



## Limits to [Tree] Growth

In Volume 8, Number 2, *How Trees Grow*, we noted that growth as measured by the mean annual increment (MAI) changes over the life of the stand and has also tended to increase from one rotation to the next. But there are limits to how fast trees and grow and how fast the growth rate can be increased.

### *Increasing the MAI*

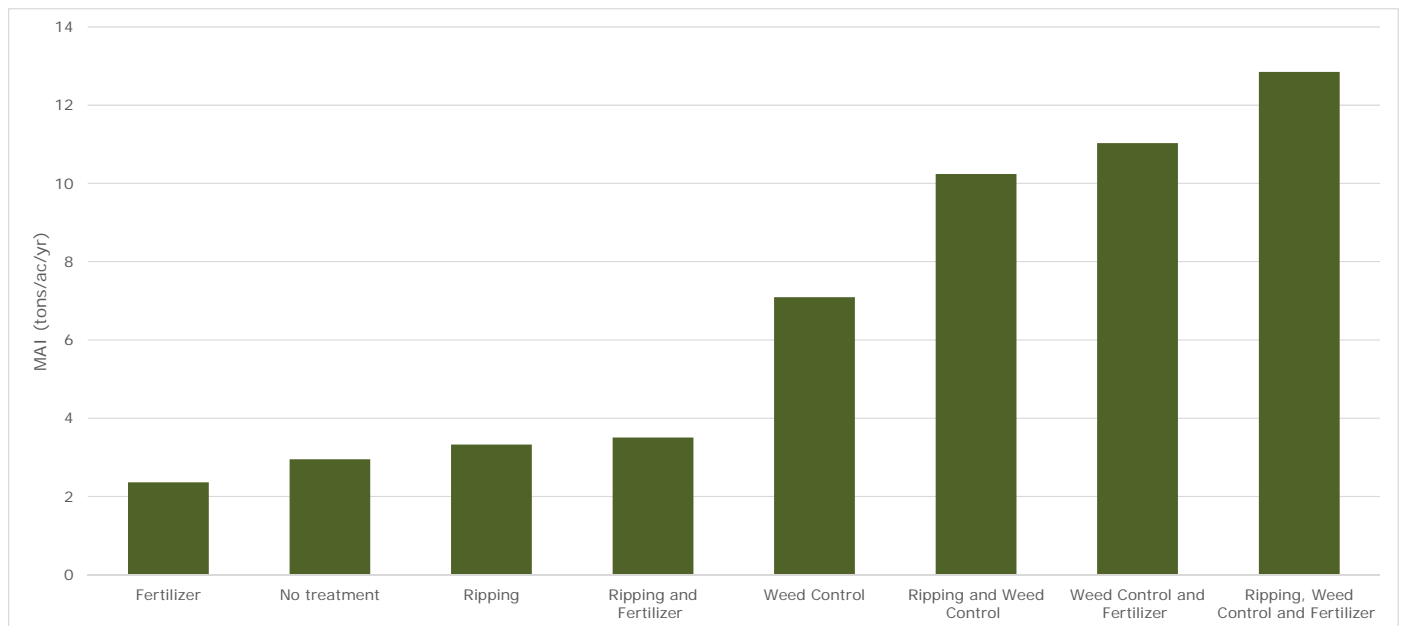
The MAI of a stand can be increased through improving the genetic quality of the seedlings planted or through silviculture treatments. Figure 1 shows the results of some research in Australia on the growth of eucalyptus. Stand growth can be increased using several different treatments and combinations of treatments.

Note that applying fertilizer alone results in less growth than doing nothing because competing vegetation takes nutrients away from the trees. In fact, weed control alone produces one of the strongest responses in the stand.

### *Increasing the MAI Over Time*

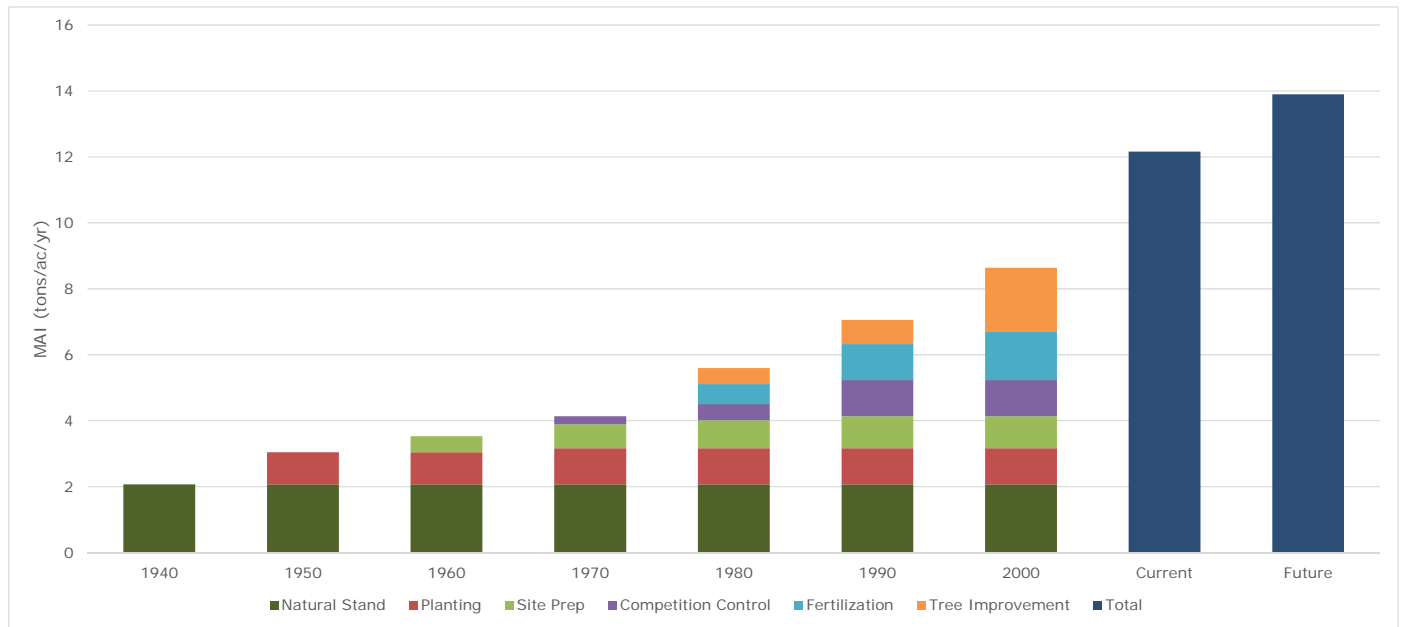
Figure 2 shows how the MAI of southern pines grown in the US has changed over time. Starting from a base growth rate of about 2 tons per acre per year in the 1940s, MAI has increased to about 12 tons per acre per year. 1940s growth rates were based on measurements from naturally regenerated stands without any silviculture treatments. Planting stands instead of letting them regenerate naturally increased growth rates by more than 50 percent.

**Figure 1. MAI (Age 10) Under Different Silviculture Treatments, *E. globulus*, SE Australia**



Source: Baker and Battaglia, 2007

Figure 2. MAI for Southern Pine in the US South Over Time



Source: Fox et al, 2007

There seem to be limitations to just how much a given treatment can boost the MAI. For example, the chart suggests that we may have done about all we can to boost the MAI with site preparation because that bar has levelled off. But advances in fertilization and tree improvement (genetics) are still boosting growth rates.

The MAI of southern pines in the US South has been increasing at a compound annual rate of 2.4 percent since 1940.

*But only over time.*

### Existing Stands

The MAI of existing stands cannot be increased.<sup>1</sup> The genetic quality of already-planted trees cannot be changed. If some sort of weed control was not applied shortly after the trees were planted, any

<sup>1</sup> At least not in any significant and cost-effective way. Stands that were planted too densely can be thinned, but probably not exactly to the “correct” spacing—and it will cost something to do that. Fertilizer could be applied at any time, but the trees are not likely to respond as well as they would if the fertilizer was applied at the “correct” time.

growth that was subsequently lost to competing vegetation cannot be recaptured. If new research shows that a different combination of silviculture treatments and tree spacing would boost the MAI, that new research cannot be applied to existing stands.

### This Year’s Stands

You are also unlikely to notice any significant difference in the growth rate of the trees you planted this year compared to the trees you planted last year. The difference in genetic quality is likely to be very slight from one year to the next. Nurseries don’t annually produce seedlings that grow 2.4 percent faster than the previous year’s seedlings—but they periodically release seedlings that are significantly better than the most recent model. The site preparation work you did this year is probably not much different than what you did last year, but it may be quite different than what you were doing ten years ago.

**The Next Rotation**

On the other hand, the trees you planted this year should grow much faster than the trees they are replacing in the stand you just harvested. Figure 2 suggests that the MAI of this year’s stand will be just over 12 tons per acre per year, which is more than 70 percent higher than the MAI of the stand you planted on this same land back in 1990 (25 years ago).

The genetic quality of the trees is likely to be much better—the geneticists have had 25 or 30 years to improve them since the stand was last planted. And the silviculture you apply to the stand you planted this year is probably going to be more intensive over the life of the new stand than what you applied to the stand you just harvested.

**Too Fast for Quality to Keep Up?**

How fast can we get trees to grow?

It is actually possible to grow them too fast.

Fast-growing eucalyptus clones are being grown on 7-year rotations for charcoal markets in east-central

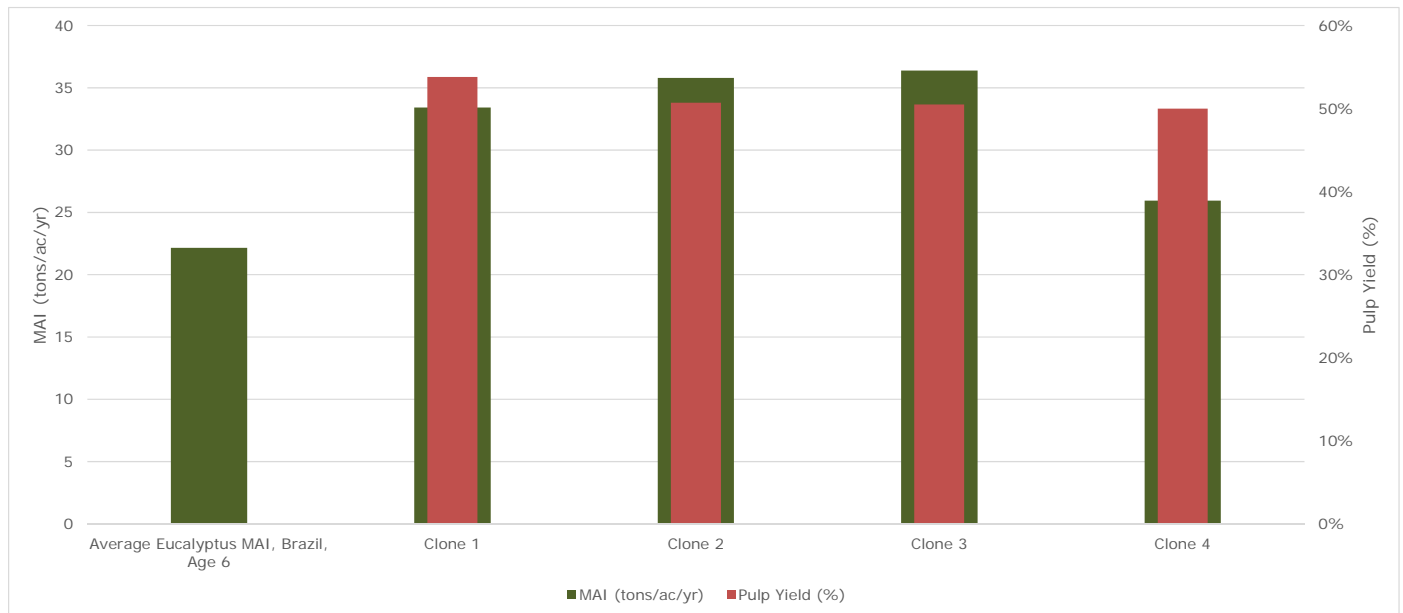
Brazil. It is common in this region to see eucalyptus with an MAI of around 20 tons per acre per year, but there is some research that is pushing the MAI up to 50 tons per acre per year. Sometimes that faster growth doesn’t work well.

Figure 3 shows some eucalyptus that broke during a windstorm. They grew too tall for their diameter or their wood density and couldn’t handle the stress.

**Figure 3. Wind-Broken Eucalyptus**



**Figure 4. MAI and Pulp Yields for Eucalyptus in Brazil**



Source: Grattapaglia, 2012

Figure 4 shows that faster growing trees are not necessarily the best for making pulp. Here, Clone 1 has the highest pulp yield (a ton of Clone 1 wood will produce more pulp fiber than a ton of the other clones) even though it is not the fastest-growing clone.

The question of quality also arises when looking at sawlog quality. Daniels (2009) pointed out an issue with maximizing the growth rate of young southern pines: the problem is that the wood produced by young trees (juvenile wood) is less dense and weaker than wood produced in older trees (mature wood). Juvenile wood is produced during the first 6-12 years of a southern pine's life. Intensive silviculture can make the tree grow faster during those years, but that does not affect the quality of the wood (i.e., it does not make the juvenile wood into mature wood) or change the age at which the tree starts producing mature wood.

He noted that silviculture practices that increase the growth rate in younger trees (such as wider spacing of trees) increases the diameter of the "juvenile core". Increased growth after the tree starts producing mature wood will result in a log that contains a higher percentage of mature wood.

### Summary

Genetic improvements in planting stock and an increasing intensity in silviculture practices has improved the MAI of southern pines in the US South by 2.4 percent per year.

This improvement is not a steady, annual rate. The improvements come in jumps as new research (and seedling development) find new processes that have a significant impact on growth.

Fast growth is not sufficient for tree growers. It is important to monitor changes in wood quality that result from significantly increased growth rates.

### References

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