OLC Scappoose

WSI Applied Remote Sensing and Analysis

Data collected for:
Oregon LiDAR Consortium

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Contents

Base station set up over control “SCAP1”

Project Overview

WSI has collected Light Detection and Ranging (LiDAR) data for the Oregon Scappoose Study Area for the Oregon Department of Geology and Mineral Industries (DOGAMI). The Oregon LiDAR Consortium's Scappoose project area encompasses approximately 36,600 acres in Columbia and Washington County, Oregon. The study area is predominantly comprised of rural and forested lands.

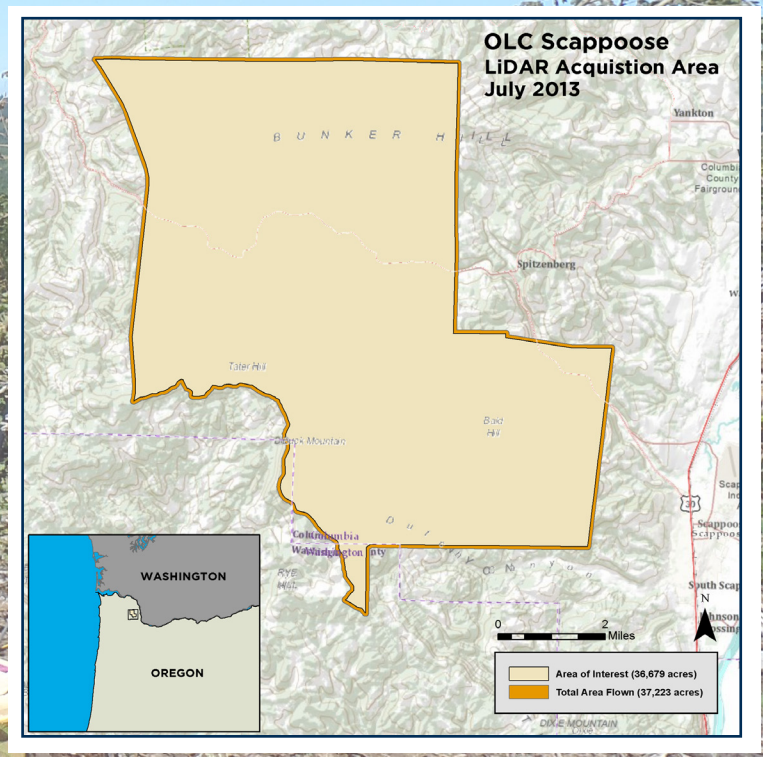
The collection of high resolution geographic data is part of an ongoing pursuit to amass a library of information accessible to government agencies as well as the general public.

Between July 1, 2013 and July 2, 2013, WSI employed remote-sensing lasers in order to obtain a total area flown of 37,223 acres of which 36,679 acres comprise the area of interest. Settings for LiDAR data capture produced an average resolution of at least eight pulses per square meter (ppsm).

Final products created include LiDAR point cloud data, one meter digital elevation models of bare earth ground model and highest-hit returns, intensity rasters, study area vector shapes, and corresponding statistical data.

Scappoose AOI Data Delivered August 31, 2013	
Acquisition Date	7/1/2013 - 7/2/2013
Area of Interest	36,679 acres
Total Area Flown	37,223 acres
Data	OGIC HARN
Projection	Oregon Statewide Lambert Conformal Conic
Datum: horizontal & vertical	NAD83 (2011) NAVD88 (Geoid 12A)
Units	International Feet

Study Area



Aerial Acquisition

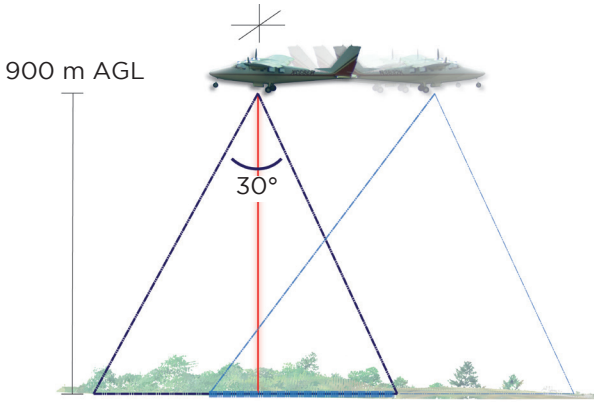
LiDAR Survey

The LiDAR survey utilized a Leica ALS60 sensor mounted in a Partenavia P.68. The system was programmed to emit single pulses at a rate of 96 to 106 kilohertz, and flown at 900 meters above ground level (AGL), capturing a scan angle of +/-15 degrees from nadir (field of view equal to 30 degrees). These settings are developed to yield points with an average native density of greater than eight pulses per square meter over terrestrial surfaces. The native pulse density is the number of pulses emitted by the LiDAR system. Some types of surfaces such as dense vegetation or water may return fewer pulses than the laser originally emitted. Therefore, the delivered density can be less than the native density and lightly vary according to distributions of terrain, land cover, and water bodies. The study area was surveyed with opposing flight line side-lap of greater than 60 percent with at least 100 percent overlap to reduce laser shadowing and increase surface laser painting. The system allows up to four range measurements per pulse, and all discernible laser returns were processed for the output dataset.

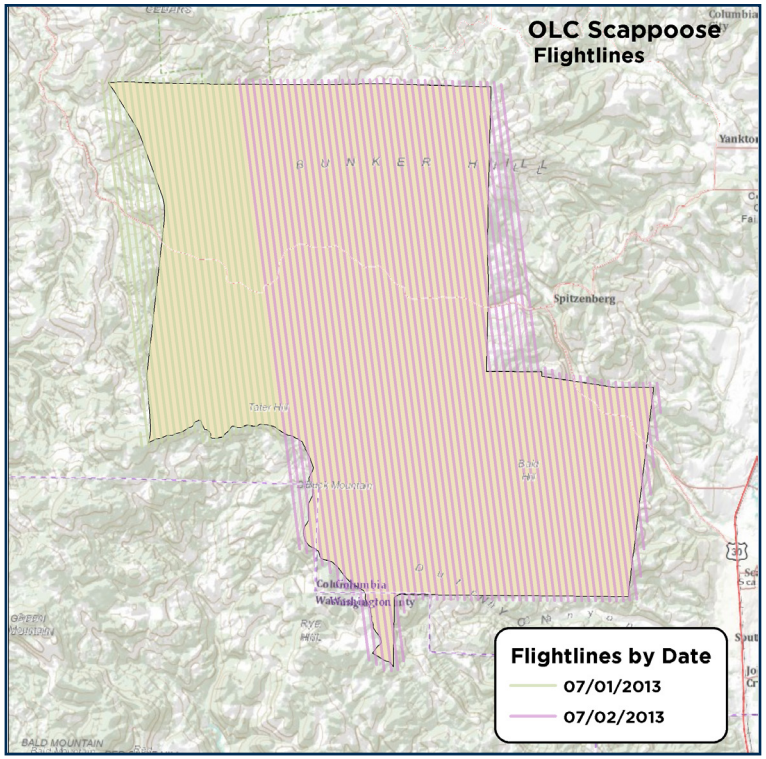
To solve for laser point position, it is vital to have an accurate description of aircraft position and attitude. Aircraft position is described as x, y, and z and measured twice per second (two hertz) by an onboard differential GPS unit. Aircraft attitude is measured 200 times per second (200 hertz) as pitch, roll, and yaw (heading) from an onboard inertial measurement unit (IMU). As illustrated in the accompanying map, 83 flightlines provide coverage for the study area.

Scappoose Delivery Acquisition Specs	
Sensors Deployed	ALS60
Aircraft	Partenavia P.68
Survey Altitude (AGL)	900 m
Pulse Rate	52.2
Pulse Mode	Single (SPiA)
Field of View (FOV)	30°
Roll Compensated	Yes
Overlap	60%
Pulse Emission Density	≥ 8 ppsm

Sensor ALS 60



Project Flightlines



Ground Survey

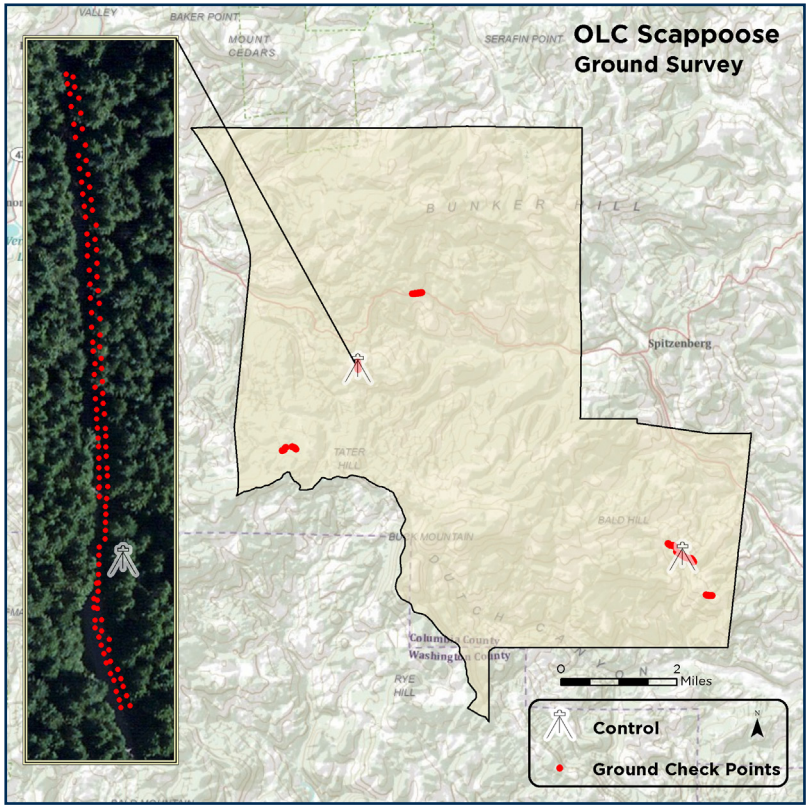
During the LiDAR survey, static (one hertz recording frequency) ground surveys were conducted over two monuments with known coordinates. After the airborne survey, the static GPS data were processed using triangulation with CORS stations and using the Online Positioning User Service (OPUS) to quantify daily variance. Multiple sessions were processed over the same monument to confirm antenna height measurements and reported position accuracy.

Instrumentation

For this study area all Global Navigation Satellite System (GNSS) survey work utilizes a Trimble GNSS receiver model R7 with a Zephyr Geodetic Antenna Model 2 for static control points. The Trimble GPS R8 unit is used primarily for real time kinematic (RTK) work but can also be used as a static receiver. For RTK data, the collector begins recording after remaining stationary for five seconds then calculating the pseudo range position from at least three epochs with the relative error under 1.5 centimeters horizontal and 2.0 centimeters vertical. All GPS measurements are made with dual frequency L1-L2 receivers with carrier-phase correction.

Monumentation

Existing and established survey benchmarks serve as control points during LiDAR acquisition including those previously set by WSI. NGS benchmarks are preferred for control points; however, in the absence of NGS benchmarks, WSI produces its own monuments. These monuments are spaced at a minimum of one mile and every effort is made to keep them within the public right of way or on public lands. If monuments are necessary on private property, consent from the owner is required. All monumentation is done with 5/8" x 30" rebar topped with a two inch diameter aluminum cap stamped "Watershed Sciences, Inc. Control." Two new monuments were established and occupied for the Scappoose survey (see table below).



Monuments			
	Datum NAD 83 (2011)		GRS 80
Name	Latitude	Longitude	Ellipsoid Height (m)
SCAP1	45 46 26.60476	-122 56 02.40038	287.974
SCAP2	45 49 15.71359	-123 02 59.23427	471.446

Methodology

Each aircraft is assigned a ground crew member with two R7 receivers and an R8 receiver. The ground crew vehicles are equipped with standard field survey supplies and equipment including safety materials. All control points are observed for a minimum of two survey sessions lasting no fewer than two hours. At the beginning of every session the tripod and antenna are reset, resulting in two independent instrument heights and data files. Data are collected at a rate of one hertz, using a 10 degree mask on the antenna.

The ground crew uploads the GPS data to the Dropbox website on a daily basis to be returned to the office for Professional Land Surveyor (PLS) oversight, Quality Assurance/Quality Control (QA/QC) review, and processing. OPUS processing triangulates the monument position using three CORS stations resulting in a fully adjusted position. Blue Marble Geographics Desktop v.2.5.0 is used to convert the geodetic positions from the OPUS reports. After multiple days of data have been collected at each monument, accuracy and error ellipses are calculated. This information leads to a rating of the monument based on FGDC-STD-007.2-1998 Part 2 at the 95 percent confidence level (see monument accuracy table).

Field ground professional collecting RTK

WSI collected 387 RTK points and utilized two monuments.

All RTK measurements are made during periods with a Position Dilution of Precision (PDOP) of less than 3.0 and in view of at least six satellites by the stationary reference and roving receiver. RTK positions are collected on 20 percent of the flight lines and on bare earth locations such as paved, gravel, or stable dirt roads, and other locations where the ground is clearly visible (and is likely to remain visible) from the sky during the data acquisition and RTK measurement period(s). In order to facilitate comparisons with LiDAR survey points, RTK measurements are not taken on highly reflective surfaces such as center line stripes or lane markings on roads. RTK points are taken no closer than one meter to any nearby terrain breaks such as road edges or drop offs. Examples of identifiable locations would include manhole and other flat utility structures that have clearly indicated center points or other measurement locations. Multiple differential GPS units are used in the ground based real-time kinematic portion of the survey. To collect accurate ground surveyed points, a GPS base unit is set up over monuments to broadcast a kinematic correction to a roving GPS unit. The ground crew uses a roving unit to receive radio-relayed kinematic corrected positions from the base unit. This RTK survey allows precise location measurement (≤ 1.5 centimeters). Further processing and acquistion information can be found in the OLC Methodology document.

Monument Accuracy	
FGDC-STD-007.2-1998 Rating	
St Dev NE	0.010
St Dev z	0.020

R7 Receiver

Accuracy

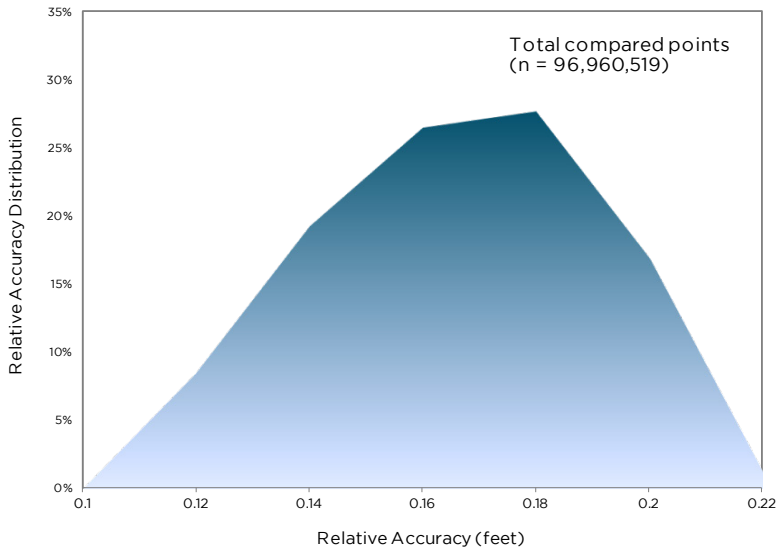
Relative Accuracy

Relative accuracy refers to the internal consistency of the data set and is measured as the divergence between points from different flightlines within an overlapping area. Divergence is most apparent when flightlines are opposing. When the LiDAR system is well calibrated the line to line divergence is low (<10 centimeters). Internal consistency is affected by system attitude offsets (pitch, roll, and heading), mirror flex (scale), and GPS/IMU drift.

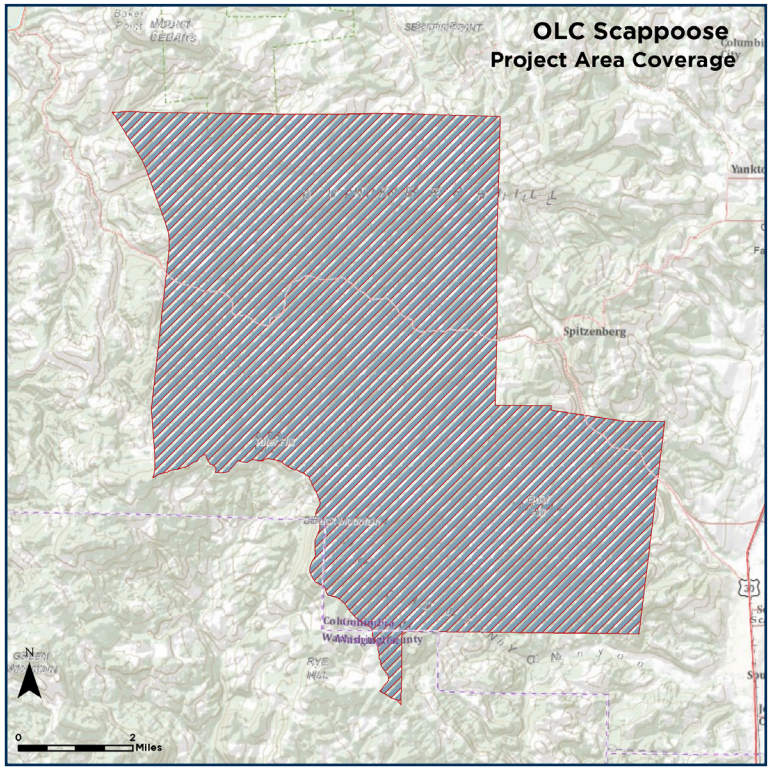
Relative accuracy statistics are based on the comparison of 83 flightlines and over 96 million points. Relative accuracy is reported for the entire study area.

Relative Accuracy Calibration Results		
	feet	meters
Project Average	0.156	0.048
Median Relative Accuracy	0.158	0.048
1σ Relative Accuracy	0.166	0.050
2σ Relative Accuracy	0.191	0.058

Relative Accuracy Distribution



Accuracy Coverage Area (100% Coverage)



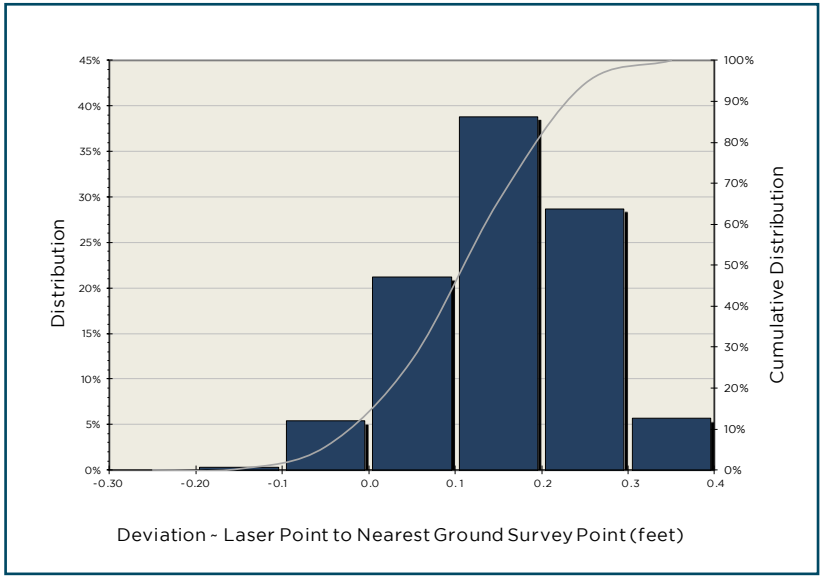
Vertical Accuracy

Vertical Accuracy reporting is designed to meet guidelines presented in the National Standard for Spatial Data Accuracy (NSSDA) (FGDC, 1998) and the ASPRS Guidelines for Vertical Accuracy Reporting for LiDAR Data V1.0 (ASPRS, 2004). The statistical model compares known RTK ground survey points to the closest laser point. Vertical accuracy statistical analysis uses ground control points in open areas where the LiDAR system has a "very high probability" that the sensor will measure the ground surface and is evaluated at the 95th percentile. For the Scappoose study area, 387 RTK points were collected.

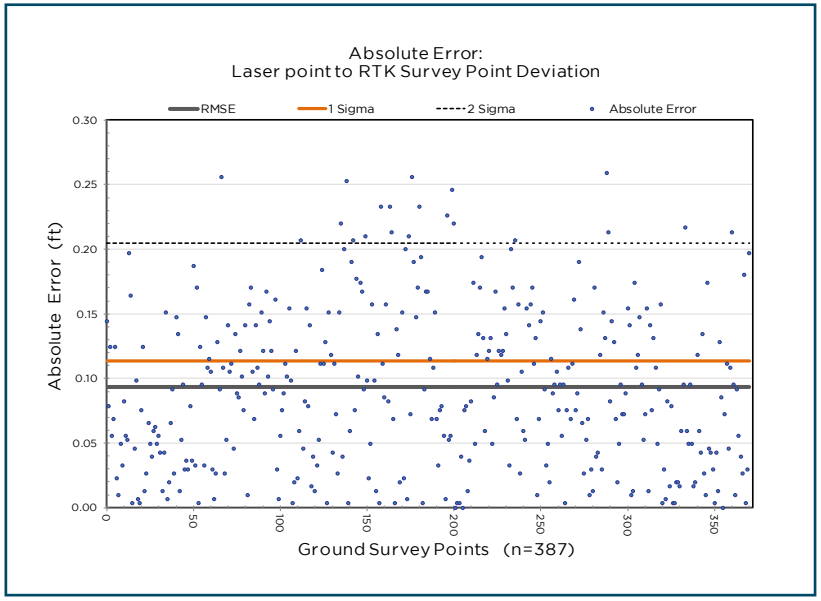
For this project, no independent survey data were collected, nor were reserved points collected for testing. As such, vertical accuracy statistics are reported as "Compiled to Meet." Vertical Accuracy is reported for the entire study area and reported in the table below. Histogram and absolute deviation statistics displayed to the right.

Vertical Accuracy Results		
Sample Size (n) = 387		
	feet	meters
Root Mean Square Error	0.09	0.03
1 Standard Deviation	0.11	0.03
2 Standard Deviation	0.20	0.06
Average Deviation	0.06	0.02
Minimum Deviation	-0.26	-0.08
Maximum Deviation	0.26	0.08

Vertical Accuracy Distribution



RTK Absolute Error



Density

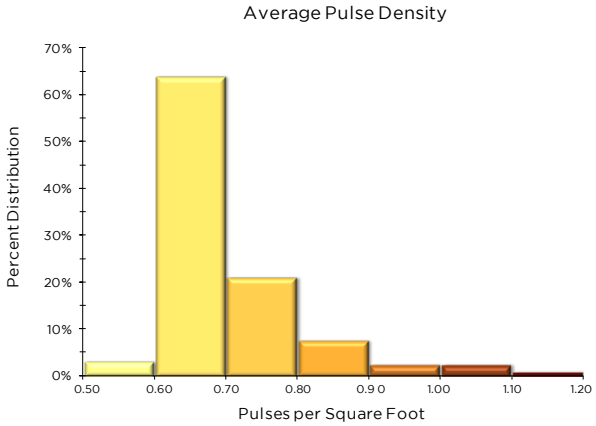
Pulse Density

Some types of surfaces (e.g., dense vegetation, water) may return fewer pulses than the laser originally emitted. Therefore, the delivered density can be less than the native density and vary according to terrain, land cover, and water bodies. The Scappoose project area is within 95% design pulse density. Density histograms and maps have been calculated based on first return laser pulse density and ground-classified laser point density.

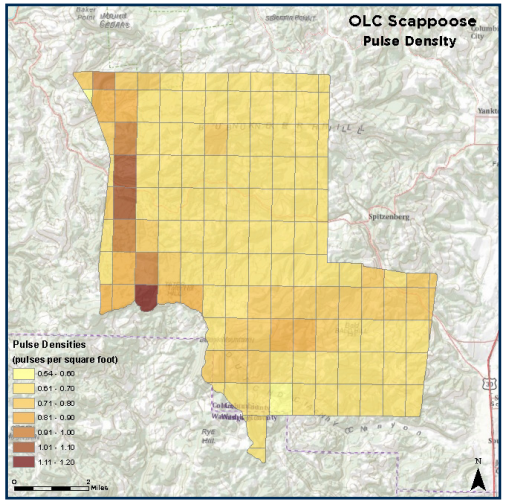
Average Point Densities			
Pulses per square foot	Pulses per square meter	Groound points per square foot	Ground points per square meter
0.71	7.6	0.03	0.35

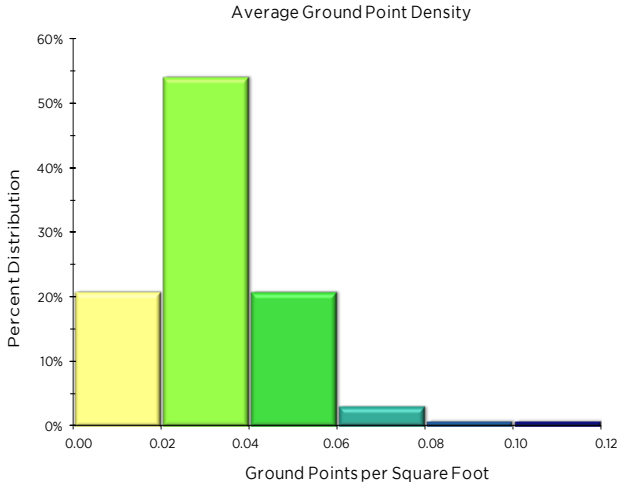
Ground Density

Ground classifications were derived from ground surface modeling. Further classifications were performed by reseeding of the ground model where it was determined that the ground model failed, usually under dense vegetation and/or at breaks in terrain, steep slopes, and at tile boundaries.

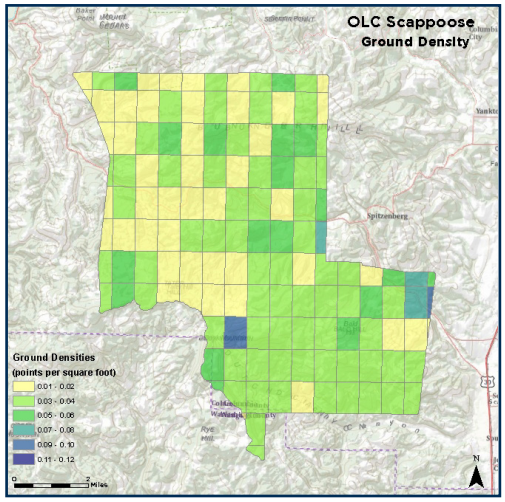


Average Pulse Density per 0.75' USGS Quad (color scheme aligns with density chart)





Average Ground Density per 0.75' USGS Quad (color scheme aligns with density chart)



Appendix

LiDAR-derived Imagery

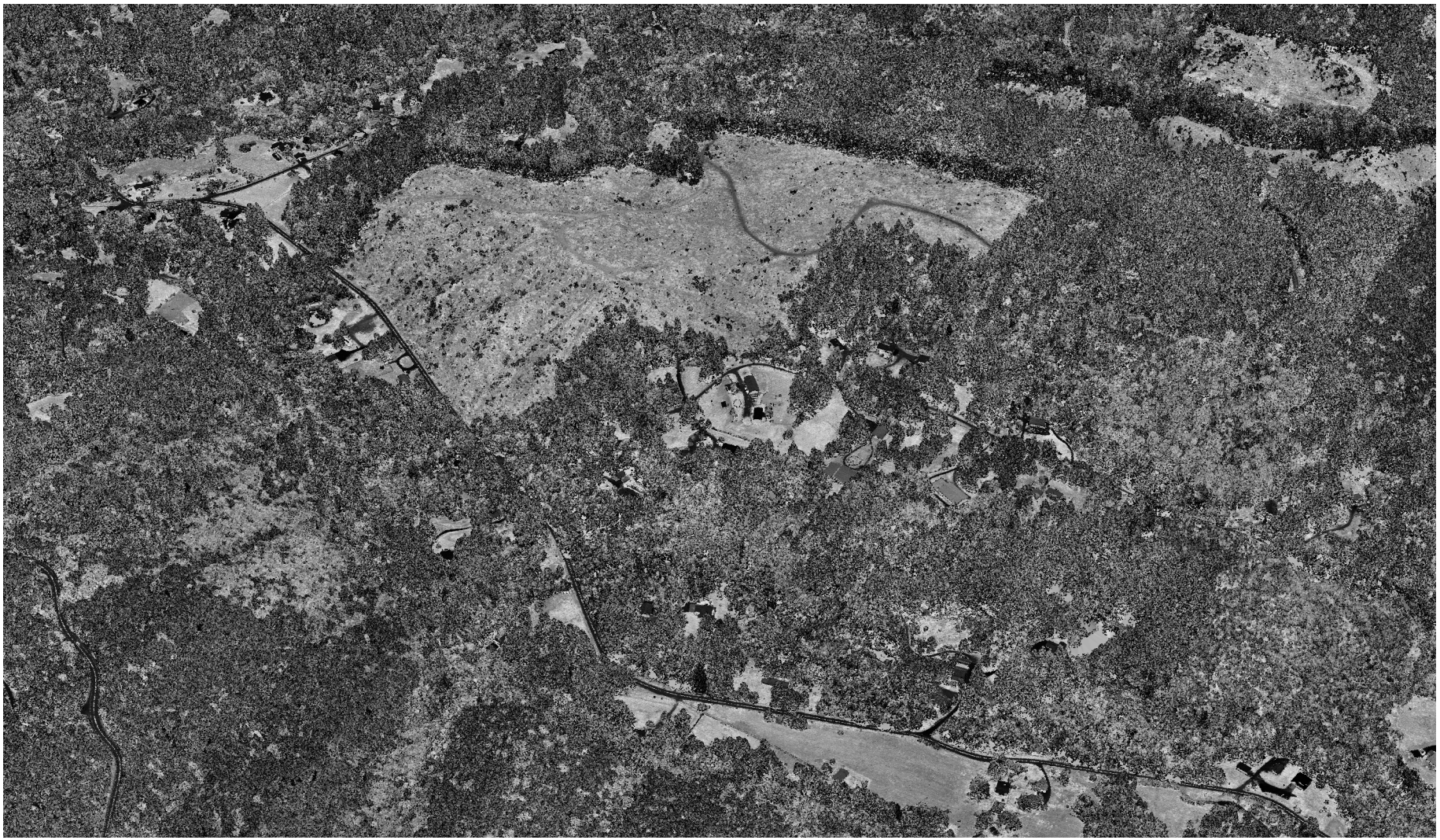
LiDAR point cloud with RGB extraction from 2012 NAIP imagery; image includes forrested lands five miles Northwest of Hwy 30 and Scappoose, Oregon.

LiDAR point cloud with RGB extraction from 2012 NAIP imagery; image includes forested lands five miles Northwest of highway 30 and Scappoose, Oregon.

LiDAR point cloud with RGB extraction from 2012 NAIP imagery; image includes forested lands five miles Northwest of Highway 30 and Scappoose, Oregon.

Bare earth hillshade of the Silver Creek Valley looking South.

Intensity image of the Scappoose study area.



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Certification

Watershed Sciences provided LiDAR services for the OLC Turnbull study area as described in this report.

I, Mathew Boyd, have reviewed the attached report for completeness and hereby state that it is a complete and accurate report of this project.

Mathew Boyd
Principal
WSI
Portland, OR 97204

I, Christopher W. Yotter-Brown, being first dully sworn, say that as described in the Ground Survey subsection of the Acquisition section of this report was completed by me or under my direct supervision and was completed using commonly accepted standard practices. Accuracy statistics shown in the Accuracy Section have been reviewed by me to meet National Standard for Spatial Data Accuracy.

Christopher Yotter-Brown, PLS Oregon & Washington
WSI
Portland, OR 97204

REGISTERED PROFESSIONAL LAND SURVEYOR

8/28/2013

OREGON
JULY 13, 2004
Christopher W. Yotter - Brown
60438 LS

RENEWAL DATE: 6/30/2014