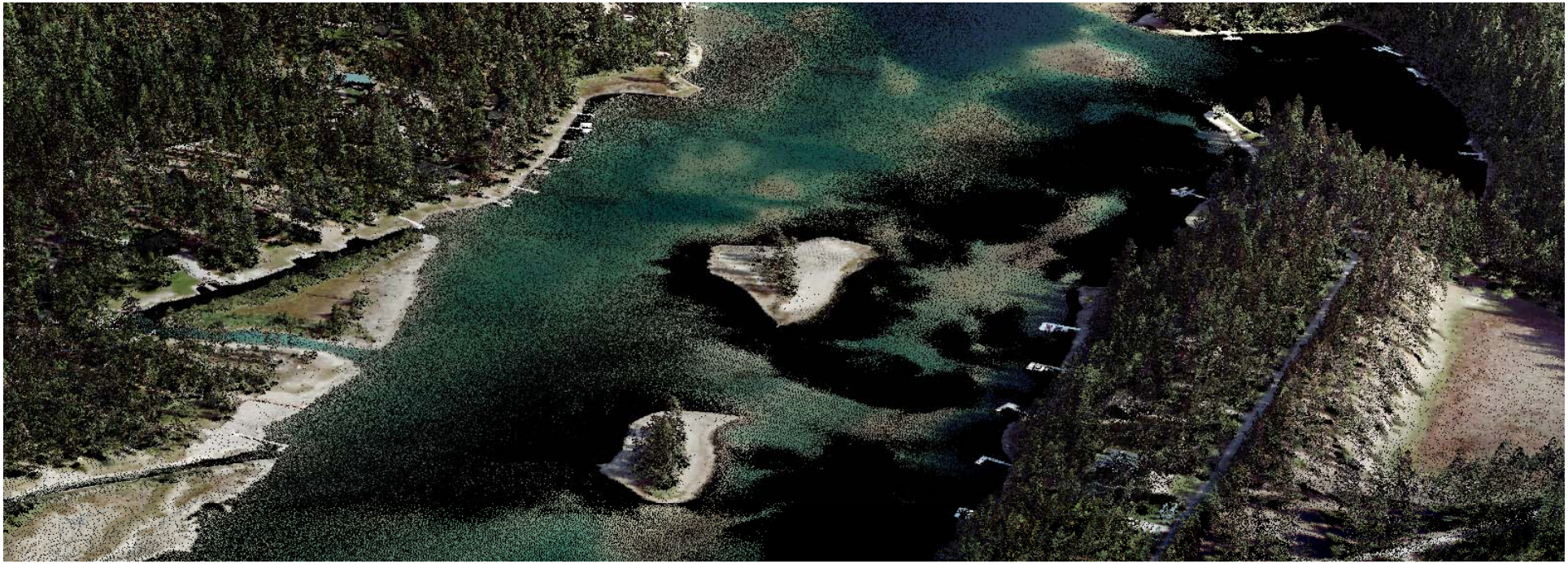


LiDAR Classification and Vegetation Analysis

Yuba River RMT Meeting
Sacramento, CA

Russell Faux, Principal
Watershed Sciences, Inc.
517 SW 2nd Street, Suite 400
Corvallis, OR 97333

Watershed Sciences

Watershed Sciences

- Mapping
  - Discrete Return LiDAR
  - Waveform LiDAR
  - Thermal Infrared Imagery
  - Airborne Digital Imagery
  - SoNAR
  - Hyperspectral
- Analysis
  - Hydraulic Modeling
  - Water Quality Modeling
  - GIS Feature Extraction
  - Forest Inventory/Fuels
  - Habitat Assessments
  - Visualization

Watershed Sciences

Vegetation Research Affiliations

Precision Forestry Cooperative – University of Washington/USFS PNW Research Laboratory, Seattle, WA

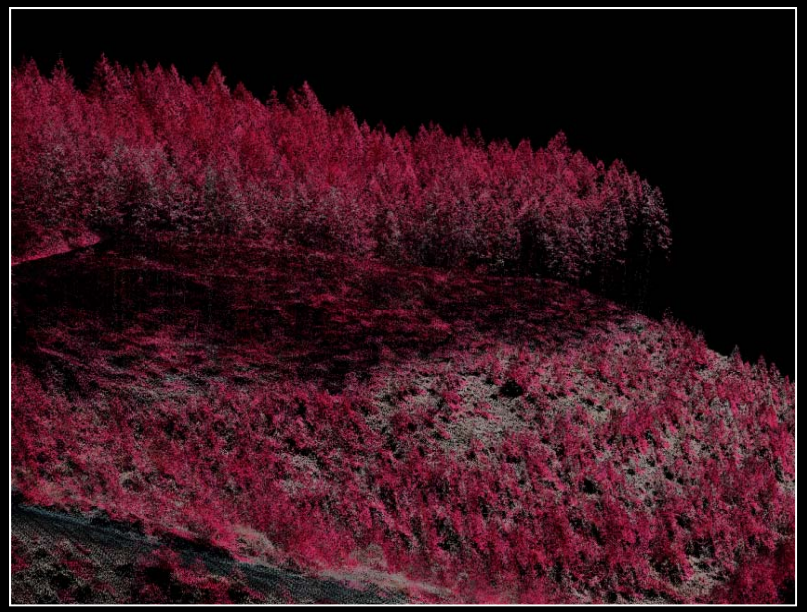
Oregon State University/USFS PNW Forest Sciences Laboratory, Corvallis, OR

Rocky Mountain Research Station, Moscow, ID

US Forest Service Research Lab, Portland, OR

Panther Creek LiDAR Research, BLM

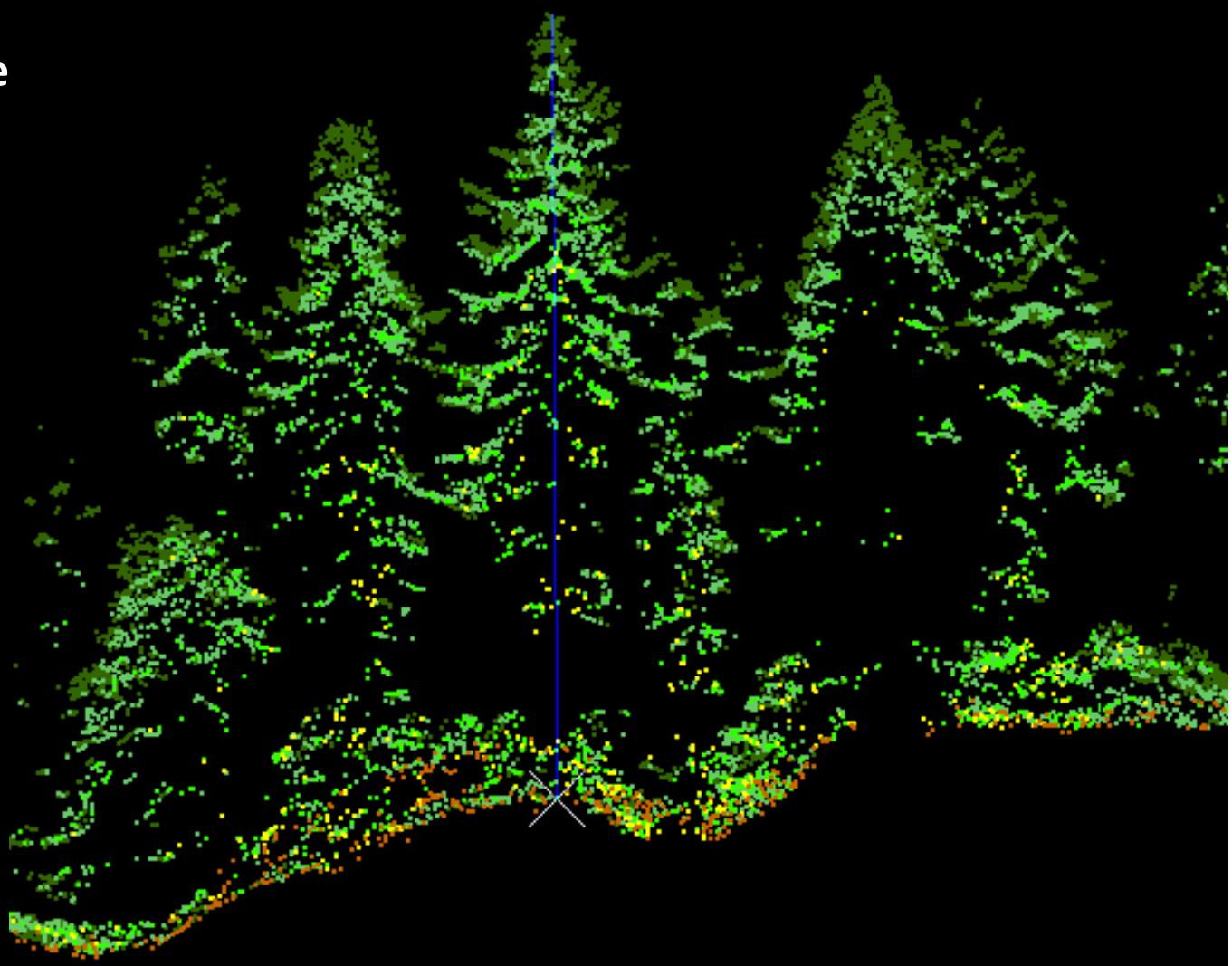
Private Industry



Watershed Sciences

Light Detection and Ranging (LiDAR)

In its most basic form, LiDAR Data are just points



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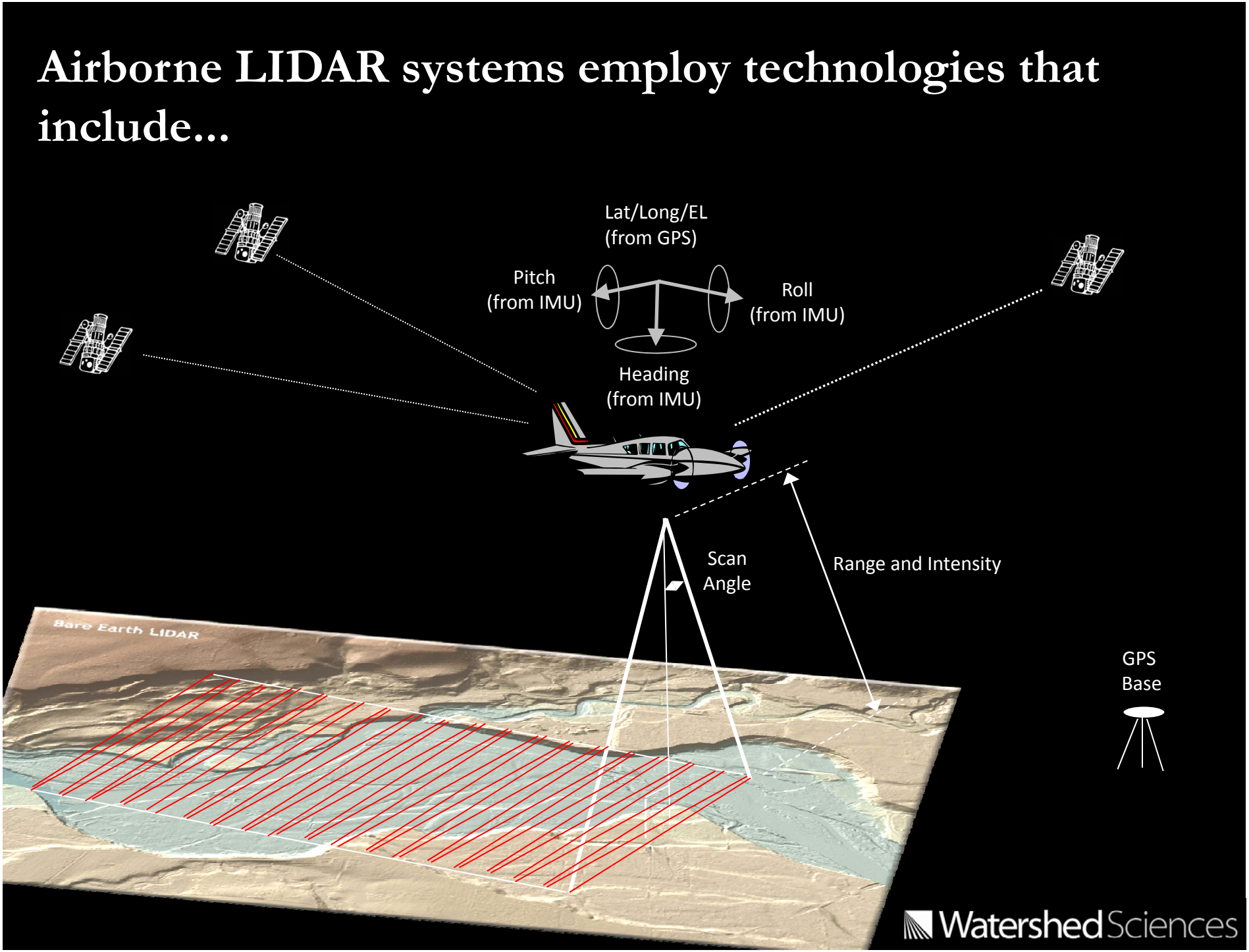
Airborne LIDAR systems employ technologies that include…



LiDAR Systems/Hardware

Airborne Platforms

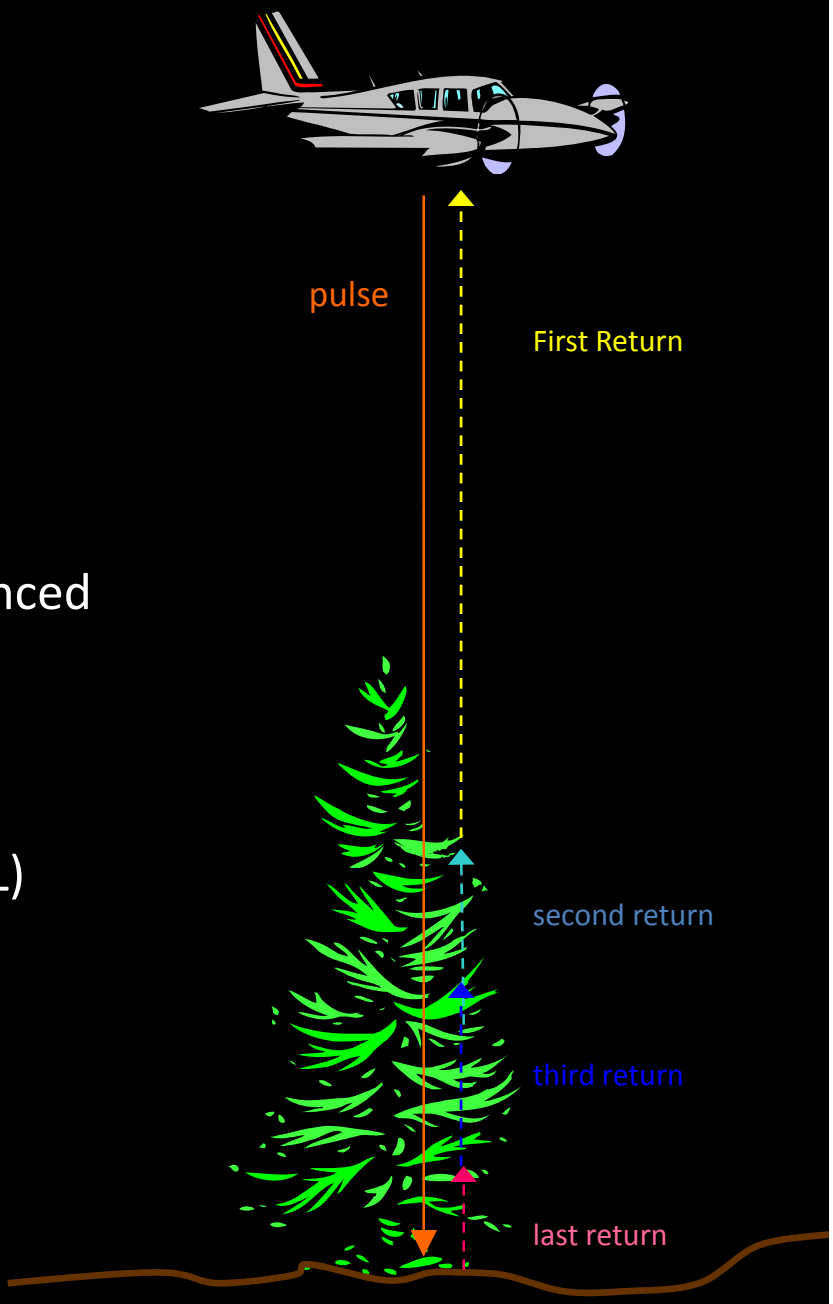
Airborne LiDAR Systems

Ground GPS Systems

Airborne LiDAR Concepts

small footprint, discrete return system

- Up to 200,000 pulses per Sec (200 KHz)
- Up to 4 returns per pulse
- Each LiDAR return is individually geo-referenced
- Records intensity of backscatter
- Sub-meter footprint (~22 cm @ 1000 m AGL)



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In its most basic form, LiDAR Data are just points

Ponderosa Pine and Juniper

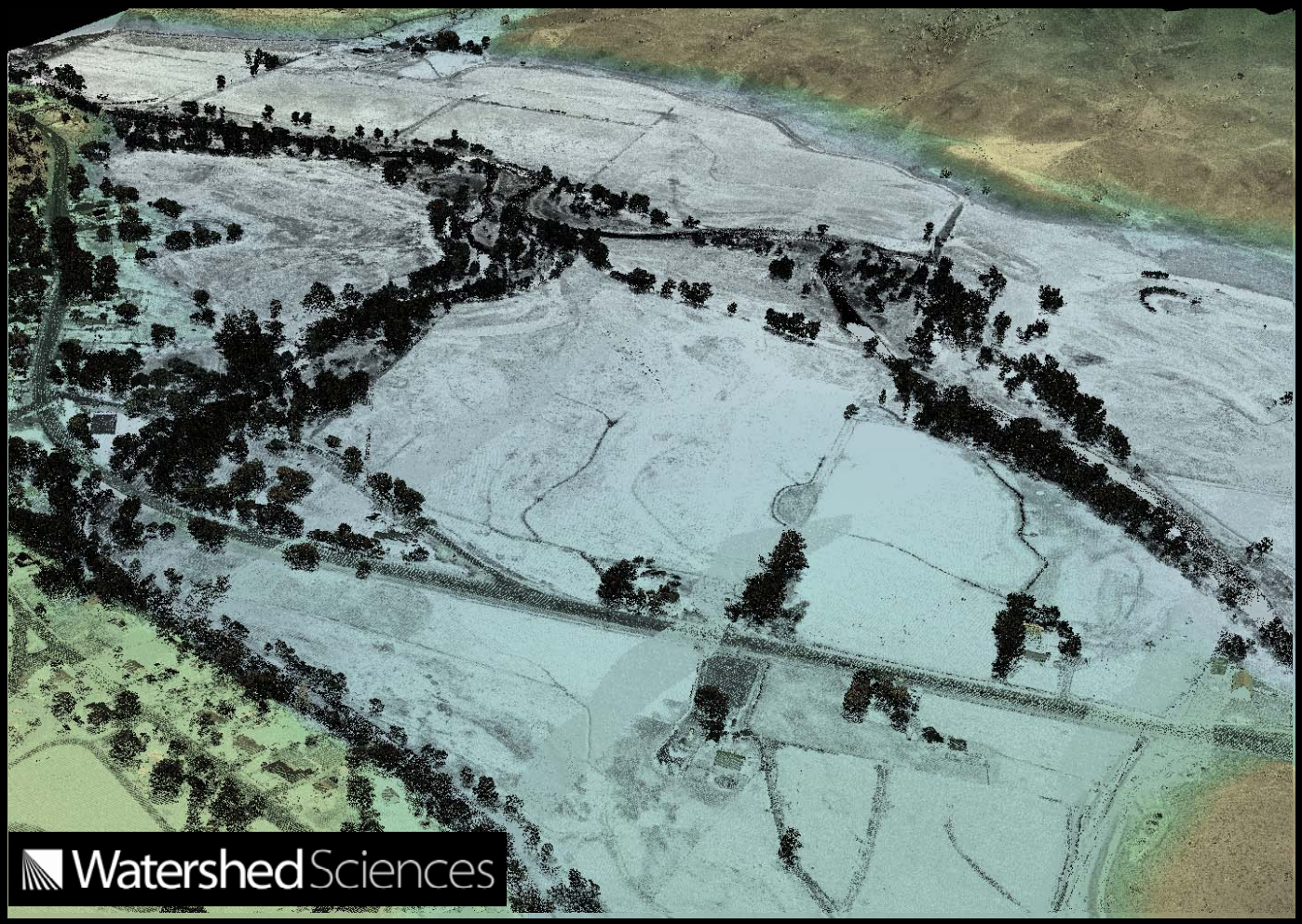
Multiple Laser Returns
are Apparent

First Return
Second Return
Third Return
Fourth Return
Ground Points

Penetration

Going from Points to Surfaces… Modeling Data

- Data clouds are massive
- TINs from data clouds
- GRIDs from TINs (Interpolated Surface)
- GRIDS are smaller and easier to work with



All Returns
Colored by Intensity

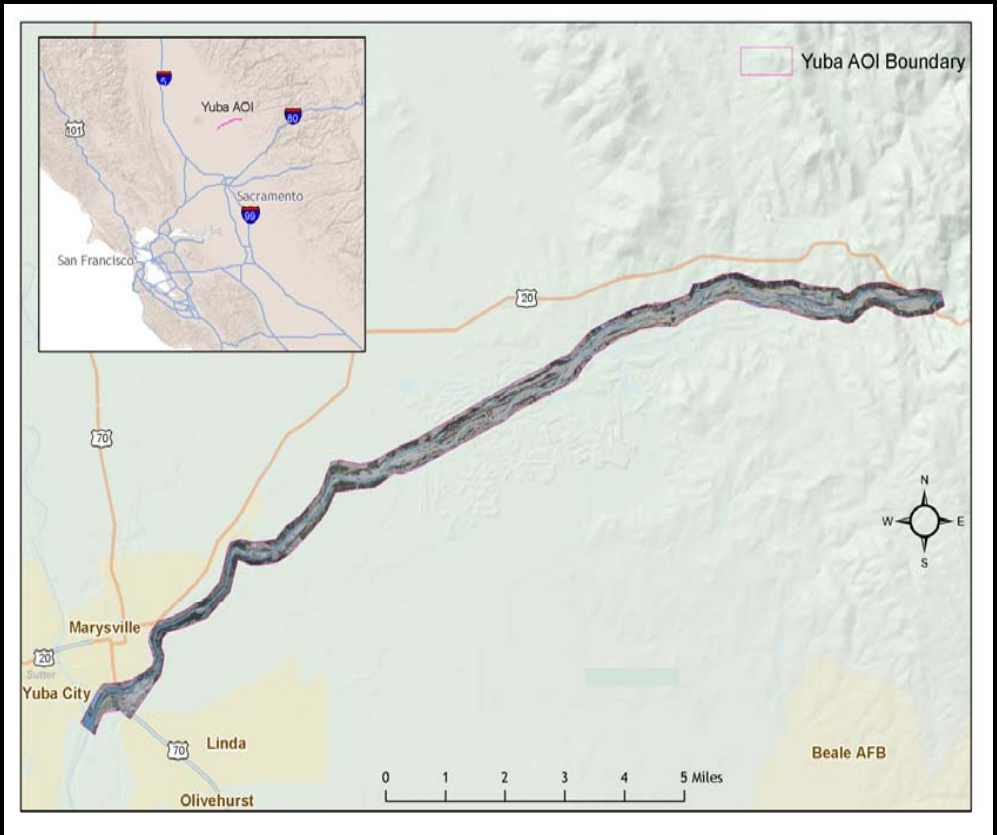
Dayville, OR

Yuba River Project Objectives:

- Removal of artifacts in existing LiDAR the was not collected or calibrated by WSI.

  - Reclassification of ground and vegetation pts
  - Creation of water surface elev. model

- Vegetation Surface Model
- NDVI from 2009 NAIP Imagery
- Derive Vegetation Metrics
- Classify Vegetation Types



Existing LiDAR Provided to WSI by Yuba River RMT and UC Davis.

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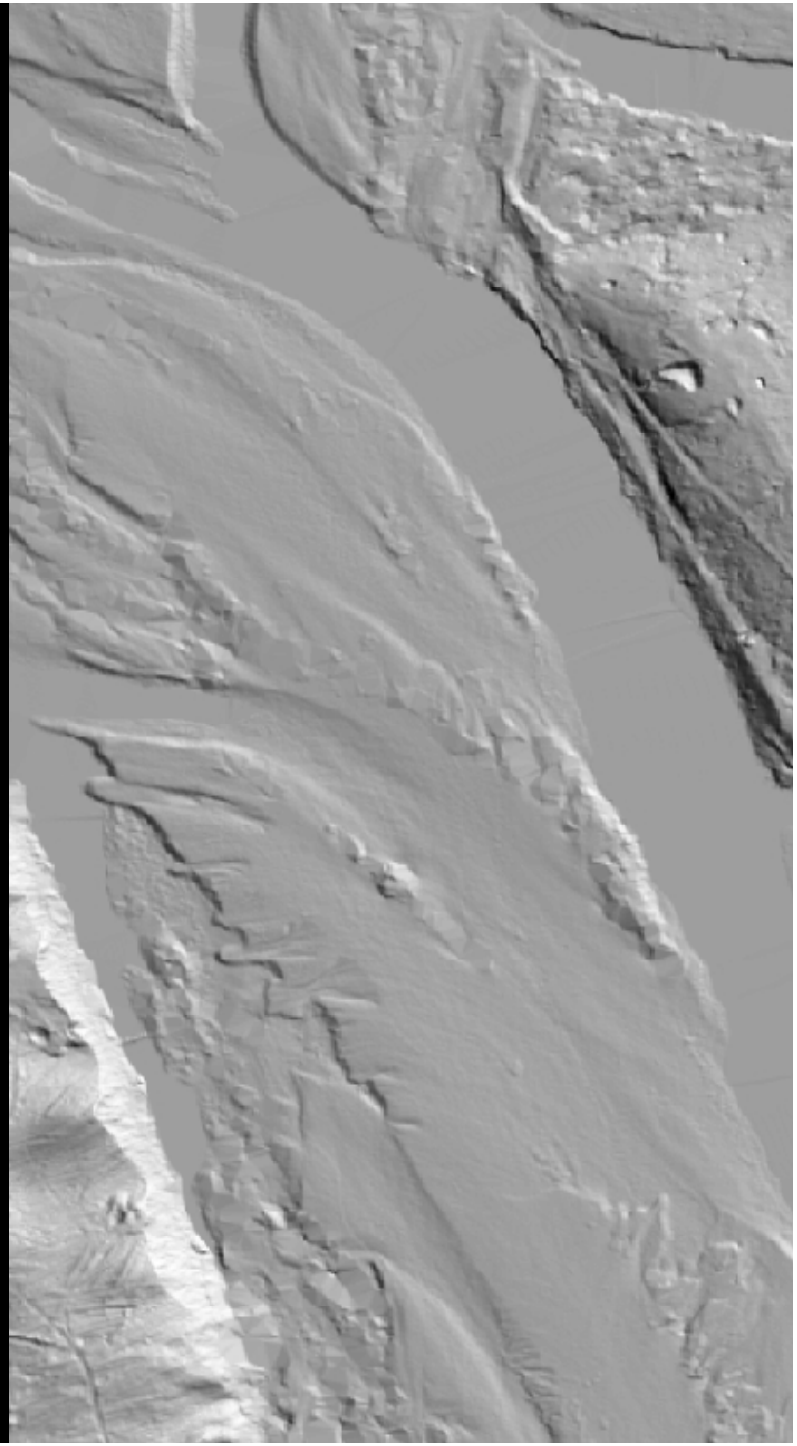
Ground Classification

- WSI Techniques:
  - -Automated Ground Classification
  - - Manual Review and Edits

- Existing Data Issues:
  - - Very Poor Calibration and Offsets
  - - Conditioning of Points



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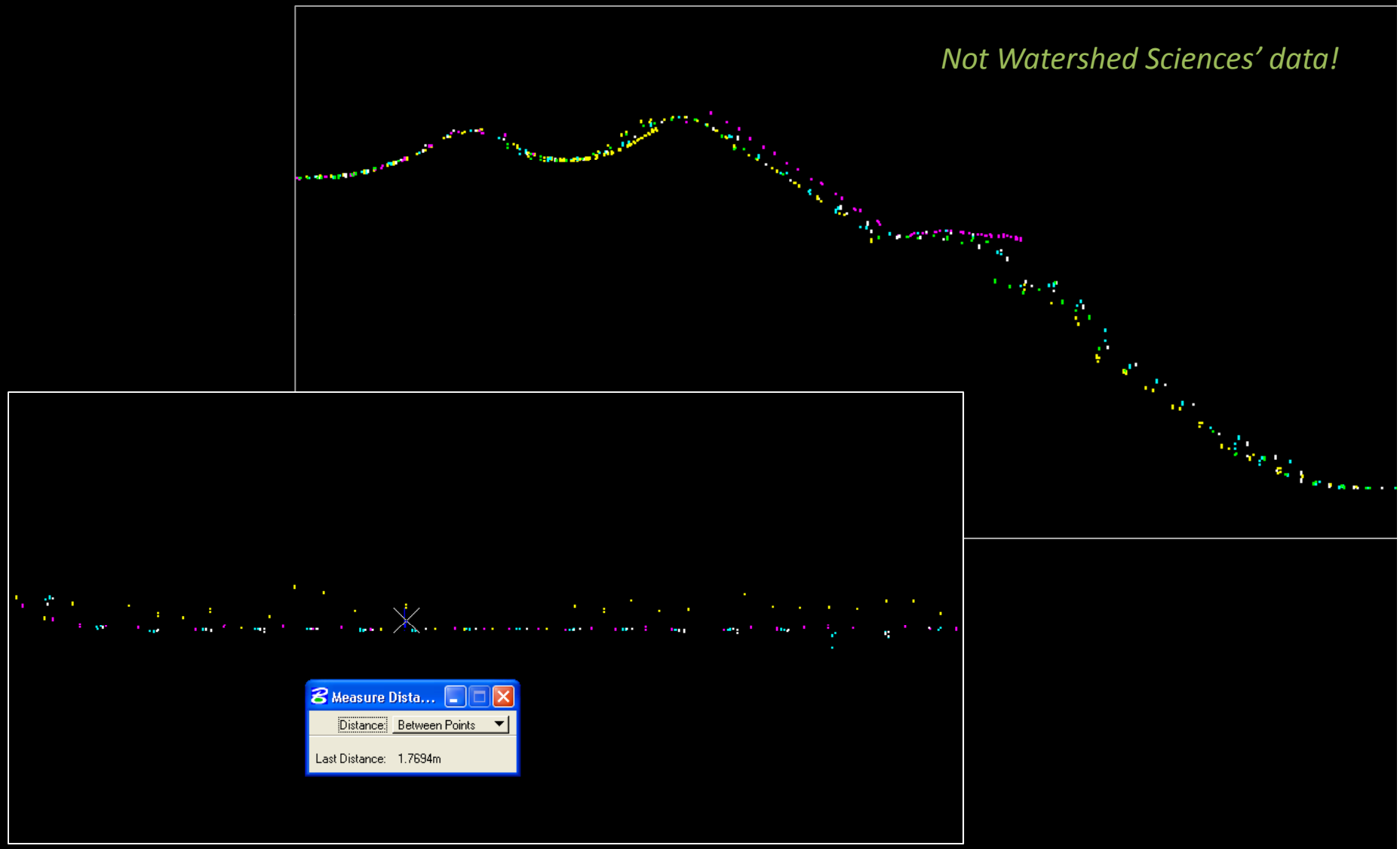
Localized Offset Errors - Yuba River Data



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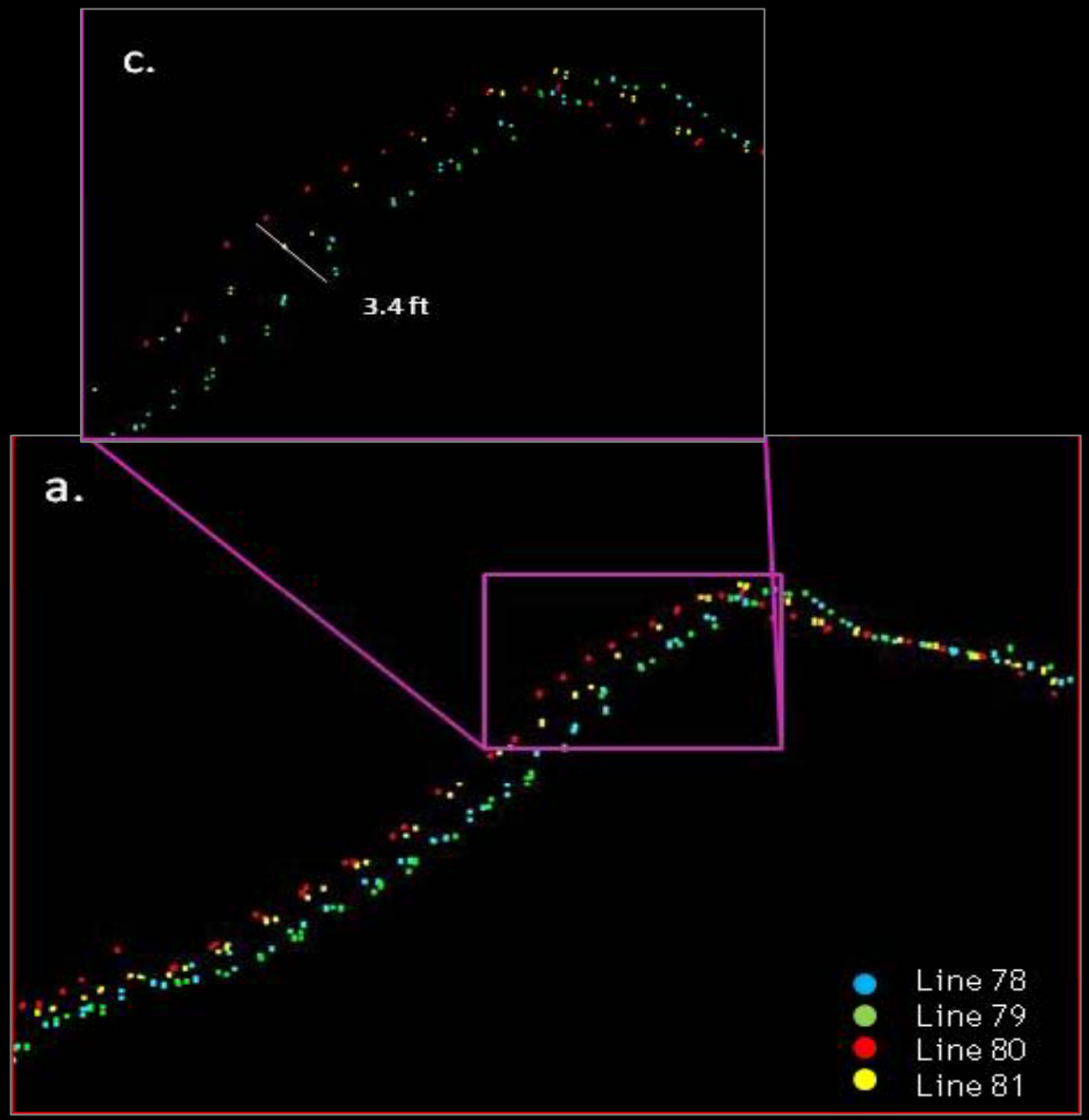
Relative Accuracy: Another Example

Not Watershed Sciences' data!



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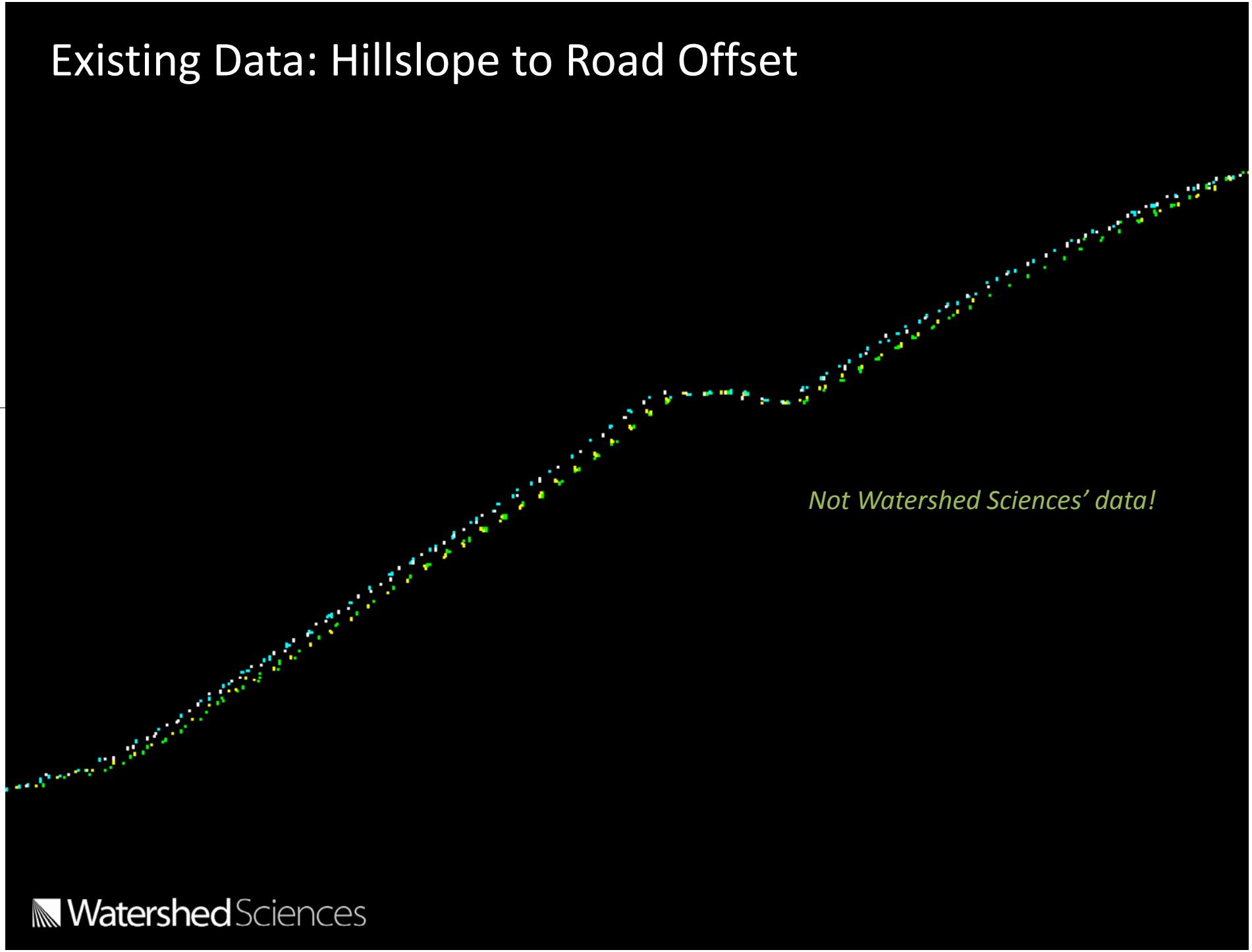
Existing Data: Hillslope to Road Offset



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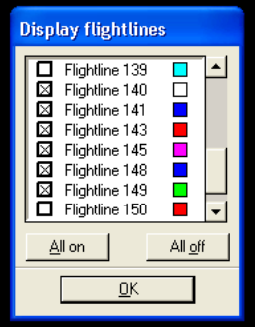
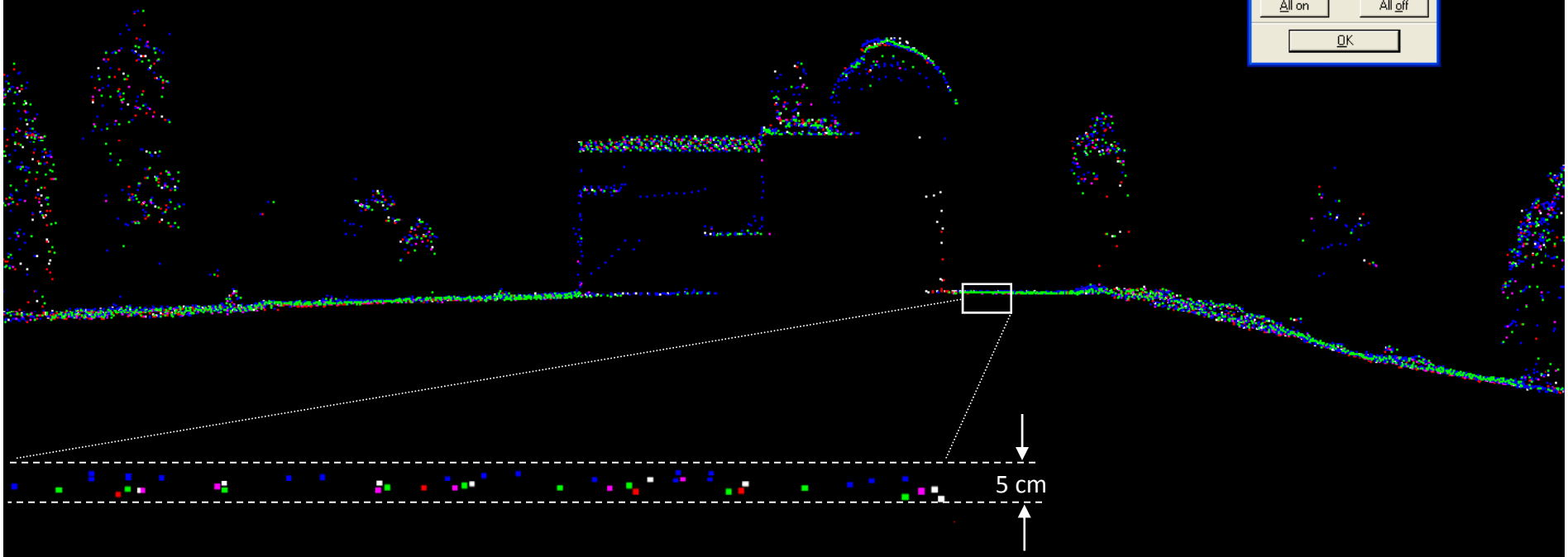
Relative Accuracy Example

- A measure of system calibration
- Measured as the divergence of points from different flight lines





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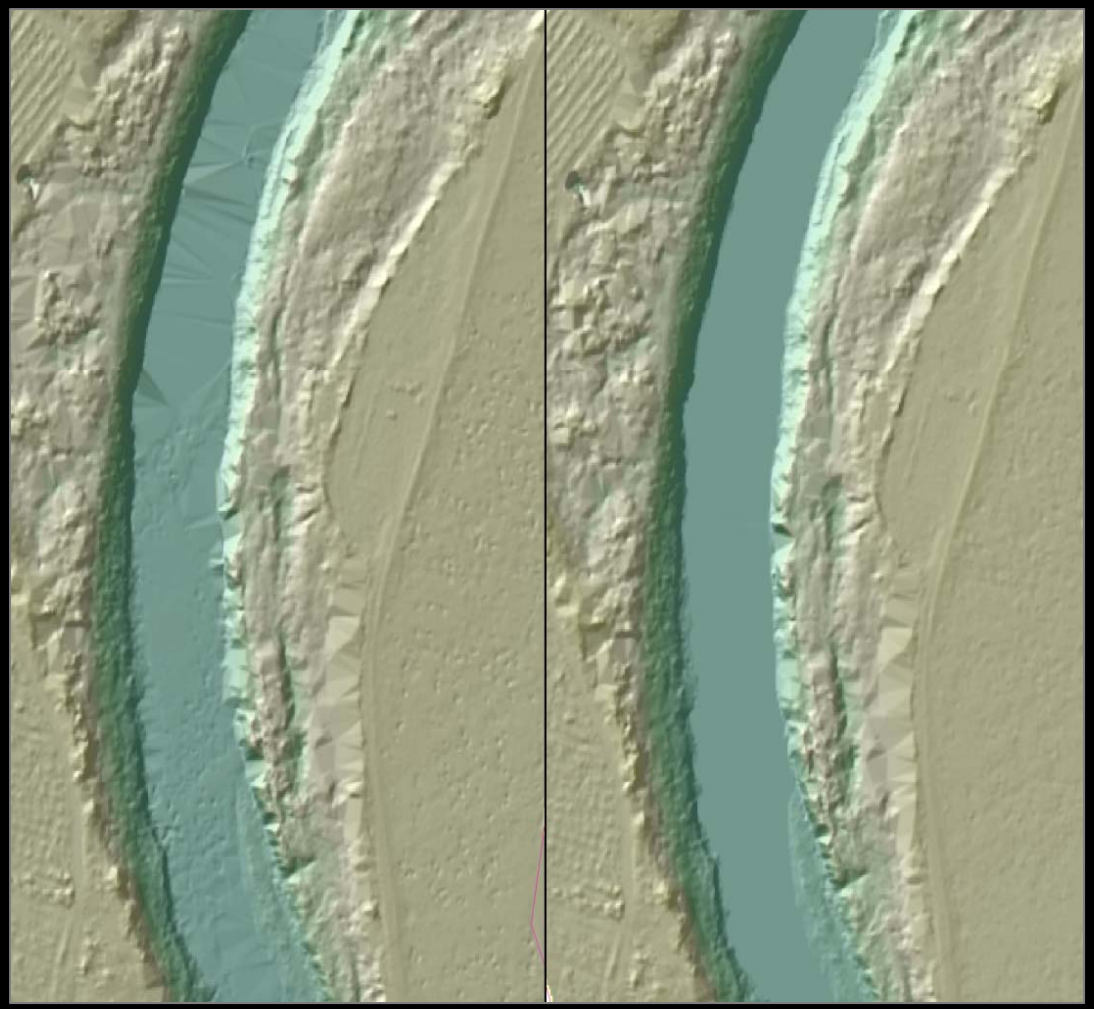
Hydro-Flattened Water Surface

- Water's edge break line created using Lidar-grammetry.
- Breaklines enforced in the ground classified returns to create a true water surface.
- Breaklines used to re-class water points.



non-flattened *flattened*

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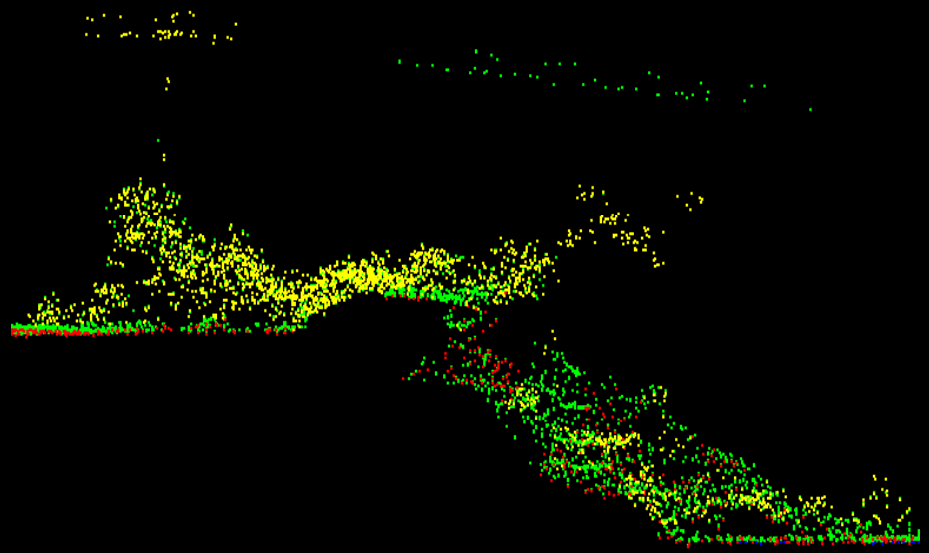
Vegetation Point Classification

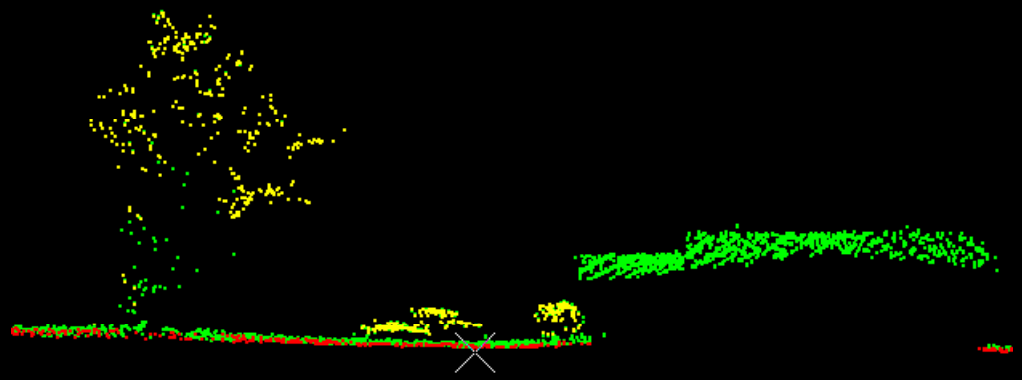
Workflow:

1. Man-made structures automated reclassification with manual review.

2. Correction surface was developed to account for localized misalignments.

3. Removal of noise points and secondary returns.





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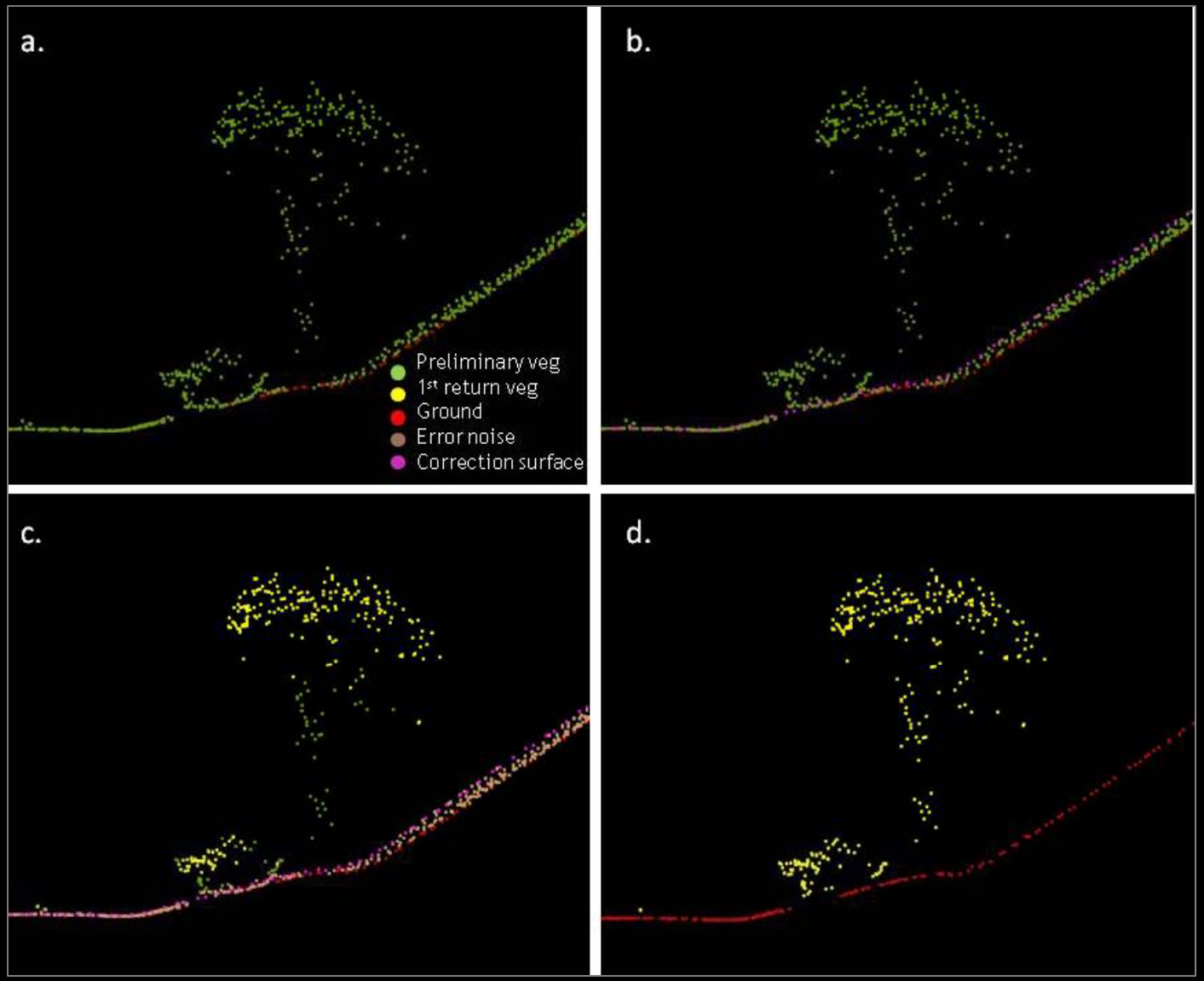
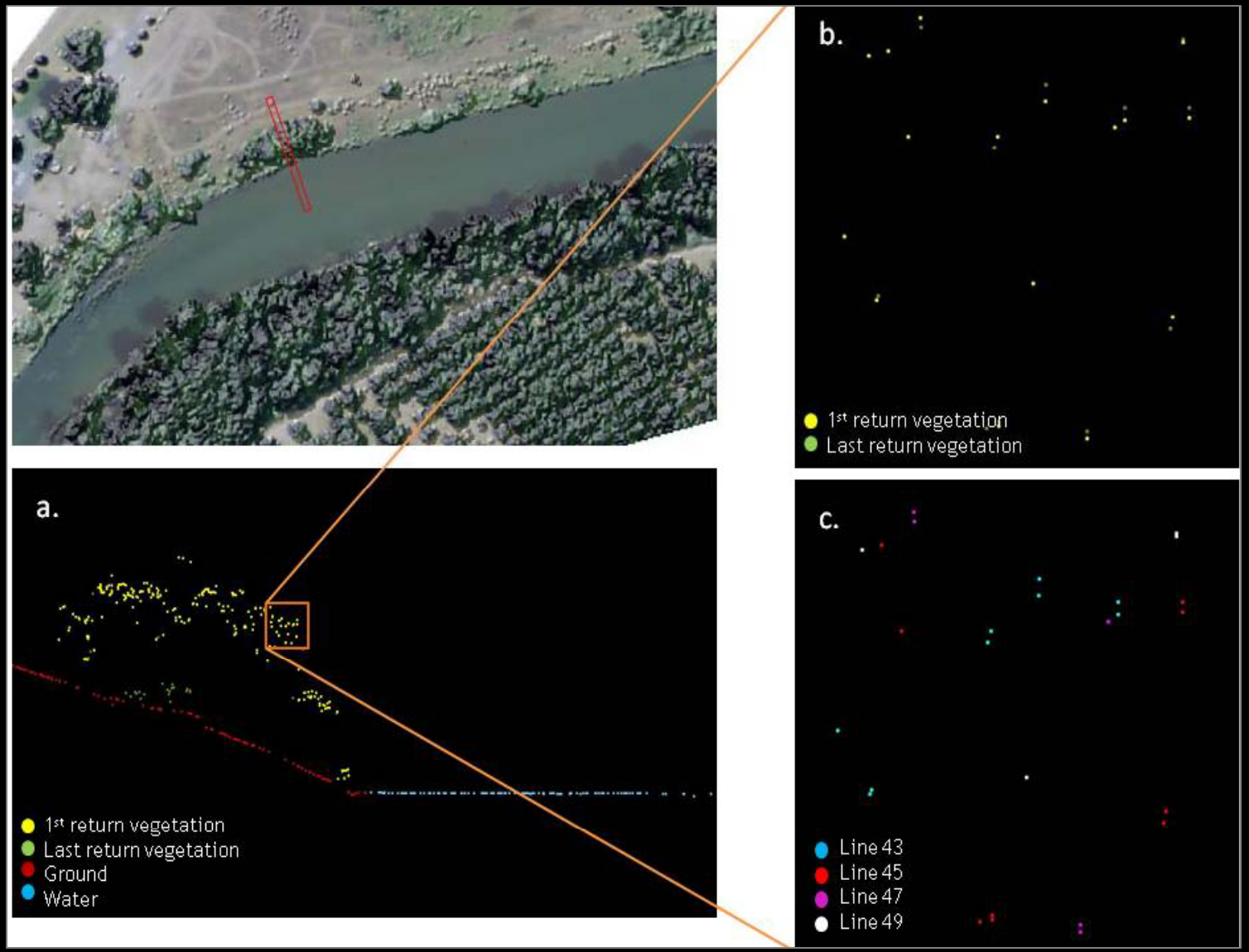
Correction Surface

Vegetation Point Classification



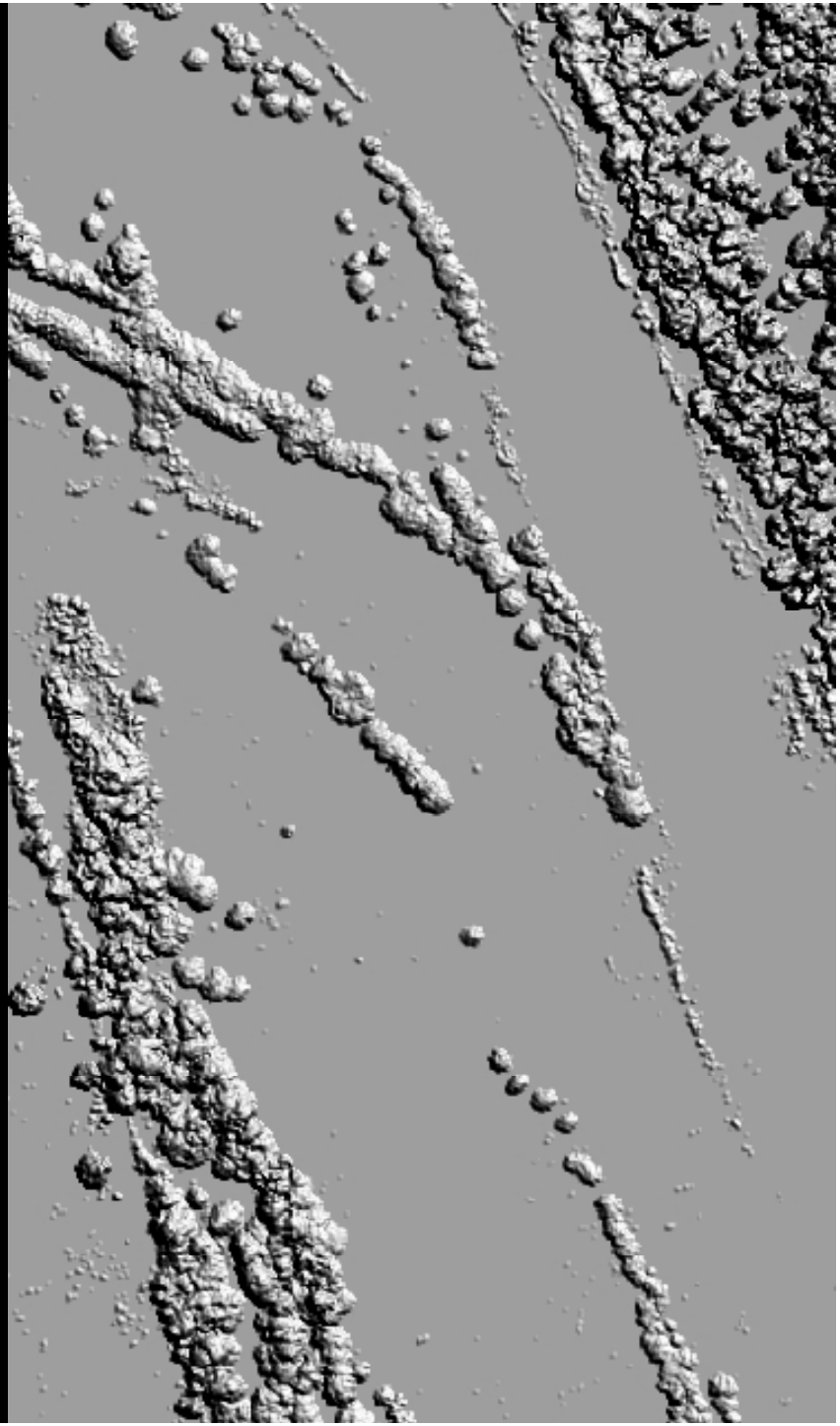
Removal of Duplicate Points

Vegetation Point Classification



Vegetation Height Model

DEM Created from the vegetation classified points normalized to the ground model



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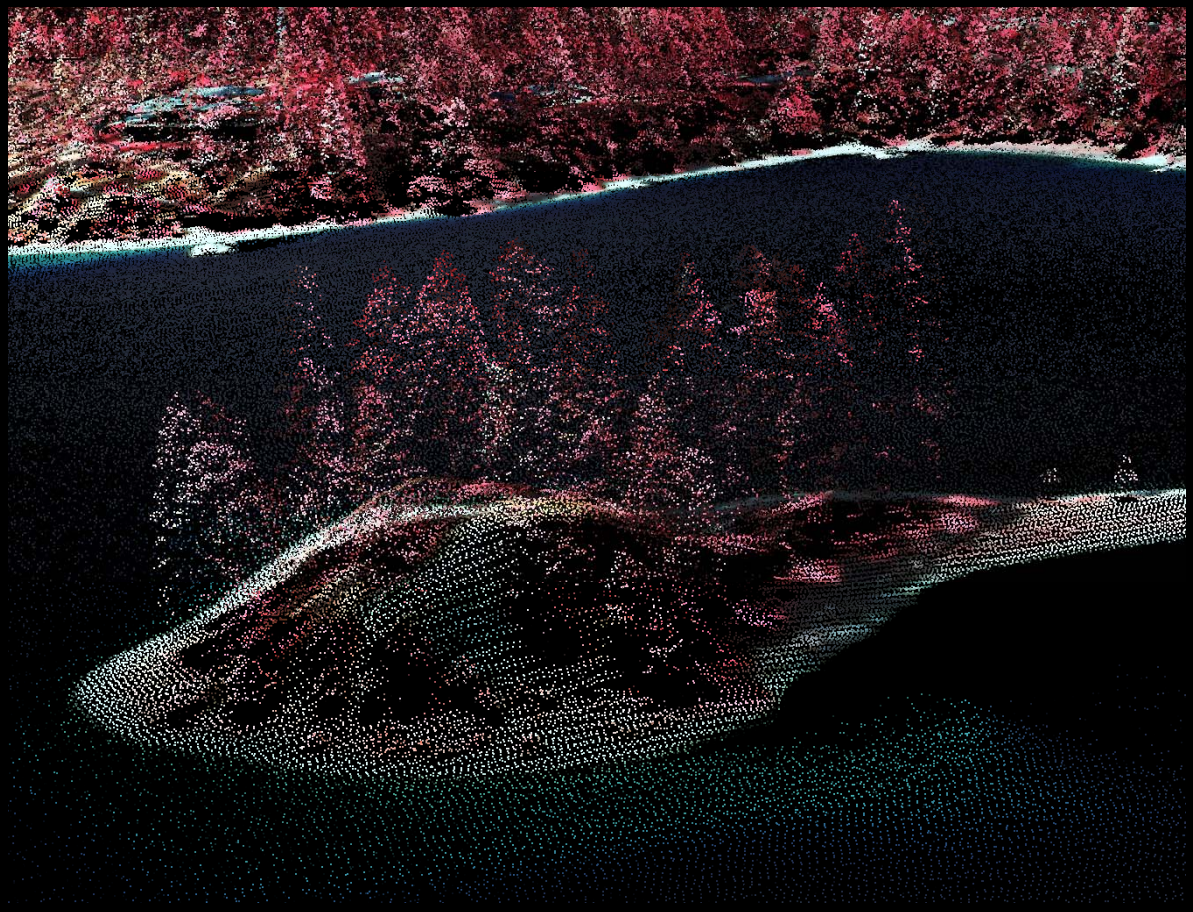
Vegetation Characterization

LiDAR point cloud provides the basis for deriving vegetation metrics to characterize structure at the stand or tree approximate scale.



Swan Lake; Flathead Lake, MT

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Stand Type Delineation Workflow:

1. Assemble data stack: 8.9 meter (29 ft) spatial resolution raster layers derived from LiDAR point cloud.

2. Principal Component Analysis: Selection of layers that account for the variability in the data strata .

3. Segmentation from PCA Data Strata: Multiple Methods Available…
   - Unsupervised using ISODATA algorithms.
   - Object-oriented classification using rules-based analysis.

5. Aggregate to Final Classes: Final LiDAR based stand types and height classes.

6. Accuracy Assessment: Using tree-plot data, calculate user, producer and overall accuracies and kappa statistics for each segmentation.

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Workflow generally follows A. Sullivan, 2008

Common Vegetation Metrics:

PCA selection of data strata can vary depending on the land cover and analysis objectives.

- **Vegetation Height (P90):** **Height at which 90% of LiDAR returns fall below.**
- **Stem Density:** # of local maxima per cell. Relative measure of density between forest stands.
- **Standard Deviation of Height:** **Std deviation of local maxima per cell.**
- **Canopy Cover:** **% total returns over returns above a specified threshold.**
- **Canopy Height Model:** **Point elevations normalize to ground elevations.**
- **LiDAR Intensities:** **Normalized 1st return intensities.**

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Automated Data Strata Sampling

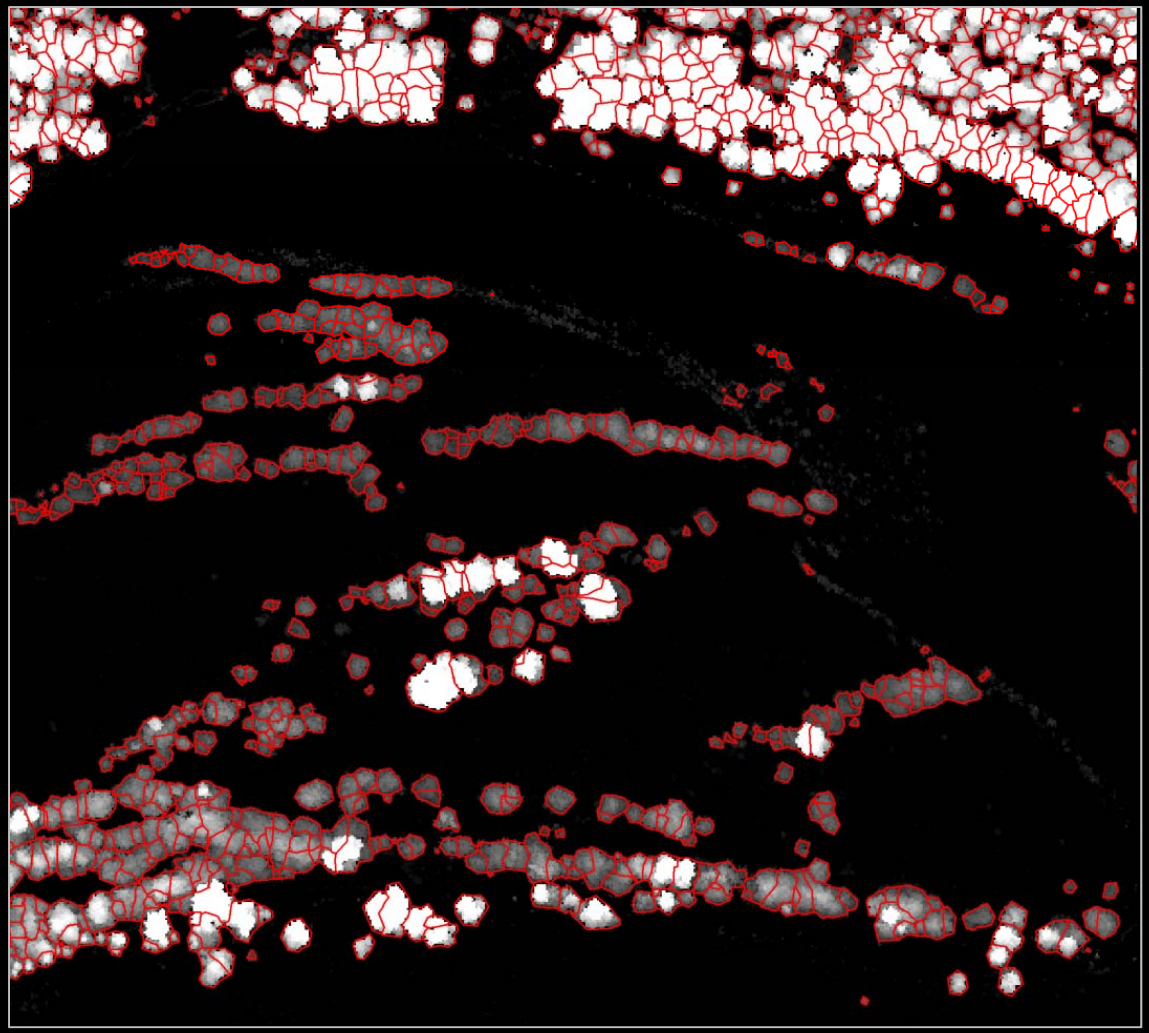
WSI LiDAR Feature Extraction Tool: In-house tool developed to generate vegetation metrics and other feature classifications. Capable of generating over 114 metrics/data strata.

USFS "Fusion" Model: Developed at Pacific Northwest Research Station, Seattle. Capable of generating 100+ LiDAR metrics/data strata.

Tree Approximate Segmentation

Inverted Normalized Vegetation Height Model

- Low pass filter
- Watershed Delineation



Tree polygons over intensity image

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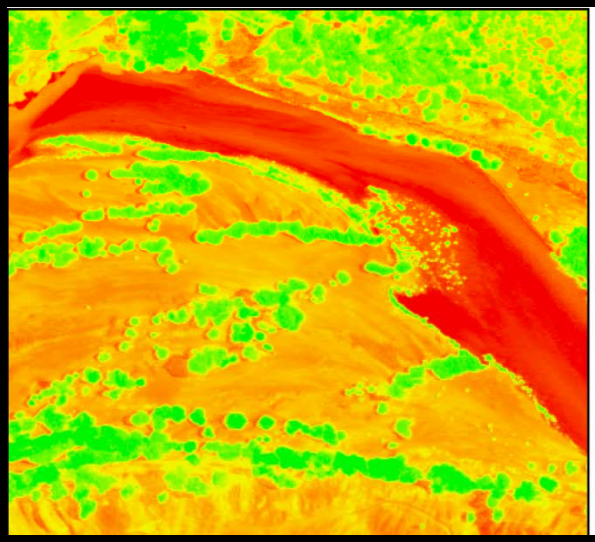
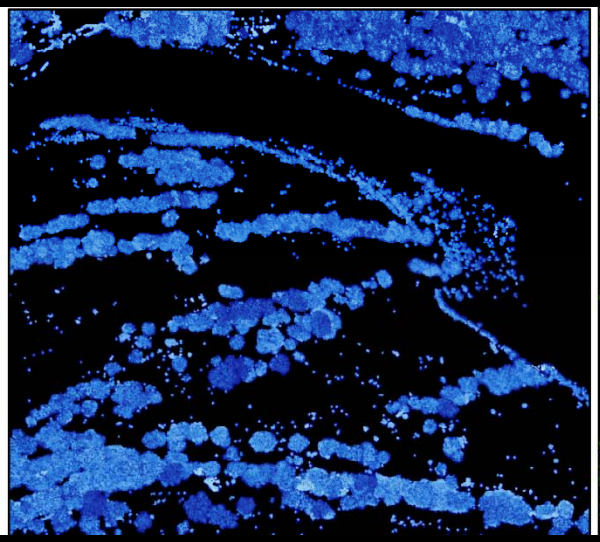
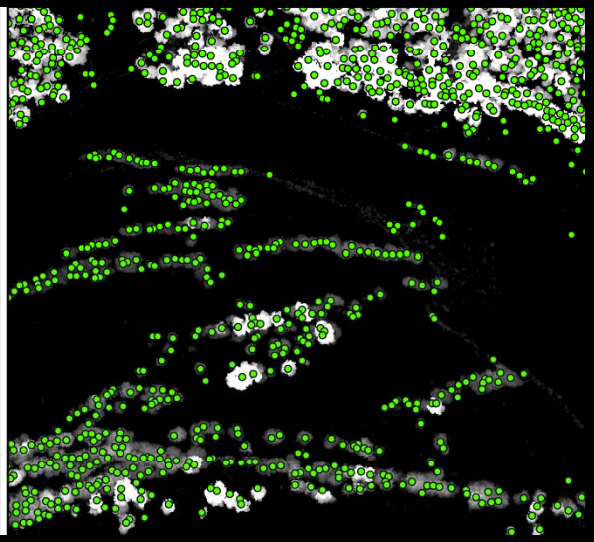
Other Base Data Layers



NDVI



LiDAR Intensities



Tree Crowns

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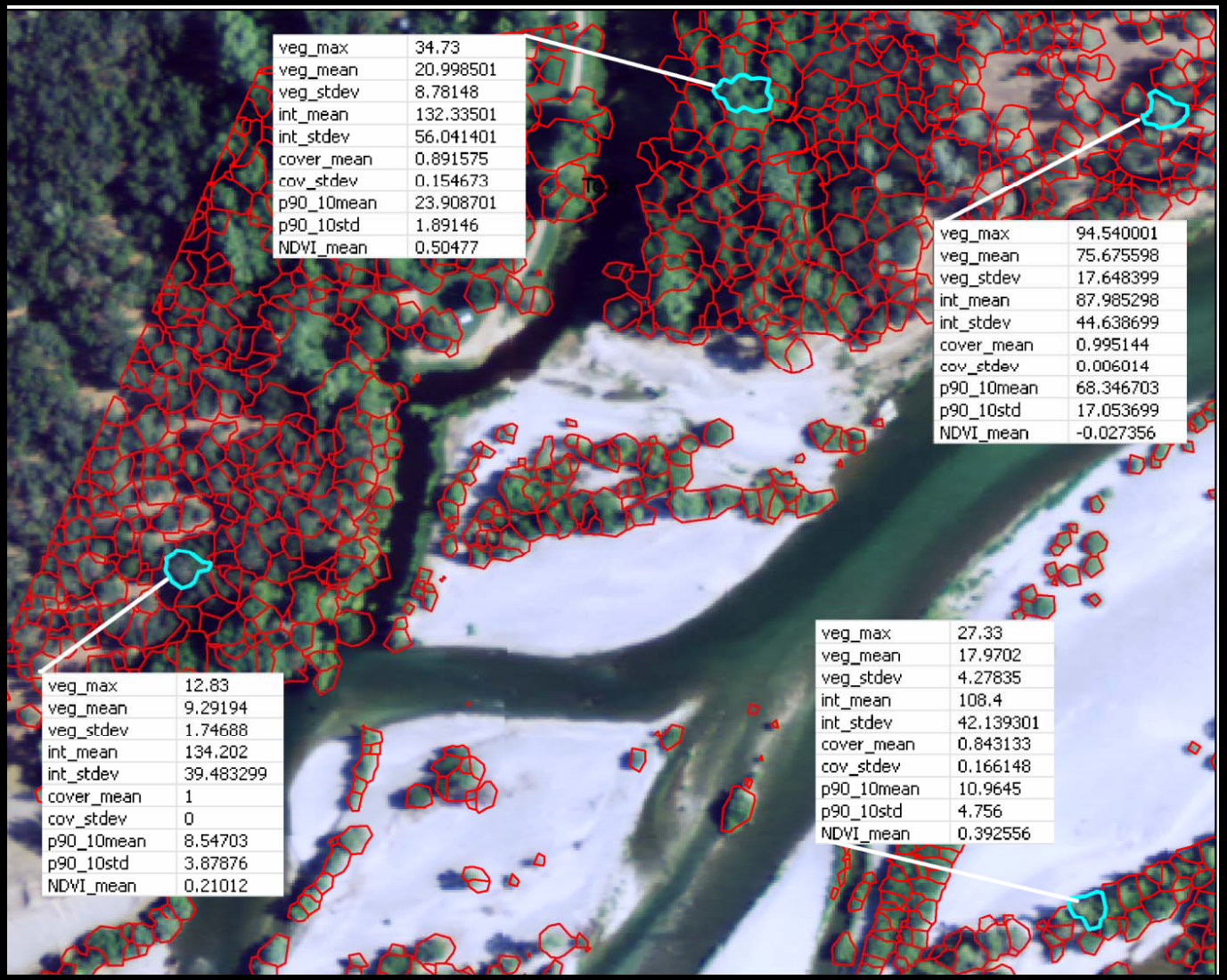
Primary Data Stack

Statistics per Tree Segmentation



Individual Tree Metrics: Height

Individual tree height is a critical in variable in forest biomass, carbon stocks, and growth and site productivity.

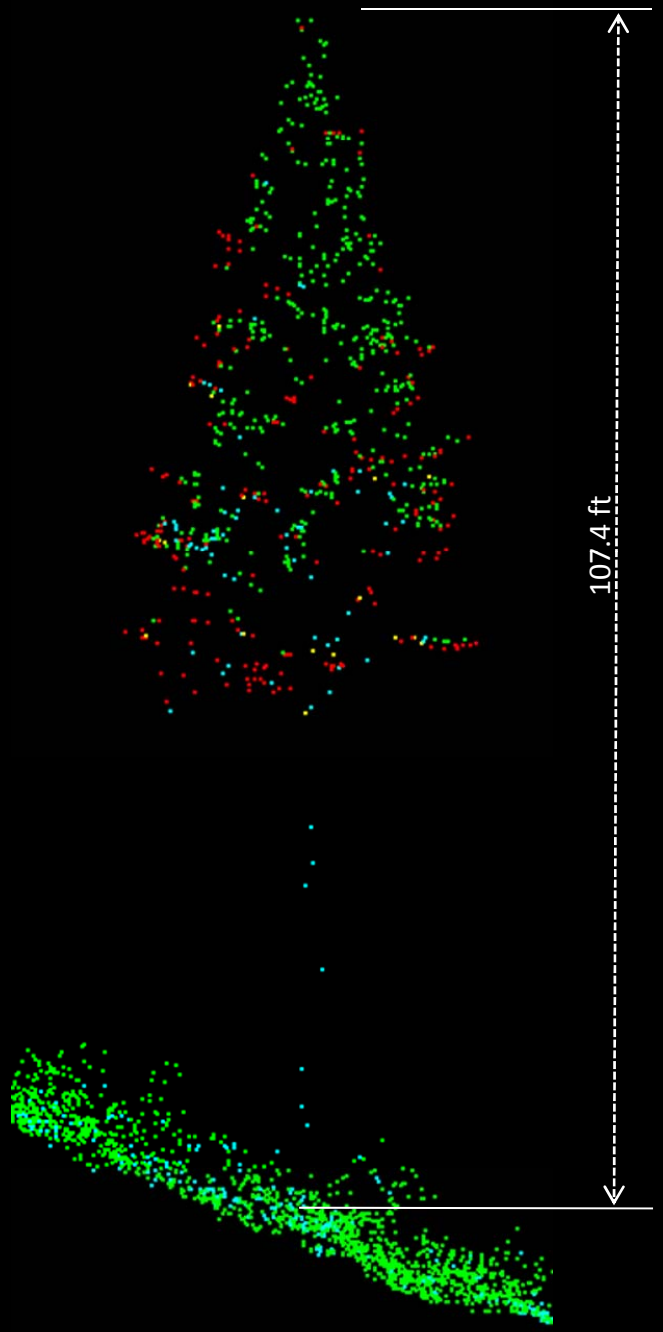
DBH is not measured directly, but highly correlated w/ LiDAR derived tree height and crown width

Individual Height Accuracies (Anderson et. al.):

LiDAR @ 6 pulses/sq m:
Ponderosa Pine: *-0.43 ±0.13 m*
Douglas Fir: -1.05 ±0.41 m

Field Techniques: *-0.27 ±0.27 m*

Digital Terrain Accuracy Directly Impacts on Individual Tree Height Measurements.



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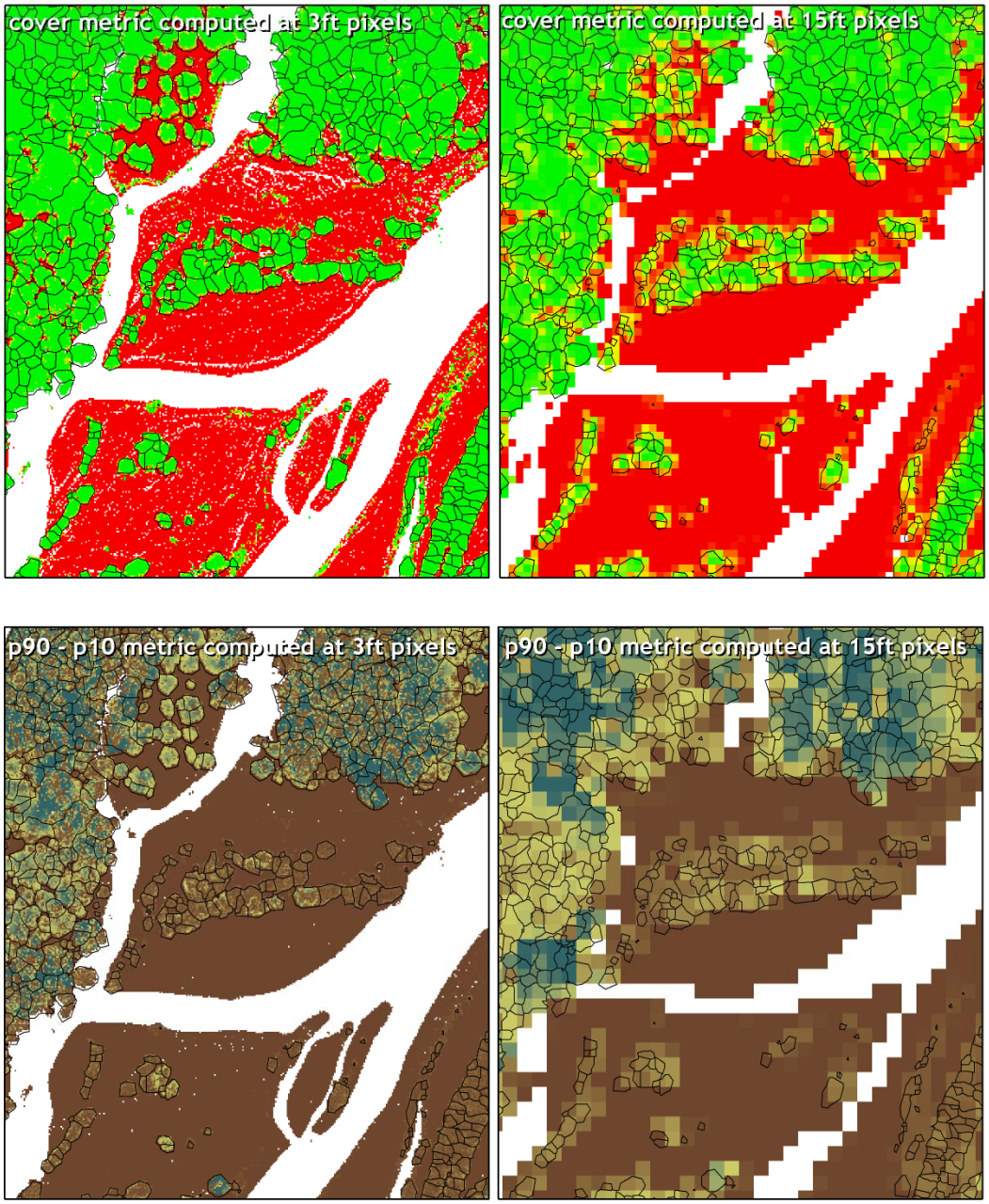
Stand Level Classifications
Influence of Spatial Scale

Spatial scale of analysis influences metric values



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Vegetation Classification Analysis
Follow-On

The Next Step:

-Rule Based Segmentation of Vegetation Classification

-Define Appropriate Output Scale (end product)

Data Needs:

-Definition of Vegetation Classes

-Plot/Survey Data (seed classification model)

Thank you