A 44MOLES CASE STUDY

What a Pilot Study in Brazil Taught Us About Building Reliable Forest Inventory

July 2026

In 2026, 44moles traveled to Brazil to meet some of the country's largest forestry companies and better understand how terrestrial LiDAR could complement existing forest inventory practices.

One of those conversations led to a pilot project with Dexco, a large-scale plantation operator exploring ground-based alternatives for plantation inventory. The open question for the client was whether a ground-based approach could deliver primary, directly measured data of sufficient precision to serve as a reliable anchor for broader-coverage monitoring methods including airborne LiDAR. The wall-to-wall reach of airborne methods is certainly valuable, but its volume estimates remain only as accurate as the ground-truth models it relies on. The pilot was designed to test not just whether terrestrial scanning could replace manual inventory, but whether the data it produced could form the calibration foundation for continuous, large-area monitoring at a cost and speed that made operational sense.

We proposed a proof-of-concept, and its objective was simple:

> ***(1) Can terrestrial LiDAR produce inventory data that forestry professionals can trust under real operating conditions, and (2) can that precision become the reference layer for scalable monitoring?***

The pilot consisted of 66 terrestrial LiDAR scanning sessions across inventory plots, 70% of which were coppice, one of the harder open problems in terrestrial LiDAR inventory. So we treated every stage of the workflow as an opportunity to understand where current technology succeeds and where it still requires human expertise.

66	70%	5
SCANS	COPPICE PLOTS	LESSONS

Five Lessons Emerged

01 Operational simplicity can improve technical reliability.

Our original workflow relied on registering multiple scans together using third-party software before processing. In practice, this introduced unnecessary complexity: registration failures required repeat processing and increased manual intervention.

For first-rotation, single-stem eucalyptus with standard spacing, we now use two unregistered scans, positioned a modest distance apart, analyzed independently rather than merged. A real advantage emerged: coverage. Two independent scans a few rows apart capture more trees and a broader spatial cross-section of the stand, picking up more of the natural within-stand variability than a single scan, or a tightly registered pair, would.

The statistical cost of the small overlap between the two scans is lower than the operational cost of registration failures.

> *The simplest workflow that produces reliable results is often the most scalable one.*

02 Forest structure matters more than project size.

One of the most valuable discussions during the pilot centered on plot design. Traditional forest inventories typically rely on fixed-area sampling, and for good reason: it's the global standard, and when applied correctly, it's statistically sound. Our workflow, however, calculates plot area dynamically.

Fixed-area plots run into two practical difficulties, both concentrated at the plot boundary: deciding whether a tree sitting directly on the edge should count, and the time it takes to measure distances to those edge trees precisely enough to make that call. Our dynamic approach avoids that particular ambiguity by design.

There's a second advantage that matters more for terrestrial scanning specifically. A fixed-area approach assumes every tree inside the boundary can be measured. In practice, understory vegetation sometimes blocks the scanner's line of sight to a tree, making that assumption impossible to guarantee. A dynamic approach works with what's actually visible and measurable from where the scan was taken.

Dead trees, harvesting gaps, and irregular spacing show up regularly in commercial plantations. Inventory methods need to account for that variability rather than assume uniform stands — a pattern we expect to keep seeing as we take on more projects.

03 Coppice remains one of the hardest problems in terrestrial LiDAR.

Multiple stems originating from the same stump create ambiguity. Today, those cases still require manual review by our analysis team, reinforcing the importance of defining where automation currently performs well and where expert review is necessary. That increases processing time, but it also preserves measurement quality.

Reliable automated segmentation for multi-stem structures isn't a solved problem anywhere in this industry yet, and a meaningful amount of engineering work has already gone into pipeline components built specifically for conditions like these.

Every coppice result still goes through manual review before it reaches a client, because automated segmentation alone doesn't yet meet our own bar for accuracy. We're actively building toward changing that: automated multi-stem segmentation is in active development now, targeted for a working solution held to the same standard as manual review by fall 2026.

04 Automation is only valuable when it improves quality.

One of the more unexpected findings was that partial automation sometimes slowed the workflow instead of accelerating it. Several automated quality-control steps still required human verification, which is not unusual in applied engineering.

Between fully manual processes and fully autonomous systems lies an intermediate stage where humans remain responsible for confirming algorithmic outputs. And in forest inventory, accuracy matters. Our priority is therefore not maximizing automation at every opportunity, but introducing automation only where it demonstrably improves both efficiency and confidence.

05 Forest inventory is more than data collection.

The pilot reinforced that collecting LiDAR data is only one part of producing a reliable inventory. Each stage influences the final result, with the earliest step in the process also the one with the least room for error. Improving only the algorithms while neglecting the surrounding workflow would not meaningfully improve inventory quality.

Manual validation takes time, and it is also temporary. As automation matures, we expect turnaround times to shorten without loosening our quality standards. The technology succeeds only when it supports the entire operational process.

What We Learned About the Product

The pilot confirmed several strengths of the Digital Forest Inventory (DFI) platform.

A permanent visual record

Traditional inventories often reduce field observations to spreadsheets. Terrestrial LiDAR preserves a full 360-degree interactive image of every scanned plot inside the DFI, so inventory managers can rotate around and inspect a tree the same way they would in the field, without a return visit.

Height and diameter measurements

Whether our measurements are more precise than a traditional manual inventory isn't really an answerable question the way it's sometimes framed. A precision claim like that depends on which method you treat as the benchmark, and that choice is subjective.

What we can say concretely: where validation is complete, we measure height for every tree in the plot. Traditional inventory typically measures height on a subset of trees and models the rest from their diameter. We also capture more than one diameter reading per tree instead of just the single measurement that standard practice relies on. Today, those extra readings mostly make our volume estimates more robust; using them to refine expected stem shape per tree is next on our roadmap.

Looking further out, aggregating these direct, tree-level measurements across regions and clones is also how we intend to build a broader reference dataset. Such a dataset would be useful for refining our own models and potentially, for calibrating other coverage methods like airborne LiDAR, that estimate volume rather than measure it directly.

Better operational transparency

DFI allows managers to understand how measurements were generated and where manual validation was applied. The same plot viewer that helps our own team verify quality also gives clients a way to check our work themselves.

Looking Forward

> *The lessons from this pilot demonstrate that the future of forest inventory will be defined by giving foresters better tools: fewer repetitive measurements, more time for judgement, smaller crews in safer conditions, and reliable data that managers can verify and contextualize without leaving the office.*
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> *One thing we didn't set out to test, but which became clear over the course of the pilot, is how this kind of ground-truth precision might extend beyond ground-based inventory on its own. Wall-to-wall methods like airborne LiDAR offer coverage that terrestrial scanning can't match economically. Nonetheless, each plot we scanned added a reference point to a database that bridges the gap between what a sensor sees from the sky and what is actually growing on the ground. The logical next step for the industry is to use that reference database to calibrate wall-to-wall airborne acquisition, managed as a single pipeline from ground precision to scaled*

coverage, with 44moles coordinating both the calibration protocol and the flight operations through specialized partners.

We expect that this next step comes with a real trade-off: at wall-to-wall scale, verifying any single tree the way our plot viewer allows today becomes much harder. We think the trade can be worth it for large-area monitoring.

This experience will continue to shape the direction in which we develop DFI, especially as it concerns both the rollout of automation that genuinely adds value and the integration of ground precision into continuous, large-area monitoring.

ABOUT 44MOLES

44moles develops LiDAR systems for digital forest inventory, helping companies and landowners work with better data. Our work focuses on solving practical inventory problems while advancing automation responsibly through close collaboration with forestry professionals.