HRIS Forest Inventory Reliability Metrics

Understanding the Variable Spatial Accuracy of Your Stand Attribute Models

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A comprehensive and reliable forest inventory
at high resolution, accessible at multiple scales.
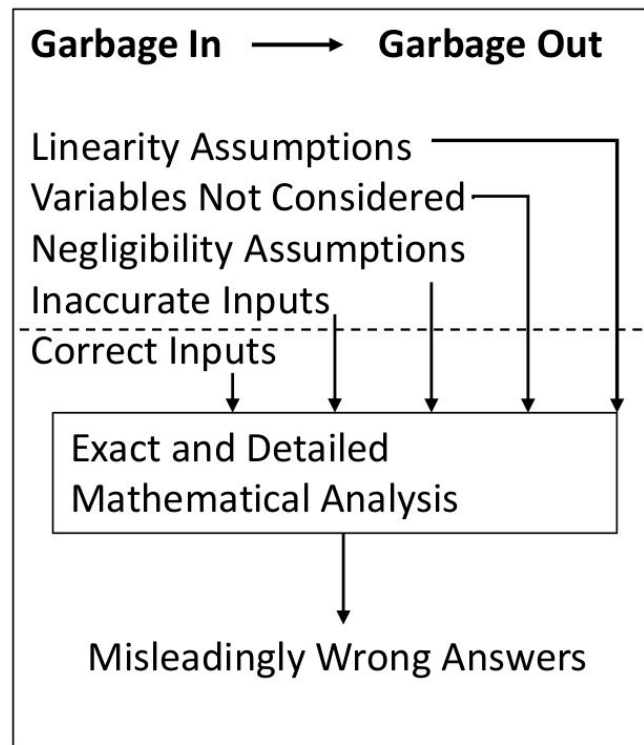
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Status quo inventory lacks confidence and reliability

As a result, **we spend additional resources** on planning and reconnaissance to locate timber.
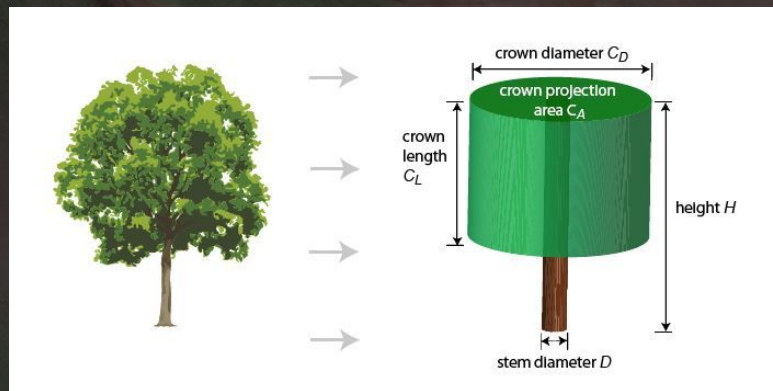
Our **goal**...*an inventory that we can <u>trust</u> and <u>use</u>!*

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Where Did Things Go Wrong?

Garbage In ⟶ Garbage Out

Linearity Assumptions
Variables Not Considered
Negligibility Assumptions
Inaccurate Inputs
- - - - - - - - - - - - - - - - -
Correct Inputs

Exact and Detailed
Mathematical Analysis

↓

Misleadingly Wrong Answers

From: Borders, B. 2011.

ALL MODELS ARE WRONG, *SOME ARE USEFUL*

Confidence Metrics in Your Inventory Adds Certainty in your Decision Making

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Two general categories of prediction uncertainty:
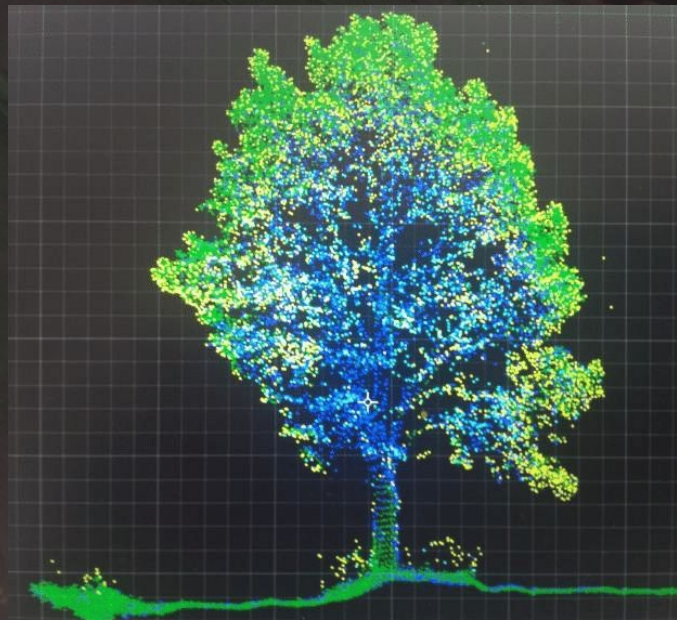
1) Global Model Uncertainties
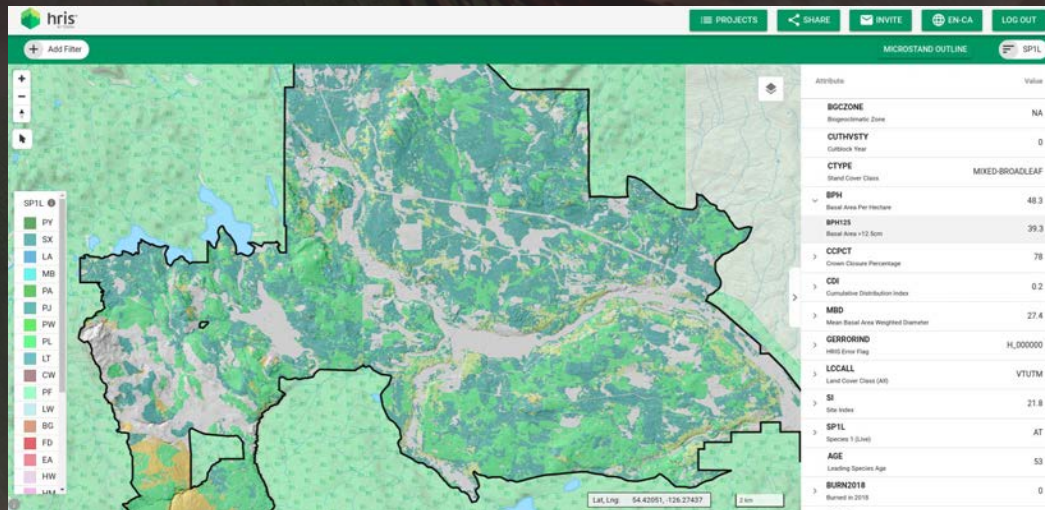Describes Attribute Reliability Across Entire Inventory

2) Local Model Uncertainties
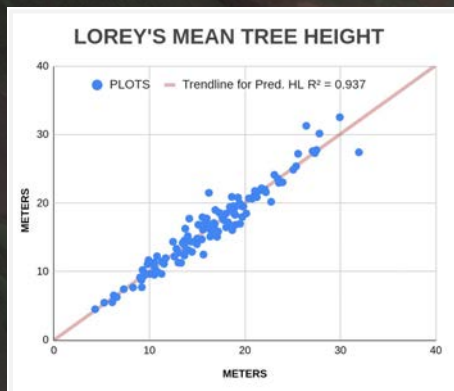Applies to Individual Stands or Regions
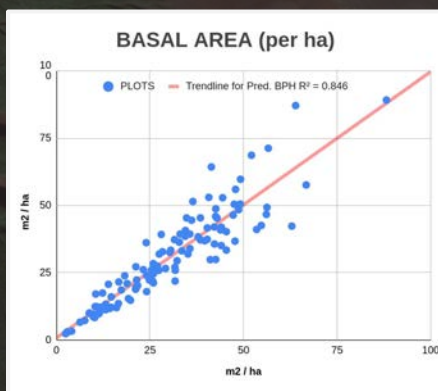
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Global Inventory Model Stats
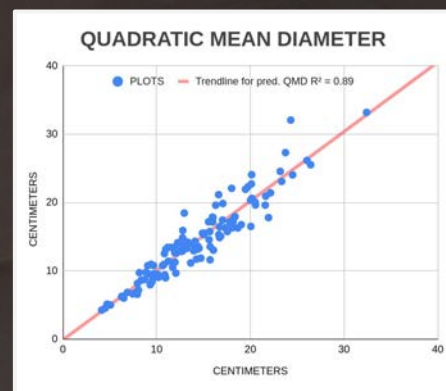
Characterizing Average Uncertainty and Errors

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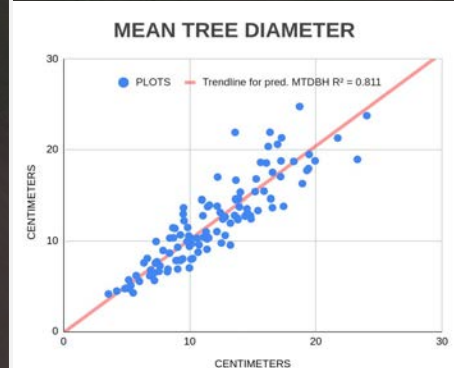# Area-Based HRIS Stand Structure Models - Accurate, Consistent, Unbiased

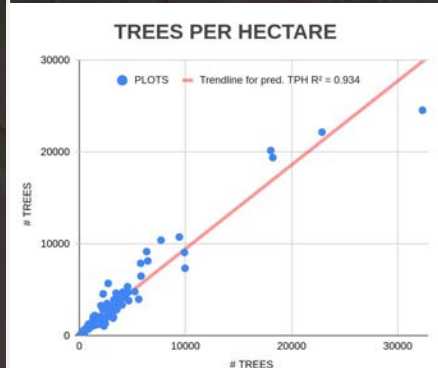**LOREY'S MEAN TREE HEIGHT**
$R^2 = 0.94$ RMSE = 1.4 m

BASAL AREA (per ha)
$R^2 = 0.85$ RMSE = 6.7 m2/ha

QUADRATIC MEAN DIAMETER
$R^2 = 0.89$ RMSE = 1.9 cm

MEAN TREE DIAMETER
$R^2 = 0.81$ RMSE = 2.2 cm

TREES PER HECTARE
$R^2 = 0.93$ MAE = 1-3% tph
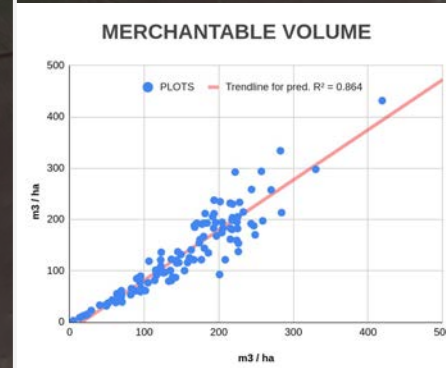
MERCHANTABLE VOLUME
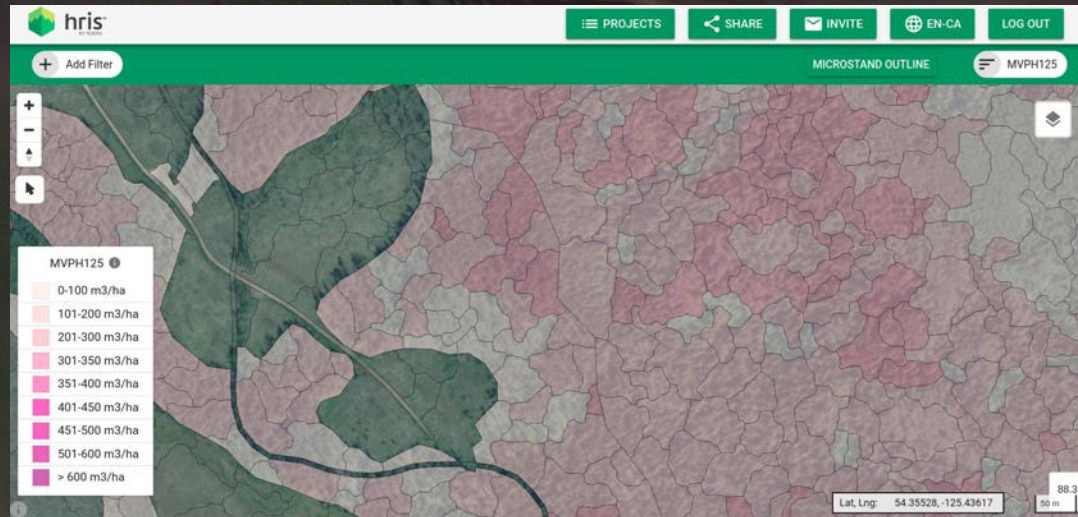$R^2 = 0.86$ RMSE = 35 m3 / ha

Localized Inventory Model Stats

Characterizing Uncertainty and Errors by Microstand

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Uncertainty & Consistency in Data Inputs

LIDAR

Point Density
Scan Angle
Footprint
Swath Overlap
Steep Terrain
Intensity Normalization

IMAGERY

Mosaic Seamlines
Colour Balancing
Radiometric Corrections
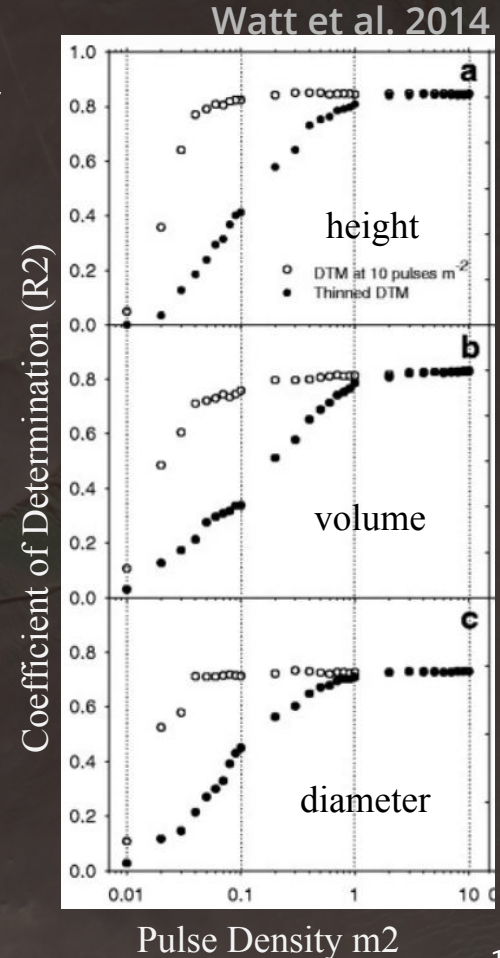Snow and Clouds
Shadows and Hotspots
Resolution

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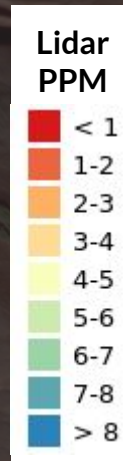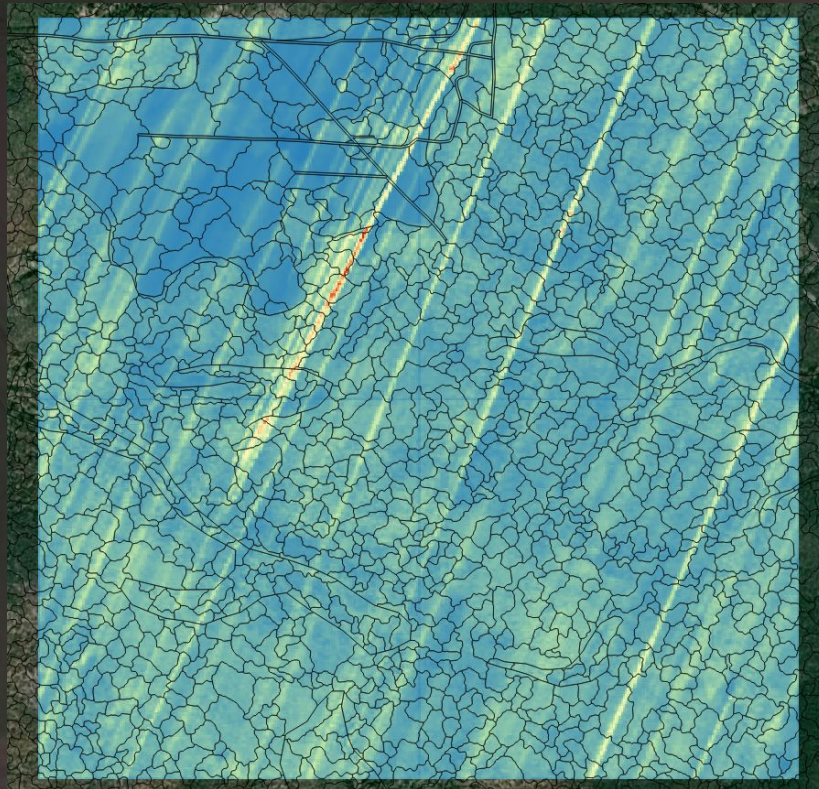
Uncertainty in Data Inputs

LiDAR indices and the potential impacts they can have on producing unbiased, reliable and consistent estimations.

Source: Roussel et al. 2018

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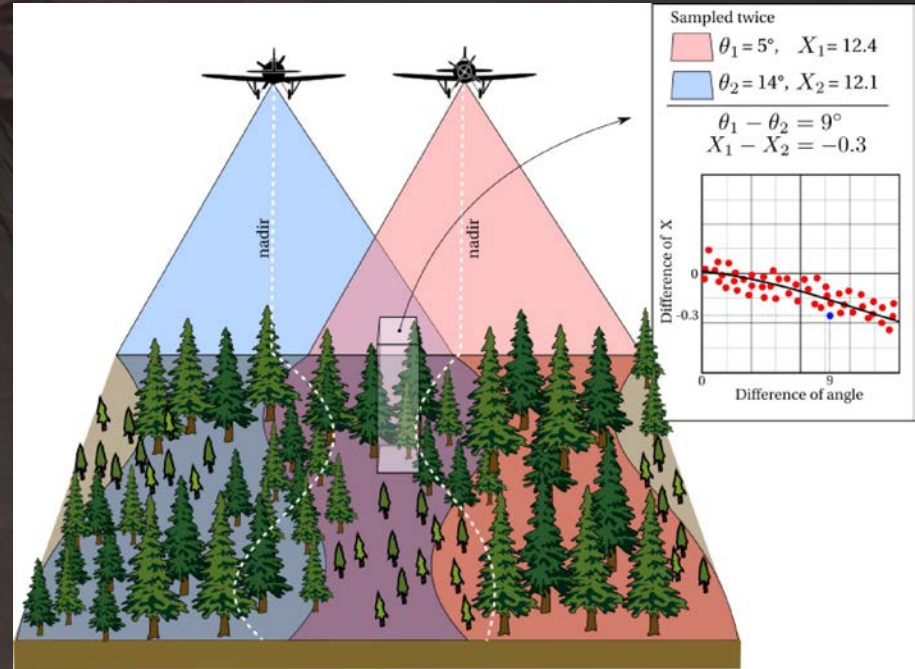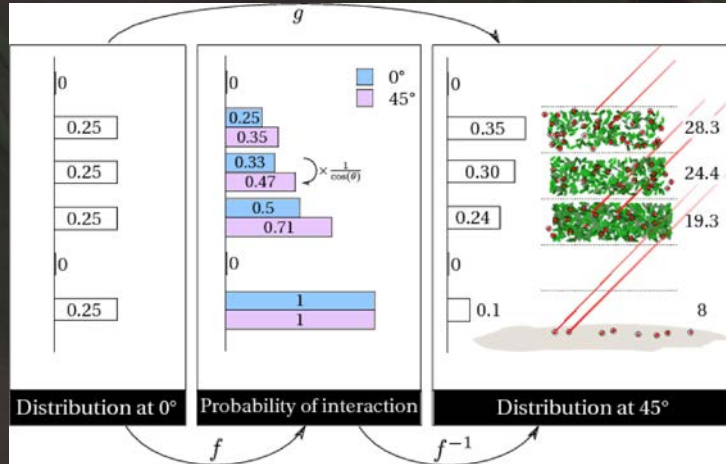
LiDAR pulse density typically varies across the landscape, and can influence your model accuracy

Lidar PPM

- < 1
- 1-2
- 2-3
- 3-4
- 4-5
- 5-6
- 6-7
- 7-8
- > 8

2 km

height

○ DTM at 10 pulses m⁻²
● Thinned DTM

volume

diameter

Coefficient of Determination (R2)
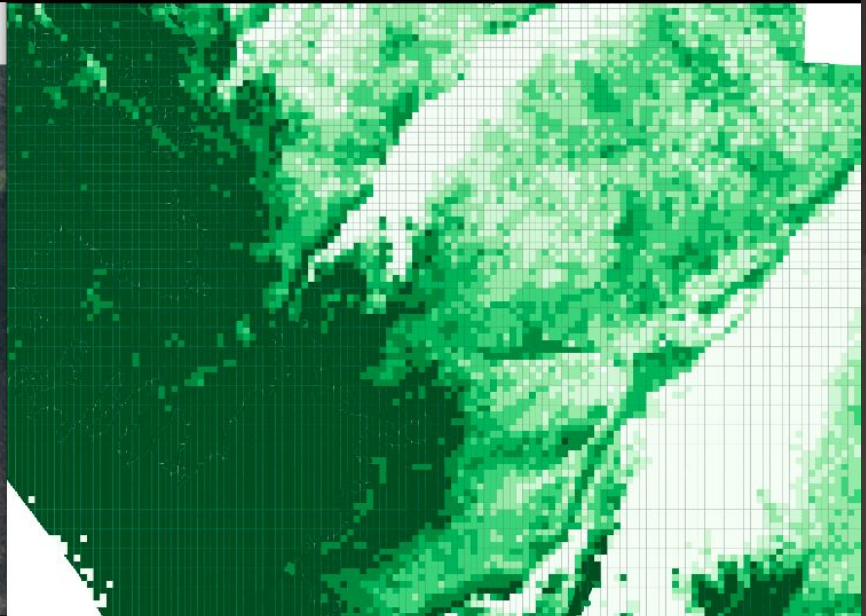
Pulse Density m2

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Dealing with imagery inconsistency: **SNOW**

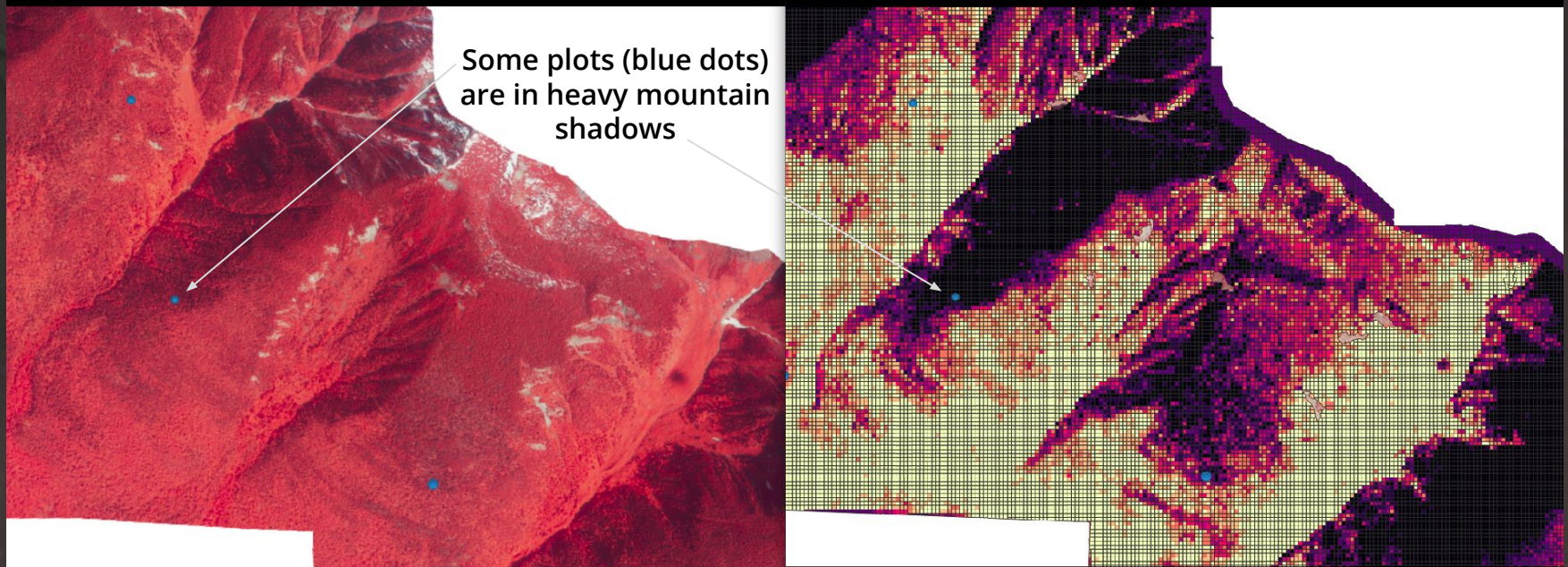Adding quality control flags to the gridcells and microstands
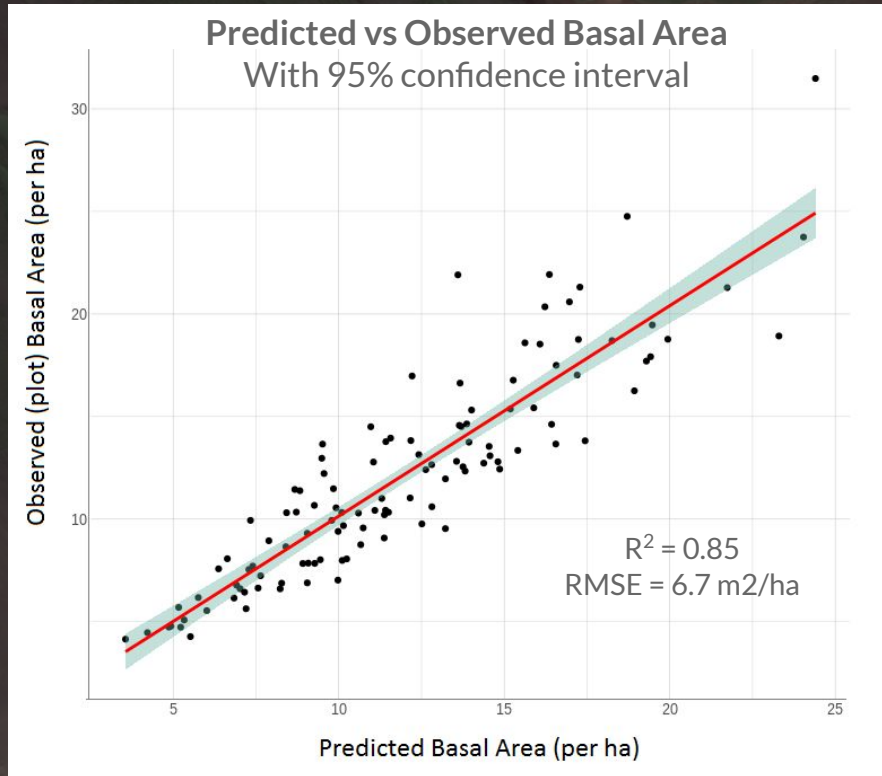

Early season imagery

Spectral vegetation indices

Dealing with imagery inconsistency: **SHADOWS**

We can create different prediction models for areas based on imagery input quality

Some plots (blue dots) are in heavy mountain shadows

Variable Uncertainty in Predictive Models

Predicted vs Observed Basal Area
With 95% confidence interval

$R^2 = 0.85$
RMSE = 6.7 m2/ha

Observed (plot) Basal Area (per ha)
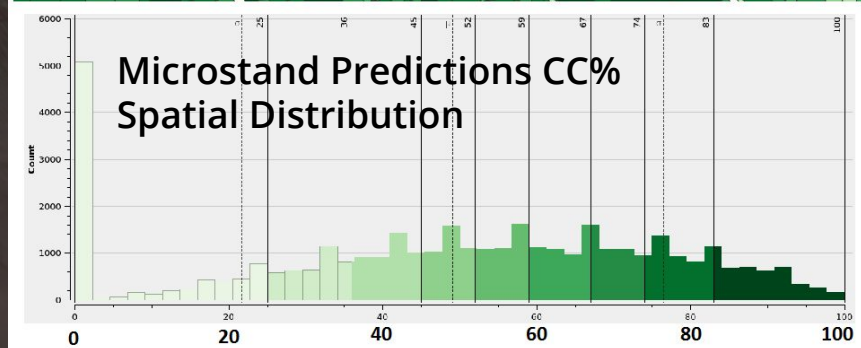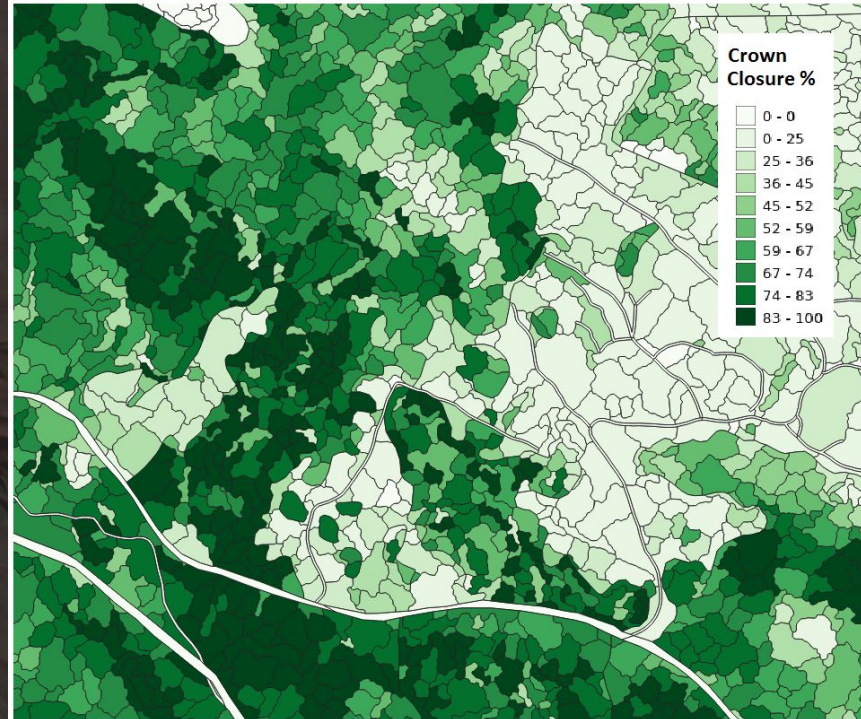
Predicted Basal Area (per ha)

Biometric prediction errors tend to scale positively with magnitude

Caused by limitations of ground sample inputs and/or limitations of remote sensing data

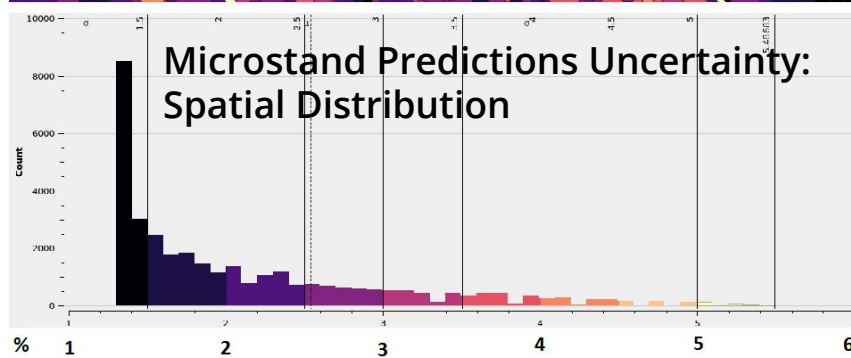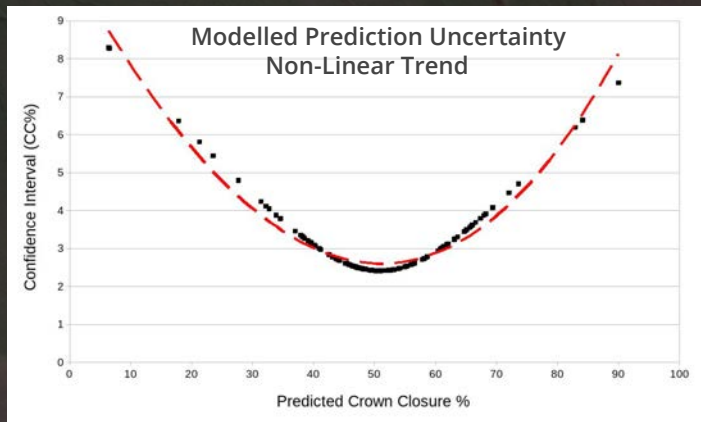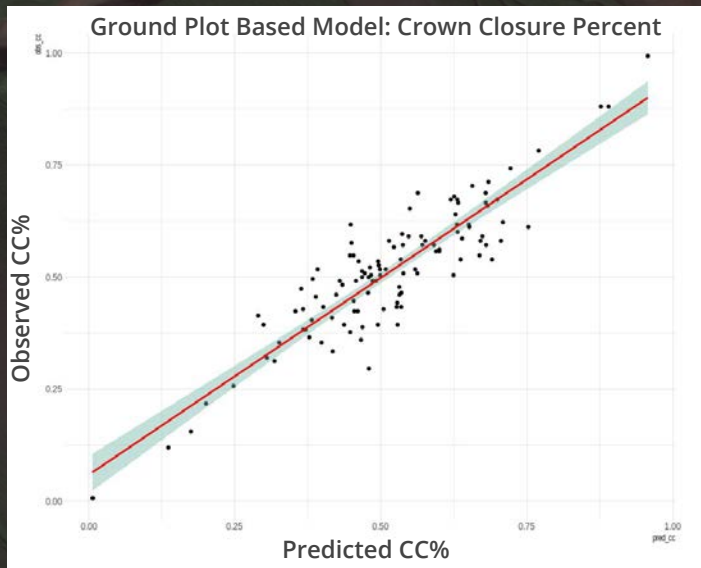Higher biomass can saturate some remotely sensed indices
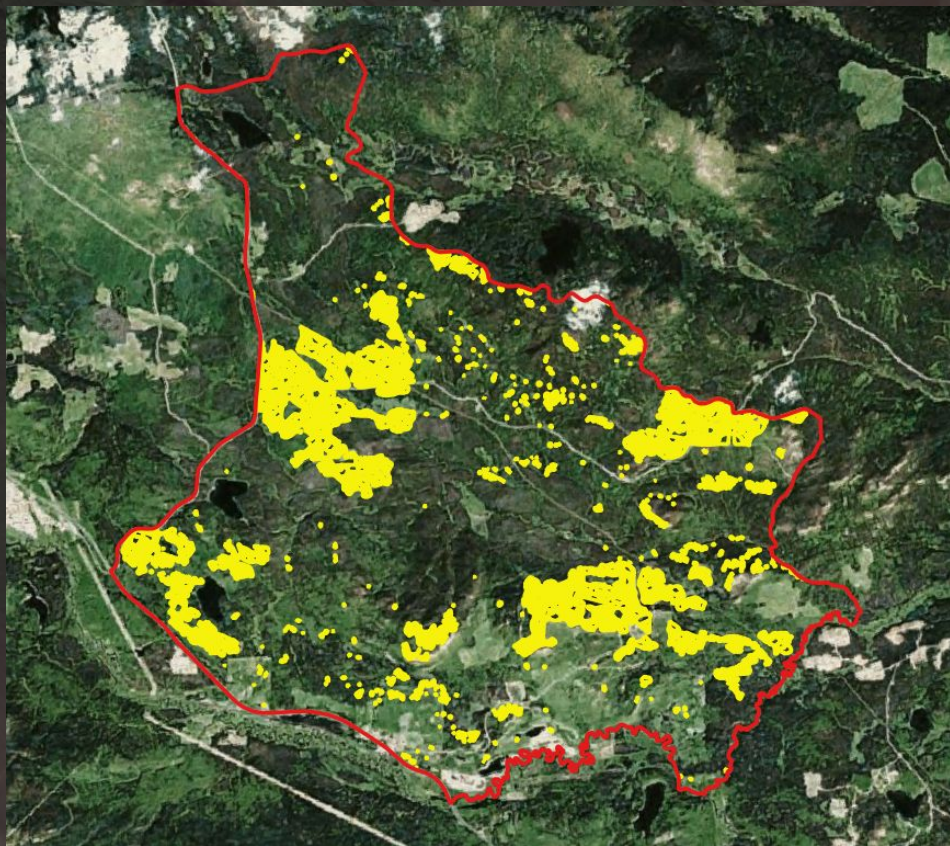
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600 acre subset of 300,000 acre inventory

Spatial Variance of Prediction Confidence

Non-Linear Example: CROWN CLOSURE

Crown Closure %
- 0 - 0
- 0 - 25
- 25 - 36
- 36 - 45
- 45 - 52
- 52 - 59
- 59 - 67
- 67 - 74
- 74 - 83
- 83 - 100

Microstand Predictions CC% Spatial Distribution

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Ground Plot Based Model: Crown Closure Percent

Modelled Prediction Uncertainty
Non-Linear Trend

Microstand Predictions Uncertainty:
Spatial Distribution

Prediction CI
as % CC
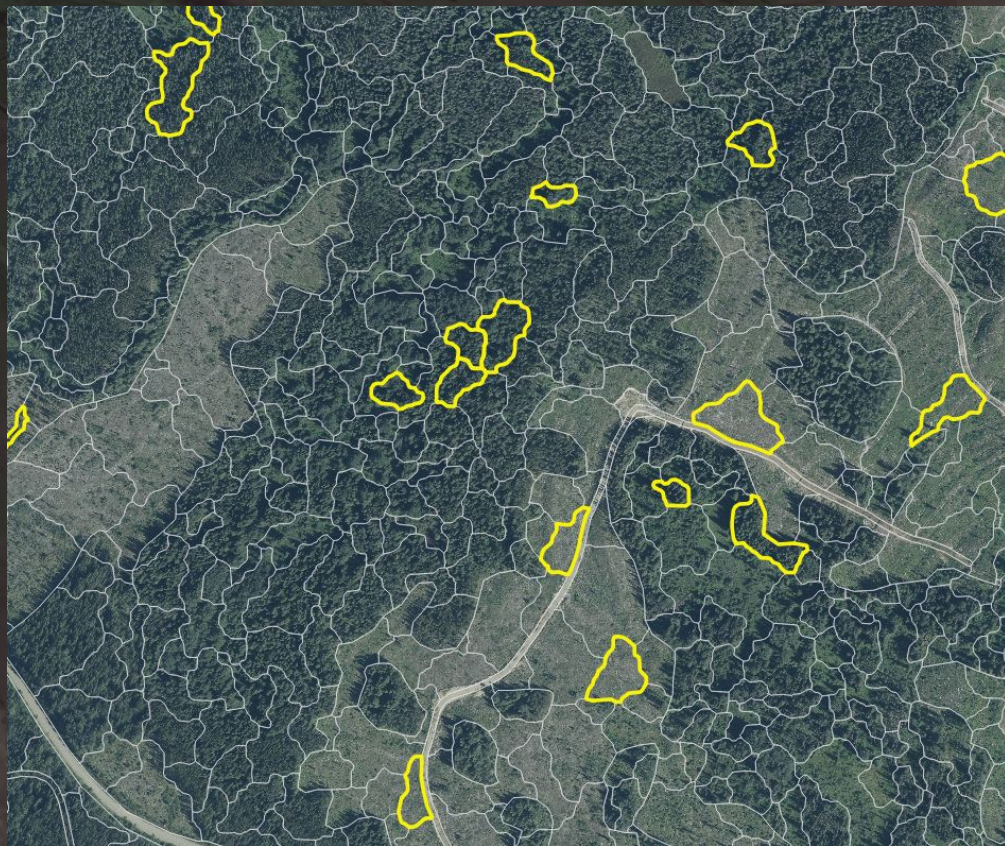1 - 1.5
1.5 - 2
2 - 2.5
2.5 - 3
3 - 3.5
3.5 - 4
4 - 4.5
4.5 - 5

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Sorting Stands by Confidence Levels

Identify stands with lowest confidence to understand whether to cruise more in certain areas

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Planning Your Inventory by Confidence Levels

Report confidence level statistics of stands selected for operational planning for risk analysis and reduction
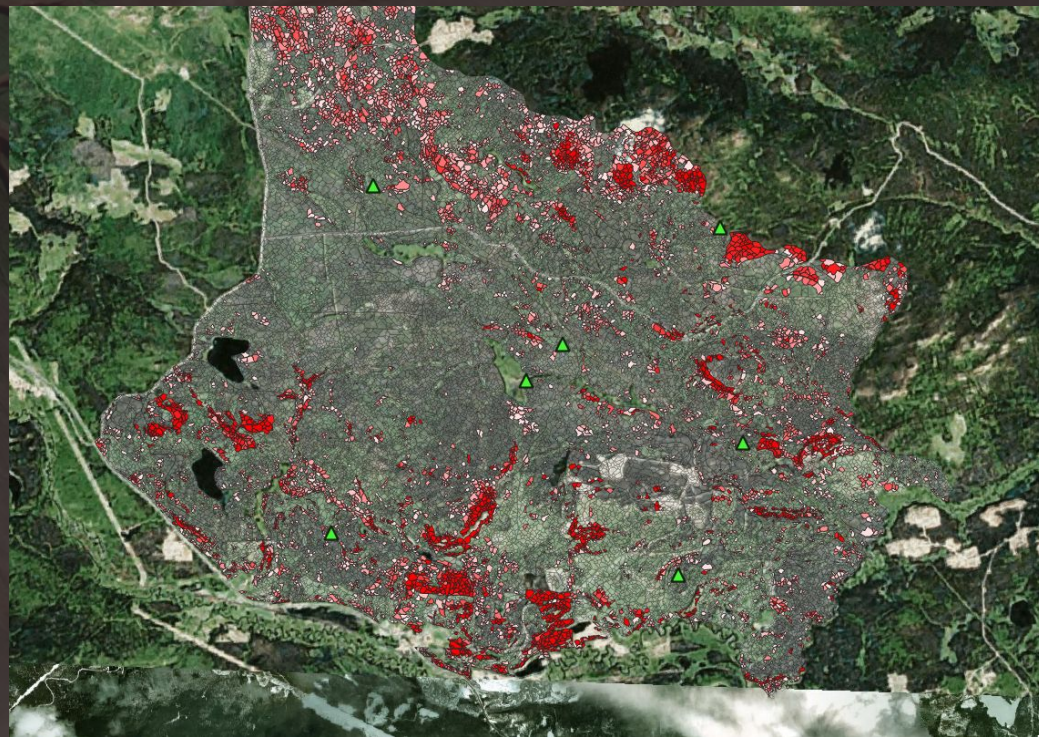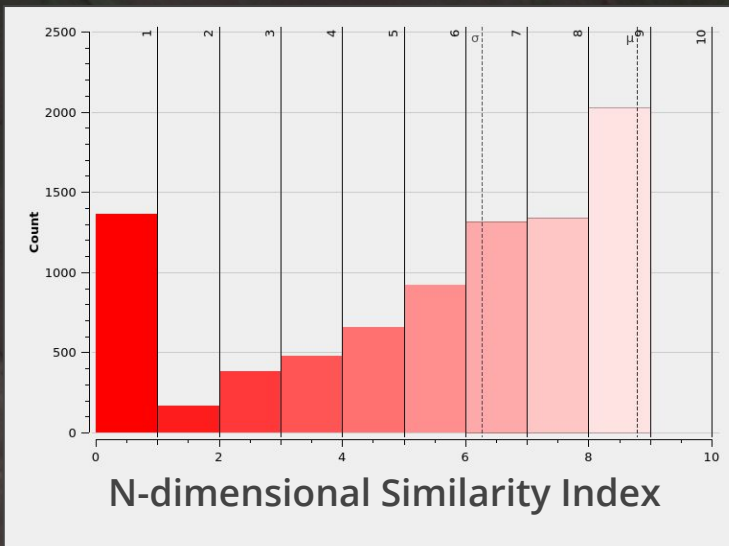
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Stand - Plot Similarity Index

Measures the multivariate similarity of each stand to the plot reference data. Useful as a general metric for visualizing where model extrapolation and potential uncertainty are greatest

Index from 0 to 10 (low to high attribute similarity)

N-dimensional Similarity Index

Should you trust the 14 day forecast as much as the 4 day forecast?
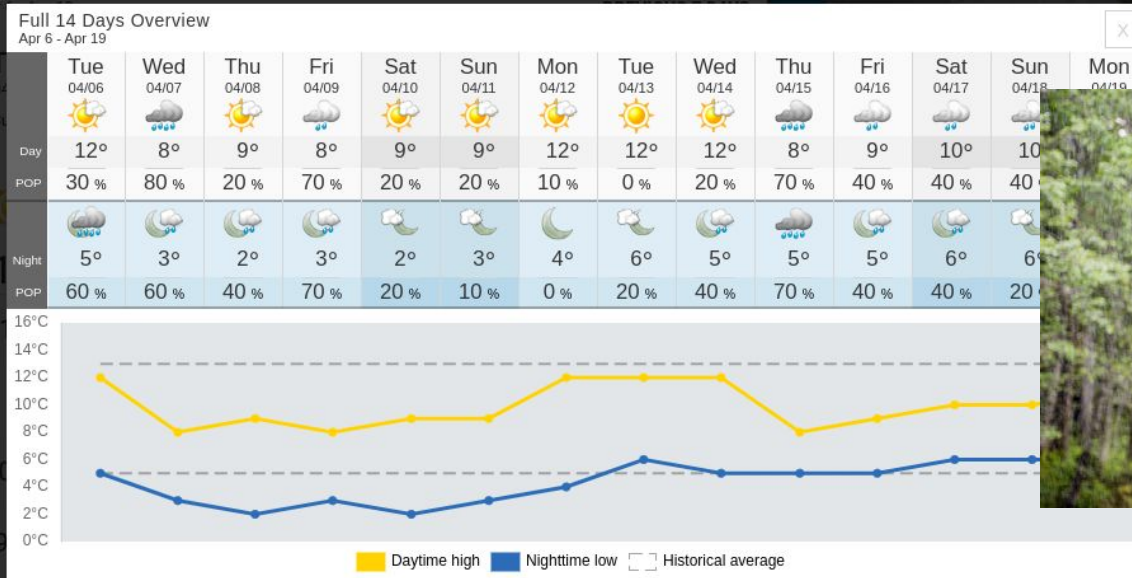
Not all predictions should be treated equally when your plans depend on that information

High Resolution Inventory Solutions

Comprehensive and **reliable** forest inventory at **high resolution.** Accessible at multiple scales.
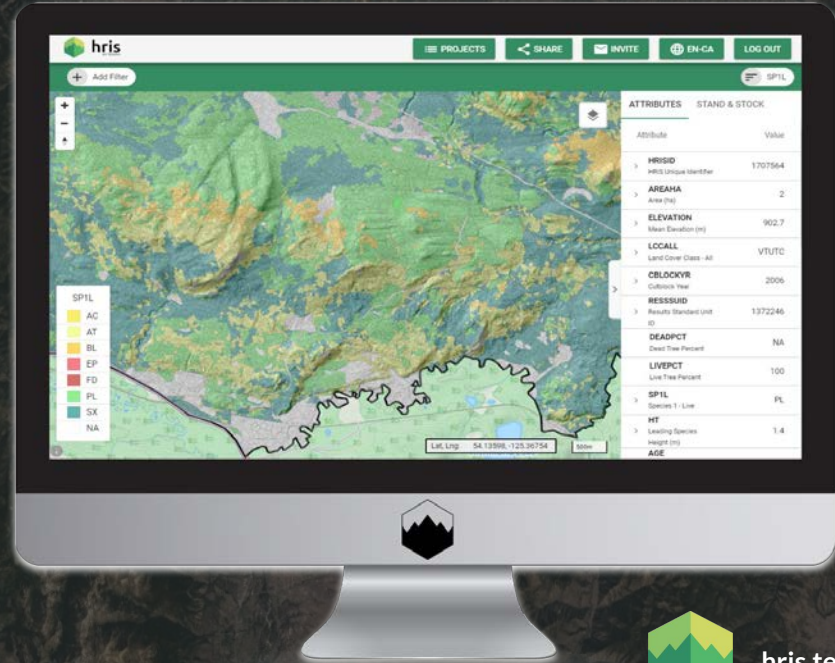
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A comprehensive and reliable

HRIS Forest Inventory

at high resolution.

High Resolution Inventory Solutions

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