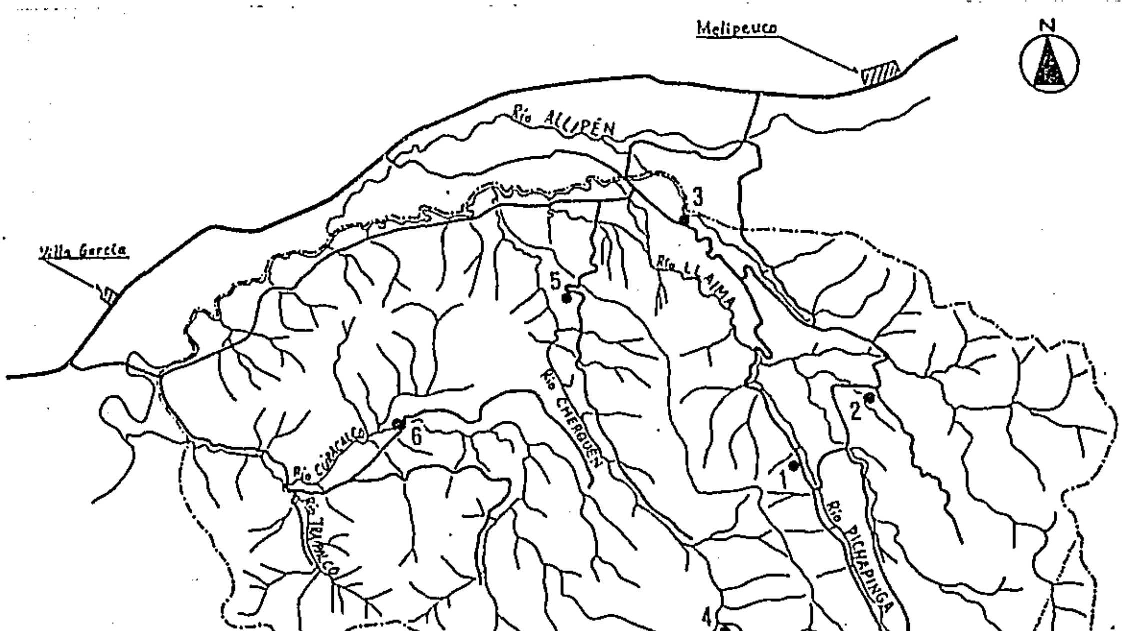


Fig. 6-2-3 Drainage System and Environmental Survey Sites in South Model Area

6) Climate

Meteorological data were collected at observation stations in and around the Study Area (listed in Table 6-2-2) to check the monthly temperature, rainfall, sunshine hours, wind direction and wind velocity.

(1) Temperature

Temperature data for Lonquimay, Temuco and Cunco are compiled in Table 6-2-3.

Table 6-2-2 Locations of Meteorological Stations and Types of Recorded Data

Station	Lat.S	Long.W	Elevation (m)	Relative Location to Study Area	Observation Period	Type(s) of Data
1. Los Guindos	38°03'	71°49'	440	inside Study Area	1935-1953 (19 years)	monthly rainfall
2. Laguna Malleco	38°12'	71°48'	830	inside Study Area	1962-1965 (4 years) 1969-1970 (2 years)	monthly rainfall
3. Curacautin Sendos	38°26'	71°54'	570	inside Study Area	1981-1990 (10 years)	monthly rainfall
4. Lonquimay	38°26'	71°15'	900	28km east of central point of eastern border of Study Area	1964-1968 (5 years)	monthly rainfall, monthly temperature, sunshine hours, air pressure, wind direction and velocity
5. Hueñivales	38°46'	71°41'	-	inside Study Area	1940-1947 (8 years)	monthly rainfall
6. Temuco (Maquehue)	38°46'	72°38'	114	53km southwest of southern border of Study Area	1979-1989 (11 years)	monthly rainfall, monthly temperature
7. Cunco Sendos	38°56'	72°02'	360	3km southwest of southern border of Study Area	1981-1990 (10 years)	monthly rainfall, monthly temperature

Source : Based on data collected by the Direcion Meteorologica de Chile
Note : Study Area Boundaries: 37°53'-39°05'S 71°35'-72°00'W

Table 6-2-3 Monthly Temperature Data In and Around Study Area

1. Mean Monthly Temperature (°C)

Station	1 Jan	2 Feb	3 Mar	4 Apr	5 May	6 Jun	7 Jul	8 Aug	9 Sep	10 Oct	11 Nov	12 Dec	Mean Annual
Lonquimay	13.6	11.8	11.0	7.0	4.7	1.9	1.0	2.5	4.8	7.2	10.0	11.6	7.3
Temuco	16.2	15.7	13.7	11.0	9.2	7.3	7.1	7.9	8.8	10.8	12.7	15.0	11.3
Cunco	17.5	16.7	14.6	11.5	9.1	7.8	7.8	8.2	9.7	11.6	13.6	13.0	11.7

2. Mean Monthly Maximum Temperature (°C)

Lonquimay	23.9	21.8	20.8	17.1	11.8	6.9	6.3	8.8	13.0	15.6	19.9	19.6	15.2
Temuco	24.5	24.4	22.3	18.1	14.4	11.7	11.8	13.2	15.2	17.3	19.6	22.3	17.9
Cunco	26.0	25.4	22.0	17.3	13.7	12.5	12.5	13.0	15.5	17.5	19.8	18.6	18.6

3. Mean Monthly Minimum Temperature (°C)

Lonquimay	4.8	4.0	2.8	0.4	-0.1	-1.7	-2.3	-2.1	-0.9	-0.7	3.2	4.8	1.2
Temuco	9.2	9.0	7.7	6.1	6.0	4.4	4.0	4.3	4.2	5.6	6.9	8.8	6.3
Cunco	9.1	8.0	7.2	5.7	4.5	3.1	3.1	3.4	4.0	5.7	6.4	7.4	5.6

(2) Rainfall

Data on the mean monthly rainfall in and around the Study Area are given in Table 6-2-4. The annual rainfall at Observation Site Nos. 1, 2, 3 and 5, all of which are located in the Study Area, is as high as 1,700-4,000mm. The mean monthly rainfall from October to April, i.e. favourable plant growing season, is 50-360mm. From July to September, the mean monthly rainfall is 140-730mm and there is a period of snow in places of 1,000m above sea-level or higher. The maximum monthly rainfall at Los Guindos exceeds 800mm in winter, i.e. from May to September.

(3) Sunshine Hours

The mean daily sunshine hours at Lonquimay for each month are given in Table 6-2-5.

(4) Wind Direction and Velocity

The wind direction and wind velocity at Lonquimay are also given in Table 6-2-5. The prominent wind direction is west with east and southeast being the least frequent wind directions. The maximum wind velocity is around 22-30m/sec. throughout the year.

Table 6-2-4 Monthly Rainfall In and Around Study Area

1. Mean Monthly Rainfall (mm)

Station	1 Jan	2 Feb	3 Mar	4 Apr	5 May	6 Jun	7 Jul	8 Aug	9 Sept	10 Oct	11 Nov	12 Dec	Annual
Los Guindos	87.7	99.3	150.5	223.9	730.6	642.8	655.6	531.7	365.8	189.	195.2	108.5	3981
Laguna Malleco	72.4	86.6	71.2	244.1	363.6	677.9	422.4	679.9	292.6	193.5	223.9	153.1	3481
Curacautin	73.9	43.1	77.3	112.7	299.1	291.2	217.3	193.3	140.4	136.7	83.3	55.6	1724
Lonquimay	41.6	63.6	37.8	98.9	201.5	248.4	213.7	221.9	108.9	108.7	103.7	150.6	1599
Huenivales	70.7	166.0	171.6	251.1	623.9	416.0	429.9	301.3	201.8	216.4	366.4	182.4	3398
Temuco	46.8	41.5	51.9	83.7	203.3	166.0	148.7	133.9	88.3	71.4	54.2	36.5	1126
Cunco	48.0	67.4	91.5	128.4	310.9	345.8	296.3	259.4	178.1	166.3	96.9	70.7	2060

2. Maximum Monthly Rainfall (mm)

Los Guindos	368.0	307.0	490.9	570.0	1248.0	1381.0	1313.0	1056.0	856.0	641.0	470.0	258.0	1381
Laguna Malleco	188.8	269.9	166.4	494.7	649.7	905.5	703.7	1058.9	363.7	335.0	451.8	310.3	1059
Curacautin	162.5	105.3	167.5	214.7	577.6	414.6	352.6	267.9	159.2	260.7	232.2	275.2	578
Lonquimay	116.0	144.0	76.0	208.0	279.0	411.0	343.0	382.0	174.9	158.0	246.0	258.0	411
Huenivales	194.0	298.0	319.0	602.0	1348.0	797.0	1151.0	517.0	343.0	328.0	627.0	385.0	1348
Temuco	144.5	138.8	95.7	199.8	381.9	233.7	222.8	253.7	135.6	180.2	154.0	114.0	254
Cunco	82.0	136.0	132.4	279.5	714.7	503.6	473.0	391.2	365.0	363.5	255.6	293.2	504

3. Minimum Monthly Rainfall (mm)

Los Guindos	0.0	2.0	12.0	18.0	108.0	164.0	198.0	122.0	73.0	20.0	43.0	0.0	0
Laguna Malleco	13.5	0.0	53.4	168.7	147.5	470.1	86.5	534.8	190.0	80.1	116.9	20.1	0
Curacautin	0.0	0.0	23.1	26.9	86.2	202.1	125.3	115.8	89.4	51.6	7.8	0.0	0
Lonquimay	1.0	16.0	12.0	32.0	82.5	98.0	90.6	126.5	52.0	63.5	50.0	84.0	1
Huenivales	0.1	11.0	62.0	65.0	175.0	116.0	111.0	170.0	75.0	114.0	193.0	51.0	0
Temuco	2.7	0.0	5.4	32.6	50.5	82.9	85.5	72.0	31.3	4.2	2.7	1.6	0
Cunco	5.0	16.6	19.1	31.3	75.7	236.9	189.6	109.5	79.0	87.3	7.0	0.0	0

Source : Based on data collected by Direcion Meteorologica de Chile

Table 6-2-5 Maximum Rainfall in 24 Hours, Sunshine Hours, Wind Direction and Wind Velocity Recorded at Lonquimay Station at Centre of Study Area

Month Item	1 Jan	2 Feb	3 Mar	4 Apr	5 May	6 Jun	7 Jul	8 Aug	9 Sep	10 Oct	11 Nov	12 Dec	Annual
Max. Rainfall in 24 Hour Period (mm)	19.5	31.0	12.8	27.5	45.9	47.5	50.0	47.5	34.3	30.9	34.7	45.4	—
Mean Daily Sunshine Hours	9.7	7.6	7.0	5.4	3.4	1.8	2.3	3.8	5.5	7.2	8.5	8.2	5.9
Mean Monthly Direction 1)													
N	2.2	2.6	4.6	4.0	7.0	3.0	8.8	8.2	8.0	5.6	2.8	2.2	59.0
NE	0.8	0.4	3.4	1.4	0.6	1.0	0.8	2.0	2.4	3.4	1.3	2.2	19.7
E	0.8	0.6	0.4	1.0	0.0	0.4	0.0	0.8	0.8	0.0	0.5	1.2	6.5
SE	1.2	0.8	0.6	0.4	0.0	0.6	0.2	0.0	0.2	0.4	0.0	1.2	5.6
S	18.4	15.6	11.4	5.6	5.0	3.8	4.0	4.2	6.2	9.6	15.5	13.2	112.5
SW	21.0*	18.6*	11.6	7.4	8.6	9.4	10.6	13.8	13.0	18.6	24.0*	21.4	178.0
W	18.8	15.6	16.8*	11.0	17.2*	16.4*	14.8*	13.8	18.2*	21.2*	15.8	23.6*	203.2
N	3.4	5.2	9.8	13.4*	10.6	12.0	12.4	14.4*	13.0	11.0	9.0	7.8	*
no wind	27.0	25.8	34.8	45.8	43.8	43.8	41.4	35.8	28.2	23.4	21.3	20.0	122.0
													391.1
Mean Monthly Max. Wind Velocity (m/s)	27.4	24.8	29.6	24.0	25.6	24.6	22.4	26.2	22.4	22.4	26.5	24.8	—

Source : Based on data collected by Direcion Meteorologica de Chile
Notes : 1) Monthly wind direction are based on relevant data recorded at 08:00, 14:00 and 20:00 daily.
2) * indicates most prominent wind direction.

7) Flora

Existing plant species in the Model Areas, identified by the forest resources survey, list of species found in the Malleco reserve forest and interview surveys, are given in Table 6-2-6 with additional information on species subject to national or regional conservation efforts.

8) Fauna

An interview survey was conducted on local residents (those also interviewed on water quality, see 6-2-5) to identify wild fauna in the Model Areas through which it was found that 17 species of mammals and 38 species of birds live in the North Model Area while 15 species of mammals and 40 species of birds live in the South Model Area as shown in Appendixes 10 and 11. The results of survey in both Model Areas are mentioned in Table 6-2-7.

When asked to confirm the list given in Table 6-2-7 the CONAF Office at Los Guindos provided the additional list given in Table 6-2-8. In short, fauna in the Model Areas should consist of those species list in these 2 tables. No information on fish was obtained.

Table 6-2-6 List of Wild Flora in Model Areas

Local Name	Scientific Name	Red List Category National	Red List Category Region IX
Tree			
1. Olivillo	*Aextoxicon punctatum*		
2. Luma	*Amomyrtus luma*		
3. Araucaria	*Araucaria araucana*	V	
4. Ciprés	*Austrocedrus chilensis*	V	
5. Peumo	*Cryptocarya alba*		R
6. Trevo	*Dasyphyllum diacanthoides*		
7. Notro	*Embothrium coccineum*		
8. Ulmo	*Eucryphia cordifolia*		
9. Avellano	*Gevuina avellana*		
10. Huallo, Huayo	*Kageneckia oblonga*		
11. Tepa	*Laurelia philippiana*		V
12. Laurel	*Laurelia sempervirens*		
13. Piñol, Avellanillo	*Lomatia dentata*		
14. Radal	*Lomatia hirsuta*		
15. Arrayán	*Luma apiculata*		
16. Raulí	*Nothofagus alpina*		V
17. Ñirre	*Nothofagus antarctica*		
18. Coihue	*Nothofagus dombeyi*		
19. Roble	*Nothofagus obliqua*		
20. Lenga	*Nothofagus pumilio*		
21. Lingue	*Persea lingue*		V
22. Lleuque	*Prumnopytis andina*	R	
23. Mañío	*Saxegothaea conspicua*		
24. Pelú	*Sophora microphylla*		
25. Tineo	*Weinmannia trichosperma*		
Shrub			
26. Maqui	*Aristotelia chilensis*		
27. Corcolén	*Azara lanceolata*		
28. Azara	*Azara sp.*		
29. Michay	*Berberis darwinii*		
30. Michay	*Berberis montana*		
31. Michay	*Berberis pearcei*		
33. Abutilón	*Corynabutilon ochsenii*	R	
34. Taique	*Desfontainia spinosa*		
35. Canerillo, Canelo	*Drymis winteri var. andina*		
36. Guindo santo	*Eucryphia glutinosa*	R	
37. Chilco	*Fuchsia magellanica*		
38. Maitén	*Maytenus disticha*		
39. Maitén	*Maytenus magellanica*		
40. Chaura, Murtilla	*Pernettya mucronata*		
41. Sauco	*Pseudopanax laetevirens*		
42. Espino negro	*Rhaphitamnus spinosus*		
43. Zarzaparilla	*Ribes sp.*		
44. Rosa mosqueta, Coralillo	*Rosa moschata*		
45. Mayú	*Sophora macrocarpa*		
Climber			
46. Boqui blanco	*Capsidium voldivianum*		
47. Pilpilboqui	*Cissus striala*		
48. Porotillo	*Elytropus chilensis*		
49. Copihue	*Lapageria rosea*		
50. Botellitas	*Mitraria coccinea*		
Parasitic plant			
51. Quintral	*Phrygilanthus mutabilis*		
52. Quintral	*Phrygilanthus tetrandus*		
Herb・Fern			
53. Helecho	*Blechnum auriculatum*		
54. Helecho	*Blechnum chilense*		
55. Helecho	*Blechnum magellanicum*		
56. Quila	*Chusquea culeou*		
57. Coirón	*Festuca sp.*		
58. Nalca, Pangue	*Gunnera chilensis*		

Red List Category; E: Endangered, V: Vulnerable, R: Rare, K: Insufficiently Known, O: Out of Dang

Table 6-2-7 List of Wild Fauna in Model Areas (Based on Interview Survey)

Local Name	Scientific Name	Red List Category (Region IX)
MAMIFEROS	MAMMALS	
1. Pudú	*Pudu pudu*	V
2. León (Puma)	*Felis concolor*	V
3. Zorro culpeo	*Canis culpaeus*	K
4. Zorro chilla	*Canis griseus*	K
5. Quique	*Galictis cuja*	V
6. Guiña	*Felis guigna*	E
7. Chingue	*Conepatus chinga*	O
8. Ratón	*Notiomys megalonyx*	
9. Tunduco	*Aconaemys fuscus*	R
10. Coipo	*Myocastor coypus*	O
11. Murciélago oreja de raton del sur	*Myotis chiloensis*	
12. Murcielago colorado	*Lasiurus borealis*	
13. Murcielago gris	*Lasiurus cinereus*	
14. Conejo	*Oryctolagus cuniculus*	
15. Liebre	*Lepus capensis*	
16. Jabalí	*Sus scofra*	
17. Rata (Guarén)	*Rattus norvegicus*	
AVES	BIRDS	
18. Tordo	*Curaeus curaeus*	
19. Zorzal	*Turdus falklandii*	
20. Diuca	*Diuca diuca*	
21. Chincol	*Zonotrichia capensis*	
22. Loica	*Sturnella loyca*	
23. Codorniz	*Lophortyx californica*	
24. Perdiz	*Nothoprocta perdicaria*	
25. Tenca	*Mimus thenca*	
26. Chucao	*Scelorchilus rubecula*	
27. Chercán	*Troglodytes aedon*	
28. Hulo (Fio-fio)	*Elaenia albiceps*	
29. Torcaza	*Columba araucana*	V
30. Tórtola	*Zenaida auriculata*	
31. Tiuque	*Milvago chimongo*	
32. Loro (Cachaña)	*Enicognathus ferrugineus*	
33. Loro (Choroy)	*Enicognathus leptorhynchus*	K
34. Peuco	*Parabuteo unicinctus*	
35. Treile (Queltehue)	*Vanellus chilensis*	
36. Jote de cabeza negra	*Coragyps atratus*	
37. Cernicalo	*Falco sparverius*	
38. Traro	*Polyborus plancus*	
39. Lechuza	*Tyto alba*	
40. Concón	*Strix rufipes*	K
41. Chuncho	*Glaucidium nanum*	
42. Carpintero	*Campephilus magellanicus*	
43. Bandurria	*Theristicus caudatus*	O
44. Condor	*Vultur gryphus*	R
45. Golondrina	*Tachycineta leucopyga*	
46. Pitio	*Colaptes pitius*	
47. Hued-hued del sur	*Pteroptochos tarnii*	
48. Carpinterito	*Picoides lignarius*	
49. Pidén	*Rallus sanguinolentus*	
50. Pato cortacorrientes	*Merganetta armata*	
51. Martín pescador	*Ceryle torquata*	
52. Cuervo, Yeco	*Phalacrocorax olivaceus*	
53. Hualravo	*Nycticocorax nycticorax*	
54. Avutarda (Canquén)	*Chloephaga poliocephala*	
55. Pintriuque (Gallina ciega)	*Caprimulgus longirostris*	
56. Aguila	*Geranoaetus melanoleucus*	

Red List Categories (Red List of Chilean Terrestrial Vertebrates, CONAF, 1988); E : Endangered, V: Vulnerable, R: Rare, K : Insufficiently Known, O: Out of Danger

6-2-8 Additional List of Wild Fauna in Model Areas (Reported by Los Guindos Office of CONAF)

Local Name	Scientific Name	Red List Category (Region IX)
MAMIFEROS	MAMMALS	
1. Monito del monte	*Dromiciops australis*	
2. Ratón de los espinos	*Oryzomys longicaudatus*	
3. Ratoncito lanudo	*Akodon longipilis*	
4. Ratoncito olivaceo	*Akodon olivaceus*	
5. Ratón topo valdiviano	*Notiomys valdivianus*	
6. Lauchon orejudo de darwin	*Phyllotis darwini*	
7. Rata arbolea chilena	*Irenomys tarsalis*	
8. Laucha común	*Mus musculus*	
9. Rata negra (asiatich)	*Rattus rattus*	
AVES	BIRDS	
10. Pato anteojillo	*Anas specularis*	
11. Aguilucho	*Buteo polyosoma*	
12. Aguilucho de cola rojiza	*Buteo ventralis*	R
13. Perdicita	*Thinocorus spp.*	
14. Tucúquere	*Bubo virginianus*	
15. Pica flor	*Sephanoides galeritus*	
16. Churrete	*Cinclodes patagonicus*	
17. Churrete acanelado	*Cinclodes fuscus*	
18. Colilarga	*Sylviorthorhynchus desmursii*	
19. Rayadito	*Aphrastura spinicauda*	
20. Comesebo grande	*Pygarrhichas albogularis*	
21. Cachudito	*Anairetes parulus*	
22. Diucón	*Pyrope pyrope*	
23. Dormilonas	*Muscisaxicola spp.*	
24. Churrín	*Scytalopus magellanicus*	
25. Rara	*Phytotoma rara*	
26. Chirihue	*Sicalis luteola*	
27. Cometocino patagonico	*Phrygilus patagonicus*	
28. Jilguero	*Carduelis barbatus*	
29. Gaviota andina	*Larus serranus*	R
30. Garza grande	*Casmerodius albus*	
31. Garza chica	*Egretta thula*	
32. Pato jergón grande	*Anas georgica*	
33. Peuquito	*Accipiter bicolor*	R
34. Halcon peregrino	*Falco peregrinus*	E
35. Tagua chica	*Fulica leucoptera*	
36. Becacina (Porotera)	*Gallinago gallinago*	
37. Viudita	*Colorhamphus parvirostris*	
38. Mirlo	*Molothrus bonariensis*	
39. Gorrión	*Passer domesticus*	
REPTILES	REPTILES	
40. Lagartija	*Liolaemus fuscus*	
41. Lagartija	*Liolaemus pictus pictus*	
42. Lagartija	*Liolaemus pictus argentinus*	
43. Lagarto	*Diplolaemus leopardinus*	
44. Lagarto	*Urostrophus torquatus*	
45. Culebra	*Tachimenis peruviana*	
46. Culebra de cola corta	*Dromicus chamissonis*	
ANFIBIOS	AMPHIBIANS	
47. Sapo de rulo	*Bufo spinulosus*	K
48. Sapo	*Bufo rubropunctatus*	V
49. Sapo	*Bufo variegatus*	K
50. Sapo	*Eupsophus taeniatus*	
51. Sapo arriero	*Eupsophus nodosus*	
52. Sapo	*Eupsophus grayi*	
53. Sapo	*Eupsophus roseus*	
54. Sapo	*Hylorina sylvatica*	
55. Sapo	*Pleurodema bibroni*	
56. Ranita de darwin	*Rhinoderma darwini*	V

Red List Categories (Red List of Chilean Terrestrial Vertebrates, CONAF, 1988); E: Endangered, v: Vulnerable, R: Rare, K: Insufficiently Known, O: Out of Danger

9) Landscape

In the central part of the Study Area is the Conquillio National Park covering 46,000ha with the snow-capped Mt. Llaima and a series of mountains and lakes visited by some 10,000 tourists in the 3 summer months. In comparison, the landscape in the Model Areas is rather modest when compared to the magnificent scenery found in some neighbouring areas in the Study Area.

6-3 Environmental Factors

It is important in the preparation of a forest management plan to fully consider the environmental implications of the plan to avoid adverse environmental impacts. Therefore, it is essential as part of the planning process to identify those environmental factors which affect the environmental aspects by the implementation of the forest management plan.

1) Environmental Factors

Environmental factors which are expected to have some impact on the living and natural environments during various stages of project implementation are listed in Table 6-3-1.

Table 6-3-1 Environmental Factors (Provisional)

Static Factors	Dynamic Factors	
	Construction	Utilisation
① Facilities		
Nurseries	• Construction Work	• Seedlings Production
Forest Roads	• Construction Work	• Transportation and Passage
Timber Yards	• Construction Work	• Loading and Unloading
Buildings	• Construction Work	• Use
Erosion Control Facilities	• Construction Work	• Water Storage and Sand Storage
Work Roads	• Construction Work	• Transportation and Passage
Firebreaks	• Construction Work	
② Forests	• Felling • Yarding • Land Preparation • Planting and Seeding • Tending	• Felling • Yarding • Land Preparation • Planting and Seeding • Tending • Stock Raising • Performance of Forest Functions

2) Environmental Aspects

Table 6-3-2 shows the environmental aspects of the ecosystem which are presumably affected by the environmental factors listed in Table 6-3-1.

3) Degree of Environmental Impact

Table 6-3-2 also shows the estimated degree of impact on the environmental aspects by each environmental factor. Those areas marked with an O require careful consideration in the planning and implementation of a forest management plan.

Table 6-3-2 Environmental Impact Matrix (Provisional): Relation Between Environmental Factors and Enviromental Aspects

Environmental Aspects \ Environmental Factors			Facilities													Forest											
			Nursery		Forest Road		Timber Yard		Building		Erosion Control Facility		Work Road			Construction					Utilisation						
			Construction	Seedling Production	Construction	Tranporation & Passage	Construction	Loading & Unloading	Construction	Use	Construction	Water & Sand Storage	Construction	Transportation & Passage	Fire Break	Felling	Yarding	Land Preparation	Planting & Seeding	Tending	Felling	Yarding	Land Preparation	Planting & Seeding	Grazing	Performance &Forest Function	
Ecosystem	Lithosphere	Topography	○		○		○		○		○	△	○		△		△										
		Soil	△	△	○		△		△		△		△		○	○	○	△	○	△	○	○	△	○	○	○	
		Vibration																									
	Hydrosphere	Hydrospheric Phenomena	△		○		△		△		○	○	△			△					○					○	
		Water Quality	△	△	○		△		△	△	○	△	△		△	△	△				△	△			△	○	
	Atmosphere	Climate														△					△					○	
		Air Quality				△								△												○	
		Noise			△	△					△		△	△												○	
	Biosphere	Flora	△		△	△	△		△	△	△		△	△	△	○	○	○	○	△	○	○	○	○	○	○	
		Fauna	△	△	△	△	△	△	△	△	△	△	△	△	○	○	○	○	△	△	○	○	○	△	○	○	
		Aquatic Organisms	△	△	○		△		○	△	○	○	△		△	△	△				△	△				○	
Landscape			△		○		△		○		○	△	△		○	○			○	△	○			○	○	○	

○ : Strong Impact
△ : Relatively Weak Impact

CHAPTER 7 TRANSFER OF TECHNOLOGY

7-1 Preparation of Forest Base Map

The transfer of technology was conducted at each of the following processes during the preparation of forest base maps.

1) Field Work (On-the-Job Training)

- selection method for pass points
- selection method for level routes and pricking points
- observation method using GPS data

2) Work in Japan (Technical Training)

- aerotriangulation
- mapping (detailed mapping, editing and drawing, etc.)
- photo processing

In addition, training was also provided on data input and the processing of graphics in relation to digital mapping processes.

7-2 Forest Management Plan

The transfer of technology was conducted in the following fields of work relating to forest management plan preparation.

1) Field Work (On-the-Job Training)

- survey method for volume table preparation
- forest inventory survey method
- interview survey method in relation to forestry activities, socioeconomic conditions and natural environment

In addition, a seminar was held at local CONAF offices to explain the objectives and contents of the Study to those related to the Study in local areas and to exchange opinions.

A transfer of technology seminar will be held in the next year to disseminate technologies and techniques relating to the preparation of a forest management plan in a more efficient manner.

2) Training in Japan (Lectures and On-the-Job Training)

- aerial photograph interpretation
- volume table preparation
- sampling design
- technical issues relating to a forest management plan, including natural forestry activities, protection forests, chemical agents for forestry use and forest roads

CHAPTER 8 FOREST MANAGEMENT PLAN FRAMEWORK

The framework of the forest management plan to be prepared in the next year is described here although assessment of the total growing stock and the preparation of forest type maps have yet to be completed. The actual contents of the forest management plan will be decided through consultations with the Chilean side.

8-1 Basic Considerations in Preparing Forest Management Plan

Taking into account the plan's compatibility with forestry decrees and its applicability to other areas consideration will be given to the following in the preparation of the forest management plan.

- Introduction of forest improvement targets
- Sustainment of forest resources
- Efficient use of forest resources
- Efficient use of land
- Conservation of the environment
- Contribution to local communities

8-2 Forest Improvement Targets

1) Creation of forests with various features.

   (1) Avoidance of uniform man-made forests through the establishment of mixed stands of uneven ages and also through the dispersion of felling areas.

   (2) Thinning of secondary forests and appropriate felling of over-mature forests.

2) Improvement and consolidation of forest road network.

8-3 Management Framework

8-3-1 Categorisation of Management Type

Forest management activities are generally conducted in accordance with the most appropriate method, determined in view of the site conditions, type and socioeconomic conditions, etc. of the forest in question. Therefore, it is convenient to categorise the management activities for each stand/forest, which is considered an independent entity from the viewpoint of forest management, and to group those forests/stands with the same operational characteristics into a single category. The degree of such categorisation depends on the level of available forestry technologies, types of socioeconomic demands for forests and forest management capability, etc.

The present condition of forests in the Model Areas are outlined below from the viewpoint of the introduction of forest management categorisation.

1) Land Ownership and Size

In terms of ownership, the forests are either national forests or private forests. Large forest owners are actively investing in forests while small owners regard the forests as a supplementary source of income. The national forests are managed as reserve forests.

2) Site Conditions

Topographically speaking, both Model Areas have both gentle and steep slopes with many undulations. Outcrops of rocks are observed in some parts of steep slopes.

As the parent material of soil in both Model Areas is volcanic ash, the introduction of restrictions on forestry activities is unnecessary except in those places where the surface layer is particularly thin with outcropped rocks.

The Model Areas are rich in fauna and the habitats of important animals are observed.

3) Forest Types

Forest types in both Model Areas are Araucaria Forests, Roble-Rauli-Coigue Forests, Evergreen Forests and man-made forests, mainly consisting of Radiata pine or Eucalypts. The Roble-Rauli-Coigue forests are further classified as secondary forests of a relatively young age and high density and over-mature forests with many inferior trees.

With regard to forest management for native species, the adoption of a specific felling method is determined by forest law based on the forest type and slope gradient. The requirements which are particularly relevant to forests in the Model Areas are given in Table 8-3-1.

Table 8-3-1 Legal Felling Methods Applicable to Native Species

Forest Conditions		Felling Method			
		Clear Felling	Clear Felling but Keeping Seed Trees	Shelterwood Felling	Selective Felling[2]
Forest Type	Roble-Rauli-Coigue	O	O	O	O
	Evergreen	—	—	O	O
Slope Gradient (%)	Less than 30	O	O	O	O
	30 or more but less than 45	O[1]	O[1]	O	O
	45 or more but less than 60	—	—	O	O
	60 or more	—	—	—	O

Notes: 1) Maximum felling area: 20ha, preservation of 100m wide forest belt required.

2) Maximum felling area: 0.3ha, preservation of 50m wide forest zone required around felling area, maximum selective felling ratio: 35% (basal area).

4) Socioeconomic Conditions

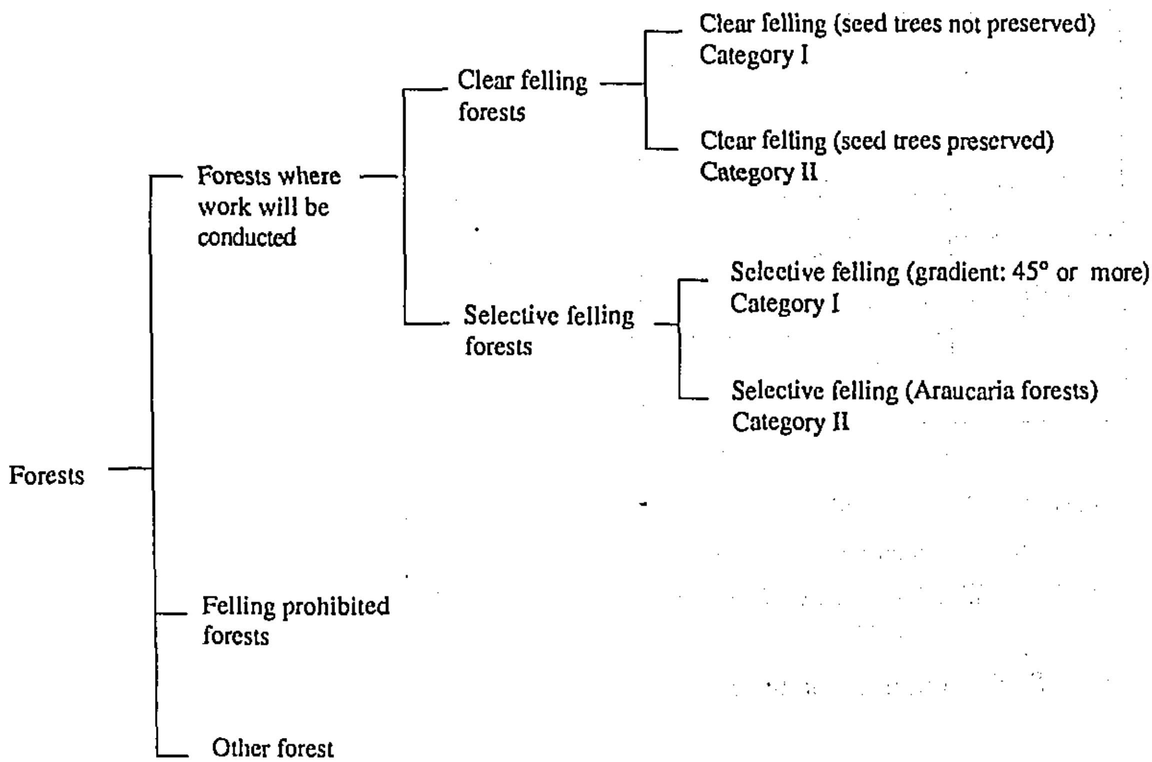
The area in which the Model Areas is located is an important supply source of sawn timber and pulpwood. Both Model Areas do not appear to have particularly more special recreational appeal than the neighbouring areas.

From the point of view of land use it can be said that most of the ranches (established by felling and conversion of native forests) are not utilized properly.

5) Forest Technology

The technical expertise in regard to the management of plantations of exotic species is fairly high. In comparison, however, operational and management experience in the case of native forests is relatively inadequate.

The following management categorisation, accompanied by the relevant felling methods, was achieved by taking into consideration the forest conditions and other related conditions in the Model Areas and by keeping in mind simplification.



With regard to national reserve forests, examination of the possible activities will be conducted based on clear information on their objectives.

8-3-2 Activities in Each Management Category

(1) Clear Felling Category I

Clear felling without the preservation of seed trees applies to man-made forests of such exotic species as Radiata pine and Eucalypts (forest type F in Table 3.1.3). Regeneration is usually conducted by planting but the naturally regenerating seedlings of Radiata pine are used if available.

(2) Clear Felling Category II

Seed trees (or upper-storey trees) are preserved despite the adoption of the clear felling method in view of the assured regeneration prospects as well as the need for soil and water conservation. This method applies to native natural (forest types HrR, Hc, HcR, Hm, Nj in table 3.1.3) or native man-made forests with a slope gradient of upto 45%. When the gradient exceeds 30%, however, the maximum felling area per site is 20ha. The primary regeneration method is planting.

(3) Selective Felling Category I

This applies to stands of native species other than Araucaria (forest types HrR, Hc, HcR, Hm, Nj in table 3.1.3) where the gradient is 45% or more. The maximum felling area per site is 0.3ha. Regeneration is mainly conducted by natural regeneration assisted by enrichment planting where necessary.

(4) Selective Felling Category II

This applies to Araucaria-Lenga-Coigue forests (forest type Am in table 3.1.3) and only species other than Araucaria are subject to felling. The regeneration method is the same as that for Selective Felling Category I.

(5) Felling Prohibited Forests

This applies to Araucaria forests (forest type Ap in table 3.1.3), steep slopes and outcropped areas with a shallow soil layer, natural forests with poor conditions and forests where the prohibition of felling is deemed appropriate in view of the protection of flora and fauna.

(6) Other Forests

These are experimental forests where activities to suit the experiment objectives are conducted. Details of these 6 categories are given in Table 8-3-2.

Table 8-3-2 Forest Categories, Subject Forests and Regeneration Methods

Category		Subject Forest Type	Regeneration Method				Remarks
			Artificial		Natural		
			Planting of Cut-Over Area	Enrichment Planting	Seeding	Coppicing	
Clear Felling	I	F	O		Δ	Δ	natural regeneration or use of naturally regenerated seedlings
	II	HrR, Hc, HcR, Hm, Nj and native man-made forests and slope gradient up to 45%	O		Δ	Δ	maximum felling area when gradient is 30% or more: 20 ha, provision of 100m wide forest belt required
Selective Felling	I	HrR, Hc, HcR, Hm, Nj with a gradient of 45% or more		Δ	O	O	selective felling rate (basal area) upto 35%, maximum felling area/site: 0.3ha,
	II	Am		Δ	O		provision of 50m wide forest belt required felling of Araucania prohibited
Felling Prohibited Forests		Ap, steep slopes, native forests with poor conditions, forests where prohibition of felling is appropriate					
Other Forests		experimental forests					

O : Primary Regeneration Method
Δ : Secondary Regeneration Method

8-4 Management Plan

1) Plan Period

Forestry activities require a long time span to achieve their objectives, necessitating appropriate long-term forest management. In this context, the management plan is very important. Any management plan covering a specific period, however, is usually subject to revision at predetermined intervals to reflect both socioeconomic changes and changes in the subject forests. The degree of the plan detail depends on the plan period. The tentative plan period for the present management plan is 10~20 years.

2) Compartmentalization

(1) Compartments

Compartments are established to enable the smooth implementation of forestry activities by indicating the exact locations of forests and are normally fixed for a long time. While the size of compartments vary depending on the degree of forestry activity intensity, it is preferable for all compartments to be of a similar size, neither too big nor too small. In general, such natural boundaries as crest lines and rivers and such fixed facilities as roads and firebreaks are used as compartment boundaries. The tentative compartment size for the present plan is some 500ha.

(2) Sub-Compartments

Sub-compartments are short-term divisions used for the convenience of management plan implementation and indicate differences in terms of felling method, species, stand type, tree age and land use category, etc. Unlike compartments, the boundaries of sub-compartments may well be altered following changes in activity objectives and the results of preceding felling.

3) Felling

(1) Rotation Age

The tentative rotation age for the plan is set at 20-25 years for Radiata pine and 12-15 years for Eucalypts. The rotation age for broad-leaf native species will be examined in the future. It may be appropriate to adopt a rotation age of 50-60 years for these native species on the basis of the discovered relation between the diameter class and tree age. The fact that native trees locally used for the production of sawn timber have a minimum diameter of 35cm is taken into consideration in the above suggestion, as is the seed bearing age for seed trees.

The possible minimum cutting cycle for selective felling is 20 years based on the need to ensure the growth of trees planted for enrichment purposes.

(2) Felling Volume

The felling volume will be determined for each Model Area. In principle, a constant felling volume (total of final felling volume and thinning volume) will be sustained taking the stand volume and increment volume in the subject stands into consideration. The allowable harvest of final felling will be determined using one of the following formulas.

$$E = \frac{Ip}{2} + \frac{Vp}{T}$$

$$E = Ii + \frac{Vo}{T}$$

where E : allowable harvest (m^3)
Ip : current increment (m^3)
Vp : current stand volume (m^3)
Vo : stand volume of over-mature forest (m^3)
Ii : increment of secondary forest (m^3)
T : average felling age (years)

(3) Felling Method

Under the present plan, final felling will be conducted as either clear felling or selective felling while naturally honouring the felling methods stipulated by the current forestry decrees. Particular attention should be paid to the following points when conducting felling, details of which are discussed in 8-3-2.

① Seed trees to be preserved must be of good quality.
② No stand within a 100m radius of an Araucaria tree should be subject to felling if Selective Felling Category II is selected.

With regard to secondary forests, aggressive thinning is planned to improve tree quality and to maximise the use of the available resources.

4) Afforestation

(1) Artificial Regeneration

a) Species

In general, the right trees will be planted in the right sites. Judging from the current situation, the main species for artificial regeneration will be Radiata pine, Eucalypts, Roble, Rauli and Coigue. The forestry decrees stipulate that stands consisting of native species should be regenerated using native species and this will basically be the case for the present plan. For the establishment of a healthy forest, it is generally useful to plant different species of different ages in order to avoid the creation of an even-aged uniform forest.

b) Planting

The planting density for the present plan will be determined based on a minimum requirement of 3,000 seedlings/ha for cut-over areas of previously forests consisting of native species as demanded by the forestry decrees and also on the actual conditions of implementing this requirement.

In the case of Radiata pine, naturally regenarated seedlings before final felling will be used.

Planting will be considered for treeless areas, including those which have been abandoned after use as grazing land.

(2) Natural Regeneration

For areas where Clear Felling Category II is selected, naturally regenerated seedlings or coppicing will be used if available.

In the case of Selective Felling Categories I and II, enrichment planting will be actively conducted in those places where natural regeneration is believed to be difficult because of dense Quila cover.

5) Nursery Operation

It is desirable to raise seedlings near planned afforestation sites in view of the adaptability of the seedlings to site conditions, transportation cost and preservation of the seedlings' vitality. The common practice is to locate a nursery at a site where mass-production is possible in order to reduce the production cost while trying to locate the site as near as possible to prospective afforestation sites.

As described in 4-3, there are some 160 nurseries in Region VIII and Region IX. The use of these existing nurseries to supply the seedlings required by the plan will in principle be advantageous from the viewpoints of economy and the efficient use of the available nursery techniques.

In any case, the particular designation of several nurseries in the Model Areas where most of the forests are privately owned will be more practical to try to establish a stable supply system taking the required number of seedlings and the production capacities of the existing nurseries into consideration.

6) Forest Roads

As described in 4-1-3, the forest road network in the Model Areas is very poor. So are the road standards and structure. Furthermore, proper maintenance is not conducted.

From the viewpoint of conducting forestry activities while preserving the health and improving the quality of forests, the firm establishment of a system to allow these activities at any time and any place is desirable. Forest roads are an essential part of such a system and, therefore, must be regarded as not only a means for transportation but also as a basic ingredient for successful forest management.

A forest road plan is prepared taking the contents of forest resources as well as the distribution of forests in the same catchment area into consideration. In practice, there is often a need to over-ride ownership boundaries to prepare an appropriate plan. To establish an efficient forest road network, the competent agency is required to take an active lead in prior coordination efforts to decide routes during the planning stage. The desirable forest road network for the Study Area and the procedure to construct such a network will be analysed when a general picture of the stands is obtained through the availability of relevant maps.

7) Erosion Control

In the Model Areas in sites containing forests consisting of overstorey, lowerstorey and undergrowth which provide cover for the land surface erosion is expected to remain at an insignificant level if drastic changes in vegetation cover are not introduced. But in the Model Areas in intensively grazed ranches, in sites where burning of forest after felling and ground yarding, etc. are practiced the processes of soil erosion are active. Moreover, there is a strong possibility that new erosion or a worsening of the present micro collapse and gully erosion will occur at these sites in the future.

The field survey revealed that surface erosion at intensively grazed ranches is the dominant form of soil erosion in the Model Areas and special measures to control the erosion are not employed.

Several measures can be introduced to control erosion, ranging from the recovery of vegetation to the erection of various types of structures. The basic direction for erosion control and soil conservation in the present plan is the suggestion of simple countermeasures by taking into consideration local conditions, technologies and materials.

8) Experimental Forest

(1) Objective of Experimental Forest

The collection of data through field tests and experiments is necessary for successful forest management in the Study Area as such data and the expertise to conduct forestry activities in native forests are lacking at present. Given the present conditions of native forests in the Model Areas, the suitability of creating an experimental forest to collect the urgently required data will be examined.

(2) Details of Experimental Forest

a) Quila Treatment Test

- Ecological study on Quila
- Study on clearing and chemical weeding of Quila
- Study on Quila regeneration after blooming

b) Thinning Test on Secondary Forest of Native Species

Test aimed at increasing the stem volume at the felling age and also increasing the stem volume of trees in a diameter class above a certain level.

c) Test on Natural Regeneration of Broad-Leaf Trees

- Tending test for existing seedlings
- Regeneration test for natural seeding and artificial seeding
- Planting test for seedlings

9) Grazing Forests

There are many grazing forests in the Model Areas as described in Chapter 5, partly because landowners cannot prepare adequate grazing land due to the land conditions and partly because the forest size owned is not large enough to practice sustainable forestry.

From the viewpoint of stock raising, most of the grazing forests have a low animal feed productivity and grazing capacity and over-grazing has led to soil erosion in places. From the viewpoint of forestry, grazing throughout the year has resulted in the poor regeneration of forests. Control of grazing by means of introducing a temporary ban on grazing and/or reduction of the grazing intensity in these grazing forests appears necessary to ensure forest regeneration while improving the grazing capacity.

In general, any plan for a grazing forest must be preceded by a proper understanding of (1) grass production volume of the forest, i.e. grazing capacity, (2) relationship between grazing and forest damage and (3) anticipated grazing capacity following the improvement of grazing land. The selection of suitable sites in the Model Areas is necessary for experiments on these 3 points. Understanding of points (1) and (2) is particularly required for both natural and man-made forests.

10) Forest Protection

(1) Forest Fires

The introduction of firebreaks and consolidation of the forest road network will be examined with a view to securing mobility for fire-fighting, preventing the spread of fires and facilitating fire-fighting activities.

(2) Damage by Diseases, Insects and Animals

Since seedlings are often eaten by or damaged by the feet of animals, particularly grazing cattle, in both natural and man-made forests, measures to prevent such damage will be examined.

With regard to damage caused by insects, which may increase in the future following intensive planting, afforestation methods to avoid the creation of an even-age uniform forest will be examined.

In the case of conducting enrichment planting using the same species after selective felling, special attention must be paid to sites where damage caused by wild rabbits and rats can be expected.

8-5 Forest Inventory Books

A forest inventory book is the main register which shows the current conditions of stands. An example of a forest inventory book was shown to the Chilean side for approval and it was agreed that the format shown in Fig. 8-5-1 will be used for the present study purposes.

Compartment	Sub-Compartment	Location	Ownership Type	Land Use & Vegetation Type	Forest Category	Topography			Area (ha)			Forest Conditions							Method of Operations		Remarks
						Gradient (°)	Bearing	Elevation (m)	Forest	Non-Forest	Total	Forest Type	Tree Height Class	Density Class	Age	Volume (m^3) per ha	Volume (m^3) Total	Increment Rate	Felling	Regeneration	

Fig. 8-5-1 Format of Forest Inventory Book

Appendix-1 Study Team Members

The members of the field survey teams and their respective periods of assignment in Chile are as follows.

(1) First Year (Fiscal 1990)

Study Team for Forest Resources Management Plan

Field of Assignment	Name	Survey Period
Team Leader	Yutaka Taguchi	Dec. 17,1990 ~ Jan. 5, 1991
Deputy Team Leader Forest Management Plan	Tadashi Ujiie	Dec. 17, 1990 ~ Jan 30, 1991
Forest Survey	Mohammed Osman Atif	Dec. 17, 1990 ~ Jan 30, 1991
Land Use/Vegetation	Junzo Watanabe	Dec. 17, 1990 ~ Jan 30, 1991
Socioeconomy	Tsutomu Yoshimura	Dec. 17, 1990 ~ Jan 30, 1991
Environmental Assessment	Shuichi Miyabe	Dec. 17, 1990 ~ Jan 30, 1991
Surveys/Aerial Photography Supervision	Shun Takagi	Dec. 17, 1990 ~ Jan.17, 1991
Control Point Survey	Mitsuo Saito	Dec. 24, 1990 ~ Feb. 10, 1991

Supervisory Team

Field of Assignment	Name	Period
Study Supervision	Shinji Ogawa	Dec. 17, 1990 ~ Dec. 26, 1990

(2) Second Year (Fiscal 1991)

Study Team for Forest Resources Management Plan

Field of Assignment	Name	Survey Period
Team Leader	Yutaka Taguchi	Oct. 5, 1991 ~ Oct. 16, 1991 Nov. 24, 1991 ~ Dec. 5, 1991
Deputy Team Leader Forest Management Plan	Tadashi Ujiie	Oct. 5, 1991 ~ Dec. 10, 1991
Forest Survey	Toshio Okamura	Oct. 15, 1991 ~ Dec. 10, 1991
Forest Management Plan	Mohammed Osman Atif	Oct. 15, 1991 ~ Nov.25, 1991
Environmental Assessment	Namio Ohyama	Oct. 15, 1991 ~ Nov.25, 1991
Land Use/Vegetation	Junzo Watanabe	Oct. 5,1991 ~ Dec.10, 1991
Forest Survey	Teruji Nakamura	Oct.15,1991 ~ Dec.10, 1991
Socioeconomy	Tsutomu Yoshimura	Oct. 5,1991 ~ Dec.10, 1991
Surveying Supervision	Hirohisa Okuhara	Sep.19,1991 ~ Nov.14, 1991
Mapping	Mitsuo Saito	Sep.19,1991 ~ Nov.14, 1991
Mapping	Yasuo Ishiguro	Sep.19,1991 ~ Nov.14, 1991

Supervisory Team

Field of Assignment	Name	Period
Study Supervision	Shigeyuki Seto	Nov. 24, 1991 ~ Dec. 3, 1991

Appendix-2 Study-Related Government Organizations and Officials in Chile

- Corporacion de Fomento de la Producción (CORFO)

Jorge Catepillan Urbina	:	Director, Enterprise Bureau (also Chairman of the Board of Directors of INFOR)
Alvaro Briones Ramirez	:	Director, Development Bureau
Eduardo Fernandez Montero	:	(Development Bureau)
Raul Rossi Valpuesta	:	Assistant Director, Agricultural and Forestry Directorate, Development Bureau
Guillermo Guerra M.	:	Chief, Forest Division, Agricultural and Forestry Directorate, Development Bureau

- CORFO (Concepcion Office)

Mario Elizondo Arenas	:	Regional Director

- Instituto Forestal (INFOR)

Tomas Balaguer Quiles	:	Director
Jose Antonio Prado D.	:	Assistant Director
Roland Bennewitz B.	:	Chief, Forest Management and Inventory Division (DOI)
Sergio Fuenzalida A.	:	DOI (Remote Sensing)
Carlos Bahamondez Villarroel	:	DOI (Data Processing)
Patricio Gonzalez Diaz	:	DOI (Forest Mapping)
Sergio Cortez Riquelme	:	DOI (Forest Mapping)
Emilio Torres Balbontin	:	DOI (Forest Mapping)
Marjorie Martin Stuven	:	DOI (Forest Mapping)
Roberto Blanco Pauez	:	DOI (Forest Mapping)
Roberto Ipinza Carmona	:	DOI (Forest Mapping)
Luis A. Otero D.	:	Economic Study Division (Environmental Issues)
Cesar Alarcon	:	Silviculture Division
Fernando Tallar D.	:	Legal Advisor

- INFOR (Concepcion Office)

Jorge Cabrera Perramon	:	Director
Hans Groose W.		

- Centro de Información de Recursos Naturales (CIREN)

Pedro Goic Karmelic	:	Executive Director
Jose Antonio Bustamante G.	:	Technical Secretary
Enrique Zarate C.	:	Chief, Department of Production and Commercialization
Patricio Lara G.	:	Department of Studies

- Corporacion Nacional Forestal (CONAF)

Juan Franco De La Jara	:	Director General
Juan Moya Cerpa	:	Technical Director
Leonardo Araya Valdebenito	:	Chief, Forest Management and Development Department
Jorge Lopez H.	:	Director,.Forest Seed Centre

- CONAF (Region VIII Office)

Rodolfo Contreras Moncada	:	Chief, Technical Department
Marisol Almarza Trujillo	:	Officer in charge of Forest Control Programme
Hugo Barrueto	:	as above (Bio Bio Province)
Maria Ines Crosi Garate	:	Study and Planning Section

- CONAF (Region IX Office)

Benjamin Cornejo Paves	:	Director
Santiago Gomez	:	Chief, National State's Protected Wildlands Programme
Andres Duarte Catalan	:	Chief, Technical Department
Hector Hugo Castro Moran	:	Chief, Forest Management Programme
Hector Esterio	:	National State's Protected Wildlands Programme
Sergio Meza V.	:	Study Section
Rafael Bahamondez	:	Watershed Management Programme
Jorge Vera Martinez	:	Melleco National Reserve Forest
Nemo Ortega	:	Forest Management Programme

- Military Geographical Institute (IGM)

Carlos A. Carvallo Yañea	:	Director
Jorge Luis Tapia Castillo	:	(Reference Data)

- Military Aerial Photography Service (SAF)

Rodolfo Acuña Guimpert	:	Director
Hugo Luchinger Madrid	:	Chief, Commercial Squadron

Appendix 3 Existing Volume Tables for Native Species

Species	Source	Year	No. of Sample Trees	Prepared By	Locations from where Sample Trees were Collected	Use Category	DBH (cm) Range	DBH (cm) Unit	Log Size-Tree Height (m) Range	Log Size-Tree Height (m) Unit	Error Ratio (%)	Correlation Coefficient	Min. Diameter (cm)	Volume Formula
Araucaria (*Araucaria araucana*)	A	1952	18	CORFO	Valdivia	IV	30~234	5	3.75~30m	3.75			(25)	$V=bD^2+CIX$ (regression formula available for each log size)
"	"	1969	26	INFOR, Rolando Peters	Lonquimay, Malleco	"	40~152	"	3.75~18.75	"	8.8		"	
"	"	"	26	"	"	III	"	"	"	"	14.3		"	
"	"	1952	18	CORFO	Valdivia	"	30~234	"	3.75~30	"			"	
Rauli (*Nothofagus alpina*)	"	1952	15	CORFO	"	IV	30~295	5~20	"	"			"	
"	"	1971	69	Oscar Grosse	Niblinto Malleco	"	25~120	2	3.75~18.75	"	12.8	0.952	"	$V=a+bD^2+CD$ (regression formula available for each log size)
"	"	"	"	"	"	III	20~120	"	"	"	10.7	0.956	"	
"	B	1990	75	Hans Ferreira	① Neltume	T	6~34	"	5~25	5	13.3	0.99	Tree Top	$V=0.00207+0.00003\ D^2H$
"	"	"	13	"	② Jauja	"	12~36	"	10~30	"	8.9	0.99	"	$V=0.01411+0.00002689\ D^2H$
"	"	"	21	"	③ Melipeuco	"	10~40	"	15~30	"	14.3	0.99	"	$V=-0.00085+0.000028329\ D^2H$
"	"	"	11	"	④ LLancacura	"	"	"	"	"	11.2	0.98	"	$V=-0.00978+0.000031564\ D^2H$
"	"	"	36	"	⑤ Maquehua	"	10~40	"	10~30	"	7.1	0.99	"	$V=0.00265+0.00002795\ D^2H$
"	"	"	156	"	Total of ① ~ ⑤	"	6~44	"	5~30	"	9.2	0.99	"	$V=0.00762+0.000028017\ D^2H$
"	"	"	75	"	Neltume	III	16~34	"	2~10	2	10.9~82.2	0.73~0.97	15	$V=a+bD^2+CD$ (regression formula available for each log size)
"	A	1952	15	CORFO	Valdivia	"	30~295	5~20	3.75~30	3.75			(25)	
Roble (*Nothofagus obliqua*)	"	1952	22	CORFO	Valdivia	IV	30~295	"	3.75~30	"			"	
	B	1990	50	Hans Grosse	Neltume	T	8~40	2	10~30	5	9.4	0.99	Tree Top	$V=0.02582821+0.000028502\ D^2H$
	A	1952	22	CORFO	Valdivia	III	30~295	5~20	3.75~30	3.75			(25)	
	B	1990	50	Hans Grosse	Neltume	"	16~40	2	2~14	2	7.6~15.3	0.81~0.99	15	$V=a+bD^2$ (regression formula available for each log size)
Coigue (*Nothofagus dombeyi*)	A	1952	16	CORFO	Valdivia	IV	25~396	5	3.75~30	3.75			(25)	
	"	"	"	"	"	III	30~396	"	3.75~30	"			"	
	B	1990	50	Hans Grosse	Neltume	T	8~40	2	10~30	5	6.4	0.99	Tree Top	$V=0.012104781+0.000029462D^2H$
	"	"	"	"	"	III	16~40	"	2~12	"	12.1~17.8	0.88~0.96	15	$V=bD^2$ (regression formula available for each log size)
Canelo (*Drymis winteri*)	A	1952	10	CORFO	Valdivia	IV	30~140	5	3.75~22.5	3.75			(25)	
"	"	"	"	"	"	III	30~140	5	3.75~22.5	3.75			(25)	
Laurel (*Laurelia semprevirens*)	"	"	8	"	"	IV	30~170	5	3.75~30	3.75			(25)	
"	"	"	"	"	"	III	"	"	"	"			"	
Lenga (*Nothofagus pumilio*)	"	1969	50	David Campos	Rió Rubens Magallanes	II	20~100	2.5	3.65~12.8	1.83	18	0.97	(25)	$V=16.99+0.025\ D^2H$
"	"	"	"	"	"	I	"	"	"	"	14.6	0.98	(25)	$V=3.983+0.00342\ D^2H$
Lingue (*Persea lingue*)	"	1952	8	CORFO	Valdivia	IV	30~295	5~20	3.75~30	3.75			"	
"	"	"	"	"	"	III	"	"	"	"			"	
Lleuque (*Podocarpus andina*)	"	"	11	"	"	IV	30~210	5~10	3.75~18.75	3.75			"	
"	"	"	"	"	"	III	"	"	"	"			"	
Luma (*Amomyrtus luma*)	"	"	5	"	"	IV	30~150	5	3.75~18.75	3.75			"	
"	"	"	"	"	"	III	"	"	"	"			"	
Olivillo (*Aextoxicon punctatum*)	"	"	62	"	"	IV	30~220	5~10	3.75~30	3.75			"	
"	"	"	"	"	"	III	"	"	"	"			"	
Tepa (*Laurelia philippiana*)	"	"	71	"	"	IV	30~295	5~20	3.75~30	3.75			"	
"	"	"	"	"	"	III	30~295	5~20	3.75~30	3.75			"	
"	B	1990	50	Hans Grosse	Neltume	T	6~40	2	5~30	5	15	0.98	Tree Top	$V=0.01270452+0.000031284\ D^2H$
"	"	"	"	"	"	III	16~40	2	2~12	2	5.7~16.5	0.83~0.99	15 cm	$V=bD^2$ (regression formula available for each log size)
Ulmo (*Eucryphia cordifolia*)	A	1952	15	CORFO	Valdivia	IV	30~315	5~20	3.75~30	3.75				
"	"	"	"	"	"	III	"	"	"	"				

Notes
Source A - Recopilacion de Tables de Volumen para Especies Nativas, Ferreira R. Oscar, Santiago, Chile Instituto Forestal, 56p, Informe Tecnico, 43, 1973
Source B - Antecendentes Generales para el Manejo de Renovales de Rauli, Roble, Coigue y Tepa, Hans Grosse W., Victor Cubillos D., Concepcion, Chile, Instituto Forestal, Agusto de 1990

Use Categories -
T : Total stem volume table upto tree top
I : Stem volume table upto certain diameter
II : Converted figure of I into sawn timber
III : Based on obtainable log length
IV : Converted figure of III into sawn timber

Appendix 4 Required Time for Inventory Plot Survey

Plot No.	Access				AP-SP		Plot Survey						Total Time	Survey Team Members			
	Survey Base → Getting Off Point		Getting Off → Point-AP	Return Journey	Clearing and Surveying		Forest Type	Plot Set-up	Tree Measuring		Natural Regeneration Survey			Study Team Members	Chilean Side	Local Worker	Total
	Distance (km)	Time (mins)	Time (mins)	(mins)	Distance (m)	Time (mins)		(mins)	No. of Trees	Time (mins)	No. of Regeneration	Time (mins)	(mins)				
1	9.0	80	30	220	—	—	Over-Mature Forest	45	29	60	156	40	365	2	1	6	9
2	9.0	80	20	200	—	—	Secondary Forest	35	104	85	108	30	350	2	2	5	9
3	10.5	70	30	200	300	50	Secondary Forest	40	33	40	455	55	385	2	1	6	9
4	16.5	70	15	170	—	—	Secondary Forest	60	98	70	228	40	340	2	2	5	9
5	14.0	90	20	220	30	20	Over-Mature Forest	80	18	40	299	40	400	2	2	6	10
6	—	—	15	30	325	115	Secondary Forest	35	179	90	169	40	310	4	4	6	14
7	38.0	170	35	410	—	—	Over-Mature Forest	75	15	45	489	80	610	1	2	6	9
8	18.0	120	—	240	110	30	Over-Mature Forest	70	91	60	163	60	460	2	3	5	10
9	18.0	120	15	270	20	15	Over-Mature Forest	20	32	60	100	35	400	2	3	5	10
Ave.	14.7	89	20	218	87	26	Over-Mature Forest	51	67	61	241	47	403	2.1	2.2	5.6	9.9

Note: AP; Access Point, SP; starting Point

Appendix 5 Openness Grade of Canopy Measurement Method

1. Hemispherical Photograph

Camera : Canon AE-1
Lens : Canon Lens FD 20mm, 1:2.8
Filter : Canon 72mm UV 1x
Film : Black and White, ASA 400

To take the hemispherical photographs, the camera was placed as level as possible on the ground. 2 photographs, i.e. one with a standard exposure and another with a slightly under-exposure, were taken for each sample plot due to the difficulty of obtaining a clear contrast between the sky and deciduous trees at the time of photographing when new leaves had just begun to appear.

2. Developing and Printing

Photographic Printing Paper : Fuji WP-FM-2 Card-Size (170x90mm)
Finishing : Soft Finish

Prints include mount and photo number.

3. Image Analysis

Personal Computer : NEC-PC-9801 VX
Image Scanner : Sharp Colour Scanner JX-450
Colour Monitor : Sony KX-21HD1

(1) AD (Analogue to Digital) Conversion of Photographs

The hemispherical photographs (black and white) were converted to 0-255 digital data by the image scanner and displayed on the colour monitor. The reading accuracy was set at 300 BPI (bits/inch).

(2) Setting of Threshold

The value (threshold) to mark the boundary between the openness and the crown on the digital images was set at 15 after a series of trials using samples.

(3) Calculation of Openness Grade of Canopy Ratio

The openness grade ratio for each converted image was calculated as the ratio of pixels with a value of 15 or more in the total number of pixels of each image (approximately 26,000).

Appendix 6 Current Conditions of Rauli Man-Made Forest (at El Morro)

(as of November, 1991)

No.	Species	DBH (cm)	Tree Height (m)	No.	Species	DBH (cm)	Tree Height (m)	Remarks
1	Rauli	22	12	16	Rauli	29	15	a) Site Conditions - EL. 630m, bearing: S40W, gradient: 2°
2	Rauli	25	13	17	Rauli	31	15	
3	Rauli	26	16	18	Rauli	31	17	b) Sample plot Sizes: 20mx20m
4	Rauli	30	16	19	Rauli	28	17	c) Tree Age - unknown (estimated to be around 38 years old based on tree annual ring count)
5	Rauli	31	16	20	Rauli	14	13	
6	Rauli	30	17	21	Rauli	25	16	d) Mixture of 4 Lingue (diameter of 15-20cm and tree height of 10-13m)
7	Rauli	23	16	22	Rauli	14	15	e) Many under-storey Avellano (diameter of 5~12cm and tree height of 6-9m)
8	Rauli	11	14	23	Rauli	26	15	
9	Rauli	22	16	24	Rauli	21	16	f) Crown Density: approx. 75%
10	Rauli	12	12	25	Rauli	20	16	g) Existence of many naturally regenerated Lingue and Avellano seedlings
11	Rauli	27	15	26	Rauli	20	16	
12	Rauli	22	16	27	Rauli	14	12	
13	Rauli	22	16	28	Rauli	18	12	
14	Rauli	13	16	29	Rauli	15	13	
15	Rauli	34	17					

Appendix 7 Standard Afforestation Costs

(A) Standard Afforestation Costs (Excluding Small-Scale Afforestation)

(Unit: $/ha)

Planting Density (per ha)	Method Seedlings Raised	Species and Region								
		I,II,III	IV	RM,V,VI	VII,VIII		IX,X		XI,XII, Palena	Pascua Island
		Exotic, Native	Exotic, Native	Exotic, Native	Exotic	Native	Exotic	Native	Exotic, Native	Exotic, Native
100	Pot	79,906								
500		99,178								
625		116,427	85,791	104,082	62,937	90,924	62,937	90,924	86,146	118,947
830		143,151	97,546	117,580	71,728	107,744	71,728	107,744	100,531	137,191
1,100		174,760	112,705	135,789	83,871	130,517	83,871	130,517	120,341	162,788
1,250			124,040	146,389	91,984	144,667	91,984	144,667	132,132	178,439
1,600			141,890	170,854	107,066	173,464	107,066	173,464	158,072	212,096
625	Bare Root								66,459	
830				58,219	40,365	73,335	44,033	77,359	71,226	67,252
1,100				62,254	43,052	85,733	46,726	89,764	75,992	72,915
1,250				63,578	43,621	91,607	47,294	95,637	78,801	76,599
1,600				70,501	48,793	109,532	52,464	113,559	89,023	83,711
1,800				72,918	51,213	119,187	54,886	123,216	93,491	88,120
2,000				75,598	53,894	129,128	57,568	133,159	97,957	92,691
2,500				79,282	57,655	150,754	61,321	154,776	109,627	103,488

Source: CONAF

(B) Standard Afforestation Costs (Small-Scale Afforestation)

(Unit: $/ha)

Region					Remarks
I, II, III	IV	RM, V, VI	VII, VIII, IX, X	XI, XII, Palena	Applicable to afforestation upto 2 ha with a planting density of over 1,250/ha
239,080	202,775	234,552	167,288	223,248	

Source: CONAF

Appendix 8 Interview Survey Results for North Model Area (Socioeconomic Survey)

No. of House holds	Location	No. of Family members	Land Ownership (ha)						Domesticate Animals							Forestry			Forest Inventory Plot No.	Remarks
			Farmland	Grazing Land	Native Forest	Man-Made Forest	Other	Total	Cattle	Horse	Sheep	Pig	Goat	Chicken	Other	Sawn Timber	Material for Chips	Other		
1	La Coigua	8	2	12	90.8	7	8.2	120	(6)6	-	10	3	-	10	-	o	o	-	P.39	
2	Menuco	10	0.25	6	40	-	43.75	90	(2)10	1	15	3	-	10	-	o	o	-	P.17	
3	La Nueve	10	1.5	2	121.1	1	15	140.6	(5)15	-	15	3	-	8	-	-	o	-	P.23	
4	Los Nirres	2	-	*40	69.5	0.5	-	110	(6)11	1	20	1	-	20	-	o	o	-	P.47	*including shrubland
5	Los Nirres	11	0.5	1.5	21	-	2	25	(2)8	1	4	-	3	5	19	-	o	charcoal	P.43	
6	Amargo	9	1	6	48.6	-	-	55.6	2	-	14	1	-	7	-	-	-	beekeeping	P.42	caretaker
7	Pemehue	6	0.5	24.5	29	-	-	54.6	(4)12	2	8	7	5	10	-	o	-	-	P.60	
8	Pemehue	4	0.5	40.2	48.3	-	-	89	(2)9	1	-	1	-	8	-	-	-	-	P.4	
9	Pemehue	3	1	20	34	2	-	57	(2)14	1	8	2	4	10	-	-	-	-	—	caretaker
10	Pichiamargo	4	0.1	15	33.9	2	-	51	(2)6	2	11	3	9	6	4	o	o	-	P.26	
11	Pichiamargo	6	0.25	5	95.25	0.5	-	101	(2)3	-	13	3	3	5	-	-	o	-	—	
12	Pichiamargo	14	3.2	4	55.8	2	-	65	-	-	2	-	1	30	31	o	o	-	P.25	caretaker
13	Pichiamargo	8	0.5	21	44	1.5	-	67	(4)11	2	9	1	2	8	2	o	o	-	—	
14	Amargo	2	-	10	20	-	-	30	-	-	-	-	-	-	-	-	-	-	—	
15	Amargo	5	1	20	45	30	-	96	(6)12	4	24	4	-	10	-	-	o	-	P.45, 46	
16	Amargo	7	0.4	15	41.1	6.5	-	63	(2)6	-	-	-	-	-	-	o	o	beekeeping	—	
Number of Relevant Households			14	16	16	10	4	16	(13)14	9	13	12	7	14	4	8	11	-		
	Average (1)	6.8	0.8	15.1	52.3	3.3	4.3	75.9	(2.8)7.8	0.9	9.6	2	1.7	9.2	3.5	50%	69%	-		
	Average (2)	6.8	0.9	15.1	52.3	5.3	17.2	75.9	(3.5)8.9	1.7	11.8	2.7	3.9	10.5	14.0	-	-	-		

Notes: Average (1); Total value of each column is simply divided by the total number of households
Average (2); Total value of each column is divided by the number of relevant households
Forest Inventory Plot No.; No. of forest inventory plot established on land owned by households interviewed.
Figures in the brackets refer to the number of oxen used for various works.

Appendix 9 Interview Survey Results for South Model Area (Socioeconomic Survey)

No. of House holds	Location	No. of Family members	Land Ownership (ha)						Domesticate Animals							Forestry			Forest Inventory Plot No.	Remarks
			Farmland	Grazing Land	Native Forest	Man-Made Forest	Other	Total	Cattle	Horse	Sheep	Pig	Goat	Chicken	Other	Sawn Timber	Material for Chips	Other		
1	Cherquen	8	-	35	98	-	-	133	(2)9	2	9	-	15	8	6	o	o	-	177	
2	Curacalco	4	-	13.5	66.5	-	-	80	(4)15	1	-	-	-	14	-	o	o	-	127	
3	Molulco	5	1	14	34	-	-	49	9	2	12	1	-	8	-	o	-	roof tile	108	
4	Cherquen Curacalco	15	-	60	181	-	-	241	(4)44	4	8	-	-	20	20	o	o	-	-	
5	Cherquen	3	0.5	6.5	2	-	-	9	(2)6	1	-	-	-	4	-	-	-	-	122	
6	Pichapinga	2	-	30	20	-	-	50	3	1	-	-	-	6	2	-	-	-	-	
7	Pichapinga	4	0.5	30	5	1	35.5	72								o	-	-	-	
8	Llaima	3	3	21	119	-	-	143	-	1	4	-	-	12	-	o	-	-	-	
Number of Relevant Households		8	4	8	8	1	1	8	6	7	4	1	1	7	3	6	3	-		
	Average (1)	5.5	0.6	26.3	65.7	0.1	4.4	97.1	(1.7)12.2	1.7	4.7	0.1	2.1	10.3	4.0	75%	38%	-		
	Average (2)	5.5	1.3	26.3	65.7	1.0	35.5	97.1	(2.0)14.3	1.7	8.2	1.0	15.0	10.3	9.3		-	-		

Notes: Average (1); Total value of each column is simply divided by the total number of households
Average (2); Total value ofeach column is divided by the number of relevant households
Forest Inventory Plot No.; No. of forest inventory plot established on land owned by households interviewed.
Figures in the brackets refer to the number of oxen used for various works.

Appendix 10 Wild Fauna in North Model Area (Based on Interview Survey)

Local Name	Inventory Plot Nos. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
MAMIFEROS																	
1.Pudú	○	○	○	○	×	○	○	○	○	×	○	○	○	○	○	○	○
2.León(Puma)	○	○	○	○	×	×	○	○	●	○	●	○	●	●	●	○	●
3 Zorro culpeo	●	○	○	○	○	○	○	○	○	●	●	●	●	●	○	●	○
4.Zorro chilla	●	○	○	○	○	○	○	○	○	●	●	●	●	●	○	●	○
5.Quique	○	×	×	○	×	×	○	○	○	×	○	○	○	○	○	○	○
6.Guiña	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
7.Chingue	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
8.Ratón	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
9.Tunduco	×	○	○	○	?	?	*	*	*	*	○	○	○	○	○	*	*
10.Coipo	*	*	*	○	×	×	*	*	*	*	×	○	×	×	×	*	*
11.Murciélago oreja ratón	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
12.Murcielago colorado	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
13.Murcielago gris	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
14.Conejo	○	◉	○	○	○	◉	◉	◉	○	○	○	◉	◉	○	○	○	○
15.Liebre	○	◉	○	○	○	◉	◉	◉	○	○	○	◉	◉	○	○	○	○
16.Jabalí	×	×	×	×	×	×	×	×	×	×	×	×	×	×	○	×	●
17.Rata(Guarén)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
AVES																	
18.Tordo	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
19.Zorzal	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
20 Diuca	○	×	×	○	○	○	○	○	○	○	○	○	○	○	○	○	○
21.Chincol	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
22.Lloica	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
23.Codorniz	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
24.Perdiz	×	×	×	×	○	○	○	○	○	○	○	○	○	○	○	○	○
25.Tenca	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
26.Chucáo	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
27.Chercán	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
28.Huio(Fio)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
29.Torcaza	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
30.Tórtola	○	○	×	○	○	○	○	○	○	○	○	○	○	○	○	○	○
31.Tiuque	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
32.Loro(Cachaña)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	×
33.Loro(Choroy)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	×
34.Peuco	○	○	○	○	○	○	○	○	○	○	●	○	○	●	○	○	○
35.Treile(Queltehue)	○	○	○	○	○	○	×	○	×	×	○	○	○	○	○	×	○
36.Joto	○	○	○	○	×	×	○	○	○	○	○	×	○	○	○	○	×
37.Cernicalo	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
38.Traro	○	○	○	○	●	○	○	○	○	○	×	○	×	○	○	○	○
39.Lechuza	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	×
40.Concón	○	○	○	○	○	?	○	○	○	○	○	○	○	○	○	○	○
41.Chuncho	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
42.Carpintero	○	○	○	○	×	○	○	○	○	○	○	○	○	×	○	○	○
43.Bandurria	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
44.Condor	○	○	○	○	×	×	○	○	○	○	○	○	○	○	×	○	×
45.Golondrina	○	○	○	○	○	○	×	×	×	○	○	○	○	○	○	○	×
46.Pitio	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
47.Huet-huet	?	○	?	?	○	○	*	*	*	*	○	?	○	○	○	*	*
48.Carpinterito	○	○	○	○	×	?	*	*	*	*	○	○	○	○	○	*	*
49.Pidén	○	○	○	○	○	○	○	○	○	○	×	○	○	○	○	○	○
50.Pato correntino	×	○	×	○	○	○	○	○	○	○	×	○	×	×	○	○	○
51.Martin pescador	×	○	×	○	○	○	*	*	*	*	○	○	○	○	○	*	*
52.Cuervo	○	○	○	○	○	○	*	*	*	*	○	○	○	×	×	*	*
53.Huairavo	○	○	×	○	○	○	*	*	*	*	○	○	○	○	○	*	*
54.Avutarda(Canquén)	○	○	×	○	×	×	*	*	*	*	×	×	×	×	×	*	*
55.Pintriuque(Gallina ciega)	○	○	×	○	○	×	*	*	*	*	○	○	○	○	×	*	*
Total ○ : Sighted	48	50	43	52	44	44	43	44	43	42	49	51	50	49	50	44	40
× : Not Sighted	5	4	10	2	10	8	3	2	3	4	6	3	5	6	5	2	6
? : Unknown	1	0	1	1	1	3	0	0	0	0	0	1	0	0	0	0	0
* : Not Surveyed	1	1	1	0	0	0	9	9	9	9	0	0	0	0	0	9	9

● : Causing damage to domestic animals.
◉ : Causing damage to agricultural products

Appendix 11 Wild Fauna in South Model Area (Based on Interview Survey)

Local Name	Inventory Plot Nos.					
	1	2	3	4	5	6
MAMIFEROS						
1.Pudú	O	O	X	O	O	O
2.León(Puma)	●	O	O	●	O	●
3 Zorro culpeo	●	O	●	O	O	O
4.Zorro chilla	●	O	●	O	O	O
5.Quique	?	O	X	O	O	X
6.Guiña	●	O	O	O	O	O
7.Chingue	O	O	O	O	O	O
8.Halón	O	O	O	O	O	O
9.Coipo	X	O	X	O	O	O
10.Hurciélago oreja ratón	O	O	X	O	O	O
11.Hurcielago colorado	O	O	X	O	O	O
12.Hurcielago gris	O	O	X	O	O	O
13.Conejo	O	O	O	O	O	O
14.Liebre	O	◉	O	O	O	O
15.Rata(Guarén)	O	O	O	O	O	O
AVES						
16.Tordo	O	O	O	O	O	O
17.Zorzal	O	O	O	O	O	O
18 Diuca	O	O	O	O	O	O
19.Chincol	?	O	O	O	O	O
20.Lloica	O	O	O	O	O	O
21.Codorniz	?	O	O	X	X	X
22.Perdiz	X	O	O	O	O	O
23.Tenca	O	O	O	O	O	O
24.Chucáo	O	O	O	O	O	O
25.Chercán	O	O	O	O	O	O
26.Hujo(Fio)	?	O	O	O	X	O
27.Torcaza	O	O	O	O	O	O
28.Tórtola	O	O	O	O	O	O
29.Tiuque	O	O	O	O	O	O
30.Loro(Cachaña)	O	O	O	O	O	◉
31.Loro(Choroy)	O	O	O	O	O	◉
32.Peuco	●	●	●	●	O	●
33.Treile(Queltehue)	O	O	O	O	O	O
34.Joto	O	O	O	O	O	O
35.Cernicalo	O	O	O	O	O	O
36.Traro	O	O	O	O	O	O
37.Lechuza	X	O	X	O	O	O
38.Concón	X	O	O	O	O	O
39.Chuncho	O	O	O	O	O	O
40.Carpintero	X	O	X	O	O	O
41.Bandurria	O	O	O	O	O	O
42.Condor	X	O	X	O	O	O
43.Golondrina	O	O	O	O	O	O
44.Pitio	O	O	O	O	O	O
45.Huet-huet	?	?	X	O	O	?
46.Pidén	O	O	O	O	O	O
47.Pato correntino	?	O	O	O	O	O
48.Martin pescador	?	O	O	O	O	O
49.Cuervo	O	X	O	O	O	O
50.Huairavo	X	O	O	O	O	O
51.Avutarda(Canquén)	X	O	X	O	O	X
52.Pica flor	O	O	O	O	O	O
53.Churrete	?	O	O	O	O	O
54.Rara	?	?	O	X	O	X
55.Jilguero	?	O	O	X	X	?
Total O : Sighted	37	52	44	52	52	49
X : Not Sighted	8	1	11	3	3	4
? : Unknown	10	2	0	0	0	2

● : Causing damage to domestic animals.
◉ : Causing damage to agricultural products