

Stand development simulation using LiDAR generated tree and stand characteristics in a Tree and Stand Simulator (TASS)

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Presentation to
2021 Operational LiDAR Inventory (OLI) Meeting
Virtual – April 7, 2021

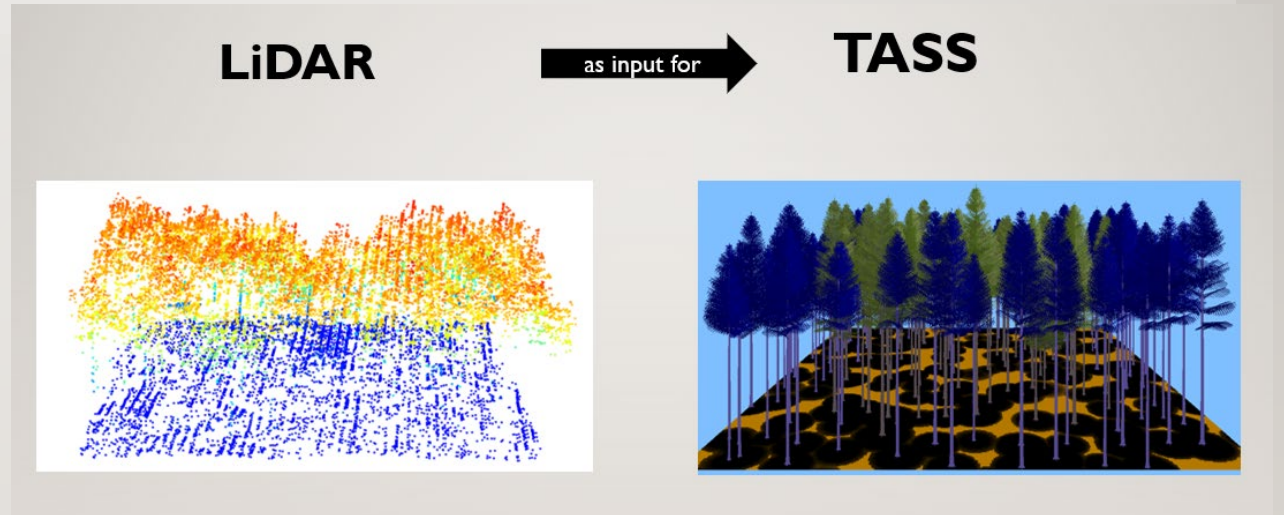
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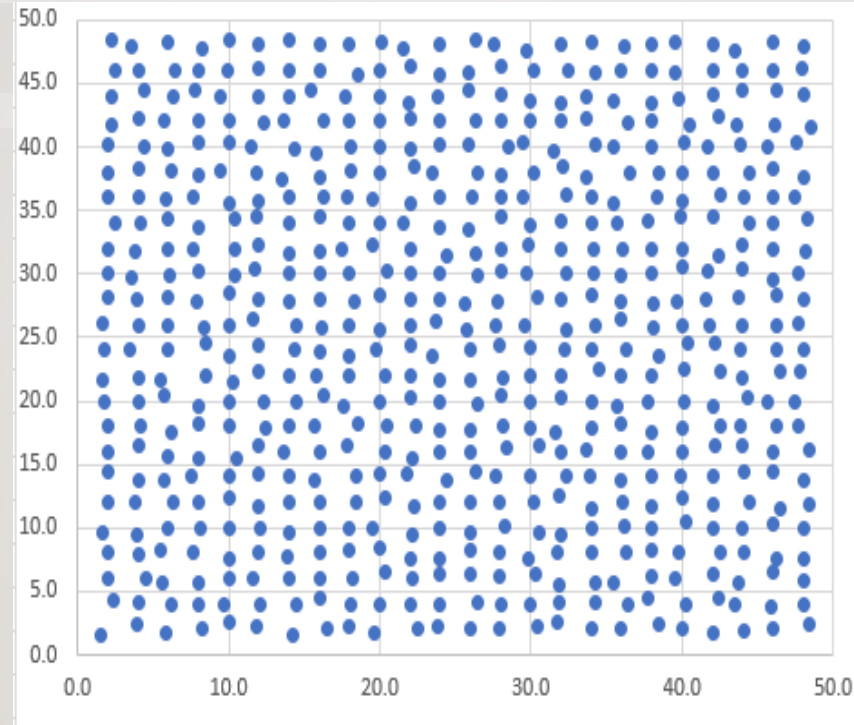
OVERVIEW

- TASS model structure
- LiDAR for stand initiation inputs
 - Height
 - Stem distribution
 - Crown
- Project direction
- Questions/Comments



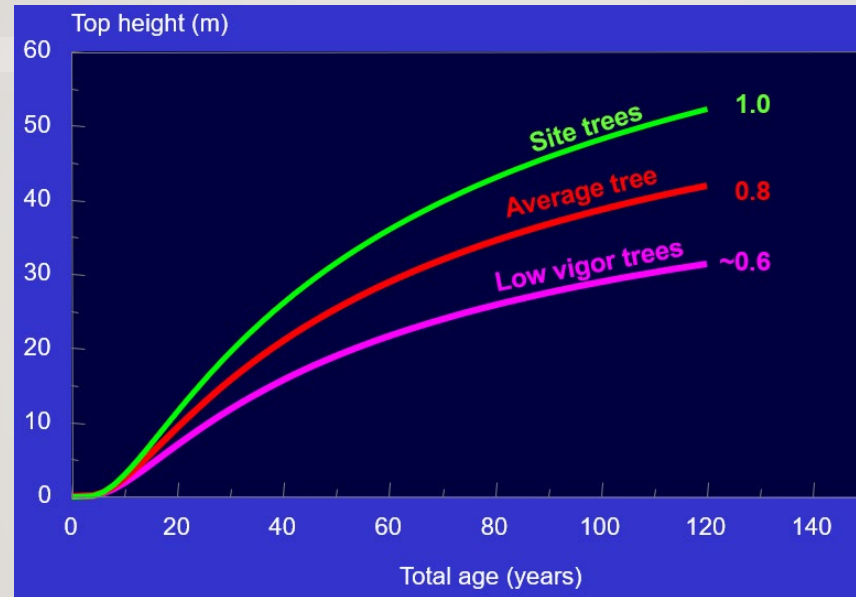
TASS

- ✓ Distance Dependant
- ✓ Individual Tree



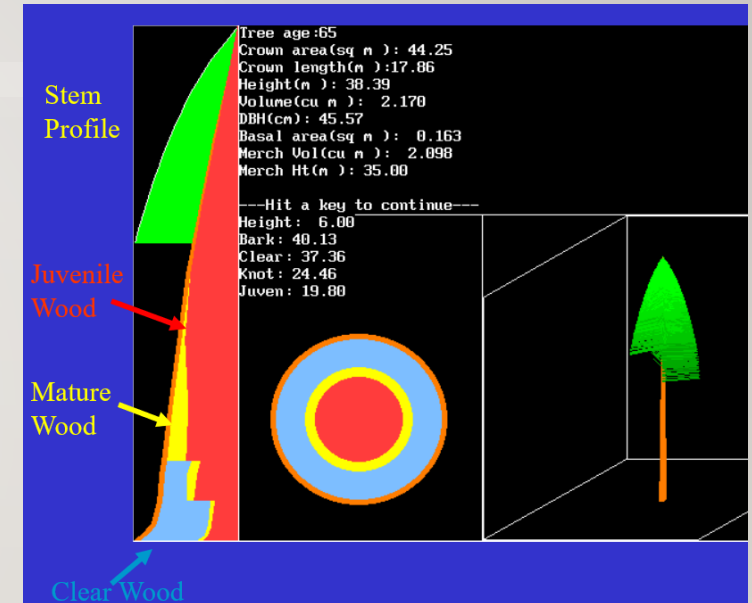
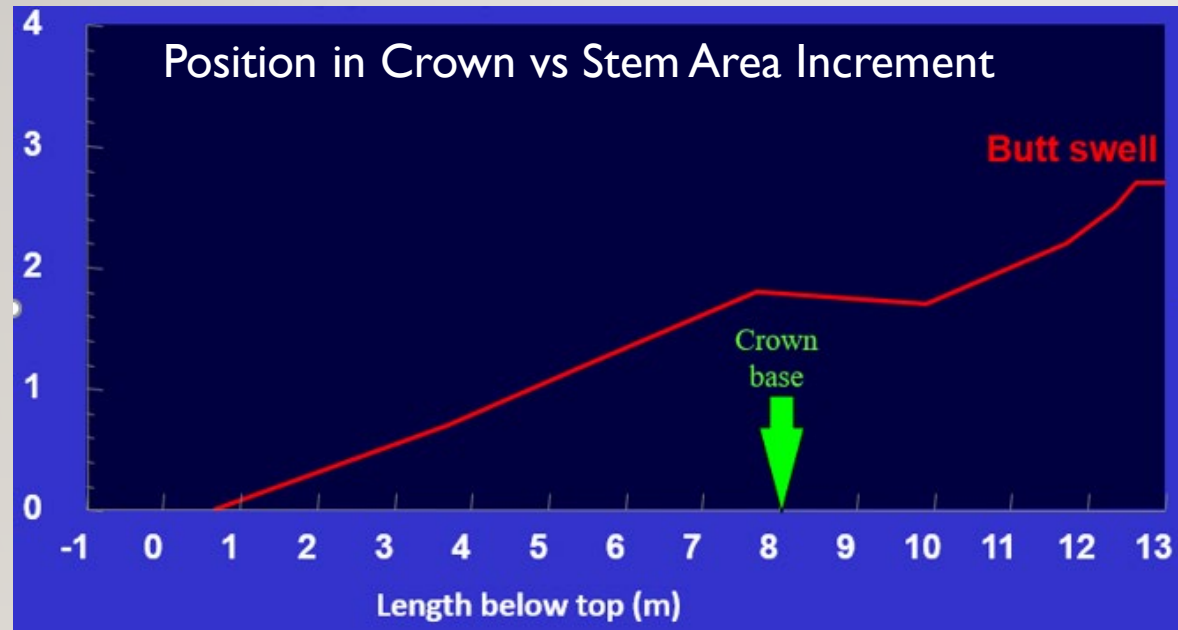
TASS

- ✓ Height based
- ✓ Crown growth



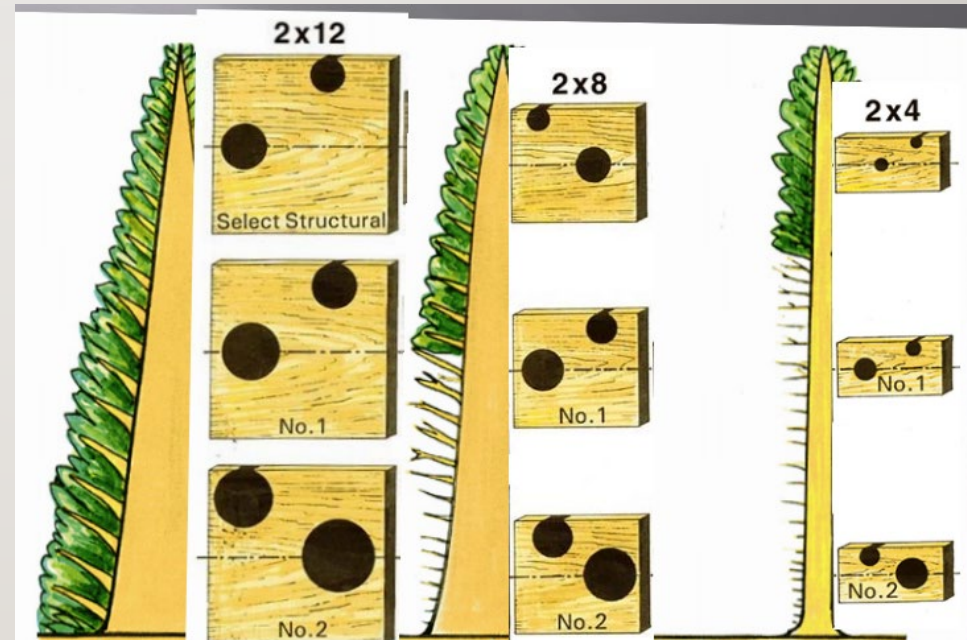
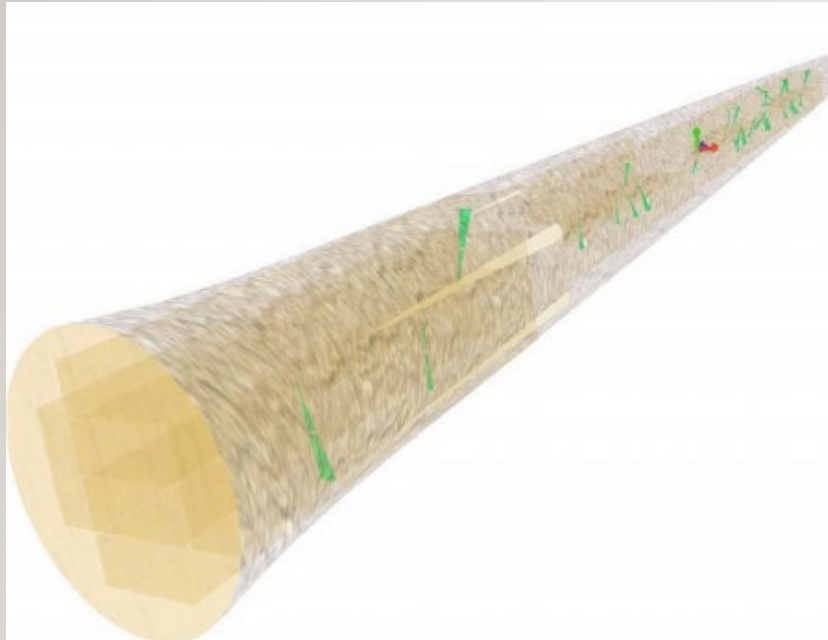
TASS

- ✓ Stem increment driven by crown
- ✓ Wood quality influenced by crown



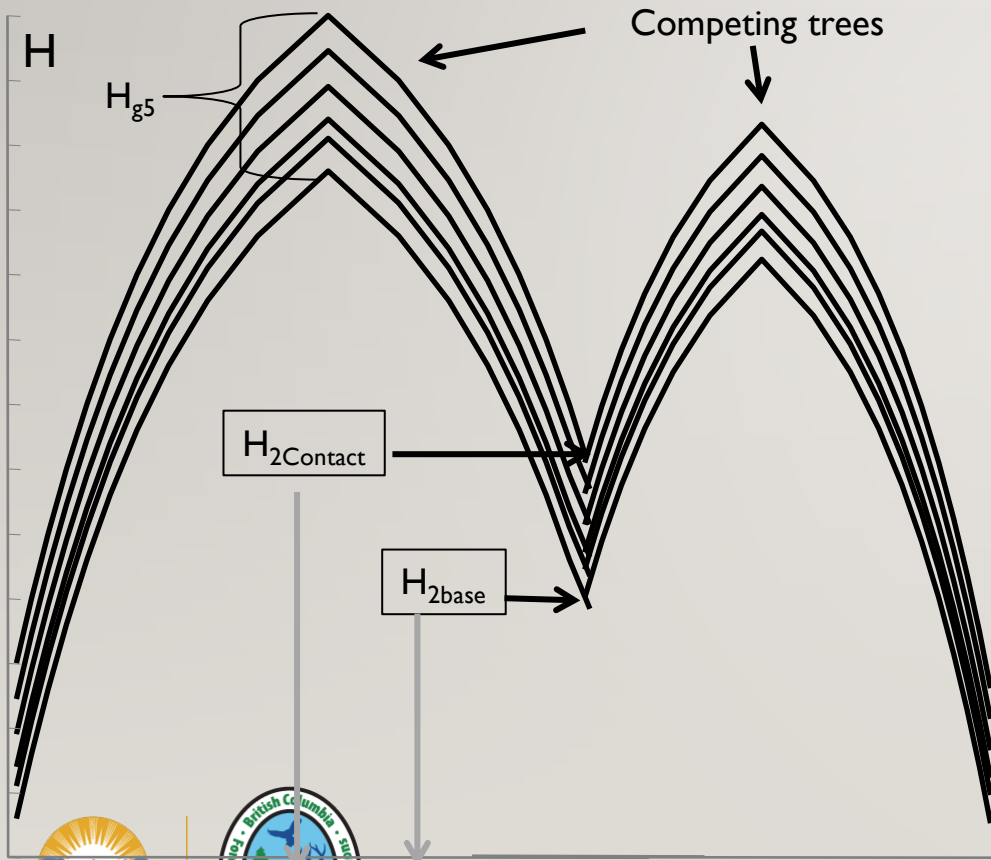
TASS

- ✓ Wood quality including branch location and knot size influenced by crown

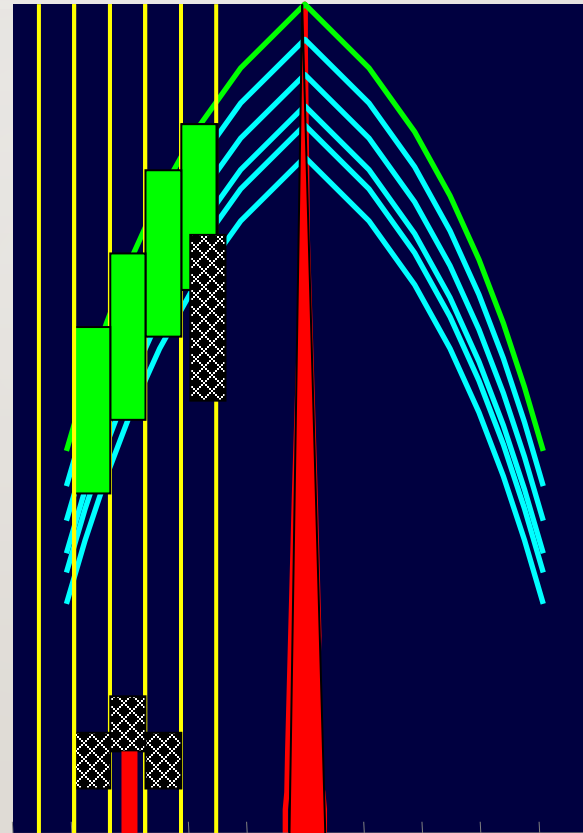


TASS

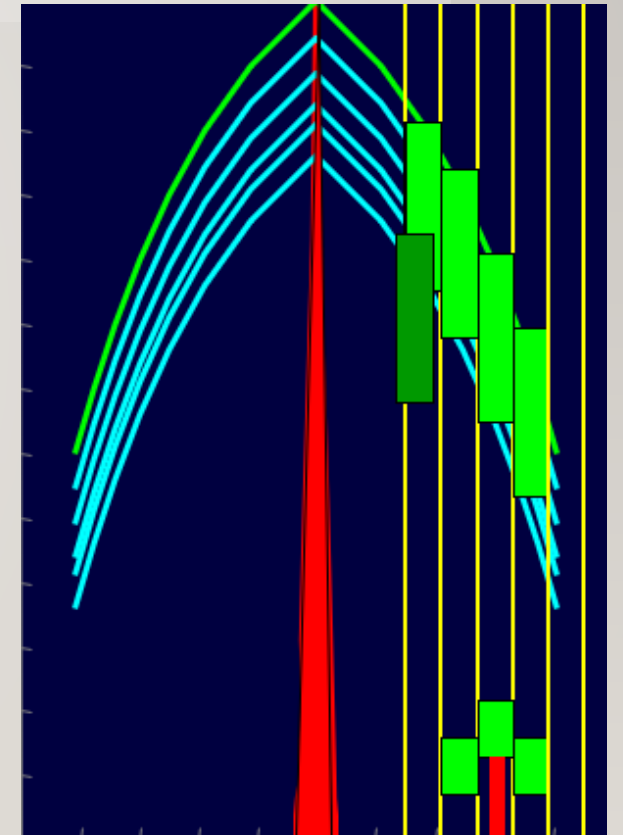
✓ Crown competition



TASS II



TASS III – light model



TASS

Current uses

- ✓ Treatment exploration (silviculture decision making, research)
- ✓ Create strategic level managed stand yield tables from regeneration information
- × - weakness in regen information and lack of info beyond “free growing” stage
- ✓ Projection of stem mapped young stand monitoring plots

Current Inventory – aerial photo based with ground based audit

- × stand polygon level attributes
- × no individual tree/gap distribution information
- ✓ inventory specific stand level empirical model available
- × - not developed for managed stands

LiDAR



TASS



- Spatial Distribution
 - trees
 - gaps
- Height
 - trees
 - ground
- Crown
 - individual trees
 - stand level

What does LiDAR do well?
What can TASS use?

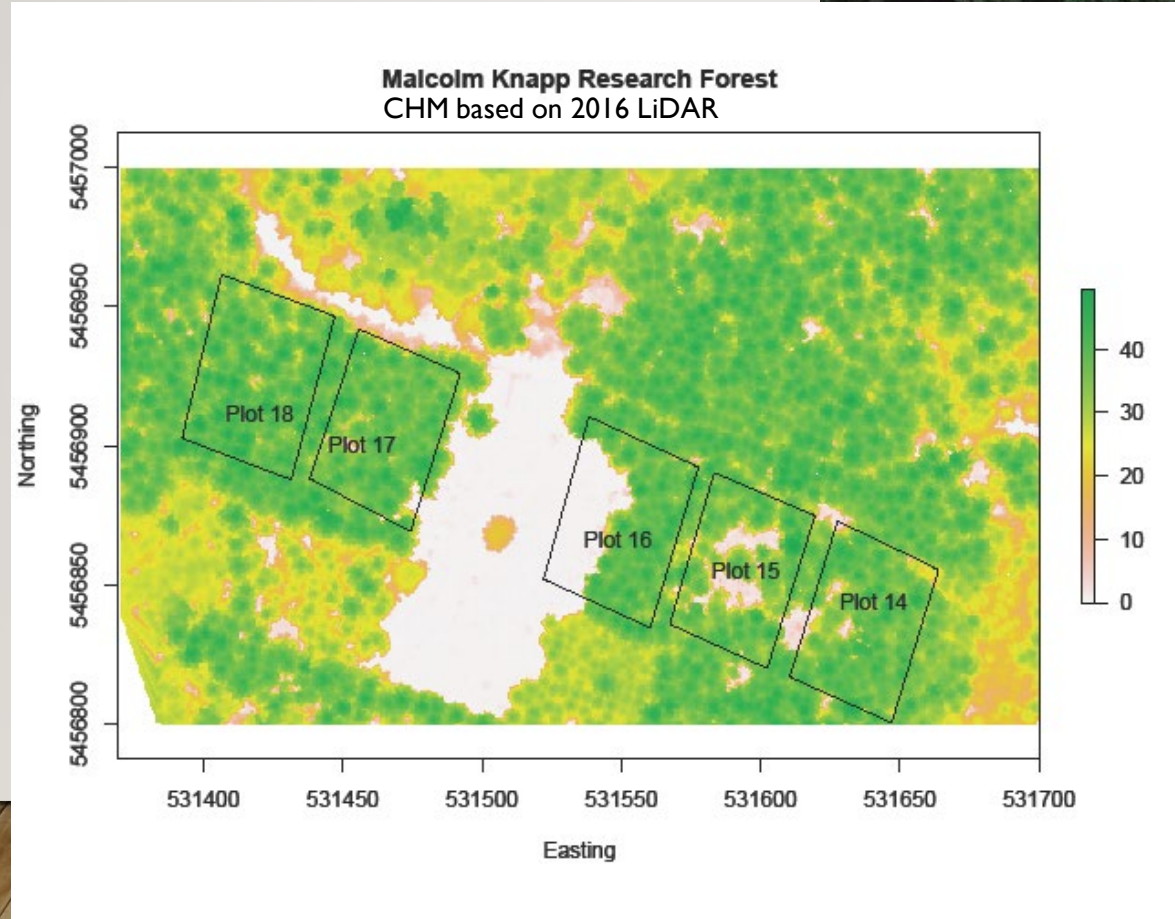
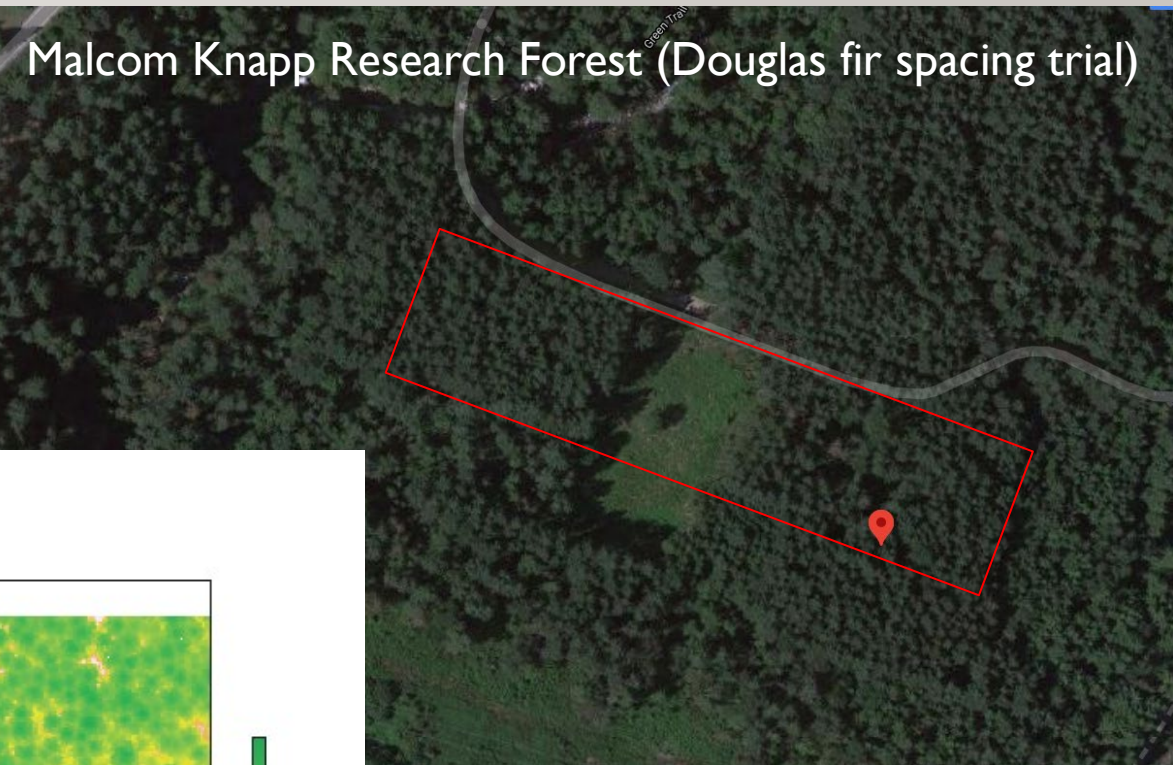


- Tree list
 - stem map
- Height
 - site index
 - individual trees
 - ground elevation
- Crown
 - tree growth
 - wood quality

Ideas and preliminary results

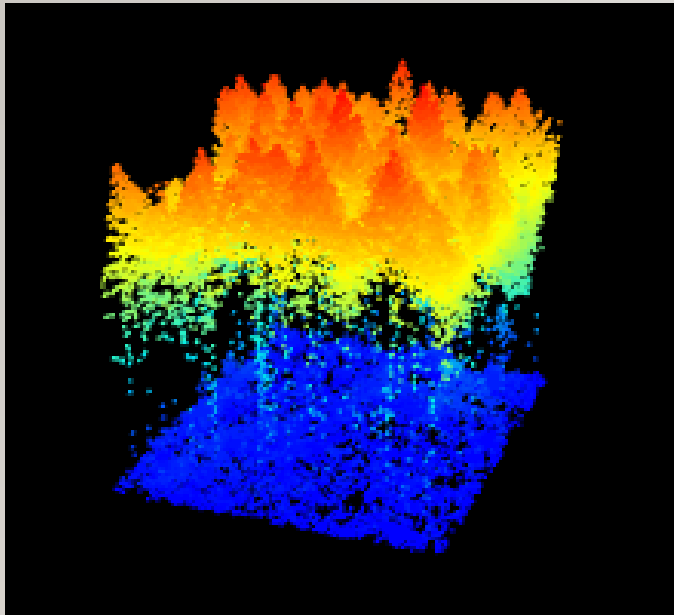
Pilot Study

- Malcom Knapp Research Forest
- Mature stand with known stand initiation (1958) information
- Periodic measurement of ground plots
- Two LiDAR scans (2010 and 2016)

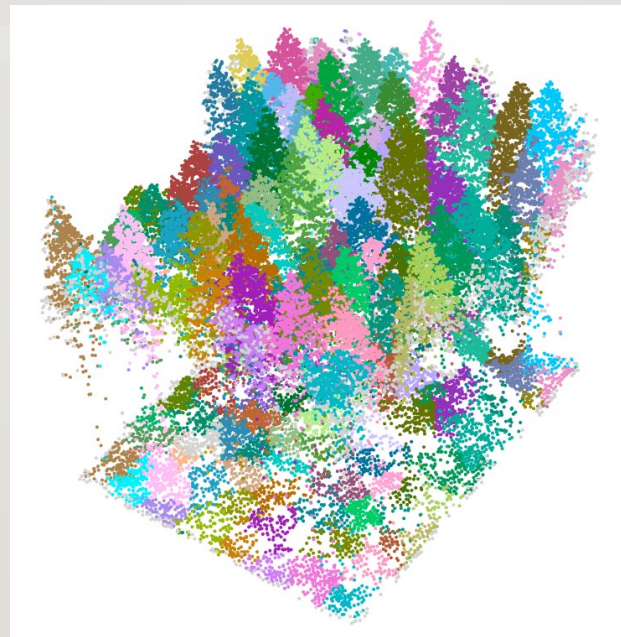


Generating Individual Tree Attributes

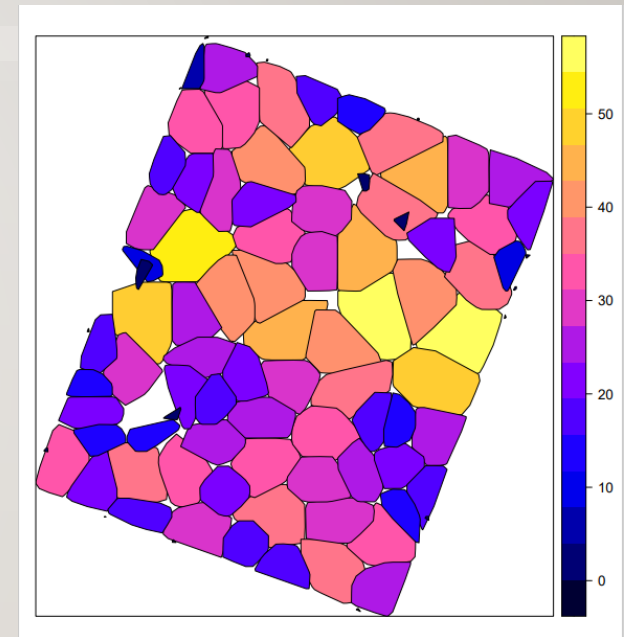
LiDAR points



Individual tree segmentation



Crown delineation



Output: XY coordinates of trees, tree height, crown area, LiDAR points grouped based on segmented tree IDs

Improving TASS Tree List Initiation with LiDAR

TASS Inputs

1. **Site index**
2. Individual tree information
 - height
 - dbh
 - spatial coordinates
 - crown
3. Other information
 - terrain map

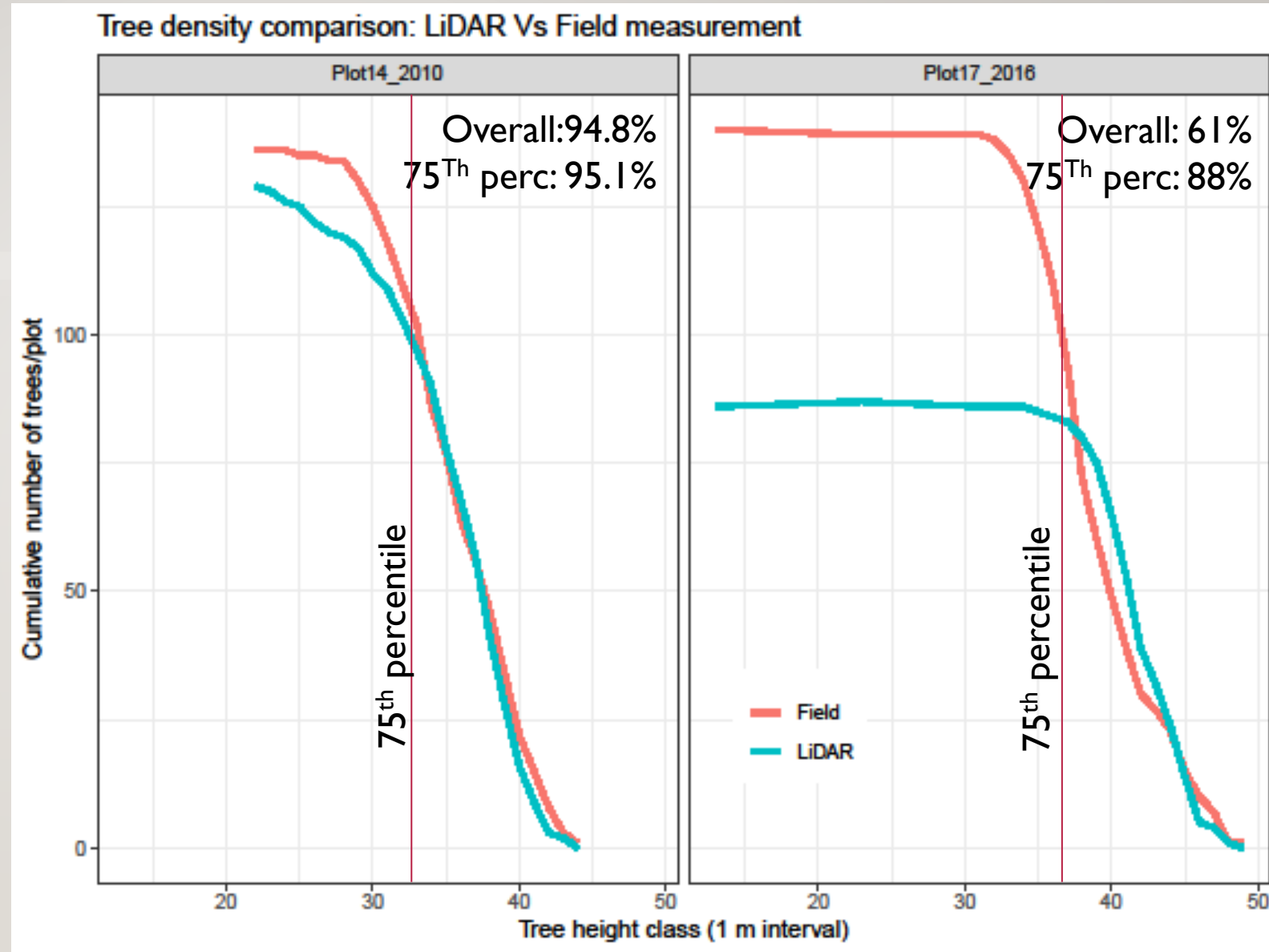
LiDAR Information

1. **Top height**
2. Individual tree
 - height
 - not directly
 - x- and y- coordinates (& gaps)
 - crown
3. Digital terrain model

Top Height

Tree Density Comparison (LiDAR vs Ground Plot)

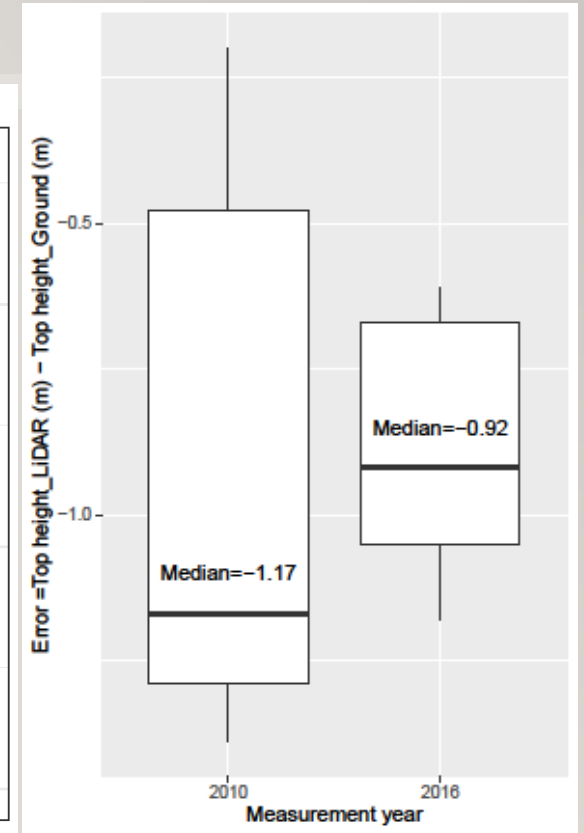
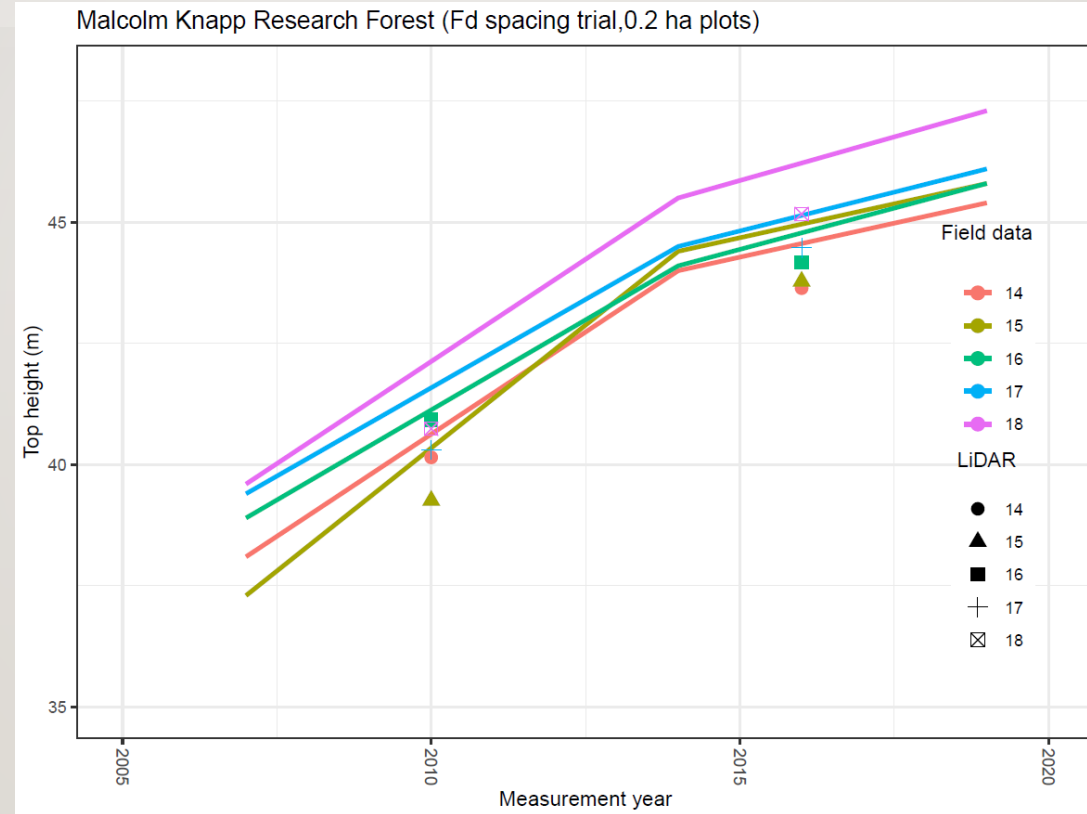
- Dominant trees (site/top height trees) detected and segmented more precisely
- Most of the tree detection error seem to be in the lower height trees (<75th percentile of the stand height)



Top Height

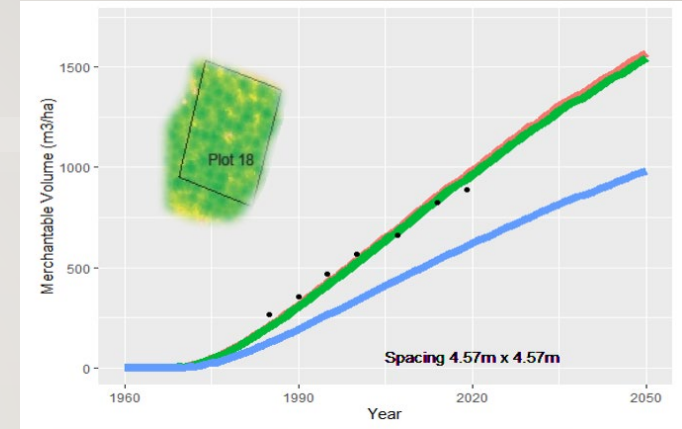
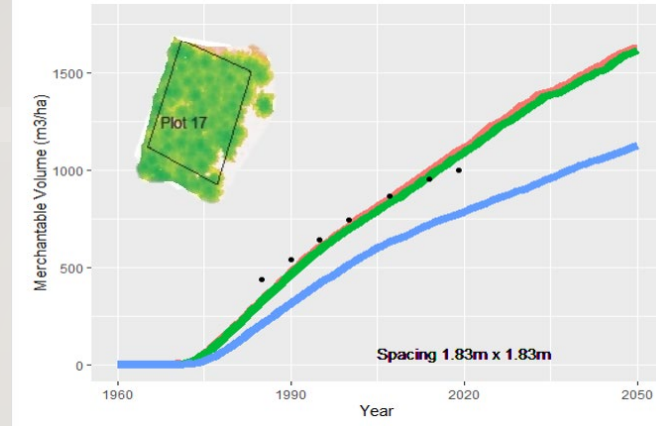
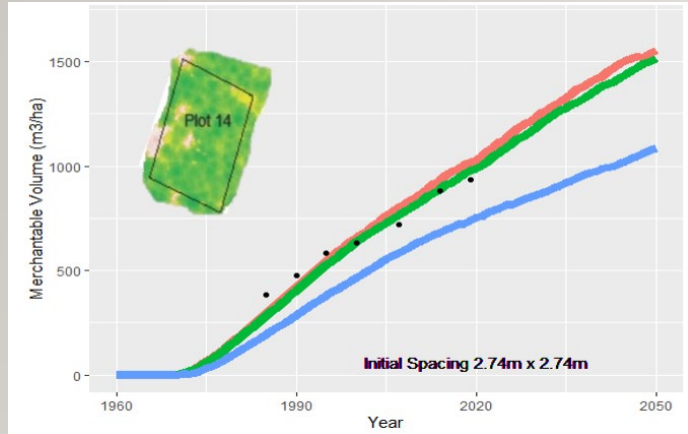
Comparison (LiDAR vs Ground Plot)

- On an average, LiDAR underestimates the top height by 0.9 m.
- Higher density LiDAR seems to be more precise

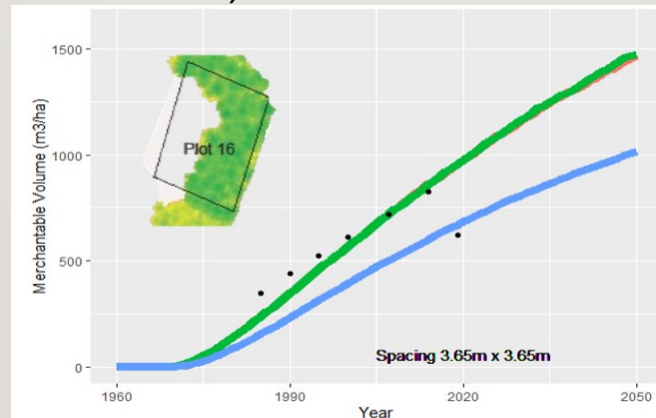
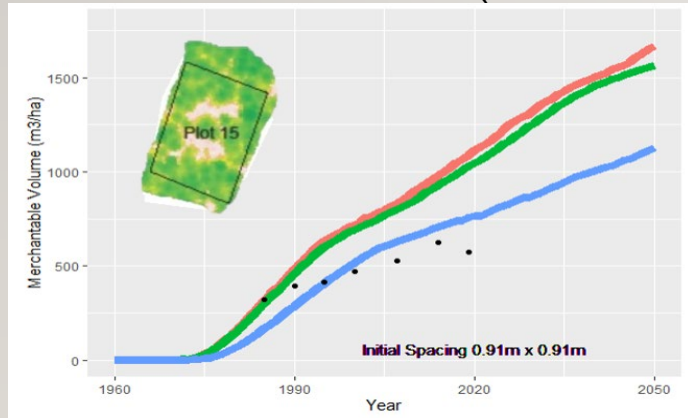


Merchantable Volume Projection – 3 site index sources

Relatively undisturbed plots



Plots with disturbance (root rot and wind throw)



Points

- Ground plot measurement

Lines: TASS bare ground initiation simulation using the following SI source

- Red line: Ground plot top height and age
- Green line: LiDAR top height & ground plot age
- Blue line: Provincial site productivity layer

TASS v3.01.21 simulation

Improving TASS Tree List Initiation with LiDAR

TASS Inputs

1. Site index
2. Individual tree information
 - height
 - dbh
 - spatial coordinates
 - crown
3. Microsite information
 - terrain map
 - microsite

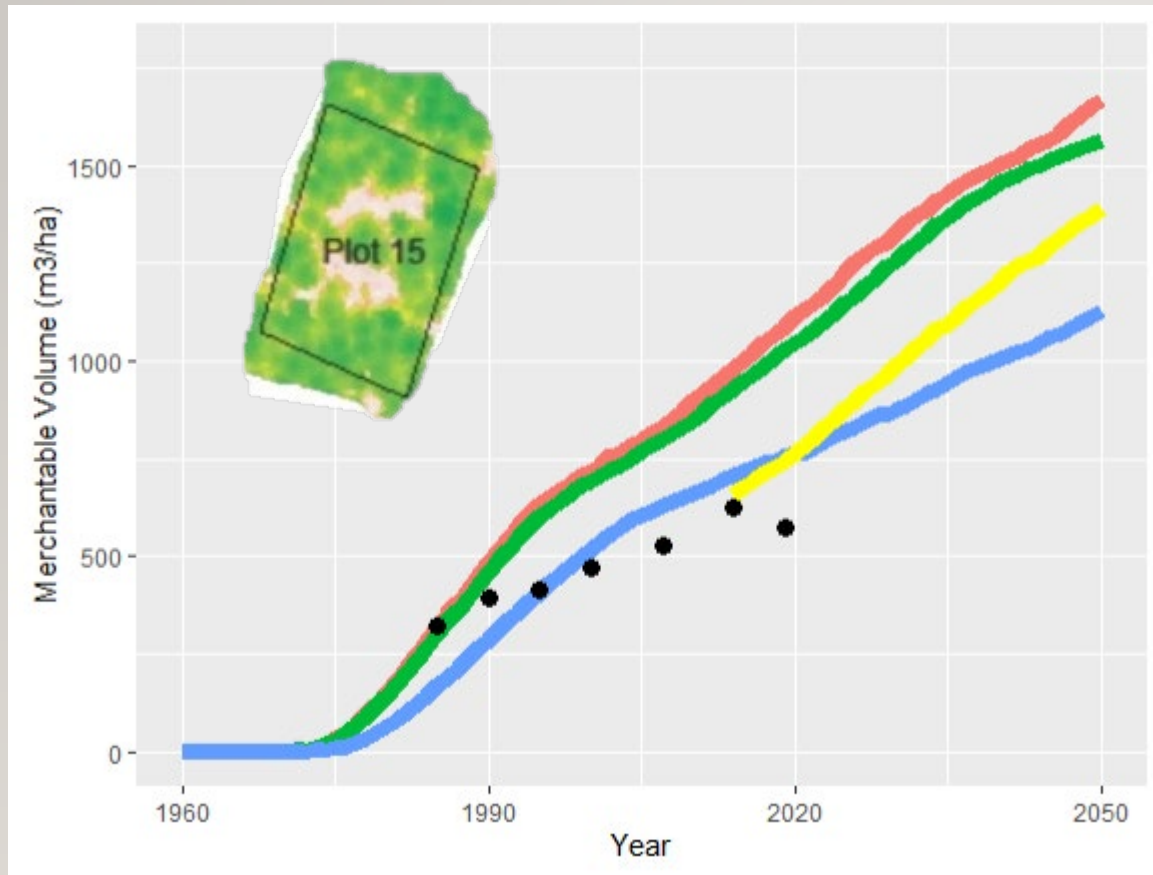
LiDAR Information

1. Top height
2. Individual tree
 - height
 - not directly
 - x- and y- coordinates (& gaps)
 - crown
3. Other
 - digital terrain model
 - composite info (ht, location)

Issues for Tree List Generation from LiDAR

Attributes	Issues
Trees per ha	False detection of tree-top, missing trees (sub-canopy trees), identifying dead trees
Species	This is a Douglas fir spacing trial. In other cases, it will be very challenging.
Tree coordinates	Matching tree coordinates, one vs many within the search area
Tree height	Slight under-estimation for dominant trees, more error on mid canopy trees.
DBH	Predicted using height and crown area as predictor. Error propagation: error on height and crown width
Crown width	Not evaluated yet as there was no ground measurement available. Expecting that LiDAR will under-estimate due to crown overlap.

Projection from Individual Tree List



Points

- Ground plot measurement

Lines

TASS bare ground initiation simulation using the following SI source

- Ground plot top height and age
- LiDAR top height & ground plot age
- Provincial site productivity layer

TASS tree list initiation simulation using

- 2014 ground plot tree list initiation

Improving TASS Tree List Initiation with LiDAR

TASS Inputs

1. Site index
2. Individual tree information
 - height
 - dbh
 - spatial coordinates
 - crown
3. Other information
 - terrain map

LiDAR Information

1. Top height
2. Individual tree
 - height
 - not directly
 - x- and y- coordinates (& gaps)
 - crown
3. Digital terrain model

Individual Tree Crown Attributes (Fdc)

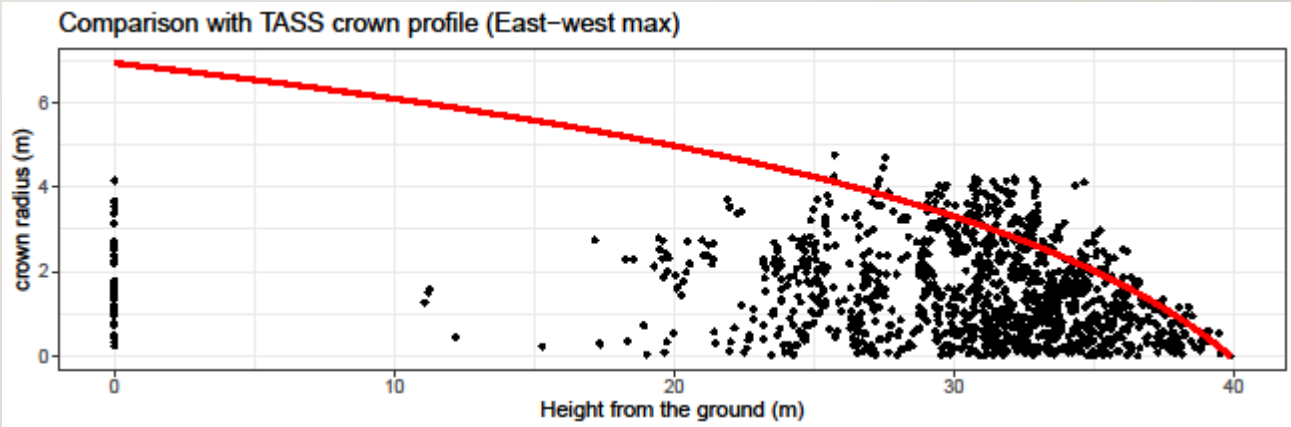
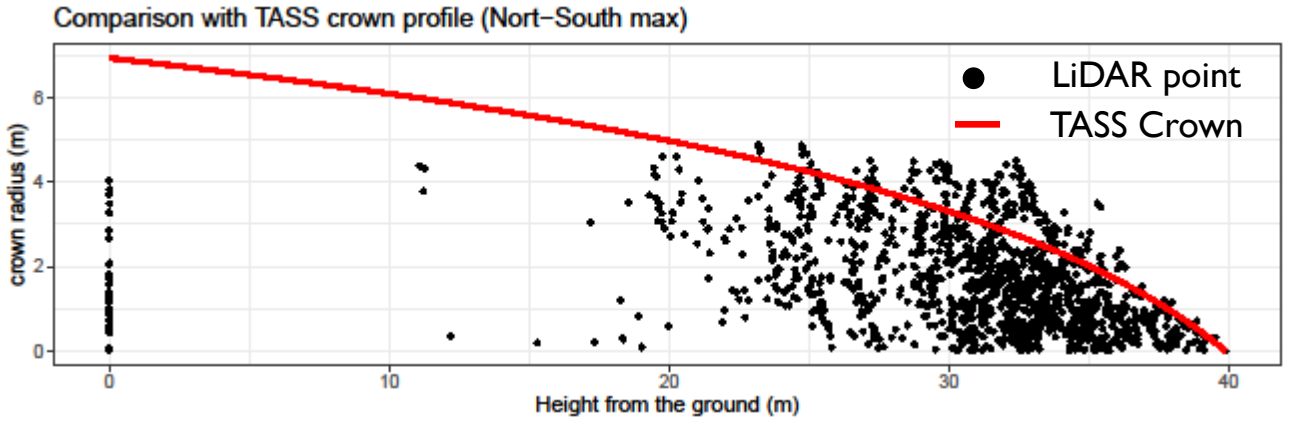
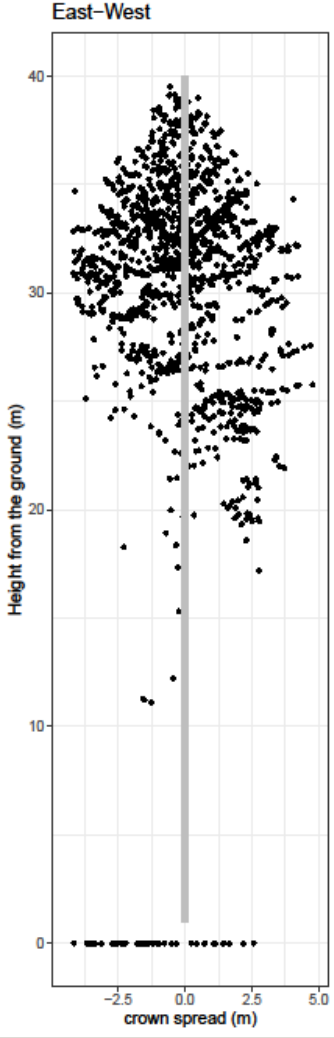
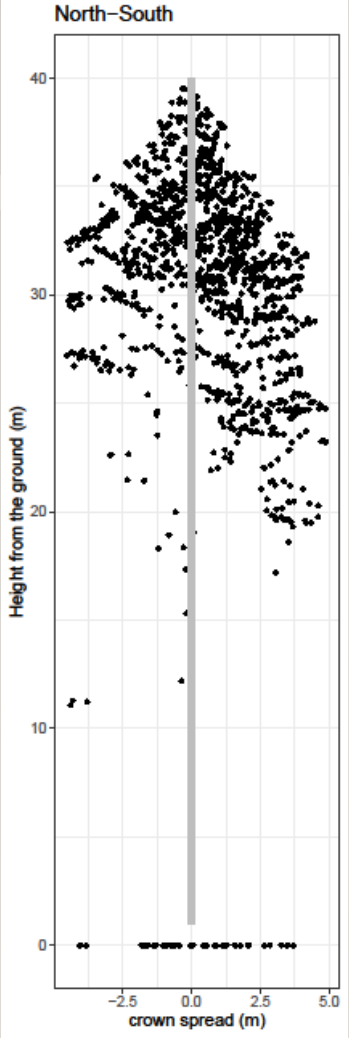
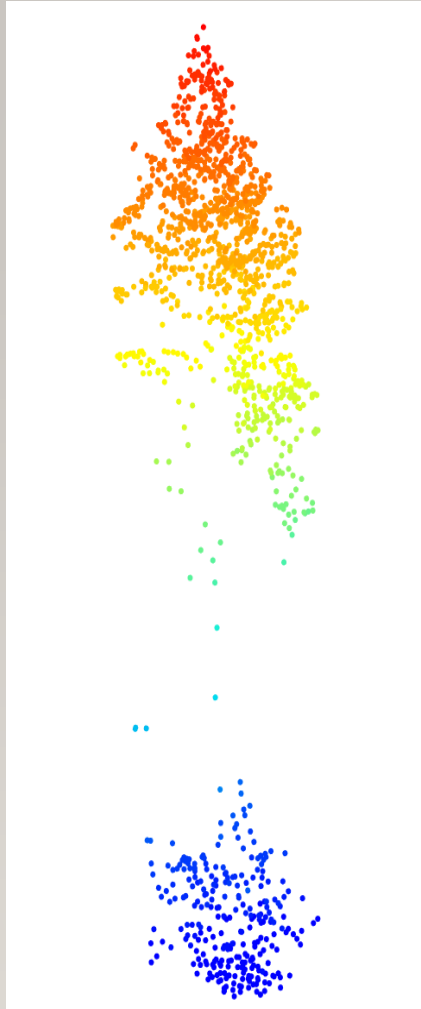
Fdc crown profile in TASS:

$$CR = 3.43 \cdot \ln(L/6.1 + 1)$$

where,

CR=crown radius (m)

L=depth into crown (m)



Improving TASS Tree List Initiation with LiDAR

TASS Inputs

1. Site index
2. Individual tree information
 - height
 - dbh
 - spatial coordinates
 - crown
3. **Other information**
 - **terrain map**

LiDAR Information

1. Top height
2. Individual tree
 - height
 - not directly
 - x- and y- coordinates (& gaps)
 - crown
3. **Digital terrain model**

Conclusions

- The preliminary results show that the input information obtained from LiDAR may help improve TASS projection (timber volume and value)
 - **Site index adjustment:** *stand specific LiDAR estimated top height can be combined with species and stand age information obtained from other sources*
 - **Individual tree information:** *LiDAR potentially provide tree and crown information for dominant and co-dominant trees (a valuable component from timber perspective)*
 - **Missing tree components:** *Other statistical relationships may need to be used to predict number, size and distribution of trees in the lower canopy*

Future direction

Overcome current issues and challenges

- more data (stem map, crown)
- different methods and tools
 - LiDAR processing
 - quantifying tree biometric properties
 - combining remote sensing data types
- need for collaboration

Operational considerations

- TASS initiation routine improvements
 - various sites/species
- validation
- forest level attribution (e.g. , sampling scheme)

Acknowledgements

- The success of this project is built upon the TASS vision of Ken Mitchell and the work over the past 4 decades of TASS team members and contributors. Thanks to the UBC Malcolm Knapp Research Forest for sharing the data with us.

References

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