GEMFORM : Forestry software for stand tables and yield projections in Guyana

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Executive summary

This report describes a consultancy visit by Denis Alder to the Guyana Forestry Commission Support Project between 5th October and 3rd November 2001. The terms of reference were to convert existing stock survey and inventory data sets into a standard form, and provide a program to produce stand tables including sampling errors, and to make stand projections based on models developed during earlier visits. The growth model was however to be supplemented by functions for recruitment and logging damage. The consultant was also expected to link all the data sets to the woody plants database; and to re-analyse volume functions to produce volume equations for net, defect free volume to a 30 cm top.

Not all these topics could be completed within the time available. A software package was written in Visual Basic called GEMFORM, which was designed to take a wide variety of input formats and produce stand tables according to user defined layouts, with sampling statistics. This program also included an updated stand projection model, with recruitment and logging damage, and able to calculate iteratively sustainable yields over the projection horizon. This software is largely complete and robustly tested with regard to its modelling and stand table output functions, and to inputs from stock survey data in a variety of formats. Time however did not permit the general interface to inventory data sets (involving many actual and possible formats) to be completed.

A two-day training course in Visual Basic for Excel was given, covering basic programming, principal program control statements (FOR, IF, DO etc.), common objects, properties and methods in Excel, especially the Range object, and the relationship between its Visual Basic-defined properties and methods and the normal interactive operations on cell ranges in Excel. The 7 staff members of the Forest Resources Information Unit participated.

The IFP tree volume data were revisited and tree volumes recalculated to give under-bark volume, net of any defect, to top diameters of 30 cm or above. These data where added to the VOLUME EQUATIONS spreadsheet from the previous visit, and revised form factors and form heights calculated by species and for general use. The average defect free form height across species is 10.2, whilst the equivalent form factor (based on a known merchantable length within the tree) was 0.63. A table of values by species is given in the report. As a rule of thumb, it can be said that commercial volume (defect-free, 30 cm minimum top) will be 10 x basal area.

The issues relating to species lists were explored, and the report describes a recommended approach. The simplistic use of one-to-one linkages of local and botanical names is unworkable, but a standard list is need for many purposes. It is suggested a database is set up that includes a thesaurus of local names, a list of standard names and mnemonic codes, and a botanical list based on the Woody Plants database. The linkage of the standard names to the local name thesaurus and woody plants database can be mediated by a linkage list that will permit the fuzzy connections to be managed and edited as necessary via a suitably designed form. The consultant recommends that development of this system be treated as a training exercise, and that at least two workshops are held to emphasise institutional acceptability and commitment to application in all sections of GFC of the resulting standard list.

To complete both the species list work and the inventory input functions of GEMFORM will require a further month of inputs, with approximately two weeks dedicated to either aspect, which the consultant suggests may be considered for January 2002.

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Acknowledgements

The consultant would like to thank those he has worked closely with at GFC during this mission, including Chris Turnbull, Neil Bird, Jagdesh Singh, Mohammad Khan and Darin … for their inputs and assistance. He would also like to thank NR International Ltd, who have organised this consultancy, for their administrative support.

List of abbreviations

CIDA .... Candadian International Development Agency
DAO .... Data Access Objects
DFID .... Department for International Development of the United Kingdom
FAO .... Food and Agriculture Organization of the United Nations
FIDS .... Forest Industries Development Survey
FRIU .... Forest Resources Information Unit
GEMFORM .... Guyana Empirical Model for Forest Management
GFC .... Guyana Forestry Commission
GFCSP .... Guyana Forestry Commission Support Project
IFP .... Interim Forestry Project
SQL .... Structure Query Language
SSM .... Silvicultural Survey Macros
TREMA .... Tree Recording and Mapping (a software package)
VB .... Visual Basic

Use of proprietary names and trademarks

Where this report refers to Excel, Access, FoxPro, Visual Basic, Office as proper nouns, then it is referring to the software products of those names produced by Microsoft Corporation. It acknowledges Microsoft's proprietary rights in respect of these names.

Disclaimer

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Introduction

Terms of reference

This report describes a consultancy visit undertaken by the author to the Guyana Forestry Commission between 5th October and 3rd November 2001. The key points for the agreed terms of reference for the assignment were as follows:

1. Modification of the existing Silvicultural Survey software to cater for pre-harvest and sample plot data. The main developments will be:
   - Adapting modes of operation, forms, tables and graphics from the present ones used for the silvicultural survey, with modifications as appropriate to each category of data
   - Further developing the stand projection model to include modelling of tree recruitment and the effects of logging damage in relation to future yields
   - For sample data, developing functions for data selection and for creating basic statistical reports (sampling errors and confidence ranges) to accompany outputs
   - Refining existing volume functions to provide estimates of recoverable bole volumes for principal species and species groups
   - Fully integrating the GFC woody plants database as the central species reference file
   - Overseeing the conversion/transfer of all existing datasets into the new format by GFC staff
2. Training for GFC staff in the use of the software developed and in related aspects of advanced use of MS Access and Excel for forest inventory data management and modelling.

This assignment is a follow-on from work undertaken in September/October 2000, which has been described in detail in a report titled *Development of growth models for applications in Guyana* (Alder,2000). During that period a computer program was developed to facilitate data input and report generation for the silvicultural survey, a type of post-harvest stock survey. A major part of that study was the analysis of permanent sample plots established and measured by the Tropenbos Foundation and Barama Company Limited, and the development of a simple growth model based on those data. This model was incorporated in the silvicultural survey software.

It was appreciated at the time that more flexibility was required in terms of data inputs for the growth model. GFC acquires data in several formats, from stock surveys and inventories, and also has several historical inventory datasets that have been archived and documented by the GFC Support Project. There was also a need for the capacity to produce the types of stand tables in the Silvicultural Survey software for these other data sources, and to calculate inventory sampling errors.

The forest inventory consultant had proposed the use of TREMA for this purpose (Wright, 1999). Efforts have been made in this direction, but TREMA was only likely to be viable if it was upgraded to Windows from its present MS-DOS version; although promised, this has never happened. As a DOS package, there are serious problems of connectivity with software such as Word and Excel that must be used for report writing.

Assessment of tasks

Although the concept is been suggested of standardising and converting the various datasets, the consultant felt this was not very feasible or appropriate. There are reasons that there are wide differences in formats. Different types of surveys are directed at different purposes and gather varying kinds of data; techniques evolve as thinking changes; data processing systems, and the skills required to use them, are in a continual state of flux.

A different approach has therefore been adopted of reviewing and classifying the kinds of datasets that exist, and designing a single package that can undertake two tasks based on them:

- Produce stand tables of species by flexible classifications of diameter classes, cumulative diameter classes or tree attributes, summarising tree numbers, basal area or volumes per ha or on a total area.
- Provide projections using a simple stand projection model. These include simulated harvesting, and logic to estimate sustainable yields over several cycles.

The name GEMFORM has been adopted for this software, as an acronym for Guyana Empirical Model for Forest Management.

The issue of species lists and the woody plants database was also reviewed. It was felt that, although there is progress towards a standardised forestry field list, this has not yet been finalised; and the historical and existing datasets in any case have their own various and eccentric varieties of species list which the software would have to cope with. This report will hopefully clarify some of the design and technical issues relative to species lists as a component of forestry information processing. GEMFORM has therefore been designed to cope with many kinds of lists, or indeed, none at all and should be adaptable to future developments within GFC in this regard.

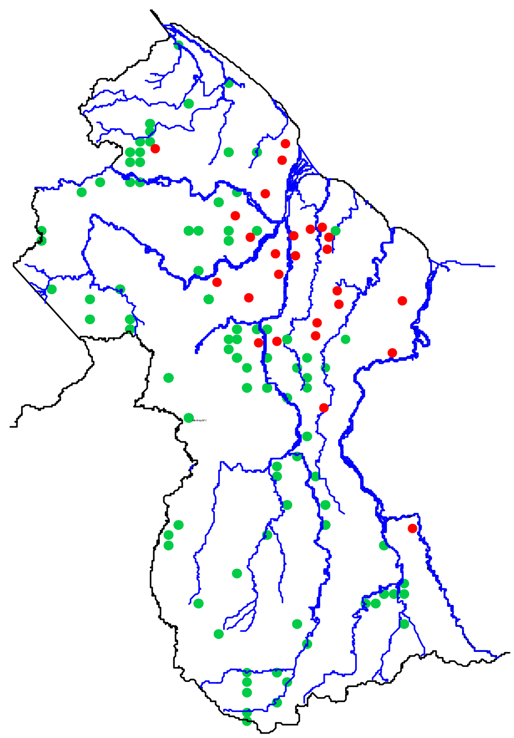
During the earlier assignment, the consultant had reviewed and re-analysed the tree volume samples from the Canadian Interim Forestry Project of 1992. It was noted however that that work had included log sizes down to the measurement limit of 10 cm, and small trees form 10-30 cm, whereas the absolute minimum size for practical utilization is of the order of 30 cm diameter. The IFP study also includes quality estimates for each log section, which could be used to restrict the volume tables only to strictly useable log volumes in commercial terms. The Terms of Reference, as noted above, address these points, and the consultant has re-processed the data using these stricter criteria to produce revised and more conservative volume functions. The procedures are documented in this report.

The training issues in the TORs have been addressed through an internal training workshop in Visual Basic techniques for Excel . The key points and exercises covered are described in this report.

Classification of forest surveys

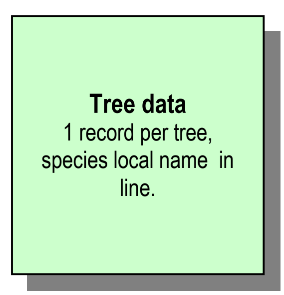
The history of forest inventories in Guyana has been reviewed and their characteristics described in some depth by Wright (1999). Two major inventories have been converted into Access databases, the FAO-assisted FIDS Inventory of 1972, and the Canadian CIDA-assisted IFP inventory of 1992. The coverage of these inventories is shown in Figure 1, with each location comprising a cluster of a variable number of plots. The botanical data from these inventories has been used as the basis for the recently revised GFC forest type map of Guyana (ter Steege, 2001).

Figure 1 Location of FIDS (1972, green) and IFP (1992, red) inventory clusters



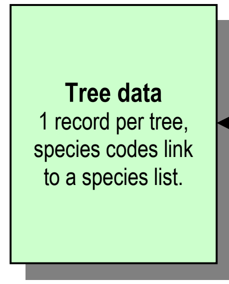
Various other surveys have been carried out including 100% stock surveys (pre-harvest) and silvicultural surveys (post-harvest), *ad hoc* inventories relative to concession or timber lease agreements, and inventories on Iwokrama forest reserve (Iwokrama, 2000; Alder, 2001).

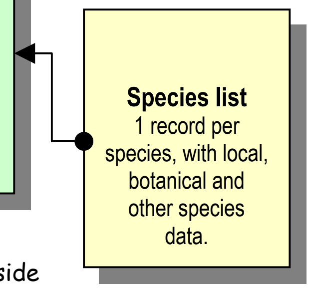
These various datasets conform to four basic structural models, indicated by the following diagrams:



1. A flat file, with one record per tree, species name typed in as text, and no separate species list or header records. This type of structure is typical of the pre-harvest stock survey data.

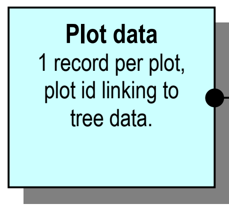
2. Tree data with a linked species list. This characterises the silvicultural survey. A separate species list allows common species-related data to be placed in the list and looked up during processing.

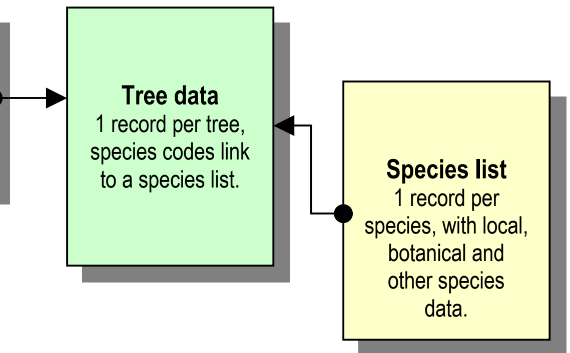




The relationship between species and trees is one-to-many (1-m), ie. one species may link to many tree records. The arrow direction shows the 'many' side of the relationship.

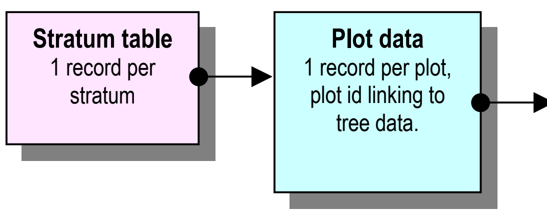
3. Plot data linked to trees (1-m), themselves linked to species (m-1).

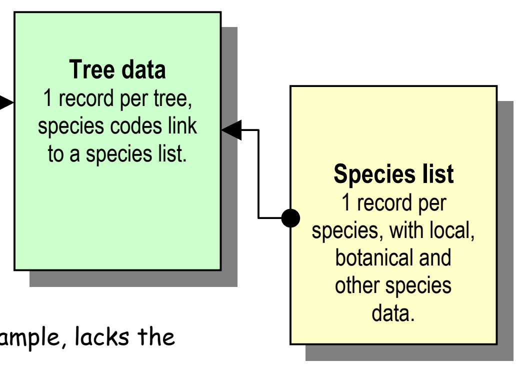




The converted IFP data in Access, is in this format. All the files converted to TREMA require this layout, with an SCODE field linking a header record with tree data.

4. Plot-tree-species data grouped by strata. This is the most typical layout for forest inventory data collected by stratified random sampling. The stratum table will typically contain stratum area, forest type description and ownership information.





The IFP data set uses this type of relationship, although in the converted database, the links are only loosely defined. The stratum table, for example, lacks the essential area information.

Formal database concepts

It is useful to be clear about some database concepts. A *table* consists of *records* and *fields*. For example, a table of tree data has one record per tree, with fields such as species, diameter, height, quality and so on. A *database* is a collection of related tables. Depending on the system in use, the tables may be in separate files (as with FoxPro) or combined into a single file, as with Access.

Tables in a database are linked by *key fields*, such as species code or plot id. The key field must occur in both parties of a linked pair of tables. Ideally the key field will have the same name in both tables, although this is not usually required.

Relationships exist between records in different tables linked by a key field. These can be *one-to-one* (1-1), *one-to-many* (1-m), or *many-to-many* (m-m). The one-to-many relationship is the most important in many contexts and tends to involve formalised behaviour in database systems such as Access. A 1-m relationship implies that on the one side, there is a single record, linking on the many side to many records. In a species list, a single species entry links to many tree records for example.

Referential integrity is an optional characteristic of key fields that can be enforced in Access and most formal relational databases. It implies two rules:

1. *On the one side, a key can only occur once*. In other words, you are not allowed to enter two records with the same species code in a species list, for example.
2. *On the many side, every key must correspond to an entry in the table representing the one side*. Thus, you cannot enter a species code for a tree unless it is represented in the species list.

These rules both reduce mistakes, and internally, allow faster and more efficient algorithms to be applied for querying and summarizing data. Without them, data is likely to *disappear* when summarized using queries on linked tables (ie. records that cannot be married up between the tables will simply be ignored, without any warning to the user).

The TREMA database

TREMA was recommended by the project's forest inventory consultant (Wright,1999) as a software package that could be used to store and standardise all the inventory data sets held by GFC. Although a lot of effort has been made to convert datasets to TREMA, it has in the end has proved to be something of a disappointment, due to the following limitations:

- It is a DOS-based package. As such it does not conform to the usual standards for text formatting, cut and paste, and so on for Windows-based programs.
- It is based on a now obsolete standard for FoxPro for DOS (version 2.6) and has only limited compatibility with current versions of Visual FoxPro (version 6).
- TREMA has very limited processing capacity in its own right. It serves mainly to impose certain disciplines on forestry datasets. As such, its actual processing functionality is marginal, whilst a considerable learning curve is involved in getting to grips with its eccentric menus and nomenclature.
- Technical support has proved to be more or less non-existent. It is not a commercial package, but rather a project spin-off from the mid-1990's, and must be regarded now as frozen in its present configuration. A promised Windows version has never materialised.

Although *the continued use of TREMA is not recommended by this consultant*, the datasets already stored are easily accessible by other packages provided their original file names are understood. TREMA files are DBF (FoxPro 2.x) formatted and can be opened directly by MS Office applications such as Access and Excel. Excel can be used to examine TREMA files and understand their structure. Required tables can be easily imported into Access and reformatted and restructured for a more convenient design.

Access

The two principal inventory datasets held by GFC are the FIDS and IFP data. Both of these have already been converted to Access with assistance from Hans ter Steege. The author has added a species list to both these files which provides growth model codes for the most common species in both tables, to facilitate stand projections with GEMFORM or MERLYN.

Access has many positive features and is strongly recommended as the basis for future forest inventory data management within GFC. Its positive points include the following:

- Ease of use, a flat learning curve, wide available of reference books of all levels.
- Wide compatibility with other packages, including FoxPro (*eg.*. TREMA files, Iwokrama inventory data, ArcView files).
- Powerful but easy-to-learn techniques for data extraction, cross-tabulation, summarisation and processing via queries. Queries can be formulated visually for beginners, or in SQL for advanced users. Provides a training platform for SQL.
- Easy migration to and linkage with Microsoft SQL Server, to which an Access database can serve as a front-end. SQL Server is likely to be used for production[1] databases within GFC in the medium term[2].
- Easy linkage to Excel, which is the most useful system for analysing and presenting data, especially for *ad hoc* (one-off) tasks.
- Programmable via Visual Basic, again minimizing the learning curve relative to computer programming skills.

Excel

Excel is universally familiar to computer users in the office. In GFC, stock surveys and silvicultural surveys are entered and processed using Excel, and it is also suitable for processing inventory plots, as exemplified by the MERLYN software. However, few users appreciate the depth and power of Excel, which has a large repertoire of facilities, processes and functions for every kind of summarisation, cross-linkage of data (table lookups), cross-tabulation, statistical, mathematical and engineering calculations, optimisations, etc. It is also fully programmable with Visual Basic. This latter mode both extends the power of and automates the tasks which Excel can perform; and at the same time provides an easy route for technical staff to learn computer programming.

The linkages of Access and Excel are close and easy. The most efficient technique is to use Access to store data for large tasks, and use queries for the primary analysis. The resultant query tables can be opened in Excel, formatted for publication, converted to graphical form, or used as the basis for further analyses using the specialised features in Excel.

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[1] I define *a production system* in information technology is one in regular and standardised use for routine and ongoing tasks, such as an accounts system or an enterprise management information system (MIS).

[2] As advised by Tony Farnum, installing GFCs network server system (farnumt@wow.net), October 2001.

Excel is not suited for all data processing tasks. It has the following limitations:

- Recalculation time of large spreadsheets is an exponential function of their complexity. In spite of the improvements in computer power year by year, it still unsuitable for tasks which involve *repetitive calculations* on large datasets (*eg*.. beyond 1,000 records).

- Excel is not suited for shared access over a network, because of the spider's web of linkages that tend to ramify among cells. Although the operating system will mediate shared access on a network, a file will become effectively locked up by a single user unless it is very simple.

- Excel in its present version (this may change) cannot do SQL queries *on its own internal tables or worksheets*. As SQL is a very powerful summarising technique for data, this is a significant limitation. (Note however that Excel can run SQL queries on external data, *eg*.. in Access, from Visual Basic).

- Excel has size limitations which prevent its use with large datasets (c.65,000 records per sheet). Processing speed is likely to become an issue long before this limit is reached.

- Excel lacks internal checks on the integrity of calculations. In other words, it is easy to make mistakes by wrongly stipulating, for example, the range of cells to be included in a SUM formula, without this being apparent. There are many kinds of subtle error that can occur which can cause incorrect results. In critical areas (such as an accounts system), the use of Excel may be unacceptable for this reason.

- It is difficult to implement security in Excel, beyond simple password access. There is no structure for levels of authorised use, for example.

It is possible to fully process large forest inventories in Excel. However, the consultant does not recommend this. Its present use for stock surveys and silvicultural surveys is essentially transitional, because the procedures and scope of application are still developing. For *ad hoc* work, where applications need to be developed quickly and used only a few times, Excel is unsurpassed. Once these operations become routine and standardised, then the data processing should be redesigned to use a database plus, perhaps, Excel macros for the final stages of the output.

SQL (structured query language)

SQL has been mentioned in several contexts above. It is a standardised language for querying databases that is employed within almost all databases packages in widespread use, including for example Access, FoxPro, Dbase, Paradox, Oracle, Microsoft SQL Server, MySQL and others. SQL statements can be used within Visual Basic in Excel to extract and summarise data from any of the above types of database.

Access provides good facilities for learning SQL, as it is possible to flip between the visual query developer that uses drag-and-drop methods to develop a query, and an SQL editor, that shows the constructed query as an SQL statement.

Although Access can be used effectively in large measure without learning SQL, there are several reasons for data analysts to learn it:

- Once the basic principles have been grasped, it is quicker and easier to formulate complex queries in SQL rather than via the Access query editor.
- Using queries in Visual Basic requires a knowledge of SQL.
- Some types of complex queries (notably UNIONs of datasets) can only be executed in SQL.
- A knowledge of SQL is required for products such FoxPro, Microsoft SQL server (which may be used at GFC in future), or for work on Internet databases.

The first two points are the most important – the latter are likely to be in the domain of the computer professional.

The consultant recommends that if the opportunity presents itself*, an internal training course should be held in the FRIU on Access queries and SQL*. It would have been desirable to achieve this within the present visit, but time has been insufficient.

Inventory data processing as a system

Inventories can be considered to be one-off, *ad hoc* tasks, or routine data processing activities (production systems). In Guyana the former approach dominates at present, and is likely to do so for some time to come, until forest management systems have settled down and become in large degree standardised. This makes the development of related software such as GEMFORM harder as it is not possible to know in advance exactly how the data may be presented, or what information be regarded as typical. The table overleaf shows some of the differences that exist between current types of inventory data held by GFC. This table does not include permanent sample plots, whose features are discussed in an earlier report (Alder, 2000); there may also be data held on some commercial inventories (*eg.*. Vergenoegen Sawmill Ltd, 1997) that the consultant is not aware of.

However, what is apparent from this assessment is the variety of formats and systems used, and the incomplete nature of much of the data. A well-organized inventory for management planning should use the type 4 file structure of Strata-plots-trees-species noted on page 7. For growth modelling, incomplete or unbalanced sampling (only commercial species, only commercial stems, high diameter limits, diameter limits that vary with species) drastically limit the techniques that can be employed to the simplest kind of stand projection.

Table 1 : Features of principle forest inventory and stock survey data sets held by GFC

(This is not an exhaustive list. Some commercial inventories may not be included, nor are permanent sample plots)

Inventory	FIDS	IFP	Pre-harvest stock surveys	Silvicultural surveys	Management inventory	Rapid Assessment Surveys
Status	Archived data. Inventory project completed by FAO 1972.	Archived data Inventory project completed by CIDA in 1992.	Done on demand. Procedures developed under GFCSP	Monitoring and management investigation task developed under GFCSP.	East Kurudini Management Inventory undertaken under GFCSP, March 2000	Management planning tool developed under GFCSP.
Computer software	Original not known (probably FORTRAN). Now held as Access database. No specialised inventory software.	Originally GW-BASIC with ASDCII data. Now held as Access database. No specialised inventory software.	Excel worksheets, various formats used ad hoc in each case.	Formalised Excel workbook structure with Visual Basic macros produces stand tables and growth projections.	TREMA including stand table add-in for analysis. Data in FoxPro 2.x files.	Excel worksheets. Processing using worksheet functions.
Species list	As Access table with local name, family, genus, species, integer code. Nomenclature revised by ter Steeg (2001).	Local and botanical name, numeric codes (different to FAO). Nomenclature revised by ter Steeg (2001).	No separate species list or codes. Local name in tree table. Lookup validation list in some versions.	Separate species list, local name used as code. List gives commercial status, diameter limit , model for projections.	TREMA master list, based on Woody plants database. Numeric species code. Original list extended for fuzzy IDs.	Individual species not identified in data .
Stratification	Stratified by API and location. Stratum details stored in plot headers include location, forest type, No stratum area info now available. Stratification re-worked by ter Steege(2001).		Not applicable – single stand survey.	Not applicable – single stand survey.	Systematic, but post-stratified by 100 ha blocks for reporting.	Stratified by blocks. A line of plots per block.
Plots	Fixed area from 0.1 to 1 ha, mostly 0.4 or 0.5 ha. Separate plot header table with plot size, inventory date, location and site data.	Point samples, BAF mostly 6-8, some 4, a few 2. Separate plot header table with plot size, location and site data. Smallest tree 7 cm.	100% inventory of commercial stems of good quality, with log length, minimum size 30 cm. Methods have varied as techniques evolved.	100% survey of commercial species over 30 cm, non-commercial 60 cm dbh+.	1000 m2 circular plot, trees 35 cm dbh+, inner 400 m2 plot trees 10 cm+. Plots on lines at 100 m intervals.	Point sample, BAF 4. Only commercial trees counted.
Tree data.	One record per species per plot. Species name, code, diameter tallies by 4" classes across record. Smallest tree included: 12" dia (30.5 cm)	Species, dbh and risk class.	Tree dbh, species local name, log length.	Dbh, stem quality (form, decay, damage). Stump diameters.	Dbh, risk class (stem quality), log length of useable trees.	Individual tree details not recorded.
Prognosis for modelling.	Date too old. High minimum size. No quality information, no stratum areas.	Useful data. No stratum area but can be inferred for vegetation types.	Data incomplete. Simple projection of commercial yield over 1-2 cycles possible.	Modelling software developed. Projects yields over 2 cycles. Recruitment not modelled.	Useful for modelling. All required information.	Not useable for modelling under current paradigms.

The development of GEMFORM

The design concept

GEMFORM is intended to meet the need for summary stand tables in various formats, and for stand projections, sustainable yield and allowable cut estimates, based on the datasets that actually exist or are likely to be collected in future. This implies the ability to accept the following formats:

- *Access, FoxPro (TREMA) or Excel data sources*. This basically involves two classes of data. The Microsoft data access objects (DAO) library can handle Access and FoxPro files in the same way within Visual Basic, subject to a few simple constraints, such as that the FoxPro files must reside in the same directory. Excel files need to be handled differently, and require separate input routines.

- *File organization types 1-4* as detailed in the previous chapter (pages 6-7). This is relatively straightforward in Access, involving 4 basic SQL skeleton queries. In Excel it is much more complicated, both because there is more freedom about how data may be laid out, and because linkages of data tables is not automatic.

For stand table outputs, the following are features that should accommodate the majority of requirements that the consultant has experienced:

- *Diameter class columns*. These are conventional classes, 10-19 cm, 20-29 cm, etc. The software needs to allow variable class widths and numbers of classes, including no diameter class columns.

- *Totals above a certain minimum diameter*. These types of class are often more useful than conventional classes since one is concerned with volumes, tree numbers etc. above specified size limits. The software should allow variable numbers of total columns above different specified limits, or no totals.

- *Totals columns by tree quality classes*. If categories have been measured, such as damage, defect, sweep, stumps, then these need to be presented as totals.

- *Selection of input trees by categories*. There should be a general facility to include or exclude trees according to certain criteria (such as merchantability).

- *Rows should be organized by species*. This is fundamental to a stand table design.

- *Sub-totals should be possible by species groups*. Species grouping implies the existence of a species list with a group category, but assuming this is present, the software should be able to sub-total in this way.

- *Rows and groups should be sortable by various criteria:* Species name, frequency or volume (common first) are normal possibilities. Species groups need to have a special sorting facility since their preferred order may not be numerical or alphabetical. The sorting should be hierarchical, by species within groups, then by groups.

- *For sample inventories, sampling errors need to be displayed.* To avoid undue complexity in designing the software, this is proposed to be possible for diameter totals columns or for species group subtotals, but not for individual species or diameter classes. Sampling errors can be presented as sample error % (the percentage ratio of standard error to the mean) or as a reliable minimum estimate to a specified degree of confidence (*eg.*. 95%).

Finally the table should summarise one of a number of possible options: tree numbers per km^2 or for the total area, basal area per ha, or volume per ha or total volume.

These various options define the stand table. For growth projections there are options relative to stand management (felling cycle, length of projection, harvestable diameters, useable species groups), logging damage levels, recruitment assumptions, definitions of codes indicative of decay or form defect, and yield regulation options. In the growth projection method for the Silvicultural Survey Macros (Alder, 2000), the model determines the sustainable yield over two cycles. GEMFORM has been specified to similarly estimate sustainable yield over any number of felling cycles by an iterative search process.

Modules in GEMFORM

Figure 2 shows the modules in GEMFORM and their relationship to data sources, user options, and outputs.

Two types of data source are considered: Excel worksheets, and MS Access-compatible databases (Access and some versions of FoxPro and Dbase files).

Depending on the data source, two distinct approaches are needed to building data into a standardised internal format. The Access-compatible data will be extracted and summarised principally via SQL queries; whilst the Excel-compatible data will be processed using Excel worksheet functions and Visual Basic macros.

On this internal data structure, data can be summarised either into stand table format, or into cohort format. The latter summary is used by the stand projection module to perform growth simulations.

User options define the type and layout of the data source, the details of how data should be summarised for stand tables, and options for modelling, including forest management assumptions.

The output comprise either stand tables of current stock, or projections of future yields and estimates of sustainable yield.

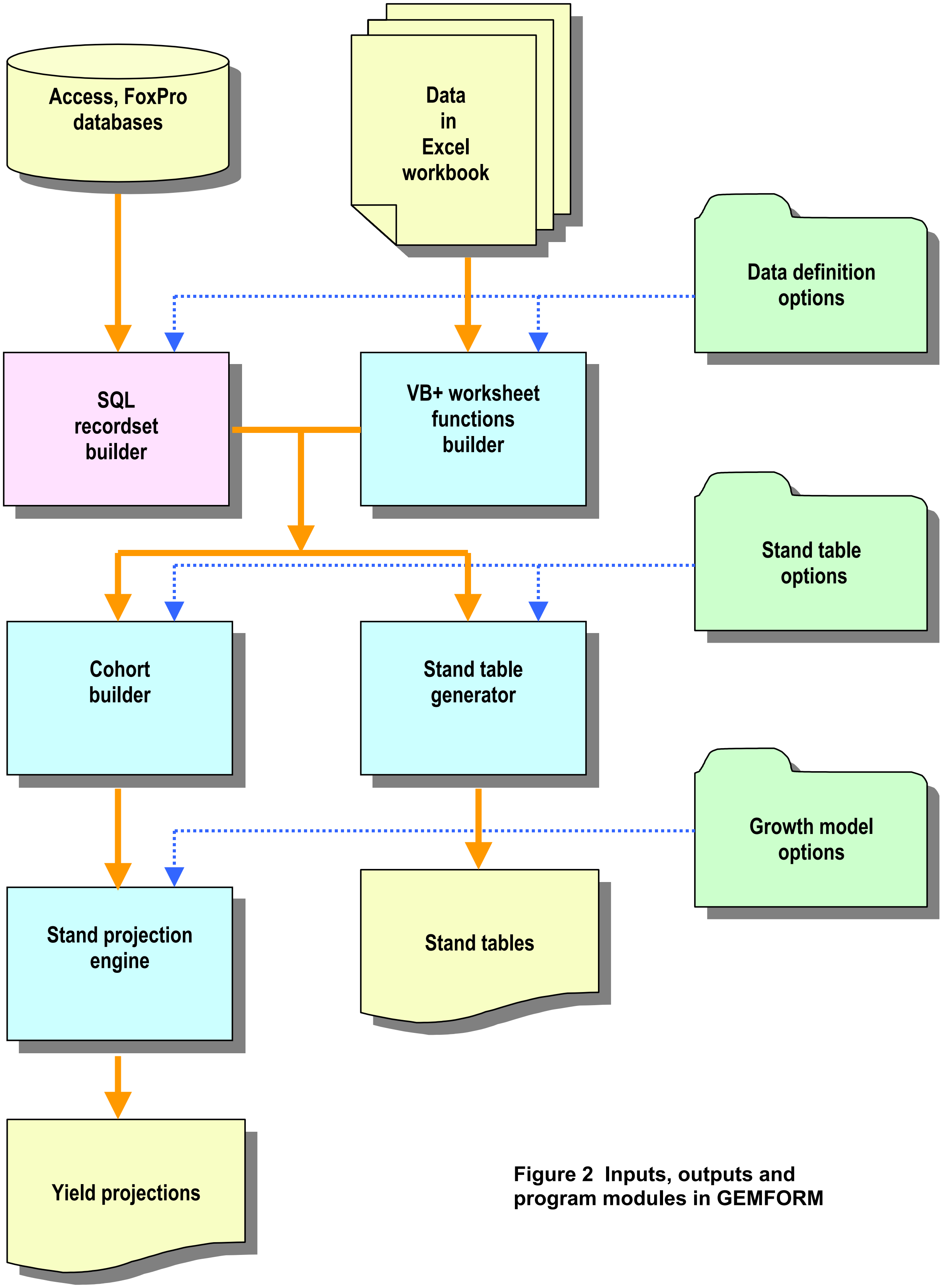
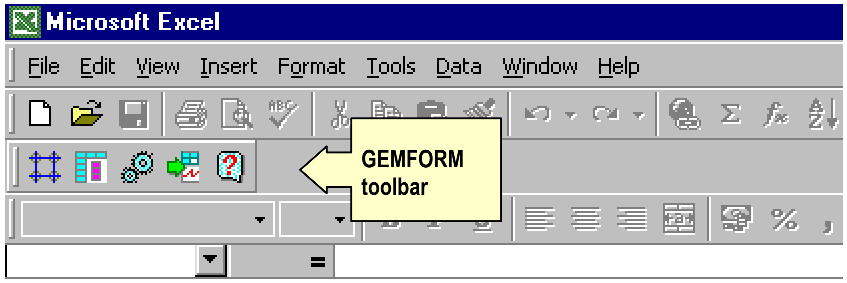


Figure 2 Inputs, outputs and program modules in GEMFORM

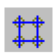
Running GEMFORM

GEMFORM is run for the first time by clicking on GEMFORM.XLS from the Windows Explorer, or by opening it from the Excel open file menu.

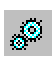
A toolbar will appear in the Excel toolbar region as shown below.



Clicking on the various buttons will give access to the following tools:

 Sampling design and source data layout options

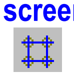
 Stand table design

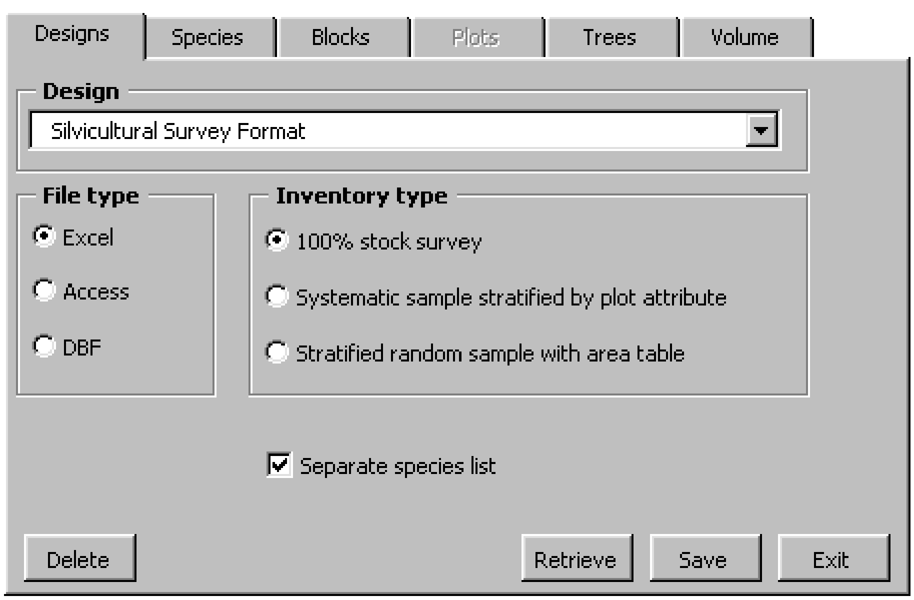
 Growth model settings and forest management options

 Execute the stand table or growth model modules

 GEMFORM help – which comprises the text in this and and the following pages of user guidance, cross-referenced in hypertext format.

The sampling design screen





The sampling design screen appears as shown above when the design button is pressed. On the Designs tab, as shown above, the following options and actions can be performed:

A design name can be selected from a list, or a new design name typed in. Selecting or typing a design name does not directly alter the settings on the form or save the settings to file. Thus must be done by pressing one of the following buttons:

Retrieve Retrieves the named design from file. The parameter settings on the screen form will be updated to those of the saved design.

Save Saves the current settings under the name shown in the Design box. If this design already exists, its previous settings will be overwritten

Delete The named design will be deleted from the list. This operation cannot be undone.

Exit Closes the design form. This has the same effect as the Close W1ndow button at the top right of the form.

One of the **File type** options can be selected. This indicates the type of source data, either an Excel workbook, an Access database, of a directory containing FoxPro 2.x DBF files. Note that if FoxPro files are used they must all be in the same directory.

One of the **Inventory type** options should be selected. This can be a 100% stock survey, or data organised into sample plots, which will be treated as a stratified random sample. If the data includes a list of strata or blocks with their areas, then the third option should be selected. If there is no stratum area table, then the second option will be selected. In this case the system can post-stratify by a plot attribute, but can only calculate per ha statistics, and not area totals.

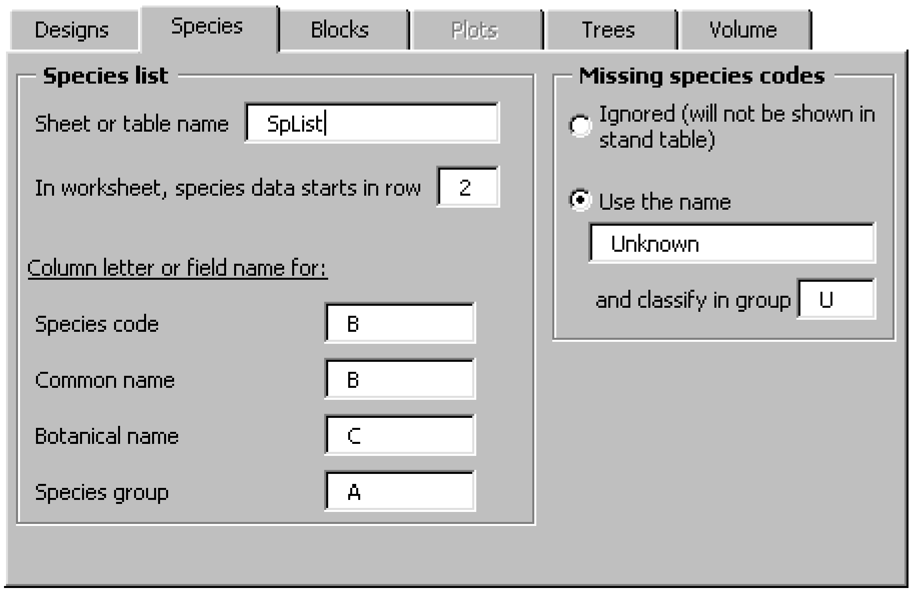
The **Separate species list** box should be checked if there is a linked species list. If not, then species names should be entered directly with the tree records. In this case, although stand tables can be produced, grouping is not possible; nor can the growth model module be used.

The **Species tab** of the design form, as shown overleaf, gives information about the species list. If the species list checkbox is cleared on the Designs tab, this tab will be disabled and inaccessible. Otherwise it will be visible.

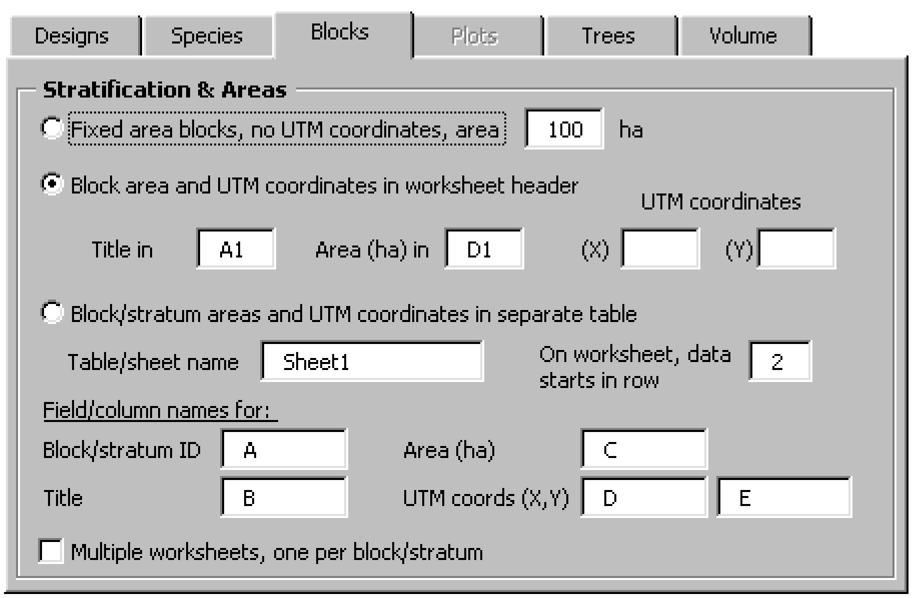
The **Species list** frame encloses option settings relating to the location and layout of the species list. The *sheet or table name* gives the name of a table (Access or FoxPro) or worksheet (Excel) that contains the species list. If it is an Excel worksheet, the first row of the species list, excluding any header or titles, must be given in the box labelled *...data starts in row....* For database tables (FoxPro or Access), this box is ignored.

The remaining boxes in the frame give either the column letter (Excel), or the field name (database) for the indicated items. If the items are not present, they can be left blank. In the example shown, the list is referenced by local name, so column B is marked as both the *Species code* and the *Common name*. More usually, these will be distinct.

The species group controls summary outputs in the stand table, and also the designation of commercial species in the growth model.



The **Missing species codes** box shows how GEMFORM will handle species in the data which have no entries in the species list. They can either be ignored, or substituted with the common name indicated, and classified in a default group.



The **Blocks** tab of the sampling design form specifies the stratification or blocking of the data. For a stock survey, blocks are the unit on which the survey is carried out, and the **Plots** tab will be disabled, as shown above.

There are three ways in which block or stratum data can be specified:

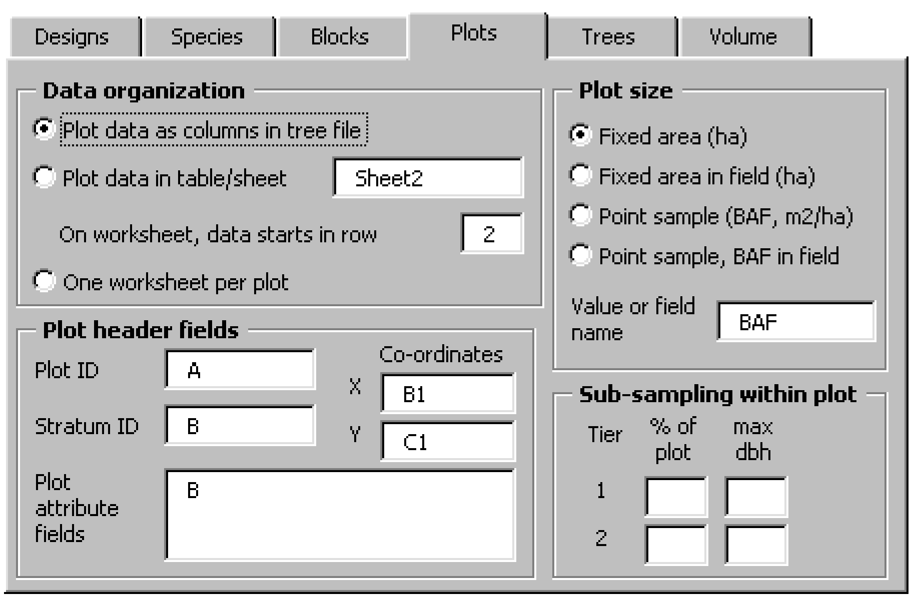
- For the simplest case of a single stock survey, the area can be entered directly opposite the *Fixed area block* option button, which should be selected. In this case the *Block title* which appears on the stand table and model projections will be the data sheet name. This should accordingly be amended to something descriptive, and not simply left as the Excel default *Sheet1* etc.

- Block areas and a block title can be inserted in the header of the data sheet when using Excel data. This option is not available for database sources. In this case the *Block area … in worksheet header* option should be selected, and cell references given for the title and area data, which must be on the same sheet as the tree data.

- A separate table can be used, either on another worksheet for Excel data, or in a database table, to give stratum or block IDs, titles and areas. If this option is used then the tree data and plot data formats must include a stratum ID that links to this table.

The references to UTM coordinates on this form can be ignored, and these fields left empty. The consultant had envisaged some facilities to link the inventory or stock survey data to the GIS system, but time has not permitted this aspect to be explored.

The **Plots** tab, shown below, will be disabled if the *stock survey* option is selected on the **Designs** tab, but requires to be completed for inventory data.



This allows for three basic styles of **Data organization**. The first is where there are no detailed plot headers, but simply a plot number in the tree file. This is the simplest possibility.

The second option is for a separate plot header table. If this is selected, then the database table or worksheet name must be given. If it is a worksheet, the starting row in the sheet is required.

The third option is only appropriate with quite large plots, with worksheet data. In this case, one worksheet per plot may be adopted.

If a separate plot header table is used, then the columns or fields in it are entered in the frame **Plot header fields**. The coordinate fields X and Y are not used in this version of GEMFORM. The attribute fields to be used for post-stratification can be listed: Each stratum will comprise a unique combination of attributes. Therefore only those attributes which are to be used as a basis for stratification should be listed. If a separate stratum list is being used, these attribute fields will be ignored.

The **plot size** is determined according to one of several possible options. If it is fixed throughout the sample, then the plot area in ha is entered in the text box below (**value or field name**). If the plots are fixed area plots, but different plot sizes are used in different localities within the sample, then plot size must be entered in the plot header table. In this case, the field name or column letter is entered in the text box. If point sampling is used, then the basal area factor (BAF) in metric units (m2/ha) is given in the text box; if the BAF varies from plot to plot, then it must be present as a field in the plot header table, and the field name is given.

For fixed area plots, **sub-sampling within the plot** is commonplace. GEMFORM allows two tiers of sub-sampling. The larger sub-sample should be listed first, as a percentage of the plot size, with the largest diameter included on the sub-sample. An inner sub-sample can also be included, using the same defining variables.

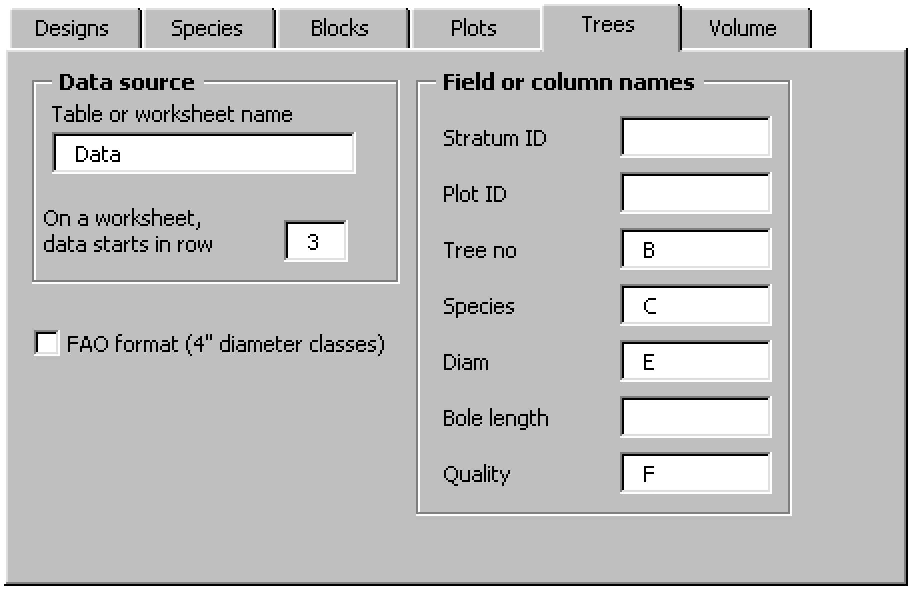
GEMFORM cannot cope with the following two kinds of sub-sampling:

- *Sub-sampling based on species*, *eg.* commercial species on the main plot and non-commercials on a sub-sample.
- *Sub-sampling across sets of plots*, as for example when every fourth plot might be treated as a sub-sample and measured to different standards.

There are in any case significant reasons for avoiding either of these two methods.

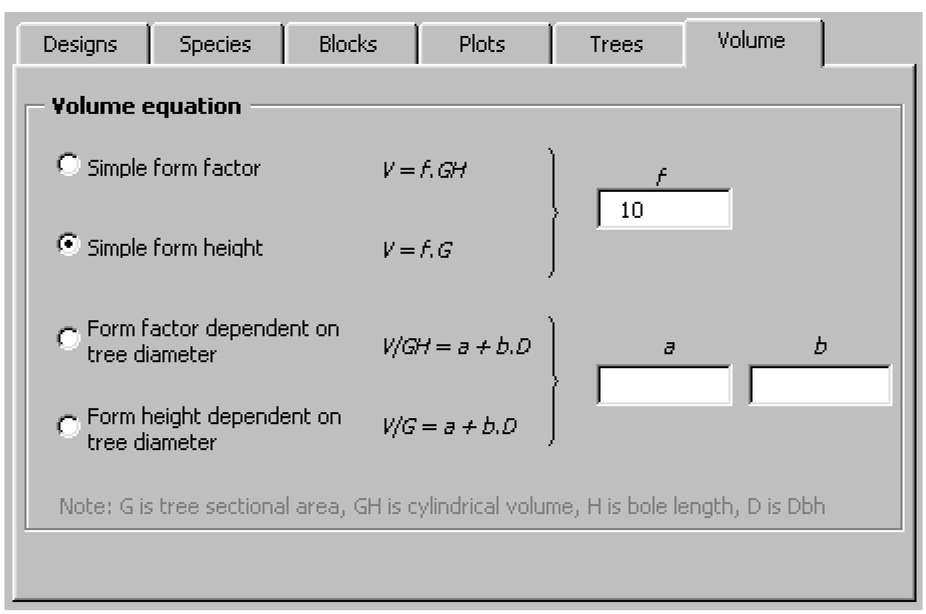
The **Trees** tab gives details on how the fields for the tree data table are laid out, and what is included. The layout is shown below. The **data source** will be either a database table name or a worksheet name. If the latter, then the starting row for the tree data needs to be given. The **field or column names** that are always required are species and dbh. Depending on other aspects of data layout and processing, other key fields and variables may be needed. Stratum and Plot ID will normally be needed for inventory data. If the stratum ID is present in a separate plot header table, it is not needed in the tree data, although it can be used. The

Plot ID will always be required for inventory data, but can be left empty for stock survey data.



Tree number is not presently used. It relates to GIS capabilities that may be introduced in a later version. At present it can always be left blank. Bole length is optional, but will be required if a volume equation is specified based on form factor. Tree quality is required if quality data is to be tabulated in the stand table, and is necessary to distinguish trees with decay or damage, and form defect, in the modelling component. If it is not present, the model will treat all trees present in the data as being sound and of good form.

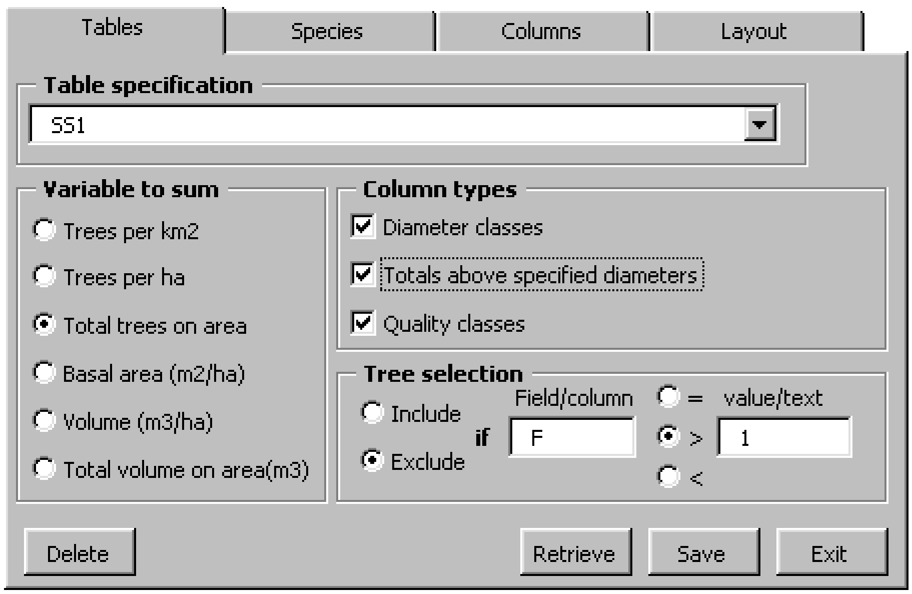
The **Volume** tab specifies the volume equation to be used. The origin of these four possible forms of equation is discussed in the section on volume analysis (page 32).



The equation to be used is defined from the appropriate option button, and the relevant coefficent(s) are entered as indicated. Note that if an equation based on form factor is used, there must be a bole height or useable length field stipulated on the **Trees** tab. If this is not measured, then an equation based on form height must be adopted.

Stand table specification

Options on the dialog form to specify stand tables are grouped onto four tabs. The first tab, as shown below has options for saving and retrieving named specifications that work in the same way as those for the design form (see page 16).



Selection from the **variable to sum** option group determines what variable will be shown on the table. This also appears in the variable heading (see output example overleaf).

The **column types** checkboxes determine which columns will appear. These are further specified on the **Columns** tab.

The **Tree selection** function allows data to be selected according to values in a specific column. Data which matches the criteria will either be included or excluded, depending on the option button.

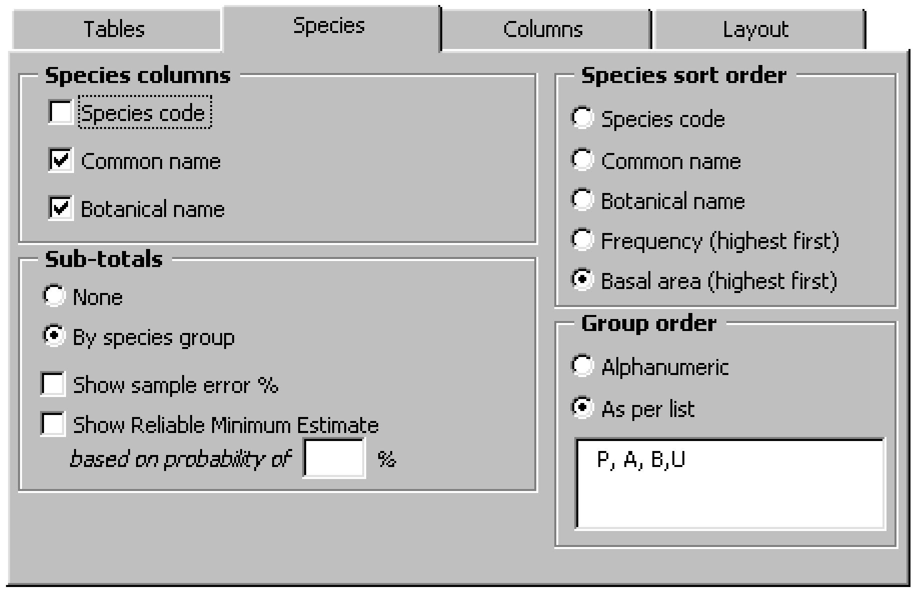
The format of a typical stand table is shown overleaf. The number of columns is variable, and depends on the diameter classes and quality classes chosen. A table can have all or any of the column types: diameter class, total above a diameter limit, or quality class. The species names columns are also flexible, and can include a code, common name, and botanical name, in any combination. Rows can be sub-totalled by groups, with groupings being flexibly defined by the user. The order of species and group rows can be adjusted according to alphabetical order, frequency or basal area. The group order can also be defined from an arbitrary list.

Appearance of a stand table output by GEMFORM.

The number of columns is determined by user settings for diameter classes, totals above diameter limits, and quality classes. Summary rows for species groups are use definable. Tree numbers, basal area or volume can be summarised. With inventory data sampling statistics can be displayed for sub-total rows or for totals above diameter columns.

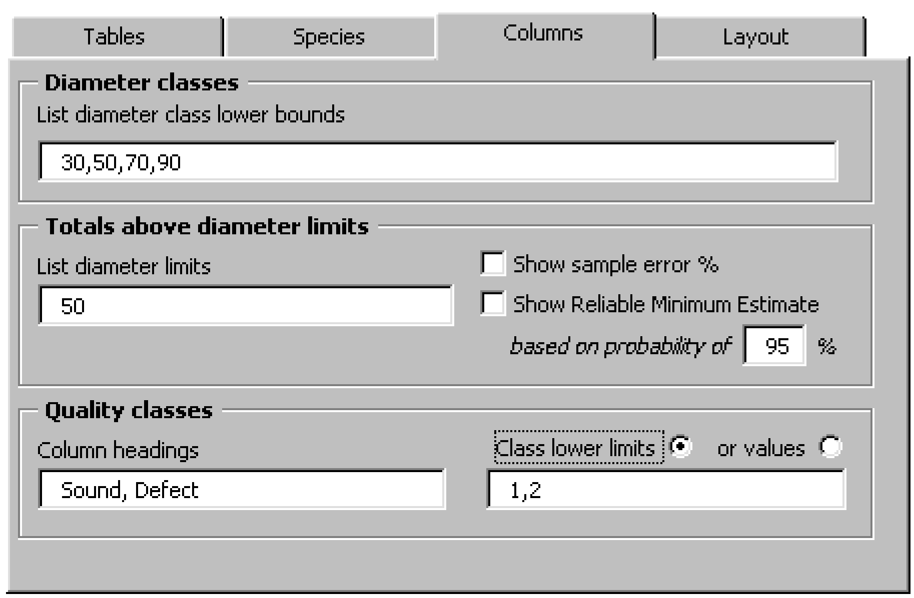
Stand table of Total stocking for Silvicultural survey 3 (100 ha)								
Species		**Diameter class (cm)**					**Quality**	
Common name	*Botanical name*	*30-50*	*50-70*	*70-90*	*90+*	*50+*	*Good*	*Defect*
Morabukea	*Mora gongrijpii*	889	326	46	8	380	441	828
Greenheart	*Chlorocardium rodiei*	369	213	41	9	263	150	482
Silverballi, Kereti	*Ocotea puberula*	779	92	5	1	98	268	609
Wamara	*Swartzia leiocalycina*	320	57	1	2	60	118	262
Bulletwood	*Manilkara bidentata*	28	31	30	15	76	51	53
Sub-total (P)		**2,385**	**719**	**123**	**35**	**877**	**1,028**	**2,234**
Soft Wallaba	*Eperua falcata*	96	50	12	3	65	42	119
Kabukalli	*Goupia glabra*	249	15		1	16	45	220
Huruasa	*Aberema jupunba*	45	35	16	1	52	15	82
Kaditiri	*Sclerolobium guianense*	58	48	4		52	3	107
Maporokon	*Inga alba*	77	33	4		37	24	90
Fukadi	*Terminalia amazonia*	60	22	9	2	33	24	69
Itikiboroballi	*Swartzia benthamiana*	48	26	6	1	33	18	63
Shibadan	*Aspidosperma cruentum & album*	61	14	7		21	46	36
Burada	*Parinari campestris*	39	17	8	2	27	36	30
Futui	*Jacaranda copaia*	94	12			12	22	84
Baromalli	*Catostemma commune*	77	14	1		15	42	50
Maho	*Sterculia pruriens & rugosa*	60	12	2		14	31	43
Dukali	*Parahancornia fasciculata*	27	11	3		14	30	11
Simarupa	*Simarouba amara*	14	10	2	1	13	5	22
Silverballi, sawari skin	*Ocotea canaliculata*	12	12	1		13	14	11
Karohoro	*Schleffiera morototoni*	23	9			9	4	28
Silverballi, Kereti poor		34	3			3	3	34
Manni	*Symphonia globulifera*	17	4	1		5	9	13
Ulu	*Trattinickia demerarae & rhoifolia*	18	2	1	1	4	13	9
Kurokai	*Protium decandrum*	35					11	24
Dalli	*Virola surinamensis & sebifera*	25	2			2	12	15
Purpleheart	*Peltogyne*	14		2		2	7	9
Suya	*Pouteria speciosa*	6	5	1		6	7	5
Wadara	*Couratari guianensis*	1	1	4		5	1	5
Silverballi, yellow	*Aniba hypoglauca*	4			1	1		5
Tatabu	*Diplotropis purpurea*	10		1		1	4	7
Silverballi, brown	*Licaria cannella*	13	1			1	8	6
Silverballi, Wabima		3			1	1	1	3
Silverballi, pear leaf	*Ocotea acutangula*	8	1			1		9
Hububalli	*Loxopterygium sagottii*	2	3			3		5
Barakaro	*Ormosia coccinea*	4	1			1	1	4
Hachiballi	*Pera*	2		1		1	2	1
Silverballi, Gale		5					2	3
Dukalli		1	1			1	2	
Baromalli, sand	*Catostemma fragrans*	2						2
Tonka Bean	*Dipteryx odorata*		1			1		1
Sarebebeballi	*Vouacapoua macropetala*	1						1
Haiawa	*Protium guianense*	1						1
Sub-total (A)		**1,246**	**365**	**86**	**14**	**465**	**484**	**1,227**
Yaruru	*Aspidosperma exselsum*		19	26	3	48		48
Kakaralli, Black			35	8		43	12	31
Monkey Pot	*Lecythis davisii & zabucajo*		11	12	3	26	3	23
Kakaralli werimeri			17	6		23	11	12
Manarieballi, Red			7	5		12	2	10
Duka	*Tapirira marchandii & obtusa*		5	6		11	3	8
Aruadan	*Couepia exflexa*		3	2	2	7		7
[Unknown]			6	2		8		8
Asepoko	*Pouteria guianensis*		2	2	1	5		5
Devildoor	*Glycydendron amazonicum*			2	1	3	1	2
Kokoritiballi	*Pouteria reticulata*		3	2		5		5
Uya	*Parkia ulei*		2	2		4		4
Paripiballi	*Chrysophyllum pomiferum*		1	3		4		4
Kakaralli	*Eschweilera spp.*		2	2		4		4
Koraroballi	*Hymenolobium sp.*			1	1	2		2
Warakaioro	*Laetia procera*		2	1		3	1	2
Kamahora	*Pouteria*		2	1		3		3
White Cedar	*Tabebuia insignis*		3			3		3
Konoko	*Licania sp.*		1	1		2		2
Manariballi , like	*Pseudopiptadenia suavolens*				1	1	1	
Bauawa			2			2	1	1
Apakaito			2			2		2
Kakaralli, fine-leaf				1		1		1
Dukuria	*Sacoglottis guianensis*			1		1	1	
Trysil	*Pentaclethra odorata & macroloba*			1		1		1
Black Heart			1			1		1
Imiriaballi			1			1		1
Corkwood, Hill			1			1		1
Kamakuti			1			1		1
Manobodin	*Emmotum fagifolium*		1			1		1
Duru	*Apeiba echinata & petoumo*		1			1		1
Kautaballi	*Licania alba & majuscula*		1			1		1
Imoradan			1			1	1	
Marishiballi	*Licania canescens & micrantha*		1			1	1	
Manariballi	*Pithecellobium pedicellare*		1			1	1	
Canawaballi			1			1		1
Barabara	*Diospyros*		1			1		1
Sub-total (B)			**137**	**87**	**13**	**237**	**39**	**198**
Unknown		221	11	6		17	61	177
Sub-total (U)		**221**	**11**	**6**		**17**	**61**	**177**
TOTAL (all species)		**3,852**	**1,232**	**302**	**62**	**1,596**	**1,612**	**3,836**

The **Species** tab determines which of the possible **species columns** may be shown, including code, common name or botanical name. The **species sort order**, in terms of rows in the output table, can be set as indicated. Species are sorted within groups, which may appear in alphanumeric order, or according to an arbitrary list. If groups are not included in the list, they occur in alphanumeric order starting after all the explicitly ordered groups.

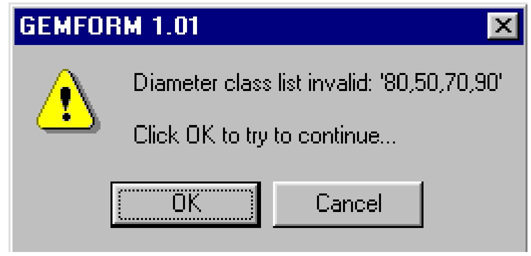


Sub-totals by species groups can be suppressed if not required. With inventory data the sub-totals can be supplemented by sampling error % and/or reliable minimum estimates to a designated confidence interval.

The **Columns** tab specifies the classes used for each column. Note that each group on the form only has an effect if its respective checkbox on the Tables tab is set.



Otherwise, any entry is ignored. For **diameter classes**, the values given list the lower bounds of the classes. Thus the entry 20,50,70 would form three classes: 20-49.99 cm, 50-69.99 cm, and 70 cm or above. The headings would show as 20-50, 50-70, 70+. Any number of diameter classes may be given. The classes can be of variable width. However the entries must be in ascending, non-overlapping order or an error will result when data processing starts, as the example opposite shows.

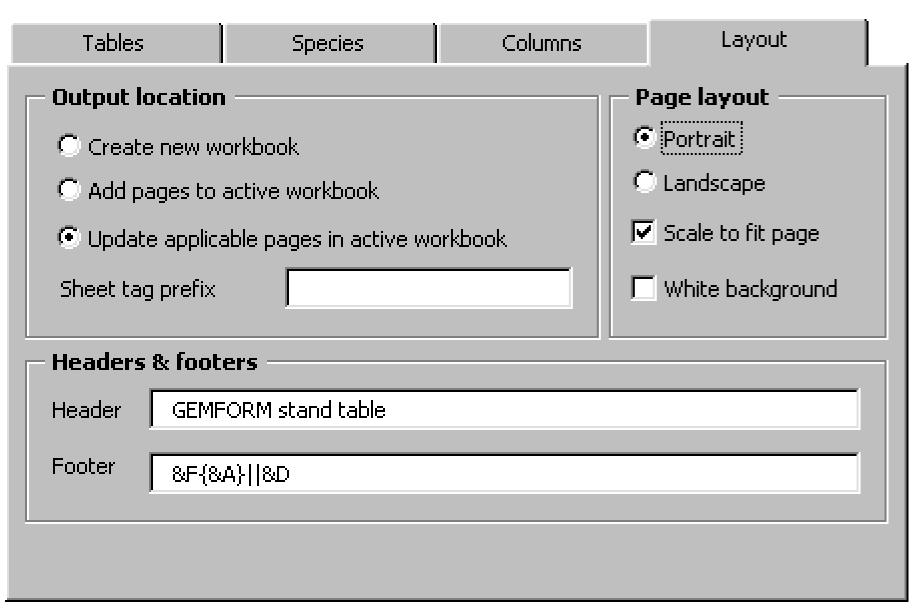


For **totals above diameter limits**, a list of entries such as 35, 50, 60 would define three classes, headed 35+, 50+, and 60+. The 35+ classes would include all trees 35 cm dbh and above; the 50+ classes would include all those 50 cm dbh and above, and so on.

With this type of class, it is possible to have sampling error or confidence limit columns with inventory data if the relevant boxes on the form are checked. For 100% stock surveys, the checkbox entries are ignored as there is no sampling error.

If a quality field has been defined on the **Trees** tab of the **Designs** form (see page 21) then columns based on tree **quality classes** can be defined. The column headings are listed on the left. These should be brief as they will determine column width and will not wrap onto more than one line (although column width will have a minimum of 6 characters, irrespective of the heading). The corresponding quality values are listed in the text box opposite. These values can represent either exact values, or class lower bounds, depending on whether the quality codes are attributes or a represent a logical sequence in alphanumeric order.

The **Layout** tab determines some general layout features of the generated sheet.



The Output location option determines whether the stand table is written to a new workbook, or the currently active one (which will normally be the same workbook as the data if the data source is Excel). If the latter, an existing stand table of the same name can be overwritten or a new one created every time.

The created sheet name will use the block title, enclosed in braces {title}. If you have selected the **add pages** option, then this name will be supplemented by !, !! etc to generate unique names if a table for the same block or stratum already exists.

The created name can be prefixed with a standard text. This is only useful if option 1 on the **Blocks** tab of the **Designs** form is chosen, where there will be no title and the original block code may be something rudimentary such as *39V*. This will then allow the output to be generated *{block 39V}*, with the prefix text *block*, for example.

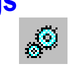
Some commonplace page layout settings can be made. It is useful to select **Landscape** mode for tables that are wider than they are deep. Checking the **scale to fit page** box forces the entire table to print on one page. The **white background** box suppresses colouring of cells, which will have their default Excel appearance.

The **headers and footers** can be set for printed output. Any text can be included. The vertical bar | separates the left, centre and right portions of the header or footer. Ampersand codes defined in Excel can be used. The most common of these are:

&F	Workbook (file) name
&A	Worksheet name
&D	Time of printing
&P	Page number
&N	Total number of pages

Numerous other codes exist, which will be found under the *Excel Visual Basic Help* by requesting the paper clip to find *Formatting Codes for Headers and Footers*. Unfortunately, the standard Excel help does not retrieve this information.

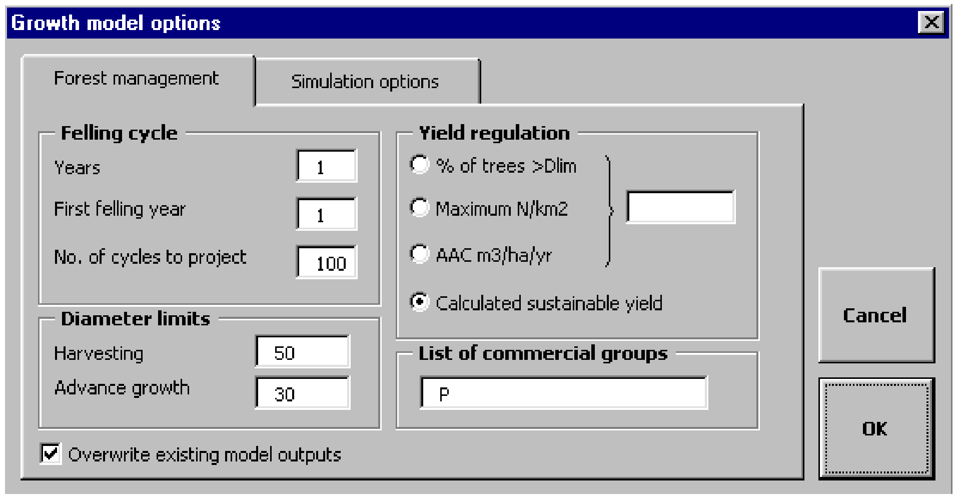
Growth projection settings



The dialog form for setting up growth projections is shown overleaf. This has two tabs, relating to **forest management** options, and options that influence the technical aspects of the simulation (**simulation options**). The **OK** button saves the setting made. The **Cancel** button, or the close window control, will not save changes to the form.

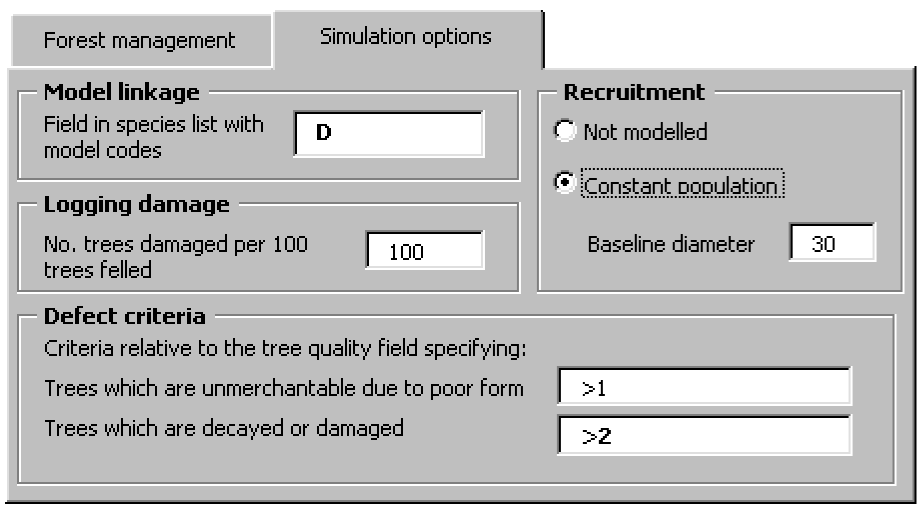
Under the **Felling cycle** group, the felling cycle, the year of felling, and the number of cycles to project can be set. The felling cycle can be as short as one year. The number of cycles is limited only by the columns on the worksheet (250), but practically, projections beyond 200 years are meaningless.

The **yield regulation** group allows yield to be controlled by setting a fixed maximum cut in each cycle in terms of tree numbers, or volume, or by cutting a constant percentage of stems. In all cases the harvested stems must be above the specified minimum diameter limit. The fourth option, **calculated sustainable yield** iteratively estimates the maximum volume yield that will be constant across all felling cycles.



The **diameter limits** govern firstly, harvesting, and secondly, the lower limit to which the stock of advanced growth is displayed. The **list of commercial groups** should comprise those species groups which are to be harvested. In order for the model to run, a species group column must be defined in the species list (see the species tab on the design form, page 18). If no entry is made in this text box, then no harvesting will be done by the model.

The **simulation options** tab exposes some more technical choices about how the model should run, as shown below.



The **model linkage** field in the species list needs to be specified. The species list must include a model code. In the consultant's earlier study (Alder, 2000), a list of 181 species were given with model codes. This can be used as the basis for classification. The silvicultural survey macros, also developed at that time includes a list primarily based on field names with model codes. These reference should be used to set up a field for model codes to link with the set of growth models.

Logging damage needs to be set from empirical data, which can include both the silvicultural surveys and the Tropenbos logging studies. The damage ratio relates to larger trees, 30 cm or so plus, although no strictly defined size limit is used. However, the model does not have sufficient detail to estimate effects of skid trails on the destruction of small trees, unlike for example, SYMFOR. A 1:1 ratio, as indicated above (100 trees damaged per 100 trees extracted) seems to approximate general experience from other logging damage studies.

Recruitment is normally modelled by assuming a constant replacement of all trees lost, either by mortality or by harvesting. However, this can optionally be switched off, for comparability with the silvicultural survey macros, which do not model recruitment. If recruitment is not modelled, projections beyond 50-60 years will be serious underestimates for species such as Baromalli, which grow at around 0.5 cm yr^{-1}. For Greenheart, projections up to 100 years may be made without considering recruitment.

The baseline diameter field should give the smallest measured diameter in the stock survey or inventory. Recruitment compensating for natural mortality is calculated relative to this; it assumes the existence of a regular exponential distribution below the baseline diameter. Recruitment related to harvesting is treated as true regeneration, with tree cohorts of diameter zero being initiated. Consequently this class of recruitment will involve a considerable lag before it achieves the advance growth minimum diameter (Greenheart might theoretically take 100-150 years to reach 30 cm dbh on the basis of current data).

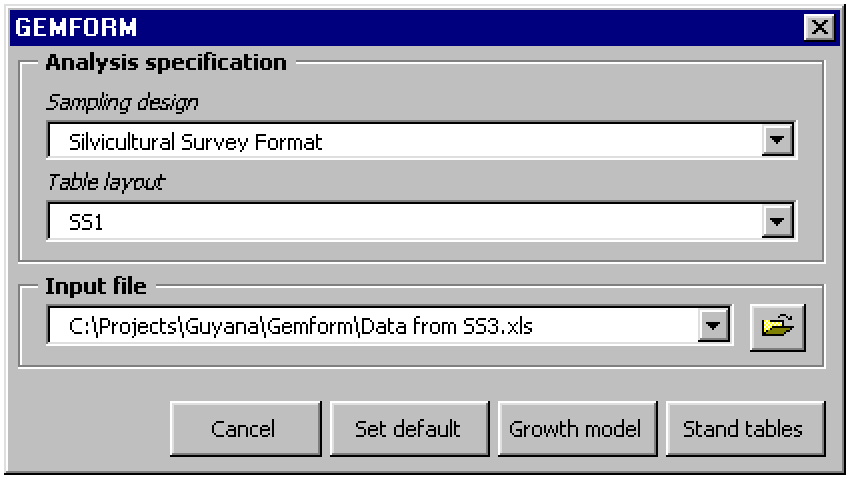
Different mortality rates are applied to trees with decay or damage, whilst trees which have form defect (*eg.* sweep, forking) but are otherwise healthy are excluded from harvesting, but have normal mortality. For the model to be able to assign trees to these categories, the applicable quality codes need to be indicated in the **Defect criteria** area. Codes applicable to poor form are shown in the first box, and those to decay or damage in the second. There are four ways of coding the criteria.

- > *q* — indicates that any tree with a quality code alphanumerically higher than *q* will be considered to belong to that defect class.
- = *q* — indicates that the quality code must be exactly equal *q* for the tree to be classified as of poor form or with decay/damage.
- < *q* — similarly indicates that the code should be less than *q* for the tree to be classified in that category.
- ~ *q,…* — gives a comma-separated list of codes indicating the class of defect.

Generating stand tables or model outputs

Once the various options have been set up, the output button can be clicked to generate a stand table or stand projection. The dialog form is shown overleaf. This allows selection of the design criteria for the data source from a list of possible values that may have been saved. For a stand table, the table formats can also be saved and re-selected at this point. Finally the data source file can be selected either from a list of those previously used, or by selecting the *File open* button, from any accessible file on the computer or local area network.

The action buttons will either run the **Stand table** or **Growth model** modules. The **set default** button will set the current design, table and file choices as the default, but will not run either of the output modules. The **Cancel** button closes the form without action.



The **cancel** button has however one useful side effect: It resets the cursor to its normal behaviour. If the program fails for any reason, the cursor may be left as an *Hourglass*, which is somewhat confusing. Clicking **cancel** on this form will reset the normal cursor.

Appearance of stand projection outputs

The typical appearance of the stand projection output is shown below. One table is produced for each stratum or block, with the block title and area shown in yellow. There is one column for each felling cycle, plus the initial condition in year zero. The stand statistics represent the status immediately after harvesting, except for the initial column, which shows the stand as it is at the time of measurement.

GEMFORM stand projection			**Period**	**Initial**	**Year 20**	**Year 40**	**Year 60**	**Year 80**
Forest block/stratum	*Area (ha)*	*Size*	*Stand component*	*Trees (n/km2) by felling cycle*				
Silvicultural survey 3	**100**	50+	*Harvest*	-	183	185	194	200
		50+	*Harvestable, retained*	333	254	209	144	36
		30-49	*Advance growth, sound*	1,179	1,028	889	790	771
		30+	*Defective, damaged*	3,461	3,414	3,367	3,319	3,270
		30+	*Non-commercial species*	475	461	451	442	432
				Volume (m3/ha) by felling cycle				
		50+	*Harvest*		5.4	5.4	5.4	5.4
		50+	*Harvestable, retained*	9.6	7.5	6.1	3.9	0.9

The top data row shows harvested tree numbers per km^2, with the applicable minimum diameter in column C. The second row shows trees which are suitable for harvesting in terms of size, health and form, but have been retained in order to regulate future yields. The third row shows the advance growth between the diameter limit given in the **advance growth** box of the **forest management** section of the **growth model** form, and the harvesting diameter, given on the same form. The applicable limits are shown in column C of the worksheet. The advance growth shown is sound (not decayed or damaged) and of good form. The fourth row shows the total number of trees of commercial species above the advance growth diameter threshold which have either form defect or are decayed or damaged, and hence unmerchantable. The fifth row gives the total number of non-commercial species, without regard to their condition, above the lower diameter limit.

The harvested trees and retained trees above harvestable size are also shown in terms of volume per ha on the 7th and 8th rows. The effect of the yield regulation can be seen in the above example. The volume harvested is exactly equal in each cycle.

Technical aspects of the model

The growth model is based on the same coefficient values and species groupings as the Silvicultural Survey Macros (Alder, 2000). The table of model coefficients is stored within GEMFORM. The data sheets of GEMFORM are normally hidden to protect them from accidental alteration, but they can be revealed by setting the *IsAddin* property of the *Workbook* object to *False* in the Visual Basic Window (Alt+F11).

Recruitment is modelled using similar logic to that developed for the IwoPlan model (Alder, 2001), but with some refinements. When a tree dies (natural mortality) it is replaced by a recruit tree of the same species. The size of this recruit is determined by the minimum diameter for advance growth (see page 27 and notes on the following page). This method is equivalent to assuming a balanced exponential diameter distribution below the minimum measured diameter (Meyer, 1952). For harvested trees, there is similar replacement on a one-for-one basis, but the size is assumed to be zero (ie a seedling 1.3 m high), and the number of seedlings is calculated so that at the annual mortality rate for the species, there will be one survivor when the commercial diameter limit is reached. This results in a 'flush' of seedlings following harvesting, but with a considerable lag (30-50 years) before they grow through the small size classes and are noted in the advance growth category.

The model design is a little different from the SSM. It is a cohort model. This is necessary to reflect the diversity of data sources, whereas the SSM was designed exclusively for 100% surveys. The SSM employed a hybrid strategy, with tree list modelling for diameter growth, followed by classification into diameter classes after one or two cycles to calculate mortality. This method is not suited either for sample data, or for modelling over many cycles.

At the same time, the model is very simple, because the data is often very crude. High minimum diameter limits are frequently used (30-35 cm), and in some samples only commercial species, or only species of merchantable quality, are recorded. With such data, it is not possible to include density dependent effects.

Long-term projections will be influenced strongly by the recruitment assumptions, which, being based on constant rates, will always drive the stand to assume an exponential diameter distribution (ie, equal Q ratios). Projections of less than 100 years may be quite accurate, as the validation tests discussed in Alder(2000) indicate. However, sustainable yields over such time horizons are essential a matter of liquidating stocks of advance growth in a progressive and equable manner.

Consequently, the models estimates of sustained yield will always tend to be higher for shorter projections than for very long ones. Reliable long-term estimates of sustainability – the forester's concept of *'in perpetuity'* – depend totally on knowledge of recruitment behaviour, which is still critically deficient in Guyana.

Another critical issue for sustainability in Guyana relates to the fertility of the soil. On many Guyanese soils, nutrients are probably a limiting factor to growth, and the way exploitation effects them is likely to be most critical. There is also an interaction with fire, as even low-intensity ground fires can destroy litter and cause significant productivity effects on low-nutrient sites. These matters should be regarded as priorities for research. In terms of modelling, the consultant would like to see whole stand eco-physiological approaches to investigate nutrient issues and the synthesise available knowledge in a management context. Better modelling of recruitment depends essentially on data, and for this, the long-term retention of the Tropenbos and Barama PSPs should be regarded as of the highest priority.

Background and objectives

During the consultants earlier visit (Alder,2000), the tree volume measurements from the IFP data, comprising about 1800 sample trees were converted into an Excel file with tree dbh, bole length, gross volume and underbark volume. The only available information from the IFP were the printer files, and the conversion process therefore involved writing a program that could read these as ASCII data and strip out the white space and irrelevant layout material to give raw section measurements.

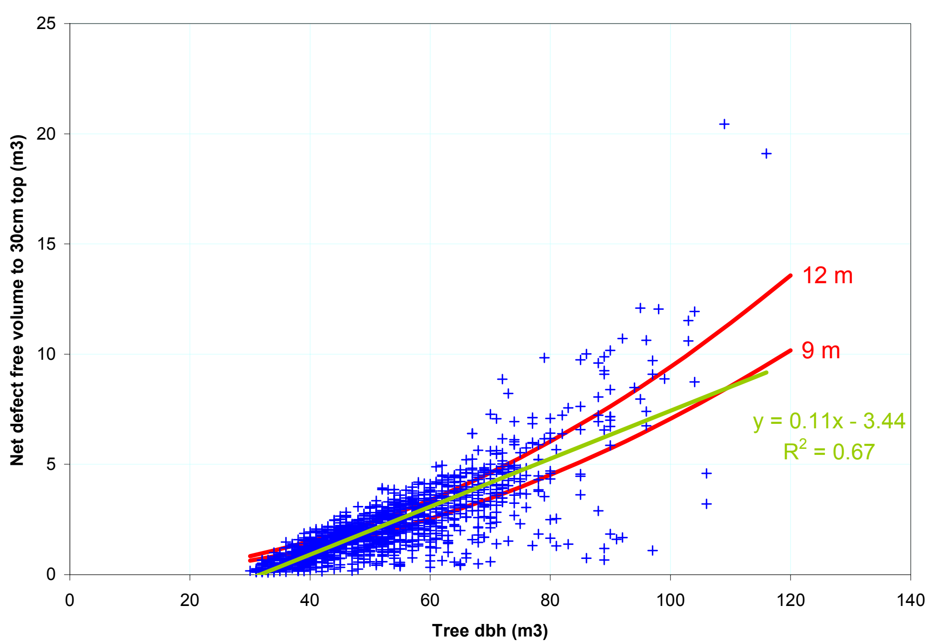
It was however noted by GFC that these volume equations were derived on bole sections down to 10 cm diameter, and that the volumes included defective sections. The consultant was therefore requested to recalculate these equations to gives ones that were restricted to section diameters 30 cm and up, and to exclude defective log lengths.

Methods

This was done during this visit by an adaptation of the earlier program, to calculate two additional output columns: The defect-free bole length, based on an IFP risk class of zero (ie no sweep, decay or forking of the section) and stopping at the last section whose small-end diameter exceeded 30 cm; and the defect-free underbark volume calculated over that length.

These output data, the associated analysis, and the macro for reading and decoding the original IFP volume files are contained in an Excel workbook called VOLUME EQUATIONS (REVISED 2001).XLS.

Form height



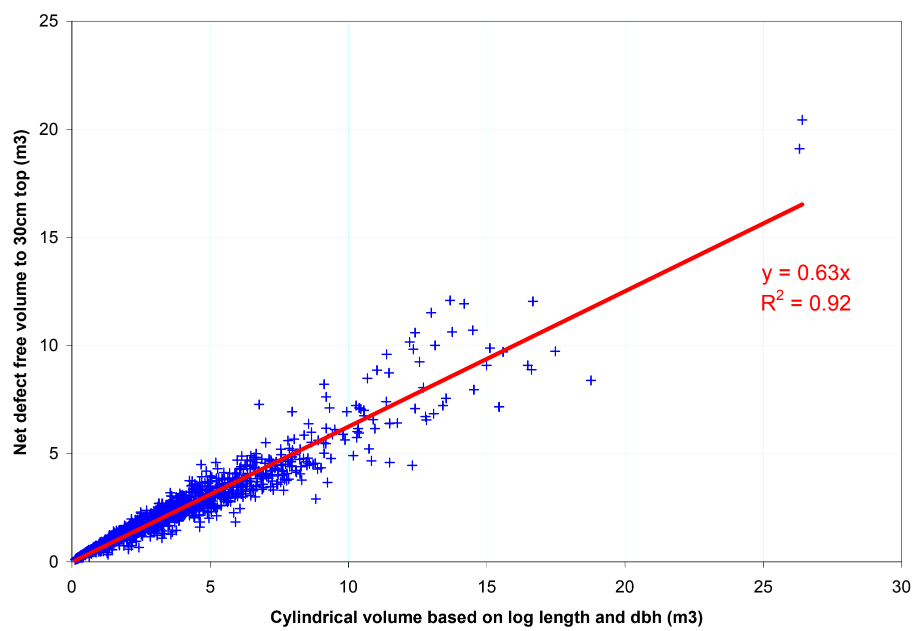
The general relation for all species between tree dbh and volume to a 30 cm top diameter, underbark and net of defect is shown in the figure above. A simple linear regression with an R^2 of 0.67 fits the data better than a logarithmic one, as the data tends to a volume of zero at a dbh of 30 cm, by definition.

For simple volume calculations, an average form height (ratio of volume to tree basal area) is very useful. The mean form-height for all the data, estimated by regression, is 10.2 m. The graph shows in red the form height lines for 9 and 12 m, which can be compared with the linear regression of net volume on diameter (green). Within the range of most practical importance, from 50-70 cm, a form height of 10 provides an adequate rule of thumb, with 10.2 m being the precise estimate.

Form height depends weakly on dbh, and is also somewhat different from species to species. However, the variance of the defect-free volume is substantially higher than that of gross volume, and there does not seem to be any strong justification for more elaborate methods. Species by species tables are shown below, which can be used for maximum precision for those individual species.

Form factor

Form factor is defined as the ratio of tree volume to the volume of a cylinder of the same diameter and height. It tends to vary with diameter and between species. However these effects are usually weak, and an average form factor is a reliable way of estimating volume, provided bole length can be measured.



The figure shows data for the net defect free volume plotted against cylindrical volume calculated from dbh and defect-free log length. The mean form factor is 0.63. The regression through the data is almost identical to the ratio line (slope 0.61, intercept 0.10) with an R^2 of 92%.

Table of volume estimators by species

The table below lists the mean form factors for all species sampled with 10 or more sample trees. The statistics shown are numbers of sample trees (Nt), the form factor for net volume (defect free, minimum 30 cm top diameter), form height for net volume, and the mean ratio of net volume to gross overbark volume (including defect). The latter shows the difference between these volume estimators and those in the earlier report. In addition to the 38 species listed, another 99 were sampled with 10 or fewer trees. 58 out of 1509 trees were not identified.

Species	Nt	FFnet	FHnet	Net:OB
GREENHEART	208	0.71	10.45	0.71
BAROMALLI	88	0.63	10.94	0.60
WALLABA SOFT	59	0.67	9.86	0.68
HAIARIBALLI	53	0.63	9.40	0.64
KAKARALLI BLACK	53	0.69	7.70	0.57
MORABUKEA	52	0.67	9.28	0.62
SHIBADAN	35	0.64	10.12	0.61
WALLABA ITURI	35	0.67	9.60	0.68
MOROBALLI	34	0.69	10.51	0.70
WAMARA	32	0.75	11.31	0.72
KAUTABALLI	27	0.71	8.23	0.59
KABUKALLI	26	0.64	7.27	0.51
KARAHORO	26	0.61	9.01	0.67
KUROKAI	22	0.65	8.18	0.61
SUYA	22	0.60	9.91	0.63
CRABWOOD	21	0.61	8.62	0.64
IMIRIMIABALLI	21	0.78	7.32	0.51
MARISHIBALLI	21	0.70	8.39	0.55
KOKORITIBALLI	20	0.69	8.64	0.55
KOROKORORO	19	0.61	10.03	0.74
PURPLEHEART	18	0.72	13.68	0.77
MAHO	16	0.64	10.46	0.66
SILVERBALLI OTHERS	16	0.73	9.47	0.60
MAHO SMOOTH LEAF	15	0.62	8.39	0.56
MANARIBALLI	14	0.65	8.53	0.60
FUTUI	13	0.65	10.00	0.63
MONKEYPOT	13	0.59	4.93	0.39
SIMARUPA	13	0.62	10.40	0.70
WARAKOSA	13	0.74	6.33	0.50
KAKARALLI SMOOTH LEAF	12	0.77	5.89	0.45
MORA	12	0.72	11.82	0.72
SAREBEBEBALLI	12	0.68	8.34	0.65
AROMATA	11	0.73	7.73	0.52
HURUASA	11	0.61	7.26	0.64
MAPOROKON	11	0.62	7.06	0.52
BAROMALLI SAND	11	0.59	12.54	0.72
SURADAN	10	0.65	7.27	0.58
WADARA	10	0.66	8.99	0.57

Species list conversion

The problem of species lists

The author has alluded in his earlier reports to the problem of species lists in Guyana. There are many lists in use, some of them historical such as the CIDA and FAO lists, some of them current, such as the Barama and Tropenbos lists for their PSP work, and various *ad hoc* lists in use within the GFC Support Project. Iwokrama have largely borrowed the Tropenbos list, but introduced one or two entries of their own. An attempt at standardisation within GFC, based on the Smithsonian list of Woody Plants of Guyana (LWPG), has become somewhat chaotic because of the impossibility of mapping loose field identifications on the discrete botanical names in the LWPG.

These problems have mainly arisen because most people approach the species list problem in terms of creating a *flat file* or simple table, with one entry per species. This does not work well when identification is based primarily on local names; even for botanical identification, there is usually a process of refining that requires that identifications to the generic level will be improved at a later stage.

Local name identifications have an imprecise linkage to botanical names. Several botanical species may have the same local name. These will not necessarily be in the same genus. Additional, each species will have several local names, in different dialects or regional usages.

A proposed approach

For field use, for statistical presentation, and for databases of species attributes such as growth models, volume equations, wood properties, prices and inventory statistics, a simple table is essential. In this table, the species name should be a standardised local or trade name, that is adopted by GFC and used consistently in all forms of field survey, monitoring and statistical summaries.

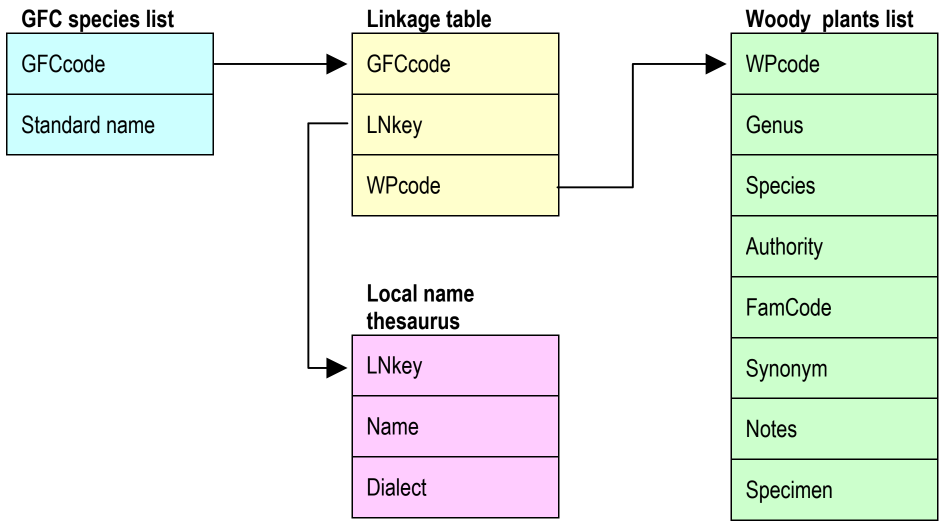
This name should have a standard code, either numeric or mnemonic. The author recommends the latter as it is useful in contexts other than purely for data entry (for example, as legends on graphs or maps where space is too limited to show full names). However, the main purpose of a code is to avoid mistakes and ambiguities during data entry, and with experience, to speed up the completion of field sheets as full names no longer need to be written down.

This practical and standardised list I refer to as the GFC species list.

Botanically, there is already a check list, developed by the Smithsonian Institute, which is held on a database by the GFC herbarium. This contains 1885 species that are known to occur in Guyana as trees, shrubs or lianas. This can be referred to as the Woody Plants database.

Scattered through the various existing lists are variant local names, in some cases with dialect information. This information can be re-organised into a thesaurus of local names, with dialect for each variant.

These three data tables can be linked within an Access database as shown in the diagram overleaf.



In this arrangement, the GFC list, local name thesaurus, and woody plants list are all simple lists. Each contains only that data which can be internally consistent. The ambiguity and fuzziness for the connections among these lists is catered for by the linkage table. This contains triplets of codes: GFC list code, local name code, and Botanical WP code. For each entry in the GFC list, there would typically be several local name entries, and several botanical name entries.

This type of database cannot be used in Access without designing specific forms and reports for input and output. The basic form required would be a species management form, which would show:

- The standard name list as the primary entry.
- A window of all corresponding local names with their dialects.
- A window of all corresponding genera and species
- Popups to allow species or local names to be added or removed via the mouse. These selections would be programmed to update the linkage table.

The report form would include a flat file list with local names and species shown, if required, as comma separated lists on the same line as the standard name and code.

The above presentation is simplified with regard to the botanical database. It will be more efficient if the hierarchical structure of this is represented (family, genus, species) by having three separate linked tables. This will allow identifications to only the family or generic level to be handled properly. This three tier structure can also be handled within the botanical code, in the same way as used by EMBRAPA in Brazil.

Specialised linkage tables are also required to regenerate historical lists (the FAO and IFP lists) and external lists (Tropenbos, Iwokrama, Barama). These are needed for conversion or access to data using original codes.

Implementation

For the consultant such as the author to develop the above system, code the species management form and the basic report formats and queries to generate practical tables would require about one week to design and code the system, and convert and link existing tables and data.

However, of itself this would be of little value. GFC needs to accept the institutional implications. This requires meetings and seminars at both senior management and lower technical levels to introduce the idea of a standard GFC list to be used consistently for all work, including monitoring, statistics, inventories, stock surveys and every other activity within GFC that involves reporting or coding species data.

Furthermore, sustainability in the use of the system requires a clearly defined responsibility of maintaining the list. Let us say that this is agreed to be within the FRIU. It is necessary that the FRIU is fully conversant with the techniques and procedures for creating and updating the species management form and output reports, so that these can be modified on demand. There is therefore a substantial training component.

The consultant therefore considers that a process of 14 working days is required to

- Code and design the system and convert existing data.
- Undertake in parallel with this, training within the FRIU in Access form design, report design and query methods, together with some related Visual Basic training.
- An initial workshop that would be directed towards senior staff, and would result in a formal output of acceptance and agreement with regard to the procedure to be adopted.
- A final workshop especially for users of species lists: field staff, monitoring staff, and external organisations to promote the standardised list and adopt it for all GFC authorised species records.

In the conclusions to this report, the consultant has suggested that this process should be combined with the work that is needed to complete GEMFORM. This would be more efficient than undertaking it as a 'stand alone' activity, especially given the time lapses that are needed to properly organise and promote a public workshop.

Description of training course

On 25th-26th October the consultant gave an in-house training course to seven personnel within the Forest Resources Information Unit of GFC. This course was divided into short sessions of teaching, of about 30 minutes each, followed by hourly sessions of practical work to absorb and practice the taught material. The objective was to develop sufficient knowledge of key techniques in Visual Basic for Excel that the participants could apply it to significant tasks, and could begin to develop their skills through learning on their own. Visual Basic is well suited for this, being easily accessible through Excel, and having a good supporting Help system.

The components of the course, and the topics covered, are listed in the table following. This course needs to be supplemented by a similar one in SQL and Access queries, and a linking course showing how SQL queries can be used in Visual Basic from Excel to extract and process data from Access databases in Excel.

Material covered in the 2-day training course on Visual Basic with Excel

Topic	Method	Description
Basic skills for improved worksheets (Exercise 1)		
Naming excel sheets	Click twice on sheet tab to rename	*Use named sheets in your workbooks to improve clarity.*
Commenting cells	**Insert**→**Comment** in a cell	*Write comments on column headers and around calculations.*
Absolute addressing	{F4} key changes address mode	*Range addresses like A1 are absolute addresses. The don't change as cell is copied. A1 is a relative address.*
Named ranges	Type name into left box of formula bar	*Named ranges make formulae clearer and quicker*
Formatting cells	{Ctrl+1} formats any selection	*Use colours, fonts, borders, alignment, merged cells for improved clarity and quality.*
Introducing Visual Basic (Exercise 2)		
Starting Visual Basic	{Alt-F11}	*Brings up Visual Basic editing window. Note project window, properties window, and program editing window. Insert a blank sheet using Insert Module from menu.*
Macro subroutines	SUB *name*… END SUB	*Type SUB followed by a name of your choice on the program editing window*
Cells object	CELLS(r,c)	*Type Cells(1,1)="Hello" after the SUB statement*
Running a macro	{Alt-F8}	*Brings up list of runnable macros. Selecting your macro and running it will place "Hello" in call A1 with above example.*
Variables	DIM x DIM y AS type	*Defines variable x. This can hold values and be used in controlling loops, indexing etc. Variables can be of various types, but by default are VARIANT (any type).*
Iteration	FOR v= start TO END…. NEXT v	*Repeats the enclosed statements for each value of v from start to end. Use it to output 'Hello' into cells 1 A1 to A10.*

Help	{F1} on a keyword	*Help is not installed in Visual Basic by default.* ***In order to make progress you must install and use it.*** *You will need the original MS Office system disk to install help.*
Running macros	{F5}	*Selecting* (*Run macro) from the toolbar or pressing F5 will run the macro where the editing cursor is currently positioned.*
Using buttons to run macros	**View→Toolbars→Forms** *Button*	*Bring up the forms toolbar and drag a button onto you worksheet. Right clicking on the button will bring up the Assign Macro dialog. Select your current macro exercise. Left clicking on the button will run the assigned macro.*
Objects, properties and methods (Exercise 3)		
Objects	*eg.* SELECTION, RANGE	*A* *__object__* *is named logical entity, with specific* *__properties__* *and* *__methods__*. *The* SELECTION *object is whatever is currently selected by the mouse.* RANGE *is a range of one or more cells.*
Properties	*eg.* SELECTION.VALUE=X SELECTION.FONT.BOLD=TRUE	*Properties are quantities or other objects that form part of an object. Quantities can be* *__assigned__* *directly using = (assignment). Properties can also be objects which themselves have properties that can be assigned values, as in the* FONT *example.*
Methods	*eg.*. SELECTION.CLEAR SELECTION.SORT	*Methods invoke processes that are carried out on objects. Most methods require parameters. Some methods have the same names as objects, which can be confusing, eg.* RANGE *method.*
Object browser		*Object browser button shows the names of all objects in Excel accessible from Visual Basic, with their properties and methods. If* HELP *is installed, gives details and examples.*
Range properties and methods (Exercise 4)		
Range method	*eg.* RANGE(CELLS(1,1),CELLS(10,10))	*Defines a range of cells as an object.*
Assigning objects	SET *x* = SELECTION	*Use the set statement to assign an object to a variable. This is a useful shorthand, and in this example, would let you refer to the same group of cells even if the selection changed while the macro was running.*
Fonts	FONT.BOLD=TRUE FONT.ITALIC=TRUE FONT.COLOR=RGB(*red,green,blue*)	*Can set all the characteristics of the font including bold, italic, size, font type (eg. Arial), color.*
A note about colours	*object*.COLORINDEX=*n*	*Various things can be coloured, such as fonts, cell interiors, cell borders, lines and points on graphs. These can be set by the* COLORINDEX *property, which has a value from 1-56. Run the ViewColorIndex macro to see what these are.*
Used range	ACTIVESHEET.USEDRANGE	*Range comprising all cells in the worksheet in use*
End method	*range*.END *direction* {END}+*arrow key on worksheet*	*Moves to the end of a range in the direction indicated by one of the keywords* xlToLeft, xlToRight, xlUp, *or* xlDown.
Visual Basic and worksheet functions (Exercise 5)		
Text functions	*Ucase(s), Lcase(s),Left(s,p), Mid(s,p,q)*	*Text variables in VB are known as* *__strings__*. *Example 6 shows a macro that can be used to convert upper case formatted characters into Proper case (ie. first letter capital, rest lower case).*

Text concatenation	*+ or &*	*The + or & symbols in VB can join text. In Excel, & must be used.*
Worksheet text functions	UPPER, LOWER, LEFT, MID, PROPER, *etc.*	*There are some worksheet functions which have the same name and function as their VB equivalents (eg. LEFT, MID) and others that do the same under different names (UPPER versus UCASE). Worksheet functions can be used in VB by preceding them with WORKSHEETFUNCTION.*
User -define functions	FUNCTION…END FUNCTION	*User-defined functions can be written with the FUNCTION-END FUNCTION statements and used within worksheets in the same way as worksheet functions. Illustrated by the AddOne function.*
Collections of objects	*eg.* COLUMNS, ROWS	*Collections defined as collections of similar objects accessed by numeric or text indices. Illustrated by COLUMNS and ROWS properties of a range.*
Iteration through collections	FOR EACH *item* IN *collection*	*FOR EACH command works through a set of items in a collection. Combined with the ROWS and COLUMNS properties, this provides a way of working through all cells in a range, as illustrated by the FirstCapital macro example.*
Pivot and consolidate operations (Exercise 6)		
Multiple choices in macros	SELECT CASE…END SELECT	*The SELECT CASE statement allows multiple alternatives to be considered, and one chosen, based on the value of a variable. Illustrated by the Dclass user-defined function.*
Pivot tables	**Data→Pivot table**.. wizard	*Pivot tables allow 2-way classification of data. Powerful when combined with User-defined functions to generate class values from continuous data. Illustrated with the Dclass and Dclass2 UDF examples.*
Freeze panes	**Window→Freeze panes**	*Freezing panes in the middle of the screen allows the top and bottom of a large spreadsheet to be seen at the same time. Selection of the whole set or of particular columns can be made quickly without scrolling. The {END} +arrow key also speeds up moving around large sheets.*
Consolidating data	**Data→Consolidate**	*The* consolidate *function is a way of building a list of unique values from a large data file (eg. a species list) and obtaining counts, sums etc. without the complications and automatic features associated with pivot tables.*
Programmed table lookups (Exercise 7)		
User dialogs	MSGBOX *function*	*Using the MSGBOX function to output alerts and information. Selection of icons for information and error messages.*
General location properties	ACTIVECELL, CURRENTREGION, ADDRESS	*ACTIVECELL defines the current cell on the worksheet. CURRENTREGION is the block of data surrounding a specified cell. ADDRESS gives the address of a range on A1 format. The macro SeleRegion illustrates the technique for using these properties.*
Custom toolbars	**View→Toolbars→Customize**	*Addition of new buttons to the Excel toolbars, with techniques for assigning them to run macros, changing their images, and creating new button designs.*
Looking up data from other tables	VLOOKUP(*item, list,ans,exact*|*nearest*)	*The VLOOKUP function is the most useful of a number of worksheet lookup functions. The SpeciesName macro illustrates its use to extract a botanical name from a list, given a local name.*

Introductory error handling	ON ERROR RESUME NEXT ERR.NUMBER	*In many contexts working with objects in macros, errors are bound to occur, and need to be handled by the program. The SpeciesName macro has to cope with names not in the list for example. SpeciesName2 illustrates use of basic error handling to do this.*
Making decisions in programs	IF …. THEN….ELSE…ENDIF	*IF statement in multiline format is introduced. The SpeciesName2 macro uses the IF statement to give different messages depending on whether a species is found or not.*
Searching and copying data from one sheet to another (Exercise 8)		
Wildcard searching and filtering	**Data→filter→autofilter** **edit→find**	*Filtering using the contains criteria with wildcard characters (*, ?), explained. Similar effect of wildcards with the find operation.*
Referencing worksheets	SET *variable*=WORKSHEETS(*name*) *wks*.CELLS(*row,col*) *wks*.ACTIVATE	*Assignment of worksheet references to variables. Reference to cells and ranges on worksheets other than the active one. Activating a worksheet. Illustrated in macro CopySp.*
Breaking out of macros	IF… THEN EXIT SUB *{CTRL}+{BREAK} key*	*One line if statement combined with EXIT SUB statement to leave macro in the middle when necessary. Stopping running macros with Ctrl+Break key. Illustrated in macro CopySp.*
Indefinite iteration	DO…LOOP UNTIL …	*Indefinite looping, not based on counting or working through sets as with FOR, is accomplished with the DO…LOOP combination. Illustrated in macro CopySp.*
Programming the Excel Find function	*range*.FIND(*value*) *range*.FINDNEXT(*from*)	*The FIND method, applied to a range, searches it for the specified data. FINDNEXT repeats the same search further down the file. The method of using these to locate all instances of a string programmatically via DO… LOOP is Illustrated in macro CopySp.*
Copying ranges in macros	*range.COPY target*	*The copy method copies a range to a destination. Its use is illustrated within the CopySp macro to copy a row from a table to different row on another sheet.*
Inputting information via a dialog	INPUTBOX*(prompt)*	*The INPUTBOX function gives a simple dialog for inputting text information. It is illustrated in the CopySp macro.*

Conclusions

Summary of work completed

During the 28 day period of this assignment, the consultant has been able to code, test and provide basic training relating to a system for the general analysis of forest inventories and stock surveys. The program also includes a cohort-based growth model, drawing on analyses from earlier work, to make projections of sustainable yield.

Although the program is fully functional with respect to stock surveys stored in Excel, time has been insufficient to complete the critical module for inputting and internally standardising the various possible formats of inventory data, or for reading stock survey data stored in Access files. The figure on page 15 shows the missing module in pink.

As discussed on page 32, the IFP volume data has been recalculated to give tree-by-tree data in an Excel file for volumes under-bark net of defect, to a minimum under-bark top diameter of 30 cm. These data are saved in the file VOLUME EQUATIONS (REVISED 2001).XLS. General form factors and form heights have been calculated which can be used with GEMFORM or in other contexts, such as the Rapid Assessment Surveys. Commercial stand basal area times form height gives a good estimate of commercial volume. Where lengths can be estimated, the form factor method is more precise, but this does depend on an unbiased length statistic: Ocular estimates are often biased and need to be verified with instrument cross-checks if the form factor method is to be used in inventories.

The general estimators for volume net of defect, under-bark, to 30 cm minimum top diameter are:

Form factor	0.63
Form height	10.2 m.

The consultant has reviewed the situation with regard to species lists and formulated a strategy for resolving this issue . However the work involved is not trivial, involving substantial training aspects if it is to be sustainable within GFC, and 14 days work is considered necessary for completion (see page 35).

Two days training in Visual Basic has been given to members of the FRIU (see page 38). This continues a process of enhancing their database and data analysis skills which is necessary if GFC is to fulfil its mission without dependence on external help.

Further work

It is clearly highly desirable to complete the forest inventory capabilities of GEMFORM. The consultant considers that 14 days are required for this (exclusive of any travel overheads) comprising:

- Coding of a module to read inventory data in the various formats discussed in the text, from database sources (4-5 days).
- Testing and debugging with available data sources (4-5 days).
- Completion of the online documentation (2 days).

- In-service training specifically on the use of GEMFORM (2 days).

This work could be done in the UK, in which case the training component would be provided as ongoing email support and assistance with the use of the package relative to specific cases until full confidence is gained.

A lower priority, but still useful in the consultants opinion, is to progress the species list issue. GEMFORM has been designed on the assumption that there is no particular standardised list. However, the lack of standards, and the attempt to resolve the problem using inappropriate technical approaches, as discussed on page 35, is a continual waste of time and source of confusion.

The consultant proposes that the design of a database and conversion of existing species data should be conducted as a training exercise, and combined with internal and public workshops to firstly, obtain full agreement and acceptance of concepts; and secondly, to disseminate the new standardised list publicly.

It is estimated that this work can be achieved in 14 days in total. It would be best conducted in coordination with the completion of GEMFORM, as a one month visit which the consultant would be able to make at present in January 2002.

General conclusion

This second visit to the Guyana Forestry Commission Support Project by the biometrics consultant has resulted in some useful outputs, but loose ends remain due to insufficient time with respect to some aspects of the work. GFC's data processing and field survey tasks are not yet highly defined or standardised. There are also several incompatible historical datasets that must be accommodated. This implies that a high degree of flexibility has to be designed into software intended for long-term utility. This need for flexibility considerably complicates the programming task.

The consultant has suggested, that depending on available resources, two options exist to complete the work. In the UK, 14 days can be spent solely on the finalisation of the data input module of GEMFORM, related documentation, and technical support by email to GFC in the use of the system. Alternatively, this can be combined with work to finalise issues relating to species list management, with further and better in house training in both aspects, as a one month consultancy to be undertaken in January 2002.

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Georgetown,
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