Planning and monitoring tools for natural forest management in Uganda

A technical report submitted to the Uganda National Forest Authority, April 2005.

Denis Alder

Denis Alder Consulting
9 Stansfield Close, Oxford OX3 8TH, UK
http://www.denisalder.com

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Summary

This report describes the further evolution of two planning and management tools for natural forests in Uganda: EI (Exploratory Inventory) and ISSMI (Integrated Stock Survey and Management Inventory). They have been developed since 1998 as improvements on earlier inventory and stock survey methods. Their context is discussed within the forest management framework, with EI providing information for preliminary zoning of felling series, and for more detailed allocation of annual felling series within 10-year working plans. ISSMI supports annual harvesting operations, providing demarcation and stock survey procedures, stock mapping, and harvest and protection lists for both marketing of timber, and monitoring and control on the ground.

The EI software comprises three packages: EiSys for data entry and quick stand summary reports, EiMap for mapping inventory blocks, transects and plots as GIS compatible files, and for generating random inventory layouts, and EiPac for more flexible stand tables including sampling errors and defect allowances. EiPac also includes a stand growth model for allowable cut and sustained yield estimation.

The ISSMI software covers data entry, tree georeferencing, mapping in GIS files, stand tables, block summary lists, tree lists, and a new harvest list intended to facilitate marketing of timber felling rights. ISSMI is directed at strong monitoring and control of felling to enable polycyclic stand management. It includes two mapping tools, the Excel-based block mapper, and a GIS-linked quick mapping system.

The report describes work undertaken over 5 weeks of January-February 2005 to improve the above packages and add new facilities, as well as provide more extensive training in their detailed use and general application in the forest management context. The work has included improved transparency for identifying linked databases, new reports for EiSys (quick stand tables and a stand summary report), a random inventory transect GIS generator, corrections to EiPac stand tables, and calibration, testing and further development of the growth model in EiPac for use in Uganda. For ISSMI, the quick mapping tool has been made fully GIS-compliant, and new reports have been added to assist bidding list preparation. The tree selection procedure has been re-written and simplified. For both suites, volume equations have been revised to allow net and gross volumes to be calculated. Net volumes discount volume for lower stem quality scores, and exclude the poorest trees from commercial volume.

As well as ongoing *ad hoc* training during the 5 week period, several formal seminars were given to senior NFA management, emphasising the context and issues relating to forest planning. Repeated themes in discussion were the appropriate felling cycle, the cost of ISSMI, the accuracy of volume equations, and the low sustainable yields of natural forest. Felling cycle should be standardised; forest production or sustainability is insensitive to cycle length, provided appropriate felling control is enforced, but continuous uncertainty of policy undermined forest planning. A 30-year cycle was agreed as a compromise between the recommendations of different authorities that should be adopted by the NFA for planning purposes. ISSMI costs were comparable with similar stock survey systems, but care was necessary in overloading the NFA costing with non-operational elements, as this would distort decision making. Sustainable yields were likely to be around 0.7 m^3/ha/yr, rather than Dawkins' pan-tropical estimate of 1 m^3/ha/yr. Social and environmental benefits therefore had to be taken into account in economic analysis of natural forest management in order to justify its viability. Volume equations need to be updated; this work had been recommended in detail before, but not prioritised. As a stop gap, estimated net volume factors had been added to the most useful EI and ISSMI output tables. The consultant also emphasised the importance of PSP re-measurement if they were not to be lost.

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Acknowledgements

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Disclaimer

This report describes the author's own work, and any errors or omissions are his sole responsibility. It does not necessarily reflect the views or policies of the National Forest Authority.

List of abbreviations

AAC	Annual Allowable Cut
CFI	Continuous Forest Inventory
CFR	Central Forest Reserve
DFID	Department for International Development of the UK
EC	European Community
EDF	European Development Fund
EI	Exploratory Inventory
FR	Forest Reserve
FRMCP	Forest Resources Management and Conservation Programme
FRP	Forest Rehabilitation Project
GEMFORM	Guyana Empirical Forest Model
ISSMI	Integrated Stock Survey and Management Inventory
ITTO	International Tropical Timber Organisation
LAN	Local Area Network
MYRLIN	Methods of Yield Regulation with Limited Information
MS	Microsoft Corporation
MTF	Moist Tropical Forest
NFA	National Forest Authority
NFMCP	Natural Forest Management and Conservation Project
NFM	Natural Forest Management
PSP	Permanent Sample Plot
RIL	Reduced Impact Logging
RME	Reliable Minimum Estimate
SFM	Sustainable Forest Management
SQL	Structured Query Language
TOR	Terms of Reference
TSS	Technical Services Section
UFD	Uganda Forestry Department
UTM	Universal Transverse Mercator projection

Introduction

Terms of Reference

This report describes work undertaken by the author between 12th January and 11th February 2005 for the Uganda National Forest Authority (NFA). The detailed terms of reference (TOR) are given in *Appendix A* on page 50.

In summary, the work has covered three areas, as noted in §1-3 of the TOR. These are:

- Improvements to the EI suite of software for processing forest inventories, especially to calibrate the growth model for allowable cut and sustainable yield calculation, and to derive indicative recommendations for the same.
- Improvements to the ISSMI stock survey software to eliminate a number of bottlenecks to its use and provide additional facilities of practical value.
- Training of managers in the use of these software, especially in the context of developing management plans for sustainable timber production from Central Forest Reserves (CFRs).

Report overview

This report is divided into three main sections. *Using the EI forest inventory and modelling software* (p. 5) describes the three programs (*EiPac*, *EiSys*, *EiMap*) developed to support Exploratory Inventory (EI), especially with reference to features that have been modified or added during this visit and to their application for longer-term planning and management of natural forest. *Using the ISSMI harvest planning and control software* (p. 26) reviews the ISSMI field procedures and software for stock survey and harvesting control, especially the most recent improvements. *Modelling and forest management issues* (p. 39) explains the growth model assumptions and local calibration process for EiPac, and its application for allowable cut and sustained yield estimation. Installation procedures for all the software packages are described in detail in *Appendix B* (p. 52).

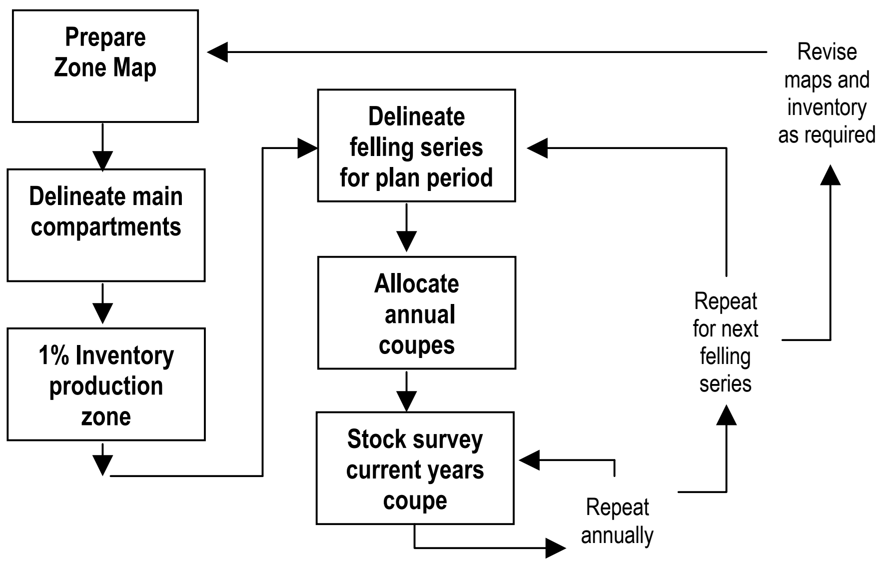
Both ISSMI and EI have a significant background of development behind them, and have been extensively applied on the ground (4,400 ha of field operations for ISSMI stock control and management inventory, and 32,000 ha covered by low-intensity EI inventory). The consultant has made five visits since 1998 to develop the field procedures, provide training and write and test the software that has been used during this development period. The relevant report details are listed in the References. These can all be downloaded from the author's website at http://www.bio-met.co.uk.

Forest planning context

During this visit, emphasis has been placed on the application of the EI and ISSMI procedures within a forest management context. Several training seminars have been held on this issue, as well as continuing *ad hoc* training with key staff.

Figure 1 shows the general procedures required for management planning in Uganda's natural forest timber production reserves. The operations are cyclic, and involve three layers, each with its own periodicity. The initial process, which might be repeated at long intervals as circumstances dictate, involves mapping and zoning the forest, and undertaking an exploratory inventory at low intensity. There is then a regular period for producing and updating forest working plans; this is typically undertaken on a 10-year basis. Each 10-year plan will delineate a 10-year felling series of annual coupes. There is then an annual planning process for each coupe, typically involving stock survey and selection of trees for harvesting.

Figure 1 : Phases in forest management planning



Felling cycle and operating areas

A key issue in planning and budgeting the forest management operations is determination of the felling cycle. In earlier reports, the author has recommended a 15-year polycyclic system, using ISSMI as a control system to provide continuous forest inventory (CFI), and subdividing working forest into 4-ha blocks. These are grouped into felling units called polyblocks based on the ISSMI management inventory results. This system was recommended based on a number of key observations:

- Effective selection systems in several European forests, Australia, Costa Rica and elsewhere which have obtained international certification are based on very short polycyclic felling of 5 or 10 years.

- Short polycyclic fellings are socially acceptable and understandable for community and small-scale forestry, and can be integrated within a participatory process. Long felling cycles result in long periods when areas of forest are without any apparent activity or monitoring. This encourages encroachment and illegal use.

- Short polycyclic felling allows the infrastructure of the survey operations to be retained over cycles, reducing long-term costs and providing Continuous Forest Inventory data that greatly strengthens and improves forest management.

- Short polycyclic felling can be combined with re-stocking with valuable indigenous species to ensure proper tending and management of the re-planted areas, increasing long-term yields by a factor of four or five times whilst retaining the environmental benefits of natural forest.

- Short polycyclic felling maintains a continuous and visible presence in the forest which deters encroachment and provides a physical infrastructure to facilitate enforcement. It is therefore a very positive and practical system in terms of forest conservation.

However, this idea of a 15-year felling cycle has proved controversial, as the context is not generally understood, and it is assumed that the longer the felling cycle, the more beneficial this must be in terms of forest conservation. Osmaston (2000) provides an expert case for long felling cycles of the order of 75-90 years to be applied in Uganda, for example.

The difficult with these *pro* and *contra* arguments is that until a felling cycle has been determined and fixed institutionally, the planning process as outlined in Figure 1 remains in a state of confusion and cannot be properly budgeted, neither can the logistics of field work be organised. The felling cycle determines the areas to be covered by annual coupes and 10-year felling series. This is illustrated by Table 1 based on a 30-year cycle, which shows the relative areas to be covered by management planning operations in the Uganda, based on a total figure for natural forest in production zones of the CFRs of 130,000 ha. The formulae allow the various areas instanced in Table 1 to be adjusted depending on decisions adopted for the felling cycle and planning period. The table shows an example both for the whole forest, and for a specific reserve (Kalinzu CFR) to give an idea of the scales involved.

Table 1 : Areas to be covered by management and harvesting plans relative to felling cycle

Planning unit	Symbol	Uganda	Kalinzu CFR
Zoned for timber production, ha	A	130,000	5,500
Felling cycle, years	T	30	30
Planning period, years	p	10	10
Areas to be allocated now as felling series	A.(p/T)	43,333	1,833
Area for annual coupes and stock survey operations	A/T	4,333	183

If, instead of a 30 year cycle as in the example above, a 15-year cycle were adopted, then the areas to be covered by ISSMI would be twice as large, and the costs of annual operations would double. However the total harvest would be similar on a 15, 30, 60 or 90 year cycle, and hence operating costs are lower with longer cycles. In a plantation, there is a definite optimum rotation. In natural forest, a similar situation prevails, but analysis with growth models show the curve is much flatter, and the optimum cycle is much less important than the cost of operations (see Alder, 1999d).

However, environmental constraints do not allow the really heavy fellings that are required on long cycles. To be efficient, a 90-year felling cycles must fell about 90 m3/ha, which with consequential felling damage is a *de facto* clear felling. This is not acceptable to the environmental or conservation community, even if the areas involved are much smaller.

A similar, although slightly less strong argument prevails with a 60-year cycle: damage is so heavy that the forest structure is entirely destroyed, whilst if felling is restricted to lighter operations, there is a loss in total yield, rendering such a felling cycle sub-optimal.

With a 15-year cycle, at the other extreme, the fellings are light and can be well controlled by procedures such as ISSMI. The operation is socially and environmentally friendly. However, costs are high because of the large areas to be covered each year if full production is to be sustained.

It is therefore reasonable to propose a compromise, as has arisen in discussions within the NFA during the consultancy, of a 30-year cycle. This will work well in terms of felling intensity (of the order of 20-30 m^3/ha in well stocked stands, or around 3-4 m^2/ha in terms of basal area removed). This is not so heavy as to provoke strong environmental objections. The areas to be covered are half those of the originally proposed 15-year cycle, and hence costs per annum are halved.

The issue of the felling cycle needs to be placed at the beginning of things, and determined and agreed institutionally, so that planning can move forward. It is then possible to determine what area should be covered within each planning area by a 10-year working plan. This can demarcate the most suitable annual coupes for felling. These coupes may then be scheduled for ISSMI operations and for tendering for felling rights or other marketing procedures.

The role of this report

This report is not a polemic on any particular felling cycle or other forest management issue. It simply describes the use of improved versions of software to support natural forest planning, management and monitoring. Such systems are essential in some form or other if the forestry is to be anything other then a *laissez-faire* charter for unsustainable logging. There must be methods of inventory and mapping, and there must be growth models for evaluating sustainable yield. In natural tropical forests, it is also essential to have stock survey methods for harvest tree selection and harvesting control. The EI and ISSMI suites described here provide these systems, and are now well-developed in their practical aspects in Uganda. The author believes that the structured data management involved will also lead into systems of Continuous Forest Inventory. These will in the medium term inevitably greatly improve the quality of forest management, and lay to rest much of the quite justifiable concern that exists about the sustainable management of natural tropical forests for timber production.

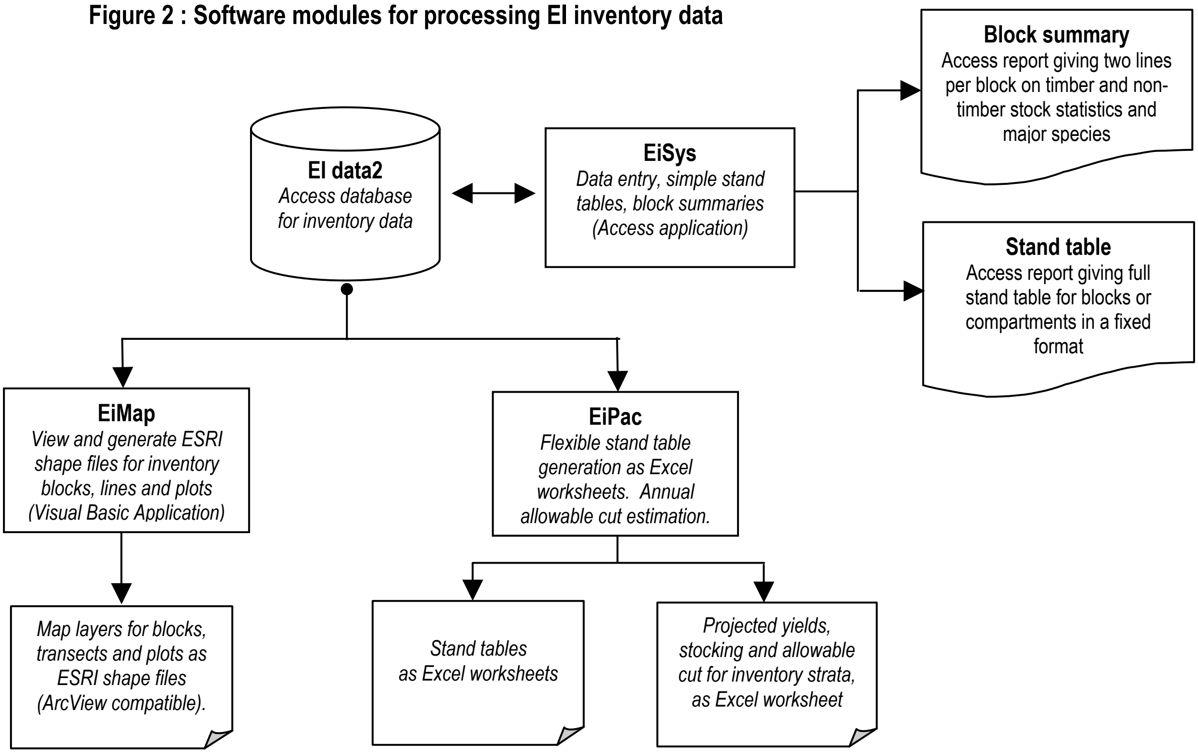
Using the EI forest inventory and modelling software

Overview

The EI (Exploratory Inventory) software consists of three modules, *EiSys*, *EiPac*, and *EiMap*, which between them handle data entry, various formats of stand tables, projections of allowable cut and mapping of inventory blocks, transects and plots.

These software were largely developed during earlier visits by the consultant, and have been previously documented in relevant reports (Alder, 2000, 2002b). Figure 2 shows their different functions and outputs in diagrammatic form. A central Access database, currently called EI DATA2, holds the inventory data and related species lists and other linked files. This database does not include any program codes, forms or reports, and should be located on a central server, so that all users are working on the same data.

Figure 2 : Software modules for processing EI inventory data



The application EISYS manages data entry and editing to this database, and also provides two formats of quick report. These are stratum summaries (blocks or compartments) which in one or two pages summarise the results from an inventory, and stand tables, which are more extensive printouts giving a detailed species list and diameter class breakdown for each stratum. *EiSys* is an Access (.mdb) file. It contains forms, reports and queries and program code (Visual Basic), and links to the *EI Data2* database. *EiSys* should normally be installed on each local workstation where it is required, as operational problems can occur if it is run from a central server by more than one user at a time.

EIMAP is a program that can be used to visualise the progress of an inventory, check geographical coordinates of plots for correctness, and also generates shape files (GIS files compatible with ESRI ArcView and many other mapping packages). The *EiMap* maps can also be copied and pasted to common programs such as MS Word and MS PowerPoint as graphics files for documentation and presentation purposes. Given an underlying map layer of forest boundaries (compartment or zone map), *EiMap* can also generate a random grid of blocks and transects to help in preparing new inventory projects. *EiMap* is written in Visual Basic linked to the ESRI MapObjects library of GIS procedures, and is compiled as a file called *EiMap.exe*, which must be properly installed on each workstation where it is to be run. It will not run from a central server without this local installation process.

EiPac is an adaptation and development of an older program called GEMFORM (see Alder, 2001). It is designed to be a general purpose tool for processing inventories of natural forests with many species to give stand tables and projections of annual allowable cut. It allows considerable flexibility in stand table layouts. It is written in Visual basic within Excel, and is installed simply as an Excel file, *EiPac.xls*. Its outputs are generated as separate Excel workbooks with stand tables of projections of future yields. *EiPac* can read inventory databases in many different formats, but for the purposes of this report, the documentation focuses upon its use with the EI database of.

Modifications made during this consultancy

During this visit a number of improvements and extensions have been made to the three EI programs, and also small changes to the structure of the original EI database, *EI Data2*. These are summarised in Table 2 below.

Table 2 : Improvements and modifications made to EI software

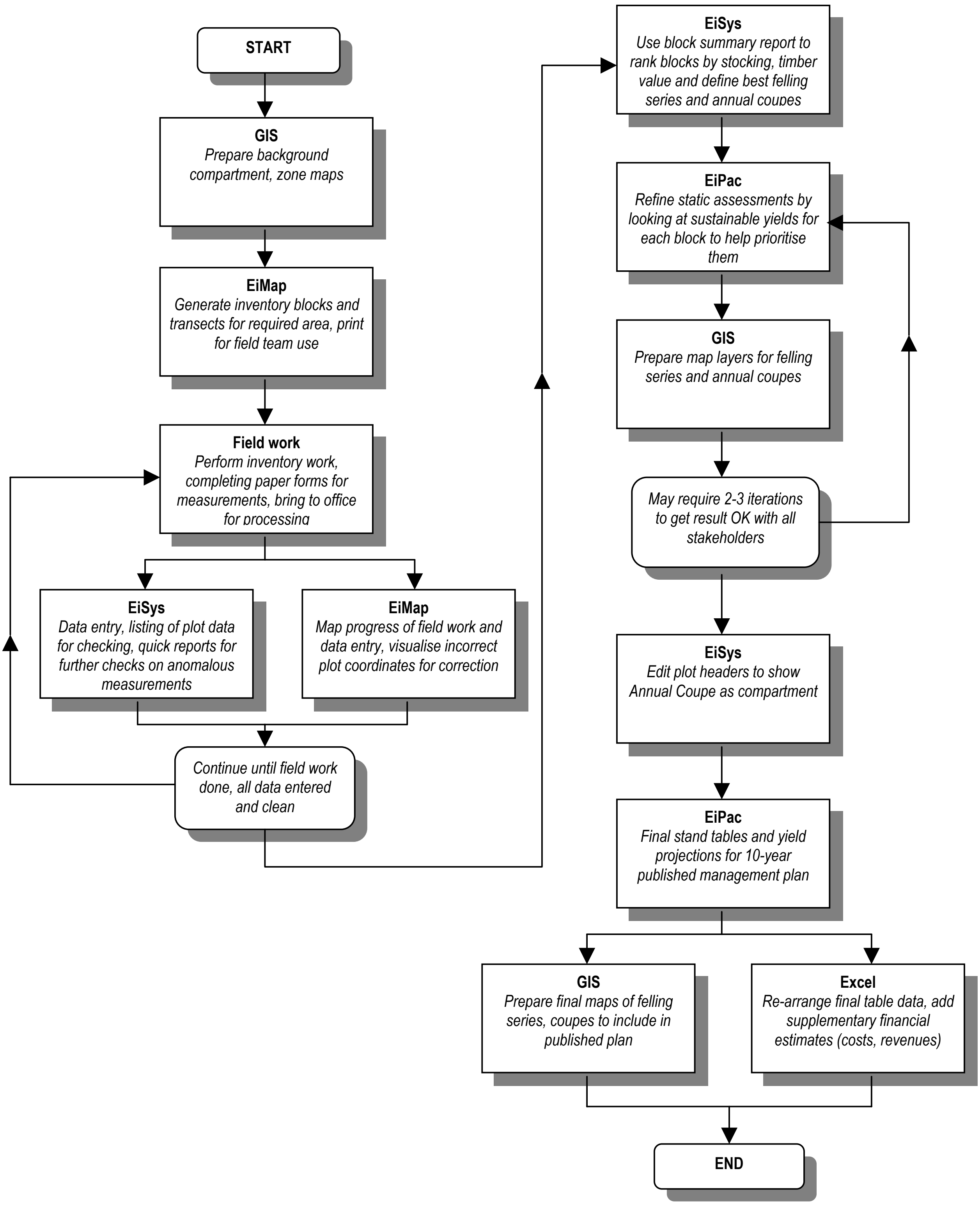
EI data2	Database holding forest inventory data	► *Species list cleaned up* ► *Reserve field renamed as Forest* ► *Growth model parameters table added* ► *Growth models and diameter limits added to species list*
EiSys	Data entry program	► *Better and more obvious linking to database to avoid installation and configuration problems* ► *Common Dialog replaced by Win API for better Windows 2000, Windows XP compatibility* ► *Quick reports added for stratum (block or compartment) summaries and stand tables for compartments.*
EiMap	Map generator for blocks, transects and plots	► *Facility to generate random transects for new inventory areas added*
EiPac	Flexible inventory and stand table program with growth model for allowable cut estimation	► *Simplified selection of data subset by forest added.* ► *Corrected calculation error for total of several stratum stand tables* ► *Growth model calibrated with provisional Uganda models* ► *Growth model adapted for multiple diameter limits*

Sequence of activities using EI programs

Figure 3 shows the logical sequence of activities envisaged when using the various EI programs.

Initially, as part of the forest inventory planning process, *EiMap* can be used to generate random blocks and transects. These can be copied directly to Word documents using cut-and-paste to provide field instructions. The generated block and transect map layers can also be processed by GIS software to produce higher-quality and larger size maps for management of the inventory operations, but this is probably optional: Small A4-sized maps in Word may suffice for control.

Figure 3 : Sequence of activities using EI software for management planning



As the field work is undertaken, data forms are returned to the office and entered on the database using *EiSys*. During this process, the quick report facilities in *EiSys*, and the mapping of plots by *EiMap* should be run periodically and used to detect data errors, which should be cleaned up as the data is being captured and processed.

On completion of the inventory, there are several outputs which are used to assist the planning process.

Initially the block summary report is run to give stockings by blocks. The objective is to identify optimum areas to be demarcated as a 10-year felling series. Various considerations will come into play at this point, some of them social or related to conservation issues. However, in terms of timber management, the inventory blocks with the highest commercial stocking will be those which should be prioritised for inclusion in the felling series.

Table 1 shows the area requirements for the felling series, which depend on the felling cycle, and the planning period. If the forest area is 5,000 ha, the felling cycle 30 years, and the plan period 10 years, then 5,000 x10/30 ha, or 1,666 ha is required. This needs to be subdivided into at least 10 annual coupes. If operations are to be divided into two main areas within the reserves, 20 annual coupes might be required.

At this stage, the coupes need to be mapped as sub-compartments. The *EiSys* program, combined with *EiMap*, should then be used to adjust the compartment number of each plot to its correct sub-compartment.

It is then possible to proceed with modelling and estimation of allowable cuts and yields. Stand tables and sub-compartment summaries can be produced using *EiSys* (for simple tables and printed reports) and *EiPac* (for more flexible stand tables and easy conversion to Excel). Allowable cut estimation can be done for each annual coupe using the growth model option to give an idea of average volume yields that sustainably can be taken from each coupe, and the equivalent in numbers of harvest trees per ha, to be used as a specification for ISSMI for the first year's coupe.

From this process, coupes can be ranked from those with the highest to lowest allowable cut. This should generally be the sequence in which they are cut. However, various other practical considerations also come into play, such as the way infrastructure may be developed, which may influence the sequence of operating the coupes.

However, the outcome, based on this data, should be a series of coupes within the 10-year felling series, to be operated in year 1, year 2 etc. through to year 10.

The yield from a given compartment when it is harvested in year 1 is not the same as if it is harvested in year 10. To give more accurate yields when the first felling is 2 or more years after the year of inventory, the *year of initial harvest* can be set in the EiPac growth model. This allows the effect of the accrued growth to be seen over 2, 3, 4 years etc., and provides more accurate data for the management plan tables.

The output from this process should be a 10-year management plan, which in addition to the usual descriptive information about the forest, includes the following:

- General map for the forest, with the delineated felling series and annual coupes within it.
- Stand tables for the main timber species within each coupe, and estimated yield at harvest.
- Estimates of sustainable yield in terms of m3/ha and equivalent numbers of trees to be felled, to be used as the basis for detailed within-coupe planning using ISSMI.

Installation of EI software

It is best to install both ISSMI and the EI software packages as a single operation. Step-by-step instructions for installation are given in Appendix B. During this consultancy, the EI software was successfully installed on three computers in the Technical Services Section (all Windows 2000), one in the Forest Management office (Windows XP) and for one consultant (Windows XP configured in Norwegian). Problems arising during this process were dealt with and the resulting experience is summarised in the decision tree in Appendix B.

EI database structure

The EI database, called EI DATA2.MDB is an Access 2000 database which is central to the operation of all the EI programs. They all read data from it, and *EiSys* also adds data and allows it to be edited. Some of the tables, notably *Species* and *Models*, need to be edited to set up various possible forest management scenarios. Changes to table names, field names. Indices or linkages may well render one or more of the functions in the various EI programs inoperable as documented here. However *EiMap* and *EiPac* are inherently very flexible, and can be re-configured to process different datasets if required.

Figure 4 : Tables and relationships in the EI database

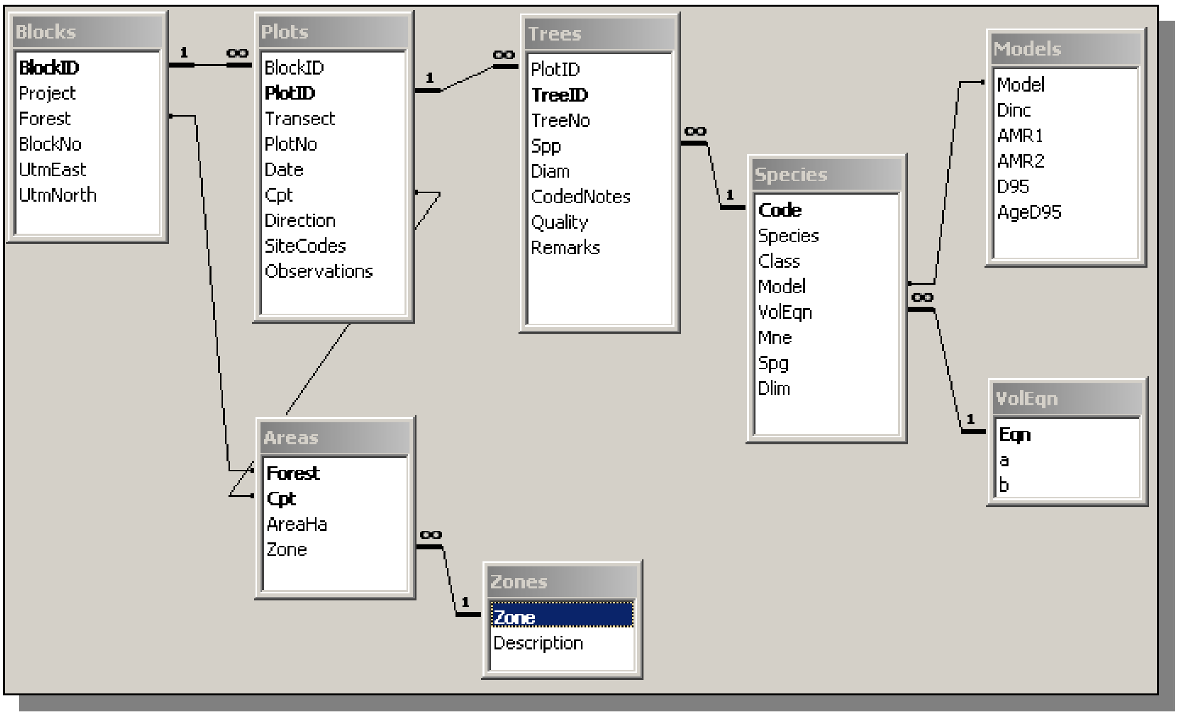


Table 4 overleaf gives a data dictionary for the EI database. This simply explains the various field names in each table, their data type, and what they are for.

When data is added to any of the tables, it must respect the one-to-many (1-∞) links shown above. Records cannot be added to the table on the 'many' side of a relationship unless there is a corresponding entry on the 'one' side. For example, tree data cannot be added unless each *PlotID* has a corresponding *PlotID* entry in the *Plots* table. The *EiSys* data entry form manages this automatically, but if data has to be added manually, it must be done in the correct sequence, with any required records added to the 'one' side of a related table first.

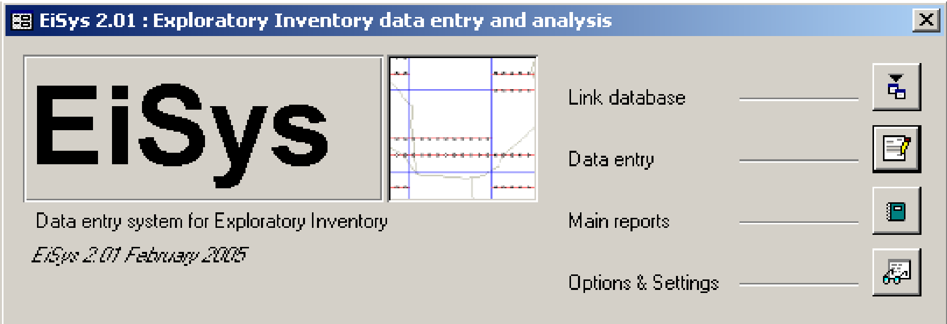
Table 4 : Dictionary of field names in the EI database

Table	Field	Type	Description
Areas	Forest	TEXT	*Name of forest reserve*
	Cpt	TEXT	*Compartment number (may include letters)*
	AreaHa	DOUBLE	*Area in ha*
	Zone	LONG	*Numeric code for zone (eg. Production), links to Zones table*
Blocks	BlockID	LONG	*Unique internal number identifying inventory black*
	Project	TEXT	*Name used to link several reserves if a single planning unit*
	Forest	TEXT	*Name of forest reserve (used to link to Areas table)*
	BlockNo	LONG	*Inventory block number (should be unique within a forest reserve)*
	UtmEast	LONG	*UTM Easting of SW corner of inventory block, metres*
	UtmNorth	LONG	*UTM Northing of SW corner of inventory block, metres*
Plots	BlockID	LONG	*Internal inventory block ID, links to Blocks table*
	PlotID	LONG	*Internal unique plot identification code*
	Transect	BYTE	*Transect number within block*
	PlotNo	BYTE	*Plot number, unique within transect*
	Date	DATE/TIME	*Date of measurement*
	Cpt	TEXT	*Compartment within which plot falls (this may be edited)*
	Direction	TEXT	*Direction of measurement of transect lines, E-W or W-E*
	SiteCodes	TEXT	*A string of 2-letter site codes, separated by commas*
	Observations	MEMO	*Any observations or comments made by the measurement team etc.*
Trees	PlotID	LONG	*The unique internal plot identification code, links to Plots table*
	TreeID	LONG	*A unique internal tree identification code*
	TreeNo	INTEGER	*The tree number, as recorded on inventory form*
	Spp	INTEGER	*Species code, links to Code in the Species table*
	Diam	DOUBLE	*Tree diameter at 1.3 m or above buttress, in cm*
	CodedNotes	TEXT	*A string of 2-letter coded notes, separated by commas*
	Quality	INTEGER	*Stem quality score from 1 (worst) to 5 (best)*
	Remarks	MEMO	*Any observations or comments made by the measurement team etc*
Species	Code	INTEGER	*The species code, must be unique within this table*
	Species	TEXT	*Latin name of the species*
	Class	LONG	*1 for commercial timber trees, 2 otherwise*
	Model	TEXT	*A code for the applicable growth model, links to the Models table*
	VolEqn	TEXT	*A code for the applicable volume equation, links to VolEqn table*
	Mne	TEXT	*A three-letter mnemonic for the species used in reports and maps*
	Spg	LONG	*A numeric species group, matching ISSMI SpeciesGroups table*
	Dlim	LONG	*Harvesting minimum diameter limit, used by EiPac growth model*
Models	Model	TEXT	*Growth model code, must be unique, links to Species table*
	Dinc	DOUBLE	*Average diameter increment, cm/yr*
	AMR1	DOUBLE	*Annual mortality rate, healthy trees*
	AMR2	DOUBLE	*Annual mortality rate, damaged/diseased trees*
	D95	DOUBLE	*Diameter below which 95% of species population falls*
	AgeD95	DOUBLE	*Age equivalent to D95 diameter*
VolEqn	Eqn	TEXT	*Volume equation code (must be a letter A-Z), links to Species table*
	a	DOUBLE	α *coefficient*
	b	DOUBLE	β *coefficient*
Zones	Zone	LONG	*Code number for a zone, links to Areas table*
	Description	TEXT	*Description of the zone (eg Production, Buffer, etc.)*

EiSys user's guide

EiSys is an MS Access 2000 file (called *EiSys.mdb*) which is easy to install simply by copying to the local computer (see Appendix B) but must be correctly linked to the EI database before its functions will work. When the program is started (by clicking on it from the Windows Explorer, for example), the screen shown in Figure 5 will appear.

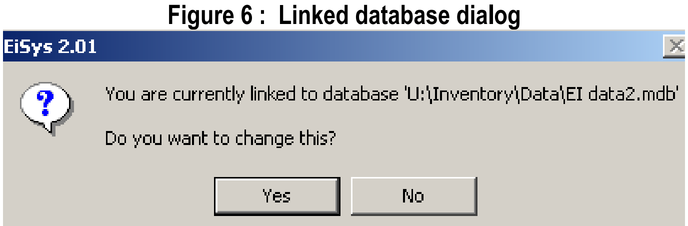
Figure 5 : EiSys start-up screen



Linking databases

Clicking the *Link Database* on the above screen button will bring up the dialog box as shown in Figure 6. This shows the location and name of the linked database. If it is correct, then click no. If you want to change the linked database, Click yes. A standard file open dialog will come up which can be used to find the database to be linked. Under the present configuration, it should be called *EI data2*, and will be resident on the NFA server.

Figure 6 : Linked database dialog



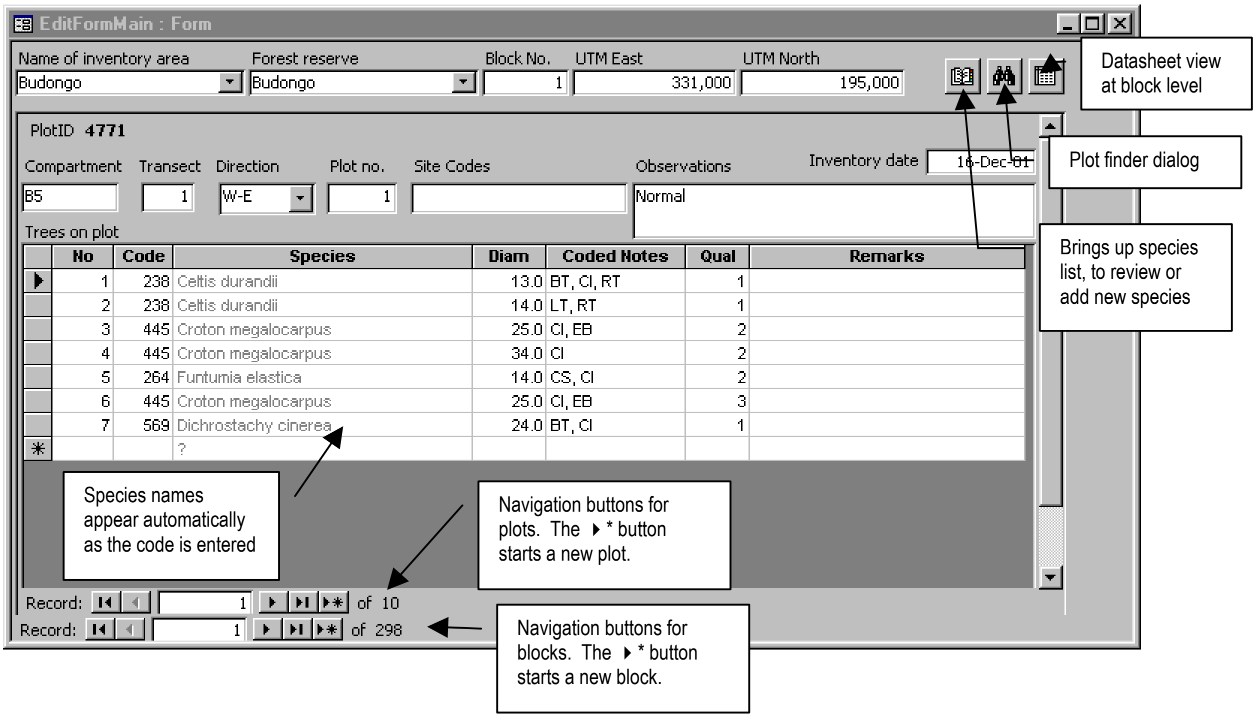
It is strongly recommended that all work that involves data entry or editing or production of management plans is done on a central master database. This will avoid confusion with partial data sets, different data versions, etc. However, demonstrations or training can be done on local copies of the master database.

The database needs to be linked only once, when EiSys is first installed on a workstation. This does not need to be repeated each time the program is started. However, no harm is done if the database is re-linked superfluously – it does not change any settings or result in any loss or change of data.

Data entry

Clicking the *data entry* button from the *EiSys* startup screen (see figure 5) brings up the main data entry form, which is shown in Figure 7 overleaf. The annotations on this diagram show how new inventory block or new plot data may be started. When editing existing data, the navigation buttons can be used to move between consecutive blocks or plots. The *Plot Finder* button brings up a dialog that can be used to locate an existing forest-block-plot entry for editing. Species names are filled in automatically as soon as the species code is entered. A new species code cannot be entered directly in the form, but must be first added to the species, which can be viewed and edited in table format by pressing the *Species list* button. This brings up the species list table and allows new records to be added or existing information to be amended.

Figure 7 : Data entry screen for EiSys



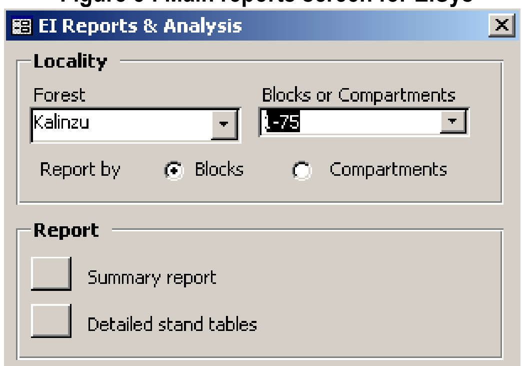
It is very important that all data entry is done on a central database located on the NFA Server, and not to a local copy of the database. When setting up a workstation for data entry, ensure that the *Link database* option has been used to do this. It is very difficult to merge datasets which have been entered on two different databases by mistake.

Main reports

The main reports button on the startup screen (see Figure 5) will bring up the dialog form shown at the right. This allows selection of one of two possible reports, the *Summary report*, or *Detailed stand tables.*

The *Forest* box has a list of forests in the EI database. One of these must be selected: An error message occurs if either of the report buttons is pressed with no forest selection.

Figure 8 : Main reports screen for EiSys



The reports can be stratified either by inventory blocks (the default) or compartment ID. When the *Report by* option is Blocks, then the drop-down labelled *Blocks or Compartments* will contain a single number range, which is the range of block numbers occurring in that forest. In the example above, it is 1-75. This can be replaced by typing in any list of block numbers, using formats such as:

1-10, 12, 13, 18-23
1-20, 40-55
3,7,9

When the option is Compartments, *number ranges such as those shown above cannot be used*. This is because the Compartment ID is treated as characters, even when it may appear to be purely numeric.

Instead, to allow the selection of groups of compartments, wildcard characters * and ? can be used. * represents any sequence of characters, and ? any single character. The following examples illustrate some possible valid entries

N*	*any compartments beginning with N*
N?	*compartments N1-N9, but not N10 etc. (must be a single character after the N)*
1*	a*llows, 1, 1a, 10, 101 etc but not 2, 2a etc.*
1?	*allows 10, 11, 19, 1a, 1b but not 1 or 100 (must be 2 characters, starting with 1)*
*	*all compartments within that forest (any characters)*

The present version does not allow compartment combinations to be listed, such as 'N*, B*' to pick all compartments starting with N or B, for example.

The Summary Report

The summary report takes the format shown in Figure 9 overleaf. This is an example of the report output exactly as saved to MS Word. There are three lines for each block or compartment. The first line summarises data for all timber species, and the second for all non-timber species. The decision as to which category a species is in depends on the setting in the *Class* field of the *Species* table, as described in Table 4. The third line is the total for all species.

Stem numbers per ha are given by fixed diameter classes for each class of species. These can be used to decide if regeneration is adequate, or if artificial regeneration (re-stocking) may be needed, and also allows 'back of the envelope' calculations of future yields. It also shows the numbers of trees likely to be harvestable above diameter limits of 40 or 50 cm, although it should be noted that this table gives no stem quality information.

Total bole volumes are given for all size classes, as gross and net figures, as is basal area. The net volume is adjusted for stem quality (see the definition of net volume on page 37). Typically, to enter a compartment or block for harvesting, the total basal area should be in excess of 27 m2/ha (see Osmaston, 2000). When grouping blocks and compartments into felling series and coupes, the basal area and net timber volume can be used to rank blocks for the timing of felling. Those with highest net volumes and basal areas in excess of 27 m^2/ha should be felled first, and those with the lowest basal areas felled later in the planning period. Over a 10-year planning period, basal area will not develop by more than 5 m^2/ha, so any blocks with basal areas below 22 m^2/ha should be excluded from a current 10-year felling series.

The report also lists the five most common timber and non-timber species, with the percentage of basal area they account for. The percentage of basal area accounted for by all other species is shown by the notation ~*(12%)* [12% of basal area as unlisted species]. The species are identified by a 3-letter mnemonic, if given in the species list, or otherwise by their code number. The Mne field of the Species table can be edited to add or modify species mnemonics (see Table 4). This information is useful in planning marketing strategies, by indicating the common timber species that will make up the bulk of the volume. The common species also indicate the forest type, and will therefore imply certain possibilities for forest management and requirements for stand improvement measures, protection, regeneration.

Figure 9 : Example of the EiSys Summary report

Forest inventory summary

Kalinzu Forest Cpts 2?

Based on 310 plots sampled around Aug 2001

Compartment	Class of spp.	Tree numbers per ha by diameter class 10-19	20-29	30-39	40-49	50-69	70-89	90+	Management indicators Volume (m3/ha) Bole	Net	Basal area m2/ha	No. plots	Most common species with % BA,
21	Timber	93	80	20	7	13	3	-	85.3	36.4	14.7		206(30%), Fua(23%), Ced(13%), Crm(8%), Nbm(5%) ~(21%)
	Other	120	3	7	-	10	7	-	53.8	22.9	9.1		404(60%), Myh(9%), Tro(5%), Spc(4%), 610(4%) ~(19%)
	Total	*213*	*83*	*27*	*7*	*23*	*10*	-	*139.2*	*59.4*	*23.8*	*6*	
24	Timber	101	66	34	10	8	5	4	138.9	85.6	19.2		Pae(30%), Fua(26%), Sae(11%), Ced(8%), 555(6%) ~(19%)
	Other	54	24	11	7	7	2	1	40.3	10.4	7.5		404(18%), Mcs(13%), 773(6%), Spc(6%), 598(4%) ~(52%)
	Total	*154*	*90*	*45*	*17*	*15*	*7*	*5*	*179.3*	*96.0*	*26.7*	*70*	
25	Timber	92	53	23	15	14	4	6	146.2	91.8	19.9		Pae(22%), Fua(17%), Ced(8%), 206(6%), Fam(6%) ~(41%)
	Other	84	23	11	10	12	3	2	74.0	24.1	12.7		404(35%), Fic(13%), 598(11%), Pna(5%), Psm(3%) ~(32%)
	Total	*176*	*76*	*34*	*25*	*25*	*7*	*8*	*220.2*	*115.9*	*32.6*	*80*	
26	Timber	72	43	21	23	15	5	7	159.1	101.6	22.0		206(23%), Pae(22%), Sae(12%), Fua(10%), Dry(8%) ~(25%)
	Other	150	51	15	11	6	-	2	60.4	19.6	12.1		598(23%), 404(22%), Tro(11%), Mgc(10%), Fic(9%) ~(25%)
	Total	*222*	*94*	*36*	*34*	*21*	*5*	*9*	*219.4*	*121.2*	*34.1*	*41*	
27	Timber	36	34	20	13	11	4	2	81.7	41.3	12.4		206(21%), Sae(18%), Pae(15%), Fua(9%), Ced(7%) ~(30%)
	Other	98	22	9	3	4	1	-	28.9	11.0	6.0		598(25%), 404(22%), Mgc(14%), Pna(6%), 773(5%) ~(29%)
	Total	*134*	*56*	*30*	*16*	*14*	*5*	*2*	*110.6*	*52.3*	*18.4*	*49*	
28	Timber	67	26	14	3	4	1	1	54.4	31.4	8.0		Pae(27%), Fua(16%), Sae(12%), 206(7%), Fam(7%) ~(31%)
	Other	76	21	9	5	-	1	-	28.1	7.2	5.7		598(19%), Pna(17%), Tro(12%), 404(12%), Mgc(7%) ~(33%)
	Total	*144*	*47*	*23*	*7*	*5*	*2*	*2*	*82.5*	*38.6*	*13.8*	*44*	

The number of inventory plots is also shown which have contributed to the data. For block summaries, this will normally be 20 plots for 1 km² designs. Incomplete blocks may indicate edges or errors in the data, and need to be checked against the map. Data based on less than 10 plots should not be considered reliable enough for decision making.

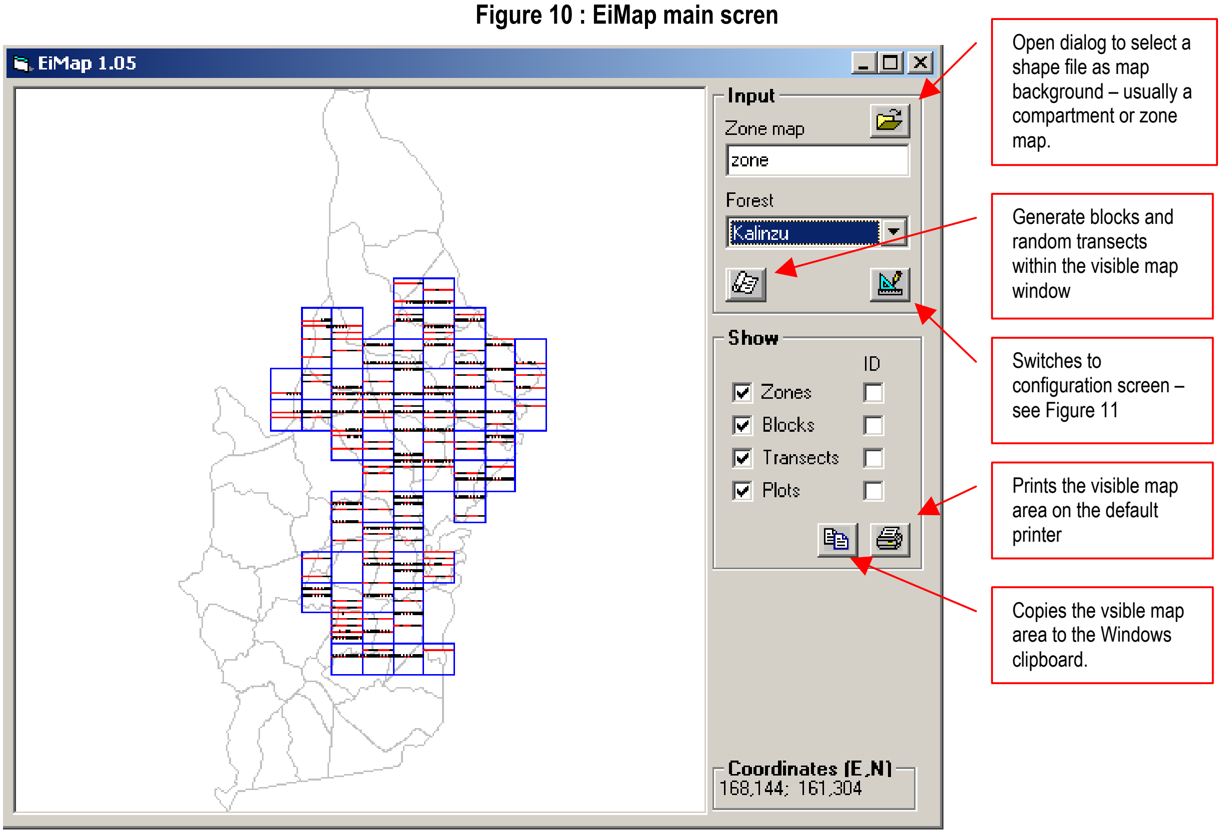
Detailed stand tables

These follow a similar layout, but include one line of data per species, with the full species name, code number and mnemonic listed. This is necessarily quite a voluminous listing, with 1-2 pages per block or compartment. Unless there is interest in the exact composition of less common species, this report is less useful than the summary listing. Its functions are also duplicated by the more flexible facilities found in EiPac which are described later. However, the EiSys stand tables can be produced very simply and quickly, whereas Eipac is quite a complicated program to set up and use.

EiMap user's guide

EiMap is a utility for displaying inventory blocks, transects and plots on background maps of a forest. During this consultancy a new facility was added to allow random transects to be generated for new inventory projects. EiMap is a Visual Basic program which uses the ESRI MapObjects library to create and display ArcView shape files. Appendix B describes how to install it.

Figure 10 : EiMap main scren



When the program starts, it will display the map screen as shown above. This will probably be blank the first time the program is used, but subsequently it will remember settings between each session, and open with the last map displayed. There are three sets of controls to the right of the map, whilst the map area itself has special functions when the mouse is moved or clicked over it.

Setting the map window

The Input frame on Figure 10 has several controls which set up the map to be displayed.

The Open button brings up a standard Windows *File open* dialog which can be used to locate a shape file of a background map for the map window. It is important to note that the output shape files generated by the program will be put in the same directory. *You must therefore have write access to this directory, or an error will occur*. It cannot, for example, be a directory on a CD, which cannot be written to.

The name of the selected file will appear in the text box labelled Zone Map. In the example in Figure 10, this is called *zone.shp*.

The drop down list labelled Forest will contain a list of all the forests in the connected EI database. Selecting one of these will result in one of two possible actions: If shape files exist for the inventory blocks, transects and plots for the forest, they will be added to the map window. If on the other hand, the relevant shape files do not exist, they will be generated from the current information in the EI database.

It is important to note that any generated shape files are not updated automatically from the data in the EI database. The must be manually deleted from the Windows Explorer before they can be recreated in updated form.

Each ArcView shape file is defined by 3 three windows files, with the extensions .shp, .shx, and .dbf. EiMap generates the following files for any selected forest:

~EI*forest*BLOCKS.SHP, .SHX, .DBF
~EI*forest*TRANS.SHP, .SHX, .DBF
~EI*forest*PLOTS.SHP, .SHX, .DBF

Here, *forest* will be substituted by the name from the pull-down, *eg*.. Kalinzu. The Block and Transect files have line topology, whilst the Plots file has polygon topology (each plot being mapped as a 12.6 m circle). The ~ is used to indicate that these files are temporary.

If the drop down list is empty, so that no forest can be found, then the program is not connected to a valid EI database. Refer to the *EiMap configuration* section below.

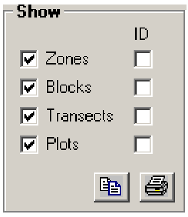
The Generate button will create shape files for blocks with randomly located transects within the visible map window. By zooming and panning the map, the area to be covered can be controlled. Each click of the button will give a different random configuration. This function will work even if there is no connected EI database. The generated shape files have the fixed names:

~GENERATEDEIBLOCKS.SHP, .SHX, .DBF
~GENERATEDEITRANSECTS.SHP, .SHX, .DBF

and will be written into the same directory as the background zone map. Once a set of blocks and transects have been generated that are suitable for work, it is recommended therefore that they are renamed to avoid overwriting them accidentally.

The Design button switches to the configuration screen, which is discussed fully in the section on *EiMap configuration*.

Displaying, copying and printing layers



In the **show** box on the Eimap screen (Figure 10) , checking the boxes Zones, Blocks etc. will turn on or off the display of the relevant map layer. the Zones layer is the background map, whatever it map represent. The Blocks are the inventory blocks, shown in blue lines. Transects are shown in red, and always run East-West. Plots are drawn as yellow circles, to the correct scale.

If the corresponding ID box is checked, then the block, transect and plot numbers will be shown.

The print button will print the currently displayed map on the default printer. It does not print any framing, scales, legend or other map decoration, and is only useful for draft maps. To print publication-quality maps, the shape files need to be processed in ArcView.

The copy button is more useful. It copies the map as a Windows metafile to the clipboard. It can then be pasted into Word, PowerPoint or drawing programs and then enhanced with explanations, text, etc for publication or presentation.

Panning and zooming the map window

The map can be zoomed and panned using the mouse buttons. Dragging with the left mouse button on the map will create a tracking rectangle. When the button is released, the window will zoom to this rectangle. Dragging with the right mouse button will pan the map. Double clicking will revert to the last zoomed window.

The **coordinates** box shows the current position of the mouse pointer in UTM coordinates (Easting, Northing). This is useful for locating a specific point, or checking distances between points (the coordinates represent metres from the origin of the local UTM zone).

The EiMap configuration screen

Clicking on the design button toggles between the normal map window, shown in Figure 10, and the configuration screen, shown in Figure 11.

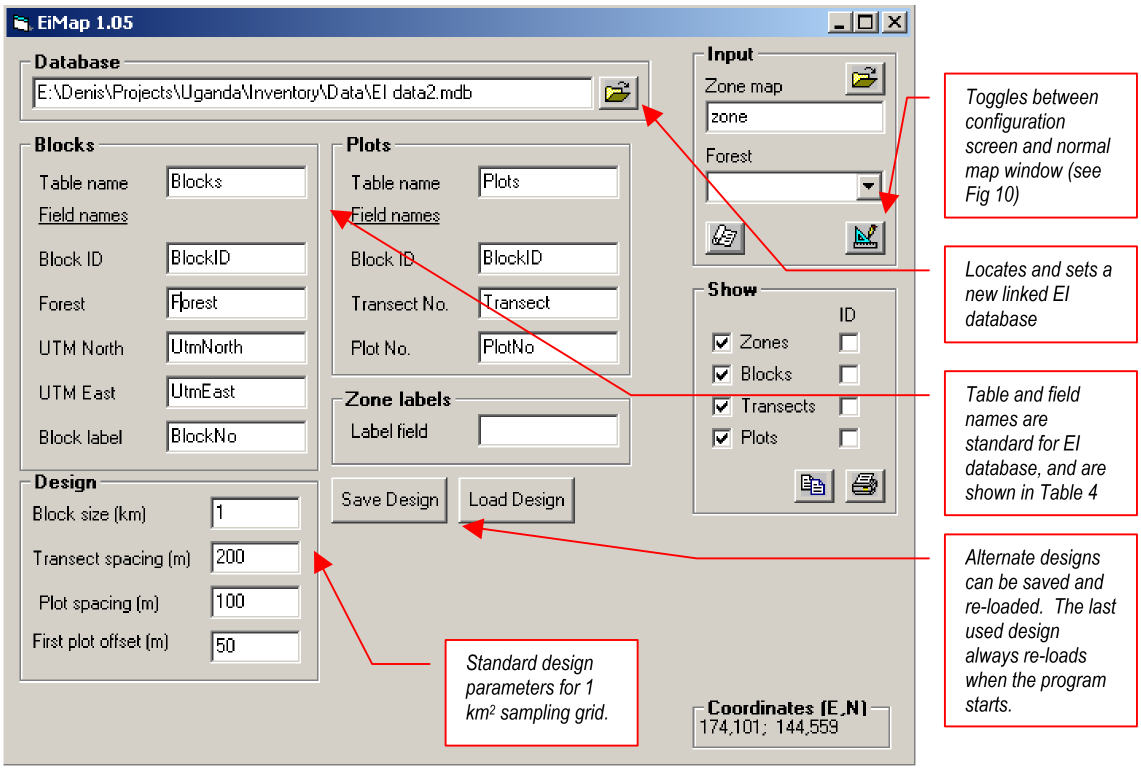
In the configuration window, *the most important function is the Database setting box at the top left of the screen*. This should show the name of the EI database that EiMap is linked to. If it does not, the file open button should be used to locate and set the correct database.

The Blocks, Plots and Design settings are standard, and do not normally need to be changed. The table and field names shown correspond to those listed in Table 4. The design is for a 1 km^2 grid with 200 m spaced transects, and 10 plots per transect, with the first plot being 50 m in form the transect start.

The design settings are always saved when the program closes in a file called EIMAP.INI. This file is located in the same directory as the EiMap program itself. This file is re-loaded on start-up.

If the configuration settings appear different than those shown in Figure 11, then Eimap will not run properly. They should be edited to show the standard settings, and saved as the default by closing the program.

Figure 11 : EiMap main screen



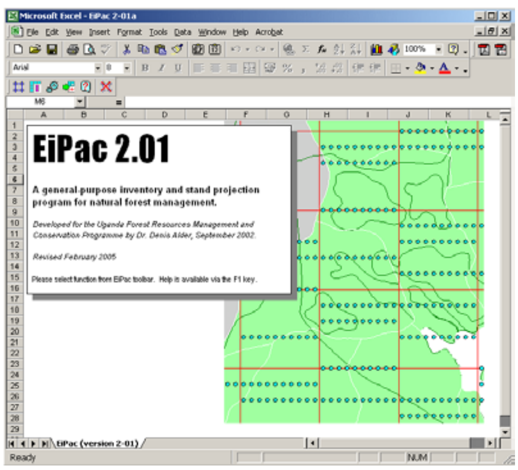
EiPac user's guide

EiPac is an Excel file (*EiPac.xls*) which contains programs for analysing many types of natural forest inventories and for the estimation of annual allowable cut. This section describes the use of the program with particular reference to the EI database and inventory design.

EiPac usage has been described in an earlier report (Alder, 2002b), but the present version (EiPac 2.01a) includes significant changes, so this user's guide has been substantially revised. Table 2 summarises the changes made. The most important of these were:

- Addition of a facility to filter the inventory dataset by forest. This eliminates the need to set up intermediate tables and files.
- The calibration and full activation of the growth model for this version.
- In addition, some corrections have been made, the most important of which is to ensure that stratum stand table data correctly adds up to the forest total stand table.

Figure 12 : Appearance of Excel screen after starting EiPac



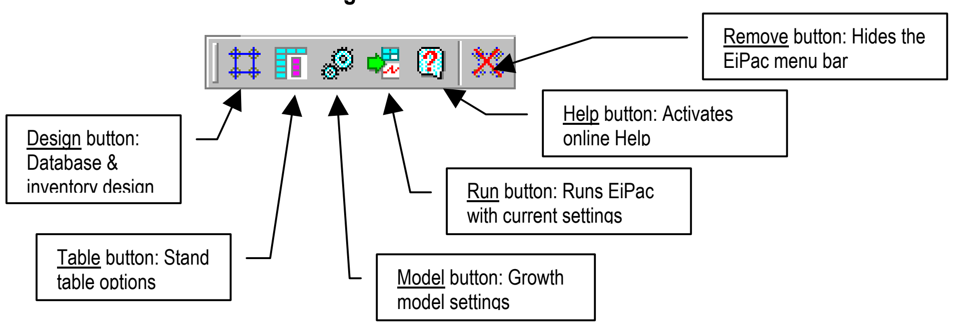
The installation procedures for EiPac are described in Appendix B.

Starting EiPac

When EiPac starts, a single worksheet will be seen as shown in Figure 12 which is designed to identify the program. Most of the operational components of the program are hidden as Visual Basic code and hidden worksheets. However, these components are not proprietary and can be easily accessed through Excel menus if changes need to be made.

While EiPac is active, a menu bar will appear in the Excel window as shown in Figure 13. This allows access to the various EiPac modules. This menu bar will disappear when EiPac is closed.

Figure 13 : The EiPac menu bar



The Design button activates a tabbed dialog that allows all aspects of the inventory design to be specified, including the database tables and field names to be used. The Table button activates a dialog to specify the columns in the stand table to be generated, how species are to be shown, sampling error rows or columns, and general layout features. The Model button specifies settings and options for the growth model. The Run button opens specified input and output files and runs the program to generate outputs. The Help button can activate online help, and the Remove button will remove the EiPac menu bar if it is not desired.

The Design, Table, Model and Run buttons are described in detail in the following sections.

Inventory design

Figure 14 shows the various settings which are required on the design form to produce stand tables stratified by compartment. These correspond to the current tables and fields shown in Table 4 and the linkages shown in Figure 4.

The Design and Table forms both save any settings entered in the fields when the form is closed. The settings are saved according to the name given on the drop down list called Design. In Fig 14 (a), for example, the settings will be saved as *'Uganda EI standard'*.

If a new name is typed in the Design text box, then the settings will be saved under that name when the form is closed.

As soon as a different design name is selected from the Design drop down list, then the settings for that design are loaded.

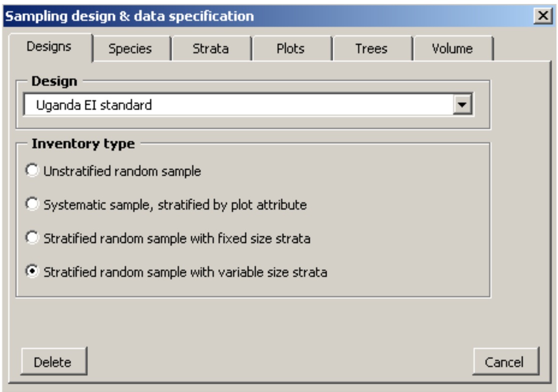
This scheme allows several different inventory designs or types of table to be remembered and recalled easily. If too many redundant names build up in the drop down list, then can be deleted by selecting them, and then clicking the Delete button.

The Cancel button will close the form without saving any changes to the settings.

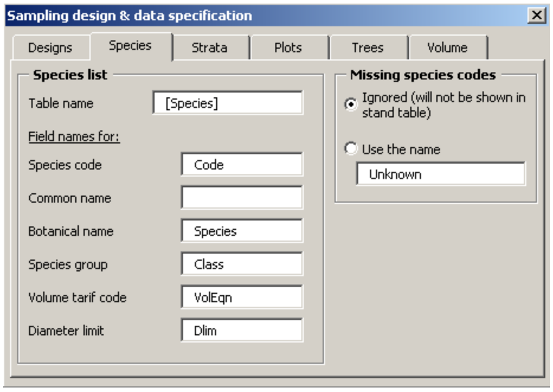
Figure 14 : Options on the Eipac Design form

For specifications for tables and fields shown below, see Table 4

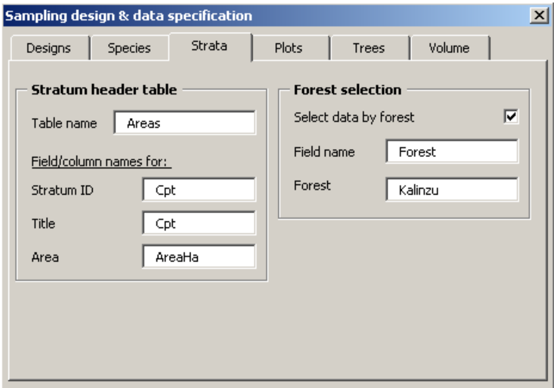
(a) For stand tables by compartment, select the fourth option shown.



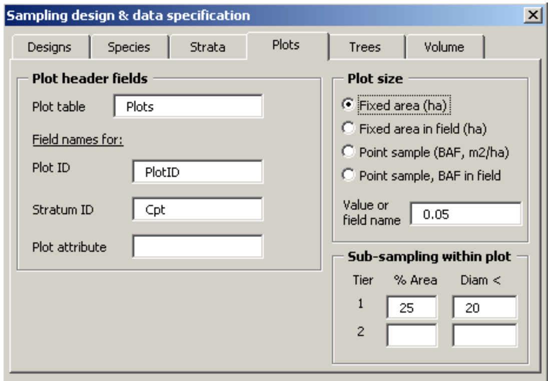
(b) Standard species list table and field names. The species group can also optionally be Spg.



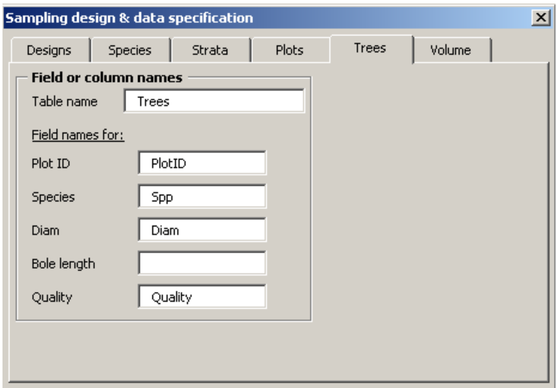
(c) The Areas table is used to stratify by compartment. The Forest field on the Areas table is used to select the forest reserve to be processed.



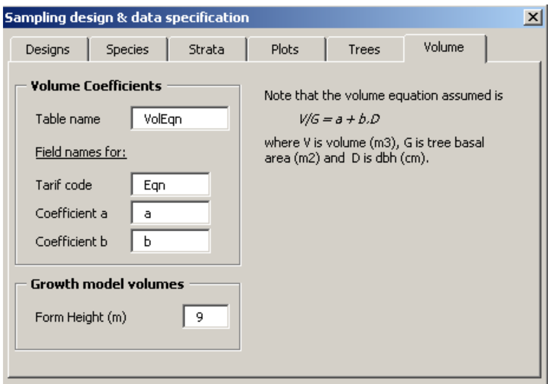
(d) The standard settings for the EI data are shown, based on 500 m2 circular plots with a 25% sub-sample for trees 10-19 cm (ie. below 20 cm).



(e) This defines individual tree data. Bole length is not recorded, only species, diameter, and stem quality. Coded notes are not processed by Eipac.



(f) EiPac in this version allows only the volume equation shown. The coefficients table links to the species list via the Eqn field.



Note that when EiPac is closed from Excel, you will normally be asked by the system if you wish to save any changes. You must reply *yes*, or otherwise any changes made to settings will be lost.

Three other types of inventory design are shown on Fig 14(a). To use these, minor amendments need to be made to the EI database. The consultant has not done these due to lack of time, but they can be done remotely if need be. These amendments are summarised below:

Unstratified random sampling	*To enable forest selection with this option, a Forest field needs to be added to the Plot table, and filled in with appropriate forest names or codes.*
Systematic random sample, stratified by plot attribute	*As above, for forest selection, plus a suitable plot attribute code. This could be derived logically from the list of site codes.*
Stratified sampling with fixed area strata	*As above.*

It also remains possible to extract subsets of plots into another database, as described in Alder (2002b, pp12-13), but this is a relatively cumbersome procedure which has to be repeated for each forest, whereas the above are consistent solutions that can be applied to all data.

Stand Table options

EiPac is designed to allow for flexible stand table outputs. The facilities which are additional to those in EiSys stand tables (see Figure 9) include:

- *variable diameter classes*
- *tabulation of quantities above a specified diameter limit (cumulative diameter classes)*
- *selection of variable to be tabulated (tree numbers, volumes, basal area)*
- *table columns based on tree quality classes*
- *sampling error and reliable minimum estimate calculation*
- *options for presentation of species and species groups*

Figure 15 shows the option tabs on the EiPac Table dialog, which comes up when the Eipac Table button is pressed, and illustrates briefly the various possibilities in table design.

As with the Design form (Fig 14), all settings made are automatically saved when the form is closed, unless it is closed with the Cancel button (see Fig15 a). They are saved against the name given in the table specification text box. A pre-existing specification can be selected by picking one of the existing names from the drop-down list, By default, the last specification used will be shown when the table is re-opened. The Delete button can be used to remove table specifications from the drop down list.

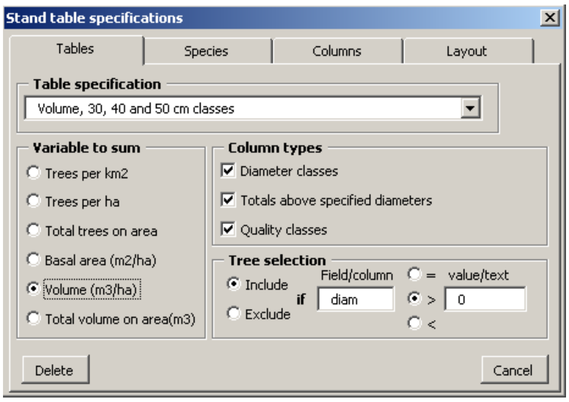
Tables can be based on stem numbers, basal area or volume, and may include simple dimater classes, cumulative classes (totals above specified diameters) and quality classes. It is also possible to filter the data to complete exclude specified trees (for example, quality classes below 3 from a volume summary).

Rows in the table can be sorted alphabetically by species name, by species code, or in descending or ascending order of abundance, which may be specified as total stem numbers or total basal area of the species. Sub-totals can be produced for species groups. These sub-totals can be followed by a row giving sampling errors and reliable minimum estimates (RME) for each sub-total if desired. The order of species groups can be alphanumeric (alphabetic or numeric ascending order) or it may be as per a defined list.

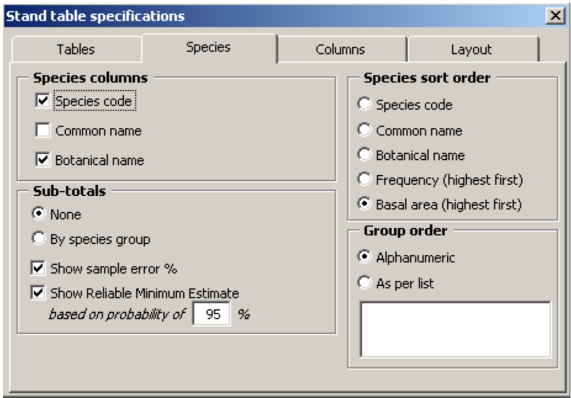
Figure 15 : Options on the Eipac Table form

For specifications for database tables and fields shown below, see Table 4

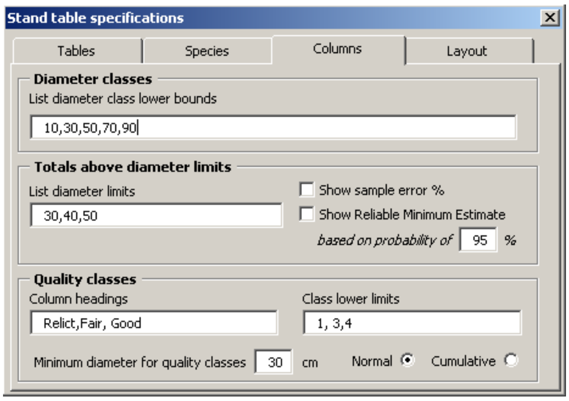
(a) The Tables tab defines the general features of the table. Table specification allows a named specification to be created, saved, and recalled. Variable to sum defines the basic variable shown in the table. Column types switches on or off the display columns without the need to delete their specifications on the Columns tab. Tree selection allows a variable in the Trees table (see Fig 14e) to be used to filter data.



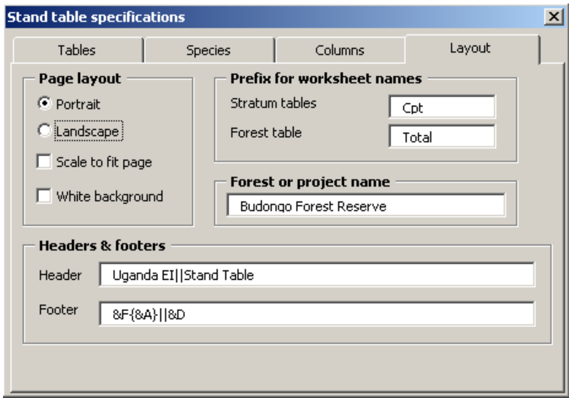
(b) The Species tab controls appearance of the table by rows (species). Species columns indicates which species names and codes should appear. Species sort order determines the order of rows within species groups. Sub-totals controls appearance of a sub-total row for species groups, with an optional sampling error and/or RME row below. Group order allows species groups to appear in any given order.



(c) The Columns tab gives details of classes and limits used for columns. Diameter classes specifies a list of conventional diameter class lower bounds. Totals above diameter limits lists the lower bounds for cumulative diameter classes. These may have an optional error column for sampling error or RME. Quality classes defines headings and lower class limits for quality class columns, together with the minimum diameter for trees to be included.



(d) The Layout tab controls formatting features. Page layout sets page orientation, scaling and turns off the background colours. Prefix for worksheet names controls the tab names used in Excel for each table. The Forest or project name appears as part of the heading text on each table. Headers and footers use standard Excel codes to control printed headers and footers.



The tables can include various types of column. These are switched on or off by the Column types options (see Fig 15 a), and specified in more detail on the Columns tab of the Tables form (see Fig 15 c).

Table output is always to an Excel workbook, but they are formatted for immediate printing. Various settings on the Layout tab improve the documentation of the generated worksheets and their printed appearance.

Growth modelling options

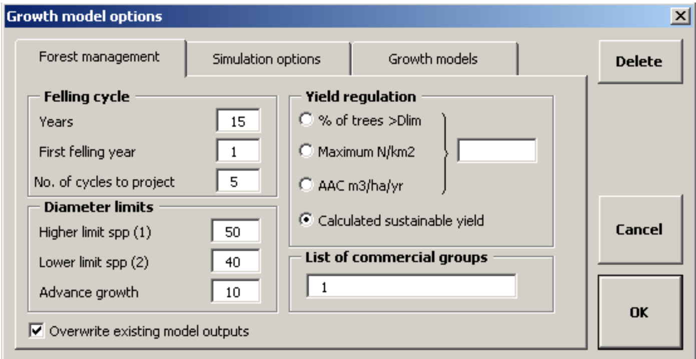
The Model button of the EiPac toolbar (see Fig 13) brings up a dialog form with various option tabs, as shown in Figure 16. These combine with information in the Models and Species tables of the EI database (see Table 4) to control how stand projections are done to estimate future yields and sustainable levels of harvesting.

For running what-if simulations, the user will normally only vary the settings on the *Forest management* tab. The *Simulation options* tab is set with calibration and setting up of the model and should not be modified by the average user. The *Growth models* tab identifies the location and structure of the data table with the model parameters used. In the present context, this will be the *Models* table in the EI inventory database, as shown in Table 4. The *Source file* may however changed depending on how EiPac is installed. Please refer to Appendix B for the installation procedure.

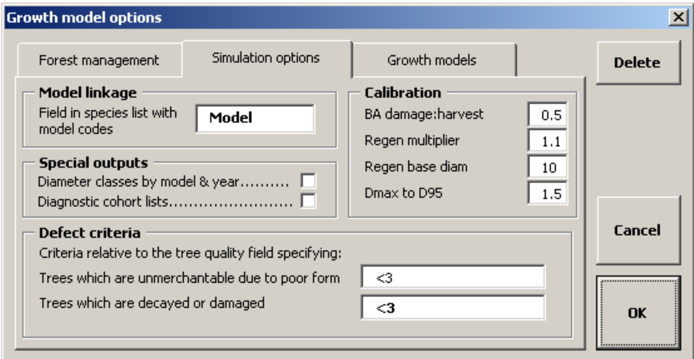
Figure 16 : EiPac growth model settings

For specifications for database tables and fields shown below, see Table 4

(a) The Forest Management tab controls features of the model that normally may be varied in what-if simulations. The Felling Cycle options set the length of the felling cycle, and the year of first felling relative to the inventory date. The number of cycles projected will effect the calculated maximum sustainable yield. The Diameter Limits are used to set minimum felling diameters for 2 categories of species (see Dlim in Table 4). Yield regulation sets how felling is regulated in addition to diameter limit. By setting % of trees to 100%, everything commercial is felled. Calculated sustained yield gives equal yields for each projected cycle. List of commercial groups list codes in the field given on the Species Group field (see Table 14, top right box).

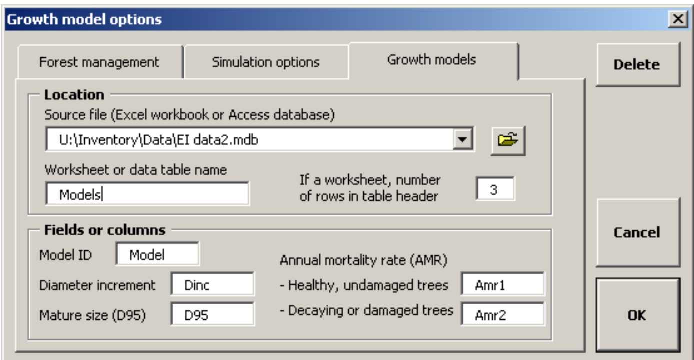


(b) The Simulation options tab gives some settings which are not normally adjusted by the user. The Model linkage depends on the database structure (see Table 4). Calibration settings are discussed on pages 39-42. Special outputs are for testing and explaining the operation of the model, and should normally be turned off. Defect criteria depends on the inventory measurement technique and standards. Currently quality classes below 3 are likely to be too defective to use, and associated with significant tree health problems.



(c) The Growth models settings are defined by the location of and layout of the growth models. When EiPac is installed on a local workstation, the file open button must be used to set the correct source file, which will be the EI database. The other settings should be left as shown, and correspond to fields in the Models table as listed in table 4.

Please note that the source file setting shown here is not correct for the NFA system. Please refer to Appendix B for installation advice.



In Figure 16(a), the *Felling Cycle* box contains three factors which may be set by the user. *Years* gives the length of the felling cycle. *First felling year* is the year from the start of the simulation when the first felling will be done. *No. of cycles to project* controls the length of the simulation, in felling cycles.

The *Diameter limits* options allow two different diameter limits to be set, for different groups of species. Table 4 shows a *Dlim* field in the *Species* list. This should contain values 1 or 2, referring to the *Higher* or *Lower* diameter limits in the EiPac growth model.

The *Yield regulation* box provides four alternative options for controlling felling in Eipac simulations, in addition to the minimum felling diameter and the felling cycle. The *% of trees > Dlim* option will define what percentage of mature trees (*ie.* above the minimum diameter limit for that species) are felled, by stem numbers. A setting of 100% will fell all trees, whilst 50% would retain half the mature trees for the next cycle. *Maximum N/km*^{2} limits the maximum number of stems to felled. For example, 600 would limit felling to 600 matures trees per km^2, or 6 trees per ha. *AAC m*^{3}*/ha/yr* sets an annual allowable cut in terms of volume. For example, 1 would limit felling to 1 m^3/ha/yr, or on a 25 year felling cycle, for example, to 25 m^3/ha for each felling. *Calculated sustainable yield* means the model will search for the highest volume yield that can be maintained as constant across the number of felling cycles being projected.

List of commercial groups links to the species group field that is specified on the EiPac *Designs* form (see Figure 14). The *Species* tab of that form specifies a field that defines the species groups (*Class* in the example). Values within that field that match the list of commercial groups given here will be considered commercial, and will be included for felling. In the present context, the *Class* field of the *Species* table in the database should contain either a 1 (commercial) or 2 (non-commercial).

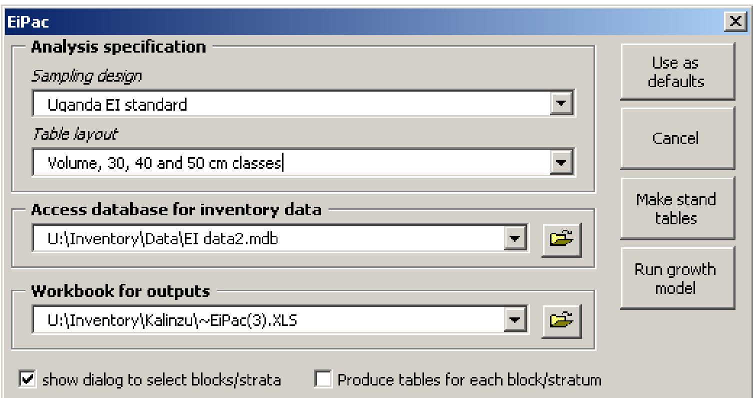
The checkbox *Overwrite existing model outputs* will mean that each time the model runs, it writes results to the same worksheet, called *Yield forecast*. If this is left clear, then a new worksheet will be created with a higher sequential number, *eg.*. *Yield forecast 2*, *Yield forecast 3*, *etc.*

The underlying logic of the modelling process and the local calibration that has been made for Uganda's natural forests during this consultancy are described further in the chapter [Modelling and Forest Management Issues](#) (p 39). This also includes a number of practical examples varying the above options to illustrate various different outcomes.

<u>Running EiPac</u>

When the <u>Run</u> button is clicked on the EiPac toolbar (see Fig 13), the dialog box shown in Figure 17 will appear.

Figure 17 : The Run dialog for EiPac



The <u>sampling design</u> drop down will show by default the last sampling design viewed or edited (See Fig 14). However, an alternative can be selected if appropriate. In the context of the Uganda EI, *the most important point to note here is that forest reserve selection is set on the Strata tab (Fig 14 c) of the design form*. Therefore, to get output relating to a particular reserve, it is important to be sure that the sampling design displayed in the box on the run form has the correct forest reserve specification.

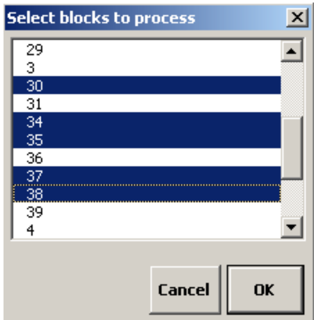
The Table layout will again by default be the last table setting viewed or edited (See Fig 15). An alternative table setting can be selected from the drop down if appropriate. This is only applicable for stand tables, and has no effect on the growth model.

The Access database for inventory data should be set once during installation process, as described in Appendix B, and need not be altered thereafter. It should refer to the current EI database on the NFA server, or a local copy that is valid and up-to-date for the work being done.

The workbook for outputs can be left blank, in which case a default Excel file called *~EiPac(n).xls* (where n is a number set to give a new file) will be created in the default directory (usually *My documents*), or a filename can be located with the file name button or selected from the drop down list (recently used files).

The Use as defaults button will save the currently displayed drop down settings so that they appear as defaults the next time the Run dialog box is opened. It is recommended this is done when setting up EiPac during installation (see appendix B).

Fig 18 : Stratum selection popup



The Cancel button closes the dialog box without saving any changes that have been made.

If the checkbox *Show dialog to select blocks/strata* is ticked, then the dialog form shown in Figure 18 will appear. This allows one or more compartments to be selected for stand tables or growth modelling. If the box is not ticked, the selection dialog does not appear, and all compartments in the forest will be processed.

The checkbox *Produce tables for each block/stratum* is applicable only to the make stand tables operation. It has no effect on the growth model outputs. When it is checked, a separate table will be created for each compartment, as well as a final forest summary table. If it is clear, then only a single forest summary table is produced.

Examples of the outputs produced by EiPac are shown in the chapter Modelling and Forest Management Issues (p 39).

Other features

The EiPac menu bar has two other buttons (see Fig 13), neither of which is particularly useful in the present version:

 The Help button invokes the Windows Help file *EiPac.hlp* as a context sensitive help file. At the present time this has not been updated from EiPac 1.00, and is somewhat out of date. When a new release of this can be prepared, it will be supplied. It is installed simply by copying it into the same directory as EiPac.xls.

 The Remove button removes the Eipac menu bar completely. This was designed for an early version where Eipac was configured as an Excel add-in. In this situation, the menu bar would persist even after the application was unloaded, and needed to be manually deleted. In the current version, using the *Remove* button simply renders EiPac inoperable: It must be closed and re-loaded to make the menu bar re-appear.

Using the ISSMI harvest planning and control software

Introduction

ISSMI is an acronym for Integrated Stock Survey and Management Inventory. It has been developed in Uganda since 1998, and comprises a combination of field procedures and software tools to support the harvesting and re-stocking phases of sustainable natural forest management.. The background to its development is described in a series of reports (Alder 1998, 1999a, 1999b, 1999c, 2000, 2002b). The field procedures and silvicultural concepts are described in Uganda Forestry Department (now NFA) standing orders and reports.

ISSMI has been field test extensively – database records show that about 3,600 ha of forest have been surveyed and demarcated by this technique, and several workshops have been held to disseminate the ideas associated with it.

This present visit has concentrated on addressing two aspects:

- Some improvements to the software, covering installation, mapping, tree selection, block summary reports and a tidying up of obsolete features.

- Issues regarding the forest management context and costs of ISSMI, especially the felling cycle, and the relationship between ISSMI and EI.

This chapter also brings into a single source reference material on the software that has hitherto been spread through other reports, as well as documenting changes and new features added during this visit.

The role of ISSMI in natural forest management

ISSMI is primarily a methodology and linked software package for efficient stock survey prior to harvesting. Stock survey is typically applied in natural forest under polycyclic management, and is a procedure intended to identify the location of trees suitable for harvesting, appropriately mark and map them, and also identify key features or areas for conservation, protection or ameliorative treatment. It is a normal technique in natural tropical forest management where reduced-impact logging (RIL) is being carried out, or where certification of sustainable forest management is intended.

ISSMI also uses the field work of the stock survey to achieve a number of other aims at minimal added cost . These would normally be achieved through separate activities and surveys, and would therefore be more costly, as well as being less integrated in terms of data systems. These are:

- <u>Management inventory</u>, to provide information on the size, species, and quality class distribution of advance growth. This is needed to provide predictions of future yield and to assess the sustainability of current harvesting. The management inventory also identifies areas where ameliorative treatment (restocking, or planting with indigenous species) is needed due to an absence of regeneration or to low total stocking.

- <u>Tree and boundary marking for harvest control</u>. This facilitates the monitoring and regulation of felling, ensures that only those trees specified are actually felled, and allows protection of valuable seed trees or species of ecological or conservation importance.

- Boundary marking for re-stocking operations. Many of Uganda's natural forests have suffered from uncontrolled exploitation over the last 2-3 decades, and need some form of ameliorative treatment. ISSMI provides the necessary infrastructure, through its system of block lines clearly marked on the ground and in the GIS system, to apply, monitor and manage such operations.

- Continuous forest inventory. CFI provides a long term-system for continuously strengthening the information and scientific basis for sustainable forest management. ISSMI provides closely geo-referenced plot and tree data, as well as physical markings on the ground (block boundary trenches) in a well-documented and rigorous database. This information can be re-used after decades to evaluate forest change and response to harvesting, silviculture, and re-stocking, greatly improving scientific knowledge and our confidence in the sustainability of management in tropical forest.

These additional functions involve only minor extra costs relative to the basic stock survey. In an earlier report (Alder, 2002b), operating costs for ISSMI based on then available information were estimated at €25 per ha, which were within the typical range for tropical forest stock survey operations around the world (€20-€35), as reported by Reid & Rice (1997). About 10% of the costs of ISSMI are due to the additional work of establishing and measuring the management inventory plots. These costings do not include overheads, supervision by senior staff, or data processing, all of which are in most regards fixed costs that will be incurred relative to any harvesting, or even if only protection management is applied.

Current updates to the ISSMI software

During the consultancy covered by this report, the ISSMI software has been upgraded from version 2.11 to version 2.15. The main changes made have been:

Showing the linked database A *Where* menu has been added which shows the full path of the linked database. In the past, operational and installation problems could often be traced to linkages to non-existent or moved databases. This menu clearly and easily shows which database is being used.

Tree selection improved The tree selection procedure (*Silviculture* menu) has been completely re-written. In the earlier version, there were too many spatial rules, which confounded each other and often resulted in no selections being made at all. The new method is more transparent and faster to apply.

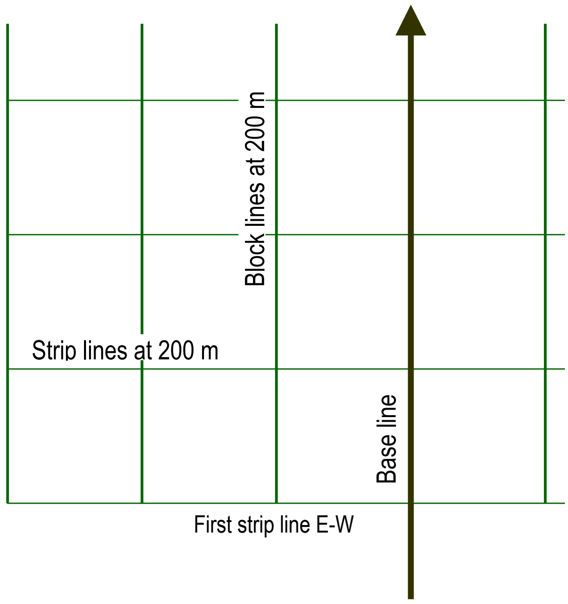
Quick mapper and GIS output revised The previous quick mapping program (*Issmimap.exe*) has been replaced by one that uses GIS modules, and now supports much faster and fully scaleable zoom and pan functions, as well as providing outputs as ArcView-compatible shape files or as Windows metafiles. The new program is called *Issmimap2.exe*. The previous GIS output menu has been removed, as this function is provided through the quick mapper.

Gross and net volumes Several key reports, including the new Block list, the Tree List, Harvest List, and Excel-based Block Map show net as well as gross volumes. Net volumes discount defective volume to give a figure that will more realistically represent sawmill input.

Two new reports have been added. The Harvest List report is intended to support the sale of timber by competitive bidding, by providing a report suitably formatted for direct attachment to bidding documents. The Block list report is designed to assist in decisions about polyblock allocation and reservation of complete blocks by giving a one line summary per block of gross and net volumes, numbers of harvest and reserved trees, major species composition, and block basal area and advance growth based on inventory plot data.

Description of field procedures for ISSMI

Figure 19 ISSMI block lines are cut at 200 m intervals East-West and North-South



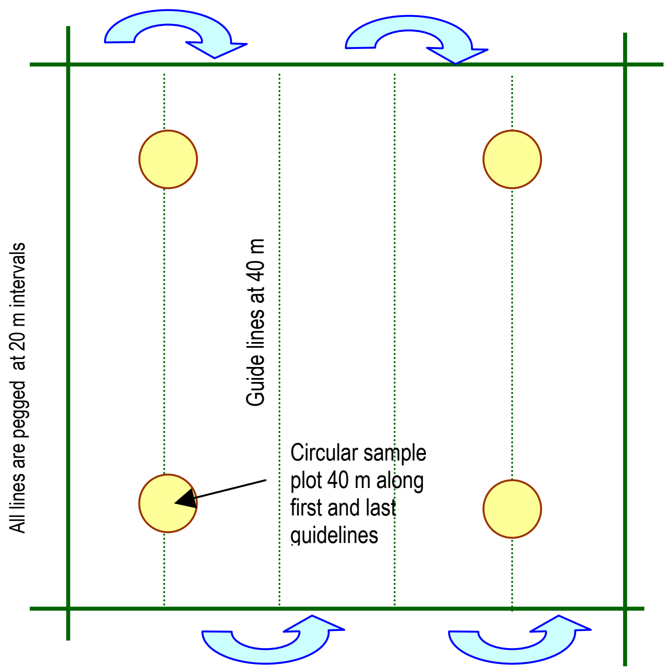
In order to provide a single-source reference on ISSMI, the field methodology is re-printed here, based on material taken from earlier reports (Alder 1998, 1999a-c).

The ISSMI field operation is carried out on a planned felling coupe (a compartment or sub-compartment) a few months before harvesting.

Figure 19 shows the procedure at the coupe level. A base line is established in a North-South (NS) orientation at a convenient access point. It may be located relative to a pre-planned grid using a GPS. From this primary base line, an initial strip line is cut in an East-West (EW) direction.

Further NS block lines are then cut at 200 m intervals from the first strip line. Additional strip lines are cut every 200 m along the NS baseline. This subdivides the forest into a series of 200 x 200 m (4 ha) blocks.

Figure 20 Layout of lines and plots within 200 x 200 m blocks



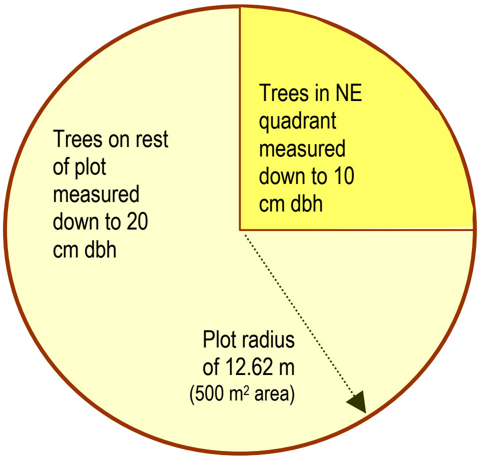
Once this demarcation has been done over a sufficient area, a team then cuts guide lines at 40 m intervals in a NS direction in each block (see Figure 20). These guide lines divide the block into 5 NS sweeps.

Stock survey is carried out usually be two teams each with blue paint, a diameter tape, and a skilled tree spotter. They move up each sweep with a single booker, who stays in the guide line to the west of the sweep. For each tree over the specified minimum diameter, the position north from the block's southernmost boundary is recorded (0 to 199 m), and the distance east within the sweep is estimated (0-39 m). These, together with the sweep number, record the tree's position within the block. Each stock tree has a number painted on its buttress or bole, as close to the ground as possible so that it will remain visible if the tree is felled. The number is painted on the due north side of the tree if buttressing permits, or as near thereto as possible. The trees within a block are numbered sequentially.

The sweeps are surveyed in a zig-zag fashion (see arrows on Figure 20), moving north on the first sweep, turning and going south on the second, and so on. The sequence of stock numbers follows this pattern.

On the first and last guidelines, at 40 and 160 m, a temporary sample plot is established. This is a circular plot of 12.62 m radius (500 m^2) on which all trees down to 20 cm are measured. On the NE quadrant of this plot, trees down to 10 cm are measured (see Figure 21).

Figure 21 Layout of circular sample plot



For the stock survey, the standard procedure prescribes that all trees down to 50 cm are recorded. Some species, such as *Funtumia elastica,* may be recorded down to 40 cm, if their prescribed felling diameter is less than 50 cm.

The data recorded for each species comprise species identification, diameter at breast height or above buttress, a stem quality code ranging from 5 for a perfect bole to 1 for a tree with no possible timber use – severely misshapen, rotten or otherwise unusable. A series of coded notes are provided to record observations about the tree – broken top, decay, damage, climbers, deformation, and so on. The same system of measurement is used for stock trees and smaller trees measured on the TSPs.

The trees over 50 cm (or 40 cm for some species such as *Funtumia elastica*) are measured on 100% of the forest area. Trees from 20 to 49 cm are measured on 5% of the area by a systematic sample. Pole sized trees, from 10-19 cm, are sampled on 1.25% of the area.

The ISSMI database

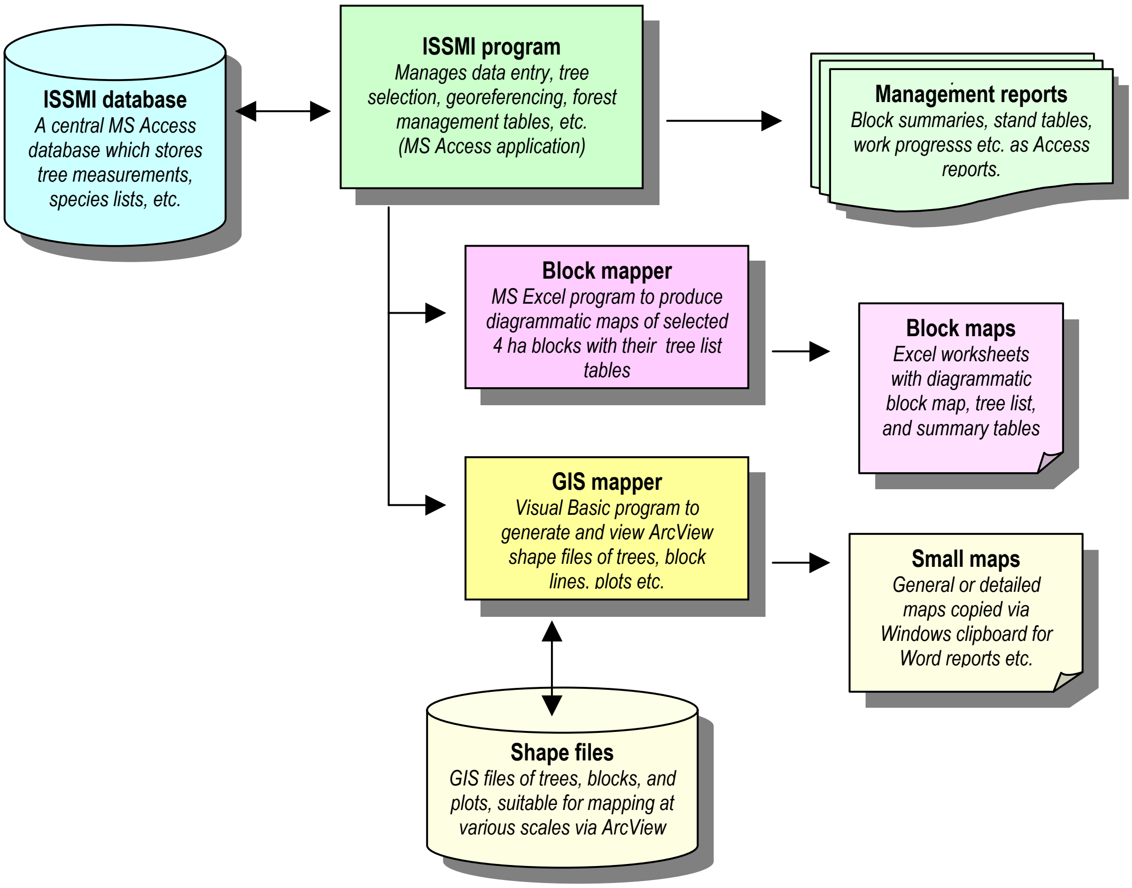
Field data is recorded on paper forms, which are brought in to the office for entry onto the ISSMI database. Figure 22 shows the software systems involved.

The main ISSMI program is an MS Access application which is linked a central database which contains all the data collected during ISSMI surveys, together with supporting information. This program can produce various analyses to support forest management which are output as Access reports. These are described in detail in later sections. Additionally it can invoke two types of mapping program. The Block mapper produces Excel diagrammatic maps of single 4-ha blocks, with tree locations, a tree list table, and a summary table of gross and net volumes by species. The GIS mapper generates shape files which can be processed by a GIS system such as ArcView to produce maps at various scales, with many possible designs. Additionally, it allows the ISSMI map data (block lines, plots, and trees) to be viewed, panned, zoomed, and copied to the Windows clipboard for use as small (sub-A4) maps in Word reports or PowerPoint presentations.

The ISSMI database itself resides in a file called ISSMI DATA2.MDB. This is an MS Access database. In normal configuration (see Appendix B), the database should reside on the central server NFA server, whilst the ISSMI programs should be installed on each local workstation that uses the system.

The ISSMI database contains the tables and relationships shown in Figure 23. Table 5 gives descriptions for each field in the database. Although some other tables may be found in the database, they are temporary and can be deleted without affecting operation of the system.

Figure 22 : ISSMI software systems



Field data from stock surveys (ie. stock tree data) are stored in the linked tables *Blocks* and *StockTrees*. *Blocks* contains one record per 4-ha ISSMI block, whilst *StockTrees* has one record per tree. The internally-generated *BlkID* field links these two tables.

The field data from the management inventory plots is likewise stored in the linked tables *InvPlots* and *InvTrees*. There is one record per plot in *InvPlots*, and one record per tree in *InvTrees*. They are linked by the internally-generated *PlotId* field. Inventory plots and ISSMI blocks are linked by the combined fields *Forest-Cpt-Block*.

The species list is in the table *Species*, which links to a table defining species groups, and a separate table for volume equation coefficients.

Three other tables exist permanently as part of the system, but do not have simple links to the main tables, and are not shown in Figure 23. They are however listed in Table 5 with their fields. One of these is *Silvics*, which are sets of silvicultural regimes that may be applied for tree selection. the other two are called *SiteCodes* and *TreeCodes*, which contain coded notes for sites and for individual trees.

Figure 23 : Tables and relationships in the ISSMI database

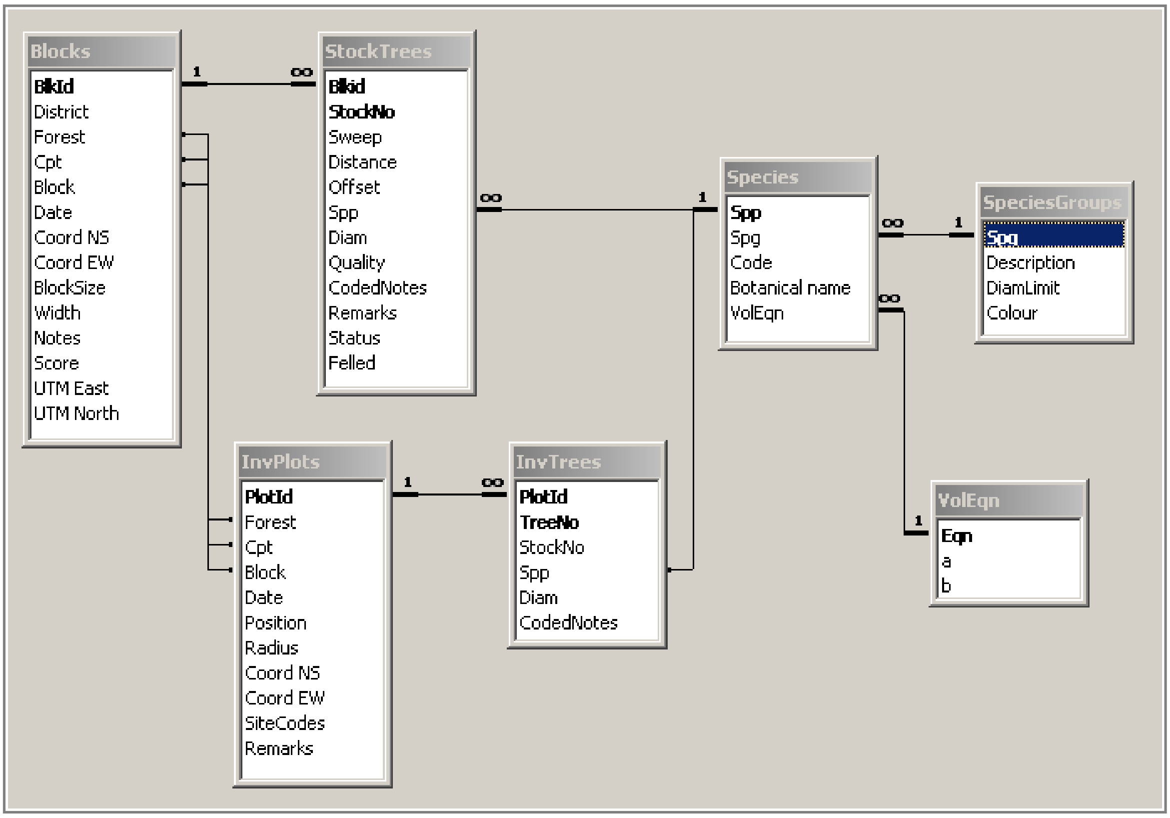


Table 5 : Dictionary of field names for the ISSMI database

Table	Field	Type	Description
Blocks	BlkId	TEXT	*Internally constructed unique block identification code*
	District	TEXT	*Name of forest district*
	Forest	TEXT	*Name of forest reserve*
	Cpt	TEXT	*Compartment number (may include letters)*
	Block	INTEGER	*ISSMI block number. This must be unique within the forest.*
	Date	DATE/TIME	*Date of field survey*
	Coord NS	TEXT	*Local y-coordinate of SW corner of the block, m*
	Coord EW	TEXT	*Local x-coordinate of SW corner of the block, m*
	BlockSize	INTEGER	*Block area in ha (normally 4 ha)*
	Width	SINGLE	*Block linear size in m (normally 200 m)*
	Notes	TEXT	*List of coded notes for the block. These should be in the SiteCodes table.*
	Score	SINGLE	*Not used at present, but reserved for a calculated ranking for the block.*
	UTM East	DOUBLE	*UTM coordinate, East*
	UTM North	DOUBLE	*UTM coordinate, North*
StockTrees	Blkid	TEXT	*Internal block identification code, links to Blocks.BlkID*
	StockNo	INTEGER	*Tree stock number*
	Sweep	INTEGER	*Sweep number in block*
	Distance	INTEGER	*Distance of tree along sweep (y-direction)*
	Offset	INTEGER	*Distance of tree from boundary of sweep (x-direction)*
	Spp	INTEGER	*Species code, links to Species.spp*
	Diam	SINGLE	*Tree diameter in cm*

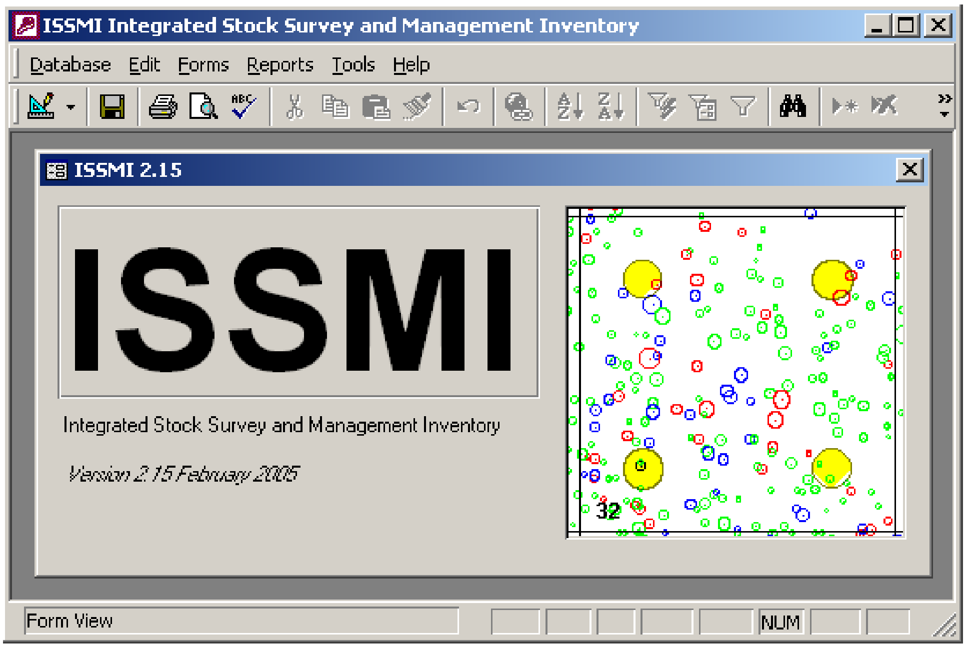
Table 5 *(continued…)* **: Dictionary of field names for the ISSMI database**

Table	Field	Type	Description
	Quality	INTEGER	*Stem quality code, 1 to 5*
	CodedNotes	TEXT	*List of 2 letter codes, separated by commas. Must be in TreeCodes.note*
	Remarks	TEXT	*Full text comments or observations*
	Status	INTEGER	*Code inserted by tree selection process (1=seed tree, 0=reserve, -1=harvest)*
	Felled	BOOLEAN	*True if monitoring shows tree has been felled*
InvPlots	PlotId	TEXT	*Unique internal inventory plot identification*
	Forest	TEXT	*Name of forest reserve*
	Cpt	TEXT	*Compartment number (may include letters)*
	Block	INTEGER	*ISSMI block number. This must be unique within the forest.*
	Date	DATE/TIME	*Date of field survey*
	Position	TEXT	*Corner of block where plot is, may be SW, SE, NW, NE*
	Radius	SINGLE	*Plot radius in m, normally 12.62 m (assumed if blank or invalid)*
	Coord NS	TEXT	*Local y-coordinate of plot, generated by software from position and block*
	Coord EW	TEXT	*Local x-coordinate of plot, generated by software from position and block*
	SiteCodes	TEXT	*List of 2 letter codes, separated by commas. Must be in SiteCodes.note*
	Remarks	TEXT	*Full text comments or observations*
InvTrees	PlotId	TEXT	*Unique internal inventory plot identification, links to InvPlots.PlotId*
	TreeNo	INTEGER	*Tree number on inventory form*
	StockNo	INTEGER	*Tree stock number if over 50 cm or a smaller stock tree*
	Spp	INTEGER	*Species code, links to Species.spp*
	Diam	SINGLE	*Tree diameter in cm*
	CodedNotes	TEXT	*List of 2 letter codes, separated by commas. Must be in TreeCodes.note*
Species	Spp	INTEGER	*Unique numeric species code.*
	Spg	INTEGER	*Species group number, links to SpeciesGroups.spg*
	Code	TEXT	*Optional 3-letter code for the species for use in map and table outputs*
	Botanical name	TEXT	*Botanical name for practical use (Genus species)*
	VolEqn	TEXT	*Single letter code for the tree volume equation, links to Voleqn.eqn*
SpeciesGroups	Spg	INTEGER	*Unique species group code number*
	Description	TEXT	*Brief description (not more than 20 letters recommended) of group*
	DiamLimit	SINGLE	*Felling diameter limit, used by tree selection process*
	Colour	TEXT	*Colour of group on GIS maps (does not affect Excel block mapper)*
VolEqn	Eqn	TEXT	*Unique 1-letter code for the volume equation*
	a	DOUBLE	*Intercept coefficient*
	b	DOUBLE	*Slope coefficient*
Silvics	Name	TEXT	*Short name for silvicultural regime*
	Description	MEMO	*Full description (any amount of text, but only 2 lines shown on form)*
	HmaxNha	SINGLE	*Maximum number of trees to be harvested per ha*
	Hgroups	TEXT	*List of species groups eligible for harvesting*
	HminQual	INTEGER	*Lowest quality code acceptable for harvesting*
	RejectCodes	TEXT	*Coded notes which if present, will result in tree being rejected for harvest*
	NminHa	SINGLE	*Minimum number of reserve stock trees per ha requiring to be left after harvest*
	NseedHa	LONG	*Number of seed trees desired per ha*
	SeedGroups	TEXT	*List of species groups from which seed trees may be selected*
SiteCodes	Note	TEXT	*A unique 2-letter coded note*
	Description	TEXT	*Full text explanation of the code*
TreeCodes	Note	TEXT	*A unique 2-letter coded note*
	Description	TEXT	*Full text explanation of the code*

ISSMI start-up and menu system

When the ISSMI program is started, the screen shown in Figure 24 will appear. The menu bar at the top will replace the standard MS Access menu. Table 6 shows the full menu layout with a summary of actions for each menu item.

Figure 24 : The ISSMI start-up screen and top-level menu



Linking databases: The *Database* menu

The *Open* menu is used to link the ISSMI program to the ISSMI database (see Figure 22). It brings up a standard Windows file open dialog box, which should be used to locate and open the required database.

The *Where* menu shows the current linked database. This should be used to check that the correct database is being used, especially if any problems occur running the software. There are two important issues regarding linked databases that should be noted:

1. *All ISSMI users working on data from the same forest area should operate on the same database*. Serious confusion will result if multiple copies of the database are created, and it will be found to be quite difficult to merge, for example, data entry work, if it is done accidentally on two different databases. This databases should, in the NFA context, be located on the central network server in a directory to which all ISSMI users have access rights.

2. The *Where* function should be used to check the linked database after installation and from time to time, and all users need to be properly aware and informed about using the correct database. If any problems occur when running ISSMI, then the first issue to be examined should be whether the correct database is being used and is currently accessible over the network.

Copies of the main database should only ever be used for demonstration, training and testing purposes, and should never be used for data entry.

Table 6 : The ISSMI menu system

Menu			Description and usage
Database►	**Open**		Brings up an open database dialog box to allow the linkage to the ISSMI database to be established or changed.
	Where		Displays the full path of the linked ISSMI database.
	Exit		Closes ISSMI. The same effect is achieved by closing the ISSMI dialog box.
Edit►	**Undo**		Reverses the last operation if possible.
	Copy		Copies a selection to the clipboard.
	Cut		Copies a selection to the clipboard and deletes it.
	Paste		Pastes the clipboard at the current position, replacing a selection if made.
	Delete Record		Deletes the current record.
	Find		Finds text in a table or form.
	Find Next		Finds next instance of the same text.
	Replace		Finds and replaces text in a table or form
Forms►	**Stock Survey**		Opens list of blocks to select one for editing. The **Tools>Form View** will display the selected block as a data entry form for stock tree data.
	Inventory Plot		Opens inventory plot form for data entry and editing.
	GeoReference		Form to allow UTM coordinates to be entered for a specified block, and then applied to the whole compartment via the **Apply** button.
	Silviculture		Form to set the tree selection criteria for harvesting and seed trees, and apply them to a specified compartment.
	Species groups		Form to set species group names, minimum diameter limits, and colours for the quick mapping module.
	Species List		Displays the species list, and allows new entries, editing of names, species group or volume equation to be applied.
Reports►	**Mapping►**	**Quick Map**	Starts the quick mapping module. This generates and views ArcView shape files to map trees, blocks and plots.
		Block Map	Starts the Excel block mapping application. Draws detailed maps of single blocks with lists of trees by harvesting category, for harvesting control and monitoring.
	Selected yield►	**Species summary**	Produces a report for a selected compartment of species tree numbers by harvest, seed tree and reserve categories, with harvest volumes. It also gives a stand table by 20-cm classes to assess recruitment and sustainability.
		Group summary	Summarises harvest, seed and reserve tree numbers and volumes by species groups.
		Tree List	Designed for monitoring and control of harvesting, lists for each block the harvest, reserve and seed trees with individual stock numbers, gross and net volumes.
		Harvest List	Designed for bidding or contractor use, lists trees to be felled on each block by species with stock numbers, gross and net volumes, but not reserve or seed trees.
	Stand Tables		A general stand table for a compartment, with user-definable size classes, summarisation of tree numbers, basal area or volume, and cumulative or class values, per ha or for the whole area.
	Block List		A summary list of blocks in a compartment, with tree numbers, gross and net volumes for harvest and reserve trees, principle species on each block, etc.
	Data check►	**Block**	Lists the stock tree data for a given block, with all details, in a format similar to the field data sheet, for checking purposes.
		Plot	Lists the data for an inventory plot, with all details, in a format similar to the field data sheet, for checking purposes.
	Work summary		Summarises numbers of blocks, plots and trees in the database by compartment.

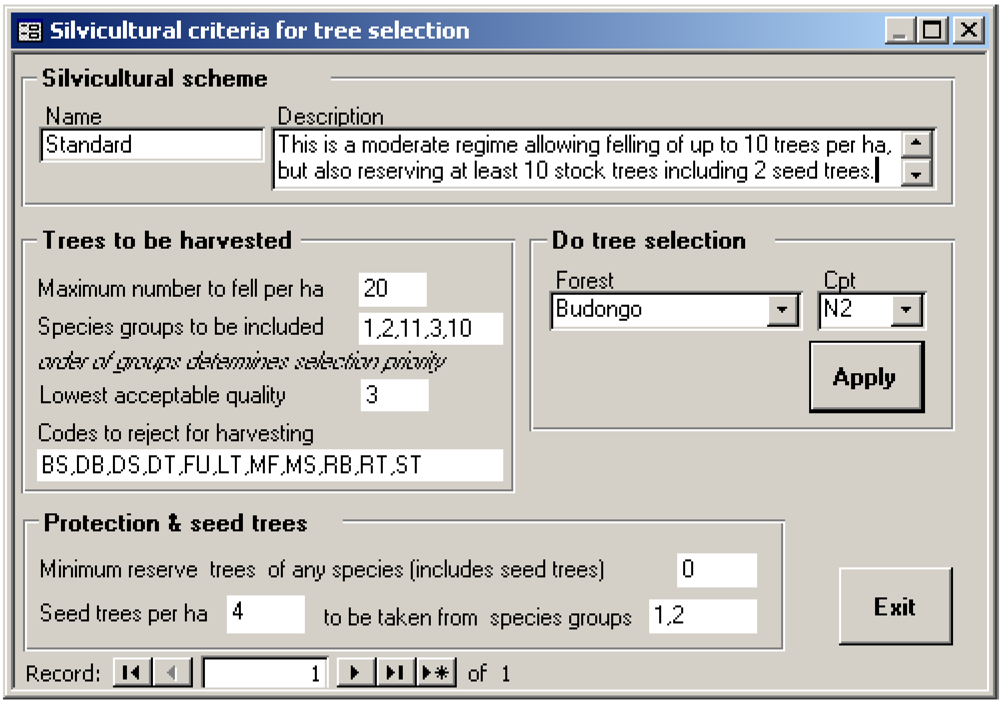
Table 6 *(continued…)* **: The ISSMI menu system**

Menu		Description and usage
Tools ►	**Datasheet view**	Toggles the current form into datasheet view, if allowed.
	Form view	Restores normal form view for a datasheet.
	Sort ascending	Sorts the datasheet on the selected columns in ascending order.
	Sort descending	Sorts the datasheet on the selected columns in descending order.
	Print	Prints the current form or datasheet.
	Print preview	Previews the printed format of the current form or datasheet.
	Page setup	Sets printer information such as paper size, margins, orientation, etc.
	ISSMI design	Opens the Access database window for ISSMI and restores the standard menu.
Help ►	**ISSMI Help**	Brings up the ISSMI online help manual
	What's this	Gives standard Access help where the context allows

Tree selection for harvesting

The *Forms* ► *Silviculture* menu is used to select trees for harvesting. It brings up the dialog box shown in Figure 25. This part of the software has been re-written during this consultancy. Version 2.15 onwards of ISSMI use the system described here. Earlier versions are different, and should not be used.

Figure 25 : Silviculture dialog box for tree selection



Three categories of tree are defined. These are seed trees, harvest trees, and reserved trees. Once the tree selection procedure has been applied to a compartment, the the category is recorded in the Status field of the StockTrees database table (see Table 5) with codes +1 (seed trees), 0 (reserved trees) or –1 (trees to be harvested). The status code is then used all reports and mapping outputs to identify and classify trees by these categories.

Seed trees are trees that are commercially valuable but which need to be strictly protected because they are becoming locally rare.

Harvest trees are those trees which are required to be harvested. They will be commercial species, of sufficiently good form and free from defect to provide at least one economic sawlog.

Reserved trees are all other trees included in the stock survey. They include non-timber species, and timber species of too poor a quality to be economically harvested. They may also include good timber trees where the numbers of these exceed the specified allowable cut.

In the dialog box (Figure 25) the silvicultural scheme frame allows a short name to be given to the harvesting regime, together with a text description. Harvesting regime specifications are stored in the data table *Silvics* (see Table 5). New specifications can be added by clicking the ▶* button at the bottom of the form. The record navigation buttons allow pre-existing harvesting specifications to be displayed and modified. The *Edit ▶ Delete Record* menu will allow an existing scheme to be deleted from this data table.

The Trees to be harvested frame includes all the specifications for the harvest trees, including the maximum number per ha, the species groups which are commercial, the lowest acceptable stem quality, and a list of critical codes notes which will indicate that the tree is unusable.

The Protection and seed trees frame allows a minimum number of reserved trees to be specified per ha. This number will include any seed trees allocated. It also specifies the number of seed trees and their species groups, which should be from amongst the most valued timber species.

The Do tree selection frame defines the compartment to which the harvesting regime is to be applied, via pull down lists. The *Apply* button will causes tree status to be updated in accordance with the rules given.

In logical terms, when the *Apply* button is pressed, ISSMI will work through block by block within the designated compartment. It will first select *seed trees*, prioritising the largest and best quality. Trees are actually sorted from best to worst by a weighting factor calculated as Diameter x Quality. Thus a tree of diameter 80 cm and quality 5 would have a higher weight (80 x 5 = 400) than a tree of diameter 90 cm and quality 4 (90 x 4 = 360) and would be preferred.

It will then select *harvest trees* provisionally, again sorting from best to worst, and excluding any harvestable trees that are below the required quality standard, or which have coded notes from the list given, indicating that they are unsuitable or unavailable for harvesting.

This provisional list is checked against the number of required *reserve trees*. If there are not enough reserves, then some of the harvest trees (the smallest, lowest quality) will be moved to the reserve list to make up numbers.

This tree selection method does not use the spatial calculations (minimum distances between trees) of the earlier versions, but because selections are always made from the largest trees downwards, and these tend to be naturally the most dispersed members of the population, it still gives good results in terms of a well-spread harvest with little 'clumping' of selected stems. The earlier 'spatial' version was problematic in practice as it was difficult to foresee the effect of different buffer prescriptions, and often resulted in the logical impossibility of making any selections.

Changes in volume calculation: Gross and net volumes

Several of the reports now show both net and gross volumes. . This was done in response to the view that ISSMI tended to overestimate available volumes as it did not take into account stem quality.

Net bole volumes are calculated using the following discounting factors for stem quality:

Quality class	% of Gross Volume
5	100 %
4	80 %
3	60 %
2	0 %
1	0 %

When the felled volume sampling has been completed, it will be possible to allocate these factors more scientifically, but these values gave good correspondence with measured volumes for some trial areas, and agreed with the expectations of forest managers.

The volume discounting is done within the routine *VolNet* in module *Utility* of the ISSMI program, and the factors applied can be readily varied there.

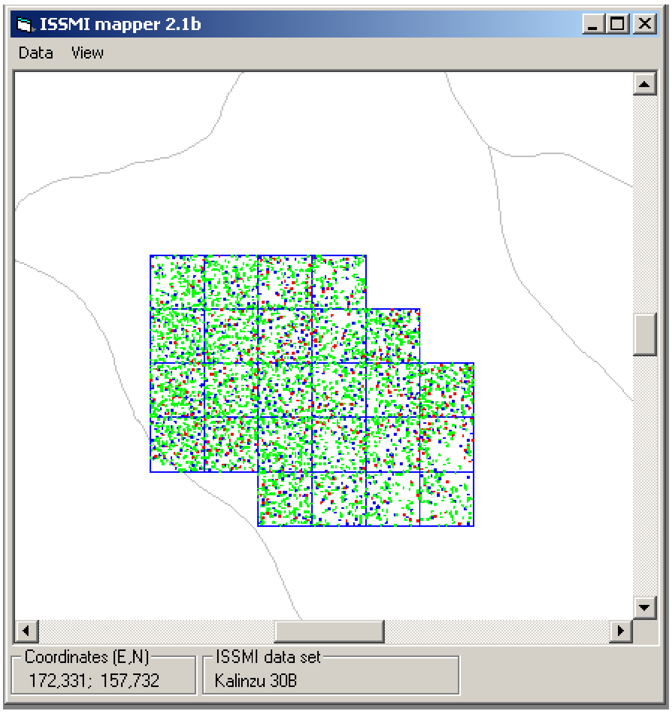
Also during this consultancy, the volume estimates provided by the volume functions were again examined and discussed in presentations to forest managers. Although based on Relascope sampling, and therefore not very accurate, the functions appear to be consistent with international experience for natural forest volume equations, and are unlikely to be consistently very biased. A detailed explanation of the derivation of the volume models has been given in earlier reports (Alder, 1999a, p5-6; Alder, 2000, p14) which have also emphasised the importance of a program of felled volume sampling to update and improve these equations.

Revisions to ISSMI mapping and GIS functions

In earlier versions, ISSMI had three map-related facilities. These were: (i) A Visual Basic program called *issmimap* which provided a limited on-screen mapping facility via the *Reports* ► *Mapping* ► *Quick Map* menu;
(ii) An Excel program to print symbolic maps of single blocks together with tree lists and summary tables of species and volumes using the *Reports* ► *Mapping* ► *Block Map* menu, and (iii) output of text files formatted for conversion by ArcInfo in GIS coverages of trees, and block boundaries.

This situation has now been simplified and improved in several respects. The Excel block mapping

Figure 26 : ISSMI quick mapper, version 2



program work similarly to the earlier version, but now shows both net and gross volumes. It also allows a user-defined map key or text to be added to each output map, to improve the usefulness of the maps within tender documents and similar commercial applications.

The GIS and on-screen mapping facilities have now been combined in a program called *issmimap2*,which is accessed via the *Reports ► Mapping ► Quick Map.* When started, this will appear as shown in Figure 26, although the displayed map will vary. There are two main menus Data and View, a map area, and at the bottom, display of the current cursor position in geographic coordinates, and the current compartment.

The map area can be panned or zoomed using the mouse buttons, in the same way as for the EiMap program (see page 17). The various menu functions are set out in Table 7. The program generates ESRI shape files for trees, plots and block lines which are saved in the same directory as the background map layer (typically a compartment map). The shape files have the standard names constructed according the template:

~**Is***L_Forest_Cpt.ext*

where:

~**Is** is a prefix common to all generated shape files from this program.
L may be the letter B, T or P, for Block, Tree or Plot map layers respectively.
Forest is the name of the currently selected forest (*eg*.. Kalinzu, Budongo).
Cpt is the designation of the current compartment (*eg*. 34, N10)
ext is one of .dbf, .shp, .shx. Each ESRI Shapefile consists of 3 parts, with these extensions.

Table 7: Menu system for ISSMI mapper version 2

Menu			Description and usage
Data►	**ISSMI database**		*Sets the linked ISSMI database*
	Background map		*Sets the background map*
	Compartment		*Brings up a list from which the compartment to be mapped is selected*
	Clear map		*Removes all map layers*
	Save settings		*Saves current settings in a file other than the default ISSMImap.ini*
	Load settings		*Loads settings from a file other than the startup default ISSMImap.ini*
View►	**Background**		*Shows or hides the background map layer*
	Blocks		*Shows or hides block boundaries as blue lines. If the shape file does not exist, it is generated from the ISSMI data.*
	Trees		*Shows or hides trees as circular crown projections. The colour scheme depends on the* **Colours** *menu setting. If the shape file does not exist, it is generated from the ISSMI data.*
	Plots		*Shows or hides inventory plots as yellow circles. If the shape file does not exist, it is generated from the ISSMI data.*
	Labels►	**Block No**	*Shows or hides block numbers if the* **Blocks** *layer is displayed.*
		Stock No	*Shows or hides tree stock numbers if the* **Trees** *layer is displayed.*
		Species	*Shows or hides species 3-letter codes if the Trees layer is displayed.* **Stock No** *and* **Species** *code cannot be shown together, so only the last selected will be shown.*
	Colours►	**Selection status**	*Shows trees according to the colour scheme: Red = Seed tree, Green=Reserved tree, Blue=Tree to be harvested.*
		Species groups	*Shows trees according to the colour scheme for the species group selected from the ISSMI* **Forms ►Species groups** *menu.*
	Copy map		*Copies the visible map area to the Windows clipboard as a metafile, suitable for pasting into Word or PowerPoint as a diagram.*
	Print map		*Prints the visible map area. This is done without legend, scales, titles etc. To generate a quality printed map, the shape files should be opened in ArcView and the print formatting set up as required.*

EiPac growth model : Concepts and calibration

The EiPac model (page 24) allows issues of sustained yield and felling cycle to be examined in a reasonably objective way. However, it is important to understand the behaviour and the limitations of the model in order to interpret the indications that it gives.

Logic of the growth model

Many kinds of growth model can be constructed for moist tropical forest (MTF). Osmaston (2000) describes one kind of conceptual model. Alder (1995, 1999d) discusses some of the strategies for modelling, and compares their effectiveness and outcomes. Of particular relevance to EiPac is Alder (2002a)[1], which describes alternative simple growth modelling methods based on diameter class and cohort projection. EiPac is a cohort model that is closely similar to the GEMFORM model described in that paper. The paper shows that the cohort projection method can be quite accurate when applied over relatively short periods (up to 30-40 years), and is generally more accurate than diameter class projection when tree by tree inventory measurements are available.

The basic logic of the cohort model is very simple. The raw tree data from the inventory is grouped first of all into cohorts, which have the same size (to ±0.5 cm), the same growth model code, defect and decay status, and harvesting diameter limit. Each cohort is characterised by its current diameter at time t (d_t), and the number of trees per km² in the cohort (n_t). Increment and mortality depend on the growth model code and decay status, and can be defined as *i* cm/yr for mean increment and *m* %/yr for mean mortality. With a felling cycle of *c* years, the diameter and number of trees in each cohort at the end of the felling cycle is calculated as:

Diameter: $$d_{t+c} = d_t + c.i \qquad \{1\}$$

Stocking: $$n_{t+c} = n_t.(1-(1-m)^c) \qquad \{2\}$$

In other words, diameter growth is assumed to be at a constant rate over the whole felling cycle, and is simply added to the original diameter of the cohort. Mortality is assumed to be a constant compound interest process at a constant percentage rate over the whole felling cycle.

This scheme, although very simple, works surprisingly well in cases where it has been possible to test it with long term sample plot data in natural tropical forests (as discussed in Alder, 2002a).

Recruitment is a different matter. Experience with PSP data and ecological and silvicultural observations in natural forest show that it is very variable over time, and cannot easily be encompassed by simple assumptions or limited PSP data. There is a definite period when the model will not be greatly affected by the recruitment of new trees to the harvestable diameter, and projections can be considered reasonably reliable. With overall average increments of about 4 mm/yr, a minimum measurement diameter of 10 cm, and a harvesting diameter for some species of 40 cm, this will be (40-10)/0.4 or 75 years.

[1] This paper can be downloaded from http://www.bio-met.co.uk/pdf/ittokl.pdf (390kb)

Accordingly it should be appreciated that projections with EiPac beyond 75 years are unlikely to be very realistic, and will reflect stand diameter class and species distributions that depend wholly on the very simple recruitment model used.

The recruitment model assumes that all trees which die during a period are replaced by an equivalent number of recruits, and that this process occurs evenly throughout the felling cycle. If the number of trees lost from mortality is N_r, then total recruitment over a period is also N_r. This is simulated in the model by creating in each year a cohort with diameter d_b, (which should be the minimum measurement size in the inventory data, typically 10 cm) and an arbitrary stocking, say w. Each of these cohorts is then grown in size and reduced in numbers from its year of creation to the end of the felling cycle using equations {1} and {2} above. Final, the actual stockings n_c are calculated by the adjustment:

$$n_c = N_r.w_c/\Sigma w_c \qquad \{3\}$$

which ensures that they add to the required total N_r, exactly replacing mortality over the cycle.

The key point about this assumed method of modelling recruitment is that the resulting stand will have a 'balanced' diameter distribution of negative exponential form (reverse J shape) whose steepness depends on the mortality and increment rates. Stem numbers will overall also remain constant.

Figure 16 (b) on page 23 shows two adjustment factors in the Calibration box which arbitrarily modify the above process. The *Regen base diam*, as noted above, is the diameter at which recruitment is defined to occur (d_b), and should be the same as the lowest measured size in the inventory data, in this case 10 cm. The *Regen multiplier* is a factor used to multiply calculated losses to give N_r, and adjusts for some 'leakage' of information which results from curtailing cohorts with very small stockings.

Modelling of harvesting and logging damage

Harvesting is modelled by reducing the stem numbers in each cohort that is eligible for felling by the fraction to be removed.

Eligibility depends on species group, diameter, defect and decay status. If the species group is one of the *List of commercial groups* (see Figure 16 (b) on page 23) then it will be included, otherwise not. If the diameter is above the minimum felling diameter for the species, then likewise, it is eligible. Cohorts marked as decayed or defective are ineligible.

The fraction to be removed depends on the *Yield regulation* stipulation (see Figure 16 (a) on page 23), and is calculated from total eligible stocking or volume to meet whatever target is being applied. In the case of the *Calculated sustained yield*, the program iterates through different felling fractions over a number of cycles until a level is achieved that is sustainable over all cycles.

Recruitment following harvest is based on simple replacement. If N_h stems are felled, and a *Regen multiplier* (Figure 16 b) of f is used, then $f.N_h$ stems of diameter d_b are assumed to arise as recruits following harvesting.

Felling damage depends on the *BA damage:harvest* ratio (See Figure 16 b). If this ratio has a value of 0.5, for example, then it is assumed that if 5 m2/ha are logged, then 0.5 x 5 or 2.5 m2/ha are damaged in the residual stand. This damage is applied equally through all size classes. If the ratio is H_g, then the damage is modelled by splitting cohorts so that (1- H_g) of the stocking remain healthy, and the remaining H_g stems are classified as decayed. Decayed stems attract a higher mortality rate, and also are not harvestable in future cycles.

As a rule of thumb, the consultant has found typically that damage is roughly on a 1:1 ratio of basal area with catepillar tractor logging. There is no empirical data as to damage factors in typical Ugandan conditions, but it is fair to assume lower rates with the light equipment or manual methods typically in use, and a value of 0.5 has been applied for the various simulation trials shown here.

Calibration of the model

There is no generally available growth data for natural forest species in Uganda. A number of permanent sample plots (PSPs) were established by the Forestry Department from 1998 onwards, but they have not yet been re-measured. Hence, only assumed values for increment and mortality rates can be adopted. To assist in this process, the author has used the framework and approach suggested by the MYRLIN project (see http://www.myrlin.org and Alder et al, 2002)[1].

Figure 27 : MYRLIN schema for increment estimation from tree typical size

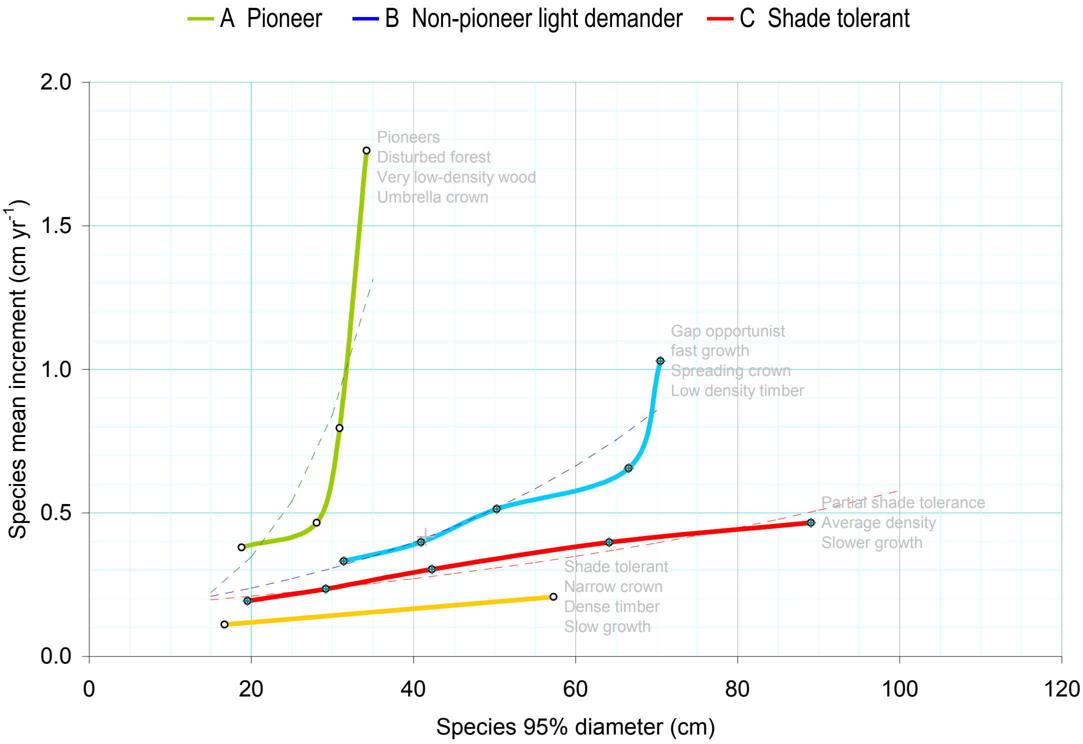


Figure 27 illustrates the basic ideas. Alder et al (2002), in examining mean increments of many tropical species from different regions, found that typical patterns occurred dependent on species mature size and ecology. The species mature size was estimated from extensive inventory data sets, and defined as the 95% frequency point on the cumulative diameter distribution. Ecology could be broadly grouped into pioneers, non-pioneer light demanders or gap opportunist species, long-lived emergents, and more or less shade tolerant species.

Using this scheme and all available EI inventory data for Uganda, the D_{95} values were estimated for all species and grouped into 5-cm classes. Species were also grouped based on the modality or shape of their diameter distribution into those more or less likely to be light demanding (blue line) or shade tolerant (red line) or extreme pioneers (green line). From this a growth model group code was generated for all represented species, in the form 45B or 100c, where the leading digits represent the 5-cm D_{95} class, and the letter A, B or C represents the pioneer, light-demander, or shade tolerant banding.

[1] A draft copy of this paper can be downloaded from http://www.bio-met.co.uk/pdf/ifr2002.pdf (666 kb).

This scheme is highly provisional as it depends on the limitations of available inventory data, and the extent to which it reflects the disturbance history of the forest. Heavy disturbance more or less distorts the idealised equilibrium diameter distribution that is assumed in estimating D_{95} . The ecological attributions of the species need to be also adjusted based on local knowledge.

Given D_{95} and model class A – C, mean diameter increment (D_{inc}) could be estimated from the dotted regression lines shown on Figure 27. Knowing D_{inc} and D_{95}, then average Annual Mortality Rate (AMR) could be estimated, using the procedures described in Alder *et al* (2002).

Based on the consultant's experience with similar data in the past, the mortality rate for trees with decay or damage was estimated at three times the healthy trees, whose rate was itself estimated as half that arrived at by the direct calculation from the MYRLIN method (see Figure 3 in Alder *et al*., 2002).

Species tend to have a definite upper diameter limit beyond which they are unlikely to be found. This maximum diameter is hard to estimate, as it necessarily relates only to very rare trees, but it can be approximates as D_{95} times a constant factor, which probably lies between 1.5 and 2 in most cases. In the model configuration dialog (see Figure 16 b on page 23) this is called *Dmax to D95*, and should typically be set to 1.5.

These estimates were stored in the *Models* table of the EI database (see Table 4, page 10), from which they are picked up according to the field settings in the *Growth Models* tab (Figure 16 c) of the EiPac settings.

Sustainable yield estimation : Examples and issues

The first step in examining the sustainable yield and appropriate current levels of harvesting is to look at the diameter distributions of the stands that form part of the prospective felling series. This can be achieved in compact form using the EiSys summary report (see page 13).

Figure 28 overleaf shows the summary report for four compartments from Kalinzu FR. These have been selected to illustrate a range of different situations. Figure 29 shows the diameter distributions of the commercial species. The graph is plotted with the Y-axis on logarithmic scales, to make it easier to compare the values over their wide numeric range. Table 8 below contrasts the management approach required for each. It is assumed that the minimum basal area for entry for felling is taken as 27 m2/ha (Osmaston, 2000).

Table 8 : Management implications of different types of diameter distribution

Compart-ment	BA m2/ha	Management approach
10	26.9	*Basal area just adequate for felling. Better if deferred for a few years in the felling series. Advance growth strong relative to mature trees, should produce increasing yields in future relative to current harvest.*
24	26.7	*Basal area just adequate for felling. More mature stocking than Cpt 10, but less advance growth. Can be scheduled before Cpt. 10 for felling, although should also be deferred in felling series (not in first year).*
28	13.8	*Low basal area, should be protected in first 10-year felling series and considered for remedial re-stocking if possible. Cause of low stocking (illegal felling, fire) to be investigated and protection instituted if possible.*
35	33.8	*Basal area well above felling criteria, but has lowest advance growth of all except Cpt. 28, so yield at first felling probably not repeatable at next cycle. However, felling will probably stimulate re-growth, and ultimately yields will increase. Should be scheduled for earliest felling in series.*

Figure 29 : Summary details of compartments used for modelling examples

Forest inventory summary

Kalinzu Forest Cpts 10, 24,28,35

Based on 227 plots sampled around Sep 2001

Compartment	Class of spp.	Tree numbers per ha by diameter class 10-19	20-29	30-39	40-49	50-69	70-89	90+	Management indicators Volume (m3/ha) Bole	Net	Basal area m2/ha	No. plots	Most common species with % BA,
10	Timber	179	92	45	7	12	2	3	130.7	88.0	20.6		Sts(17%), Bop(14%), Pae(14%), Fua(11%), Phd(7%) ~(37%)
	Other	80	17	6	4	1	-	1	47.9	9.2	6.2		Fic(75%), Uvc(6%), Tcn(5%), Myh(3%), Pof(2%) ~(9%)
	Total	*259*	*110*	*50*	*10*	*13*	*2*	*4*	*178.6*	*97.2*	*26.9*	*21*	
24	Timber	101	66	35	12	11	6	4	146.9	88.5	20.6		Pae(28%), Fua(25%), Sae(10%), Ced(8%), Sts(7%) ~(23%)
	Other	54	24	10	5	4	1	1	32.4	7.5	6.1		Mcs(16%), 773(7%), Spc(7%), Cul(5%), Myh(4%) ~(60%)
	Total	*154*	*90*	*45*	*17*	*15*	*7*	*5*	*179.3*	*96.0*	*26.7*	*70*	
28	Timber	82	27	15	4	4	1	1	58.1	33.5	8.7		Pae(25%), Fua(15%), Sae(11%), Sts(8%), Cgr(6%) ~(34%)
	Other	62	20	8	4	-	1	-	24.4	5.1	5.0		Cul(21%), Pna(19%), Tro(14%), Mgc(8%), Mcs(4%) ~(33%)
	Total	*144*	*47*	*23*	*7*	*5*	*2*	*2*	*82.5*	*38.6*	*13.8*	*44*	
35	Timber	104	46	32	22	28	8	6	204.9	125.8	27.8		Sts(31%), Dry(16%), Fua(10%), Pae(7%), Ced(7%) ~(30%)
	Other	109	24	7	1	3	1	1	30.2	10.5	6.0		Uvc(15%), Psm(12%), Wau(9%), Fic(7%), Lnj(5%) ~(52%)
	Total	*213*	*70*	*39*	*23*	*31*	*10*	*7*	*235.0*	*136.4*	*33.8*	*92*	

Figure 29 : Diameter distributions of commercial timber on four compartments in Kalinzu FR

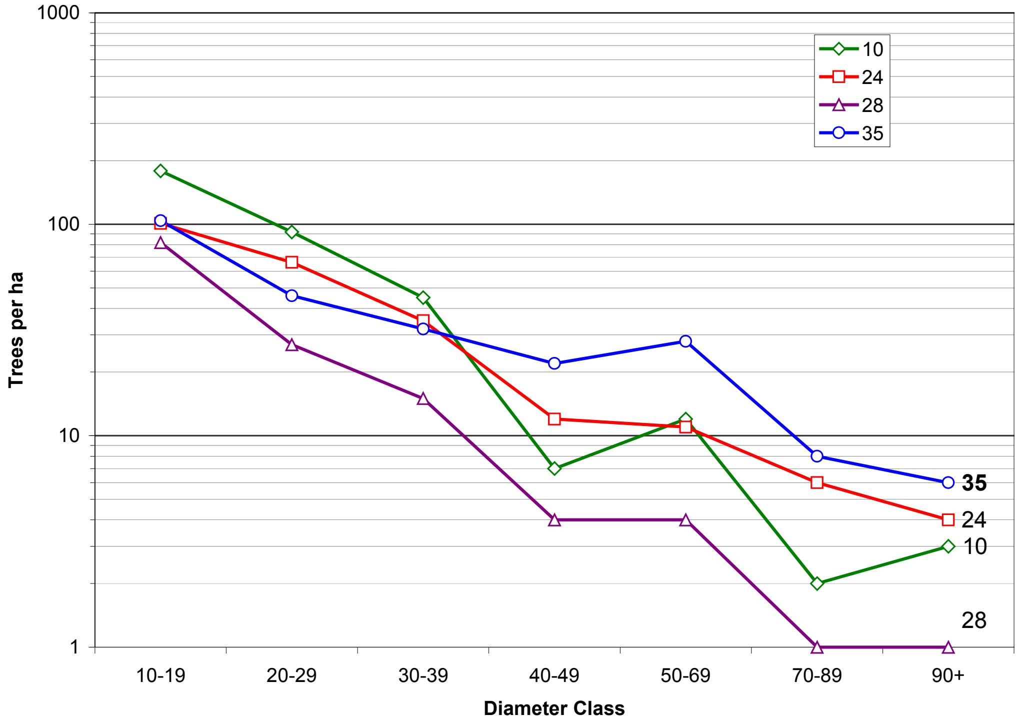


Figure 30 : Eipac projections for Kalinzu compartments 10, 24 and 35

Yield Forecast: Kalinzu Forest Reserve			Period	Initial	Year 5	Year 35	Year 65
Forest block/stratum	*Area (ha)*	*Size*	*Stand component*	*Trees (n/km2) by felling cycle*			
Cpt 10	**192.2**	40/50+	*Harvest*	-	468	743	872
		40/50+	*Harvestable, retained*	1,333	596	187	9
		10-40/50	*Advance growth, sound*	27,048	22,071	17,222	13,420
		10+	*Defective, damaged*	5,619	11,194	17,033	20,736
		10+	*Non-commercial species*	10,857	10,972	11,272	10,914
		10+	*Stand basal area m2/ha*	26	24	24	23
				Volume (m3/ha) by felling cycle			
		40/50+	*Harvest*		19.7	19.7	19.7
		40/50+	*Harvestable, retained*	56.4	25.1	5.0	0.2
Cpt 24	**271.3**	40/50+	*Harvest*	-	430	500	723
		40/50+	*Harvestable, retained*	1,943	1,127	409	-
		10-40/50	*Advance growth, sound*	15,914	14,258	12,700	8,121
		10+	*Defective, damaged*	5,514	7,807	9,968	13,694
		10+	*Non-commercial species*	9,857	9,989	9,965	9,385
		10+	*Stand basal area m2/ha*	25	22	16	13
				Volume (m3/ha) by felling cycle			
		40/50+	*Harvest*		18.3	18.3	18.3
		40/50+	*Harvestable, retained*	78.6	47.9	14.9	
Cpt 35	**385.8**	40/50+	*Harvest*	-	722	711	834
		40/50+	*Harvestable, retained*	4,652	2,851	568	-
		10-40/50	*Advance growth, sound*	16,565	15,935	15,037	9,541
		10+	*Defective, damaged*	3,435	5,403	8,462	13,675
		10+	*Non-commercial species*	14,565	14,787	14,773	13,679
		10+	*Stand basal area m2/ha*	33	28	19	16
				Volume (m3/ha) by felling cycle			
		40/50+	*Harvest*		23.2	23.2	22.2
		40/50+	*Harvestable, retained*	144.9	91.5	18.0	

Figure 30 illustrates the projections from EiPac for compartments 10, 24 and 35. Compartment 28 is not included as the basal area is too low to schedule it for felling. The first felling year in these projections is specified as 5 years, based on the fact that the inventory data was gathered in 2001, and we might expect this to begin in 2006. The felling cycle is 30 years, with projections over 2 cycles.

Sustainable timber yield for fellings in year 5, 35 and 65 are around 20 m^3/ha. With a 30-year cycle, this gives an AAC of 0.66 m^3/ha/yr. In the author's experience this is a fairly typical figure for tropical high forest. As an operational specification for ISSMI (see page 35), this can be translated to 24 trees per 4 ha block (6 trees per ha).

If this simulation is re-run over a longer period, sustained yields will drop. However, as noted earlier, this is very much dependent on the regeneration modelling, which is based on assumptions rather than valid empirical models. In cases where the author has had good PSP data to base the work on, sustained yields of around 0.6-0.8 m^3/ha/yr are normally indicated.

It is recommended therefore that EiPac projections are based on a maximum period of 75 years, as noted earlier.

Variations in stand structure can be very localised. At the level of a 10-year plan, it is necessary to develop a general AAC figure that is achievable on average over the whole felling series. Better figures will result if obviously unsuitable stands are excluded from the series. Higher yields depend on the adequacy of the larger advance growth. It is noticeable in Kalinzu FR, for example, that the advance growth is notably deficient in some stands. The diameter class curve for compartment 35, for example, shows high stockings of larger trees, 50 cm +, but substantially fewer trees in the 10-40 size range than compartments 10 and 24. This is evident on the ground by the appearance of a gallery-type forest. In the author's experience, this is typically seen in drier areas where fires are not uncommon.

The low yields which EiPac will predict for most natural forest in Uganda are in fact typical. The widely used 1 m^3/ha/yr suggested by Dawkins (1964) is an optimistic figure. The author's experience in Costa Rica, Guyana, Brazil, Ghana, and Papua New Guinea[1] with a variety of different models and solid PSP data have all tended to suggest that 0.7-0.8 m^3/ha/yr would be a safer working figure. The estimates that EiPac produces are of this order with most of the EI data that has been looked at, except with obviously understocked stands.

[1] Relevant references can be seen and downloaded from the author's website, http://www.bio-met.co.uk, under the references menu.

Conclusions

This report has described developments in the ISSMI and EI software, and their usage relative to planning and management in natural forest. The EI software has been developed over several visits by the author since 2000, and the ISSMI programs since 1999. A good deal of work has been done on the ground with both these systems, and field procedures are now well developed and operationalised, as is the data entry.

ISSMI has been used to support stand-level management, particularly by providing an infrastructure on the ground to regulate harvesting, with maps and tables from the software being used as supporting information. Currently, ISSMI is generating tree lists that are being used directly as bidding documents for the marketing of natural forest felling rights. A total of 4,400 ha has been surveyed using the ISSMI method since 1999.

The EI system of low intensity inventory has likewise been extensively applied, and has supported a number of significant projects in Sango Bay, Mabira, Kalinzu and parts of Budongo, covering in all some 32,000 ha of forest.

With the work described here, a number of operational issues with the software have been improved. These have included the points noted on pages 6 and 27. The EI growth modelling facilities are now operational, and can be used to make provisional estimates of sustainable yield. There are also additional reports to make the EI data more useful for management planning, especially the block or compartment summary report (page 13). It is easier to select data for a particular forest for EI analysis with EiPac: Formerly this required quite a complex procedure to set up an intermediate database.

Several seminars and training sessions have been held, especially relating to the three stages of management planning: initial mapping and inventory, delineation of a 10-year felling series and management planning, and then annual coupe planning and management. The EI procedures and software supports the first two stages, whilst ISSMI is primarily directed at coupe management and harvesting control.

Among the issues discussed in these seminars have been the costs of ISSMI, the low yields from natural forest, and the accuracy of volume estimates. The cost issues, relative to the functions that ISSMI provide, are discussed on pages 26-27. Low yields are a feature of sustainable management of mixed tropical forest, with figures around 0.7 m^3/ha/yr being quite typical; they imply that this type of forestry will always require multiple use and a social and environmental economic analysis in order to be justifiable. Systems like ISSMI become more, not less necessary under such circumstances, but their efficiency can be enhanced through careful control of extraneous costs.

The gross bole volume estimates of earlier versions have now been improved by adding net volume calculations to several of the EI and ISSMI reports of most direct management significance. The net volume makes realistic allowances for defective stems, according to the procedures described on page 37.

Work was carried out to improve the ease of installation of the software, and provide training in this process. All the main installation situations encountered at the NFA were tested, including local and network installations under Windows 2000 and XP, and also with Norwegian language systems. The installation kit and procedure is described in Appendix B.

This report has also tried to emphasise the overall context of the planning process. Hitherto, both EI and ISSMI operations have been done in a somewhat piecemeal and disconnected way. There is a need in future for all operations to be coordinated within the management process, with a national strategy for zoning the production reserves into felling series, the preparation of 10-year working plans for the immediate felling series, and the ISSMI operations on current years coupes. Of course, the process of institutional change and the uncertainty associated with it have delayed the settling down of the planning process. There is now a clear need within the NFA to have a period of stability, with natural forest planning and management operating according to some straightforward procedures in a routine way.

Beyond the application of the procedures presented in this report, the author does not have strong recommendations to make. However, there should not be endless policy indecision over issues such as the felling cycle or the allowable cut. Arbitrary decisions need to be made, and then enforced effectively over a substantive period of time for the sake of stability and development. It is a case, sadly, that the more different consultants are involved in such matters, the more different opinions will arise, and the less actual progress there will be. The author is content to accept the proposal for a 30-year felling cycle as a compromise between those who, like himself, would prefer a short (15 years) polycyclic system, and others, such as Osmaston (2000) who argue for a much longer monocyclic period (60-90 years). Likewise in terms of AAC, Dawkins (1964) long ago suggested 1 m^3/ha/yr as a pan-tropical mean, and it is a figure that has been widely used and adopted. The author believes it to be generally a little over-optimistic, but not to such an extent that it would do grave damage to the forest. He is therefore not opposed to planning on such a basis.

However, the author would wish to see the permanent sample plots established since 1998 re-measured. Some are now seven years from establishment, which is too long a period to leave a PSP: Paint marks and tree numbers become eroded and lost, and definitive and accurate re-measurement becomes increasingly difficult. The importance of PSPs in establishing proper growth models cannot be over-emphasised. The techniques for calibration described on page 41 are provisional approximations, and need to be replaced with more scientifically established figures.

He would also like to see the volume sampling exercise recommended in various earlier reports completed. It is now clearly appreciated within the NFA how important good volume tables are, with known sampling errors and scientific and objective defect allowances and taper data. Hopefully, completion of this will now be given a higher priority.

In terms of technical support for the software described here, the author regards this as an enduring commitment, and he will give whatever assistance may be possible by email in terms of general advice or problem resolution for the EI suite of programs or for ISSMI. He is always ready to undertake such further work on the ground as may be required.

The EI and ISSMI procedures have evolved over the last six years and become embedded as part of the process of natural forest management in Uganda. It is hoped now that there will be a period of consolidation when the practices will translate into a stable and effective management and planning system that combines profitable timber production with long-term natural forest conservation.

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Note that post-1995 reports and papers by Alder et al can be downloaded as PDF files from http://www.bio-met.co.uk.

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Reid, JW; Rice , RE (1997) Assessing Natural Forest Management as a Tool for Tropical Forest Conservation. *Ambio* 26 (6) 382-386.

Appendix A : Terms of Reference

Terms of Reference for a Consultancy to Improve the Integrated Stock Survey and Management Inventory Practices in the Tropical High Forest

Introduction

Since 1998, the Forest Resources Management and Conservation Programme (FRMCP) have been developing practices for management of natural forests in Uganda. As a result, field and office practices for Exploratory Inventory (EI) and Integrated Stock Survey and Management Inventory (ISSMI) in the Tropical High Forest (THF) have been developed and put in practice in some Central Forest Reserves (CFR). This has been done through technical support provided by Dr. Denis Alder, a THF management specialist. The approach has been a series of inputs by the consultant interspersed with application on the ground so that specialist interventions are directed at solving practical problems.

At this stage, the field practices have been adopted and their application at field level has stabilized. In the office, a number of practical aspects still need to be incorporated into the software to ease decision-making and further guide post-harvest silvicultural planning. This will require more input by the same consultant who has been helping to develop the practices.

Objectives of the Consultancy

During this visit, the consultant will:

1. Improve the software for growth modeling so that it can be used to estimate annual allowable cuts (AAC) for each forest.
2. Improve the ISSMI software so that it can be easily used for planning of harvesting and post-harvesting management.
3. Train the relevant senior managers of the NFA in the application of the software for decision-making

Specific Activities

Objective 1: Growth modeling for estimation of AAC

a. Improve the current EiPac growth model to enable estimation of AAC for each CFR and ultimately for all CFRs, provide outputs by species, and allow for multiple diameter limits
b. Prepare a detailed guide to use of EI/ISSMI data for determination of felling series or polyblocks

Objective 2: Use of software for planning of harvesting and post-harvesting management.

a. Improve the ease of using the mapping functions
b. Improve the tree selection functions with respect to existing and felling gaps, sites of ecological sensitivity (e.g. water courses), and balancing seed trees between species, among others.
c. Prepare a broad guide to using the management inventory information for decision-making
d. Address current bugs and problems met by staff in using the software and enable them to sort them out in future.
e. Enable the incorporation of changes made by forest managers as they implement harvesting and post-harvesting operations

f. Enable incorporation of enrichment planting ie track the seedlings planted, their locations and performance.

Objective3: Train NFA managers in the application of the software for decision-making

a. Install the ISSMI/EI software on the LAN so that selected managers can access the data at their desks
b. Train selected managers in using the software for compartment management planning and monitoring harvesting and post-harvesting work.

Appendix B : Installation of EI and ISSMI software

Introduction

Like any software, ISSMI and EI programs must be correctly installed on the local workstation before they will run properly. Simply clicking on and running files from another network location will not usually result in correct operation. There are three phases to the installation:

- Copying directory structure and files from their archive
- Setting correct database links and default directories
- Installing the mapping components

The first two steps can be done by most workstation users. The third requires local machine Administrator privileges on Windows 2000 and Windows XP.

The ISSMI and EI programs and their installation procedure have been tested with Windows 98, Windows 2000 and Windows XP, all running Microsoft Office 2000.

Version numbers

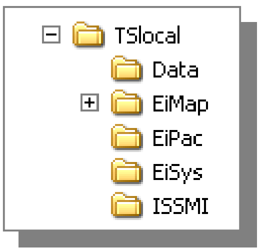
All of the programs show version numbers at the top of their opening screens. When reporting errors or troubleshooting problems, *it is important to check the version number*. Older versions of the programs exist on the NFA network and will cause confusion if run inadvertently in place of the latest versions. These older versions contain bugs or problems which have subsequently been fixed, and *they should simply be deleted and replaced by the latest versions*. At the time of writing these are:

ISSMI	2.15	February 2005
EiSys	2.01b	April 2005
EiPac	2.01	April 2005
Eimap	1.05	February 2005

It is re-emphasised – **do not use older versions of the software than those listed above**. Delete any old versions and replace them with those listed.

Downloading the installation kit

The above versions, plus working copies of the databases for demonstration and training, can be downloaded from http://www.bio-met.co.uk/uganda/tslocal.zip. The file size is 14 MB. When unpacked, this will have the directory structure shown opposite.



This should be unpacked and copied in its entirety to a directory of the same name on the local computer hard drive (usually C:\).

This setup includes working copies of the ISSMI and EI databases in the directory *\TSlocal\Data*. However, these are for demonstration only, and *should not be used as the working databases for entry of real data.*

Database location

There are existing working versions of the ISSMI and EI databases located on the NFA server. All the instructions in the following sections for installation which refer to database location are given for the demonstration copies in the installation kit. However, it is very important that for working copies of the ISSMI and EI software (as opposed to demonstration or training copies), connection is made to the databases on the NFA server.

In the EI database (*EI data2*), some changes to the *Models* and *Species* tables have been made since the versions left with the NFA in February 2005. To incorporate these, the existing *Models* and *Species* tables in the NFA Server master should be renamed (*eg*. *Models1*, *Species1*) and the new tables copied from the *EI data2* database in the current version of *TSlocal*.

Key points to note:

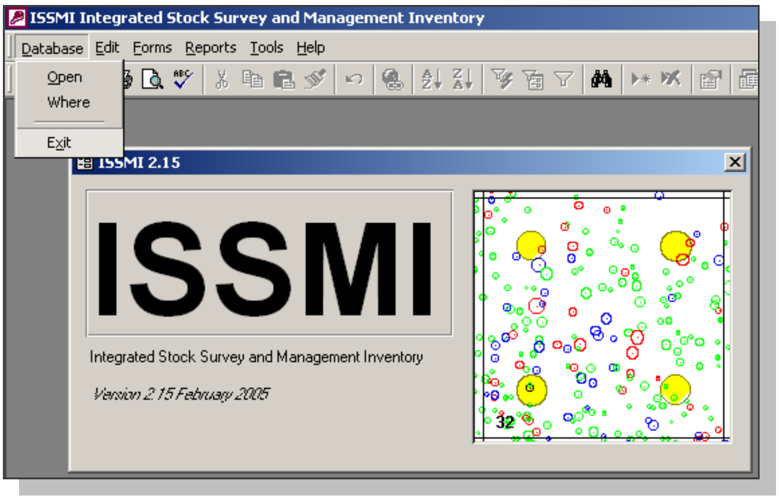
- ☑ Make sure working copies of ISSMI and EI programs connect to master databases on the NFA server.
- ☑ For demonstration and training only, connect to the databases supplied in *\TSlocal\data*.
- ☑ This guide illustrates installation using the *\TSlocal\data* versions.
- ☑ Make sure the *Models* and *Species* tables on the NFA master copies of the *EI data2* have been updated as explained above.

Program installation

Please refer to the section above regarding database location. In this section, databases are assumed to be in *C:\TSLocal\data*. However, for working databases, this should be replaced by the correct location on the NFA server. For demonstration and training, the instructions given here can be followed exactly.

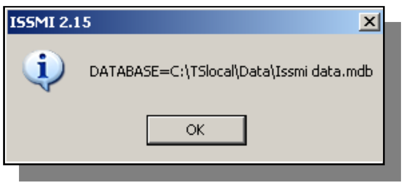
ISSMI

Start ISSMI by clicking on the file *Ismi2-15.mdb* from the file explorer. If following instructions given here, it should be located in *C:\TSlocal\ISSMI*.



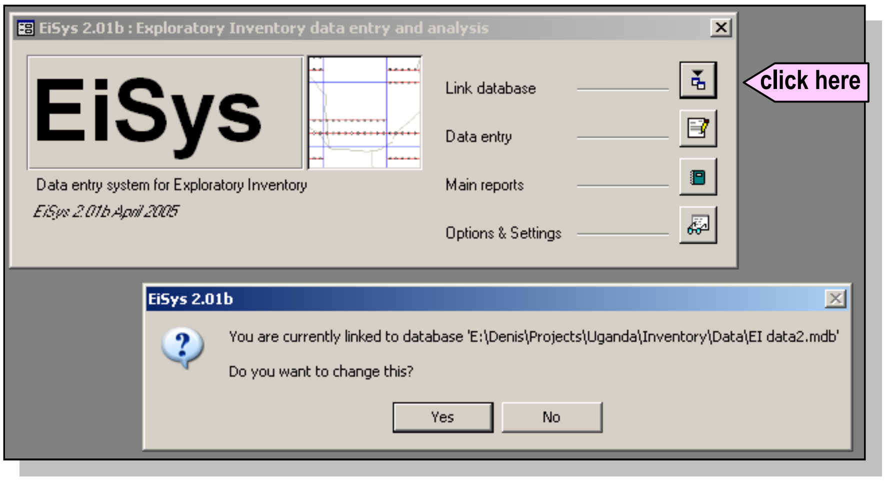
Then select *Open* from the *Database* menu. An *Open file* dialog box will appear. Use it to navigate to *C:\TSlocal\data\issmi data* and double click.

ISSMI is now correctly set up to operate.



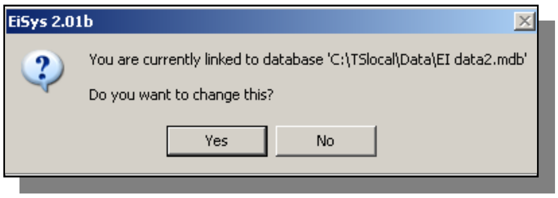
The *Where* menu can be used at any time to check the location of the currently connected database, as shown at the left.

EiSys



Start EiSys by clicking on the file *EiSys 2.01.mdb* from the file explorer. If following instructions given here, it should be located in *C:\TSlocal\EiSys*.

The EiSys startup dialog should appear, as shown at the right top. Click on the button *Link database*. The dialog box "*You are currently linked to database …*" will appear as shown. Click the *Yes* button. A file open dialog box will appear. Navigate it to open the file *C:\TSlocal\data\EI data2.mdb*. EiSys will respond with the message "*Linked tables set up OK*".

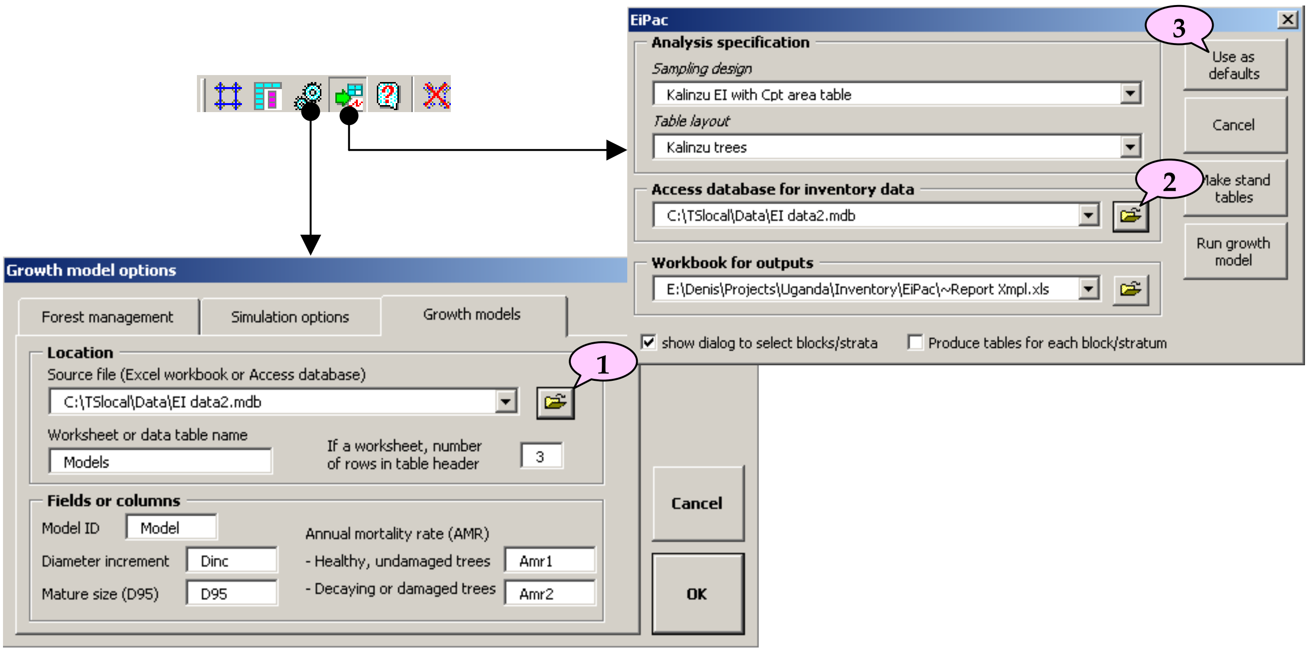


EiSys is now ready to use. If you click *Link tables* again, it should show the dialog at the left. If so, click *No*.

Note that when closing the EiSys application it will ask "*Do you want to close the EI database?*" Respond *Yes* to this until you are familiar with the system and have specific reasons to leave the database open.

EiPac

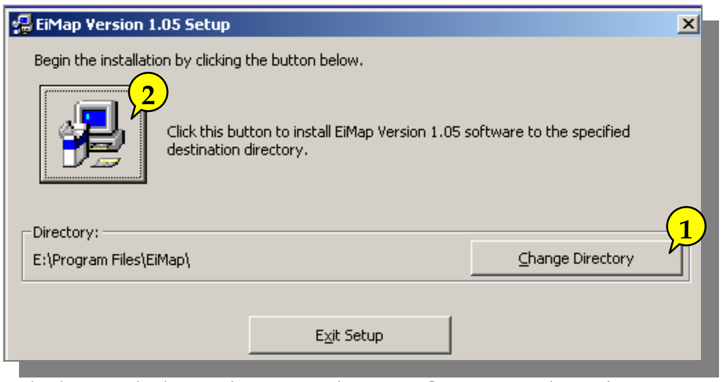
Start EiPac by clicking on the file *EiPac 2-02.xls* from the file explorer. If following instructions given here, it should be located in *C:\TSlocal\EiPac*. In Excel, the EiPac menu bar will appear. Click on the  symbol, and then the file open button ①. Navigate to the file *C:\TSlocal\data\EI data2.mdb* and double click. Close the *Growth models* dialog. Then click on the  symbol. Click on the file open button ②, and navigate to *C:\TSlocal\data\EI data2.mdb*. Click the *use as defaults* button ③ to close the dialog. Close Excel, responding *Yes* to the "*Do you want to save changes?*" message.



EiMap

Installing EiMap will also install the ISSMI GIS mapper. This process needs to be done by a user logged in with *Adminstrator* privileges for the local machine.

Using the Windows explorer, navigate to the file *C:\TSlocal\EiMap\Install\Setup.exe* and click on it. An installation Wizard will start. Click the Next button to the second screen, which should appear as shown at the right.

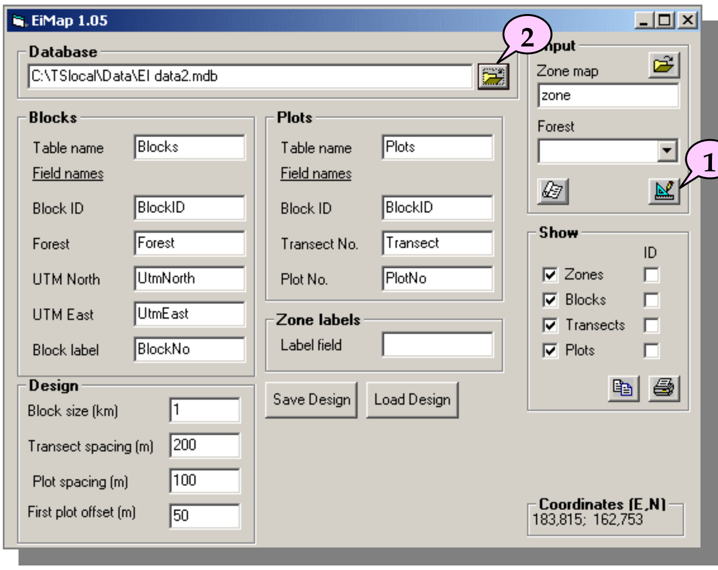


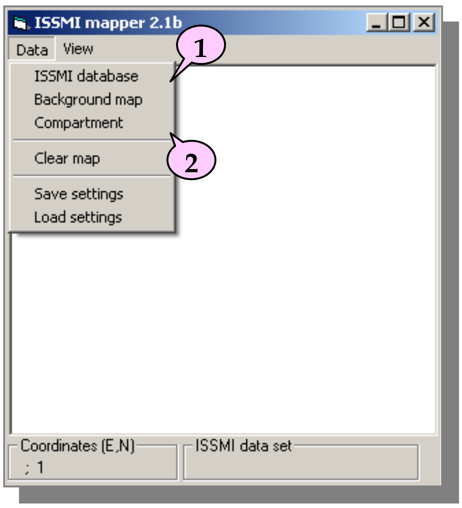
Click the *Change Directory* button ①, and navigate to select *C:\TSlocal\EiMap*. Close the file selection dialog. Click on the setup button ② to complete the installation.

EiMap installation loads a number of Visual Basic and ESRI MapObjects libraries onto the local machine. Several NFA machines have already been set up for EiMap and Issmimap2 – if done once, the setup process does not need to be repeated.

Upgrades of *EiMap.exe* or *Issmimap2.exe* can be installed simply by copying them over older versions, without needing to run the Setup program again.

After installation, start EiMap by clicking on *C:\TSlocal\EiMap\EiMap.* Click the design button ①, and then the file open dialog ②. Set the database directory to *C:\TSlocal\data\EI data2.mdb.* Close the EiMap window to save the settings.





ISSMImap

To finalise installation, set the database link for the ISSMI mapping program *Issmimap2.exe*. Use the Windows explorer to click on *C:\TSlocal\ISSMI\Issmimap2.exe*. The program window will appear as shown at left. Select ① ISSMI database from the menu. This will give a File open dialog. Use it to navigate to *C:\TSlocal\data\issmi data* and select it.

Once the database has been set, clicking *compartment* ② will bring up a list of compartments. If it produces an error message instead, then the database has not been properly set. Close *Issmimap2* to save the settings.

Troubleshooting

Most problems that arise with ISSMI and the EI programs in their present versions will have the following sources:

- ☹ *Various error messages*. The program is linked to a database that does not exist, to the wrong directory, or to a database that has been moved. Check which program the database is linked to, and that it is the correct one to use. The above installation guide shows how to check and renew the database links of all the programs.
- ☹ *Various error messages*. The program is an obsolete version. Check the version number against the list on page 52.
- ☹ *Various error messages*. Problems with the EiPac growth model can be traced to the *Species* and *Models* tables not having been updated as instructed on page 53.
- ☹ *Various error messages*. Some older copies of the ISSMI and EI databases have a different structure. Do not use these. The database structures should match those shown in Table 4 and Table 5.
- ☹ *Various error messages*. It is important that the decimal separator is a point, not a comma. European language systems (eg. Norwegian) often have comma set as the decimal separator by default. Systems in this mode cannot run ISSMI or EI programs correctly.
- ☹ *Data that has been entered cannot be found*. In this case it is likely that the data entry has not been done on the master database on the NFA server, or you are not working on the master database but a local copy.
- ☹ *The Setup program does not work*. This has been found on some of the older versions of Windows 2000, possibly because of a corrupted operating system. It will also happen if you try to run Setup when you do not have *Adminstrator* privileges for the local machine.
- ☹ *EiMap or Ismimap2 will not start*. This indicates they have not been installed on the local machine.
- ☹ *Various error messages*. You are using a linked database that is on a network path that is not currently accessible.

If you are unable to trace the source of a problem, please contact the author by email for assistance at denis@bio-met.co.uk.