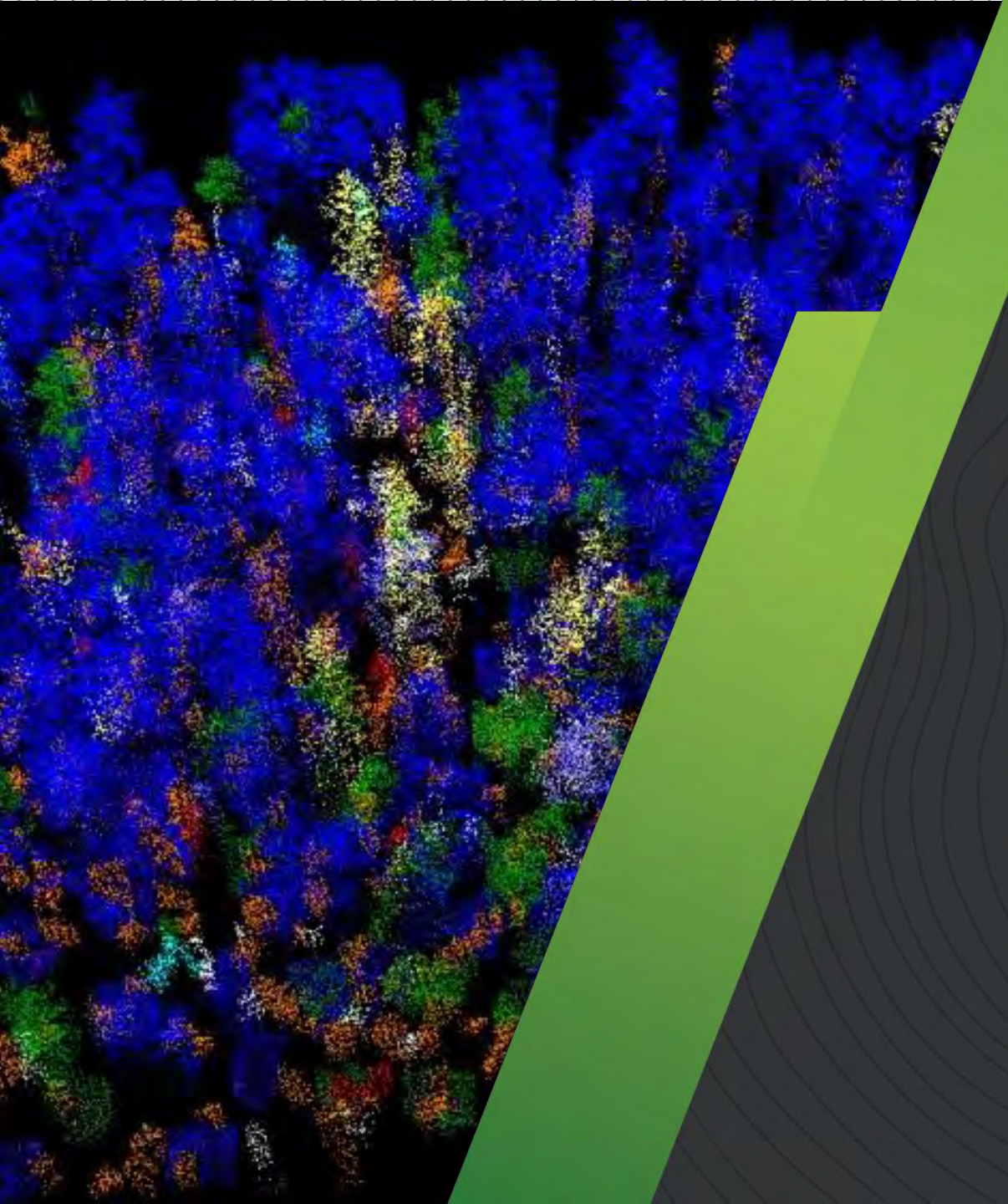

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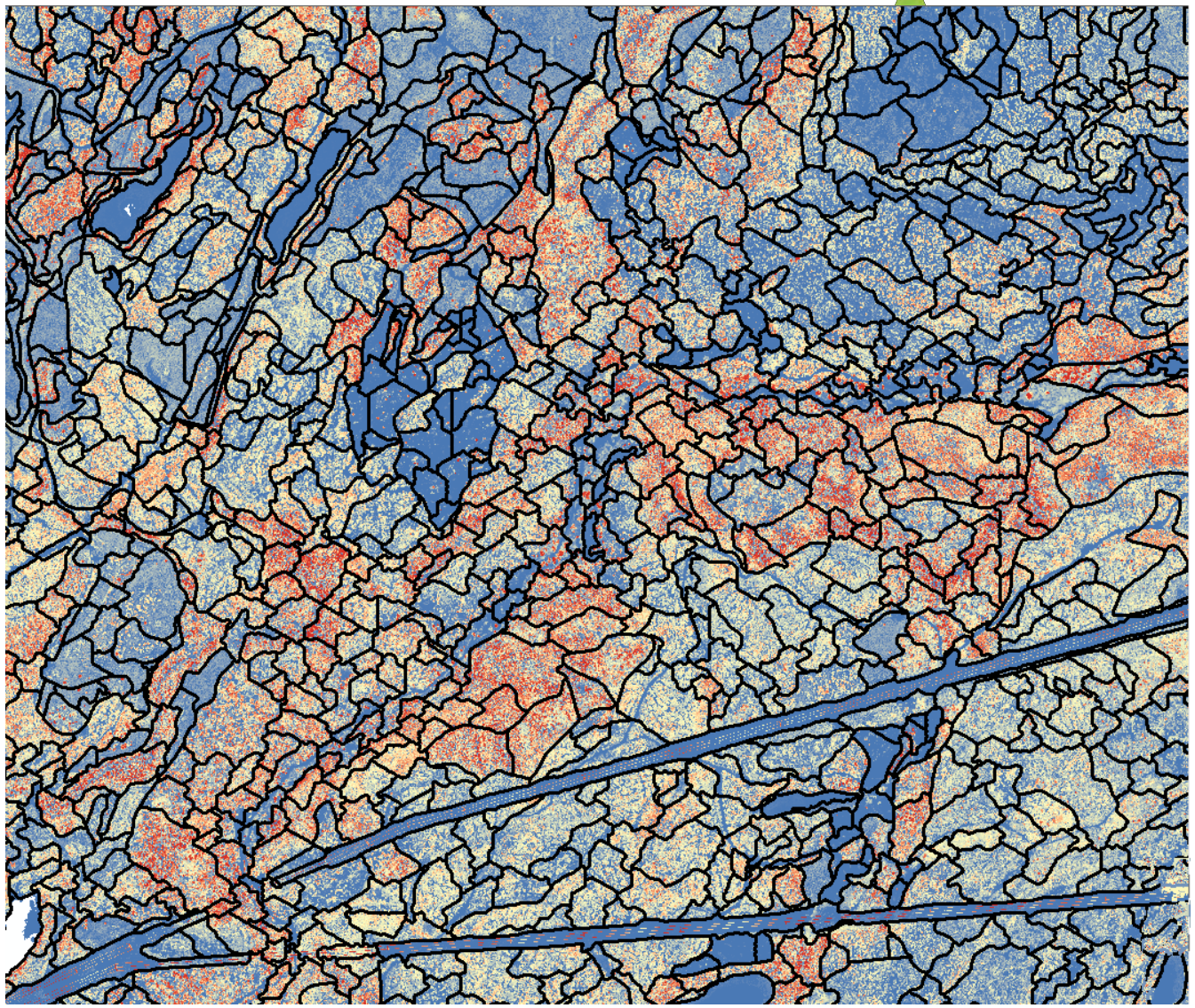
LiDAR & Satellite Forest Inventories

Trade-offs and Synergies

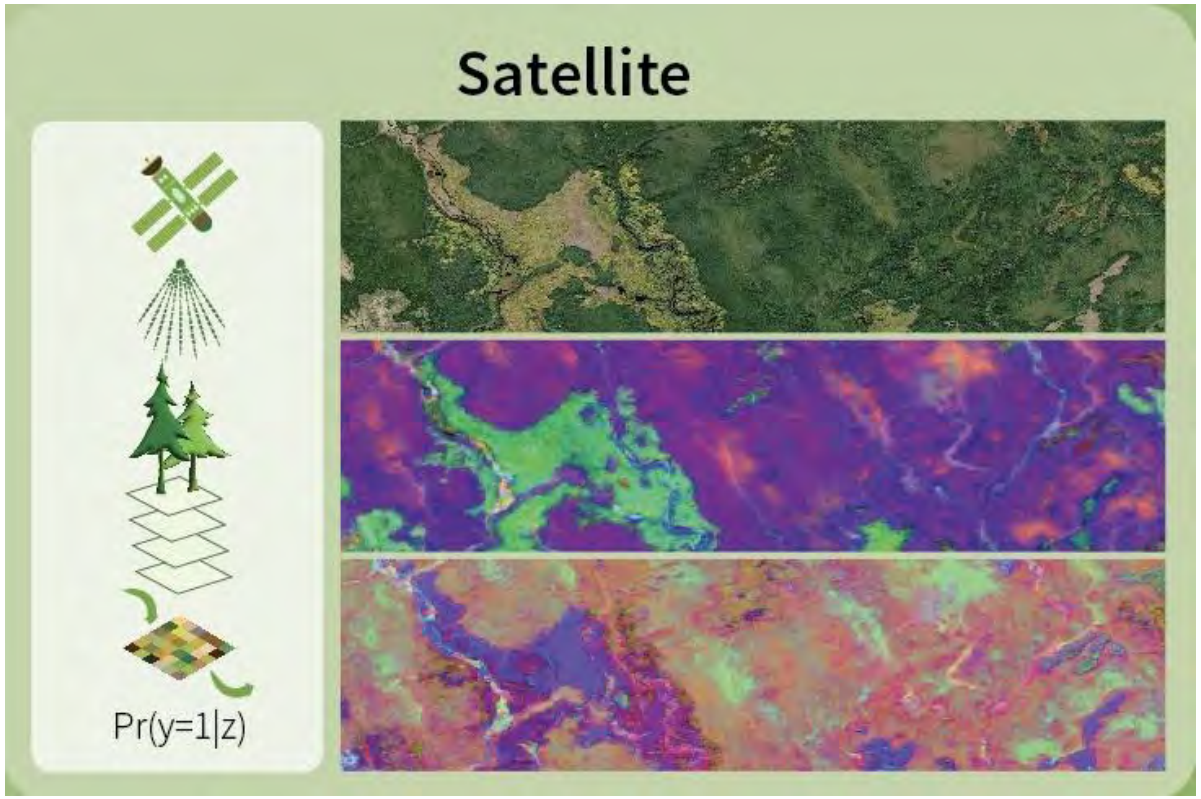
Mike Parlow and Cam Brown
April 6, 2022

Outline

- Satellite Inventory
- Area-Based Inventory (EFI)
- Individual Tree Inventory (ITC)
- Trade-offs



Satellite-Based Forest Inventories



- ✓ Low cost or free inputs available and immediately accessible
- ✓ Very large scales possible
- ✓ Temporal analysis advantage
- ✓ Speed of overall project
- x Clouds/haze/smoke can present challenges
- x Moderate accuracy/resolution

Good option for lower resolution, low cost requirements (Species.

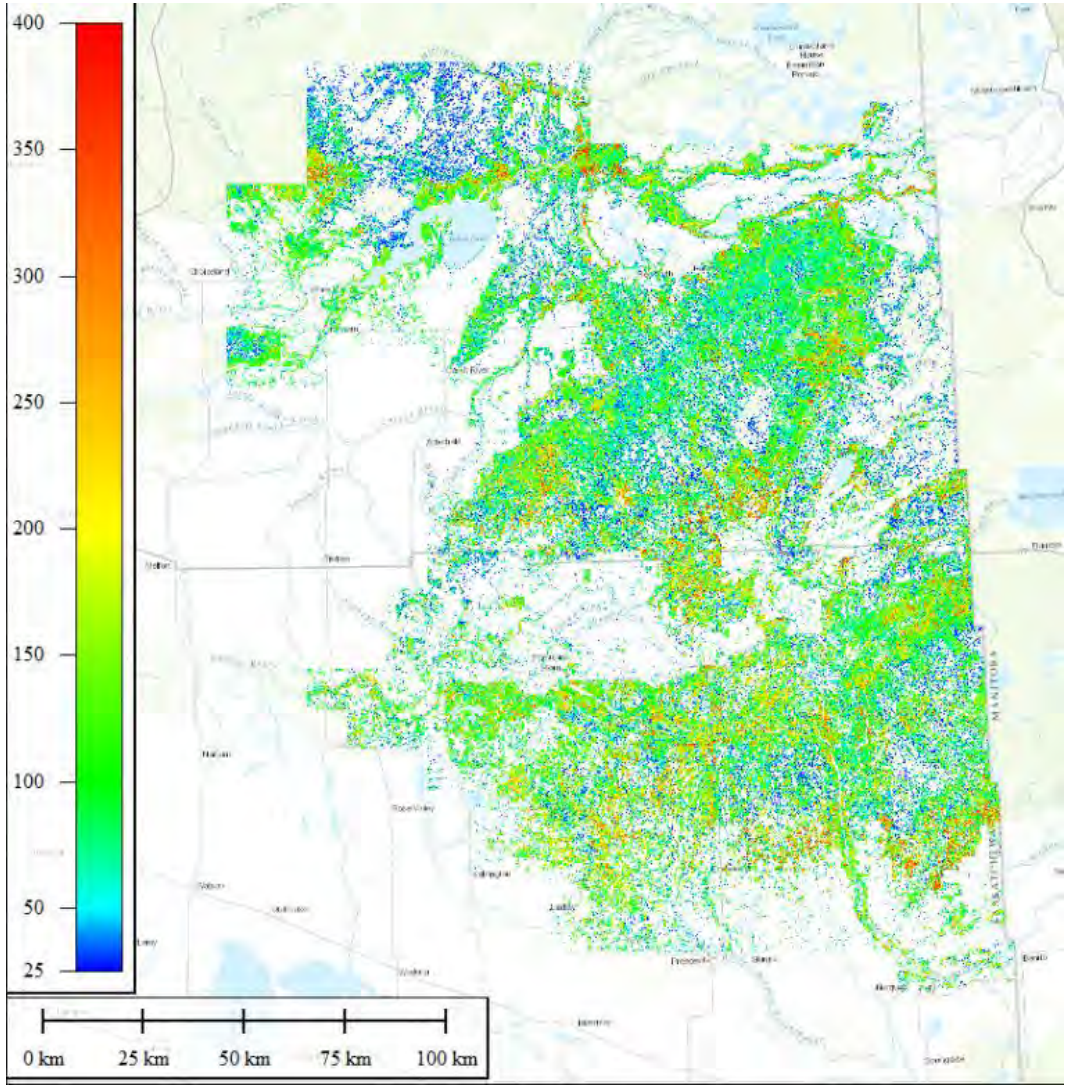
Satellite-Based Forest Inventories

Gross Merchant Volume

2 Million ha in Saskatchewan

20 meter pixels

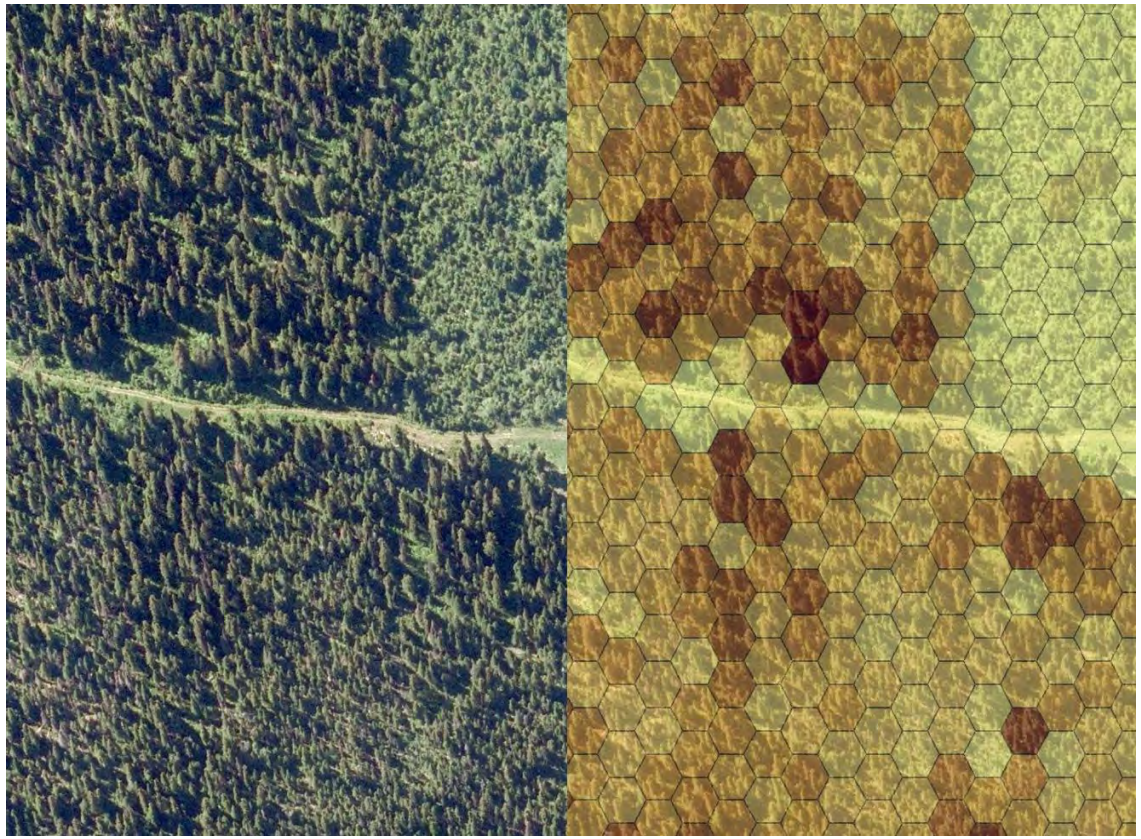
Low Cost (< $0.05/ha)



Area-Based Inventories

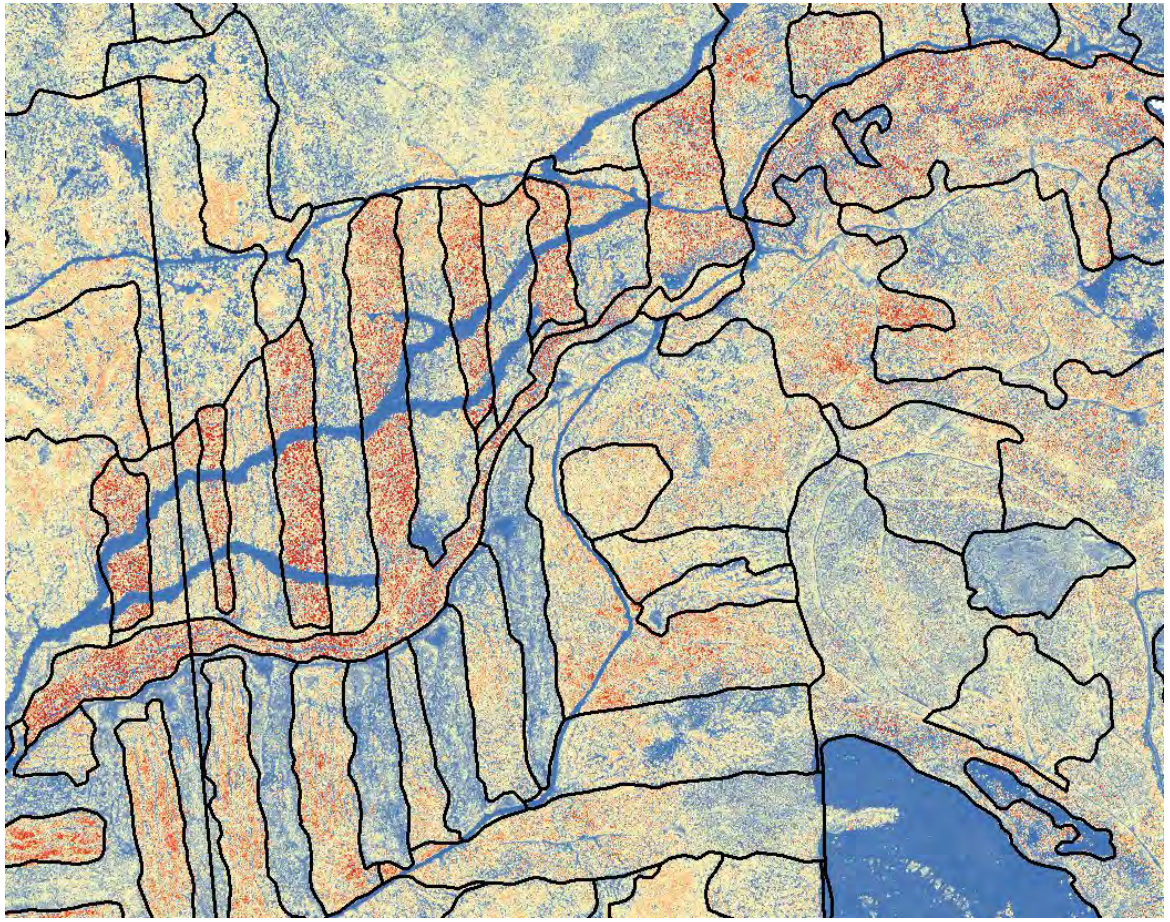
- ✓ Can work with low point density LiDAR
- ✓ Larger areas are cost effective
- ✓ Statistically defendable volumes
- x Tree data is generalized (stems/products)
- x Plot data collection can be costly
- x No species from LiDAR in this approach

Good option for large areas with focus on high accuracy Volume, HT, BA, Cover%.

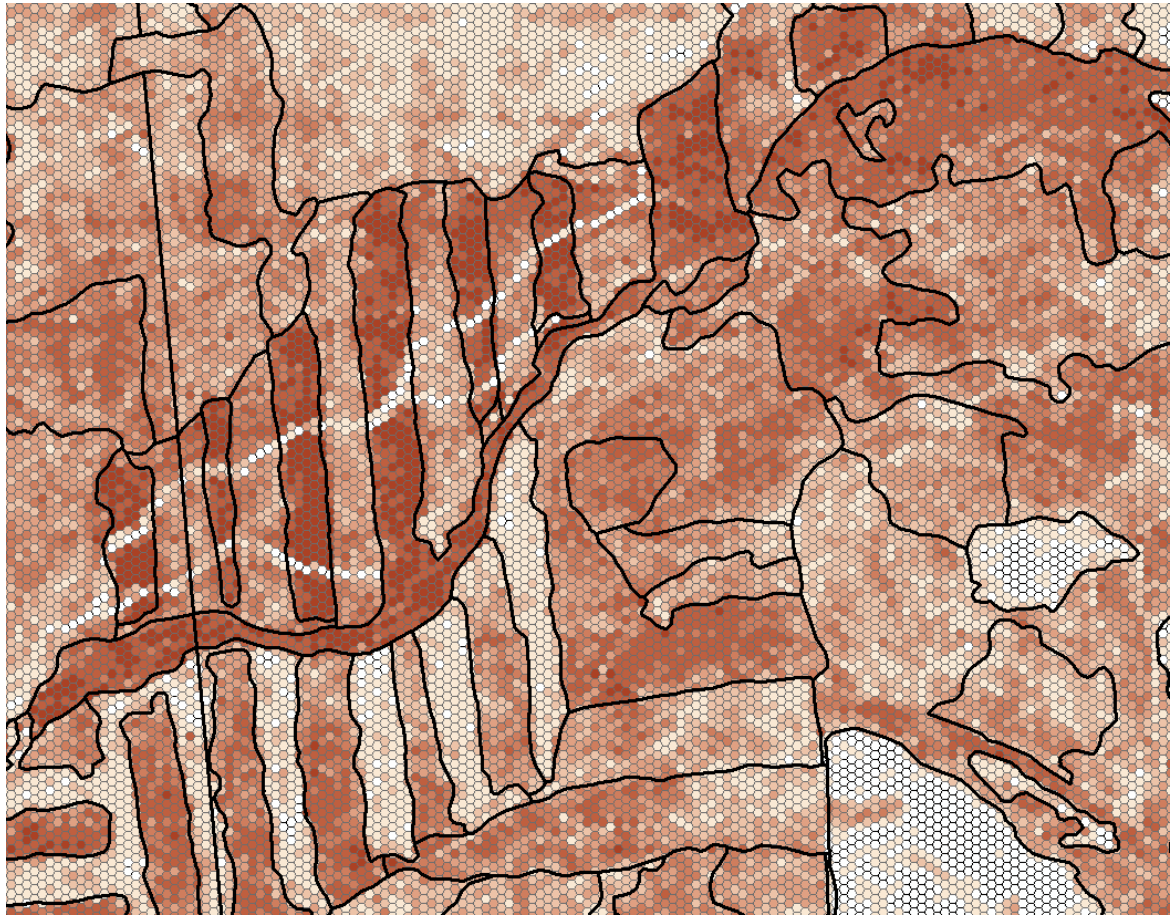


Area-Based Inventories

CHM Left – m3/ha Right



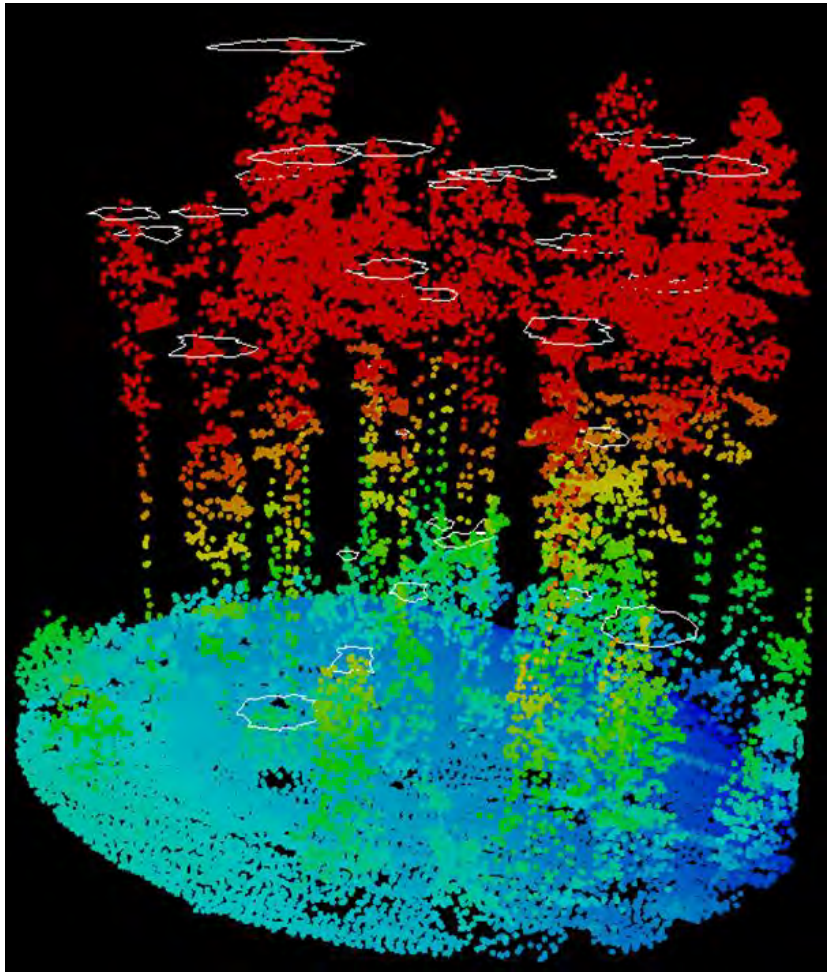
CHM (Ht + Density)



Volume / Ha

Individual Tree Inventories

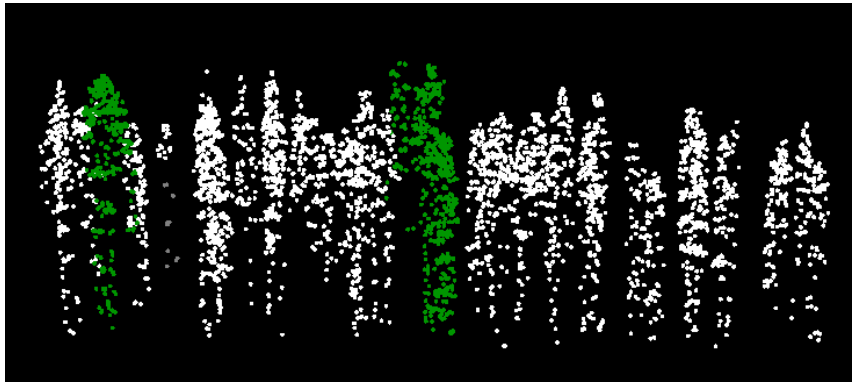
- ✓ Tree lists with species
- ✓ Best accuracy for height
- ✓ Product and piece size
- ✓ Large areas benefit from economies of scale
- ✓ No ground plots required
- x Requires higher point density LiDAR (>10ppm)
- x Partial capture of smaller and/or under-canopy trees
- x LiDAR collection can result in longer timelines

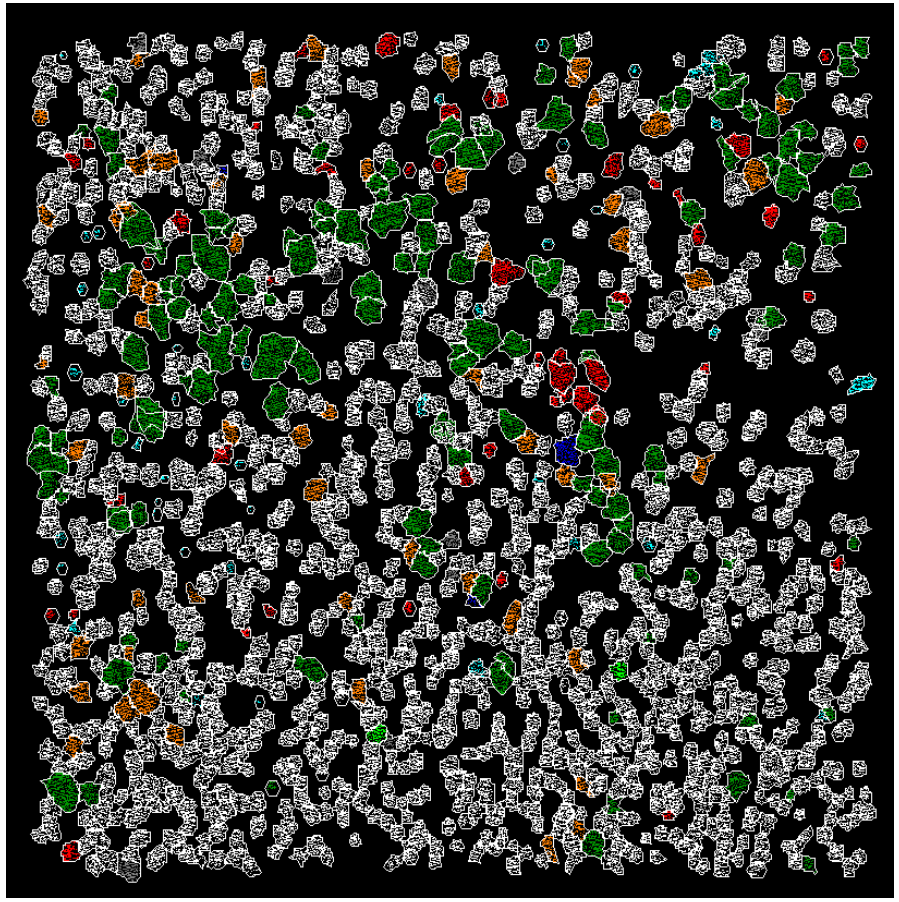


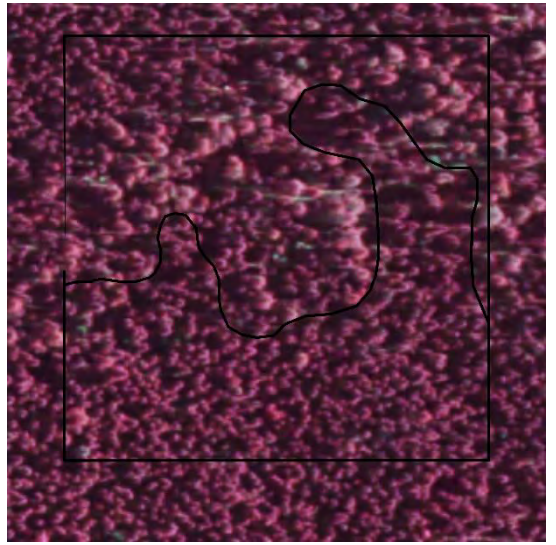
Preferred option for high resolution requirements.

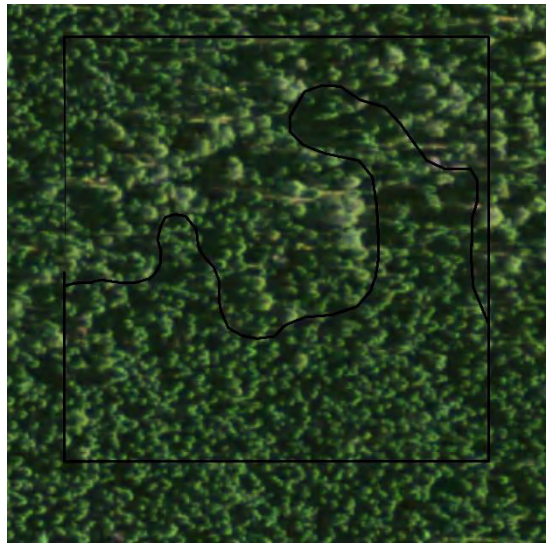
Sample Area – Black Spruce with Pine

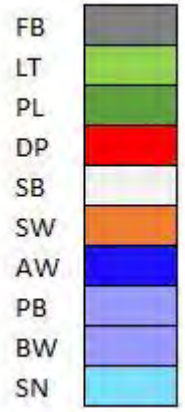
Ph2_Area2_14	FB	LT	PL	SB	SW	AW	PB	BW	DE
Photo Interp Canopy Cover %	4%	1%	16%	71%	6%	1%	0%	0%	2%
Machine Learning Predicted Canopy Cover %	**1%**	**0%**	**20%**	**68%**	**6%**	**0%**	**0%**	**0%**	**5%**







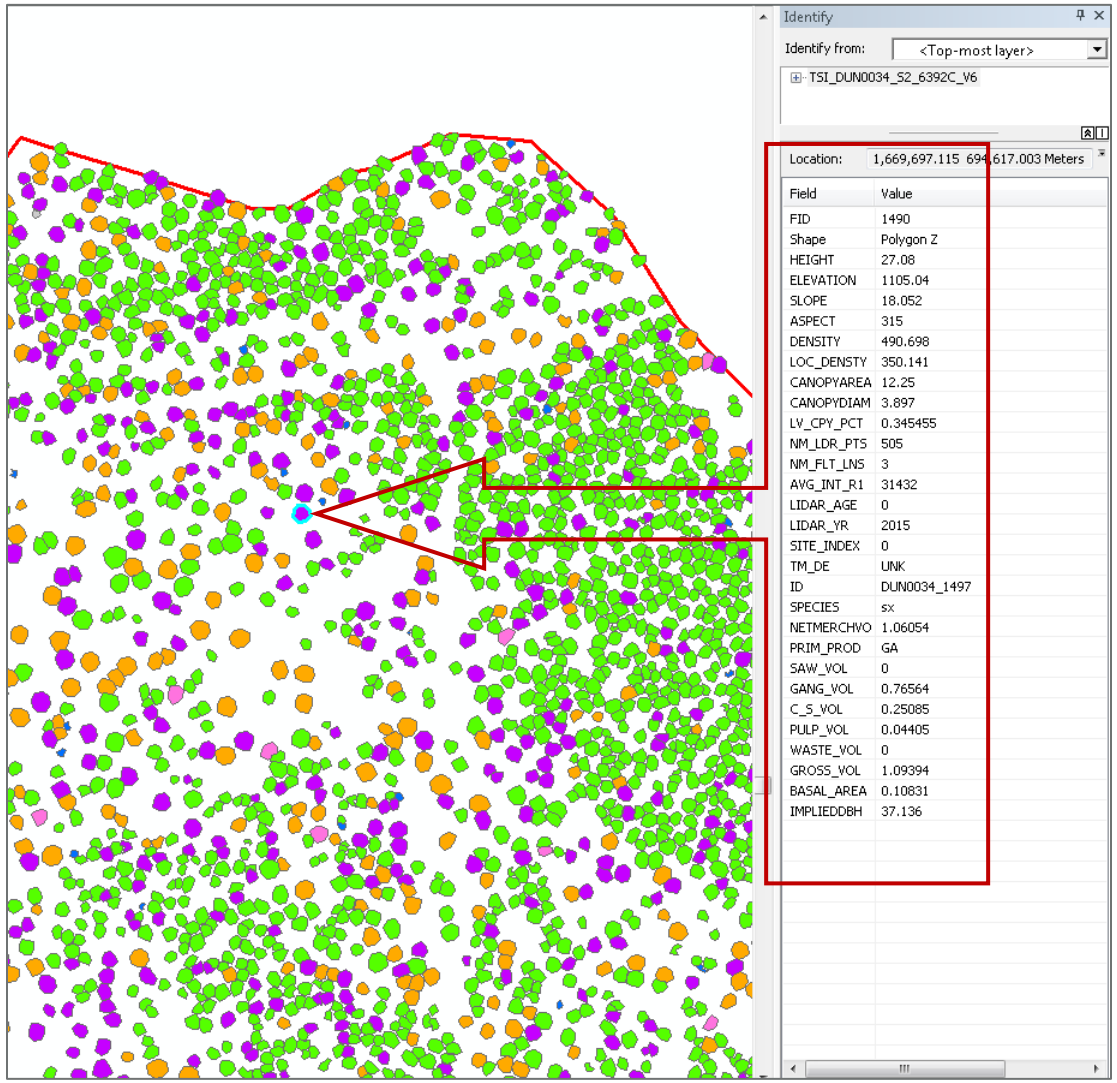




Sb leading area with secondary species Pl.

Average Height: 17.1m

Individual Tree Inventories

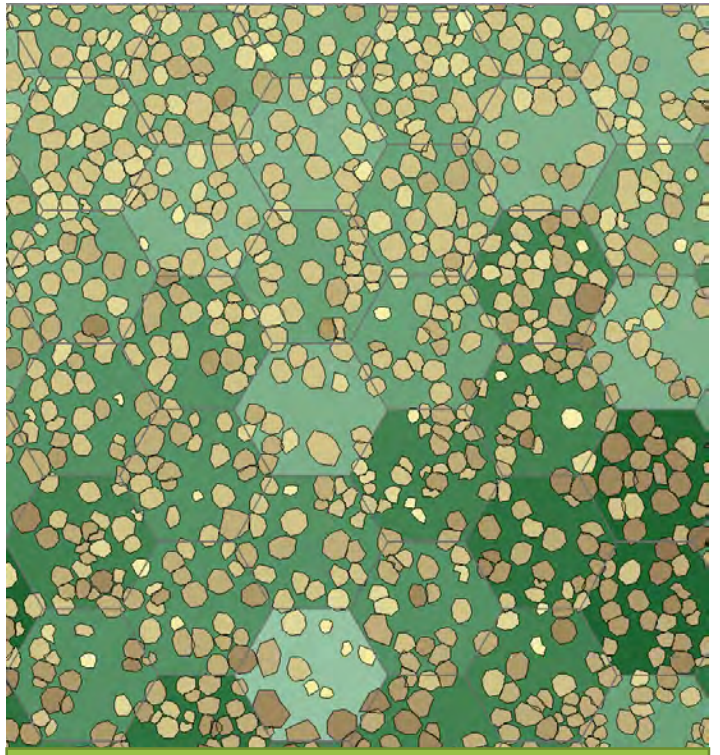


- Each tree has a unique id and associated list of attributes
- Highlighted example shows a Sw tree:
  - 27.1m Ht
  - 37.1cm DBH
  - 1.09 m3
  - Log Product Breakdown
- Can produce stand and stocking tables, based on the LiDAR stem **census** within any user defined polygon.

Hybrid Processes

- Sat + Lidar ABA – increased predictor variables in ABA (imagery) + species provided

- Sat + ABA + ITC - best of all worlds at pixel level
  - Species data, log products.
  - SPH, volume, height and DBH
  - Stand/stock tables, tree lists, etc
  - Statistically validated results

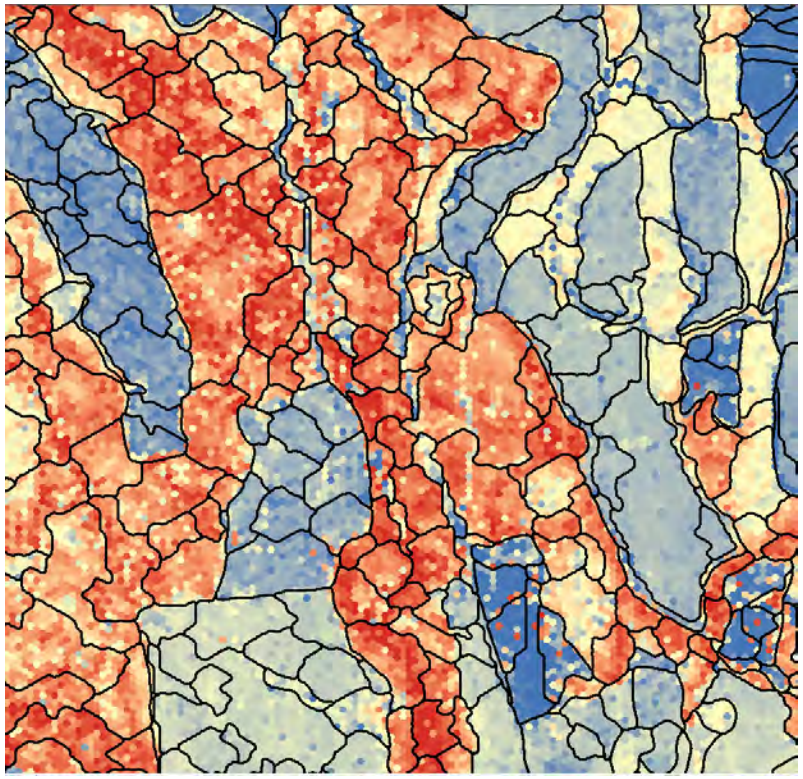


Completed ITI/ABA inventories in BC, Alberta, and Ontario (SPL)

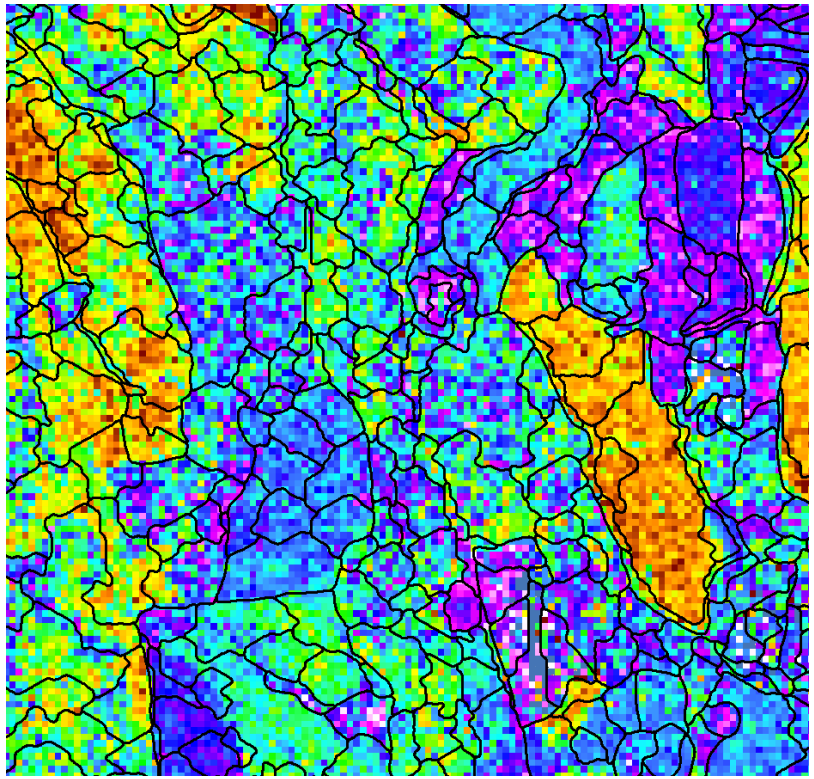
Creating Polygons

Input Datasets and Final Polygons

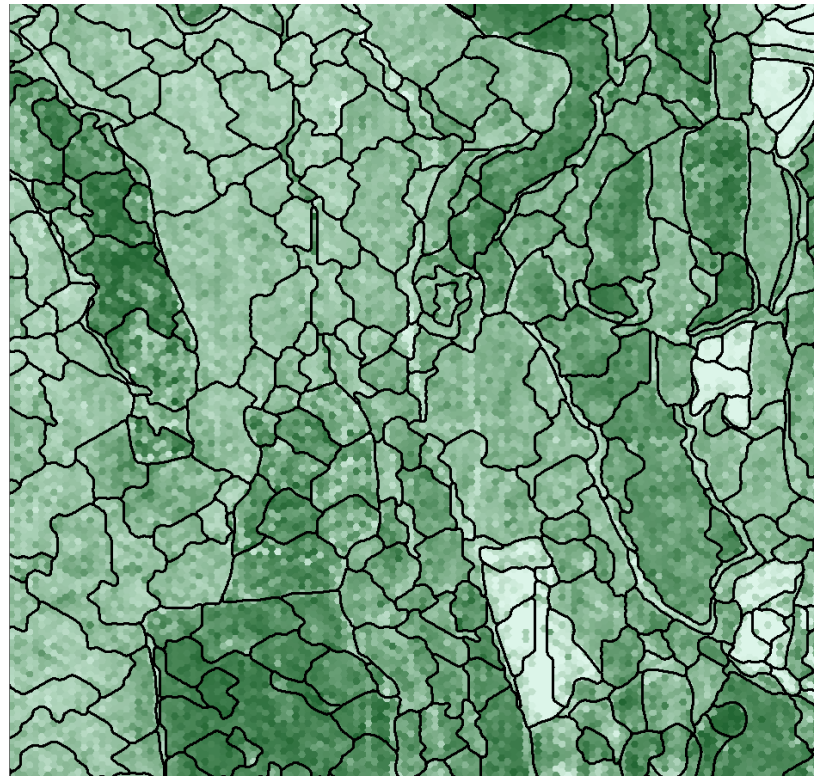
Top Height



Species Index



Crown Cover



Final Polygons Example

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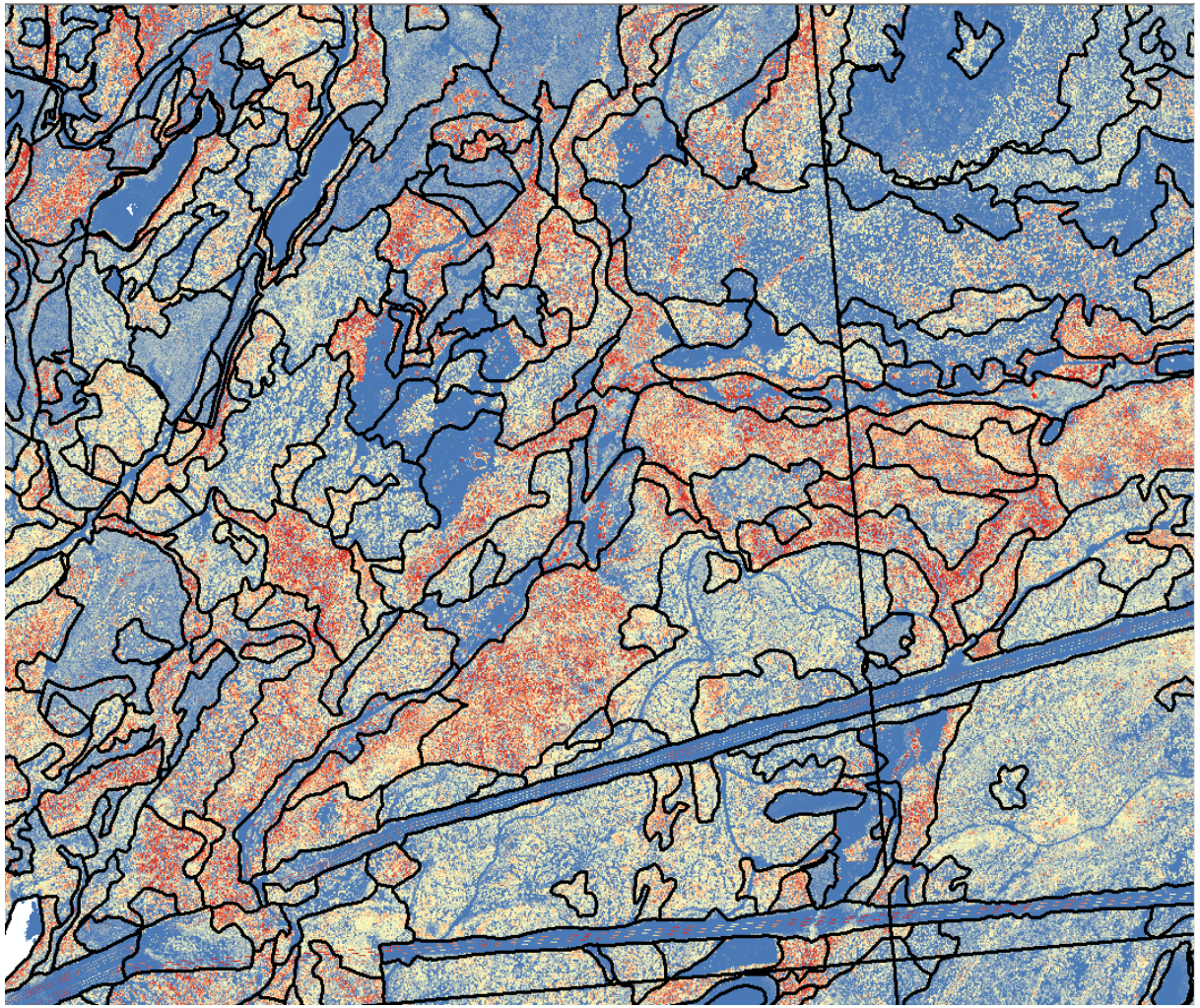
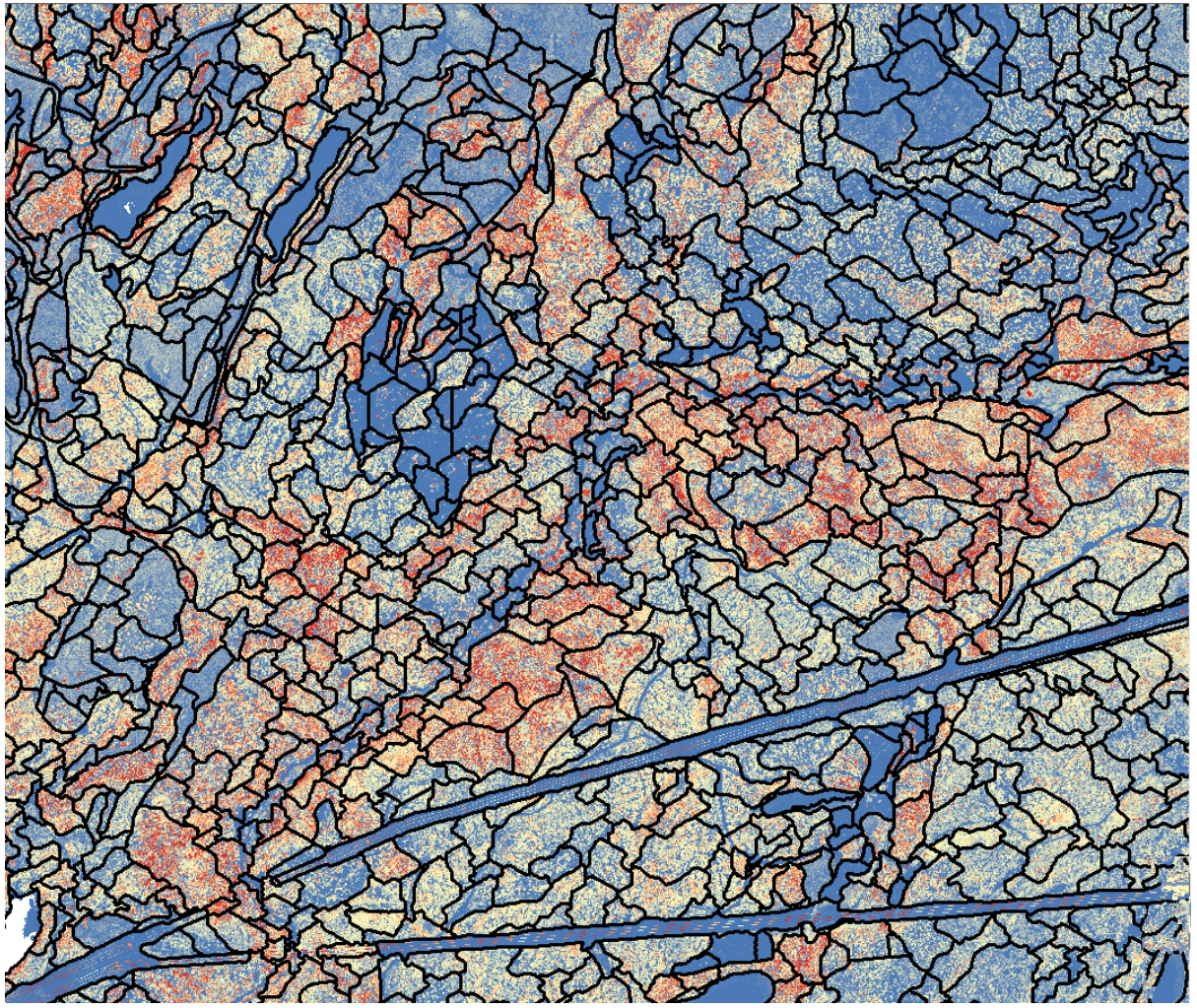
Photo Interp (7 ha avg) vs Automated (2 ha avg)



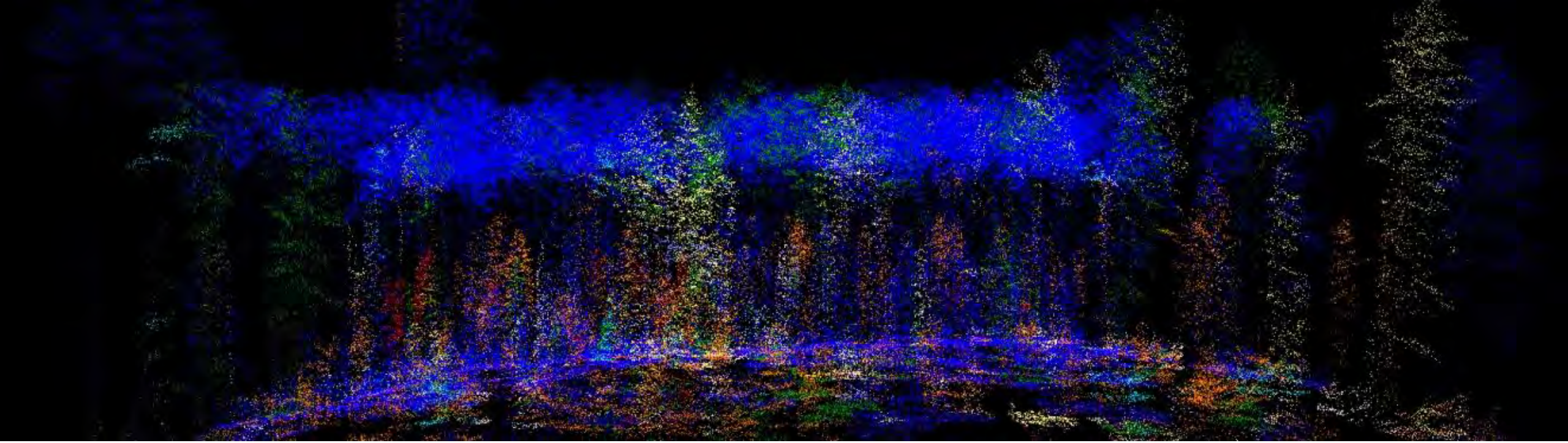


Comparisons and Trade-offs

Consideration	Pure Satellite	Satellite + LiDAR EFI	LiDAR ITC
Input Data	Sentinel Satellite Data (Multispectral + Radar)	Sentinel Satellite Data (Multispectral + Radar) 8 pts/m^2 LiDAR (ALS)	20cm Stereo Imagery / Ortho 16 pts/m^2 Lidar (ALS)
Species	Species % by Volume or CC (mod accuracy)	Species % by Volume or CC (mod accuracy)	Species % by Volume or CC (high accuracy)
Product Resolution	10m pixels 1-10 ha polygons (Auto)	20m pixels 1-10 ha polygons (Auto)	Individual Trees /Polygons 20m pixels 1-10 ha polygons (Auto)
Terrain Outputs (Slope, Aspect, Elev, Streams / wet area)	No	Yes	Yes
Height (Dominant Ht, Lorey Ht)	Species % by Volume or CC (moderate to high accuracy)	Species % by Volume or CC (moderate to high accuracy)	Species % by Volume or CC (high accuracy)
Volume (Gross and Net Merch)	Moderate accuracy	Moderate to high accuracy	High accuracy

Comparisons and Trade-offs

Consideration	Pure Satellite	Satellite + LiDAR EFI	LiDAR ITC
Density	SPH (poor accuracy) CC (mod accuracy)	SPH (mod-high accuracy) CC (very high accuracy)	SPH (mod-high accuracy) CC (very high accuracy)
Piece Size	Vol per ha / SPH (avg) (mod accuracy)	Vol per ha / SPH (Avg) (mod-high accuracy)	Piece Size Distribution (mod-high accuracy)
BA/ DBH	Avg BA (moderate accuracy) QMD (poor accuracy)	Avg BA, QMD (mod accuracy)	BA by DBH classes, QMD (mod-high accuracy)
Tree List	No	No	Yes
Stand/Stock Tables	No	No	Yes
Changes to Utilization Standards	Difficult	Difficult	ITC – Simple Polygons - Difficult



Thank you!

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