11 Bolivia

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11.1 Brief description of forest management in Bolivia

Bolivia started to implement the Forestry Law (# 1700) in 1996. Since then the Bolivian forestry sector has changed significantly from an unplanned and exploitative logging regime to an organized system based on reduced impact logging techniques and management plans elaborated by trained forestry technicians and professionals. It has also expanded access to forest harvesting by allowing rural and indigenous communities the right to manage forest resources along with private companies. The law also provided a suite of technical tools to ensure the sustainable use of the forest resource. The 1996 forestry law and its implementation has resulted in a diversification of species being used for timber production, an increase in the amount of finished forest product exports, and improvements towards forest sustainability. This latter aspect is most evident in the approximately two million hectares of tropical forests that have been certified as sustainably managed under the Principles and Criteria defined by the Forest Stewardship Council (FSC) (Certificación Forestal Voluntaria 2008).

Despite Bolivia's status as a sustainable forestry leader, there are political, socioeconomic, and ecological challenges to sustainable forest management. Most of these challenges have their origins outside the forestry sector and are related to the development vision being used in the country. These limitations are of concern to the sustainability of Bolivia's forestry sector and their recognition is important in order to be able to mitigate their effects in the future. The rest of this chapter will expand upon the successes and challenges to sustainable forest management in Bolivia.

11.2 Forest reserves and off-reserve tree resources and their utilization

Bolivia is one of the most biodiverse and forest-rich countries in the world, with more than half of its ecosystems in good or excellent conservation status (Ibisch 1998, 2005). The high biodiversity of Bolivia is due to the fact that its territory varies strongly in geomorphology, topography, climate, and soil. Four major ecological regions can be distinguished in Bolivia: the Andean Region, the Amazon Region, the Brazilian Shield Region, and the Great Chaco Region (Navarro & Maldonado 2002). In these broad ecological regions there are 18 Holdridge Life Zones or 199 different ecosystems. These ecosystems comprise a great diversity of forest ecosystems, which vary largely in forest structure, floristic composition, and number of species. Forest types range from cloud forests to tropical dry forests, to Amazonian rain and wetland forests, to Andean mountain forests.

About half of Bolivia is covered with forest: about 53,000,000 ha (BOLFOR II 2008). The Bolivian government has classified about 41,235,500 ha as Permanent Production Forested Lands (TFPP, *Tierras Forestales de Producción Permanente; Decreto Supremo* 26075). The majority of the TFPP are considered production forests (68 %) that have to be managed following the technical norms and practices defined by Forestry Law # 1700. The rest of the TFPP have restrictions on their use because these areas are either included in the national system of protected areas (26 %) or their final major land use category is still to be defined (6 %).

The production forests are located in 7 of the 9 departments of the country and comprise mostly lowland forests. These forests are divided into six regions based on ecological and timber production potential: Chiquitania, Bajo Paraguá, Guarayos, Choré, Pre-andean Amazon and Amazon (Table 11.1). Of the 68 % (i.e. 28,190,600 ha) classified as production forests, 8.5 million ha are currently managed for sustainable timber production (Table 11.2) (Cámara Forestal de Bolivia 2008a). About 25 % of the area under forest management is certified as sustainable forest managed under the scheme of the FSC (Certificación Forestal Voluntaria 2008).

Table 11.1. Average density, basal area, and volume estimates for the six regions in the Bolivian lowland forests. dbh= diameter at 1.3 m aboveground, BA= Basal Area, MDC= minimum diameter for cutting. Data from Dauber et al. 2000.

Region	Density dbh ≥20cm (#/ha)	BA dbh ≥20cm ($m^2.ha^{-1}$)	Volume dbh ≥20cm ($m^3.ha^{-1}$)	Density dbh ≥MDC ($N.ha^{-1}$)	BA dbh ≥MDC ($m^2.ha^{-1}$)	Volume dbh ≥MDC ($m^3.ha^{-1}$)
Chiquitania	110	11.7	43	24	4.5	19
Bajo Paraguá	84	8.6	51	5	2.1	16
Guarayos	78	11.0	47	10	3.9	19
Choré	119	17.5	89	13	5.9	33
Pre-andean Amazon	89	13.2	77	9	4.5	30
Amazon	103	15.2	116	7	3.1	27

Table 11.2. Area under forest management and number of contracts by user type and legal rights. Data is from 2007. (Cámara Forestal de Bolivia 2008a).

Legal Rights and User Type	Area (ha)	%	Number of Contracts
Concessions			
Local Social Associations	906,574	11	39
Private companies	5,399,278	64	85
Universities (for research)	262,368	3	3
Properties			
Management areas in indigenous community-owned land	723,168	8	29
Privately-owned property	1,078,275	13	677
Management under previous law			
Harvest contracts	112,000	1	1
TOTAL	**8,481,663**	**100**	**834**

11.3 Historical development in forest exploitation

Bolivia lacked a coherent forest policy until 1974 when the first Forestry Law was enacted. The objective of this law was "development of the forest sector for socio-economic benefits through the use and protection of the forest resources". This law declared all forest to be owned by the state (in accordance with the previous State Constitution), and gave the state the right to issue permits for using the forest both on public and private land (Benneker 2008). Permits were given to enterprises on an annual, short (for 3 years), medium (for 10 years) or long-term (for 20 years) basis. These permits were called logging contracts, and could only be obtained by registered enterprises. To register, enterprises had to present a forest management plan, a reforestation program, and had to demonstrate that they had the ability to process logs. After obtaining a contract enterprises paid revenues and fees based on the volume extracted, which generated a lot of corruption and little control of logging activities.

These requirements for obtaining a contract effectively excluded local and indigenous communities from receiving logging contracts (Benneker 2008). This exclusion caused social conflicts among stakeholders because not all actors had legal access to exploit the forest commercially (Quevedo 2006). The social conflicts culminated in an indigenous march upon the capital city in 1990 to demand, among other things, the rights of indigenous communities to harvest their forests legally and sustainably. This indigenous movement set the social and political stage for the passing of Bolivia's 1996 forestry law (BOLFOR II 2009).

By 1996 there were 173 enterprises operating over an area of 21 million ha of forest, corresponding to 40 % of all the forest in the country (Contreras-Hermosillo & Vargas Rios 2007). Most of the logging contracts given (around 185 by 1996) were short-term contracts, because long-term contracts were difficult to obtain as they had to be approved by the national congress (Contreras-Hermosillo & Vargas Rios 2007). Logging was virtually unregulated and characterized by high-grading, no planning, poor

harvesting techniques and inefficient milling. Nearly all timber harvested belonged to just three species – mahogany (*Swietenia macrophylla*), Spanish cedar (*Cedrela fissilis*) and Spanish oak (*Amburana cearensis*). Mahogany accounted for 60 % of the total export value between the 1980s and early 1990s, and much of it left the country as unprocessed logs (Fredericksen et al. 2003). The consequences of these logging practices were that harvestable trees of the abovementioned species became scarce in most Bolivian forests, residual stands partially lost value due to damage and timber theft, and wildlife poaching compromised forest diversity (Fredericksen et al. 2003).

Forestry Law # 1700 (*Ley Forestal 1700*), passed in 1996, created the legal and institutional framework for a new forest management regime. The law defined access to forest harvesting and provided a suite of technical tools to ensure the sustainable use of forest resources including, among others, the use of reduced impact logging (RIL) techniques during logging operations. Most of these technical tools required by law are commonly required by certification schemes like the one of FSC. Additionally, the new law democratized the access to forests by allowing both private companies and local people grouped in Local Social Associations (*Agrupación Social del Lugar, ASL*) to obtain forestry concessions through the national and municipal governments, respectively. Furthermore, indigenous communities were allowed to legally manage forests within their Indigenous Community-owned Lands (*Tierras Comunitarias de Origen, TCO*), while private property owners were allowed to manage forests within their individual properties. Of the more than 8.5 million ha of managed Bolivian forests, around 75 % are managed by industry through forestry concessions and 32 % is managed by groups that were not recognized under the previous law (Table 11.2) (Cámara Forestal de Bolivia 2008a).

The Bolivian forestry sector has also changed in other aspects. In the last ten years the list of commercial tree species harvested in Bolivia has grown to include "lesser known species" or alternative species previously under-utilized in the market. In 2006, more than 380 tree species were harvested for a total volume of 980,285 m^3. However, ten species accounted for 51 % of this volume with the top five most harvested species being *Hura crepitans* (14.9 %), *Dypterix odorata* (7.4 %), *Tabebuia* sp. (5.7 %), *Ceiba pentandra* (5.7 %) and *Amburana cearensis* (3.7 %) (Superintendencia Forestal 2007). Bolivia's capacity for producing forest products has also increased over the years. In 1995, 64 % of forest products exports were in the form of semi-finished products. By 2003 this figure had changed significantly as 61 % of the forest products exported were finished products, generating a total of 145 million US dollars. Currently, Bolivia exports over 50 different types of finished wood and non-timber forest products and more than 20 semi-finished products.

11.4 Productivity, annual allowable cut, silvicultural systems

Production forests have been divided into six regions based on their hydrologic regimes, location, and timber production potential: Chiquitania (6.3 million ha), Bajo Paraguá (3.8 million ha), Guarayos (4.2 million ha), Choré (1.6 million ha), Pre-andean Amazon (4.1 million ha) and Amazon (8.8 million ha). The regions differ in average tree density, basal area, and volume (Table 11.1, Dauber et al. 2000), as well as in number of species harvested and taxonomic identity of the commercial species. Additionally, diameter growth rates differ, with trees from the Chiquitania growing slowest (mean growth rate

0.18 cm.y^{-1}) and trees from Guarayos growing fastest (0.39 cm.y^{-1}) (Dauber et al. 2003, 2005). Consequently, these regions also differ in the volume to be recovered for the second harvest (using a cutting cycle of 25 years; Dauber et al. 2005).

In Bolivia the annual allowable cut is not based on a fixed volume per ha but on the amount of harvestable trees found in a given annual logging compartment. Harvestable trees are inventoried, measured and marked for harvest in each annual logging compartment, following the rule that 20 % of the harvestable trees of every commercial species is left as seed tree. Forest managers use this inventory to prepare an annual operational plan that indicates the estimated harvestable volume to be harvested in the following year. The inventory is also used for other aspects related to forest management, such as elaboration of (logging) maps. The operational plan is revised and approved by the *Autoridad de Fiscalización y Control Social de Bosques y Tierra* (ABT) that grants, regulates, and controls harvesting rights. In 2009 the ABT replaced the former *Superintendencia Forestal* (SF) institution created by Forestry Law # 1700.

The SF granted permission to cut on average 1,291,070 m^3 round wood per year during the period of 1999-2006. The actual extracted volume corresponded, however, to only 40 % of the allowed cut (MDRAMA 2007). Harvesting intensities in Bolivia are rather low compared to intensities elsewhere in the tropics; they range from 1-6 trees/ha (equivalent to 2-10 m^3.ha^{-1}) depending on forest type.

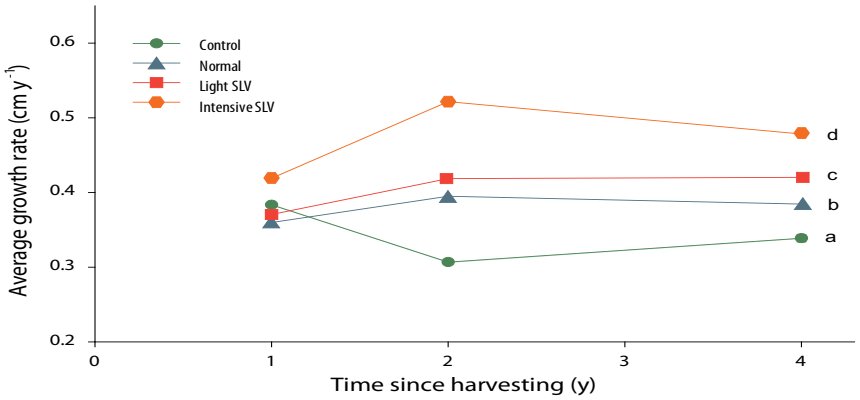

Figure 11.1. The effect of treatment on average tree growth rates through time after different management treatments were applied in a moist forest in the Guarayo region. Data are means ± 1 SE based on all trees sampled in each treatment. Different letters represent significant differences over time. Intensity of logging and application of additional silvicultural treatments increases from control (no logging) to intensive silviculture (SLV). All logged treatments were logged using reduced impact logging techniques. See Table 11.3 for more details on treatments applied.

The main silvicultural treatment currently being applied in Bolivia is timber harvesting itself (Fredericksen et al. 2003). Very few additional silvicultural treatments are used to increase growth rates of future crop trees or to promote the regeneration of commercial species (Snook et al. 2007). This is probably due to the lack of specific information on silvicultural practices within the current legislation (see MDSP 1998; Snook et al. 2007;

Sabogal et al. 2007). Several studies have shown, however, that additional silvicultural treatments are needed to guarantee sustained timber yields (Dauber 2003; Blate 2005; Dauber et al. 2005). Moreover, it has been shown that the application of RIL techniques results in lower growth rates than when RIL is applied together with additional silvicultural treatments (Fig. 11.1; see later for more detail on treatments applied). Thus, application of additional silvicultural treatments together with RIL will produce more timber volume for subsequent harvests (Peña-Claros et al. 2008).

Silvicultural treatments are evaluated in the Long-Term Silvicultural Research Program (LTSRP) that is carried out by the Bolivian Institute of Forest Research (IBIF) in different Bolivian forest types. The LTSRP established a network of large-scale (20-27 ha) replicated plots which received one of four treatments that differed in intensity of logging and the application of additional silvicultural treatments (Table 11.3). The LTSRP is currently underway in the Guarayo, Bajo Paragua, Amazon and Chiquitania regions (see Table 11.1). It monitors over 82,000 trees and covers over 640 ha, using a nested design. The LTSRP plots are established at an operational scale to estimate the logistical feasibility and cost-effectiveness of different silvicultural interventions, as well as the long-term impacts of silvicultural treatments on biodiversity, stand dynamics, and forest ecosystem functions. These plots can also be used to assess the viability and trade-offs of other management options, such as the development of carbon sequestration reserves (e.g., Blate 2005). For more details on methods used and treatments applied see Peña-Claros et al. (2008) and Villegas et al. (2009). The LSTRP plots are part of the National Network of Permanent Plots also managed by IBIF (IBIF 2008).

Table 11.3. General description of treatments applied to LTSRP plots established in different forest types in Bolivia. C=control; N=normal; LS=light silviculture; IS=intensive silviculture. • = management practice applied; • • = management practice applied with double intensity. For more details on methodology see Peña-Claros et al. (2008), Villegas et al. (2009).

Management practices	Treatments			
	C	N	LS	IS
Pre-harvest inventory of merchantable commercial trees, using specific minimum cutting diameters (50 – 70 cm dbh)	•	•	•	•
Lianas cut on merchantable trees 6 months before logging		•	•	•
Skid trial planning		•	•	•
Retention of 20 % merchantable commercial trees as seed trees		•	•	•
Directional felling		•	•	•
Merchantable trees harvested using species-specific minimum cutting diameters (50–70 cm in dbh)		•	•	• •
Pre-harvest marking of future crop trees (FCTs) ≥ 10 cm dbh			•	• •
Lianas cut on FCTs 2 – 5 months before logging			•	• •
Post-harvest liberation of FCTs from overtopping non-commercial trees by girdling			•	• •
Soil scarification in felling gaps during logging				•
Post-harvest girdling of non-commercial trees > 40 cm dbh				•

Photo 11.1. Future crop tree being monitored for its growth rate in LTSRP plots located in the dry forests. The blue line was painted to make the tree more visible during logging operations. (Photo L. Poorter)

Photo 11.2. Lianas have a negative effect on the growth rates of commercial tree species. Research done so far in several forest types in Bolivia showed that liana cutting results in higher growth rates of trees. (Photo M. Peña-Claros)

In the LTSRP plots, additional silvicultural treatments are applied to individual trees or individual logging gaps to reduce application costs and minimize impacts on biodiversity and other ecosystem services. These additional treatments aim to enhance the growth and regeneration of commercial individuals, especially future crop trees (FCT). FCTs are individuals of commercial species that are too small to be harvested in the first cutting cycle (i.e., for most commercial species individuals with 10-50 cm dbh), but that have an adequate form and growth potential and are expected to be harvested in the future (Photo 11.1). Treatments applied to enhance growth rates of FCTs are cutting of lianas growing on FCTs (Photo 11.2) and girdling of non-commercial trees overtopping FCTs (Peña-Claros et al. 2008; Villegas et al. 2009). Results showed very convincingly that FCTs grow faster when treated than when non-treated, in the Guarayo and Bajo Paragua regions (Peña-Claros et al. 2008; Verwer et al. 2008; Villegas et al. 2008) as well as in the Chiquitania region (Villegas et al. 2009). The results also indicate that trees respond more strongly to liana cutting than to liberation from competing trees (Verwer et al. 2008; Villegas et al. 2009). Given that certain tree species have been shown to respond negatively to liana load in terms of reproduction (e.g., Nabe-Nielsen et al. 2009), we expect that the abovementioned silvicultural treatments will also have a positive effect on regeneration of commercial species by increasing the chances of individual trees to become reproductive and by increasing fruit production.

In Bolivia about 78 % of the commercial species are found to have regeneration problems. This is mainly due to lack of seed trees, the small sizes of logging gaps which create environmental conditions that are not suitable for regeneration, and competing vegetation limiting regeneration (Mostacedo & Fredericksen 1999). Studies assessing regeneration abundance in Bolivian logged forests have found that many commercial species better regenerated in areas disturbed by logging, such as logging gaps, skid trails, and logging roads (Fredericksen et al. 1999; Fredericksen & Mostacedo 2000; Pariona & Fredericksen 2000; Fredericksen & Pariona 2002). Consequently, in the LTSRP plots the treatment

applied to enhance the regeneration of commercial species is soil scarification in logging gaps (i.e. topsoil removal; Table 11.3). This treatment aims to produce adequate microsite conditions for regeneration by removing the existing vegetation, woody debris, and litter and by exposing mineral soil. Soil scarification has been applied when logging gaps met several criteria: located in flat terrain, existence of seed trees in their surrounding, lack of existing advanced regeneration, and possibility of cleaning the area with a skidder blade rapidly (on average 3.5 minutes for 100 m^2) to reduce soil compaction. Six years after treatment application treated gaps had 2.5 times higher densities of commercial species than untreated logging gaps but no difference in growth performance was found (Prieto 2008).

11.5 Current practice

The Bolivian Forestry Law and its technical regulations require the application of several management practices (MDSP 1998). These management practices need to be followed in all areas under forest management larger than 200 ha regardless of ownership. The management practices required are:

- A general forest management plan (Plan General de Manejo Forestal, PGMF);
- A forest inventory to develop the PGMF;
- Designation of protected areas within the forest management area;
- Identification and protection of keystone tree species and important areas for wildlife, such as roosting areas, salt licks, and caves;
- Division of the forest management area into logging compartments and annual harvesting areas, requiring the use of a minimum cutting cycle of 20 years;
- Protection of species with low abundances (less than 0.25 trees with a diameter of > 20 cm per ha);
- A census of commercially harvestable species. The census is the basis for preparing the annual operational forestry plan, which is required to obtain permits for transporting timber. The operational plan includes field maps used to locate harvestable trees, seed trees, land characteristics (slopes, water bodies), and roads to be opened;
- The use of minimum diameter for cutting (MDC) commercial species. The MDC is defined in the regulations and is specific for species and ecoregions;
- Retention of 20 % of merchantable trees as seed trees;
- Prohibition of hunting within forest management areas;
- Annual reports of harvesting activities;
- Establishment of permanent plots to monitor and evaluate the impact of timber harvesting in the forest;
- Plans for wood provision, procurement and processing (only applicable when the forest manager owns a sawmill).

Harvesting rights are given to concessionaires for 40 years by the ABT (formerly SF). The harvesting rights are required to be renewed every five years through an auditing process. If companies pass the audit satisfactorily, the harvesting rights are renewed for another 40 years. Unfortunately, so far these audits have never taken place at an operational scale due to budget and technical shortcomings of the former SF.

11.6 Main issues restricting sustainable forest management at present (silvicultural, economical, political)

The Bolivian forestry sector has changed significantly since the enactment of the 1996 forestry law. These changes are best seen by the fact that 25 % of the area under forest management is certified under the FSC scheme. In spite of Bolivia's great advances in terms of planned harvesting (through the use of reduce impact logging techniques), there are still several constraints to sustainable forest management.

Modeling simulations have shown that the volume to be recovered for the second harvest will only be a fraction of what is being currently harvested (Dauber et al. 2005; Keller et al. 2007), but it increases if silvicultural treatments are applied to future crop trees (FCT) (Dauber et al. 2005). Experimental work done at the LTSRP plots indicated also that the application of silvicultural treatments results in higher growth rates of FCTs (Peña-Claros et al. 2008; Villegas et al. 2009). However, to sustain long-term timber yields, it is necessary to consider several (combinations of) options, such as the application of silvicultural treatments to increase growth rates, the use of different rotation cycles for different species, the focusing on fast growing species with good regeneration rates, and the improvement of harvesting and milling efficiency (Fredericksen 2003).

Given that Bolivian forests are so diverse in structure, composition, dynamics, and responses to forest management, it is necessary to define technical norms that incorporate specific practices for each forest type. These norms should also consider and incorporate the ecological and species-specific information that has been generated over the last 10 years. The incorporation of research results into management guidelines has proven to be a slow process in Bolivia and elsewhere. For example, the forest certification movement has heavily promoted the application of RIL techniques to reduce undesirable logging damage. But the need for applying silvicultural treatments to improve the growth of residual trees and to move towards long-term sustained yields in tropical forests has not received the promotion that it merits (Peña-Claros et al. 2008; Putz et al. 2008).

The implementation of the Forestry Law has faced several challenges, most of them originating outside the forestry sector and its regulations. These problems have resulted in an increase in the deforestation rate, an increase in the incidence of wildfires, the expansion of illegal forestry sector activities, an unequal distribution of the economic benefits, and the persistence of imperfect markets dominated by lack of information about wood prices and by single buyers who determine both prices and transaction conditions (Pacheco 2007). Other problems include (Contreras-Hermosillo & Vargas Rios 2007; Pacheco 2007; Benneker 2008):

- Land tenure in Bolivia is insecure, and even forest concessions and areas under forest management in indigenous territories have been occupied by colonist farmers;
- Titling land ownership has been slow and costly. This process has also indirectly promoted deforestation because in many cases only agriculture and livestock production were considered valid economic functions to grant land titles;

- The agricultural frontier is expanding because land is becoming more scarce and also because it is believed that deforestation will help solidify land claims;
- An agrarian vision of development is valued more than forest-based development;
- Illegal logging is persisting;
- The timber production chain is poorly developed;
- There is a lack of a good network of roads, which increases the cost of transport;
- Economic benefits generated by the forestry sector are unequally distributed;
- There are institutional weaknesses for implementing the forestry law;
- There is lack of technical support from the national or local governments to assist small producers, farmers, and indigenous people with their forest management enterprises;
- There is no integrated vision on the forestry sector and other economic sectors such as agriculture;
- Unfavorable taxation conditions for the forestry sector compared to the agricultural sector in terms of fees persist (concessionaires pay between 1-8 US$/ha per annual logging compartment depending on user type, while agricultural land owners only pay 0.03 US$/ha).

In conclusion, Forestry Law # 1700 and its implementation has allowed Bolivia to become one of the world's leaders in sustainable tropical forest management with an increasingly diverse forest products sector, expanded access to forest management for diverse actors, and saw significant areas certified as sustainably managed forest. In the past several years, Bolivia has been undergoing intense political, institutional, and economic changes. One major change was the creation of the *Autoridad de Fiscalización y Control Social de Bosques y Tierra* (ABT) within the *Ministerio de Desarollo Rural y Tierras*. The ABT has replaced the *Superintendencia Forestal* as well as the *Superintendencia Agraria* and has structurally integrated the agriculture- and forestry-related governmental institutions. This change has created some short-term uncertainty in the forestry sector but it could also promote long-term stability in the forestry sector, given that forestry and agricultural policies are so intimately connected. It remains to be seen how these institutional changes, as well as other changes taking place in the country, will affect the forestry sector in the long run and whether Bolivia's standing as a world leader in sustainable forestry will be enhanced or diminished.

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