

**Modelling seed germination and  
seedling survival of  
*Eucalyptus delegatensis* R. T. Baker  
to facilitate  
optimal reforestation.**

by

Michael Battaglia

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This thesis contains no material which has been accepted for the award of any other degree or diploma in any tertiary institution and to the best of my knowledge, and belief, this thesis contains no material previously published or written by another person, except when due reference is made in the text of the thesis.

*Michael Gattayr*

## Abstract

Land managers increasingly are being involved in making quantitative evaluation of management options. Forests, however, are complex biological systems and predictions require the synthesis of many processes. Traditional approaches to evaluating options have been to replicate experiments in time and space. Not all questions are amenable to such approaches, and even where they are, inferences may be of only limited application. In an increasingly complex decision making context, land managers will require access to more sophisticated techniques. This thesis illustrates the collection of basic data, its synthesis into a physiological model, and its use as a tool to address a typically complex management question - the time at which *Eucalyptus delegatensis* R.T.Baker seed should be sown in forest regeneration operations. The species is widely exploited for commercial forestry in South-Eastern Australia and its germination physiology is moderately complex, providing an appropriate test for the usefulness of the modelling approach.

The germination response of seedlots from five provenances to temperature, stratification, soil matric potential and interrupted imbibition was examined. The species was found to have a distinct temperature optimum between 15 and 20°C, and a minimum temperature for germination of approximately 2°C. Short periods of exposure to high temperatures did not substantially affect germination performance. Stratification greatly increased the range of temperatures over which a high proportion of the seed germinated. Increases in the rate of germination with stratification are related to accrued thermal time during stratification. Pre-imbibing seeds at water potentials down to -2 MPa increased the rate of germination. However, no advantage was found after pre-imbibing at lesser soil water matric potentials. This increased germination rate was associated with a shortening of the time to commencement of germination and more synchronous germination. Germination rate and germination capacity were impeded by soil matric potentials below -0.01 MPa, and germination was totally inhibited by soil matric potentials below -0.5 MPa. Soil matric potential and temperature interacted in their effects on germination capacity, and seeds germinating at near optimum temperatures were less sensitive to soil moisture stress. Seeds survived dehydration within sixty hours of the commencement of imbibition, but were increasingly affected by dehydration thereafter. The rate of imbibition was influenced by the ambient temperature and solution water potential. At modest levels of water stress imbibition was not impeded and the observed reduction in germination capacity was probably due to the inhibition of

growth related processes. Differences in germination response were detected between the seedlots and these could be related to their geographic origin.

The proportion of variability in seed and germination traits attributable to inter- and intra-site components varied between traits examined. The germination rate of seed was not significantly different between trees within a site, or between trees from different sites. Variation in seed size and the proportion of dormant seed in seed samples was mainly affected by site effects. The sensitivity of seed samples to the water stress levels applied also varied substantially between sites but additionally the seed from the drier site exhibited a highly significant between-tree variability. It was concluded that the proportion of variation in seed and germination characteristics attributable to between-, and to within-site effects, could be partly related to the scale at which selective forces were presumed to operate. Nevertheless, a substantial amount of variation in response existed within the seed collected from the one tree.

The role of age and microtopographical variation in enabling seedlings to withstand frost and drought was explored in glasshouse studies. The frost resistance of *E. delegatensis* was found to vary with seedling age over the first six months of development. Much of this variation was found to be a result of the differing sensitivity of leaves originating from different leaf nodes, although older leaves from the same node may have been more frost resistant than recently expanded leaves. Newly emergent seedlings appeared to be the most susceptible stage of the tree's lifecycle to death by frost.

Small scale variation in soil conditions, at the scale of tens of centimetres, markedly affected the germination and establishment of seeds and seedlings under moisture limiting conditions. Microsites that afforded protection, and probably resulted in increased humidity, caused a marked increase in germination number and rate. The mean survival time was significantly higher on these protected microsites than on less protected microsites, or on microsites that restricted root penetration. The importance of this variability in microtopography was strongly influenced by season and the level of environmental stress, and was diminished as seedlings aged. Due to the different requirements for seed germination and seedling growth, a favourable microsite for germination was not necessarily a favourable site for seedling survival. A comparison of seed and seedling responses to water stress indicated that for *E. delegatensis*, at least, selection due to microsite differences at the time of germination may not affect the developmental characteristics of the seedlings.

At two geographically close sites that differed significantly in climatic profile, seed of *E. delegatensis* and *Eucalyptus amygdalina* Labill., a species that frequently replaces *E. delegatensis* on drier sites, was sown at twelve times of the year. Regular censuses of seedlings were conducted. The pattern of survival of over twenty thousand seedlings, comprising one thousand two hundred identified cohorts was followed. The influences of weather, seed harvesting, site preparation, time of emergence and time of sowing on emergence, growth and survival were examined. By modelling temperature and soil moisture it was found that germination in the field was influenced strongly by ambient temperature and soil moisture and that the commencement of germination flushes in spring and autumn were well correlated to threshold values of soil moisture and air temperature predicted from laboratory studies. A model of seasonal patterns of seedling mortality was developed and concluded to be highly age dependant. Although age dependant mortality rate was relatively constant at a given site between seasons and years, with each season containing its own compliment of hazards, it was necessary to make allowance for stochastic events, such as severe frosts and drought, to satisfactorily model survivorship.

A mathematical model of germination was developed for *E. delegatensis* based on the physiology of underlying processes. The accuracy of this model in predicting the time course of germination under conditions of fluctuating temperature and moisture was examined. This model was used to examine the results from the field trial. In combination with a mortality function derived from field observation, this germination model was used to make recommendations on the optimum times of sowing for the east coast of Tasmania, to explore the importance of 'safe sites' for germination, and to investigate the implications of different seedlot dormancy responses on reproductive success.

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