REPORT ON BAMBOO THEMATIC STUDY IN THE FRAMEWORK OF FAO FRA 2005 FOR LATIN AMERICA (BRAZIL, CHILE, ECUADOR, MÉXICO, PERÚ)

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Introduction

This report is a synthesis and an analysis of information contained in the national reports on bamboo resources for Latin American countries. These reports were presented as part of the FAO Forest Resources Assessment Program, FRA 2005.

Information analysis focused onto the five Latin American countries who participate in the Global Bamboo Thematic Study and Workshop, taking place in may 2005 in Beijing and organized by FAO and INBAR. Participating countries for this event are: Ecuador, Peru, Chile, Brazil, and Mexico.

In the first part of the report, the state of information is analyzed for Ecuador, Chile and Peru. This analysis is based on the presented national reports and on information requirements for bamboo, as proposed in the "Global Bamboo Resources Assessment Update 2005. This document estimates how available databases satisfy formulated queries, and fields of priority are detected to define strategies that improve the current state of information. The Brazil report was not available at the moment the present report was elaborated, and a preliminary report was available for Mexico. Nonetheless, the bibliographical review and consultation to secondary sources do provide information on bamboo resources in these countries.

Part two of the report presents complementary information related to bamboo resources in Latin America, based on bibliography and internet searches, and on consultation to experts. This review provides background information on regional bamboo resources, for various fields of interest: biodiversity, stocks, main uses, research, development and transfer projects geared towards value adding and based on bamboo resources.

In the later part, the study delivers its conclusions and recommendations so that improvement strategies can be defined for the level of information associated to bamboo resources in Latin America.

2. Summary of the Bamboo Thematic Study (BTS)

2.1 General Analysis for the State of Information

Revision of Ecuador, Peru and Chile reports shows that delivered information corresponds to the main sources of information, and to consultations to experts from the respective countries. By analyzing all three reports, it is therefore possible to quantify how the requirements presented in GBFRA 2005 forms, are satisfied by the state of information on bamboo resources in these countries. As well, fields of quantitative and qualitative improvement are identified.

Table 1 shows the proportion of GBFRA queries that received answers, per field and per country.

Table 1

Analysis of Information state in relation to GBRA requirements					
	Number of Consultations	**% Responded Consultations**	**Ecuador**	**Peru**	**Chile**
Extent of Bamboos	6	61	4	5	2
Ownership of Bamboo	6	11	2	0	0
Characteristics of Bamboo	6	72	4	5	4
Bamboo Growing Stock	3	22	0	1	1
Bamboo Biomass Stock	9	19	4	0	1
Diversity of Bamboo	5	100	5	5	5
Bamboo Removal	6	44	3	3	2
Value of Wod Removal	6	39	3	2	2
Non Wood Bamboo Product Removal	27	0	0	0	0
Value of Non Wood Bamboo Product	15	0	0	0	0
List of Bamboo sp	1	100	1	1	1
List of Main pest	1	100	1	1	1
Total	91		27	23	19
% Responded	**25**		**30**	**25**	**21**

The proportion of answers for all three countries reaches 25% of the 91 formulated queries. Nonetheless, an important fact to outline is that only 2 of the 11 presented topics do not present available information. These are topics related to non timber bamboo products, be it harvest or value generation. Both fields concentrate a large proportion of the formulated questions (46%), for queries related to 6 products and three periods of time. The absence of information existing in relation to these fields, explains the total low percentage (25%) of answers.

On a quantitative standpoint, both fields related to non timber bamboo products present the lowest level of information, but the latter does not necessarily imply that such fields require first priority on data collecting. A low proportion of answers corresponds to the absence of information, but also quite often to an absence or limited scale of activity, and to informal

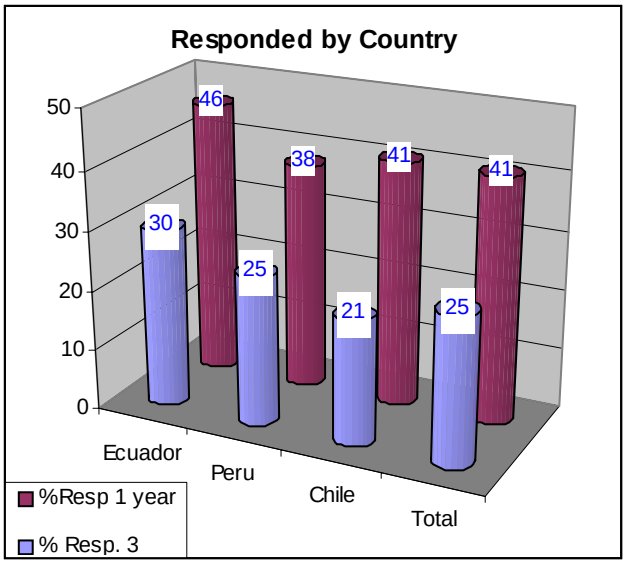
markets. These scales of handmade and non-generalized production, probably do not justify focusing efforts onto systematically collecting data.

There are two fields that appear with a low level of information and with different assessment methods : Growing Stock and Biomass Stock. Given its commercial or non commercial application to all bamboo cover areas, generating reliable data for such variables may be considered of prime importance. In this case, these variables would be particularly relevant to generate environmental accounts, to develop estimates of potential carbon sequestration, to identify areas of relevant standing stocks for investments or rural development projects, etc.

Land ownership is again another field showing low levels of information. It is a relevant subject in that it allows large scale planning and is necessary for projections on resources tenure. Incorporating the resource to geographic information systems would allow matching the corresponding information with lands in national parks, in forest reserves, in indigenous territories, belonging to forest companies, to small, medium or large landowners, etc. This would deliver a more complete vision of resource tenure. In the case of Chile, where maps are integrated to a GIS, matching with digitalized ownership structures such as the Sistema Nacional de Áreas Silvestres Protegidas del Estado (SNASPE, the National State System of Protected Forest Areas), is feasible.

The low level of answers (25%) results from the fact that, although all three countries do have information for most of searched variables, such information presents as a static nature, for only one period. In most queries, dynamic information for 3 periods is demanded. In the case of Chile, systematic studies on bamboo were initiated in 1999, consequently a period of information already exists. For Ecuador and Peru, previous information on bamboo cover areas is available, and some data from 2 time periods is mentioned, but employed methods prevent such data from being homologated. However, worthy of note is the fact that all three countries do have information for most variables – although only for a recent year – which does represent a basis for following monitoring systems.

By restricting the analysis presented in table 1, and by considering only one period of time for information totals, the proportion of answers per country and per topic does considerably increase and reaches a global percentage for answers of 41% (Graph 1)



Graph 1. Percentage of answers for 1 and 3 periods of evaluation

2.2 Summary of information, per subject and per country

The following tables show a summary of delivered information for the three analyzed countries, and for the main variables. Sources and associated methods are mentioned further in the document.

Table 2

	Extent of Bamboo Forest (1000 ha)		
	1990	**2000**	**2005**
Ecuador			
Monopodial bamboo area		4,28	5
Sympodial bamboo area		5	5
Total		**9,28**	**10**
Peru			
Monopodial bamboo area			
Sympodial bamboo area	3998	7211	
Total	**3998**	**7211**	
Chile			
Monopodial bamboo area			
Sympodial bamboo area		900	
Total		**900**	

Ecuador data corresponds to 2003, and a projection was done for 2005. Information was generated from updating of a 1985 inventory, which tool place in the coastal area. Monopodial bamboos are introduced species, an what appear under “sympodial” corresponds to the main commercial species, *Guadua angustifolia*. The 1985 inventory determined a 14.619ha stock for *Guadua angustifolia*. In 1999 the ECU/99/001 Project contracted consultants to update this inventory and determined an area of 10.880 ha. The different sources and specialists in Ecuador agree to the fact that Guadua areas have been

consistently decreasing. (Informe Técnico Final – "contribución al ProDOC" , Proyecto ECU/99/001, jun 99.)

Peru information was generated from 1995 Peruvian maps, based on LandSat images, and where forest classification units were delimited. The images utilized for vegetation classification were 2000 Landsat TM, in photographic printed format, thus obtaining forest maps and the corresponding explicative statements.

The 1995 map defines only a classification for forests that include bamboo, the so-called "*Guadua sp sprouts"*. It is worth noting how their appearance makes identification of such forests quite easy to delineate through satellite images. The 2000 forest map defines 7 classifications for bamboo-containing forests. Notable discrepancies in area correspond to the level of resolution used for the elaboration of 1995 and 2000 maps.

In the case of Chile, the "Catastro Nacional Vegetacional (National Vegetation Inventory) is a prospective large-scale study for areas of productive potential (land use map, and GIS). It serves as a basis for stratification. Satellites images are used as auxiliary material. Sample plots will be carried out in the field and field/satellite image relationships are being developed. According to the inventory, bamboo species are present in six dominance levels. The first three levels are considered with productive potential.

Table 3

	Characteristics of Bamboo Forest (1000 ha)		
	1990	**2000**	**2005**
Ecuador			
Natural bamboo forest	14,62*	24,9*	5
Plantation		0,249	5
Total	**14,62***	**25,26***	**10**
Peru			
Natural bamboo forest			
Plantation	3998	7211	
Total	**3998**	**7211**	
Chile			
Natural bamboo forest		900	
Plantation			
Total		**900**	
Mexico			
Natural bamboo forest	S/I		
Plantation		1,94	
Total			

Concerning Ecuador, the 1985 inventory presents14.000 ha of Guadua, while thirteen years later the project "Evaluation of Bamboo in Latin America" estimates a stock of 24.000 ha. These numbers appear literally contradictory, and it is guessed that they result from

methodological differences. Discrepancies with Londoño can be explained by the fact that the 1985 inventory was conducted exclusively on the coastal region, and did not consider the eastern side of the Andes Mountains nor the Inter Andean Valleys.

However, it is indeed valid to conclude that this species area of occupation has been gradually decreasing, and it is believed that current natural formations remain under 5,000ha in size.

Table 4

	Bamboo Growing Stock Total weight (tons)		
	1990	2000	2005
Ecuador			
Bamboo Growing Stock			
Peru			
Bamboo Growing Stock		151,9	
Chile			
Bamboo Growing Stock		26,65	

In Peru, the 1995 forest map includes volume data. The 2000 area classification has a higher resolution but volumes are not included. This classification defines 8 forest types that include bamboo.

For the case of *Chusquea culeou* in Chile with Dominance Type I and II, the stock of dry standing culms is estimated to 26 million tones distributed over 180.160 ha. Minimum accepted diameters in the market are variable according to the product, but there is a demand for diameters as small as 1 cm.

Table 5

	Bamboo Biomass Stock million metric ton dry weight		
	1990	2000	2005
Ecuador			
Above-ground biomass of Bamboo		3,14	0,62
Below-ground biomass of Bamboo		0,88	0,18
Total		**4,02**	**0,8**
Peru			
Above-ground biomass of Bamboo			
Below-ground biomass of Bamboo			
Total			
Chile			
Above-ground biomass of Bamboo		44,4	
Below-ground biomass of Bamboo			
Total			

The estimates for Ecuador resources are derived from an application of the following relation: dry weight for the above-ground part of the plant corresponds to 72% of the plant total weight (culm 47%, branches and foliage 25%), rhizomes and roots represent 28%.

According to trials established in Chile, 40% of the above–ground biomass correspond to branches and foliage, and 60% to the culms. These percentages were applied to all of the occurrences of *Chusquea culeou* in Dominance Types I and II.

Table 6

Diversity of bamboo species	Ecuador	Peru	Chile	Brazil	Mexico
Native Bamboo genera	6	8	1	17	8
Native Bamboo species	42	36	11	135	39
Introduced Bamboo species	5	N.I.	0	N.I.	N.I.
Critically endangered Bamboo species	0	0	0	N.I.	0
Endangered Bamboo species	0	0	0	N.I.	3
Vulnerable Bamboo species	0	0	0	N.I.	0

Concerning Peru, the country report mentions only 8 species: 6 from the Genus *Guadua*, 1 from the genus Bambusa, and 1 from the genus Elythrostachys (Source: Project "Manejo y Aprovechamiento de la Paca", Paca management and use). This information clearly differs from that of the project "Evaluation of Bamboo Resources in Latin America" (Londoño, 1998) which in Peru recognizes 8 genera and 36 species and evaluates this country as one of those with most biodiversity in the region. This data is the one considered by the present report, for the Diversity table.

Table 7

	Bamboo wood Removal		
	1990	2000	2005
Ecuador (ton)	35.000	36.000	53.000
Peru (culms)	40.000	130.082	331.568
Chile (ton)		5.600	12.500

Chile information comes from a 2000 market-size study, operated through interviews to the main producers and traders. The estimates were 4.5 million culms in annual transactions and, through growth projections for kiwi, vineyards and incorporation of new users such as forest companies, or 10 million canes in 2005.

Ecuador information is derived from historical volumes, as Guadua cane extraction authorizations issued by the Ministry of the Environment.

Peru information corresponds to the number of transported canes, information obtained from the Forest Transport Waybills delivered by the Instituto Nacional de Recursos Naturales (Natural Resources National Institute). 2005 projections were done based on a data series from the year 1999.

Table 8

	Value of Wood Removal, million USD		
	1990	2000	2005
Ecuador (ton)	1,33	1,23	3,07
Peru (culms)		0,51	4,23
Chile (ton)		1,00	2,90

The figures used to estimate the value of removed products, were FOB prices in Peru and internal market prices in Chile. Chilean prices come from surveys to producers and are projected for 2005 with a 30% increase corresponding to an increase in standing bamboo prices. This is but one impact of the bamboo project and of flowering-related scarcity of the resource, in the productive areas. The figures utilized for Ecuador are FOB values for exportations and on-site harvest prices for the internal market.

Table 9

	Main Reported Uses				
Reported Uses	Ecuador	Peru	Chile	Mexico	Brazil
Handicrafts	x	x		x	x
Mining			x		
Agriculture			x		
Construction	x	x		x	x
Furniture			x	x	
Pulp and Paper					x
Tobacco Industries			x		
Forestry					
Objects of daily use					x
Panels y floors	x	x			
Curtains		x			
Ornamental use				x	x

Table 10

List of Main Pest species			
Order – Family	Insect	Bamboo sp.	Damage
Coleoptera Cerambycidae	*Platynocera virescens*	*Ch. Culeou- Ch. Quila*	Live wood
Coleoptera- Anobiidae	*Hadrobregnus sp.*	*Ch culeou*	Dead wood
Coleoptera Bostrichidae	*Dicordylus marmoratus*	*Ch culeou*	Dead wood
Coleoptera Bostrichidae	*Dexicrates robustus*	*Ch culeou*	Dead wood
Coleoptera Bostrichidae	*Lyctus sp.*	*Ch culeou*	Dead wood
Coleoptera Bostrichidae	*Micrapate scabrata*	*Ch culeou*	Dead wood
Coleoptera Bostrichidae	*Neoterious mystax*	*Ch culeou*	Dead wood
Scarabeidae	*Podishnus agenor*	*Guadua angustifolia*	
Curculionidae	*Parisoschoenus sp*	*Guadua angustifolia*	
Formicidae	*Atta cephalotes*	*Guadua angustifolia*	
Formicidae	*Crematogoster sp*	*Guadua angustifolia*	
	Mielobia sp.	*Guadua angustifolia*	
	Dinoderus minutes	*Dendrocalamus sp. bambusa sp, Guadua sp*	
	Kalotermis brevis	*Guadua sp.*	
	Trichoderma sp.	*Guadua sp.*	
	Aspergillus sp.	*Guadua sp.*	

2.3 Experiences in Remote Sensing Applications and Geographic Information Systems, for Bamboo Resources in the Region.

Brazil

Information on bamboo cover areas in Brazil still is a problem to solve. However, it is known that the Amazonas and Acre States contain the largest areas with this resource. In 1993, the RADAM project used information such as satellite images, aerial photos and field surveys, and estimated the bamboo-dominated area to approximately 18 million hectares in the Amazone region. Researcher Ximena Londoño (personal contact) reported that some of the areas she visited in these forests are not dominated by bamboo, the later being simply another element of the jungle. Nonetheless, the existence of climbing bamboos – reaching the higher strata of the canopy – produces a wrong interpretation of satellite images and appears as bamboo-dominated pockets.

Experiences in Peru

In the Madre de Dios Department of Peruvian wet tropical jungle, Geographic Information Systems we utilized along with conventional linear transects, in order to survey the distribution and abundance of *Guadua Angustifolia* – locally known as Marona – in a 200km^2 study area. This project was carried out with government and non-government organization resources.

In countries like Colombia, Ecuador, Costa Rica, *Guadua angustiofolia* plantations or natural polygons have been successfully managed, although in very few cases was this in lowland wet tropical forest areas.

The study developed between June and September 2001 generated:

- Marona distribution and abundance maps, using satellite imaging and GIS, special analysis, and conventional identification techniques.
- Determination of Marona distribution, as a relation to specific forest types or to human or natural disturbances.
- Determination of coppice characteristics, in terms of amounts of live culms, DBH (diameter at breast height), amounts of dry or dead culms, amounts of recently germinated culms, light levels, and soil water conditions.
- Determination of growth rates and above-ground biomass

The Marona distribution area is restricted to flooded forest habitat, where spatial distribution is strongly associated to fallen tree gaps. Light conditions, together with clay predominance in soils, are the main factors affecting its distribution.

According to a spatial analysis based on reflectivity information on 222 plots, there are 63.7 km^2 with a high probability of Marona presence, which represents 32% of the study area. However, the characteristics of this species reflectivity and on its surrounding vegetation are not clearly differentiated.

Independently from the potential area of Marona occurrence, GIS and special analysis failed to provide reliable estimates due to coppice small sizes and to the insufficient separation or spectral superposition of the different types of vegetation. Typical 30cm spatial resolution plots determined the format used for Landsat images.

Results determined an average density of 24 coppices per ha and 5.7culms per coppice, or 137 culms per ha. Daily height growth of 16cm was detected. Results suggest that Marona is currently at the recovery stage of a flowering process, which has been occurring the last 5 years.

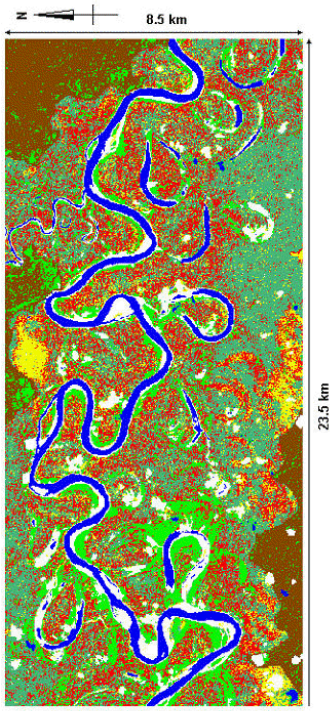


Fig. 2. False colour composite image of a supervised classification analysis showing the extent of various reflectance classes across the study area. Red = floodplain forest with high likelihood of *Marona*; Dark green = floodplain forest with low likelihood of *Marona*; Blue = water bodies and cloud shadows; White = beaches, short grass and clouds; Light green = forest of high reflectance dominated by secondary vegetation, *G. weberbaueri*, *G. sarcocarpa* or bambusoids; Brown = terra firme forest; Yellow = palm dominated swamp forest. (http://www.geocities.com/marona_mdd/mar_results.htm)

Chile

The native bamboo cover and stock study was conducted with sampling methods. The stratification basis used was the Catastro y Evaluación de los Recursos Vegetacionales Nativos de Chile (Chilean Native Vegetation Inventory). A two-stage sampling design was applied. Stage 1 stratification used satellite imaging, while stage 2 was based on estimates and field survey of certain sampling plots.

Preliminary information indicates presence of the genera Chusquea at various levels of cover and dominance, on approximately 3.5 million hectares. However, in only 900.000 ha were these species present within the first three dominant stories (out of 6 levels, as defined by the Catastro Vegetacional). These three stories are the potentially productive ones.

Species Chusquea culeou (colihue) y Chusquea quila (quila), concentrate over 80% of Chusquea cover area in Chile. 80% of the potentially productive resources are located between regions IX and XI.

Chusquea culeou stocks within the main two dominance levels, reach 26 million tons of standing dry material, if only culms are considered.

Feeding a Geographic Information System allows generating thematic maps of high interest for a specific resource such as Bamboo (Ej. Slope range, a legally and environmentally relevant factor, or distance to roads, an operatively important factor).

The following diagram shows how bamboo resources in Chile have been addressed by three forest evaluation tools of the country.

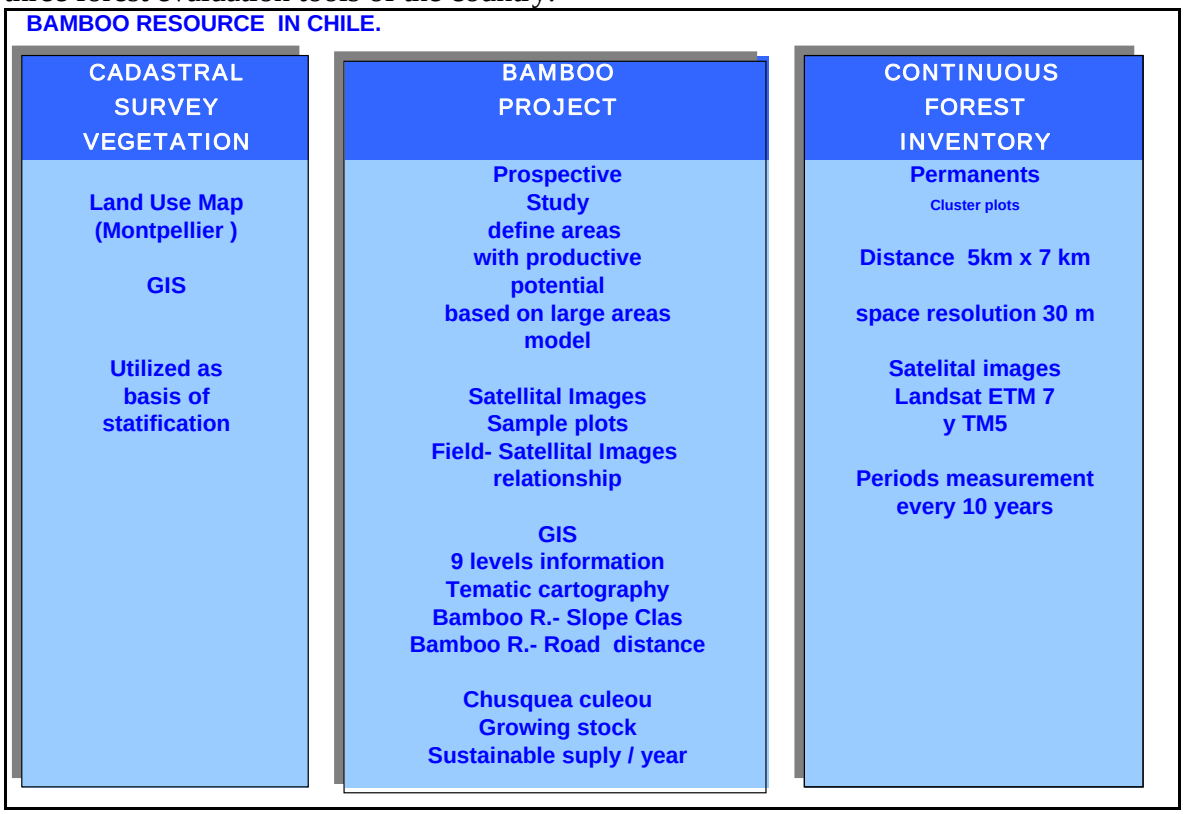


Fig 3

The Catastro Vegetacional Nacional (National Vegetation Inventory) delivered a first stratification of the resource, cover information, and some digitalized mapping. The Bamboo R&D utilized such information in addition to new satellite imaging and field data, thus adding studies on standing stocks for the main species. Bamboo is now added to the

list of inventories species in the permanent plots of the Inventario Forestal Continuo (Continuous Forest Inventory). These plots have been set in 2 of the 3 main native forest regions of the country, in order to permit constant monitoring of the resource.

Ecuador

In Ecuador a study determined potential areas for *Guadua angustifolia* plantations. Silvics were defined for the species. By comparing these requirements with various GIS information levels, areas were identified and mapped, susceptible to be forested with this species. Such GIS applications are highly interesting for countries like Ecuador or Colombia, which extensively use the resource and face the need to increase their bamboo stocks. The following figure is a map defining forest areas, as incorporated in the Ecuador country report.

The following criteria were used, based on the ideal growing conditions for *Guadua*.

- Altitude between 400 and 1800 meters above sea level
- Temperatures between 18 and 28 °C
- Annual precipitation over 1200 mm

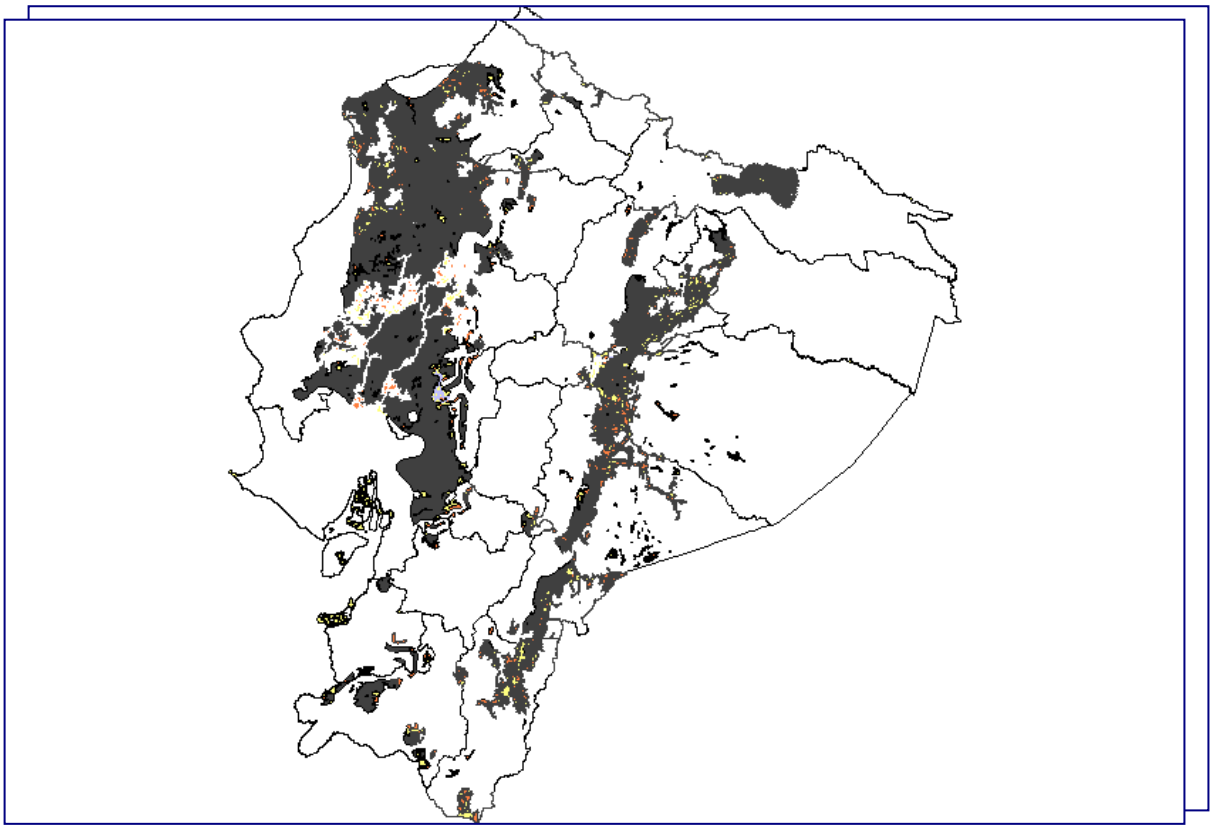


Figure 4

Colombia. *Guadua angustifolia* stock inventories in Colombia's "coffee axis"

Available aerial photos of the zone and systematic sampling were utilized to estimate the Guadua pockets percentage of cover (mapping minimum area 0.3 ha). The result was 3.9% with an error of 10.7%. This is equivalent to 40.357 ha of cover in a total study area of 1.0290524 ha (Morales D., Kleinn C., 2004). The inventory was conducted in 2002.

A field inventory was also carried out in order to obtain information on the number of stems, diameter at breast height for each stem, health conditions and other features.

Maturity of guadua stems was found at 3.7% regeneration, 18.6% mature guadua, and 8.1% dead guadua. Average stem density was 6,940, with an average diameter of 10.8cm. the total average culm length reached 19m, the apparent volume was 1,053 m^3/ha, and above-ground biomass was 81.5 ton/ha.

3. Bamboo Resources in the Region – Revision of Complementing Sources of Information

3.1 Bamboo Resources: Stocks and Biodiversity

Within the American continent, native bamboos exist in all countries but Canada (Londoño, 2002).

Bamboo distribution in Latin America is located in latitudes ranging from 27° North (*Otate acuminata* in Northwestern Mexico), to 47° South in Chile (*Chusquea coleou*) which also happens to be the southern limit of natural Bamboo distribution in the world. The equatorial Andes also witness the highest known presence of these species (4300m), with a formation known as Páramo.

In America there are 41 genera and 451 species, which represents almost half of the world's bamboo diversity.

The Southern region of Bahía in Brazil, also known as "Mata Littoranea", is the area presenting the highest bamboo species diversity in America. It contains 22 genera, or 48% of all genera present in this continent.

On a taxonomical point of view, bamboos belong to the Poacae family and to the bambusoideae subfamily, and they can be divided in two main tribes:

1) Herbaceous bamboos or Olyrodae, and
2) Woody bamboos or Bambusodae

Table 11

	N° of present genera	N° of present species	Main areas of biodiversity concentration
Herbaceous bamboos	**20**	**106**	**Bahía (Eastern Brazil) Amapa (Northern Brazil and Guayanas) Choco (Panama and Colombia)**
Woody bamboos	**21**	**345**	**Cordillera de Los Andes (Andes Mountainrange) 87% of sps.**
Total in America	**41**	**451**	**Southern Bahía 22 genera (48%)**

Source: Clark 2001, Londoño 1990, Sodestrom, Judziewicz & Clark, 1988

Woody bamboo species diversity increases with elevation, the highest species diversity being recorded in elevation ranges of 2000 to 3000m above sea level. Under 1000m the following genera dominate: *Artrostylidium, Guadua,* and *Rhipidocladum*. Above 3000m can only be found genera *Chusquea, Neurolepis* and *Aulonemia*.

America provides nearly 95% of the world's genus diversity for herbaceous bamboos. These bamboos usually grow in the herbaceous story of tropical and subtropical jungle. (29° Latitude North to 34° Latitude South), from Mexico to Argentina. Their main value on a pragmatic point of view, is as ornamental plants.

Genera Olyra, Pariana and Cryptochloa present the widest range of natural distribution, and the largest number of species. Within the Bambuseae tribe – woody bamboos – 9 subtribes are recognized, 5 of which in the American continent. Subtribes Artrostylidinae, Chusquinae, Guaduinae and Neurolepidinae are exclusive of the American continent. The subtribe Arundinariinae is present both in America and in other continents.

Taxonomic studies of American bamboos have advanced only in the last 50 years. Works by McClure, Calderón, Sodestrom, Ellis and more recently Clark, Davise, Judziewicz, Londoño and Zuloaga, contributed to clarifying the limits of tribes under which bamboos of the American continent are grouped.

The highest species diversity is found in Brazil , Colombia, Venezuela and Ecuador, as shown in graph **N**°2 (Londoño 1998).

Graph N°2 shows the quantity of species and genera present in each country of the region. Brazil is the country with most bamboo biodiversity, followed by Colombia, Venezuela and Ecuador.

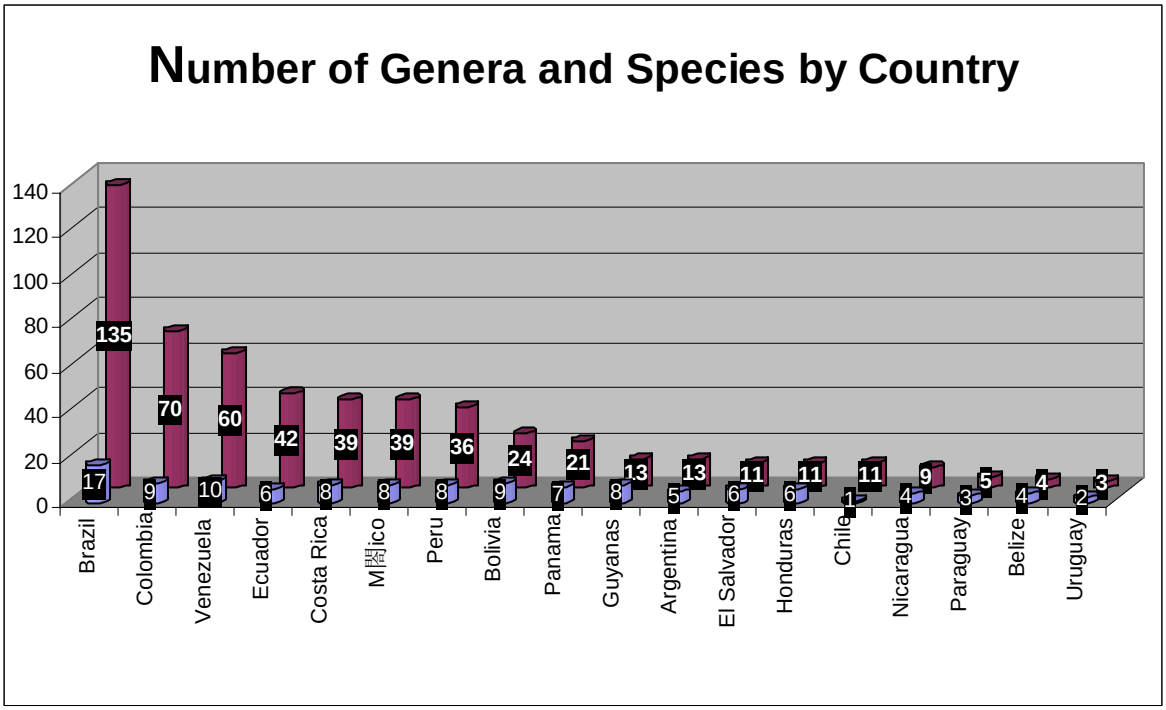


Figure 5. Source. Londoño , 1998 Evaluation of Bamboo Resources in Latin America

It is believed that the different bamboo species in Latin America cover approximately 11 million hectares (not accounting for natural areas in the Amazon region), and that 11% of the area occupied by Andean forests do contain bamboo species.

Nevertheless, recent estimates (Judziewiz et al.,. 1999) calculate that in the single Amazon region, bamboo is a dominant species on 18.000.000 ha.

Colombia, country which presents a long tradition in *Guadua angustifolia* use, a continuous decrease in guadua stands has been experienced. Current estimates are of 31.352ha of natural guadua stands, and 4892 for planted guadua.(Castaño F., Moreno R., 1992).

Costa Rica, Colombia, Brazil, Venezuela and Ecuador have initiated several forestation programs based on bamboo, and especially from the genus *Guadua*. El Niño natural phenomenon in Ecuador, is a reminder of the need to reforest riparian areas with bamboo species.

3.2 Uses

Historical and Traditional Uses

According to Ecuador architect Jorge Morán, no less than 50 million persons in Latin America use bamboo products on a daily manner, for traditional or modern uses, from handicraft to complex modern buildings.

Since the pre-Columbian era, bamboo has been used by several cultures in Latin America.

Massive or Industrial Uses

Pulp and Paper
The foremost industrial experience for bamboo massive utilization in Latin America, is the company Itapagé from Marañao State, Brazil. This company has an installed capacity of 72.000 tons / year for bamboo-based paper production, and a medium-term increase of 144.000 tons / year is projected. Production is aimed at packaging paper and relies on over 25 years of experience. Supply is based on a 100.000ha stock of cultures, and constitutes the largest commercial bamboo plantation in the world. With such an extensive area, the company enjoys 200 years worth of guaranteed supply (Dr. Antonio Beraldo, personal communication)

Currently, in Brazil, introduced Asian bamboos play the main economical role, and especially those from genera *Bambusa* and *Dendrocalamus*. Of the 17 genera native from the country, only 5 are considered with potential uses: *Actinopladum, Chusquea, Guadua*, and *Merostachys.*

Social housing
Building social housing is one of the most relevant bamboo uses in Latin America. In the city of Guayaquil - Ecuador, 1 million inhabitants – 50% of the population lives in houses made of bamboo. Such houses have also been massively used in Colombia, and during the last few years Costa Rica has adopted a strategy to generalize social housing buildings made of bamboo. The Foundation Hogar de Cristo in Ecuador has built over 100.000 bamboo social houses in 33 years, and 75 houses are daily delivered to families in need.

In Costa Rica and Colombia, programs have also been implemented to promote rural houses made of bamboo.

Architecture
During the last years, bamboo – especially the species *Guadua angustifolia* – has established itself as an interesting structural and decorative material for modern architecture. Architects in Colombia, Ecuador and Bolivia, have been proposing innovating buildings based on bamboo, and have achieved the acceptation of *Guadua angustifolia* as construction material, including in countries with such strict regulations as Germany. Moreover, natural catastrophes such as the earthquake of Armenia, Colombia, have validated the anti-seismic characteristics of bamboo as a structural material.

Panels and Flooring
The bamboo panels and flooring industry has been developing in the region during the last few years. This year, a panel plant has initiated production in the department of Quindío, Colombia.

3.3 R&D and technology transfer projects, aiming at bamboo resources value adding

Brazil

The potential of bamboo as industrial raw material has been widely studied in Brazil, underlining the development technologies for the improvement of pulp and paper productive processes, which have been applied at industrial level for several years.

In the Campiña State University of Sao Paulo, the efforts have established a bambusetum and various productive technology projects.. These include production of panels and structures of bamboo and cement, laminated bamboo panels, bamboo carbon trials, production of starch and ethanol.(Beraldo A. 2005).

In the Universidad Católica de Río de Janeiro, a field of investigation of bamboo-based design has been developing.

Ecuador

Establishing the INBAR Latin American Regional Office, has been contributing to the generation of the main R&D and transfer experiences in the country. The following table shows the structure of the projects sponsored by INBAR in Ecuador, their objectives, and implementation periods.

Table 12. INBAR PROJECTS IN ECUADOR

PROJECT	TITLE	OBJECTIVES	INTERVENTIÓN	DURATIÓN and AMOUNTS
FECD-INBAR (Santo Domingo)	Complement planting and *Guadua* community management in western Pichincha		Co-funding And technical assistance	3 years, starting in November 2002 US$ 614.065 (INBAR: US$ 85.915)
PRODEPINE (Tena)	Wawa Sumaco reforestation sub project	**1.** Improving socio-economic and environmental conditions of the Wawa Sumaco Community members, through activities of Guadua reforestation in the Pingullo river watershed. **2.** Improving and using the areas of Guadua natural regeneration in Wawa Sumaco and in surrounding communities. **3.** To motivate and develop reforestation of deforested areas at least in the Pingullo river watershed (7 km).	INBAR technical assistance (Talag project, executed by ECUABAMBU)	6 months, starting in September 2003 Talag: US$ 13.250 Wawa Sumaco: US$ 9.350
European Union	Bamboo pilot	**1.** To foment economical	Execution	3 years,

	project. Development of a participative model, sustainable and replicable, using bamboo in order to mitigate rural poverty in Andean countries	development of the project communities, through bamboo culture, management, use, transformation and trading, under principles of sustainability and equity. **2.** To guarantee that families and organizations - in the project community area - benefit from the legitimate capacities and structures, for the efficient performance of their role in bamboo resources management, and accordingly to their own vision of development **3.** To guarantee the ability of technicians and other members of supporting institutions, local organizations, and communities, to follow the processes until appropriating bamboo production, organization and trading activities, for target groups. **4.** To validate, systematize, and communicate the replicable experiences and results of bamboo-based rural development, in Ecuador and in the Andean region	Members: CEDERENA ECUABAMBU FAU Hogar de Cristo	starting on may 1st, 2003 EUR 1.000.000

Peru

In Peru, besides initiatives related to resources quantification and classification, several experiences have been developed in order to generate value on bamboo. During the 1980's several studies were conducted bamboo for pulping and silvicultura, in a private body (for *Guadua angustifolia*). Universities, and especially the Universidad Nacional Agraria La Molina, later on conducted various studies on resources technological classification, carbon analysis, activation trials, and studies on mechanical properties in panels.

The future steps for Peru consist in promoting bamboo consumption and constructions, in updating databases for natural areas, for production, for imports, and in elaborating business plans.

Chile

The case of Chile is specific because it is the only country to have already developed R&D and transfer programs, based on solid bamboo species.

A flow chart in Fig 6 shows the strategy adopted to incorporate value to bamboo resources in Chile.

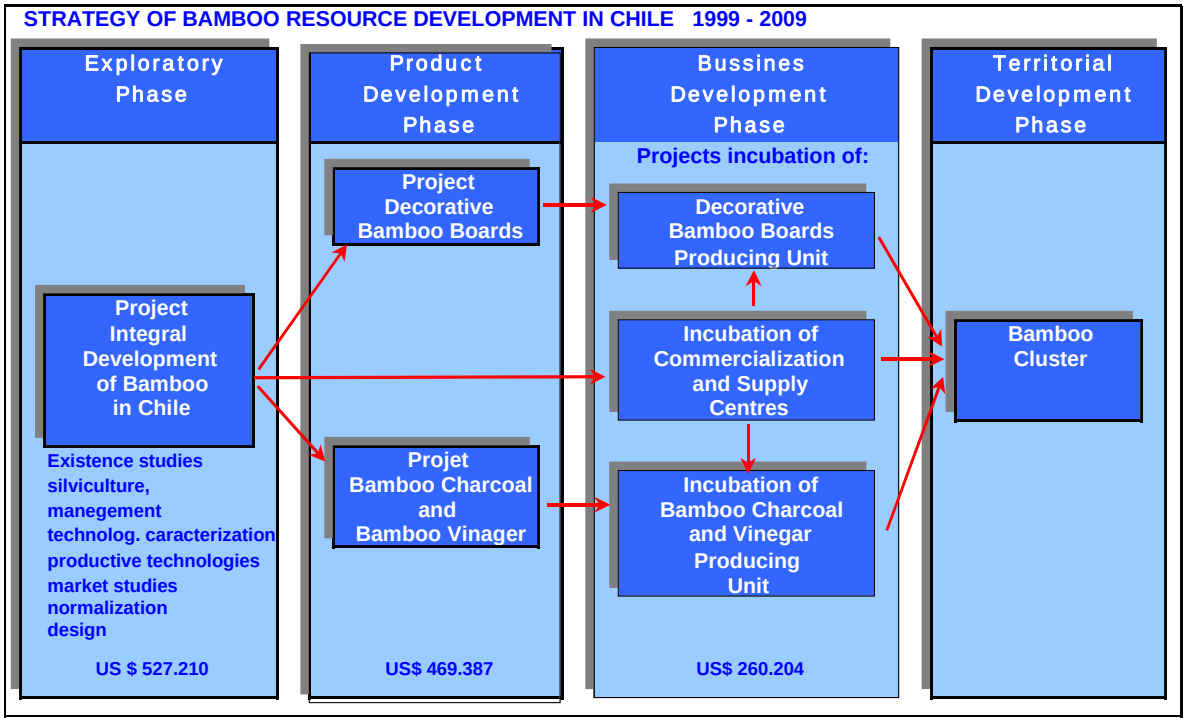


Figure 6

Traditionally, species from genera Chusquea, present in Chile, have been seen as undesirable species, and in best cases have been used with very little added value.

In 1999, Fundación Chile associated to the Universidad Austral (Southern University) and Instituto Forestal (Forestry Research Institute) initiated a preliminary project funded by the Comisión Nacional de Ciencia y Tecnológía (National Science and Technology Commission). The objective was to turn bamboo into an economical and environmental resource.

Studies on resource stocks, management and culture, determined that a sustainable raw material supply is possible, in order to implement productive alternatives of industrial nature, for bamboo in Chile. Technological studies concluded that national bamboo use is technologically feasible, in order to produce: decorative panels, activated and non activated bamboo carbon, carbon production by-products, pulp and paper, and other products.

Considering the promising results of the preliminary project, two further projects were awarded funding: “Bamboo decorative panels” and “Bamboo carbon”. Of the two projects, the first one – currently at an execution stage – seeks a high added value commercial exit for high quality raw material. The second one- initiated in march 2005- will allow to use lower quality canes.

In order to provide a secure, timely supply in several ranges of quality, Fundación Chile has developed the first stage of a project geared towards promoting the implementation of

Stocking and Primary Processing Centers for Bamboo Canes in Province, and applied for funding of the second stage.

Future steps will seek the implementation of technology transfer strategies, gestation of companies producing decorative panels, bamboo carbon and vinegar, as well as the promotion of bamboo culms as a resource for exportation. Efforts will have to be coordinated between supply, trading, and export units, as well as between future productive centers for various products, forest owners, the state forest administration and other relevant actors. This will allow for generation of a bamboo cluster in Chile's southern region.

Colombia

Colombia and Costa Rica are the countries where the most efforts have been done in bamboo resources research, development, and transfer.

These days the main advances have been related essentially to the formation of a Guadua productive chain, with support from the Ministry of Agriculture. A National Guagua Consultation Council was created. Representatives of the government, of companies, of institutions, and of the Colombian Society, all joined this council.

In 2002 started the creation of norms for *Guadua angustifolia*, in association with the Instituto Colombiano de Normas Técnicas y Calificación (Colombian Institute for Technical Norms and for Qualifications). To date, two technical norms are available for "Harvest and post harvest for *Guadua angustifolia* culms", and for "*Guadua angustifolia* culm drying and treatment"

The Sociedad Colombiana del Bambú (Colombian Bamboo Society), Universidad Nacional de Colombia (National Colombia University), Universidad Tecnológica de Pereira (Pereira Technological University), and Research Centers like CENICAF, have initiated studies in such fields as: CO2 sequestration by *Guadua angustifolia,* anatomical studies of the culm, and genetic features of the species.

Through the Bamboo-Guadua Project, the European Union – together with the Freiburg University, Imperial College from England, CATIE from Costa Rica, Universidad de la Costa from Costa Rica, and Perira Technological University – gave birth to research in the fields of Guadua market and marketing, Guadua, silvicultural studies, and Guadua forest inventories in Colombia y Costa Rica.

Guadua-based construction systems are another widely studied field in this country.

Costa Rica

The Costa Rica national bamboo project is a complete 15 year study covering such fields as bamboo culture, management, and conservation. It also covers construction technologies and rural housing promotion, especially for *Guadua angustifolia*. The project started with

US$ 26.000 in resources, brought by the United Nations Development and Housing Program, and later on received US$300.000 from the Dutch Government (Chavez C, 1998)

Bolivia

In Bolivia, the Center for Agricultural Tropical Investigation and Research (CATIE) has been leading the research, investigation and transfer initiatives. It has focused its projects on bamboo production and transformation in indigenous communities, on studies of the productive chain, and on integral management and monitoring projects for 15 permanent plots. During the last few years several modern architecture projects have been developed to use Bolivian bamboos, as well as transfer activities to promote bamboo as construction material (Tacuabol Workshop)

Venezuela

Several technology transfer experiences have been developed to promote sustainable use of bamboo, in agricultural production areas. Pilot units foment the use for rural housing, for fences, and stables. Some projects also attempt to organize the productive chains in rural municipalities.

Argentina

The Tucumán national University has developed different projects in the fields of bamboo rural housing, mechanical studies, and antiseismic properties of this material.

The Darwinian Botanical Institute conducted a complete study on native bamboo anatomical features.

4. Conclusions and Recommendations

Bamboo resources in Latin America are highly important for biodiversity, as environmental resource, and for their socio-economical potential.

Because of the traditional uses it has been receiving, of the new massive or industrial utilizations it can be potentially subject to, and because of the R&D and transfer project investments, the resource deserves adequate quantifying and description through criteria to be homologated in the region and in the world.

Recommendations on Information Collecting and Homogenization, in different countries

Centralizing information

Information on bamboo resources (diversity, distribution, etc) and on its uses, is very dispersed. It needs to be centralized in a single point

that can later on spread it. It is suggested that the INBAR Regional Office play this role.

Regional workshops are suggested in order to homogenize information. Each country specialist should participate in the respective fields (Ej. Biodiversity or bamboo resources specialist, inventory specialist, bamboo ecnomics specialist, etc.)

Diversity

For Biodiversity, the INBAR project "Evaluation of Bamboo Resources in Latin America" is considered a high quality baseline. It gives an idea of bamboo diversity to all countries of the region, and is a good start for further and more specific studies that may deemed necessary.

Obtaining complete, homogenous, and reliable baseline information on taxonomy must be one of the next challenges for the region.

Stocks

The Latin American situation shows a clear need to homogenize the criteria for resource inventory or to homogenize stock information through indirect mechanisms.

Indeed, the comparison between various results of quantification studies tend to be complex, because of their distinct motives and implementations, and because of the inherent diversity of bamboo resources in terms of species and cover. Stocking surveys in Latin America have been targeting objectives as diverse as biodiversity, pulp and paper industry establishment pre-feasibility studies, or social housing programs.

New technologies like GIS or satellite images are constantly more accessible to developing countries. Their use has already shown its efficiency in several countries of the region. It nonetheless needs consistent field verification. Indeed, the complexity of bamboo resources and their diversity in shapes and dominance levels, may cause significant errors. For example, remote sensing can overestimate climbing bamboos because these are more noticeable. For these reasons, field inspections are highly useful and must be associated to such technologies.

One of the problems for bamboo resource inventory in the region is the small size of certain polygons. This is the case for example of Guadua pockets in Ecuador, highly important for their use but whose area can be as small as 0.5 ha. In such cases, it is believed that agricultural surveys are an adecuate tool.

It is relevant that countries generate quantifying methods for bamboo resources, that match or be compatible with other forestry or agricultural quantification systems. In Chile, the Catastro Vegetacional Nacional (National Vegetation Inventory) is the reference and provides a first stratification of the resource, cover information, and some digitalized mapping. The bamboo R&D project used such information, complemented it with new satellite imaging and field information, and furthermore added information on standing stocks for the main species. Bamboo is now inventories as part of the permanent plots of the Inventario Forestal Continuo (Continuous Forest Inventory). These plots are located in

2 of the 3 main native forest regions of the country, thus allowing constant monitoring of the resource.

Although inventories or surveys often correspond to clearly productive objectives, bamboo quantifying should be in line with more modern concepts of national forest inventories and collect information to estimate biomass. Promising results from the Project “Captura de Carbono Atmosférico” (Atmospheric Carbon Sequestration) in Colombia, show how important direct biomass information can be, or at least estimates through functional relations based on productive evaluation data.

In order to create more intensive quantification methods for the more precious species, countries must identify target species based on their use. Indeed, amongst the numerous bamboo species, only a very limited number is actually utilized.

Economical information

Capturing economical information on the value of removed resources, arises from various country management tools or databases, when these are believed valid and possible to homologate. It must be remembered that all these accountings correspond to formal trading evaluations, while much of the removed resources transit in an informal market or are used for self consumption. For each of the three more deeply analyzed countries, one can distinguish a formal and valid tool that captures such information: units transported through ground loads (Peru, Ministry of Transportation), Allowed Harvest Volumes (Ecuador, Ministry of the Environment), surveys to the main producers and dealers combined with projections based on the growth of main users like kiwi producers, vineyards, and mining (Chile, Bamboo R&D Project)

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Recommendations of modifications to the FRA form include adding:

Number of endemic species in the country, and their listing.

In case a country has established studies to define potential plantation areas (such as Ecuador), it is recommended to allow incorporating such information. This way, a background will be created on the potential increase in the area of bamboo resources.

The form should allow collecting information on flowering processes, in order to validate what is already known on each species flowering cycles. This tool can be an adequate way of recording, acquiring, or validating information on each species flowering cycle.

Consultations on bamboo products – for firewood or not – are considered sufficient so far. However, its is proposed to widen the range of information to bamboo uses and

environmental services. For example, in Peru, Bamboo is mentioned as an important type of windbreak, riparian protection has been especially emphasized in Ecuador after the El Niño phenomena, and carbon sequestration is a subject that has seen promising results in Colombia.

Another type of relevant information is the management situation of natural or planted bamboo polygons. That is, what area or proportion of the area is under management plan.

Stocks of certified or non-certified bamboo-containing forests, is again another interesting variable to detect in the future. Although such processes may currently be seldom involving bamboo, such cases are relevant to detect because they can be used as models for other countries or regions.

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