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College of Natural Resources

DIGITAL FOREST AFFILIATES

EXTRACTION OF TREE HEIGHT GROWTH INCREMENTS FORM PAIRED TEMPORAL POINT CLOUDS : LIDAR + LIDAR & LIDAR + 3D NAIP

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Advisor : Dr. Mark Kimsey

April, 22 2026

OLI Operational Lidar Inventory
GMUG Growth Model User's Group

CONTEXT

FOREST INVENTORIES

Accurate **+**
Timely **+**
Spatially explicit

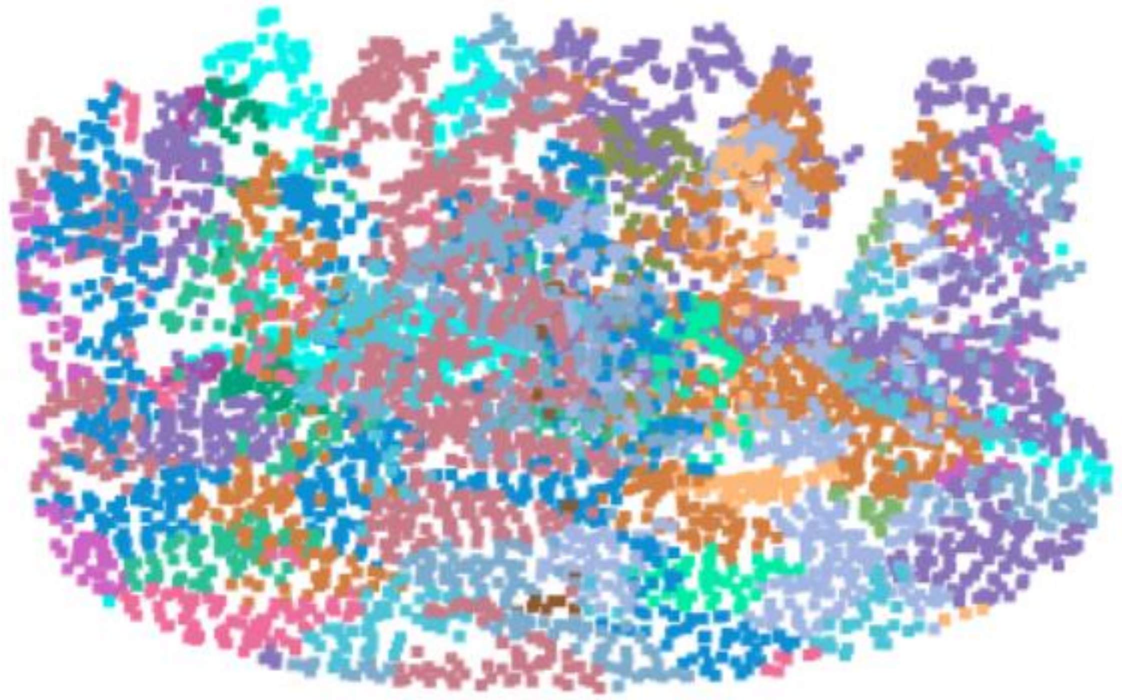
Forest Attribute Estimation

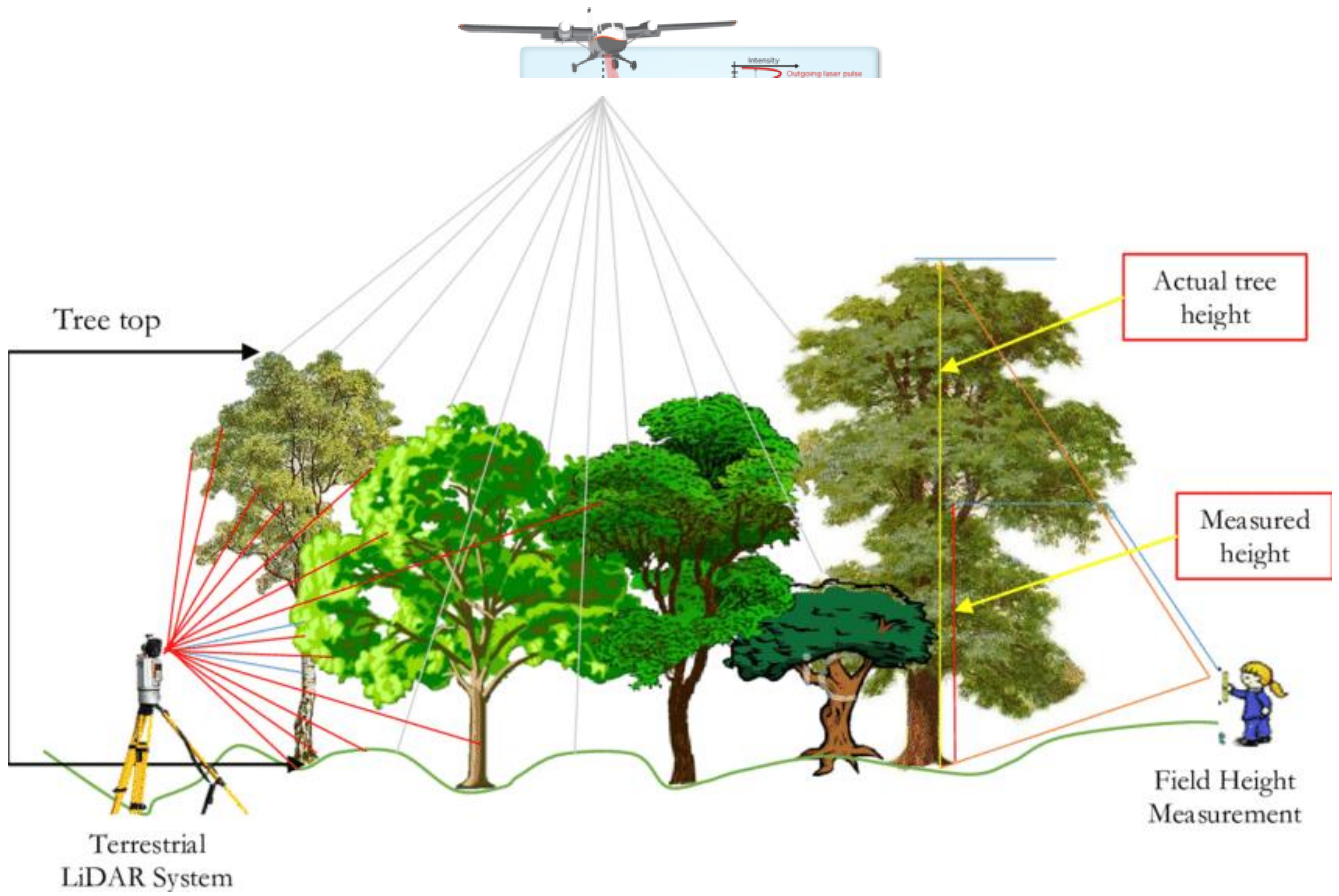
- Species composition
- Tree diameter
- Heights
- Density

Growth and productivity, Carbon, Biodiversity

CONTEXT

Data field collection : expensive, time consuming, limited to small areas, source of errors





Adapted from Ojoatre, 2016

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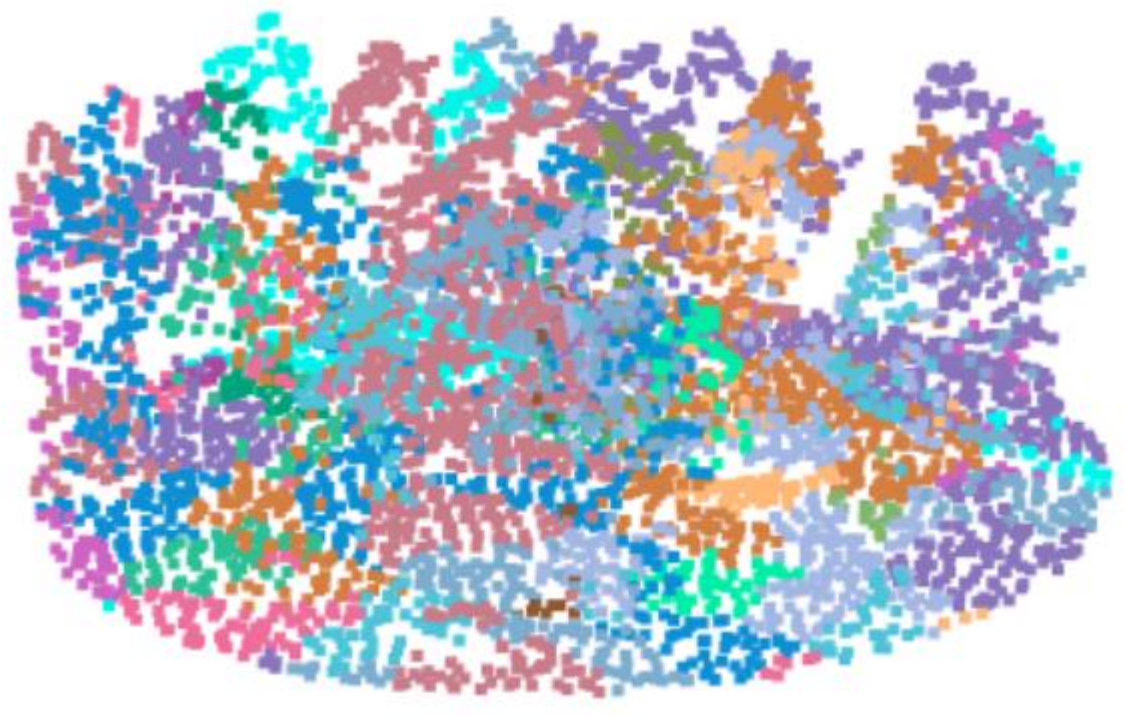
CONTEXT

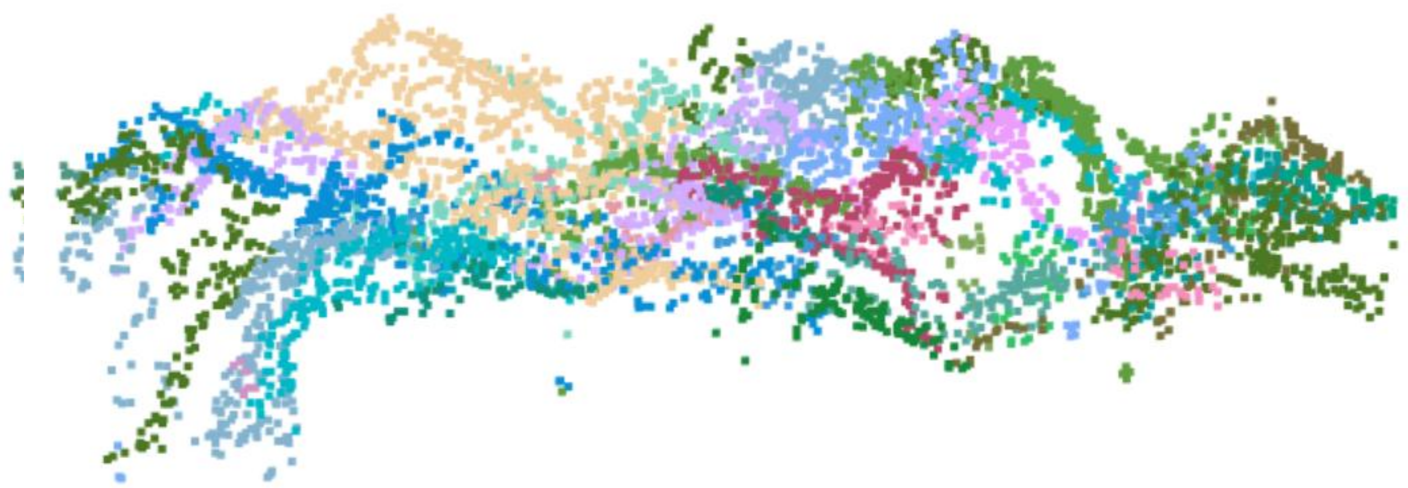
- ❑Key Technologies: ALS and DAP
  - ✓Essential for assessing forest structure (ALS)
  - ✓Measure tree heights
  - ✓Extract crown boundaries
  - ✓Determine tree locations
  - ✓Enhance the accuracy of forest inventory data

ALS (3DEP)



- ❑ DAP ≠ ALS :
- ✓ Limited to canopy surface
- ✓ Depends on external DTM
- ✓ Bigger coverage
- ✓ High temporal availability (low-cost acquisition)

3DNAIP



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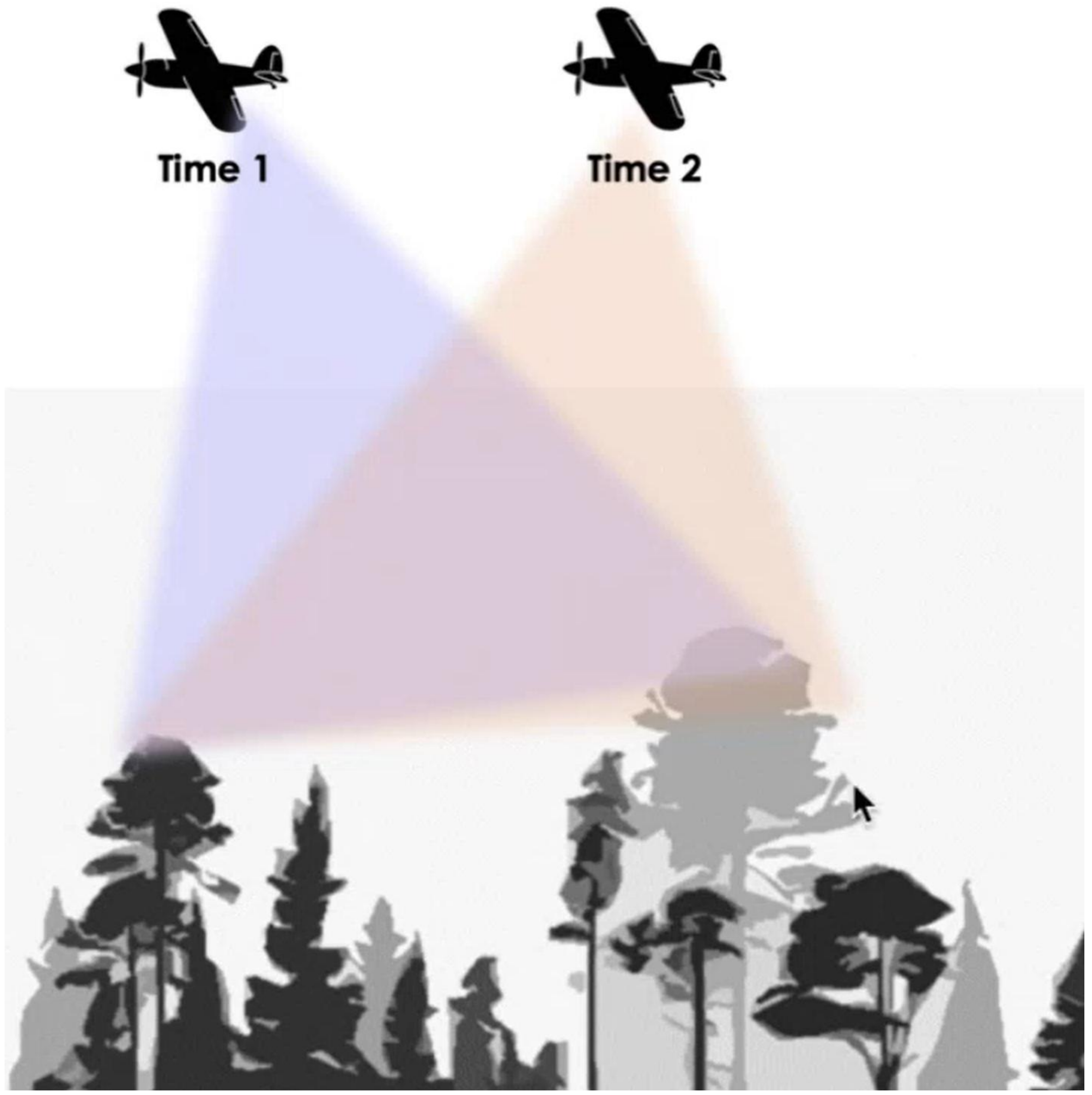
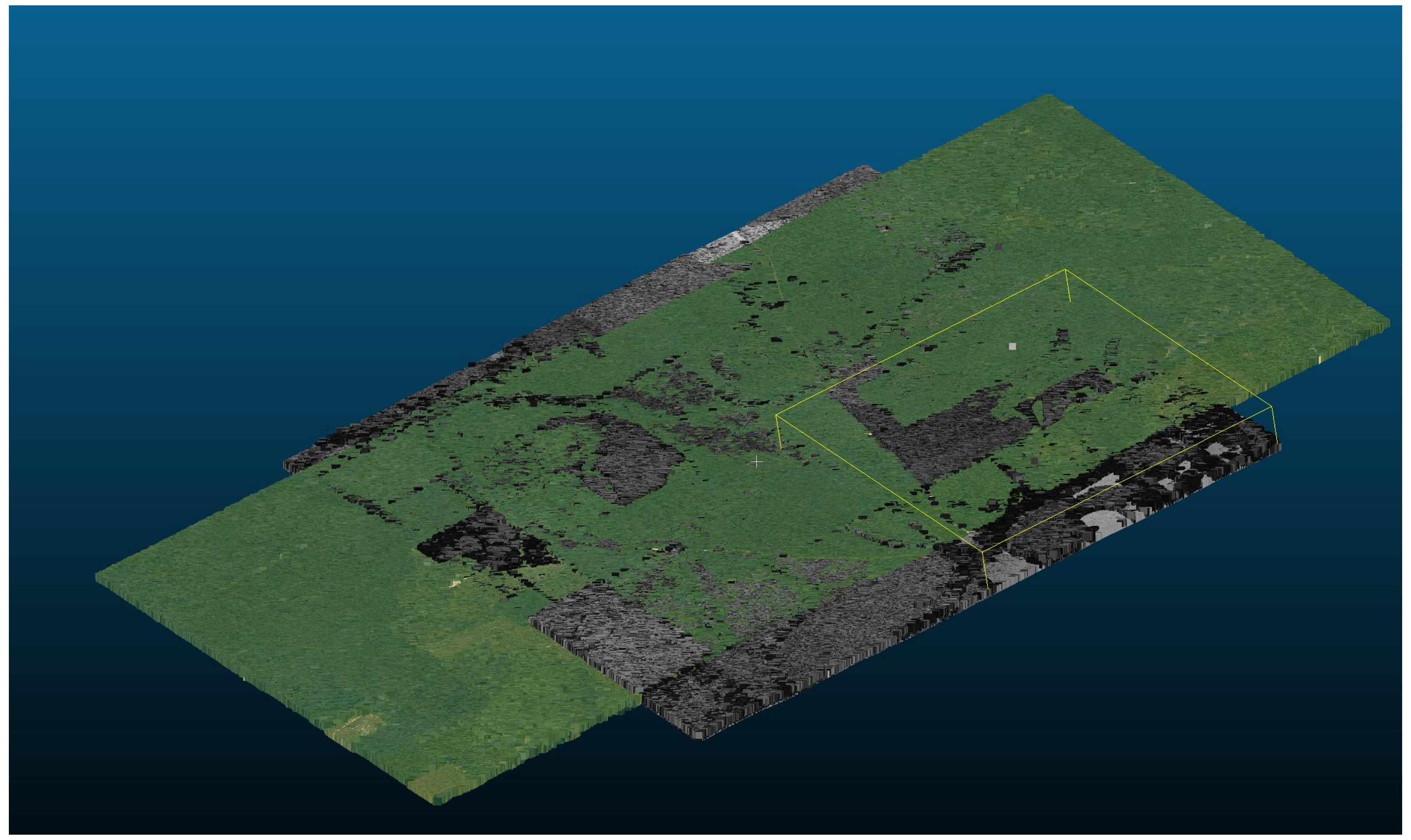
CONTEXT

Issues in acquisition of remote sensed times series data

- ✓Forest management
- ✓Sensor heterogeneity
- ✓Terrain complexity
- ✓Preprocessing methods
- ✓Processing artifacts

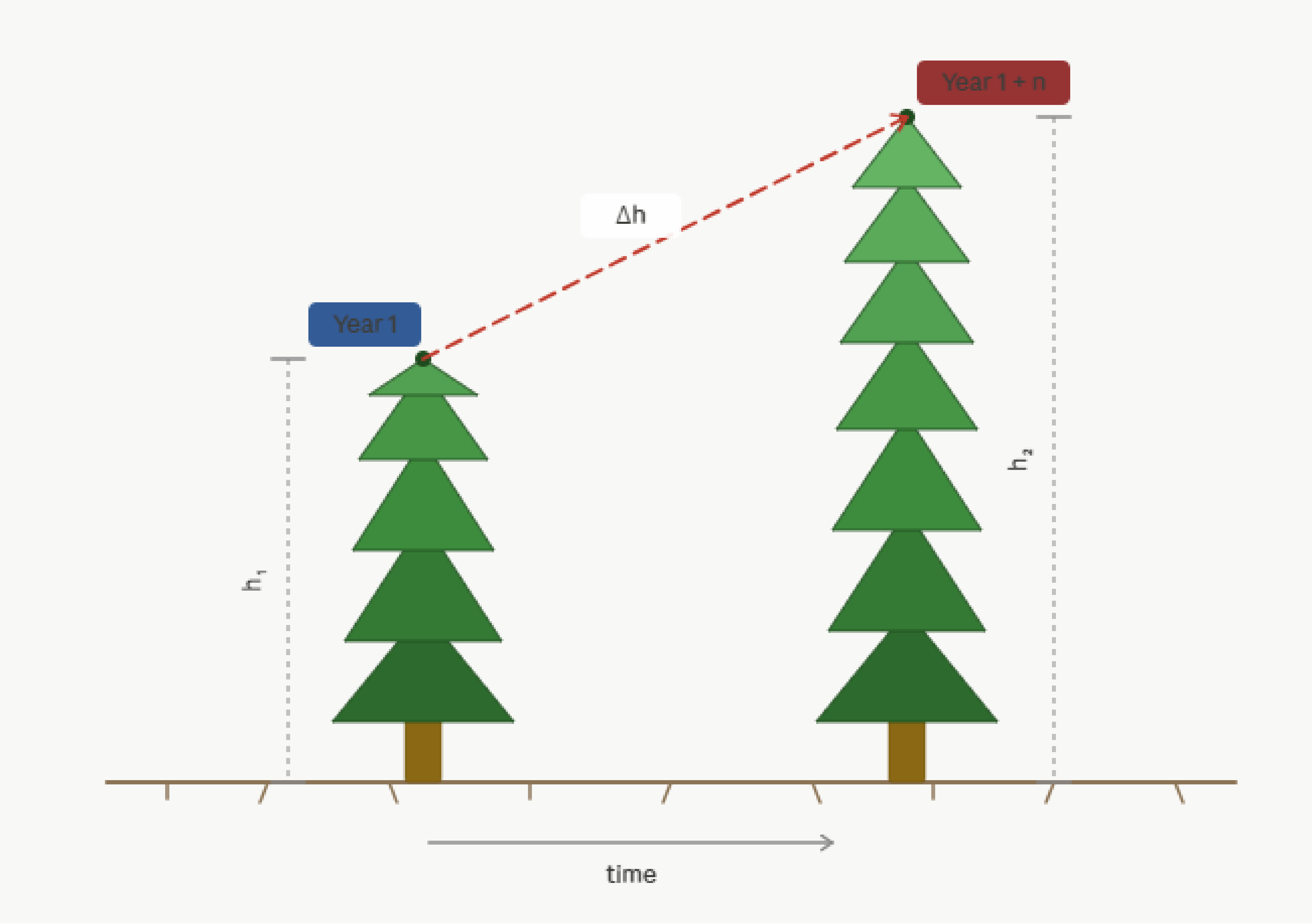




2017 DEP vs 2023 3DNAIP

OBJECTIVE

Assess the compatibility of LiDAR and 3D NAIP point clouds for estimating periodic height increments and supporting large-scale site productivity mapping



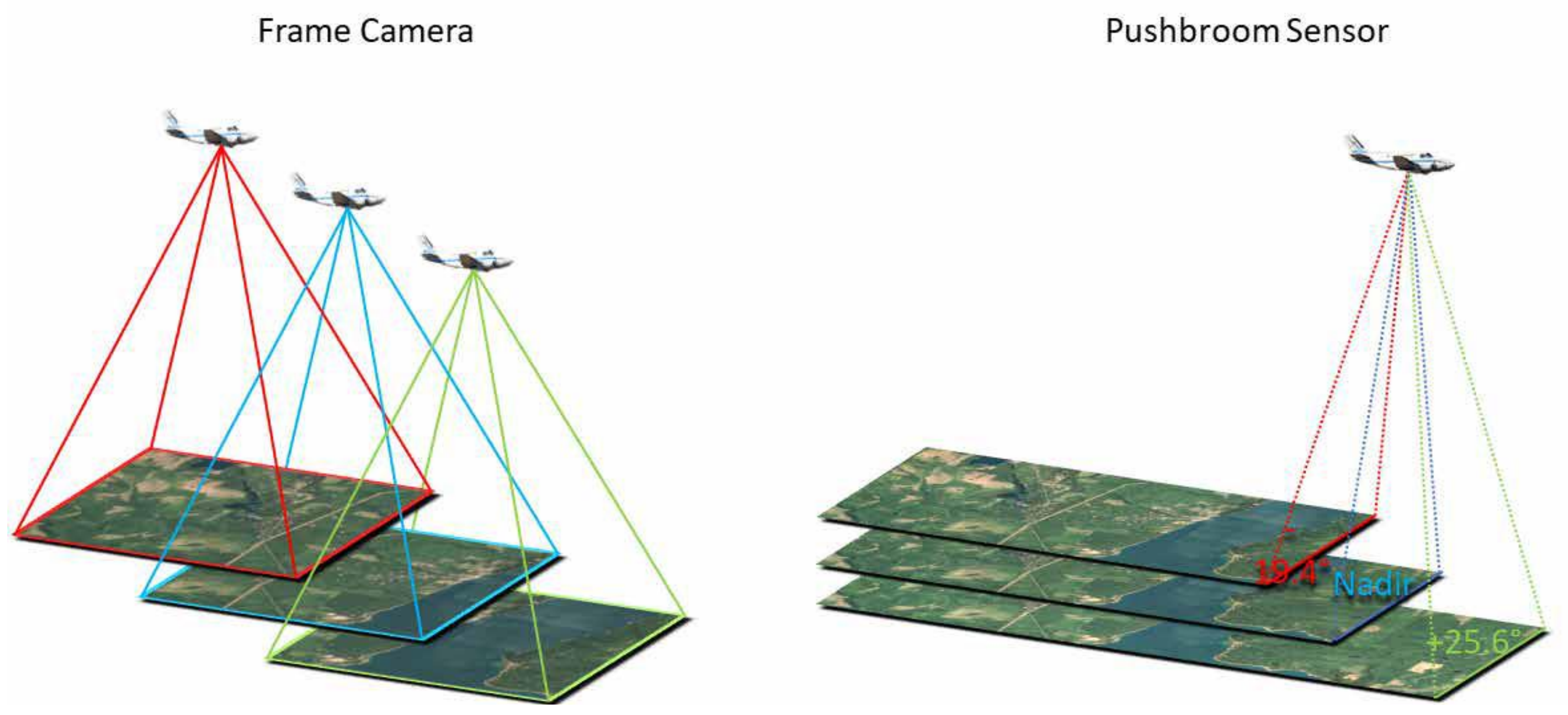
DATA SOURCES

Lidar

USGS 3DEP data with a focus on datasets QL1, QL2 with minimum of 5-year separation between paired 3DEP and 3D NAIP datasets

3D NAIP

Frame-based acquisitions (2023)



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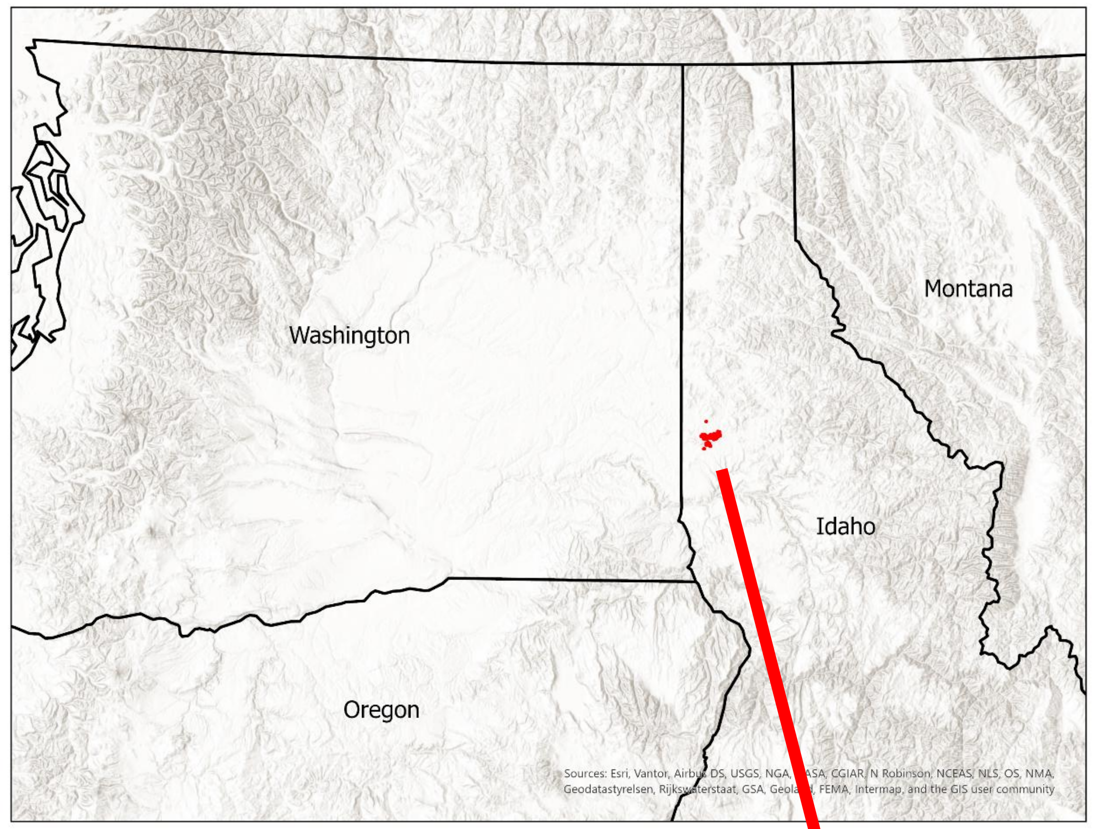
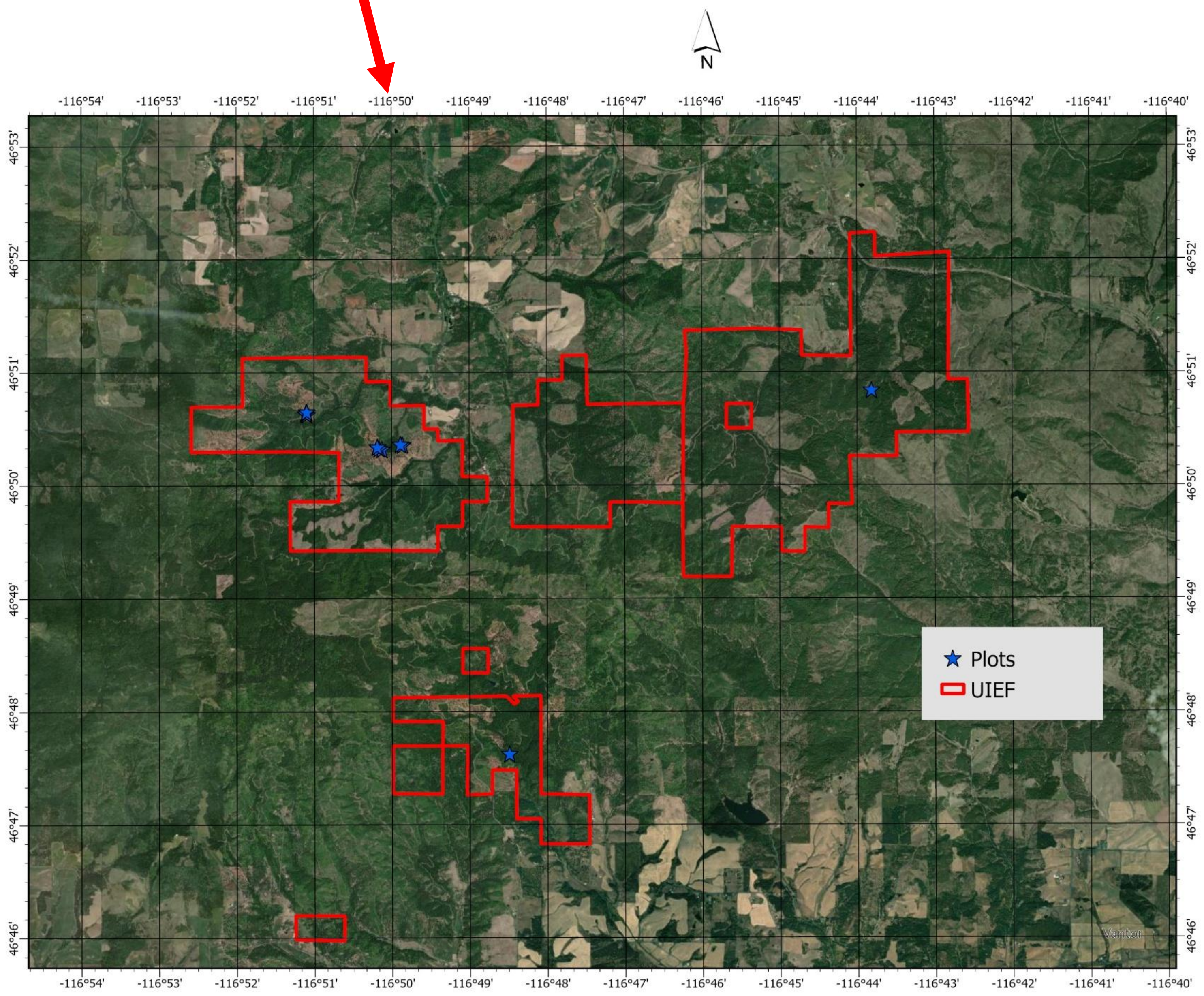
AREA OF INTEREST

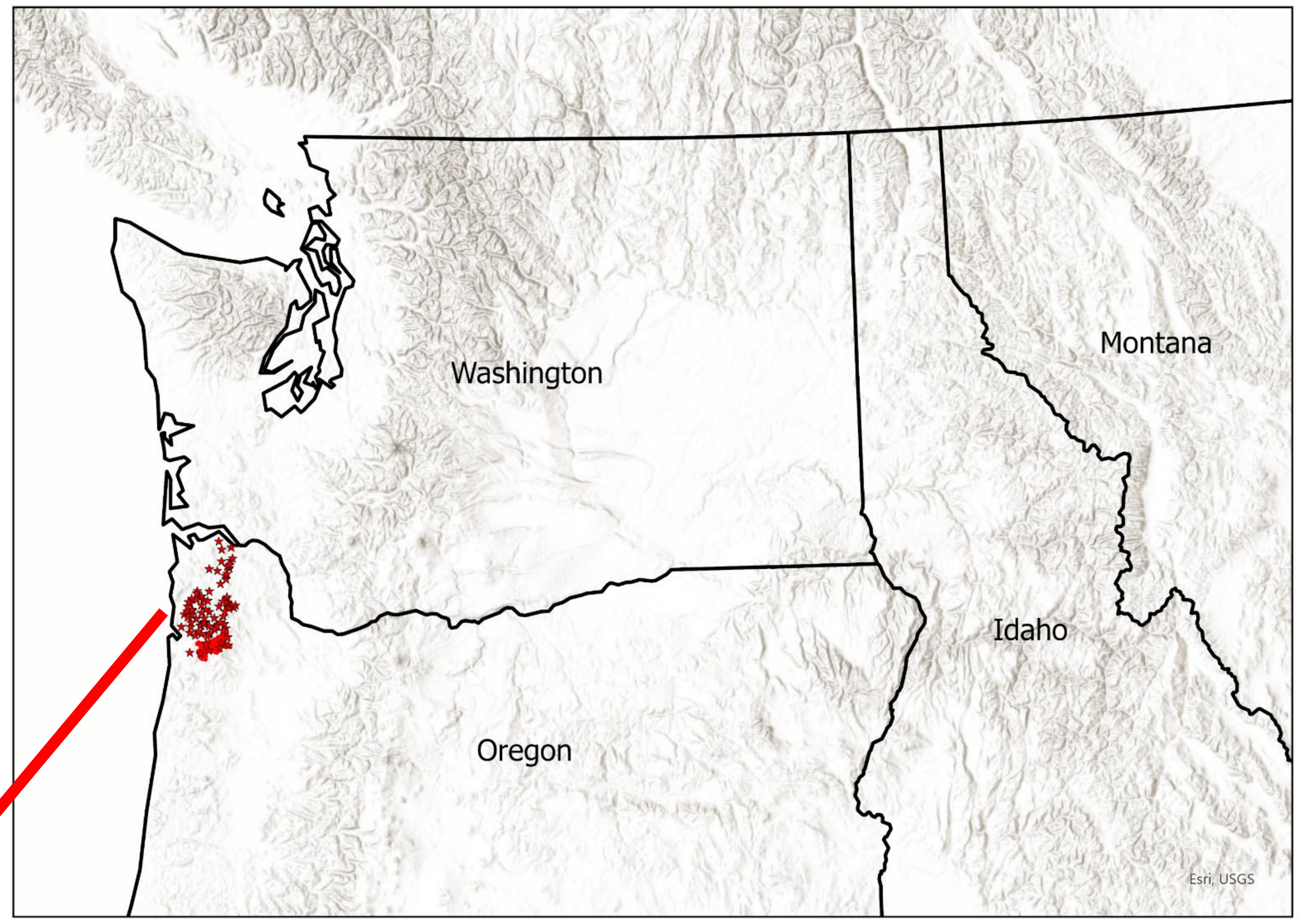
Moscow Mountain, Idaho



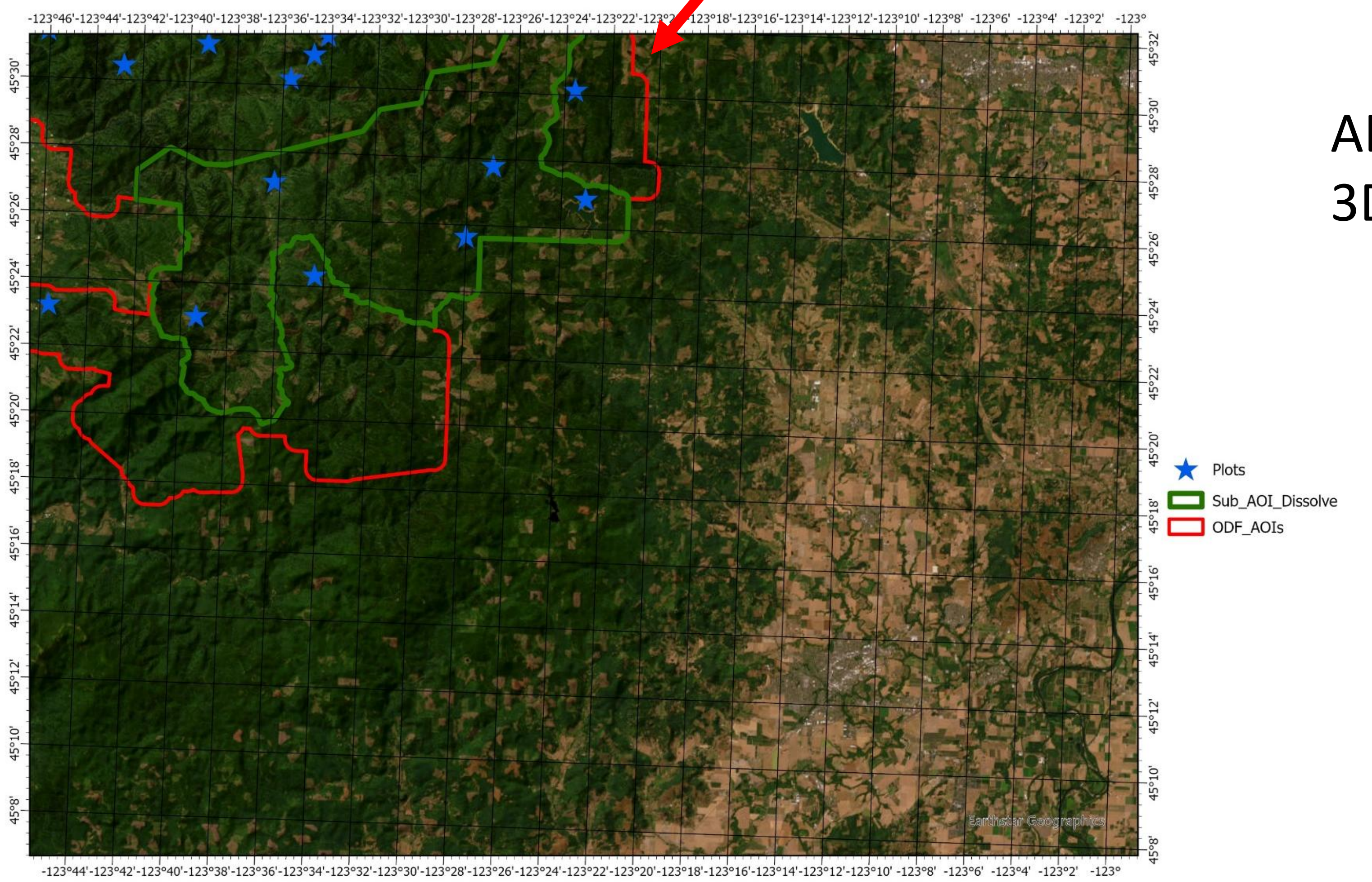
ALS : 2016 (DEP), 2022
3DNAIP 2023



Tillamook, Oregon (ODF site)



ALS : 2012, 2022 (DEP)
3DNAIP 2023



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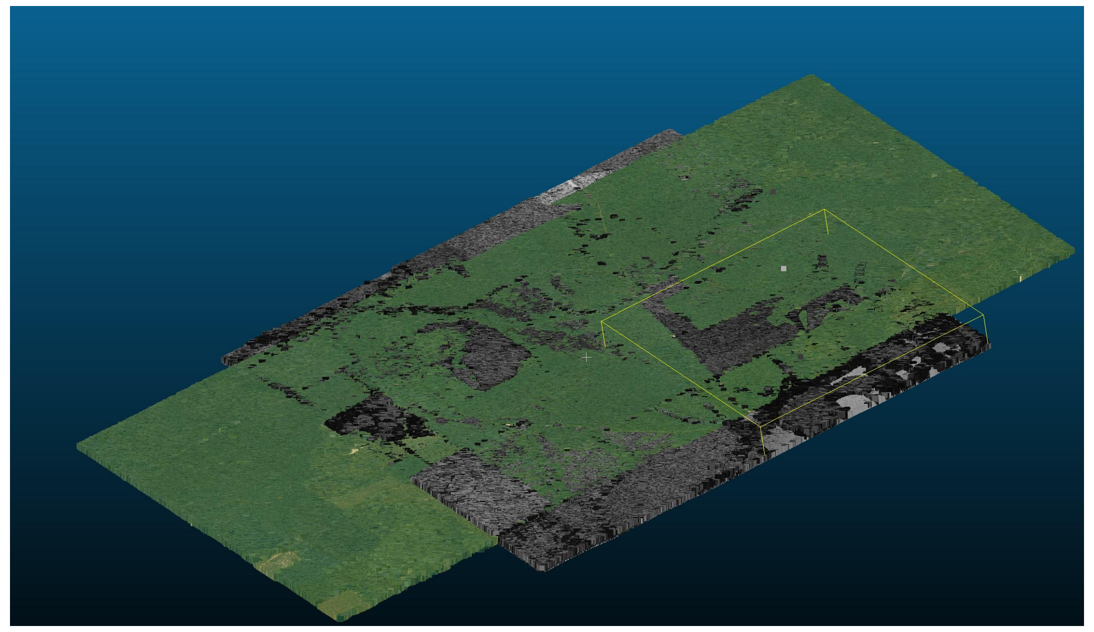
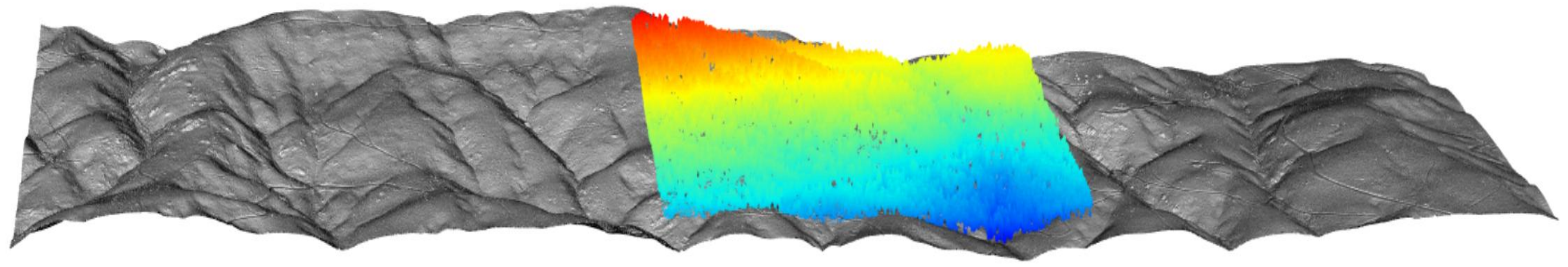
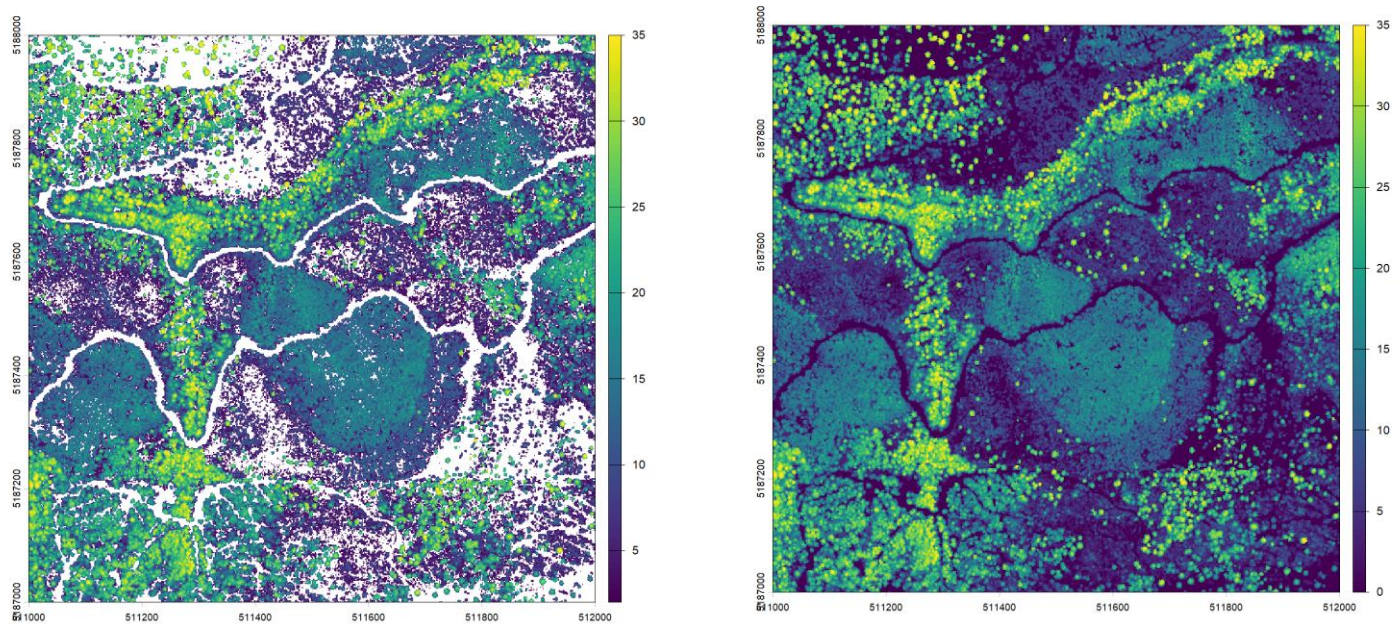
WORKFLOW

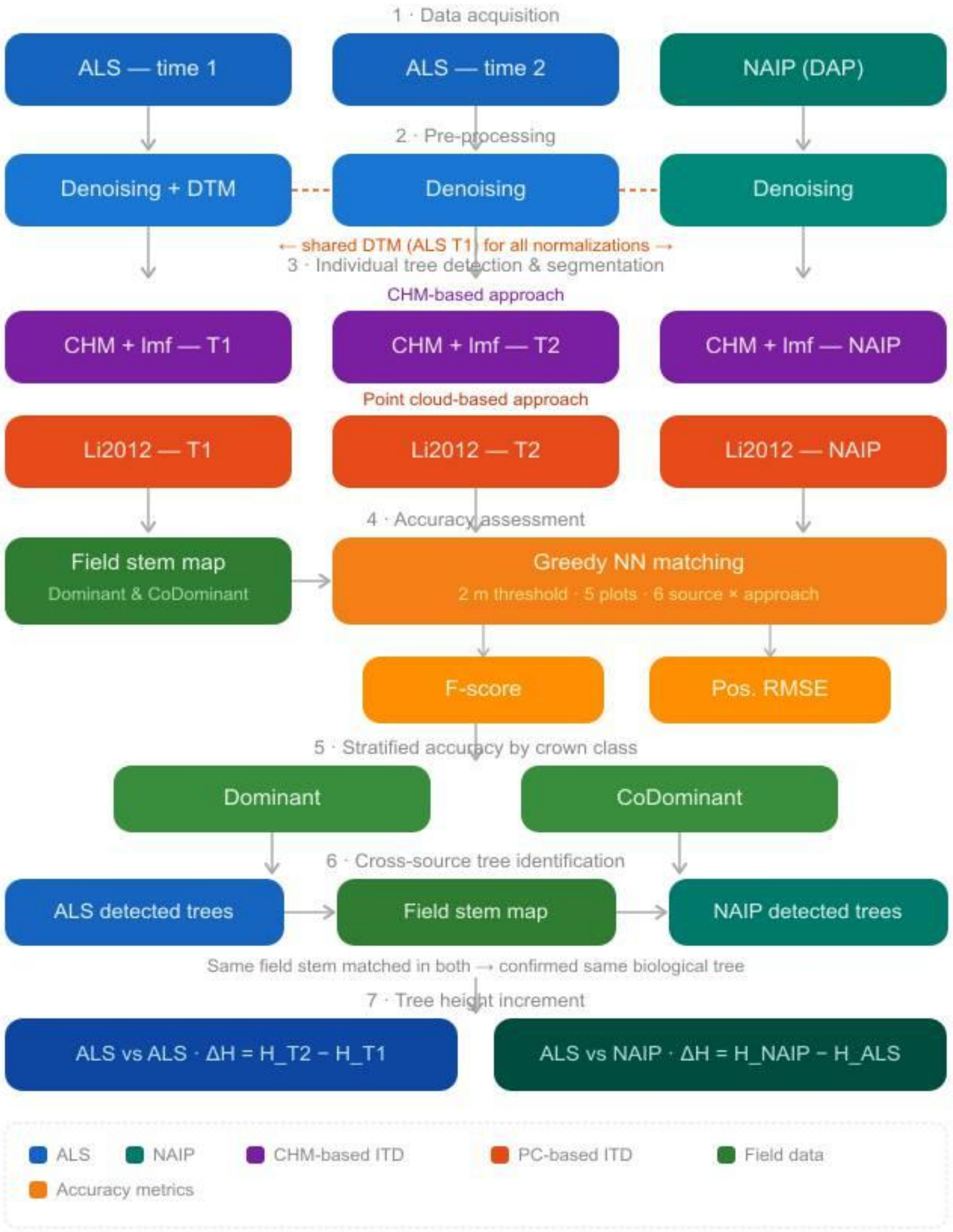




0.5 m resolution DTM



0.5 m resolution CHM smoothed



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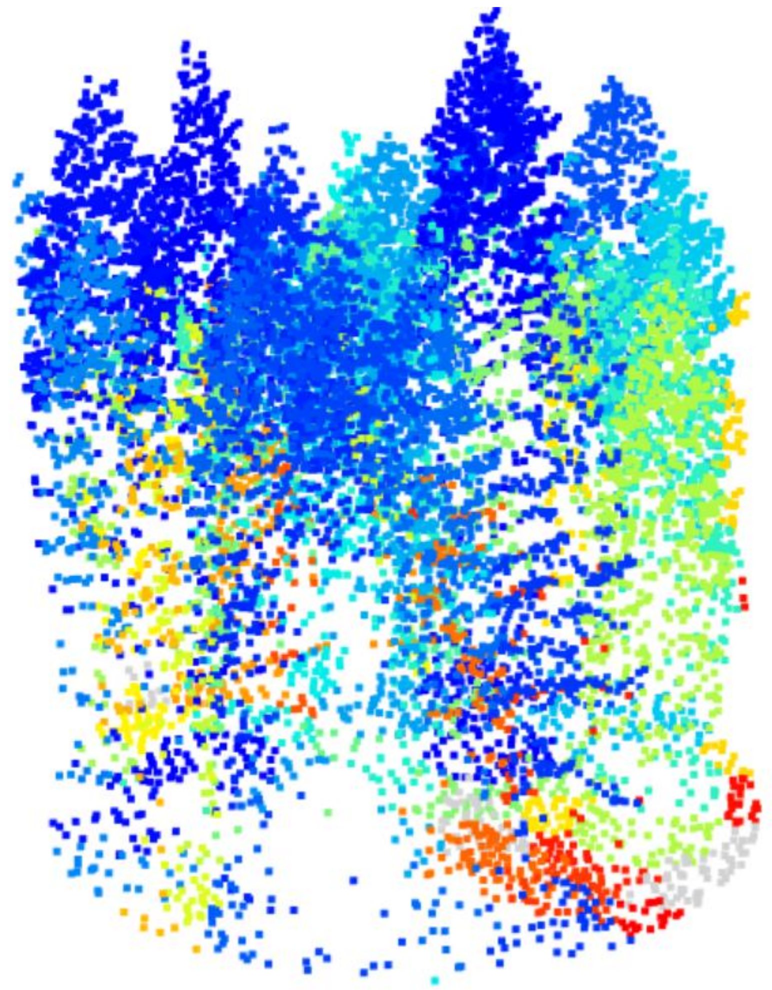
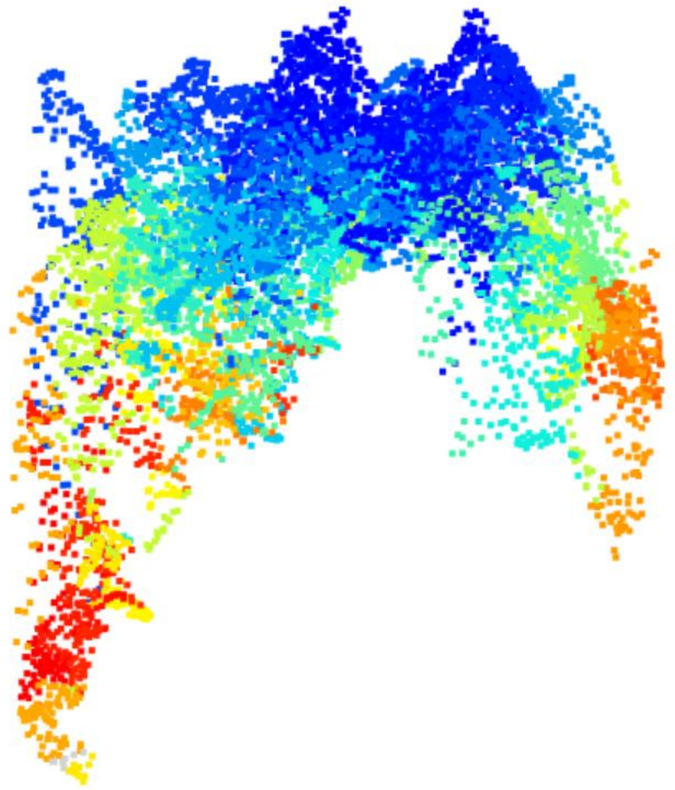
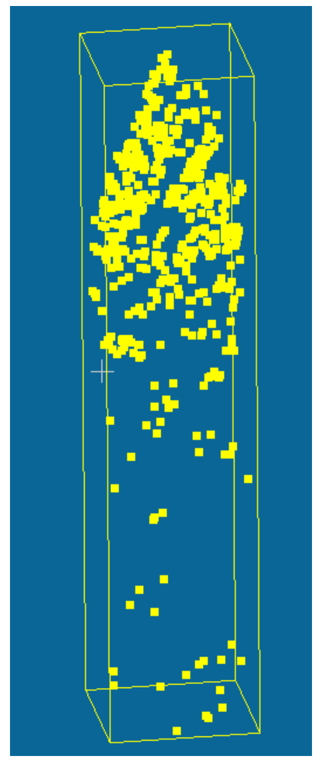
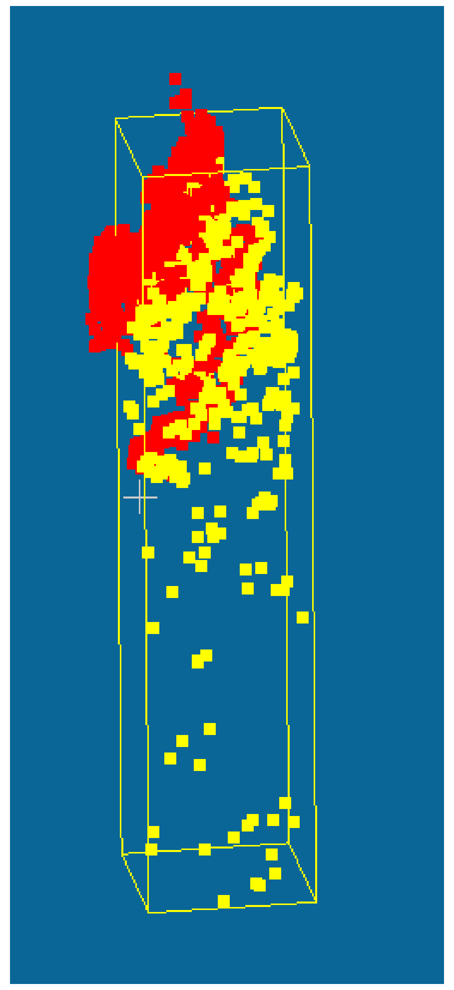
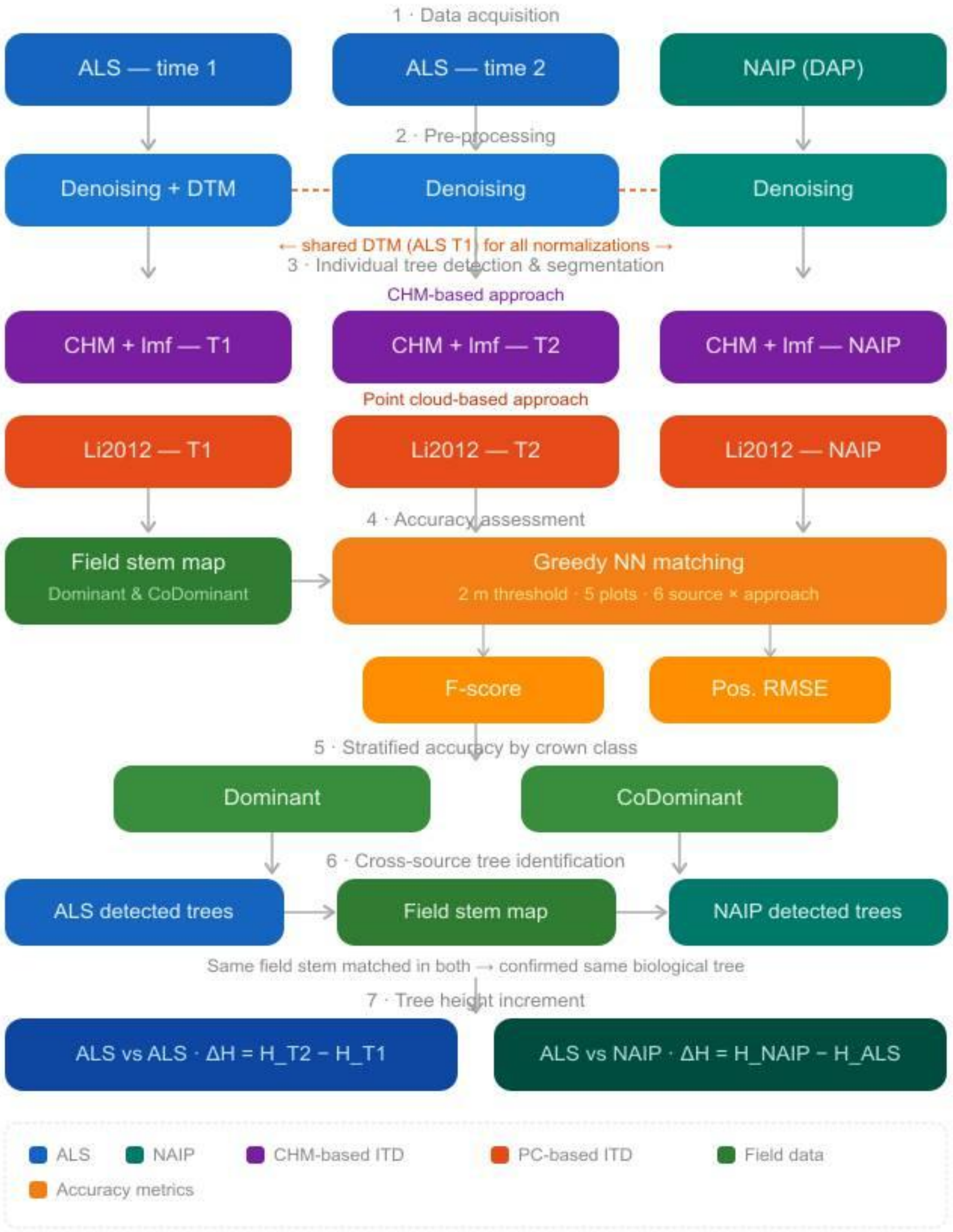
WORKFLOW











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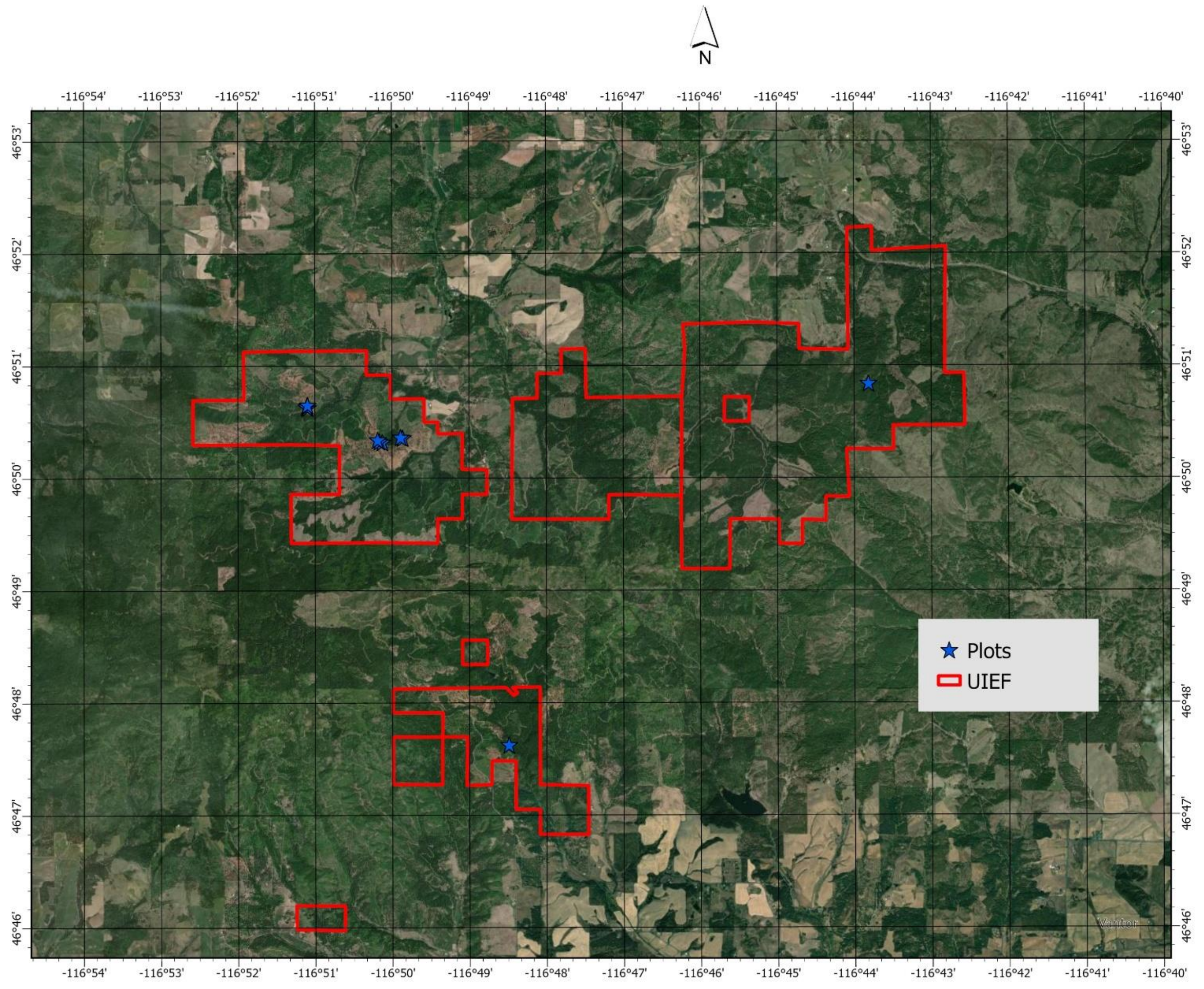
RESULTS

Moscow Mountain Individual Tree Detection Accuracy (5 plots)



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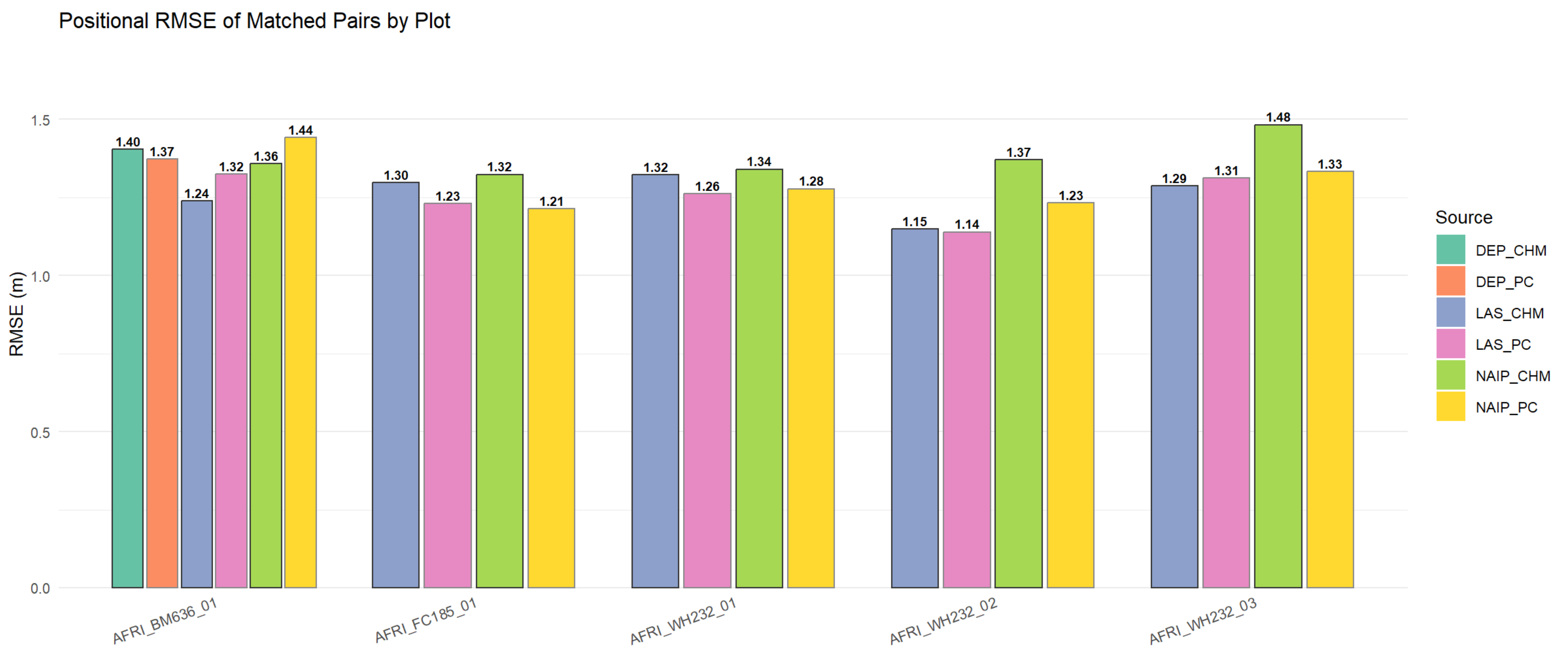

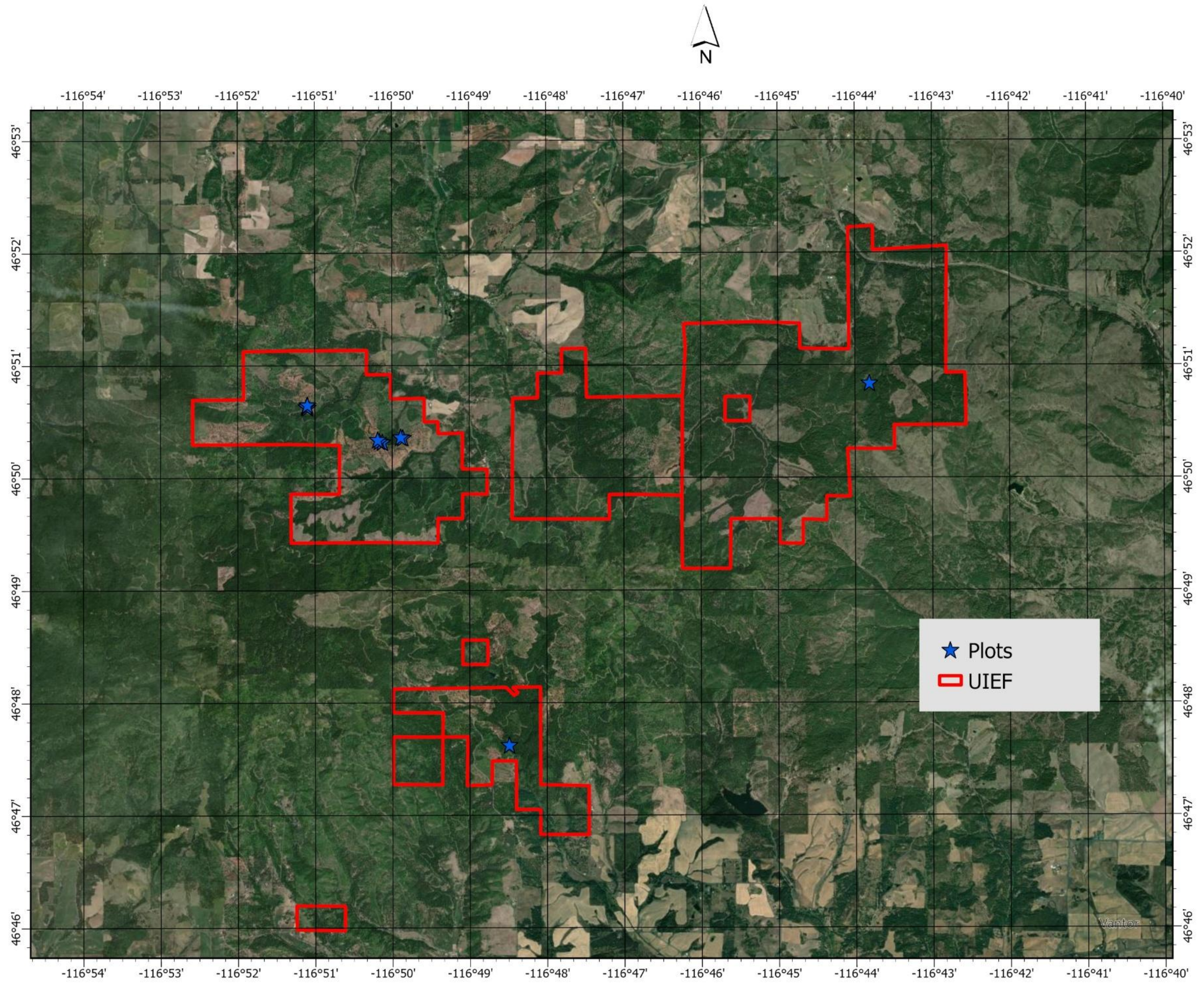

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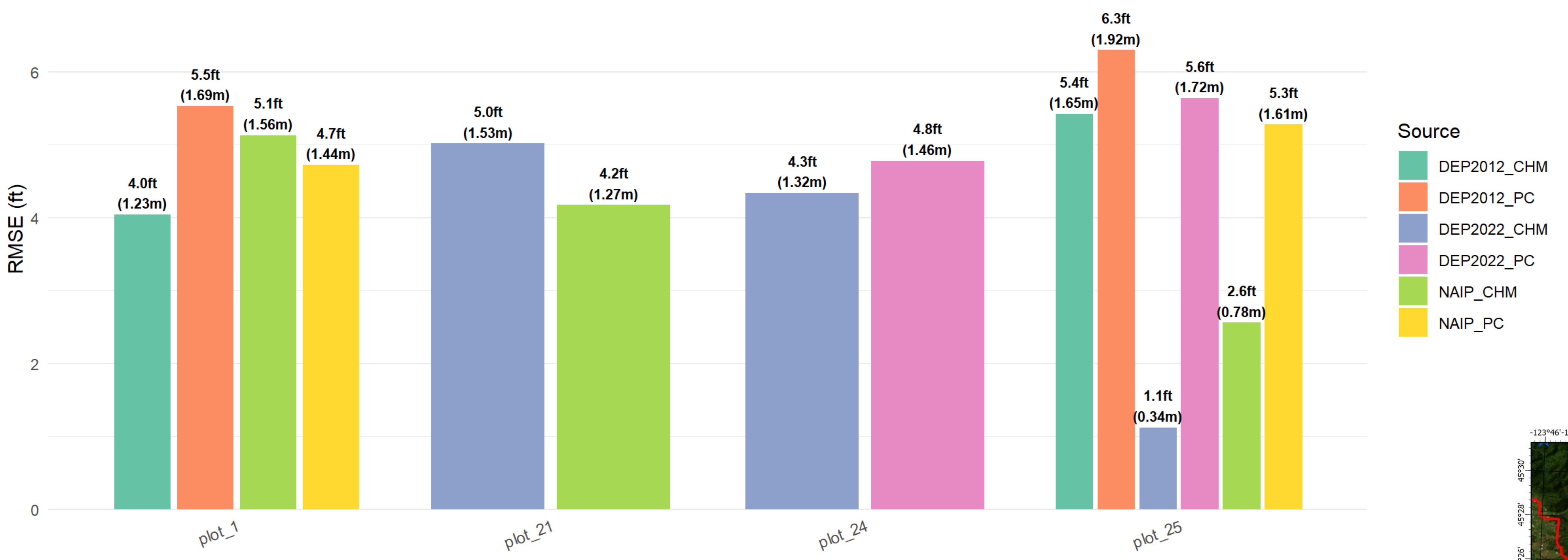
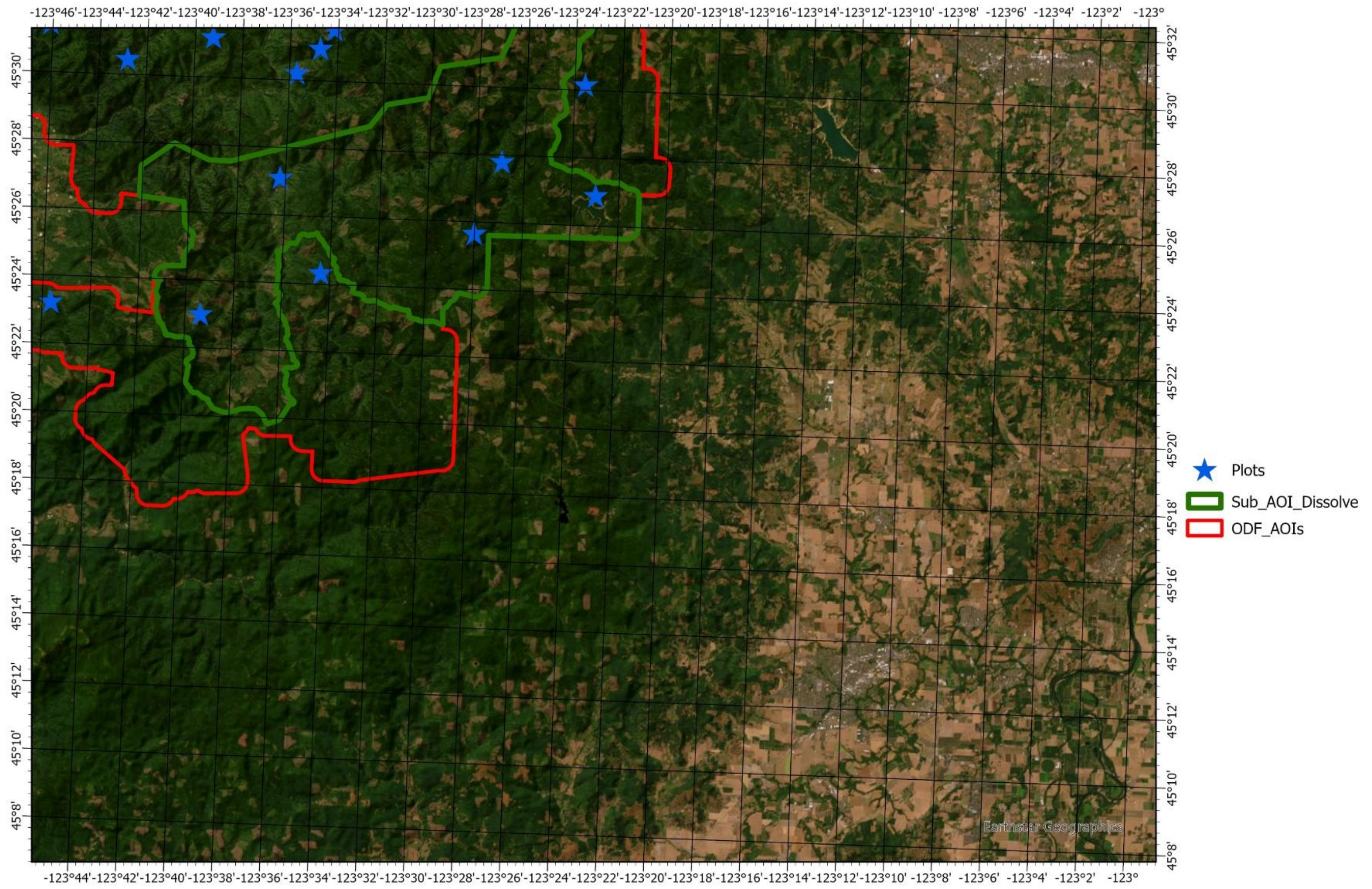
RESULTS

Western Oregon Individual Tree Detection Accuracy

Positional RMSE of Matched Pairs | Oregon plots





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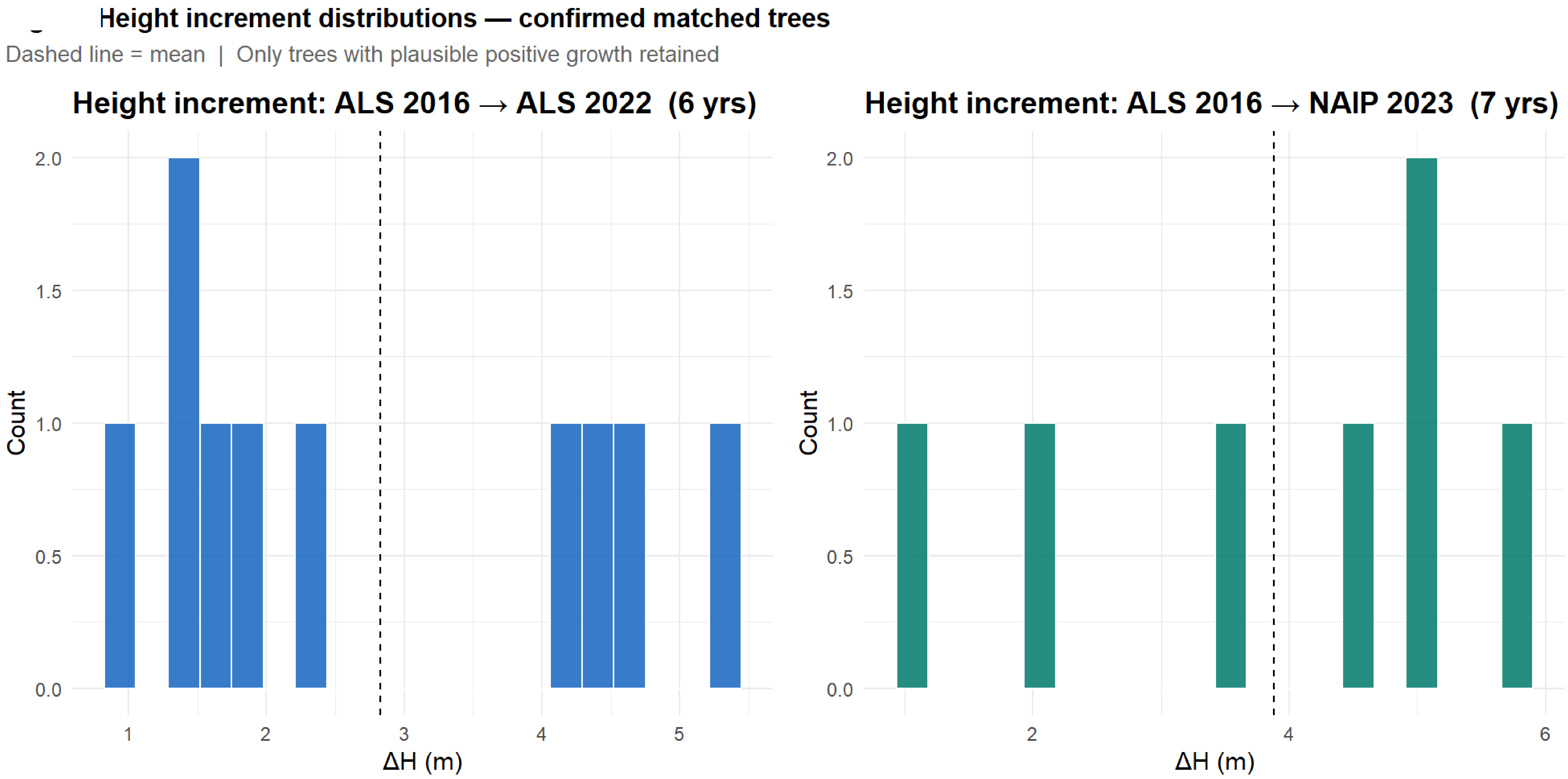
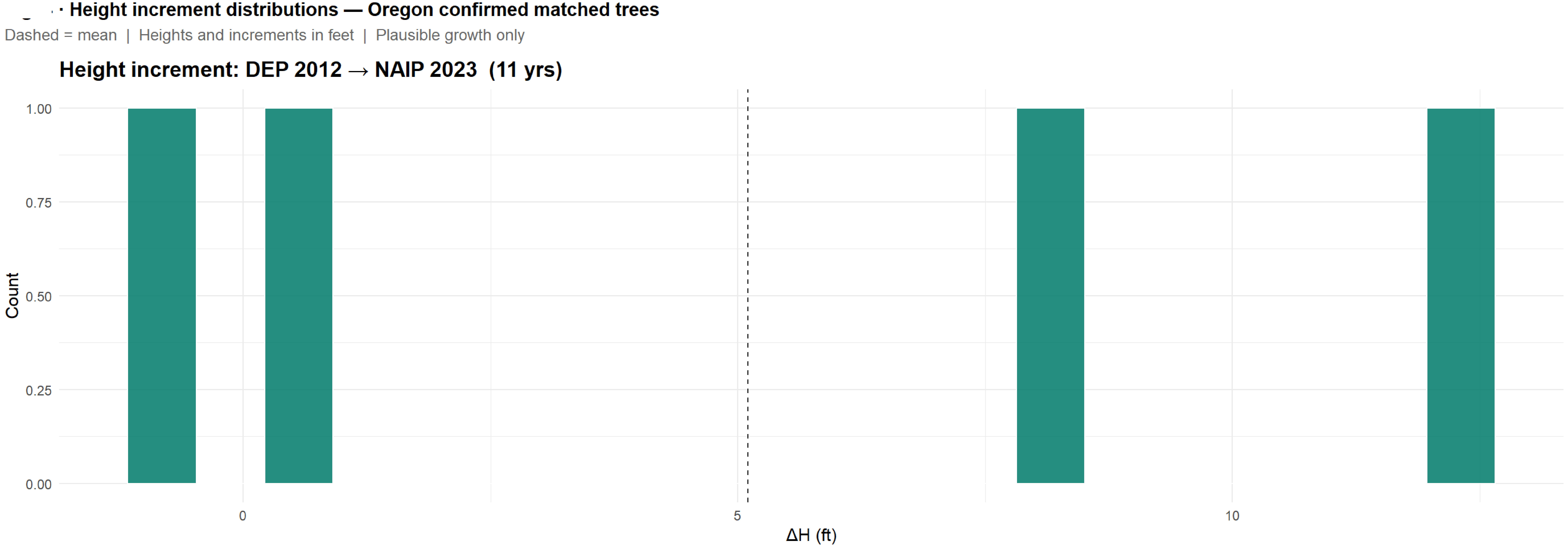
RESULTS

Moscow Mountain Tree Height Increment



RESULTS

Western Oregon Tree Height Increments



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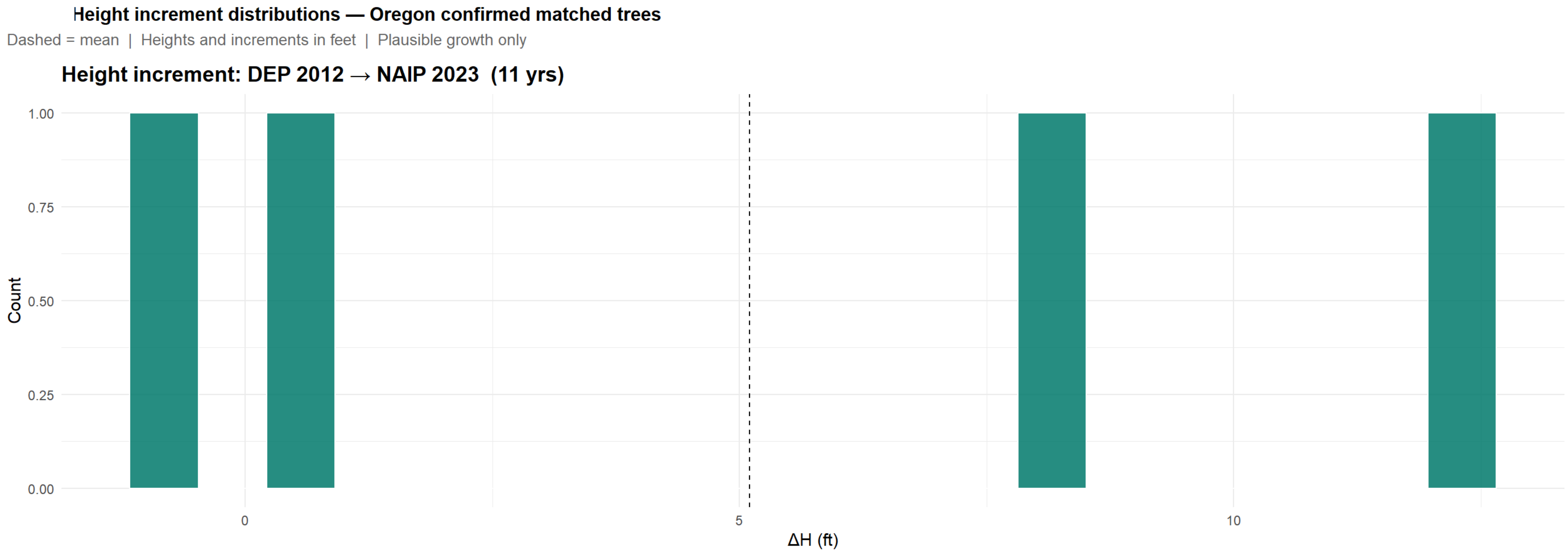
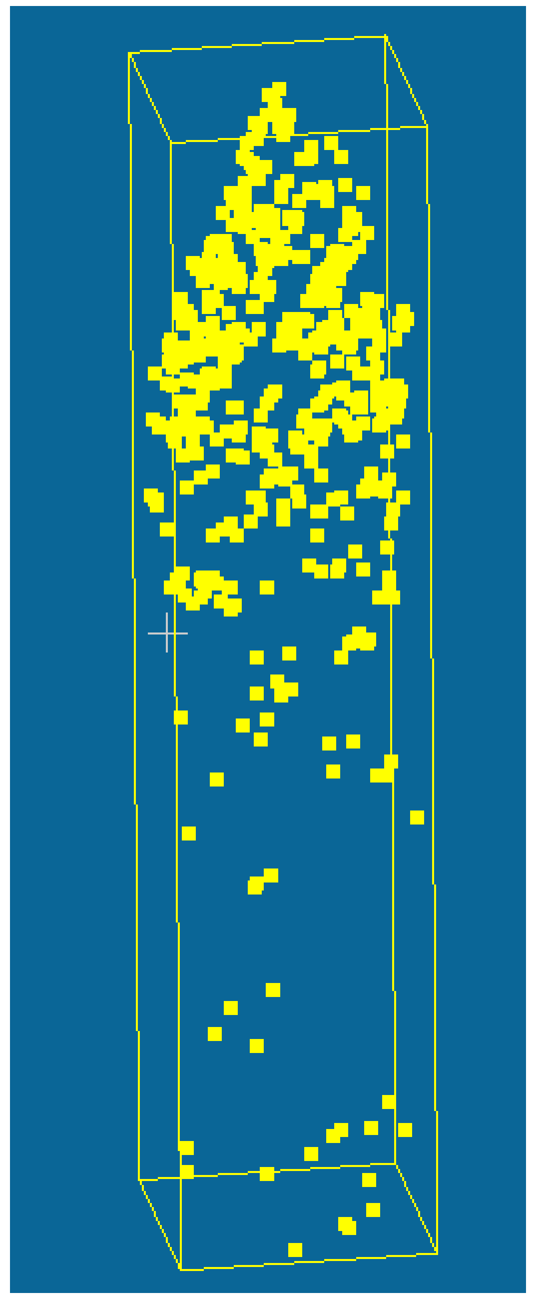
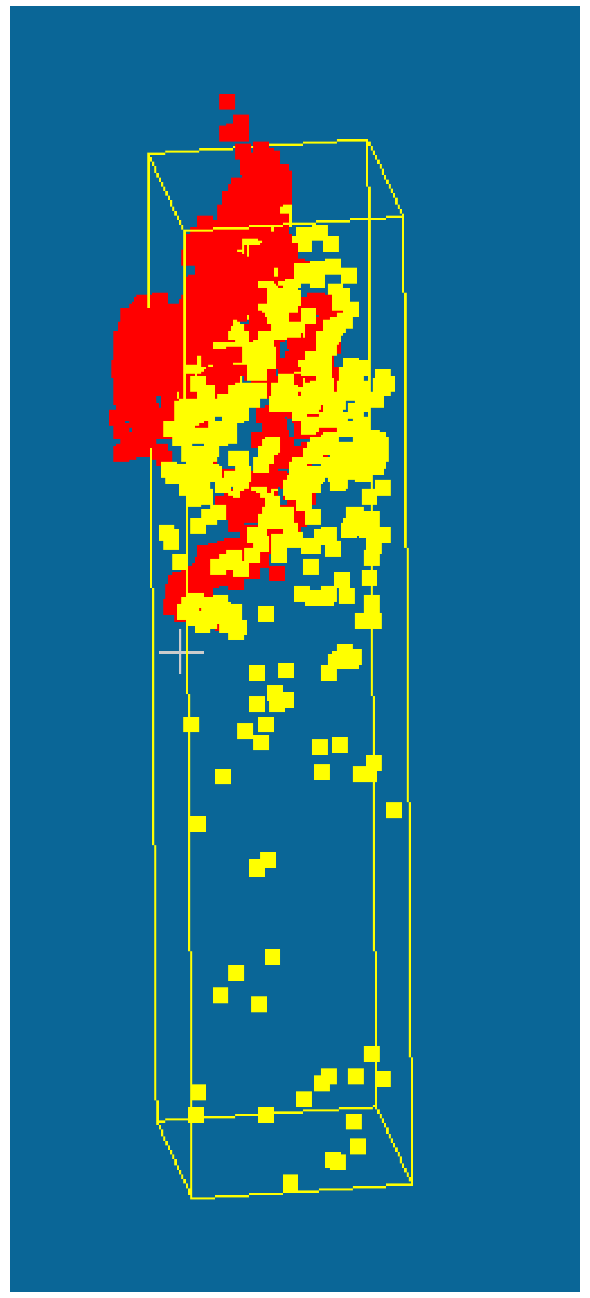
RESULTS

Western Oregon Tree Height Increment





3DEP 2012 , max Z = 122.76 ft



3DNAIP2023 , max Z = 134.9 ft

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CONCLUSION

3DNAIP offers a low-cost alternative that can support tree and stand level analysis for site index

Individual tree identification across acquisition dates (2016, 2022, 2023) is the critical step that makes bitemporal height increment analysis possible.

Segmentation uncertainty directly propagates into growth estimates, making robust detection and matching essential for site index applications.

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QUESTIONS?

WORKFLOW

Vertical biais assessment (Denoising)

Unsupervised algorithm using Gaussian Process Regression to detect outliers and denoise point clouds

The Visual Computer
https://doi.org/10.1007/s00371-025-04049-7

RESEARCH

Check for updates

3D point cloud denoising via Gaussian processes regression

Ickbum Kim[1] · Sandeep K. Singh[2]

Accepted: 4 June 2025

Abstract

Accurate three-dimensional reconstruction of complex scenes is paramount to further advancements in shape modeling, autonomy, and computer vision. A key aspect is noise removal, whereas other challenges include limited view angles, noise interference, and the presence of outliers. Outliers and noise can significantly compromise 3D reconstructed models and jeopardize downstream applications, especially those requiring near-real-time processing like proximity operations and autonomous driving. In this study, a novel method for point cloud denoising and outlier detection, Stochastic Regression for Denoising with Random Sampling (STORED), is presented. STORED integrates concepts from Random Sample Consensus and Gaussian Process Regression to address prevalent challenges in existing algorithms. By iteratively scoring outliers based on prediction confidence, STORED identifies and removes outliers, and performs denoising with weighted predictions. The algorithm demonstrates robust performance across synthetic datasets with various shapes and outlier compositions, both qualitatively and quantitatively. While challenges remain in handling discontinuities and complex surface features, STORED shows promising potential for enhancing stereo reconstruction and spatial analysis tasks. The source code is available at

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WORKFLOW

Vertical biais assessment (Denoising)

- ✓ Struggles with canopy edges and discontinuities
- ✓ Reduced performance in complex forest Structure
- ✓ High computational cost limits large-scale use

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WORKFLOW

Vertical biais assessment (Denoising)

```
=== Outlier Removal Analysis by Flight Line ===
Flight line 12955: 92/484 removed (19.0%)
Flight line 12961: 251/482 removed (52.1%)
Flight line 41077: 101/429 removed (23.5%)
Flight line 41080: 208/452 removed (46.0%)
```

The Visual Computer
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RESEARCH

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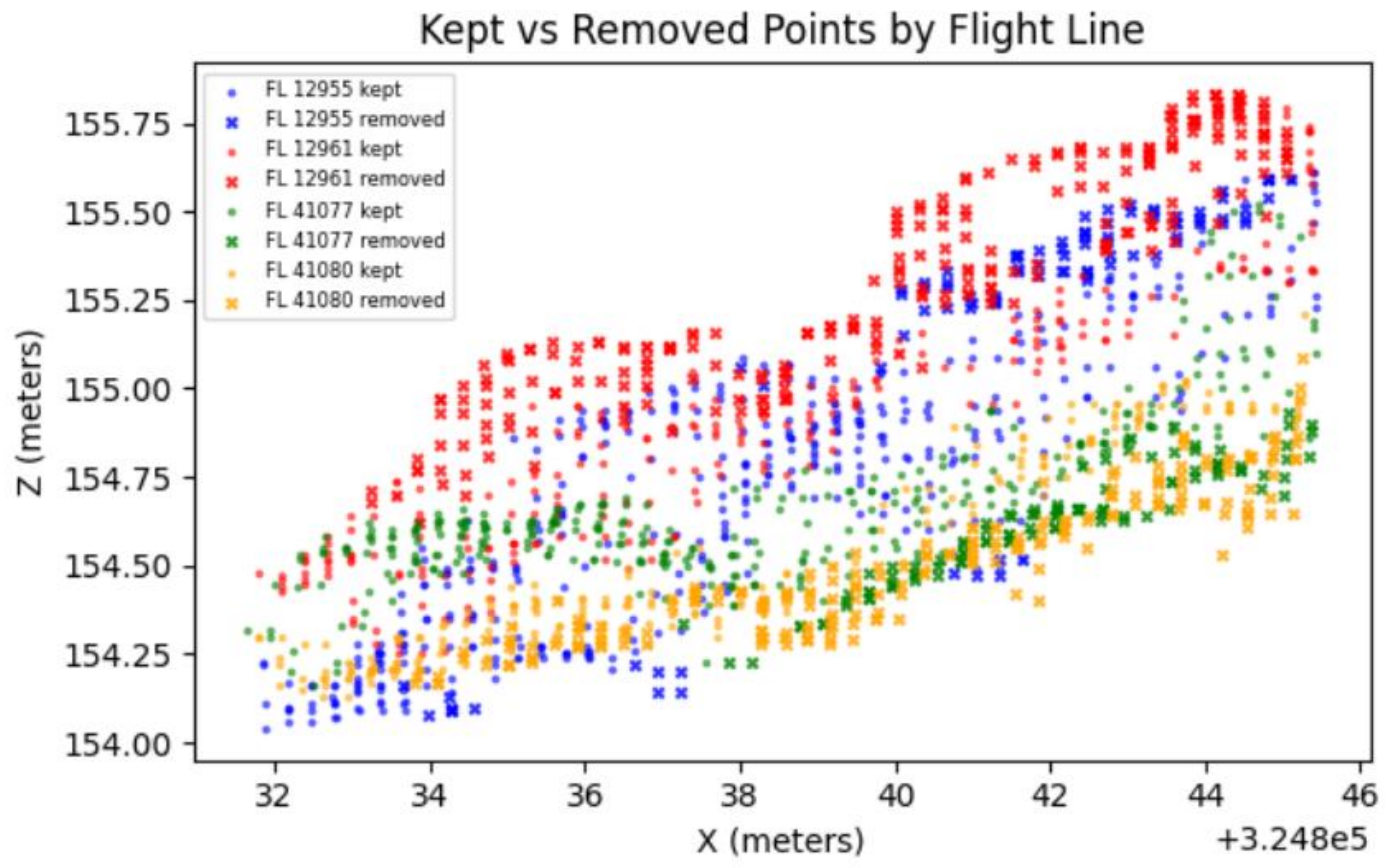

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