Management of Mopane in Southern Africa

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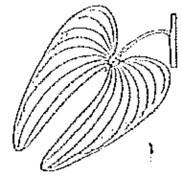
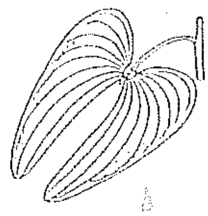
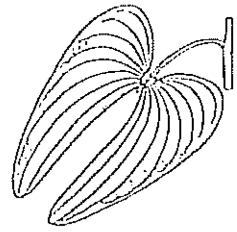




CHAPTER FIFTEEN

RECOMMENDED PROCEDURES FOR THE ESTABLISHMENT OF PERMANENT SAMPLE PLOTS (PSPs) IN THE MOPANE DOMAIN: A DISCUSSION PAPER.



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ABSTRACT

Permanent Sample Plots (PSPs) allow the acquisition of data for determining the sustainability of the mopane resource. Based on the plenary session of the workshop (Chapter sixteen), the level of use, sustainable yield and pattern of the resource throughout the SADC region appear to be the most critical biological issues in the mopane domain. Some of these questions can be answered by a biogeographic overview and some by the establishment and monitoring of PSPs. Both in combination are a powerful tool for resource management. A consistent methodology is presented for plot establishment, layout, data collection and data storage for PSPs. Compatibility rather than standardization is sought in view of the wide area and many political boundaries in the region. The most important key to success will be co-operation, collaboration and networking by those with an interest in the sustainability of mopane woodland.

Keywords; Permanent Sample Plots (PSPs), stratification, height, diameter, volume, basal area, TURBOVEG, BECVOL, MOPTHIN, biogeographic overview, sustained yield, *Colophospermum mopane,* biodiversity, variables.

INTRODUCTION

Mopane, *Colophospermum mopane* (Kirk ex Benth.) Kirk ex J. Léonard, provides a large range of resources that are of critical importance to the people of the SADC region. Rapidly increasing demands (Chapter twelve) therefore urge an evaluation of the sustainability of the mopane woodlands. Based on the plenary session of the workshop (Chapter sixteen), the level of use, sustainable yield and pattern of the resource throughout the SADC region appear to be the most critical biological issues in the mopane domain. Some of these questions can be answered by a biogeographic overview and some by the establishment and monitoring of Permanent Sample Plots (PSPs). Both in combination are a powerful tool for resource management.

The regular recording of variables concerning tree growth from PSPs allow the derivation of growth models for height, diameter, volume and basal area that are critical in estimates of sustainable yield of a timber resource. A network of PSPs covering the range of environments where mopane occurs, could allow variation in growth rates to be assessed throughout the mopane domain. Many other products are also derived from mopane woodland. Depending on the variables recorded, such plots also allow measurements of the sustained yield of a variety of other forest resources including non-timber products (e.g. Kohl *et al.* 1994). Records of other components of the biota and of the habitat can provide a regional assessment of changes in biodiversity (e.g. Wardell-Johnson and Horwitz 1996). PSPs may also allow the collection of the data necessary to determine changes in stand structure and composition so that they can be correlated with surrounding land uses, climate change etc. (e.g. Franklin and DeBell 1988).

There is a marked discrepancy in the numbers of PSPs across the SADC region, with countries such as Angola and Moçambique having no PSPs in place. Namibia has very few plots, while countries such as South Africa have many. However, even countries with large numbers of PSPs do not have an established framework for maintaining these plots, for recording the data, or for data storage or retrieval. This paper seeks to provide a consistent methodology for plot establishment, layout, data collection and data storage for PSPs in the mopane domain. It, along with the proposals by Mkosana and Kwesha (1994), is suggested as a starting point for discussion on the role and approach of PSPs in the SADC region. It will then be necessary for participants in each of the countries where mopane is an important resource, to collaborate towards determining an approach that can be implemented widely in the region. This could be accompanied by collaborative proposals for the establishment of PSPs in the region.

SELECTION OF PERMANENT SAMPLE PLOTS

Overview and site selection.

A biogeographic overview (see McKenzie 1988, McKenzie *et al.* 1996), would allow PSPs to be established from the

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range of one-off survey plots. Hence, the establishment of PSPs should follow from a good understanding of the biogeographic pattern across the mopane domain. This would allow the most cost-effective establishment of these plots. In practice, however, the establishment of some PSPs is usually carried out during, rather than subsequent to, a biogeographic overview. While there are few PSPs in the region there are many non-permanent plots which can provide guidance about locations of PSPs. Aerial photographs or other imagery acquired through remote sensing provide a good guide for stratification for the location of survey plots. Geological or vegetation maps where available also provide a means for the stratification of sample sites.

Whatever the inherent quality of the mopane resource, an attempt should be made to locate plots in sites of minimal disturbance. Hence degraded or heavily utilized stands should be avoided. Therefore, areas that have some security of purpose and that are less likely to be greatly changed by human activity should be favoured in the establishment of PSPs. The first step should therefore be the production of a map of potential sites within the mopane domain. This may be obtained through examination of recent Thematic Mapper (TM) imagery. Each country or region should decide what level of security is sufficient for their purposes. This would not detract from using other sites during the biogeographic overview stage of the project. However, it would focus attention to potential sites suitable for the establishment of PSPs. Mkosana and Kwesha (1994) suggested that Permanent Increment Plots (PIPs) should be established within Strict Natural Reserves (SNRs) because of the cost of establishment and the likelihood of their loss from other sites. The potential for loss or degradation of PSPs from other than protected areas is demonstrated for communal land in Zimbabwe by Mushove in Chapter two. Nevertheless, several PSPs may be established in the grounds of Ogongo Agricultural College (for example) as discussed in Chapter fourteen by Flower. This area is not within the formal conservation reserve system but is an informal protected area with considerable security of purpose.

The fire and management history of the site should be determined. This is because growth rates in such sites may be heavily influenced by the management regime. However, no silvicultural treatment should be carried out at such sites. In addition, the least possible disturbance should be made to the site during measurement periods. This will ensure that the plot remains representative of the surrounding vegetation type. Silvicultural treatments are best carried out as experiments quite separate to the establishment and maintenance of PSPs.

Where possible, sites should be chosen that are within a larger area of a visually similar vegetation / soil type. The presence of variation (e.g. gaps within the tree canopy, minor depressions and runoff channels during downpours) within all plots is acknowledged. However, a plot should not cross boundaries between obvious vegetation types (e.g. streamline vegetation, terrace vegetation, plain vegetation). Rather, separate plots should be established in each major vegetation type in each area, as determined by aerial photographs or other means of remote sensing. Plots should be located parallel with resource gradients. Numbers of plots should be greatest both for biogeographic survey and for PSPs near stream zones, even though most of the mopane resource occurs on the plains. This is because variation in community patterns is greatest near water courses (see Wardell-Johnson and Williams 1996 for an example from south-western Australia). Plots should be replicated in similar environments in different regions. However, it is also important for individual plots to stand alone in providing a reliable estimate of basal area and changes in increment over time for a particular forest stand.

Plot size and shape

Plot size should be at least the minimum required to get a reliable measure of the biomass and size-class distribution of the trees in any stand over time. Hence, the required plot size is likely to vary over the mopane domain. For example, plots in mopane woodland and shrubland sites illustrated by Plates A, 4 or 7 should not be less than one hectare in size. Plots in open woodland as illustrated by Plate 2 should be considerably larger. However, plots of 0.25 ha (i.e. 50 m x 50 m) may be of sufficient size in dense mopane thicket (as illustrated in Plate 8). A standard plot size is therefore not sought. However, it is imperative to note the size of the plot on both the tie sheet and the assessment forms.

Although, there is a tendency to use circular plots for rapid or one-off survey, square or rectangular plots are considered more appropriate where they are to be permanent plots. This is because it is easier to determine mapped locations of individual trees from base-lines and corner points than from a centre point (though see Schmid-Haas *et al.* 1993). In most cases square plots are preferable. However, linear plots may sometimes be appropriate (e.g. along ephemeral water courses). This is particularly so in drier areas where mopane plays a crucial role both in resource supply and biodiversity conservation. For example, the approach to forest inventory currently used in Namibia (Chakanga *et al.* 1997) where circular plots are used, may provide sites suitable for a biogeographic overview, and for PSPs. This program is also valuable in training local people in collection, measurement and recording of the type of data generated by a system of PSPs.

It is not considered necessary to divide plots into subplots, provided that the precise location of each tree can be readily determined in subsequent measurement periods. Subplots may however be necessary in dense mopane stands. It may be appropriate to consider subplots for the recording of floristic data. For example, any small variation in substrate, drainage or position in the landscape profile should be recorded as a separate releve and mapped as such. It is likely that minor topographic variation may have a major influence on floristic composition in areas of muted topography (see Wardell-Johnson and Horwitz 1996 for an example from south-western Australia). During the first survey period, a species-area curve should be generated to decide the required plot size, for floristic measurements.

Plot location description and demarcation

The plots should be established by compass and chain from known permanent markers. Location boundaries are appropriate. It should be noted that road junctions sometimes change. A standard tie sheet showing the compass and chain distances and location of the plot should be kept on permanent record in both the local and central forest offices. These tie sheets should be taken from a 1:50 000, or greater, scale map of the district. This is the largest scale map widely available within the SADC region, though in some cases, maps of smaller scale will have to suffice. The Global Positioning System (GPS) location should be recorded for the central point. The level of precision of the GPS measurement should also be recorded.

PSPs should be carefully and fully demarcated in the field. As these plots have considerable value, based on the cost required to establish and maintain them, it is important that all relevant people are alerted to the presence and value of the plots. The intention should be to establish dialogue and co-operation between all those who have a stake in the long-term maintenance of the PSPs. The value of the plots will increase with time.

Plots should be marked with a central point and four corner metal stakes well sunk into the ground (i.e. during times of moist soils) to minimize the chance of subsequent appropriation and should be replaced whenever they have been removed. Trees should also be marked. The position of each tree in the plot should be recorded exactly by compass and tape. The distance of the tree from each of two corner posts should also be recorded. This will allow the location of each tree to be plotted using a variety of computer programs.

Tree demarcation and measurement.

Mkosana and Kwesha (1994) provide detailed guidelines on the demarcation of plots and trees within PSPs. Their guidelines for tree marking should be closely adhered to. Thus all trees are numbered using an aluminium tag nailed to the tree 20 cm above the DBH band, using five centimetre nails (an allowance of 2 - 3 cm being left to cater for growth). A unique number to that tree in the plot is engraved on the tag. All trees greater than or equal to four centimetres DBH are tagged and numbers painted on larger trees. Mkosana and Kwesha (1994) also advocate a method for ensuring that all successive measurements are made at the same point. The point of measurement should thus be marked on each measured tree at a standard height of 1.3 m above ground level. A continuous painted ring around the stem with white paint marks this point. Leaning trees should be measured on the leaning side. Leaning and straight trees should be measured on the upper slope. Each stem is treated separately for trees that fork below 1.3 m. DBH is taken as usual for trees that fork above 1.3 m. If there is a swelling, then the tree should be measured above the swelling where the bole is regular. This height should be recorded.

In addition to DBH, measurements that will allow estimation of tree yield parameters based on Smit's (Chapter four) program BECVOL should also be recorded on all trees. These include the parameters used for tree height, height of maximum canopy diameter, height of first leaves, maximum canopy diameter (first and second measurements) and base diameter of foliage at height of first leaves (first and second measurements).

According to Mkosana and Kwesha (1994), the first measurements should be made soon after the establishment of the plot and should be repeated after three years and subsequently thereafter every five years. These authors suggest that measurement be taken during February to April when the trees are in leaf (despite this being the time of active growth), to facilitate identification. Trees recruited in the second measurement, that is new, unnumbered trees equal to or above four centimeters DBH are referred to as Series II and allocated unique numbers. Numbers for dead trees should not be used.

Mkosana and Kwesha (1994) list five activities associated with the remeasurement of trees. These are the minimal clearing of access lines, revising the tree position map, checking and replacement of tree labels, slightly loosening nails to allow for growth and repainting all rings at the measurement mark.

Other measures.

The mopane workshop concentrated primarily on matters other than biodiversity conservation. However, it is now widely accepted that the maintenance of biodiversity has a major influence on economic sustainability (e.g. Tilman *et al.* 1994, Ehrlich 1994). Although, PSPs are primarily established for the monitoring of tree growth, they are valuable for monitoring a wide range of environmental changes (e.g. Kohl *et al.* 1994). Therefore, the minimum required measurements should not be limited to tree growth. Three other types of measurements are suggested in addition to tree growth as being the minimal data recorded at every visit to each PSP. These include the standard site measurements required from each site, measurements of floristics and measurements of environmental change or disturbance. Standard measurements required at each visit include; date of visit, plot number, plot size, location, surveyor's name, plot map reference. Additional measurements such as altitude, slope and aspect which should not change between visits should also be reassessed as a check on previous accuracy.

The minimal measurements required to assess floristics are a record of the presence of all vascular plant species in the plot. If only a subset of taxa are recorded, it becomes very difficult to compare plots from different regions. McKenzie *et al.* (1996) discuss this issue based on biogeographic surveys in south-western Australia. If the plot covers more than one discernible vegetation type at the fine scale of a releve then separate releves are required for each habitat (e.g. local drainage channel, plain). If the plot contains limited discernable variation, then the floristics plot should be centred on the centre point of the plot. The floristics plot is a subset of the PSP. Wardell-Johnson (unpublished data) found a plot size of 50 x 50 m to be sufficient to record the floristics in the Highland Savanna vegetation type. The same site should be used in each subsequent measurement period. Each plot should be assessed at least twice in any one year, at least once during the peak flowering season (January - March in northern Namibia). It may be necessary to link in with several organizations to ensure that this condition can be met. These data can be used by the program TURBOVEG to provide an explicit analysis and assessment of the floristics of the plots and hence the region (see Inions *et al.* 1990, Wardell-Johnson and Williams 1996).

Measurements of site disturbance and change are also required at each plot. These include; grazing intensity, fire records and impacts, timber removal and plot interference.

DATA RECORDING, ENTRY, RETRIEVAL AND STORAGE

Ideally, standard data sheets should be used throughout the region. In practice, provided that the variables recorded are the same and measured in the same way, then rather seek compatibility than standardization. A standard tie sheet and set of measurement forms could be compiled once standard or compatible methodology is determined and accepted.

Data should be entered directly onto the databases provided by various computer packages. Hard copies of the original data forms should be retained at both the forestry station and at the central headquarters. Many databases allow data checking at the time of input. This saves much time and minimizes the possibility of errors in the data. However, data checks are available through mapping the position of each stem using computer programs. A computer generated map of the trees determined from the previous sample period should be taken into the field at each assessment period.

TURBOVEG (Hennekens *et al.* 1996) is a software package designed for the analysis of vegetation data. It consists of routines to store, select, export and analyze vegetation data, and to present results in tables and distribution maps. In addition to TURBOVEG which is used for data input (i.e. releves), the package includes some programmes which are used for data analysis. These include TWINSPAN, TWINBAT, SHAKE, SHAKEBAT, COMBI, KOPPEL, TABHEAD and SHIFTTAB.

MOPTHIN (Smit 1994a) consists of a collection of descriptive models for estimating and predicting various aspects of the dynamics related to thinning of mopane, while BECVOL (Smit 1994b) provides biomass estimates from canopy volume. Other programmes allow mapping of the location of individuals within a Plot based on the distance of the individual to two Plot corner locations.

Estimation and summarization of inventory data can be carried out using the same programmes. Smith and Iles (1988) provide a simple system for graphically comparing multivariate similarity between a large number of sample plots. The production of inventory results in map form can be done using various compatible packages such as MAPINFO and IDRISI. Selected data can be overlaid with other georeferenced data such as roads, streams and administrative regions to produce maps.

DATA AVAILABILITY AND COLLABORATION

The importance of collaboration, networking and data sharing was emphasized in the plenary session of the workshop and a framework for ensuring the success of this approach is provided in Chapter sixteen. In the end the success of a programme of biogeographic overview and of the establishment of PSPs throughout the region will depend on the cooperation and good will of the participants in the programme. The networking established through the association of vegetation scientists in the introduction and use of TURBOVEG is a fine example of the success of co-operation and collaboration in the SADC region.

CONCLUSIONS

The plenary session of the workshop identified the establishment and monitoring of PSPs as perhaps the most critical area of biological research in the mopane domain. Without the data required to determine sustainability, there can be little serious planning to achieve sustainability by the communities that depend on the mopane resource. It is important to emphasize that recommendations for PSPs did not just come from the biologists at the workshop, but rather from the whole range of people dependent upon the sustainability of the mopane resource. Without information, managers cannot make informed decisions on the mopane resource, a resource that once seemed endless, but which is clearly getting frayed around the edges. Both a biogeographic overview and the establishment of PSPs are urgently needed throughout the mopane domain.

Although it is generally noted that there is only limited obvious variation within mopane woodland, it is likely that a biogeographic overview and the establishment of PSPs will provide many surprises. For example, Mendelsohn and Roberts (1997) have provided an environmental profile and atlas of Caprivi where they have identified six land types, one of which is mopane woodland. Within mopane woodland, seven vegetation units were identified. Hence, although mopane woodland is generally recognized as being relatively uniform, this may be because it occurs in a generally topographically subdued landscape. There is yet to be a careful look at the variation in floristics (for example) across the mopane domain (Chapter one). It is likely that a surprising amount of variability will be found in the system (see Wardell-Johnson and Horwitz 1996 for a reassessment of the biodiversity of a topographically subdued region).

A biogeographic overview, while important to examine variation within the mopane domain, should be accompanied by the establishment and monitoring of a set of PSPs. A plot-based approach in combination with remote sensing would provide an overview of the productivity and a biogeographic overview, while important to examine variation within the mopane domain, should be accompanied by the establishment and monitoring of a set of PSPs. A plot-based approach in combination with remote sensing would provide an overview of the productivity and biogeography of mopane woodland (Chapter sixteen). Once such an overview is provided, the condition of the resource can be monitored and mapped using satellite imagery at regular intervals. Although this approach allows the monitoring of change, it provides little information on sustainability. A subset of those plots used to derive measurements of the mopane resource may be chosen as PSPs. In practice, both steps could be carried out simultaneously. In any case, a sound knowledge of variation in growth rates throughout the mopane domain can be best derived from PSPs. This will be a necessary step if we desire to achieve sustainable levels of exploitation in the mopane domain.

It is now necessary for those who seek the establishment of a set of PSPs in the region and to carry out a biogeographic overview to collaborate towards determining the details of a proposal that can be implemented widely in the region.

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