FOR 274: From Photos to Lidar

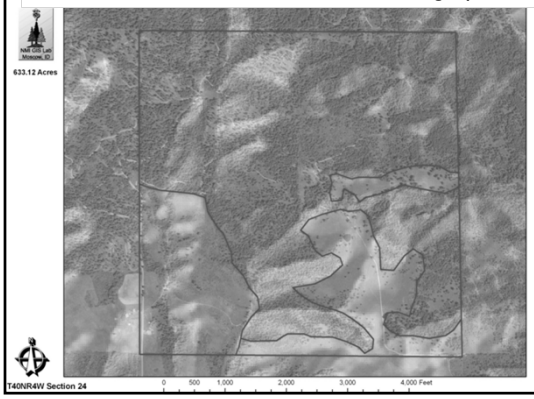
Introduction to LiDAR

- What is it?
- How does it work?
- LiDAR Jargon and Terms
- Natural Resource Applications
- Data Acquisition Standards

Readings:

Western Forester April 2008

The Forest: Lets Start With Aerial Photographs!



Aerial Photographs: Overview

Airphoto acquisition

↓

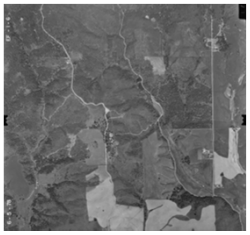
Airphoto interpretation

↓

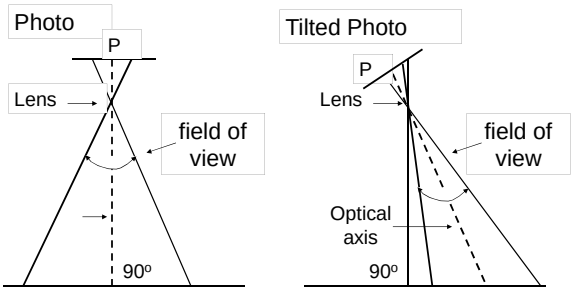
Cartographic/GIS Analysis

↓

Data to Users



Aerial Photographs: Overview

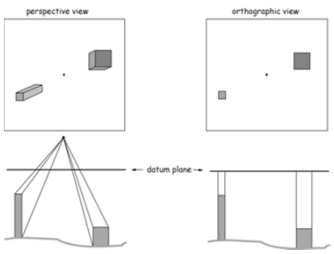


a) Vertical aerial photography

b) low oblique

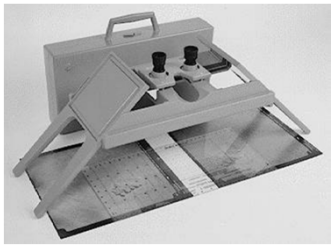
Aerial Photographs: Overview

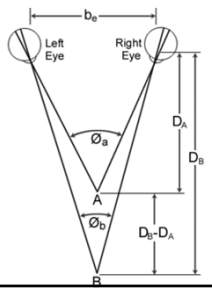
Radial Displacement



Aerial Photographs: Overview

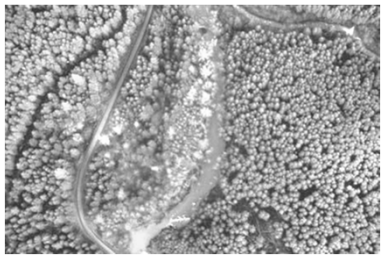
Stereoscopy – The science of perceiving depth (and thus height) with two eyes/vantage points





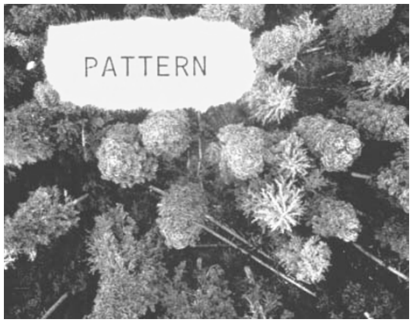
Aerial Photographs: Assessments

Visual Association: we can identify trees and rivers and thus use expert knowledge to infer what species are likely to occur near the river.



Aerial Photographs: Assessments

Pattern and Shape: we can identify trees by their branches

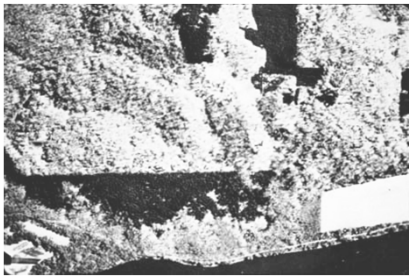


Aerial Photographs: Assessments

Pattern and Shape: we can also identify natural forests from human generated environments

Aerial Photographs: Assessments

Color and Tone: we can easily separate conifers (dark) from hardwoods in winter or early spring



Aerial Photographs: Assessments

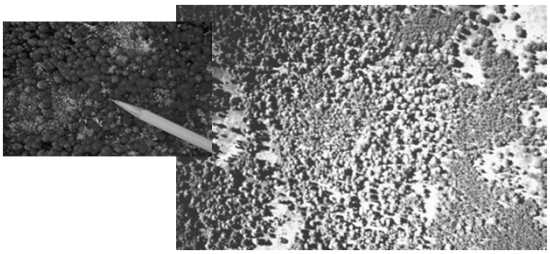
Color and Tone in Infrared Film: we can easily separate conifers from hardwoods as hardwoods reflect more infrared radiation and so appear brighter

Aerial Photographs: Assessments

Texture: can easily separate conifers (rough) from hardwoods (smooth)

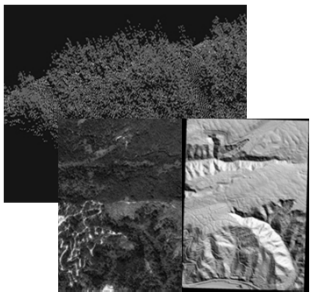
Aerial Photographs: Assessments

Color and Tone in Infrared Film: we can easily separate healthy trees as they appear red and diseased trees appear green



LiDAR for Operational Forest Management

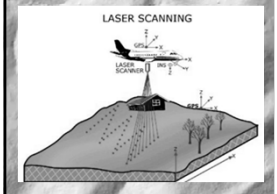
But now we have …



Lidar: What is it?

Light Detection and Ranging

Essentially a laser rangefinder that has been strapped to the belly of an airplane.



The time for the light to travel to and from the target is used to determine distance:

Distance = Speed x time

This distance and the position of the airplane is used to get elevation and location.

Lidar: The Pulse

As the lidar pulse travels to the target the light fans out (as the distance from the target can be several kilometers)

Lidar footprint = Height x divergence

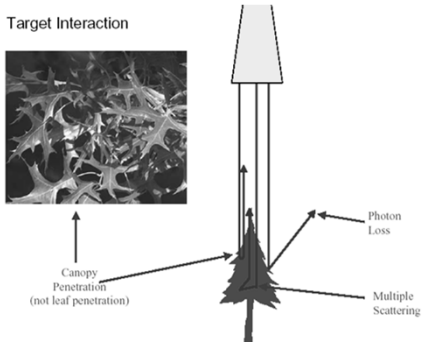
The footprint is the effective area that the laser light encompasses

Divergence is the degree by which the light fans out from a straight line (measured in radians: 1 rad = 57.3 degrees)

Typical divergence = 0.25-4 mradians per 1000m

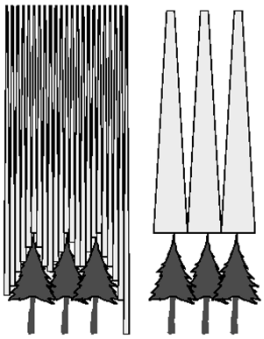
Source Lefsky (2005)

Lidar: The Pulse



Source Lefsky (2005)

Lidar: The Pulse



Low Divergence:

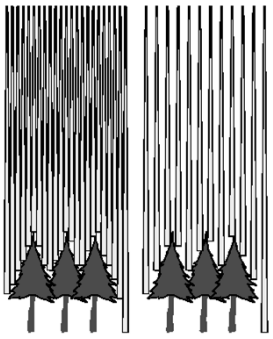
Canopy penetration and some pulses will reach the ground

High Divergence:

Reduced canopy penetration and low percentage of pulses hitting and RETURNING from the ground

Source Lefsky (2005)

Lidar: The Pulse



Low Spacing:

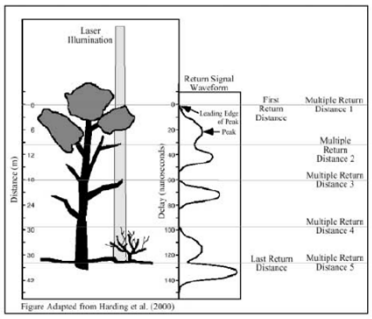
Canopy penetration and some pulses will reach the ground

High spacing:

Less pulses hitting and RETURNING from the ground

Source Lefsky (2005)

Lidar: The Main Kinds



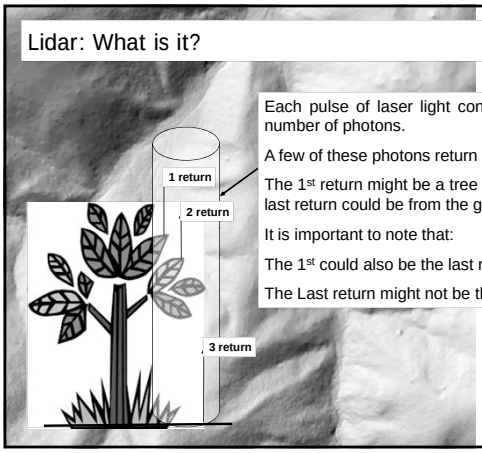
Two main types:

Waveform Sampling

Discrete Return

Source Lefsky (2005)

Lidar: What is it?



Each pulse of laser light contains a large number of photons.

A few of these photons return to the sensor

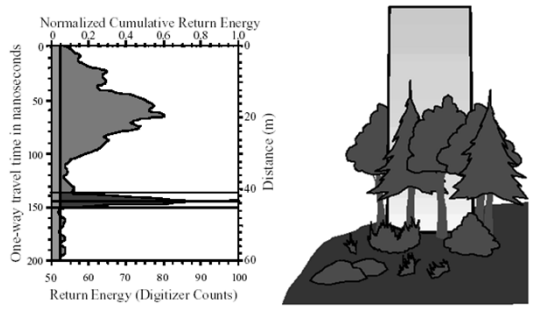
The 1st return might be a tree top, while the last return could be from the ground.

It is important to note that:

The 1st could also be the last return.

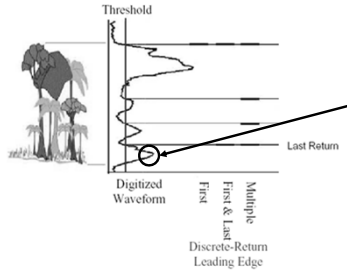
The Last return might not be the ground.

Lidar: The Main Kinds



Source Blair and Harding NASA GSFC

Lidar: The Main Kinds



Sometimes the last return can be a 'false summit' in the signal.

This results in noise in the resultant height data (seen as dips and peaks within the lidar image)

Source David Harding NASA GSFC

Lidar: The Main Kinds

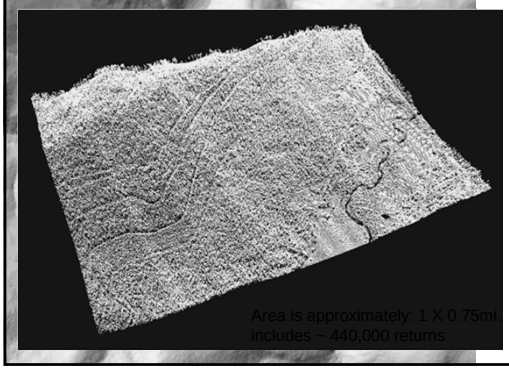
Advantages of Waveform Lidar:

- No signal processing errors
- Enhanced ability to characterize canopy information over large areas
- Global satellite datasets available
- Compatible with other RS global datasets

Advantages of Discrete Return Lidar:

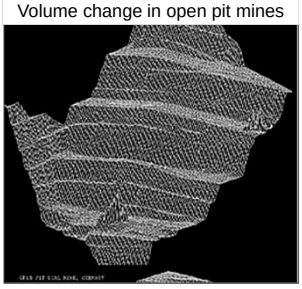
- High spatial resolution (0.05-2.00 m)
- Small diameter footprint
- Flexibility in available data processing methods
- Highly available

Lidar: What the Data Looks Like

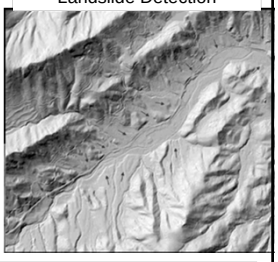


Lidar: Geomorphologic Applications

Volume change in open pit mines



Landslide Detection



Utilities map power lines for signs of damage:

Lidar: Mapping Fault Lines

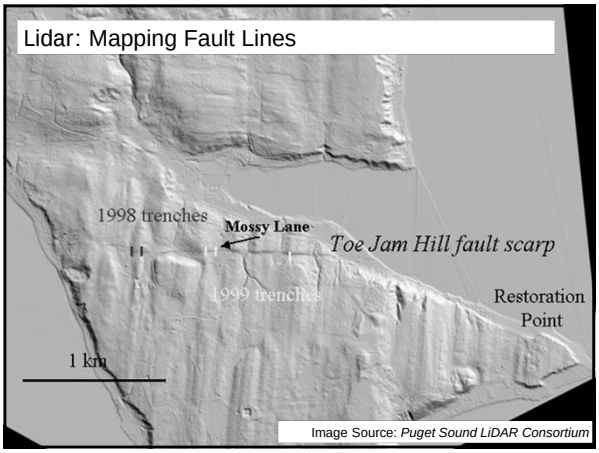
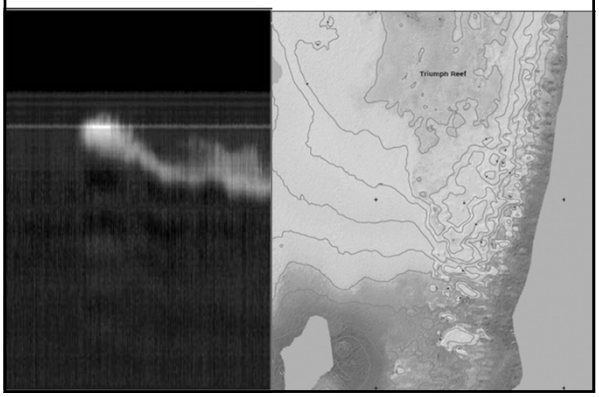
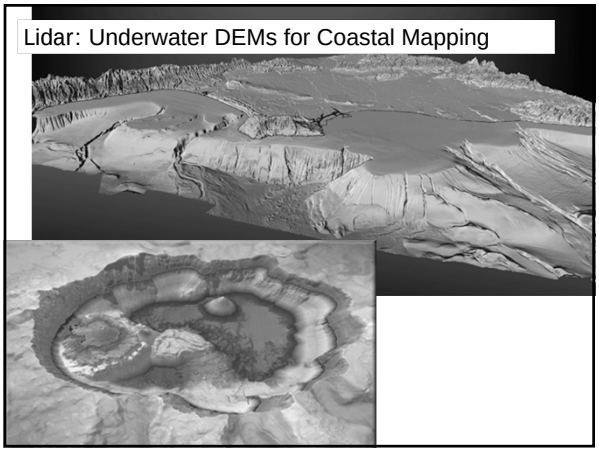


Image Source: *Puget Sound LiDAR Consortium*

Lidar: Riparian and Coastal Ecology



Lidar: Underwater DEMs for Coastal Mapping



Lidar: Forestry

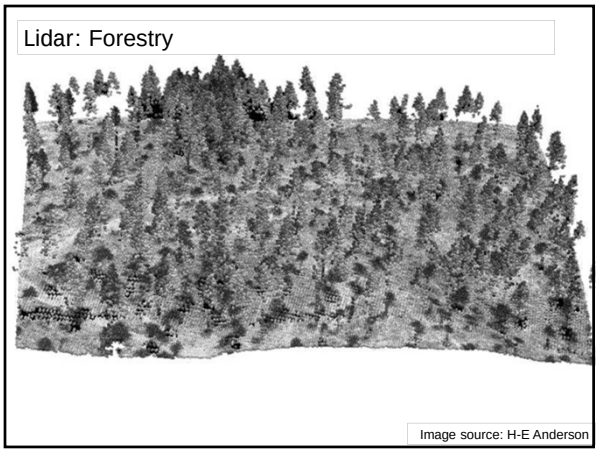


Image source: H-E Anderson

Lidar: Forestry

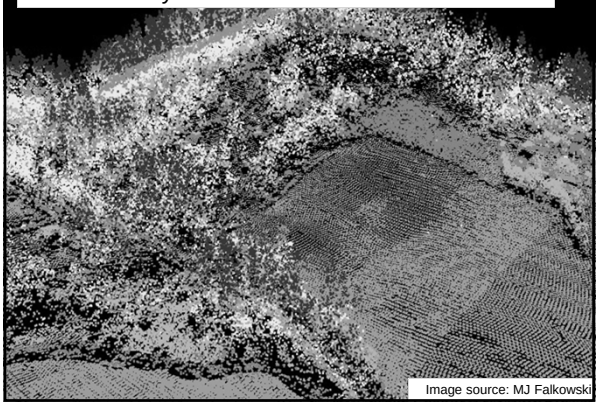


Image source: MJ Falkowski

LiDAR: Data Acquisition Standards

Although the use of LiDAR is widespread in forestry people are inconsistent on how they collect the data

If we want to compare measurements between different areas we need the data to be collected using standard properties

One day you may be asked to get a LiDAR acquisition for your forest: so its important that you know what to ask for!

Source: Evans et al 2009

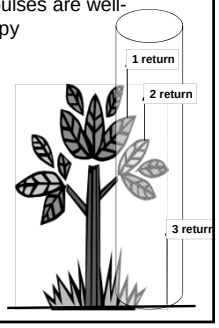
LiDAR: Data Acquisition Standards for Forestry

Pulse Repetition Frequency (number of pulses per second):

This should be high enough so that the pulses are well-distributed vertically throughout the canopy

Number of Returns:

When using Discrete Return LiDAR ask for at least 3 returns per laser pulse



Source: Evans et al 2009

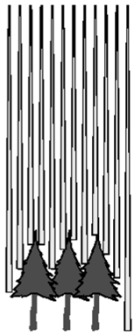
LiDAR: Data Acquisition Standards for Forestry

Post-Spacing

Average horizontal spacing between pulses (may be multiple returns per pulse).

<u>Ask for a maximum post spacing of 70 cm</u>

If after shrubs or seedlings, ask for a post spacing closer to 15cm



Source: Evans et al 2009

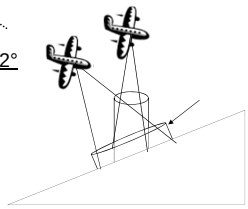
LiDAR: Data Acquisition Standards for Forestry

Scan-Angle:

The maximum off-nadir angle the sensor head swings to. High scan angles can distort the LiDAR footprint (worse on slope).

<u>Ask for a maximum scan-angle of 12°</u>

The total view angle is then 24°



Source: Evans et al 2009

LiDAR: Data Acquisition Standards for Forestry

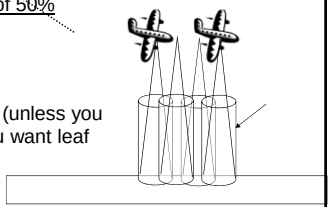
Flight Line Overlap:

This ensures features are well “sampled”.

<u>Ask for a flight line overlap of 50%</u>

When to Collect Data:

Avoid bad weather or snow (unless you are snow modeling). Do you want leaf on or leaf-off data?



Source: Evans et al 2009

LiDAR: Data Acquisition Standards for Forestry

Accuracy Standards:

Vertical Root Mean Square Error < 15cm

Horizontal Root Mean Square Error < 55cm

The vendor should calculate errors using real time geodetic surveys (GPS and total stations)

Source: Evans et al 2009

LiDAR: Data Acquisition Standards for Forestry

Typical Lidar Products to ask for:

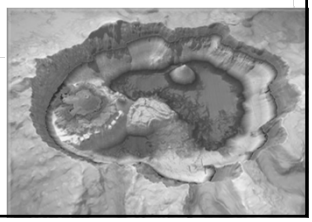
Ground Surface Model (Digital Elevation Model)

Digital Surface Model (surface of all non ground returns)

Intensity (+ aerial Photograph)

Point Heights (DSM – DEM)

Canopy Height & Density



Source: Evans et al 2009

FOR 474: Forest Inventory

Next Time …

Using LiDAR data to produce DEMs