PRODUCTIVITY AND ENVIRONMENTAL IMPACTS OF TETHERED LOGGING

A CASE STUDY IN SOUTHERN OREGON, USA

WOODAM CHUNG

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PART

STUDY SITE & OBJECTIVES
Study site
14 ha (35 acres) clear-cut
Elevation: 380-520 meters
60+ year old Doug. fir stand (500 trees per ha)
Avg. tree size: ~1.2 m³ (220 bf)
Silty clay loam soils

Climate
Mean annual temperature: 11.6 °C
Precipitation: 880 mm
Cool wet winter and warm dry summer
Logging occurred in March – April 2018

Tethered feller-buncher
Comparison between mechanized (11 ha) and manual timber falling (3 ha)
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#1: Estimate **CUTTING** productivity and cost (machine vs. hand)

#2: Examine the effects of machine cutting on **YARDING** productivity and cost

**Hypothesis #1:** Machine cutting has higher productivity and costs than hand cutting

**Hypothesis #2:** The ability of the machine to swing and pile trees near skyline corridors improve yarding efficiency
OBJECTIVES

Soil Impacts and Sediment Transport

#1: Characterize and quantify soil IMPACTS
#2: Evaluate soil EROSION and SEDIMENT transport potential

MACHINE – SOIL – WATER

Hypothesis #1: Machine tracks creates a “tillage effect” on the surface soil – loosening surface soils while mixing organic matters with mineral soil materials

Hypothesis #2: Soil disturbance along machine corridors causes an increase in erosion and sediment transport potential
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METHODS
Detailed Time Study

Cycle time data collection
GoPro video footage
Timber cruise data
Mill tickets

Delay-free cycle time regression models
• Hand cutting
• Machine cutting
• Machine swinging
• Yarding after hand-cut
• Yarding after machine-cut

Hourly production rates

Machine Rates

Hourly machine costs
System costs
METHODS – SOILS

Sample locations
A total of 22 sample stations located in each of the pre-selected machine and hand cut corridors.

Soil physical properties
- Bulk density (top 6 cm of soil)
- Soil penetration resistance
- Rut depth
- Infiltration rates
- Soil moisture contents

Erosion and sediment potential
- Soil moisture changes over time
- Shallow subsurface runoff
- Sediment production rates
- Rainfall precipitation

Pre- and post-harvesting

Machine tracks

Sub-samples

30’

Machine corridor

Between machine tracks, in the tracks, and outside tracks
Hand cut areas – high density of skyline corridors

Machine cut areas – high intensity of disturbance

METHODS – SOILS
METHODS – SOILS

LONE ROCK RESOURCES
RESULTS
**ECONOMICS**

**Productivity**
- Hand cutting (delay-free): 59 sec/tree
- Machine cutting (delay-free): 27 sec/tree
- Machine swing: Approx. 30% of total machine hours
- Yarding (hand cut): 4.8 min/turn, 610 bf/turn
- Yarding (machine cut): 3.5 min/turn, 970 bf/turn
- 27% faster, 60% more volume -> 130% higher productivity

**Machine costs**
- Hand cutting: $53/hour
- Machine cutting: $310/hour
- Yarding: $390/hour
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## Unit production costs
- Hand: $86
- Machine: $58
- 32% ↓
Pre-harvesting soil conditions

- A total of 22 sample stations located in each of machine and hand cut corridors
- No difference in the average soil penetrometer measurements between machine and hand cut areas prior to harvesting
Post-yarding

- Ratio > 1; Compacted soil
- Ratio = 1; No change
- Ratio < 1; Loosened-up soil

* significant at p < 0.05; ** significant at p < 0.005; *** significant at p < 0.001
Bulk density

* significant at $p < 0.05$; ** significant at $p < 0.005$; *** significant at $p < 0.001$
Infiltration Rates

- Pretreatment
- Post falling
- Post yarding
- Use k-value, saturated hydraulic conductivity (cm/s)

* significant at p < 0.05; ** significant at p < 0.005; *** significant at p < 0.001
Sediment Transport

- Installed September 2018
- Precipitation of 880 mm between October 2018 – June 2019
- No sign of sediment transport observed
Cost and productivity
More expensive cutting, but potential efficiency gain from yarding
Could be more cost effective

Coverage vs. intensity of soil disturbance (visual observation)
Less coverage of disturbance
Higher intensity of disturbance

Soil density (compaction)
Decrease in soil density observed at surface soil
No significant increase in soil density observed

Moisture content
Not much difference in water infiltration rates
Higher moisture content in track compared to non-track

Sediment transport
No transport observed
Seedling Growth Experiment

Future Soil Impact Experiments
Tethered logging in WA (November 2019)
Tethered logging in ID (April 2020)
ACKNOWLEDGMENT

Brennan Garrelts, LRT
Brett Morrissette, OSU
Preston Green, OSU
Ben Leshchinsky, OSU
Francisca Belart, OSU
Kevin Bladon, OSU
Jeff Hatten, OSU
John Sessions, OSU
Cameron Minson, OSU
Zach Lesley, OSU
Logan, OSU
Chad Bebeau, OSU
Adam Coble, ODF

Nick Gravelle, OSU
Robert Bancroft, OSU
Derek Ojua, OSU
Shane Uffleman, OSU
George, OSU
Ji She, OSU
Duckha Jeon, OSU
Pedro Belavenutti, OSU
Adrian Gallo, OSU
Michael Bunn, OSU
Austin Finster, OSU

Lone Rock Logging Crew
THANKS

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