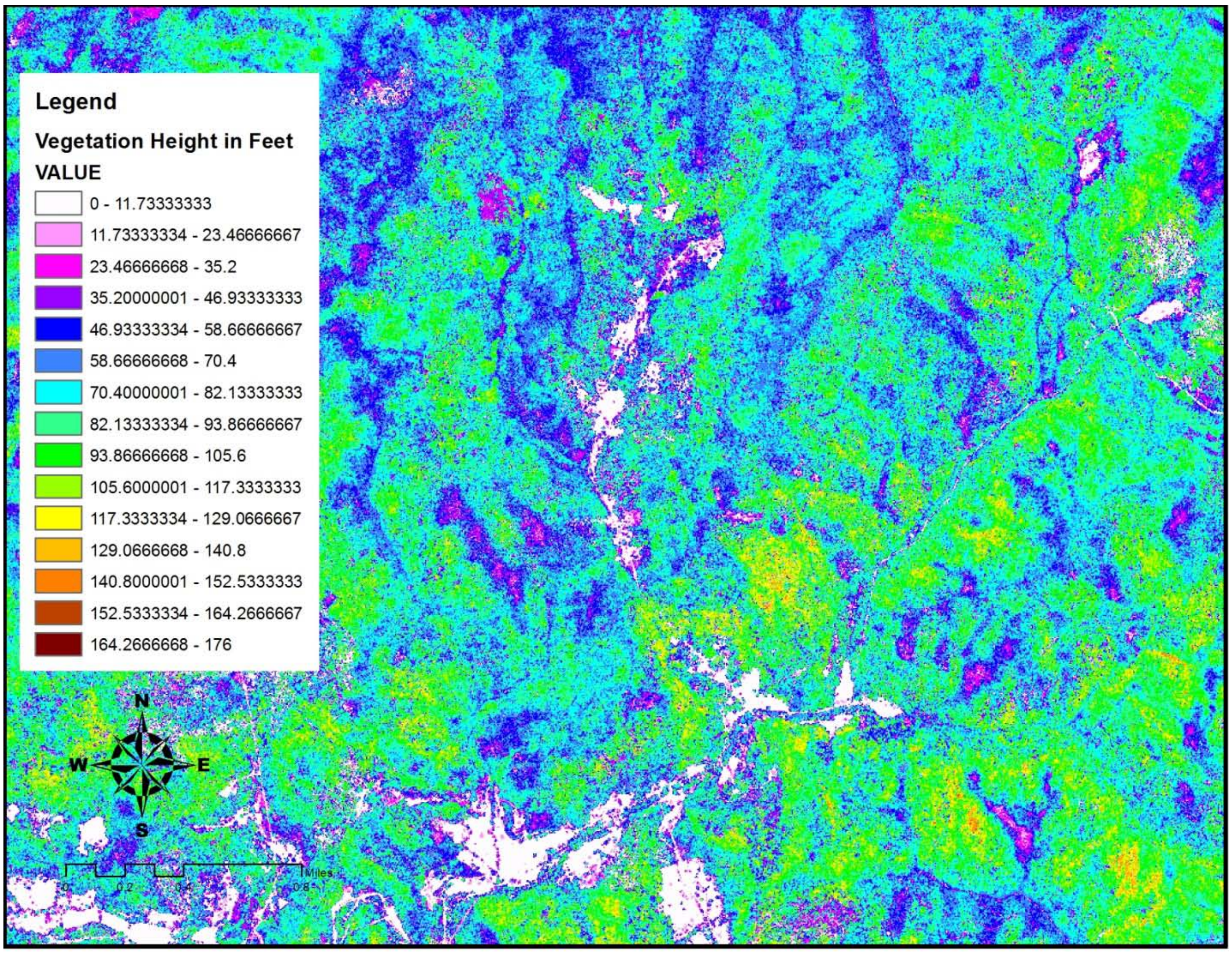
Development of LiDAR Based Vegetation Models for Nantahala-Pisgah National Forests and Surrounding Lands

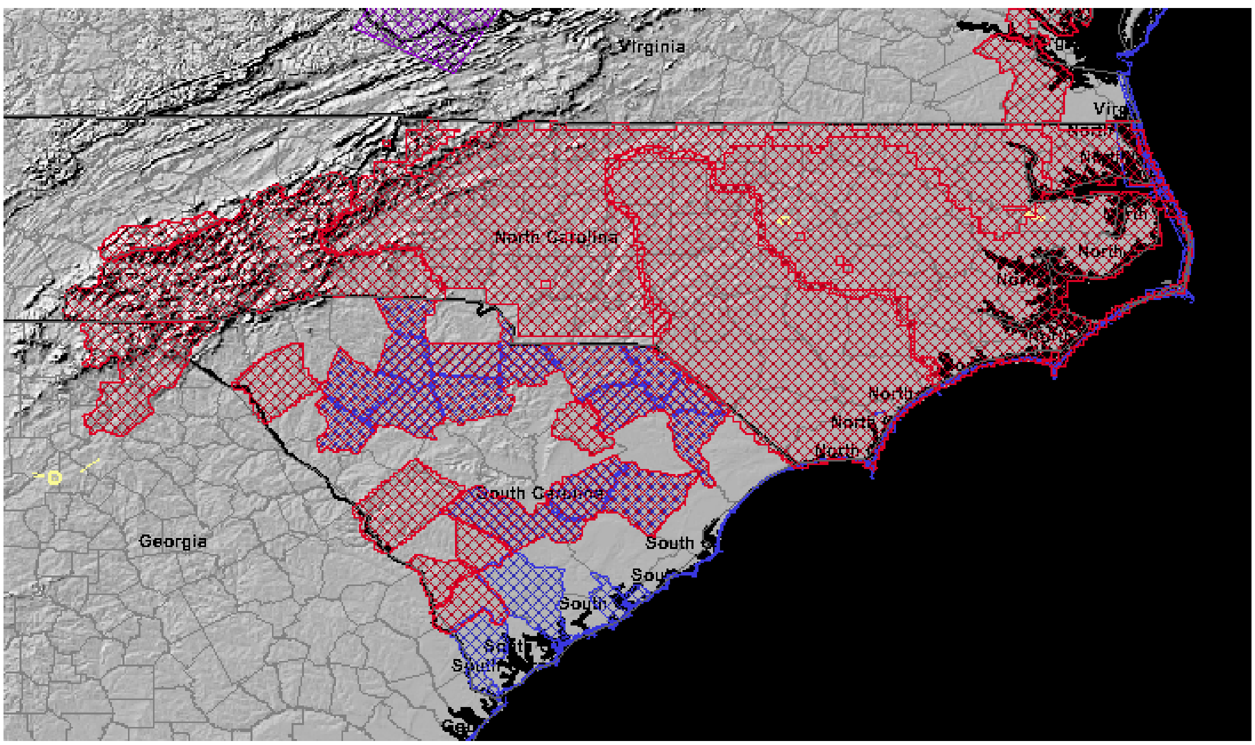
By Josh Kelly, Public Lands Biologist, Western North Carolina Alliance



A close-up of the canopy height model of the Tuckasegee Quadrangle

Introduction

In 2012 the Blue Ridge Fire Learning Network commissioned the creation of Light Detection and Ranging (LiDAR) based vegetation models covering the area of Nantahala-Pisgah National Forest and surrounding lands, an area covering approximately 3.8 million acres. LiDAR technology employs a laser scanner on an aircraft equipped with hyper-sensitive gps, altimeter, and other positional hardware. The laser scanner emits particles and waves of light that bounce off objects between the aircraft and the surface of the earth; the speed and intensity at which light returns to the scanner defines points in three dimensional space. LiDAR data were collected for North Carolina between 2001-2005, with data for the North Carolina Mountains collected in 2003 and 2005. Conservationists in North Carolina are fortunate to have LiDAR data at their disposal because, along with enabling the creation more detailed and precise maps of the ground surface, LiDAR data can be filtered to produce models, or maps, of the vegetation structure above the surface of the earth.

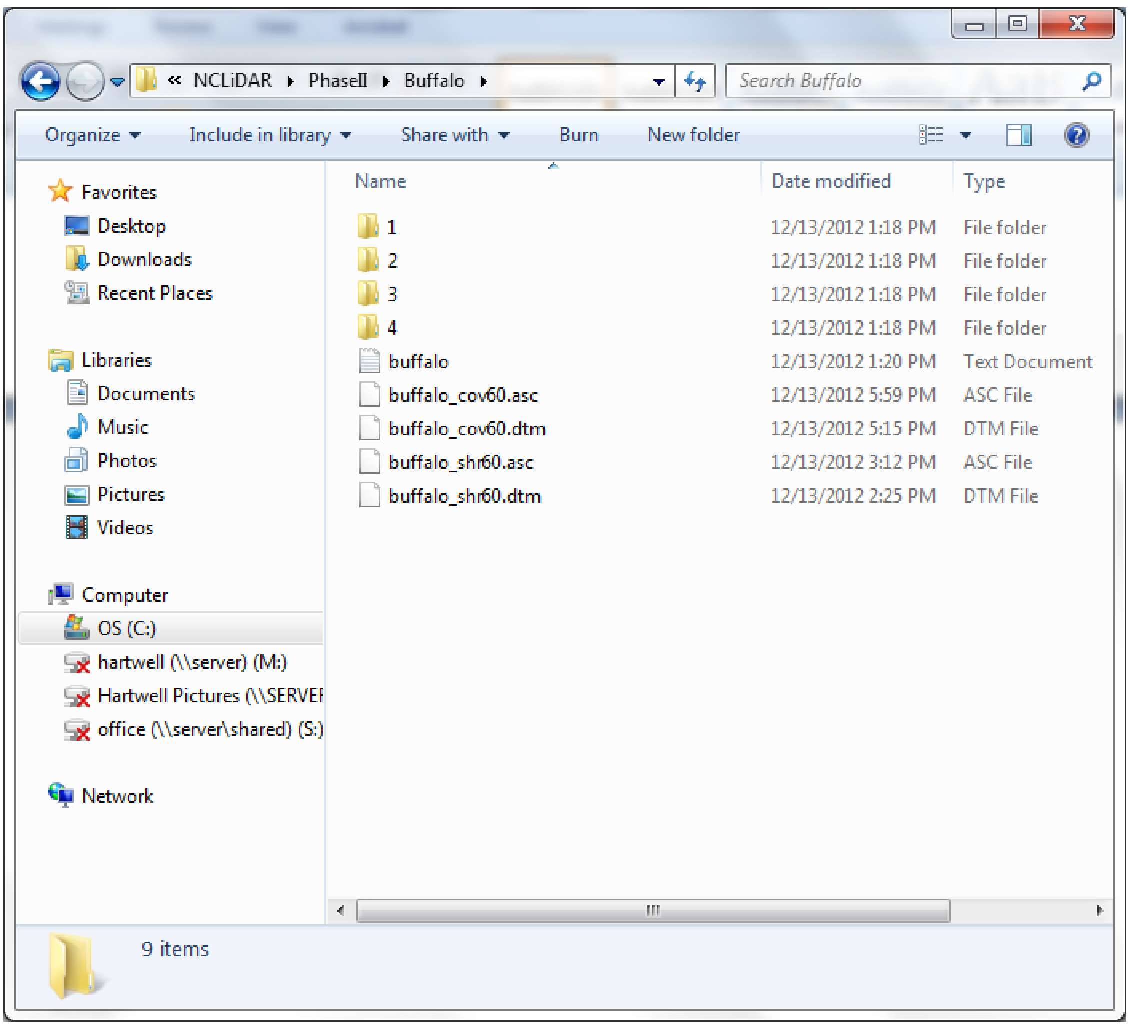


Availability of LiDAR data in the Southeast from http://lidar.cr.usgs.gov/LIDAR_Viewer/

In order to inform fire managers and other conservationists, the Southern Blue Ridge Fire Learning Network commissioned the creation of canopy height, canopy cover, and shrub density rasters from Josh Kelly of the Western North Carolina Alliance. This report describes the results of that project.

Methods

LiDAR data were acquired from the Click Website, http://lidar.cr.usgs.gov/LIDAR_Viewer/, which enables downloads of free, publicly available, LiDAR data for the United States. LiDAR data were organized and tiled into files corresponding to USGS 7.5' Quadrangles and processed with Fusion Software, a free software package from the US Forest Service Pacific Northwest Research Station. Models for canopy height, canopy cover and shrub density were processed for each Quadrangle in the study area. Because it is 4X more data dense than the 2003 data (Phase II), the 2005 (Phase III) data available for the majority of the study area allowed the creation of models at a smaller pixel size that are more accurate and precise than those from Phase II, generally corresponding to the Grandfather Ranger District, east of the Continental Divide.



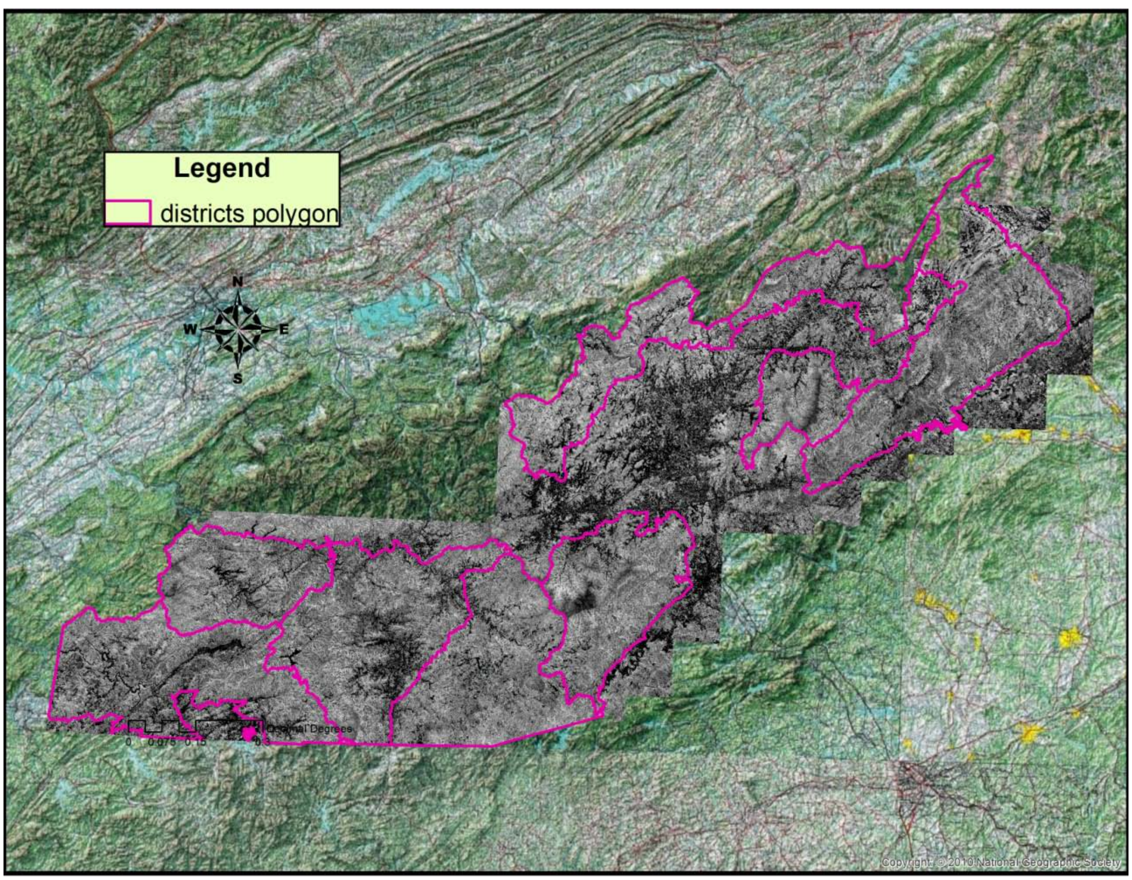
The Buffalo Cove Quadrangle organized into 4 tiles with a batch file, .dtm files, and ascii files

Canopy Height Models

Canopy height models were processed using the canopy model routine in the command line dialogue box. Canopy height models compute vegetation height for each pixel by subtracting the ground surface from the first returns to yield a vertical height. Canopy height models were produced at 9 and 20 ft pixel sizes for the Phase III data and 40 ft for the Phase II data. A model of vegetation height at 60 ft pixel size for the entire state is already widely available. An example script or the Buffalo Cove quadrangle file listed above is:

canopymodel /outlier:0,190 /ground:c:\nclidar\ground\grandfather.txt
c:\nclidar\buffalo\buffalo_chm40.dtm 40 F F 2 0 2 2 c:\nclidar\buffalo\buffalo.txt

The /outlier switch was used in all canopy height models such that values <0 and >190 feet were excluded. For more information on Fusion Software, see the folder labeled "Fusion Tutorials" on the external drive delivering the data products. Exercise 8 provides specifics on the canopy model routine.



Canopy height Models produced for all districts of Nanthala-Pisgah National Forest

Canopy Cover Models

The cover routine in Fusion command line reveals what proportion of first returns encountered vegetation versus what proportion reached the ground surface or a chosen lower limit above the ground surface. For the Nantahala-Pisgah cover files, that lower limit was chosen as 15 feet so as to differentiate between the upper canopy and the shrub cover. See Fusion Tutorial 11 for specifics on the cover routine.

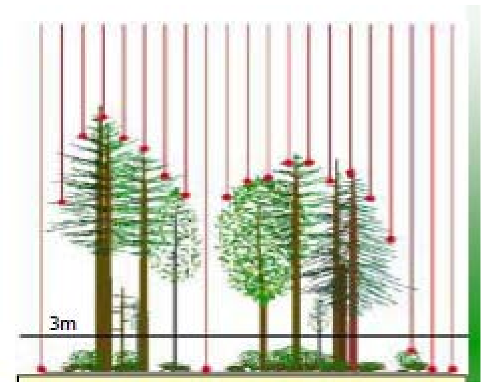


Diagram of the canopy cover concept from Fusion Tutorial 11

The output produces files in which all pixels are given a value of % canopy closure from 0 to 100. These canopy closure files should be very useful in identifying open woodland structure and early succesional habitat, among other uses. The script used for Phase III data using the Cruso Quadrangle as an example was:

Cover c:\nclidar\ground\pisgahrd.txt c:\nclidar\cruso\cruso_cov40.dtm 15 40 F F 2 0 2 2 c:\nclidar\cruso\cruso.txt

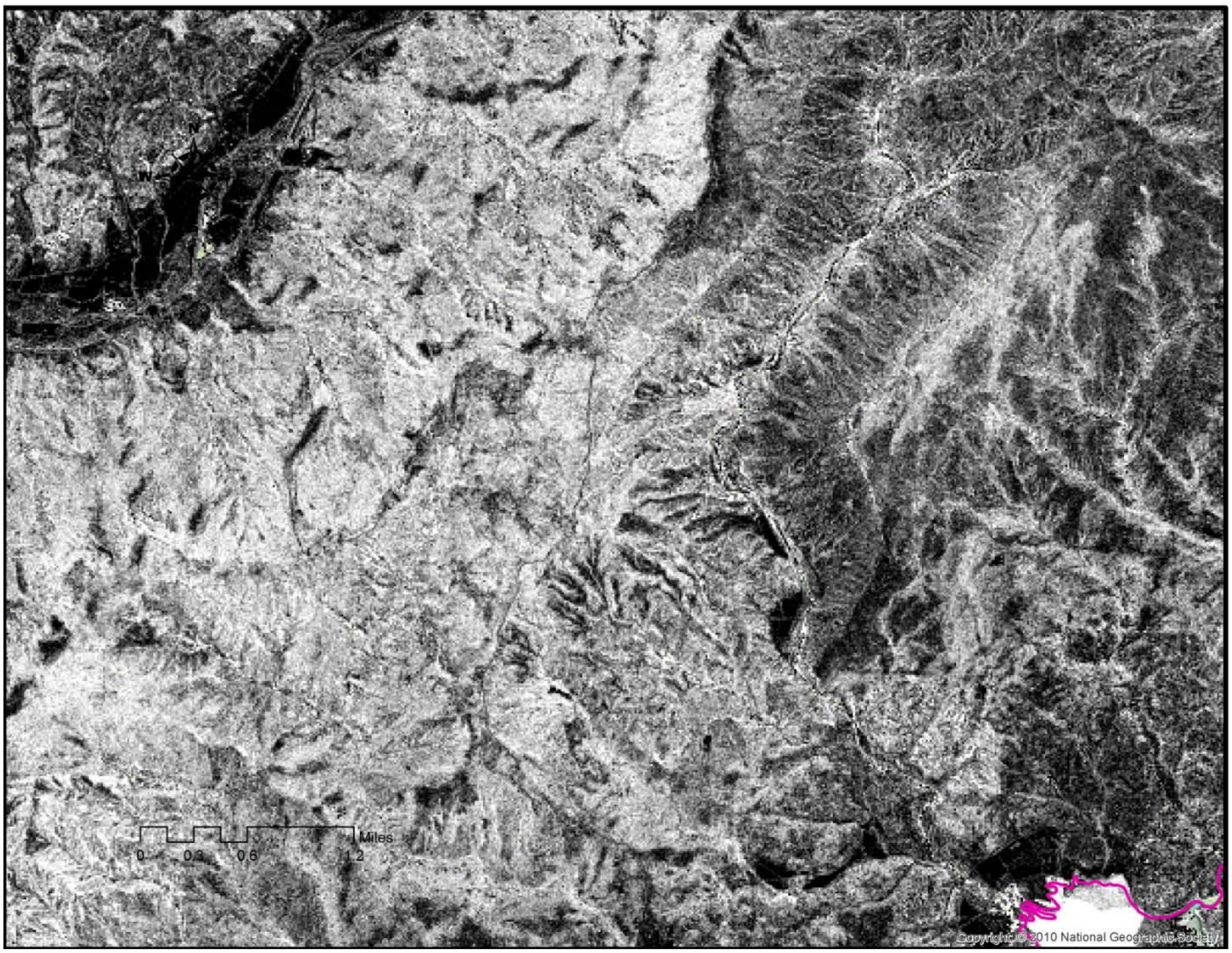
Phase III data was processed on a 40’ pixel size and Phase II on a 60’ pixel size because of the lower density of returns. A problem was encountered in the Phase II data such that the /all switch was required to run the cover routine; the result being a decrease in the average cover value in the Phase II project area that may require calibration to be useful.

Shrub Density Models

The shrub density models were also created using the cover routine, but also used the /all switch, for all returns, and the /upper switch, which places an upper height limit on the stratum of vegetation being analyzed. For the purpose of this project, shrub density was evaluated between 1 and 15 feet above ground level. One foot was chose as the lower limit so that errors in ground files did not influence shrub density and the 15 ft upper limit was chosen so as to compliment the canopy cover files listed above. Information on vegetation density calculations can be found in the Fusion Tutorials, Exercise 11. The specific script used for the Cruso Quadrangle, as an example, was:

Cover /all /upper:15 c:\nclidar\ground\pisgahrd.txt c:\nclidar\cruso\cruso_shr40.txt 1 40 F F 2 0 2 2 c:\nclidar\cruso\cruso.txt

Like the canopy cover files, shrub density models were created at 40 ft pixel size for Phase III data and 60 ft pixel size for Phase II data. Shrub density is expressed in percent cover with values between 0 and 100.



A view of LiDAR derived shrub density from Dobson Knob, with white indicating high shrub density and black low shrub density

Ground Files

Ground files were used to calculate all values for canopy height, shrub density, and canopy cover. These files can be found in the folder labeled “Ground” in the NCLiDAR folder. These ground files origninated as DEMs by the North Carolina Division of Transportation from LiDAR data for all counties in North Carolina. The county level DEMs were converted to ascii format and then .dtm format for use in Fusion Software.

File Nomenclature

Because ArcMap was used to convert ascii files to rasters to complete the production of data products, all raster files were required to be 13 characters or less. This led to the necessary shortening of many quad names. As a rule, the first letter of each quad was left intact and raster files names were chosen to be intuitive for most users. All files were given suffixes to denote the type of vegetation model and the pixel size of the file, and all vegetation models are grouped in folders by their type, such as “chm_9”, which denotes canopy height models at 9 ft pixel size.

Table 1: Guide to File Suffixes

File Name	Translation
_chm9	Canopy Height Model at 9 ft pixel size (Phase III)
_chm20	Canopy Height Model at 20 ft pixel size (Phase III)
_chm40	Canopy Height Model at 40 ft pixel size (Phase II)
_cov40	Canopy Cover Model at 40 ft pixel size (Phase III)
_cov60	Canopy Cove Model at 60 ft pixel size (Phase II)
_shr40	Shrub Density Model at 40 ft pixel size (Phase III)
_shr60	Shrub Density Model at 60 ft pixel size (Phase II)

Results

LiDAR vegetation models were produces for 123 quadrangles encompassing the entire proclamation boundary of Nanthala-Pisgah National Forest; an area over 3.8 million acres. Over 120 gigabytes of raw data was processed to produce 2.5 gigabytes of vegetation models at several cell sizes. These products should allow analysis of the contemporary condition of the structure of vegetation communities in the study area at a level of detail not previously possible. As an example, LiDAR data is available for private land where access is often not possible and data on forest succesional stage and structure cost prohibitive to collect, even if access were granted. LiDAR vegetation models could therefore help the US Forest Service meet its mandate for taking an “All Lands Approach” to forest planning under the 2012 Planning Rule of the NFMA.

Obvious uses of the data include using tree height and canopy cover to determine forest age and structure, using shrub density to help evaluate live fuel loads and dry forest degradation from fire suppression, and using canopy height models to help estimate carbon stocks. Most useful to conservation land managers though, will likely be using LiDAR data to quantify the amounts of various structural and succesional conditions across all major ecosystems in the region in order forecast management needs into the future.

Also delivered with the final product are the 120 gigabytes of raw data used to develop the vegetation models. Raw data is present in compressed folders, and uncompressed in folders organized by USGS quads. This will allow other users to view and manipulate data at the quadrangle level fairly easily without having to embark on the arduous task of retrieving and organizing tiles from the Click website.