



EXERCISE 2

Lidar Quality Check: Assesment of Pulse Density in ArcGIS

Introduction

Your first step when acquiring your lidar data will be to do a quality assessment. It's important to check that your lidar data has a high enough number of pulses per square meter (ppm) to meet your specifications, and it's also useful to be aware of where your data has a higher or lower pulse density. This exercise will walk you through some simple work flows to evaluate the quality of your data, and the tools that you'll need to measure the point and pulse density of your lidar.

Required Data

- GTAC_training_lasDataset.lasd (created in the previous exercise)

Prerequisites

- Completion of Exercise 1





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Part 1: Measuring Return Density

Note: If this is your first time using lidar, or the terminology gets confusing and you feel like you need a refresher, you can watch GTAC's [Intro to Lidar course, available at this link](#). Below is a quick explanation of several terms used in this exercise.

The laser that a lidar sensor emits is referred to as a “pulse”. The pulse travels from the lidar sensor, interacts with the landscape (the vegetation, buildings, bare ground, etc.), and is reflected back to the sensor. The reflected pulse registers a “return” or a 3D point in space. But a pulse can interact with multiple objects on the landscape, which means that multiple returns, or points, can be recorded from a single pulse. Because of this, the point density can be considerably greater than the pulse density. Lidar quality is measured in pulse density, but measuring the point density can give you clues about the land cover in an area.

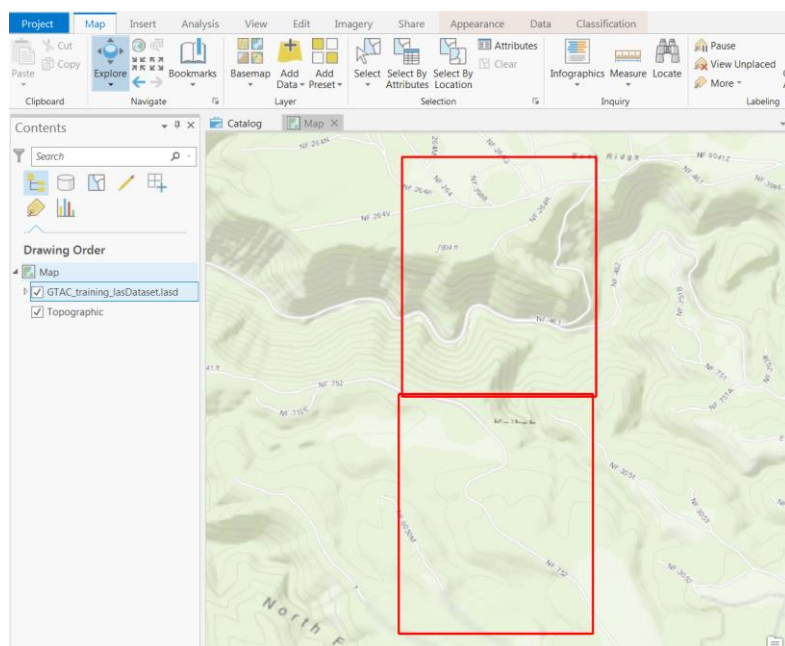
Lidar quality is typically measured in pulses per square meter (ppm). The more pulses that are emitted over a given area, the higher the pulse density, and the higher the Quality Level (QL) of the data. QL2 data needs to have at least 2 ppm meter, while QL1 data (which is forestry grade lidar) needs to have at least 8 ppm.

Frequently your first step when acquiring lidar data is to run a quality check. When lidar is flown, there are certain specifications that need to be met. One of the most commonly measured is the density of pulses (typically represented as pulses per square meter, or ppm). This is important to know, because the density is a measurement of the lidar resolution, and influences how accurately you can measure things like canopy height and vegetation density. In this section you'll learn to measure the point density in each of the tiles to get an idea of the lidar resolution across the landscape.

A. Open ArcGIS Pro and Load Data

If you already have ArcGIS Pro open and have the `GTAC_training_lasDataset.lasd` loaded, you can skip to section B.

1. Launch ArcMap from the start menu by clicking **Start, All Programs, ArcGIS, ArcGIS Pro, ArcGIS Pro**.
2. In the window that opens, you can either create a new project or load the project you created in the last exercise. If you start a new project, click **Blank** in the **Create a new project** pane on the right.
3. In the Create a New Project pop-up, give the project a name. You can save the project location as the default.
4. Click **Ok**.
5. In the upper left corner click **New Map**. If you don't see the New Map button, make sure you're on the **Insert** tab on the toolbar at the top of the ArcGIS Pro window. This will open a global map.
6. On the **Map** tab in the toolbar at the top, click **Add Data**.
7. In the dialog box that opens, navigate to the `GTAC_training_lasDataset` that you created in the previous exercise and add it to the map. This will zoom you to the LAS Dataset.



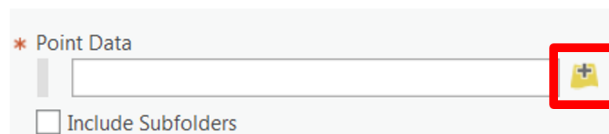
B. Measuring Tile Point Spacing

A common first step in a lidar processing workflow is to measure return density per las tile. When you have many las tiles over an area, it's good to take this step to make sure that your tiles have a high enough point density to meet your specifications for forestry-grade lidar. Here you'll learn to measure average point spacing in a las tile.

1. In the ArcGIS Pro map window, make sure you are in the map view (if you're continuing from Exercise 1, you may have a scene window open).

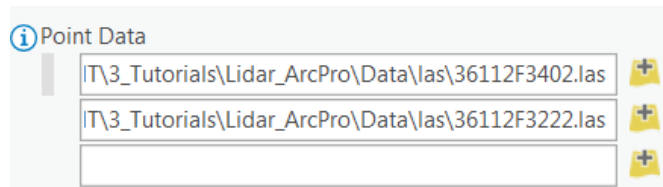


2. In the **Analysis** tab at the toolbar at the top of ArcGIS Pro, click **Tools** to open the geoprocessing pane.
3. In the **Find Tools** search bar at the top of the geoprocessing pane, type **Point File Information**. In the results that appear, click **Point File Information (3D Analyst Tools)** to open the tool.
4. In the **Point Data** section at the top of the tool, click the yellow folder icon on the right to select which point files you want to load.

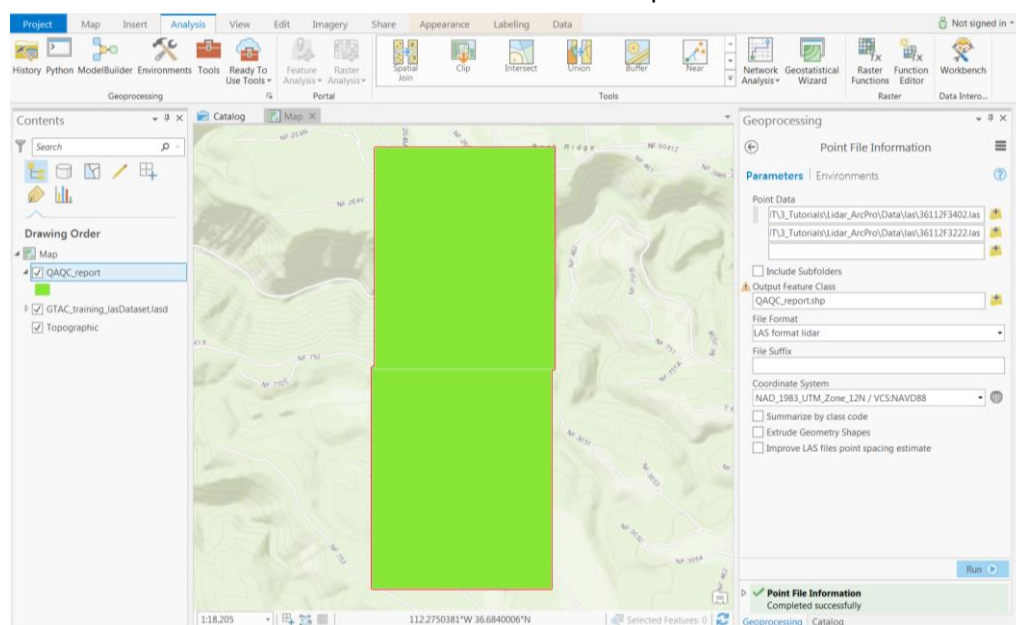


Note: The Point File Information tool is unlike most ArcGIS Pro tools in that it is able to read information from the las headers, so you input the raw las files to the tool, not the LAS Dataset file that you created previously. Most lidar tools in ArcGIS Pro need to operate on a LAS Dataset, and don't take .las files as input.

5. In the dialogue that opens, navigate to the **data folder** that you downloaded for the course and select the two las files.



6. In the **Output Feature Class** section, name the output **QAQC_report**.
7. The rest of the options can be left as their default, but check the box labeled **Improve LAS files point spacing estimate**. This will slightly improve the point density measurement.
8. Click **Run** to run the tool. It will look similar to the output below.



9. In the **Table of Contents** pane on the left, right click on **QAQC_report**, then click **Attribute table** to open the attribute table. The table will open in your ArcGIS Pro window.

QAQC_report						
Field:	Add	Delete	Calculate	Selection:		
	Shape	FileName	Pt_Count	Pt_Spacing	Z_Min	Z_Max
0	Polygon	36112F3402.las	28025651	0.238313	2270.51	3311.94
1	Polygon	36112F3222.las	26885296	0.243297	2161.17	3195.62

You can see here that the first las tile has a point count of 28,025,651 points and an average point spacing of about 0.2383 meters. You're only using 2 tiles here, but when you're looking over a large area where lidar has been flown you may have hundreds or thousands of las tiles.

Note: To check the units of the dataset, right click the LAS Dataset in the contents pane on the left, then click Properties to open the Properties window. Then click the Source section. The Data Source section will list the units that the LAS Dataset is in.

C. Estimating Point Density from Point Spacing

So far you've measured point spacing, or the average distance between points in these two las tiles. But you want to measure point density, not point spacing. In this section you'll learn how to translate those measurements.

1. First you'll need to add column in the QAQC_report table to record point density. In the **Field** toolbar above the table, click **Add**.

FID	Shape	FileName	Pt_Count	Pt_Spacing	Z_Min	Z_Max
0	Polygon	36112F3402.las	28025651	0.238313	2270.51	3311.94
1	Polygon	36112F3222.las	26885296	0.243297	2161.17	3195.62

2. In the field name section that appears, type **Pt_density**.

Visible	Read Only	Field Name	Alias	Data Type	Allow NULL	Highlight	Number Format	Domain	Default	Length
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Z_Max	Z_Max	Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Numeric			
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Shape_Length	Shape_Length	Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Numeric			
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Shape_Area	Shape_Area	Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Numeric			
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Pt_density		Long	<input checked="" type="checkbox"/>	<input type="checkbox"/>				

3. In the **Data Type** section that appears, click the dropdown next to Long and change it to **Float**.

Visible	Read Only	Field Name	Alias	Data Type	Allow NULL
<input checked="" type="checkbox"/>	<input type="checkbox"/>	FileName	FileName	Text	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Pt_Count	Pt_Count	Long	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Pt_Spacing	Pt_Spacing	Double	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Z_Min	Z_Min	Double	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Z_Max	Z_Max	Double	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Shape_Length	Shape_Length	Double	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Shape_Area	Shape_Area	Double	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Pt_Density	Pt_Density	Float	<input checked="" type="checkbox"/>

4. In the toolbar at the top of ArcGIS Pro click **save** to save the field.
5. Once the Pt_density field has been added, you can **close** the Fields: tab.

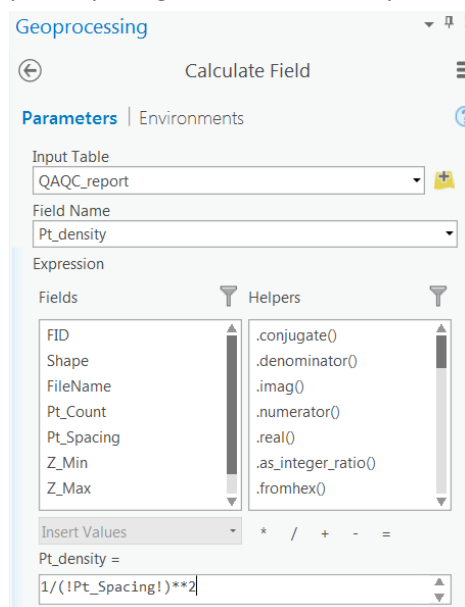


6. You'll see in the QAQC_report attribute table that the Pt_density has been added to the end of the table, which right now is filled with 0's (or marked as Null). Now you'll calculate the point density values per tile to replace the 0's. With the QAQC_report attribute table open and the QAQC_report layer selected in the table of contents pane, you can click the **View** tab in the **Table** section in the toolbar at the top of the ArcGIS Pro window.



Note: When you have the QAQC_report layer selected there will be two View tabs available. You must click the View tab in the Table section.

7. In the View tab in the Table section in the ArcGIS Pro toolbar, click **Calculate Field**. This will open the Calculate Field tool in the geoprocessing pane.
8. In the Input Table section, click the dropdown button on the right side and select **QAQC_report**.
9. In the Field Name section, click the dropdown button on the right side and select **Pt_density** from the list of options.
10. In the Expression section, below the Fields section you'll see an empty box labeled PT_density=. In that box, type **1/(!Pt_Spacing!)**2**. This expression will take one over the point spacing value in the tile squared, giving the point density.



11. Click **Run** to run the tool.
12. When the tool is run you'll see that the point density per square meter for each tile has been calculated per tile and added to the Pt_density field in the attribute table.

Pt_density
18.0642
17.32349

When you have a full lidar data set with hundreds or thousands of tiles, you can use this same workflow to measure the point density of all of them, then check to see if any tiles fall below a desired point density.

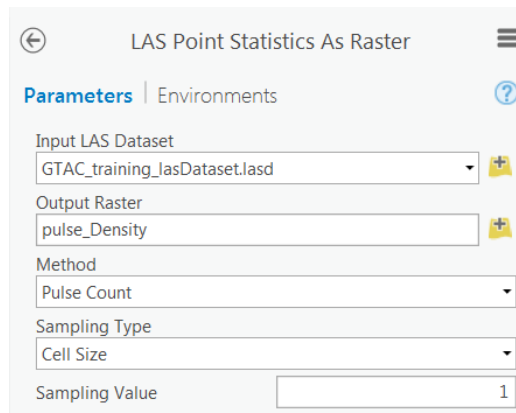
13. You can now close the attribute table.

Part 2: Visualizing Pulse Density

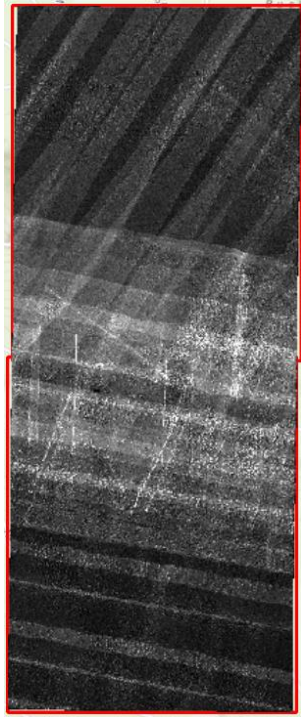
Typically when forestry lidar is flown the desired Quality Level (QL) is QL1. QL1 lidar has at least 8 pulses per square meter (8ppm). In this section you're going to learn how to measure and visualize the ppm in your LAS Dataset.

A. Creating a Pulse Density Map

1. Click on the **Analysis** tab at the top of the ArcGIS Pro toolbar.
2. Click **Tools** to open the geoprocessing pane.
3. In the **Find Tools** search bar at the top of the pane, type **LAS Point Statistics As Raster**, then click on **LAS Point Statistics As Raster (Data Management Tools)** to open the tool.
4. In the Input LAS Dataset section, click the dropdown arrow on the right side and select **GTAC_training_lasDataset**.
5. In the output raster, you can save the raster where you want. Name it **pulse_Density**.
6. You can leave the Method as Pulse Count and the Sampling Type as Cell Size, but change the **Sampling Value** to 1.



7. Click **Run** to create the pulse density raster. It will take a moment to run. When it does you'll see an image similar to the one below. Brighter areas have higher values, and represent a higher pulse density. Darker areas have a lower pulse density.



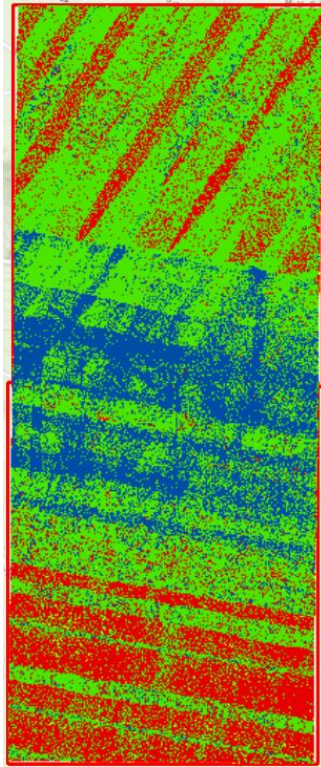
Note: Lidar is flown in a series of overlapping flight lines. Where these flight lines overlap more, more points are recorded, which is why there is such an obvious striping pattern in the density map. When canopy density rasters are created, you should normalize the rasters based on the overlapping points to remove the striped pattern. ArcGIS Pro has tools for identifying overlapping points, but no simple workflow for creating normalized canopy density rasters. To create metrics like that you'll likely need to use a dedicated lidar processing software such as Fusion.

B. Classifying the Pulse Density Map

1. Make sure that you have the **pulse_Density** layer selected in the table of contents pane.
2. In the ArcGIS Pro toolbar at the top of the window, click **Appearance** in the Raster Layer section.
3. In the Rendering section in the Appearance tab, click the **Symbology** button to open up the Symbology pane.
4. In the first Symbology section, click the dropdown on the right side and click **Classify**. This will change the display from a stretched raster to a classified raster.
5. You have a number of options regarding the classified raster that you can adjust. First change the **Classes** to 4.
6. Change the **Method** from Natural Breaks (Jenks) to **Manual Interval**.
7. Now you can adjust the Class breaks to better display the pulse density.
 - i. In the Class breaks section adjust the **Upper value** of the first section to **1**.
 - ii. Adjust the **Upper value** of the second section to **8**.
 - iii. Adjust the **Upper value** of the third section to **20**.
 - iv. Leave the upper value of the final section at its maximum.

8. Now you should adjust the colors to make it easier to distinguish the classes. You can follow the color scheme in the example below.

- i. In the Class breaks section, click the symbol color of the first section and adjust it to yellow.
- ii. Click the symbol color of the second section and adjust it to red.
- iii. Click the symbol color of the third section and adjust it to green.
- iv. Click the symbol color of the final section and adjust it to blue.



Note: Think about why you used these colors and numbers to classify the pulse density map. The first class you colored yellow, which are pixels where there are 0 pulses in that square meter. Luckily, there are very few of these pixels. The second color, red, are areas where there are less than 8 ppm. There are some portions of the image that are red, indicating fewer than 8 ppm, but you shouldn't worry too much about these areas as long as most of the area isn't red and the point density of the tiles is relatively high (around 16 or 17 as you saw in the last part of the exercise). Areas colored green are "within specification", between 8 and 20 ppm, and areas colored blue have more than 20 ppm. This is because there multiple overlapping flight lines.

9. Just like in the last part of this exercise, you can scale up this workflow and create a pulse density map of your entire study area. This is a good first step in a lidar processing workflow so that you get a good sense of the quality and resolution of your lidar data.

Congratulations! In this exercise you've learned to run some simple quality checks on your lidar data to assess its point and pulse density.