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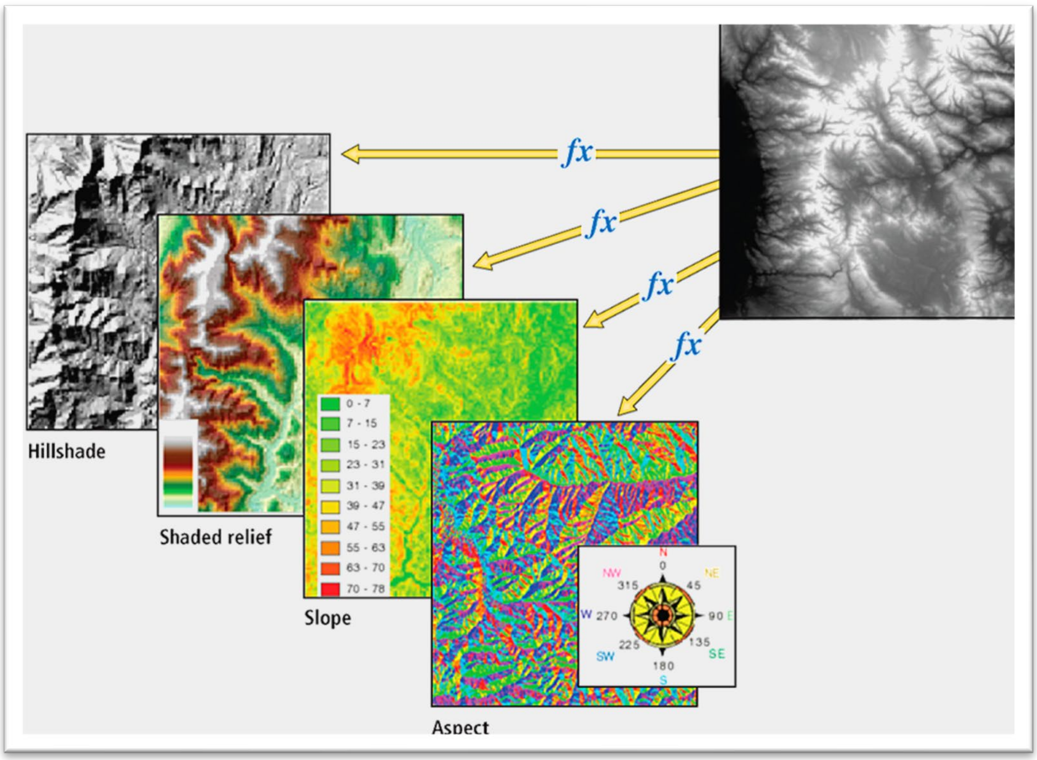
# EXERCISE 2

# Surface Analysis




## Introduction

In this exercise you will create a variety of raster datasets that attempt to portray some pattern of the surface—such as slope, aspect, or a hillshade. Through creating the simplistic model, it is our hope that you will begin to see the potential that lidar derived high resolution DEMs can provide to many land management objectives.

Within the exercise, the surface layers are created using the Spatial Analyst tools and utilize a single-layer raster, usually a Digital Elevation Model (DEM). Spatial Analyst is designed to help you work with the cell-based structure of raster datasets. The advantage of using a cell-based structure over other GIS structures such as vector datasets is that raster data can represent a continuous surface (e.g., elevation). In addition, raster data uses a uniform storage structure regardless of whether the dataset is depicting points, lines, or polygons. This uniformity becomes important when you want to work with multiple data types in the same environment. The surface rasters become useful during visualization but can also be used to support advanced analysis of the landscape, such as suitability and susceptibility analysis. In this exercise we will use a DEM from the Lincoln National Forest.

## Required Data

- **South_dem** – lidar-derived DEM that is the basis for most of the operations in this exercise. 1-meter spatial resolution with height values (z-values) in meters.
- **ObservePoint.Shp –** Used to create a viewshed of the area of interest

As with any of these exercises, you are welcome to use your own data. If you don't, then it is assumed that you will use the DEM provided in the zip file. If you are using your own data, it needs to be a DEM in Grid, TIFF, or ERDAS Imagine format, with an associated projection.

## Prerequisites

- Install ESRI ArcMap on computer and have basic understanding of how to use the software.

## Table of Contents

# Part 1: Create an Aspect Raster

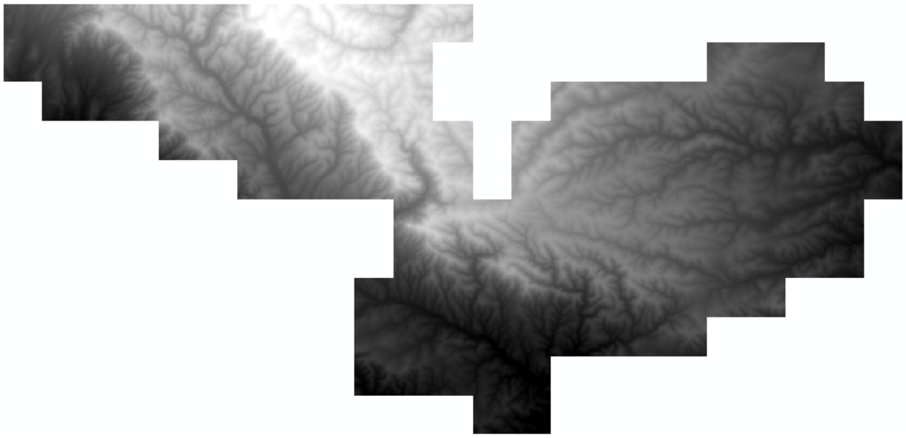
## A. Start ArcMap

1. If it is not already open start ArcMap by clicking on the Start button and navigating to **All Programs, ArcGIS** and then open ArcMap**.**
2. Open a blank map.

## B. Add the DEM

1. Click the **Add Data** button (see following graphic).

2. Navigate to **South_Data\DEM** and add **south_dem.** Your DEM should look similar to this:



## C. Activate Spatial Analyst Extension and Open ArcToolbox

1. If you haven't already, activate the **Spatial Analyst** extension. From the **Customize** menu, choose **Extensions.**
2. In the **Extensions** dialog, put a checkmark next to **Spatial Analyst**, this makes that extension available to use.
3. Click **Close** to dismiss the **Extensions** windows.
4. If the **ArcToolbox** window is not visible, click the **ArcToolbox** button (see following graphic) and dock the window next to your **Table of Contents.**

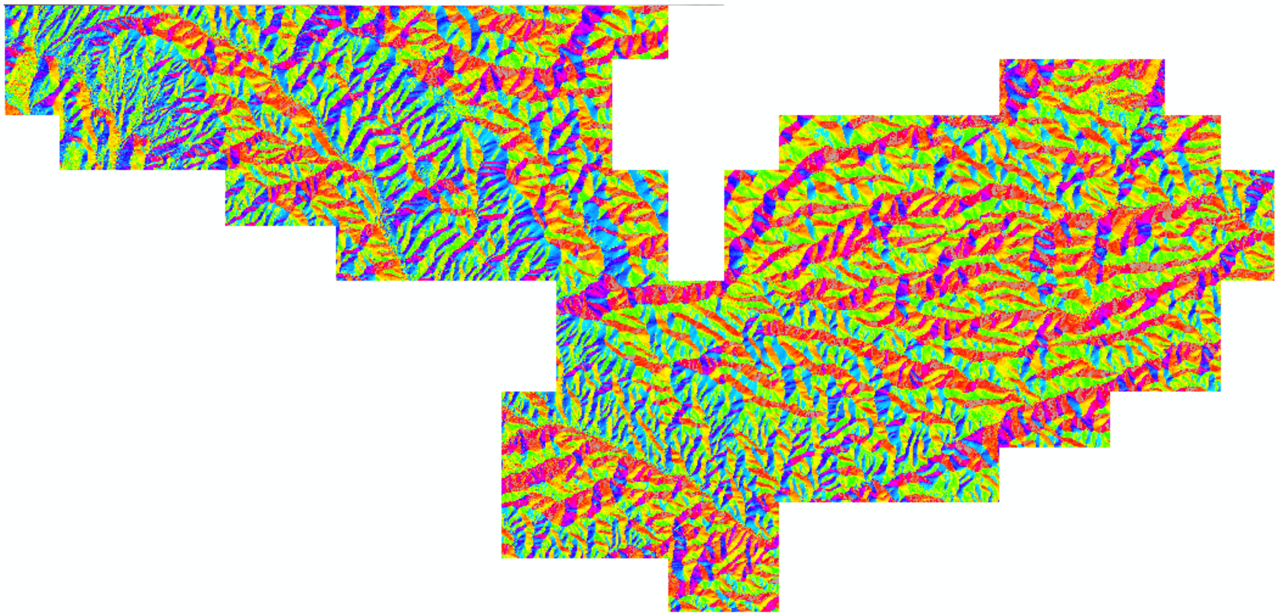
## D. Locate and Run the Aspect Tool

1. From the ArcToolbox, navigate to the **Aspect** tool by expanding **Spatial Analyst Tools**, **Surface** and then click **Aspect.**
2. For the **Input raster** choose the **DEM** from the drop-down menu.
3. Save your **Output raster** in **Outputs** and call it **LincolnNF_south_asp.tif**.
   i. Remember: If you don't put an extension ("**.tif**" or "**.img**") on the end of your raster, it will default to an ESRI Grid raster which has a naming limit of 13 characters.

4. Click **OK** to run the process.
    i. The output aspect raster will automatically be added to your ArcMap instance.
    ii. The Colors indicate which direction that the slope faces. They are attributed with both the cardinal direction name and the degrees from 0 to 360.

### E. Inspect the Results

1. Notice that the legend distinguishes "gray" as "flat", which indicates that it doesn't really have an "aspect" associated with it. In rasters with larger water bodies, these will normally be colored gray.
    i. NOTE: If you re-add this Aspect layer to a later instance of ArcMap, it will not be displayed using the color scheme you see after it is first generated.



*Why use the Aspect tool?*

*With the Aspect tool, you can:*

*1. Find all north-facing slopes on a mountain as part of a search for the best slopes for ski runs.*

*2. Calculate the solar illumination for each location in a region as part of a study to determine the diversity of life at each site.*

*3. Find all southerly slopes in a mountainous region to identify locations where the snow is likely to melt first as part of a study to identify those residential locations likely to be hit by runoff first.*

*4. Identify areas of flat land to find an area for a plane to land in an emergency.*

*5. Identify areas that may be more susceptible to landslides after a fire.*

# Part 2: Create a Slope Raster

## A. Set Slope Parameters and Run Process

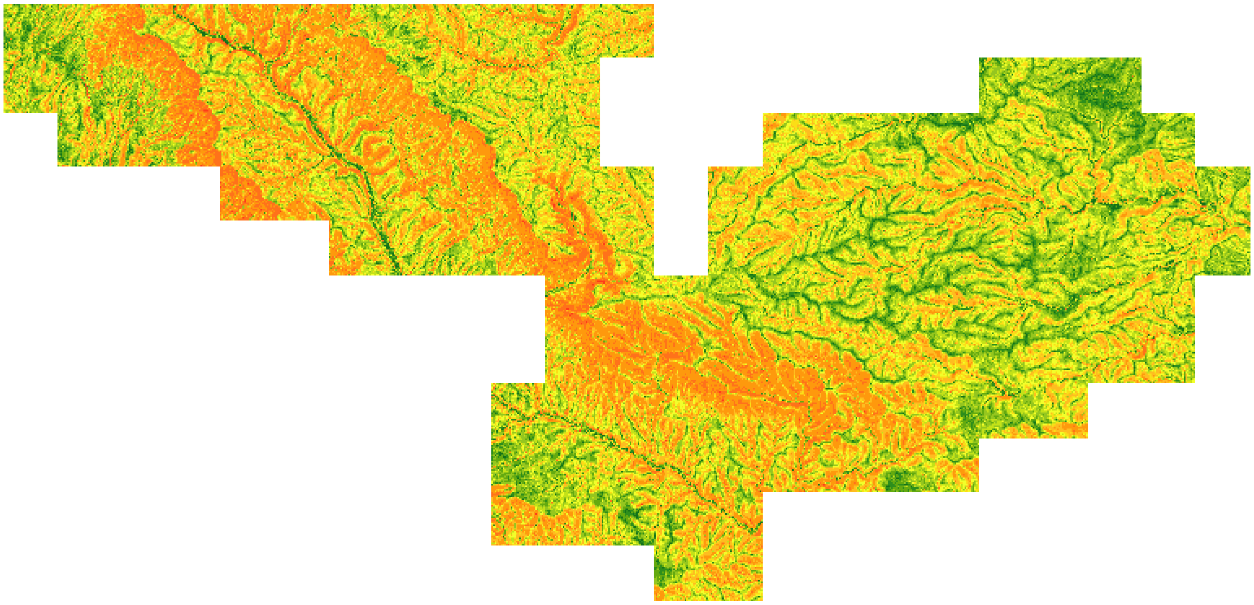
1. From the **Spatial Analyst** toolset navigate to **Surface** and then find the **Slope** tool
2. Chose **south_dem** as the **Input Raster.**
3. Set the **Output raster** as **Lincoln_south_slope.tif** in the appropriate location **(Outputs).**
4. Set the **Output Measurement** unit to **Degree.**
5. Leave the **Z Factor** at **1.**

Note: The z-factor is a conversion factor between horizontal and vertical units, which is important when your vertical and horizontal units are different. For example, in this dataset the ground distances etc. are in meters, but the elevation, tree heights, etc. are in feet. Because of this we need to do a conversion so that the slope, and other derivatives using both horizontal and vertical units in their calculations are correct, and 1 foot = 0.3048 meters. If the lidar was delivered to you with the units, the same then there would be no need to change the z factor.

6. Click **OK** to run the process.

## B. Inspect the Results

1. Use the **Zoom** and **Pan** tools to inspect the results.
   i. You should notice that the steeper slopes are in red, and the least steep slopes are in green (see image below).



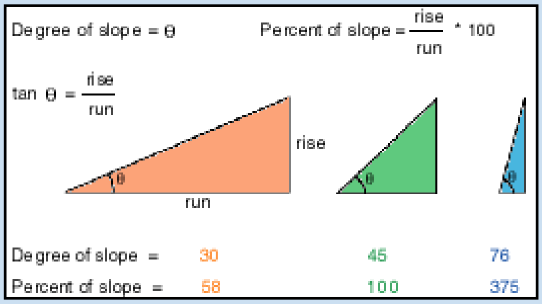
***Note:*** *How do Degree and Percent relate? A rough estimate of a 100 percent slope would be about 45 degrees. See the below table. Why use the Slope tool?*

*With the Slope tool, you can:*

*1. Find areas of relatively flat land for suitable building purposes.*

*2. Find all slopes in a mountainous region greater than a specified percent or degree (e.g. for landslide analysis, by watershed boundary, etc.)*

*3. Identify areas of flat land to find an area for a plane to land in an emergency*




# Part 3: Create a Hillshade Raster

## A. Add the NAIP Imagery

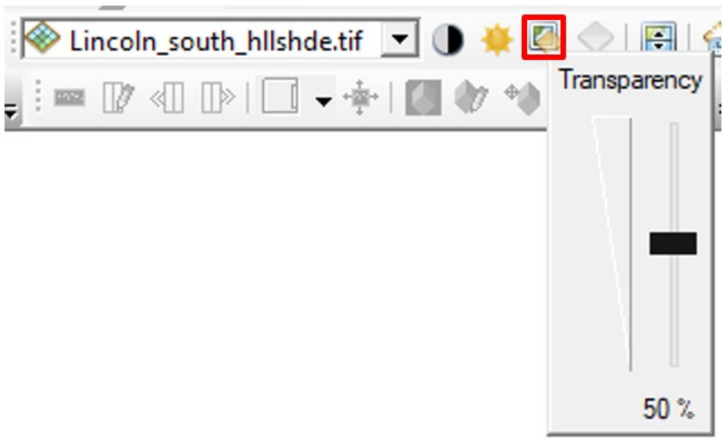
1. To use as reference after the **Hillshade** has been created, please click the **Add Data** button and navigate to **…\South_Data\NAIP** and add **Lincoln_NF_NAIP2020_5m.tif**
2. Uncheck the **NAIP** image to "turn it off" in your Data View, you will turn it back on later.

## B. Run the Hillshade Tool

1. From the **Spatial Analyst** toolset, navigate to **Surface** then **Hillshade…** and open the Hillshade tool.
2. Set **Lincolnnf_dem_south.tif** as the **Input raster.**
3. Set the **Output raster** with an appropriate name in the appropriate location.
4. Leave all other settings at their defaults—Azimuth at 315 and Altitude at 45.
5. Set the **z factor** to **1**.
6. Save the **Hillshade** to an intuitive location and click **OK** to run the process.
   i. The new **Hillshade** will be automatically added to your ArcMap instance.

## C. Adjust the Transparency

1. Activate the **Effects** toolbar (Hint: Right click in the gray space next to your other toolbars to activate the toolbar drop down menu—locate the Effects toolbar in the list and click on it).
2. Dock the toolbar with the others.
3. Turn off all other layers except your newly created **Hillshade** and the **NAIP image.**
4. On the **Effects** toolbar change **Layer** to the Hillshade you just created—from the drop-down menu.
5. Activate the **Transparency** button—outlined in red in the following graphic.
6. Set the **Transparency** to 50% by dragging the bar on the right-hand side.



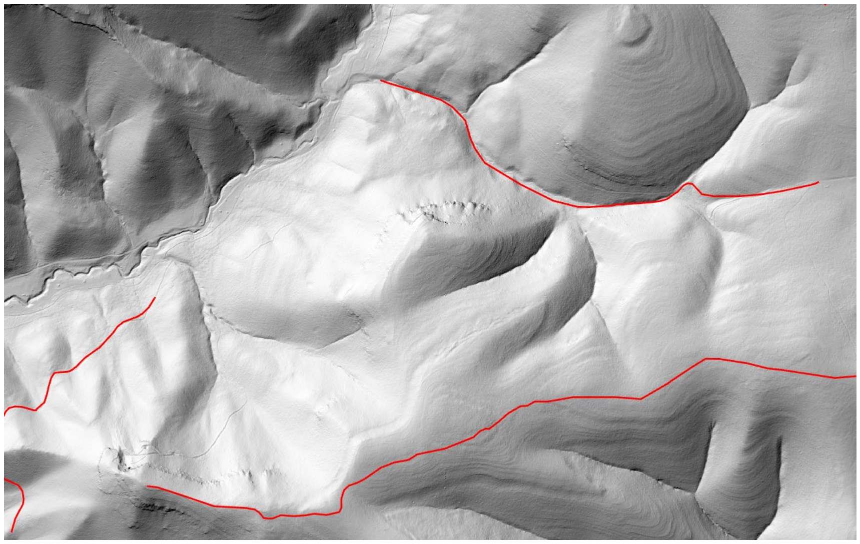

7. Make sure your NAIP image (**Lincoln_NF_NAIP2020_5m.tif**) is on in the Display and located below your **Hillshade** layer in the **Table of Contents.**
   i. See the following graphic for what part of your **hillshade** should look like.

8. Try experimenting with different view angles when creating a hillshade raster. To do this, run the tool again but change the view angle value. This may be of particular use when trying to identify new roads that are not in your road network.
9. Below (left) is the original hillshade made from the defaults and on the right is a hillshade with the view angle at 150.

# Part 4: Interpret New Features from a Hillshade

## A. Explore Hillshade

1. With your original **hillshade** visible as the top layer add the **South_roads.shp** layer from **…\South_Data\Vector.**
   i. Change the **color** and **width** of the roads so you can see them better (e.g. Red and Width of 2). Double click the actual road symbol below the Roads layer in the Table of Contents pane to access these options.
2. **Zoom** into portions of the **hillshade** where there are roads and try to find areas where roads have not been digitized yet (HINT: Look at the eastern portion of the image).
3. The image below shows areas where there may be new roads or trails that have not been digitized. These may be other features besides roads and more research would need to be done to inform changes to your roads GIS.



# Part 5: Create Contours from DEM

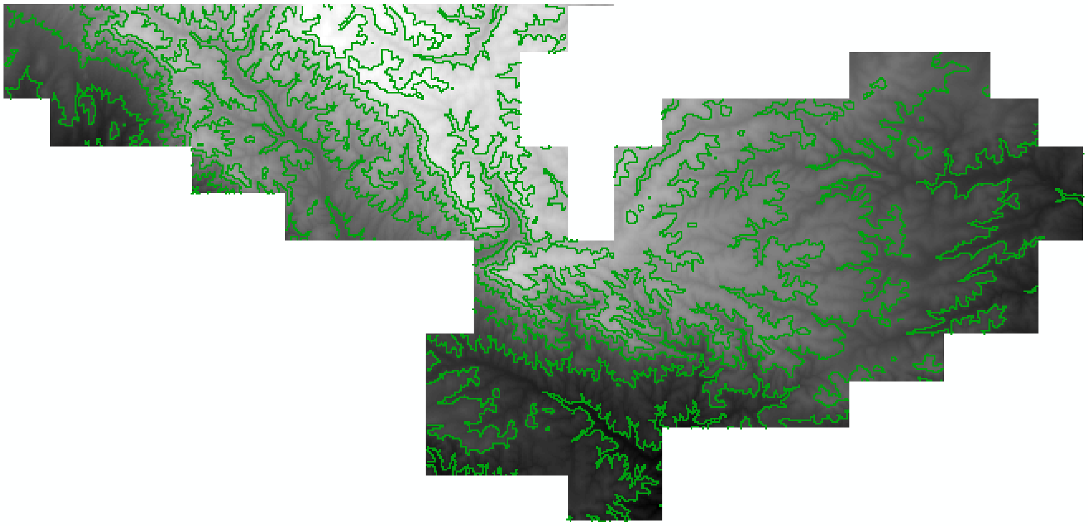
Contours may be useful as a less dense elevation model and also for producing topographic maps for other so it may be of use to create contours to simplify your DEM.

## A. Run The Contour Tool

1. Within the **ArcToolbox**, and from the **Spatial Analyst** toolset, click **Spatial Analyst, Surface,** and then **Contour…**
   i. The **Contour** dialog will open.
2. Make sure the **south_dem** is set for the **Input raster**, you can choose it from the drop-down menu.
3. For your **Output polyline features** save them in an intuitive location, like the Outputs folder, and call them **contours_100m**. They will be in shapefile format.
4. Choose a Contour interval:
   i. This is up to you and based on what you are using the contours for. Recall: What is the linear unit for your DEM? The same units (e.g. meters or feet) will be applied to your contours.
   ii. **Suggested interval:** 100 (for shorter processing time)
   iii. **Base contour:** 0
   iv. **Z factor**: 1
   v. As you change the contour interval, the output information based on input contour definition is updated.
5. Click **OK** to run the process.
6. Once finished, the contour shapefile will be added to your ArcMap instance.

## B. Inspect the Results

1. Check out the newly created contours (see following graphic). **Are they adequate for your analysis\needs?** If they are not, you can re-run the process with a different interval.



# Part 6: Create a Viewshed (Optional)

Next, you will use the Viewshed tool, which can be used to understand what parts of a landscape are visible from a given location on a DEM. Why should you create a Viewshed layer? You can answer these sorts of questions: Which areas can be seen from a fire lookout tower that is 15 meters high? Can two proposed wilderness campsites be positioned along a river so they won't be visible to one another?

## A. Add the Shapefile Observepoint.Shp

1. Click the **Add data** button.
2. Navigate to **…\South_Data\Vector** and add the **ObservePoint.shp**
3. Turn off any other layers but leave your **Hillshade** and the newly added point shapefile on.

## B. Locate the Viewshed Tool

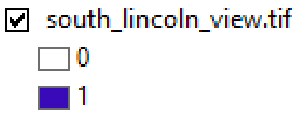
1. From the **Spatial Analyst** tools, navigate to **Surface,** then click **Viewshed**.

## C. Set the Parameters and Run the Process

1. Set **south_dem** as the Input surface.
2. Set **ObservePoint** as the Observer feature.
3. Choose the appropriate Output location and call the output **south_lincoln_view.tif**
4. Set the z score to 1
5. Click OK to run the process.
   i. Your **Viewshed of ObservePoint** will be added to ArcMap automatically and may look similar to the next graphic. Using layer transparency, you can display a hillshade raster underneath your output from the viewshed analysis to visualize the relationship between visibility and terrain.

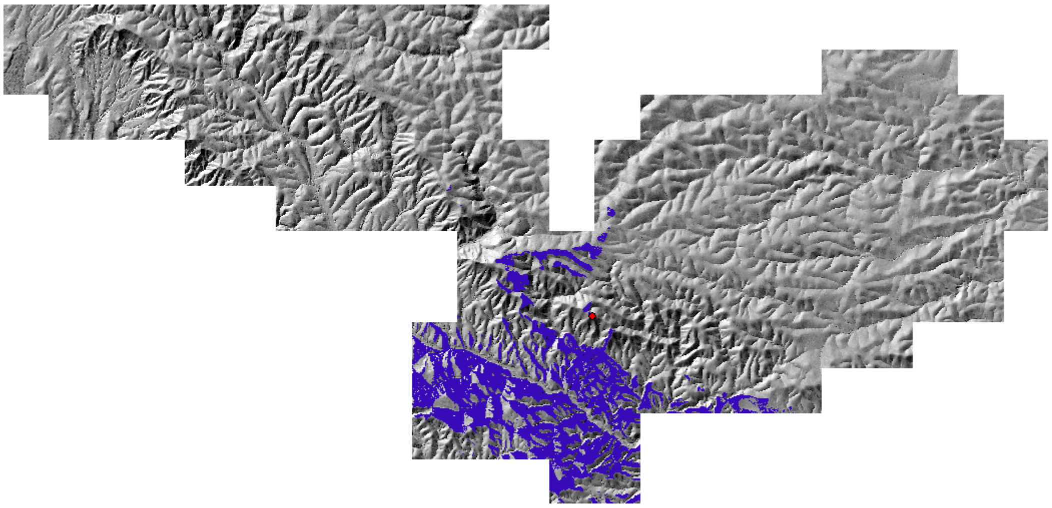
ii. This tool does not take into account the heights of objects around the point, such as trees or buildings for its analysis when used with a Bare Earth DEM. To take into account above ground objects when running this tool, you will need to use a LiDAR derived Digital Surface Model (DSM).

6. If need be, set the "Not Visible" to **No Color**—either in the Layer Properties or by right clicking on the square with the value 0 and changing it to No Color.




## D. Generalized Steps for How to Edit Viewshed Parameters in the Attribute Table

1. To further control the output of your viewshed you can add a new field and some values in the attribute table of your shapefile.
2. For example, open the **Attribute Table** of your observation point shapefile. From the **Options button,** choose **Add Field**. Fill out the dialog, using one of the following names (which work as a parameter in your Viewshed analysis):
   i. Spot, OffsetA, OffsetB, Azimuth1, Azimuth2, Vert1, Vert2, Radius1, Radius2.
   ii. For more information about Viewshed analysis search the ArcGIS Desktop help.
3. Feel free to explore these options to see how you may use them for your own analysis needs.



4. Some of these surface layers will be drawn on for the Landslide Hazard exercise, which goes through a workflow to create a rudimentary landslide hazard map.

**Congratulations!** You now have a basic understanding of how to create basic surface layers in ArcMap using a lidar derived DEM. If you are moving on to the Bare Earth Derivatives track, then you will draw on the slope and aspect layers you just created for Exercise 1a: Landslide Hazard Mapping.