Predicting plantation growth, water and salinity impacts with application to farm and catchment planning in south-western Victoria.

Nico Marcar[1], Charlie Hawkins[1], Tivi Theiveyanathan[1], Brendan Christy[2], Tom Jovanovic[1], Debbie Crawford[1], Philip Polglase[1], Anders Siggins[1], Jacqui England[1], Keryn Paul[1] and Auro Almeida[1]

[1] CSIRO Forest Biosciences, PO Box E4008, Kingston, ACT 2604 Australia
[2] DPI Victoria, 1145 Chiltern Valley Road, Rutherglen, Victoria 3685 Australia

Introduction

The Corangamite Catchment (13,350 km^2) is located in south-western Victoria (west of Port Phillip Bay), Australia. Annual rainfall varies from about 2000 mm in the south (coastal mountain ranges) to around 500 mm in the inland volcanic plains and stony rises of the central and northern parts. Land use is predominantly agriculture, including dairy in the higher rainfall areas to the south, broad-acre cropping in the north and mixed cropping and grazing throughout the extensive volcanic plains in the centre. There are also more than 45,000 ha of plantation forestry, mostly *Pinus radiata*, and *Eucalyptus globulus* (URS 2003) mainly in higher rainfall (> 700 mm) areas, with smaller farm forestry plantings (including *E. cladocalyx*) where rainfall is lower.

Land salinisation (an estimated 17,250 ha of land affected at 1,500 locations; Nicholson *et al.* 2006) and stream salinity result in considerable financial and environmental costs across the region. Twelve areas requiring salinity control measures have been identified by the Corangamite Catchment Management Authority (CCMA). Tree planting may help reduce salinity, while providing other benefits such as timber production, carbon sequestration and improved biodiversity in these areas.

This paper briefly describes application across the catchment of the Scenario Planning and Investment Framework (SPIF) tool to identify locations where tree planting on agricultural land would provide the greatest net commercial and environmental benefits. The SPIF tool was developed as part of the Commercial Environmental Forestry (CEF) project (Polglase *et al.* 2006). The tool provides a means to interrogate multiple layers of spatial information on predicted plantation growth, water use, salinity impacts, carbon storage, biodiversity value and economic value to enable improved estimates of net impacts of tree planting at farm and regional-scales. It enables natural resource managers to target plantation developments to locations which will produce the highest net benefits.

This project produced the underlying GIS layers to enable assessments of both regional and farm-scale impacts. It aimed to provide CCMA, plantation companies and landholders with a better understanding of the potential impacts of planned forests and a means to improve reporting of their likely impacts.

Materials and Methods

Five forestry scenarios – *E. globulus* (for sawlogs and pulp), *E. cladoclayx* (sawlogs), *Corymbia maculata* (sawlogs) and *P. radiata* (sawlogs) – were modelled using 3-PG+ (a version of the widely-used 3-PG plantation growth model, using a daily water balance time step) operating within the Catchment Analysis Tool (CAT)[1] to generate spatial layers of predicted plantation growth, live carbon sequestration, water use, stream flow and salinity and sediment movement for 12 salinity-prone sub-catchments in the north of the CCMA region. The CAT is a suite of models (including the forest growth model 3-PG and the groundwater model 2CSalt) and tools developed by Vic DPI to predict impacts of land use changes on recharge, stream flow, water yield, salt and nutrient loads and biodiversity (Beverly *et al.* 2006). In order to validate CAT/3-PG for growth and carbon sequestration, soil texture, depth and growth data were collected from 32 existing plantations within the central and northern Corangamite. In addition, a

[1] Referred to subsequently as CAT/3-PG

modified version of spatial 3-PG (the most recently tested version of 3-PG) was run for 21 scenarios. The scenarios were developed in consultation with Vic DPI and forestry companies as a compromise between reasonable practices for species being considered and constraints of modelling. Models were run for the entire plantable area (i.e. not occupied by roads, buildings, parks, existing native forest and plantations).

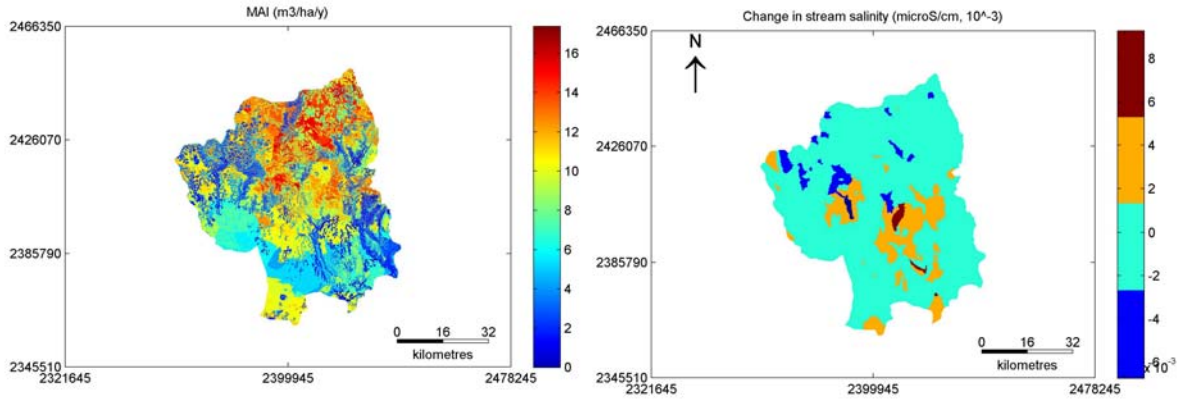
The study area was divided into 1 ha pixels. The CAT/3-PG framework was applied to each pixel in the 12 salinity target areas of the northern CCMA region (total area 424,904 ha), while the modified spatial 3-PG model was applied across the entire CCMA region. Both models used spatial input data layers (including soil depth, soil texture, fertility index, remnant vegetation, existing plantations, cadastre, road networks, hydrogeology and digital elevation). Spatial output layers incorporated into the SPIF tool included predicted growth, plantation water use, carbon sequestration, stream flow, stream salinity biodiversity score and net present value (NPV) for application to both region and farm.

There was extensive consultation and engagement with the Private Forestry Development Committee (PFDC), plantation companies, private (non-forestry) companies and landholders to assess their needs for developing 'on-farm' forestry designs. Two landholder workshops at different locations in the region were held to test this process and engage with these stakeholders.

Results and Discussion

Initial testing of CAT/3-PG and spatial 3-PG suggests that these models capture the effect of major environmental gradients on growth for the four species considered. There was generally good agreement between observed and predicted stream flows and salt load using 2CSalt in CAT. Detailed comparisons between outputs from CAT/3-PG and spatial 3-PG are yet to be completed.

Impacts of stream flow and salt load varied with species, scenario and sub-catchment. For example, for new *P. radiata* plantations over a 30-year rotation covering the entire plantable area, plantations reduced stream flow relative to current practice by 11% to 50% depending on sub-catchment, whilst salt loads to streams were reduced by 5% to 46% depending on sub-catchment. The scenario that generated the largest reduction in stream flow and salt load relative to current practice was 25 year sawlog rotation of *E. globulus* plantation whilst least reduction was 35 year old sawlog rotation for *C. maculata* plantation. Overall (across all scenarios), annual change in stream flow and salt load was reduced by about 39% and 42% respectively. Example spatial outputs for *P. radiata* (sawlogs) for growth and change in stream salinity[2] are given in Figures 1a and 1b.



(a) (b)

Figure 1. Spatial output layer for northern Corangamite catchment from CAT/3-PG modelling for MAI (m^3 ha^{-1} y^{-1}) (a) and change in stream salinity (μS cm^{-1} x 10^{-3}) (b) for *P. radiata* (30 year rotation, initial stocking of 1500 stems per ha, and final stocking of 250).

[2] 'End-of-valley' salinity (EC in μS cm^{-1}) was calculated by dividing salt load by stream flow

Working with Vic DPI, the results for the different scenarios was used as a basis for engaging with various land holders and forestry companies to develop plans for locating tree planting sites 'on-farm' to simultaneously satisfy commercial and environmental considerations. A particular focus was to try to incorporate designs that benefited overall farm productivity and profitability. Predictions of growth, water use, reduction in stream flow and salinity, change in sediment export, biodiversity value and financial benefit of proposed plantings were provided, including maps and reports used to guide investment decisions. An extension of this work will be to determine these plantations affect overall farm profitability.

Conclusions

This project has calibrated and extensively verified a set of models used to provide information on water and salinity impacts of tree planting for multiple impact assessment spatially, and especially at farm-scale, and with improved stakeholder engagement. This work will build the capacity of local government and forestry personnel to apply these models.

Acknowledgments

This project was undertaken jointly by Ensis (a joint venture between CSIRO and NZ Forestry (Scion))[3] the Corangamite Catchment Management Authority, the Department of Primary Industries (DPI) Victoria and Central Victorian Farm Plantations. The Commercial Environmental Forestry (CEF) Program, jointly funded by the Department of Agriculture, Forestry and Fisheries (DAFF), aimed to promote plantation forestry for multiple net environmental and commercial benefits. Aligned with this is a project funded by the CRC Salinity which aims to provide more certainty for landholders to adopt farm forestry for salinity management.

References

Beverly, C., Christy, B. and Weeks, A. (2006) Application of the 2CSalt-model to the Bet Bet, Wild Duck, Gardiner and Sugarloaf catchments in Victoria. Department of Primary Industries Victoria.

Polglase, P., Booth T., England, J., Falkiner, R., Hawkins, C., Jovanovic, T., Marcar, N., Paul, K., Theiveyanathan, T., van Dijk, A., Freudenberger, D., Cawsey, M. and Barrett, G. (2006) Commercial Environmental Forestry: Targeting New Forests for Multiple Benefits. In: Sustainable Forestry – Everybody Benefits -. Conference Proceedings of the Australian Forest Growers International Biennial Conference – Launceston, Australia. 22-25 October 2006. p. 168-175.

Nicholson, C., Dahlhaus P., Anderson G., Kelliher C. and Stephens M. (2006) Corangamite Salinity Action Plan 2005 – 2008. Corangamite Catchment Management Authority, Colac, Victoria. http://www.ccma.vic.gov.au/publications/Uploaded/SalinityActionPlan.pdf

URS (2003) Agriculture and forestry in the Corangamite Region. Dept. of Sustainability and Environment. January 2003.

[3] Ensis is now CSIRO Forest Biosciences with an informal relationship with Scion as Ensis operating for joint projects only.