

About this manual

This manual is designed to guide the design and implementation of strategic forest resource appraisals (FRA's)¹ in Guyana and as one option, describes a procedure used and recommended by the Guyana Forestry Commission for the gathering of new information on forest composition and terrain. The manual's aim is twofold:

- To provide general guidance to GFC and forest concession staff involved in carrying out (and/or providing training in) FRA's, including technical staff, supervisors, field crew chiefs and office personnel.
- To provide instructions for implementing one type of FRA - a forest inventory using circular sample plots. This is to assist GFC in any strategic inventory work it carries out and also to provide industry with a possible procedure for gathering strategic planning information within concession areas. The procedures have been found to work well and can usefully be considered by concession holders in need of new forest composition information.

The manual is divided into three sections.

1. Part One provides general guidance on the process for conducting strategic FRAs, including some of the main options available with regard to their design and implementation. This section aims to assist senior staff in planning FRA's under different objectives and circumstances.

2. Part Two describes a current GFC procedure for conducting forest sampling inventory work. The procedure also serves to provide one option for new information gathering within the general framework set out in Part One.

3. Part Three provides supplementary information on the sampling procedure set out in Part Two – guidance notes on field procedures, look-up tables, field forms, followed by a list of relevant reports and publications.

Due to the wide scope of this manual, it may be useful to copy particular sections of the document for particular staff (e.g. the field procedures can be extracted and laminated).

To avoid duplicating existing publications, this document is kept closely focused on the Guyanese context: to supplement this list of other useful references relating to forest resource appraisals is presented in Appendix *. This list is deliberately restricted to publications which are presently available in the GFC library and/or Forest Resources Management Division.

¹ The term forest resource appraisal is used here to denote the characterizing a forest area for a stated purpose. This activity therefore subsumes others such as conducting forest surveys, inventories and assessments, but it is emphasized that FRA's may also entirely consist of office based activities where existing information is found to be adequate.

Introduction

Strategic forest resource appraisals (FRA's) are defined here as investigations carried out with the aim of characterizing the whole area of forest under management. Each appraisal is effected in a manner designed to effectively support rational forest management decisions of some specific kind. In keeping with the GFC system for managing Guyanese state forests, two distinct strategic planning goals are involved:²

Government: ***“improved sustainable forest resource yields while ensuring the conservation of ecosystems, biodiversity and the environment”***.

Concession holders: ***“maximized returns on investment, through the harvesting and marketing of timber, subject to the relevant laws and regulations”***

The principles followed in this manual are as follows:

- 1) Definition of FRA objectives (and therefore information required) must relate specifically to the objectives of management and to the particular decisions that have to be made;
- 2) Maximum use is made of existing information to meet these defined information needs – any new data gathering must be clearly justified and precisely focused;
- 3) Field work must be simple and cost-effective, addressing only those defined information needs which are not adequately met by existing information;
- 4) Processing and presentation of data into relevant information is explicitly designed to address the objectives of the FRA.

In brief, the planning of FRA's is based on:

- clear objectives and information requirements (*“What we need and why”*),

set against the availability of:

- **existing information and**
- **resources (skilled personnel, equipment, time and money) required to assemble this information and if necessary to collect more (*“What we have”*).**

² Both levels are considered strategic in that they relate to a high-order goal of the managing agency and in both cases are applied to the entire land area to be managed.

PART ONE Process and options for FRA's

This section describes the stages involved in designing and implementing FRA's and provides a broader perspective on some of the technical options available.

Defining Purpose

The purpose of any FRA is to support decision making of some particular kind. Relating back to the two strategic planning contexts distinguished in the introduction, FRAs are carried out in Guyana for one of two main purposes:

1. To provide information to GFC, the GFC Board and government institutions to foster "improved sustainable forest resource yields while ensuring the conservation of ecosystems, biodiversity and the environment".

This requires decisions to be made on (among other things):

- Classification of forests by predominant and potential use
- Identification of priority areas for forest development
- Calculation of annual allowable cut for productive classes
- Preparation of forest management plans for State Forest Permissions
- Development of prescriptions for sustainable management of forest types

2. To provide information to concessionaires to achieve "maximized returns on investment, through the harvesting and marketing of timber, subject to the relevant laws and regulations"

This requires decisions to be made on (among other things):

- What areas can be production forest?
- What species are present in commercial quantities?
- What areas should be protection forest?

For more detailed planning of timber production and marketing, the following also becomes relevant:

- What is the present composition and likely sustained yield of the main productive forest types?

Defining Objectives

The objectives of an FRA are comprised of two components:

1. The decision(s) that will be made to achieve the purpose
2. The question(s) to be answered in order to make the decision(s)

i.e. *"Specific questions to be answered by the FRA to support the achievement of a stated purpose"*

The objectives of an FRA are based on the following:

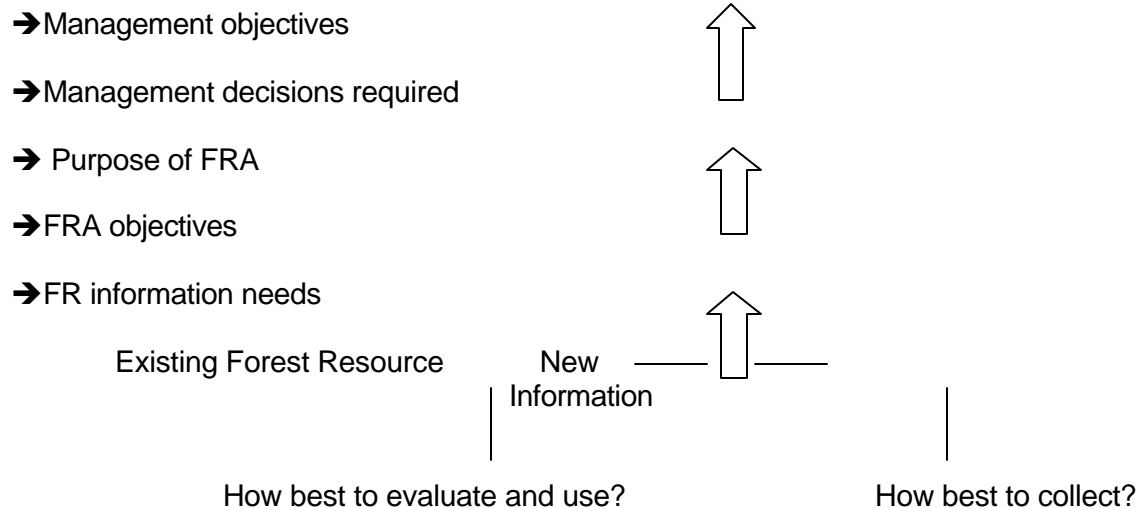
- objectives of management (since the purpose of the FRA is to support the achievement of these)
- the decisions which need to be made to achieve management objectives
- broad categories and detail of information thought to be required to support these decisions
- level of resources likely to be available for any exercise undertaken (personnel, time, equipment)

The following background information is needed at this stage to guide the process (in hard-copy form or viewed on-screen):

- The GFC regional forest type coverage for the area at 1:50,000 – 1:250,000 scale (depending on the size of the area of interest) with concession and/or other relevant legal boundaries superimposed;
- Locations of existing inventory/survey data
- Any existing reports summarising information relevant to the decisions to be made

Figure 1, below sets out the process in brief.

Purpose of forest management



In the above, the → arrows show how, starting at the top, each element in the planning process determines the one immediately below.

The upward arrows indicate how the resulting forest resource information supports the achievement of the FRA objectives and by doing so, support the management objectives.

As shown above, once the preliminary objectives for the FRA have been developed, these need to be translated into specific information and data requirements.

Defining information needs

The procedure set out in Part Two caters for a particular set of information elements which are considered necessary/useful to support rational planning for the two main stated levels of purpose (government/concession holders), i.e: *“the information needed to answer the specific questions to achieve the stated purpose”*

GFC's future strategic FRA's involving new data collection will tend to include most/all of data/information the elements set out below. This is because these elements are believed to be relevant to characterizing forest resources to support strategic level management. Moreover, wherever possible it is important to maximise consistency between past and present information. However it is emphasized that if in future different policies, criteria and/or mechanisms are applicable, information needs will need to evolve accordingly.

Private companies (or NGOs) following these procedures may wish to modify the information collected based on their own particular objectives and/or internal procedures³, but it is advised that this should only be done if there is a good reason for doing so. For example companies may wish to exclude certain data elements to simplify the exercise and expedite data collection and processing. It is important that only information required to achieve the specified objective(s) is compiled and/or collected.

To ensure a close linkage between manner of forest characterisation and the objectives, each of the latter must be translated into a list of specific categories of information required to achieve it. This list can in turn be translated into specific categories of data required to produce the information categories (see below).


Precision required

It is important to define how reliable each type of information must be to achieve the objectives. A balance must be struck, since getting more reliable information usually requires more resources. The important decision to be made is therefore: what is minimum level of reliability required to adequately address the specified objective(s) – *“how imprecise can we afford to be in our estimates (for example of annual timber production)?”*

To rationalise the process of translating objectives into information and data needs, the following table is completed.

Table 1 Information Analysis Framework

³ These might include site classification or the method used for stem quality assessment.

Objective	Questions to be answered	Information required	Precision required	Data required	Data definition	Source	Output
Identify and characterize productive areas	How much potentially productive forest is there and where is it?	Distribution, area and expected productive status of each main FT	+/- 10% on FT areas	% and area covered by each type knowledge of which types are usually productive	FT's as per GFC database	<i>GFC vegetation database</i> Ground truthing exercise	Map showing main FTs, land status summary table
	Which of these areas are actually workable?	Distribution and extent of three main terrain classes	+/- 10% on area of FTs assessed as productive	Slopes gradients Soil types Elevation Accessibility	0-10. 10-20, >30 degrees 7 classes metres as a currently or potentially accessible due to absence of major swamps, rivers, difficult terrain	<i>Topo maps</i> <i>Soil maps</i> <i>General terrain info from JERS radar imagery</i> (Use new high resolution JERS data when available) Modified Sampling inventory (no plots needed)	Areas with terrain classes marked on map
	What commercial species are present?	List of species known to be present in the area	N/A	Names of commercial and non-commercial species recorded in/ around the area	Definition of commercial and non-commercial species	Inventory data/ summaries/ knowledge Reconnaissance visit	Species list for each FT, preferably in order of expected frequency
	What is the Basal area per hectare in relation to GFC guidelines?	BA per hectare > 10cm dbh BA of merchantable stems Stand condition profile ("disturbance" or "impacts")	20 SE% on BA all spp above 10cm dbh	BA data, including for subset of merchantable stems	Definition of commercial and non-commercial species and specifications Disturbance/ impact classification	Existing data if adequate in coverage, precision and recent capture – if not: RAP procedure	Summaries of BA/ha and disturbance/ impact rating
Predict potential production from the productive types	What is the current stock ?	Estimates of composition and standing volume/BA within identified prod. areas	+/- 20% error on BA of commercial species	Forest inventory tree data	Definition of commercial and non-commercial species and specifications	<i>Inventory data/ summaries</i> New sampling inventory work	Stand tables for each main FT, sorted by totals Statistical report for each table
	What sustained yield options are available?	Modeled projections of sustained yield options using above data	+/- 20% over 60 years?	Annual increment, mortality and cumulative damage estimates; static data as above	See Alder report. GFC 1990	 Remeasurements of existing PSP's; new plots established	Projected stand tables based on defined cycle, and diameter limits

(cont)

Objective	Questions to be answered	Information required	Precision required	Data required	Data definition	Source	Output
Identify areas to be protected	<p>What areas are unproductive in any case?</p> <p>What productive areas are worthy of protection?</p>	<p>Areas not qualifying as productive</p> <p>Areas with special Conservation values, eg:</p> <p>Presence/ distribution of endemics</p> <p>Rare plants/, animals vegetation types</p> <p>Rare animal habitats</p>	<p>See above</p> <p>Threshold values not defined</p>	<p>Unproductive areas – see above</p> <p>Plant and animal distributions</p> <p>Other biological/ ecological information on rare species</p>	Undefined at present	<p>Unproductive areas – see above</p> <p>Botanical collections</p> <p>Forest Inventory data</p> <p>CSBD (UG), EPA records</p> <p>Specialist biological surveys</p>	<p>Thematic maps summarizing forest types (including unproductive areas) - as above, distribution of endemic flora/fauna</p>

Sources of information:

Required information will usually come from two sources:

- **existing** sources (reports, maps, aerial photos, data etc) and
- **new** field work (e.g. establishing lines and sample plots in the area of interest).

The next stage is therefore to see how much of this information already exists and how much use it can be to the FRA.

Assemble and evaluate existing information

Due to the high cost of carrying out field exercises, maximum use needs to be made of existing information.

The previous table provides a profile of information and data requirements relative to objectives. It also indicates the most appropriate source(s) for each category of information. An evaluation of existing information relative to information needs allows the identification of any need for new information.

A wealth of existing information is available for much of the State Forest Area. However, the coverage of this information is not uniform across the State Forest - it varies in detail, degree of documentation and in age (much of it being over thirty years old).

As the first stage of evaluating this existing information, the officer in charge of the FRA will assemble relevant available information for the area in question, as specified in the information analysis table⁴. The following table sets out the main categories of existing FRI and their use:

⁴ This information is now available to concession holders through GFC's Forest Resources Information Unit.

Table * Summary of main categories of FRI available

Information category	Main examples	General use for FRA's	Limitations
Maps	1:50,000 base maps GFC's regional forest type database land use infrastructure soils, geology,	essential for compilation of FR maps indicates distribution and proportion of productive/unproductive types input to land use planning indicates present capacity to operate may be composition differences within a single gross forest type (e.g. "mixed") soil, combined with slope/topography is a good indicator of terrain	topographic series more useful than "planimetric" age of information relative to likely changes (human and natural)
Aerial photographs	1:41,000 Terra 1:30,000 RAF 1: 10,000 CIDA	To carry out new interpretations or cross-checking of existing vegetation maps	age of information relative to likely changes (human and natural)
Inventory locations and available data-files	previous inventory work in or around the area	produce indicative stand tables for main FTs and characterize range of site types	Proximity and amount of work carried out and its age relative to likely changes (human and natural)
Reports on forest inventory and related resource assessments	Valuation Report FIDS reports IFP Summary reports	provide forest and site descriptions and background info on how these were produced	as above
GFC Knowledge (particularly FRMD/FMD)	Areas worked Locations and extent of forest roads General accessibility of areas, including navigability of creeks Forest condition, including particular disturbances General observations on forest and company history	Important for supplementing and up-dating other information – should be routinely harnessed Incorporated onto FR Map and used for planning field exercise	Depends on availability of experienced field officers

An important component of this existing information is quantitative data on forest composition ("inventory data"), provided it can be reliably used. In some cases, inventory summaries exist, but without the original data (e.g. the Valuation and Reconnaissance Surveys). Also, previous appraisals may have covered only a part of the present area of interest, probably using a different methodology than that used now. To assist interpretation of existing forest composition information/data a brief profile of each main category of forest composition data is provided below, with recommendations on its potential uses and limitations (see the right-hand column "Utility").

Table * Summary of available forest composition data

Dataset	Date of origin	Description	Coverage	Utility
Valuation and reconnaissance surveys	1926 - 1950	26 specified areas – summaries of results only - available in electronic format	32% of state forest quarter degree sheets sampled	Good background info for areas not exploited/ disturbed since – Useful for general species presence and relative frequency, including across northern part of state forest; not useful for detailed analysis
Forest Industries Development Surveys	1969 - 1971	1029 plots in 77 main locations Data and summaries available in electronic format	28% of state forest quarter degree sheets sampled also covered non state forest	High for areas not exploited/ disturbed since Data can be queried by FT for particular areas, but sampling errors must be checked
Great Falls Inventory	1975	Data and summaries available in electronic format	Total area of 579,870 acres sampled at a 0.04 intensity	Useful data for this area, though commercial volumes probably affected by logging
Interim Forestry Project	1989 - 1995	7737 plots in 26 main locations Data and summaries available in electronic format	8% of state forest quarter degree sheets were sampled, but relatively high intensity at each location	High Data can be queried by FT for particular areas, but sampling errors must be checked
Recent GFC	1995 – present	Several forest sample inventories: Aravina woods, RIL study, Correia Mining, SFP RAP Silvicultural Surveys - 3 100 ha blocks PSPs: 1ha plot at Moraballi Reserve Data and summaries available for all of above in electronic format	Specific areas DTL and IFI concessions	High – good recent data on forest composition and condition in specific areas
Recent other	1990 – Present	Several forest sample inventories: WAICO, Iwokrama, Bartica Triangle PSPs: DTL: 2 x 1ha plots Tropenbos (Pibiri) Barama: Around 50x 1ha plots All data available for above in electronic format	Specific areas Within DTL concession Within BCL concession	High –good recent data on forest composition in specific areas Used for production of growth models to date; also have value as good static data sets
Botanical collections		3 Guyanese Herbaria	Many parts of the country	High – GFC databases can be used to query locations of endemic, rare and localised species

To emphasise the need for care when using existing information resources, some of the main issues are summarized for reference in the following table:

Table * Issues to consider when using existing information

Issue	Causes	Utility/ course of action
out of date	age known disturbances since it was collected (fire, logging, mining etc)	Assess areas most likely to have been affected, relative to locations of collection and new info needs. Old data may be quite valid in undisturbed areas. Ground-truthing (or fly-over) may suffice to update existing information
incomplete in content/ detail	doesn't cover all species, size classes, forest types of interest; raw data unavailable – only summaries	Identify what new data is required to fill key gaps in existing information - design field programme accordingly
incomplete in coverage	doesn't adequately cover the area of interest	Examine gaps in coverage relative to other information (e.g. FT maps) and assess importance. Assess difficulties in accessing areas not previously covered
of dubious or unknown quality	No report, credentials of staff unknown or doubtful	Use as a secondary reference only (cross-check)

As the purpose of the exercise is to carry out a focused appraisal of the forest resource under management, the next stage is prepare a preliminary appraisal using available information. This can then be supplemented by new data collection as necessary to meet the defined requirements.

Prepare a preliminary Forest Resource Appraisal

Once objectives have been clearly stated and existing information resources compiled and appraised, a preliminary FRA is produced. This consists of a map of the area with supporting summary tables. The generic format set out here can be modified according to the particular circumstances.

Forest Resource Map

Scale

For overview purposes it is useful to have a single large map sheet covering all of the relevant area. Depending on the size of the area, the scale will to vary between 1:50,000 and 1:250,000.

Larger scale maps showing specific parts of the area can be produced if necessary to allow the fine tuning of plans.

Information to include:

The map will be produced to conform with the information requirements specified in the information analysis table, above. It will therefore show legal/administrative boundaries, land cover (distinguishing the main forest types), topography/ terrain along with infrastructure and access.

Any other available maps showing useful information (particularly relating to land use) should also be kept on hand throughout the planning process.

1. Identify and copy 1:50,000 sheets with coverage of the study area and mark the boundaries of the latter (if this is a concession, use the existing theme held by FRIU)
2. Superimpose regional vegetation types⁵.
3. Add any additional information available on locations and condition of roads, navigability of rivers/creeks, locations of any known logging camps and areas of logging activity
4. Using the land cover types as strata (distinct forest areas) classify each cover polygon into one of four indicative classes:
 - i) productive and harvestable – mixed/wallaba/mora forest on workable and potentially accessible terrain and considered to be in good condition
 - ii) potentially productive but likely to have been worked out – as per i), but considered to have been thoroughly harvested
 - iii) permanently unproductive (e.g. scrub, dakama, savanna, clearings)
 - iv) other unproductive (swamp and marsh, burned areas)

⁵ GFC's regional forest type database is the best source for this information for most concession areas

FRA Summary Tables

Tables are required to summarise areas by land cover and potential land use: two are required initially, presenting the above information:

- a) For the whole concession area
- b) In greater detail for the productive forest component, i.e:

a) Land cover status table (areas measured from FR map)

Cover type	Area (ha)	% of total concession	Productive for forestry (Y/N)	Current use	Comments
Mixed forest 1h	24833	25	Y	None	
Wallaba forest 2b	12003	13	Y	None	
Dakama scrub 2c	46938	49	N		
Compound	6	.07	N	Company offices and accommodation	
Quarry	4	.05	N	Disused	Potential for road material
Total	92,683	100			

b) Productive Forest Summary

Forest Type	Total Area	Unworkable area	Harvestable Area	Harv % of FT	% of concession area	Species observed	Other likely species	Condition
1h	5698	2349	2349	50	12	Greenheart, Morabukea, Kabukalli, Suya, Bulletwood	Kereti, Letterwood,	Logged c.1985
2b	7800	4800	4800	45	28	Soft wallaba Fukadi Shibidan Locust		Locally degraded

If forest composition data are available for the area, preliminary stand tables are produced, preferably by main forest type. If data are scarce and/or questionable, if possible a preliminary species list is produced based on reports, botanical collections and GFC knowledge.

Evaluate adequacy of existing information in meeting information needs

If the existing information is considered to meet the requirements set out in the information analysis table (page **) no new data will be required. If however some net information/data requirements are a constraint upon completion of the above, the next stage is to plan and undertake their collection. This net information/data requirement is carefully specified with reference to the table.

For relevant existing information, determine:

- **Coverage** in relation to the present area of interest, likely representativeness if coverage differs
- **Reliability** - Precision, age, management/disturbance history

Then determine the overall level of resources available for the FRA

Two broad situations will exist:

1. Existing info adequate

– carry out an office exercise – finalise preliminary FRA

2. Additional info needed

– plan a field programme to efficiently capture required data, taking account of resource budget/resource constraints. One of the following scenarios are likely to apply; current GFC procedures are indicated in each instance:

a) If new information is needed to update vegetation/terrain/ accessibility to confirm productive forest areas – API and ground truthing procedure

b) If new, up to date information on forest condition and indicative stocking is needed rapidly – Rapid Appraisal Procedure

c) If new quantitative forest composition information is needed – Sample plot procedure (See Part Three of this manual)

d) If new information is needed on plant and animal populations and habitats – specialist biological surveys

In each case care is taken to define what data is required to provide the necessary information. It is important to emphasise that there are many possible approaches and procedures available to address the collection of new data - the procedures referred to here are those currently in place in GFC.

Stage II Planning the collection of new information

Determine what resources are available

Personnel: A list of persons and skills required for the exercise (see below) is compared to a list of available personnel. This will include office and field staff, supervisors as well as technicians and assistants.

If inadequate personnel are available, the options are to postpone the exercise, modify its design, recruit and train new staff, or to contract staff to carry out the work. The best option will depend on the urgency of the exercise, the nature of the staff shortfall, the ease with which new staff can be hired and trained and the availability of contractors/consultants who could undertake the work.

It should be emphasized that assigning staff to specific duties should be undertaken with great care. Using inexperienced or otherwise inappropriate staff for particular tasks can seriously compromise the entire exercise – and will hence waste rather than save money.

Money: A budget figure may have been allocated to the work. Whether this is the case or not, the assumption should always be to achieve the objectives of the exercise at the least cost. It is important to take full account of all staff requirements, including managerial inputs and all office expenses.

A budgeting spreadsheet is used in GFC for the costing of exercises; this is particularly useful for exploring the cost implications of different approaches to achieving objectives (see above), e.g.

- Different proportions of field and office work – e.g. placing emphasis on compiling and processing existing information (combined with ground truthing) as opposed to a full programme of new field data collection
- Different methodologies which could be used to gather the required data/information (e.g. use of aerial photos in place of field work)
- Using a contractor to carry out field work as opposed to company staff

The lowest cost option should be adopted. If a budget has been allocated to the exercise, it will be straight-forward to determine whether the lowest cost option is within this budget.

Time: A strict time limit may apply, for instance if a management plan must be submitted by a certain date.

Prepare sample design and confirm methodology/ procedure for data collection

Sampling design refers to the way in which sample units (the parts of the forest to be measured and/or assessed) are distributed within the *population of interest* (the whole area of forest that we are interested in). The sampling design adopted is a reflection of the factors highlighted above – objectives, information needs, information available and resources available (human, material, financial, time).

The ACF or forest manager will use the preliminary Forest Resource Map to prepare a preliminary design for the proposed new data collection exercise, based on the above factors.

This is explicitly based on:

- the objectives of the exercise

- the new information/ data requirements identified during Stage I, above.
- the size and nature of the particular area of interest (accessibility, distribution of important forest types, terrain)
- the resources available (personnel, money, time)

As a background to Part Three, the following section provides an overview of information relevant to forest composition sampling.

Sample units

a) What shape?

A great deal of discussion has taken place over the optimal size and shape of sample units. All of the main approaches have been used at various times in Guyana, mainly influenced by the experience of the inventory officer/specialist leading the exercise.

Type of unit	Strengths	Weaknesses	Guyanese Examples
Transects	Cover variation well	High perimeter to area ratio – extra care must be taken with borderline trees; transects must be sub-divided if statistics are to be calculated	Valuation and Reconnaissance surveys c. 1926 - 1950 Iwokrama 1996; Tropenbos Bartica Triangle 1999
Fixed area plots	Circular plots are the most efficient shape, but impractical above around 0.1ha (c18m radius). Rectangular (incl square) plots easier to establish and measure above this size.		Forest Industries Development Survey (FIDS) Iwokrama strategic inventory (1999) GFC Strategic Forest Inventory procedure
Sample points	Very efficient for rapid basal area estimation, particularly where tree diameters and species not required. Place greater emphasis on sampling the larger size classes, which may be desirable in some instances.	Mathematical basis not intuitive	Grayum (1971) Interim Forestry Project (1989 – 95) GFC 1995 – 1997 GFC SFP rapid assessment 2001

All of the above have been shown to produce useful results. All require a well trained and motivated team.

b) How many are needed?

It is usually possible to predict approximately how many plots (or subdivisions of a transect) will be required to obtain a reliable estimate of the composition of a forest type within a maximum sampling error % at a given confidence level. This requires some idea of the variability of the parameter of interest (e.g.) within the population of interest (expressed as the Coefficient of Variation – CV %).

If several parameters are of interest, the same process should be followed for each, since they may differ in their variability (and indeed in the precision required from the inventory). This may well result in different number of plots required for each parameter to meet its Sampling error requirement. In this case, priorities must be set, relative to available resources. There may be the option, however to measure the other parameter in only a proportion of the plots, since this will achieve the desired precision.

The number of plots required is estimated for each forest type or other land unit by using:

a) the expected Coefficient of Variation (CV%) of the variable of interest (e.g. stems per hectare or basal area per hectare >10cm dbh, all species). This is a measure of the variation existing in the forest – if a series of plots were established; they will tend to have different numbers of trees in them. The CV% of the forest sampled in these plots is a measure of how variable the forest is in terms of numbers of stems per unit of area. If this value is not known (e.g. from previous inventories), it can be estimated. The more specific the parameter, the higher its variability is likely to be between plots. A figure of 100 – 140% is recommended for stems per hectare >10cm dbh.

b) the precision of information required (expressed as maximum acceptable Sampling error %) The desired sampling error should be as determined in the information analysis table. This will usually be in the region of 15% (at 95% confidence level) for important forest types (all stems and species) but may be lowered to 20% for less important types or where, for instance, harvesting may not be planned for a number of years.

The following table is used to estimate the number of plots required using these two pieces of information:

Expected CV% of stems >35cm per hectare	Maximum Sampling error% which can be tolerated		
	10	15	20
40	64	28	16
60	144	64	36
80	256	114	64
100	400	178	100
120	576	256	144
140	784	348	196

This is based on the formula:

$$n = \frac{t^2 \times CV\%^2}{E\%^2}$$

Where n is the number of plots required⁶

CV% is the coefficient of variation percent

E% is the desired sampling error

t is the value of Student's t for (n-1) degrees of freedom and at the required probability level (95% is recommended)

An alternative is to define a particular sampling intensity e.g. 1% (based on previous findings and perhaps on resource constraints) and calculate how many plots are required to achieve this. This method works for both fixed area plots and transects.

⁶ This formula is appropriate for small sampling fractions (below 5%)

The resulting estimate of the number of plots required (by one method or the other) is used in conjunction with the FR Map to develop the final sampling design.

c) Where to place sample units on the ground? – sampling designs

Emphasis is placed on obtaining reliable estimates of forest composition in potentially productive forest types, other types being sampled at lower intensity or omitted. A smaller number of plots may be required if some amount of local/regional data is already available, provided this can be combined with the new data for further analysis.

A compromise is usually sought between distributing the new plots as widely as possible across each important forest type and the difficulty and controlling the costs involved in doing so. The aim of the resulting compromise is to ensure that the data collected in each forest type is representative of that type throughout the whole study area, including the parts not sampled. This depends on accurate stratification, again using the GFC vegetation database in most cases. Use may also be made of soil and geological maps, which may provide additional clues to the likely compositional variation within otherwise (apparently) uniform forest photo-types.

Sample designs are applied to the **sample frame**, or entire area of interest. This is the gross area to be characterized by the appraisal.

However, the design of the inventory should be based on the **net sample frame**. This requires two deductions:

- Unproductive parts of the area (since these are of little interest)
- Parts of the area which cannot be physically accessed (at reasonable cost – with reference to available resources);

The resulting net sample frame should be superimposed on the forest resource map and used to determine the sample design.

Approaches to sample design:

Type of Design	Description	Strengths	Weaknesses	Guyanese Examples
Grid	Regular grid is laid onto the map of the study area; plots are located at the intersection points of this grid	Even coverage useful for mapping forest site attributes	Possible bias	None (except in context of multi-stage sampling (see below))
Systematic lines	The point of commencement, bearing and length of a series of sample lines are determined with reference to the area map, then overlaid on the map with no adjustment. Normally a series of parallel sample lines is established, running at equal intervals from a suitably located base line (cut line, road or river)		Possible bias To reduce this risk, the orientation of sample lines can be set so that it is perpendicular to any suspected patterns of variation, most importantly creeks, roads and sloping terrain.	SFP RAP, RIL feasibility study, GFC pilot inventory
Subjective lines	Additional information about the area is used to purposefully select the line locations	Allows for access constraints. Cost-effective use of resources.	Possible bias	IFP inventories (e.g. UNAMCO)
Random	locations for the desired number of plots determined randomly (often using	Provides a truly objective sample, with improved	Difficult (and therefore expensive) to implement	None

	random number tables)	statistical validity		
Multi-stage	Sample frame is subdivided into successively smaller sub-components. A random selection of these components is made at each stage and is used as the basis for the next subdivision and selection	Statistically efficient	Can be difficult to implement, due to random selection of sample locations - access can be a serious constraint. Statistics more complex than other methods	Great Falls, Ebini Itaki

The main sample designs recommended for data collection at concession level are:

Small areas with good access – systematic lines throughout area to be sampled (including use of a systematic grid). These can take account of forest type or can be independent of land cover/land use (particularly if an objective of the work is to objectively assess these attributes), with plots located on some other systematic basis (cf. SFP Rapid Appraisal).

Large areas with poor access – selective lines wherever access can be gained, but with emphasis on penetrating main forest types. If access is reasonable, a systematic design can be considered, again stratified by each main forest type. Access lines can be branched to provide extended coverage of each area entered. This is the preferred approach to ground truthing of API information.

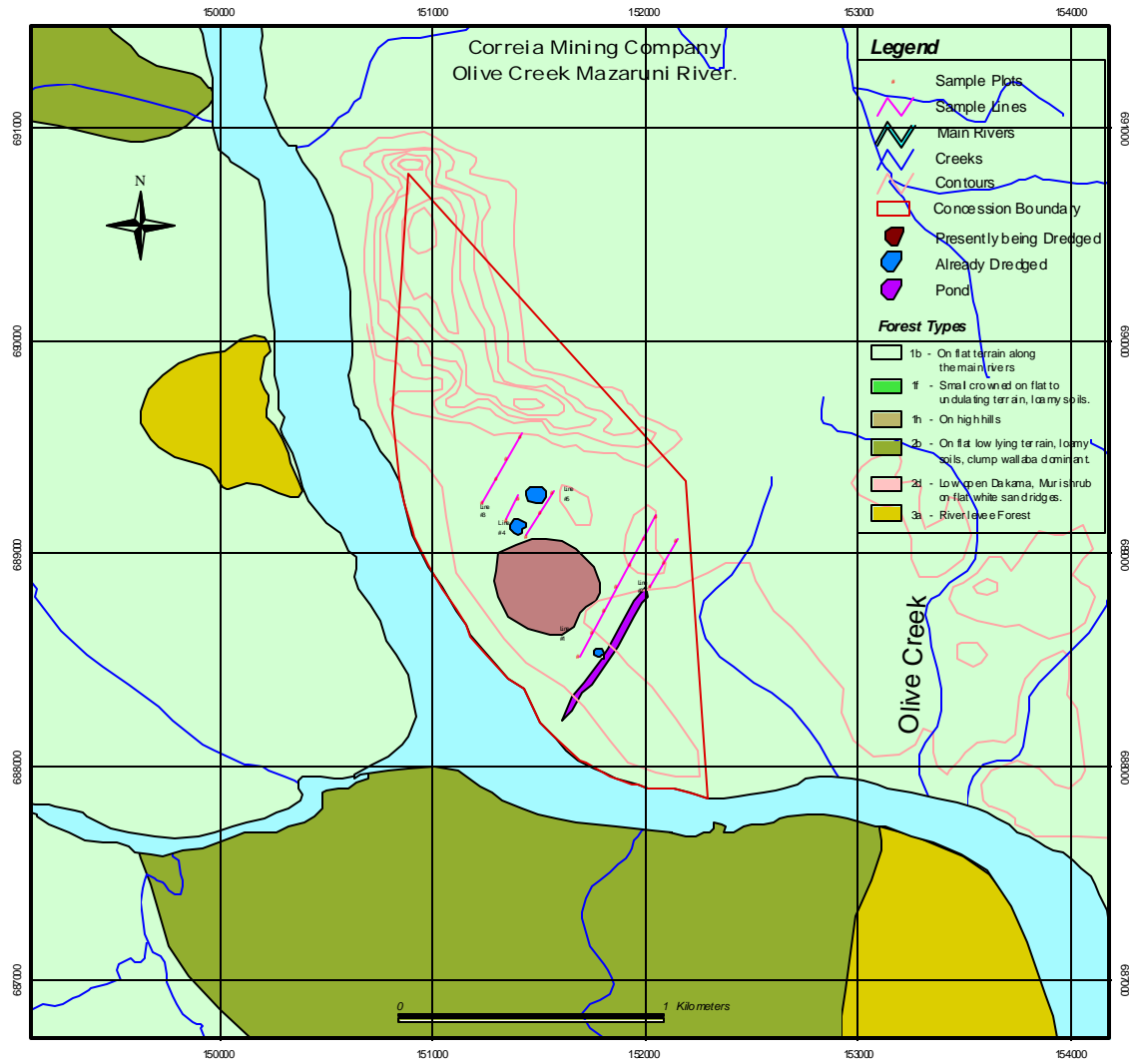
An important factor in the design is the amount of work that can be done in a day. If sample lines are used, they should be of a length achievable in one day, taking account of travel time. In some cases it may be necessary to plan for a line taking two days, particularly if it is possible to establish a temporary camp at a suitable location. Such a camp can be used to further extend the area sampled.

Summary of Key points:

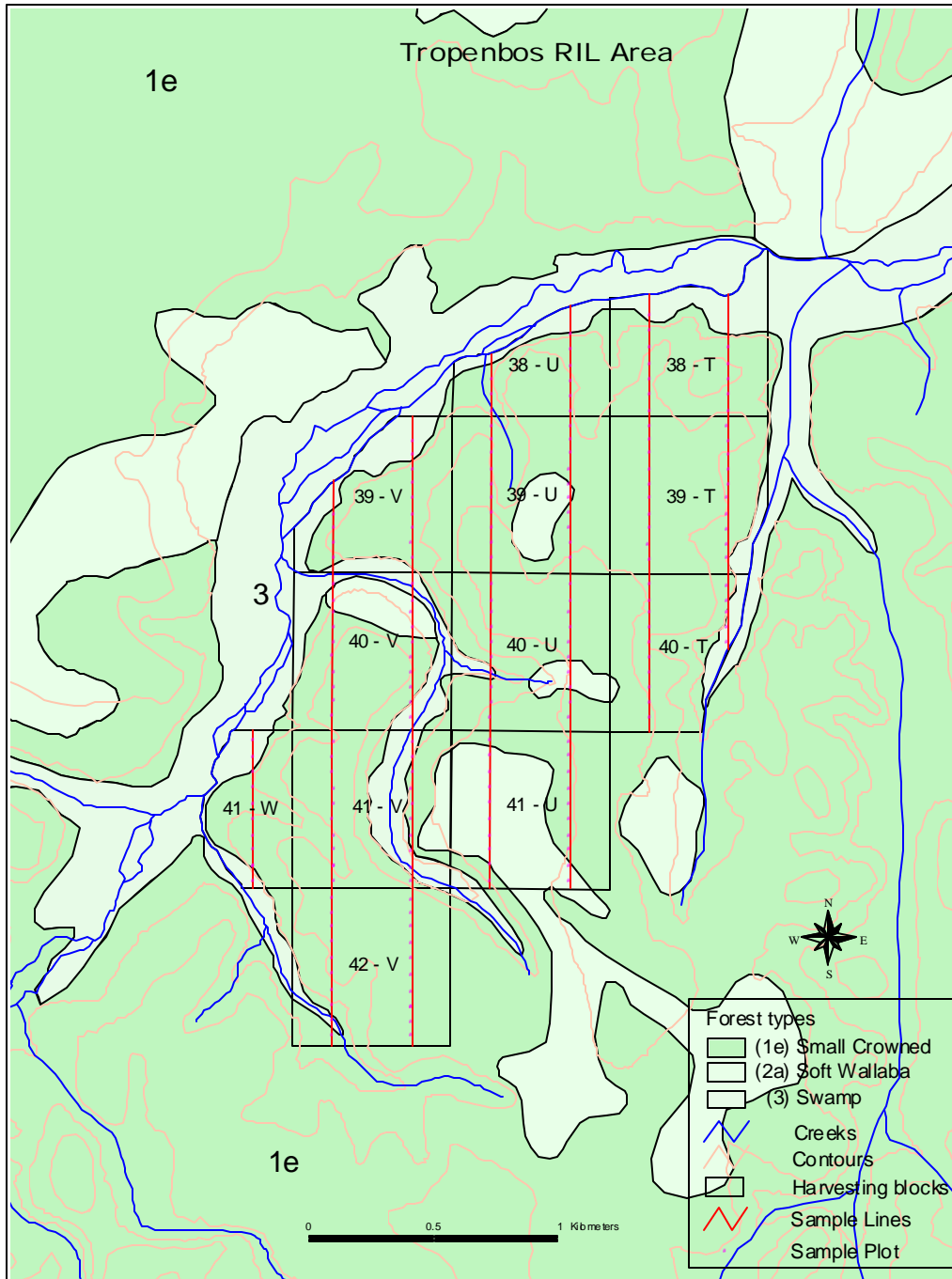
- Stratification by the main forest types usually increases efficiency; moreover it enables sampling intensity to reflect the importance of each type
- The amount of field work that can be done in a day is an important factor in developing an efficient design
- Use can be made of temporary camps where feasible, as this extends the net sampling frame

Examples of several recent GFC sample designs are provided below.

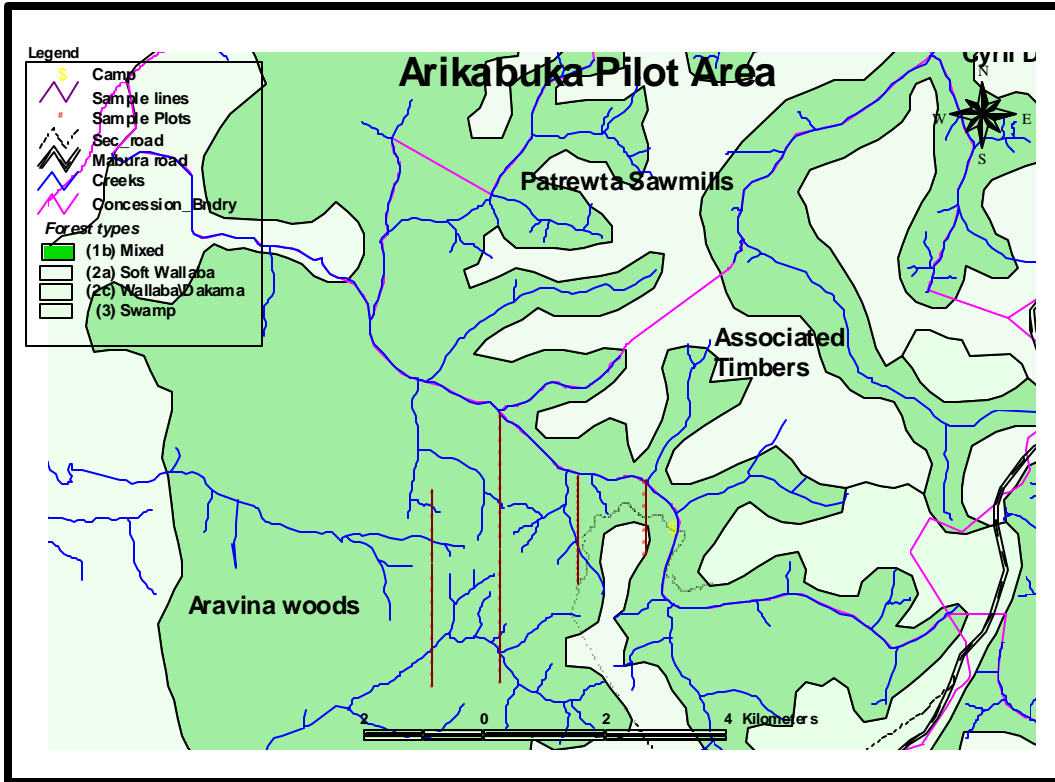
**2. Small, remote but otherwise accessible area - field work limited to one day.
Systematic lines established in main forest type, perpendicular to main river.**



3. Small accessible area – a 2% sample was required. Systematic North-South lines at 500m intervals.



4. Small accessible area. Systematic lines placed at 1km intervals perpendicular to main drainage pattern.



Make Reconnaissance Visit

A reconnaissance exercise will normally be made to the area of interest, particularly if:

- it is not well known and if a substantial field programme is being considered (all of the below aims being relevant)
- a visit is all that is required to confirm key information about the area (aim iii), below)

The aim of such reconnaissance visits is to:

- i) Explore access into and within the area, in the light of the draft sampling design already developed. A record should be made of how long is required to gain access from Head Office, including any details of transport services which may be required (e.g. vehicle ferry time tables and costs). If river transport is to be used, the navigability of such rivers will be assessed by direct observation (as far as possible) and by discussing this with persons familiar with the area
- ii) Identify suitable sites for camping, or if company accommodation is to be used, its suitability for GFC purposes
- iii) Make a visual inspection of forest conditions relative to expectations
- iv) Address any other specific matters identified by the officer in charge of the planning exercise

All such visits result in a brief report describing the findings of the visit in relation to the above.

This is supported by an annotated map showing the locations visited and any locations with a bearing on the findings of the visit.

The findings of the reconnaissance visit are used to finalise the planning of field work. The findings of the visit may require that substantial changes are made to the preliminary design already developed or to the sequence in which the work will be implemented. It may also indicate that the objectives of the work need to be modified.

The next stage is to assemble available information to compile a preliminary Forest Resource map, with supporting summary tables. This procedure provides the basis for appraising the adequacy of existing information and for designing any further field exercises required.

Data handover

Data sheets are received and signed for in the office by the FRIU staff, who make a further check before making a photocopy of all sheets (**see FRMD procedure for field data management**)

Data entry and processing

The purpose of data processing is to convert collected data into the outputs specified in the information analysis table (as completed at the start of the appraisal process). This table provides a blueprint for the required data processing and reporting, though other analyses may be added if desired (and if appropriate to the available data).

The FI Data Analyst and support staff are responsible for data entry, processing and report output. Though these activities will follow a routine procedure, the supervising officer may specify particular variations, depending on the exact nature of the exercise undertaken. The sample plot procedure that follows illustrates the main types of information outputs relevant to a strategic FRA.

Part Two - GFC procedure for conducting forest sampling inventories

Introduction

The following procedure is a combination of office and field exercises aimed at providing specific information to characterize of a piece of forest at a point in time. As emphasized in Part One this FRA, like any other, is carried out in a manner that serves a particular stated purpose. It is assumed that the FRA process has been followed and that new information on forest composition and terrain is required.

“Sampling” refers to the fact that only a portion of a forest area is measured in order to make estimates applicable over larger parts of the area. Sampling is used where it is too expensive, too difficult or indeed impossible to survey the whole area and where estimates of true values are sufficient to allow rational strategic planning. This is a common situation in Guyana, where strategic forest management decisions must be applied to large, often inaccessible concession areas. The value of sampling inventories is that they can provide *adequately precise and reliable* information on the location and composition of productive forest areas for management planning purposes in a relatively short time and at reasonable cost.

Stage I (Define Objectives and Information Needs) is assumed to have been covered as per Part One.

Stage II Plan new information collection

A plan is developed based on the preliminary FRA, the amount of new data required and the resources available, as per Part One.

Stage III Implement field work

The document “Procedures for FRMD Field Exercises” should be referred to for general procedures on implementing field work. Therefore only those aspects specific to implementing FRA field activities are included below.

Carry out initial briefing, orientation and training

As soon as the camp is established and the crew are installed, it is important to ensure that they are fully acquainted with the plans for the forest inventory and the procedures to be used.

A map of the area, including proposed sample lines and observation points (including plots) should be placed in a prominent position within the camp. If possible, this should remain there for the duration of the exercise. The field supervisor should talk the crew through the planned sequence of events. An experienced crew will not require excessive explanations of procedures, except to confirm that the procedure will be as previously used, highlighting any changes or special factors.

It is advisable to establish several practice lines and plots near to the camp before commencing the main exercise. This will not only provide useful training/ refreshing, but will also provide an early quality check which could reveal problems to be address before the main work begins. As well as improving the general quality of the data collected in the inventory, this could potentially save a great deal of time and resources by avoiding a failed consistency check at the end of the exercise.

Field work

Sample lines are established according to the planned sampling design using a combination of GPS and compass and chain. Sample plots are established at a specified distance along each line, again as set out in the inventory plan.

Crew Composition

Team	Designation	No.	Duties
<i>Line cutting team:</i>	Team leader	(1)	Booking, overall supervision
	Compass operator	(1)	Sets bearings, operates GPS;
	Line personnel	(2)	Cut, measure and mark sample lines as directed by Compass Man
<i>Enumeration team:</i>	Team leader	(1)	Booking. Overall supervision, makes final decision on plot observations, arbitrates over difficult tree measurements, Risk Class assessment and status of borderline trees;
	Tree spotter/ measurer	(1)	Identifies and measures each tree within the sample plot, assessing each for Risk Class;
	Plot establishment personnel	(2)	Moves around the plot perimeter, placing marker pickets at intervals, assists in checking of borderline trees;

Plot establishment and measurement

At each plot centre, the following sequence of activities is implemented:

- 1) A circular main plot of 0.1ha is established (17.84m radius on flat ground), within which all live trees 35cm dbh and above are recorded in section 2a of the form (species, dbh and risk class). Slope correction is applied to the radius if the slope is greater than 5%. The GPS unit is activated as soon as the crew arrives at the plot location and is set in averaging mode.
- 2) Any trees located on the boundary of the plot (“borderline trees”) are carefully assessed by the PEP and enumeration personnel. The tape is stretched from the plot center to the side of the tree. If more than half of the tree stem is within the plot it is included in the sample; if less than half, it is excluded.
- 3) Within this plot stumps and NTFPs are also recorded (sections 2b and 2c respectively).
- 4) Plot observations are made in section 1 of the field form. This includes plot location, provided a GPS reading can be obtained within the time available.
- 5) A sub-plot of 0.02ha is established (7.98m on flat ground), using the same method as above, within which all live trees 10cm and over are recorded in section 3 of the form (species, dbh and risk class)⁷. Slope correction is applied to the radius if the slope is >5%.

⁷ No tree height measurements are taken, though the forest type will be described as “low” if the canopy is less than 15m (confirmed by clinometer).

The following procedure is recommended for plot establishment and tree measurement:

1. The two plot establishment personnel (PEP) each cut a 1.5 metre stick, to which a length of flagging ribbon is attached at one end.
2. The first PEP collects the end of a 30 metre tape which is dispensed from the plot centre by the crew chief, then plants this stick in the ground on the sample line at the correct plot radius (see above). The tape is then released and spooled back to the plot centre by the crew chief.
3. Working clockwise from the plot centre, the second PEP repeats this procedure, planting his marker stick at around 45° to the cut line (from the plot centre), i.e. at around one eighth of the way around the plot perimeter from the starting point.
4. The tree spotters enumerate the trees within this segment of the plot, calling on the PEPs to check the distance to any borderline trees within the segment.
5. When the tree spotters are about to complete this segment of the plot (i.e. using the second marker stick for reference), the first PEP moves to the plot centre, collects the 30m tape and proceeds to a point around 90° from the cut line and plants the marker stick at 18m from the plot centre.
6. The tree spotters then move onto the second segment of the circle;
7. Stages 5 and 6 are repeated until the starting point had been reached. In this manner, the plot is enumerated in more-or-less 8 segments.

All fields requiring codes or standard entries (e.g. soil type, forest type, crown cover, risk class etc.) are completed with reference to an accompanying code sheet (see Appendix *).

A field crew can establish 10 or more of the above sample plots per day, provided that a separate crew is in working in advance to establish the lines and plot positions (see crew compositions above).

Figure a) the crew at work within the plot

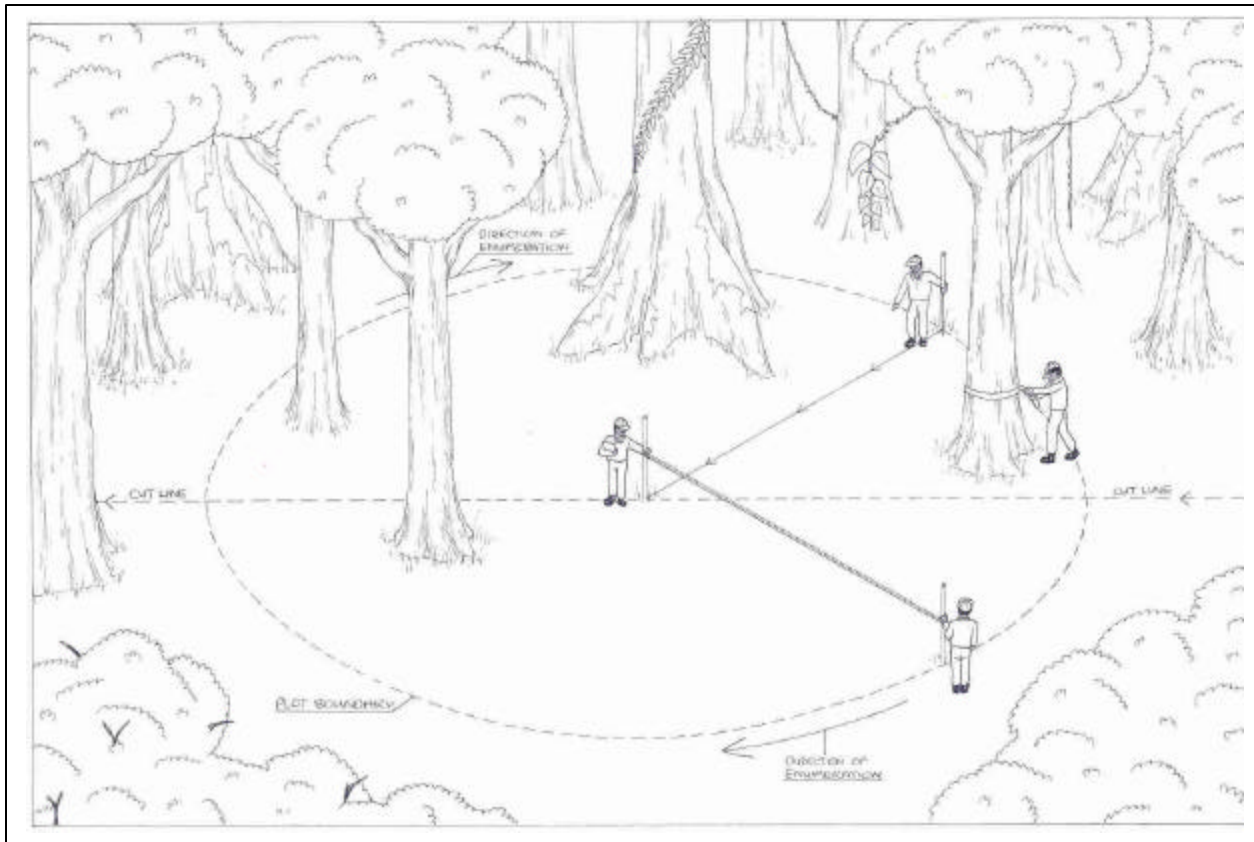
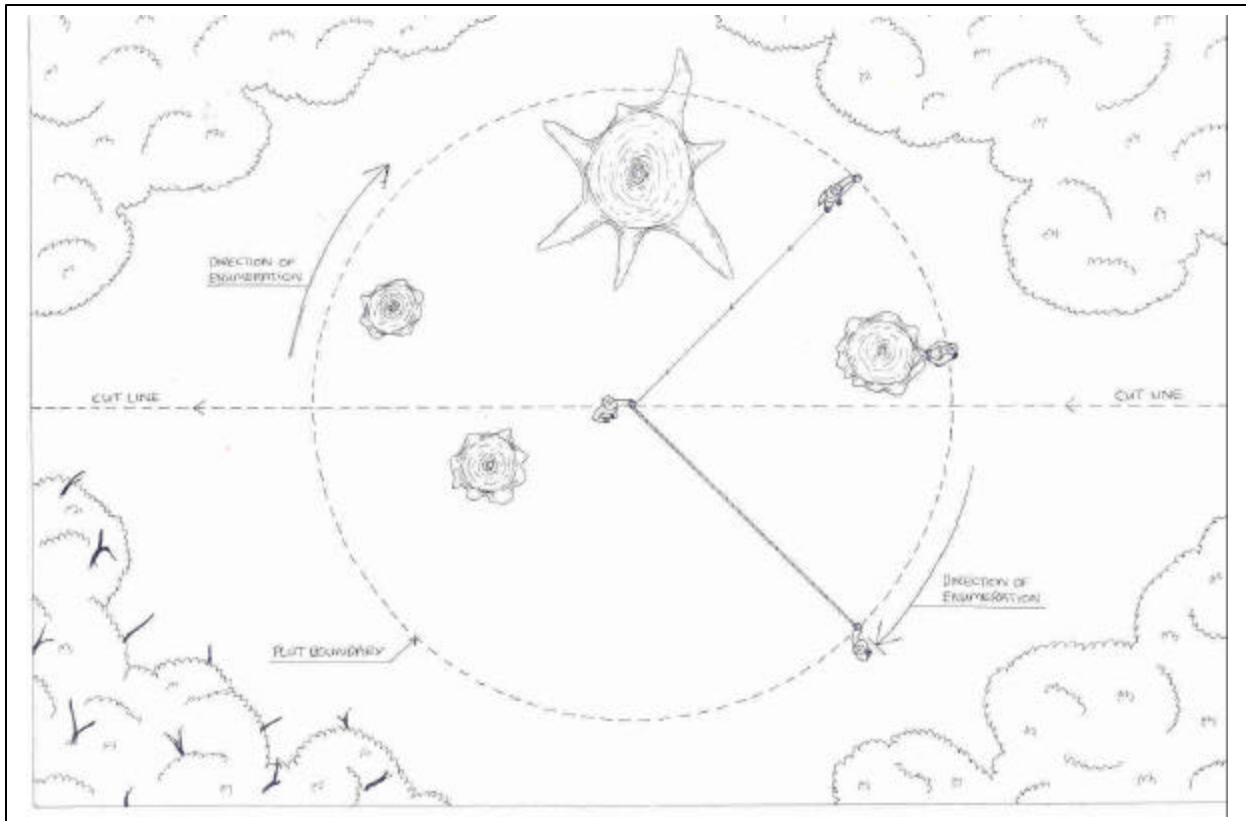


Figure b) plan view of the same scene



Data quality control and safety

Field forms are checked by the crew chief at the end of each day to ensure that no omissions, inconsistencies or unclear entries have been made. The forms are then put into a clear order by the crew chief and submitted to the inventory supervisor, who will make a further check and ensure that each pile of forms is clearly labelled before they are safely stored or forwarded to head office. A secure, fire- and water-proof location must be used by the SFA for storage of all data.

Consistency check

In order to be confident in the quality of the data collected, a proportion of the plots established are re-measured at the end of each inventory exercise (or before the crew moves to a new location as part of the same inventory). A senior supervisor should be present for this exercise (e.g. ACF) – it is not to be supervised by the officer overseeing the original work.

The recommended proportion of plots for re-measurement is:

< 100 plots	10%
100 - 500 plots	10 plots (i.e. 2 – 10%)
> 500 plots	2%

Particular care is taken over the check measurements: it is therefore assumed that they are the correct ones against which the originals are gauged.

The following table is completed for the combined data from plots re-measured in a consistency check. As a worked example, it assumes an original inventory of 250 plots. The consistency check therefore re-measured 10 of these. Assuming that the original inventory of these plots recorded a total of 50 trees > 35cm and 100 trees 10 – 35 cm, the following would apply (consistency figures are invented in this example):

a) Tree/stump numbers

Variable	Check value	Original value	Difference (%)	Allowable difference (%)	OK? (Yes/No)
Total Number of trees > 35cm dbh	50	46	8	10	Y
Total Number of trees 10 - 35cm db	100	102	2	10	Y
Total number of stumps	24	22	8.3	10	Y

The percentage difference is calculated using the formula:

Difference % = (difference between the two values divided by Check Value) x 100

e.g. (for trees > 35cm):

$$\begin{aligned} &= (4/ 50) \times 100 \\ &= 8\% \end{aligned}$$

b) Tree/ plot attributes

Attribute	Consistent	Inconsistent	Difference (%)	Allowable difference (%)	OK? (Yes/No)
Risk Class	46	4	8	10	Y
Tree identification	48	2	4	10	Y
Dbh (+/- 2cm)	41	9	18	10	N
Soil type	9	1	10	10	Y
Disturbance	8	2	20	10	N

Here, the difference % is calculated using the formula:

Difference % = (Inconsistent value divided by sum of values) x 100

e.g. (for Risk Class)

$$\begin{aligned} &= (4 / (46 + 4)) \times 100 \\ &= (4 / 50) \times 100 \\ &= 8\% \end{aligned}$$

Interpreting the results of the consistency check

The exercise must record **scores of “Y” throughout the right-hand column** for it to be considered acceptable.

If acceptable:

The crew should be given positive feedback on their performance. Attention should nonetheless be paid to any aspects of the procedure which showed errors (although they were within the allowable range), since these are indications of potential future weaknesses. These may also indicate that particular crew members are in need of additional training. They may also indicate a need to improve the description of the procedure in this manual.

If not acceptable:

If one or more entries in this field score a “N” a decision is made by the supervisor as to whether

- a) the problems identified can be rectified individually. This depends on the nature of the problem(s) identified. (e.g. by sending a small team back to check or rectify disturbance type), or whether...
- b) the problems are so serious that the whole exercise needs to be repeated. This is a serious situation which must be avoided at all costs - if the procedures in this manual are followed carefully by an experienced and well supervised crew, it should never arise. Due to the high cost of repeating the survey, the supervisor will immediately report any such situation to his line manager and await instructions.

Stage IV - Data analysis – (to be updated/ superceded by Denis Alder)

Outputs

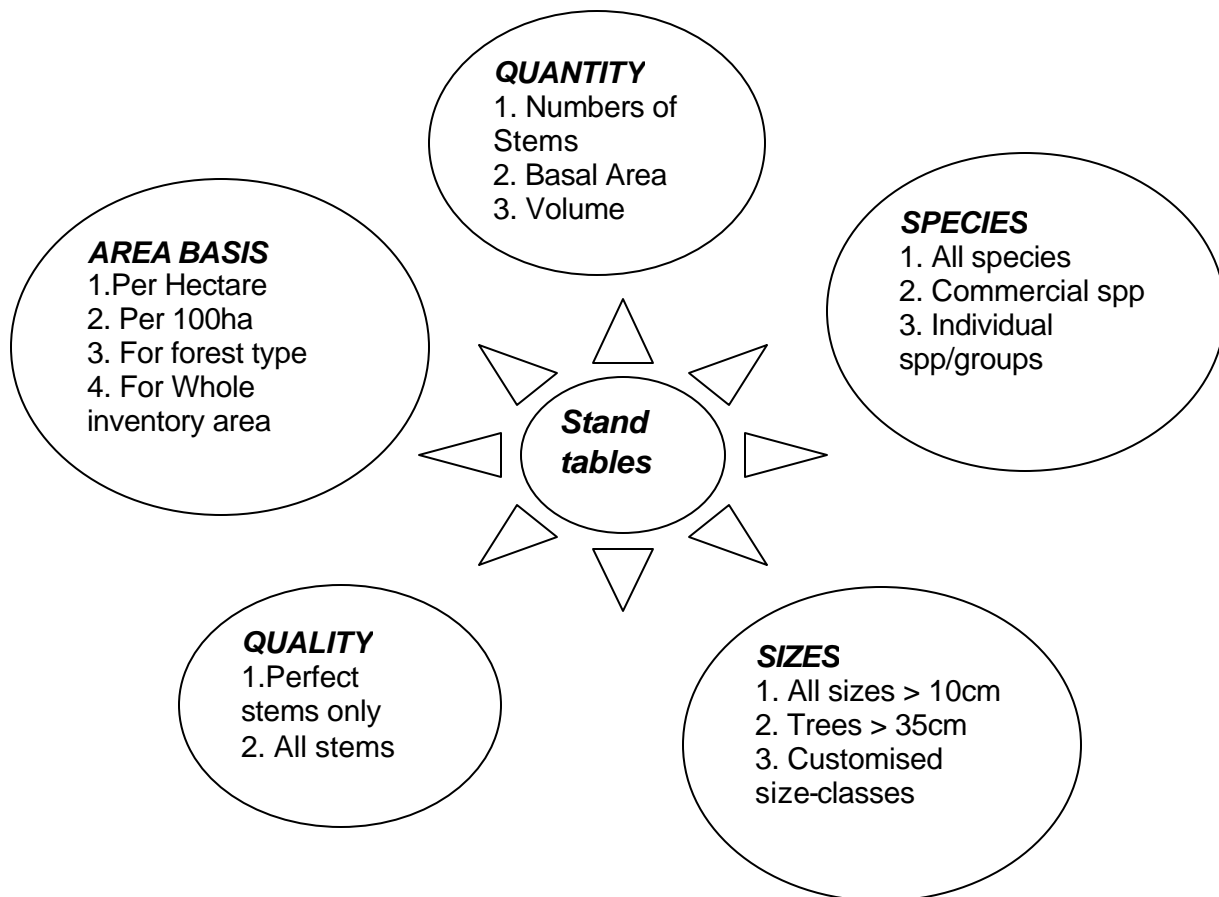
The outputs from the forest inventory must explicitly match those identified in the information analysis table developed earlier. Having collected data in such a way to address these, is essential to tailor all data processing and reporting to achieve each objective in turn.

The main information outputs from the procedure described here include:

1. A final version of the Forest Resources Map, accompanied by the updated Land Status and Productive Forest Summary tables.
2. Stand tables for each forest type (stems and/or Basal Area per hectare), sorted by species prevalence (i.e. most common species come first in the table).. If desired each table (which is on a per hectare basis) can be scaled up to reflect estimated values for the whole area covered by each stratum (forest type).

The following diagram sets out some of the options available when preparing stand tables for various purposes.

Main options for content of stand tables



Example of a simple stand table

Stand table	Arikabuka 2% Inventory				Stems per hectare			Grand Totals
	Species	Dbh	Classes					
	10-29	30-49	50-69	70-89	90-109	110-129	130-149	
Morabukea	69.3	18.6	7.5	1.6	0.2			97.2
Baromalli	42.2	4.2	0.1					46.6
Soft Wallaba	20.3	10.1	4.5	0.4				35.3
Black Kakrall	22.9	5.8	0.6					29.3
Greenheart	8.8	7.0	7.7	2.4	0.4			26.4
Kautaballi	19.3	3.7	0.4					23.5
Ituri Wallaba	11.8	5.1	0.9	0.1				17.9
Wamara	10.3	5.7	0.7	0.0				16.8
Aromata	13.1							13.1
Others	152.5	22.6	7.1	2.0	0.5	0.1	0.0	184.8
Totals	370.5	82.8	29.7	6.5	1.1	0.1	0.0	490.9

The above stand table was produced using the pivot table function in Excel. In order to do this, each sample tree in the datafile is weighted according to the size of the plot it was in and the total number of plots included in the analysis. This provides estimates on a per hectare basis (which can be modified to some other area basis). An extra field is added in the data table to calculate and hold this weighting value for each tree. The pivot table then uses this field to sum the number of trees per hectare in each cell of the pivot table. The FRIU worksheet "Standproj.xls" (produced by Denis Alder) clearly illustrates the worksheet functions required to calculate this weighting for the sample plot procedure.

Separate tables showing *Confidence limits* should be produced for these estimated values, as these provide a clear indication of the how well the estimates are likely to reflect the true range of population values⁸. An example of such a table is provided below.

Wallaba Forest	Arikabuka								
Stems per ha 95% confidence range (- to +)									
SPECIES	10	<35	35	<60	60-	<85	%	TOTAL	
	-	+	-	+	-	+			
Wallaba Ituri	27	148	10	36	1	7	24	114	
Wallaba soft	33	124	10	27	0	5	21	100	
Baromalli (4 spp)	18	123	0	11	0	0	16	75	
Korokororo	9	58	0	11	0	4	8	40	
Yekoro (4 spp)	0	42	0	0	0	0	4	21	
Kulishiri (10 spp)	0	27	0	0	0	0	3	12	
Awasokule (14 spp)	0	20	0	0	0	0	2	8	
Marishiballi (6 spp)	0	20	0	0	0	0	2	8	
Serebedan (3 spp)	0	26	0	0	0	0	2	8	
Waraia (14 spp)	0	20	0	0	0	0	2	8	
Duka	0	14	0	3	0	0	1	5	
Itikiboroballi	0	14	0	3	0	0	1	5	
Awati	0	14	0	0	0	0	1	4	
Hikuribianda (4 spp)	0	14	0	0	0	0	1	4	
Imirimiaballi	0	14	0	0	0	0	1	4	
etc	etc	etc	etc	etc	etc	etc	etc	etc	
TOTAL	310	519	47	73	2	17	100	484	

Confidence limits for totals of size classes are for all species combined

⁸ At present, these can be produced by the data management software TREMA, which is being progressively phased out by GFC. Forthcoming work by Denis Alder will provide statistical reports via an Excel/Access software package.

3. Stock tables produced from the stand table using agreed volume functions. The best functions available at present are the form heights developed by Alder (2000). These provide gross rather than net volume estimates at present and are due for further refinement to address this. These functions are used to produce an estimated volume for each tree in a new field in the data file. As in the stand table, this figure can be weighted by size of plot and numbers of plots in the analysis, providing a weighting figure that can be used to produce a pivot table in Excel (as below). Usually the data file will be filtered before it is pivoted, in order to leave those species, size classes and stem qualities of interest to the manager.

The same tables are reproduced with each cell of the stand table displaying the confidence interval at 95%. The utility of producing stock tables largely depends on the quality of functions or equations used for volume estimation. Scaling up can be carried out as per stand tables, to provide estimates applicable to a particular area represented by the data.

Example of a simple stock table

Stock Table	Arikabuka 2%			Volume per hectare – all species, sizes, qualities				
Species	Dbh	Classes						
	<30	30-49	50-69	70-89	90-109	110-129	130-149	Grand totals
Morabukea	20.8	27.2	23.4	8.8	1.8			82.0
Greenheart	3.2	10.6	25.4	14.0	4.0			57.2
Soft Wallaba	6.1	14.0	14.0	2.1				36.3
Baromalli	11.8	5.4	0.4					17.5
Black kakaralli	7.5	7.6	1.8					16.9
Ituri Wallaba	3.9	7.0	2.8	0.5				14.2
Wamara	3.9	7.8	2.0	0.3				14.0
Shibidan	2.3	3.8	4.1	2.6		0.7		13.4
Kautaballi	7.0	5.3	1.1					13.3
Ituri Wallaba	1.9	4.3	0.5					6.7
Kokoriteballi	2.8	1.8	1.6		0.4			6.7
Others	35.4	22.5	16.4	8.9	4.0	0.6	0.9	88.8
Grand totals	106.5	117.3	93.6	37.2	10.2	1.3	0.9	367.0

Key points on customising stand and stock tables:

- As illustrated in the examples above, these tables are normally sorted by the (right hand) “Grand Totals” column, thereby highlighting species in order of their numerical importance. This enables one to tell at a glance not only what species are present in the stand surveyed, but also what are the most common species and what are the least common.
- Before doing anything else, it is important to check that the results look right. In particular, check if the most common species are what would be expected and that the grand total (the bottom right hand cell of the table) is within the expected range of values. This will vary between forest types and site histories, but for high forest should be in the range of 400 – 650 stems per hectare above 10cm diameter. Clearly if the table shows only trees above 30cm diameter, this likely range will be considerably lower (particularly if limited to commercial species and qualities). Figures should be compared with those in existing tables produced on an equivalent basis.
- In per hectare tables decimal places should be limited to one, by selecting the range of table values and using the decimal place control on the main Excel toolbar.
- Diameter classes are can quickly be created using the Data/ Group and Outline/ Group function. First click on the diameter class label in the pivot table, then activate the above

function. Diameter class specifications can be input in the resulting dialogue box, as required.

- Pivot tables are intolerant of many editing and formatting functions. Where this is indicated (by an Excel Message box) the pivot table must be copied and pasted back in place (or to a new worksheet) using the Edit/ Paste special function, checking the “Values” box.
- Excel provides a wide range of options for formatting tables (as well as charts and graphs), which can then be cut and pasted in to a report as necessary (as above). Pasted tables can still be edited in Word, e.g. to add titles or adjust the font or cell colours.

4. Stand projections are produced as required. These can be used to explore sustained yield timber production options for each productive forest type. An example of a basic stand projection output table is shown below. This is taken from the provisional model contained in the file “Standproj.xls” (see above).

Original stand	<i>(Diameters in cm, volume m3, units per total area sampled)</i>							
Diam field	Dbh	Dbh	Dbh	Dbh	Dbh	Dbh	Dbh	Dbh
Size criteria	>=10	>=20	>=30	>=40	>=50	>=60	>=70	>=80
Sum of trees	72482	35909	18024	10797	5914	2739	1389	715
Sum of volume	57152	50283	40175	32020	23016	14182	8956	5544
Class label	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-
Trees	36573	17885	7227	4882	3176	1350	675	715
Volume	6869	10108	8154	9004	8834	5226	3412	5544
First cycle	30							
Sum of trees	29393	14566	7324	4375	2407	1112	556	287
Sum of volume	43067	33775	24854	18801	13051	7674	4597	2806
Trees	14827	7242	2949	1968	1295	556	269	287
Volume	9292	8920	6054	5749	5377	3077	1791	2806
Harvest %	0%	0%	0%	0%	50%	40%	30%	20%
Harvest trees	#N/A	#N/A	#N/A	#N/A	648	223	81	57
Harvest volume	#N/A	#N/A	#N/A	#N/A	2688	1231	537	561
Second cycle	25							
Sum of trees	13879	6879	3465	2064	1140	526	259	134
Sum of volume	31225	22765	15922	11631	7909	4504	2586	1566

5. Summaries (including charts) of plot attributes (soil type, slope, disturbance etc) are produced by importing the appropriate summary data into Excel. The information is presented in a summary table setting out of %'s of plots by each class of attribute (see below). If desired, this summarised information can be used to produce graphs (e.g. pie charts) using Excel's Chart Wizard.

Summary of attribute data for forest types sampled (figures provided for example only)

	Forest type (from vegetation maps)					
	1	1h	1k	2a	2c	3b
Number of plots	100	80	50	50	20	20
Soil type % :						
White Sand	0	0	0	84	10	0
Brown Sand	89	67	36	6	75	0
Loam	11	33	0	0	15	0
Clay	0	0	5	0	0	5
Pagasse	0	0	0	10	0	85
Laterite	0	0	64	0	0	0
Other	0	0	0	0	0	0

Flooded	0	0	0	0	0	10
Forest type %:						
<i>Wallaba</i>	0	0	0	85	10	0
<i>Dakama</i>	0	0	0	5	35	0
<i>Mora</i>	0	0	0	0	0	20
<i>Mixed</i>	42	70	22	5	0	0
<i>Mixed Morabukea</i>	20	30	64	0	0	0
<i>Mixed Greenheart</i>	38	0	14	0	0	0
<i>Swamp</i>	0	0	0	0	0	25
<i>Marsh</i>	0	0	0	0	0	35
<i>Savanna</i>	0	0	0	0	25	0
<i>Scrub</i>	0	0	0	5	30	0
<i>Plantation</i>	0	0	0	0	0	0
<i>Other</i>	0	0	0	0	0	0
Crown closure%						
0 – 25	0	0	0	0	45	0
26 – 50	0	0	0	10	40	25
51 – 75	5	13	10	10	15	30
76 - 100	95	87	90	80	0	45
Mean slope %	6	18	12	3	2	0
Mean aspect (°)	180	138	308	101	108	207
Undisturbed %	25	40	45	55	85	95
NTFPs present (%)	78	75	46	45	10	35
(Of which) Harvestable NTFPs (%)	67	42	46	45	0	25

6. Summary of stump information (if there are many plots, this can be summarized for each forest type that has been harvested). Due to the variable intensity of harvesting, stump data from sampling inventories are of relatively low precision, except where small areas are intensively sampled.

Mixed forest type

Species	Number of stumps	Mean stump diameter (cm)	Mean stump height (m)	Estimated Stumps/ 100 ha
Greenheart	20	56	0.9	
Morabukea	15	58	1.2	
Wamara	30	44	0.8	
Others	35	48	0.8	
Totals				

If data are collected on NTFPs it can also be summarized in a table such as the following:

Summary of NTFP frequencies NTFP Species	Harvestable		Not harvestable	
	% of plots	Plants per ha	% of plots	Plants per ha
Kufa	9.7	1	3.2	0.3
Mukru	4.8	0.5	3.2	0.3
Kapodulla	16.1	2	1.6	0.2
Mamuri	1.6	0.2	0	0

Plot observations are perused by eye – if any particular types of observation are of interest, these can be summarized by numbers (and or %) of plots where such observations were made. Where this interest is anticipated, emphasis should be placed on consistently collecting such information at the planning stage.

Mapping/GIS

A final version of the FR map is produced for the concession/study area, showing updated information on geographical features, infrastructure, land cover and locations of field data collection. This is based on the original FR map, with information added and refined based on the new work carried out.

GIS software (such as ArcView) is presently used by GFC to produce a final map of the inventory area. As well as requiring appropriate skills and equipment, the time taken for this activity greatly depends on the availability of digitised base maps (particularly those at 1:50000 scale). Once information is input, GIS software provides a rapid means for producing customized maps and is particularly useful for measuring areas.

Report

A report is produced for each inventory exercise, consisting of a full description of objectives, study area, inventory activities, results and budget. A generic format for GFC FRA reports is given in Appendix **.

Appendices 1. Guidance on collecting tree and site attributes

Tree data

Tree identification

All live trees are measured above 10cm diameter at breast height. This requires a high level of tree identification skills.

The following points are important during tree identification:

The GFC reference list is used for recording and checking tree names.

All features of the tree should be checked against each other until a positive identification can be made. This requires a definite confirmation of at least two characters, one of which should preferably be the leaf. Where necessary binoculars can be used to inspect distant leaves, often assisting with locating a fallen leaf on the ground.

Trees should be identified to the most precise name possible. This depends on the tree spotter being fully confident in the knowing the exact species. Examples are "fine leaved Kakaralli", smooth-skinned Arara" or even mixes such as "Baromalli fragrans"

If the tree spotter is unsure about the name of a specimen, other members of the team should be consulted. **If there is no clear consensus within the group, it is important that the tree is recorded as "Unknown."** In such cases, a sample of leaves and any other available material should be collected and given to the GFC Botanist.

DBH

Tree diameter is measured in conformance with standard GFC procedures⁹. Except in special cases (see below) tree diameters are measured at breast height with a fiberglass or metal diameter tape.

The standard GFC procedure is followed. One particular convention is of note:

Where buttresses or other protrusions clearly swell the diameter of a tree at breast height, two situations apply:

- a) If it is possible to place the tape 10cm above the top of the swollen section, the diameter measurement should be made at this point. If not,
- b) If it is not possible to reach this high above the swelling, the dbh should be estimated by eye. Field staff should practice this skill by checking their estimates with a tape.

Risk Class

This provides an indication of the commercial status (or potential) of each tree, when the information is used in conjunction with species and minimum diameter requirements.

It is important that each tree is assessed from all sides, by walking around it, carefully inspecting for decay and poor form from ground level up into the crown. The minimum recoverable bole length which qualifies a tree for a perfect (0) rating can be set as required. The procedure in this

⁹ This is standard for all static appraisal work (PSP measurement requires special variations). See GFC procedure form.

manual uses a 3 metre minimum. As with pre-harvest inventory, it is important for staff to gain an understanding of applying these tree attributes by spending time in the field during harvesting operations.

The rating is applied to all trees in the plot, including the non-commercial species and sizes. Clearly its utility for predicting future commercial quality of a particular small tree is somewhat limited, but in summary form the rating can provide information on the general form and potential of existing smaller size classes.

Stump diameter

This is recorded using the reverse side of the diameter tape (i.e. the side with a normal centimeter scale). The diameter is measured across the longest distance through the center point of the stump, then at a right angle to this; the two measurements are averaged. The height of the stump is also measured and recorded. If this is not even, the highest and lowest points are measured and averaged.

Site assessment

Soil type This is assessed next to the plot center. A cutlass is used to scrape away any litter on the ground and dig a 5cm pit into the soil. This pit is examined for the following main features:

Whitish, sandy, little organic matter:	White Sand
Brownish/reddish, gritty	Brown Sand
Smooth, moist texture, grayish	Clay
Rich red soil with even texture	Loam
Peaty, organic matter near to creeks	Pagasse
Hard, concreted/gravelly, reddish	Laterite
Under too much water to assess	Flooded
Location with other soil/ no soil	Other

Slope

This is measured for three main purposes:

- Correction of cut lines
- Correction of plot radius
- Provides data on slope as an indication of terrain

A Suunto clinometer is used for these measurements. In each case, the technique used is that the clinometer operator marks a thin stick with flagging ribbon at eye level, then sights on this point during clinometer readings. This is to ensure that the clinometer's line of site is parallel to the ground, therefore following (and measuring) the predominant angle of slope.

Aspect

This is a measurement of the bearing towards which any slope present in the plot is facing. If a slope has been measured (as above, for correcting the plot radius), the technician simply takes the bearing in the same direction.

Canopy Openness

This is a visual assessment made looking straight up from the plot center.

Details of the other site attributes are provided on the Codes for Observations sheet (Appendix *). In all cases observations are made at the plot center or within the plot area.

Appendix * Examples of information needed for national forest zoning¹⁰.

Question	Discussion Points
1. What criteria should be used to identify and demarcate conversion forests ?	<ul style="list-style-type: none"> ▪ Areas already committed to non-forestry use ▪ Areas low in commercial stocking ▪ Land capability characteristics ▪ Proximity to major infrastructure ▪ Utilize IUCN classification ▪ Allow for inter-category movement in classification. ▪ Hydro-power feasibility studies ▪ Avoid the residual land use option
2. What criteria should be used to identify and demarcate protection forests ?	<ul style="list-style-type: none"> ▪ Accessibility ▪ Corridors along river banks, Buffer zones ▪ Areas of high biological/archeological/heritage significance ▪ Utilize IUCN classification ▪ Allow for inter-category movement in classification ▪ Ecologically fragile areas ▪ Areas characterized by high species endemism
3. What criteria should be used to identify and demarcate production forests ?	<ul style="list-style-type: none"> ▪ Areas free of competing land uses ▪ Proportion of Forest resources of high commercial value ▪ (Review definition of production forests to address the full range of forest goods available in viable quantities). ▪ Accessibility
4. How to address the requirements and expectations of indigenous/rural communities?	<ul style="list-style-type: none"> ▪ Conduct socio-economic surveys on Amerindian uses of the forests they actually own ▪ Consultations with Amerindian/Rural Communities ▪ Review Amerindian legislation to align it with other legislation ▪ CHPA planning process to extend to those rural communities in a phased way. ▪ Buffer zones specifically identified ▪ Accelerate the official titling of Amerindian lands

¹⁰ From GFC workshop on forest zonation - internal PDD memo 2001

GFC's Booking Form for Sample Plots

Part 1: Plot information

Crew members (initials): _____ Date: _____ General location: _____
 Line number: _____ Line Bearing (true): _____ Plot number: _____
GPS North: _____ West: _____ EPE: _____ Waypoint name: _____

 Slope %: _____ Slope aspect: _____ Soil type: _____
 Forest Type: _____ Disturbance: _____ Canopy Closure: _____

Main Plot Observations: _____

Part 2: Main Plot:

Plot radius (m): _____

a) Trees (all species)

Minimum dbh (cm): _____

Tree	Species	Dbh	Risk	Log length/m	Tree	Species	Dbh	Risk	Log length/m
1					22				
2					23				
3					24				
4					25				
5					26				
6					27				
7					28				
8					29				
9					30				
10					31				
11					32				
12					33				
13					34				
14					35				
15					36				
16					37				
17					38				
18					39				
19					40				
20					41				
21					42				

b) Stumps

Minimum diameter (cm): _____

Stump	Species (if known)	Diam	@ Ht	Stump	Species (if known)	Diam	@ Ht
1				6			
2				7			
3				8			
4				9			
5				10			

(All stump diameters and heights in centimeters)

Stump/ logging observations:

2c) Main plot – NTFPs (plants, fruits, vines and orchids)

#	Species	Host tree	Harvestable size? Y/N	#	Species	Host tree	Harvestable size? Y/N
1				10			
2				11			
3				12			
4				13			
5				14			
6				15			
7				16			
8				17			
9				18			

(Host tree – main tree on which NTFP is living on)

Part 3: Sub-Plot (all tree species) Plot radius:

Minimum dbh (cm):

Tree	Species	Dbh	Risk	Log length/m	Tree	Species	Dbh	Risk	Log length/m
1					22				
2					23				
3					24				
4					25				
5					26				
6					27				
7					28				
8					29				
9					30				
10					31				
11					32				
12					33				
13					34				
14					35				
15					36				
16					37				
17					38				
18					39				
19					40				
20					41				
21					42				

Part 4: Presence of Animal (Mammal, Birds, Reptiles, Amphibian and Fishes)

Type of animal	Seen (Y/N)	# of individual	Other indication	Animal name
Arboreal				
Terrestrial				
Aquatic				

(Arboreal-animal living in tree; Terrestrial-animal living on land; Aquatic-animal living in water)

Appendix * GFC Forest Resource Management Division - Codes for observations at sample plots

Crew members - put initials in following order: crew chief, booker, tree spotter, others...

FOREST TYPE	SOILS	RISK CLASS
WALLABA		
DAKAMA	WS WHITE SAND	0 PERFECT
MORA	BS BROWN SAND	1 DECAY
MIXED	LO LOAM	2 SWEEP
MIXED - MORABUKEA	CL CLAY	4 FORK
MIXED - GREENHEART	PA PAGASSE	
SWAMP	LAT LATERITE	Add scores if more than one type of defect. Only record defects which would prevent recovery of at least one 3 metre log.
MARSH	OTH OTHER	
SAVANNAH	FL FLOODED	
SCRUB		
PLANTATION		
OTHER		

Add:

LOW if canopy is below 15m within main plot

ROPEY if >10 vines (lianas) are observed within main plot

DISTURBANCE		CROWN CLOSURE	
0	UNDISTURBED	0	0 - 25%
1	RECENT LOGGING (LESS THAN 5 YRS)	1	26 - 50%
2	OLD LOGGING (MORE THAN 5 YRS)	2	51 - 75%
3	FARM	3	76 - 100%
4	WINDFALL		
5	FIRE		

Plot observations: record any of the following *if they occur in the main plot*: frequent or unusual plants (shrubs, trees < 10cm dbh, vines, orchids etc) which cannot be recorded in main sections of form; any trees observed in flower or fruit; any animal and bird sightings including tracks and holes/nests etc; details relevant to future management of the forest - e.g. roads, skid trails, clearings, rock outcrops, lakes, possible eco-tourism sites (e.g. viewpoints, waterfalls).

Stump assessment observations (main plot): record any useful information about the stumps or logging practices, e.g. whether logs converted at stump, extracted whole, also if significant wastage/ damage is observed. Note if any non-logging stumps observed within the plot e.g. due to road or skid trail.

Appendix * Slope correction table for adjusting plot radius

Slope	Main plot radius	Sub plot radius	Slope
Percent	(0.1ha plot)	(0.02ha plot)	Degrees
0 - 4	17.84	7.98	0 - 2
4	17.85	7.98	2.3
5	17.85	7.98	2.9
6	17.86	7.98	3.4
7	17.86	7.98	4
8	17.87	7.98	4.6
9	17.88	7.99	5.1
10	17.89	7.99	5.6
11	17.89	7.99	6.3
12	17.91	7.99	6.8
13	17.92	7.99	7.4
14	17.93	7.99	8
15	17.94	7.99	8.5
16	17.96	8.00	9.1
17	17.97	8.00	9.6
18	17.99	8.00	10.2
19	18.01	8.00	10.8
20	18.03	8.01	11.3
21	18.05	8.01	11.9
22	18.07	8.01	12.4
23	18.09	8.01	13
24	18.11	8.02	13.5
25	18.14	8.02	14
26	18.16	8.02	14.6
27	18.19	8.03	15.1
28	18.22	8.03	15.6
29	18.25	8.03	16.2
30	18.28	8.04	16.7
31	18.31	8.04	17.2
32	18.35	8.04	17.7
33	18.38	8.05	18.3
34	18.42	8.05	18.8
35	18.46	8.06	19.3
36	18.50	8.06	19.8
37	18.54	8.07	20.3
38	18.59	8.07	20.8
38	18.59	8.07	21.3
40	18.68	8.08	21.8
41	18.73	8.08	22.3
42	18.78	8.09	22.8
43	18.84	8.09	23.3
44	18.90	8.10	23.7
45	18.96	8.10	24.2
46	19.02	8.11	24.8
47	19.09	8.11	25.2

Appendix * Report Format

Format for Forest Resource Appraisal Report

1. Objectives

What needed to be decided or determined and by whom

Information needs analysis: Present completed Info analysis table

2. FR Report

Present Forest Resource Report:

(FR Map and FR Summary Tables):

- a) Land status table (areas measured from maps)
- b) Productive Forest Summary

Refer to completed FR map, to be attached to the report

c) Other summaries, as required by the FRA objectives, e.g.

- (i) Summary table setting out, for each Forest Type: area, number of samples, total stems, basal area and gross volume **per hectare** (defect-free trees of commercial species above 35cm) with sampling error %.
- (ii) Individual stand tables for each major forest type by stems per hectare and Basal Area;
- (iii) Individual stock tables for each major forest type for all defect-free trees >35 cm;
- (iv) Summaries e.g. (pie charts) of plot attributes (forest types, soils, disturbance, canopy openness).

3. Description of work carried out

Describe existing information and how it was assembled,

Describe process for its evaluation relative to identified needs

Definition of new information/ data required

Summarise Resources available (Personnel, Money, Time)

Provide Brief description of sample design and methodology/ procedure used for any new data collection:

- a) Decision on number and location of Sample plots
- b) Decision on sample decision

Provide other information which influenced the planning process for the exercise

Briefly describe new work carried out:

a) Reconnaissance Visit

b) Description of any field work

Procedure used (provide details on any aspects differing from the procedure set out in Part Two)

Crew Composition – name, designation

Map showing lines and plots established (using the FRA maps schemes)

- (i) Navigating to sampling unit locations
- (ii) Establishment of sampling unit
- (iii) Measurements on sample unit
- (iv) Instruments used
- (v) Tree and other field measurements such as growth, mortality, soil and topographic conditions

Reference is made to relevant GFC procedures manuals, highlighting any divergence from these.

Method and Results of Consistency check

Description of data processing carried out

- (i) Software and methods used for producing estimates of totals (and their sampling errors) and desired expressions of quantity e.g. stand and stock tables,
- (ii) Description of data management procedures

C Appendices

Appendix 1

Budget breakdown

Appendix 2

List of equipment

Appendix * Example of use of spreadsheet for budgeting office and field costs of an FRA

Cost of Forest Resource Appraisal									
Name of Exercise: Training by GFC at CRL concession									
Vehicles									
Vehicle#	FC/day	# of Days	# of KM	Avg KM/Litre	Price/Litre	Total Cost			
1	PGG 5010	\$ 16,318.32	22	800	14.71	\$ 50.30	\$ 361,738.58		
2	PGG 5009	\$ 16,318.32			14.71	\$ 50.30	\$ -		
3	PFF 6291	\$ 7,792.11	4	260	14.71	\$ 50.30	\$ 32,057.49		
4	PFF 7792	\$ 7,601.15			14.71	\$ 50.30	\$ -		
5	PFF 1720	\$ 512.82			14.71	\$ 50.30	\$ -		
6	PFF 5658	\$ 512.82			14.71	\$ 50.30	\$ -		
Total		\$ 49,055.54					\$ 393,796.06		
FC - Fixed costs, includes depreciation, interest, insurance, tyre wear costs									
Labour									
Name	Designation	# Field Days	# Office Days	TFC	TOC	Total Cost			
1	J Evans	ACF Inventory	3	6	\$ 11,104.82	\$ 17,809.64	\$ 28,914.47		
2	H Boyan	Inventory Officer			\$ -	\$ -	\$ -		
3	R Peters	Senior Field Asst			\$ -	\$ -	\$ -		
4	L Walcott	FA: Crew Chief	22	4	\$ 40,644.15	\$ 4,456.51	\$ 45,100.66		
5	A Calestro	FA: Booker		4	\$ -	\$ 4,456.51	\$ 4,456.51		
6	A Bratwaith	FA: Tree Spotter	10		\$ 22,067.72	\$ -	\$ 22,067.72		
7	F Sutherland	FA: Tree Spotter			\$ -	\$ -	\$ -		
8	I McAndrew	FA: Line Cutter	22	2	\$ 37,671.33	\$ 1,958.00	\$ 39,629.33		
9	M Jarvis	FA: Line Cutter			\$ -	\$ -	\$ -		
10	A Alicock	FA: Crew Chief			\$ -	\$ -	\$ -		
11	I Stoll	FA: Booker			\$ -	\$ -	\$ -		
12	S Roberts	FA: Tree Spotter			\$ -	\$ -	\$ -		
13	L Prince	FA: Tree Spotter			\$ -	\$ -	\$ -		
14	M Rodrigues	FA: Line cutter			\$ -	\$ -	\$ -		
15	G Gonsalves	FA: Compass man			\$ -	\$ -	\$ -		
16	E Jeremiah	FA: Cook			\$ -	\$ -	\$ -		
17	T Adrian	FA: Cook			\$ -	\$ -	\$ -		
18	E Richards	Driver			\$ -	\$ -	\$ -		
19	W Canterbury	Driver			\$ -	\$ -	\$ -		
20	F James	Driver			\$ -	\$ -	\$ -		
21	S Browman	Driver			\$ -	\$ -	\$ -		
22	??	Computer Operator	0		\$ -	\$ -	\$ -		
Total					\$111,488.03	\$ 28,680.67	\$ 140,168.70		
Assumes that GFC will provide food in field, Otherwise costs will change in the related Labour worksheet.									
TFC is Total Field Cost; TOC is Total Office Cost									
Consumables									
Item	# of teams	# req /team	# of work days	Price/Unit	Life	Total Cost			
a Inventory									
1	Data Sheets	1	20	20	\$ 12.00	n.a	\$ 4,800.00		
2	Traverse Sheets	1	10	20	\$ 12.00	n.a	\$ 2,400.00		
3	Pencils	1	2	20	\$ 25.00	1 inventory	\$ 50.00		
4	Flagging tape	1	1	20	\$ 279.00	1 inventory	\$ 279.00		
5	Permanent Marker	1	2	25	\$ 122.00	1 inventory	\$ 244.00		
6	First Aid Kit				\$ 14,830.00	40 days	\$ -		
Total							\$ 7,773.00		
b Camping									
1	Nails		Lb		\$ 55.00	1 inventory	\$ -		
2	Kerosene		Gallon	2	\$ 160.00	1 inventory	\$ 320.00		
3	AA battery	1		10	\$ 90.00	40 days	\$ 900.00		

4	Large Battery		1	2	\$ 218.00	40 days	\$ 436.00
	Total						\$ 1,656.00
	Total Consumable Items Field Cost						\$ 9,429.00
	Office - Consumables Cost (mapping materials, diskettes etc)						
	Total Consumable Items Cost						\$ 9,429.00
	Special Wear Items						
	Items	Cost/day	# of Days				Total Cost
	All	\$ 1,615.48					-
	Total						-
	Total Cost for Inventory						543,393.76

Example of a summary table

Fixed Costs			
	<i>Vehicles</i>	\$ 45,978.62	49%
Variable Costs			
	<i>Labour</i>	\$ 36,508.05	39%
	<i>Consumables</i>	\$ 7,796.25	8%
	<i>Special Wear Items</i>	\$ 3,666.76	4%
Total Costs		\$ 93,949.67	100%

Appendix ** Recommended reading

Strategic reviews/ technical reports on Guyanese forest resource information and survey methods

Alder, D. (2000) Development of growth models for applications in Guyana. Consultant report, Guyana Forestry Commission Support Project

Hawthorne, W.D. (1997) Forest resources of Guyana. Report on information development and management within the Guyana Forestry Commission. Consultant report, DFID Guyana Forestry Commission Support Project

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De Milde, R. and De Groot, D. (1970) Reconnaissance Survey of the More Accessible Forest Areas. Rome (UNDP/FAO)

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Carter, J.(1996) Recent approaches to participatory forest resource assessment. Rural Development Forestry Study Guide 2. Overseas Development Institute, London.

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