The *NEW* Ontario Woodlot Association: Initiatives on Private Land to Support Sustainable Forest Management

Huronia Woodland Owners Association Talk

ONTARIO WOODLOT ASSOCIATION
EST. 1992

HURONIA WOODLAND OWNERS

Ben Gwilliam

- Private Land Inventory Analyst (OWA)
- Background in computer science and forest conservation (Hon B.S.c, UofT)
- Worked in arboriculture
- MFC internship with OWA
- Leading private land inventory project (5 years)
- R.P.F in training

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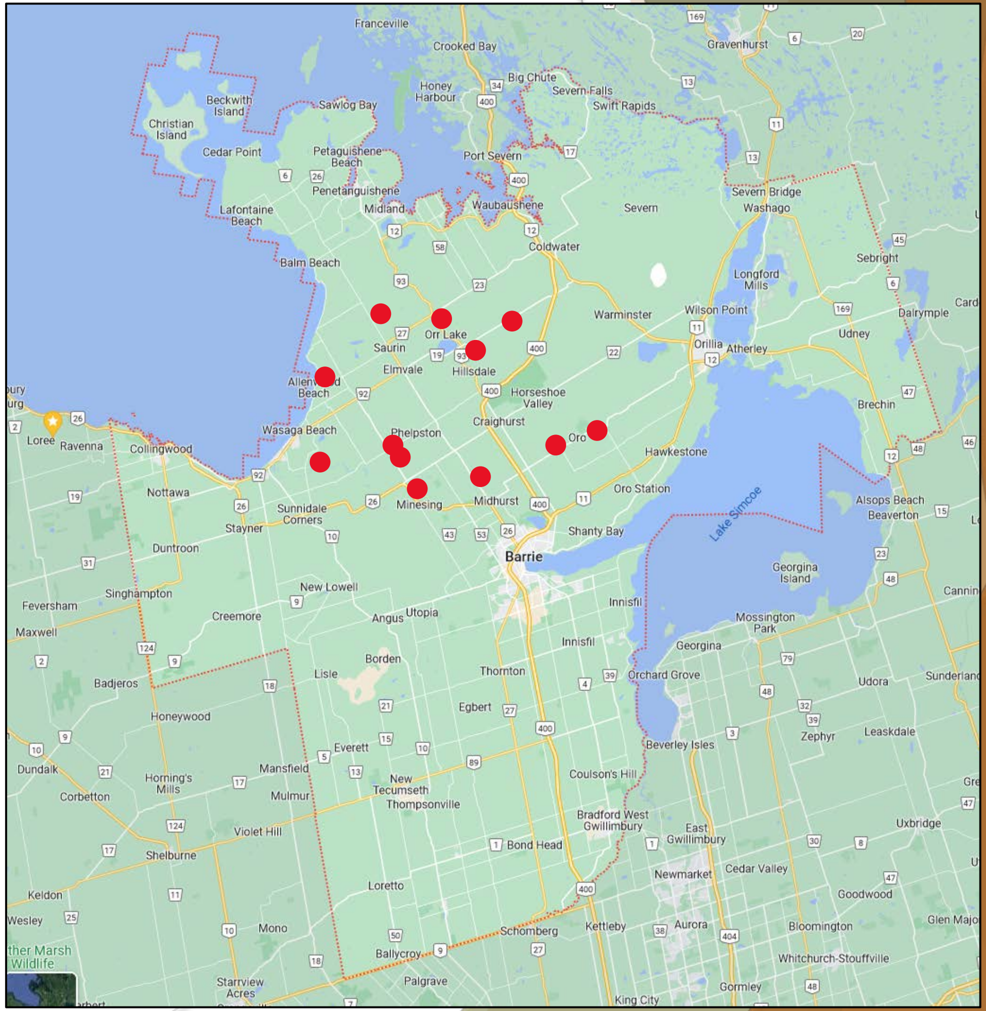
Agenda

- OWA Initiatives
  - Community Forest Owners Cooperative Program
  - Forest Stewardship Council Group Certification Program
  - Community Forest Carbon Offsets Program

- Private land inventory project
  - Lidar and eFRIs
  - Products and benefits
  - Climate change adaptation training
  - FSC expansion

Community Forest Owners Co-operative Program - Huronia Pilot

- ~20 participants in various stages of contract and management within close proximity of each other in Huronia
- Mix of landowners and land conservancies and expand to community forests
- OWA handles all aspects of management through its network (foresters, permits, tree-marking, harvesters, selling to mill) -> vetted
- Implement biodiversity monitoring protocol
- Position landowners to be FSC certified and access carbon offset markets
- Realized profit + benefit of good management, conversion to natural forest types, and invasive species control



Forest Stewardship Council
Group Forest Management Certification

- Achieved FSC certification in 2003 (through EOMF)
  - FSC C018800 Group Certificate Holder
- Certification Working Groups (CWGs) guide program
- More than 74,000 ha or 180,000 ac certified
  - 13 Community Forests
  - 2 Private commercial forests
  - 81 Private woodlots
  - 5 maple syrup producers

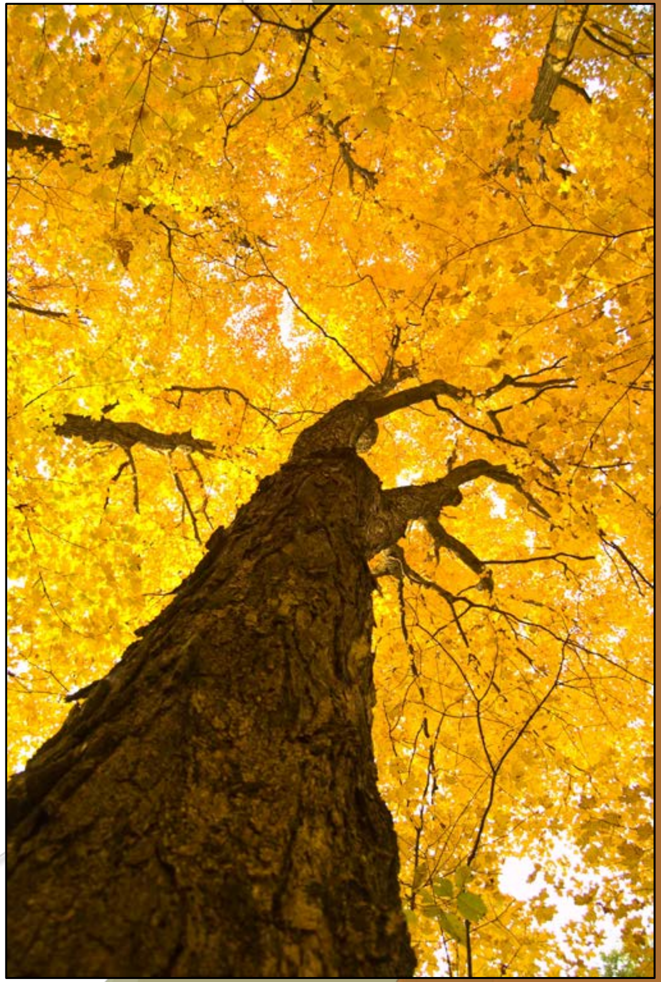
FSC

Forest Stewardship Council
Group Forest Management Certification

- Benefits of Certification
  - Enhance your product value
  - High public support
  - Credible and defendable for community forests
  - Framework for sustainable forest management
  - Confidence to harvest
  - Third-party verification
  - Market access
  - Up-to-date best practices
  - Networking and learning
  - Framework for carbon offsets

Community Forest Carbon Offsets Program

- Forest owners can sell their carbon stored into the carbon market
- EOMF/OWA has partnered with Anew (formerly Bluesource) as of 2018
- Currently only areas > 5000 acres are financially viable
  - Working on developing pooling of multiple landowners carbon
- Must be third-party certified (FSC, SFI)
- OWA handles all paperwork, auditing, and liaison with carbon offset supplier -> Turn-key



Enhancing Carbon Capture and Biodiversity in Ontario's Privately Owned Forests using Best Management Practices Informed by High Resolution Inventory

“Private Lands Advanced Inventory Project”

ONTARIO WOODLOT ASSOCIATION

Environment and Climate Change Canada

Environnement et Changement climatique Canada

Partners

CRIBE centre for research & innovation in the bio-economy

Ontario
Ministry of Natural Resources and Forestry

Confederation College

Eastern Ontario Model Forest
www.eomf.on.ca

Algonquin College

South Nation Conservation
de la Nation Sud

Invasive Species Centre

Fleming

TreeDimensions

Climate Risk Institute

University of Toronto

Project Breakdown

- 5 – year project (2027)
- Three main objectives:
  - 1. High-resolution private land inventory
    - Not been done since 1978
  - 2. Climate change adaptation training program
  - 3. Forest Stewardship Council (FSC) certification program

High-resolution Private Land Inventory

- Landowner decision-making
- MFTIP development
- Other OWA projects
- Municipal/Conservation operational planning
- Private land forest industry

FSC Expansion Program

Climate Change Adaptation Training Program

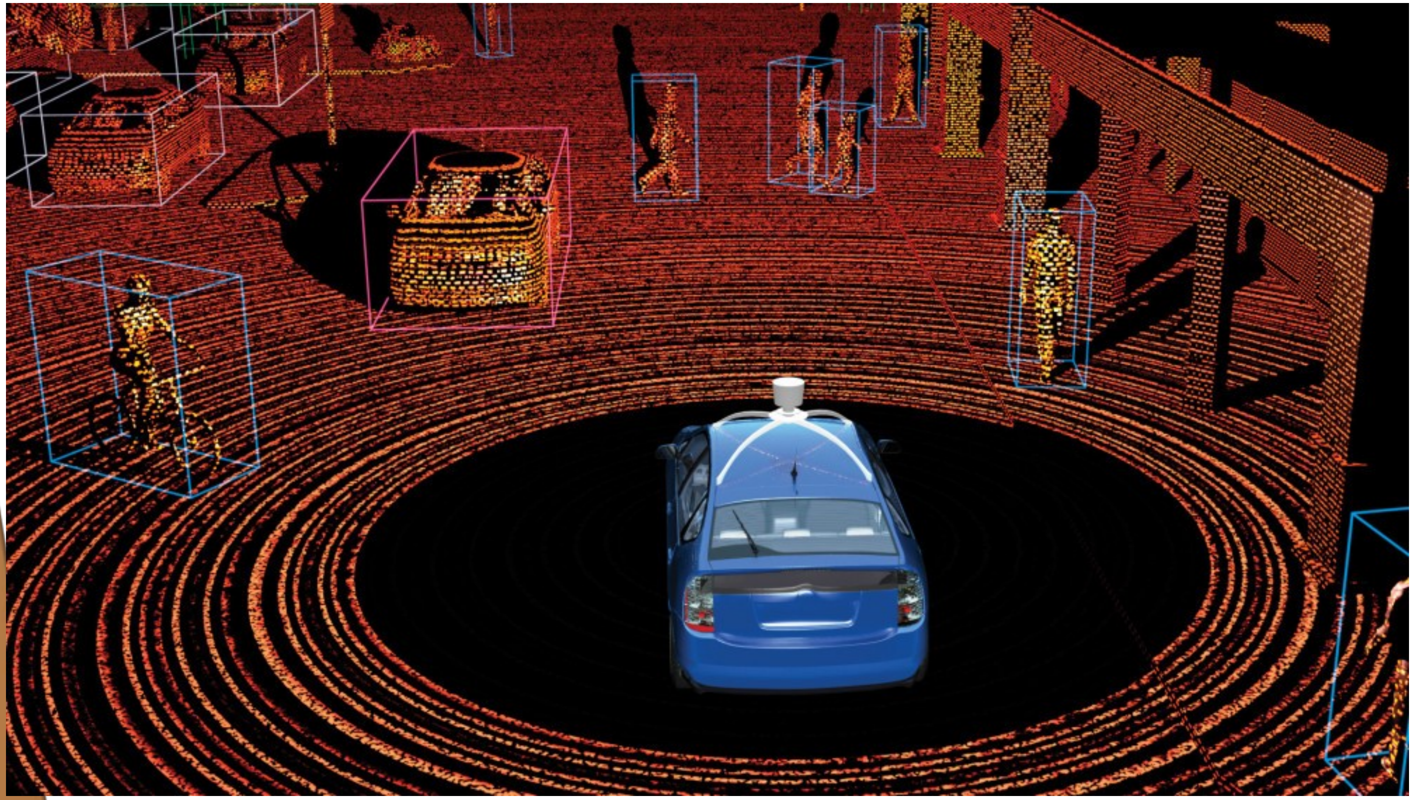
High-Resolution Private Land Inventory (breakdown)

- Enhanced Forest Resource Inventory (eFRI)
- Based on available LiDAR data within past 5 years (MNRF, Provincial, or OWA)
- Produce all forest resource inventory attributes
- Produce other LiDAR products (detailed terrain mapping, water/wetness index, canopy height)
- Species identification based on ground truthing and multispectral data
- Secondary focus on modelling carbon stocking and wildlife habitat

What is LiDAR and enhanced forest resource inventories?

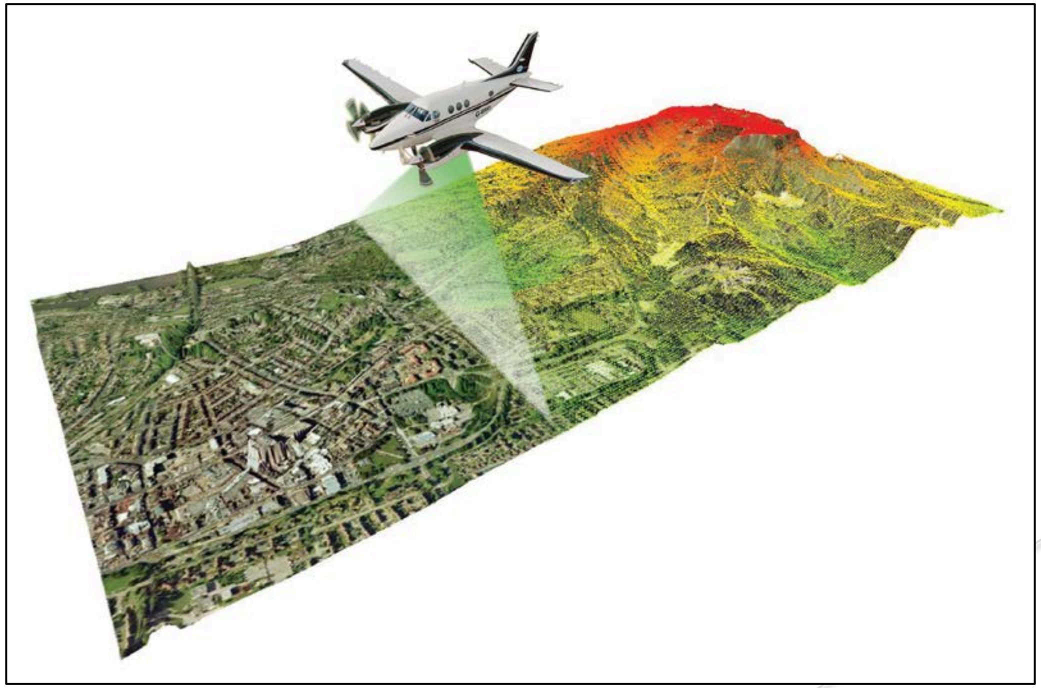
LiDAR - Light Detection And Ranging

- Industrialization 4.0 -> Photonics (The manipulation of light energy or LASERS)

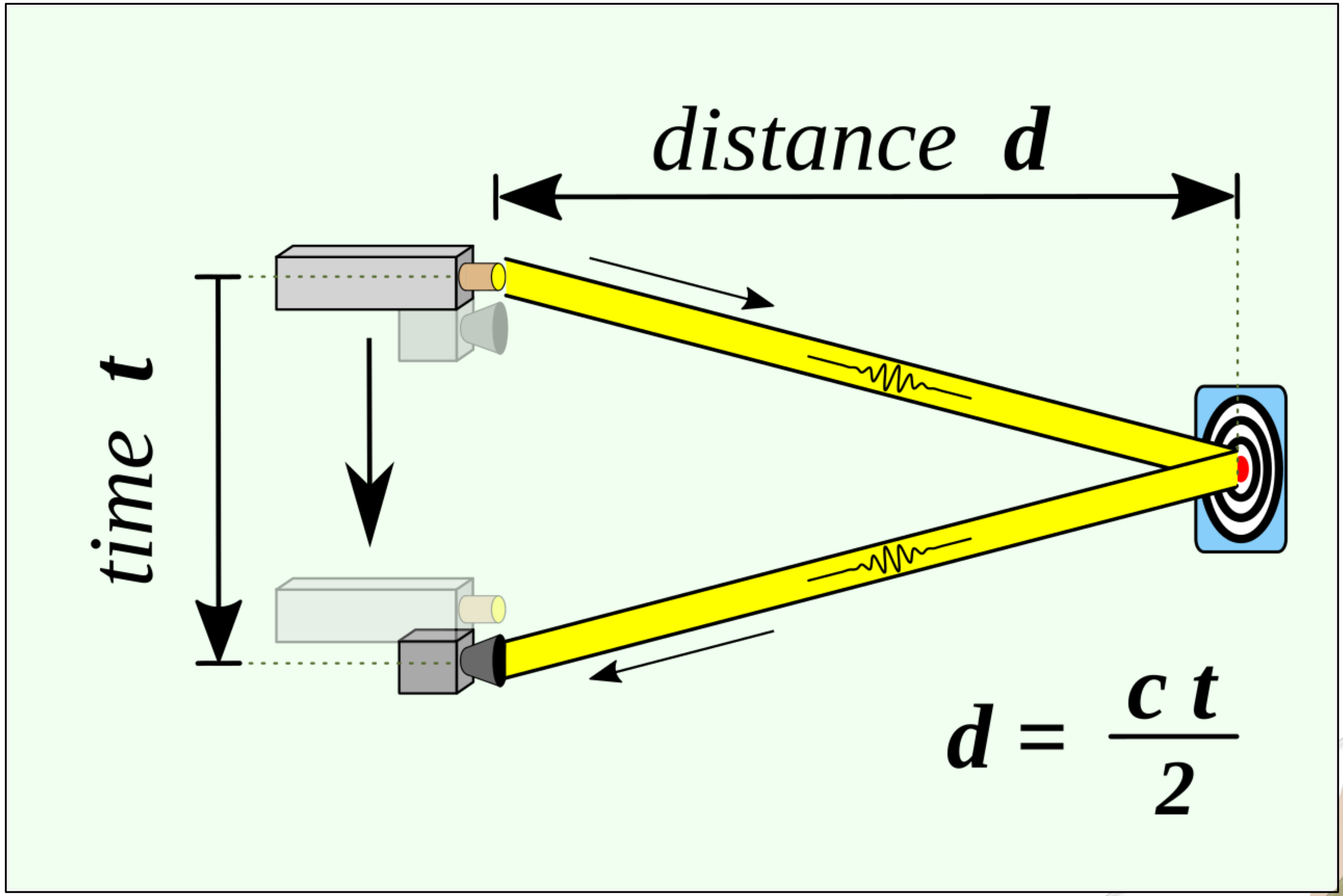


LiDAR - Light Detection And Ranging

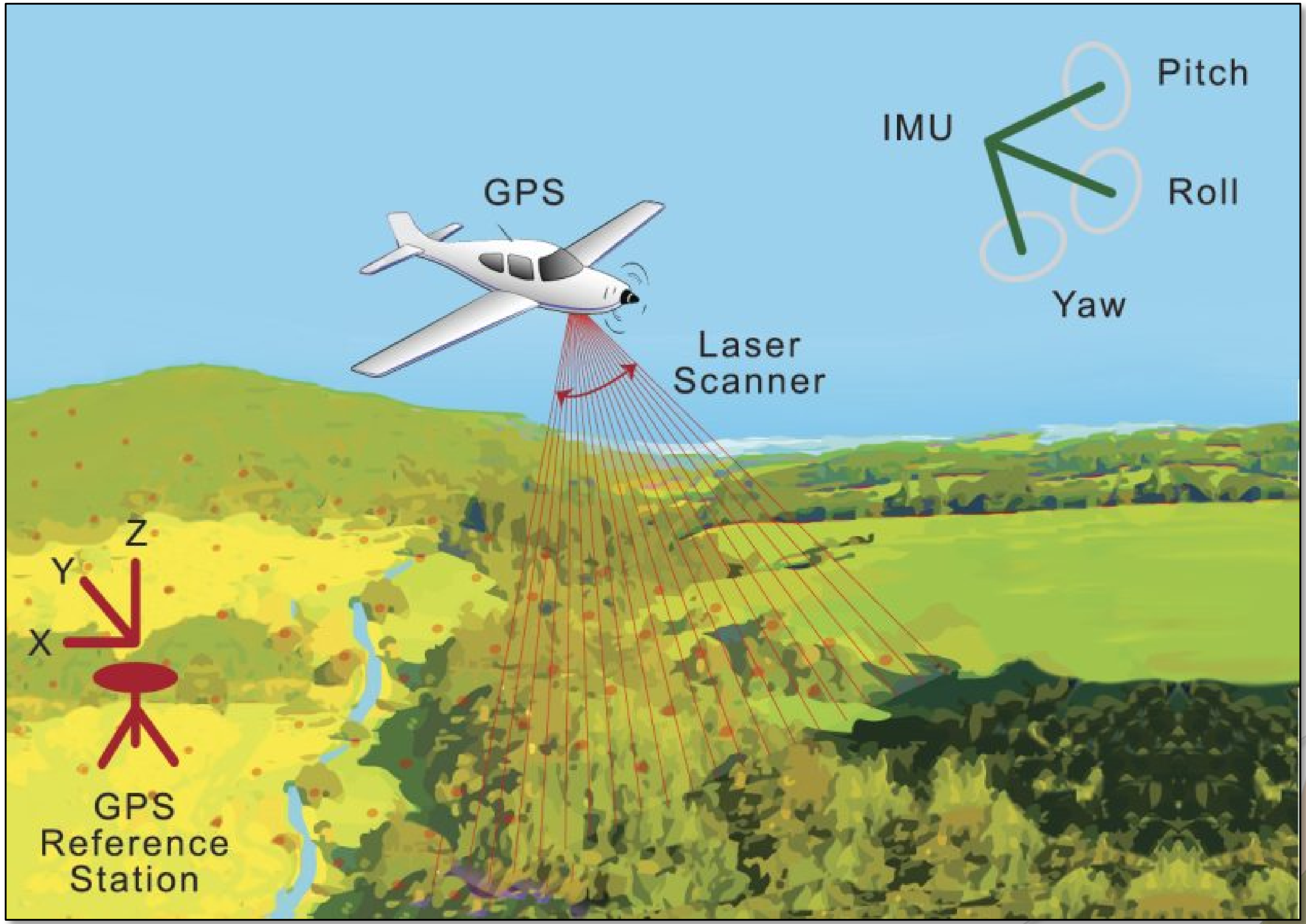
- Active sensor that uses light emitted as a laser (similar to RADAR and SONAR)
- Measures structure of the terrain and objects
- Aerial platform is primarily used in forestry applications



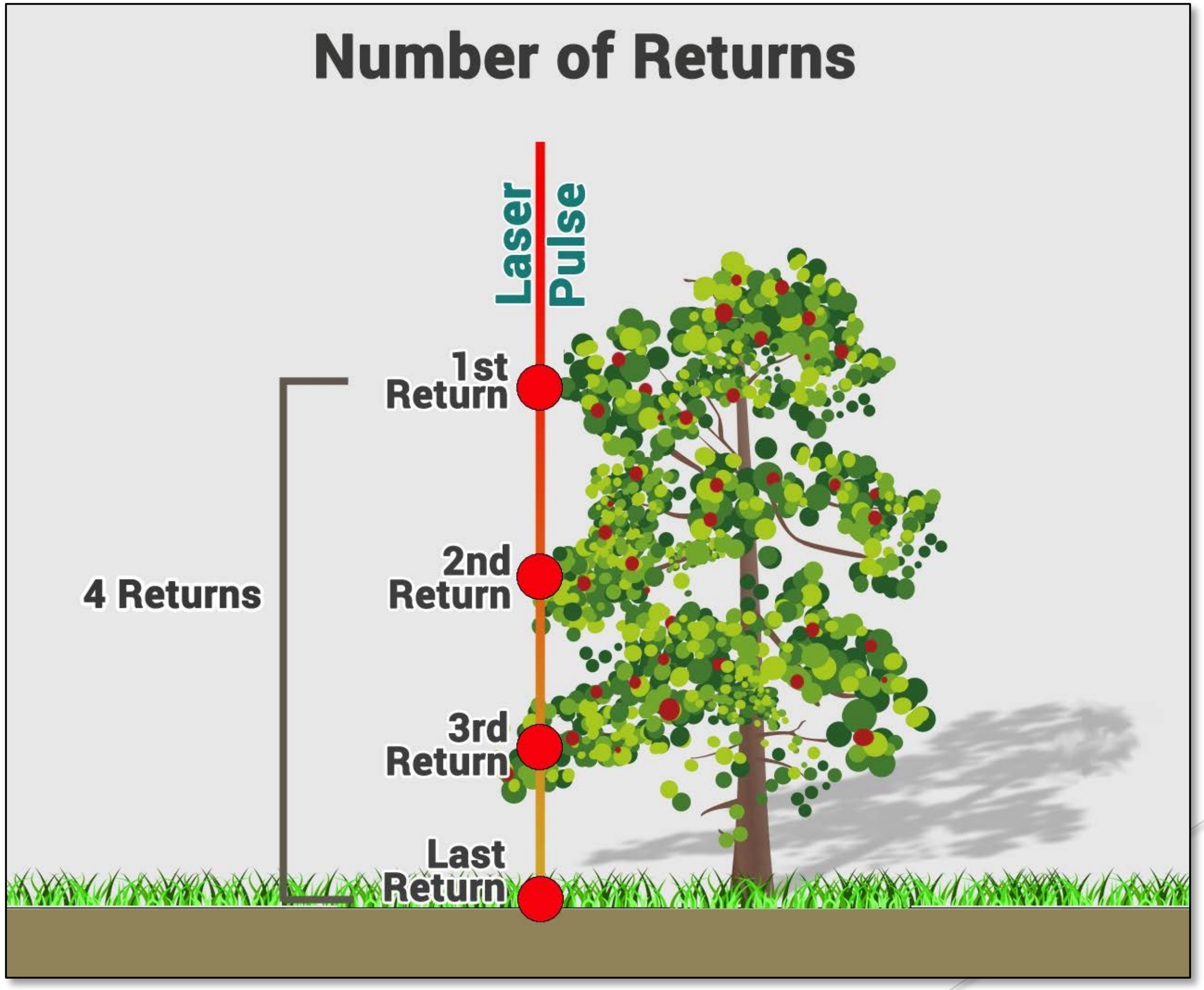
LiDAR: Basic Principles



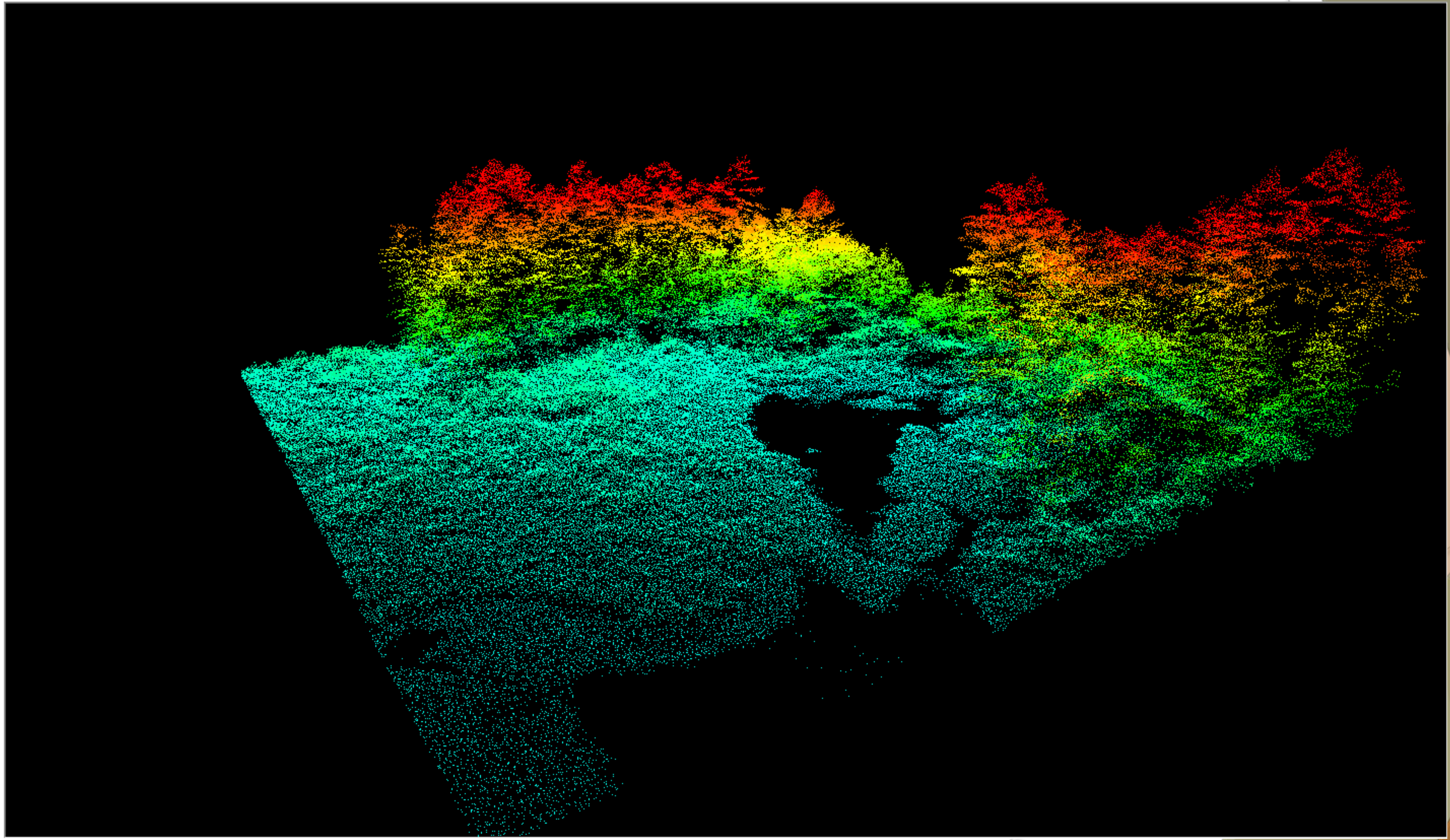
LiDAR: Basic Principles - In the air



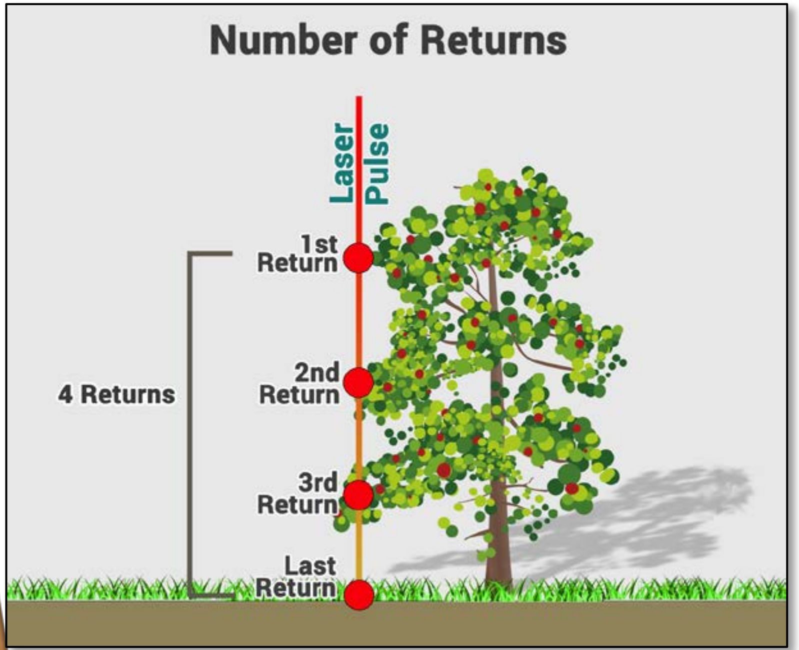
LiDAR: Basic Principles – On the ground

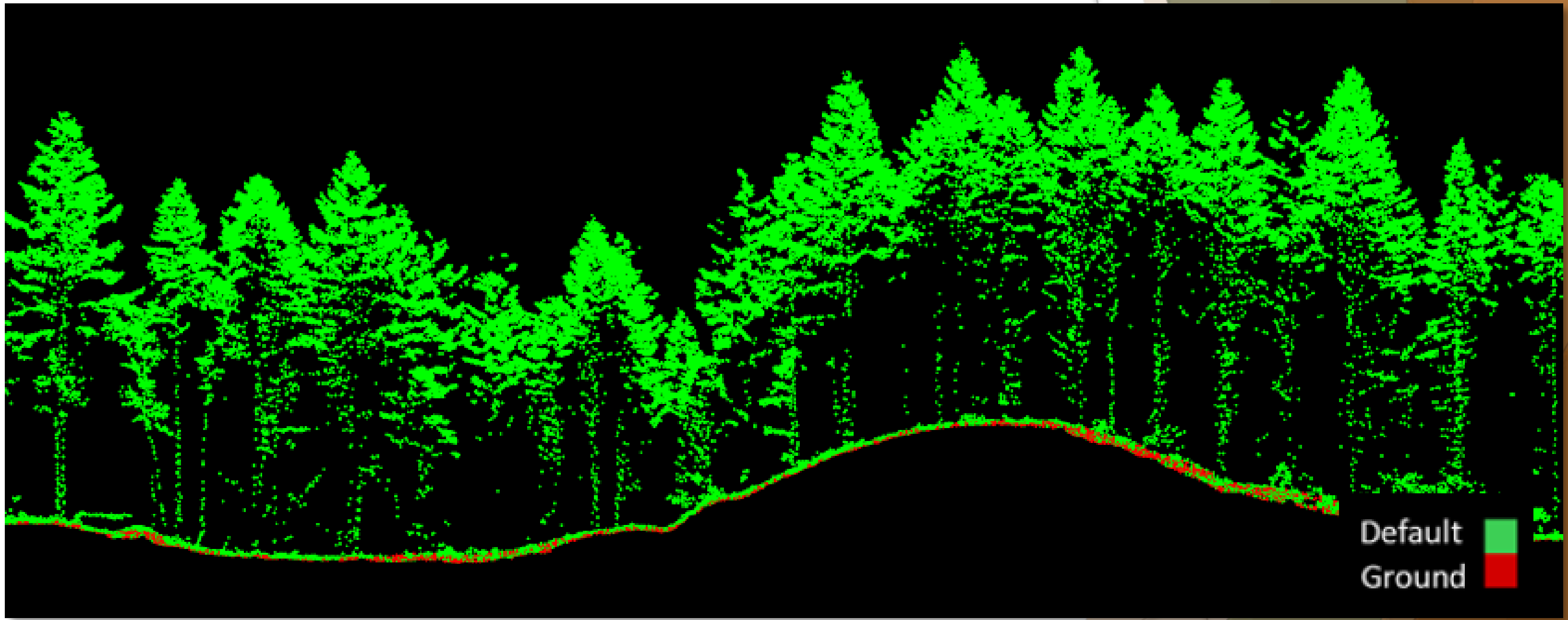


LiDAR: The Point Cloud

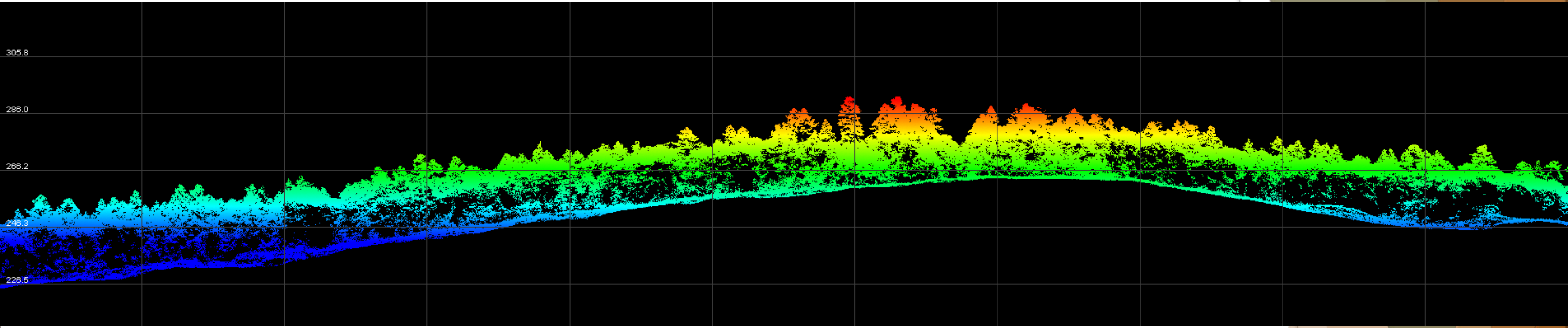


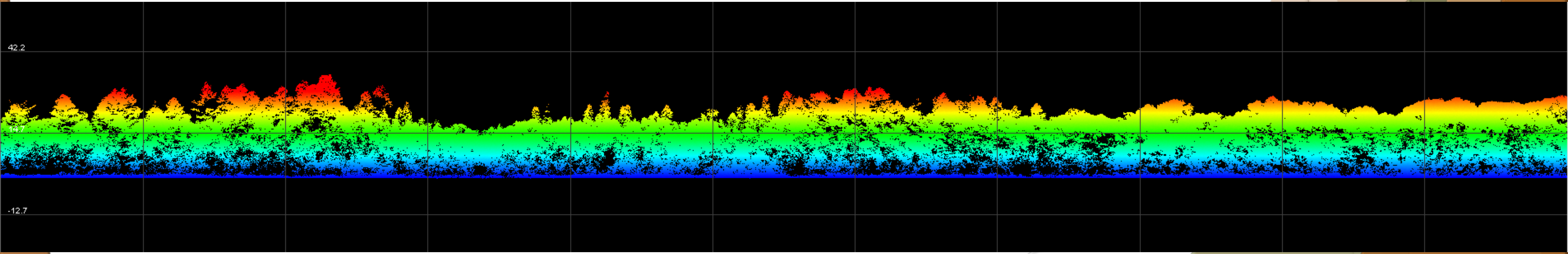
LiDAR: Point Cloud



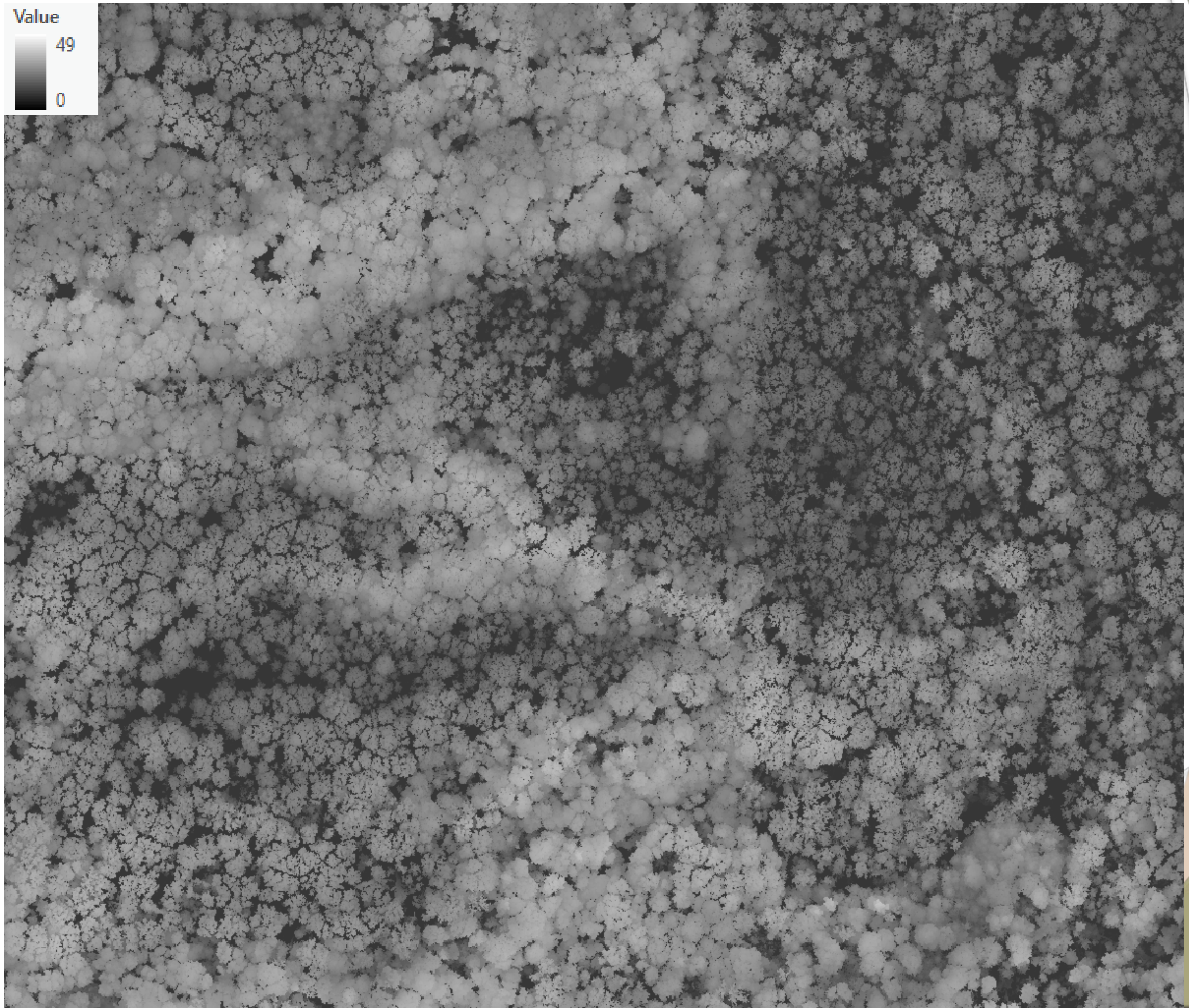


LiDAR: How does this relate to forestry?

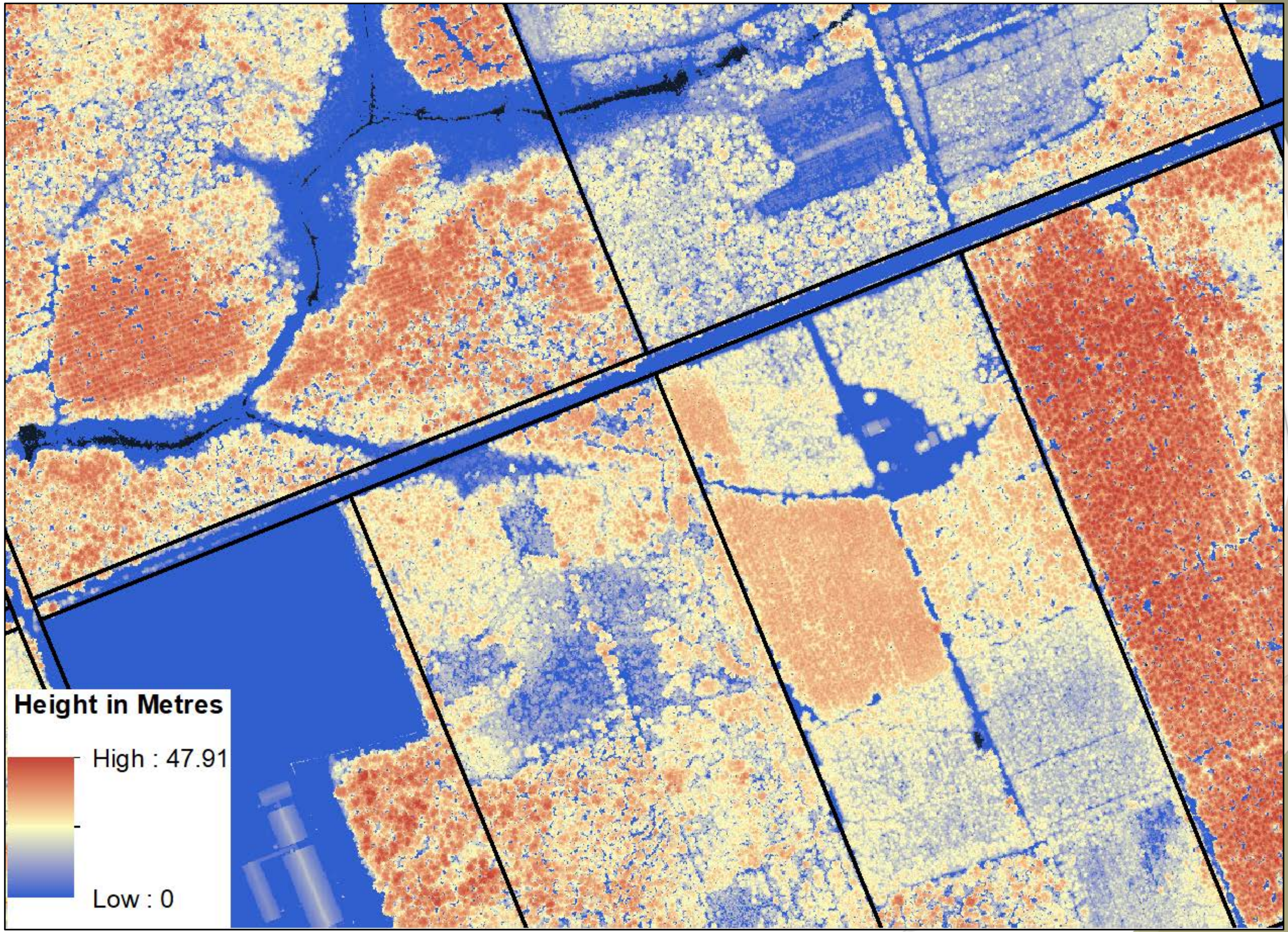




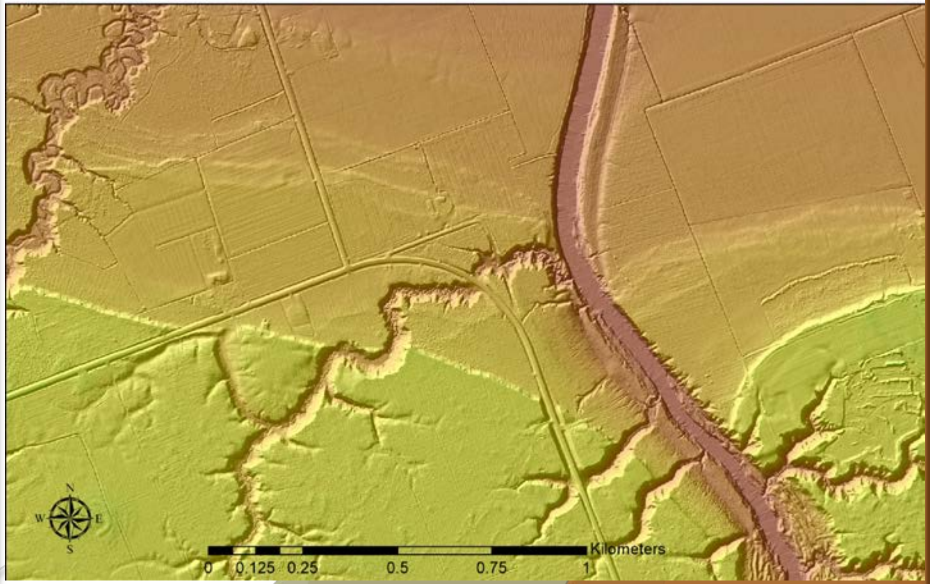
LiDAR Forestry Products: Canopy Height Model



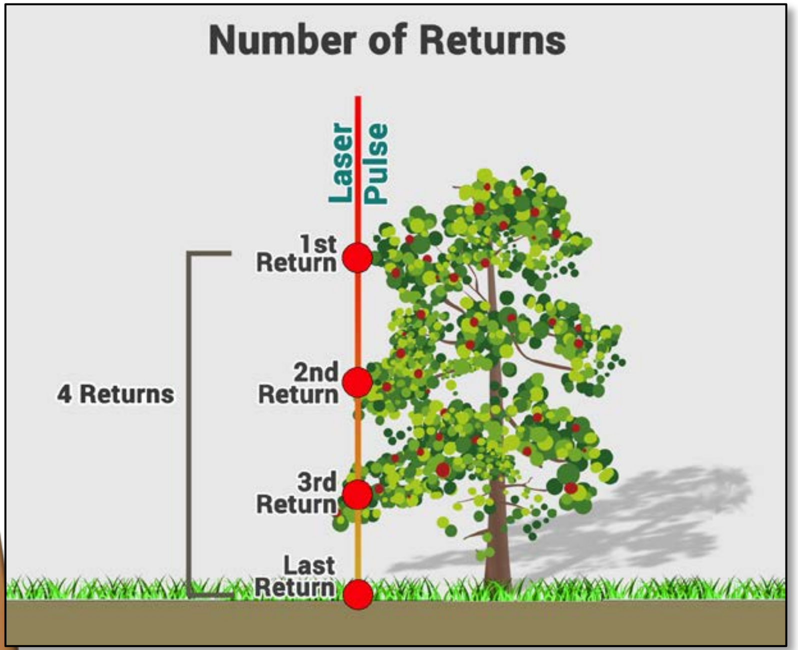
LiDAR Forestry Products: Canopy Height Model



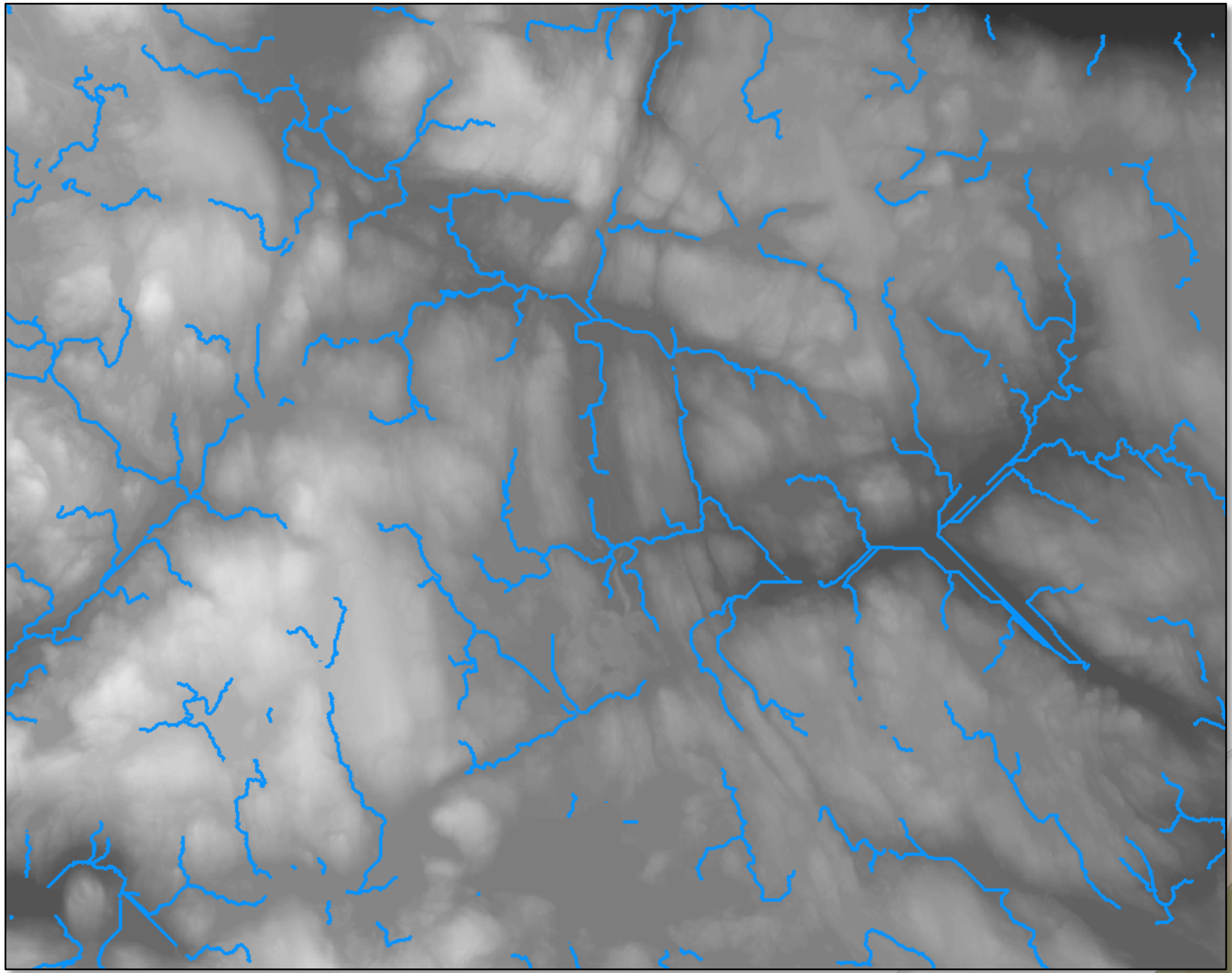
LiDAR Forestry Products: Digital Terrain Model



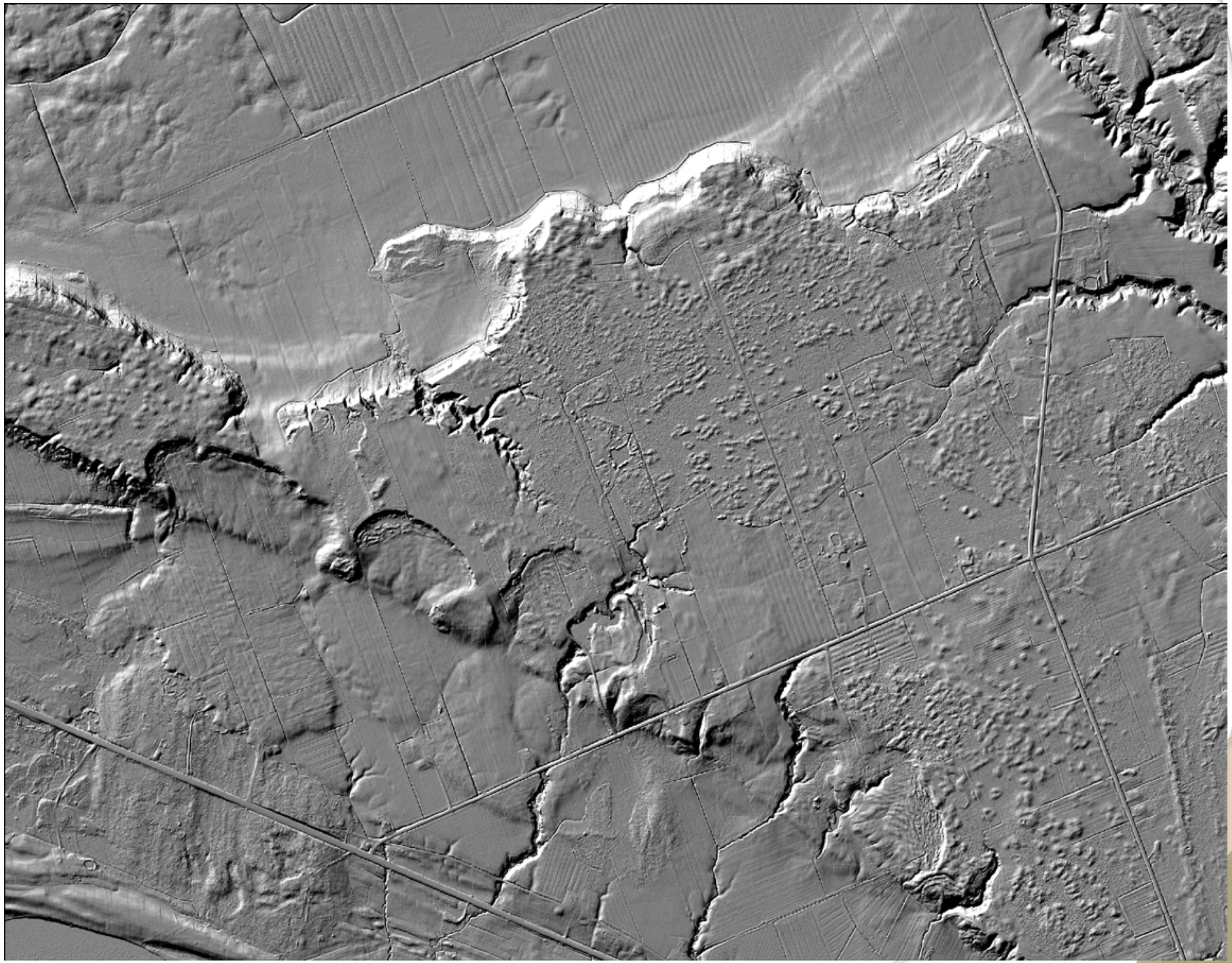
LiDAR Forestry Products: Digital Terrain Model



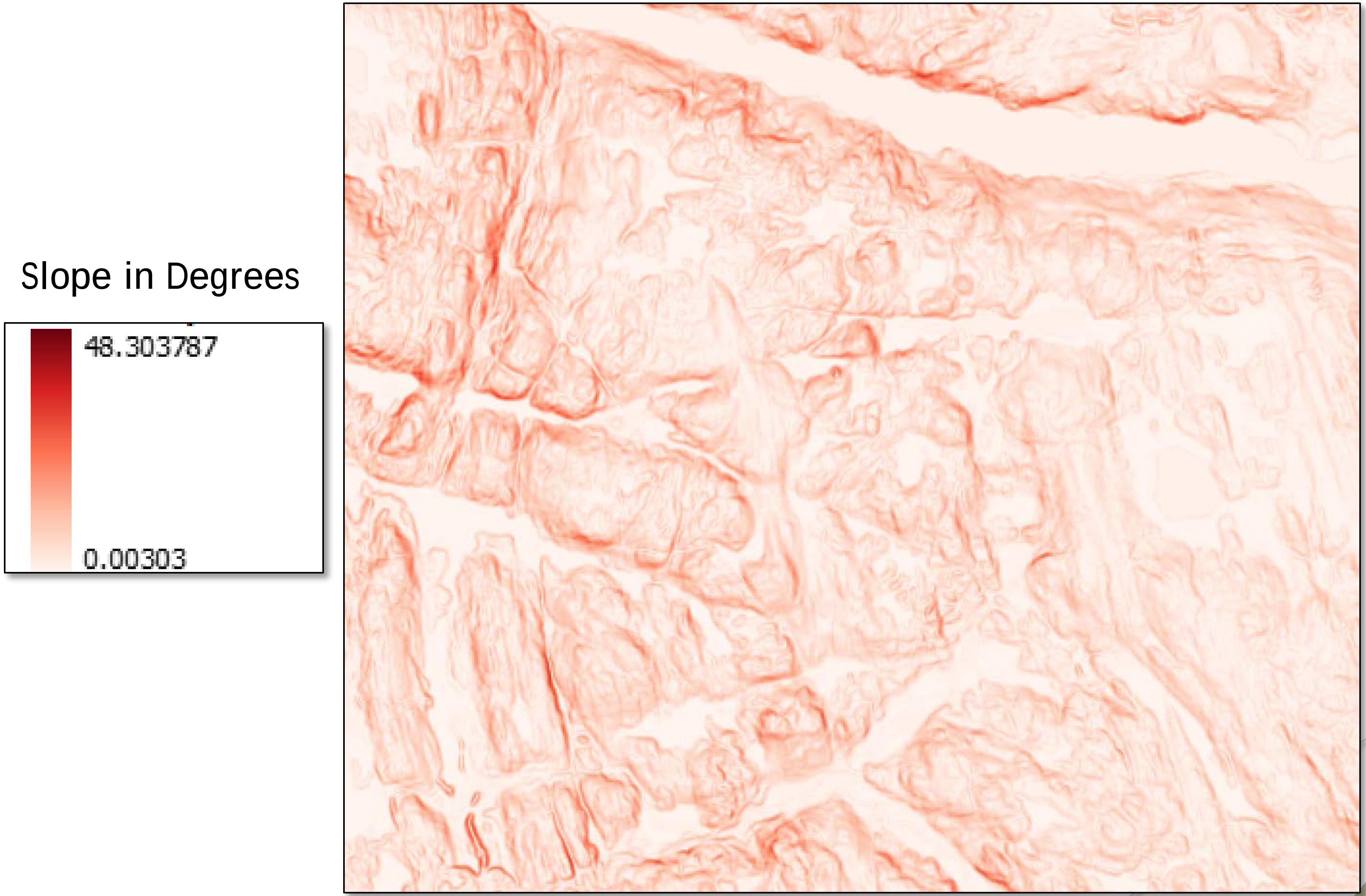
LiDAR Forestry Products: Predicted Watercourses



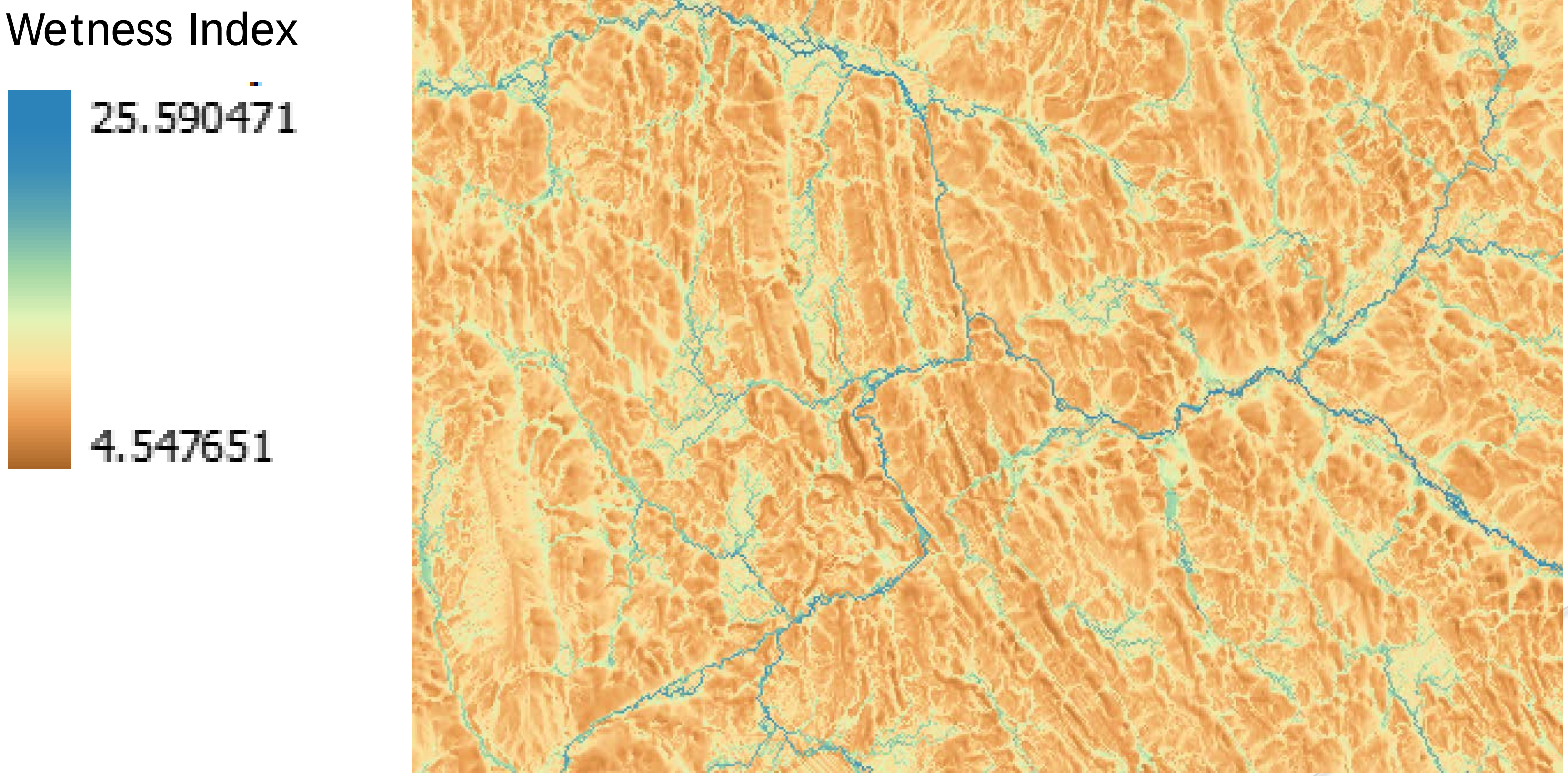
LiDAR Forestry Products: Hillshade model



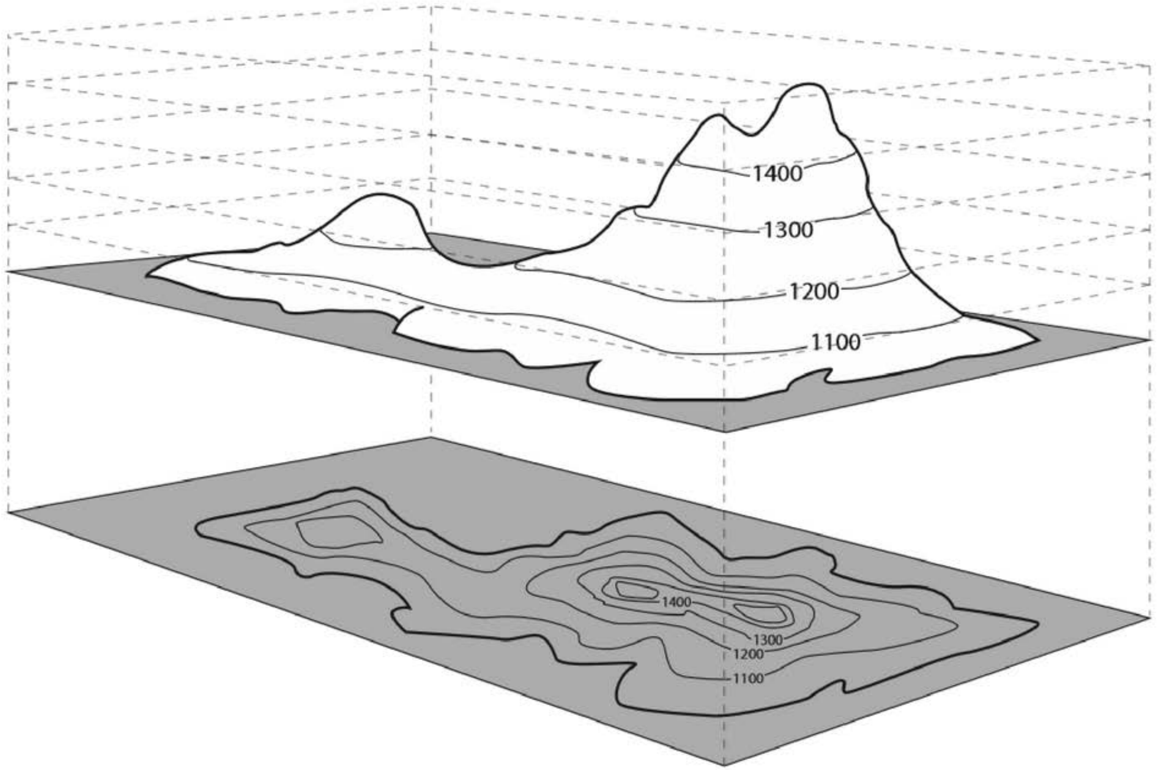
LiDAR Forestry Products: Slope

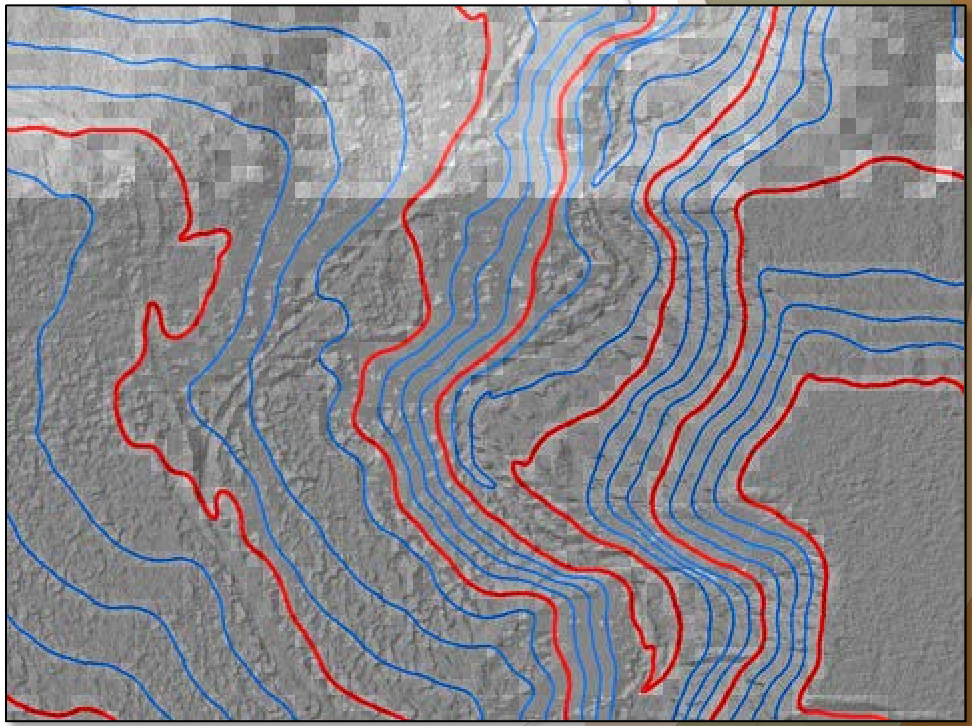


LiDAR Forestry Products: Topographic Wetness Index



LiDAR Forestry Products: Contours





LiDAR Forestry Products:
Indirect (Predicted) Products

LiDAR Forestry Products: Indirect Products

- Modelled based on LiDAR data to make predictions
  - Machine Learning (Random Forest)
- Inventory attributes such as:
  - Basal area
  - Volumes
  - Biomass
  - Canopy complexity
  - Dbhq (average diameter)
- Requires **extensive** ground truthing -> Forest Tech Programs

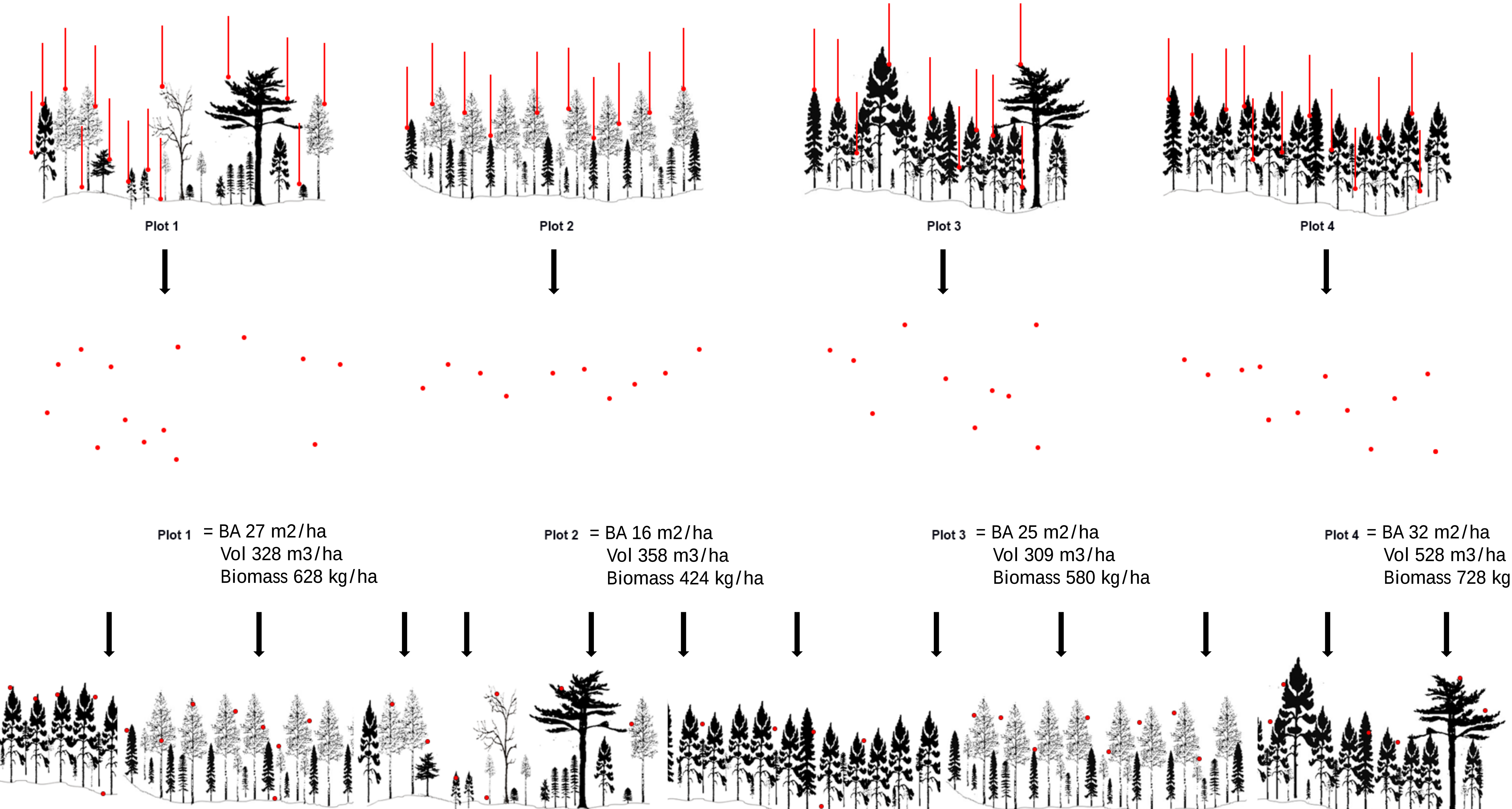
How to produce inventory attributes from LiDAR

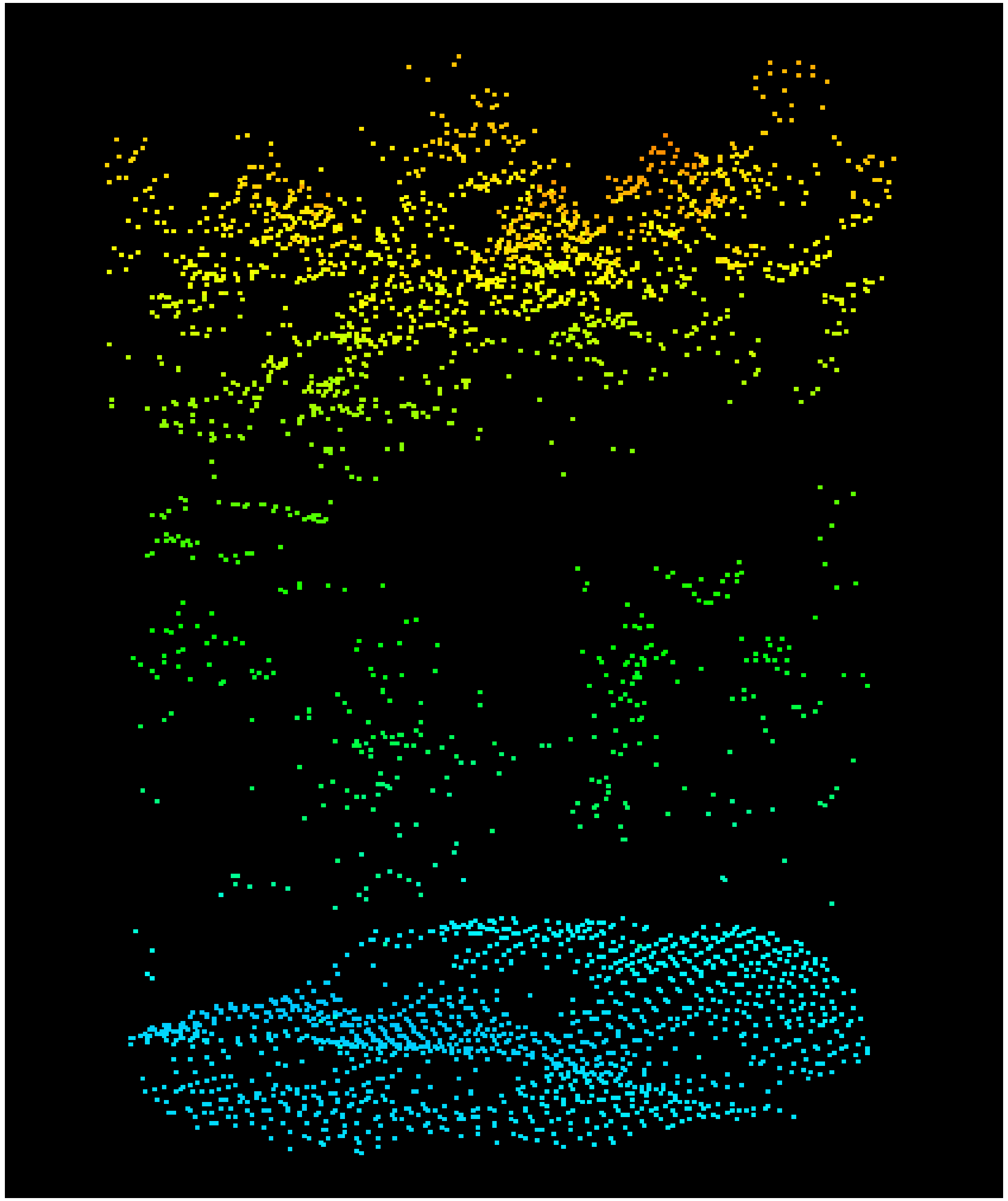
- Ground truthing = 100 – 200 plots for a county-sized area (~ 2000 km2)
- Each plot is fixed-area 400 m2 measuring
  - Tree heights -> ideally all
  - Diameters
  - Species
  - Crown height
  - Live AND dead

How to produce inventory attributes from LiDAR

- This approach is called an **Area-Based** inventory

- We are taking what we know about inventory attributes (volumes, basal areas, q-mean diameter) at each measured plot (from the heights and diameters) and applying to all similar areas outside of these plots


Plot 1
Plot 2
Plot 3
Plot 4
Plot 1 = BA 27 m2/ha
Vol 328 m3/ha
Biomass 628 kg/ha
Plot 2 = BA 16 m2/ha
Vol 358 m3/ha
Biomass 424 kg/ha
Plot 3 = BA 25 m2/ha
Vol 309 m3/ha
Biomass 580 kg/ha
Plot 4 = BA 32 m2/ha
Vol 528 m3/ha
Biomass 728 kg

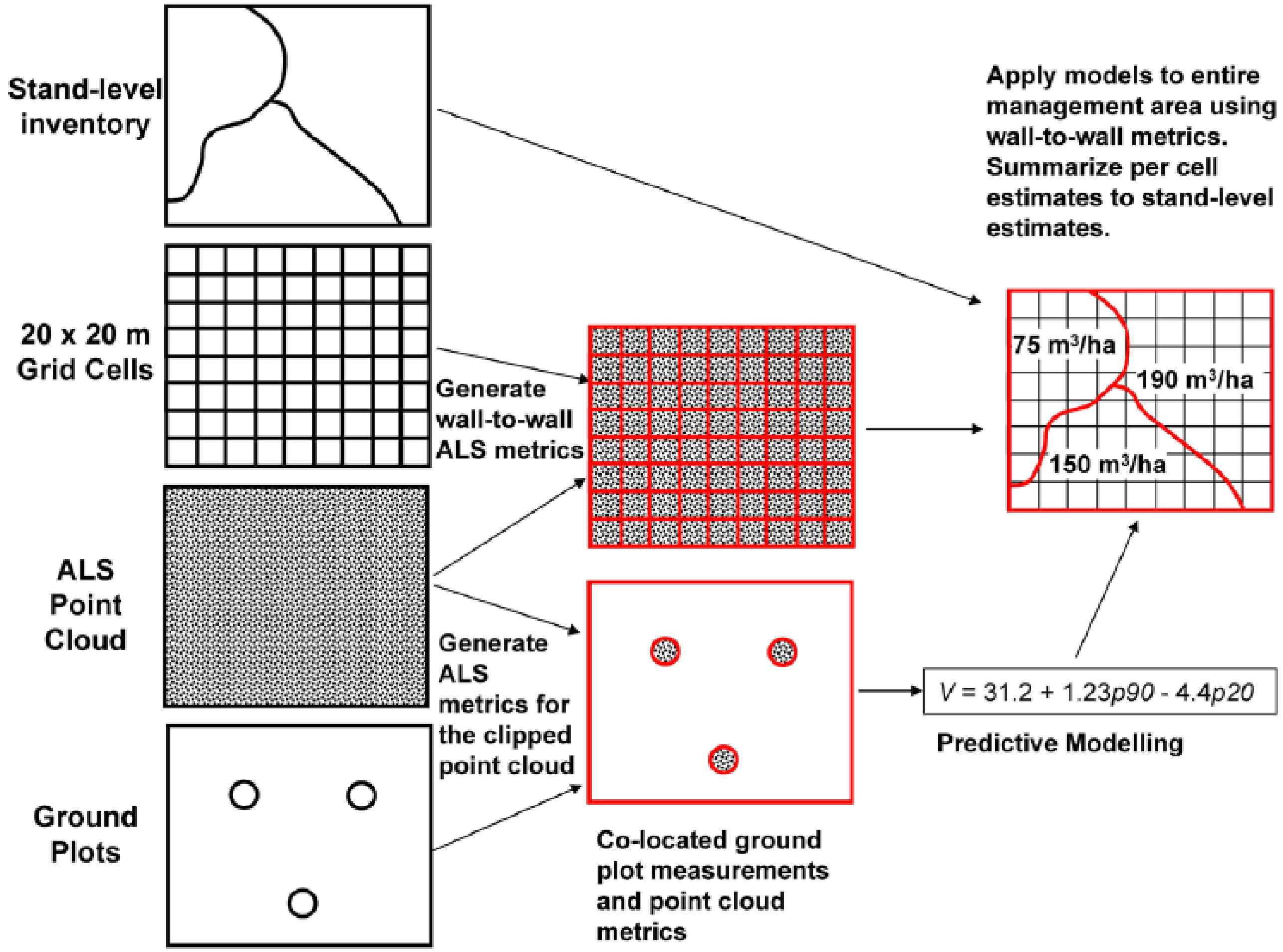


= -BA 27 m2/ha

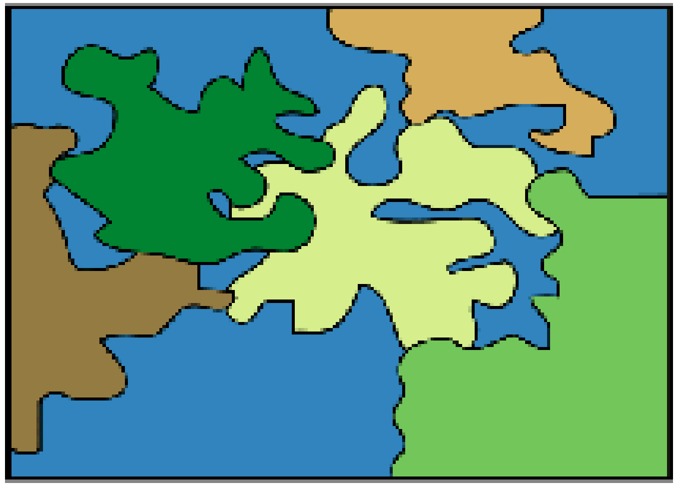
-Merch Vol 328 m3/ha

-Biomass 628 kg/ha

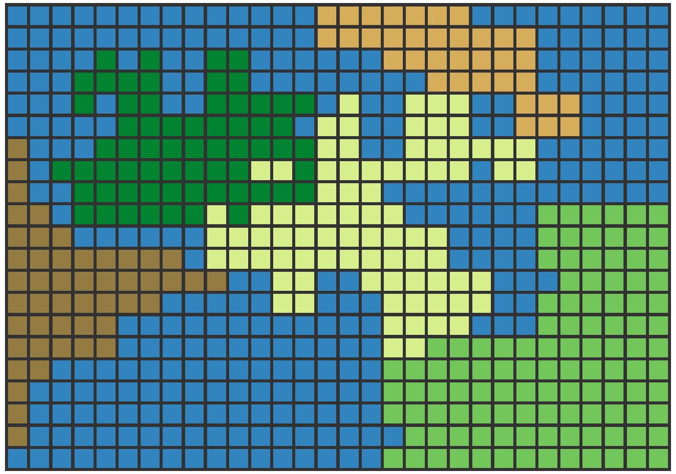
How to produce inventory attributes from LiDAR



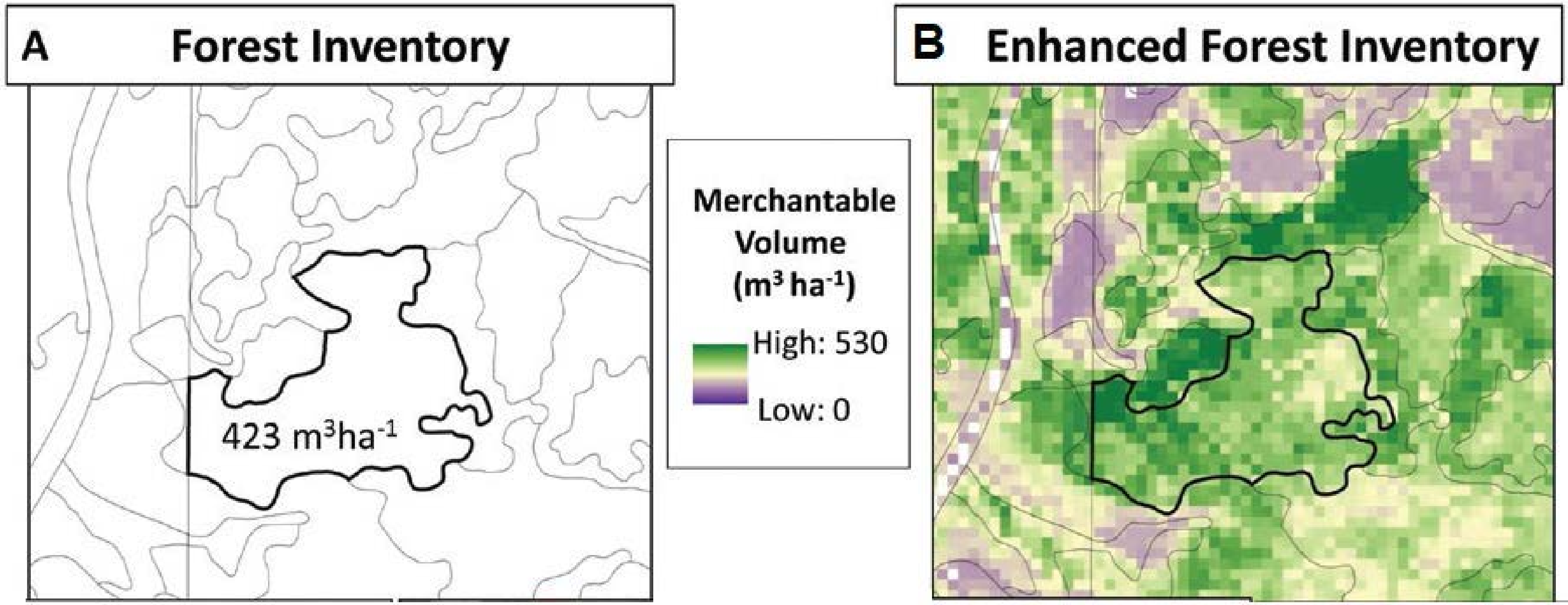
The enhanced Forest Resource Inventory



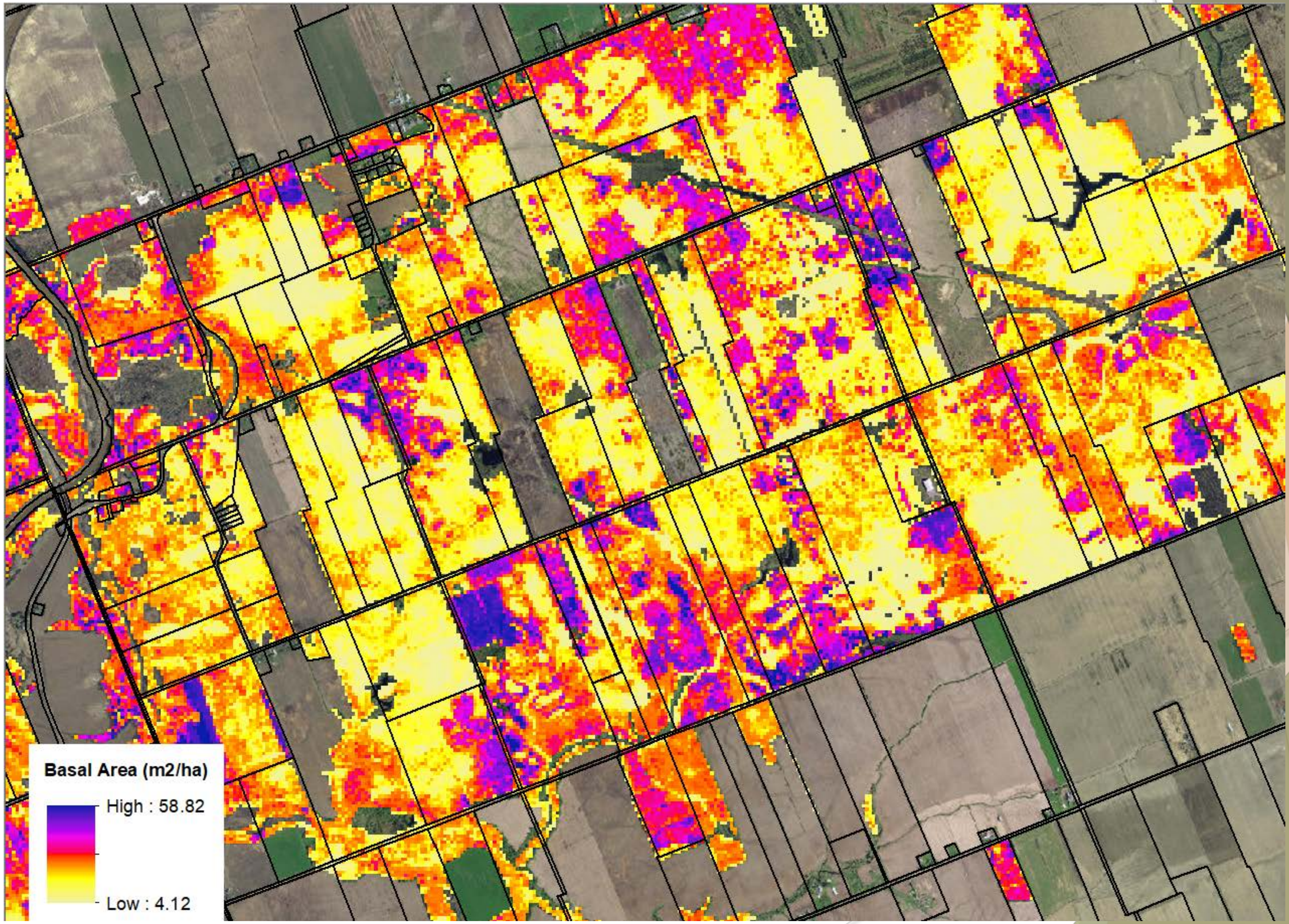
Polygon features



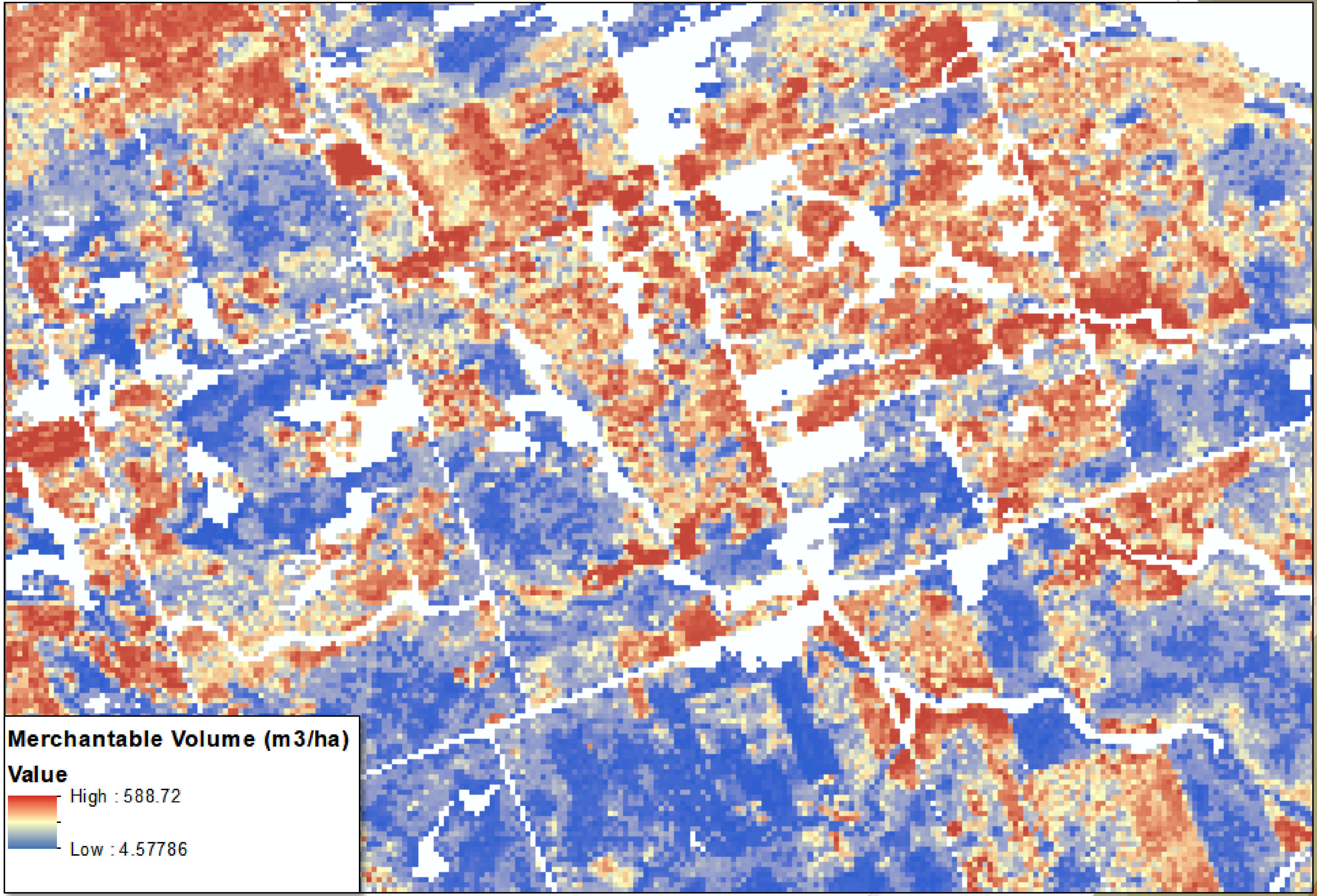
Raster polygon features



eFRI – Basal Area in Prescott and Russell



eFRI - Volume in Prescott and Russell



Inventory Attributes Predicted

- Top Height (m)
- Average Height (m)
- Merchantable Basal Area (m2/ha)
- Quadratic mean Dbh (cm)
- Merchantable VBAR (m3/m2)
- Total VBAR (m3/m2)
- Merchantable Above Ground Biomass (kg/ha) **-> Carbon Sequestration**
- Merchantable Volume (m3/ha)
- Total Merchantable Volume (m3/ha)
- Stems (stems/ha)
- Density measurements -> Canopy and understory -> Avian and mammal habitat

* Most of these measurements (BA, Vol, Stems) by size class (Pole, Small, Med, Large)

LiDAR Accuracy

silviculture

A Comparison of Accuracy and Cost of LiDAR versus Stand Exam Data for Landscape Management on the Malheur National Forest

Susan Hummel, A.T. Hudak, E.H. Uebler, M.J. Falkowski, and K.A. Megown

ABSTRACT

Foresters are increasingly interested in remote sensing data because they provide an overview of landscape conditions, which is impractical with field sample data alone. Light Detection and Ranging (LiDAR) provides exceptional spatial detail of forest structure, but difficulties in processing LiDAR data have limited their application beyond the research community. Another obstacle to operational use of LiDAR data has been the high cost of data collection. Our objectives in this study were to summarize, at the stand level, both LiDAR- and Landsat (satellite)-based predictions of some common structural and volume attributes and to compare the cost of obtaining such summaries with those obtained through traditional stand exams. We found that the accuracy and cost of a LiDAR-based inventory summarized at the stand level was comparable to traditional stand exams for structural attributes. However, the LiDAR data were able to provide information across a much larger area than the stand exams alone.

Keywords: silviculture, forest management, LiDAR, inventory, stand exams

Remotely sensed data are helping people understand the dimensions and distribution of trees in forested areas that are too large or rugged to survey on foot alone. This is a global trend that is helping document the status of forests worldwide. Because remotely sensed data are typically collected above the canopy, one persistent question is how well such data can be used to inform operational decisions in forestry. It is an important question because digital remote sensing data are now supplanting the aerial photo surveys that forest-ers used for decades. Landsat satellite imagery is inexpensive and has been useful at a regional scale, but lacks the higher spatial resolution preferred for local project decisions. Light Detection and Ranging (LiDAR) data are receiving more attention because of their detailed structural information and established accuracy in research studies (Eid et al. 2004, Næsset 2002, 2009). Progress in addressing the question about operational uses of LiDAR is being made for some local forest attributes (e.g., Hudak et al. 2008b, Hollaus et al. 2009, Falkowski et al. 2010). Information is still lacking, however, on how the different sources of remotely sensed data and the methods to process them into useable information compare with one another in terms of a gain in knowledge about forest conditions relative to their overall cost. To address this need, we evaluated how information derived from both Landsat satellite and LiDAR data compared, in terms of accuracy and cost, with data collected by using traditional field exams. We also considered how the physical size of a management area might impact the relationship.

Background

A historical focus on increasing timber yield via forest management contributed to early field methods for estimating tree growth at different levels of competition (Hummel and O'Hara 2008): measurements or observations of forest structure were typically made within small, homogeneous units, or stands. Today, however, wood fiber is just one of many resources considered by forest managers, who may be responsible for decisions impacting multiple resources over large, heterogeneous land-

Operational implementation of a LiDAR inventory in Boreal Ontario

Murray Woods[1], Doug Pitt[2], Margaret Penner[3], Kevin Lim[4], Dave Nesbitt[1], Dave Etheridge[5] and Paul

ACT
sting Light Detection and Ranging (LiDAR) data set captured on the Romeo Malette Forest near Timmins,
ed to explore and demonstrate the feasibility of such data to enrich existing strategic forest-level resource i
Despite suboptimal calibration data, stand inventory variables such as top height, average height, basal ar
olume, gross merchantable volume, and above-ground biomass were estimated from 136 calibration p
ed on 138 independent plots, with root mean square errors generally less than 20% of mean values. Stand
per ha) were estimated with less precision (30%). These relationships were used as regression estimators t
ite of variables for each 400-m² tile on the 630 000-ha forest, with predictions capable of being aggr
er-defined manner—for a stand, block, or forest—with appropriate estimates of statistical precision. T
demonstrated that LiDAR data may satisfy growing needs for inventory data to scale operational/tactical,
ic needs, as well as provide spatial detail for planning and the optimization of forest management activiti
ords: forest inventory, Light Detection and Ranging (LiDAR), models, Seemingly Unrelated Regression

Roméo Malette près de Tim
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MDPI

dual Tree Height Information d Surveys, LiDAR and UAV-DAP mber Species in Northern Japan

Owari [3], Naoyuki Furuya [4] and Takuya Hiroshima [5]

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Abstract: High-value timber species such as monarch birch (*Betula maximowicziana* Regel), cast aralia (*Kalopanax septemlobus* (Thunb.) Koidz), and Japanese oak (*Quercus crispula* Blume) pl important ecological and economic roles in forest management in the cool temperate mixed fores in northern Japan. The accurate measurement of their tree height is necessary for both practic management and scientific reasons such as estimation of biomass and site index. In this study, v investigated the similarity of individual tree heights derived from conventional field survey, digit aerial photographs derived from unmanned aerial vehicle (UAV-DAP) data and light detection ar ranging (LiDAR) data. We aimed to assess the applicability of UAV-DAP in obtaining individu tree height information for large-sized high-value broadleaf species. The spatial position, tree heig and diameter at breast height (DBH) were measured in the field for 178 trees of high-value broadle species. In addition, we manually derived individual tree height information from UAV-DAP ar LiDAR data with the aid of spatial position data and high resolution orthophotographs. Tree heigh from three different sources were cross-compared statistically through paired sample t-test, correlati coefficient, and height-diameter model. We found that UAV-DAP derived tree heights were high correlated with LiDAR tree height and field measured tree height. The performance of individu tree height measurement using traditional field survey is likely to be influenced by individual speci Overall mean height difference between LiDAR and UAV-DAP derived tree height indicates th UAV-DAP could underestimate individual tree height for target high-value timber species. Tl height-diameter models revealed that tree height derived from LiDAR and UAV-DAP could be bett explained by DBH with lower prediction errors than field measured tree height. We confirm the applicability of UAV-DAP data for obtaining individual tree height of large-size high-valu broadleaf species with comparable accuracy to LiDAR and field survey. The result of this study w be useful for the species-specific forest management of economically high-value timber species.

forests MDPI

Article

Direct Measurement of Tree Height Provides Different Results on the Assessment of LiDAR Accuracy

Emanuele Sibona [1], Alessandro Vitali [2], Fabio Meloni [1], Lucia Caffo [3], Alberto Dotta [3], Emanuele Lingua [4], Renzo Motta [1] and Matteo Garbarino [1,2,*]

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Abstract: In this study, airborne laser scanning-based and traditional field-based survey methods
trees as a reference dataset.
ere applied to four circular
d within the Alpine Space
ditional field-based (indirect
ods were compared by using
g. Our results show that tree
real heights (DIR) of felled
hat showed the smaller mean
field (DIR) data, followed by
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eights (DIR) than traditional
ical shape crowns.

s; ground control point

HYDROLOGICAL PROCESSES
Hydrol. Process. **22**, 1747–1754 (2008)
Published online 8 August 2007 in Wiley InterScience
(www.interscience.wiley.com) DOI: 10.1002/hyp.6770

Stream network modelling using lidar and photogrammetric digital elevation models: a comparison and field verification

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Abstract:

A conventional, photogrammetrically derived digital elevation model (DEM; 10 m resolution) and a light detection and ranging (lidar)-derived DEM (1 m resolution) were used to model the stream network of a 193 ha watershed in the Swan Hills of Alberta, Canada. Stream networks, modelled using both hydrologically corrected and uncorrected versions of the DEMs and derived from aerial photographs, were compared. The actual network, mapped in the field, was used as verification. The lidar DEM-derived network was the most accurate representation of the field-mapped network, being more accurate even than the photo-derived network. This was likely due to the greater initial point density, accuracy and resolution of the lidar DEM compared with the conventional DEM. Lidar DEMs have great potential for application in land-use planning and management and hydrologic modelling. The network derived from the hydrologically corrected conventional DEM was more accurate than that derived from the uncorrected one, but this was not the case with the lidar DEM.

KEY WORDS stream network; hydrologic modelling; DEM; lidar; hydrologic correction; watershed delineation; flow accumulation

Received 31 October 2006; Accepted 21 March 2007

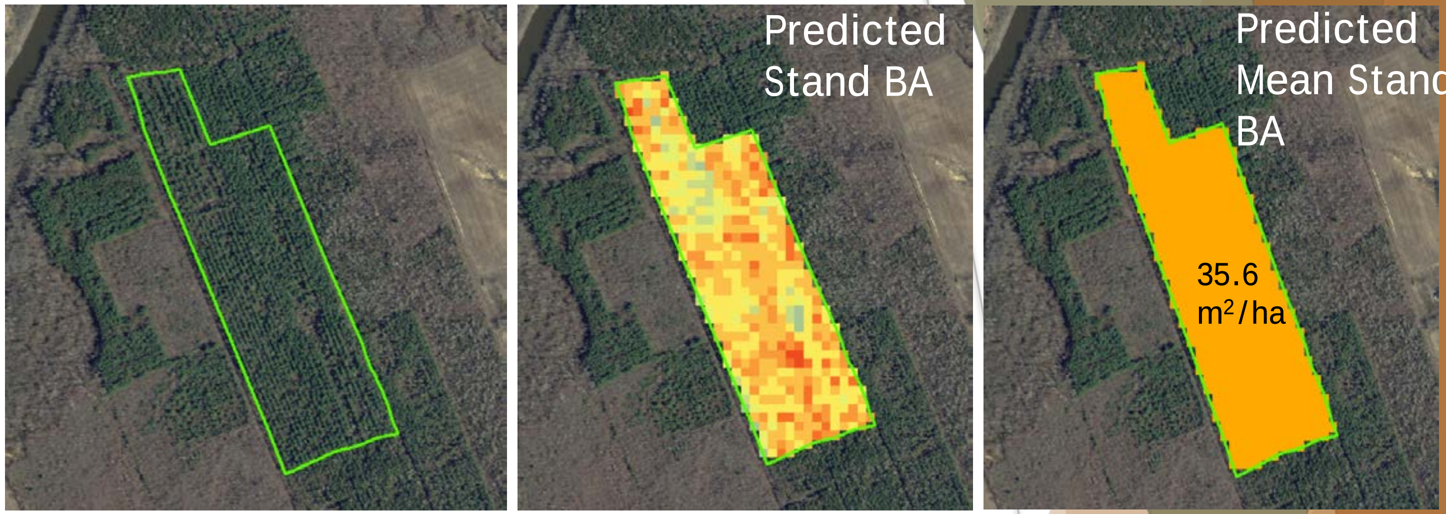
LiDAR Validation

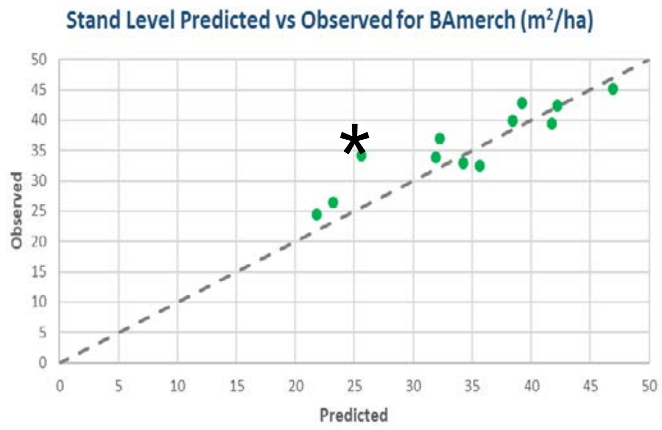
Stand Level Validation of Basal Area

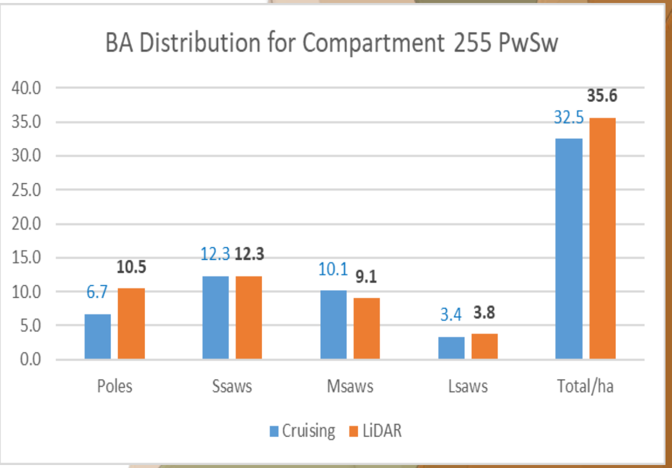
		Cruising Summary		LiDAR Summary
Compartment	Forest Type	Sample Pts	BA (m2 ha)	BA (m2 ha)
204	White Pine	17	45.2	46.9
16	Hwd	16	26.6	23.2
17	Red Pine	3	40	38.4
198	White Pine	18	43	39.2
230	Hwd	4	24.5	21.8
209	White Spruce	6	33	34.2
264	SwPr	8	37	32.2
256	PrPw	9	42.4	42.2
265	Sn	3	34	31.9
255	Red Pine	5	39.6	41.7
255	PwSw	19	32.5	35.6

RMSE m^2 ha	2.7
RMSE%	8%
MeanBias m^2	1.0
Bias%	3%

Operational Cruising Example

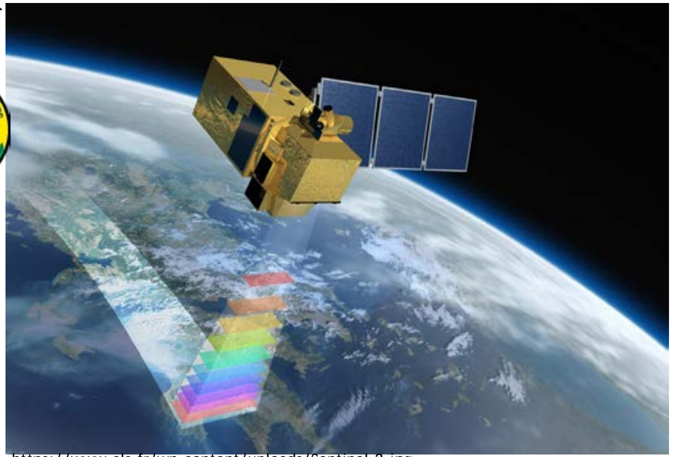




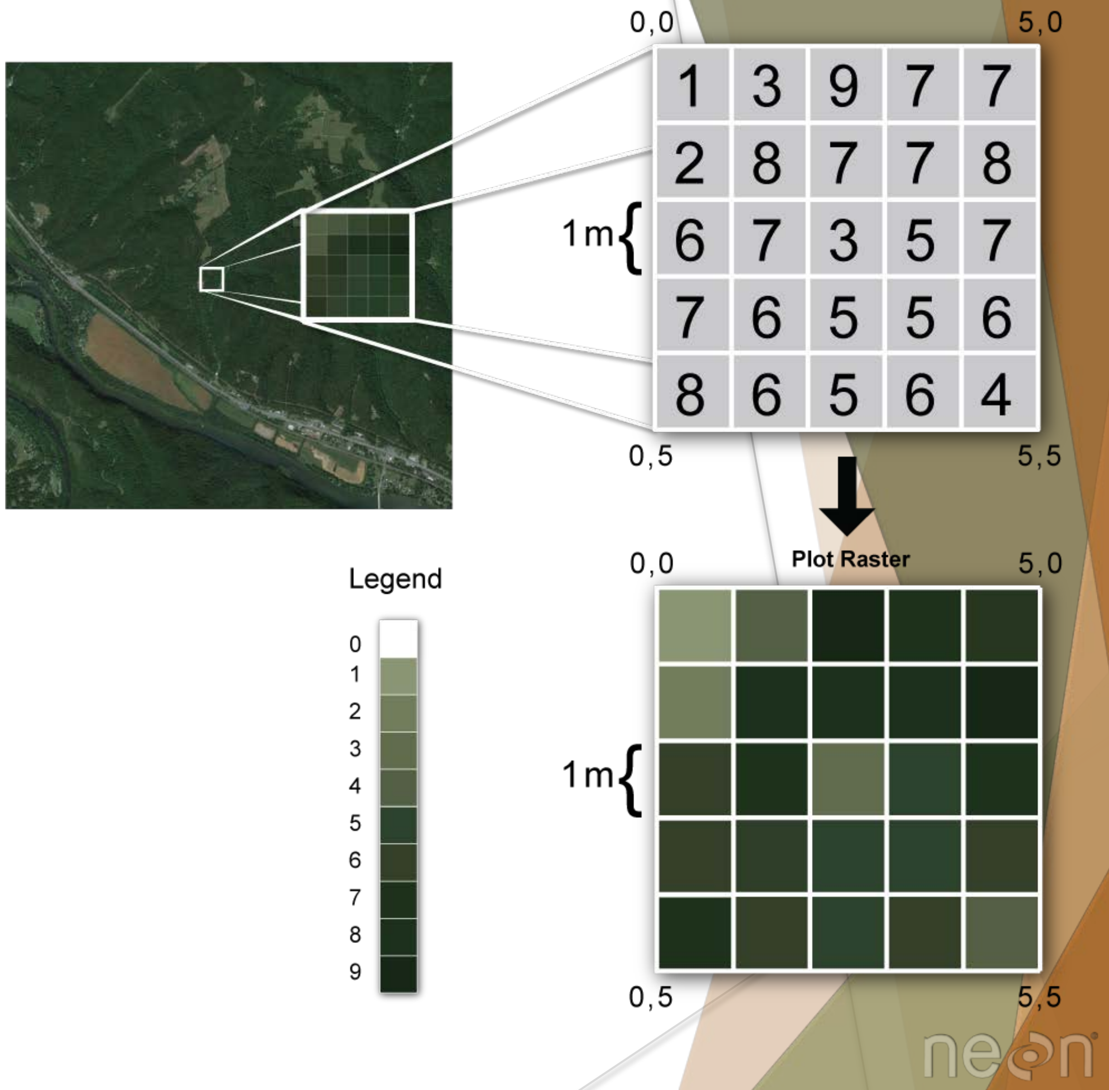


Species?

Species Predictions

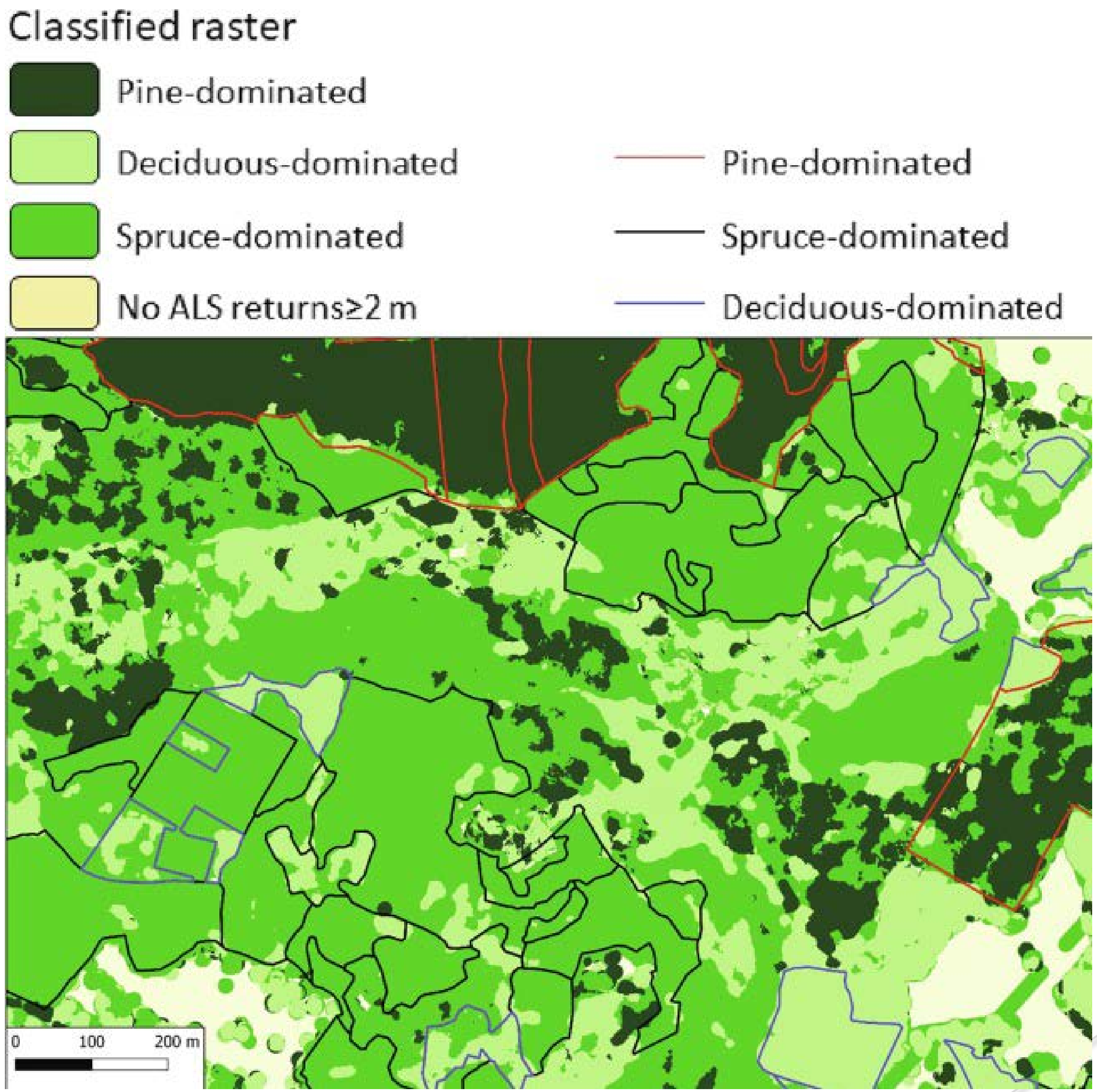


https://www.cls.fr/wp-content/uploads/Sentinel-2.jpg



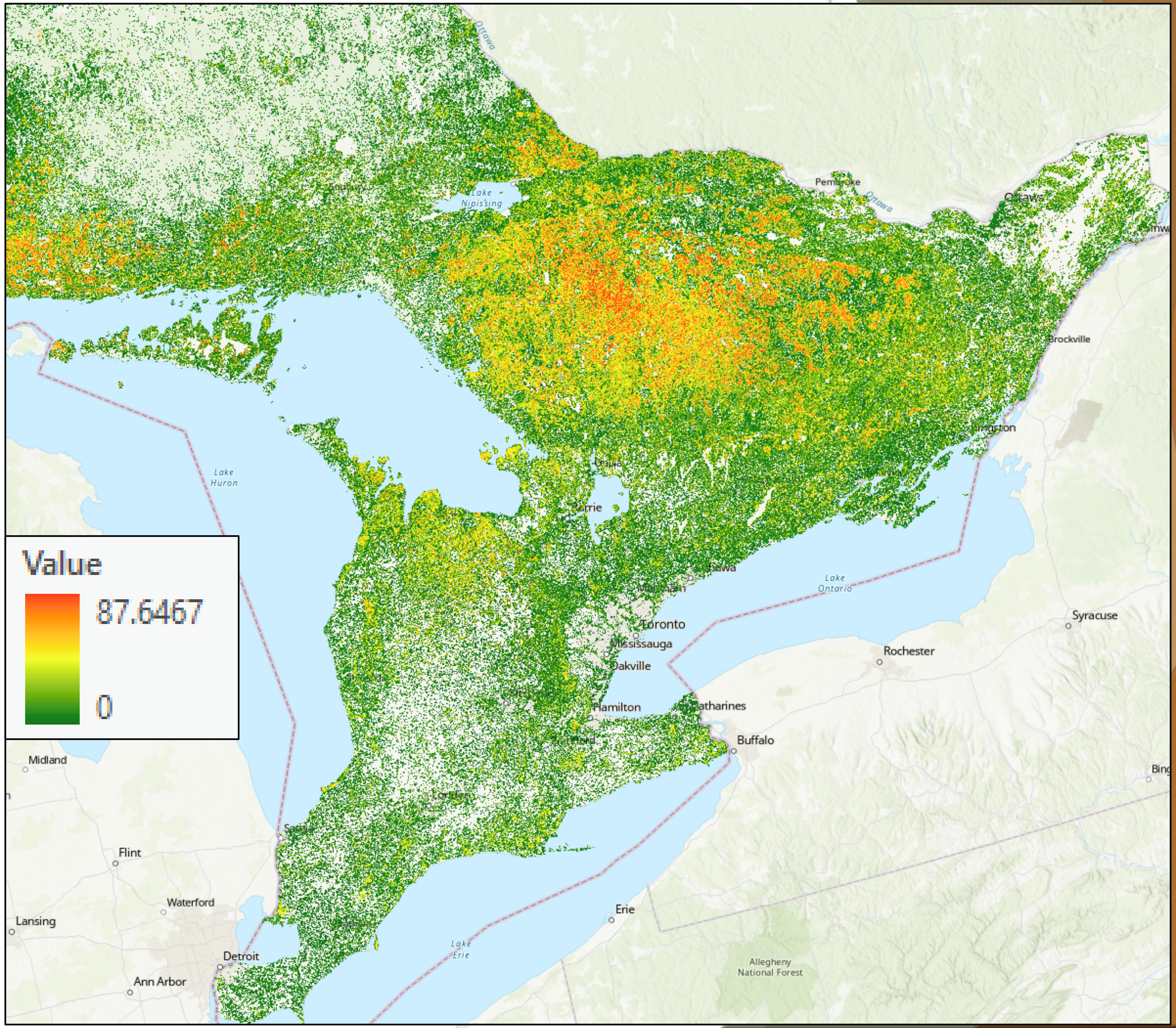
- Publicly available satellite data (Sentinel-2/Copernicus)
- 10m x 10m cells – 20% smaller than a parking space
- Data analyzed with a machine-learning algorithm (AI)
- Useful for identifying species or species groups
- Hardwood/conifer
- Intolerant hardwood/tolerant hardwood
- Spruce/pine
- **NFI Database + supervised classification + SOLRIS 3.0 OR field data/previous inventory**

Species Predictions - Supervised Classification



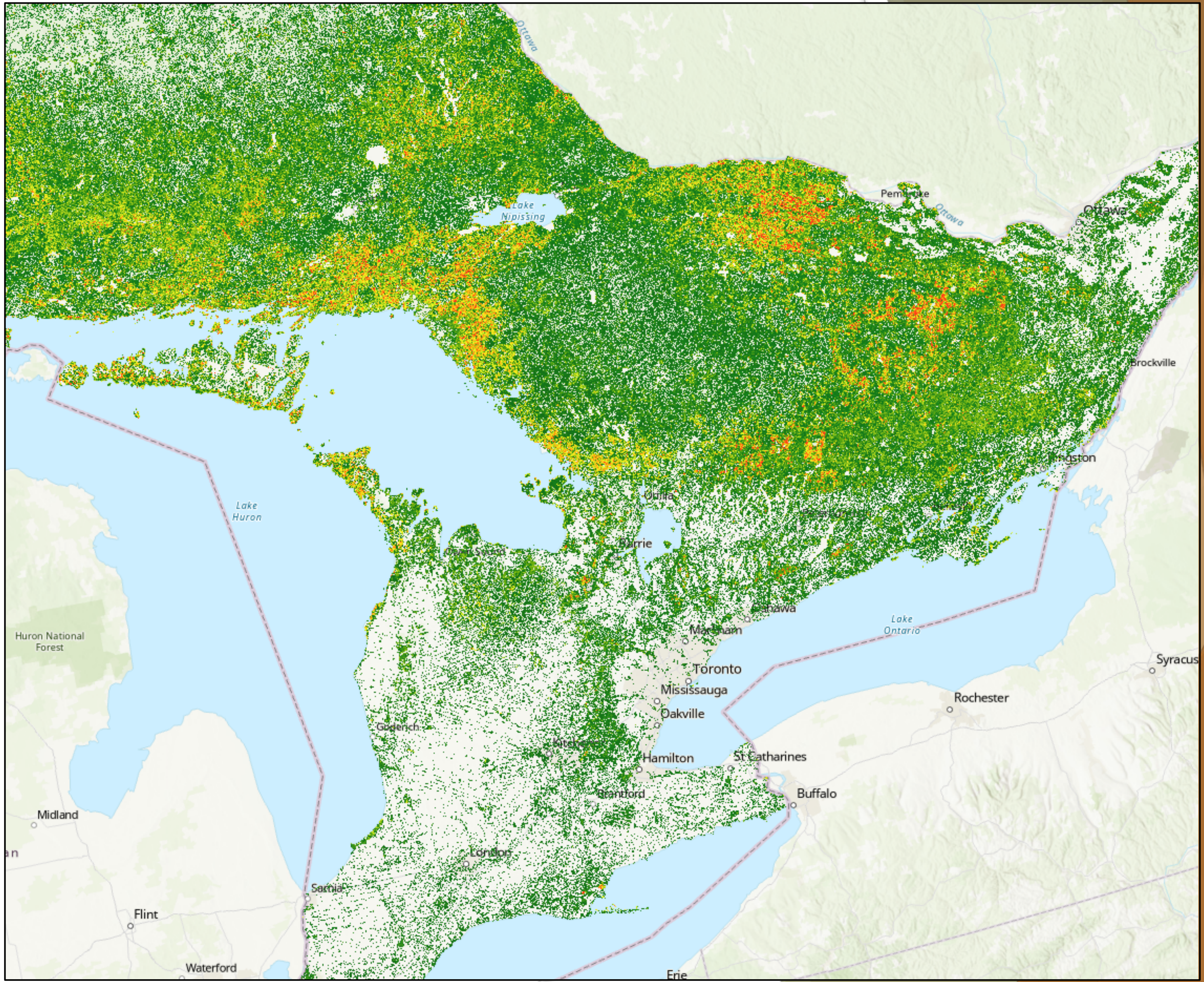
Species Predictions - NFI Database

- Sugar Maple
- 1km2 grid cells
- Based on 20km x 20km network of plots



Species Predictions - NFI Database

- White Pine
- 1km2 grid cells
- Based on 20km x 20km network of plots



How will you benefit from the program?

How are we leveraging the Private Lands eFRI?

- Producing inventory attributes to be used by landowners and forest professionals
  - Promote forest industry on private land
  - Find areas of high-value or in need of thinning

- Measuring carbon storage on a landscape or property
  - Finding target/priority areas
  - Consecutive measurements will give us carbon flux

- Determining suitable habitat for avian species (canopy densities) and thermal cover for moose or deer (understory density, tree height) -> Biodiversity

- Terrain, water, and forest information to support MFTIPs -> Better maps + stand information

- Inform other projects such as the OWA's Living Laboratories and CLT production, Maple Syrup production, identifying rare forest conditions (butternut) or suitable planting sites on landscape (for chestnut and other species)

Benefits as a member of the public?

- As the project is funded publicly, all data produced will be available online.

- This includes all lidar-derived inventory layers (basal areas, volumes, etc.)

- As well as predicted-species layers

Benefits as a member of the OWA?

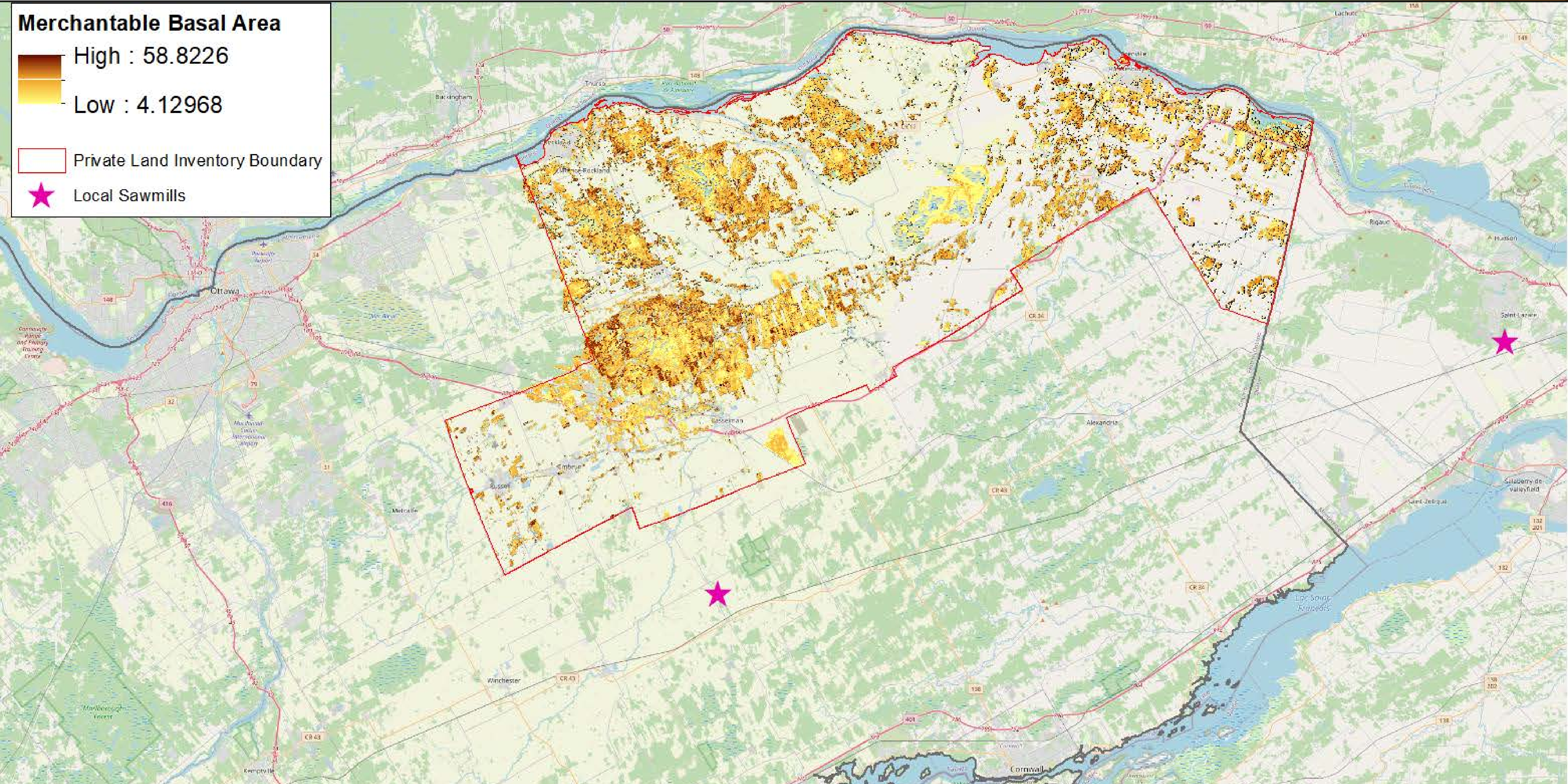
- Workshops/videos designed to assist with accessing and analyzing the data

- A la carte data delivery clipped to your property

- Derived data such as topographic wetness index, slope, contours, stream predictions, hillshade, etc.

Project Areas

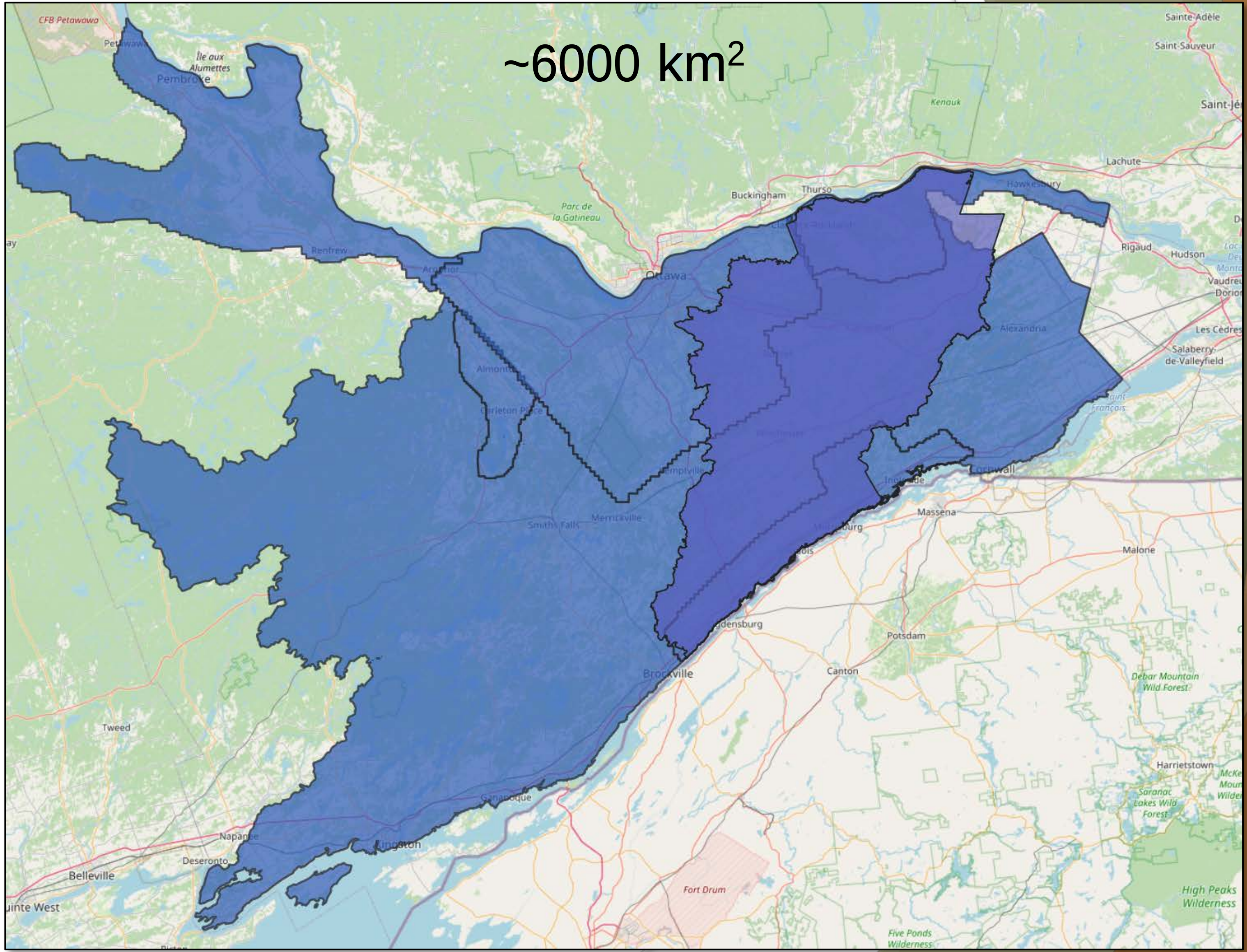
PLAFRI Prescott-Russel Pilot Project (2021)



PLAFRI Roadmap 2022-2023 (SOUTH)

Summer/Fall 2022 -
Establish additional plots to expand inventory coverage to surrounding CAs

Finish additional calibration plots and deliver inventories by **November 2022**



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PLAFRI Roadmap 2024-2026 (SOUTH)

- Hamilton/Niagara Region (3000 km^2) (2021 LiDAR data)
- Lake Simcoe Region (2000 km^2) (2021 LiDAR data)
- Lake Huron Region (4000 km^2) (2022 LiDAR data)
- Quinte/Belleville to Bancroft (7500 km^2) (2022 LiDAR data)
- Smaller projects where possible (Mississauga, Halton, etc.)

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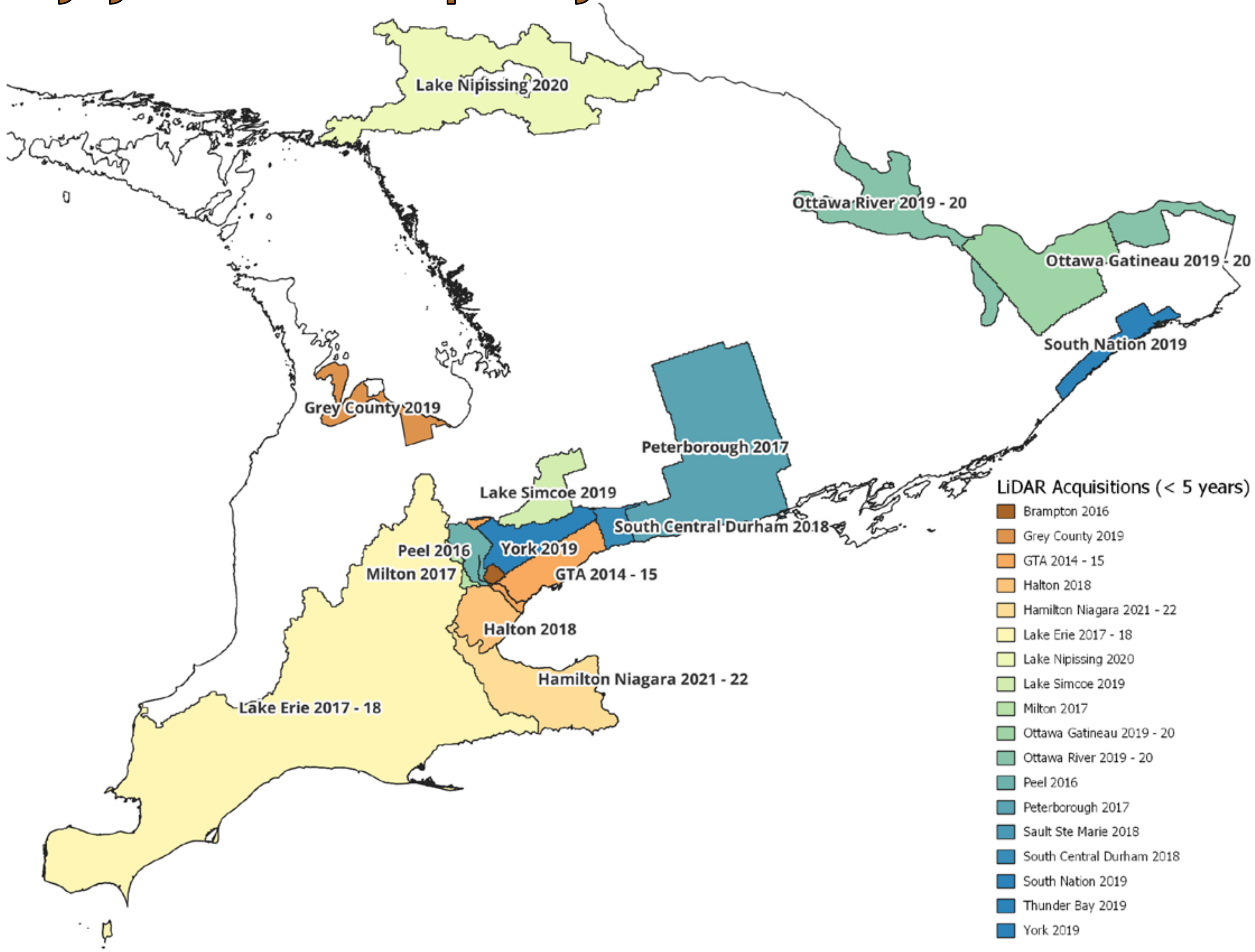
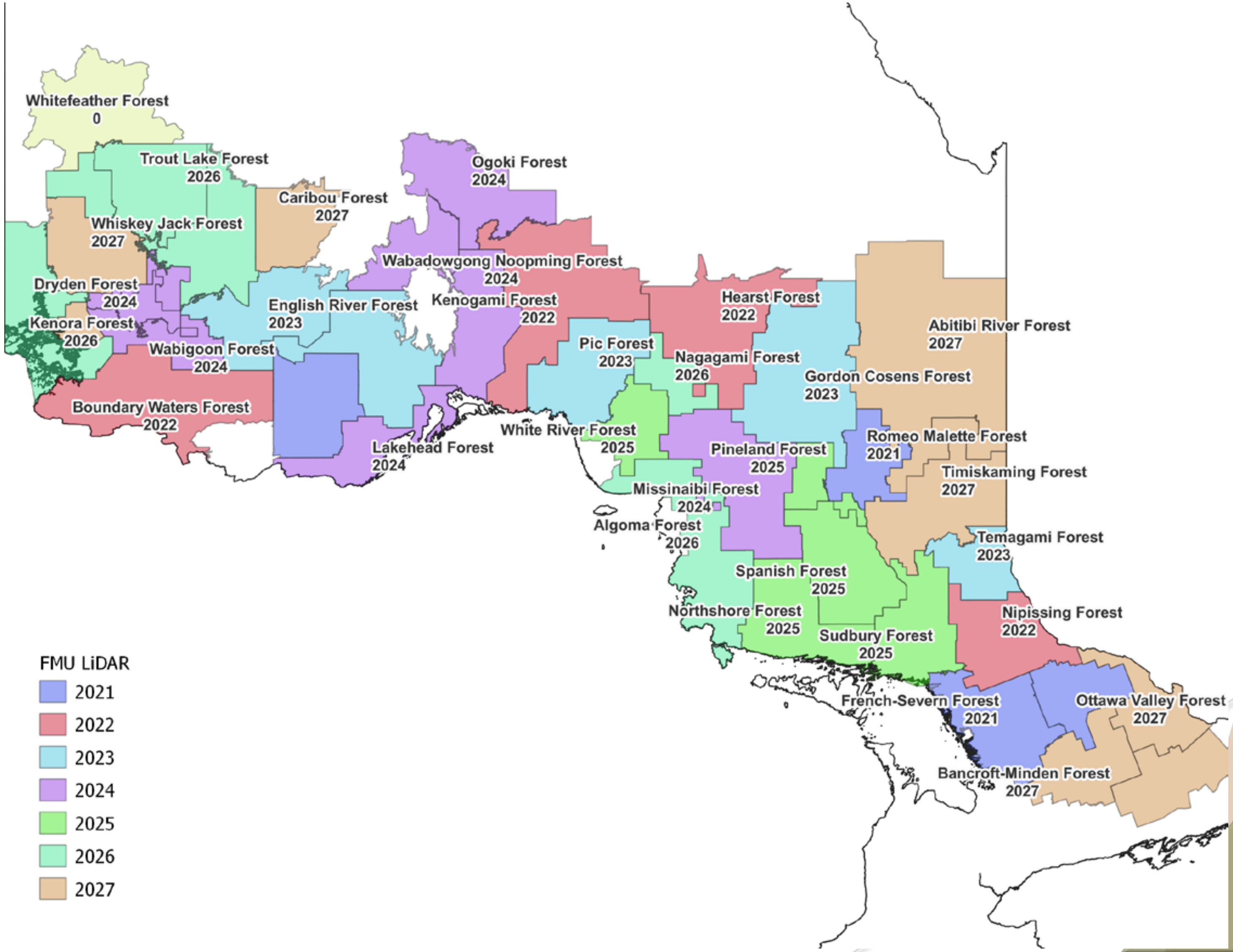
Data availability
- The South

No data? Lobby your municipality!



Where are we leveraging the Private Lands eFRI?

- The North



Climate Adaptation Training

Climate Change Adaptation Training

- Partnership between OWA and Climate Risk Institute (CRI)
- CRI: non-profit, academically affiliated organization focused on advancing practice and delivering services related to climate change risk assessment, adaptation planning, policy evaluation and resiliency. Already have adaptation training for engineers and urban planners. Forestry is a good fit.
- Training for forest owners, forest managers, and forest practitioners to adapt their forests to climate change.
- Students:
  - Bring their own property, a woodlot or forest they own or manage, to the course
  - Learn about practical, climate adaptation tools and strategies that are applicable at the forest and stand level
  - Conduct a vulnerability assessment of their land
  - Develop an adaptation plan for their land
- Training is based on the proven and effective US Forest Service Adaptation Workbook process
- Goals: 200 landowners trained, 50 practitioners trained representing 6,000 ha of land

FSC Expansion Program

Forest Stewardship Council Certification Expansion

- Expansion of FSC program
- Grow certified land in program by 6,000 ha
- Target non-traditional group members (private business, universities, commercial forests)
- Communications, marketing, program administration improvements
- Increase added value for program participants, such as: marketing forest products, increased public recognition, additional management and marketing tools
- Pilot FSC Canada’s Ecosystem Services Procedure
  - Verify and quantify ecosystem services on private land (water, soil, biodiversity, recreation, carbon)
  - Ex. Area of forest cover restored, tonnes of annual carbon sequestration, length of recreational trails built, etc.
- First step for increased recognition, both public and financially, for the services provided to society by private forests

OWA Equipment Acquisitions for Value-Added Services

PLAFRI Equipment Acquisitions

8x **Vertex hypsometers**

- Ultrasonic sound works in dense bush
- Accuracy within ±1%
- Used for measuring tree heights to calibrate LiDAR

8x **Submeter GNSS units (Emlid Reach and EOS Arrow)**

- Survey grade
- Used to establish calibration plots
- Capacity to log RINEX data

NAS Storage Solution for hosting inventory data

- 20 terabytes (with room for expansion)

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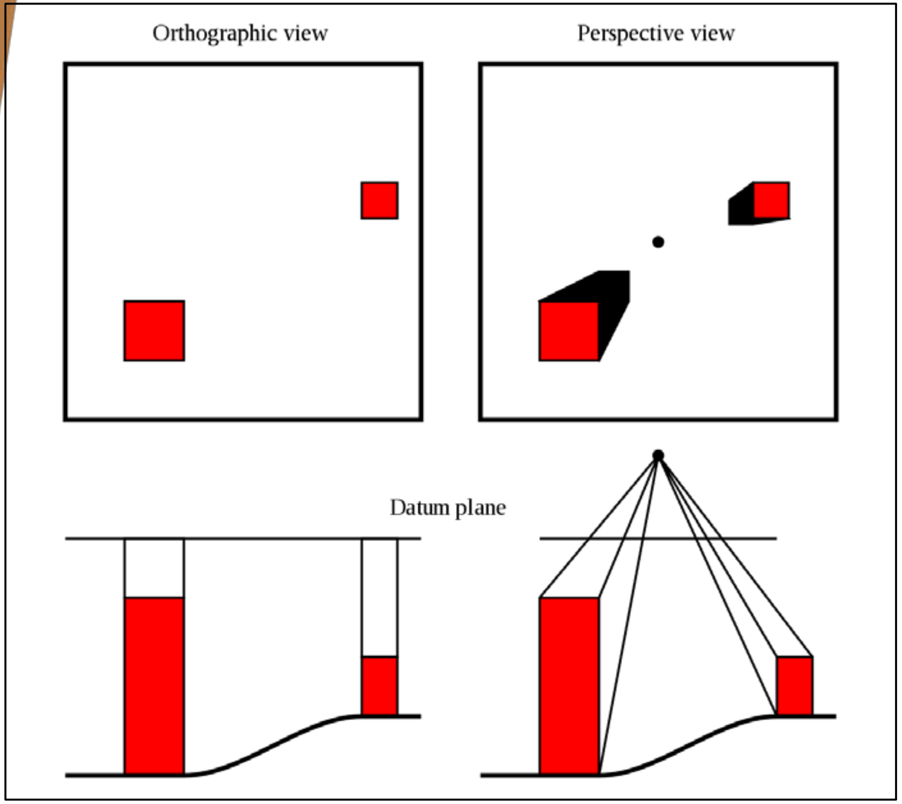
PLAFRI Equipment Acquisitions

2x **Mavic 3 Enterprise Drones**

- Survey-grade UAV mapping drones
- Can produce georeferenced cm-level accurate **2D orthophotography**



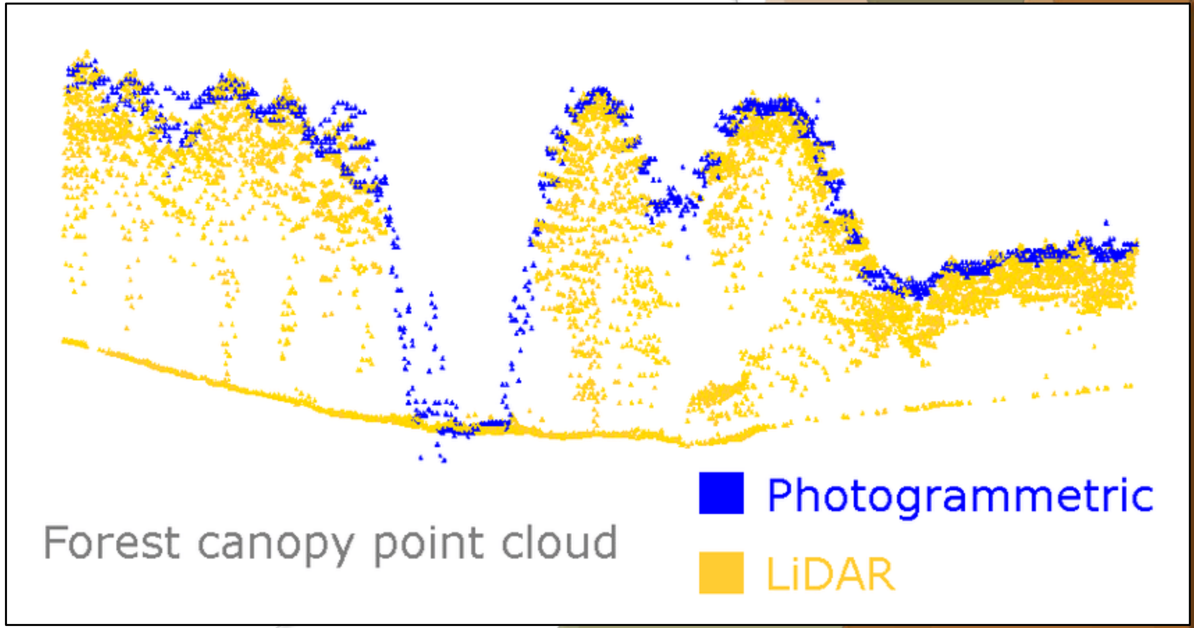
Flattened image can used for measurements and stand delineation

Can be used for gap/damage analysis and automatic tree crown detection

PLAFRI Equipment Acquisitions

2x **Mavic 3 Enterprise Drones**

- Can be used to produce point cloud data from **3D photogrammetry**
- Can produce inventory information for areas already flown with LiDAR even if it is 10+ years old



Thank You OMSPA!

Questions?

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  - Sionaid Eggett -> sionaid.eggett@ontariowoodlot.com
- **FSC and Carbon Offsets Program Contact**
  - Glen Prevost -> glen.prevost@ontariowoodlot.com • 705-358-4261