Improving small-plantation and woodlot inventory

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supported by forest growers commodity levy

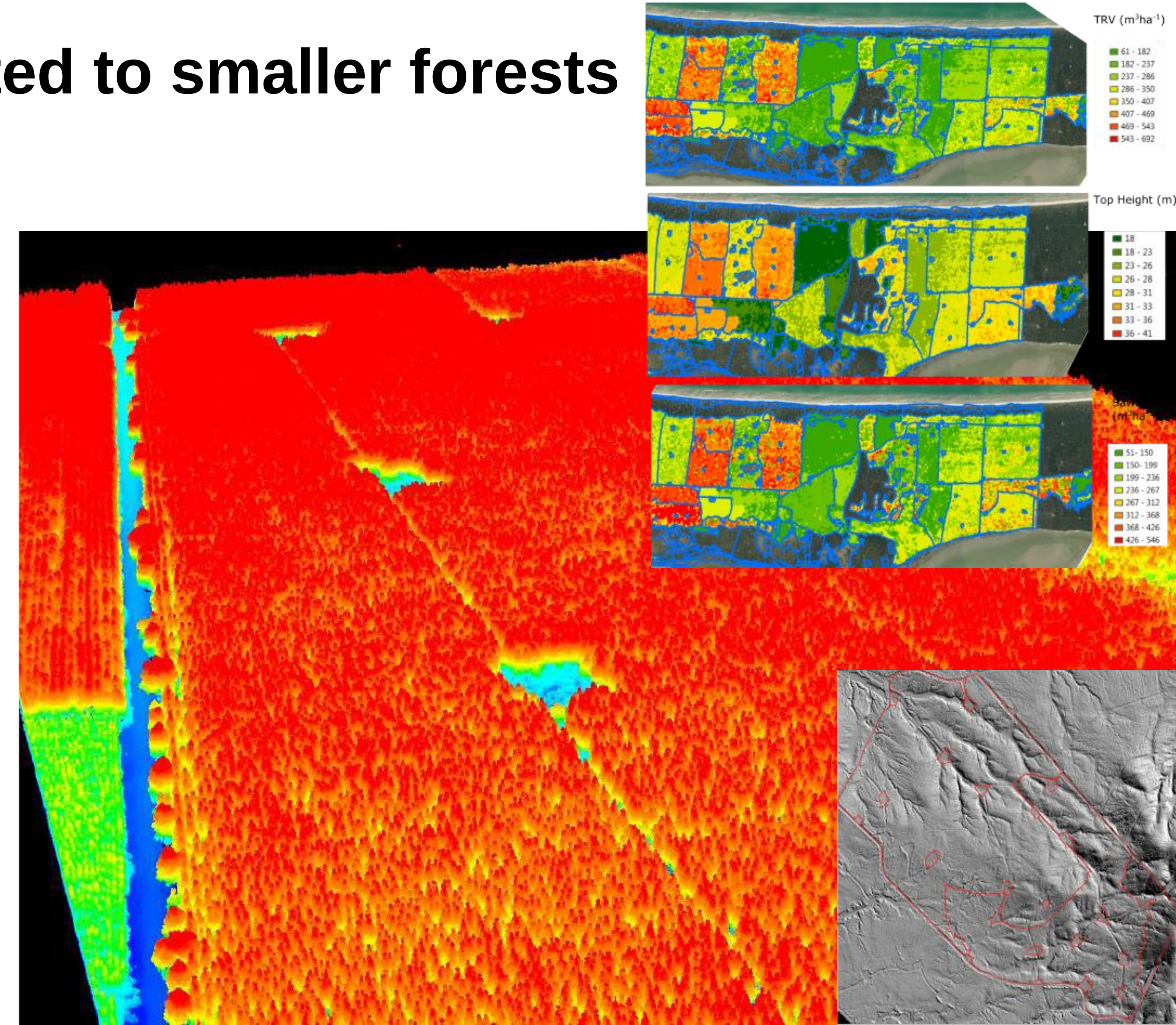
Contents

Introduction and background

RS solutions are not well suited to smaller forests

Why?

- Due to the requirements for large sample size (e.g. k-NN).
- No access to economies of scale for smaller areas.
- Complexities in data processing may require in-house expertise or engaging consultants at some expense.



Woodlots are an awkward size to measure efficiently…

- Large enough to require a reasonable sample size but too small to invest in extensive field measurement…An adequate sample size may be too expensive.

- How many plots can I afford to measure?...
    - 1 day = 8 plots… 2 days = 16 plots.

- Can I rely on the estimate from a small sample size?

- Should I even calculate PLE from a small sample?

Goal: Carry out research that improves small-plantation and woodlot inventory

- To investigate approaches that make measurement more cost effective and / or better.

- To make the benefits of remotely sensed data and novel statistical methods available to small-forest growers.

- This includes both existing data and new data.

- To disseminate the findings to woodlot growers.

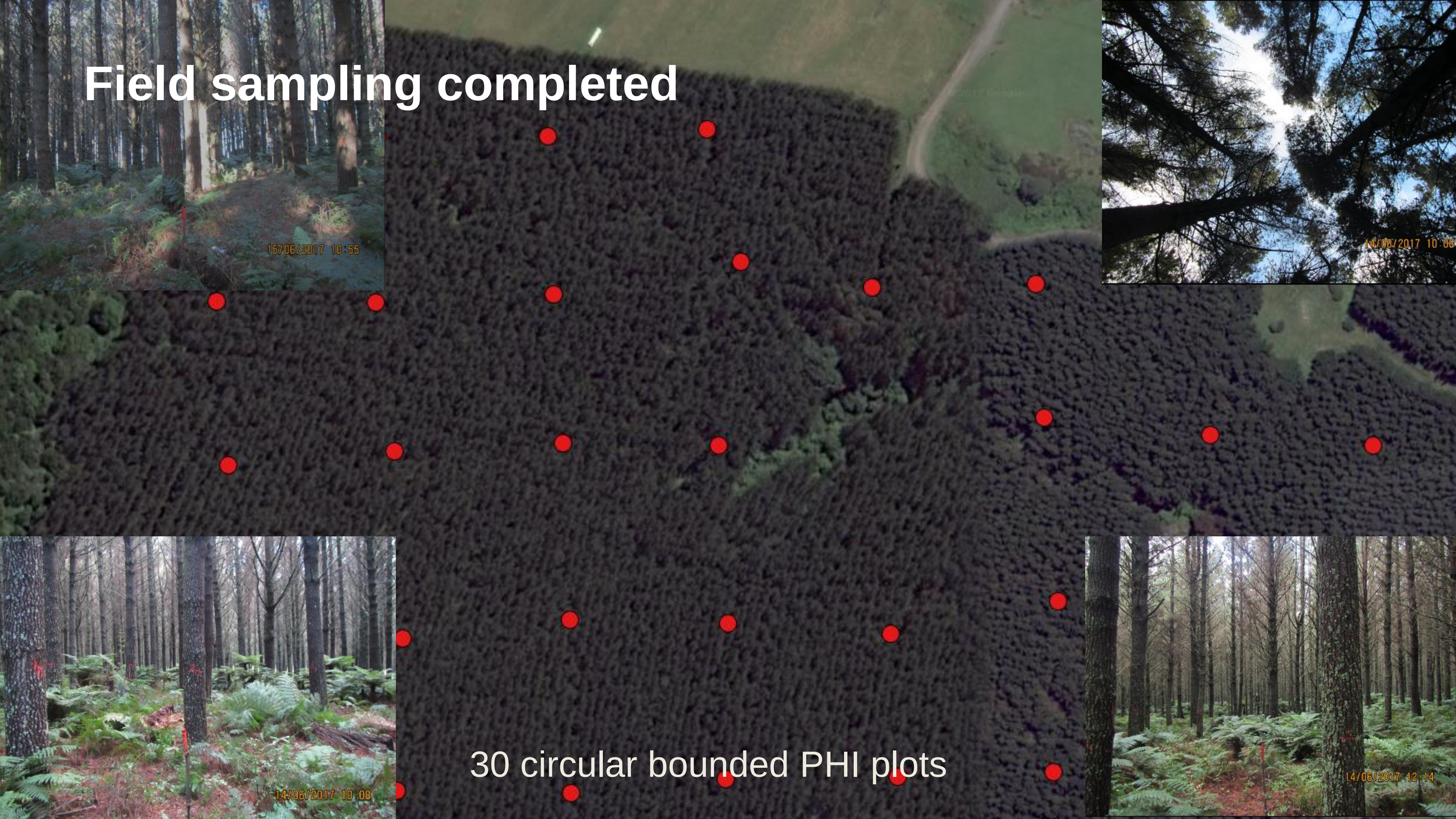
1. UAVs for forest inventory

Can we develop methods to make UAVs useful for small-plantation inventory

Horohoro Forest – A typical New Zealand woodlot

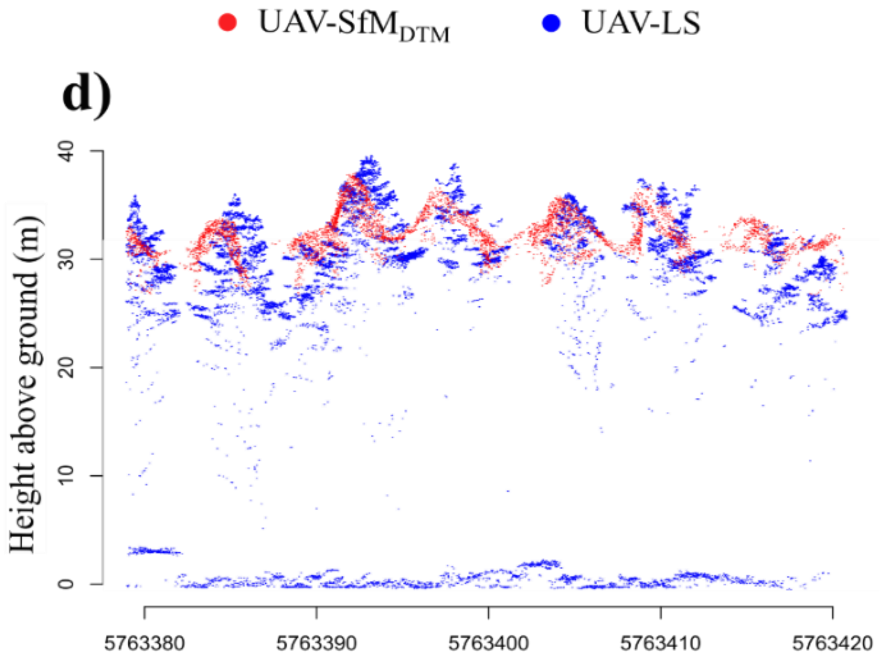
- Located in the central North Island (Rotorua)
- ~40 ha
- Planted 1993
- *Pinus radiata*
- Forestry right

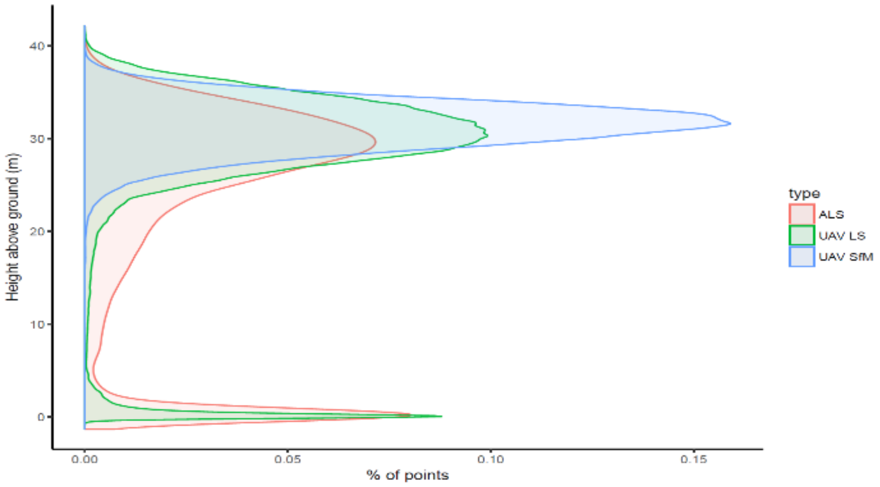
Field sampling completed

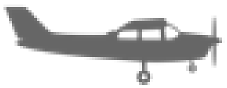


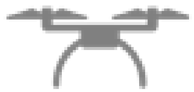
30 circular bounded PHI plots

We acquired UAV and conventional RS data to investigate suitable methods.









AL
S

10 pls/m^2
Foot print = 35 cm
Spacing = 31 cm

UAV-LS

700 pls/m^2
Foot print = 10 cm
Spacing = 4 cm

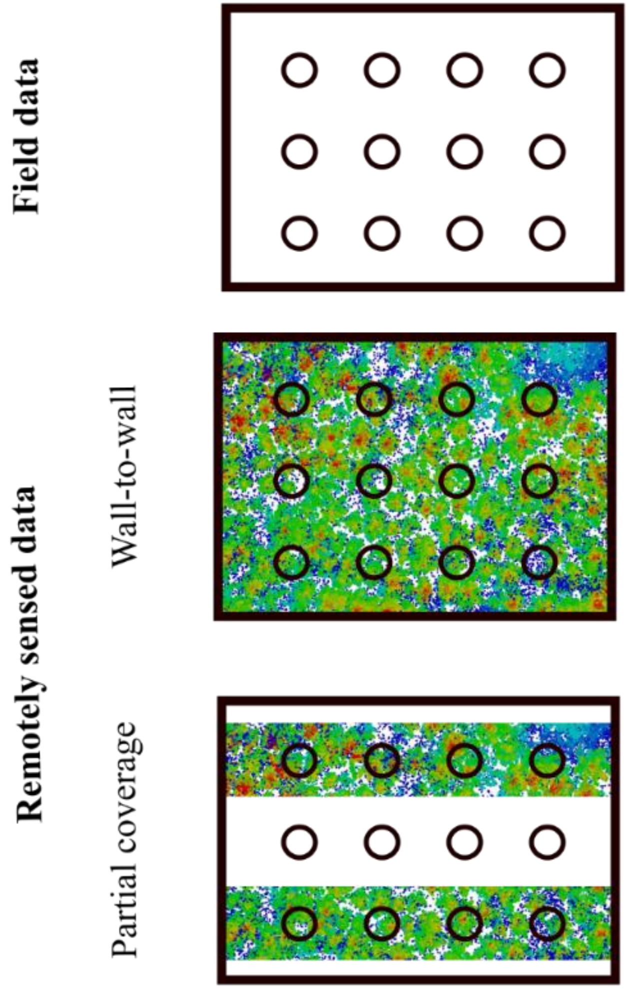
SfM$_{DTM}$ SfM

- Derived from overlapping images
- Very low cost
- No specialist equipment
- SfM doesn’t require any knowledge of the terrain

Model Development (Key result summary)

- SfM_{DTM} and UAV-LS provided the best models for Top Height.
- SfM_{DTM} outperformed UAV-LS and ALS in the prediction of TRV.
- Spectral metrics extracted from the imagery were useful for predicting several stand attributes.
- Even without a DTM the SfM metrics were useful for predicting some attributes (not Height).
- Models developed were good enough to be useful even with a small sample size for most variables.

We examined three sampling frameworks for these data sources



Inferential framework (study case)

Sampling Frameworks and estimation

Design-based (case A) — Plots only - baseline

$$\widehat{Var}\,(\hat{\mu}_A) = \frac{\sigma_Y^2}{n(n-1)}$$

Model-based (case B) — Smaller woodlots

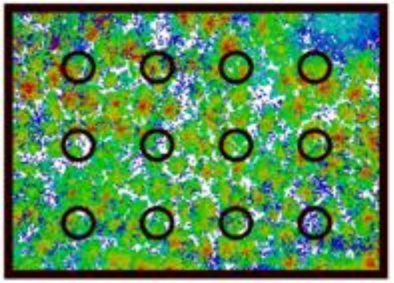
$$\widehat{Var}\,(\hat{\mu}_B) = \boldsymbol{\iota}_U{}^T \boldsymbol{K}_U \widehat{\boldsymbol{Cov}}(\widehat{\boldsymbol{\beta}}_S) \boldsymbol{K}_U{}^T \boldsymbol{\iota}_U$$

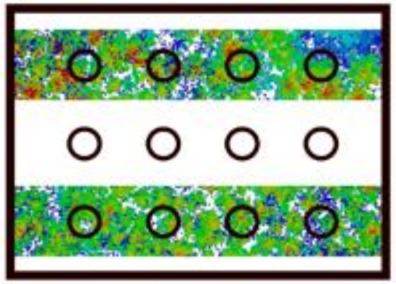
$$\widehat{\boldsymbol{Cov}}(\widehat{\boldsymbol{\beta}}_S) = \frac{\widehat{\boldsymbol{g}}_S^T \widehat{\boldsymbol{g}}_S}{n-r-1} (\boldsymbol{K}_S{}^T \boldsymbol{K}_S)^{-1}$$

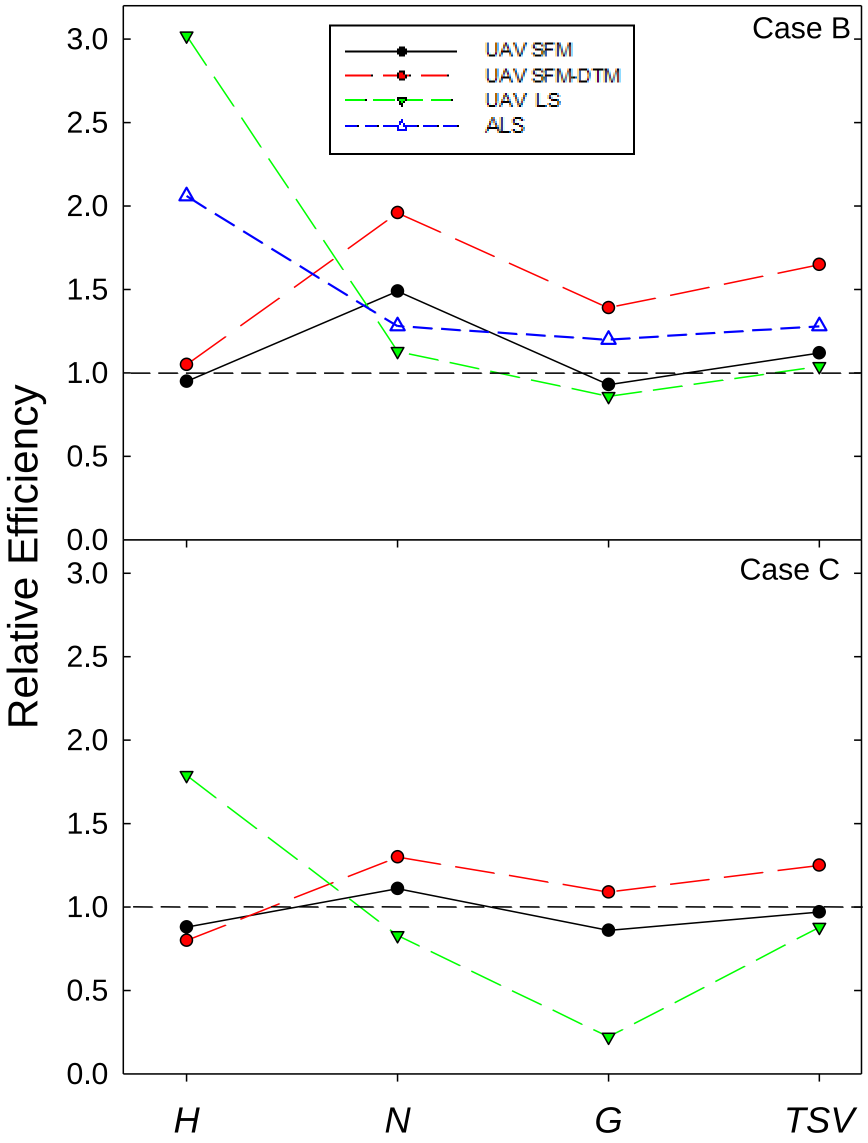
Hybrid (case C) — Larger woodlots

$$\widehat{Var}\,(\hat{\mu}_B) = \left(\frac{1}{M}\omega^2\right) + \boldsymbol{\iota}_{S_a}{}^T \boldsymbol{K}_{S_a} \widehat{\boldsymbol{Cov}}(\widehat{\boldsymbol{\beta}}_S) \boldsymbol{K}_{S_a}{}^T \boldsymbol{\iota}_{S_a}$$

Estimation results and relative efficiency







- Including RS data almost always enhanced the efficiency compared to using plots alone.
- Efficiency gains were greatest when using wall to wall estimation but partial coverage also offers a viable option for improving precision.
- The gains in efficiency varied by forest parameter, platform, and sensor

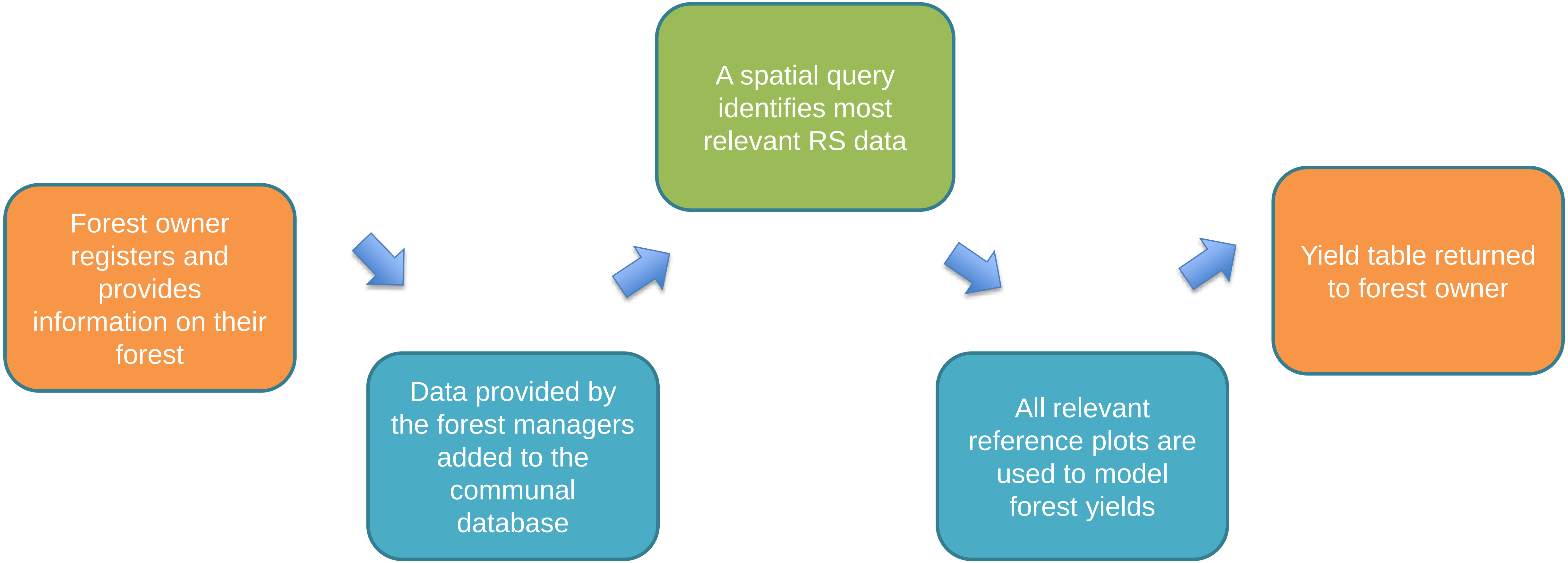
Theme 1 Conclusions

- We have developed and trialled a new statistical estimator that allows UAV data to be incorporated into woodlot inventory
- We have shown that this can be applied either with total coverage or with partial coverage of the forest.
- We have found that plot numbers can be reduced significantly or precision can be increased by using these methods.
- We showed that UAV data can be as accurate as more traditional (plane) data
- Photogrammetric (cheaper) data was as useful as laser scanning.

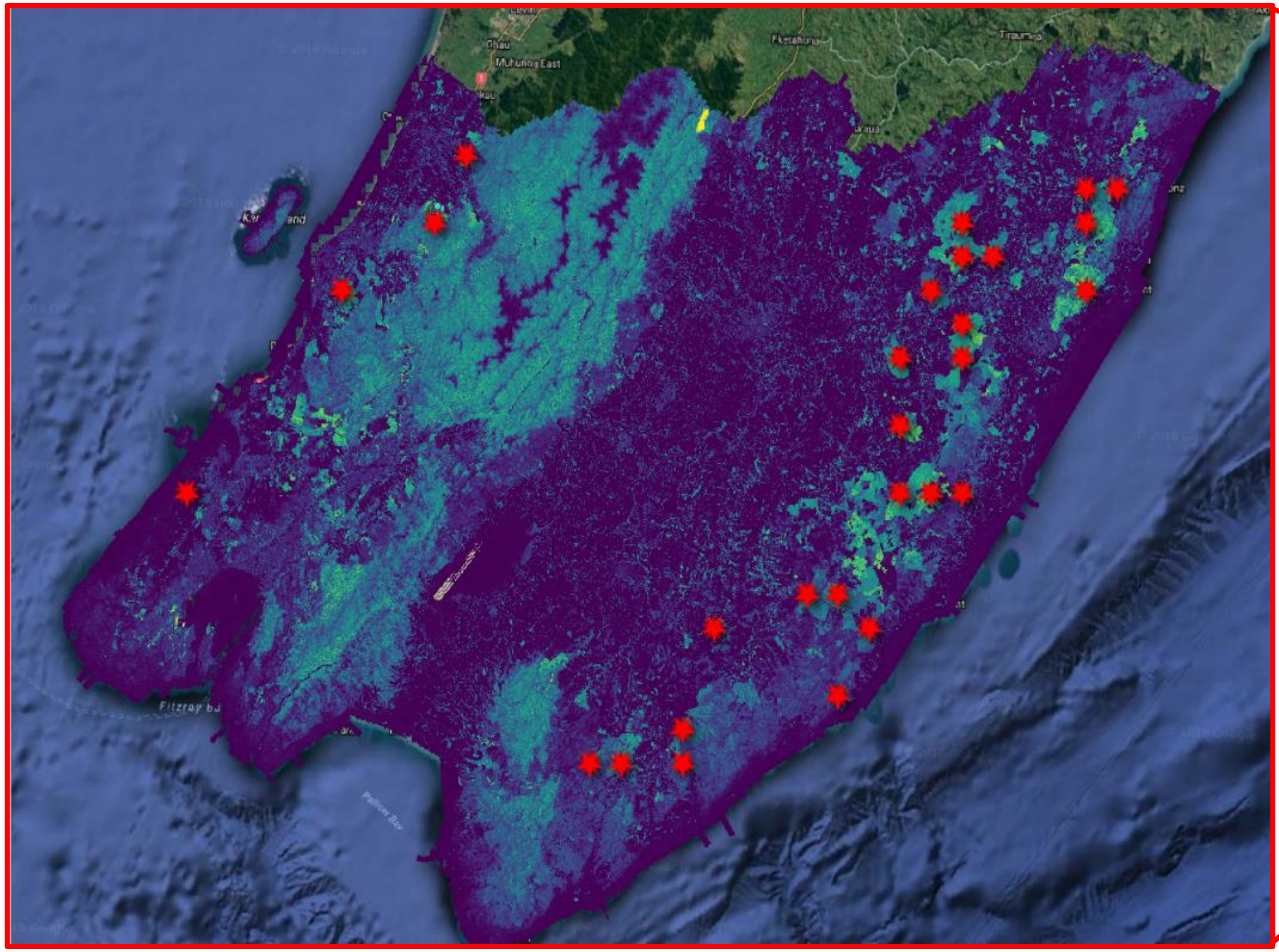
2. A community approach

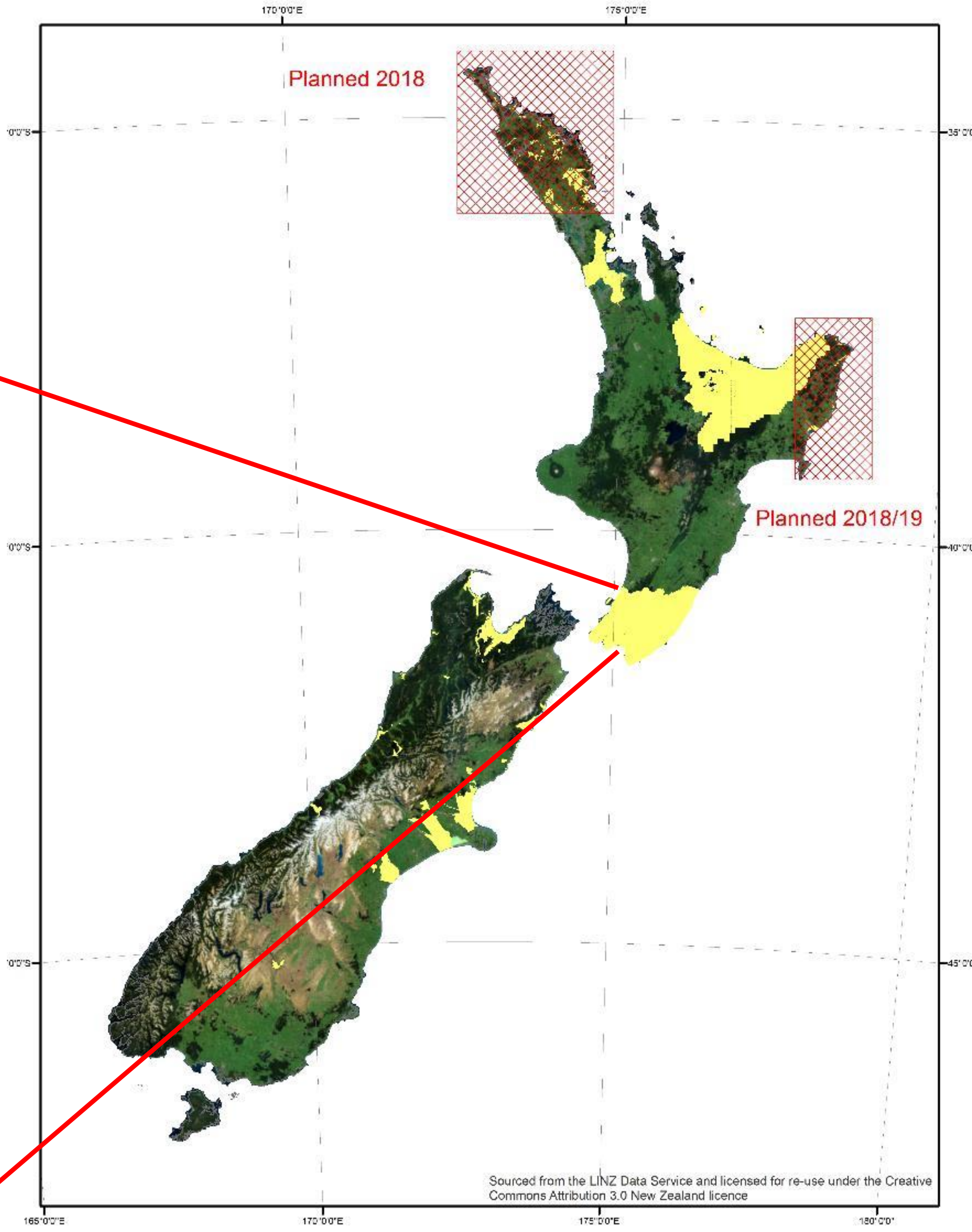
Through prudent data sharing, can we make the benefits of pre-existing RS data available to small-forest growers as if they were large-forest growers.

Community data sharing approach - proof of concept

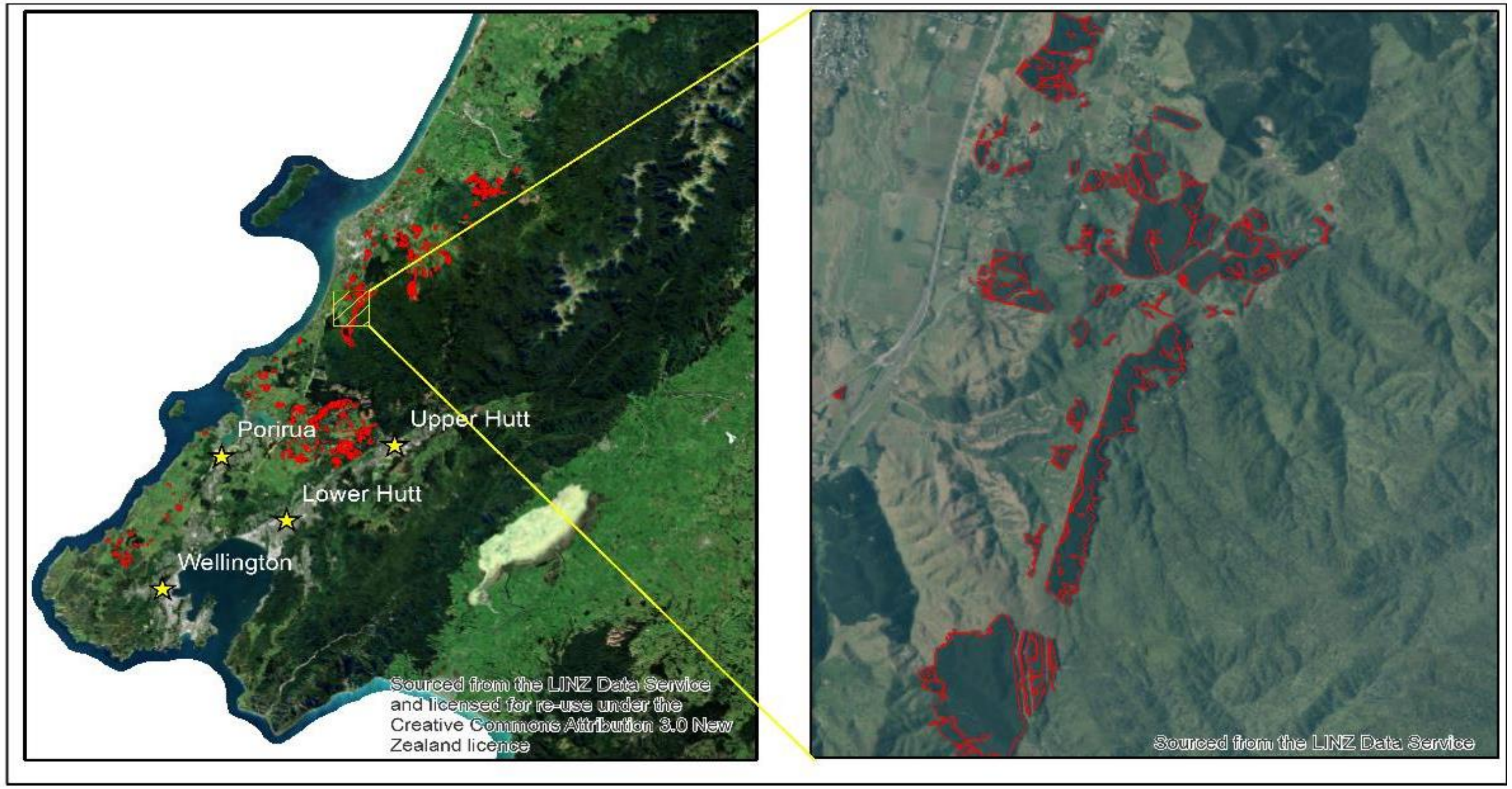


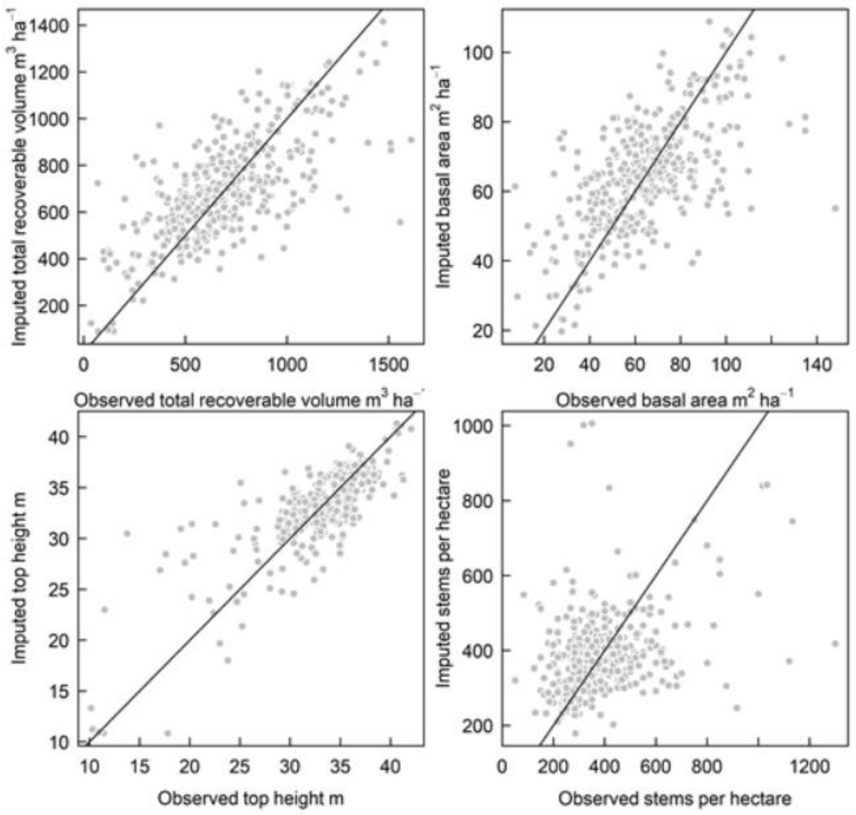
What data is available and where is this currently possible?



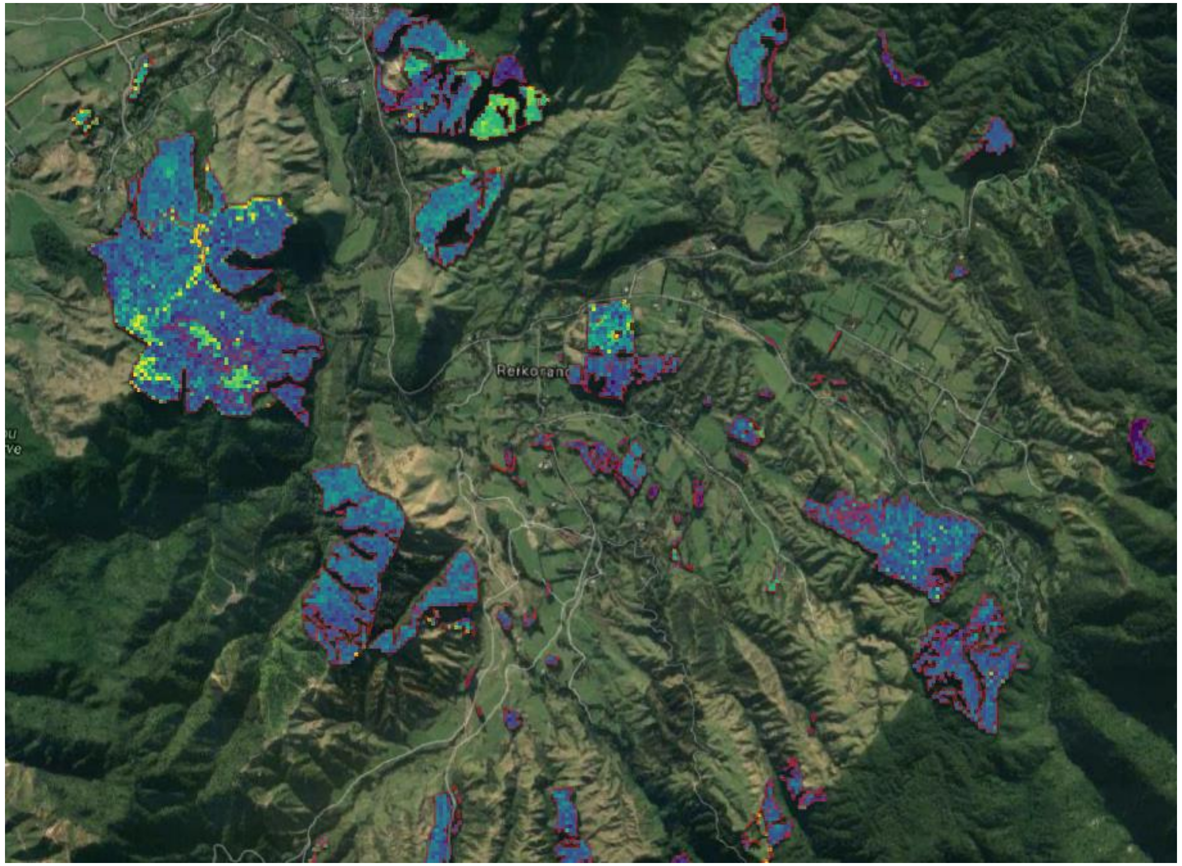


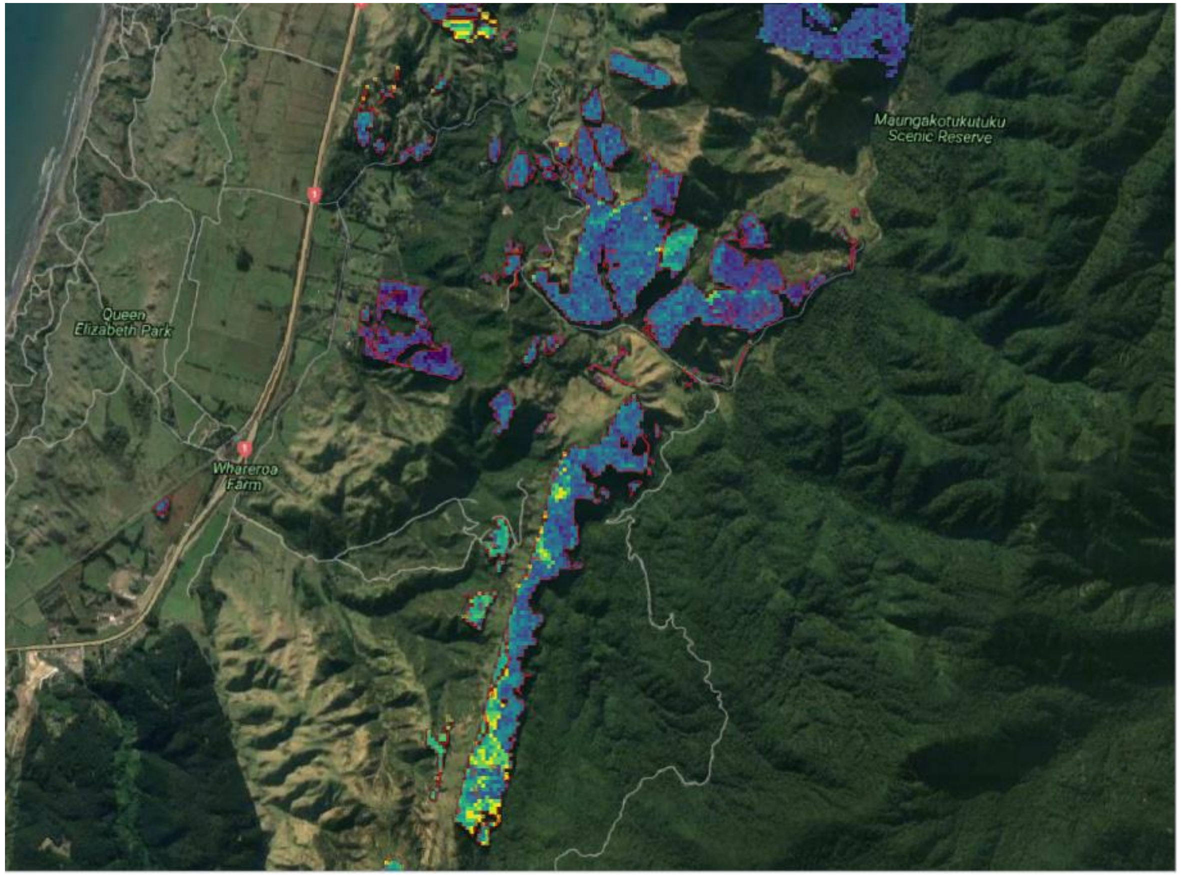
We identified forest boundaries, acquired plot data, and fitted models of forest yields





We have produced region wide maps





Validation

Variable	Measured	Predicted
Top Height	32.7	31.8
Volume	546.9	610
Basal Area	49.5	59.3
Stocking	262.7	360

Concluding comments

This project has delivered new solutions using emerging technology in a manner that is suitable for small-forest growers.

We now have methods for generating cost effective 3D information on forest structure from UAV imagery. We have developed methods for statistical inference to include this into woodlot inventory.

A proof of concept for a plot sharing approach for a community of small-forest growers using open access RS data has been completed and show promise.

Project outputs

Tree Grower article
Dash, J.P., and Watt, M.S., 2017. Improving small-plantation and woodlot inventory using remote sensing… How can you help? Tree Grower 38 (2).

Article written and published in Friday Offcuts
https://foresttech.events/improving-small-plantation-and-woodlot-inventories/

Youtube video on the project
https://www.youtube.com/watch?v=9REd2GhTqsw&t=19s

Coverage in Scion's Connections
http://www.scionresearch.com/about-us/about-scion/corporate-publications/scion-connections/past-issues-list/scion-connections-issue-26,-december-2017/new-ways-to-measure-and-value-small-forests

Forest Growers Research Conference, Christchurch 2017 Presentation
https://fgr.nz/documents/improving-small-plantation-woodlot-inventory/

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