Examining Hemlock Mortality in the Southern Appalachians
Through Decline Mapping and Comparative Viewshed Analysis

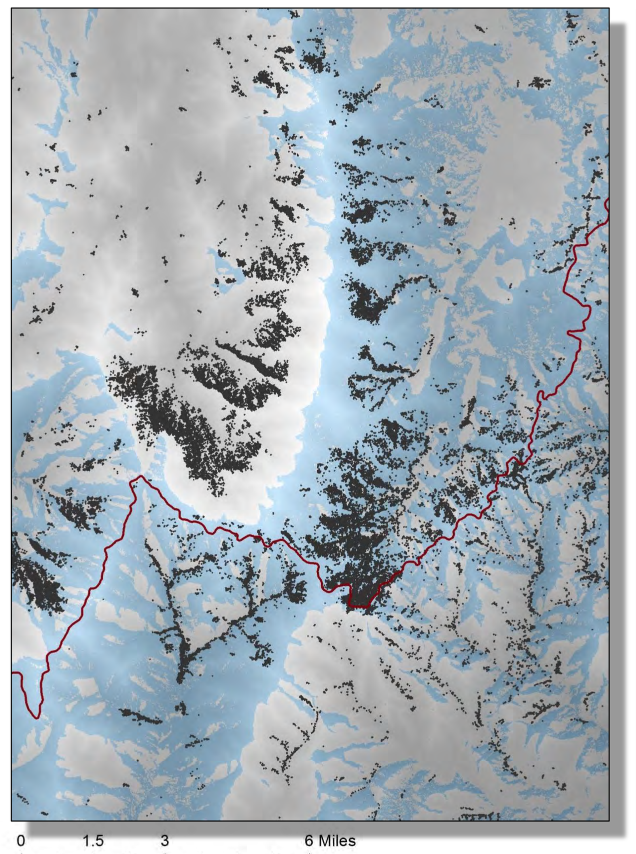
Sara Thompson[1], Steven P. Norman[2]
sthomps2@unca.edu, stevenorman@fs.fed.us
[1]UNC Asheville NEMAC, Asheville, NC; [2]USDA Forest Service Eastern Threat Center, Asheville, NC

Introduction

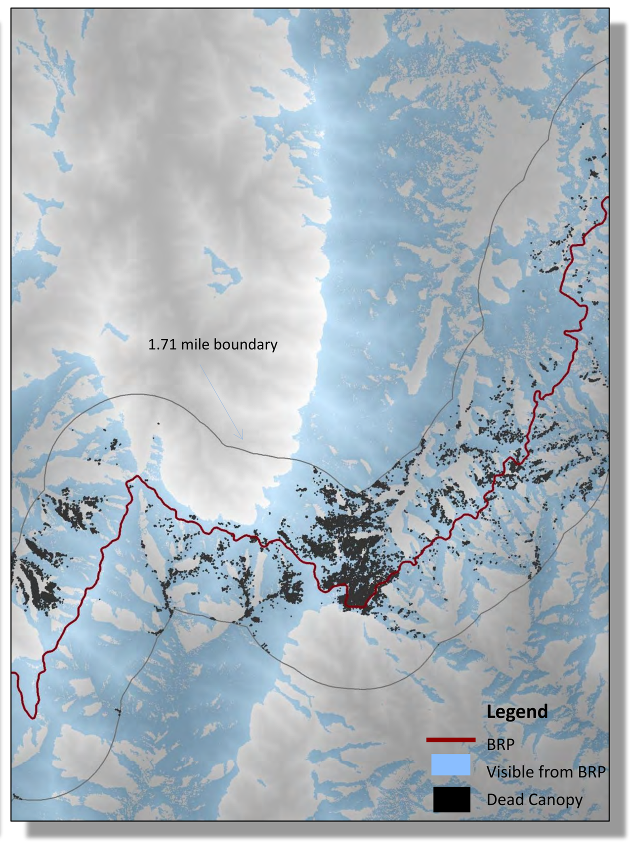
The infestation of the invasive hemlock wooly adelgid (*Adelges tsugae*) has resulted in a prolific loss of eastern and Carolina hemlocks trees (*Tsuga canadensis* & *T. Caroliniana*) in the southern Appalachians. Extensive hemlock mortality may impact local forest dynamics because they provide important habitat for several bird species, provide a unique microclimate that supports trout populations, regulate stream flow through transpiration, and provide various other ecosystem services[1]. Additionally, mortality is prevalent along certain areas of the Blue Ridge Parkway (BRP) where tourism generates considerable revenue each year. Therefore, it is important to monitor and analyze their decline.

Objectives

- Map hemlock decline in two study areas
- Generate viewsheds to analyze visible mortality from the BRP
- Compare results between two different viewshed analysis methods
- Analyze most visually impacted scenic overlooks/vistas on the BRP



Total Dead Hemlock Canopy in respect to visible area from BRP from DSM viewshed



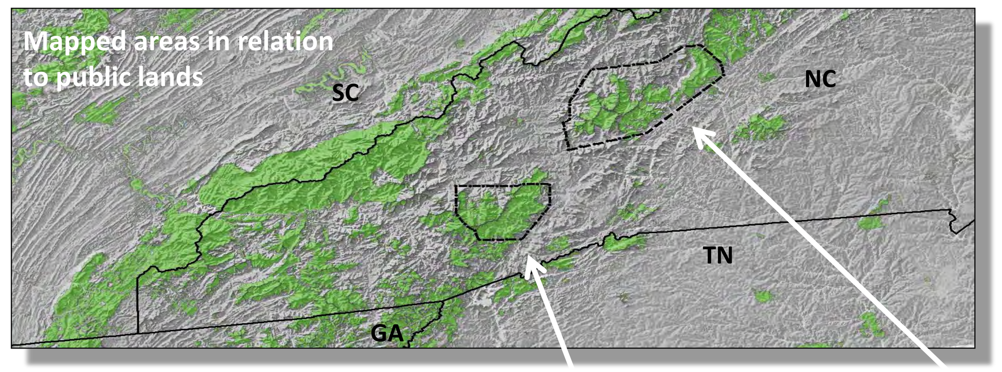
Dead hemlock canopy within visible viewshed & average visibility distance (1.71mi)

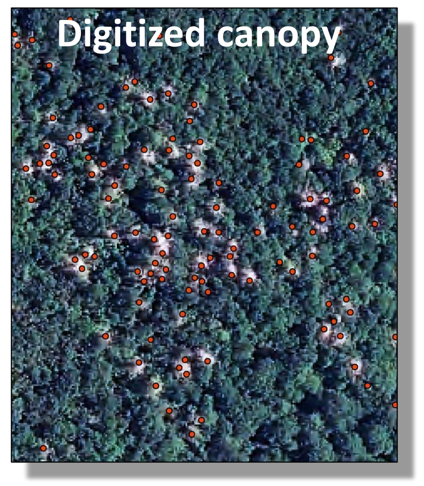
Methods: Viewshed and Visibility Analysis

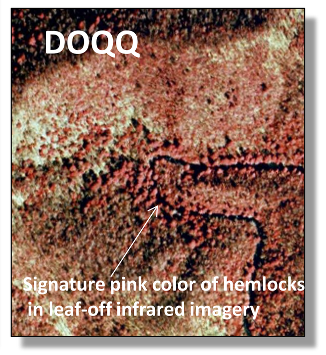
The BRP was digitized as a polyline in ArcMap for each area. Two viewsheds were generated from the BRP polyline using two different elevation model inputs. The first viewshed was created using a bare-earth digital elevation model (DEM) and the second viewshed was created using the LIDAR digital surface elevation model (DSM).

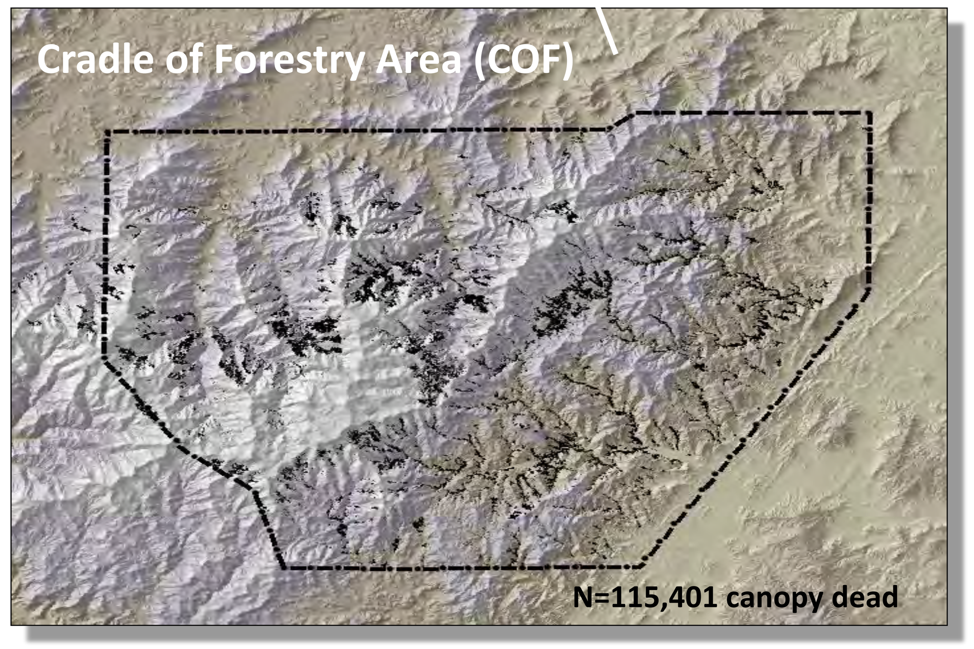
To examine a viewer's visual experience of hemlock mortality from the BRP, informal field observations were made to assess the average maximum distance at which dead hemlock stands are still visible. A map was created, using the DSM viewshed and the maximum distance (1.71mi) buffer, which only includes mapped dead hemlock points that are within the viewsheds visible range and the viewer's visible range

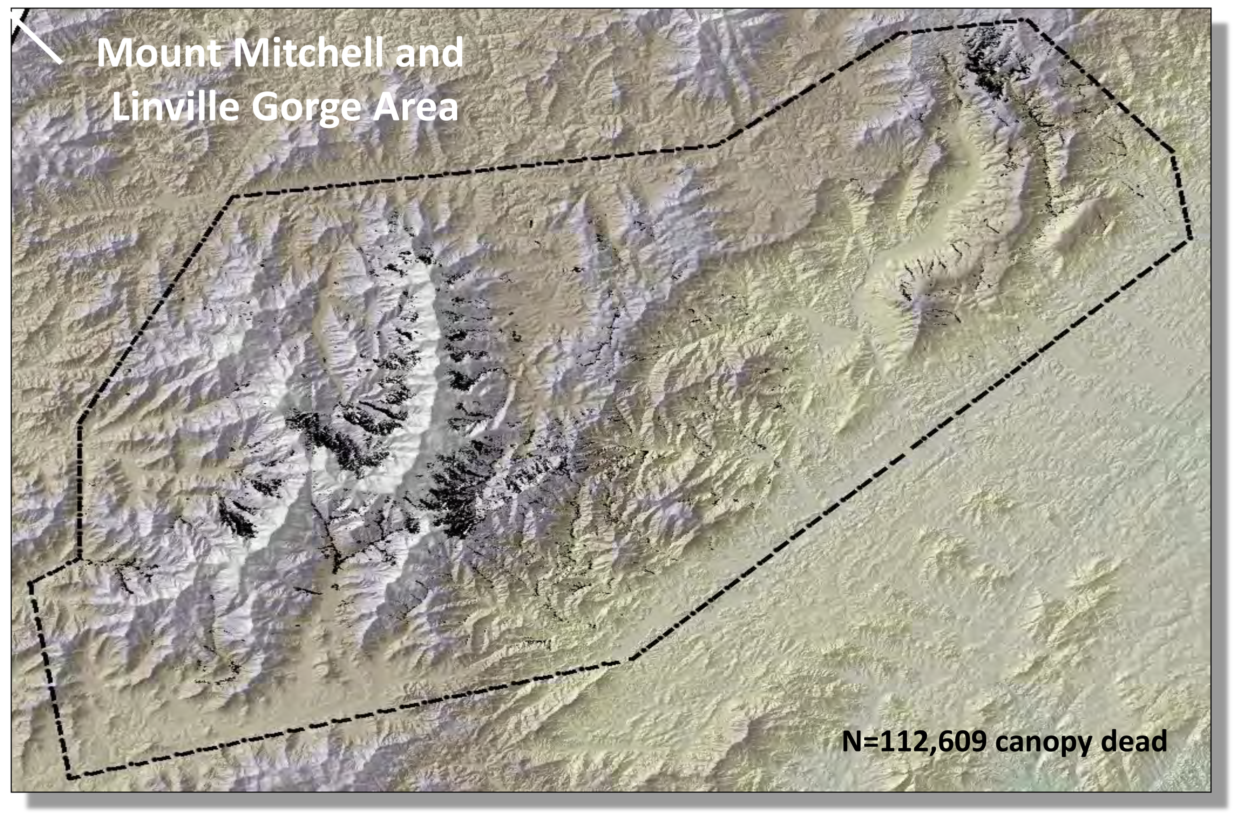
Finally, major scenic overlooks along the BRP were digitized. In ArcMap, the DEM and DSM viewsheds, the decline maps, and the maximum distance boundary were used to determine the number of mapped dead trees within the visible viewshed range and 1.71mi boundary for each overlook. Overlooks were ranked from most dead visible to least dead visible. A comparison was made to investigate the resulting differences between an analysis using a DEM vs. a DSM.











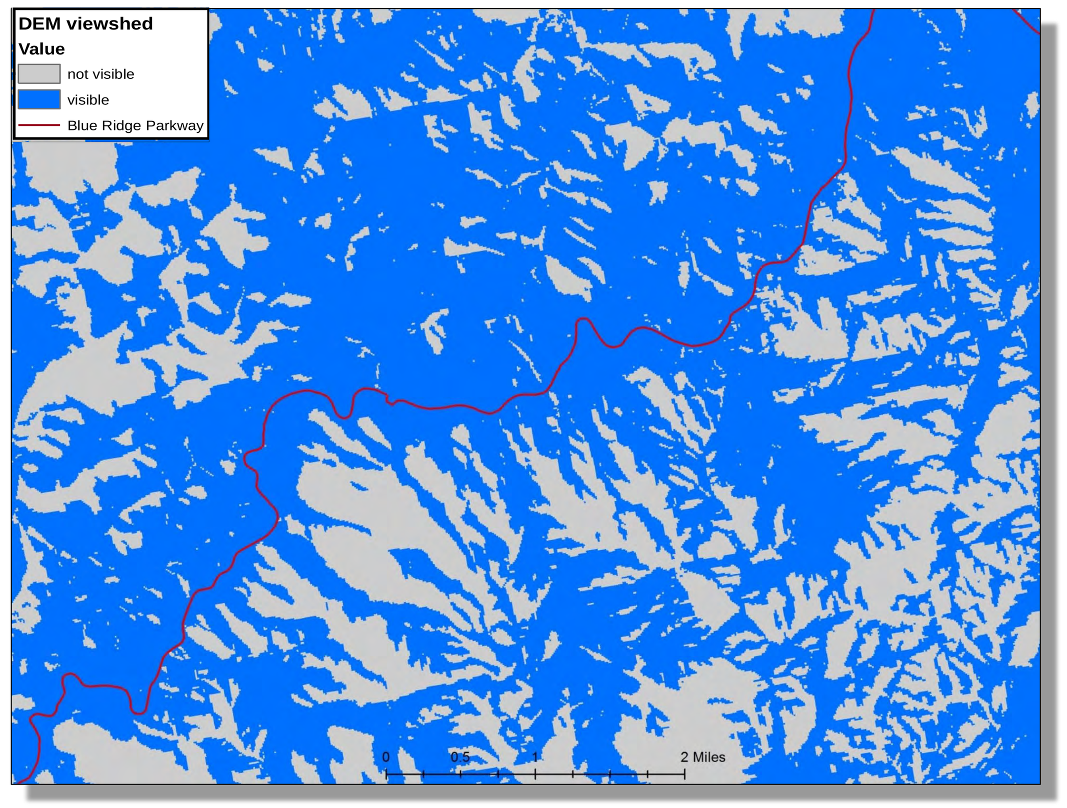
Mapping Canopy Decline

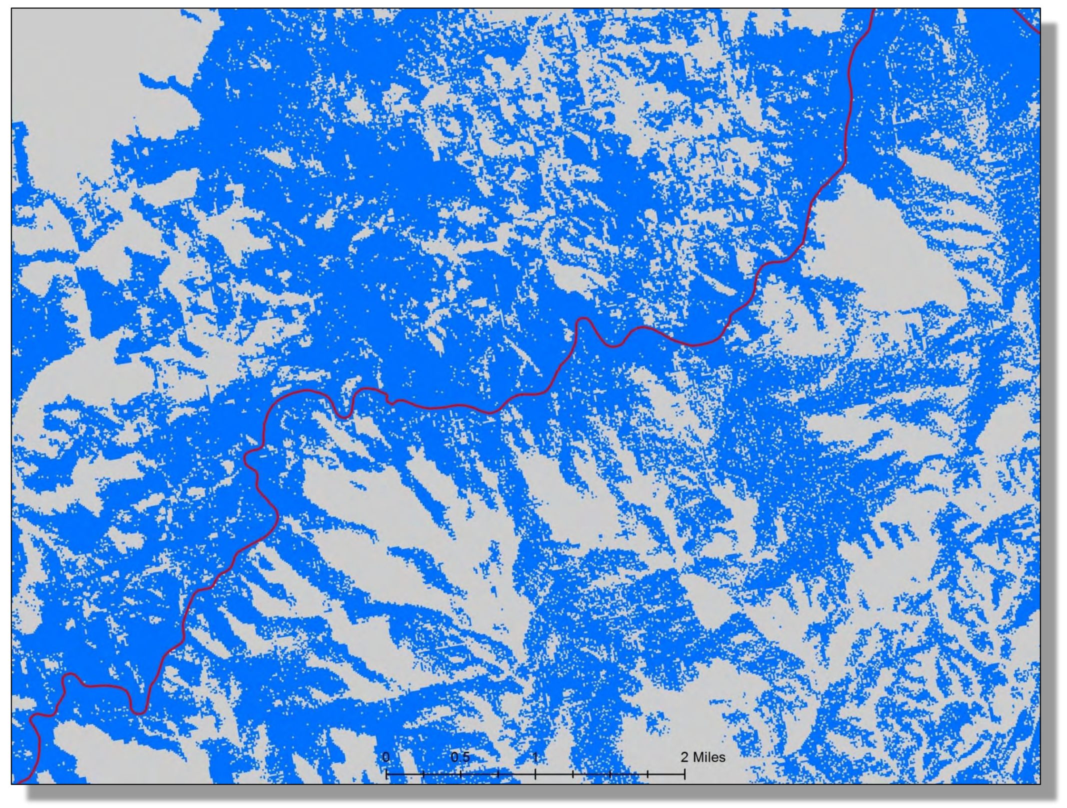
Two WNC study sites (Mt. Mitchell/Linville Gorge & Cradle of Forestry area) were selected to map hemlock decline. Summer 2010 NAIP aerial imagery was used to digitize the dead/dying hemlock canopy in ArcMap. A 1998 infrared leaf-off DOQQ was used in addition to known habitat limitations, such as elevation, to distinguish hemlocks from other evergreen species.

In the 1600km^2 Mt. Mitchell area, 112,609 dead trees were digitized, and 115,401 trees were digitized in the 400km^2 in the Cradle of Forestry area. These maps provide supporting evidence that hemlock decline is prevalent throughout its range in the southern Appalachian mountains.

Importance

Current vegetation decline monitoring technology is often large-scaled and encompasses a wide variety of ecosystems and vegetation communities. These systems are useful for detecting major trends across large geographic regions, but they cannot provide local or species specific data. Fine-scale decline maps create the opportunity to extrapolate more accurate data that is specific to a region, species, or event (such as HWA infestation). More so, these fine-scale maps can be important for forest management, relevant research, and historical databases.





Above: two viewsheds created for Mt. Mitchell area using the same observer polyline (the BRP) input. The image on the left was generated from a bare-earth DEM where the image on the right was generated from a LIDAR Digital Surface Model.

DEM vs. DSM: Results

For both study areas, the DSM viewshed resulted in less visible area from the BRP than the DEM. The Mt. Mitchell DEM viewshed resulted in 6% more than visible area than the DSM. The COF DEM viewshed resulted in 3% more visible area than the DSM. The comparison between the most affected scenic overlooks/mileposts using two different elevation models resulted in a similar ranking scheme. Only two overlooks, 18 & 25, were ranked differently. With the DEM input, the count of mapped dead visible from each overlook was higher than the DSM count for more than 85% of observations.

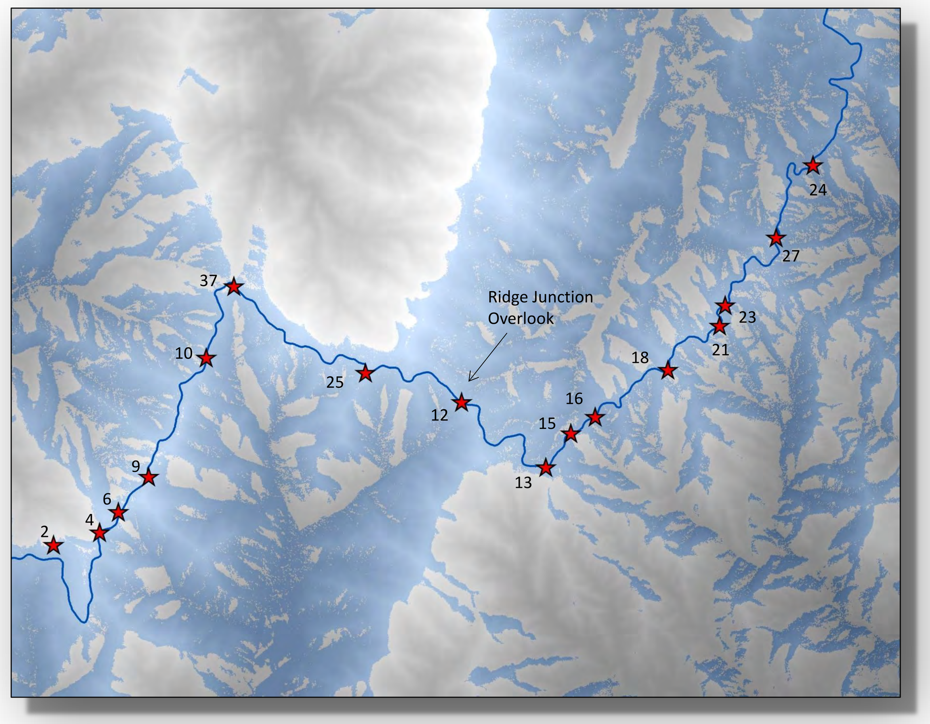
DEM

Map ID #	Count of Mapped Dead
12	15418
16	13411
15	13211
13	11858
25	3831
9	3656
18	3529
20	3354
23	3211
21	3058
6	3019
27	2721
10	2694
4	2640
2	1845
37	1741
24	1464

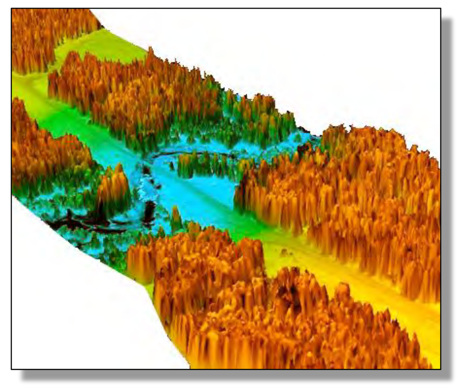
DSM

Map ID #	Count of Mapped Dead
12	14990
16	13119
15	13070
13	11713
18	3511
9	3506
25	3477
20	3316
23	3182
21	3041
6	2918
27	2759
10	2631
4	2567
2	1771
37	1539
24	1440

These tables show how a DEM (left) and DSM (right) analysis rank each of these Mt. Mitchell scenic overlooks from most to least visible dead canopy. The number of mapped dead visible to each overlook is shown.



Above: Map of Mt. Mitchell showing major scenic overlooks (red stars) with ID # (see tables, left). Ridge Junction (ID # 12) is ranked the highest in both the DEM and DSM analysis . For names of overlooks, contact sthomps2@unca.edu.


Example of LIDAR Digital Surface model[2]

Below: Table showing percent of total area determined as visible for each entire study area and each elevation model input.

	DEM Viewshed	DSM Viewshed
Mt. Mitchell Visible (%)	43.07	37.08
Mt. Mitchell Not Visible (%)	56.93	62.92
COF Visible (%)	50.02	46.91
COF Not Visible (%)	49.98	53.09

Conclusion: Which is Better?

A bare- earth DEM is an elevation model that considers the earth's bare surface only. The LIDAR DSM accounts for tree canopy height, buildings, structures, and other 3D features. For this study, the DSM viewshed likely results in a more accurate depiction of visibility from the BRP due to the topography of the region. On the BRP, there are locations where the forest canopy can block a viewers line of sight. Therefore, the DEM viewshed likely overestimates what is actually visible from a given point.

DEM's are currently the basis for most viewshed analyses. While DEM's may be suitable for assessing large open areas such as fields, they are not practical for study sites with complex surface features. A movement towards DSM based viewshed analyses may be more realistic and provide better real-world solutions.

Acknowledgements

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References

1. Vose, J,M., Wear, D.N., Mayfield III, A.E., & Nelson, C.D. 2012. Hemlock Wooly Adelgid in the southern Appalachians: Control strategies, ecological impacts, and potential management responses. Forest Ecology and Management 291: 209-219.
2. www.gisboc.ro