# IwoPlan

User's guide and technical manual

*Prepared by Denis Alder*
*Consultant in Forest Biometrics*
denis@bio-met.co.uk

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**Iwokrama International Centre for Rainforest Conservation and Development**
Georgetown, Guyana
http://www.iwokrama.org

# Summary

This manual describes how to use the IwoPlan model. IwoPlan is a program in Visual Basic that models growth and management of natural tropical forest. The forest is represented as divided into many management units of variable size. Each unit has growth modelled by simple stand projection. The model uses GIS files representing rivers and roads to develop a logical transport network. This is extended by simulation to add forest roads and trails to extract timber or non-timber forest products such as canes or oilseed. Management units are allocated for harvesting based on their accessibility and cost of extracting products, as well as constraints such as harvesting cycle. The model outputs include maps of species distribution and product distribution, species stand tables, product tables, yields over time for defined products, costs analysed by infrastructure development, transport, and extraction and in-forest processing. Net revenues are calculated, and discounted net worth at various interest rates.

Users can supply their own base maps of roads, rivers, management units and forest types, species lists, stand tables by forest types, and growth models, to effectively simulate any mixed tropical forest management project. Products, costs and management units are also defined by the user. The interactive maps allow selected areas to be protected from harvesting to create amenity areas, buffer zones, etc.

The manual is divided into four parts. A *Concepts* section deals with the general principles and assumptions of the model. A *Case studies* section describes three cases studies: Conventional timber production by mechanized logging, timber production using chain-sawing at stump and manual or animal porterage of boards, and production of canes and oilseed as examples of non-timber products. A *Menu reference* section provides detailed user information on each menu action and dialog form. A *Configuration section* provides technical information for specialist users on installing the model and configuring it for new projects or baseline data.

# Contents

## Acknowledgments

The IwoPlan model and this manual have been prepared with financial assistance from the International Tropical Timber Organisation. The author would like to thank those who have contributed to his work on this project, especially David Hammond, David Hughell, Vijay Datadin, Barry Evans and Peter van der Hout. The basic growth models used in IwoPlan originated from work for the Guyana Forestry Commission supported by the UK Department for International Development. The present Director-General of the Iwokrama Centre, Dr. Kathryn Monk, and the Director of Programme Support, Mr. Peter Walton, have facilitated the work on this manual.

## Disclaimer

The IwoPlan model, and the contents of this manual, are supplied with or refer to various maps and data for training purposes that relate to the Iwokrama Forest. This data is supplied purely for purposes of demonstrating the use of IwoPlan, and is not intended to provide an accurate representation of past, current or future resource, boundaries, locations, costs, operations or plans within the forest. It is entirely the users responsibility to verify the accuracy of any inputs to or outputs from the model. Statements made in this manual relative to possible management options or scenarios are purely for training and exemplification purposes and do not represent policies or recommendations either of the author or of the Iwokrama Centre. Neither the Iwokrama Centre nor the author accept any liability of any kind with respect to the use of the model by third parties.

## Copyright

# Introduction

## What is IwoPlan?

IwoPlan is a computer package designed to assist in planning the sustainable production of forest resources, including both timber and non-timber plant products. It has been developed by Iwokrama primarily for its internal use, but the model is suitable for general use in any tropical forest situation where the necessary basic information is available.

The model is designed to calculate yields, harvest schedules, costs, prices and net revenues given information about the transport network (roads and rivers), forest types, species, growth rates, products, processing and transport methods, and unit costs. It can take into account different options for management to give various scenarios for managing the forest.

The outputs are in the form of maps, graphs and tables. These can be copied into other packages such as MS Word or MS Excel for publication or inclusion in printed reports. The map formats are also available as files that can be read by the ArcView GIS system.

## Who is this manual for?

This manual is for two kinds of IwoPlan user. The first are those who want to use the model to discuss or review issues of forest planning, or to develop forest management plans for a specific project which has already been set up in the model. Users at this level need to have a good knowledge of forest planning concepts, and some familiarity with using common computer packages such as MS Excel, but they do not need specialist knowledge of GIS or database techniques.

The second kind will be those users who set up or modify the configuration data for the model. This includes the maps and forest inventory summaries used. This requires especially a knowledge of the ArcView GIS system, and also experience in manipulating forest inventory data in either FoxPro or Excel, to generate the necessary stand table summary file. This manual provides the necessary information to take such users through the configuration process.

## How is the manual structured?

The manual is divided into four main sections. The first, entitled Concepts, describes the key ideas and methods underlying the model.

The second, Case Studies, goes through the setting up and running of model scenarios for three possible planning situations (conventional mechanised logging, timber production with processing at stump, and production of canes and oilseed as non-timber products).

The third section, Menu Reference, gives an explanation of all the program functions accessible from the menu system in the form of a user's reference guide.

The fourth section, Configuration, is for the more technical user, and explains how the GIS files and inventory data is set up, and also explains how the various work files generated by the program as it runs can be used to import maps and results back into ArcView or Excel with a high degree of detail. It also includes first-time installation of the program.

## Further reading

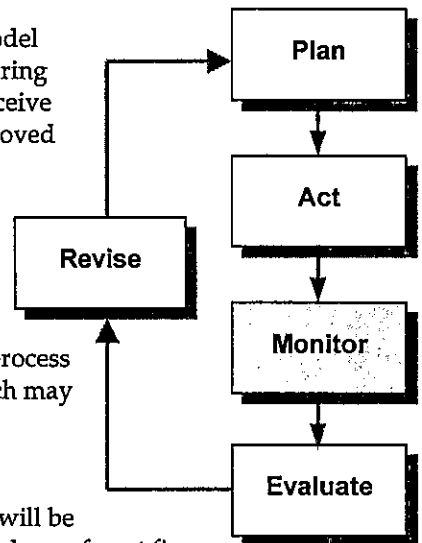
The background to the development of simple growth models for use in Guyana is given by Alder (2000). The models and volume functions in that report are those used in the demonstration data provided with IwoPlan.

A short technical paper which summarises the use of IwoPlan is given by Alder et al. (2001).

General background to growth model design for natural forests will be found in Alder (1995).

### Models and reality

Models guide our actions in many aspects of life, not least in the inner workings of the brain. They are able to do this usefully, in spite of obvious deficiencies and approximations they may contain, provided that we constantly monitor the results of actions we take and revise our planning process accordingly.




This process is illustrated in the diagram at the right. The model provides or informs a plan, upon which basis we act. Monitoring and evaluation of the results from the action allows us to perceive deviations, and to adjust the model and the plan to give improved actions.

As an example, consider catching a cricket ball. The brain does not compute with any accuracy the exact speed of the ball, forces required in muscles, etc. It simply instructs us to move towards the ball. As we do so, the flight of the ball and the body's posture are monitored and adjusted and the process updated, many times a second, until, hopefully, a perfect catch may be achieved.

In forestry, the process is obviously much slower. Plans are typically formulated and updated over a 5-10 year cycle, but will be adjusted more rapidly if circumstances change drastically, such as a forest fire, collapse of an established market, etc. IwoPlan is one among many tools that can assist in developing such plans. To be useful in this role, it does not need to be a perfect model. It only needs to give suggestions that will lead us to take actions in approximately the right direction. However, the model itself should (if it is used effectively) be continuously improved through the monitoring and evaluation process.

This section discusses the concepts on which IwoPlan is based. Some of these involve great simplifications of the real world. Through monitoring, we may establish whether these are critical or not. We may for example, adjust the nature of the plant growth models, or decide to alter the way the transport network is simulated or costs calculated. At the same time, in a future cycle of application, we would use later and more current data, to maintain as close a correspondence as possible between the actual situation, and the planning model that guides us.

### Time periods and time limit

IwoPlan divides all its calculations into 5-year periods. Graphs and tables of yields and costs over time are per 5-year period. The model projections can continue for several hundred years if required, but the model will become increasingly unrealistic over very long periods. Practically speaking, for forest planning purposes, it is a good idea to use a 100-year time limit.

This 5-year period is used in IwoPlan to reduce the number of calculations that the model needs to carry out, so that it will give results fairly quickly (2-3 minutes on a 400 MHz computer). It also simplifies and summarises the amount of tabulated output. It does however mean that

IwoPlan cannot provide detailed information for year-by-year planning. It is essentially a tool for long-term, strategic planning.

## Management units

IwoPlan assumes that the forest is divided into a number of distinct management units (MU). The MUs are known to the model through a GIS shape file in which the MUs are represented as polygons.

MUs can be any size, and can relate to physical features or be arbitrary. In Guyana it is common to use 1 km square blocks (100 ha) as MUs in forest planning. Iwokrama (at least in the data shown here) uses variable units based on stream watersheds, with sizes ranging typically from 300 to 2500 ha.

*An important assumption of the model is that a whole MU will be completely harvested in any given 5-year time period.* An MU cannot be partially harvested in one period and completed in the next. This means that the MUs must be small enough so that this gives reasonably realistic planning. Very large MUs, or a great variation in MU size, will give rather 'lumpy' outputs from one period to the next, because of the requirement that a whole MU is processed in one 5-year period.

As a guideline, the forest should be broken into at least 100 MUs, of as equal a size as possible. The demonstration data provided with IwoPlan includes 405 MUs.

## Forest types and stand tables

In IwoPlan, the forest must be described and mapped in terms of forest types. There can be any number of forest types, and in a simple case there could be just one, covering the whole planning area. Each forest type has to be described by a stand table. This gives the species in each forest type, in terms of numbers of stems per $km^2$, by 10 cm diameter classes. The species do not need to be tree species: they could be lianas, palms or other plants.

The Configuration section explains exactly how the forest type map and the stand table data are input into the model.

When IwoPlan runs, the forest type map is overlaid with the management units map and used to calculate a table which gives the area of each forest type within each management unit. This is then applied to the stand table for the forest types to calculate an average stand table for each management unit.

## The transport network

One of IwoPlan's main functions is to calculate the costs and revenues from producing various products. In order to do this, it must estimate the costs of transportation. This involves components such as building roads and bridges, making cataracts navigable, making and maintaining trails, and then calculating distances along roads and trails to extract produce. To do this, there are a number of aspects of the model concerned with transport network simulation.

### The processing base

IwoPlan assumes a single processing base for all products. This can be moved interactively anywhere on the map, but there cannot be two bases. All marketing prices are calculated relative to the base.

### Streams and rivers

Streams and rivers are assumed to be potential transport routes. However, not all are equally navigable. The GIS map layer that described the river and stream system must assign a value to each section which indicates how easily it can be navigated by small or large boats. The Configuration section explains how this is done.

IwoPlan reduces the navigability of rivers to three classes: none, small boats, or large boats. The model understands that small boats can be used to extract non-timber plant products, but only large boats can be used to extract timber in bulk or as logs. Log rafts are treated as being the same as large boats for navigability assessment.

### Roads

Roads fall into three categories. *Permanent roads* are described on a GIS map layer (see Configuration section). These roads are not costed by IwoPlan for construction or general maintenance. However, those sections which are actively used for timber transport do have a maintenance charge calculated while they are in use.

*Forest roads* may be major or minor roads. Major roads are established by the model as they are needed, and are assumed to join management unit centroids[1]. These roads are actually mapped as they are generated by the simulation, although their alignments should not be taken as realistic. Minor roads are calculated to be of a certain length within each centroid, according to the character of the logging operation, as described in Alder *et al* (2001). Minor roads are assumed to fall into disuse as soon as logging is completed, and are not maintained. Major roads remain in use, and attract a maintenance charge, as long as the are *en route* to any active logging area during any 5-year period.

In the model, major roads can, conditionally, cross streams or rivers. Whether they will do so depends on the index for bridgeability assigned to each river or stream. How this should be set up is described in detail in the Configuration section. If a bridge is needed, its cost is added to that for constructing that particular segment of road.

### Trails

The model only builds roads for mechanised logging of timber. For extraction of non-timber products, it constructs trails. These involve an annual cost for as long as they remain in use, and involve a different per km cost structure to roads. Trails are conceptually intended to be animal transport or porterage routes, but the model is consistent enough to allow them to be regarded as routes for mechanised vehicles such as tractors. Trails between MU centroids are maintained according to the same rules as major roads, *ie.* so long as they are used in transit to another MU that is actively being harvested. The length of trails within MUs, required for harvesting, are calculated only according to a density factor and are not explicitly mapped. This employs the same logic as for minor timber roads.

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[1] A centroid is the geometric centre of a polygon, equivalent to the centre of a circle.

### Transhipment and joining of routes

Transhipment occurs where one kind of transport route runs into another involving incompatible transport system. It occurs between trails and roads, trails and streams, streams and roads.

For mechanised timber, a yarding and loading cost is charged each time transhipment occurs. For NTPPs, if a trail runs to a road, then the goods are assumed to move by road from that point, but there is no loading charge as such.

Some constraints are imposed in the model to prevent certain types of route connections. Roads cannot develop from streams or trails, but must join to other roads, and ultimately the permanent road network. In the present version, this logic does however prevent mechanical logging of coupes accessible only by river, as the model does not allow the logically necessary major road from the river to the MU centroid to be built. Whether this is a realistic constraint depends substantially on the navigability of the river network to ferries able to carry trucks, bulldozers, etc.

## Allocation of coupes

Management units are allocated as harvesting coupes for timber or non-timber products according to a number of logical criteria. Potential coupes must first of all satisfy the following constraints:

- There must be some product available to harvest, after calculating the stock and allowing for conservation criteria such as minimum stocking and percentage of retained stems.
- A period at least equivalent to the designated felling cycle for the product in question must have elapsed since the MU was last harvested.
- The coupe must be on, or adjacent to another MU that is on, a transport route suitable for the product in question.

Coupes satisfying these criteria are organised into a list, which is then prioritised according to one of three possible options (selected via the Options menu). These sorting criteria may be:

- *Distance*: MUs closest to the processing base by any possible route are given highest priority.
- *Product density*: MUs with the highest available ahrvest per/ha are given priority.
- *Unit cost*: MUs with the lowest unit cost of production are given priority. This is the most complex option, as it involves evaluating how the transport network may be extended to each coupe under consideration, and including road and bridge construction costs in the unit cost for accessing that MU, as well as the incremental maintenance cost for the entire route from the unit to the base. It also factors in product density, as MUs with higher product density will tend to have lower unit costs.

Having prioritised coupes, they are then selected in sequence (from highest to lowest priority) until the allowable cut constraint designated for a product is satisfied.

Products can be defined as being extracted according to two general methods, referred to as L-type (logging) and N-type (NTPP). Only one coupe list is generated for all L-type products, whereas the N-type products are harvested independently of each other. This respects the reality that different types of timber species will be logged jointly, in a single operation; whereas NTPPs such as liana, oilseed and palm leaf collection would be planned independently.

### Species and products

Individual species are represented in the model to the extent that they are described and recognised in the stand table data provided for each forest type. However, management simulation is carried out at the level of products. Products may be produced by one or more species. A single species could also produce several products (such as *Carapa guiananesis*, which may produce both high-quality timber and oil seed).

Products have the following properties assigned to them by the user as the model is set up, which largely control how the simulation will proceed:

- They have *conversion factors* assigned, which may be relative to species volume, stem numbers, or basal area, according to the users choice.
- They have *management and conservation criteria*, including harvesting cycle, numbers or percentage of stems to be retained, minimum harvesting diameter, and allowable cut per period (the aggregate amount of the product to be produced on the whole project in one 5-year period).
- They have an associated technical *extraction system*. This is broadly L-type (logging, really applicable solely to timber), or N-type (non-mechanised extraction, using trails and smaller streams). Each of these has their own cost structure.
- They have a product *unit price*.

### Growth models

IwoPlan uses stand table projection as its basic growth model. This is a simplified form of matrix model, in which tree transition frequencies to the next diameter class are calculated from mean increment rates. The general method is described in detail in Alder (1995) . It is the same technical model as that used for the MYRLIN model, which is documented online at http://www.myrlin.org. (Alder et al., 2002; Alder, 2002).

Several species can share the same set of growth model parameters. The growth models are each given a code letter (A-Z), and in the species list, the relevant code letter also supplied. This is explain further in relation to the Species list and Growth models set-up menus, and the configuration topic on growth models.

The growth models supplied with the demonstration data for Iwokrama forest are those developed by Alder (2000) for the Guyana Forestry Commission, based on an analysis of permanent sample plots established and measured by Tropenbos and Barama Company Limited. The models for non-timber products are based on simple assumptions described in Alder (2001) and Alder et al (2001).

## Background information for the case studies

Three case studies are presented in this section to show how IwoPlan can be set up and used to evaluate different situations. These are conventional timber production via mechanised logging, timber sawn at stump using a manually portable technology such as chain saw with guide bars, and production of canes and oilseed.

It is important to emphasise in this section that the data used is imaginary, and not intended to provide real arguments for or against any system of use. Relative costs, technical factors, species use and the like are based on the authors experience and some reports and publications, which are cited where appropriate. However, the primary purpose of this section is to demonstrate how to set up and run IwoPlan, what kind of technical, cost and price data needs to be collected, and how the outputs should be interpreted. It should also be noted that the resource data about Iwokrama Forest, and its subdivision into management units, is based on interim work and may not be currently accurate or valid.

The background information is that provided in the *Installation kit* for IwoPlan, as described in the Installation section. This comprises the river and stream maps, with provisional coding of navigability and bridgeability; the map of the permanent road system; the map of forest management units; stand tables of forest types from interim inventory results; and growth models based on Alder's (2000) work for the Guyana Forestry Commission.

## Preliminaries: Checking the processing base

All three case studies presented here assume that processing and sales will be based at or near the ferry over the Essequibo River at Kurupukari. To ensure that this is the case, please refer to the Setup » Transport network item in the Menu reference section to see how to adjust the transport network base. The example shown in the diagram there has the processing base located at Kurupukari.

## Case study 1 : Mechanised logging

This case study examines the potential for producing and selling logs based on several high-valued species on a sustainable basis. It is based on the assumption of mechanical extraction and transport of logs to the landing at Kurupukari, where logs could either be auctioned to other companies, or processed *in situ* by a mechanised sawmill.

### Defining which species are commercial timbers

The first step in setting up this case study is to update the product codes in the species list. This can be opened via the Setup » Species list menu (see p. 26). The code GH should be entered in the Products field of the species list for Greenheart, and OT for other commercial species, which we will assume are Purpleheart, Kabukalli, Locust, Aromata, Black Kakaralli, Crabwood and

White Cedar. Ensure at this stage that neither the GH or OT codes occur against any other species in the list.

**Setting product specifications for timber**

The second step is to define relevant information in the *Products specification* table (see Setup » Product specification, p.27) . In the first row of this table, the codes GH and OT should be entered in columns 2 and 3 (column 1 cannot be edited). Any other columns should be deleted at this stage. Against *Product name*, enter *Greenheart* and *Other Timber* respectively. These product names need to be kept short; they appear in graph legends and table headings, and the outputs will be messy and unreadable if they are too long.

Against *yield basis* enter V (in uppercase) for both . This means that yield will be determined based on stem volume.

Against *yield multiplier*, enter 0.7 for both GH and OT. This means that 70% of stem volume, on average, is actually extracted from the forest as logs. This allows for lopping of defective sections, and meeting of length specifications. Clearly, for a real study, some information from other commercial operations should be used to arrive at a supportable empirical figure. It would however be excessively optimistic to assume that 100% of stem volume is extracted.

Price per unit, for volume based products, means price per m³ at the point of sale or final delivery (*eg.* FOB Georgetown). The currency unit is shown as $. This may be taken as either US or Guyana $, but it is necessary to be completely consistent. One cannot have some prices in US$ and others in GY$. For this case study, we assume all costs and prices are in US$. In this part of the table, assume the Greenheart price is $70/m³, and other timbers average $60/m³.

**Product specification form for case study 1**

Product specifications

| | | |
|---|---|---|
| Product code | GH | OT |
| Product name | Greenheart | Other Timber |
| Yield basis | V | V |
| Yield multiplier | 0.7 | 0.7 |
| Price per unit | 70 | 60 |
| Units per standard load | 1 | 1 |
| Transport method | L | L |
| Post-harvest survival | 0 | 0 |
| Harvesting damage factor | 1 | 1 |
| Minimum felling diameter | 50 | 50 |
| Harvesting cycle | 60 | 60 |
| Retained stems | 50 | 50 |
| Minimum stock | 200 | 200 |
| Allowable Cut | 50000 | 50000 |

Cancel OK

The *Units per standard load* entry is directed mainly at NTPPs and non-mechanised transport systems. For timber it should be entered as 1 as all transport variable costs will be given per m³.

The *Transport method* should be entered as L (in uppercase). This indicates the use of mechanised logging and truck transport.

*Post-harvest survival* must be entered as zero. This factor is designed for NTPPs such as palm leaves, canes and oilseed whose harvesting does not kill the plant, but may reduce its survival. For logging, the tree is necessarily killed and its survival is therefore zero.

*Harvesting damage factor* should be about 1 for mechanical logging. This is the proportionate reduction in stem numbers in each size class that occurs relative to percentage of volume removed in harvesting. Thus, if 30% of standing volume were removed in felling, the model would, with a HDF of 1, reduce all size classes of the remaining stand by a further 30% of their post-harvest value to allow for felling damage. If the HDF had been given as 0.5, then the further reduction would be 15%. An HDF of 1 is good rule of thumb for typical mechanical logging, provided that all or most of the volume is enumerated. This factor can be adjusted for local techniques based on empirical information.

The *Minimum felling diameter* is the smallest tree that may be harvested. This may be either a legal or economic limit, whichever is most effective. For this case study, we will assume that it is 50 cm for both types of timber (GH and OT).

The *Harvesting cycle* is the minimum return period before a particular stand can be harvested again. For this study, we assume the Tropenbos-Guyana recommendation of 60 years.

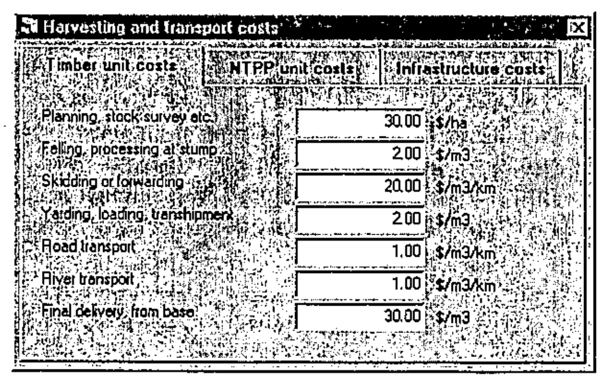
The *Retained stems* indicates the % of stems above the minimum size limit that will not be felled. This may be considered a statutory conservation measure. It may equally be an empirical value, based on defect rates and operational efficiency, reflecting the % of stems that are not actually used. We will assume a value of 50% for both types of species.

The *Minimum stock* comprises the smallest number of stems per $km^2$ that must be present above the diameter limit before a management unit can be considered viable for felling. This may be a statutory conservation regulation (2 trees per ha, or 200 stems per $km^2$ is a figure used in Ghana, for example). It may also be considered an economic limit. If average volume per tree is 10 $m^3$ (a good rule of thumb for Guyana), and 20 $m^3$/ha is the minimum economic harvest with mechanised logging, then again 2 trees/ha (200 trees/$km^2$) represents an appropriate minimum for entry. For the case study, we will assume this figure of 200 trees/$km^2$ is realistic.

The *allowable cut* determines the yield target which the model will try to maintain. This may be limited by the size of the available resource, or by constraints on marketing, processing and transport. For the moment, we will enter a figure of 50,000 $m^3$ for both the GH and OT columns, but will come back to discuss this further in the section *Estimating the allowable cut*. This figure is the volume that will be allowed to be cut per 5-year period.

The *Product specifications* form should be closed by clicking the *OK* button. If the form is closed using the *close window* box, *Ctrl-F4*, or the *Cancel* button, changes which have been edited into it will not be saved.

**Defining timber production costs**




The menu Setup » Transport costs brings up a dialog form that allows cost information relative to timber extraction and processing to be entered. The transport costs for timber for the case study are based on typical figures, but clearly this data needs to be defined as accurately as possible.

*Planning costs* are applied per ha in the time period when an MU is actually harvested, and include inventory, stock survey, detailed road design, and supervision and overhead costs for logging. A typical value of $30/ha is used here.

Costs of *felling and processing at stump*, for a simple logging operation, include chainsaw costs, operators wages, and chainsaw and labour costs relative to cross cutting, and are given per $m^3$ of felled volume. A typical figure of $2/$m^3$ should be used.

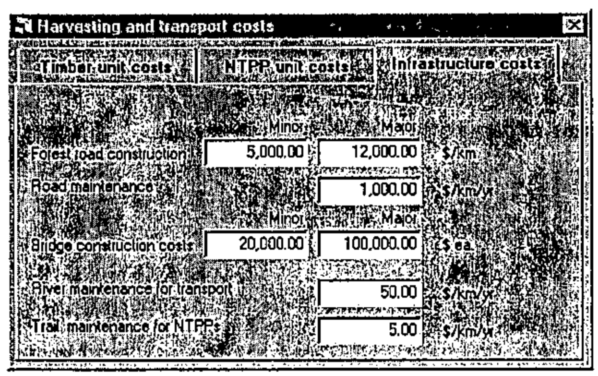
*Skidding and forewarding costs* include all the running costs of skidding: fuel and lubricants, wages, and maintenance, but not capital costs. These must be expressed per $m^3$ extracted and km hauled. These are quite sensitive to the type of equipment used and the efficiency with which it is managed. The cost of $20/$m^3$/km would probably typify catepillar logging and be at the higher limit.

*Yarding, loading and transhipment costs* are expressed per $m^3$, and include an average cost for either loading onto trucks, or transhipment from road to river transport. For the case study, an estimated figure of $2 per $m^3$ should be used.

*Road transport* is expressed per $m^3$ per km carried. For the case study, 1 $/$m^3$/km should be used. *River transport* is applied in the same way, and uses the same estimated costing for this example, although in reality the figure is likely to be lower. Note that road and river costs are strictly operating costs, and do not include infrastructure development or maintenance, which are accounted for elsewhere.

The *final delivery cost* is the cost of moving timber from the processing base in the transport network (Kurupukari in this case study) to wherever it will finally be sold. As the product prices are approximately FOB Georgetown prices for logs (according to GFC 2000 market reports), the cost of transport from Kurupukari to Georgetown is used, which was about $30 per $m^3$ in 2001.

*Infrastructure costs* are set on the third tab of the *Transport costs* form, as illustrated, and include the construction and maintenance costs for roads and bridges. They also include the costs for making rivers navigable and maintaining them in that state, and the costs for cutting and maintaining trails for animal or foot transport.




*Road construction costs* are specified for two classes of road. The *minor roads* exist within MUs, are temporary in nature, and are not maintained after logging. They are not explicitly mapped by IwoPlan, but are calculated only on the basis of a road density factor. The *major roads* are also forest roads, but they are maintained in use for more than one 5-year period. These roads are mapped by IwoPlan as it extends the road network. For the case study, it is assumed minor roads cost $5,000 per km to construct, and major roads cost $12,000 per km. Maintenance on major roads is assumed to be $1,000 per km per year.

It will be noted that the permanent road network construction and general maintenance costs, as indicated by the road map, are not costed by the model on a production-related basis. This is because they may have public use or ownership, and will therefore be supported by external funds. If charged to some extent to the project, they must be regarded as an overall fixed cost.

However, the model does apply the maintenance cost factor to any sections of the permanent road network that are in use for haulage of timber or other products.

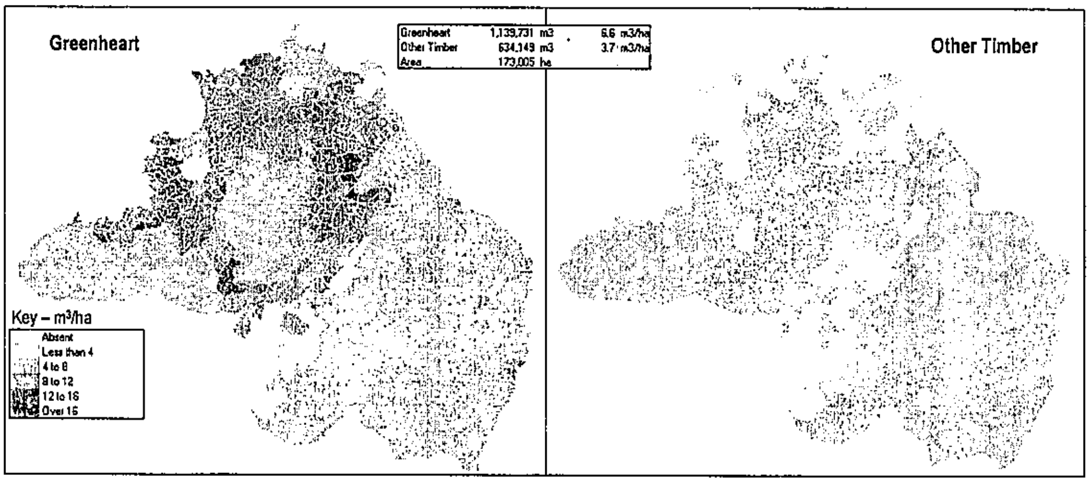
Bridge construction costs likewise fall into two classes, as discussed in the menu reference section Setup » Transport costs. For smaller bridges, a cost of $6,000 each is assumed, whilst for larger bridges, a cost of $12,000 is given.

### Options for running the model

The Setup » Options menu brings up a dialog to look at some general options. For the purposes of this case study, please follow the settings shown on the diagram in that section. The *Time limit* should be set to 100 years, and the *Initialize automatically* box checked. The *Selection policy* should be set to *Lowest unit cost.*

### Viewing timber production potential

The distribution and quantities of available timber can be viewed via the *Products distribution form.* See the Menu reference section for details of the use of this form. The figure below shows the initial distribution of Greenheart and Other Timber[1].




These maps show the net amounts available, respecting the retention %, minimum felling diameter, and minimum stock criteria given on page 9. They also include the effect of the conversion percentage (yield multiplier) relative to standing stem volume.

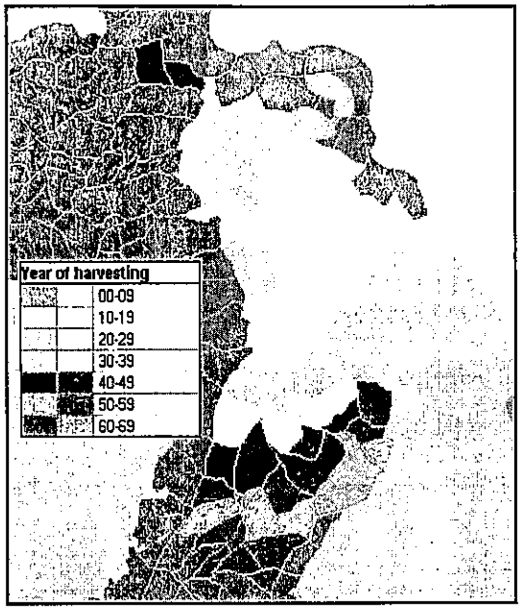
It will be apparent that this side by side comparison shows average harvestable stocks of Greenheart to be 6.6 $m^3$/ha, whilst the other timbers average 3.7 $m^3$/ha. The total area under management is 173,000 ha, with available stocks of 1,140,000 $m^3$ of Greenheart, and 634,000 $m^3$ of other timbers. It is apparent from the maps that there are parts of the forest where net Greenheart stocks are close to zero, and which are therefore unlikely to be suitable for timber exploitation.

### Viewing simulated harvesting and coupe allocation

We can now run the model, via the Run » Start menu. If the options have been set up as previously described, then viewing the Harvest Plan map will show a pattern of coupes similar to the map below. Because of the option settings, this represents the most cost-efficient harvest the

[1] This map has been composed by cutting and pasting from the IwoPlan maps. This can done with a frame grabbing tool such as Screen Rip32, or by using the *PrtSc* key to save the screen to the clipboard. This can then be manipulated using Windows Paintbrush or a similar utility.

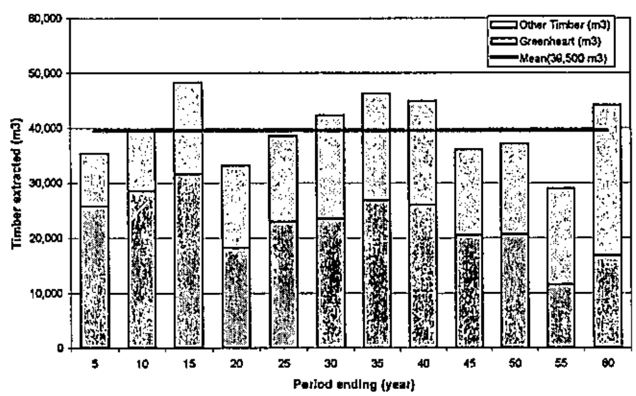
model can calculate, and should be used as a baseline is assessing basic financial feasibility before considering constraints that may need to be imposed to protect tourism and amenity.




It will be noted that the model favours harvesting close to the road and Kurupukari under this option, because this minimizes transport costs. The years of harvesting are indicated by colours, with yellows being harvested first, then greens, blues and purples. This simulation covers a single felling cycle (60 years) to avoid an unduly confused picture on the map opposite.

## Timber yields

The figure below shows the timber yields for *Greenheart* and *Other species* projected over one rotation. The histogram has been created by copying the tables from the Product yields form for *Greenheart* and *Other species* into Excel using the Copy function, and then producing a stacked bar chart from the data.

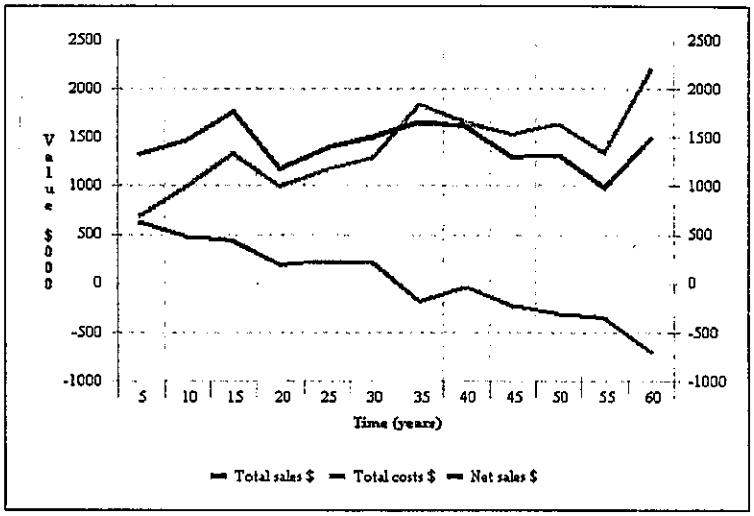



It will be seen that total harvests are mostly between 35,000 and 45,000 m³ per 5-year period, with a mean of 39,500 m³. It will be recalled that on the products form, the allowable cut was set at 50,000 m³ for both Greenheart and Other Timber. IwoPlan generally cuts below the stipulated allowable cut because it can only process whole units in a harvesting period; it will not start to cut a unit if the result of felling it would be to exceed the allowable cut.

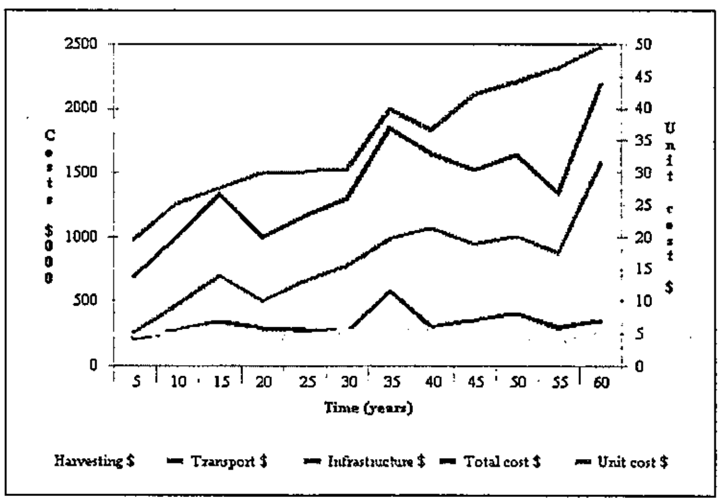
With mechanised logging, the allowable cut issue is further complicated by the fact that the two products are treated as a single item for management purposes, because one cannot mechanically-log one coupe for Greenheart, and a different one for Other Products. This problem does not arise with NTPPs and manually extracted timber, where each product will be operated independently. It will also be noted for mechanised timber products that the periodic allowable cut (PAC) will be taken as the largest stipulated PAC for any of the products listed as having the L-type transport method (see Product specifications above and explanations in the Menu reference). It is suggested therefore that to obtain a given PAC, a degree of experimentation may be required on the *Product specifications* form.

**Sales, operating costs, and financial viability**

Total sales, total costs and net revenues are shown on the Net sales graph of the Sales & Finance menu. The graph for this case study scenario is shown below. All the values shown are totals per 5-year period, in $'000s. Sales (black line) fluctuate between $1,000,000 and $1,500,000 per period, whilst costs (red line) gradually rise from $500,000 to $2,000,000. Consequently, the net revenue per period declines and becomes negative ( a net loss) after about the 30th year.

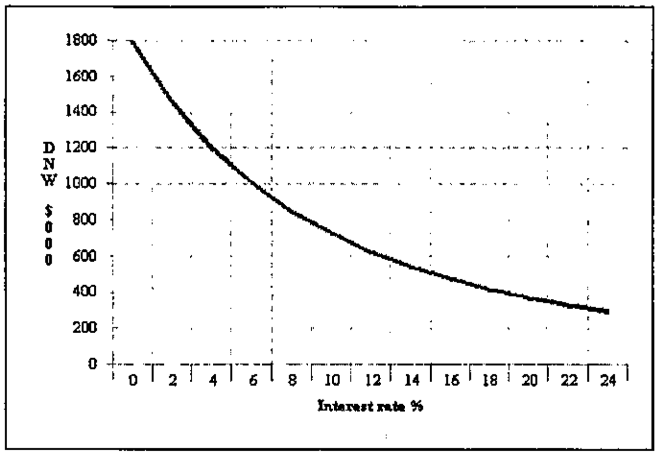



The reason for the increasing costs can be seen by examining the logging costs details,as shown in the graph below. Whereas harvesting costs remain constant over time (green), and infrastructure development and maintenance (blue) only rises slightly, the transport costs rise steeply (red). These costs are linearly related to haulage distance, and as operations move further from the base at Kurupukari, they rise substantially. It is essentially this haulage distance increase that moves the project from being profitable in its early years to giving a net loss in the later years.




The unit cost of production, shown by the magenta line and read against the right axis, rises from around $20 per m$^3$ initially, to over $50 per m$^3$ at the end of the rotation, due to this rising transport cost with increasing distance.

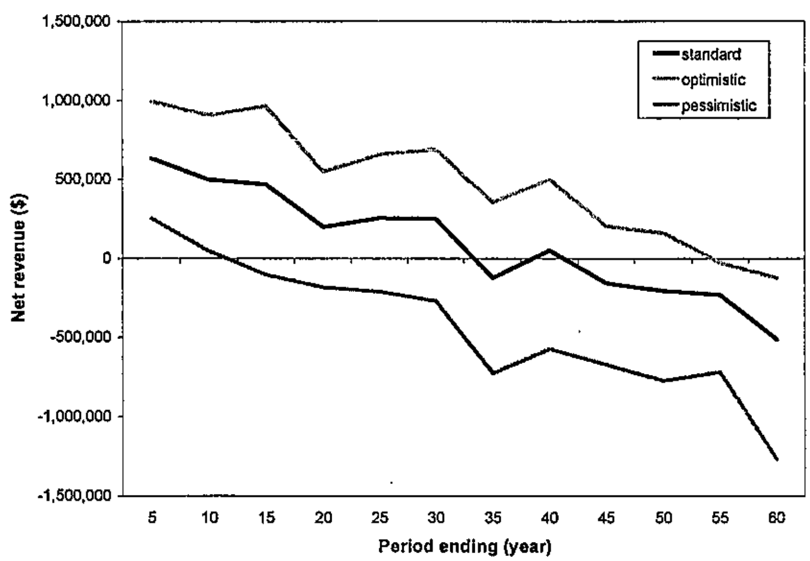
Given the uncertainties of long-term markets, costs etc., and the fact that the above projections suggest the project would move into a loss after 30 years, what would be the return on capital if the project was run only for, say, 20 years? This would be an appropriate period to write off logging equipment and timber trucks, and might be a profitable operation, whilst leaving future options open. This can be checked by changing the projection period to 20 years on the Options form, then re-running the model. The results, in terms of return on capital over 20 years, can be seen by viewing the *Capital & IRR* graph on the Sales and Finance form. This suggests that at a 10% borrowing rate, the 20-year income stream could support a capitalisation of around $700,000. It appears very likely that such a




project would be feasible. Mechanised production of $40,000 m³ per 5-year period, or 8,000 m³ per year, requires a single skidder, or even a suitably adapted agricultural tractor with logging winch, and timber truck, and could probably be capitalised at $250,000.

## Sensitivity analysis

It is desirable in this type of study to re-run the model with higher and lower critical costs and prices. The critical cost is clearly haulage, which has two important components: The road transport cost (initially estimated at $1 per m³ per km), and the final delivery cost from base to point of sale (estimated at $30 per m³). The prices are assumed to be $70 per m³ for Greenheart and $60 per m³ for other timbers. The graph below shows the net revenue using the costs and prices noted above, an Optimistic scenario, with 10% higher prices and 10% lower costs, and a Pessimistic scenario, with 10% lower prices, and 10% higher costs. The sensitivity of the results to these quite small changes are evident, and emphasise the importance of obtaining accurate estimates for critical data if the model is to lead to appropriate conclusions.




## Conclusions to Case Study 1

This case study examines a rather small mechanised timber business, using costs and prices that are as realistic as possible. It shows that under some circumstances, such an operation could be viable, but it would be by no means a license to print money, mainly due to low FOB prices for roundwood and high transport costs. This case study does not explore all the issues that IwoPlan could and should examine. For example, some management units with this type of operation should be protected to minimize tourism and visual impacts (the method of doing this is described in relation to the Harvest Plan menu). What effect would this have on costs, as it would inevitably tend to increase transport distances? Would the relatively marginal returns from mechanised logging be outweighed by costs external to the model, such as impacts on tourism? If more species were used, and PAC set higher, would there be economies of scale that would improve viability? If wood were reprocessed either at stump or at Kurupukari to give a higher unit price (but, or course, lower net yield) would these be advantageous and improve viability? These and other issues need to be examined more fully for a complete evaluation of options.

In concluding this case study, the author would also draw attention again to the Disclaimer. The results indicated here are purely to exemplify the use of the model, and do not imply any suggestions for actual management, as the base line data used is not current, and the costs and prices are too suppositional.

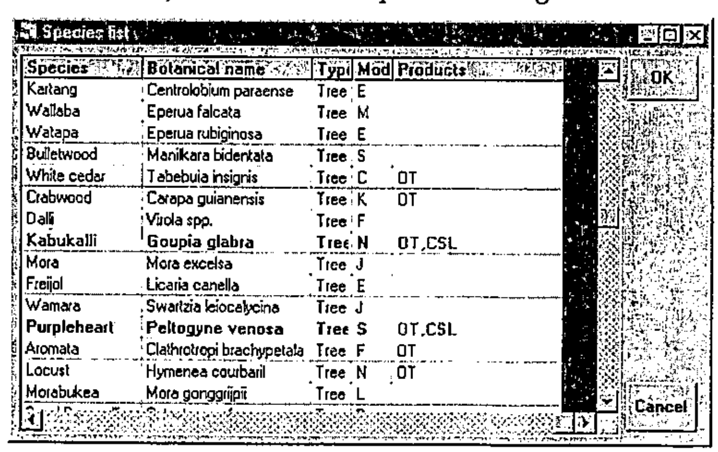
## Case study 2 : Timber processed at stump with manual extraction

This case study contrasts the mechanised extraction and marketing of logs discussed in Case study 1 with an alternative possibility. This involves felling trees and converting them into sawn boards in situ, and then extracting them by river or pack animals. The advantages of this approach are usually stated as the negligible capital required (essentially only a cash float for operating costs), the elimination of the need for a substantial road system with its high costs and environmental dis-benefits, and the efficiency of reducing bulk and adding value at tree stump. It also requires less organisation and forest management planning, and can be directly implemented by local people with only limited training.

Information about the use of IwoPlan referred to in Case Study 1 will not be repeated in this section except where directly relevant, and the reader is therefore advised to work through that case study before considering this one, even if they regard it as of little direct practicality.

### Species and product specifications

For simplicityand direct comparability, it will be assumed that the same species as considered in case study 1 are used, namely Greenheart, White Cedar, Crabwood, Kabukalli, Purleheart, Aromata, Locust and Black Kakaralli. The *Products* column of the species list should be amended to add an additional code, CSL (for chain-sawn lumber), to each of these species. The figure opposite shows how this would appear after amending Purpleheart and Kabukalli in this way.




| Species | Botanical name | Type | Mod | Products |
|---|---|---|---|---|
| Kartang | Centrolobium paraense | Tree | E | |
| Wallaba | Eperua falcata | Tree | M | |
| Watapa | Eperua rubiginosa | Tree | E | |
| Bulletwood | Manilkara bidentata | Tree | S | |
| White cedar | Tabebuia insignis | Tree | C | OT |
| Crabwood | Carapa guianensis | Tree | K | OT |
| Dali | Virola spp. | Tree | F | |
| Kabukalli | Goupia glabra | Tree | N | OT,CSL |
| Mora | Mora excelsa | Tree | J | |
| Freijol | Licaria canella | Tree | E | |
| Wamara | Swartzia leiocalycina | Tree | J | |
| Purpleheart | Peltogyne venosa | Tree | S | OT,CSL |
| Aromata | Clathrotropis brachypetala | Tree | F | OT |
| Locust | Hymenea courbaril | Tree | N | OT |
| Morabukea | Mora gonggrijpii | Tree | L | |

The product specifications need to be amended to reflect differences in harvesting, processing and extraction technique. The required amendments can be seen in red in the next figure.

Firstly, a new column is added, using the *Ctrl-Ins* key. The product code for the new column is amended to CSL, and the product name to CS Lumber

(CS standing for *chain-sawn*). Then some of the entries are amended, by comparison with the Greenheart entry from Case Study 1.

The *yield multiplier*, which gives the ratio of extracted to standing volume,is reduced to 0.2 (20%). This assumes that on average, after conversion at stump, 20% of the original stem volume will remain as sawn boards. The *unit price* for the sawn boards is given as $400 per m³ (FOB Georgetown). This reflects typical prices for air-dried boards according to Guyana Forestry Commission market reports.

**Product specifications**

| | | |
|---|---|---|
| Product code | CSL | GH |
| Product name | CS Lumber | Greenheart |
| Yield basis | V | V |
| Yield multiplier | 0.2 | 0.7 |
| Price per unit | 400 | 70 |
| Units per standard load | 1 | 1 |
| Transport method | N | L |
| Post-harvest survival | 0 | 0 |
| Harvesting damage | 0.5 | 1 |
| Minimum felling diameter | 50 | 50 |
| Harvesting cycle | 60 | 60 |
| Retained stems | 50 | 100 |
| Minimum stock | 200 | 200 |
| Allowable Cut | 5000 | 0 |

Cancel OK

The *units per standard load* are left unchanged at 1. In other words, cost, price and product calculations are again carried out in terms of m³. For further discussions of this, see the relevant menu reference topic.

The *transport method* is changed from L-type to N-type. N-type transport implies the use of the NTPP extraction cost template, based on manual, animal or small boat extraction, without construction of roads, although trails will be constructed as necessary.

The *harvesting damage factor* is reduced to 0.5. This is arbitrary, as the author has no knowledge of studies of extraction damage for this type of harvesting, but is substantially less than for mechanised logging, with its associated skid trails and log-length extraction. Damage will not be zero, however, as tree fall gaps will still be created, and the conversion of the bole will necessitate clearing a good deal of undergrowth, including regenerating poles, for proper working space around the felled tree.

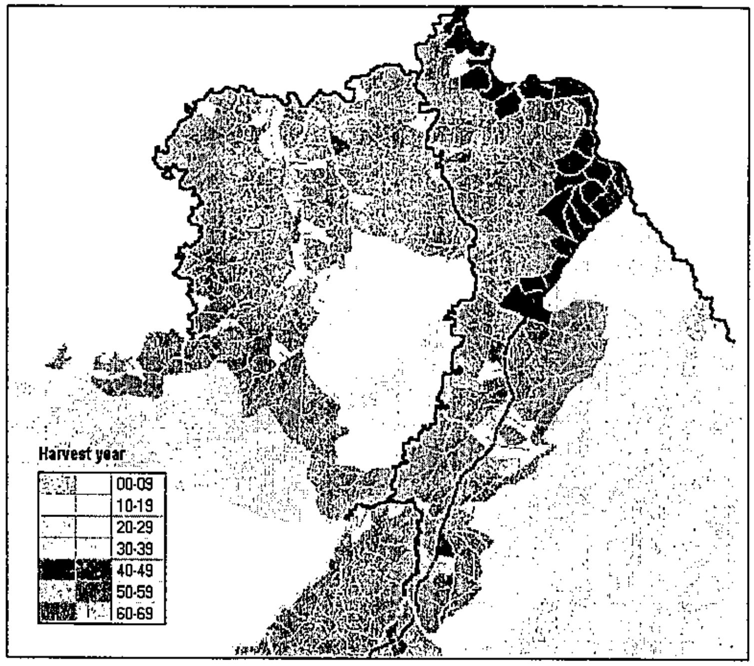
The *retained stems* are left at 50%. However, retained stems for the GH and OT products should be changed to 100%. This effectively switches off harvesting of these products. *Allowable cut* for the CS Lumber is set to 5000 m³ per 5-year period. This is based on assessment of feasibility without creating a visually intrusive industrial infrastructure at Kurupukari. It is equivalent to about 85 m³ per month, or about 10 medium-sized truck loads of sawn boards being transported to Georgetown on a monthly basis (obviously with some adjustment for seasonal transport conditions).

*Allowable cut* for GH and OT timbers should be set to zero. This, together with 100% retention, will switch off the harvesting of these products, so that only the CS Lumber will be harvested in this scenario.

## Transport costs

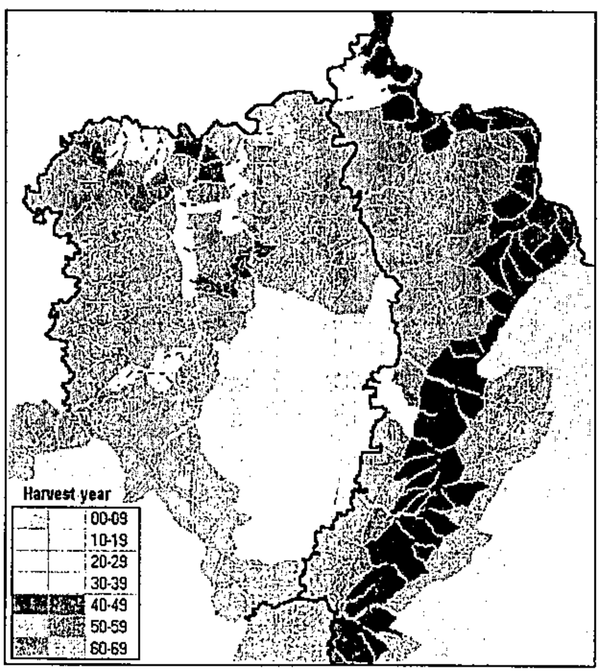
The suggested transport costs to use in this case study are given on the NTPP tab of the Transport costs form. This appears as illustrated below. The units referred to in this case will be m³, because of the setting of 1 on the *Units per standard load* entry of the *Product specification* form, as shown above, and the *Yield basis* being indicated by V (stem volume). Porterage costs are set at

\$20 per m$^3$ per km. A horse or donkey would normally require about 20 trips to carry 1 m$^3$ of lumber a km (assuming 50 kg loads), and a relatively high figure seems appropriate for this. *Road transport* costs about \$1 per m$^3$ per km. *River transport* is estimated at ¢50 per m$^3$ per km, or about half the cost of road transport. The *Infrastructure costs* are assumed to be the same as for cost study 1, with the critical values for this simulation being \$50 per km per year for maintenenace of river routes (mainly relative to cataracts and landings), and \$5 per km per year for trails. It will be noted that IwoPlan only applies a maintenance charge for trails and river routes used in any given 5-year period, but it will apply it over the whole 5-year period, which for many trails for lumber extraction may be excessive.




## Harvesting plan

To protect sensitive tourism areas from timber felling activities, management unit protection can be applied to the harvest plan form. The scheme applied for this case study is shown in the map at the right as a darker gray shading, and covers units along the Essequibo River and the main road close to Kurupukari. The units are marked for protection by (a) ticking the *Exclude selected MUs* box on the *Harvest plan* form, and then (b) clicking on the required units with the *Ctrl-Left mouse* button (see also the menu reference topic regarding mouse controls on maps).

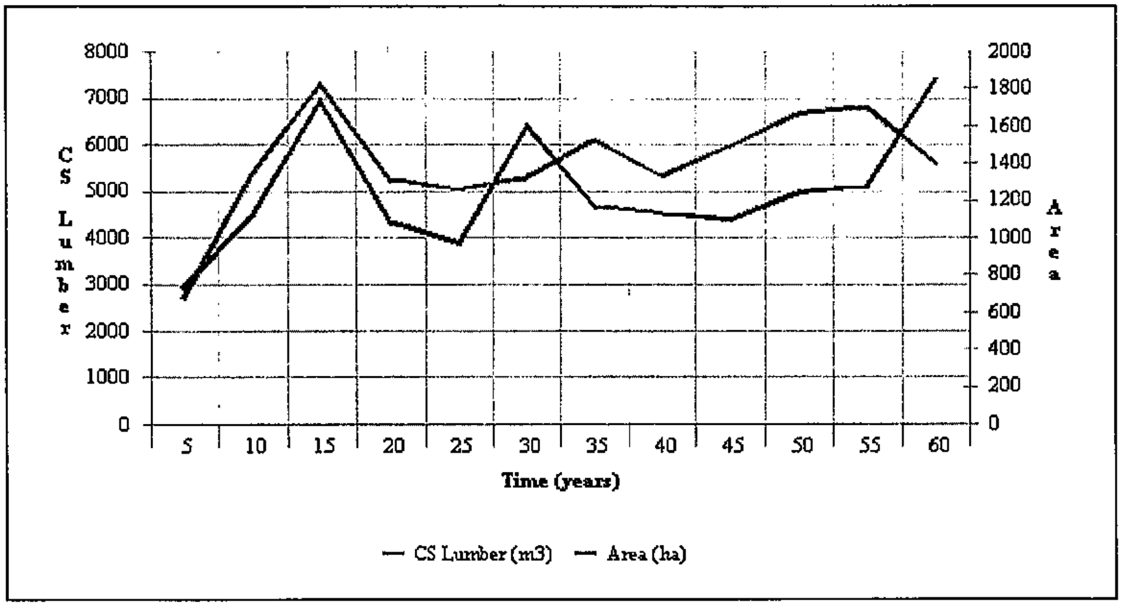



If the simulation model is run over 100 years with the above settings, and with the *selection policy* on the options form set to *Lowest cost*, with the *Aggregate MUs* checkbox cleared, then the harvest plan map shown above should be seen.

It will be seen that management units occur mainly along navigable rivers and the main road. The ribbon development along the road can be suppressed by increasing the selection of protected coupes (dark gray). Units operated in the same year are scattered in different locations. A more concentrated and easily managed pattern would result. This is shown in the example at the left, which is the basis for the financial and production analysis. In this example, the entire road has a protected zone on either side, to reduce visual impacts, as does the area along the Essequibo River. The harvested management units in each period are all adjacent, making planning and control easier. Otherwise, the options and costs are as described above.

**Financial analysis**

Production over one rotation (60 years) for the above scenario is shown below. It fluctuates mainly due to the selection of units, and could be smoothed out by making some adjustments to this. The allowable cut was stipulated as 5000 $m^3$. Production is actually between 5000 and 7000 $m^3$ in most periods. This is net product of processed boards, and is equivalent to around 25,000-35,000 $m^3$ of felled tree volume (given the conversion factor of 20%).




Sales, costs and net revenues are shown in the table at the right, taken from the Sales & finance menu. These show a sound financial position that is sustained over the rotation, with net revenues of around $1.5-$2 million per 5-year period. This is not very sensitive to any aspect of transport costs, as the reader may verify by repeating the sensitivity analysis technique described for the previous case study.

| Period (end yr) | Total sales $ | Total costs $ | Net sales $ |
|---|---|---|---|
| 5 | 1,003,189 | 208,448 | 794,741 |
| 10 | 1,985,992 | 415,622 | 1,570,370 |
| 15 | 2,699,392 | 387,953 | 2,311,439 |
| 20 | 1,940,773 | 453,133 | 1,487,640 |
| 25 | 1,856,783 | 292,711 | 1,564,071 |
| 30 | 1,950,896 | 341,368 | 1,609,528 |
| 35 | 2,255,758 | 366,361 | 1,889,397 |
| 40 | 1,964,361 | 320,291 | 1,644,069 |
| 45 | 2,206,545 | 379,028 | 1,827,517 |
| 50 | 2,462,158 | 377,115 | 2,085,043 |
| 55 | 2,516,899 | 666,169 | 1,850,730 |
| 60 | 2,078,591 | 463,535 | 1,615,056 |

The chart of discounted net revenue suggests that at 10% interest, and without considering capital costs, the DNW of this income stream over 60 years would be of the order of $2.7 million. Over the first 20 years, of the project it would be $1.9 million.

#### Conclusions regarding case study 2

The chain-sawn lumber operation analysed here is considerably more profitable than the mechanised logging operation examined in case study 1. Capital requirements would be limited, as almost all operations could be subcontracted. Visual impacts, and environmental impacts from road construction and erosion would be very much less. Supervisory and training requirements would be much simpler. The price used ($400 for air dried lumber) corresponds to averages from GFC market reports, and would be realistic. It is probable that with care, using the Iwokrama brand and with certification, a premium price could be obtained.

This case study is however, only intended to demonstrate how IwoPlan may be used to examine such questions. Transport costs and conversion rates need to be verified, and the species to be used carefully judged. The baseline data used here is weak with regard to some aspects of the inventory. The classification of stream navigability is also insufficient in these data sets (being based purely on stream order) to properly evaluate options based on river transport.

## Case study 3 : Canes and oilseed

This case study examines the viability of NTPP businesses based on the production of canes from Nibbi and Kufa, and of essential oil extracted from the seed of Crabwood (Craboil). For these studies, the costs employed are very tentative, as they involve searching, gathering, and quality selection activities in the forest. Market prices could also vary widely, depending on the efficiency with which Iwokrama could leverage certification and branding to obtain price premiums. The growth models and the resource data in the present version of IwoPlan and the associated demonstration files also need to be amended for a proper study of availability and sustainability with respect to canes.

#### Species and product specifications

To accommodate this case study, the *products* column of the species list form for Nibbi and Kufa should have the code CN (for canes) inserted, and Crabwood should have the code OS (for oilseed).

The product specifications form should be amended so that it has two columns, set up as shown in the figure opposite. The *product codes* are CN and OS, which correspond to those for the respective species in the species list. The *product names* given are *Canes* and *Oilseed*. The yield basis is calculated relative to stems (N) for canes, and relative to tree basal area (G) for oilseed.

For canes, it is noted that the URS (2002) report on cane production at Iwokrama estimates an average of 35 pieces of 4 m cane per ha, corresponding more or less on a 1:1 basis to stem counts. These are normally bundled into 100 pieces for transport and marketing, which is therefore defined as the standard load. A *yield multiplier* of 0.01 relative to stem count is therefore used in the table opposite, where the unit of yield is a bundle of 100 pieces of about 4 m length.

For oilseed, there is some published information from Brazil on Andiroba oil (Andiroba being the Brazilian name for Crabwood). Using the assumption that seed production will be proportional to basal area (the latter being itself proportional to crown area), and noting in Plowden (2001) that average production from several sample trees for 20 to 70 cm dbh was 0.8 kg per season, it is estimated that the average production per m$^2$ of basal area per 5-year period will be around 30 kg. It is further noted from Plowden (2001) that 30kg of seed yield about 1 litre of refined oil.

For craboil therefore, a *yield multiplier* of 1 is used, with the units being litres of oil. This is discussed a little further in the section on transport costs.

**Product specifications**

| Product code | CN | OS |
|---|---|---|
| Product name | Canes | Oilseed |
| Yield basis | N | G |
| Yield multiplier | 0.01 | 1 |
| Price per unit | 20 | 25 |
| Units per standard load | 20 | 33 |
| Transport method | N | N |
| Post-harvest survival | 0 | 1 |
| Harvesting damage factor | 0 | 0 |
| Minimum felling diameter | 0 | 0 |
| Harvesting cycle | 20 | 20 |
| Retained stems | 0 | 0 |
| Minimum stock | 0 | 0 |
| Allowable Cut | 0 | 0 |

Cancel OK

Prices for Nibbi and Kufa are quoted by the URS (2002) report as being around ¢5 per m length for small diameter, average quality material purchased by middlemen. A bundle of 100 pieces of 4 m length would therefore have a conservative price of around $20. For craboil, price is a matter of conjecture and marketing, but are likely to be of the order of $20-$30 per litre. A figure of $25 is used initially.

The *units per standard load* are defined here relative to a metric ton, to allow the same transport costs as were used in case study 2 to be applied. For canes, assuming a 100 pc bundle weighs about 50Kg, then there may be 20 units per ton. For craboil, a litre of oil is derived from 30 Kg of seed carried to the processing centre, or approximately 33 units (of 30 kg seed) per ton.

The *transport method* for both products is defined as N, implying a product with non-mech nised extraction and harvesting, river transport by small boats, and overland transport on porterage trails up to the existing road system.

*Post-harvest survival* is zero for canes, which are cut and harvested. For oilseed, which is derived from seeds falling to the ground and collected, there is no impact on the parent tree, and survival is 100%. The *harvesting damage factor* for both these products is zero, because there is no impact from harvesting on the residual stand. The *minimum felling diameter* is likewise given as zero for both types of product as there is no constraint of this type imposed.

A *harvesting cycle* for both types of product of 20 years is suggested. This implies that a coupe will be rested for 15 years after being harvested for 5 years. For Nibbi and Kufa, this will allow the plants to regenerate. For Crabwood, it will allow seed to become established to ensure continuity of the crop. The most appropriate cycle does however require some scientific analysis.

*Retained stems* and *minimum stock* for both products is set at zero. It is assumed that the above harvesting cycle provides a sufficiently generous protective measure. It is unlikely to be possible to police any more complicated conservation measures for this type of product.

The *allowable cut* will be estimated as discussed in the next section, and can be given as zero initially. The *Product specification* form at this stage should be closed with the *OK* button to save the settings, and the model <u>initialised</u>.

## Estimating allowable cut

To estimate maximum allowable cuts for the products, total product stocks can be examined from the Product distribution map. The table will at this stage show total stocks for canes of about 34,000 units (ie bundles of 4 m pieces), and for oil seed of 143,000 units (ie. litres of extractable oil). These should be divided by the rotation to give annual equivalents, and multiplied by 5-year periods to express allowable cuts per period. Thus maximum allowable cuts would be around 4,250 units for canes and 35,750 units for oilseed.

These figures would imply however covering the entire managed area of the reserve (173,000 ha) over a 20-year period. As an initial assessment of feasibility therefore, this case study examines operations at a smaller scale, aiming to produce 200 bundles of canes per annum, and 1000 litres per annum of oil. These correspond to periodic allowable cuts of 1000 and 5000 units respectively for canes and oilseed, which should be entered in the *product specification* form as shown above.

## Transport costs

It will be noted as discussed previously, that the *units per standard load* factors on the *product specification* form should be 20 for canes and 33 for oilseed. These will give standard loads of approximately 1 ton in each case. This allows the same transport and infrastructure costs as used in Case study 2 to be applied. In that case, calculations were based per m$^3$, but a m$^3$ of green wood is approximately equivalent to 1 ton. However, for this case study, it is assumed that the prices are based on sales made at Kurupukari. The delivery cost to from base to final destination should therefore be given as zero.

## Harvest plan

The figure opposite shows the harvesting plan for canes after 60 years (3 rotations). Some areas are protected around Kurupukari (shown in darker gray), so that the gathering activities do not impact on the immediate vicinity. The coupes in the same 5-year period are shown in the same colours. Although coupes vary between rotations to some extent, the general pattern is similar in each cycle, and the total exploited area does not extend greatly.

The pattern of coupes for oilseed is very similar. The model is predisposed to work in the same areas when two or more products are planned simultaneously because of the economies involved in sharing the infrastructure of trails and river improvements. Had this exercise included mechanised logging, it would have been seen that the location of forest roads would greatly influence harvesting patterns for NTPPs.

## Financial analysis

The table of sales, costs and net revenue shown overleaf for the two products indicates that the operation would be quite profitable, yielding net about $140,000 per 5-year period ($28,000 pa). About 85% of the sales value is due to oilseed, and 15% due to canes.

**Sales, costs and net revenues from Case Study 3**

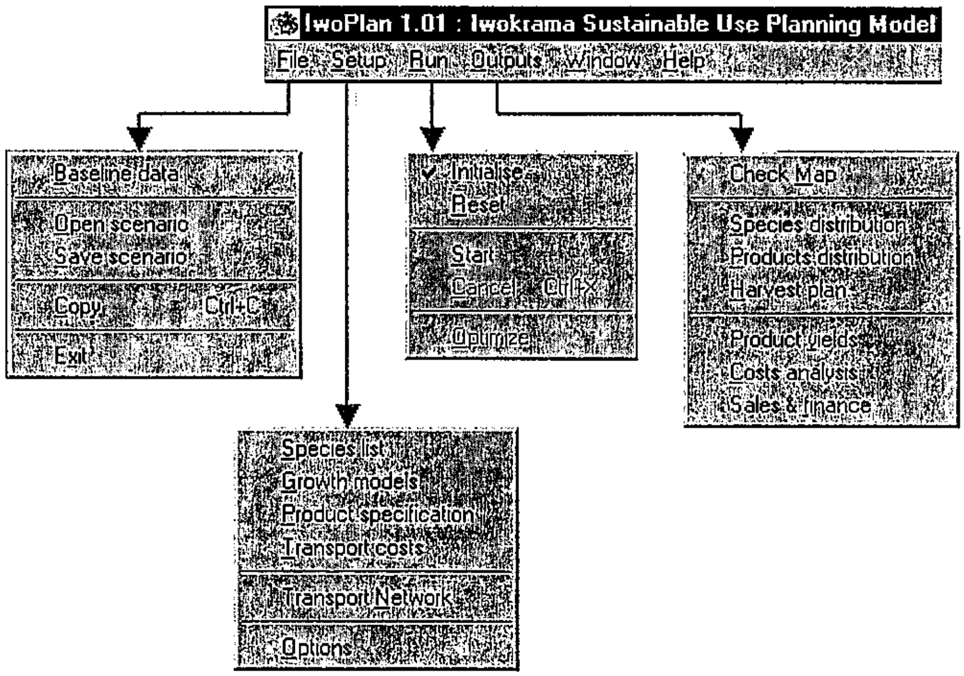
| Period (end yr) | Canes $ | Oilseed $ | Total sales $ | Total costs $ | Net sales $ |
|---|---|---|---|---|---|
| 5 | 20,406 | 128,645 | 149,051 | 8,967 | 140,084 |
| 10 | 20,934 | 144,227 | 165,161 | 11,473 | 153,687 |
| 15 | 21,848 | 126,558 | 148,407 | 11,111 | 137,296 |
| 20 | 20,130 | 125,405 | 145,535 | 12,542 | 132,993 |
| 25 | 20,841 | 126,558 | 147,399 | 9,499 | 137,901 |
| 30 | 20,789 | 137,586 | 158,376 | 11,604 | 146,772 |
| 35 | 23,664 | 127,580 | 151,244 | 11,343 | 139,900 |
| 40 | 22,145 | 135,342 | 157,487 | 13,874 | 143,613 |
| 45 | 20,840 | 125,232 | 146,072 | 9,397 | 136,675 |
| 50 | 20,789 | 130,094 | 150,883 | 11,150 | 139,733 |
| 55 | 23,659 | 135,883 | 159,542 | 12,202 | 147,340 |
| 60 | 20,562 | 128,388 | 148,950 | 13,278 | 135,672 |

## General conclusions for case studies

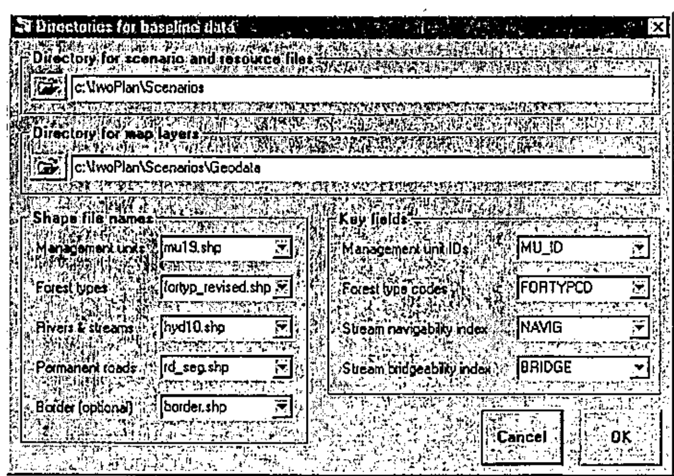
IwoPlan allows the general feasibility of different types and scales of operation to be examined quickly and visually, as shown in the three case studies discussed here. These are designed primarily for training purposes, as the costs, prices and baseline data all need to be verified. The obvious conclusion that arises, namely that mechanised logging would be unprofitable, chain saw logging the most profitable option at a corporate level, and gathering of oilseed and canes also financially viable, could be regarded as valid based on the data presented and used here. However, attention is again drawn to the disclaimer, and the reader reminded that these exercises are for the purpose of exemplifying the use of IwoPlan; the data is in many respects incomplete or suppositional, and it is not the purpose of this manual to provide real-world recommendations.

## The menu system

The menu system of IwoPlan is shown in the figure below, as it would appear fully expanded. The various menu items are explained below.




## File » Baseline data




The *baseline data* menu brings up the dialog form shown opposite. This sets the directories which contain the scenario and geodata files, gives the names of the geodata files for each type of map layer, and gives the names of the attribute fields associated with each file.

These data are technical and would not normally be changed by the ordinary user once a project has been configured. The

Configuration section discusses in detail how the map layers and their attributes should set up, and the directory structure and files required by the program.

### File » Open scenario and File » Save scenario

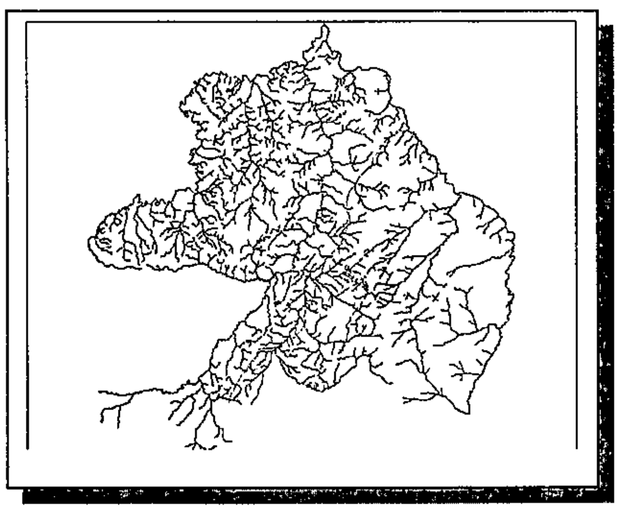
The *Open scenario* menu brings up a standard Windows file open box, which allows a scenario file to be located. These have the extension *.iwp. When a scenario file is opened, its contents will replace all the settings in the program with those in the file. Normally, scenarios contain mostly the same configuration data (map layers, inventory data, growth model, species list) and will differ from each other only in the particulars of management, products, prices, and costs.

The *Save scenario* menu likewise brings up a dialog to save a scenario file. This can be given any name, and will have the extension *.iwp. This will save all current settings and options in that file, allowing them to be retrieved at a later date.

IwoPlan uses a default scenario file called ..\SCENARIOS\DEFAULT.IWP (where ..\ is the directory containing the IWOPLAN.EXE program) when it starts up. This file is also always saved with current settings when the program is closed down. This gives the program continuity between one run and the next, as it always appears to remember its settings from the last time it was used.

### File » Copy

The *Copy* menu is the main method for transferring data from IwoPlan to another application. The map below, for example was transferred into Word using the *Copy* menu, with the default Word paste (Ctrl+V) with a textbox of an appropriate size.



The way *Copy* works will depend on the form open at the time. If it is a map (*Check map, Species distribution, Products distribution, Harvest Plan*) then the map is copied as a Windows metafile.

If it is a graph, then both the graph and its underlying data are copied. Using *Paste Special* in Word or Excel, either the image may be pasted, or the data. The latter is particularly useful in Excel, where the data will be pasted directly as a spreadsheet table.

### File » Exit

The *Exit* menu will close the program and return to Windows. When this is done, all current settings are saved automatically in the file DEFAULT.IWP. Note that closing the main IwoPlan window has the same effect as the *Exit* menu.

## Setup » Species list

The *Species list* menu brings up the species list table, as shown below. This provides information about species, and can also be edited, as noted below. The Configuration section provides a fuller discussion of the species list in relation to inventory data. Here it should be noted that the *Code* should not be edited, or the link with the inventory data file may be lost or mixed up. The local and botanical names can be edited as needed. The *Type* of plant and the growth *Model* are links to the *Growth models* form, and should also not normally be edited after configuring the model. The most important field for most users is the *Products* field, which can be edited to create new products, or to remove the relationship between a particular product and the species concerned. Several products can be listed for each species. For example, *Carapa guianensis* (Crabwood) could have the entry TI, OS, indicating that it produces both timber (TI) and oilseed (OS). The product codes are defined in the Product specification form.

Species list

| Code | Species | Botanical name | Type | Mode | Products |
|---|---|---|---|---|---|
| 1 | Bamboo | Guadua angustifolia | Grass | A | |
| 2 | Rupununi Grass | Trachypogon plumosus | Grass | A | |
| 7 | Nibbi | Heteropsis spp. | Liana | A | CN |
| 8 | Kufa | Clusia spp. | Liana | A | CN |
| 10 | Manicole | Euterpe spp. | Palm | A | |
| 20 | Ite | Mauritia flexuosa | Palm | A | |
| 30 | Karia | Astrocaryum sciophilum | Palm | A | |
| 50 | Arapipi | Astrocaryum vulgare | Palm | A | |
| 60 | Kokerite | Attalea maripa | Palm | A | |
| 70 | Buba | Socrotea exorrhiza | Palm | A | |
| 80 | Turu | Oenocarpus bataua | Palm | A | |
| 101 | Greenheart | Chlorocardium rodiei | Tree | M | TI |
| 108 | Muri | Humiria balsamifera | Tree | E | |
| 120 | SandpaperTree | Curatella americana | Tree | E | |
| 150 | Konoko | Licania cuprea | Tree | J | |
| 188 | Dakama | Dimorphandra conjugata | Tree | E | |
| 200 | Kartang | Centrolobium paraense | Tree | E | |
| 202 | Wallaba | Eperua falcata | Tree | M | |

OK

Cancel

### Editing fields in spreadsheet-like forms

It will be noted that the *Species list*, as above, the *Growth models*, and *Product specification* forms all appear somewhat like a spreadsheet. The all use the same method to edit data. Double-click on the required cell and it will change to a pink colour. In this style it can be edited. After making changes, press the *Enter* key, and the changes will be saved. Simply moving to another cell, or closing the form while the edit mode is still active, will not save the changes.

It should also be noted that if this type of form is closed by using the Window close box or by pressing the *Cancel* button, any changes made will be lost. *The form must be closed with the OK button for changes to be saved.*

## Setup » Growth models

Species growth model coefficients

| Model | Dinc | AMR | Dmax | Vf |
|---|---|---|---|---|
| Tree m | | | | |
| A | .134 | .0148 | 32.9 | 11.2 |
| B | .252 | .018 | 37.9 | 12.5 |
| C | .359 | .0339 | 29.6 | 10.6 |
| D | .222 | .0175 | 43.9 | 12.6 |
| E | .36 | .0087 | 50.3 | 12.1 |
| F | .518 | .0204 | 42.3 | 11.9 |
| G | .686 | .0225 | 54.3 | 12.6 |
| H | .983 | .0322 | 55 | 10.6 |
| J | .198 | .0157 | 54.2 | 13.6 |

OK

Cancel

The *Growth models* form appears when this menu item is pressed, as shown at the right.

For each defined type of plant form (trees, lianas, palms in the present version), a list of models will be seen. Each model refers to one or more species, with the model code indicated by a single letter. There are four parameters for each model. Average diameter increment (Dinc), annual mortality rate (AMR), 95% cumulative diameter (Dmax), and the form height (Vf), or volume/basal area ratio, are required for trees. The Concepts and Configuration sections discuss in more detail the conceptual basis of the models, and how they may be set up.

The entries in the *Growth models* form can be edited as noted above (see Editing fields in spreadsheet-like forms). However, normally growth models will be defined directly in the default scenario file (DEFAULT.IWP) during the configuration process and will not be altered by users. See the Configuration section for further details.

## Setup » Product specification

The *Product specification* form appears as shown below. This form is central to the effective use of IwoPlan, as it defines the types of timber and non-timber products, their yield characteristics, prices, transport method, management constraints and objectives, the influence of harvesting on survival (including logging damage, for example). The Case studies section gives detailed examples of the use of this form, whilst the Concepts section deals with the underlying ideas. The various entries in the form are explained briefly below. The entries are edited using the method described in the section Editing fields in spreadsheet-like forms above. *Note that changes are saved only if the* OK *button is used to close the form.*

Product specifications

| Product code | TI | OS | CN |
|---|---|---|---|
| Product name | Timber | Craboil | Canes |
| Yield basis | V | G | N |
| Yield multiplier | 0.7 | 25 | 1 |
| Price per unit | 100 | 1 | 1 |
| Units per standard | 1 | 0.2 | 0.2 |
| Transport method | L | N | N |
| Post-harvest survival | 0 | 0 | 0 |
| Harvesting damage | 1 | 0 | 0 |
| Minimum felling | 50 | 0 | 0 |
| Harvesting cycle | 60 | 20 | 20 |
| Retained stems | 50 | 0 | 50 |
| Minimum stock | 200 | 0 | 1000 |
| Allowable Cut | 50000 | 25000 | 25000 |

Cancel OK

### Product code

The product code must link with the *Products* column of the species list. The codes can be invented as required, and should preferably be short. Case is significant, so a code of p1 is not the same as P1. To avoid possible problems, use only uppercase letters and numbers.

### Product name

This name appears on various screens when selecting or reporting results for the product. It should preferably be fairly brief (around 20 letters maximum) to avoid formatting problems.

### Yield basis

The yield basis for a product can be volume in m³ (V), stem basal area in m² (G) or per stem (N). This basis is then multiplied by the yield multiplier to get the actual yield per stem. Timber will invariably have a volume basis (V). Other products may normally be calculated relative to stems. For example lianas will have a yield per stem. Seeds, resins or other products that may be related to tree size can be specified as per unit basal area if sufficient data is available to develop such an allometric ratio. Entries other than uppercase V, G or N will be treated as N.

### Yield multiplier

The yield multiplier is used to calculate the actual yield for the product, in whatever units are appropriate. For timber, this will represent a recovery factor for product taken out of the forest. If boards are sawn at stump, then a factor of 20-30% would be appropriate. For logs, perhaps 70-80% of the mensurational volume may be removed. These percentages should be expressed in decimal form (eg 45% should be given as 0.45). For lianas, where the product is probably expressed in length, then the multiplier could be an average length according to the units used (ft., m). The value entered must be numeric and greater than zero.

#### Price per unit

This should be the sale price of the unconverted unit at the destination. Prices in IwoPlan are shown with a $ prefix, although the model has no idea of US$, Guyana $ etc. However, all financial data must be in the same currency units throughout the model. Currencies with high denominations may cause problems with formatting in some contexts, especially on graphs. For simplicity and standardisation in international reports, US$ accounting is suggested. The value entered must be numeric and greater than zero.

#### Units per standard load

The concept of a standard load is geared towards human or animal-based transport systems, where products may be hand-carried or carried on pack animals. It is therefore applicable more to non-timber products. This multiplier calculates how many units of yield comprise one standard load. All non-timber product transport costs are stated relative to this load. Timber could also be extracted in a similar way (*ie.* manually or by animals) in which case, the scaling should be much as shown above (ie about 0.03 of a m3 constitutes a 30kg load). Note that this field is only applied when the transport method (see below) is specified as N; it is ignored otherwise. The value entered must be numeric and greater than zero.

#### Transport method

IwoPlan caters for two types of transport cost structures, which are coded in this field by N or L. N-type transport relates particularly to non-timber products, although it could be applied to manhandled boards sawn at stump. It uses as the base a concept of a standard load, which needs to be defined in practice but is probably around 30 kg (*ie.* what a person can carry any significant distance or load manually onto a canoe etc.). N-type transport can use trails and rivers in the transport network.

L-type transport is fully mechanised, and is applicable to logs and timber. It assumes costing on a per m3 basis, and is restricted to road and forest road networks. If values other than uppercase L or N are entered, L-type transport is assumed. Note that for management purposes, all L-type products are treated jointly as being operated on the same coupes, whereas N-type products will have independently allocated coupes.

#### Post-harvest survival

When product is removed from a stem, does the stem survive? For timber, the answer is clearly no (although one might envisage coppicing, perhaps). Therefore, for timber, this factor should be zero. Harvesting a liana likewise removes the stem in question. For gums and resins, and leaves, much depends on how the harvesting is done, but post-harvest survival should be a factor up to 1 (indicating 100% survival). The value entered must be numeric and in the range 0-1.

#### Harvest damage factor

Removing small non-timber products or lianas does little or no damage to the residual stand. However, felling large trees clearly does. This factor indicates the proportion of stems in each diameter class that will be lost after logging as a result of damage, relative to the intensity of logging. Logging intensity is defined as basal area logged over total stand basal area before logging. For example, if logging intensity is 15%, and the damage factor is 0.8, then 0.8 x 15%, or 12% of the residual stock of each diameter class will be assumed to be lost as damage. As a rule of thumb a damage factor of about 1 is appropriate. The value entered must be numeric and greater than zero.

### Minimum felling diameter

Natural forests are typically managed in part by specifying a minimum felling diameter, below which trees may not be removed. This is specified in IwoPlan on the product table, where the diameter limit will be applied to all species that produce a given product. The value given must be numeric, representing a diameter in cm. It may be zero.

### Harvesting cycle

The felling or harvesting cycle is a critical control measure to avoid over-exploitation of a plant resource. In IwoPlan, all 'L-type' products (ie mechanical logging) is assumed to be done on a single coupe, so the felling cycle needs only to be specified for one - it will then be applied to all. For N-type products, each may have its own harvesting cycle. If different L-type products are given different cycles, IwoPlan will take the longest and apply it to all. A zero value will indicate no harvesting, but this will only work for L-type products if all are set to zero. The value entered must be numeric and a multiple of 5. A value of 5 indicates continuous harvesting (because the model works in 5-year steps - see p. 3).

### Retained stems

Another conservation or control measure applied to timber, and also appropriate for non-timber products, is the proportion of stems to be left unharvested. They are specified here as a percentage, ie 50 means 50% of stems will be left unharvested. The *Retained stems* can also be used to indicate a proportion of stems that might be unharvested due to defect or unsuitability, although above the required size limit. The value entered must be numeric and in the range 0-100.

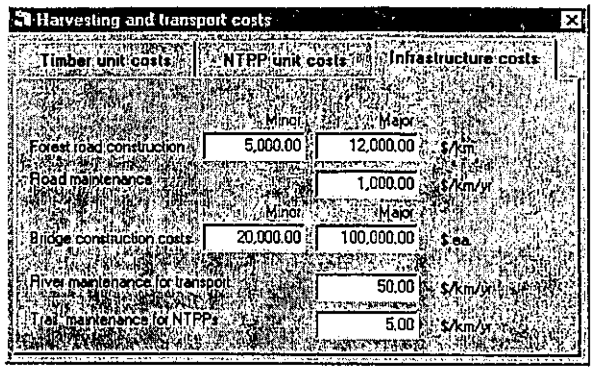
### Minimum stock

A percentage retention does not protect the future of the stand if stocking is low. This factor allows a minimum stock to be specified, in terms of stems per $km^2$ (ie. 100 x n/ha) above the diameter limit. If this level is not present, the management unit cannot be harvested. The value entered must be numeric and zero or above.

### Allowable cut

The allowable cut designates the targeted harvesting level. It is a periodic figure, so if IwoPlan is running with a 5-year time step (as is built-in with version 1.01), the allowable cut is the quantity per 5 years. It is specified in terms of product units after application of the yield multiplier. For timber units this is m3 of product. IwoPlan will harvest successive management units within a period until the last one harvested causes the periodic allowable cut to be exceeded. Adjusting this figure allows scenarios for different scales of operation to be explored. The value entered must be zero or above. See also the notes on this in Case study I relative to mechanised harvesting.

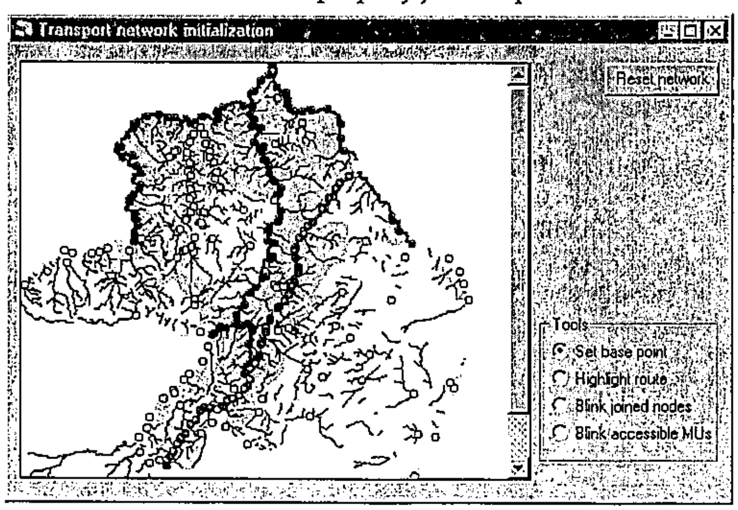
## Setup » Transport costs




The *Transport costs* dialog appears as opposite as a tabbed box, divided into three categories: *Timber units costs, NTPP unit costs*, and *Infrastructure costs*. Entries on the *Timber unit costs* tab are applied to products with the L-type Transport method designated on the *Products specification* form. These would typically be timber extracted by mechanical logging. Cost factors on the NTPP tab would be applied to products with the N-type transport method, being typically non-timber products, but possibly also manually extracted wood products processed at stump. The *Infrastructure cost* tab applies costs that are linked to different classes of infrastructure in the map layers. Minor roads are internal forest roads within MUs. Major roads are the mapped forest road segments linking MUs. Minor bridges are those crossing rivers with a *Bridgeability index* of 1. Major bridges are those which cross rivers with a *Bridgeability index* of 2. (See the Configuration section for a further explanation of the bridgeability index).

## Setup » Transport network

The Transport network menu item brings up the form which appears below. The main purpose of this is to check and regenerate the logical transport network used by the model. This only needs to be done if either (1) the model is being installed for the first time, (2) the transport network files appear to be corrupted, or (3) the processing base is being changed. This form also has on it some software tools for diagnosing and checking problems with the network. These could arise because of errors in the road or river system map layers, whereby sections of the network are not properly joined up or are inappropriately classified.




To relocate the processing base, ensure the option button labelled *Set base point* is checked. Then double click on the map where the base is to be located. The map can be zoomed in or out, or panned using the *left mouse button* (zoom in), *right mouse button* (pan), or *shift+right mouse button* (zoom out). When the base is located accurately, click on the *Reset network* button to regenerate the files.

The Reset network button rebuilds three sets of work files used by IwoPlan. These are *~MUlinks*, and the ArcView Shape file sets *~tNet1.** and *~tNet2.**. These are located in the directories set in the File » Baseline data form. After this has been done, the *Transport network* form closes. If it is re-opened, the diagram shown below will appear, with the processing base (yellow spot) located appropriately.

If the work files are missing or not in the correct format, then one of several things may result. It may be impossible to open the *Transport network* form, with the program giving an execution error and then closing. Or the form may open with a blank map area, or the map area will be complete, but will not show the route and node structures indicated above.

If the form opens, but is either blank or contains a map but lacks route and nodes, simply press the *Reset network* button to regenerate the files. If it cannot be opened at all, then the files *~MUlinks*, *~tNet1.** and *tNet2.** must be entirely deleted. This will allow the form to be opened normally and the network to be reset (ie. the files will be regenerated correctly).

The most likely causes of these problems are directory changes. Please note that if the File » Baseline data form is used to change the scenario or geodata directories, the program will not find the work files, and will behave as indicated.

The *Highlight route* tool can be used to check that a transport route is fully joined up. Double clicking on a node will highlight in yellow the shortest route from the node to the base point.

The *Blink joined nodes* tool shows which nodes are directly linked to any other. Double clicking on a node causes the joined nodes to flash.

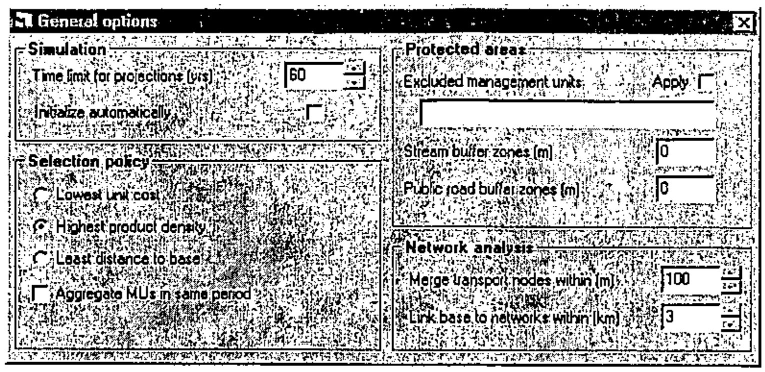
The *Blink accessible MUs* shows which MUs are directly accessible from any other.

These three tools will rarely be of interest to the normal user. They do demonstrate features of the transport network logic that are useful in presentations and discussions, but their main objective is to diagnose faults in program logic and/or GIS files structure. If for example, routes in a GIS file are not fully joined up, then gaps will occur in the network which can be detected using these tools.

There are two settings in the Setup » Options form under the *Network analysis* section that influence how the transport network is built up. The setting *Merge transport nodes within (m)* gives a tolerance factor to allow for routes that do not properly join up. A setting of 100 m is recommended. If a low or zero value is used, the GIS input files for roads and rivers *must* be processed through the ArcInfo CLEAN function (or its equivalent in other packages) to ensure that routes are fully joined up.

The *Link base to networks within (km)* allows a specified processing base to be linked to the transport network by a spur road, provided it is within the designated distance of a route. If this is zero, the processing base will be inaccessible unless it is positioned precisely on a route.

## Setup » Options




The *Options* form includes several miscellaneous options. In the *Simulation* box, the total time limit for projections can be set. The *Initialize automatically* box will ensure that the model is initialised whenever certain key settings are changed. Otherwise this process must be done manually before the model is run. For slower computers, it may be found better to leave this box clear.

The *Selection policy* frame allows for three ways of allocating management units for harvesting. The *Lowest unit cost* option will select the first and subsequent MUs based on the lowest unit cost of production, taking into account all costs including infrastructure construction and maintenance. The *Highest product density* option will select the first and subsequent MUs without regard to cost, but simply picking those with the highest amounts of product per ha. This is useful where costs are very uncertain, as high product densities will tend to minimize harvesting costs. The *Least distance to base* option is another option that may be used when costs and price data are very weak. It will pick management units for harvesting that are closest to the base point. The *Highest product density* option will give better results where products are remote but occur in well aggregated areas, and are not generally ubiquitous. The *Least distance* option will be better for more or less uniformly distributed products.

The checkbox marked *Aggregate MUs in same period* ensures that, if several MUs are to be harvested in the same period, they will all be adjacent. Otherwise, the model may tend to scatter them around. The aggregating of MUs may be realistic, especially with the *Highest product density* option, but it will be sub-optimal on a pure cost basis, if the *Lowest unit cost* option is selected.

The *Protected areas* frame allows specified MU numbers to be listed, and protected from any harvesting when the *Apply* checkbox is ticked. When management units are selected for protection on the *Harvest Plan* map form, they will automatically be listed here and the *Apply* checkbox ticked. That provides a more visual, map-oriented way of protecting units. Units protected in this way will not be harvested at all. This provides a way of protecting amenity areas, tourism facilities, and of excluding areas of steep topography, swamp etc.

In the present version of IwoPlan, stream and road buffer zones are not calculated, so the entries in the buffer zone boxes will be ignored by the program.

The settings in the *Network Analysis* frame influences how the transport network is constructed from base map information (roads, and rivers), and is discussed in the Setup » Transport network section.

## The Run menu


The *Run* menu, as illustrated at the right, provides for four functions relative to starting and stopping simulations. All of these act directly, without bringing up intermediate dialog forms.

The *Initialise* function builds tables of pre-processed information in memory and resets the resource data to its initial state. This function can be executed automatically if the *Initialise automatically* checkbox is ticked on the Setup » Options menu. For faster computers, it is recommended that this is done. For slower computers, the initialisation process can take 20-30 seconds and may be tedious if it is invoked unnecessarily, as for example when changing several product options prior to running the model. For such cases, manual initialisation via the *Run » Initialise* menu will be more convenient. It should be noted that the *Initialise* function will close any map windows that are open when it is executed.

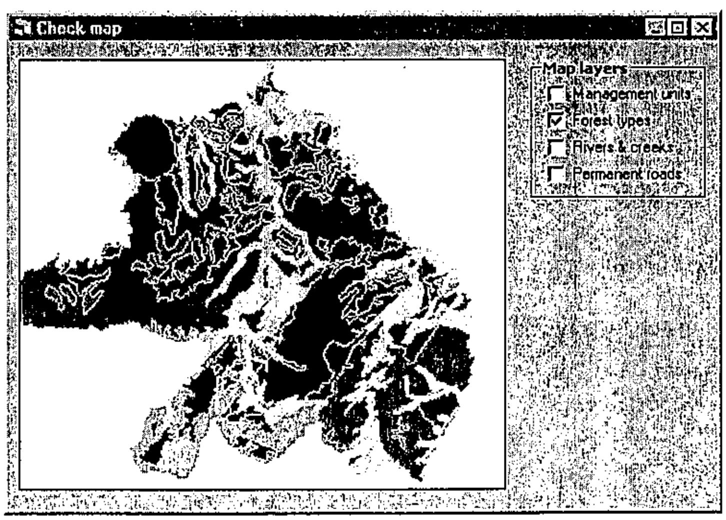
When the model requires initialisation, the *Reset* and *Start* menus will be grayed out, as will all the Output sub-menus except for the check map.

The *Reset* function is similar to *Initialise* but faster and more limited. It resets the resource data to year zero. Whereas *Initialise* will close any open map windows, *Reset* allows maps to remain open, and updates the appearance directly.

The *Start* menu runs the simulation model until the time limit is reached. Any maps or graphs open will update interactively whilst this is in process.

The *Cancel* menu is normally inactive (shaded gray) but becomes active whilst the simulation is running, and can be used to cancel a run. The model will stop at the end of the last completed time period with all maps and displays updated to that point.

## Outputs » Check Map

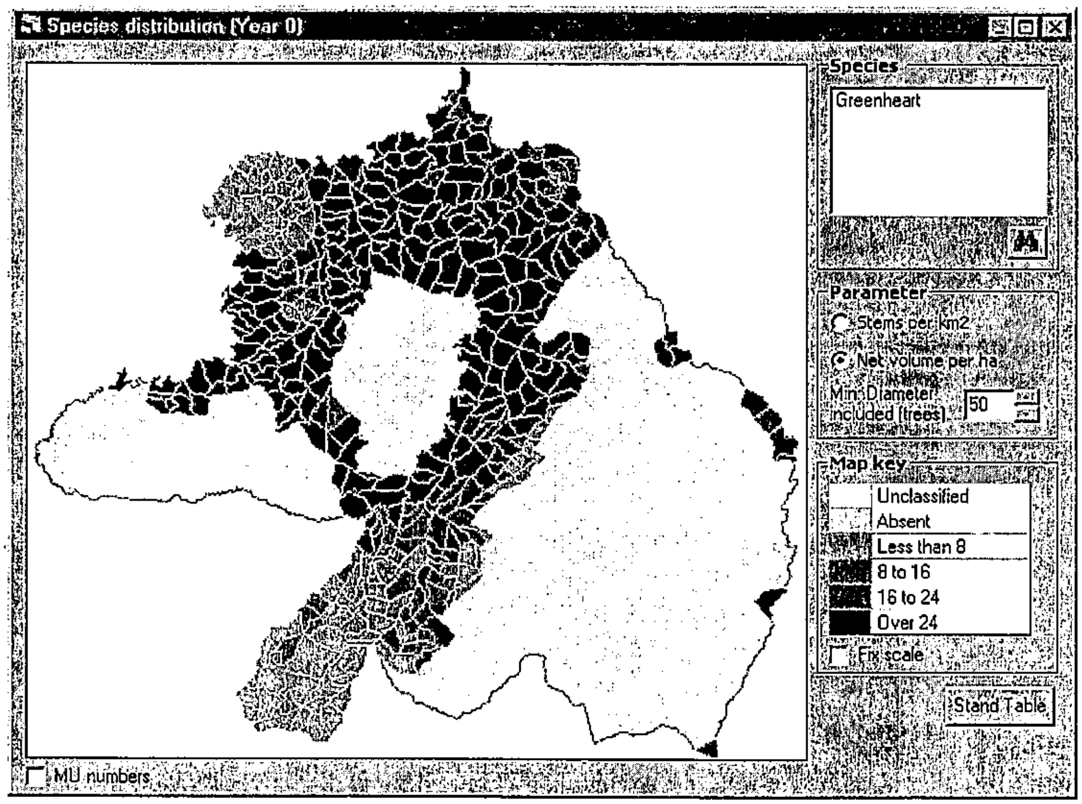



The check map form is used mainly to verify that the correct geodata files have been selected. Clicking on each layer will add it to the map, and clearing it will remove it. The order in which the layers are clicked determines how they overlay each other. The figure to the right shows how the check map form will appear with the forest type layer displayed using the demonstration data provided. If the check maps do not appear correctly, please check that the system is properly configured (see Map layers and GIS files and File » Baseline data).

The check map can be zoomed in or out, or panned using the *left mouse button* (zoom in), *right mouse button* (pan), or *shift+right mouse button* (zoom out) in the same way as for other maps.

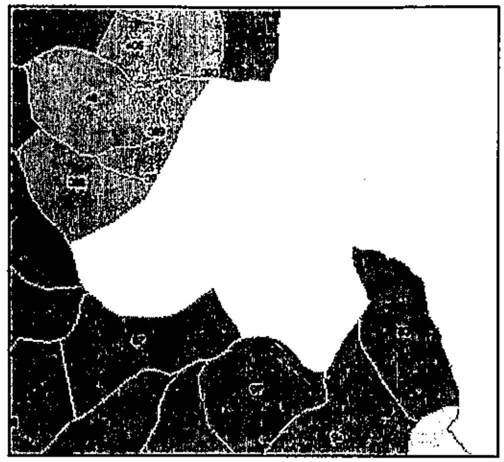
**Outputs » Species distribution**

The species distribution map appears as shown below. Initially, it will be blank, until at least one species has been selected. To select species to display, click on the binocular button in the *Species* frame. A pop-up list of species will appear. One or more species can be selected, using standard Windows methods. Clicking on an item will select or deselect it. Holding shift and clicking an item will select all species between the first and last one clicked. Holding *Ctrl* and clicking can be used to select several species which are not adjacent, or de-select one species without affecting other selections. When the selection window is closed with the *OK* button, then the species chosen will appear listed in the *Species* frame of the map form. In the example shown below, a single species, Greenheart, is shown.




The map can show either volume in $m^3/ha$ or tree numbers per $km^2$, according to the options selected in the *Parameters* frame. The data can also be censored to include only trees above a specified diameter. The example shows volumes for Greenheart trees of 50 cm and above. The diameter limits must correspond to those used internally by IwoPlan. It should be noted that the map does not update immediately when the diameter limit is changed. The map can be updated by either double-clicking on the diameter field, or by clicking one of the option buttons in the *Parameters* frame.

The *Map key* shows the colours representing species density, using the units indicated in the *Parameter* frame. In the example above, species density is shown in terms of $m^3/ha \geq 50$ cm diameter. The scale normally automatically adjusts itself each time the map is updated. The *Fix scale* checkbox, if ticked, prevents the scale changing when the map is updated; this is useful when watching species changes over time as a simulation progresses, or directly comparing the density of different species.

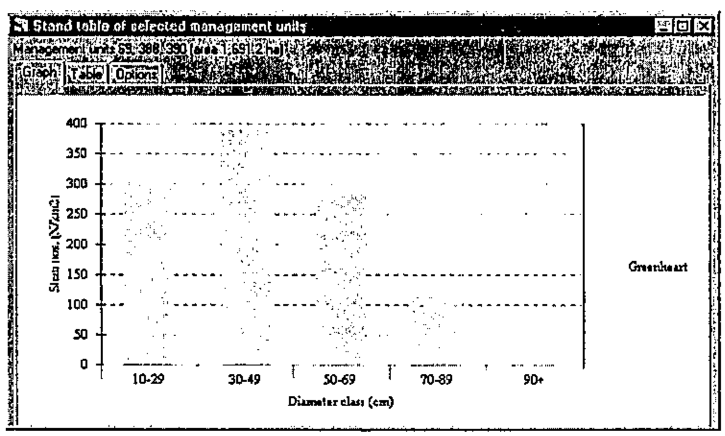


The map can be zoomed in or out, or panned using the *left mouse button* (zoom in), *right mouse button* (pan), or *shift+right mouse button* (zoom out).

The *MU numbers* checkbox, if ticked, displays the number of each management unit. This is only likely to be useful when the map is zoomed in to a fairly large scale, as otherwise the numbers will be overlaid with each other and unreadable.

The *Stand table* button will only work when one or more units are selected. Selection can be done in two ways. Holding the *Ctrl* key and clicking with the left mouse button will select a single unit. Holding the *Ctrl* key and dragging with the right mouse button held down creates a rectangular area that will select all MUs whose centroids fall within the rectangle. MUs can be de-selected either by clicking on them individually with the left mouse, or en masse by doing the *Ctrl*-Right mouse button action outside of any designated MUs. Selected MUs appear in bright yellow, as shown on a zoomed-in section of the above map.

The stand table button brings up a table and histogram for the selected species and management units. The example opposite shows a histogram of trees per km$^2$ by 20-cm diameter classes for Greenheart. The *Options* tab of this form allows stem numbers, basal area or volume to be tabulated , in normal or cumulative form, with 10- or 20-cm diameter classes, per unit area or as area totals. The *Table* tab shows the histogram data as a table. Either the table or the histogram can be output to other packages via the File » Copy menu.



#### Quick reference for mouse button actions on maps

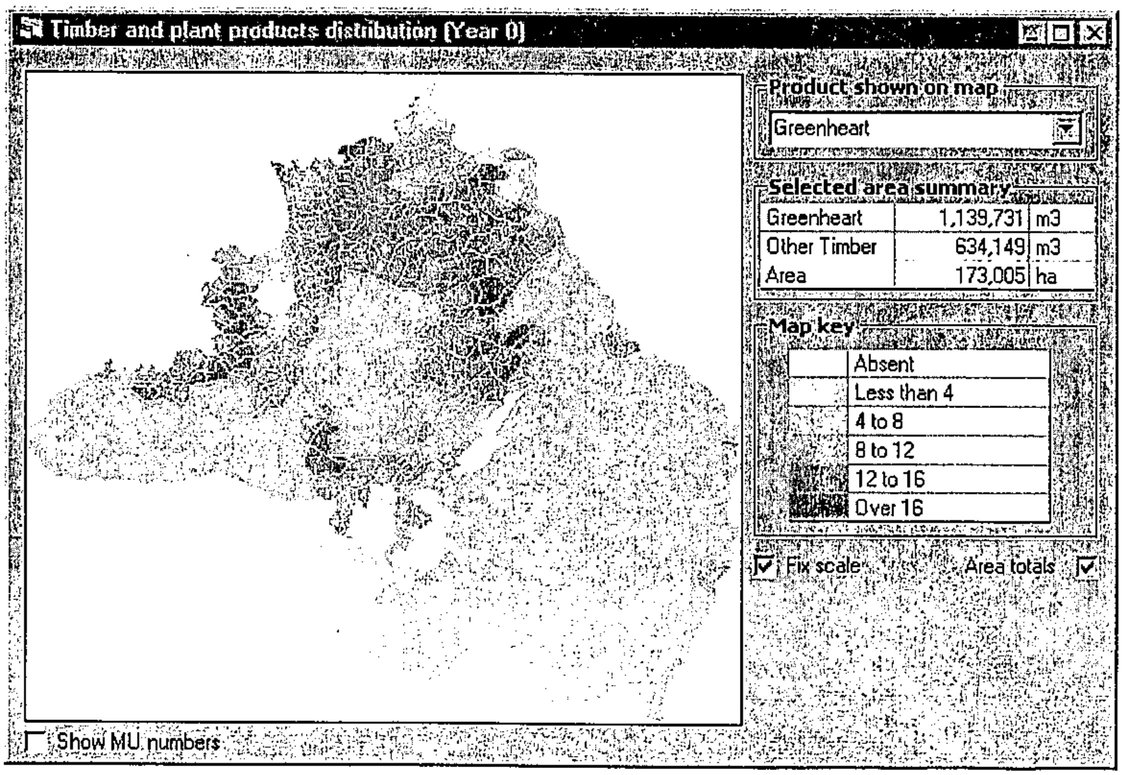
The various maps produced by IwoPlan all use the same mouse button combinations. These are summarised in the table at the right. CTRL and SHIFT refer to the keyboard keys which should be held down prior to clicking the mouse. LEFT and RIGHT are mouse buttons. The action may be either a single click (*click*) or a dragging action, where the mouse button is held down, moved to create a target rectangle on the screen, and then released (*drag*).

| Button | Action | Effect |
|---|---|---|
| LEFT | *drag* | *zooms in on the area shown by the drag rectangle when the button is released.* |
| RIGHT | *drag* | *pans the map to follow the mouse cursor as it is dragged.* |
| SHIFT-RIGHT | *click* | *zoom out to previous view (position of cursor does not matter).* |
| CTRL-LEFT | *click* | *selects the management unit under the mouse cursor.* |
| CTRL-RIGHT | *drag* | *selects all management units whose centroids fall within dragging rectangle.* |

Note that when management units are selected on one map, they will also appear marked as selected on another.

## Outputs » Product distribution

The product distribution map appears as shown below. It shows the actual products available to harvest based on the *Product specifications* criteria. In the map below, for example, the volumes in m³/ha are shown for Greenheart trees which are over the minimum diameter of 50 cm, after deducting an allowance for a minimum stocking of 200 trees/km², and an allowance for 50% retention after harvest, and a 70% conversion factor, as shown in the example on page 9. In other



words, *the map shows net extractable quantities of products, respecting all conservation and management criteria.*

The pull down list in the frame *Product shown on map* will list all defined products. Selecting one will update the map to display the distribution of that product.

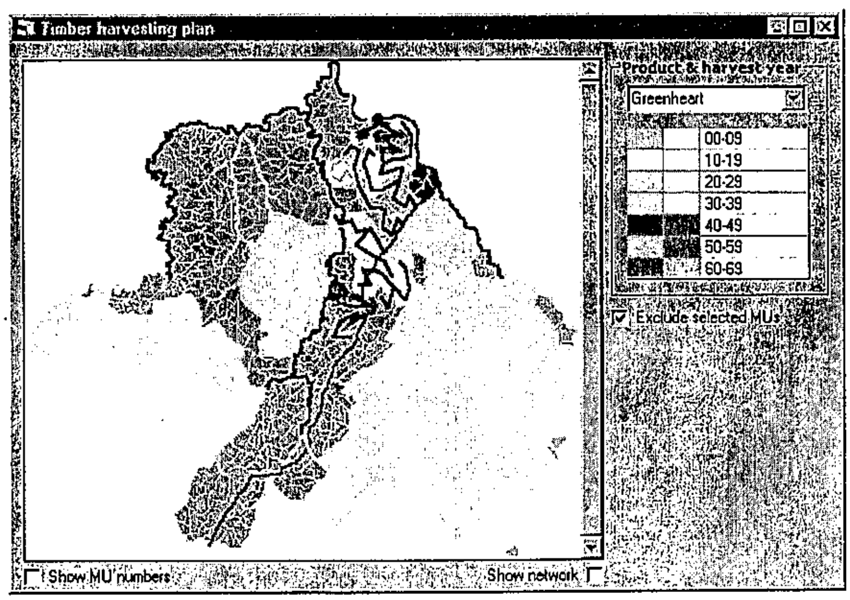
The table in the frame entitled *Selected area summary* lists all the products, and gives either their quantity per ha, or their total quantity, depending on whether the checkbox *Area totals* is ticked or not. If no management units are selected, this table will include all management units. Otherwise, it will give totals only for selected units, which appear blue on this map. Units are selected using the mouse as described in the preceding section.

The scale is always shown in per ha units for the selected product, and normally automatically adjusts itself each time the map is updated. The *Fix scale* checkbox, if ticked, prevents the scale changing when the map is updated; this is useful when watching product availability change over time as a simulation progresses, or directly comparing the density of different products.

The *MU numbers* checkbox, if ticked, displays the number of each management unit. This is only likely to be useful when the map is zoomed in to a fairly large scale, as otherwise the numbers will be overlaid with each other and therefore unreadable.

## Outputs » Harvest plan

The Harvest Plan map shows the management units which are harvested for a particular product, coloured according to the year of operation. The map can also show the notional transport network whose development is simulated by the model if the checkbox *Show network* is ticked.

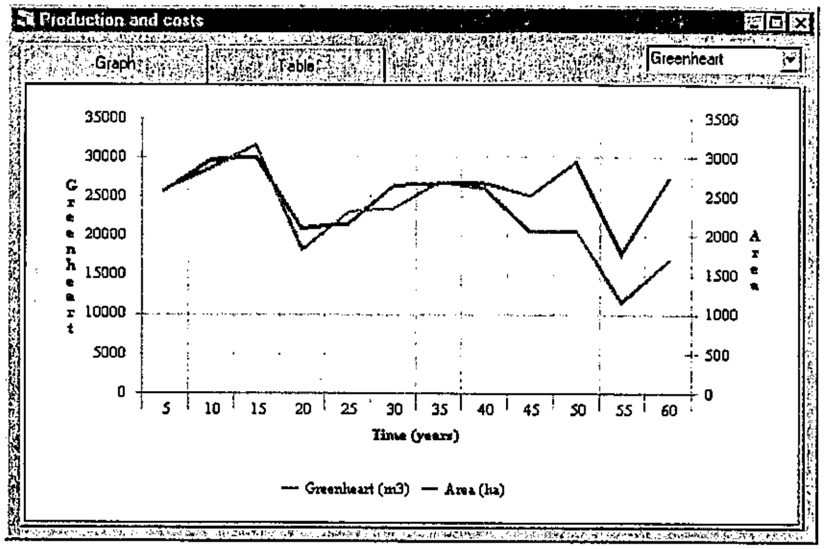



If the *Exclude selected MUs* checkbox is ticked, then any management units selected with the mouse will be excluded from harvesting for any product. This is useful for applying local and provisional protection criteria, or for accounting for topographic barriers that are not otherwise represented in the model. MUs selected in this way will appear listed on the Options form.

The map can be zoomed in to examine detail, and at this level, the *Show MU numbers* checkbox is useful to identify individual management units.

## Outputs » Product yields

The *Product yields* menu shows a tabbed dialog box, as shown below, which can display either a graph or a table. The information given shows the total harvested quantities over time for a selected product (red line), and the total area harvested (blue line). The red line is read off the left y-axis, and the blue line of the right axis.




The general level of production in the model is controlled by the *Allowable cut* parameter on the Product specifications form. In this example, it was 25,000 m³ per 5-year period. Actual production fluctuates because only whole management units can be harvested.

In tabular form, the same data is shown, together with average production per ha, as illustrated below.

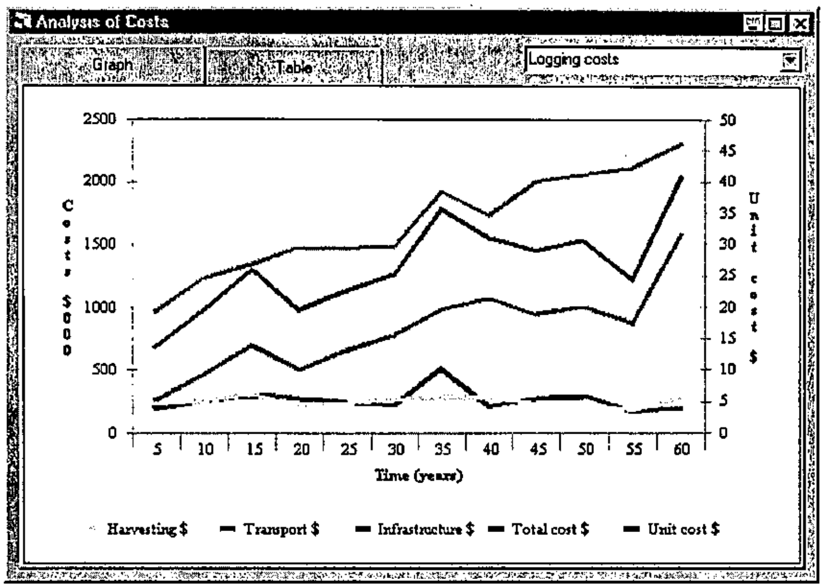
**Production table from the *Table* tab of the *Product Yields* form**

| Period ending (yr) | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 |
|---|---|---|---|---|---|---|---|---|---|
| Area (ha) | 2,081 | 2,151 | 2,639 | 2,669 | 2,665 | 2,508 | 2,941 | 1,765 | 2,723 |
| Greenheart (m3) | 18,209 | 22,982 | 23,485 | 26,833 | 26,043 | 20,534 | 20,663 | 11,589 | 16,849 |
| Production per ha | 8.75 | 10.68 | 8.90 | 10.06 | 9.77 | 8.19 | 7.03 | 6.56 | 6.19 |

## Outputs » Costs analysis

The *Cost analysis* form allows costs to be viewed in three different ways. For mechanically logged products, the logging costs view, as illustrated below, shows total cost per 5-year period (in $'000s) and average unit costs (in $/m³ ) for three components of logging: *Harvesting* (including felling, processing at stump, skidding and loading), *Transportation*, and *Infrastructure* costs (road and bridge building, road maintenance). This graph also shows the total cost, or sum of the three components above, and the unit cost, or total cost divided by total production. This format of graph can also be produced for NTPPs.

It will be noted on the graph that the component costs (green, blue, red lines) and total costs (black line) are read off the left y-axis. The unit costs (magenta line) are read off the right axis.

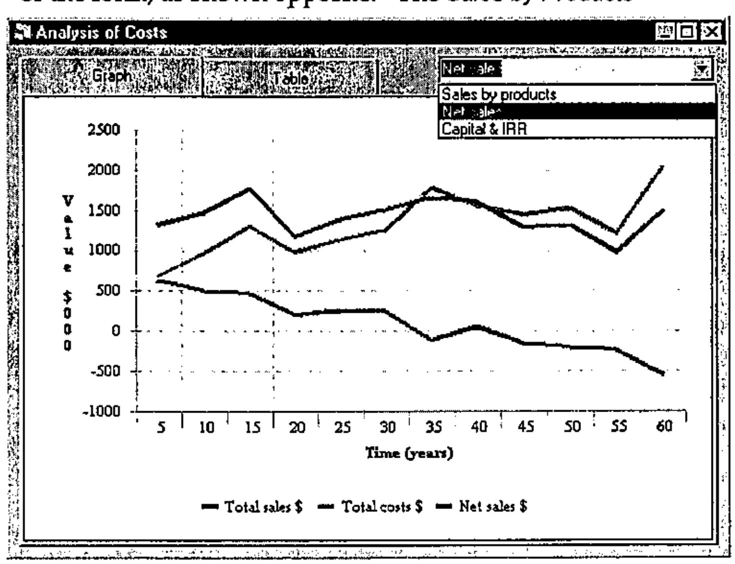



Another possible view shows total costs for all products on a single graph. For this graph, separate species of mechanically logged timber are treated as a single item (logging costs), whereas NTPPs and manually extracted timber will have separate lines for each defined product.

The costs can also be shown as unit costs by products, in another view of the graph selected via the pull-down menu. The data on the graph can be viewed as a table via the *Table* tab; this table can be cut and pasted directly to Excel via the File » Copy function for further analysis or reformatting.

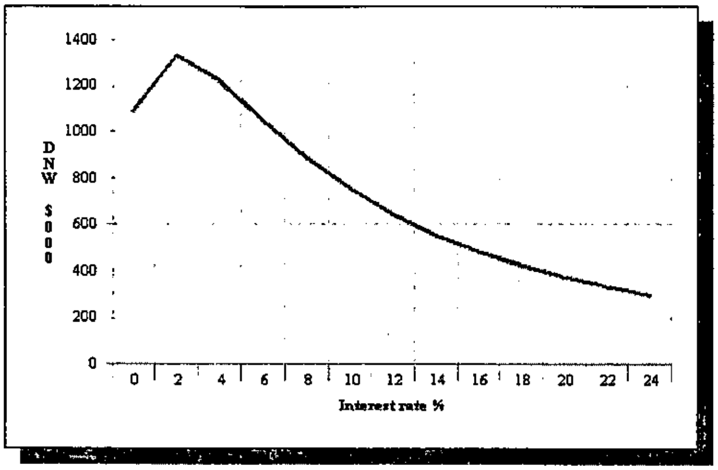
## Output » Sales & Finance

The *Sales & Finance* form provides three key graphs that represent in many respects the "*bottom line*" of a project. These are selected via the pull down menu at the top right of the form, as shown opposite. The *Sales by Products* graph shows the total gross sales per 5-year period by products. The *Net sales* graph shows the total sales of all products (black line), the total project costs (red line) and the net sales (blue line).




The *Table* tab shows the figures from both graphs in tabular format. It has columns for sales by products, total costs, total sales and net sales. This can easily be copied to a spreadsheet for further analysis (see File»Copy).

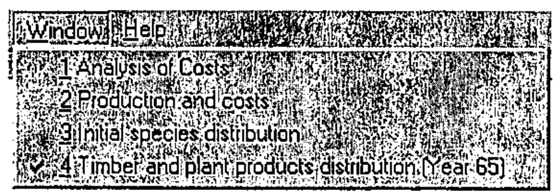
The *Capital & IRR* graph calculates the discounted net worth (DNW) of the income stream represented by the net sales at interest rates from 0 to 24% in 2% increments. These are plotted as a graph, and can be used either to indicate the level of investment the project would support (discounted to year zero) at any given interest rate, or conversely, to calculate the internal rate of return (IRR) given a fixed initial investment. This form of the graph is shown below.




In this example, at 10% interest pa, the income stream would have a DNW of around $700,000; conversely, if $700,000 was the initial investment used to generate the income stream, the IRR would be 10%.

## The Window menu

The Window menu has no sub-menus, but rather shows a pull-down list of open forms. Selecting one of these forms will make it active. This is useful mainly where one form is hidden under another, and cannot be activated by directly clicking on it. The image at the right shows how the menu appears with four forms open. The currently active form will be ticked.

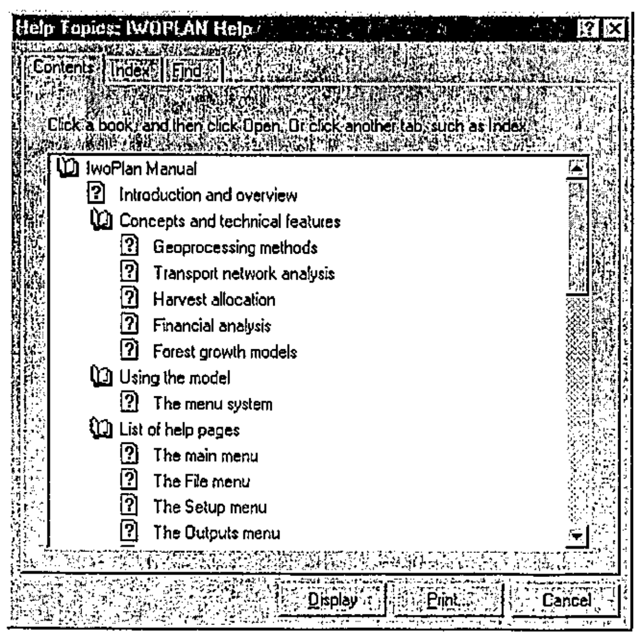



It is important to note that if more than one map form is open at a time, the model will not be able to run simulations over time. Only one map form should therefore be open when running the simulator.

## The Help menu

The *Help* menu brings up the online Help system's contents Window, as shown opposite. Clicking on the relevant details brings up appropriate help.

The most useful section is the *menu system* page, which allows help to be located via the menu bars. All the available help pages are listed under the *List of Help pages*, whilst conceptual and background information is given under the *Concepts and technical features* entry.



## First-time installation of IwoPlan

To install IwoPlan on a computer, the operating system must be Microsoft Windows NT, 98, 2000 or XP. The hardware must comprise *at least* a 400 Mhz processor, with 64 MB of RAM and 30 MB of free hard disk space. If used on a machine of lower specification, it may run excessively slowly and be difficult to use. On networks, IwoPlan must be installed on the local workstation, or on a private network directory[1].

Installation files can be downloaded from the internet. There are two files which must be downloaded:

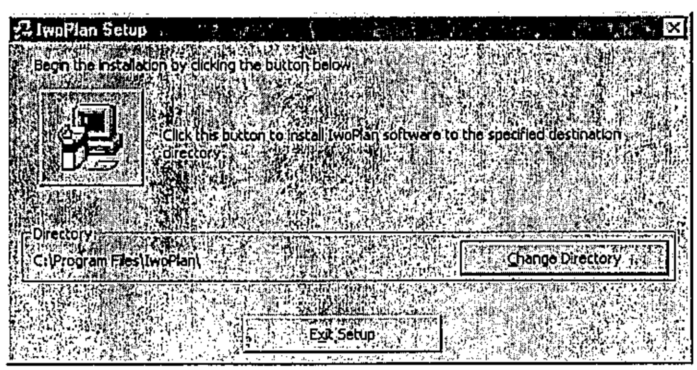
- http://www.bio-met.co.uk/iwoplan/install.zip (10.1 MB)
- http://www.bio-met.co.uk/iwoplan/scenarios.zip (0.9 MB)

It is recommended that a file is created called C:\IWOPLAN on the local hard disk of the target computer. If another directory is used, then the name must be substituted in the instructions which follow where C:\IWOPLAN is referred to. Note that during installation, if using a secure version of Windows (*eg*. Windows NT), the user must have privileges to add files to the system directories and amend registry keys.

Download the two files noted above into C:\IWOPLAN; or if you are using the CD version of the installation kit, copy them from the CD. Unpack them using a WinZip-compatible utility ensuring that the *Include original path* option is ticked. This should create the following sub-directories, each containing various files:

- C:\IWOPLAN\INSTALL
- C:\IWOPLAN\SCENARIOS
- C:\IWOPLAN\SCENARIOS\GEODATA

In the ..\INSTALL directory will be found a file called SETUP.EXE. This should be executed. It will bring up an installation Wizard. Follow this through its default button options until the screen shown at the right is reached. Then use the *Change Directory* button to locate and set C:\IWOPLAN (or your chosen alternative) as the installation directory. Click on the installation button (computer icon) to complete the process.




[1] If installed in a shared (public) network directory, the program may lock up or crash if used by two users simultaneously.

Once installation is completed, the files in the directory ..\INSTALL are no longer required for operation and can be deleted or archived elsewhere if disk space is critical. Similarly, the original *.zip files can be removed. This will save about 22MB.

The program will be found as an entry under the Windows *Start » Programs* menu, and can be executed from there. It can also be executed by the Windows Explorer, for example, by clicking on the file C:\IWOPLAN\IWOPLAN.EXE.

At this stage, if the suggested default directory C:\IWOPLAN\ has been used, then the program can be used directly to work through the various examples given in the Case studies section. If a different directory has been used, then refer to the further configuration instructions given in the following sections before trying to use the program.

## Updating an installed version

When IwoPlan is updated, only the file IWOPLAN.EXE in the installation directory C:\IWOPLAN needs to be replaced. The latest version of IWOPLAN.EXE can be downloaded from the web directly by entering the URL on the Internet browser:

http://www.bio-met.co.uk/iwoplan/iwoplan.exe

When the browser asks if the file is to be run or saved to disk, it should be saved to C:\IWOPLAN, thereby overwriting the earlier copy.

No other action is necessary when updating IwoPlan. When the updated version is loaded, the version number will be seen on the title bar.

## Map layers and GIS files

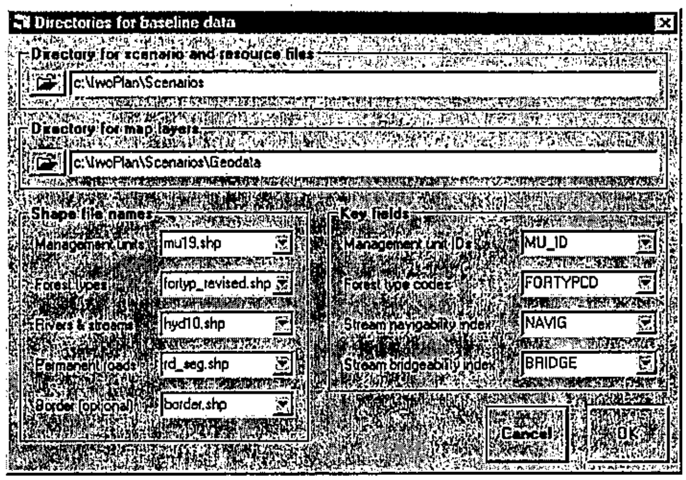
IwoPlan requires four sets of ArcView-compatible shape files, representing map layers for rivers, roads, management units, and forest types. An additional layer is optional, but is recommended. This represents the project boundary. The installation kit includes demonstration versions of these files, which are early versions of studies on Iwokrama forest. Each shape file set comprises at least the following three files: *.shp (the map vector information), *.shx (the geoindex file), *.dbf (the map attribute table). Additionally, *.sbn and *.sbx files may be seen. These latter are work files and do not need to be present initially.

If one of the required map layer file sets or components is missing, or is in a directory that is not recognised, then IwoPlan will not work properly. Faults of this kind can be detected using the File » Check map menu, before attempting to run any other *Setup* or *Output* menu function.

### Setting the map layer directory, file names and attribute fields

The directory containing the map layers, if the recommended default installation is followed, will be C:\IWOPLAN\SCENARIOS\GEODATA. However, the map layers may be in any directory, provided that all the required layers are in the same one. The map layers directory is set via the File » Baseline data menu, which brings up the dialog box shown below right. Clicking on the *open file* button in the *Directory for map layers* frame will allow the directory containing the map layer files to be located. Double-click on any shape file within the required directory to set it as the map layers directory. Note that the directory cannot be correctly set by directly typing into the text box (the field is not editable).

When the directory is changed, all the entries in the *Shape file names* frame will become blank. Each type of shape file and its associated key field must be re-set, as described in more detail in the following sections. Once this has been done, the form may be closed and the settings saved by clicking the *OK* button. If the form is closed via the *Cancel* button, by *Ctrl-F4*, or by the X button on the top right of the form window, the settings will not be saved.




**The Management Units layer**

In the default installation, the management units layer is represented by the files MU19.SHP, MU19.DBF and MU19.SHX. This file set can be replaced by another file containing map information about management units. The following criteria should be observed when developing an MU map layer:

- The management units should be of as nearly equal size as practicable. Very large management units should be split, and small ones merged to achieve this.
- For good results in simulated projections, there should be *at least* 100 MUs per project. The demonstration file contains about 400 MUs.
- It is important to note that the shape file must have polygon topology.
- Management units which are bisected by larger rivers or streams are undesirable; waterways should be used if possible as natural boundaries. Otherwise, infrastructure costs will be under-estimated by the model, as it will not recognise the need for bridges where rivers bisect a single MU.

Only one management unit attribute (ie. field in the *.dbf file) is required by IwoPlan. That is the management unit *identification number* (abbreviated to MUID). The MUID must be a number (numeric field) and should not exceed 32767 in value.

The MU shape file is set on the *Baseline data* form by selecting the appropriate shape file from the *management units* pull down in the *Shape file names* frame. The MUID field is then selected by picking the appropriate attribute field for *management unit IDs* in the *key fields* frame.

**The Forest Types layer**

The forest types map layer in the default installation is given by the file set FORTYP_REVISED.*. This file can be replaced by another file representing forest types. The forest types *must be represented by polygons* (*ie.* have polygon topology). The attribute (*.dbf) file should contain a field with the forest type code. This can be any alphanumeric code, but it must the same as the code used in the stand table file, which describes the forest types in terms of species and stocking.

The forest type shape file is set on the *Baseline data* form by selecting the required file name from the *forest types* pull down in the *Shape file names* frame. The appropriate attribute field for *forest type codes* is then selected in the *key fields* frame.

### Streams and Rivers

In the demonstration data set, the rivers and streams are described in the HYD10.SHP shape file. This file can be replaced by another file representing hydrology. This map layer *must have linear topology* (*ie.* it should not contain lakes or large rives represented by polygons). Two important attributes need to be set for each segment of river or stream. These are the *navigability index* and the *bridgeability index*. These values must be integers. For navigability, they may be between 0 and 2, and for bridgeability, from 0 to 3. The table below indicates appropriate values for these indices.

**Attribute fields required for *Rivers & Streams* map layer**

| | |
|---|---|
| **Navigability index** | |
| 0 | Not accessible and navigable for product extraction |
| 1 | Accessible and navigable to small boats for transport of NTPPs and manually loaded boards. |
| 2 | Accessible and navigable to large boats for transport of logs and crane-loaded timber (*eg.* capacity at least 5 tons), or navigable by log-rafts. |
| **Bridgeability index** | |
| 0 | Can be bridged by culverts, with cost subsumed into normal road construction cost. |
| 1 | Can be bridged by single span log bridge (*eg.* max 20 m), with cost defined as *minor bridge* on infrastructure costs form. |
| 2 | Requires2+ spans, with average cost given by *major bridge* on infrastructure costs form. |
| 3 | Not bridgeable within the context of normal forest road construction. |

In the demonstration file (HYD10.SHP) these indices have been estimated in relation to stream order (*ie.* number of branches above the Essequibo River main stream). More realistically, they need to be estimated from river width and presence of cataracts, or direct surveys of more significant waterways.

The rivers and streams shape file is set on the *Baseline data* form by selecting the appropriate shape file from the *Rivers & streams* pull down in the *Shape file names* frame. The appropriate attribute fields for *navigability* and *bridgeability* are then selected in the *key fields* frame.

### Roads

In the demonstration data set, the road system is described in the RD_SEG.SHP shape file. This file can be replaced by another file representing a road system. This map layer *must have linear topology*. This file does not need any attributes. The roads mapped should be permanent roads that are constructed and maintained with funds that are outside the project costing (*eg.* public roads). The shape file is set via the *Permanent roads* pull down in the *Shape file names* frame.

### Project border

The project border or boundary layer is optional, and could be omitted. It appears as a background on the Species, Products and Harvest maps, with areas inside the border but not covered by any management unit being shown in a background shade of pink (species map) or green (products, harvest maps). If the layer is missing, these areas will simply be blank. The topology of this layer may be either linear or polygon. The shape file is set via the *Border* pull down in the *Shape file names* frame.

### Steps in setting up new map layers

After the shape file names and key fields have been set on the *Baseline data* form, it must be closed with the *OK* button to save the information. If doing this for the first time with new map layers that have not yet been checked, *the IwoPlan program should at this point be closed and re-started.* This is important as it will force the settings to be written to disk in the default scenario file. Otherwise, if the program crashes while testing the files, the settings have to be re-entered, which is somewhat tedious.

After re-starting IwoPlan, go first to the File » Check map menu and review each layer in turn. Various problems could occur. If the files are in the wrong format, or a member of the shape file set is missing, or the files are in the wrong directory, the program may crash after a rather uninformative message such as "*Valid object expected as argument*". If this occurs, revert to the *Baseline data* form and ensure the correct directories are used and correct layer and field names given.

If this does not resolve the problem, test each layer again in ArcView, and ensure that they can be viewed correctly from the IwoPlan geodata directory, as given on the *Baseline data* form.

Once the files can be viewed in the *Check map*, and there are no scaling or overlay discrepancies due to incompatible GIS coordinates, then the intermediate files used by IwoPlan need to be set up by following the procedure in the Setup » Transport network section.

## Forest inventory and the stand table file

The stand table file *sttab.iwd* will be found in the default scenarios directory C:\IWOPLAN\SCENARIOS after completing the standard installation process. This file gives a description of each forest type in terms of species and stem numbers by size classes. Part of the file is listed in the text box below. This comma-separated file format can be imported into or saved from *Microsoft Excel*, or saved from a database file using the comma-separated option.

```
ForType,Code,Species,N/km2,0-9,10-19,20-29,30-39,40-49,50-59,60-69,70-79,80-89,90-99,100+,,
DF,101,Greenheart,695,,40,30,40,238,188,59,50,40,10,,,
DF,108,Muri,20,,,,10,,,,10,,,,,
DF,188,Dakama,1546,,178,178,149,436,317,168,40,50,20,10,,
DF,202,Wallaba,1387,,50,188,178,446,287,158,50,20,10,,,
DF,304,Bulletwood,30,,,10,,,20,,,,,,,
DF,306,White cedar,60,,,20,,20,20,,,,,,,
DF,307,Crabwood,158,,,20,69,59,,10,,,,,,
DF,308,Dalli,10,,,,,10,,,,,,,,
DF,312,Kabukalli,50,,,,,,10,20,10,10,,,,
DF,316,Mora,368,,10,30,40,99,59,40,20,30,30,10,,
DF,318,Freijol,10,,,,10,,,,,,,,,
DF,326,Wamara,397,,30,50,50,158,59,20,20,10,,,,
DF,338,Purpleheart,10,,,,,,,,,,10,,,
DF,440,Aromata,70,,20,20,,20,10,,,,,,,
...
...
...
```

The first line of the file are headings, which are useful if the data is imported into Excel, but are ignored by IwoPlan.

The second and subsequent lines consist of a forest type code, a species code, a species names, and then stem numbers per $km^2$ by diameter classes. The diameter classes, as indicated by the heading line, comprise 0-9 cm, 10-19 cm, etc, up to 90-99 cm, then 100 cm and above.

The forest type code must correspond to the codes in the forest type code attribute field of the forest type map layer.

The species codes must link to the species list, which is defined in the Setup » Species list table. This species list is physically stored within a scenario file, whose format and contents are described in the next section, and can be manually edited there. It should be noted that the species codes must be integer numbers less than 32768.

It would be very difficult to create the stand table file directly with a text editor. The normal routes to creating the stand table file would be via a forest inventory program which can create files in a suitable format in Excel. The Excel tables are then saved as comma-separated files (CSV) with a structure as above. Both the MYRLIN and GEMFORM programs can generate tables in a suitable format from a variety of inventory plot designs. MYRLIN is documented at and available from http://www.myrlin.org. GEMFORM is available from http://www.bio-met.co.uk/gemform.

It should be noted that the species name field in the STTAB.IWD file is not the name used by IwoPlan. That is given by the name in the species list corresponding to the linked species code. The name in the above file is for reference purposes only, and could in principle differ from the name in the species list.

## The default scenario file

The default scenario file is called DEFAULT.IWP, and must be present in the directory named in the *Directory for scenario and resource files* frame of the Baseline data form. This file is a text file, and can be viewed and edited with a standard text editor. It is supplied with the standard installation, but may need to be modified manually if a new species list or different growth models are adopted. The species list and growth models can be modified from the relevant setup menus (see Setup » Species list and Setup » Growth models), but this can be very slow if there are many changes to be made.

The default scenario file is always saved whenever IwoPlan is closed, using all current settings under the various *Setup* menus. It is therefore important, if making changes that may modify the scenario file in a major way, to save the earlier version manually before making the changes. This can be done via the File » save scenario menu.

The scenario file consists of various sections, each headed by a title in square brackets, such as *[Baseline]*, *[Species]*, *[Tree models]*, etc. These sections could appear in any order. Following each section are a series of entries in the style *key=value(s)*. It may be noted that in the *[Baseline]* and *[Options]* sections, the key names correspond to global variable names within IwoPlan.

### The species list section

The first part of the species list section appears as shown opposite. It is introduced by the section code *[Species]*. The species code is followed by an equals sign, then the common name, botanical name, life form (grass, liana, palm or tree), growth model letter, and optionally, one or more product codes.

```
[Species]
1=Bamboo, Guadua angustifolia, Grass, A
2=Rupununi Grass, Trachypogon plumosus, Grass, A
7=Nibbi, Heteropsis spp., Liana, A, CN
8=Kufa, Clusia spp., Liana, A, CN
10=Manicole, Euterpe spp., Palm, A
20=Ite, Mauritia flexuosa, Palm, A
30=Karia, Astrocaryum sciophilum, Palm, A
50=Arapipi, Astrocaryum vulgare, Palm, A
60=Kokerite, Attalea maripa, Palm, A
70=Buba, Socrotea exorrhiza, Palm, A
80=Turu, Oenocarpus bataua, Palm, A
101=Greenheart, Chlorocardium rodiei, Tree, M, GH
108=Muri, Humiria balsamifera, Tree, E
120=SandpaperTree, Curatella americana, Tree, E
...
...
```

This list can be created

programmatically if it is very long, as for example from a database file, and then edited into the DEFAULT.IWP file using a text editor. The codes on the left of the = sign must correspond to the species codes in the stand table file STTAB.IWD.

**The growth models section**

The growth models may be in several sections, headed by *[Tree models],[Liana models],[Palm models]* or *[Grass models]*, these being the four life forms currently recognised by IwoPlan. Each section may define a number of models, with one line per model. The model code, which must be a single capital letter, is to the left of the equals sign. To the right are the four parameters of each model. For tree models, these are diameter increment, mortality rate, 95% diameter percentile, and the form height coefficient for volume calculation. The source and rationale of the growth models are discussed in the Concepts section. As with the species list, the list of growth models will usually be derived from some other spreadsheet analysis, and it will probably be found to be more convenient to cut and paste it directly into the default scenario file than to edit the Growth model form.

```
[Tree models]
A= .134,  .0148,  32.9,  11.2,  0,  0
B= .252,  .018,  37.9,  12.5,  0,  0
C= .359,  .0339,  29.6,  10.6,  0,  0
D= .222,  .0175,  43.9,  12.6,  0,  0
E= .36,  .0087,  50.3,  12.1,  0,  0
F= .518,  .0204,  42.3,  11.9,  0,  0
G= .686,  .0225,  54.3,  12.6,  0,  0
H= .983,  .0322,  55,  10.6,  0,  0
J= .198,  .0157,  54.2,  13.6,  0,  0
K= .524,  .0187,  63.5,  13,  0,  0
L= .34,  .0072,  69.7,  13.6,  0,  0
M= .218,  .0082,  71.1,  13,  0,  0
N= .561,  .0197,  93.4,  12.5,  0,  0
P= .527,  .0091,  78.1,  13.8,  0,  0
...
...
```

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