Port Blakely Tree Farms – five years of LiDAR inventory (a practitioner's perspective)

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Abstract

Port Blakely has been using LiDAR for inventory purposes since 2015 and this technology has now become the company's primary option for forest inventory. Although there have been challenges to implementing this technology, the benefits have been found to far outweigh these, including being a game changer for harvest reconciliations. The company has undertaken five LiDAR inventory projects to date with future capture and recapture plans in place. The precision of the LiDAR inventory projects has been found to be comparable to, if not better, than traditional mid-rotation and pre-harvest inventory estimates. LiDAR inventory projects also provide benefits, such as numerous GIS spatial surfaces that aid forest management and information that can assist with future growth modelling and site classification purposes. This technology has an exciting future and the process of completing LiDAR imputation projects is constantly developing and evolving.

Introduction

Port Blakely has been using LiDAR technology for the past nine years, including the last five years for the purpose of LiDAR-derived inventory. The company developed an interest in LiDAR with the specific intent of providing accurate tree height measurements for approximately 9,000 ha of Douglas-fir resource. LiDAR was captured in 2011, and Canopy Height Models (CHMs) were created from the LiDAR Point Cloud that were used to accurately stratify five individual forests by tree height and prioritise the timing of the waste thinning operations. After gaining experience of what this technology could do – specifically highly accurate Digital Terrain Models (DTMs) and CHMs – the company looked for options to progress the implementation of LiDAR in other areas of its forest resource.

In 2015, Port Blakely partnered with Scion to undertake a LiDAR imputation project on Matakana Island. This project was followed by a joint project in 2016 with Land Information New Zealand (LINZ), Scion and Interpine, and used Port Blakely's Geraldine Forest as a forestry case study to support the LINZ business case for government investment in national LiDAR capture. The company has since captured a further three projects and has recently completed the recapture of one forest area. These later projects have been completed by Interpine, an international innovator in the development and utilisation of LiDAR technology for inventory purposes.

Approach taken and challenges in transitioning to LiDAR inventory

Port Blakely's approach to implementing LiDAR inventory systems has been to complete projects at the forest level, with later projects merging forests within proximity to each other. To date, the focus has specifically been on radiata pine in the age class range from 15 to clearfell, but in 2021 the company is planning to capture two Douglas-fir forests using a LiDAR imputation approach. Once the initial LiDAR capture and imputation project is undertaken, the intention is to recapture forest areas on a four to five-year return frequency where scale and forest structure allows.

The road to implementing a LiDAR inventory system has been one of trepidation. If you had a highly uniform resource with scale, making the decision to use a LiDAR imputation system would be relatively easy. However, this has not been the case for Port Blakely's forest resource, especially in the South Island where climatic conditions (such as wind and snow) increase the variability of the resource. Each LiDAR inventory project has its unique challenges that need to be considered, which largely relate to the variability of the resource from a regime, age-class and productivity perspective. Consideration therefore needs to be given to the weighting of plots in different stratum to provide the best estimates for key areas of interest, with the recognition that this approach will likely provide less precise estimates for areas less intensively sampled.

Precision achieved from LiDAR inventory

From a simplistic perspective, the key point of difference between a traditional mid-rotation and pre-harvest inventory and a LiDAR imputation inventory is that the traditional approach has a considerable number of ground plots installed within the area of interest (AOI), but only samples a low percentage of the total AOI. In contrast, a LiDAR imputation project has a lower number of ground plots installed in the AOI (in some cases none), but the LiDAR captures 100% of the AOI.

From Port Blakely's experience, this difference results in a more precise capture of the variability of the resource and an improvement in Total Recoverable Volume (TRV) predictions. Typically, a downgrade adjustment of between 6–15% would need to have been made for mid-rotation and pre-harvest inventories to align with harvest actuals, but this adjustment has not been necessary for the LiDAR inventory projects completed so far. Log grade level precision may be partially compromised depending on the variability of the resource. However, the harvest reconciliations that Port Blakely have completed to date have shown that the LiDAR inventory is providing an adequate prediction of aggregated log grade products (Pruned, Saw1, Saw2, Saw3 and Pulp). Pre-harvest calibration and validation inventories that have been undertaken in stands where LiDAR inventory has been captured also support this finding.

Additional benefits of moving to a LiDAR inventory system

A LiDAR inventory project provides the traditional yield table outputs and associated precision estimates that you would expect from a pre-harvest or mid-rotation inventory. However, in addition to these products, there are a number of spatial surfaces that can be produced that aid in understanding the variability of the resource sampled and provide benefits to other areas of resource management. Port Blakely typically requests the following spatial surfaces from LiDAR inventory projects and incorporates a subset of these layers into the company's GIS for operational access, Site Index, 300 Index, basal area, stems per hectare, height, TRV and aggregated log grades. Figure 1 shows a small section of a TRV surface (note the scale of the pixels on the edge of the surface are at 25 x 25 m).

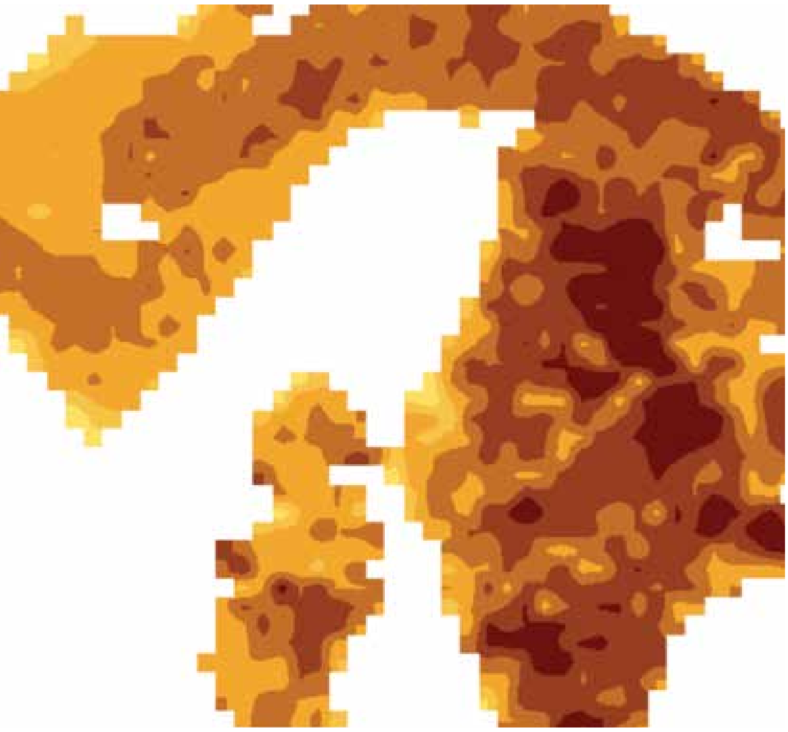

Figure 1: Total Recoverable Volume (TRV) surface

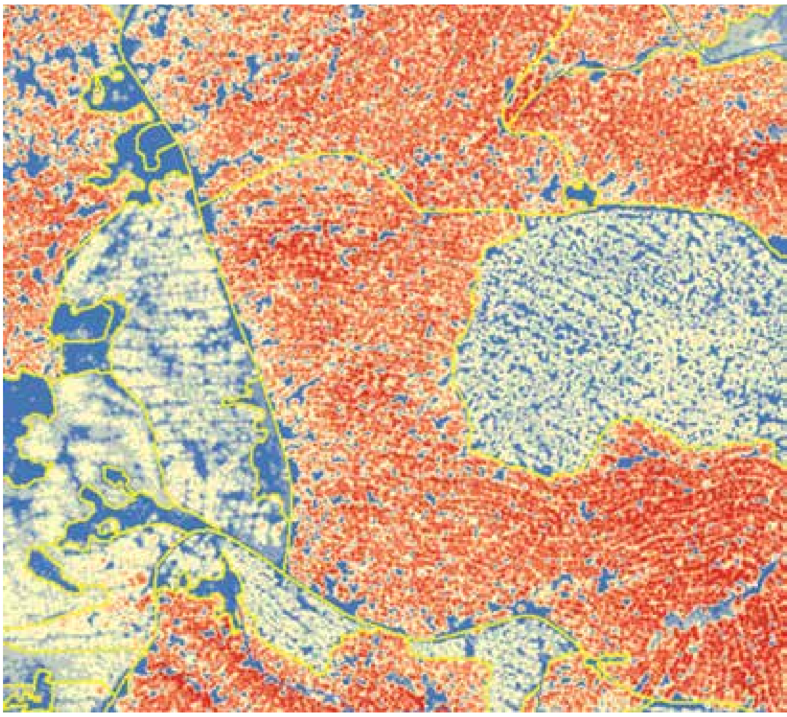

Figure 2: Canopy Height Model (CHM)

In addition to these products, the LiDAR captured for inventory projects also allows the ability to create useful terrain and vegetation surfaces. Port Blakely publishes the following LiDAR generated surfaces in the company's GIS – CHM, aspect, Digital Terrain Model (DTM), hillshade and slope. Figure 2 shows a small section of a CHM.

By moving to a LiDAR inventory system, the yield predictions are no longer bound at the stand level. A LiDAR inventory provides a yield prediction at a pixel level, typically 25 x 25 m, and inventory predictions can be extrapolated to any AOI defined within the bounds of the project area captured. This is especially useful for harvest reconciliations as inventory areas can be cookie-cut to fit harvested areas post-harvest. Also, during the harvest planning phase this system allows the assessment of harvest volumes for defined areas, which can then be fed into financial and operational models to assess the optimal harvest timing for different harvest unit options. A recent project of this nature also allowed the estimation of recoverable volume from planned road lining operations.

As mentioned, Port Blakely plans to complete a recapture of forest level LiDAR inventory projects at a four to five-year return frequency. When completing recapture for previously captured areas, there is the potential to reuse the plots from the previous capture, which will provide huge financial savings. Port Blakely will be testing this approach for the first time in 2021 in the company's Geraldine Forest, and plans to install 60 new plots as well as utilise the 200 plots installed in the previous LiDAR project from 2016.

Lastly, Port Blakely has found that a LiDAR inventory system provides a level of simplicity relating to inventory management. Although the individual projects are more complex, there are many stands captured within a single LiDAR inventory project and there is no longer the need to complete multiple age-based mid-rotation and pre-harvest inventory at the stand level (with the exception of validation and calibration inventories as required). A LiDAR inventory system also allows the capture of small stands that may not have been considered viable to capture using traditional mid-rotation and pre-harvest inventory techniques.

Potential use for growth modelling and site productivity classification

Port Blakely expects that the LiDAR inventory datasets that are being collected will have significant benefit for future growth modelling and site classification purposes. The company is now starting to recapture forest areas with new LiDAR imputation projects that were previously captured four to five years ago. If the company continues this recapture cycle it will not take long to accumulate a collection of sites where 100% spatial capture has been completed multiple times over the same forest area. For these areas, there will be a time series prediction of how this forest area is growing at a fine resolution. This dataset could then be used to calibrate and project future growth simulations that have the ability to account for variation across a site associated with different features on it (e.g. aspect, ridge tops, valleys).

Over the last five years, Port Blakely has been working with Professor Euan Mason from the School of Forestry at the University of Canterbury in Christchurch to create high resolution site productivity surfaces for the company's radiata pine sites using hybrid mensurational/physiological modelling (see Mason, Holmstrom & Nilsson, 2018). This year we have started to understand the relationships between the Site Index layers produced from Euan's work and the Site Index layers produced from the LiDAR imputation projects. The intention is to use the Site Index layers generated from the LiDAR imputation projects to calibrate and validate Euan's Site Index layers, which will then be used (along with other GIS spatial surfaces and operational forester knowledge) to create a new generation of site productivity classifications for the Port Blakely radiata pine resource.

How could this technology be developed further?

From Port Blakely's perspective we would be interested in the following aspects of this technology being developed:

- **The potential to replace LiDAR with photogrammetry**:
  Overseas examples have shown that there is the potential to replace the LiDAR Point Cloud used for inventory projects with a photogrammetric Point Cloud (created from aerial imagery) for subsequent imputation projects once an initial LiDAR DTM has been obtained. If this was proven to be effective for the New Zealand capture environment, there could be significant cost savings achieved
- **Improvement in log grade prediction:**
  Although the harvest cut-outs that Port Blakely has completed have shown that LiDAR inventories are providing an adequate prediction of aggregated log grades, this area could still be developed further. The move to a single-tree inventory, as opposed to plot-based, is likely to further improve log grade prediction and is an option that Interpine are working on and could be available soon
- **Plot number requirements:**
  Currently there is a rule of thumb that approximately 200 plots need to be installed per LiDAR inventory project. It would therefore be useful to further understand the sensitivities around this number, especially regarding significant regime variations and how plot numbers could vary depending on the precision required.

Summary

In summary, Port Blakely has been fortunate to have had opportunities to enter the world of LiDAR imputation projects by leveraging off research projects and a national business case project for forestry capture. We are also fortunate to have had Scion's expertise in developing aspects of this technology, and the help of a company such as Interpine who have taken an exemplary lead in deploying this technology to industry. We have learnt a lot about the implementation of this technology on the journey so far, but we still have a lot to learn on the way ahead as this area evolves.

If you are interested in entering the world of LiDAR inventory, please feel free to contact me to discuss this further. It may also be of interest to consider what LiDAR is being captured in your area as part of the Government's national LiDAR capture project. This LiDAR will be freely available and could be a good way to kick-off a LiDAR inventory project.

Reference

Mason E.G., Holmström E. and Nilsson U. 2018. Using Hybrid Physiological/Mensurational Modelling to Predict Site Index of *Pinus sylvestris L.* in Sweden: A Pilot Study. *Scandinavian Journal of Forest Research*, 33(2): 147–154. Retrieved from: http://dx.doi.org/10.1080/02827581.2017.1348539

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