Use of Large-scale 3D Multispectral Digital Aerial Imagery for Analysis of Forest Structure

Sandra Brown and Dana Slaymaker
Winrock International
Email: sbrown@winrock.org

WINROCK INTERNATIONAL
Putting Ideas to Work

For work on carbon measuring and monitoring—needed:

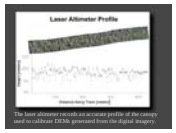
Cost efficient and accurate and precise means to measure and monitor C and overall project performance

- Off-the shelf technology
- Fit on single engine planes such as Cessnas (common throughout the world)
- Accessible to more remote areas
- Available as needed and under clouds

Multispectral 3D Aerial Digital Imaging System

- Fits in a portable camera pod,
- Will fit into commercial airline luggage
- Attaches to any Cessna in about an hour

Example of M3DADI data in 3D



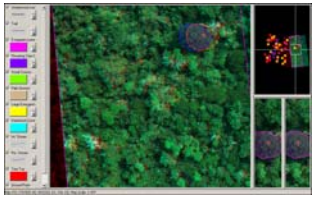
This 3D approach provides methods for studying and mapping terrestrial systems. Data from a laser is used to calibrate tree height, measured, and re-flown to monitored change in the forest on an individual tree level.

Applications:

Measuring carbon in forests

- Overlay plots on imagery transects
- Measure all tree crown areas in plots
- Use relationships between crown area and dbh
- Use relationships with crown area to estimate dbh
- Estimate biomass per tree from estimated dbh

Noel Kempff Mercado National Park, Bolivia



Individual trees can be identified and measured for height and crown diameter using 3D glasses.

Results of carbon measurements from digital imagery system vs. measurements from field teams

- For the mixed liana forest strata in the Noel Kempff project:

Method	Mean t C/ha	95% CI % of mean
Ground-218 plots x 0.06 ha	89.6	8.7
Imagery-40 plots x 1 ha	87.7	7.3

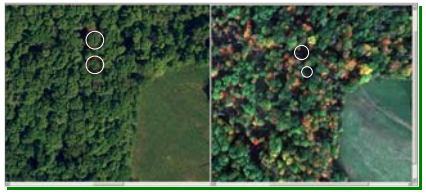
Quantifying impacts of harvesting on carbon stocks

Measuring logging impacts

Install logging impact plots and measure the damage and slash remaining from harvest in relation to amount harvested

Statistics	Damage: C per t C
Belize-43 logging impact plots	
Range	0.7 – 7.0
Mean	3.1
S.E.	0.2
95% CI (% of mean)	± 13%
Bolivia-102 logging impact plots	
Range	0.6 – 11.5
Mean	3
S.E.	0.15
95% CI (% of mean)	± 10%

Selective logging in a temperate forest



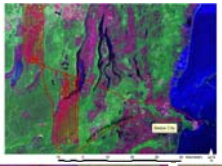
Flown in May 2002 before harvest (left) and in October 2002 after harvest (right). Can identify which trees have actually been removed, measuring their crown diameter and height to determine the amount of biomass or timber extracted

Measuring carbon of heterogeneous systems e.g. Pine savanna of Río Bravo Conservation and Management Area, Belize:

- Determine if multi-spectral, 3D aerial digital imagery (M3DADI) system can decrease the need for extensive ground measurements while creating accurate and precise carbon estimates in a cost-effective manner
- Two steps:
  - Collect and analyze digital imagery
  - Collect and analyze ground data to use in combination with imagery

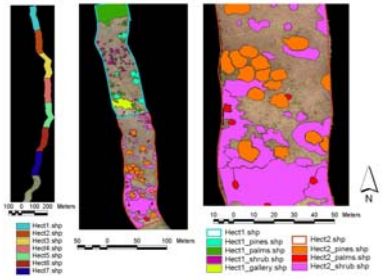
How to measure the carbon stocks in this complex system

- Consists of many sub-types but difficult to stratify as they are widespread with no distinct boundaries
- Because very heterogeneous, would need many ground plots to sample for high precision



Collection of digital imagery

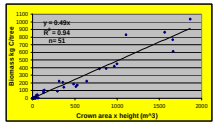
Analyze ~1 ha plots on the imagery to obtain area of crowns or cover and tree heights



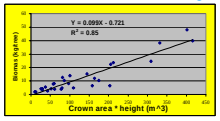
Areas of each vegetation type per plot

Plot number	Total plot	Grasses	Shrub	Pine	Palms
	Area (m^2)				
1	10,000	8,721	376	522	281
2	9,933	5,700	2,959	1,087	187
3	10,204	3,792	2,919	3,039	455
.....	.....	.....	.....	.....	.....
19	9,855	5,590	3,256	908	101
20	9,777	5,321	3,406	1,008	42
Total (m²)	192,424	98,765	62,836	23,967	9,378

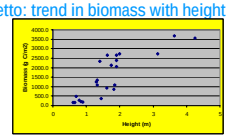
Pine trees: relationship between biomass per tree and crown area x height



Hardwood trees: biomass and crown area x height



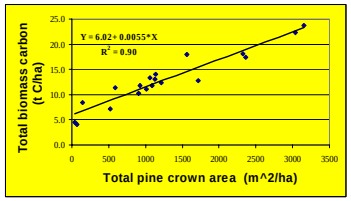
Palmetto: trend in biomass with height



Carbon stocks by vegetation type

Plot number	Pine t C/ha	Shrub t C/ha	Palms t C/ha	Grass t C/ha	Total t C/ha
1	3.4	0.4	0.2	2.6	7.1
2	7	3.0	0.1	1.7	11.8
.....	.....	.....	.....	.....	.....
19	5.3	3.3	0.1	1.7	10.3
20	6.1	3.4	0.0	1.6	11.1
Stats					
n=	19	19	19	19	19
Mean	7.7	3.3	0.4	1.5	12.9
SE	1.3	0.5	0.07	0.2	1.2
C.V. (%)	72.4	64.9	76.8	44.0	40.6
95% CI (% of mean)	25.7	22.4	29.6	15.7	16.1

Total biomass carbon is a function of pine tree crown area



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Other tools for forest structure analysis/monitoring:

- High-resolution image mosaics
- Canopy DEM change analyses