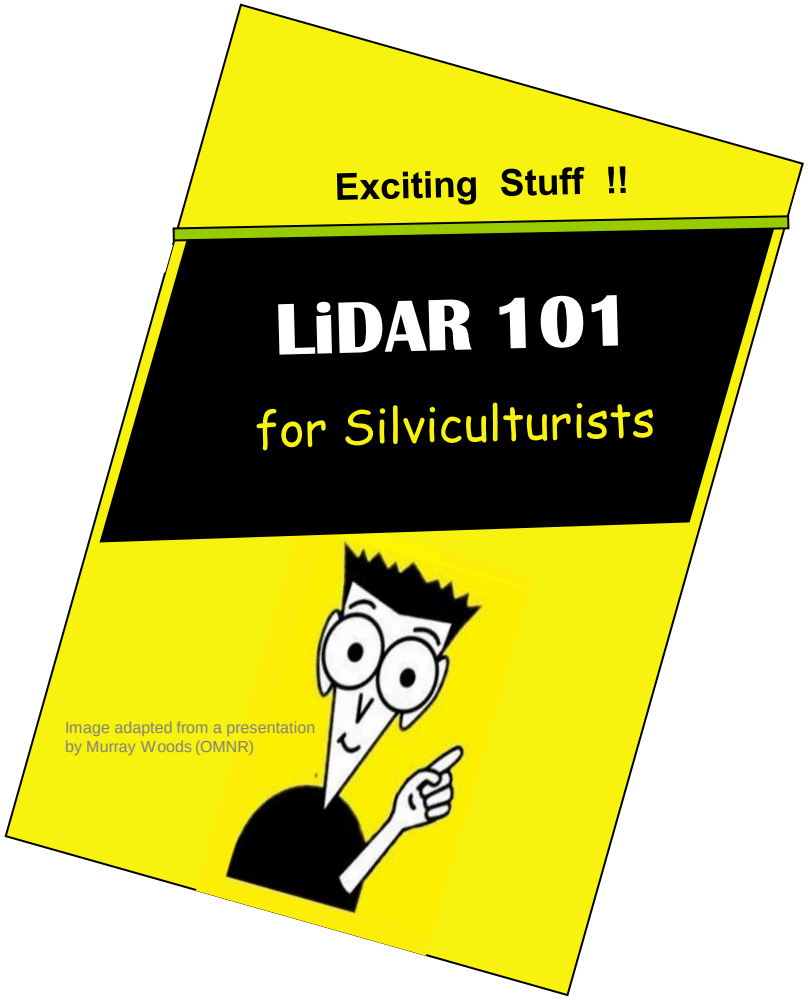
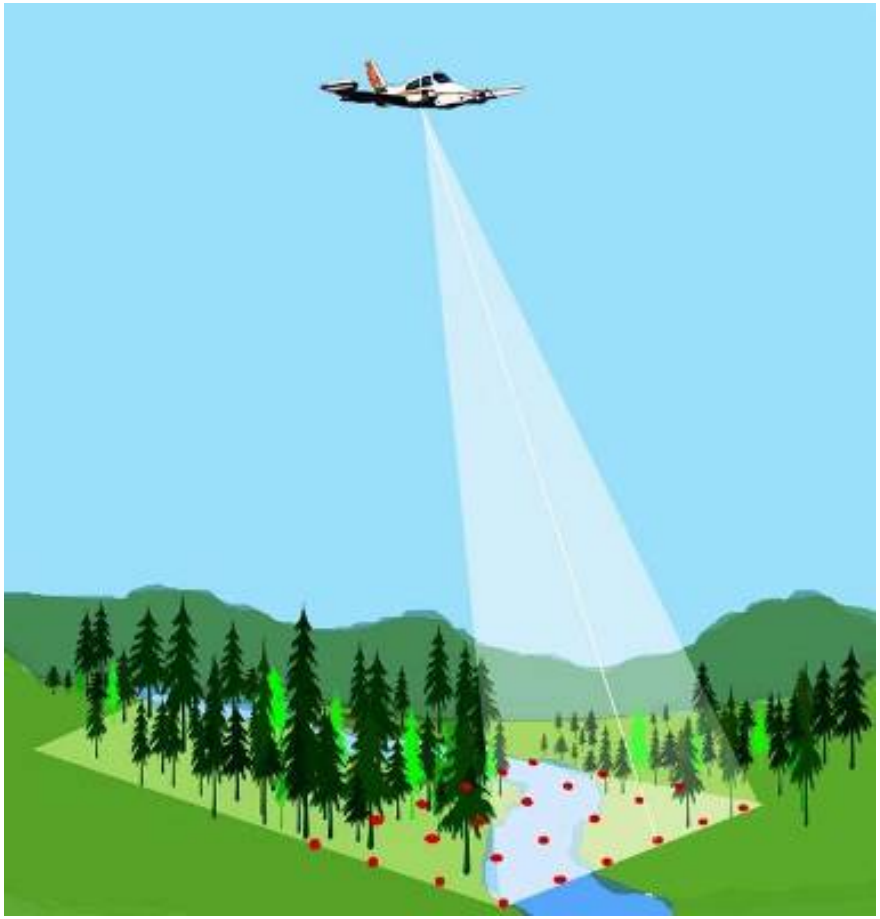
COASTAL SILVICULTURE COMMITTEE

NANAIMO 2013.02.28



Roger Whitehead
Natural Resources Canada
Canadian Forest Service
Canadian Wood Fibre Centre
Victoria, BC

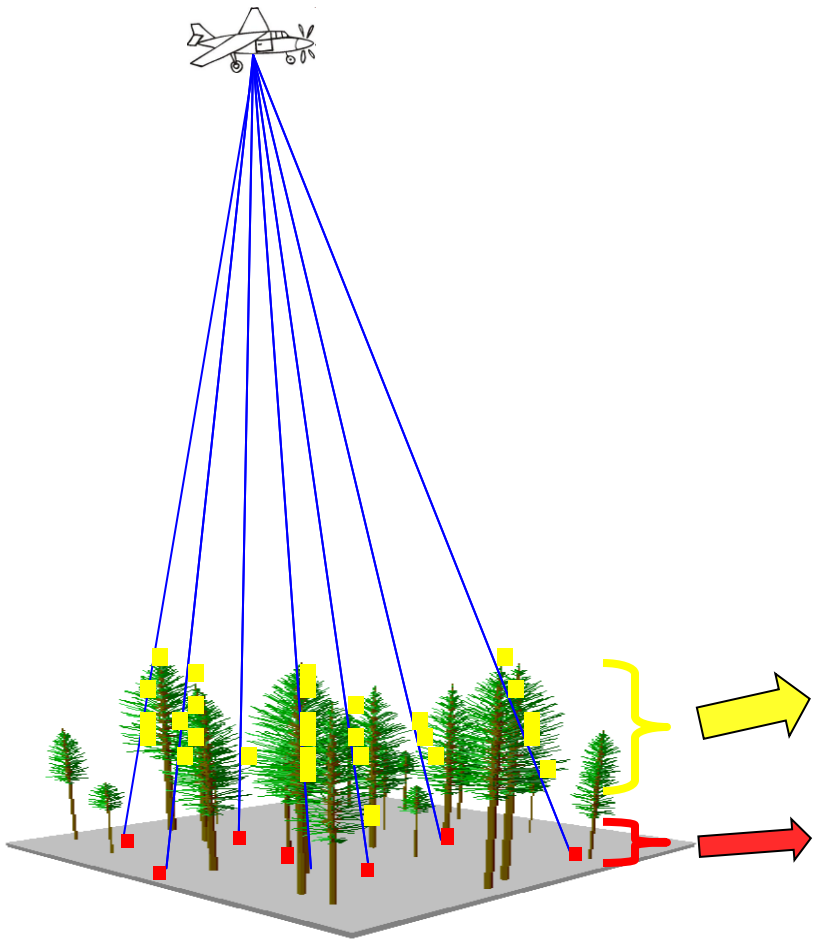
LiDAR is not magic... But, it's close!



LiDAR can…

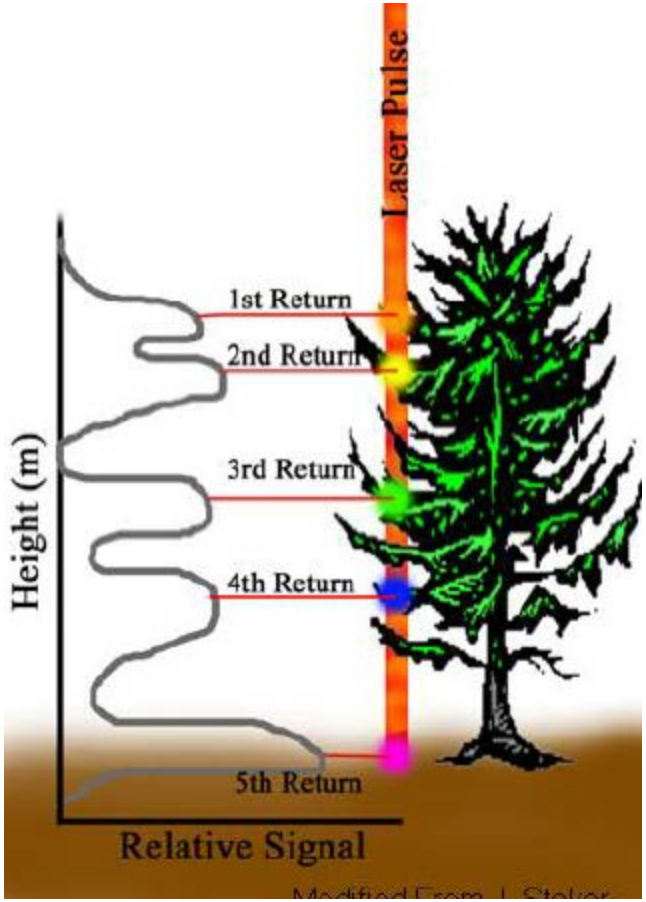
- Map terrain & some forest attributes at much higher spatial resolution & accuracy than usual
- "See ground features through the trees"
  - (sort of…)

Airborne Light Detection And Ranging



- Airborne laser scanner…
  - emits LASER pulses
  - senses energy reflected from objects impacted
    - intensity, distance & angle relative to an on-board GPS & IMU
    - stored as a digital “point cloud” with x,y,z & I_v for each return
- Other returns describe the vegetation canopy
- Last returns describe terrain

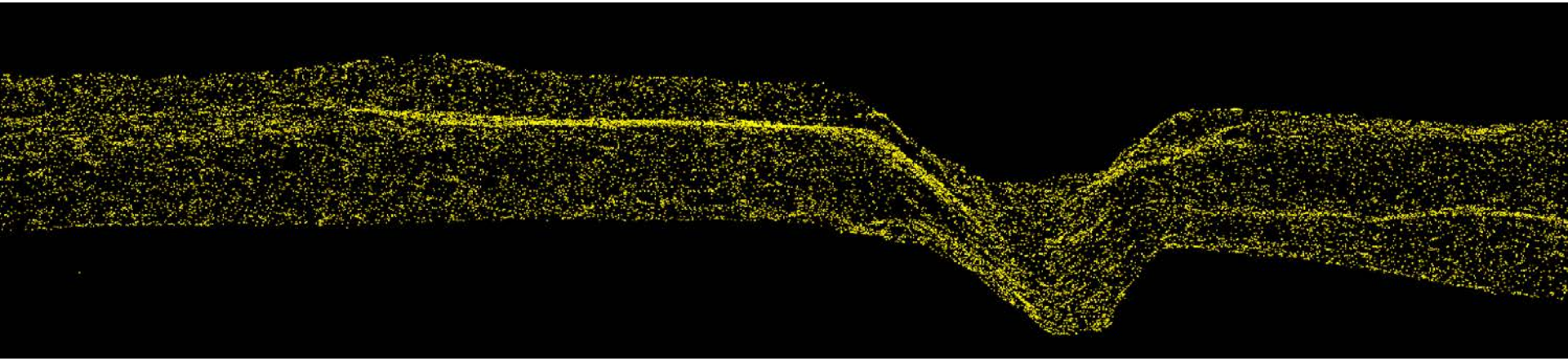
Multiple returns from each pulse…



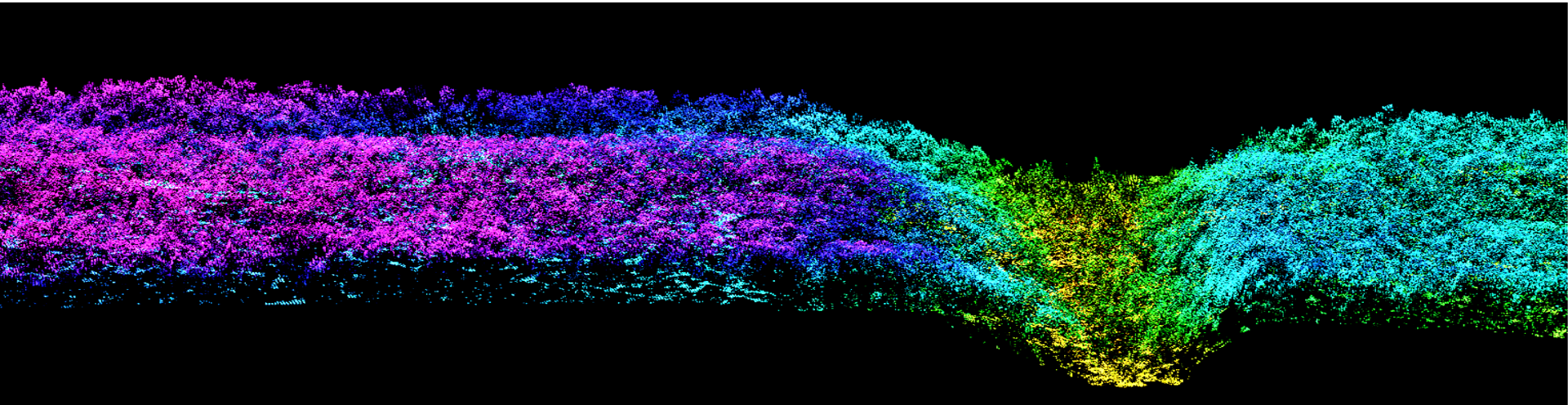
- "Footprint" of pulse at ground-level is usually about 30 cm diameter
- Some energy passes through upper canopy, & impacts lower vegetation
- Some may hit the ground

Pre-processing → separation of “Ground”

Ground Hits → useful for Digital Terrain Modeling (aka DEM)

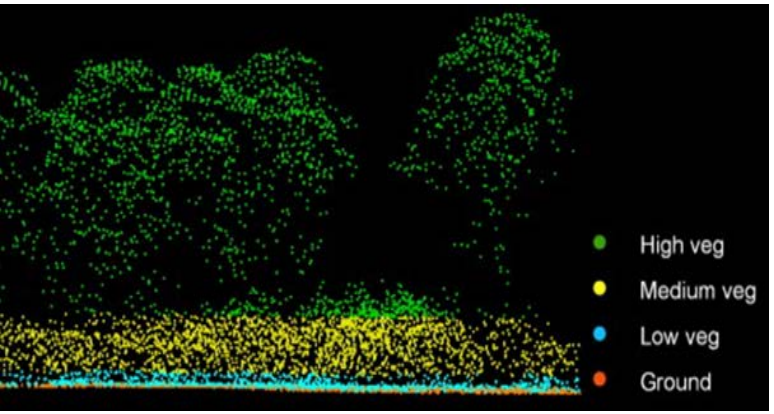


Non – ground hits → useful for canopy structure

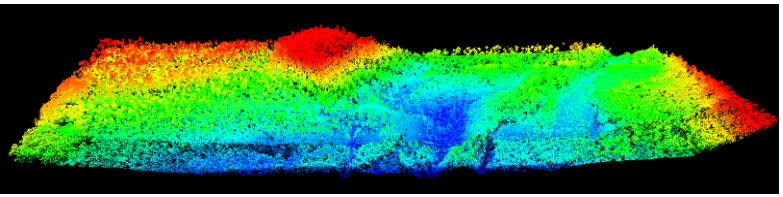


Typical Orthophoto & LiDAR Products

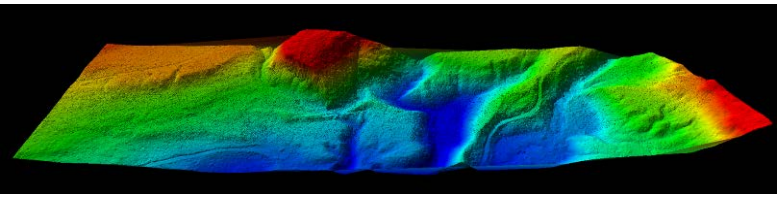
- RGB (LiDAR rectified)



- Raw Point Cloud
- Point classification



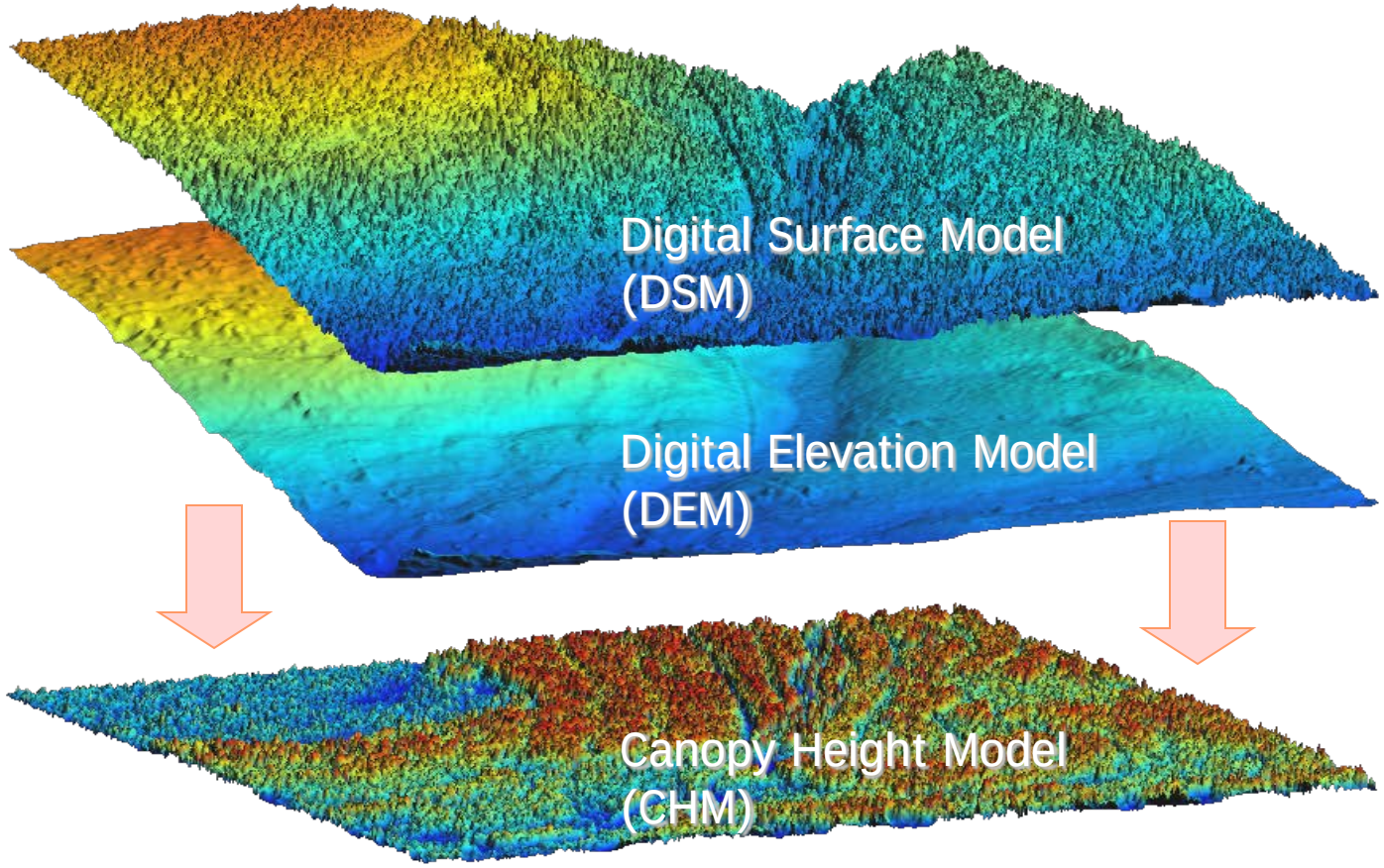
- Digital Surface Model



- Digital Elevation Model

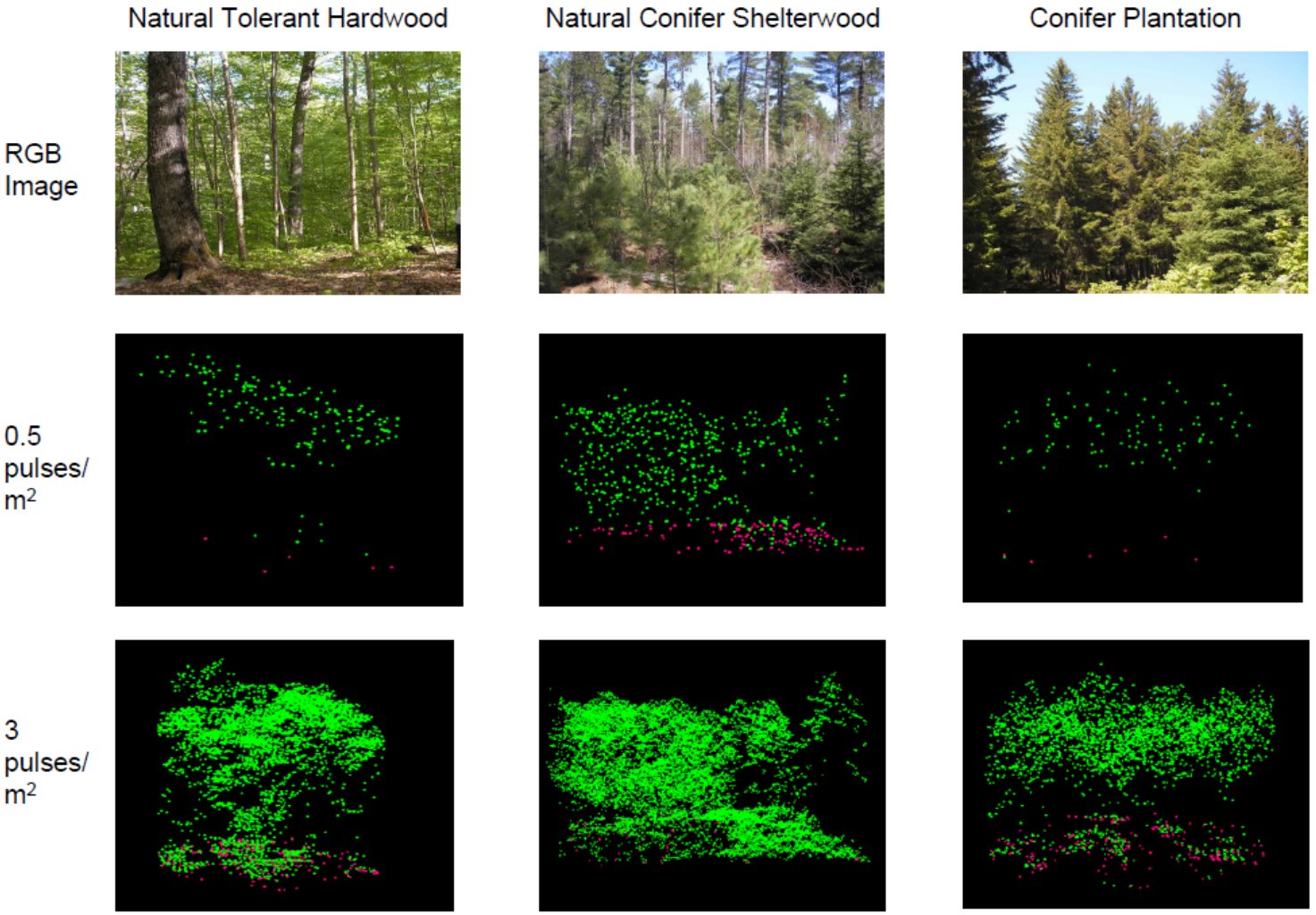
Further processing → more information

Subtract DEM from DSM → Canopy Height Model



From: St.-Onge, B., Treitz, P., Wulder, M., Kurtz, W. & Gillis, M. 2004. Restropspective mappling of structural and biomass changes in forest ecosystems using photogrammetry and laser altimitry. Am. Geophys. Union/Can. Geophys. Union Jt. Assembly, Montreal, May 17-21

Seeing through the trees…



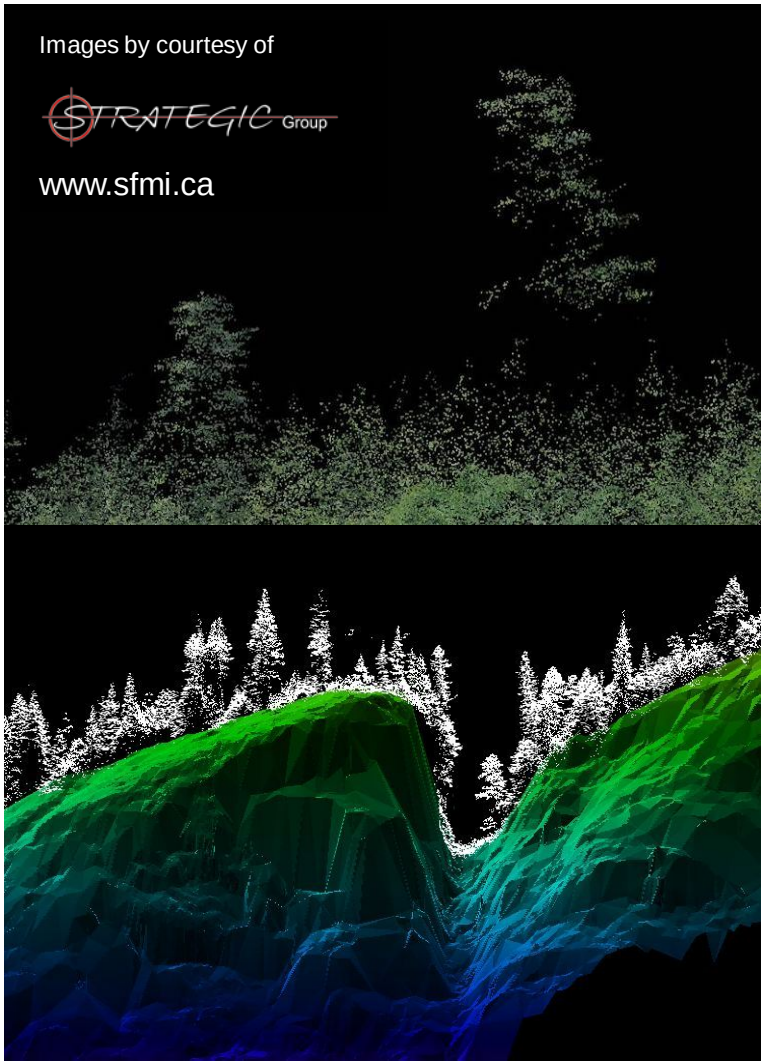
LiDAR and Large Scale Digital Photography Uses in Natural Resource Management Workshop
Sept. 10-11, 2008, University of Northern British Columbia, Prince George, BC

Source: Woods et al. (2008)

LIM geomatics

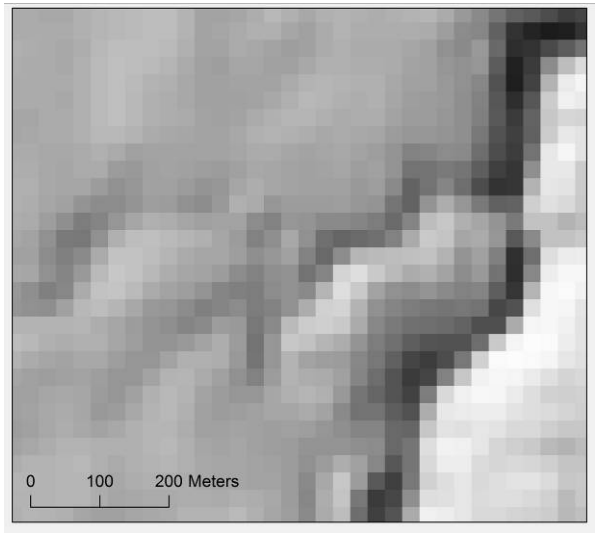
Ontario

Higher point density now available

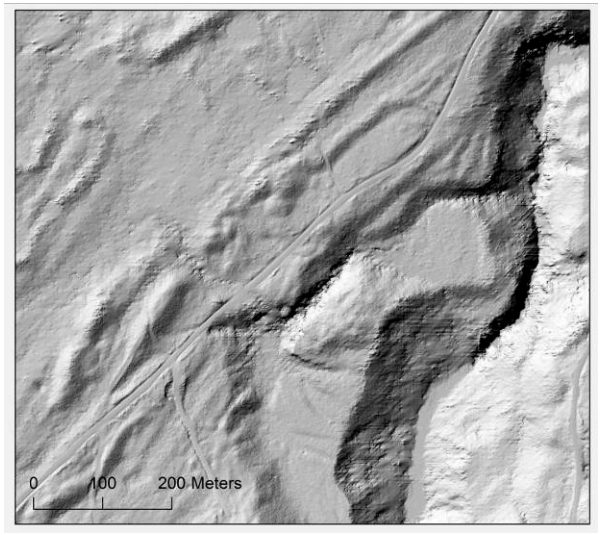


- 8-12 hits/m^2 common
  - higher resolution
  - larger dataset
- More complex terrain needs high hit density for terrain mapping
- With very dense cover, classification of ground hits is *still challenging*

Improved accuracy & resolution



- TRIM2
  - 25m resolution
  - 10m vertical accuracy



- LiDAR
  - 1m resolution
  - 10–30 cm vertical accuracy

TRIM2 data courtesy BCMFLNRO, FAIB

Images courtesy Joanne White, NRCan, CFS, PFC

Using LiDAR products…

Sore knees, bad back & worn boots

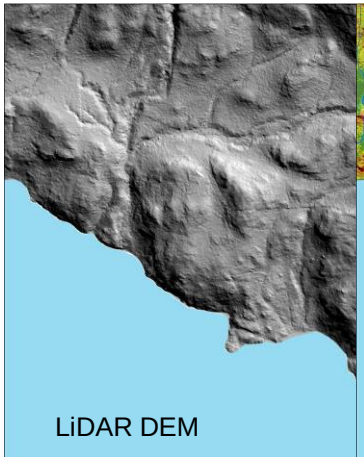
- LiDAR DEM & CHM
  - are very useful supplements to traditional planning & layout tools
  - should make your knees, back & boots last much longer

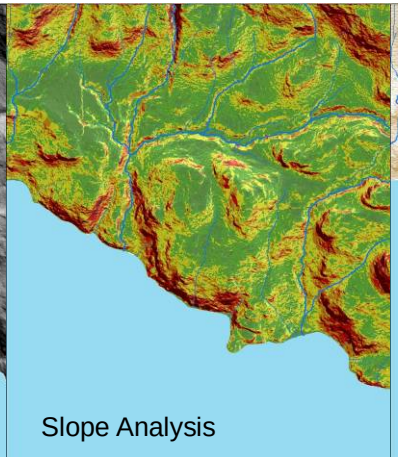
Images by courtesy of

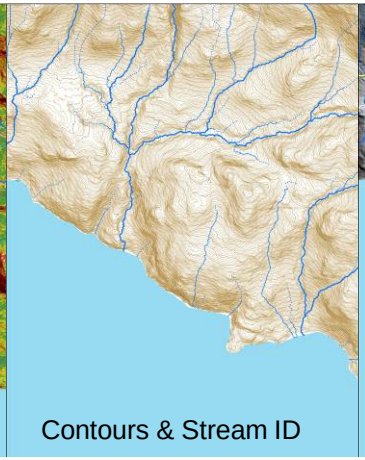
STRATEGIC Group

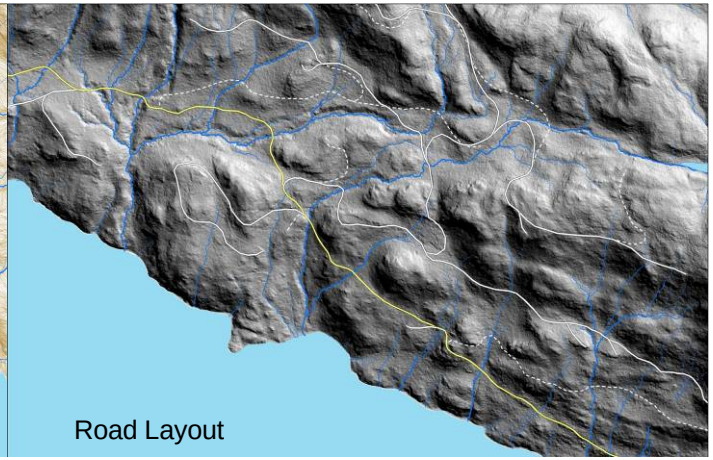
www.sfmi.ca

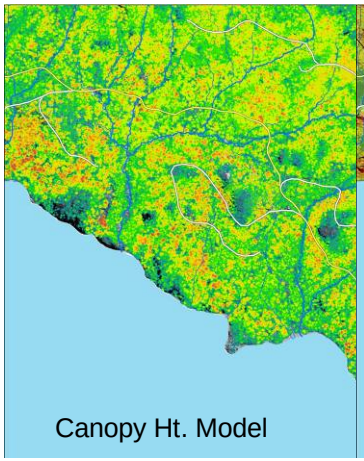
In fact, it’s a whole new world…

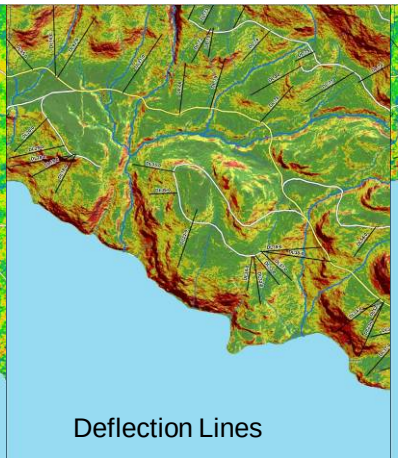

LiDAR DEM


Slope Analysis

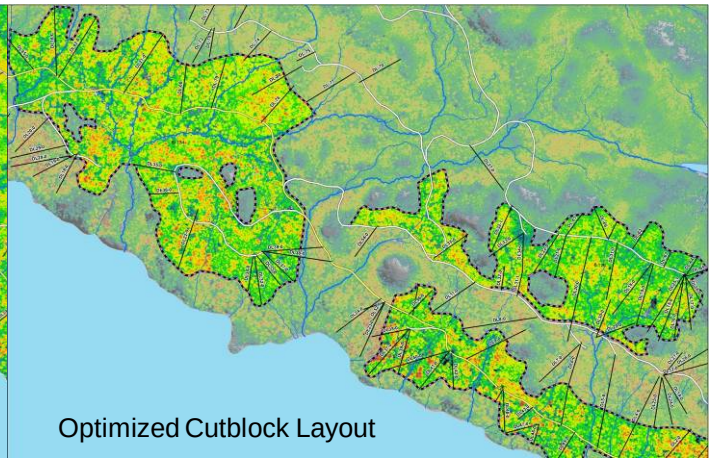

Contours & Stream ID


Road Layout


Canopy Ht. Model


Deflection Lines


Preliminary Layout


Optimized Cutblock Layout

Images by courtesy of

STRATEGIC Group

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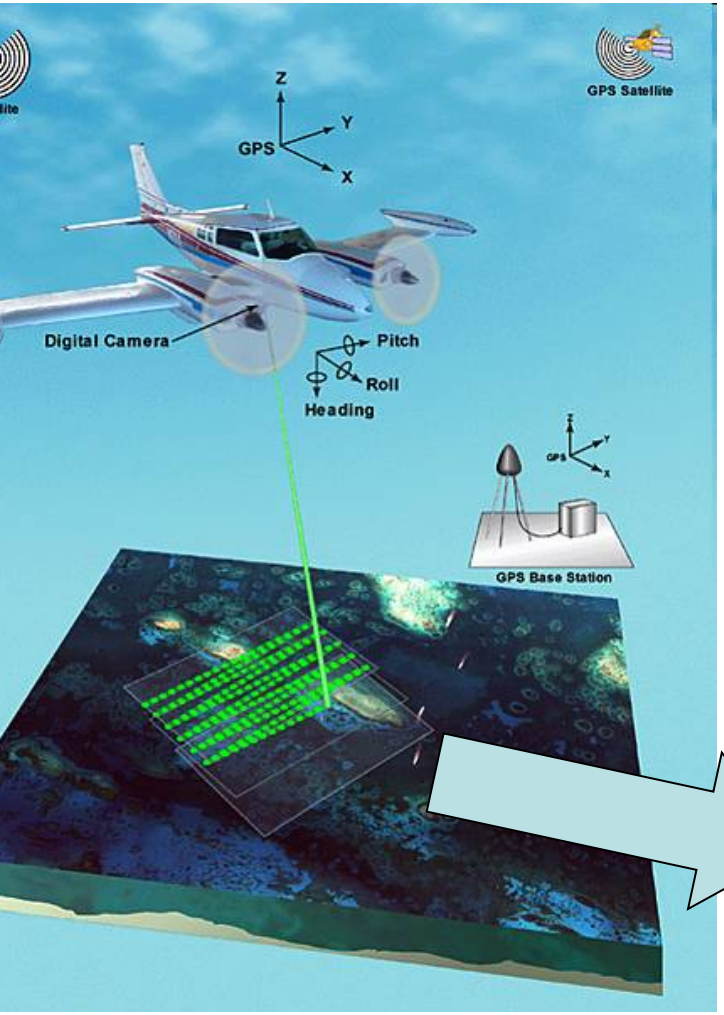
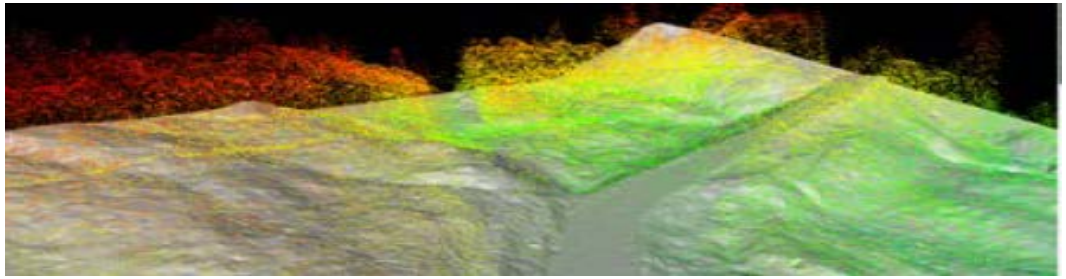
There's still more info in the point cloud…

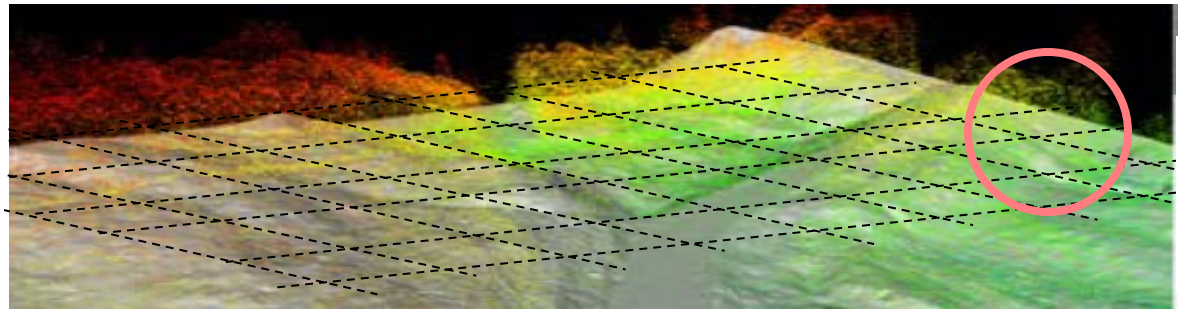


- The raw Point Cloud is a very large dataset…
- …can be mathematically processed to extract value
- → Enhanced Forest Inventory

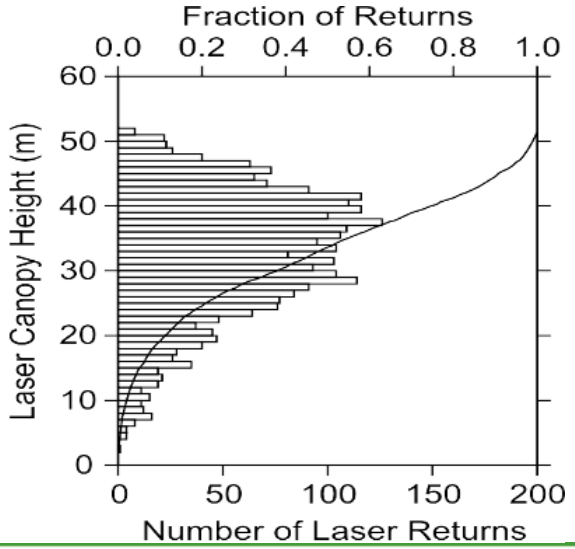


Above-ground returns → “Canopy Metrics”

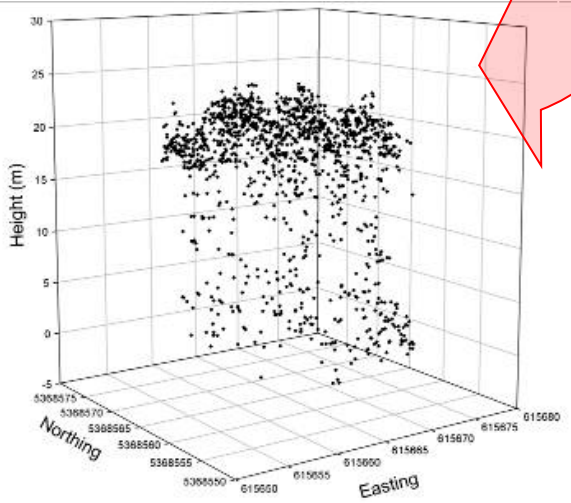
“Tiles” → Mosaic → “Grid Cells”



Plot-level “Canopy Metrics”



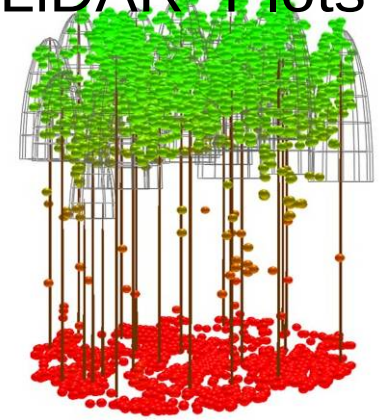
LiDAR “Plots”



Ground Calibration → Prediction Models

GPS-located Ground Plots

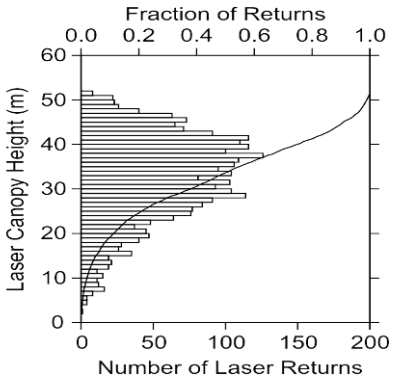
Co-located LiDAR "Plots"



"Plot-level" Inventory Metrics

Height(s)	Fuel Load
DBHq	Biomass
BA	Carbon
Volume	Piece-size
Density	etc.

"Plot-level" Canopy Metrics

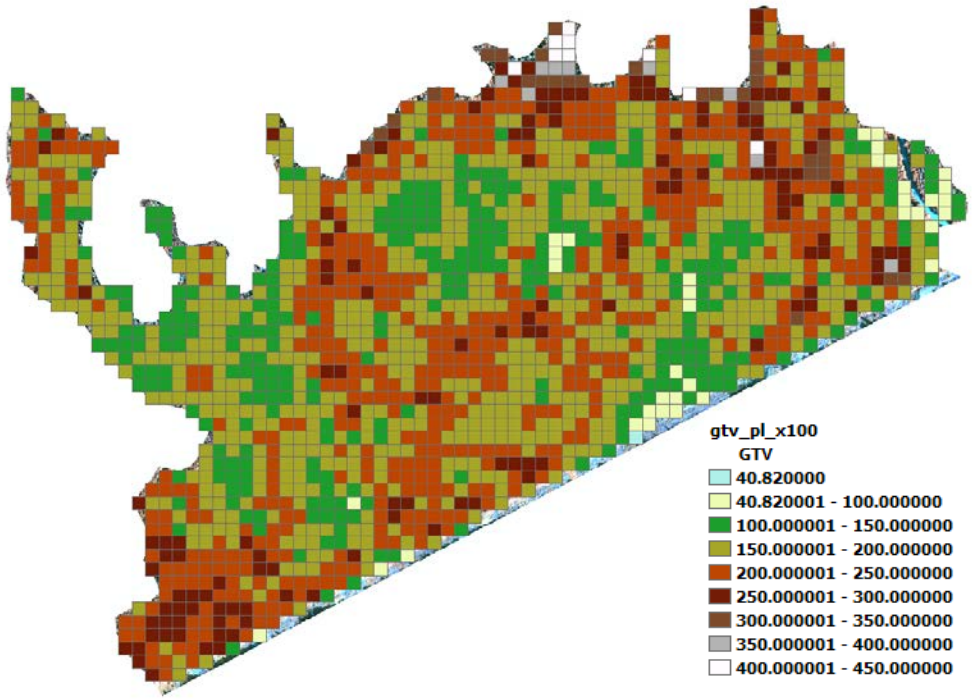


Regression Analyses

Prediction Models

Jack Pine			
Dependent variable	Prediction equation	RMSE	CV %
TOPHT (m)	6.8 + 0.86 x *p90*	0.76	3.8
AVGHT (m)	15.82 + 0.35 x *p80* + -7.53 x *d7*	1.05	6.5
QMDBH (cm)	0 + 0.78 x *p90* + 7.79 x *d7*	1.54	9.0
SUMBA (m^2 ha^{-1})	8.52 + 2.78 x *mean* + -0.41 x *p20*	5.92	19.0
SUMGTV (m^3 ha^{-1})	82.70 + 1.23 x *meanxp90* + -2.52 x *p20*	44.85	18.0
SUMGMV (m^3 ha^{-1})	31.32 + 1.23 x *meanxp90* + -4.44 x p20	36.67	18.8
BIOMASS (Kg ha^{-1})	52049.357 + 551.34 x *meanxp90*	24478	19.2
Black Spruce			
TOPHT (m)	0 + 1.0 x *p90* + 7.01 x *d6*	1.24	7.4
AVGHT (m)	5.08 + 0.65 x *p90*	1.13	8.8
QMDBH (cm)	4.68 + 0.62 x *p90* + 3.13 x *d6*	1.37	9.7
SUMBA (m^2 ha^{-1})	0 + 4.64 x *mean* + -2.68 x *p20*	4.83	18.7

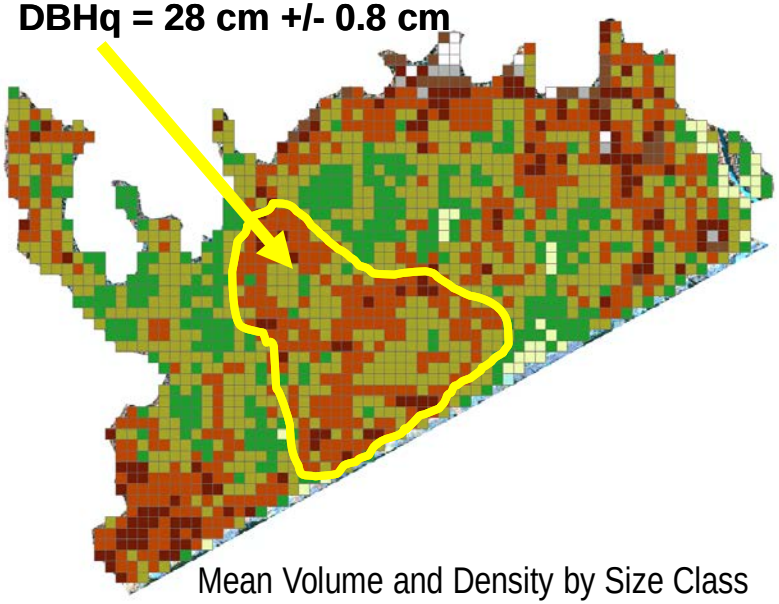
Scaling up to inventory…

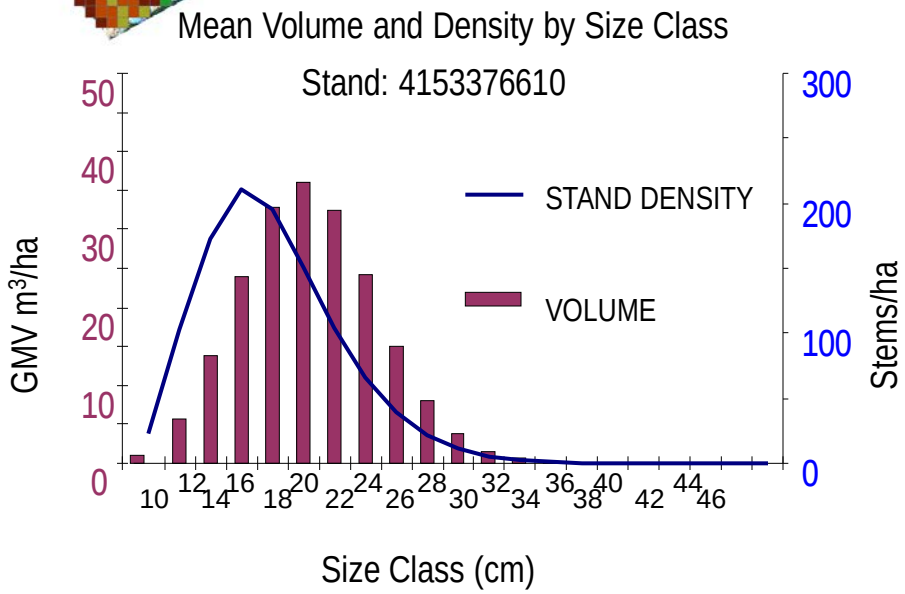


- The appropriate prediction model is then applied to every grid-cell → predicted attributes, which are "mapped" as GIS rasters
- Although the LiDAR dataset is huge… the products (GIS layers) are not and can be easily used

Volume = 22,690 m³ +/- 940 m³

DBHq = 28 cm +/- 0.8 cm

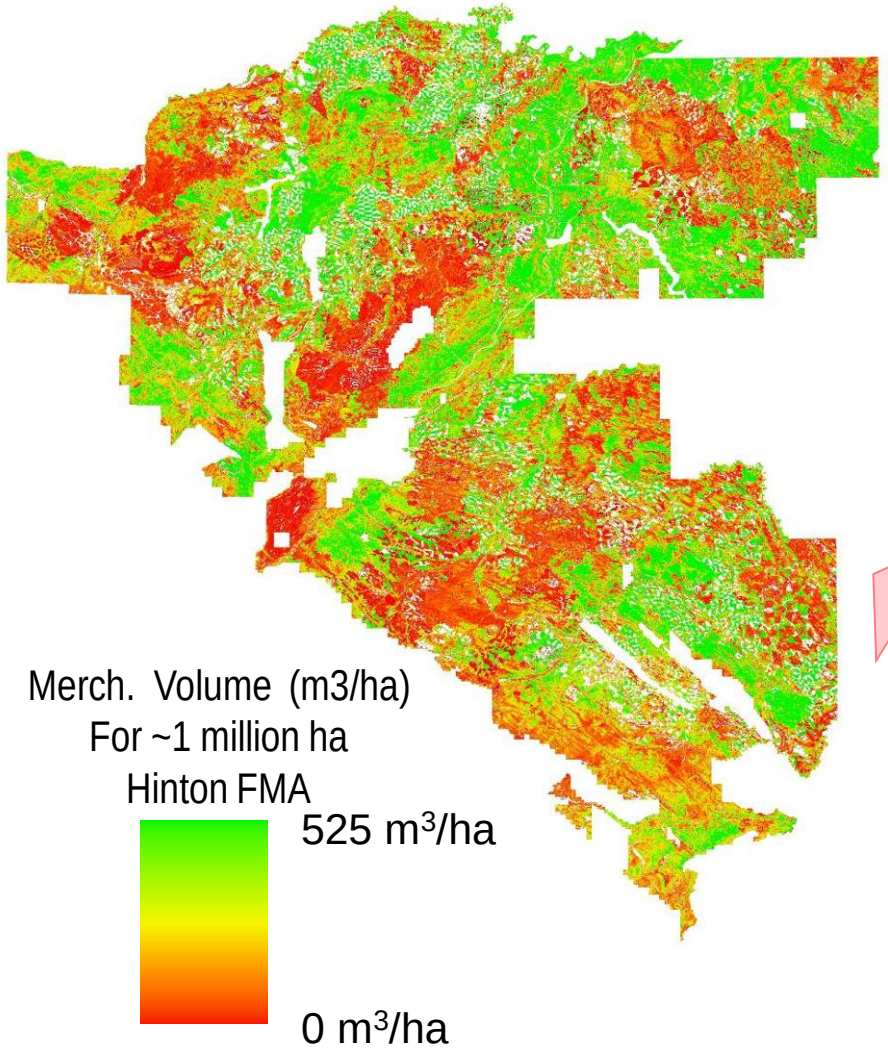




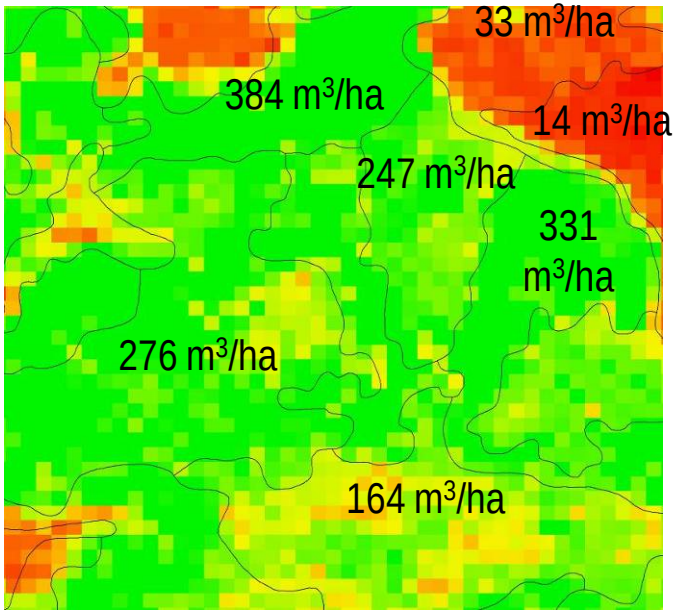
- Statistically-sound, sample-based estimates *for every grid-cell*
- Spatial…
  - mean & confidence interval for parameters in *any chosen polygon*
- *High Resolution*
  - *within–polygon variability*

Figures courtesy Murray Woods & Kevin Lim

Scalable from plot to landscape…



- This high resolution, spatial data can be summarized @ any scale of interest
  - from polygon to drainage to license depending on coverage



Yeah… but are the predictions any better?

Weight-scaled volume from 272 cutblocks harvested since LiDAR acquisition compared to predictions from LiDAR vs. Cover Type Adjusted Volume Tables

Block Size (m^3 X1000)	Source of Prediction	Predicted Volume – Scaled Volume	Statistically significant?
< 5 n = 138	**LiDAR** **CT Vol. Table**	**-6.7%** **-23.7%**	**No** **Yes**
5 – 10 n = 76	**LiDAR** **CT Vol. Table**	**+1.8%** **-17.4%**	**No** **Yes**
10 – 15 n = 25	**LiDAR** **CT Vol. Table**	**-1.2%** **-22.3%**	**No** **Yes**
15 – 20 n = 15	**LiDAR** **CT Vol. Table**	**-4.4%** **-23.5%**	**No** **Yes**
>20 n = 18	**LiDAR** **CT Vol. Table**	**+6.6%** **-17.4%**	**No** **No**

Vol.T. underestimated scaled volume by 19.8%
LiDAR overestimated scaled volume by 0.6%

West Fraser Mills Ltd.

Information courtesy Hinton Wood Products
A division of West Fraser Mills Ltd.