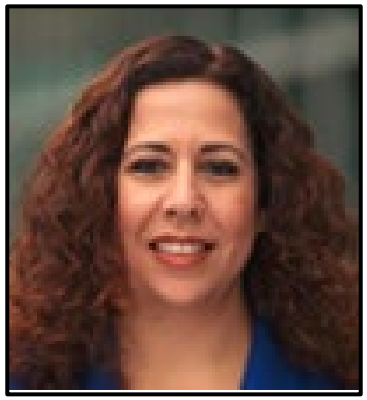
Fuel Characterization and Fire and Smoke Modeling for Understanding Fire Behavior on Military Lands

March 10, 2022

Welcome and Introductions



Rula A. Deeb, Ph.D.

Jennifer Nyman, Ph.D., P.E.

SERDP ESTCP

Webinar Agenda

- **Webinar Logistics** (5 minutes)
  Dr. Rula Deeb and **Dr. Jennifer Nyman**, Geosyntec Consultants
- **Overview of SERDP and ESTCP** (5 minutes)
  Dr. Kurt Preston, SERDP and ESTCP
- **Physics-Based Modeling of Fire Behavior and Smoke Plume Development: How Much is Enough?** (25 minutes + Q&A)
  Dr. William (Ruddy) Mell, USDA Forest Service
- **Wildland Fuel Characterization for Next-Generation Fire Behavior Modeling** (25 minutes + Q&A)
  Dr. Susan Prichard, University of Washington
- **Final Q&A Session**

Wildland Fuel Characterization for Next-Generation Fire Behavior Modeling

Susan Prichard, Ph.D.
University of Washington

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Presentation Outline

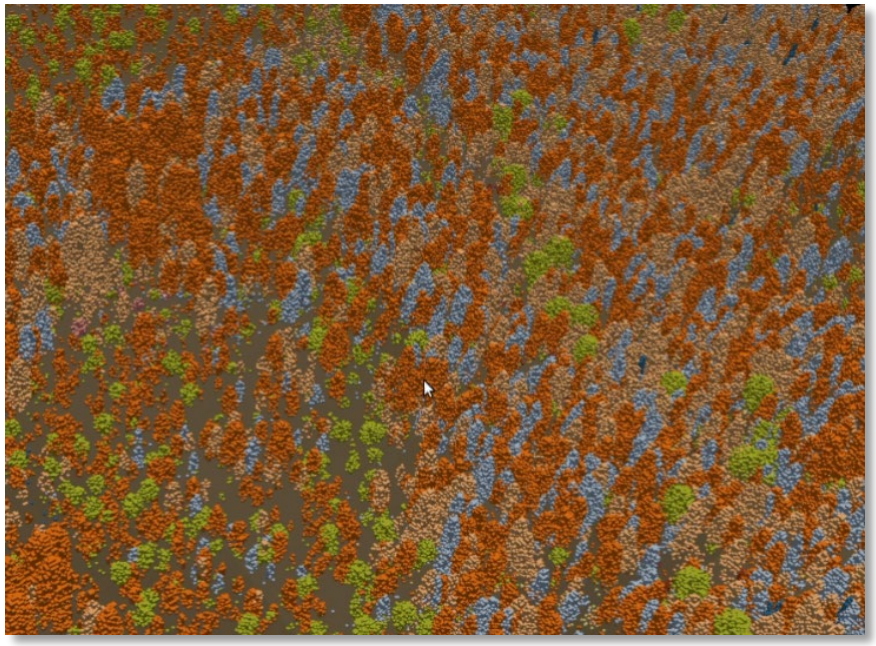
- Background
  - Fuel characterization for prescribed burn planning
- 3D fuels project overview
- Preliminary findings
- Relevance to DoD land managers

Overview

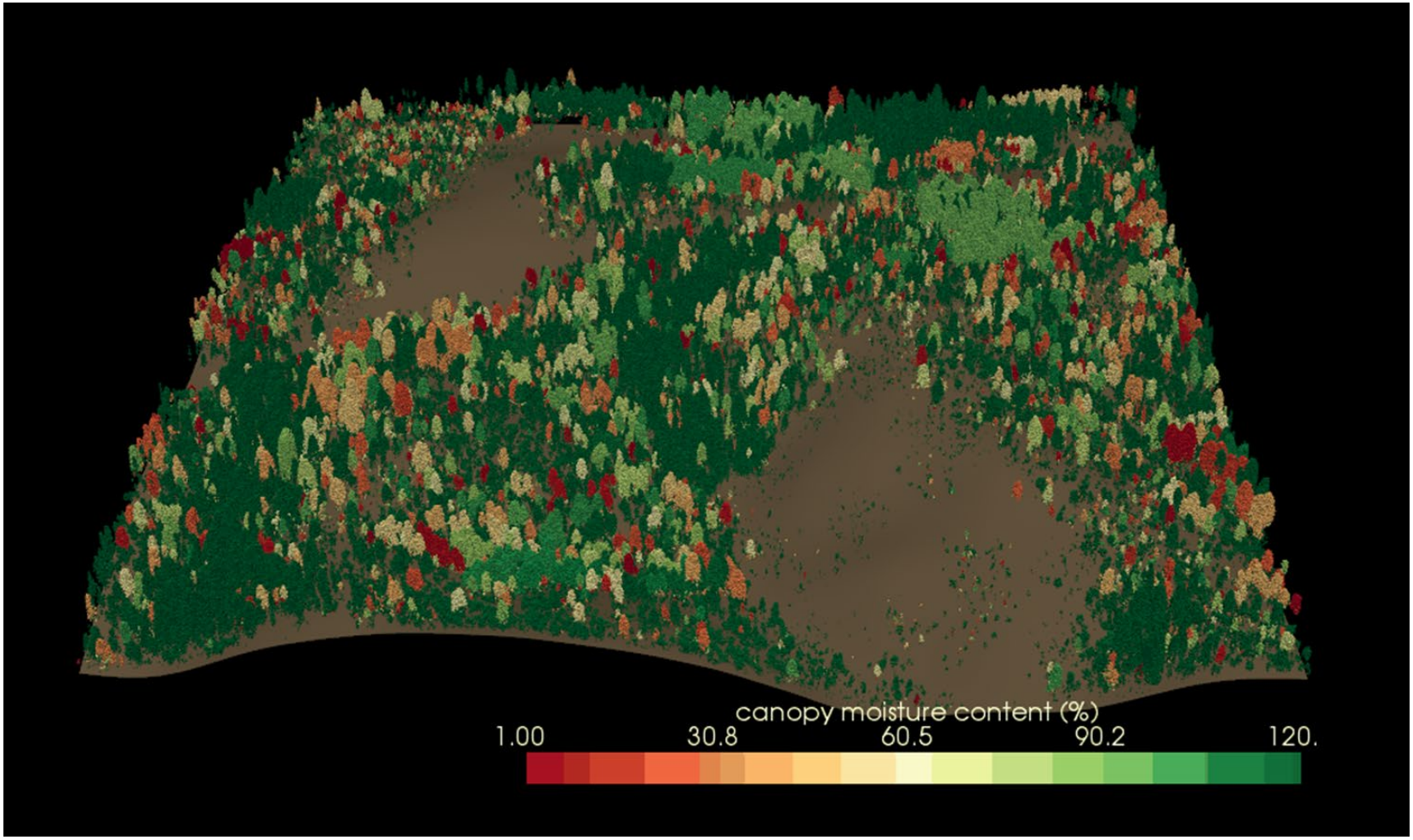
Fire-Adapted Pine Forests

Landscape 3D Fuels Datasets

- FASTFUELS
  - 6 x 6 km tiles
  - Provides input data for physics-based fire and smoke models
  - 1 m^3 voxels with attributes
  - Allows multiple data sources

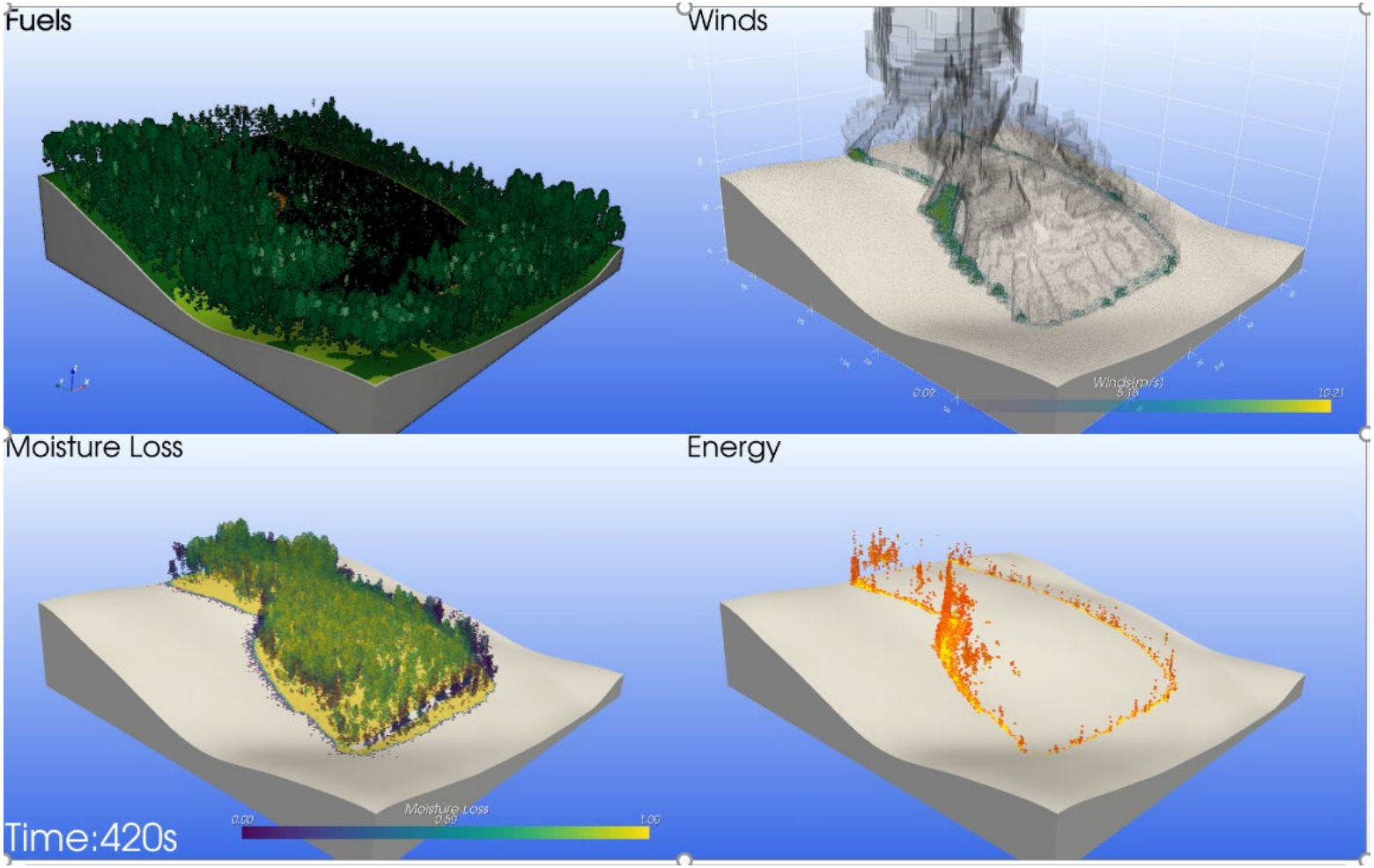


Surface Fuels and Fire Behavior Modeling



Sample Fire Behavior Simulations

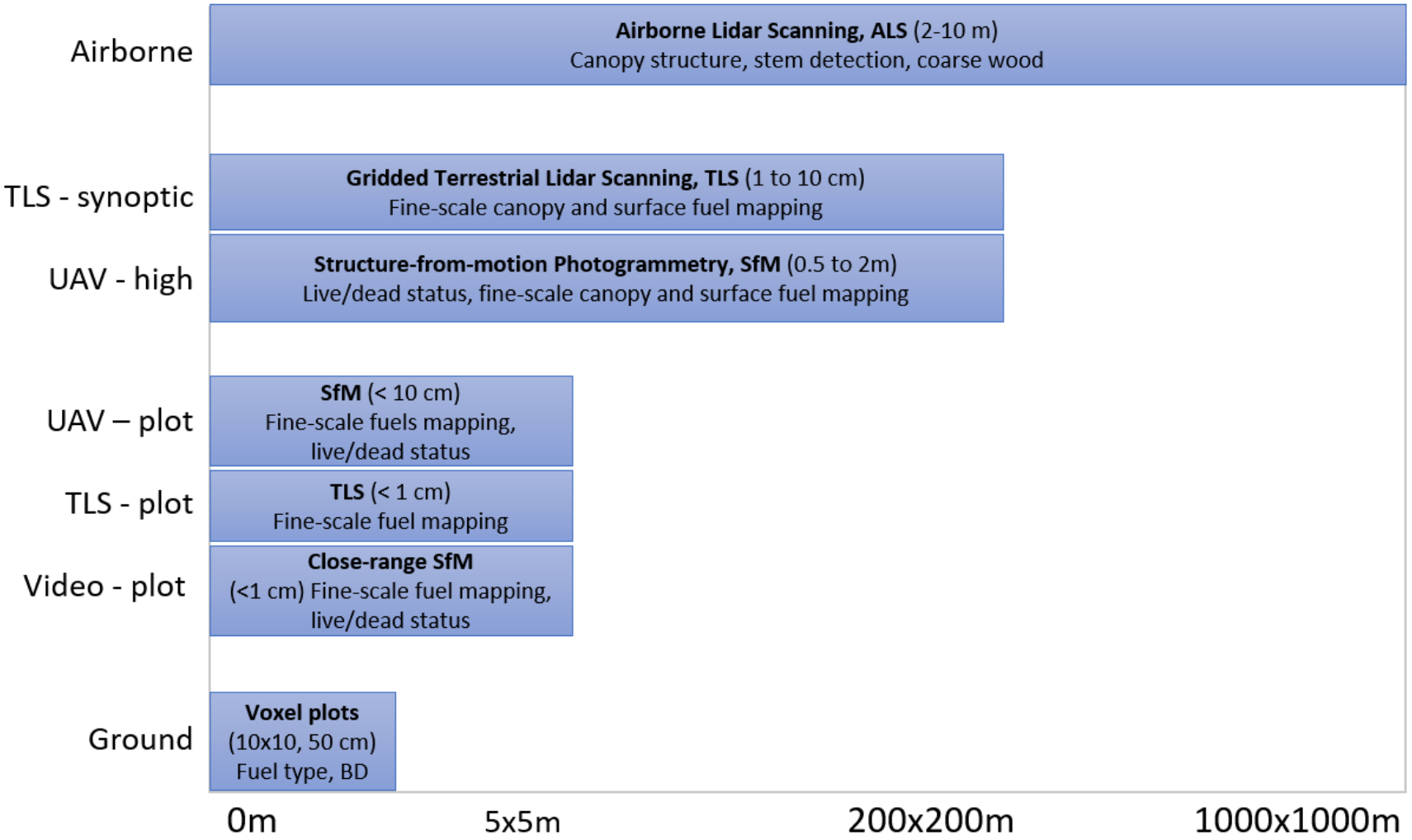
QUIC-Fire Simulations



3D Fuels Project – Overview

- Evaluate hierarchical sampling methods for 3D fuel characterization
  - Required for next-generation physics-based models of fire behavior and smoke production
- Research objectives
  - Develop building blocks for next-generation fuels mapping of SE pine and western pine/grasslands
  - Create a prototype for understory fuel characterization and mapping applications (FastFuels, FuelsCraft)

Sampling Design



Field Sampling

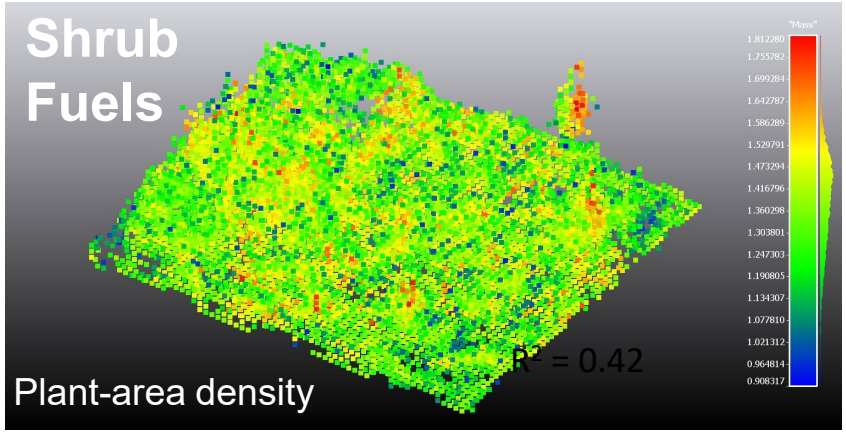
- Hierarchically-sampled imagery datasets
  - Terrestrial lidar scanning (synoptic, 5m x 5m plots)
  - UAS-based structure-from-motion photogrammetry
  - Close-range photogrammetry (hand-held video)
  - Destructive 3D volumetric biomass plots

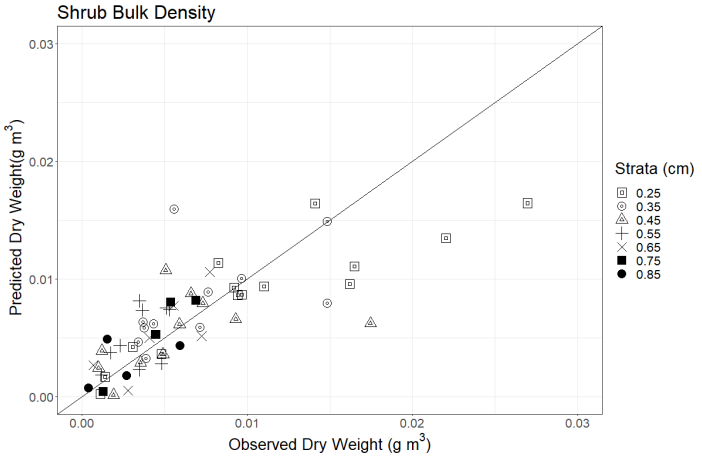
SE Flatwoods

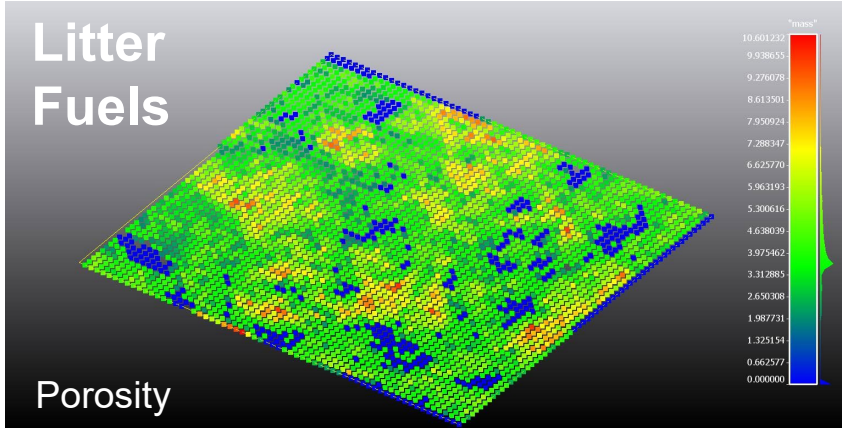
Osceola NF, FL	Tate's Hell A, F	Tate's Hell B, FL	Aucilla, FL
			
1-yr rough	2-yr rough	3-yr rough	>4-yr rough

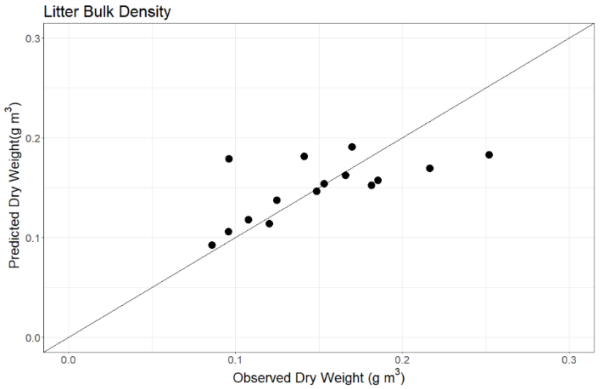
Note: UAS = Unmanned Aerial System

Terrestrial Lidar Scanning Models



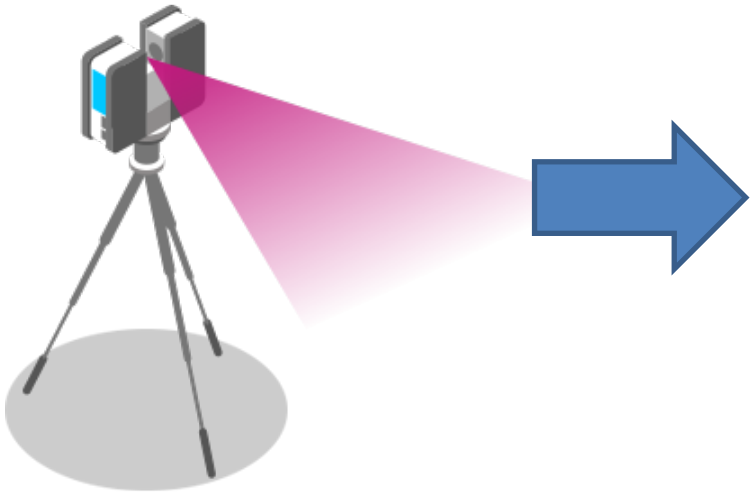




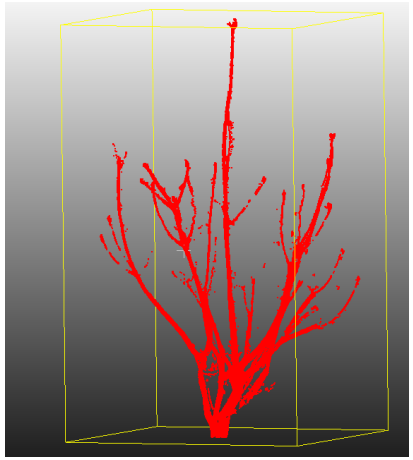


Quantitative Structural Models (QSM)

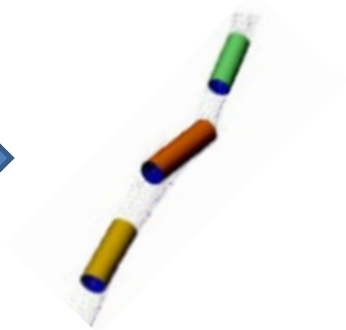
TLS Scan



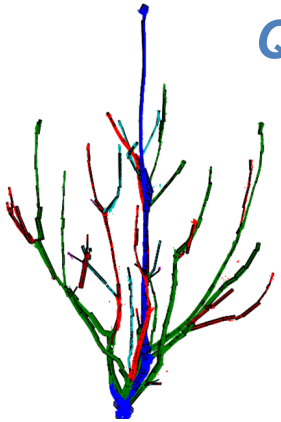
TLS Point Cloud



Cylinder Fitting



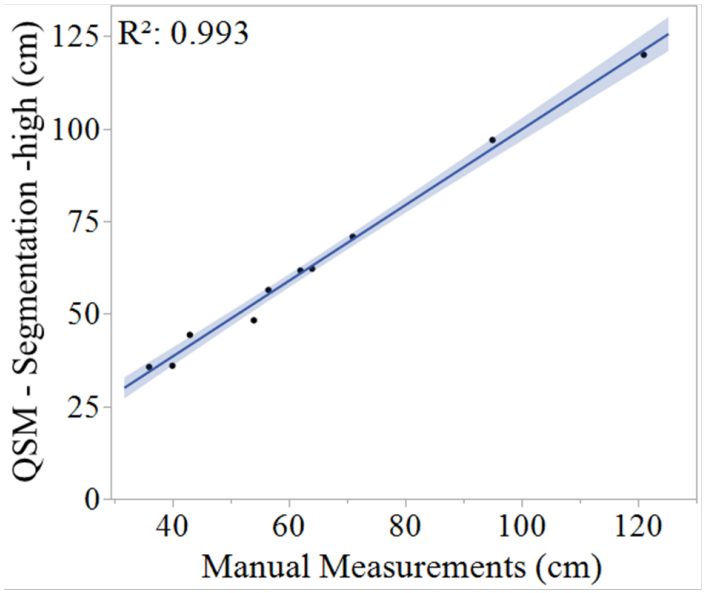
QSM Model

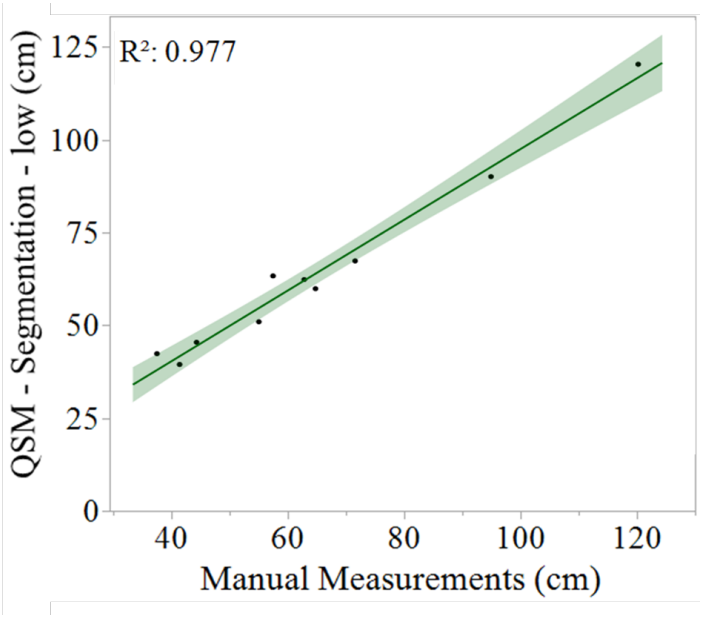


Note: TLS = Terrestrial Lidar Scanning

QSM Models

- Based on 10 architecturally different shrubs
- Evaluated heights, branch detection, branching orders, diameters, and lengths

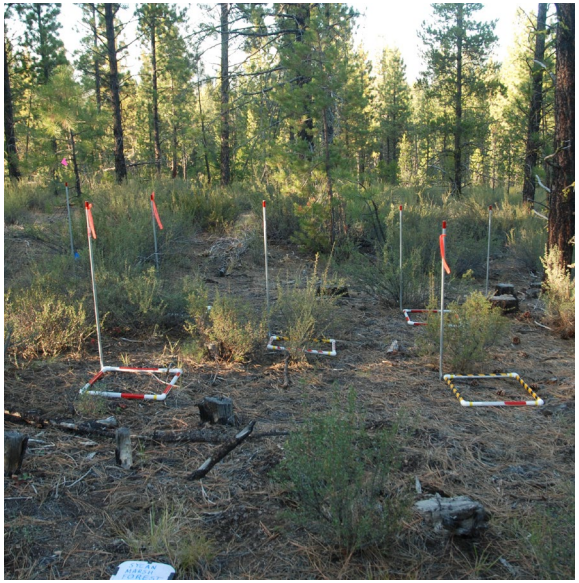




Close-Range Photogrammetry

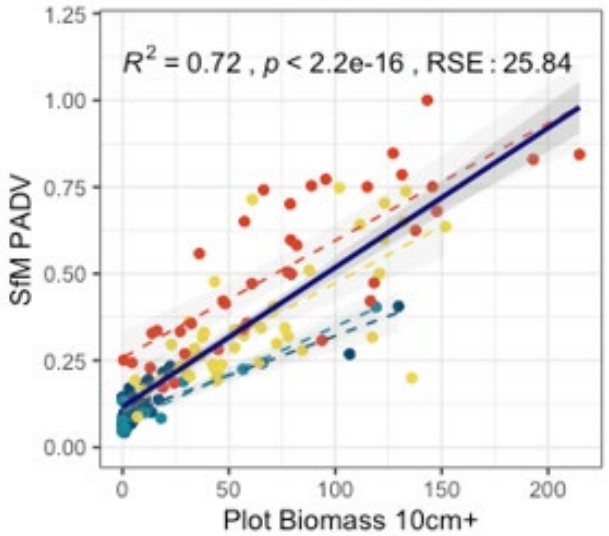
- GoPro-derived photogrammetry
  - Alternative to terrestrial lidar scanning for characterizing understory fuels?

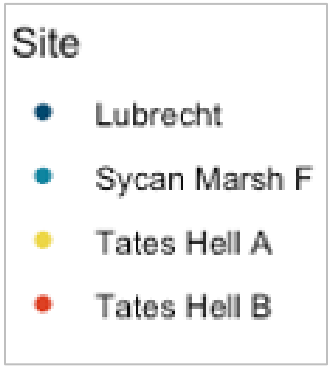
Sampling plot

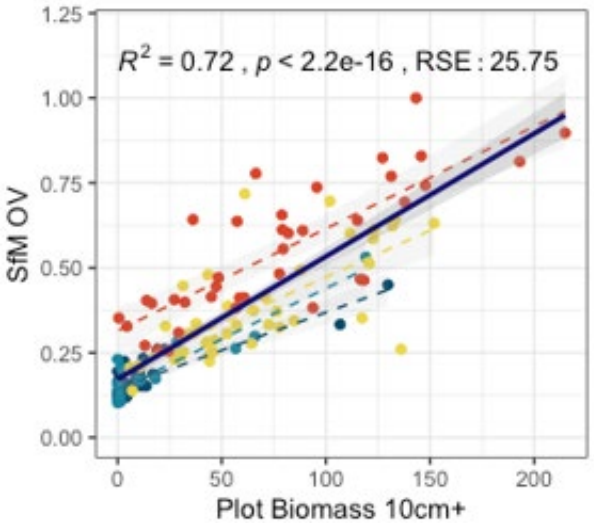


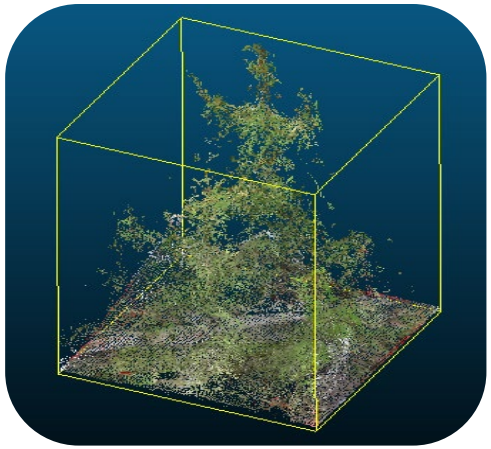
Photogrammetry

Photogrammetry Models







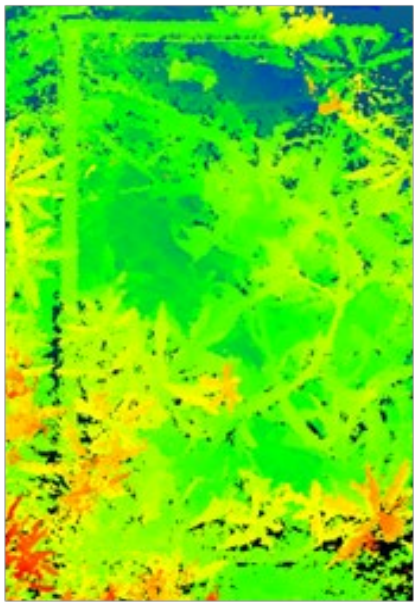


Object-Based Fuel Characterization

Ortho Photo

RGB Point Cloud

Height

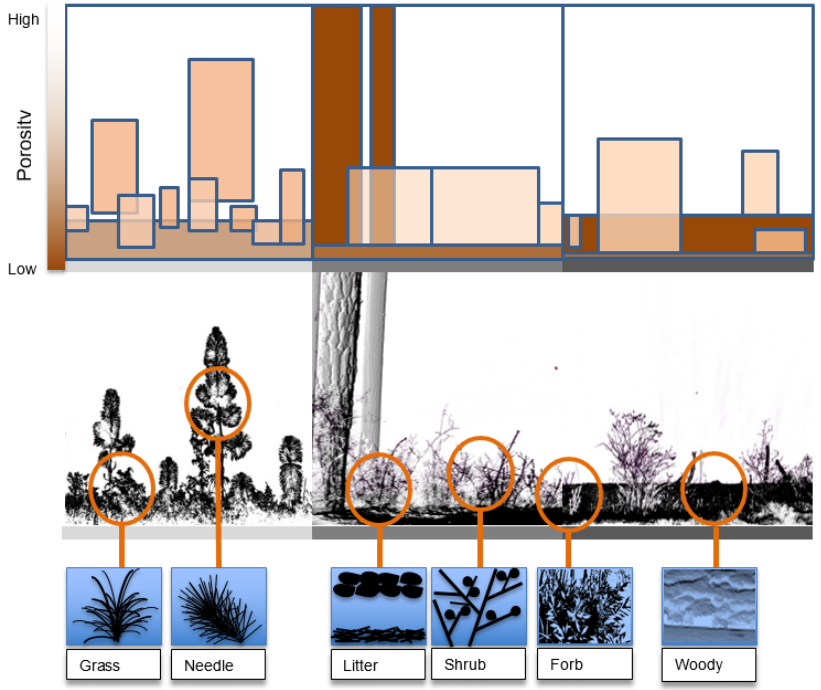


Live/Dead Classification

Fuel Metrics

Canopy gaps - lacunarity

Surface fuel porosity



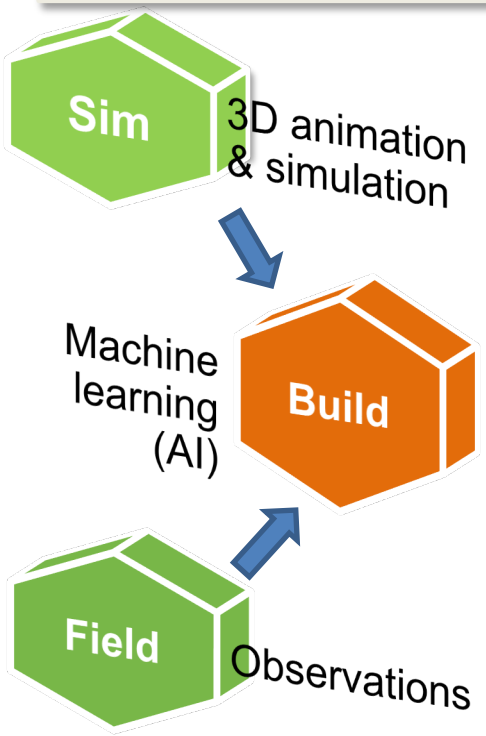
Synthetic Fuelbeds

- Basis
  - Measured probability distributions (cover, height)
  - Representative fuel types

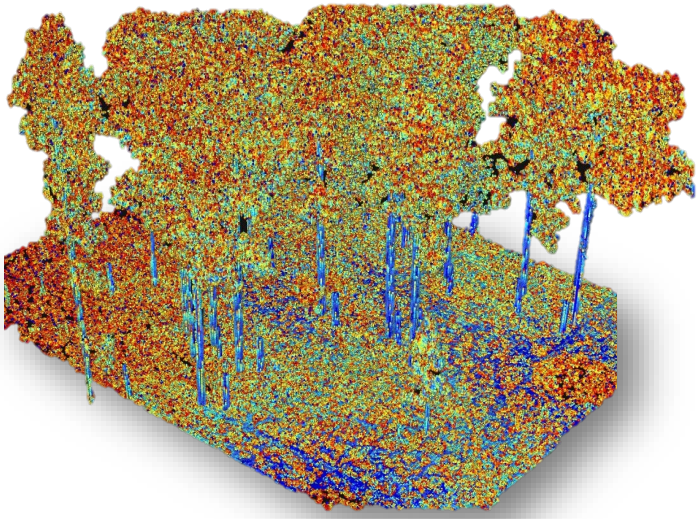
Fuel Mapping

Prescribed Burning Support

FUELSCRAFT



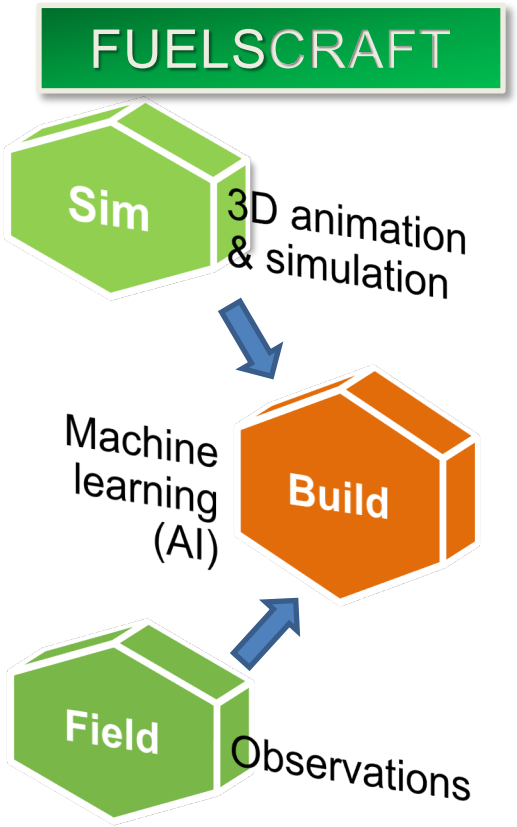
Fire Model Inputs

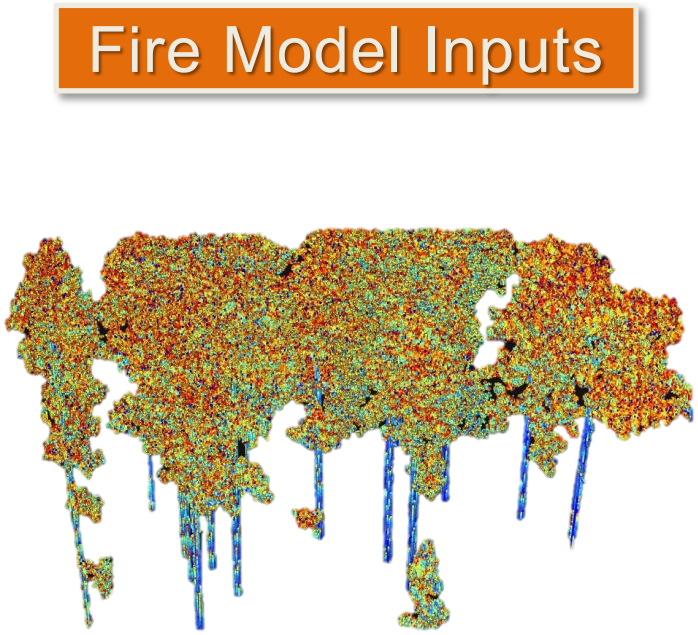


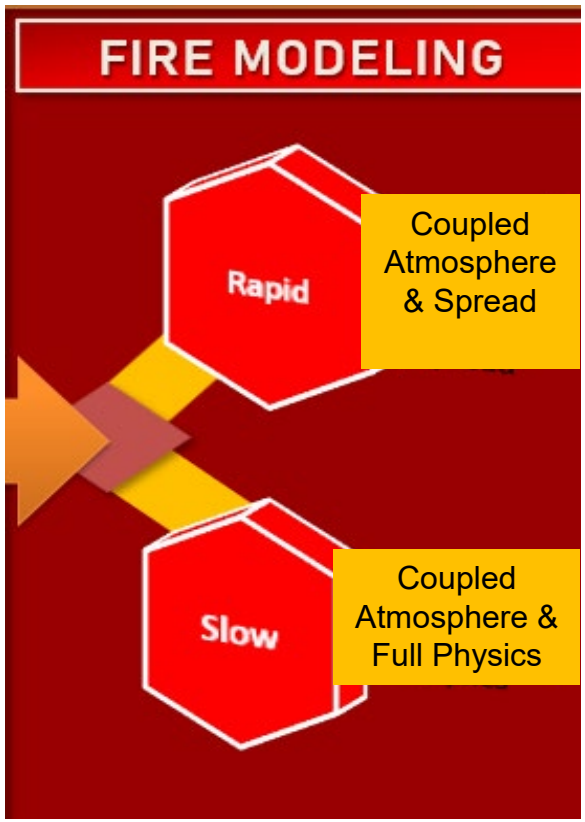
Mapping

Fuel Mapping

Prescribed Burning Support







Test Datasets

Mapping and Machine Learning

SE Forest				
Aucilla	**Blackwater**	**Osceola**	**Tate's Hell A**	**Tate's Hell B**
Suwannee River Water Mgmt District, FL	Blackwater State Forest, FL	Osceola National Forest, FL	Tate's Hell State Forest, FL	Tate's Hell State Forest, FL
>5 year rough	2 year rough	1-2 year rough	1-2 year rough	2-3 year rough
Mesic flatwood - developed flatwood	Mesic flatwood - open w/ wiregrass/flatwood	LLP flatwood	Slash pine plantation - flatwood understory	Slash pine plantation - flatwood understory

Western Forest			
LANL Forest	**Lubrecht**	**Methow**	**Sycan Forest**
Los Alamos National Laboratory, NM	Lubrecht Experimental Forest, MT	Methow Wildlife Area, WA	Sycan Marsh Preserve, OR
Moderate shrub	Low shrub / high duff	Moderate shrub	Low shrub / sparse
Ponderosa pine - gambel oak	Ponderosa pine - Douglas-fir - low shrub	Ponderosa pine - bitterbrush	Ponderosa pine bitter brush

Conclusions

- Fire and smoke modeling are quickly advancing
- Next-generation models require 3D inputs
- Although airborne lidar is making canopy fuel characterization easier, surface fuels are challenging
- Critical advancements to prescribed fire science and management

Benefits to DoD

- Prescribed burning is a common management tool on DoD lands in the southeastern U.S.
- This project advances prescribed fire science and contributes to improved fuel mapping and fire behavior modeling for decision support
- Improved fuel characterization and fire modeling can inform safer and more effective windows for prescribed burning
- Next-generation fuel maps also improve smoke prediction capabilities

Acknowledgements

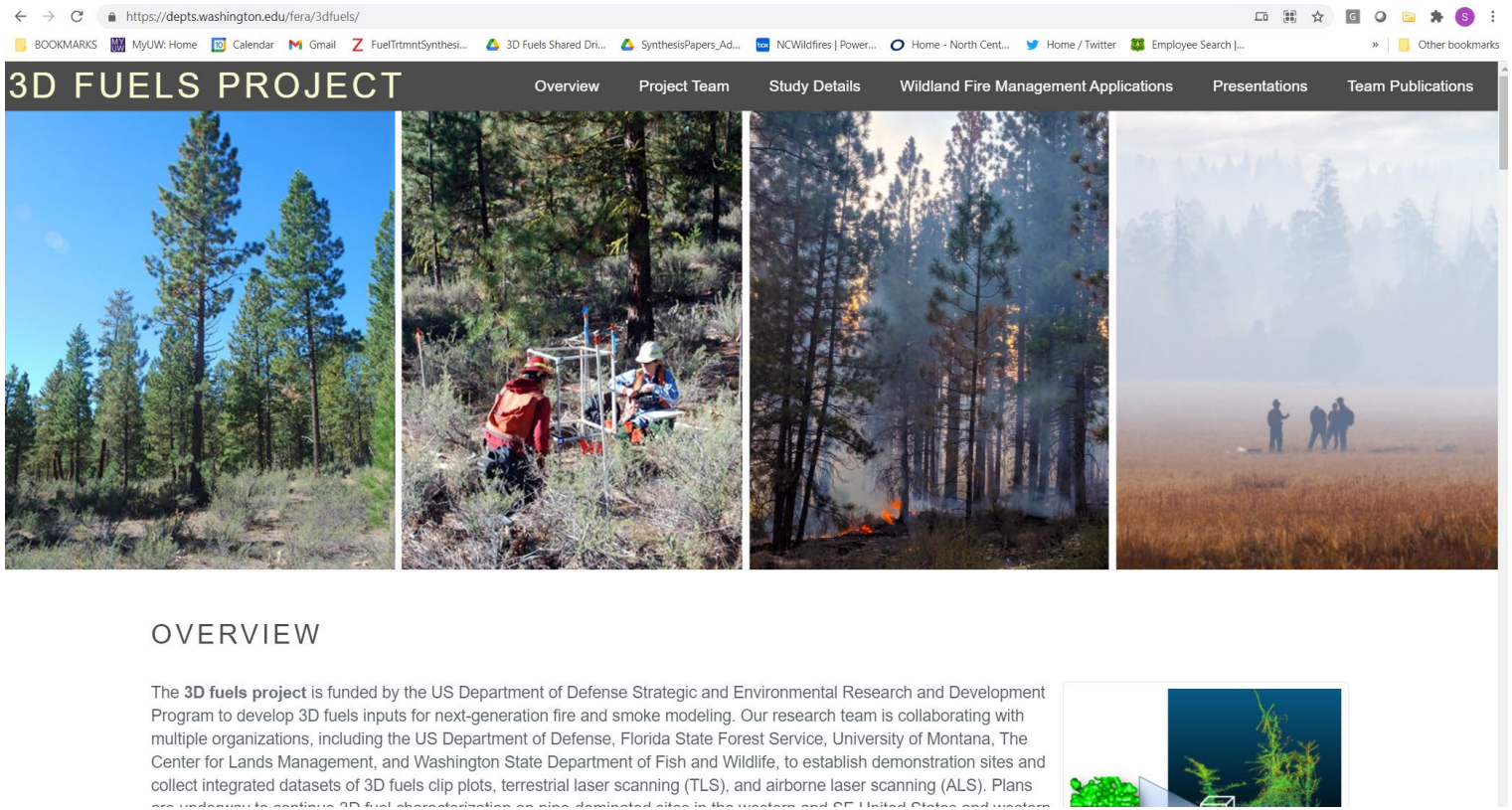
- Dr. Eric Rowell
  - Tall Timbers Research Station
  - Specialist in 3D fuel characterization and modeling
- Jim Cronan
  - USFS PNW Research Station
  - Fire and fuels specialist, field supervisor
- Dr. Andrew Hudak
  - USFS Rocky Mountain Research Station
  - Object-based fuel characterization
- Mr. Ben Bright
  - USFS Rocky Mountain Research Station
  - Geospatial data manager
- Dr. Adam Watts
  - USFS PNW Research Station
  - Fire and fuels specialist, Federal PI
- Dr. Nick Skowronski
  - USFS Northern Research Station
  - Specialist in 3D fuel characterization and experimental burns
- Dr. Russ Parsons
  - USFS Rocky Mountain Research Station
  - Specialist in 3D fuel modeling
- Dr. Maureen Kennedy
  - University of Washington, Tacoma
  - Quantitative Structural Modeling
- Dr. E. Louise Loudermilk
  - Southern Research Station
  - 3D fuel characterization, fire behavior

Acknowledgements

- Graduate students
  - Jonathan Batchelor
    - University of Washington
    - Ph.D. student – TLS and photogrammetry
  - Michelle Bester
    - West Virginia University
    - Ph.D. student – QSM
  - Gina Cova
    - University of Washington
    - Ph.D. student – close-range photogrammetry

Project Website

https://depts.washington.edu/fera/3dfuels



For additional information, please visit

https://www.serdp-estcp.org/Program-Areas/Resource-Conservation-and-Resiliency/Air-Quality/Fire-Emissions/RC19-1064

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