Pinaleño LiDAR

New Tools for Forest Restoration

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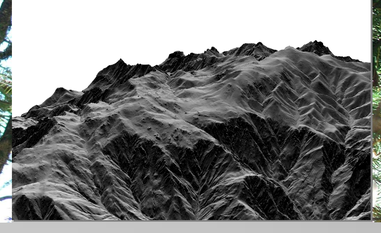
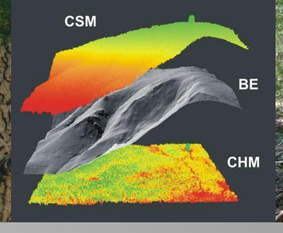


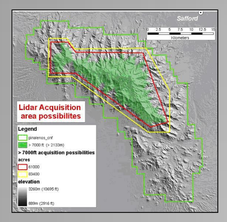


INTRODUCTION

Changes in forest conditions have led to large and severe wildfires and devastating insect outbreaks in the Pinaleño Mountains of Southeastern Arizona. The risk of additional wildfires and insect outbreaks has prompted a restoration effort to reduce further threats to forest resilience and provide habitat sustainability for the Mount Graham red squirrel (MGRS) (*Tamiasciurus hudsonicus grahamensis*), a federally listed endangered species.

Airborne Laser Scanning or LiDAR is a more cost effective means to gather forest structure and biomass information for project planning, implementation and monitoring in remote mountainous terrain.

PROJECT GOALS and OBJECTIVES



Enhanced mapping of the forest structure to better understand Mount Graham Red Squirrel habitat and provide supporting data for restoration project implementation and monitoring.

- Mapping of biomass, canopy fuel and forest structure characteristics
- Mapping of old growth mixed-conifer (key MGRS habit)
- Mapping of recent disturbances
- Continuous, non-discrete forest inventory data
- Collection of forest inventory data in locations where data is difficult to obtain by traditional forest inventory methods

WHAT IS LIDAR? Light Detection And Ranging also called Airborne Laser Scanning

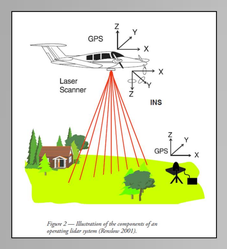


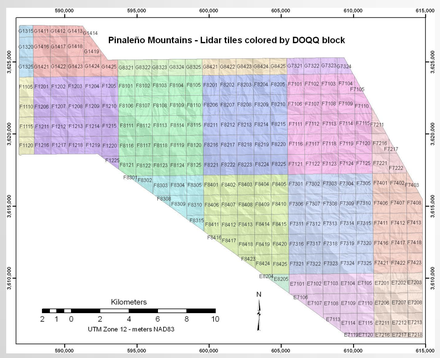
Figure 2 — Illustration of the components of an operating lidar system (Renslow 2001).

LiDAR is an active remote sensing system that uses laser light to determine elevation. The travel time of each laser pulse to objects on the ground and back is divided by two and multiplied by the speed of light to calculate the precise distance.

An airborne LiDAR system scans, receives, and georeferences multiple pulse returns from the ground, treetops, rooftops, and other objects tens of thousands of times per second. The system uses an inertial navigation system (INS) and a global positioning system (GPS) to determine the location of each LiDAR return in three dimensions, automatically adjusting for the "look angle."

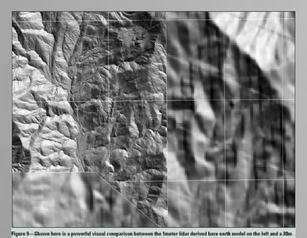
PROJECT DATA SUMMARY

Acquisition dates	September 22–27 2008; Leaf-On
Aircraft	Cessna Caravan
Lidar scanner	Leica ALS50 Phase 2
Pulse rate	70 to 90 kHz
Scan rate	52.2 Hz
Maximum returns per pulse	4
Scan angle	+/-15 degrees
Beam divergence	19 – 29 cm
Flight above ground level	800 – 1300 m
Flight line configuration	Opposing adjacent parallel lines
Flight line overlap	50% sidelap
Average lidar pulse return spacing	7.36 points/m2
Average ground point density	0.98 points/m2
Acquistion area	85,518 acres
Total numbers of returns	2,892,925,979

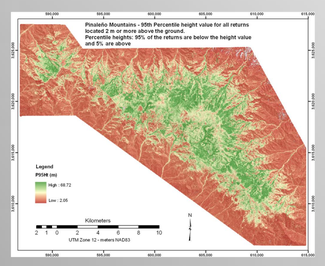


LAS data tiles (236) and DOQQ grids (18)

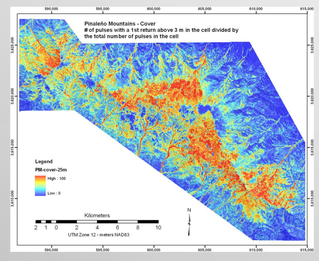
PRODUCTS DERIVED DIRECTLY FROM LIDAR DATA



LiDAR Bare Earth 2 meter models (upper left window) contrasted with standard USGS DEM 30 meter model



Canopy Height Models (CHM) and derivatives of canopy height such mean height or covariance of height

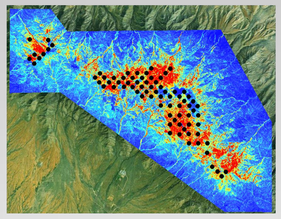


Canopy Cover Model and derivatives of canopy cover such as percent of all returns over mean height / all returns

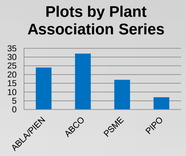
LiDAR as an active sensor that directly measures forest attributes of tree heights and vegetation cover and produces Bare Earth Digital Elevation Models (DEM), while attributes such as biomass and other secondary attributes are modeled on relationship of LiDAR height and cover metrics.

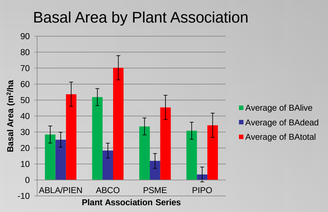
FUSION Software is utilized to process and analyze LiDAR data for forest applications. FUSION software and tutorials can be downloaded from RSAC Website: http://www.fs.fed.us/eng/rsac/fusion/

FIELD DATA COLLECTION AND SUMMATION



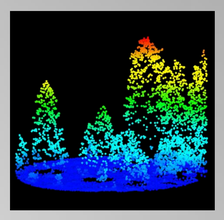
80 twentieth (0.05) ha field plots were sampled and mapped at sub-meter precision





LIDAR METRICS CLIPPED AT PLOTS LOCATIONS

0.05 Hectares = approximately 25 meter diameter



Total number of returns
Count of returns by return number (support for up to 9 discrete returns)
Minimum
Maximum
Mean
Median (output as 50th percentile)
Mode
Standard deviation
Variance
Coefficient of variation
Interquartile distance
Skewness
Kurtosis
AAD (Average Absolute Deviation)
L-moments (L1, L2, L3, L4)
L-moment skewness
L-moment kurtosis
Percentile values (1th, 5th, 10th, 20th, 25th, 30th, 40th, 50th, 60th, 70th, 75th, 80th, 90th, 95th, 99th percentiles)

In addition to the above metrics, *CloudMetrics* also computes various ratios of returns above a *heightbreak* when the */above:#* switch is used:

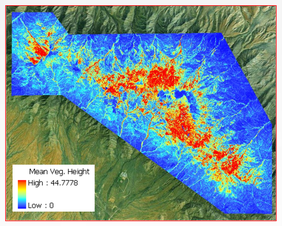
Percentage of first returns above a specified height (canopy cover estimate)
Percentage of first returns above the mean height/elevation
Percentage of first returns above the mode height/elevation
Percentage of all returns above a specified height
Percentage of all returns above the mean height/elevation
Percentage of all returns above the mode height/elevation
Number of returns above a specified height / total first returns * 100
Number of returns above the mean height / total first returns * 100
Number of returns above the mode height / total first returns * 100

MODELING FOREST STRUCTURE USING LIDAR

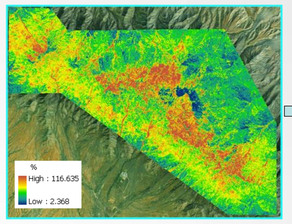
Apply Regression Equation and Develop Model

Equation for Biomass = (ax/b - cy/d) / (1+ x/b + y/d) + Offset
a = -2.7375875450033640E+04
b = -2.3665464379090434E+01
c = -1.2228895147411651E+06
d = 9.4128309407458164E+02
Offset = 1.4279090512283406E+03

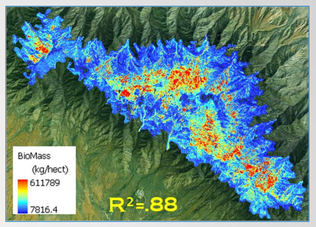
Height Variable
X = Mean Height



Cover Variable
Y = (all returns above mean/(total first returns) *100



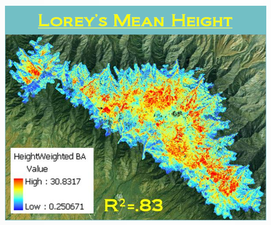
Biomass Model

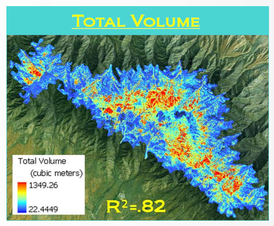


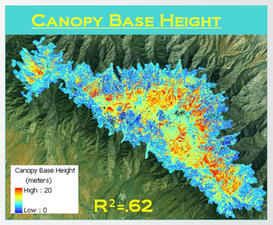
Linear and non-linear models were developed between the field plot data and the corresponding clipped LiDAR metrics and mapped at 25 meter cell size.

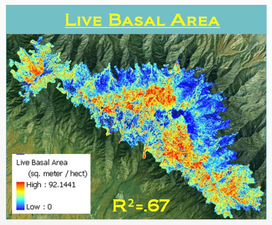
Once modeled, GIS layers can be developed using FUSION software. Validation and final clipping of the data reflect forested areas over 7,000 ft (2,134 m) elevation and adjusted for aspect effects to reflect targeted forested areas.

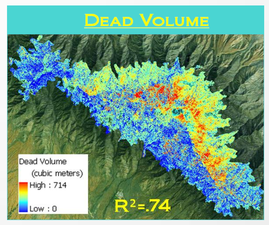
FOREST STRUCTURE MODELS

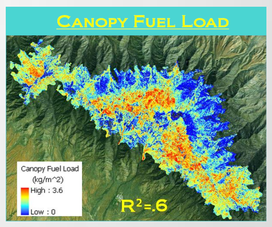










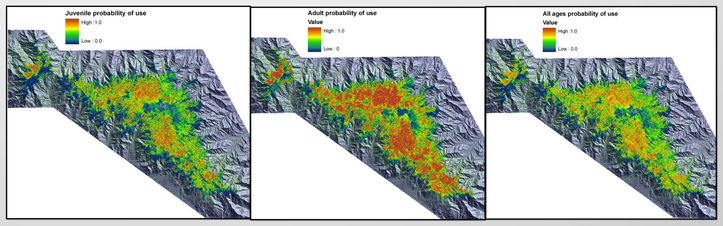


Modeled Forest Structure Parameter	1st LiDAR Predictor	2nd LiDAR Predictor
Canopy Fuel Load	Percentage all returns above mean	(all returns above mode) / (total first returns) * 100
Canopy Base Height	Elev Variance	Elev Coefficient of Variation
Cubic Volume Dead	Percentage all returns above mean	(all returns above mean) / (total first returns) * 100
Basal Area Live Trees	Percentage all returns above mean	
Total Cubic Volume	Elev P60	(all returns above mean) / (total first returns) * 100
Lorey's Mean Tree Ht	Elev Mean	Elev Skewness
Biomass	Mean Height	(all returns above mean) / (total first returns) * 100

FUSION software, tutorials, and documentation are available at: http://www.fs.fed.us/eng/rsac/fusion/

MOUNT GRAHAM RED SQUIRREL HABITAT USE MODELS

University of Arizona Wildlife Researchers combined spatial data of adult and juvenile squirrels and LiDAR models to develop probable habitat use models of adults, juveniles and all ages

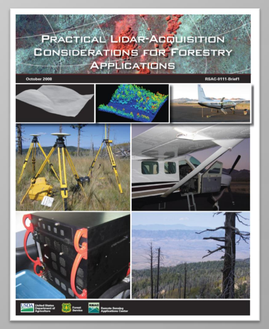


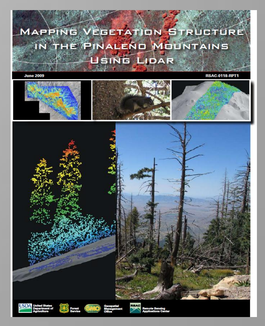
Predicted Habit Use of MGRS from LiDAR-Derived Models

Model	Adult	Juvenile	Both
Canopy Cover	+		-
Mean Tree Height	+	+	+
Live Basal Area		+	+
Total Basal Area		-	-
Coeff. Variation Tree Ht	+	+	+
Vegetative Structural Stage			+

DOCUMENTATION AVAILABLE

Pinaleño LiDAR Phase 1 and Phase 2 reports are available from the RSAC Web sites: http://www.fs.fed.us/eng/rsac/documents/
Phase 3 Report is in preparation





USDA FOREST SERVICE
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Project Partners:
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USFS Southwest Region, Engineering , Albuquerque, NM
USFS Remote Sensing Applications Center and RedCastle Resources, Salt Lake City, UT[b]
USFS Southwest Region, Forest Health, Arizona Zone Office, Flagstaff, AZ[c]
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