Description of Methods for Identifying Charcoal Hearths along the Blue Mountain of Pennsylvania.

Benjamin P. Carter
Muhlenberg College
May 29, 2018

Purpose: This data was created in order to identify historic charcoal hearths in the landscape of the Blue Mountain. It includes a polygon that identifies the research area (Carter 2018a), a digital elevation model (Carter 2018b), a hillshade model (Carter 2018c), a slope analysis (Carter 2018e), and a point file of potential charcoal hearths (Carter 2018d). These charcoal hearths are along a 20.5 km stretch of the Blue Mountain within the counties of Lehigh, Carbon and Schuylkill Counties. The approximately 56 km^2 area contains much of State Game Lands #217 and nearby private and public lands.

Hearths are particularly easy to identify on slopes, because they are 10-15 meter in diameter round areas that are flat and level. This makes them distinct on slopes.

Initially, a streaming hillshade provided by PAMAP (Pennsylvania Department of Conservation and Natural Resources 2018a; 2018b), a collaborative project of local, state and federal agencies was used to identify charcoal hearths. Data is available though the Pennsylvania Spatial Data Access program as well as via the user-friendly Pennsylvania Imagery Navigator (PASDA 2018b). Streaming data is available here:
REST: http://imagery.pasda.psu.edu/ArcGIS/rest/services/pasda/PAMAP_Hillshade/MapServer
WMS: http://imagery.pasda.psu.edu/arcgis/services/pasda/PAMAP_Hillshade/MapServer/WMSServer?SERVICE=WMS&request=getcapabilities

The streaming data (WMS) was viewed in QGIS (version 2.18.17), an open source GIS software package. Using this data, I constructed a point layer (initially as an ESRI shapefile, but published as a GeoJSON file; Carter 2018d).

While I was able to identify 298 charcoal hearths in the streaming data, it became clear that resolution was lower than the original data. The streaming data is based upon “Class 8,” or Model Key, points which are “thinned-out ground points used to generate digital elevation models and contours”. This, of course, produces a derivative that is much lower resolution than the original data. Therefore, I went back to the original data, which is available online (PASDA 2018a) and on the Pennsylvania Imagery navigator (PASDA 2018b). Description is available (PA-DCNR 2018a, 2018b, 2018c).

The original LiDAR point cloud was provided in the .las format (citation) in “NAD83 horizontal datum, GRS80 ellipsoid, NAVD88 vertical datum, and GEOID03 National Geodetic Survey” (PA-DCNR 2018c) and in the PA State plane (North or South) and employs feet as the unit of measure.

Using LASTools (version downloaded March 3, 2018 (https://rapidlasso.com/lastools/), a lightweight collection of tools for viewing, modifying and managing LiDAR data in a GUI (graphical user interface) that can also be run via command line, I converted the downloaded LiDAR data into a DEM. The process required a few steps.

First, and most importantly, the Class 2 points (i.e., the last return or ground points) AND the Class 8 (rather than just the Class 8 points as PASDA employed in their streaming data) were separated from the other points (e.g., those that bounced off trees). This is easily done through the GUI (graphical user interface) of las2las. One of the important components of LASTools is that it records the text of the command so you know exactly what processes were carried out in the command line. For clarity and replicability, commands are present herein. Though these commands are easily completed through the GUI, it may change; the command line will not.

```
las2las -i "filename.las" -keep_classification 2 -keep_classification 8 -target_sp83 PA_S -olaz
```

Note that filename.las is simply a list of file names to be used in the command.

The command “-olaz” losslessly compresses each .las file to a .laz (or lasZip) file that is c. 7-20% the size of the original. The command “-keep_classification 2 -keep_classification 8” keeps only Class 2 and 8 points. Additionally, the “-target_sp83 PA_S” command converts the data to NAD 83 (North American Datum 1983), Pennsylvania South in meters rather than in feet as in the original data.

Before we construct our final product, it is important to break it into smaller tiles using lastile.exe. These smaller tiles can be especially important with large quantities of data. Additionally, to use the unlicensed lastile (which is appropriate for educational purposes), you must reduce the size of each tile, otherwise programmatic errors are introduced. You should also add a buffer which leaves each tile with a degree of overlap with its neighboring tiles. When converting from point cloud to DEM, a TIN (triangular irregular network) is constructed, which is essentially a series of triangles connecting points to create a surface between all points. If no buffer is used, the edges of the TIN are distorted because triangles in the area between the two tiles cannot be constructed. A buffer allows the construction of overlapping tiles that should match up (though it does leave some artifact in the resulting data).

```
lastile -i "filename.laz" -o "tile.laz" -tile_size 1000 -buffer 25 -olaz
```

The command “-tile_size 1000 -buffer 25” breaks the .laz file into tiles 1000 meters by 1000 meters with a 25 meter buffer.

The tiled point cloud then can be used to create a digital elevation model (DEM), a raster file (in TIFF format) where each pixel has elevation as an attribute via blast2dem.

```
blast2dem -lof “file list” -elevation -odir  “directory” -otif
```

This command uses the “blast2dem” application to convert the point cloud into a DEM. The command “-elevation” stores elevation data in each pixel (rather than other types of data, such as slope).

The resultant tiles were then stitched back together in QGIS (v. 2.18.17) using the Raster- Merge command (citation). This was then clipped to the research area (Carter 2018b). Two derivatives of the DEM were created, using the Terrain Analysis (version 0.1), including a hillshade (Carter 2018c)and a slope analysis (Carter 2018e). The hillshade was constructed using the default settings (azimuth= 300, vertical angle= 40, z-factor= 1.0) as was the slope analysis (z-factor=1).

Potential charcoal hearths were identified largely through the visual scanning of the slope analysis (DOI: 10.5281/zenodo.1252977) which was visualized using the defaults settings (i.e., using a gray scale where black represents low slope and white steep slope) in QGIS. Charcoal hearths are immediately apparent on sloped terrain because the are approximately 10-15 meters round areas that are flat and level. This means that on steep slopes (visualized as white or light gray) these areas (visualized as black) are highly visible. Although the hearths are circular, the platforms upon which they rest are often extended on two sides. These are likely parts of paths that colliers (charcoal burners) used to access the hearth. Therefore, they often appear to be more shaped like eyes than perfect circles, especially on steeper slopes. Similarly, because charcoal hearths were built into the landscape, often the slope uphill of the charcoal hearth was particularly steep (i.e., lighter gray than the slope of the terrain) where earth was dug away. Much of the earth excavated from the uphill side was used to build the hearth platform, which also meant that the slope on the downhill side was also steeper than the surrounding terrain. Therefore the dark hearth is often surrounded by lighter areas, making it look very much like an eye (dark) with upper and lower eyelids (light). The slope analysis is not particularly useful for identifying charcoal hearths on flat terrain. Additional methods have been developed to identify these, but neither that analysis nor the resultant data is not included herein. The slope analysis was viewed at between 1:1250 and 1:10,000 scales and locations matching the description above were marked with a point (initially in shapefile format). The author, Ben Carter, scanned the entire area and a student, Heather Lash of Muhlenberg College, scanned the northern half of this area. Visual identifications made by these two were then compared. Any disagreement between the two analysts (i.e., points that one identified as a charcoal hearth but the other did not) were closely reexamined. Initially they were simply compared with aerial photos (via Google Earth), which showed that a number of the “hearths” were out buildings or the pads to powerlines or towers. Any disagreements that were not obviously false identifications, the Profile Tool plugin (version 4.0.2) was used on the original DEM. This would show the profile of the terrain. Flat areas between 8-20 meters on slopes are likely hearths. In a number of locations and on lower slopes, areas that looked the right size and had steep slopes on both sides turned out to be pits rather than hearths.

The fields and variables within the vector file (Carter 2018d) are as follows:

Field= id- a unique ID; the numbers have no significance.

Field= Version- describes whether the hearth was first identified through the streaming data or through the reworked data.

Variable- “streaming”- This potential charcoal hearth was identified using the original streaming data.

Variable- “postLAS”- This potential charcoal hearth was identified using the slope analysis indicated above.

Field= HLL- These potential charcoal hearths were identified by Heather Lash, a 2018 graduate of Muhlenberg College.

Variable- “notassessed”- These points (the southern half of the research area) were not inspected by Heather Lash.

Variable- “notrecognized”- These points were not recognized as potential hearths by Heather Lash.

Variable- “recognized” - These points were recognized as a potential hearths by Heather Lash.

Field= BPC1- Potential charcoal hearths identified (or not) by the author, Benjamin Carter.

Variable- “notrecognized”- These points were not recognized as potential hearths by Carter.

Variable- “recognized”- These points were recognized as a potential hearths by Carter.

Field “Confirmed”- These are potential hearths confirmed as such after an examination of any points that one analyst (Carter or Lash) but the other did not.

“hearth”- These points that are are most likely charcoal hearths after the reexamination described above.

“nohearth”- These points that are are most likely NOT charcoal hearths after the reexamination described above.

All data was converted to World Geodetic System (WGS) 1984 (EPSG: 4326) in QGIS. All ESRI shapefiles were converted to GeoJSON.

Data References

Carter, Benjamin P. (2018a). Blue Mountain Charcoal Project Research Area (Version 0.1.0) [Data set]. Zenodo. http://doi.org/10.5281/zenodo.1252418

Carter, Benjamin P. (2018b) Digital Elevation Model for Blue Mountain Charcoal Research Project (Version 0.1.0) [Data set]. http://doi.org/10.5281/zenodo.1252441

Carter, Benjamin P. (2018c) Hillshade Analysis of "Digital Elevation Model for Blue Mountain Charcoal Research Project" (Version 0.1.0) [Data set]. http://doi.org/10.5281/zenodo.1252520

Carter, Benjamin P. (2018d) Identified Charcoal Hearths from "Slope Analysis of 'Digital Elevation Model for Blue Mountain Charcoal Research Project'" (Version 0.1.0) [Data set]. http://doi.org/10.5281/zenodo.1252985

Carter, Benjamin P. (2018e) Slope Analysis of "Digital Elevation Model for Blue Mountain Charcoal Research Project" (Version 0.1.0) [Data set]. http://doi.org/10.5281/zenodo.1252977

References

Pennsylvania Department of Conservation and Natural Resources (PA-DCNR)

2018a PAMAP. Pennsylvania Department of Conservation and Natural Resources.

<http://www.dcnr.pa.gov/Geology/PAMAP/Pages/default.aspx >. Accessed 6 March 2018.

2018b PAMAP Documents. PA DCNR - Geology - PAMAP LiDAR. Accessed 6 March 2018.

<http://www.docs.dcnr.pa.gov/topogeo/pamap/documents/index.htm >

2018c PAMAP Lidar Elevation Data. PA DCNR - Geology - PAMAP LiDAR.

<http://www.docs.dcnr.pa.gov/topogeo/pamap/lidar/index.htm >. Accessed 6 March 2018.

Pennsylvania Spatial Data Access Program (PASDA)

2018a PAMAP Program - LiDAR LAS files; 2006 - 2008 - DCNR PAMAP Program <http://www.pasda.psu.edu/uci/DataSummary.aspx?dataset=1244 > Accessed 6 March 2018.

2018b Pennsylvania Imagery Navigator <http://maps.psiee.psu.edu/ImageryNavigator/ > Accessed 6 March 2018.