Growth and survival of rimu seedlings in South Westland forests

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Abstract

The rates of growth and survival of natural seedlings and planted rimu seedlings over 15 to 34 years was measured in Ianthe and Saltwater Forests. Survival of natural seedlings after 15 years was 28% and height growth averaged 4 cm per year. Survival of planted seedlings after 17 years was 85% and growth averaged 16 cm/year over 35 years. It is predicted that around 15% of natural seedlings survive 35 years to reach an average height of 1.4 m.

Introduction

Rimu (*Dacrydium cupressinum* Lamb.) is New Zealand's most common podocarp that once dominated the central lowland forests on the West Coast. After a century of exploitation most remaining areas of lowland forests are now protected in the South Westland World Heritage Area. However two areas, Saltwater and Okarito Forests, are legally gazetted for the sustainable management of rimu and other native timbers.

Sustainable management of rimu in these forests involves helicopter harvesting of single trees or small groups of trees over an expected natural rotation of 500 years (James, 1992). Determining an appropriate sustainable yield requires the use of predictive models of forest growth (Howard and Valerio, 1992). The number of seedlings present in the forest, and their growth and survival rates, determines the numbers of saplings that will be available over the next century to replace the trees harvested or lost through natural mortality.

Rimu seedlings have height growth varying from 0.81 cm per year under natural forest conditions (June 1982) to 15 - 30 cm per year for seedlings growing without overhead cover (Foweraker and Hutchinson, 1934). Both studies covered less than a four-year period. Both June (1982) and Wardle (1963) found seedlings took more than 30 years to reach 1m.

This paper updates earlier studies (James and Franklin, 1978, James, 1984) which followed the progress of tagged natural and planted rimu seedlings over a 10 and 17 year period, respectively. The growth of natural seedlings over 15 years and planted seedlings over 15 to 34 years can now be quantified.

Methods

1 Natural Seedlings

The James and Franklin (1978) trial is located within a 2 ha area of lowland rimu forest in Ianthe Forest (Lat. 43°,01',29.0S, Long. 170°,38',36.7E). The site is a gently-sloping terrace at 50 m altitude and 7 km from the coast. The subsoil consists of a mix of greywacke, schist, and granite stones, sands and silts, deposited during the last ice age. The soils are saturated humic silt loams with low pH and nutrient status.

Logging in 1969 using a rubber-tyred log skidder removed 32% of the merchantable volume (357 m^3/ha). In 1970, 35 quadrats of 0.28 m^2 were established under a variety of light and soil conditions. Rimu seedlings were permanently marked with small numbered metal tags and measured annually for height. An earlier report (James and Franklin, 1978) presented data for the years 1970 - 1975. The trial was partly destroyed by logging in 1994 but survivors were reassessed in 1995 after a gap of 10 years.

2 Planted Seedlings

(a) Saltwater: In this trial seedlings raised from seed collected in Saltwater Forest were planted in 1978 on a gently-sloping terrace with physical characteristics similar to those at the Ianthe site (Lat. 43°,08',10.2S, Long. 170°,25',21.5E). The forest was selectively logged in 1977 by high-lead cable logging with 25% of the merchantable volume harvested.

Groups of 10 tagged seedlings were planted along the logging lanes. The lanes were 400 m long and varied from 3 to 20 m wide and converged together at a central landing. The forest between the lanes was relatively undisturbed with a canopy height of 30 - 40 m.

The planting site of each seedling was recorded in 1978 based on four degrees of soil disturbance (undisturbed, organic, mixed A and B horizon, or B Horizon) and four classes of micro-site (flat, depression, mound, or near a stump). Remeasurements of height and diameter at 1.4 m above ground (dbh) were made in 1982, 1985, and 1995, and the light conditions estimated as either open or shaded.

(b) Ianthe and Wanganui: In 1961 seedlings raised from seed collected at Pureora, West Taupo, and wildings collected from Wanganui Forest, were planted in clearfelled areas of Ianthe (Lat. 42°,02',13.8S, Long. 170°,38',15.2E) and Wanganui Forests (Lat. 43°,06',22.6S, Long. 170°,28',17.4E). Both sites contain a mixture of terrace, similar to the Ianthe site, and small terminal moraine where the soils are gley podsols.

The seedlings were planted in groups (12 and 50 seedlings) in conditions varying from full exposure to moderate shade from angiosperms, principally remnant sub-canopy kamahi (*Weinmannia racemosa*) and *Quintinia acutifolia*, and a few planted *Pinus contorta* and *Eucalyptus delegatensis*.

The seedlings that were permanently tagged in 1963 were remeasured in 1984 (James 1984). Other planted seedlings that were not tagged in 1963 were also measured for height and diameter (dbh), and permanently tagged in 1979. All seedlings were measured again in 1984 and 1995.

Results

1 Natural Seedlings

The data showed high recruitment rates on the disturbed ground for the initial two years following strong mast years recorded for rimu in 1969 and 1970 (James and Franklin, 1978). Few seedlings establishing in subsequent years survived under the shade of fern competition. The mortality rate of seedlings that established soon after disturbance was initially high but slowed after 10 years. The cumulative survival rate after 15 years was 28.8% and after 25 years was 21% (Figure 1).

The average annual height growth rate over 15 years for the Ianthe seedlings was consistent at 4 cm/year. At 15 years the average seedling height was 0.58 ± std err. of 0.04 m (Figure 2). Unfortunately, it was not possible to obtain a valid height estimate at 25 years because seedlings remaining after the 1994 logging were predominantly the subdominant specimens of those

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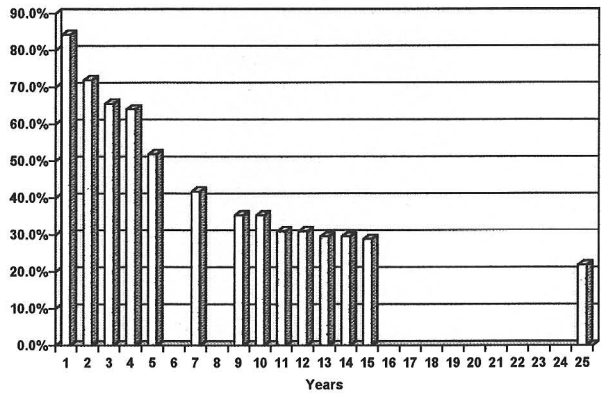
present in 1985. There was also insufficient data to measure the influence of light and ground conditions.

Figure 1 Cumulative Survivorship of Natural Rimu Seedlings



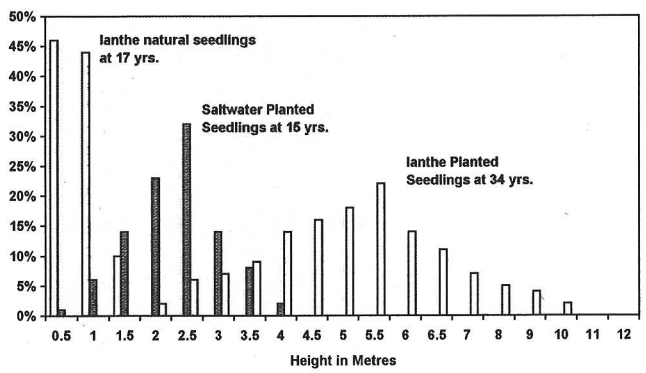
2 Planted Seedlings

Seventeen years after planting, 85% of seedlings in Saltwater Forest still survived. They averaged 2.1 ± 0.05 m height (Figure 2) and 1.2 ± 0.06 cm diameter (dbh). The average height growth rate for the period was 12.3 cm/year. Statistical tests revealed no significant differences in height or diameter resulting from microsite or soil differences. Seedlings under moderate shade were significantly shorter ($\bar{x}$ = 1.8 ± 0.12 m) and thinner ($\bar{x}$=1.0 ± 0.14 cm) than those always under open light conditions (P<0.001, P<0.002, respectively).

After 34 years the seedlings planted in Ianthe and Wanganui Forests (Figure 2) averaged 5.5 ± 0.09 m height (an average growth rate of 16.1 cm/year) and 5.5 ± 0.16 cm diameter at 1.4 m above ground (dbh). There was no difference in height growth between forests or stock provenance, but the Pureora seedlings had larger diameters (6.18 ± 0.29 cm) than the local stock (5.25 ± 0.38 cm) (normal variable = 1.92, p<0.1), continuing a trend found at age 17 years (James, 1984).

An interesting difference was found in the reaction of seedlings to fertiliser application made at the time of planting. Those seedlings that received fertiliser had similar heights but significantly smaller diameters at age 34 years (Fert. 4.8 ± 0.30 cm, No Fert. 6.8 ± 0.36 cm, P<.001). Unfortunately, it was not possible to assess the effect of fertiliser on survival, as too many seedling tags were lost over the 34 years.

Figure 2 Height frequency distribution for Natural and Planted Rimu Seedlings.



Rimu seedlings at Ianthe Forest at 17 and 34 years after planting.

Discussion and conclusions

The natural seedlings in the Ianthe Trial established on a variety of sites after selection logging. Some sites were open with exposed subsoil similar to the conditions on the uproots of windfallen trees where rimu seedlings often establish naturally. Other sites had little soil disturbance but more open light conditions because of logging.

Although no measurements were made, it is reasonable to assume that light conditions were initially more open compared with sites opened by natural wind falls or where trees are harvested in a sustainably-managed forest. The selection logging removed approximately 25% of the merchantable timber volume, whereas with modern sustainable logging less than 5% of the merchantable timber is taken on a single tree-basis. Natural openings in these forests typically involve the wind fall of one to three trees.

The trial shows the stages seedlings must pass through to become saplings. In the first three years of life a seedling has to establish amongst the competition of existing tree roots and the dense ground cover of ferns and bryophytes typical of lowland rimu forest. Its chance of success is greatest where there is a brief absence of competition on exposed mineral soil caused by uproots or on the rotting trunk above the root competition and dense fern cover. Other seedlings are successful at times where light levels reaching the forest floor may increase following a synchronous decline of the mature rimu trees and the associated hardwood trees.

For the next 25 years or so the seedling must outgrow fern species which grow to around one metre high and smother nearly all seedlings that germinate later than the first three years following disturbance. The Ianthe data show that the rate of seedling

loss declines after 10 years. From then on losses result from physical damage through fallen tree branches, especially if the forest is undergoing a general decline at the time. The seedlings on the wet sites face intense competition from other rimu and silver pine seedlings.

Planted rimu seedlings have a marked advantage in that they are initially equivalent in height to 10-year-old natural seedlings and then gain a respite from neighbouring root competition through the act of planting. These advantages allow a high proportion of seedlings to outgrow the competing vegetation and consequently survival rates are quite high at 85% after 17 years.

This soil cultivation during planting is probably the reason why no response could be attributed to soil disturbance from logging in the Saltwater trial. Even seedlings placed into undisturbed forest gain the effect of disturbance as a 20 x 20 x 20 cm sod of soil is inverted and mixed during planting.

The light response at Saltwater needs to be put into perspective. The shade categories used related only to competing ground vegetation, and seedlings classed as unshaded seedlings had an estimated 30% overhead shade because of the high forest alongside the haul lanes. Many of the planted seedlings at Ianthe and Wanganui are out in the open, as the original forest was clearcut. This may account for their slightly better growth performance than the Saltwater seedlings.

This data provides useful information needed for improved yield prediction models. The recorded growth estimate over 25 years of 4 cm/year and a survival of 22% provides a "rule of thumb" for natural rimu seedlings in lowland forest conditions. This suggests that it will take around 35 years for a rimu seedling to grow into sapling size (above 1.4 m height). By that time only 15% of seedlings will survive if the present trend continues. One can therefore forecast that there should be a minimum of 233 seedlings/ha present in the forest continuously to ensure that at least one seedling/ha/year becomes a sapling.

By contrast, planted rimu seedlings show considerably better growth and survival over the first 35 years. The Ianthe and Wanganui plantings are three times the height and many times the diameter of natural seedlings. Only 20 planted seedlings are needed to be present in the forest continuously to ensure one seedling/ha/year becomes a sapling.

Nonetheless, planting is used sparingly in Saltwater and Okarito Forests because the goals of sustainable management are not to alter the status or natural ecological processes of rimu in these lowland forests. No planting is done where natural seedlings are present. Elsewhere, three to five seedlings are placed in suitable sites in the vicinity of felled trees. No fertiliser is applied. The results observed at Ianthe support practical experience that chemical fertiliser application might be harmful to rimu seedlings in a natural forest environment.

Acknowledgements

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Pine pitch canker – the threat to New Zealand

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Abstract

Pine pitch canker caused by the fungus Fusarium subglutinans f. sp. pini is a serious disease of many species of pine and has severely affected Pinus radiata in California since its discovery in 1986. The fungus, together with its bark beetle vectors, causes dieback, reduced growth, reduced timber quality due to stem deformation, reduced seed crops and tree mortality. A number of potential pathways for the entry of the pitch canker fungus into New Zealand are recognised. These are live plant material, Pinus seed, plant debris associated with used logging machinery and vehicles, timber used as wood packaging and insects known to transmit the disease in North America. There would be no climatic barriers to the fungus or to introduced vectors if they escaped the quarantine net. If the fungus were to become established in New Zealand its spread would probably be limited by the paucity of suitable resident insect vectors. Hylastes ater, Hylurgus ligniperda and Pineus laevis would be the most likely vectors of the disease. Airborne inoculum appears to play no part in disease spread in California but it is a major source of infection of Pinus species in the south-eastern United States. Its potential importance in New Zealand cannot be predicted.

Introduction

Pine pitch canker caused by the fungus *Fusarium subglutinans* f. sp. *pini* is a serious disease of many species of pine. It was first described (Hepting and Roth, 1946) on *Pinus virginiana, P. echinata* and *P. rigida* in North Carolina in the United States of America. In the following 15 years the known host range expanded as the disease was discovered in more of the south-eastern states of the USA, and considerable damage to pines was periodically reported, particularly in plantations and seed orchards of *P. elliottii* and *P. taeda* (Blakeslee and Oak, 1979; Kuhlman *et al.* 1982; Barrows-Broaddus and Dwinell, 1983). The disease was not seen on *Pinus radiata* until 1986 when the first record was noted in Santa Cruz County, California (McCain *et al.* 1987). Since then the disease has spread and become prevalent on *P. radiata* in most coastal counties of California (Correll *et al.* 1991; Storer *et al.* 1994; 1995).

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