Using Ground-Based Harvesting Machinery on Steep Slopes

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Forest Harvesting in New Zealand

- Pine plantations, 25 year rotation, large clear cuts,
- Ground-based machines most common and cost-effective harvesting ➔ primarily modified excavator and large wheeled grapple skidders...

- lifted and widened track base and modified cab for better vision and improved protection.
New Zealand Steep Terrain

“up to 25% increase in productivity” - (Acuna et al. 2010)
NZ Machine Limits

Forest Practice Code:
30% (18°) Wheeled,
40% (23°) Tracked

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Static stability dependant on load position and machine type (MacLean & Visser 2011)
Study Purpose

• What are the actual machine slopes of machines harvesting on ‘steep’ terrain in NZ?
• What is the relationship between machine slope and ground slope?
• Are there differences between machine types?
• Are purpose built machines (i.e. European) better than excavator based (NZ) machines?
Machine Comparison

• Comparisons will be made between; wheeled vs. tracks, functions using similar machines e.g. felling vs. shovelling and European vs. New Zealand machines.
Methodology

- Measure actual machine slope (Digital Inclinometer)
- Machine location (GPS) + Slope Map (GIS)
- Replicated study in NZ and Europe
Data Collection and Analysis

• Machine slope collected using data loggers along all three axis
• The vehicle is tracked using GPS
• Data is combined for a spatial representation
• The terrain slope established using digital terrain models
Machine Slope – first 10min

Elapsed time (h:mm)

Slope (degrees)

Machine Slope
10m contour ave
Limit
Machine Slope — first 10 min

**Graph Details:**
- **Slope (degrees):**
  - 0:00:00,0 0:02:00,0 0:04:00,0 0:06:00,0 0:08:00,0 0:10:00,0
  - **Ave. Surface slope(5):**

**Legend:**
- **Machine slope (degrees):**
  - 5.7 - 10.5
  - 10.6 - 13
  - 13.1 - 14.9
  - 15 - 16.4
  - 16.5 - 17.8
  - 17.9 - 19.2
  - 19.3 - 20.6
  - 20.7 - 21.9
  - 22 - 23.3
  - 23.4 - 24.5
  - 24.6 - 25.6
  - 25.7 - 26.7
  - 26.8 - 27.8
  - 27.9 - 28.9
  - 29 - 29.8
  - 29.9 - 30.8
  - 30.9 - 32.3
  - 32.4 - 33.9
  - 34 - 35.7
  - 35.8 - 39.4

**Graph Notes:**
- **Elapsed time (hh:mm:ss.0):**
- **Machine Slope:**
  - First 10 minutes

**Additional Notes:**
- **Surface slope:** Averaged over 5 measurements.
Machine Slope

- Ave. Surface slope (10)
- Legal maximum
- 5 min moving average

Slope of plane (degrees)

Elapsed time (h:mm:ss.0)
Distribution of Machine slope

Number of observations

Range of observations (degrees)

- 0 to 5
- 5 to 10
- 10 to 15
- 15 to 20
- 20 to 25
- 25 to 30
- 30 to 35
- 35 to 40

The graph shows the distribution of machine slope angles, with the highest number of observations in the range of 25 to 30 degrees.
The Machines experience

• Machine slope vastly different to terrain slope

• Reasons:
  – Skid trails affect the machines operating slope and are not factored into the DTM calculations
  – Driving over obstacles such as stumps particular when operating a rigid tracked vehicle
  – Operator skill – taking care on the steep slopes and not on the lower slopes.
Where to from here

• Early phase of study, so welcome any and all input!!
• Further data collection in New Zealand during November with the crews shifting onto steep terrain with the drier summer conditions
• Data also collected from machines in Europe with a focus on purpose built steep terrain machines