Comparison of impacts on soils between CTL and WT harvesting

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Cut-to-length (CTL) system

Whole tree (WT) system

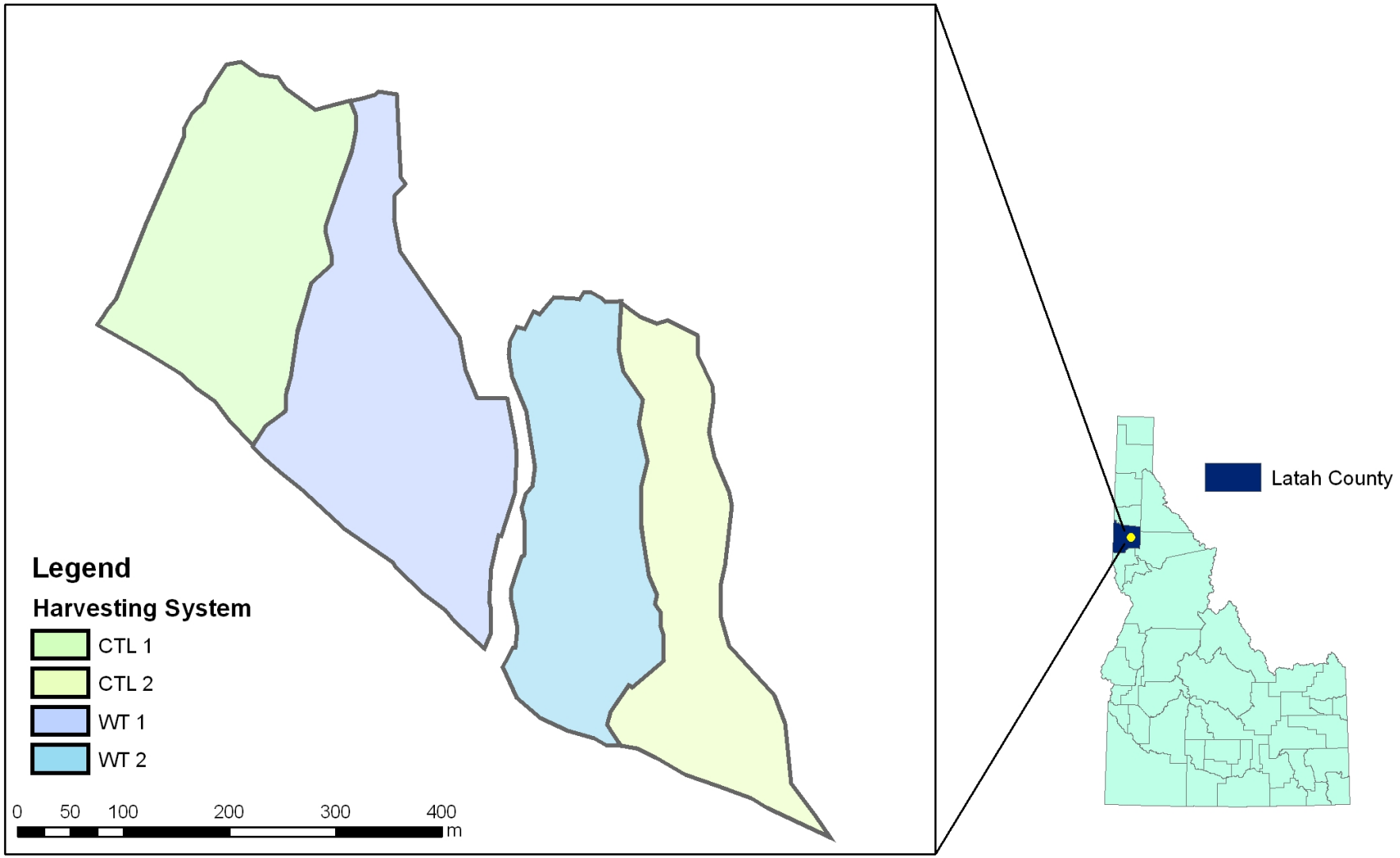
Objective of this study

The goal of this study was to broaden the existing knowledge on soil impacts from WT and CTL harvesting by:

- quantifying the trail areas (i.e. extent) used for primary wood transport
- measuring degree of soil compaction after harvesting activities
- developing models to predict % increase of soil bulk density and soil resistance to penetration

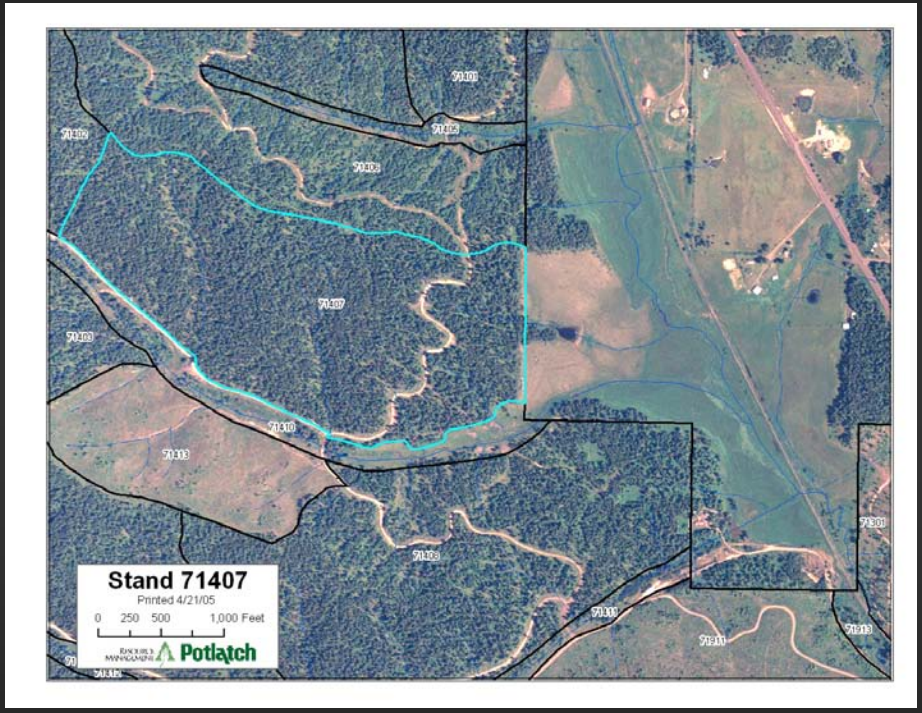
Study Method

Study site

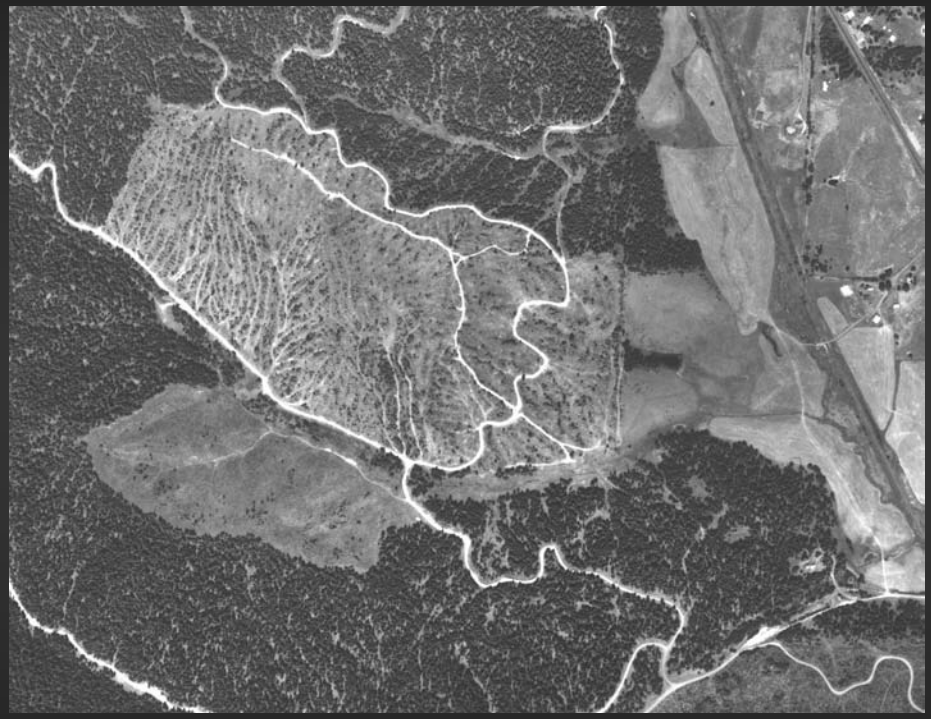

N
Legend
Harvesting System
CTL 1
CTL 2
WT 1
WT 2
0 50 100 200 300 400
m
Latah County

Site descriptions

Unit	Area (acre)	Soil	Stand composition	Ave. DBH (in.)	Ave. tree height (ft)
CTL 1	12.05	ashy silt loam	Grand fir (68.1%) Douglas fir (19.7%) Lodgepole pine (7.9%) Western larch (4.3%)	10.6	66
WT 1	14.85				
CTL 2	9.88				
WT 2	11.24				



Before harvesting



After harvesting

CTL Harvesting System

❖ **Harvesting : May 31 – June 16 2005 (17 days)**

Valmet 500T

Valmet 890

WT Harvesting system

- **Harvesting:** May 31 – June 14 2005 (15 days)

Timbco hydro

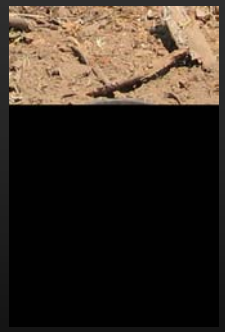
CAT D-5

Processor :
Kumatsu PC220LC

Loader :
Kumatsu PC200LC

How do we measure soil compaction?

Soil resistance to penetration



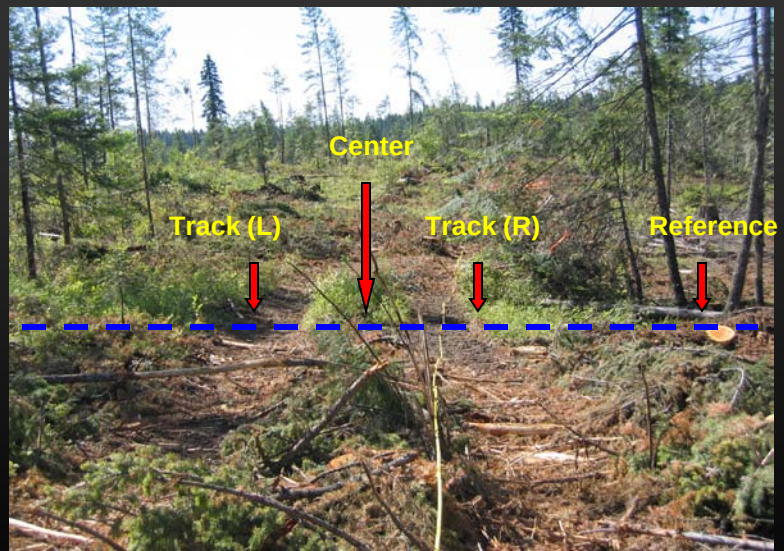
Soil bulk density

Soil resistance to penetration

- **Soil moisture content: 25 – 30%**
- **Sampling points:**
  every 100 ft on all trails

  track (L) - center – track (R)
  - reference (off-trails)

  soil depth:
  3 in., 6 in., and 9 in.



Soil bulk density

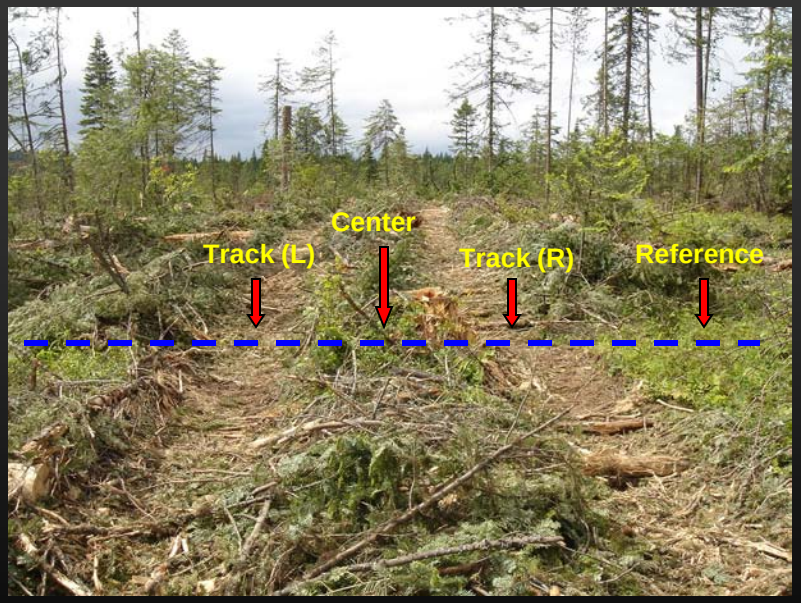
- **Core sampling**
- **Sampling points:**

  every 200 ft on all trails

  center - track (L or R) - reference (off-trail)

  soil depth :

  3 in., 6 in., and 9 in.



Data collection

Number of machine pass

- Collected during harvesting operations
- Machine pass = one empty trip + one loaded trip of skidder or forwarder

Slash data: CTL units only

- Collected 20 slash sample data (heavy and light) from each CTL harvest unit
- Downed wood debris survey (Brown 1974)

  - Heavy: 8.2 lbs/ft^2
  - Light : 1.5 lbs/ft^2
  - Bare: None

Data collection

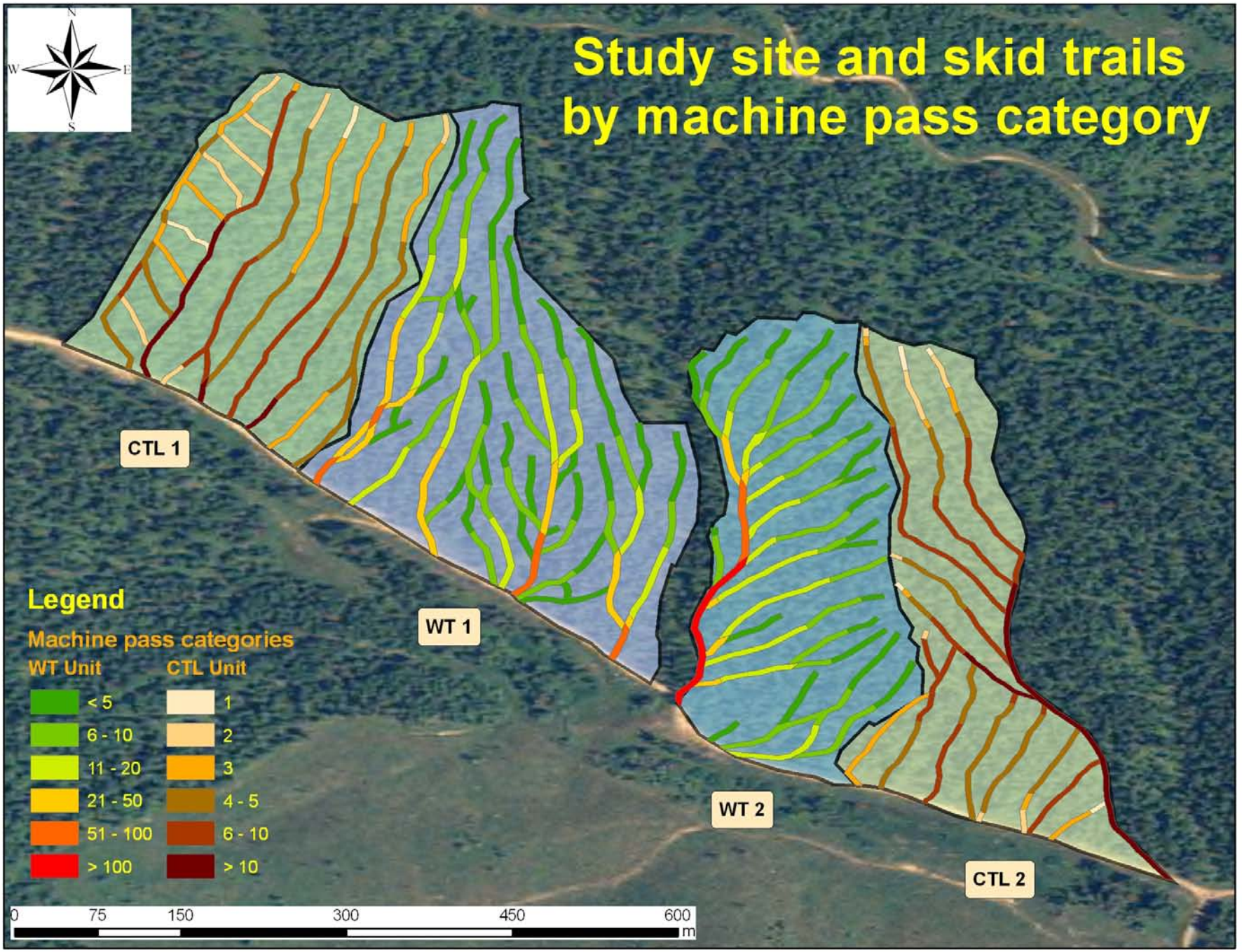
Trail map

- Collected trail location points using Trimble Geo XT at every 50ft along the centerline of trails

Width of trails

- Every 50 ft on the odd number trails
- Measured width of center and track on the CTL forwarding trails

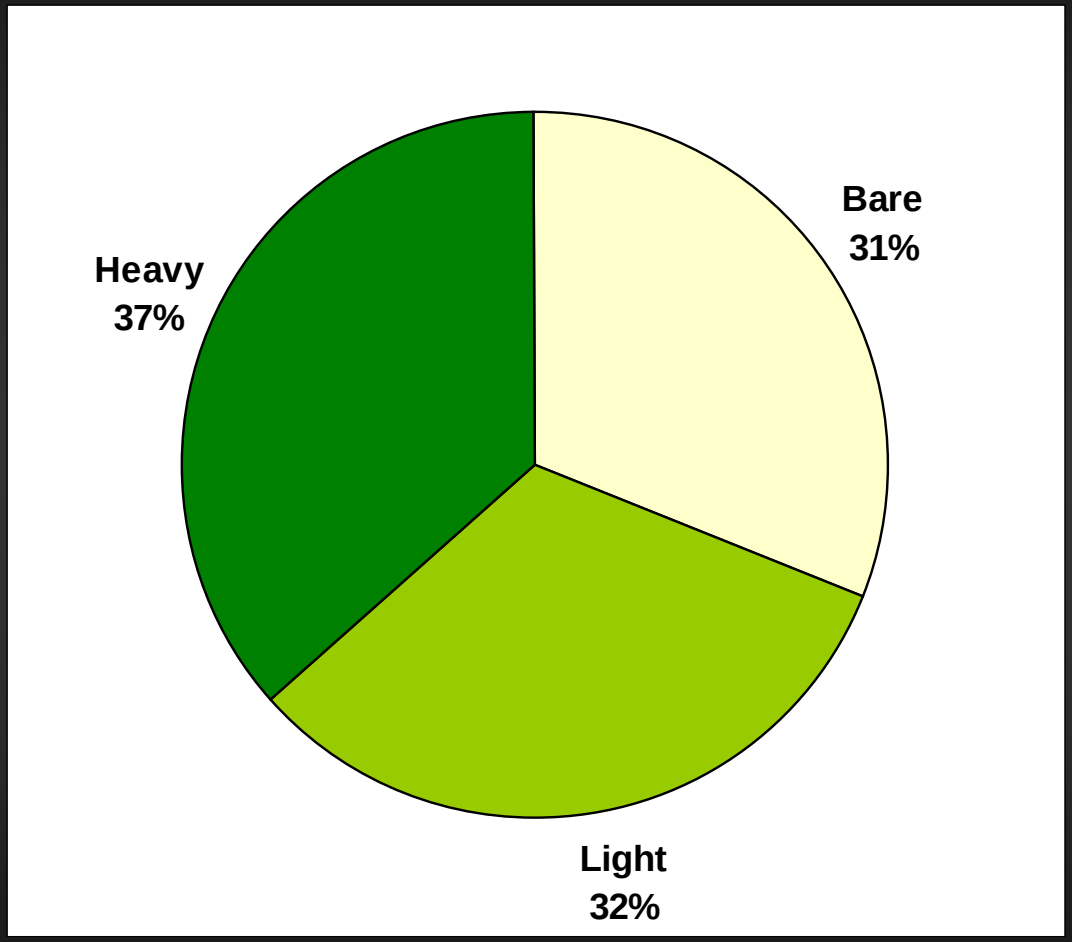
Results


Study site and skid trails by machine pass category
N
W
E
S
CTL 1
WT 1
WT 2
CTL 2
Legend
Machine pass categories
WT Unit
< 5
6 - 10
11 - 20
21 - 50
51 - 100
> 100
CTL Unit
1
2
3
4 - 5
6 - 10
> 10
0
75
150
300
450
600
m

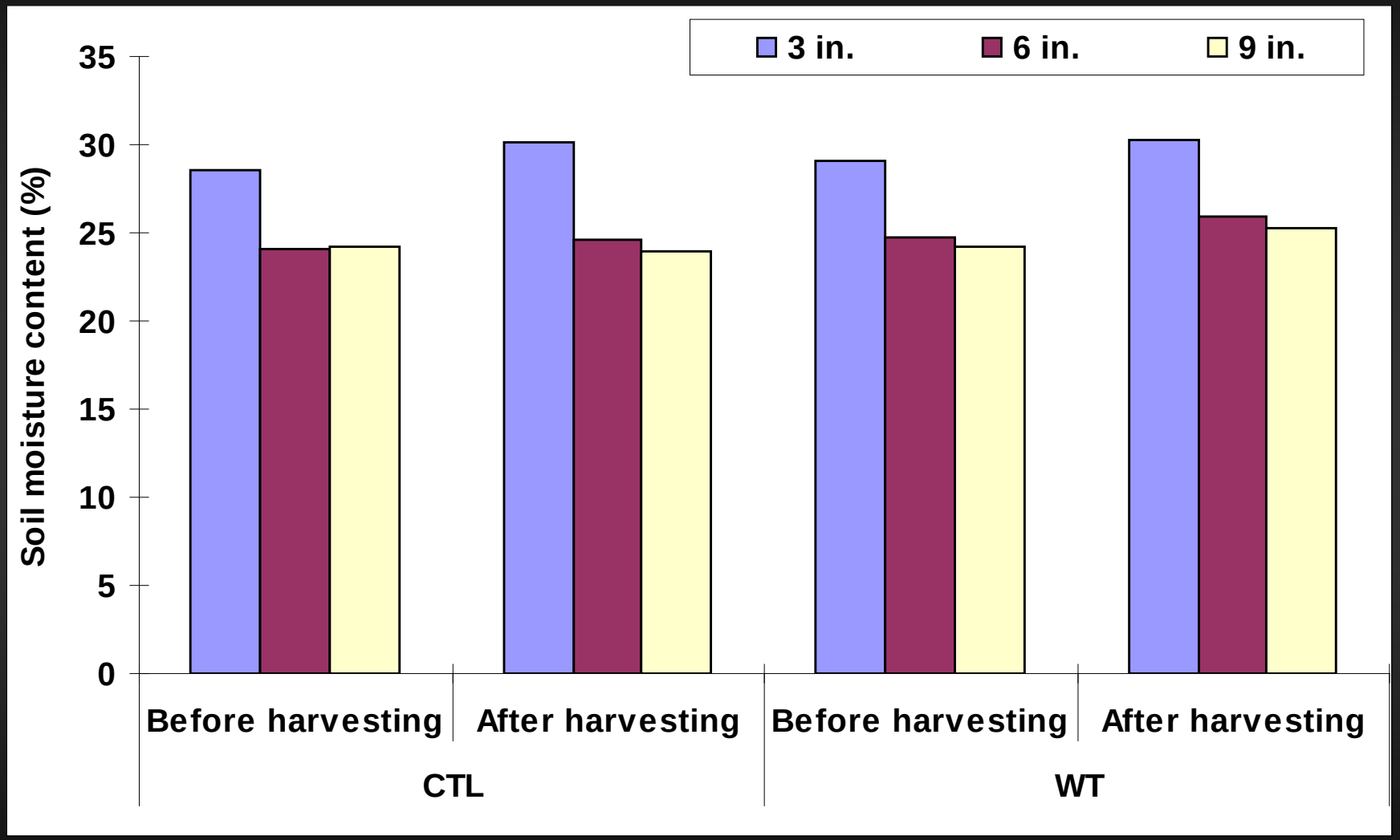
Forwarding/Skidding trails

Unit	Width of trails			Length of trails (ft/ac)	Area of trails	
	n	Mean (ft)	S.D. (ft)		acre	%
CTL 1	75	11.92	0.60	713	2.34	19.47
CTL 2	78	11.84	0.54	745	2.00	20.25
WT 1	117	14.65	2.58	781	3.90	26.28
WT 2	82	15.18	2.87	700	2.73	24.28

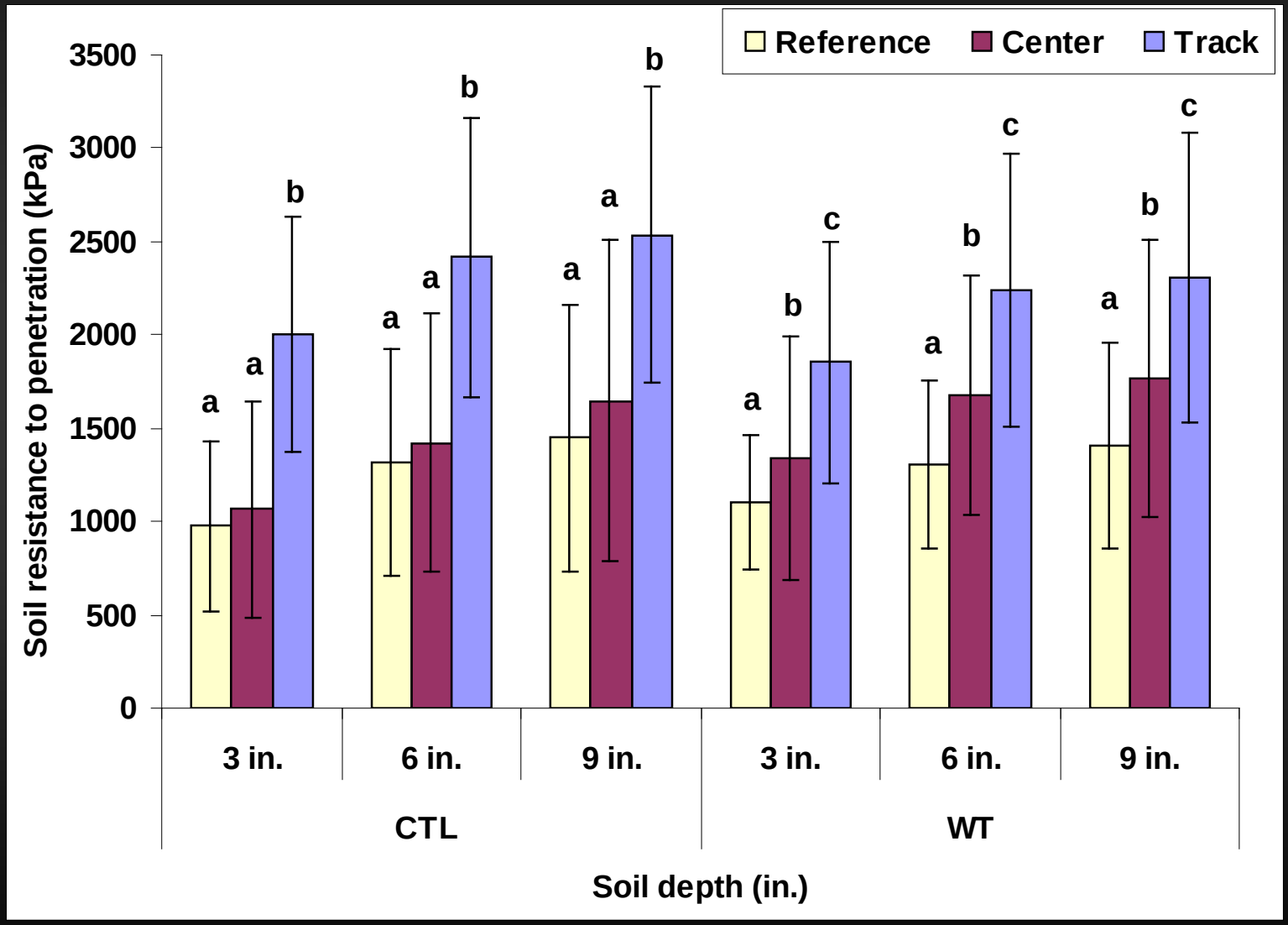
Slash on the CTL forwarding trails



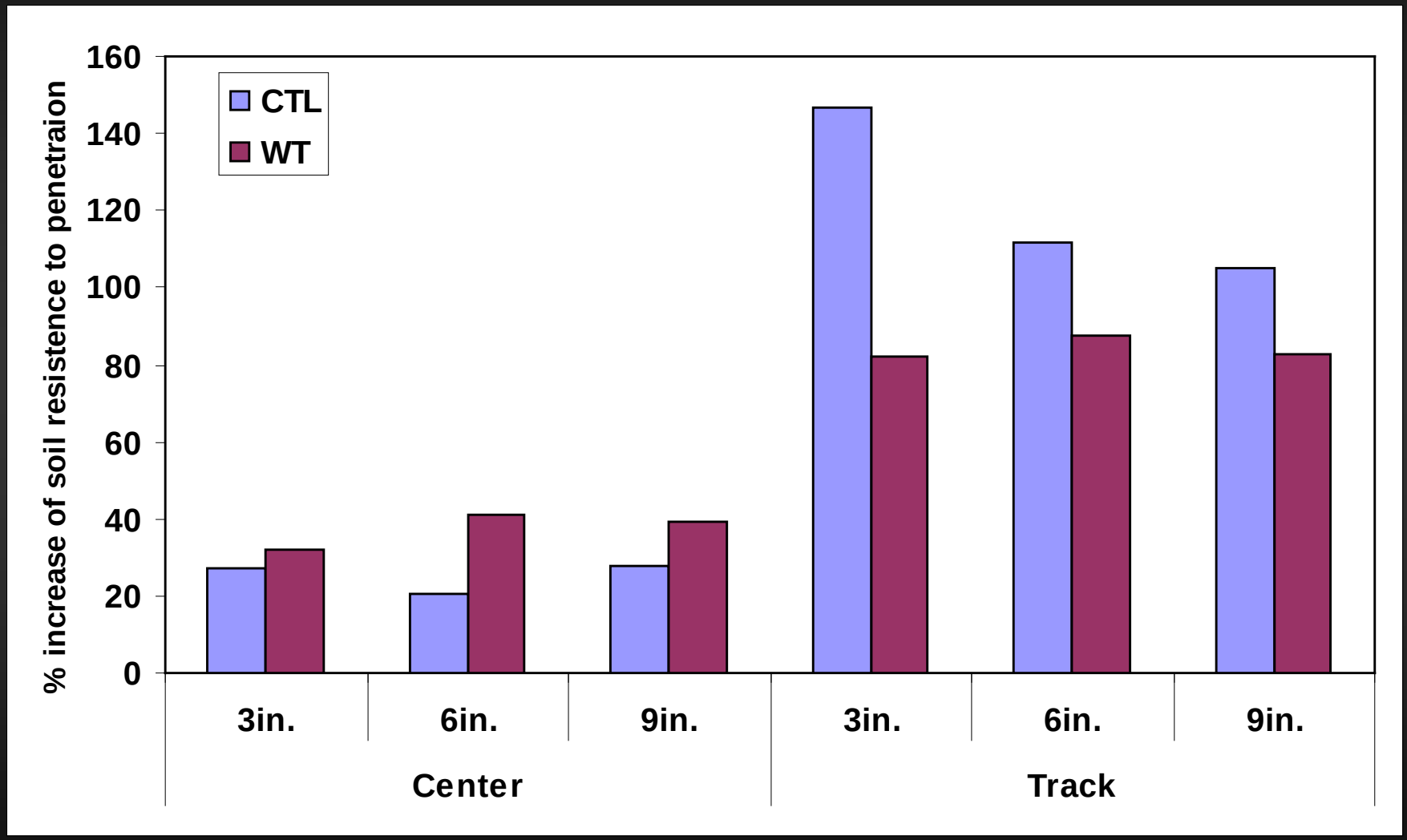
Soil Moisture Content



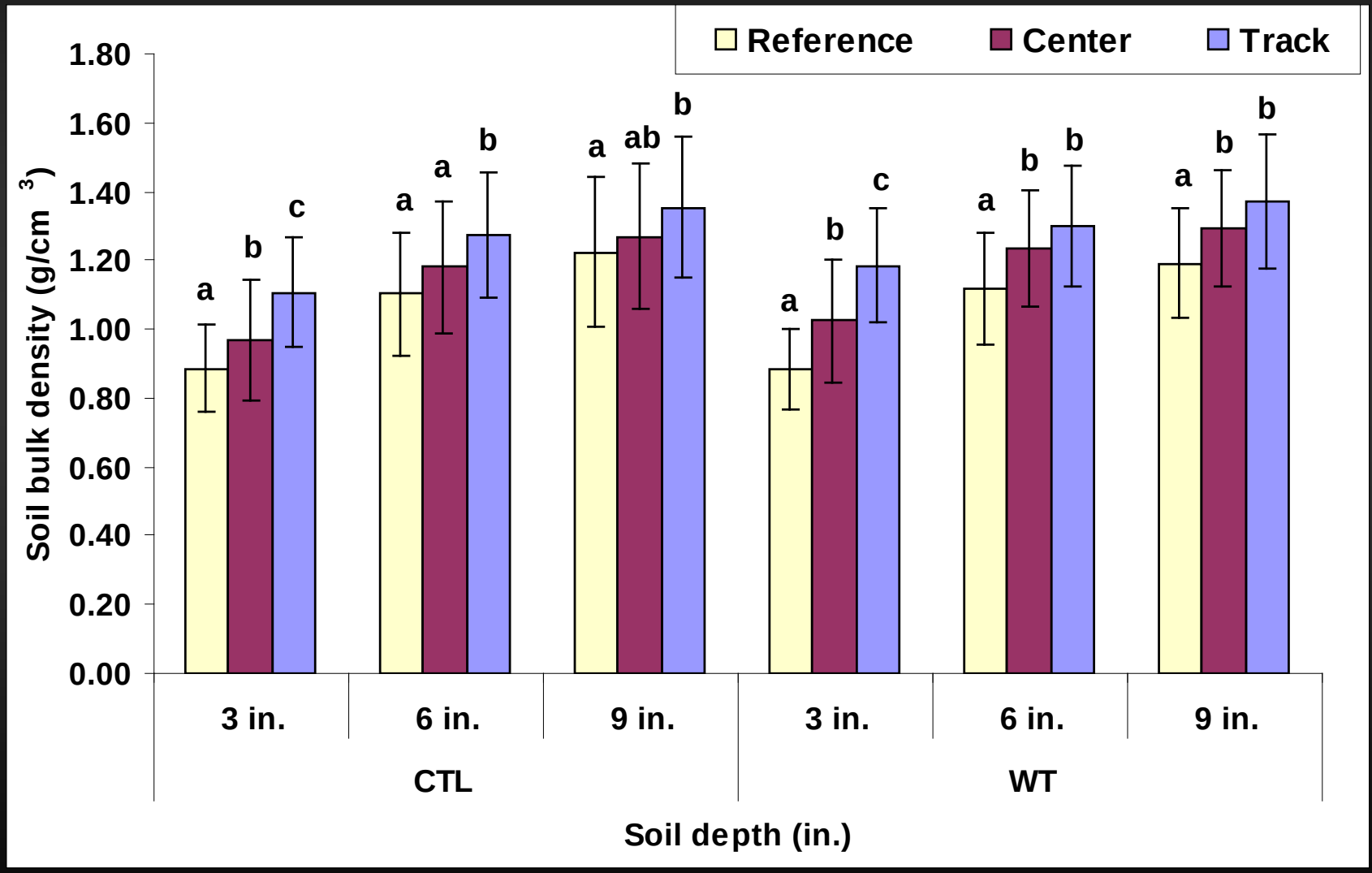
Changes in soil resistance to penetration after harvesting



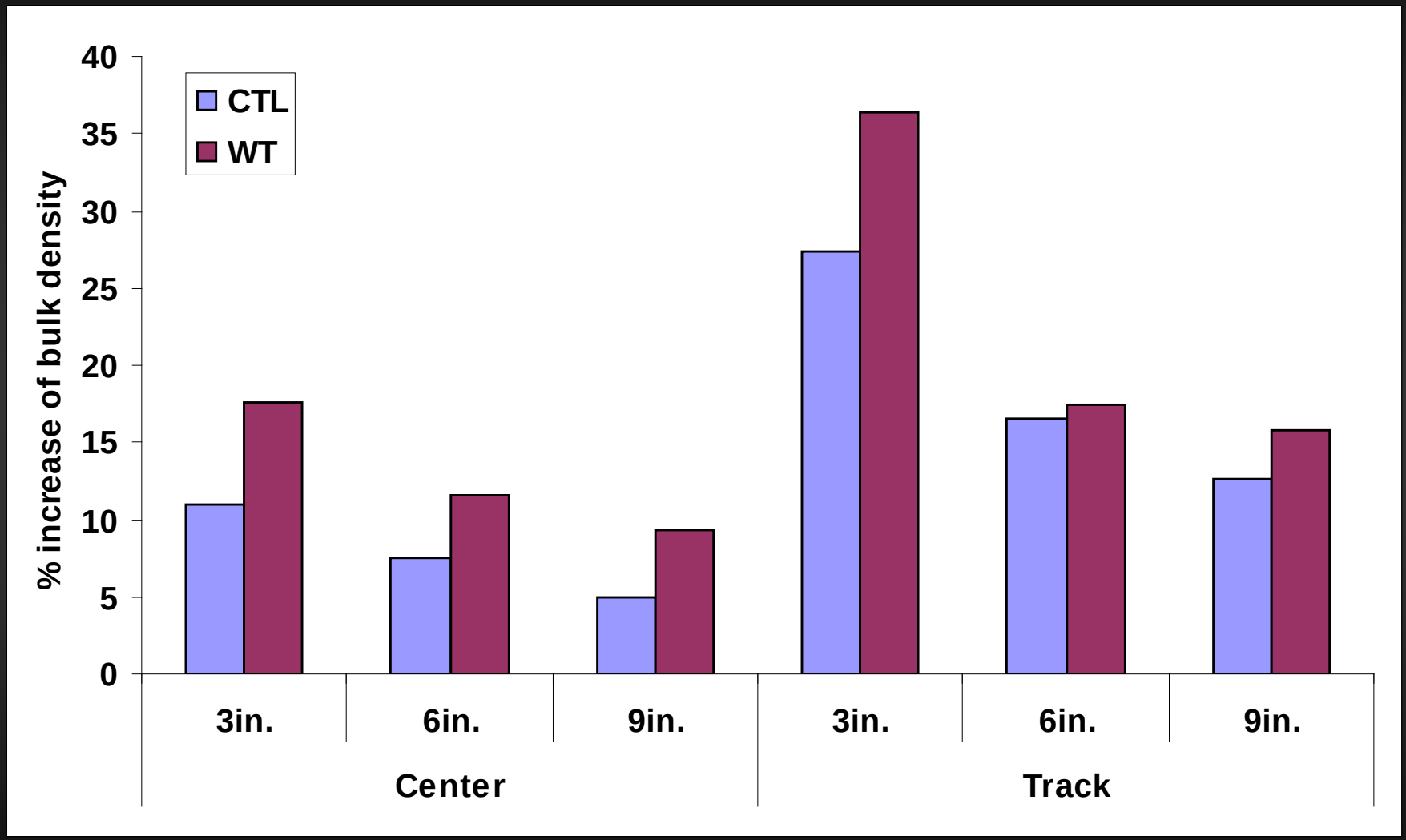
% increase of soil resistance to penetration



Changes in soil bulk density after harvesting



% increase of soil bulk density



Skid trail area: CTL vs. WT

Harvesting system	Harvest unit (acre)	Trail width (ft)	Trail length (ft)	Skid trail area in the harvesting units	
				acre	%
CTL	21.93	11.88	15,946	4.34	19.86
WT	26.09	14.93	19,459	6.63	25.41

Harvesting system	Harvest unit (acre)	Trail width (ft)	Track width (ft)	Trail length (ft)	Compacted area in the harvesting units	
					acre	%
CTL	21.93	11.88	5.87	15,946	2.15	9.80
WT	26.09	14.93	-	19,459	6.63	25.41

Model to predict % increase of soil resistance to penetration

(Soil moisture content was 25 - 30%)

Harvesting system	Soil Depth		R^2
CTL	3 in.	% increase = 1844.06 + 32.60ln(N*) – 20.26ln(D*) – 233.16ln(I*) – 84.58(S1) – 42.37(S2)	0.59
	6 in.	% increase = 1240.70 + 46.37ln(N) – 16.26ln(D) – 151.03ln(I) – 55.00(S1) – 34.56(S2)	0.65
	9 in.	% increase = 1284.78 + 50.82ln(N) – 20.90ln(D) – 155.58ln(I) – 25.92(S1) – 17.98(S2)	0.67
WT	3 in.	% increase = 1177.87 + 13.23ln(N) – 17.58ln(D) – 146.06ln(I)	0.53
	6 in.	% increase = 1293.22 + 22.99ln(N) – 16.57ln(D) – 161.72ln(I)	0.53
	9 in.	% increase = 1238.61 +19.67ln(N) – 20.78ln(D) – 148.93ln(I)	0.54

*** N: number of machine passes, D: distance (ft) from landing area, I: initial value of soil resistance to penetration, S1: heavy slash = 1 and others = 0,and S2: light slash = 1 and others = 0**

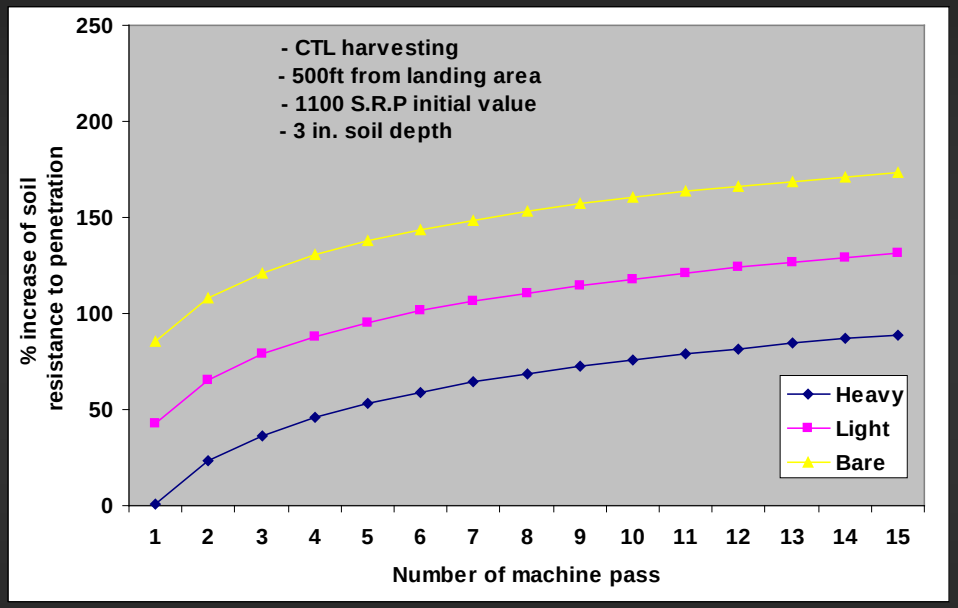
Model to estimate % increase of soil bulk density

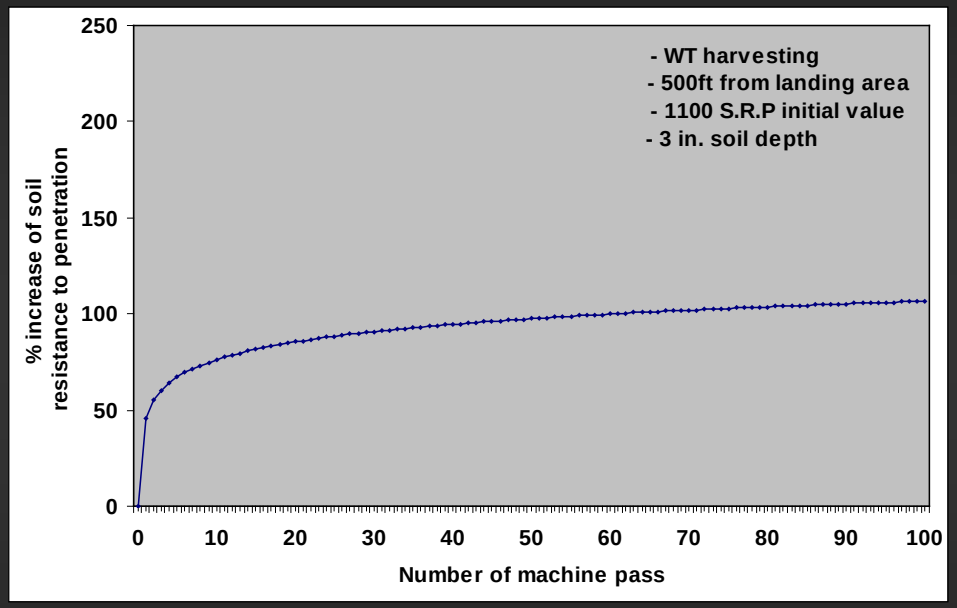
(Soil moisture was 25 - 30%)

Harvesting system	Soil Depth		R^2
CTL	3 in.	% increase = 79.43 + 0.11ln(N) – 9.36ln(D) – 104.70ln(I) – 13.63(S1) – 12.63(S2)	0.55
	6 in.	% increase = 36.01 + 3.63ln(N) – 2.79ln(D) – 51.92ln(I) – 8.49(S1) – 3.02ln(S2)	0.37
	9 in.	% increase = 58.10 + 2.41ln(N) – 4.87ln(D) – 65.99ln(I) – 3.65(S1) – 2.65(S2)	0.40
WT	3 in.	% increase = 17.69 + 5.72ln(N) – 1.16ln(D) – 106.50ln(I)	0.47
	6 in.	% increase = 57.78 + 3.57ln(N) – 6.95ln(D) – 47.95ln(I)	0.49
	9 in.	% increase = 62.08 +3.73ln(N) – 7.63ln(D) – 41.64ln(I)	0.36

*** N: number of machine passes, D: distance (ft) from landing area, I: initial value of soil bulk density, S1: heavy slash = 1 and others = 0, and S2: light slash = 1 and others = 0**

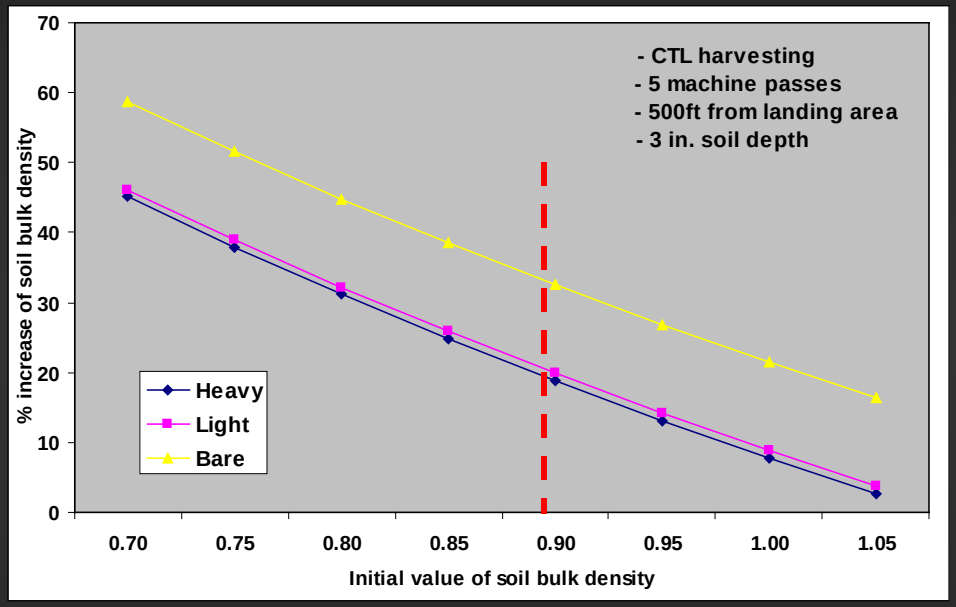
% increase in soil resistance to penetration (S.R.P) with increase of the number of machine pass

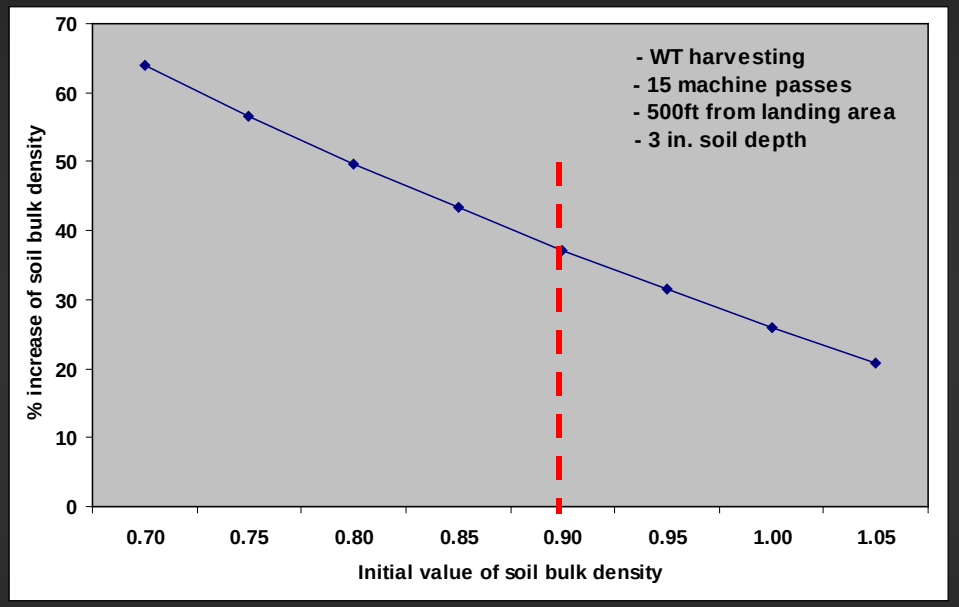




(Soil moisture: 25 - 30%)

Changes of % increase in soil bulk density over various initial values of soil bulk density





(Soil moisture: 25 - 30%)

Conclusion

- **CTL system used less trail areas in a harvest unit:**
  CTL (20%) vs. WT (25%)

- **At 25 ~ 30% soil moisture content,**
  - ✓**In the track of trail, both CTL and WT harvesting caused a high level of soil compaction.**
  - ✓**In the center of trail, CTL tends to leave less degree of soil compaction than WT.**

- **% increase of soil resistance to penetration and bulk density:**
  - ✓**Decreased with increase of soil depth**
  - ✓**Increased with increase of the number of machine passes**
  - ✓**Decreased with increase of distance from landing**
  - ✓**Decreased with increase of initial value of soil resistance to penetration and bulk density**

- **In CTL harvesting, slash covered ~70% of the forwarding trails and tended to be effective in minimizing soil compaction.**

Questions?