



CHAPTER 5 - SEED SOURCE and BREEDING

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The natural distribution of redwood in both latitude and altitude offers the opportunity to select seed sources that could do well in New Zealand but very little formal breeding has been undertaken in New Zealand to date. There has been more emphasis on using existing collections as a starting point rather than developing a broad genetic base for long-term tree improvement programmes. However, the ability to grow redwood as cuttings allows growers to reproduce elite material. This provides opportunities for selection and clonal propagation of elite material. Those planting forests should ensure they have the best genetic material available that has a proven track record in New Zealand.

Provenance Trial

The first full test of redwood seedlots was a trial established in Rotoehu Forest in 1981. This compared nine seedlots - eight from the natural range and one from the Redwood Grove at Rotorua. The poorest performer was the Redwood Grove source.

Kuser clonal provenance trials in New Zealand

Background

These trials derive their name from Professor John Kuser, a long-time redwood scholar of Rutgers University, who in 1983 initiated a collection of seedlings from 98 different stands in locations throughout the natural range of redwood to evaluate provenance variation in this species.

Redwood provenance trial

The 1981 Rotoehu trial was assessed for diameter and stem form in January 2001.

There were noticeable differences in tree size across the site with trees on the lower slopes being larger than those on the higher ground. Stem diameter of the individual trees was extremely variable and this tended to obscure any differences between seedlots.

However the measurements suggested that seedlots from the Korbels area of California performed well for growth and that the Whakarewarewa Long Mile seedlot was the slowest growing. If past damage caused by possums is discounted then most seedlots had acceptable stem form.

The trial was planted at 950 trees per hectare and had an effective stocking rate of around 660 trees per hectare. The overall average diameter on this site at age 20 years from planting was 320 mm compared with 280 mm for the Whakarewarewa seedlot. A few of the largest trees in the trial were over 600 mm in diameter.

Source: Vincent 2001

The intention was to compare the impact of various environmental conditions on the relative performance of material from throughout the natural range of redwood at a number of sites. This would provide information as to the best part of the natural range for selecting plant material.

Note that this was not a provenance trial in the traditional sense, in that the collection focused on just two random seedlings from each part of the range.

The reason for using vegetative propagation rather than seed was the difficulty of collecting seed from all populations because redwood has relatively few good seed crop years in California. The collection comprised of 198 genotypes, mostly young seedlings but occasionally cuttings from sprouts or older seedlings. During 1984 Dr Kuser delivered all his plants to the Simpson Timber Company nursery at Korbel for rooting. The Korbel stool beds were replicated at the University of California (Berkeley) Russell Reservation research facility, and a Californian Division of Forestry site at Jackson State Forest. The latter site was not maintained and only the two sites now exist in California. Replicate stool beds now exist in France and Spain.

New Zealand Trials

Recent redwood trials in New Zealand began back in 1990. Bill Libby was working at the then Fletcher Challenge facility at Te Teko in the Bay of Plenty, and encouraged the importation and evaluation of some of the Kuser collection. Fletcher Challenge Forests established a small number of tissue-cultured plants in a few trials in the late 1990s. A number of the clones from the above importations have been used in two series of clonal trials established by the NZ Farm Forestry Association on sites provided by members throughout the country. These trials provide an opportunity to compare sites throughout New Zealand.

A number of other clones were imported at a later date. Wade Cornell of Diversified Forests imported more clones from the Russell Reservation site in late 2000 along with other selections from redwood's natural range.

Sequoia Action Group research packs (2002)

During the winter of 2002 the Sequoia Action Group of the New Zealand Farm Forestry

Association established small trial plantings of 64 trees (up to eight representatives of eight clones) on 53 sites throughout the country (see Chapter 3).

Kuser Trial Establishment (2003-2006)

During 2001, the Soper-Wheeler Company with their then New Zealand subsidiary "JPS", now The New Zealand Redwood Company (NZRC), imported to New Zealand 182 clones of the original 198 in the Kuser collection. Jim Rydelius, the Manager of NZRC at the time, was involved in the initial selection and propagation of the Kuser Clones and in the Simpson Redwood breeding programme undertaken during his time with the Simpson Timber Company at Korbel, California.

Stool beds were established at the Southern Woods Nursery in Canterbury. The Kuser clones were multiplied by cuttings and in 2003; 174 clones were established in clonal trials at three New Zealand sites. A further eight trials were established in 2004-2006 with 136-160 clones on each site. The objectives of these trials were to establish long term field tests that would quantify variation in growth, form and wood properties. To help to achieve this, trial sites have been distributed throughout New Zealand so that site variability in terms of altitude, latitude, soils type and climate will allow the evaluation of the clones for site x genotype interaction. Sites range from 40 m above sea level to 595 m. Each trial site has been planted with 8 replicates of each clone set out in six blocks of 36 trees at 3 m x 3 m spacing. Seedlings of a single seedlot are included as a control. The trial design, establishment and monitoring has been coordinated by Scion-Genetics and NZ Forestry Ltd.

Giant sequoia trials

In the early 1970s, Lauren Fins, as a PhD student of Bill Libby's at University of California, Berkeley, undertook a seed collection of up to 50 trees in each of 34 of the scattered natural stands. Most of the seed was extracted from cones harvested by squirrels. The study was quite extensive, looking for differences

in seed and isozymes at the individual-tree and provenance levels. When the study was completed much seed had been used, but there was enough to make up 16 seedlots comprising seed from at least five trees per grove (or provenance), which was sent to New Zealand.

This seed was sown in a glasshouse at Rangiora nursery in December 1975 and seedlings were pricked out into PB3 containers. The seedlings were planted out on three sites, Hanmer (Canterbury), Craigieburn, (Canterbury), and Beaumont, (Otago), in winter 1977 and cuttings were planted on a further two sites in 1978, Rai Valley (Nelson), and Kakahu, (South Canterbury). A further planting of 112 unidentified cuttings was planted out adjacent to the seedling trial at Beaumont, the best planting site chosen.

The trial stocking is unusual, with the giant sequoia planted at 6 m x 5 m, then interplanted with larch to provide a spacing for the mixed stand of 3 m x 2.5 m. The initial stand composition featured larch (*Larix decidua*), at 1,000 stems/ha and giant sequoia at 333 stems/ha. The nurse species planted at Craigieburn was birch (*Betula verrucosa*), rather than larch.

The giant sequoia were fertilised and released with Caragard, to control weeds. The spray damaged a number of trees at Kakahu. Half of the larch were removed at Hanmer and Beaumont in 1986. Early growth was painfully slow, in spite of the fertilising and releasing from weeds.

The Rai Valley site was assessed in 1981, when the cuttings were then aged three years. All other sites were assessed in 1983, when the seedlings at Hanmer, Beaumont and Craigieburn were six years old and the cuttings at Kakahu were five years old.

Best provenances reached only two metres in height at the best site, Beaumont, six years after planting. Average height at the other sites was around one metre, although survival at all sites planted with seedlings was high at 90-100%. Survival of cuttings planted at Beaumont was 98%, while Kakahu ranged from 29 to 92% and Rai Valley from 50 to 100%. Possible explanations for the lower

survivals of cuttings are that Kakahu and Rai Valley were harder sites and the spray damage at Kakahu.

The Beaumont trial was measured in 1987, 1989 and 2002. The rate of height growth improved considerably at Beaumont after age 6, with the trees trebling their height to around six metres by age 12. Height growth for each seedlot was graphed against time for the Beaumont data (Figure 9) and the slope of the line becomes much steeper after age six. One seedlot shows slightly faster height growth between ages 10 and 12 but for most the rate of growth is constant from age 6 to age 12.

The 1978-planted cuttings appeared to be growing at least as well as the seedlings at this site, with the 30 cm difference in height in 1983 roughly equal to one year of early height growth for the seedlings, planted a year earlier. Form assessment showed that malformation is negligible at this site, with three trees being forked and four trees possessing ramicorn branches. The largest tree at age 12 was 9.5 m in height and 330 mm in diameter and had grown 2.7 m in height in two years.

The New Zealand seedlot from Raincliff was notable for its poor performance relative to the Californian seedlots. This is very different from the usual story in New Zealand conifer plantations, in which the neighbourhood inbreeding of natural stands is typically broken down, and some natural and silvicultural selection can occur for adaptation to local conditions, to produce more vigorous seed than natural stands in the country of origin. The poor performance is most likely due to deleterious effects of inbreeding, and caution must always be taken when collecting from sources of unknown origin. At age 25 the best seedlot was over 17 m tall and the poorest 13.5 m tall. Most of the seedlots had similar heights to each other at age 25 years, but progeny from the New Zealand Raincliff stand was significantly shorter.

The best tree from each seedlot had scion material taken in 1989 and the resultant grafts are growing at Proseed's Amberley Seed Orchard since 1990.

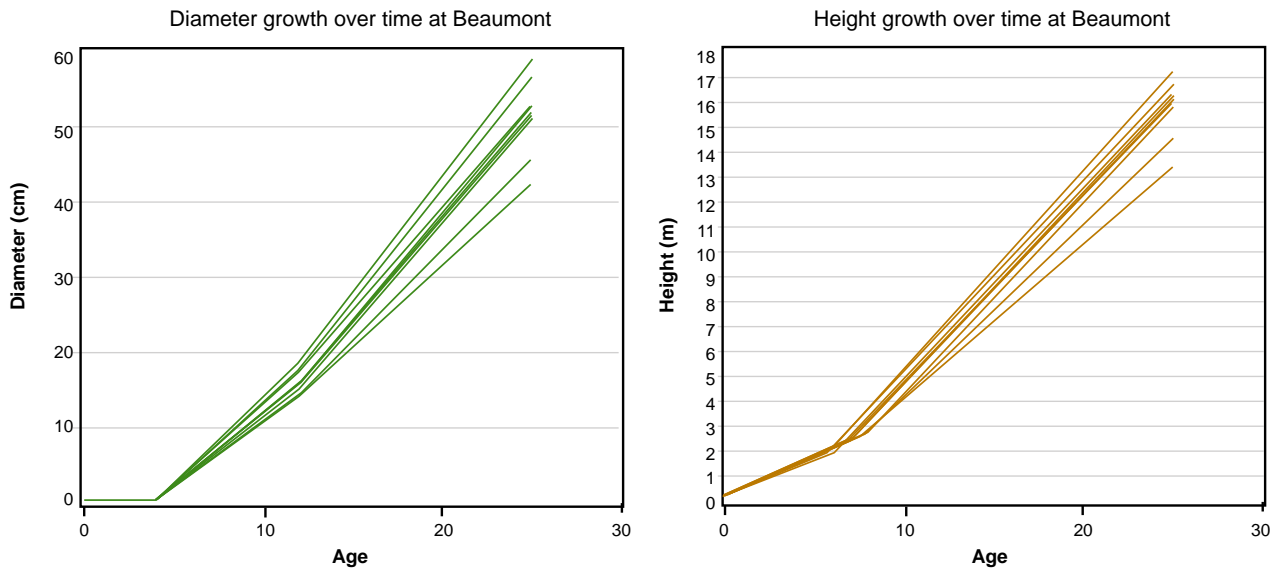


Figure 9: Seedlot mean height and diameter at Beaumont, 1983, 1987, 1989 and 2002



Figure 10: Beaumont Trial at age 27 years

The trial at Hanmer was assessed in 2002, when tree heights had improved from an average of 1.4 metres at age six years to around 12 m at age 25. The largest tree was 18 m tall and 700 mm in diameter. Provenance means from the 2002 assessment are shown in Figure 12. An average-sized tree of 300 mm diameter and 14.6 m in height from the North Calaveras provenance is shown in the photo below.



Figure 11: Giant sequoia at Hanmer, aged 25 years

The Hanmer trial had more seedlots tested than Beaumont. The best-performing seedlot at Beaumont was not the best at Hanmer, but progeny from the Raincliff stand averaged the poorest on both sites. Inbreeding depression is a very plausible explanation for the poor performance of the Raincliff seedlot. The seedlot register reveals that there were only four trees in the parent “stand”. All four trees could well have come from a single seed parent, so the seed would result from brother/sister mating. Conceivably, all four trees could have grown from cuttings taken

from a single tree, so that all seed would be selfed, therefore highly inbred. Whatever the case, no further seed should be collected from this stand. Regrettably, there have been a number of seed collections from Raincliff over the years, and this may explain some of the failures of this species in New Zealand.

At Hanmer, only two trees had kinked stems, which appeared to have been caused by weed competition. Only one tree was forked. Branching was fine, with no branches larger than 2 cm. The 25-year-old trees could be pruned with light secateurs.

Once giant sequoias are fully established, from a slow start their growth rate improves considerably. Height growth in excess of one metre per year can be attained, along with diameter growth of over 25 mm per year on trees over 10 years old, on good sites. The Beaumont site, benefiting from extra water nutrients by being at the foot of a slope, with a deep river terrace soil, is evidently an ideal site for this species.

Vegetative propagation of giant sequoia

Difficulties in obtaining seed, poor seed germination, and some high levels of inbreeding, make vegetative propagation of known superior genetic sources an attractive option for the species. Rangiora nurserymen found the species easy to propagate from 18-month-old seedlings and it is a species which can produce coppice growth when felled. Ideally, plants should be grown from outcrossed seed produced in the Amberley orchard and multiplied vegetatively, or cuttings harvested from the coppice of superior mature trees. Care must be taken to avoid maturation of select material.

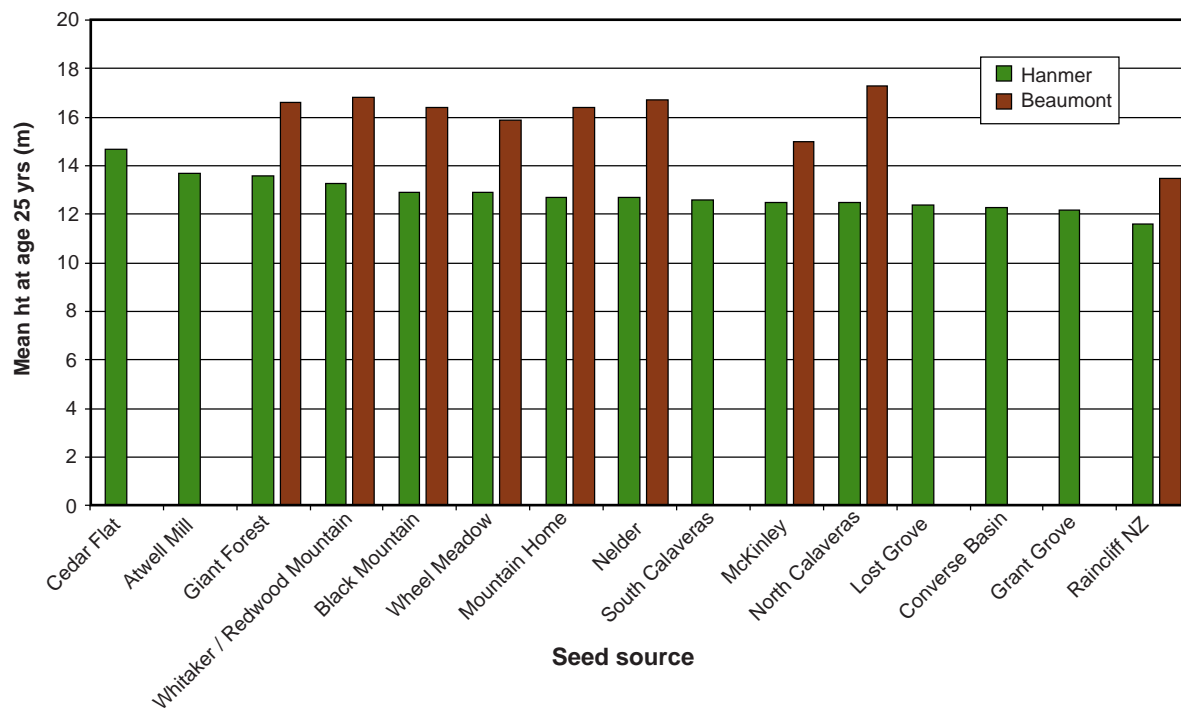


Figure 12: Mean provenance height for Hanmer and Beaumont sites at age 25 years



Key Points

- The Kuser collection, while representing a geographic spread, is not a true provenance-wide selection of seed sources.
- The Kuser collection has provided material for a range of trials on 64 sites throughout New Zealand from 2002-2006
- Limited redwood provenance evaluation has been carried out on one site, established in 1981.
- Giant sequoia provenance trials were established on five sites in 1977-1978.
- Progeny from the Long Mile Grove redwoods and Raincliff giant sequoia trees perform poorly compared with other provenance seedlots.
- Future selections of redwood and giant sequoia should be based on a wide genetic base and with regard to wood properties.
- There has been no breeding for redwood in New Zealand, but there is potential for significant improvement of redwood performance for both growth and wood properties.

Suggested reading:

Fins and Libby 1982

Knowles and Miller 1993

Libby 1993

Saunders and McConnochie 2007

Vincent 2001

