FBRI/FPS Update

2024 Growth Model Users Group Meeting
Water Resources Education Center
Vancouver, Washington
April 10, 2024

Dan Opalach, PhD
President & Senior Forest Biometrician
Forest Biometrics Research Institute

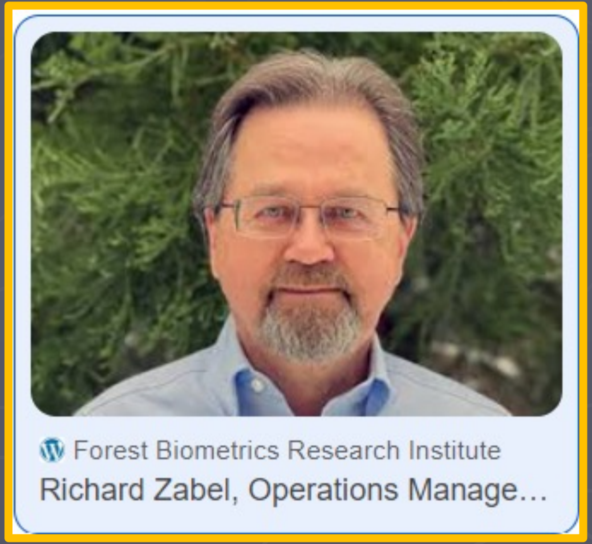
Forest Biometrics Research Institute

The Agenda For Today
FBRI/FPS Update

- FBRI – Overview of the Institute
- FPS Technical Support
- FPS Fortran programming
- University of Idaho/FBRI Fellowship program
- Enterprise Services Update – Additional forest biometrics services that FBRI makes available to its members
- FPS Pro: The next generation of FPS

Forest Biometrics Research Institute (FBRI)
Overview of the Institute

- FBRI is a 501(c)(3) nonprofit organization founded by Dr. Jim Arney in 2002
- The Forest Projection & Planning System (FPS) is the Institute's flagship software program
  - FPS software, training, and technical support are provided to the Institute's member organizations
  - The current version is FPS 7.60 which was distributed in March 2023
- FBRI's Mission: Provide FPS to forestland owners and managers to assist them with forest inventory, growth & yield projections, and forest planning
- 70+ member organizations financially support the Institute
- Five-member Board of Directors
  - Ken Borchert (chair), Bruce Ripley, Brian Sharer, Marc Vomocil, and Dave Walters
- FBRI Contractors
  - Richard Zabel (administration)
  - Brock Purvis (technical support)
  - Halli Hemingway (remote sensing)
  - Dan Opalach (forest biometrician)
- Eastern FBRI Office ???
  - John Foppert (administration) and Neal Maker (forest biometrician)



Richard Zabel

FPS Technical Support Program
Many Aspects

- FBRI has a full-time Technical Support Manager, Brock Purvis
  - Responds to requests within 24 hours
  - Convenes quarterly on-line User Group meetings
  - Conducts in-person FPS training workshops
    - FPS Forest Inventory Basics – April 17 & 18, Portland, Oregon
    - FPS Harvest Scheduling – October 15 & 16, Portland, Oregon
  - Develops FPS training webinars and makes them available on FBRI's web site
  - Duties as assigned
    - Site visits to FBRI member companies
    - Tasks associated with FBRI Enterprise Services agreements
      - FPS Audits
      - SiteGrid Localization
      - Long-term Harvest Planning

Brock Purvis

Workshop Material – Hot Topics!

Populating FPS 7.60 with Census-Level Inventory Data

- Generally speaking, FPS is not designed to hold census-level inventory data
- If you have census-level inventory data there are four options for populating the PLOTS table:

Option 1. Draw a sample of 1/10-acre plots from the population of trees

- Do not create more than 99 plots per stand
- Using Option 1 is the focus of FBRI's current research (see Hemingway and Opalach 2024)

Option 2. Develop an average 1-acre tree list from the population

- Results in one plot per stand based on all the data
- Limit the tree list to 500 trees or less

Option 3. Blanket the property with 1-acre fixed area plots

- Limit the tree list to 500 trees or less in each 1-acre plot
- Do not create more than 99 plots per stand

Option 4. Create one plot using the stand boundary

- Maximum stand size is 40 acres
- Enter no more that 20,000 trees in each 40-acre plot
- Must use the FPS re-merchandizer to collapse the DBHCLS table

Option 5. *??? What is the upper limit for trees per acre in FPS 7.60 ??? Stay tuned!!!*

Fortran Programming

- In 2023 the calculation of short log volumes was localized to take into account regional rules for scaling butt logs
  - Idaho ≠ Washington ≠ Oregon ≠ California
- Bugs and enhancements planned for 2024
  - Cubic foot volumes are suspect
    - We've noticed inconsistencies which must be investigated and fixed
  - For some stands the FPS Re-merchandizer tool is "losing track" of the LOG_MIN value specified in the SPECIES table
    - May result in a few small merchantable logs (<1% by volume) getting excluded from per acre volume totals
  - Provide users with more options for loading census-level inventory data into FPS

Dan Opalach

Fortran Programming
Calculation of Scribner Short Log Volumes

- In FPS 7.60 butt log taper assumptions for short log rules <u>depend on region – there are four (4)</u>
  1) California — FpsTree_CA.dll
     - Taper for butt logs is defined to be 1" in 10 ft for all species
  2) Idaho — FpsTree_ID.dll
     - The butt log rules in Idaho are a bit complicated
     - The state is divided into three "areas"
       - NORTH IDAHO AREA, SOUTHWEST IDAHO AREA, SOUTHEAST IDAHO AREA
       - FpsTree_ID.dll is based on the rules in the NORTH IDAHO AREA
  3) Eastern Oregon — FpsTree_OR.dll
     - Taper is 1" for logs 21 to 31 feet in length, and 2" for logs 32 to 40 feet
  4) Eastern Washington — FpsTree_WA.dll
     - For larch taper is 1" for logs 21 to 40 feet in length
     - For all other species taper is 1" for logs 21 to 31 feet in length, and 2" for logs 32 to 40 feet

University of Idaho/FBRI Fellowship Program

CNR Graduate Student Funding

The College of Natural Resources offers a series of resources to help graduate students succeed in their program of study.

Fellowships

Forest Biometrics Research Institute (FBRI) Fellowship

The College of Natural Resources in partnership with the Forest Biometrics Research Institute (FBRI) hosts a competitive fellowship program. The goal of this program is to increase the number of qualified M.S. and Ph.D. graduates proficient in advanced biometrics and silvicultural practices. As part of this program, PhD students will complete 27 credits of statistics, biometrics, and silviculture courses.

University of Idaho/FBRI Fellowship Program

FBRI Scholarship Recipients:

- Halli Hemingway—Bennett Lumber Products
- Patrick Whalen—Inland Empire Paper Company

Left to right: Halli Hemingway, Jim Arney, Patrick Whalen

FBRI Enterprise Services

1. Provide default site productivity GIS layers to members (5-acre grid size)
2. Conduct in-person or on-line customized FPS training sessions
3. "Localization" of site productivity GIS layers using the 10m SiteGrid method
   - Can be based on felled-tree data, traditional site tree measurements, CFI data, FIA data, bi-temporal lidar data
4. Estimation of site index using bi-temporal lidar data
5. FPS inventory audits
6. ***Coming Soon!!!*** Lidar-based forest inventories

Enterprise Services

FBRI Enterprise Services

Current Projects

- **Lidar-based forest inventory**
  - Developed a forest inventory for Bennett Lumber using lidar data and satellite imagery—*Hemingway and Opalach (2024)*
- **Estimation of site index using bi-temporal lidar data**
  - Wrote an R program to estimate site index from bi-temporal lidar data
  - The program has successfully been applied to data from coast Douglas-fir, inland Douglas-fir, white fir/grand fir, and ponderosa pine
- **"Localization" of a site productivity GIS layer using the 10m SiteGrid method**
  - Predicted site index at a resolution of 1 acre for a large ownership in Idaho
  - Predictions were aggregated by stand to generate property-wide site productivity maps

Enterprise Services

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Research Article

OXFORD

SAF
forests, resources, communities.

Biometrics

Integrating Lidar Canopy Height Models with Satellite-Assisted Inventory Methods: A Comparison of Inventory Estimates

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Abstract

Forest management inventories are essential tools for planning, sustainability assessment, and carbon accounting. The operational difficulties and cost to obtain field measurements for large landscapes is often prohibitive. Remote sensing offers an alternative to field-based sampling but has often been used in an area-based approach. The most recent remote sensing techniques can produce a census-level tree list, but these data are monetarily and computationally expensive. This research examines two remote sensing approaches compared with field-based methods to build forest management inventories for the same forest land base in north central Idaho, USA. Estimates of volume, density, and height were compared by stand and at the total ownership level. Incorporating lidar data reduced overall error and bias when compared with using satellite data alone. The low-pulse density of the lidar data used in this analysis resulted in underprediction of density for high-density stands. Species predictions proved challenging, with accuracies of 66% at the stand level and 54% at the individual tree level. Further research to refine species predictions in complex environments is encouraged.

Integrating Lidar Canopy Height Models… Hemingway and Opalach (2024)

- Three different forest inventories for the same forestland property are compared
  1. Traditional field-based method used to collect data
  2. Data from satellite images only
  3. Combination of satellite imagery and lidar data

Halli Hemingway

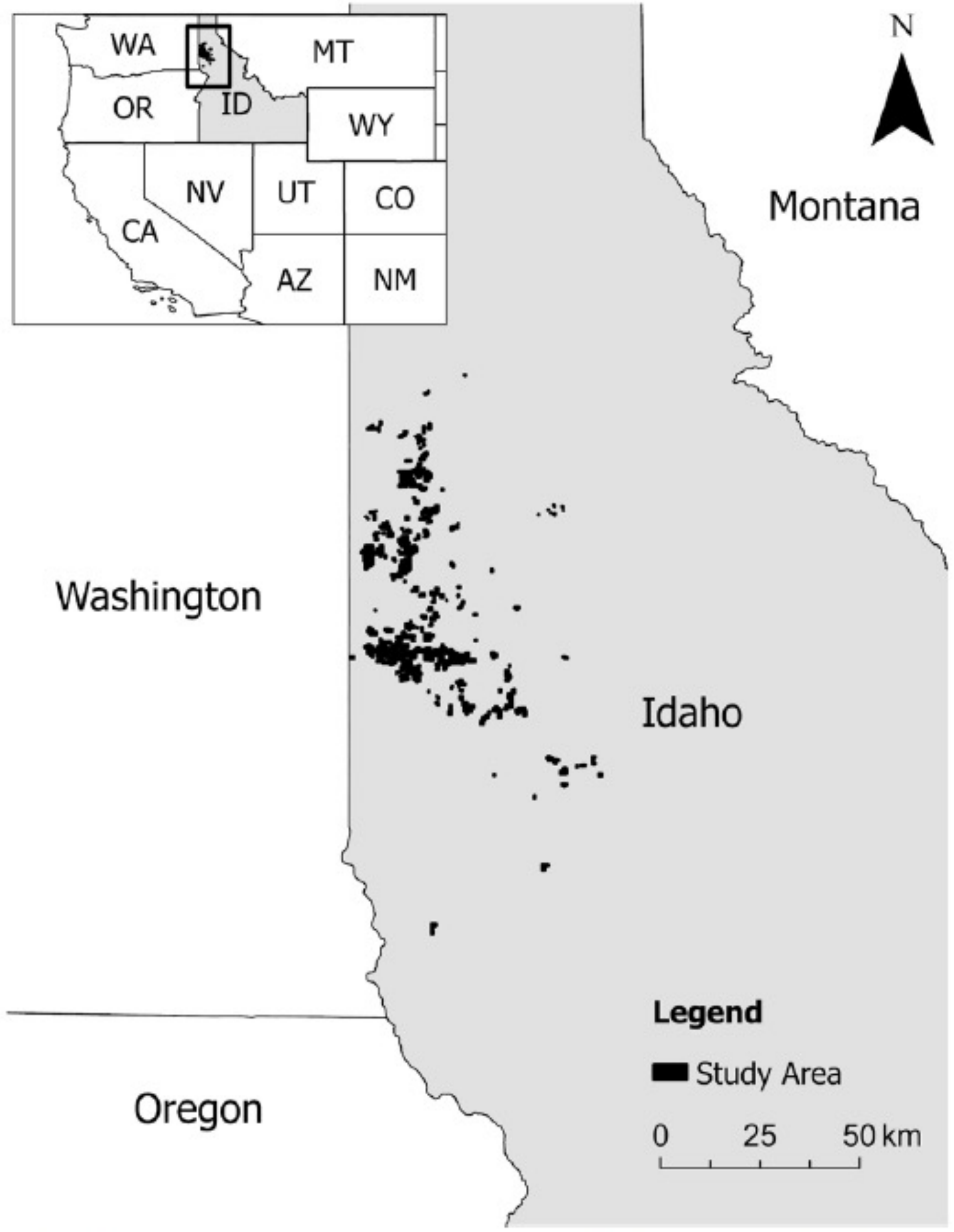


Figure 1 Map of the study area in north central Idaho. Upper left inset map shows the location of the study area in relation to the western United States.

Integrating Lidar Canopy Height Models…

Figure 1. Study area in north central Idaho

Integrating Lidar Canopy Height Models… Hemingway and Opalach (2024)

- Plot data
  - Orthogonal sample with respect to species, height classes, and density classes
  - 38 locations selected for measurement – tree species (80% single species), total height, DBH for all trees >7”
  - 1/10-acre plots
- Data analyzed with the following R functions
  a) randomForest to identify important satellite band predictor variables and then
  b) Support Vector Machine (SVM) to develop the model to predict species, total height, and density

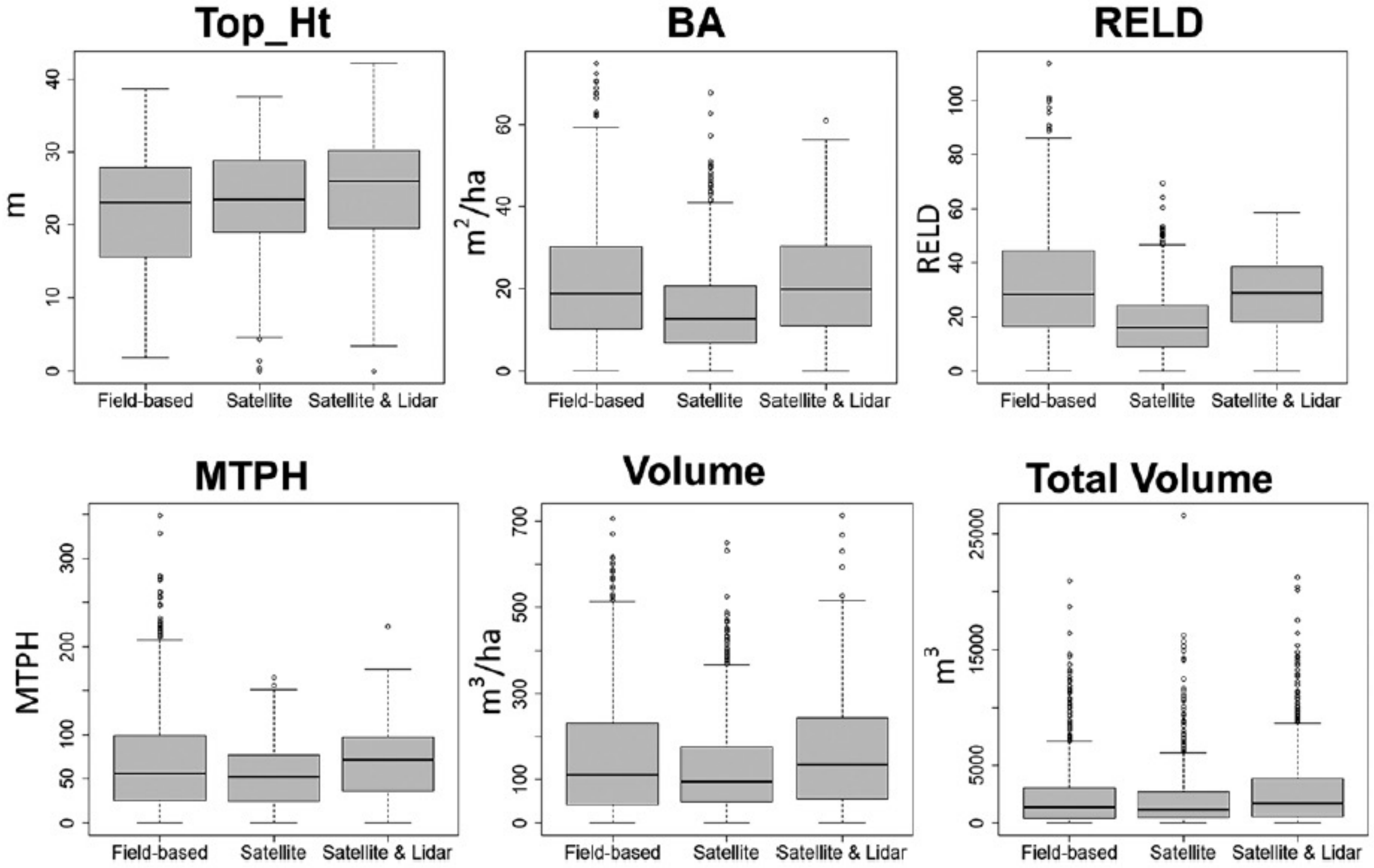


Figure 2 Boxplots comparing distributions and differences of stand top height (m), basal area (m^2/ha), relative density (Curtis 1982), merchantable trees per hectare, cubic volume (m^3/ha), and total cubic volume (m^3) from field-based cruises, satellite-only predictions, and satellite and lidar predictions.

Table 4. Total study area cubic volume by species comparison of field-based cruise, satellite-only, and satellite and lidar estimation methods. All actual total volumes were multiplied by the same undisclosed factor to maintain confidentiality of sensitive information while maintaining numeric relationships between estimates. Tree species codes: NT, nontimber; PSME, *Pseudotsuga menziesii*; ABGR, *Abies grandis*; PICO, *Pinus contorta*; PIPO, *Pinus ponderosa*; THPL, *Thuja plicata*; LAOC, *Larix occidentalis*; TSHE, *Tsuga heterophylla*, PIEN, *Picea engelmannii*; PIMO3, *Pinus monticola*.

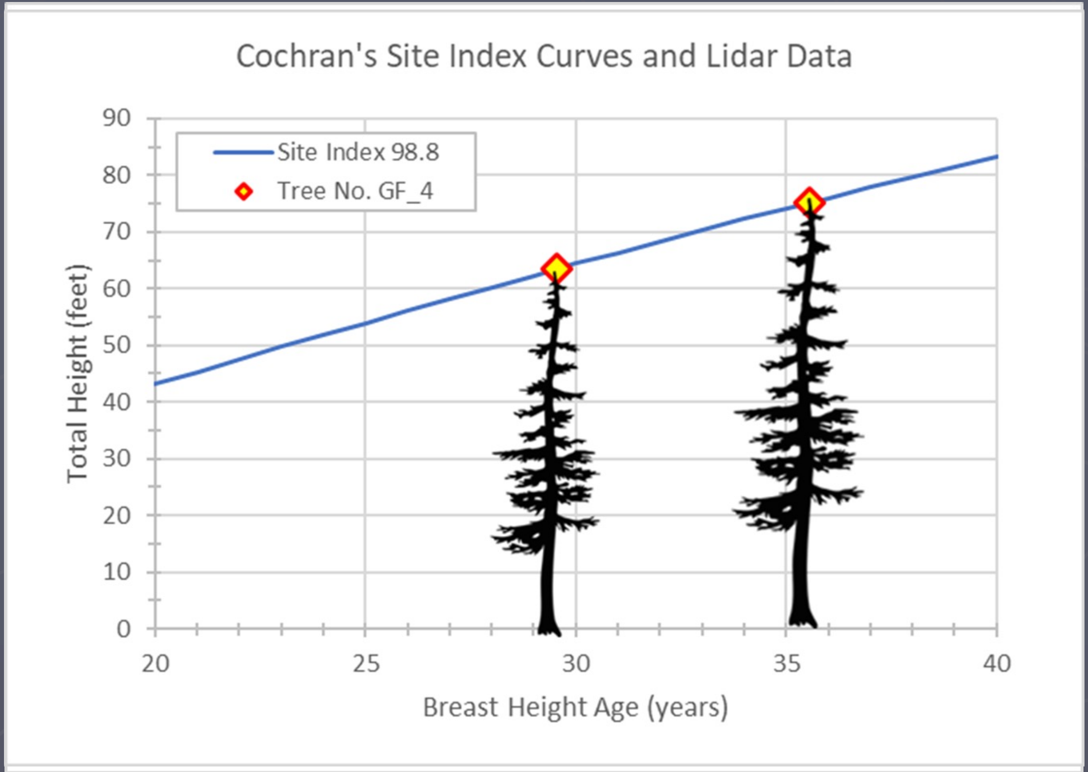
Field-based cruise volume			Satellite-only volume			Satellite and lidar volume		
Species	m^3	Percent of total	Species	m^3	Percent of total	Species	m^3	Percent of total
PSME	353,578	30	PSME	144,511	15	PSME	254,419	20
ABGR	251,162	21	ABGR	286,157	29	ABGR	312,069	24
PICO	12,836	1	PICO	7,043	1	PICO	14,630	1
PIPO	188,938	16	PIPO	225,235	23	PIPO	315,080	24
THPL	278,639	24	THPL	305,175	31	THPL	373,359	29
LAOC	71,249	6	LAOC	12,062	1	LAOC	18,376	1
TSHE	7,714	1						
PIEN	3,999	0						
PIMO3	3,162	0						
Total	1,171,277			980,184			1,287,934	

Satellite-only 16.3% less

Satellite & lidar 10.0% more

Estimation of Site Index using Numerical Methods with Bi-Temporal Lidar Data

- Statement of the Problem
  - Find the site index curve that goes through the tip of the tree at both points in time
- Two cases:
  1. Simple site index equations
  2. Complicated site index equations



Literature Review

The following papers utilize simple site index equations

- *Age-independent site index mapping with repeated single-tree airborne laser scanning* by Solberg et al. (2019)
- *Assessing Site Productivity via Remote Sensing—Age-Independent Site Index Estimation in Even-Aged Forests* by Penner et al. (2023)
- *Direct and indirect site index determination for Norway spruce and Scots pine using bitemporal airborne laser scanner data* by Noordermeer et al. (2018)

Estimation of Site Index Using Bi-Temporal Lidar Data for Complicated Site Index Equations

- Given the “complicated” site index equations used throughout the West, we developed a numerical method to estimate site index using bi-temporal lidar data that can easily handle such equations
- This numerical method can be applied to any tree species (in the world) that has a well-defined site index equation
- Additional details regarding our numerical method will soon be published in an appropriate journal
- What follows are results for a test dataset that was provided to FBRI by the Colville Tribe

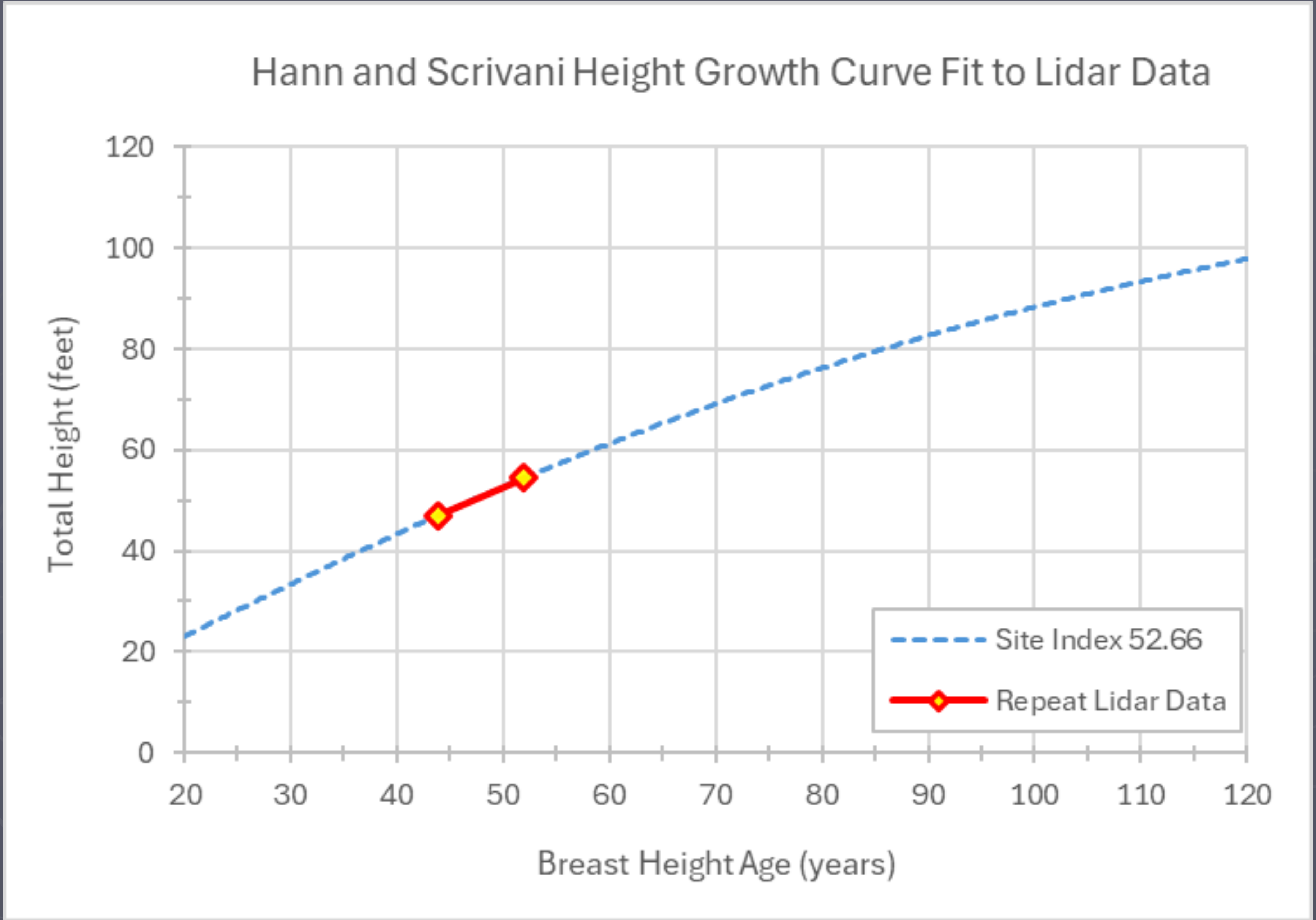
Estimation of Site Index Using Bi-Temporal Lidar Data for Complicated Site Index Equations

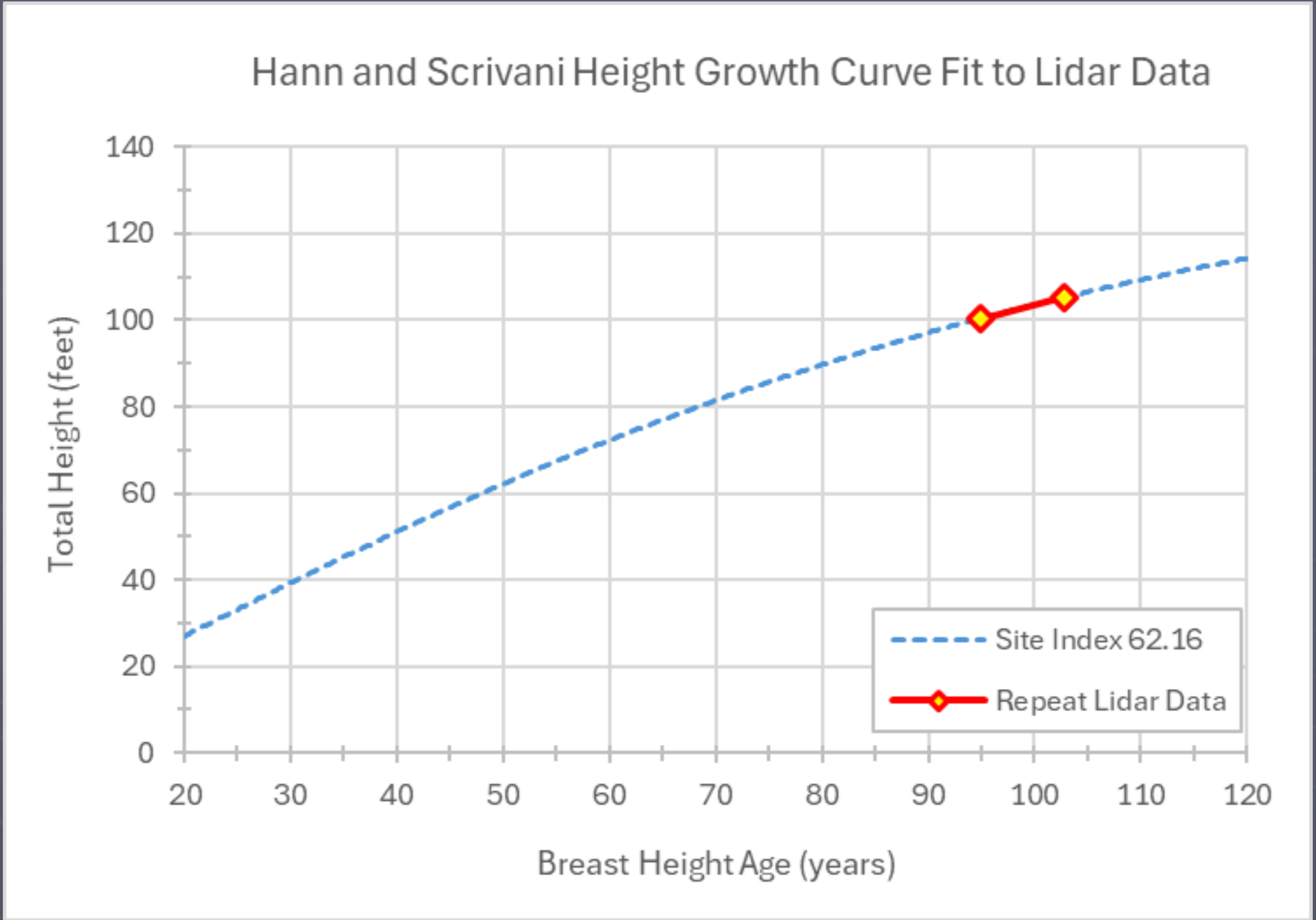
- We obtained repeat lidar data from the Colville Tribe
  - The flights were spaced eight years apart
- A 100 m^2 plot grid was laid over the landscape
- Ponderosa pine plots were identified using a model developed from Sentinel-2 image data
- A canopy height model (Esri) was fit to the lidar data from each flight
- The maximum canopy height was determined for each plot for each flight
- The site index for each plot was calculated by finding the curve that best described the change in maximum canopy heights

Hann and Scrivani (1978) Height Growth Equation for Ponderosa Pine

To develop an equation for predicting dominant height growth of Douglas-fir in southwest Oregon, Scrivani (1986) used the combined data from all 89 site-quality trees to examine five parameterizations of the Weibull equation and six procedures for estimating parameter values. This analysis resulted in selection of the following equation:

$$H - 4.5 = (S - 4.5)\left(\frac{1.0 - \mathrm{EXP}(-\mathrm{EXP}[a_0 + a_1 \ln(S - 4.5) + a_2 \ln(A)])}{1.0 - \mathrm{EXP}(-\mathrm{EXP}[a_0 + a_1 \ln(S - 4.5) + a_2 \ln(50)])}\right) \quad [1]$$


Hann and Scrivani Height Growth Curve Fit to Lidar Data
Total Height (feet)
120
100
80
60
40
20
0
20
30
40
50
60
70
80
90
100
110
120
Breast Height Age (years)
Site Index 52.66
Repeat Lidar Data


Hann and Scrivani Height Growth Curve Fit to Lidar Data
Total Height (feet)
0
20
40
60
80
100
120
140
20
30
40
50
60
70
80
90
100
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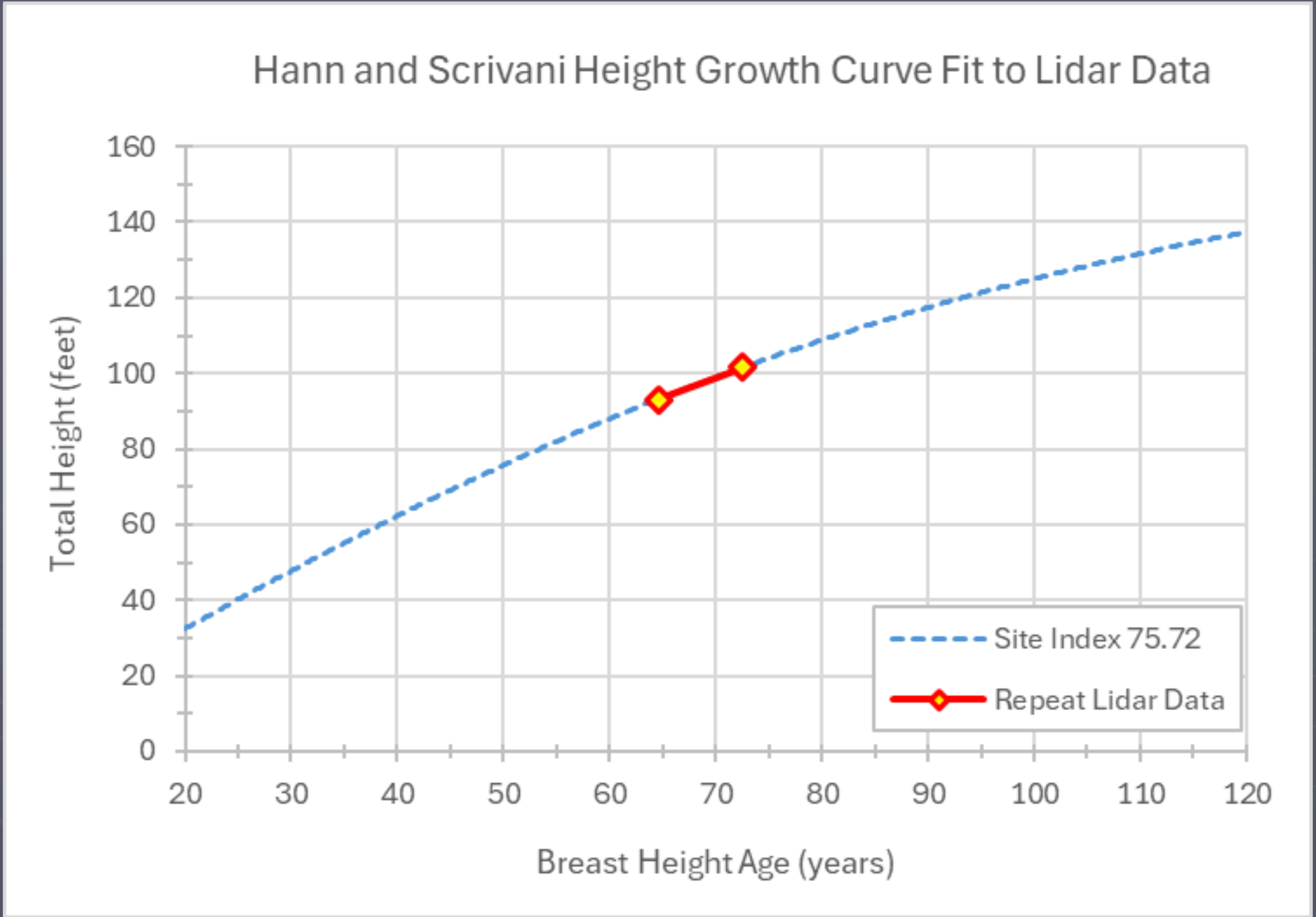
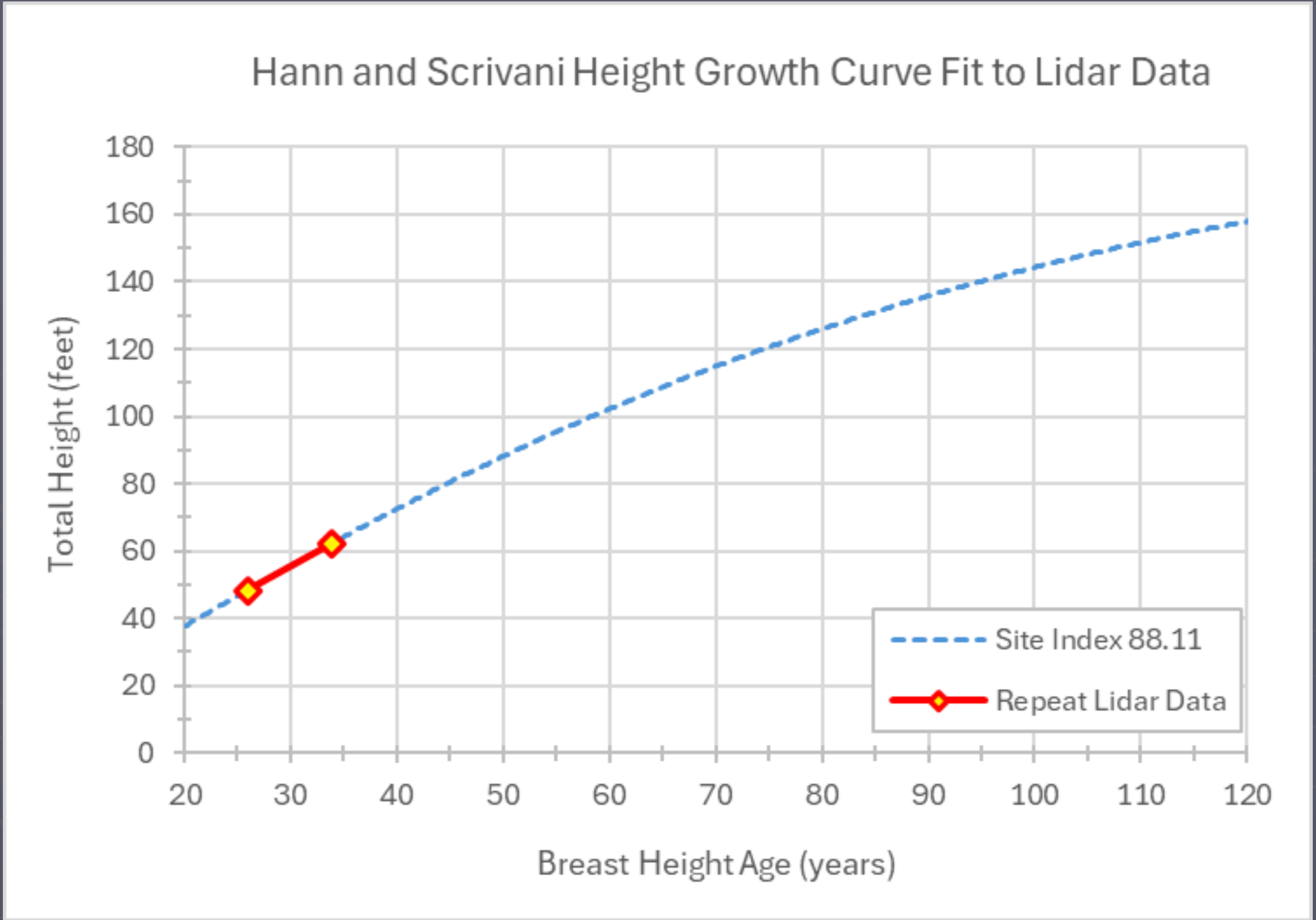
120
Breast Height Age (years)
Site Index 62.16
Repeat Lidar Data



Hann and Scrivani Height Growth Curve Fit to Lidar Data
160
140
120
100
80
60
40
20
0
Total Height (feet)
20
30
40
50
60
70
80
90
100
110
120
Breast Height Age (years)
Site Index 75.72
Repeat Lidar Data


Hann and Scrivani Height Growth Curve Fit to Lidar Data
Total Height (feet)
180
160
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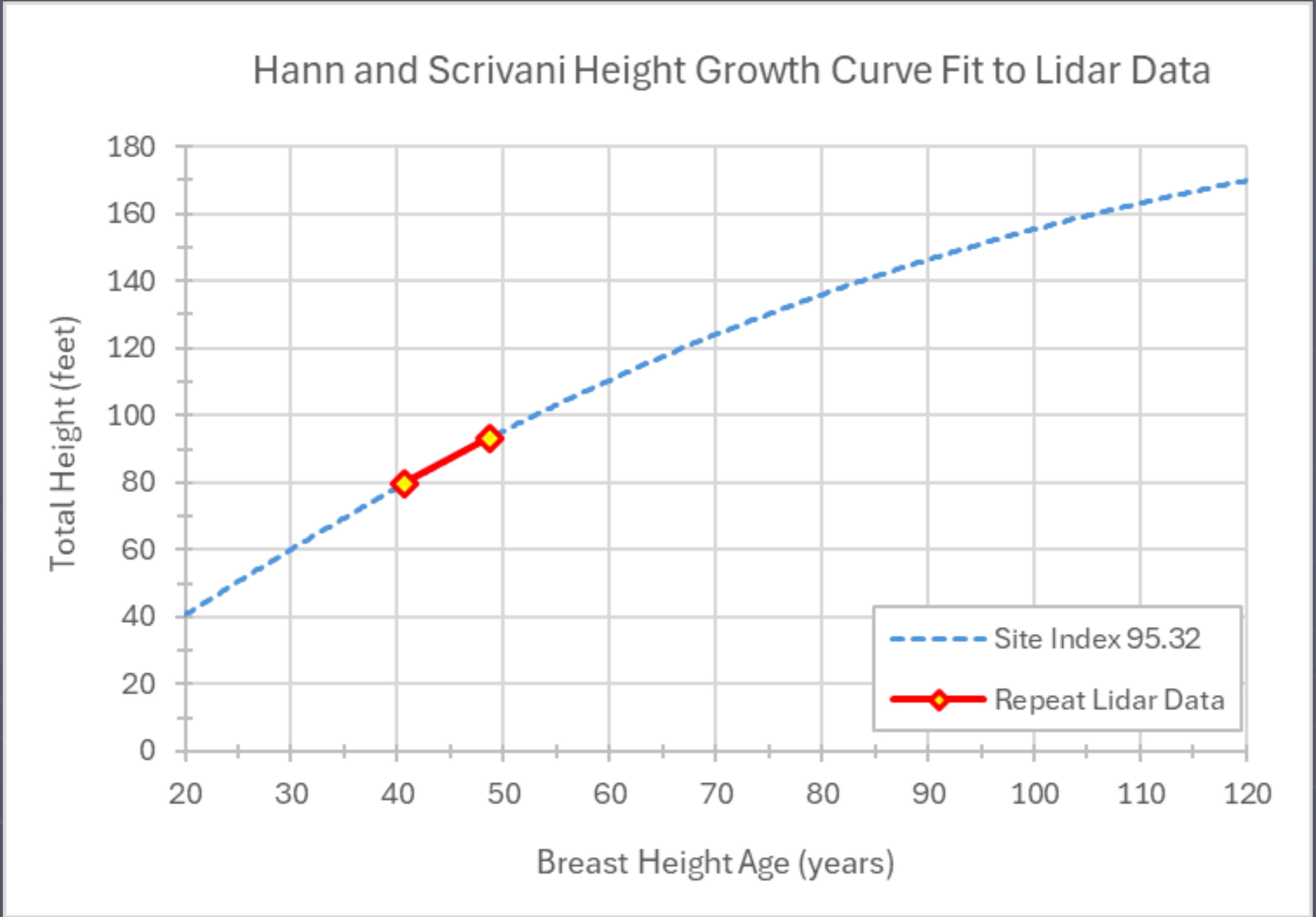
100
110
120
Breast Height Age (years)
Site Index 88.11
Repeat Lidar Data


Hann and Scrivani Height Growth Curve Fit to Lidar Data
Total Height (feet)
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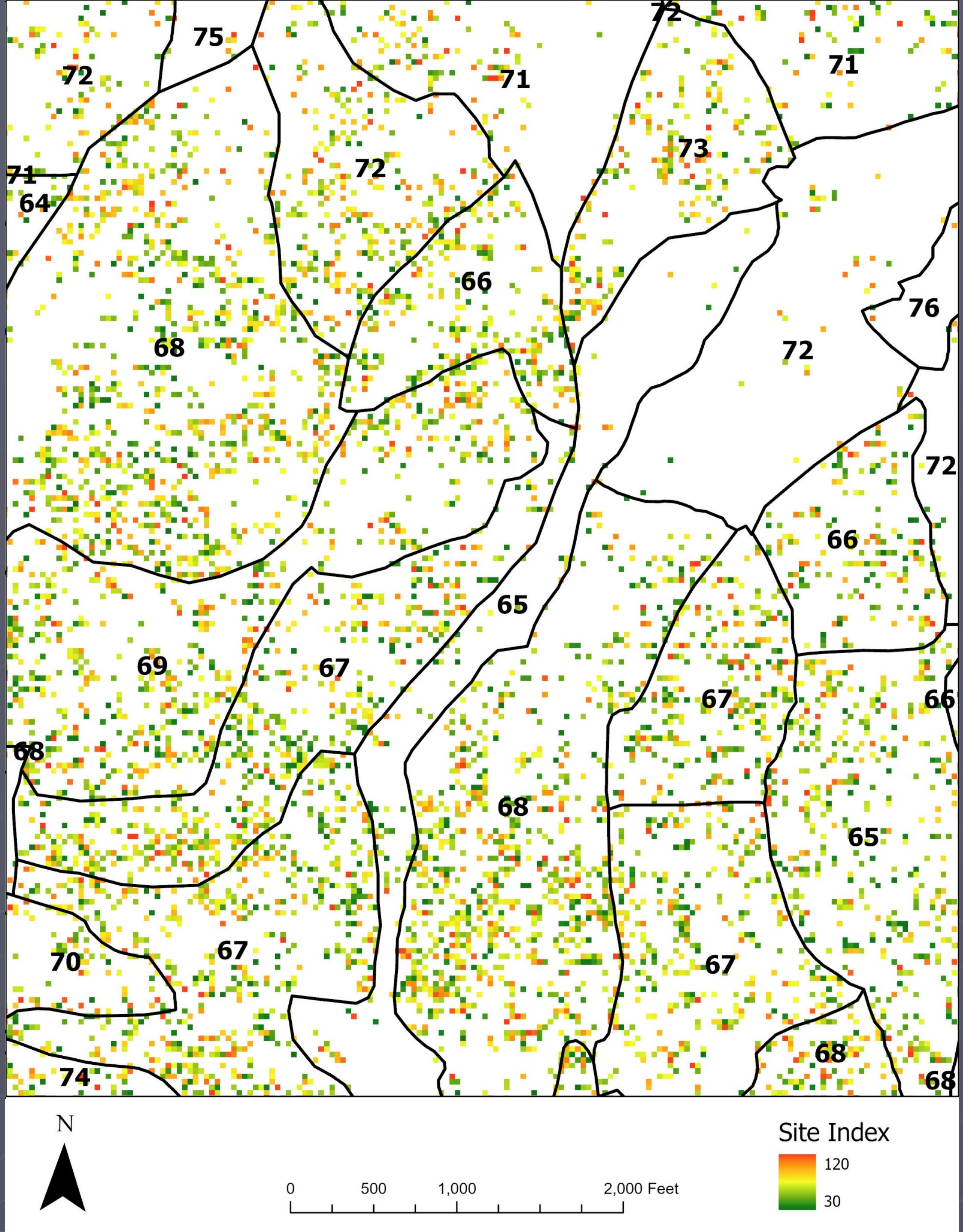
Breast Height Age (years)
Site Index 95.32
Repeat Lidar Data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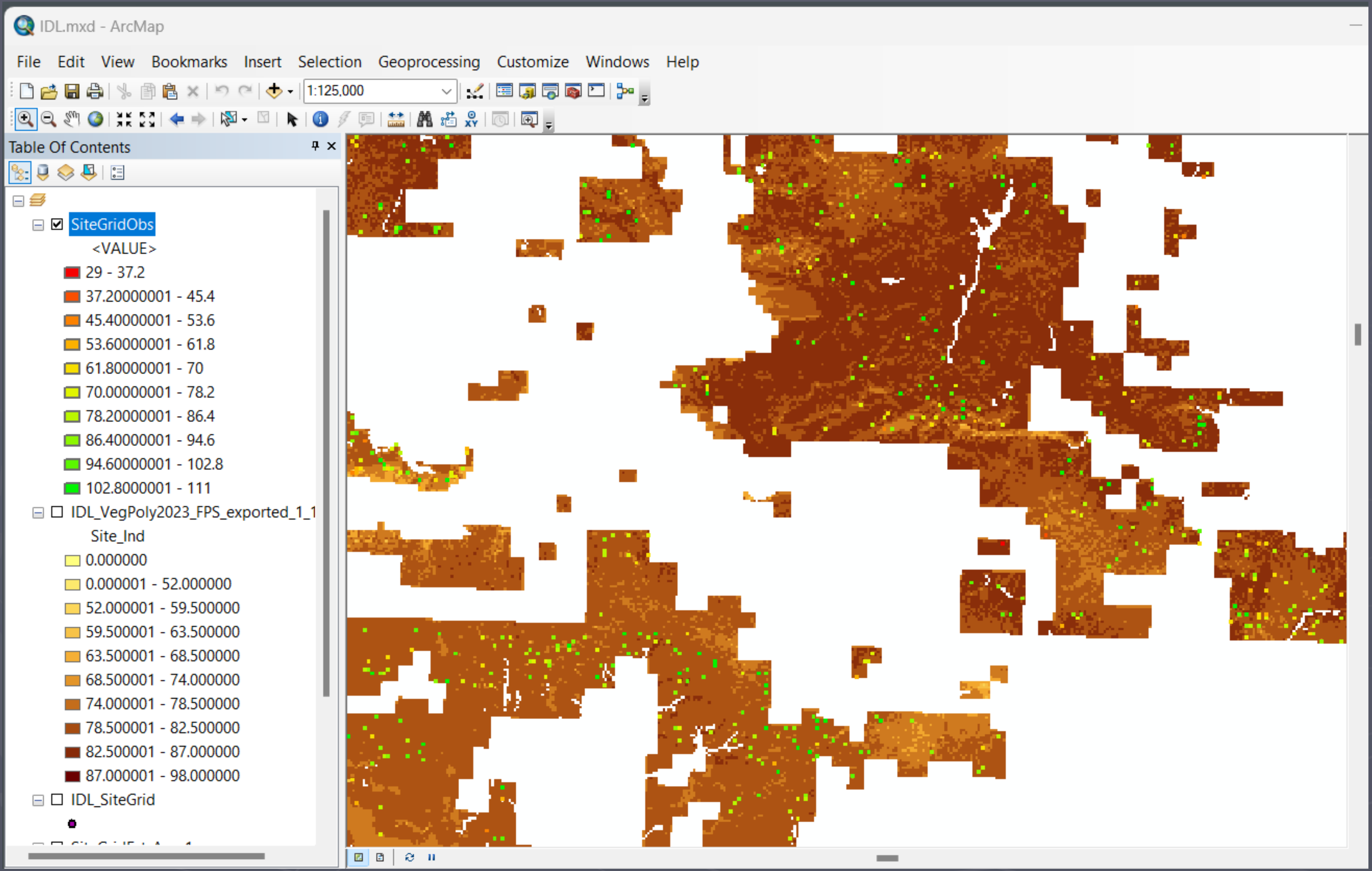
68
65
70
67
67
68
74
68
N
0
500
1,000
2,000 Feet
Site Index
120
30

Last Project: Localization of a SiteGrid
(a SiteGrid is a GIS layer that contains site productivity metrics)

- Utilized existing site index data collected on timber cruise plots
- Developed regression equations to predict site index based on environmental factors such as elevation, slope, aspect, annual precipitation, and soil depth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45.40000001 - 53.6
53.60000001 - 61.8
61.80000001 - 70
70.00000001 - 78.2
78.20000001 - 86.4
86.40000001 - 94.6
94.60000001 - 102.8
102.8000001 - 111
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59.500001 - 63.500000
63.500001 - 68.500000
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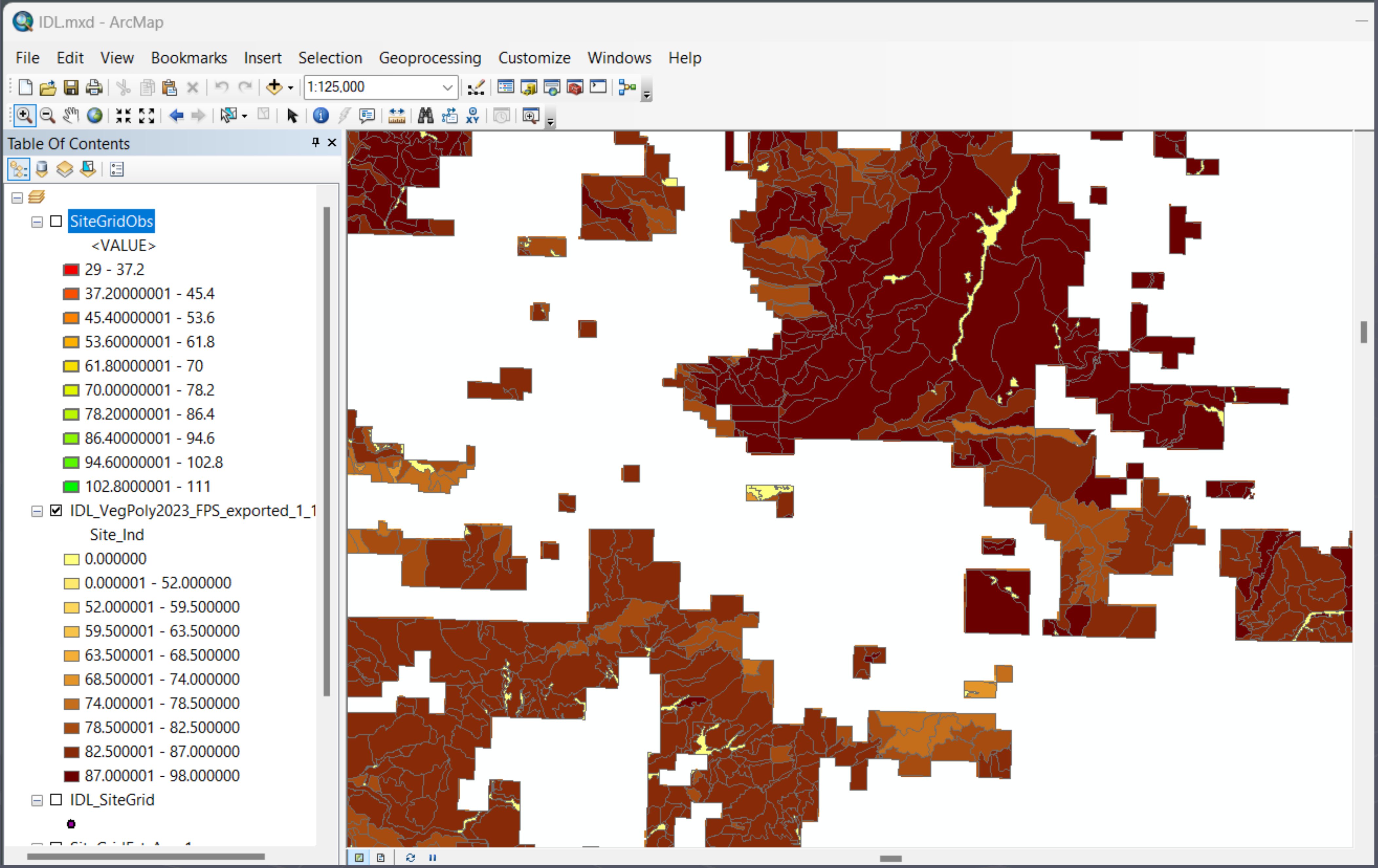
74.000001 - 78.500000
78.500001 - 82.500000
82.500001 - 87.000000
87.000001 - 98.000000
IDL_SiteGrid



IDL.mxd - ArcMap
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78.500001 - 82.500000
82.500001 - 87.000000
87.000001 - 98.000000
IDL_SiteGrid

FPS Pro

- **FPS Pro** is the name for the next generation of FPS
- Dr. Jim Arney referred to the current version of FPS as a 4^{th} generation forest management application because it was the fourth computerized growth model he had built during his career
- **FPS Pro** will be the 5^{th} generation in the evolution of FPS
- FBRI has a contract with Dr. Kerry Halligan with Woodland Solutions Group (WSG) to help us "evolve" FPS over time into **FPS Pro**—currently we have two projects underway with WSG:
  - Project 1: FPS Architecture Review
  - Project 2: ArcGIS Pro add-in for FPS Pro

Project 1: FPS Architecture Review

- Project goal — Review the existing architecture of FPS 7.60 and propose options for a technology update that could address some or all of the following issues:
  - FPS "bugs"
  - Microsoft Access 2 GB file size limitation
  - Unshackle FPS from Microsoft Access
  - Provide users with options regarding data storage
  - Improve integration with GIS software
  - Speed up FPS applications
  - Process census-level forest inventory data

Project 2: ArcGIS Pro add-in for FPS Pro

- Project goal — Develop a timber harvest planning application for ArcGIS Pro
  - Project partners
    - FBRI, Portland, Oregon
    - Idaho Department of Lands (IDL), Boise, Idaho
    - Lone Rock Timber, Roseburg, Oregon
  - The purpose of the app is to assist FPS Pro users with timber harvest planning and annual depletion/inventory updates
  - In the current Microsoft Access version of FPS this is called the lump/split program

Questions?

Forest Biometrics Research Institute