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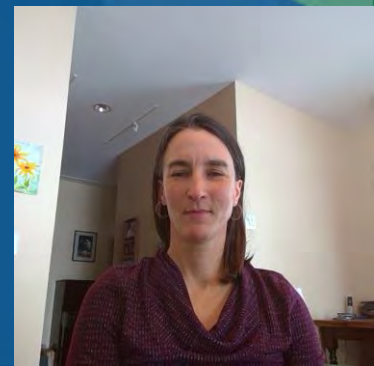
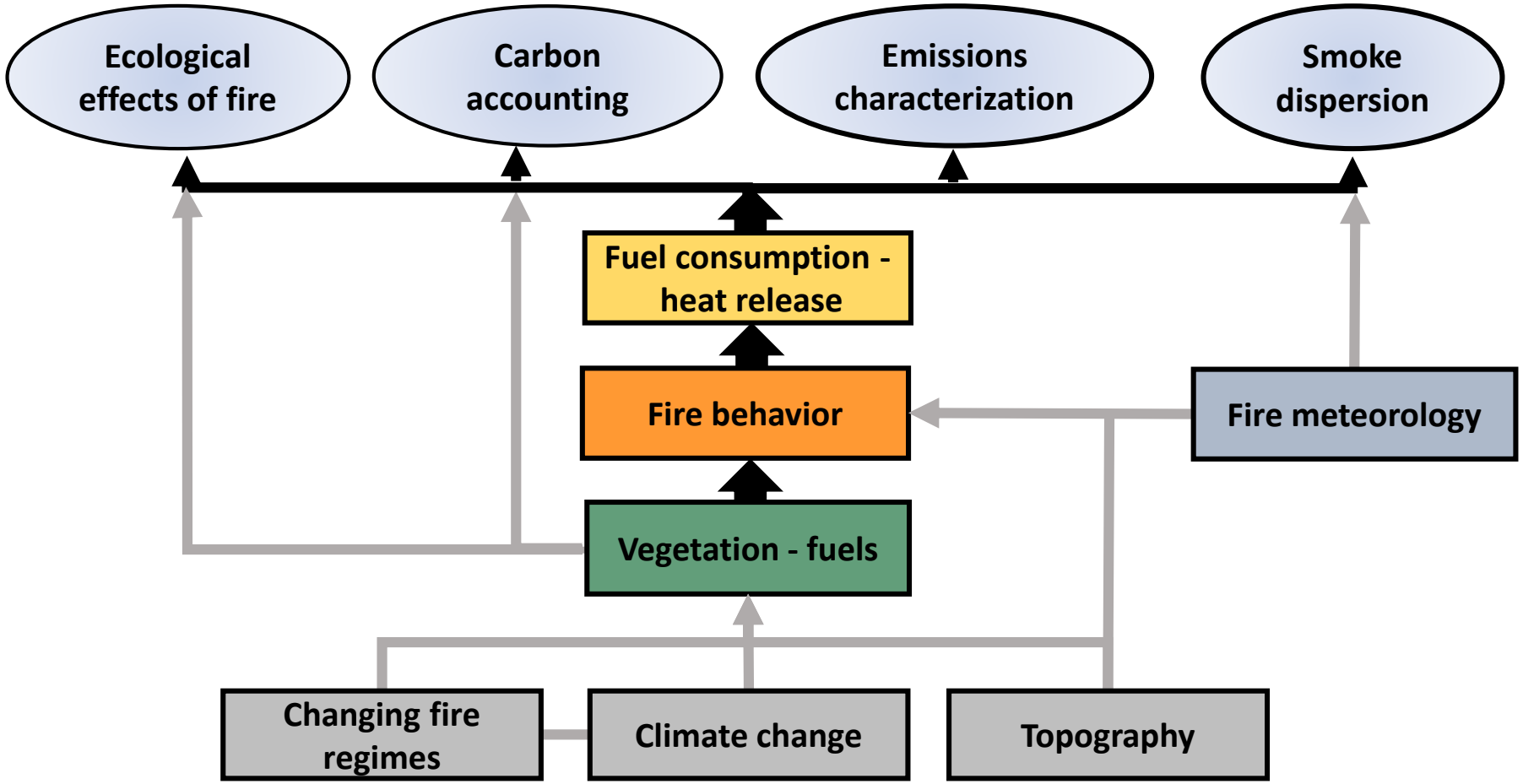
3D Fuels Library as Related to Inter-Project Collaboration and Shared Data

Susan J Prichard

SERDP • ESTCP
SYMPOSIUM
2020 • Enhancing DoD's Mission Effectiveness

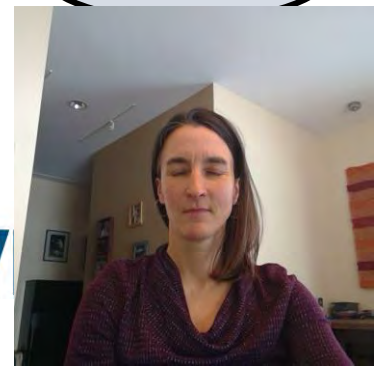


SERDP Core Fire Science Strategy



Legend

Core fire science area



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SERDP Fire Science Projects

Hoffman
Prichard/Ottmar

3D Fuels

Fire Behavior

Butler
Hoffman
Parsons
Skowronski
Weise

Hoffman
Hudak
Prichard/Ottmar

Fuel Consumption

Ecological Effects

Hoffman
Skowronski

Geospatially and temporally coordinated model evaluation datasets (SERDP/FIREX-AQ/FASMEE)

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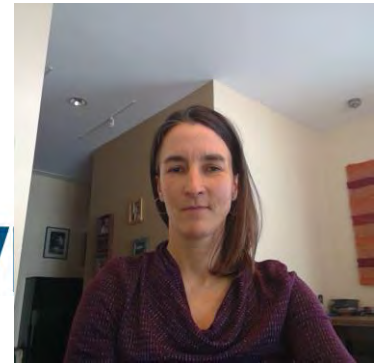

3D fuel characterization for evaluating physics-based fire behavior, fire effects, and smoke models on US Department of Defense military lands (RC19-C1-1064)

Performers: Susan Prichard, Roger Ottmar, Ben Bright, James Cronan, Christie Hawley, Andrew Hudak, Louise Loudermilk, Russ Parsons, Eric Rowell, Carl Seielstadt, Nick Skowronski, Carlos Silva

Students: Jonathan Batchelor, Michelle Bester and Gina Cova

Technology Focus

- *Develop and evaluate hierarchical sampling methods for 3D fuel characterization required for next-generation physics-based models of fire behavior and smoke production.*

Research Objectives

- *Create building blocks (physical fuels libraries, 3D fuel models, sampling resolu next-generation fuels mapping of SE pine and western pine/grasslands*

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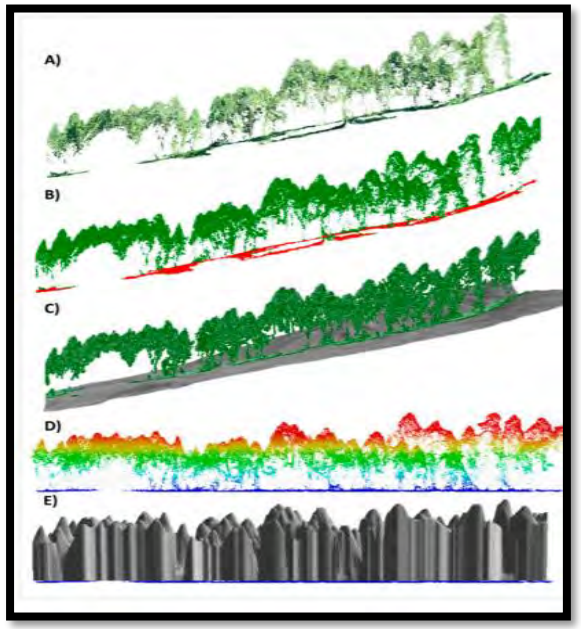
Technical Approach: Hierarchical sampling design

Coarse scale (5 x 5 x 5 m)
ALS canopy & modeled surface fuels

Meso scale (1 x 1 x 1 m)
Canopy and understory fuels

Fine scale (0.1 x 0.1 x 0.1 m)
TLS & close-range photogrammetry

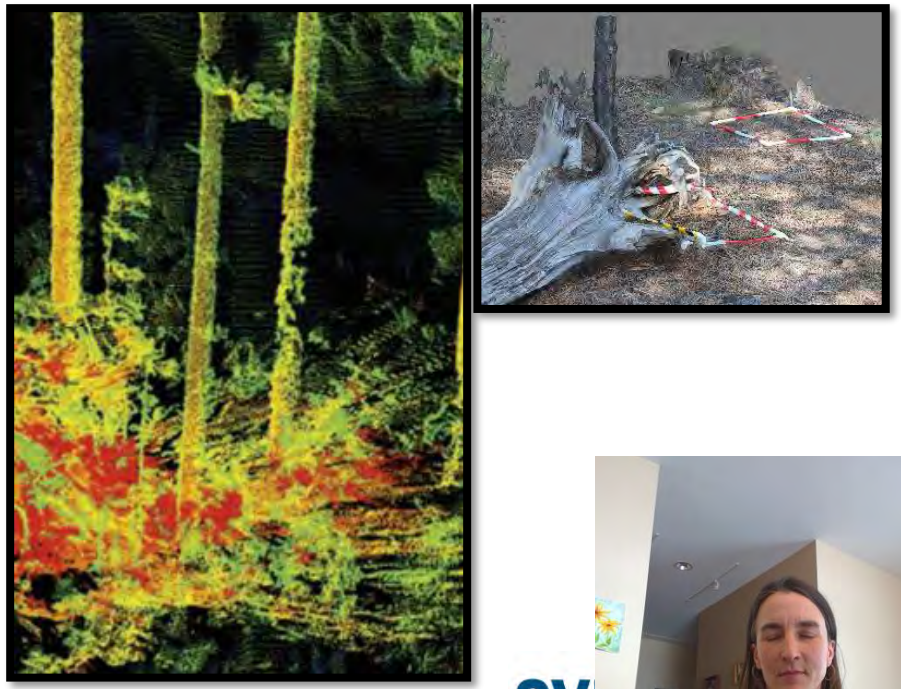
Canopy fuel characterization & landscape mapping



(Mohan et al. 2017)

Synoptic TLS, Drone-based photogrammetry

(Rowell et al. 2020)



(Hudak et al. 2020)

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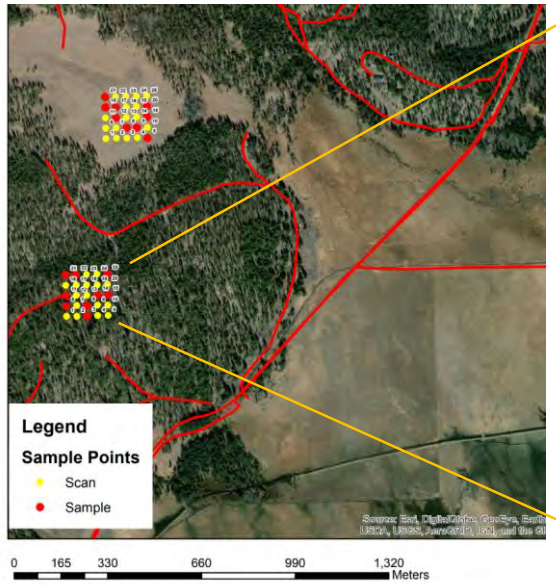
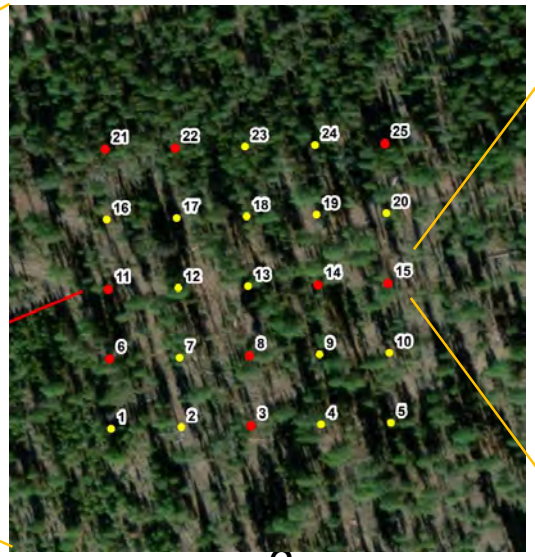
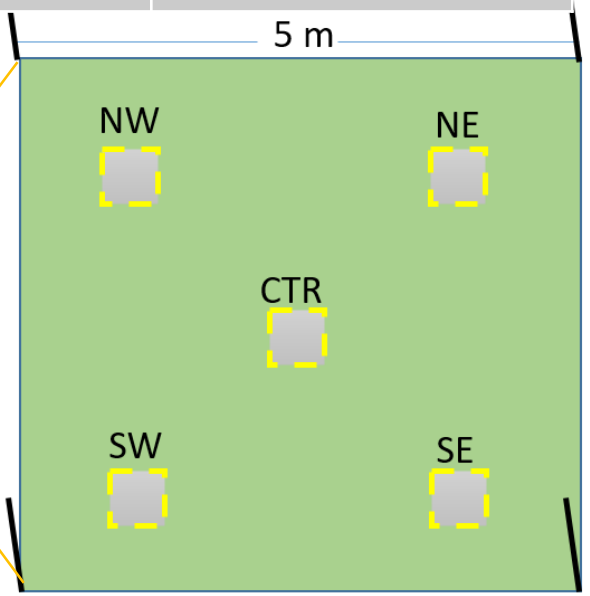
Study Design

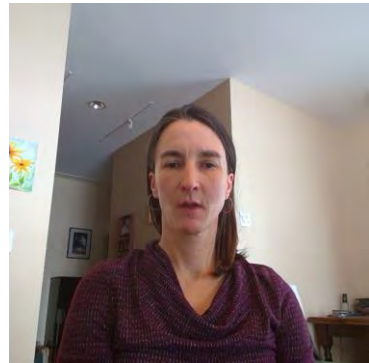
Spatial scale	Dimensions	Imagery	Resolution
Site (synoptic)	200x200 m	ALS TLS SfM (UAS)	5m < 1m
Macro plot	5 x 5 m (n = 18)	TLS	
Voxel plot	0.5 x 0.5 m x 1 m (n = 45)	TLS SfM (close range)	







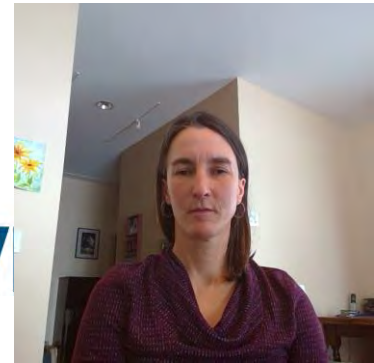
Sycan Marsh Reserve, Oregon



3D Fuel Characterization of Pine Forest Structure

Southern pine (FL)

Western pine (MT)



Study Areas

SE flatwoods understory

Tate's Hell A, FL

Tate's Hell B, FL




SE loblolly/sweetgum forests


1 yr rough


2 yr rough


3 yr rough


4-5 yr rough

Study Areas

Western grasslands

Sycan, OR

Tenalquot, WA

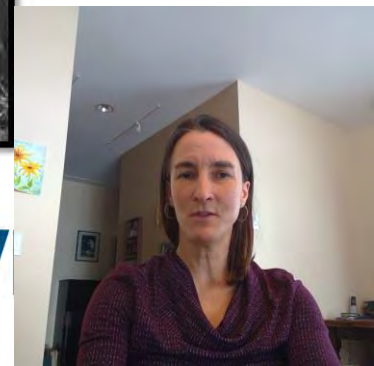
Glacial, WA

Western ponderosa pine forests

Lubrecht, MT

Sycan, OR

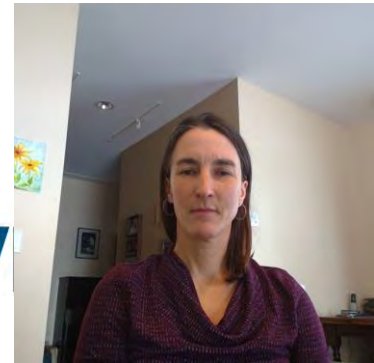
Methow, WA



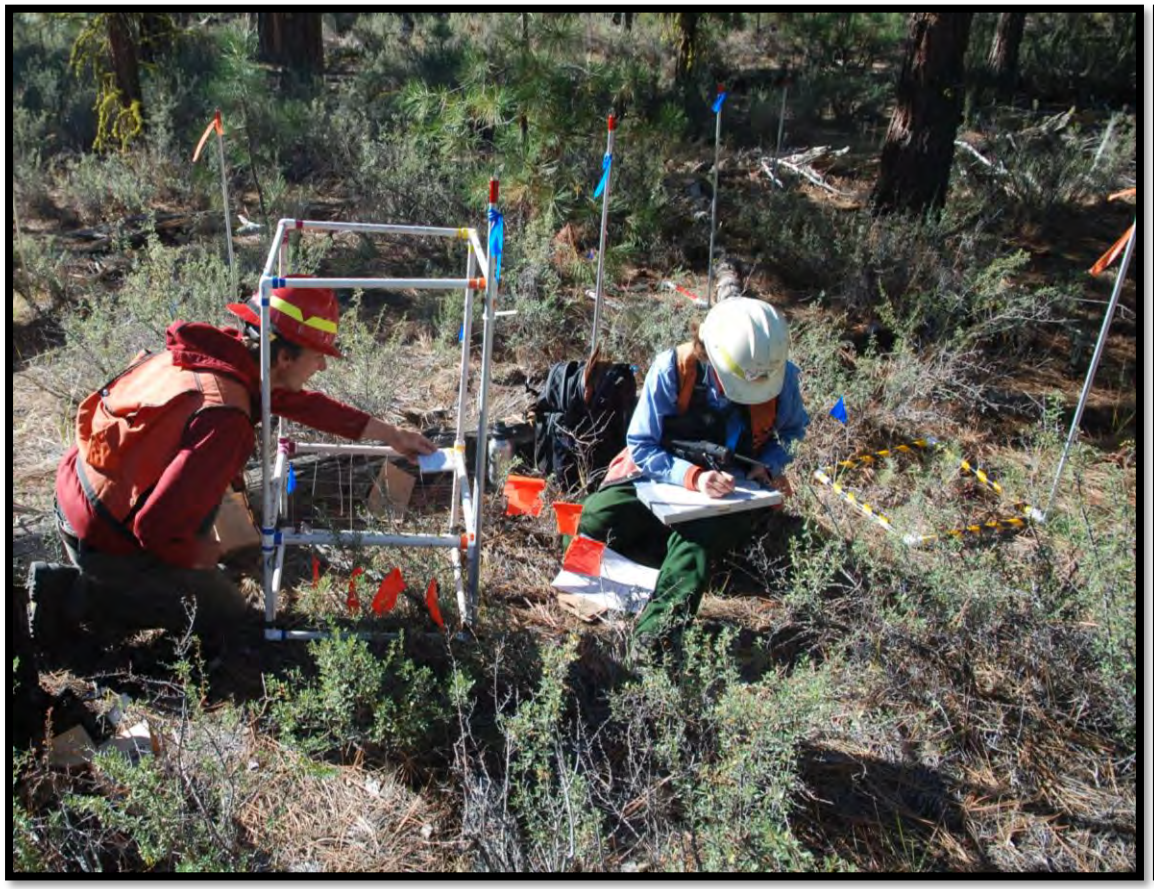
Additional Sites

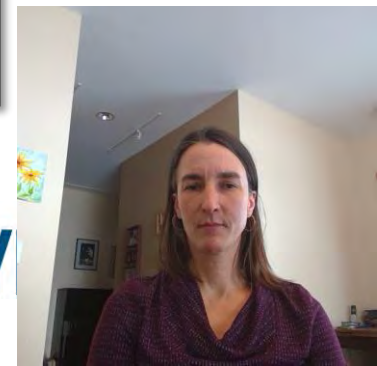
Blackwater, FL

Pebble Hill, FL



Voxel Plot Sampling





Project Work Plan and Website

3D Fuels Work Plan

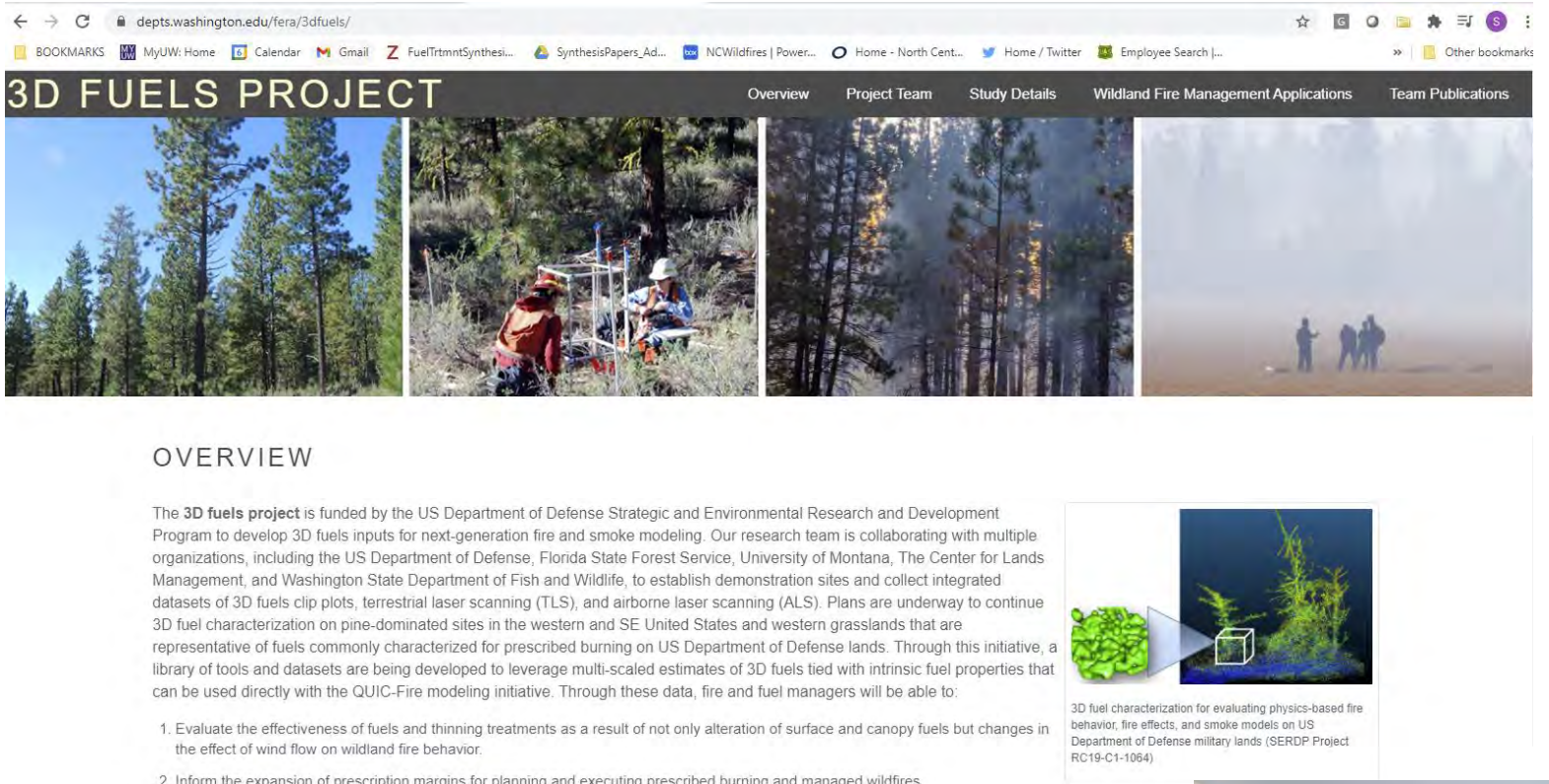
SERDP Project RC19_C1_1064

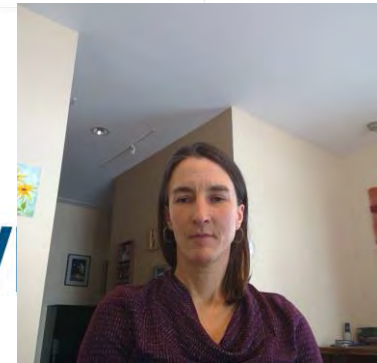
3D fuel characterization for evaluating physics-based fire behavior, fire effects, and smoke models on US Department of Defense military lands

Project Team:

Susan Prichard (overall lead), Roger Ottmar (federal PI), Andrew Hudak (coPI), Maureen Kennedy (coPI), Russ Parsons (coPI), Eric Rowell (coPI), Carlos Silva (coPI), Nicholas Skowronski (coPI), Jonathan Batchelor (PhD student), Michelle Bester (PhD student), Gina Cova (Ms student)

Table of Contents:





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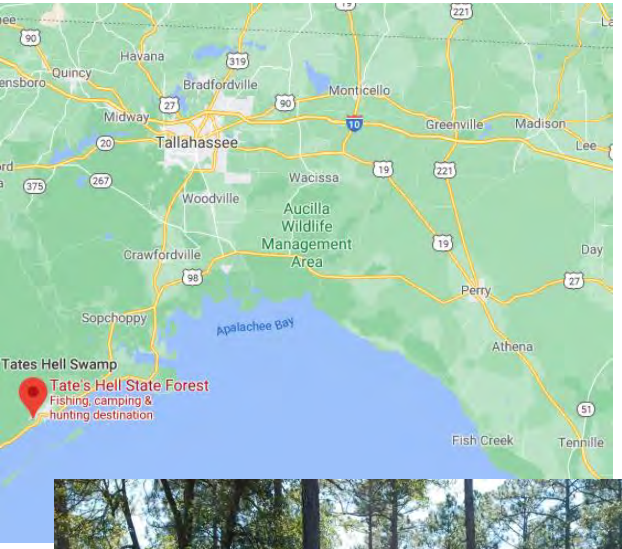
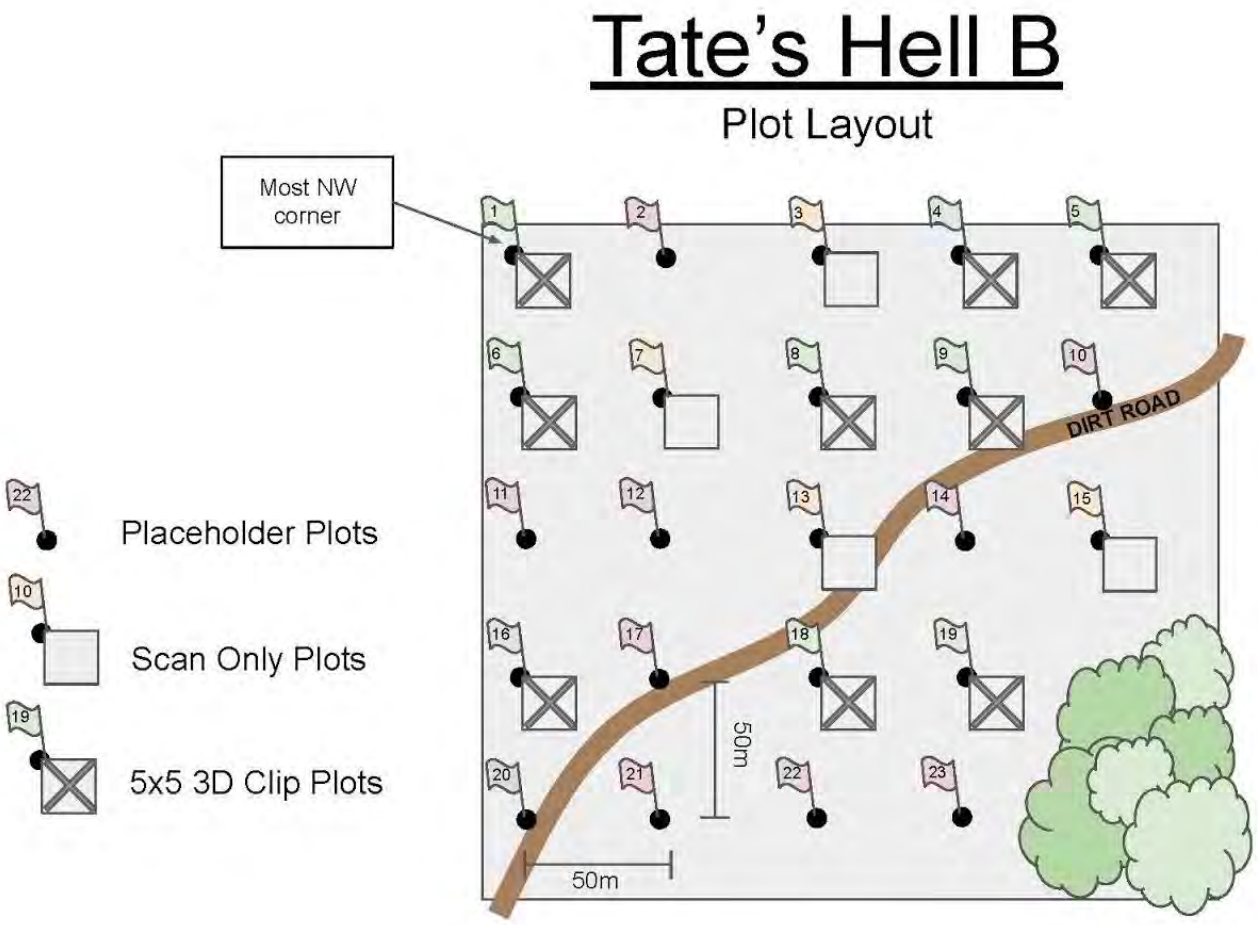
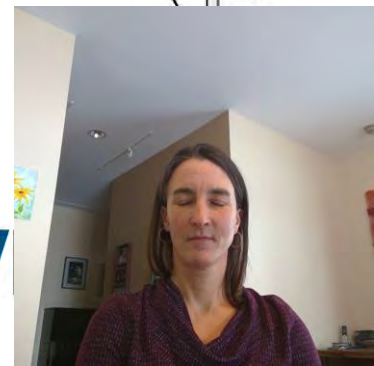
Sample 3D Fuels Dataset







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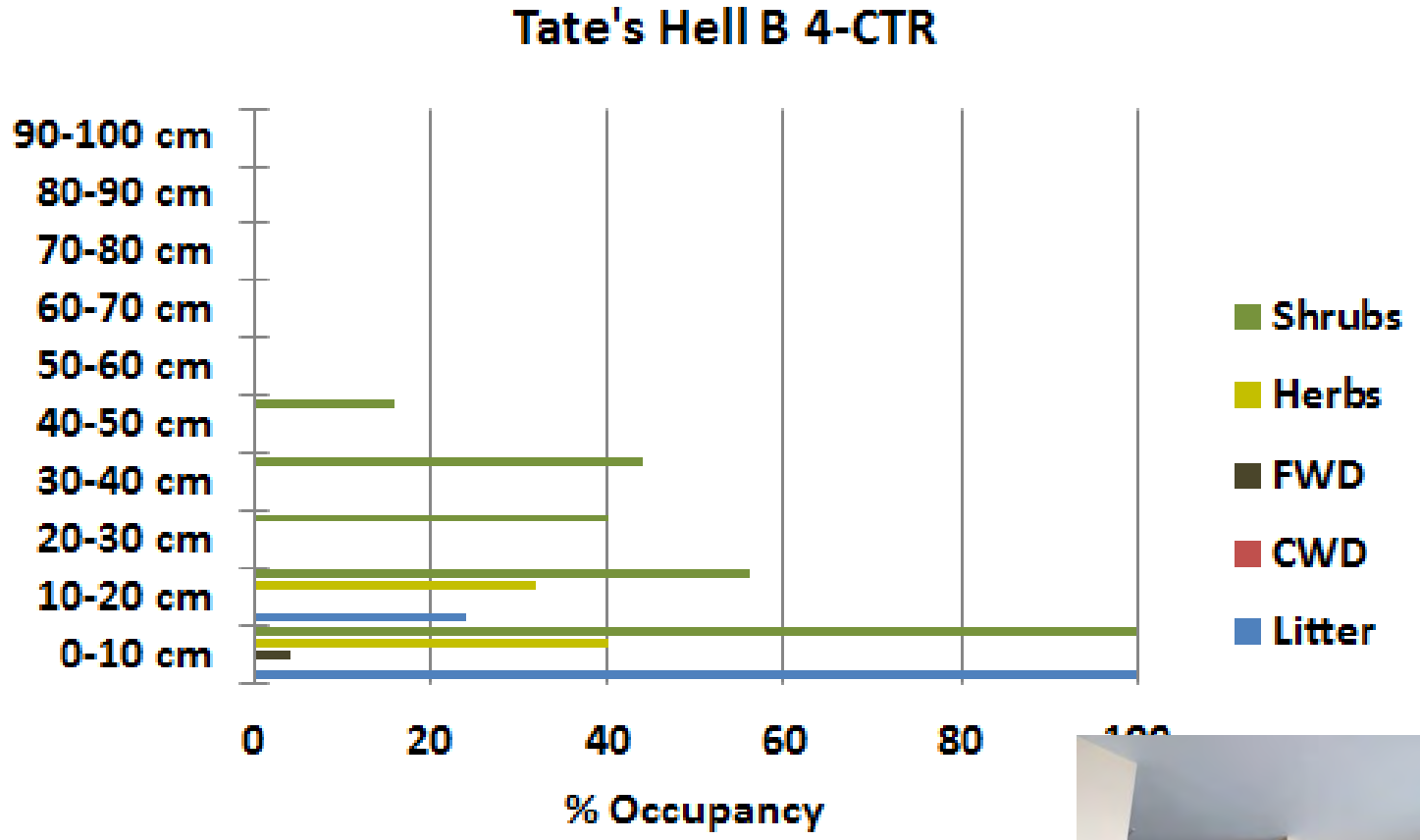
Tate’s Hell

Voxel Plot: B 4-CTR
Site: Tate’s Hell State Forest, Florida
Location: To be added
Overstory: Slash pine (*Pinus elliottii*)
Dominant fuel types: pine litter, shrub litter, perennial grass, gallberry (*Ilex spp.*)



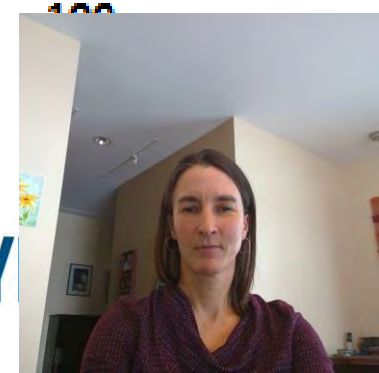


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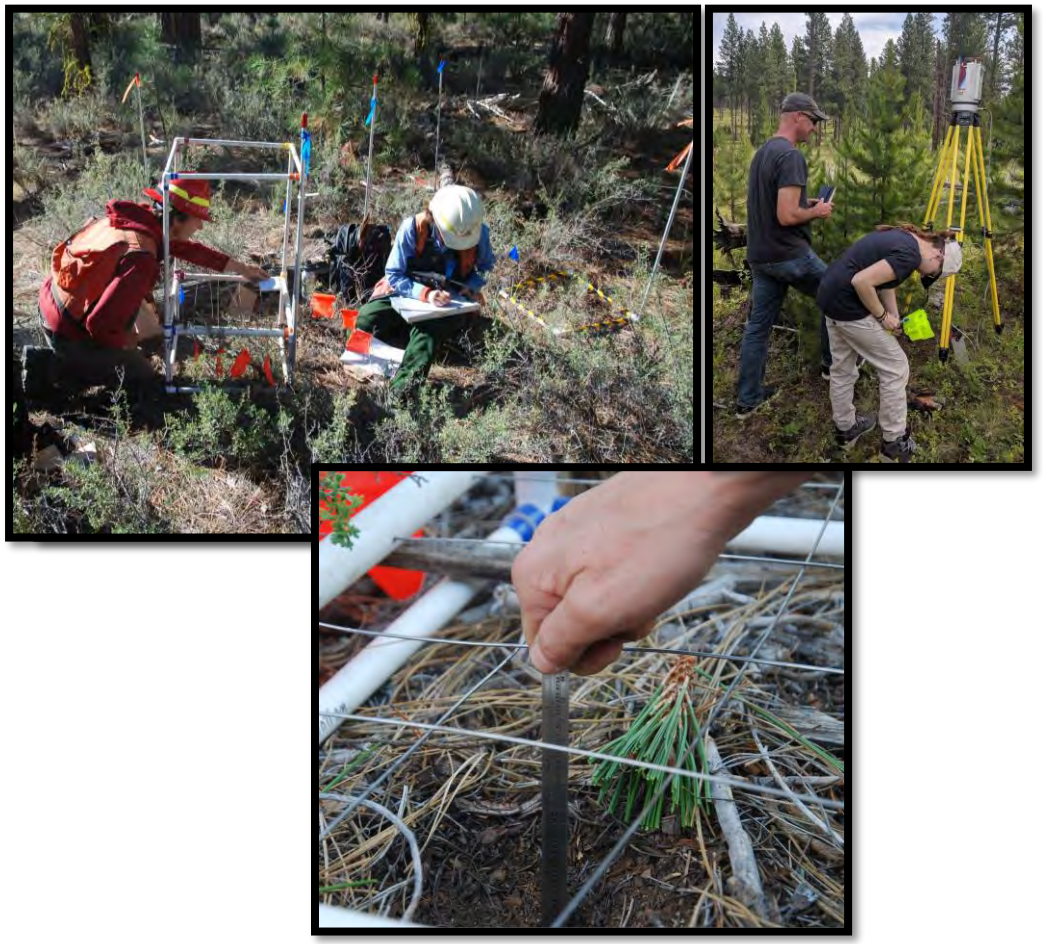
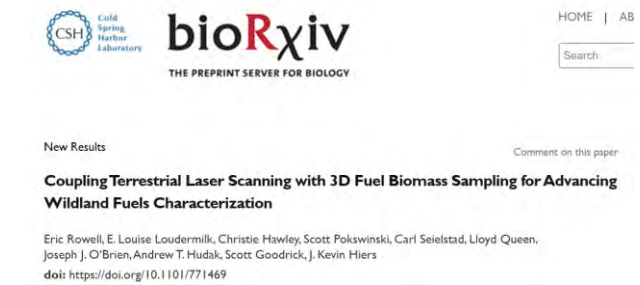
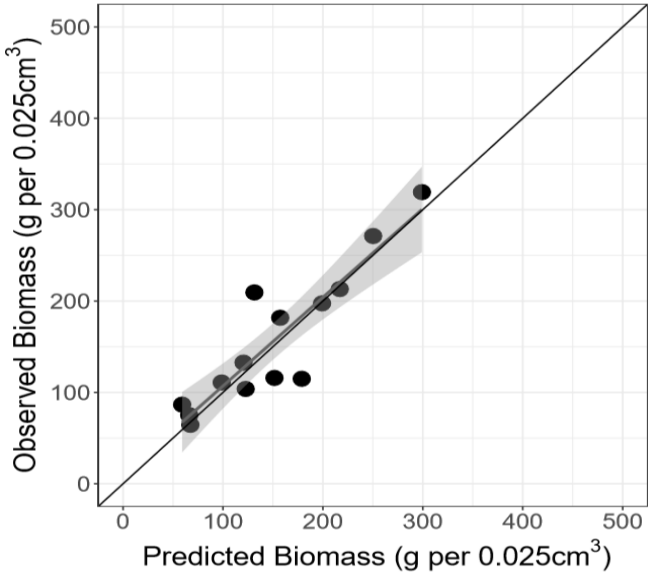
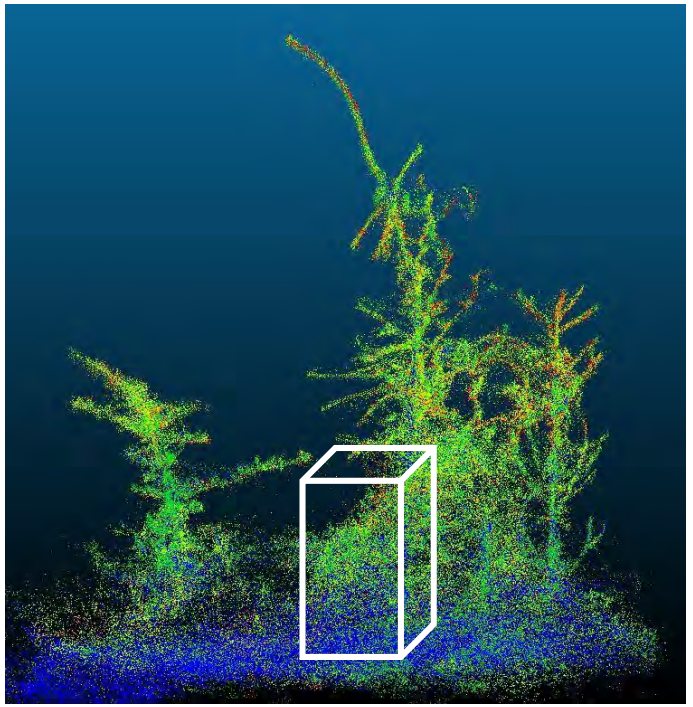
Image Calibration with Field Data





0-10cm stratum





Porosity Index

$$(\lambda) = 1 - \frac{\Sigma}{Volu}$$

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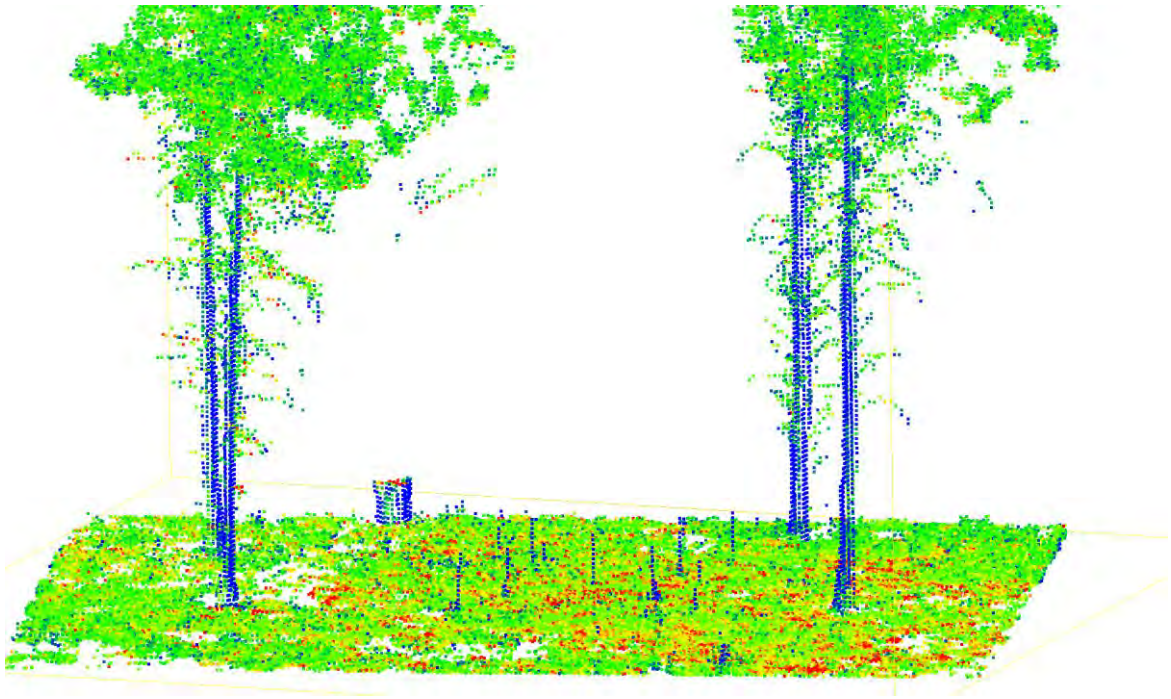
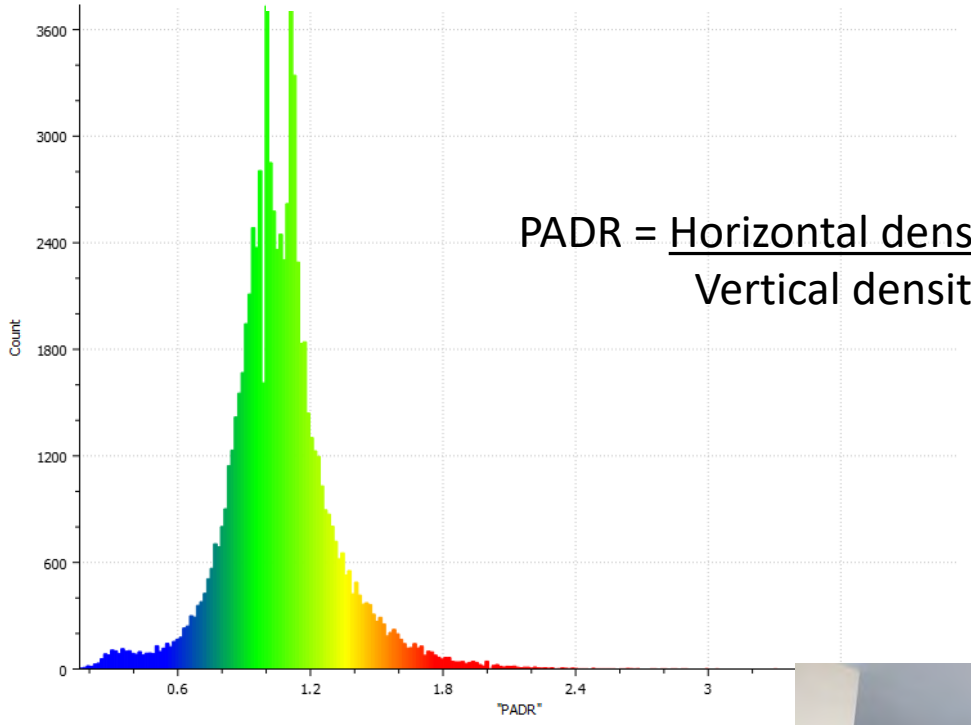
Plant Area Density Ratio

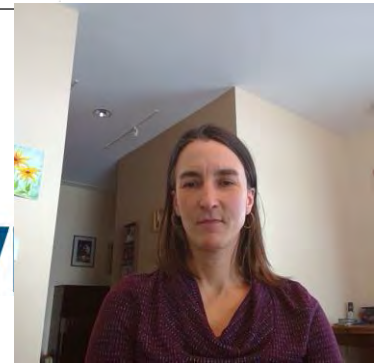
Plant Area Density Ratio
(derived from TLS point cloud)



Plant Area Density Ratio
(histogram)



PADR = $\frac{\text{Horizontal density}}{\text{Vertical density}}$



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Predictive Bulk Density Models

Density of occupied voxels
Hudak et al. (2020)

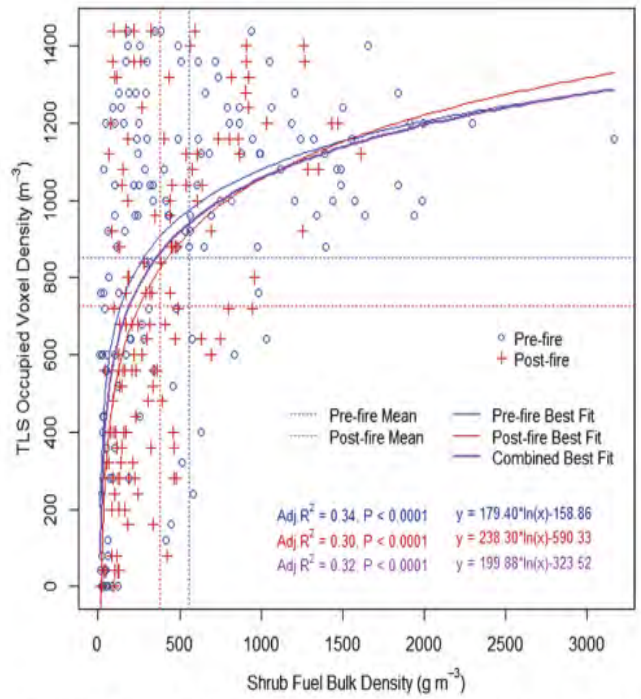
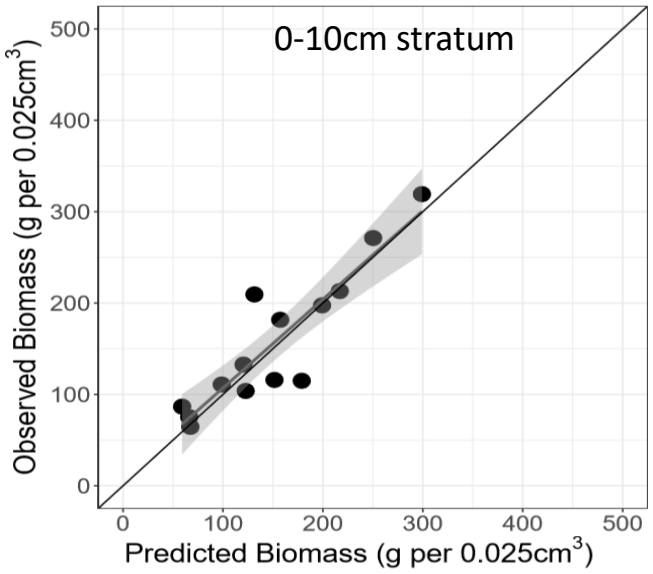
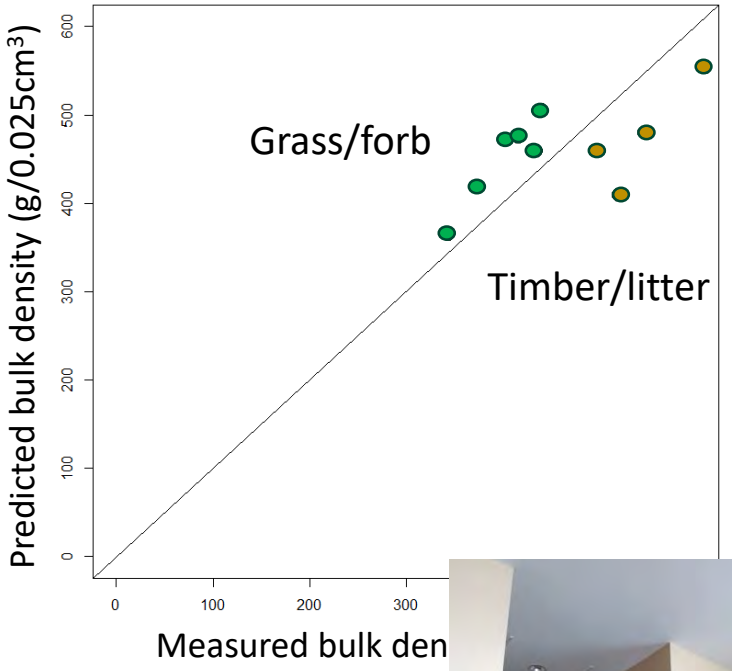


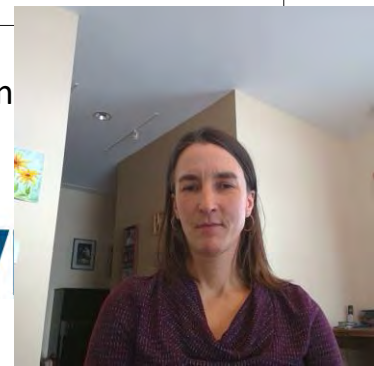
Figure 8. Natural logarithm relations between shrub fuel bulk density measured in 3D shrub sample plots and the density of voxels occupied by terrestrial laser scanning (TLS) points extracted from the point cloud within corresponding virtual *x*, *y*, *z* frames (0.5-m × 0.5-m × 0.1-m intervals). Because the pre- versus postfire functions differed so little, all data were pooled into a single combined equation.

Porosity Index
Pebble Hill



Porosity Index + H/V ratio
(Lubrecht – preliminary)





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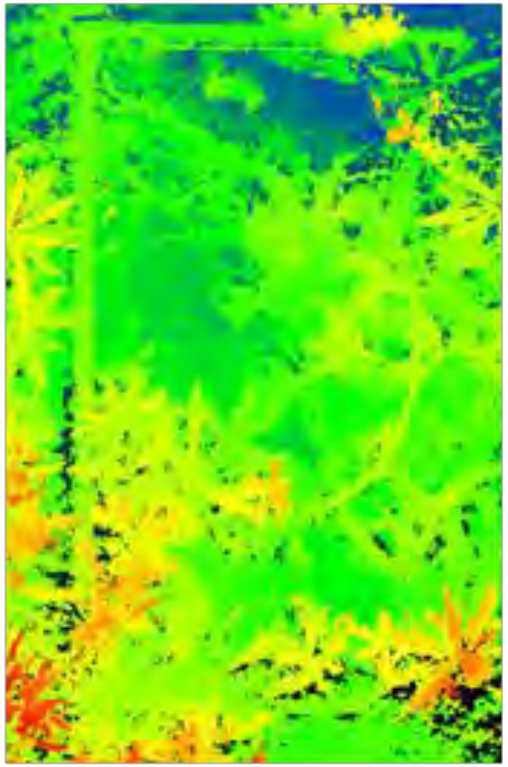
Object-based Fuel Characterization (I)

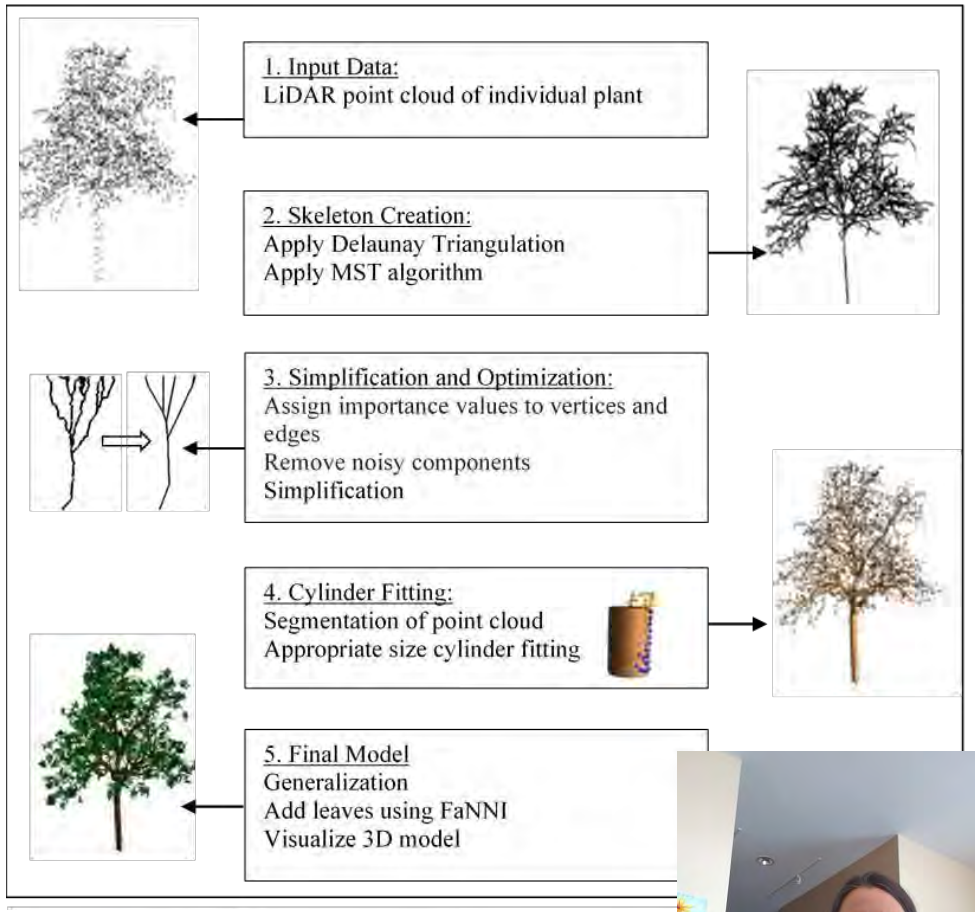
Ortho Photo | RGB Point Cloud | Height | Live/Dead Classification

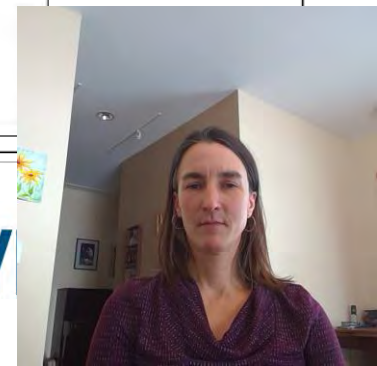





Object-based Fuel Characterization (II)

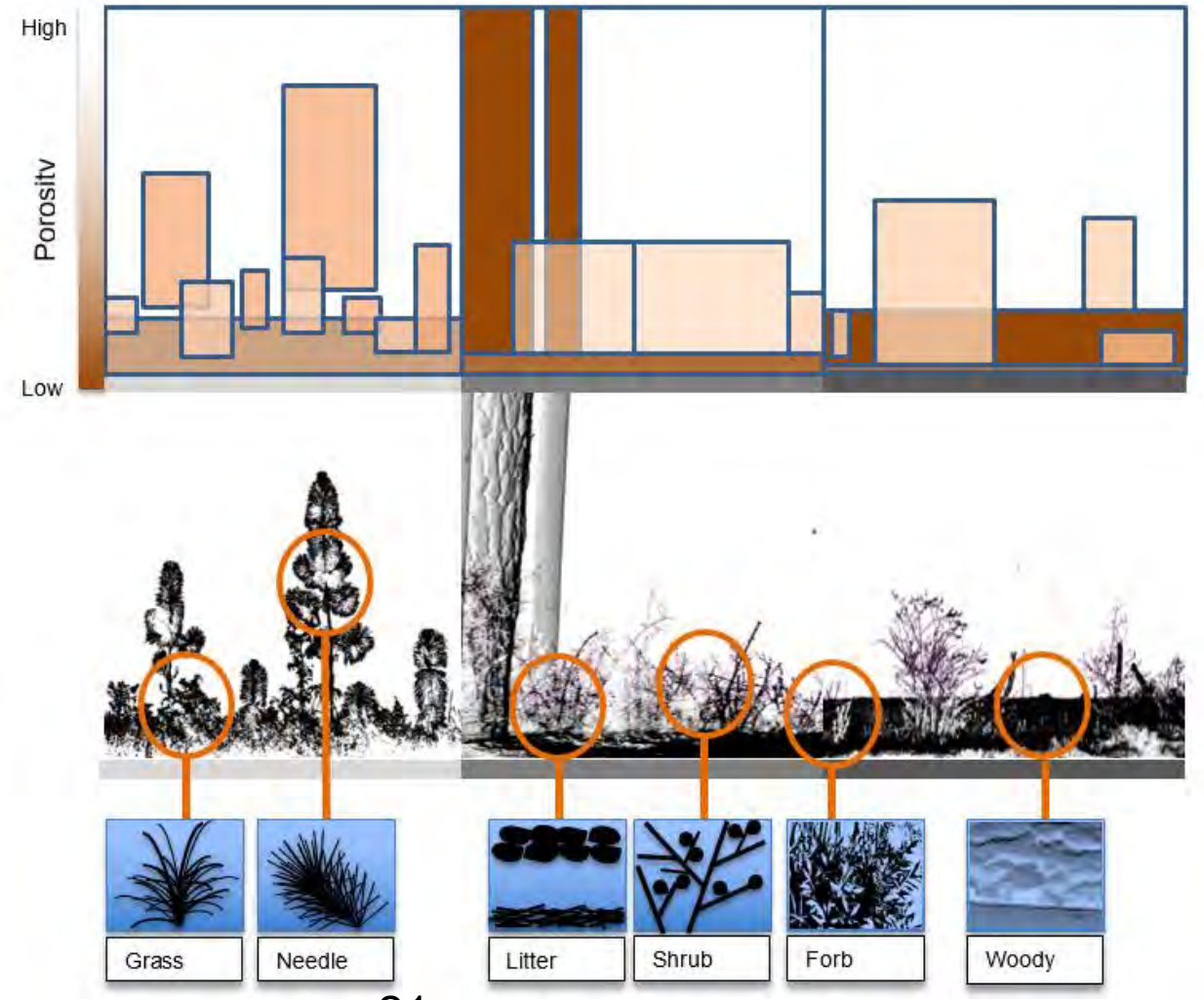
Quantitative Structural Modeling (Bester/Skowronski)





Landscape Metrics and Mapping

Canopy gaps (lacunarity)



Landscape Mapping

Local TLS

Local Photogrammetry

Training data informs:
- ALS data
- NAIP Imagery
- User based polygon Data

Training Model: Validation Voxel Sampling

If no coarser data available, synoptic scale is final product

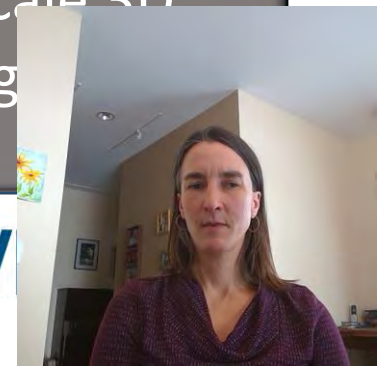
Synoptic Photogrammetry

Synoptic TLS

Training Model

Landscape Scale 3D Veg

SY



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JFSP Wildland Fire Data Synthesis

FIRESCIENCE.GOV
Research Supporting Sound Decisions

Project team:
Susan Prichard (PI)
Eric Rowell (Tall Timbers)
Alina Cansler (UW)
Roger Ottmar (USFS)
Michael Billmire (Michigan Tech)
Matt Jolly (RMRS)
Duncan Lutes (RMRS)
Kurtis Nelson (USGS)
Birgit Peterson (USGS)

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Wildland Fuel Characterization for Fire Science and Management: synthesis of existing knowledge and research needs (JFSP Project 20-S-01-3)

I. ***Introduction to wildland fuels***
- *Traditional approaches to wildland fuel characterization*
- *Emerging technologies*

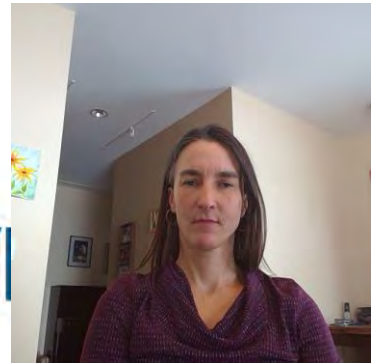
II. ***Current application of wildland fuel datasets in fire behavior and effects modeling***

III. ***Next-generation fuel characterization***
- *Requirements for multi-scaled fuel characterization inputs to computational fluid dynamics models*
- *Sources and limitations of existing datasets for fire and smoke modeling*

IV. ***Spatial and temporal dynamics of wildland fuels***
- *Challenges in creating relevant and up-to-date maps of wildland fuels, including impacts from disturbances*
- *Ecosystem process modeling of live and dead biomass*
- *Fuel moisture dynamics*

V. ***Recommendations for fuel libraries and code repositories***
- *Prototype development*
- *Design recommendations*

VI. ***Research needs***



Questions?

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