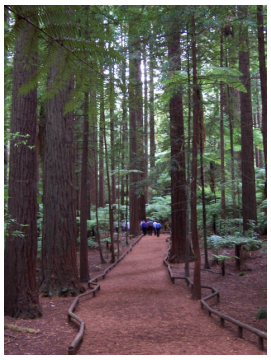
Modern Forest Measurement, Information Systems and Management

When the stand mean just doesn't do it any more

Cris Brack
Chair of Forestry, Waiariki Institute, Rotorua

Forest management pressure is intensifying

- Public goods and services from forests expanding
- Plantation forests expected to meet ever-more exacting requirements
- Just-in-time inventories and infrastructure
- Desire for more product differentiation
- International conventions and scrutiny
- Increased inventory needs as consequence



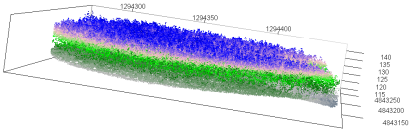
Increasing demands, data sources, technologies not new

Increasing demand for quality and quantity of information

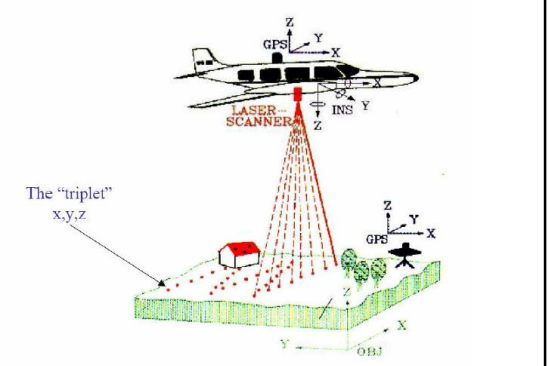
Sources of information and collections techniques	Year	Requirements and technologies affecting forest inventory
Maps of areas of forests	1800	Perceived shortage of fuelwood (Central Europe)
Visual estimation of timber over small areas	1825	
Random and strip line surveys. Tree volume tables developed	1850	
Statistically sound surveys developed	1875	
Forest mensuration relationships increasingly used, e.g. volume : basal area	1900	Increased demand for information over large areas in North America and Australia
Stratified sampling, aerial survey	1925	Major advances in technology including aircraft devices and computing devices
Textbooks on statistically based survey methods. Variable probability sampling (plotless cruising)	1950	Increasing demand for multiple resource information, and information to aid large industry developments
Sophisticated models (e.g. taper models), use of laser and sonic technology	1975	Microcomputers and GIS become freely available
Multi-phase, multi-stage inventories. Linear and non-linear regression models. Expert systems	2000	Increasing concern over biodiversity and ecologically sustainable development
	2025	

Increasing cost of human labour. Decreasing cost of technology

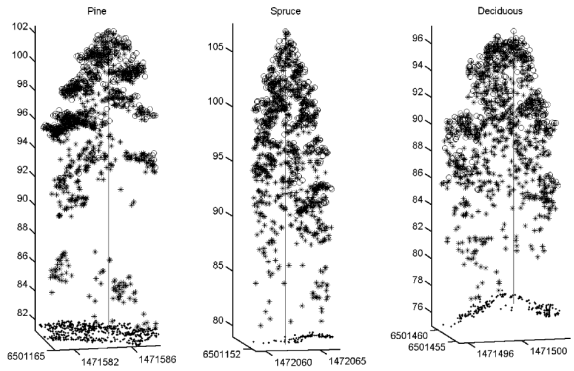
Phase change



So, what is LiDAR?



Næsset et al. Scand. J. For. Res. 19 (2004)



Waveform LiDAR, 2007

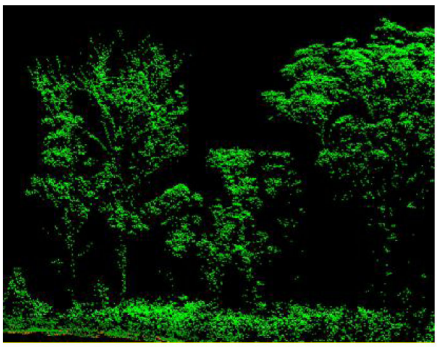
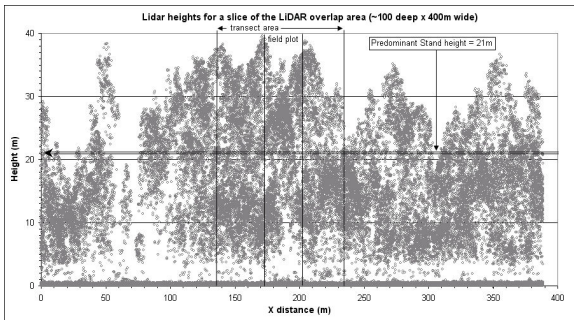


Figure 7: A 3D sample of high density laser point data from the new LiteMapper 5600 sensor (Source: Digital Mapping Australia Pty Ltd).

7

LiDAR swath through the forests



Single trees, mapped over entire blocks

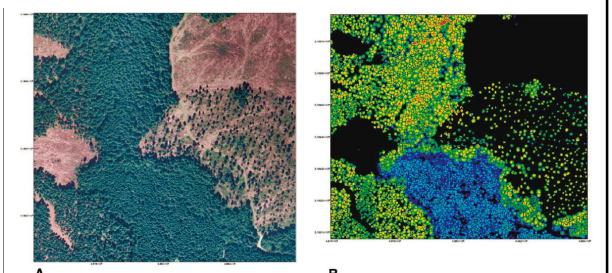
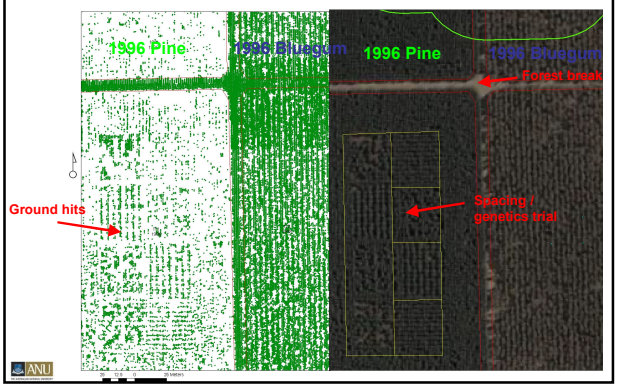


Figure 2. (A) Orthophotograph of selected area (courtesy of Washington Department of Natural Resources), and (B) individual tree-level segmentation of the LiDAR canopy height model via morphological watershed algorithm (color-coded by height; black lines indicate boundaries around crowns).

9

Producing a DEM under forest canopy



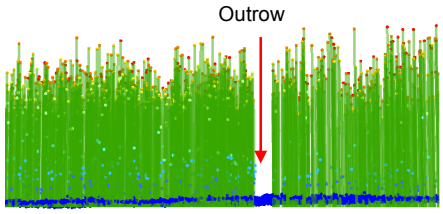
Predictive models – over two decades ago

Maclean and Krabill (1986): Area under LiDAR canopy profile is predictor of stand volume

Nelson et al (1988): average height of laser hits is a predictor of stand volume

Magnussen et al (1998):quantiles of LiDAR height distribution are predictors of height

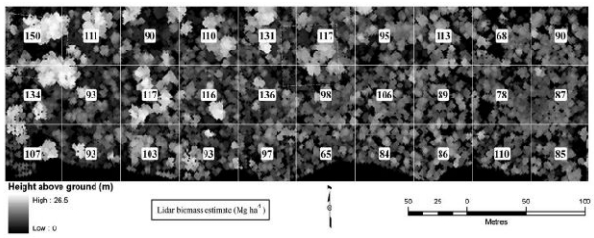
Means et al (2000), Næsset (2002), Holmgren (2003): quantiles are predictors of volume



Visualisation of LiDAR data set over a SQ I plot at Lands,1988 plantation (courtesy Greg Saunder)

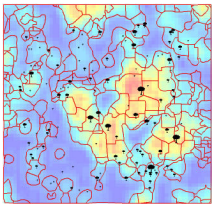
11

Variation across a landscape – around simple mean

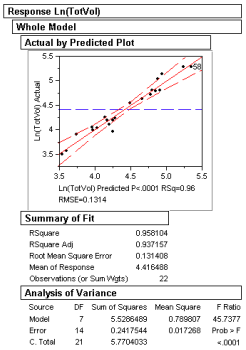


12

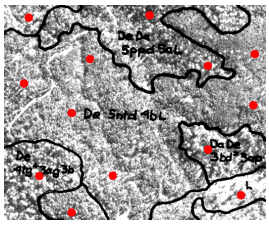
Single tree and Stand Models. Multi-phase sampling

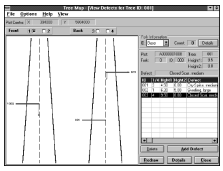


Single tree taper function, based on height and distance to neighbour



But this is what we still do for assessments

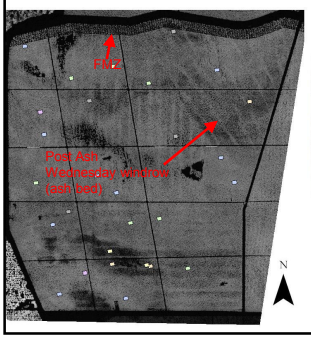




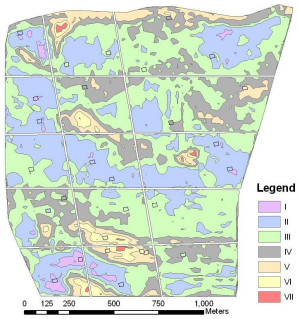
- Forest maps
  - stand types
  - attributes
  - net harvestable area
- Mean from plot-based inventory
  - $m^3\ ha^{-1}$
  - $\$\ \ ha^{-1}$

LiDAR SQ map compared to LiDAR first return height image

First return height image

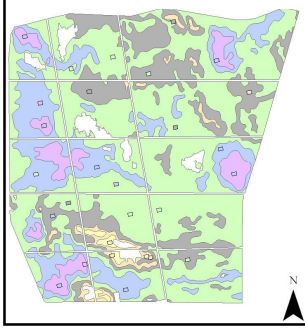


LiDAR SQ map ($V_{10} = a\ h_{>3.0,m}^{\ b}$)

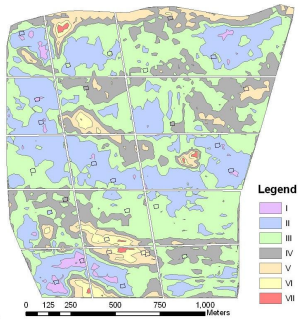


LiDAR SQ map compared to conventional SQ map

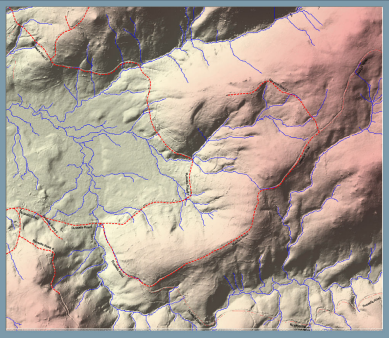
Conventional SQ map



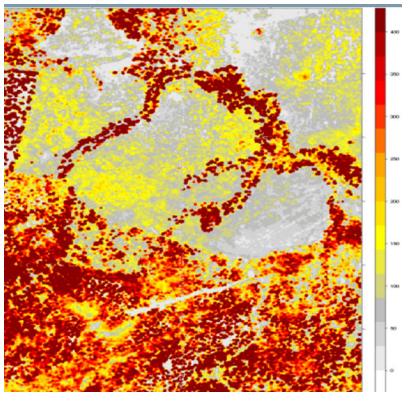
LiDAR SQ map



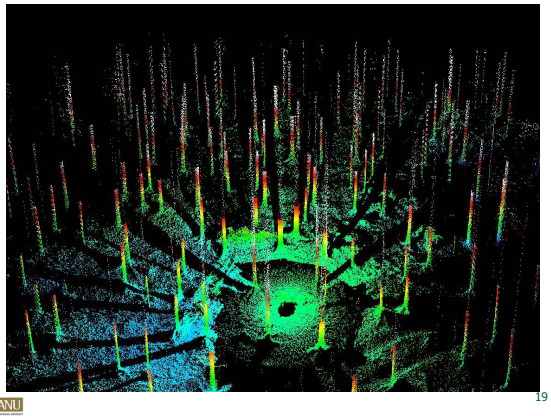
Where we've come from....and where we are now.



Forestry Tasmania

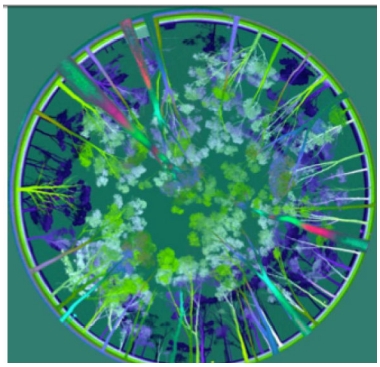


Other exciting "stuff" – terrestrial LiDAR

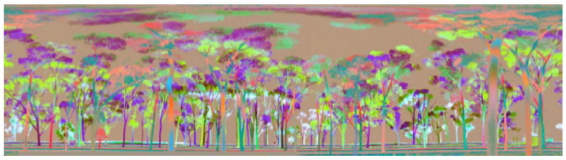


19

Ground-based LiDAR (hemispherical view)

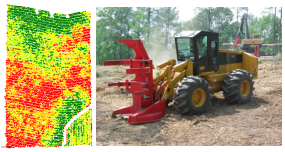


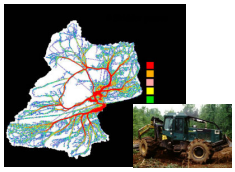
20



21

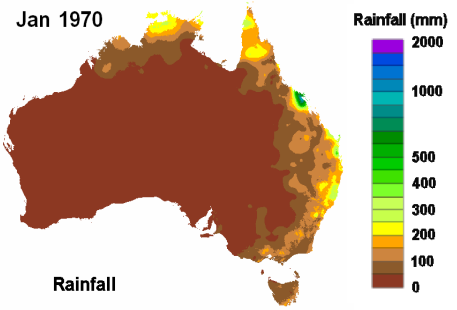
Other sources of detail geospatial point data





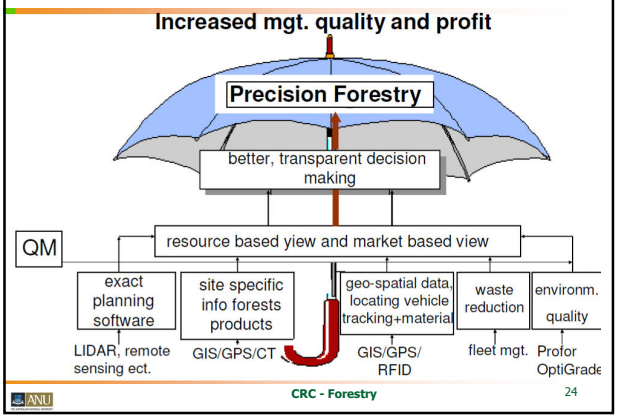
22

Integrate spatial and temporal information



23

Why? Precision forestry



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24

So, the challenge – coping with a phase change

- What do we 'do' with all this data?
- Now that high resolution DTM, canopy and position is so freely available…
  - What can GIS do to improve management decisions?
    - Faster, safer, more efficient roading, harvest plans…
  - Present information in meaningful ways?
    - The end of the contour?
  - Avoid just summarising everything back to a mean value?
    - Better modelling / sampling?
    - Product differentiation

25

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26