the Mpingo Conservation Project

MCP Tanzania Community-Managed Forests FSC Group

ED02 Group Guidelines on Forest Assessment and Sustainable Harvesting

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Contents

Definition of Terms

Allowable Cut – the quota of trees which can be sustainably felled in a set period of time as determined by a Harvesting Plan.

CBH – Circumference at Breast Height (130cm)

DBH – Diameter at Breast Height (130cm)

FMU – a Forest Management Unit; large forests or those with distinct heterogeneous parts maybe partitioned into two or more FMUs, each of which is managed separately.

LMDH – the Legal Minimum Diameter for Harvesting of a given tree species under Tanzanian law

MCP – the Mpingo Conservation Project, Tanzanian registered NGO no. 1739.

MNRT – the Ministry of Natural Resources & Tourism, United Republic of Tanzania

NTFP – Non-Timber Forest Product, can include firewood and charcoal, and other forest products which consume wood.

PFI – Participatory Forest Inventory, the method described in this document

PFM – Participatory Forest Management, the legal process in Tanzania under which rural communities can take control over their local forests.

PFRA – Participatory Forest Resources Assessment, one of the key steps in the PFM process

TAC5 – Total Allowable Cut in 5 years

VLFR – Village Land Forest Reserve, an area of forest set aside by a Village under the PFM process

VNRC – Village Natural Resources Committee, the sub-committee of the Village Government with responsibility for over-seeing management of community-owned forests.

Introduction

This document sets out the approved methodology for carrying out a Participatory Forest Inventory (PFI) for use in community-managed forests entered into the MCP's Group Certificate Scheme. It is explicitly focused on the Participatory Inventory component, and does not set out methods for assessment of NTFPs or socio-economic uses of forest products, both of which can be important elements of a comprehensive Participatory Forest Resources Assessment (PFRA). It also does not discuss Threat Reduction Assessments and other qualitative management tools. Instead we concentrate on the single task of determining an Allowable Cut of certain selected timber species which can be sustained by the forest under consideration. This focus is necessary if we are to gain the precision necessary for determination of an Allowable Cut which we can be reasonably confident will indeed be sustainable.

We begin with a brief discussion of why existing, 'traditional' methods for a PFRA do not yield results of sufficient quality for adequate determination of a sustainable timber harvest. We then outline the methodology developed by MCP to carry out a PFI and analyse the data, and conclude with a statistical analysis as to how and why it works. Finally we construct a model for sustainable yields which allows determination of the Allowable Cut.

Sustainability

A brief remark is appropriate here about the definition of sustainability. There have been many definitions coined over time which incorporate a whole range of concepts of ecosystem and environmental, social and economic sustainability. The most commonly cited "To meet the needs of the present without compromising the needs of the future" (Brundtland 1987) is insufficiently precise to be very useful in detailed analysis. Tanzania's Forest Act 2002 requires forests to be managed "sustainably", but nowhere defines exactly what is meant by that. For our purposes we shall thus restrict ourselves to the narrow issue of resource sustainability; the calculated off-take should not exceed the capacity of the forest to replace or renew the resource in the time frame concerned. In the case of timber, this means that the Allowable Cut should not exceed the amount of new timber (of said species) which the forest accumulates in the period under consideration.

Participatory Approaches

Of all the steps involved in developing a forest management plan under PFM, assessment of forest resources is the most technical. Even at its most basic it involves computing simple statistics such as the mean which are likely to be beyond the capacity of many rural communities. At a workshop on PFRA organised by the Forestry & Beekeeping Division in 2004 it was noticeable how few of the presentations by projects and organisations were truly participatory. Most involved input from community members but then the assessment itself was written by technically adept facilitators. This means that communities do not fully understand how the key numbers in the assessment are obtained. Since these key numbers go on to inform some of the most important aspects of the management and harvesting plans it risks leaving communities in the role of policeman for someone else's policies which is not what PFM is supposed to be about.

The methodologies outlined in this document are fully participatory, involving communities at every stage along the way to produce a harvesting plan. This inevitably involves many simplifications compared to typical inventory methods used by professional foresters. The challenge is to get the right trade-offs between simplicity and scientific rigour. We have therefore reduced the statistical element of the analysis to a single step which can be computed through use of a simple pre-calculated look-up table which can be provided to the community. Every other step of the analysis is completely transparent to the VNRC members managing the forest; with sufficient training and experience they should thus be capable of carrying out their own Participatory Inventory themselves without any external assistance, although it is likely to take communities a bit of practice to reach this skill level.

Productive Forest / Harvestable Area

This document makes frequent reference to the area of Productive Forest or Harvestable Area. This is distinct from the overall area of forest in that it excludes any areas within the forest set aside as strict conservation zones, or in which logging maybe forbidden because the area is close to a river or water-source or steeply sloped.

PFM Context

Participatory Forest Management (PFM) is the legal process in Tanzania under which rural communities can take control over their local forests, and is defined within the 2002 Forest Act and supplementary regulations and supporting documents. The end result is known as a Village Land Forest Reserve (VLFR), and is governed by a management plan and local byelaws.

The methods set out in these guidelines apply to community-managed forests established under the PFM process, and hence incorporate constraints of the PFM process. In particular, in south-eastern Tanzania, where this method was developed, selective logging is the norm. Individuals of target species are scattered unevenly across the forest. The VLFRs which are set aside by communities in following the PFM process may be quite small (as low as ~500ha in size), and so geographically dividing the VLFRs into coupes according to the estimated rotation time of the tree (a simple and common way of managing a sustainable cut) may leave some coupes entirely free of target species. This is not appropriate for rural communities who expect to receive a sustainable income from the forest, and so instead we will consider an Allowable Cut across the entire forest.

Secondly, normally, under PFM, a forest management plan lasts for five years, so we shall be interested in calculating, on a species-by-species basis, the Total Allowable Cut over 5 years (TAC5), without worrying about how that cut should be distributed temporally within those five years.

Flaws of Traditional PFRA

The quantitative assessment of forest resources conducted under a PFRA typically has three flaws:-

1. Lack of Focus
2. Over-reliance on the Mean
3. Insufficient Data

We shall consider each in turn.

Lack of Focus

This is not necessarily a flaw in the science, in that an unfocused assessment can still produce the results required. However, it is a flaw when one considers the inevitable trade off in terms of labour costs; the investment of effort required by communities, and the financial cost of that effort (both to communities and technical facilitators). For example a PFRA in the village of Ruhatwe took around two weeks to complete, and yet still failed to yield sufficient data for adequate calculation of a sustainable harvesting quota.

We would generally contend that any unfocused PFRA is unlikely to yield sufficient data on any variable for which a serious quantitative assessment is required. In many cases variables such as whether there is sufficient area of bamboo to meet local community needs can probably be simply assessed visually, and on the basis of experience. Unfocused PFRAs also yield a lot of data on resources which are not expected to be exploited; again a simple visual estimate of abundance will suffice to determine whether a resource is sufficiently abundant to warrant finding a market for it, without investing unnecessary effort up front.

MCP therefore recommends that a Participatory Forest Inventory should only assess those high value timber species which the community (advised by technical facilitators) expects to exploit and to sell. Ideally this should be limited to five or six, because the more species are assessed the more work needs to be done, and the harder it is to keep track of everything.

Over-reliance on the Mean

This is common fault of forest inventories in Tanzania. The mean gives no indication of the confidence we can and should have in a population estimate. It could be based on only a single tree sighting, and yet presented on its own, as such figures often are, we have no idea what to make of it.

This problem can be resolved by either requiring a minimum sample size (e.g. 20 trees) and/or by quoting the standard error. The first solution is slightly arbitrary (although it can be supported by statistical analysis), and has the disadvantage of ruling out any exploitation of trees which nonetheless might be quite common (e.g. what to do if the survey found 18 or 19 trees). The second gives us some advice as to the degree of confidence we can have in the mean figure, but we then need a protocol for interpreting the Standard Error in relation to the mean. For instance it is a well known fact that we can be 95% confident that the actual population mean lies within 1.96 x SE either side of the estimated mean for a normally-distributed variable. So maybe we could reduce the mean by a set fraction of the standard error, and use that figure?

In fact this is exactly what computing a Confidence Limit involves. MCP requires all community-managed forests within its Group Certificate scheme to use the 75% Lower Confidence Limit of the estimate of standing stocks when calculating the Allowable Cut. This is the figure which we can be 75% confident that, based on the inventory data, the actual population exceeds; i.e. only one time in four will the actual stocks turn out to be lower than the confidence limit. Contrast this with the mean estimate, which will be higher than the actual standing stocks 50% of the time, meaning the computed Allowable Cut will actually only be sustainable 50% of the time.

Requiring use of the 75% Lower Confidence Limit is also a good way of transferring the burden of determining the appropriate effort to invest in the inventory to the forest manager (i.e. the community).

For as the overall effort invested in the inventory increases, so will the sample size for each assessed species, and thus, on average, the 75% Lower Confidence Limit will approach the estimated mean. For very small sample sizes the 75% Lower Confidence Limit is a *lot* lower than the estimated mean, while for very large sample sizes the difference dwindles to a very small proportion of the mean.

Insufficient Data

The problem of insufficient data only really becomes evident when confidence limits are computed. For instance another PFRA in the village of Kikole counted 16 mpingo (*Dalbergia melanoxylon*) in 27 10m x 10m plots, for an apparent estimated mean density of 59 trees per hectare, and which took a week to compute. But less than half (7) were of harvestable size, with the result that the estimated mean density of harvestable trees is 25.9 trees per hectare, but the 75% lower confidence limit of this is only 18.8 trees ha^{-1}, a decrease of 28% (the 95% confidence limit normally used by scientists would be substantially lower). Equally, however, the actual population mean could be substantially higher; the upper 75% confidence limit is 31.7 trees ha^{-1}; thus the range from lower to upper 75% confidence limits is equal to 12.9 trees ha^{-1}, or half the estimated mean. If we used the lower confidence limit, the community could easily be missing out on 50% of their potential income – decreasing social and economic sustainability. All this suggests we don't really know the density of harvestable mpingo, and thus we should be wary of calculating Allowable Cuts based on such small sample sizes.

Causes

There are two principle causes of these above flaws; the afore-mentioned lack of focus leads to wasted effort counting trees of no commercial value, and poor sampling design, which itself is another symptom of lack of focus. In particular, the use of sample plots, whether 10m-square or 20m-square (as recommended in FBD's PFRA guidelines) takes up a lot of time. Sample plots are good for surveying relatively small organisms; seedlings and saplings up to small trees and large bushes, but they are time-consuming to set out. There is also quite a lot of time wasted moving from one plot to another, and accurately locating them. Finally the use of sampling intensity targets based on local forest mensuration standards arbitrarily restricts freedom to adapt sampling intensity according to the rarity of the resource and size of the area under investigation.

In addition the lack of size classes in traditional PFRA does not lend itself to good management or accurate modelling, but in fact complicates analysis, as the estimated volume of each tree surveyed needs to be calculated. (Itself another source of uncertainty.)

MCP resolves these issues by using transects (on which surveying is continuous) and three simple size classes to facilitate analysis, and as a simple basis for modelling.

Participatory Inventory Survey Method

This is a good methodology to use if you have a large FMU with many hundreds of timber trees in it; you can get a good estimate of stocks within one week using this methodology. However, it is a little bit complicated, so it needs to be carefully lead by technical facilitators.

Survey Preparations

Initial Training

Before beginning a Participatory Inventory it is necessary to train the VNRC members in the transect survey methodology. This should start by reviewing the objective of the inventory and selecting the species to be assessed (should be detailed within the management plan, recommended max 6-8), and outline the principles of sampling. The trainer(s) should then demonstrate how to measure trunk girth scientifically, the three size classes, and how to walk a transect. See *ED03 VNRC Forest Management Training Curriculum* for a detailed lesson plan.

Homogeneity Check

Before starting the assessment, the facilitators should check that the FMU is reasonably homogeneous; that is to say it does not contain large sub-units (large in relation to the overall size of the FMU) which differ markedly from the rest of the FMU, e.g. half evergreen forest and half deciduous miombo. Where such clear divisions exist the FMU should be divided into two separate FMUs each of which should be separately assessed. This method is only appropriate for FMUs which are more or less homogenous (within the context of miombo being a dynamic mosaic habitat).

Materials Required

- Printed map (with scale) of the VLFR
- 10m measured out piece of rope, with a mark at 5m
- 1.5m standard tailors' tape measures (longer is better if you can find them)
- Pen and cheap notebook
- Compass
- GPS and spare batteries are useful but not essential

Depending on local conditions you may find it advisable to carry out the fieldwork whilst accompanied by a game guard.

Laying out the Transects

Sampling Intensity

The Participatory Inventory method does not involve a fixed sampling intensity. Instead surveyors should focus on recording 50+ trees of each the species of most interest, and 20+ trees for species of lesser interest. Thus the number of transects required cannot be known precisely in advance, although an experienced facilitator who is familiar with the area may be able to guestimate, and advise the community accordingly. Instead an initial number of transects (4-5 is usually appropriate) should be walked, with more added later if necessary. If the axis of the FMU the transects are traversing is much shorter than the other then more transects will clearly be needed than if the transects are roughly parallel to the longer axis (6-8 may be appropriate in this case as a starting number).

Transect Starting Points

It is very important that the locations of the transects be unbiased. The initial transects should be reasonably spaced out, *but no consideration should be given to where certain stands of trees are in doing so*. Such manipulation will invalidate the entire inventory, and where it is suspected could lead to the Forest Manager being suspended or expelled from the Group Certificate.

The best way to do this is to draw lines on a map of the FMU roughly where they are intended to run. Then estimate the distance along the boundary to the start of the transect. A group of people walking purposely can reasonably cover 4km an hour in rough terrain, and 6km/hr along a path or cleared boundary. Using these figures it is possible to estimate how long it will take the group to reach the start of the transect from the surveying base camp (usually the VLFR entrance). The team should make a carefully timed walk along the boundary in the appropriate direction, and stop as soon as the pre-calculated time is reached. That is the starting point of the transect. If the team have a GPS unit with them they should mark the starting point as a waypoint, and note the waypoint number.

Transect Routes

The transects should follow a standard compass bearing, which should be the same for all transects (so that they are parallel and never cross or overlap). This needs to be decided at the beginning. Following a compass bearing in forested terrain is never easy, and some deviation is to be expected, indeed the method expects it, so the team should not worry too much on this front. The transect should continue until it reaches the further boundary of the FMU and stop there. If the team have a GPS unit with them they should mark the end point as a waypoint, and note the waypoint number.

Adding Additional Transects

As noted above, you should aim to count 50+ trees of the main timber species that you want to harvest in order to get a good estimate of the total stocks. Keep planning and walking additional transects until you have got 50 of all of the important timber trees. For example if your FMU is for harvesting mpingo, mninga jangwa and mkongo and after the first day you have only recorded 35 timber trees in total then this is not enough. If after the second day you have recorded 51 mpingo trees, but only 23 mninga and 17 mkongo then you should keep going, recording all the timber trees until your total for all of the key species you want to harvest is over 50. However, there may come a time when further effort does not seem justified. It may not be possible to harvest sustainably some of the rarer trees.

Additional transects added later should be evenly spaced between the transects previously walked. E.g. if adding two transects (E & F) between four existing ones (A, B, C, D) then the final order should be A, E, B, C, F, D. If there is no unbiased, systematic basis for choosing which layout option to use then toss a coin or draw lots to determine between equally valid possibilities.

Further Notes

Irregularly shaped FMUs may need slightly more sophisticated treatment, and even make it appropriate to vary the direction of transects. This is reasonable so long as all decisions are clearly justifiable and noted, and taken in advance of surveying beginning.

Transect Walks

Transect Width

The transects walked should be 10m wide; 5m on either side. This can be measured in a number of low-tech ways, the two easiest are:

- Rope method: measuring out a 10m rope with a mark at 5m held by the central team member. The team can shrink its width to go round / through obstacles and then re-expand the other side.
- Human chain method: five people walking broadside, hands outstretched, fingers just touching roughly cover 10m. The group can then detach and come back together to go around obstacles. Of course it is not necessary to walk in precise formation the whole time, just as a guidance of the 10m width.

We recommend a combination of both methods to minimise the chances of trees being missed behind an obstacle, and yet be able to measure precisely whether a tree lies within the transect width. Note that the 10m should be perpendicular to the path of the transect, and thus, where necessary, distances should be checked from the closest point on the central transect path to the tree of interest. For trees that are on the boundary, where the middle of the stem is determines whether the tree is in or out.

After a certain amount of practice it can be possible to assess whether a tree is in or outside the transect purely visually (5m is not very far), with only marginal trees being explicitly checked.

Recording Trees

As previously discussed, the inventory will only assess a limited number of tree species, so most trees encountered on the transects can just be ignored. When an individual of a species of interest is found then its species should be noted and its CBH recorded. CBH is easier to measure than DBH, which requires specialist callipers, and hence in our Participatory Inventory methodology trees are assigned to size classes based on CBH rather than DBH, which is the norm in forest science and ecology. (CBH minima are given in the supplements to the Forest Act.)

The data should be recorded in a form similar to the table below. It is sufficiently simple that it can just be recorded in an ordinary exercise book without printing out dedicated data collection sheets.

<table>
<tr><td colspan="3">Transect No.</td><td colspan="3"></td><td colspan="3">Date</td><td colspan="3"></td></tr>
<tr><td colspan="4">Species</td><td colspan="4">CBH</td><td colspan="4">Size Class</td></tr>
<tr><td colspan="4"></td><td colspan="4"></td><td colspan="4"></td></tr>
<tr><td colspan="4"></td><td colspan="4"></td><td colspan="4"></td></tr>
</table>

The size class (see the section on analysis below) will be worked out later, and will form the basis of the Participatory Analysis. If the team know the class boundaries then they can fill it in now, but it is always worth recording the actual CBH as it is useful information, which can be analysed with more sophisticated methods back at the office.

Participatory Inventory Analysis

Size Classes

In order that the analysis be as simple as possible, we assign trees to one of three size classes defined according to the Legal Minimum Diameter for Harvesting (LMDH). The size classes are colour coded for easy reference and drawing of simple bar charts. They are defined as follows (DT = diameter of tree):

- Red *(not yet harvestable)* : $0.5 \times \text{LMDH} \leq \text{DT} < \text{LMDH}$
- Green *(harvestable)* : $\text{LMDH} \leq \text{DT} < 2 \times \text{LMDH}$
- Blue *(extra large trees / seed trees)* : $2 \times \text{LMDH} \leq \text{DT}$

Since within Tanzania LMDH varies according to species these size classes are particular to each species. In Tanzania all Class I timber trees have a LMDH of 24cm (*Dalbergia melanoxylon, Combretum imberbe*), 45cm (*Pterocarpus spp.*, *Millettia stuhlmanii*) or 55cm (all the rest). The table below defines the minimum CBH of each size class for each of these three LMDH categories.

LMDH (cm)	Size Class minimum CBH (cm)		
	Red	Green	Blue
24	38	76	152
45	71	142	284
55	87	173	346

In Swahili the three size classes are termed *Miti Midogo*, *Miti ya Kati* and *Miti Mikubwa* respectively. These are abbreviated to MD (red), KT (green) and MK (blue) during the Participatory Analysis and in the Harvesting Plan.

If trees were not assigned to their respective size classes whilst on the transects they should be assigned at the end. Trees which are too small to qualify for the Red size class are ignored entirely in the analysis.

Quota Calculation

The calculation of the TAC5 is outlined in the Harvesting Plan Template. It can be run entirely in the community, and runs as follows (abbreviations are based on the Swahili):-

1) The total length of transects can either be estimated from the scale map, or calculated more precisely from the UTM coordinates recorded by a GPS unit (which are scaled in metres). A 10m transect width conveniently means the length of transects in kilometres is the same as the area in hectares. Later we will add on 10% to account for deviations from the actual path plotted but this is encapsulated in the reference table so does not need to be explicitly computed at this point.

2) In order to estimate the number of trees in the whole area, we divide the total area of Productive Forest by the distance walked during the surveys. This we call the area multiplication number, which is later used to extrapolate how many trees there are in the whole of the Productive Forest.

Total length of transects (MT)	X km
Area of productive forest (EK)	X ha
Area multiplication number NK = EK / MT	X

3) The number of trees counted during the Participatory Inventory is listed for each species.

Number of Trees Counted	MD	KT	MK
Mpingo	...	...	...
Mpangapanga	...	...	...

4) Next one must calculate what would be a sustainable quota of those trees counted on the transects. MD (red) trees are too small to fell, so they are ignored. The calculation is made by reference to the MCP table of sustainable quotas. It takes into account the length of time the tree takes to grow to harvestable size and how many trees will die naturally before they reach that size. One can be more confident about stocks estimates for common trees than one can about rare trees; in general longer transects will produce higher estimates, and this is also reflected in the quota tables. The sustainable quota of observed trees of each species is given in the table below.

Sustainable Quota of Trees Counted	MKT	MMK
Mpingo	...	...
Mpangapanga	...	...

5) MD (red) trees will grow into KT (green) and MK (blue) trees to replace the ones that have been felled. But if there are not enough it is necessary to revise the quota downwards in order to be sustainable. Also roughly one third of red trees will die before they ever reach green tree size. This next stage calculates the necessary adjustment factor.

Species	Mpingo	Mpangapanga
Adjusted total of Red Trees MD' = MD x 2 / 3	...	...
Total J1 = KT + MK	...	...
Total J2 = (MD' + KT + MK) / 2	...	...
Total J3 = Minimum (J1, J2)	...	...
Red Ratio Adjustment Factor NZM = J3 / J1	...	...

6) Finally we incorporate all of the above calculations to give us the quota of trees that can be harvested sustainably from the entire productive area of the forest. The formulae to use are:-

Harvesting Quota of Green Trees: KKT = MKT x NZE x NZM

Harvesting Quota of Blues Trees: KMK = MMK = KBT x NZE x NZM

The final quotas for each species are thus:-

Sustainable Quota of Trees in Productive Forest	KKT	KMK
Mpingo	...	...
Mpangapanga	...	...

Reference Table

All the sophisticated statistics, including computation of the 75% lower confidence limit and adding on the 10% for transect deviations, are combined in the table of sustainable quotas referenced in step 4. This may vary from one species to another according to the model used, see the relevant chapter below. An example showing the current look-up table for *Dalbergia melanoxylon* is shown below. The second (working) column is normally hidden; community representatives simply look for the row with the same or lower number of trees as seen on the transects and then scan across to determine the quota for the green or blue tree size class as appropriate.

No. Trees seen on Transects	Lower Confidence Limit	Green Trees TAC5	Blue Trees TAC5
5	3.37	0.19	0.12
6	4.22	0.24	0.15
7	5.08	0.29	0.18
8	5.96	0.34	0.21
9	6.84	0.39	0.24
10	7.73	0.44	0.27
12	9.52	0.54	0.33
14	11.33	0.65	0.40
16	13.15	0.75	0.46
18	14.99	0.85	0.53
20	16.83	0.96	0.59
25	21.47	1.22	0.75
30	26.15	1.49	0.92
35	30.85	1.76	1.08
40	35.57	2.03	1.25
45	40.31	2.30	1.42
50	45.07	2.57	1.58
55	49.83	2.84	1.75
60	54.61	3.11	1.92
65	59.40	3.38	2.09
70	64.19	3.66	2.26
75	68.99	3.93	2.43
80	73.80	4.20	2.59
85	78.61	4.48	2.76
90	83.43	4.75	2.93
95	88.26	5.03	3.10
100	93.09	5.30	3.27
110	102.76	5.85	3.61
120	112.44	6.41	3.95
130	122.14	6.96	4.29
140	131.85	7.51	4.63
150	141.57	8.07	4.98
160	151.30	8.62	5.32
170	161.03	9.17	5.66
180	170.78	9.73	6.00
190	180.53	10.28	6.35
200	190.29	10.84	6.69

How and Why the PFI Method Works

The section above on Flaws of Traditional PFRA highlighted the problem of a traditional plots based approach, but why is this one better? Clearly transects on which only selected species are recorded are more efficient, but how can we be sure that we have enough data on which to calculate the TAC5? What is the origin of the 40 trees recommendation, and how do we calculate the 75% lower confidence limit? To answer all these questions it is necessary to understand the statistical underpinnings of tree surveying.

Statistical Distribution of Trees

In natural forest most trees are distributed more or less randomly at local scales. (At larger scales variables like underlying geology and altitude come into play, but locally these important environmental factors are more or less constant.) In statistical terms we say that the trees are distributed *randomly, and independently of each other*. That is to say finding one tree of a given species does not increase or decrease the chances of finding another tree of the same species. This kind of a distribution is called the Poisson distribution, details of which can be found in any modern textbook on statistics. It is akin to the Exponential distribution and is not symmetric like the Normal distribution, having a short tail on one side (down to zero), and a long tail on the other side (up to infinity). It is appropriate to many situations where the modal (most common) encounter rate is zero (or a low number) as is often the case when surveying relatively rare biological populations by sample plot.

The first thing to note about the Poisson distribution is that it is agnostic with regards to the surveying intensity, and is concerned purely with the total area surveyed. This contrasts with sample plot based surveys which frequently rely on the Normal distribution to model the number of individuals counted per plot. The randomness condition means that all the sample plots can be considered as one single plot. This does not contradict all the basic rules of good practice when biological surveying and spreading your sample plots about the study area, but facilitates easier analysis. However, it does mean we can easily add more transects as required without compromising the survey design.

It should be said that this model is an imperfect one. Many trees will cluster to a certain extent, even if there is no variation in local environmental factors simply due to the limits of seed dispersal and vegetative reproduction, which is common amongst certain species in Miombo. For instance, *Dalbergia melanoxylon*, an important timber species which predominantly reproduces by vegetative sucker or from disturbed root stock, was found not to be entirely random (Poisson test, $\chi^2_3 = 65.0$, $p < 0.001$) with some evidence of clustering[1]. However the Poisson model remains a valid one, and Monte Carlo simulations based on that deviation from random was found to have minimal impacts on actual survey results[2].

Confidence Limits

In a Poisson-distributed species, if the total surveyed area is A hectares, and in that area X individuals of a certain species and size class were found, then the unbiased estimate of the population density is $D = X / A$. We can then calculate the confidence limits as to what is the actual D using the following formula:

$$L_1 = \frac{\chi^2_{(1-\alpha/2),2X}}{2A} \qquad L_2 = \frac{\chi^2_{(\alpha/2),2X}}{2A}$$

Where L_1 and L_2 are the lower and upper confidence limits respectively, $(1 - \alpha)$ is the desired confidence level, usually 95% for scientific studies, and χ^2 is the Chi-squared distribution which can be found in most statistics books or calculated by a computer.

[1] Gregory, AM, Ball, SMJ & Eziefula, UE (1999) Tanzanian Mpingo 98 Full Report. Mpingo Conservation Project, Fauna & Flora International, UK.

[2] Ball, SMJ (2005) Analysis of PFRA Method for surveying timber stocks. Mpingo Conservation Project, Tanzania.

However we know that if the underlying density is approximately D then

$$A = \frac{X \pm E}{D}$$

Where E is the error from the actual mean. Hence we can re-write the above two equations as:

$$L_1 = \frac{\chi^2_{(1-\alpha/2),2X} \times D}{2(X \pm E)} \qquad L_2 = \frac{\chi^2_{(\alpha/2),2\ X} \times D}{2(X \pm E)}$$

We are interested in obtaining a spread between these two figures which is not excessively large so that communities will not lose out too much when they take the lower confidence limit. Thus we are interested in the interval $L_2 - L_1$ and how it compares to the actual density of trees seen D:

$$\frac{L_2 - L_1}{D} = \frac{\left(\chi^2_{(\alpha/2),2X} - \chi^2_{(1-\alpha/2),2X}\right)}{2(X \pm E)}$$

We will call this P the precision ratio. As X increases[3] then E becomes small in relation to X, except in extreme cases, and so the above equation can be approximated as:

$$P = \frac{\left(\chi^2_{(\alpha/2),2X} - \chi^2_{(1-\alpha/2),2X}\right)}{2X}$$

As can be seen this ratio depends only upon X and $(1 - \alpha)$, the desired confidence level, and not on A (although, of course, X is related to A through D, and as A increases so generally will X). Hence we can predict the number of trees we need to count in order to get this figure sufficiently low.

We can easily calculate this Precision Ratio for a range of X and $(1 - \alpha)$:-

	Confidence Level			
X	*50%*	*75%*	*90%*	*95%*
10	42%	72%	103%	123%
20	30%	51%	73%	87%
30	24%	42%	60%	71%
40	21%	36%	52%	62%
50	19%	32%	46%	55%
60	17%	30%	42%	51%
70	16%	27%	39%	47%
80	15%	26%	37%	44%
90	14%	24%	35%	41%
100	13%	23%	33%	39%

As can be seen, only once X reaches 50 trees does the Precision Ratio at the 50% confidence level drop beneath 20%, meaning that the community can be 50% confident that they are not going to miss out by more than 20% of their likely possible income, although at 40 trees we are getting close. Similarly at 20 trees they will not miss out on more than 30% of their likely possible income. Higher desired confidence levels require greater numbers of trees to be counted in order for the Precision Ratio to be within reasonable limits; indeed at low X the confidence interval can exceed the mean estimate, a very poor result.

All of the above refers to two-tailed confidence intervals. In practice we are far more interested in the lower confidence limit for ecological sustainability, rather than the upper confidence which simply increases the income for communities (and arguably the socio-economic sustainability, but that is more elastic than the ecological sustainability). Thus a 50% two-tailed confidence limit corresponds to a

[3] This approximation only remains valid where X is largish, at least 10.

75% single tailed limit, and hence the left most column above is appropriate to the confidence level we have adopted here. The above also justified why we have not adopted tighter confidence limits; this information is not for analysis and publication in a scientific journal but for use by community forest managers; we can be a little bit more forgiving, and thus require a lower effort overall be put into the inventory.

Transect Deviations

Experiments by MCP have shown that actual deviation from a transect path walked on a participatory inventory typically adds on less than 5% additional distance with a mean of around 2.5% and a maximum of 6.2%. In this method we have adopted a conservative 10% in line with the precautionary principle; increasing the length of the transects used in the calculation is effectively decreasing the density of timber trees observed.

A Theoretical Model of Sustainable Yields

In this chapter we set out a number of possible models of timber species found in south-eastern Tanzania, compare them and justify our final selection. If you are only interested in knowing the sustained yields projected under the model then skip forward to the sub-section on Final Model Definition.

Example Species

We shall consider here three species commonly logged in south-eastern Tanzania, and which are generally representative of all commercially targeted species in the area. Our model species are:

- *Dalbergia melanoxylon* called mpingo in Swahili
- *Pterocarpus spp.* (in particular *P. angolensis* and *P. holtzii*) known locally as mninga.
- *Milicia excelsa* or mvule in Swahili.

There is only limited data available on all three species. For instance their rotation time in each case is thought to be around 70 to 100 years, which is the standard textbook figure for the time taken by hardwood species to reach timber size in East Africa, whilst lack of clear growth rings in dense hardwoods makes aging of individual logs difficult.

Mortality of old-growth miombo trees is highly dependent on the frequency of fire; in northern Zambia Trapnell[4] found annual mortality was 1.72% amongst trees in late burned areas but was less than 0.4% when fire was excluded altogether. Communities managing forests are supposed to take reasonable precautions against fire intrusion, so we shall use the 0.65% annual mortality that Trapnell reported in early burned plots. Other important model parameters are set out in Table 1.

Species	Min Legal Felling Diameter (cm)	Typical Log Diameter (cm)	Typical Log Length (m)	Typical Log Volume (m^3)
D. melanoxylon	24	35	2	0.19
Pterocarpus	45	60	3.66	1.03
M. excelsa	55	60	3.66	1.03

Table 1. Model parameters for selected species. Source: MNRT and Kilwa District forestry staff.

In line with the precautionary principle we have adopted the upper figure in the range – 100 years – as the point estimate for the rotation period, and interpret that as referring to the time taken to reach the diameter of a typical log. In the absence of any data to show a more nuanced picture we have made the important general assumption that diameter growth is roughly linear, i.e. that trees whose size is within one order of magnitude of the legal minimum diameter for harvesting (LMDH) are on the straight line section of the typical sigmoid growth curve. From that we have inferred the annual incremental growth in diameter (ADI), and hence the time taken to reach the LMDH, both of which are set out in Table 2.

Species	ADI (cm)	Time to LMDH (years)	RTS
D. melanoxylon	0.35	69	74.4%
Pterocarpus	0.6	75	71.6%
M. excelsa	0.6	92	65.6%

Table 2. Inferred growth rates of selected species.

Finally we have assumed that once a tree has reached the minimum legal felling size that the straight length of stem does not further increase as the tree will have achieved its branching height long before that time. That is to say increases in merchantable volume in trees which are legally harvestable will

[4] Trapnell, C.G. (1959) Ecological results of woodland burning experiments in Northern Rhodesia. J Ecol 47(1): 129-168.

only come about through increases in girth and not in log length. A district wide assessment of timber suggested that harvestable trees have a straight stem roughly equivalent to the typical log length[5].

Model 1 : Simple Cutting Cycle

The cutting cycle or rotation period is the period of time between successive harvests. A simple basis for determining a sustainable cut is thus to consider the cutting cycle of a hypothetical clear fell, that is the length of time the community would have to wait for the forest to be re-stocked at current levels if they felled now all harvestable trees (i.e. all trees in the green and blue size classes).

In this simplest model we have assumed that these trees are all equal in size to a typical harvestable tree as described in Table 1, and that all the red trees have a diameter of 0.75 × LMDH (the mid-point of that size class). Based on the inferred growth rates given in Table 2 we calculated the age of these trees and hence the length of time it will take for them to grow into typically sized harvestable trees, see Table 3.

Species	*Red* Tree Diameter (cm)	*Red* Tree age (years)	Replacement Period (years)	# Management Periods
D. melanoxylon	18	51	49	10
Pterocarpus spp.	34	56	44	9
M. excelsa	41	69	31	6

Table 3. Inferred replacement period of selected species.

If the number of *red* trees equals or exceeds the number of *green* and *blue* trees combined we can conclude that the cutting cycle is equal to the replacement period given in Table 3. Dividing this by the five year duration period of each management plan gives the number of periods over which the cut must be allocated, which I have rounded off to the nearest whole number. Putting this all together, the TAC5 for each of the modelled species is defined as follows:

- *D. melanoxylon* TAC5 = T_{G+B} / 10
- *Pterocarpus spp.* TAC5 = T_{G+B} / 9
- *M. excelsa* TAC5 = T_{G+B} / 6

Where T is the estimated population of trees in the forest, in this model of both *green* and *blue* trees.

However this does not consider the mortality of trees. While logging will open up spaces in the forest, canopy cover is rarely close to 100% in miombo woodlands and so light competition is less of a limiting factor, and since we are considering modelling a single species at a time there can be no guarantee that these spaces will be re-occupied by the same species which was cut, although blackwood does coppice extremely well. Hence we must deduct the 3.2% mortality rate over a five year period from each TAC5 formulae given above:

- *D. melanoxylon* TAC5 = T_{G+B} × 7.0%
- *Pterocarpus* TAC5 = T_{G+B} × 8.1%
- *M. excelsa* TAC5 = T_{G+B} × 12.9%

Model 2 : Volume Increment

An alternative method commonly invoked for determination of an AAC is to consider the annual increment in timber volume, and set that as a maximum volume to be cut. Often this is done in forests being managed for more than one similar species and so it makes sense to manage them together rather than separately. However the principle can just as easily be applied to a single species at a time, and to a five-yearly increment rather than one year's growth. Table 4 sets out the calculation for each of the three demonstration species (mid point in the *blue* class was taken to be 2.5 × LMDH).

[5] Ball, S.M.J., & Gregory, A.-M. (2006) Rapid Stocks Assessment of Mpingo & Other Timber Species for Kilwa District (first full draft). Mpingo Conservation Project, Tanzania.

Species	Mid Point Diameter (cm)	Mid Point Volume (m³)	Volume after 5 years (m³)	% Increment
D. melanoxylon	36 / 60	0.20 / 0.57	0.22 / 0.60	10.0% / 5.9%
Pterocarpus	68 / 113	1.31 / 3.64	1.43 / 3.83	9.1% / 5.4%
M. excelsa	83 / 138	1.96 / 5.43	2.10 / 5.67	7.4% / 4.4%

Table 4. Calculation of volume increment over 5 years for *green* / *blue* trees.

The increment referred to is of log volume, but the proportion calculated can equally be applied to the tree population estimates, and hence can be used as the basis of the TAC5. Once again it is necessary to deduct mortality to end up with the following TAC5 for each species / size class combination:

- *D. melanoxylon* TAC5 = $T_G \times 6.8\%$ / $T_B \times 2.7\%$
- *Pterocarpus* TAC5 = $T_G \times 5.9\%$ / $T_B \times 2.2\%$
- *M. excelsa* TAC5 = $T_G \times 4.2\%$ / $T_B \times 1.2\%$

Model 3 : Extended Volume Increment

However we can improve on Model 2 by observing that if the condition that ∑*red* ≥ (∑*green* + ∑*blue*) holds then we can pair each *green* or *blue* tree with a *red* tree which is also increasing in volume. This is legitimate as the only function of the *red* trees in the model is to provide the basis of future recruitment into the harvestable *green* size class. So we can include the extra increase in volume provided by the *red* tree and then divide by the volume of the original *green* or *blue* tree, as summarised in the following equation:

$$Inc = \frac{Vol(g,5) + Vol(r,5) - Vol(g,0) - Vol(r,0)}{Vol(g,0)}$$

where $Vol(x, t)$ is the volume of tree x at time t (expressed in years). This gives us the following TAC5 calculations:

Species	*Green* TAC5	*Blue* TAC5
D. melanoxylon	11.8%	4.5%
Pterocarpus	10.5%	3.9%
M. excelsa	8.0%	2.6%

Table 5. TAC5 as proportion of standing trees under Extended Volume Increment plus Mortality model

If the condition ∑*red* ≥ (∑*green* + ∑*blue*) does not hold then these proportions can be applied to the tree population estimates, since the annual volume increment increases with size (just is proportionately smaller) and so the actual volume increment of the stand will be slightly larger than calculated.

Models Comparison & Selection

We have proposed 3 separate models. The TAC5 of *green* trees allowed under each are summarised in Table 6.

Species	Model 1 : SCC	Model 2 : SVI	Model 3 : EVI
D. melanoxylon	7.0%	6.8%	11.8%
Pterocarpus	8.1%	5.9%	10.5%
M. excelsa	12.9%	4.2%	8.0%

Table 6. Percentage TAC5 for *green* trees calculated under different models, assuming sufficient *red* trees.

Model 3 is based on the same principles as Model 2 but in all cases generates a higher yield, so will be generally preferred to Model 2, which shall be ignored henceforth.

The TAC5s for *blue* trees is lower across all species for the volume increment model compared to the cutting cycle approach as Table 7 makes clear.

Species	Model 1 : CC	Model 3 : EVI
D. melanoxylon	7.0%	4.5%
Pterocarpus	8.1%	3.9%
M. excelsa	12.9%	2.6%

Table 7. Percentage TAC5 for *blue* trees calculated under different models.

Neither Model 1 nor Model 3 is expressed in such simple numbers that they could be used in a rural community without use of a calculator, but the idea behind each is sufficiently simple that it could at least be explained to communities even if they cannot follow the calculations used to derive the proportions. In the absence of any other factors it is natural to invoke the precautionary principle once again and use whichever model gives the most conservative harvesting quota, although this can vary according to the relative proportions of *green* and *blue* trees. Alternatively one may consider the socio-economic dimension of sustainability, and note that communities will be more inclined to manage the forest properly, and according to the proper guidelines if their income from the forest is high.

It is worth noting that the harvesting plans which will be based upon these models will all have a maximum duration of five years. By the time of renewal more monitoring data will be available, and PFIs will be performed again, thus allowing us to test some of the assumptions in the models and refine them accordingly. After two whole cycles we should have enough monitoring data and experience of implementation to be able to devise much more advanced models and provide far more detailed justification of derived TAC5s. The target now is simply to produce TAC5s which maximise income now while not compromising the precautionary principle and ensuring that the forest on which much more complex calculations of TAC5s will be produced will not be greatly different from that existing today, that is to say not obviously unsustainable. Conversely, however, whilst participating communities will clearly be delighted with any future quota increase, they may be less happy to accept a decrease.

Taking that into account, and bearing in mind that at all other stages the precautionary principle was invoked, in the MCP we opted to use the mid-point figure to produce a combined model. The final combined model is presented in Table 8.

Species	*Green* trees	*Blue* trees
D. melanoxylon	9.4%	5.8%
Pterocarpus spp.	9.3%	6.0%
M. excelsa	10.4%	7.7%

Table 8. Combined Percentage TAC5 by species and size class.

Lacking any present understanding of the reasons for the differing LMDH definitions for *Pterocarpus* and *M. excelsa* which appear to be behind the different quotas (see below), we decided it would be best just to use the combined model for *Pterocarpus*, which generates a lower quota, for both genera and other species with similar characteristics. However, when the uncertainties, discussed above, that are inherent in the models' assumptions are taken into account the tiny differences between the models for *Pterocarpus* and *D. Melanoxylon* become insignificant, and hence in the MCP we will be adopting the blackwood model uniformly across all species until such time as we have better data and clear reasons to differentiate the approaches, since more blackwood than other species is expected to be harvested in community-managed forests in the early years.

In the general case there will be more *green* trees then *blue* ones, but the volume of individual *blue* trees is greater, so as a rule of thumb we would expect roughly equal timber volume contributions in a given forest area from the two size classes. If this holds then the above model generates a 7.6% yield by harvestable volume over a five year period, or 1.5% per year.

Final Model Definition

We can thus summarise our model as follows:

- For *Green* trees an offcut of 9.4% is sustainable
- For *Blue* trees an offcut of 5.8% is sustainable
- In total an average yield of 7.6% by volume should be sustainable

Heart Rot

Quality is a critical issue in blackwood harvesting billets for export and many blackwood trees are not merchantable due to heart rot and other common faults; roughly 33% of blackwood trees suffer in this way[6]. The easiest way to deal with this is to reduce the TAC5 by 33% and simply discard all logs which turn out to be of insufficient quality, allowing harvest of another to replace it. However that assumes this proportion does not significantly vary with age. A more nuanced approach would be to model rates of infection as an increase in mortality, although infected trees can still act as seed trees. This is reflected in the reference table presented above in the section on Participatory Inventory Analysis.

Discussion

The parameters used are critical in the models. For instance if the rotation period for blackwood is about 70 rather 100 years, the annual growth rate becomes 0.5cm per year, which pushes up the proportion of *green* trees harvestable under model 3 from 11.8% to 18.6%, which represents over 50% more money for communities. Going forward, results from ongoing monitoring work being conducted by the MCP, and any other contributory data which can be found, should serve to refine the parameters used in these models, test the critically important assumption of uniform growth, and thus better determine the TAC5 for each species. The precautionary principle becomes less important when one has a high degree of confidence in the data.

Monitoring data will also allow for construction of much more complicated models than are featured here such as matrix-based cutting cycle analysis and yield scheduling. Such complex models can serve two purposes. They can either become the basis of harvesting criteria themselves, or they can demonstrate that when assumptions underlying simpler models are removed the results do not greatly vary, thus improving confidence in the simpler models. For example all the models above assume that the population age structure within each size class is roughly similar; more sophisticated analysis will show whether indeed this matters, and if it does what sort of adjustments should be made on that basis. It may also show whether a greater number of size classes would make any great difference to the models. More immediately it should illuminate how frequently the condition

$$\mathrm{RTS} \times \sum red \geq \left(\sum green + \sum blue\right)$$

holds and what to do when it does not.

Another assumption which could be tested and appropriately modified is the linear growth model of girth increases. This is a major simplification, implying that all three modelled species have a simple quadratic volume curve. Variations in the volume equation for general mixed forest across the tropics can lead to differences in the Mean Annual Increment of up to 50%[7]. There is nothing to suppose that the three species modelled here will not display a similar sensitivity if sufficient data can be obtained to derive a more complex girth growth model.

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[6] Ball, S.M.J., & Gregory, A.-M. (2006) Rapid Stocks Assessment of Mpingo & Other Timber Species for Kilwa District (first full draft). Mpingo Conservation Project, Tanzania. Also supported by loggers' anecdotes.

[7] Vanclay, J.K. (1996) Estimating Sustainable Timber Production from Tropical Forests. Centre for International Forestry Research, Bogor, Indonesia.

Harvesting the Timber

Converting to Cubic Metres

The Allowable Cut is defined in terms of tree size classes, but FSC require output estimates in terms of cubic metres. Timber is also sold by the cubic metre, so converting the TAC5 to cubic metres is also useful in order to estimate likely income.

In order to do this we need to know the length of an average log which can be found out by asking loggers, sawmillers and the District Forestry Officer. For example a typical *Dalbergia melanoxylon* log is 1.5m to 2.5m long. Taking a 2m log as our guide then we find that:

- A *green* log of *Dalbergia melanoxylon* is between 0.090m^3 and 0.362m^3 in volume
- A *blue* log of *Dalbergia melanoxylon* can be anything upwards of 0.362m^3 in volume

Based on more detailed survey data, from VLFRs and other forests in Kilwa, MCP recommends the following conversion:

- A typical *green* log of *Dalbergia melanoxylon* is 0.16m^3 in volume
- A typical *blue* log of *Dalbergia melanoxylon* is 1.32m^3 in volume

When estimating volumes prior to felling, it is best to assume a yield of only one log per tree.

Timing the Harvests

The Allowable Cut defined in this document covers a period of five years. It is up to the community forest managers how that is distributed temporally within that five year period. However, it is not inappropriate for the Group Manager to make certain recommendations on how that issue should be managed. In particular it is recommended that communities should avoid making a single large harvest right at the beginning of the management period; rather than cashing in on their forest resource as soon as possible it is better if the harvests can be spread out so that the community gets a more stable income from the forest. There are two principle ways this can be done:

- Harvesting different species in different years
- Splitting large TAC5 allowances for a single species into two or more sub-quotas

Where a TAC5 is especially large it can be simply divided by five and one fifth harvested each year of the management plan. However, where the TAC5 is smaller this may not be appropriate as the logging company may not be able to realise sufficient timber to justify the investment in the harvesting operation. Consultation with likely customers is thus advised in advance.

A final option is to revisit the forest and assess other species which were not included in the original inventory. Such assessment should focus on reasonably common species, e.g. *Brachystegia spp.*, which may not fetch quite such a high price as more highly prized timbers, but nonetheless can be profitably sold. Rare or previously logged species, in contrast, are always going to be difficult to assess and will always lead to low TAC5s.

Pricing the Timber

Group members are free to price the timber from their forests however they like. MCP recommends following standard practice in forestry, and selling it by the cubic metre. (In any case under Tanzanian law each log needs to be measured so their dimensions can be noted on the transit pass, and group members are required to inform MCP of the total volume sold.)

As of October 2008, the Tanzanian government royalty rate for *Dalbergia melanoxylon* is TZS 160,000/- per cubic metre. Thus, at those rates:

- A mid-size *green* log of *Dalbergia melanoxylon* is worth 25,600/-
- A typical *blue* log of *Dalbergia melanoxylon* is worth at least 211,200/-

For the purposes of budget estimation these should be rounded off to assume:

- Each *green* tree of *Dalbergia melanoxylon* will yield 25,000/-
- Each *blue* tree of *Dalbergia melanoxylon* will yield 200,000/-

(This ignores the possibility of multiple logs per tree, thus providing conservative estimates of income.)

This is reasonable since the number of *blue* trees will always be small compared to the number of *green* ones, and thus it will be possible to price most logs straight away from simplicity and transparency, and just concentrate on the few extra large ones which should be measured individually.

Pre-Harvest Selection

Individual trees should be selected and marked prior to harvesting. Under the Group Certificate rules this is left up to the forest manager subject to two conditions:-

- Harvesting should not be excessively concentrated in one part of the forest. Consecutive harvests of the same species should instead be reasonably distributed throughout the forest so as to maintain the distribution of stocks.
- Not all the harvestable trees from a single area should be taken. One way to achieve this is to harvest, or offer for harvesting, only every other tree in an area. Since individual trees will not be numbered strict policing of this rule will not be possible; instead Group Inspectors will simply wish to check that there are roughly the same number of recent stumps and standing trees within a given area.

Trees that have been selected for harvesting should be marked in some way. Since the mark is only temporary, a simple slash mark with a *panga* will suffice. Between tree selection and harvesting community forest managers will be expected to remember roughly where the trees selected are.

Harvesting Area Rotation Period

The rules of the group certificate stipulate that harvesting should be spatially distributed throughout the forest area as evenly as possible. Within any single five year management plan there should be no return to a given patch of forest. However, many timber species are patchily distributed, and so a particular patch will generally be visited several times over longer time frames.

Harvesting quotas are computed to ensure that there are sufficient stocks of younger (*red*) trees to replace those scheduled for harvesting. *Red* trees are defined as having a DBH > half LMDH, hence we can assume that they will take half the time species' take to reach timber size from seedling to complete the rotation of stocks. Our model is predicated on a standard 100 year time to timber size for all species, so our full rotation period is 50 years.

Under the Group rules, when any patch is harvested no more than 50% of the standing timber can be taken. We thus need to know what period of time it will take for those original 50% to be replaced. On average roughly 50% of existing *Red* trees at harvest time will be in the upper half of the *Red* tree size range, and hence will mature into *Green* trees within half of the full rotation period, i.e. over a period of 25 years. That is to say after 25 years we can expect a harvested patch to more-or-less resemble its state at the original harvest. Hence the minimum return time to any harvested area should be 25 years as given in group certificate rule R22h.