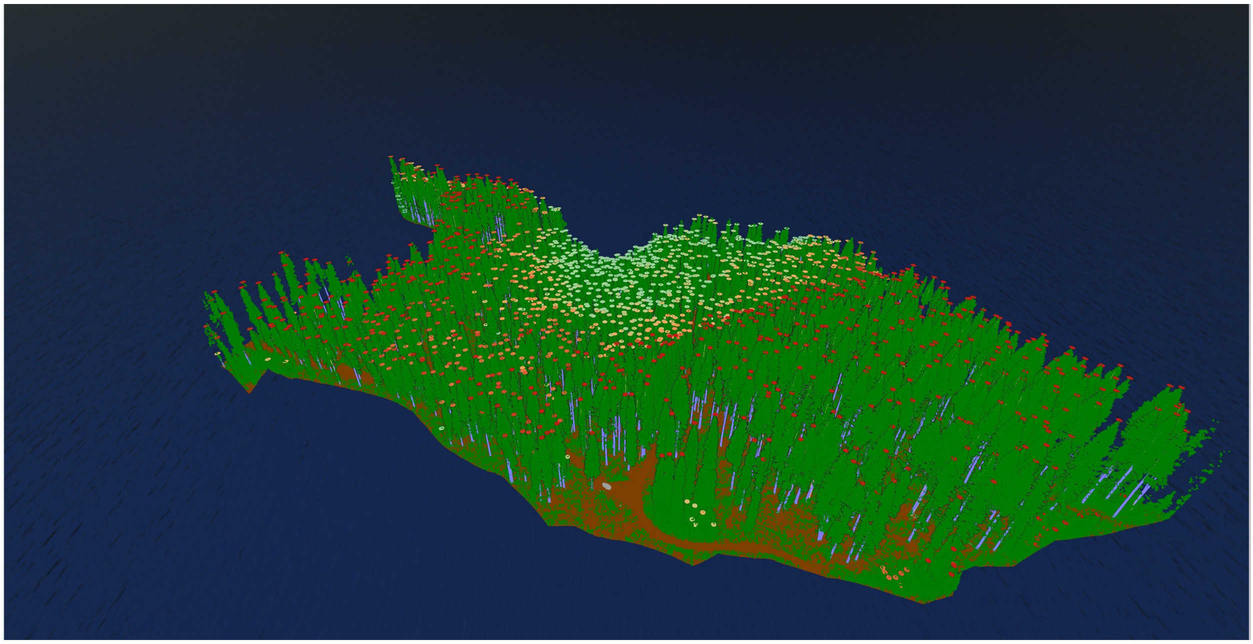
Agcopter LLC Tree-Level Timber Inventory from Aerial LiDAR

70 Acre Pilot Results



70 Acres: every stem detected, filtered, classified by DBH, and placed in 3D over the canopy. 2,102 trees on 70.7 acres.

Summary

This report presents the results of a wall-to-wall stem-level timber inventory of a thinned 70 Acre stand, produced from a set of aerial-LiDAR drone flights by AgCopter.

Metric	70 Acre Stand
Stand area	70.7 acres (28.6 ha)
Trees inventoried (≥ 8.3" DBH, ≥ 33 ft tall)	2,102 stems
Stocking	30 stems/ac
Total basal area	6,053 ft²
Per-acre basal area	85.6 ft²/ac
Mean DBH	20.7"
Stems ≥ 31" DBH (peeler class)	296 stems (40% of basal area)

Each tree in the inventory carries an individual GPS location, measured DBH, total height, and product-class assignment. The point cloud can be delivered with the report, so any tree can be inspected and verified independently. The same flight also produces a canopy height model, bare-earth digital terrain model, drainage network, and photographic 3D scene of the stand — useful for harvest planning, road and skid-trail layout, and riparian buffer compliance.

What deliverables are possible per stand

A deliverables package for one stand, produced from a set of drone flights, can include:

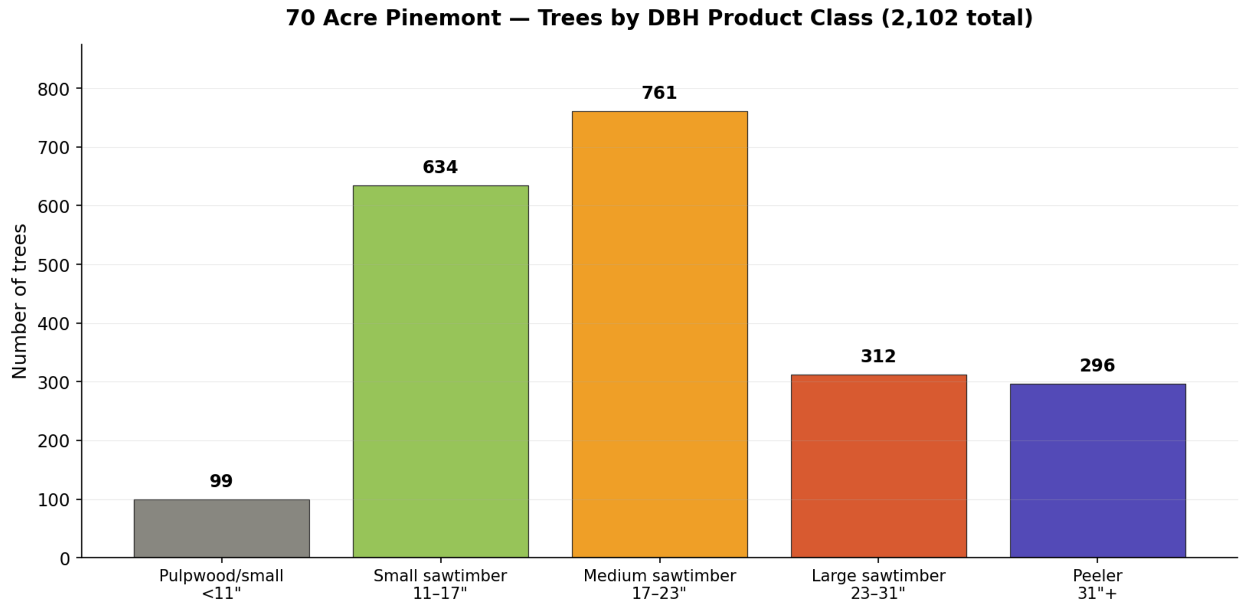
Deliverable	Form	Use
Stand-level rollups	PDF report + spreadsheet	Cruise summaries, sale prep
Per-tree inventory table	CSV / shapefile / KML	Stocking records, GIS, harvest planning
Product-class and height-class charts	Embedded + image files	Visual reporting
DBH × height stock table	Embedded + spreadsheet	Bucking and sort planning
Basal-area-weighted stock table	Embedded + spreadsheet	Stand valuation, identifying value concentration
Canopy height model (CHM)	Shapefile (per-tree crown polygons)	Crown structure analysis, stocking and spacing
Digital terrain model (bare-earth DTM)	GeoTIFF raster	Roads, skid trails, slope analysis
Digital elevation model (DEM, first return)	GeoTIFF raster	Sun-shade modeling, top-of-canopy reference
Synthetic drainage network	Shapefile	Riparian buffer compliance, road-crossing planning
Photographic 3D scene (Gaussian splat)	Browser-viewable file	Remote site walk-through, no software install
Source point cloud	LAZ	Independent verification of any tree
QC log	PDF	Documentation of any flagged anomalies and resolutions

Per-stem attributes carried in the GIS layers:

- Persistent tree ID (identifiable on any future flight of this stand).
- DBH in cm and inches; circle-fit quality metric.
- Total height in m and ft; crown polygon area; height percentiles P10–P90 within the crown.
- Trunk length, base elevation, and canopy height elevation.
- Trunk lean angle in degrees and lean direction as azimuth.
- Product class assignment and structural-anomaly flag (snag, broken-top, lean, multi-stem).
- Shared-crown count: how many other trees share the same canopy polygon (0 = alone in its crown; ≥1 = co-dominant cluster).
- UTM Zone 10N coordinates or State Plane (sub-foot horizontal precision).

70 Acre Stand — Results

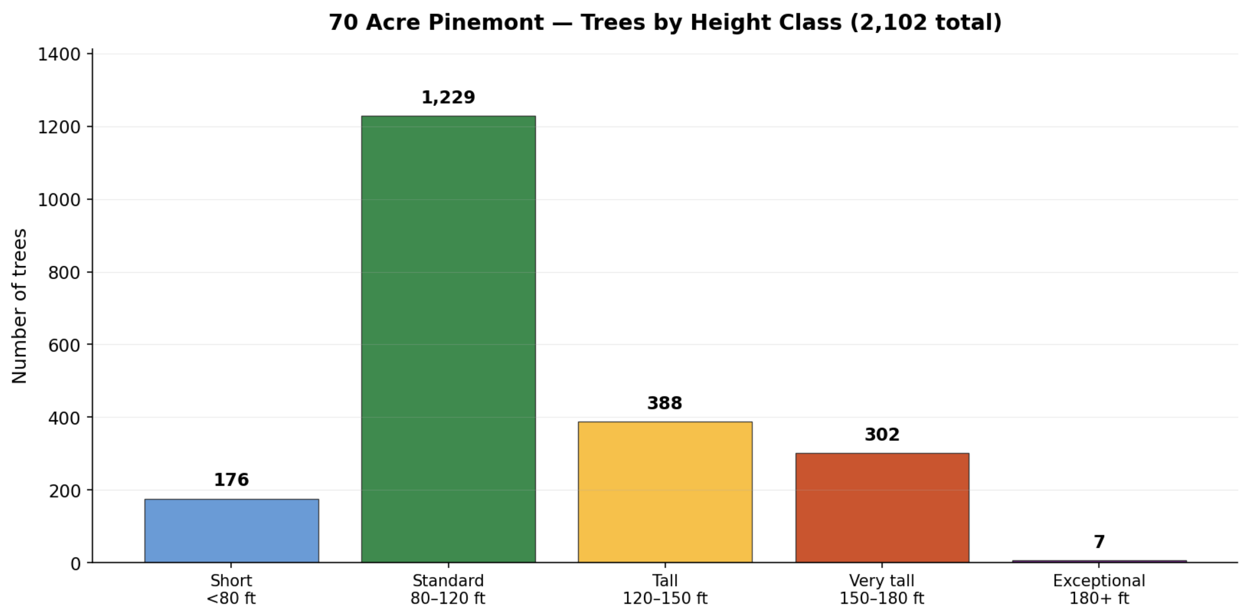
Distribution by product class



Trees grouped by Pacific Northwest product class. The stand is anchored by medium and small sawtimber, with a substantial peeler-class population of 296 trees.

Of 2,102 stems, the largest cohort (761 trees, 36%) falls in the 17–23" DBH range. The 296 stems at 31"+ DBH represent 14% of total stems but a disproportionately large share of total basal area, as shown in the chart on the next page.

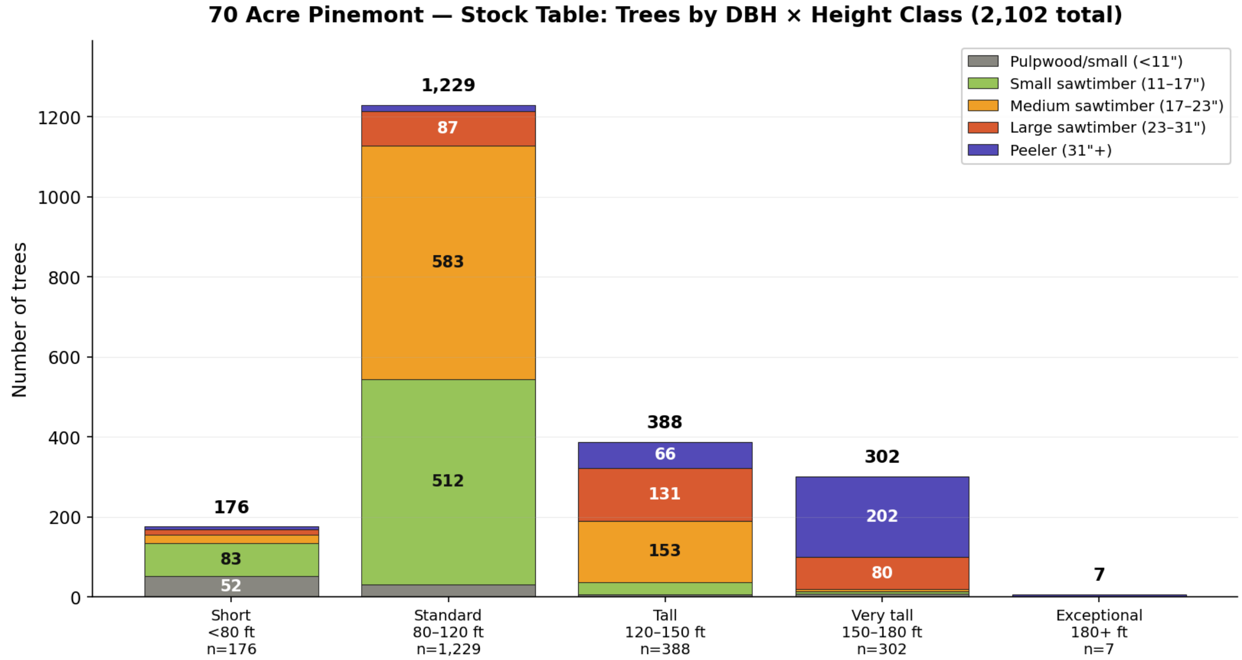
Distribution by height class



Trees grouped by industry height class. The stand has 309 trees over 150 ft tall, including seven exceeding 180 ft.

Standard-height trees (80–120 ft) account for 1,229 of 2,102 stems — the dominant cohort left after thinning. The 309 trees over 150 ft contribute disproportionately to long-log volume potential.

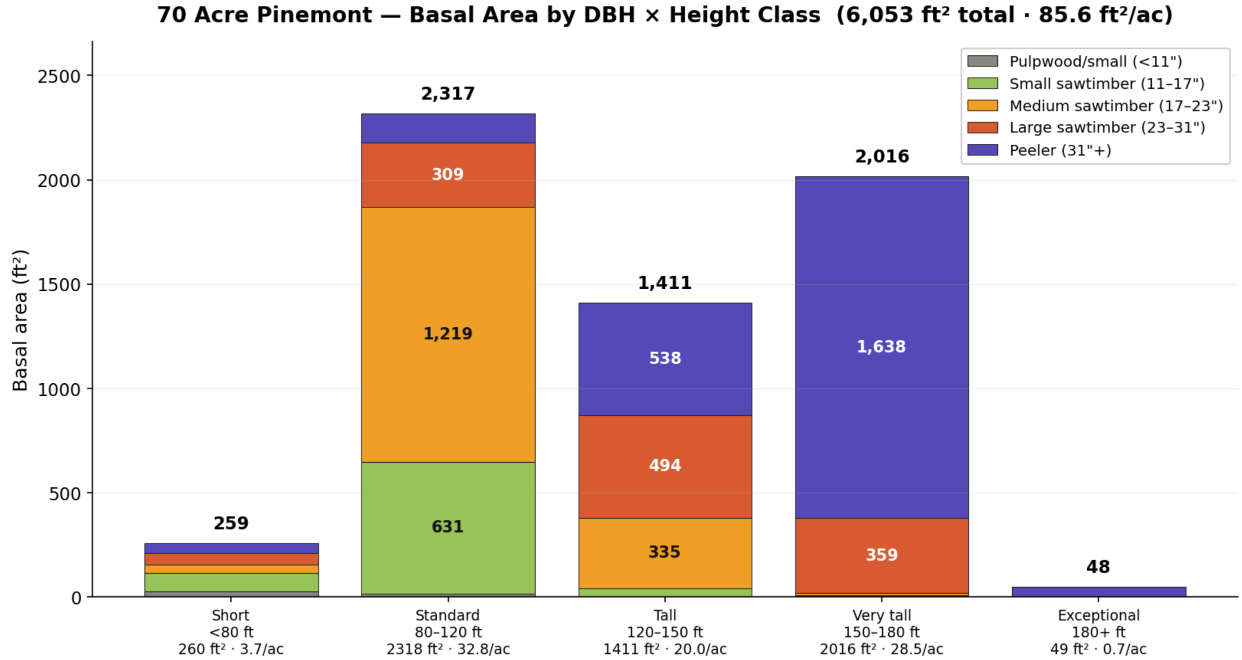
Stock table — stems by DBH × height



The DBH × height matrix: how many trees fall into each combined size class. The largest single cell is medium sawtimber at standard height (583 trees).

The stock table answers a question that single-axis charts cannot: what does each tree actually look like in both dimensions at once? A 31"+ DBH peeler that is only 80 ft tall yields fewer logs than a 31"+ peeler at 160 ft. The stock table separates these cases — useful for bucking plans, sort assumptions, and accurate volume estimation downstream.

Stock table — basal area by DBH × height



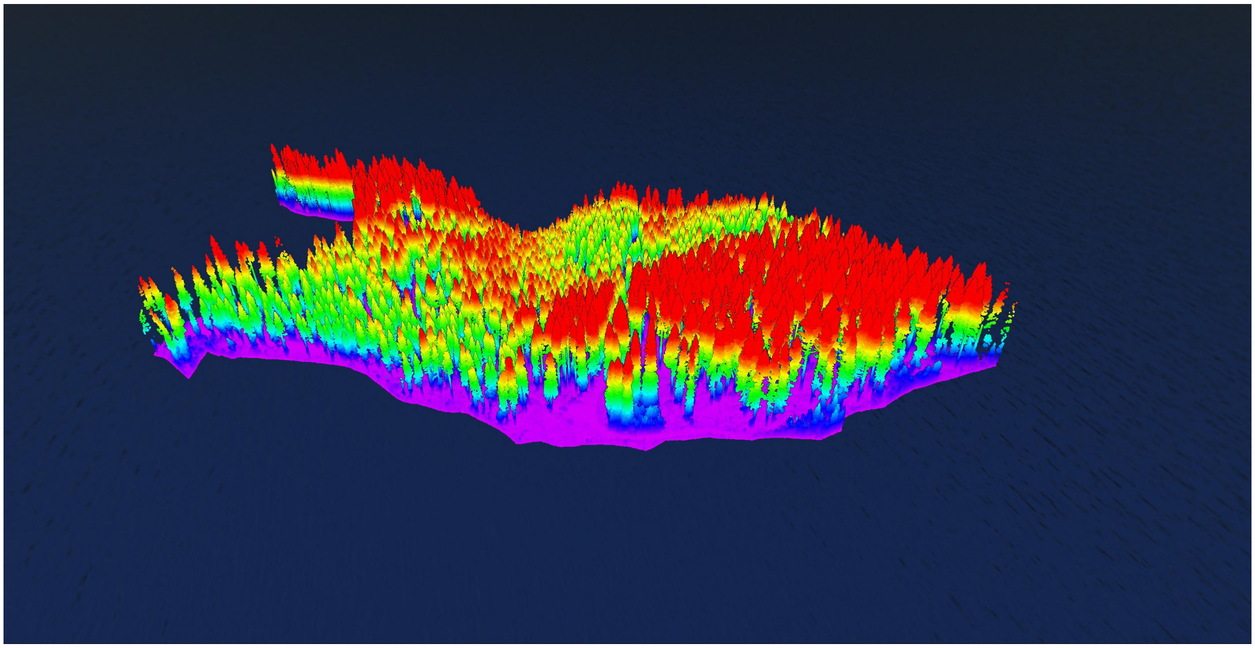
The same matrix weighted by basal area instead of stem count. Total stand BA is 6,053 ft² (85.6 ft²/ac), well within the typical post-thin range for a healthy older Douglas-fir stand.

This is the chart most useful for valuation. Basal area scales with cubic-foot volume potential, so where the BA is concentrated is where the stand's value lives.

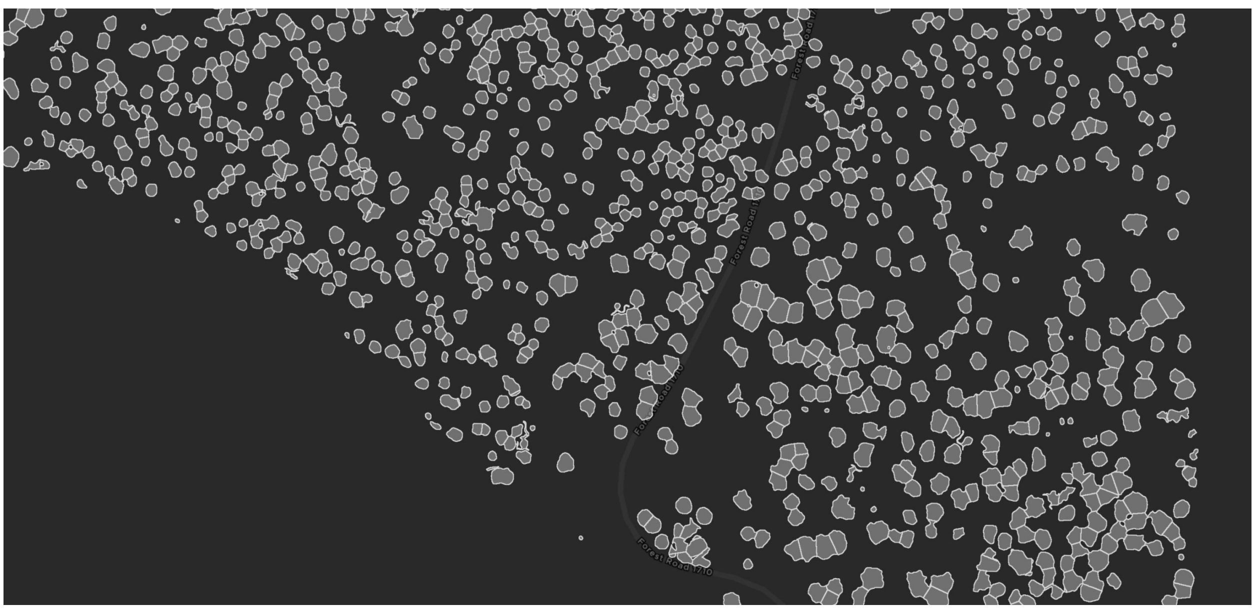
The single largest cell on this chart is peeler × very-tall — 1,638 ft² of basal area in 202 stems, more than any other DBH × height combination. Peelers as a group carry 2,414 ft² of BA — about 40% of stand total — despite being only 14% of stems. The classic cruise approach reports this number through plot averages and expansion factors. Here it is computed from every stem directly.

Additional insights about the stand

Canopy height model (CHM)

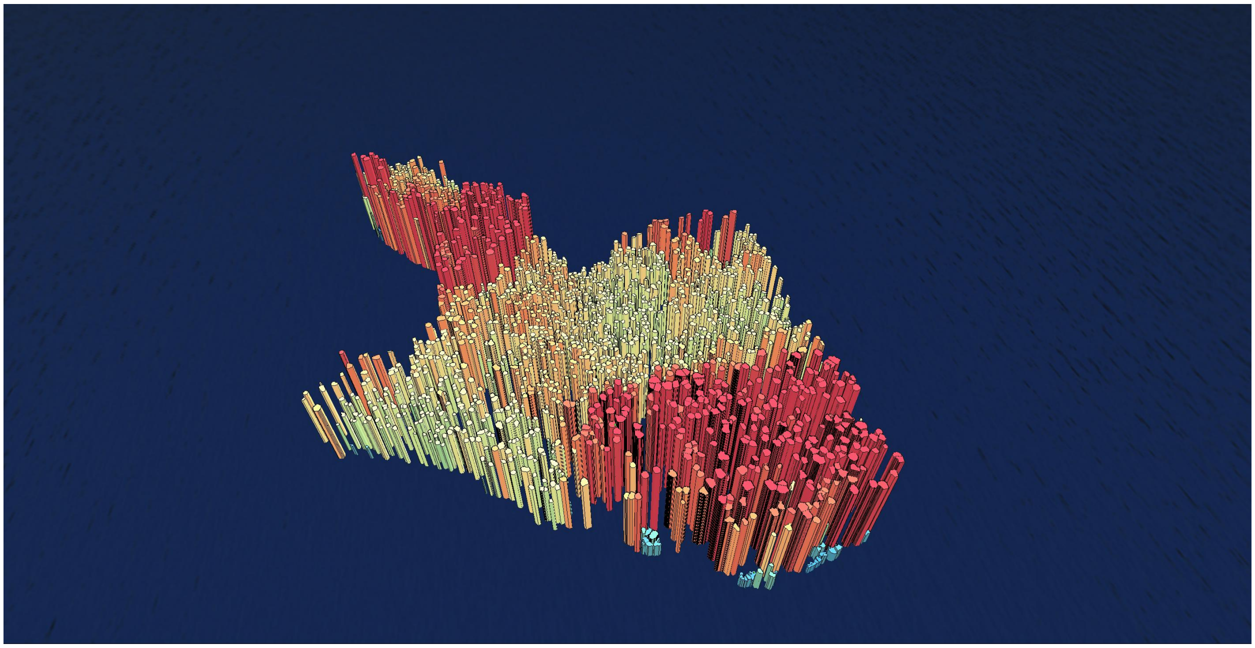


70 Acre canopy surface, colored by tree height above ground. Tallest in red, shorter individuals in blue/violet. Useful for visualizing the vertical structure of the canopy at a glance.



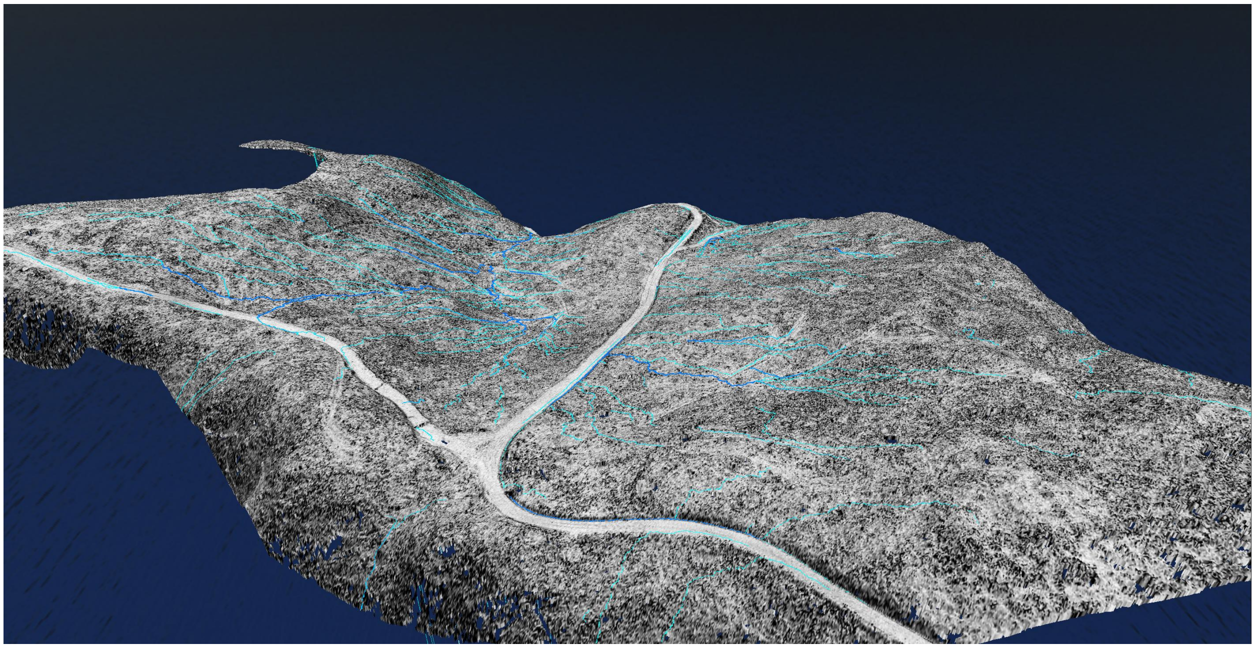
Top-down view of the same CHM, delivered as a per-tree crown polygon shapefile. Reveals horizontal spacing, gaps, and clumping — directly readable as stocking pattern. Roads remain visible as gaps.

The CHM is delivered as a shapefile of per-tree crown polygons. Each polygon carries the tree's height, crown area, and link back to its tree_id in the stem inventory. This format supports stand-level analyses — gap detection, dominant-cohort mapping, edge effects, stocking irregularity — that complement the per-tree inventory.



Per-tree canopy heights rendered as cylinders, colored from blue (shortest) through yellow to red (tallest). Provides an immediate visual read on the stand's height distribution and spatial structure.

Digital terrain model (DTM) and synthetic drainage



Bare-earth DTM with synthetic drainage channels overlaid. Useful for identifying stream crossings, wet-weather skid-trail constraints, and riparian buffer geometry.

The DTM strips away vegetation and shows ground elevation alone. Synthetic drainage is computed by routing flow across the DTM surface. In stands with poor existing topographic data, this is often the best available representation of where water actually moves on the ground.

Operational applications:

• Road and landing condition assessment — terrain detail reveals surface irregularities, drainage crossings, and grade changes useful for haul-road maintenance planning.

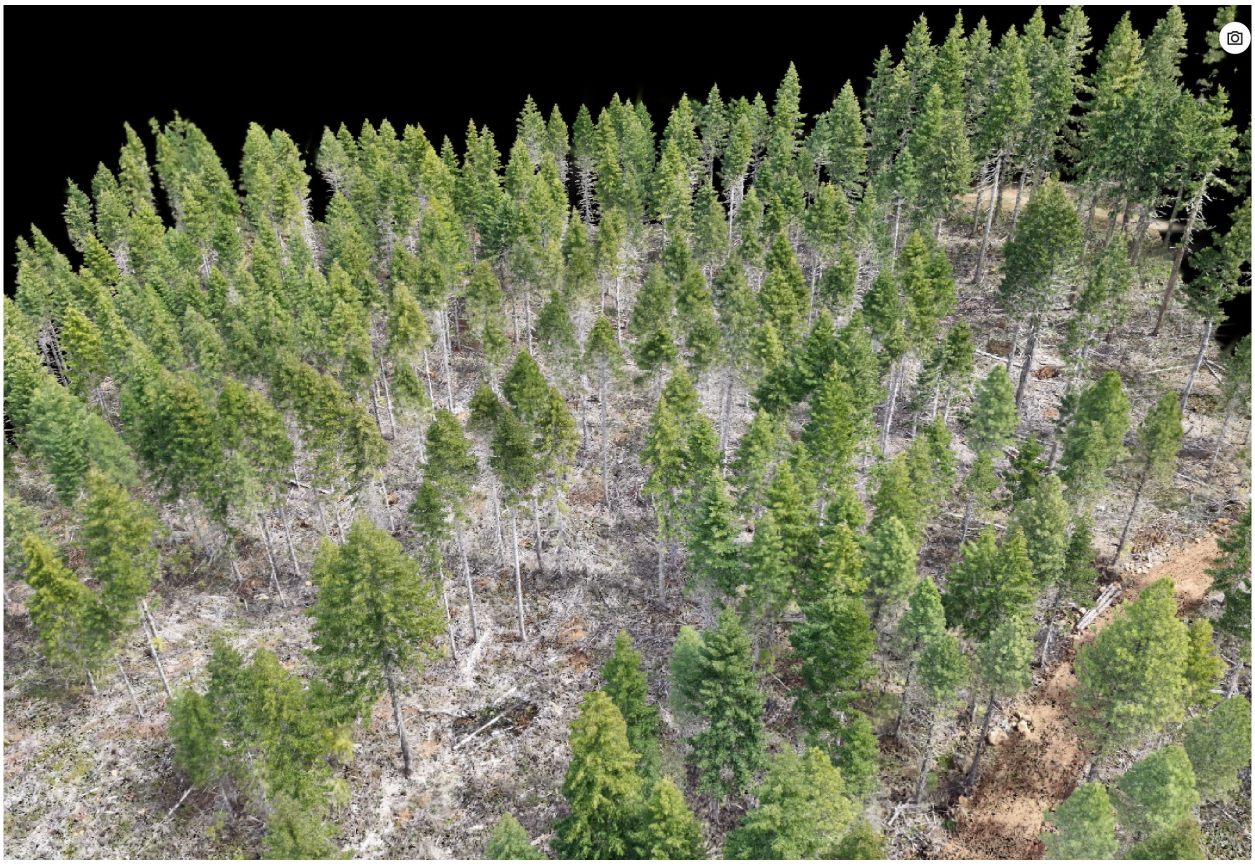
• Landing design and layout — slope, drainage, and surface models support landing placement decisions before any ground disturbance.

• Drainage and hydrology mapping — the DTM reveals flow paths, ephemeral channels, and stream crossings at higher resolution than typical regional topographic data.

• Slope and aspect mapping — derived per-cell from the DTM, supporting equipment access planning and erosion-risk evaluation.

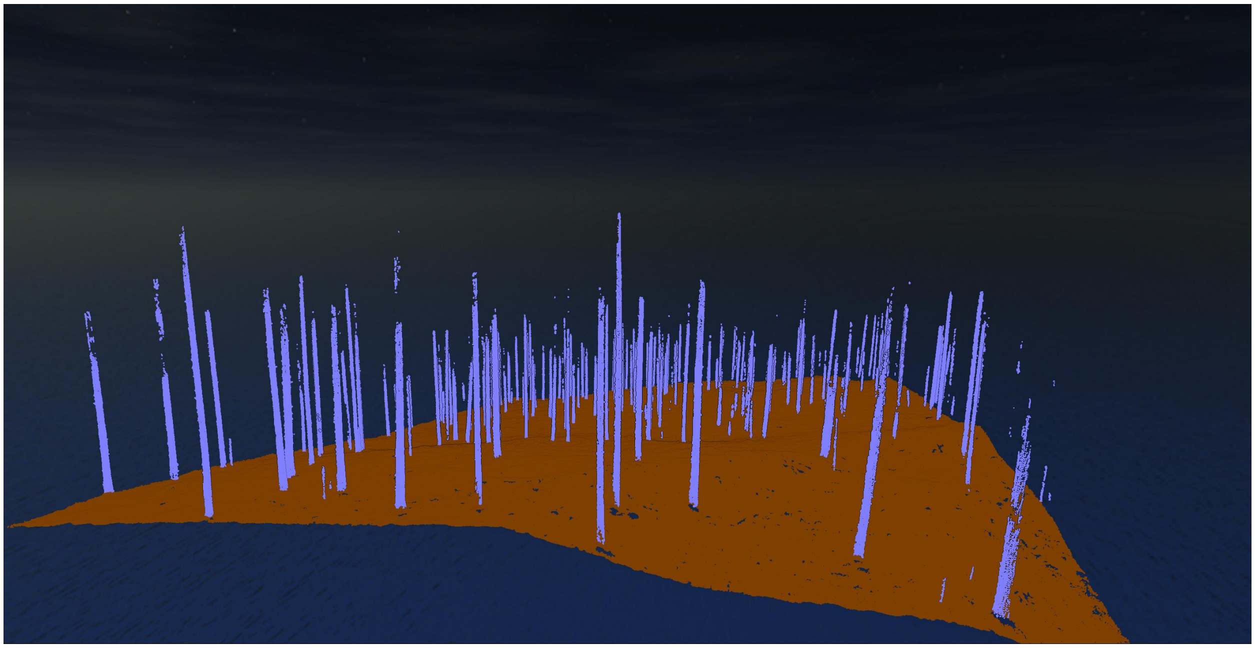
• As-built documentation — additional flights at later dates provide before/after terrain comparison for road, landing, and stream-crossing compliance records.

Photographic 3D scene (Gaussian Splat)

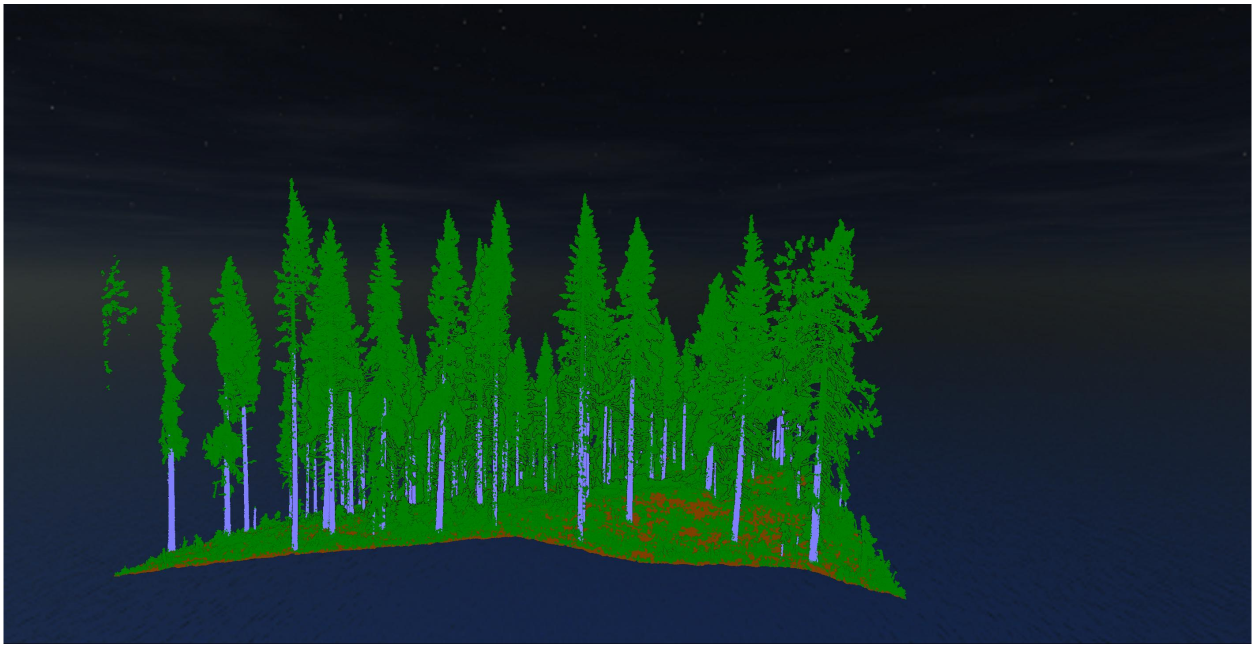


A photo-realistic 3D rendering of the 70 Acre stand (Gaussian splat). Above: aerial canopy view.

The photographic scene runs in a web browser with no LiDAR or GIS software. Foresters can pan, zoom, and walk through any part of the stand from a desktop. Useful for pre-harvest planning conversations, contractor briefings, and remote inspections without a field visit.



Stems detected and isolated from the LiDAR point cloud, separated from foliage and ground returns. Each individual stem is then circle-fit at breast height (1.3 m) to measure DBH.



Crowns segmented (green) and stems isolated (purple) for a section of the stand. Each is a separate tree record in the final inventory.

Accuracy and limitations

70 Acre stand accuracy results

Two independent ground-truth checks help measure the accuracy of this inventory.

Tape-vs-LiDAR DBH check. 22 trees on the 70 acre stand were measured with a diameter tape on the ground and compared against their LiDAR-fitted DBH from two separate flights conducted a few weeks apart. The LiDAR-measured DBH was within 1.5–2% of tape across both flight datasets. The agreement is within the variability of tape measurements themselves. The result also demonstrates flight-to-flight consistency — measurements taken on a different day return the same numbers, which matters for any monitoring use of the system over time.

Stem-level outlier review. After the standard QC pass, the residual stem-level error rate against point-cloud verification was 0.7% (15 trees out of 2,117 candidates required correction; 2,102 retained). All 15 errors were found at the top of the DBH distribution where stems physically touch or overlap — the regime where any inventory method, including ground cruising, has the most trouble. The middle 95% of the inventory (trees between 11" and 30" DBH with clean fits) showed no detected errors.

For comparison, conventional cruising might report 5–15% sampling error at the stand level depending on plot density. The aerial LiDAR result on this stand is approximately an order of magnitude tighter at the stand-summary scale, while also providing per-tree spatial detail.

Where the method needs care

• Stems below the 8.3" DBH and 33 ft height threshold are excluded by design. This is appropriate for sawtimber inventories but means the system does not deliver stem counts of regeneration.

• Bark-overlap pairs (two fits that physically intersect) are flagged automatically; in this stand they were almost always one tree split into two fits by sparse point cloud at breast height. QC review confirms or merges these.

• Shared canopy polygons. On the 70 cre stand, 380 trees (18%) share a crown polygon with at least one neighbor, including 56 trees in clusters of three or four. Crown-derived height for these stems represents the height of the shared canopy mass rather than each individual sub-stem's exact height. Each tree carries a shared_crown_count attribute so users can filter or weight accordingly. For trees in the inventory not contained in any crown polygon (172 in this stand), height is taken from the trunk fit length, which is conservative but not affected by the crown-sharing question.

• Species classification is not currently part of the pipeline. The inventory is species-blind and treats the stand as the dominant species. Adding species classification from crown shape, CHM texture, or Biodrone is feasible — see future possibilities, below.

Verifiability

The point cloud is delivered with the report. Any tree in the inventory can be located and inspected by the forester directly — diameter, height, position, and surrounding stems are all measurable in the cloud.

Structural feature detection

A real advantage of stem-level LiDAR inventory is the automated identification of structural features that conventional cruises either miss or record only as subjective field notes. Four categories were detected on the 70 acre stand — leaning trees, anomalously short stems (snag and broken-top candidates), multi-stem and forked trees, and pole-grade candidates. All counts are computed automatically from the per-tree data — every flagged stem has a precise location and is included in the delivered GIS layer for field follow-up.

Leaning trees

36 stems show trunk lean angles exceeding 10° from vertical (1.7% of the inventory), with 111 stems leaning more than 5° (5.3%). The maximum measured lean is 39.1°. Lean angle and direction are computed from the 3D trunk axis vector for every stem — data unavailable from any ground-based cruise. This information supports felling-direction planning, identification of wind-damage clusters, and risk-rating of stems for hazard prescriptions.

Anomalously short stems (snag and broken-top candidates)

78 stems are flagged as more than 1.5 standard deviations shorter than the height predicted by their DBH within this stand. This catches standing dead snags, wind-snap survivors, and broken-top trees whose DBH suggests a much taller tree than the LiDAR observes. Many of these will be valuable wildlife snags worth retaining; some will be damaged trees worth recording for a salvage decision.

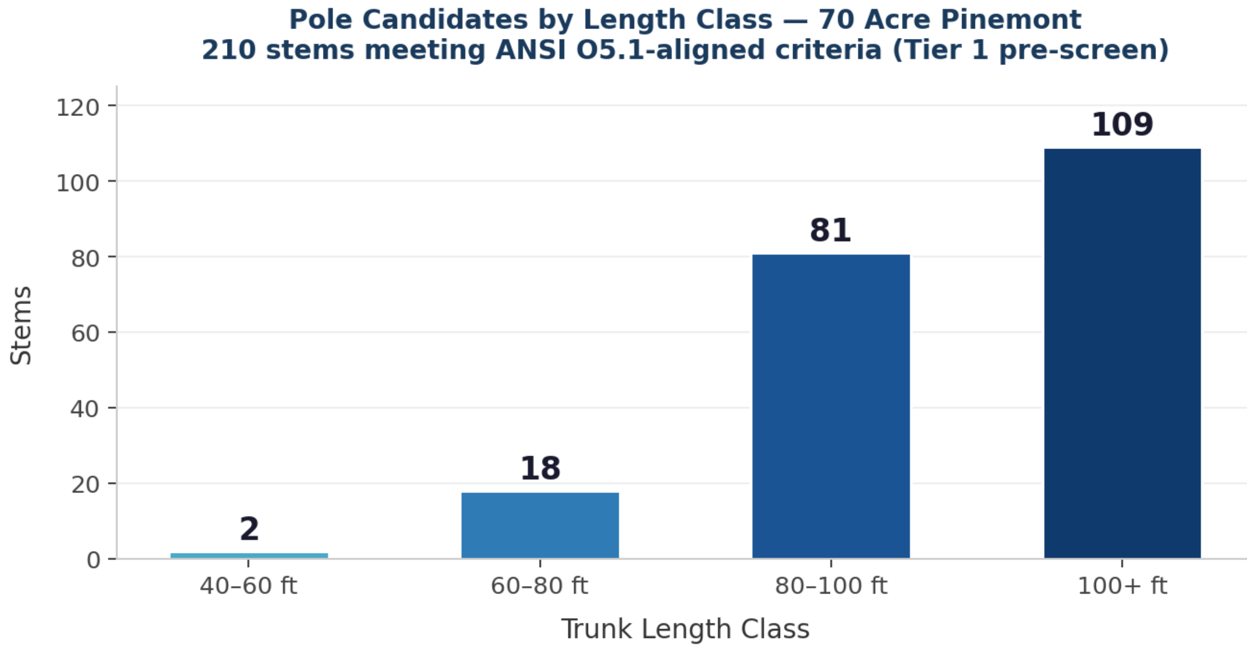
Multi-stem and forked trees

During QC review of the 70 Acre stand, the most common geometric ambiguity in the point cloud was sparse stem returns at breast height — the algorithm would fit two adjacent circles where there was one stem. These were resolved during QC by merging to a single tree with the cloud-measured diameter. A small number of true multi-stem and forked-base trees were also identified and recorded with their combined diameter. The QC log delivered with the report documents each of these decisions; no stems were dropped without explanation.

Pole-grade candidates (ANSI O5.1 pre-screen)

210 stems in the 70 acre inventory meet all five LiDAR-measurable criteria for utility-pole pre-qualification under ANSI O5.1 (the governing North American standard for wood poles, published by the American Wood Protection Association). The criteria applied simultaneously: DBH 10–25", trunk length > 40 ft, trunk lean < 1.0° from vertical, lower-bole sweep deviation within 1" per 10 ft of length (measured from multi-slice circle-fit centers), and circle-fit reduced chi-squared (r_redchi) $< 1\times10^{-5}$ indicating sound stem geometry at breast height. These 210 stems represent 10% of the 2,102-tree inventory.

The chart below shows the distribution by length class. The dominant tier is 100+ ft (109 stems), which corresponds to larger transmission-class poles commanding the highest per-unit premiums. The 80–100 ft class (81 stems) covers the most commonly traded distribution-pole lengths. The lean and bole-sweep filters do significant work: a loose pre-filter using only DBH range, length, and r_redchi (omitting the sweep check) returns 1,339 candidates — the ANSI-calibrated criteria reduce that by roughly 6×, retaining only stems that actually pass the sweep tolerance.



Field grading required for ANSI O5.1 acceptance — knots, decay, growth rate, spiral grain, and shake are not LiDAR-detectable.

All 210 candidates are delivered as a separate KML layer, color-coded by length class, so the forester can navigate directly to each stem in the point cloud. Per-stem attributes include DBH, trunk length, lean angle, maximum bole sweep (mm and percent of length), number of slices used for the sweep check, and r_redchi. Field grading for knots, decay, growth rate, spiral grain, and shake remains required for ANSI O5.1 acceptance — these are not assessable from aerial LiDAR.

What this enables

Available now

• Wall-to-wall stem inventory rather than plot-based sampling — every tree above the threshold is measured, not extrapolated from a sample.

• Per-tree spatial data for harvest planning, including pre-bucking, sort planning, and identification of high-grade or legacy trees worth special handling.

• Stand-level rollups (BA/ac, stem counts by class, basal-area-weighted stock tables) feeding directly into cruise reports, sale appraisals, and silviculture prescriptions.

• Wall-to-wall terrain products (DTM, DEM, drainage) supporting roads, buffers, and slope analysis.

• Photographic 3D scene for remote inspection and contractor briefing.

• Stand-over-stand monitoring at stem level. Each tree carries a persistent ID. Reflying a stand at any future date — whether after a thin, after a windstorm, or simply at year five of a rotation — produces a directly-comparable inventory of the same individual trees. Growth, mortality, recruitment, and disturbance are measurable per stem rather than estimated from sample plots. This applies to any stand Agcopter has previously flown.

Possible with refinement

• Per-tree stem taper curves, merchantable-volume-to-top (8" or 6"), and board-foot volume (Scribner Decimal C, International ¼", or other client-preferred rule). Computed by fitting taper to multi-height stem slices from the same point cloud. Initial taper analysis on this stand with the existing slice configuration produced reasonable per-tree volumes; an upper-bole-focused slice configuration plus a small calibration step (10–15 trees with optical dendrometer or felled-stem measurements) would validate the taper extension into the upper bole and produce defensible MBF/ac numbers.

• Species classification from crown shape, CHM texture or Biodrone, and seasonal LiDAR flights. Useful in mixed stands; less critical for monoculture Douglas-fir.

• Defect and damage flagging from stem-level anomalies — broken tops, leaning trees, candelabra forks.

How this inventory complements existing cruise practice

Attribute	Traditional plot cruise	AgCopter LiDAR inventory
Sampling intensity	10–20% (typical plot density)	90-100% — stems above threshold
Individual tree locations	No	Yes — sub-meter, every stem
DBH accuracy	High (diameter tape)	1.5–2% of tape on this stand (22-tree check)
Height	Moderate (clinometer, dominant trees)	High — crown height model, every stem
Crown data	Not measured	Per-tree polygon, area, and height profile
Trunk lean	Not measured	Angle and direction, every stem
Snag / structural anomalies	Subjective field notes	Automated, located, attributed
Terrain model (DTM / drainage)	Not produced	Centimeter-class, same flight, full stand
Repeatability	Cruiser-dependent	Within 1.5–2% across separate flights
Return-visit monitoring	New full cruise required	Same persistent tree IDs reflown
Deliverable format	Tally + summary table	GIS-ready shapefiles + report + cloud

Agcopter LiDAR inventory gives foresters a layer of stand data that wasn't previously available at this resolution: a wall-to-wall stem-level inventory at requested thresholds, crown and terrain mapping across the full stand, and a verifiable point cloud behind every measurement. Combined with whatever cruise data, sale appraisal information, and institutional knowledge a forester already brings to a stand, this data supports decisions about silviculture, harvest timing, road and landing layout, riparian buffer compliance, sale structure, and monitoring — decisions where the value at stake on a single stand can be substantial.