Design and implications of a decision-support system for planning timber and non-timber production in the Iwokrama forest

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Introduction

This report describes the development of a decision support system to assist management of the Iwokrama Forest sustainable use area (SUA). It addresses particularly a description of the main features of the system, the underlying assumptions in the models, issues and deficiencies relative to calibration and resource base data, a discussion of how the model should be applied to assist in developing the SUA management plan, some preliminary indications from application of the model, and some suggestions to how the model might be developed in future to enhance its usefulness.

This work was undertaken as a consultancy undertaken by the author at the request of the Iwokrama International Centre for Rainforest Conservation and Development, with a total duration of 105 days. The terms of reference emphasise the need for a decision support system, the estimation of growth and sustainable yields of timber and non-timber products, development of harvesting schedules and a draft harvesting plan. This consultancy was supported under an ITTO project with Iwokrama.

It was decided and agreed at the inception of the consultancy that this problem should be approached by developing a simulation model that would have the capability to assess scenarios for management of timber and non-timber products in a flexible manner, generating maps of coupes, and graphs and tables of yields, production costs, sales revenues, and net revenue and profitability estimates. However, the actual capture of cost and price data was excluded from the terms of reference as this was intended to be undertaken by another consultant working in parallel. This system would give Iwokrama staff the opportunity to rework calculations after completion of the consultancy in the light of emerging priorities and perspectives, especially in relation to the consultative and participatory aspects of management plan development.

Features of the decision support system

Basic structure

The model was developed as a Visual Basic 6 programme called IwoPlan. The mapping features built-in use a library of routines called MapObjects 2, supplied by ESRI. The programme was designed to be a simple stand-alone package that could be easily installed on any desktop PC and used with little expertise to evaluate management scenarios. It was felt that this would minimize dislocations that might arise due to personnel changes within Iwokrama as far as forest planning skills were concerned., as the programme would have a short learning curve.

To assist this a comprehensive Help system was developed. This exists both as a standard Windows help file (IwoPlan.hlp) and as a set of linked HTML files that collectively constitute a website. This is accessible over the Iwokrama local area network (LAN) and may also be placed on Iwokrama's own web site (www.iwokrama.org). This help system comprises some 38 text pages of detailed information about using the model and is not reproduced in this report but should referred to for further detail regarding practical aspects of the model. The initial pages of the help system discuss the structure of the model from a user's perspective.

Resource data

Data from the standard inventory plots were compiled into stand tables by forest type to provide the baseline data used by the model. The forest types, forest inventory system and plots are described in some detail in the Iwokrama zoning report (Iwokrama, 2000).

The total set of data comprises 1222 plots of 0.1 ha (some having been adjusted from continuous lines for standardisation). Relative to Iwokrama's total area of 360,000 ha, this is a sample of 0.003%. This is rather low as a basis for forest planning. A more typical figure for a preliminary inventory would be 0.1 to 0.5 %. There are also some deficiencies in the data. Only a sub-set of species (the key species) were fully sampled on the majority of plots. This renders impossible the application of density-dependent stand growth models. Examination of the data showed that for all species, the 5-9 diameter class was oddly deficient. In addition, there was an over-representation of very large trees. Both of these causes can be attributed to lack of training and/or control with respect to the original field work, which was undertaken over several 'campaigns' mainly between 1997 and 2000, as detailed in the zoning report (*op. cit.*). There was also no overall statistical design for the inventory, so it is not possible to estimate sampling error at the management unit level. As can be seen from the above table, several forest types are so under-represented that *post-hoc* error estimates have little meaning except relative to overall means.

Type	Name	Plots
DF	Dakama forest	101
LF	Liana forest	0
MGB	Mixed greenheart, sand baromalli forest	134
MGK	Mixed greenheart, black kakeralli, wamara forest	603
MKW	Manicole, kokerite, soft wallaba forest	13
MLH	Mixed low stature forest on high hills	74
MMC	Mora, manicole, crabwood, trysil forest	215
MS	Muri scrub	10
WF	Wallaba forest	72
Total		**1222**

Should timber management in fact emerge as an important activity in Iwokrama's SUA (a far from certain possibility, as will be discussed), then a new inventory, with higher sampling intensity, better field control, proper statistical design and full measurement of all species, will probably be required at some stage in future.

The stand table file is viewable in Excel, but exists as a text file called *StTab.Iwp* for use by IwoPlan. It comprises stem counts per km^2 by 10 cm classes for the 38 tree species, 2 species of lianas, and 7 species of palm. The term species is used loosely, as primary identifications were by local name.

Good satellite imagery, map data and GIS coverages exist for Iwokrama, and the resource data in this respect appears strong, a fact which would make a re-inventory relatively easy to design and inexpensive to perform[1]. IwoPlan was designed to read this map data directly, using the MapObjects library, and process it by geometric intersection to derive a table of area weights for each forest type on each management unit. This is a completely flexible process within the model: The resource data as a stand table file, the forest type map, and the management unit subdivisions can be modified and updated at will.

Growth models

The limitations in the inventory data noted above have required that a rather simple growth modelling strategy be used, without density-dependent influences on stand growth. As the consultant had recently completed a study for the Guyana Forestry Commission on this topic (Alder, 2000), these models were adopted directly. That study also included revised commercial (net of defect) volume functions. The GFC models were themselves based on data provided by the Tropenbos Foundation and Barama Company Limited (though a cooperation with the Edinburgh Centre for Tropical Forestry).

[1] The consultant would guess that a well-designed two-stage, two-phase stratified random sample using a tract system with 0.1% intensity could be completed over 12 months for $350,000 – or the price of two Catepillar 528 skidders, to put it in an industrial perspective. This would aim to give sampling error at the management unit level of 15% for Greenheart on timber use areas.

The GFC models however only included trees down to 20 dm dbh. As a part of this study, the original data was recompiled to include trees down to 10 cm. It was found that this made no difference to the basic models, which were therefore adopted as they stood.

The GFC models do not include recruitment. Examination of the Tropenbos data sets (see work by Van der Hout, 1999, 2000 and Zagt, 1997 for background and related studies) showed little recruitment for any key species, especially Greenheart, which is the dominant timber tree in Iwokrama forest. The consultant after some trial and error therefore adopted an ad hoc model in which trees which die or are removed in felling are replaced by an equivalent recruit in the 5-9 cm after a 5-year lag. In Alder (2000) it was noted that stand projection without recruitment could be quite accurate until size classes were exploited that would have included recruitment. In the case of Greenheart, for example, this might be after 60-80 years. IwoPlan therefore can provide long-term projections, but those beyond about 80 years must be regarded as more for demonstration and training purposes than for accurate estimation of yield, as they will be based dominantly on assumed recruitment.

For non-timber plant products, growth data is essentially absent. There are some anecdotal suggestions. For example, van Andel (2000) reports local knowledge that if only half the stems of Nibbi or Kufa are cut, it will recover within 5 years, but if all are cut, it will die. For palms, the consultant has some experience of data from Costa Rica, where palms are incorporated into the SIRENA model (Alder, 1997), which show little diameter growth for many species (as may be expected from the physiognomy of palms) and mortality rates of about 3% per annum (a half-life of about 23 years). For IwoPlan, this model was adopted for Nibbi, Kufa: an AMR of 3%, and zero diameter increment. This gives a very simple demographic model for the species. For palms, an AMR of 3% was also adopted, with increment of 1 mm/year, as found in Costa Rica, and a maximum size of 30 cm. These are purely assumed models, and need in future to be backed up by research.

The IwoPlan help system details how growth model parameters can be input and calibrated.

The design of IwoPlan is such that all the coding for growth is in one routine (GrowSim). A stand density attribute is calculated (basal area) and could be used as a variable in future models, but is meaningless with present data. Species have a life form attribute, presently either Tree, Liana, or Palm, which can be used to select structurally different types of models if information becomes available. For example, in Nibbi and Kufa, length is an important aspect of yield and of growth. A suitable model could be developed based on quite short-term studies (5 years, probably) which would sufficiently elucidate the dynamics of these species to show: Mortality as a function of the number of stems harvested, rates of length increment, and species life-span and age distribution.

Palms likewise show little or no diameter growth, but substantial and rapid height growth. They are relatively shade sensitive. Specific studies could be directed at these aspects, although a longer period would be required than for lianas.

Given suitable models, IwoPlan can be relatively easily updated in these respects.

Harvesting allocation

The harvesting allocation model is certainly the major logical component of IwoPlan. It consists of several parts. There is firstly, the network analysis, that converts map information on roads and rivers, provided as GIS files, into a network of interconnected nodes and routes, classified as small or large rivers, permanent roads, forest roads, and trails. A secondary network of incipient or potential routes is also constructed between management unit centroids. This calculates distances between MU centroids and whether or not bridges would require to be built. Both these data structures are saved as files which can be reviewed and used externally, as described in the workfiles topic of the Help system.

Harvest allocation is based first on the idea of accessibility. An MU must be adjacent to an existing node on the network. This may be part of the permanent infrastructure, or it may be a route that has developed within the simulation, *ie.* A forest road or a trail. For different products, there are different logical criteria which determine accessibility. For mechanized logging, the adjacent infrastructure must be a road. For NTPPs, there is no restriction – it can be a road, river, stream or trail. At the moment, this logical behaviour is programmed in, but with some revsion of the program, various product transport categories could be defined in an open-ended way, with user-definable junction criteria.

The reason that, at the moment, the model does not permit mechanized logging to occur adjacent to a river is that it is considered improbable such a situation could exist in isolation from the road network. Although logs can be transported by river, the heavy equipment used in the logging operation would have to come overland, and once a road existed, it would probably be used for extraction as well. Again, this logic could be modified or made more flexible.

The Help system gives considerably more information about the logic of the transport system. It may be noted for this report that the model's transport network algorithms would require development to produce a realistic road network. However, the author has seen recently that the program could be simplified, so that roads and trails are not explicitly presented spatially, but the required information for costing is conserved. This would be a minor but desirable improvement, a simplification that makes the program more transparent and maintainable by others, and does not confuse by mapping patently unrealistic routes.

Within an MU, the model calculates road and trail costs according to a density factor. For skid trails and roads, there is an optimum balance of average road density and skidding distance that depends on the road construction cost and the skidding cost, assuming road haulage costs are relatively negligible. This can be shown by calculus to be approximately optimal when

$$L = \sqrt{\frac{S.V}{2R}} \qquad \text{-\{eqn.1\}}$$

where L is roading intensity, in km/km^2, S is skidding cost, in \$/m^3/km^2, V is yield harvested, in m^3/km^2, and R is road construction cost in \$/km. IwoPlan uses this function to calculate average road lengths and skidding distances within an MU, given the unit costs indicated above, which are program inputs. Consequently it can calculate total road constructions costs within the MU and total skidding costs.

Roads are therefore classified as major forest roads, which are explicitly represented as geometric objects, and minor roads, whose costs are only calculated via this density function. The major roads can also attract a maintenance cost if they remain in use as routes to MUs elsewhere on the network, whereas it is assumed that minor roads are constructed but not maintained after logging ceases. This maintenance cost is charged internally to the MU which originates the product, and is charged only over the additional length of road that is maintained due to that MU being in use, not over the total length of road used, as some routes may be shared by several MUs, and the latter method would lead to double charging of costs.

It has been found through running the model that in fact its allocations are quite insensitive to major road construction, but are mainly determined by the internal road network in each MU, which is not explicitly represented. It seems therefore that the model could in future be simplified by eliminating this explicit representation of simulated roads with little loss of utility.

The allocation process assembles in each time period, and for each product being actively exploited, a separate list of units which are accessible and which respect the felling cycle for the product (*ie* the time elapsed since last harvesting must be more than the indicated cycle for the product). It also only considers units that have harvestable product (as some may not).

Units are then selected sequentially from this list according to three possible policies, one of which is picked by the user as a scenario option. These are:

- MUs are selected which have the lowest unit harvesting cost.
- MUs are selected which have the highest product density
- MUs are selected which are as close as possible (in terms of transport route) to the base.

This process is repeated until a target Allowable Cut is reached, at which point the selection of units terminates for the period. When a unit is selected, the appropriate infrastructure is created, and this influences both the cost of existing units, and their accessibility, so the list is completely revised with each selection.

A variant may be imposed as another user option. This requires that all units selected after the first are adjacent to the last one harvested. This avoids units being scattered into different locales within the SUA in the same period.

Harvesting selection can also be modified by protecting some MUs so that they are not harvested. This can, for example, be used to avoid ribbon development along the public road.

An important aspect of the transport network is the idea of a base. It is assumed that all products will eventually pass through a central point, essentially the Kurupukari field station or nearby. In fact, the program has been designed so that this base can be located anywhere within the map domain, and the logical transport network redefined relative to it. But this is considered to be a facility for future applications of the program, rather than an issue with the present context of strategic management of the Iwokrama SUA. In operation, it may be that actual purchases of goods may be made by Iwokrama from contractors at roadsides, bush landings and such like. But in terms of the economics of the whole enterprise, Iwokrama still needs to cost the flow of goods through its logistic network.

Costing and financial calculation

The key elements of cost calculation differ between NTPP and timber products, in that the information for NTPPs has been simplified, and it is less clear what the unit of transport may be. Current advice is that it should be in Kg, although IwoPlan simply refers to a unit 'load'. For timber however, all calculations are done in m^3 and the stages are presented here.

- There is firstly, a flat cost per unit area for each harvested unit for inventory and management costs. This would include planning for RIL, stock survey, tree marking, boundary marking and similar activities. Several studies suggest costs in the range $30-35 per ha (see summary in ITTO, 2001). These costs are applied only in the period a unit is harvested.

- There is a felling cost, in $ per m^3. In IwoPlan, this is also assumed to include the cost of any conversion done at stump, which may include flitching with a chainsaw, or simple cross cutting to remove defective sections of log, excessive buttress etc. The model provides for a recovery coefficient, relative to the mensurational volume of the bole calculated by the volume equation. The cost is applied to the volume before the recovery factor, but it is the volume after recovery which is then used in subsequent cost calculation.

- There are road construction costs, which have been discussed in the previous section. The major forest roads include both a capital cost, in $/km, when they are first constructed, and a maintenance cost, in $/km, which is applied in any subsequent periods that the road remains in active use. Their length is not directly related to MU area, but is calculated by the networking algorithms as the distance from the MU centroid to the nearest appropriate (ie road) node on the existing network.

  Within the MU, distances of road constructed are calculated from equation {1} discussed in the previous section as proportional to the square root of the product of unit skidding cost and yield, divided by the road construction cost. This is a mathematically derivable formula,. In practise, it should have an empirical coefficient that reflects the skill of the management and intrinsic obstacles to constructing an optimum logging road layout. A value of 1 for this coefficient is optimal, and is used by IwoPlan.

- There may be bridge construction costs. This again is handled by the logical network algorithm, but is conditioned by a Bridegability Index (BI), which is attribute data supplied to the model as part of the streams and rivers GIS coverage file. This index may be 0, 1, 2 or 3. If zero, then the stream is too small to require an individually costed bridge (ie. It can be crossed by culverts and earth ramps, or simple log bridges with earth decking, which are subsumed into normal road construction cost). If the BI is 1 then the river requires a minor bridge, whose cost is given on the cost input form (see the IwoPlan help file for details of this). A BI of 2 indicates a major bridge, with appropriate cost entered (this would be similar to the DTL bridge over the Demerara River, for example). A BI of 3 is not practically bridgeable, and would render a unit beyond the river inaccessible via that route.

- There is a road haulage cost, which is calculated as distance over the network. At the moment there is no 'shortest route' algorithm, and if a road curves around on itself to link to another, more direct route, the product's transport cost will be over estimated. Given the overall shortcomings of the input data to the model, this is however a rather minor deficiency which could be overcome if it were considered important. The haulage cost is calculated as the quantity of product *after conversion at stump* times the unit transport cost and the distance over the network.

- There is a road maintenance cost. This is a rather complex idea, as a route's maintenance cost will be shared among several MUs. When a unit is harvested, a route is tagged with the 'year last used'. Another unit, making partial use of the same route in a later period, will be costed with maintenance on those sections whose 'year last used' is not current, implying that they are being activated specifically for the MU in question. Total maintenance costs of the network over a period will be correct by this method (there will be no double counting), but attributions to an individual MU might not be. Again, this is a very minor issue, although it could theoretically influence cost-based allocation decisions.

- There is a skidding cost. As discussed above, roading intensity within a unit can be calculated, and this leads also to a figure for average skidding distance. This, times volume and unit cost, gives total skidding cost for the product from the unit.

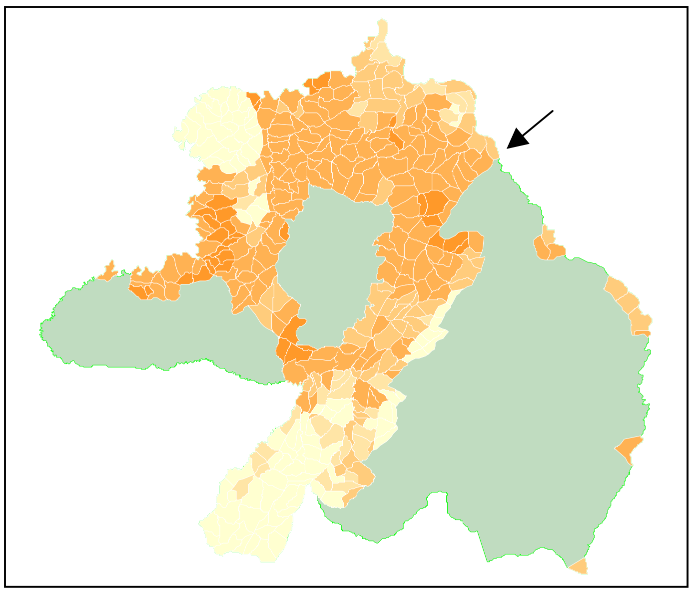
- There is a cost for loading. This is usually given per m^3, and is assumed to occur twice for timber products: in the forest, and at the base as an unloading cost. The transport algorithms automatically calculate the number of 'transhipments' required depending on the route transitions: From road to river, river to road, trail to river, trail to road. The model assumes that there is a standard loading cost that is applied to all these events. For logging, only road transport is applicable, so there will always be only two transitions (loading and unloading). For NTPPs where river transport can occur, or trails meet roads, more are possible. A different cost is however applied to NTPPs.

- For NTPPs only, transport costs are applicable to trails and rivers. There are also maintenance costs for trails and for rivers (clearing rapids, preparing landings etc.). For trails, maintenance and construction costs are assumed to be the same. The same maintenance algorithm is applied to rivers and trails as for roads. That is, they are only charged when in use, and the charge is shared among the using units in the same way.

On the whole, the system of costing is quite straightforward, and can be readily elaborated if better information becomes available for NTPPs.

Some management implications

Timber operations

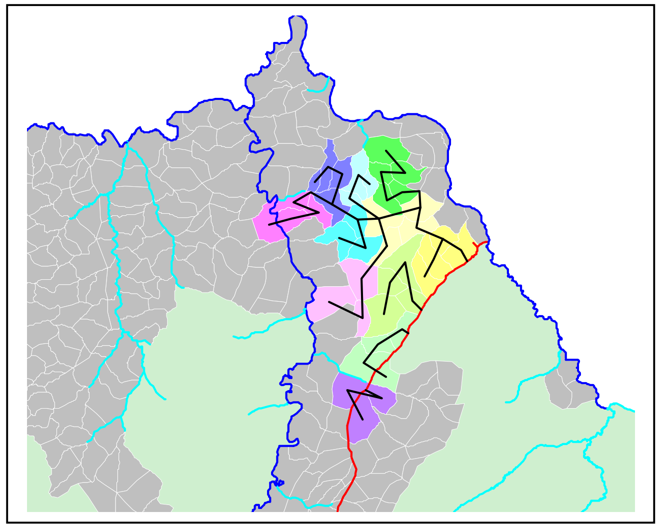


The adjacent map is taken from IwoPlan and shows the distribution of Greenheart currently available for harvest assuming that there is a 50 cm minimum diameter limit, 50% of stock above this limit is retained after harvest, and a minimum of 200 trees/km^2 are required before entering a block. These would be typical criteria for a moderate and environmentally sensitive logging operation.

This suggests that the optimum operating areas for timber are relatively close to Kurupukari (arrow). The Village Use Area, not shown on this map, has some of the highest stocks of Greenheart. The southern part of the reserve is clearly unsuited for timber operations, due to the lower resource of Greenheart (which alone is typically about 50% of commercial timber volume) and distance from Kurupukari. Average available yields, excluding the white shaded areas and those which are less accessible, are around 10 m^3/ha of Greenheart, and 4 m^3/ha of other first class timbers.

Using typical timber operating costs, and allowing IwoPlan to develop coupes over a 50 year period with a target production of 10,000 m^3 per year of logs of Greenheart and other first class species (Purpleheart, Kabukalli, Locust, Aromata, Black Kakaralli, Crabwood, and White Cedar), produces the pattern of coupes in the map below. For this scenario, forest road construction is assumed to be $12,000 per km for major roads (shown on map), and $6,000 per km for feeder roads (not maintained). Management costs (stock survey, RIL planning etc.) are assumed to be $30 per ha;

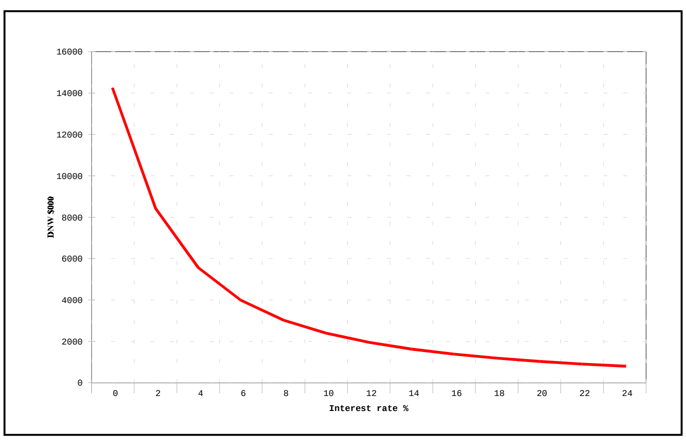
felling and cross cutting is \$2 per standing m^3, with 70% recovery to extracted logs. Skidding is \$20 per m^3 per km. Transport costs to Kurupukari are \$1 per m^3 per km. These figures are all biased towards the high end of typical costs. Logs are assumed to have a price FOB Georgetown of \$100 per m^3, with delivery costs of \$30 per m^3 (ie. \$70 per m^3 FOB Kurupukari). Log prices are based on GFC market data (GFC, 2000) but assume a premium for Iwokrama-branded, certified and trackable product (\$100 per m^3 versus \$75 average Georgetown log prices). Delivery costs are based on advice from P. van der Hout and A. Mendes, relative to DTL delivery costs and the current condition of the road from Mabura to Kurupukari.



On the map showing coupes, blocks of the same colour represent a single five year period, in the order: yellows, greens, blues, magenta tones, darker tones of the same hue preceding lighter ones. The period covered is 60 years, with each coupe active for 5 years.

The outputs show that of the 50,000 m^3 target yield per 5-year period, about 61% comprises Greenheart, and 39% other first class species. Over the 60 year cycle, average coupe size is 1889 ha, and annual yield is 6017 m^3 of logs.

This scenario suggests that average costs delivered to Kurupukari are \$31 per m^3, but these rise over the rotation from \$17 initially to \$41 at the end, as distances increase and infrastructure maintenance becomes more important. Initially, the project has a net revenue of \$318,000 per annum on total sales of \$421,000, but after 60 years, this has fallen to \$149,000 per annum. To some extent these declines are attributable to the transport algorithm's deficiencies, which do not handle well the bridging of major rivers, or a situation where some initial sub-optimization would lead to a better long term result.



To log 10,000 m^3/year requires one or two primary skidders, one of which should be a bulldozer for road making, two or three trucks, workshop support facilities, and could certainly be established with a capitalization of the order of \$1,000,000. Doubling this figure to allow for incidental startup costs, suggests as the graph indicates, that an IRR of 12% would be realized on the cost stream from this scenario.

Examination of this and other scenarios suggest that a viable timber business, conforming to strict environmental standards, can be operated at Iwokrama with today's prevailing economic conditions.

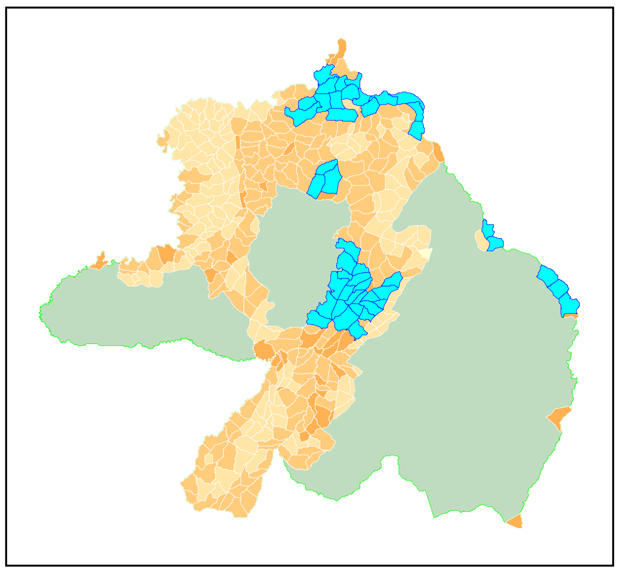
It is not very meaningful to examine very large scale enterprises, or consider questions of long term sustainability against the current baseline data. If existing data is correct, there are issues in the regeneration and recruitment of Greenheart that will be critical in future (ie in 80-100 years time). Iwokrama needs to have support for a program of forest research and monitoring if it is to be able to achieve this long-term sustainability on a guaranteed basis.

The scenario examined is very conservative, and consists of a single cycle of 60 years, with 50% retention of commercial stock above 60 cm. It is profitable with rather high cost assumptions and not especially optimistic market prices. This and similar scenarios could be presented as a portfolio to potential business partners, and would in the consultant's view, be attractive. There is probably a need to add value through further processing, but IwoPlan presently cannot analyse this option.

Value-added options can be conceived of in three formats: Milling in the forest, at log landings; milling at Kurupukari or a similar point within Iwokrama, and milling in Georgetown or elsewhere. Each has its own pros and cons. IwoPlan could be extended to consider the processing costs and break of bulk implied by each option, and this would probably be desirable in terms of providing information to attract business partners. However, it cannot be done in time for the completion of the current cycle of activities related to management planning.

Non-timber products

IwoPlan has comparable facilities for the handling of non-timber products. It is difficult however to evaluate the harvesting scenarios because of the lack of any useful cost information relative to (a) cutting of trails, and (b) carrying of products long distances, and (c) market prices. Nor have the necessary allometric studies been done to properly relate yields to the stem counts measured on the inventory.



However, considering Nibbi and Kufa as potential products, we can evaluate possible yields. The IwoPlan products map to the right shows the densest areas of Nibbi and Kufa highlighted. These are all accessible either by road or river, with walking distances of a few kilometres. The total area highlighted is 24,800 ha, with an average yield of Nibbi and Kufa of 10.2 stems per ha. 86% of this comprises Nibbi. This map, as explained in relation to timber, shows only harvestable product, after allowing for any regulations imposed. In this case, as studies indicate that not more than 1 in 2 stems should be harvested to retain viability (van Andel, 2000), a harvesting restriction has been imposed of 50%, so that actual stock is around 20 stems per ha in the marked zones.

Assuming manpower exists to harvest about 500 ha annually, then a yield of 5000 stems per year, or 25,000 stems per 5-year period could be expected. This can be modelled in IwoPlan if cost and price data can reasonably be assumed.

Conclusions

The IwoPlan decision support system that has been developed during this consultancy is an asset that Iwokrama can use in various ways to evaluate options for managing Iwokrama Reserve. Some examples have been discussed here. Others were given at a presentation to the 3rd SUA Management Committee Meeting on 8th July 2000.

There is no doubt from typical and conservative cost and price information that a modest timber business could be established within Iwokrama Reserve. The scenario discussed in this report suggests net annual revenues of around $318,000 initially, although these would tend to decline over a felling cycle as distances increase to around $148,000 after 60 years. This is based on an allowable cut of 10,000 m^3 per annum, which should be manageable for an organisation such as Iwokrama without envisaging any internal transformation into an industrial corporation. The reserve itself might support theoretically, annual yields around three times this level, but there would be serious logistic and environmental issues. *The author recommends, on the basis of his experience in the timber industry, that the planning team adopts a timber production scenario no larger than that proposed (10,000 m^3 per annum), and probably embracing the management rules indicated: 60 year cycle, 50% retention of commercial trees, 50 cm minimum dbh.* This scenario would involve harvesting around 400 ha per annum. This is a logistically feasible management and control task for Iwokrama to undertake.

This scenario would support a capitalisation of around $2 million with an IRR of 12%. The equipment required to log 10,000 m^3 per annum would in fact cost around $1 million. This should be an attractive proposition for a business partner who can add value to logs sustainably produced under Iwokrama's brand.

With regard to NTPPs, the consultant is unable to offer any clear guidance, as he has no experience in this field. It does seem from the IwoPlan analysis that around 5,000 stems of Nibbi and Kufa (86% Nibbi) could be sustainably harvested per annum from accessible areas, assuming a logistic constraint of 500 ha harvested annually. The return period would be around 50 years. These areas do not conflict with timber production areas. There is insufficient data to cost or evaluate this option financially.

IwoPlan has been developed over a relatively short period (100 days) and is a complex program internally, although simple to use. At the time of writing, Iwokrama still awaits delivery of ESRI's MapObjects software that will allow IwoPlan to be configured as installable from a single file on any PC. The consultant will finalise the installable version as soon as this is received. IwoPlan has some potential in its own right, apart from as a planning tool, to assist in promoting issues such as business partnerships, certification, and Iwokrama's scientific profile. It would benefit from some additional development work, to improve the allocation algorithm, and to include more processing and costing options in a flexibly way.

IwoPlan is also potentially scalable, and has been designed with this in mind, so that it can be applied to more localised annual planning within a timber management area. Adaptions to this end could be included with the above refinements.

IwoPlan depends heavily on the inventory data available to Iwokrama. This constitutes a sample of 0.003% (122 ha on 360,000 ha) and has some obvious defects noted in the report. The consultant would suggest that if funding can be found, a new, better designed and executed inventory would be desirable. In future, sustained yield management will require a range of monitoring and sampling systems, including continuous forest inventory, growth plots for timber and NTPPs (which would probably not be the same designs or locations). It will be best if all these issues can be integrated into a single study to clearly define the systems that will be required.

In conclusion, it is clear that whilst business opportunities exist for both timber and non-timber products, they are not of vast scale, and should not be over-emphasised. The consultant considers the nutrient-poor status of many Guyanese soils to be an important limiting factor to sustainable timber management that should not be overlooked. There are many uncertainties regarding the regeneration of Greenheart, in particular, which need to be resolved fully for there to be confidence in a totally sustainable management system. IwoPlan as a tool can calculate results for any set of regulations for controlling yield. The consultant's proposals are conservative with the above issues in mind. With further research, and better information, yields might confidently be increased.

Denis Alder
9th August 2000

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