

FVS Growth Projections of a Lidar Inventory

GMUG 2024

Jacob Strunk



Peter Gould



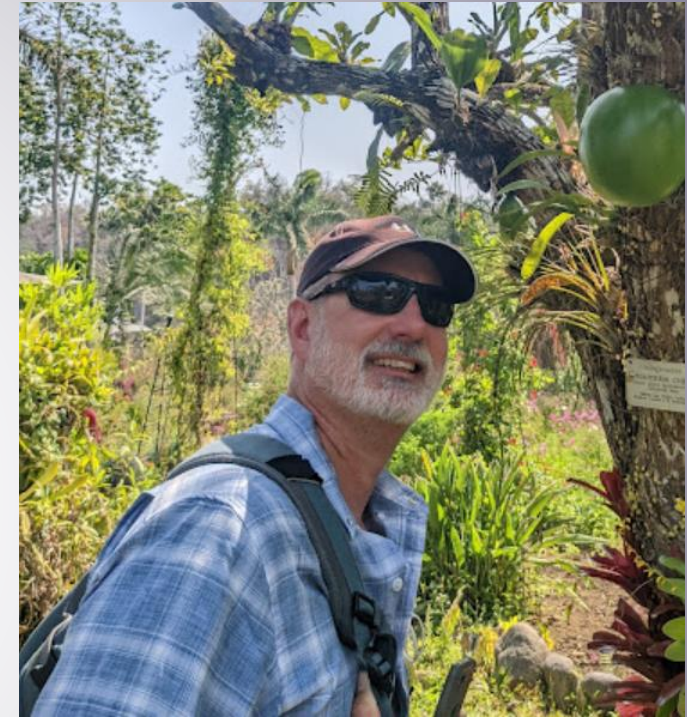
Jacob Strunk



R&D things forest sampling, estimation, modeling, mapping, GNSS, remote sensing. Likes travel and outdoor family adventures.

PhD, MSc Forestry, Stats Oregon State University
BS, MS Forestry, University of Washingtons

Peter Gould



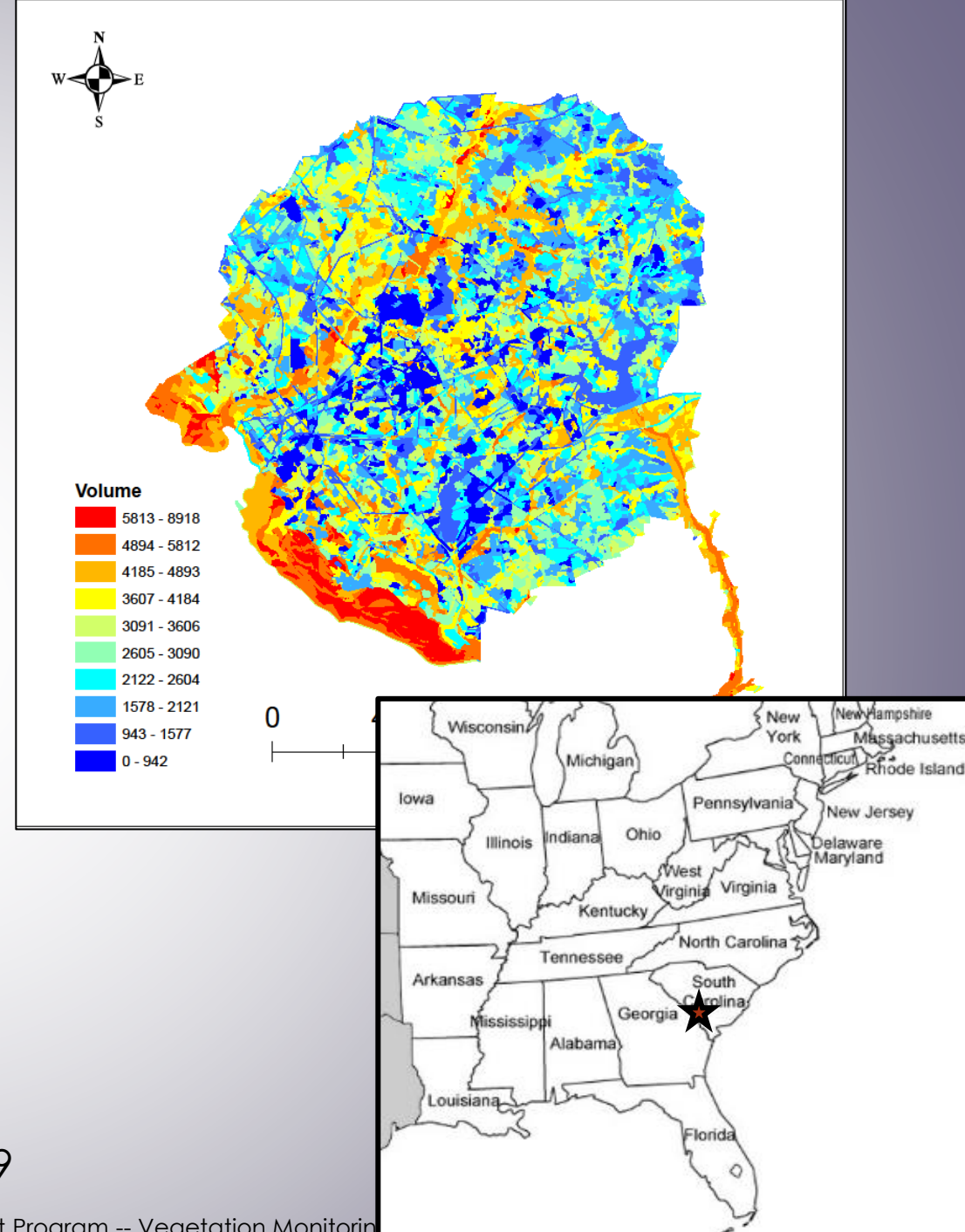
Peter is a great resource for all things technical! Forest biometrics, growth and yield, remote sensing, coding, visualization, software development, design circuit boards or data loggers, drones,

PhD Penn State
BS Northern AZ University

Savannah River Site in South Carolina

- 1) 200k ac total, 170k ac forest
- 2) Wood production & Conservation
~50 / 50 split
- 3) kNN Lidar inventory, 2019*
 - A. Tract-wide
 - B. Stand-level
 - C. Rasters (30 m)

*A Lidar inventory was also performed by VMaRS in 2009



Lidar Inventory

Good for Current conditions!

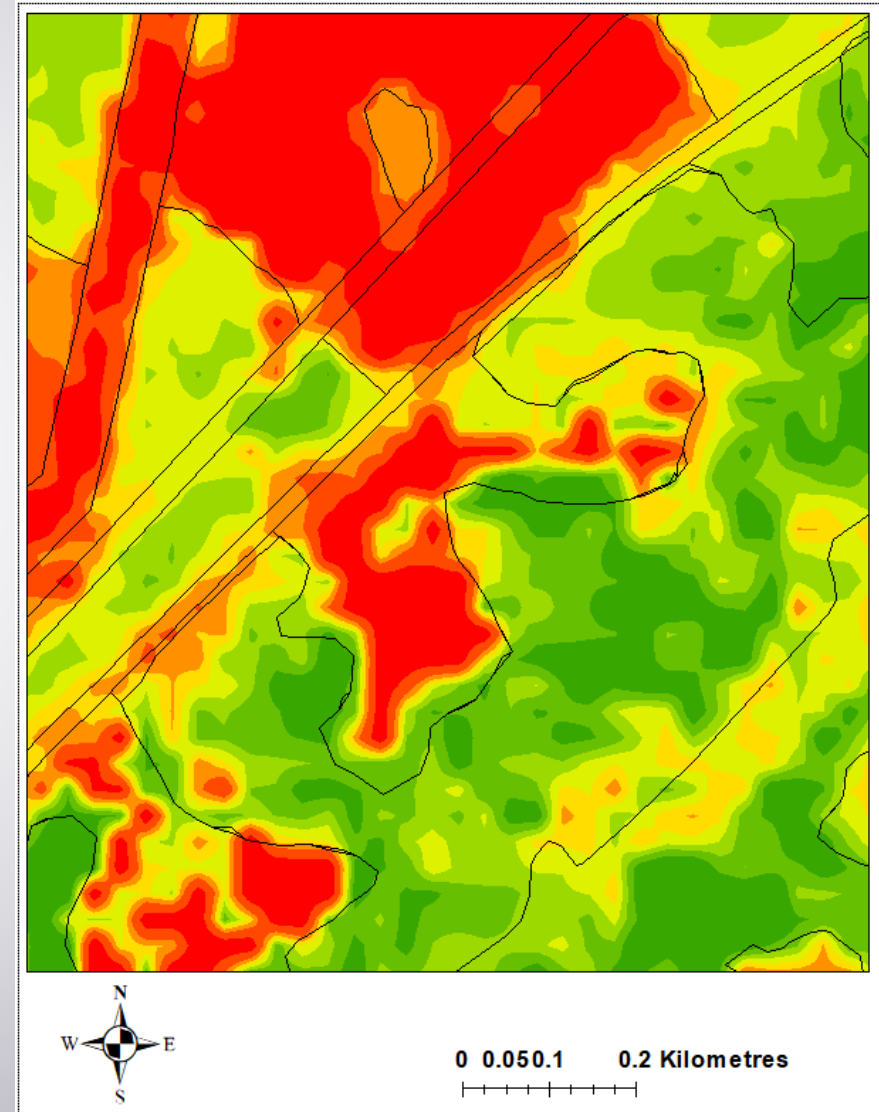
1) Strategic & Tactical Inventory today

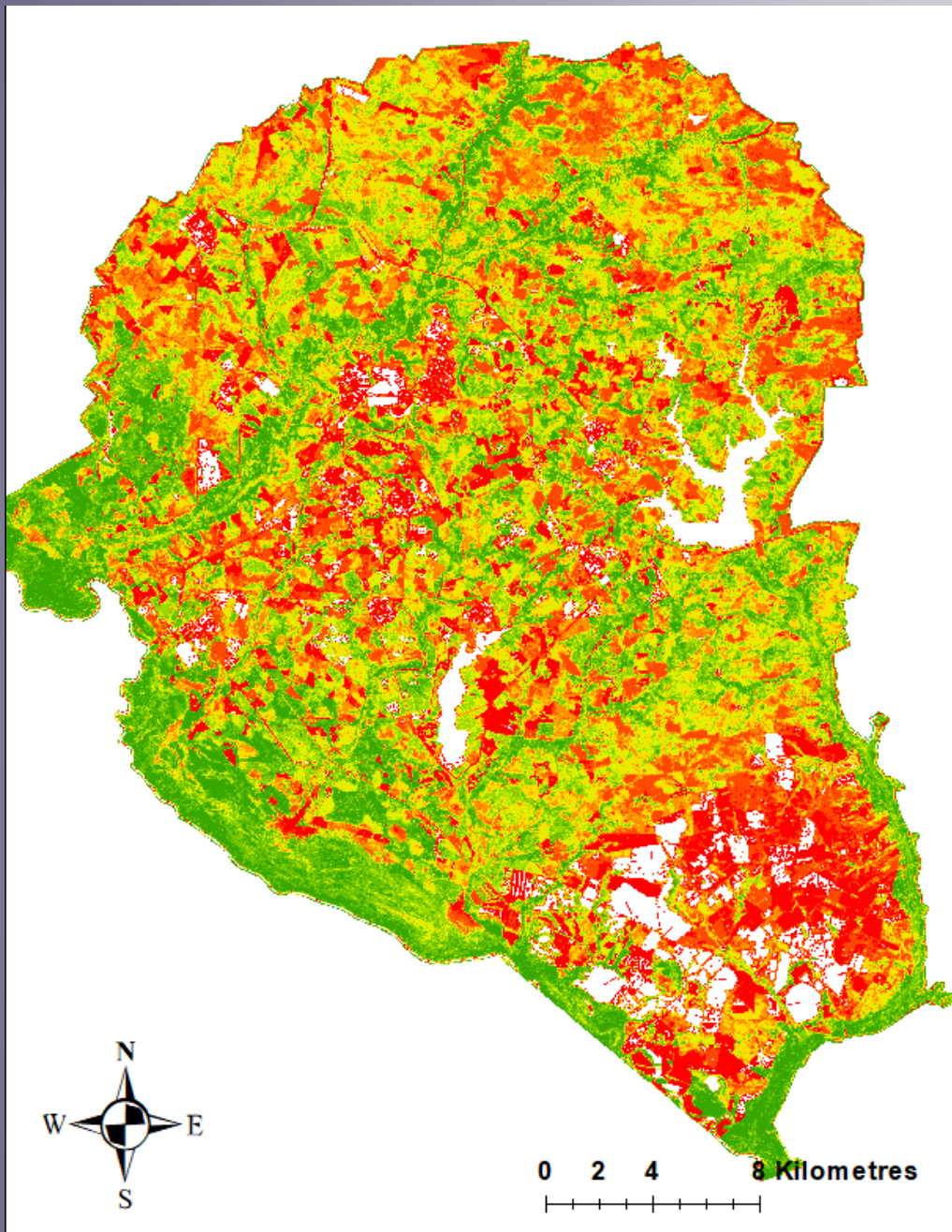
Tactical: Jacob L. Strunk and Robert J. McGaughey. 2023. Stand validation of lidar forest inventory modeling for a managed southern pine forest. *Canadian Journal of Forest Research*. **53**(2): 71-89. <https://doi.org/10.1139/cjfr-2022-0032>

2) Wall-to-wall, consistent, fine-scale, single-date forest inventory

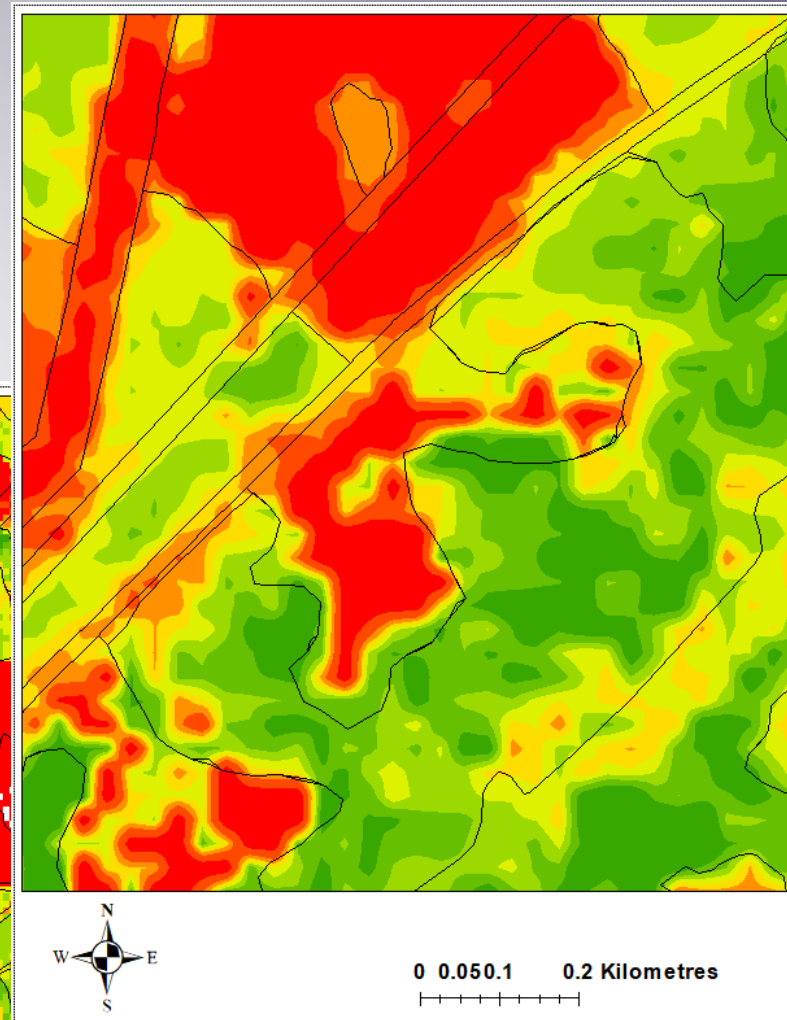
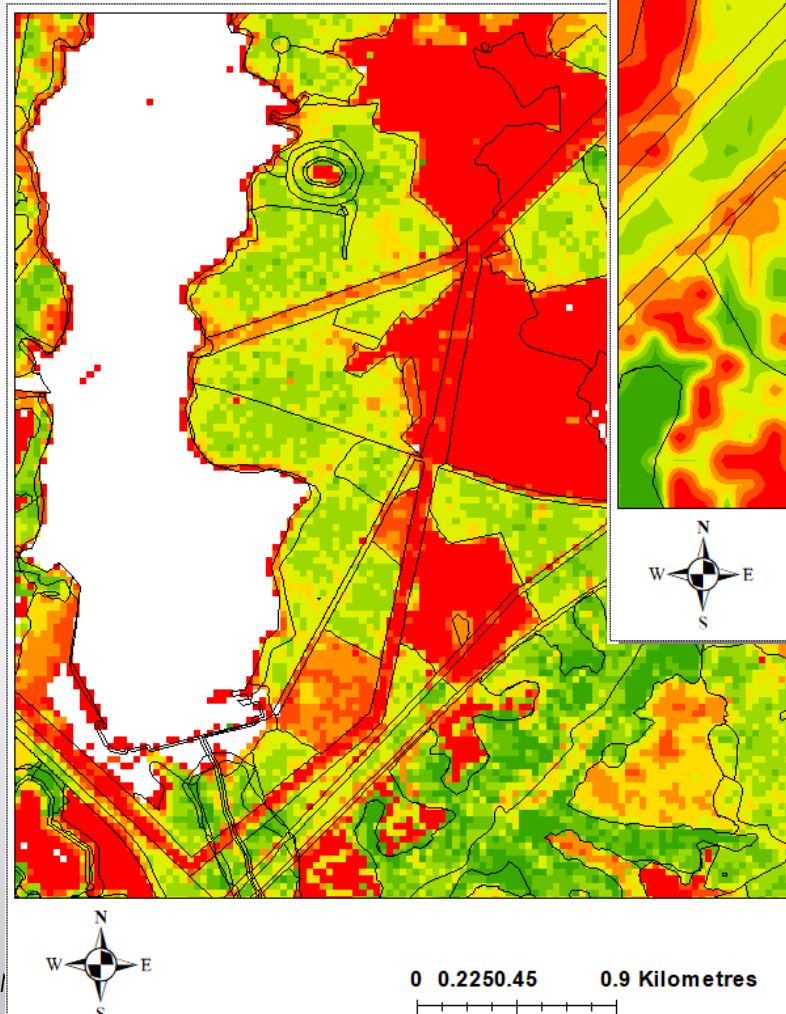
3) Cost Efficient (for stand-level+ detail)

- A. ≈\$250k for 200k acres
- B. 550 plots (\$75k)
- C. Lidar (\$60k)
- D. Analysis (\$115k)

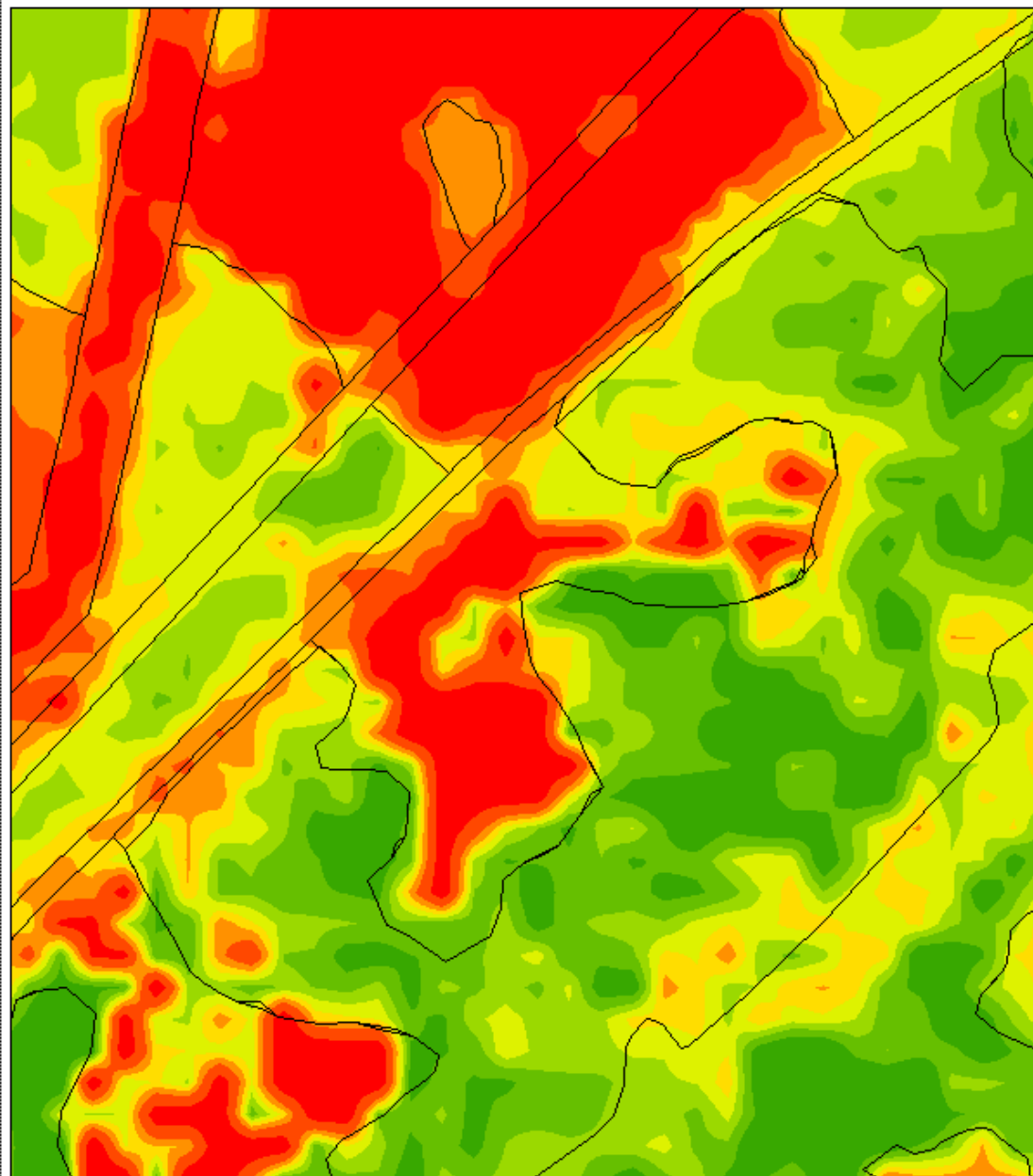




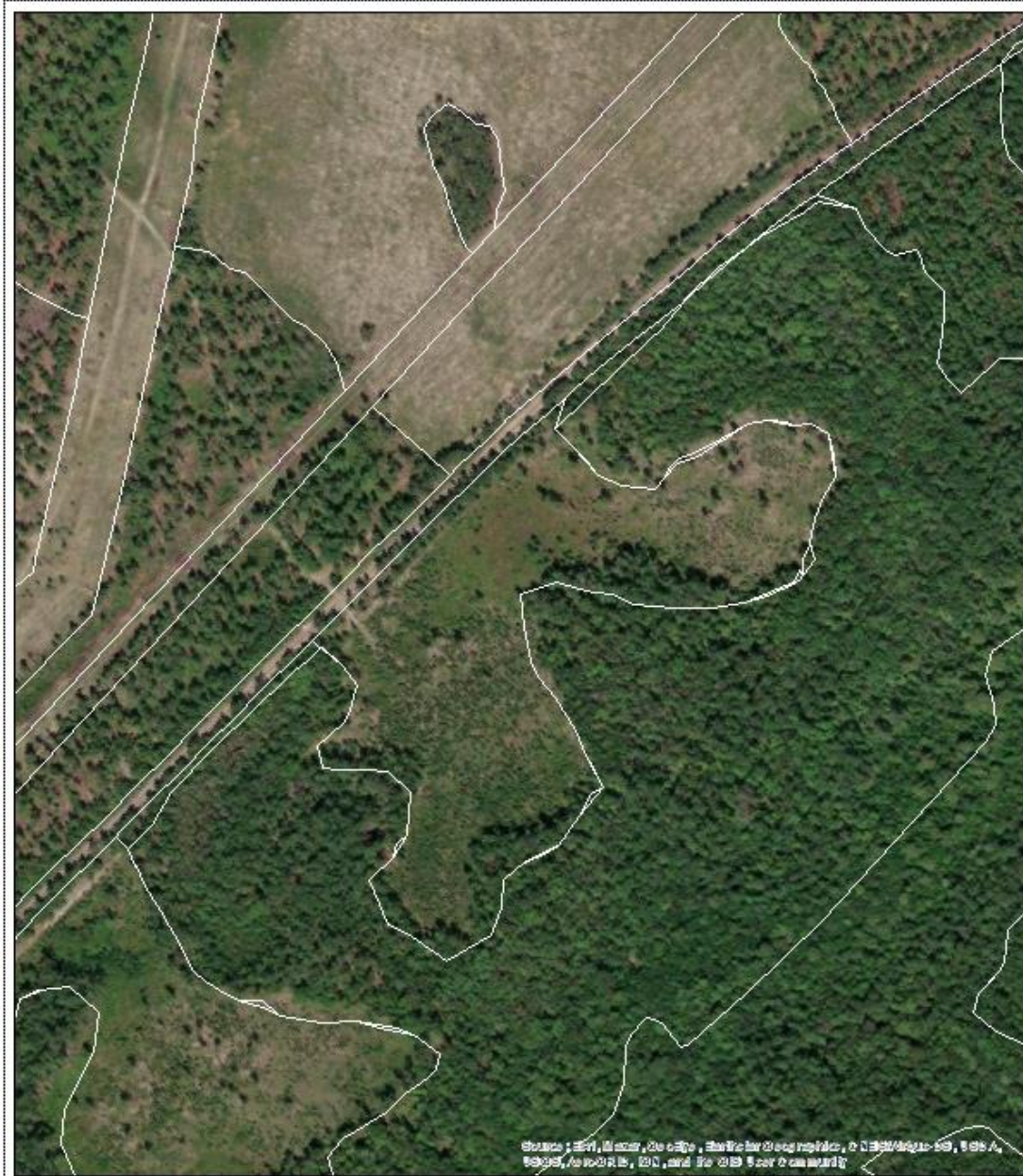
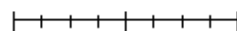
USDA Forest Service -- Pacific Northwest Research Station -- Forest /



and Assessment Team



0 0.050.1 0.2 Kilometres



Source: 1:50,000 scale, 1:25,000 scale, 1:10,000 scale, 1:5,000 scale, 1:2,500 scale, 1:1,250 scale, 1:625 scale, 1:312 scale, 1:156 scale, 1:78 scale, 1:39 scale, 1:20 scale, 1:10 scale, 1:5 scale, 1:2 scale, 1:1 scale, 1:0.5 scale, 1:0.25 scale, 1:0.125 scale, 1:0.0625 scale, 1:0.03125 scale, 1:0.015625 scale, 1:0.0078125 scale, 1:0.00390625 scale, 1:0.001953125 scale, 1:0.0009765625 scale, 1:0.00048828125 scale, 1:0.000244140625 scale, 1:0.0001220703125 scale, 1:0.00006103515625 scale, 1:0.000030517578125 scale, 1:0.0000152587890625 scale, 1:0.00000762939453125 scale, 1:0.000003814697265625 scale, 1:0.0000019073486328125 scale, 1:0.00000095367431640625 scale, 1:0.000000476837158203125 scale, 1:0.0000002384185791015625 scale, 1:0.00000011920928955078125 scale, 1:0.000000059604644775390625 scale, 1:0.0000000298023223876953125 scale, 1:0.00000001490116119384765625 scale, 1:0.000000007450580596923828125 scale, 1:0.0000000037252902984619140625 scale, 1:0.00000000186264514923095703125 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Is Lidar any Good for Growth Projections?

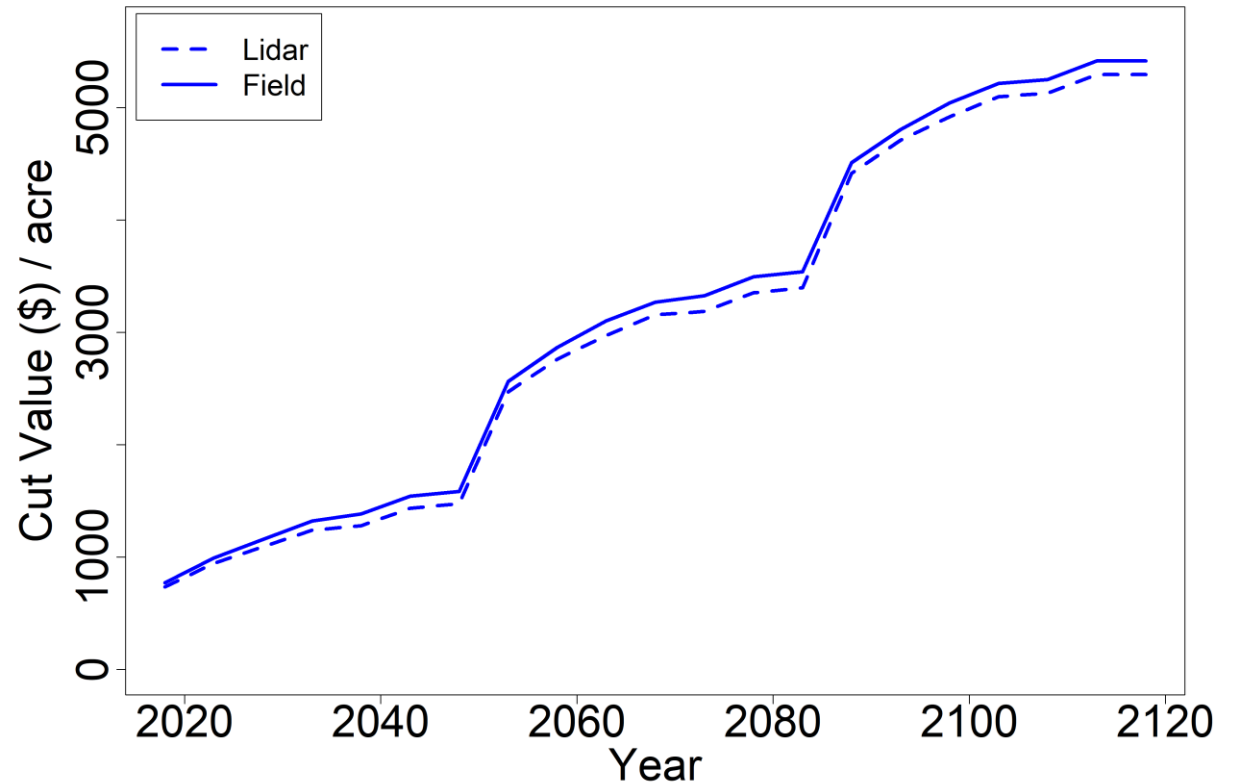
1) Grow and compare stand-level inventories

A. Lidar

B. Field

2) 6 Scenarios (high to low intensity)

3) “Tract” vs Stand performance



Analysis

- **USFS Forest Vegetation Simulator (FVS)**

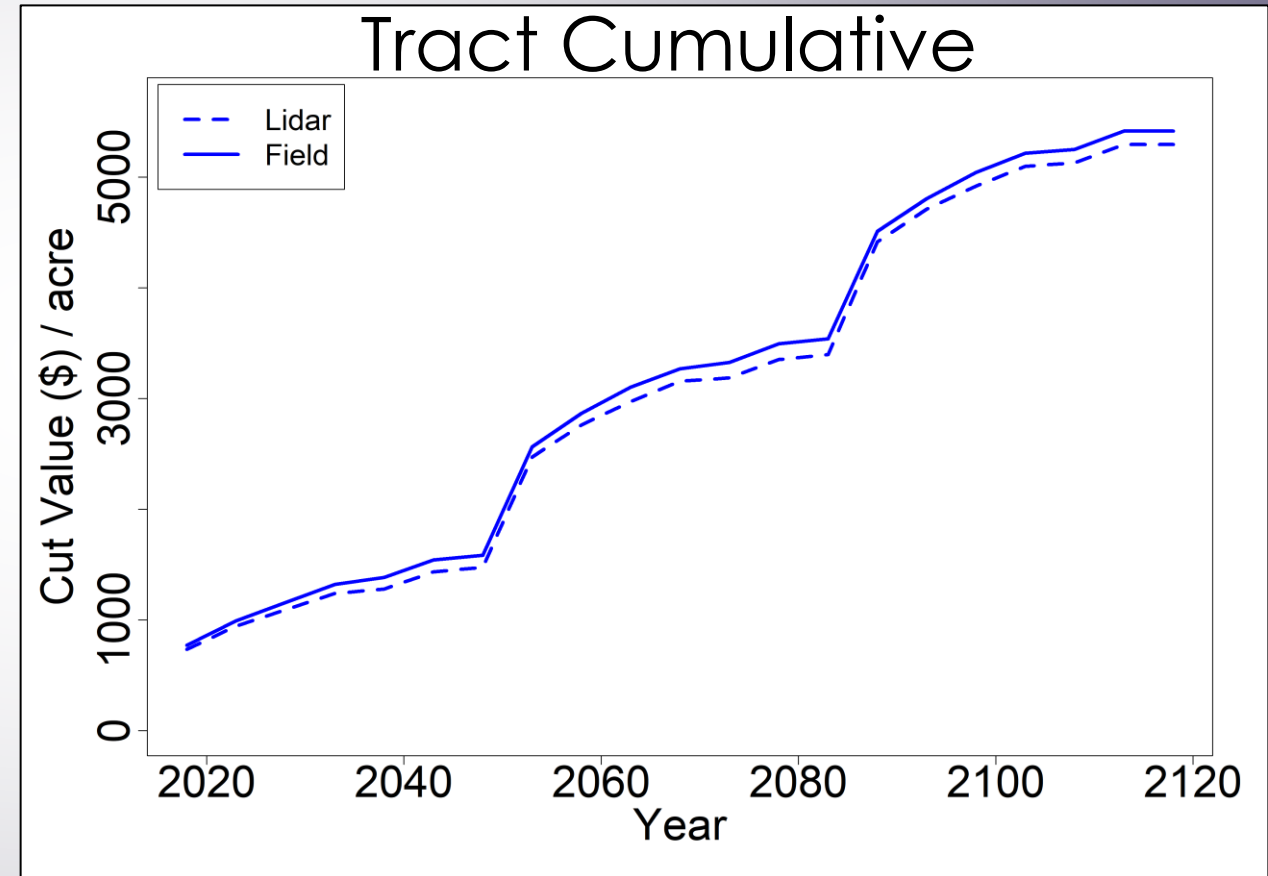
- SN Variant
- 5 year periods
- 100 years

- **Scales**

- Tract
- Stand

- **Metrics**

- Volume
- Carbon
- Value
- Net present value (NPV)
- Temporal Agreement



FVS Growth Projections

Individual Tree based growth model

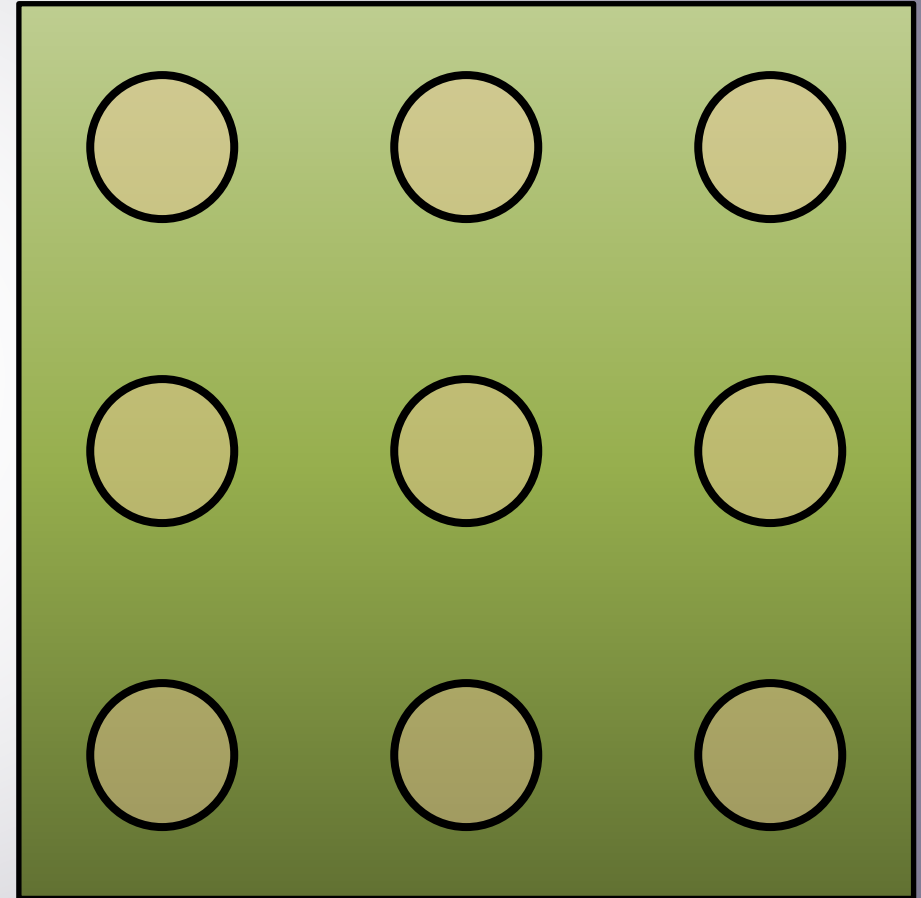
1. Plant (375 vs 550)
2. Thin to 70 sq ft / acre (0,1,2 x thins)
3. Harvest rotation (35, 50, 60, never)

Management scenarios

- A. 375 plant / acre, No Thin, 35 yr harvest
- B. 550 plant / acre, No Thin, 35 yr harvest
- C. 550 plant / acre, 1 Thin, 35 yr harvest
- D. 550 plant / acre, 2 Thin, 50 yr harvest
- E. 550 plant / acre, 2 Thin, 60 yr harvest
- F. No management (let grow)

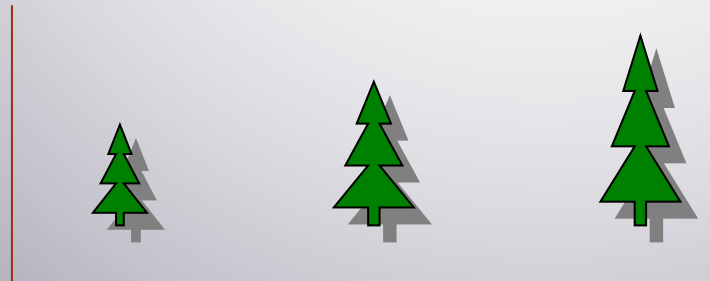
50 x Validation Stands

- 5 acres / stand
- 9 x plots / stand
 - 1/10th acre plots



Strategic (Tract-level) Inventory:

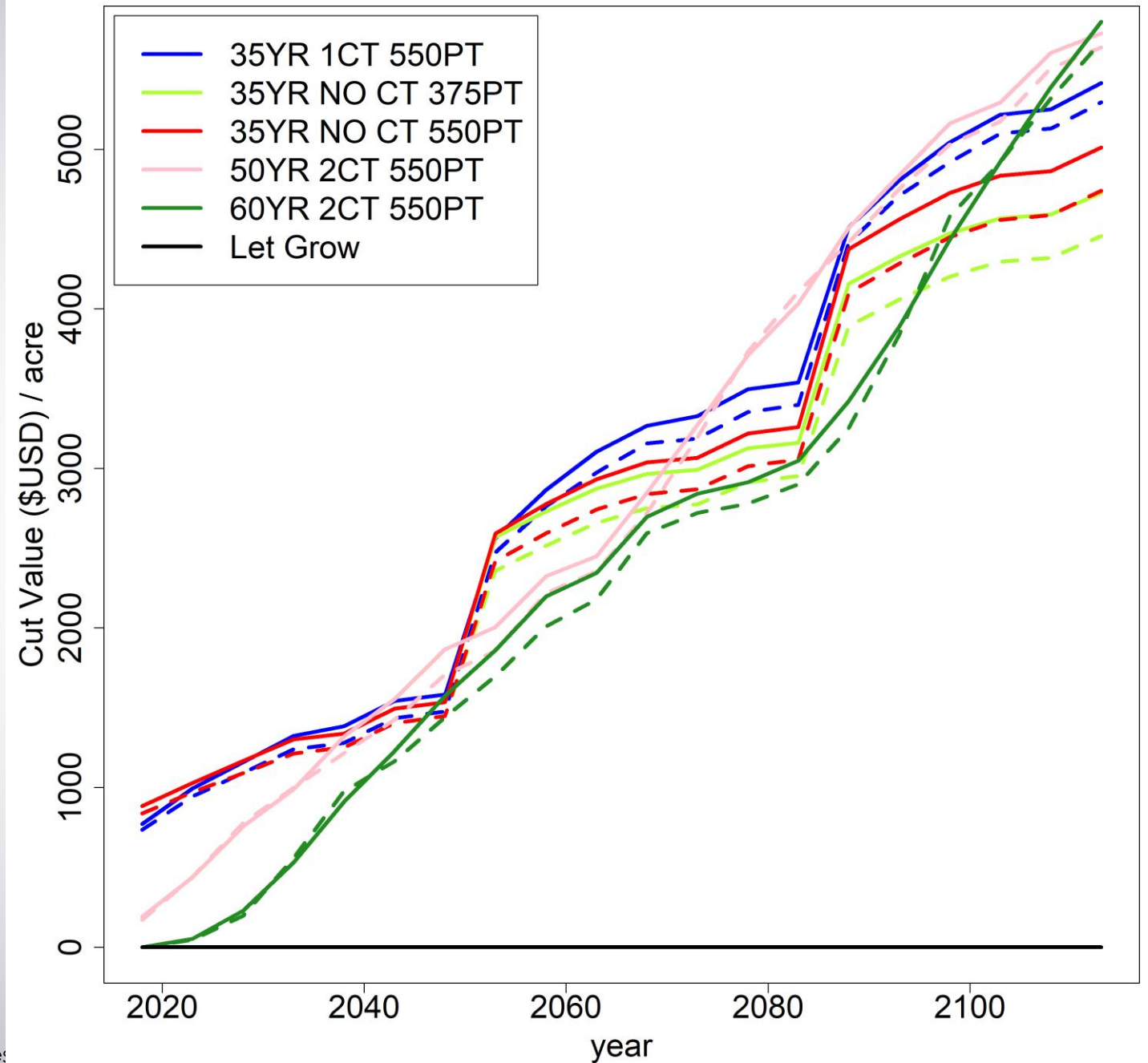
1. Growth projections: Lidar VS Field
2. Differences by management strategy



Lidar and Field: \approx Exact match

Cyclic – no clear winner

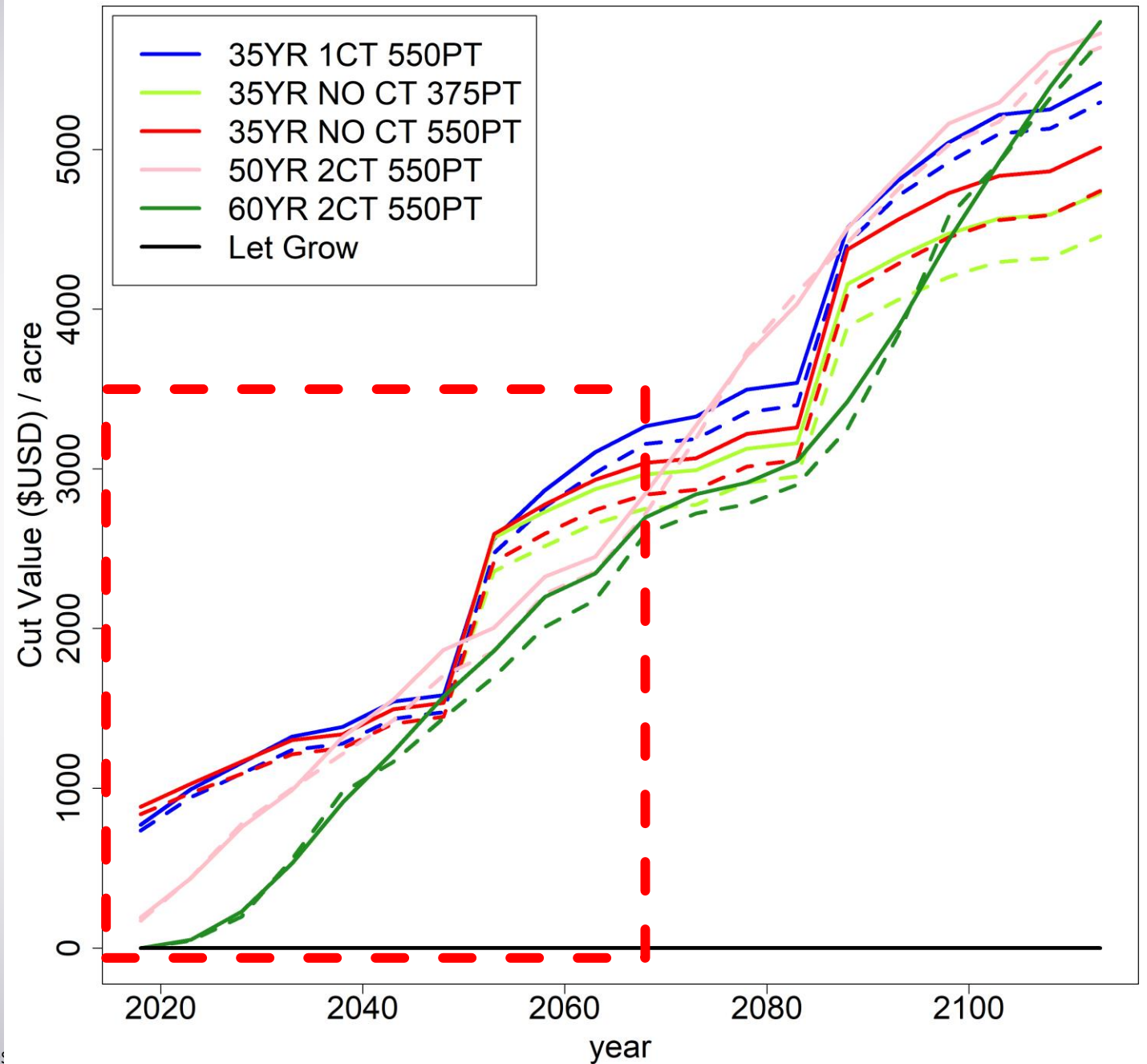
- 35YR 1CT?
- 50 or 60 yr?

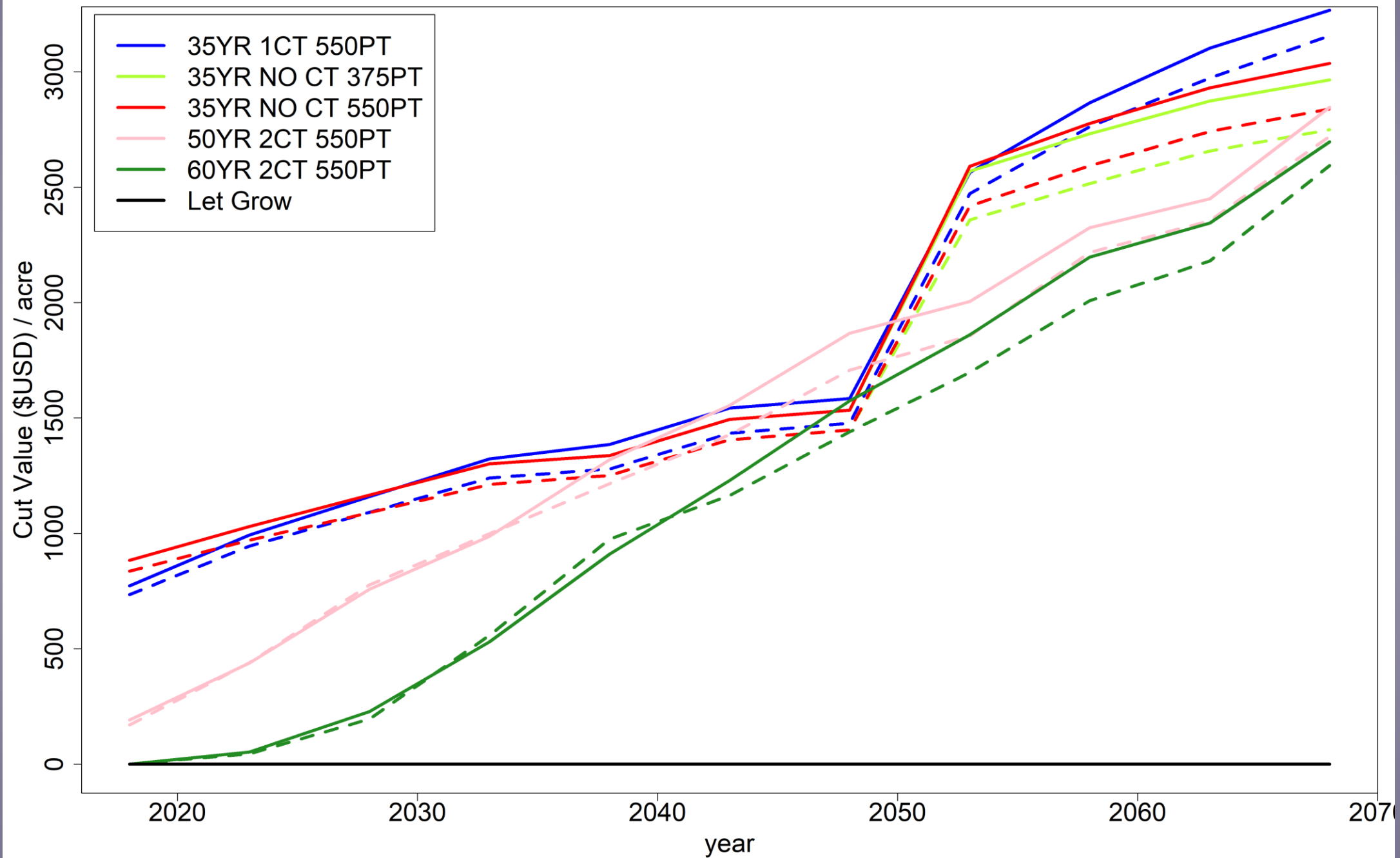


Lidar and Field: ≈ Exact match

Cyclic – no clear winner

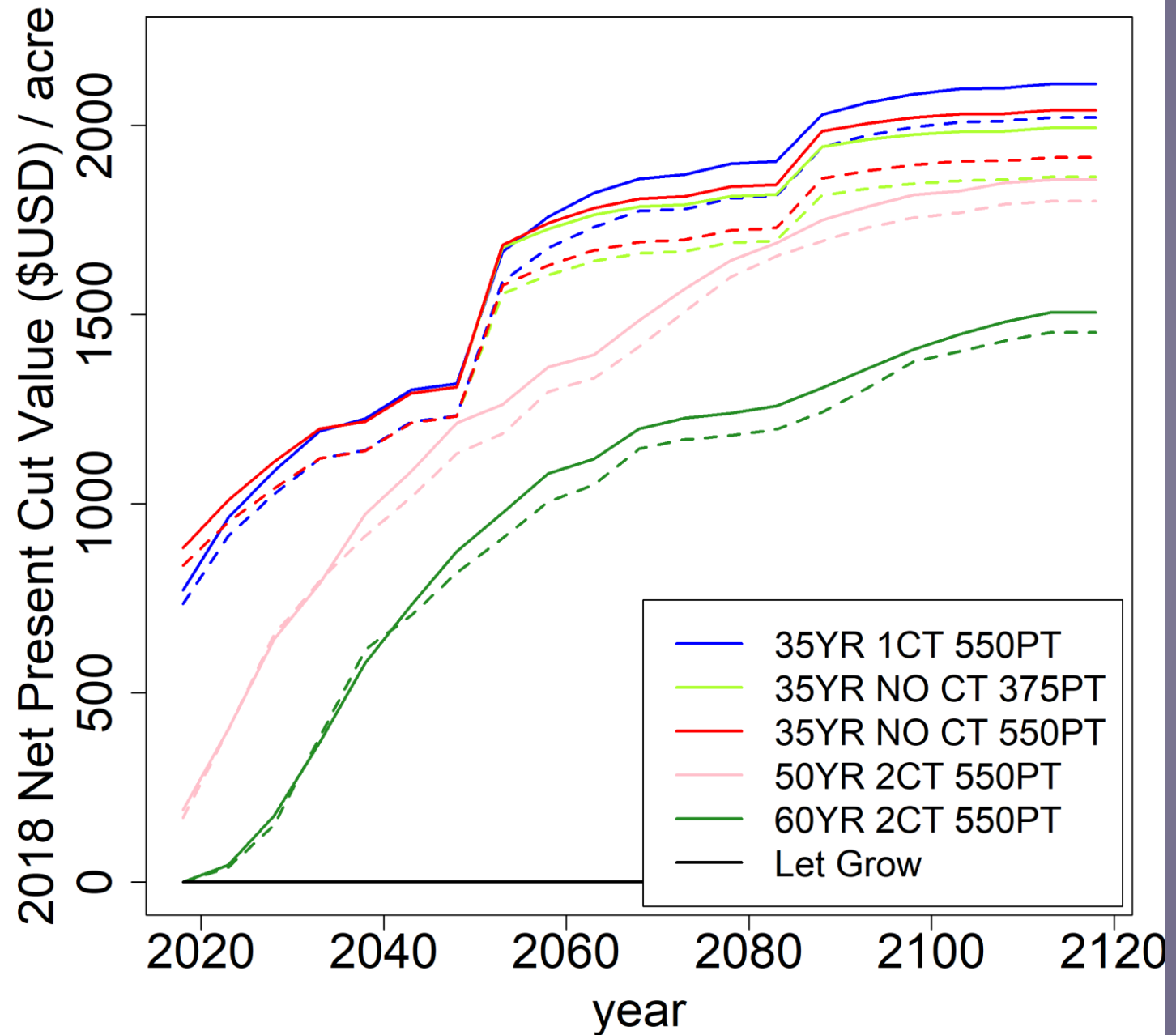
- 35YR 1CT?
- 50 or 60 yr?





NPV (3%, 2018): More Interesting

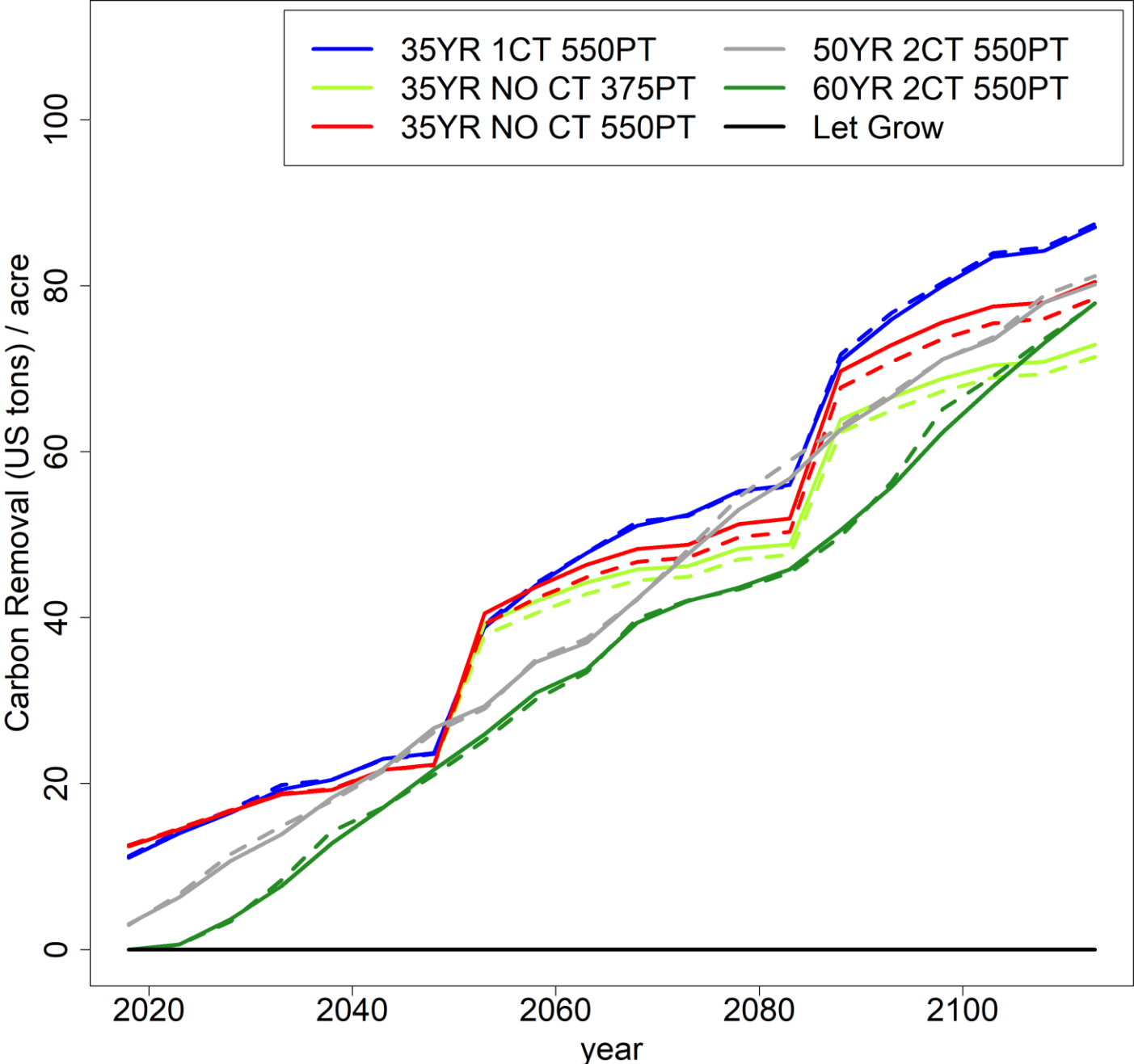
- Shorter rotations win ...
- CT / no thin, planting density effects minimal



Carbon Removals as wood timber

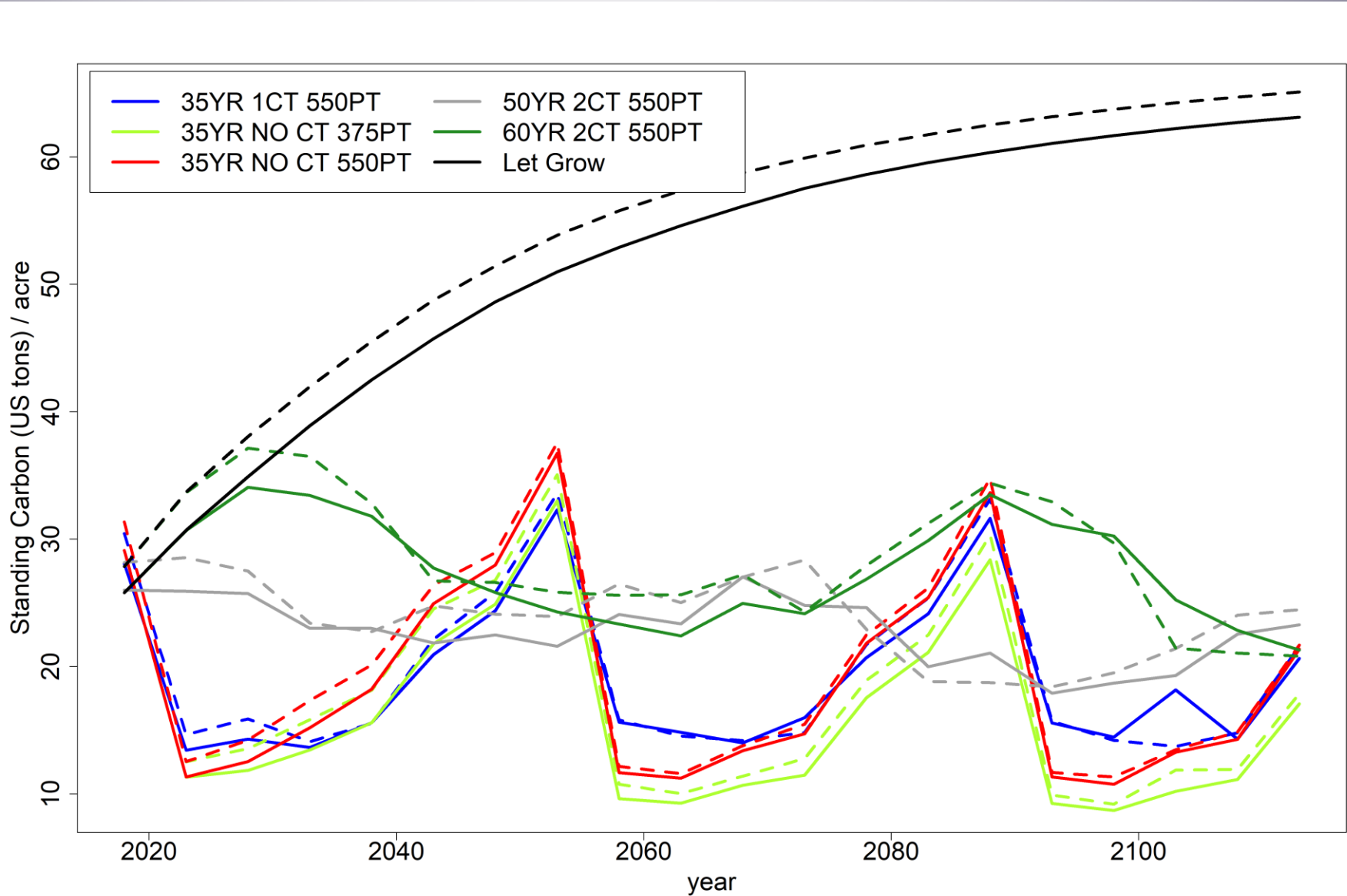
- Shorter rotations win ...
- CT / no thin, planting density effects minimal

	lidar	field
35yr_1thin_550	0.92	0.92
35yr_no_thin_375	0.75	0.77
35yr_no_thin_550	0.83	0.85
50yr_2thin_550	0.85	0.84
60yr_2thin_550	0.82	0.82
let_grow	0.00	0.00

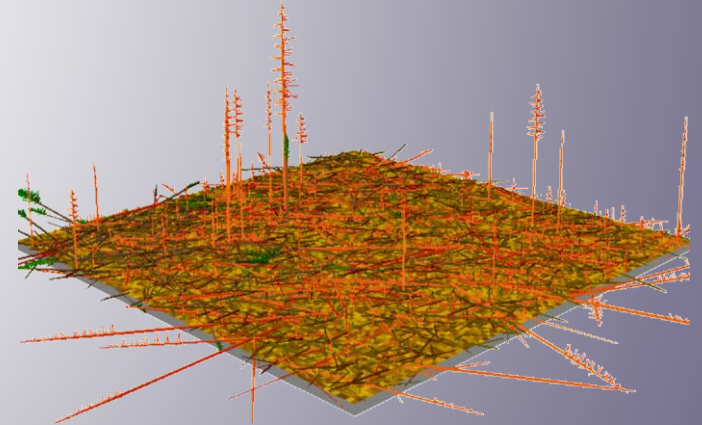
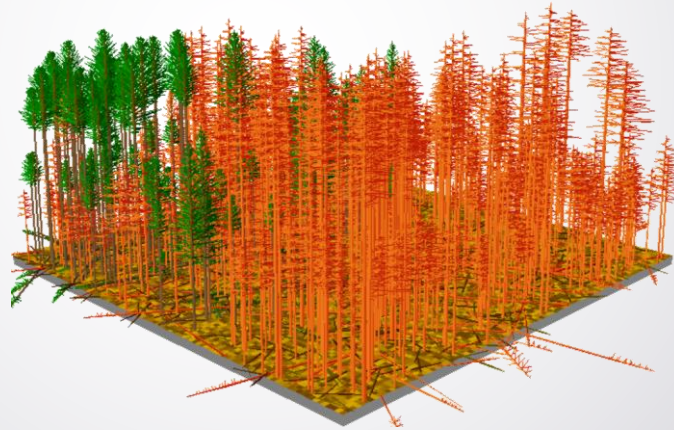
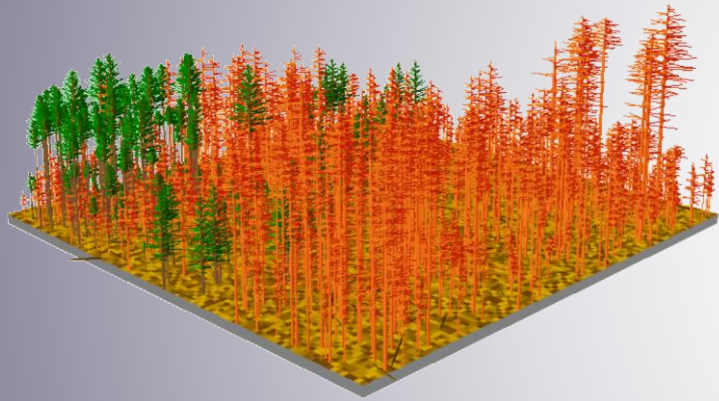


Standing Carbon

Lidar and Field: *Close Match*



Tactical (Stand-Level) Inventory



*Visualizations from SVS Software made by Robert J McGaughey

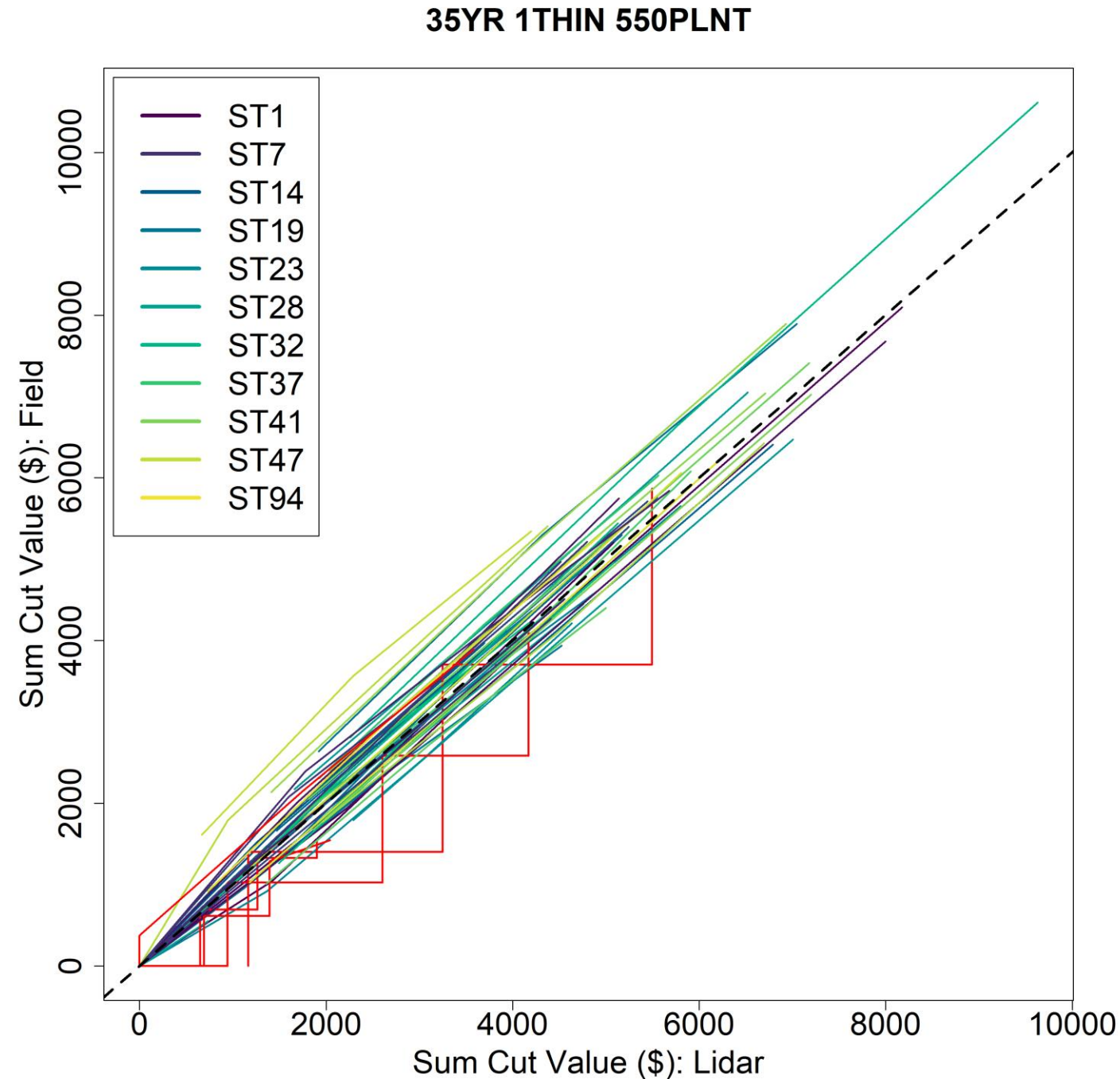
Example: Temporal Trends by Stand

RED = Mgmt YR Mismatch

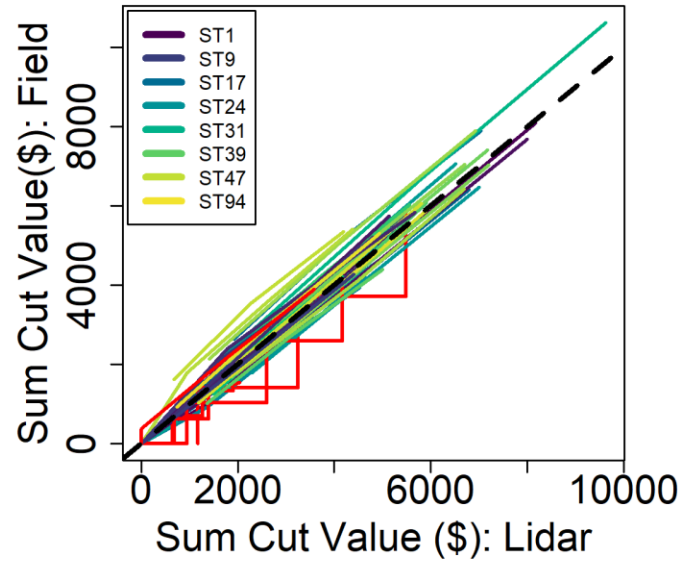
Example:

Lidar thinned 2023

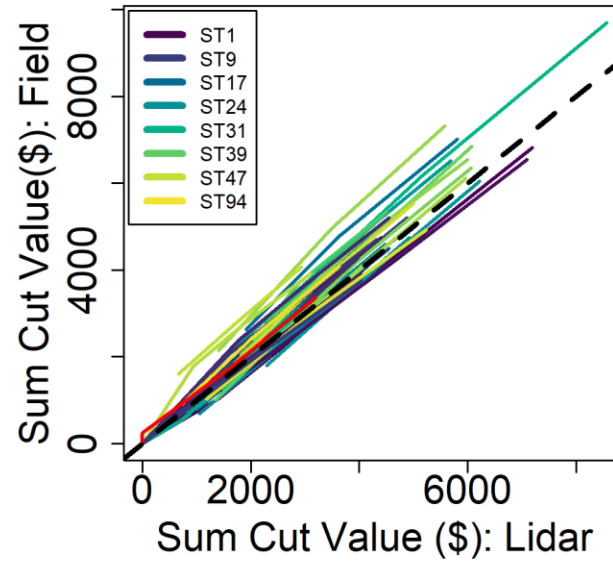
Field thinned 2025



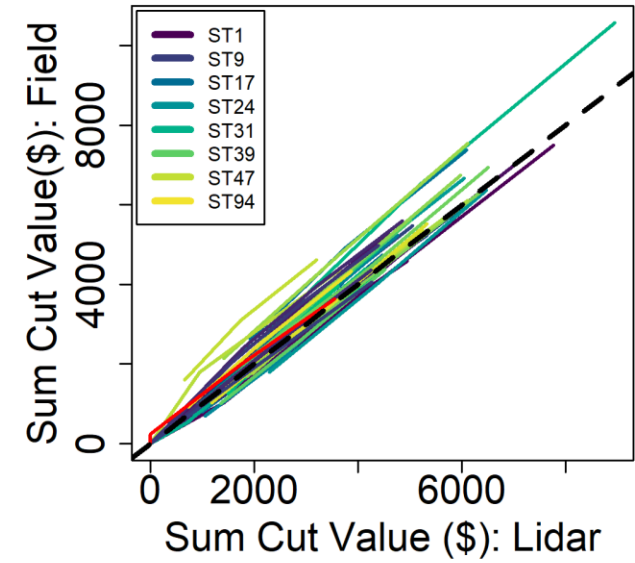
35YR 1THIN 550PLNT



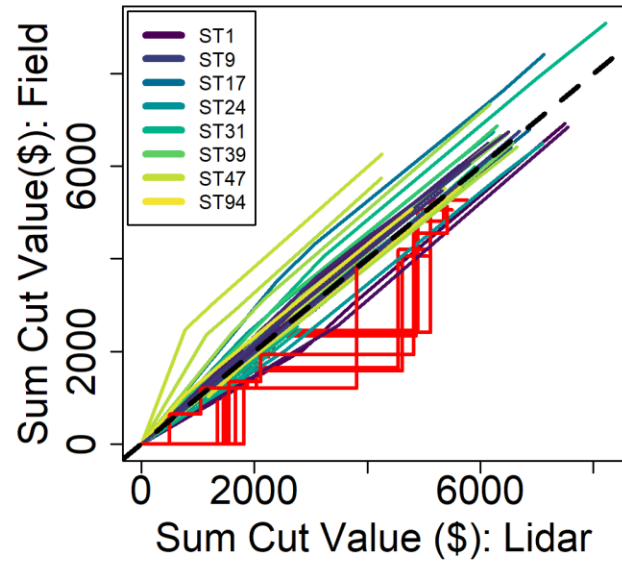
35YR NO THIN 375PLNT



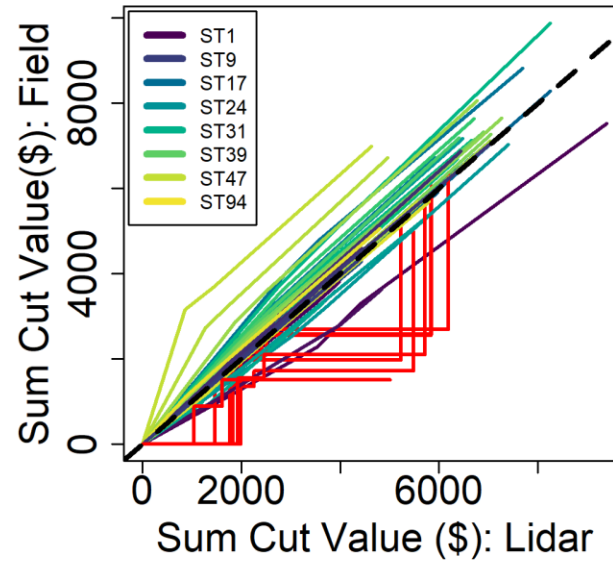
35YR NO THIN 550PLNT



50YR 2THIN 550PLNT



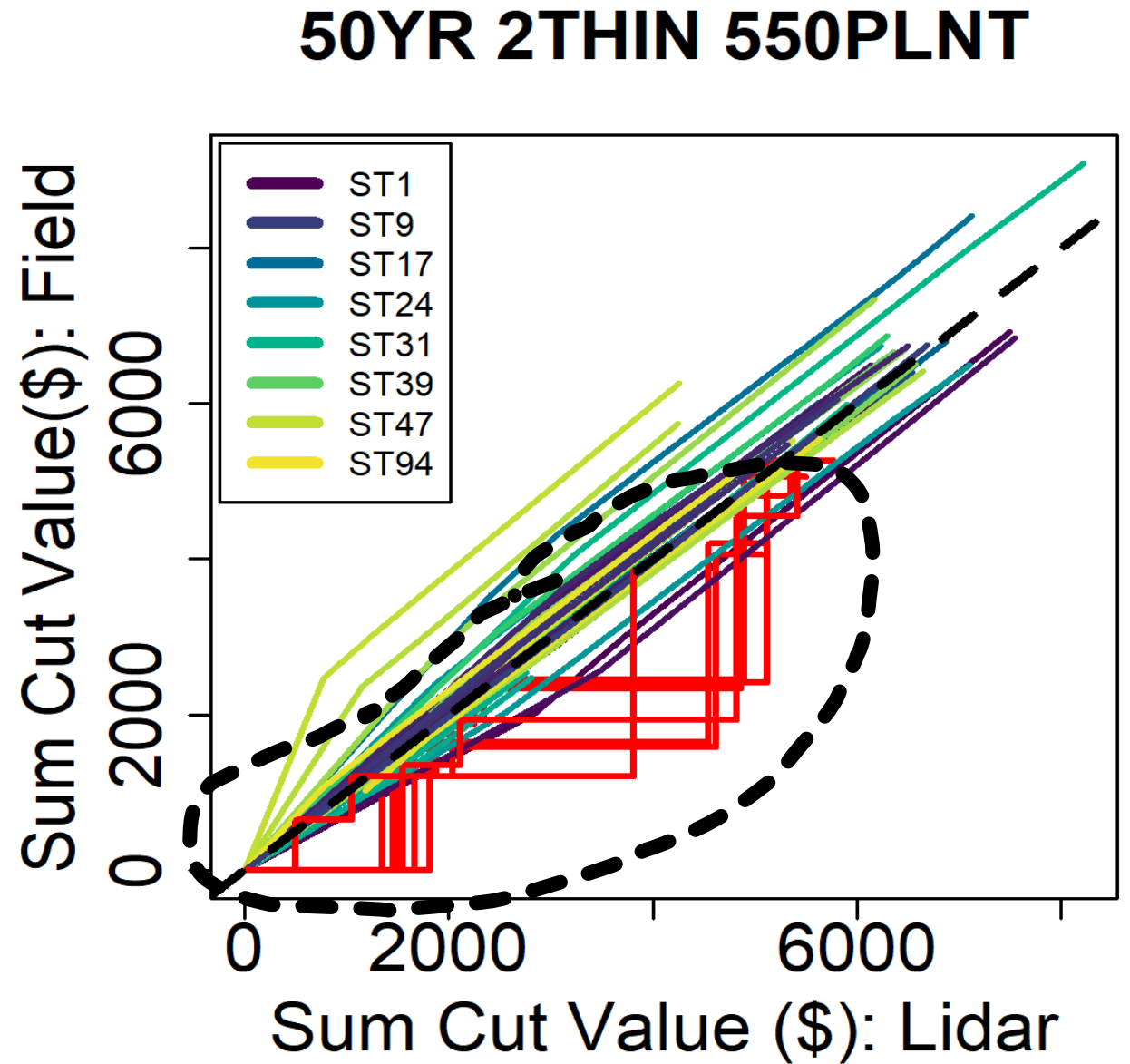
60YR 2THIN 550PLNT



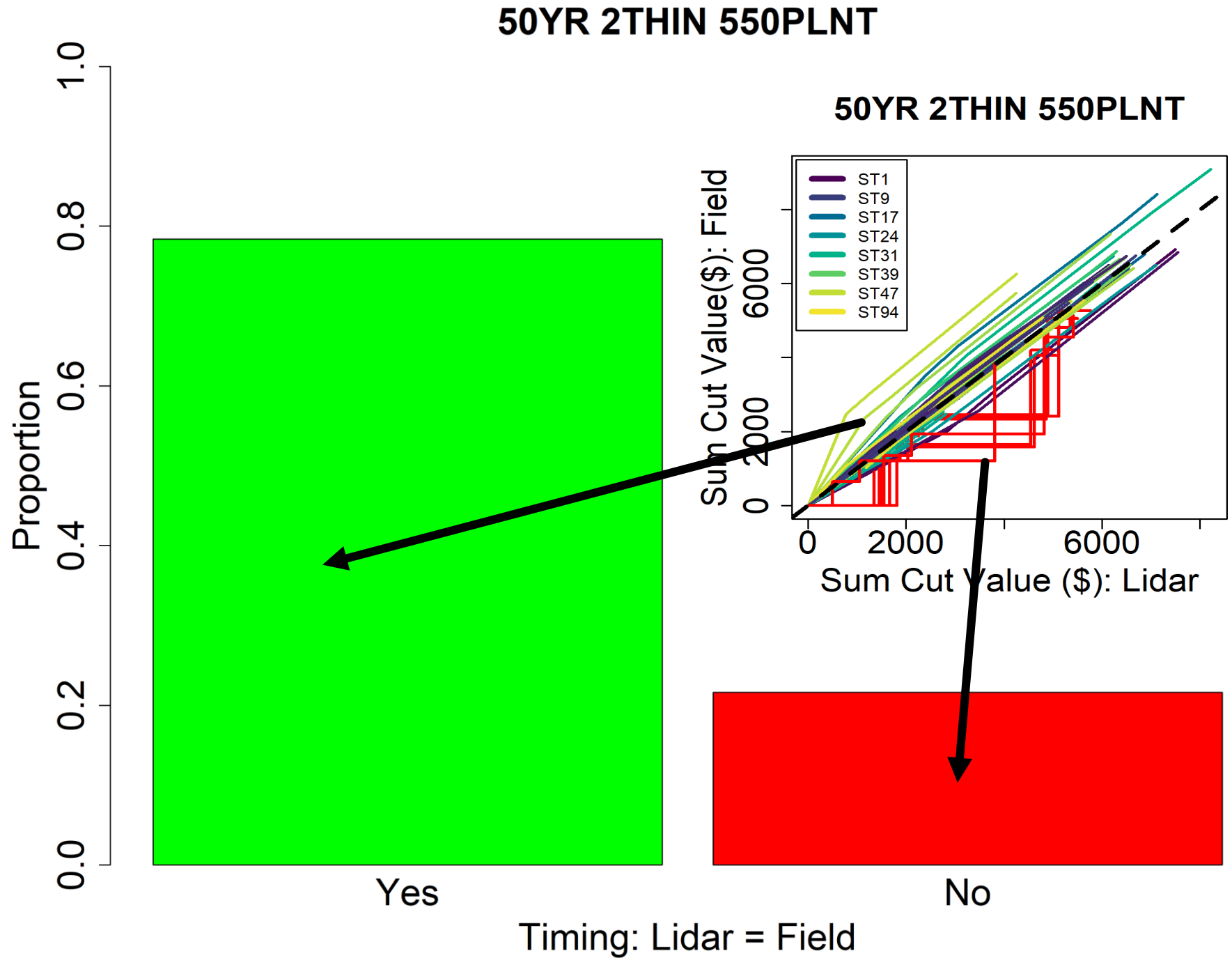
1) Initial Divergence

BUT

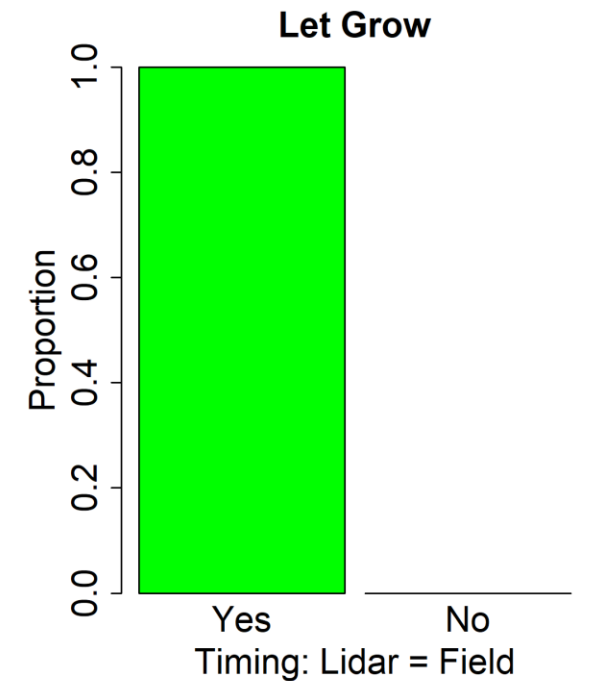
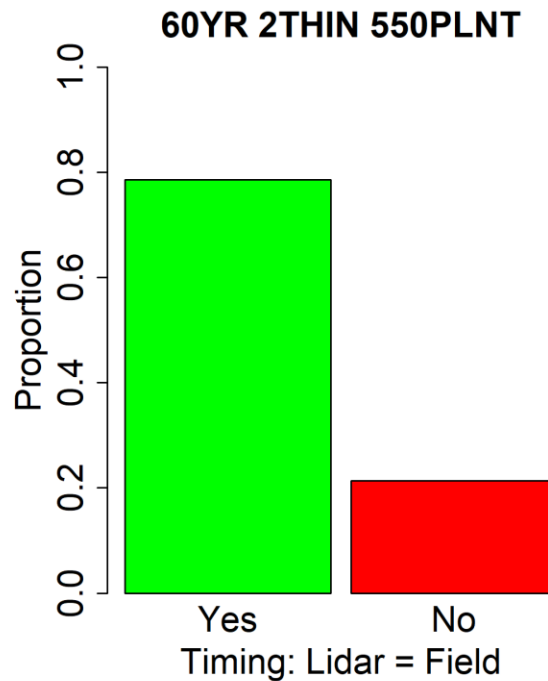
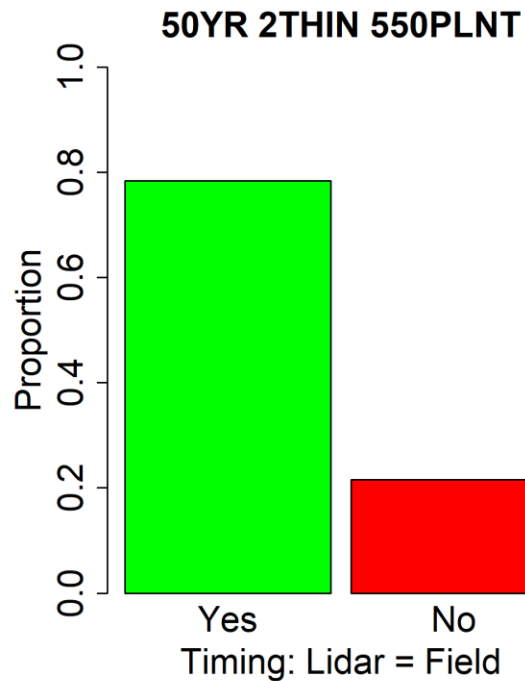
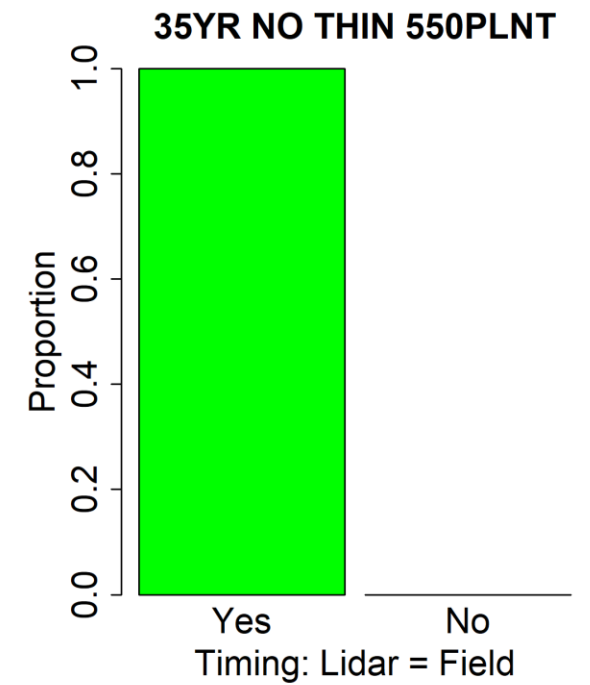
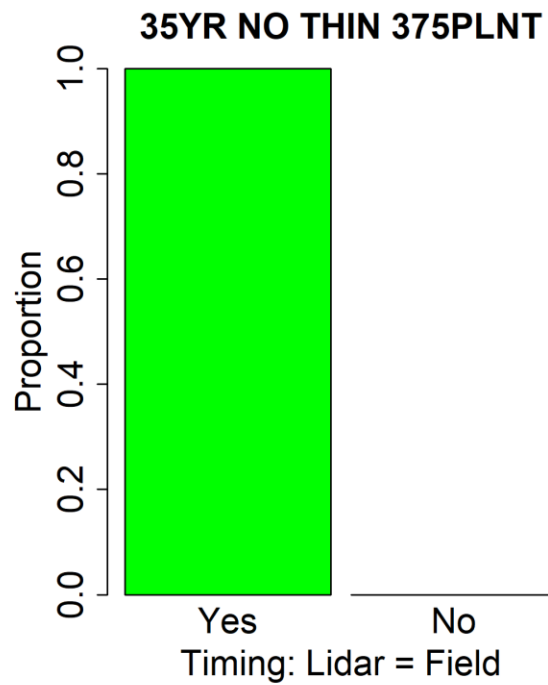
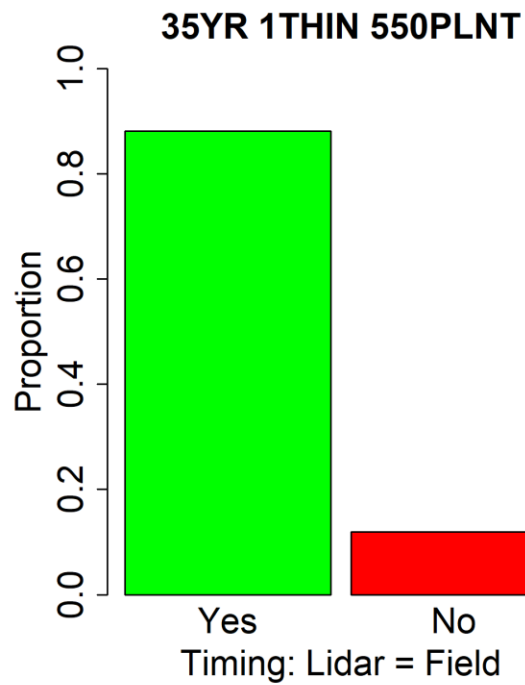
2) Reverts back to trend lines



Timing Agreement



Timing Agreement

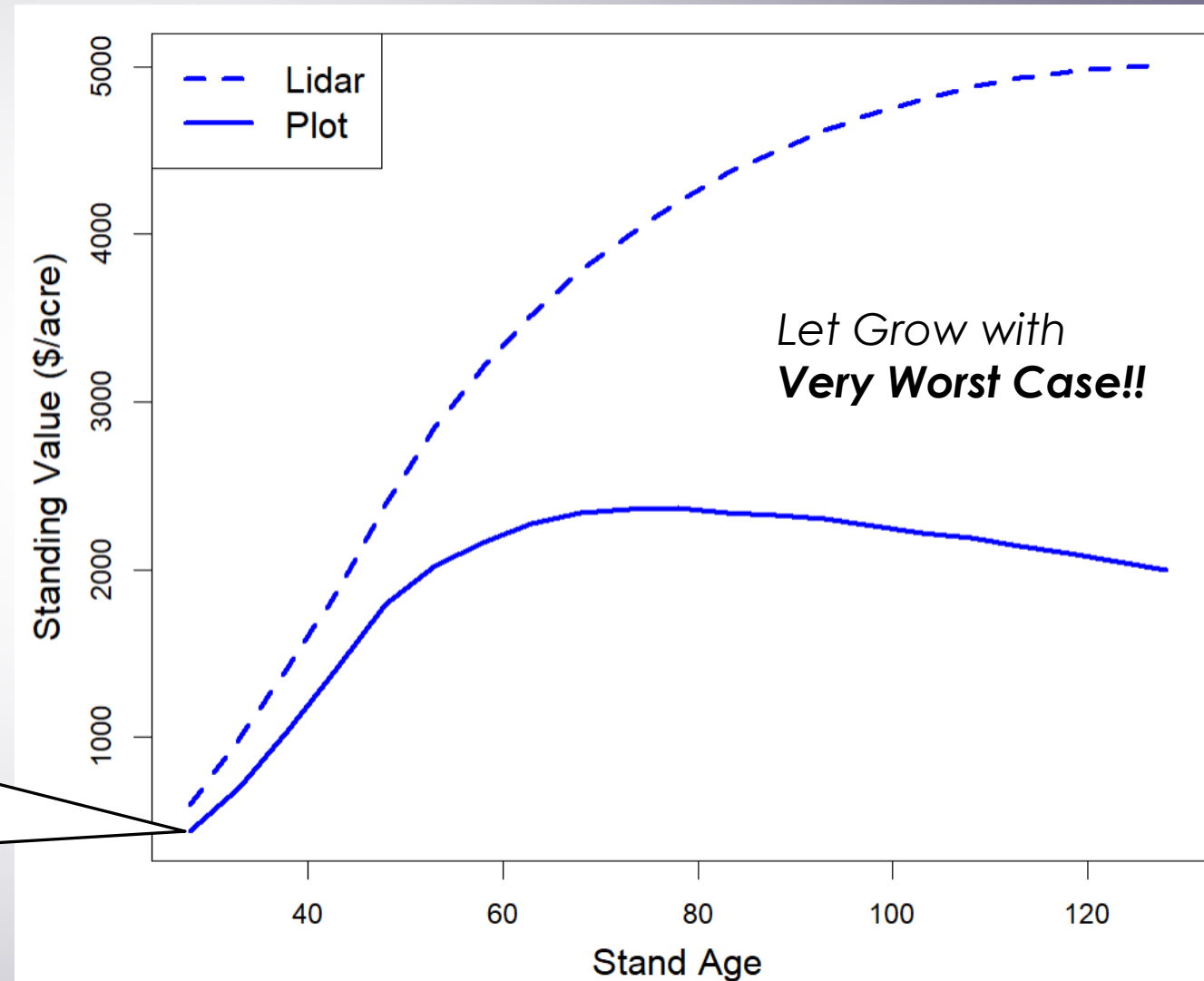


Diagnostics

Which factors in the **initial** tree lists cause projections to diverge over time?

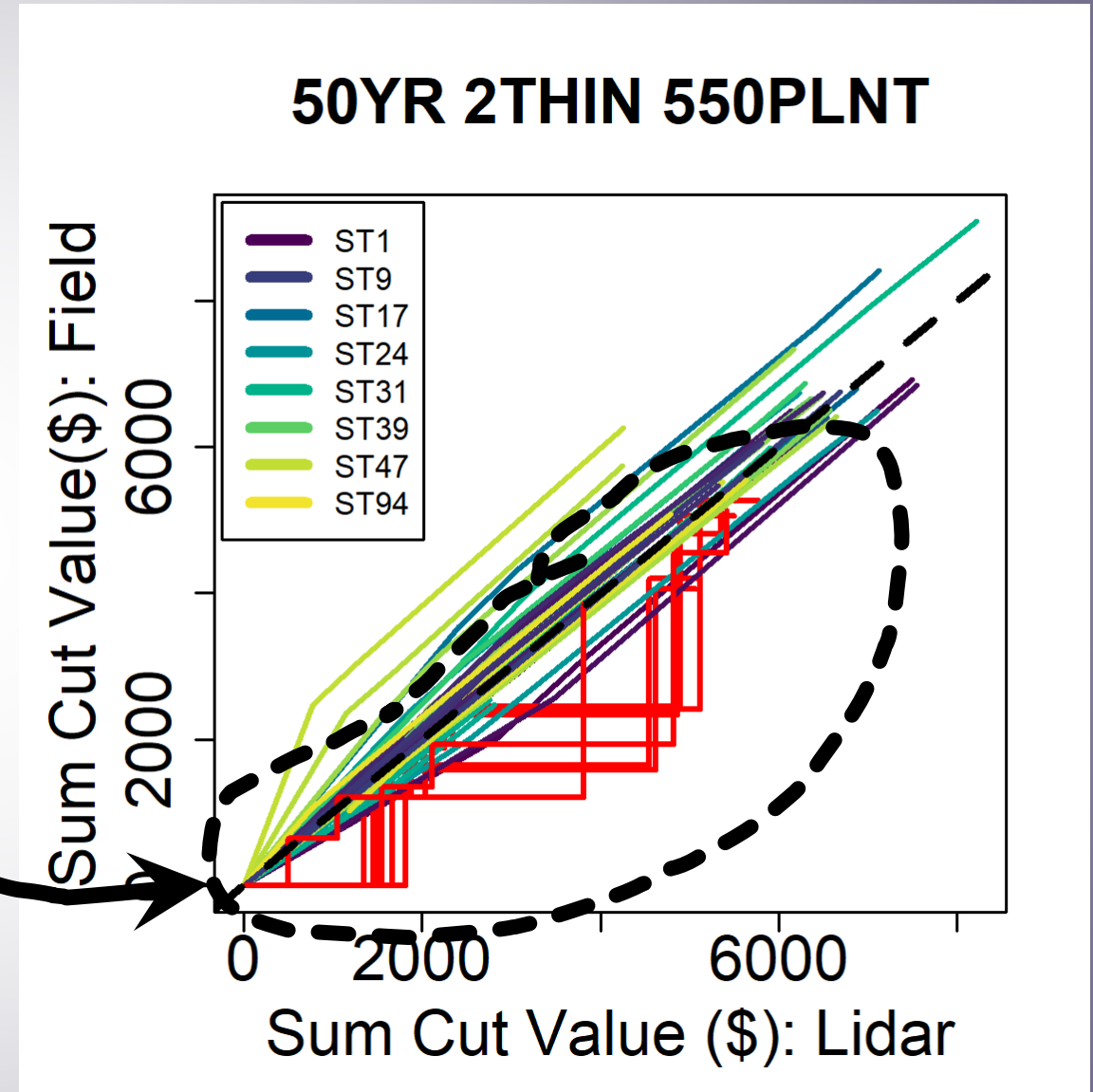
- 1) QMD has a moderate influence on basal area and trees per acre
- 2) Hardwood proportion has a strong influence on volume and value over time

Example Stand MS1:
Lidar inventory 17% HWD
Plot inventory 63% HWD



Conclusions

- 1) Lidar and Field projections VERY similar!
 - A. Tract
 - B. Stand
- 2) Stand-level mismatch
 - A. Exists
 - B. *Temporary* divergence...**
- 3) Muddy inference: “best” mgmt strategy
 - A. No clear winner in total dollars
 - B. Shorter rotation have higher NPV
 - C. Longer rotations less cyclic*
- 4) HW Proportion
 - A. Biggest indicator of errors
 - B. Focus on species predictions (lidar) !
- 5) *Plan is to look at forest estate models next



END

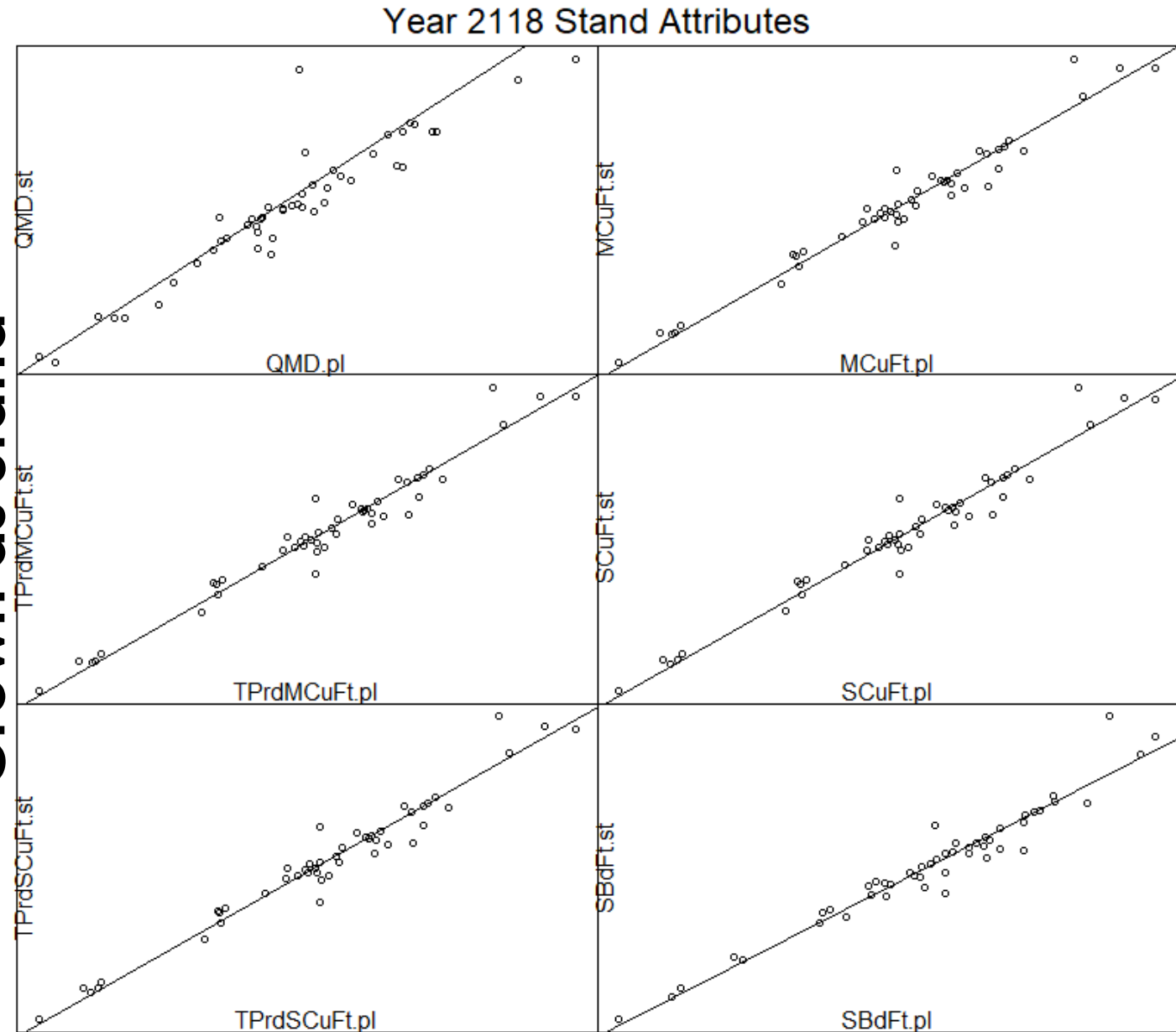
Questions?

FVS

Effect of Stand vs Plot

- 1) Grow tree
 - A. 100 years
 - B. As plots (+error)
 - C. As stands
- 2) Yes: Stand level differences
- 3) ~Unbiased at 100 years
- 4) No effect from ht errors
- 5) Results same at 2038

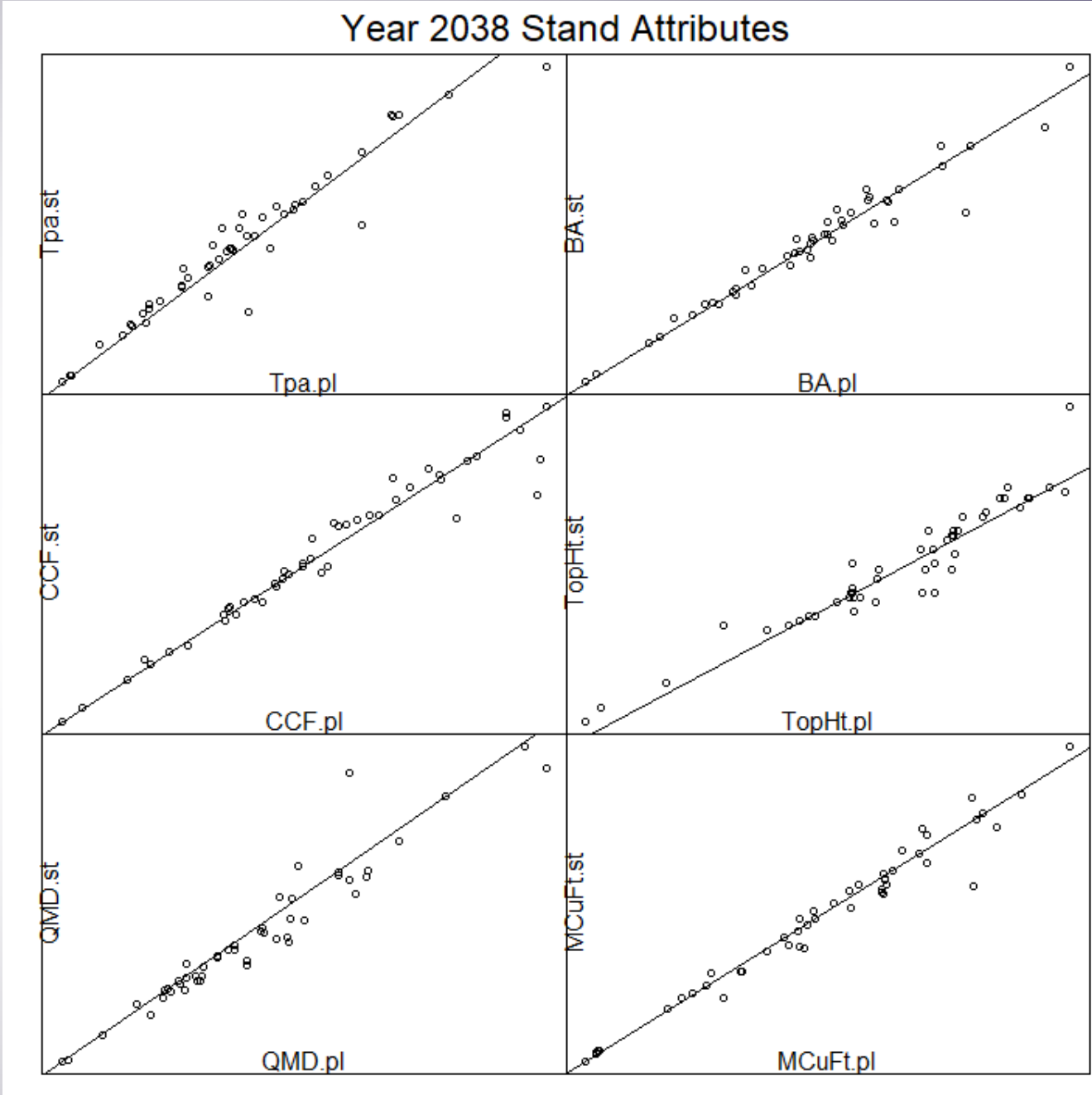
Grown as Stand



Grown as Plot (+ Ht error)

Year	mcft_Bias%	mcft_CV%
2018	-0.12	0.59
2038	-1.06	5.00
2058	-5.46	8.28
2078	-0.24	4.51
2098	-0.38	4.64
2118	-0.41	4.85

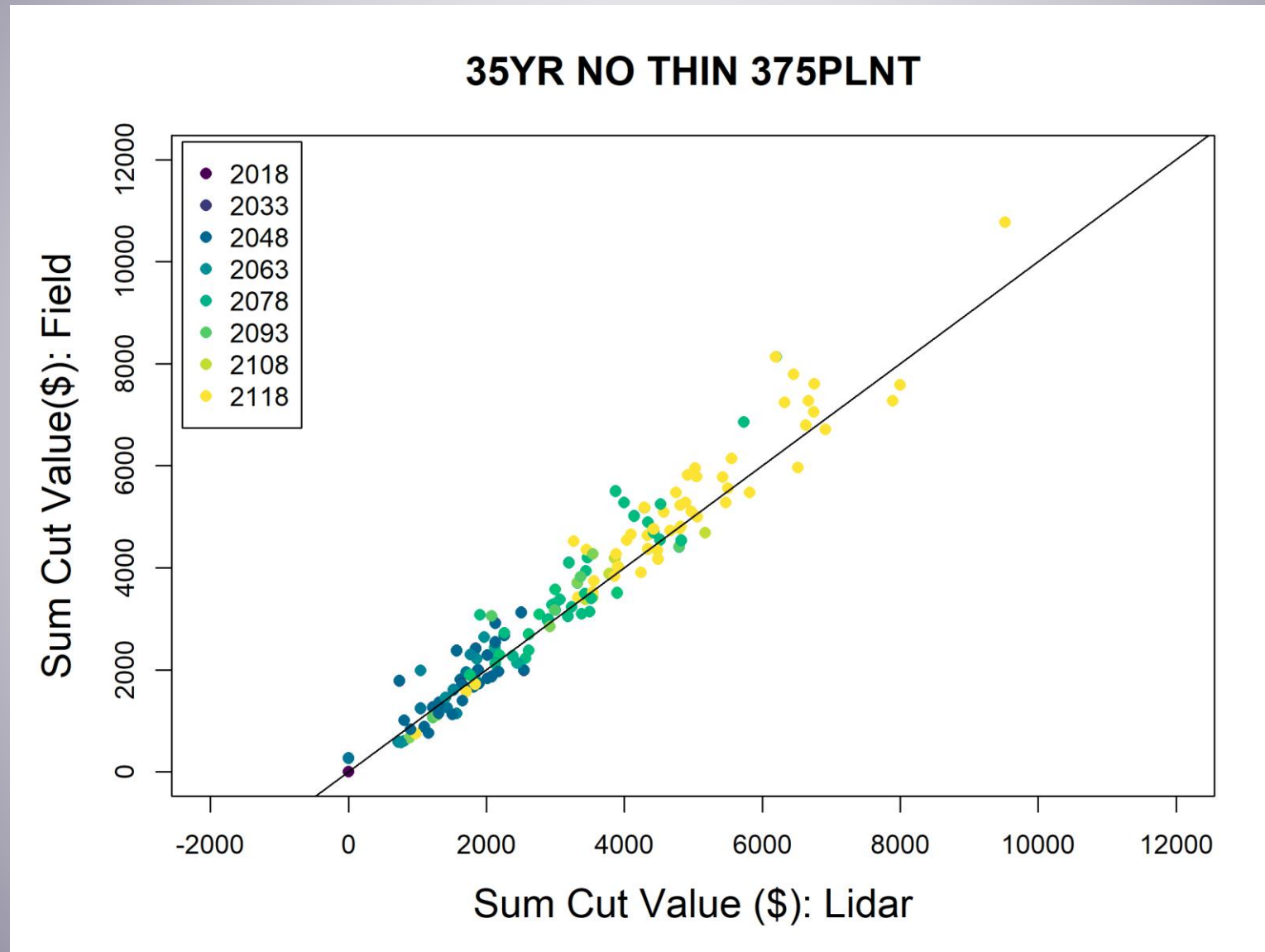
Grown as Stand



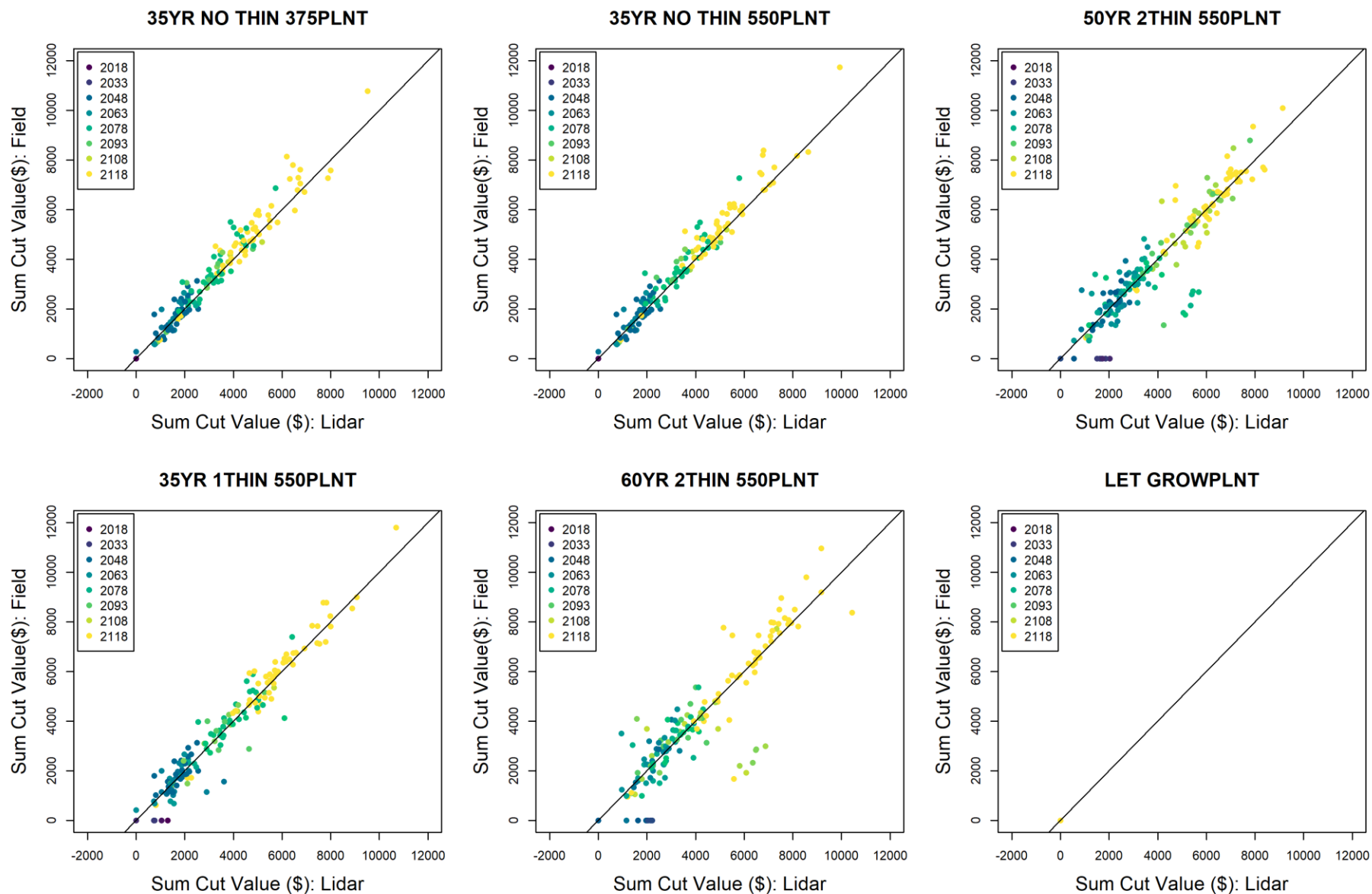
Grown as Plot (No Ht error)

OLD SLIDES

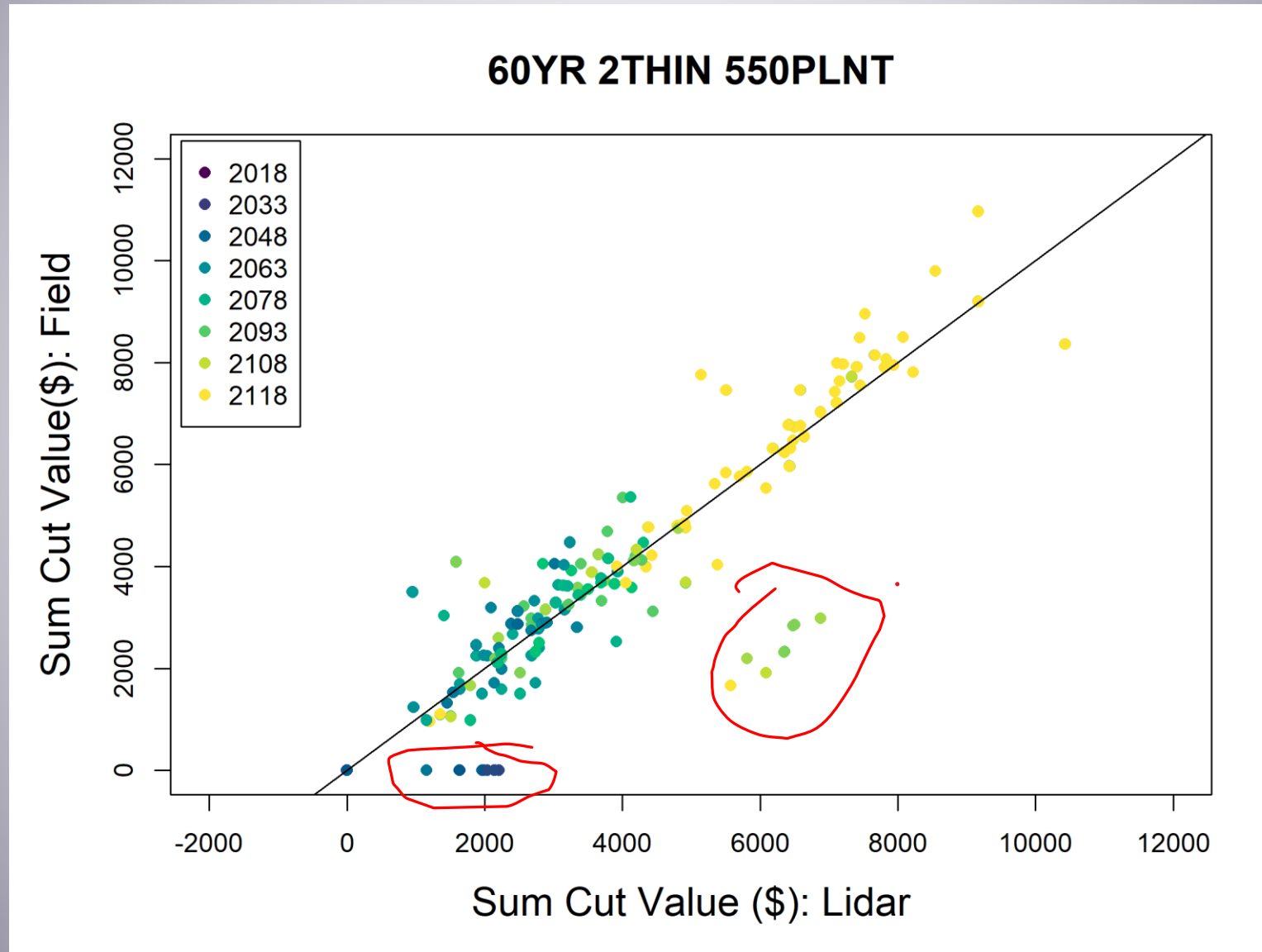
100 Years, Lidar VS Field: Cut Values Match



6 Scenarios: Cut Values (\$) Match

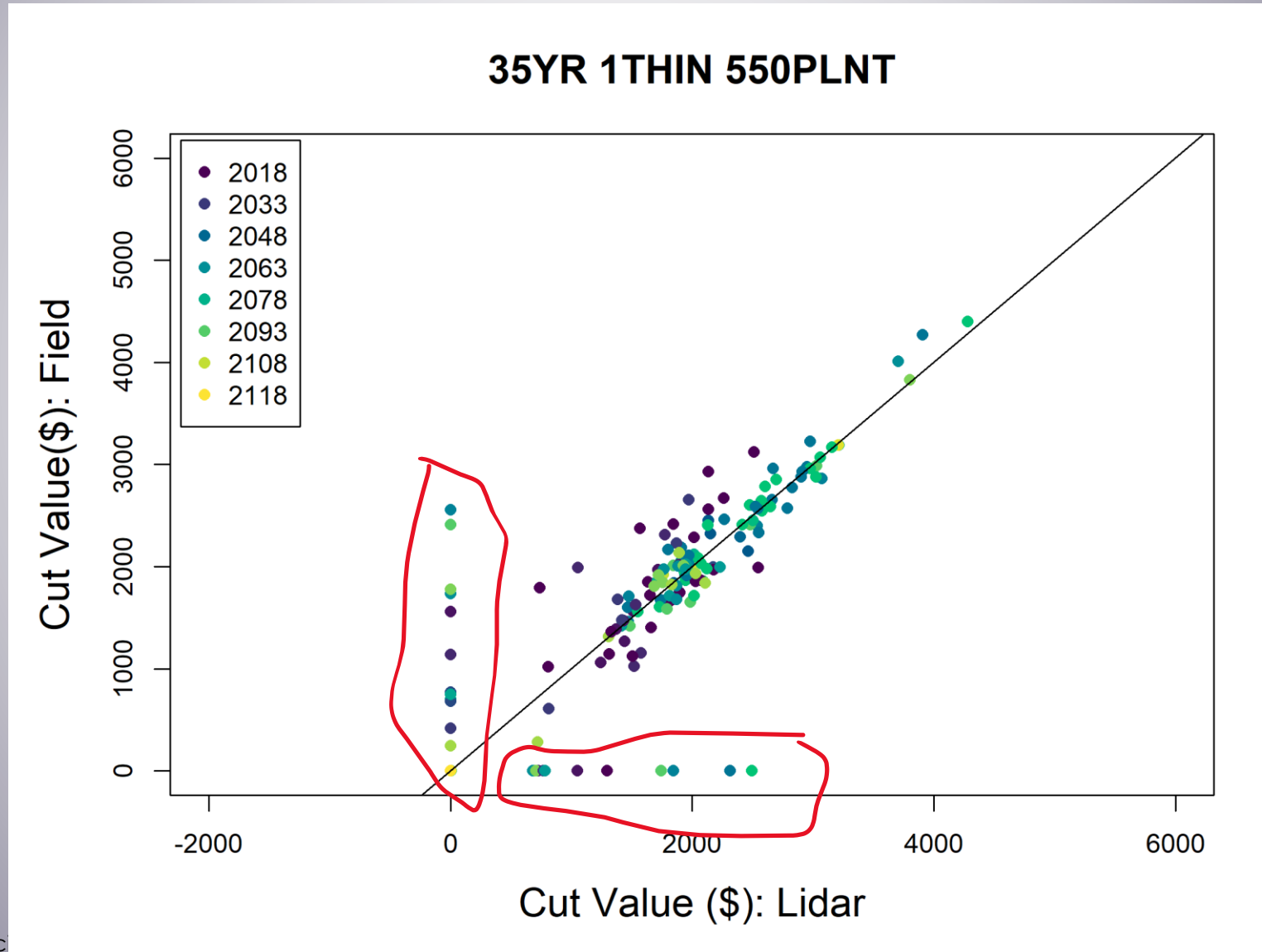


Temporal Mismatch – More Complex Mgmt

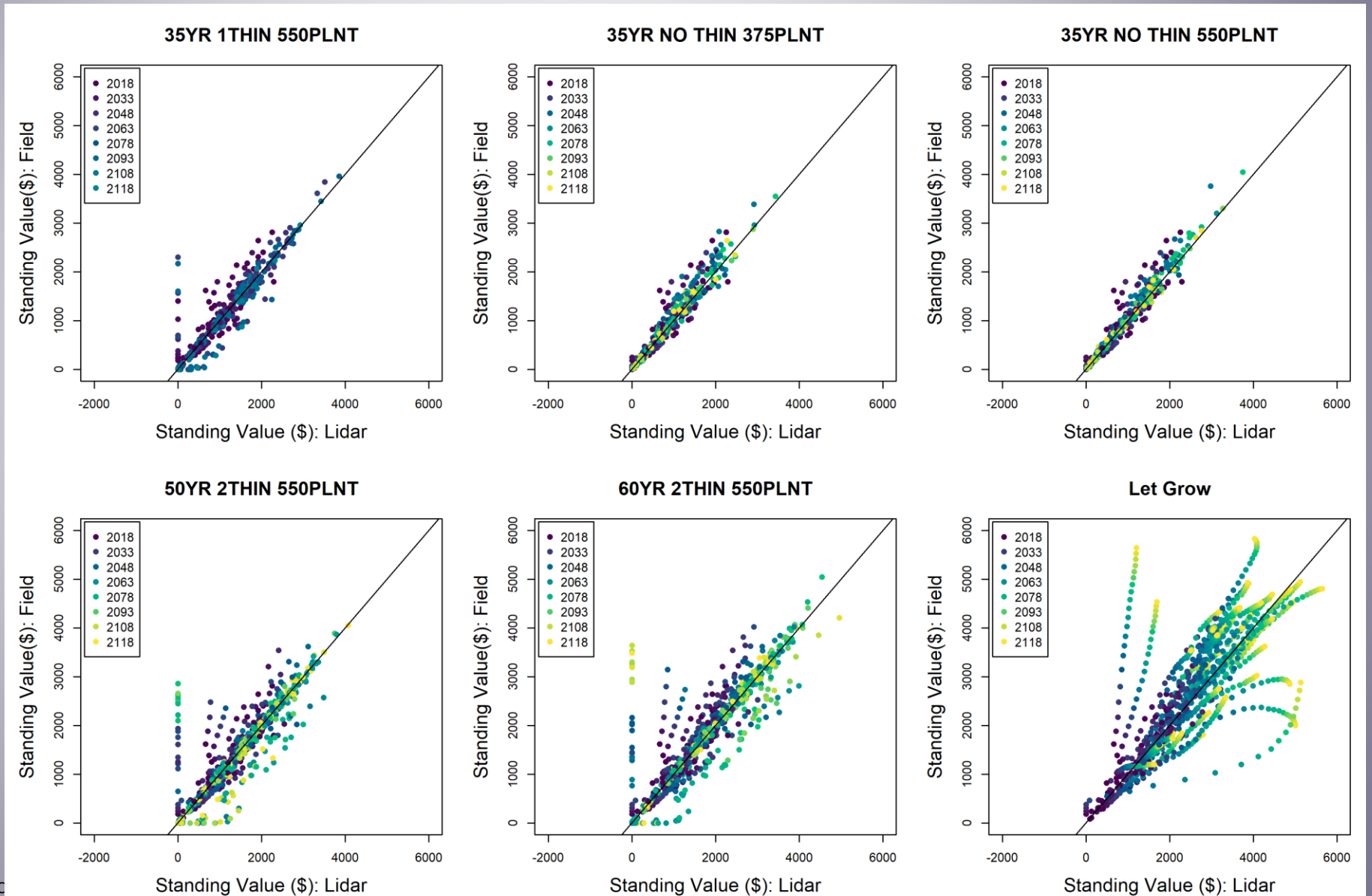


Annual (periodic) Cut Values

Approx. 1-period timing mismatch



Standing Value




Two More Questions


1) How to run the data

- A. As plots?
- B. As stands?

2) Effect of height predictions (e.g., add height errors)

- A. Distribution of heights compressed
- B. Volume residuals upward biased?

 Forest Vegetation Simulator

 U.S. FOREST SERVICE
Caring for the land and serving people

Project title: **Project_1**

Last accessed: **Mon Apr 04 16:06:00 2022**

Run contents: 0 stand(s), 0 group(s)

Release date: 20220311
Local configuration

[Simulate](#) [View Outputs](#) [Visualize](#) [View On Maps](#) [Manage Projects](#) [Help](#)

[Manage project](#) [Import input data](#) [Import runs and other items](#) [Downloads](#)

[Upload inventory database](#) [View and edit existing tables](#) [Upload Map data](#) [Append .csv data to existing tables](#) [Upload Climate-FVS data](#)

Mode ☒ Edit ☐ New rows

<< previous rows next rows >> 1 to 20 of 1356

Number display rows

Table to process
FVS_Standinit

Variables to consider
STAND_CN
STAND_ID
VARIANT
INV_YEAR
GROUPS
ADDFILES
FVSKEYWORDS
LATITUDE
LONGITUDE
REGION

Find stand (ID):

[Remove all rows and commit](#)
[Commit edits or new rows](#)

	Delete	STAND_CN	STAND_ID	VARIANT	INV_YEAR	GROUPS
1	<input type="checkbox"/>	3315584010602	090521000330002	cs	2015	All_Stands Project=inventory Forest_Type=501 Variant=c
2	<input type="checkbox"/>	3315588010602	090521000330007	cs	2015	All_Stands Project=inventory Forest_Type=503 Variant=c
3	<input type="checkbox"/>	3315591010602	090521000330010	cs	2015	All_Stands Project=inventory Forest_Type=402 Variant=c
4	<input type="checkbox"/>	3315594010602	090521000330011	cs	2015	All_Stands Project=inventory Forest_Type=402 Variant=c
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7	<input type="checkbox"/>	3315604010602	090521000330033	cs	2015	All_Stands Project=inventory Forest_Type=503 Variant=c
8	<input type="checkbox"/>	3315608010602	090521000330034	cs	2015	All_Stands Project=inventory Forest_Type=515 Variant=c
9	<input type="checkbox"/>	3315612010602	090521000330035	cs	2016	All_Stands Project=inventory Forest_Type=510 Variant=c
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FVS_Standinit

The predefined table structure used for initializing stand/plot information when using the STANDSQL keyword FVS_Standinit

Variable	Label	Data Type	Description
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Plot Grid (550 plots)

