# Cut-to-Length Thinning in California's Redwood Forests: Productivity, Cost, Soil Impacts, and Residual Stand Damage

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2, August 2017


Redwood

# Growing interest in redwood thinning using a CTL system…


VS

Individual

Clump

# Cut-To-Length Method

## Harvester

## Forwarder

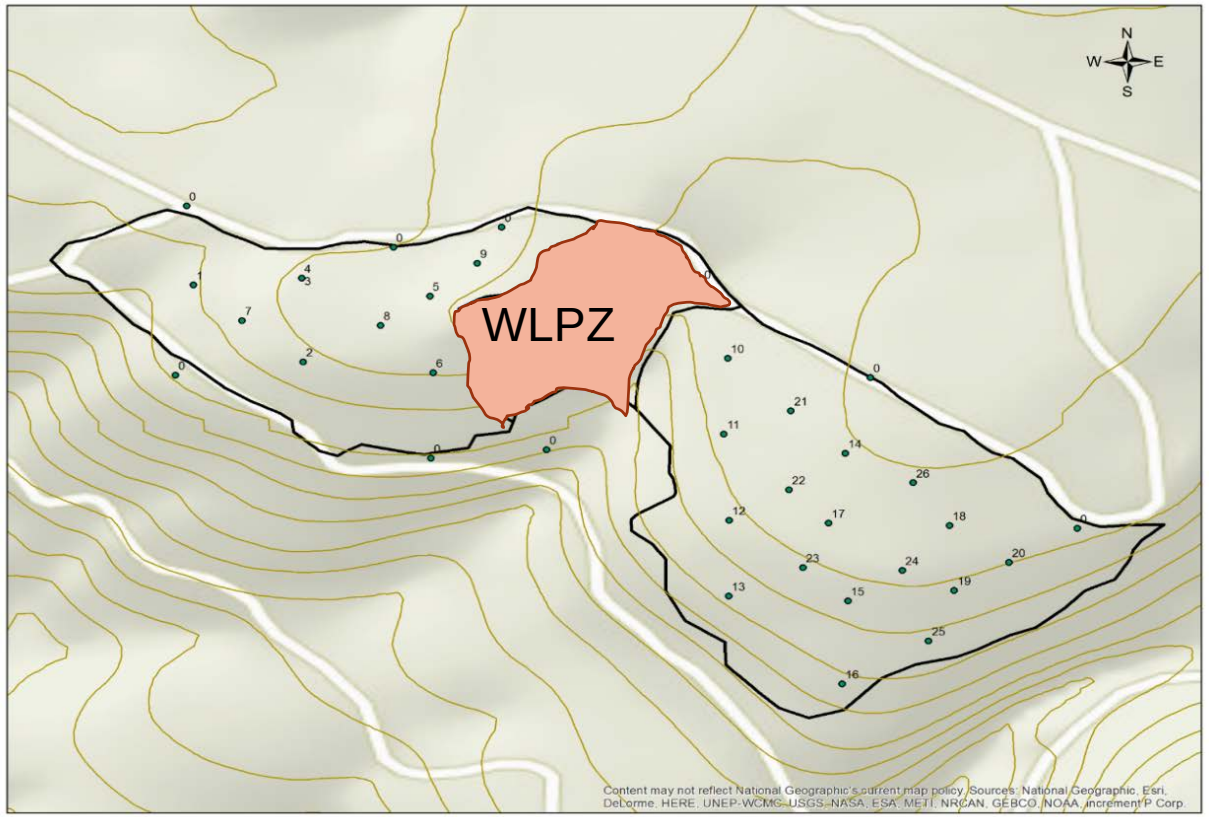
# Study Objectives

- ✓ Determine productivity and cost of a CTL commercial thinning operation in redwood stands

- ✓ Evaluate soil impacts during winter CTL thinning operations.
  - bulk density (BD)

- ✓ Examine residual stand damage: individual vs. clump trees.

# Study Area



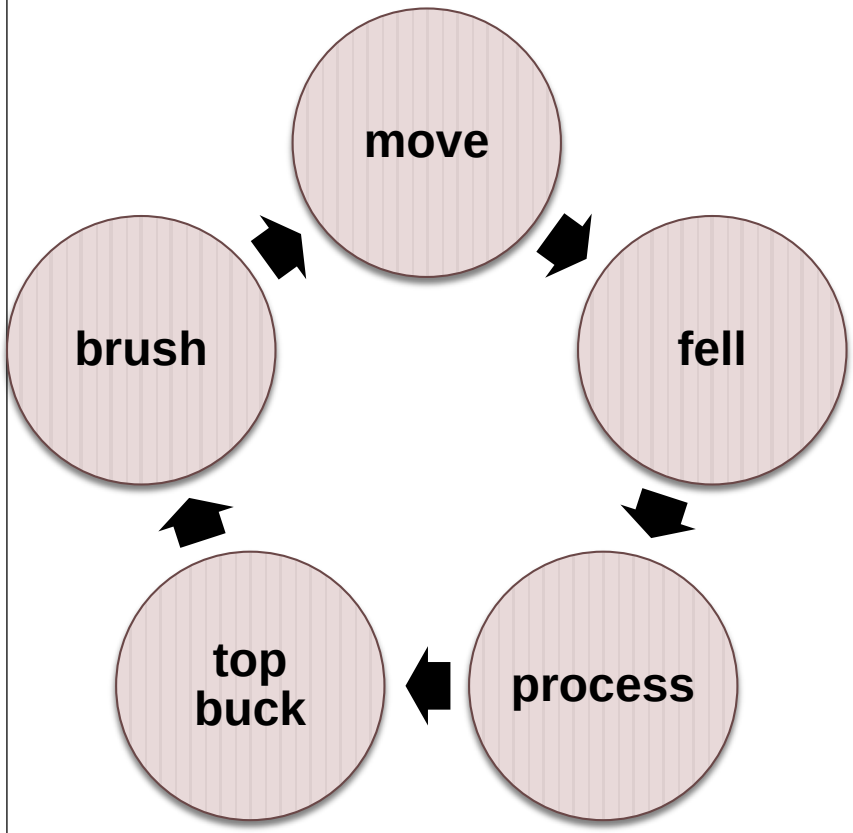

- 10.1 ha on industrial timberland
- Watercourses and Lake Protection Zones (WLPZ)
- 25-30 years old trees commercially thinned

| | Pre-Thinning | Post-Thinning |
|---|---|---|
| Avg. DBH (cm) | 20 | 23 |
| Avg #stems/clump | 6 | 3 |
| Avg. basal area ($m^2$/ha) | 99 | 40 |
| Stand density (tph[a]) | 2393 | 769 |
| Species composition (%) | | |
| redwood | 77 | 79 |
| red alder | 17 | 15 |
| Douglas-fir | 5 | 4 |
| Sitka spruce | 1 | 2 |

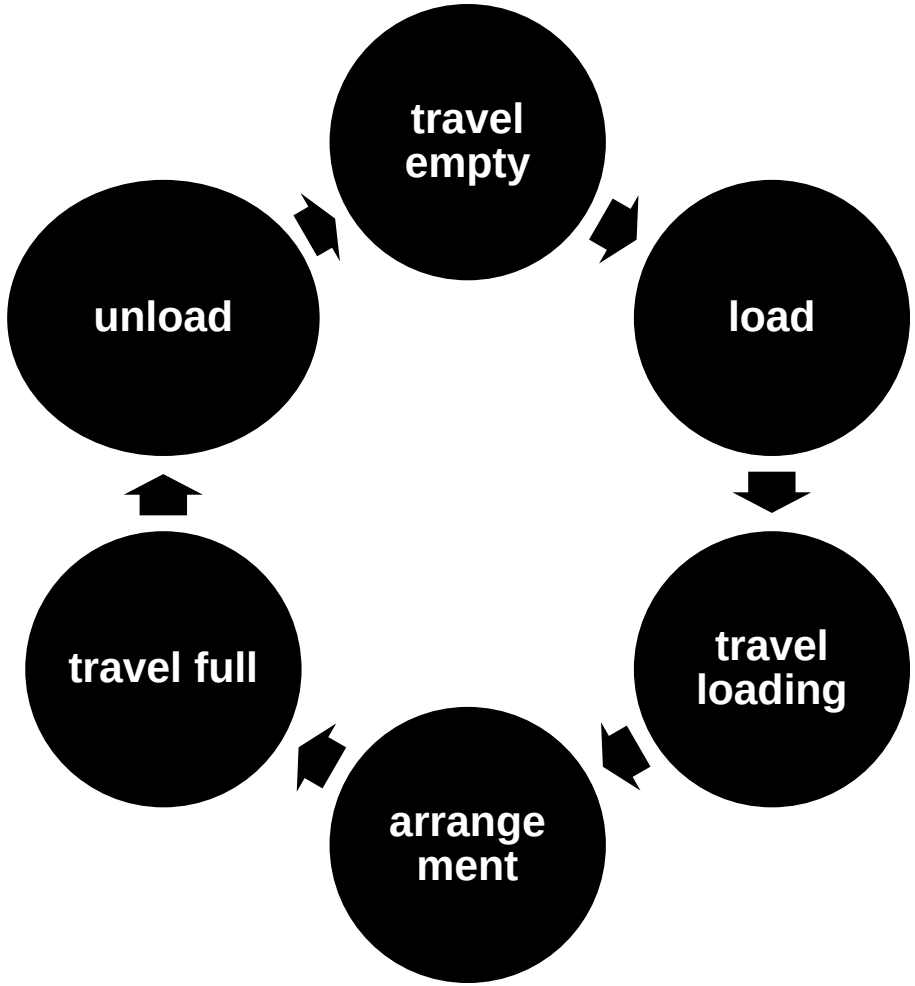
[a] trees (>5cm in DBH) per ha

# Detailed Time and Motion Study

## Felling/Processing Cycle




## Forwarding Cycle



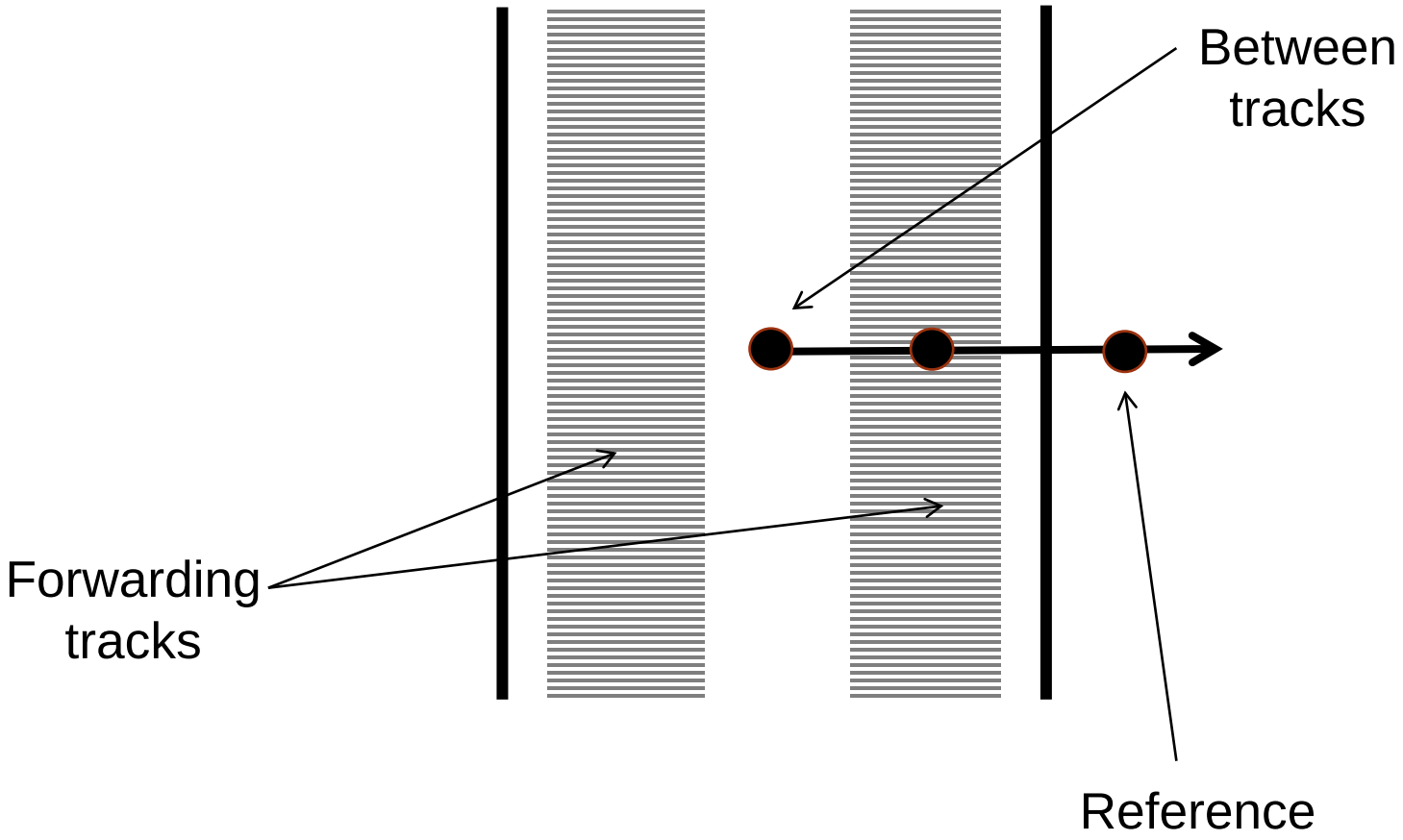

## Loading Cycle

- deck to truck
- bunk to truck
- arrangement
- move to deck
- deck to bunk

## Delay Analysis

- mechanical
- operational
- personal

# Data Collection: Bulk Density

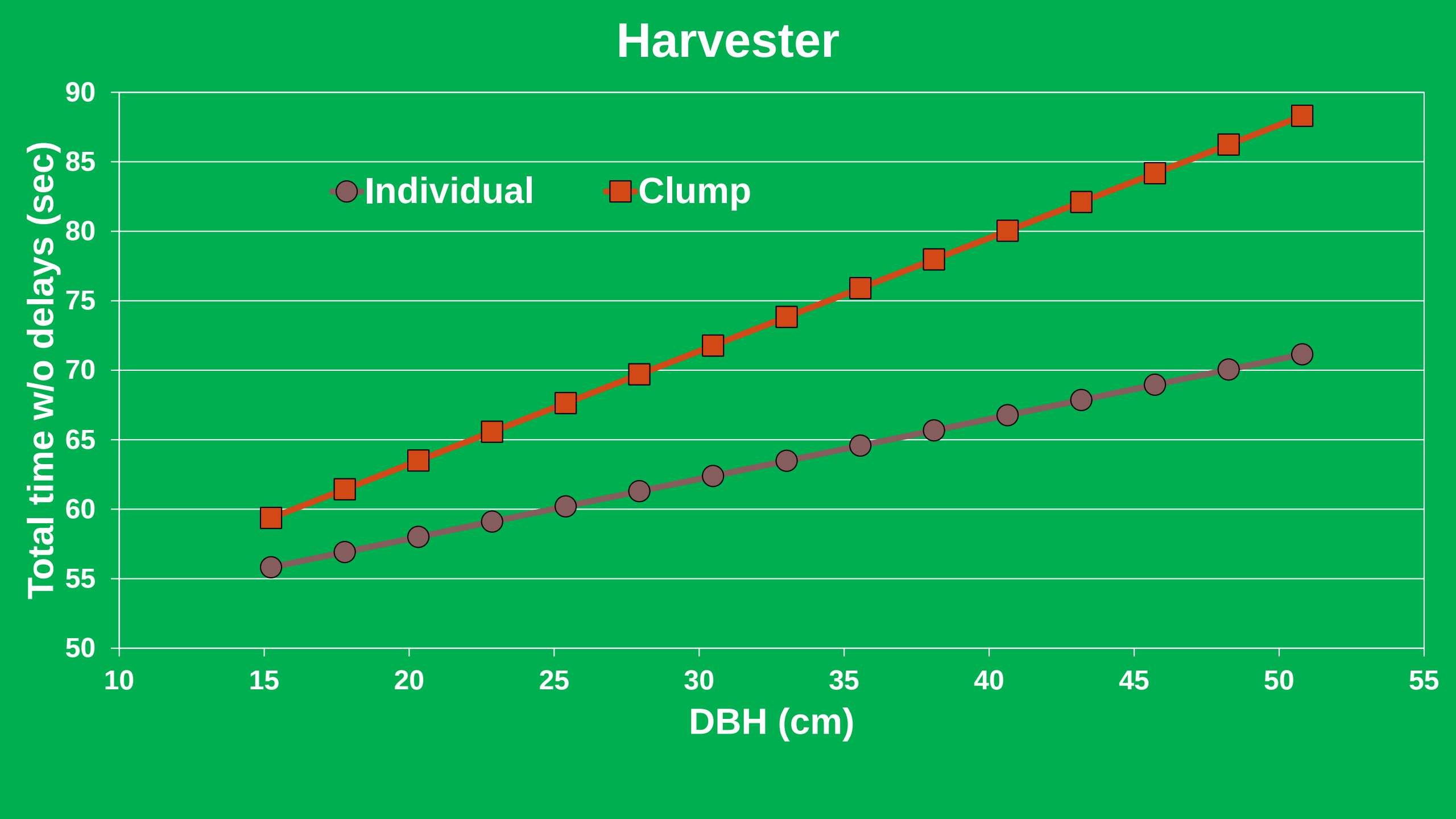



# Data Collection: Stand Damage

- Removal of the bark down to cambial layer, exposing sapwood
- Systematic plot sampling
- Data collection

  - Number of trees damaged
  - Scar width and length

# Results


Harvester
Individual
Clump
Total time w/o delays (sec)
90
85
80
75
70
65
60
55
50
10
15
20
25
30
35
40
45
50
55
DBH (cm)

# Stump-To-Truck Cost ($/m$^3$)

| | Machine Cost ($/PMH[a]) | Hourly Production (m$^3$/PMH) | Thinning Cost ($/m$^3$) | Percent of Total Cost (%) |
|---|---|---|---|---|
| Harvester | 230.9 | 27.7 | 8.3 | 42.4 |
| Forwarder | 183.6 | 22.4 | 8.2 | 41.7 |
| Loader (Forwarder) | 183.6 | 58.9 | 3.1 | 15.9 |
| Total | 598.1 | | 19.7 | 100 |

[a]productive machine hour

# Bulk Density (BD)

| Soil depth (cm) | BD on the track ($g/cm^3$) |
|---|---|
| 0-5 | 0.83 |
| 10-15 | 1.08 |
| 20-25 | 1.13 |

| BD Desirable ($g/cm^3$)* | BD affecting root growth ($g/cm^3$)* | BD restricting root growth ($g/cm^3$)* |
|---|---|---|
| <1.30 | 1.60 | >1.75 |
| <1.40 | 1.55 | >1.65 |

*Pierce et al. (1983)

# Scar Size and % Damage

| Scar width | | | Scar length | | |
|---|---|---|---|---|---|
| Individual (cm) | Clump (cm) | p-value* | Individual (cm) | Clump (cm) | p-value* |
| 8.1 | 9.1 | 0.1611 | 16.7 | 28.1 | 0.0001 |

| Minimum scar width (cm) | % of damaged trees (%) |
|---|---|
| None | 16.2 |
| > 5 | 13.9 |
| > 10 | 7.6 |
| > 15 | 3.2 |
| > 20 | 1.7 |

- Fungal decay is better correlated with scar width rather than length (Wallis and Morrison,1975).
- Scars less than 10cm in width were closed within 10 years with no decay developed. (Han and Kellogg, 2000).

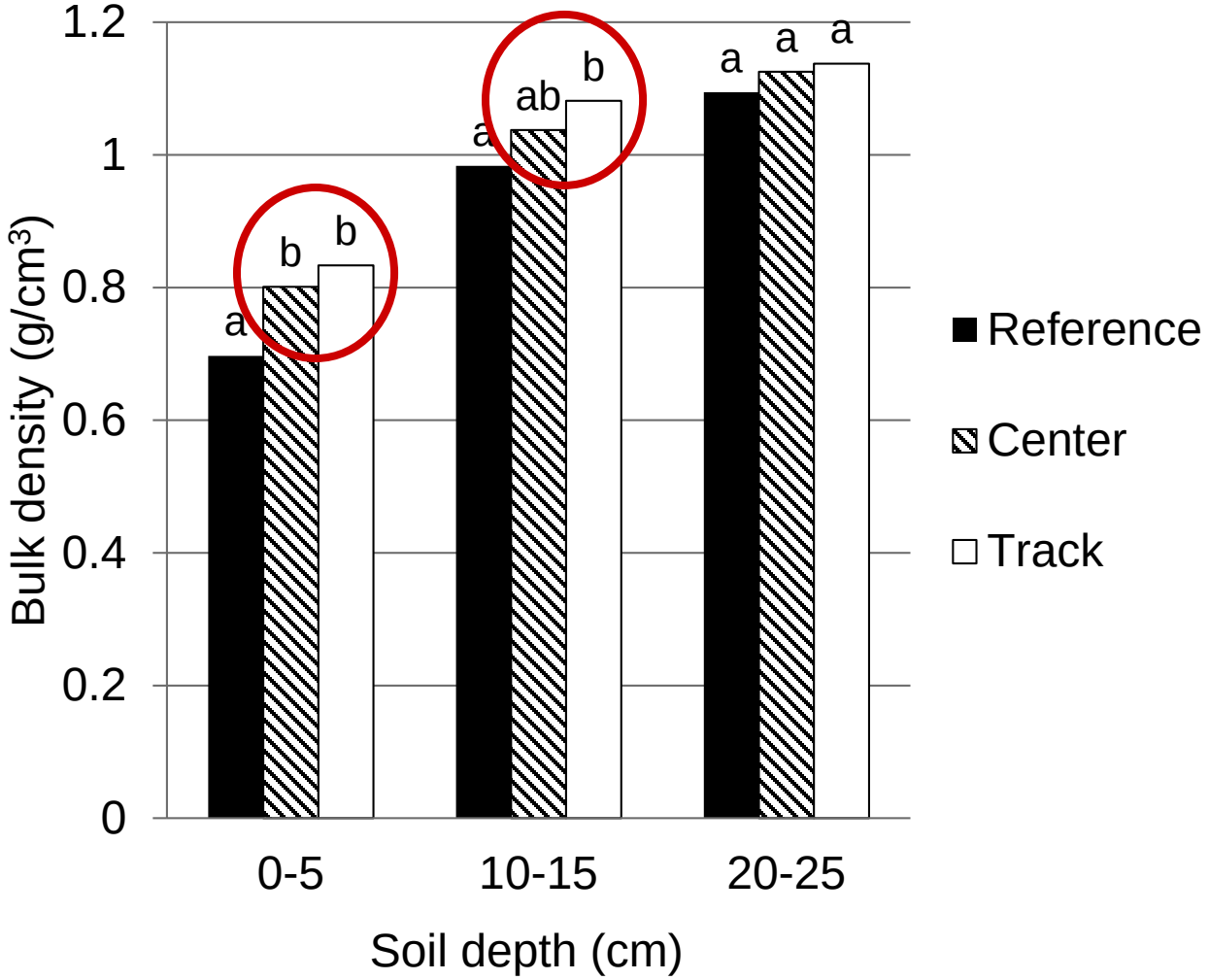
# Conclusion

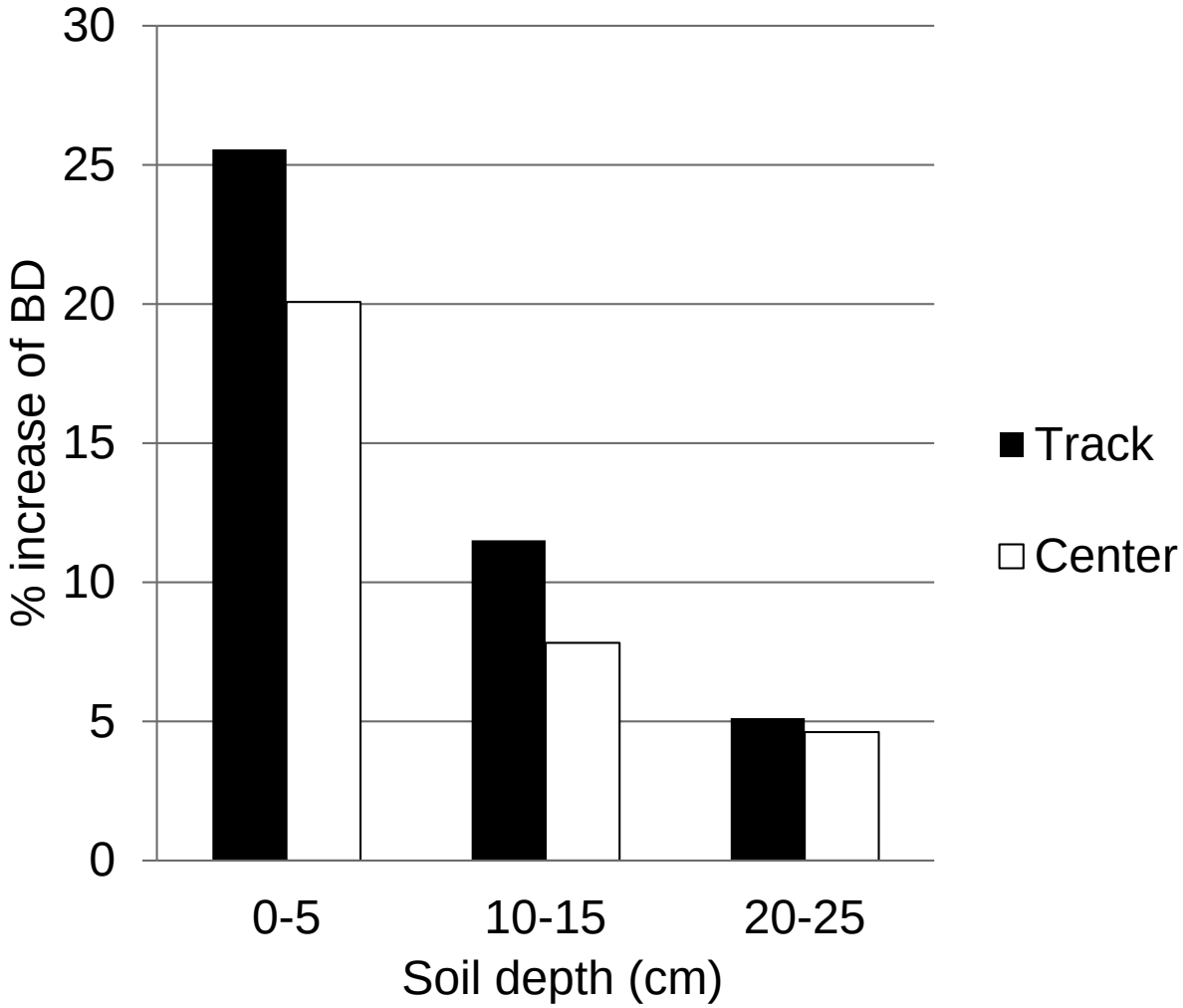
- The cost of thinning young redwood stands using a CTL system was comparable, as observed in other conifer stands.
- Productivity of CTL thinning in redwood forest was affected by tree type (individual vs. clump).
- Soil bulk density was increased, but the severity of soil compaction was not detrimental to tree growth.
- The amount of damage (>10cm in scar width) to residual trees was 7.6%.

⇒ Winter thinning of redwood forests using a CTL system appears to be operationally feasible.

# Questions?

# Bulk Density (BD)



# Water Infiltration Rate (WIR)

| Measurement | Soil depth (cm) | Reference | Center | Track | p-value* |
|---|---|---|---|---|---|
| WIR (cm/hr) | 0-5 | 1.25±1.48[a] | 1.87±2.78[a] | 1.17±1.43[a] | 0.6579 |

- An increase in bulk density did not always associate with a significant decrease in water infiltration (Aust et al.1992).
- The lack of forest residues and bare soil by high intensity rainfalls are factors of soil erosion (Franzluebbers 2001).

# Data Collection: Water Infiltration Rate


mini-disc infiltrometer