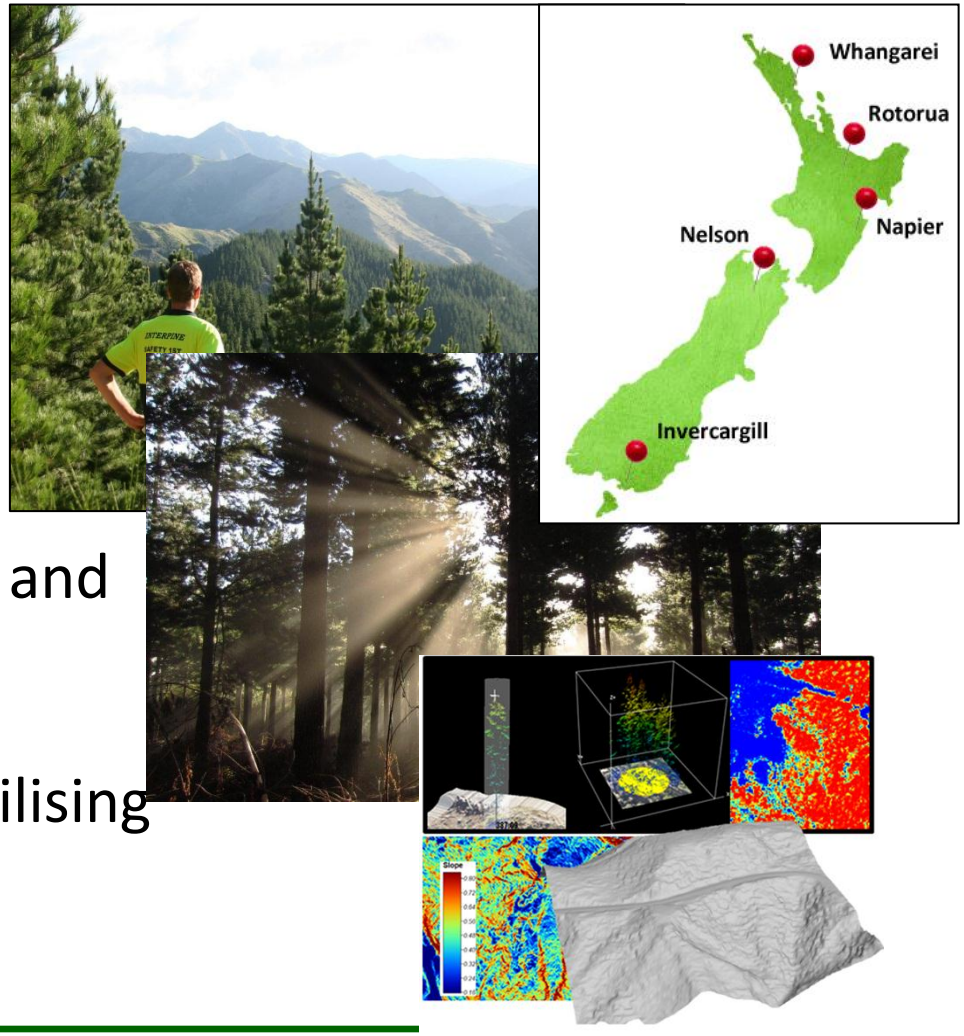
How effective are LiDAR-based inventory systems?

Jonathan Dash
Hamish Marshall
Interpine Forestry Limited

Interpine Forestry Limited

Introduction

- Forestry Innovation
- Established 1980
- Rotorua head office
- ~50 staff working across NZ and Australia
- Involved forest inventory utilising LiDAR since 2007.



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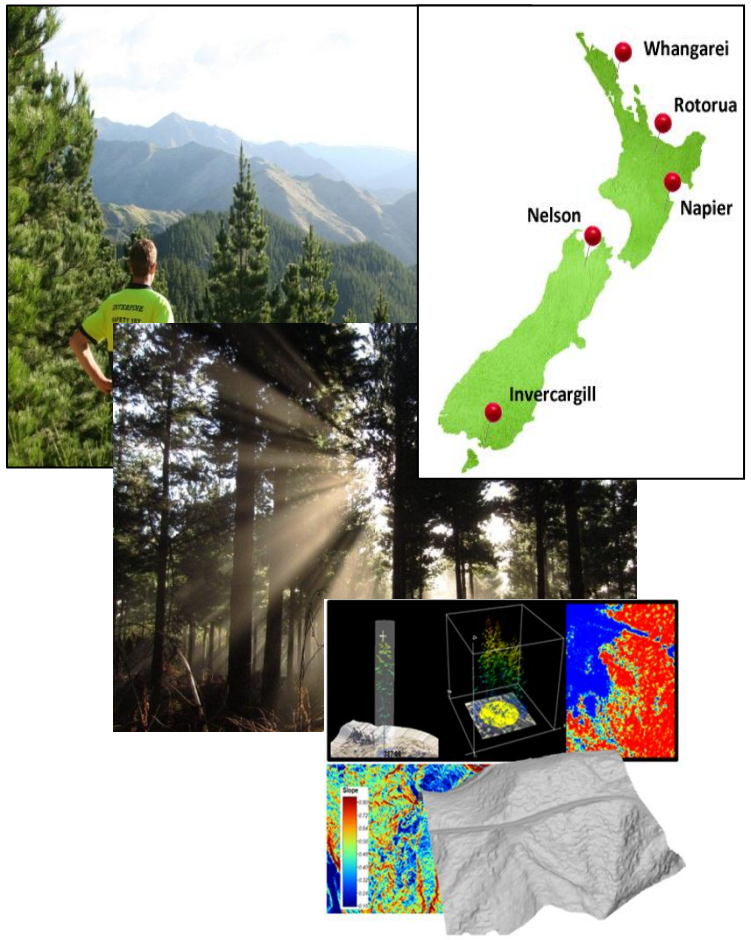
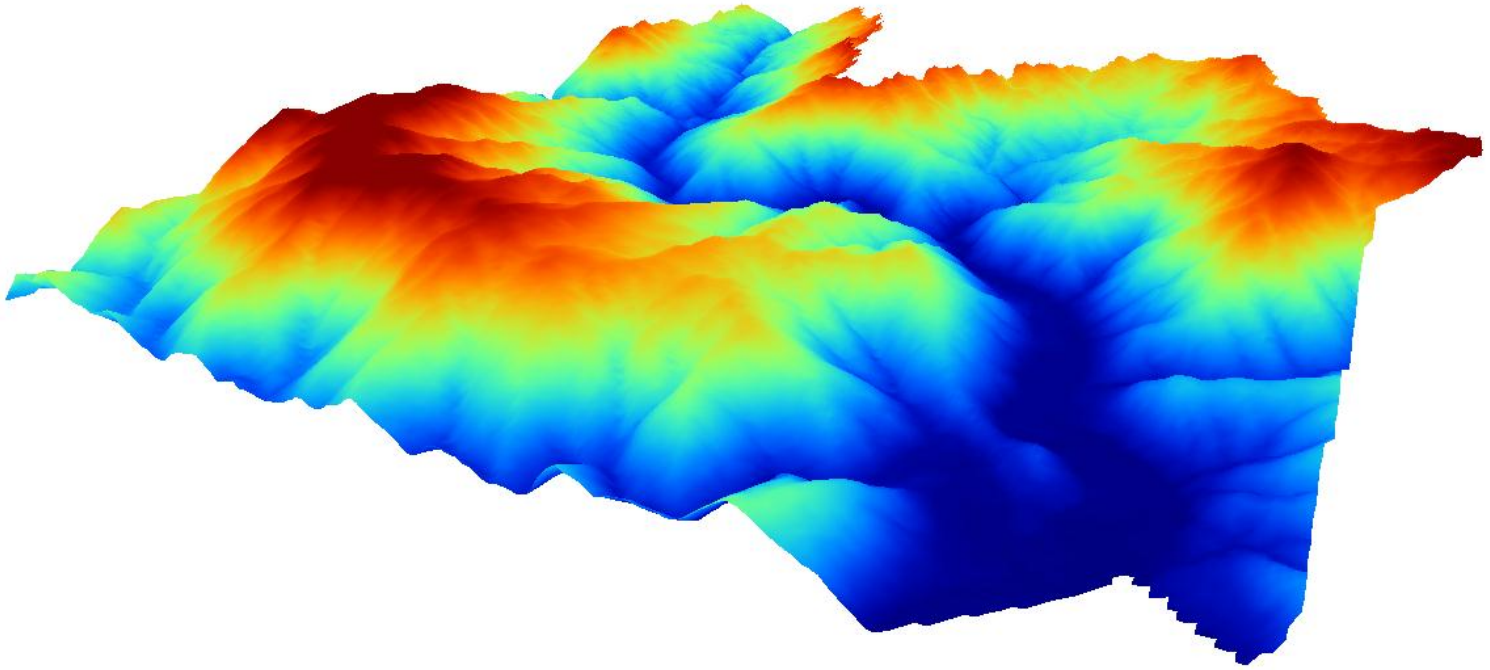
2. Practical advice for using LiDAR in forest inventory
   - Sampling design
   - Installing Ground plots
   - Plot Size
   - Dealing with Edge Plots

3. Getting Results from LiDAR
   - Improving the precision of traditional inventory

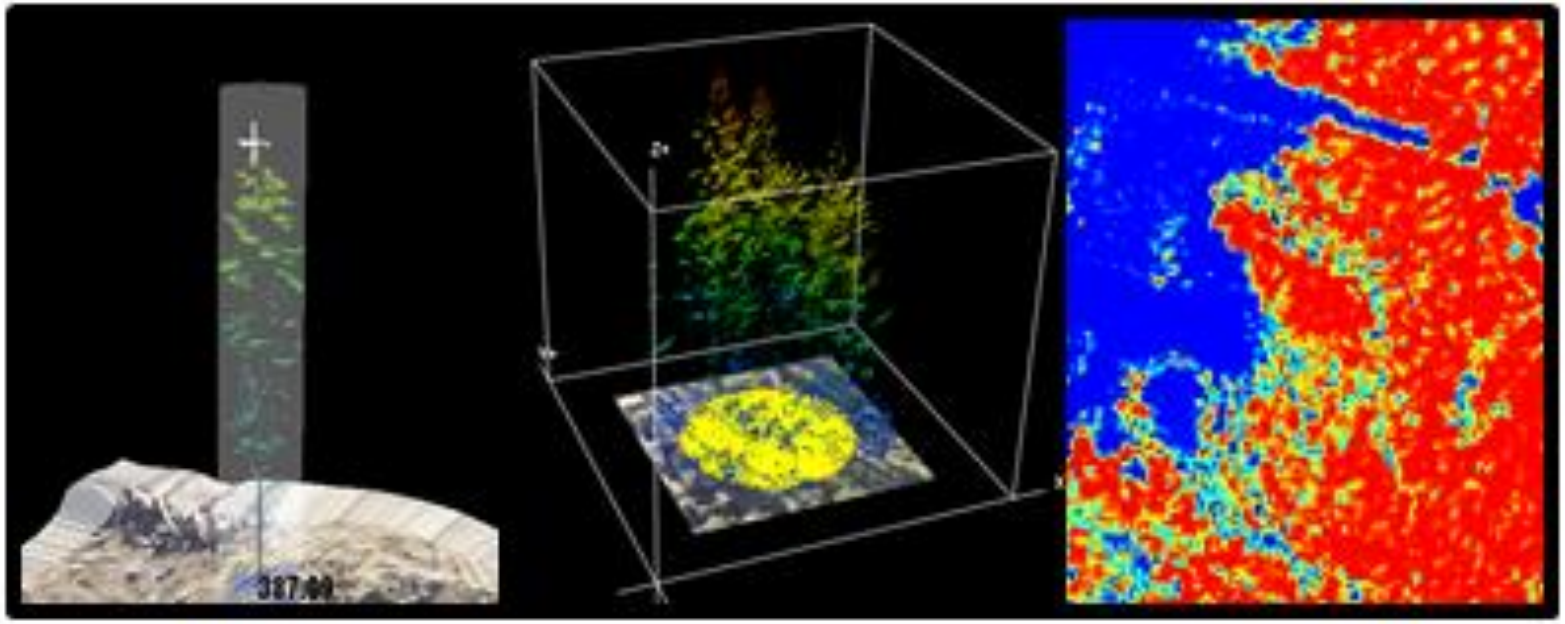


LiDAR in Forestry



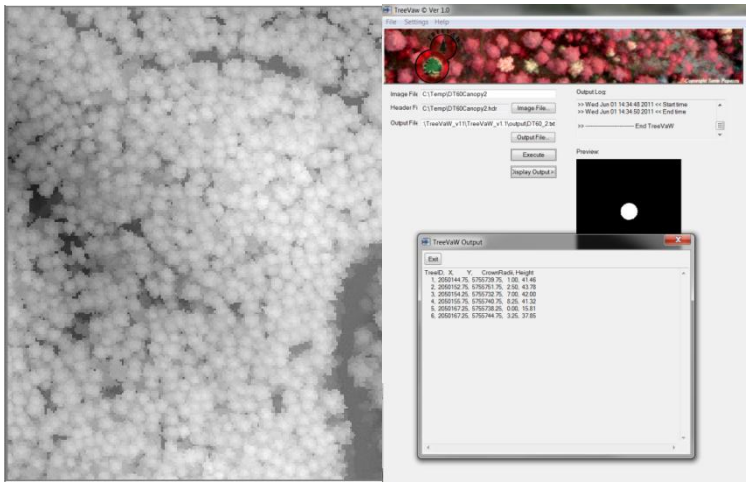
We know that LiDAR can be used to create DEM, but how can it used in FOREST INVENTORY?

LiDAR in Forest Inventory?



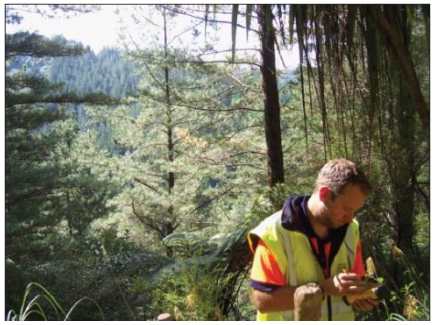
LiDAR in Forest Inventory

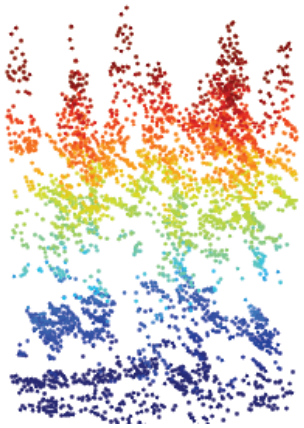
- The following forest inventory information can be obtained from using **just** LiDAR data
  - Tree Heights
  - Tree Locations
  - Tree Counts
  - Stratification



To get VOLUME (m^3/ha) etc, we still need ground plots

Integrating LiDAR and Ground Plots

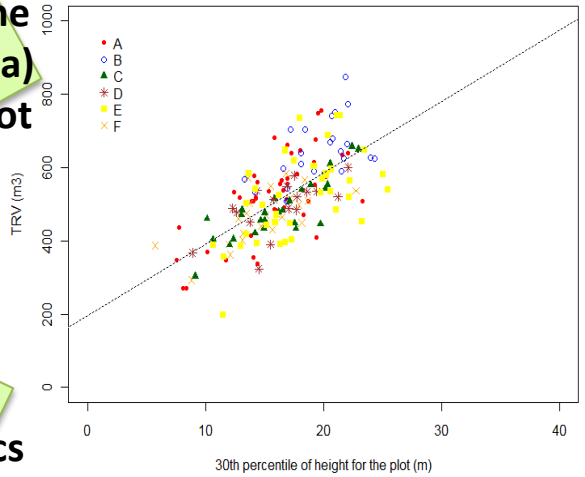




Ground plots → **Volume (m3/ha) per plot**

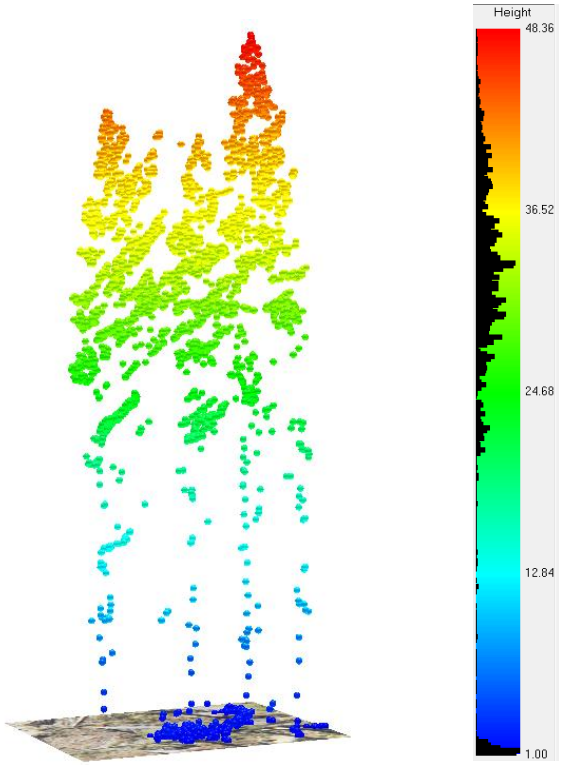
LiDAR Analysis → **Plot metrics**

Derive Relationship



Volume predictor model

What are LiDAR Metrics?



- LiDAR Metrics are statistics on:
  - Coverage metrics (e.g. number ground returns etc.)
  - Height of the point cloud (Percentiles, skew, means etc.)
  - Or the return intensity of the point cloud

Can be calculated at a tree, plot or forest resolution

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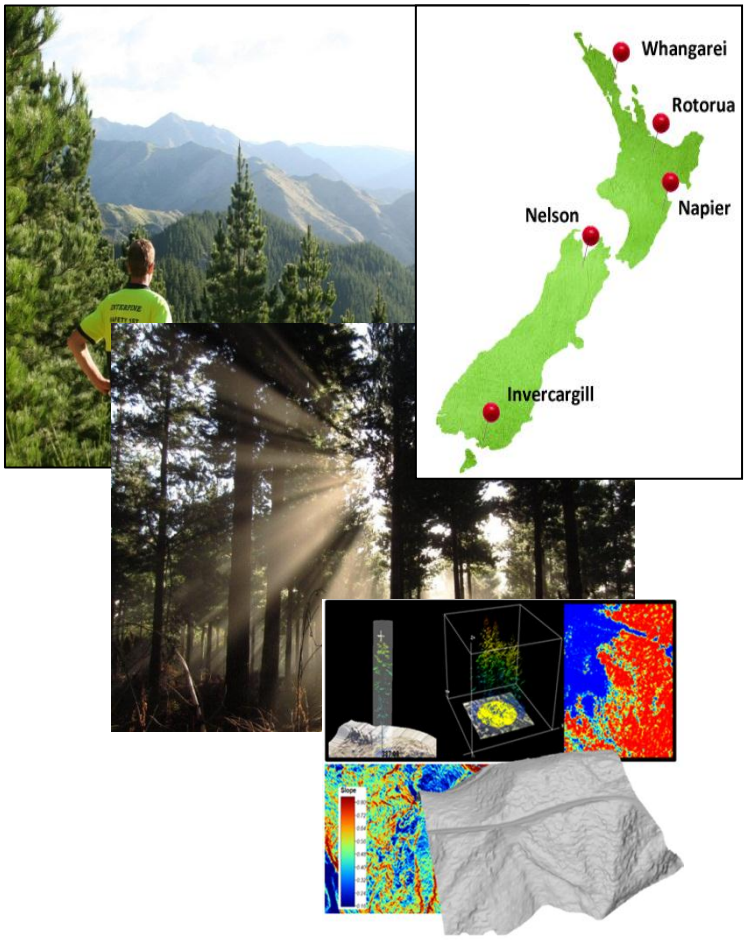
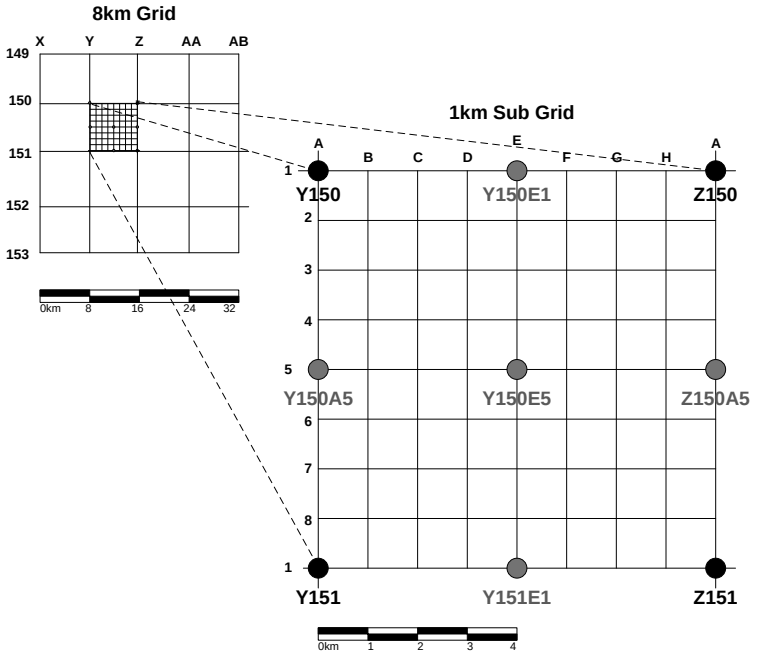


Sampling Design

Where should we put our ground plots?

- General guidelines:
  - LiDAR data should be collected prior to field measurement to take advantage of this information.
  - For a model based approach plots should be placed where they can sample the full range of the predictor variable.
  - Risks of fully model based approach can be addressed and minimised.



Sampling Design

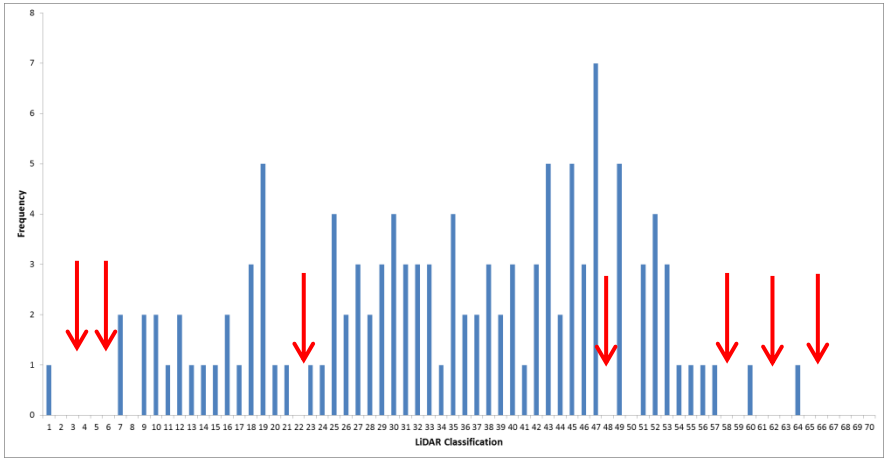
Where should we put our ground plots?

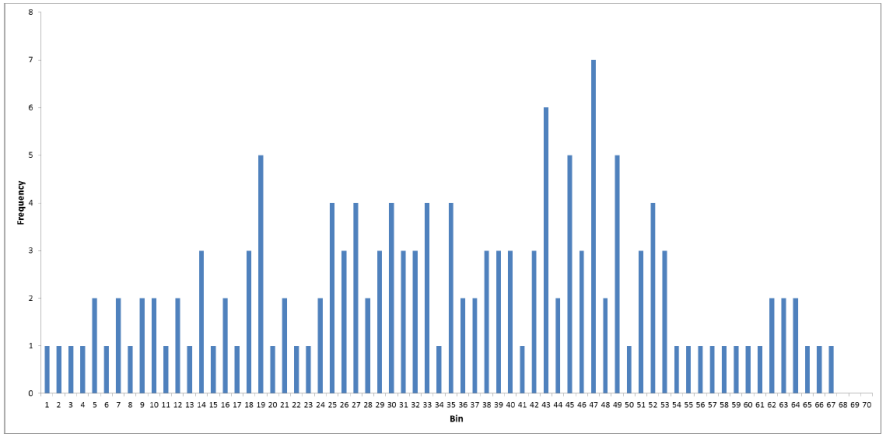
- Option 1
  - Traditional grid based inventory (SRS)
- Option 2
  - Full model based approach
- Option 3
  - Hybrid approach

Sampling Design

Western Australian Example

- Hybrid approach followed.
- Estate segregated according to LiDAR metric classification
- A proportion (120/150) of plots laid out on a grid with a randomised start point.
- Histogram of plot frequency in each predictor variable bin.
- Remaining plots used to target the estate areas where there would be no ground sample of a specific LiDAR class.

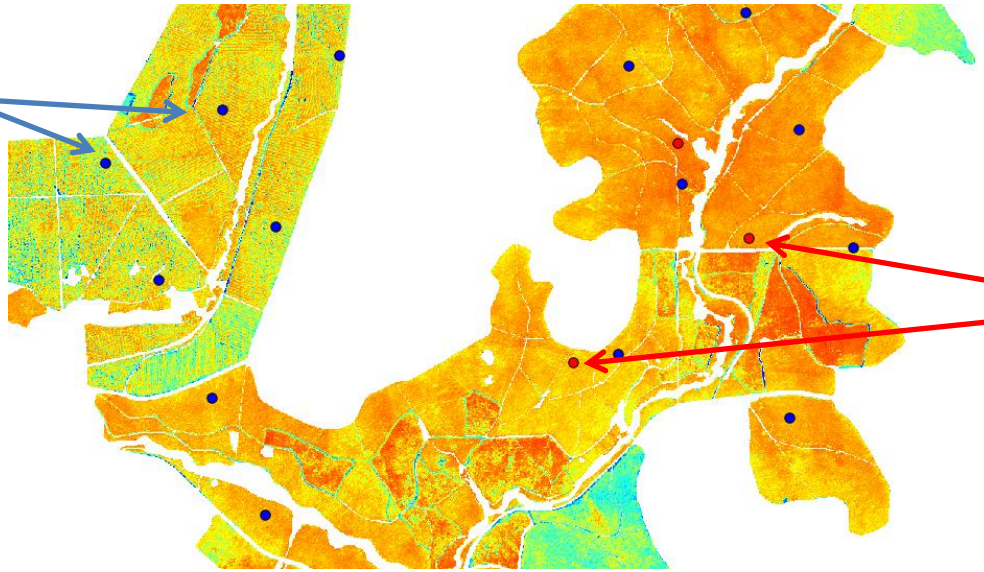




Sampling Design

Western Australian Example

Blue plots located established on grid



Red plots located at random in areas with desired LiDAR metric value

The Hybrid Design meant that:

- The grid based plots could be used to simply calculated the TSV (PLE 7%) for the estate without the LiDAR model – (Risks mitigated)
- Including all the plots will provide samples throughout the range of the predictor variable including the extremes

Ground Plots

Are aerial LiDAR ground plots special?

- High-grade GPS coordinates are required.
- Trimble Pro-XT device paired with a rugged windows mobile device.
- GPS raised to 5m height
- Survey grade GPS
- Differential correction
- In NZ typically aim for collection of 100 points. (Less may be appropriate for Aus)

Ground Plots

Are aerial LiDAR plots special?

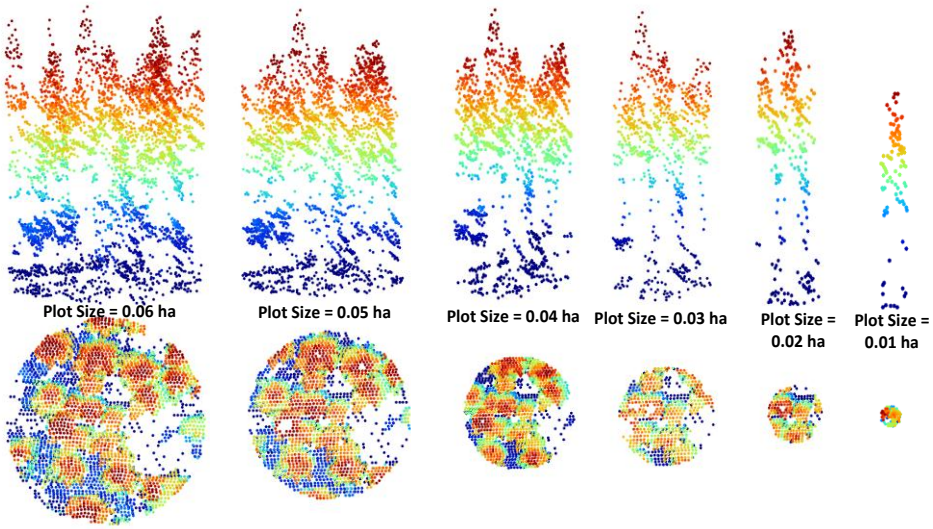
Implications

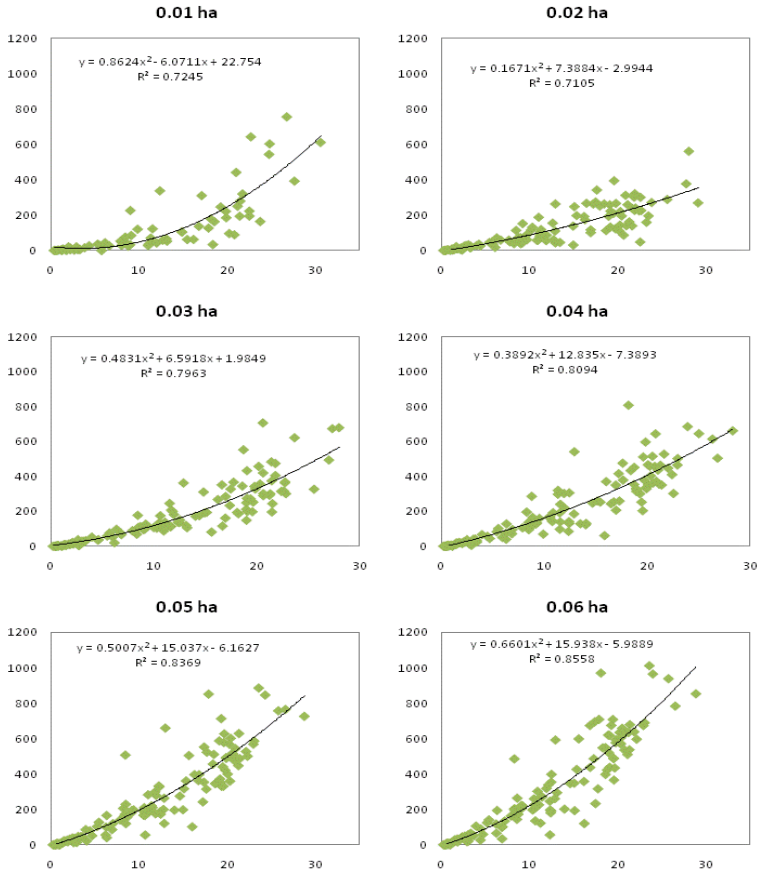
- Additional Equipment
  - GPS
  - Additional Field PC
  - Tripod
  - Survey Pole

- Reduced productivity
  - Acquisition rate dependent on weather and vegetation conditions.
  - Slow acquisition can become expensive

Ground Plots

Is there a correct plot size?





National level dataset

Effective plot size altered

Volume model fitted several times

Gonzalez-Aracil 2011

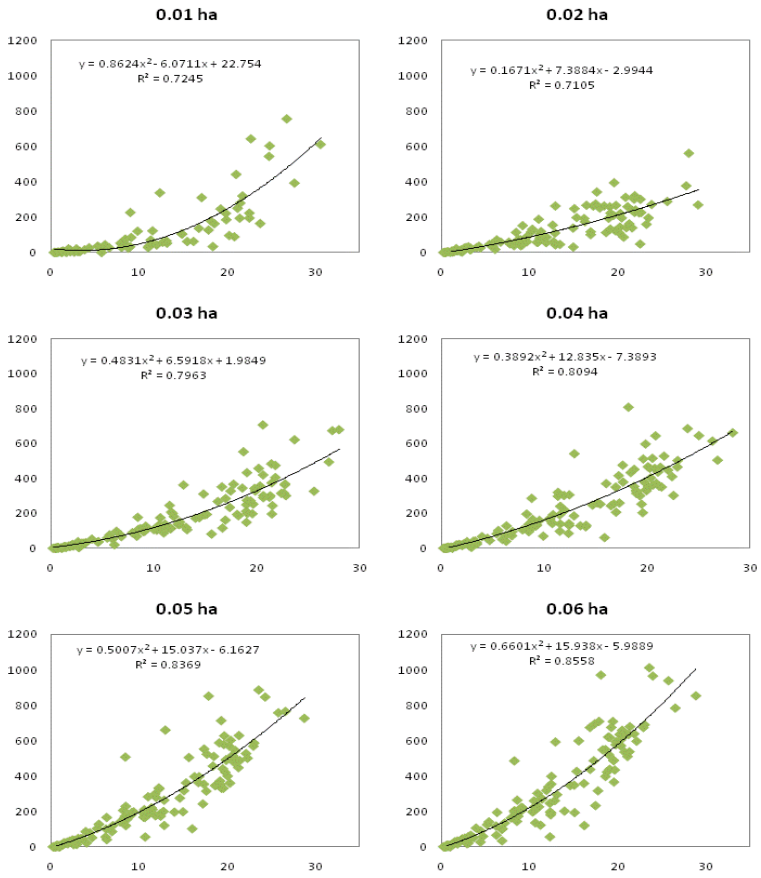
Ground Plots

Is there a correct plot size?

Bigger plots result in stronger relationships

Seems to be a significant increase at a plot size of 0.04 ha for *P. radiata*

This is still an area of active research.



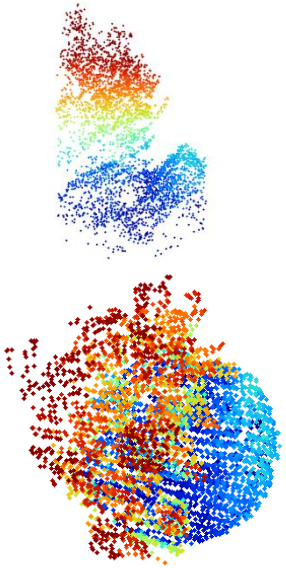
Ground Plots

How should we deal with Edge Plots?

Circular LiDAR plots

LiDAR plots match ground plots

a)



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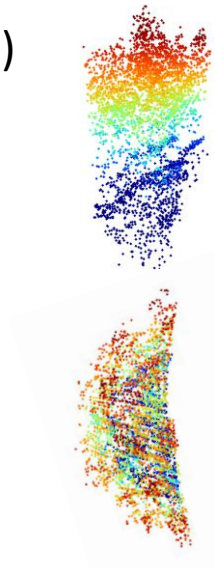

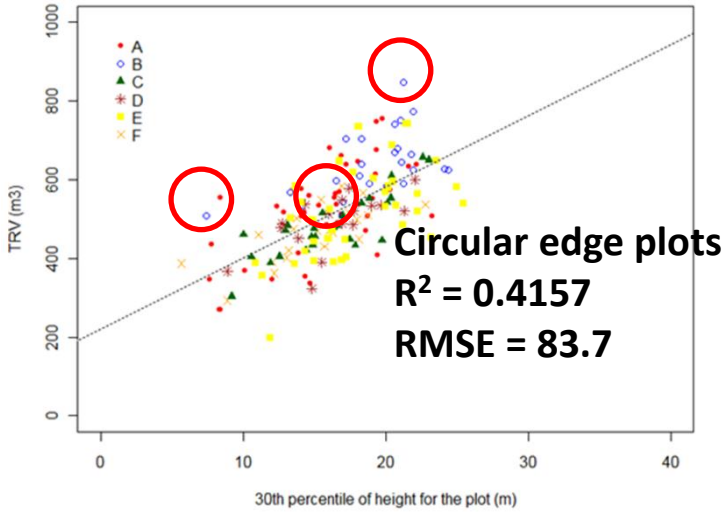

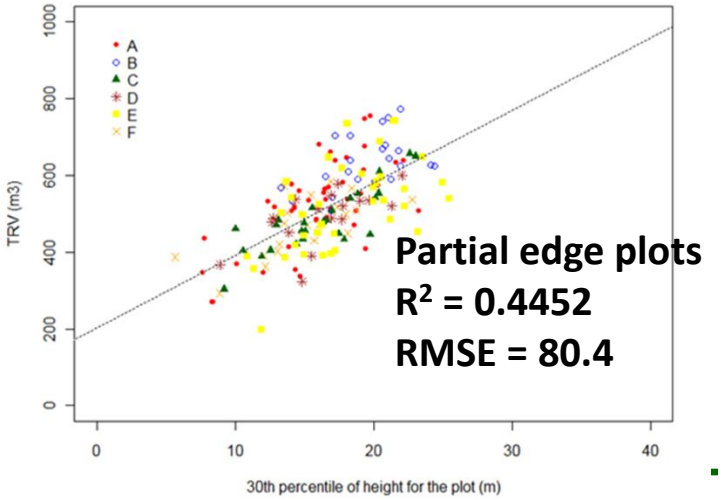

Edge plots are important – LiDAR must match the ground plot

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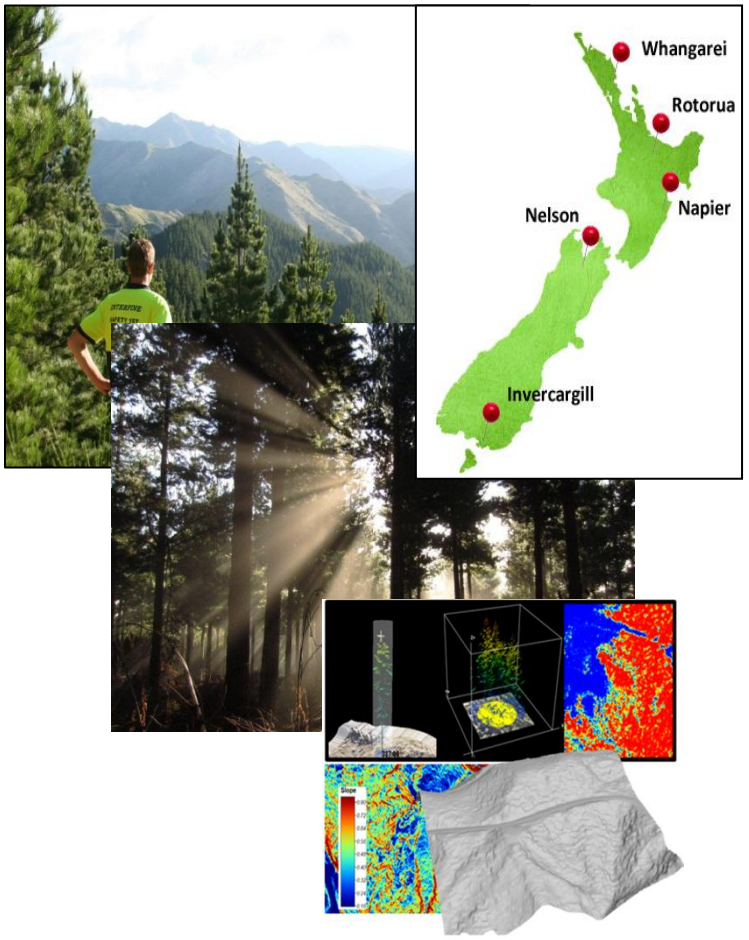
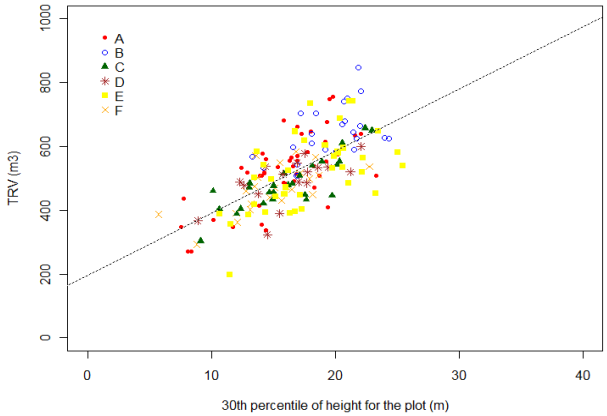
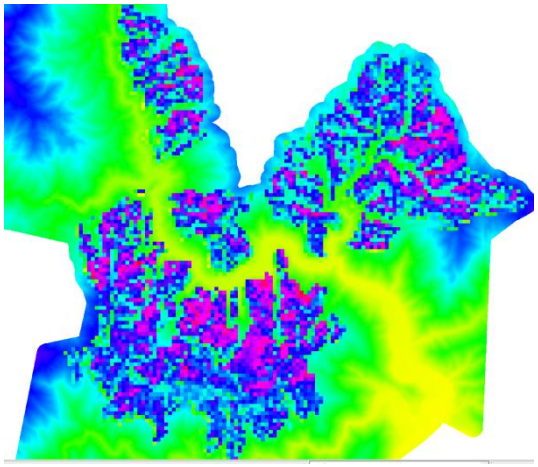
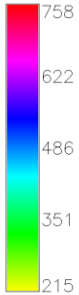


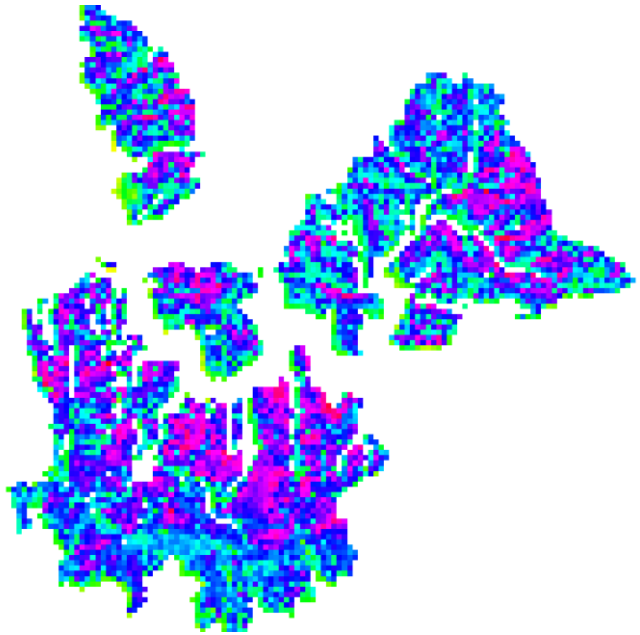
Using LiDAR

Integrating plot data and LiDAR metrics



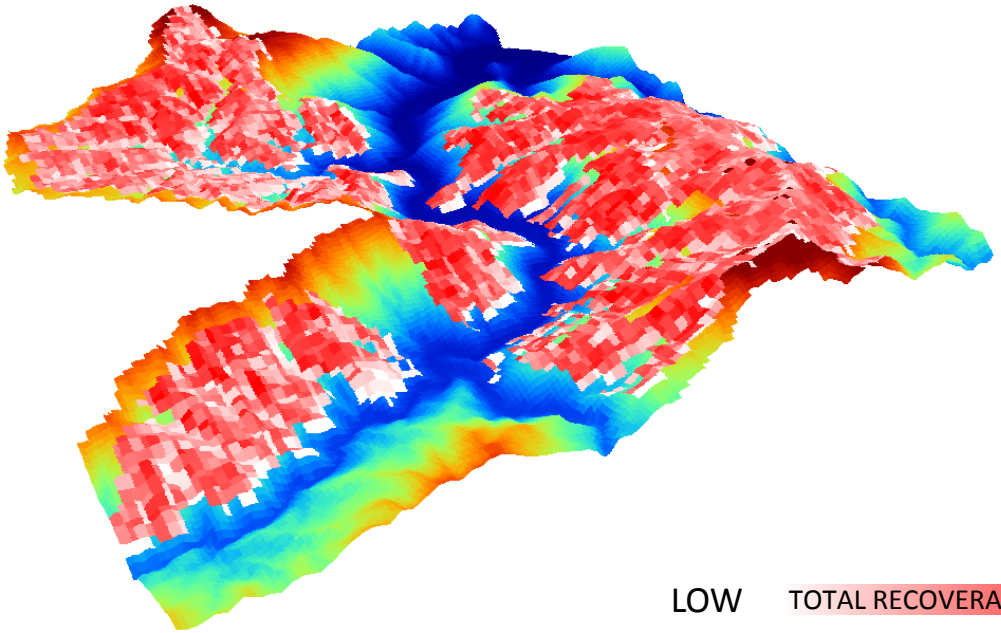






TRV Surface

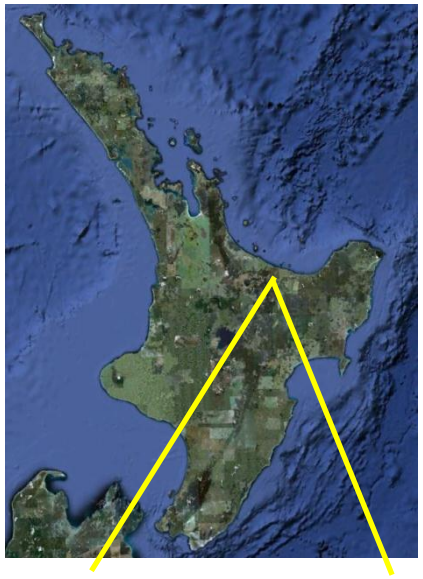
Producing Results



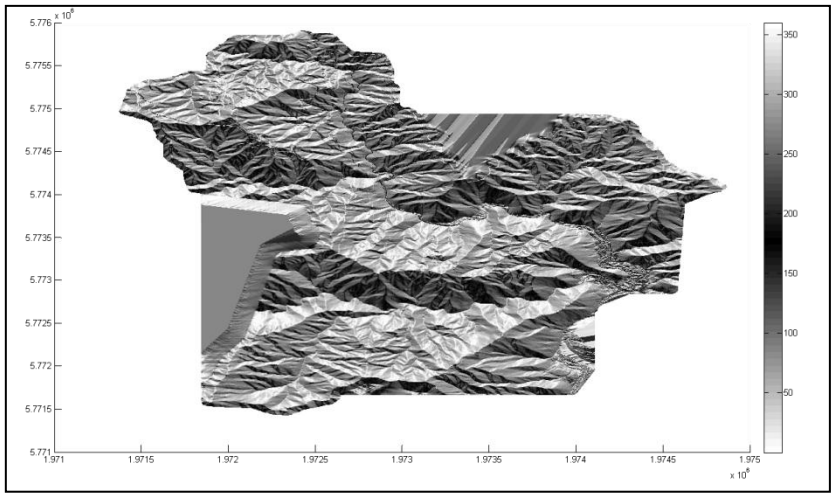
Lets us look at our forest in new ways

Improving Precision

Eastern Bay of Plenty Example



- Can we improve inventory precision using LiDAR as an auxiliary variable?
  - Eastern Bay of Plenty, New Zealand
  - Forest contained a traditional grid based inventory
  - Extremely steep broken terrain
  - Wall to wall LiDAR at 2 pulses per square metre



Improving Precision

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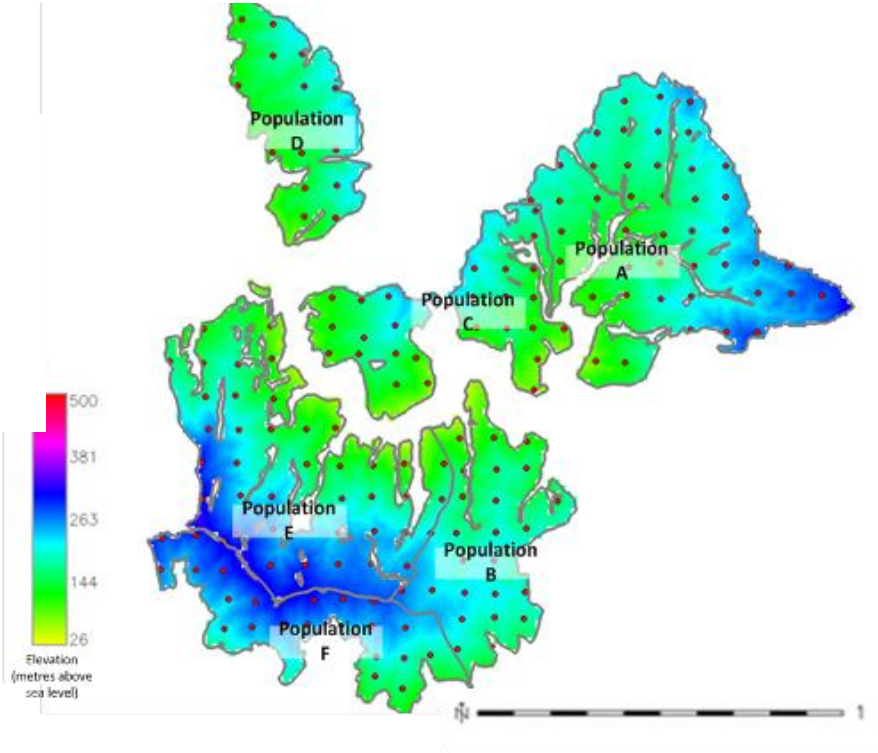
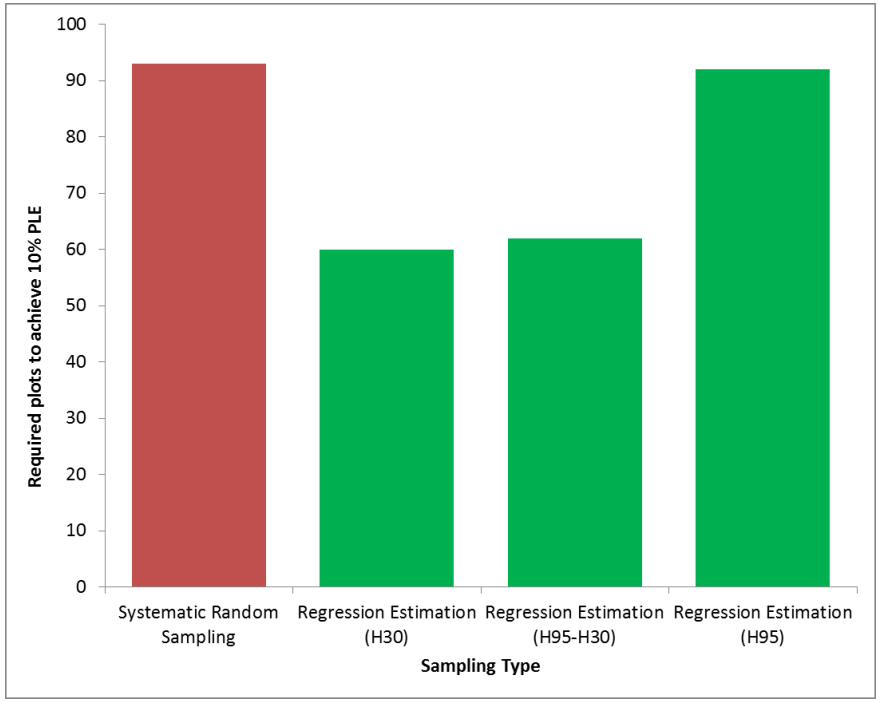
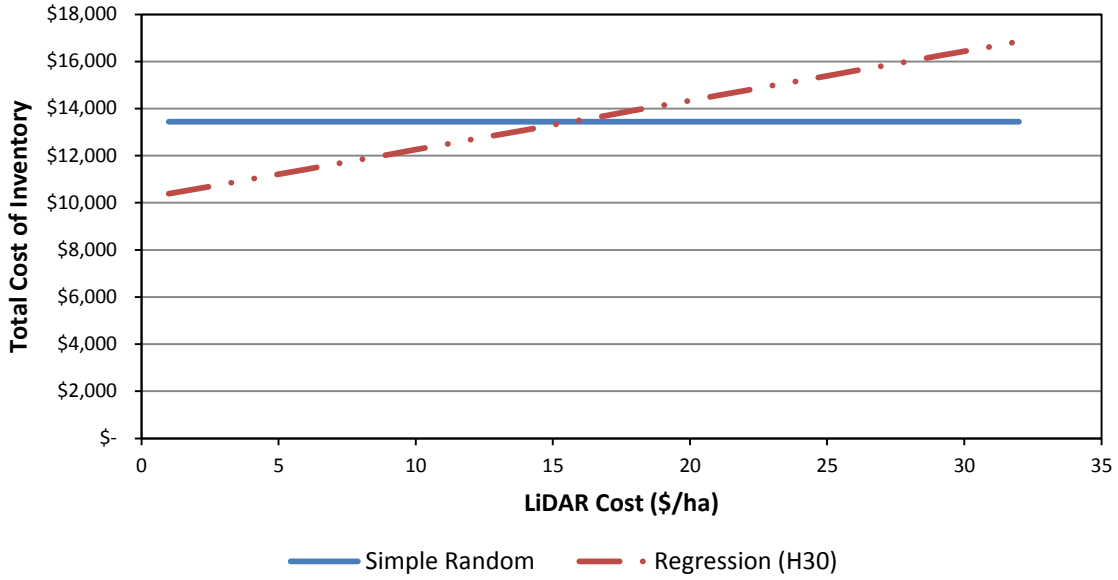




Using REGRESSION ESTIMATION Inventory plot numbers can be reduced whilst maintaining precision.

Regression Estimation

Breakeven LiDAR costs

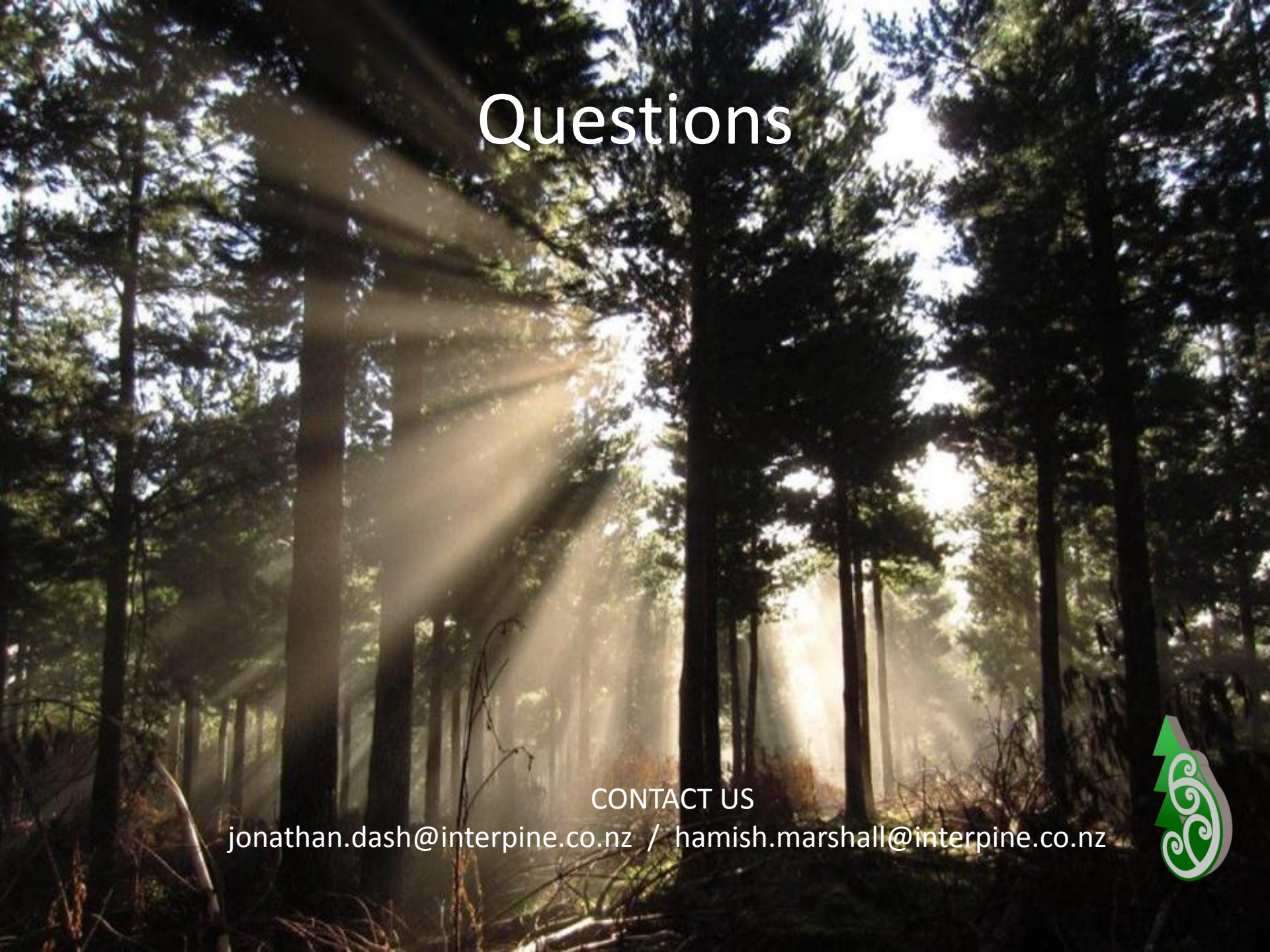


Inventory utilisation could contribute $15 per hectare towards cost of flying LiDAR without changing the inventory budget

Acknowledgements

- Future Forest Research
- PF Olsen Ltd
- Ministry for the Environment
- Susana Gonzalez-Aracil *(Interpine research student)*
- Outline Imagery

Questions



CONTACT US
jonathan.dash@interpine.co.nz / hamish.marshall@interpine.co.nz