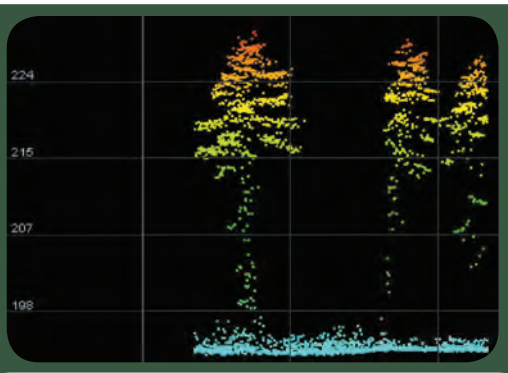
"Shining a Light on Forests"

LiDAR and Enhanced Forest Inventory for Improved Forest Management



This image is of elevation results from a LiDAR flight. Note that the tops of the vegetation and the ground surface are outlined – a result of multiple LiDAR returns.

You're lost and trying to get home at night with only a worn map to guide your way. The twilight illuminates some parts of your map, but others are heavily distorted. You have a general idea of where you're going and skills to get you there, but you know there will likely be some wrong turns and backtracking along the way with the little information you have. The challenge of working with such limited information is a common occurrence in the forest management decision-making process. Forest managers typically base their decisions on knowledge gathered from a small percentage of the forest, and adjust these decisions in the field as the work progresses. This 'dark map' reality is changing as hardworking and dedicated people across the country are lighting the way with a forest management tool known as 'Light Detection And Ranging' (LiDAR).

This tool is gaining ground in the Great Lakes – St Lawrence (GLSL) Forest region through outreach programs and workshops like the one held at the Petawawa Research Forest (PRF) on December 9, 2015. The technical workshop shared the PRF's LiDAR knowledge and experiences with local stakeholders and land managers. Furthermore, this workshop facilitated discussion with and feedback from these organizations on how the Petawawa Research Forest can maintain industry applicability by engaging in current or potentially relevant research.

Organizations represented at the December 9, 2015 technical workshop hosted at the PRF:

- Algonquin Forestry Authority
- Canadian Nuclear Laboratories
- LaRose Forest
- Mazinaw-Lanark Forest Inc.
- Natural Resources Canada
- Ontario Ministry of Natural Resources and Forestry
- Ontario Woodlot Association
- Ottawa Valley Forest
- Renfrew County

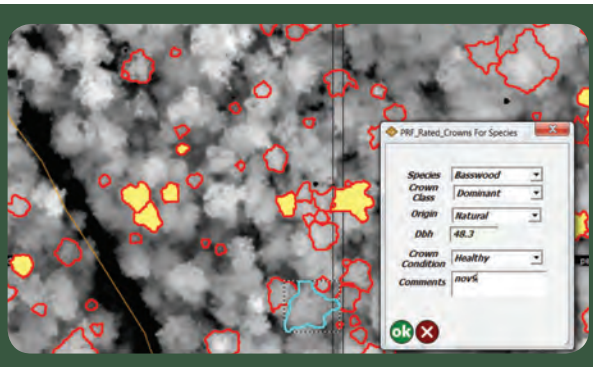
Located west of Ottawa in the GLSL region, the PRF is Canada's oldest research forest, established in 1918 with the initiation of a forest management research program. Presently, this property is an actively managed forest that combines forest research with operations across its 10,000 hectares. Peter Arbour, Operations Manager of the PRF, has recently focused on goals that are in line with its values: to use leading-edge technologies and approaches in forest management; and to demonstrate Best Management Practices in forestry representative of the GLSL region. Both of these goals are encompassed in the LiDAR research projects taking place on the property. "Enhanced Forest Inventory is currently forming one of the pillars of research at the PRF, and I'm excited about its direct applicability to forest industry. It shows a marked increase in the precision and characterization of forest inventories, which allows for better planning and, ultimately, more cost effective operations. It's very satisfying to be part of research that can have such a positive impact, an impact that we have seen firsthand in our own operations," explains Peter.

More about the Petawawa Research Forest :

The PRF is home to over 2000 historical and current experiments and demonstrations related to forest management. These sites have been implemented and maintained for nearly 100 years of PRF history. With every season, more experiments are added in order to address current and anticipated issues in forestry.

The entirety of the PRF has been flown for LiDAR most recently in 2012 from a manned aerial vehicle. Murray Woods, Senior Forest Analyst from the Forest Resource Inventory Section of the Ontario Ministry of Natural Resources and Forestry, with his extensive knowledge and experience in LiDAR, described the process of collecting information for LiDAR at the technical workshop. As planes fly over the landscape, LiDAR laser pulses are directed at the ground. When the lasers hit solid enough objects, part of the laser beam is returned to the aerial vehicles and recorded. This process can continue through multiple layers of vegetation (to produce multiple laser returns) until the ground is reached for a final return. The time and direction of the returning laser beam provide information on the height and global position of the objects on the ground. This information is combined with altitude and orientation data of the aerial vehicle during flight to further refine the laser return measurements. This data is then used to produce comprehensive, incredibly accurate, global position-referenced 3D maps of objects (i.e. vegetation) above the ground, and of the ground itself.

These 3D maps have been created and broken into small scale grids across the forest. "LiDAR is providing a measurement and prediction of the forest (in the case of the PRF) for each 25 x 25 m area. Never have we had this resolution or been so informed," Murray Woods adds. Typically, forest data collection would entail field crews conducting inventory work at the stand level, covering about 1-2% of the area, which is later extrapolated across the stand. Not only the quantity, but the quality of information generated by LiDAR means that forest managers can make more informed and effective decisions. With precise terrain information, road and culvert placement can be better directed to reduce sedimentation and runoff at a much lower cost. Detailed maps of wet areas and vegetation will improve seasonal harvest planning and lead to better protection of sensitive areas. Moreover, LiDAR can aid in the identification of unique habitat areas which are incorporated into forest management planning.



This computer interface allows on-the-ground verification, linking trees identified on LiDAR maps with their real-life counterparts. Each polygon outlined in red is a definitive tree as identified through specialized computer software.

Some of the greatest benefits from LiDAR outputs have been in the area of silviculture supporting forestry best management practices. LiDAR-based digital maps are able to provide an accurate inventory of forest resources, in terms of volumes and distributions of tree sizes at a detailed scale. This new data has been tested and has shown substantial improvement in accuracy over conventional inventory data. With greater confidence in forest inventory, managers can more economically and precisely implement appropriate silvicultural practices to improve forest health over a range of situations. "The creation of forest inventory attributes using LiDAR is one of the most exciting developments I have seen in my 39 year career in resource management. I really believe we are on the cusp of changing how we do business in the forest management sector with this technology," remarks Al Stinson, Canadian Institute of Forestry's (CIF) Past President and current member of the CIF Executive.

The development of this technology is moving forward with increasing speed and the PRF is a central player in helping another facet of its advancement. The digital maps generated by LiDAR can provide valuable stand information across the landscape. Building on this information, the next step is identifying tree species through LiDAR alone. To this effect, Murray Woods is coordinating the effort to identify individual trees from LiDAR maps and to link them to their real-life counterparts on the ground. Lindsey Russell, a Registered Professional Forester, is leading the on-the-ground verification at the PRF and can already see the potential value in this work, "The results from recent LiDAR research and verification will put forest managers strides ahead in terms of forest planning capabilities, if they were to adopt this technology. If LiDAR proves to be capable of species specific identification it will certainly be the icing on the cake."

Going forward the PRF will likely be flown for multi-spectral LiDAR, which will not only return the spatial data that is becoming standard with LiDAR, but will include tree species predictions. This information will be integrated into the ever-changing and responsive strategic plan for the PRF that informs its forest management practices. Additionally, individual sections of the Petawawa Research Forest have been flown using unmanned aerial vehicles, or drones. These flights are being used to explore possibilities behind strengthening the reliability of LiDAR outputs from drones, hopefully making this technology more cost-efficient in the future. The benefits of LiDAR-based mapping are numerous and the time and money saved by using this technology can be focused into other intensive management activities in the forest. Historically, LiDAR acquisition and processing was considered cost-prohibitive in supporting forest management activities. However, advances are lowering the cost barriers of this technology and LiDAR is becoming more cost-effective for a greater range of organizations.

Technicians behind a bank of computers with displays of outputs from an unmanned aerial vehicle (a drone) in flight. The PRF will continue to be flown for LiDAR and imagery using drones in the future in efforts to make drone flight outputs more reliable and cost-efficient.

At the end of the workshop, many of the participants had learned a lot about recent and ongoing activities at the PRF, and about possibilities of integrating LiDAR into their operations. "We are grateful to have the PRF as a near-neighbour, to learn from about new technologies and innovation, and to engage in information exchanges with," says Lacey Rose, Renfrew County's Forester and a participant of the December 9, 2015 technical workshop. In addition, the Petawawa Research Forest was able to gain valuable insight into which areas to focus on so that they stay relevant to those involved in forestry operations. With the continued hard work, innovation and dedication of the people developing LiDAR solutions, this valuable technology will soon be an integral part of forest management across the country.

Thanks to Peter Arbour, Katlijn MacAfee, Lindsey Russell & Murray Woods for helping tell their story. Written by Melissa Vekeman, CIF-IFC.