



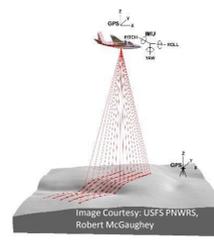
What is LiDAR?

Technological background

Light Detection and Range is an emergent technology that employs infrared lasers to measure three dimensional structure at high resolution (e.g. Terrestrial and Industrial LiDAR units survey X,Y,Z space to within ± 1 mm RMSE, Aerial LiDAR (above) typically survey X,Y,Z points within ± 10 cm RMSE. The density of point clouds (Figure 1) are dependent upon the repetition rate of pulses, ideal collections for vegetation analysis (Figures 2-7) contain between 4-12 points per m^2 .

Present Study background

In 2007 and 2008 Pima Association of Governments (PAG) contracted a private vendor to fly LiDAR over 1,800² miles of Pima County (Figure 8). Concurrently the USFS and USGS also contracted LiDAR over the Pinaleno (2008) and Huachuca Mountains (2009). The purpose of the flights (excluding USFS Pinaleno) was to collect information for a 'bare earth' terrain model. This data is below standards (Laes et al. 2008) for LiDAR based vegetation analysis (of internal vegetation canopy metrics). Even with a less than optimal vegetation data collection, these LiDAR datasets over southeastern Arizona show great promise for assisting conservation efforts in characterizing wildlife habitat and establishing baseline vegetation characteristics (such as fire behavior models). Informed parameterization requirements of future LiDAR flights will strengthen inference and broaden potential stakeholder uses.



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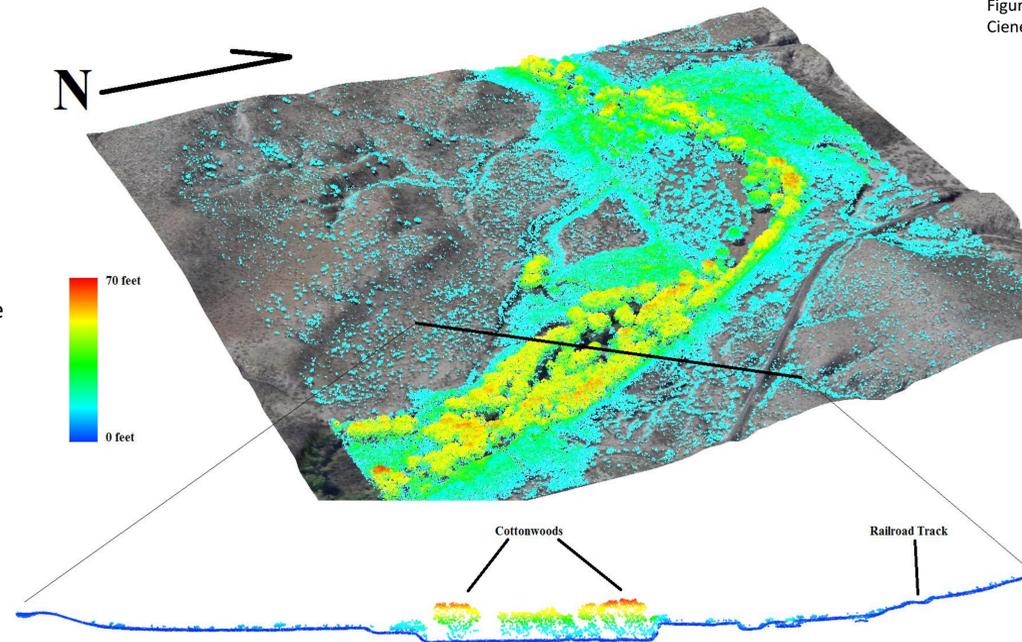


Figure 1: 3D composite image of LiDAR point cloud, Bare Earth Surface Model, and 2008 Aerial Photography. A 'Virtual Transect' line across Cienega Creek shows differences in point return heights.

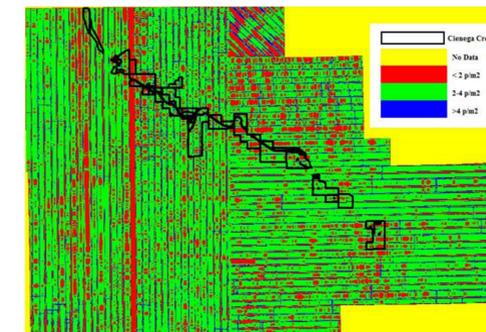


Figure 6: 2008 PAG point return density over Cienega Creek.

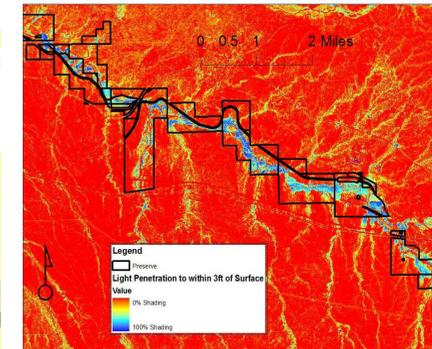


Figure 7: Canopy Light Penetration. Riparian areas (specifically the cottonwood dominated woodlands) intercept nearly 100% of the point returns above ground surface.

Table 2: Cienega Creek Preserve point return densities.

	Points / Meter ²	Density	Percent of Area
Minimum	0	<2 p/m ²	22.21%
Maximum	33.08	>4 p/m ²	11.64%
Average	2.67	2-4 p/m ²	66.14%
Standard Deviation	1.17		

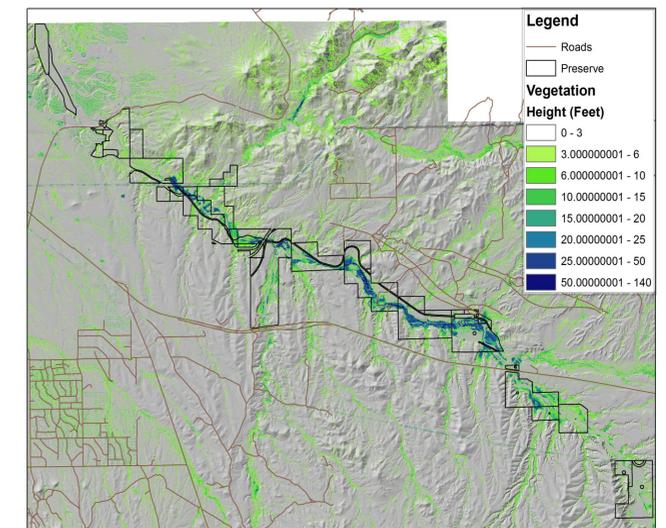


Figure 8: 6-ft pixel Canopy Height Model for Cienega Creek Preserve

Vegetation Structure

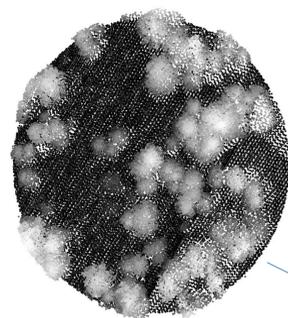


Figure 2: Individual large trees are visible (lighter gray = taller return height)

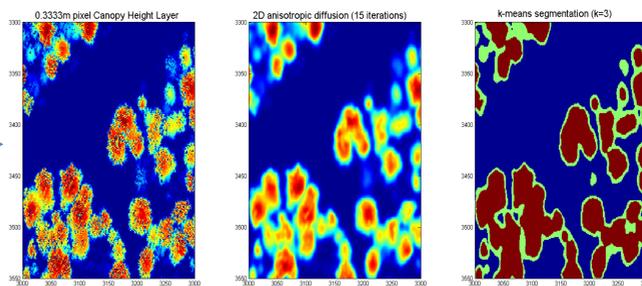


Figure 3: A 2-D image of canopy heights, filtered with 2D anisotropic diffusion, and segmented using a k-means filter (Mathworks MATLAB 2010).

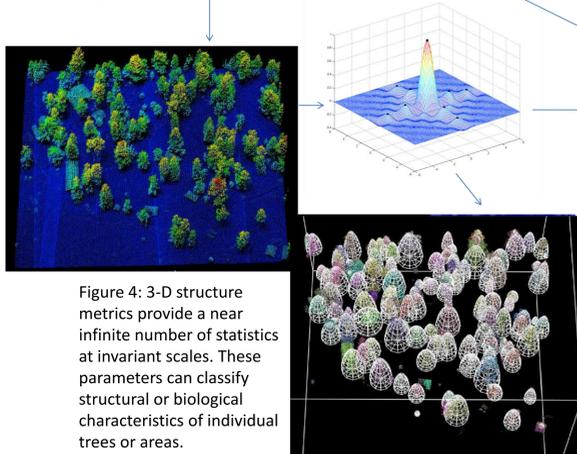


Figure 4: 3-D structure metrics provide a near infinite number of statistics at invariant scales. These parameters can classify structural or biological characteristics of individual trees or areas.

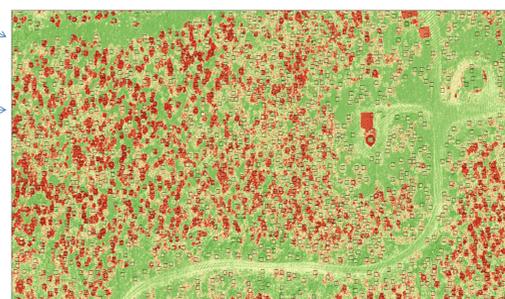


Figure 5: Intensity from LiDAR returns can show defoliated spruce and fir (Red-blobs), here shown near the Mount Graham International Observatory. A local-maximum algorithm based on canopy height segmented likely trees as black squares.

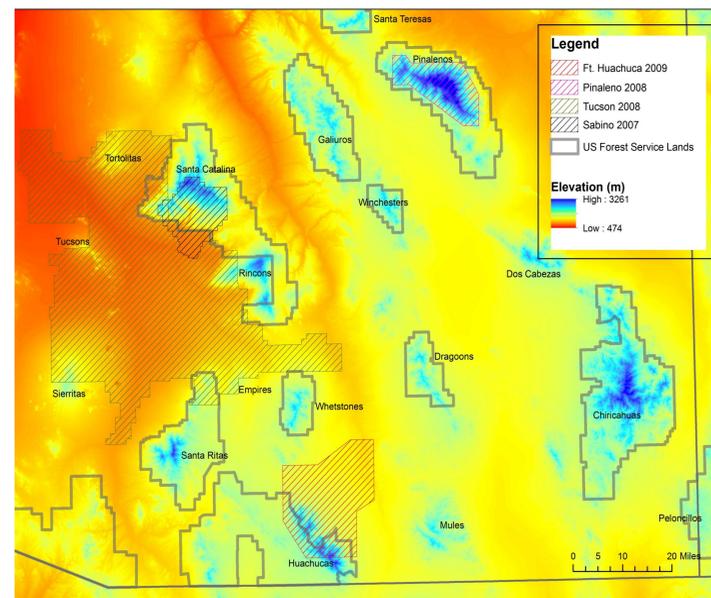


Figure 9: Southern Arizona LiDAR coverage.

Future Research Applications

Vegetation growth rates and climax vegetation are limited by top down (climatic) drivers. Quantification of vegetation spatially and temporally from LiDAR could be applied to studies in sciences such as:

- Ecology
- Climatology
- Geomorphology
- Hydrology
- Biology

Additionally, LiDAR derived structural parameters may help quantify the effect of bottom-up controls on vegetation (i.e. fire, grazing, land use clearing) and help illuminate landscape processes (such as soil development, erosion, plate tectonics, and basin subsidence from ground water extraction).

Acknowledgements

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References

For more information and detailed references see: Swetnam and Powell (2010) Supplement E: Example of the Use of LiDAR for Monitoring Vegetation Characteristics: An example from the Cienega Creek Nature Preserve, available at:

<http://www.pima.gov/cmo/sdcp/Monitoring/index.html>

Also see: Fire and Restoration Ecology Lab (FREL): <http://cals.arizona.edu/research/frel/>