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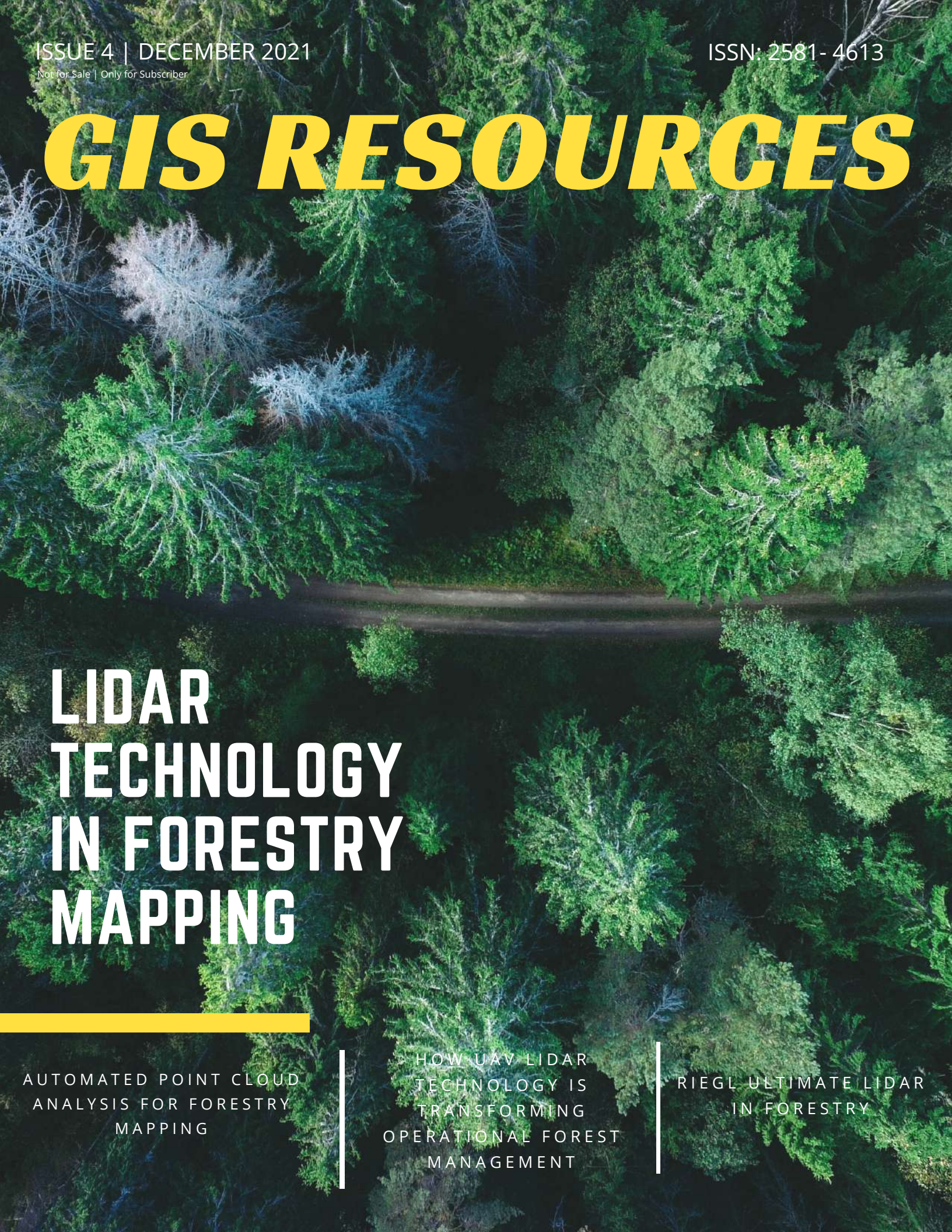
GIS RESOURCES



LIDAR TECHNOLOGY IN FORESTRY MAPPING

AUTOMATED POINT CLOUD ANALYSIS FOR FORESTRY MAPPING

HOW UAV LIDAR TECHNOLOGY IS TRANSFORMING OPERATIONAL FOREST MANAGEMENT

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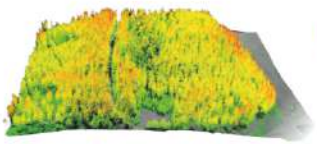

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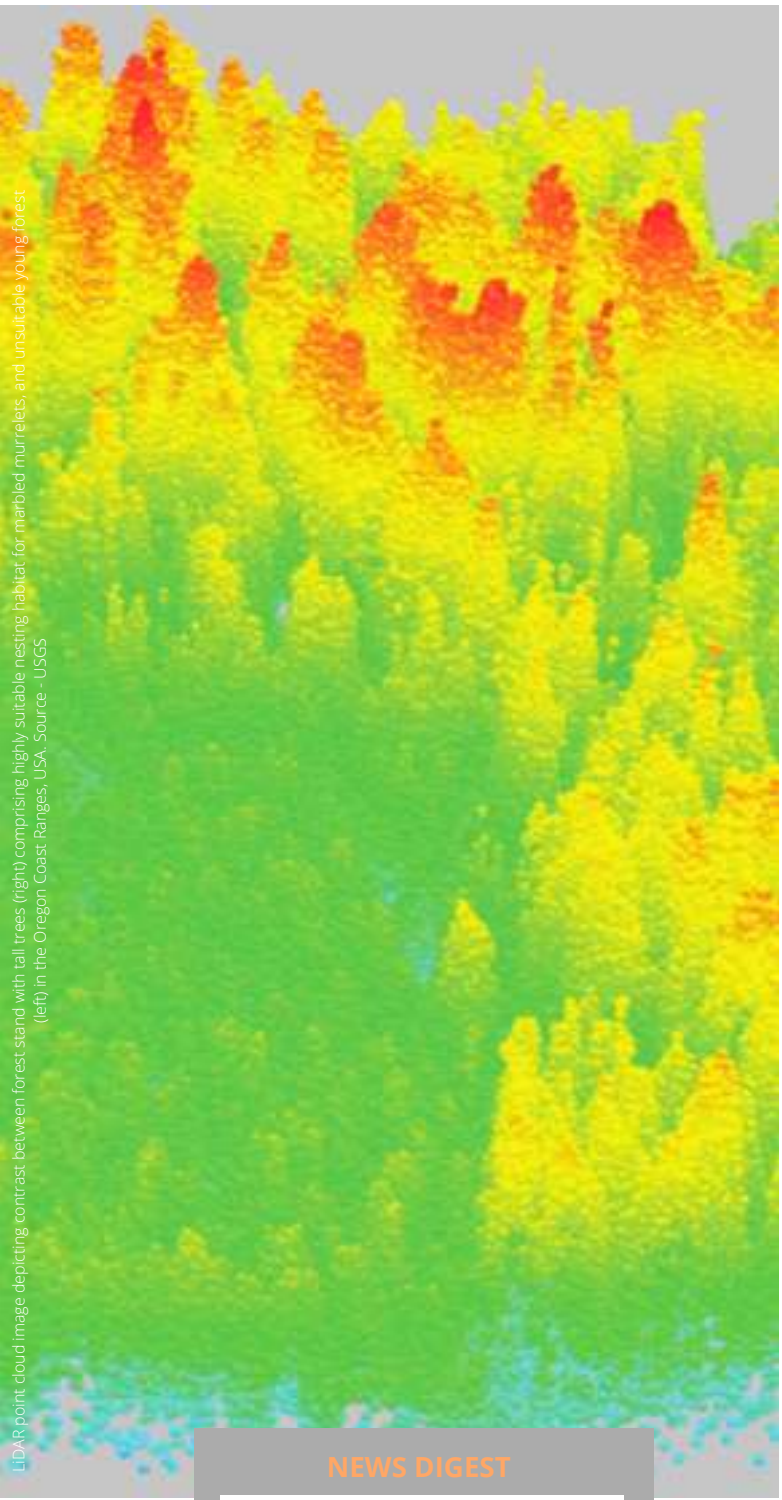

LIDAR point cloud image depicting contrast between forest stand with tall trees (right) comprising highly suitable nesting habitat for marbled murrelets, and unsuitable young forest (left) in the Oregon Coast Ranges, USA. Source - USGS

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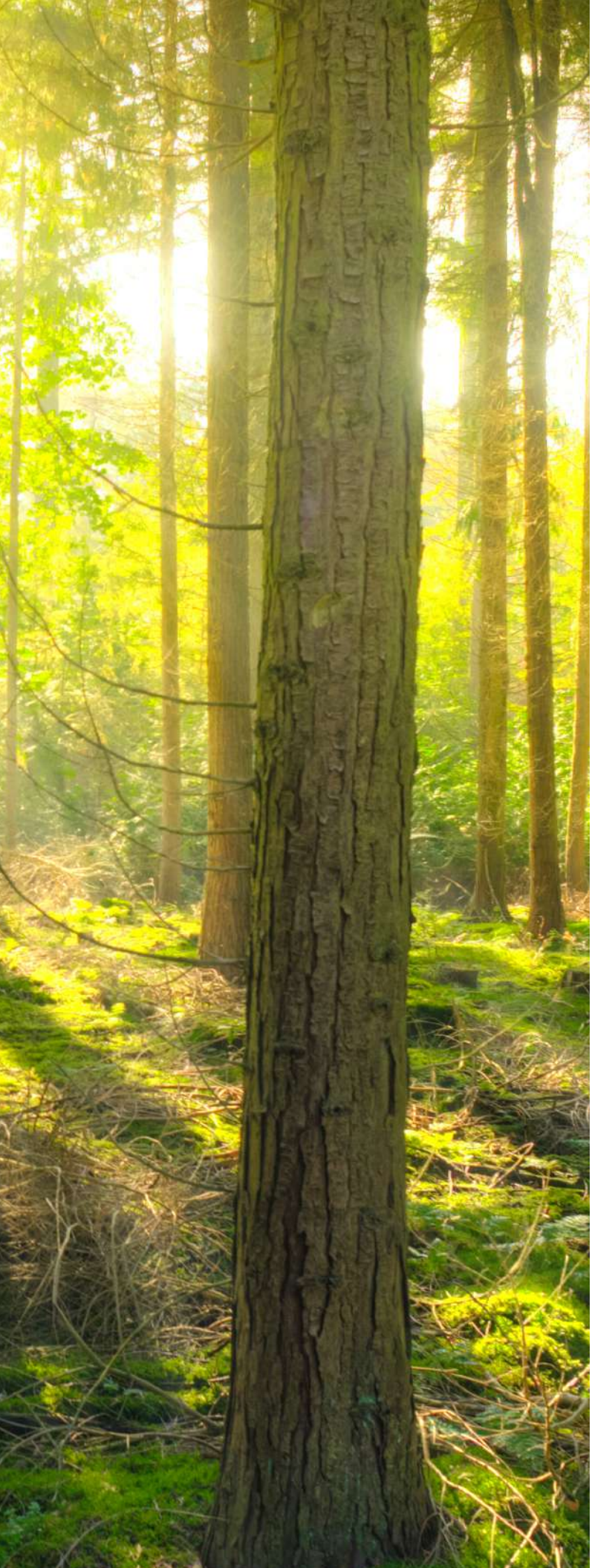


editor's note

Geospatial technology incorporates a huge gamut of technologies. With technology progressing from photogrammetry to LiDAR, the technology enables the capture of positions, both vertical and horizontal. A huge point cloud of data is captured to generate LiDAR maps that give absolute and relative positional accuracy. This allows viewers of the data to know where in the world the data was collected and how each point relates to objects in terms of distance (both vertical and horizontal).

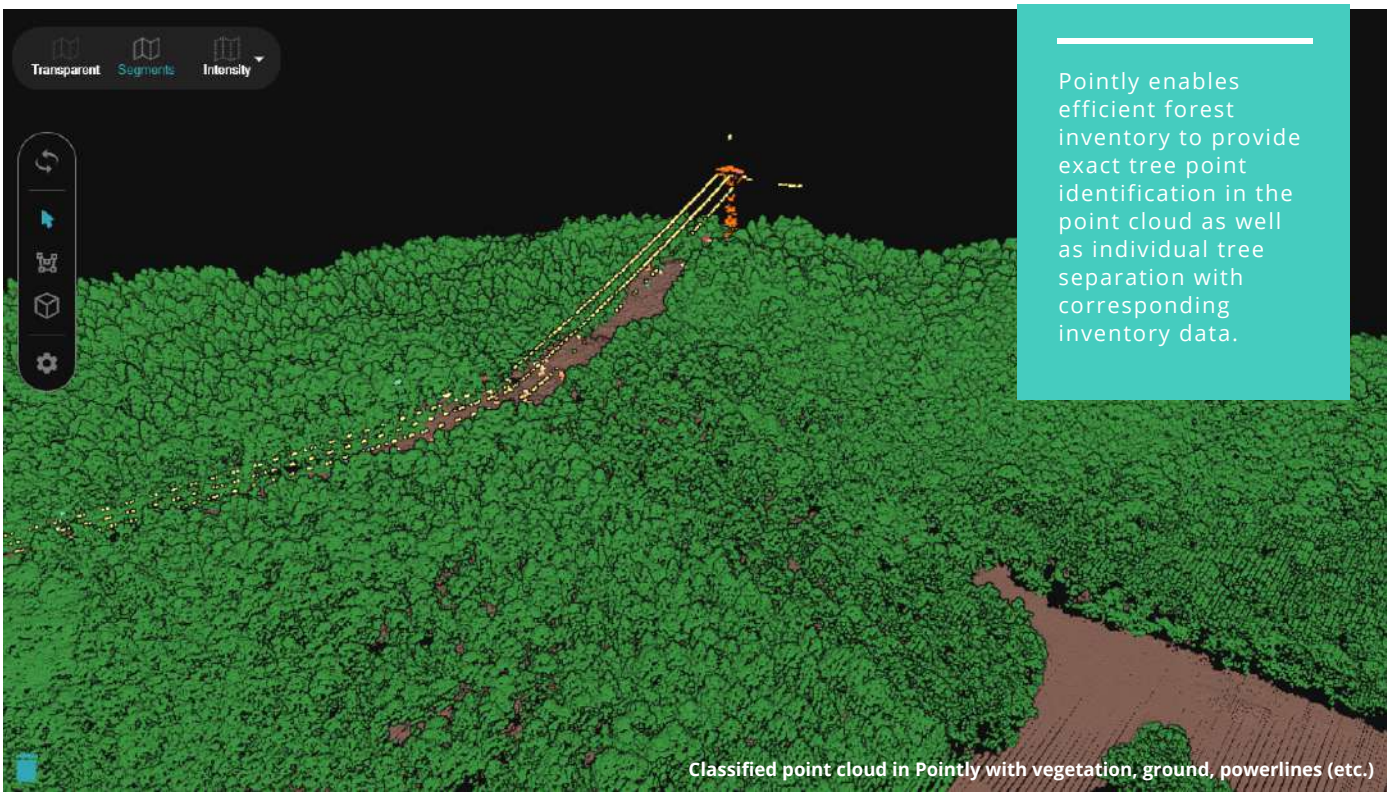
Terrestrial and Airborne LiDAR provides accuracies comparable to the best technologies and has proven to provide accurate, reliable and repeatable data.

I need not dwell on the LiDAR technology and its benefits and uses in forestry as there is enough information available in literature. Combined with GPS, GIS, Visualisation and AI, the technology provides quick and accurate data that can, at instance, be used in real time. Administrators and Planners can rely on this technology to provide actionable data.

Ashok Prim
Editor

Automated Point Cloud Analysis for Forestry Mapping

The Pointly team developed a processing pipeline, that takes point clouds as input and outputs a shapefile with the location and metadata of single trees.



Classified point cloud in Pointly with vegetation, ground, powerlines (etc.)

Pointly enables efficient forest inventory to provide exact tree point identification in the point cloud as well as individual tree separation with corresponding inventory data.

Pointly's Approach to an AI Supported Conduction of a Forest Inventory

It's probably nothing new that due to technological advances in recent years both aerial and terrestrial LiDAR surveys have become widely used to map entire forests and extract needed information. Modern sensors can emit millions of pulses per second and are able to collect point cloud data with very high point densities. With state-of-the-art cloud solutions and high-performance computing, large amounts of gathered 3D data can be processed and stored. Nevertheless, there is still a lot of labor-intensive manual work when it comes to the analysis of forest surveys from LiDAR sources, e.g. to determine single tree instances and to extract further inventory information like the number of trees, their canopy shapes, heights or diameters. The unordered structure of the point clouds makes it challenging to process these large amounts of data algorithmically.

Pointly's specialized team of data scientists developed an universal approach to automatically conduct forest inventories with the help of AI and smart algorithms. The approach helps to minimize human error, reduces costs a lot and speeds up the process to give insights faster. Pointly is a company based in Germany and has specialized in AI

About Author

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solutions for 3D point clouds. They offer a SaaS platform, also called Pointly, for fast and user-friendly manual 3D point cloud classification. In addition to the manual classification tools, the platform will offer automated classification features and options to train your own neural network soon. Complementing the classification platform, Pointly also offers Services regarding 3D point cloud analysis. Here customers can get tailormade AI solutions with full support from proof of concept to highly scalable applications.

Forest Inventories

A forest inventory is the gathering of information on the health and diversity of a community forest. It can provide details such as tree condition, species, size and location.

A forest inventory can serve many different purposes:

- Identify insect or disease problems of trees
- Better isolate the causes of changes in the landscape through monitoring changes over time
- Help urban planners to develop maintenance and management plans
- Analyze and optimize the environmental impact of trees as a part of sustainable forest
- management
- Inform the residents about their community forests
- Determine the value of community trees regarding increasing property values
- Visually assess timber and determine potential fire hazards and the risk of fire.

What's Necessary for That?

Point clouds are a complex data type to work with. They are computational-heavy, require lots of storage and high bandwidth. Often, they are used for large-scale or in-depth analysis to obtain valuable information about contained objects and spatial properties. The results are typically other data-products like a shapefile, vectors, simplified 3D models or even a csv containing information about certain objects in the point cloud.

To automate the analysis of those datasets it is beneficial to classify the point clouds first. Pointly enables its users to efficiently manually classify even very large point clouds with the help of easy-to-use selection tools to generate customized training data. One of those tools is for example the Segment Selector, where users can classify whole areas with one click as you can see in the image below. These segments are pre-calculated based on the existing point cloud dimensions and other geo-features.

This training data is used to train the AI model to automate the classification of the point clouds.

Sid Hinrichs (Strategy, Sales and Finance at Pointly) says as a rule of thumb *"the better the quality of the training data and the more you have, the more robust can the AI model become"*. A robust model means that the automatic classification of new point clouds reaches high accuracies. Depending on the use case the model must be tweaked to reduce either the number of false-positive or false-negative errors for certain object classes.

"The quality and quantity of training data is the crux of the matter for the success of the AI application."

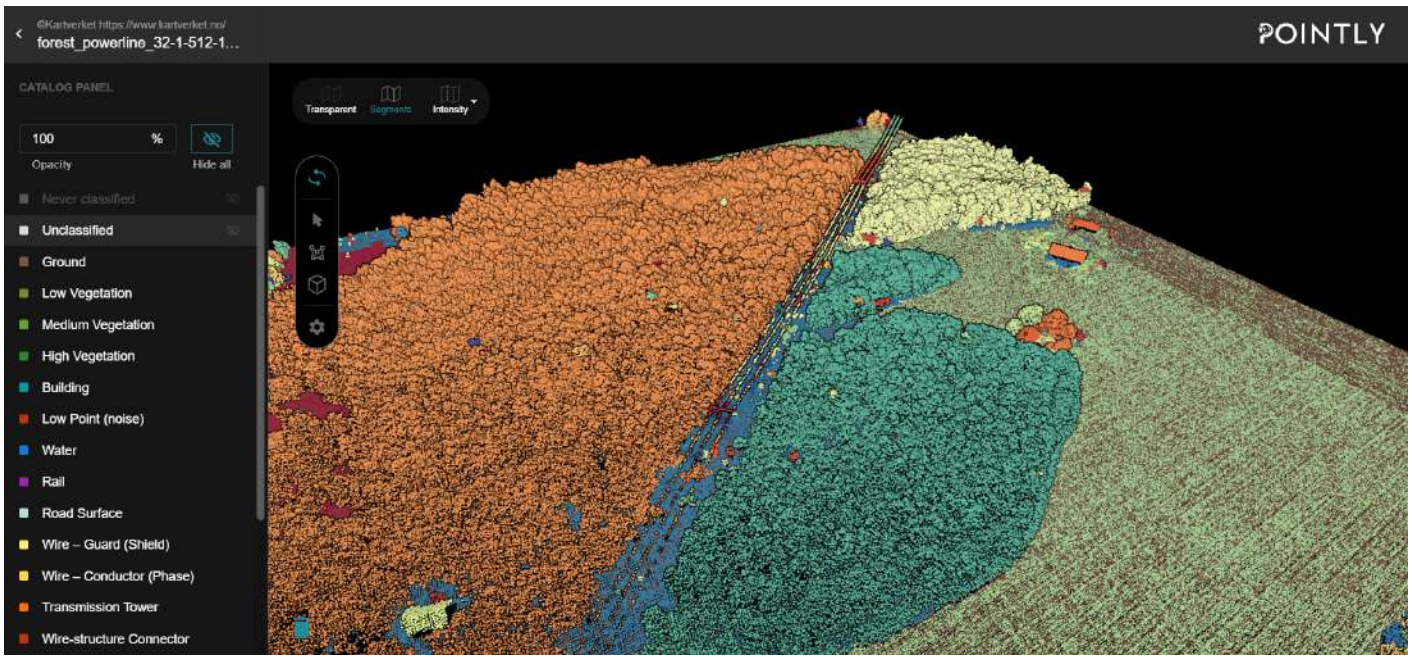


Figure 1: Segment view of a point cloud in Pointly (the classes on the left side do not reflect the color of the segments).

"Though, it's hard to say how much data you exactly need and how good the quality of the raw data needs to be. That always depends on the complexity of the use case. We usually evaluate this on a first sample dataset with our customers and define their exact requirements to figure out what's necessary and possible with our approaches", Sid Hinrichs states.

Challenges of Pointly's Approach

LiDAR point clouds of trees can be extremely diverse depending on the applied acquisition method (e.g. airborne or terrestrial LiDAR scanning). That is why one of the biggest challenges was to develop algorithms based as little as possible on the specific characteristics of the different scans, so that they could be used universally. Those differences could be:

- Flight altitude
- Density of the point cloud
- Time of flight (e.g. winter or summer)
- What was measured (some scanners measure partial reflections of the laser, some don't, sometimes intensity is part of it or not).

Another factor is that trees are very diverse themselves and can have different dimensions on different parts of the world. Even the time of the year where the scan was performed is an important factor to consider. The same tree can look very different between summer and winter. Developing universal approaches required testing and adjusting different methods like watershed separation or region growing from detected tree stems.

Implementation

The Pointly team developed a processing pipeline that takes point clouds as input and outputs a shapefile with the location and metadata of single trees. The pipeline combines deep learning and different smart algorithms to identify tree points and separate individual trees from above, both with visible tree trunks and without.

Figure 2: Various types of trees in different seasons.

Figure 3: Classified point cloud in Pointly with vegetation, ground, powerlines (etc.).

Initially, the vegetation and other classes like Ground, Buildings, Low + High Vegetation, Power Lines, Poles and Vehicles were classified manually to generate a comprehensive set of training data for training a neural network. However, by the use of the Pointly Platform and its easy-to-use selection tools this task could be performed in just a few days of effort. Using the neural network, the classification can be fully automated. Additional point cloud dimensions such as Intensity values or number of returns from the LiDAR scanner are important features for this classification step.

Using the classification, all points including high vegetation can be then extracted and all remaining points are filtered out. To determine the single tree instances from the high vegetation points some additional processing steps need to be performed. These steps for the instance segmentation are traditional GIS methodologies which need to be adopted to work optimally on the present dataset. To reach the desired results, a combination of tree features such as crown maxima, tree stump positions and more geospatial algorithms is used. Stump position and height can be determined for each tree segment, whereas the crown extent is determined by means of 2D projection.

Afterwards, the results of classification and instance segmentation can be transferred into other common geo data types (i.e. GeoJSON, Esri shape file) and are enriched with additional information such as height attributes and diameters.

Possible Results

Pointly's goal is to enable a more efficient forest inventory to provide exact tree point identification in the point cloud as well as individual tree separation with corresponding inventory data such as object-ID, exact position, height or crown's extent as a result.

The actual output and analysis per object can be extended or adapted from case to case. With the applied approaches it is also possible to differentiate between deciduous and coniferous trees.

Conducted inventories can be delivered as a map layer, including tree counts, canopy shapes as well as tree heights and additional metrics. The generated outputs can be further adapted to the client's needs and for example be provided as a CSV or condensed to a report. The actual classified point cloud, including information about the tree instances can be delivered as well. The point cloud data can become quite large but can be useful for further analysis or visualization purposes.

If you are interested in getting your own automated forest inventory with the help of Pointly or have other Use Cases considering trees (like change detection or evaluations of the health of the trees, risk analysis, etc.) you can get in contact with Pointly via www.pointly.ai or email to info@pointly.ai.

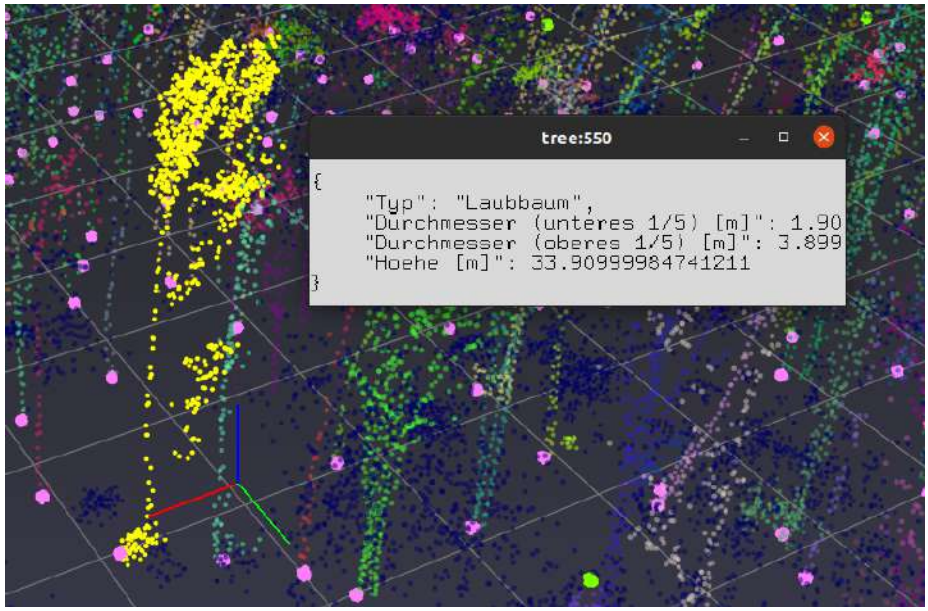


Figure 4: Deciduous trees with attributes.

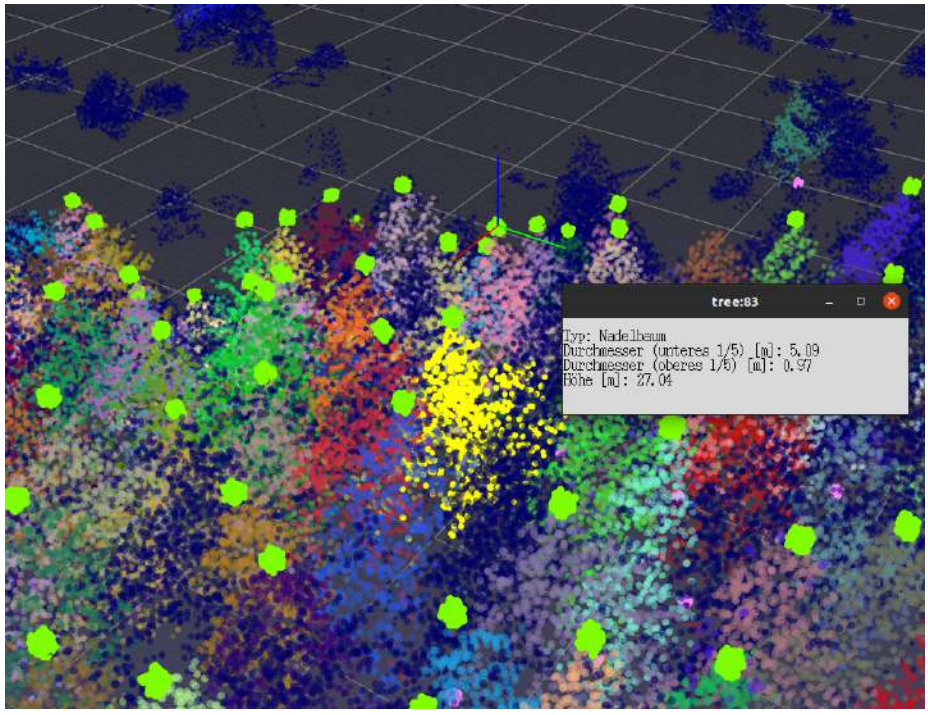
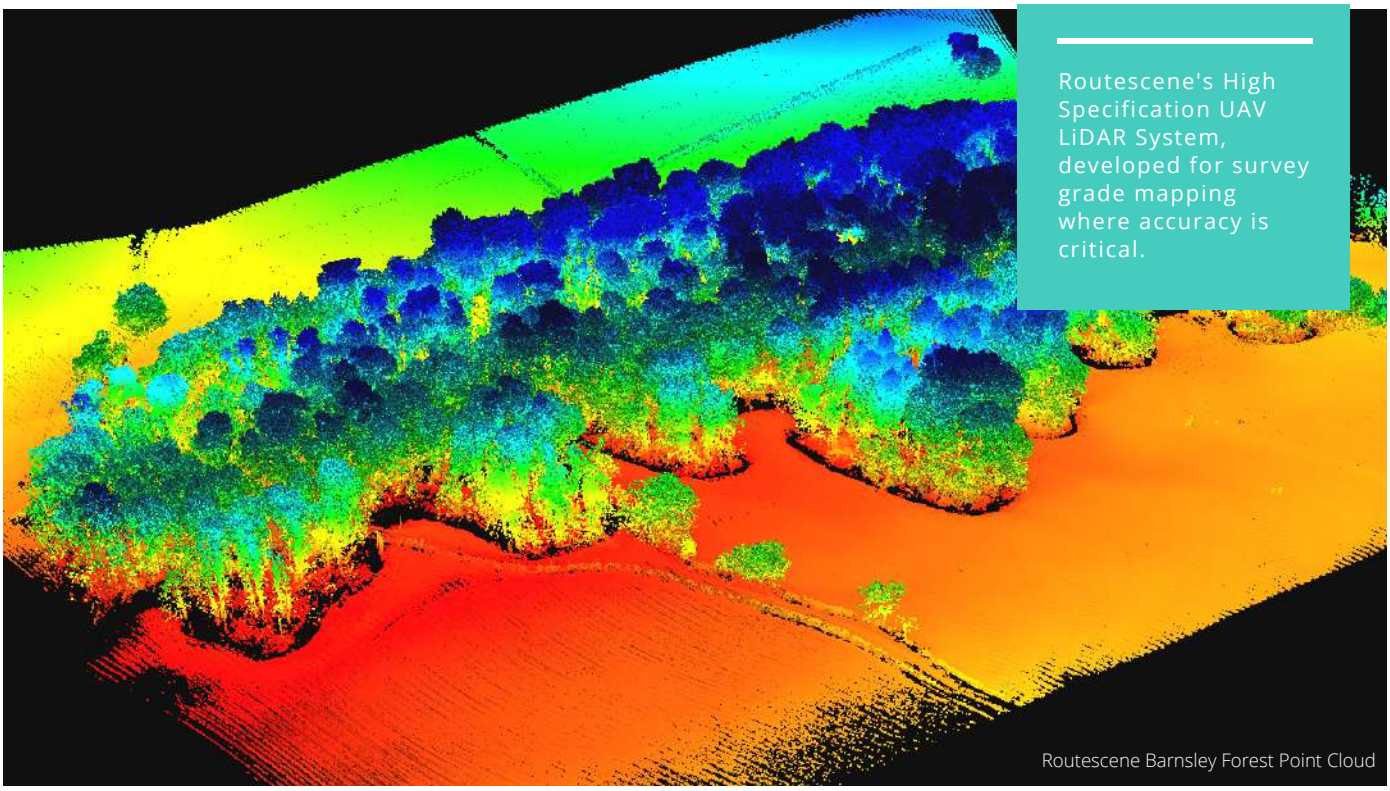


Figure 5: Coniferous trees with attributes.

How UAV LiDAR Technology is Transforming Operational Forest Management

Routescene® design, develop and manufacture integrated 3D LiDAR mapping solutions specifically for use on drones.



Routescene's High Specification UAV LiDAR System, developed for survey grade mapping where accuracy is critical.

Routescene Barnsley Forest Point Cloud

This case study from Routescene demonstrates the value of UAV LiDAR derived point cloud data for operational forest management. Traditionally gathering metrics and information for forest management has been undertaken using airborne photogrammetry or by manually walking the site. More recently airborne LiDAR has been recognized as a useful tool and now drone derived LiDAR data is proving its significant worth to monitor and manage the health and value of a forest.

Point cloud data and the Digital Terrain Models (DTMs) created can be used to establish meaningful metrics such as tree height and growth rate. These measurements are critical to assess forest health, limit the spread of diseases, prepare carbon capture and biomass estimates, ascertain drainage patterns and fuel load estimates for forest fire prevention.

The UAV LiDAR Forestry Survey

An area of woodland (10.9 acres / 4.4 hectares) was surveyed in Yorkshire, UK. The equipment used for this project was Routescene's High Specification UAV LiDAR System, developed for survey grade mapping where accuracy is critical. The Velodyne HDL-32 LiDAR sensor used in this system has a proven record of

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This article was written in collaboration with Dr Chloe Barnes, 2Excel Geo.

robustness, high accuracy and high resolution. It can operate in dual return mode and provides a scan rate of up to 1.4 million points per second from 32 different lasers with a wide field of view. This means the system excels in the penetration of dense vegetation enabling both the ground and individual trees to be mapped to a high level of detail.

For this project a critical metric to be determined was the "Diameter at Breast Height" (DBH) for each tree. This is challenging as it requires as high resolution data as possible to be captured of the tree trunk. To achieve this the drone needs to be flown in tight flight lines and low and slow over the canopy. This demands careful survey and flight planning, factoring in extra flying time, and to accurately determine the safety margin between the drone and the canopy to avoid any collisions with particularly tall trees.

The drone was flown at an average height of 45m and velocity of 5m/s. This enabled the UAV LiDAR system to collect a total of 8,912,679 points, used to create an incredibly dense 3D georeferenced point cloud. This high point density meant trees could be individually identified, with metrics and information extracted on an individual tree basis. This approach is particularly useful in variable heterogeneous forest environments such as this site.

Processing the Results

Processing for this project was undertaken using Routescene's proprietary LidarViewer Pro software, designed specifically for large LiDAR survey datasets.

Identifying individual tree crowns

From the LiDAR point clouds the identification of individual tree crowns can be achieved through many approaches. For highly detailed point clouds such as the Barnsley dataset, algorithms to identify individual trees can be applied directly to the LiDAR point cloud. This typically provides a more detailed segmentation as the methodology uses information from the point cloud to locate and identify individual trees. Following segmentation structural metrics can be derived using all points associated with the tree. The individual tree identification using the entire point cloud for the Barnsley dataset identified a total of 321 trees.

Creating a DTM to assess ground characteristics

A Bare Earth Model or DTM was created in LidarViewer Pro by using a series of filters to extract the model.

The Bare Earth Model is in the first instance created within the computer's memory using a grid of cells containing statistical information (min, max, mean, standard deviation). The minimum height values are used to seed the model and then these points are moved downwards based on the topology of adjacent cells. This iterative process results in a Bare Earth Model which removes features such as buildings and trees, whilst retaining the natural topography.

The resultant model is then used as a filter in its own right, with the whole point cloud being passed through the model, and any point that is within a certain distance of the model will be retained, whilst the rest of the points are discarded. This method allows for a very high-resolution ground model to be created.

DTMs generated from points classified as ground returns can be a useful dataset for forest management. In particular, information about ground characteristics such as slope can inform the planning and execution of timber harvesting, by establishing where ground could be waterlogged to best locate skid trails and prevent excessive damage by forestry equipment; and to inform drainage planning.

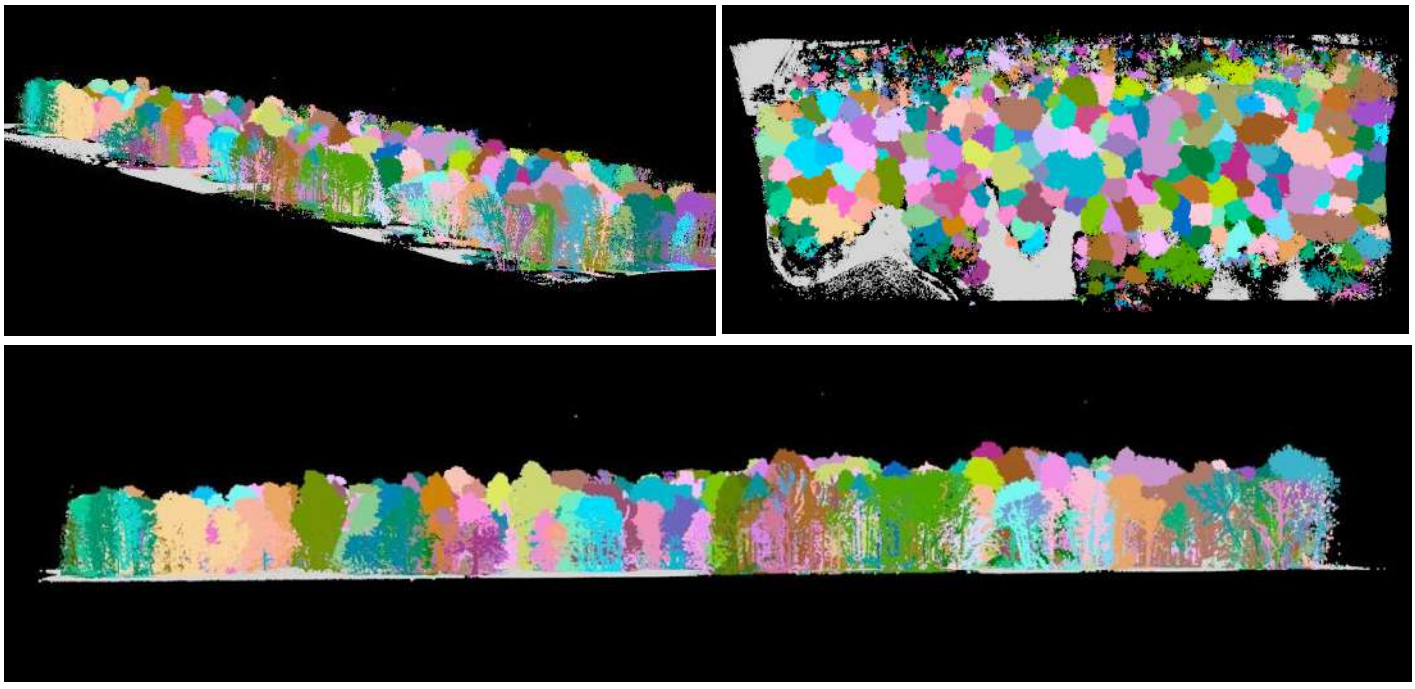


Figure 1: Detailed tree segmentation to individual tree level.

Standard height metrics

Standard metrics summarizing height can provide a basic overview of the forest structure. This can be calculated for the forest stand or calculated for each individual tree. A forest stand is a contiguous community of trees sufficiently uniform in composition, structure, age, size, class, distribution, quality, or location to distinguish it from adjacent communities. Due to the strong relationship between canopy height and other biophysical parameters, this data can be used to estimate information such as stand volume, biomass, basal area and mean stem diameter.

Applications in Forest Management

The given metrics (Table 1) and other structural information that can be derived from point clouds can be useful for a variety of forest management tasks.

Forest fire mitigation

Canopy bulk density (CBD) and canopy base height (CBH) are important parameters for canopy fuel estimation in fire modeling.

Standard Height Metrics	Stand
Average Height	12.56m
Standard Deviation	4.19
Skew	-0.59
Percentiles	
P50	13.20m
P75	15.73m
P90	17.45m
P95	18.25m

Table 1: Standard height metrics.

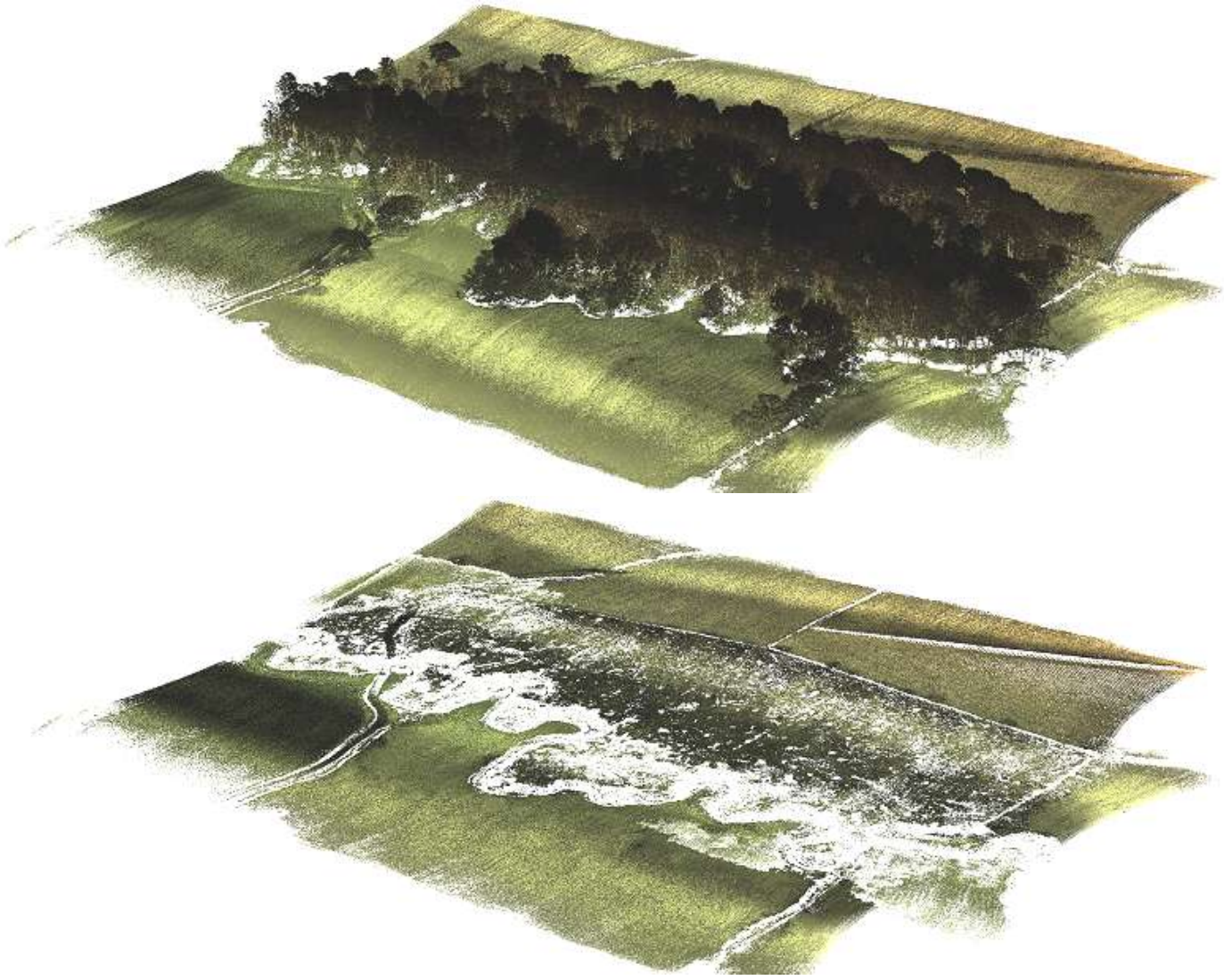


Figure 2: Point cloud of the woodland (top) and Bare Earth point cloud (bottom).

CBH is the average height from the ground to the underside of the canopy.

Identifying disease

Bicentile metrics which represent the percentage of LiDAR returns recorded at different tree height percentiles have been used alongside canopy cover and canopy density metrics for the detection of canopy defoliation associated with disease.

Carbon sequestration

LiDAR metrics have been used to derive information pertinent to carbon sequestration which enables the amount of carbon dioxide that is stored in the forest to be quantified. The Woodland Carbon Code (WCC) (www.woodlandcarboncode.org.uk) is the quality assurance standard for woodland creation projects in the UK, and generates independently verified carbon units. The WCC has created a carbon assessment protocol which details how the biomass of existing woodland is to be determined. Some of the steps to undertake the carbon assessment include: deriving a tree stem volume estimate for each species; estimating, for each stand of trees, the allocation of biomass in different parts of the tree; and then finally converting the biomass estimates to their carbon equivalents.

Measuring forest changes over time

Investment in forestry is a long term strategy both for environmental and commercial purposes. The repeated assessment of a forest over time will highlight structural changes for example defoliation, which can be associated with disease, and can be used to identify and limit outbreaks of pests and infection. Such monitoring over time also informs growth rates, the carbon sequestration, the windthrow, deforestation and post-harvesting residue quantification.

Conclusion

The resulting survey produced DTMs that will inform future conservation and land management. High resolution LiDAR point clouds provided 3D data for the detailed assessment of forest structure at the individual tree level.

This information can be useful for tree mapping, timber volume, biomass volume and pre-harvesting assessments. Repeating the survey will inform structural changes through the seasons and over time. LiDAR technology can also be fused with other remotely sensed information such as hyperspectral or thermal imagery which could provide an even more accurate picture of the health of our forests and assist with the classification of tree species. As LiDAR and other remotely sensed technology continue to develop, more information can be acquired to help prevent forest decay and inform conservation.

The information collected can be utilized for a number of different scales to provide information to

forest management activities. For example, even though small proportions of a complete forest may be scanned using a UAV LiDAR system, describing the characteristics of these parcels can provide sufficient representative information for the majority. The results can be used to develop management objectives, for instance growth monitoring and harvesting planning.

About Routescene®

At Routescene® we're always looking beyond the point to help solve real problems. We design, develop and manufacture integrated 3D LiDAR mapping solutions specifically for use on drones. Designed by surveyors, our survey-grade end-to-end systems solve specific industry problems, save time, improve efficiencies and increase productivity. We've made it simple for you.

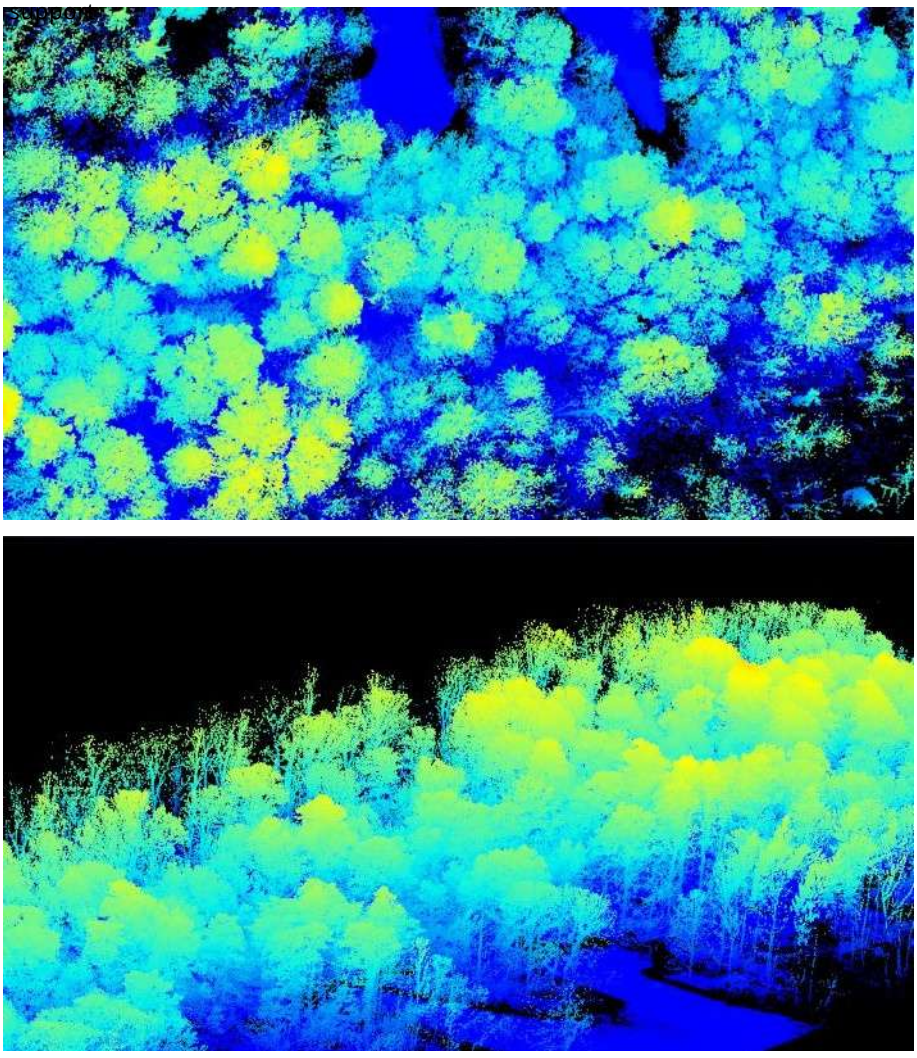
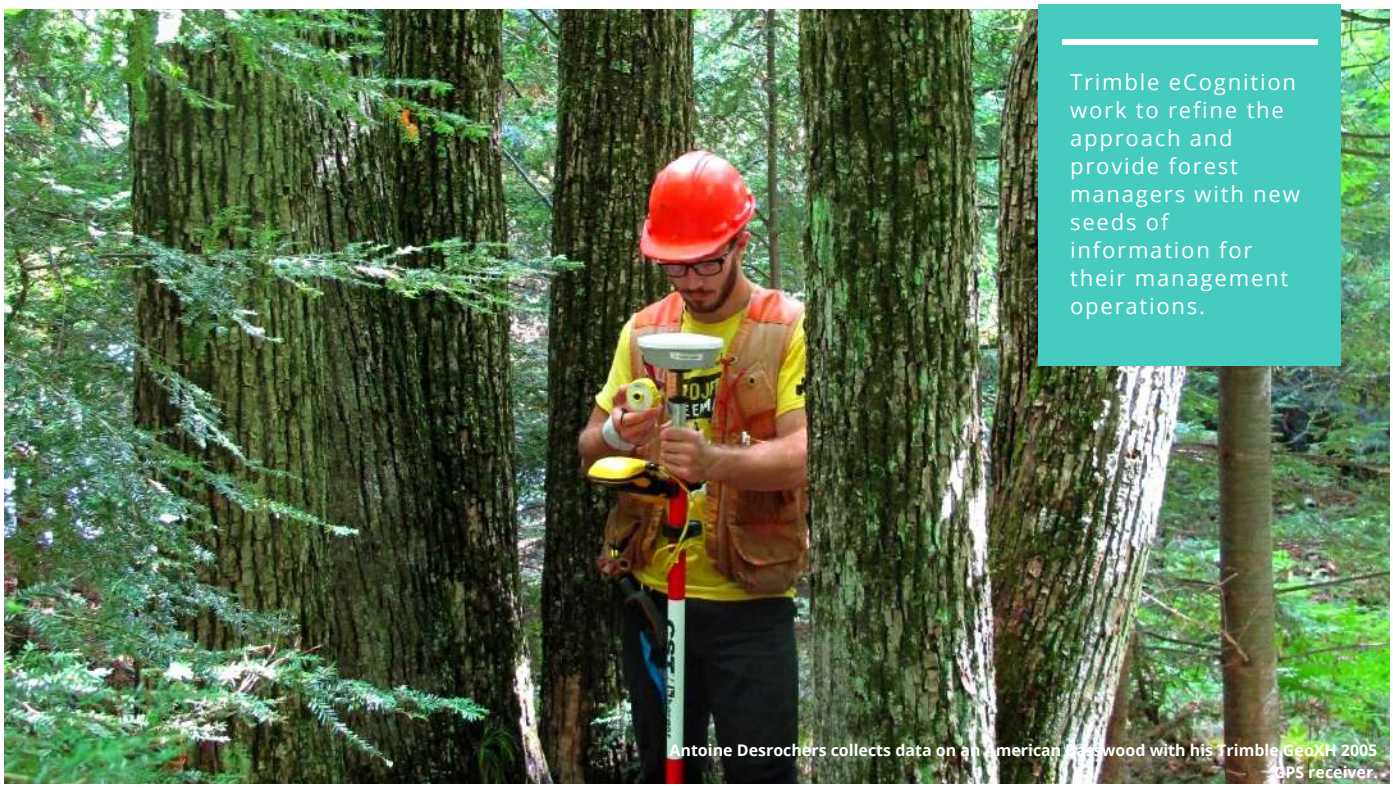


Figure 3: LiDAR point cloud showing the effects of defoliation.

Into the Woods

The CERFO team shared the results with forest managers, many of whom can already see the potential value in having a tree-specific data layer in their GIS for developing targeted harvesting or planning.



Antoine Desrochers collects data on an American beech wood with his Trimble GeoXH 2005 GPS receiver.

Trimble eCognition work to refine the approach and provide forest managers with new seeds of information for their management operations.

Forest management in the Canadian province of Quebec is serious business. With forest landscapes that cover an area twice the size of Sweden, Quebec's forest industry is valued at around $10 billion CAD ($7.8 billion US), the second largest amount of any Canadian province, and employs about 65,000 people.

Managing Quebec's forests is also serious business.

Although forest managers have used geospatial tools such as aerial photography, optical satellite imagery and GIS software to assess their properties, the process of classifying forest land and delineating forest stands, i.e., a contiguous group of trees that are sufficiently homogeneous in species, density and size, has typically been a laborious combination of photogrammetry and drawing features by hand.

"Standard practice is to manually delineate forest species at the stand level, which is time consuming and subject to misinterpretation," says Mathieu Varin, head of the Centre D'enseignement et de Recherche en Foresterie de Sainte-Foy (CERFO) remote sensing laboratory. "Automizing that process and scaling it down to classify individual trees would allow managers to individually oversee specific tree species and develop targeted silviculture and harvesting plans."

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As an applied research center, Quebec City's CERFO has been a key supporter of the forestry business. Working with partners and forest managers, CERFO develops tools to help owners better manage, assess and inventory their present-day holdings in order to develop long-term operational strategies.

In his work at CERFO, Varin has spent considerable focus on using satellite imagery and object-oriented image analysis (OBIA) technology to build an automated forest classification and mapping solution that would target mapping trees at the individual tree level.

His recent research has centered on using very high-resolution satellite imagery, LiDAR data, and Trimble's eCognition OBIA software to study the ability to automatically identify individual Broadleaf and Conifer trees in dense, complex forests–trees that are especially challenging to classify.

"Identifying and delineating Broadleaf trees are difficult because their branches are interlaced and the individual tree crowns are not always pure," says Varin. "It is particularly difficult to classify them in stands that contain trees of the same height and age. And in Broadleaf-dominant forests, Conifer trees like Balsam Fir are challenging because they are generally small and they'll be in the Broadleaf's shadow. However, the analytical intelligence of OBIA software makes classifying and mapping these tree types possible."

Based on the promising results, Varin may be cultivating a new path for efficient, targeted tree management.

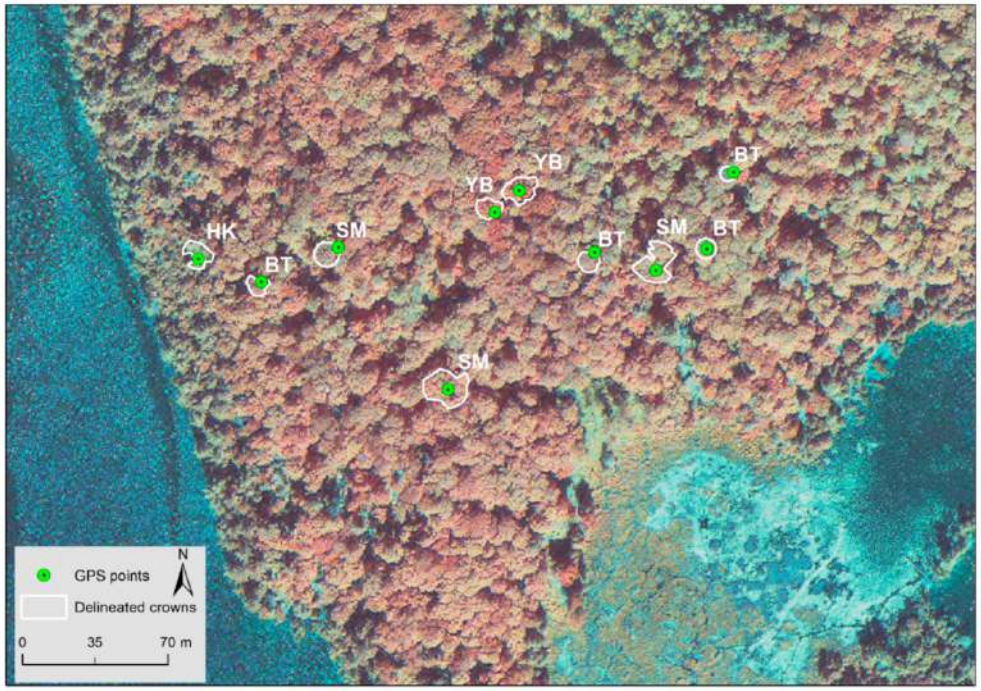


Figure 1: Based on GPS positions, a team used photo interpretation to manually delineate tree crowns to fit the crown to the correct tree on the WorldView-3 images. The background image displays WorldView-3 in false colors (infrared, green and blue).

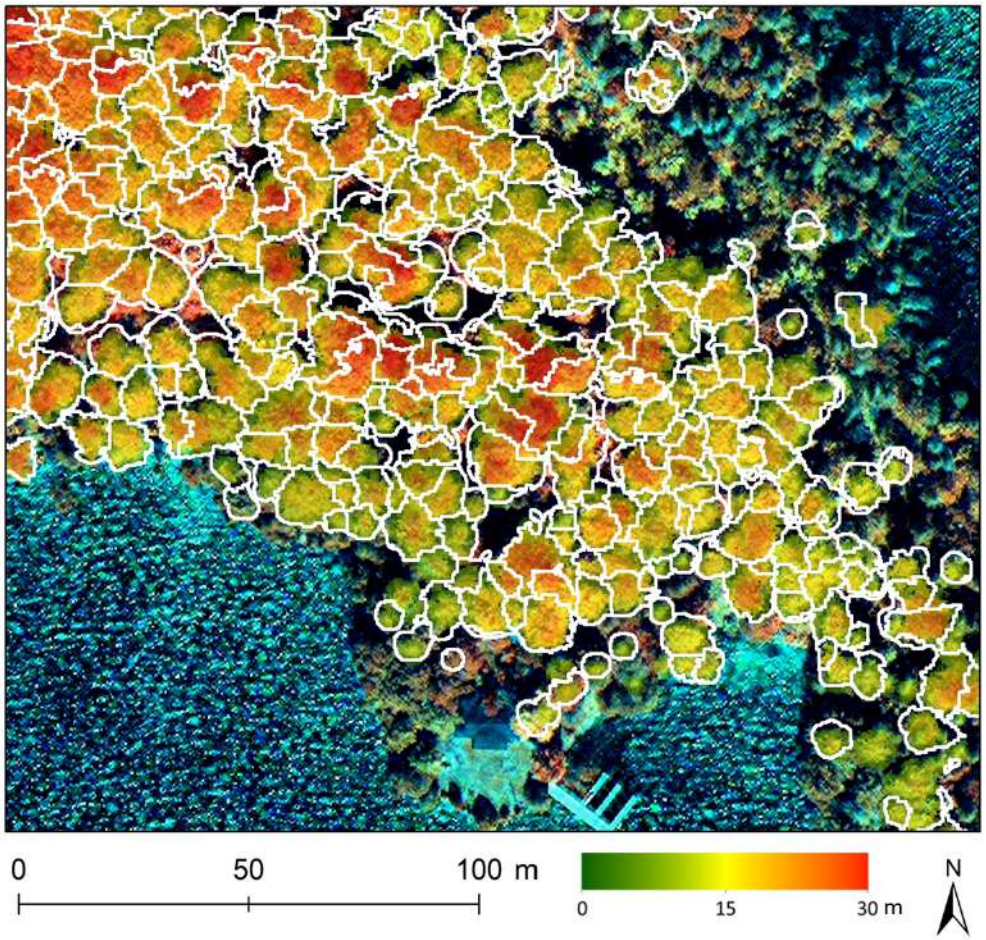


Figure 2: Individual tree crown segmentation based on LiDAR (canopy height model) and WorldView-3 imagery. The background image displays WorldView-3 in true colors.

Tree-specific

Varin and colleagues not only wanted to test the automated classification method on Broadleaf and Conifer species, they wanted to test it in a complex forest. They chose three areas of interest (AOI) totaling 26 square kilometers in the Kenauk Nature preserve, one of the largest private nature reserves in North America. Located in the southwest of Quebec, the property encompasses 26,000 ha (65,000 ac) of heterogenous forest.

For the data analysis and classification they acquired two 30-cm WorldView-3 satellite images, orthorectified them with a 5-m LiDAR DEM and then mosaicked them. The LiDAR data was also used to create a canopy height model (CHM) which they overlaid on the mosaic.

Based on existing aerial imagery, researchers first identified relevant trees for field data collection. Using Trimble Pro 6H GPS receivers, teams navigated to the pre-selected trees in each AOI to capture their position, height, diameter and species type. In total, they surveyed 515 trees, which they further processed into 338 reference samples for both training eCognition and validating the results.

With the data sources prepared, Varin and his team were ready to test the eCognition classification workflow. Using advanced artificial intelligence and machine-learning algorithms, the software focused only on trees higher than 17 meters and used the WorldView mosaic and the CHM to first segment the whole AOI into individual tree crowns. From there it considered pre-defined object thresholds and textural indices to identify and delineate Broadleaf trees from Conifers, and then it targeted the individual species within those two groups. In about two hours, eCognition classified 11 tree types including Red Oak, Sugar Maple, Balsam Fir, Eastern Hemlock and White Spruce.

"The delineation process was surprisingly quick and precise," says Varin. "The overall accuracy for Conifers was 94 percent. That is very good considering the complex heterogeneity of the AOI."

The CERFO team shared the results with forest managers, many of whom can already see the potential value in having a tree-specific data layer in their GIS for developing targeted harvesting or planning. They also recognize the value of this OBIA-based approach as a viable enhancement to the traditional classifying and mapping methods using photogrammetry.

Supported by that positive feedback, Varin and colleagues are furthering their eCognition work to refine the approach and provide forest managers with new seeds of information for management operations.

"A significant research and development advantage with eCognition is that it's incredibly teachable," says Varin. "Through this project we developed a workflow with which we can repeat the same process or we can challenge the software to extract a whole new set of details that we haven't produced before. Because it absorbs various forms of data, strictly follows rules and adapts when the information or rules change, it really is an ideal student."

Such a learning environment could lead to exciting new branches of tree analysis for the serious business of forest management.

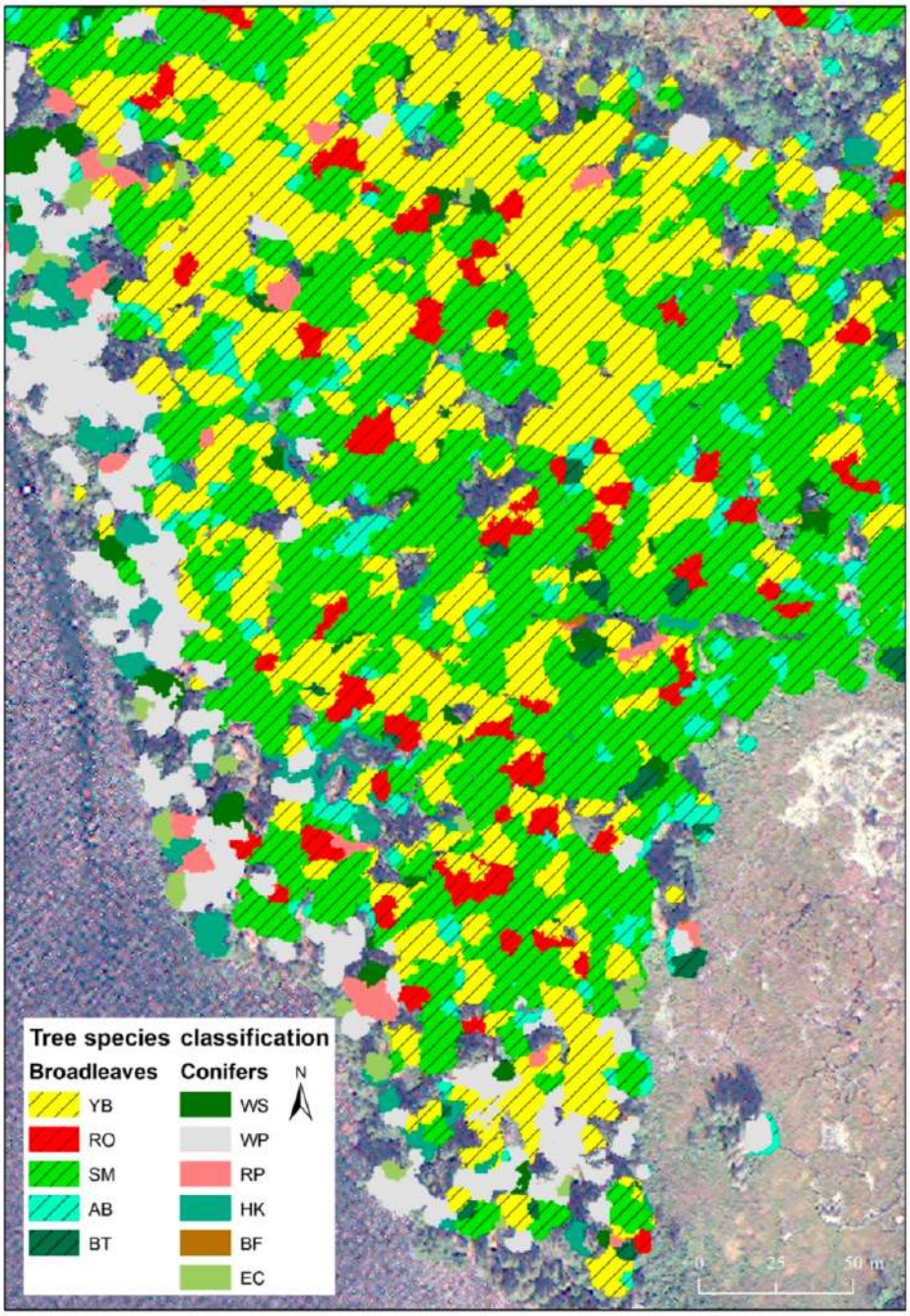
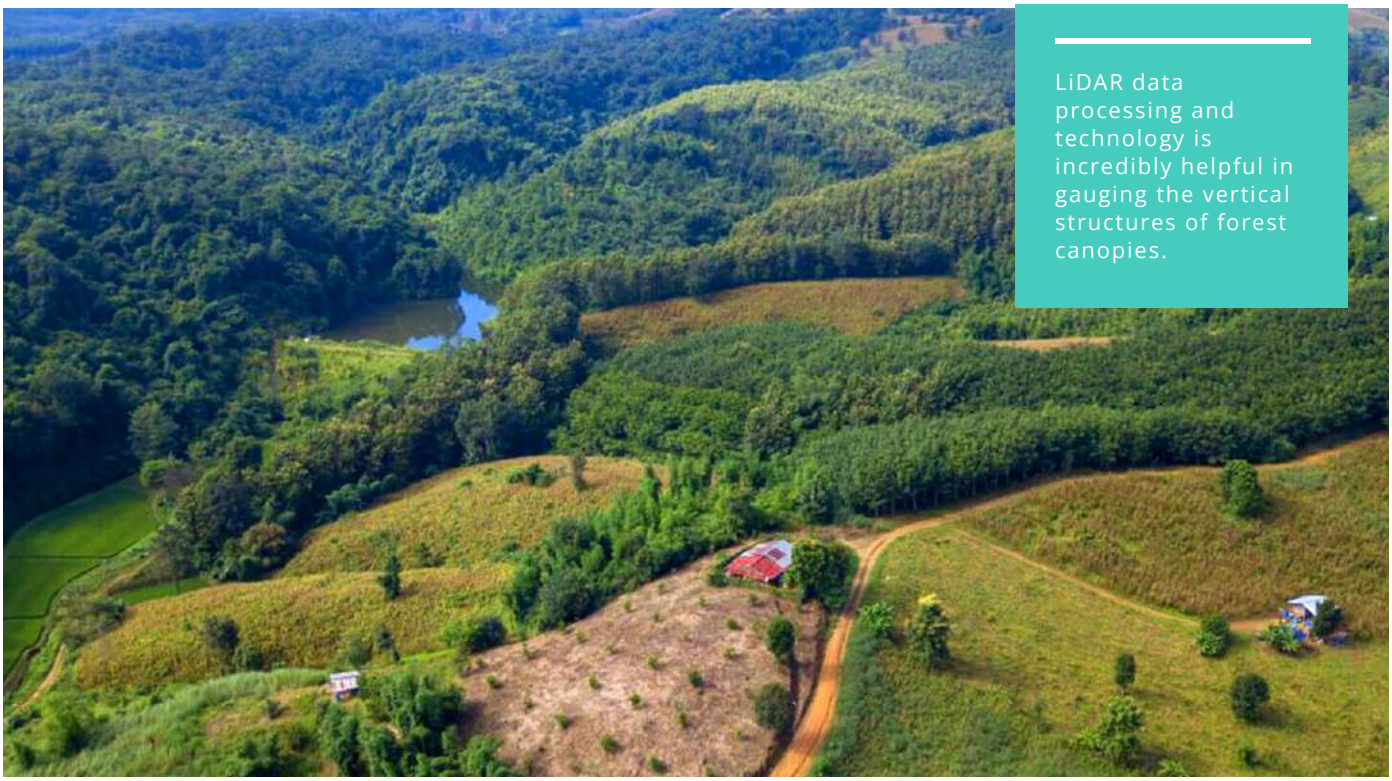


Figure 3: In total, it took eCognition about two hours to classify 11 tree types including Red Oak, Sugar Maple, Balsam Fir, Eastern Hemlock and White Spruce.

LiDAR Technology in Forestry Mapping

LiDAR provides high-precision data pertaining to forest ecology or the habitats belonging to densely vegetated regions.



LiDAR data processing and technology is incredibly helpful in gauging the vertical structures of forest canopies.

Light Detection and Ranging (LiDAR), a breakthrough technology when it comes to remote sensing for forest inventory management and forestry applications. LiDAR data processing tools and techniques enable the technicians and forest professionals for mapping and determining diverse forest structural characteristics such as canopy, vegetation, speciation, etc.

The forest professionals estimate the stand volume, canopy heights, aboveground biomass, basal areas, and other varied aspects of forest for project uses and are prime examples of use of remote sensing in forestry thus the use of LiDAR instruments are providing accurate results for all above. LiDAR has been a breakthrough technology when it comes to forest management and mapping. LiDAR has made it possible for forest professionals and scientists to map the forest terrains and make sure to keep it as a natural resource for years. LiDAR remote sensing in forestry thus the use of LiDAR instruments are providing accurate results.

LiDAR in Forestry Management

Planning of forests and their management

LiDAR data processing and technology is helpful in gauging the vertical structures of forest canopies. The density, height, timber volume, basal area, and biomass may be with success obtained from measuring systems.

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As an example, small-footprint LiDAR can give elaborate measurements of various types of cover prime topography. Even the biggest canopies may be understood simply by measuring with LiDAR services. These tools give correct data for classifications of ecological various scientific uses of forest resources. Measuring systems like the LiDAR additionally facilitate in understanding sophisticated forest structures for generating possible forest inventory.

Forest mapping and precision forestry

LiDAR knowledge offers in-depth and correct analysis of geographical terrains and also the quality of forests in those areas. The standard of soil, elevation of land, and every one alternative factor to be thought-about for mapping forests is obtained through different LiDAR services. LiDAR inputs are equally helpful for increasing website productivity in context to overall yield, quality of trees, etc. they supply precise knowledge for specific wooded sites in order that they'll be targeted to achieve the required results.

Prevention of forest fires

The latest measuring device used for accustomed map, manage-monitor the unfolding and damages attributed to wildfires. LiDAR services provide correct insights concerning the terrains and forests that may be protected once a wildfire breaks out. Advance planning will scale back the risks of permanent damages to an over-sized extent. It helps response crews set up evacuation procedures and routes in property ways that before the hearth becomes uncontrollable.

Ecological and land Classification (ELC)

ELC and connected remote sensing services give high-end correct data regarding specific wooded areas and landscapes. Conventionally, this kind of knowledge was obtained through exploitation. LiDAR technology provides additional data for estimating and phase transition upon the land that ought to be committed to forestry. The areas that ought to be allotted to environment management, forest infrastructure, etc. may be determined with accuracy with the assistance of measuring device information.

Study of forest ecology

LiDAR provides high-precision data pertaining to forest ecology or the habitats belonging to densely vegetated regions. The knowledge helps researchers perceive the sort of animals that inhabit specific forest regions and the species capable of living in them. There are many LiDAR system varieties (ground, mobile and aerial based) that suggest pathways that contribute to the forest system, thereby increasing edges to an out sized community of researchers.

Polosoft Technologies being an avid LiDAR company intends to throw light on some important applications of LiDAR technology in forestry. LiDAR technology can help forest managers in handling significant impediments through useful and tailored approaches based on accuracies and resolutions.

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RIEGL Ultimate LiDAR in Forestry

RIEGL scanners capture and provide highly accurate, extremely effective, and good-quality 3D LiDAR data.

RIEGL Ultimate LiDAR™ provides an extremely accurate, efficient, and reliable data capture process for forest monitoring and management.

***RIEGL* VZ-400i Terrestrial Laser Scanner and *RIEGL* VUX-120 UAV LiDAR Sensor during a joint field campaign in the forestry sector.**

Forests are critical to the environment's health. Their ability to regulate climate and water resources, carry out ecological functions and provide habitat for plants, animals, and human beings makes them the backbone of biodiversity. But unfortunately, these ecological primers are rapidly disappearing due to the challenges of the 21st century climate change and global warming. Deforestation is not only considered as one of the leading causes of global threats, but these pressures in return also impact the existing conditions of forested areas.

For tracking the changes in climate and better accessing of forest structure, disturbance, management, and resources, LiDAR (Light Detection and Ranging) is identified as an indispensable tool[5]. The laser scan data does not only save time but also aids in post-processing. LiDAR is a breakthrough remote sensing technique that gains appreciation from scientists around the globe due to its unprecedented accuracy. It has immensely modified digitization in multiple fields of applications due to high accuracy and meaningful data acquisition of large areas.

LiDAR technology has revolutionized forest structural characterization in recent times[1]. It has emerged as a vital tool for assessing Vegetation

About Author

Saurabh Singh

M.Tech. in Geomatics
A Geospatial Enthusiast

Canopy Structure (VCS). This is especially true for dense and complex forest canopies that prohibit manual and destructive sampling.

It doesn't matter how advanced the technology is, what counts are the instruments that gauge the ability of any technology. *RIEGL* is a leading developer and provider of laser scanners and laser scanning systems, and has been for more than 40 years. It has a proven record in research and development by producing world-class laser sensors with cutting-edge technology that fulfill the measurement tasks with absolute accuracy.

LiDAR in Forestry

Background knowledge regarding LiDAR would be helpful before bringing the subject to the most recent advancements in this field. Airborne laser profile systems were first introduced in the late 1970's and early 80's, but were commercialized only in the mid 90's. Every literature that talks about LiDAR agrees on the fact that Europeans have taken the lead when it comes to this technology.

Professor Friedrich Ackermann is referred to as the 'pope' of LiDAR technology in the European world. His motivation to study LiDAR was based on the requirement of Digital Elevation Models (DEMs) in forests[2]. Furthermore, in the early 2000's LiDAR developments in forestry progressed as it was used to perform three-dimensional (3D) analysis of forest structure and terrain. Since then, there is no looking back as many foresters and researchers consider LiDAR as the break-through Remote Sensing (RS) technique for forestry applications.

Furthermore, its ability to map topography and forest canopy with an ultra-high level of accuracy is unparalleled to any other remotely sensed data. Researchers have evaluated individual leaf-off deciduous trees, specified forest inventory parameter including timber volume and stem density, predicted single stem volumes, etc. by utilizing LiDAR.

Kinds of LiDAR

Classification of LiDAR sensors can be performed based on their platforms, underlying technologies, and mode of operations. If the sensor is attached to a fixed-wing aircraft, helicopters, or unmanned platforms the LiDAR scanning will be termed as airborne laser scanning (ALS). Whereas, if the technology utilizes static laser scanners, then it is coined as terrestrial laser scanning (TLS).

However, both ALS and TLS are well-established and renowned capturing technologies for forest applications. If on one hand, ALS data allows for forest mapping at a large scale, TLS data on the other hand delivers point clouds at a high level of detail for relatively smaller regions. Hence, TLS data, covering small parts of the area acquired by an airborne campaign, may be useful to "calibrate" the airborne-based estimation of forest inventory parameters. This is how the two data acquisition procedures complement each other optimally.

In recent times however, due to the advancements in technology, the usage of small unmanned aerial vehicles (UAV) has dramatically increased. UAVs have been recognized as important remote sensing tools, thanks to novel algorithms such as Scale Invariant Feature Transform (SIFT), that can directly geo-reference and rectify imageries using low-accuracy camera positions. These platforms can be altered and fitted with various sensors such as laser scanning sensors or digital cameras.

There are multiple companies that manufacture scanners and scanning systems for users but one that is known for its outstanding technology, assembling, and potency is the famous *RIEGL* Laser Measurement Systems.

***RIEGL*'s Ultimate Waveform LiDAR™ Technology**

RIEGL delivers guaranteed innovations in 3D. Its scanners capture and provide highly accurate, extremely effective, and good-quality 3D data. The brand gained the trust of its customers by committing to supplying quality, reliability, durability, and highest performance products and services. Its priority is to serve the users with cutting-edge hardware for all kinds of LiDAR technologies i.e., terrestrial, industrial, mobile, airborne, bathymetric, and UAV-based laser scanning coupled with equally state-of-the-art software packages. This combination results in outstanding data acquisition and processing that in return yields potent solutions for a wide range of surveying applications.

The digitization of waveform signals is the fundamental technology of the *RIEGL* laser measurement systems. It offers distinctive methodologies for resolving range uncertainties, multiple targets per laser shots, optimal measurement distribution, calibrated amplitudes, and reflectance estimates along with continuous integration and system components correction. Additionally, the Ultimate LiDAR™ 3D scanners from *RIEGL* have a wide range of performance characteristics and assist in continuously serving as a foundation for constant 3D innovation in this industry.

RIEGL's Ultimate Waveform LiDAR™ technology emphasizes pulsed time-of-flight laser radar technique in numerous wavelengths. The comprehensive range of *RIEGL* LiDAR sensors and systems delivers an extraordinary high-density point cloud ideally appropriate for further post-processing in forestry. Advanced processing methods ensure that all the information in the scan data is exploited rightfully in every possible way. Excellent vegetation penetration and the computation of comprehensive terrain models are made possible by the multi-target capabilities. Point classification is the foundation for tree detection, tracking growth, height modeling, and detection of Coarse Woody Debris (CWD).

A few examples of the airborne (ALS), terrestrial (TLS), and UAV-based (ULS) scanners manufactured by *RIEGL* are discussed in the next section.

Airborne Laser Scanning

Airborne LiDAR or laser altimetry technically referred to as airborne laser scanning is an active remote sensing technique that determines the topography of the Earth's surface by measuring the round-trip duration of an emitted laser pulse. The principle involves a photodiode that records the backscattered echo from a laser that discharges brief infrared pulses towards the Earth's surface. It aids in capturing 3D data of large areas, for instance, agricultural and forestry sites with extreme accuracy, effectiveness, and promptness. Besides, airborne laser scanning is one of the best and most important methods for gathering data for forest resource management.

RIEGL airborne laser scanners and scanning systems are quite reliable as they utilize up-to-date state-of-the-art laser processing technology. They are aimed to meet the most demanding requirements in airborne surveying and are exceedingly compact, easy to handle, and cost-effective.

RIEGL produces a wide range of airborne scanners and scanning systems. *RIEGL*'s VQ-1560 Series is specially designed for covering large areas. These Dual Channel LiDAR scanning systems offer additional bays for two cameras and a high-performance inertial measurement unit (IMU) / global navigation satellite system (GNSS) unit complements the system. The two cameras used are a 150 megapixels RGB camera and a thermal or near-infrared (NIR) camera. The former is used as the primary camera while the latter is secondary. The design features a mounting flange for interacting with typical hatches or gyro-stabilized leveling mounts, making the system ready for straightforward integration to helicopters and fixed-wing planes.

One of the scanning systems of the *RIEGL*'s VQ-1560 Series named as VQ-1560i-DW Dual Wavelength LiDAR system is especially suited for applications in forestry. It combines two laser beams at two different wavelengths, i.e., green at 532 nm and infrared at 1064 nm, each operating at a laser pulse repetition rate of up to 1MHz, resulting in a total of more than 1.3 million measurements on the ground per second. Also, it formulates two separate point clouds with intensity registering in green and infrared wavelengths. The VQ-1560i-DW allows the derivation of 3D spectral indexes like the Green Normalized Difference Vegetation Index (GNDVI) throughout the canopy.

So, the condition of forests can be monitored by detecting spectral changes in the lower parts of the tree crowns, where the first indicators for tree diseases unfold. Additionally, the forest understory can be mapped, which is prone to spark wildfires. This 3D vertical spectral mapping capability is unique and provides excellent data to validate the conditions of forested areas concerning tree species, tree health, and underwood structures.

For instance, in Figure 1, ALS point cloud is processed for a huge, forested area. The maps reveal information regarding the forest canopy height, crown coverage, and vegetation mask for the particular area.

The possibility to acquire measurement data of ultra-wide areas and to provide profound data of large, forested areas makes airborne laser scanning especially interesting for scientific and research projects. For example, Prof. Jorg M. Hacker, Chief Scientist at Airborne Research Australia, and Flinders University, has been using *RIEGL* airborne laser scanners for numerous projects. In 2020, Prof. Hacker along with his team documented the horrifying bush fires and helped restore burn areas.

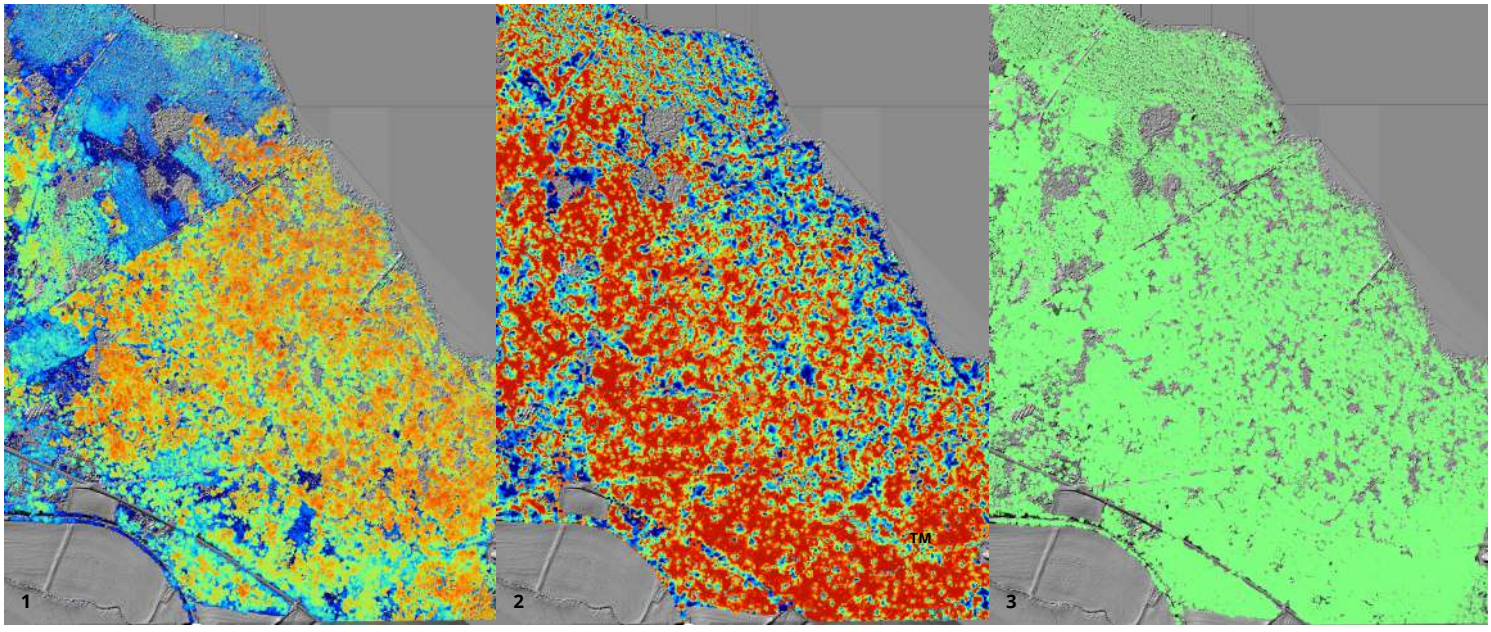

Figure 1: 1) Forest canopy height: Tree heights are color-coded (blue to red) according to the height above ground. 2) Crown coverage map: The terrain is colored by the percentage of vegetation coverage. 3) Vegetation mask: Areas of vegetation 3m and above, exceeding 10 sq m.

Terrestrial Laser Scanning

Ground-based light detection and ranging commonly referred to as terrestrial laser scanning is an active imaging method that utilizes millions to billions of 3D points to automatically measure the surrounding 3D space[4]. It derives the 3D position of items within the scanner field of view using range-finding measuring technology. This technology finds its applications in a wide variety of fields including surveying, engineering, environmental sciences, and forestry.

In the field of forest inventory and monitoring, TLS has proved great potential. It focuses on the rapid semi-automated determination of stand parameters such as tree density, height, diameter at breast height (DBH), whole-tree volumetric assessment, individual modeling of branch architecture, and characterization of vegetation types. In addition, it presents precise measurements of trees in the forest, which are planned and evaluated using statistical models. They are intended to answer the question of how much timber is in the forest, how much is growing each year, and what type of damage is increasing or decreasing.

The process of terrestrial laser scanners is expressed in the given figures. In this example the entire data has been processed using the tool 3D Forest.

3D Forest

It is an open-source software application recognized by world researchers for segmentation, visualization, measurement, and export of various tree parameters of TLS data. The X-ray view of the cross-section of forest captured by TLS is shown in Figure 2 whereas Figure 3 highlights how segmentation, calculation of tree heights, crown coverage, and convex hull of individual trees can be calculated. Moreover, the question of how much carbon is sequestrated in the forest and whether biodiversity is flourishing or not has been

Figure 2 : Cross-section of forest captured by TLS, visualized in X-ray view.

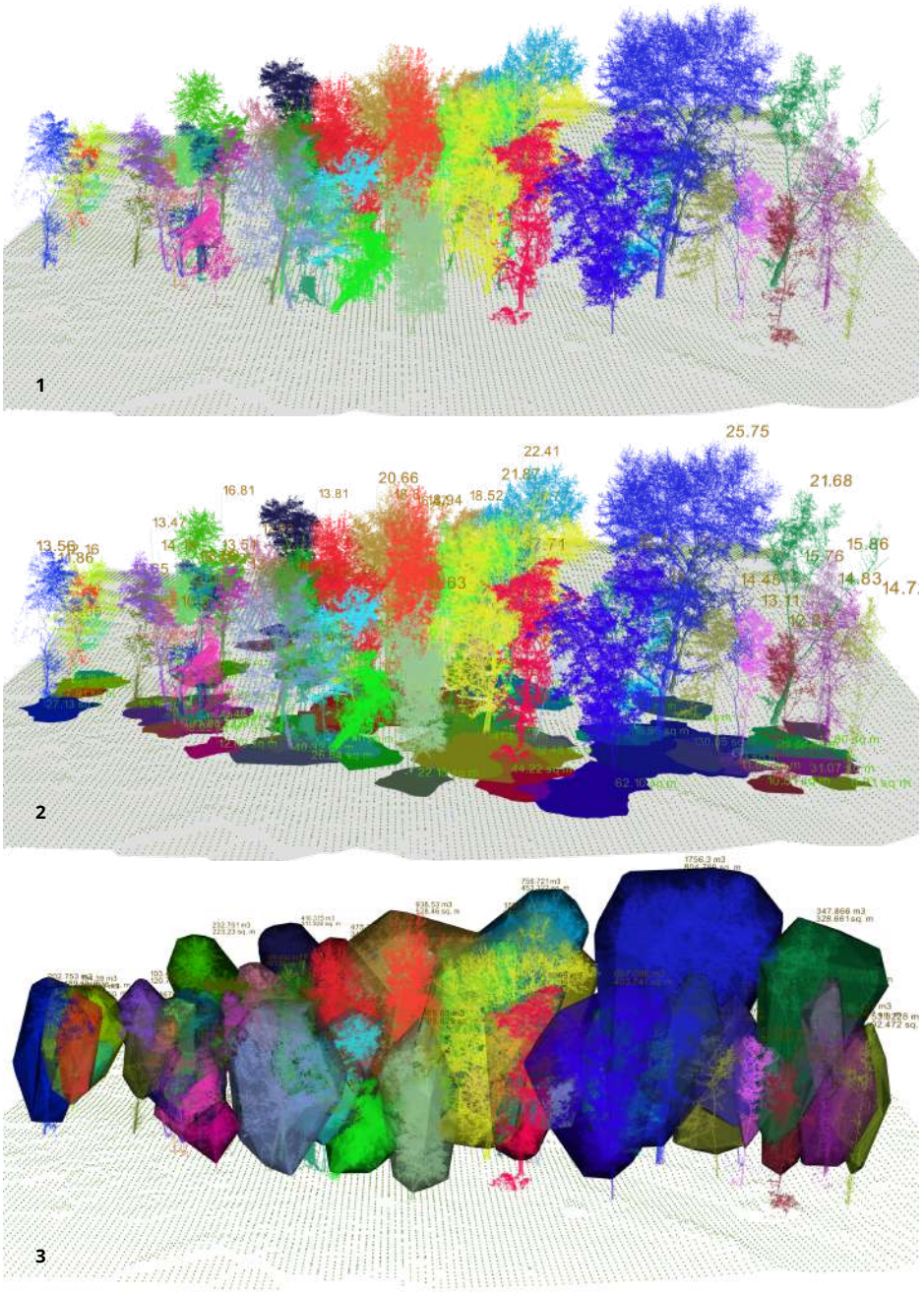

Figure 3: 1) Single tree segmentation of the terrestrial point cloud. 2) The point cloud is segmented to individual trees. From the segmented point clouds, tree heights and the crown coverage area are derived. 3) The convex hulls of the single trees are calculated from the segmented point cloud.

investigated by the researchers. In most cases, several hundred sample plots are distributed over the forest area to be investigated, and very precise measurements are then taken. In general, a distinction is made between national forest inventories, which are usually carried out by state institutions, and operational forest inventories, which support the sustainable forest management of a forest enterprise.

RIEGL's TLS quickly and accurately produces detailed and extremely accurate 3D data. All the *RIEGL* TLS scanners are tough and portable instruments that have been rigorously tested to ensure reliable performance even in the most unpredictable and extreme environments.

One of *RIEGL*'s terrestrial laser scanners is the *RIEGL* VZ-400i. It can be used on a tripod or mounted on a mobile platform in a Stop-and-Go-Mode which makes it capable of recording a scan area of 360 degrees in a horizontal direction and 100 degrees in the vertical direction. The standard point spacing of 7mm at 10m is recorded in just 45 seconds – resulting in 20 million 3D measuring points, which can also be colored with simultaneously acquired photos. Each measuring point is assigned a 3D coordinate, first calculated in a scanner's coordinate system, and subsequently geo-referenced by means of GNSS automatically.

On the one hand, this provides the exact geo-location of each individual tree on the globe. But much more - namely the entire environment - is measured with millimetre precision from such a single scan. A multi-target capability allows obtaining several echoes for each single measurement pulse. Even the densest vegetation can be penetrated to show exact data of every layer from the tree crown to the forest ground. To get a gapless digital twin of a piece of forest, the scanner must be set up at several different locations. The *RIEGL* technology allows you to do up to 50 scan positions within an hour.

Applying so many scan positions, scan shadows are eliminated. The scan positions are co-registered automatically and simultaneously during the scanning in the scanner. Additional built-in sensors, e.g., inclination sensors, acceleration sensors, GNSS receiver, etc., supplement this registration method.

This type of registration turned out to be extremely robust without the need for external reference targets. This proved to be a great advantage over other registration methods, especially in a densely overgrown forest. In post-processing, a so-called "multi-station adjustment" is registering the scan positions with each other and - if necessary - includes external control points measured by total stations, to ensure a higher-level control.

Figure 4 : A *RIEGL* terrestrial laser scanner at work.

Günther Bronner, CEO from Umweltdata, an Austrian service provider of laser measurements for forest inventory, has been working with a *RIEGL* VZ-400i for more than 2 years. For him, it was a very appealing idea to leave the tedious and error-prone measuring of trees to a scanner. But only the *RIEGL* VZ-400i could convince him with its performance. “External targets? - You don't need them! Precise planning of the set-up points? Levelling of the scanner? Forget it! 15 minutes per scan? With the VZ-400i, a scan takes half a minute! We tried it and the result convinced us.", Bronner reports excitedly. In the *RIEGL* Podcast “Forest Inventory by Means of Laser Scanning Technology” available in the *RIEGL* Newsroom he gives an insight into his work and experiences with the VZ-400i.

UAV-based Laser Scanning

Unmanned aerial vehicles (UAVs) have gained importance in recent times since they provide a cost-effective solution for investigations that demand high temporal frequency for small areas using aerial remote sensing.

They offer improved spatial resolution and accuracy as their use provides for high-quality temporal images captured at lower altitudes and speeds.

Recent research has utilized UAV-mounted laser scanning systems (ULS systems) to characterize the 3D structure of ecosystems, including forestry volume, estimation of biomass, carbon storage, and mapping biodiversity. In addition, to complement terrestrial laser scan data, airborne data acquired by UAV-based laser scanning offers new perspectives in commercial forest inventory. Scan data acquisition by drone enables a different look from above and a different angle of incidence to penetrate through the forest to get even better ground penetration data.

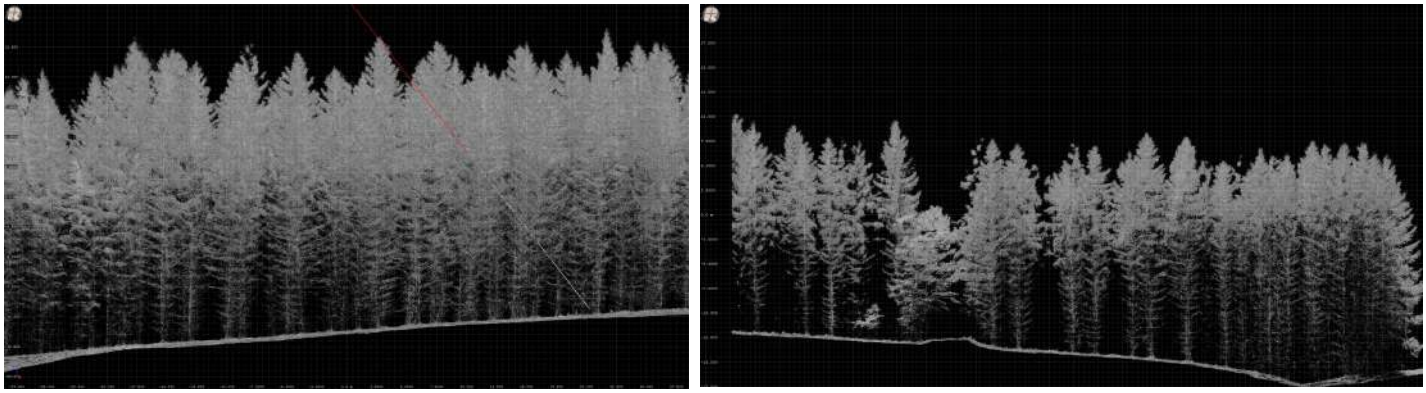

Figure 5 : Cross section of a typical UAV-born laser scan in forestry, reflectance scaled view.

Figures 5 and 6 explain the process of how ULS point cloud is processed. In Figure 6, single trees in a raw ULS point cloud are delineated and then a volumetric stem model is derived from it.

The data has been processed with the software Lis Pro 3D by Laserdata. Laserdata is a technology-driven firm that specializes in administrating, processing, and analyzing geographic point cloud data.

RIEGL offers a broad range of UAV LiDAR sensors and systems that can be used with numerous renowned UAVs to acquire high-density airborne data; in case airborne surveys by helicopter or fixed-wing planes are not efficient due to the costs, the size of the area in question, or the time frame given for data acquisition. UAV-based data is used to provide segmented point clouds displaying single trees. 3D piped models of the tree stems can be extracted from volume models for biomass measurement.

Moreover, *RIEGL* is the first company to deliver a fully integrated system suited for demanding UAV-based surveying missions with their exclusive surveying platform named RiCOPTER. It is a remotely piloted X8 array foldable octocopter specifically designed for UAV-based laser scanning (ULS).

The combination of UAV-based and TLS LiDAR data results in a point cloud of increased, extended informative value. It is also of use to get more detailed data on specific spots of the whole scanned environment.

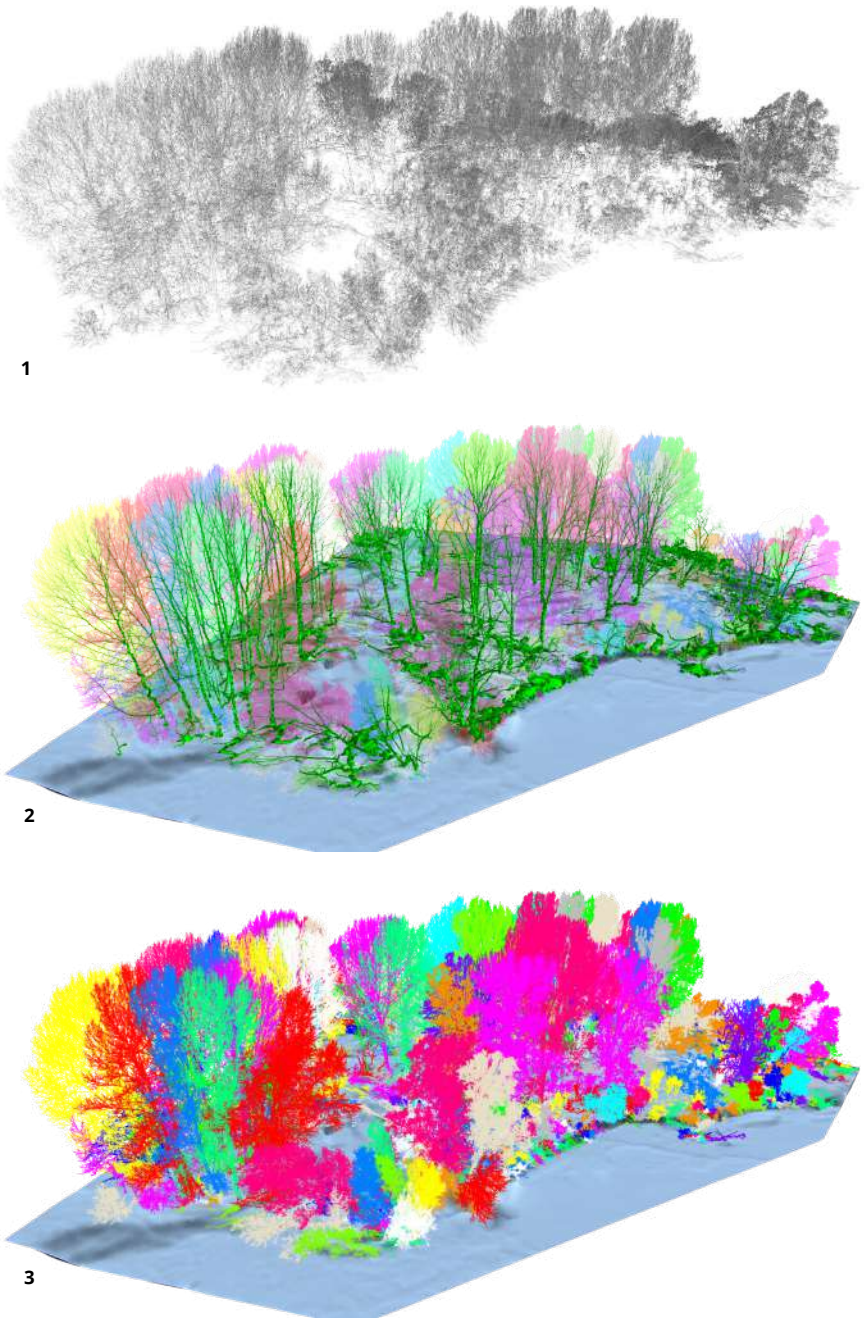

Figure 6: 1) Raw UAV point cloud colored by reflectance. 2) Single tree delineation of a UAV point cloud. 3) A volumetric stem model is derived from the segmented point cloud.

Difference between ALS, TLS, and ULS

All - ALS, TLS, and ULS - find their applications in forest management and monitoring. ALS is often acquired from manned aircraft that allows it to cover large ranges of areas, but it requires a significant amount of budget and infrastructure. TLS generates dense point clouds that allow single canopy elements such as stems and branches to be determined for decent project areas. So, ALS can cover large areas whereas TLS can provide data with extremely high resolutions[3]. In addition to ALS and TLS, ULS provides an alternative to the previous two by offering very reasonable mobilization costs and infrastructure requirements with rapid mapping speed – UAVs are very economical when compared to manned vehicles.

In figures 7, 8 and 9, top views of all scanning systems for a typical forested area reveal the suitability of each scanner according to their capability.

Conclusion

RIEGL Ultimate LiDAR™ in forestry has gained appreciation and earned the trust of scientists and researchers over the years. It provides an extremely accurate, efficient, and reliable data capture process for forest monitoring and management. It's fast-scanning ability provides a boost to forest management and conservation activities. For commercial use in forestry or scientific projects, *RIEGL* Ultimate LiDAR™ provides profound data, to digitally preserve the current situation, and to simulate future scenarios to make the right decisions for today and tomorrow; for both the private forest owner and forest manager as well as for the global decision-makers.

Find more details on the broad *RIEGL* product range for laser scanning applications in forestry at *http://www.RIEGL.com/*.

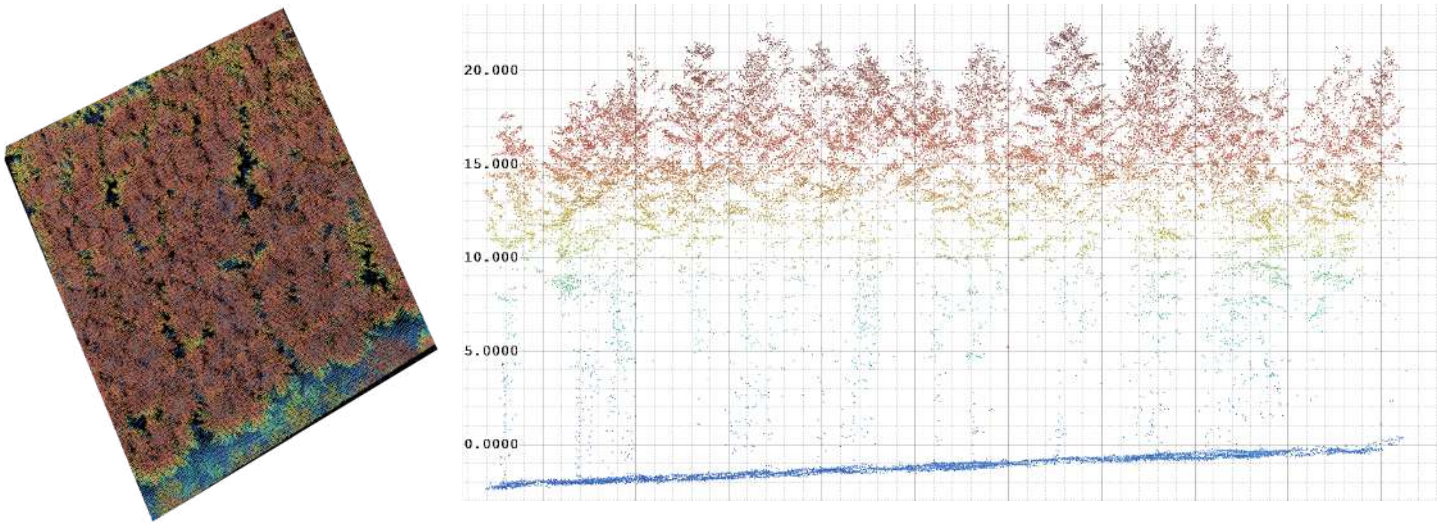

Figure 7: Top view and cross-section of a forestry airborne laser scan (~170 pts/m2): canopy and ground are very well covered. Suitable for large area acquisitions.

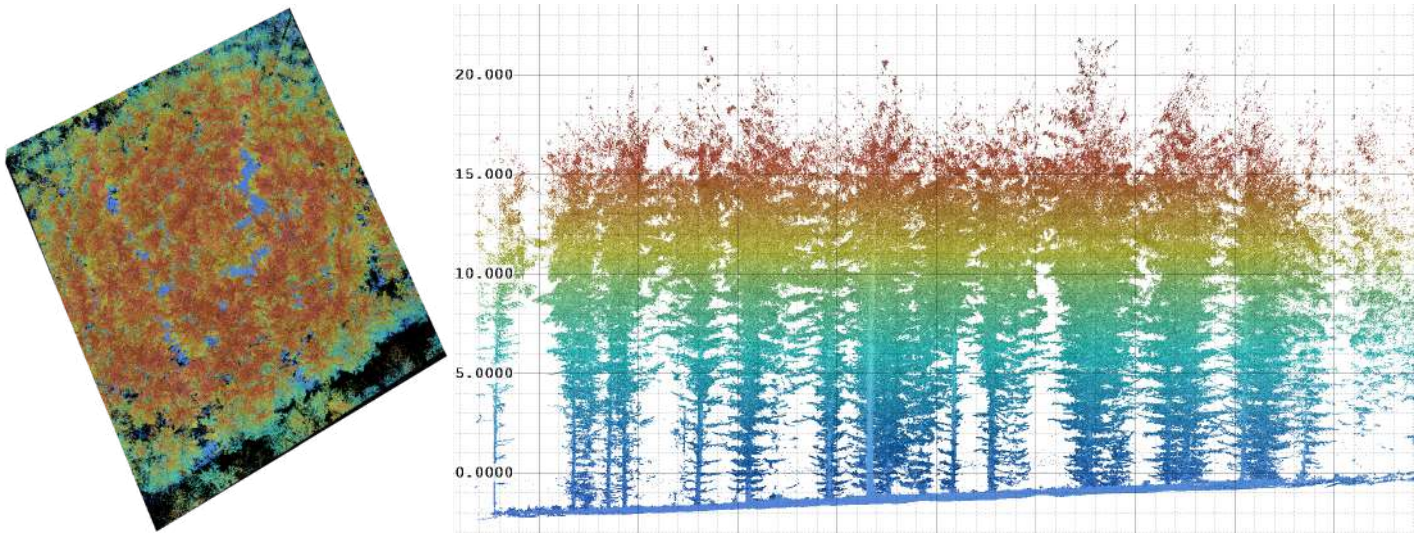

Figure 8: Top view and cross-section of a typical terrestrial laser scan in forestry (~90k pts/m2). This method provides a very dense point cloud on the ground and stems. Detailed analysis can be derived for individual plots.

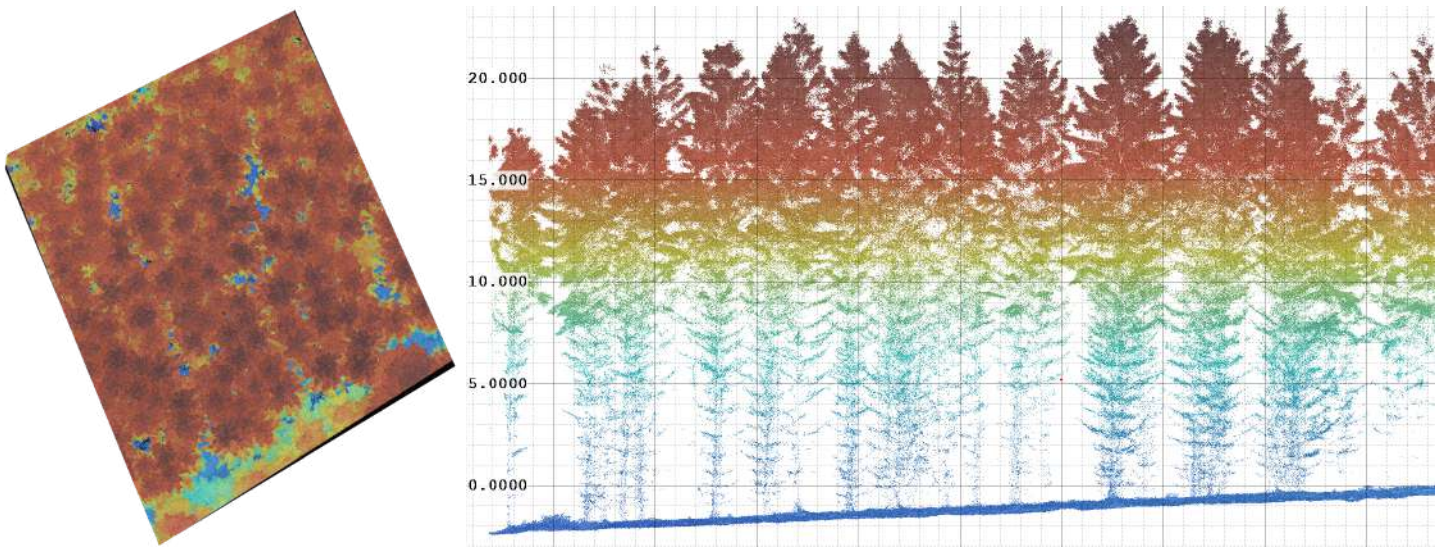

Figure 9: Top and cross-section view of a UAV-based LiDAR collection (~9k pts/m2). Due to the oblique measurement directions, the canopy, stem, and ground is exceptionally well covered. Suitable for plot measurement or medium size project areas.

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BUSINESS

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Trimble Expands Sensor Integration and Support for its Geospatial Monitoring Solution

Trimble has introduced the latest version of its core geospatial automated monitoring software—Trimble® 4D Control™ version 6.3. The software provides automated movement detection to enable informed decisions about infrastructure for surveying, construction and monitoring professionals. Version 6.3 adds new capabilities for the software to work in combination with the Trimble SX Series Scanning Total Stations' advanced imaging and measurement capabilities. This version also supports industry-leading vibration and weather station sensors and a streamlined workflow between the Trimble Access™ Monitoring Module in the field with the new T4D Access Edition used in the office.

Partnership Announced by SI Imaging Services with GHGSat for Methane Emissions Monitoring

SI Imaging Services (SIIS) has embarked on a collaborative partnership with GHGSat, a Canadian satellite company specializing in greenhouse gas monitoring from space. Effective June 16th, 2021, SI Imaging Services is acting as GHGSat's first reseller within South Korea and East Asia. The partnership's main objective is to provide remote-sensing data of methane emissions in South Korea. GHGSat is the first, and currently only firm to launch satellites into orbit capable of high resolution, low threshold greenhouse gas (currently methane) detection and measurements around the world every day.

Trimble and Microsoft Partner to Drive Digital Transformation Across Industries

Trimble and Microsoft has announced a strategic partnership to advance technology adoption and accelerate the digital transformation of the construction, agriculture and transportation industries. By leveraging the Microsoft cloud, Trimble and Microsoft will collaborate to develop, build and deliver industry cloud platforms and solutions that connect people, technology, tasks, data, processes and industry lifecycles. This collaboration represents a significant milestone to advance Trimble's Connect and Scale 2025 strategy, which centers on building industry-leading cloud platforms.

Hexagon Announces Partnership with Airbus for Near Real-time Airborne Bathymetric LiDAR Surveillance System

Hexagon's Geosystems division has announced a partnership with Airbus to integrate two Leica Chiroptera 4X bathymetric LiDAR sensors for maritime surveillance into the C295 MSA, Airbus' Maritime Surveillance Aircraft. Hexagon's new technology enables detection of underwater objects in near real-time, a significant innovation in the airborne bathymetry industry. The cutting-edge solution was developed to meet Airbus' requirements and will first be implemented in two C295 MSA purchased by the Irish Air Corps (IAC). The unique object detection feature enables real-time LiDAR data visualisation and analysis during the flight. Being able to locate the precise position of the object allows operators to preview and analyse information captured below water immediately — a process which previously could take up to several days.

Bentley Education Program Expands to Global Scope

Bentley Systems, Incorporated has announced the global expansion of the Bentley Education program – offering seamless access to learning licenses of over 60 popular Bentley applications, at no cost, to all eligible students and educators, from middle schools through higher education levels, via the Bentley Education portal. Now, with global expansion, the Bentley Education program is accessible to all students and educators at middle schools, high schools, community colleges, polytechnics, institutes, and universities across the world to employ Bentley applications in their classrooms, labs, and at home.

City of Toronto Selects Trimble Unity for Water Infrastructure Management

Trimble has announced that Toronto Water has selected the Trimble® Unity™ software platform to support its vision to improve operational efficiency across the entire organization. Trimble Unity can automate asset and infrastructure management workflows, improve data accuracy by eliminating redundancy and streamline processes between field and office teams to enhance Toronto Water's commitment to customer service and quality.

RedTail Delivers LiDAR System to DoD's Explosive Ordnance Disposal Community

RedTail LiDAR Systems has delivered six LiDAR systems to the 707th Ordnance Company stationed at Joint Base Lewis-McChord. These systems will provide Explosive Ordnance Disposal (EOD) technicians an opportunity to assess how LiDAR can be used to enhance their operations. The RedTail LiDAR Systems RTL-450 was integrated onto the Teledyne FLIR SkyRaider Unmanned Aerial System (UAS) to address a broad range of the EOD community's 3D mapping needs. The 3D maps generated – commonly referred to as point clouds – allow operating areas to be viewed from any perspective using the rotation and zoom capabilities provided within the viewer software.

Bentley Systems Announces Seequent's Acquisition of Advanced Resources and Risk Technology (AR2Tech)

Bentley Systems, Incorporated has announced that its Seequent business unit has acquired Denver-based Advanced Resources and Risk Technology, LLC (AR2Tech), a developer of geostatistical software applications. The acquisition provides Seequent with state-of-the-art geostatistics algorithms, technology, and IP for complex geospatial problem solving, complementing its geological modeling solutions and workflows, to help solve earth, environmental, and resources challenges.

25 years of successful cooperation between GAF AG (Germany), DLR (Germany) and Antrix (India)

GAF, the German Aerospace Center (DLR) in Neustrelitz and Antrix Corporation have a successful cooperation stretching back 25 years. In 1996, they signed agreements for the purpose of receiving Indian Earth observation data and distributing the data to European customers on an exclusive basis. That was the starting point for 25 years of successful cooperation and the acquisition of millions of scenes so far – and on into the future.

PlanetObserver Enhanced User Experience with New Online Map Service

PlanetObserver and Kalisio reveal My Planet Maps, a new subscription-based online map service that delivers immediate streaming access to fresh and global data. It includes performant vector and raster georeferenced basemaps. By accessing data through a reliable web map service, users save the costs of handling, storing and updating their data products internally.

Geospatial Data: New Nationwide UAS Solution Provides Imagery at 50x the Resolution of Commercial Satellites

Beagles Systems GmbH, a Hamburg-based startup wants to compete with satellites on these terms and their drone network solution offers on-demand imagery, from a remote location, at resolutions up to 50 times higher than currently available from commercial satellite data providers. Specifically, with the aid of their Beagle M drone in combination with the corresponding sensor technology the company is capable of delivering image data in a resolution of just 1cm per pixel at revisit times many times faster than satellites are capable of, regardless of cloud coverage. Earth-based UAV systems do not benefit from this and so need constant charging/refueling in order to maintain the responsiveness and endurance needed for on-demand services over large areas – and this is where the Beagle Systems charging hangar comes into play.

Transerve Has Been Granted a Patent for Their Online Spatial Analytics Platform's Micro-Service-Based Design

Transerve, a location intelligence firm that allows digital transformation and effective decision making, has received a patent for its invention named "System and method for revenue and asset management based on micro-service architecture." The company uses bespoke applications for asset tracking/mapping, project monitoring, spatial data collection with geo-tagged photos and videos, and sharing maps with key stakeholders or the general public. The company's solutions are being used in a variety of industries, including government, infrastructure, environment, estate management, smart cities, agriculture, and telecommunications.

Leica Geosystems Announces Substantial Safety Awareness Aolution Enhancements

Leica Geosystems has announced substantial enhancements to their modular safety awareness solutions the Leica iCON PA10 and PA80 for construction sites. After initially concentrating on pedestrians, the enhancements now include collision avoidance in hazardous conditions involving sensor-enabled machines, objects, and restriction zones.

India Signed Arrangement on the Joint development of a Small Satellite for Bhutan

India signed the implementing arrangement on the joint development of a small satellite for Bhutan. The agreement was inked by Shri R Umamaheswaran, Scientific Secretary, Indian Space Research Organisation, and Shri Jigme Tenzing, Director, Department of Information Technology and Telecom, Bhutan on September 24, 2021, in a virtual signing ceremony. The ceremony was attended by Ambassador of India to Bhutan Ruchira Kamboj, Ambassador of Bhutan to India Major General Vetsop Namgyel, and other senior officials from the Government of India and Royal Government of Bhutan.

HERE launches Intelligent Speed Assistance Map for Automakers to Comply with EU Regulation

HERE Technologies, the leading location data and technology platform, has announced the launch of the HERE ISA Map, delivering vehicle systems and drivers fresh and accurate speed limit information on any road. The HERE ISA Map was designed for automakers to comply with requirements under the European Union's (EU) new Intelligent Speed Assistance (ISA) regulation aimed at road safety and reducing Co2 emissions. ISA is an in-vehicle feature helping drivers to acknowledge and comply with legal speed limits on any given road. For an optimal experience, a detailed map with correct speed limit information is crucial.

USGIF Launches 2022 Scholarship Campaign

The United States Geospatial Intelligence Foundation (USGIF) announces the launch of the 2022 USGIF Scholarship Campaign, its most ambitious fundraising effort to date. Since starting the scholarship program in 2004, USGIF has demonstrated its commitment to GEOINT education by awarding more than $1.5 million in scholarships to highly deserving students, from high school seniors to Ph.D. levels.

Hawkeye 360 Raises $145 Million in Series D Round to Expand Dominance of the Commercial Radio Frequency GEOINT Market

HawkEye 360 Inc., the world's leading commercial provider of space-based radio frequency (RF) data and analytics, has announced it has closed $145 million in new funding, priming the company to achieve transformational growth in its data and analytical services product line. This Series D round was led by New York-based global private equity and venture capital firm Insight Partners and Seraphim Space Investment Trust (LSE:SSIT), the world's first listed space tech fund. Additional funding was provided by the Strategic Development Fund (SDF), the investment arm of UAE's Tawazun Holding.

PRODUCT LAUNCH

September 16 - December 15, 2021

Avenza Releases Geographic Imager 6.4 for Adobe Photoshop

venza Systems Inc., producers of the Avenza Maps ® app for mobile devices and geospatial plugins for Adobe ® Creative Cloud ®, including MAPublisher ® for Adobe Illustrator ®, has announced the release of Geographic Imager ® 6.4 for Adobe Photoshop ®. This latest version is fully compatible with the most recent version of Adobe Photoshop 2021 and introduces the ability to store embedded georeferencing within the saved Photoshop document format. Geographic Imager 6.4 also brings forward scripting support for the export of point, text, and vector layers, updated map store upload options, coordinate system updates, and a host of bug fixes.

Hexagon Announces Leica ContentMapper

Hexagon's Geosystems has introduced the Leica ContentMapper, an innovative and highly efficient airborne imaging sensor for large-scale geospatial mapping projects. With a 40,000 pixels swath width, this latest generation camera provides the highest performance for content programs, capturing high resolution imagery at unprecedented rates. The new camera provides double the resolution at the same flying parameters compared to previous systems and keeps up with the fastest flying speeds while creating highly accurate and detailed imagery even in challenging lighting conditions.

SimActive Releases Version 9.0 with Distributed Processing

SimActive announces the release of Correlator3D version 9.0 with distributed processing to boost processing power using multiple PCs. The new capability allows to significantly accelerate speed by taking profit of the computing resources available on the local network..
The new version automatically dispatches tasks on different PCs and allows to dynamically adjust computing power during processing.

HERE Launches Advanced Real-time Traffic Service

HERE Technologies has announced the launch of its new HERE Advanced Real-Time Traffic service. It introduces new lane-level information and expanding inner-city coverage to help drivers reach their destinations more efficiently and stress-free. HERE Advanced Real-Time Traffic is the industry's first traffic service that provides accurate speeds on arterial lanes with congestion at intersections, as well as the different speeds on roads with high-occupancy vehicle lanes (in Australia, Canada, New Zealand and USA).

Hawkeye 360's Third Satellite Cluster Begins Commercial Operations

The third cluster of satellites launched by HawkEye 360 Inc., the world's first commercial company to pioneer radio frequency (RF) data and analytics from space-based satellites, has achieved initial operating capability and has begun to deliver RF data and insights to clients. The trio of satellites, known as Cluster 3, entered orbit aboard a SpaceX Falcon 9 rocket June 30th and has moved into formation and completed functional testing.

Pix4D Launches the viDoc RTK Rover, an iPhone Case that Enables Handheld Professional 3D Scanning

The viDoc rover and PIX4Dcatch solution can replace the need for cumbersome and expensive survey tools such as RTK GNSS rovers and terrestrial scanners for a fraction of the price. The viDoc RTK is a very easy-to-use handheld device used to 3D model just about any small area or structure. Combined with processing in PIX4Dmatic with both LiDAR and photogrammetry data, it's an exciting new and accurate product. When paired with the PIX4Dcatch mobile app, the two products create a workflow that turns iPhones or iPads into an accurate terrestrial scanning device, with centimeter-accurate RTK positioning from your existing NTRIP network. he result is a survey-grade tool in the pockets of professionals, replacing heavy LiDAR scanners and rovers.

Trimble's New GNSS Base Station Gives Users Improved Satellite Tracking and Remote Operation for Civil Construction, Geospatial and Agriculture Applications

Trimble (NASDAQ: TRMB) has introduced the Trimble® R750 GNSS Modular Receiver, a connected base station for use in civil construction, geospatial and agricultural applications. The R750 provides improved base station performance, giving contractors, surveyors and farmers more reliable and precise positioning in the field. The R750 can be used to broadcast Real-Time Kinematic (RTK) corrections for a wide range of applications, including seismic surveying, monitoring, civil construction, precision agriculture and more. Access to all available satellite signals provides improved performance and reliability when used with a Trimble ProPoint™ Global Navigation Satellite System (GNSS) rover. ProPoint gives users improved performance in challenging GNSS conditions, with ground-breaking signal management.

HxGN Content Program introduces Metro HD City Program

Hexagon Geosystems has announced the launch of Metro HD City Program, a new offering of ultra-high-resolution 2D and 3D digital twins of major cities as an off-the-shelf product through the HxGN Content Program. In addition to the Content Program’s standard product offerings of orthophotos and digital surface models, Metro HD will expand the data stack to include high-definition true orthophotos, obliques, digital terrain models, LiDAR point clouds, 3D building models (LOD2), 3D meshes, and land use maps. Cities captured in 2021 include Munich, Cologne, Vienna, Milan, Amsterdam, Stockholm, Tokyo, Dallas, New York, Stuttgart, and Frankfurt. More cities will be added in early 2022. The program uses a hybrid urban mapping sensor, the Leica CityMapper-2, that concurrently collects LiDAR and aerial imagery. The derived products, based on the strength of each subsystem, result in superior accuracy in most applications.

PlanetDEM – A Highly Reliable Digital Elevation Model

PlanetObserver has released PlanetDEM, its new global Digital Elevation Model (DEM) with a 30m and a 90m resolution. This new DEM offers an updated, reliable, and homogeneous 3D dataset of the entire Earth's land mass to serve a wide range of military and civil applications. It is based on ALOS World 3D – 30m (AW3D30) open-source data from the Japan Aerospace Exploration Agency (JAXA).

Hemisphere GNSS Introduces Next-Generation A631 GNSS Smart Antenna

Hemisphere GNSS announces its next-generation multi-frequency, multi-GNSS A631 GNSS smart antenna. The all-new A631 is a complete redesign of the previous generation version (AtlasLink) and offers added benefits and value to an already impressive range of features and functionality. The A631 smart antenna processes and supports over 800 channels with flexible and scalable simultaneous tracking of every modern and planned GNSS constellation and signal including GPS, GLONASS, BeiDou (including Phase 3), Galileo, QZSS, IRNSS, SBAS, and Atlas® L-band. The A631 is powered by Hemisphere's recently announced next-generation Lyra™ II digital ASIC, Aquila™ wideband RF ASIC, and Cygnus™ interference mitigation technology.

Hemisphere GNSS Introduces Next-Generation R620 GNSS Receiver

Hemisphere GNSS has introduced the next generation R620 GNSS receiver, a compact, versatile, and full-featured positioning system. The first GNSS receiver using next-generation ASIC technology to deliver best-in-class, industry-leading performance and precision The wide range of functionality and ease-of-use built into the R620 makes it an ideal fit for a variety of land and marine applications requiring high-precision positioning. The R620 GNSS receiver is a complete refresh of the previous version (R330) and includes an all-new lowprofile ruggedized enclosure.

Trimble Releases Turnkey Autonomous Robotic Scanning Solution

Trimble has announced the release of the Trimble® X7 3D laser scanner and Trimble FieldLink software fully integrated with Boston Dynamics' Spot® robot. This exclusive turnkey solution from Trimble, jointly developed with Boston Dynamics, facilitates autonomous operation on construction sites and takes advantage of the robot's unique capabilities to navigate challenging, dynamic and potentially unsafe environments. Trimble's 3D data capture technology, integrated with Spot, enables a continuous flow of information between the field and the office for consistent, on-going documentation of jobsite progress.

Hexagon Introduces Security & Surveillance Portfolio for Rail

Hexagon's Safety, Infrastructure & Geospatial division, in partnership with Hexagon's Geosystems division has introduced Hexagon's Security & Surveillance portfolio for rail. Comprised of an integrated set of solutions proven in rail operations around the globe, the portfolio unites 3D surveillance systems with best-in-class security, dispatching and collaboration software. It enables rail operators to better protect their assets, passengers and freight to reduce disruptions and improve safety and customer satisfaction.

YellowScan Announces a New Addition to the Mapper Product Line, the Mapper+

YellowScan, a global leader and designer of next generation of UAV LiDAR solutions, is proud to has announced the launch of newest LiDAR addition to our Mapper product line, the Mapper+. The YellowScan Mapper+ was developed for users that are looking for more precision and range than the Mapper, but are not yet ready to invest in a higher end platform. Of course, the Mapper+ comes with the service and support that YellowScan is known for, enabling customers to quickly gain the skills and trust in their new system to successfully complete their survey missions.

GEO EVENTS

Feburary 06 - 08, 2022
Geo Week
Denver, CO, USA
https://www.geo-week.com/

Feburary 07 - 09, 2022
DGI 2022
Twickenham Stadium, London
https://dgi.wbresearch.com/

April 1 – 3, 2022
State of the Map US 2022
Tucson, AZ, USA
https://2022.stateofthemap.us/

May 09 - 12, 2022
Geospatial World Forum 2022
Amsterdam, The Netherlands
https://geospatialworldforum.org/

June 20 - 25, 2022
8th International Conference on Cartography and GIS
Nessebar, Bulgaria
https://iccgis2020.cartography-gis.com/

July 12 – 13, 2022
ICGGIS 2022
Ottawa, Canada
https://bit.ly/32isJdd

September 19 -21, 2022
Eurocarto 2022
Vienna
https://eurocarto2022.org/

Landsat 9 Satellite – Latest and Powerful Satellite in the Landsat Series

NASA has successfully launched Landsat 9 satellite. The Landsat 9 satellite will be the most powerful satellite in the Landsat series of satellites. Landsat 9 satellite will be able to image the entire Earth every 16 days, and when combined with Landsat 8 entire planet can be scanned in 8 days. In other words, together Landsat 9 and Landsat 8 will provide a temporal resolution of 8 days. This is achieved because Landsat 9 will be placed in an orbit that is 8 days out of phase with Landsat 8 to increase temporal coverage of observations.

DGI Geospatial Intelligence for National Security

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