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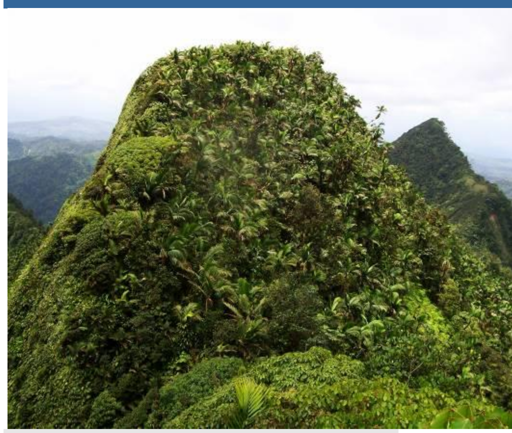

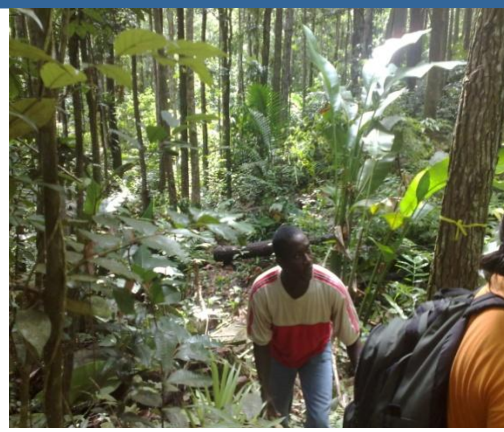

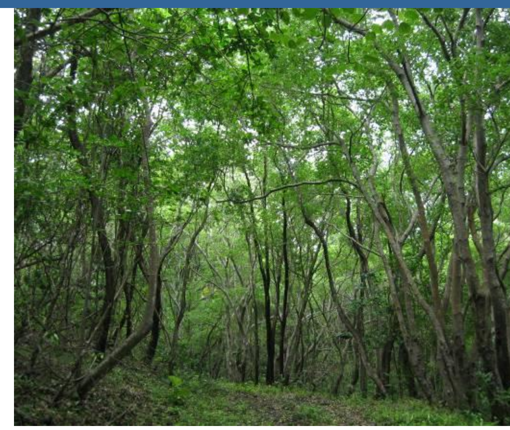

NATIONAL FOREST DEMARCATION AND BIO-PHYSICAL RESOURCE INVENTORY PROJECT

CARIBBEAN – SAINT LUCIA

SFA 2003/SLU/BIT-04/0711/EMF/LC

TIMBER INVENTORY OF SAINT LUCIA'S FORESTS

By

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2009

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Executive Summary

The 2009 Saint Lucia forest timber inventory was carried out as part of the National Forest Demarcation and Bio-Physical Resource Inventory Project, funded by the European Community

The inventory field work was carried out from January 2009 to May 2009, based on a design prepared after examination of past inventories of Saint Lucia. During the inventory a total of 12,636 trees were measured in 416 sample plots. Following the field work, the field data were analysed and results collated.

The inventory results found the land under Forestry Department control has an average of 540 trees per hectare, with an average of 305 cubic metres of timber per hectare, totalling approximately 2.8 million cubic metres of timber in the forest reserve. The average timber volume per hectare in 1982 was approximately 187 cubic metres, with an estimated 1.3 million cubic metres total volume in the then forest reserve.

Assuming an approximate average volume in 1982 of 200 cubic metres, versus an approximate average volume of 300 cubic metres in 2009, the forest can be seen to have increased by at least 50% in volume over the past 27 years.

The current inventory estimated an average stocking in the forest of approximately 542 stems per hectare, ranging from a low of approximately 480 to a high or approximately 600. The 1982 inventory reported a mean stocking of 289 stems per hectare, ranging from 275 to 344 by forest management class. The 2009 inventory results show an average increase in stocking of approximately 85%.

The increase in stocking and volume between the 1982 and 2009 inventories indicates Saint Lucia's forests have recovered strongly from the effects of Hurricane Allen in 1980. This strong recovery shows that the forests of Saint Lucia are capable of relatively rapid recovery from disturbance, indicating that selective logging could be considered a viable forest management alternative.

Inventory results show that 60% of the timber volume is contained in 10 species, with 17% contained in *Sterculia caribaea*, mainly in smaller size classes, and an additional 10% contained in *Dacryodes excelsa*, mainly in large size classes. Fully 4% of the timber volume in the forests of Saint Lucia is contained in large *Dacryodes excelsa* trees. This amounts to a total resource of approximately 120,000 cubic metres of large size *Dacryodes excelsa.*

The information collected in the inventory is stored in a modern forest management information system, and can be extracted for detailed analysis in alternative software. All data are available for future growth and yield analysis. All data have been entered into electronic form, and, provided secure backups are made at regular intervals, will be available for future inventory planning.

The timber inventory carried out in 2009 has successfully updated information previously only available from inventories over twenty years ago. The Saint Lucia Forestry Department has access to stratified estimates of tree volume by species by size class for the entire forest reserve, capable of being broken down by range or to lower forest management levels.

Saint Lucia's Forestry Department now has a modern forest inventory system set in place, with a cadre of staff and other individuals trained and experienced in conducting a modern forest inventory. This provides a secure basis for the implementation of future forest timber inventories, which should be undertaken at more regular intervals, perhaps every five years.

Introduction

The 2009 Saint Lucia forest timber inventory was carried out as part of the National Forest Demarcation and Bio-Physical Resource Inventory Project, funded by the European Community under the Saint Lucia SFA2003 Programme of Economic and Agriculture Diversification and Poverty Reduction through Integrated National Resources Management "To survey and demarcate the physical parameters of the public forest reserve and conduct a comprehensive biophysical inventory/ assessment and management system of forest resources".

The second component of the NFD and BPRI Project is to conduct an inventory of the bio-physical resources of Saint Lucia. This task has been divided into separate but related resource inventories. A biological inventory of the plants and animals of the forests of Saint Lucia is reported elsewhere. This report covers a traditional forest timber inventory conducted on a nation-wide basis.

The forest timber inventory field work was carried out from January 2009 to May 2009, based on a design prepared after examination of past inventories of Saint Lucia. Following the field work, the field data were analysed and results collated. This report describes the timber inventory process in detail and presents the overall results, with discussion of some aspects of the results.

Background information on Saint Lucia

Saint Lucia is located within the Windward Islands of the Lesser Antilles in the West Indies. Its closest neighbouring islands are Martinique, 32 km to the north and Saint Vincent, 40 km to the south. Saint Lucia is the second largest island of the Lesser Antilles with an area of 616km^2, with the maximum length and width of 43km and 21km, respectively. The human population is close to 166,838 residents, giving a mean density of approximately 1,036/km^2, but much of the island's interior is uninhabited.

Volcanic in origin, Saint Lucia has a mountainous topography dominated by a central ridge running almost the full length of the island from north to south. Numerous steep offshoot ridges extend to both sides of the coasts. Some valleys are broad and occupied by large banana plantations, including Cul-de-suc, Roseau and Mabouya. These valleys, together with the area around the town of Vieux-Fort in the South, account for most of the flat lands of the country. The central southern part of the country has high mountains (Mount Gimie being the highest at 958m). The coastlines, particularly the east coast, are deeply indented by near-vertical cliffs with some narrow sandy beaches.

The island's tropical marine climate is characterized by relatively uniform high temperature throughout the year. The dry season is roughly from January to April and the rainy season from May to August, with usually sunny, warm weather from September to October. Tropical storms and hurricanes are infrequent, with the majority of West Indian tropical cyclones passing to the north of Saint Lucia. The hottest period is May to October, and the coolest, December to March, giving a mean annual temperature of approximately 26°C at sea level. Annual rainfall varies from 1,524-1,778mm in the north to 2,540-3,683 mm in the mountainous interior of the south.

There are approximately 21,692 hectares of natural vegetation types in Saint Lucia, of which 9,186 hectares are within the expanded Government Forest Reserve (protected forests). Graveson (2009) describes the different types of forest cover, which range from a very xeric littoral shrubland and mangroves on the coast to a lush rainforest and elifin shrubland in the high peaks.

Approximately 30% of Saint Lucia's land area is pastoral and arable land. Originally the mainstay of the economy, agriculture has been in decline in recent years, contributing only 3.4% of Gross Domestic Product (GDP) in 2005, with bananas the principal export crop. The economy of Saint Lucia has shifted to a service economy, with tourism the largest economic sector, accounting for 13.6% of GDP in 2005.

Objectives

The objectives of the Project include the following statement from the project Terms of Reference.

> *To conduct a comprehensive biophysical inventory/assessment and management system of forest resources to produce, inter alia, a forest resource monitoring system; obtained through ground survey, remote sensing, assessment and review of existing data that will serve as the basis for strategic sustainable planning and management of forest resources.*

The objectives of the timber resources inventory were to quantify the amount of timber available in the forest resources of Saint Lucia on a nation-wide basis. This is to complement the details to be collected in the biophysical biodiversity resource inventory.

This objective was taken to mean the forest timber inventory should produces estimates of timber volume by species by region, with estimates of the distribution of volume by tree size within species. In contrast to the biodiversity inventory, the forest timber inventory only sampled areas of the state forest resource.

Previous Inventories

1 Consideration of previous inventories

Documents available from the previous forest inventories of Saint Lucia were examined to assist in the planning of the current inventory, to learn from past experience, and to ensure that comparisons could be made between the 2009 inventory and data from the past inventories.

This process was restricted due to the lack of access to the original inventory data and some reports. Moreover, as the most recent inventory was conducted in 1989, and then only on approximately 350 hectares of plantation forest, the reality is that the past inventories can provide only limited guidance for a modern inventory. In the period since the previous inventories, the forests have changed, in particular the plantation forests, which inspection showed had become infiltrated with native species, and could not be considered pure plantations to any large degree.

A further consideration was the manner in which forest inventory has changed in the past twenty years, in particular developments in tropical forest inventory. In the past, less robust statistical methods had been widely used, in part due to the need to ensure that the inventory crews could navigate the forests. For reasons of field team safety as much as for survey purposes, strongly systematic survey techniques were favored. The advent of modern GPS units has meant that forest sampling can make use of methodologies which were impractical thirty years ago.

In 1949 J. S. Beard conducted and inventory and developed forest type classifications, as well as stand tables representative of each type (Beard, 1949). In 1962 an inventory was carried out to estimate volume, basal area, and stocking for forests on actual and proposed forest reserves at the time. Volume tables were developed for the eight most common species, and the forest was classified into productive and unproductive forest on the basis of basal area. (Goodlet, 1970)

In the aftermath of Hurricane Allen sample plots were established to assess the damage caused by the hurricane. The plots showed a loss of approximately 40% of standing volume, with approximately 80% of volume affected by damage or mortality. (Whitman, 1980)

In 1982 a nationwide national forest inventory was carried out as part of the CIDA Forest Management Assistance Project (Piitz, 1983). This inventory concentrated on all of the natural forest of Saint Lucia. This inventory was the most thorough sampling of the forests of Saint Lucia, and provided the best information for planning of the current inventory.

The 1989 plantation inventory (Consortium Interfor, 1989) was restricted to less than 360 hectares of plantation forest. For design purposes, the 1989 inventory provided little information. The summary data included in the report is twenty years old, and inspection of the plantations showed considerable intergrowth of native species. The plantations had developed into a separate vegetative class, as is recognised in the vegetative map produced by this project (Graveson, 2009).

The current inventory is intended to be a national forest resources inventory, capable of providing estimates of the forest resources of St. Lucia. As such, the 1982 inventory provided a better basic for the design of the 2009 inventory. Additional details of the 1982 inventory are given below.

2 National forest inventory 1982

Two volumes of inventory results and calculations were prepared for the 1982 inventory, but only Volume 1, containing the main inventory design features and main results, was available during the inventory planning and implementation period. The 1982 inventory was carried out using strip plots, and had the following inventory characteristics.

1982 Inventory characteristics	
Strip interval	400
Nominal plots size	0.1
Sampling intensity	1.8%
Approx. no. Plots measured	1089
Area inventoried	6002 ha.
Area sampled	108.9 ha.
Total area of forest	**6781 ha.**

Table 1 1982 inventory characteristics

The following forest management classes were defined for the 1982 inventory.

Forest Management Class	Description
Exploitation forest	Areas of forest with slope less than 30 degrees not requiring protection for other values
Protection/Production forest	Areas of forest with slopes less than 30 degrees requiring protection for other values, while allowing limited production
Protection forest	Areas of forest with slope greater than 30 degrees and any other areas requiring protection

Table 2 Forest management classes in 1982 inventory

The following table shows the estimates of stocking and total volume from the inventory by forest management class.

Forest Management Class	Mean stocking	Mean Total Volume
Exploitation forest	344	205
Protection/Production forest	305	194
Protection forest	275	183
All forest types	289	187

Table 3 Mean stocking and total volume (1982)

The 1982 inventory returned the following estimates of total wood volume in Saint Lucia by forest management class based on administrative units. (Piitz, 1983 – Table 6).

Administrative Unit	Exploitation	Protection/ Production	Protection	Total
Northern Range	0.8	106.7	30.0	137.5
Millet Range	0.0	31.3	234.0	265.3
Dennery Range	89.8	15.7	177.9	283.4
Soufriere Range	0.0	62.0	218.3	280.3
Quillesse Range	46.0	97.0	163.0	306.0
All ranges	**136.6**	**312.7**	**823.2**	**1,272.5**

Table 4 Total volume in 1982 by management class and administrative unit (,000 cubic metres)

The inventory included estimates of the inventory accuracy, which were calculated to give a standard error of estimate of 2.4% and a coefficient of variation of 8.1% for the overall forest estimated mean total volume of 189 cubic metres per hectare. However the calculations used did not accurately reflect the error in volume estimation, approximately 14% on average, which means that the true error in the estimation of total volume was most likely around 10%. In addition, the use of continuous strip plots divided into arbitrary sample plots is not a sound sampling method.

3 Timber plantation inventory 1989

An inventory of the timber plantations was conducted in 1989, as part of the St. Lucia Forest Management and Conservation Project, under the auspices of CIDA (Consortium Interfor, 1989). This inventory concentrated only on the timber plantations, which occupied 356.57 hectares, composed of Honduras Mahogany, *Swietenia macrophylla*, Blue Mahoe, *Talipariti elatum*, and Caribbean Pine, *Pinus caribaea*. The plantations were divided into 11 strata, based on species and productivity, and a total of 91 sample plots of size 35 ha. were established.

The inventory estimated that the plantations contained 45,722.7 cubic metres of timber at the time of the inventory. Interim volume tables are referred to in the report and graphs are shown of volume on dbh. However no coefficients or regression statistics are provided. No estimates of the accuracy of the inventory were located.

Inventory Design

4 Design of 2009 inventory

The 2009 inventory design was based on a stratified randomized strip model. Stratification is the process of dividing a population to be sampled into groups of similar sampling units, based on population characteristics. In the case of the forest timber inventory, the population characteristics were based on management land units.

Annex 1 lists the management units used in the inventory, in the final form of use.

The forest was initially divided into 20 sub-strata based on their land classification. The land classification units were combined to form seven management strata, as an extension of the Range-based strata used in the 1982 inventory.

The principles of random sampling dictate that each sampling unit has an identified probability of being sampled, with the probability being equal within a stratum. Individual stratum may have differing sampling intensities, reflection differing managerial importance. However, within each stratum, each area of forest must have the same probability of selection as a sampling unit.

The probability of sampling was reflected in the sample design within each stratum. Strata were sampled with randomized sample plots located on gridlines established along access corridors. The procedure followed was to identify the start of a strip line, and then establish sampling units at randomized intervals along the strip line. This was done by locating the first sampling unit, measuring the sampling unit, and then preceding along the strip line a randomly determined interval.

The sampling units were strip plots, located on either side of the strip line, 5m from the centre of the strip line. Sampling units were to be sized to ensure that an average of at least 20 trees is measured within each sampling unit within each stratum. Each strip plot was a predetermined length, with the length varying between strata. The length was initially set at 70 metre and later decreased to 50 metre after initial results showed the plot size was too large[1].

Sample plots were only established on sites a slope under 30 degrees. Areas with a slope greater than 30 degrees are classified as protection forest, and will never be harvested. In addition, such areas present dangers to the field crew in establishment of sample plots. As a result, the estimates derived from the inventory reflect land with a slope of less than 30 degrees.

The use of GPS units to locate sample points adds flexibility to the design, as this means that the sample plots can be combined into alternative groupings via post-stratification, with less positivity of bias due to subjective classification of the groupings.

[1] A forest sampling unit should sample at least 20 trees on average. In excess of 20 trees indicates too large a sampling unit. However, as the forest stocking varies, the sample unit should be set so that few plots have fewer than 10 trees. This can mean some plots will have a large number of trees. In the final analysis, the number of trees in a plot ranged from 3 to 81, excluding one empty plot, with an average of 30.

5 Definition of forest units

The concept of a forest unit was used in an inventory. A forest unit is defined as the smallest unit of forest subject to management. In plantation forestry such a forest unit is often termed a stand. In natural forests the forest unit concept is of less use, and is harder to define. Forest units are sometimes defined on a watershed basis.

For the 2009 inventory forest units were defined using administrative boundaries. Early on an attempt was made to include the management classes using in the 1982 inventory. However, this proved impractical, due to the extremely varied nature of the forests of St. Lucia, and due to the lack of recent management of the exploitation/plantation forest.

During the planning stage it was assumed that vegetative class would be used to assist in forming forest units. However, the vegetative classification work was proceeding at the same time as the forest timber inventory work. This meant that vegetative classes could not be used to define forest units at the time of the inventory field work.

Ultimately the forest units could only be defined on an administrative basis. Forest units were defined to be the individual forest estate blocks identified for the boundary survey exercise associated with the timber inventory. Areas were taken from the Forestry Department's area figures as developed by the Forestry Department GIS.

The SL FMIS (Tennent, 2009b) allows forest units to be combined to form strata. Plots cannot be redistributed easily with forest units, but alternative combinations of forest units can be defined as alternative stratifications.

6 Slope classes

The project GIS system was used to develop slope classes to investigate whether slope classes could be used for stratification. Unfortunately the slope classes derived were composed of units too small to be used for stratification. Whereas there are some areas with a slope uniformly greater than 30 degrees, in most cases the areas of steep forest were too small to be effectively mapped, given the mapping accuracy available at the time of inventory planning.

For this reason, slope class was not considered in the design of the inventory, but was considered in the sampling system. Areas of greater than 30 degree slope were excluded from the inventory. As a result, it should be noted that the results derived from this inventory reflect only land with a slope below 30 degrees.

7 Sampling intensity

For the calculation of sampling intensity the forest units were combined into strata based on groupings of similar forest units. This initial stratification was based on land blocks, and did not consider the forest Range administrative units of the Forestry Department.

The sampling intensity was based on the managerial unit's characteristics, taking into account the nature of the terrain and remoteness of the area. A further characteristic considered was the local population of the St. Lucia fer de lance, a snake with dangerous venom. This resulted in some areas being under sampled to avoid snake bite incidents.

The initial sampling intensity was set at 0.5% after calculating the estimated sample size using data from the 1982 inventory. However, after sampling half of the first forest unit, the large Castries Waterworks unit, it was apparent from initial examination that this was too high a sample intensity, as the precision of estimate for this initial strata was excessively low. The initial plot size of 70 m. resulted in numerous sample plots with an excessive number of trees measured, with a maximum of 81 and an average of 39 trees per plot. The size of the strip plot was lowered to 50m, which gave an average of 28 trees per plot. The sample intensity was lowered to .25% by redistributing the sampling lines.

In some smaller areas of forest a higher sampling intensity was utilized to give a lower PLE. The size of individual forest units may preclude strip sampling. In such cases random sampling will be utilized.

8 Data recorded

The information recorded in the timber inventory sampling units was the species and diameter at breast height of all trees over 10 cm. dbh. Tree heights were not recorded in the field plots, as was quality and tree dominance not recorded.

During the initial sampling period the field crews spent considerable time in identifying tree species. After the first month the major species were known, and less time was needed to identify species. In 205 cases the species could not be confirmed, and these trees were recorded as being of unknown species. Annex 2 includes a species list used in the inventory.

Other local data were recorded on the plot sheets for the information of the biodiversity component of the project. This included such information as the location of resin trees, bird sightings, and other local information that could be used by the other investigators.

9 Volume

The volume of trees in the inventory was calculated using volume functions developed during the 1982 forest inventory. The volume of tropical trees is difficult to estimate without the destructive sampling of large numbers of trees. For the purposes of the 2009 inventory the well established relationship between the diameter of a tree and its volume was relied on.

The 1982 inventory produced six local volume functions based on data recorded from 318 trees divided into species groups. The following table reproduced from Piitz, 1982 shows how the species groups were defined.

Species group	Tree species
1	Contrevent, Penny piece, Bois cote, Chataignier, Cacolie, L'Encens
2	Bois blance, La glu, Dedefouden, Feuille dorre, Balat chien, Laurier, Laurier mabre
3	Bois reviere, Bois pain marron, Debasse
4	Bois D'Amande, Casse, Corosol marron, Mahaut cochon
5	Laurier sp. (excluding L. Mabre), Gommier, Bois de Masse
6	All others

Table 5 Species groups (Piitz, 1982, Table 23)

The techniques used were not those that would be used in 2008, but inspection of the graphs shown in *Appendix B: Volume Equations* of the 1982 inventory report show an acceptable fit for all six equations. Efforts to locate the original data were unsuccessful, and so a decision was made that the volume functions would be used in the form recorded in the 1982 inventory. Peltz (1983) lists two sets of coefficients, coefficients for total tree volume, and coefficients for merchantable volume.

Table 6 shows the coefficients for the volume function, which is described on page 16.

Volume group	Species Group						
	Coefficient	**1**	**2**	**3**	**4**	**5**	**6**
Total Volume	k	2.0917	2.3733	2.3393	2.3835	2.2097	2.3368
	b	0.00041	0.00020	0.00021	0.00015	0.00032	0.00019
Merchantable Volume	k	2.0714	2.3460	2.3227	2.4032	2.2361	2.3272
	b	0.00036	0.00018	0.00018	0.00011	0.00024	0.00016

Table 6 Volume function coefficients (Piitz, 1982, Tables 24 – 25)

As the criteria used to define merchantable volume are generally subjective, and as timber processing procedures have changed since 1982, the Total Volume coefficients were used for volume calculations in the timber inventory. Figure 1 shows the Total Volume functions graphically.

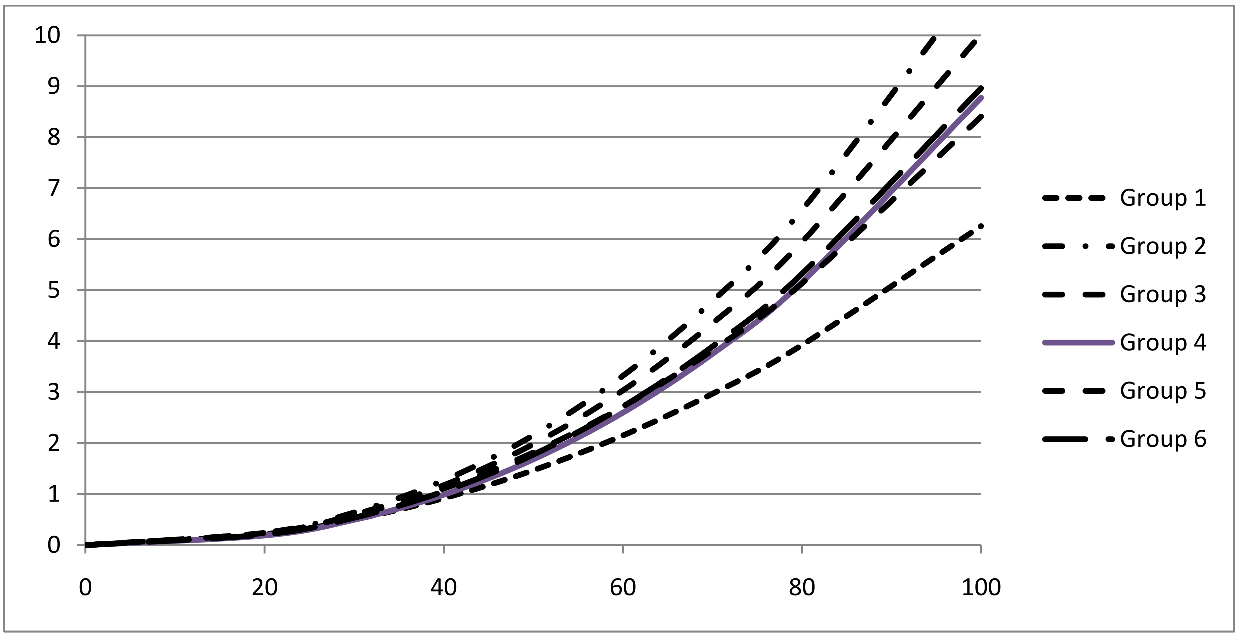

Figure 1 Total volume on dbh by species group

From Figure 1 it is apparent that groups 4 and 6 are essentially the same, with group 5 only marginally lower. For this reason, the volume functions were combined into 5 groups, defined as below.

Species Group	Piitz Group	Group description	k	b
A	2	High volume	0.000200	2.37330
B	3	Medium high volume	0.000210	2.33930
C	4,6	Average volume	0.000247	2.28905
D	5	Low average volume	0.000320	2.20970
E	1	Low volume	0.000410	2.09170

Table 7 Volume functions used in 2009 inventory

The coefficients for Species group C were estimated by generating data from the Piitz coefficients and then fitting the same function to the data generated.

These new species groups were applied to the species identified in Table 5. For all other species, volume was estimated using the Group C function.

10 Crown class

During the 1982 inventory crown class was recorded, but not analysed. Crown class was not recorded in the 2009 timber inventory, as the separate biological inventory which is collecting information on forest structure will provide information on forest structure including crown class. Crown class was collected on the permanent sample plots which were established as a separate part of the project.

11 Quality assessment

The 1982 inventory included the estimation of the quality of trees from the timber production perspective. Each tree was classified into Quality class A, suitable for saw log production, and Quality class B, not suitable for saw log production.

The inventory results included the division of total and merchantable volume into the two classes, A and B. The results showed approximately 70% of the total volume was in class A, and 30 % in class B.

These classes are obviously subjectively defined, and the use of such classes would lead to problems in ensuring that the quality classes were being assigned correctly by all inventory team members. Moreover, saw log production is not the only use for standing trees, and improvements in processing since 1982 have provided methodologies whereby a greater percentage of a standing tree can be processed.

Given the difficulties in defining objective quality classes, and the relative low value of the information that can be provided, quality class information was not collected in the inventory sample plots.

12 Field procedures

The 2009 timber inventory was carried out using two teams each composed of a Forestry Department team leader supported by a forest technician, with additional Forestry Department staff members, with two cutlass men providing assistance. The teams moved throughout Saint Lucia, and after initial changes in team composition a consistent team structure was maintained to encourage team motivation.

The two teams initially operated as one to ensure that standard procedures were used by both teams in subsequent sample plot establishment.

Field procedures were as follows.

1. The field team travelled to the location of the gridline to be sampled, having a specialised map produced by the GIS consultant in their procession
2. The team then proceeded to the point the gridline started, and then proceed along the gridline to the point where the first plot was to be located, using compass and GPS.
3. The starting point of the plot was recorded using the GPS when the position could be so recorded.
4. The first plot was located by establishing the central line, and measuring all trees above 10 cm in dbh within 5 metres of the central line. Trees were entered into preprinted plot sheets numbered sequentially.
5. For each tree the dbh and species was recorded.
6. All trees within the pre-determined plot length were recorded. The plot size remained as pre-determined, even if the plot had a low number of trees, and even if the plot had no trees.
7. The team leader recorded such comments as are felt necessary on the back of the plot sheet. Any unusual incidents or observations were recorded and noted to the Project Leader on return.
8. After measuring the plot the team next proceeded along the gridline the pre-determined random distance before establishing the next sample plot.

Further details on field procedures are provided in the Saint Lucia Forest Inventory Guide, published separately (Tennent, 2009a), which also includes the plot sheet used for collection of the inventory data.

13 Sampling order of priority

A specified order of priority was established to control the inventory sampling. The initial sampling was conducted in the areas nearest to the Forestry Department headquarters, so that results could be calculated overnight, and so that the inventory team could make daily reports on progress. The less remote areas were sampled first to enable procedures to be developed, and to fine tune the inventory data collection routines. The initial sample plot data was transferred to the Forestry Department headquarters on a daily basis, so that the data could be examined for any inconsistencies or inefficiencies. This allowed the inventory design to be modified rapidly to ensure that the most efficient design is established.

Inventory results

14 Inventory field work

The inventory field teams operated from 12 January to 31st May. During this time 416 sample plots were located along approximately 65 kilometres of cruise lines, with measurements collected from 12,636 trees.

Figure 2 shows the location of sample plots established in the inventory, with the colour of the plot location reflecting the plot basal area.

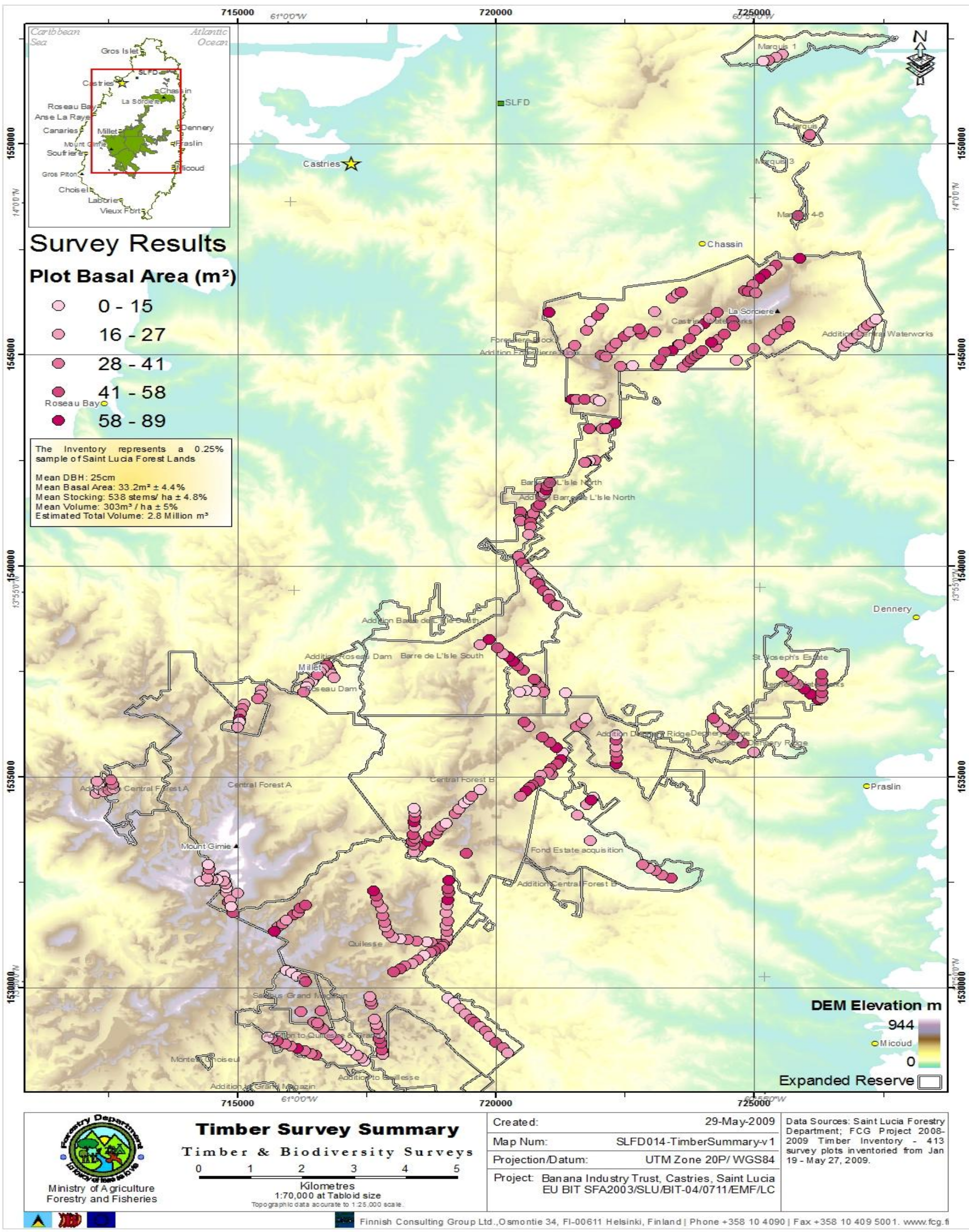

Figure 2 Location of inventory sample plots

15 Processing of inventory results

All inventory measurements were recorded on a standard form, and were processed by the SL FMIS (Tennent, 2009b). The SL FMIS system stores all plot measurements, to enable tree distribution tables to be prepared. Individual tree diameters and species have been stored. Volumes were calculated using the volume functions prepared for the 1992 inventory,

Statistical calculations were done at the basal area and stocking level, as volume in this inventory is a derived variable. As such, error calculations will be available for stocking and basal area, but not volume. Volume error estimates can be expected to reflect the basal area estimates, given that the volume estimates will have a larger error due to the error of volume prediction.

The SL FMIS calculates the average estimates with PLE[2] for each stratum based on the formulae for simple random sampling. The overall combined estimates are calculated using formulae for stratified random sampling, where the area of each stratum is used as a weight on the stratum variance.[3]

The SL FMIS is able to provide estimates at the forest unit level, stratum level, and national level. Estimates at all levels have a valid error of estimate.

The inventory field data were processed as soon as the field sheets became available in the Forestry Department project office. This enabled the sampling intensity achieved to be followed weekly, so that the sampling intensity could be increased or decreased as necessary. This also allowed the production of weekly maps showing the progress of the timber inventory, along with the production of weekly updates on estimated volumes.

The weekly updates assisted in the programming of the SL FMIS, and also provided feedback to the field teams which greatly improved morale. The field teams were able to see the results of their efforts rapidly, which increased their interest in their tasks.

[2] PLE is ‘probable limit of error’, forestry statistical term refereeing to the 95% confidence limits expressed as a percentage of the mean.
[3] See page 16 below for details of the statistical calculations.

Accuracy of inventory results

16 Description of statistical calculations

The statistical calculations carried out on the inventory field data were based on the sample plot summary data. The sample plot summary data which were calculated include the simple mean of diameter at breast height, the basal area, and the stocking. No heights were collected during the timber inventory. Volume was calculated using the volume functions for the 1982 inventory as described above.

The following functions descript the calculations carried out. All variables are standard forestry variables.

1. Mean diameter $= \sum_1^n d \;/n$
2. Basal area $= \frac{\pi \sum_1^n d^2}{40000} /a$
3. Stocking $= \frac{n}{a}$
4. Volume $= k.d^b$

   Where:

   d = diameter breast height
   n = number of trees in sample plot
   a = area of sample plot
   k, b are coefficients, as shown above in Table 6.

The inventory summary statistics were calculated for each stratum using the standard formulae for simple random sampling without replacement.

$$s^2 = \frac{\sum_{i=1}^n x_i^2 - (\sum_{i=1}^n x_i)^2/n}{n-1}.$$

Where:

S^2 = sample variance
x = variable of interest
n = sample size (number of sample plots in a stratum)

The overall forest estate estimates were calculated using the standard formula for stratified random sampling, with strata weights according to strata area.

$$\bar{x}_w = \sum_{h=1}^{H} W_h \bar{x}_h,$$

and

$$\mathrm{Var}(\bar{x}_w) = \sum_{h=1}^{H} W_h^2 \,\mathrm{Var}(\bar{x}_h).$$

Where

x = variable of interest
Wh = stratum weight (c.f. stratum area)
H = Number of strata

and the associated means and variances are calculated for each stratum as above.

17 Sample intensity and precision achieved

Table 8 below shows the sampling intensity achieved for each of the strata defined by land location with the precision of the basal area estimate of each stratum and for the inventory overall.

Stratum	Total Area	Area Sampled	No. Plots	Sampling intensity	Precision achieved[1]
Barre de l'Isle	1212.8	1065.6	64	0.30%	9.5%
Castries Waterworks	1425.1	1396.8	106	0.51%	8.1%
Central Forest A	2069.3	2037.3	50	0.12%	15.4%
Central Forest B	1959.1	1959.1	72	0.18%	11.7%
Dennery	392.5	392.5	20	0.25%	19.7%
Marquis	193.8	182.8	7	0.19%	39.0%
Quilesse	1925.3	1676.7	97	0.29%	8.7%
Areas not sampled	7.8				
Total area sampled	**9185.9**	**8710.7**	**416**	**0.26%**	**4.4%**

[1] Refers to precision of BA estimate

Table 8 Sampling intensity achieved in inventory

As expected, the precision follows the number of plots established in each stratum, rather than the sampling intensity, demonstrating clearly that sample size is more important than sample intensity, as defined by the percentage of area sampled.

It should be noted that the Central Forest B stratum lower level of precision of estimate achieved is due in part to the higher proportion of land over 30 degrees slope, which was not sampled, and in part to the exclusion of the central area of the block, which has a dangerously high population of Fer de Lance, the native Saint Lucian pit viper.

The Marquis stratum also has a low level of precision of estimate, due to the low sample size taken. This stratum is by far the smallest stratum, a mere 2% of the total forest estate. A lower precision of estimate was considered sufficient in this stratum.

As shown in Table 9, 7.8 hectares of forest estate were not sampled, or included in the strata defined. These small parcels of land, the smallest being less than 500 sq. m. in area, are scattered across Saint Lucia, and in some cases not occupied by forest.

Summary of inventory results

The overall inventory results are summarized below, by administrative strata.

Stratum	Total Area	Area Sampled	No. Plots	Mean BA	Mean Stocking	Mean DBH	Mean Volume
Areas not sampled	7.8						
Barre de l'Isle	1212.8	1065.6	64	41.6	597	29.8	386
Castries Waterworks	1425.1	1396.8	106	40.3	555	30.4	380
Central Forest A	2069.3	2037.3	50	22.1	478	24.3	201
Central Forest B	1959.1	1959.1	72	35.3	525	29.2	321
Dennery	392.5	392.5	20	38.4	588	28.8	357
Marquis	193.8	182.8	7	26.0	699	21.8	212
Quilesse	1925.3	1676.7	97	33.5	567	27.4	299
Totals	**9185.9**	**8710.7**	**416**	**33.4**	**542**	**28.0**	**305**

Table 9 Overall summary of inventory results

Table 9 shows that the mean volume in the forests of St. Lucia ranges from 201 to 386 cubic metres per hectare, with a weighted average of 305. Table 9 indicates that the St. Lucia crown forest reserves contain approximately 2.8 million cubic metres of wood.

The inventory analysis further broke down the estimates by stratum into stocking, basal area, and volume by species and diameter size class, with the whole inventory volume results as shown in Annex 3. These data are of considerable use for management planning purposes. However, the data are more readily utilized via the SL FMIS, and which can export the data in spreadsheet format for further planning and which can use the data for planning purposes.

During the inventory 12,636 trees were measured in 416 sample plots. Annex 2 includes a list of species identified for the timber inventory, and also includes the frequency with which these species were observed. From Annex 2 it can be seen that the most common species measured was *Sterculia caribaea* with *Aegiphila martinicensis, Guarea macrophylla* and Ternstroemia *oligostemon* among the least common species measured inside the forest.

The SL FMIS can be used to develop estimates for alternatively defined strata. This is a relatively simple process, involving the designation of new strata in the SL FMIS, and the reallocation of each forest unit to the new strata. Any of the strata shown above can be recombined into greater strata, or the under-lying forest units can be combined into completely different strata.

An exhaustive analysis of alternative stratifications is outside the scope of this report, as there are an unlimited number of alternative manners in which the basic inventory data can be reanalysed. However to provide Range-based estimates to enable comparison with the 1982 inventory, and for the point of illustration, the inventory analysis was rerun with the forest units combined on the basis of forest Range. Table 10 shows the results when the inventory is analysed by range.

Stratum	Area	Area Sampled	No. Plots	Mean BA	BA Precision achieved	Mean SPH	Mean Volume
Northern Range	1613.9	1579.6	113	38.6	8.1%	572	361
Millet Range	155.5	121.8	13	23.0	26.7%	698	189
Dennery Range	1984.0	1808.4	96	39.6	7.7%	621	364
Soufriere Range	157.4	113.3	15	26.2	20.1%	505	234
Quillesse Range	5274.9	5087.6	179	30.0	8.0%	502	273
Forest Total	**9185.9**	**8710.7**	**416**	**33.4**	**4.7%**	**542**	**306**

Table 10 Inventory results by Range

Note that the overall basal area precision of estimate is slightly less precise in Table 10, at 4.7%, compared with Table 8Table 9 at 4.4%. This is due to the inclusion of unsampled areas in the analysis by Range, and due to the unbalanced sampling intensity when compared with the sampling intensities shown in Table 8.

The results in Table 10 can be compare directly with the results of the 1982 inventory, but are less balanced that the results for the stratification the inventory was designed around. This shows the advantage that can be gained from a balanced sampling design.

Table 9 and Table 10 show inventory summary details by per hectare totals for all species. For forest management, additional detail is required on the distribution of timber by species and potential log size. Such detailed information is exemplified in Annex 3. Table 11 shows a summary of the total volume by species and dbh class for the average forest areas of Saint Lucia.

Species	Volume within dbh classes (m3)								Total Volume (m3)
	< 15	**15 - < 25**	**25 - < 35**	**35 - < 45**	**45 - < 55**	**55 - < 65**	**65 - < 75**	**> 75**	
Sterculia caribaea	3.7	8.8	11.3	11.9	9.8	4.0	2.1	1.5	53.1
Dacryodes excelsa	0.1	0.8	1.3	2.8	3.2	3.7	4.9	13.2	30.0
Hibiscus elatus	1.5	5.3	6.9	4.4	3.6	1.2	0.2	0.4	23.5
Licania ternatensis	0.3	1.0	1.7	2.7	3.4	1.4	1.6	0.7	12.8
Ocotea leucoxylon	0.6	2.0	3.0	3.2	1.4	1.0	0.6	0.3	12.1
Swietenia macrophylla	0.5	1.6	2.2	2.0	2.4	1.5	0.1	0.6	10.9
Sloanea caribaea	0.1	0.4	0.5	0.6	1.1	1.9	2.1	4.2	10.9
Pouteria pallida	0.1	0.4	0.6	1.1	1.8	1.5	1.5	3.1	10.1
Sapium caribaeum	0.2	1.0	1.2	2.3	1.8	1.1	0.9	1.3	9.8
Guatteria caribaea	0.5	1.4	2.4	2.1	1.5	0.7	0.9	0.2	9.7
All other species	10.7	25.8	26.4	18.8	14.8	8.9	6.1	10.9	122.4
Total Volume	**18.3**	**48.5**	**57.5**	**51.9**	**44.8**	**26.9**	**21.0**	**36.4**	**305.3**

Table 11 Mean total volume by species and dbh class

Goodlet (1970) provided an examination of indigenous species in demand in Saint Lucia at the time of his study. Table 12 shows the current estimates of standing volume for the species identified by Goodlet. [4]

[4] Some species names have changed since 1970. New species names have been identified from the local names provided by Goodlet (1970). In some cases the local names are ambiguous.

Species	Volume within dbh classes (M3)								Total Volume (m3)
	< 15	**15 - < 25**	**25 - < 35**	**35 - < 45**	**45 - < 55**	**55 - < 65**	**65 - < 75**	**> 75**	
Hieronyma caribaea	0.0	0.1	0.2	0.8	0.5	0.6	0.3	0.5	3.0
Aniba ramageana	0.0	0.1	0.1	0.0	0.0	0.3	0.2	0.0	0.7
Pouteria pallida	0.1	0.4	0.6	1.1	1.8	1.5	1.5	3.1	10.1
Simarouba amara	0.2	0.8	2.4	1.4	1.0	0.6	0.3	0.3	7.0
Chimarrhis cymosa	0.2	0.2	0.2	0.2	0.3	0.2	0.3	0.0	1.6
Byrsonima martinicensis	0.0	0.2	0.3	0.6	0.3	0.0	0.0	0.0	1.4
Pithecellobium jupunba	0.3	0.5	0.9	1.0	0.4	0.2	0.1	0.0	3.4
Dacryodes excelsa	0.1	0.8	1.3	2.8	3.2	3.7	4.9	13.2	30.0
Beilschmiedia pendula	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.3
Ocotea eggersiana	0.1	0.2	0.3	0.1	0.4	0.0	0.0	0.0	1.1
Tabebuia heterophylla	0.0	0.2	0.3	0.5	0.2	0.1	0.0	0.0	1.3
Sapium caribaeum	0.2	1.0	1.2	2.3	1.8	1.1	0.9	1.3	9.8
Sterculia caribaea	3.7	8.8	11.3	11.9	9.8	4.0	2.1	1.5	53.1
Byrsonima spicata	0.3	0.9	1.4	0.7	0.6	0.1	0.4	0.0	4.4
Tovomita plumieri	0.6	1.8	0.6	0.0	0.1	0.0	0.0	0.0	3.1
All other species	12.5	32.4	36.2	28.5	24.4	14.5	10.0	16.5	175.0
Total Volume	**18.3**	**48.5**	**57.5**	**51.9**	**44.8**	**26.9**	**21**	**36.4**	**305.3**

Table 12 Volume of species previously in demand (after Goodlet, 1970)

Discussion

Throughout any consideration of the results from the 2009 inventory it must be born in mind that the 2009 inventory did not sample forest areas with slopes over 30 degrees. As such, any comparison with earlier inventories must not include comparisons for areas with high slopes. In particular, the 1982 inventory results for the Protection forest management class cannot be compared with the 2009 results.

Any management planning should also keep in mind that while assumptions can be made about the possible volumes on steeply sloped areas, such assumptions should be supported by ground inspection.

Similarly, the 2009 inventory did not sample plantations separately from other areas of forest. No estimates are given for plantation areas. The plantation areas were not estimated specifically in part due to the unavailability of plantation maps at the planning stage, and in part due to the relatively low area occupied by plantations, approximately 350 hectares.

It should be noted that Graveson (2009) classified the plantation areas as a separate vegetative class, on the basis that many of these old established plantations are now reverting to a new forest type comprised of the original plantation species and infiltrated native species.

The inventory results shown above in Table 9 and Table 10 show the land under Forestry Department control has an average of 540 trees per hectare, with an average of 305 cubic metres of timber per hectare, totalling approximately 2.8 million cubic metres of timber. This is the overall estimate, and of limited value for detailed forest management planning. Further inventory volume details are provided in the Annexes, and are available through the SL FMIS (Tennent, 2009b).

The average timber volume per hectare in 1982 as reported by Piitz (1983) was approximately 187 cubic metres, with an estimated 1.3 million cubic metres total volume. The 1983 timber inventory was carried out using slightly different management classes and methodologies than the 2009 inventory. The 2009 inventory did not sample steep land, and as such comparison with the 1982 inventory may best be made with the results for the Exploitation or Protection/Production forest management classes, which had estimated volumes of 205 and 194 cubic metres respectively.

Assuming an approximate average volume in 1982 of 200 cubic metres, versus an approximate average volume of 300 cubic metres in 2009, the forest can be seen to have increased by at least 50% in volume over the past 27 years. This is an average increase of approximately 2% per year. It should be noted that this is a net increase, and does not include any loss of timber volume via mortality over the past 27 years.

Table 9 and Table 10 show an average stocking in the forest of approximately 542 stems per hectare, ranging from a low of approximately 480 to a high or approximately 600. Piitz (1983) reports a mean stocking of 289 stems per hectare, ranging from 275 to 344 by forest management class. The 2009 inventory results show an average increase in stocking of approximately 85%.

The increase in stocking and volume between the 1982 and 2009 inventories shows the forests of Saint Lucia have recovered strongly from the effects of Hurricane Allen in 1980. This strong recovery shows that the forests of Saint Lucia are capable of relatively rapid recovery from disturbance, indicating that selective logging could be considered a viable forest management alternative.

From Table 11 it can be seen that 60% of the timber volume is contained in 10 species, with 17% contained in *Sterculia caribaea*, mainly in smaller size classes, and an additional 10% contained in *Dacryodes excelsa*, mainly in large size classes. Table 11 also highlights that fully 4% of the timber volume in the forests of Saint Lucia is contained in large *Dacryodes excelsa* trees. This amounts to a total resource of approximately 120,000 cubic metres of large size *Dacryodes excelsa*.

Table 12 shows that over 40% of the standing timber is contained in the 15 species identified as previously in demand by Goodlet (1970). However, two of the species have almost been eradicated (*Aniba ramageana* and *Beilschmiedia pendula*), and a further four species show less than 2 cubic metres of timber volume per hectare on average.

Four species from Table 11, the high volume species, are included in Table 12, the species in demand. These are the two identified above, *Sterculia caribaea* and *Dacryodes excelsa*, with *Pouteria pallida* and *Sapium caribaeum* in addition, each contributing approximately 10 cubic metres per hectare to Saint Lucia's average total volume.

Further to the above, the follow table shows the top eight species by estimated volume in 1982 inventory with the 2009 estimates of total volume for the same species.

Species	Volume 1982 (m3)	Volume 2009 (m3)
Sterculia caribaea	11.4	53.1
Dacryodes excelsa	29.8	30.0
Licania ternatensis	11.0	12.8
Sloanea caribaea	19.6	10.9
Pouteria pallida	14.5	10.1
Sapium caribaeum	6.8	9.8
Guatteria caribaea	7.5	9.7
Talauma dodecapetala	7.1	3.5

Table 13 Top volume species from 1982 inventory (after Piitz, 1983) with 2009 estimates

Most 2009 estimates are higher than the corresponding 1982 estimate, although the estimate for *Dacryodes excelsa* is essentially the same. The 1982 estimate for *Sloanea caribaea* is much higher than the 2009 estimate, which is contrary to expectation. However, seven of the top eight species by estimated total volume in 1982 are found in the top ten species by estimated total volume in 2009.

This analysis provides examples of the type of information which can be derived from the inventory data. Now that the staff of the Saint Lucia Forestry Department have training in inventory, inventories should be carried out at regular intervals, perhaps every 5 years, to ensure that the information is kept up to date.

Conclusion

The timber inventory carried out in 2009 has successfully updated the information previously only available from inventories over twenty years ago. The Saint Lucia Forestry Department now has access to stratified estimates of tree volume by species by size class for the entire forest reserve, capable of being broken down by range or to the lower level of the forest units sampled.

The information collected in the inventory is stored in a modern forest management information system, and can be extracted for detailed analysis in Microsoft Excel or alternative software. The SL FMIS can be used to calculate detailed estimates of volume available through thinning operations.

All data are available for future growth and yield analysis. All data have been entered into electronic form, and, provided secure backups are made at regular intervals, will be available for future inventory planning and analysis.

Saint Lucia's Forestry Department now has a modern forest inventory system set in place, with a cadre of staff and other individuals trained and experienced in conducting a modern forest inventory. This provides a secure basis for the implementation of future forest timber inventories. Future forest inventories should be undertaken at more regular intervals, perhaps every five years.

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Annexes

The following annexes are included below.

Annex 1 Forest units

Forest Unit	Range	Inventory Stratum	Area	Number of plots	Volume estimate
Addition Barre de L'isle North	Millet	Minor fragmented forest land	1.72	0	0.00
Addition Barre de L'isle South	Dennery	Barre de l'Isle region	147.27	0	0.00
Addition Central Forest B	Quilesse	Central Forest B	148.98	5	278.18
Addition Central Waterworks	Dennery	Castries Waterworks and surrounds	28.31	0	0.00
Addition Dennery Ridge large	Dennery	Dennery Ridge, Waterworks, St Josephs Estate	96.04	3	216.73
Addition Forestierre Block	Northern	Quilesse region	4.73	0	0.00
Addition Roseau Dam	Millet	Central Forest A	32.02	0	0.00
Addition to Central Forest A	Quilesse	Central Forest A	248.09	15	251.37
Addition to Grand Magazin	Soufriere	Quilesse region	38.11	0	0.00
Addition to Quillesse	Quilesse	Quilesse region	196.55	19	252.30
Addition to Quillesse & Grand	Quilesse	Quilesse region	187.30	0	0.00
Barre de L'isle North	Dennery	Barre de l'Isle region	225.58	31	348.57
Barre de L'isle South	Dennery	Barre de l'Isle region	741.02	19	409.70
Barre de L'isle South (East)	Dennery	Barre de l'Isle region	98.95	14	290.02
Castries Waterworks	Northern	Castries Waterworks and surrounds	1396.81	106	380.07
Central Forest A	Quilesse	Central Forest A	1667.44	22	193.71
Central Forest B	Quilesse	Central Forest B	1459.74	55	329.50
Dennery Ridge	Dennery	Dennery Ridge, Waterworks, St Josephs Estate	72.04	5	319.96
Dennery Waterworks	Dennery	Dennery Ridge, Waterworks, St Josephs Estate	145.00	10	441.23
Fond Estate acquisition	Dennery	Central Forest B	350.43	12	305.52
Forestiere Blocks	Northern	Quilesse region	18.54	0	0.00
Marquis 1	Northern	Marquis region	132.66	4	174.14
Marquis 2	Northern	Marquis region	35.40	2	273.89
Marquis 3	Northern	Marquis region	14.74	1	407.74
Marquis 4-6	Northern	Marquis region	11.05	0	0.00
Montete Choiseul	Soufriere	Minor fragmented forest land	6.06	0	0.00
Quilesse	Quilesse	Quilesse region	1366.82	63	311.02
Roseau Dam	Millet	Central Forest A	121.78	13	188.70
Saltibus Grand Magazin	Soufriere	Quilesse region	113.28	15	233.56
St. Joseph's Estate	Dennery	Dennery Ridge, Waterworks, St Josephs Estate	79.39	2	406.93

Annex 2 List of tree species measured in the timber inventory

The following table shows the species found during the timber inventory, with their local name, and the frequency the species was observed, in number observed per 1,000 measured. This list of species and local names was edited by Project Botanist Mr. Roger Graveson.

Species	Local Name	Frequency
Aegiphila martinicensis	Bwa kabwit	0.1
Anacardium occidentale	Ponm acajou, Nwa, Cashew	0.3
Andira inermis	Anjlen	3.4
Aniba ramageana	Lowyé kannèl	1.6
Artocarpus altilis	Bwapen, Chatany, Breadfruit, Breadnut	3.4
Beilschmiedia pendula	Lowyé wouj	0.8
Bursera simaruba	Gonmyé modi	1.0
Byrsonima martinicensis	Bwa tan wouj	4.4
Byrsonima spicata	Bwa tan	17.0
Casearia decandra	Bwa koko kawèt	2.5
Cecropia schreberiana	Bwa kannon	15.8
Ceiba pentandra	Fwonmajé, Silk cotton	0.2
Chimarrhis cymosa	Bwa wivyé	8.1
Chrysobalanus cuspidatus	Kaka wat	0.1
Chrysochlamys caribaea	Bwa mang, Palitivyé wouj	0.4
Chrysophyllum argenteum	Bwi	0.7
Coccoloba pubescens	Bois Grande Feuille	1.1
Coccoloba swartzii	Bwa lanmowi, Wézinyé	2.0
Cordia reticulata	Sip	19.2
Cordia sulcata	Sip blan, Bwa sip	0.6
Cornutia pyramidata	Bwa kasav	1.3
Dacryodes excelsa	Gonmyé	27.5
Daphnopsis americana	Maho pimen	1.3
Daphnopsis macrocarpa	Maho pimen gwan bwa	0.4
Diospyros revoluta	Babawa	1.3
Endlicheria sericea	Lowyé fè	6.6
Erythrina poepigiana	Mòtèl	0.2
Exostema caribaea	China	0.4
Ficus americana	Fijé ti fèy	0.3
Ficus species	Fijé species	3.2
Gliricidia sepium	Glory cedar	0.4
Gmelina arborea	Gmelina	2.2
Guapira fragrans	Mapou	5.9
Guarea glabra	Acajou gwan bwa	5.6
Guarea macrophylla	Bwa di woz	0.1

Guatteria caribaea	Kòsòl mawon, Ti kachiman bwa	29.8
Guazuma ulmifolia	Bwa lonm	3.2
Guettarda scabra	Bwa madam	0.4
Gymnanthes hypoleuca	Bwa sadin	7.5
Haematoxylon campechlaxuml	Kanpèch, Logwood	2.8
Hibiscus elatus	Blue mahoe	124.5
Hieronyma caribaea	Bwa damand	4.4
Hirtella pendula	Pann zòwèy, Zikak fwans	4.0
Inga ingoides	Kakoli	15.0
Inga laurina	Pwa dou	3.5
Licania ternatensis	Bwa di mas	26.3
Ilex sideroxyloides	Ti siton	0.6
Lonchocarpus heptaphyllus	Savonnèt gwan fey	26.2
Mangifera indica	Mango	4.1
Manilkara bidentata	Balata	2.1
Margaritaria nobilis	Bwa mil bwanch, Bwa zo bèf	0.6
Marila racemosa	Bwa pwa	2.4
Miconia species	Bwa senn	16.0
Micropholis crotonioides	Glan	3.6
Micropholis guyanensis	Fèy dowé	17.9
Myrcia deflexa	Bwa kwéyòl.	16.9
Myrcia fallax	Bwadfè	11.0
Myrtaceae species	Bwa di bas	0.2
Nectandra membranacea	Lowyé sann, Lowyé gwan fey	15.9
Ocotea species	Lowyé gwo gwenn	2.1
Ocotea eggersiana	Lowyé ti fèy	4.3
Ocotea leucoxylon	Lowyé mabwé	43.2
Ormosia monosperma	Dédéfouden, Pwa bwa wawi	6.9
Persea urbaniana	Lowyé zaboka	2.0
Pimenta racemosa	Bwaden, Bayleaf	0.3
Pinus caribaea	Caribbean pine	9.8
Pithecellobium jupunba	Dalmawi	9.3
Pouteria semicarpifolia	Kontwévan	1.3
Pouteria multiflora	Pennépis	6.7
Pouteria pallida	Balata chyen	15.1
Protium attenuatum	Lansan	42.3
Quararibaea turbinata	Bwa lélé, Swizzlestick tree	1.5
Rubiaceae species	Ti kafé	2.5
Rudgea citrifolia	Bwa lay	12.0
Samanea saman	Saman, Masav	0.3
Sapium caribaeum	Lagli	13.9
Simarouba amara	Bwa blan	17.2

Sloanea caribaea	Chatannyé	10.2
Spondias mombin	Mouben, Hog plum	0.2
Sterculia caribaea	Maho kochon	177.3
Swartzia caribaea	Kas. Muscad mawon	20.8
Swietenia macrophylla	Honduras mahogany	45.8
Symplocos martinicensis	Bwa blé, Zolivyé	13.5
Tabebuia heterophylla	Pòwyé, White Cedar	3.7
Tabernaemonta citrifolia	Bwa let	0.4
Talauma dodecapetala	Bwa pan mawon	1.9
Tapura antillana	Bwa kot wouj	14.6
Tectona grandis	Teak	0.1
Ternstroemia oligostemon	Miwiz	0.1
Tovomita plumieri	Palitivyé jòn	19.5
Zanthoxylum caribaeum	Lépini wouj	0.9
	Unidentified trees	16.2
	Bois Glo (local name suspect)	0.7
	Bois L`eau (local name suspect)	5.2

Annex 3 Average volume by species and diameter class

	<15	25	35	45	55	65	75	>75	Total
Aegiphila martinicensis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Anacardium occidentale	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Andira inermis	0.0	0.2	0.2	0.1	0.0	0.6	0.1	0.0	1.2
Aniba ramageana	0.0	0.1	0.1	0.0	0.0	0.3	0.2	0.0	0.6
Artocarpus altilis	0.0	0.2	0.1	0.2	0.3	0.0	0.0	0.0	0.8
Beilschmiedia pendula	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.3
Bursera simaruba	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.3
Byrsonima martinicensis	0.0	0.2	0.3	0.6	0.3	0.0	0.0	0.0	1.4
Byrsonima spicata	0.3	0.9	1.4	0.7	0.6	0.1	0.4	0.0	4.4
Casearia decandra	0.1	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.6
Cecropia schreberiana	0.2	1.5	1.4	0.7	0.2	0.1	0.0	0.0	4.2
Ceiba pentandra	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1
Chimarrhis cymosa	0.2	0.2	0.2	0.2	0.3	0.2	0.3	0.0	1.7
Chrysobalanus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chrysochlamys caribaea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chrysophyllum argenteum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Coccoloba pubescens	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.2
Coccoloba swartzii	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.3
Cordia reticulata	0.4	0.9	0.6	0.3	0.2	0.1	0.1	0.2	2.9
Cordia sulcata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cornutia pyramidata	0.1	0.3	0.0	0.2	0.0	0.0	0.0	0.0	0.5
Dacryodes excelsa	0.1	0.8	1.3	2.8	3.2	3.7	4.9	13.2	30.0
Daphnopsis americana	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1
Daphnopsis macrocarpa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diospyros revoluta	0.0	0.1	0.0	0.1	0.0	0.2	0.0	0.0	0.3
Endlicheria sericea	0.2	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.7
Erythrina poepigiana	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Exostema caribaea	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
Ficus americana	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2
Ficus species	0.0	0.0	0.4	0.2	0.1	1.0	0.4	1.8	3.9
Gliricidia sepium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gmelina arborea	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.3
Guapira fragrans	0.2	0.3	0.1	0.1	0.1	0.0	0.0	0.4	1.1
Guarea glabra	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.5
Guarea macrophylla	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Guatteria caribaea	0.5	1.4	2.3	2.1	1.5	0.7	0.9	0.2	9.6
Guazuma ulmifolia	0.0	0.1	0.2	0.3	0.0	0.1	0.0	0.0	0.7
Guettarda scabra	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Gymnanthes hypoleuca	0.2	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.4
Haematoxylon	0.1	0.3	0.2	0.2	0.0	0.0	0.0	0.0	0.9
Hibiscus elatus	1.5	5.3	6.9	4.4	3.6	1.2	0.2	0.4	23.4
Hieronyma caribaea	0.0	0.1	0.2	0.8	0.5	0.6	0.3	0.5	3.0
Hirtella pendula	0.1	0.2	0.1	0.0	0.1	0.0	0.0	0.0	0.5
Inga ingoides	0.2	0.6	0.9	1.0	0.6	0.1	0.1	0.3	3.9
Inga laurina	0.0	0.1	0.2	0.1	0.2	0.0	0.0	0.0	0.6
Licania ternatensis	0.3	1.0	1.7	2.7	3.4	1.4	1.6	0.7	12.8
Ilex sideroxyloides	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
LN Bois Glo	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
LN Bois L`eau	0.2	0.4	0.3	0.1	0.1	0.0	0.0	0.0	1.0
Lonchocarpus	0.4	1.5	1.1	0.3	0.3	0.0	0.0	0.0	3.6

	<15	25	35	45	55	65	75	>75	Total
Mangifera indica	0.0	0.2	0.4	0.0	0.2	0.3	0.3	0.7	2.2
Manilkara bidentata	0.0	0.0	0.0	0.2	0.2	0.3	0.5	1.2	2.5
Margaritaria nobilis	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.3
Marila racemosa	0.2	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.8
Miconia species	1.3	0.6	0.0	0.0	0.0	0.0	0.0	0.1	2.1
Micropholis crotonioides	0.1	0.2	0.1	0.2	0.7	0.6	0.5	0.3	2.7
Micropholis guyanensis	0.3	1.0	2.1	0.5	1.2	0.7	0.3	0.2	6.3
Myrcia deflexa	0.6	0.9	0.5	0.3	0.0	0.0	0.2	0.0	2.4
Myrcia fallax	0.3	0.6	0.6	0.3	0.5	0.0	0.1	0.0	2.4
Myrtaceae species	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1
Nectandra membranacea	0.4	0.9	0.3	0.1	0.0	0.0	0.0	0.0	1.7
Ocotea species	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.3
Ocotea eggersiana	0.1	0.2	0.3	0.1	0.4	0.0	0.0	0.0	1.0
Ocotea leucoxylon	0.6	2.0	3.0	3.2	1.4	1.0	0.6	0.3	12.1
Ormosia monosperma	0.1	0.2	0.7	0.9	0.8	0.1	0.1	0.3	3.1
Persea urbaniana	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Pimenta racemosa	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
Pinus caribaea	0.0	0.4	0.5	0.3	0.0	0.0	0.1	0.0	1.4
Pithecellobium jupunba	0.3	0.5	0.9	1.0	0.4	0.2	0.1	0.0	3.3
Pouteria semicarpifolia	0.0	0.1	0.1	0.2	0.4	0.1	0.3	0.0	1.2
Pouteria multiflora	0.1	0.3	0.3	0.7	0.6	0.4	0.5	0.8	3.8
Pouteria pallida	0.1	0.4	0.6	1.1	1.8	1.5	1.5	3.1	10.1
Protium attenuatum	1.0	2.2	1.8	0.7	0.5	0.4	0.1	0.0	6.7
Quararibaea turbinata	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Rubiaceae species	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Rudgea citrifolia	0.5	0.5	0.2	0.0	0.0	0.0	0.0	0.2	1.3
Samanea saman	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Sapium caribaeum	0.2	1.0	1.2	2.3	1.8	1.1	0.9	1.3	9.9
Simarouba amara	0.2	0.8	2.4	1.4	1.0	0.6	0.3	0.3	7.0
Sloanea caribaea	0.1	0.4	0.5	0.6	1.1	1.9	2.1	4.2	10.9
Spondias mombin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sterculia caribaea	3.7	8.7	11.3	11.9	9.8	4.0	2.1	1.5	52.9
Swartzia caribaea	0.3	1.5	1.4	1.5	0.6	0.2	0.2	0.0	5.6
Swietenia macrophylla	0.5	1.6	2.2	2.0	2.3	1.5	0.1	0.6	10.7
Symplocos martinicensis	0.2	0.7	1.3	0.9	0.4	0.0	0.0	0.0	3.5
Tabebuia heterophylla	0.0	0.2	0.3	0.5	0.2	0.1	0.0	0.0	1.4
Tabernaemonta citrifolia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Talauma dodecapetala	0.0	0.1	0.2	0.3	0.3	0.0	0.3	2.3	3.5
Tapura antillana	0.2	0.8	1.6	1.4	1.8	1.1	0.2	0.5	7.5
Tectona grandis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ternstroemia oligostemon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tovomita plumieri	0.5	1.8	0.6	0.0	0.1	0.0	0.0	0.0	3.1
Unknown	0.5	0.9	0.5	0.4	0.2	0.0	0.1	0.3	2.8
Zanthoxylum caribaeum	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.2
Totals	18.2	48.4	57.4	51.9	44.7	26.8	21.0	36.3	305.3