Erosion sources and sediment pathways to streams associated with forest harvesting activities in New Zealand

Kristopher Brown* and Rien Visser

***Post-doctoral Fellow, Forest Engineering, U. Canterbury**

19th Biennial Southern Silvicultural Research Conference

Blacksburg, Virginia, USA

March 15, 2017

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

- Catchment studies show there is still a sediment spike at harvest time.
- Old rule of thumb: 90% of problem originates from 10% of area (i.e., roads, trails, landings)
- BMP implementation standards much higher – **where is the sediment coming from?**
- Field surveys for “breakthroughs” (Rivenbark and Jackson, 2004; Lang et al., 2015) or road-to-stream connectivity (Wemple et al, 1996) identified the following as major sources:

Road-stream crossings

Road drainage structures

Surface runoff interaction with gullies

NZ forest harvesting outlook

- Increasing harvest volumes: Could reach 42 Mm^3/yr by 2025
- ‘New’ harvest locations are often steep, erodible, and **require road access**

Research objectives

- Quantify the spatial frequency of breakthroughs associated with recent harvests
- Identify common causes of breakthroughs and how often they occur
- Evaluate hydrologic connectivity and potential rates of sediment delivery at road-stream crossings
- Evaluate the characteristics of adjacent hillslopes that do and do not contribute sediment
- Suggest BMP improvements to reduce connectivity

Site selection criteria

1) At least one perennial or intermittent stream, as evidenced by well-defined, scoured channel
2) Recent harvest (3 to 12 months ago)
3) Harvested sites to remain in plantation forestry
4) Harvest area < 20 ha

Extraction type (# of sites)

Ground-based (9)
Cable yarder (9)
Both (5)

Site locations

Bay of Plenty (2)
Wairarapa (1)
Tasman (3)
Canterbury (10)
Otago (5)
Southland (2)

Field Methods

- Walk intermittent and perennial stream channels, look for sources of concentrated runoff to the stream

- Identify and describe the source
  - Hydrologic contributing area
  - Slope
  - Surface cover
  - Topography and aspect
  - Soil disturbance from roads, skid trails, or ruts from machine traffic

What is a breakthrough?

Any evidence of concentrated overland flow (e.g., surface scour) and/or sediment delivery to the stream channel.

Measuring upslope contributing areas

Contributing and non-contributing hillslopes

Width

Length and Slope,

Aspect, Topography

Impact from roads or machine track disturbance

Predicting breakthrough likelihood given hillslope characteristics

- Logistic regression used to predict the log odds of a breakthrough given the following predictors:
  - upslope contributing area
  - slope gradient
  - bare soil percentage
  - aspect
  - topography (convergent, divergent, or planar slopes),
  - hydrologic influence of roads, skid trails, or machine tracks

Stream crossing approaches

<u>**Measurements**</u>

Length to nearest water control structure

Road and ditch width

Slope

Cover

Surface roughness

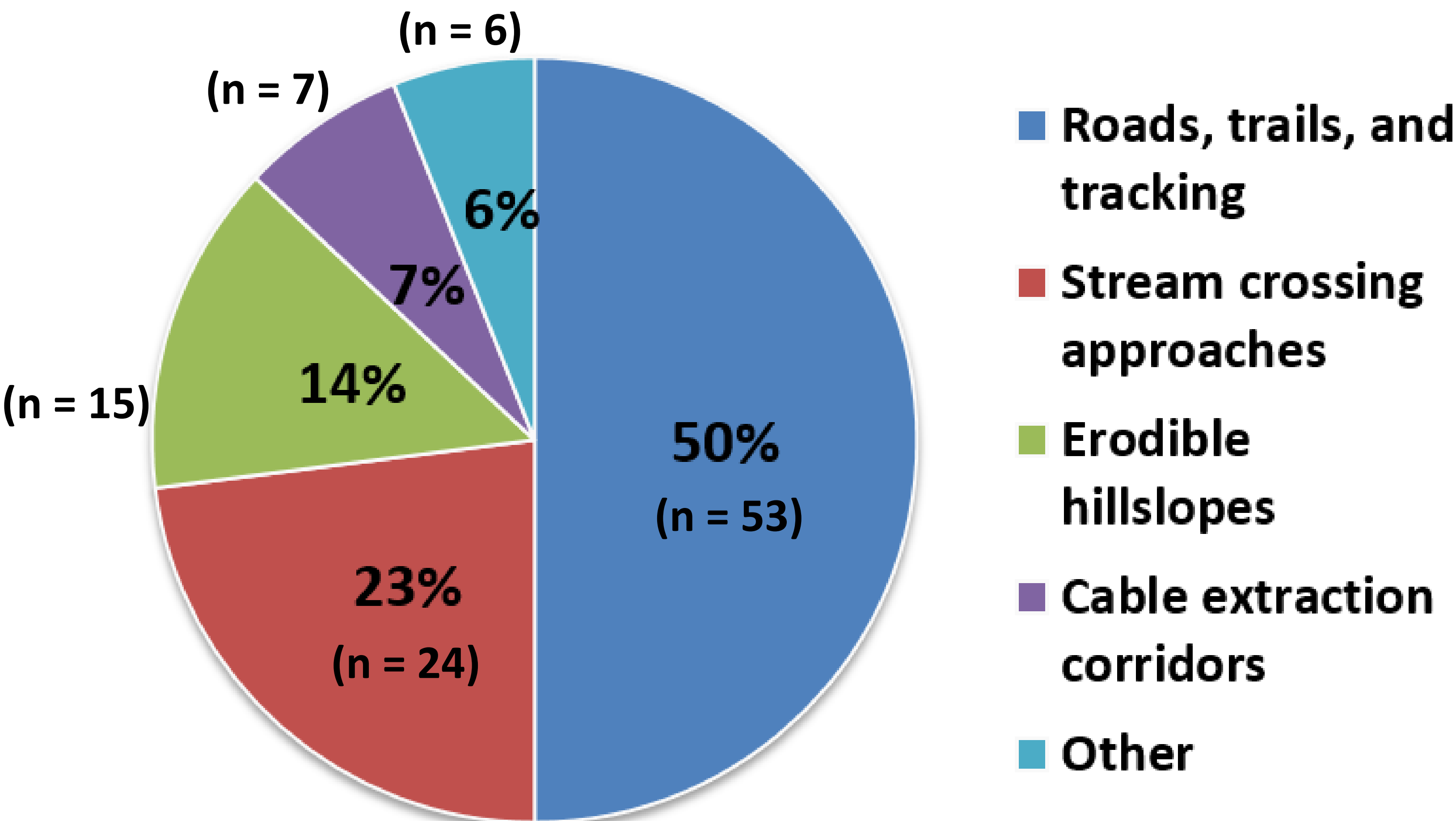
Estimate potential erosion on road surfaces and ditches (USLE-forest)

Spatial frequency of breakthroughs

- **23 km of stream channel, 552 harvested ha, 106 breakthroughs**
- **3.4 breakthroughs per km** of stream*
- **1 breakthrough for every 6.5 hectares***

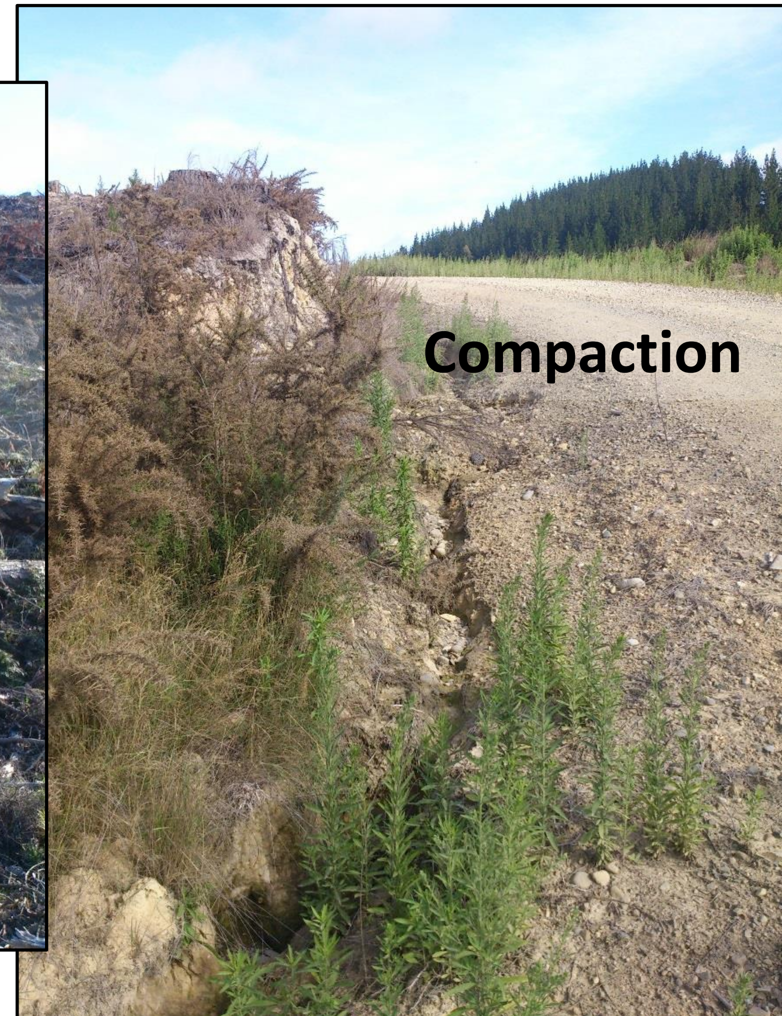
*Summary stats are median values

Breakthrough sources

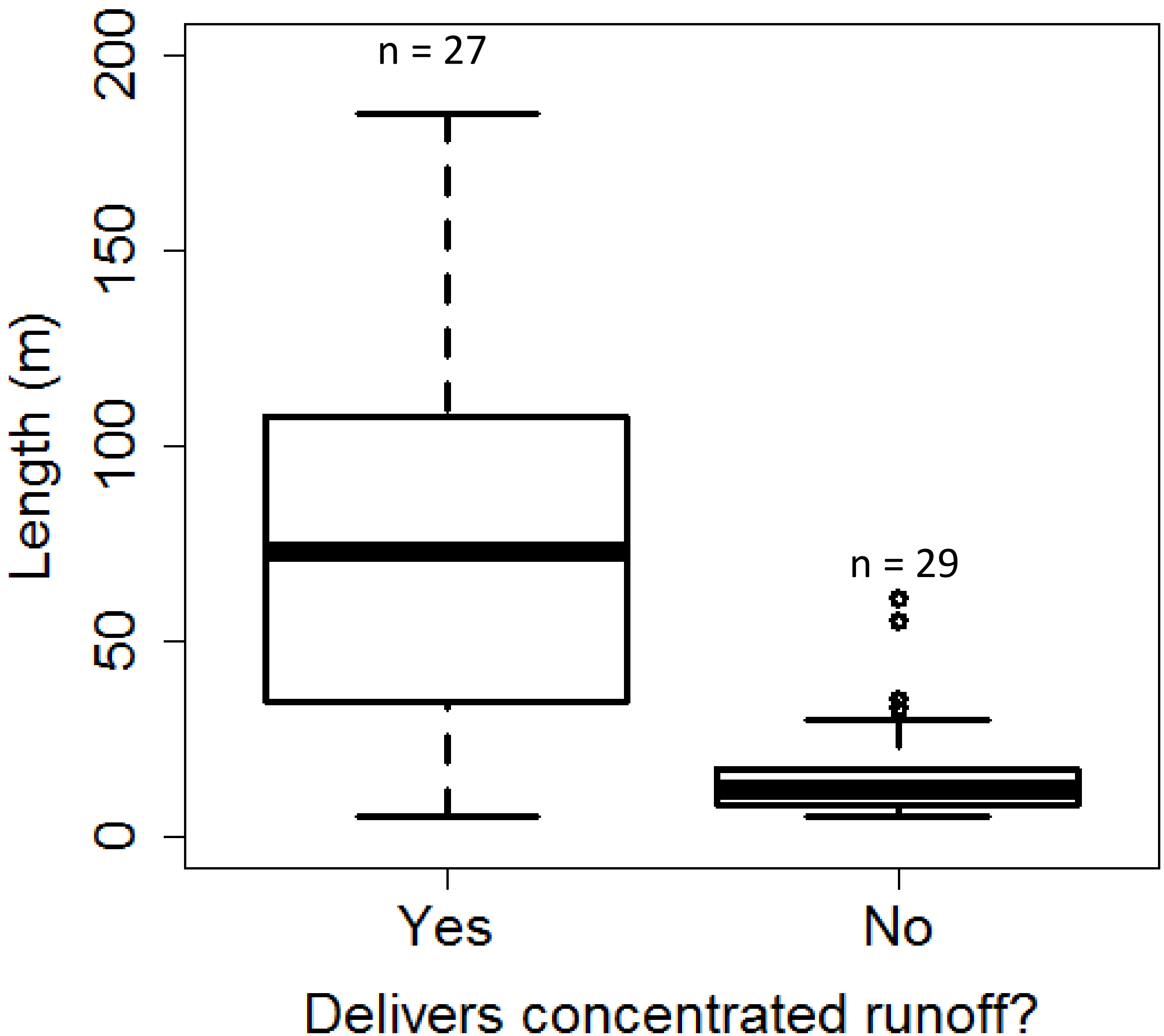


Road-stream crossing approaches

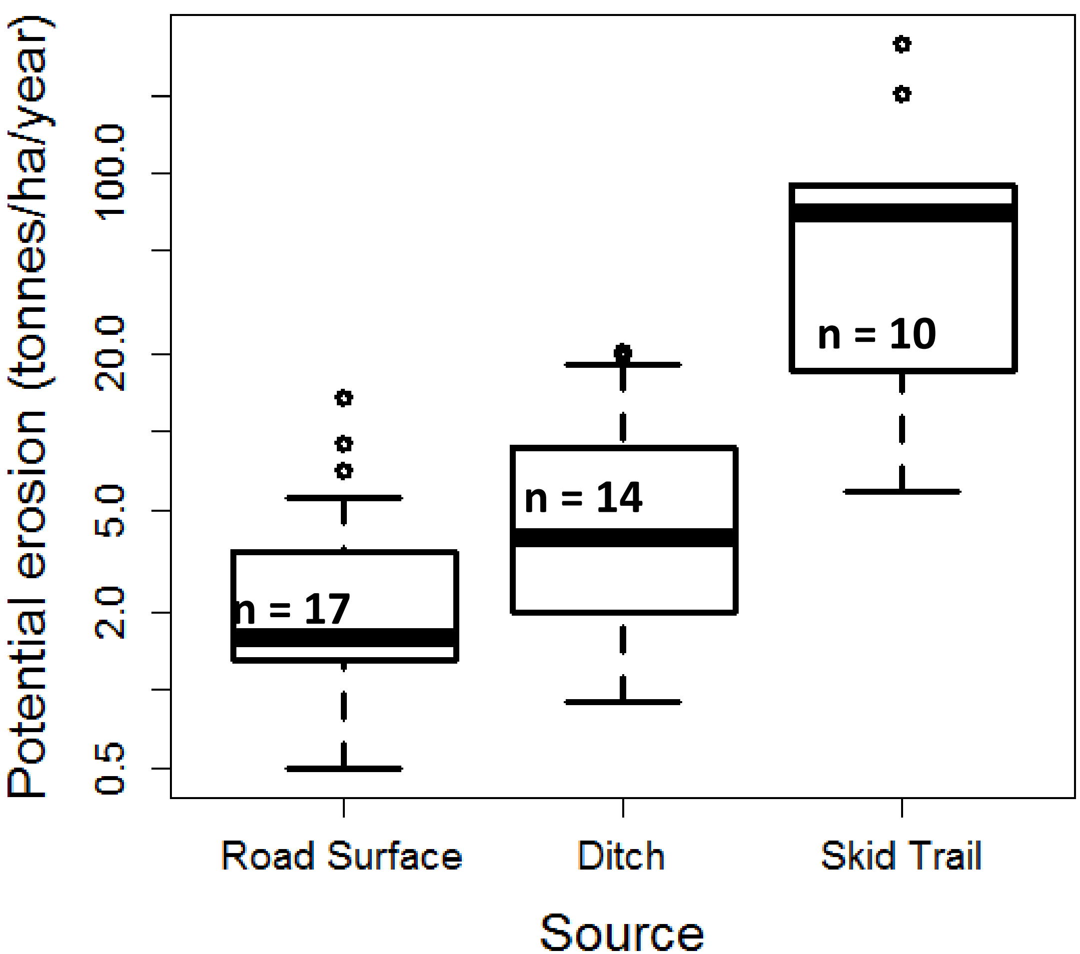
- Permanent stream crossing approaches delivered concentrated runoff more often (17 of 21 cases) than temporary crossings (10 of 35 cases).



Effect of stream crossing approach length on connectivity



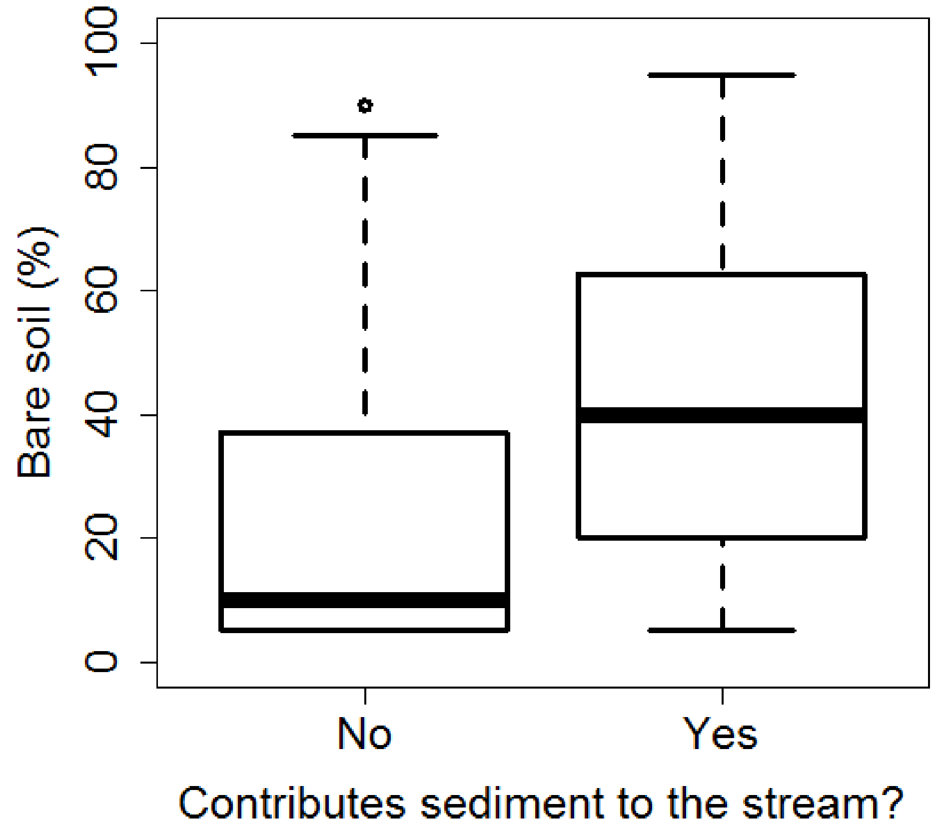
Potential erosion on stream crossing approaches that deliver concentrated runoff




Temporary track crossing
204 t/ha/yr

Breakthrough likelihood of occurrence for hillslopes adjacent to streams

- More bare soil led to higher breakthrough likelihood
- Slopes with no roads/trails OR only machine traffic reduced breakthrough likelihood



Conclusions

- Breakthrough spatial frequency for ground-based skidding was 1.9 times that of cable yarding.
- 73% of breakthroughs were related to roads, trails, stream crossings, or machine traffic disturbance on hillslopes.
- Road surface type (gravel, bladed or overland trail) and drainage length was important for understanding hydrologic connectivity at stream crossings.
- Steep skid trail approaches with poor water control and surface cover can result in potential erosion rates exceeding 100 tonnes/ha/yr

BMPs to reduce connectivity: focus on roads

- Pre-harvest planning:
  - Locate roads and stream crossings to avoid steep grades (reduces earthworks and makes water control easier)
  - Maintain a buffer (e.g., an SMZ or simply a slash barrier) between disturbed soil and streams
- Space water control structures based on road grade and soil erodibility
- Close temporary stream crossings, where applicable, with water control structures and application of surface cover
- Inspect roads and skid trails periodically post-harvest to ensure BMPs are functioning properly