

Operationalizing Lidar in Forest Inventory

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Group/Meeting Objectives

Facilitate operational use of lidar in forest inventory:

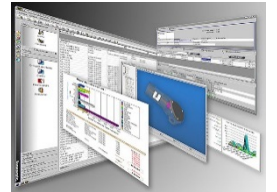
- Demonstrate operational technologies
- Compare and contrast with more traditional approaches
- Describe advantages
- Describe limitations
- Describe resources
- Facilitate Communication
 - Forest managers
 - Lidar vendors
 - Analysts
 - Software developers

Why Isn't Lidar More Widely Used for Inventory?

- Perceptions & tradition (boots on the ground, components, etc.)*
- Lack of a-z operational software tool chains
- Disconnect between research and reality
 - Hundreds (thousands?) of manuscripts
 - >Few deal with operational issues (e.g. species by diameter class)**
- Operational limitations

*species / diameter (product) demo

**some Scandinavian researchers



Operational Limitations

- They are significant!

Operational Limitations

- Need to “stick lidar into” inventory software
- Few people understand lidar/inventory
- Few consultants specialize in using lidar for inventory
- Inventory software can’t ingest lidar
 - >Statistician programmers necessary
 - >From scratch systems
- Requires HP-GPS
- A-typical plot design
- Lack of resources (books, tutorials, etc.)

Overcoming Operational Limitations (1)

- Difficult to “stick lidar into” inventory software
 - Pilot aimed at sticking lidar inventory into Assisi
- Few people understand lidar/inventory
 - Add capacity to vendor capabilities (lidar derivatives)
 - Add modeling, prediction to Inventory software
- Few (none?) consultants specialize in lidar in inventory
 - Engage consulting groups
 - Engage vendors

Overcoming Operational Limitations (2)

- Requires HP-GPS
 - Make GPS guides / resources available
- A-typical plot design
 - manageable
- Lack of resources (books, tutorials, etc.)
 - Hopefully this group can begin to compile available resources in one place

Remaining Hurdles

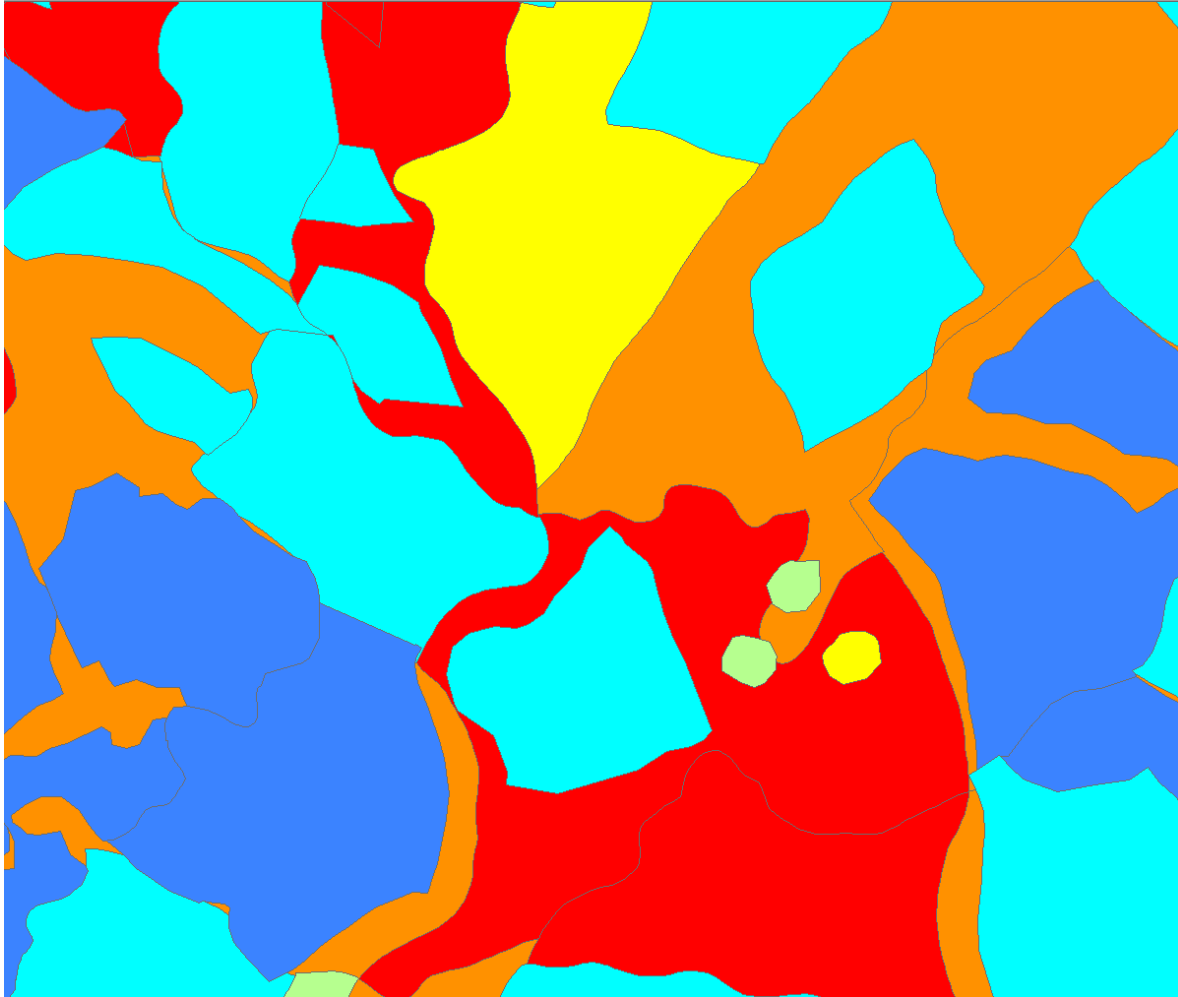
- Software
- Need for people with technical capacity (lidar vendors or consultants)
 - Acquire lidar
 - Generate lidar derivatives
 - Fit models
 - Make wall-to-wall outputs
 - Push to inventory software
 - Push to GIS environment

Forest Inventory with Lidar Advantages

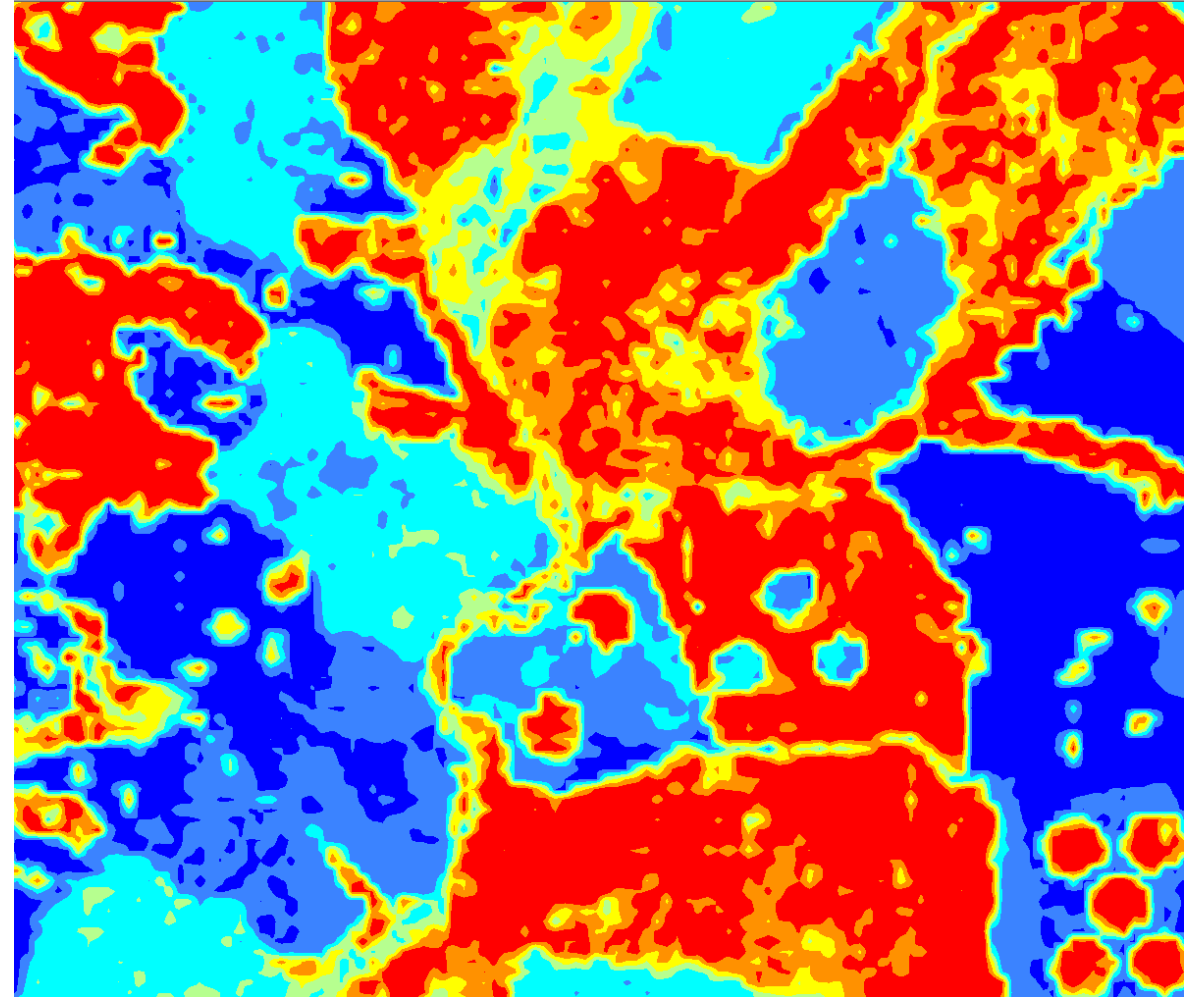
- High resolution
- High precision
- Wall-to-wall height / cover
- Fast
- Inexpensive
- DEM
- Low management overhead

High Resolution

Stand Inventory



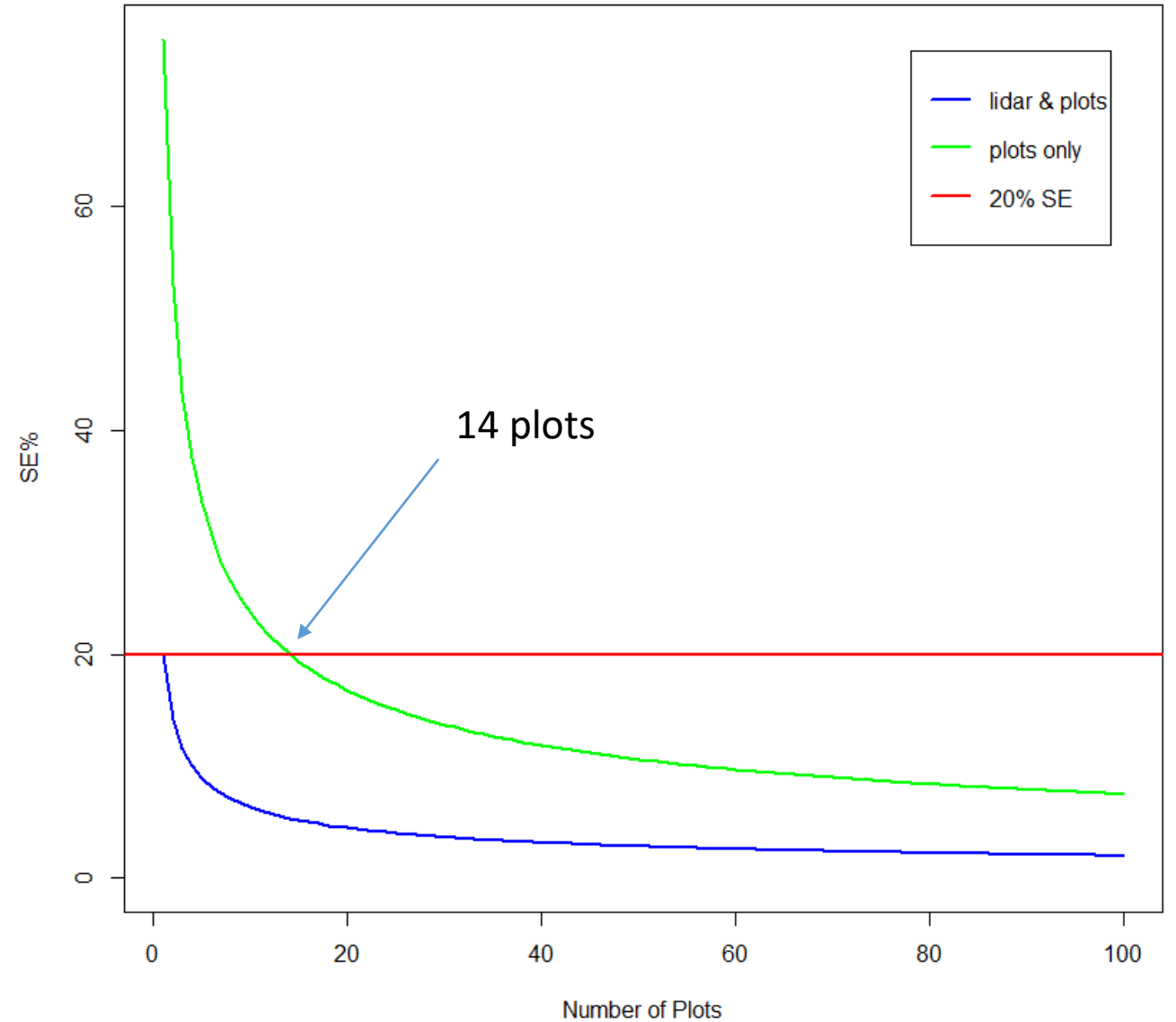
Lidar Inventory



*Images borrowed from a WA DNR presentation by Peter Gould

High Precision

- Need 14 field plots for every 1 lidar plot (volume)
- 1 lidar plot: \$300
- 14 field plots: \$910



Fast

- Inventory huge areas in a single year

Fast

- WA DNR – 1.4 Million acres inventoried - 1 year scratch to operational
- WA DNR – update, 2.0 Million acres (re-)inventoried at year 3
- Frequent updates become feasible
- Wall-to-wall inference feasible / defensible
- Rapid change estimates feasible

- Plot-intensive inventories often lag...
 - 10 year periods become 20 year inventory periods...
 - Difficult to make unbiased wall-to-wall inference
 - How to make inference from some proportion of measured landscape
 - Change estimates difficult

Not That Fast – Land Acquisitions

Land Inventory:

Need 6 months + typically (lidar acquisition, analysis)

Good Value

- Plot-Based Inventory Costs (1 plot / 5 acres)
 - Cost / plot: \$65
 - Cost / acre: $\$65 / 5 = \mathbf{\$13 / acre}$
 - (add \$1 /ac for photo stand delineation)
- Lidar-Based Inventory Costs (e.g. 1 plot / 300+ acres)
 - Cost / plot: \$300
 - Cost / acre lidar: \$0.75
 - Cost / acre: $\$300/300 + \$0.75 < \mathbf{\$2 / acre}$

Low inventory management overhead

Example: Land Owner with 1 million acres

- Plot Only Strategy (stands)
 - ~ 1 plot / 5 acres
 - 200k plots
 - 100+ plot measurement contracts
 - 8+ dedicated validation plot staff
- Lidar inventory
 - ~1 plot / 500 acres
 - 2k plots
 - 2-8 contracts for plots
 - 2 dedicated validation plot staff
 - 2-5 contracts for lidar

A False Perception

“We can’t use lidar because we need species, dbh, product etc.”

- **Can** get DBH, product from lidar
 - Dominant species from other sources
- **Can’t** reliably get it from plots at stand-level

https://jacobstrunk.shinyapps.io/species_demo/

Lidar Analysts are part of the problem

- Components are more difficult
-> We like to ignore them....

Can often get components as well with lidar as with field plots (stand level)

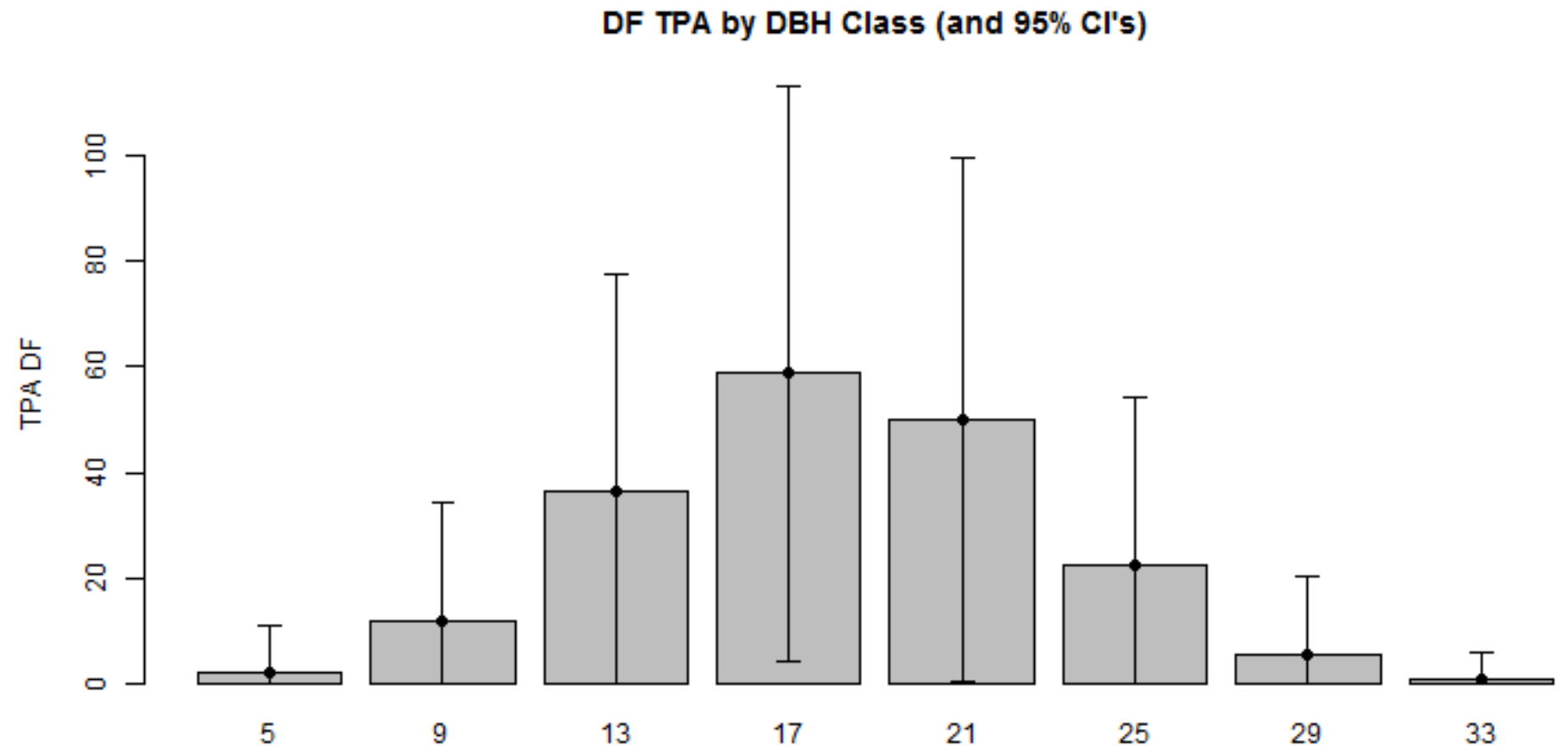
Components Example (No Lidar)

Plots: 20

TPA: 200

CV%: 125

Bins: 4 inch



2 inch bins?

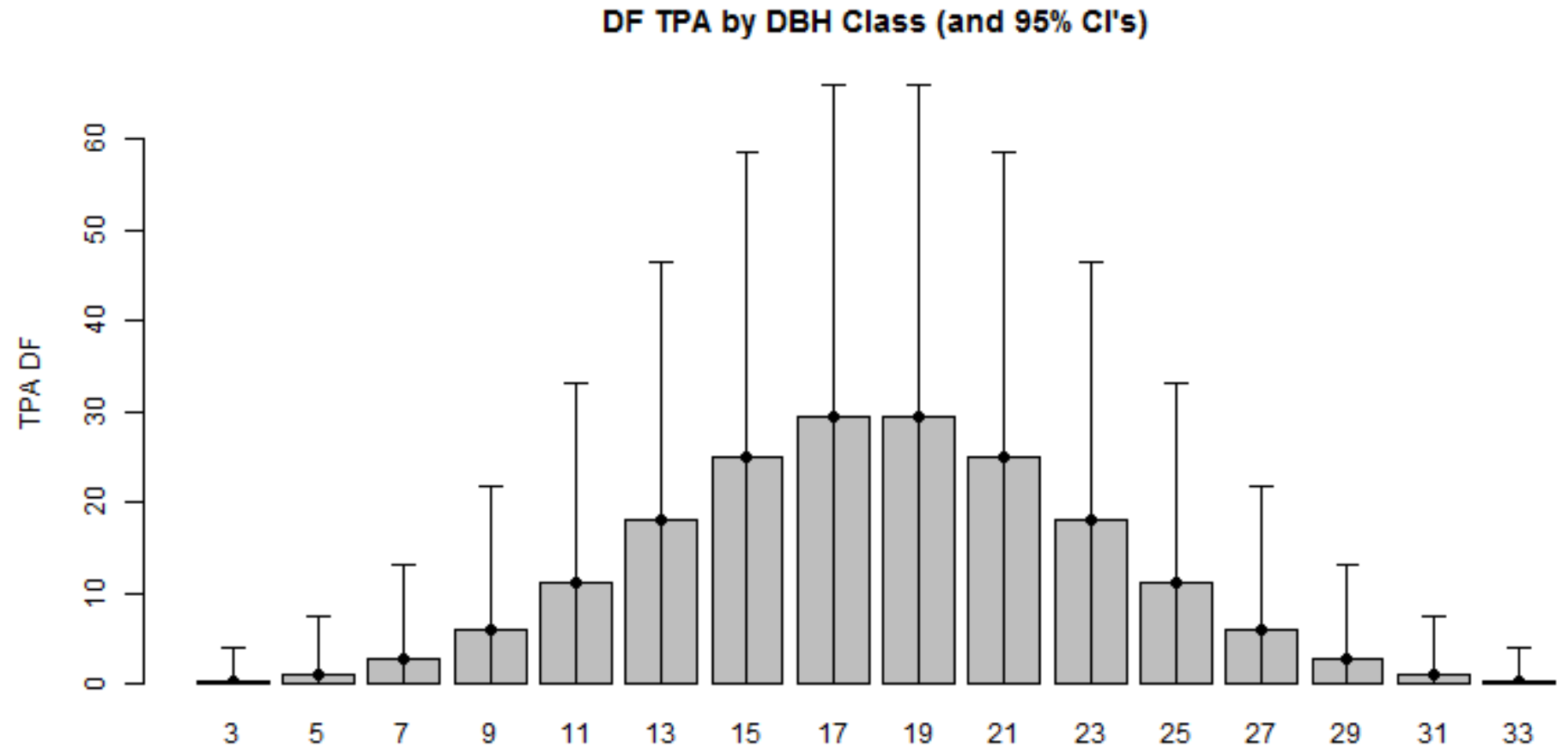
Components Example (No Lidar)

Plots: 20

TPA: 200

CV%: 125

Bins: 2 inch



- The smaller the component \rightarrow the greater the percent error

Statistical Takeaway

1. Component estimate precision *ALWAYS* worse than total
2. Smaller the component -> poorer precision
3. Software may use $SE/total\%$ for components
 - Creates weird effect
 - Components appear more precise than totals

Precision Examples

Precision:

Total volume > DF Volume > DF x DBH > DF x DBH x Grade

Reasonable numbers (SE%):

10% > 20% > 60% > 98%

Unreasonable numbers (SE%):

10% > 10% > 8% > 3%

Conceptual takeaway (Components)

- Need a better sense of error tolerance
- If people “need” components (stand level)
 - They don’t really have them
- There is a perception that 10 – 30 plots in a stand can support inference about components
- The statistics don’t support this perception

Resources

- To be expanded

Visualization tools

- CloudCompare
- FUSION
- lastools
- ArcGIS

Lidar Processing tools

- FUSION
- lastools
- ArcGIS

Lidar Librarys

- R: lidR, lasR, rLIDAR
- Python: laspy, liblas, LIDar-tools
- C++: liblas, pdal, laslib
- C#: laszip.net
- Java: lidar.java

Lidar Vendors

- Quantum Spatial
- GeoTerra
- Harris?
- ...

Thank you

Lidar/Inventory Consultants

- PNW
 - Tesera (Ca, BC)
 - (a few individuals)
- Worldwide
 - Lim Geomatics (Ca)
 - Blum
 - ...