TETHERED CTL IN WESTERN OREGON

Productivity, cost and environmental impacts of steep slope harvesting in western Oregon.

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College of Forestry

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Oregon State University

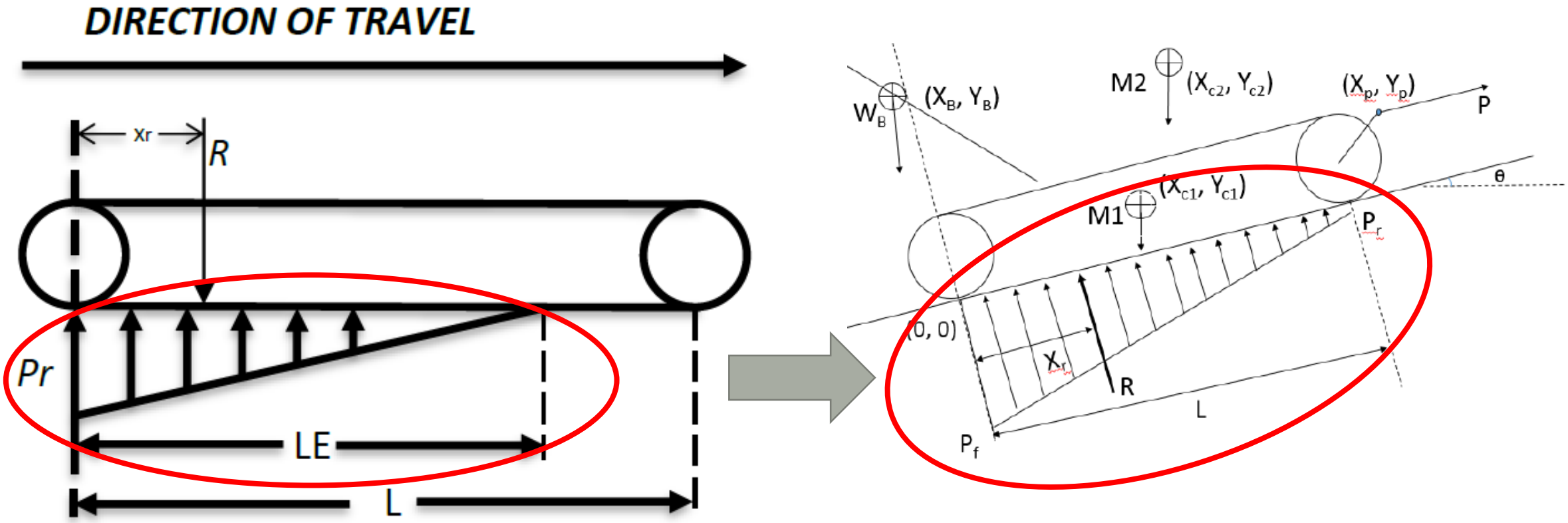
Steep Slope Harvesting

- Research Introduction (NIOSH Project) and Goals
- Theory Interlude
- Study Overview
- Methodology, Results and Discussion
  - Dry Bulk Density, Penetration Resistance
  - Productivity and Cost
- Visual Impacts
- Take-away Messages, Management Implications

NIOSH Research Introduction & Goals

- Motivations:
  - Logging is “difficult, dirty, dangerous, and declining”
  - Logging is the first step in an industry that generates over $5.2 billion in revenue for Oregon alone
  - Workforce, mechanization, political environment are all drivers of change
- Research Arms & Goals:
  - Assessing practical and physiological response of logging workers
  - Assessing environmental impacts of various steep-slope harvesting systems
  - Measure shift-level productivity of felling and yarding as part of worker risk exposure
  - Development of guidelines and design criteria for new logging systems

Soil impacts are dictated by…



Images courtesy of FE 470 Class Notes


…And soil type!

Research Project Overview

- Study to asses soil impacts as well as productivity and cost
- “Quick Draw” harvest unit
- Thinning on Oregon State University Research Forest
- Unassisted and cable-assisted Ponsse[1] Bear and Elephant King
- Private harvesting contractor

[1]Mention or depiction of machines or trade names does not constitute endorsement by Oregon State University or any agency of the federal government.

Photos courtesy of Dr. Woodam Chung

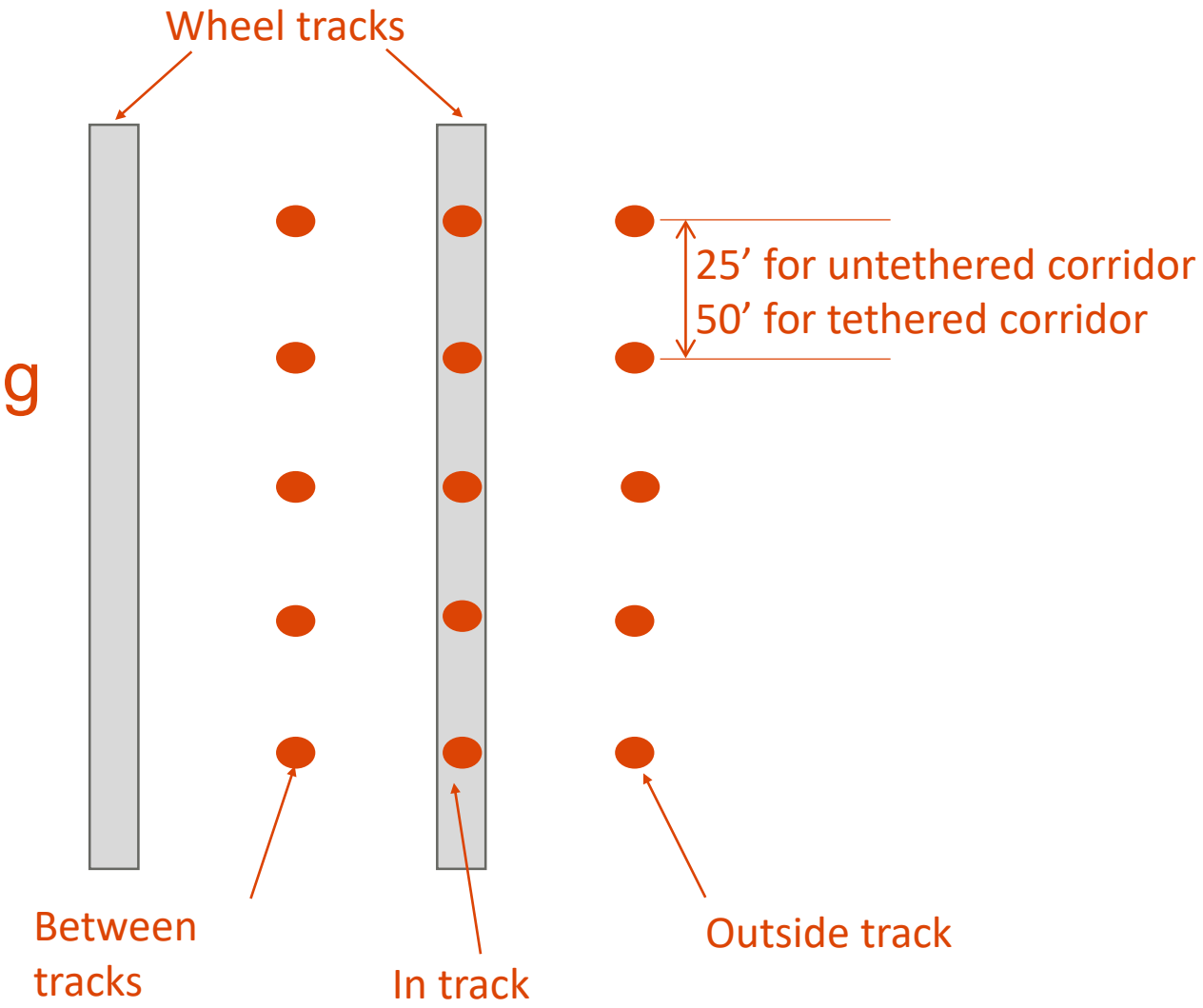
Research Project Overview

- Predominantly Douglas-fir
  - 7-18” DBH, 108’ tall cut trees; initial density ~118 TPA; cut from 175.5 ft^2/ac to 122.8 ft^2/ac (52.5 ft^2/ac cut)
- Clay soils, dry operating conditions
  - Research done in August 2017

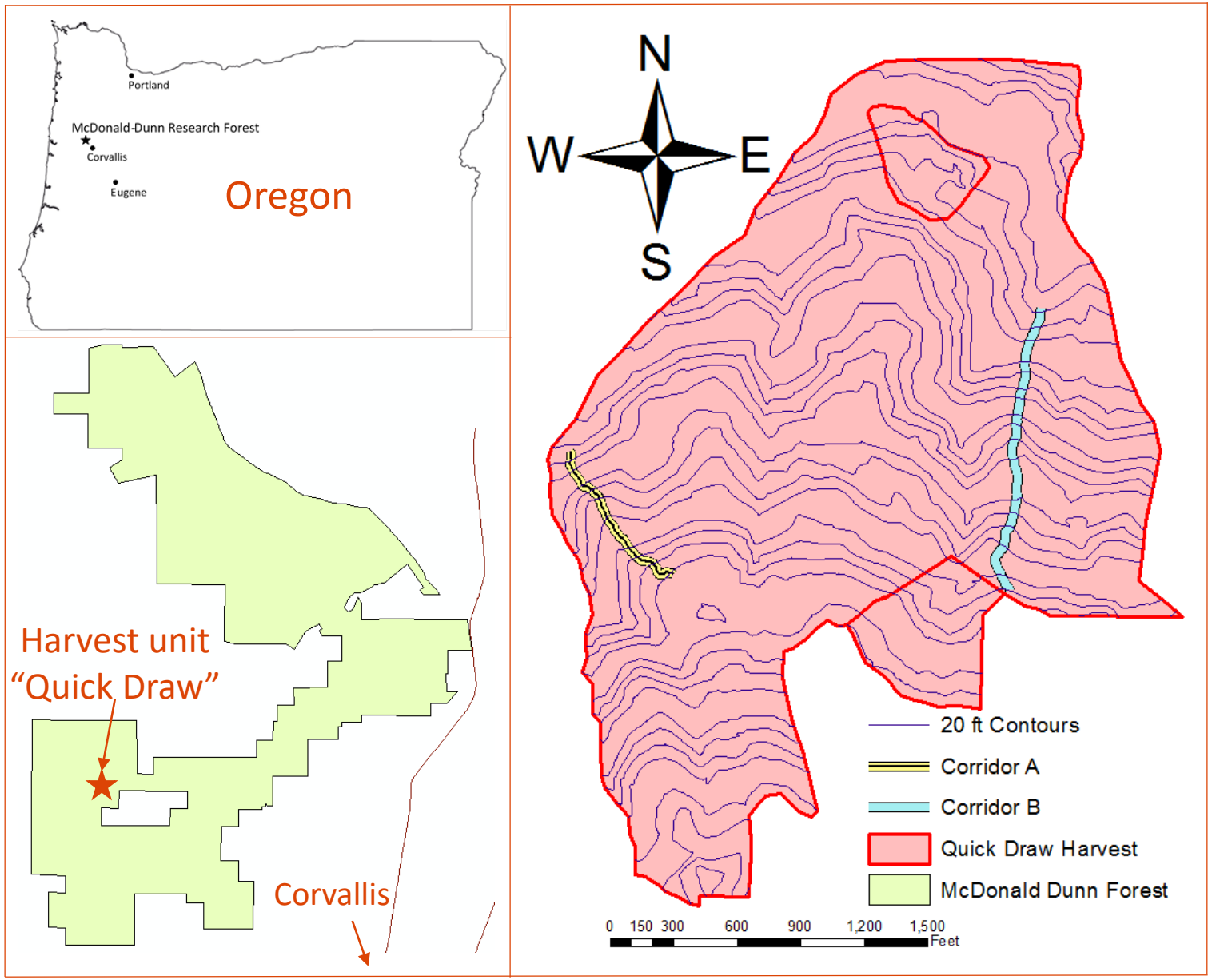
Photos courtesy of Dr. Woodam Chung

Methodology, Environmental Impacts

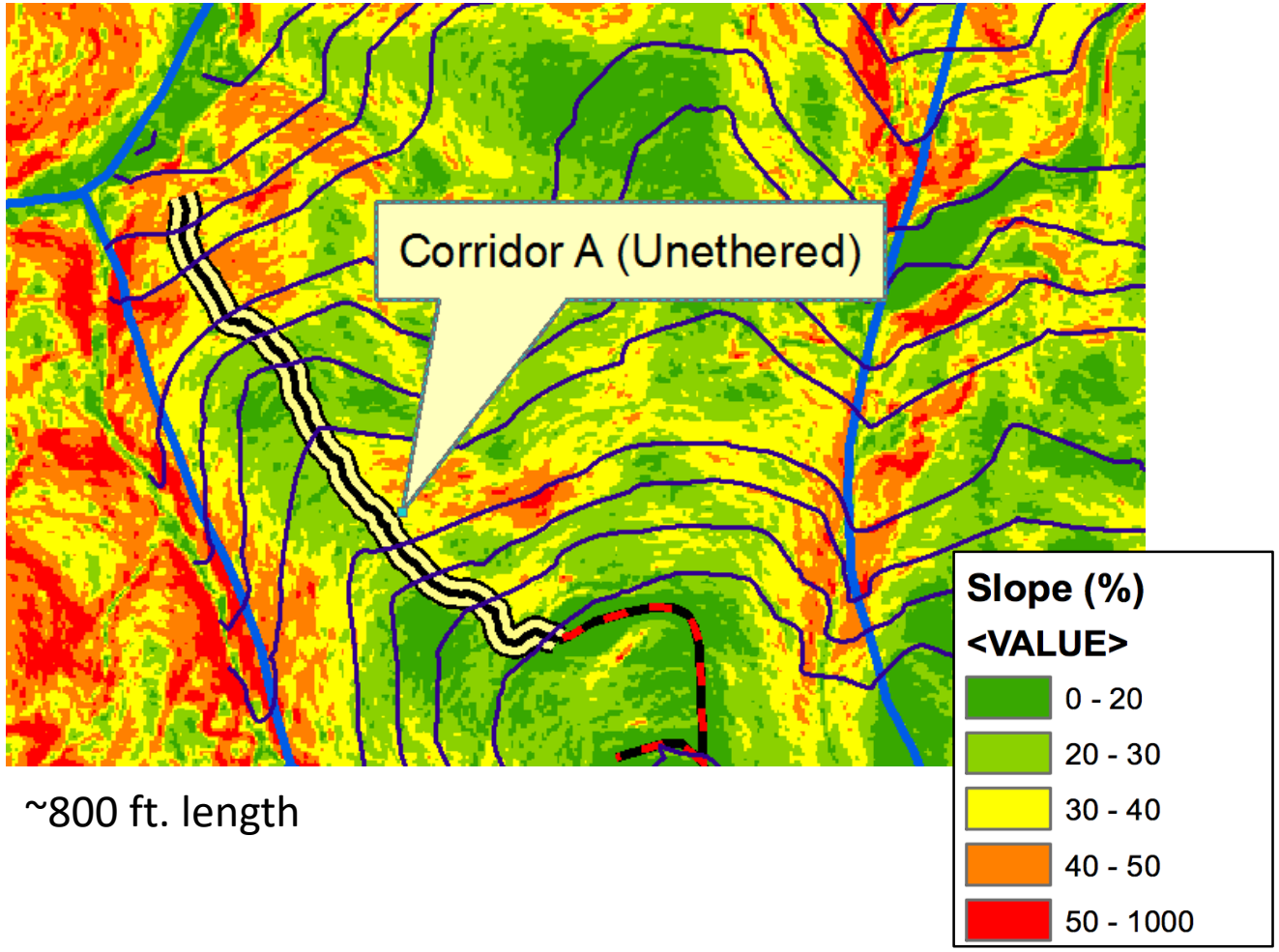
- Paired corridor approach
- Fixed sampling before harvest, after harvesting, after forwarding
- Surficial and at-depth measurements taken
  - Dry bulk density and penetration resistance



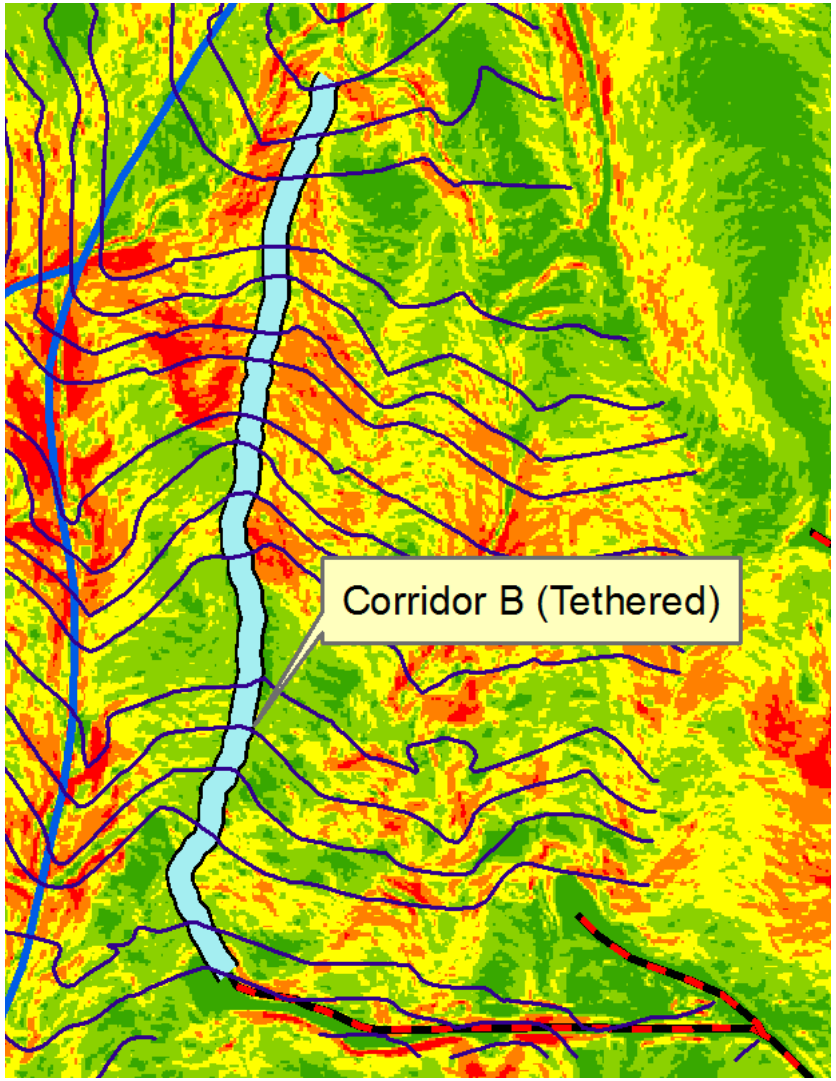
Harvest Unit



Harvest Unit



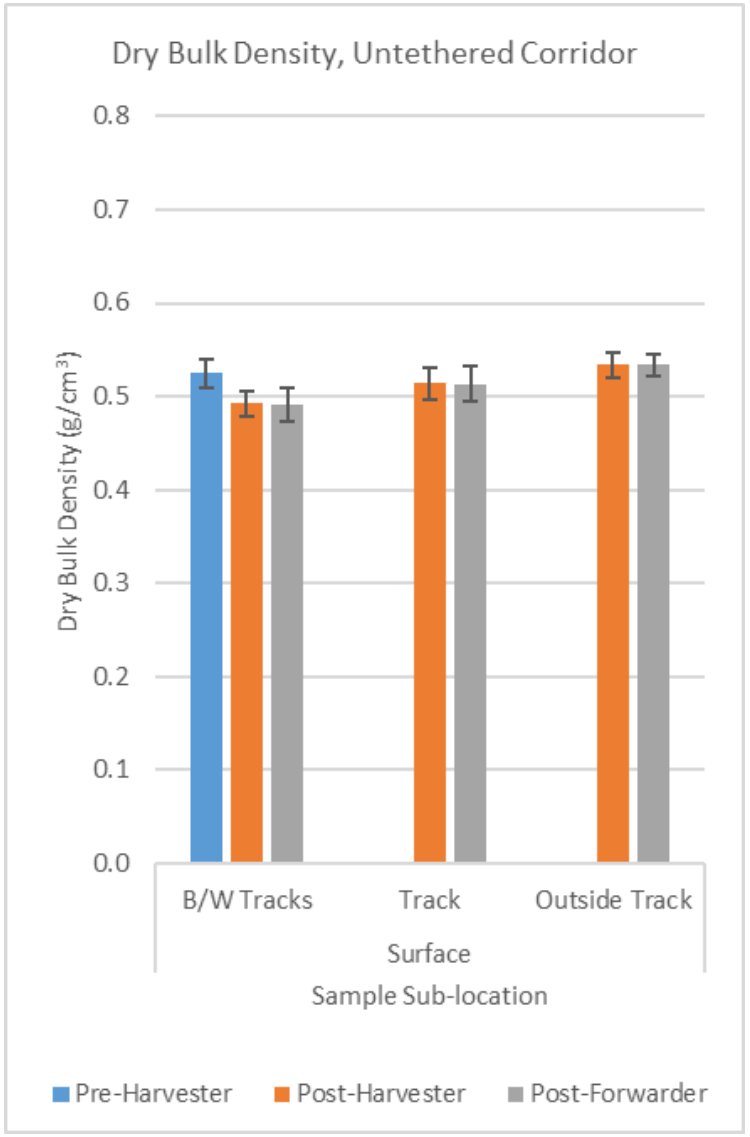
~800 ft. length

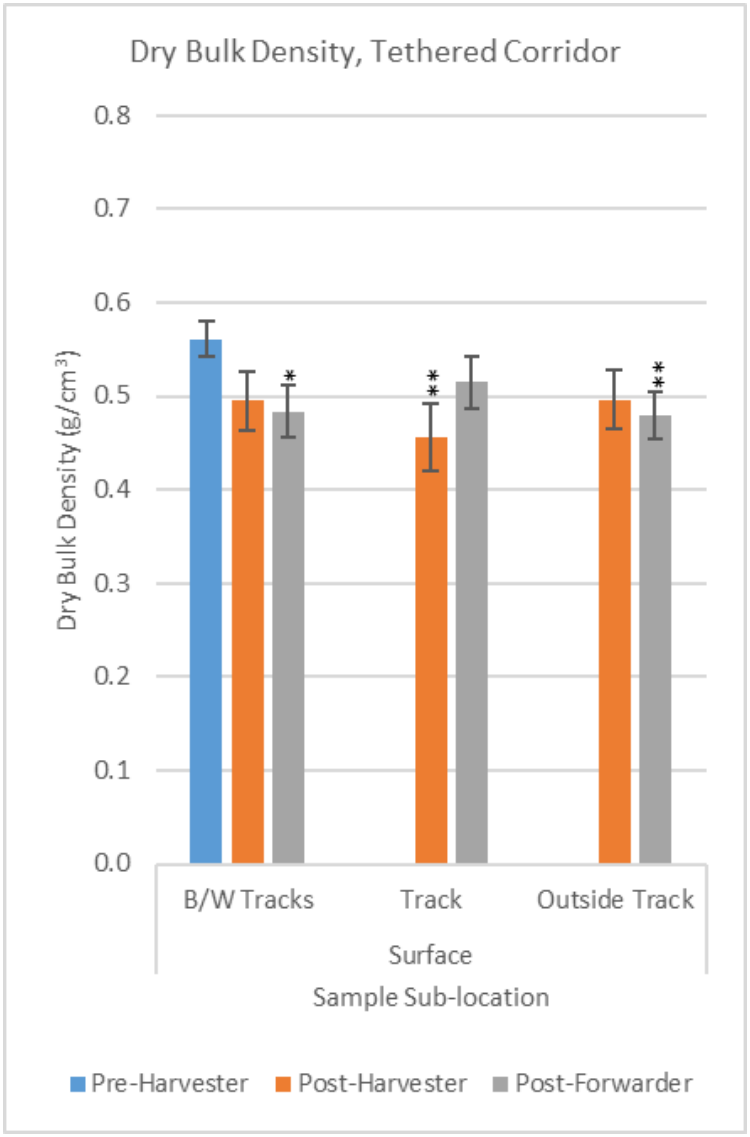


~1,450 ft. length

Results

Dry Bulk Density


Dry Bulk Density, Untethered Corridor
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Dry Bulk Density (g/cm³)
B/W Tracks
Track
Outside Track
Surface
Sample Sub-location
Pre-Harvester
Post-Harvester
Post-Forwarder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Dry Bulk Density (g/cm³)
*
**
**
B/W Tracks
Track
Outside Track
Surface
Sample Sub-location
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Results

Penetration Resistance

Static Cone Penetrometer

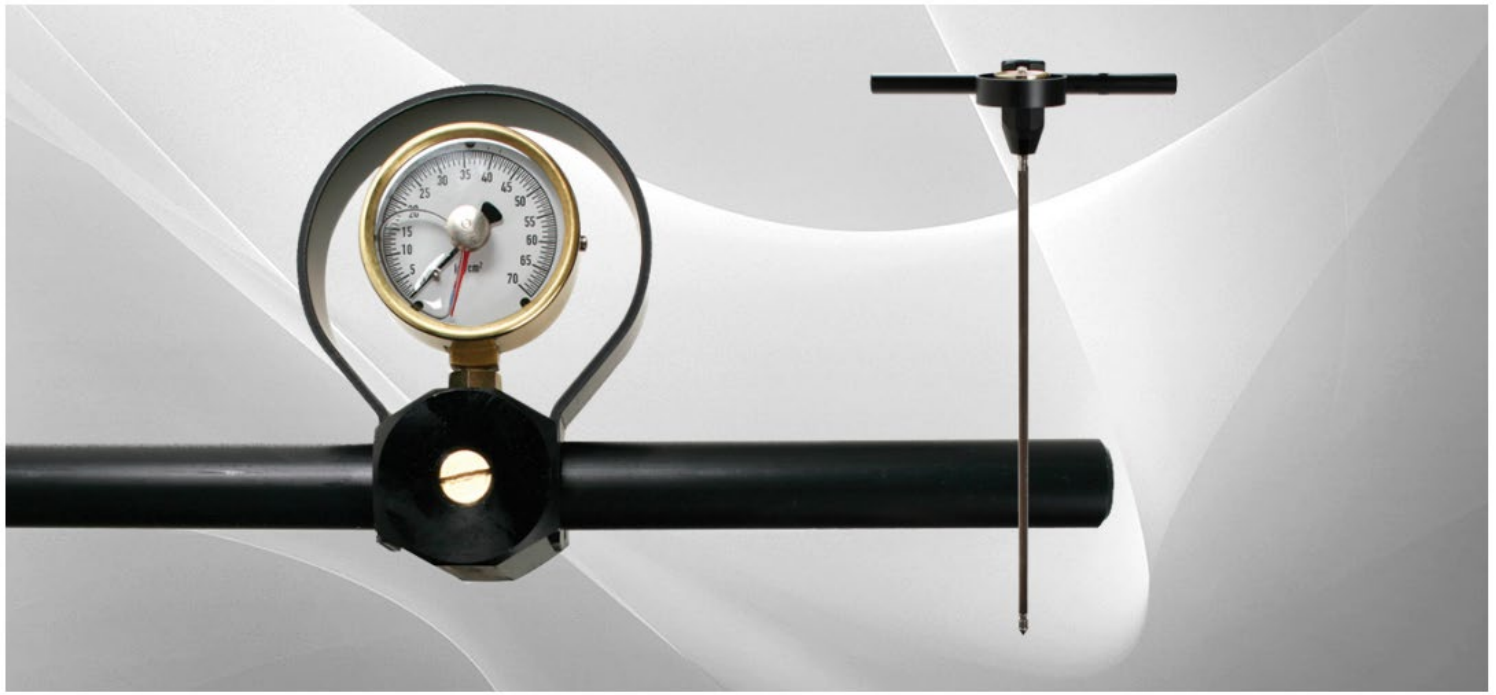
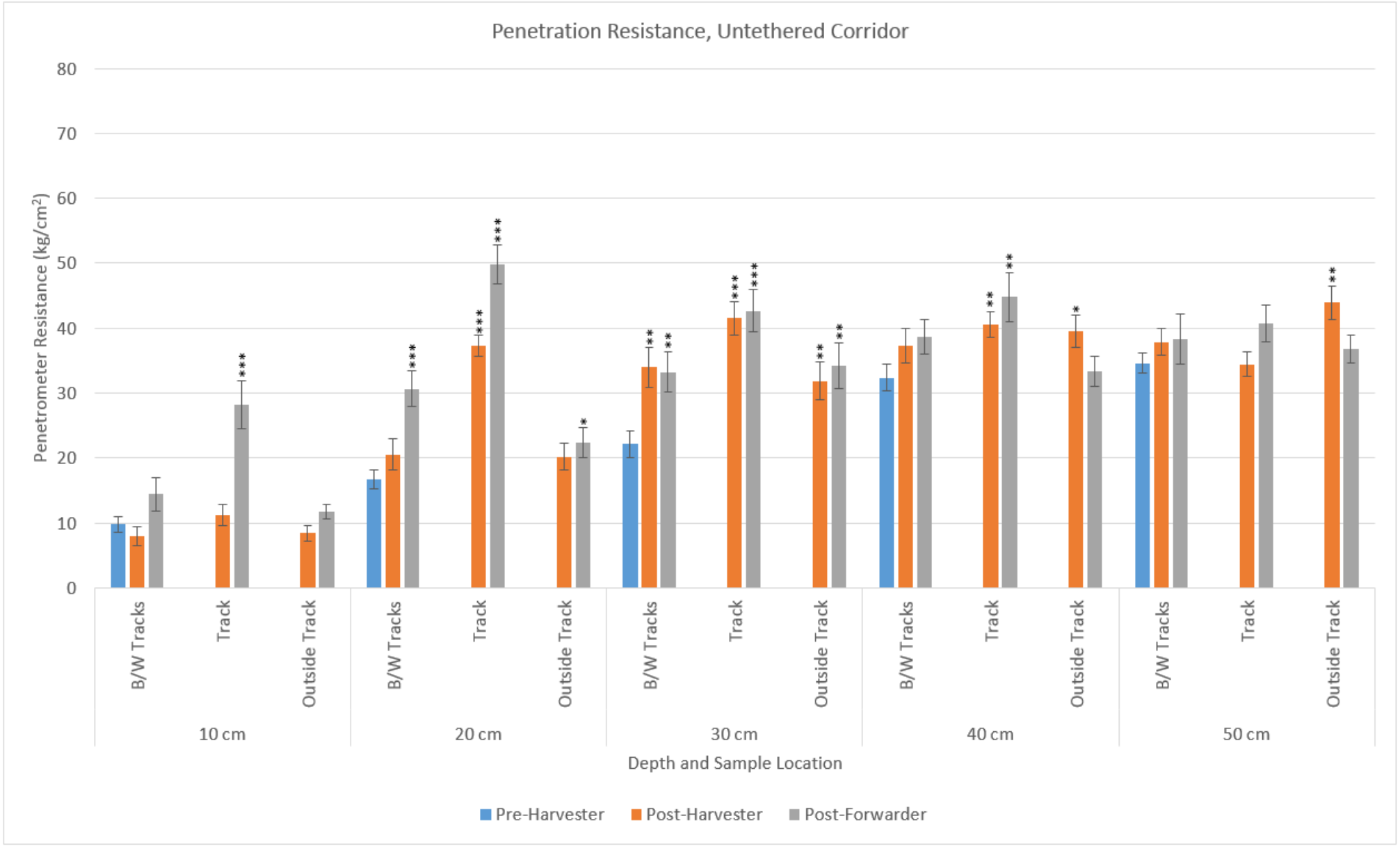
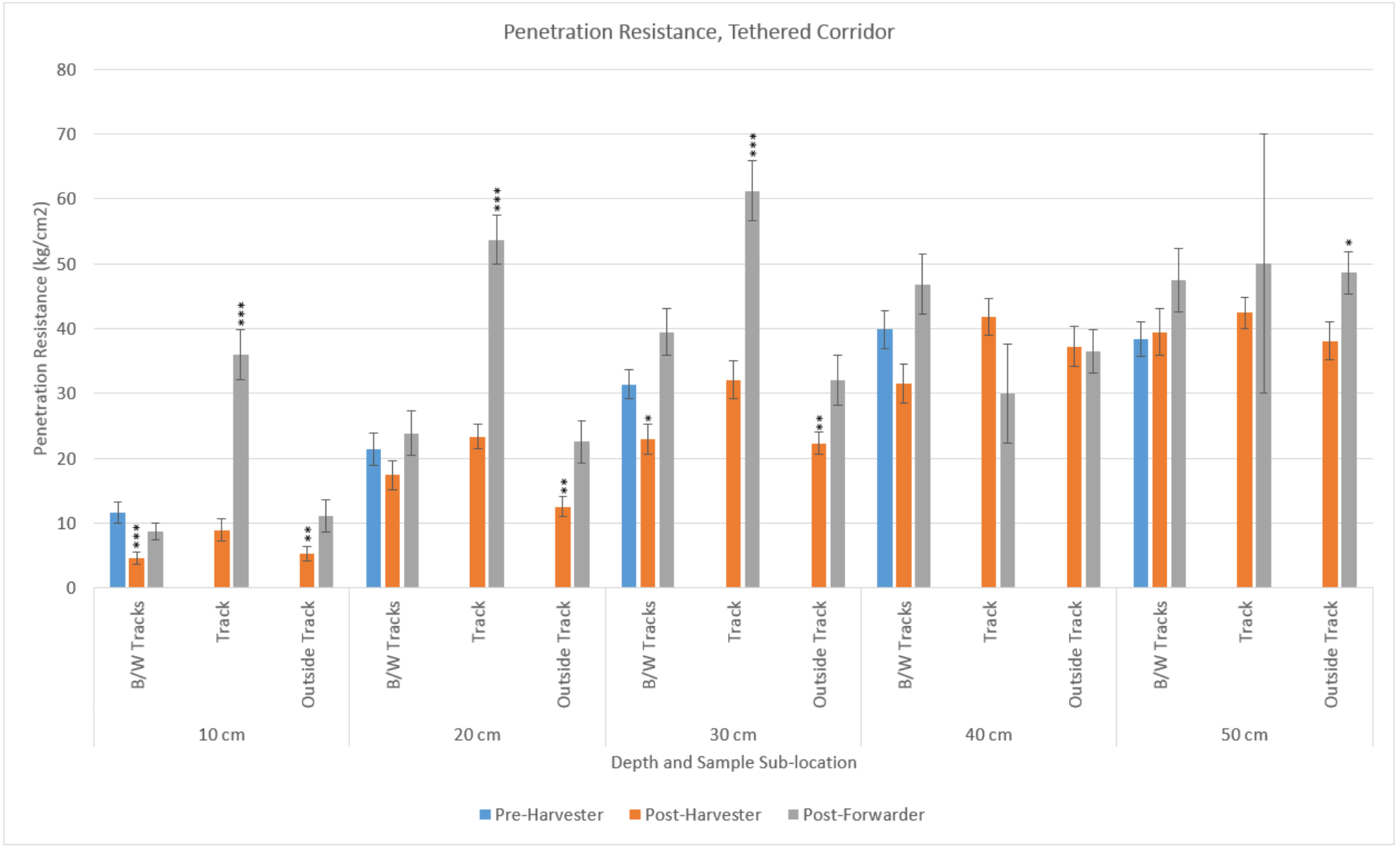


Photo from Humboldt Manufacturing website (www.humboldtmfg.com)


Penetration Resistance, Untethered Corridor
Penetrometer Resistance (kg/cm²)
80
70
60
50
40
30
20
10
0
B/W Tracks
Track
Outside Track
10 cm
20 cm
30 cm
40 cm
50 cm
Depth and Sample Location
Pre-Harvester
Post-Harvester
Post-Forwarder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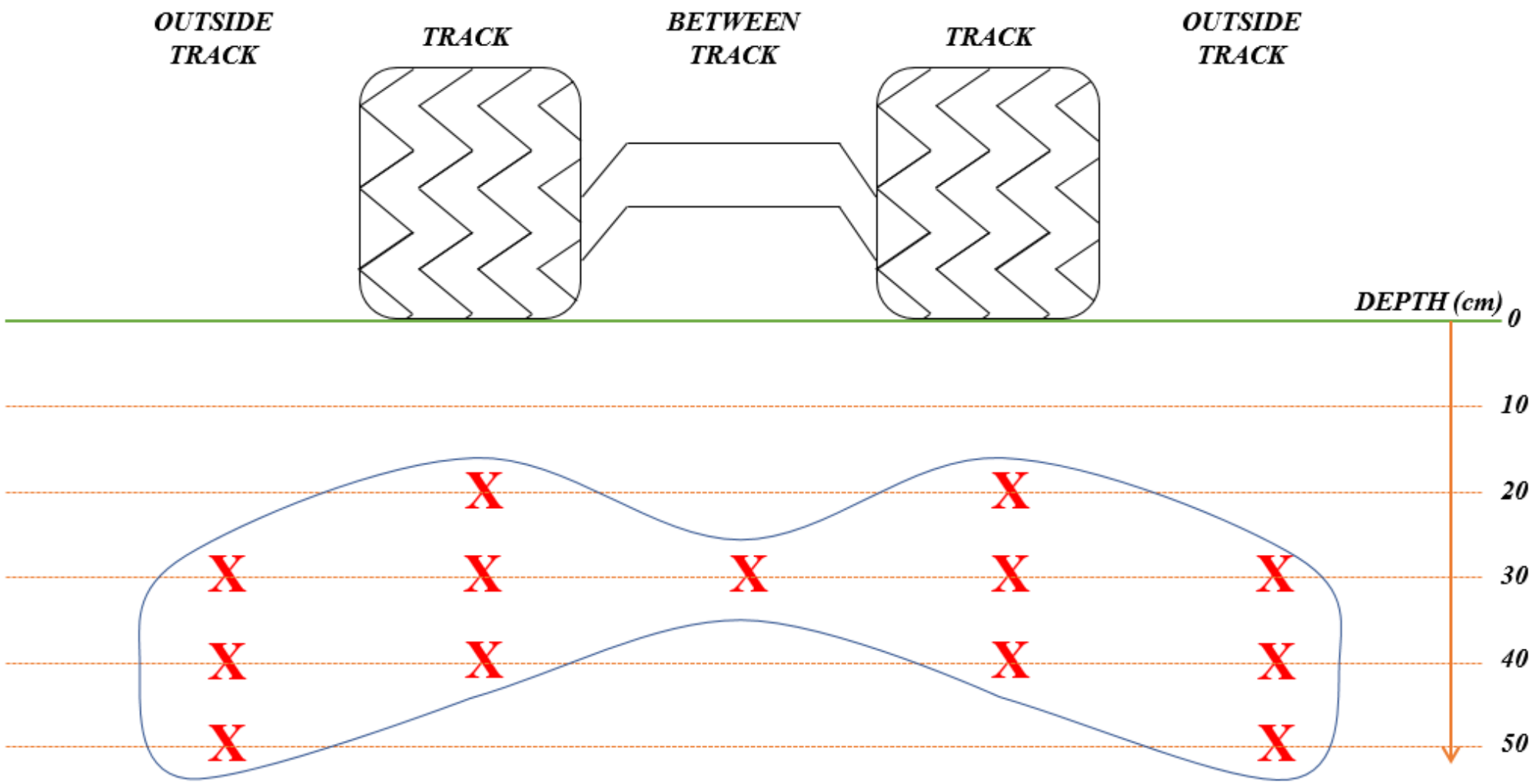
Pre-Harvester
Post-Harvester
Post-Forwarder

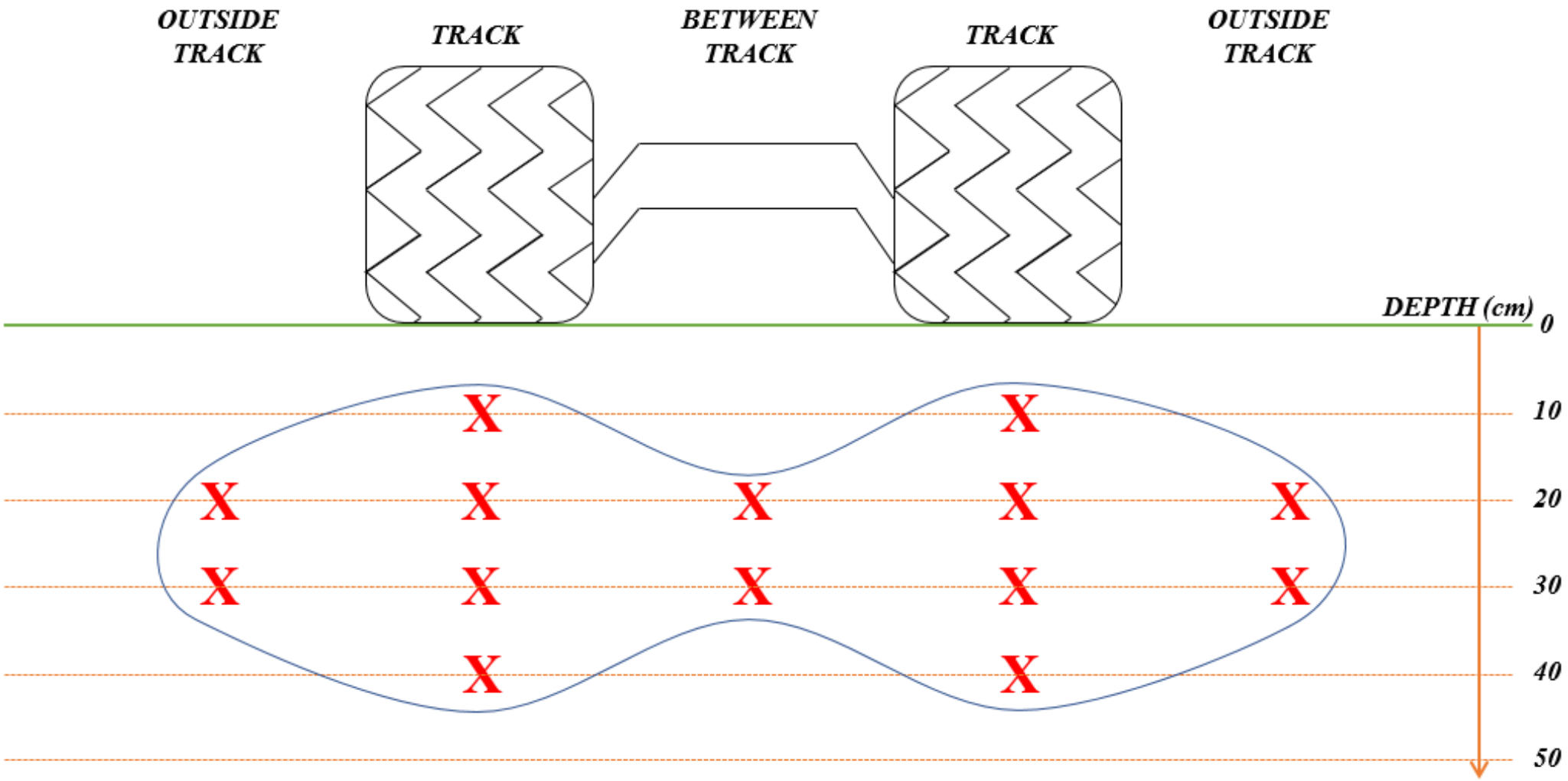
UNTETHERED, POST-HARVESTER



Legend:

X = statistically significant ***increase***.

UNTETHERED, POST-FORWARDER



Legend:

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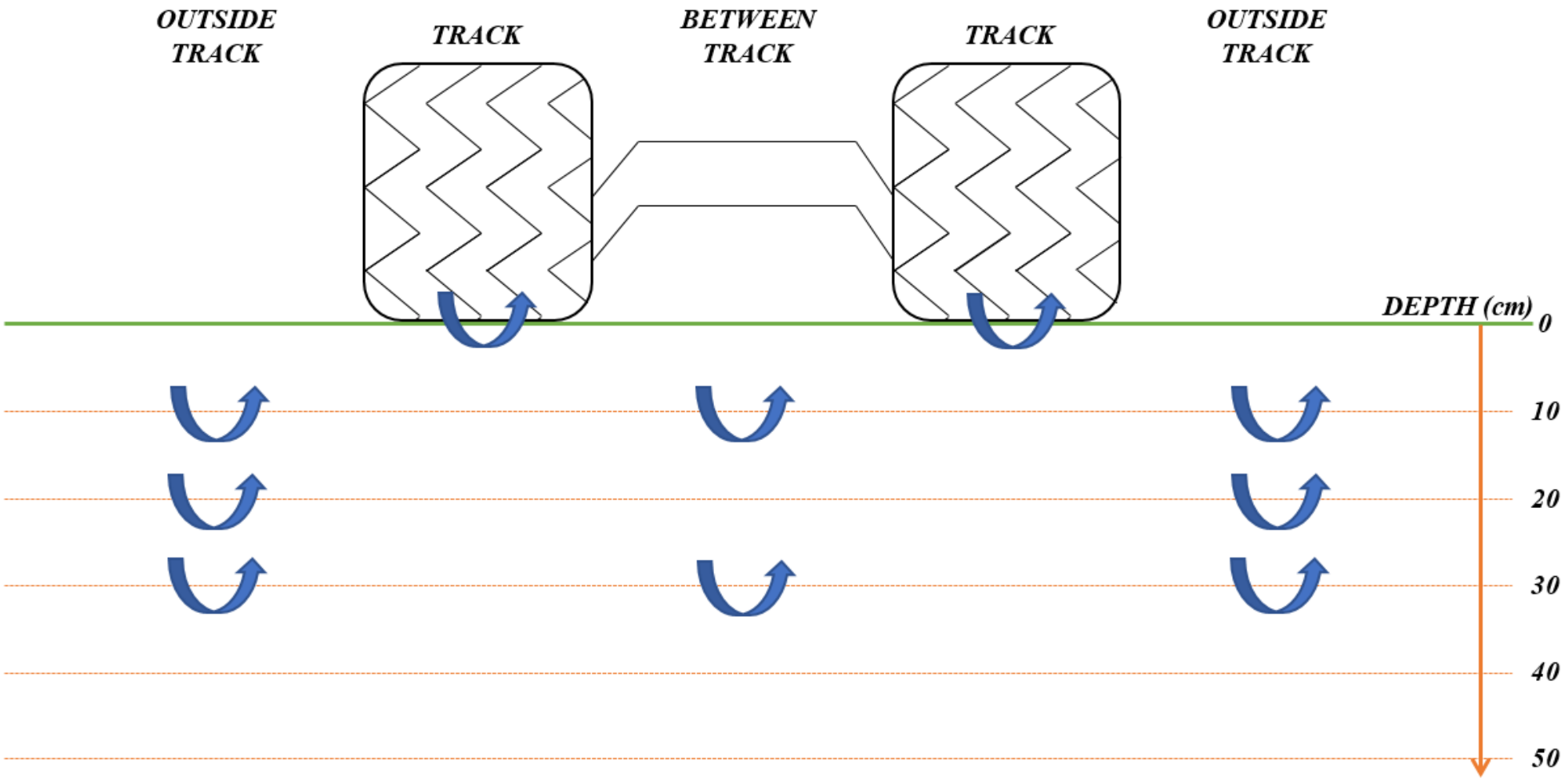
TETHERED, POST-HARVESTER

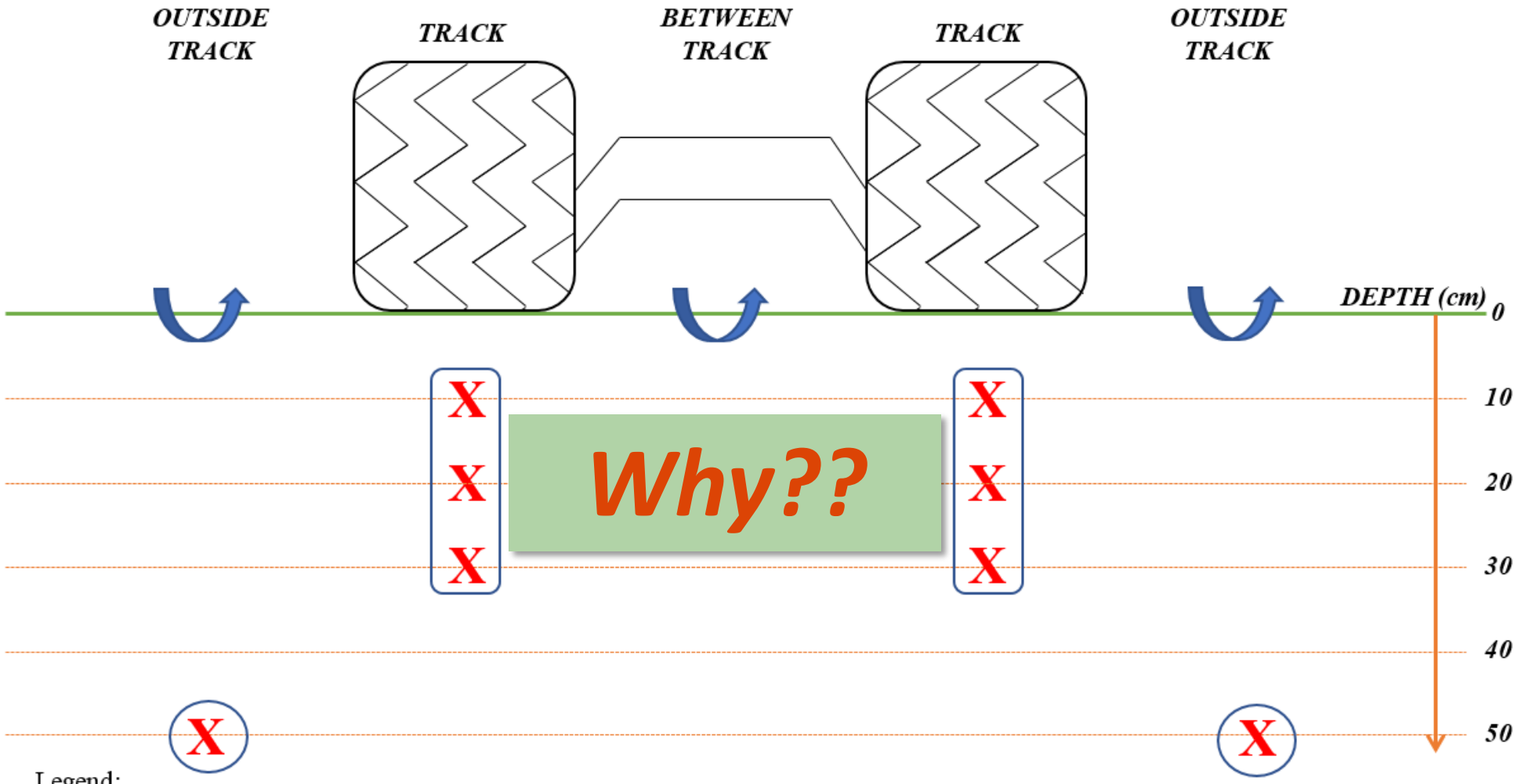


Legend:

X = statistically significant ***increase***.

= statistically significant ***decrease***.

TETHERED, POST-FORWARDER

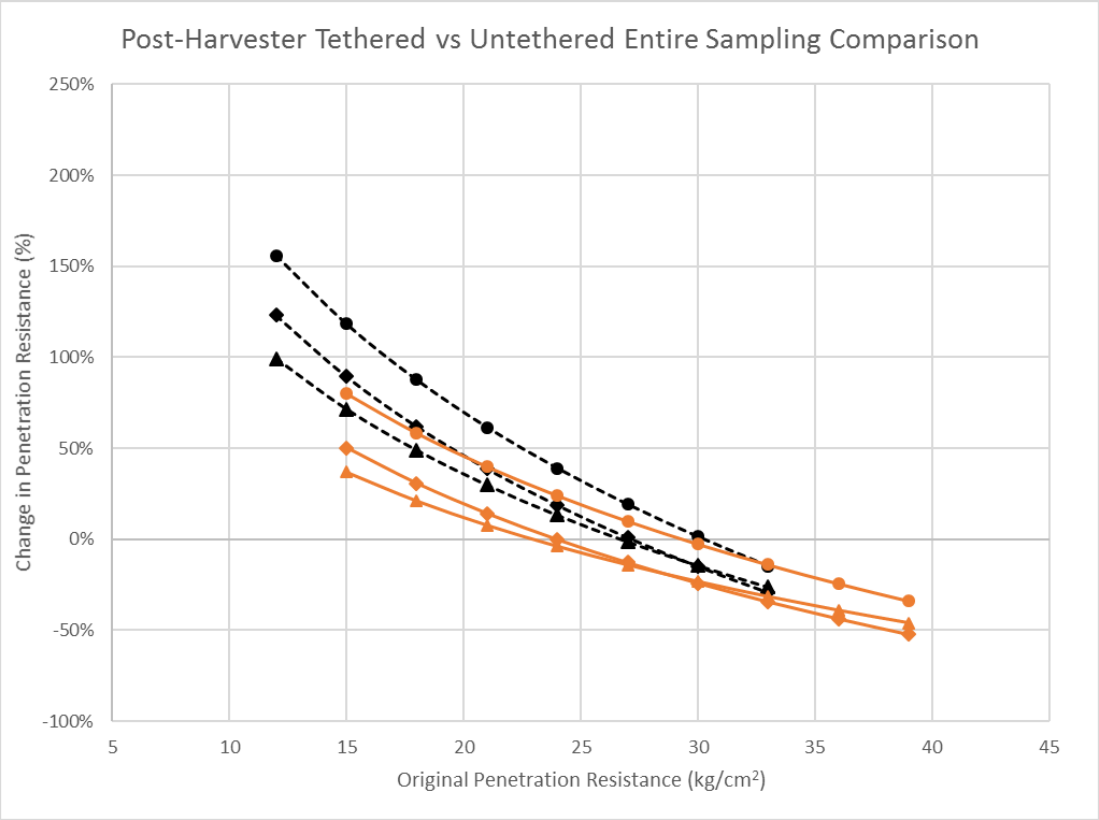


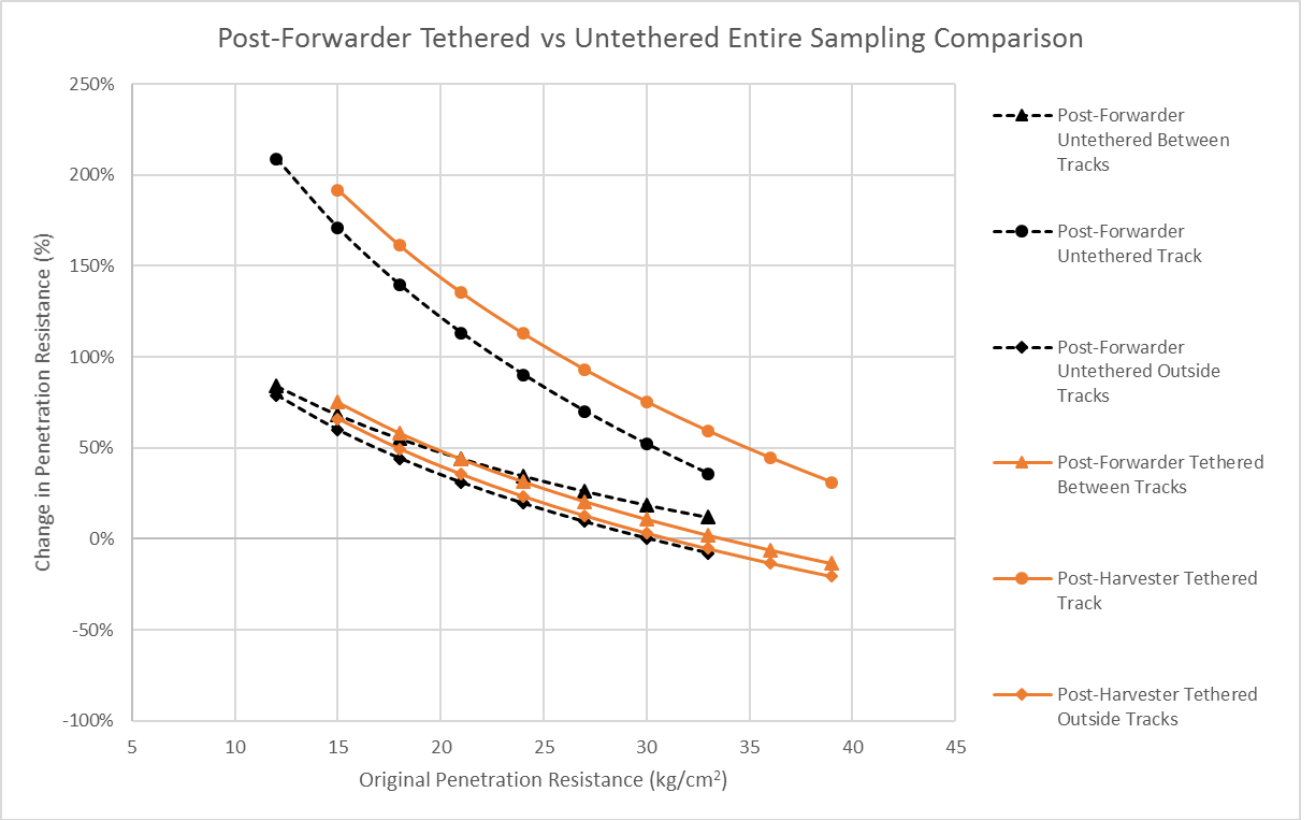
Why?

- Original soil condition
  - Looser materials contract, while denser materials expand
- Corridor A (untethered) soil was about 20% looser than corridor B (tethered) soil. Significant!

- Slope? No.
- Passes? No.

- Original soil condition
  - Looser materials contract, while denser materials expand





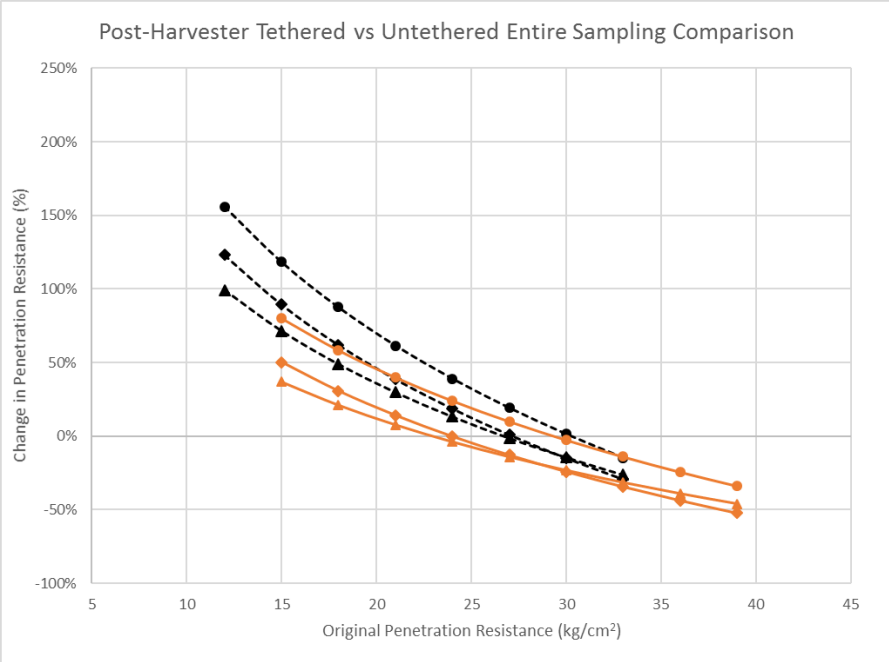
- Original soil condition
  - Looser materials contract, while denser materials expand

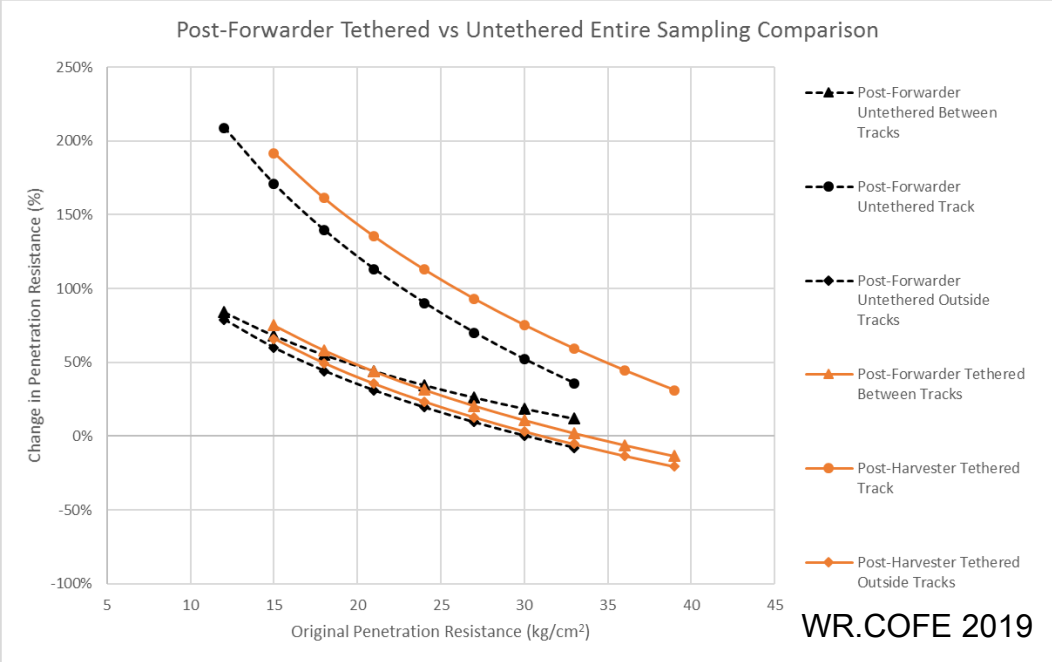
Post-Harvester

Rank	Location	% Change
1	Untethered Track	51%
2	Untethered Outside Track	30%
3	Untethered Between Tracks	22%
4	Tethered Track	7%
5	Tethered Between Tracks	-15%
6	Tethered Outside Track	-17%

Post-Forwarder

Rank	Location	% Change
1	Untethered Track	106%
2	Tethered Track	89%
3	Untethered Between Tracks	41%
4	Untethered Outside Track	27%
5	Tethered Between Tracks	18%
6	Tethered Outside Track	11%

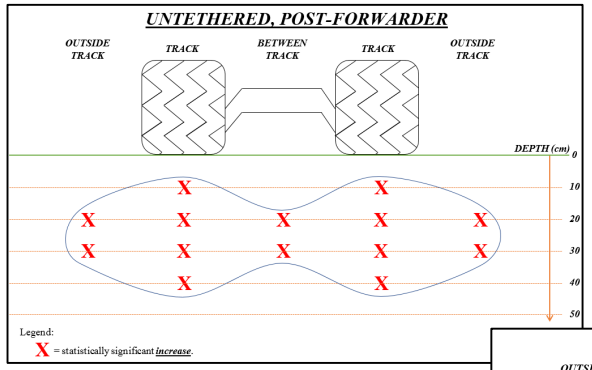




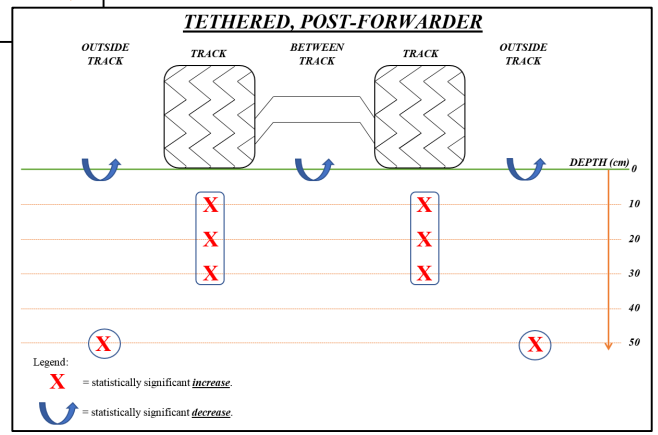
Soil Discussion

Horizontal benefits

- Controlled ‘track wander’
- Less significant ground coverage!

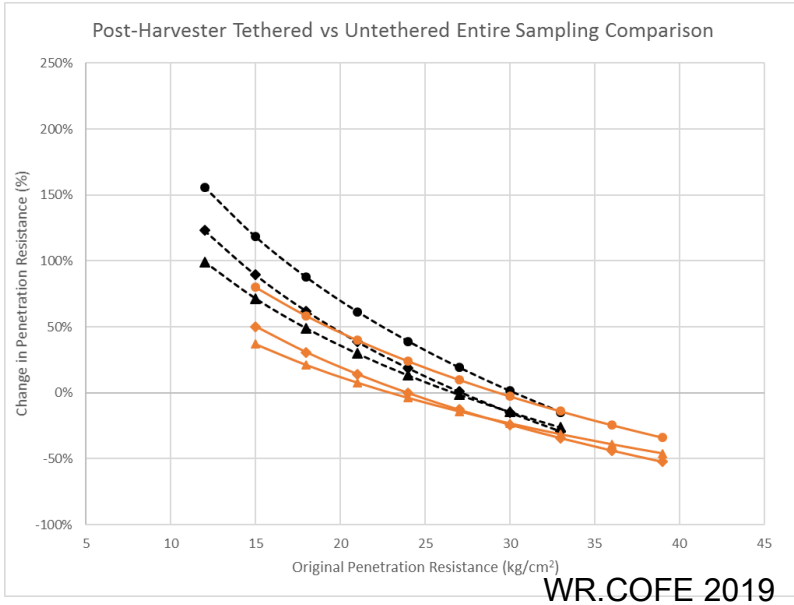


versus…



Vertical benefits

- Reduces maximum ground pressure → reduces shear displacement (maintaining soil profile) → enables more passes to reach densification



Productivity & Cost

Methodology, Harvesting & Forwarding Productivity

- Detailed time study of unassisted & cable-assisted harvester & forwarder via paper/stopwatch and video recording
- GPS tracking of machines to determine precise movement distances
- Tree size (dbh) observed from harvester display in cab

Photos courtesy of Dr. Woodam Chung

Harvesting & Forwarding Productivity

- Machine costs generated via publicly available cost models
- Harvesting/forwarding productivity models generated through regression techniques
- “Coupled” versus “uncoupled” system to show productivity ranges
- 19 ft^3/log measured at roadside after forwarding

Coupled System Productivity

Machine	MBF/PMH	Utilization	MBF/SMH	System Productivity (MBF/SMH)	U_F%
Untethered Harvester	25.7	80%	20.5	6.4	25%
Untethered Forwarder	8.0	80%	6.4		80%
Tethered Harvester	17.6	75%	13.2	7.1	40%
Tethered Forwarder	9.5	75%	7.1		75%

Coupled System Cost

	Costs Per SMH						
Machine	Fixed	Variable	Operator	TOTAL	(per MBF)	System ($/SMH)	Unit Cost ($/MBF)
Untethered Harvester	$133.55	$43.80	$42.30	$219.65	$34.38	$535.09	$83.75
Untethered Forwarder	$135.40	$137.73	$42.30	$315.43	$49.37		
Tethered Harvester	$144.77	$79.53	$42.30	$266.61	$37.60	$600.50	$84.70
Tethered Forwarder	$146.54	$145.06	$42.30	$333.89	$47.09		

Uncoupled System Productivity

Machine	MBF/PMH	Utilization	MBF/SMH	Machine Productivity (MBF/SMH)	U_F%
Untethered Harvester	25.7	80%	20.5	20.5	80%
Untethered Forwarder	8.0	80%	6.4	6.4	80%
Tethered Harvester	17.6	75%	13.2	13.2	75%
Tethered Forwarder	9.5	75%	7.1	7.1	75%

Coupled System Productivity

	Costs Per SMH						
Machine	Fixed	Variable	Operator	TOTAL	(per MBF)	System ($/SMH)	Unit Cost ($/MBF)
Untethered Harvester	$133.55	$140.70	$42.30	$316.55	$15.42	$597.07	$59.33
Untethered Forwarder	$116.93	$121.29	$42.30	$280.52	$43.91		
Tethered Harvester	$144.77	$147.72	$42.30	$334.79	$25.42	$635.69	$67.86
Tethered Forwarder	$128.95	$129.65	$42.30	$300.89	$42.44		

Harvester Productivity Difference: Why?

- Different harvester operators…
- Tethered operator stopped more frequent

- Narrower operating window while operating to maintain lead with tether, or to avoid sidehill on steeper slopes?

Visual Impacts

Photos courtesy of Dr. Woodam Chung

Post-Harvester

Post-Harvester

Post-Forwarder

Take-Away Messages, Management Implications

- ***Soils are complex, site conditions are important! Wet, dry, clay, sand, etc…***
- Horizontal and vertical benefits through careful implementation of cable-assistance
- Financially practical
- As we develop steep-slope technology, where are our new opportunities for improvement?
  - Operator training/ability
  - Machine maintenance/design
  - Regulatory environment

THANK YOU! QUESTIONS?

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Photo courtesy of Dr. Woodam Chung