Exercise 7

Raster Data Analysis - Working with Topographic Data

Objective – Learn the Basics of Terrain Analysis

7.1 Introduction

In this exercise, you will learn about topographic data and how to use it for analysis. You will learn how to create datasets such as slope, aspect, and hillshades using QGIS. You will then learn how to combine them using raster algebra.

This exercise includes the following tasks:

- Task 1 Terrain Analysis
- Task 2 Reclassification
- Task 3 Using the Raster Calculator

7.2 Objective: Learn the Basics of Terrain Analysis

The objective of this exercise is to learn the basics of terrain analysis using QGIS. This will include created hillshade images, generating slope and aspect datasets and using the Raster Calculator to perform raster algebra.

7.3 Task 1 - Terrain Analysis

7.4 Task 1.1 - Creating a Color Hillshade Image

In this task, you will use a digital elevation model to create several terrain related datasets: slope, aspect, and hillshade. These elevation derived datasets can be important in site selection and other terrain based spatial analyses.

1. Open QGIS.

2. Starting with a new project add the `35106-B4.dem` raster from the exercise directory to QGIS.

This raster layer has elevation values for each cell. This type of data is referred to as a digital elevation model, or DEM, for short. This particular dataset covers the Sandia Mountains on the east side of Albuquerque, New Mexico (shown in figure 7.1, on the next page). The light areas have the highest elevation and the dark areas the lowest elevation.

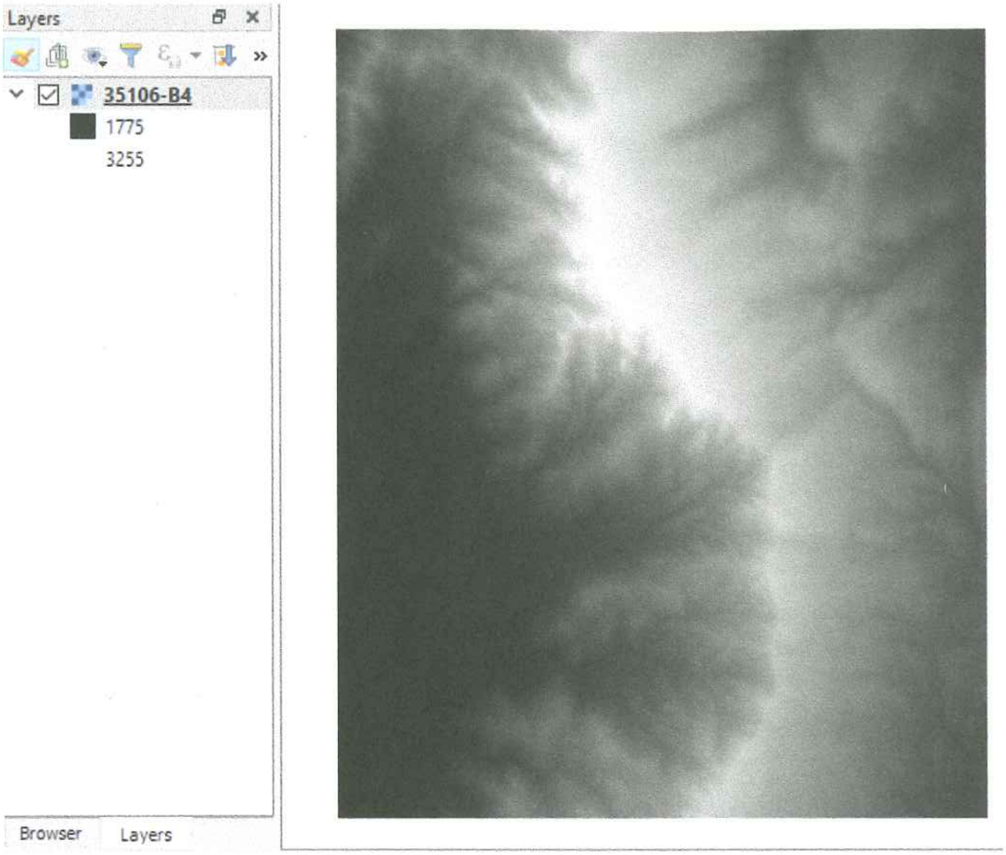


Figure 7.1: Digital Elevation Model (DEM) in QGIS

3. Let's explore the properties of the raster dataset.

4. Open the Layer Properties for the DEM and choose the Information tab. Notice that the raster is in the UTM coordinate system. UTM has X/Y coordinate values in meters.

5. Also notice that the Pixel size is 10 x 10. This means each cell represents a 10 by 10 meter area. There is other useful information here such as the Data type, Dimensions and Statistics for the values in the raster.

6. Now switch to the Symbology tab. Find the Min/max Values Settings section and expand it. The elevation values (Z) of a DEM are typically either feet or meters. The min value probably reads 1775 and the max value 3255. However, your values may differ slightly depending on your Min/max Values Settings. The default setting is Min/max . However, there are other options such as Cumulative count cut which removes data outliers and Mean +/- standard deviation.

You can set the default behavior for Min/Max values. Click on Settings | Options and choose the Rendering tab. In the Raster section you can set default settings for raster contrast enhancement. See figure below.

7. You can also set how thoroughly QGIS scans the raster dataset for min/max values. By default the Statistics extent is set to Whole raster. Click this drop down and note that you can also set this to Current canvas and Updated canvas. The last setting will update the statistics and data rendering to just those in the visible extent and will update that as you pan/zoom the map canvas.

8. The default Accuracy setting is Estimate (faster). Click the drop down for this and note that you can also choose Actual (slower).These settings can be very useful when working with a very large raster dataset, or when you want

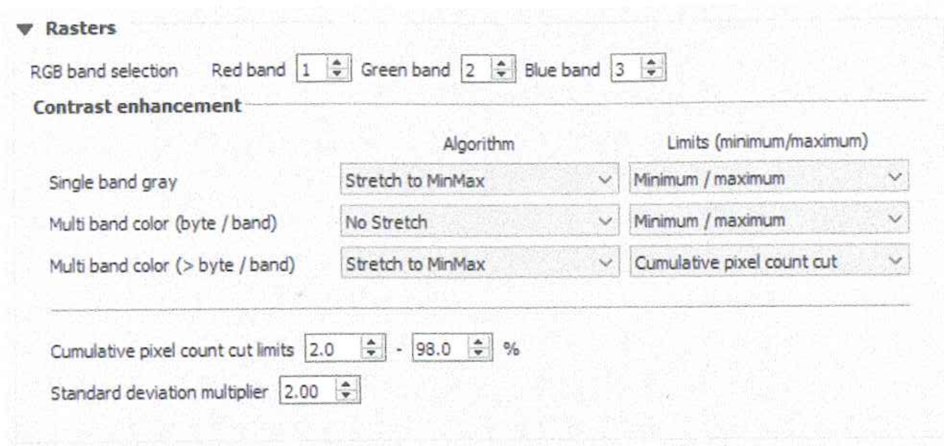


Figure 7.2: Raster Rending Settings

statistics on just the visible extent.

9. Set the Min/max Values Settings to Min/Max, the Statistics extent to Whole raster and the Accuracy to Actual (slower) and click the Apply button. The values should now read 1775 to 3255 which are the actual min and max values of the DEM.

10. The Sandia Mountain range reaches 10,678 feet above sea level. Therefore, you can deduce that these elevation units (Z values) are in meters. Before working with DEMs, it is important to understand what unit the X, Y, and Z values are in. In this case, all three are in meters.

11. Close the Layer Properties window.

12. Save your project as `Terrain.qgz` in the exercise directory.

13. You will use the Raster Terrain Analysis toolset to create the several elevation related datasets. Open the Processing Toolbox.

14. Find the native QGIS Raster terrain analysis section and expand it to see the available tools.

15. First you will create a hillshade image which will allow you to get a better feel for the terrain in this area. Double click the Hillshade tool.

16. Use the following parameters (shown in figure 7.3, on the following page).

a. Elevation layer = 35106-B4
b. Z factor – 1.0 (this is a conversion factor between the X/Y and Z units. Since all three are meters you can leave this at 1.0)
c. The QGIS defaults for Azimuth and Vertical angle (sun position) are 300 and 40 respectively. The Esri defaults are 315 and 45. You can experiment with those values.
d. Save the output Hillshade layer ti the `exercise_7_Data/MyData` folder and name it `Hillshade.tif`
e. To set the Hillshade output format, click the ellipsis button and choose Save to file. . . . Set the Save as type to TIF files (*.tif)
f. Click Run and then Close.

The resulting hillshade should resemble the figure 7.4, on the next page.

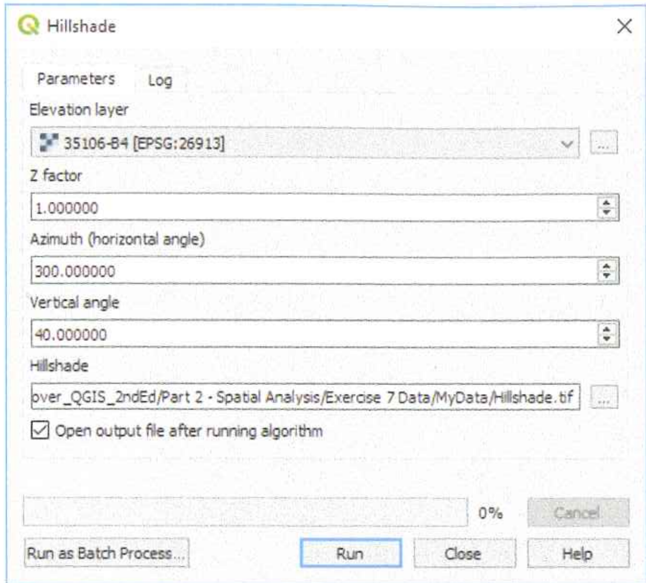


Figure 7.3: Hillshade Tool Parameters

There is also a *Hillshade* renderer available. Another suitable approach is to simply *Duplicate* the DEM layer and render the copy as a Hillshade image. When using this renderer it is best to visit the *Resampling* section and set the *Zoomed in* resampling to *Bilinear* and the *Zoomed out* to *Cubic* for better rendering. You now know how to generate a hillshade dataset. However, this approach would achieve the same end without needing to create a separate layer!

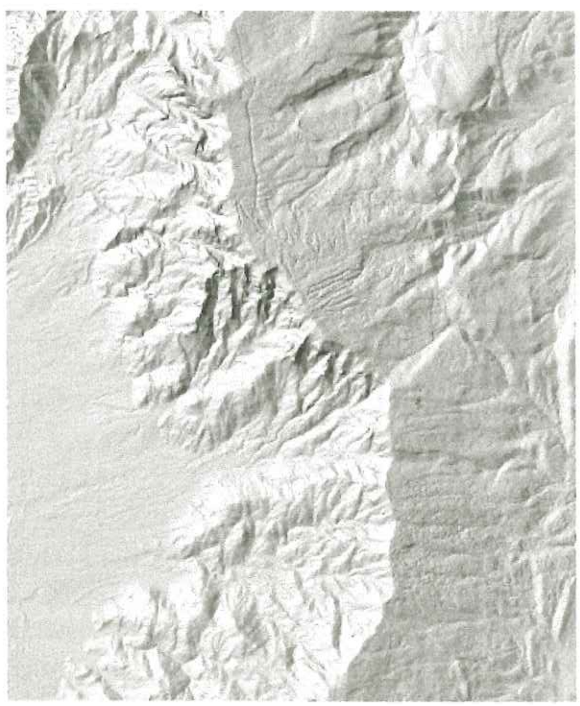


Figure 7.4: Hillshade Layer

This is a grayscale hillshade rendering. Now you will use both the original DEM and the hillshade to create a color hillshade image.

17. Make sure the Hillshade layer is above the DEM layer in the Layers Panel.

18. Select the DEM layer (35106-B4)and open the Layer Styling Panel .

19. Switch to a Singleband pseudocolor renderer.

20. Click the Color ramp drop down and choose Create New Color Ramp. Shown in figure 7.5.

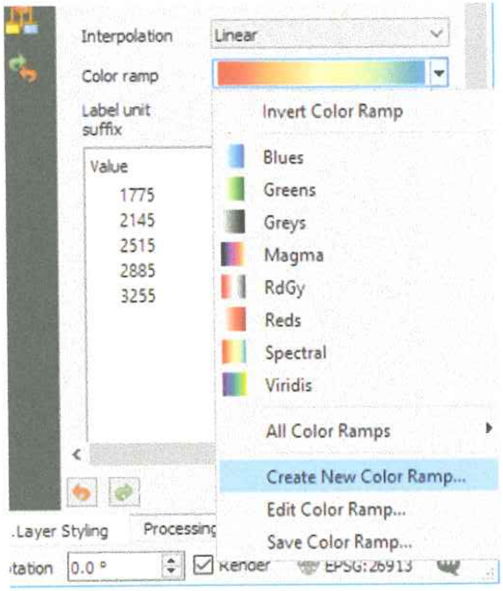


Figure 7.5: Color Ramp Menu

21. In the Color ramp type window choose Catalog: cpt-city and click OK. Shown in figure 7.6.

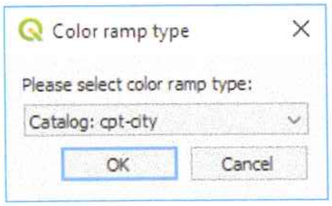


Figure 7.6: Color Ramp Type

22. In the Cpt-city Color Ramp window select the Topography category.

23. Select cd-a or sd-a and click OK.

> To save this color ramp click the drop down Color Ramp menu and choose Save Color Ramp. Name the ramp, tag as you wish and click OK. It will now appear in your list of color ramps!

24. Expand the Min/max Values Settings and ensure it is set to Min/max values and that the Accuracy is set to Actual (slower).

25. Now change the target layer in the Layer Styling Panel to the Hillshade layer.

26. Scroll down to the Layer Rendering section set the Blending mode to Multiply.

27. Your map should now resemble the figure 7.7.

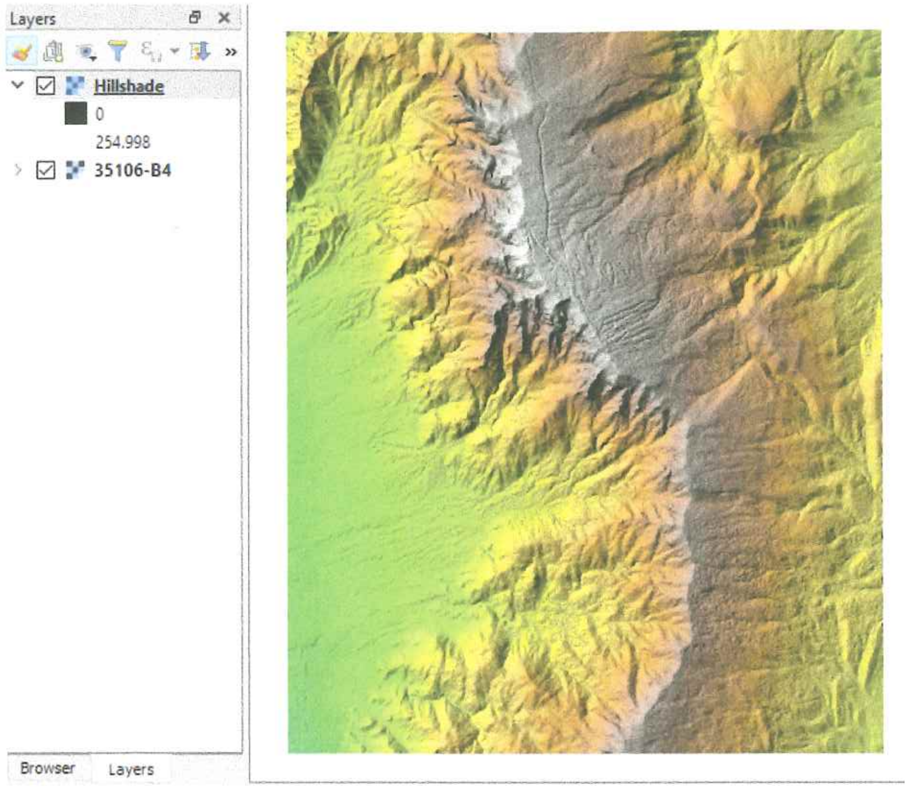


Figure 7.7: Color Hillshade Image

7.5 Task 1.2 - Calculating Slope and Aspect

1. Now you will create a Slope dataset. From the Processing Toolbox return to the Raster terrain analysis section and open the Slope tool.

2. Complete the Slope tool as shown in the figure 7.8 below then click click Run and Close when it is complete.

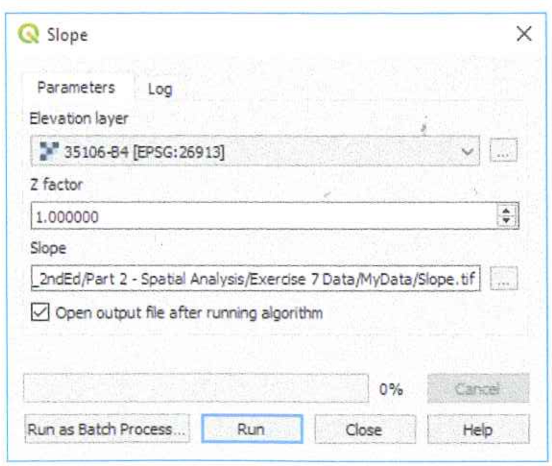


Figure 7.8: Slope Tool

The slope raster shows the steepest areas in white and the flattest terrain in black. The tool determines the steepness of each pixel by comparing the elevation value of each pixel to that of the eight surrounding pixels. The slope values are degrees of slope (shown in figure 7.10, on the following page).

> Because the QGIS Processing Toolbox contains tools from multiple providers there are often multiple tools that do roughly the same thing. If you need slope in percentages you can use the GDAL | Raster Analysis | Slope tool.

Now you will create an Aspect raster. Aspect measures which cardinal direction the terrain in each pixel is facing (north facing vs. south facing etc.)

3. From the Processing Toolbox double click on the Aspect tool. Fill out the Aspect tool as shown in the figure 7.9 below then click Run and Close when it is complete.

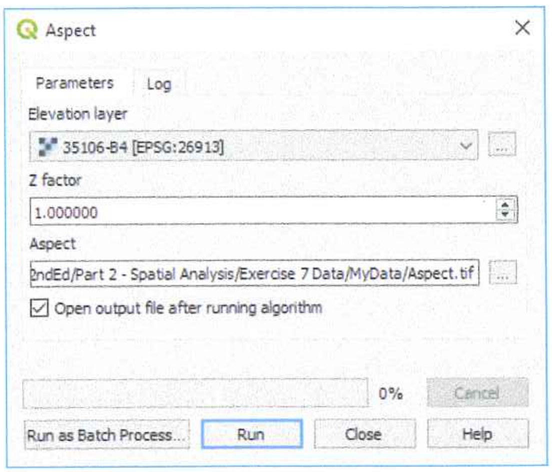


Figure 7.9: Aspect Tool

The output should resemble the figure 7.10, on the following page with values ranging from 0-360 representing degrees (0=north, 90= east, 180 = south and 270 = west).

4. Save your project.

7.6 Task 2 - Reclassification

Now that you have created the slope and aspect data you will reclassify them into meaningful categories. Raster reclassification is a method for aggregating data values into categories. In this case, you will be reclassifying them into categories important to identifying habitat suitability for a particular plant species. Once the slope and aspect data have been reclassified you will combine them in Task 3 to identify suitable habitat areas.

This plant requires steep slopes. You will classify slope raster into three categories: 0-45, 45-55, and > 55.

1. Open QGIS and open `exercise7.qgz` if it is not already.

2. Search in the Processing Toolbox for *Reclass* and find the Raster analysis | Reclassify by table tool.

   a. The Raster layer will be Slope.
   b. Next you will set up the Reclassification table. Click the ellipsis button to open the Fixed table window.
   c. For row # 1 set the Minimum to 0 and the Maximum to 45. Set the Value to 1.

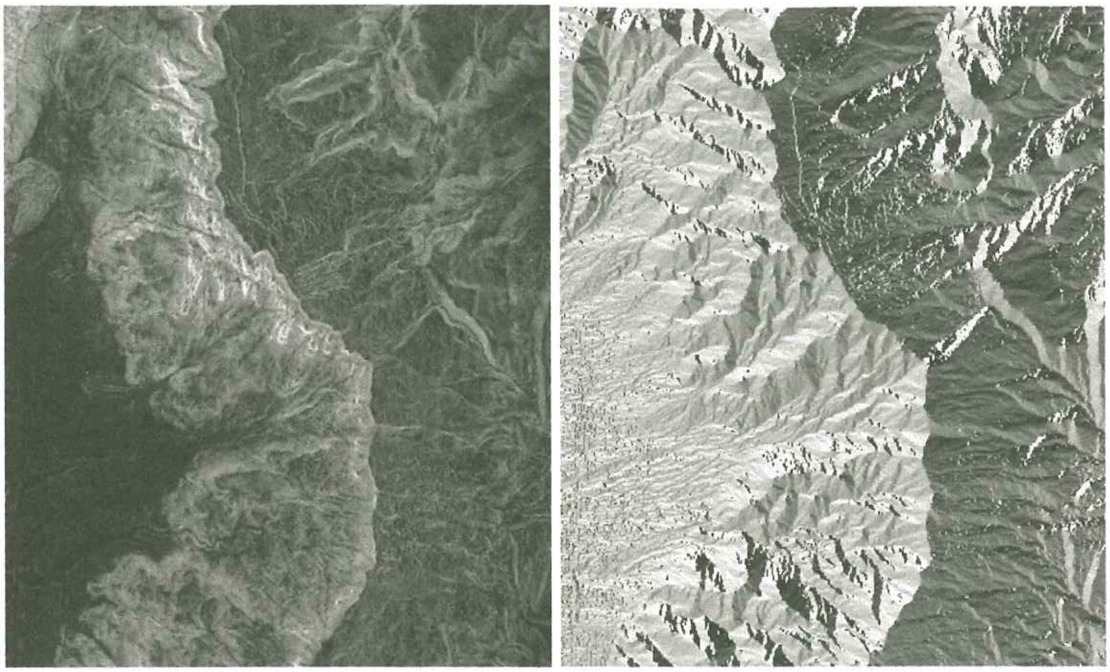


Figure 7.10: Resulting Slope (left) and Aspect (right) Layers

d. Add two more rows and set them up as shown in figure 7.11. Note the maximum cell value (75.480842590332) for row 3 was obtained from the Layer Properties | Information tab.

e. Click OK to close the Fixed table window.

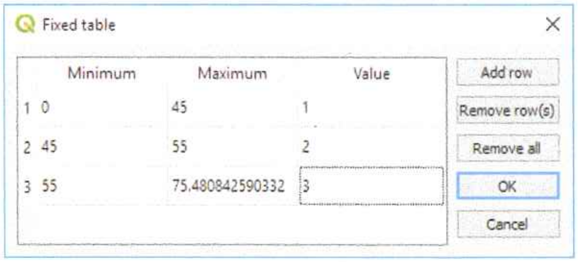


Figure 7.11: Reclassification Table Set Up In the Fixed Table Window

3. Open the Layer Styling Panel with the target being the Reclassified slope raster.

4. Set the render type to Paletted/Unique values and click Classify.

5. Make the pixels with a value of 3 dark green, those with a value of 2 a light green and those with a value of 1 white.

6. Give the layer a Blending Mode of Multiply.

7. Turn off all the layers other than the Reclassified slope raster and the Hillshade. See figure 7.13, on page 186.

Now you will recode the Aspect data in the same fashion. This plant prefers west facing slopes. Hence the west facing slopes will be set to 3, the north and south are the next best location so set them to 2, and the eastern slopes can be set 1. Remember that the values of the aspect raster are compass bearings or azimuths (270 is due west, 0 is north, 180 is south and 90 is east). You will classify the aspect data into eight cardinal directions.

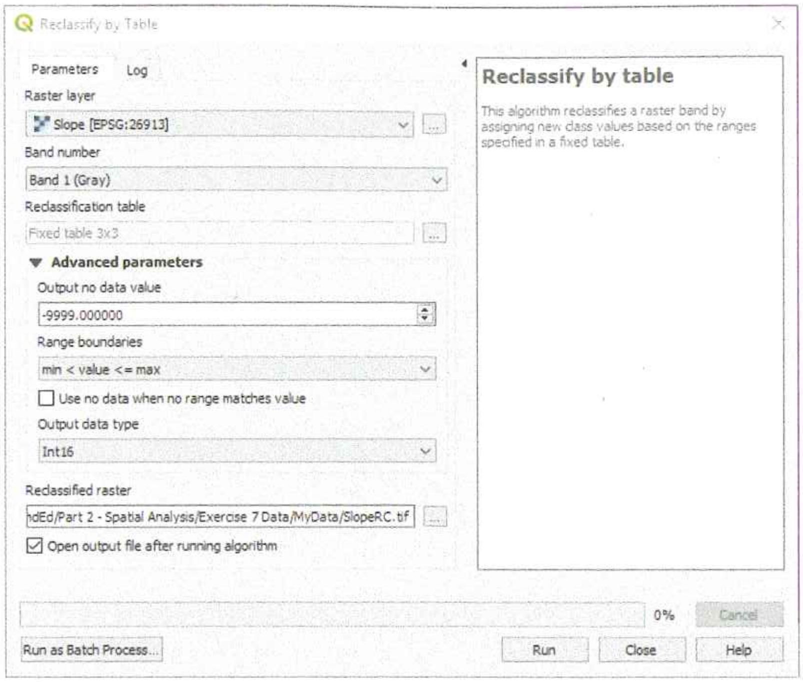


Figure 7.12: Reclassification By Table Tool

8. From the Processing Toolbox open the Raster analysis | Reclassify by table tool. Remember that it will now also appear in the Recently used category.

a. The Raster layer will be Aspect.
b. Next you will set up the Reclassification table. Click the ellipsis button to open the Fixed table window.
c. Set up the table as shown in figure 7.14, on the next page.
d. When done OK to close the Fixed table window.

9. Right-click on the Reclassified Slope layer and choose Styles | Copy Style.

10. Right-click on the Reclassified Aspect layer and choose Styles | Paste styles.

11. Rename the layers to *Reclassified Slope* and *Reclassified Aspect* respectively.

12. Save your QGIS project.

7.7 Task 3 - Using the Raster Calculator

Now you will use the Raster Calculator to combine the reclassified slope and aspect data. The Raster Calculator allows you to combine raster datasets mathematically to produce new outputs. For example, raster datasets can be added, subtracted, multiplied, and divided against one another. This procedure is also known as raster algebra. In this task you will add the two reclassified rasters together. Since each raster has ideal conditions coded with the value '3', an area that ends up with a pixel value of 6 would be ideal.

1. Open QGIS and open `exercise7.qgz` if it is not already.

2. From the menu bar choose `Raster | Raster Calculator`. The loaded raster datasets are listed in the upper right window. Below it is a panel of operators and an expression window (see figure 7.15, on page 187).

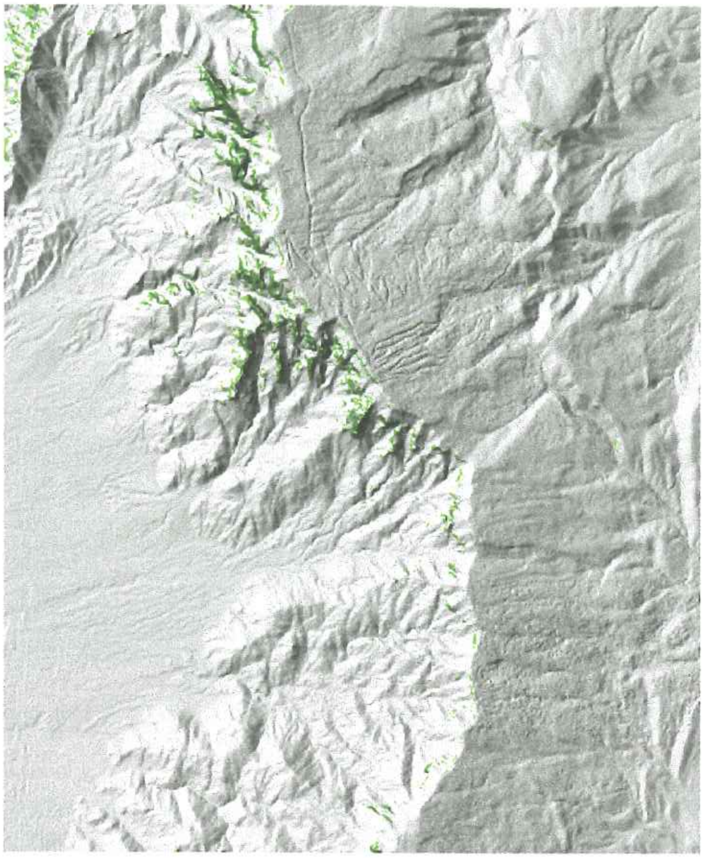
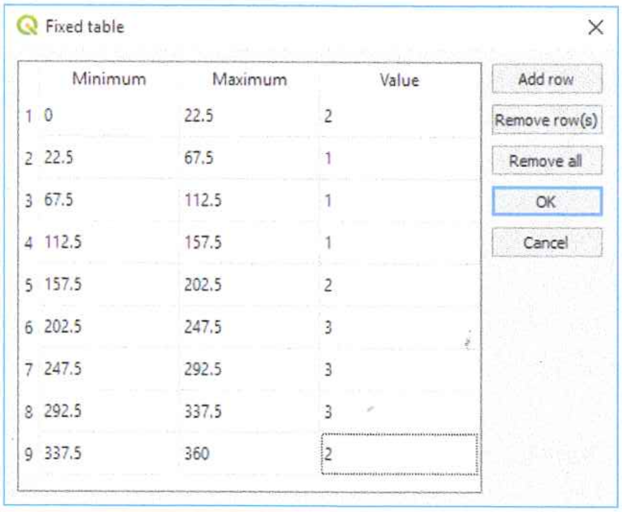


Figure 7.13: Reclassification Slope with Hillshade



	Minimum	Maximum	Value
1	0	22.5	2
2	22.5	67.5	1
3	67.5	112.5	1
4	112.5	157.5	1
5	157.5	202.5	2
6	202.5	247.5	3
7	247.5	292.5	3
8	292.5	337.5	3
9	337.5	360	2

Figure 7.14: Aspect Reclassification Table Set Up In the Fixed Table Window

3. Do the following to add the two reclassified rasters:

   a. Double-click on `Reclassified Slope@1` to place it in the Raster Calculator expression.
   b. In the Operators section, click the addition sign.

c. Then double-click on the `Reclassified Aspect@1` raster.
d. In the Result Layer section name the Output layer `Exercise_7_Data/MyData/PlantHabitat.tif`.
e. Choose an Output format of GeoTIFF.
f. Click OK.

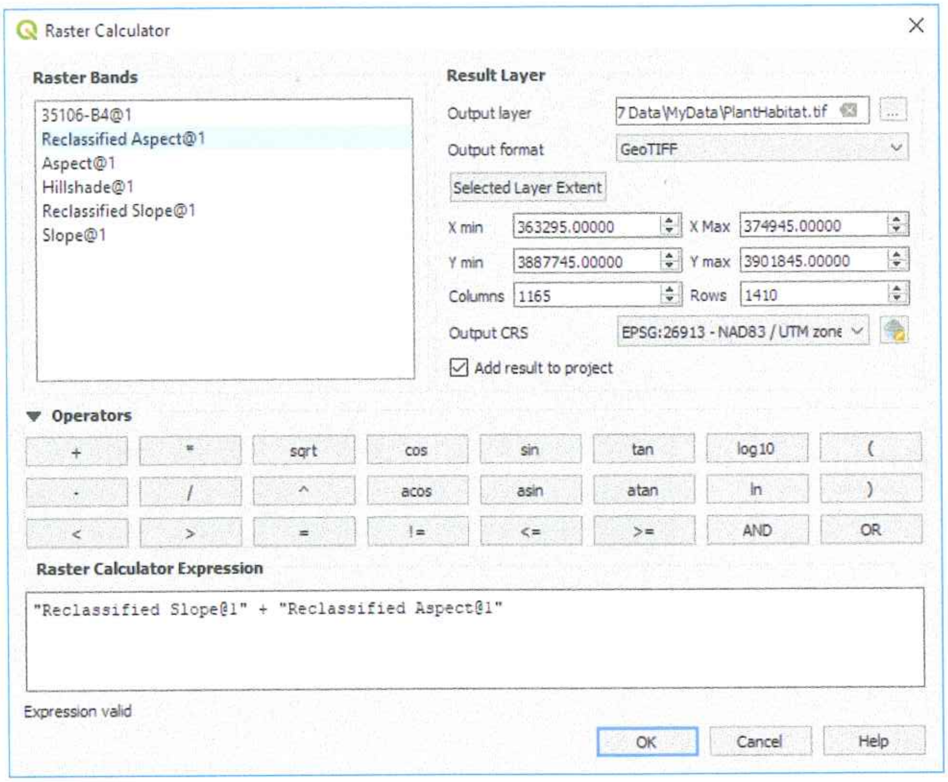


Figure 7.15: Raster Calculator

4. Using what you know apply the Paletted/Unique Values renderer to the Plant Habitat layer.

5. Select values 2-6 and select the Greens Color ramp.

6. Apply a Blending Mode of Multiply to the layer.

7. The final raster will resemble the figure 7.16, on the next page.

8. Save your QGIS project.

7.8 Conclusion

In this exercise, you were exposed to terrain analysis, creating derived datasets from elevation data (DEMs). You then went on to reclassify two terrain related datasets (aspect and slope), and combine them to produce a suitable habitat layer for a plant species. This is another method of doing site selection analysis. Raster data are well suited for these types of analyses.

7.9 Discussion Questions

1. What other real world applications of terrain analysis can you think of?

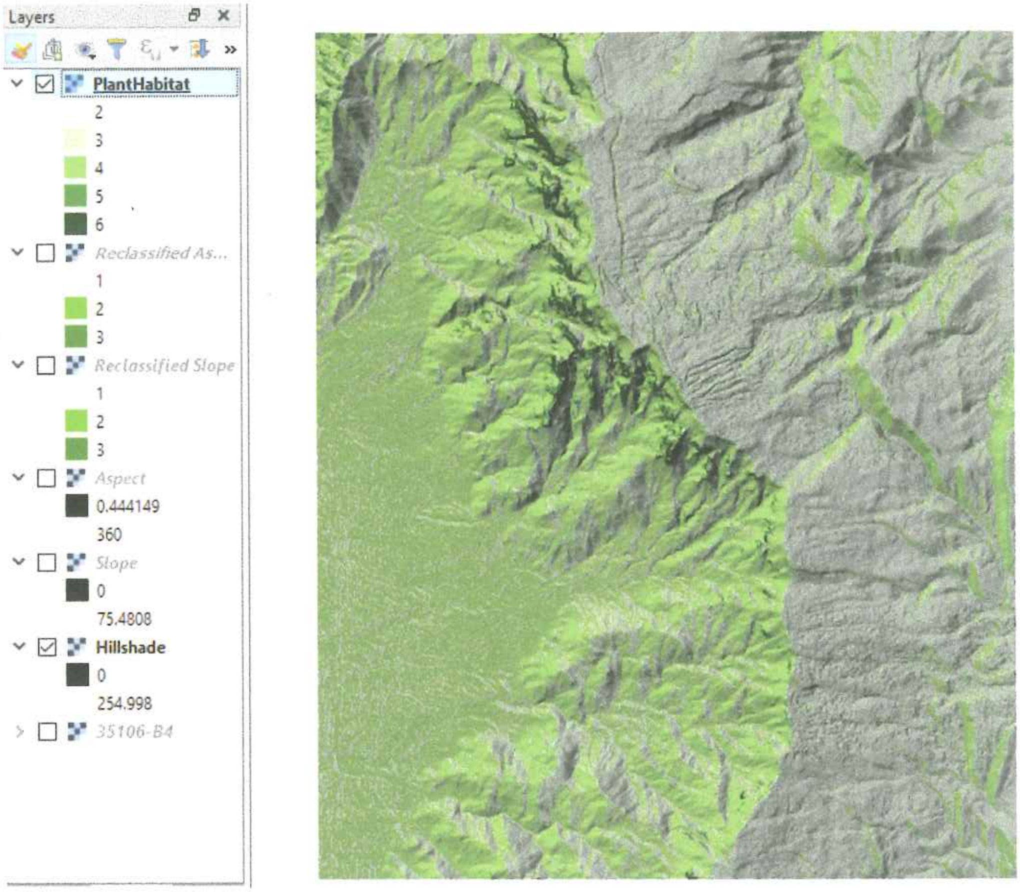


Figure 7.16: Plant Habitat

2. How does this suitability analysis compare to the site selection analysis done with the vector data model in Exercise 5?

7.10 Challenge Assignment

Another scientist is interested in developing a map of potential habitat for another species that prefers rugged, steep west facing slopes. Use the same Raster Terrain Analysis tools to develop a Ruggedness Index. Recode the Ruggedness Index into three categories:

- Min: 0 Max: 20 Value: 1
- Min: 20 Max: 40 Value: 2
- Min: 40 Max:(lookup) Value: 3

Combine the resulting reclassified ruggedness index with the reclassified slope and aspect from the exercise to create the final result. Compose a map showing the results.