Advances in the use of remote sensing within New Zealand

Michael Watt, Research Leader, Scion
Provide remote sensing research that adds value to the forest sector and to New Zealand
Over the last five years remotely sensed data has been used to:

- Predict stand metrics for Douglas-fir
- Predict stand metrics for radiata pine more accurately, use these predictions for precision forestry purposes
- Prove the use of satellite data as an inexpensive alternative to LiDAR for inventory
- Predict leaf area index which could be a useful diagnostic of fertiliser deficiencies
- Develop a set of metrics that take LiDAR to the next level for inventory purposes
- Compare terrestrial LiDAR systems for inventory purposes
- Spatially predict wind risk to radiata pine using LiDAR data
- Identify needle mortality, symptomatic of a disease, using multispectral data from UAV and satellite
The utility of LiDAR for predicting key stand metrics in Douglas fir has been proven.

LiDAR acquired at a low pulse density can be used to generate accurate predictions of stand metrics in Douglas fir

For radiata pine a national model for predicting height and volume from LiDAR was developed.

Methods to model site productivity (Site Index and 300 Index) from LiDAR, satellite imagery and environmental data have been demonstrated.


...these models of Site Index and 300 Index have application for predicting optimal final crop stocking for structural and pruned regimes.


Methods for characterising stand structure for radiata pine based on LiDAR, satellite imagery and environmental data have been developed and evaluated.

Comparison of stereo-satellite imagery and LiDAR for inventory shows satellite imagery could be an inexpensive substitute.


<table>
<thead>
<tr>
<th>Dimension</th>
<th>LiDAR</th>
<th>Satellite</th>
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<tbody>
<tr>
<td>MTH (m)</td>
<td>1.6</td>
<td>2.0</td>
</tr>
<tr>
<td>BA (m²/ha)</td>
<td>11.2</td>
<td>11.3</td>
</tr>
<tr>
<td>Stocking (s/ha)</td>
<td>107.9</td>
<td>110.1</td>
</tr>
<tr>
<td>TRV (m³/ha)</td>
<td>90.4</td>
<td>90.5</td>
</tr>
<tr>
<td>TSV (m³/ha)</td>
<td>105.2</td>
<td>105.4</td>
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</tbody>
</table>
Demonstrated that useful models of Leaf Area Index (LAI) can be developed from an extensive LiDAR dataset collected across Kaingaroa Forest.

- Model predictions made with a reasonable level of precision
- Predictions could be useful when combined with hyperspectral data for identifying nutrient deficiencies


High density LiDAR project – voxel vs. std metrics

High density aerial point clouds collected from 74 plots in a radiata pine forest using VUX-1 scanner attached to a helicopter

Objective: Compare predictive precision of models created using voxel-based metrics (Voxel) with that of standard metrics (Base)
VUX1 Data: Sub-plot
Results – method comparison

• Increasing pulse density had little effect on model precision

• Relatively constant gains in precision for BA, stocking and volume from use of voxel-based metrics across pulse density gradient

• Major improvements in $R^2$:
  • BA – 0.22 (0.44 to 0.66)
  • Stocking – 0.24 (0.34 to 0.58)
  • Volume – 0.23 (0.53 to 0.76)

Cloud2stem software – direct estimation of diameter
An extensive comparison of two existing terrestrial laser scanning tools (Faro Focus and ZEB1) was undertaken across a range of stand conditions in Kaingaroa Forest.
Remotely sensed data have been used as inputs into the ForestGALES model to predict the risk of wind damage spatially across a study area.
Structural and spectral changes in radiata pine canopies associated with needle death, have been quantified by a UAV.

These techniques have been extended to allow monitoring of physiological stress from satellite imagery.

Conclusions

• LiDAR is extremely valuable for forest inventory within New Zealand

• Research demonstrates LiDAR can be used for prediction of Site Index, 300 Index, stand metrics, leaf area index

• A new class of metrics termed voxelised metrics have been developed and these provide further gains for inventory precision

• Photogrammetric point clouds from satellite provide inventory estimates almost as precise as those derived from LiDAR

• Remotely sensed data has considerable utility for prediction of wind risk and disease damage
Acknowledgements

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Thank you

Michael Watt
Research Leader - Geomatics
Michael.Watt@scionresearch.com