Logging Utilization Research in the Pacific Northwest: Residue Prediction and Unique Research Challenges

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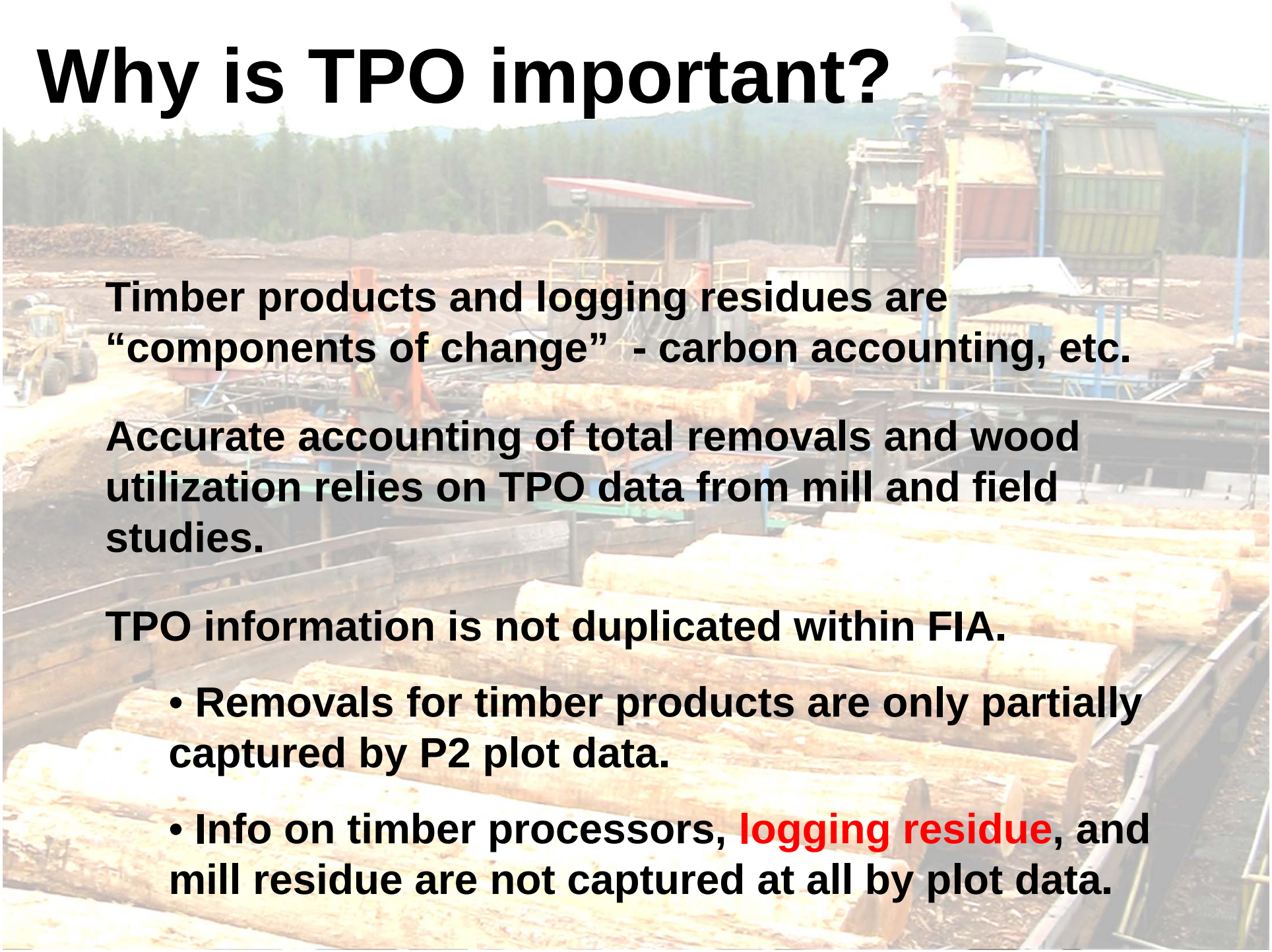
Outline

- Introduction to timber products output (TPO)
- Logging utilization research objectives
- Methods
  - Sampling challenges
  - Sample protocol- site and tree selection, measurements
  - Simulation to check for sampling bias
- Results- residue ratio by entire project and regions
  - Simulated versus “real” data outcomes
- Residue guidelines for managers
- Future research

Why is TPO important?



Timber products and logging residues are "components of change" - carbon accounting, etc.

Accurate accounting of total removals and wood utilization relies on TPO data from mill and field studies.

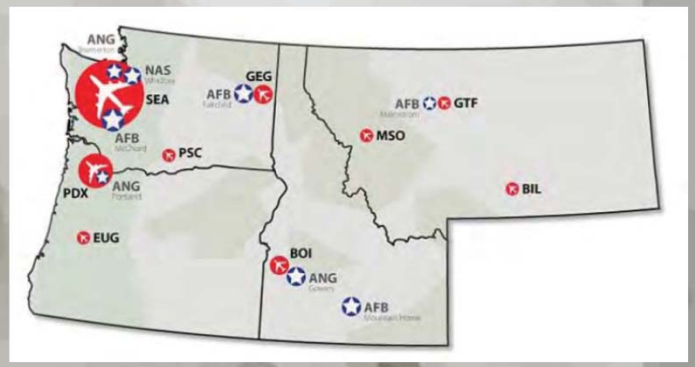
TPO information is not duplicated within FIA.

- **Removals for timber products are only partially captured by P2 plot data.**
- **Info on timber processors, logging residue, and mill residue are not captured at all by plot data.**

Logging Utilization Research Objectives

The overall goal was to acquire and analyze the data needed to develop/update TPO harvest residue data for each state in the 4-state Pacific Northwest NARA region.

- Biomass for energy production
- Nutrient recycling- LCA
- Carbon dynamics
- Fuels management
- Fire behavior
- Wildlife habitat
- Operational efficiency



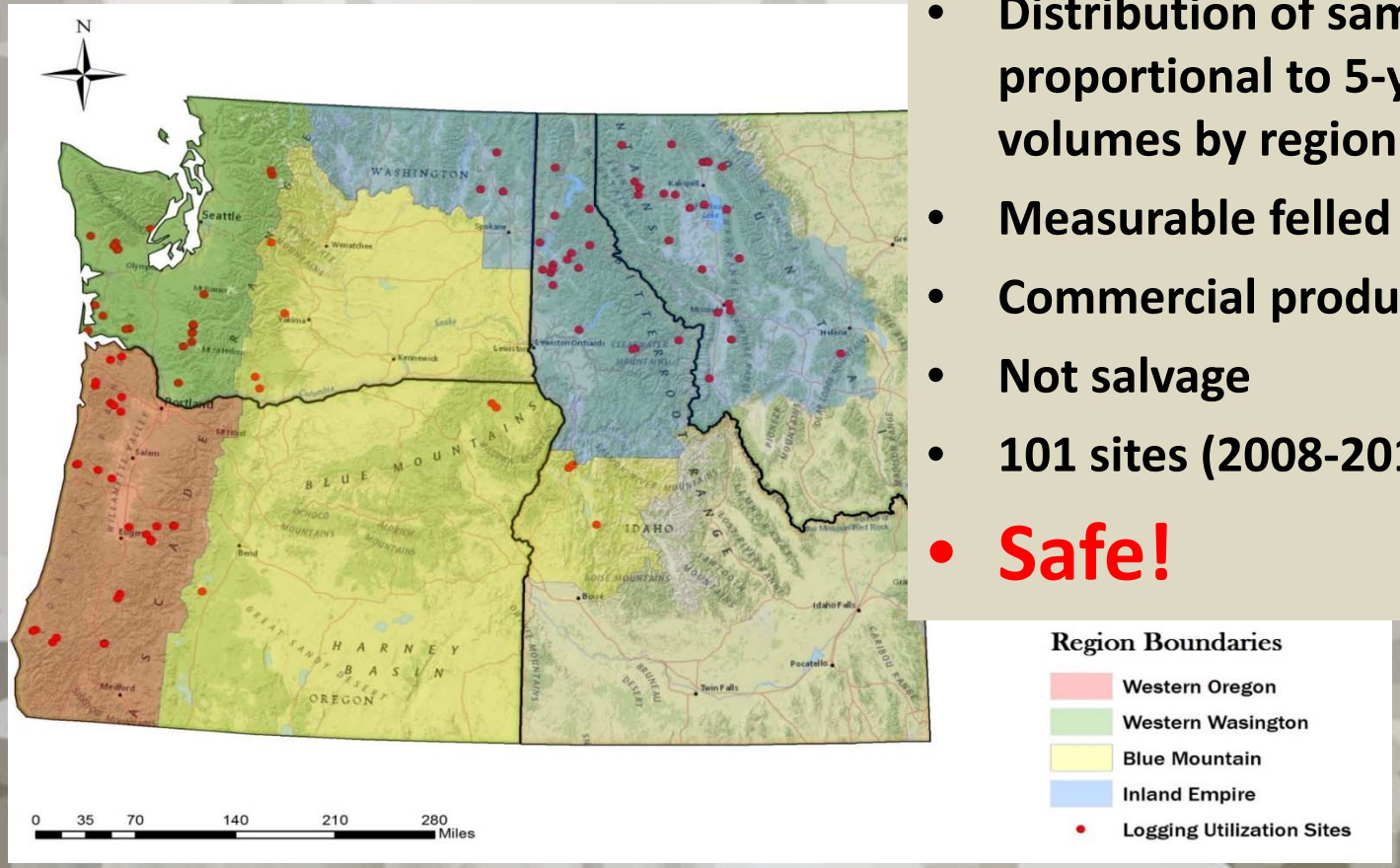
Sample design problem: comprehensive lists of logging sites do not exist, so we can't select sample sites at random and conduct probabilistic design-based sampling

Site	Acres	Ownership	Silv. Rx	Date felled	Date yarded	Date hauled	Total volume harvested (MBF Scribner)
1	25	USFS	SW	Oct. 1 2015	NA	NA	NA
2	20	Smith	CC	Oct. 5 2015	Oct. 7 2015	Oct. 9 2015	600
3	50	Jones	CC	Sept. 20 2015	NA	NA	NA
4	15	Doe	Thin	Sept. 15 2015	Sept. 15 2015	Sept. 17 2015	750
5	60	ODF	SW	Oct. 10, 2015	NA	NA	NA

What to do?

- **Model-based sampling.**
- **Model error serves as a surrogate for design-based sampling error.**
- **Sample weighting, stratification, and clustering where possible (keep the design-based tools in the toolbox).**

Logging Utilization Sample Sites



Site selection

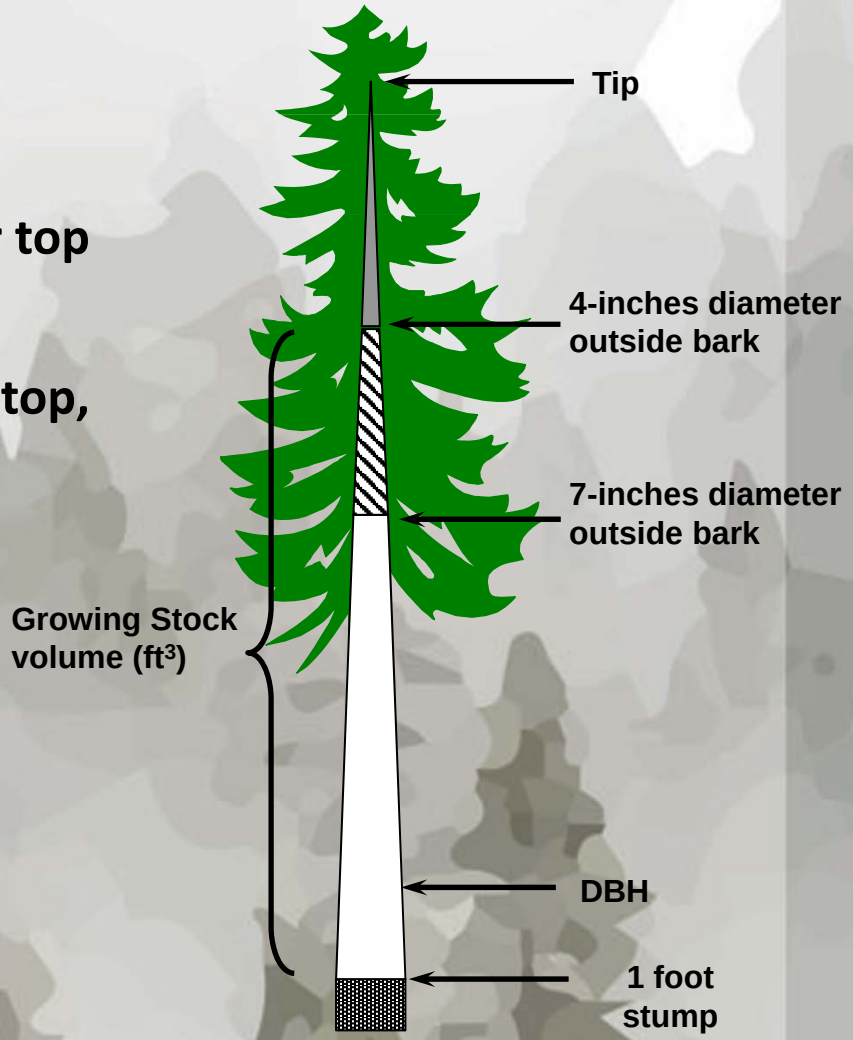
- Four strata = "Regions" based largely on Bailey's Ecoregions.
- Distribution of sample sites proportional to 5-year harvest volumes by region
- Measurable felled trees & stumps
- Commercial products
- Not salvage
- 101 sites (2008-2013)
- **Safe!**

Region Boundaries

- Western Oregon
- Western Wasington
- Blue Mountain
- Inland Empire
- Logging Utilization Sites

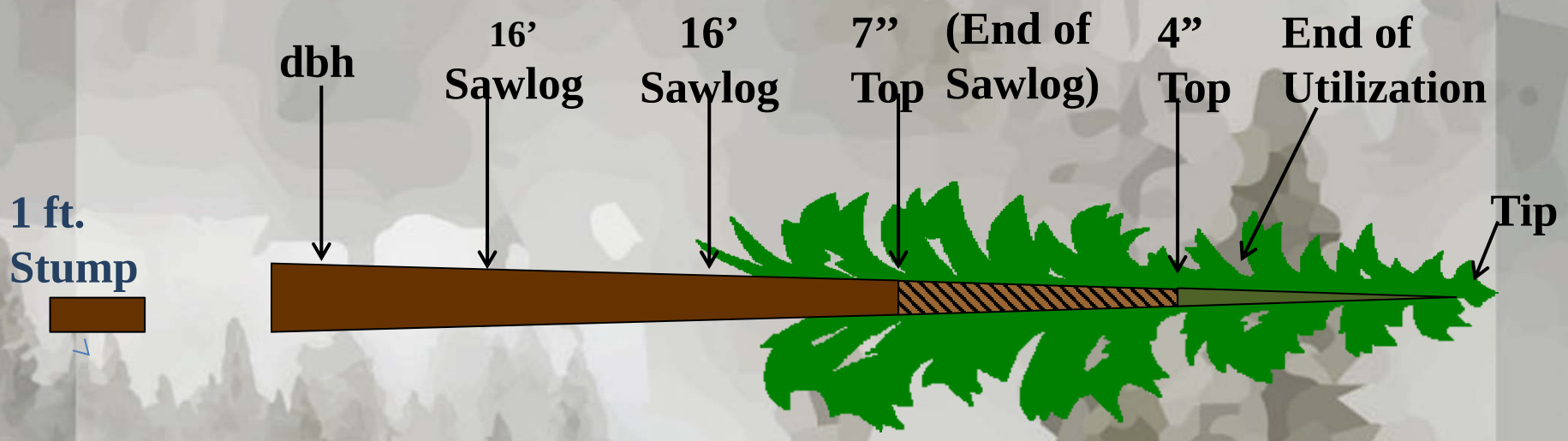
Logging Utilization Sampling Methods

- Focus was growing stock.
- Cutting card was a utilization guide.
- Checked log decks and residue piles for top diameters.
- Used FIA definitions: 1’ stump, dbh, 4” top, growing stock, etc.
- Identified each bole section as used (product) or not (residue)



Methods

Measuring trees



Methods

- The response variable is the residue ratio (expressed as ratio of means).
- Residue ratio is a function of only *bole wood.*
- Ratio is *scalable*; beneficial for land managers.

$$RR = \frac{\text{Growing stock residue volume (bole wood only)}}{\text{Delivered volume}}$$

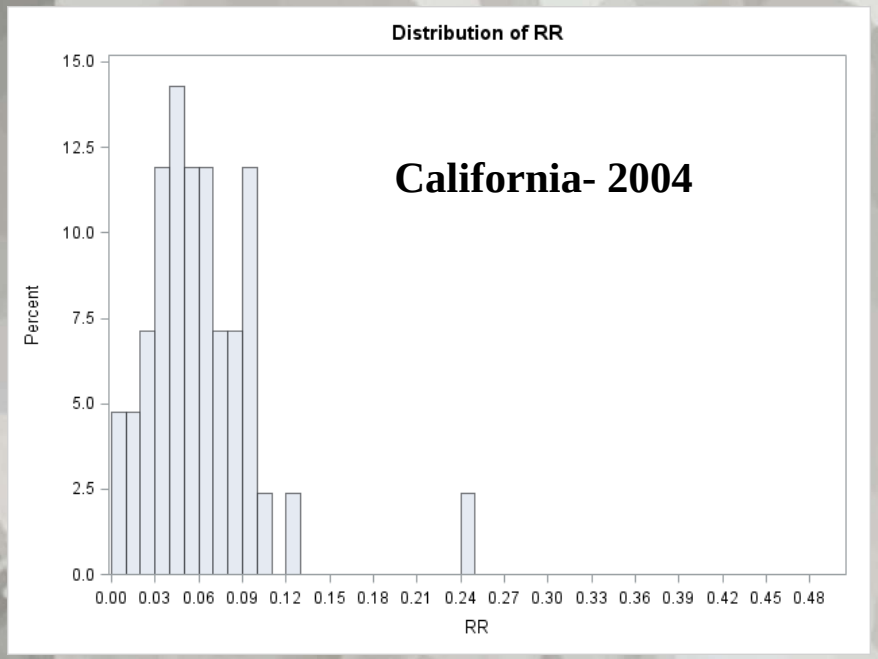
Analysis

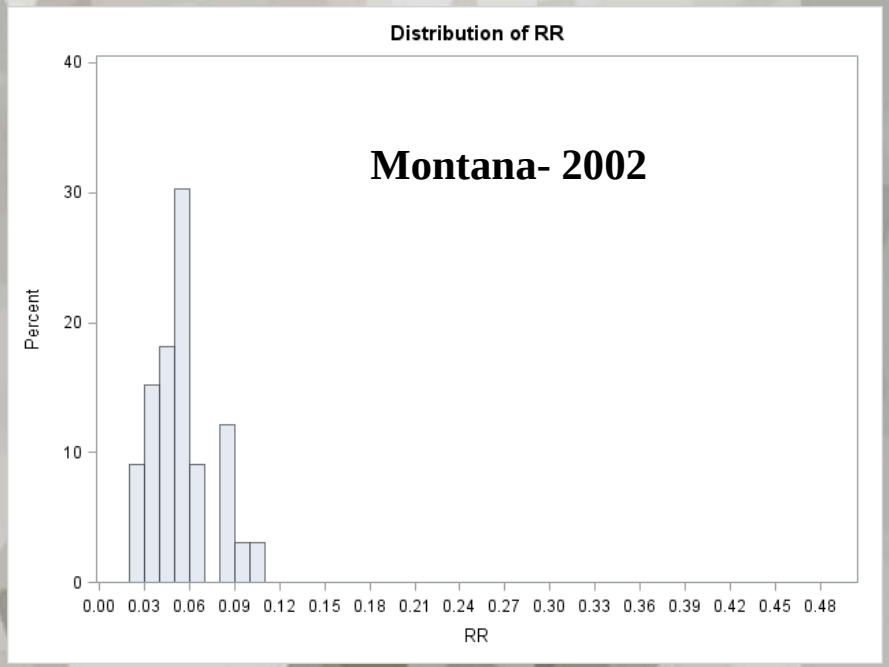
- **Residue ratio (RR) of means modeled with multilevel (sites within regions) linear mixed model.**
- **Sample weighted by regional proportion of harvest volume.**
- **Residue ratio also calculated with classic design-based survey sample software.**
  - **Why?- design-based has been “business as usual”. Have we biased our samples by not choosing sites at random?**

(2001 trees sampled within 101 sites within 4 regions)

Analysis

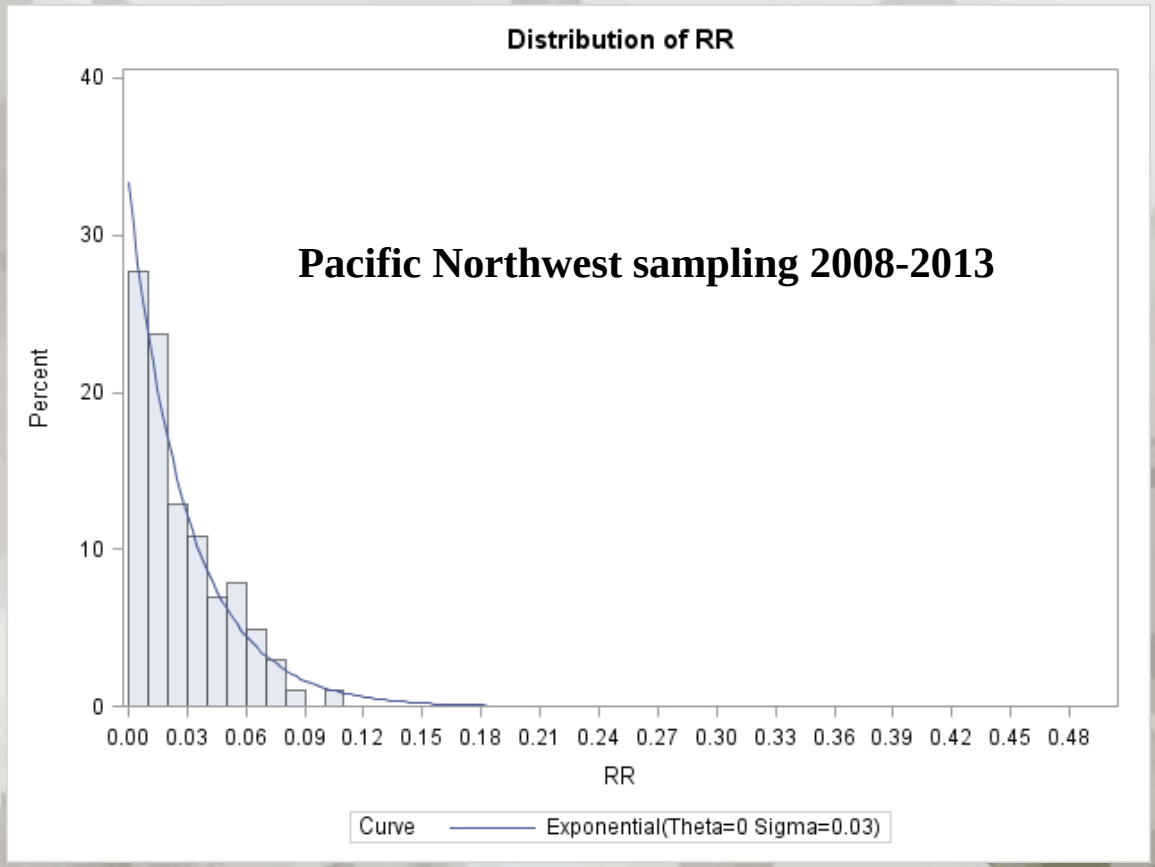
- Again…could our logging site selection be biased?
- Simulate residue ratio distribution to obtain the "true" population; compare with "real" data.
  - But what is the theoretical distribution of the residue ratio- the "true population"?
  - Past projects: California and Montana suggest a normal, log normal, or chi square distribution





Analysis

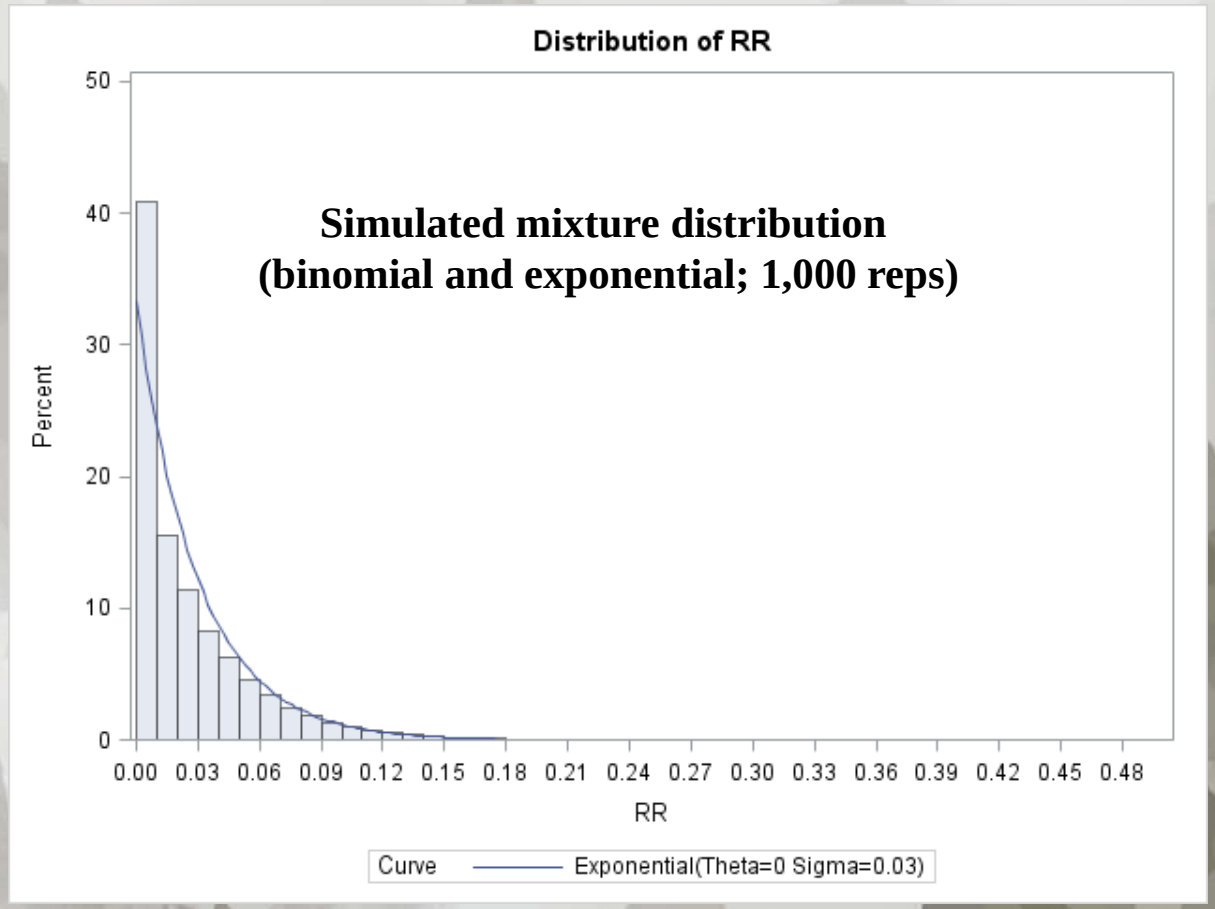
But the 2008-2013 sample suggests an exponential distribution



Analysis

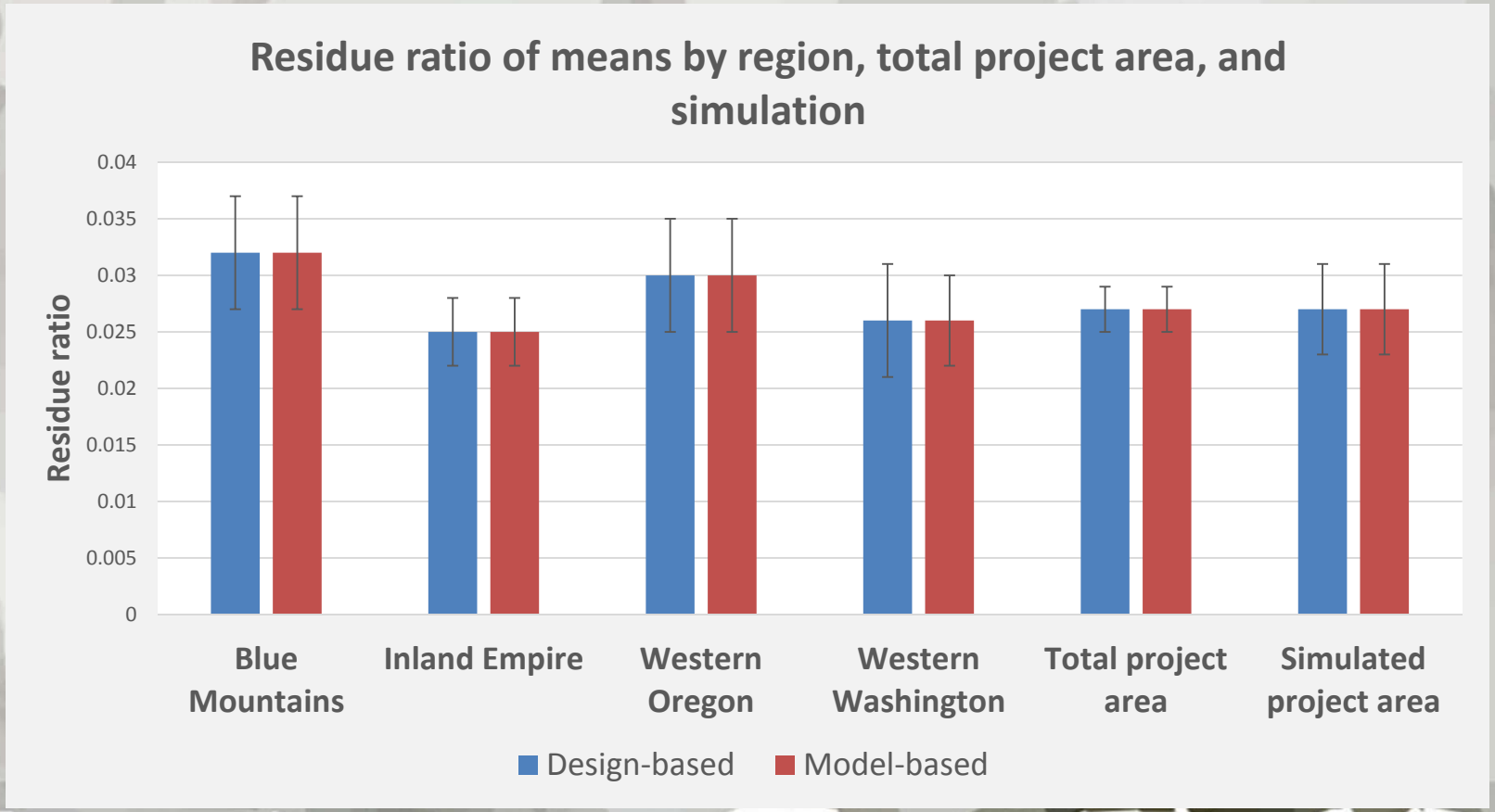
Decision- go with mixture distribution (mostly exponential)

Why?- sample trees consistently second growth; low stump heights, mechanized felling, pulp taken on most sites- all contribute to low RRs.



Results

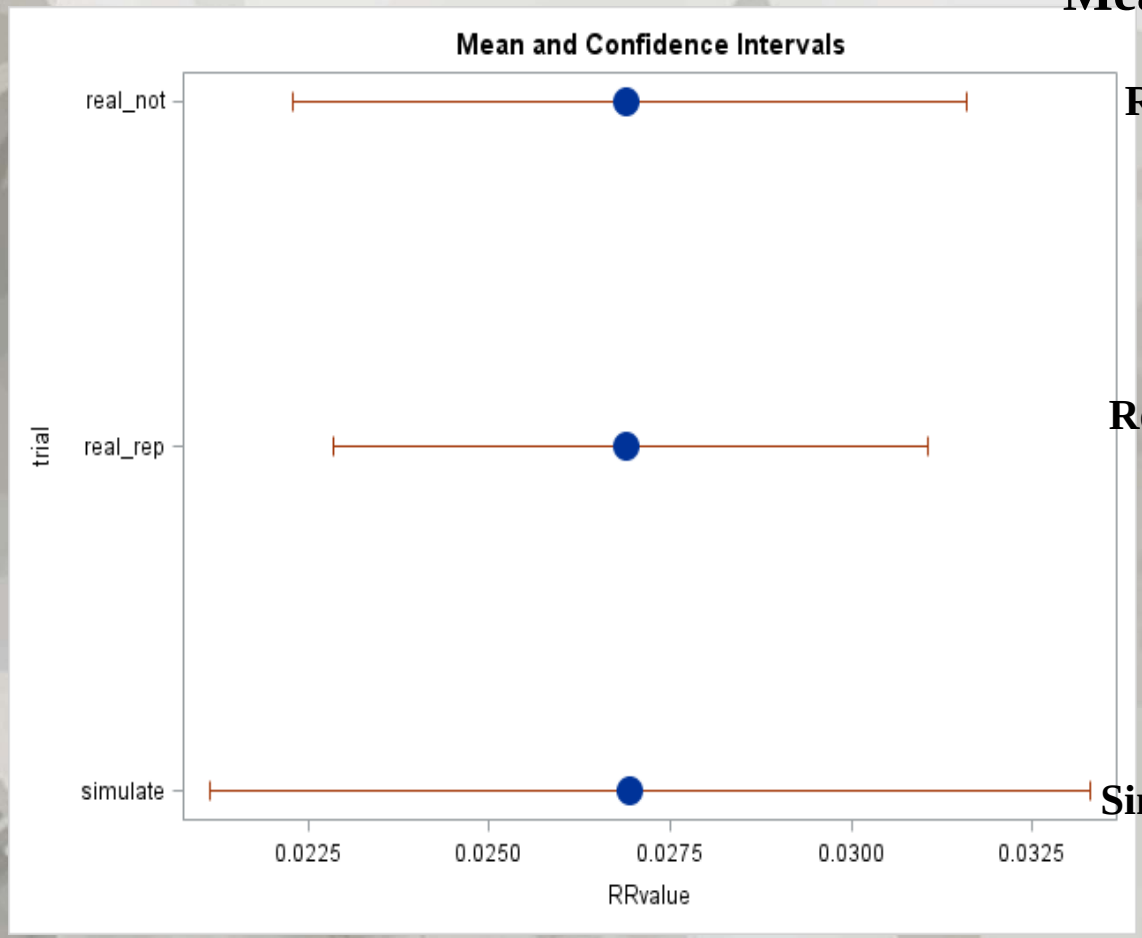
- Project as a whole residue ratio for 4 states = 0.027 or 27 cubic feet of growing stock residue per 1,000 cubic feet mill delivered.
- Residue ratios varied little by region.
- Design and model-based produced essentially identical residue ratios and standard errors.
- "Real data" outcomes within 1 percent of simulated (minimal bias).



Results

Could detect little bias- compared "real" data with simulated and bootstrap of real data.

Means and 95 % CIs



Real data (101 sites)

Real data- 1,000 reps- bootstrap

Simulated- 1,000 reps- then 1,000 draws

Final note on sampling

- **Model-based sampling is a reasonable way to structure a logging residue sampling protocol; simulation suggested that sample was likely not biased.**

- **But design-based sampling may be a wiser choice, if you can obtain comprehensive lists of active logging sites.**

- **Are there alternative ways to conduct probabilistic design-based sampling?**

Residue Guidelines for Managers

Important variables:

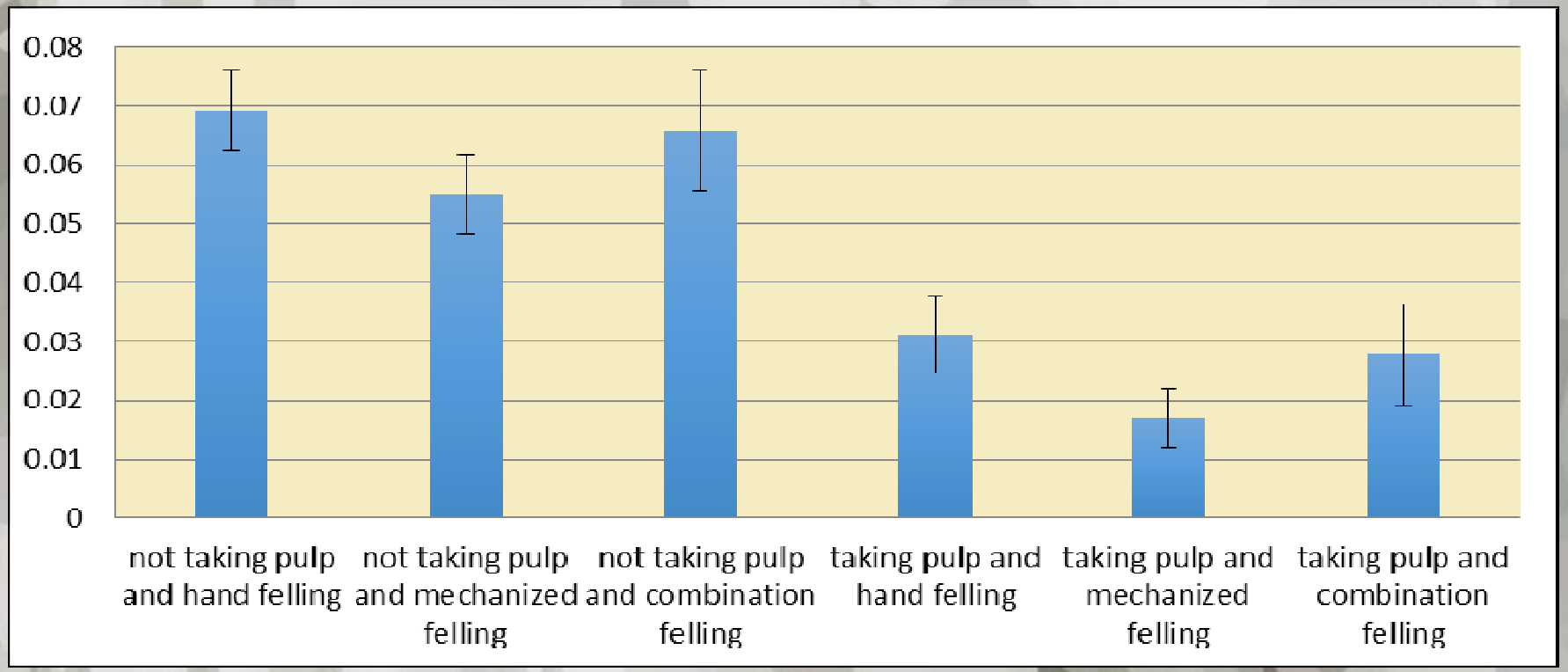
Taking pulp-

***yes or no*.**

Falling method-
Mechanized vs. hand (chainsaw)

Residue Guidelines for Managers

Residue Ratio by pulp removal and felling method



Summary

- **Project as a whole residue ratio for 4 states = 0.027 or 27 cubic feet of growing stock residue per 1,000 cubic feet mill delivered.**

- **Essentially no difference in design and model-based residue ratios.**

- **Little difference in residue ratios by region.**

- **Simulation suggested minimal sample bias (but more work needed and each project area's logging site residue ratios can be unique- hard to know distribution in advance).**

- **Research provides useful residue information for land managers.**

Thank you for your time!

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