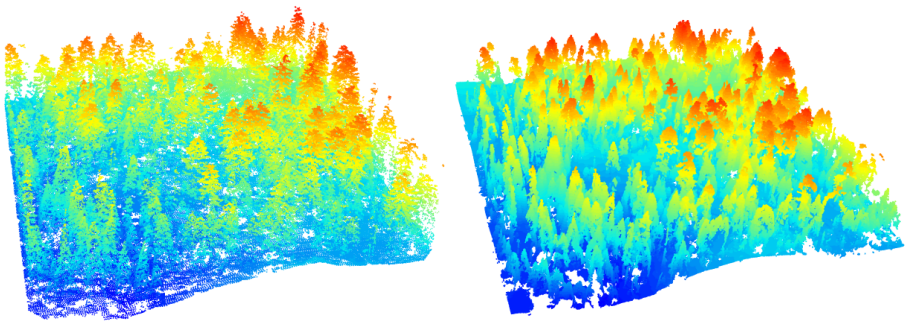
Forest Measurements & Ecology Lab



Example of lidar (left) and UAS 3D DAP (right) point clouds for a old-growth mixed-conifer forest at the Teakettle Experimental Forest in Fresno County, California.

UAS DAP for Small Area Forest Inventory and Monitoring

Light Detection and Ranging (lidar) is the standard method remotely sensed data for characterizing forest vegetation structure, and when combined with field plot data can be used to accurately estimate and map forest attributes such as biomass. However, lidar can be cost prohibitive for smaller areas such as private non-industrial landowners or repeat measurement. This research assessed the ability of low-cost commercial off the shelf Unpiloted Aerial System (UAS) based three dimensional digital aerial photogrammetry (DAP) and high-precision Geographic Positioning Systems (HPGPS) to create accurate 3D data and predictions of key forest attributes. We compared UAS DAP digital surface models and regression predictions of key forest attributes to lidar and field plot data, across a wide range of forest types and structural conditions in California, USA. Additionally we assessed surface model and forest attribute prediction accuracy for UAS DAP collected straight down (nadir), 35 degrees off-nadir (angled), and multi-angled (nadir and angled combined). Digital terrain models derived from UAS DAP were comparable to lidar across sites, although model accuracy was low in mature Douglas-fir forests. UAS DAP model predictions of key forest attributes were comparable to field plot data and lidar based predictors. Off-nadir imagery did not greatly improve digital surface models, but had lower accuracy surface models in tall dense forest forests. UAS DAP models combined with low-cost HPGPS can accurately generate digital surface models and forest attribute predictions across a range of forest types and structural conditions across California. However, UAS DAP surface models and forest attribute predictions were less accurate in tall dense forests

Model Type	AGB		TPH		BAH		QMD		LHT	
	R^2	nRMSD	R^2	nRMSD	R^2	nRMSD	R^2	nRMSD	R^2	nRMSD
Lidar	0.74	0.10	0.68	0.11	0.84	0.10	0.68	0.12	0.75	0.10
Nadir	0.66	0.11	0.53	0.14	0.77	0.12	0.70	0.11	0.70	0.11
Angled	0.69	0.11	0.60	0.13	0.76	0.13	0.67	0.11	0.74	0.10
Multi-angled	0.69	0.10	0.53	0.13	0.77	0.12	0.67	0.12	0.74	0.11

Comparisons of plot-level observed forest metrics of aboveground biomass (AGB), trees per hectare (TPH), basal area per hectare (BAH), quadratic mean diameter (QMD) and lorey's mean height (LHT), to predictions made by lidar and UAS DAP models.

Management Implications

Unpiloted Aerial System based three dimensional digital aerial photogrammetry (UAS DAP) can be used to create digital surface models and estimation of key forest attributes that are comparable to lidar and field data.

UAS DAP surface models and forest attribute predictions have lower accuracy in tall dense forests.

The inclusion of off-nadir angled UAS imagery did not significantly improve UAS DAP accuracy.

In combination, UAS DAP and High Precision Global Positioning Systems (HPGPS) can be a cost-effective solution for small forestland owners who want detailed remote sensing data to support forest inventory and monitoring.

Publications:

Lamping, J.; Zald, H.; Graham, J.; Madurapperuma, B.; Comparison of Low-Cost Commercial Unpiloted Digital Aerial Photogrammetry to Airborne Laser Scanning Across Multiple Forest Types in California. *In prep.* To be submitted to *Remote Sensing*

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