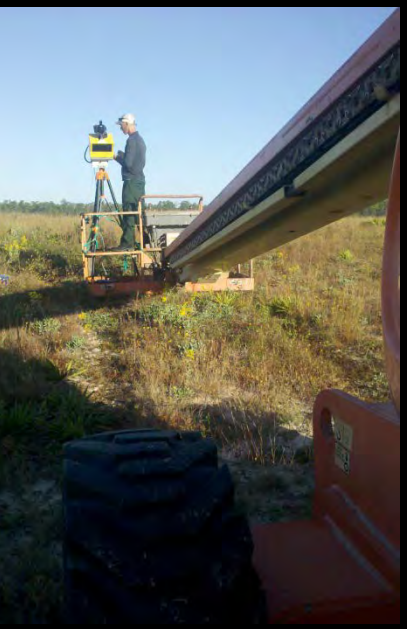
Ground LiDAR fuel measurements of the Prescribed Fire Combustion and Atmospheric Dynamics Research Experiment

Eric Rowell, Erik Apland and Carl Seielstad



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National Center for Landscape Fire Analysis

College of Forestry and Conservation — Where Ideas Take Flight

Joint Fire Science Program

Rocky Mountain Research Station

The University of Montana

Overview:

- Describe the Terrestrial Laser Scanning Field Mission.
- Present Processing Methods and Data Produced.
- Discuss Fuel Modeling,Mapping, and Change Detection.
- Examine Preliminary Results.

Purpose: Science and Applications

- To map fuel properties at fine grain for validating fire models *(field fuels data, photos/images)*
- To better understand relationships between vegetation structure and fire behavior and effects *(thermal camera and flux package data)*
- To decompose the relative contributions of fuels and wind on fire behavior at fine grain *(wind, thermal camera, video, airborne thermal data)*
- To study performance of laser scanning for characterizing vegetation properties of landscapes through comparison of airborne and terrestrial lidar *(airborne laser altimetry data)*

Instrument Specifications:

- Optech ILRIS 3_6D ER Scanner
- 1535 nm wavelength laser
- 10 kHz scan speed; scans in 40° blocks
- 13 mm spot at 5 m; 29 mm spot at 100 m
- Range of ~1700 m at 80% reflectivity
- Spot spacing to 1 mm.
- Records x,y,z,i
- SLR camera collects RGB images.

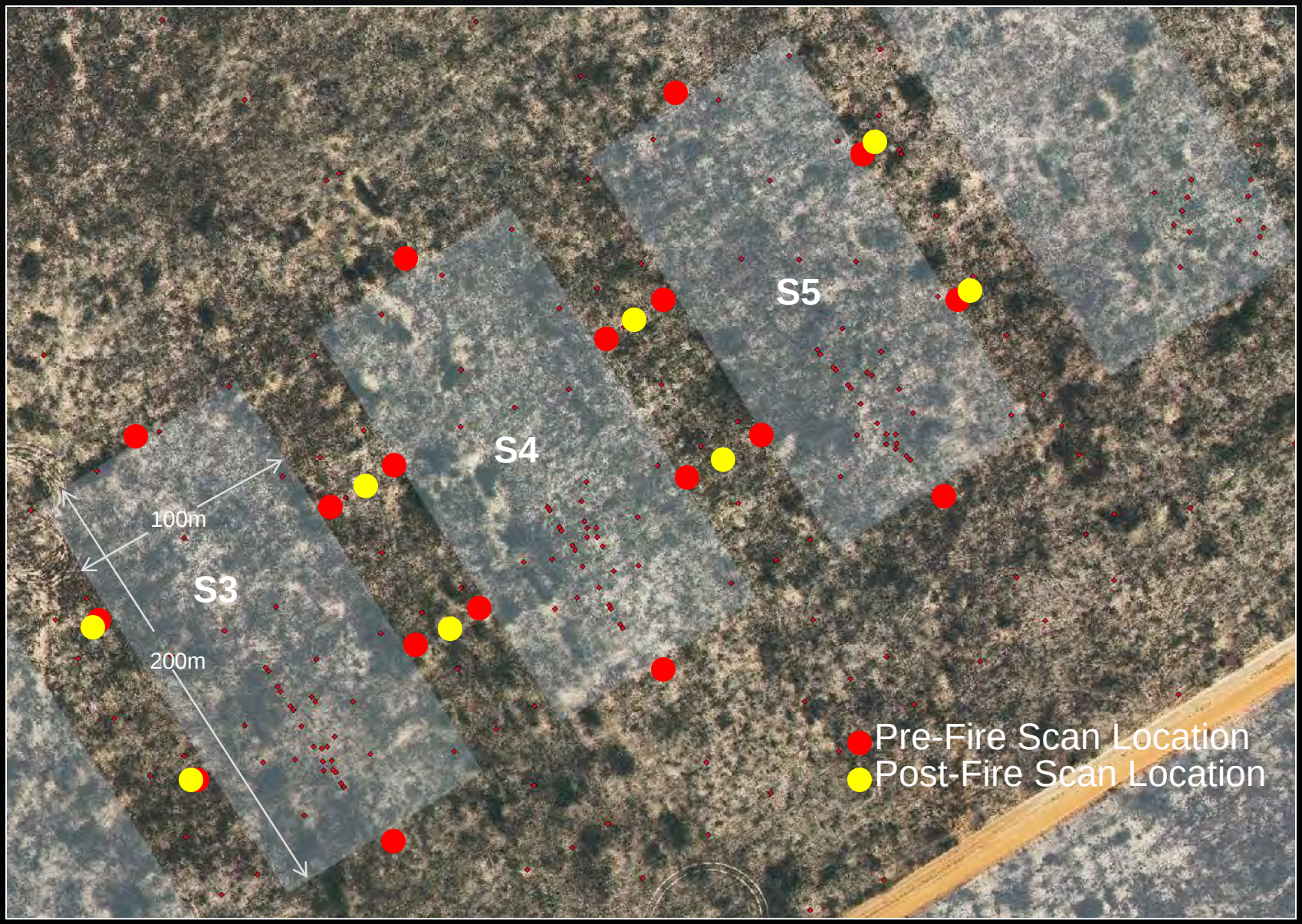
Scanning Protocols:

- Scan from boomlift 16-27 m AGL.
- Remote operation of laser system.
- Reflective targets set at clip-plot and at unit corners.
- 95 good scans; 15 bad scans
- Average 27 minutes per scan- 49 hours
- 60 hours of instrument set-up.

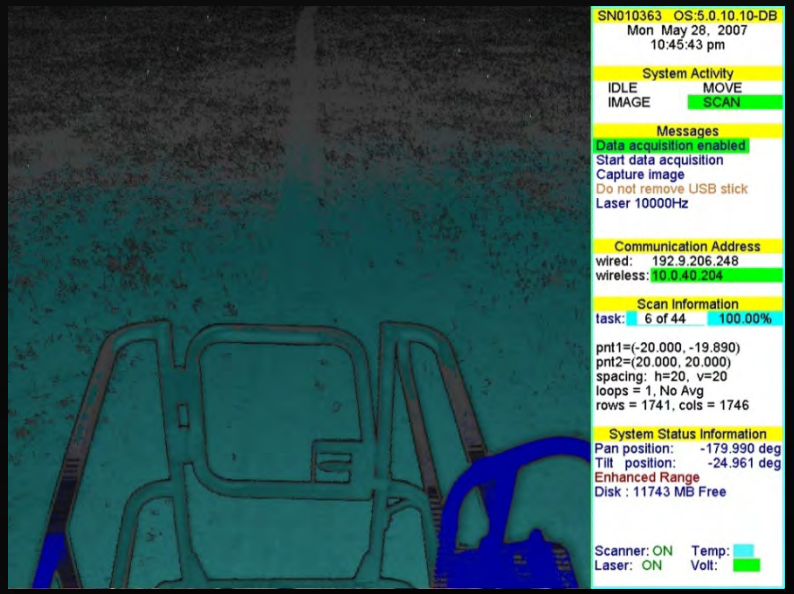
Scanning Protocols:

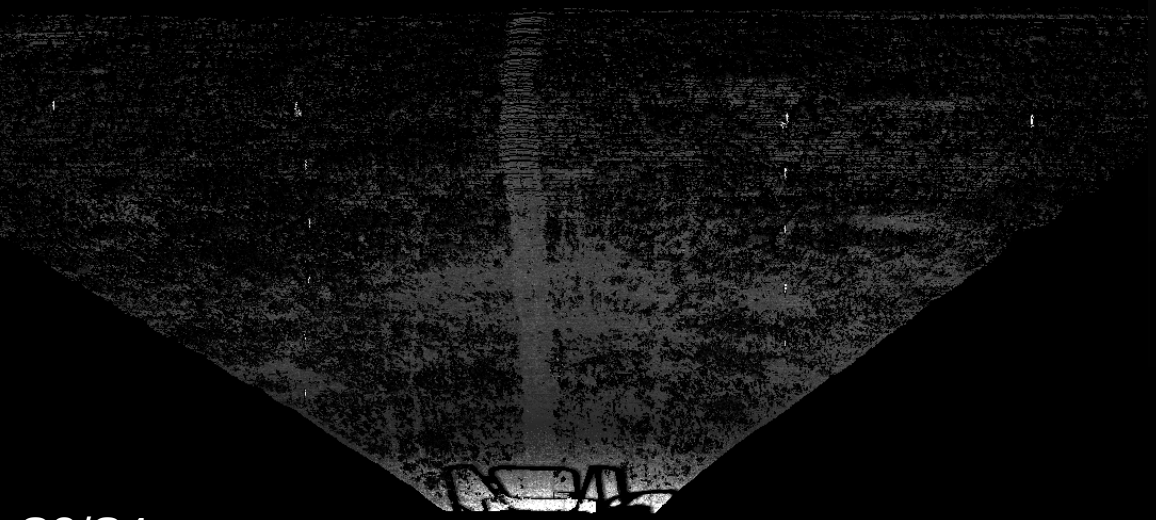
- Scanned pre- and post-fire.
- Spot spacing 36mm at 100m for large units (S-Blocks)
- Spot spacing 6mm at 25m for small units (Highly Instrumented Plots (HIPS))
- Laser spot size at 100m: 29 mm
- Laser spot size at 25m: 18mm

Data Acquisition: S-Blocks



Data Acquisition: S-Blocks



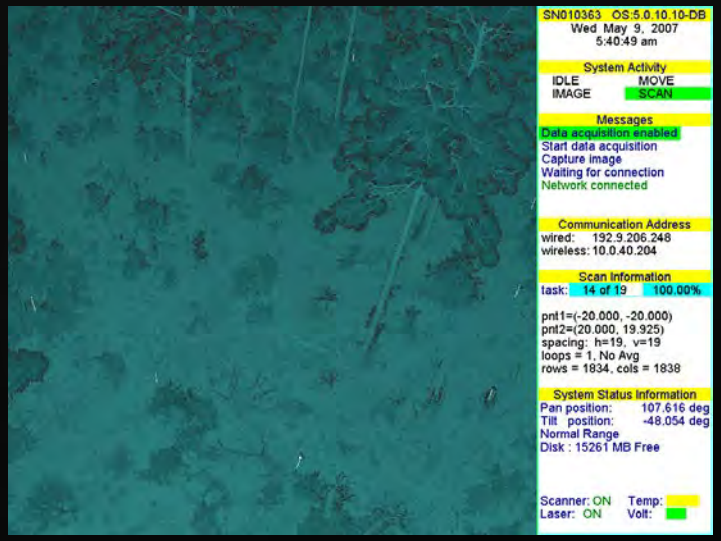


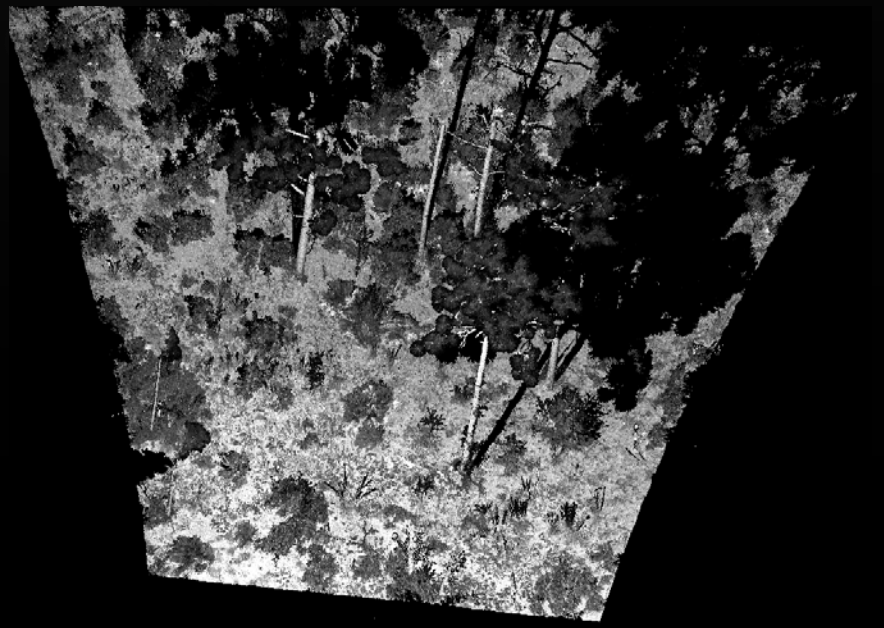
S3/S4

Data Acquisition: HIPS

Data Acquisition: HIPS

L2FH2





Methods: Parsing, Rotating, Merging

Parsing

1. Laser data are exported to .pif and .xyz formats

Aligning

1. In Polyworks IMAlign adjacent scans are combined using tie points, manual, and automated align.
2. Alignment rotation matrices exported.

Rotating and Merging

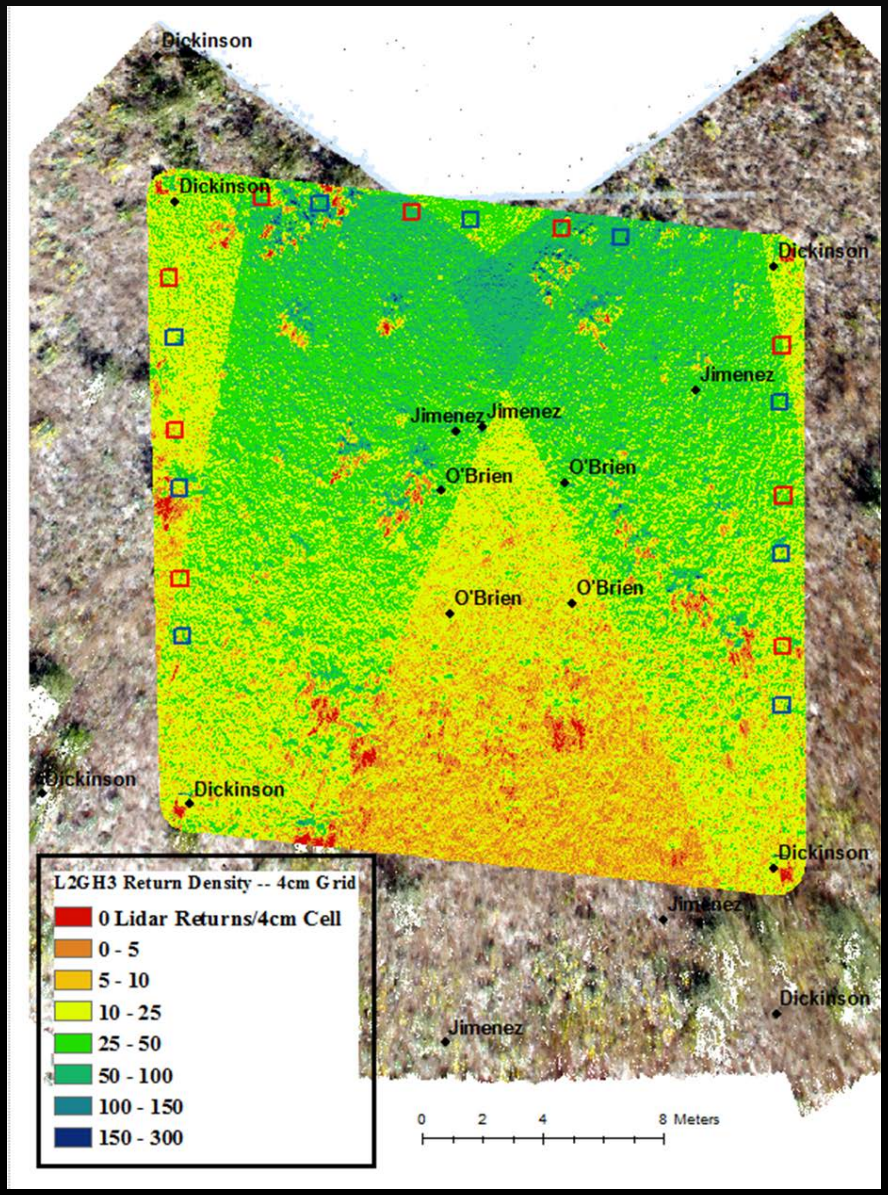
1. .xyz data are rotated using matrices in IDL-scripted TLS Processor 1.2beta
2. Aligned data are merged into a single dataset using IDL-scripted TLS Processor 1.2beta.

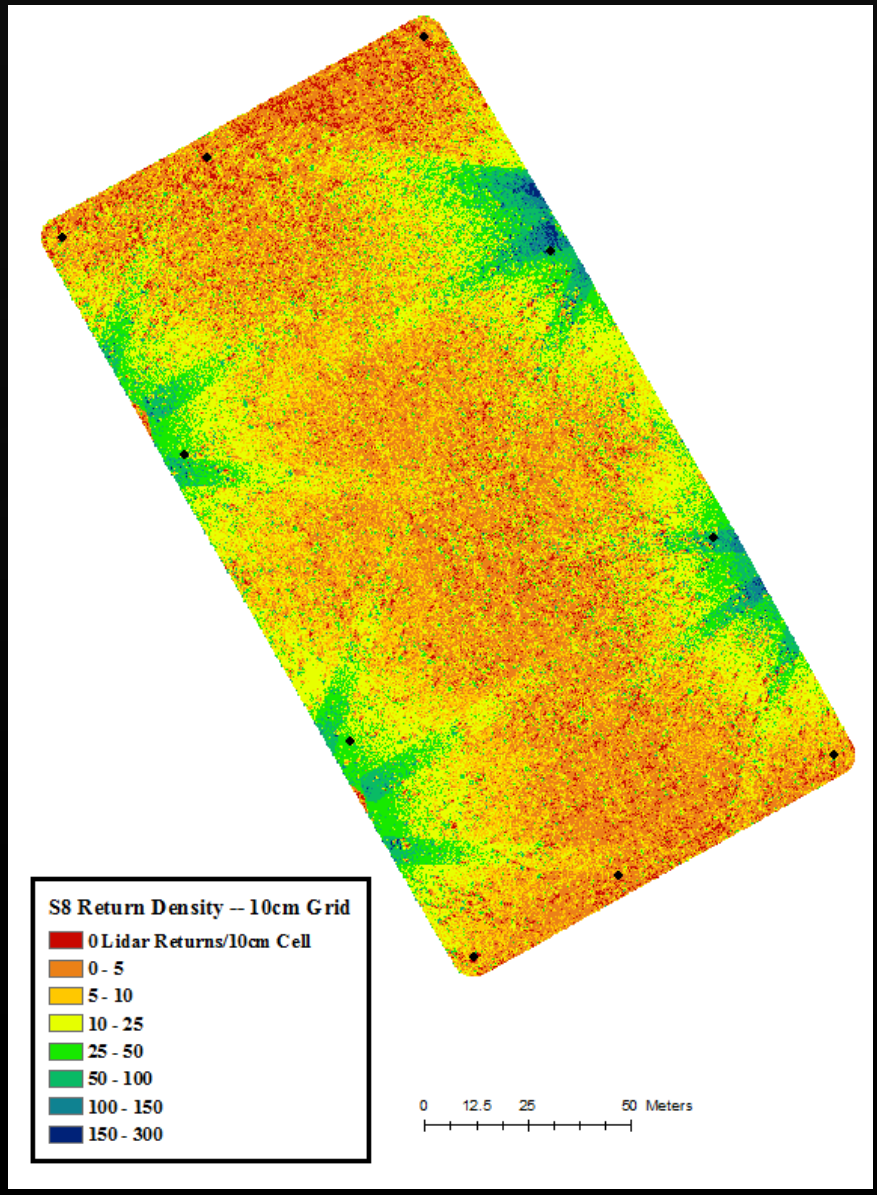
Methods: Height Normalization

Generate Bare Earth Surface

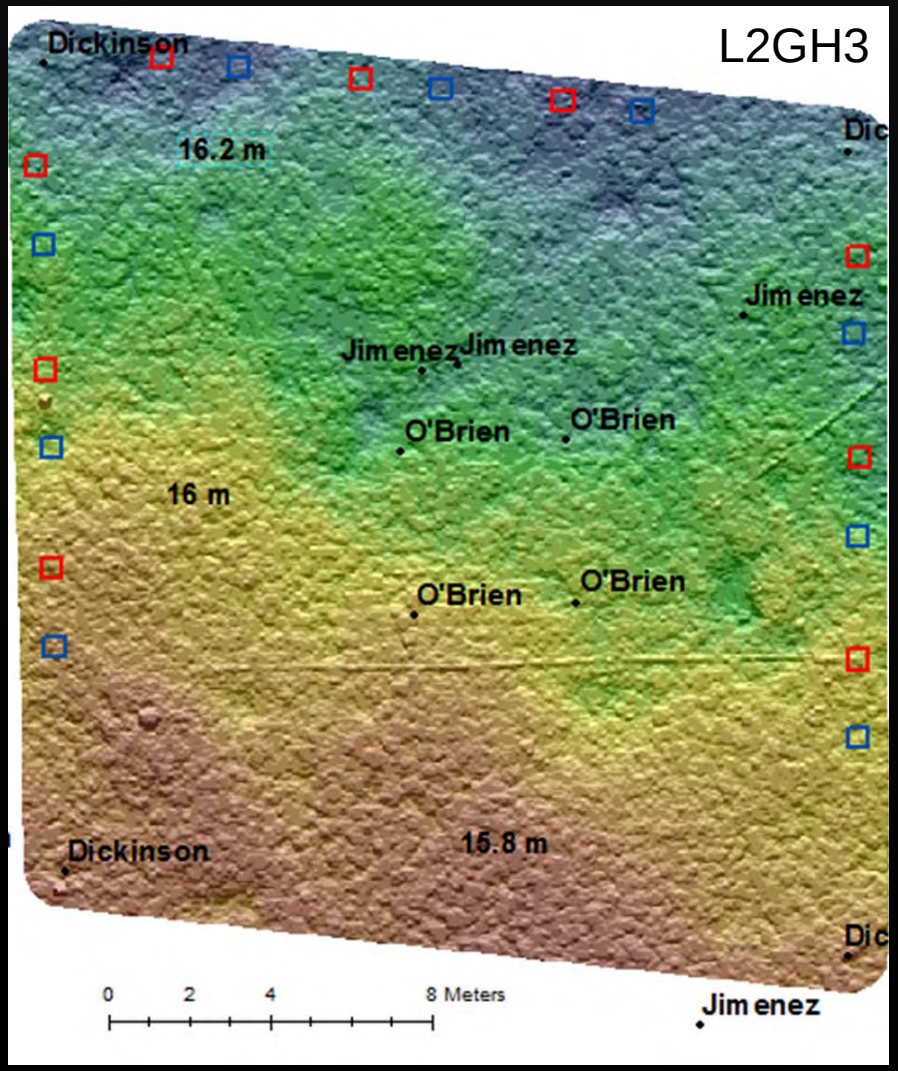
1. Convert TLS pointcloud to LAS format.
2. Use LAStools LASground algorithm, with settings for ground area, de-spiking height and ground surface variability for TIN creation.
3. Normalize heights of vegetation points to heights above ground surface (CHM) using LASheight.

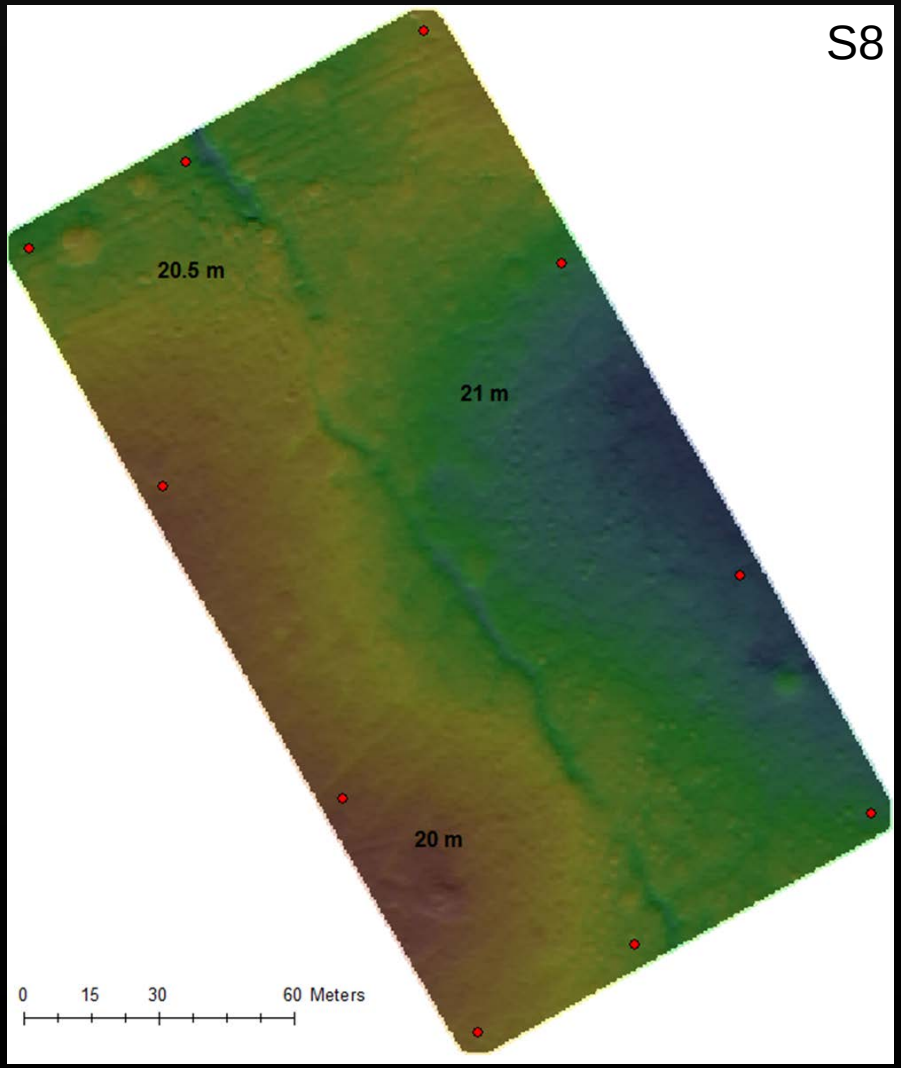
Data Density & Grain Size





The Bare Earth DEM





Methods: Derivation of Metrics

Vertical Height Metrics
Percentile
Min, Max
Mean, Median, Mode
Variance, Std Deviation
Inflection
Ratio above/below

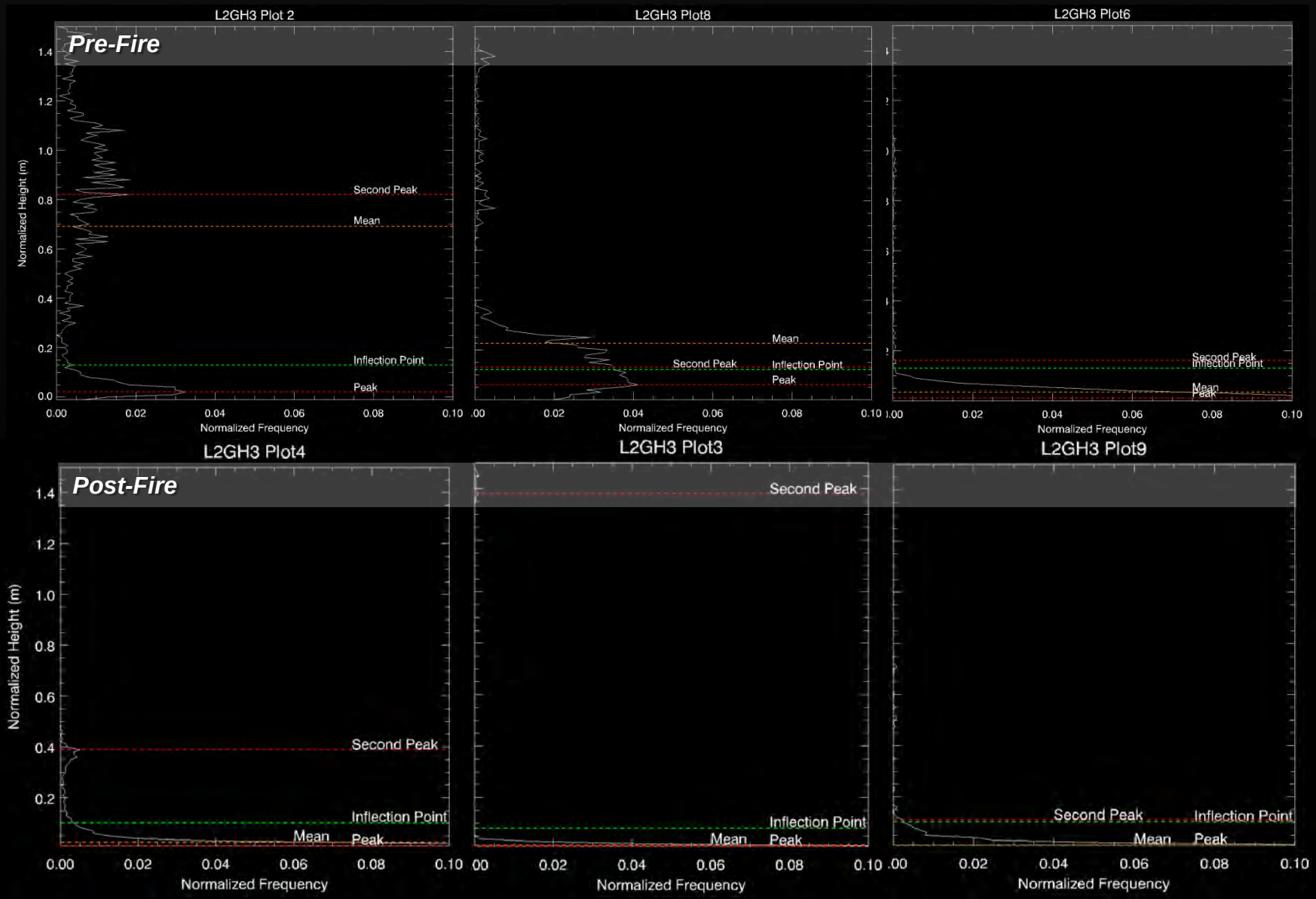
Horizontal ‘Cover’ Metrics
Laser Gap Fraction
Return Density
Convex Hull (surface area)

Volume Metrics
Proportion Filled Volume
Convex Hull (volume)

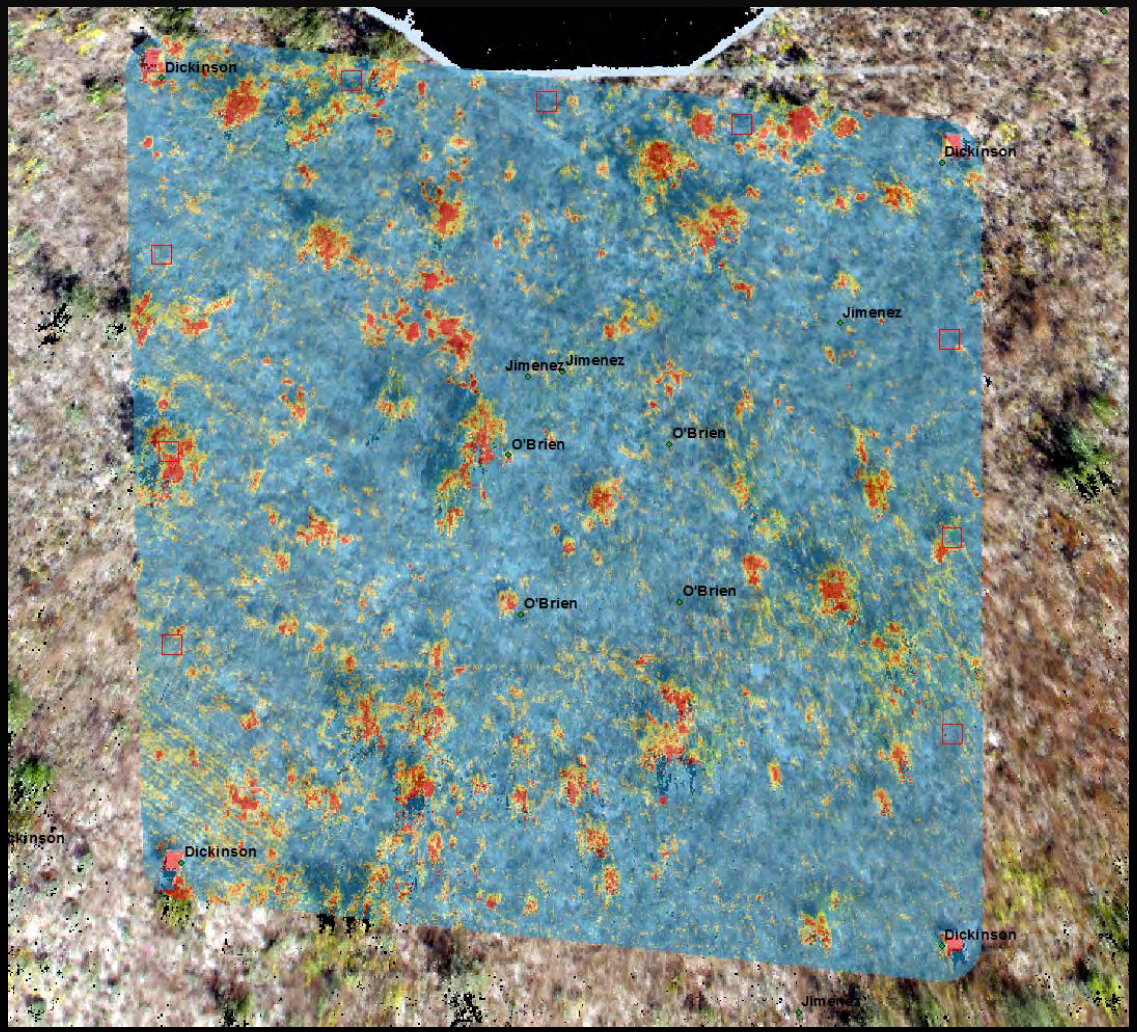
Reflectance Metrics
Laser Intensity
Red, Green, Blue

Height Metrics

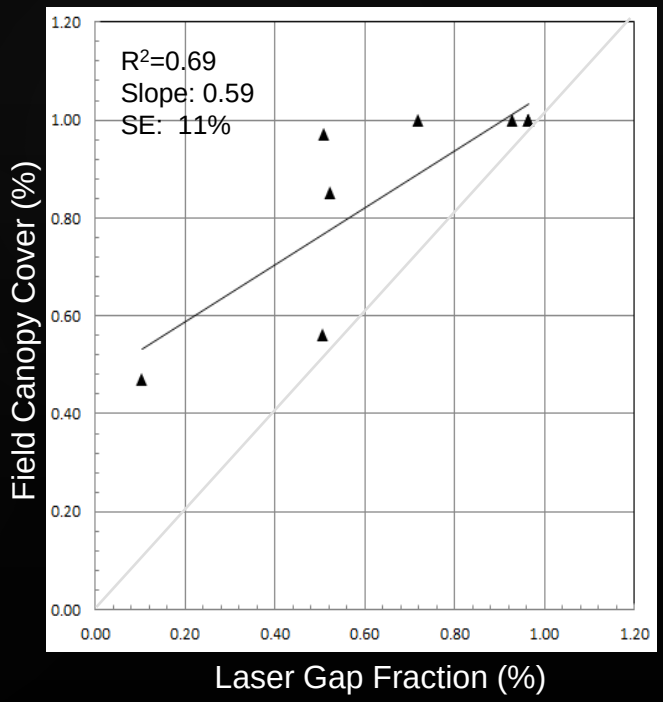
Oak Dominated | Grass Dominated | Grass/Bare Dominated



Cover Metrics: Laser Gap Fraction

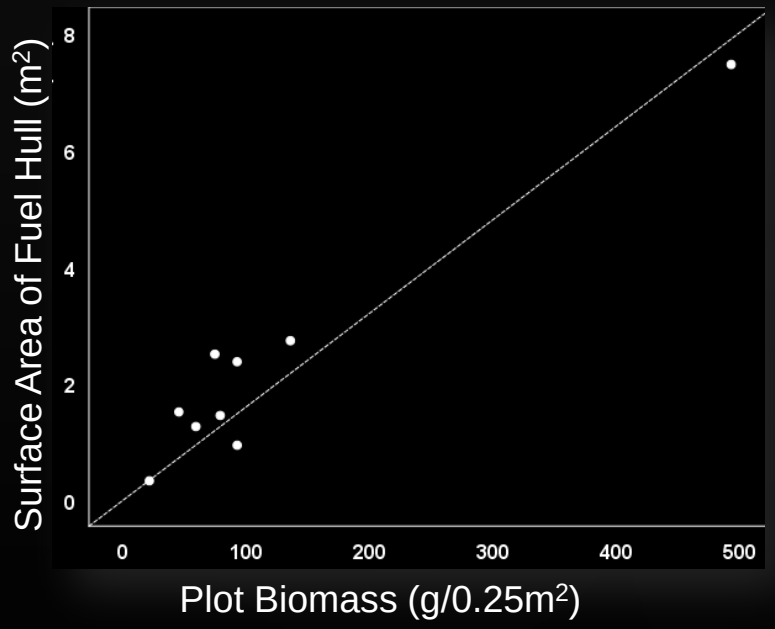


Laser Gap Fraction (L2GH3)



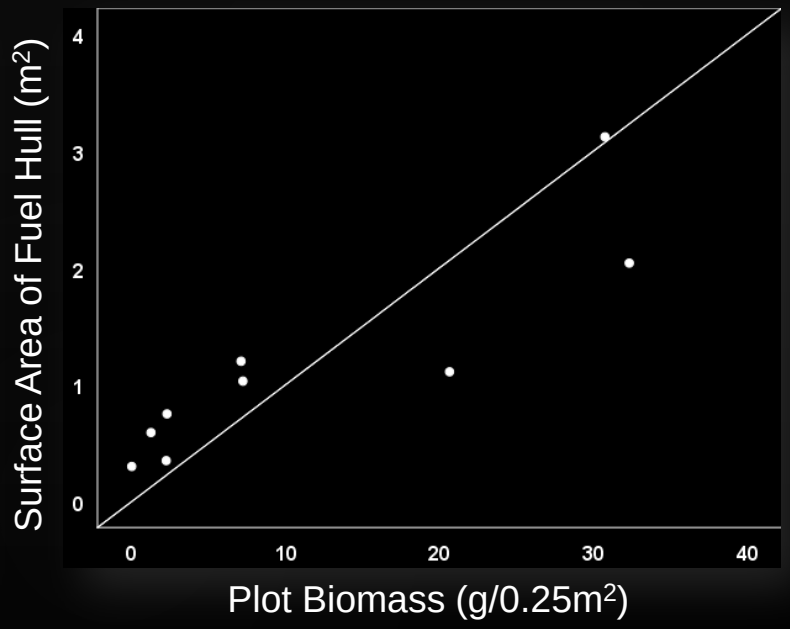
Modeling: Biomass

Pre-Fire (L2GH3)



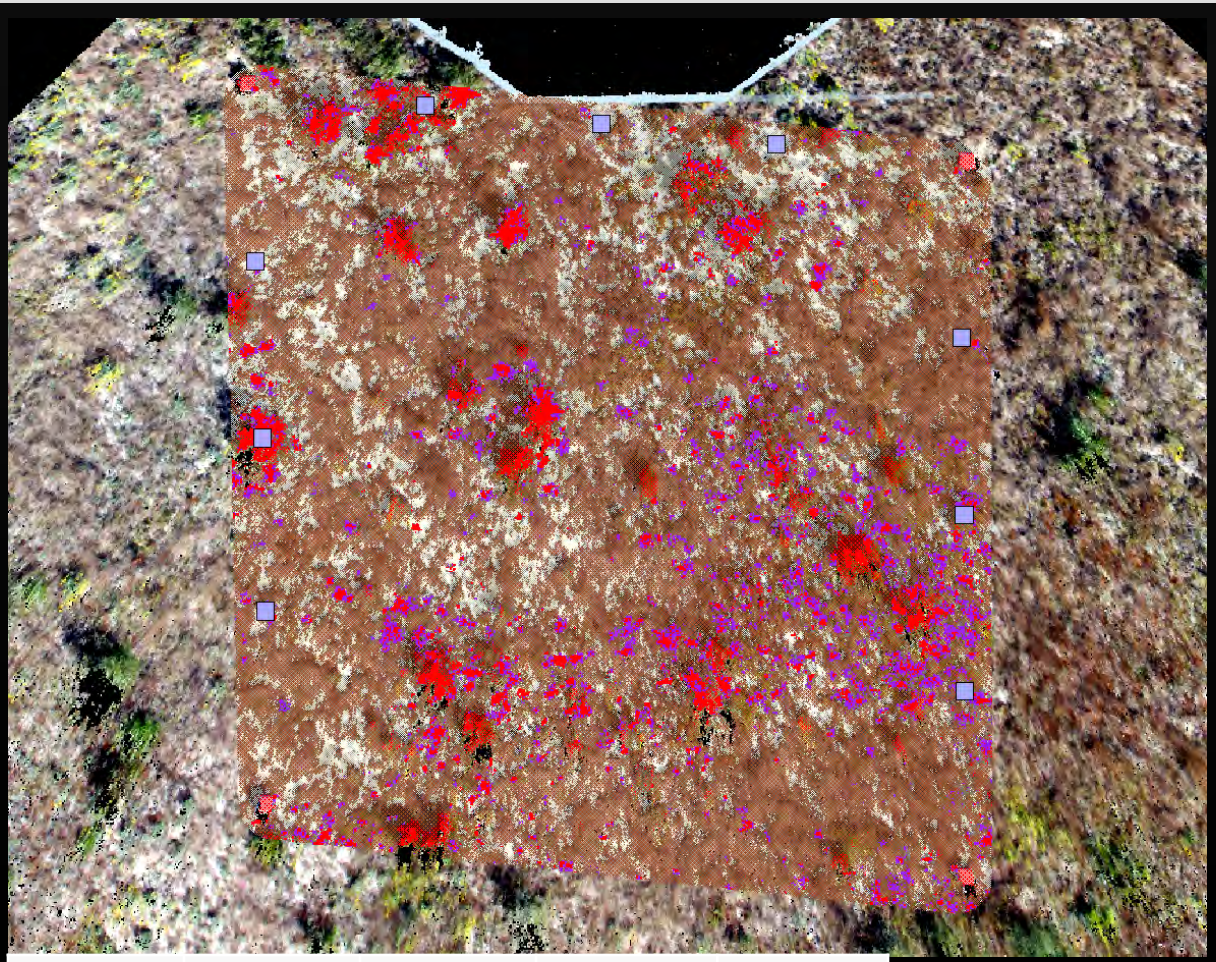
Fuel Class	R	R^2	Std Error
Total biomass (peak)	0.96	0.93	0.59
Biomass exc. litter (peak)	0.97	0.93	0.59
Total biomass (inflection)	0.87	0.76	1.08

Post-Fire (L2GH3)



Fuel Class	R	R^2	Std Error
Total Biomass (peak)	0.89	0.79	0.44
Biomass exc. Litter (peak)	0.83	0.69	0.54
Biomass exc. woody (inflection)	0.88	0.77	0.45

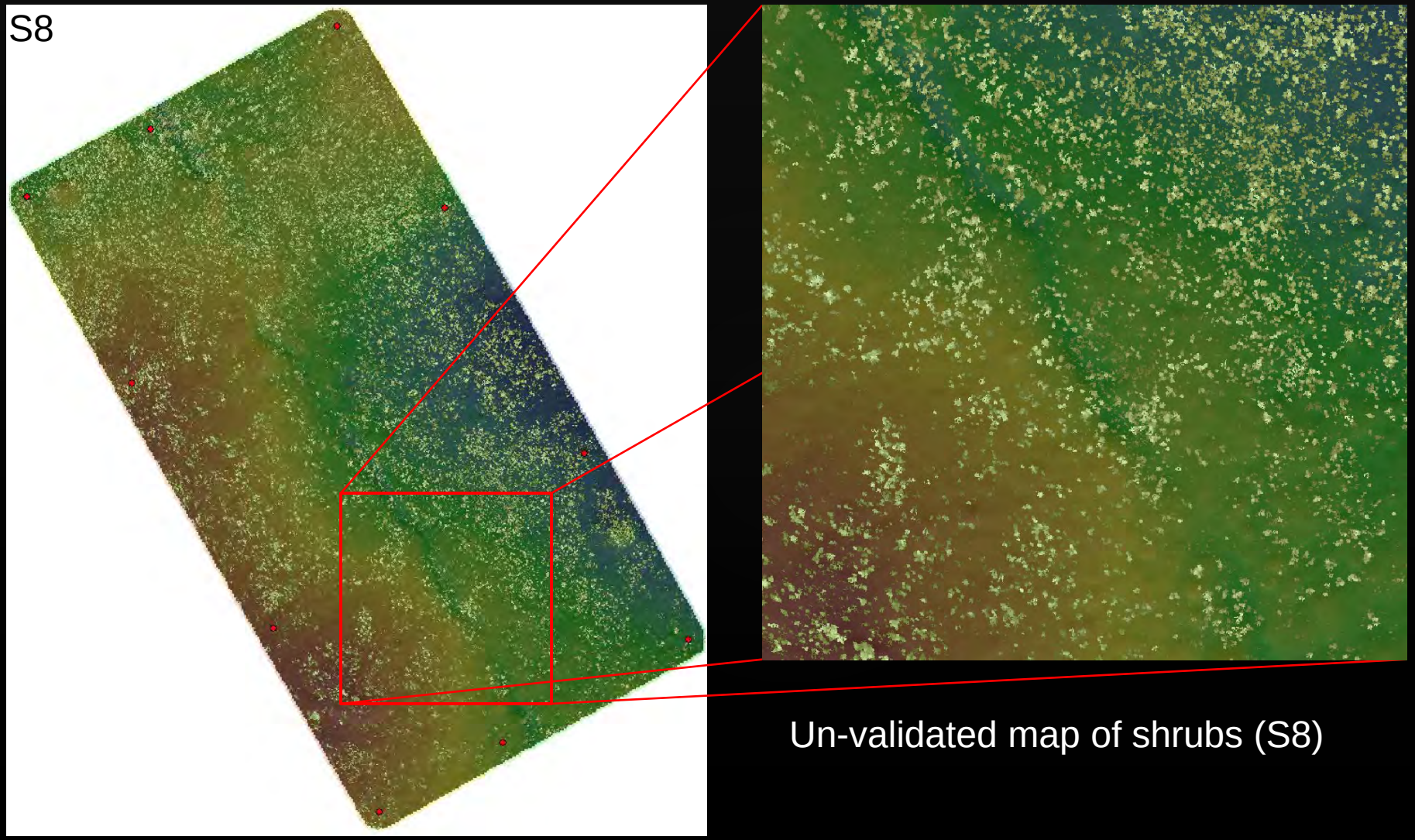
Mapping:



		Reference		
	Shrub	Grass/Forb	Bare	Row Total
Shrub	22	2	0	24
Grass/Forb	2	28	8	38
Bare	0	5	13	18
Column Total	24	35	21	80

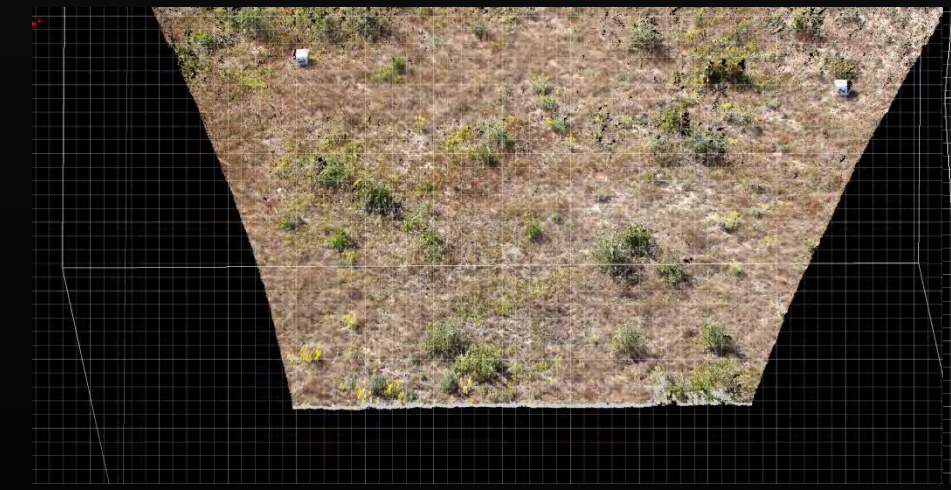
- 10 Class ISODATA using height and gap metrics.
- Merged to 3 classes.
- Overall per-pixel accuracy: 79%
- Shrub per pixel accuracy: 91%
- Some confusion between Grass and Bare.
- Little differentiation between Grass and Forb.

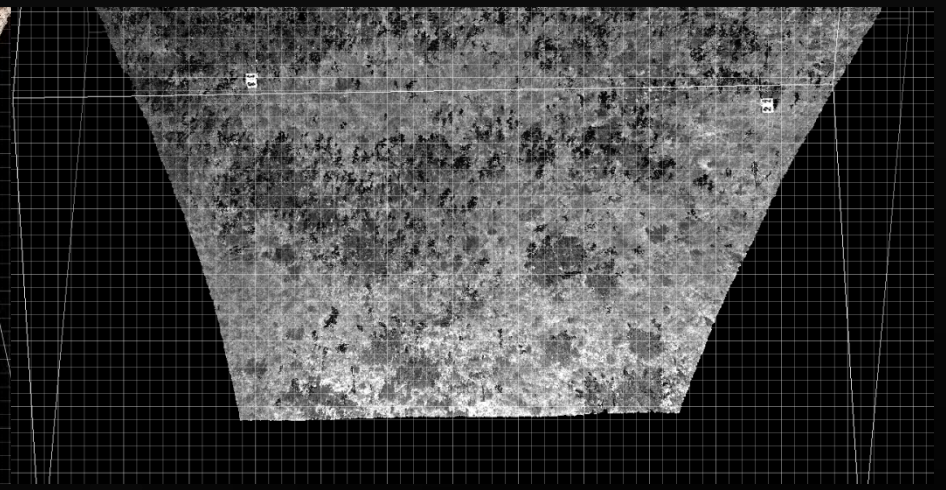
Mapping:

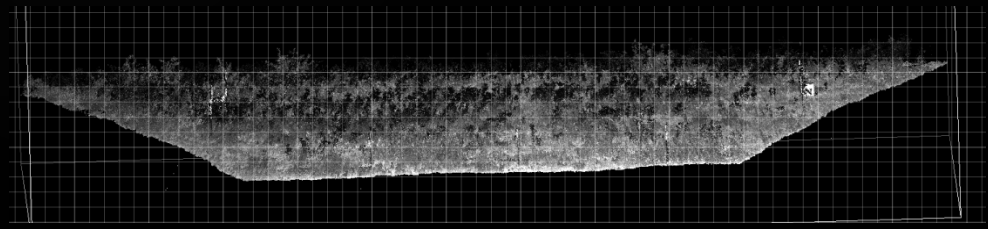


Un-validated map of shrubs (S8)

Intensity/Reflectance Metrics







RGB Mapped to Point Cloud (L2GH3)

Laser Reflectance (L2GH3)

Summary:

- Comprehensive TLS datasets were collected pre- and post-fire for six 2 ha burn blocks and nine 0.04 ha highly instrumented plots, coincident with many field/clip plots.
- A processing stream was developed to merge and project many scans, and to classify and normalize points.
- A suite of gridded height, cover, and intensity metrics is being generated for each dataset.
- Fuel height is the native derivative of the data. Modeling fuel mass using height and convex hull is promising.
- Shrub, grass/forb, and bare ground can be classified effectively on at least three plots.

Tentative Data Delivery:

- Merged, unclassified laser point clouds in UTM projection (xyzi) for each S-Block and HIPS pre- and post- fire.
- Bare earth DEMs.
- Grids at $1m^2$ (S-blocks), $0.25m^2$ (HIPS) for some fraction of laser metrics.
- Grids of Fuel Metrics- pending outcomes of analyses.

- We are still soliciting input on grain size, metrics, and data formats.