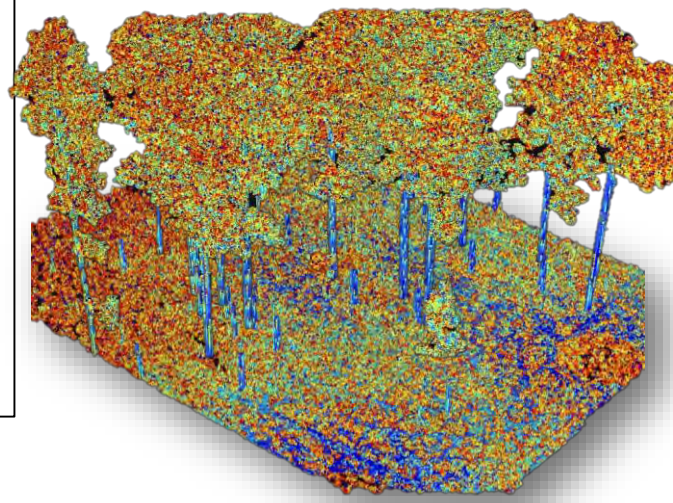
3D fuel characterization for evaluating physics-based fire behavior, fire effects, and smoke models on US Department of Defense military lands (RC19-C1-1064)

Susan Prichard (University of Washington)

Objectives

- *We are using a combination of remotely sensed imagery and field sampling to develop 3D fuel characterization required for next-generation physics-based models of fire behavior and smoke production.*
- *We are focused on forest and grassland types that are commonly burned on US Department of Defense and Department of Energy sites.*



Project Team

Susan Prichard (project lead)
Roger Ottmar (federal PI)
Christie Hawley (collaborator)
Andrew Hudak (coPI)
Louise Loudermilk (collaborator)
Maureen Kennedy (coPI)
Russ Parsons (coPI)
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Gina Cova (Ms student)

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Technical Approach

To date, we have sampled 8 of 16 planned sites.

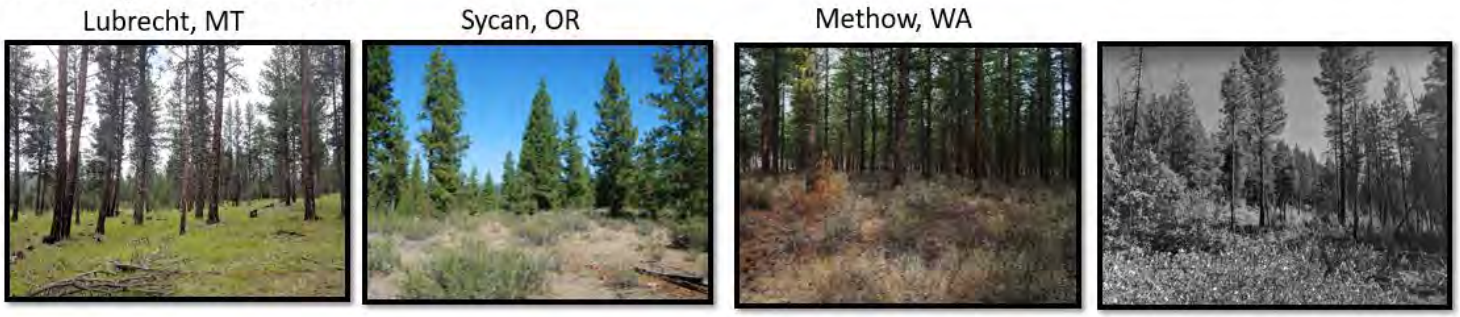
At each site, we collect hierarchically-sampled imagery datasets including:

- 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 are sampled following site scanning.

SE pine flatwoods

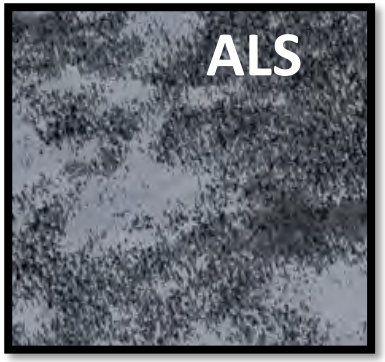
Western ponderosa pine



Representative photos of SE pine and western pine sites. Color photos are sites that have been sampled. Black and white photos are placeholders for sites yet to be sampled.

Hierarchical Sampling Design

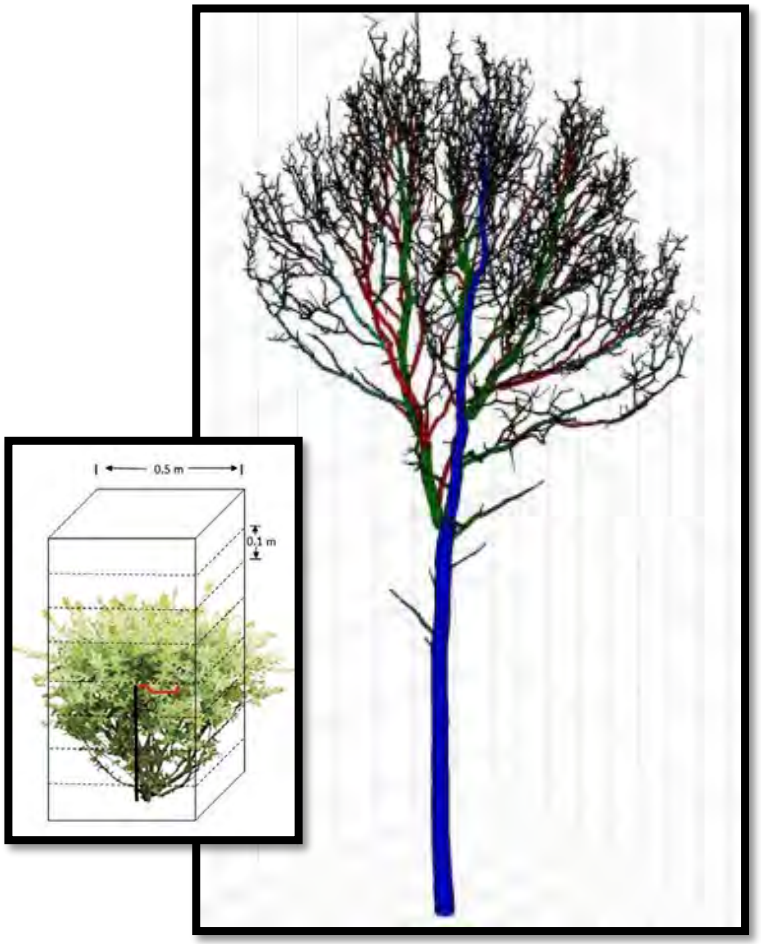
- Synoptic ALS, TLS and photogrammetry (200 x 200 m)
- Plot-based TLS & low-altitude SfM photogrammetry (5 x 5 m)
- Close-range photogrammetry with GoPro video. (5 x 5 m)
- Volumetric field sampling (0.5 x 0.5 m) to calibrate imagery with known fuel typing and bulk density measurements.



Object Based Fuel Characterization

Our research team is developing ways to interpret 3D point cloud imagery. Approaches include:

- Classification of live vs dead fuels
- Fuel typing (shrub, grass, coarse wood, litter)
- Building quantitative structural models of shrubs (emphasis on common shrubs in the southeastern US)
  - Volume (cm^3)
  - Crown density, porosity
  - Crown distribution
  - Surface-area-to-volume ratios – ignitability and combustibility



Results to Date

1) Completed work plan and launched project website
2) Processed imagery
   - Terrestrial lidar
   - UAS-based SfM photogrammetry
   - Close-range photogrammetry
3) Optimized scripts for point cloud processing.
4) Data analysis:
   - Occupied volume
   - Comparative models of terrestrial lidar-based metrics (e.g., porosity) vs measured bulk density.

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

3D Fuels Work Plan

SERDP Project RC19_C1_1064

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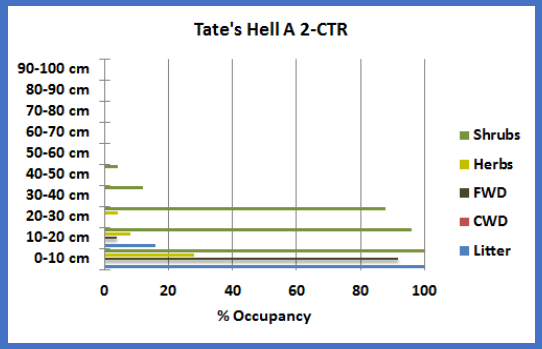
Occupied Volume:



Modeled relationship between TLS-based porosity index and measured biomass (0-10 cm).

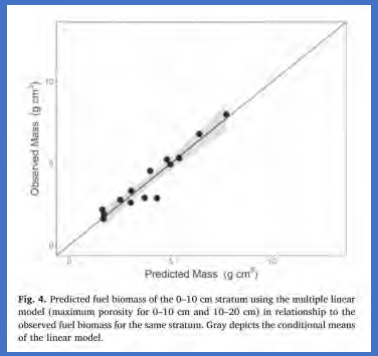


Fig. 4. Predicted fuel biomass of the 0–10 cm stratum using the multiple linear model (maximum porosity for 0–10 cm and 10–20 cm) in relationship to the observed fuel biomass for the same stratum. Gray depicts the conditional means of the linear model.

Lessons Learned and Next Steps

Lessons learned

3D fuel characterization is needed for next-generation models of fire behavior and smoke.

We are building a library of calibrated 3D point clouds that can be used for model evaluation.

Next steps

- Data analyses
  - Calibration of point clouds vs. measured values
  - QSM modeling
  - Object-based fuel characterization
- Landscape metrics and mapping
- Model sensitivity analysis

Recent publications

Rowell et al. (2020)
https://doi.org/10.1016/j.foreco.2020.117945
Hudak et al. (2020)
https://doi.org/10.1093/forsci/fxz085

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