Modelling the uncertainty of climate change impacts on *Eucalyptus fastigata* productivity in New Zealand

D.F. Meason[1] (dean.meason@scionresearch.com), J.H.N. Palma[2] (joaopalma@isa.ulisboa.pt), and D. Harrison[1]
[1]Scion, Rotorua, New Zealand, [2] Forest Research Centre, University of Lisbon, Portugal

Introduction

Eucalyptus fastigata (H. Deane & Maiden) is fast growing, has good wood properties and can tolerate a number of different environments in New Zealand (NZ). A case-study (Meason & Mason 2014) suggested that under 2ºC rise in global temperature under climate change (CC), its growth will increase to rival *Pinus radiata* - the dominant forestry species. Modelling future productivity is fraught with uncertainties; variability of a future climate, extreme weather events, etc. **One of the biggest contributors to uncertainty is lack of site information** (e.g. soil). This information is expensive to obtain for forests, but could have a profound impact on modelling. Few forest CC studies have explored these uncertainties, let alone acknowledge them. **The objectives of the study are:**

1. **Investigate *E. fastigata* productivity in NZ under IPCC scenarios.**
2. **Understand the level of uncertainty of future productivity with varying soil properties.**

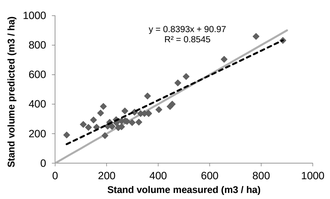


Figure 1: Model predictions of stand volume compared with 36 measured values from seven sites of the calibration dataset

Materials and Methods

The hybrid process-based model 3PG, Physical Principles for Predicting Growth (Landsberg & Waring, 1997), was parameterised for *E. fastigata*. The model produced a good fit with an R^2 = 85% (Fig. 1). Productivity under the current climate had a large range (Fig. 2), with an average mean annual increment of 27 m^3/ha/yr.

Climate change scenarios were based on the United Nations Intergovernmental Panel on Climate Change (IPCC) 2007 Special Report on Emission Scenario (SRES) B1, A1B and A2 scenarios for projections at 2040 and 2090.

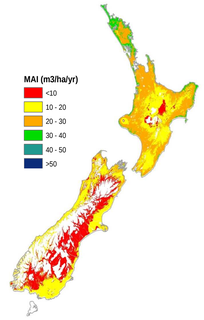


Figure 2: Modelled productivity under current climate

New Zealand CC projections were based on the Canadian Centre for Climate Modelling and Analysis CGCM3 global circulation model scaled down to a 5 km grid by the National Institute of Water and Atmospheric Research (NIWA). Each NZ CC projection was run through 3PG with different initial winter plant available soil water content (ASW):

Water storage capacity		Soil Depth
Low	• **ASW 50mm**	Shallow (~50cm)
↓	• **ASW 100 mm**	↓
	• **ASW 150 mm**	
High	• **ASW 200 mm**	Deep (+2m)

Figure 3: *Eucalyptus fastigata* mean annual increment (MAI) productivity at 30 years using ASW 200 mm initial value by 2090 CC scenario

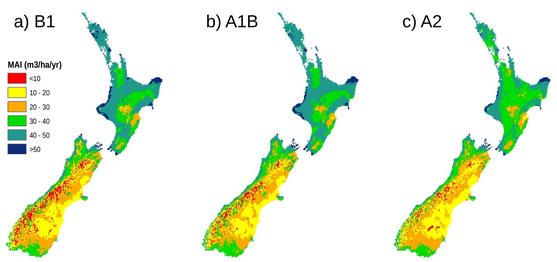
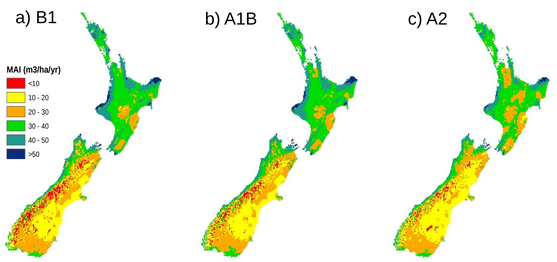


Figure 4: *Eucalyptus fastigata* mean annual increment (MAI) productivity at 30 years using ASW 50 mm initial value by 2090 CC scenario



Results and Discussion

- Productivity of *E. fastigata* increased from current productivity for all climate change scenarios (Figs. 2 - 4). This was primarily due to the decrease in frost days.
- Using ASW 200, there was little difference between B1 and A1B scenarios. Productivity was lower for scenario A2 in the North Island (Fig. 3).
- Using ASW 50, the increase in productivity was lower in the East Coast of both islands (Fig. 4), as expected with a decrease in precipitation with CC (not shown).
- The ASW 50 A2 scenario identified regions in the North Island where shallow soils would impact productivity (Fig 4c)
- When ASW was low, productivity was in a narrow evapotranspiration range (Fig. 5). When ASW was high, productivity spanned a larger evapotranspiration range.

Preliminary results showed that CC would likely increase *E. fastigata* productivity throughout NZ. However, ASW analysis revealed that regions where shallow soils would impede productivity more than others. Shallow soils (low ASW) combined with reduced rainfall (not shown) and high evapotranspiration reduced its productivity envelope (Fig. 5). The results identified regions were soil information is critically important for accurate CC modelling.

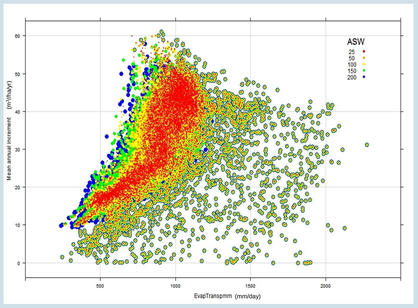


Figure 5: Impact of evapotranspiration rates on *Eucalyptus fastigata* mean annual increment productivity at 30 years) by plant available soil water content – ASW (mm)

Conclusions

The study investigated the potential productivity of *E. fastigata* as a forestry species under CC and the level of uncertainty caused by modelling. The 3PG model revealed that CC would be beneficial to productivity. Plant available soil water (ASW) analysis revealed some regions to be more sensitive to CC than others. These preliminary results clearly show the risks of making generalised assumptions for modelling inputs. This type of analysis can be used to identify 'at risk' regions where intensive data collection can be targeted.

Acknowledgements

We would like to thank the TRANZFOR program (contract number PIRSES-GA-2008-230793) for making this international collaboration possible. We would also like to thank NIWA for providing the climate change scenario data.

References

Landsberg, J.J. & R.H Waring. (1997). A generalised model of forest productivity using simplified concepts of radiation-use efficiency, carbon balance and partitioning. *Forest Ecology and Management* , 95, 209-228.

Meason, D.F. & W.L. Mason. (2014). Evaluating the deployment of alternative species in planted conifer forests as a means of adaptation to climate change – case studies in New Zealand and Scotland. *Annals of Forest Science,* 71, 239-253.

www.scionresearch.com

September 2014