# Estimation of Growth Rates at Kielder Forest using Airborne Laser Scanning

Amy Woodget[a], Danny Donoghue[a], Patrice Carbonneau[a] and David Woodhouse[b]

[a]University of Durham, UK

[b]Forestry Commission, Kielder District, UK

# Introduction

*'Estimation of Growth Rates at Kielder Forest using Airborne Laser Scanning'*

- Forest Management – up-to-date, accurate data

- ALS has shown promise for tree height and biomass

- Carbon stocks & climate change

- Assess potential for growth

- Error quantification
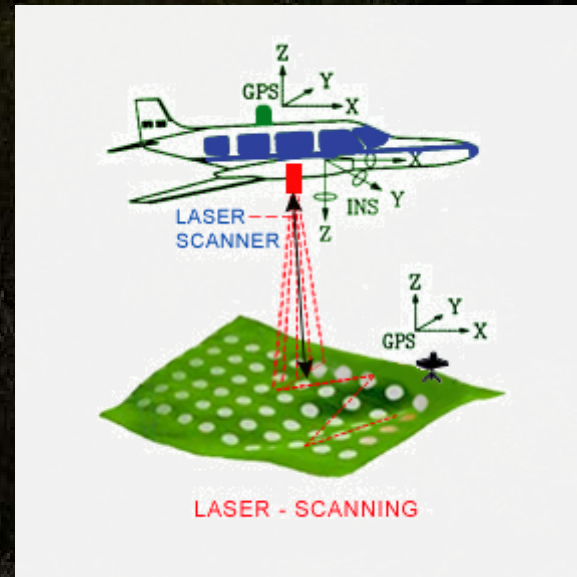


*Source: www.gis.gov.ae*
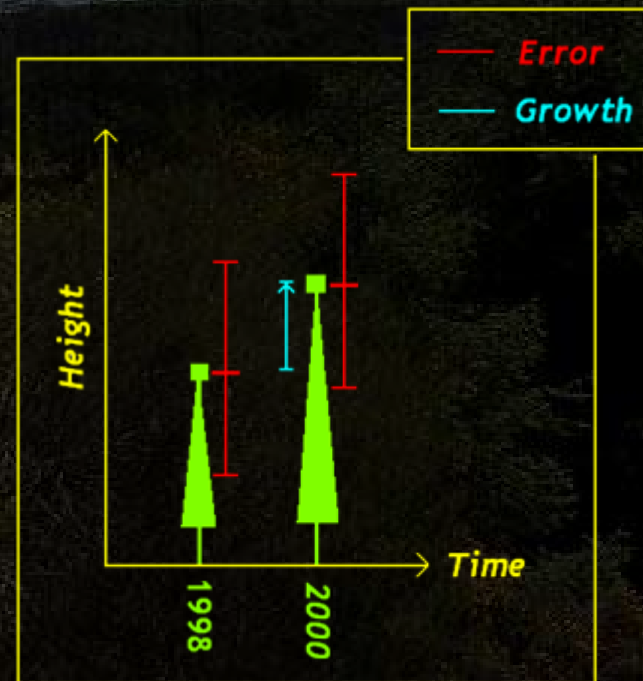
# Background

## *Use of LiDAR for <u>Growth</u> Estimation*

### <u>Yu et al., 2004</u>

- Kalkinnen, Finland

- 1998-2000

- Tree-to-tree matching algorithms

- $R^2 = 0.29$

- Height underestimation – 67cm = <u>serious issue!</u>

### <u>Yu et al., 2006</u>

- Follow up paper

- 1998-2003

- Hausdorff technique

- $R^2 = 0.68$

# Background

*The Focus So Far...*

**Geographical Region:**

Less densely stocked, slow growing forests of Scandinavia

**Scale:**

Individual tree level growth

**Other:**

Ground truthing still essential

So what does this mean for my research?

# Aims & Originality

## Aims:

i.   Quantify growth rates using multi-temporal (2003, 2006) airborne LiDAR data from Kielder Forest;

ii.  Verify by ground truthing and;

iii. Test the accuracy of the ground truth equipment.

## Originality:

Combination of…

i.   Stand level growth

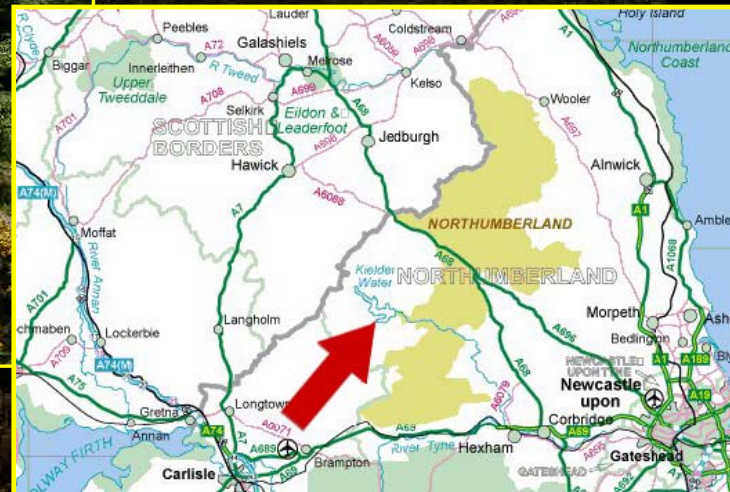ii.  Temperate, fast growing forest

iii. Ground truth error

# Field Location

## Kielder Forest, Northumberland

- Forestry Commission
- Plantation Forest: 62,000 ha
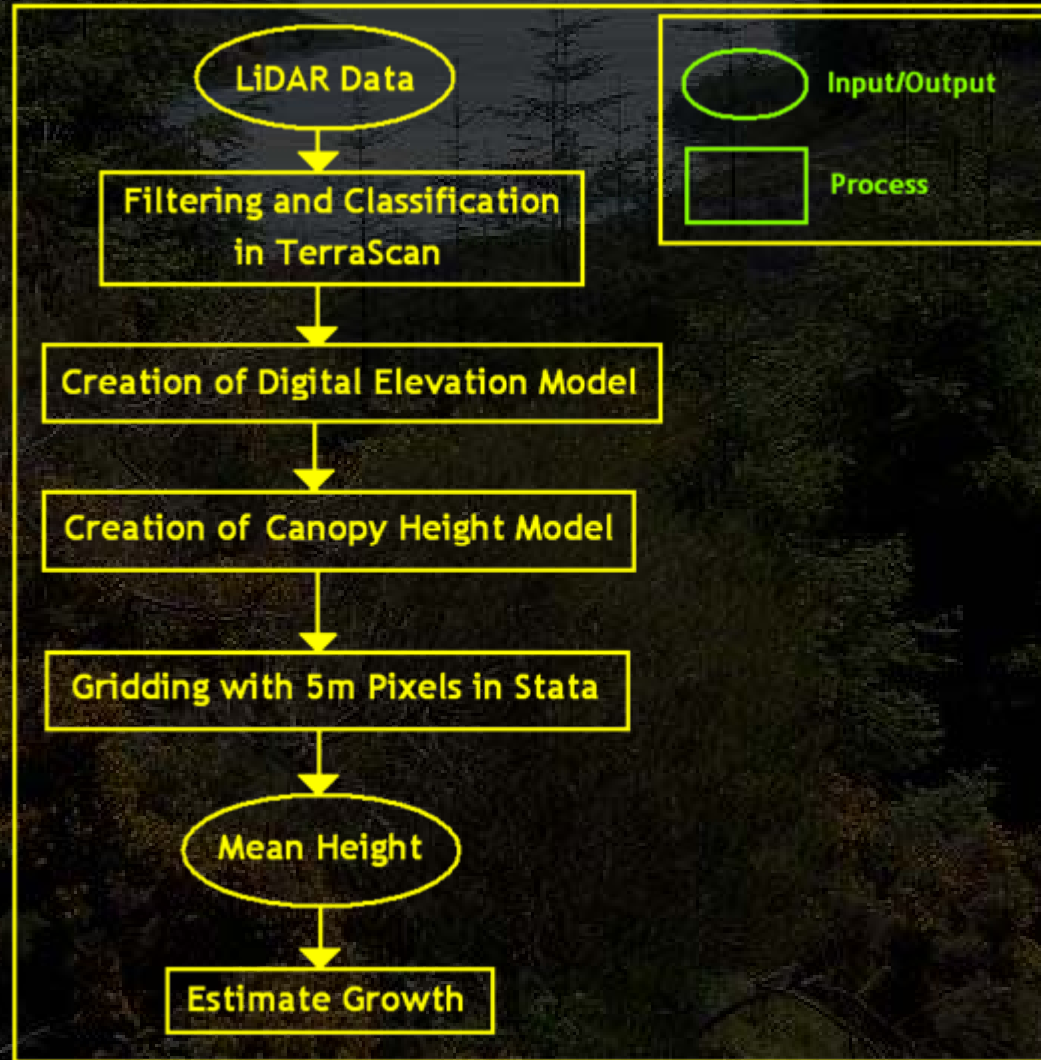- Sitka Spruce



Source: www.hadrianswallcountry.org



Source: www.calvert-trust.org.uk

# LiDAR Processing

*Methodology*

*LiDAR Overview 2006*



LiDAR Data

Filtering and Classification in TerraScan

Creation of Digital Elevation Model

Creation of Canopy Height Model

Gridding with 5m Pixels in Stata

Mean Height

Estimate Growth

Input/Output

Process

# LiDAR Processing

*Estimating Growth...*

### Mean Height Data
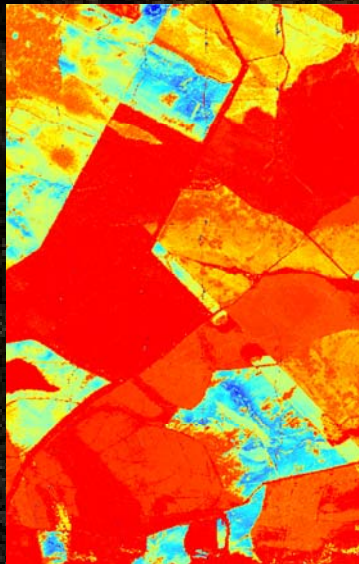


2006
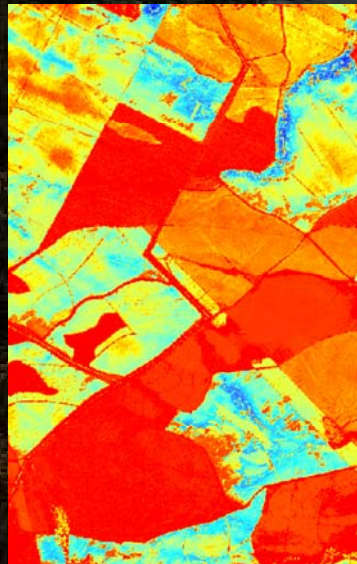
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2003

=

### Growth
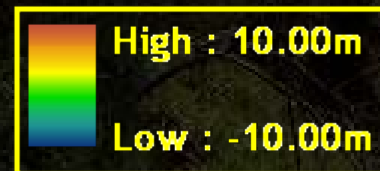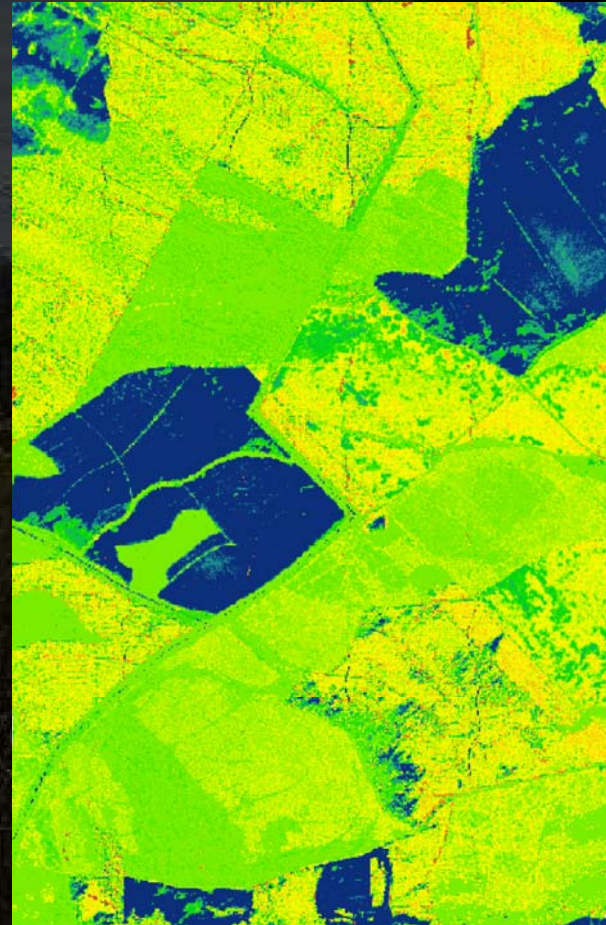



High : 30.00m
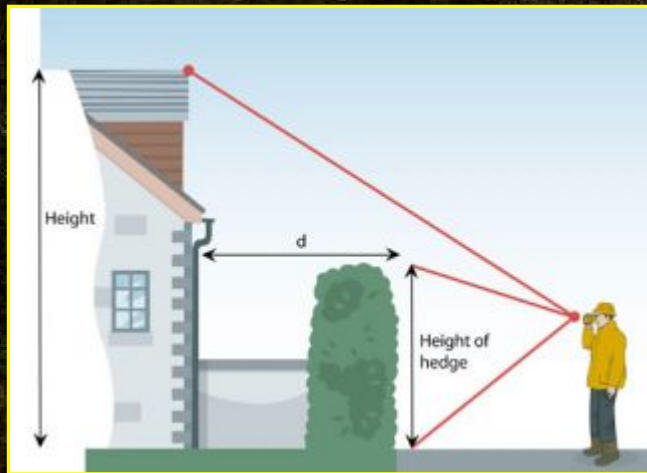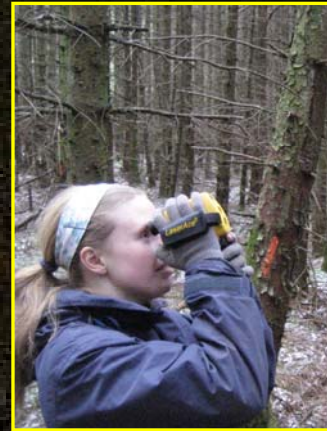Low : 0.00m


High : 10.00m
Low : -10.00m

# Ground Truthing

## *Verification of LiDAR*

- Using a Vertex Hypsometer

- 0.02ha circular plots
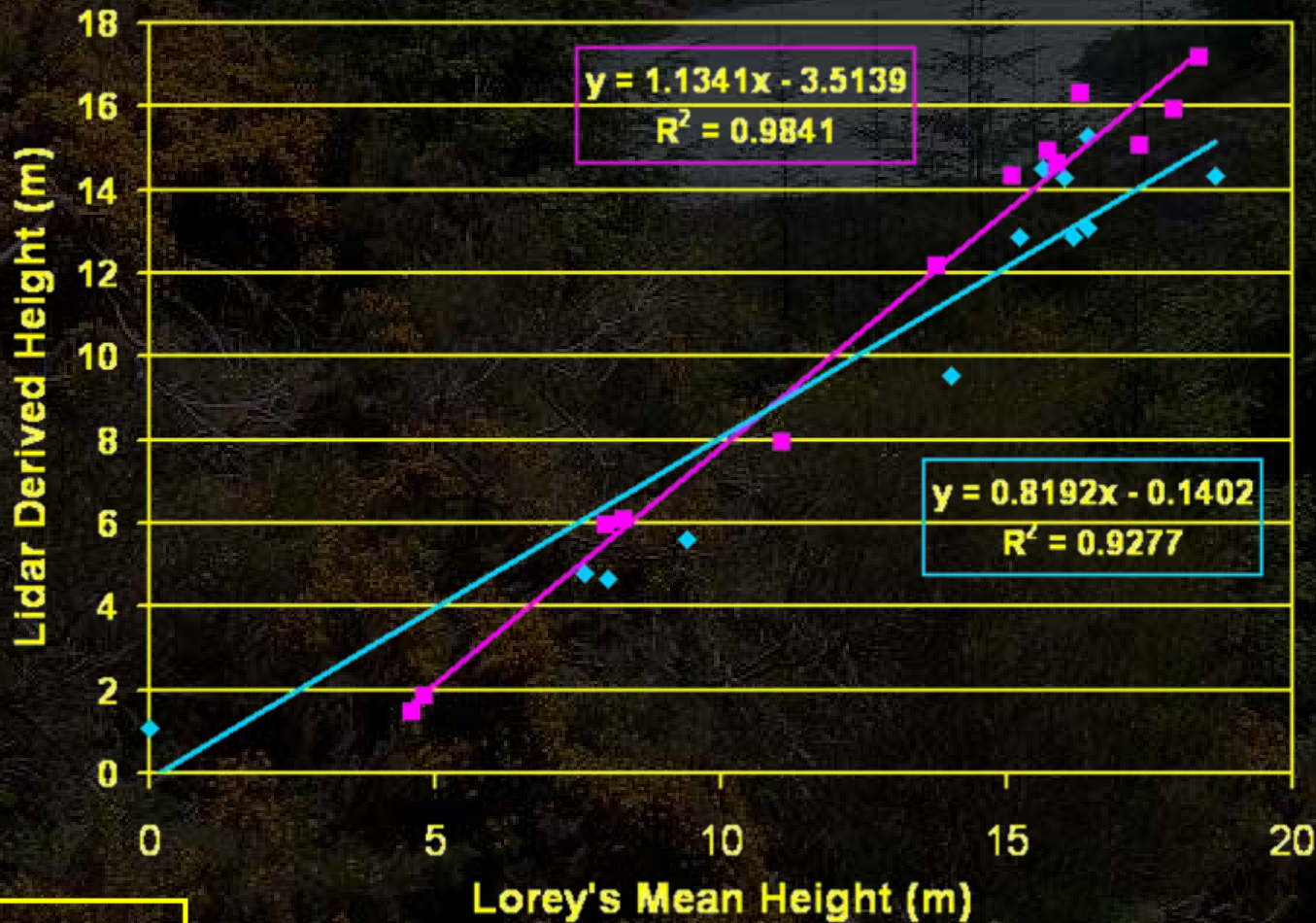
- Various ages

- Height, dbh etc.

*Use of LaserAce*

# Height Regressions

*Comparing the LiDAR with the Ground Truth Data*

Chart: Lidar Derived Height (m) vs Lorey's Mean Height (m)

$y = 1.1341x - 3.5139$
$R^2 = 0.9841$

$y = 0.8192x - 0.1402$
$R^2 = 0.9277$

Legend:
— 2006
— 2003

# Growth Regressions

*Comparing the LiDAR with the Ground Truth Data*

Scatter plot of LiDAR Derived Growth (m) versus Field Derived Growth (m).

$$y = 0.5558x + 0.7529$$
$$R^2 = 0.1998$$

• Weak correlation, despite removal of all negative values

# Ground Truth Error?

- Errors are expected within the LiDAR

- Ground truth data is assumed to be 'true'

- But what is the error associated with ground truth data collection?

  - Instrument accuracy?

  - User variability?

## The Trial

- 15 trees AND 9 users

- 3 height measuring devices

  1. Vertex Hypsometer

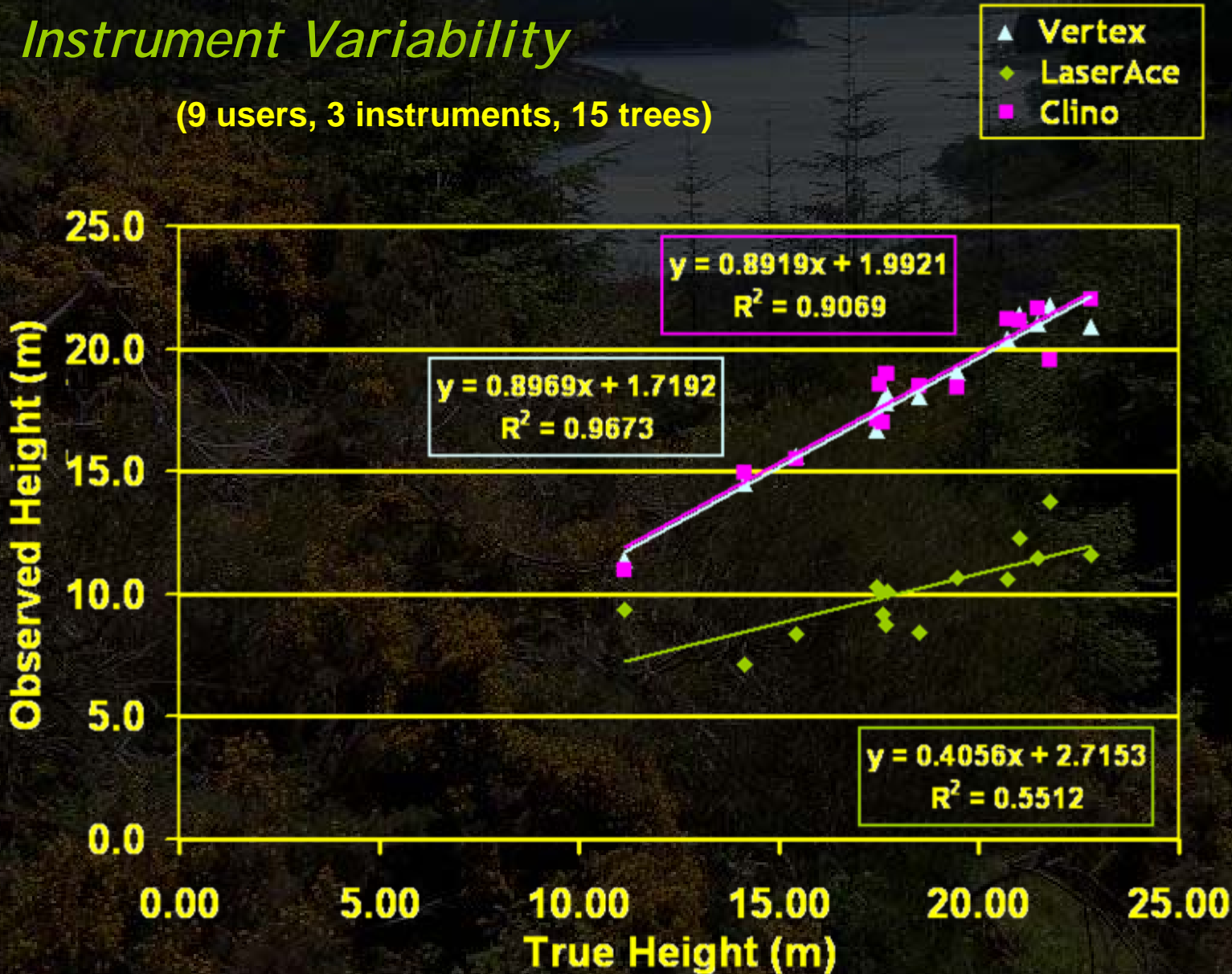  2. Suunto Clinometer

  3. LaserAce

# Ground Truth Error

## *Instrument Variability*

**(9 users, 3 instruments, 15 trees)**

Legend:
- ▲ Vertex
- ◆ LaserAce
- ■ Clino

$y = 0.8919x + 1.9921$
$R^2 = 0.9069$

$y = 0.8969x + 1.7192$
$R^2 = 0.9673$

$y = 0.4056x + 2.7153$
$R^2 = 0.5512$

Y-axis: Observed Height (m)
X-axis: True Height (m)

# Ground Truth Error

*Instrument and User Variability*

The Vertex...

# Ground Truth Error

## *Instrument and User Variability*

The Suunto Clinometer...

# Ground Truth Error

*Instrument and User Variability*

The LaserAce...

# Ground Truth Error

*Summary...*

- Vertex seems most accurate

  — Strong positive correlations with 'true' height  ($R^2$=0.97)

- <u>BUT</u>- scatter is still considerable

  — As much as 2m

- Growth over the 3 years is small

  — 0.2 - 1.8m

- Therefore growth is undetectable?



Errors associated with growth estimation are actually larger than the estimated growth itself

(with respect to the ground truthing)

# Conclusion & Future Work

Introduction

Background

Aims & Originality

Field Location

LiDAR Processing

Ground Truthing

Results

Discussion

Conclusion

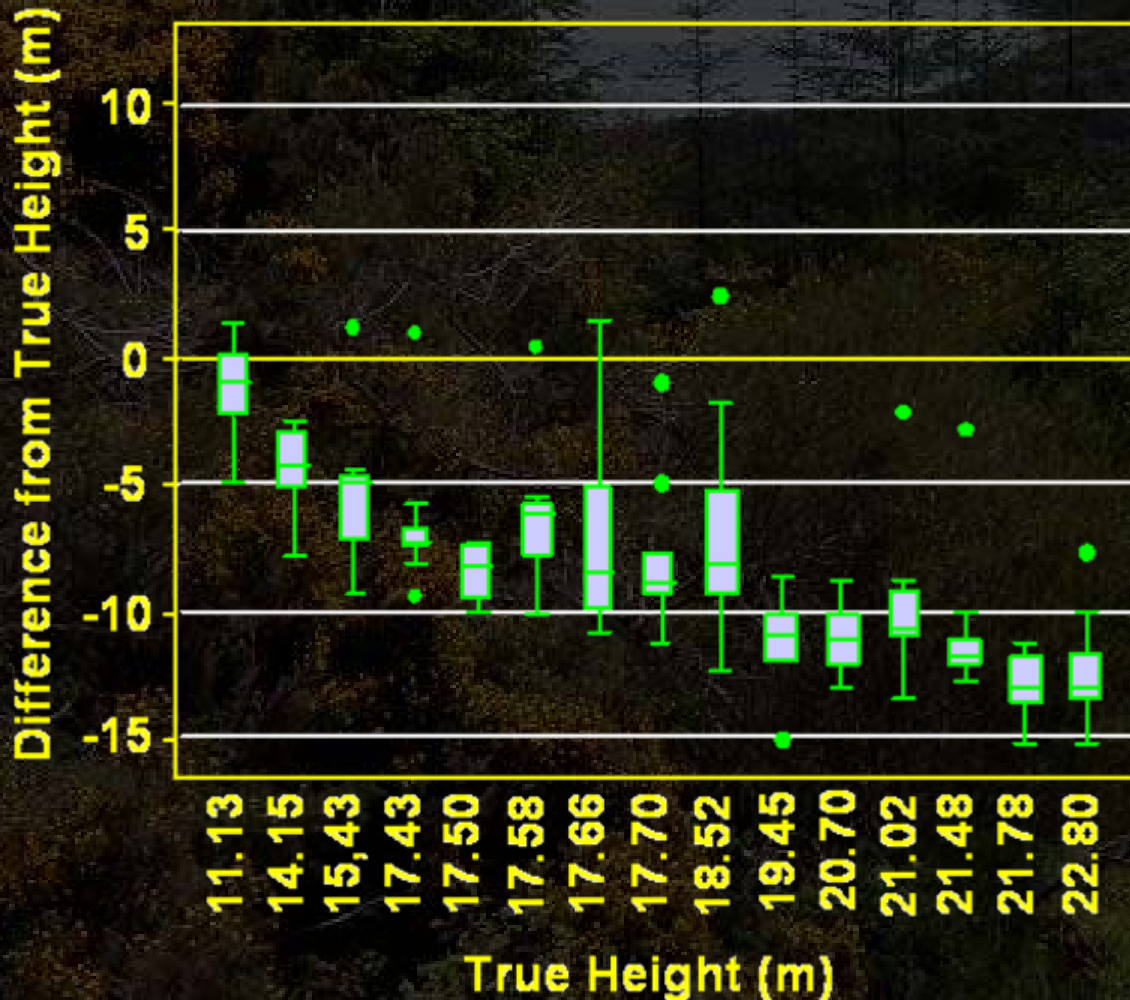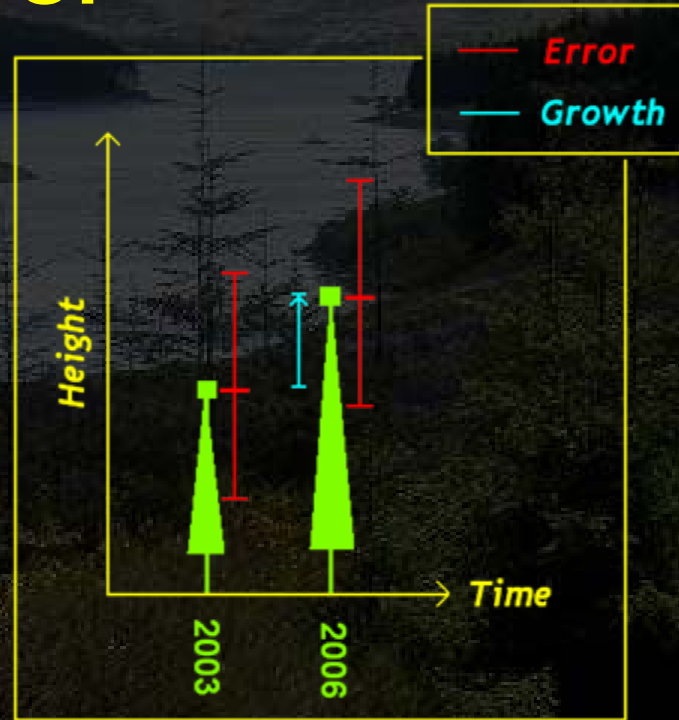**Original Aim:** growth at Kielder using ALS 2003-2006

**Findings:**

- Strong positive correlations for HEIGHT ($R^2 = 0.98$)

- Poor correlations for GROWTH ($R^2 = 0.2$)

- Significant errors in Vertex data (2m)

- Causes any growth to be undetected

What does this ground truth error mean for estimating growth using LiDAR?

Need to understand errors and biases in order to develop a repeatable, robust methodology