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Future Forest Erosion Species Trial – Progress Report

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EXECUTIVE SUMMARY

Objectives

- Determine the performance of nine exotic tree species selected by Scion for their potential to be useful for erosion control, with a focus on below-ground root growth.

Methods

- A randomised block treatment with three replicates of each species for each of 3 years was established in July 2010 near Gisborne.
- Plants were extracted annually and above- and below-ground parameters were assessed and related to both root collar diameter and diameter at breast height (dbh).

Results

- Minor losses due to browsing and/or water-logging of Tasmanian blackwood, redwood and eucalyptus occurred soon after planting, but these losses were not significant enough to compromise the objectives of the trial.
- Plants delivered from the Scion nursery showed significant variation between species, and this carried through to Year 1. This variation in plant size reflects standard commercial practice in terms of supply of plant materials.
- At age 1, the best performing species across a range of parameters was alder, followed by Tasmanian blackwood, and cherry.

Conclusions

- Differences between species for many growth parameters, including root metrics are unlikely to emerge until the plants are considerably older – at least 4 years old.
- At this stage of the trial, recommending which species might be the best performer or the most effective in terms of a future erosion forest species is not possible.

INTRODUCTION

Future Forests Research Ltd and Scion, within MSI research programme ‘Forest and Environment’ (C04X0806), subcontracted Landcare Research to establish a trial of exotic species in 2010. The aim of the trial was to use annual measures of below-ground growth performance to assess the suitability of these species for erosion control in North Island hill country.

BACKGROUND

The sustainability of the New Zealand forest industry and its resilience in the face of climate change are key drivers for the shape of future forests. In future, there is likely to be an increasing focus on non-wood benefits and values or services from forests be they plantations or indigenous forests (O’Loughlin 2005). One of those services relates to the use of forests for controlling or reducing erosion.

There is well-established literature on the benefits of trees, shrubs and grasses for reinforcing soils to control or reduce both surficial and mass-movement erosion (e.g. Phillips et al. 1990; Marden & Rowan 1993; Phillips & Marden 2005; Stokes et al. 2008).

While the collection of below-ground information is difficult, time-consuming, and expensive, such data are necessary in order to develop quantitative models that incorporate root information for use in predicting the likely effects of vegetation on slope stability (Schwarz et al. 2010; Phillips et al. 2011) and hence the effectiveness of revegetation policies.

We focused on the root development in a field plot trial established near Gisborne of young exotic species considered potential candidates for future ‘erosion forests’.

METHODS

The Gisborne field trial site is located on a low-lying, even-surfaced alluvial terrace adjacent to the Taraheru River, in Gisborne City. The soil is free-draining, Te Hapara Typic Sandy Brown Soil (Hewitt 1998) and requires irrigation in summer. The site (50 m by 20 m) was tilled before planting. The current trial was established on the same site as a previous plant growth performance trial, to allow valid comparisons between native and exotic species.

In the trial, a randomised block treatment with three replicates of each species for each of 3 years was established in July 2010. Species trialled are listed in Table 1 and included:

- redwood (*Sequoia sempervirens*),
- oak (*Quercus robur*),
- a eucalypt species (*Eucalyptus fastigata*),
- Douglas-fir (*Pseudotsuga menziesii*),
- cherry (*Prunus serrulatus*),
- Tasmanian blackwood (*Acacia melanoxylon*),
- red alder (*Alnus rubra*),
- cypress (*Cupressus lusitanica*), and
- radiata pine (*Pinus radiata*).

Table 1 Seed sources and nursery treatment

Species	Source and Treatment
Quercus robur	Seedlings sourced from a local tree where seed had fallen and germinated in leaf litter/bark garden. 2009 germination.
Eucalyptus fastigata	Direct open-ground sown into commercial nursery bed, October, 2009.
Pseudotsuga menziesii	Direct open-ground sown into commercial nursery bed, October 2009.
Sequoia sempervirens	Direct open-ground sown into commercial nursery bed, October 2009.
Prunus serrulatus	Transplanted from under a local tree where the seed had fallen and germinated in the leaf litter. 2009 germination.
Acacia melanoxylon	Direct open-ground sown into commercial nursery bed, October 2009.
Alnus rubra	Direct open-ground sown into commercial nursery bed, October 2009.
Cupressus lusitanica	Direct open-ground sown into commercial nursery bed, October 2009.
Pinus radiata	GF 19 improved seed. Direct open-ground sown into commercial nursery bed, October 2009.

Seedlings were supplied by Scion's Nursery in Rotorua (Figure 1). As part of commercial nursery practice, the roots were conditioned/undercut. Plant spacing was 2.5 m. To ensure the survival of 1-year-old seedlings, weed mat was laid to reduce competition from weeds, trickle irrigation was installed, and wire cages were placed over plants to limit browsing damage by hares and pūkeko.

Figure 1 Seedlings at planting stage July 2010: ***Eucalyptus fastigata*** **and** ***Acacia melanoxylon***.

Root system extraction and measurement methods followed well-established procedures (Watson et al. 1999; Marden et al. 2005; Czernin & Phillips 2006). Root systems were extracted using an air spade (an ultrasonic high pressure device to remove soil from around the roots) and/or by hand.

Once removed from the ground, the plants were destructively sampled to determine a range of parameters, all of which are related to root collar diameter (ground line diameter) and diameter at breast height (1.35 m; dbh) (where plants are large enough). Ten sample trees for each species were also destructively sampled at the time of planting (Year 0). Components were oven-dried and biomass is given as dry weights (grams).

Various parameters can be used to assess the performance of a species in terms of its erosion-control effectiveness (Phillips et al. 2000; Stokes et al. 2009). Above-ground growth parameters measured included height, canopy spread, root collar diameter and diameter at breast height (dbh) (where applicable). Below-ground growth measurements included maximum root depth and lateral root spread. The latter, together with canopy spread, was taken as the average of the maximum diameters measured in two directions. The root system of each plant was photographed before being partitioned into its biomass components.

Above-ground biomass was measured by separating the foliage, branches and stem. Below-ground components were partitioned into root bole, tap, lateral, and sinker roots. Roots were further partitioned into diameter size-classes (<1 mm (fibrous), 1–2, 2–5, 5–10 and 10–20 mm) (Watson & O'Loughlin 1990), and the total length of roots in each diameter size-class (excluding fibrous roots) was measured.

Extractions were made in July 2011 after one year in the ground for three of each species according to the trial design. Further extractions are scheduled for July 2012 and July 2013.

RESULTS

There were minor losses of Tasmanian blackwood, redwood and eucalyptus soon after planting due, we suspect, to browsing by animals (rabbits/pukekos) or water-logging of the sites. Douglas-fir showed initial signs of stress due to the post-planting ‘ wet period’ but losses were not significant enough to compromise the objectives of the trial.

Examination of the data indicates:

1. Significant differences existed between species for most parameters at the time of planting and this carried through to Year 1.
2. At age 1, the best performing species across a range of parameters was alder, followed by Tasmanian blackwood, cherry, and *Cupressus lusitanica* (Table 2, Figures 2–6).
3. Total root length (roots >1 mm) from 1-year-old alder ranged from 60 to 190 m (Figure 4).
4. Root depth was highly variable between species and between the two ages of plants (Figure 3).
5. Mean root spread for alder ranged from 1 to 3.5 m (Figures 2 & 9).
6. Biomass of 1-year-old alder reached approximately 1 kg above- and 0.7 kg below-ground (including root bole or stump) (Figure 8).

Table 2 Example data for alder and cherry

Parameter	**Alder**		**Cherry**	
	0 year	**1 year**	**0 year**	**1 year**
Number of trees sampled	10	3	10	3
Tree height (m)	0.83	2.86	0.79	1.51
Canopy spread (m)	0.11	0.97	0.13	0.55
DBH (mm)	N/A	20	N/A	8
Root collar diameter (mm)	13	49	9	27
Maximum root spread diameter (not radius) (m)	0.39	2.60	0.22	1.69
Maximum root depth (m)	0.18	0.28	0.17	0.21
Total above-ground biomass (g)	18	996	11	232
Total below-ground biomass including stump/root bole (g)	20	731	11	197
Total root length > 1 mm (m)	4.12	140.08	1.63	29.63

N/A = not assessed.

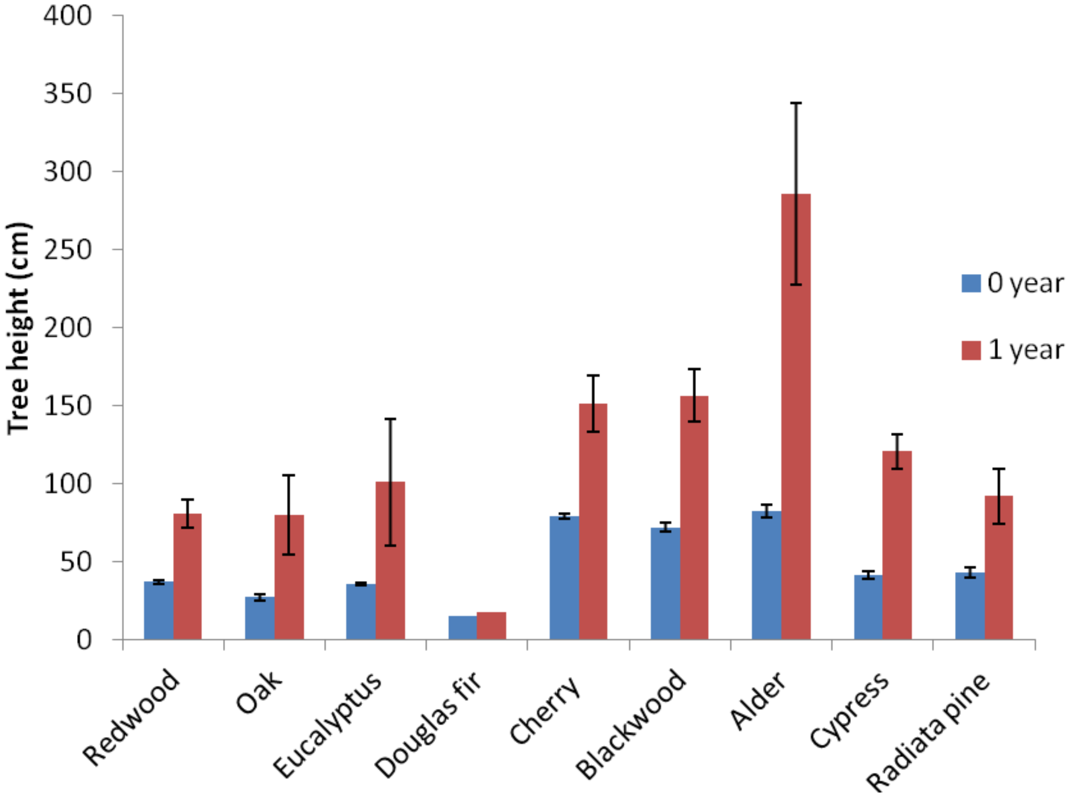

Figure 2 Mean tree height for each trial species at planting and 1 year. Vertical bars are one standard error of the mean.

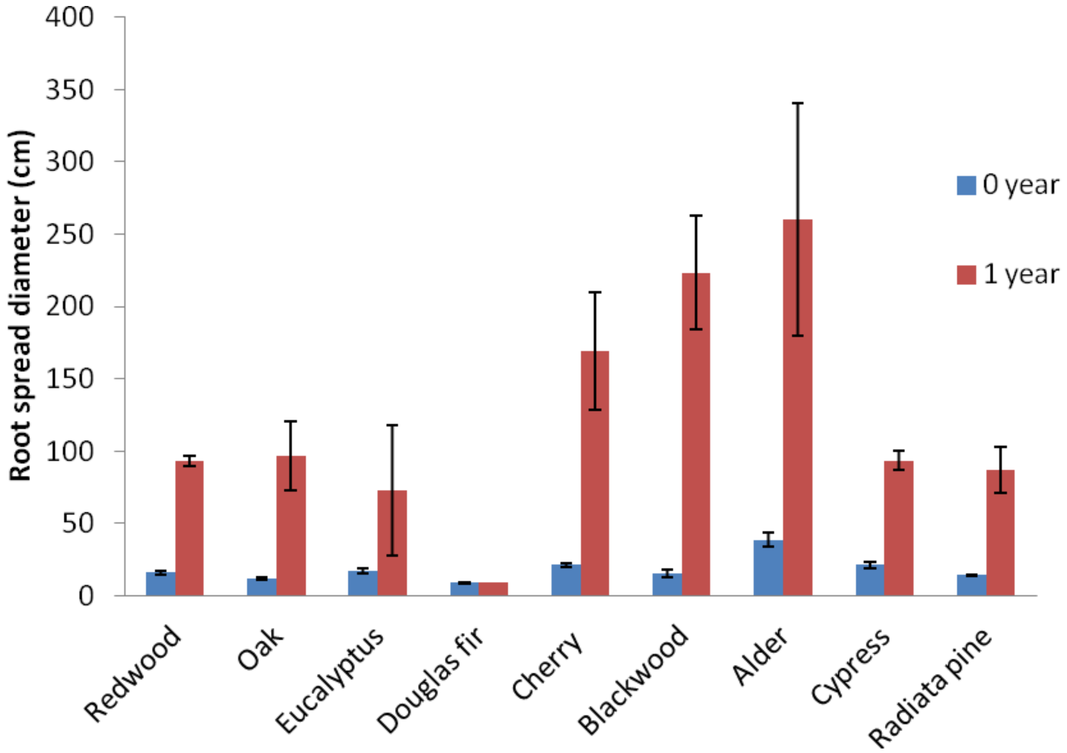

Figure 3 Mean maximum root spread for each trial species at planting and 1 year.

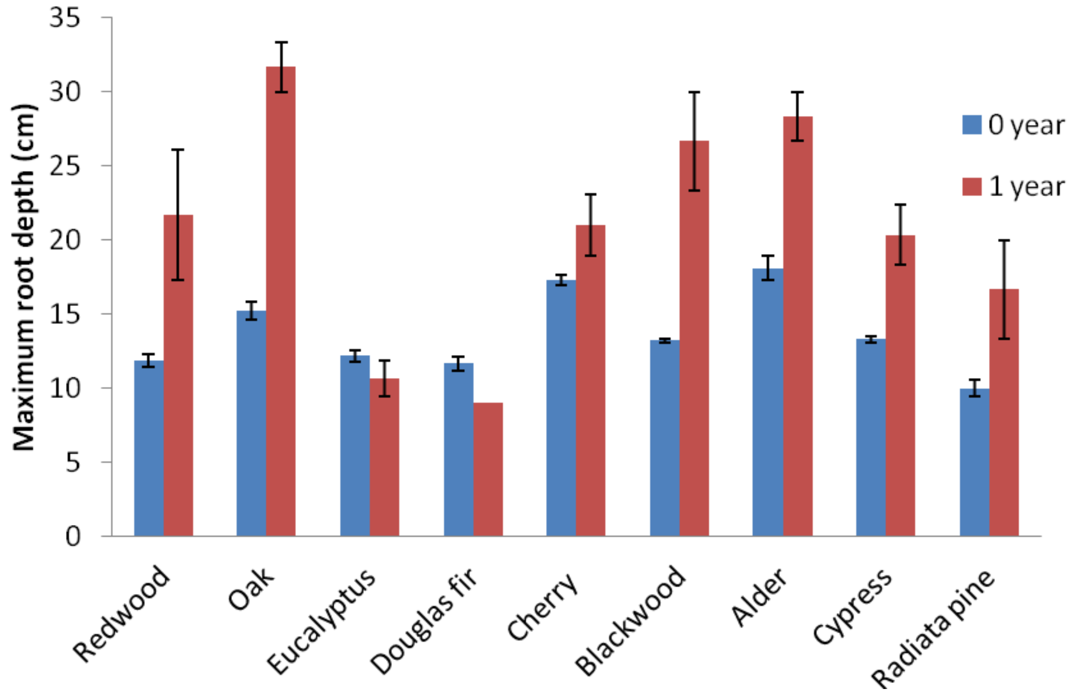

Figure 4 **Mean maximum root depth for each trial species at planting and 1 year.**

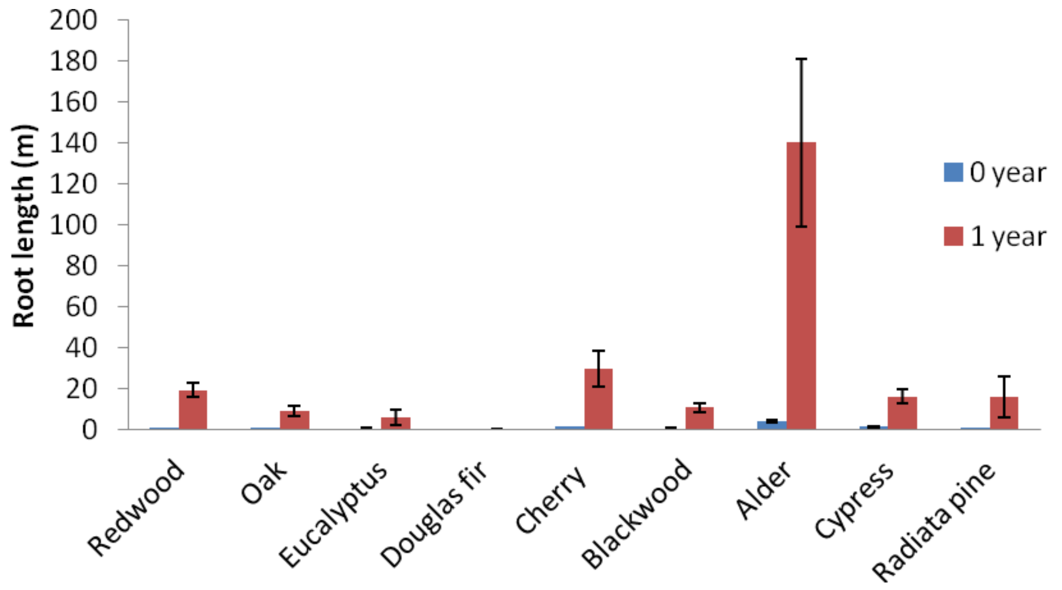

Figure 5 Mean total root (>1 mm in diameter) length for each trial species at planting and 1 year.

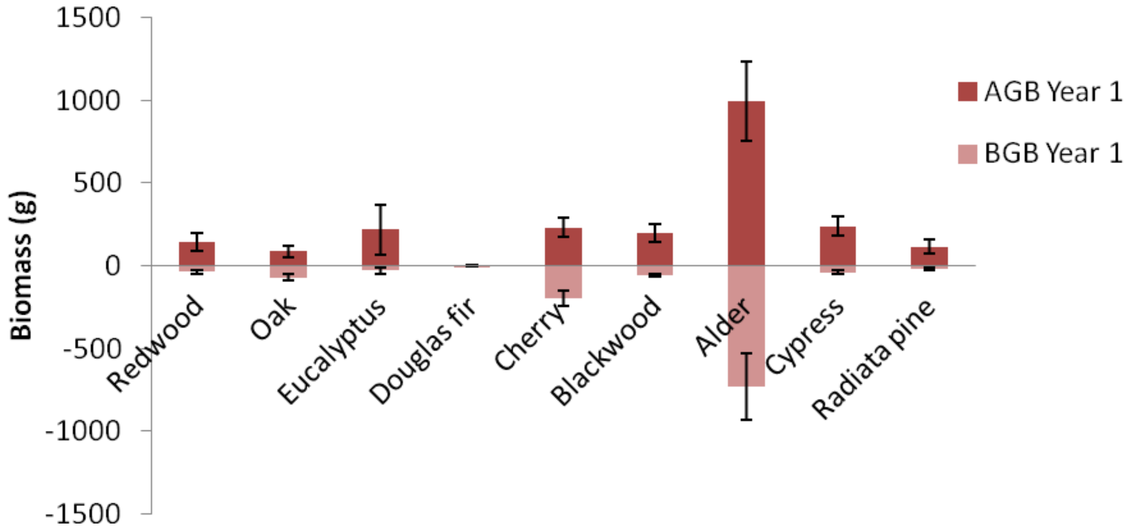

Figure 6 Mean above- and below-ground biomass for each trial species at 1 year.

DISCUSSION

The significant difference in planting material as it came from the Scion nursery is probably the biggest factor in interspecies variation in the range of parameters measured. Species like alder, cherry, and oak were considerably larger plants than radiata pine and Douglas-fir, and this continued to show for the first year of growth in the trial plot. The trial aimed to use ‘nursery-raised’ planting grades that would normally be used by the forest or ‘establishment’ sector rather than having planting materials of the same size and grade.

While one can make some general observations about plant performance, these should be taken in the context that ‘true’ differences between species are unlikely to emerge until the plants are considerably older – at least four years old.

Some of the growth differences may also be attributed to the presence of a high water table at the time of establishment, which in some species such as Douglas-fir may have been an inhibiting factor, while in others such as alder it may have enhanced growth.

At this stage of the trial, recommending which species might be the best performer or the most effective in terms of a future erosion forest species would be premature. Based on previous trials, we anticipate that by the time the plants have had three years in the ground, further species differences will emerge and we should be in a position to make statements on their relative performance in terms of soil reinforcement.

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