

Forest canopy structure characterization using high-density UAV LiDAR

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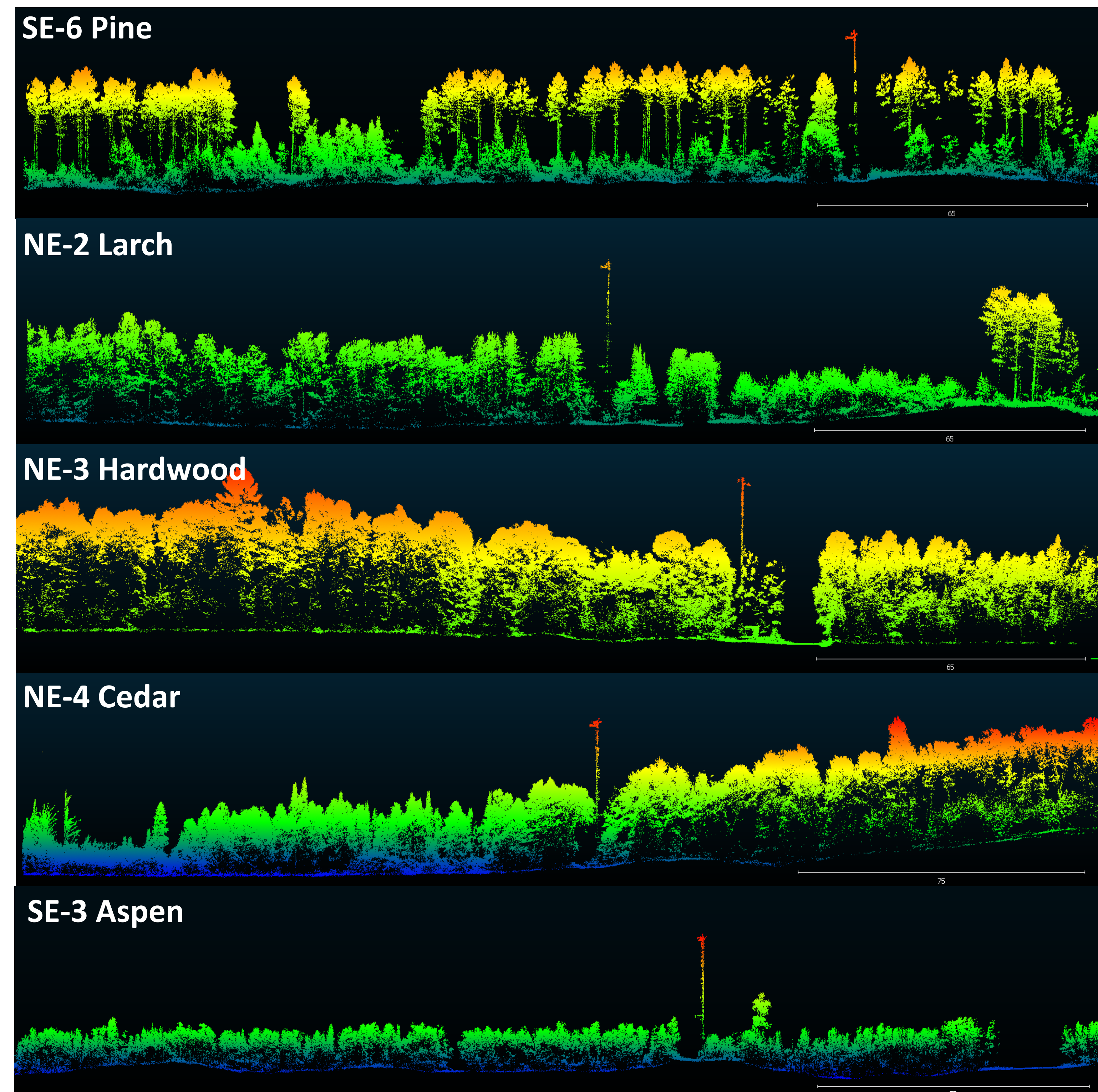


Abstract

Representation of the type, shape and composition of the canopy is a key component for estimation and modeling of forest land-atmosphere water and carbon budgets. The ability to gather multi-return LiDAR data allows the full detection of the forest structure from the top of the canopy to the understory vegetation. **This study employed a UAS LiDAR system to acquire high density point cloud data of the dominant forest tree species in Northern Wisconsin.** UAV-based LiDAR data was collected with a hexacopter equipped with a Routines LidarPod LiDAR system that includes a 32-laser head Velodyne LiDAR with a GNSS RTK system. Point cloud density averaged 600 points per meter squared with a vertical accuracy of 2-5cm. In coordination with the NSF-funded CHEESEHEAD project, surveys were conducted within footprints of 11 flux towers and areas surveyed ranged between 0.25-1 squared km per site. We targeted 6 forest types including Aspen, Pine, Poplar, Larch, Cedar, Aspen and Hardwood and described their main canopy structure attributes. This study represents the first effort to characterize the forest canopy structure by tree type in Northern Wisconsin employing UAV LiDAR data. In addition, this study serves as a key baseline dataset for up-scaling ecosystem structure and modeling land-atmosphere gas interactions at a regional level.

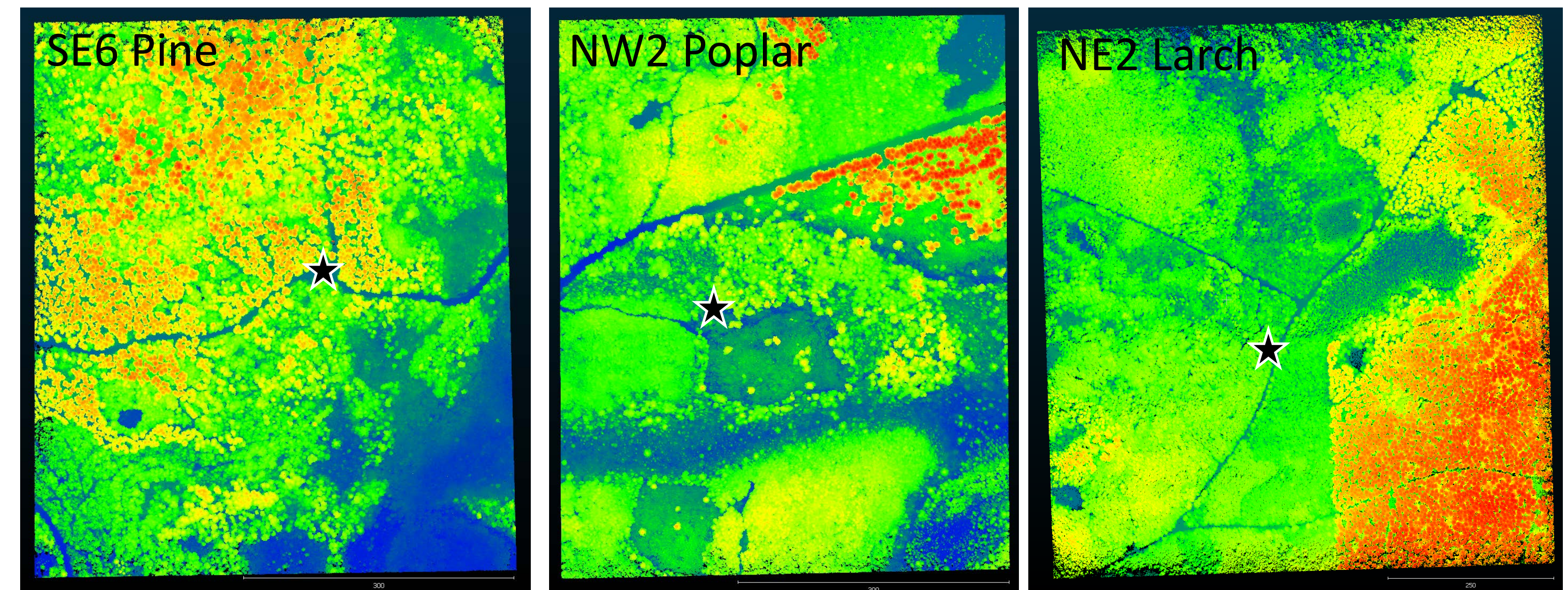
Study site & UAS deployment:

The UAS LiDAR and photogrammetry system was deployed in June 25-29, 2019, within the footprint of CHESSEHEAD site flux towers in Price County, WI. (Fig. 1). We used an hexacopter M600Pro from DJI shown below equipped with a Routines LidarPod.

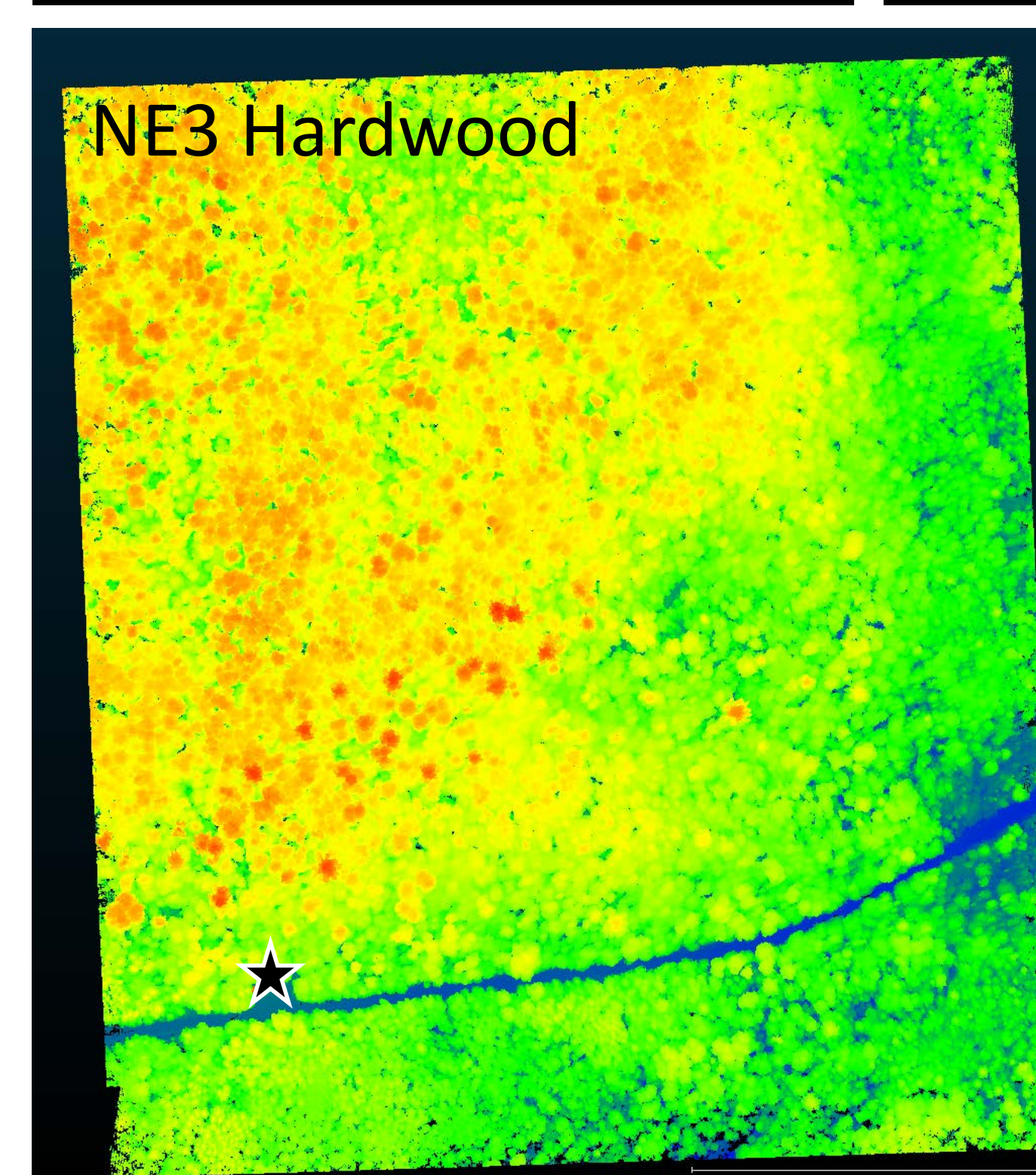


Survey:

UAS Lidar surveys were conducted within footprints of 11 flux towers and surveyed areas ranged between 0.25 to 1 squared km per site (see table below). We targeted 6 forest types including Aspen, Pine, Poplar, Larch, Cedar, Aspen and Hardwood. This study represents the first effort to characterize the forest canopy structure in Northern Wisconsin employing UAV LiDAR data.



| Site | Canopy Type | LiDAR Footprint | Canopy plots |
|---------------|----------------------|---------------------------|-----------------|
| NE-2 | Larch | 0.5 km ² | 4 |
| NE-3 | Hardwood | 0.25 km ² | 1 |
| NE-4 | Cedar | 0.25 km ² | 2 |
| SE-3 | Aspen | 1.0 km ² | 2 |
| SE-4 | Tussock | 0.1 km ² | n/a |
| SE-5 | Aspen | 0.25km ² | 2 |
| SE-6 | Pine | 0.25 km ² | 3 |
| SW-2 | Poplar | 0.25 km ² | 1 |
| SW-4 | Hardwood | 0.25 km ² | 2 |
| NW-2 | Poplar | 1.0 km ² | 1 |
| NW-5 | Grass | 0.1 km ² | n/a |
| Total: | 11 flux sites | 4.2 km² | 18 plots |



UAS Airframe: Vulcan Raven X8 Heavy-Lift

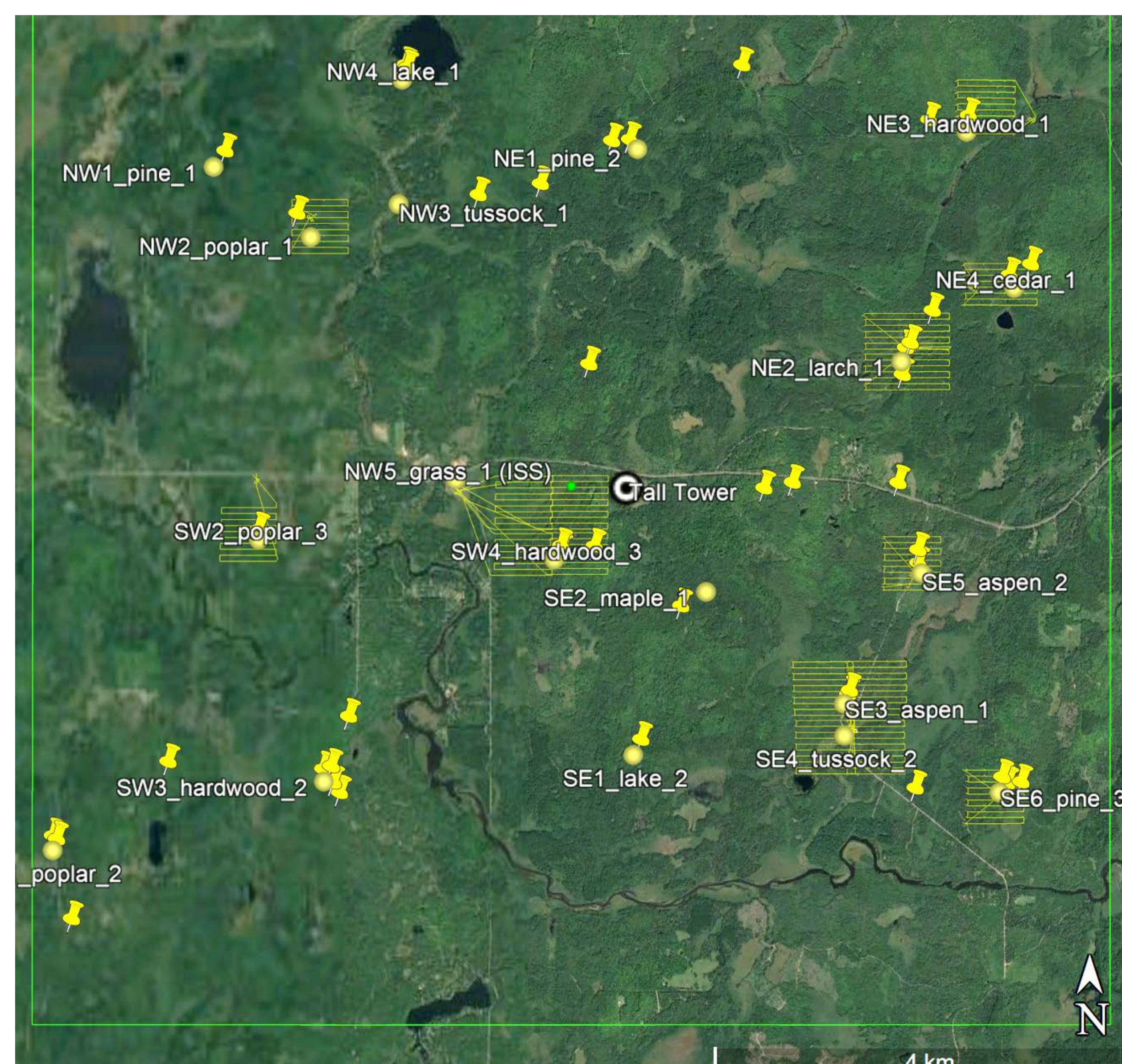
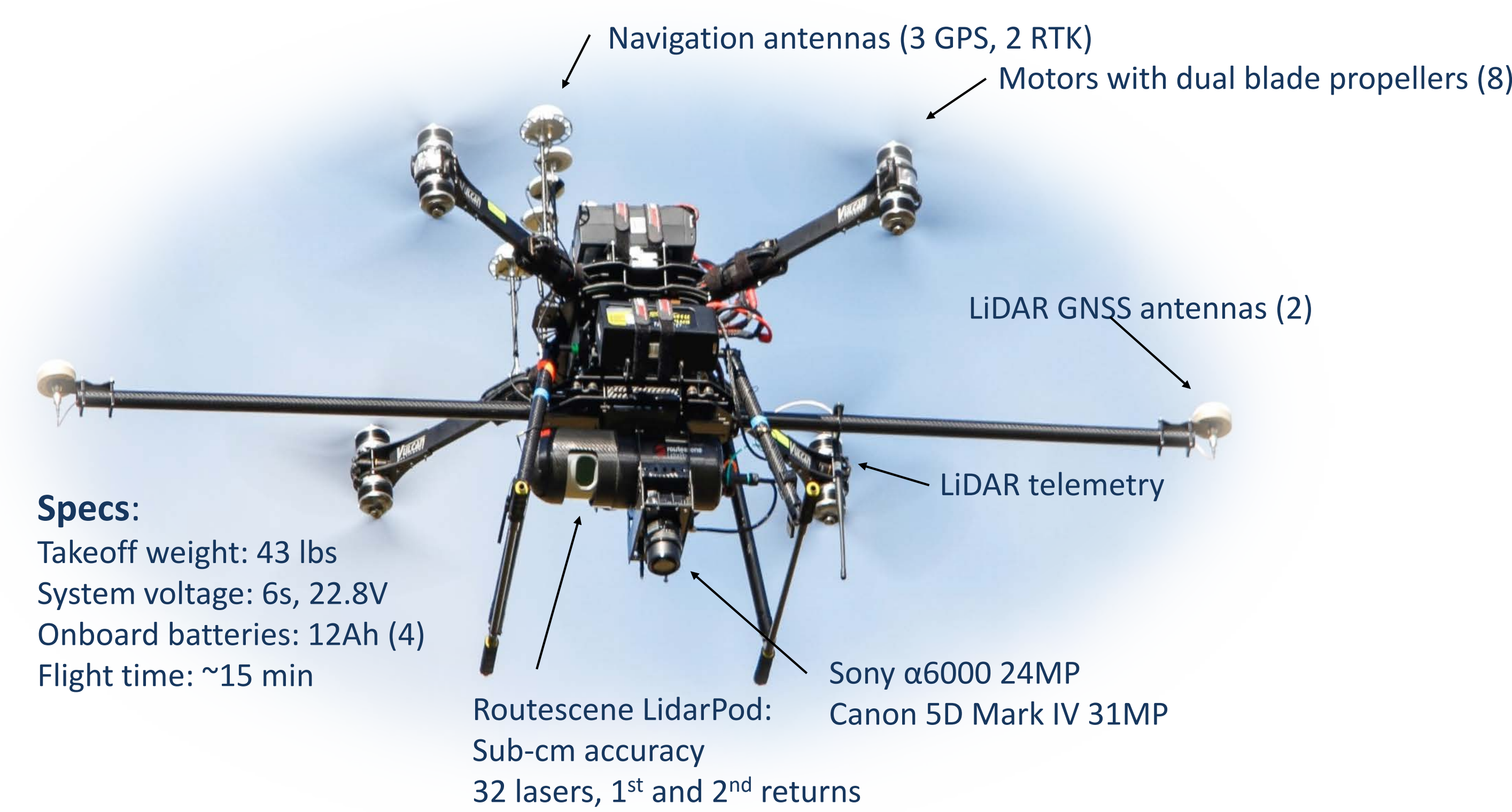
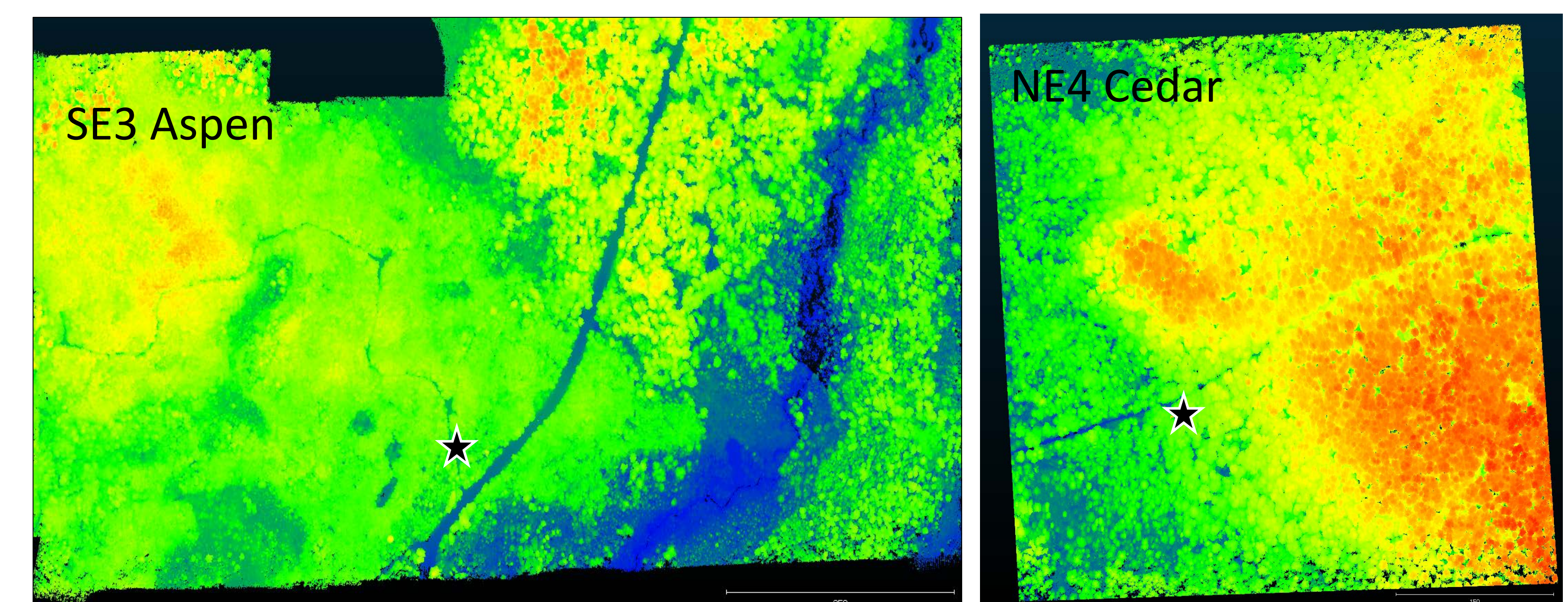
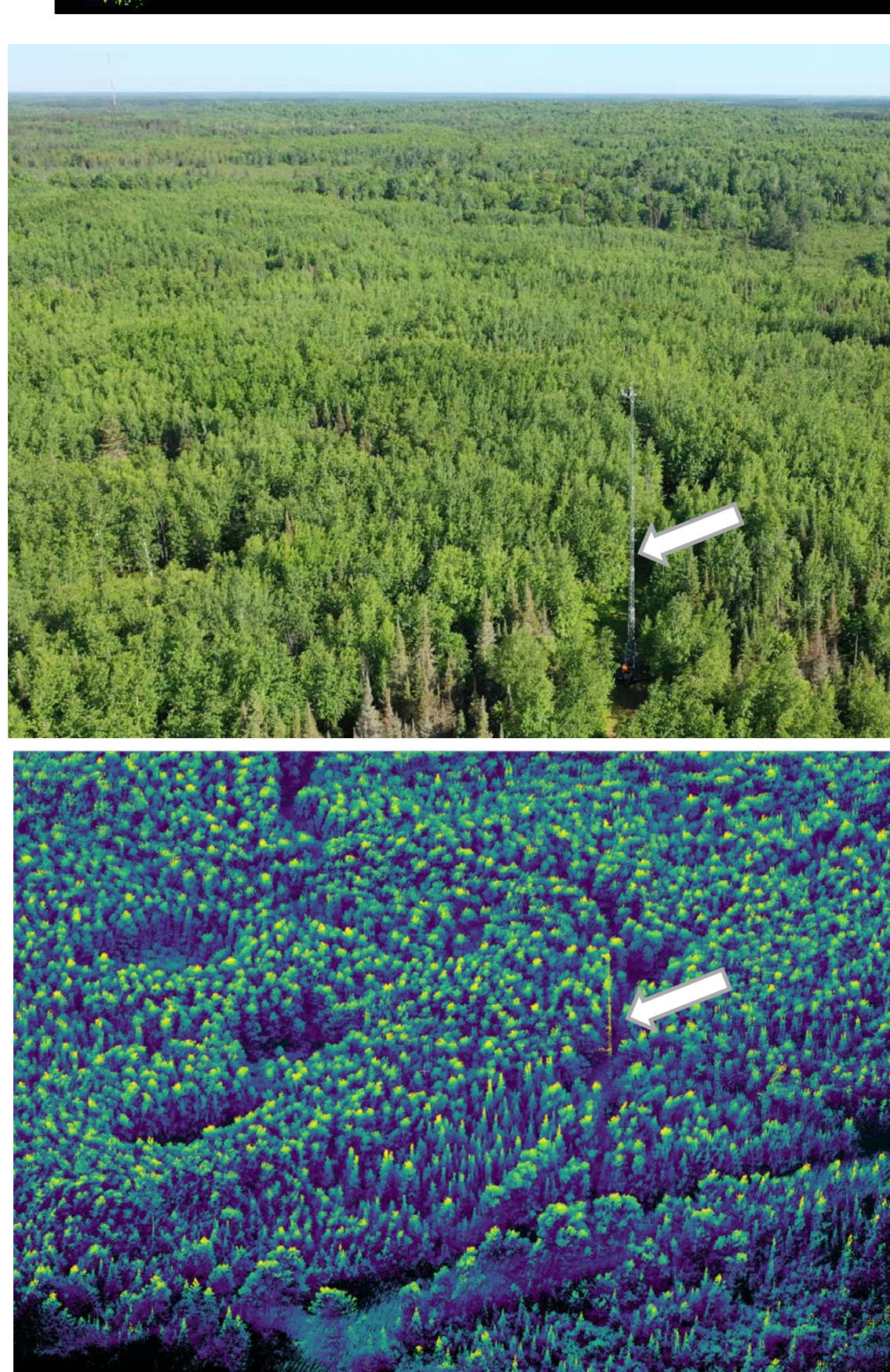


Fig 1. UAS LiDAR footprints (yellow lines) in the CHESSEHEAD study area (Green box). Flux tower sites (circles) and field canopy plots (pins).

Project overview: Structure characterization of the forest canopy represents a keystone dataset to better understand forest function. This survey is nested in the CHESSEHEAD project: The Chequamegon Heterogeneous Ecosystem Energy-balance Study Enabled by a High-density Extensive Array of Detectors (CHEESEHEAD) is a high-density observing network coupled to large-eddy simulation experiments to advance spatiotemporal scaling methods for heterogeneous land surface properties and fluxes, evaluate realistic large eddy simulations in complex landscapes, and test theories on the scales at which the lower atmosphere responds to surface heterogeneity.



Above: UAS LiDAR pointclouds of different sites and canopy types colored by elevation (blue=lower, red =higher). Star indicates flux tower.



Aerial view (top) and pointcloud view colored by height (bottom) of site SE-3 dominated by Aspen. Arrow indicates flux tower

Future plans:

- Extrapolate LiDAR data and associated ecosystem structure and function to the regional scale using airborne LiDAR data by DNR.
- Integrate airborne hyperspectral imagery for cover classification and derivation of main structural patterns for tree species.
- Develop a fine-scale classification of LiDAR pointclouds by tree species based on structural patterns.