Watershed Research and Training Center

California Water Data Consortium Lidar Derived Data Product workshop

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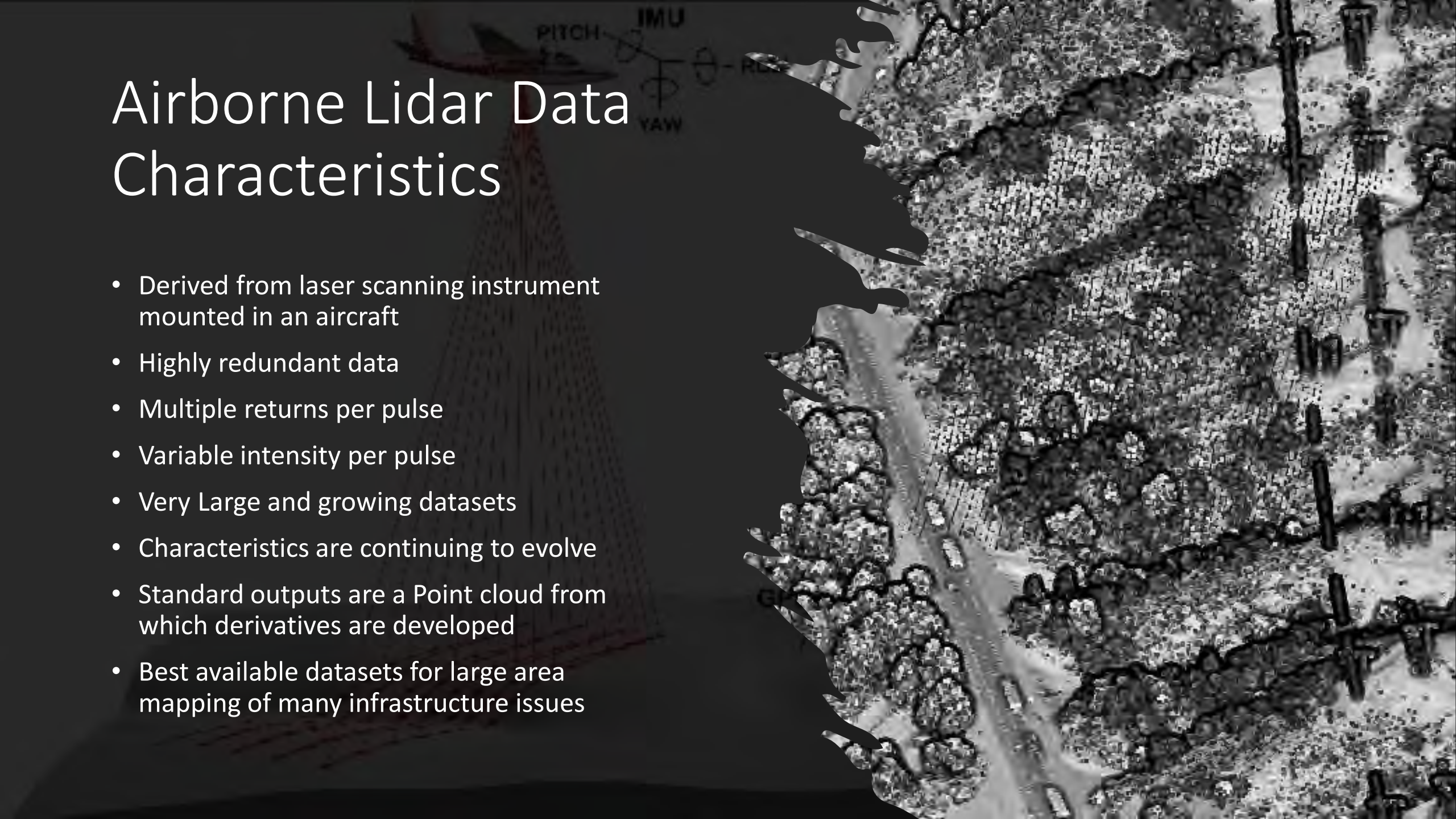
Airborne Lidar Data Characteristics

- Derived from laser scanning instrument mounted in an aircraft
- Highly redundant data
- Multiple returns per pulse
- Variable intensity per pulse
- Very Large and growing datasets
- Characteristics are continuing to evolve
- Standard outputs are a Point cloud from which derivatives are developed
- Best available datasets for large area mapping of many infrastructure issues



Four Analysis Trees

- High resolution raster methods
  - Samples small numbers and interpolates in data gaps, n ~ 0.1 -10
    - DEMs, Digital elevation Models
    - DSMs, Digital surface models
    - CHMs, Canopy Height model
- Low resolution raster methods
  - Samples large numbers point cloud points n ~10 – 10000s plus
- Point based classification/categorization
  - Uses procedures to categorize point class membership
  - Standard LAS categories or you can write a new data dictionary using extra dimensions
- Vector object methods
  - Often links to existing vector already in use

Anatomy of a LAS file

Header

Table 3: Public Header Block

Item	Format	Size	Required
File Signature ("LASF")	char[4]	4 bytes	*
File Source ID	unsigned short	2 bytes	*
Global Encoding	unsigned short	2 bytes	*
Project ID - GUID data 1	unsigned long	4 bytes	
Project ID - GUID data 2	unsigned short	2 byte	
Project ID - GUID data 3	unsigned short	2 byte	
Project ID - GUID data 4	unsigned char[8]	8 bytes	
Version Major	unsigned char	1 byte	*
Version Minor	unsigned char	1 byte	*
System Identifier	char[32]	32 bytes	*
Generating Software	char[32]	32 bytes	*
File Creation Day of Year	unsigned short	2 bytes	*
File Creation Year	unsigned short	2 bytes	*
Header Size	unsigned short	2 bytes	*
Offset to point data	unsigned long	4 bytes	*
Number of Variable Length Records	unsigned long	4 bytes	*
Point Data Record Format	unsigned char	1 byte	*
Point Data Record Length	unsigned short	2 bytes	*
Legacy Number of point records	unsigned long	4 bytes	*
Legacy Number of points by return	unsigned long [5]	20 bytes	*
X scale factor	double	8 bytes	*
Y scale factor	double	8 bytes	*
Z scale factor	double	8 bytes	*
X offset	double	8 bytes	*
Y offset	double	8 bytes	*
Z offset	double	8 bytes	*
Max X	double	8 bytes	*
Min X	double	8 bytes	*
Max Y	double	8 bytes	*
Min Y	double	8 bytes	*
Max Z	double	8 bytes	*
Min Z	double	8 bytes	*
Start of Waveform Data Packet Record	Unsigned long long	8 bytes	*
Start of first Extended Variable Length Record	unsigned long long	8 bytes	*
Number of Extended Variable Length Records	unsigned long	4 bytes	*
Number of point records	unsigned long long	8 bytes	*
Number of points by return	unsigned long long [15]	120 bytes	*

Point Data Record

Table 18: Point Data Record Format 7

Item	Format	Size	Required
X	long	4 bytes	*
Y	long	4 bytes	*
Z	long	4 bytes	*
Intensity	unsigned short	2 bytes	
Return Number	4 bits (bits 0, 1, 2, 3)	4 bits	*
Number of Returns (given pulse)	4 bits (bits 4, 5, 6, 7)	4 bits	*
Classification Flags	4 bits (bits 0 – 3)	4 bits	
Scanner Channel	2 bits (4-5)	2 bits	*
Scan Direction Flag	1 bit (bit 6)	1 bit	*
Edge of Flight Line	1 bit (bit 7)	1 bit	*
Classification	unsigned char	1 byte	*
User Data	unsigned char	1 byte	
Scan Angle	short	2 bytes	*
Point Source ID	unsigned short	2 bytes	*
GPS Time	double	8 bytes	*
Red	unsigned short	2 bytes	*
Green	unsigned short	2 bytes	*
Blue	unsigned short	2 bytes	*

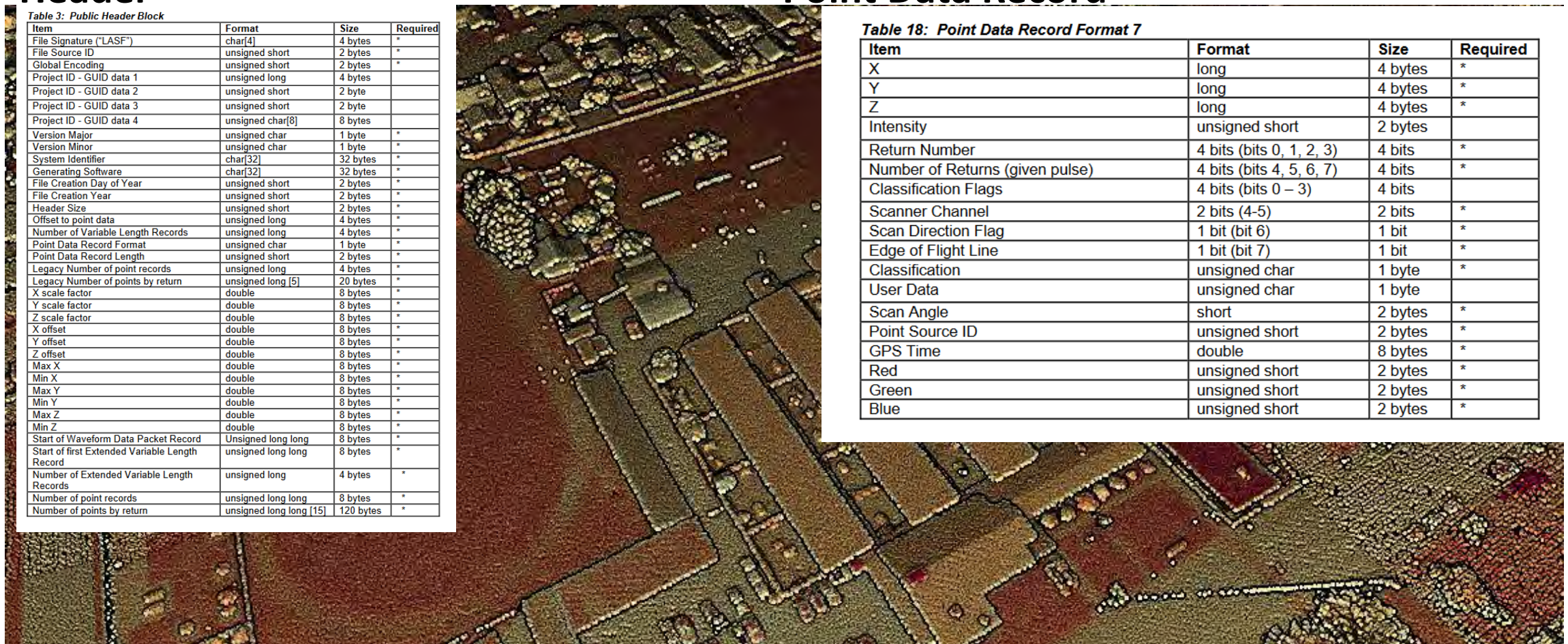
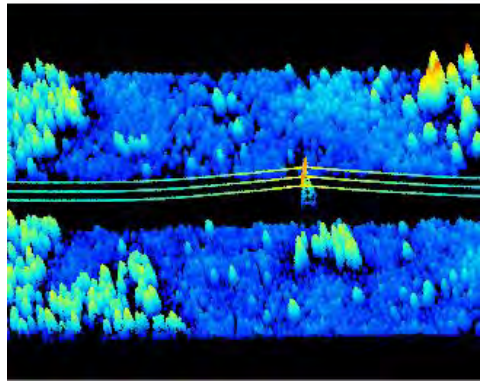
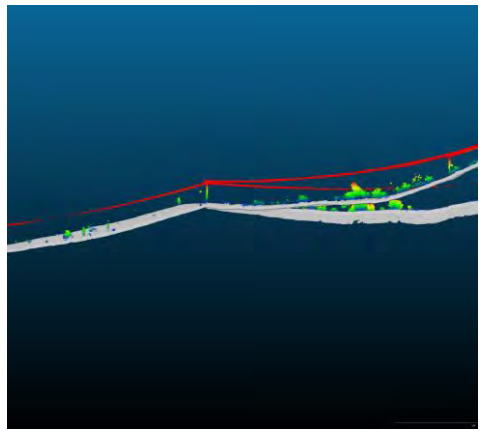
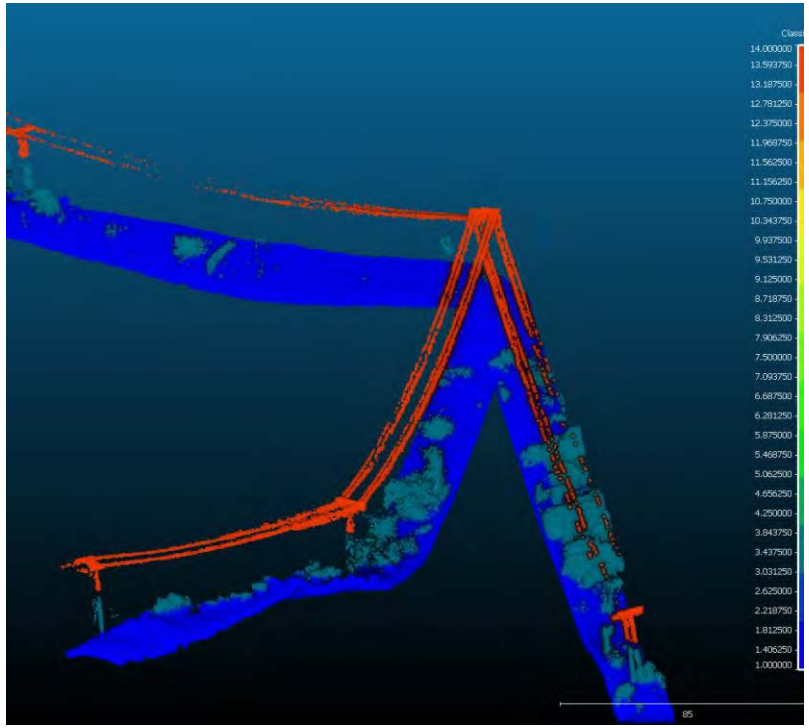


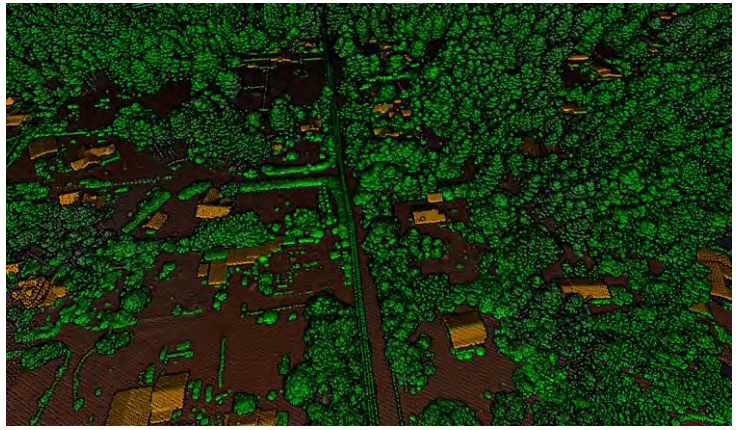
Table 17: ASPRS Standard LIDAR Point Classes (Point Data Record Formats 6-10)

Classification Value	Meaning
0	Created, never classified
1	Unclassified[3]
2	Ground
3	Low Vegetation
4	Medium Vegetation
5	High Vegetation
6	Building
7	Low Point (noise)
8	Reserved
9	Water
10	Rail
11	Road Surface
12	Reserved
13	Wire – Guard (Shield)
14	Wire – Conductor (Phase)
15	Transmission Tower
16	Wire-structure Connector (e.g. Insulator)
17	Bridge Deck
18	High Noise
19-63	Reserved
64-255	User definable

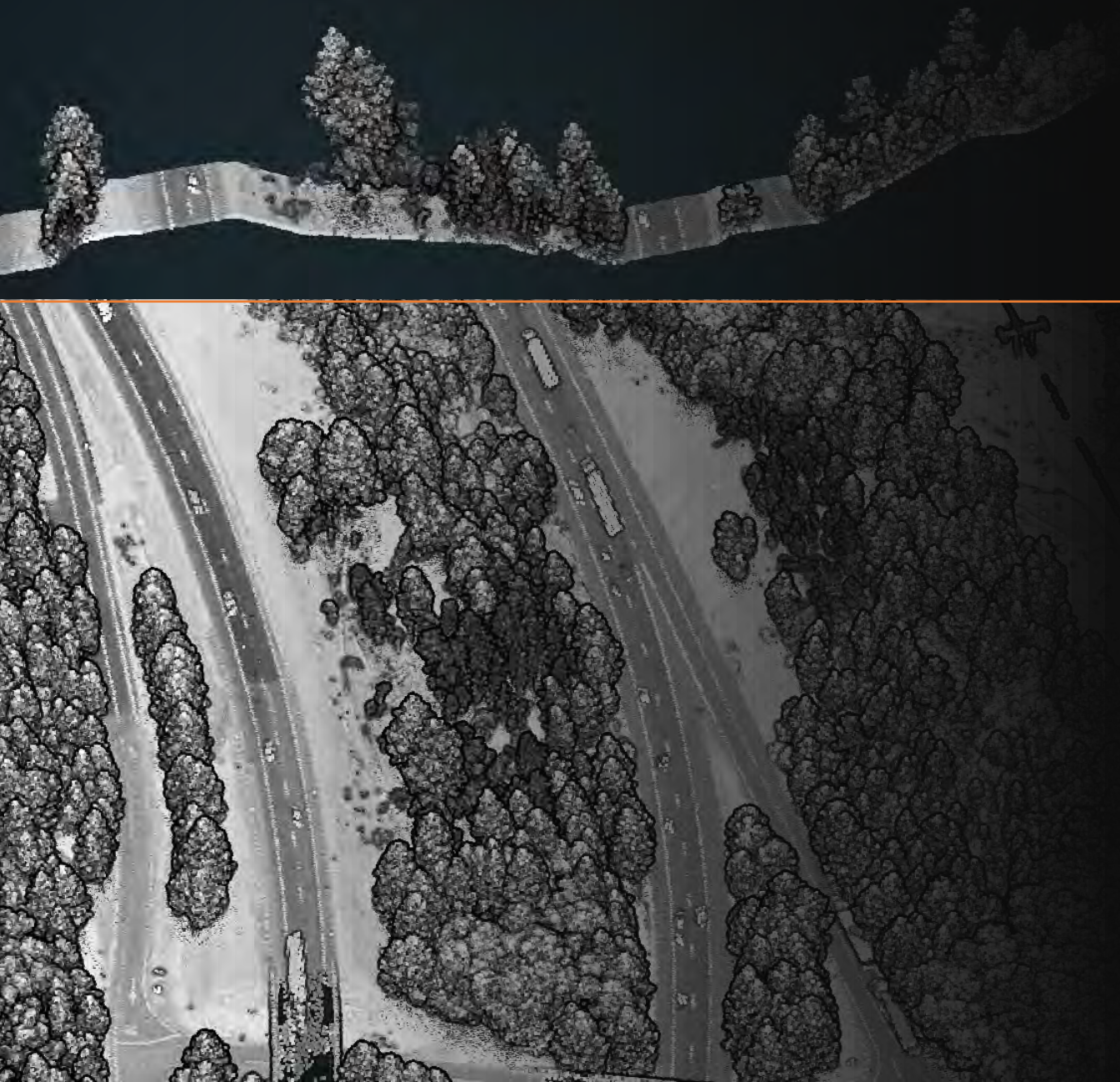






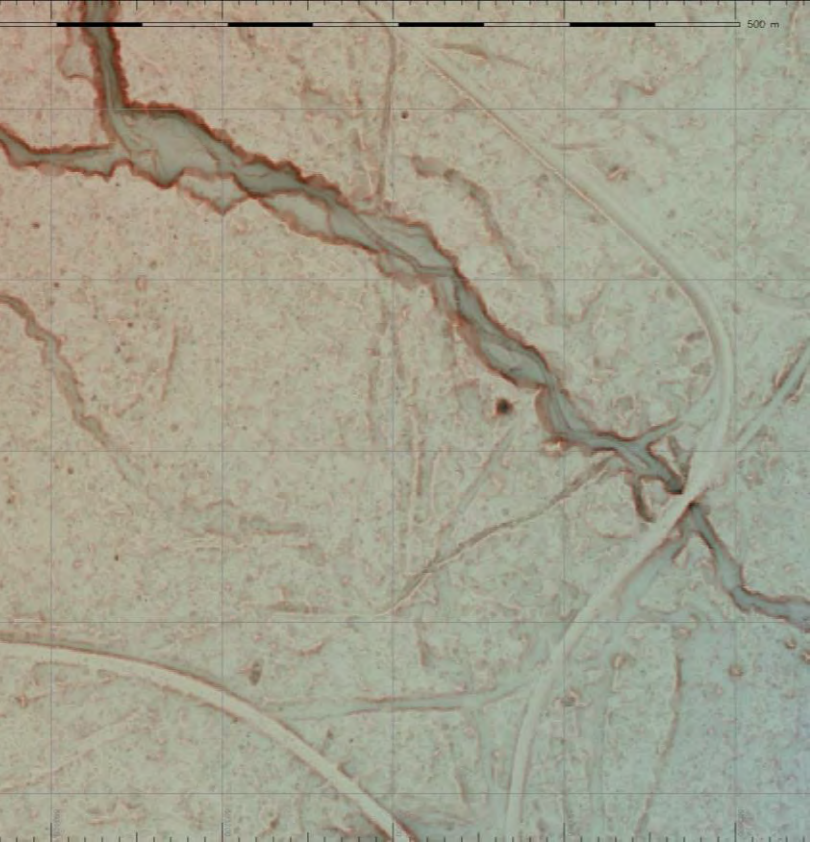


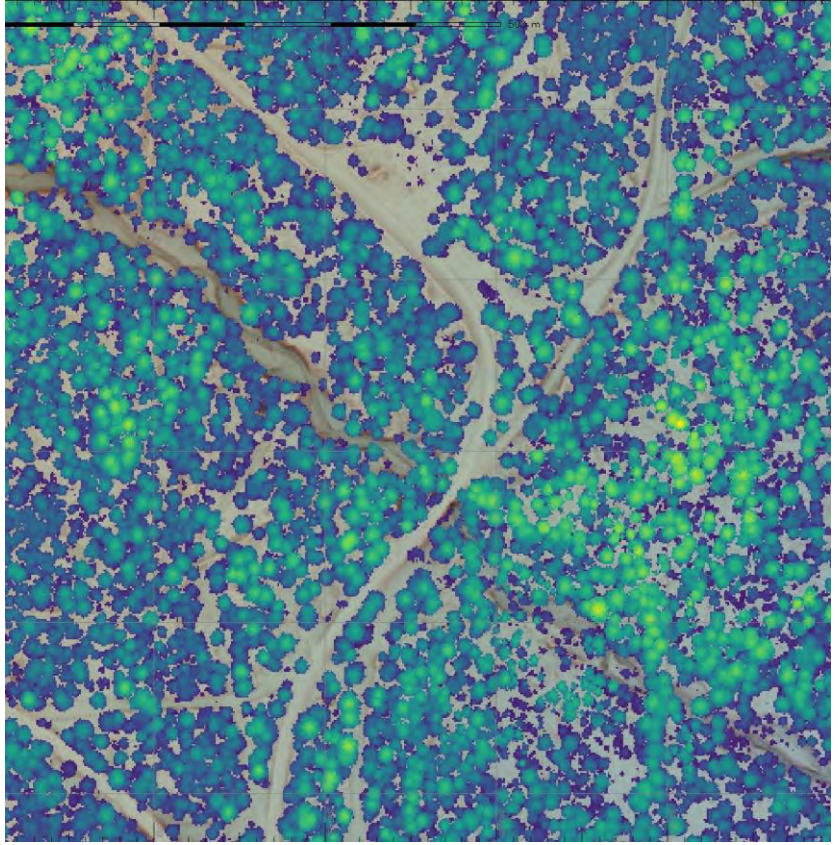
Advanced Classification of Point Clouds

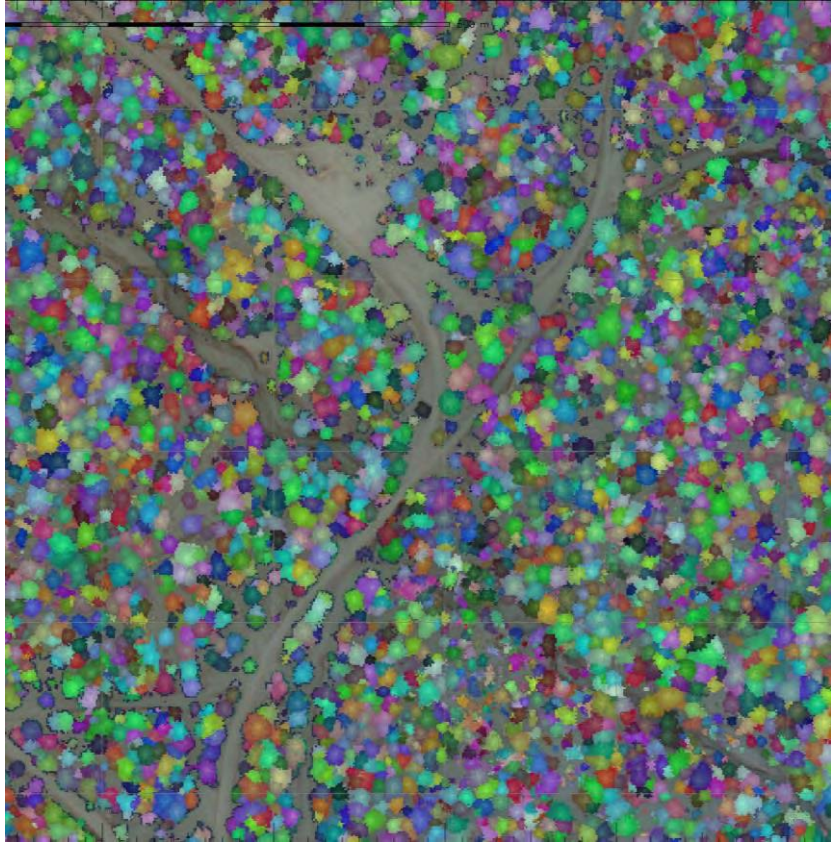


Intensity

- Can detect material changes
- Very effective for discriminating between leaves and stems in trees(snags and live trees)
- Intensity Calibration is not standard for USGS 3DEP



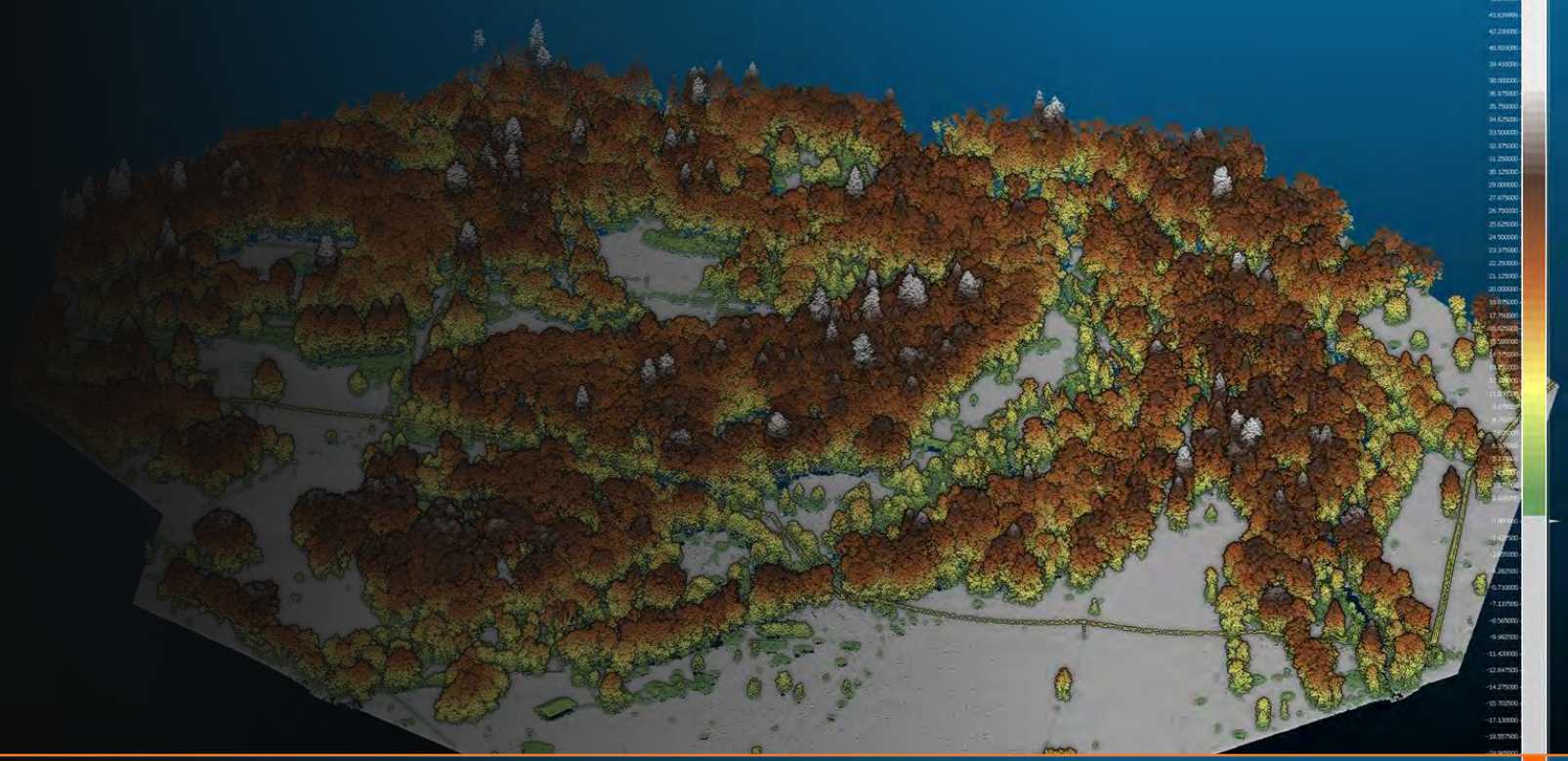




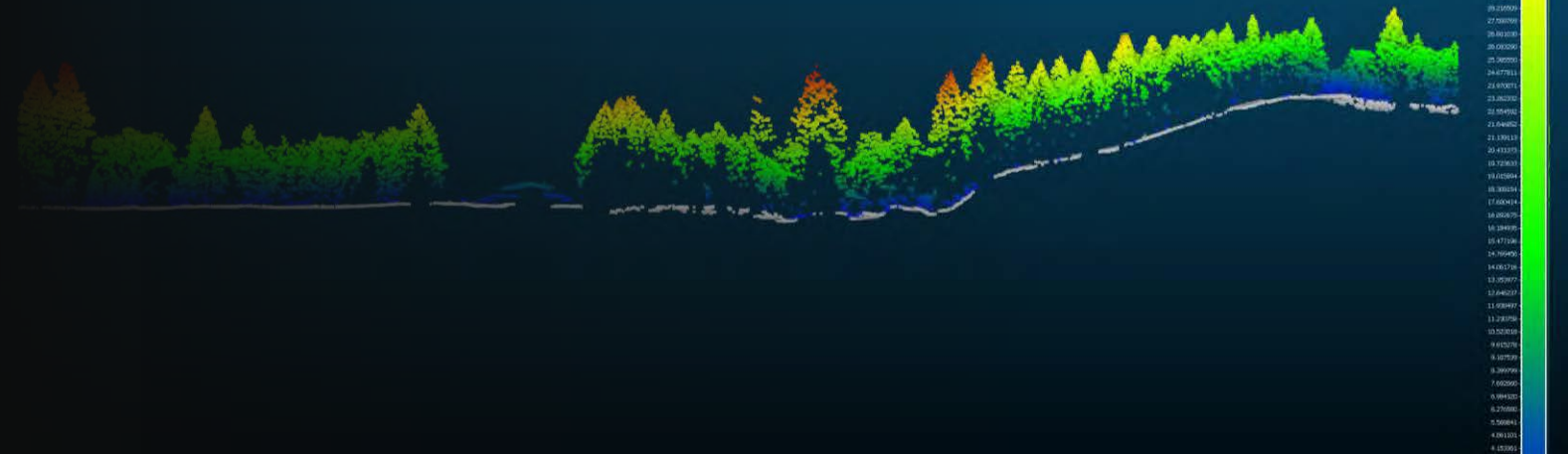
Common high resolution raster routines

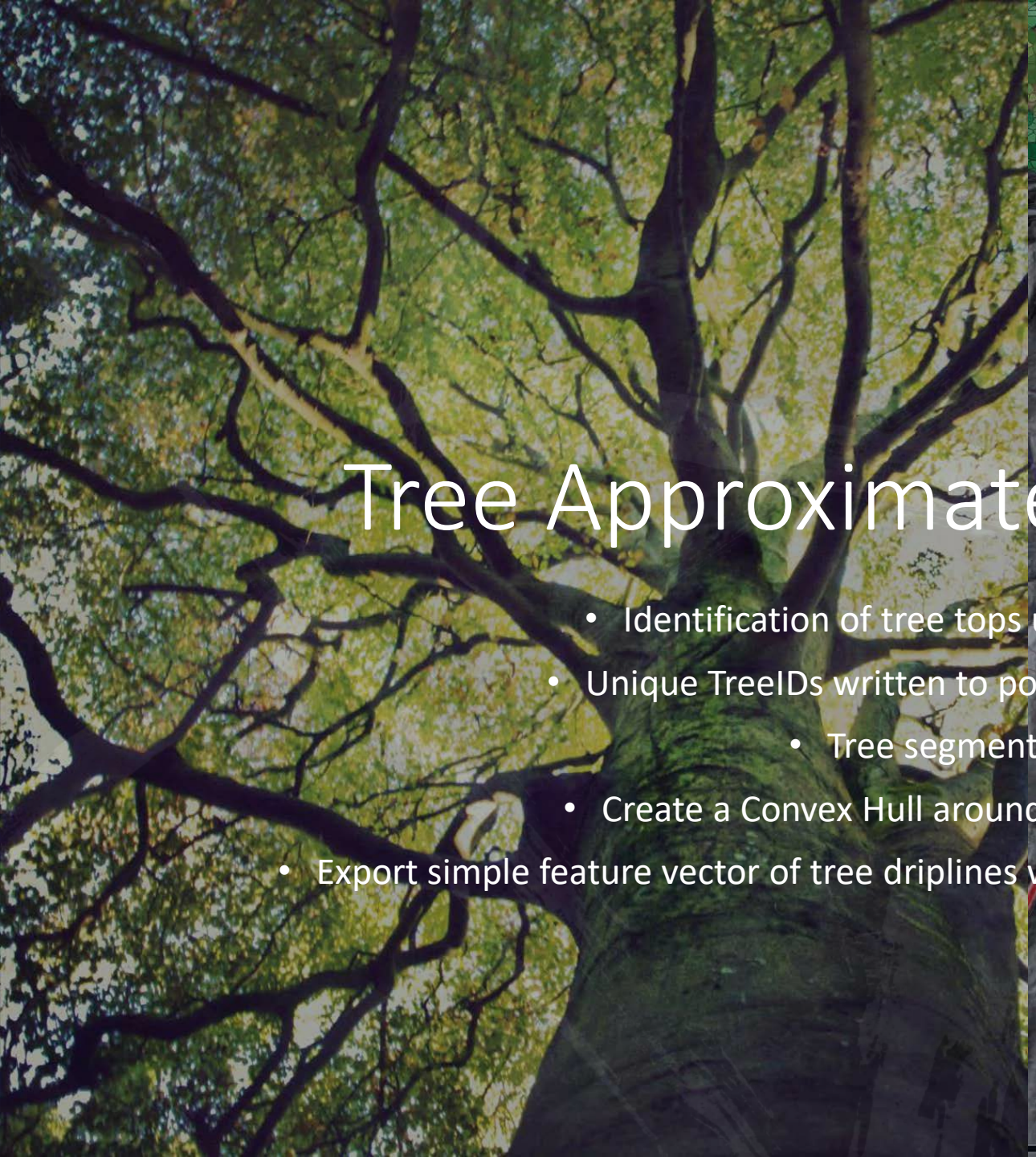
- Red Relief image map
  - Enhance topographic readability by emphasizing local relief
- Canopy Height Model
  - Relative height above ground of tree canopy surface
- Tree segmentation using a watershed method
  - Creates individual tree units

LAS extra dimensions



Recent LAS standards allow us to write extra dimensions into the point data record



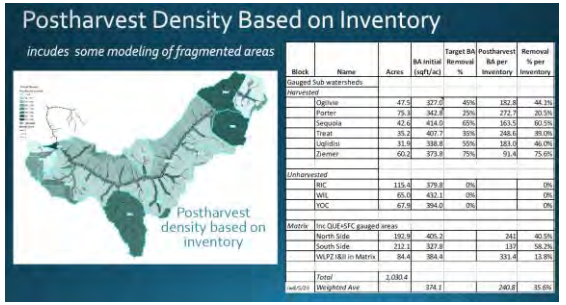


Tree Approximate Objects (TAPO)

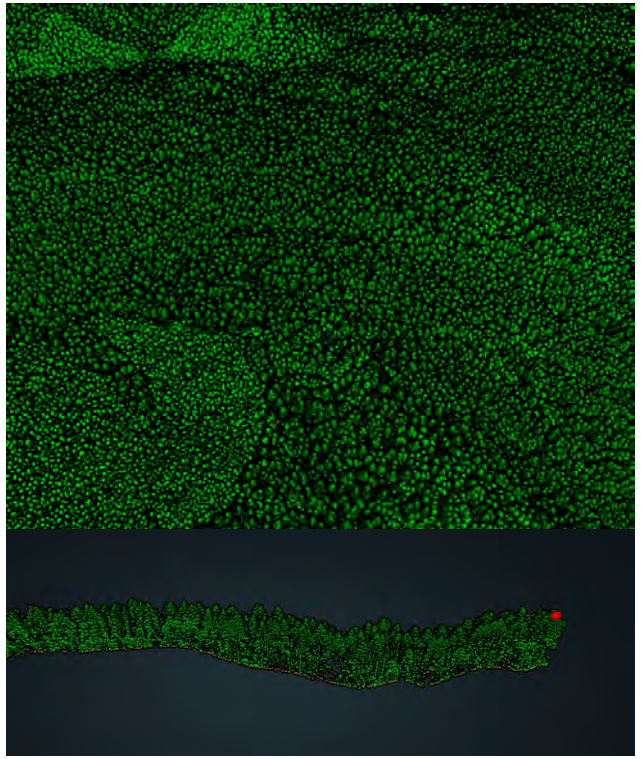
- Identification of tree tops using a local maximum filter
- Unique TreeIDs written to point records as extra dimension
- Tree segmentation of points
- Create a Convex Hull around all tree points for every tree
- Export simple feature vector of tree driplines with statistics from the points in the point cloud

Post Treatment Point Cloud of the 60 acre Ziemer Watershed in the Caspar Creek phase 3 experiment.

- **Caspar phase 3 experiment harvest report.**
- **2017 USGS QL1 Lidar**
- **300 points per sq meter photogrammetric point cloud collected post treatment in May 2020 by Humbots SDA for USFS PSW Research Station.**



Block	Name	Acres	BA initial (sqft/ac)	Target BA Removal %	Postharvest BA per inventory	Removal % per inventory
Gauged Sub watersheds						
Harvested						
	Ogilvie	47.5	327.0	45%	182.8	44.1%
	Porter	75.3	342.8	25%	272.7	20.5%
	Sequoia	42.6	414.0	65%	163.5	60.5%
	Treat	35.2	407.7	35%	248.6	39.0%
	Uqlidisi	31.9	338.8	55%	183.0	46.0%
	Ziemer	60.2	373.8	75%	91.4	75.6%
Unharvested						
	RIC	115.4	379.8	0%		0%
	WIL	65.0	432.1	0%		0%
	YOC	67.9	394.0	0%		0%
Matrix	Inc QUE+SFC gauged areas					
	North Side	192.9	405.2		241	40.5%
	South Side	212.1	327.8		137	58.2%
	WLPZ I&II in Matrix	84.4	384.4		331.4	13.8%
	Total	1,080.4				
	Weighted Ave		374.1		240.8	35.6%



Analysis Ready Data, Cloud Optimized lidar storage and distribution

Entwine Point Tile

- Currently supported by the USGS, Amazon, and HOBU for 40,000,000,000,000 3DEP points
- Provides capacity to stream points hierarchically
- Supported by potree and Cesium viewers as well as an option for direct streaming from applications

Cloud Optimized Point Cloud

- Compliant with LAZ 1.4 standard
- Improves ability to do range reads on at rest data
- Modeled very closely on the Cloud Optimized Geotiff standard
- Currently supported by Cesium
- Provides methods for data federation of point cloud assets