Chapter 6
Argentina

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6.1 The National Forest Inventory of Native Forests in Argentina

6.1.1 History and Objectives

Located at the southern tip of South America, Argentina is a Federal Republic consisting of 23 provinces and one federal district, with a population of 40 million people and covering an area of 3.76 million km^2. At world level, Argentina is the eighth largest country in the world, with a maximum length from north to south of 3694 km and from east to west of 1423 km. Due to the geographic location, geology and topography, Argentina has different native forest types: ranging from the subtropical forests in the northern latitudes to the sub-antarctic forests in southern latitudes. The total native forest area is about 300000 km^2.

Between 1776 and 1822 policy was formulated relating to the exploitation of forests in the vicinity of the Ciudad de Buenos Aires. The object of the Council, at this time, was the protection of the common areas belonging to the colonies. It had two major objectives: (a) the provision of firewood and charcoal at fair prices, and (b) to prevent the unsustainable cutting of those forests. However, between 1820 and 1830, the vision changed towards the economic contribution that forests could make.

In 1880, a national law was enacted (N° 1054), becoming the first comprehensive and detailed regulation about several aspects of forest in the country. But in 1903 this law was replaced by the national law No. 4167, which only had two items relating to forests. Therefore, the importance of forests in national legislation was reduced.

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C. Vidal et al. (eds.), *National Forest Inventories*,
DOI 10.1007/978-3-319-44015-6_6

The Forest Technical Section (*Sección Técnica Forestal*) was created in 1932, within the structure of the Ministry of Agriculture. The national law No. 13273 was enacted in 1948, which created a unique national forestry agency with the name of National Forestry Administration. This law assigned a budget for the execution of the first Argentine forest map and can be considered the first policy step towards a national forest inventory. However, the map was never produced.

In 1973 the National Forest Institute (*Instituto Forestal Nacional*, IFONA) was created as the sole technical unit to manage the national forests. During the 1980s IFONA defined forest types and productivity classes of native forests in Argentina. This set of maps, named the "*Pre Carta Forestal*", was considered as the first step toward a complete cartography of the country. The maps were obtained from the visual analysis of satellite images data (MSS—LANDSAT) with the support of field checks. Then, the World Bank and the Inter-American Development Bank financed IFONA to design the first national forest inventory. International experts were invited to cooperate with the basic guidelines of the forest inventory and several proposals were made. Although the technical and financial aspects were approved, the project was not implemented due to institutional problems. In 1991 IFONA was dissolved and its tasks were distributed among three institutions: (1) the current Ministry of Agriculture, Livestock and Fisheries, in charge of plantation forests; (2) the current Secretariat of Environment and Sustainable Development (SADS) in charge of native forests; and (3) the National Agricultural Technology Institute in charge of the research.

6.1.2 Sampling Methods and Periodicity

In early 1990, the need of carry out a NFI in Argentina was reaffirmed due to information needs and for decision making related with national forest policy. The SADS considered the need to begin the NFI of native forests and in 1995, the first tasks associated with the planning of the national forest inventory began. The forest inventories information carried out in Argentina came from regional and provincial forest inventories. Table 6.1 shows the most important forest inventories.

As seen from Table 6.1, the data were collected using regionally different methodologies. The absence of a national forest inventory using a standardised methodology and a number of provincial or regional forest inventories are responsible for a limited knowledge about the quantitative composition and the structure of the native forest in Argentina. Moreover, this limited information constituted an obstacle for the development of forest policies. To improve this situation the Argentine government decided to undertake the First National Native Forest Inventory, called "*Primer Inventario Nacional de Bosque Nativo*" (PINBN), financed by the World Bank in 1996, with a view to:

Table 6.1 List of local forest inventories

Forest Inventory	Region	Design	Mapping
Plan Noa II (1970–1975)	Provinces of Salta, Tucumán, Jujuy and Santiago del Estero	Stratified with systematic sampling ordered on a grid of 4 × 10 km. The sampling unit was a cluster with 8 circular plots	Visual interpretation Aerial photographs Scale from 1:35,000 to 1:80,000
Provincia de Santiago Del Estero (1994)	Territorial divisions of Copo and Alberdi (north of the province)	Stratified with systematic sampling ordered on a grid of 4 × 10 km. The sampling unit was a cluster with 9 circular plots	Satellite processing Images: Landsat-TM. Scale: 1:400.000
Provincia de Tucumán (1995)	Subtropical western forest of the province	Stratified with systematic sampling ordered on a grid of 4 × 10 km. The sampling unit was a cluster with 8 circular plots	Satellite processing Images Landsat-TM Maps. Scale: 1:135.000
Provincia De Formosa (1996)	Included private property and its objective was the development of a forest management plan	Systematic sampling on a square grid of 500 × 500 m per side. The sampling unit was a rectangular plot with 50 m long and 10 m wide	Satellite processing Images Landsat-TM Maps Scale: 1:250.000
Provincia De Tierra Del Fuego (1998)	Whole Province of Tierra del Fuego	Systematic sampling on a square grid of 7.5 × 7.5 km. The sampling unit was a cluster with 4 circular plots	Satellite processing Images Landsat-TM Maps 1:750.000

- obtain basic information about native forest resources of the country for forest policy formulation
- create and maintain an updated database of these resources
- improve the operational capacity in the management and use of the database.

On February 6th of 1998, the SADS and the partnership of two Canadian companies: Simons Reid Collins and Tecsult International Limited, and an Argentine company, Aeroterra, signed a contract for consulting services for the execution of the first national inventory of native forests and the establishment of a national system of forest assessment. The three companies were identified as the Consultant. The project began in April 1998 and ended in 2007. In 2002 the Canadian companies left the project and from April 2004 Aeroterra continued with the work.

The constraints and responsibilities of the Consultant in all aspects of the technical service were defined in the Terms of Reference. These terms expressed that the methodology as a whole was an absolute responsibility of the Consultant. The SADS was the responsible for the project performed by the Consultant and the product deliverables. The following objectives were established for PINBN:

1. Provide appropriate information for the development of national forestry conservation and development policies
2. Determine the information needs at national level in relation to statistical issues and decision-making
3. Establish regional level extension, conservation status, risks and productive situation of native forests
4. Assist in planning the use of forest resources at the national level and to provide a general framework for planning at sub-national scales

The PINBN covered the native forest area included in Argentine territory. From the six phytogeography regions established in Argentina, six forest regions were named as: Selva Misionera, Selva Tucumano Boliviana, Parque Chaqueño, Región del Monte, Región del Espinal, and Bosque Andino Patagónico. Table 6.2 and Fig. 6.1 details the geographical location and boundaries of each forest region. Figure 6.1 shows a map with the location of the six defined Forest Regions and Fig. 6.2 shows the map of forest cover in Argentina.

The area corresponding with each forestry region was separated in two sub-areas: (1) native forest, and (2) non-native forest. Forest land was classified into

Table 6.2 Geographic location and boundaries of the Argentine forest regions

Forest region	Description of the geographic location and boundaries
Selva Misionera	Located in the Province of Misiones and a small portion of northeastern of the province of corrientes. It is bordered to the north and east by Brazil, on the south by Brazil and the province of corrientes, and on the west by Paraguay
Selva Tucumano Boliviana "Yungas"	The region is extended from the border with Bolivia until the north to the province of Catamarca; shows a discontinuous band in the provinces of Salta, Jujuy, Tucuman and Catamarca; its main characteristic is the altitudinal distribution of vegetation zones
Parque Chaqueño	It completely covers the province of Formosa, Chaco and Santiago del Estero, and partially the north of Santa Fe and San Luis, the east of Salta, Tucumán, Catamarca, San Juan, La Rioja and the north and west of the province of Córdoba
Monte	It covers the south of Salta, the center of Catamarca, La Rioja and San Juan; the east-central zone of Mendoza; a small strip located at the northwest of San Luis, the west of La Pampa, south of Buenos Aires, east of Neuquén; and north of Rio negro and north-east of Chubut
Espinal	Cover a strip going from the center-south of Corrientes, north and center of Entre Rios, center of Santa Fe; east, center and south of Córdoba; center and south of San Luis; and then go down to the east and center of La Pampa, concluding with a smaller surface involvement in the south of Buenos Aires
Bosque Andino patagónico	Narrow strip bordering the Andes Cordillera, and extended from the northern province of Neuquén to Tierra del Fuego at the southern end

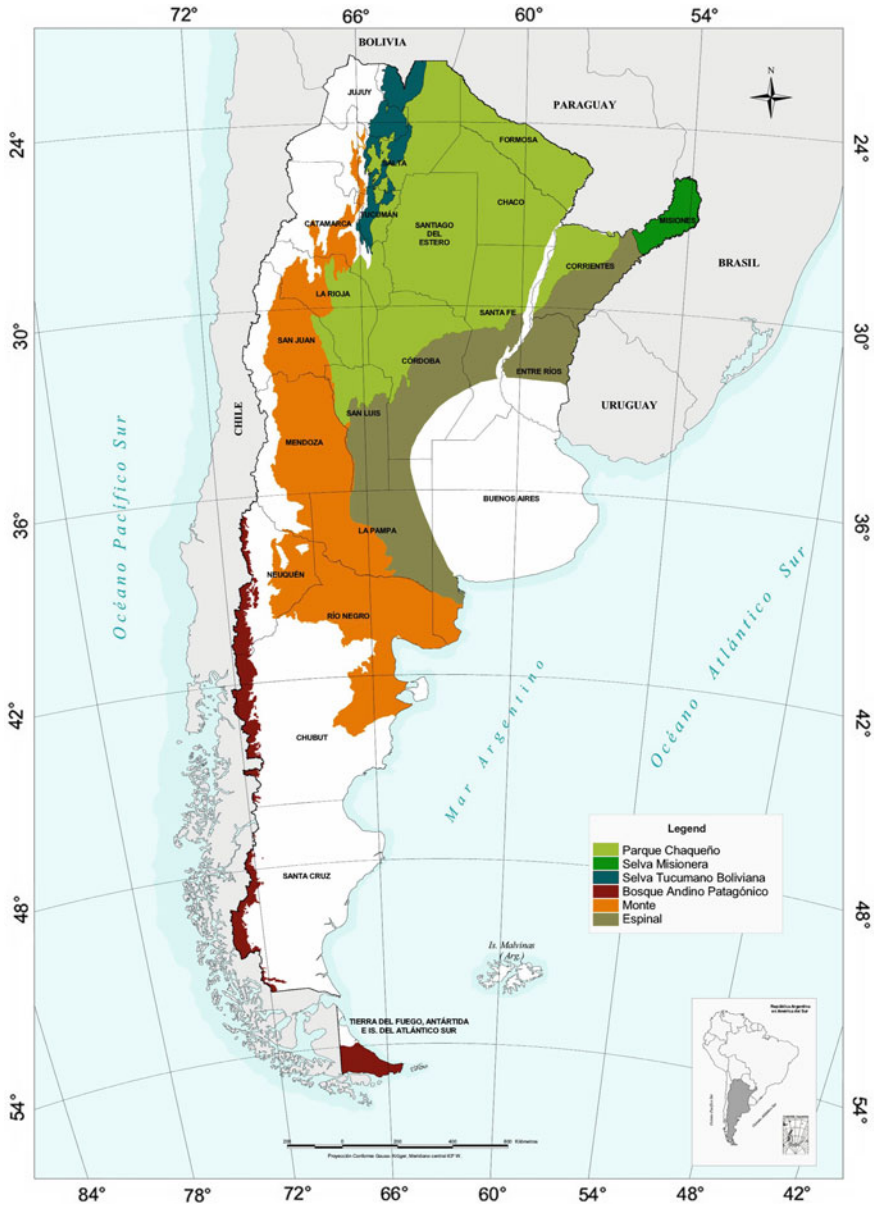

Fig. 6.1 Map of the defined forest regions of Argentina

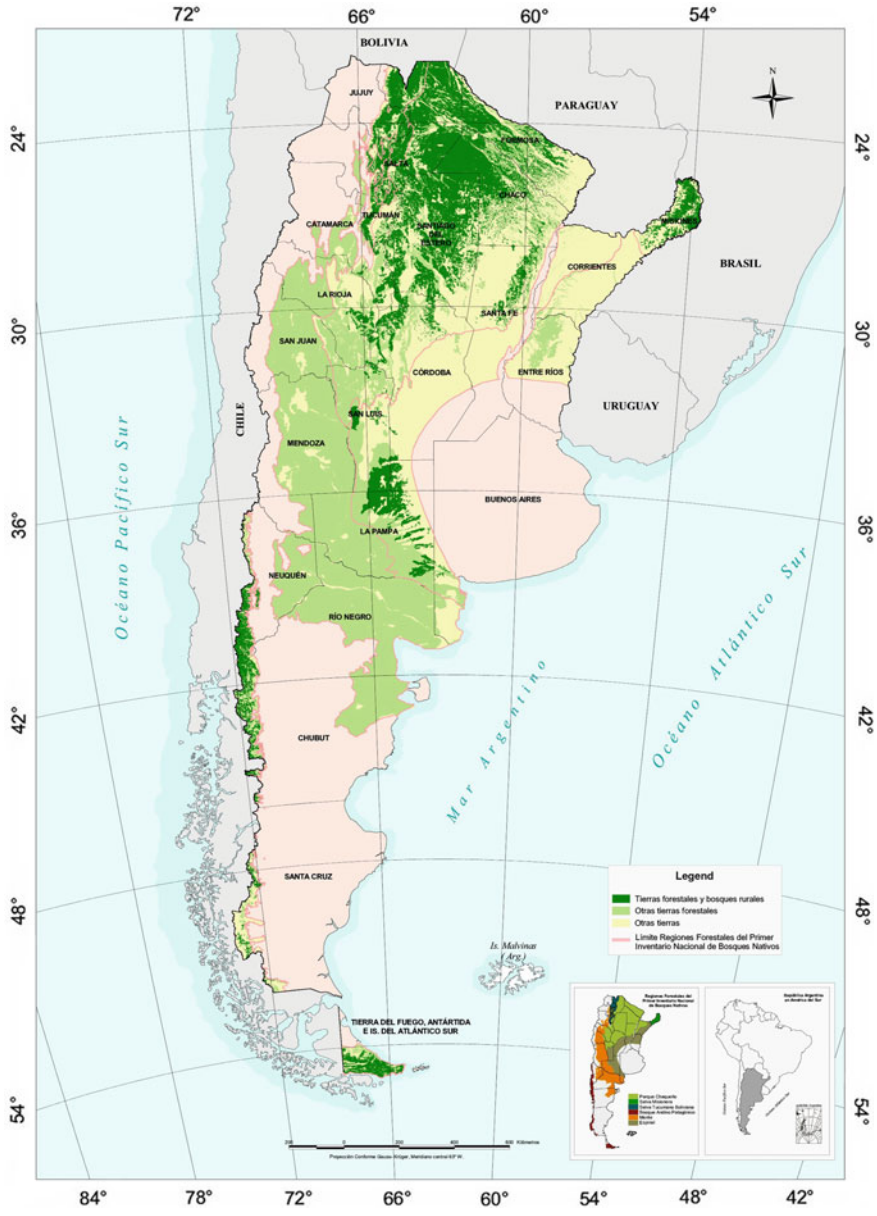

Fig. 6.2 Map of forest cover within the defined regions of Argentina

three hierarchical levels where the higher number represented a greater level of detail. Level 1 corresponds to the broadest scale and is represented by each of the six defined forest regions; so there are six level 1 regions. In each forest region of Level 1 forest lands were classified and separated into more homogeneous zones, and each of these subdivided zones correspond with an area of Level 2. This sub-classification was based on species composition and topographic aspects. Table 6.3 details the Level 1 and Level 2 land classification.

6.1.2.1 Remote Sensing

Remote Sensing was used to define and identify native forest strata and the corresponding classes of land use. These activities were performed for each particular region at Level 1 and Level 2 with the following main steps:

- Selection of satellite images
- Georeferencing
- Preliminary stratification
- Final stratification
- Analysis of the accuracy of the produced maps.

Satellite images were selected considering: (a) the extent of the inventory area, (b) the characteristics of each region, especially its topography and the phenology

Table 6.3 Land classification at level 1 and at level 2 with their corresponding names

Level 1	Level 2
Selva Misionera	Selva del Parque Iguazú
	Selva de cobertura cerrada
	Selva de cobertura variable
	Selva de cobertura abierta
Selva Tucumano Boliviana	Selva de transición
	Selva montana
	Bosque montano
Parque Chaqueño	Quebrachal
	Colonizadoras
	Bosque alto
	Bosque ribereño
Monte	No tiene Tierras Forestales
Espinal	Bosque de Caldén
	Bosque de Ñandubay
Bosque Andino patagónico	Bosque de Lenga
	Bosque de Coihue
	Bosque mixto
	Bosque de Ciprés
	Bosque de Araucaria
	Bosque de Roble pellín

of species, and (c) the level of perception and the precision of the different sensors available. The material used was preferably from LANDSAT-5 TM, and in a lesser extent from Landsat-7 TM, TERRA-ASTER and CBER 2-CCD. The material used corresponded to satellite LANDSAT 5-TM system, and in a lesser extent LANDSAT 7-TM, TERRA-ASTER and CBER 2-CCD systems.

The satellite material was processed with ERDAS IMAGINE software and supported by topographic maps provided by the Military Geographical Institute (IGM) with a scale of 1:100,000. The preliminary stratification was carried out by the visual identification method to differentiate between forest and non-forest land. A final stratification was completed on lands with native forest that could be assessed in the field and was sub-divided into two sub-categories, level 1 and level 2. In the case of non-forested areas and areas with native forest that would not be assessed, this phase was to record classes of land use. Finally, the quality of the forest maps obtained as a result of the final stratification was evaluated by performing an error matrix analysis.

The IGM developed a mapping system, composed of 20 vector layers at a scale of 1:250,000. Other digitised sources were used to update and complete this information. This action led to introduce a new category in the attribute tables. The edition of the SIG-250 charts, supplemented with data from own surveys of Aeroterra, made it possible to obtain a digital base map of the represented area. The Gauss-Krüger map projection, which divides the argentine territory in seven meridian strips numbered from west to east, was used to transfer mapping data to a flat surface. The Gauss-Krüger system is the official projection system used in Argentina.

6.1.2.2 Sampling Design

The sample design was a systematic square grid, with points located at intervals that vary for all forest regions (Table 6.4).

The sample plot unit used in the different forest regions had a very different structure, so they are described separately.

Región Espinal

The sampling unit was a cluster with three circular plots located on a square of 100 m side, where only three vertices of the square contained plots. In three vertices of the square two circular plots with different size were installed. The bigger plot, identified as Plot A, had an area of 500 m^2, where data were recorded for trees with

Table 6.4 Level 1 grid size by forest region

Forest region	Grid size (km)
Selva Misionera	10
Selva Tucumano Boliviana	20
Parque Chaqueño	50
Bosque Andino Patagónico	10
Espinal	10 18
Monte	No sampled

dbh greater than or equal to 10 cm (dbh ≥ 10 cm). The smaller plot, identified as Plot B, had an area of 12.5 m^2, where data were recorded for trees with dbh under 10 cm (dbh < 10 cm). Plot B is used to assess regeneration. Figure 6.3 show the sampling unit and the plots used in the *Región del Espinal* (Informe Regional Espinal Segunda Etapa,2007).

Región Selva Misionera, Serlva Tucumano Boliviana, Parque Chaqueño and Bosque Andino Patagónico

Each sampling unit consisted of a set of plots in a repeated sequence. Three types of subplots were used within each plot, each one associated with a range of dbh and named A, B and C. Plot A was associated with a range of dbh equal or over 30 cm (dbh ≥ 30 cm); Plot B was associated with a range of dbh equal or over 10 cm and lower than 30 cm (10 cm ≤ dbh < 30 cm); and Plot C was associated with a range of dbh lower than 10 cm (dbh < 10 cm), considered as regeneration. However, the shape of the sampling units was not the same in all regions. Figure 6.4 show the constitution of the sampling unit with the conformation of the plots and Fig. 6.5 shows the internal structure of each plot with the corresponding subplots A, B and C (Informe Regional Bosque Andino Patagónico 2007; Informe Regional Parque Chaqueño 2007; Informe Regional Selva Misionera2007; Informe Regional Selva Tucumano Boliviana 2007; Informe Regional Monte 2007).

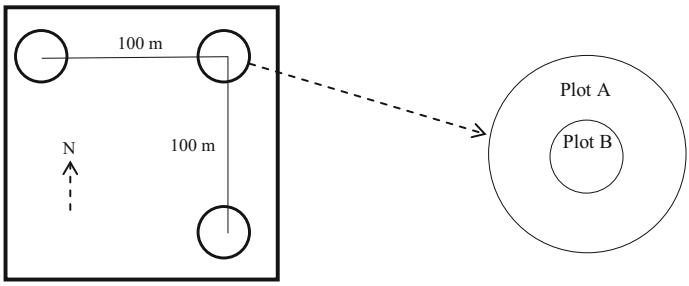

Fig. 6.3 Sampling unit with the plots used in the *Región del Espinal*

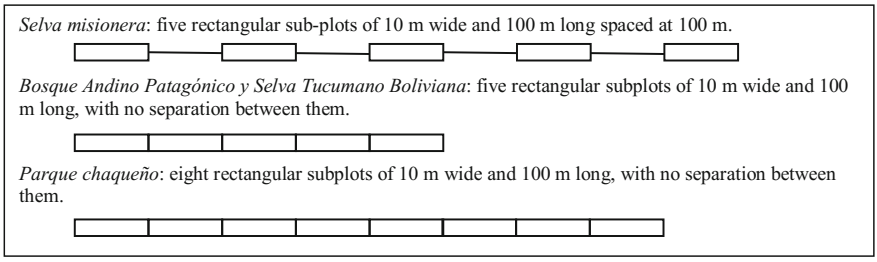

Fig. 6.4 Sampling units used in each forestry region

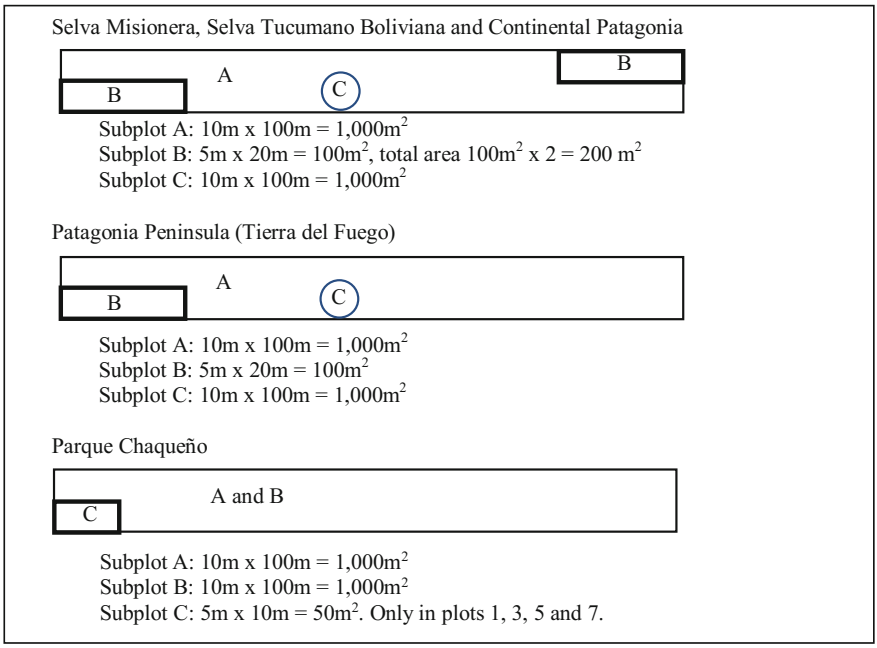

Fig. 6.5 Subplot by type of sampling unit and its dimensions

6.2 Land Use and Forest Resources

6.2.1 Classification of Land and Forests

The outputs are mainly cartographic products. There is less information associated with the structure and composition of forests (Informe Nacional, 2007).

6.2.1.1 General Land Classification

The classification used and definitions adopted were from the FRA 2000 (FAO 2001) definitions (Table 6.5).

6.2.1.2 Forest Classifications by Forest Regions and Sub-regions

The country is divided in six forest regions (Level 1) which are classified into smaller sub-regions (Level 2); nineteen sub-regions. The total number of tree species for which data were collected during the national forest inventory was 361, of which only 10 species were coniferous. Table 6.6 shows the results corresponding to the areas identified for Level 1 and Level 2, and the percentage of the total.

Table 6.5 Definitions used in the forest cover classification

Land cover	Definition
Forest land	Land with tree crown cover of more than 20 % and higher than 10 ha. The trees should be able to reach a minimum height of 7 m at maturity in situ. It may consist either of closed forest formations where trees of various storey and undergrowth cover much ground
Other forest land	Land where: (a) crown cover is greater than 5 % and less than 20 %, with trees able to reach a height of 7 m at maturity in situ; (b) crown cover is more than 20 % but the trees are not able to reach a height of 7 m at maturity in situ; (c) land where shrub cover is more than 20 %
Agroforestry land	Transition zone between forest and agricultural environment. They are a set of patchy rural forests in mixed with agricultural crops
Rural forest	Composed of the remnants of native forest in an agricultural landscape with less than 1000 ha in area. This class is not in the FRA 2000 documents
Other land	Land not classified as forest or other wooded land. Includes agricultural land, meadows and pastures, built-on areas, barren land, and others

Table 6.6 Total level 1 and level 2 native forest area

Level 1			Level 2		
Name	Area (km^2)	Area (%)	Name	Area (km^2)	%
Selva Misionera	9147	2.8	Selva del Parque Iguazú	402	0.12
			Selva de cobertura cerrada	1119	0.35
			Selva de cobertura variable	6865	2.12
			Selva de cobertura abierta	761	0.23
Selva Tucumano Boliviana	37,329	11.5	Selva de transición	17,904	5.52
			Selva montana	11,699	3.61
			Bosque montano	7726	2.38
Parque Chaqueño	212,784	65.6	Quebrachal	161,102	49.67
			Colonizadoras	24,336	7.50
			Bosque alto	25,508	7.86
			Bosque ribereño	1838	0.57
Monte	0.0	0.0	No sampled	0.0	0.0
Espinal	46,115	14.2	Bosque de Caldén	29,714	9.16
			Bosque de Ñandubay	16,401	14.2
Bosque Andino Patagónico	18,952	5.8	Bosque de Lenga	10,199	3.14
			Bosque de Coihue	1907	0.59
			Bosque mixto	5083	1.57
			Bosque de Ciprés	945	0.29
			Bosque de Araucaria	779	0.24
			Bosque de Roble pellín	39	0.01
Total	324,327	100.00	–	–	100.00

Table 6.7 Mean values of number of trees (N) per hectare, basal area (living trees) and volume (Gross Overbark)

Region	Level 2	Trees density (Stems per ha)	Basal area (m^2/ha)	Volume (m^3/ha)	Total volume (1000 m^3)
Selva Misionera	Selva protegida del Parque Iguazú	301	25.0	214	8603
	Selva de cobertura cerrada	334	24.3	211	23,611
	Selva de cobertura variable	296	19.0	163	111,900
	Selva de cobertura abierta	299	17.1	147	11,187
Selva Tucumano Boliviana	Selva de transición	344	15.3	98	175,459
	Selva Montana	297	18.2	121	141,558
	Bosque Montano	345	15.1	77	59,490
Parque Chaqueño	Quebrachal	183	6.9	31	499,416
	Bosque alto	151	6.6	31	79,075
	Bosque ribereño	98	7.5	34	6249
	Colonizadores	148	9.1	48	116,813
Bosque Andino Patagónico	Bosque de Lenga	381	41.2	487	496,691
	Bosque de Ciprés	548	22.0	130	12,285
	Bosque de Coihue	249	44.0	606	115,564
	Bosque Mixto	390	45.1	493	250,592
	Bosque de Araucaria	291	55.0	429	33,419
	Bosque de Roble pellín	288	27.3	182	710

6.2.2 Wood Resources and Their Use

Estimates of standing stock are based on the sample tree measurements on the plots. They are calculated as volume of stem wood over bark of living trees. Table 6.7 shows the mean values of number of trees, basal area and volume per hectare, estimated for Level 1 and Level 2.

References

FAO (2001) Global forest resources assessment 2000. Main report. FAO forestry paper 140. FAO, Rome, Italy

Primer Inventario Nacional de Bosques Nativos. Informe Nacional (2007) Secretaría de Ambiente y Desarrollo Sustentable. República Argentina

Primer Inventario Nacional de Bosques Nativos. Informe Regional Espinal Segunda Etapa (2007) Secretaría de Ambiente y Desarrollo Sustentable. República Argentina
Primer Inventario Nacional de Bosques Nativos. Informe Regional Bosque Andino Patagónico (2007) Secretaría de Ambiente y Desarrollo Sustentable. República Argentina
Primer Inventario Nacional de Bosques Nativos. Informe Regional Parque Chaqueño (2007) Secretaría de Ambiente y Desarrollo Sustentable. República Argentina
Primer Inventario Nacional de Bosques Nativos. Informe Regional Selva Misionera (2007) Secretaría de Ambiente y Desarrollo Sustentable. República Argentina
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