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CLIENT REPORT (Confidential)
Assessment of likely nitrogen demand of the Jones Road Land Treatment scheme *Eucalyptus botryoides* stand

REPORT INFORMATION SHEET

REPORT TITLE	***ASSESSMENT OF LIKELY NITROGEN DEMAND OF THE JONES ROAD LAND TREATMENT SCHEME*** **EUCALYPTUS BOTRYOIDES** ***STAND***
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EXECUTIVE SUMMARY

Report Title: Assessment of likely nitrogen demand of the Jones Road Land Treatment scheme *Eucalyptus botryoides* stand

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The problem

An estimate of the current annual uptake of nitrogen (N) by a 10-ha stand of 27-year-old *Eucalyptus botryoides* is needed in order to inform a nitrogen flux model.

Client Initiatives

The client contacted Scion and asked for the current N demand of the stand to be estimated based on various parameters.

This project

Relevant literature was reviewed and pertinent data utilised along with available information about the stand to estimate current N dynamics in this *E. botryoides* stand.

Key Results

All available information indicates N uptake will be low (0 – 10 kg N ha^{-1} $year^{-1}$) in this stand. This estimate is based primarily on assumptions obtained from relevant literature due to a lack of site data and biomass partitioning models for *E. botryoides* in suitable age ranges.

Implications of Results for Client

Harvesting the current *E. botryoides* stand and replanting the area with this or another suitable species under a short rotation regime would increase N uptake rates.

Introduction

The Jones Road Land Treatment Scheme utilises a 10-ha stand of *Eucalyptus botryoides* as a sink for waste water, delivered through a drip irrigation system. The nitrogen (N) concentration of this waste water was reported to be 5 mg L^{-1} in 2001 (Robinson et al. 2001), although this figure will likely fluctuate with time (Pocernich and Litke, 1997). An estimate of the current annual uptake of N by the existing *E. botryoides* stand is needed to inform a nitrogen flux model that is being constructed.

Background information

The following information about the stand was available:

- The stand established at the Jones Road Land Treatment Scheme was plnted in 1988 at an unknown stocking rate;
- A mean stocking rate of 1366 stems ha^{-1} was determined using plots established in 2000;
- In 2000, the mean standing volume was 203.6 m^3 ha^{-1} and the mean annual increment (MAI) was 16.4 m^3 ha^{-1} $year^{-1}$;
- Sometime after 2000, an attempt was made to induce coppicing by harvesting several rows of trees;
- Coppicing failed, and a small number of rows of *Acacia melanoxylon* were planted or otherwise became established in these rows;
- The current stocking rates of both species are unknown, but *E. botryoides* still dominates the stand (estimated at 90%)

Methods

In addition to the report of Robinson et al. (2001), published literature relevant to this project was identified using the Scopus database with a range of search terms related to the issues explored in this report. Relevant papers are cited within the text.

Results

Data for a number of parameters are required in order to estimate of the current annual uptake of N by the existing *E. botryoides* stand. These are outlined below along with any limitations on the accuracy of the relevant data.

Biomass production and allocation

Information on current stocking rates is required in order to accurately determine biomass production/allocation (and consequently nutrient demand) at an individual tree and stand level (e.g. Pinkard and Neilsen, 2002). Such information is not available here so this assessment will need to rely on estimated data. Some limited growth modelling data for *E. botryoides* plantations do exist (e.g. Walsh et al., 2008) but these do not provide sufficient detail to assess biomass allocation and associated nutrient demand. Also, such data always focus solely on initial growth (e.g. 0 – 10 years) due to the interest in *E. botryoides* predominantly as a short rotation forest species. Consequently, this assessment will utilise on age-based indicators of growth and biomass development generic to the performance of similar *Eucalyptus* species.

Factors affecting stand nitrogen demand

Madgwick et al. (1991) conducted by a meta-analysis of growth data from various *Eucalyptus* species, and identified a number of relationships between biomass and basal area. Estimates of stand basal area were taken from Robinson et al. (2001) and combined with functions outlined by Madwick et al. (1991). This indicated that the Jones Road Land Treatment scheme *E. botryoides* stand supports a foliar biomass of 4000 – 9000 kg ha^{-1}, which would comprise for the most substantial pool of N at the site. The lower range of values may be the most accurate, as nutrient amendment has been shown to proportionally decrease *E. botryoides* foliar biomass production in relation to woody biomass (twigs, branches and stem wood volumes), albeit at much younger age classes than this stand (Guo et al., 2002). This uncertainty cannot be resolved without field measurements. However, given the age and initial stocking rate of the stand it can be assumed with high confidence that a closed canopy has developed and foliar biomass is no longer actively increasing. Therefore, no demand for N to support additional canopy expansion is likely.

Examination of the available literature indicates that foliar N pools are well regulated within post-canopy closure stands of *E. botryoides*, and it is phosphorus that has a much greater chance of becoming limiting (e.g. King, 1996; Hooda and Weston, 1999). The N required to rebuild the cohorts of foliage lost annually through normal aging processes is provided partially by internal translocation of N from the aging foliage as it becomes senescent (Saur et al. 2000), while the acquisition of N released during the decomposition of foliage lost in previous years and other residues present on the forest floor meets the bulk of the remaining demand. Therefore, external N demands to support the maintenance of the foliar biomass are minimal once the stand has developed the amount of foliage required for canopy closure (most likely achieved by age 8 – 12, with some variation for site conditions and thinning).This position is supported by research into the dynamics of the decomposition of *E. botryoides* foliage. The leaf litter of *E. botryoides* is known to decay relatively rapidly (Lamb, 1985), and it has also been shown that this is accelerated further with fertiliser addition (Guo and Sims, 1999), which can be considered analogous to the waste-water irrigation treatment applied here. However, this system for the retention of N can be disrupted by events that cause the sudden loss of foliage, from which no nutrient translocation occurs. Such an event will likely causes a temporary increase in N uptake as the lost foliage is rebuilt (e.g. Pinkard and Beadle, 1998), but will generally result in little impact on N dynamics in the long term as the greater pool of N being made available through decomposition of sudden foliage loss will eventually be recovered with the same level of efficiency as observed with normal foliage mortality.

Another pathway influencing external N demand by this *E. botryoides* stand is the turnover of root biomass, which follows an annual cycle (e.g. Kätterer et al., 1995). Only small amounts of data are available regarding root dynamics in general, but the same general trends apply – in mature systems external demand is very low due to the effective recovery systems used to retrieve nutrients before root death, and then after it has occurred. Therefore, it is assumed that external demand for N to support the replacement of roots lost to normal turnover is also minimal.

The presence of *A. melanoxylon* in the stand also needs to be considered as it is an N-fixing legume. Studies of *A. melanoxylon* in *Eucalyptus* stands have shown that fixation by young plants is significant and tends to increase with age (Hamilton et al., 1993). Furthermore, it appears that *A. melanoxylon* remains particularly effective at fixing N for longer during the life of the plant than other *Acacia* species (Pfautsch et al., 2009), exacerbating this impact. However, a detailed assessment of the N accumulation rates of this species is outside the remit of this report.

Estimation of current N uptake by the *E. botryoides* stand

The lack of site-specific data and consequent necessity for various assumptions precludes the provision of a specific figure for current annual N uptake by this *E. botryoides* stand. It is estimated that this value would fall within the range of 0 -10 kg N ha^{-1}, but this estimate is based on data relating to the species and eucalyptus in general, and must therefore be treated with circumspection. What is relatively certain is that N uptake will be substantially less than the annual N input figure of 44 kg ha^{-1} calculated by Robinson et al. (2001). When the additional N input from *A. melanoxylon* is considered, the impact of the plant system on the balance of N in the stand may, in fact, sum to zero.

The simplest approach to improve the accuracy of the uptake figure is to perform a multi-year assessment of the foliar biomass in the stand. This will confirm the extent and stability of the current canopy mass, which represents both the greatest and most dynamic pool of N in the tree.

Recommendation for future action

Harvesting the current stand and replanting using a short rotation model is considered the best approach for increasing N uptake rates. The management of any new stand can be supported by the substantial body of literature devoted to the management of *E. botryoides* and other eucalyptus species in short rotations.

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