PRODUCTIVITY AND ENVIRONMENTAL IMPACTS OF TETHERED LOGGING

A CASE STUDY IN SOUTHERN OREGON, USA

WOODAM CHUNG

CONTRIBUTORS: BRETT MORRISSETTE, PRESTON GREEN, BEN LESHCHINSKY, KEVIN BLADON, JEFF HATTEN, JOHN SESSIONS

Oregon State University

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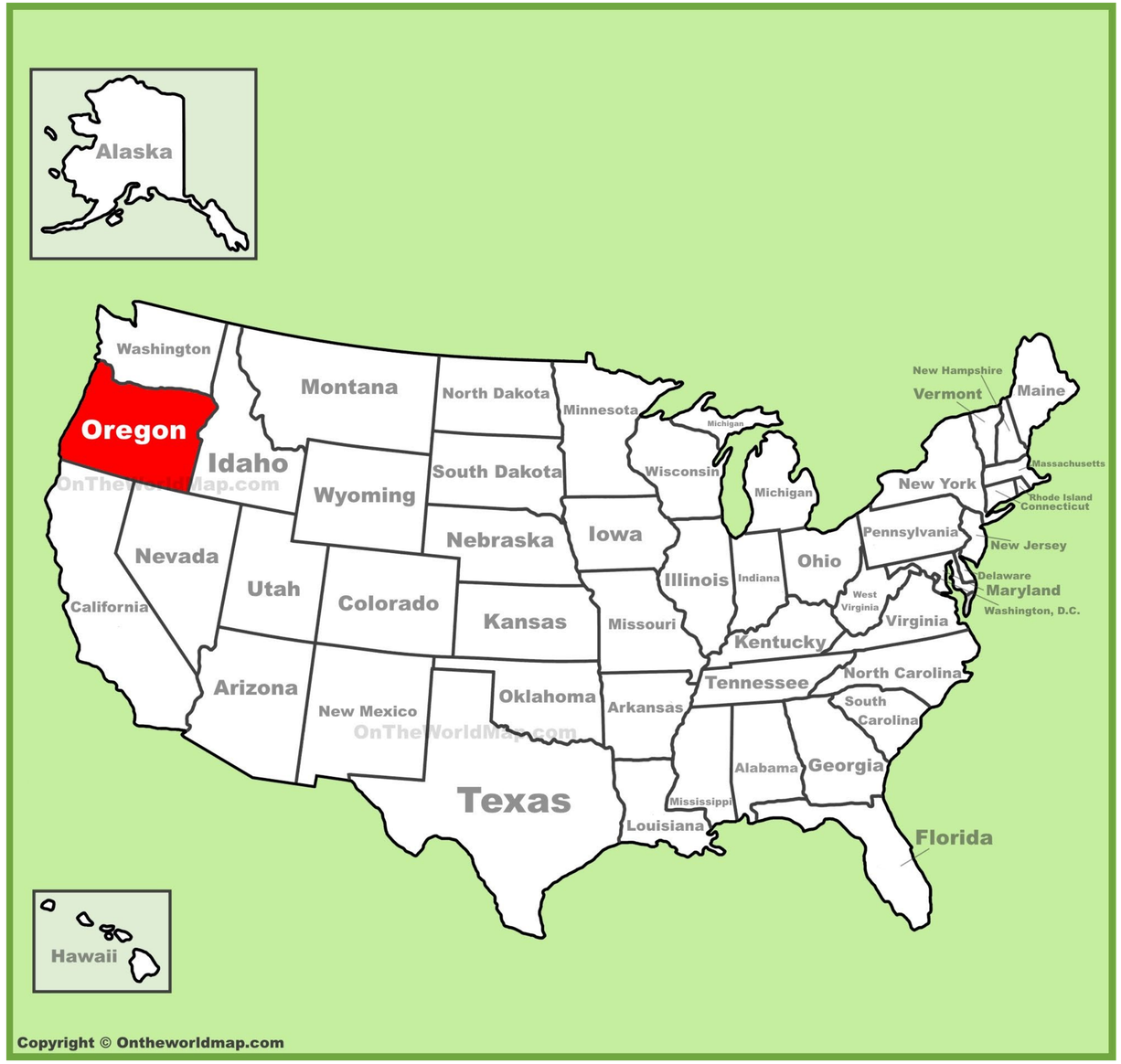
PART

STUDY SITE & OBJECTIVES

STUDY SITES

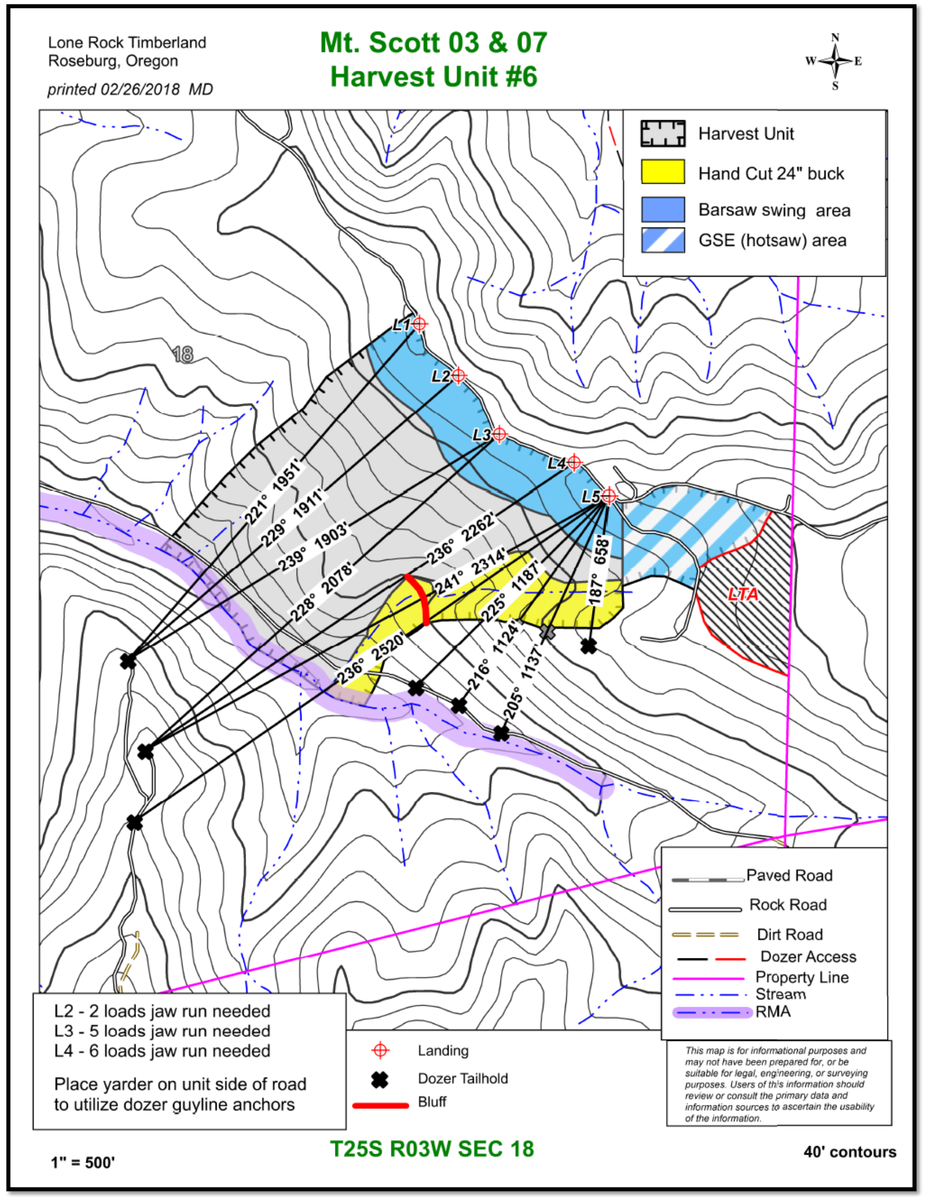
LONE ROCK RESOURCES



STUDY SITES

LONE ROCK RESOURCES

- 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)



A logging site near Sutherlin, OR

STUDY SITES

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OBJECTIVES

Economics

#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

2

PART

METHODS

METHODS – PROD.

Detailed Time Study

Cycle time data collection

GoPro video footage

Timber cruise data

Mill tickets

Delay-free cycle time regression models

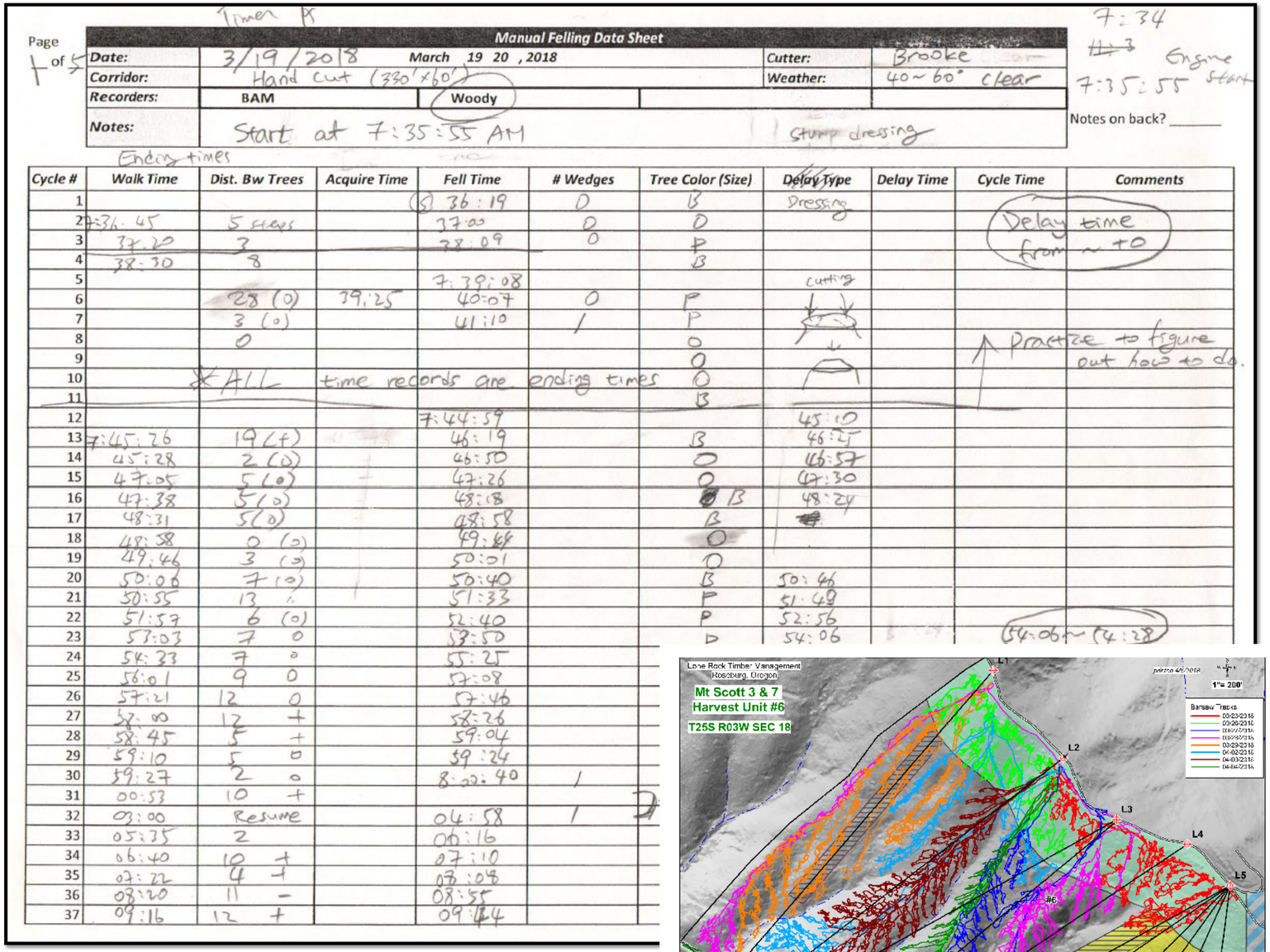
- Hand cutting
- Machine cutting
- Machine swinging
- Yarding after hand-cut
- Yarding after machine-cut

Hourly production rates

Machine Rates

Hourly machine costs

System costs



Timer K

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Manual Felling Data Sheet

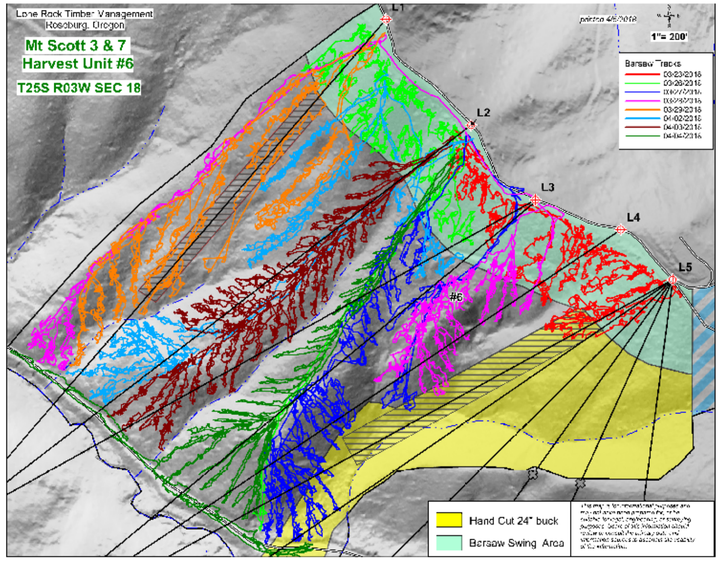
Date:	3/19/2018 March 19 20 , 2018	Cutter:	Brooke
Corridor:	Hand cut (330'x60')	Weather:	40~60° clear
Recorders:	BAM / Woody		
Notes:	Start at 7:35:55 AM		

7:34 Engine start 7:35:55

Notes on back? _____

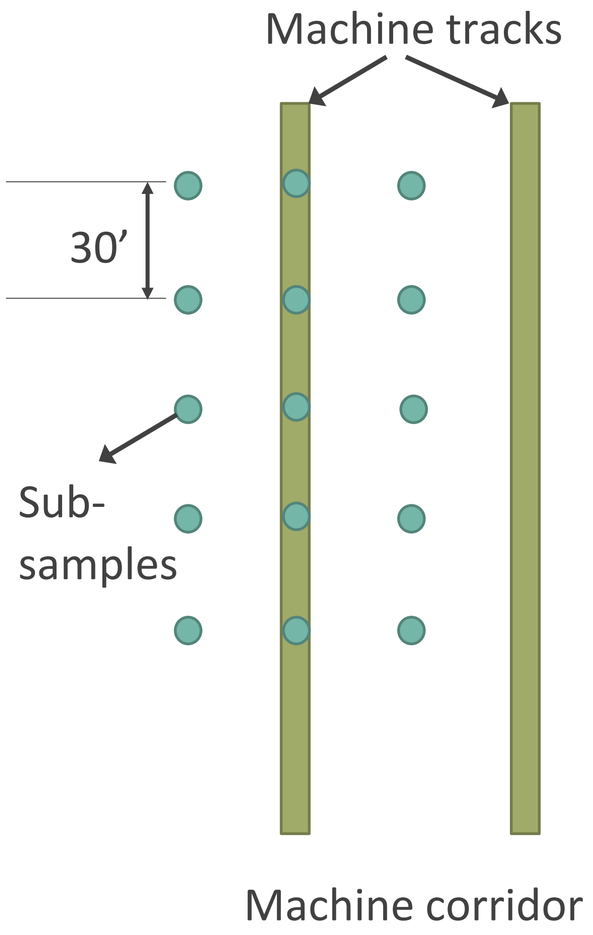
Ending times

Cycle #	Walk Time	Dist. Bw Trees	Acquire Time	Fell Time	# Wedges	Tree Color (Size)	Delay Type	Delay Time	Cycle Time	Comments
1				(S) 36:19	0	B	Dressing			
2	7:36:45	5 steps		37:00	0	O				Delay time from ~ +0
3	37:20	3		38:09	0	P				
4	38:30	8				B				
5				7:39:08			cutting			
6		28 (0)	39:25	40:07	0	P				
7		3 (0)		41:10	1	P				
8		0				O				Practice to figure out how to do.
9						O				
10		*ALL	time records are	ending times		O				
11						B				
12				7:44:59			45:10			
13	7:45:26	19 (f)		46:19		B	46:25			
14	45:28	2 (0)		46:50		O	46:57			
15	47:05	5 (0)		47:26		O	47:30			
16	47:38	5 (0)		48:18		B	48:24			
17	48:31	5 (0)		48:58		B				
18	48:58	0 (0)		49:44		O				
19	49:46	3 (0)		50:01		O				
20	50:06	7 (0)		50:40		B	50:46			
21	50:55	13		51:33		P	51:49			
22	51:57	6 (0)		52:40		P	52:56			
23	53:03	7 0		53:50		D	54:06			54:06 ~ (4:28)
24	54:33	7 0		55:25						
25	56:01	9 0		57:08						
26	57:21	12 0		57:46						
27	57:00	12 +		58:26						
28	58:45	5 +		59:04						
29	59:10	5 0		59:24						
30	59:27	2 0		8:00:40	1					
31	00:53	10 +								
32	03:00	Resume		04:58	1					
33	05:35	2		06:16						
34	06:40	10 +		07:10						
35	07:22	4 +		08:08						
36	08:20	11 –		08:55						
37	09:16	12 +		09:44						



METHODS – SOILS

Pre- and post-harvesting



Between machine tracks, in the tracks, and outside tracks

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

SOIL COMPACTION

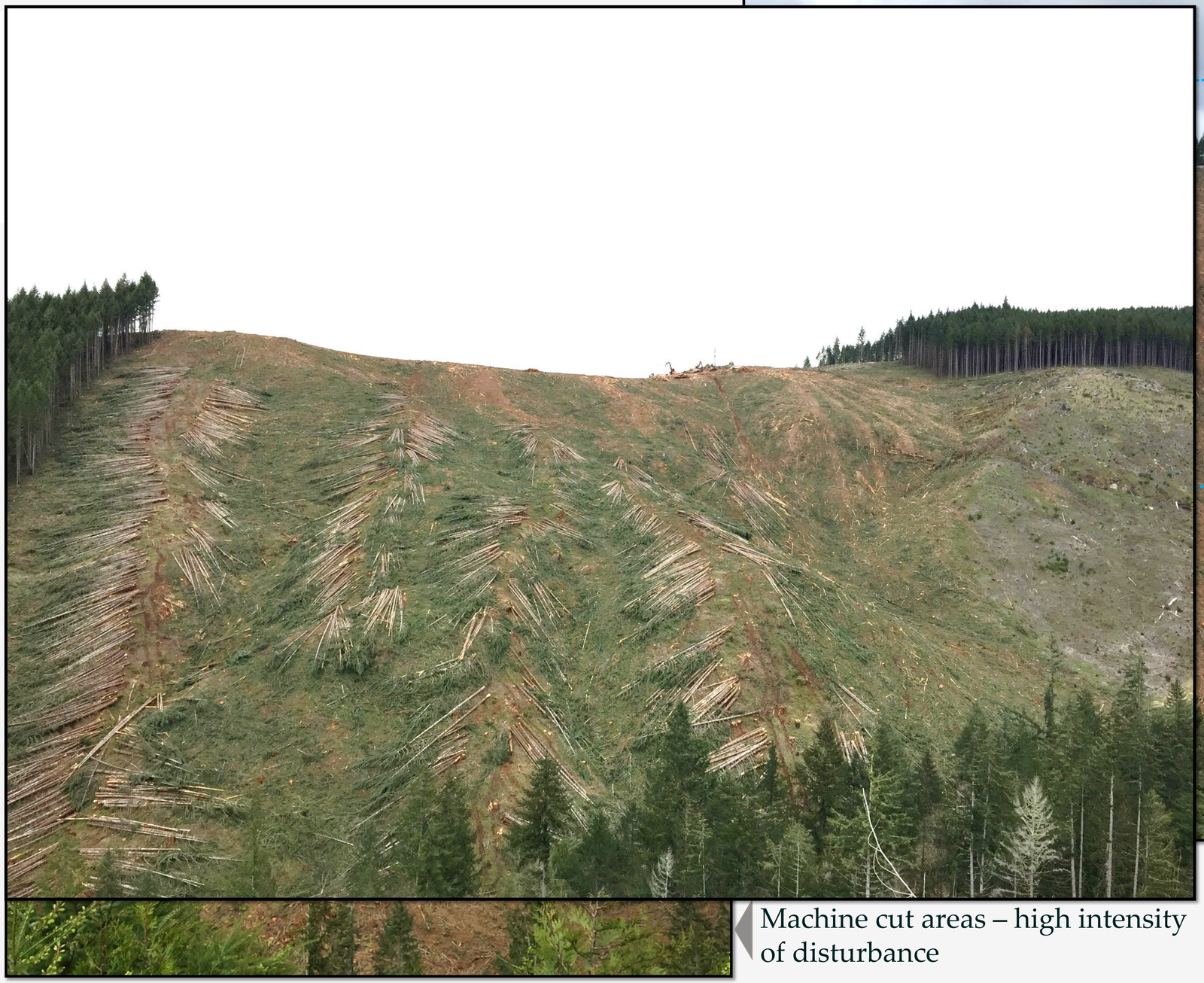
MOISTURE CONTENT

SILT FENCES

METHODS – SOILS

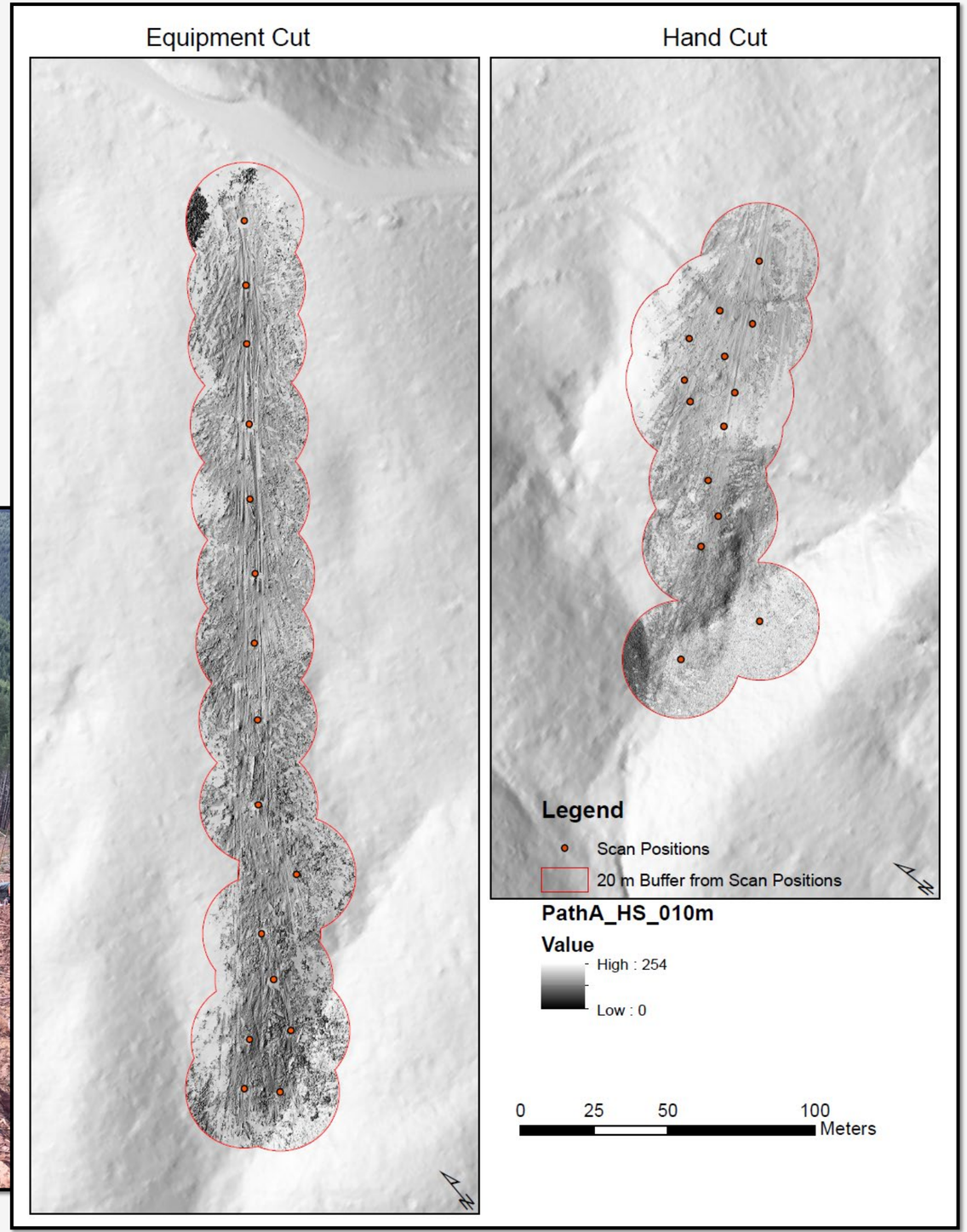
LONE ROCK RESOURCES

METHODS – SOILS



Machine cut areas – high intensity of disturbance

METHODS – SOILS



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LONE ROCK RESOURCES

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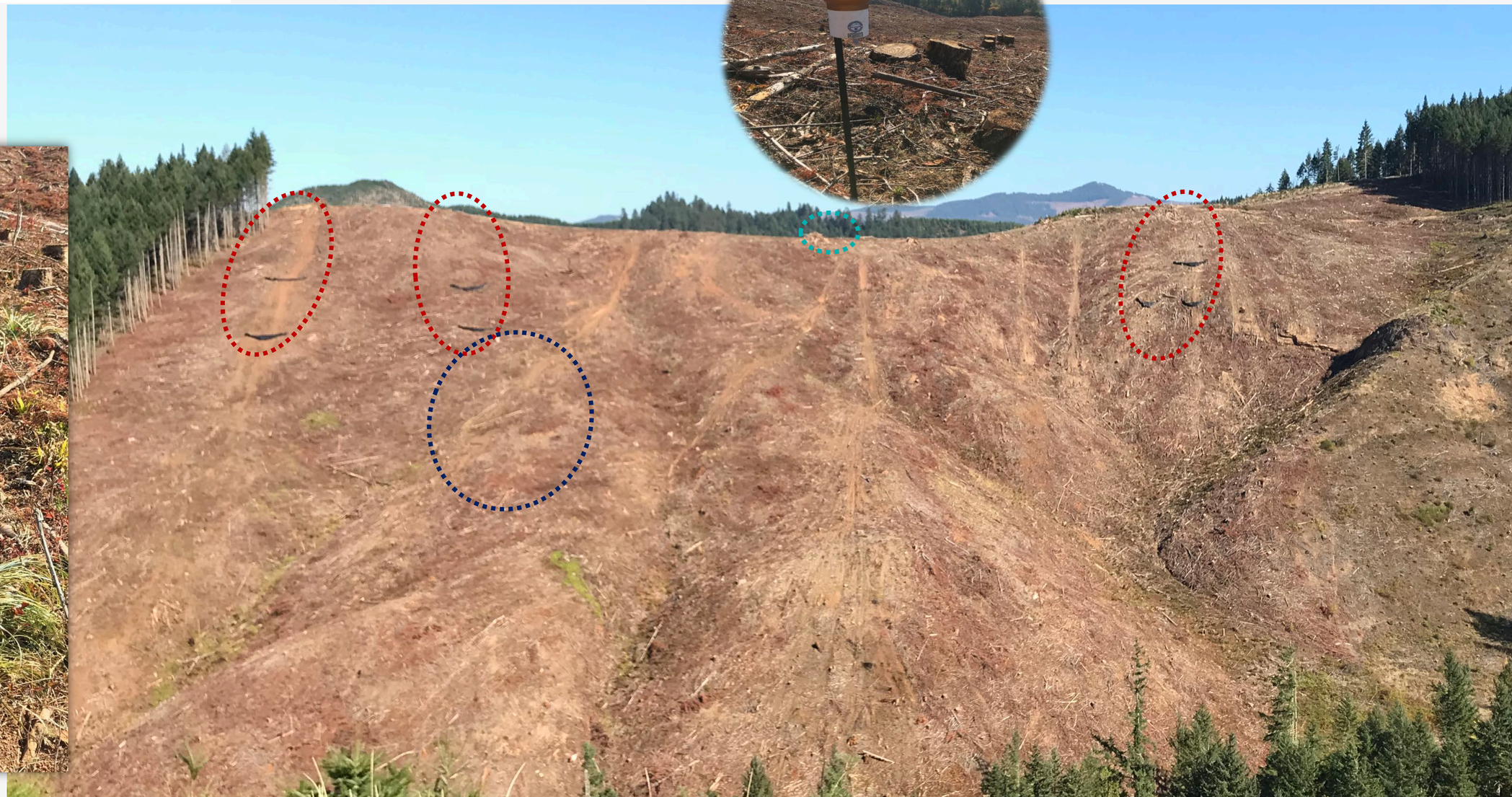

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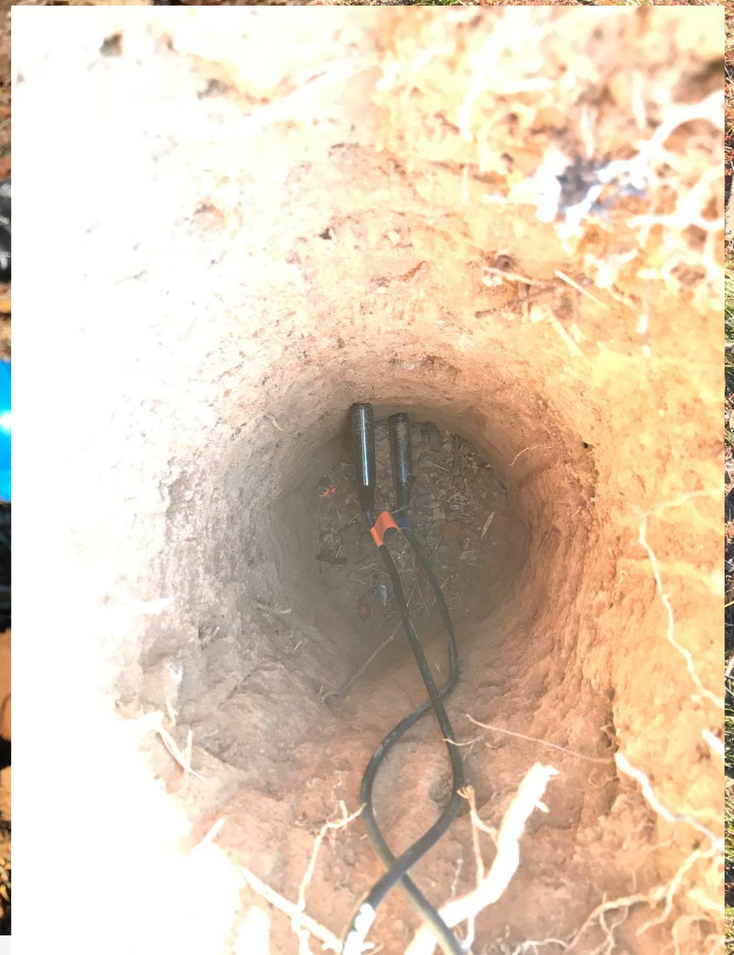

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PART

RESULTS

ECONOMICS

Machine costs

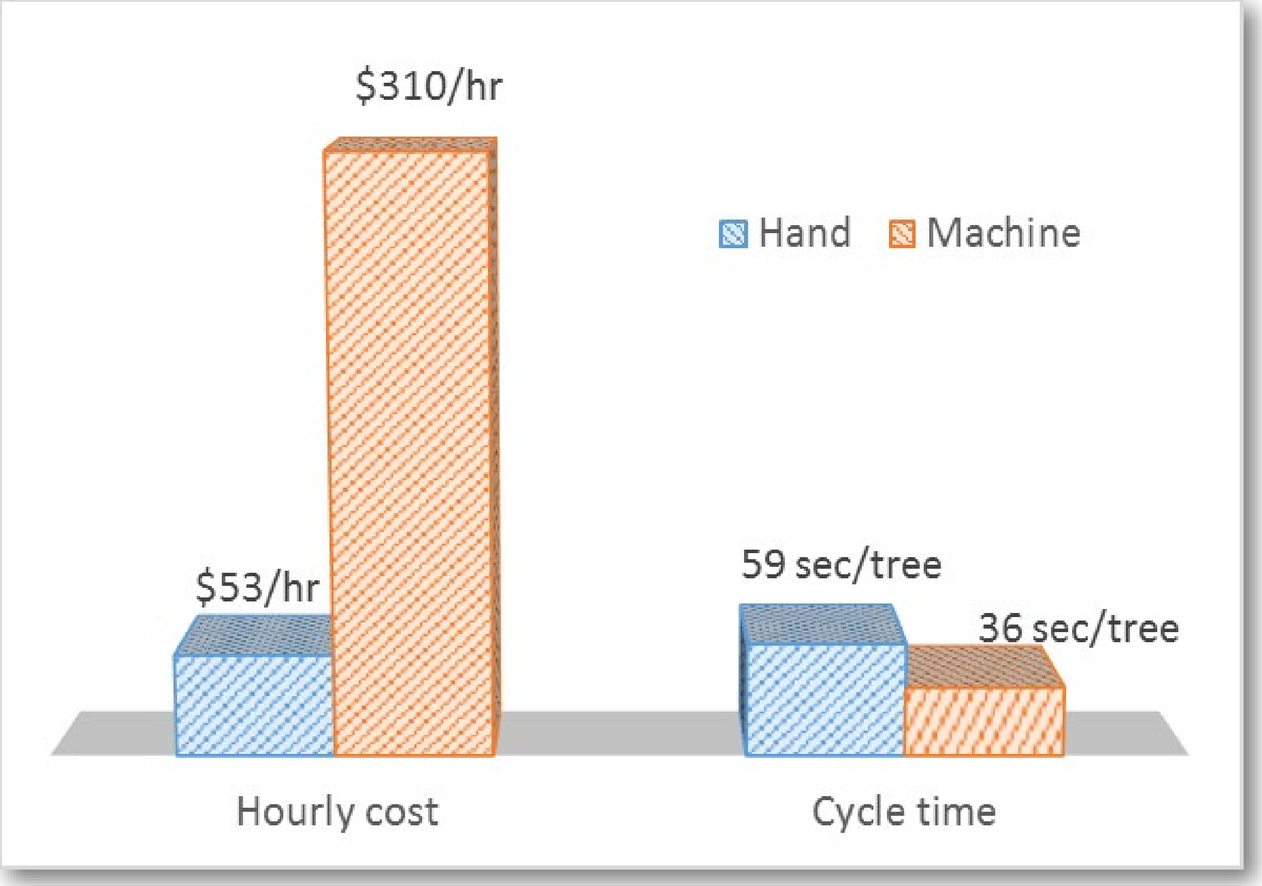
- Hand cutting: $53/hour
- Machine cutting: $310/hour
- Yarding: $390/hour

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

Cutting



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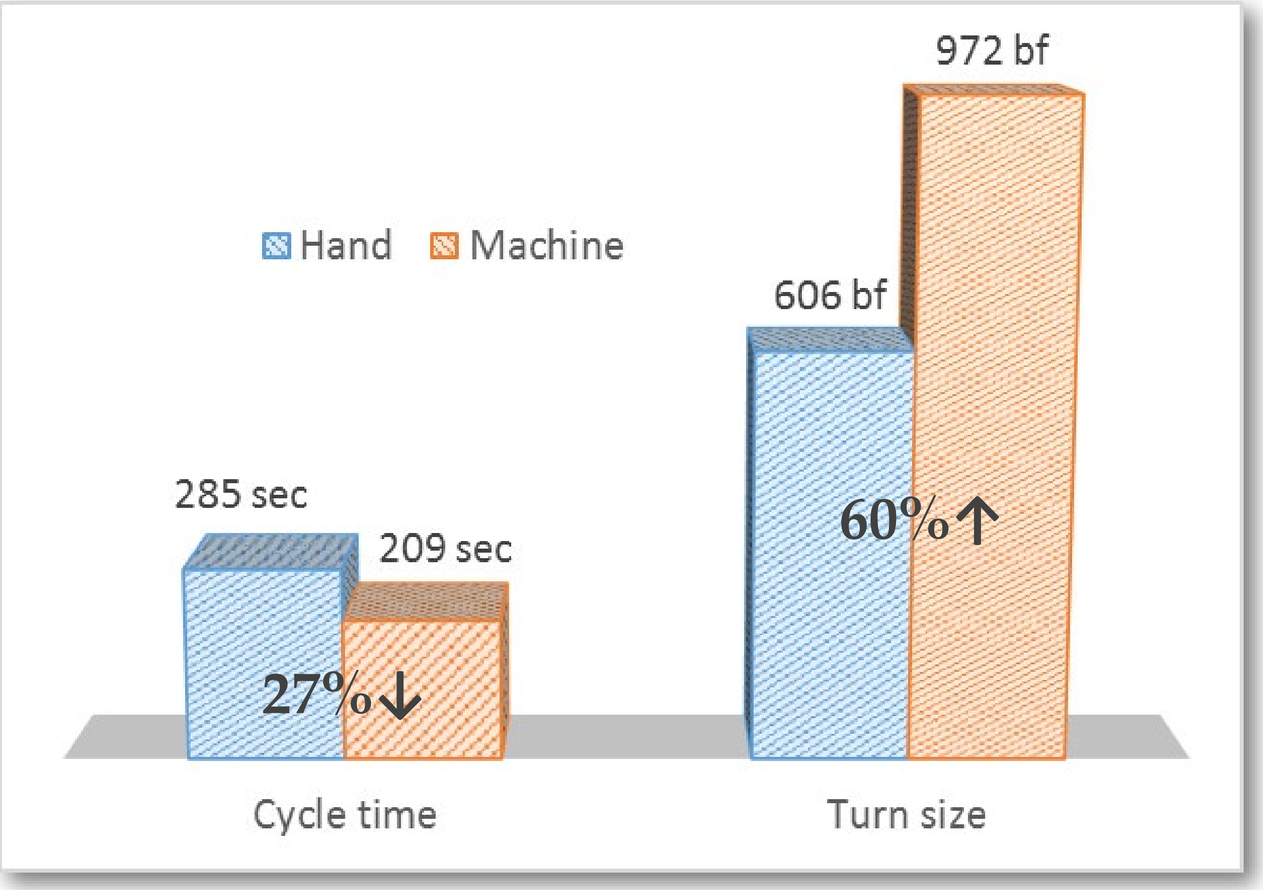
Yarding



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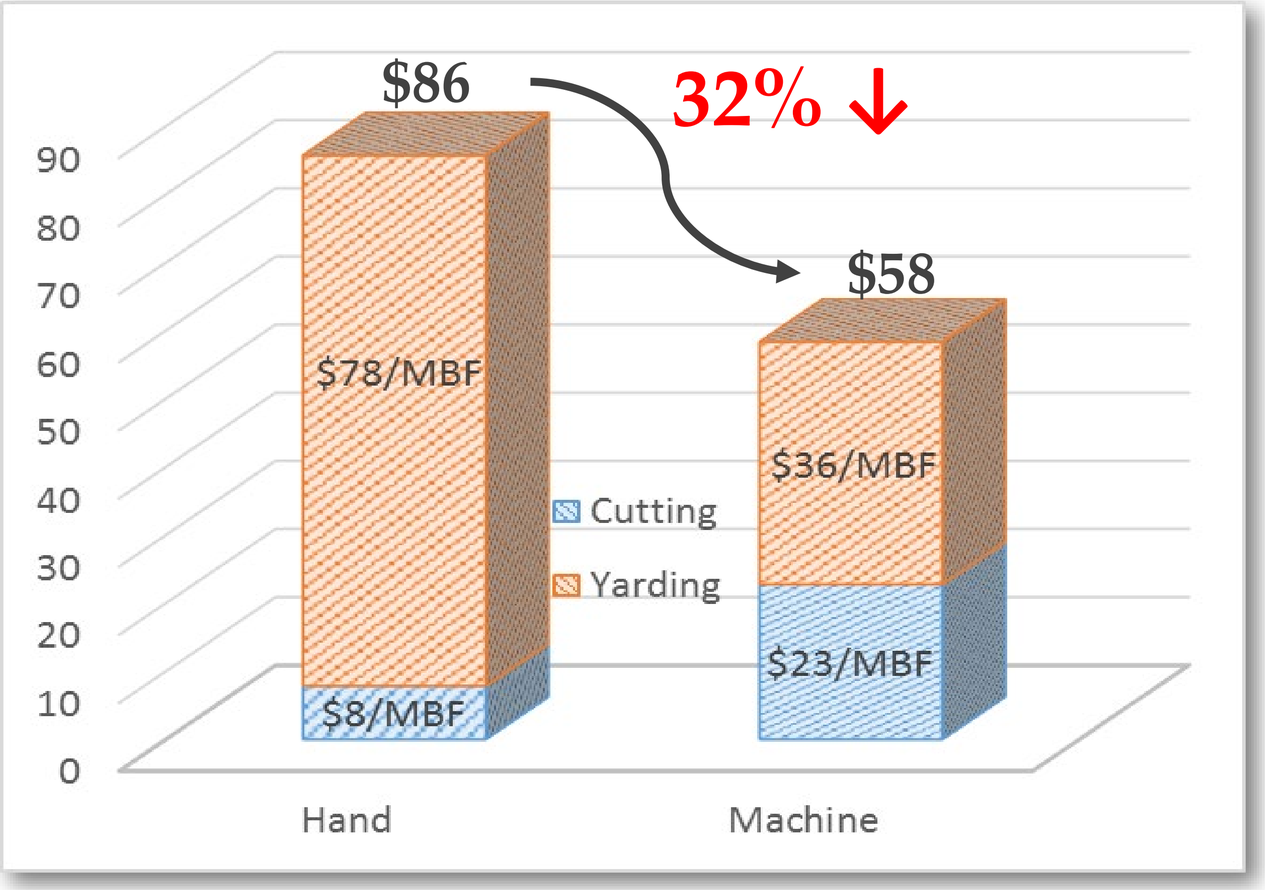
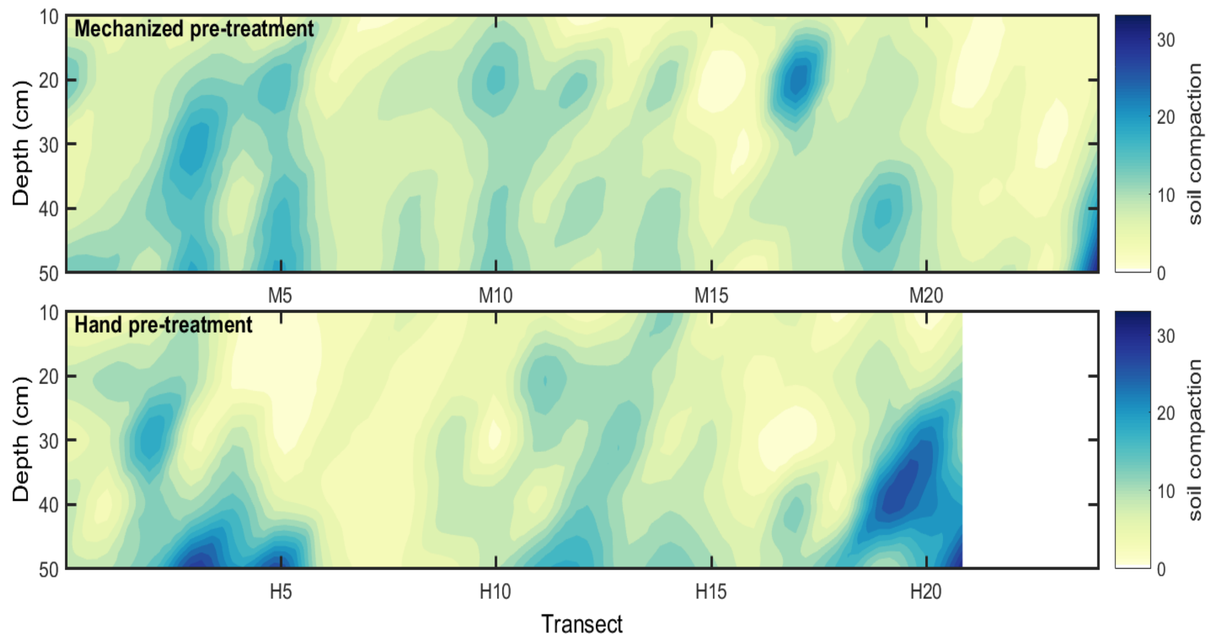
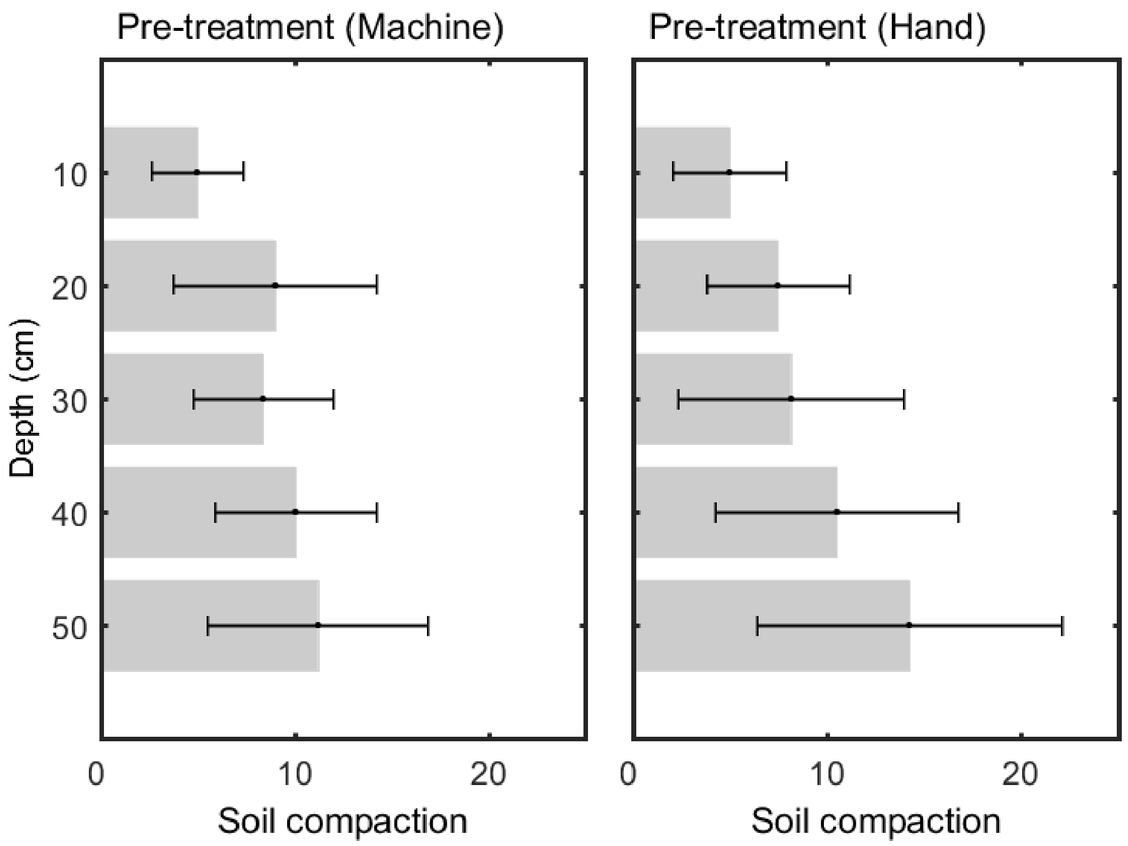
Unit production costs



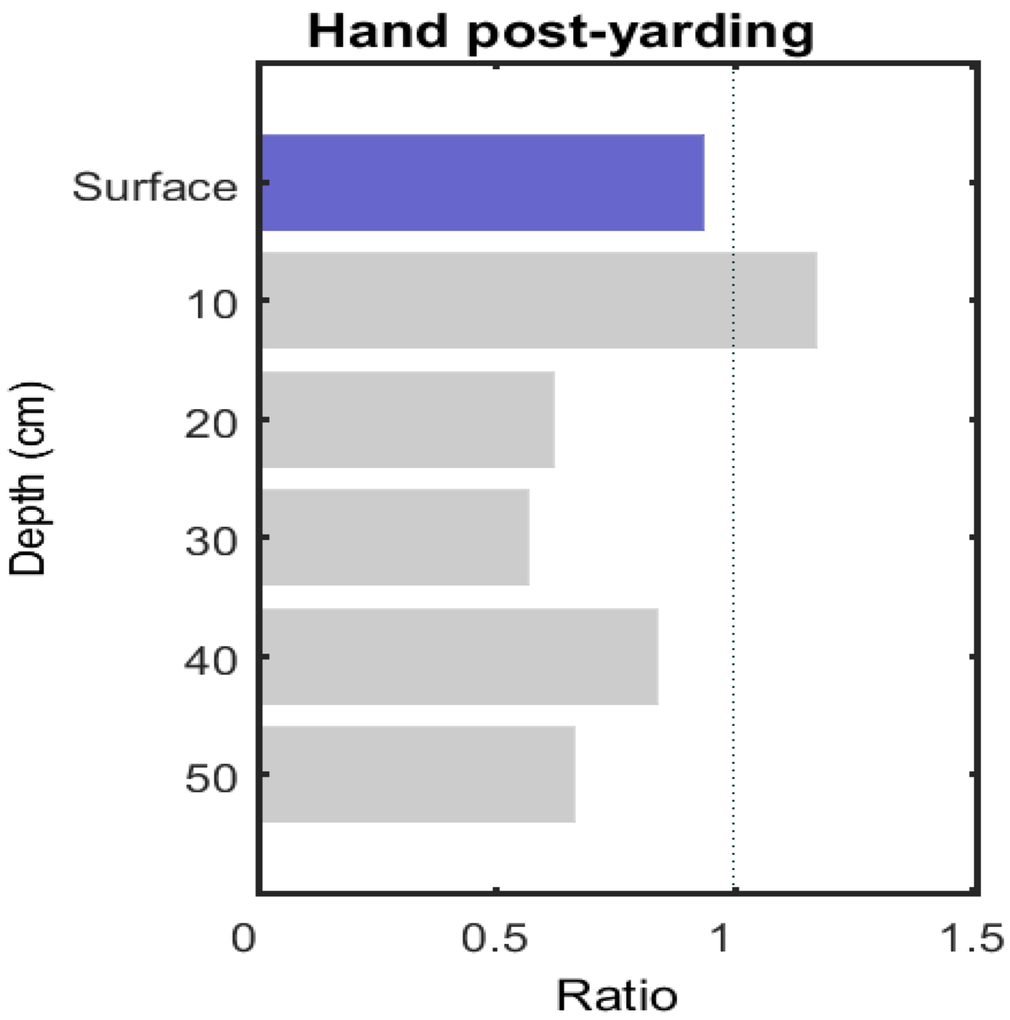




Pre-harvesting soil conditions

- 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 $p < 0.001$

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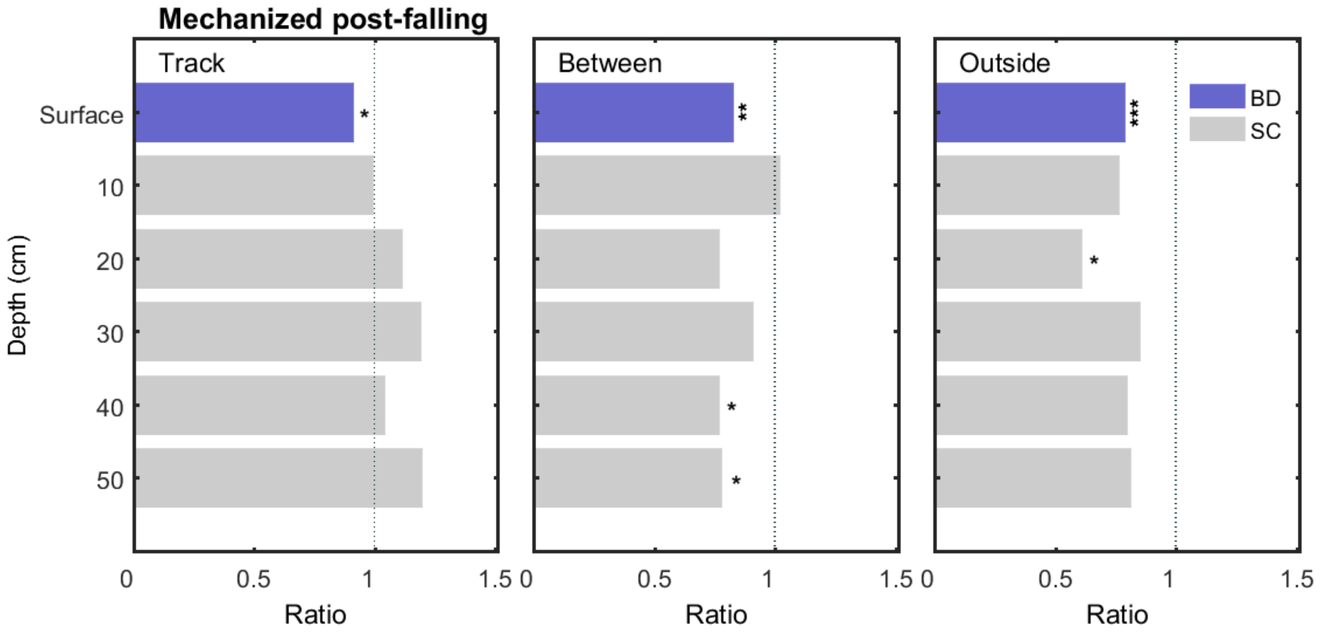
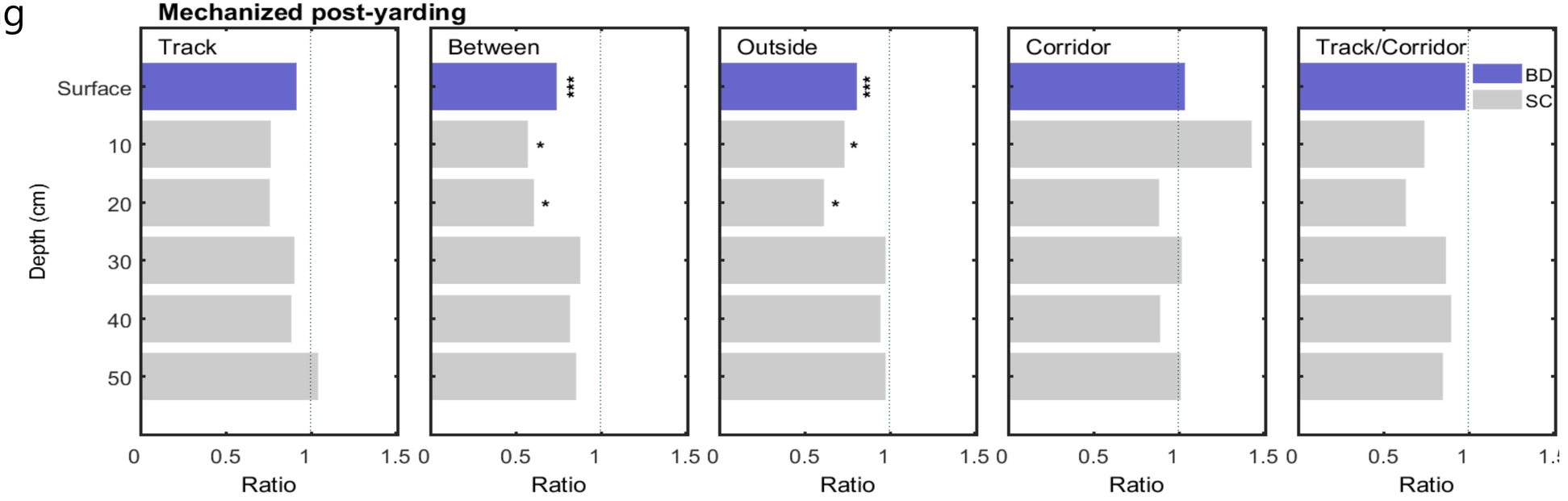
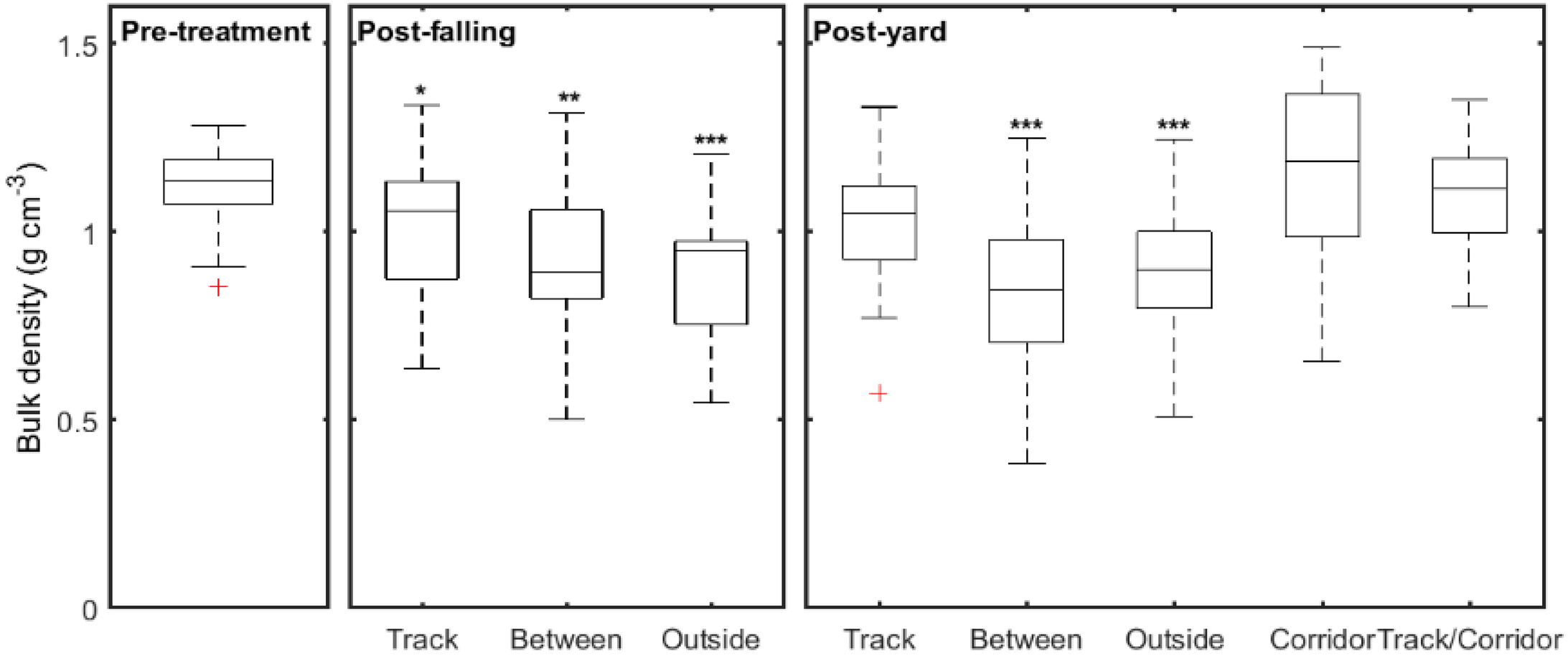
Machine post-felling



Machine post-yarding



Bulk density

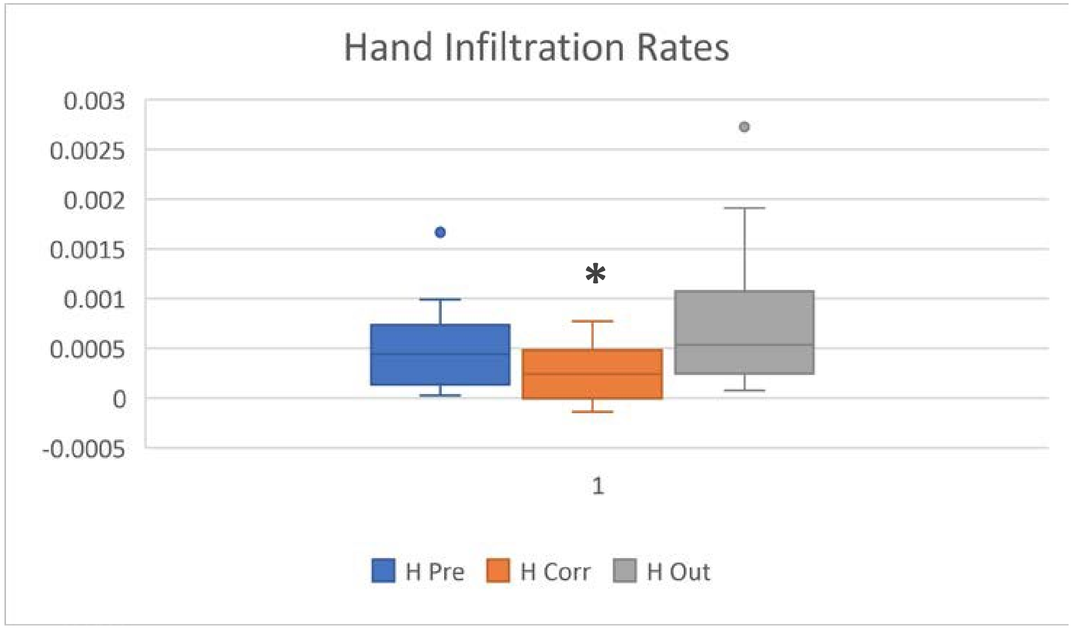


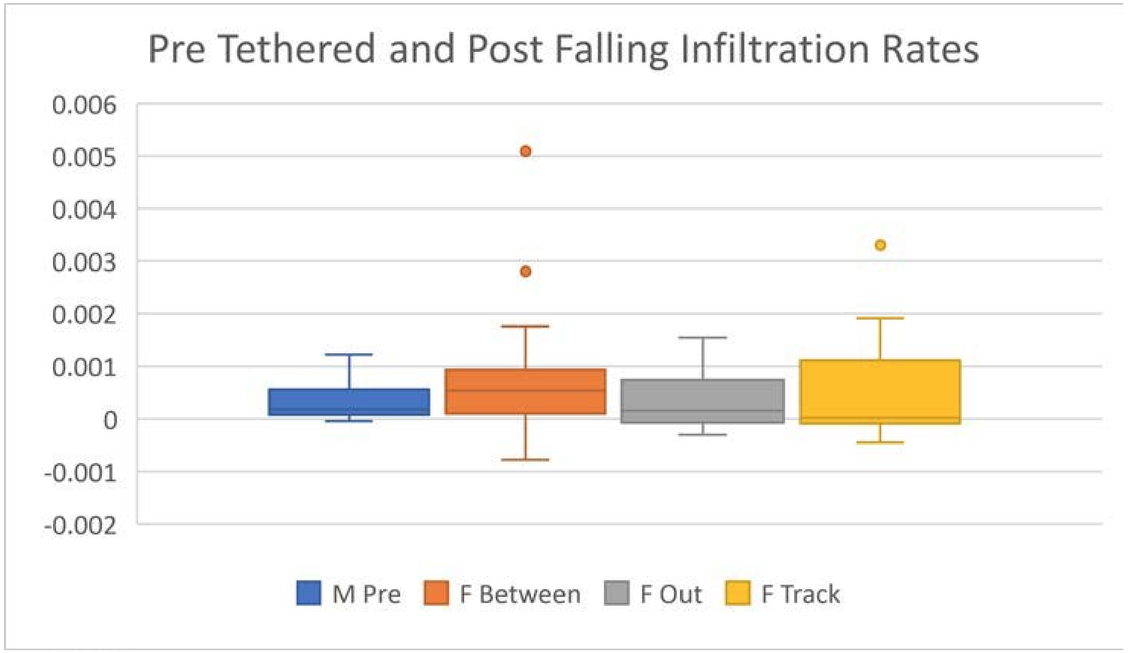
* significant at $p < 0.05$; ** significant at $p < 0.005$; *** significant at $p < 0.001$

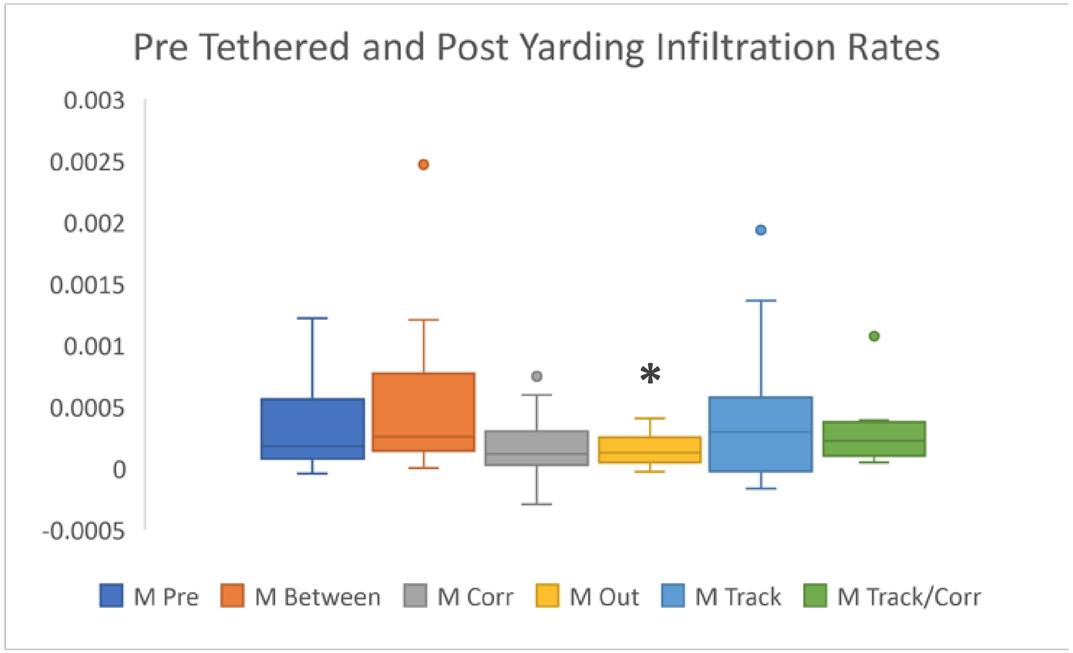
ENVIRONMENT

Infiltration Rates

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





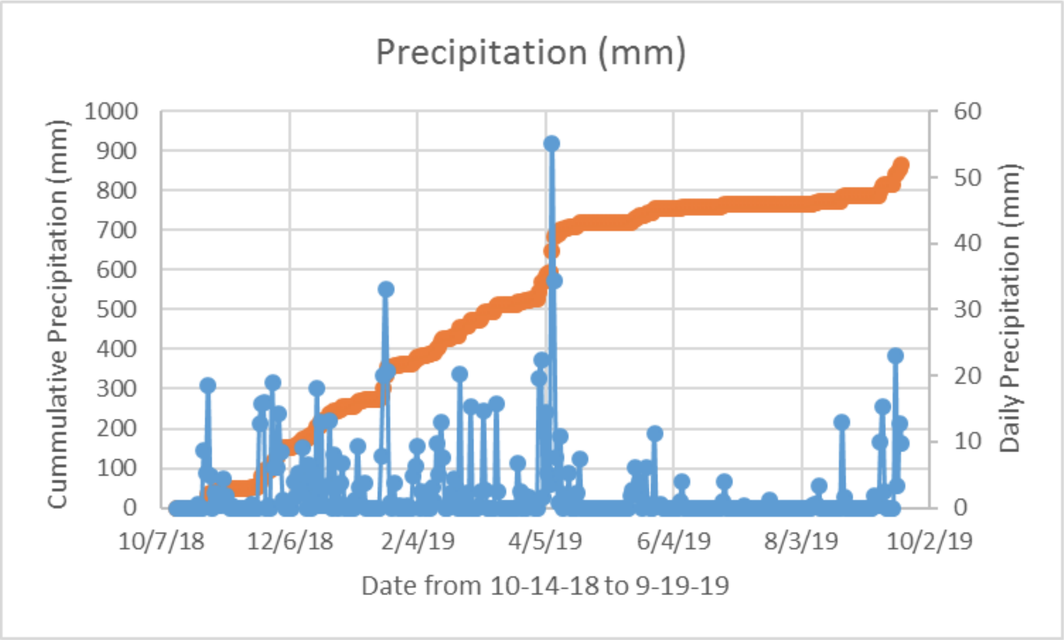


* significant at $p < 0.05$; ** significant at $p < 0.005$; *** significant at $p < 0.001$

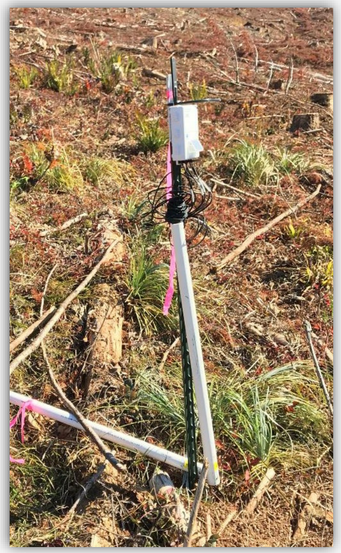
ENVIRONMENT

Sediment Transport

- Installed September 2018
- Precipitation of 880 mm between October 2018 – June 2019
- No sign of sediment transport observed



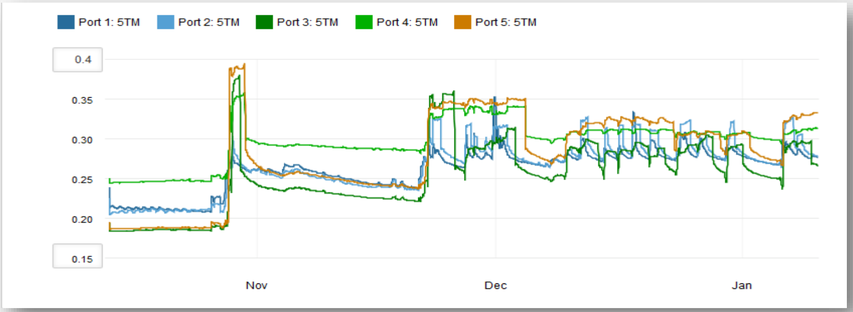
ENVIRONMENT

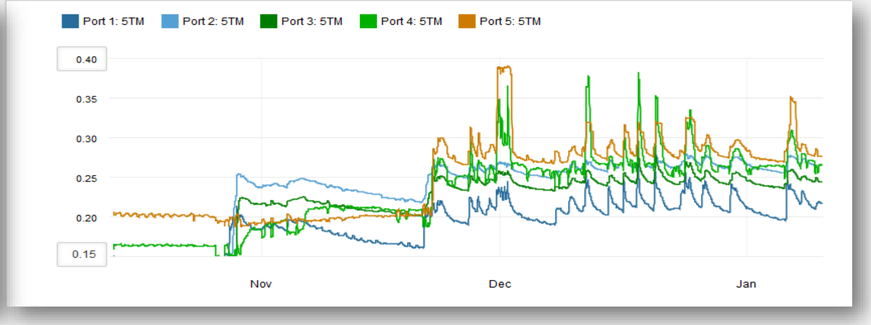


Machine Track

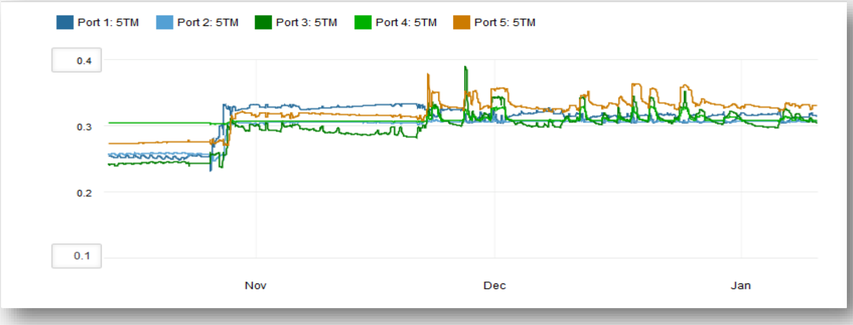
Non-track

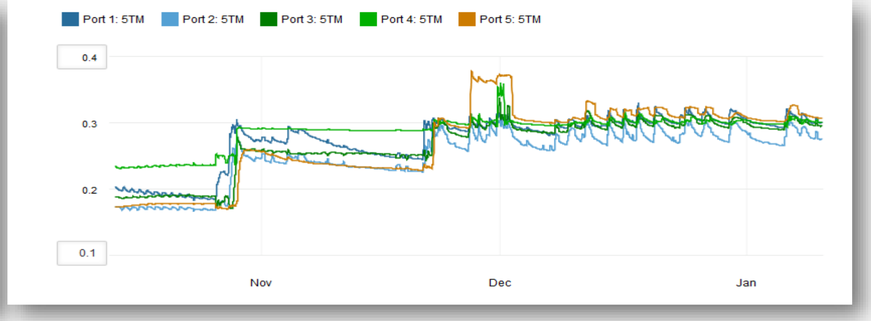
Location #1



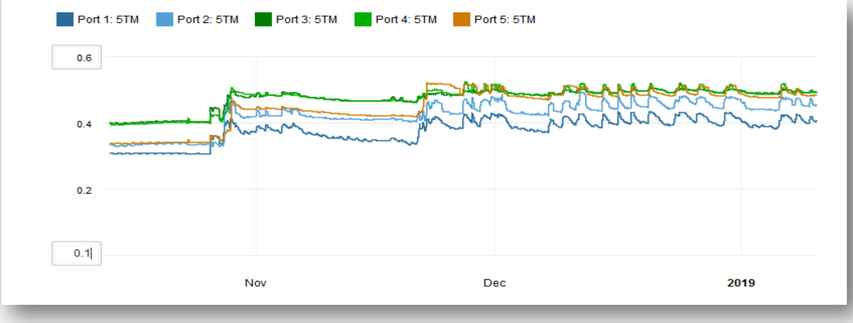


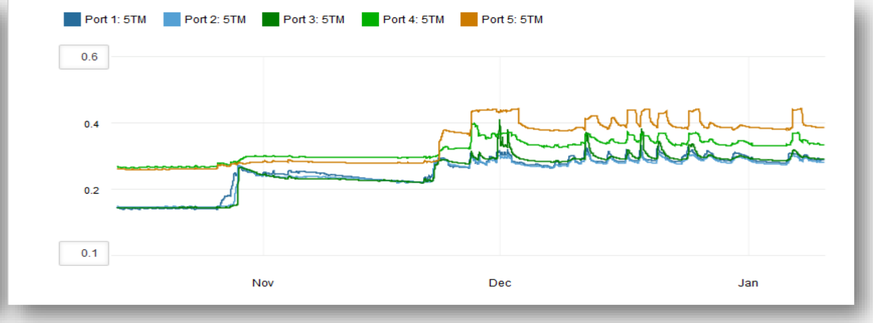
Location #2



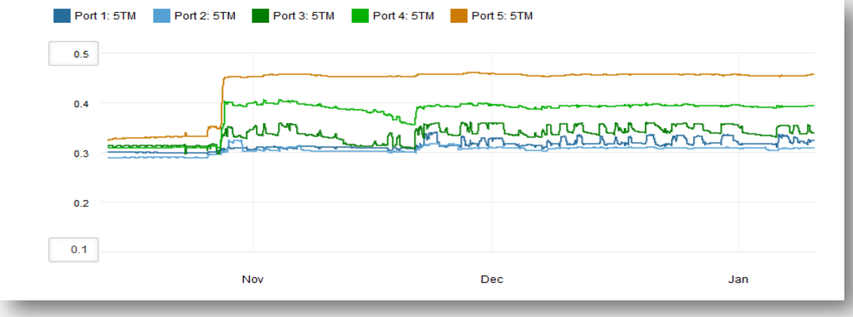


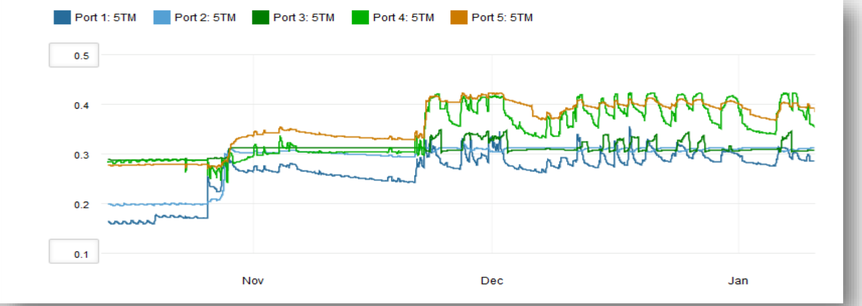
Location #3





Location #4





SUMMARY

Economic and Environmental Impacts of Cable-Assisted Logging

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

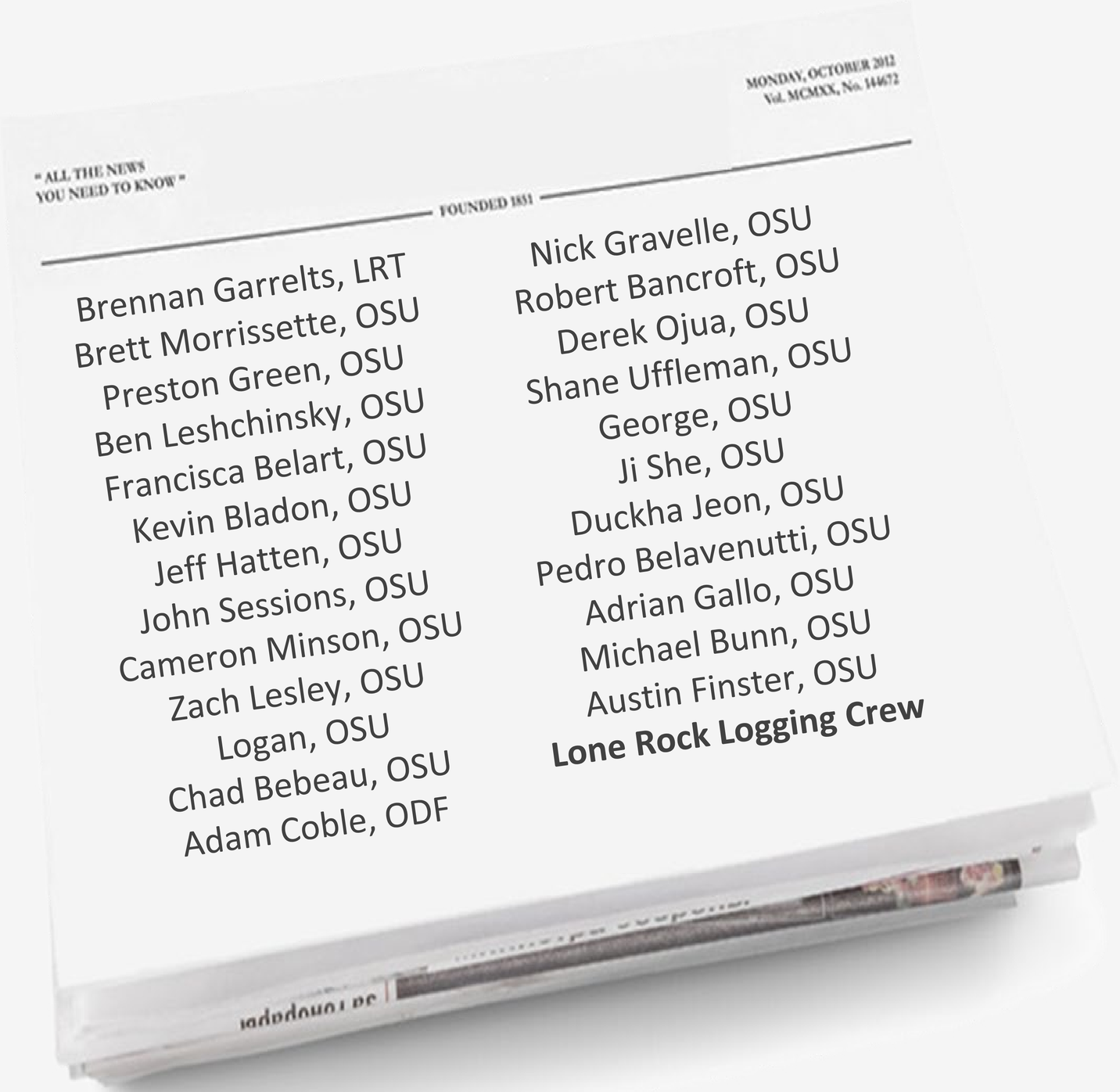
ENVIRONMENT

Seedling Growth Experiment

Future Soil Impact Experiments

Tethered logging in WA (November 2019)
Tethered logging in ID (April 2020)

ACKNOWLEDGMENT



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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

Oregon State University

LONE ROCK RESOURCES

THANKS

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