Pull-out strength of Pinus radiata roots and application in models to assess slope stability
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Outline

• Background and quick update
• Modelling process
• Radiata root strength as we have known it
• Data collection – root distribution
• Root pull-out strength experiments
• What it means
• Where next
Background & Issues

Land sustainability – erosion control

Debris flows & slash management

Natural landscape response

Window of vulnerability
Erosion and sediment mitigation

Want to model stand behaviour based on understanding of root reinforcement and then link to slope stability and debris flow hazard.
RA 3.2b

1. Size the Problem
   National Database

2. Erosion susceptibility & Landslide hazard approaches

3. Mitigation & management options to close the window

Outcome:
Forest industry’s license to operate has been maintained under new intensive management practices

- Improved understanding of effectiveness of mitigation for Forestry Co’s & RC’s
- Improved our ability to model role and effect of vegetation in landscapes for slope stability, hazard mitigation, sediment reduction, site productivity effects, etc
Roots & root models - recap

- Root tensile strength is a function of diameter (Wu et al. 1979)
- Roots don’t break all at once (Waldron and Dakessian 1981; Pollen and Simon 2005)
- Roots have different failure mechanisms (Waldron and Dakessian 1981)
- Root geometry (length) and the elastic modulus are functions of their diameter (Waldron and Dakessian 1981; Schwarz et al. 2010)
- Root tortuosity influences root elasticity and the failure mechanism (Schwarz et al. 2011)

- Wu model – overestimates soil shear strength → slope stability
- Fibre bundle model – better representation what happens
- Focus been on lateral not vertical root reinforcement
- Focus on shallow landslides
- Most models focus on tension and not compression
Methods: Overview of modelling approach


Root strength - common NZ trees

(Small roots: 1-4 mm diameter)

Willows 30-125 MPa

Exotics

Riparian plant trial
Old FRI data

Pinus radiata root strength

N=188  
Min D=1.3 mm  
Mean D=5.3 mm  
Max D=13.9 mm

N=100  
Min D=2.1 mm  
Mean D=4.2 mm  
Max D=5.8 mm

N=99  
Min D=13.9 mm  
Mean D=12.3 mm  
Max D=13.7 mm

y = 5E+06x^{1.8}  
R^2 = 0.6522

Landcare Research Science Series No. 7.
*Pinus radiata* root distribution data

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**8 year**
- dbh ≤ 20 cm
- Total Weight ≤ 36 kg

**16 year**
- dbh ≤ 45 cm
- Total Weight ≤ 231 kg

**25 year**
- dbh ≤ 60 cm
- Total Weight ≤ 584 kg

FIG. 2 — Side elevations of the three age-classes of *P. radiata*, showing the changes in root morphology up to Year 25.

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**Pinus radiata** root pull-out strength

Tests to calibrate the RBMw model for calculation of root reinforcement – root diameters 10-50 mm

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Root pull-out results

Root distribution

Örtig, 2012
Application of the Root Bundle Model for the calculation of root reinforcement
Application of SlideForNET in the Paihiatuha area

Frequency-Magnitude distribution of shallow landslides

Without vegetation

With vegetation (6y)

With vegetation (16y)
Application of SlideForNET in the Paihatuha area

Paihatuha (sandstone) Area
Arial photograph 1944

- Mapped landslides 1944-2011
- Modelled landslides SlideforMAP

Background colors indicate topographic wetness index
Where should I focus the resources to mitigate shallow landslides?

Map of mitigation efficiency of vegetation against shallow landslides
- without vegetation - with vegetation
How will SOSlope look like for practical application?

**INPUT files**

1. **DEM** > generation file with grid of cells (1 x 1 m)
2. File with **VEGETATION** data > position (x, y, z), dimensions (DBH), species: derived by LiDAR or Stereoanalysis.
3. Distribution of **SOIL PROPERTIES** > probability distribution of soil mechanical parameters for shearing and compression
4. **HYDROLOGICAL CONDITIONS** > distribution of water content derived by numerical models

**OUTPUT files**

- n number of predisposition maps giving the POSITION and the DIMENSION of shallow landslides
- Runoff simulator
- Probability maps of **DEBRIS FLOW RUNOFF**

Kalberer, 2007
http://research.nzfoa.org.nz/
www.scionresearch.com/nds

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