14. CONSTRUCTING A YIELD TABLE FOR SMALLHOLDER FORESTS

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INTRODUCTION

Informed decisions about land use require estimates of future yields and returns. Yield tables are a convenient way to document likely yields from tree plantations. This paper outlines a pragmatic procedure to compile yield tables for smallholder plantings in Leyte, Philippines.

Yield tables were first compiled in Europe about 1787 (Reventlow 1787), but comparable forest management guidelines have been in existence for much longer (e.g., the Chinese Lung Ch'uan codes). These early yield tables were simple lists indicating the expected volume at a given age. Since then, yield tables have become more diverse and sophisticated, and modern examples include yield tables that report both total and merchantable volumes for a range or site conditions, alignment charts that allow inference of volumes to any merchantable limit (e.g., Bruce 1929), and computer simulation packages that allow yields to be simulated for diverse silvicultural regimes (Vanclay 1994). However, these approaches share the common goal of informing users of the expected timber harvest at a given time in the future. For many smallholders, this goal implies simplicity and timeliness. This paper outlines how to quickly construct a yield table with limited data. Although the resulting yield table should be considered a ‘first approximation’ which should be revised as additional data become available, it will nonetheless provide objective data to assist landholders and extension officers to make objective decisions about likely returns to tree growers.

When sufficient data are available, the construction of a yield table for an established industrial plantation owner is a relatively easy matter. Such a yield table can be created by measuring the volume per plot on a range of plantings, and fitting a yield function using linear regression (Vanclay 1994). This is easy for an established industrial plantation estate, where plantings tend to be large, uniformly managed, and confined to a limited range of site conditions. Constructing a yield table for smallholder forests in Leyte is more challenging because there are few old plantations, and because the large range of site (e.g., geology, topography, elevation) and stand conditions (spacing, thinning, fertilizing, pest and control) means that yields may vary greatly from one smallholder forest to another.

Obviously, the initial spacing of seedlings has a major effect on their growth rate and the age at which they attain a merchantable size. The wide range of different spacings adopted by smallholders poses some challenges, but long-standing research into the influence of spacing on volume production offers a solution. A series of experiments with conifers in Europe (Wiedemann 1932, Langsæter 1941, Møller 1944) and with Eucalypts in South Africa (O'Connor 1935) demonstrated that the *total* woody volume production per hectare is relatively unaffected by stand density, for a wide range of density. Thus a yield table based on the total woody volume per hectare should be relatively insensitive to the variations in stand density observed in smallholder woodlots.

Our interest in not only in the total woody yield, but also in the merchantable yield above a specified merchantability limit. Thus, in addition to the yield table, we need a basis for estimating the merchantable fraction of the total woody volume production.

DATA REQUIREMENTS

An efficient system for predicting future plantation yields requires three components:

1. A yield table to predict gross wood volume at a given age
2. An adjustment to estimate the merchantable component of individual stems
3. A system to predict the variation in stem size for a stand of a given stocking.

A yield table can be constructed from observations of yield per hectare for a range of stand ages. Obviously, we expect that yields may vary according to site, so it is appropriate to stratify according to site quality and/or soil type. In the longer term, repeated measurements will reveal the precise stand development trajectory and confirm the adequacy of the stratification, but measurements of temporary plots should provide an adequate interim yield table. Thus the first approximation to a yield table requires data to be collected on the total woody volume per hectare of selected species (e.g., gmelina, mahogany, mangium) in stands of known age (Figure 1), within defined strata based on environmental attributes such as underlying geology and elevation.

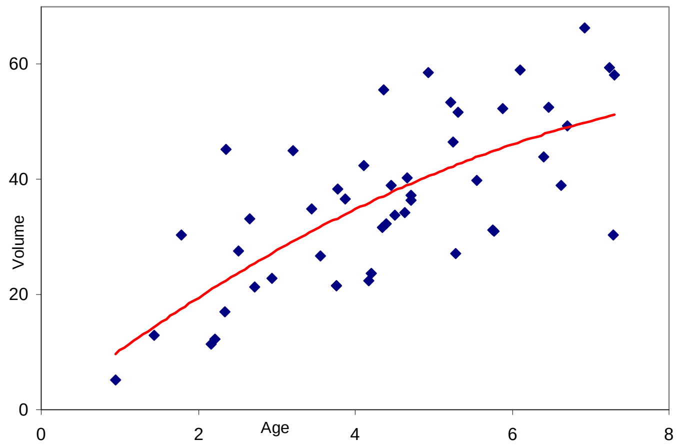

Figure 1. Hypothetical illustration of data used to construct a yield table.

Clearly, the total woody volume is of limited interest. Smallholders considering tree planting also need to know the wood volume exceeding a given size limit, that may be saleable to a sawmill or logbuyer. Fortunately, it is relatively easy to infer this merchantable fraction of the total woody volume. It is well established that tree trunks tend approximate the frustrum of a parabola in shape, and this means that the sectional area (i.e., diameter squared) tends to vary linearly with position on the stem (relative height). This means that the merchantable fraction of a tree can be estimated from the equation:

$$v_m = v_t * \{1 - (sed/d)^2\} \quad (1)$$

where v_m is the merchantable volume exceeding a specified small end diameter (*sed*), and v_t is the total woody volume of a tree with basal diameter *d*. For many trees, the diameter under bark at stump height *d*, is approximately the same as the diameter over bark at breast height (dbh), and this can be used as an interim measure until a reliable relationship is calibrated for this relationship between diameter over bark at breast height and diameter under bark at stump height. Similarly, equation (1) is a first approximation, and can be replaced with a more sophisticated stem form equation (e.g., Vanclay 1982, Goodwin 2004) as data become available.

In a well-managed even-aged planting where all the trees are approximately the same size, equation (1) can be used to estimate the merchantable fraction of the yield predicted in Figure 1. However, smallholder stands vary considerably in spacing, and as a result, may have wide range of stem sizes (dbh) within any age class, especially in stands with high stocking. These stands will have a larger merchantable volume than is indicated by the naive application of Figure 1 and Equation 1, because the largest trees have a much larger volume than the average tree, while the smaller trees tend to have a slightly smaller volume than the average tree. This does not mean that an overcrowded stand will have a higher merchantable volume than a well-stocked stand, but that an overcrowded stand may have a merchantable volume slightly greater than that indicated by the tree of mean volume. The difference is not large, but may influence smallholder decisions, so the yield table should be adjusted for the variability within stands. To calibrate this relationship, we simply need to examine the diameter distributions gathered during routine inventory in stands with a range of stand density.

A further adjustment needs to be made for stem straightness, as a substantial number of trees in many smallholder plantings, especially in gmelina plantings, many be too crooked to yield any merchantable material. A simple adjustment based on the likely recovery is likely to be adequate (Figure 3).

FIELD PROCEDURES

Field inventory should record the diameters of each stem within each inventory plot. Other project objectives require that these yield plots be co-located with the biodiversity plots (Wardell-Johnson, this volume), and there are operational efficiencies in using compatible plot designs. In addition, there are dangers in using rectangular plots of fixed area, as these may introduce bias unless carefully aligned with the centre of planted inter-rows. Thus it is proposed to sample stands using circular plots of 5 metres radius, and thus 78.5 square metres. Many smallholder plantings were established at 1x1 or 1.5x1.5 metre spacings, and such a circular plot will involve the measurement of 50 to 75 trees. Although this is a relatively large number of trees, it should be achieved quickly and easily in these young stands. In older, thinned stands, this plot size is likely to require the measurement of 15 to 25 trees, an ideal sample size. Mature stands that have been thinned several times may have a stand density as low as 400 trees/hectare, and in these situations, it is proposed that the plot area should be increased (to 10 m radius) to ensure a sample size of at least 7 trees/plot. Thus, in any plot, if a 5 m radius plot fails to include at least 7 crop trees, the radius should be doubled to 10 metres.

On each plot, the diameter of each tree should be recorded. Unless a good single-tree volume equation is available (Baynes, this volume), it will also be necessary to measure upper stem diameters and heights to allow volumes to be inferred. In addition, it would be useful to measure the total height of the tallest tree on each plot to assist in the future development of site index equations.

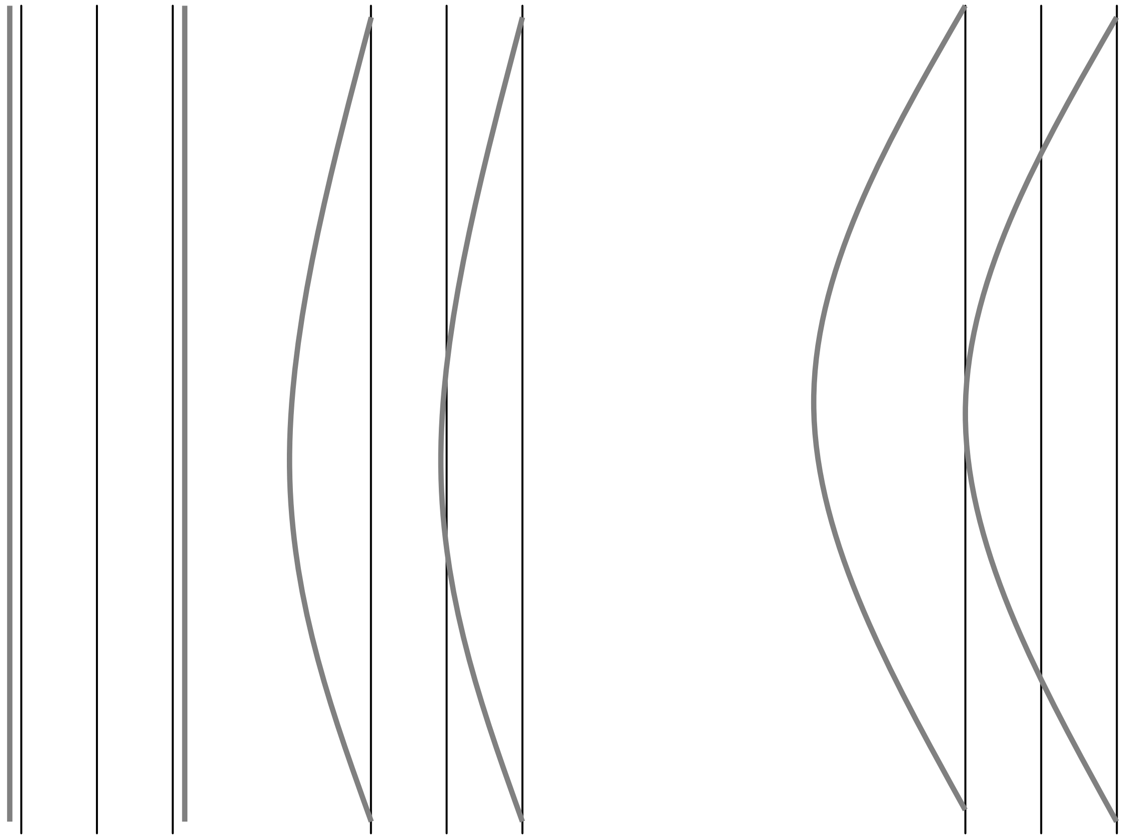

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Figure 3. Simple visual adjustment to likely recovery from sections of logs.

At least two plots should be established within each planting selected for sampling. This will allow within stand variation to be determined. In plantings covering a larger area, it may be appropriate to stratify by age class and site attributes (e.g., soil, slope) and sample within each stratum.

The quality of the resulting yield table will depend on the total number and the variability of plots sampled, but it is envisaged that thirty sites (for each species; each site with at least two plots) should be sufficient, especially if a wide range of ages is sampled.

CONCLUSION

Yield tables can be compiled from data from diverse stands, if the yield table is based on total woody volume. Taper equations can be used to generate log assortment tables and infer the merchantable volume exceeding a specified small end diameter.

REFERENCES

Vanclay, J.K. (1982), Volume to any utilization standard for plantation conifers in Queensland, Queensland Department of Forestry, Research Note No. 36, 8 p.

Vanclay, J.K. (1982), Stem form and volume of slash pine thinnings in south east Queensland, Queensland Department of Forestry, Technical Paper No. 34, 17 p.

Vanclay, J.K. (1994), *Modelling Forest Growth and Yield: Applications to Mixed Tropical Forests*, CAB International, Wallingford, U.K. xvii+312 p.