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Development of a productivity assessment tool for native spotted gum forest on private land based on estimates of forest growth on Crown land

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Development of a productivity assessment tool for native spotted gum forest on private land based on forest growth on Crown land

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Introduction

Native spotted gum dominant forests occur across a wide range of sites and contain a complex mix of tree species and age classes. They extend from near Cooktown in northern Qld to Orbost in Victoria[1] and occur in high rainfall areas on the coastal ranges through to relatively dry sites in western Qld. Given their extensive distribution, spotted gum dominant forests are one of the most economically important forest types for timber production. Spotted gum is the most commonly harvested hardwood timber in Qld and one of the most important hardwood forest types for sawlog production in NSW. The private native forest resource in southern Qld and northern NSW is a critical component of the hardwood timber industry, particularly in light of the reduction in future availability of timber from Crown forest (i.e. under the South East Queensland Forest Agreement logging of native forest on public land is due to cease by 2024). Currently half or more of the native forest timber harvested in northern NSW and Qld is sourced from private land. The private resource also represents an important alternative source of income for landholders to supplement traditional livestock grazing enterprises.

Reliable estimates of forest productivity are essential for improved predictions of timber yields for the private native spotted gum resource in southern Qld and northern NSW. The aim of this research was to estimate the potential productivity of native spotted gum forests on private land by making use of available inventory data collated from Qld and northern NSW for spotted gum forest on Crown land (i.e. state forests). We measured a range of site-related factors to determine their relative importance in predicting productivity of spotted gum forest. While measures such as stand height and height-diameter relationships are known to be useful predictors of productivity[2,3], we aimed to determine productivity for a site where this information was not available. There is surprising little published information on native spotted gum forest growth rates (although some estimates are available for NSW[4]).

Through estimation of stand growth rates we developed a spotted gum productivity assessment tool (SPAT) for use by landholders and extension officers. We aimed to develop a tool to allow private landholders to see the benefits of maintaining their timber resource. This paper summarises the information used to develop the SPAT with a particular focus on forest growth relationships.

Methods

Site selection and field sampling

For the purposes of this study we defined spotted gum forest as a forest or woodland where 30% or more of the stems (>10 cm DBH) in the stand were spotted gum. This definition takes into account the fact that many spotted gum forests contain a mix of other tree species. Using this definition we were able to select sites for which growth data was available in Qld and northern NSW. Queensland data was obtained for: (i) permanent growth plots (i.e. detailed yield plots); and (ii) selected forest research experiments. Yield plots were established in Qld from the 1950s to assess the volume of growing trees and provide resource estimations across different forest types. Data for northern NSW was obtained from State Forests NSW and also originated from a network of permanent growth plots established for resource estimations.

Between December 2008 and June 2009 a total of 129 plots across 28 different state forests were visited. At each site we recorded: soil type[5], depth to relevant horizons (those layers present in the soil at a given plot), soil colour (based on Munsell colour charts[6]), soil texture (i.e. an estimate of the percentage of clay, silt and sand in the soil), field soil pH in all horizons, slope, aspect, position in landscape (lower, mid, upper, ridge), landform (level or gently undulating plains, gently undulating rises or low hills, undulating or rolling hills, steep hills), understorey structure (grassy, with shrubs <2 m, or with mid-stratum of small trees and tall shrubs 2–10 m in height), basal area and an estimate of merchantable height.

Tree growth data used

We focussed our analysis on 124 plots in Qld and 14 plots in NSW (Figure 1). Where several plots were located within close proximity representative plots were selected for measurement and others were excluded. Plot sizes varied from 0.04 to 0.5 ha (average 0.33 ha) and plots were either rectangular or circular. Period of data collection varied between plots. On average (across the 138 plots) growth increment data was calculated for 10.2 years. The earliest measurements used were made in 1971 and the latest measurements were made in 2009. The increment data include all removals during the period of interest.

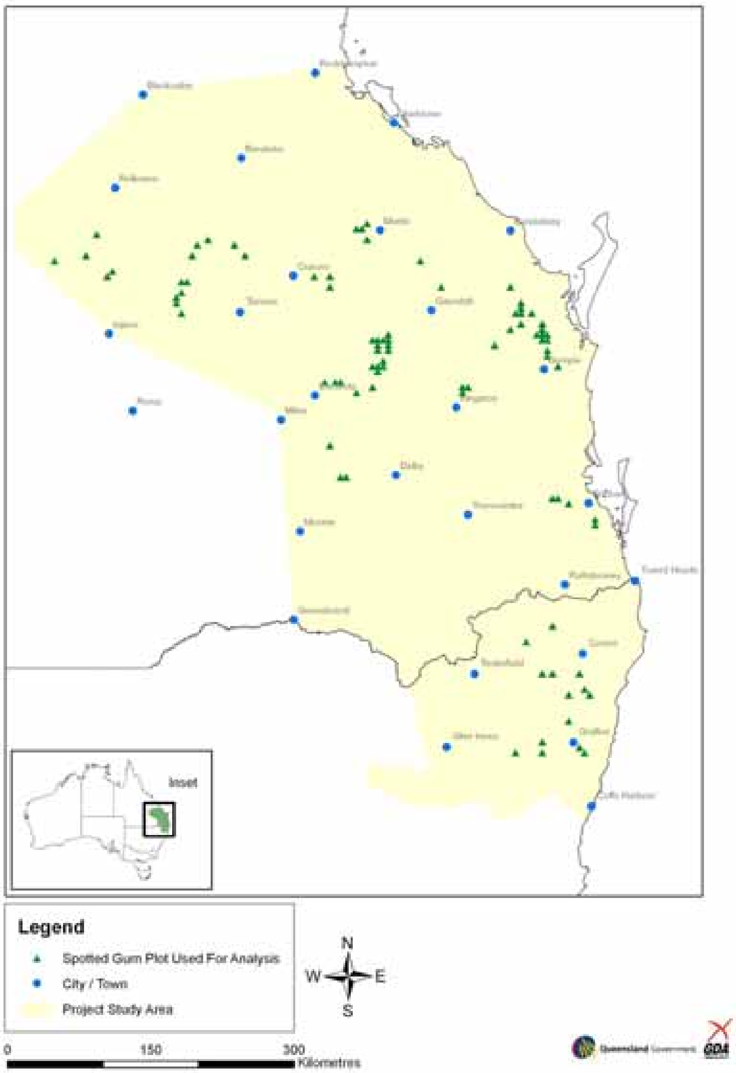

Figure 1. Locations of the 138 plots across the project study area.

We analysed growth for all trees with a DBH >10 cm, as this was generally the minimum DBH measured. Our analysis is based on all tree species contained within the forest, not just spotted gum. Stem volumes were estimated using a DBH based volume equation developed for this forest type. This equation included an adjustment to take into account that trees in the west of the study area on average have a lower stem volume (shorter bole for a given DBH) than those in the east.

Analysis of the spotted gum growth data

In addition to the site variables recorded in the field we also investigated the influence of climatic variables that were based on spatially interpolated daily Bureau of Meteorology data[7] for each plot extracted using the Data Drill program (http://www.longpaddock.qld.gov.au/silo/). Climatic variables included: annual rainfall (mm), evaporation (mm), potential evapotranspiration (calculated using the FAO Penman-Monteith formula), average minimum temperature (°C), average maximum temperature (°C), average minimum relative humidity (%, estimated from minimum temperature), average maximum relative humidity (%, estimated from maximum temperature). From this data we also estimated length of dry periods (average number of consecutive dry months per year in the increment period, where a dry month was defined as a month with <30 mm of rain) and Prescotts soil moisture index (PSMI[8]).

To make use of the field soil descriptions we converted the soil colour categories to a continuous variable using the Buntley and Westin index[9]. Based on horizon colours and depths, soil types and using expert knowledge, we derived a soil fertility class for each plot, with classes ranging from one (most fertile) to four (least fertile).

We analysed the effects of the above variables on periodic annual increment (PAI) for basal area and volume using GenStat (Release 11.1). We used all-possible subset regression for screening of explanatory variables to select the best explanatory variables for regression. This method allowed determination of the best model for each number of explanatory variables and provided output to compare competing models. Correlation matrices were used to determine whether explanatory variables were highly correlated. In many cases the climatic variables were highly correlated and it was not sensible to use several climatic variables in the regression model. Where two statistically significant variables were correlated we ran models with both variables included, and then dropped the least significant variable from the model.

Through a series of analyses we determined that annual rainfall was consistently the best predictor of basal area PAI and volume PAI. Adding other non-correlated variables did not greatly improve the regression model. However, a number of variables did have a significant influence on spotted gum volume PAI on their own (e.g. potential evapotranspiration, evaporation, maximum humidity, maximum temperature, minimum humidity, minimum temperature, soil pH at top of A horizon, longitude, slope, number of consecutive dry months per year, PSMI). Interestingly, soil variables, such as soil fertility class, and the Buntley-Westin index had no significant influence on basal area or volume PAI.

Grass growth predictions for the SPAT

Pasture production was estimated using tree basal area and pasture production relationships derived from the GRASP pasture growth model[10]. This model uses historic rainfall data to predict pasture growth for a given tree basal area (for a given basal area it assumes that trees make a proportion of the water and nitrogen resources unavailable for pasture growth). Polynomial regressions between pasture growth and tree basal area were run for the range of different land types and regions included in the SPAT. Appropriate land types (i.e. those containing spotted gum) were selected from the large number of grazing land types in the StockTake database[11].

Carbon predictions for the SPAT

The carbon component of the SPAT was based on the FullCAM carbon accounting model[12]. We used a growth model (tree yield formula) which assumes that undisturbed sites asymptotically approach an equilibrium basal area which is an expression of the productivity of a site. This equilibrium basal area is based on the forest productivity index (FPI) and allows an estimate of the maximum biomass production for a given site. The FPI (described by Richards[13]) is a measure of site productivity due to soil, sunlight, rainfall, evaporation, and frost. In the SPAT FPI is obtained by entering a latitude and longitude. FPI was averaged over a 1 km² grid for use in the tool and was only calculated within the defined study area. In providing an estimate of tree carbon the SPAT assumes that 50% of biomass is carbon, and that 25% of the tree carbon is stored in the tree roots.

Results and discussion

For the selected 138 plots standing basal area varied from 2.7 to 29.1 m²/ha. Basal area increments ranged from 0.01 to 0.86 m²/ha/year with an average of 0.21 m²/ha/year. Similar basal area increments were reported for a study in NSW spotted gum forest[4]. Standing stem volumes varied from 5.0 to 105.9 m³/ha. Volume increments ranged from 0.08 to 4.6 m³/ha/year with an average of 0.86 m³/ha/year.

There was a significant quadratic relationship between basal area PAI and rainfall ($F_{2,135}$ = 80.1, P <0.001) which explained 54% of the variance in the data (Figure 2).There was also a significant quadratic relationship between volume PAI and rainfall ($F_{2,135}$ = 73.3, P <0.001) which explained 51% of the variance in the data.

The SPAT assumes that for a given site stand productivity does not vary across the range of standing basal areas (5–15 m²/ha) that are typical of mixed timber and grazing enterprises. This is because there was no significant relationship between volume PAI and standing basal area where tree basal area was less than 15 m²/ha (P >0.05, Figure 3). This suggests that for a site where an equilibrium basal area has not been reached, a forest with lower basal area will put the same volume of wood into fewer trees than in a forest with higher basal area. Thus forest management can be used to lower the basal area of non-merchantable trees and maintain productive growing conditions for merchantable trees. Users of the SPAT need to provide an estimate of the proportion of the forest that is unmerchantable (which will be heavily influenced by past management), as this will have a large bearing on the financial returns gained from the forest. A stand that has been well managed will have a higher proportion of merchantable trees than a stand that has not been well managed.

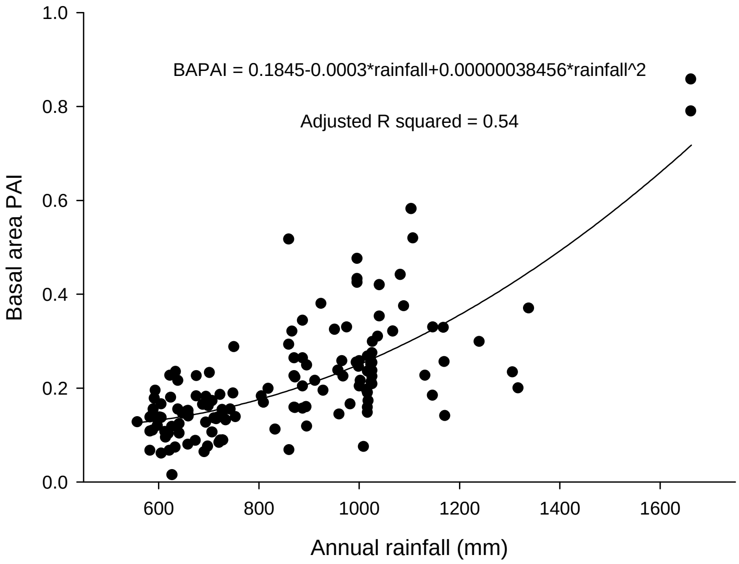

Figure 2. The quadratic relationship between basal area PAI (m²/ha/year) and annual rainfall over the relevant period of growth for each plot.

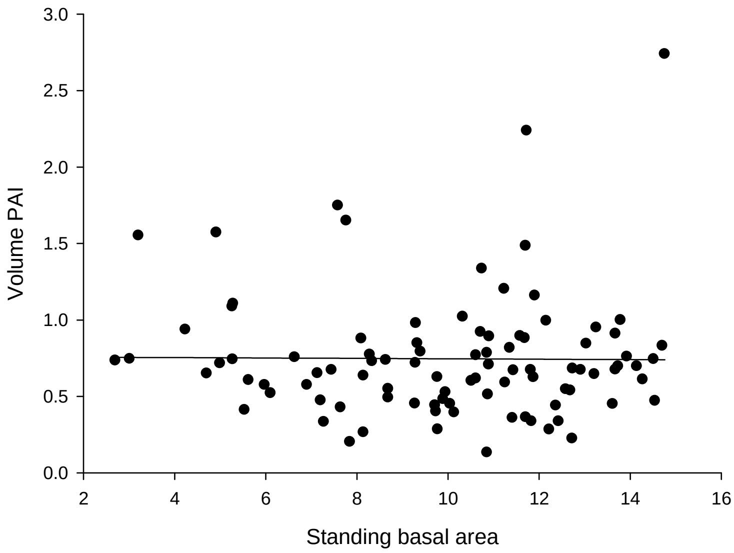

Figure 3. The lack of relationship between volume PAI (m³/ha/year) and standing basal area (m^2/ha) for plots with a basal area <15 m²/ha.

The SPAT is in the form of a Microsoft Excel spreadsheet and can be downloaded from: http://agbiz.business.qld.gov.au/plants/459.htm

The SPAT incorporates the data described above to allow an estimation of:

1: Tree growth rates (basal area and volume PAI, based on input of annual average rainfall) on specific sites and financial returns based on user inputs (i.e. prices of products obtained from the forest and the proportion of the forest that is unmerchantable).

2: Pasture production (annual grass production, utilisable grass production and carrying capacity) and expected financial return from livestock grazing at a given site. This is dependent on providing the correct region, land type, land condition, tree basal area and livestock price.

3: Above-ground tree biomass and carbon stored in trees for a specific site. This is dependent on providing a latitude and longitude for the site of interest and the basal area of the forest.

It is assumed that the results reported here from Crown forests can be applied to private native forest. While this is a reasonable assumption with regard to stand productivity[14], there may be some differences in tree growth rates between Crown and private forest due to management history (e.g. differences in forest harvest history, fire management and grazing management). Long term monitoring of plots established on private lands is required to allow a future comparison of growth rates between private and Crown lands.

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