GROWTH AND YIELD OF SOME PLANTATION SPECIES OF THE LOWLAND TROPICS IN ECUADOR

Denis Alder
Consultant in Forest Biometrics
denis@bio-met.co.uk

SUMMARY

The volume growth of five major plantation species of the lowland tropics are compared. These are Chuncho (*Cedralinga cateniformis*), Cutanga (*Parkia multijuga*), Jacaranda (*Jacaranda copaia*), Laurel (*Cordia alliodora*), and Pachaco (*Schizolobium parahybum*). Mean annual increment of volume to a 20-cm underbark top diameter are estimated by two different methods. One involves construction of a simple yield model for fully stocked stands. The other is by direct regression of mean volume and age. Both give comparable results except for Pachaco, where disease has reduced actual stocking below the optimum. Maximum MAIs of 20-cm underbark volume are about 23 m3/ha at age 15 for Chuncho, 15 m3/ha/yr at age 25 for Cutanga, 16 m3/ha/yr at age 15 for Jacaranda, and 8 m3/ha/yr at age 10 for Laurel. Pachaco yields are currently between 10 and 20 m3/ha/yr but very dependent on the health of the stand. Quoted yields depend very much on technical volume limits, and for Laurel, for example, vary from 15 m3/ha/yr at age 5, 8 m3/ha/yr at age 10, and 3 m3/ha/yr at age 15, depending on whether volume limits of 10 cm overbark, 20 cm underbark, or 35 cm underbark are used. It is noted that natural forest production of 1 m3/ha/yr of quality logs above 60 cm may not be markedly less than that of quality hardwood plantations to the same dimensions, and the volume limit used must be considered when comparing MAIs.

INTRODUCTION

In this presentation, I am going to discuss the estimated growth and yield of some of the plantation species that have been tested by FFJMD in Ecuador. This work was originally carried out in July 1998 under a visit sponsored by DFID. The material in this presentation is extracted from the report of that visit (Alder, 1998). It describes two methods of estimating mean annual increment curves for species, and shows the comparative results for five major species. All the data are tentative at this stage, as much more knowledge is required of provenances, sites and silvicultural conditions. It may be also noted that for several of the species, FFJMD is currently undertaking an active program of tree improvement that may lead to better growth.

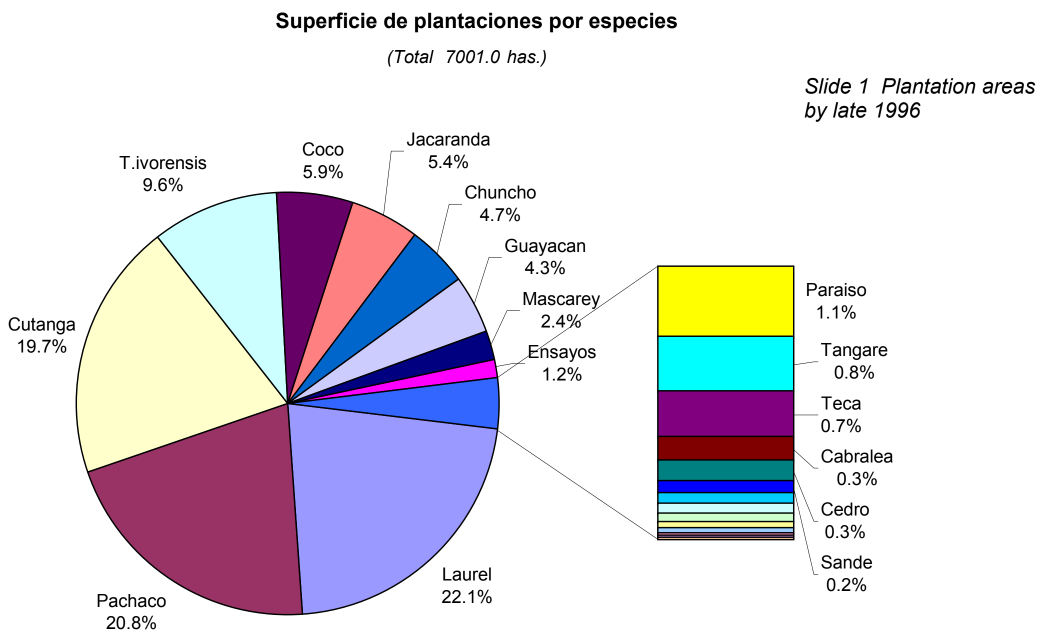
AREAS PLANTED TO DIFFERENT SPECIES

Slide 1 shows the areas under the different plantation species by late 1996. It indicates the relative importance of the different species discussed. It should be noted that the large areas under Pachaco shown at that time have been actively converted to other species as the Pachaco mortality syndrome has progressively affected stands, so these figures are no longer strictly accurate, and are intended to give only a general idea of relative importance.

The botanical and local names used are given in the list below.

Chuncho*	*Cedralinga cateniformis*
Coco	*Virola spp.*
Cutanga*	*Parkia multijuga*
Guayacan V.	*Cybistax donnell-smithii*
Jacaranda*	*Jacaranda copaia*
Laurel*	*Cordia alliodora*
Pachaco*	*Schizolobium parahybum*
Paraiso	*Melia azadiracta*
T.ivorensis	*Terminalia ivorensis*
T.superba	*Terminalia superba*

Those marked with an asterisk (*) will be considered in this presentation in more detail. Of the others, Coco may become important inter-planted with other species, and is a significant species as natural regeneration, but has too slow a growth in pure stands. *Terminalia ivorensis* and *T. superba* are exotics which show potential, but need to be proven as disease-free over a longer period. There is also not sufficient information for yield projections at present. Paraiso is unlikely to become important because of its strong branching habit. Guayacan has potential, but there is insufficient data as yet for comparisons.

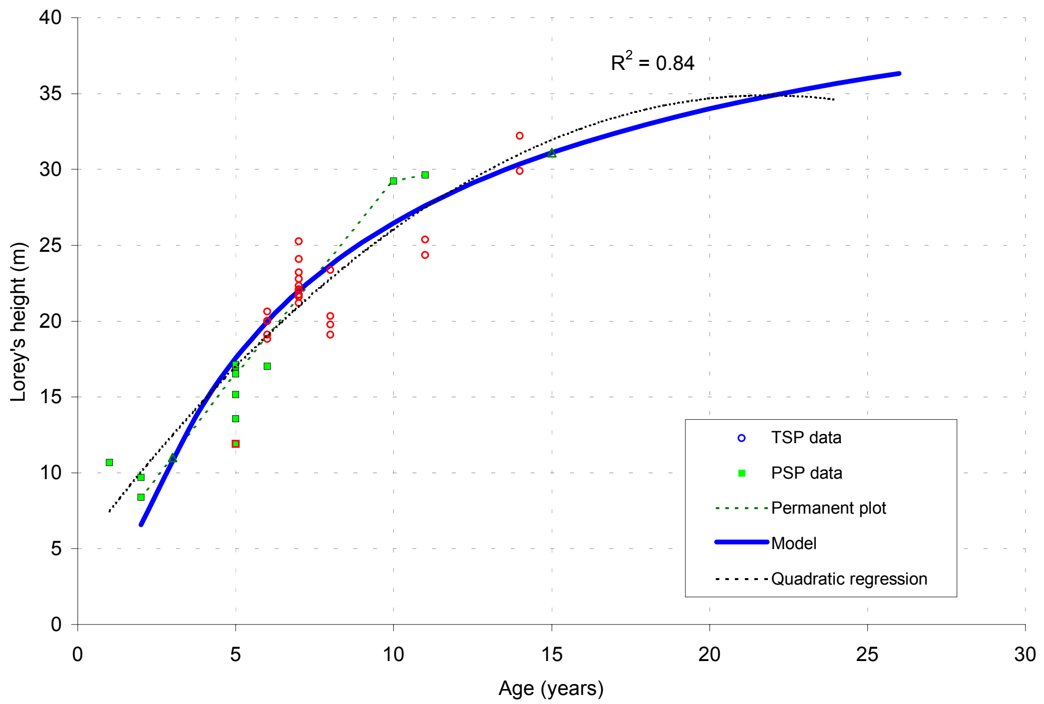


BASIC YIELD MODELS USING EICHORN'S RULE

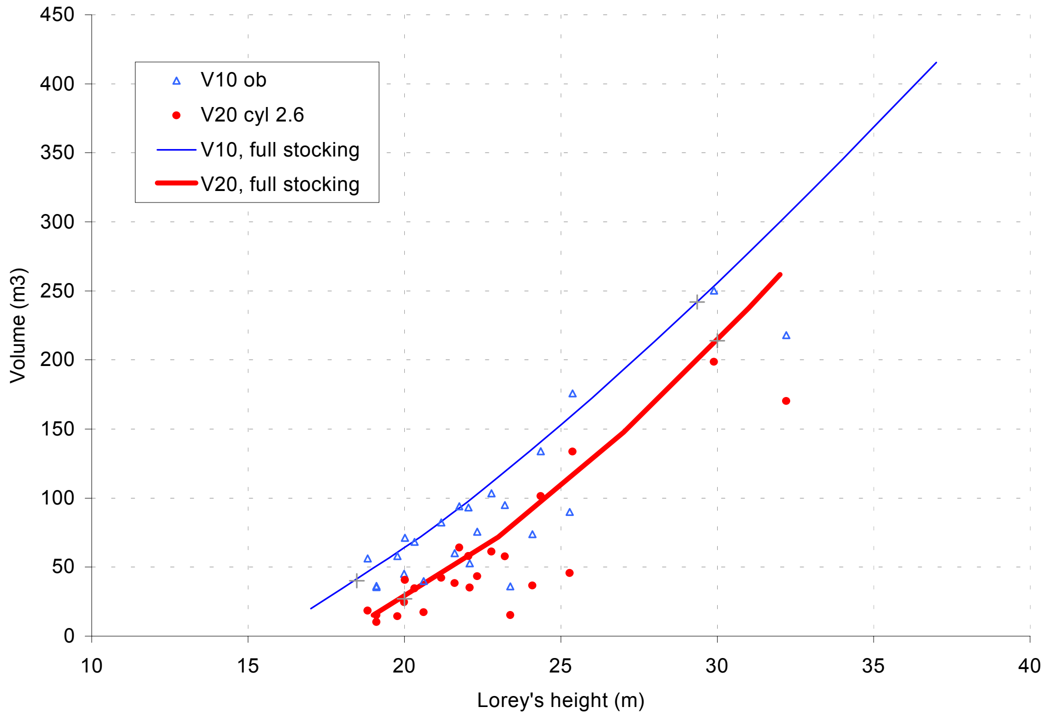
A simple yield model can be constructed using height-age and volume-height curves. The method is illustrated using the data for Jacaranda. For each species, a curve of Lorey's height on age was constructed as shown in Slide 2. A second pair of curves was constructed for stand volume against Lorey's height based on the principle of Eichorn's rule as shown in slide 3 (Alder, 1998; Alder & Montenegro, 1999). For this curve, the upper limit of the trend was estimated to indicate the volume development of fully stocked stands. Combining height-age and volume-age allows an MAI curve to be drawn as shown in Slide 4. For the volume and MAI curves, volumes are shown to 10-cm top diameter over bark based on Smalian's rule, and to underbark for cylindrical sections of 2.6 m length and minimum 20 cm diameter. The latter represents the real commercial volume and is mainly used for comparisons in this presentation.

This method is based on the assumption that at least some of the plots represent fully stocked stands. It also assumes the tendency of the height-age curve to reach a limit at full stocking which is closely definable by a logarithmic curve.

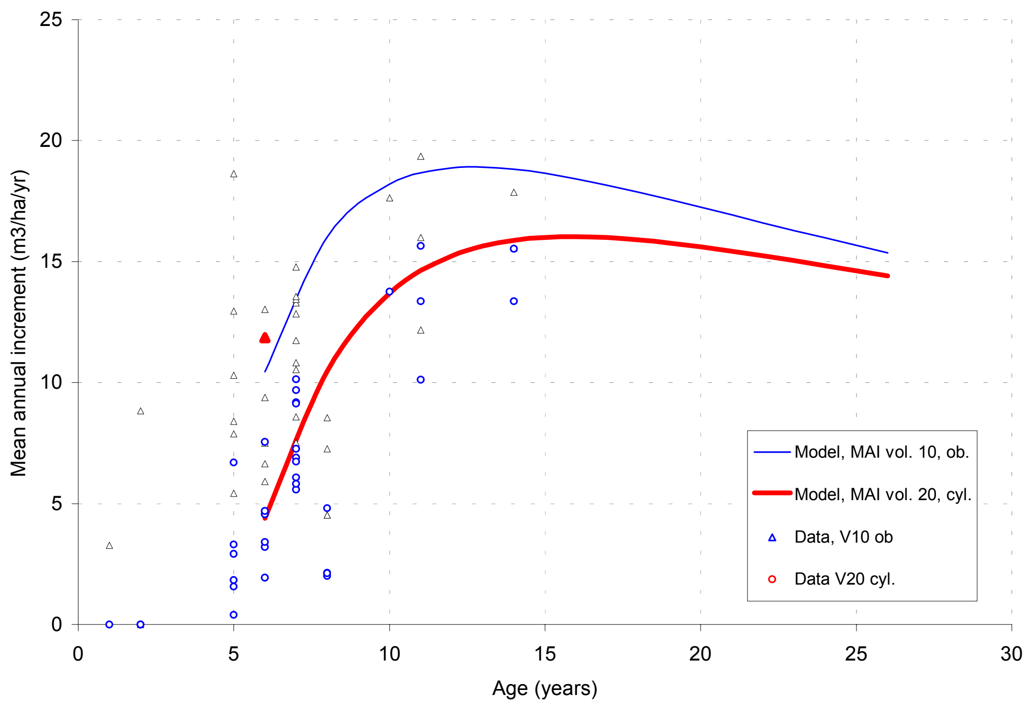
Slide 5 compares the MAI curves for the five species analysed in this way, and shows MAIs for 20 cm commercial underbark volume.



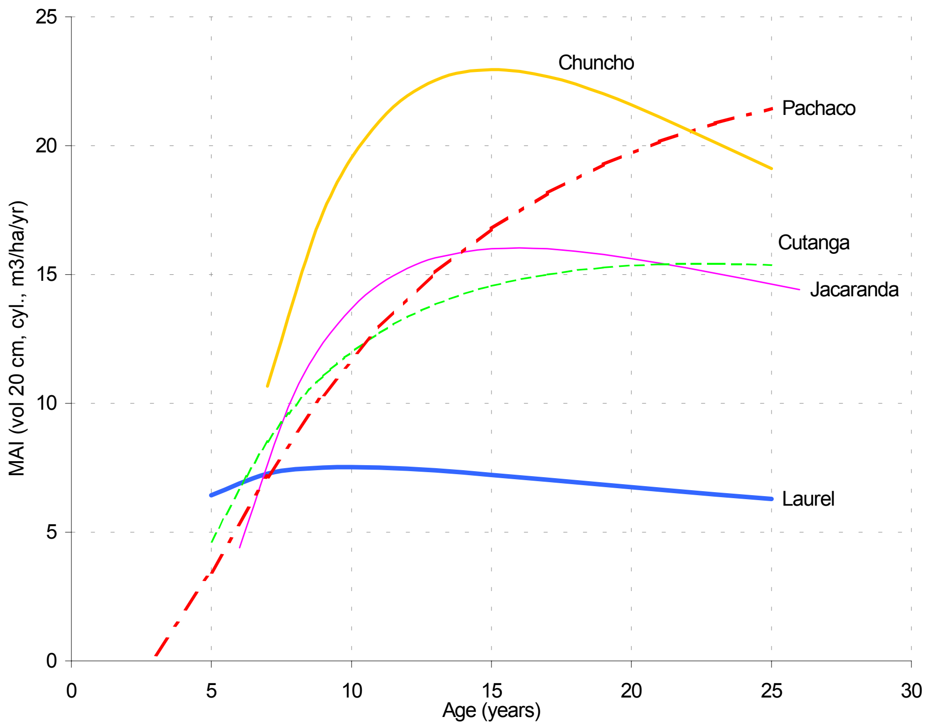
Slide 2 Construction of stand height curve for Jacaranda



Slide 3 Stand volume-height curve for Jacaranda, assuming full stocking



Slide 4 MAI curves for Jacaranda based on height-age and volume-height models



Slide 5 Comparison of MAI for 5 species assuming full stocking

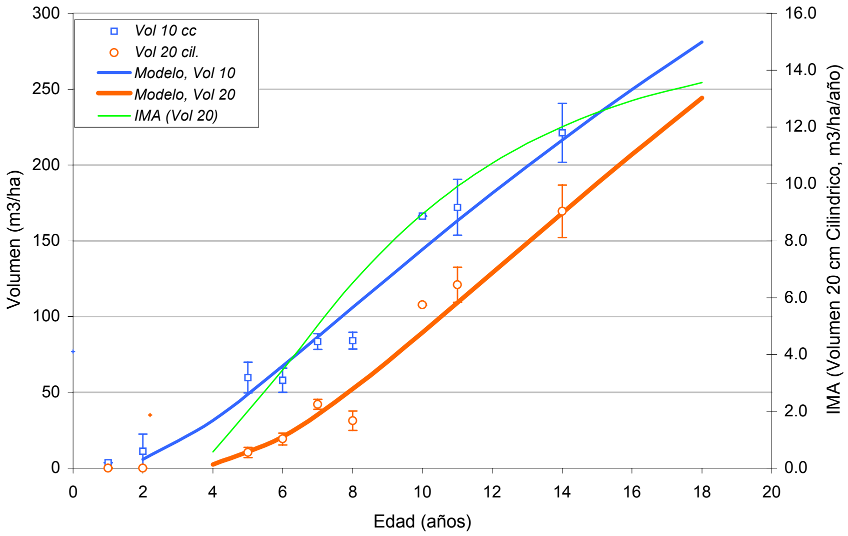
MAI CURVES BASED ON ACTUAL VOLUMES

The curves constructed by the preceding show the potential of species at full stocking, and corrects to some extent for accidental effects due to the distribution of planting years and sites. A simpler and more direct method is to summarize standing volumes by age classes, as shown in Slide 6. Here the points are the means for the 10-cm over-bark volume (blue) or 20-cm under-bark volume (red). The error bars show the standard error of the mean. The fitted regression (blue and red lines) is based on the Schumacher equation:

$$V = \alpha.\exp(\beta A^{\gamma})$$

where V is stand volume, A is age, and α, β and γ are coefficients. The green line shows the MAI for 20-cm underbark volume, calculated by dividing volume by age. This line should be read against the right-hand axis. Slide 6 demonstrates the method for Jacaranda. Slide 7 shows these actual mean MAI curves for 20-cm underbark volume.

Rendimiento actual - Jacaranda

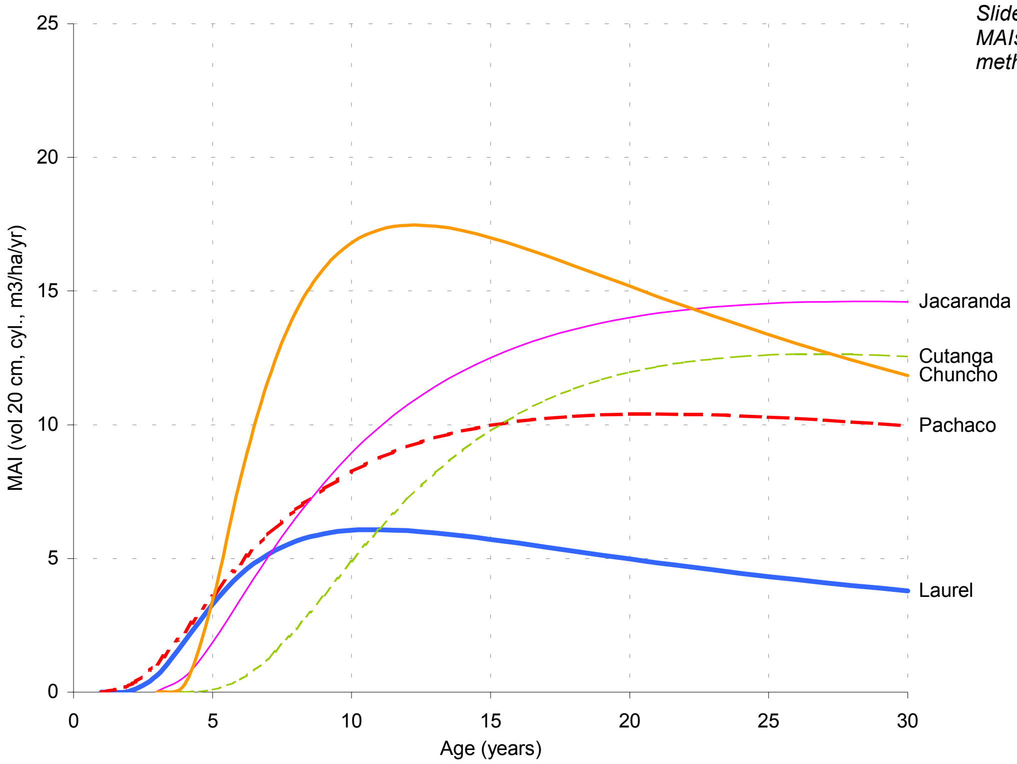


Slide 6 Direct method of constructing MAI curves from volume-age regression, illustrated for Jacaranda

Discussion

With the exception of Pachaco, the results from the two methods give similar results, and suggest the likely yields and optimal rotations for the species included. For Pachaco there is a large difference between the optimal, fully stocked curves, and the actual MAI curve due to the influence of mortality on the stocking of the stands.

For Laurel, the database is strong, and has allowed the construction of a more sophisticated yield model, as discussed in Alder & Montenegro (1999). The mean situation for Laurel shows maximum yields of volume above 20-cm diameter occurring at about 10 years. This maximum occurs earlier on better sites (about 7 years) and later on the worst sites (15 years). The maximum MAI is about 6 m3/ha/yr at average stockings, and may be improved to 8-9 m3/ha/yr with a planting regime to achieve average stockings around 200 trees/ha at maturity. As has also been noted in Alder & Montenegro (1999), Laurel is sensitive to site and requires the development of some method of site selection to avoid planting in unsuitable locations. Laurel does not show a strong diameter response to wide spacings, unlike wider crowned species, and is naturally slender. Optimum timber yields will therefore be achieved by using higher stand densities than present average values.

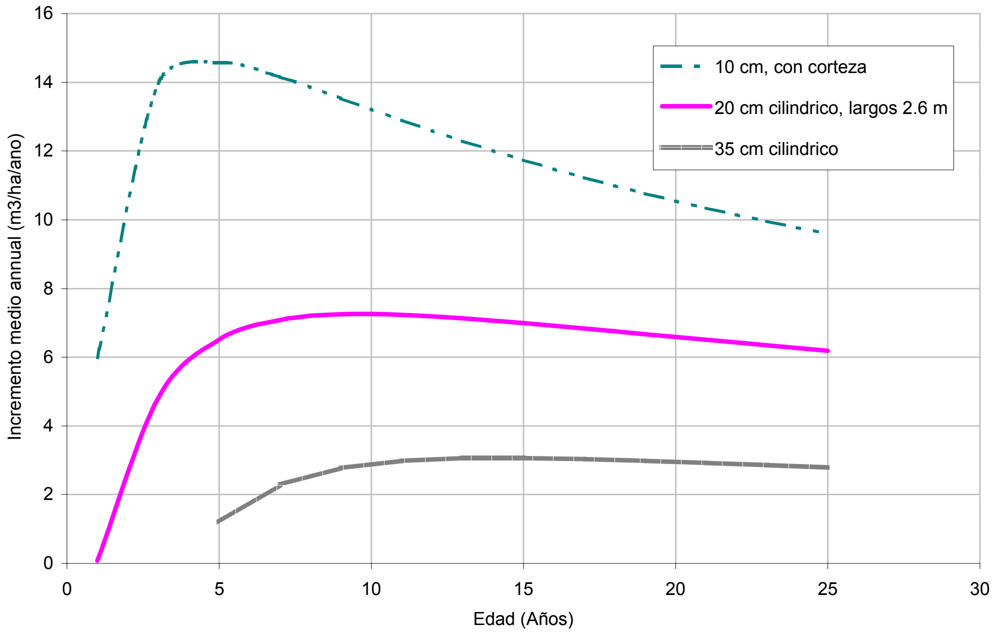


Slide 7 Comparison of MAIs based on direct method

Jacaranda and Chuncho appear to be promising species in terms of production. Chuncho in particular appears to produce high yields at an early age, but the data at the moment is very limited, and more plantations need to be established on different sites before its performance can be fully evaluated. Jacaranda is used as a plantation species in Malaysia for example, and may have a good potential in Ecuador.

Cutanga has an interesting growth habit, with very rapid height growth until nearly full height is achieved, with little diameter development. This can be seen in the MAI curves, which show almost zero commercial volume before age 5, and quite a late culmination.

These presentations show volume underbark to a 20-cm top diameter. If a higher diameter limit is used, yields are considerably lower and the culmination of MAI much later. This is illustrated in slide 8, which compares 10-cm overbark volume, 20-cm underbark, and 35 cm underbark MAI curves for Laurel. At present, the wood industries in Ecuador are considering plantations as a source of relatively large diameter logs, comparable to those harvested from natural forests (60 cm +). Such an approach is extremely wasteful of wood. Economics strongly favour investment in conversion machinery that can routinely use material down to 20-cm for solid wood conversion, with additional benefits from the use of fibre and chips on sizes between 10 and 20 cm.



Slide 8 MAI of Laurel for different technical volumes

This strong difference in MAI and volume production depending on the technical diameter limit has two further important implications. It is, firstly, false to compare yields from plantations grown for fibre, such as *Eucalyptus globulus* or *E. europhylla*, directly with those grown for solid wood. When grown for fibre to diameter limits of 10 cm, yields of 20-30 m3/ha/yr can readily be achieved for many species. Solid wood volumes to a 20-cm minimum diameter will typically be about half these figures, and may be less if close spacings are used.

Secondly, when plantation yields are compared with those from natural forests, the issue of wood dimensions and quality must also be considered, together with the multiple use aspects of natural forests. The sustainable production of high quality hardwoods above a minimum diameter of 60 cm from natural forests may be about 0.75-1 m3/ha/yr, as discussed in my earlier presentation in this conference. These will also be logs of excellent wood quality. Equivalent yields to the same dimensions from many plantation species may typically be only 2-3 times higher. It is false to compare total volume production from a plantation with sustainable yield of logs from natural forest, and conclude, for example, that the former may be 10-20 times more efficient than the latter.

Finally and in conclusion, it may said that systems of wood production based on plantations, on sustainable natural forest management, and also on agrisilvicultural systems are not exclusive alternatives, nor is one better than the other in general. They represent, in different contexts, the best approach, and often must exist in a mosaic for optimum land use, human benefits, and biodiversity conservation.

References

Alder, D; Montenegro, F (1999) A yield model for *Cordia alliodora* plantations in Ecuador. Manuscript submitted for publication in *International Forestry Review*.

Alder, D (1998) Volume and growth models for some plantation species in Ecuador. Internal report for DFID/Fundación Forestal Juan Manuel Durini.