USAID/Conservation of Central American Watersheds Program

Sustainable Forest Management Plan for the Deep River Forest Reserve

Thomas Gomez Sr. & Sons

Grant Number: 412FO-APSO1-THOM

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Date: August 28, 2009

THOMAS GOMEZ SR. & SONS
FOREST INDUSTRY

SUSTAINABLE FOREST MANAGEMENT PLAN
DEEP RIVER FOREST RESERVE

Document prepared by:

Adolfo Vinicio Linares Reynoso

Forest Management Specialist for the Conservation of Central American Watersheds Program

CCAW-USAID

Revised by: Mauro E Salazar

Regional Forest Director WWF

Toledo District, Belize

2009

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Abbreviations

APO	Annual plan of operations
BAHA	Belize Agricultural Health Authority
CC	Cutting cycle
CDE	Centre for Development of Enterprise
DBH	Diameter at breast height
FD	Forest Department
FR	Forest Reserve
FSC	Forest Stewardship Council
GOB	Government of Belize
GWFR	Grants Works Forest Reserve
Ha	Hectare
IDB	Inter American Development Bank
IPM	Integrated Pest Management
KD	kiln dried
LIC	Land Information Centre
LKS	Lesser known species (hardwoods)
LSD	Land and Surveys Department
MCD	Minimum cutting diameter
MNRE	Ministry of Natural Resources and the Environment
MPR	Mountain pine ridge
NTFP	Non timber forest products
OB	Over Bark
PSP	Permanent sample plot
RBCMA	Rio Bravo Conservation and Management Area
RIL	Reduced impact logging
SCP	Southern Coastal Plain
SFM	Sustainable forest management
SFMP	Sustainable forest management plan
TGS	Thomas Gomez and Sons
TFAP	Tropical Forest Action Plan
TIDE	Toledo Institute for Development and the Environment
TWD	The Wood Depot
UB	Under Bark
YLL	Yong Lumber Ltd.

1 EXECUTIVE SUMMARY

In the past years the Government of Belize has granted nearly 150,000 hectares of tropical forest to the country's forest industry. However, strong efforts are needed towards ensuring responsible forest management and natural resources sustainability. Most Forest Management Units´ rotation cycles have been estimated without of research and monitoring of forest response to current harvesting practices and regeneration. Under this scenario both forest integrity and sustainability demand on more attention to ensure that Sustainable Forest Management principles are accomplished.

To address these issues the Conservation of Central America Watersheds Program, CCAW; an USAID sponsored project provided support to one of the pioneer forest industry in southern Belize, managed by Mr Thomas Gomez & Sons. Primarily, an evaluation of the management plan was carried out to determine the level of application of sustainable practices, and also to evaluate the feasibility of the former stated rotation cycle, according to the forest natural regeneration and the industry round timber annual demand. As per these preliminary analyses it was determined that strong adjustments were demanded to update Mr. Thomas Gomez and Sons management plan, and therefore general forest inventory was performed from April to June 2009 using the PROCAFOR regional methodology for pine forests. No major analysis were conducted in the remaining broadleaf species patches, since severe past harvests have reduced them to bushy forest that are in a naturally recovery process.

From the supervised classification of the SPOT image, the production forests within the defined FMU area was estimated as to 5,587.5 ha (26.3%) of the total area (21,294 ha). However, it was observed during the forest inventory that pine interacts with savannah and broadleaved areas. The final Pine stratification considered some of this area, only where sampling plots took place to verify pine existence, ascending the productive pine forests to 6090.45 ha. Production forests are located on lands without biophysical limitations, such as steep slopes, unstable soils or endangered ecosystems.

The final general forest inventory data analysis and updated rotation cycle yield an estimated annual harvesting of 2,500m^3 of logs in approximately 200 ha of pine forest every year in a rotation cycle of 30 years with a 30 cm MCD. The area does not have to be fixed, since the 2,500m^3 could be harvested in less area, leaving area for next´s year APO. In other words, the compartments are formed by volume and not by area. The estimated volume of total available timber in the license area is about 256,389m^3; which is all pine (*Caribbean pine*). The estimated annual volume growth of 0.7037 m^3/ha for pine will allow for a felling cycle of 30 years based on the envisaged production of 400,000 board feet per year. No figures exist for hardwoods; most of trees affected by hurricane have already been salvaged. Damage from Hurricane Iris especially to the broadleaf forest has been extremely severe.

This management plan was performed by using proved methodology that WWF has applied all through Latin America, and thus all pre-harvesting, harvesting and post-harvesting activities were considered to ensure that no considerable damages are caused to forest ecosystems integrity during the harvesting stage.

2 INTRODUCTION

As part of the USAID's Conservation of Central American Watersheds Program, Thomas Gomez & Sons has received technical and professional assistance in order to improve their environmental and business management performance. The grant "*Promoting forest certification standards, as a tool for ensuring responsible forest management and trade within the forest industry in Belize.*" has helped to strengthen forest management activities; along with administration and business management of TGS.

TGS is a family owned business managing the Deep River Forest Reserve under a 40 year concession as part of the Forest License LTFL 1/05 assigned by the government. Previously, TGS had a Sustainable Forest Management Plan with a unique structure that included three different companies (TGS, YL and TWD), managing 74,227 ha in five different areas of the southern coastal plains. The 17.9% (13,290 ha / 32,826 acres) of the area under license and management belongs to TGS; and was set under a 10-year rotation cycle according to the SFMP approved by the Forest Department.

The present plan is an update of the previous SFMP in order to include additional forest area to the SFM scheme. Also, enhance the forest type classification mechanism used in the previous plan that lacked a proper stratification or ground survey; and finally, determine a more certain timber yield for business purposes of adding value to the timber production. The TGS SFMP update will allow securing a constant timber production by establishing more equitable harvesting compartments for pine production.

After carrying on a supervised classification and a ground survey of the pine forest (Chapter 6), a systematic forest inventory with 0.46% intensity was implemented (chapter 7). The information was gathered using the PROCAFOR methodology with 1000m^2 circular plots consisting of DBH ($\geq$10cm), Total Height, age, increment, bark, soil type, fuel type, slope and any other characteristics relevant for management purposes. The results of the inventory are discussed in chapter 7 and provide information to determine the different scenarios that could take place with different rotation cycles, annual allowable cut and harvesting compartments (chapter 9).

The rest of the SFMP document has a general description of the company (chapter 3) and the entire FMU area (chapter 4). It continues with a description of the objectives and management strategy (chapter 5). Chapter 8 describes the entire sylvicultural system with the different regeneration methods and post harvesting treatments. The rest of the chapters (10-20) continue to describe the different operations in relation to harvesting, non timber forest products, markets, roads, environmental services, environmental conservation measures, monitoring and research, forest protection, information management and finally a schedule to implement all the different activities; with the sole objective of having a Sustainable Forest Management process for the TGS FMU.

The update of the SFMP for the TGS FMU has required great effort, being the result of a joint endeavor among personnel from TGS and CCAW. The present plan set the base for a proper sustainable forest management scheme to be implemented by TGS for the next 30 years. TGS will continue their pioneering process in setting a precedent of SFM being implemented by a private company; and will allow the Forest Department and others to continue supporting such a difficult task of consolidating SFM in Belize.

3 COMPANY PROFILE

3.1 Thomas Gomez and Sons

Thomas Gomez and Sons (TGS) were registered as a company in 1995. It is currently one of the oldest operating licensees on the Southern Coastal Plain (SCP). Mr. Gomez started to work the Southern half of the Deep River Forest Reserve east of Deep River in 1989 when he began extracting power poles and piles for the Wood Depot. In 1995 Tomas Gomez and Sons started to produce lumber from both hardwoods and pine.

Currently, TGS continues to produce planed and rough pine and hardwood lumber. It has two outlets, one in Punta Gorda and another in Belize City.

TGS has expressed an interest in a long term SFM license since 1998 and is currently licensee to a 40 year contract to manage the Deep River Forest Reserve. TGS is in their fourth year of working under SFM criteria and a SFMP plan prepared together with Young Lumber and The Wood Depot.

The production base of the company consists of:

- The extension of the Long Term Forest License LTF-05 was updated to 21,243.9 ha (52472.47acres) after adding 7,954 ha, located to the west of the Deep River, to its initial 13,290 hectare granted.

- Existing logging operations, consists of 1 team equipped with D-4 bulldozer, 2 skidders, 2 loaders, rubber wheeled tractors, 2 tow heads with logging trailers. It is capable of quickly fielding an additional logging team. The company also has a small excavator, backhoe, and dump truck, and an adapted grader blade. TGS employs altogether 24 employees.
    - current own production: 3,600 m^3 logs/year
    - output is about 1,700 m^3 lumber/year (328,000 bf/year)

- The existing sawmills
    - Current milling capacity: 5 m^3/day (2,100 bf/day). Occasionally 3,000 bf/ day.
    - The estimated volume of total available timber in the license area is about 256,389m^3; which is all pine. No figures exist for hardwoods; most of trees affected by hurricane have already been salvaged. Damage from Hurricane Iris especially to the broadleaf forest has been extremely severe.

- The estimated annual volume growth of 0.7037 m^3/ha for pine will allow for a felling cycle of 30 years based on the envisaged production of 400,000 bf/yr.

- The current (and planned) input needs of the company are 2,543 m^3 of logs per year. These needs are satisfied with the company's license resource according to the calculated annual allowable cut of 4,263 m^3/yr. As the company consolidates and the forest stands are regulated, more volume of the annual allowable cut could be harvested.

- Planned downstream processing includes Molding to utilize lumber with a limited market demand.

4 BASIC RESOURCE DATA

4.1 Legal status of the management area

The rights and responsibilities of the licensee are as described in their license agreement. The area covered by this management plan is located in the Southern Coastal Plain area of Belize (south) particularly in the Deep River Forest Reserve

Forest Reserves are national extractive reserves declared by the Minister responsible for Forestry through a Statutory Instrument under the Forest Act and are considered protected areas. The extraction of most natural resources (timber, minerals, wildlife, and water) in forest reserves is permitted as well as their use for recreation and tourism. Temporary cultivation traditionally related to the subsistence of persons engaged in a permitted extraction activity within the forest reserve is also allowed but no permanent agricultural crops may be planted. Licensees and their employees are normally allowed to camp or reside in a forest reserve and to erect such structures as are required for habitation, the processing of timber, and other ancillary activities with the understanding that these structures must be removed once the license or permit expires or is revoked. There are four forest reserves, which are encompassed in the SCP area, namely, Mango Creek Forest Reserve no. 1, Mango Creek Forest Reserve no. 4, Swasey Bladen Forest Reserve, and Deep River Forest Reserve.

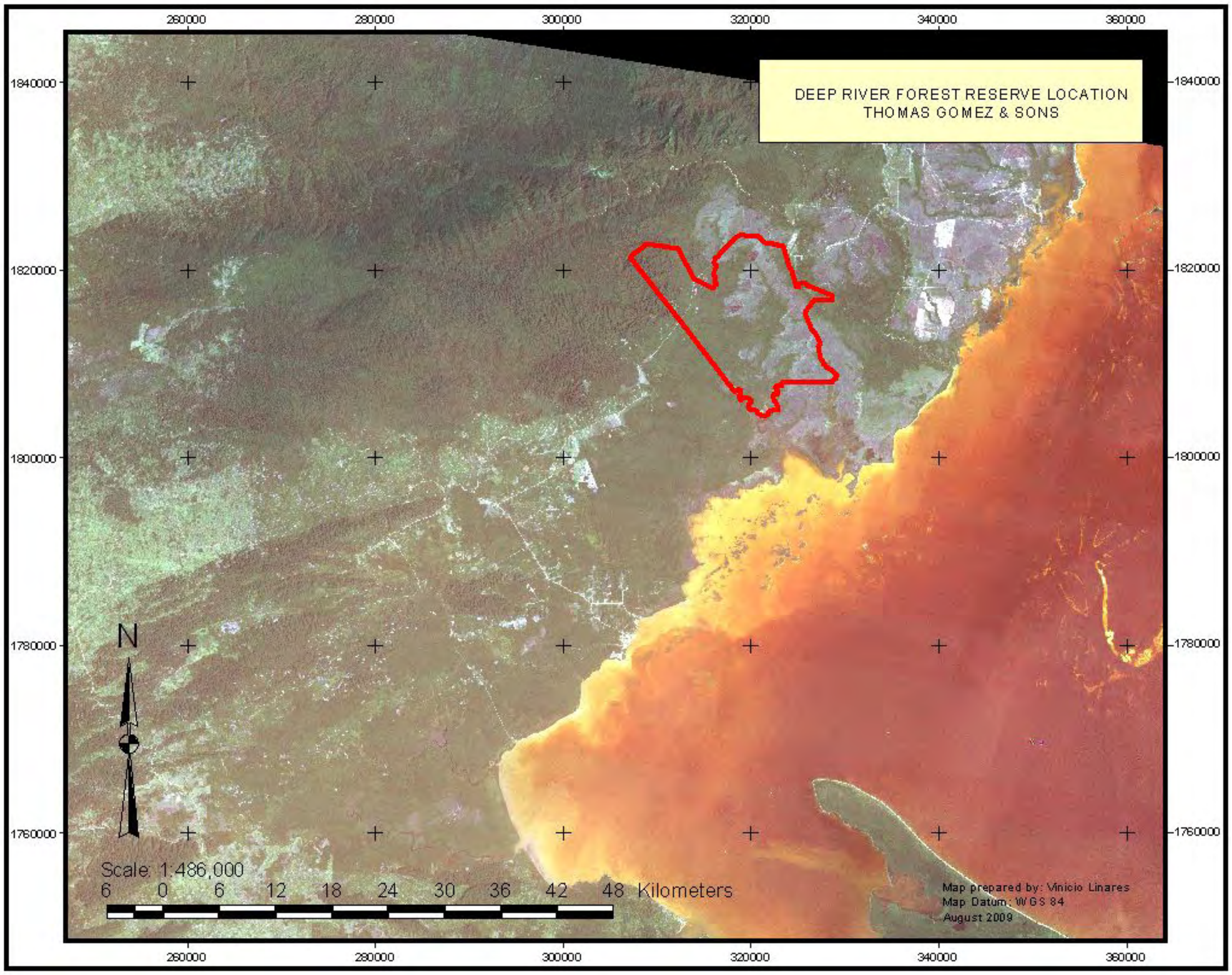
Deep River Forest Reserve was originally gazetted in 1941 with an area of 98,496 acres. In 1990 the northern part of the reserve was re-designated under the National Parks System Act as part of the Bladen Nature Reserve. Numerous agricultural excisions from the forest reserve have been made, all without due recourse to appropriate de-reservation procedures. The justification for its designation as a forest reserve was to enable protection and manage the exploitation of mahogany and pine. The present estimated area of the Deep River Forest Reserve is 67,304.8 acres (27,237.4 ha) (Meerman, 2005).

4.2 Geographic location of the management area

The management area is located in the Toledo District on the Southern Highway 70 km away from Punta Gorda.

The largest urban area is Independence, which is approximately 160 km from Belmopan, 240 km from Belize City and 80 km from Stann Creek Town. The port of Big Creek adjoins it. There is a small forest station at Savannah, 5 km from Independence.

Map1: Location of the Thomas Gomez & Sons Forest Management Unit



4.3 Description of the boundaries of the forest license

The boundaries of the long-term forest license for Thomas Gomez and Sons have undergone some modification when compared to the boundaries of the previous SFMP under which this company worked for the past four years. The area of the present long term sustained forest management license is bounded in the **north** by the Southern Highway; in the **east** the boundary is located farther south than Deep River to a point where it meets with Southern Highway at 312088 east and 1814677 north. It then heads southeast towards Flour Camp where it meets with Hope creek at 318248 east and 1806895 north. I then head south on Hope Creek until it intersects Deep River and starts going north until it reaches the point 323198 east and 1822487 North. It heads east on the border line of Paynes Creek National Park, until it reaches a point at upper freshwater creek, 328506 east and 1808022 north, to start heading north along the creek until it reaches 325646 east and 1815420 north, to continue north until it reaches the southern highway at 313171 east and 1822487 north.

4.4 Physical characteristics of the area

The authors find the comprehensive description of the biophysical aspects of the SCP made by Johnson and Chaffey (1974) still relevant. Hence, most of the present chapter is a transcription of the portrayal made by them in their report of the SCP 1970 inventory, which appears in the following paragraphs in italics.

4.4.1 Topography and hydrology

The SCP is a flat plain backed on the west by the foothills of the Maya Mountains and traversed by a number of streams and rivers flowing eastward from the mountains to the sea.

The low land adjoining the coast consists of swamps and lagoons. Inland, the land surface rises gently along the alignment of a former shoreline to the main terrace which is about 15 m above sea-level. Inland again, both on the surface of the plain and at the base of the hills, there are more small changes in elevation associated with yet other old beach terraces.

Close to the hills the topography of the plain tends to be more undulating, especially near to where watercourses emerge from the hills and former alluvial fans have been subjected to peneplanation. The boundary between plain and foothills, about 30 m above sea-level, is abrupt, and the hills themselves are steep and dissected by deep valleys. The gradient in ground elevation from the coast to the base of the hills has been rendered virtually imperceptible over most of the plain by erosion and the leveling of the old beach terraces.

Apart from the shallow valleys cut by the watercourses, most of the plain proper is devoid of macro-relief. There are a few small limestone hills protruding steeply from the plain between the Swasey Branch and Deep River. A small group of these, called the Sierritas, includes one hill which rises to 210 m. There are one or two instances of the peripheral erosion of a limestone hill having proceeded to a point below the level of the surface of the plain with the resulting formation of a moat-like depression around the base of the hill. Some more rolling hills which appear to be composed of or heavily overlain by gravel occur at Las Lomitas, just south of the Sierritas.

Drainage north of the Swasey Branch is mainly by means of small watercourses which rise in the foothills and form a sub-parallel pattern of drainage where they cross the plain. The valleys occupied by the smaller streams tend to be steep-sided while those of the one larger river - the South Stann Creek, which drains the eastern end of the Cockscomb Basin - is more gently sloping.

South of the Swasey Branch most of the smaller creeks have been captured by the major rivers traversing the plain. The density of drainage is lower than in the northern part and the pattern of drainage is typically subdendritic to centripetal. The Swasey Branch drains most of the Cockscomb Basin and the Bladen Branch drains the majority of the southern face of the Maya Mountains south of Richardson Peak. The third major river, Deep River, is fed partly from the foothills but largely from the plain itself.

Because of the prevailing flatness of the plain, micro-relief has greater significance than it does in hillier terrain. There are numerous seasonal lagoons and swamps formed in depressions of about 1 m depth. In places a terraced micro-relief has been produced by the movement and deposition of sand by surface runoff.

The rivers and streams in the southern Coastal Plain provide water of good quality throughout the year. There is no true water-table on the plain except at depth, only a perched water-table which may be absent during the dry season and at or above ground level during wetter periods of the year.

The boundaries of the seasonal lagoons expand and contract according to the prevailing level of the perched water-table. The water in the lagoons and surface floodwaters, as is that in the rivers, is clean and potable.

Although the gradient of the land surface is slight, it is sufficient to ensure the gradual surface runoff of floodwater into creeks and swamps. The slow lateral movement of a large body of water causes sheet erosion. It. may be a matter of days or weeks before floodwater drains off.

Because of the size and nature of their watersheds, the main rivers crossing the plain are liable to sudden and severe flooding. The Swasey Branch, South Stann Creek and Sittee River appear to be most liable to flash-flooding.

4.4.2 Geology and soils

The southern Coastal Plain is a wave-cut platform which is overlain by marine deposits of silt and medium to coarse sand derived from siliceous rocks of the Maya Mountains. According to Dixon (1956) the deposits north of the Swasey Branch are more recent than those to the south of it. As far south as the Swasey Branch, Dixon has not mapped the underlying rock. South of that, the coastal deposits are underlain by shales and sandstones.

True alluvium has been deposited in the shallow valleys cut by the water courses traversing the plain. Along the western edge of the plain where it adjoins the foothills are other alluvial deposits, the eroded remnants of old river fans.

A few limestone hills protruding above the surface of the plain are all that remain of the former limestone capping.

The soils of the southern Coastal Plain are formed on a variety of parent materials and have been classified and mapped by Wright et al. (1959). The area between Sittee River and Deep River is occupied mainly by soils of the Puletan suite developed on coastal deposits of sand and clay. Alluvial soils of the Monkey River, Melinda and Ossory suites have been developed in the valleys of streams flowing across this area. The area south of Deep River is occupied by soils of the Toledo suite developed on shale and sandstone. Towards the west of the project area small areas of soils formed on foothills of granite, quartzite, shale and limestone are found. The coastal fringe has soils associated with mangrove swamps behind discontinuous sand beaches.

4.4.3 Climate

The climate in the SCP is classified as subtropical wet, and is characterized by high temperatures and high rainfall, with a marked dry season occurring from February to April. During the dry season the fire hazard is high due to high temperatures and low relative humidity. Hurricanes may occur from June to November; according to records, nearly all sites in the management area have been hit by at least one in the course of the last 45 years.

Climatic data are available from several stations spread throughout the whole territory of the management area. Data for five sites are shown here: Hershey, Middlesex, Maya King, Savannah and Big Falls. Hershey is located in the Sibun River watershed some 8 km from the western boundary of the Manatee FR. Middlesex lies in the North Stann Creek valley less than 2 km from the southwestern limit of Manatee FR. Maya King is located in the South Stann Creek watershed near the northeastern limit of the SCP section. Savannah is near the centre of the SCP, close to the village of Independence. Big Falls is located on the plain about 25 km southwest of the southern extreme of the Management Area. The time span of climatic data available varies among sites, and ranges between 10 and 40 years.

4.4.3.1 Rainfall

Rainfall doesn't show great variation in the area. Mean annual precipitation ranges from 2,332 mm in the north to 2720 mm in the south, with higher values near the higher elevation hills, such as Middlesex (see **Table 1**). Rainfall near the coast to the north is likely lower, around 2,000 mm.

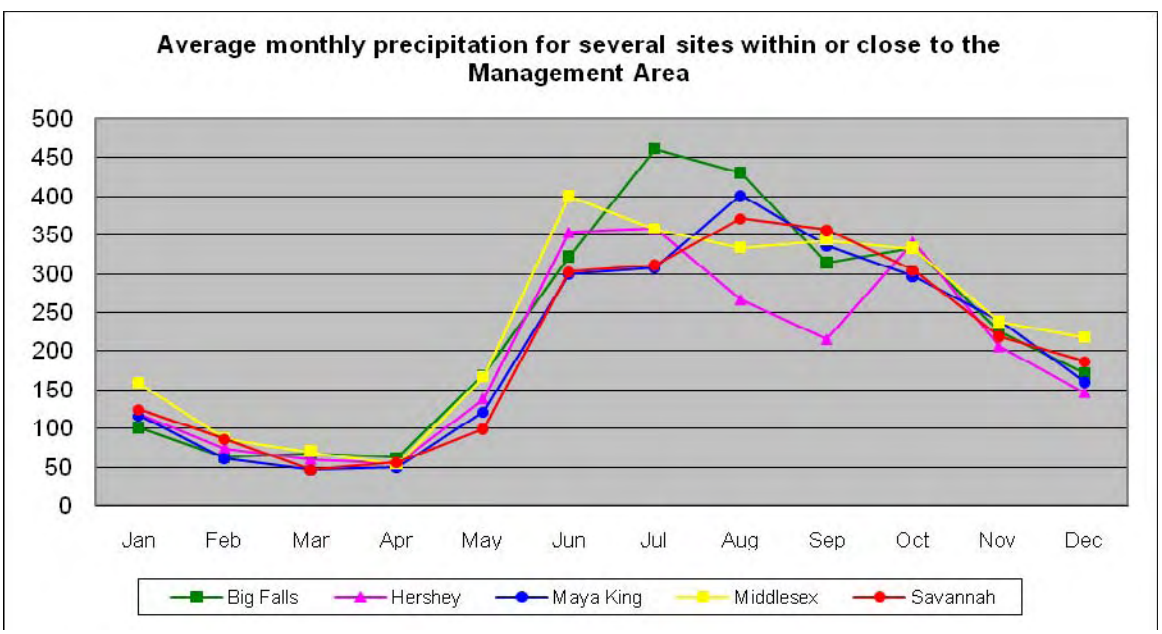
Rainfall distribution is also similar among sites. Average monthly precipitation is low from January to May, with dry months (less than 100 mm) in all sites during February, March and April. Sites closer to higher elevations (Middlesex) tend to have a slightly wetter dry season. The rainfall peak varies from June to August depending on the location (see **Figure 1**). The north (Hershey) seems to have a slight rainfall depression in September.

Table 1. Average annual rainfall at five stations near the management area

Site	Years of data	Average annual rainfall (mm)
Hershey	10	2,331.8
Middlesex	40	2,758.1
Maya King	10	2,430.0
Savannah	24	2,461.4
Big Falls	10	2,719.9

Source: Met Service, 2005

Figure 1. Average monthly precipitation for several sites within or close to the Management Area



Source: Met Service, 2005

4.4.3.2 Temperature

Annual average temperature variation in the management area is low. Annual average daily temperature ranges from 26.3°C to 27.5°C, with the lowest value at Middlesex, the site closest to the highest hills (see Table 2). Annual average maximum daily temperature ranges from 30.1°C at Savannah to 31.5°C at Big Falls in the southern end. Annual average minimum daily temperature varies from 20.5°C to 22.5°C, with the lowest value again at Middlesex.

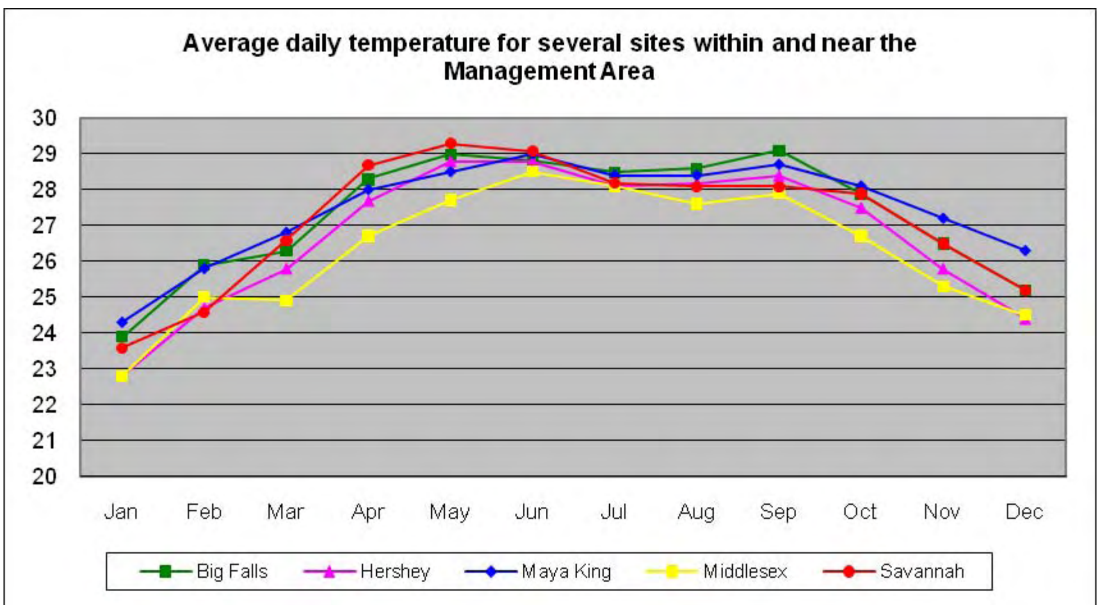
Monthly average daily temperature shows a significant variation throughout the year (see Figure 3). The coolest month is January with all sites having a monthly average daily temperature below or at 24°C. Temperature increases steadily until it peaks in June-July, with values around 29°C in all sites. Then, temperature starts decreasing again towards the end of the year, with a slight increase in September, and a sharper drop after November. The monthly average daily temperature curve is lowest at Middlesex and Hershey; Middlesex being closest to the highest hills, but both sites being furthest inland compared to the other sites.

Table 2. Average daily temperatures at five stations near the management area

Site	Years of data	Annual average daily temperature (°C)	Annual average maximum daily temperature (°C)	Annual average minimum daily temperature (°C)
Hershey	10	26.8	30.6	21.2
Middlesex	15	26.3	30.6	20.5
Maya King	10	27.5	31.3	22.0
Savannah	17	27.2	30.1	22.5
Big Falls	10	27.3	31.5	21.6

Source: Met Service, 2005

Figure 2. Average daily temperature for several sites within and near the Management Area



Source: Met Service, 2005

4.4.3.3 Relative humidity

Table 3 gives an impression of mean annual relative humidity in the project area. Data are available for only two stations.

Table 3. Mean annual relative humidity at two stations

Station	Period	r.h. (%)
Stann Creek	1933-9; 1945-70	79.2
Punta Gorda	1935-9; 1945-51; 1955-66	80.6

Source: Belize Department of Agriculture cited in Johnson and Chaffey, 1974.

4.4.3.4 Wind

Prevailing winds are onshore from the east, from which direction persistent light winds blow throughout the dry season. During the middle months of the year the less stable conditions may produce winds of high velocity; tropical cyclones may occur with associated hurricane-force winds. From October until the end of the dry season, winds remain predominantly easterly to north-easterly, except for occasional spells lasting three-four days during which cool winds blow from the north. Wind is an important factor in fire hazard, and hurricanes can cause severe mechanical damage to forest trees.

Belize is situated within the hurricane belt of the tropics and is periodically subject to hurricanes and tropical storms. The location timing and severity of hurricanes is highly unpredictable. Occasionally there may be two hurricanes within a year but gaps between occurrences of 20 years are also recorded. Hurricanes cause damage across broad swathes of the country, Hurricane Hattie damage was found to be very severe within 10 – 15 miles from the route taken by its centre and severe between 15 - 30 miles from its central path. Natural pine forests appear to suffer less damage than natural broadleaf forests but pine plantations suffer most damage. Plantations are a high risk venture since high levels of investment are confined to relatively small areas.

Table 4. Major hurricanes that have affected Belize during the period 1931 – 2000.

Year	Date	Name	Maximum Sustained Winds (mph)	S_S Scale
1931	Sept 10	…	130	3
1934	Jun 5 -8	...		TS
1941	Sept 28	...	75	TS
1942	Aug 27	...	85	1
1942	Nov 8	…	80	1
1943	...	...	...	...
1945	Oct 3	...	70	1
1960	Jul 15	Abby	70	TS
1961	Jul 24	Anna	70	TS
1961	Oct 31	Hattie	180	5
1969	Sept 3	Francelia	95	1

Year	Date	Name	Maximum Sustained Winds (mph)	S_S Scale
1971	Sept 10	Edith	90	1
1971	Nov 20	Laura	60	TS
1974	Sept 1	Carmen	130	3
1974	Sept 19	Fifi	95	2
1978	Sept 18	Greta	115	3
1998	Oct 22- Nov 9	Mitch	155	4
2000	Sept 28- Oct 6	Keith	120	3
2001		Iris		

4.4.4 Special Features

The Thomas Gomez & Sons License contains hot springs. These features have potential for the development of ecotourism activities; however, any such undertaking will be the subject of a specific development plan and do not form part of the present SFMP.

4.5 Description of the vegetation types

Three broad types of vegetation community occur in the management area: savannah, broadleaved forest and mixed pine/broadleaved forest (locally called Broken Ridge).

4.5.1 Savannah

*This consists typically of a coarse sward of bunch grasses and sedges with scattered (or absent) to rather dense mature pine (**Pinus caribaea** var. **hondurensis**); palmetto (**Acoelorraphe wrightii**) occurs singly or in clumps. Other small trees, shrubs and suffrutices may be present as a discontinuous under-storey. Prominent among these are various species of the **Melastomaceae**, species of oak (mainly **Quercus oleoides**) and craboo (**Byrsonima crassifolia**). Other characteristic species, as recorded by Hunt (1970), include Savannah white poisonwood (**Cameraria latifolia**), Coco plum (**Chrysobalanus icaco**), Calabash (**Crescentia cujete**), Yaha (**Curatella americana**), and (**Ximenia americana**).*

The floristic and physiognomic features of the pine savannah vary with a number of environmental factors, among which drainage, timber harvest and the incidence of fire appear to be the most important.

The most complete study of the Central American savannahs is that by Beard (1953) who defines savannah as:

"...... a plant formation of tropical America, comprising a virtually continuous, ecologically dominant stratum of more or less xeromorphic herbs, of which grasses and sedges are the principal components, with scattered shrubs, trees or palms sometimes present..... The essential point is that the herb stratum is ecologically dominant."

*Hunt comments on the misleading appearance of uniformity of the herb stratum which conceals a considerable variation in species composition, depending on drainage. Only the extremes of wet and dry conditions are conspicuous. The dry extreme is characterized by **Trachypogon spicatus** and **Paspalum pectinatum** and the wet extreme by, **Mesosetum filifolium** and **Rhynchospora globosa**.*

*On the poorer drained savannahs, pine is stunted and sparse and the frequency of other woody species is also much reduced, except for clumps or more extensive blocks of **Acoelorraphe** (Beard's palm phase), **Quercus** and locally abundant **Cameraria**. Bartlett (1935) suggests that the growth of pine may be inhibited by a high concentration of salt in the soil. The very open type of savannah occurs mainly along the eastern edges of the project area on the lower-lying terraces descending towards the sea.*

Under conditions of better soil drainage and a lower incidence of fire, a denser stocking of both pine and other woody species occurs. Eventually this better stocked savannah (Beard's orchard and pine phases) merges into Broken Ridge. There are extensive areas of pine savannah - that is savannah with a woody component predominantly of pine - although the density of pine is very low.

*Orchard savannah is distinguished by having a considerable stocking of woody species other than pine. Two distinct variants are those described by Bartlett as 'nanzal' and `encinal'. Nanzal is distinguished by the predominance of craboo (**Byrsonima crassifolia**). Encinal is pure oak woodland and occurs in the form of isolated, well-defined islands. The trees comprising the oak woodland may be of a considerable size with well-developed bushy crowns. Ground cover under the oak is sparse or absent and a considerable proportion of the ground surface consists of exposed white sand. Patches of encinal occur particularly in the vicinity of Mango Creek.*

4.5.1.1 Savannah development and the role of fire

The origin and maintenance of the Central American savannahs has been the subject of considerable speculation and study.

*Broadly, two main theories of savannah development have arisen. On the one hand, authors such as Charter (1941) and Beard (1953) have attempted to explain savannah as a consequence essentially of edaphic factors, especially soil drainage. In contrast and more recently, the pine savannah of the Miskito Coast - the largest area of **Pinus caribaea** savannah in Central America and similar in many respects to the Coastal Plain of Belize - has been described as a fire disclimax which, in the absence of fire, reverts to broadleaved forest (Munro, 1966; Taylor 1962). The same view is held by Luckhoff (1964) in relation to most of the Caribbean pine savannahs in Central America, although he observes that the pine savannah of the Coastal Plain in Belize appears to be determined exclusively by soil characteristics. Budowski (1956) and Parsons (1955), the latter with reference to the Miskito Coast, envisage savannah development as a consequence of soil degradation which, in turn, is the result of the removal by fire of former broadleaved forest.*

Authors subscribing to either view have tended to see fire as an influence of man and have discounted lightning as a cause. In Belize (and elsewhere in Central America, vide Beard, 1953) the degree of adaptation of the vegetation to fire is such that it seems doubtful whether it could have occurred wholly since man's arrival in the Americas, which Beard quotes as being between 10,000 and 25,000 years ago. In the uplands of Belize, it is well established by observation that lightning caused fires are frequent in pine savannah and occurs occasionally in broadleaved forest. Fire records are not available for the Southern Coastal Plain; although Wolffsohn (1967) reports that lightning-caused fires are unknown there.

Over most of the Southern Coastal Plain, where drainage is poor both externally and internally - the result of topography and the sand-over-clay savannah soils - it seems likely that fire is of much less significance in maintaining the savannah (whatever its origin) than on better sites. Certainly, for practical purposes, the immediate problem on these areas is not the possibility of a return to *broadleaved vegetation but the failure to achieve regeneration of pine because of recurrent fire. On the more deeply draining soils on the plain and in the adjacent foothills, where fairly rapid invasion by broadleaved forest can occur, fire is probably of decisive importance. Here, Luckhoff's conclusion that the development of Broken Ridge is the consequence of the prolonged absence of fire is almost certainly correct.*

4.5.2 Mixed Pine/Broadleaved Forest

This type of vegetation (Broken Ridge) is transitional between broadleaved forest and pine savannah and falls within the marginal forest category described by Hunt (1970).

Broken Ridge occurs on the better-drained soils, which are capable of supporting pine and broadleaved species, the balance between the two apparently being determined by fire. In the absence of fire, pine savannah becomes Broken Ridge, which in turn becomes broadleaved forest. In physiognomy there is a graduation from the early transitional vegetation, having an open structure without canopy closure and with trees and shrubs of various sizes, to the more uniform and continuous broadleaved thicket and woodland with an over-storey of over-mature pine.

Floristically, Broken Ridge is very variable, the species composition probably depending particularly upon soil drainage, as well as on other factors. Common woody species, apart from pine and various Melastomes, are ***Acoelorraphe wrightii***, ***Byrsonima crassifolia*** *and* ***Quercus oleoides***. *As Broken Ridge develops, trees more typical of true broadleaved forest, such as negrito (****Simaruba glauca****), tend to emerge from the low canopy. Broken Ridge thicket does not cast a dense shade and is frequently laced with* ***Scleria bracteata***.

4.5.3 Broadleaved Forest

Strips of broadleaved gallery forest occupy the river valleys. The strips associated with the major rivers are substantial and extend as broad swathes several hundred metres wide. The riparian broadleaved forest on the plain merges with the more extensive blocks of broadleaved forest in the foothills.

*The physiognomic and floristic characteristics of the broadleaved forest are variable. At its most developed it is Cohune Ridge, that is, high forest dominated by the cohune palm (****Attalea cohune****). This type of forest has an open structure near the ground, with few under-storey and shrub species because of the shade cast by the top canopy. Cohune Ridge occurs along the major rivers, chiefly upstream towards the foothills of the Maya Mountains. At the other extreme, broadleaved forest may be only low thicket, with emergent small trees reaching a height of 10-15 m. There may be a sparse herbaceous ground cover, and cutting grass (****Scleria bracteata****) is frequently present. This type of forest occurs along the western edges of the plain towards the foothills and on some of the alluvial fans, between the Trio and Bladen Branches, for example.*

*Merchantable species occurring in the broadleaved forest of the Coastal Plain include mahogany (****Swietenia macrophylla****) and rosewood (****Dalbergia stevensonii****), both of which are exploited on a small scale. Rosewood is of importance in the vicinity of the Bladen Branch of Monkey River and Deep River. Although, at present these species are becoming increasingly scarce, and others like nargusta (****Terminalia amazonia****), santa maria (****Calophyllum brasiliense****) and yemeri (****Vochysia hondurensis****) are being utilized.*

4.6 Description of the principal fauna

*Among the larger mammals, the only species commonly seen on the open savannah is a deer, (**Odocoileus truei**). This is hunted for meat, as are armadillo (**Tatusia spp**.), gibnut (**Paca paca**) and the two wild pigs, peccary (**Tajassu tajacu**) and warrie (**T. pecari**), all of which are found more commonly in the broadleaved forest and Broken Ridg. Four species of cat occur in the area. These are jaguar (**Felis onca**), puma (**F. concolor**) ocelot (**F, pardalis**) and tiger cat (**F. glaucula yucatenica**). Other mammals worthy of note are tapir (**Tapirus bairdii**), kinkajou (**Potos flavus**), quash (**Nasua nasica**), fox (**Urocyon cinereo argentus**), bush dog (**Galictis barbara**), various anteaters (**Tamamdua spp**.) and oppossums of the genera **Caluromys, Didelphis, Marmosa** and **Philander**.*

*Birds that are hunted for meat are the curassow (**Crax rubra**), guan (**Penelope purpurascens purpurascens**) and chachalaca (**Ortalis vetula intermedia**). Two other conspicuous bird species are the oscellated turkey (**Meliagris ocellata**), which is protected (although formerly a game species), and the John Crow or turkey vulture (**Cathartes aura**).*

4.7 Economic environment

4.7.1 Existing physical infrastructure

The principal physical infrastructure that has had the most impact on human activity and development in the SCP is the Southern Highway, which traverses the SCP from its junction with the Hummingbird Highway, between the eastern foothills of the Maya Mountains and the Caribbean Sea. It is interesting to note that the construction of the Southern Highway was started and for the most part completed by the Forest Department in 1970**.** The paving of this 167 kilometer stretch of gravel road which started in 1997, is perhaps the most significant infrastructure impact on the SCP. By 2002 most of the highway with the exception of the section form Golden Stream to Big Falls was paved. All of the major agro-industries processing facilities are also connected to this very important highway. The paving of the Southern Highway has in effect accelerated developmental activities on the SCP.

The upgrading of the Southern Highway has no doubt also facilitated the upgrading and expansion of the national electrical power grid to most of the communities on the SCP as well as the major agro-industries. It is evident that the relative availability of electrical power in most communities on the SCP (with the exception of Bladen, Trio, and Medina Bank) has also had an effect on socio-economic development within the SCP.

Most of the communities on the SCP with the exception of Santa Rosa/San Roman Bladen and San Pablo have potable water which is pumped from a well and gravity fed directly to each household from an elevated tank. A potable water supply system is being constructed for Santa Rosa and San Roman. Community hand pumps remain in use in most villages.

4.7.2 Social infrastructure

History

Unlike other areas of Belize, there is very little evidence of cultivation in the SCP project area during the period of the Maya civilization (300 BC – 900 AD). Similarly, the foothills edging the west of the Coastal Plain were not settled by the ancient Mayas given the paucity of limestone (although this is not the case with their present descendants). With the exception of subsistence farming practiced by the few inhabitants of the coastal settlements, the southern coastal plain remained relatively uninhabited until the late 19th century. The construction of the Southern Highway, which began in the 1960's, contributed immensely to the development of agricultural settlements on the SCP. The introduction of banana cultivation at a commercial scale and the utilization of timber resources with accompanying forest management activities on the SCP also contributed to development of infrastructure and an increase in population on the SCP.

Communities in the SCP Area, near de Deep River Forest Reserve

There are 22 communities in the area as listed in table 5**.** These communities are legally recognized as villages under the Village Council Act. The communities of Santa Cruz and Bladen are the most recently established. There are also other nascent communities such as "Aldana Ville" at the junction of the Trio road and the Southern Highway, and San Pablo near Red Bank that have no legal status as villages. The banana, shrimp, and citrus industries have had a significant effect on the population dynamics of these communities. In some cases these large agro industrial enterprises have also created their own infrastructure to house their workforce and their families.

Table 5. Population of villages near the management area: 2000

Community	Total Population	Male	Female	Household	Average H/H Size
Bella Vista	431	240	191	95	4.5
Bladen	391	213	178	83	4.7
Cowpen	399	226	173	97	4.1
George Town	763	414	349	171	4.5
Hopkins	994	483	511	197	5.0
Independence	2,881	1,447	1,434	636	4.5
Kendall	95	60	35	23	4.1
Maya Centre	293	153	140	55	5.3
Maya Mopan	427	210	217	73	5.8
Medina Bank	93	45	48	17	5.5
Monkey River	176	92	84	40	4.4
Red Bank	657	324	333	111	5.9
Riversdale	685	407	278	196	3.5
San Juan	415	249	166	125	3.3
San Roman	351	166	185	59	5.9
Santa Cruz	54	28	26	10	5.4
Santa Rosa	185	95	90	30	6.2
Silkgrass	728	405	323	165	4.4
Sittee River	312	175	137	83	3.8
South Stann Creek	395	262	133	140	2.8
Swasey	289	173	116	80	3.6
Trio	383	213	170	93	4.1

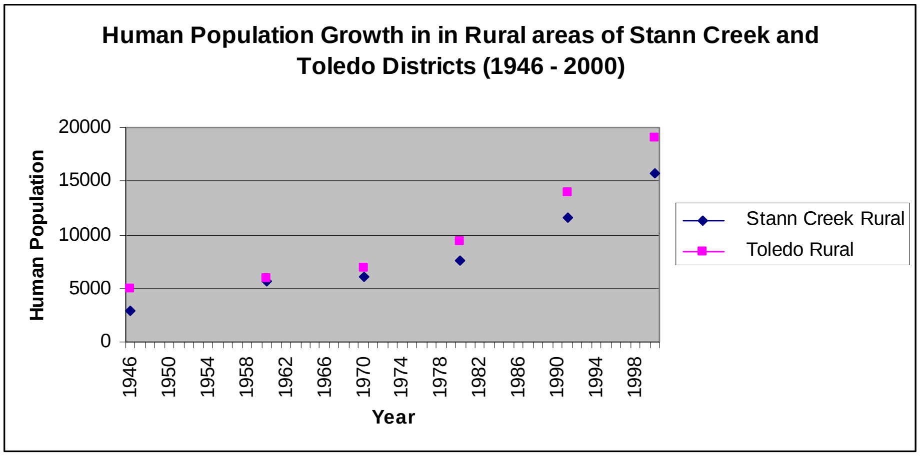
Source: Central Statistical Office

Demographics

The resurgence of the banana industry, the establishment and expansion of shrimp farming on the SCP, and the continued expansion of the citrus industry coupled to the development and modernization of physical infrastructure has no doubt influenced population dynamics on the SCP. The construction of the Southern Highway to Punta Gorda has facilitated the northward migration of predominantly indigenous settlements in what are now the communities of Medina Bank, Maya

Mopan, San Roman, and Santa Rosa. Red Bank was established principally to resettle Guatemalan indigenous immigrants who had unofficially settled in a protected area inside Belize near to the Guatemalan border. Improved road communication and transportation has also influenced the establishment of small farmsteads along the Southern Highway.

Figure 3. Human Population Growth in Southern Belize



Job opportunities in the banana farms and shrimp farms have attracted Guatemalan, Honduran, and Salvadoran immigrants to the SCP whose numbers continue to increase as can be seen by comparing the 1991 and 2000 statistics for the Stann Creek and Toledo Districts.

Table 6. Population by ethnicity (%) for Stann Creek and Toledo: 1991 and 2000

	Total	Mestizo	Creole	Garifuna	Maya	East Indian	Mennonite	Chinese	Other	DK/NS
1991										
Stann Creek	100	23.7	25.1	36.2	8.1	3.8	0.1	0.2	2.9	
Dangriga	100	3.9	21.5	70.3	0.7	1.6	0.0	0.4	1.6	
S.C.Rural	100	34.7	27.1	17.2	12.2	5.1	0.1	0.0	3.6	
2000										
Stann Creek	100	30.2	21.3	31.0	11.9	3.1	0.1	0.4	1.7	0.2
Dangriga	100	11.9	19.7	62.8	1.0	1.4	0.1	0.9	1.9	0.2
S.C.Rural	100	39.8	22.1	14.3	17.6	4.0	0.1	0.1	1.7	0.2

Source: Central Statistical Office

While the Placencia Peninsula is not in the project area, the rapid growth of the tourism industry on this narrow stretch of land has also impacted on population growth not only on the peninsula but has also influenced demographic patterns in communities in the SCP project area as well.

4.7.3 Other resource activities

The resources of the management area undergo the pressure of development activities taking place inside and outside the license boundaries, mainly due to the presence of numerous human settlements and access roads as described in previous chapters. Clearing of forest areas for the practice of agriculture is taking place in some of the areas within the license. These activities are occurring mainly near to villages located in the border of the management area, such Medina Bank and Bladen. In most cases, the agricultural settlements are located on fertile soils occupied by broadleaved forest, however, new settlements have also been found on poor soils in pine forest. There is an urgent need for the MNRE to enforce the laws related to colonization of National Lands and Forest Reserves, to apply a clear policy on sustained resource utilization, and to halt further degradation of forest resources within the management area.

Several NTFP are being used within the management area. Perhaps, the most important is the palmetto (***Acoelorraphe wrightii***). Palmetto is the most abundant palm species in the SCP. It is a small palm of multiple stems that often grows in clumps and occurs profusely throughout the plain. Local people frequently harvest the seeds. The racemes are collected with ripe fruits and transported to an access road were the seeds are removed by thrashing. The seeds are used in the production of a drug against human prostate gland cancer. Despite the numerous palmetto dried racemes found on the access roads, palmetto harvesting occurs mainly as an informal activity. The production volumes and the contribution of this activity to the local economy are unknown.

A similar situation occurs with another palm species, the bay leaf (***Sabal mauritiiformis***). The leaves are harvested for roof thatching. It is becoming very popular for roof construction mainly in tourism facilities. Bay leaf is rather scarce in the SCP; hence, there is a risk of resource depletion if management measures are not taken.

Hunting is a widespread activity in the management area. Several species of animals are caught alive for selling as pets. Spider monkey, yellow-headed parrot, scarlet macaw, and many other less conspicuous species are the subject of illegal trade. However, there is no evidence that such activity occurs in a significant commercial scale. Many other game species, both major and minor, are killed mainly for local consumption, and family subsistence. Among the most important are: deer, pecari, gibnut and quam.

But uncontrolled and illegal hunting is not only a harmful activity for the species concerned, it is also a very damaging activity for the general ecosystem, since it is the main indirect cause of forest fires in pine stands and savannahs. Deer hunters, aware of the fact that deer prefers feeding on newly sprouting areas, set fire to woody vegetation. The fire extends out of control throughout the savannah and pine forests, killing wildlife and natural regeneration of, especially pine.

Paradoxically, some locals see the management of deer for game purposes, as an economically attractive alternative for a sound use of open savannah areas, given the application of proper fire control measures. Regarding the NTFP mentioned above, palmetto appears to be of particularly high economic potential, given its great abundance and natural resilience to fire.

5 Objective and strategy of management

5.1 Objective

The optimized, cost-effective use of forest land and resources in the license area, which provides a secure, predictable and affordable source of timber and other forest products and services for the licensee and other possible stakeholders.

5.2 Strategy

The licensees will gradually introduce active, scientific forest management, and increase the economic stake of local communities in forest management and protection through employment and support for small forest based enterprises.

Both the pine and broadleaf forests are in poor condition as a result of the combined and inter related effects of recent hurricane damage, bark beetle attack, much too frequent burning (often due to arson), logging, and under resourced management. There has been substantial conversion of forestland, which continues. Priority forest areas and forest stands have been identified and these will be brought into improved management which will hopefully halt further land conversion on unsuitable lands, reduce wild fires and forest vulnerability to wild fire, reduce vulnerability to bark beetle attack, reduce vulnerability to land use changes to agriculture, and to a limited extent reduce vulnerability to hurricane damage.

Sustainable Forest Management is a key element in the management of these resources. For the past three years TGS has been working with SFMP, and is the reason why this SFMP is being updated to include more realistic field information.

The adoption of sustained forest management will involve many adjustments that can only be fully achieved over a suitable transition period. It will require a substantial managed investment over a period of years. The transition will provide for a gradual planned development of the businesses with all the advantages of scientific forest management but without unmanageable short-term difficulties. During this period the quantity and quality of wood available from the license areas will be reduced and it will be necessary for the licensees to import wood.

The inventory, which has had to respond to the realities of the limited baseline information and time constraints, provides a basis for broad planning of the entire management area and detailed management at the level of the annual plan of operations area. Successive APO inventories and locally applied practical research will provide a basis for incremental refinements in management and planning.

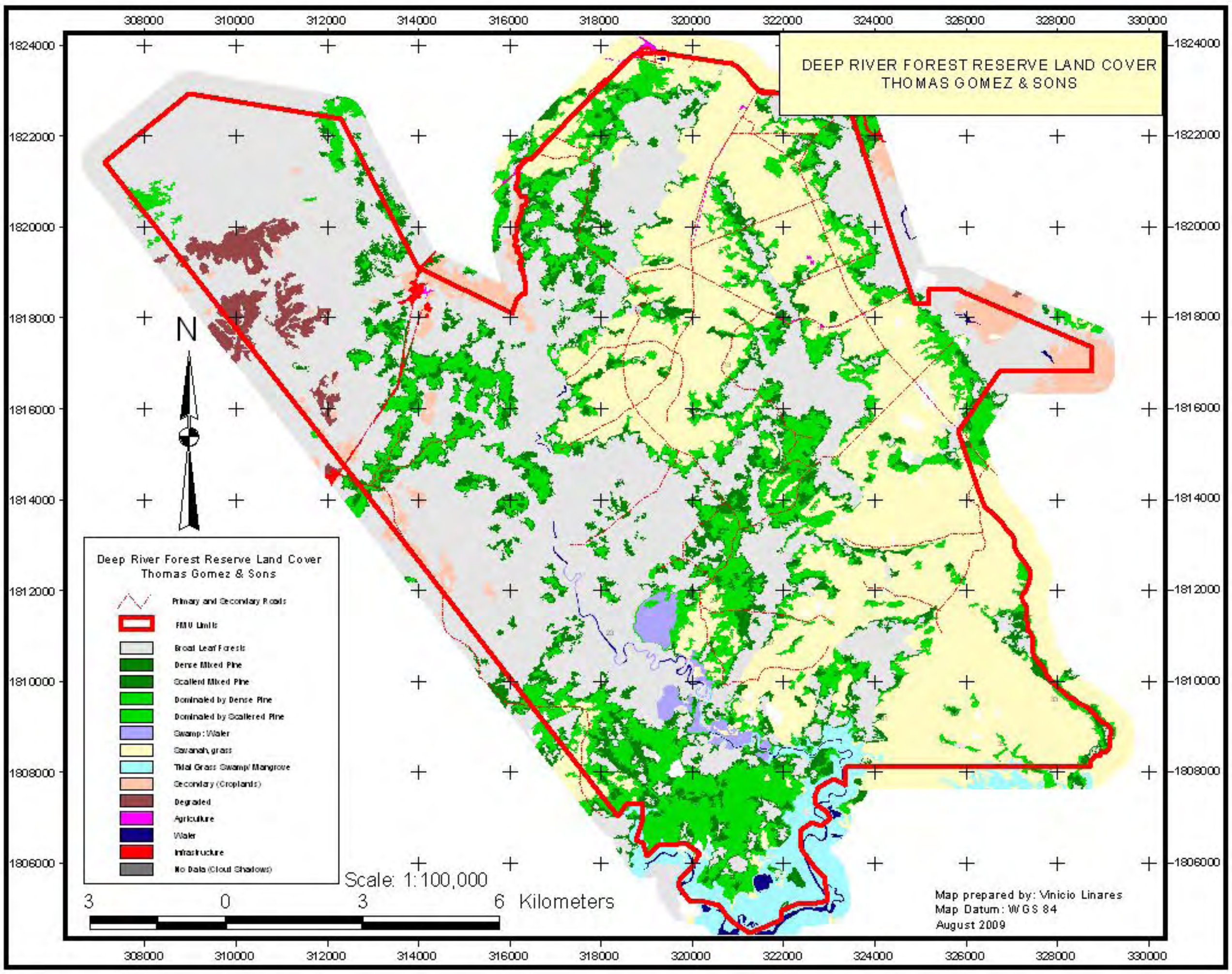
The incremental expansion of forest management activities from timber management to forest management for the sustained utilization of other forest goods and services such as NTFP's or the development of tourism potential whether through community participation or directly by the licensees is also an integral part of this general strategy. However, complementary resource use initiatives will have to be carried out with their own specific objectives, strategies, business and management plans that will have to be developed at the appropriate juncture.

6 FOREST PLANNING

6.1 Forest cover classification

The land cover within Deep River Forest Reserve is shown in **Map 2**.Three general vegetation types (Pine, broadleaved and savannah) were recognized as the most important for the SFMP level, these areas area.

Map 2. Deep River Forest Reserve Land Cover



The pine forest type included from relatively low-density pine stands (<40% canopy closure) to dense pine stands (>70% canopy closure). In most cases, grassland or shrubby areas with scattered pine (density less than 10 to 20 stems/ha larger than 10 cm DBH) were considered as Pine. Mixed pine/broadleaved stands with greater pine dominance were also considered within the pine forest type. Broadleaved forest type contains all broadleaved-dominated areas with varied canopy structure; including dense stands (rarely big trees) and hurricane damaged forest. From a timber production standpoint, the broadleaved forest type present in the Deep River forest Reserve is non-productive; therefore, it is being considered as protection forest.

The savannah type comprise from grassland dominated areas to shrubby broadleaved vegetation with sparse trees interspersed within a grassland matrix. The savannah type was important in being characterized because of the need of subtracting this phase from the pine forest type whose boundaries are often unclear. The final mapping of the pine forest area was only possible at an advanced stage of the forest inventory work. Even though more than 60 points were sampled and most of the area was walked for the supervised classification of the SPOT satellite image, still some gaps were unclear to be classified until after the forest inventory.

6.2 Production forest

For the supervised classification of the SPOT image, the production forests within the FMU area estimates to 5,587.5 ha (26.3%) of Pine of the total area (see table 11). However, it was observed during the forest inventory that pine interacts with savannah and broadleaved areas. The final Pine stratification considered some of this area, only where sampling plots took place to verify pine existence, ascending the productive pine forests to 6090.45 ha. Production forests are located on lands without biophysical limitations, such as steep slopes, unstable soils or endangered ecosystems.

Table 7. Deep River Forest Reserve Land Cover areas.

Land Use Type	Area (ha)	%
Pine: Dense Pine dominated	2190.2	
Pine: Scattered Pine dominated	966.5	
Pine: Mixed Dense Pine	1930.0	
Pine: Mixed Scattered Pine	500.8	
PINE FOREST TOTAL	5587.5	26.3
Broad Leaved Forest	8477.2	39.9
Savannah (Grass with shrubs and pine)	5737.6	27.0
Wetlands	175.8	0.8
Mangrove	386.9	1.8
Water	87.7	0.4
Secondary (Wamil)	314.4	1.5
Agriculture	40.5	0.2
Degraded	293.9	1.4
Infrastructure	28.7	0.1
No Data (Clouds)	113.6	0.5
Total	21243.9	100.0

Timber salvage and logging operations in low productivity broadleaved areas will be planned and executed within the framework of the APO. However salvage of hurricane damaged timber should not be confined to the current APO compartment as timber quality in most damaged species deteriorates very rapidly. Furthermore, soil disturbance caused by logging operations now should enhance conditions for profuse natural regeneration rather than later when damage to newly established natural regeneration should be avoided.

6.3 Non-production forest

Non-production forest consists mainly of open and shrubby savannah without trees of commercial value, or with very few of them, including pine. Broadleaved forests are also included within the non-production forest category. The broadleaved forests covers 8,477.2 ha (39.9%), the savannah covers 5,737.6 (27%) and the rest other classifications represent 1441.6 ha (6.8%) of the total management area. It should also be noted that whilst the objective of management in production forests is optimizing timber production, there are areas in production forests where because of topographic, biodiversity conservation, or other constraints logging should not occur. This detailed planning will take place at the compartment level through the APO.

7 INVENTORY OF FOREST RESOURCES

7.1 Timber resources-management level inventory

The forest inventory was carried out between May 2009 and July 2009. The team in charge of the work consisted of CCAW-Forest Management Specialist, two senior foresters and 6 TGS´ workers divided into 2 field crews. The Supervised SPOT 2009 image analysis and the intensive ground truth survey for pine stratification was carried out during April and part of May 2009. Data analysis and writing of the final report was carried out in August 2009.

7.1.1 Type of inventory and sampling design

Initially, it was intended to carry out a 1% level inventory stratified by forest type; however, major limitations impeded the development of such procedures. These limitations being, at the time of launching the inventory fieldwork, the harsh working situation due to the close and high vegetation associated with pine, the excessive rainy conditions, time limitations to develop an even more detailed Pine stratification, and the development of more sampling plots in the already stratified Pine area.

The development of a preliminary pine stratification map was useful to determine a systematic sampling design for the forest inventory. The distribution of 600 sampling plots (0.1ha) along the classified Pine area (5587.5 ha) was intended to attain a 1% sampling intensity; however, due to the limitations previously discussed, only 377 sampling plots were implemented giving an intensity of 0.67%. Of the 377 Sampling Plots, only 257 (25.7 ha) plots encountered proper Pine forest to carry on the sampling and further analysis; resulting in a sampling intensity of 0.46% for the entire Pine forest. Even though it is a small number it is considered normal for this type and size of forest inventories.

Sample plot location and layout

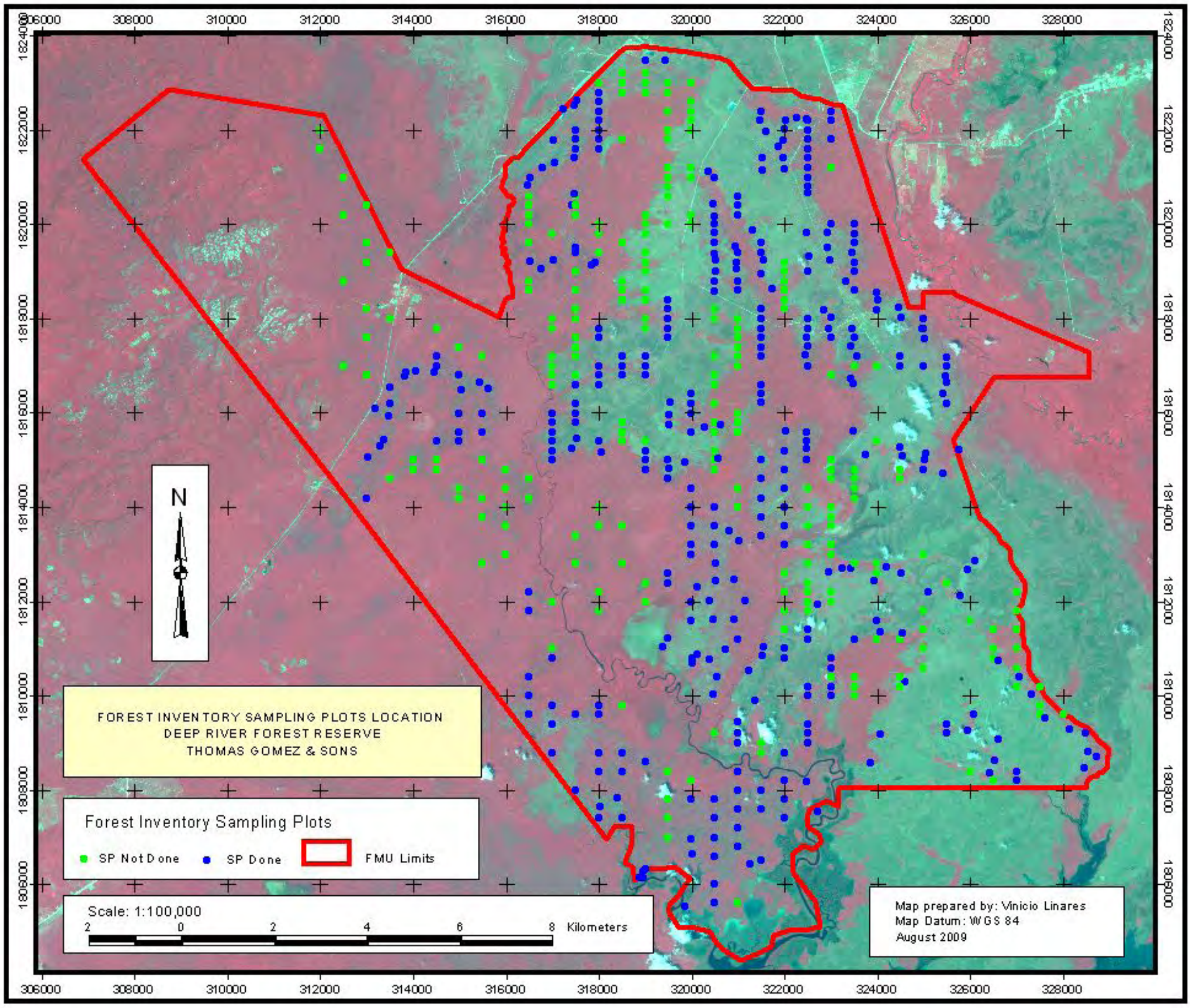
A set of sampling plots was systematically distributed, with the use of GIS Software, along the Pine forest stratified area (see map 2). Vegetation was assessed in points located every 500 m between lines oriented north – southeast – west and 200 m along lines. Using the PROCAFOR methodology, Circular Sampling Plots of 0.1 ha (17.84m radius) were use to gather the required information. The Plot center in the field was located with the use of GPS unit. The DATUM used was WGS 84. Coordinates were previously defined for all plots; however, if the plot center required to be shifted a couple meters to include Pine forest as part of the sampling it was done registering the new set of coordinates.

Tree measurements and data collection

The inventory was focused on Pine forests only; therefore, all Pine trees were measured at breast height (DBH=1.3m) using a diameter tape or caliper. All trees above 10 cm in DBH were measured in the plot. Two representative trees were selected in every plot, and only these were subject to several other measuring such as Age, 5yr increment, bark thickness, total height and damages.

UTM coordinates plus relevant environmental information for every plot were also recorded, including slope, shrub layer, fire occurrence, site quality, soil type. General comments were made by crew heads on aspects such as evidence of bark beetle attack or hurricane damage.

Map 3. Forest Inventory Sampling Plots Distribution



Regeneration

Given the unambiguous evidence that pine regeneration is scant throughout the SCP, mainly because of the annual occurrence of uncontrolled fires, it was decided that recording regeneration information was not essential. Already by 1972, Johnson and Chaffey reported the low density of pine regeneration as a result of fire. Still, existence Pine seedling and saplings were counted in every plot in order to identify regeneration patterns and determine possible treatments.

Detailed stand treatments and management at the compartment level will require updated information on regeneration, but this will be produced by means of specific surveys during the APO elaboration or through the establishment of permanent research sample plots.

Timber volume calculations

The formula or volume table used to calculate volume of the Pine stand is the one developed by the PROAFOR methodology for *Pinus Caribaea*. It is a simple formula that requires overbark diameter and estimated height (mathematical regression) to output the tree gross underbark volume. The equation is:

$$\mathbf{V_{Total} = 0.0684728026 + 0.0000309465 \times D^2 \times h}$$

D = DBH in cm
H = Total height in m, estimated with mathematical regression
V= Volume in m^3

7.1.2 Forest inventory results

The inventory results are presented by general forest type, for the entire production Pine forest area in the Deep River Forest Reserve. The 257 plots sampled in Pine forest provide the following results and analysis.

Frequency Calculations (Trees/ha)
In general, the average frequency present in the FMU shows a decreasing distribution where stem numbers progressively decrease as the diameter increases. This type of distribution is characteristic of young stands, where small individuals are more numerous, and probably reflects the second growth condition of the pine forests in the management area. The scarcity of stems in the larger classes is the result of the frequently repeated logging events that affect the pine forests in the FMU. This is proven by the high frequency of tree stumps found during the inventory work, where most of the sample plots showed stumps belonging to trees harvested rather recently.

The frequency information obtained during the forest inventory is classified into DBH classes in order to obtain a subtotal count, which then is multiplied by a Constant to calculate the corresponding trees/ha. The Expansion Factor for a 1000 m^2 circular plot is 10 (10,000 m^2/1000 m^2) meaning that every stem present in the plot represents 10 trees per ha. This Expansion Factor when divided by the number of plots (257) gives out a constant (0.039) that when multiplied by the subtotal DBH Classes results in the number of trees per ha. The following table presents the number of pine stems per hectare by size class and the total amount of stems per hectare for the entire Pine forest, which is 120.6 trees/ha.

Table 8. Number of pine stems per hectare by size class.

DBH	Sub-Total	Trees/Ha
10	101	3.94506
12	158	6.17148
14	224	8.74944
16	273	10.66338
18	381	14.88186
20	393	15.35058
22	343	13.39758
24	305	11.9133
26	251	9.80406
28	192	7.49952
30	171	6.67926
32	110	4.2966
34	77	3.00762
36	35	1.3671
38	26	1.01556
40	20	0.7812
42	15	0.5859
44	8	0.31248
46	1	0.03906
48	3	0.11718
52	1	0.03906
Total	3088	120.6

Expansion Factor for 1000m²	10
Number of Plots	257
k (EF/Plots)	0.039
# Trees/Ha = (Subtotal*k)	

Height Regression Model

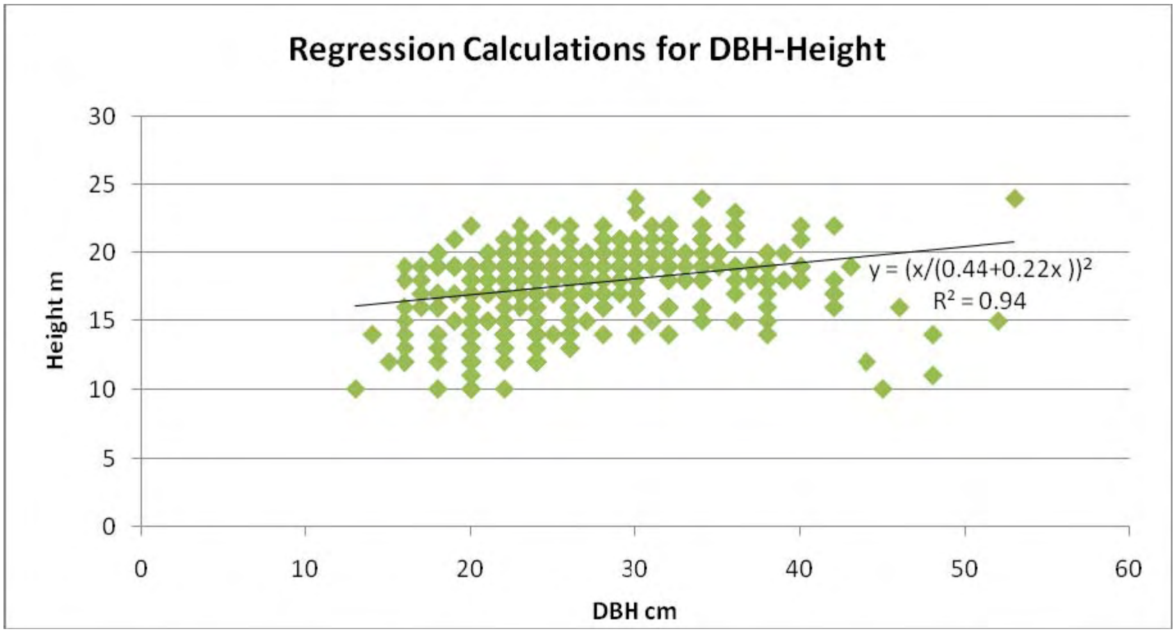
Using a sample of 518 representative trees measured along the FMU, a regression model was carried out to determine the Height correlation to DBH. The following table presents the different regression models applied to the sample, where the Spaniard regression showed up the highest correlation and was chosen to determine height for the DBH classes present (see **table 9**).

Table 9. Height Regression Models

	REGRESION NAME	REGRESION TYPES	COEFICIENT A	COEFICIENT B	COEFICIENT C	R
1	LINEAL	H=A+B*DBH	14.63583801	0.115683907		0.288784605
2	EXPONENTIAL	H=A*e^(B*DBH)	2.679691762	0.006885094		0.279314212
3	LOGARYTMIC	H=A+B*LN DBH	5.803662925	3.65922859		0.331774856
4	PARABOLIC	H=1.3+A*DBH+B*DBH^2	1.086490843	-0.016711522		-0.736926824
5	POTENTIAL	H=A*X^B	2.142885808	0.221206459		0.325937104
6	SPANIARD	H=(DBH/(A+B*DBH))^2	0.436831204	0.222008639		0.940596391
7	NASLUND	H=1.3+(DBH/(A+B*DBH))^2	0.492257213	0.229472715		0.928984132
8	CUADRATIC	H=A+B*DBH+C*DBH^2	4.529180855	0.843461767	-0.012382646	0.412951138

MEAN DBH	26.67	MAX DBH	53	MAX HEIGHT	24
MEAN HEIGHT	17.72	MIN DBH	13	MIN HEIGHT	10

Figure 4. Spaniard Regression Model Calculation for DBH Height



Standing Volume Estimates

The standing volume for Pine forest in the Deep River Forest Reserve is 42.1 m^3/ha. The volume was calculated using the PROCAFOR methodology formula discussed above. Table 15 shows the different DBH classes with corresponding Height (m) estimated with regression model, Volume/tree (m^3) estimated with the PROCAFOR formula, Trees/ha and Volume (m^3/ha) for the productive Pine forest in the FMU.

The following table presents the statistical analysis for the volume estimations and the general forest inventory from the different sampling plots. The Sampling Error (EM) is 2.53 m^3/ha for the entire Pine Forest area resulting in 6.02 %. This value is relatively low, since for this type of inventories and forest the maximum to be considered is 20%. This value also indicates that the forest inventory sampling design was adequate, being able to sample the variability of the forest.

Table 10. Statistical Analysis of the pine volume estimates and forest inventory

1	Total	10776.72	m³/ha	
2	Vol medio	42.09656	m³/ha	
3	St Dev	20.70245	m³/ha	
4	Covar	49.17849	%	
5	sx	1.293903	m³/ha	
6	Em	2.536051	m³/ha	95%
7	EM%	6.024365	%	
8	LC	44.63261	m³/ha	
9	LC	39.56051	m³/ha	

Table 11. Stem density and volume per hectare for Pine according to diameter class

DBH (cm)	Height (m)	Volume / tree (m³)	Trees/ha	Volume/ha (m³)
10	14.16588887	0.112311271	3.94506	0.443074703
12	14.97535761	0.135207429	6.17148	0.834429945
14	15.5967933	0.163075371	8.74944	1.426818175
16	16.08861094	0.19593167	10.66338	2.089293849
18	16.48739916	0.233786448	14.88186	3.479177183
20	16.81720316	0.276646234	15.35058	4.246680147
22	17.09445948	0.324515429	13.39758	4.347721422
24	17.33077777	0.377397106	11.9133	4.496044939
26	17.53458807	0.435293475	9.80406	4.267643344
28	17.7121578	0.498206167	7.49952	3.736307117
30	17.86824252	0.566136413	6.67926	3.7813723
32	18.00651535	0.639085157	4.2966	2.745893287
34	18.12985805	0.717053137	3.00762	2.156623355
36	18.24056304	0.800040936	1.3671	1.093735964
38	18.34047664	0.888049024	1.01556	0.901867067
40	18.43110243	0.981077781	0.7812	0.766417963
42	18.51367725	1.07912752	0.5859	0.632260814
44	18.58922777	1.182198499	0.31248	0.369413387
46	18.65861329	1.290290933	0.03906	0.050398764
48	18.72255852	1.403405005	0.11718	0.164450999
52	18.83650046	1.644698654	0.03906	0.064241929
TOTAL			120.61728	42.09386665

Table 12. Pine Stem density and volume per hectare Inverse Cumulative Average

DBH (cm)	Trees/ha	Inverse Cumulative	Volume/ha (m³)	Inverse Cumulative
10	3.94506	120.61728	0.443074703	42.09386665
12	6.17148	116.67222	0.834429945	41.65079195
14	8.74944	110.50074	1.426818175	40.816362
16	10.66338	101.7513	2.089293849	39.38954383
18	14.88186	91.08792	3.479177183	37.30024998
20	15.35058	76.20606	4.246680147	33.8210728
22	13.39758	60.85548	4.347721422	29.57439265
24	11.9133	47.4579	4.496044939	25.22667123
26	9.80406	35.5446	4.267643344	20.73062629
28	7.49952	25.74054	3.736307117	16.46298295
30	6.67926	18.24102	3.7813723	12.72667583
32	4.2966	11.56176	2.745893287	8.945303528
34	3.00762	7.26516	2.156623355	6.199410241
36	1.3671	4.25754	1.093735964	4.042786886
38	1.01556	2.89044	0.901867067	2.949050922
40	0.7812	1.87488	0.766417963	2.047183856
42	0.5859	1.09368	0.632260814	1.280765893
44	0.31248	0.50778	0.369413387	0.648505079
46	0.03906	0.1953	0.050398764	0.279091692
48	0.11718	0.15624	0.164450999	0.228692928
52	0.03906	0.03906	0.064241929	0.064241929
TOTAL	120.61728		42.09386665	

Figure 5. Pine Frequency and Volume distribution comparison.

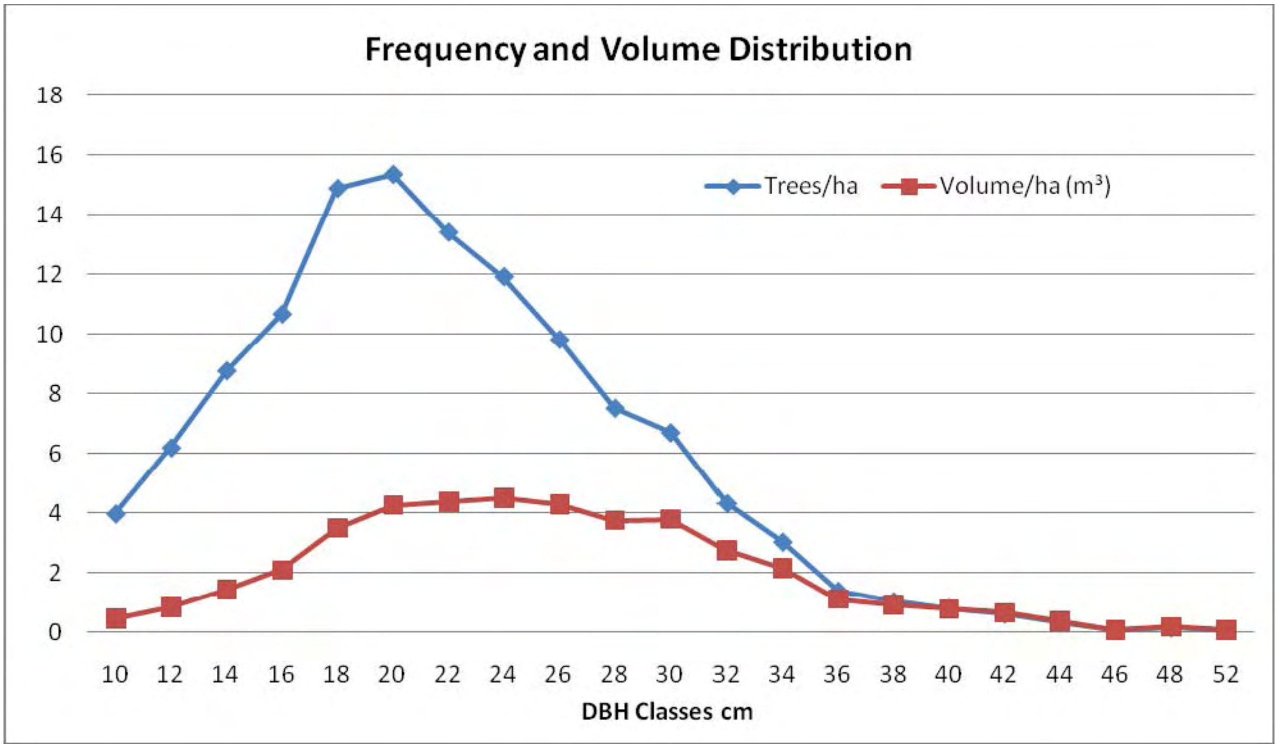
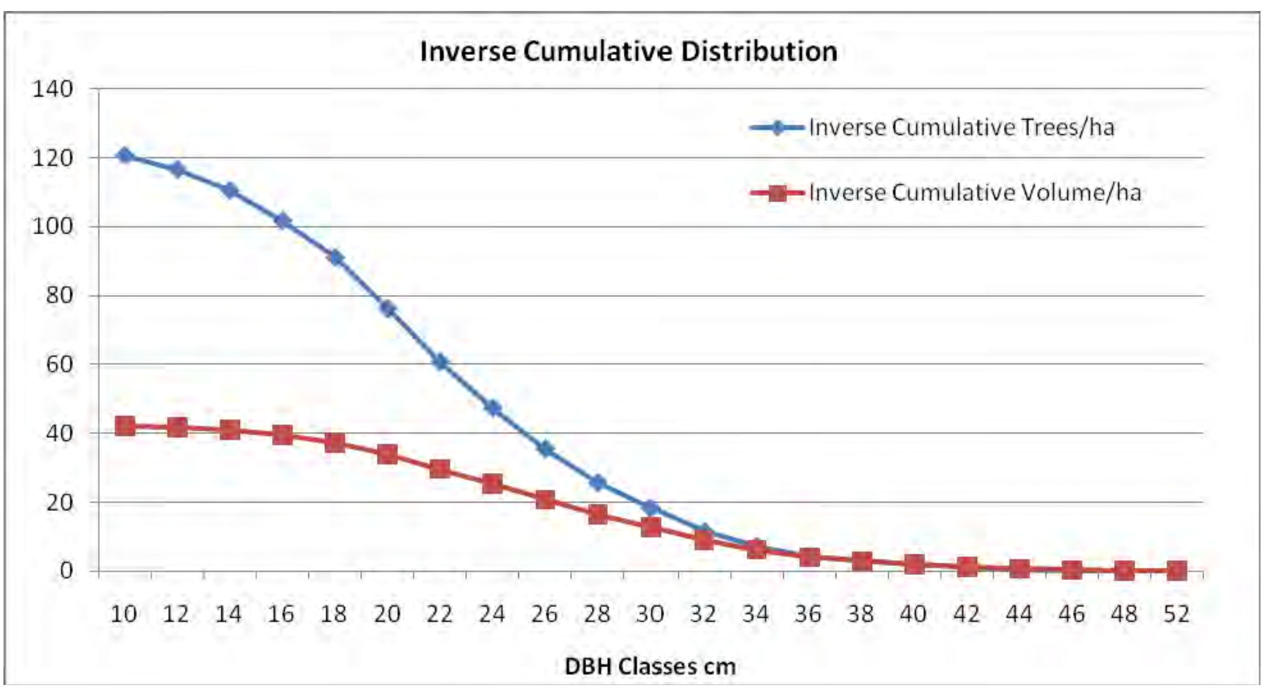


Figure 6. TGS-4 Inverse Cumulative Distribution



Defective timber

Defective timber was analyzed for pine in terms of stem quality (mainly shape) and damaged wood (rotten, burned or mechanically damaged). The total number of defective stems accounted for 2.3% of the sample. The majority of the non-utilizable timber (90%) was due to poor stem quality, whereas, only 10% was due to damaged wood. To a large extent, this reflects the damage caused by the hurricane Iris, which curved strongly and irreversibly some of the stems that did not fall. Average percent damaged wood per tree, in those trees exhibiting defects, was 14.2%, and did not show any trend with regard to the size of the tree. However, total timber losses were high in the larger size classes, but this is likely to be an effect of the small sample size in those classes.

Forest stratification

The forest inventory showed that the overall area figures found for the vegetation types are consistent with those reported by Johnson and Chaffey (1974) in the 1972 SCP forest inventory.

Non-productive forests represent a significant proportion (73.7%) of the total surface of the combined license areas. Management implications of this are very important because it means that for every hectare under production there is 3.8 hectares to take care of. Releasing non-productive land could alleviate this burden; however, most non-productive areas are strongly interlaced with production forests, making operationally difficult to segregate non-productive areas. Another alternative is to transform non-productive areas into productive land, either for timber production or NTFP. Transformation of vegetation into productive forest through reforestation is not seen as a viable option for the savannah areas, due to the low soil fertility and consequent low growth rate and marginal expected income on the investments. However, plantation forestry is considered a very good alternative for the low productivity broadleaved forests, particularly because of the fact that these forests occur on low-lying areas of level terrain and fertile soils where pine would grow very well.

The forest inventory information was also useful to finalize the Pine forest stratification in order to define managing compartments. Using the PROCAFOR methodology, the different Pine sectors were classified in the different types of forest. The methodology usually defines P0-Young Forest, P1-Medium Forest, P2-Mature Forest and PE-Harvested Forest, based on the DBH classes, volume, regeneration and previous harvesting. For the case of Deep River Forest Reserve it was very difficult to classify the area according to those parameters, since all the area has been previously harvested, making it very irregular and with individuals in almost all of the DBH classes.

The present achieved stratification also includes the association of the stand density with broadleaf or savannah. This stratification will have to be validated as the APOs are implemented.

P0- Young/medium mixed scattered forest (988.8 ha)

P1- Young/medium Mixed dense Forest (2101.3 ha)

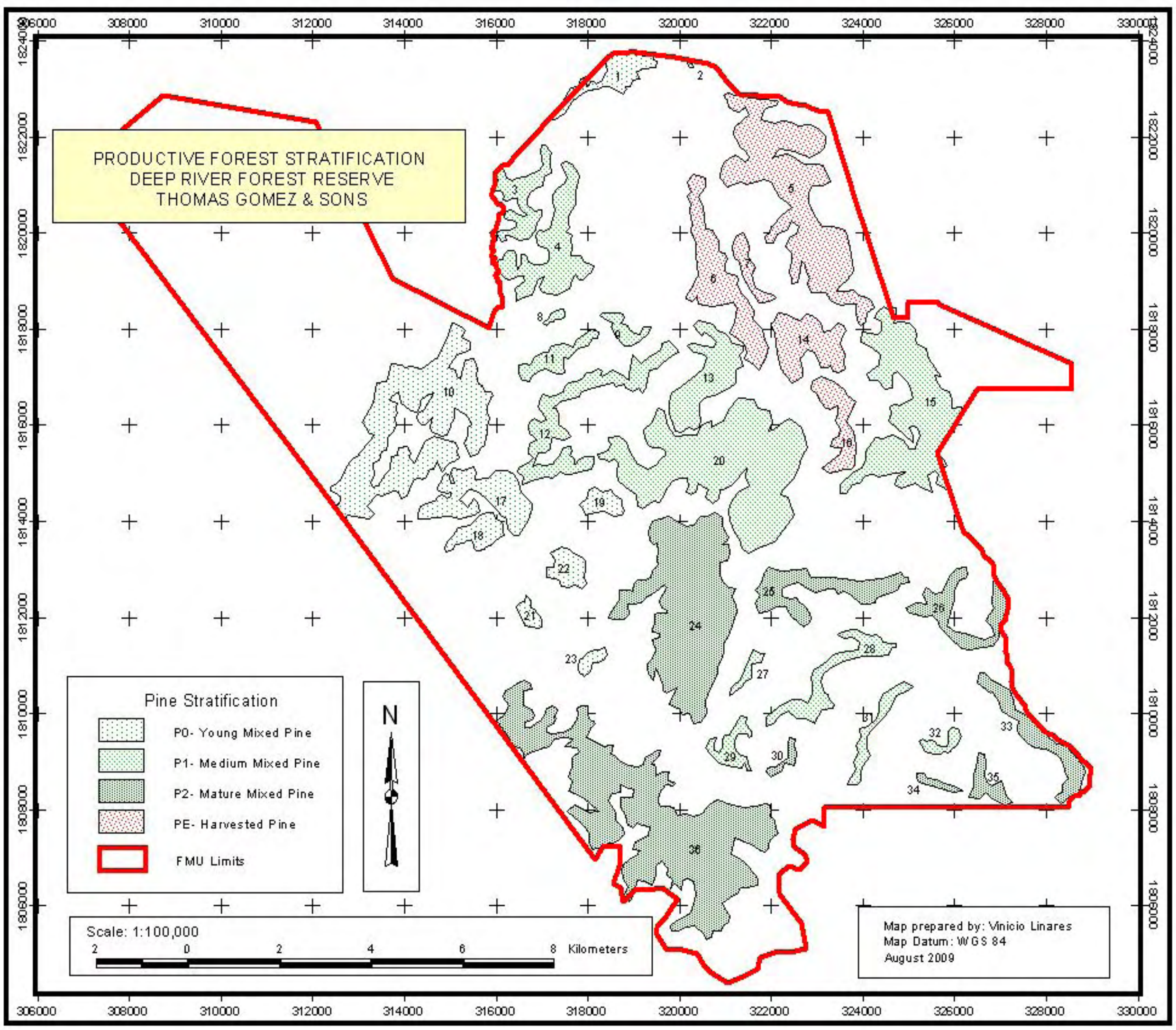
P2- Relatively Mature Forest (11984.3 ha)

PE- Forest Harvested in the last 4 years by TG (1016.0 ha)

Table 13. Pine Productive Forest Stratification Compartments

ID	Ha	TYPE	ID	Ha	TYPE	ID	Ha	TYPE	ID	Ha	TYPE
1	84.9	P0	10	547.4	P0	19	38.9	P0	28	109.0	P1
2	0.9	P0	11	53.3	P1	20	676.7	P1	29	45.1	P1
3	97.3	P1	12	199.3	P1	21	20.6	P0	30	16.0	P2
4	203.1	P1	13	166.1	P1	22	51.4	P0	31	49.5	P1
5	527.1	PE	14	144.4	PE	23	18.5	P0	32	21.8	P1
6	214.3	PE	15	439.4	P1	24	624.8	P2	33	106.6	P2
7	39.0	PE	16	91.2	PE	25	152.7	P2	34	12.8	P2
8	7.1	P1	17	169.3	P0	26	114.6	P2	35	37.8	P2
9	15.7	P1	18	57.0	P0	27	18.0	P1	36	919.0	P2

Map 4. Pine Productive Forest Stratification Compartments



7.2 Pre-harvest inventory

A pre-harvest inventory or commercial census will be the basis for the planning and execution of the harvesting operation; and will be a fundamental part of the APO. The pre-harvest inventory has to reliably estimate the volume of timber that will be extracted from a given compartment.

For pine, the relatively high number of harvest trees per unit area, even in the poor conditions of the pine stands, makes it too costly to carry out a 100% inventory. Alternatively, a systematic inventory stratified by forest type (stand structure), with a reliable estimate of tree density and timber volume above the MCD, is considered appropriate. Statistically, the estimated variables must have a sampling error no greater than 20% for the size class above 30 cm DBH. Stratification according to forest types is necessary, since stands with different size distribution may require different treatments; however, the strata can be combined for the statistical analysis of density and volume of harvest trees. This is due to the fact that, from a statistical point of view, tree density above MCD may be low. Furthermore, such procedure has no effect on the harvesting operational aspects.

Given the relatively small size of the harvesting compartments (200-300 ha of effective productive pine area), the mapping of the forest/vegetation types will be done by tracking the area by foot, and recording the forest/vegetation boundaries by means of a GPS receiver. This will finish consolidating the compartments already identified.

Sample plots for the pine inventory will be located at grid points. The grid will be a subdivision of the cartographic grid (UTM); the density will be according to the size and distribution of forest types. A separation no greater than 200 to 500 m is likely to be suitable for most cases; however, it can be narrowed to 100 m if necessary. Given the relatively low stocking of the forest, plot size can't be too small. A size of 500 m^2, 1,000 m^2 or 2,000 m^2 is recommended, depending on the size and density of the stand.

The diameter of all trees above 10 cm DBH will be measured with a diameter tape. Regeneration from seedling to 10 cm DBH will be sampled in one fourth of the area of each sample plot. Regeneration will be recorded as counts of individuals per size class.

Tree volume will be estimated using PROCAFOR´s volume table. However for the near future the construction of a two entry table, using DBH and commercial height is recommended. Such a table would be more reliable at estimating real volumes under the present growing conditions that pine trees undergo in the FMU and SCP. Ideally, the initiative for the elaboration of this tool should be of the FD, in cooperation with research organizations.

Defective timber will be assessed following the same procedures applied in the present inventory

7.3 Post-harvest inventory

The post-harvest inventory is the basis for the application of thinning or sylvicultural treatments; however, they will be carried out only when economically and sylvicultural justifiable. Low density pine stands and low productivity broadleaved forests more than likely do not need a post-harvest inventory. However, for those stands that are productive enough to substantiate post-harvest inventories and further treatments, the inventory procedures to be applied will be basically the same as the ones described for the pre-harvest sampling inventory with some modifications in order to decrease costs. In line with this, the requirement for meeting statistical reliability will be based on a sampling error of 20% of the average basal area estimate for the remaining tress above 10 cm DBH.

For those cases where logging damage is very low, a post-harvest inventory is not considered necessary for the application of thinning, which can be based on the pre-harvest inventory data.

Since regeneration estimates will be obtained from the pre-harvest inventory; the post-harvest inventory will not include regeneration counts; except for those cases where logging had caused significant changes to the regeneration density.

7.4 Non-timber forest resources

As discussed in chapter 4.8., palmetto (***Acoelorraphe wrightii***) is assumed to be the NTFP of higher economic potential in the management area. However, detailed studies are required in order to confirm this assumption; and to produce baseline information for the elaboration of a specific SMP.

If the economic feasibility of sustained management of palmetto were eventually verified, it would certainly represent an interesting option for greater involvement of the neighboring communities in the management activities of the area, including fire prevention and control.

8 SILVICULTURAL SYSTEM

The planning of forest activities for the following five years 2010-2015 should consider the following as priority:

- Thinning for P1 dense areas (>20 m^2 of basal area / ha)
- Seed trees along the selective cut
- Completion of the PE areas with little regeneration, and
- Forest fire protection

8.1 Regeneration method

Stand density and structure in those forests subject to harvesting will be restored through natural regeneration. Since the major obstacle for natural regeneration in the has been fire, the mechanism to enhance natural regeneration will be the implementation of a fire control program by the licensees. Although fire suppression is necessary to avoid pine seedling mortality during the early stages of the stand development, the complete absence of fire will lead to an increase of the broadleaf dominance, which eventually will be detrimental to the pine growth and regeneration. Also, the steady accumulation of burning material in fire protected areas increase the risk of wild fires. Thus, along with fire suppression measures, controlled burning will be an important activity of the fire control program. More details on such a program are given in section 18.3.

Pine stands with a dense broadleaved under-storey, which inhibits pine regeneration, will be subject of repeated prescribed burning events, in order to promote the formation of a park like condition which would be suitable for pine regeneration. Whenever possible, previous to the burning of these areas, cutting or felling of the broadleaved component will be desirable, either manually (with machetes), or mechanically (with tractors or bulldozers). This procedure will also reduce the prescribed fire damage.

In those areas where despite fire control measures, regeneration keeps at low levels, soil scarification techniques and drainage improvements will be tested. Soil scarification will be done by means of an agricultural plow attached to a wheeled tractor. Drainage improvements, particularly in those areas where impeded drainage is likely to be the limiting factor for regeneration; will be made by digging canals with a hydraulic excavator or back hoe.

8.2 Post harvest treatments

Post harvest treatments will vary according to stand density and level of competition. In general, thinning will be necessary in those stands where a significant proportion of trees of future harvest remain suppressed either by commercial or non-commercial trees. Nonetheless, thinning will be implemented when it is economically justifiable, which means, that thinning operations, when sylviculturally needed, will be applied to those stands producing enough economic return to cover the costs of post-harvest treatments.

Given the heterogeneous nature of the pine stands, thinning will be applied following the procedures of the so-called “free method” (INAB, 2001) recommended for natural stands. It is based on the principle of identifying focal desirable trees and eliminating the ones that cause strong competition to them. Thinning intensity is regulated by considerations on crown spreading condition and, optionally, on basal area reduction criteria based on post-harvest inventory information.

In pine / broadleaved mixed stands, or in stands with high occurrence of low stem quality pine trees, liberation thinning may be necessary. Elimination of undesirable trees will be done by means of felling or using the poison-girdling technique. Stands with high density of good quality pine stems will be treated by means of commercially oriented thinning, reducing the remaining basal area by at least 25%.

Post-harvest treatments or thinning may or may not be part of the APO for harvesting operations, which will depend on the particular structure of the stands occurring within the compartment being harvested. If stands where very little harvesting will take place are present in the compartment, then, it is convenient to schedule a post-harvest treatment at the same time that more productive stands are being harvested. This will increase the volume extracted from the compartment, and will also make a more efficient use of the resource investment for the harvesting operation. However, if the compartment only has stands where significant logging will occur, then it is not possible to determine a priori the need of post-harvest treatments. In such a case, the post-harvest treatment has to be planned and executed as part of a subsequent APO.

According to the results of the forest inventory, it is expected that in general terms most pine stands in the license area will not require post harvesting treatments, since the majority show a rather high level of canopy opening and low stem density.

8.3 Supplementary planting and plantation forestry

Supplementary planting is not considered economically feasible as part of the sylvicultural treatments in none of the production forest types (pine and broadleaved) within the license areas. Natural pine stands in the SCP occur where the soil fertility is low or marginal to the development of broadleaved forest (King et al, 1989). Planted pine in these soils is not expected to show optimum growth rates, as can be seen in the poor developed pine plantations near Independence (except for the areas were mixed pine/broadleaved forest occur, which are not extensive). If the licensees are to engage in plantation forestry, the better soils (naturally occupied by broadleaved and broadleaved/pine forests) have to be chosen for this purpose in order to optimize the cost/benefit ratio of the investment.

8.4 Broadleaved forests Protection

The Deep River Forest Reserve has 39.9% of broadleaved forest, which was seriously affected by hurricane Iris and later rapidly salvaged by TGS reducing its economic and productive potential. This forest requires special attention to be protected against fire, in order to increase the recovery rate of the forest. As the plan evolves, some alternatives to be considered are the enrichment of these areas with valuable timber species, such as Mahogany, Rosewood, Santa Maria, among others. In the future, the area might also be considered as part of a REDD program initiative that would come to strengthen the TGS process being implemented in the Deep River Forest Reserve.

8.5 Death and over mature trees

Trees with high percentage of defects or Death and over mature trees will be marked and protected during harvesting operations. These trees will not produce lumber anymore; therefore, their environmental characteristics will play an important role as habitat for different birds and insects species contributing to create an adequate balance in the ecosystem.

9 GROWTH AND YIELD

9.1 Growth and forest regulation

The basic principle of any SFMP is the conservation of the forest, maintaining the productive capacity, in order to guarantee a maximum sustainable yield. To achieve this maximum sustainable yield, as a general rule, no more than what the forest could grow and naturally or artificially recover could be extracted from it. For this, the forest dynamics need to be understood, since changes occur in the frequency, dimensions, and form of trees over a period of time. These changes are usually named growth or increment.

Growth needs to be defined in relation to a variable or parameter against its period of time. The most important variables that require their growth rate to be estimated are volume, height, DBH and basal area. The method used to identify the increment was the counting and measuring of rings from increment borings at DBH in order to project an increment table to estimate the forest growth and behavior.

In irregular forest like the present in Deep River Forest Reserve, the renovation of the forest cover is produced continuously by incorporation of new individuals into the upper diametric classes and the decrease on the existent cover by natural mortality of selective harvestings. Therefore, there is no continuity in the forest cover, which is composed by trees of all the possible size classes. In this case it makes no sense to consider age as a reference to calculate the medium increment. In irregular forests, the growth rate is estimated by its Current Annual Increment (CAI)

Diameter Growth Projection

Table 18 show the summary of the calculation for the diameter growth, using the 5 yr increment and bark measurements for the representative trees measured in the sampling plots (complete table in appendix). The increment of the forest stand in the Deep River Forest reserve is 2.38 cm for every five years, being the annual increment 0,47 cm.

Table 14. Diameter growth analysis for the Deep River Forest Reserve.

No.tree	DBH ob	Bark	DBH ib	Incr (5yrs)	Dbh ib	dbh ob	Periodic DBH ob	Periodic Yearly dbh ob increment
No.	D	B	d= (D-2B)	L	dp=d-2L	Dp=K(dp) k=D/d	ΔD=K(2L)	ΔD/5
1	19	1.8	15.4	0.7	14	15.1144	1.51144	0.302288
2	19	1.8	17.2	0.8	15.6	16.84176	1.72736	0.345472
3	31	2.2	28.8	1	26.8	28.93328	2.1592	0.43184
508	38	1	37	1.2	34.6	37.35416	2.59104	0.518208
509	53	2.5	50.5	0.7	49.1	53.00836	1.51144	0.302288
Total	13571	750.4	12818.8	561.32	11696.16	12627.17	1212.002	242.4004
Average	26.66208	1.474263	25.18428	1.10279	22.9787	24.80781	2.381144	0.476229

5 yrs cm	2.381144
1 yr cm	0.476229

Basal Area Growth Projection

Table 15 shows the change in basal area, with respect to a change in diameter, which can be approximated as the first derivative of the following basal area. The Basal Area of the Deep River Forest Reserve grows at a rate of 2.46% every year.

Table 15. Basal area growth projection analysis for the Deep River Forest Reserve

DBH (cm)	I DBH/yrs	M	Actual Trees/ha	BA m2	Future Trees/ha	Move 0 Class	Move 1 Class	BA1 m2/ha	BA2 m2/ha
10	0.30	0.15	3.94506	0.008	3.353	3.353	0.592	0.031	0.026337
12	0.30	0.15	6.17148	0.011	5.830	5.239	0.933	0.070	0.065941
14	0.39	0.19	8.74944	0.015	7.982	7.049	1.700	0.135	0.122873
16	0.54	0.27	10.66338	0.020	9.495	7.795	2.868	0.214	0.190913
18	0.53	0.27	14.88186	0.025	13.778	10.910	3.972	0.379	0.350617
20	0.51	0.25	15.35058	0.031	15.418	11.446	3.904	0.482	0.484382
22	0.51	0.26	13.39758	0.038	13.876	9.971	3.426	0.509	0.527457
24	0.47	0.24	11.9133	0.045	12.524	9.098	2.816	0.539	0.566571
26	0.48	0.24	9.80406	0.053	10.275	7.460	2.344	0.521	0.545545
28	0.47	0.23	7.49952	0.062	8.092	5.748	1.752	0.462	0.498276
30	0.43	0.22	6.67926	0.071	6.987	5.235	1.444	0.472	0.493889
32	0.55	0.27	4.2966	0.080	4.564	3.120	1.176	0.346	0.367065
34	0.48	0.24	3.00762	0.091	3.456	2.280	0.728	0.273	0.313786
36	0.46	0.23	1.3671	0.102	1.780	1.052	0.315	0.139	0.181208
38	0.44	0.22	1.01556	0.113	1.106	0.791	0.225	0.115	0.125395
40	0.41	0.20	0.7812	0.126	0.847	0.622	0.159	0.098	0.106394
42	0.50	0.25	0.5859	0.139	0.600	0.440	0.145	0.081	0.083088
44	0.28	0.14	0.31248	0.152	0.414	0.269	0.044	0.048	0.062967
46	0.60	0.30	0.03906	0.166	0.071	0.027	0.012	0.006	0.011818
48	0.30	0.15	0.11718	0.181	0.111	0.099	0.018	0.021	0.020136
52	0.24	0.12	0.03906	0.212	0.052	0.034	0.005	0.008	0.011071
TOTAL	9.20	4.60	120.62	1.74	120.61	92.04	28.58	4.95	5.16

M=I/C
IBA = BA2-BA1
IBA = 0.21 m2/ha
IBA%= IBA/(BA1+BA2)*trees/ha
IBA%= 2.464033

M= Growth rate
I= DBH periodic Increment in cm
C= Class Interval

Stand Table Projection

The estimation of periodic volume growth can be determined by the movement of trees from one diameter class into the next diameter class. The stand table, the average volume by diameter class, and periodic diameter growth values were required for these calculations. The periodic diameter growth can be estimated from increment borings (table 18) or from permanent plot data. Movement of trees into the upper diameter classes is based on the assumption that trees are evenly distributed throughout a diameter class and that all trees within a diameter class grew at an identical rate, equal to the estimated average diameter growth rate (The Forestry Handbook). **Table 16** presents the calculations for the periodic volume growth.

Table 16. Calculations of Periodic Volume Growth by Stand Table Projection

DBH	IDBH (5yrs)	Actual Trees/ha	Trees Rising	Trees Stationary	Future Trees/ha	Vol/tree (m3)	Present Stock	Future Stock
10	0.70	3.95	1.38	2.56	2.56	0.11	0.443075	0.287999
12	0.70	6.17	2.16	4.01	5.39	0.14	0.83443	0.72907
14	0.90	8.75	3.94	4.81	6.97	0.16	1.426818	1.136996
16	1.25	10.66	6.64	4.02	7.96	0.20	2.089294	1.559269
18	1.24	14.88	9.20	5.68	12.33	0.23	3.479177	2.881755
20	1.18	15.35	9.04	6.31	15.51	0.28	4.24668	4.290083
22	1.18	13.40	7.93	5.46	14.50	0.32	4.347721	4.706924
24	1.09	11.91	6.52	5.39	13.33	0.38	4.496045	5.029694
26	1.11	9.80	5.43	4.38	10.90	0.44	4.267643	4.742614
28	1.08	7.50	4.06	3.44	8.87	0.50	3.736307	4.419996
30	1.00	6.68	3.34	3.34	7.39	0.57	3.781372	4.184926
32	1.27	4.30	2.72	1.57	4.92	0.64	2.745893	3.141727
34	1.12	3.01	1.69	1.32	4.05	0.72	2.156623	2.901292
36	1.07	1.37	0.73	0.64	2.32	0.80	1.093736	1.859159
38	1.03	1.02	0.52	0.50	1.22	0.89	0.901867	1.087154
40	0.94	0.78	0.37	0.41	0.93	0.98	0.766418	0.915124
42	1.15	0.59	0.34	0.25	0.62	1.08	0.632261	0.666801
44	0.65	0.31	0.10	0.21	0.55	1.18	0.369413	0.647628
46	1.40	0.04	0.03	0.01	0.11	1.29	0.050399	0.146156
48	0.70	0.12	0.04	0.08	0.10	1.40	0.164451	0.145265
52	0.55	0.04	0.01	0.03	0.07	1.64	0.064242	0.114029
52					0.01	1.77	0	0.019043
TOTALS	21.30	120.62	66.19	54.43	120.62	15.72	42.09	45.61
						5 yr volume growth		3.52 m3/ha
						1 yr volume growth		0.703m3/ha

The periodic growth in table 20 is survivor growth since no allowance was made for in-growth or mortality. Mortality data can be estimated from permanent growth plots. Annual mortality rates can be estimated for individual species groups and diameter classes. These annual rates can be estimated for individual species group and diameter classes. These annual rates can be used either to reduce the number of trees in the present stand table (column 3) before projecting the movement of trees or to reduce the number of trees in the predicted stand table (column 6) after projection. In-growth can be estimated by inventorying the smaller diameter classes and including them into the the stand table projections process. Like mortality, in-growth information can also be estimated from permanent plot records (The Forestry Handbook).

9.2 Calculation of cutting cycle and annual allowable cut

Several possibilities were analyzed to define the Annual Allowable Cut (AAC) for the Deep River Forest Reserve; initially the concept of managing area was considered. On the other hand, having knowledge about the forest's growth from information directly coming from the field allows the making of adequate decisions towards considering harvesting the forest increment.

The following table presents a summary of the Annual Allowable Cut for the Deep River Forest Reserve. TGS will be harvesting around 60% of the growth/year in approximate 200 ha of Pine.

Table 17. Annual Allowable Cut for the TGS FMU

Annual Allowable Cut Volume over bark allowed to be harvested yearly. Do not harvest more than the forest's growth AAC=Annual Growth		
Annual Growth	0.7	m^3/ha/yr
Total Area	6,090	ha
Volume	42.1	m^3/ha
Total Volume	256,389	m^3
Growth	4,263	m^3
Growth	767,340	bf
Owner Desired Harvest	2500	m^3
	450,000	bf

Given the heterogeneous population structure of the natural pine stands these will be treated under a polycyclic harvesting scheme; which means that the standing biomass will be only partially removed during each intervention, and that the time period between interventions (cutting cycle) is enough to allow for the reposition of the harvested volume by the remaining trees. Annual or periodic cohorts of naturally regenerated trees enter the system replacing the ones that grow to the larger size classes or die.

Then, the cutting cycle depends upon the growth rate of the remaining stand, which in turn is a function of the stem density, size and growth rates of individual trees.

Despite of the fact that the assumed growth rate is not high and the average stem distribution projected does not correspond to a rich stand condition. The Pine forests of Deep River, in spite of their poor looking conditions, have the potential to recover the actual harvestable timber stockings in a relatively short period of time. Why is it then, that actual average harvestable volumes are so low (12 m^3/ha)? The reason seems to be clear; they have been the subject of too frequent repeated logging, where the volume increment is being removed continually, and not enough time and protection has been provided to any given stand, so it can accumulate higher timber volumes. The alternative answer would be that the average diameter growth rate is 4 mm/year, which may be the case for some of the poorest soils. These findings are certainly encouraging for the licensee, since they imply that forest restoration in the management area is mainly a matter of not too long periods of time coupled with the implementation of effective protection measures.

Calculations were made for the range of values of the indicated variables that were considered possible, according to the existing information on growth rates mentioned above and the information present in Table 15. Nine different scenarios were projected with the previous information. One different harvesting protocol was considered feasible in conformity with the low stockings found in the larger size classes:

The following table presents nine scenarios that are projected based on volume increment and the information present on the **table 18** above the proposed MCD.

Table 18. Annual Harvesting Scenarios for TGS FMU

Annual Harvesting Scenarios								
Scenario	MCD	# AHB	Available tree/ha	Volume m^3/ha	Cutting area (ha.)	Total No. trees	Total Vol. m^3	Total Vol. (bd. ft.)
1	30	30	18.2	12.7	200	3648.2	2545.3	458,160.33
2	30	34	18.2	12.7	175	3192.2	2227.2	400,890.29
3	30	40	18.2	12.7	150	2736.2	1909.0	343,620.25
4	25	30	35.5	20.7	200	7108.9	4146.1	746,302.55
5	25	34	35.5	20.7	175	6220.3	3627.9	653,014.73
6	25	40	35.5	20.7	150	5331.7	3109.6	559,726.91
7	25	50	35.5	20.7	120	4265.4	2487.7	447,781.53
8	25	60	35.5	20.7	100	3554.5	2073.1	373,151.27
9	35	17	7.3	6.2	360	2615.5	2231.8	401,721.78

30 - 100: Cutting of all trees above 30 cm DBH Average timber volume to be actually harvested under this protocol is 12.7 m^3/ha.

9.3 Division of the forest into annual harvesting units

The location, shape and size of the compartments were defined by the existence of Productive Pine Forest, the annual allowable cut, the accessibility of production forest, the productivity of the stands, the connectivity of the road system within the area, and the presence of natural barriers, such as rivers, swamps or hills. The pine forest in the Deep River Forest Reserve was divided into 36 Compartments in relation to forest cover and structure.

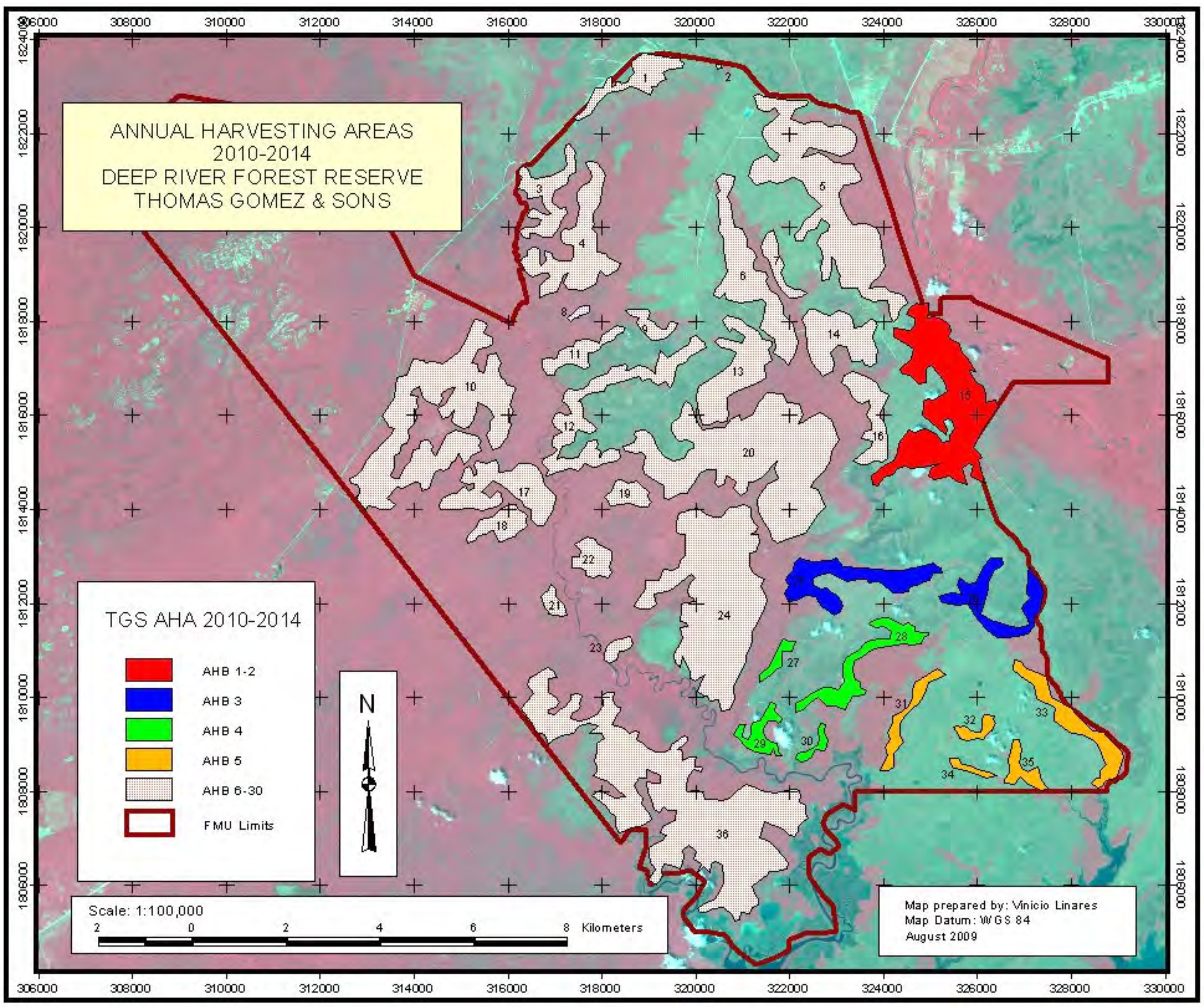
Table 19. Annual Harvesting Blocks for 2010-2014

Compartment	Acres	Hectares	Total Ha/yr	Type	AHB Year
15	1085.839	439.425	439.425	P1	**1 & 2**
25	377.277	152.679	267.254	P2	**3**
26	283.12	114.575		P2	
27	44.42	17.976	188.078	P1	**4**
29	111.474	45.112		P1	
30	39.589	16.021		P2	
28	269.267	108.969		P1	
33	263.312	106.559	228.486	P2	**5**
35	93.335	37.771		P2	
34	31.751	12.849		P2	
32	53.907	21.815		P1	
31	122.298	49.492		P1	
TOTAL	**564.603**	**1123.243**			

The system of compartments shown in Maps 4 and 5 should not be considered as definite for the total length of the cutting cycle, since increased operational field experience and forest knowledge may determine the convenience of adjusting boundaries and locations. It is recommended that the compartmentalization be revised within a five-year period. That is why only the first five compartments are being suggested to start working with. In addition, these five blocks have most of the mature forest (higher DBH classes) and needs to be harvested before it deteriorates.

The intention is that TGS will work towards harvesting 2,500m^3 of logs in approximately 200 ha of pine forest every year in a rotation cycle of 30 years with a 30 cm MCD. The area does not have to be fixed, since the 2,500m^3 could be harvested in less area, leaving area for next's year APO. In other words, the compartments are formed by volume and not by area.

Map 5. Annual Harvesting Blocks for the years 2010-2014.



9.4 Schedule of timber production

Timber production will commence February 2010 for pine forests. The bulk of the timber harvesting will take place within the months of the dry season, from February to May of every year. Because of the size and production volumes, sometimes it will be necessary to implement wet season operations, otherwise harvesting of any given compartment won't be completed the same year, and the industry would run out of supply for extended periods.

Whenever a wet season harvesting operation takes place, the professional supervision will be more intense. Skidding and transportation activities will be suspended during heavy rain. The intensity of activities during dry days will depend on the water saturation level of the soil, runoff intensity and insolation time. Tree felling is not as strongly affected by rain

After the APO is elaborated, skid trails and seed trees will be marked in order to start the timber harvesting operations in each harvesting block. Detailed guidelines for timber harvesting operations are discussed in the next chapter.

10 TIMBER HARVESTING OPERATIONS

10.1 Pre-harvesting activities

Previous to the harvesting of timber in any compartment of the management area, an annual plan of operations (APO) must be elaborated and submitted to the FD. The APO provides the planning and base line information for the implementation of all harvesting and management activities that will take place in the compartment normally for a one year period.

The APO contains a detailed characterization of the environment, infrastructure and resources within the compartment so as to provide a reliable tool upon which sound operational decisions can be made. The main features included in the APO are:

- Reliable stem and timber volume stocking estimates. A sampling inventory of trees above MCD meeting a sampling error of less than 20% at 95% probability level.
- A stand type location map at 1:5,000. The map also shows the location of existing and proposed extraction roads, and proposed skid trails, log landings, camps, bridges, culverts, production forest boundaries, water courses and protection zones.
- Area statement of vegetation / forest types; including stand types, non production forests, protection forests, water bodies, etc.
- Description of the resources used in the implementation of the various operations (harvesting, post harvest treatments, etc.); including machinery, supplies and human resources by position.
- Schedule of activities; comprising the building of infrastructure (roads, skid trails, camps, log landings, bridges, etc), the harvesting and transportation operations, post-harvest treatments and others.
- Thinning plan supported by a pre-thinning, pre-harvest or post-harvest inventory, depending on the structural features of the stand and changes following logging.
- Description of envisaged mitigation measures to control undesirable impacts of tree harvesting, and linked activities.
- Training activities to be carried out aiming to improve personnel performance.
- Forest protection plan, including a monitoring program on insect pests and a fire management plan.
- Description of NTFP harvesting / assessment activities.

10.2 Type of machinery

Only a general description of the type of machinery can be given at this stage. Specific types and models will be provided in the APOs. To the extent possible, the licensees will use their own machinery in order to carry out the proposed activities; however, it is likely that contracted equipment will also be used. Thus, some types of machinery may not be included here.

Felling, bucking and delimbing will be done using regular chainsaws. Given the relatively small size of most trees, mid size chainsaws (038) are recommended. Large chainsaws will be used mainly in bridge and road construction; and occasionally in broadleaf felling.

Skidding will be performed with articulated wheeled logging tractors (skidders). Farm tractors will also be used in pine forest. Skidding tractors will be provided with a rear winch and arc to drag logs from a distance. The arc lifts log butts off the ground diminishing friction.

Crawler tractors will be used in road construction operations. CAT D5 size or larger is suggested; however, for operations in broadleaf forest no larger than CAT D6 type is recommended. It is desirable that crawler tractors are equipped with rear winch to support bridge/culvert building operations. Crawler tractors may be used also to carry out skidding and log loading operations.

Graders should be used to shape primary roads. Regular logging trucks equipped with 20 to 40 feet long trailers will be utilized for the transportation of the logs from the log landings to the industry.

Hydraulic crawler excavators and back-hoe excavators should be used in bridge/culvert/drains building operations. They will also be utilized for slope stabilization and travel way shaping.

Wheeled front end loaders will perform the log loading operations in logging yards for transportation.

10.3 Harvesting activities

Harvesting activities will be carried out under the general principles of:

- Minimizing the damage to the environment and the remaining standing forest.
- Implementing cost effective operations.

Local guidelines from the FD, license conditions, as well as general or more specific guidelines considered useful, will be observed during the development of the harvesting operations. The FAO Model Code of Forest Harvesting Practice (Dykstra & Heinrich, 1996) and the Code of Practice for Forest Operations from Guyana (GFC, 1998) have provided important guidance for the selection of operational criteria. The author’s experience on forestry operations throughout tropical America was also useful.

The set of practices that will be applied during the harvesting activities are known as reduced impact logging (RIL) or controlled logging. RIL is mostly understood as the application of directional felling and controlled skidding techniques; however, in a broader sense it includes environmental mitigation techniques applied to all aspects of timber harvesting operations. Training of forest personnel and operators on such techniques will be essential to achieve successful results.

Detailed operational guidelines are not part of a general planning document such as the present SFMP, nor is it convenient to describe them in full detail in the APO. Operational manuals relating all facets of harvesting techniques and management activities attuned to the local conditions of the license area should be written, and serve as the basis for the day to day actions. Thus, follows a broad explanation of the main aspects related to the various phases of the harvesting tasks that will be implemented in the management area.

10.4 Felling operations

The operation of several felling crews will be necessary to cope with the production needs of the industry. Felling operations will be executed year round. However, felling will be restricted to the trees and volumes specified in the APO. No felling will take place on steep slopes, nor in protection zones, such as river buffer areas. Felling won’t commence unless the skid routes have been marked in the field. Directional felling techniques will be used to carry out the felling operations. Personnel will be trained on such techniques.

Tree felling produces a major impact on forest structure and productivity; hence, it has to be executed by competent operators in order to reduce the level of damage to the remaining stand, particularly to the future harvest tress; and also to the wood being harvested. Furthermore, tree felling skillfully done is the basis for an efficient skidding operation, since trees have to be felled in the correct angle to facilitate the winching maneuver.

Directional felling techniques make use of precise cutting procedures and wedges to accurately direct the fall of the tree towards a selected direction where the least damage is caused to the remaining trees and to the log being harvested; and as previously mentioned, meeting also the most convenient skidding direction. Additionally, the tree feller has to be trained on criteria to select the desired felling direction and the making of a daily work plan.

Occupational safety is an integral part of directional felling techniques. Cutting procedures are aimed to achieve not only the desired felling results but to provide very secure working conditions to the forest workers. However, additional safety measures are implemented as well, such as the use of basic safety equipment and knowledge on first aid procedures. The felling crew is composed of the tree feller and his assistant, who also has to be trained in directional felling techniques and first aid.

Furthermore, the tree feller is responsible for recording and reporting to the supervisor, the amount of trees and tree numbers (the latter in broadleaf) he falls every day. These reports are required for the control of the felling operation.

10.5 Extraction/skidding operations

The skidding operation is the cause of the most extensive impact on soils in logging operations, especially if adequate planning of the road system is lacking; and proper transit rules are not implemented. Skidding is also the activity involving greatest variable costs in the timber extraction process; thus, it deserves major attention, careful planning and expertise from the management/operations staff.

As for the felling, production needs require the operation of several skidding teams throughout the year. Dry season and wet season operations will be implemented. Supervision of wet season operations will be intensified. Wet season operations will be restricted to areas where soil erosion will not be important, such as well drained soils. Normally, skidding will be halted during excessive rainy periods and high soil saturation conditions. However, waterlogged skid trails on flat firm ground favor skidding operations, and may be acceptable where erosion is not critical. Skidding won’t occur on steep slopes, or through protection zones, unless strictly necessary.

Trained and skilled operators will implement Extraction/skidding operations within the license areas in order to reduce environmental impacts. The skidding crew will consist of one skidder tractor, its driver and a helper. Both will receive training on appropriate skidding techniques and procedures, and first aid. The tractor driver and the supervisor will be responsible for enforcing the transit rules and skidding procedures aimed to minimize environmental impact.

As a general rule, the skidder tractor won’t be allowed to transit freely throughout the forest. It will require the authorization of the supervisor to operate using the designated routes, which will be duly marked on the terrain. The number and length of skidding trails will be minimized to the extent possible, and their location consistent with the APO harvesting map, unless hampered by major constraints, which will be justified to the FD.

The skidder operator will be responsible for keeping records of the volumes or tree numbers extracted each day, and providing these reports to the supervisor, in order to monitor the skidding operation progress.

10.6 Hauling operations

As for the felling and skidding, hauling operations in the management area will be implemented year round. However, unlike the skidding, hauling is a flash high volume operation that has necessarily to be performed in dry periods, when the trucks have no risk of getting stuck due to bad road conditions. This brings very low the risk of soil erosion due to hauling operations; nevertheless, provisions will be taken to assure that this is accomplished. Trucks won't be allowed to access log landings or logging yards, nor will loading operations or any activity in logging yards be allowed under heavy rain conditions. Proper erosion control road works will be done in order to minimize the environmental impacts. Such works may include side drains, culverts, temporary bridges, side slope stabilization and borrow pits. Also, road maintenance activities will be carried out **before** hauling operations are executed. .

10.7 Post-harvesting activities

The main post-harvesting activities taking place in any given compartment will be thinning, fire control, and forest protection.

As stated earlier, post-harvest treatments such as thinning and liberation treatment will be implemented when economically feasible. Stands producing very low volumes of timber don't cover the costs of post-harvest treatments. To the extent possible, thinning will be scheduled during the time harvesting operations are in progress in the same compartment, in order to utilize the same machinery and resources in case exploitable timber is produced.

Tree felling and skidding, as part of thinning activities will be done using the same procedures as in the regular felling and skidding operations. Post harvest treatments will be restricted to those areas subject to a specific APO where inventories have been carried out to assist treatment decision-making. No sylvicultural treatments will be done on steep slopes or protection zones.

10.8 Environmental considerations in logging

Environmental considerations are incorporated in many of the procedures applied in SFM. A number of such procedures and environmental considerations have been already discussed or mentioned. The aim of these is to minimize the impact of logging activities on the forest ecosystem for the benefit of the workers, the nearby communities and the Belizean society.

A review of previously mentioned and additional environmental considerations deemed significant follows.

The establishment and management of logging camps, workshops, warehouses, including outdoor equipment maintenance activities, must not pollute natural water bodies of any sort. Non-biodegradable discarded materials, such as plastics, aluminum cans, rubber materials, etc., have to be collected in appropriate containers and disposed in public dumps nearby. Special care has to be taken to collect all chemical and oil containers, including worn out oils and tires, and dispose them properly outside the management area. Biodegradable domestic materials, such as vegetables and food residues, can be buried near camps. Latrines have to be built in all logging camps. Used water from camps must not drain directly to natural water bodies. Risk of rain water draining from fuel/chemical deposits and logging yards directly to water bodies have to be eliminated by locating the said items in areas where such risk doesn't exist, or by building drainages to a borrow pit.

Erosion caused by logging activities will be minimized. Roads, skid trails and logging yards will be built and managed with appropriate erosion control works and maintenance measures (see section 9.6). As already mentioned, skidding and transportation will be stopped during heavy rains. The area utilized in roads and skid trails will be reduced to the extent possible by careful planning and proper operational practices. During logging or road construction activities, machinery operators will avoid dumping soils or debris into watercourses. Maximum gradient will be 12° on logging roads, and 30° on skid trails. Appropriate infrastructure such as bridges and culverts will be built to go across watercourses; level passes can be used in rocky riverbeds.

Damage to living organisms will be minimized. Directional felling will diminish the amount of damage to the remaining trees and vegetation; so does the reduction of the skid trail and road density. Limiting the width of the forest strips to be cut for road establishment (cleared way) to a minimum necessary will also contribute to reducing stand damage. The use of a MCD allows for the maintenance of the majority of the tree density and forest structure. The restriction of keeping 10 or more reproductive individuals (30 cm DBH or more) of any commercial species every 100 ha mitigates the impact on biodiversity level. No hunting will be permitted to any personnel working in the logging operations or to people from the nearby communities.

11 NON TIMBER HARVESTING OPERATIONS

As indicated in section 7.4., the planning and operational guidelines for the management of NTFP's are not part of the present SFMP. Potential NTFP's are identified in general terms. Due to its complexity, it is recommended that a specific SMP is elaborated for NTFP's.

12 OTHER GOODS AND SERVICES

It is increasingly recognized that natural and planted forests provide a wide range of benefits, other than timber, to local communities and to society in general. Forest conservation through SFM in the license area will contribute to:

- Regulate water flows; reducing the risk of flooding and consequent damage and economic loses to nearby human populations, infrastructure and agricultural activities.
- Maintain water quality for the benefit of human and wildlife health, particularly for the conservation and reproduction of freshwater and marine organisms.
- Control soil erosion, which benefits agriculture and ecosystem productivity.
- Oxygen production and carbon dioxide fixation, which alleviate atmospheric warming and air pollution.
- Biodiversity conservation, increasing the options for medicinal products and NTFP development, and genetic improvement of cultivated organisms.
- Enhance scenic beauty for the benefit of ecotourism activities.

The licensee will make every effort to maintain these positive values though the effective application of the SFMP; and the development or use of market mechanisms involving such values. However, it is clear that the possibility of enhancing other forest goods and services will depend, in the near future, solely upon the economic health of the timber industry supported by the license production forests. This is due to the fact that the values listed above are unable to generate any cash flow under the present circumstances; and it is foreseeable that the development of market mechanisms for these values will take still several years, including the most advanced initiative for the implementation of carbon offsets bonds backed by well managed forests under the Kyoto protocol and upcoming treaties after 2012.

12.1 Tourism Potential

Perhaps one of the environmental services in the management plan area that has the potential for relatively early development and marketing is tourism. TGS has manifested an interest in developing the tourism potential of their license area. The extensive savannahs with the magnificent backdrop of the Maya Mountains including the Richardson Peak range, the Deep River and its tributaries, a hot spring, wetlands, a healthy wildlife population, and a good network of forest roads all contribute to the tourism potential of this area of the Deep River Forest Reserve. The Tourism Strategy Plan for Belize identifies the Deep River Forest Reserve as being within the Parks, Protected Areas and Private Reserve's tourism zone (Blackstone Corporation, 1998). More specifically it lies between the Toledo Eco-Tourism Zone and the Mixed Use Zone which encompasses most of the non-protected areas of the SCP. TGS is also interested in examining at a future date, the potential for intensive wildlife management as a complementary mechanism to strengthen the tourism potential of the area. However, the Deep River Forest Reserve is also an area with a high hunting use and very frequent forest fires. Given the relationship between hunting and wildfires on the SCP, it stands out that these two limitations would need to be addressed for any tourism venture to be viable in the Deep River area of the management plan. The development of the tourism potential in this area should also be viewed as another mechanism for increasing the opportunities for indigenous and local communities to benefit from a more expanded mode of sustained forest management. The proximity of the south-eastern section of Deep River Forest

Reserve to the Payne's Creek National Park also strengthens its eco-tourism potential and provides an opportunity for closer collaboration with local non-government land managers such as TIDE.

13 MARKETS AND UTILISATION

13.1 Expected products

Currently, TGS is producing regular lumber in the rough form or dressed form for construction. Value adding is a major focus over the years and also minimizing waste. Other planned downstream products include doors and broomsticks. These issues are better covered in TGS strategic and business plan.

13.2 Industrialization

Much investment and training has gone into the industrialization process in TGS. Investments in molders, band saw mills, logging equipment and much more have all been accompanied by personnel training for running and maintaining this equipment.

There is the technical ability to do the proper setting and sharpening of the circular saws, band saws and chain saws for logging the forest, and milling (circular and band saw). Then bringing the finished raw material (flitches or lumber) to the resaw. Hopefully in a couple of years production will include several value added products.

13.3 Marketing, including demands and constraints

In the "old days" wood was used for the full construction of homes in Belize. Lately, wood has been used as a construction material in concrete construction. There are many homes throughout the country that have mahogany lumber 2x4's as structural members in their homes. Much of this has changed of late since pine has been more commercially available and specifically since, the Wood Depot introduced treated pine to Belize in 1986.

Since then the demand for pine in construction has been increasing and substituting hardwoods and precious woods as structural timber. There is a purpose for each type of wood and the use of the different species of woods available should be maximized to their highest benefit. Pine is now and will continue to be the preferred wood for construction and structural members in homes in Belize. In addition, since the machinery is now in place and proper drying (kiln drying in two years expected) and molding can be done the demand for hardwoods and precious woods is increasing for the finishing of homes – flooring, ceiling, molding, etc. These products and various others are currently available in the domestic market.

Minimizing waste and the use of waste has also been a major focus. Right now, shorts, sides and sawdust are being wasted in the TGS production chain; however, it is expected that in the following years this waste will be better manage in molding or as fuel for a drying kiln.

The demand for pine increases yearly as customers see the benefit of using pine for construction. There is no evidence that this will slow down. According to Mr. Gomez, 400,000 bf is enough, for now to satisfy his customers and keep the company moving. The Forest inventory shows up that this figure is almost doubled. Even though, the production for TGS will be kept around 450,000 bf for the first couple of years, and after the plan is revised it can be increased to cover TGS capacity. In addition, there are many options that are being considered including the current importation of lumber. This has been agreed upon by the Ministry of Natural Resources in order to satisfy the demand and allow companies to import timber to supply customers, and maintain the cutting at the annual allowable levels. The government has agreed to allow only companies with SFMPs to import lumber as a form of their commitment to a viable wood industry in Belize.

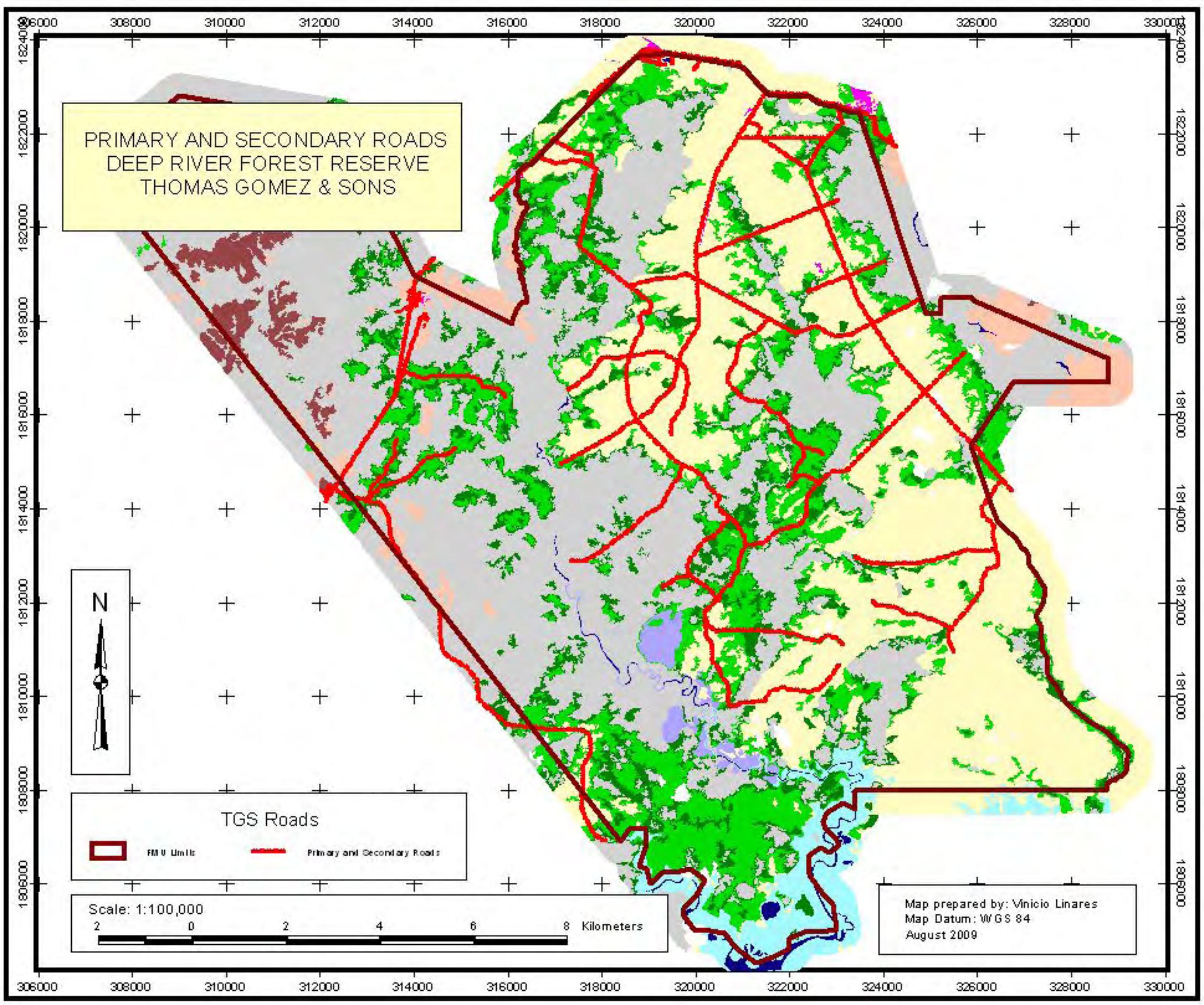
The use of hardwoods and precious woods for finishing homes and also the introduction of various lesser known species for structural timber will assist in supplying the demand for wood in the local market.

14 ROADING OPERATIONS

14.1 General road network

The road density in the license area is apparently over the optimum value; however, a number of the existing roads are obsolete and abandoned. The area accounts to 128 km of primary and secondary roads. Yet, an approximate of 7km will have to be built in order to access the annual harvesting block proposed. The majority of existing roads require maintenance to be transit at least during the dry season.

Map 6. Primary and secondary roads for the Deep River Forest Reserve.



14.2 Roading requirements

Despite the high actual road density in the FMU road building requirements are not null, due to the fact that road distribution is uneven and some of the existing roads are useless. New roads have to be built in areas where production forests are isolated because of the absence of access ways. Abandoned but well located-existing road pathways have to be restored and maintained as part of the functional road network.

Most roads to be built, will be of the type "secondary forest roads". This category refers to roads suited for trucking operations with logging trucks, connecting logging yards with sawmill or intermediate logging yards. It is roughly estimated that road maintenance requirements will be approximately double the road building requirements. Specific road building/maintenance requirements maps will be presented as part of the APO's.

14.3 Standards of construction and maintenance

Standards for secondary forest roads used in other tropical countries (Dykstra & Heinrich, 1996; GFC, 1998) were adapted to the conditions of the SCP and Manatee, through a consultation process with logging companies and contractors. Adapted standards are as follows:

Road type:	secondary forest road
Use:	logging trucks
Road width including shoulders:	8 – 10 (maximum) meters
Width of travel or carriage way:	5 – 8 (maximum) meters
Width of road clearing or cleared way:	12 – 16 (maximum) meters
Minimum curve radius:	20 meters
Maximum gradient:	12°

Maximum road width values are for swampy soil conditions. Road sections not complying with the given standards must be described and justified in the APO.

Roads must be built during the dry season. Road use should be limited to light vehicles during heavy rain. Roads should be located where possible along ridges and elevated ground to achieve good draining conditions and minimize the need for water courses crossings works. Side-drains must be excavated in order to keep the travel way in dry conditions. Turn-out drains must be built at frequent points along the way to evacuate the water collected by side drains. Wherever water flows traverse the road, either permanent or seasonal, appropriate crossing works allowing free water flow must be built (bridges, culverts, wooden boxes, corduroyed passes, level passes in rocky riverbeds, etc). Side-cuts should be stepped or shaped to minimize the possibility of collapse.

Water must not be allowed to build up behind earth fills or corduroyed roads, as drowned forest will die. Appropriate drainage works must be built across the fill (bridge, culvert, etc.) or corduroyed road to allow the free flow of water. Borrow pits may be built in order to collect water from road sections that are waterlogged.

Roads must be properly maintained during the logging operations. Prior to trucking operations, the road travel way should be shaped with a grader or bulldozer if it is in bad condition. Travel way gradient from center to the sides should be 2 to 5%. Side-drains, turn-out drains, sedimentation boxes, and borrow pits should be excavated to eliminate excessive deposited silt. Drainage works as well as water courses crossings should be kept functional at all times during logging operations, not allowing the formation of waterlogged areas upstream.

Skid trails are the ways connecting the tree stump with the log landing (barquedier). Skid trails are utilized exclusively by skidders and crawler tractors in skidding operations. Skid trails normally don’t require drainage or shaping works, nor cleared ways, unless critical conditions occur, such as steep slopes or waterlogged soils. Skid trails will not exceed 3.5 m width. Maximum gradient will be 30°. Cut and fill earth operations are allowed in skid trails on steep terrain. Proper drainage works must be built under these conditions, such as cross-drains, side-drains, turn-out drains and culverts. On swampy soils, skid trails normally require corduroying. Skid trails should not exceed a density of 200 m/ha, or 7% of the production forest area.

Where possible, logging yards or barquediers should be located on well drained terrain. If necessary drainage channels must be excavated to keep logging yards well drained. Drainage channels must not evacuate water directly to water courses or water bodies. Borrow pits may be used, or drains may go directly into undisturbed forest. Any given logging yard must not exceed 0.25 ha in size, unless justified in the APO. Logging yard density must not exceed 2.5% of the production forest area.

15 ENVIRONMENTAL CONSERVATION MEASURES

15.1 Buffer zones

The buffer zone concept explains some of the environmental conservation measures within and outside the management area. Within the management area, protection forests bordering water bodies are considered buffer zones. According to Belizean law, a 20 m forest strip bordering water bodies must be kept undisturbed. Trees within the strip act as a barrier against impacts affecting the water body. This means a 40 m wide strip (excluding river width) along permanent water courses won’t be subject to logging or silvicultural interventions. However, in practical terms, some minor impacts within these buffer zones are unavoidable. Some trees may fall inside the strip; skid trail and road sections may affect parts of the buffer zone, mostly at crossing points. Main impacts on the buffer zone should be justified in the APO (if foreseeable) or as part of the operations monitoring reports.

Within the license boundaries, areas with predominant steep slopes, above 30°, will be maintained as protection zones. These protection zones will be treated in similar way as the water bodies buffer zones explained in the previous paragraph. For practical reasons, localized steep slopes embedded in production forest may be subject to logging; however no skidding or road building will take place in these locations.

Outside of the license area, the management area itself acts as a huge buffer zone in relation to the surrounding environments. The license area functions as refuge, shelter and food source for wildlife expelled from or living in neighboring areas affected by human activities, mainly agriculture. It also acts as a barrier against negative human impacts to adjacent protected areas; such as Cockscomb Basin Wildlife Sanctuary, Bladen Nature Reserve, Payne’s Creek National Park, and Columbia River Forest Reserve. Indeed, it should be noted that Deep River Forest Reserve forms part of the so called Maya Mountain Marine Area Transect, a biological corridor linking the protected areas of the southern Maya Mountain massif with the Port Honduras Marine Reserve.

Furthermore, given the serious threats observed to the Forest Reserves; such as land colonization, milpa farming and illegal logging, the application of the present SFMP is likely the best way to effectively preserve the forest resources in those areas, and to keep these reserves as such.

15.2 Wildlife conservation

The license area contributes significantly to the conservation of wildlife. Populations of all major species of mammals and birds, such as jaguar, tapir, peccary, deer, gibnut, ocelot, quam, tinamou, red macaw, parrots and birds of prey, are found within the license area and the nearby protected areas. A more comprehensive list of wildlife species occurring in the management area ecosystems can be found in Meerman and Sabido (2002).

Pine forest and pine savannah are important ecosystems for Belizean endemic species (Meerman and Sabido, 2002). The license area contains a major portion of Belize's pine and savannah ecosystems. The implementation of the present SFMP is likely the most effective means to ensuring the conservation of pine ecosystem values in the area. The licensee will make every effort to enhance wildlife conservation values of the management area. Hunting and killing of wildlife within the license area will be prohibited. Exception is made for those activities developed by the licensee, regarding game management under a specific SMP (see section 4.8.3). Trees serving as breeding and roosting sites for yellow head parrots, scarlet macaws and other endangered wildlife species won't be harvested. A specific vigilance and protection plan (see section 18.1) will be implemented by the licensees in order to assure the enforcement of wildlife and resource protection measures.

15.3 Use of chemicals

Forest management activities often require the use of chemicals. Efficiency of liberation thinning in broadleaf forests is greatly increased with the use of arboricides. Insecticide applications are sometimes necessary in logging yards when logs have to be stored for extended periods due to unpredictable constraints. Cleaning of license boundaries sometimes require the application of herbicides. Hence, chemicals use should not be viewed as something necessarily negative. Chemicals correctly utilized don't cause environmental problems; however, every effort must be made in order to minimize the use of chemicals.

The correct use of chemicals begins with the right product selection. Chemicals rated as highly dangerous should be avoided. Mild to moderately dangerous chemicals should be used if necessary. Prohibited pesticides, according to FSC standards won't be utilized in management activities within the license area. These are:

> WHO Classes 1a and 1b: aldicarb, parathion, oxydemeton-methyl, sodium cyanide and warfarin.
> Chlorinated hydrocarbons, including aldrin, DDT, dieldrin and lindane.
> Other persistent, toxic or accumulative pesticides identified by their characteristics and defined thresholds.

The use of chemicals will be made by trained personnel. Training will be provided on chemical use and handling, correct dosage prescription, safety and first aid procedures. The use of safety equipment by application crews will be mandatory, such as safety glasses, gloves, chemical protection masks and clothing. Pesticide Control Board regulations regarding chemicals application and the FSC guidelines on the use of pesticides in forestry operations will be followed (see Appendix 8).

Additional relevant safety measures include the following: Chemicals must not be stored in living areas of logging camps. Separate storage facilities must be built for chemicals, fuels and oils. These facilities should be at least 25 m apart from living facilities, and not against the prevailing winds. Water draining from chemical storage facilities must not run directly to water bodies. If necessary drainage channels must be dug, evacuating water to dry ground or to a borrow pit. Spraying equipment must not be washed in natural water bodies; or water used for washing such equipment must not run directly to water bodies, but to dry ground. Chemicals must no be applied during rains, nor chemicals should be sprayed directly on water bodies. Chemical spills of any sort must be avoided. Empty chemical containers must be collected and disposed properly outside the management area.

15.4 Bio-diversity conservation

The present SFMP considers the entire management area basically as a bio-diversity conservation unit. As seen in many SFM units throughout tropical America, RIL and management/protection activities are not only compatible with the preservation of the bulk of wildlife (plants and animals); but in most cases enhance the conservation of the ecosystem as a whole. Thus, unlogged biodiversity reserves within the license area, as prescribed in some codes of practice of forest operations (GFC, 1998), are considered unnecessary; particularly because of the fact that Belize already possesses a huge area declared as National Parks and Nature Reserves, where all the ecosystems (and species that may be intolerant to SFM practices) included in the license area are preserved intact.

Specific bio-diversity conservation measures; such as RIL practices, application of MCD and minimum reproductive tree density maintenance, and hunting prohibition have been discussed in previous sections of this document.

15.5 Soil and water conservation

The management area includes lower sections of the watersheds of Deep River, and so maintenance of natural forest cover through the implementation of the SFMP will positively influence important mangrove, lagoon and coral reefs downstream habitats; particularly the Port Honduras Marine Reserve habitats, and Payne’s Creek National Park estuarine habitats.

Although having a positive impact on biodiversity conservation, the total area of broadleaf is predefined as protection forests (8477.2 ha),and buffer and protection zones to be designated in the APOs are preserved on the basis of soil and water conservation criteria, mainly protection of headwaters, water courses and steep slope areas.

Specific soil and water conservation measures are part of the RIL operational procedures mentioned or described in previous sections of this document, such as minimizing road area, building of appropriate drainage works, road maintenance, regulations on heavy machinery operations, appropriate disposal and use of water contaminant agents, etc (see chapters 10, 14 and 15).

Table 20 describes the different possible impacts to be caused on the environment with the management activities and the corresponding measures for prevention, mitigation and environmental control.

Table 20. Description of the Program for corrective-preventive action

Activities	Description of the impact	Measures for prevention, mitigation and environmental control
In the construction of roads	**On the soil:** - Increases erosion - Loss of nutrients - More leaching and compaction - Compaction and loss of organic material	**On the soil:** - Since there is very little relief all skid trails and fire lines will be aligned on flat terrain - Road maintenance and erosion control works (side drains, turn-out drains, burrow pits, shaping side cuts, etc.) - Stream bank conservation - Avoid skidding in wet weather - Avoid alignments >12% - Minimize trail lengths where practical through planning and ground truthing of alignments thus limiting skidding distances. - Reduce soil compaction by limiting the use of crawler tractors and heavy skidders.
	On the air: - Contamination by combustion gases - Emission of dust particles - Noise generation	**On the air:** - Enforce preventive maintenance of machinery to reduce exhaust emissions especially the regulation of injector pumps. - With respect to noise, the use of ear protectors for affected personnel is foreseen.
	On the water: - Reduces the capacity for infiltration and retention - Creation of puddles and dams	**On the water:** - Keep roads and skid trails 30.5m away from streams and waterways except where the alignment crosses same or where terrain conditions dictate otherwise - Appropriate crossing works allowing free water flow must be built (bridges, culverts, wooden boxes, corduroyed passes, level passes in rocky riverbeds, etc). - Avoid movement of timber during heavy rains
	On the flora: - Decreases natural regeneration - Creation of canopy openings that may favor invasion by weeds and introduction of invasive spp.	**On the flora:** - Favor the natural regeneration when the skid trails are abandoned. However some skid trails will be maintained as fire lines, which will assist in the protection of natural regeneration from fires.

Activities	Description of the impact	Measures for prevention, mitigation and environmental control
	On the fauna: - Modify species migration - Habitat disturbance and interruption - Facilitates hunting and fishing	**On the fauna:** - Limit the passage of persons foreign to the forest management operations - Avoid **unnecessary** entry to the ACC up to a maximum of 5 years after harvesting to permit the recovery of floral and faunal species. - Limit the opening of cut lines and roads throughout the forest - Implement a forest protection programme
In the construction and operation of camp sites	**On the soil:** - Pollution - Compaction and loss of nutrients	**On the soil:** - Construction of adequate disposal sites for organic and inorganic waste. - Place signs indicating access and exit routes to the forest, avoiding unrestricted entry to the forest. - Zones for latrines and laundry 50**M** away from waterways will be defined - Adequate disposal of fuels and oils
	On the air: - Dust emissions - Increase in noise levels	**On the air:** - Reduce noise generation by practical and economic means.
	On the water: - Pollution	**On the water:** - No dumping of organic or inorganic waste in waterways. - Signage for the location of waste disposal sites. - The washing of equipment in streams and rivers will not be permitted.
	On the flora: - Invasion by weeds - Alters the natural regeneration	**On the flora :** - Protect the natural regeneration when campsites are abandoned.
	On the fauna: - Species migration - Illegal hunting - Introduction of domestic animals	**On the fauna:** - Sensitize personnel to the prohibition on hunting and fishing - Post signs in high visibility locations in the camp and the entrances referring to the prohibition on hunting and fishing - Prohibit illegal hunting - Pets not allowed

Activities	Description of the impact	Measures for prevention, mitigation and environmental control
In felling activities	**On the soil:** - Loss of nutrients and more leaching, soils are exposed and disturbed where vegetation has been removed	**On the soil:** - The felling or removal of trees within **30.5 m** of permanent water courses or bodies is prohibited. - Limit extraction to a period no longer than two years after the first entry to the ACC - Carry out felling according to the preharvest inventory map and the sylvicultural prescriptions of the SFMP
	On the air: - Pollution by combustion gases - Increase in noise levels by the use of chainsaws in felling and bucking operations	**On the air:** - Keep engines in optimum working conditions - Keep noise reduction devices on chainsaws and other machinery in good working condition.
	On the water: - Tree tops felled in waterways	**On the water:** - Avoid forest utilization residue obstructing natural waterways - The felling or removal of trees within **30.5 m** of permanent water courses or bodies is prohibited.
	On the flora: - Decrease in species diversity due to selective felling, changes in light regimes and soil conditions influence the dynamics of forest regeneration - Damage to remaining vegetation	**On the flora:** - Minimize canopy opening and damage to the remaining vegetation through the application of directional felling techniques and operation planning - Carry out felling according to the preharvest inventory map and the silvicultural prescriptions of the SFM - Adequately supervise felling and utilization activities in order to reduce Ensure that MCD's are consistently respected. - Respect and protect the designated riparian and other buffer strips and protection areas defined in the APO - Avoid that forest utilization residue obstruct natural waterways. - Maintain a minimum of 25% of the 20-25 cm. diameter class for pine as seed trees. - Reduce to a minimum the damage to the residual tree cover through the adequate training of machinery and equipment operators.
	On the fauna: - Interruption and disturbance of faunal habitat - Loss of particular trees used as wildlife refuge/nesting sites.	**On the fauna:** - Avoid the felling of trees which are commonly known to be a refuge for key wildlife species. - FD should also give guidelines. - No hunting of wildlife or fishing by logging crews.

Activities	Description of the impact	Measures for prevention, mitigation and environmental control
In skidding activities	**On the soil:** - Erosion - Loss of nutrients and increased leaching - Compaction and loss of organic horizon material	**On the soil**: - Avoid working on during heavy rains - Utilize machinery which does not cause heavy soil compaction for skidding and hauling e.g. skidder instead of crawler tractor - Minimize the length of roads by prior planning and ground truthing of alignments hence, minimizing the area impacted by skid trails within the ACC - Making correct use of the winch to lift one end of the log - Train skidding machinery operators to avoid damage or accidents caused by inappropriate use of the machinery - Avoid unnecessary use of skid trails after three years of first entering the ACC (except where skid trails have been converted to fire lines) until the next cutting cycle. - Implementation of controlled skidding: no free transit of skidder though the forest. Skidder will transit using designated/approved routes - Establish procedures for the disposal of used lubricants and other residues in appropriate receptacles which will be transported out of the license area for recycling or removal to a legally established disposal site.
	On the air: - Contamination by combustion gases - Emission of dust particles - Increase in sound levels	**On the air**: - Keep engines in optimum working conditions - Keep noise reduction devices on skidders and other machinery in good working condition.
	On the water: - Formation of puddles and dams due to changes in the shape of the ground, obstruction of waterways - Transportation of sediments to watercourses by rain water - Alteration of flow dynamics where waterways are filled in or obstructed	**On the water**: - Construction of culverts and temporary water course crossings over streams, ditches and other water courses. - Avoid accumulation of extraction waste in or over streams, ditches, and other water sources - Sensitize and train personnel not to dispose of logging waste where it will affect the flow dynamics of water courses. - Minimize the area utilized for skid trails - Avoid skidding during heavy rain

Activities	Description of the impact	Measures for prevention, mitigation and environmental control
	On the flora: - Damage to under storey vegetation - Damage to residual trees	**On the flora:** - Protect the natural regeneration on closing the skid trails - Avoid collateral damage to the neighboring trees through the correct manipulation of extraction equipment by operators - Minimize the area utilized in skid trails.
	On the fauna: Temporary retreat of wildlife by disturbance and interruption of habitat	**On the fauna**: - Avoid the entry of machinery through routes not previously established in the skidding plan
In the construction of barquediers	**On the soil:** - Compaction - Loss of organic horizon material	**On the soil**: - Minimize the area utilized for barquediers
	- **On the air:** - Pollution by gases - Dust emission - Increase in noise levels	**On the air:** - Carry out preventive maintenance on the machines to avoid pollution by combustion gases - Limit extraction activities to the minimum period required for economic logging
	On the water: - Reduction of infiltration - Formation of puddles and stagnant water bodies - Transportation of sediments or fuel/oil residues by rain water to watercourses	**On the water:** - Appropriately locate drains within the barquediers and around them - Avoid runoff draining from the barquardier into a watercourse. - Locate barquardiers at least 100m from watercourses when possible - Avoid working during heavy rain
	On the flora: - Invasion by weeds	**On the flora:** - Promote natural regeneration on discontinuing the use of the log landing - Minimize log landing area
Maintenance and repair of machinery	**On the soil:** - Pollution	**On the soil:** - Establish an area for the maintenance and repair of machinery, close to but separate from the living facilities. Chemicals must be disposed properly. ` Empty lubricant and fuel residues in appropriate containers for their subsequent transfer to an approved site out of the forest - Residues from tractors, trucks, and other machinery should be loaded and unloaded in locations that do not allow the pollution of the environment

Activities	Description of the impact	Measures for prevention, mitigation and environmental control
	On the water: - Pollution	**On the water:** - Completely avoid emptying waste in water sources - Place warnings and signs that prohibit throwing waste on the ground or in the water. - Train personnel on the adequate disposal of waste that is produced during the maintenance of machinery. - Drains of maintenance and repair facility must no go into watercourses
Transportation of logs	**On the water:** - Fuel and oil residues washed by rain into watercourses - Transportation of sediments to watercourse	**On the water:** - The movement of logging trucks on logging roads after a heavy rain will not be permitted
	On the air: - Dust emission - Increase in noise levels	**On the air:** - Install adequate noise reduction exhaust systems and maintain vehicles in good working condition
Transportation of fuel	**On the soil and water:** - Pollution	**On soil and water:** - Implement safety measures that avoid the spillage of fuel on the soil and water, e.g. foresee that the vehicle on which the fuel is being transported has the required capacity and is in a good condition. Check the condition of the tanks or cylinders in which the fuel is transported in. - Prepare a contingency plan for fuel spills
In the intermediate or first transformation	**On soil and water:** - Pollution **On the air:** - Emission of saw dust - Increase in noise levels	**On the soil, water, and air:** - Implement appropriate measures for the elimination of organic/inorganic waste produced at the wood processing site - Seek methods for optimizing the utilization of wood waste generated during the intermediate transformation process - Provide industrial safety equipment to workers - no residue from wood processing related activities will be deposited within **100m** of a permanent water course

16 MONITORING AND RESEARCH

16.1 Previous and Current Research

Forest research on the SCP dates back to the 1930's when formal mahogany increment plots were laid down in 1938 in the 1928 Silkgrass mahogany plantations which had by then closed canopy. In 1954 the MAI was 3.64 cm. girth and 50.8 cm. height. More plots were laid out in 1959 in the 1949 Silkgrass mahogany plantations. Interest in balsa as a quick return crop sparked some research but in 1936 it was found that the initial high growth rates were not sustained. Full scale investigations into growth rates and thinning commenced in 1958. Attention did not turn to pine until 1933 when some rather casual attempts at natural regeneration in exploited forests with vigorous weed growth were tried. By 1937 it was found that an adequate restocking could be obtained by underbrushing and piling the rubbish to expose the soil. Increment plots in natural pine were started in 1936 and first measurements indicated a girth increment of 1.27 cm. to 1.905 cm. Increment plots in the Sarawee pine plantations were started in 1947 in the 1943 area. Subsequently research on pine was concentrated on the Savannah pine plantations. In 1953 fertilizer trials showed that 2 ounces of triple super phosphate per plant stimulated growth remarkably, and subsequent work demonstrated the great value of drainage, but not in quantitative terms. Direct sowing trials were only partially successful in 1956 and 1957. Utilization research was at first concentrated on the problem of extracting the non-durable secondary woods including treatment against Ambrosia beetles and other forms of post harvesting degrade. In order to discover more about the durability of different species a "graveyard" test of 48 species was laid out at Silkgrass in 1939 and a parallel series of tests against teredo worm in the Belize harbor. Data seems to have been lost in a hurricane. 1954 saw a definite advance in utilization research with the trials of diffusion treatment of green pine posts and poles which was successful and the preservation of banak logs from Ambrosia beetles for six weeks by the use of oil soluble proprietary poisons. At the same time interest was shown in the pulping properties of wood and samples of five pioneer species were sent away for paper–making tests. Pine was also pulped on three different occasions and was tested for Kraft paper, newsprint and hardboard. The tapping of pine for resin was first tried in 1936 but forgotten until 1953 when a large scale commercial trial was made. This indicated that quality was good, but the economics doubtful and a new series of experiments started in 1960 to determine the yield and periodicity of flow using the newly introduced acid method. Research on resin yield and periodicity continued in later years but only in the Mountain Pine Ridge Forest Reserve.

Introduction of exotic species has been sporadic. Primavera, *Cybistax donnel-smithii*, was introduced in 1936, Maga, *Montezuma speciosissima*, *was* introduced in 1941, Teak again and *Terminalia superba* and *T. ivorensis* in 1946. In 1953 *Gmelina arborea*, 3 species of pine and 4 species of eucalypts were introduced. Other species were also introduced but with the exception of Gmelina and Teak none of these species were planted at a commercial scale. In 1958 an arboretum was established at Melinda and one or two new species introduced to it each year. More recent research in the decades from 1960 to 2000 has concentrated on Pinus caribaea increment plots in Grants Work Forest Reserve mostly on pine plantation sites, and increment plots randomly located on the pine savannah sites on SCP. A total of about 10 increment plots were established between 1967 and 1977. 2 pine provenance and about 5 pine progeny trials were also established mostly in the Grants Work Forest Reserve between1967 to 1975. A couple pine establishment trials involving different methods of planting and sowing were also set out in the GWFR and the open pine savannah of the SCP in 1974. A seed production unit was also established in the GWFR during the same year. About 7 thinning plots were also established on the SCP in 1963. Unfortunately the quality of data available from these plots has not permitted any comprehensive analysis which provides any clear recommendations with regards to the different thinning regimes being tested. In any case, these plots no longer exist nor are the data complete. The fertilizer trials established in Savannah and Swasey Bladen Forest Reserve in 1963 were abandoned in 1979. Analysis seems to indicate that pine will only respond significantly to the fertilizers used during the first three years of establishment. Various increment plots were also established in the Gmelina plantations in the Silkgrass Forest Reserve in 1973. Most of what remains of these plantations is now leased land and private land. A Gmelina provenance trial was also established in the Silkgrass Forest Reserve in 1975. A Salmwood provenance trial was established at Mayflower in 1978. Several species trials were carried out between 1973 and 1978 mostly on broadleaf sites on the SCP. These included several species of Eucalypts, *Anthocephalus kadamba*, *Albizzia falcataria*, *Leucaena leucocephala*, quamwood, and rosewood. For various reasons including: hurricane damage, the downsizing of the Research Division of the Forest Department as well as the subsequent restructuring of the FD, and the de-facto de-reservation of areas of forest reserves on the SCP, the measurement of these plots were not continued even though in some cases the trial had not been concluded. It is very unfortunate that the analysis of plot data especially related to growth dynamics has not been carried out or has been inconclusive. It is also unfortunate that about 90 % of the research trials and plots that were established on the SCP no longer exist.

16.2 Proposals for experimental or permanent sample plots

“The quality and quantity of research to support management needs to be improved. At present both the Forest Department and the forest industry are hampered by a lack of usable information. Forest management records are inadequate to describe what has been done, where, when, why, how, and how much. Such records are essential for the interpretation of survey data, planning and control. Research and management records are also essential for the consideration of future policy options.” (Belize Tropical Forestry Action Plan, Report to the Government of Belize, 1989). It is evident that there is an urgent need to establish an intimate nexus between research and its application in the sustained management of the forest resources. Licensee like government must also weigh the cost of research versus the benefits that will be realized from forest research and its application to forest management decisions and activities. It is hoped and expected however that the long term interest by the licensees in ensuring that the investment costs of research materialize in significant benefits are more consistent and focused. A list of priorities must therefore be formulated in consultation with the Forest Department and other relevant institutions. However some are already manifestly evident.

There is very little reliable information on the growth dynamics of pine and broadleaf on the SCP. While the effects of fire are very evident, there have been very few or only superficial attempts to measure its impact on tree and seedling mortality, growth, seeding, regeneration, floristic composition, fauna, etc. as well as the impact of adequate fire management. Therefore it will be necessary to establish a series of permanent sample plots to monitor growth dynamics and the impacts of the primary biophysical elements which influence growth and tree development. The design and measurement of the PSP’s should meet internationally recognized standards. The procedure for the establishment of PSP’s in broadleaf forest is described by Bird (1998) and is a good guide. The establishment of PSP’s in the broadleaf forest of the Deep River Forest Reserve should be of particular interest as most of the forest is in the process of regeneration after the devastating effects of Hurricane Iris and most of the larger trees have been or are in the process of being salvage logged given the high degree of damage suffered by the larger trees. Guidelines for the establishment of PSP's in tropical pine forests also exist at the regional level. PSP's should be measured every three years. It is important that the lessons of the past serve us well, and therefore it may more prudent to limit the number of PSP's to a manageable number that is representative of major site variation thus increasing the certainty of their being measured punctually and consistently **with** the accompanying data analysis for the next 40 years or so.

Fire management will be a critical recurring forest management activity on the SCP throughout most of the year. Prescribed burns constitute a key element of pre-suppression activities. Therefore prescribed burning trials will have to be established to determine and/or fine tune the effects of different burn intensities on both over-storey and under-storey vegetation, and to establish and compare different key fire parameters, such as fuel loading and characteristics, rate of spread, flame heights, relative humidity, wind speed patterns, seasonality, etc. The work of Hudson et al that was started in the MPRFR in 1976 should also be revisited. Some data may also be available at the Escuela Nacional de Ciencias Forestales in Honduras. Prescribe burning trials can also be linked to the PSP series on a long-term basis.

It will be necessary to review historic research data (if found) on various establishment procedures to assist natural regeneration as well as the establishment of artificial regeneration for plantation purposes. Current knowledge on techniques and procedures for assisted natural regeneration that can be adapted to the conditions of the SCP will need to be tested on those areas where assisted natural regeneration is required. Similarly treatment of those sites with potential for the establishment of plantations including species trials need to be tested and analysed. The most immediate application of this type of research is in the broadleaf areas of the Deep River Forest Reserve devastated by Hurricane Iris in 2001 and where species enrichment planting or regular plantations may be required. Therefore appropriate research should precede any large scale planting activity. Naturally, not all research implies testing on the ground, the recorded fortunate or unfortunate experience of others may suffice to indicate a particular avenue or approach to take or avoid and which may be subject to further testing under specific local conditions.

Given the stocking density of pine and the age of the current crop, it is doubtful whether any large scale thinning will be necessary during the first cutting cycle and therefore it does not merit a high research priority. Nevertheless in those areas where dense young natural regeneration is present, thinning is advisable and it may afford the opportunity to test the reaction to different spacing. Analysis of the PSP's in the broadleaf forests as well as the preharvest inventories may provide sufficient information to design and to test the efficacy and cost effectiveness of improvement fellings in the broadleaf forests.

As more information is gathered from the pre-harvest inventory of several compartments, and the analysis of the future permanent sample plots, it may be possible in the medium term to design and commence work on the construction of a site quality index for pine which may be useful in the next cutting cycle.

The research activities that have been considered thus far are by no means exhaustive but are within the realms of what is considered to be achievable in the first 10 years of the management plan.

16.3 Current Research Activities and Sites

As has been alluded to, there are no ongoing forest research activities on the SCP as most if not all the research sites have been abandoned.

16.4 Plans for monitoring effects of logging and/or other forest management activities

The effects of logging will be monitored through a series of permanent sample plots established in the logging compartments comparing logged and unlogged plots. Great care will need to be taken in its design and execution (in coordination with the FD) as it is a costly undertaking. The work of Bird (1998) and others in establishing long term logging experiments should serve as a guide for the broadleaf forest.

16.5 Cooperation with research organizations

Close collaboration with national, regional, and international research organization will be promoted. The primary collaborator will be the Forest Department. In the area of growth dynamics the collaboration of institutions such as CATIE will be developed. The cooperation of Program for Belize, US Forest Service and TNC will be sought in the area of fire management research and training. CAMCORE based at North Carolina State University is a good potential collaborator with regards to seed conservation and the testing of potential commercial species and/or provenances including genetically improved seed. With regards to pine sylvicultural and management the Tall Timbers Research Station located in northern Florida and Southern Georgia is a good candidate for collaborative research on the SCP as well as ESNACIFOR in Honduras. The local expertise at the University of Belize should also be tapped for biophysical research and social research related to forest management.

16.6 Other Research Interests

The area of biodiversity conservation is a very important element of the sustained forest management equation. The effect of reduced impact logging on broadleaf forest on avian fauna and insects has been studied in the logging experiment in the Chiquibul Forest Reserve and at the RBCMA. There is interest in developing a collaborative relationship with institutions (such as Manomet Bird Observatory, UB) engaged in monitoring biodiversity in forest areas managed for forest production to improve the knowledge data base of impacts on biodiversity by reduced impact logging on the pine and broadleaf forests of the SCP. The pine savannahs of Belize exhibit the highest degree of floral endemism in the country, yet it has been one of the least studied ecosystems. Other globally rare flora such as Zamia spp. are found on the pine savannah ecosystems in Belize (Meerman 2005). The licensees should be open to collaboration under mutually beneficial relationships which will promote biodiversity research and provide more comprehensive data on flora and fauna in the management area as well as the impacts of anthropogenic activities in general. Links will also be established with those national and regional institutions carrying out research in forest pest protection in order to increase the knowledge base of forest pests in the SCP. This data can then be integrated into the protection plan for the forest management area.

17 FACTORS INFLUENCING SFM AND PROPOSED SOLUTIONS

17.1 Biophysical conditions

The majority of the management area presents biophysical conditions favorable to forest management. Nearly 80% of the land meets the environmental and biological requirements to be considered as production forest; which means that:

- Slopes are predominantly gentle to moderate.
- Soil texture and fertility allows for satisfactory forest growth and permits the implementation of logging operations.
- Climatic and hydrological conditions are not extreme.
- Logging operations are compatible with the conservation of most biodiversity values.
- Commercially interesting timber harvest volumes exist. Removal of such volumes does not impede timber resource restoration by the remaining stand.

Areas where such conditions are critical have been classified as non production forests and won't be subject to logging activities. Within non production forest, protection forests will be kept basically undisturbed.

Nonetheless, the control of several biophysical factors is fundamental for the success of the SFMP. These are:

- **Regeneration**. Pine regeneration is low and has been decimated by uncontrolled fires. It is expected that the implementation of effective fire control measures will reverse the disappointing picture regarding seedling establishment and growth. In those places where soil factors continue hampering regeneration, drainage works and soil scarification measures will be tested. It is likely that some of the commercial hardwoods show limited natural regeneration too. In most cases this is due mainly to high seedling mortality rates associated with low light levels in the under-storey where seedlings germinate. Timber harvest will increase light levels in the under-storey improving seedling survival; however, when additional opening is needed, liberation treatments may be applied.
- **Tree growth rates** are low due mainly to the combined effect of fire stress (for pine) and crown competition (for pine and broadleaf). Both conditions are the result of the lack of management. The implementation of effective fire control measures, thinning and liberation thinning should significantly improve tree growth.
- **Pest outbreaks**, particularly bark beetle attacks can destroy extensive areas of pine stands with dense timber stockings and/or frequent exposure to stress conditions. It is expected that the implementation of an effective IMP will minimize such risk.
- **Fire** affects not only seedling regeneration and tree growth, but it can also completely destroy valuable tree stands; putting at risk management investments. It is expected that the implementation of a successful fire management plan, with stakeholders' involvement, will minimize fire damage.
- **Soil erosion**. Extensive areas with dominant steep slopes, where logging could cause massive soil erosion, have been designated protection forests and excluded from logging operations. However, steep slopes and soils prone to erosion may occur locally within production forests and may be affected by logging activities, mainly road building and skidding. To the extent possible operating in these areas will be avoided; nonetheless, if

it becomes inevitable special care will be taken to carefully implement appropriate standard operational procedures in order to minimize environmental impacts. As a general rule, these standard procedures will be applied whenever timber extraction activities are carried out, as described in more detail in.

- **Water quality**. The main headwaters contained in the management area have been pre-defined as protection forests. Additionally, rivers and streams buffer zones will be identified and protected during APO elaboration and implementation. Appropriate standard operational procedures will ensure the maintenance of water quality..
- **Hurricane damage**. Little can be done to avoid the immense damage that a hurricane can produce. As explained in earlier chapters, hurricane damage may be very severe to severe within a swathe of 100 km. As for past records, unfortunately, the probability of any given portion of the management area being hit by a hurricane within the next 50 years is high. In case that a hurricane hits production forests in the management area, the best that can be done is to have in place procedures to implement efficient large scale timber salvage operations, in order to partially compensate for the likely tremendous economic losses. Having the present SFMP in execution would allow for a faster reaction and better damaged timber recovery.

17.2 Markets, industrialization

The market for timber products in Belize has and continues to be a small and traditional one. In Belize the focus of industrialization has been based primarily on the market demand. Most of the timber harvested and processed in Belize is used for and in the construction of housing. To elaborate the uses in the housing sector vary from all wooden homes to timber used in the construction of concrete homes, to timber used for decorative purposes in homes and offices, to storage sheds, to cabanas in the tourism industry.

As mentioned earlier the level of industrialization is based mainly on the uses of timber in Belize. That is primary and secondary transformation, the logging and processing of timber into lumber. Although the byproducts of timber that is sawdust, thinning etc have much use and can be further processed there is not much scope for the use of byproducts here in Belize. The local market for these products is small. In addition, the available raw material to justify investing in machinery for the further processing into pulp and other products is small and insignificant. The global market for pine and its derivatives, as an example, is a very competitive one. In fact an exercise was conducted to examine the viability of sending raw material for pulp to the USA. However, the cost per ton of pulp was close to the cost of transporting it to the final destination.

The use of wood in construction as mentioned earlier has much tradition here in Belize.

The current and future equipment in the country has been improving in its focus to minimize waste and to the possible use of some of the waste such as in biomass (sawdust) fired kiln driers and post peelers as an example. The likelihood of a pulp mill or a particle board mill is minimal. However, the current products coming out of the processing equipment available in Belize has improved substantially, in fact, products such as moldings can compete quality wise anywhere in the world. The wood industry in Belize is constantly improving in more state of the art equipment for improved efficiencies in production and utilization.

17.3 Social conditions

Basic social infrastructure has been discussed in section 4.8. However the dynamic demographic changes in the management areas is now straining the available social infrastructure in terms of education, health, and other social services. While the number of shrimp farms continues to increase, banana cultivation has been affected by two recent hurricanes, Mitch and Iris. Financial instability in one of the larger banana producing companies has also had a diminishing effect on employment in this industry. Most of the labor force for the banana, shrimp, and citrus farms is recruited from immigrant workers. Other economic areas such as the port facility also provide employment. The 2002 Poverty Assessment Report provides the following data: *The poverty line is one of the key factors in estimating the number of poor or non-poor persons. It is based on the minimum estimated cost of basic food and non-food items that a household requires to meet its basic needs. The poverty line is derived when a non- food cost is added to the indigent line. The non- food cost is estimated using the pattern of expenditure of the poorest 40% of the population. The cost of the food basket is inflated by multiplying the reciprocal of the food share of the poorest 40% of the population. Persons whose per-capita consumption falls below the poverty line area considered poor. The Toledo District has the highest level of poverty, 79% while the Stann Creek District has the third highest 34.8% compared to Orange Walk which has 34.9 %. The rate of poverty in rural areas is almost twice as much as in urban areas.*

The indigent line is defined as the minimum cost of food requirement necessary for healthy existence of an individual or members of a household. Therefore, the cost of the food basket established for each district was used as the indigent line in the respective districts. When an individual or household is unable to satisfy basic food needs, they fall below the indigent line and are considered very poor. Toledo has the highest indigent population in the country (56%) The proportion of indigent population in all the other districts was 7.1% or lower. Stann Creek ranked fourth with 5.6 % of the population living below the indigent line. The incidence of poverty is highest among the Mayas and lowest among the Garifunas. The Mestizos rank third and the Creole population fourth. One in every four persons living on or below the poverty line lives in the Toledo District. Toledo's poverty situation has persisted despite government’s efforts to alleviate poverty and the implementation of several projects such as ESTAP and CARD designed specifically for the southernmost district and also projects financed by the Social Investment Fund.

However, the devastation of Hurricane Iris visited on the Toledo District in 2001 affected some of the efforts made by these projects. According to the Fourth Report on Assessment of Damages Due to Hurricane Iris (Ministry of Natural Resources 2001), 21,600 persons mainly from Toledo and Stann Creek districts, were directly affected. The Impact of Iris was greatest in the area of agriculture and fisheries, tourism, forest/biodiversity resources, and housing. A preliminary estimate puts damage to agriculture as the highest, housing as second, and tourism as third for a total of $195 million. Nationally, 12.4 % of households were affected by the hurricane. However, one in every three household in Toldeo District was affected; 56.1% reported that their homes were partly damaged or completely destroyed while 40.5 % reported that their crops or livestock were destroyed. Another of the poorer districts, the Stann Creek District was also affected by Iris, which destroyed many of the banana plantations. However, there has been an increase in shrimp farming and other aqua culture activities in this district, which has provided more job opportunities.

The working poor who are classified as those persons in the labor force that fall below the poverty line comprised 29.8% of the labor force in 2002 which means that, three in every ten persons in the labor force were not able to meet their basic food and non-food requirements. Women (27.3%) in the labor force were less likely than men (31.5%) to be poor. This finding is contrary to the general belief that men have better paying jobs than women do. Most workers were engaged in elementary occupations (47%). However, poor workers were more likely than non-poor workers to be in this category. The data from the report also indicates that agricultural workers were most likely to be poor (47%) compared to those in other occupations. Further analyses by industry also show that workers engaged in non-classified agriculture (subsistence farming) and citrus were more likely than those in banana and sugar industries to be poor. Those working with Government and the tourism industry were among the least likely to be poor.

While employment in the agro-industries and the tourism industry, provide a means of earning hard currency for many of the working population in the SCP, many families are engaged (or would like to engage) in farming activities either as a means of providing the family with staple food items of corn, beans, rice, and vegetables, and/or as a complementary source of income. This culture is also prevalent in the immigrant population who increasingly are seeking to acquire national land for settlement and farming. Where there is no formal avenue available for utilizing national land (and in some cases private land) many persons will go ahead and clear areas of national land (or private land) for agriculture and then seek to formalize the process after the fact. It is interesting to note that in the 2002 National Poverty Assessment Report, insufficient land is cited by the Mestizo group as a condition of poverty. For many poor families, the cultivation of land and the use of land resources is often the only mechanism available to survive and subsist. It is very unfortunate that increasingly, more lands with limited land use capacity for agriculture is being cultivated on the SCP by the poor. Therefore, most attempts at traditional agriculture on these soils are doomed to failure thus creating a vicious circle for the poor who then need to slash and burn more areas with limited agricultural productivity.

17.4 Resource use conflicts

On the Southern Coastal Plain, traditionally, the most pronounced resource use conflict has been the frequent razing by fire of the pine savannahs for the purpose of deer hunting. Runaway agricultural fires, mostly from milpa type cultivation have also contributed to fire damage to timber resources as well as other ecological resources. The steady increase in population and human settlements and the increased access facilitated by the upgrading of the Southern Highway and the extension of other road infrastructure has no doubt magnified the problem of fire management on the SCP. However, today the foremost threat to sustained forest management is the rapid change in land use and land tenure in areas that traditionally have been used for forest production. While in the past land use changes followed a pattern of agricultural colonization of the better lands, i.e. land supporting broadleaf forests predominantly on river terraces and flood plains, the present pattern of land use/land tenure change is not discriminating in relation to soils. Most of the national land adjoining the newly paved Southern Highway or adjacent to feeder roads has been leased or purchased. It is also very unsettling to note that this pattern also seems to be now extending into the presently established forest reserves as well. Land speculation was identified as a social and environmental concern before the Southern Highway was upgraded. It continues to be an increasing concern. Unfortunately, there does not appear to be in place a formally accepted land use plan for the SCP, nor does there appear to be at present an adequate institutional infrastructure to develop and carry out such a plan in spite of several studies which provide the necessary guidelines for such a plan. For sustained forest management to succeed, it has to be carried out within the context of a rational land use regime based on environmental, social, and economic sustainability of the land resources. Most of the sustained forest management area on the SCP is constituted by land that is undisputedly of forest vocation and that are eminently unsuitable for sustained agricultural production. Parts of the forest management area lie in important watersheds in particular those watersheds that are crucial for the continuous supply of water to the main agro-industries on the SCP and the supply of potable water for the downstream communities on the SCP. It is very important therefore that urgent measures are taken by the Ministry of Natural Resources to place all national lands identified in the forest management area under forest reserve status and to strengthen legislation to maintain the integrity of the present and future forest reserves. Perhaps the promotion of small livestock husbandry may decrease the reliance on game animals as a source of meat. In this respect, the licensees should be prepared to collaborate in wider public sector and/or NGO initiatives to promote small livestock husbandry in rural communities on the SCP. These initiatives should form part of an integrated fire prevention program as discussed in Section 18 of this plan.

Communities on the SCP have traditionally used forest resources at a small scale either for their own use or at a small commercial scale whether it is bush sticks , poles, and thatch for the construction of rural dwellings and structures, medicinal plants, fruits, etc. However the expansion of markets for the traditional thatch in the construction of tourism infrastructure, as well as markets for medicinal plants have increased the commercial scale of harvesting far beyond traditional levels. The markets for rough cut lumber from preferred timber species such as mahogany and samwood which are now more expensive as milled lumber coupled to the wide availability of chainsaw mills has also increased the illegal cutting and processing of these timbers.

18 FOREST PROTECTION

18.1 Security and Vigilance Plan

Vigilance over the license area is the shared responsibility of the licensee and the Forest Department. However law enforcement is the sole responsibility of the Forest Department and other government authorities empowered by law to enforce pertinent legislation and regulations. Therefore the licensees will be responsible for detecting and reporting those activities within the license area which are in violation of the relevant regulations or which threaten the sustained management of the natural resources within the license area. As has been discussed in other parts of this management plan, the main threats to sustained forest management in the license area are: arson, illegal hunting, illegal settlements and/or agricultural encroachments, trespassing, illegal logging and harvesting of other forest produce.

A standard protocol and written format will be developed together with the Forest Department to report any activity or situation that requires action by the Forest Department or any other pertinent law enforcement agency. The objective is to enhance good communication and to provide the necessary documentation for follow up action by both the law enforcement agency and the licensees. This format should include among other things: date the report was made, date the offense or activity under investigation was discovered, nature of the offense or activity which may constitute an offense, names and or addresses of perpetrators if possible, vehicle license number if applicable, where the offense occurred, extent of damage or impact, name of person reporting the offense or unwanted activity, request for mitigation or preventive measures, to whom the matter was reported (name, post or rank, station). These reports should be incorporated into the forest management information system of the licensee for follow up, review, and planning purposes. The licensees should also undertake to provide support to the Forest Department in the prosecution of offences committed in the license area by assisting with securing evidence or providing testimony that may be required in a case.

Security and vigilance needs to commence with public awareness and education which will hopefully contribute significantly to prevention and will also act as a vehicle to promote the involvement of local authorities and the community as a whole in detecting and reporting illegal or unwanted activities that act in deterrence to the sustained forest management of the license area. Therefore public appreciation for the objectives of the sustained forest management plan, the forest rules and other pertinent legislation as it applies to the license area as well as the role of the licensee in monitoring compliance must also be an integral part of the overall public and community crosscutting outreach program. Obviously the Forest Department and other law enforcement agencies must also be an active partner in this endeavor as well as authorities within the communities.

On the ground, signage will be an important tool for reinforcing public awareness and education as well as assisting in projecting a management presence. Signs will be placed at appropriate points along the Southern Highway, explaining that the area is under long term sustained forest management by both the licensee and the Forest Department; an important prevention message (fire, milpa, and hunting) may be incorporated into this sign. Similar signs will be placed at strategic locations in close proximity to or within the license area. Other signs with prevention or forest management awareness messages will also be erected. Signing is a gradual process that will be developed in stages commencing with those that are of critical importance and progressing to providing on the ground information to the users of the forest resource and the general public. The construction of signs can also provide a mechanism for providing direct economic benefit to communities in or adjacent to the license area. It is an activity that will form part of the APO of each licensee.

With the approval of the Ministry of Natural Resources and wherever it is economically feasible and desirable the boundaries of the license area will be marked by a bulldozed line which can also act as a fire line and provide easier access by the licensee and the Forest Department for monitoring. Bulldozed lines are clearly visible as is evident in the existing property lines on a few estates on the SCP. However, in some parts of the license area this type of forest management track or line must be weighed against facilitating unwanted access into the area. Indeed in some parts of the SFM area such as the Deep River Forest Reserve, it will be necessary to construct gates across existing or newly constructed forest roads to control un-warranted motorized access for hunting (which increases the risk of wildfires), and illegal harvesting of forest produce. Limited fencing may also be necessary in some critical areas. The planning of forest roads, fire lines, and boundary lines must also be sensitive to avoiding the creation of unwanted access to strict protected areas such as the Bladen Nature Reserve.

Regular patrols at least once a month during the wet season and twice a month during the dry season will be carried out particularly in those areas of high risk for arson, illegal logging, illegal harvesting of forest produce and/ or minerals, illegal settlements and/or agriculture, and illegal hunting. Efforts will be made to include an officer from the FD on all patrols. Vigilance will also form part of other activities which require monitoring such as detection of insect attacks, wildfires, resource assessments, and all the daily forest operations which require ingress into the license area or a particular compartment. Therefore all forest workers of the licensees at all levels of responsibility will be trained to look for signs of unwanted activities and to whom and how to report any unwanted activity if found. Personnel involved in vigilance and security patrols will also have to be properly trained to avoid or defuse confrontational situations which may arise from contact with individuals involved in illegal activities. Community or local contacts should also be cultivated as a means of obtaining valuable information. Cooperative or collaborative relationships with other agencies or organizations involved with security and vigilance in or adjacent to the license area should be developed. It is also important that the three licensees develop close collaboration under a cooperative agreement in planning and carrying out security and vigilance activities.

Initially, anecdotal and historical references will be utilized to construct maps of those locations that are more vulnerable to illegal and unwanted forestry related activities. As additional geo-referenced information is collected with the passage of time these maps will be updated and shared with the relevant authorities. Staff and workers of the licenses will be encouraged to use maps as a standard tool not only for vigilance and security but for all forest management activities that require geo-referencing.

All activities connected with security and vigilance will form a recurrent element of the APO.

18.2 Integrated pest management plan

As has been discovered by recent experience, another major threat to the SFM area is the Southern Pine Beetle, *Dendroctonus frontalis* which has killed significant portions of the pine stands on the SCP. Isolated attacks by *Ips* have also been identified but mortality has been minimal. Much has been learnt by the bark beetle outbreaks of 2000 and 2001 including its identification, life cycle, mode of attack, the use of different sylvicultural methodologies to directly combat these as well as the cyclical nature of these outbreaks. The techniques and methodologies for the identification and control of these dangerous insect pests are described in detail in the publication *Pine Bark Beetles in the Mountain Pine Ridge Forest Reserve, Belize: Description of the Species and Advice on Monitoring and Combating the Beetle Infestations* produced by the Forest Department with the help of IDB. A more national strategic approach is also described in the National Forest Health and Management Plan which forms part of a regional forest health effort. For the immediate future perhaps the most important lessons to be learnt are the need for training at the field level in identifying these insects, continuous monitoring for their presence, rapid action to control and isolate outbreaks, and the sylvicultural interventions necessary to develop healthy stands which are less predisposed to these insect attacks. In addition to a continuous monitoring program which will form part of each year's annual plan of operation, a contingency plan will be developed in consultation with the Forest Department and other relevant national institutions for the control of any outbreak. The development of an integrated pest management plan for the Deep River SFM area will of course have to be guided by these two previously cited publications and other national guidelines developed by the Forest Department or other national agencies such as BAHA. Included in any IPM program will be measures to ensure that forest management activities do not unduly impact on beneficial predator habitat.

Monitoring for other insect pests including those mentioned in the sub-section below on pathology of *pine* will also form part of the SFM area monitoring program and will be included in each year's APO. With the exception of the mahogany shoot borer *Hypsipylla grandella*, Zimmerman, which is responsible for the formation of multiple shoot leaders, there are no other commonly known insect pests of natural broadleaf stands in the area. However forest monitoring for any signs of threats to forest health by insect pests in broadleaf forests will also form part of the forest monitoring activities in the annual plan of operations.

Collaborative relationships will be established and maintained with local and regional institutions that carry out research on relevant regional forest pests in order to keep current on developments and applications related to forest conditions.

Butt and Stem Decay in Standing Pine (from Johnson and Chaffey, 1974)

*The pathology of **Pinus caribaea** in Belize has been discussed by Etheridge (1968). Stem and butt decay is reportedly common in mature pine (Johnson and Chaffey 1974). Fire scars are the commonest site of infection. Williams (1965) records primary infection through fire scars by the fungus **Lentinus pallidus**, which causes cubical brown rot. Etheridge lists nine further species of wood destroying fungi isolated from pine in Belize. Rotten heartwood commonly becomes infested by the termite **Coptotermes niger**, primary termite attack being precluded by the high resin content of the wood.*

*Among insects, the termite **Coptotermes niger** is important in relation to pine, although termite infestation of trees is always secondary to fungal attack which is normally effected through fire scars (Williams, 1965).*

*Scolytid bark beetles are a serious pest of **Pinus caribaea** in Belize. The most important species is probably **Dendroctonus frontalis** Zimm (Etheridge, 1968). The injurious effect of **D. frontalis** is due to the fungus **Ceratocystis sp**. which the insect transmits. Fungal infection of a tree cannot only prove fatal but also degrades the timber by staining the sapwood blue.*

*A shoot borer, **Rhyaconia frustrana** Comstock, is recorded as affecting **P. caribaea** in Belize by Loock (1950) and Browne (1968) but its importance, if any, in the Coastal Plain is not known or is not evident.*

18.3 Fire management

The main threats to the forest of the Deep River Forest Reserve are from anthropogenic origin. Many of the pines forests are subject to uncontrolled annual burns, which kill off the younger pine trees, and reduce the vigor of older trees leaving them vulnerable to pest outbreaks and storm damage. As has been discussed elsewhere fire is the most common threat since it is a firmly embedded part of the culture of many of the nearby communities who use fire for land clearing, removing unwanted debris or vegetation, chasing away unwanted wildlife such as snakes and ticks, and attracting game species such as deer who feed on the young grass shoots that develop on the savannahs shortly after it is burnt. Therefore a forest fire management plan will have to be devised in close collaboration with the FD.

The experiences of previous forest fire protection programs carried out in the 1960's and 1970's by the Forest Department on the SCP with the assistance of the United Kingdom and Canadian Governments as well as FAO in the 1980's should provide valuable lessons. It is clear however that the three main axes of any realistic and effective fire management program are:

- Fire prevention,
- Law enforcement,
- Adequate organizational fire management capacity.

Wildfires can no longer only be viewed from the perspective of damage to property, natural vegetation, agricultural values or tourism values but there must also be recognition of the additional impact which wildfires have of increasing the vulnerability of rural communities and rural dwellers to the extremes of natural phenomena directly or indirectly. Fire prevention has to include all the stakeholders near the management area which have an interest in significantly reducing the negative impacts of wildfires which contribute to both environmental and economic losses.

A continuous educational and sensitization campaign will be necessary. This is a medium term to long term process which must change deeply ingrained cultural practices and perceptions which have been manifest for decades. It must have the strong support of the forest concessionaires, local communities, NGO's, and Government agencies that can influence behavioral changes in the indiscriminate use of fire. The financial support required is very substantial and may very well only be achievable with external support from the relevant international agencies.

Present legislation related to the negligent use or deliberate use of fire appears to have an urban focus. Specific legislation related to forest fires caused by deliberate or negligent human actions need to be drafted and enabled as well as legislation which defines the roles and responsibilities of forest users and forest fringe communities in dealing with forest fires however caused. Legislation should not focus on corrective or punitive measures alone but should also provide for preventive measures, which control access into the areas of high fire risk. For the moment the relevant section of the Forest Act pertaining to the use of forest roads may provide the necessary legal basis to control access into areas of high fire risk. For good legislation to be effective there is the need for good and continuous law enforcement by both national and local authorities. Like any good law enforcement strategy, the cooperation and support from the local communities and the concessionaires for the actions of the relevant law enforcement authorities must be developed along the lines of good communication and mutual respect.

Finally, an efficient fire management organization will be created which has both the training and the tools to carry out its function. Efficient early detection and an effective rapid response have to be the key to avoiding major conflagrations. While most of this will be the responsibility of the concessionaries, other stakeholders such as local communities, Forest Department, and NGO participation will also be required in these activities.

Pre-suppression activities such as prescribed burns aimed to reduce fuel loadings before the onset of the fire season and the construction and maintenance of a good network of fire lines and traces is also essential. The fire season does not commence in mid February as is customary for the Mountain Pine Ridge. It starts as early as mid November when the savannah sward becomes dry enough to burn (It is not uncommon to see fire spread on the upper shoots of the savannah grasses with a couple inches of water still remaining on the ground.) and continues in frequency and intensity as the dry season sets in and does not cease until the start of the rainy season. Initially fire management will have to be concentrated on the priority areas of the management plan, i.e. those areas where natural regeneration is being promoted and assisted. These areas will normally coincide with those compartments that have been logged or thinned. It is therefore expected that focused fire management will commence with the first felling compartments and grow to include all subsequent felling or thinning compartments in order to give fire protection priority to the vulnerable young natural regeneration. Experience has shown that most saplings can survive a cool ground fire once it reaches a height of 4.5 meters or so providing that the terminal bud is not affected. Initially fire management in the areas of lesser priority will have to be limited to prescribed burns to reduce fuel loading.

The dispersed nature of the license area, the land tenure pattern, the ease of access, and prevalent agricultural and hunting practices all complicate fire management. While each licensee must develop their individual fire pre-suppression and suppression capacity, it would be far more cost effective to share resources and complement the strengths and capacities of each other. Fire detection, communication, training, and planning should be a cooperative program which also provides for mutual support and assistance in fire suppression when requested by members of the cooperative. Communities and community-based organizations can also form part of this cooperative fire management programmed. There are many successful examples of fire management cooperative agreements in other countries where wildfires are a perennial problem. However, a realistic and step wise approach must be taken to develop the necessary fire management capacity in the SFM area bearing in mind that after more than 15 years without any wildfire control, fire management is being reintroduced. A fire management plan will be presented as part of each year's APO after it has had the input of the Forest Department.

Fortunately, fires in the broadleaf forests are not common occurrences although there are historic references to large fires in broadleaf forest every 30 years or so. Therefore while fire management will not be as intensive as on the pine savannahs of the area, prevention, and pre-suppression activities in the broadleaf forest will also be part of the annual fire management plan with a contingency for suppression should this be necessary.

19 INFORMATION MANAGEMENT SYSTEM

Fact documentation and record keeping is a key aspect in SFM. Oftentimes, documentation is the unique way of proving the execution of specific actions, such as conflict resolution events, stakeholders' agreements, etc. Company performance is improved and SFM evaluation costs are greatly reduced when archived records exist. Furthermore, efficient operations monitoring is only feasible when activity records and documents exist and are properly managed.

Records and documents can be managed through an information management system; which is a set of procedures and algorithms that analyze and summarize information in order achieve a better understanding of the events and processes related to such records.

Information systems greatly improve decision making in enterprise and resource management, and operations execution. Accounting is an example of a basic information system that is implemented in nearly all business undertakings. Management information systems linked to GIS are even more powerful, particularly as an aid to carry out complex forest management tasks. However, information systems are expensive and may be rather inaccessible to small companies. Fortunately, sophisticated information systems are not required to achieve SFM. A simple but reliable management information system including the main aspects of the management operations should suffice. Such management information system should include the following records:

- Daily or weekly tree felling.
- Daily or weekly log skidding volumes and trips.
- Daily or weekly log hauling volumes and trips.
- Logging yard inventories.
- Yearly production report by compartment.
- Costs registry.
- Timber salvage volume registry.
- Sylvicultural treatments registry.
- Chemical application report.
- Community agreements/resolution conflict registry.
- Accidents registry.

20 SCHEDULE FOR IMPLEMENTATION OF ACTIVITIES

Table 21. Activities to be developed within the first five-year period after launching SFMP

Activity	2010		2011		2012		2013		2014	
	I	II	I	II	I	II	I	II	I	II
Elaboration TGS APO										
Elaboration of subsequent APOs										
Improvement of management/logging infrastructure										
Training courses for company's personnel										
Implementation of logging operations										
Post harvest treatments										
Implementation of fire control program										
Implementation of forest protection and vigilance plan										
Implementation of integrated pest management plan										
Activities seeking community involvement										
Activities seeking research cooperation										
Implementation of community participatory activities										
Implementation of research activities										
Review of SFMP										

Table 21 offers a general idea of the activities to be carried out during the first five-year period after commencing timber harvesting operations. Specific tasks in each area of action will be presented in the APO activity timetable.

The first task to be accomplished will be the elaboration of APOs which will guide the licensees' yearly activities within the management area. It is recommended that subsequent APOs are prepared during the first semester of every year in order to allow enough time for approval and adjustments before its implementation at the start of the following year. Also, this permits carrying out forest inventory work during the dry season.

Completing the building of management/logging infrastructure will be necessary during forest intervention, including camps, storehouses, workshop, road works, etc.

Another important early activity will be training of personnel through short applied courses on RIL and safety methods, such as directional felling, forest roads, skidding techniques, pesticide application, first aid, environmental considerations, etc.

Implementation of logging operations include continued road building and maintenance, felling, skidding and hauling. Simultaneously, fire control and forest protection activities should start. These include fire line building, prescribed burns, people sensitization presentations, placement of warning/information signals and patrolling activities. Pest control activities should start a semester later during the rainy season when fire management tasks have freed resources and pest activity is higher.

Seeking community involvement would start also a semester later to take advantage of the increased resource availability as a result of the decreased logging intensity brought about by the rainy season. Community involvement includes community integration into fire management, forest protection and pest control activities, as well as fostering NTFP management plans. Looking for research cooperation would commence a year later once experience and control has been gained on implementation of operational activities, and resources can be more easily dedicated to developmental initiatives. By this time, it is expected that actual implementation of community participatory activities will take place.

Research projects often take a lengthy period to become implemented. Cooperation agreements have to be developed and subsequent fundraising is necessary. Hence, it is judged that a period of 2 years is at least needed to begin executing research activities.

Review of the SFMP is deemed essential rather shortly after implementation of the plan. This is so, because it is during this phase when significant discrepancies between written plans and execution of operations arise, such as feasibility and efficiency of proposed compartments and procedures. It is also a time when knowledge on operational aspects is being gained rapidly; therefore, adjustments to the plan should be added timely allowing a review at the end of the first two years of operations. Afterwards, it is not considered necessary until the end of the five-year period.

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