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ROBUST MODELS FOR SMALLHOLDER FORESTS

JEROME K. VANCLAY

Southern Cross University, Lismore NSW 2480, Australia

ABSTRACT

Forest management faces a contradiction: superb decision support systems are available, but only for few forests because the necessary requisites (data, computers, advisors) often remain elusive. Thus many forests and managers are hampered by a lack of information to guide management, and this handicap falls particularly heavily on community and smallholder forests. Whilst the best decision support requires detailed and reliable data, useful advice can nonetheless be provided with simple models that are easily calibrated and have been shown to be robust in diverse situations. This paper presents the underlying framework for a set of simple models that are easily calibrated and reliable under plantation scenarios. It illustrates the calibration and use of these models for several tropical plantation species, demonstrates the implications that can be inferred, and discusses the data required to calibrate these models for new situations.

Key words: Robust models, Data, Framework, Smallholder forest, Plantation scenarios.

Introduction

Many forest owners need better information and advice about their management options, especially for small private forests where private research is impractical. Experienced silviculturalists can often formulate good advice by subjectively appraising the size and variation of trees within a stand, but many small holders and their advisors lack that experience, and may be reluctant to thin trees to waste without compelling evidence.

One problem is that these smallholders and their advisors don't have access to good models to assist them to explore options. Worldwide, the availability of plantation growth models is unequal – there are thousands of models for a few select species (such as *Pinusradiata*), but thousands of species for which there are no models. This lack of advice is particularly severe for smallholder forests and for plantings of native species.

A few models (such as 3PG, Sands, 2001, 2010) can be adjusted for any species in any location – but this is not simple, requires an experienced specialist, and in the case of 3PG involves estimating some 50 parameters. That's too complicated for most smallholders and their advisors, who need something easier and more efficient.

Growth models do not need to be so complicated. The bare essentials involve just three trends…

1. The underlying rate at which trees grow – the height growth pattern with age is a long-established reliable measure.
2. The effect of competition – one useful measure is the response of tree diameter to crowding, and
3. An indication of self-thinning, or the death rate due to crowding.

If a model can estimate of these three trends, it's well on the way towards useful growth estimates.

Robust Growth Patterns

Several packages are available to facilitate curve-fitting, and some of these constrain curves to biologically-relevant patterns (Hyams, 2005), but often require substantial amounts of data and rarely ensure a reliable fit when data are scarce. However, Vanclay (2010) has demonstrated a series of relationships, applicable to the three trends mentioned above, that remain reliable even when data are scarce.

The height-age curve is a well-established basis for estimating site index, and there are many equations available to describe these curves – but most are too complicated for practical use when data are scarce. However, the relationship between height and the square root of age is quite close to a straight line, and gives a consistent, if approximate, fit for a wide range of species and sites over long periods (Vanclay, 2010). Transforming plantation age to the square root of (age-0.5) often results in a straight line through the origin that can be characterized with a single parameter, and can thus be estimated with few data. Fig. 1 illustrates the 50-year trend of this relationship calibrated using age 5 data from a national database of eucalypt growth data (West and Mattay, 1993; Mattay and West, 1994). Whilst this relationship (the dashed line in Fig. 1) is not exact, it does provide a good approximation over long periods.

This paper presents the underlying framework for a set of simple models that are easily calibrated and reliable under plantation scenarios.

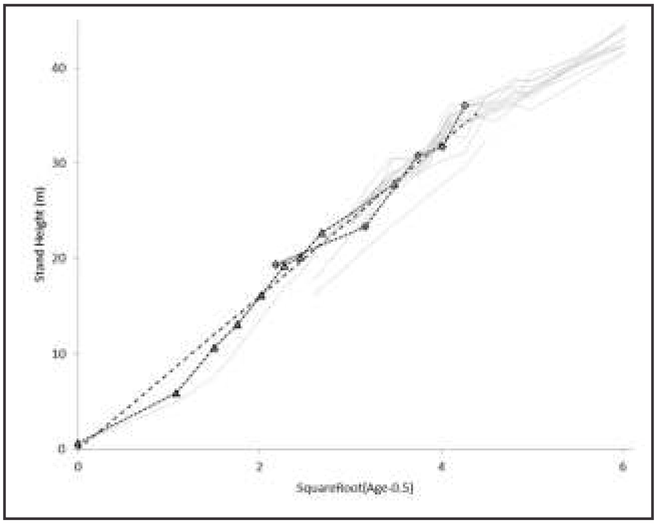

Fig. 1: Long-term trend in height versus $(\text{Age-0.5})^{0.5}$

Another simple relationship quantifies the relationship between diameter, height and stocking. The graph of Diameter against (Height-1.3)/Log (Stocking) tends to result in a straight line through the origin, and can describe the pattern of stand development for decades (Vanclay, 2009). Thinning operations can cause a temporary perturbation to this relationship, but it quickly reverts to the long-term trend. Figure 2 shows the pattern of mean diameter in 97 plots of *Eucalyptus pilularis*, all measured more than 8 times, and illustrates that this pattern remains close to a straight line for long periods of time.

It is a little more difficult to estimate mortality, but if the limiting stand basal area can be identified, then the self-thinning pattern can be modelled. If independent estimates of the limiting basal area are unavailable, then it can be estimated from just three items – the initial stocking (N_0), the current stocking (N_t), and the current basal area (G_t). These three data enable the limiting basal area Gmax, to be estimated as $G[1-(N_t/N_0)^3]^{-1/3}$ which in turn, can describe the whole-of-life pattern of self thinning. This has been tested empirically and applies to many species in many locations (Vanclay and Sands, 2009).

It seems audacious to predict long-term stand growth from just 3 parameters, namely the height-age gradient, the diameter-height gradient, and the maximum basal area, but it has been shown empirically that these parameters can provide consistent approximations of tree growth over decades. Vanclay (2010) has shown that these parameters may provide 80-year predictions with a bias of only about 5%. This may not be sufficient precision to manage a multi-million dollar industrial plantation program, but it is sufficient to provide a useful tool for smallholders, for whom this simplicity and ease of use may be very helpful.These three key parameters can be inserted into a freely-available spreadsheet (cheekily called 1PG, available from the author), to enable useful projections that encourage thoughtful evaluation of management options (Grant *et al.,* 2012).

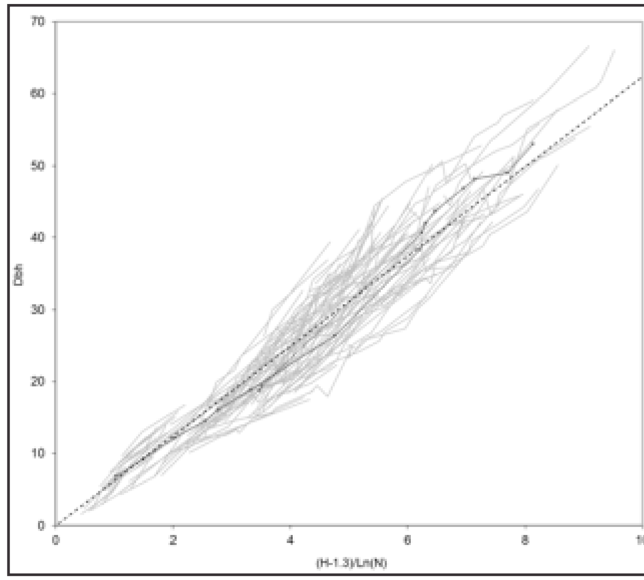

Fig. 2: Long-term trend of the relationship between Diameter and (H-1.3)/Ln(N).

Testing the model

So how well does it work in practice? The current version of 1PG was trialed first in small plantation of whitewood (*Endospermum medullosum*) in Vanuatu established as part of a development assistance project. The planting included a sufficient range of age, stocking, and tree sizes, that we could be confident of the results (Grant *et al.*, 2012). The model offered some unexpected insights – for instance, many project staff favoured wide spacings, but financial analyses using the 1PG model suggested that a stocking of 600/ha would be a good compromise (Grant *et al.,* 2012).

Word of the Vanuatu study soon spread, and there was a request to try the approach with African mahogany (*Khaya sensgalensis*) plantations in northern Australia. Although the database was restricted to 37 plots all aged less than 12 years, the approach provided useful estimate well received by the grower.

This success with modest databases begged the question: what is the smallest amount of data that will nonetheless provide an adequate model for plantation management decisions? An innovative spacing (Vanclay, 2006) in the Philippines provided an opportunity to test the model with the indigenous species known as Mayapis (*Shorea palosapis*, Gregorio *et al*., 2012). These experimental data indicated a good estimate of the size-density trend, but estimation of the height-age pattern was hampered by poor early growth of the plantings. Nonetheless, height measures at ages 3.9, 4.5 and 5.5 years gave parameters consistent with other estimates. Thus it appears that the model can be calibrated sufficiently with scant data, although it appears desirable to have data from stands older than 4 years.

A final challenge came when the Philippine NGO Genesyssought assistance with biomass forecasts from bioenergy trials. Their data were drawn from small plots, planted at 1x1m and measured bimonthly for only 22 months, and they sought guidance about future growth rates and effective management regimes. Despite these modest data, estimates obtained in this way were consistent, if slightly higher, than comparable estimates from larger, longer-term smallholder plantings. Smallholders tend to plant this species on poor sites with minimal management, so it is not surprising that the well-tended Genesys trial exhibited higher growth, especially for the height-age pattern – and it was reassuring to see the close correspondence between these estimates.

Clearly, these are not strong empirical tests, but such testing has been examined elsewhere (Vanclay, 2010) and the paragraphs above report user acceptance of the approach. Evidently this method can be applied to a wide range of situations, even with minimal data. More sophisticated models retain an important role in research and industrial management, but simple approaches such as the one illustrated here can make a useful contribution in situations where data are scarce, funds are limited, modelling skills are elementary, or plantings involve small areas or lesser-known species.

Conclusion

This series of studies with the 1PG model leads to several conclusions. Firstly, a strength of this approach is that it is objective - it does not depend on an advisor 'liking' a species (or not); rather, it offers a way to make an impartial assessment of a species performance and its potential.

Predictions can be tested easily, by comparing with other data, or by gathering data from the same plot at a later occasion – and it is easy to adjust the model on receipt of updated estimates. It is parsimonious and requires just three trends, with one parameter for each trend.

The estimates can be made, and the model run, with few data and modest computing resources – any spreadsheet software will suffice, and only beginner skills in spreadsheet use are needed.The approach supports adaptive forest management (Sayer *et al*., 1997) – if a manager has just one plot that is a little older than the bulk of the plantings, then the model and that “head-start” plot can be used to investigate options and fine-tune the management of the main estate.

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लघुधारक वनों के लिए सन्तुलित मॉडल

जीरोम के. वानक्ले

सारांश

वन प्रबंधन एक विरोधाभास का सामना करते है: उत्कृष्ट निर्णय सहायता प्रणालियां उपलब्ध हैं, किन्तु कुछ वनों के लिए क्योंकि आवश्यक सामग्रियां (आँकड़ा, कम्प्यूटर्स, सलाहकार) प्राय: दुर्ग्राहय रहती हैं। इस प्रकार प्रबंधन में मार्गदर्शन हेतु सूचना के अभाव की वजह से अनेकों वनों एवं प्रबंधकों को बाधा पहुंचती है और यह अड़चन विशेषकर समुदाय और लघुधारक वनों पर भारी पड़ती है। जबकि सर्वोत्तम निर्णय सहायता को विश्वस्त एवं विश्वसीनय आँकड़ों की आवश्यकता होती है, फिर भी उन साधारण मॉडलों के साथ उपयोगी सलाह उपलब्ध कराई जा सकती है जिन्हें आसानी से अंशशोधित करते हैं और विविध स्थितियों में सन्तुलित दर्शाया गया है। इस शोधपत्र में उन साधारण मॉडलों के एक सैट के लिए रूपरेखा प्रस्तुत की गई है, जिन्हें आसानी से अंशशोधित कर सकते हैं और रोपण परिदृश्यों के तहत विश्वसनीय हैं। यह अनेकों उष्णकटिबंधीय रोपण प्रजातियों के लिए इन मॉडलों के अंशशोधन एवं उपयोग पर प्रकाश डालता है, उन जटिलताओं का प्रदर्शन करता है जिन्हें अनुमानित कर सकते हैं, और नयी स्थितियों के लिए इन मॉडलों के अंशशोधन हेतु वांछित आँकड़ों पर विचार-विमर्श करता है।

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