# Buckhorn lidar data processing

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## Introduction

## Data

Lidar data and imagery were collected by Westfork Environmental in 2024. Lidar data were collected using a Surveyor 32 LiDAR System mounted on a DJI Matrice 600 Pro Hexacopter. Imagery was collected using an AgEagle Altum-PT camera. Imagery is delivered as single bands and a composite image with all seven bands collected by the camera.

Lidar point density averages 1171 points per square meter for aggregated data. Lidar points are extremely dense in the upper canopy but density falls off rapidly as you go down into the canopy. Ground point density (points classified as ground) averages 19 points per square meter for aggregated data.

All data are in EPSG:32610: WGS84 UTM zone 10.

## Processing (incomplete)

Lidar and image processing were done in R using the fusionwrapr and terra packages. The fusionwrapr package (<https://github.com/bmcgaughey1/fusionwrapr>) provides an R interface to FUSION (McGaughey 2023) command line programs. The processing workflow is available from GitHub (<https://github.com/bmcgaughey1/BuckhornLidar>). Be warned that this code relies on a specific file structure for input data. The FileSystem.R (<https://github.com/bmcgaughey1/BuckhornLidar/blob/b9d53dbd772fbb7ee7be019a52f31f151996d73a/RCode/FileSystem.R>) module contains the file structure and can be changed to accommodate file structures that differ from those on my computer.

Processing is divided into several R modules. Some deal with simple file conversions while others perform spatial analyses and merge data from several sources into aggregate products (both spatial and tabular data). I tried several approaches to match a perfect grid of tree locations to the lidar-derived trees but didn’t settle on a best approach.

Summarize workflow

Summarize methods…simple…matching

Summarize merging data…new measurements…UCDavis maps…Connie’s spreadsheet

Image processing used the single band images to assemble a variety of composite images. Individual image bands are stretched to values ranging from 0-255 to provide more consistent image viewing in GIS and other software. Simple composites with RGB and false-color infrared (NIR-R-G) are probably the most useful. More esoteric composites representing vegetation-useful indices (Xie, et al. 2018) were also created. Table 1 shows the vegetation indices (band combinations) that were produced. References in the table refer to references in Xi1, et al. (2018).

Table 1. Descriptions and formulae for vegetation indices created from image bands (from Xie, et al. 2018).

Table

AI-generated content may be incorrect.

## Products

There are two main product sets. The first is a set of simple measurements made using the lidar point data and canopy height models (smoothed and unsmoothed). The first set uses the perfect grid of trees to “collect” measurements. The second set contains matched lidar/field trees and the measurements for the lidar-derived trees and field campaigns. Columns and column order are different for these two sets and not all columns are included in each set.

Data are provided in shapefile and CSV formats. Attribute values in the shapefiles should match values in the CSV files. Some column names in shapefiles may have been changed to accommodate limitations of the shapefile format (column names must be 10 characters long or less).

### Geospatial files

### Images

Image files are stored in geoTIFF format for use in GIS and other software. Image files are in the *CompositeImages* folder. In addition, there is a photo book, *Buckhorn\_Imagery.pdf*, in the root folder that allows you to easily view and compare imagery. This PDF also contains hillshade images of the ground model and CHM.

### CSV files

(same attributes are also in geospatial files)

Simple measurements (FINAL\_ShiftedSimpleMeasurements.\*)

|  |  |
| --- | --- |
| Column label | Description |
| Tag | Tree tag number |
| Block | Block number (1-4) |
| Plot | Plot number |
| Row | Row in overarching grid |
| Col | Column in overarching grid |
| Live | Flag indicating tree is alive |
| Border | Flag indicating trees is a border tree |
| Filler | Flag indicating tree is a filler tree (dead/cut filler trees not included) |
| Extra | Flag indicating tree is an extra tree (planted in place of a grid tree) |
| X | Location (WGS84 UTM zone 10) |
| Y | Location (WGS84 UTM zone 10) |
| SITE | Site name (Buckhorn) |
| STEM | Indicator for multiple leader trees (“a” is tallest leader, “b” is other leader) |
| PBD |  |
| BD21 |  |
| PDBH |  |
| DBH21 |  |
| PHT |  |
| HT21 |  |
| FL21 |  |
| PCWA |  |
| CWA21 |  |
| PCWB |  |
| CWB21 |  |
| PCODE |  |
| CODE21 |  |
| PCOMM |  |
| COMM21 |  |
| CHMroughHt | “Tree” height from an unsmoothed CHM |
| CHMsmthHt | “Tree” height from an smoothed CHM |
| HighPtHt | Height of highest point within 0.5m of tree location |

Matched trees (FINAL\_Merged\_Trees.\*)

|  |  |
| --- | --- |
| Column label | Description |
| SITE | Site name (Buckhorn) |
| Block | Block number (1-4) |
| Plot | Plot number |
| Tag | Tree tag number |
| STEM | Tree tag number |
| Row | Row in overarching grid |
| Col | Column in overarching grid |
| Live | Flag indicating tree is alive |
| Border | Flag indicating trees is a border tree |
| Filler | Flag indicating tree is a filler tree (dead/cut filler trees not included) |
| Extra | Flag indicating tree is an extra tree (planted in place of a grid tree) |
| X | Location (WGS84 UTM zone 10) |
| Y | Location (WGS84 UTM zone 10) |
| PBD |  |
| BD21 |  |
| PDBH |  |
| DBH21 |  |
| PHT |  |
| HT21 |  |
| FL21 |  |
| PCWA |  |
| CWA21 |  |
| PCWB |  |
| CWB21 |  |
| PCODE |  |
| CODE21 |  |
| PCOMM |  |
| COMM21 |  |
| BasinID | Basin/Tree identifier from CHM segmentation |
| GridHighX | Location of highest CHM grid cell in basin/tree |
| GridHighY | Location of highest CHM grid cell in basin/tree |
| GridCells | Number of CHM grid cells in basin/tree (0.5m cells) |
| GridMaxHt | Maximum CHM height (smoothed CHM) in basin/tree |
| UnsmthHt | Maximum CHM height (unsmoothed CHM) in basin/tree |
| HighPtX | Location of highest point within 0.5m of tree location |
| HighPtY | Location of highest point within 0.5m of tree location |
| HighPtHt | Height of highest point within 0.5m of tree location |
| dist | Distance from lidar to grid tree |
| confidence | Match confidence based on distance between lidar and grid trees (1:0.5m, 2:0.75m, 3:1.0m, 4:1.25m) |
| DBH24 |  |
| HT23 |  |
| HT24 |  |
| HTLC24 |  |
| COMMENT |  |

## References

McGaughey, R. J. (2023). *FUSION/LDV: Software for LIDAR Data Analysis and Visualization* (Version 4.51). <http://forsys.sefs.uw.edu/software/fusion/FUSION_manual.pdf>

Xie, Q., Dash, J., Huang, W., Peng, D., Qin, Q., Mortimer, H., Casa, R., Pignatti, S., Laneve, G., Pascucci, S., Dong, Y., & Ye, H. (2018). Vegetation Indices Combining the Red and Red-Edge Spectral Information for Leaf Area Index Retrieval. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, *11*(5), 1482–1493. <https://doi.org/10.1109/JSTARS.2018.2813281>