Recovery of Simulated Sawn Logs with Sweep and Ovality

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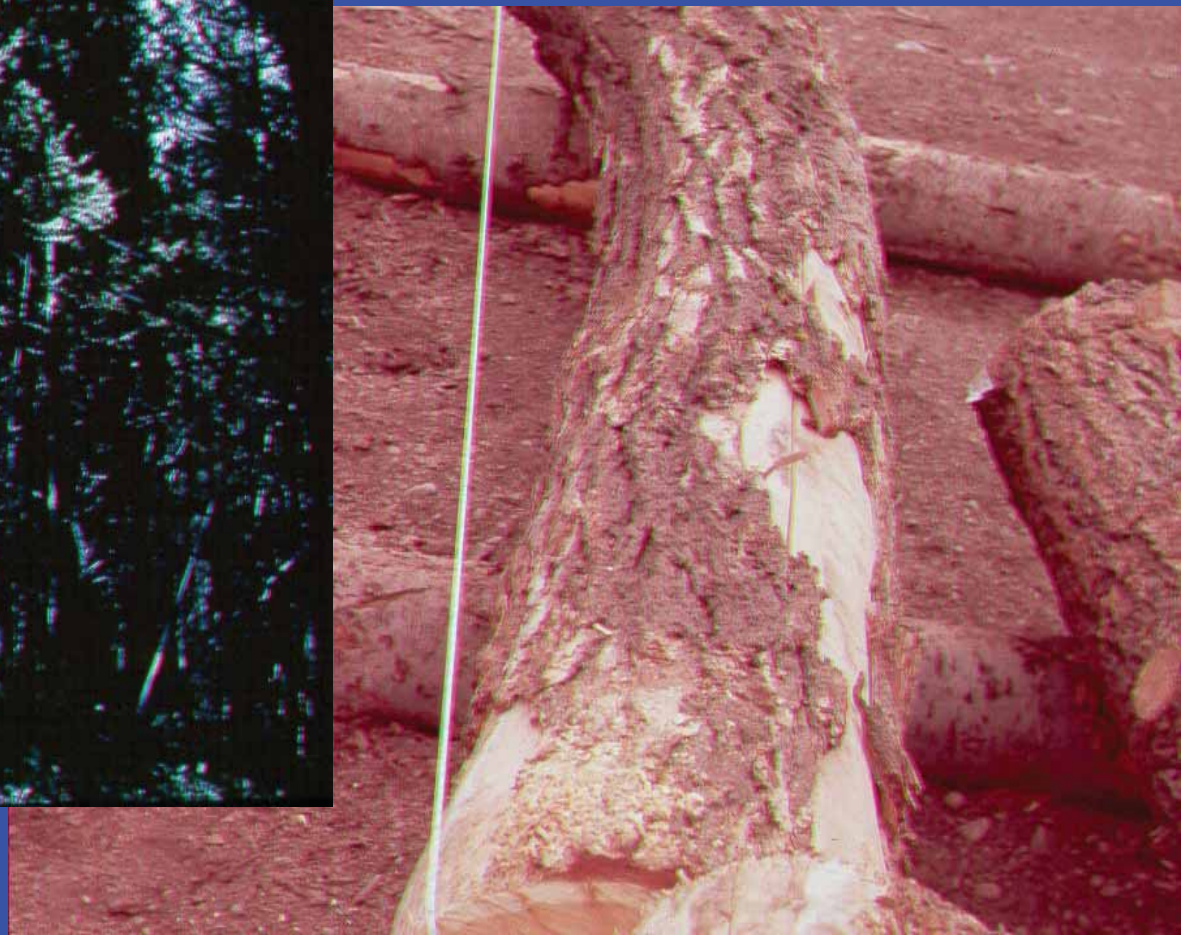
The Problem
(Sweep = deflection from straight)



The Problem

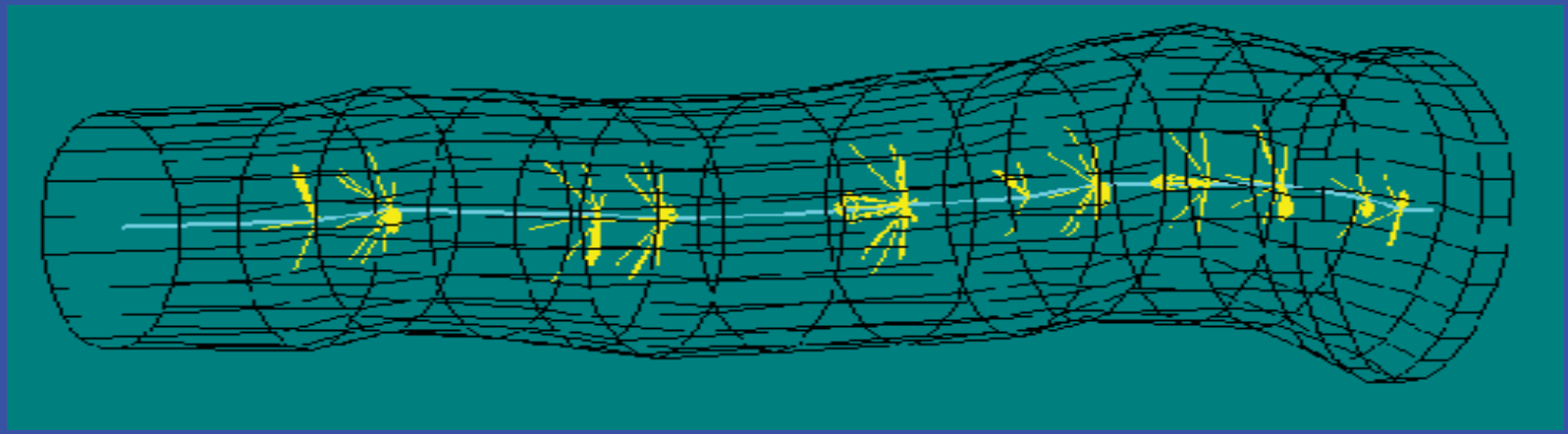
- Todoroki 1998: *"Not all logs are straight."*
- If curve-sawing not available, need to quantify expected product loss due to sweep
- Difficult to obtain a balanced sample of logs with sweep
- Unable to break confounding between sweep and other factors

The Solution: Sawing Simulation

- Digitize a representative sample of logs
  - Location & size of all knots, defects
- Systematically bend digitized logs (parabola)
- All logs retain original branching structure
  - Number, size, shape, location at pith
- Saw digital logs into boards with a sawing simulator: AUTOSAW

Data Collection: Log Diagramming

Digitized Log illustrating both sweep and out-of-roundness



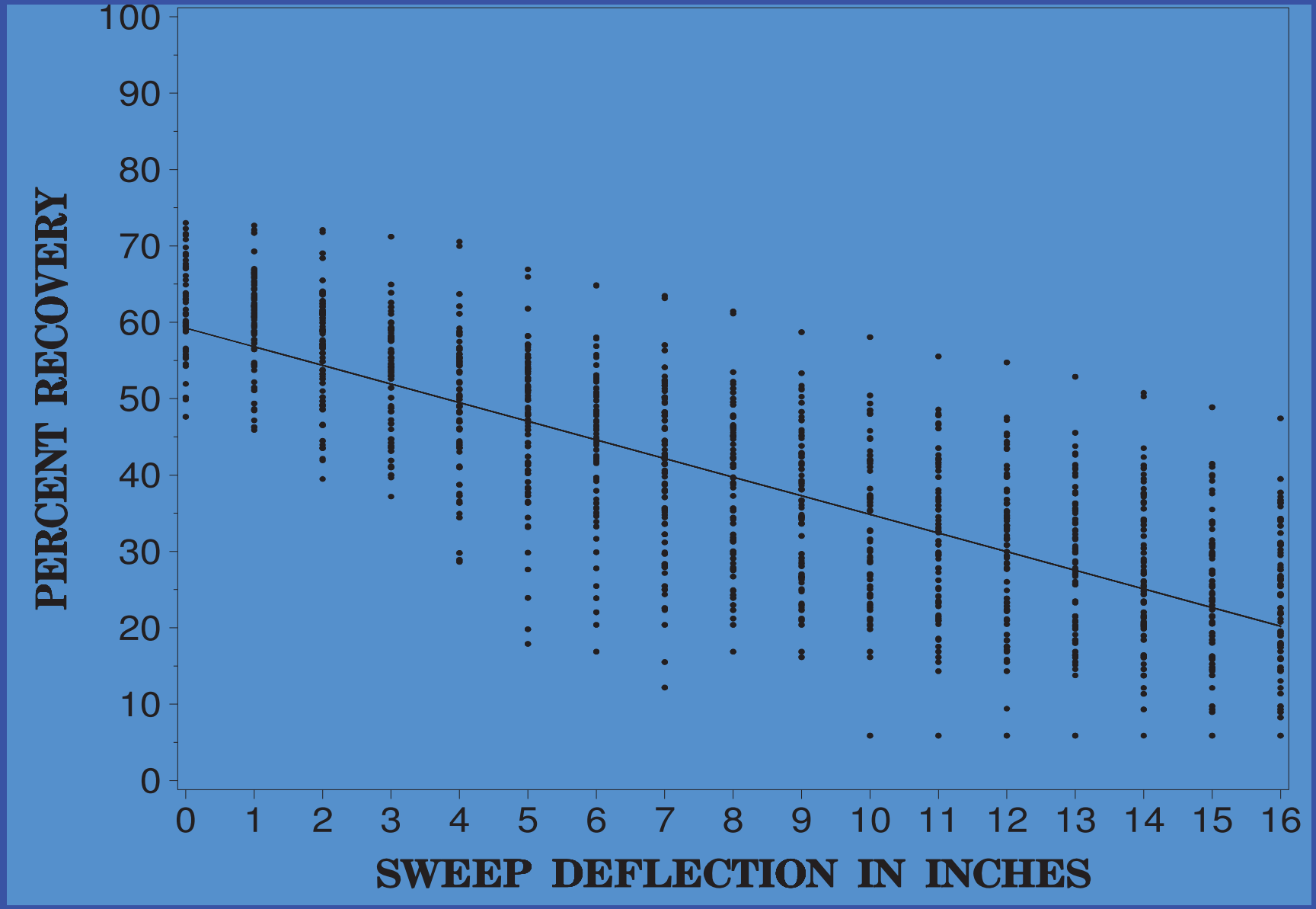
Benefits of sawing simulation

- Sawing parameters can be held constant
- Log variables, such as sweep, can be examined in isolation of other confounding factors
- Logs can be repeatedly sawn in different ways
- Able to explore the full range of variation
- Experimental Design is balanced

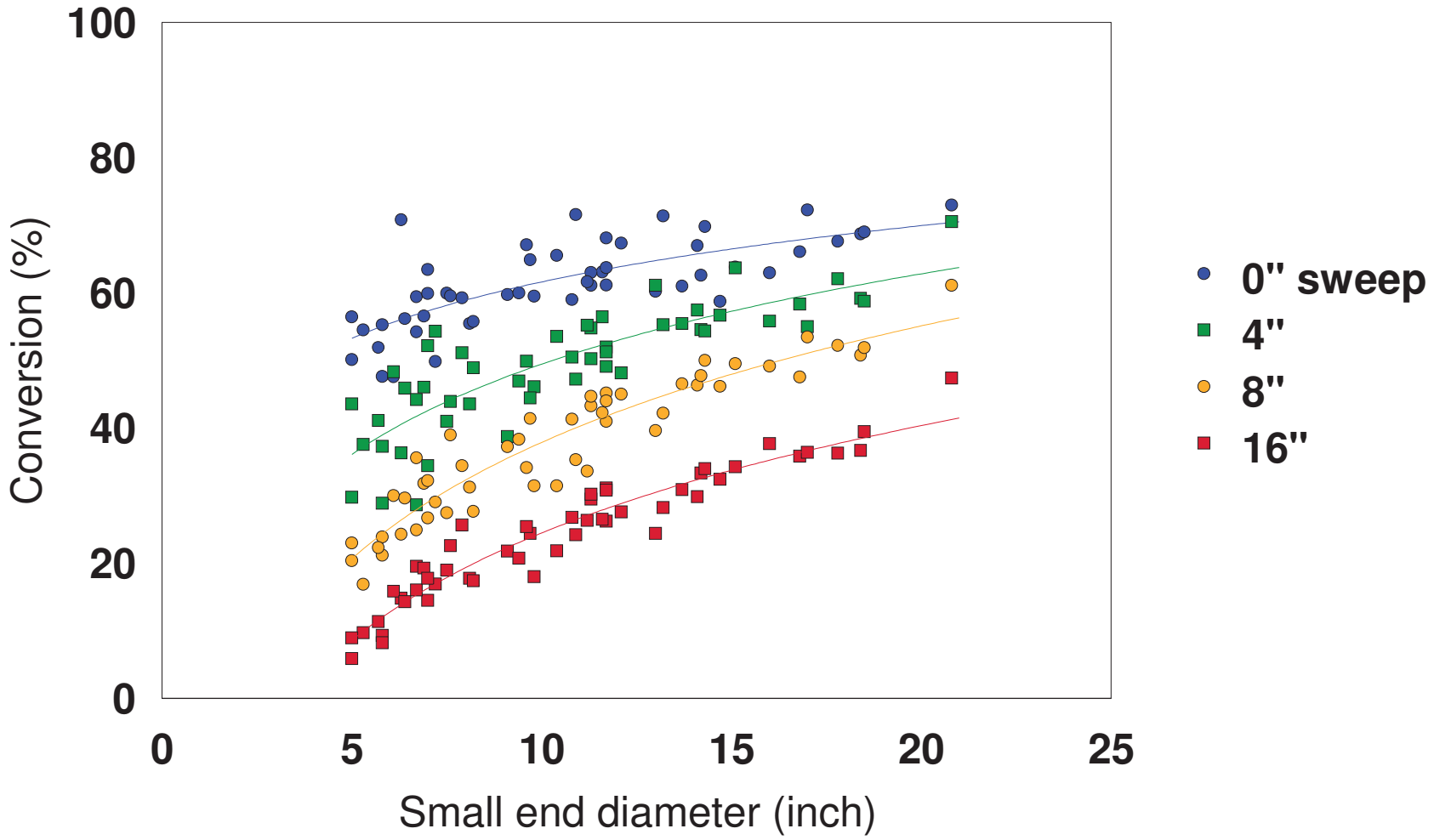
Material

- 52 Western Hemlock logs *(Tsuga heterophylla)*
  - All knots and defects measured and mapped
- Add sweep in 1-inch increments (16 times)
  - Bend in center of 16-ft logs (uniform)
  - Bend 4-ft from end (non-uniform)
  - 33 sets of 52 logs = 1716 observations

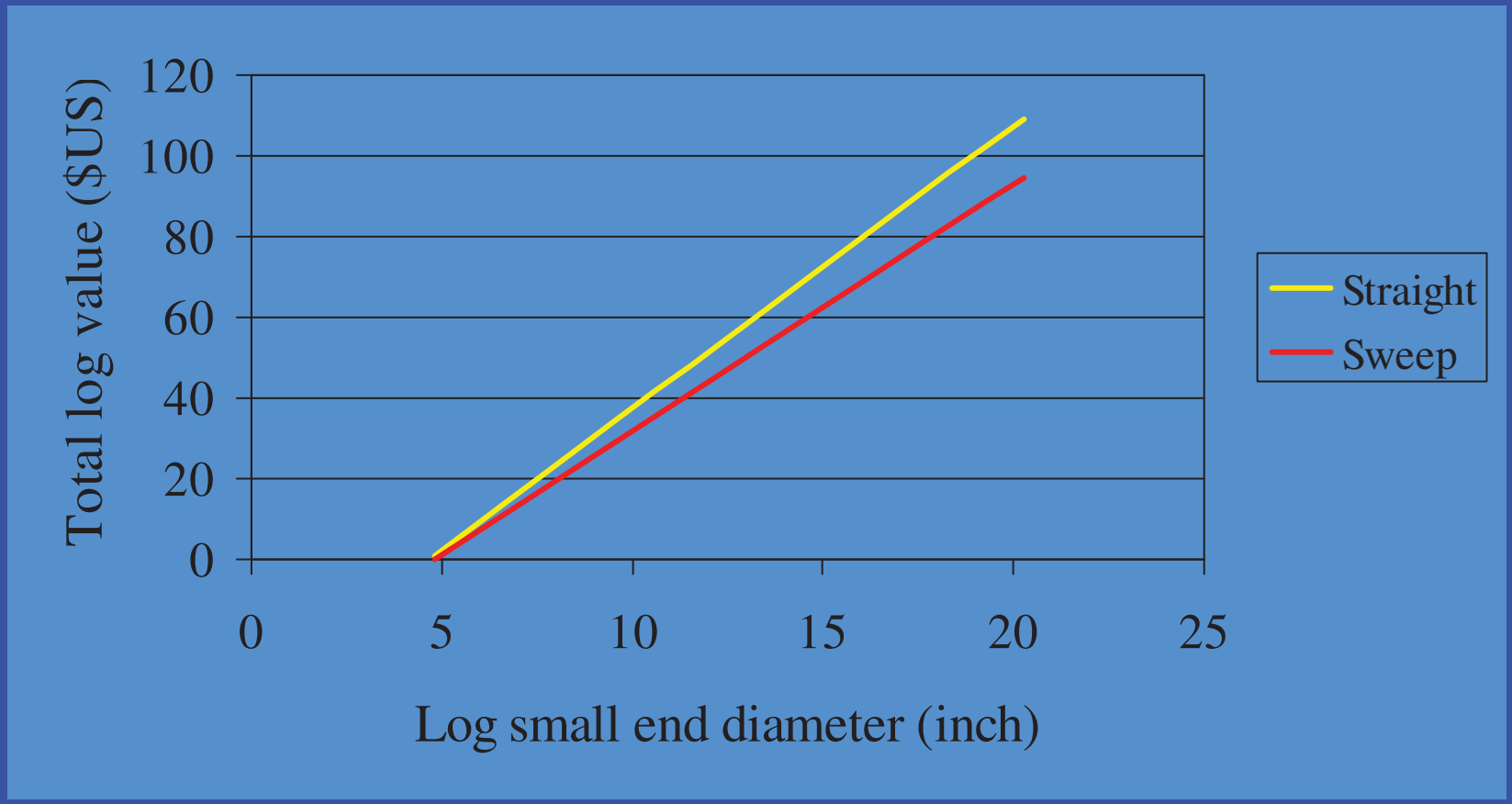
Results


PERCENT RECOVERY
100
90
80
70
60
50
40
30
20
10
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
SWEEP DEFLECTION IN INCHES

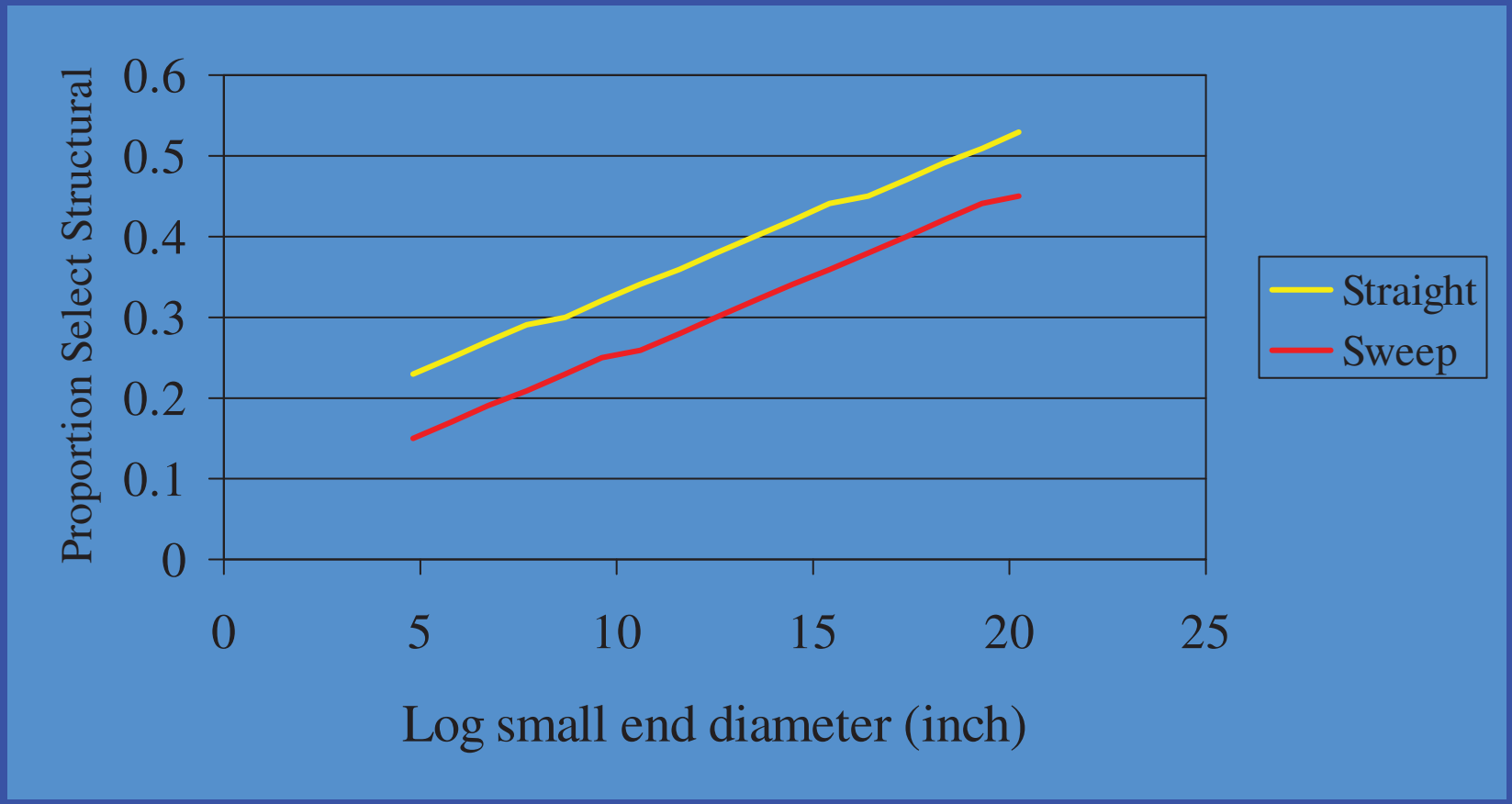
Effect of sweep on conversion



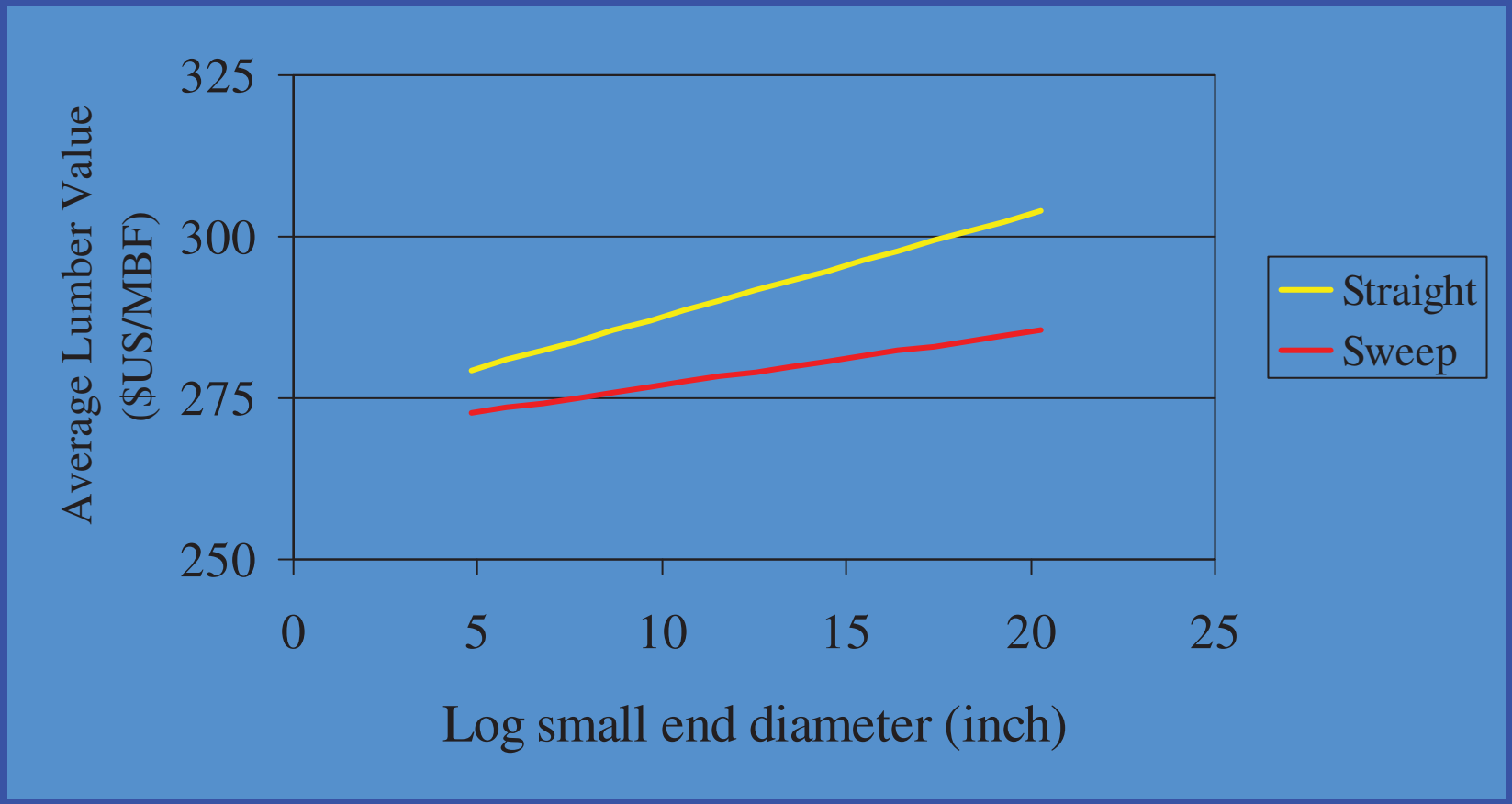
Total Lumber Value ($ per Log)



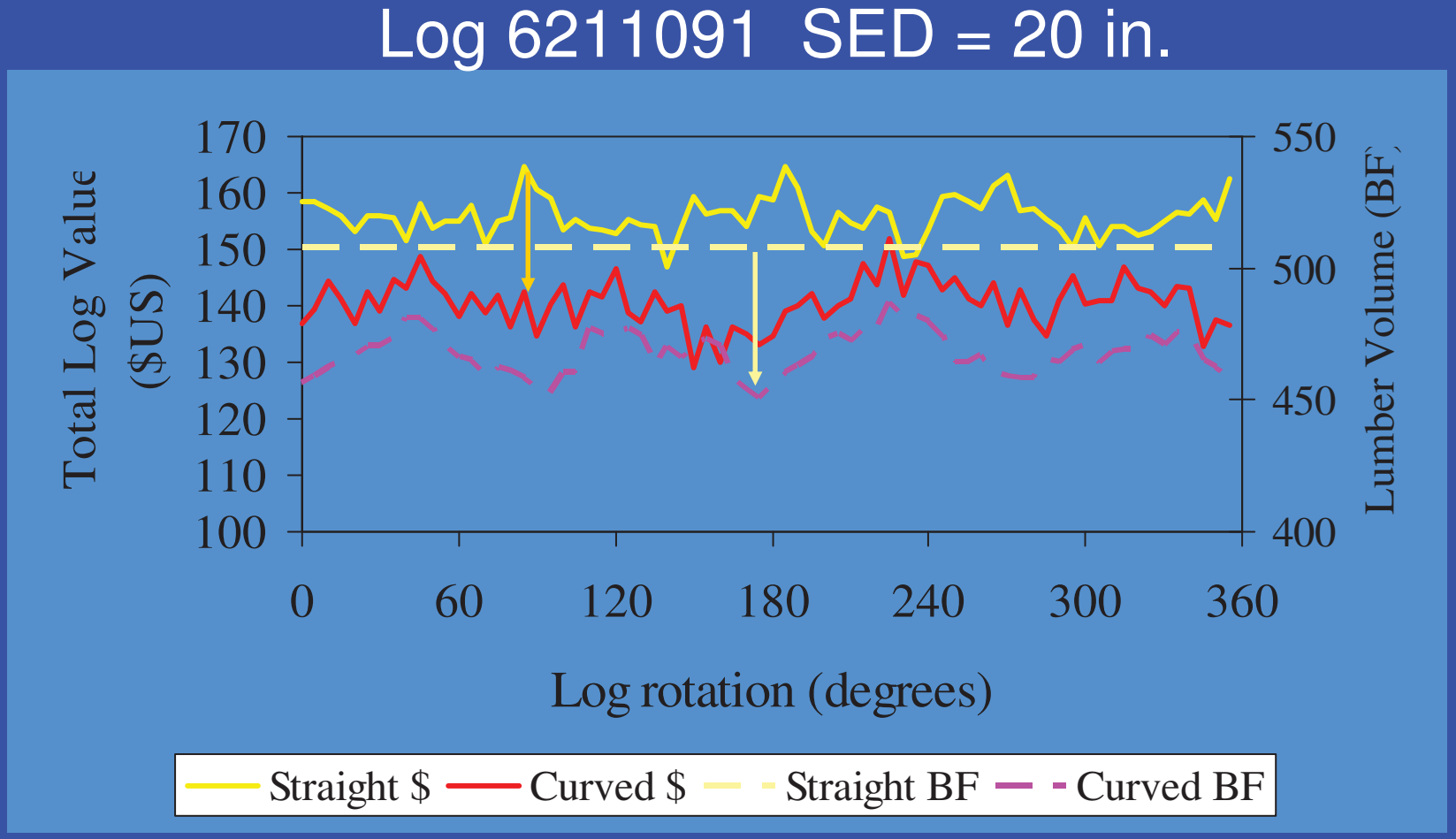
Proportion of Select Structural



Average Lumber Value ($ per MBF)



Log value & volume due to rotation: Straight vs Swept

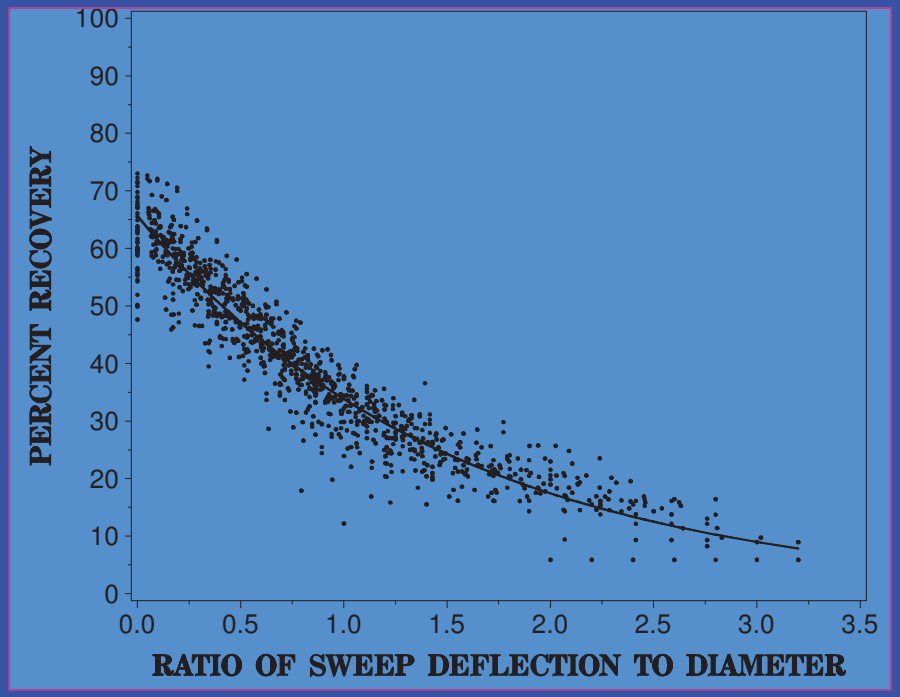


Results

- Recovery of straight logs = 59 %
  - (Volume of boards = 59% of log volume)
- Recovery declined 2.4% for each 1-inch of sweep per 16-foot log
- Declined 10% for each 4-inch of sweep
- Trend was linear
- Intercept increases with diameter
- Variation was large and constant
  - (CV = 25%)

Results: Ratio of Sweep to small-end Diameter: s/d

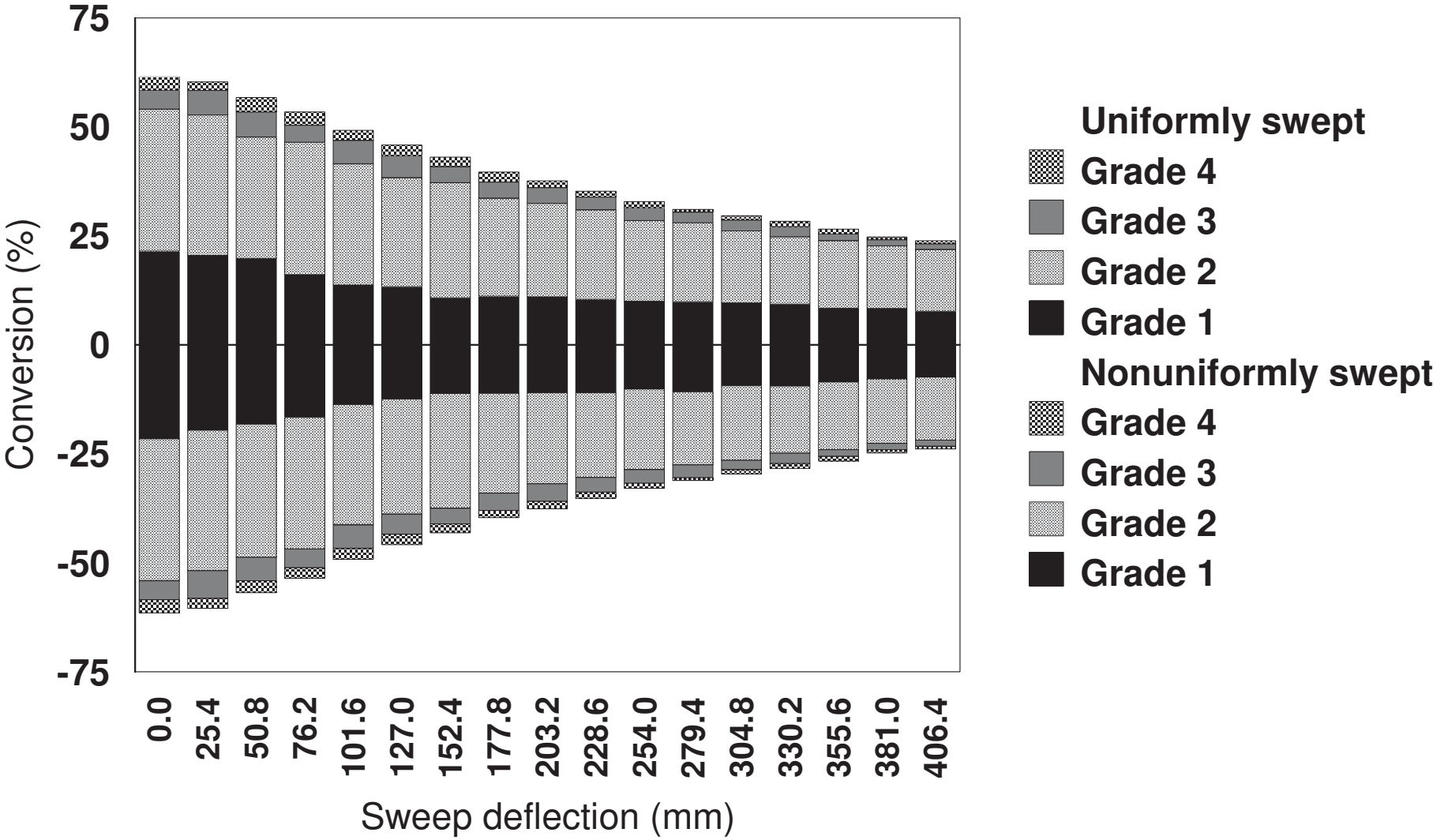
- Recovery declined nonlinearly with s/d
  - Nearly linear when s/d < 1
  - Slope is -3.2% for each 0.1 s/d (-7% and -5% in two other studies)
  - Rather tight relationship (R^2=89%)
  - No additional variation due to diameter



Results

- Recovery % the same regardless of uniform or non-uniform sweep.

Recovery %
by Sweep, Grade, & Sweep Location



Conclusions

- Expected trend of decreasing recovery % with increasing sweep was found
  - Trend was linear
  - Variation largely due to log size (diameter)
- Relation between recovery % and s/d (sweep/diam) was exponential decay, not a constant rate.
- Value loss ($/Vol) was also exponential decay

Conclusions

- Straight logs have higher value than swept logs
- Volume recovery is the main reason
- Differences in grade yield are a secondary reason
- More wane from curved logs is probably the cause

Conclusions

- Sawing discrete boards is a step function
  - Very sensitive to small changes in initial set-up
  - Large and essentially constant amount of variation always present
- Sawing simulation a useful tool for analyzing variation

Citation:

- Monserud, R.A, Parry, D., Todoroki, C.L. 2004. *Recovery of Simulated Sawn Logs with Sweep.* New Zealand Journal of Forestry Science 34(2): 190-205.

BUT.. log shape is not limited to sweep