Applied Biometrics

Mensuration Techniques, Design & QAQC

CLFA 2020 Spring Conference, Anderson, California

March 6, 2020

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Outline

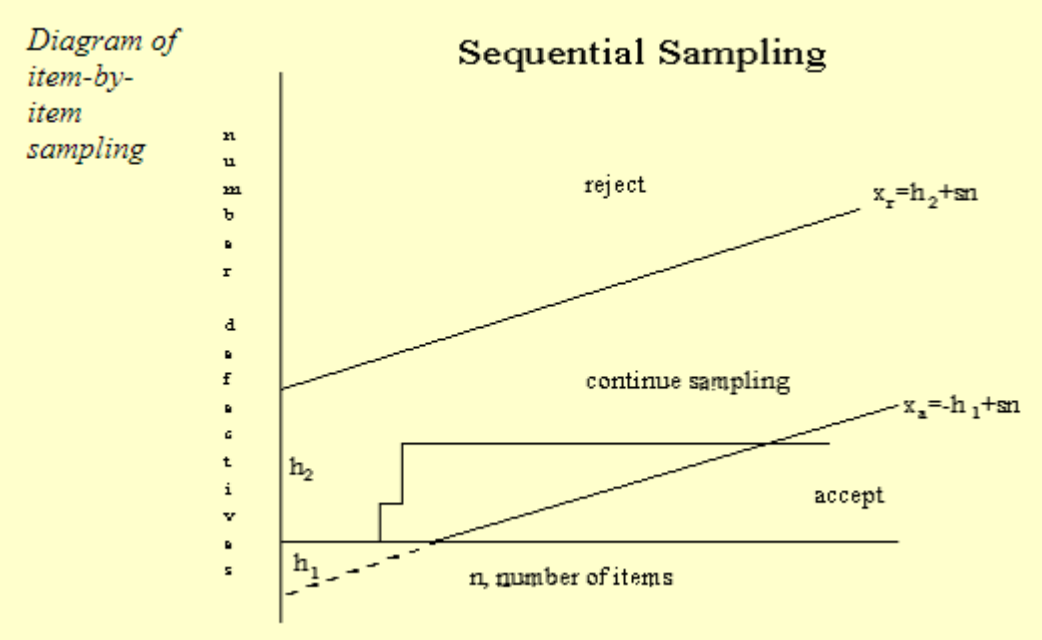
- Sequential Sampling
- Hazard Tree Inventory on the Camp Fire: Linear Features
- Inventory Topics
- Biometrics Bits
- Field Tech
- Dr DBH
- FVS New Interface & Redwood
- New Technologies
- Carbon Projects
- Property Acquisitions: Signing Off on the Inventory Data

Recent Meetings Attended

- SAF Forestry Technology Workshop, Columbia, South Carolina. May 8 - 9, 2018
- Western Mensurationists Meeting, Flagstaff, Arizona. June 17 - 19, 2018
- 2018 Joint Southern and Northeastern Mensurationists and IUFRO4.01 Conference, Blacksburg, Virginia. October 28 - 31, 2018
- SAF National Convention, Louisville, Kentucky. October 30 – November 3, 2019

Sequential Sampling

- Background
  - QA/QC WWII
  - Pharma



- Advantages
  - Limitless options with sample size and schedule
  - Can refine sampling as you go
  - Efficient design
- Disadvantages
  - Representative?
  - Randomized?
  - Inference to entire population questionable

Sequential Sampling in Carbon Projects

- Paired: Almost Always
- Methods Used Assume Variance Unknown
- When a Stratum Not Passing
  - If trending towards passing then have verifier measure more plots
  - If not, then stop and re-inventory

Hazard Tree Inventory on the Camp Fire

- Purpose
  - OES, CAL FIRE, Local Govt
  - Hazard Trees to Public Infrastructure
- Question: # of Hazard Trees to Be Removed
- Design
  - Roads
  - Parcels
- Analysis
  - Combining Two Independent Samples

More Inventory Topics (2018 WMENS Mtg)

- **Zack Parisa/James Arney**; President, SilviaTerra/President, For. Biometrics Res. Institute: *On the Evolution of the Stand and Strata*
- **Dan Opalach**; Biometrician, For. Biometrics Res. Institute: *The Maximum Stand Density Index for Coast Redwood*
- **Martin Ritchie**; Research Forester, USDA Forest Service: *The standview R-Package for Generating Density Management Diagrams*
- **John A. Kershaw**; Prof., Univ. of New Brunswick : *The Use of Mixture Distributions for Describing Stand Structure using Terrestrial LiDAR*
- **Damon Vaughan**; Ph.D. Student, No. Arizona Univ.: *Effect of Stand Basal Area on ponderosa Pine Wood Quality: Findings from a Replicated Density Experiment at Taylor Woods*

SAF Forestry Source Articles

- Biometrics Bits
  - What Type of Plot is “Most Forgiving?”, Brian Clough, Dec. 2017
    - Variable vs. fixed plots
    - Simulation of sampling in 75 sq ft stand of mixed loblolly and hardwood
    - 3 types of cruisers: Pessimistic Pete, Optimistic Olivia, and Even Evan
    - Results
      - No difference in estimated basal area
      - Use measurements for borderline trees, not estimates or alternate
  - The Map is Not the Territory: Rethinking the Stand, Zach Parisa and Max Nova
    - At SilviaTerra, we’re excited about the potential to move from a vector-based stand paradigm to a raster-based “pixel” paradigm.

SAF Forestry Source Articles

- Biometrics Bits (cont.)
  - What Is the “Right” Amount of Inventory Information to Collect?, Nan Pond, March 2017
  - Optimizing Cruising for Your Forest Type, Nan Pond, June 2017
    - Simulations in pine and hardwood stands.
    - Fixed and variable radius plots of different sizes and intensities.
    - Lowest cost does not equal lowest cost+loss.
    - Loss is loss of information when making management decisions.

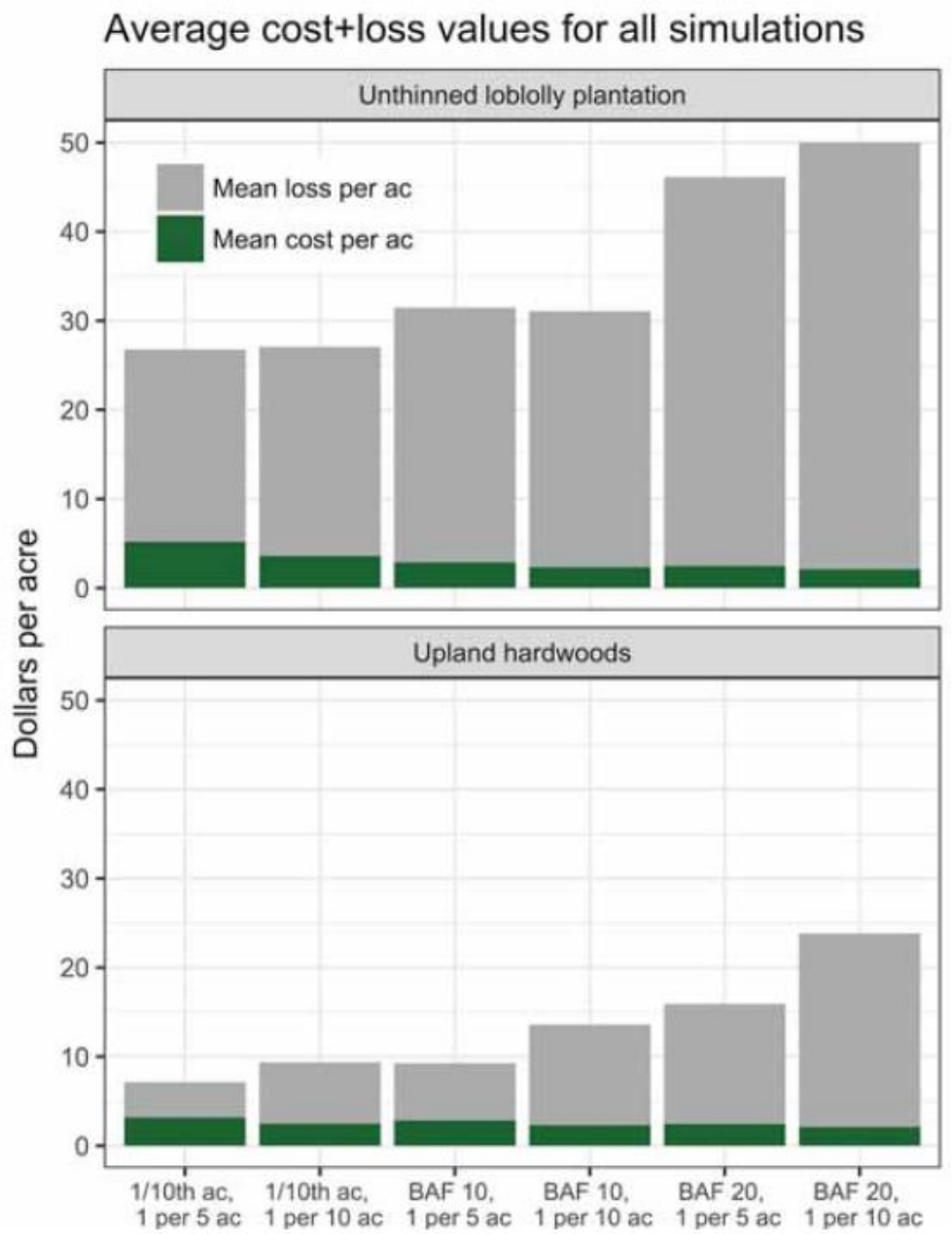


Figure 1. Simulated forest conditions: an upland hardwood forest and an unthinned loblolly pine plantation

SAF Forestry Source Articles

- Biometrics Bits (cont.)
  - VRP Sampling: Small-Diameter Struggles, Zach Parisa, Feb 2018
    - Objective of Inventory
  - Estimating a Proportion, Steve Fairweather, March 2018

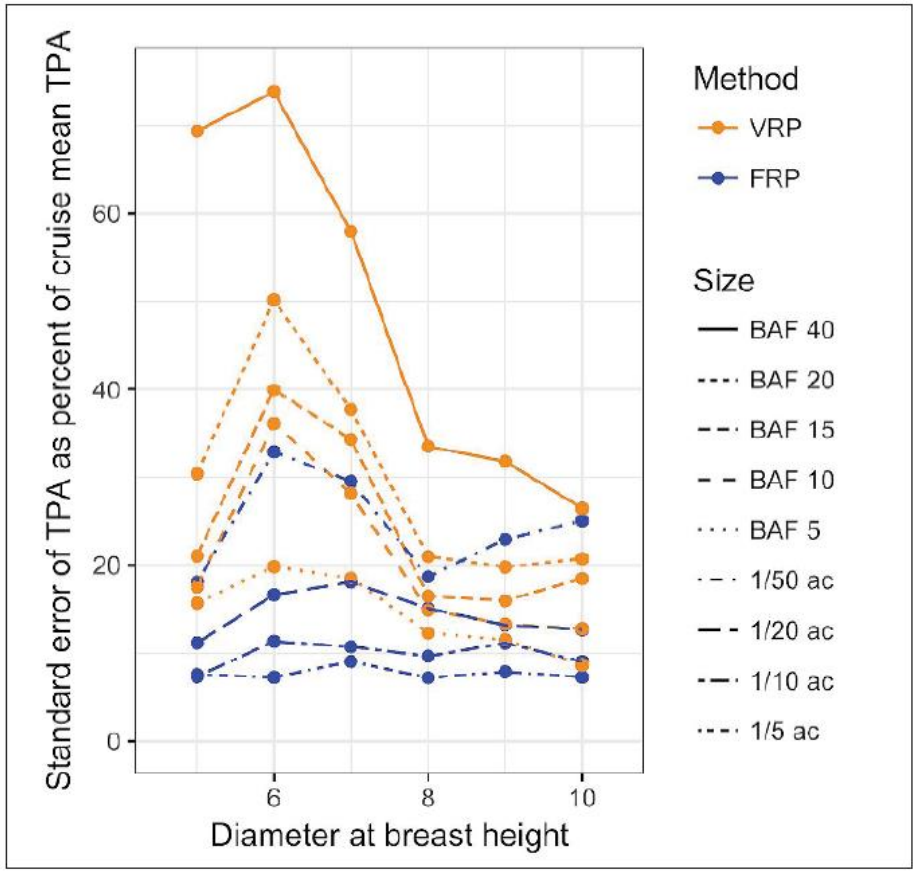
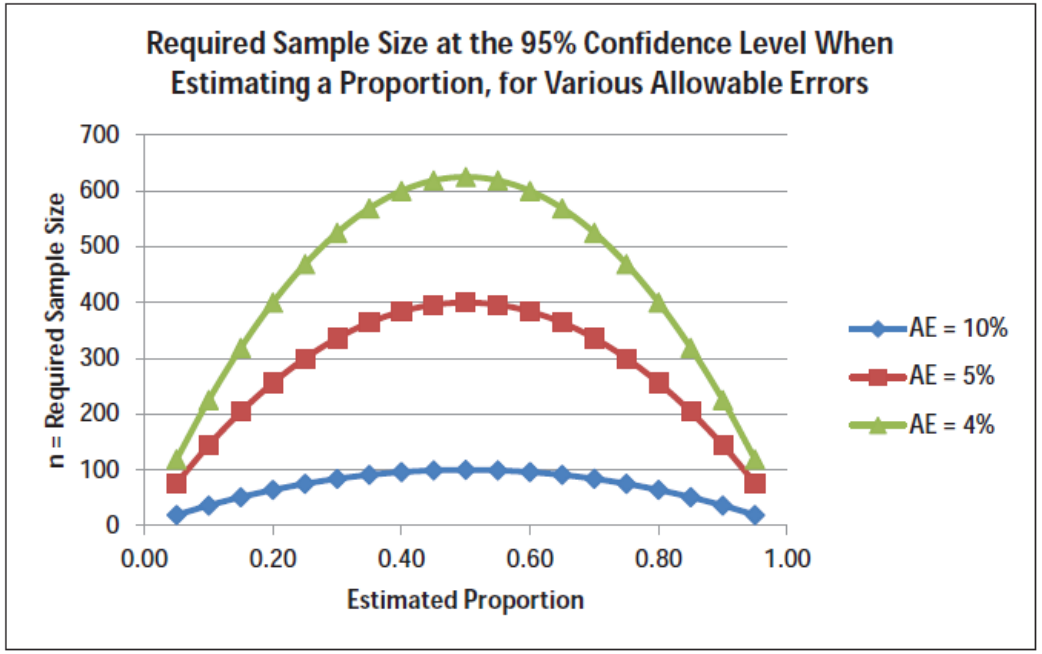


Figure 1. The standard error percentage is relatively higher in the lower diameter range for the VRP plots, especially for the larger BAFs.



$$AE = t(\mathrm{sqrt}(p(1 - p)/n),$$

$$AE2 = t2(p(1 - p)/n),$$

$$n = t2(p(1 - p)/AE2.$$

SAF Forest Source Articles

- Biometrics Bits (cont.)
  - The “Precision” in Precision Forestry, Zach Parisa and Max Nova, Oct 2018
    - “trade-off between increased precision and increased cost”
    - “the role of all this new technology is to enable you to achieve greater precision at a lower cost than traditional methods”
    - NPV is the metric, but look at entire value chain
  - Introducing forestsamplr: Free, Open-Source Forest Statistics Software, Nan Pond, June 2019
    - R Package
    - Cruise customization and comparisons

Learning to Use R

In addition to presenting a workshop on using R at the upcoming SAF National Convention, the A1 Working Group has posted three tutorial videos at tinyurl.com/yyje7nub:

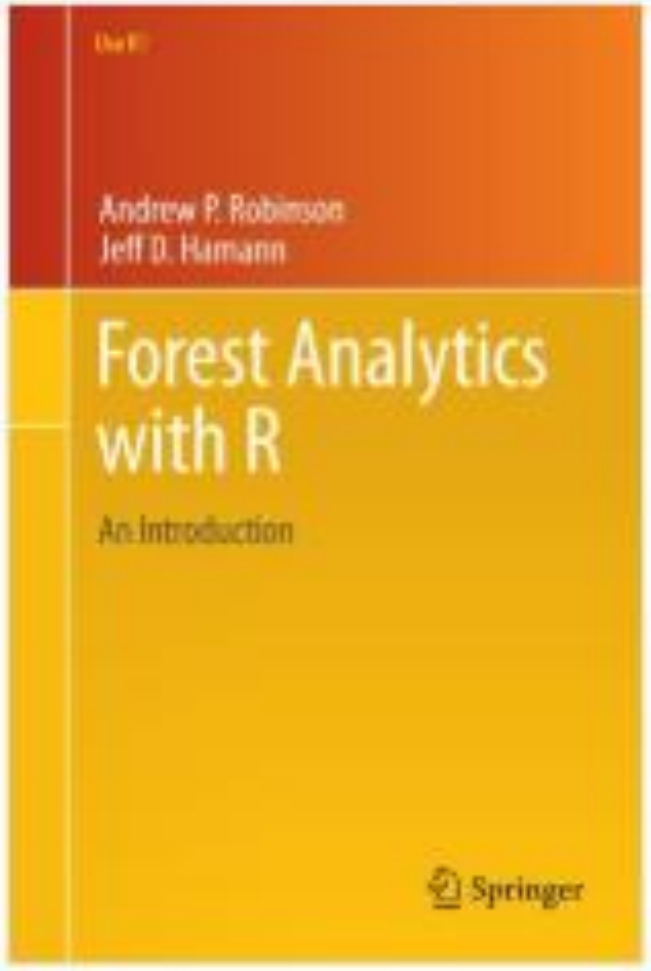
- Basics of Using R
- Introduction to R and RStudio
- Data Manipulation in R

Another resource is “R Tutorial for Beginners: Learning R Programming,” a collection of tutorials at www.guru99.com/r-tutorial.html.

- Simple random
- Cluster
- Stratified
- Systematic
- Two-stage
- 3P
- Poisson

R Statistical Software

- Freeware with many libraries
- Book
  - Part I
    - Intro to using R
    - Forest Data Management
  - Part II
    - Data Analysis for Common Inventory Methods
    - Imputation and Interpolation
  - Part III
    - Fitting Dimensional Distributions
    - Linear and Non-Linear Modeling
    - Fitting Linear Hierarchical Models
  - Part IV
    - Simulations
    - Forest Estate Planning and Optimization



SAF Forestry Source Articles

- Biometrics Bits (cont.)
  - How to Avoid a Common Mistake when Comparing Two Inventories, Henry Rodman and Nan Pond, April 2018
    - Use T or Equivalence Tests, Not Mean Comparison to CI
- DR DBH
  - A Tale of Two Cruises, Steve Fairweather, May 2018
    1. Statistically Different? Unpaired T-Test.
       - Does not matter how data collected
    2. If not different, then Combine into New Estimate.
       - Weighted Mean, 1/VAR = weights
       - New Variance is weights squared
    3. New estimate to help price negotiations or have better estimate if they fall through

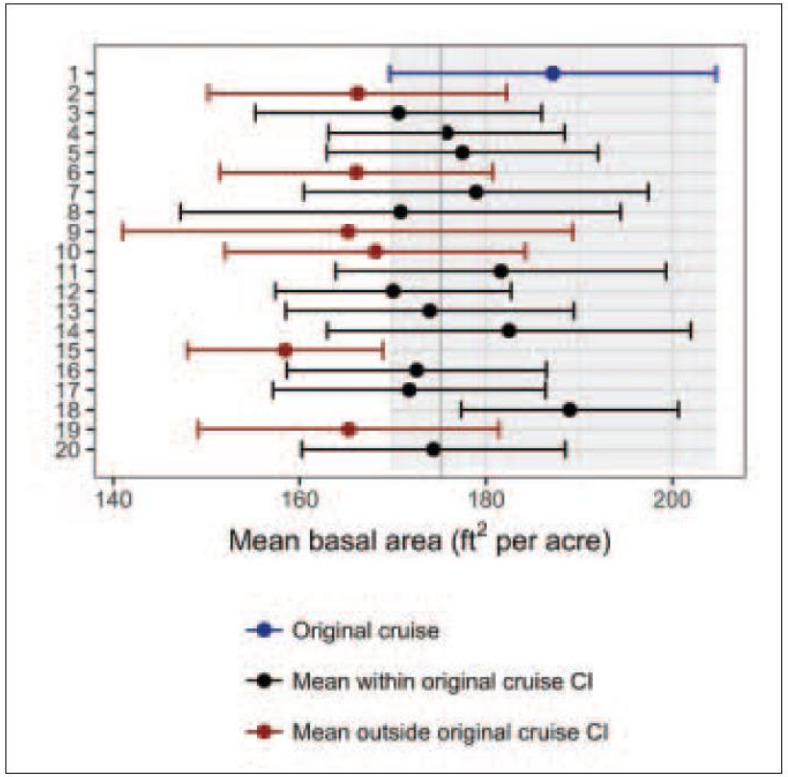


Figure 1: Twenty simulated cruises of the same stand and the confidence interval (CI) for each cruise.

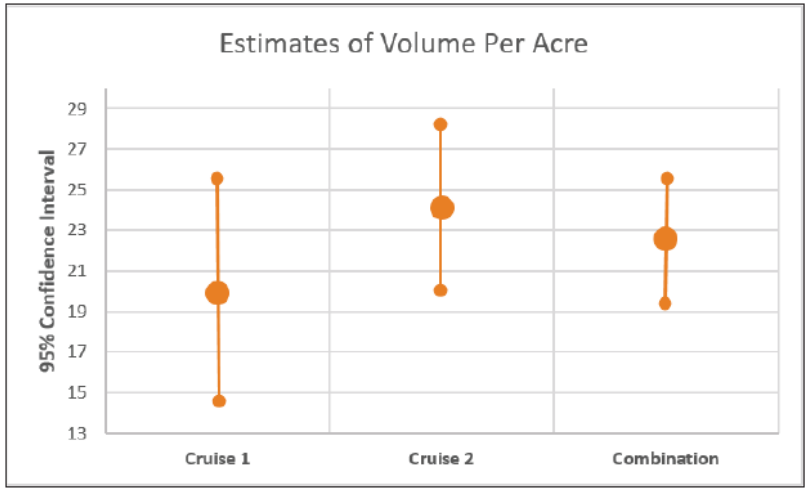


Figure 1. Comparison of two cruises

SAF Forestry Source Articles

- Biometrics Bits (cont.)
  - Sources of Error in Forest Inventory, Zach Parisa, June 2018
    - Meas. Error – Check Cruising
    - Sampling Error vs. Modeling Error
    - Should check Traditional Cruise modeling error, i.e. height and volume regressions
    - Coverage Error: “Do all areas this inventory is meant to describe have a known probability of being sampled?”
    - A Design-Based Inventory underpinning your RS coverage is insurance against Coverage Error

Error Type	Traditional Cruising Design-Based	Remote Sensing Model-Assisted	Remote Sensing Model-Based
Measurement	✓	✓	✓
Sampling	✓		
Modeling		✓	✓
Coverage	*	*	✓

Table 1. * no coverage error assuming an unbiased plot layout.

SAF Forestry Source Articles

- Biometrics Bits (cont.)
  - How Model-Assisted Sampling Can Reduce Fieldwork, Max Nova and Zach Parisa, August 2018
    - Best: Good correlation between field plot and pixels to fill in between
    - Worst: Still have traditional inventory to fall back on
    - Compare standard errors of the two approaches
    - Stack of imagery better than one layer
  - The Illusion of High Precision, Nan Pond, Dec 2018
    - Inventory precision not propagated through growth and harvest schedule
    - Could be one higher/lower in one direction
    - Me: Mathematically incorporate or use Monte Carlo Risk Analysis approach; sensitivity analysis

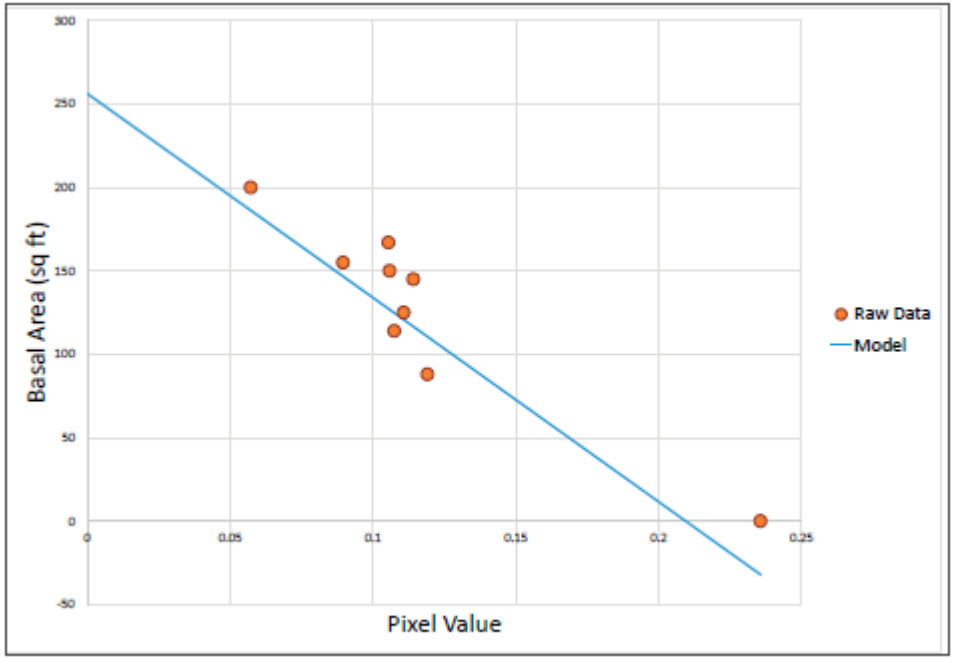


Figure 2. Plot BA vs. pixel value

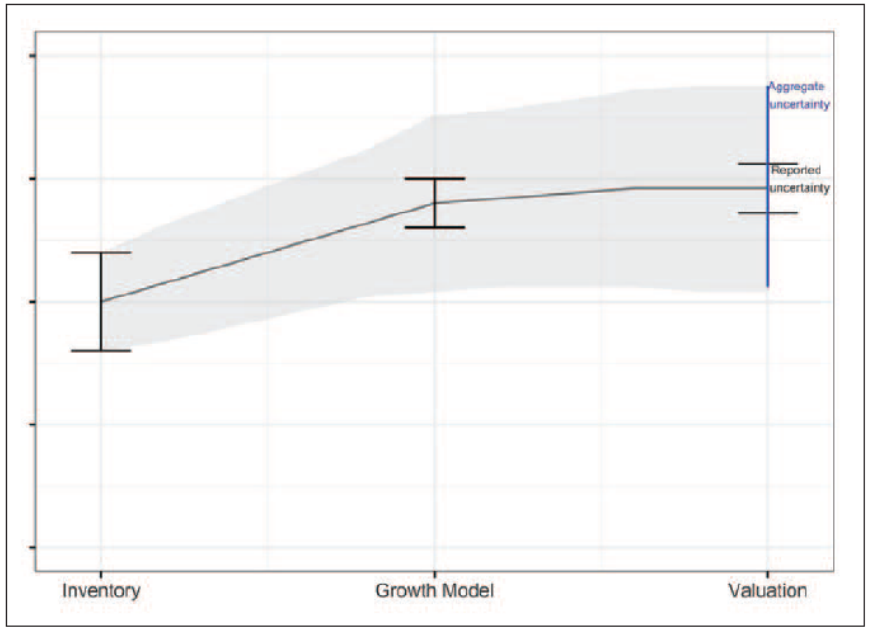


Figure 2. Imprecision should be compounded and propagated through each step of the analysis process, otherwise the end result will appear far more precise than it actually is.

SAF Forestry Source Articles

- Biometrics Bits (cont.)
  - Assignment: Compare and Contrast the Relascope and Terrestrial Lidar Tools, Zach Parisa, Feb. 2019
    - Both are used to measure the heights and diameters of trees and, in some cases, to summarize such data into plot-level attributes like basal area
    - Relascope highly evolved, TLS not far on development curve
    - "…balance my optimism with some pragmatism"
    - Me: Criterion 1000 option
  - Adjusting Your Cruise Stats with Your Field Experience: A Rigorous Approach, Brian Clough, April 2019
    - Expert Knowledge: ~80 sq ft BA +/- 5 sq ft BA
    - Bayes Theorem lets us combine expert knowledge and data
    - Confidence interval is smaller in combined estimate

Walter Bitterlich's prototype relascope. Photo by Kim Iles.

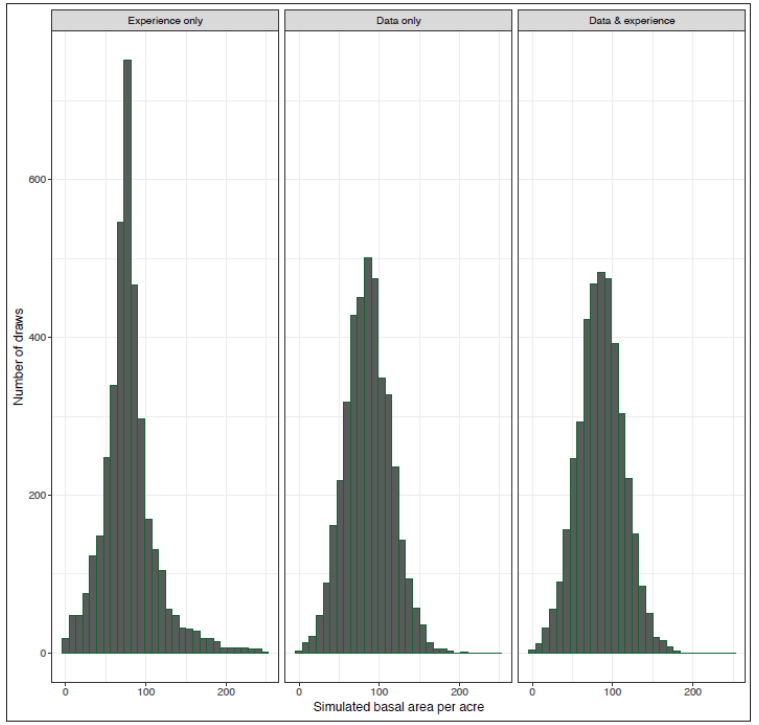


Figure 2: Histograms of three basal area per acre simulations

SAF Forestry Source Articles

- Biometrics Bits (cont.)
  - In or Out? Borderline Trees and Bias, Zach Parisa, Aug. 2019
    - Limiting Distance: Measure to the face or side of the tree?
    - Measuring to the face overestimates TPA
    - Measuring to the side underestimates TPA
    - Face has more bias than side
    - Bias is larger for bigger trees on fixed-radius plots
    - Bias is the same for all DBHs on variable-radius plots

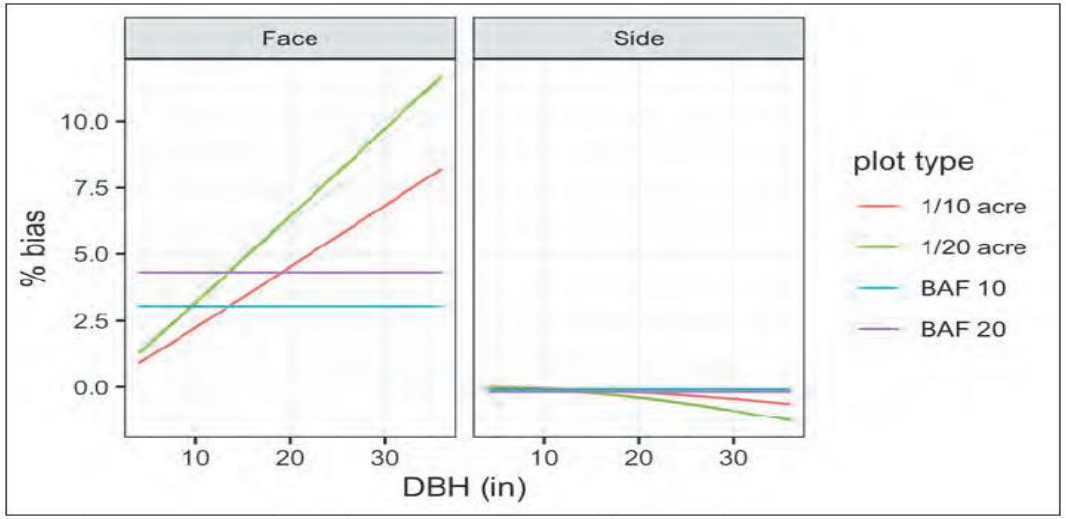


Figure 2. The percentage of bias in the trees per acre for each diameter class

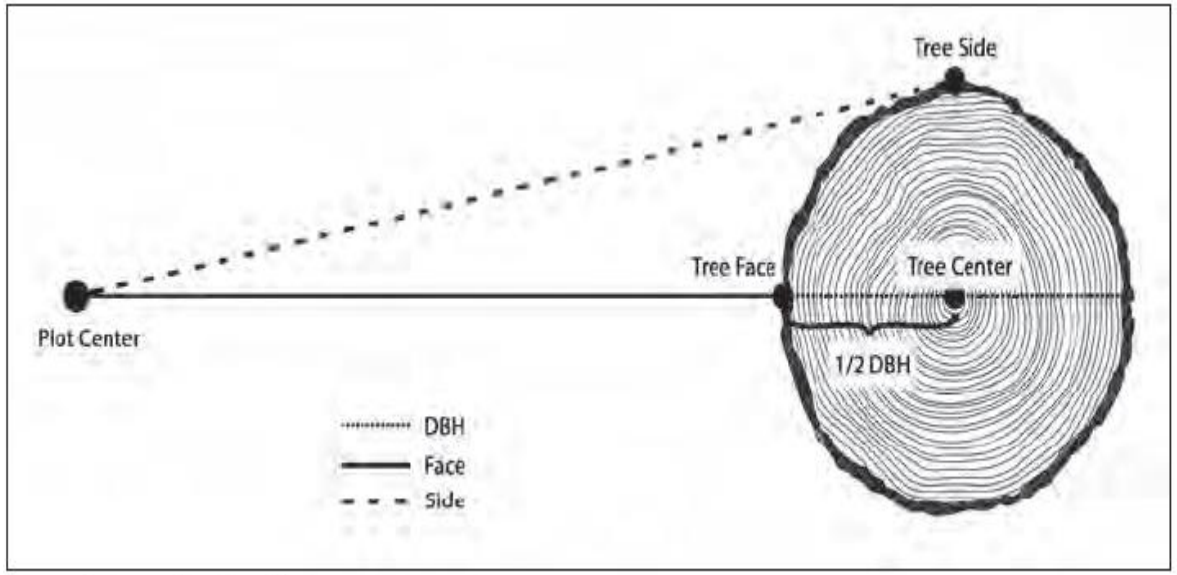


Figure 1: Approximating distance to tree center

SAF Forestry Source Articles

- Field Tech
  - Review of Handheld Group's Algix 8X, Steve Wilent, Oct 2017
    - $1,699, good review of rugged device
    - Uses Windows 10 Enterprise, not good
  - *Virtual Reality: Bringing the Forest to Classrooms, Homes and Offices, Charlie Houder, CF, April 2017*
    - Google Sheets and the AppSheet add-on
    - No coding, now part of
    - Google Cloud

This simple wooden arm, mounted on a camera tripod, lets the author collect high-quality imagery that's late processed by the Google Cardboard app into three-dimensional imagery. Photo: Charlie Houder.

A portion of a 3D panorama from the author's website (treeware.com/?page_id=1222).

SAF Forestry Source Articles

- Field Tech, Steve Wilent
  - Review of Vertex Laser Geo, Jan 2018
    - Laser and ultrasound rangefinders, GPS receiver (2.5 m accuracy), electronic compass
    - ~$2,500.00
  - Forest Metrix Pro: A Mature Tool for Cruising and Crunching Data , Oct 2018
    - Uses Filemaker Pro, on iPads, no Android
    - Reports and export to excel
  - DT301T-RTK: A Rugged Tablet with Centimeter GNSS Accuracy, April 2019
    - Windows 10
    - dual-frequency (L1 and L2) Global Navigation Satellite System (GNSS) receiver capable of real-time kinematic (RTK) positioning in the one-centimeter range
    - ~$3,400

Figure 1. DT Research's DT301T Rugged RTK Tablet with the detachable Harxon GNSS antenna. Photo by Steve Wilent.

SAF Forest Source Articles

- DR DBH (Steve Fairweather)
  - The Beauty of Stratification, January 2018
    - Overall lower variance, estimates by strata.
  - Testing Your Hypothesis, July 2018
    - Leaf-On Vs. Leaf-Off Height Measurements
  - Rules of Thumb, September 2018
    - Two examples (Maine and Russia) that worked
  - Cruising for Dollars, November 2018
    - Sample sizes for confidence intervals on range of values from a timber sale are more stringent than just for basal area or volume
    - Calculate value on a plot basis
    - Example from mixed forest: n=43 for volume, n=57 for value

H_0 : Average Difference = 0
H_A : Average Difference < 0
Alpha = 0.05

SAF Forestry Source Articles

- DR DBH (Steve Fairweather)
  - How Many Plots?, Nov. 2017
    - Three input variables:

$$n = t^2 CV^2 / AE^2$$

  - What Does It Really Mean to Have an "Unbiased" Cruise?, Sept 2017
    - Many repeated samples converge on true mean
  - Can I Flip My Regression around and Predict X from Y?, July 2017
    - No
    - Me: Not unless use special methods

CV =	70%			
Certainty/ Confidence Level =>	80%	90%	95%	99%
Approximate value of *t* =>	1.3	1.7	2	2.6
AE	Required sample size			
1%	8,281	14,161	19,600	33,124
5%	331	566	784	1,325
10%	83	142	196	331
15%	37	63	**87**	147
20%	21	35	49	83
25%	13	23	31	53

Table 1 shows values for the sample size, given a CV of 70 percent and a range of allowable errors and certainty requirements.

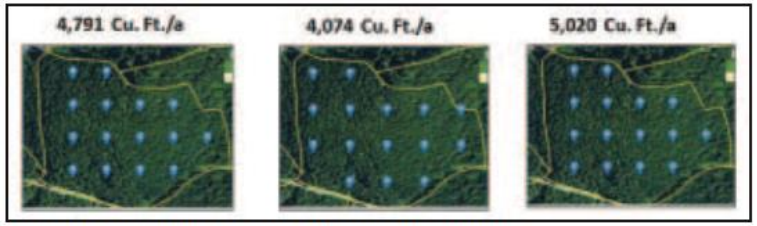


Figure 1. Three trials of the cruising simulator with the same cruise design.

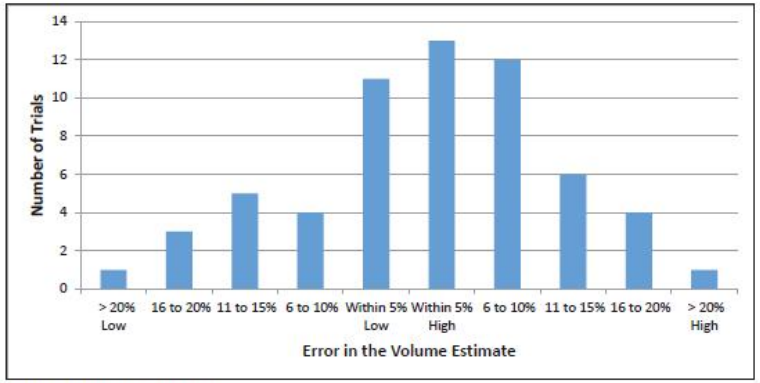


Figure 2. The results of 60 trials

SAF Forestry Source Articles

- DR DBH (Steve Fairweather)
  - A Quick Review of Line Intersect Sampling, Jan. 2019
    - Probability proportional to length
    - Need length of intersected piece to get estimate of # of pieces (like dbh to get TPA in VRP)
    - Measure diameters to get volume
  - Characterizing Riparian Buffers Using Horizontal Line Sampling, March 2019
    - BAF for specified length of line (Beers & Miller, 1974)
    - Diameter Inches, useful for girdling cost estimates
    - Record tree location along line for graph at right
    - Record DBH to get TPA and BA

Line #	Tree #	DBH (in.)	f (Diameter Inches per acre)	Trees Per Acre (f_t)	Basal Area of Tree (sq.ft.)	BA per acre (sq.ft.)
1	1	20	224.02	11.20	2.1816	24.4
	2	14	224.02	16.00	1.0690	17.1
	3	8	224.02	28.00	0.3491	9.8
			672.05	55.20		51.3
2	1	10	224.02	22.40	0.5454	12.2
	2	9	224.02	24.89	0.4418	11.0
			448.03	47.29		23.2
3	1	6	224.02	37.34	0.1963	7.3
	2	14	224.02	16.00	1.0690	17.1
	3	5	224.02	44.80	0.1364	6.1
			672.05	98.14		30.5
		Average/acre:	597.38	66.88		35.0

Table 2. Tallies on three lines of 50 feet, each using a BAF of 20.

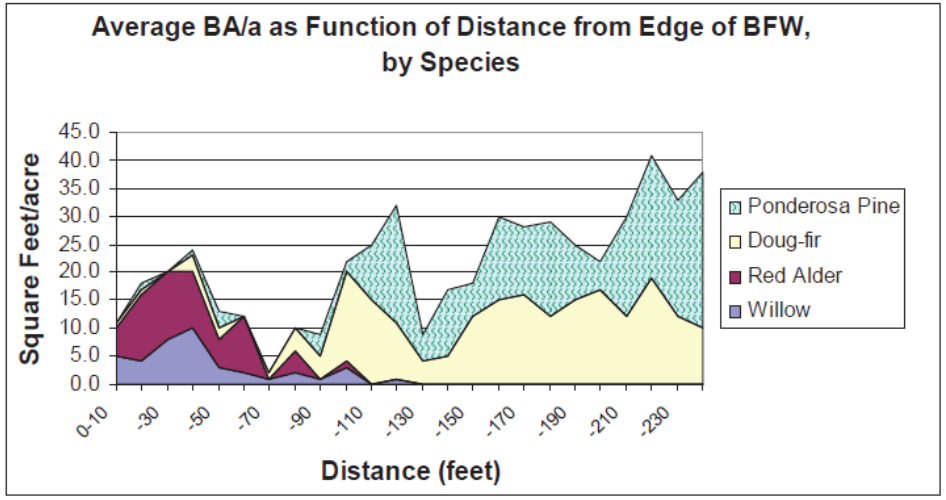


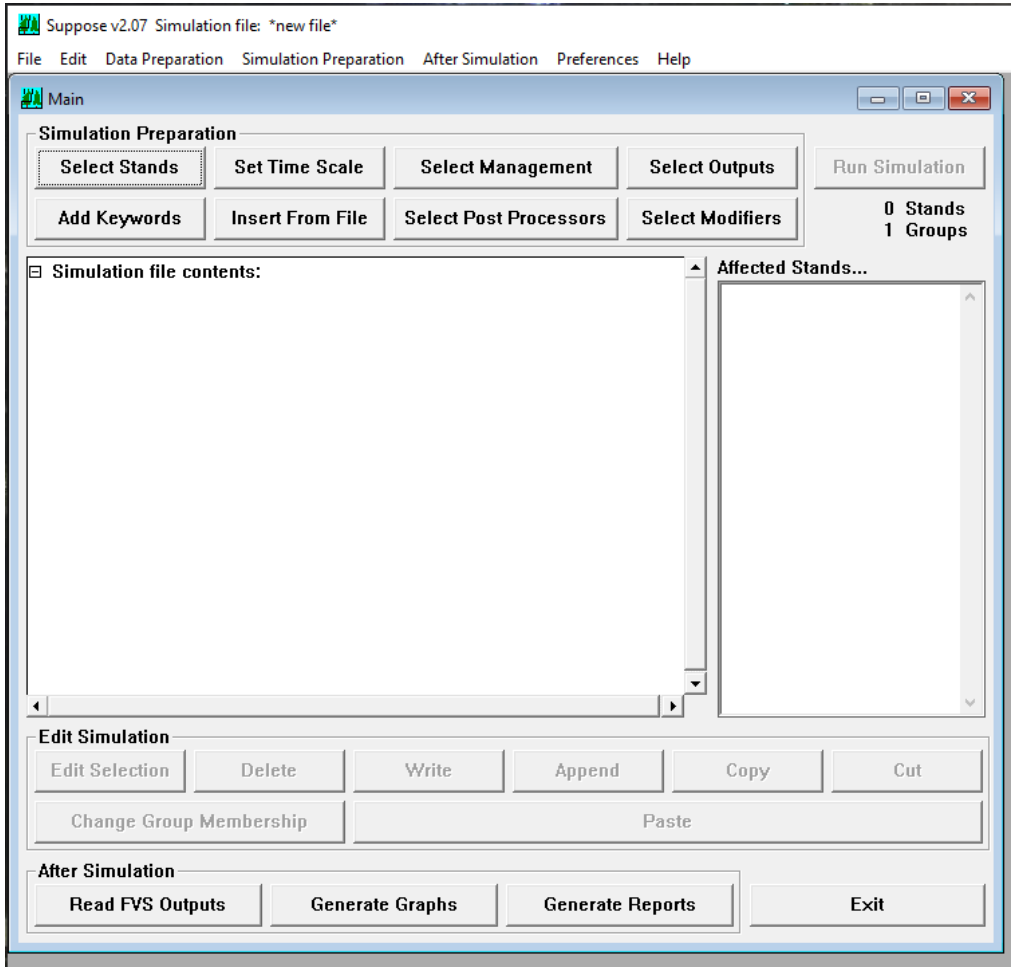
Figure 1. Example display of change in species composition with distance from the edge of the bankfull width (BFW), from a 2006 technical report titled Eastside Type F Riparian Assessment Project Phase 1 Study Plan, which can be found online at tinyurl.com/y3y5k7tx.

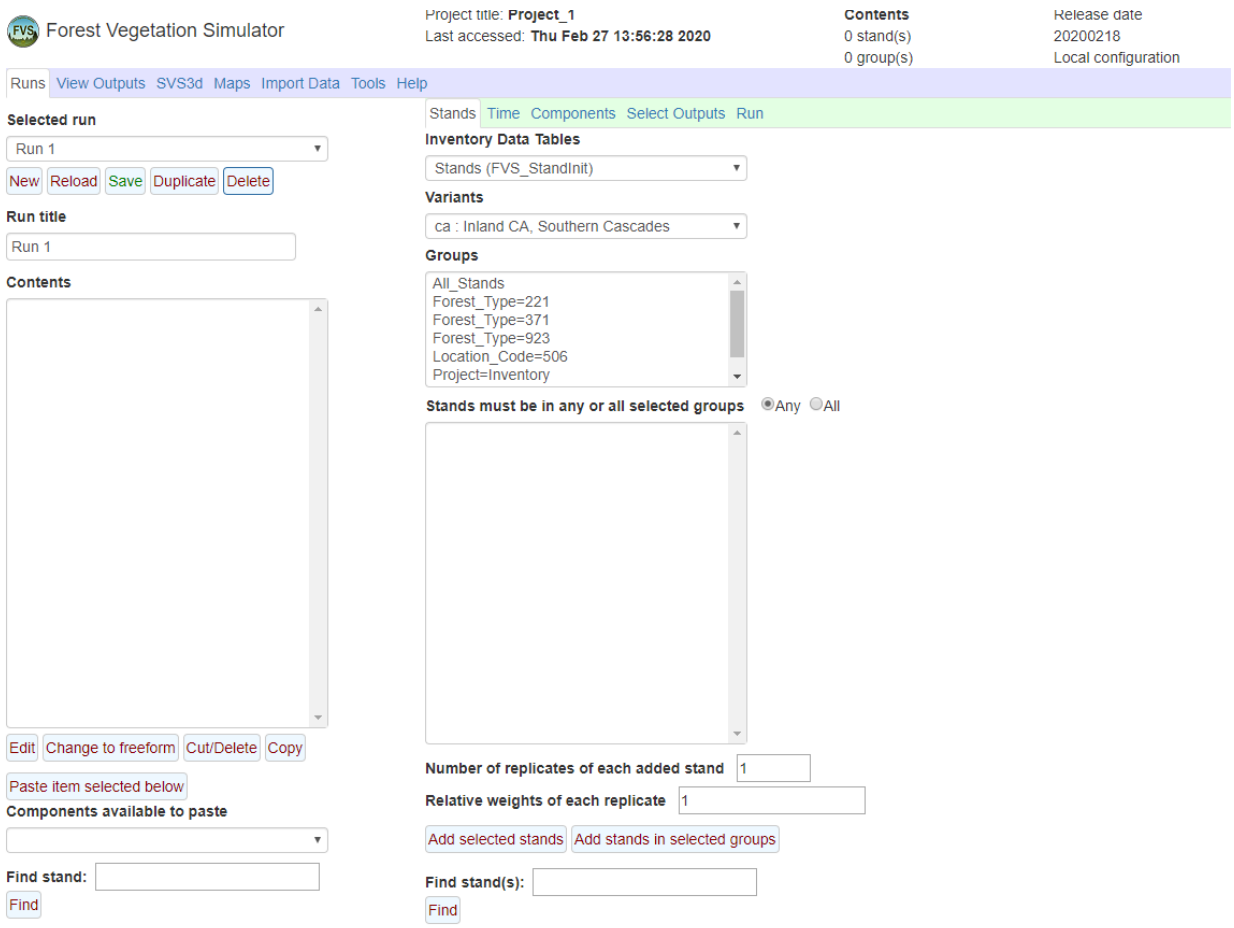
SAF Forestry Source Articles

- DR DBH (Steve Fairweather)
  - Use 3P Sampling to Cruise that Small Timber Sale, May 2019
    - Visit each tree, estimate volume, sample dbh & height
    - Sample is probability proportional to prediction
    - Use ratio to adjust estimates

Steve Fairweather demonstrates his wheeled calipers, a model made in Maine by C.W. Grover, probably in the late 1800s or early 1900s. Photos by Steve Wilent.

FVS Interfaces





Newer, Potentially Useful Technologies

- FVS will have coast redwood incorporated this year
- Calipers with electronic measurements and bluetooth
- Stockpile volume estimators
- Terrestrial LiDAR
- sUAV (drone)
  - Reconnaissance
  - Video
  - RGB photogrammetry
  - Red edge and Thermal IR

Carbon Projects

- Credit Yield Assessment
  - Data Sources
  - Preliminary Inventory
- Project Development
  - Inventory Design to Minimize Risk
    - Sampling Error Penalty
    - “Intentional” Reversals
  - Growth Modeling & Harvest Scheduling
- Verification
  - Inventory Check
    - Desk
    - Field

Property Acquisitions: Signing Off on the Inventory Data

- Crucial Estimate for Valuation
- Property Management
  - Eat what you Kill
  - Tension between Acquisitions and Managers
  - Investment Committees
- Design and Implement an Inventory
- Check an Existing Inventory
  - Strata or Stand Based
  - Check and Potentially Adjust for Issues

Applied Biometrics

Mensuration Techniques, Design & QAQC

CLFA 2020 Spring Conference, Anderson, California

March 6, 2020

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