

Report on a consultancy to the EC Natural Forest Management and Conservation Project

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(NFMCP Service contract SC/009)*

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Summary

This report describes work which has been undertaken to develop computer software for processing data from the Integrated Stock Survey and Management Inventory (ISSMI) operation. The system now has capabilities for synoptic and stock mapping, stand tables with a variety of options, summary yield tables, and lists of trees for harvesting and protection for use as a field monitoring and control tool. The underlying design of the database has also been strengthened.

Some silvicultural concepts have been developed based on the idea of species groups. Work is needed now by the Uganda Forestry Department and NFMCP to discuss and elaborate these ideas and formulate practical species groupings representing species of similar commercial, conservation, and silvicultural character that can be used as a basis for the yield allocation logic within ISSMI.

The report also describes work on a system for entering and editing PSP data called EPHRU, and presents forms for collecting tree volume data.

It is concluded that the system as it stands should be used to build up a substantial database of stock data before undertaking further significant modifications, as it is difficult to fully test the system without enough data.

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Introduction

This report describes work undertaken between 12th April and 26th May 1999 by the consultant under Service Contract SC/009 to develop computer software for the EC Natural Forest Management and Conservation Project in Uganda. The major part of the work has concerned the continued improvement of the ISSMI software to assist natural forest management. A lesser part covered a data entry and editing system for permanent sample plots (PSPs).

ISSMI is an acronym for Integrated Stock Survey and Management Inventory. The general concept has been described in earlier reports and will not be re-iterated here in detail. Preliminary software was developed by the consultant during a visit to the project in February 1999. The present assignment covered essentially the necessary further development of that work.

The permanent sample plot software described here is called EPHRU (Editing of PSPs from the High forest Region of Uganda). It is a simple system for data entry and editing, which can be extended later through the addition of analysis facilities.

Both programs are based on Microsoft Access, although ISSMI also includes a subroutine library written in Visual Basic. This report provides an overview of their operation and installation, and discusses particularly related issues of forest management and PSP procedure. More technical details regarding the use of the programs will be found in the Help files attached to each.

ISSMI data structures and relationships

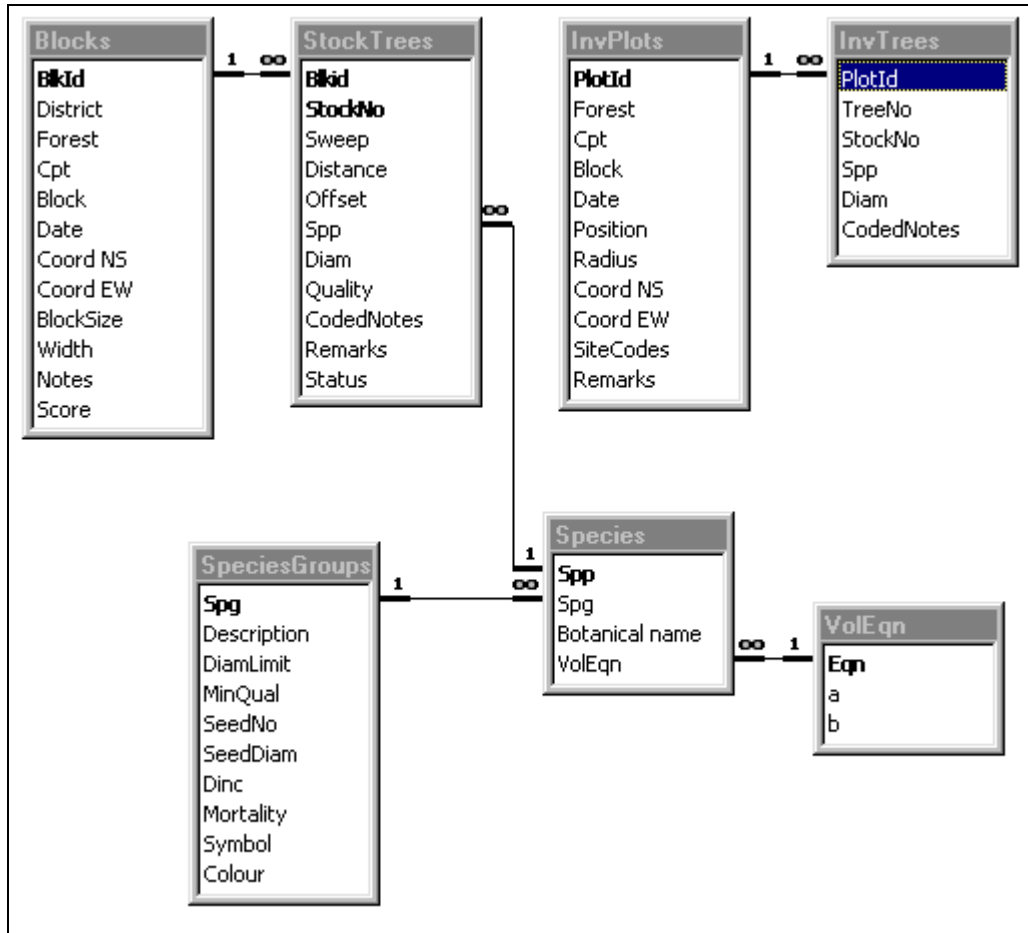
The ISSMI Microsoft Access database has the files and structures shown in Figure 1. These extend considerably those provided in the Feb'99 version, and are not compatible with it, so that data gathered using the earlier version of the program needs to be converted manually.

The main modifications and extensions made are:

- The use of block and plot identities which are now self-evident instead of arbitrary code numbers. For example Block 10 of Lwamunda Forest compartment 1 would be given a block identity (*BlkId* field) of *Lwa-1-10*. This makes the database more robust and easier to use.
- The addition of tables for species groups (*SpeciesGroups*) and for volume equations.
- Corresponding addition of fields to the species table (*Species*) for species groups and volume equations.
- Addition of a *status* field to the stock tree list (*StockTrees*), which is used to record harvest, residual and seed trees after application of silvicultural analysis.
- Some tables and fields have been renamed for improved clarity and to eliminate embedded spaces. For example the former [*Stock Trees*] table is now called

StockTrees, without the space. This improves compatibility with Visual Basic, for example.

Figure 1 Tables, fields and relationships in the ISSMI database



ISSMI Data entry and editing

The previously developed forms for entry of stock survey and sample plot data have been retained in their general format and appearance. A number of changes have been made behind the scenes to make operation faster and clearer.

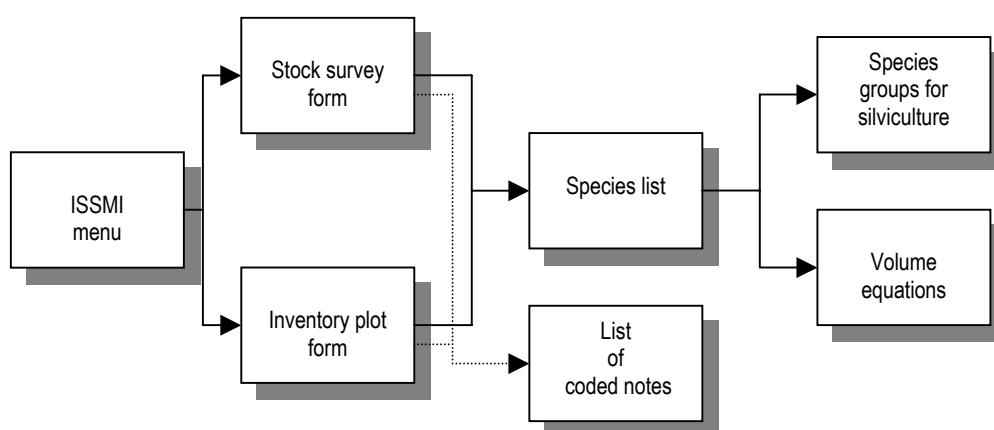
The species list is now linked automatically to stock tree or inventory plot data via the species code *Spp*. This is shown in Figure 1 as a 1–∞ (one-to-many) linkage, implying that Access will verify automatically that each species in the list has a unique number, and that each tree entered has a code which can be found in the list.

To allow new species to be entered, the data entry forms now bring up a species list automatically if the species name is double-clicked. This can be used to enter or edit a species name, or simply to change a species code number to an alternative value for a similar species name.

Within the species list itself, double clicking on the species group field (*Spg*) or the volume equation code (*VolEqn*) brings up corresponding tables, again allowing amendment or addition if required.

The coded notes for tree condition can also be expanded into full text form, and the list of coded notes viewed by double clicking on this field. New coded notes can be added as needed into this form.

Figure 2 Linkages among data entry forms



Species groups and silviculture

The consultant found it necessary to introduce some silvicultural or forest management concepts if the database was to be fully developed. The ideas presented here are preliminary and need to be discussed and elaborated.

It was necessary to provide a mechanism for presenting species data on maps that would simplify the large number of species available. For this purpose a concept of species grouping was introduced.

A species group is designated by a number in the species list, and has a matching entry in the species groups table, which is given a suitably descriptive name. For example, *Khaya* and *Entandophragma* species could be grouped as Mahogany with a group number 1. In the species group table, a symbol and colour can also be selected which is used to indicate the group on maps. However, the number of symbols and colours are limited to about eight, whereas the number of groups is not limited in principle. Practically speaking, it is probably desirable to keep the number of groups in single figures.

A species group must have a common silviculture in the present version of ISSMI. The silviculture is defined by:

- Minimum felling diameter (*DiamLimit*). Trees below this diameter will not be felled. As the stock survey is limited to 50 cm, this cannot usefully be less than 50 cm.
- Minimum acceptable stem quality (*MinQual*). Stem quality is coded from 1 (worst) to 5 (best) during the stock survey. For marginal commercial species, there is a practical consideration that poorly formed trees are unlikely to be usable. Trees of quality below the minimum are not selected for harvesting.
- Number of seed trees per hectare (*SeedNo*). This allows both for conservation and regeneration considerations. The number of selected trees are always reserved before harvest trees are selected.
- Minimum diameter of seed trees (*SeedDiam*). The numbers of seed trees are considered above this minimum diameter.

There are two other fields for species groups which are not presently used, but which are provided for use in more elaborate silvicultural algorithms which can be introduced in future. These are the mean growth rate (*Dinc*) and mean mortality (*Mortality*) rate for the group. In future these will be used in conjunction with information from the inventory plots on advance growth to calculate an allowable cut based on a simple growth model.

The present algorithm for harvest selection and seed tree reservation proceeds as follows:

- All calculations are done block by block within a compartment. This avoids undue concentrations of harvest or seed trees in small areas.
- Potential seed trees are selected by species groups as those above the minimum seed tree diameter. They are sorted from largest to smallest, and the required number selected from the largest downwards. Stem quality is not considered. This method (a) ensures seed trees tend to be large trees, and (b) because of the natural dispersal of trees sizes, ensures that seed trees are reasonably well distributed.
- If the seed tree requirements for a given species group within a block are satisfied, then harvest trees are selected as those above the minimum felling diameter and required quality standard.
- If, on the other hand, the seed trees are insufficient for a group, then no harvest trees will be selected either.
- Trees which are not selected for harvesting or as seed trees are termed residuals. They may be trees of poor form, below the harvesting specification, or below the harvestable size, or trees left because there are insufficient seed trees.

In the database, the *Status* field of the *StockTrees* table is set to -1, 0 or 1 to indicate harvestable, residual or seed trees respectively. The status can be re-evaluated

whenever the species grouping criteria are changed, but the re-evaluation is optional, allowing different criteria to be applied within different compartments.

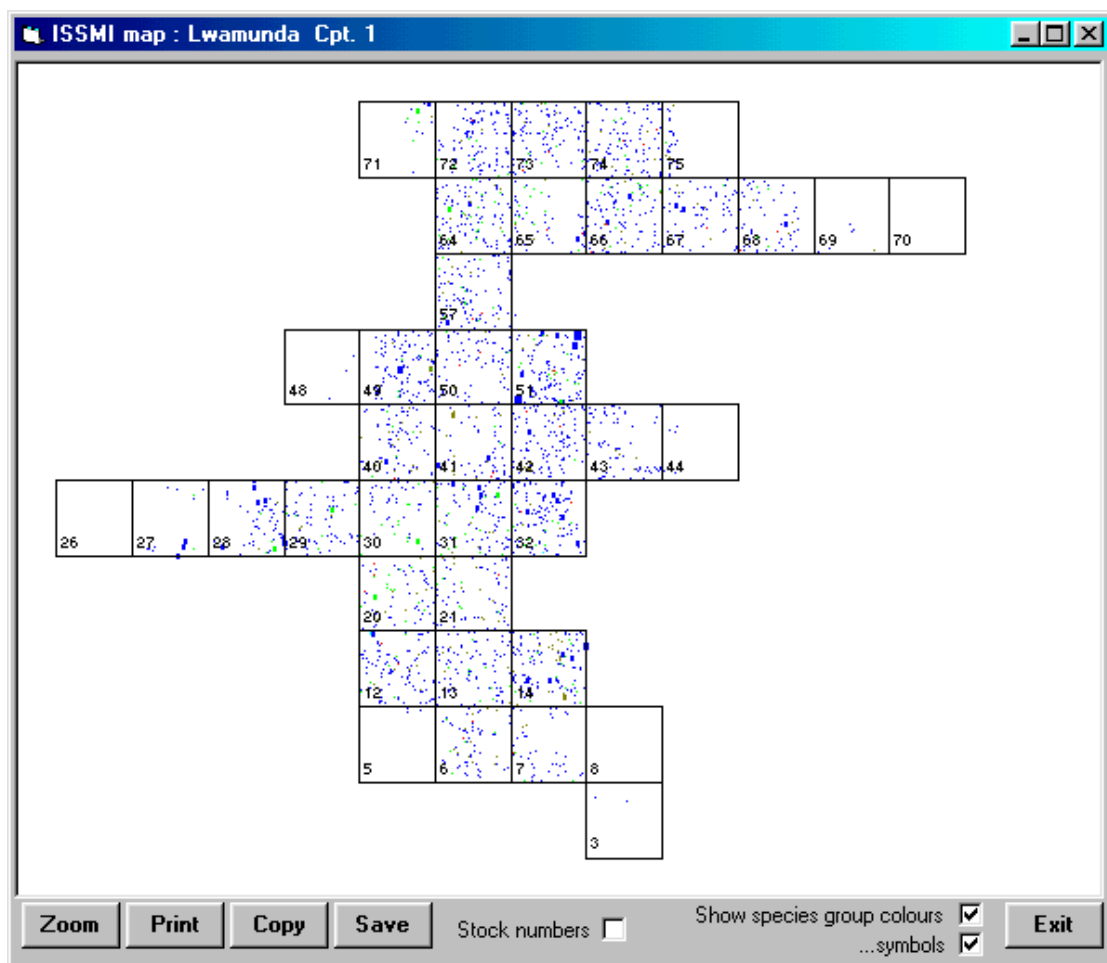
ISSMI mapping and GIS output

The ISSMI mapping system has been modified extensively from the earlier version, although the latter has been retained and updated for use with the current file structures.

Originally, an Excel file called ISSMIMAP.XLS provided detailed maps of a single block. This program has been updated so that it will continue to work with the new file structures, and can continue to be used if desired. However there are some limitations to using Excel in this way:

- Excel charts become very slow with large numbers of objects. A block map contains typically about 200 trees, which is reasonable. However, a full compartment might comprise some 10,000 points, which would become very cumbersome.
- The aspect ratio of charts is difficult to maintain, so that the X and Y scales

Figure 3 Synoptic map of a compartment



become distorted depending on the printer used and especially if the chart is copied to another program such as Word.

For this reason, and also to integrate the mapping process more closely with ISSMI, the facility is now provided by a Dynamic Linked Library (DLL) file called ISSMIMAP.DLL. This is a special purpose program written in Visual basic which is called automatically by ISSMI as needed.

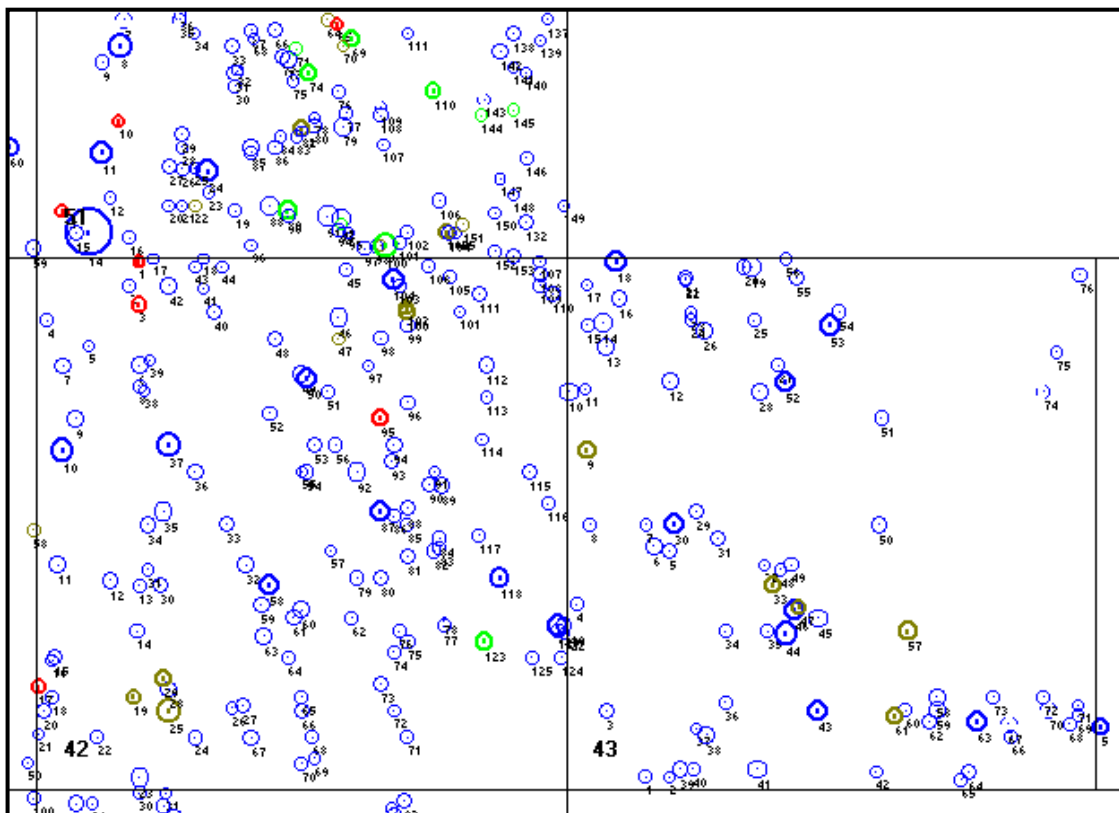
The ISSMI mapper produces two types of map. The first is a synoptic map of a compartment. An example is shown in Figure 3. This map shows each tree as a point, with larger sized points for trees over 100 or 150 cm diameter. It also shows the blocks with their numbers.

The points can be coloured according to one of two schemes. If the box labelled *Show species group colours* is checked, then the colour selected for the species group is used. If this box is cleared, then seed trees are shown in red, harvest trees in blue, and residuals in green.

This map can be printed, copied to the Windows clipboard, or saved to a file by using the *Print*, *Copy* and *Save* buttons.

Sets of blocks can be selected with the mouse. The Zoom button will then produce the second type of map. This shows individual trees on a larger scale, and can include stock numbers and different symbols for species groups. The colour scheme

Figure 4 More detailed stock map showing tree numbers



may again reflect either species groups or tree status. Figure 4 shows an example for a single block. The bold circles represent seed trees. Colours show species groups.

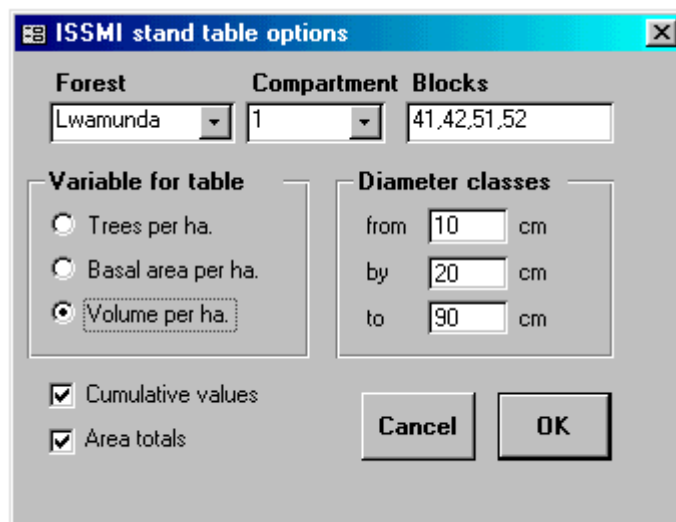
The mapper produces low-resolution images. For high-resolution or large format images, a GIS system should be used. The data that underlies these graphs can be output to a table which is suitable for reading by a GIS system. This includes the block identification, stock number, X-Y co-ordinates, species code, species group, stem quality and tree diameter for all trees in a compartment. The X-Y co-ordinates are based on the origin for the block co-ordinates within a compartment.

Stand tables of species and diameter classes

ISSMI can produce stand tables of species by diameter class for a whole compartment or selected blocks within a compartment. Figure 5 shows the options screen for stand tables.

Figure 5 Stand table options

The area covered may include a whole compartment, or selected blocks. The stand table may show tree numbers, basal area or volume. A conventional or cumulative table may be produced. The latter shows total values above a given diameter limit and is particularly suitable for basal area or volume. The figures may be given per ha or for the whole area selected. The diameter classes may also be varied. The stand table combines data from inventory plots with that from the stock survey to give estimates of stocking down to 10 cm diameter.



The stand tables produced may be printed directly or converted into a Word file using the standard Access option for this purpose. The data can also be imported into Excel for production of histograms or similar analyses.

A partial example of the output is shown in Figure 6 overleaf, as it has been imported into Word. The species are sorted by the designated species groups, with subtotals for each group. The titles reflect the area selected and the options chosen for variable, cumulative or normal diameter classes, and area totals or per hectare figures.

ISSMI Stand table Lwamunda Cpt. 1

Stock survey area 156 ha, inventory sample 1.6%, carried out 23-Nov-1998 to 19-Dec-1998

Species	Bole volume (m3) above given diameter limits (cm)				
	10+	30+	50+	70+	90+
Group 1					
103 <i>Entandrophragma angolense</i>	165				
104 <i>Entandrophragma cylindricum</i>	12	2	2		
105 <i>Entandrophragma excelsa</i>	3	3	3		
106 <i>Entandrophragma utile</i>	28	28			
107 <i>Fagara leprieurii</i>	26	26	26		
108 <i>Fagara macrophylla</i>	62	9	9	3	
109 <i>Fagara mildbraedii</i>	18	9	9		
113 <i>Lovoa trichilioides</i>	185	174	6	4	
114 <i>Lovoa swynnertonii</i>	10	10	10		
117 <i>Guarea cedrata</i>	11				
Total Group 1	520	260	64	7	

Figure 6 Part of a cumulative stand table of total volume produced by ISSMI

Yield summary table

The yield summary table is another ISSMI output option. This provides a one page summary by species groups of the silvicultural rules applied and the tree numbers and volumes for harvest trees, residuals and seed trees. It is designed to provide both a quick evaluation of selected silvicultural options, and a compartment summary of potential yield.

Detailed list of harvest and seed trees

The final type of output table in the current version of ISSMI is a list of stock numbers for trees, classified by blocks and species, that can be used for control purposes on the ground, in conjunction with stock maps. A partial example is shown in Figure 7. Tree numbers and volumes are given for each species, with seed trees, residuals and harvest trees shown separately. Against each species entry is a list of stock numbers.

ISSMI list of stock trees

Lwamunda Cpt. 1

Based on stock survey of 160 ha, performed 23-Nov-1998 to 19-Dec-1998

Silviculture Species

Trees Volume Stock numbers

Block 6

	Species	Trees	Volume	Stock numbers	
Harvest	281 Pseudospondias microcarpa	1	1.2	74	
	204 Albizzia gummifera	12	22.3	1, 20, 21, 24, 26, 39, 41, 54, 59, 62, 67, 75	
	219 Piptadeniastrum africanum	5	10.0	18, 25, 30, 37, 38	
	220 Prunus africana	4	8.2	2, 3, 6, 32	
	225 Albizzia glaberrima	3	4.7	70, 72, 76	
	240 Celtis milbraedii	8	16.7	16, 27, 28, 47, 51, 53, 56, 57	
	231 Antiaris toxicaria	10	18.8	5, 10, 36, 40, 44, 48, 49, 50, 55, 73	
	261 Erythrophleum suaveolens	2	3.7	52, 60	
	279 Polyscias fulva	1	.9	68	
	284 Schrebera alata	1	1.2	45	
	420 Blighia unijugata	1	1.0	8	
	465 Ficus spp.	2	2.3	4, 34	
	493 Mimusops bagshawei	1	1.0	66	
	556 Zanha golungensis	3	4.4	12, 29, 31	
	0 Unknown species	1	1.1	58	
	230 Aningeria altissima	1	2.6	13	
	282 Pterygota mildbraedii	1	1.6	46	
	Seed trees	219 Piptadeniastrum africanum	1	3.9	23
		261 Erythrophleum suaveolens	1	3.1	61
		420 Blighia unijugata	1	1.9	9
510 Phyllanthus discoideus		1	1.2	33	
521 Sapium ellipticum		1	1.7	69	
527 Spondianthus preussii		1	1.7	71	
231 Antiaris toxicaria		2	9.9	7, 63	
0 Unknown species	3	8.9	43, 64, 65		

Figure 7 Partial extract from the ISSMI yield list report

The permanent sample plot data entry system

A database design and editing form have been set up for processing permanent sample plot data which has been called EPHRU (Editing of PSPs from the High forest Region of Uganda). These have been designed to correspond closely with the field forms in use. EPHRU is an Access database that starts directly with the data entry form open. It includes a simple Help system to assist data entry staff, but is basically easy to use. Like ISSMI, the species list can be accessed by clicking on species names, with species being added dynamically. Similarly, coded notes can be viewed and amended in the same way.

At the present time, EPHRU does not include any reporting or analysis options.

Tree volume sampling

Volume trees should be recorded on the form shown on the following page. The sampling needs to be monitored as it progresses to ensure that it is suitably distributed by species and size classes. However, initially it is recommended that work commence in an area where exploitation is taking place after stock survey. All exploitable trees should be scaled (measured for volume) before the contractors are allowed to cross cut them. Normally, a party of three foresters can undertake the scaling, with one booker and two measurers. Standard log tapes with diameter and linear measure to 320 cm/10 m should be used to record lengths and diameters.

The measurement standards will be explained and field training given during the consultants next visit. The process is straightforward, and training can be completed in a single day.

A simple database will also be set up suitable for use in conjunction with the attached form. This has not been done so far as it is desirable to have some completed measurement forms to use to test the database form as it is designed.

It is recommended that the Forest Research Institute should undertake a study of sawn volume produced from a sub-sample of the volume scaled trees. This will allow conversion rates to be determined with tree-by-tree correspondence to the bole volume measurement. The EC Forestry Project could facilitate this through a local consultancy.

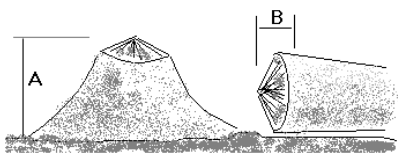
Volume tree measurement form				Officer-in-charge		Measurement Date	
Forest			Forest block		Cpt.	Block No.	Stock No.
Diameter (cm)		POM (m)	Species name				Code
Section	Length (m)	Top diameter (cm)	Defect code				
0			Stump – see note				
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
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Block and stock no: *If the sample tree has a stock number, stock survey block and tree stock number must be recorded here. For sample trees below 50 cm, or in areas not stock surveyed, these fields should be left blank.*

Diameter & POM: *The point of measurement is conventionally 1.3 m above ground or 1 m above buttress. If it cannot be reached before felling, mark a reference point, eg 2 m above ground and measure from that after felling, adding reference height to record POM.*

Diameter should be measured in cm to one decimal place eg. 55.2 cm. Height of POM should be measured in m to two decimal places, eg. 1.55 m.

Stump section. *Measurement length as A+B in diagram below, and top diameter as the base section of the first log.*



Defect codes: *Each section which is not a useable log should have a defect code entered, from the following:*

FD *Felling damage – splitting or breakage.*
BR *Section containing a lateral branch*
DH *Decay, holes, hollows, excrescences etc.*
MF *Malformed, twisted, curved, etc.*

General points:

- *Do not measure trees with multiple stems or extensive longitudinal splitting after felling.*
- *Sound sections of good log can be measured in lengths of 3-5 m.*
- *Defective sections can be as short as necessary, eg. 0.5 or 1 m.*
- *Continue measuring up to the point of crown break.*

Conclusions

The ISSMI software discussed in this report can be applied to process existing and future stock surveys according to the ISSMI standard. However, the software does need to continue to be developed in conjunction with the associated forest management and silvicultural procedures. The following particular areas will need to be reviewed in the coming months in the light of experience:

- *The efficiency of the database with large amounts of data.* So far testing has been undertaken with some 3000 trees from early stock survey work in Lwamunda forest. As this builds up to 100 to 200 thousand trees, it will probably be found that some improvements will be needed to maintain operational speed. This will need to be addressed when sufficient data has been input to the system. Ultimately, if 150,00 ha of forest were under management through ISSMI, then some 3 million trees will be stored in the system, and it will need to operate efficiently at that level.
- *The method of selecting trees.* This is based at the moment on simple criteria that have been described in the report. The method should be elaborated to consider the information on advance growth available from the inventory plots, in conjunction with estimated growth and mortality rates. Further discussion is also needed on the best method of selecting seed trees.
- *Revision or addition of reports from the database.* The reports provided may not be in the best format for management use, and it may be that other reports may be found to be useful. Ideally, modifications to reports should be bound up with a planned training course in advanced Access use, so that there is not a continuous dependency on consultancy for these types of modifications.
- *Modifications to the system for optimal linkage with GIS.* As with the preceding point, this should ideally be combined with an intensive training course, but experience is need in using current GIS output tables with a system such as ARCVIEW, to determine what additional parameters or information may be needed to optimise the process of producing large-scale high quality compartment stock maps.

However, it is important that the existing system be fully used as it stands for some time, in order to gain experience and amass data for realistic testing of new facilities.

With regard to the EPHRU system for permanent sample plots and the tree volume sampling, a forthcoming consultancy is planned which will take these matters forward. EPHRU can be used to input the existing body of PSP data, and will clearly require to have processing and analytical facilities added, but this will not become very important until the first PSPs are re-measured in 1-2 years time.

Denis Alder
09 May 2002