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

30th Jan –13th Feb 1999

Dr. Denis Alder[1]
Consultant in Forest Biometrics

Summary

This report describes the first of a series of consultancies planned to develop software and operational procedures for ISSMI (Integrated Stock Survey and Management Inventory). The basic field procedures of ISSMI are described. Stock survey is carried out by 200 m square blocks, within which 40 m guidelines are laid. Four circular 500-m² plots are laid systematically in each block to measure trees down to 20 cm. A sub-plot of 125 m² samples trees down to 10 cm. This allows a regeneration and stand structure profile to be determined for each block to facilitate silvicultural decisions and yield projections. During stock survey, all trees over 50 cm are measured and assigned a stock number, which is painted at the base of the tree. The survey system has been operational in the field for some 2 months. The consultant during this visit designed a database for the field data, with entry and editing formats for the field sheets, revised some procedures, and produced a program to draw stock maps at the block level. He also generalised existing volume equations to produce 11 provisional equations that could be used by the ISSMI software. However, the existing equations need to be supplemented by data from felled samples, and it was recommended that this be facilitated by the project. Later work planned will include various tables of tree numbers by size classes and species at block and compartment level, thematic maps of stand density, structure, and management recommendations at the compartment and forest level. Training was also provided during the visit in the use of the initial ISSMI software and in some database and Excel techniques.

[1] E-mail: d-alder@eurobell.co.uk

Introduction

This report describes a visit by the consultant to the EC Natural Forest Conservation and Management Project, Kampala, from 30th January to 13th February 1999. This is the first of a series of assignments planned to develop software, procedures, forms and provide training relative to the ISSMI concept of natural forest management.

ISSMI is an acronym for Integrated Stock Survey and Management Inventory. Its objective is to integrate three levels of forest operations – stock survey, management inventory, and diagnostic sampling – into a single combined operation. This operation provides a strong infrastructure for forest control and the practice of selection silviculture in a way that will improve the condition of the forest.

ISSMI is also an information system, based on this combined operation, that allows for the rapid production of stock maps, thematic maps of silvicultural condition, and tables of species, size class and volumes for forest planning.

The purpose of the current and planned consultancies is to provide biometric advice and computer programming support for the evolution of the system.

An overview of ISSMI

Field operations

The combined stock survey and management inventory is the basis for ISSMI. The following are the main steps and procedures:

- A base line is established in a forest compartment, on which is defined a base point which represents the zero co-ordinate for all co-ordinate measurements within the compartment. The planned layout of blocks and the position of the base point should be recorded on ISSMI Form 1.

- Lines are cut through the forest in a North-South (NS) and east-west (EW) direction at 200 m intervals, to form a series of blocks. These blocks of 4-ha each are intended to be the basic units of silvicultural management.

- Each block is assigned a number, usually in sequence of access, and is identified geographically by its co-ordinates relative to the base point. The block number is painted on a board nailed to a tree as high as practical at the SW corner of each block.

- Within the blocks, guidelines are cut at 40 m intervals in a NS direction. Trees 50 cm diameter and above are measured for diameter, scored with a silvicultural code reflecting potential utility, and identified by species. A number is painted at the base of the tree, as close to the ground as practicable, which is a sequential stock number. Blue oil-based paint of good quality is used for this purpose.

- The position of stock trees (ie. those over 50 cm dbh) is recorded, with other details, on ISSMI Form 3. The distance of the tree along the sweep is recorded from the southern boundary of the block, as is the offset of the tree from the guide line immediately to the west.

- After completing the stock survey, four temporary sample plots (TSPs) are established in each block. There are established at 40 and 160 m on guidelines 1 and 4, as shown in Appendix B.

- Each TSP is circular, of 12.6 m radius, and area 1 ha. All trees are recorded over 20 cm dbh on ISSMI Form 2. In the NE quadrant of the plot, trees over 10 cm dbh are recorded.

- Where stock trees occur on the TSP, their stock number is entered on the form, and they are included in the measurement process as with other trees. This provides a quality control on the accuracy of positional estimates, species identification, and diameter measurement.

These represent currently recommended procedures, and vary some earlier practices. There has been some experimentation with block sizes (200 and 300 m), tree marking (paint, scribes, and hammer marks), and general organisation. It was originally recommended that management inventory plots be established at the corners of the blocks, but this leads to too low a sampling percentage and an unrepresentative regeneration sample. The field forms have also been revised slightly from earlier versions.

At a later date, procedures will be included for monitoring felling operations and checking stumps within the blocks.

Data processing

ISSMI data is stored in a Microsoft Access database. At present this incorporates the preliminary data base structures and forms for entering stock survey data on Form 3 or inventory plot data on Form 2. Copies of Forms 2 and 3 are given in Appendix A.

Only one processing program so far exists. This is the stock map drawing module, contained in a Microsoft Excel workbook called *ISSMImap*. This produces stockmaps for a single block in A4 format, together with a list of species and tree numbers for each species.

The data processing procedure as it so far exists is as follows:

- Field forms are brought in as frequently as practicable (probably weekly) and added to the database via Form 2 or Form 3 input procedures.

- Stock maps may then be produced for each block as soon as data has been entered in the computer. An example is shown in Appendix C.

- Queries have been designed that show volumes and tree numbers by diameter classes and blocks. Presently these are unformatted outputs, but can readily be tidied up using Excel.

- Further functions will be developed during future consultancies.

Various other functions will be added progressively as work progresses. These will include:

- A data screening and error checking module.

- A synoptic progress map, showing which blocks and plots are in the system.
- Tabular reports of growing stock volumes and numbers.
- A thematic map of blocks showing stock density, species distribution, silvicultural condition, etc.
- Lists of trees by stock numbers recommended for harvesting.
- Lists of protected seed trees requiring special marking in the field.
- Tables of planned yields based on the selected stock list.

Application to forest management

It is envisaged that ISSMI will lead to a system in which individual blocks will be allocated for selection of harvest trees based on a number of silvicultural criteria. These will be determined at a later date, but are likely to include consideration of adequate seed trees, and adequate pole and sapling sized trees to provide a crop at the next cycle.

Within a selected block, individual trees will be selected for felling, retaining appropriate large individuals as seed trees, and prioritizing poorer stems for removal.

The criteria involved in block and tree selection will be expressed logically, so that the software will generate maps and lists of harvest and seed trees programmatically.

Monitoring of forest operations

A further field procedure to be introduced in the final stages of the development of the system will be a post-felling survey to check that removals conform to the approved list, and logging damage has been constrained within bounds.

Forest rehabilitation and re-planting

The silvicultural maps will also identify under-stocked areas of forest that may be targeted for rehabilitation. This may involve various measures to encourage seedling establishment, including liberation of young saplings from climbers or weeds, and possible re-stocking of areas with mixtures of natural species. Substantial trials will be needed however to identify appropriate species and techniques before this can be done in a routine way.

Silvicultural and felling cycles

It is envisaged that the stock survey, management inventory, harvesting allocations, monitoring and re-planting works will be undertaken on a 15-year cycle, which is termed the silvicultural cycle. This does not constitute a felling cycle which may be used for calculating allowable cuts and making strategic decisions regarding an appropriate size of timber industry. The felling cycle should probably be of the order of 60 years for general or statutory application. What ISSMI allows is for the allocation of felling series on a local scale (in 4-ha blocks) and according to the actual silvicultural conditions prevailing on the a particular site. The repeated cycle of operations allows strong management planning, monitoring and control. This will optimize both the protection of the forest from over-cutting and encroachment, its value for nature conservation and biodiversity, and its potential productivity as a timber resource.

Work completed during the assignment

The following specific items have been completed during the mission described in this report:

- The field forms 2 and 3 were designed and subsequently modified in the light of experience. Current versions are shown in Appendix A.
- The database has been set up. Its structures are not fully documented here as it will be subject to further rationalization.
- Data entered prior to the consultant's arrival was modified and re-formatted to fit the new structures.
- The data entry formats for Forms 2 and 3 were developed in the database.
- The stock mapping module in Excel was completed.
- A system of volume equations was developed, as described in the next section in more detail.
- A system of database queries was set up to demonstrate how the volume equations could be linked to produce tables of volume by species and size classes.
- Two field visits were made to Lwamunda Forest Reserve to discuss aspects of ISSMI operations on the ground, and to check the accuracy of stock maps.
- A presentation on modelling and forest management was made to interested specialists and project staff.
- Training sessions were given in the use of SQL in Access, and in the use of Macros in Excel to automate the formatting of Pivot Table outputs.

Volume equations for ISSMI

Interim equations

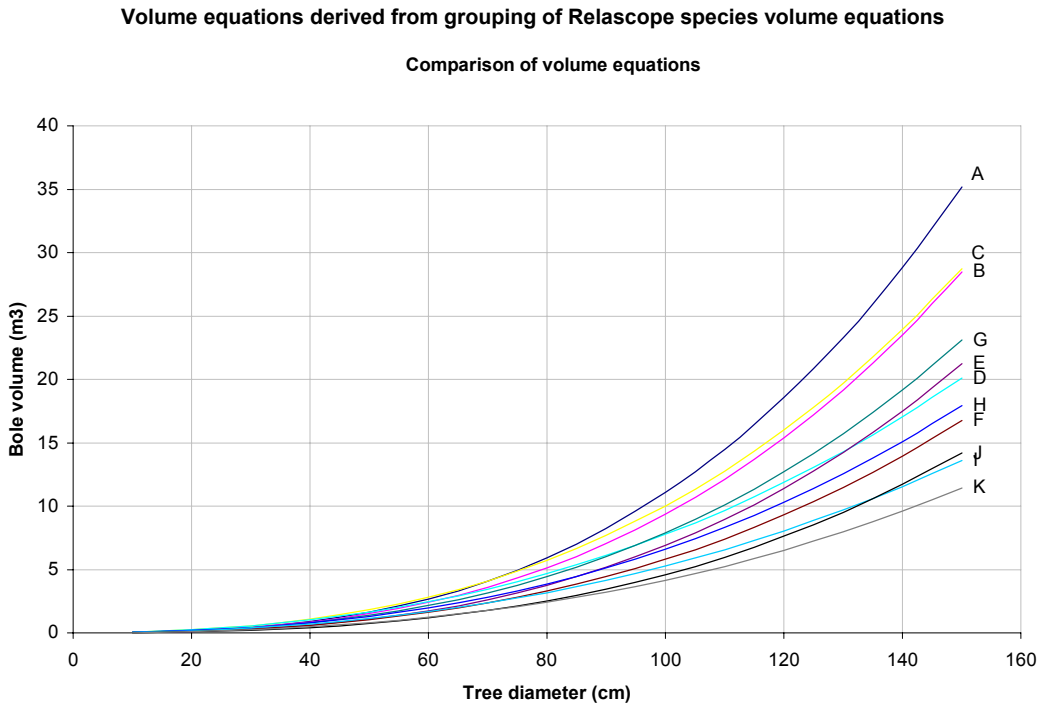
A system of interim equations for volume estimation has been developed based on the method used by the PIFIT indigenous forest inventory program. PIFIT[2] uses Relascope measurements on the lower, mid and upper stem diameters to calculate tree volumes of sample trees. These are compiled into a table of coefficients local to the inventory in question. The volume equation used is:

$$V = kd^2.(\alpha + \beta.d) \qquad \text{eqn. } \{1\}$$

Where V is the required bole volume in m^3, d is the tree diameter in cm, α and β are species-dependent coefficients, and k is the constant 0.00007854 or $\pi/4 \times 10^{-4}$.

The individual volume equations for each species from the five inventories undertaken so far were grouped according to their similarity into 11 groups. The figure below shows the eleven equations in graphical form.. Each species was assigned to a group, and a table added to the ISSMI database that gives the coefficients. A small function was also written (*VolFn*) which can be called from queries to provide tree volumes. A demonstration query was set up called *TreeVolumes* which show how the volume, species, and tree tables may be linked and *VolFn* used.

[2] PIFIT was developed by the author in 1991 under the Forestry Rehabilitation project and used at that time for inventory of Budongo FR. Under the direction of David Elungat, it has seen been applied to four other forest inventory projects.



Volume sampling

Relascope measurement is not an accurate method of determining tree volume, especially under the relatively uncontrolled conditions of a forest inventory. During the 5 inventories carried out since 1990, some 36 thousand trees have been measured, but the quality of this work is uncertain. The consultant's studies of Relascope use for volume measurement in Ghana during 1980 showed that volume errors of ±30% were quite common.

Consequently, the above equations should be provisional, and a proper volume study based on felled samples undertaken over the next one or two years to provide definitive equations. A proposal for this has been discussed by the consultant with the EC project Forest Management specialist, and a more detailed protocol for sampling, including field instructions and forms, will be prepared as part of the next assignment (1-2 days work is required). These proposals will include the following main points:

- A sample of about 2000 felled trees should be measured.
- The sample should be divided into three or four localities.
- No more than 100 trees of any one species should be sampled.
- Sampling should be made by equal numbers per basal area class. This results in more large trees in the sample, and avoids over-sampling the more common trees near the 50 cm felling limit. The protocol will include a table of sample numbers.
- Some smaller trees below 50 cm also need to be measured to fix the volume line for each species.
- Measurement will be by log-length sections of 4.2 m or less.
- Defective sections will be cut out and measured separately.
- Measurement should continue up to the commercial limit, including pieces within the crown if necessary.

- Each section will be cross-cut and measured on two axes for diameter over bark, under bark, and under sapwood. Any core defect should also be measured on the same axes.

Further work on ISSMI

The full development of ISSMI will require several further stages. Currently it is proposed that the consultant undertake two separate contracts. The first, during March/April 1999, would be for 14 working days, to cover the following items:

- Programming to produce progress maps and thematic maps according to various user-definable criteria for individual compartments.
- Programming to produce stand tables and graphs of stand structure for individual blocks, groups of blocks or campartments, based on a synthesis of stock survey and management inventory data.
- An error screening module for stock survey and inventory data, to detect logical errors.
- Form design and field instructions for volume sampling.
- Form design and initial data entry system for permanent sample plots. This will include setting up an Access database.

This work would be undertaken at the consultant's home base, with the various outputs being supplied to the project by e-mail.

During May 1999 a further visit would be made to the project to cover the following:

- Test and install the upgrades to ISSMI made in the preceding contract.
- Provide training in the use of the upgraded system.
- Provide further training in more advanced techniques with Access and Excel.
- Undertake field visits to various sites to consider silvicultural and management aspects of the system.
- Review progress in data entry and plan operational aspects of the database as it increases in sites and covers multiple forest reserves.

These proposals do not cover documentation of the system. It is suggested that this wait until most aspects of the system are finalised. Reporting up to the end of the second assignment will be brief (as with the current report), and will be in the nature of progress reports only.

Conclusions

This report covers the first stage of the software development for ISSMI. The stock map output for blocks is now function, and should directly assist forest management. Much of the foundation of the system has been constructed. The data entry methods have been formalised, and a provisional system for volume calculation developed. Useful training sessions have been given to the staff.

Several further steps remain for ISSMI to be fully developed as an information system to assist and control selection silviculture in Uganda. However, it is

envisaged that, as in the present case, each of these steps should provide a directly useful output, in terms of functional software and personnel training.

Denis Alder
Kampala
13 February 1999

Appendix A ISSMI field forms

Attached are copies of ISSMI Forms 2 and 3. ISSMI Form 1, which provides a simple grid for drawing block layouts, can be printed from an Excel file of the same name.

These forms are revised versions. Earlier formats should be destroyed and not used in the field.

ISSMI Form 3 Stock survey enumeration			sheet	of	Coded notes for site, land use etc.
Forest	Cpt.	Block	*Co-ordinates for SW corner of block* **NS**	**EW**	
OIC enumeration team		Date	Block size, m	Sweep width, m	

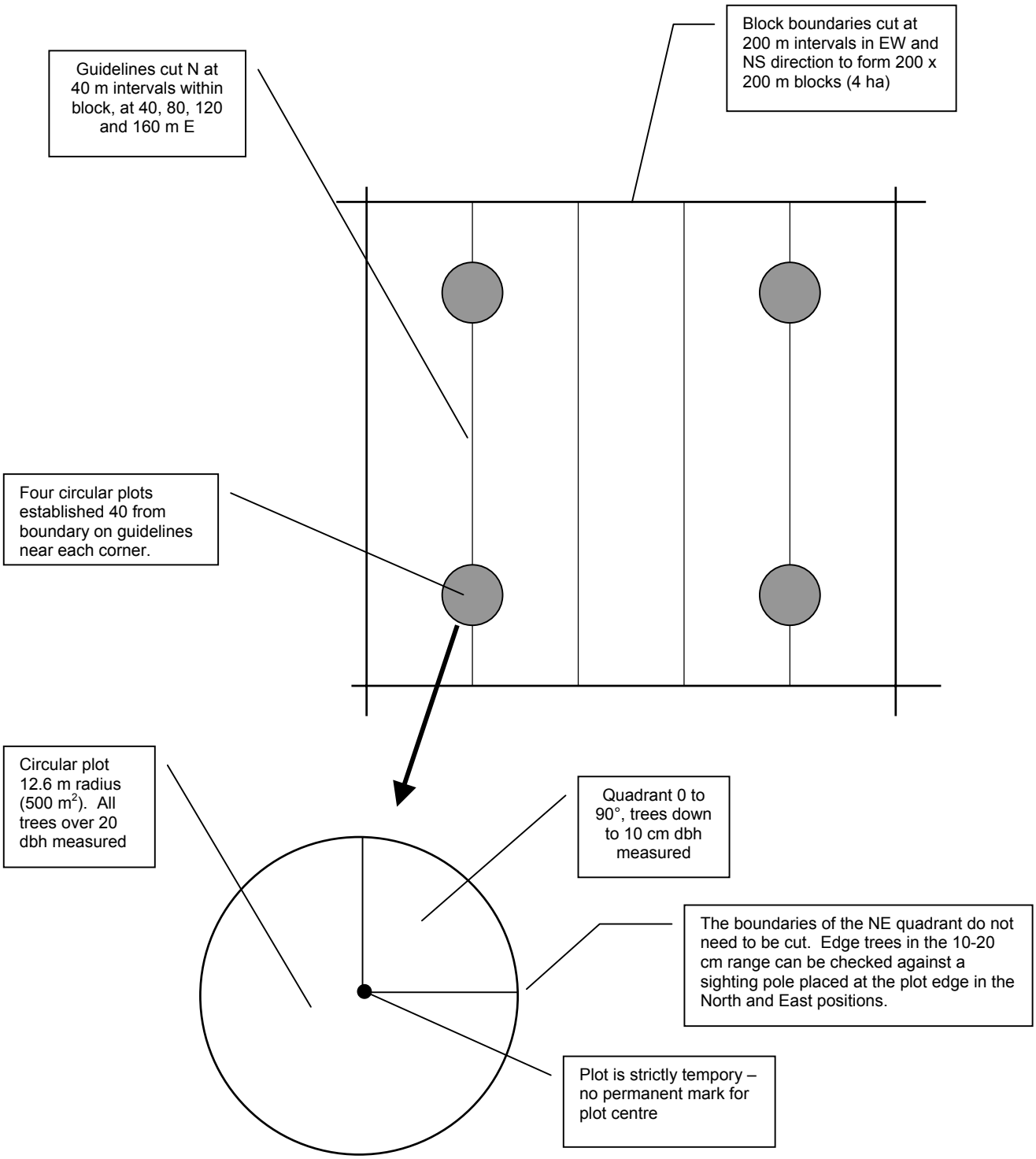
(1) **Sweep #**	(2) **Distance**	(3) **Offset**	(4) **Stock #**	(5) **Species**	(6) **Code**	(7) **Diam.**	(8) **Silv.**	(9) **Coded notes/remarks**

ISSMI Form 2	Temporary sample plot enumeration					sheet	of
Forest	Cpt.	Block	Position	Radius	Co-ordinates of plot centre NS EW		
OIC enumeration team	Date		Site codes				

	(1) Tree #	(2) Stock #	Species	(3) Code	(4) Diam	(5) Status

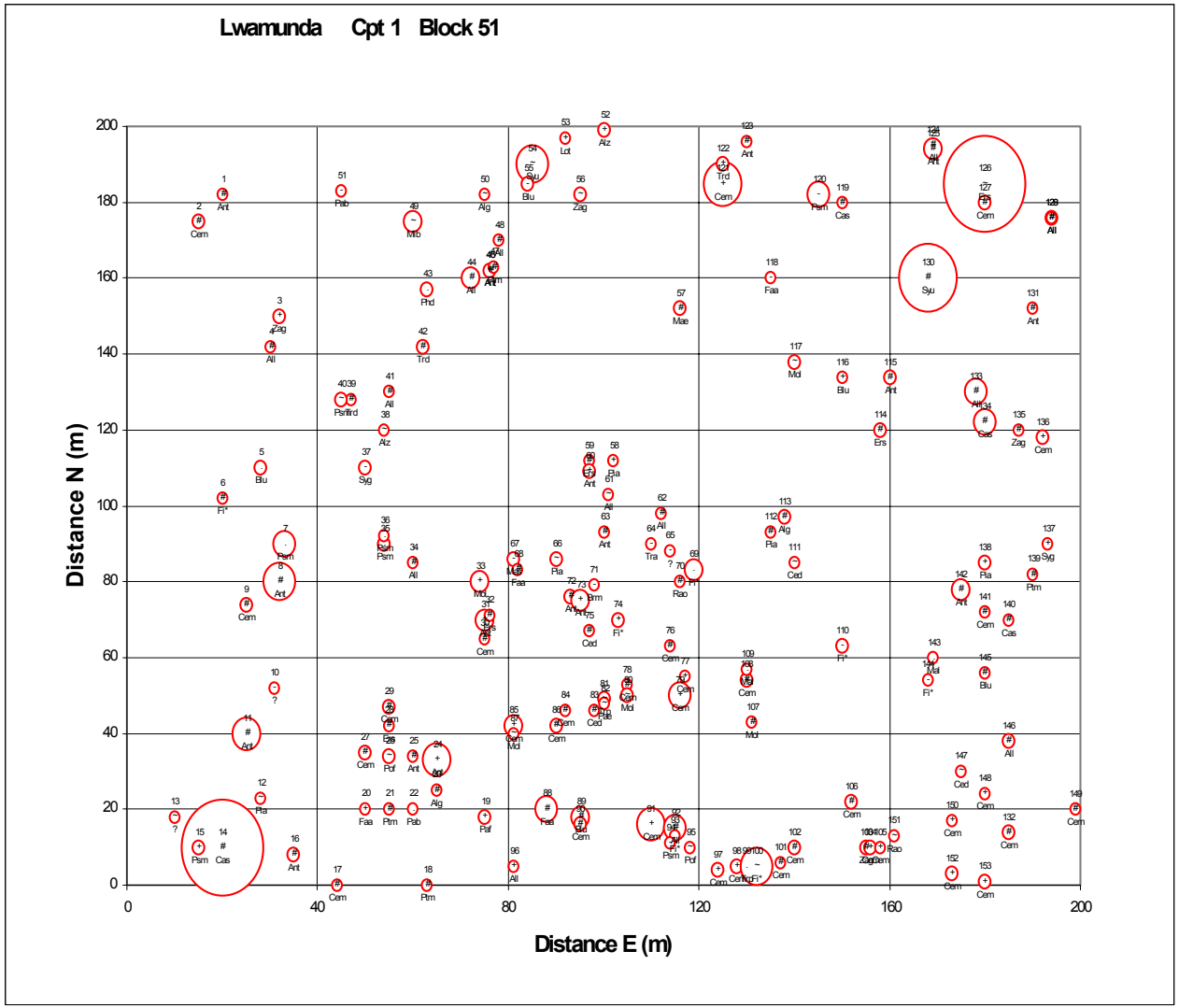
Appendix B Revised location of inventory plots

Initial ISSMI recommendations were for circular TSPs to be laid at block corners. New recommendations are for plots to be laid 40 m in from each corner, at the 40 and 160 m marks on the first and last guidelines. The NE quadrant of the plot for regeneration sub-sampling is estimated using the 0° and 90° points on the compass. No quadrant lines are cut. Suspect edge trees are checked by compass. Only trees below 20 cm need be checked in this way.



The figure and table below have been imported from Excel. The aspect ratio is slightly distorted in consequence. When printing directly from Excel, the stock map shows correct scales.

Appendix C : Example of an ISSMI stock map



Local species list			No.trees
107	Fal	Fagara leprieurii	3
113	Lot	Lovoa trichilioides	1
204	Alg	Albizzia gummifera	3
205	Alz	Albizzia zygia	2
208	Faa	Fagaropsis angolensis	4
211	Mae	Maesopsis eminii	1
219	Pia	Piptadeniastrum africanum	5
221	Syg	Symphonia globulifera	2
222	Trd	Trichilia dregeana	3
225	All	Albizzia glaberrima	14
231	Ant	Antiaris toxicaria	18
233	Cas	Canarium schweinfurthii	4
238	Ced	Celtis durandii	4
240	Cem	Celtis milbraedii	33
261	Ers	Erythrophleum suaveolens	5
267	Mal	Macaranga lancifolia	2
269	Mas	Macaranga schweinfurthii	1
272	Mol	Morus lactea	5
277	Pae	Parinari excelsa	1
278	Paf	Parkia filicoidea	1
279	Pof	Polyscias fulva	2
281	Psm	Pseudospondias microcarpa	7
282	Ptm	Pterygota mildbraedii	4
289	Syu	Syzigium guineense	2
420	Blu	Blighia unijugata	5
425	Brm	Bridelia micrantha	1
465	*Fi**	Ficus spp.	7
493	*Mib*	Mimusops bagshawei	1
505	*Pab*	Pachystela brevipes	2
###	*Phd*	Phyllanthus discoideus	1
###	*Rao*	Rauvolfia oxyphylla	2
541	*Tra*	Treculia africana	1
545	*Trp*	Trichilia prieuriana	2
556	*Zag*	Zanha golungensis	4
		Total	153