# Catchment Basin Analysis of the Thumersbach River

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*I would love to live like a river flows, carried by the surprise of its own unfolding.*
**-John O'Donohue**

**Abstract**

Continuing the ongoing exploration of ArcGIS Pro Tools, the focus this time was on Digital Elevation Models (DEMs) and their relation with river catchment basins. The study area was the basin of the Thumersbach River, and I explored the elevation and its derivatives, with special focus on the slope. In the end, I compared the results for lower-resolution DEMs.

Keywords: ArcGIS Pro, DEMs, Slope

## Introduction

I was asked to focus my work on the catchment basin of a river of my choice in the Salzburg State. I was provided two datasets: a 5m DEM of Salzburg, and a polygon layer with the catchments of Salzburg.

After exploring the catchments' dataset for a while, I decided to choose the catchment basin of the Thumersbach River, which flows into Lake Zeller, and whose catchment basin is coded `2 8272113 8`.

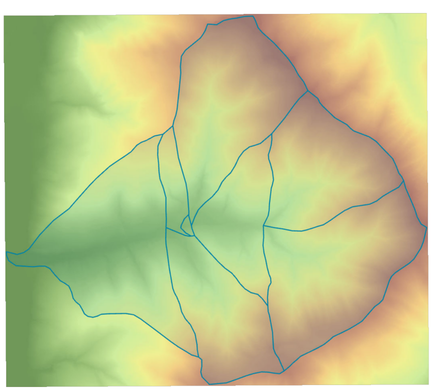

Figure 1: Elevation Layer, with the Thumersbach River's subcatchment basins on top. The greener the color, the lower the elevation. As expected, the catchment basin sits on a mostly concave area and is limited by the peaks surrounding it.

## 1 First Task

For Task 1, I was asked to create a hillshade layer for the basin and another showing the color-coded elevation.

For starters, I used the Clip Tool to crop the DEM to the extent of the catchment basin. The result can be seen in Figure 2.

After this, I used the aptly-name Hillshade Tool to generate the hillshade layer, whose result can be seen in Figure 2.

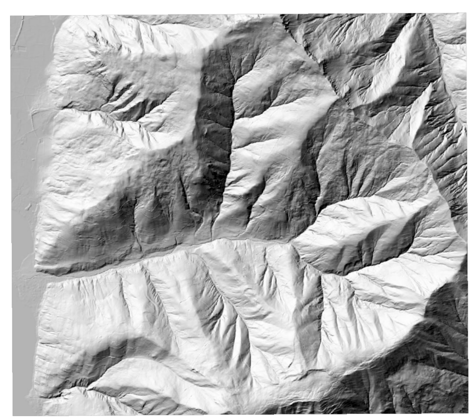

Figure 2: Hillshade layer generated using the clipped layer of the Salzburg DEM, using azimuth 315°and altitude 45°.

# 2 Second Task

For Task 2, I had to calculate the slope and aspect, and provide a slope histogram of the basin. However, my clipped layer also included the surrounding areas, so I had to remove them. Luckily, there is a tool for that!

I generated the slope layer using the Slope Tool and then I used the "Extract by Mask" Tool to remove the areas outside the catchment basin. The result can be seen in Figure. 3.

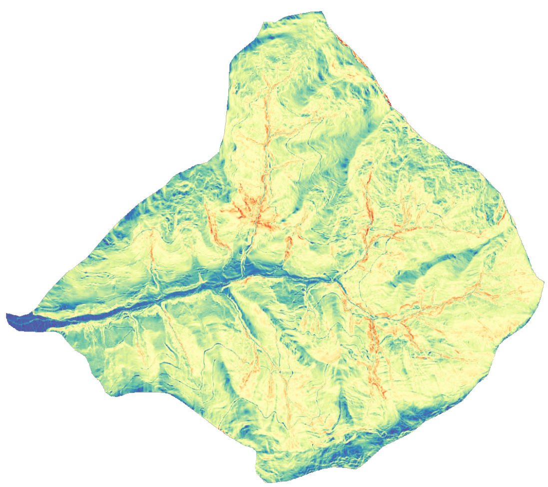

Figure 3: Slope layer after removing the areas outside the catchment basin. The bluer the color, the less steep it is.

And I repeated the same thing for the aspect, as seen in Figure 4. While doing this task, I also decided to create a new elevation layer without the surrounding areas. The reason I didn't generate the layers from the new elevation directly is because, usually, derivative-based algorithms (as is the case of the slope and aspect), reduce the number of pixels by one. By calculating the layers and only removing the surrounding areas lately, I'm hopefully preserving the number of pixels.

Finally, for the histogram, I used the helpful "Create a Histogram" Tool. The results can be seen in Figure 5. The shape is a bit skewed to the right, with the right tail being longer than the left one. On the other hand, there is a sharp decrease after the peak (mode), resulting in both the mean and median being smaller than the mode. This also matches what can be seen on Figure 3, where most of the image is green or yellow, and almost no red or dark red pixels can be seen.

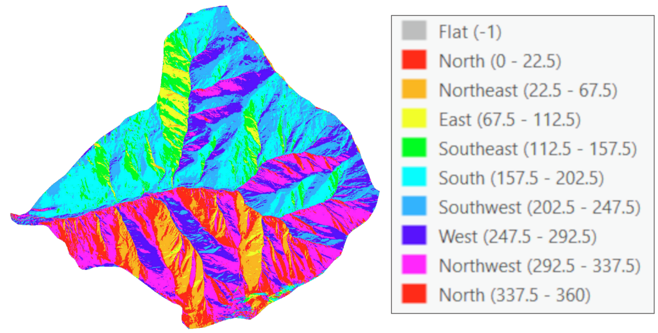


Figure 4: Aspect layer after removing the areas outside the catchment basin. Color Legend on the right

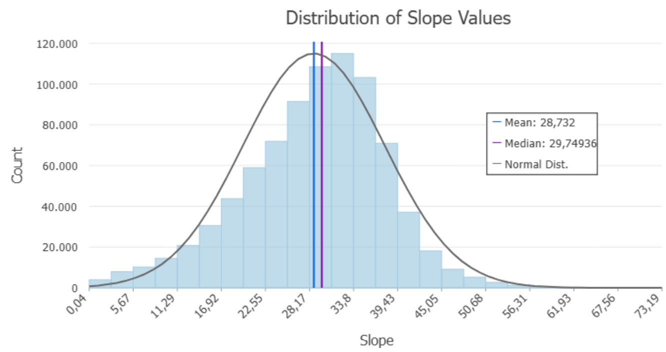


Figure 5: Histogram of the Slope in the Thumersbach River Catchment Basin. Mean value (average) marked in blue, and median value marked in purple. best-fitting normal distribution shown in grey.

# 3 Third Task

For Task 3, I was first asked to divide my Elevation layer by zones. Luckily, there's a tool for that too: the Contour Tool. I chose a spacing/interval of 250m and generated the new layer, as specified on Table 1 and visually represented in Figure 6.

| Zone Number | Lower Limit | Upper Limit |
|---|---|---|
| 1 | 749,78 | 750 |
| 2 | 750 | 1000 |
| 3 | 1000 | 1250 |
| 4 | 1250 | 1500 |
| 5 | 1500 | 1750 |
| 6 | 1750 | 2000 |
| 7 | 2000 | 2011,98 |

Table 1: Table of the lower and upper elevation limits of each of the generated zones. Although seven zones were created, the first and seventh zones are barely visible on the image.

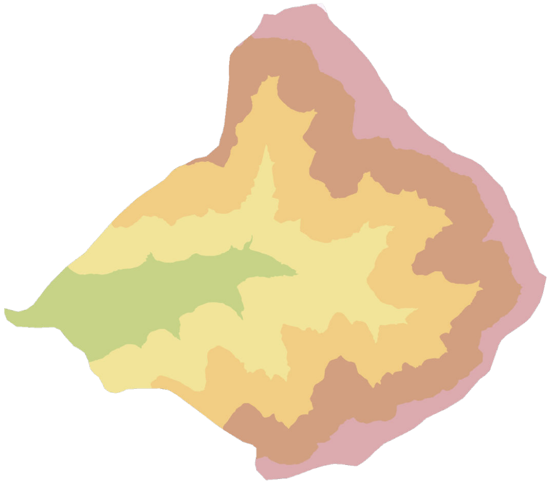

Figure 6: Elevation layer divided by elevation zone. As before, the greener the color, the lower is the average elevation of the zone.

Afterwards, I had to calculate the average slope for every zone. For that, I used the "Zonal Statistics" Tool, with the contour layer as the "Feature Zone Data" and the slope layer as the "Value Raster". The result can be seen in Figure 7 and the values are presented on Table 2.

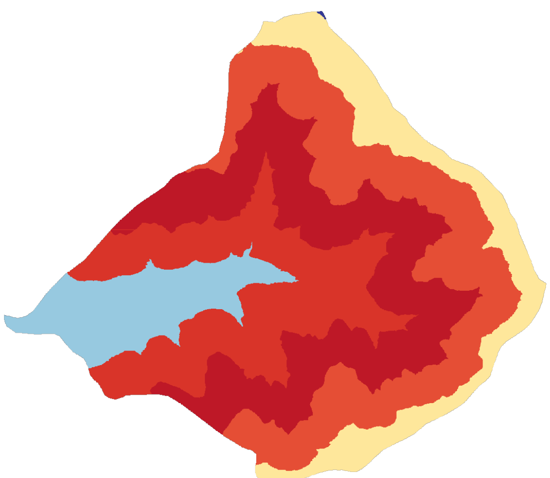

Figure 7: Mean of the slope for each elevation zone created in the previous step. The redder the color, the higher is the average slope of the zone. It should be noted that the slope's maximum is not at the summit, but along the escarpment.

| Zone Number | Average Slope (degrees) |
|---|---|
| 1 | 4,8 |
| 2 | 20,9 |
| 3 | 30,4 |
| 4 | 31,2 |
| 5 | 29,8 |
| 6 | 25,7 |
| 7 | 16,1 |

Table 2: Table of the average slope on each elevation zone created in the previous step. In accordance with the image, the maximum value is in Zone 4.

In addition to this, I also extracted slope histograms of each zone, which can be seen in Figure 8 (separate versions of the histograms were included in Figure 11 on the Appendix - Section 5). To accomplish this in an automatized way, I used the "Zonal Histogram" tool. The problem is that this tool doesn't use the real values of slope and instead splits the slope interval in 256 bins, making it hard to recover the real values afterwards. To avoid this, I used the Reclassify Tool first to reclassify my slope raster into a raster with 26 bins (the same number of bins I had used in the previous histogram). The correspondence between the slope values and the bin/class is made clear in Table 5 of the Appendix - Section 5.

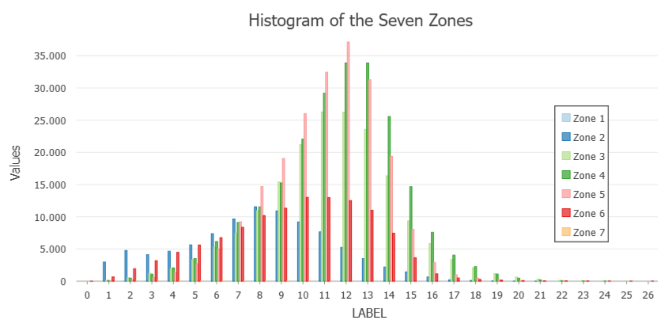


Figure 8: Histogram of the slope in each of the seven elevation zones. Zones 1 and 7 are virtually invisible.

# 4 Fourth Task

For Task 4, the goal was to redo everything using a resolution of 10m and 100m of my DEM, and comparing the results. To accomplish this, I started by creating those lower-resolution rasters with the Resample Tool. I used my Clipped Layer from Figure 2 as input and chose a Cubic Resampling Technic. Then, it was a matter of repeating all the steps twice. The most noticeable difference was the fact that only six elevation zones were created for the 100m resolution (since no pixels had an elevation below 750m), and the sixth zone didn't actually contain any full pixels.

Tables 3 and 4 show the average slope for each zone of each resolution, while Figures 9 and 10 show the histograms (separate versions of the histograms were again included in Figures 12 and 13 on the Appendix - Section 5). These histograms use the exact same classes defined for Task 3, in order to allow for a better comparison.

| Zone Number | Average Slope (degrees) |
|---|---|
| 1 | 2,4 |
| 2 | 20,4 |
| 3 | 29,9 |
| 4 | 30,7 |
| 5 | 29,4 |
| 6 | 25,2 |
| 7 | 15,3 |

Table 3: Table of the average slope on each elevation zone for the 10m resolution.

| Zone Number | Average Slope (degrees) |
|---|---|
| 1 | 17,3 |
| 2 | 25,2 |
| 3 | 26,1 |
| 4 | 26,5 |
| 5 | 20,8 |

Table 4: Table of the average slope on each elevation zone for the 100m resolution. The Zone Numbers here are not equivalent to the Numbers of the other two resolutions, given that the lowest-elevation layer is missing here.

The results for the 10m resolution are quite different from what was obtained with the 100m resolution.

For the 10m resolution, the average slope in each elevation zone is very close to what had been obtained for the original DEM, and the histogram is quite similar too; the biggest difference is that the right tail is now smaller, as the values in the 2 highest classes ended up being "smoothed out" by the neighboring pixels.

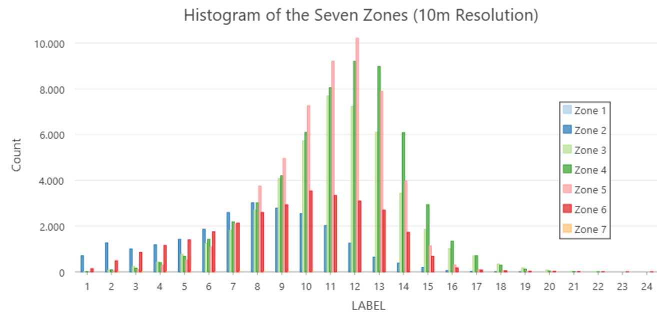


Figure 9: Histogram of the slope in each of the seven elevation zones for the 10m resolution. Zones 1 and 7 are virtually invisible.

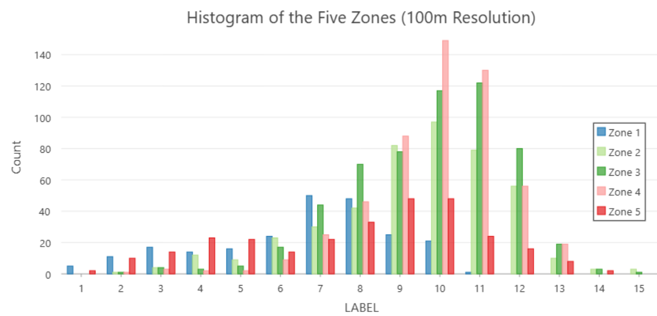


Figure 10: Histogram of the slope in each of the five elevation zones for the 100m resolution. The color scheme was chosen to match the elevation zones of the other resolutions, despite different designations.

On the other hand, in the 100m resolution, all the elevation zones have considerably lower averages, and not only do the histogram have much smaller right tails, some of them also have considerable differences in their shape. This is due to the highest classes once again being "smoothed out" by the neighboring pixels, but also the fact that the chosen interval for my histogram bins is now small in comparison to the DEM resolution, resulting in a reshuffling of values to neighboring classes. This is also why the most affected histograms appear to be the zones with a lower number of pixels (Zones 1 and 5).

# 5 Appendix

| Lower Limit | Upper Limit | Class |
|---|---|---|
| 0,04 | 2,85 | 1 |
| 2,85 | 5,67 | 2 |
| 5,67 | 8,48 | 3 |
| 8,48 | 11,29 | 4 |
| 11,29 | 14,11 | 5 |
| 14,11 | 16,92 | 6 |
| 16,92 | 19,73 | 7 |
| 19,73 | 22,55 | 8 |
| 22,55 | 25,36 | 9 |
| 25,36 | 28,17 | 10 |
| 28,17 | 30,99 | 11 |
| 30,99 | 33,80 | 12 |
| 33,80 | 36,61 | 13 |
| 36,61 | 39,43 | 14 |
| 39,43 | 42,24 | 15 |
| 42,24 | 45,05 | 16 |
| 45,05 | 47,87 | 17 |
| 47,87 | 50,68 | 18 |
| 50,68 | 53,49 | 19 |
| 53,49 | 56,31 | 20 |
| 56,31 | 59,12 | 21 |
| 59,12 | 61,93 | 22 |
| 61,93 | 64,75 | 23 |
| 64,75 | 67,56 | 24 |
| 67,56 | 70,37 | 25 |
| 70,37 | 73,19 | 26 |

Table 5: Correspondence between the slope values and the classes used in the histograms.

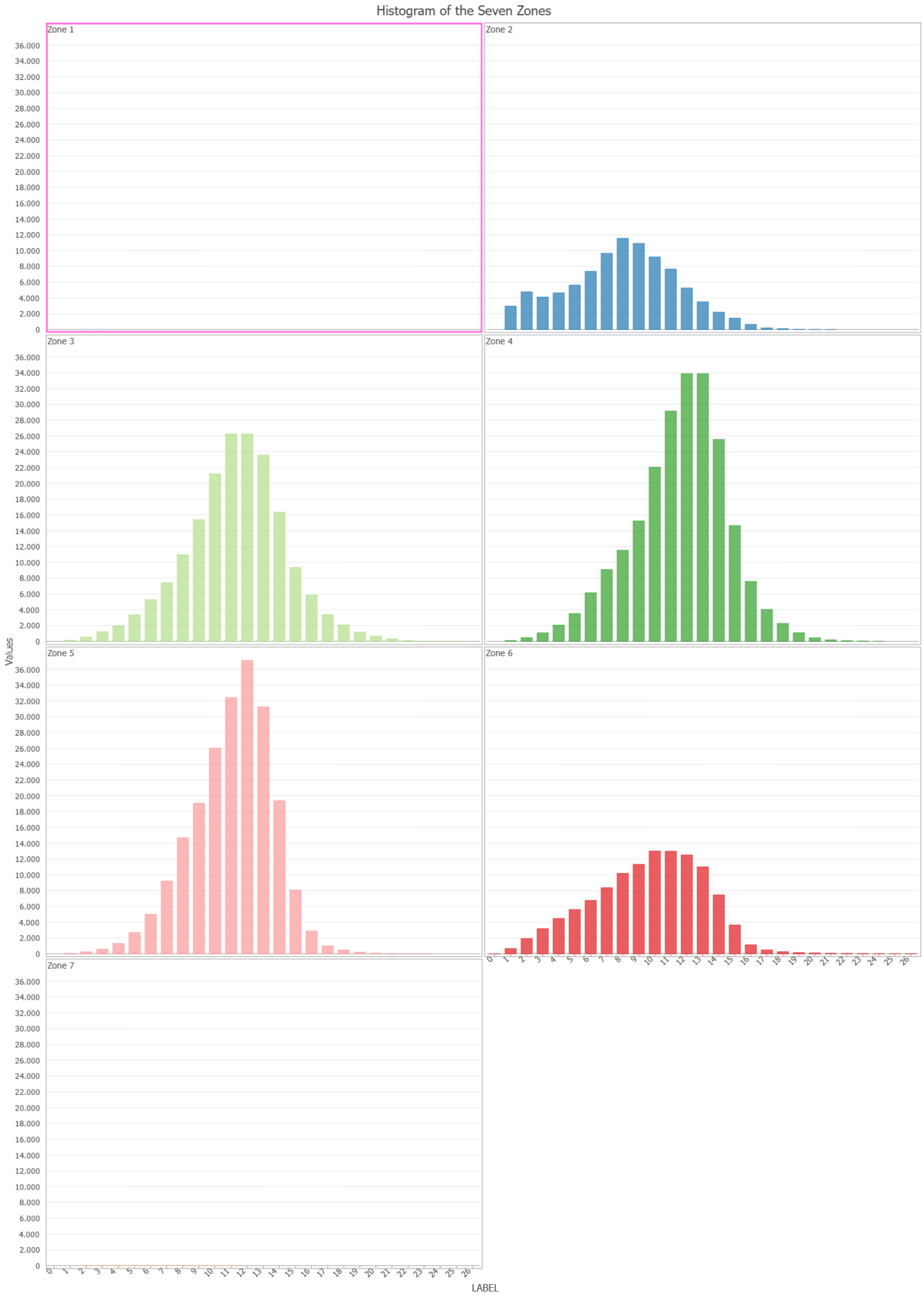


Figure 11: Separate histograms of the slope for each of the seven elevation zones of the 5m resolution.

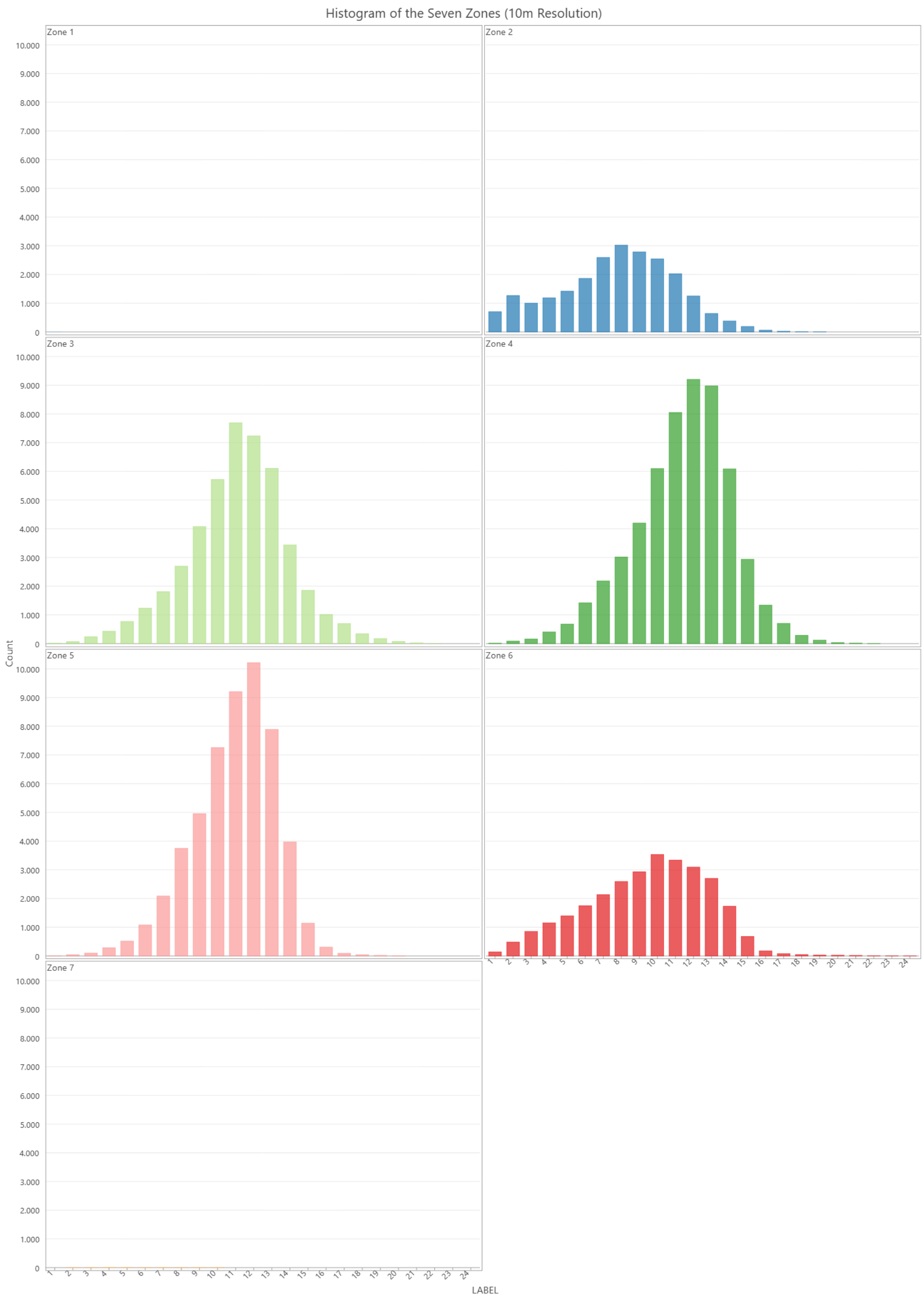


Figure 12: Separate histograms of the slope for each of the seven elevation zones of the 10m resolution.

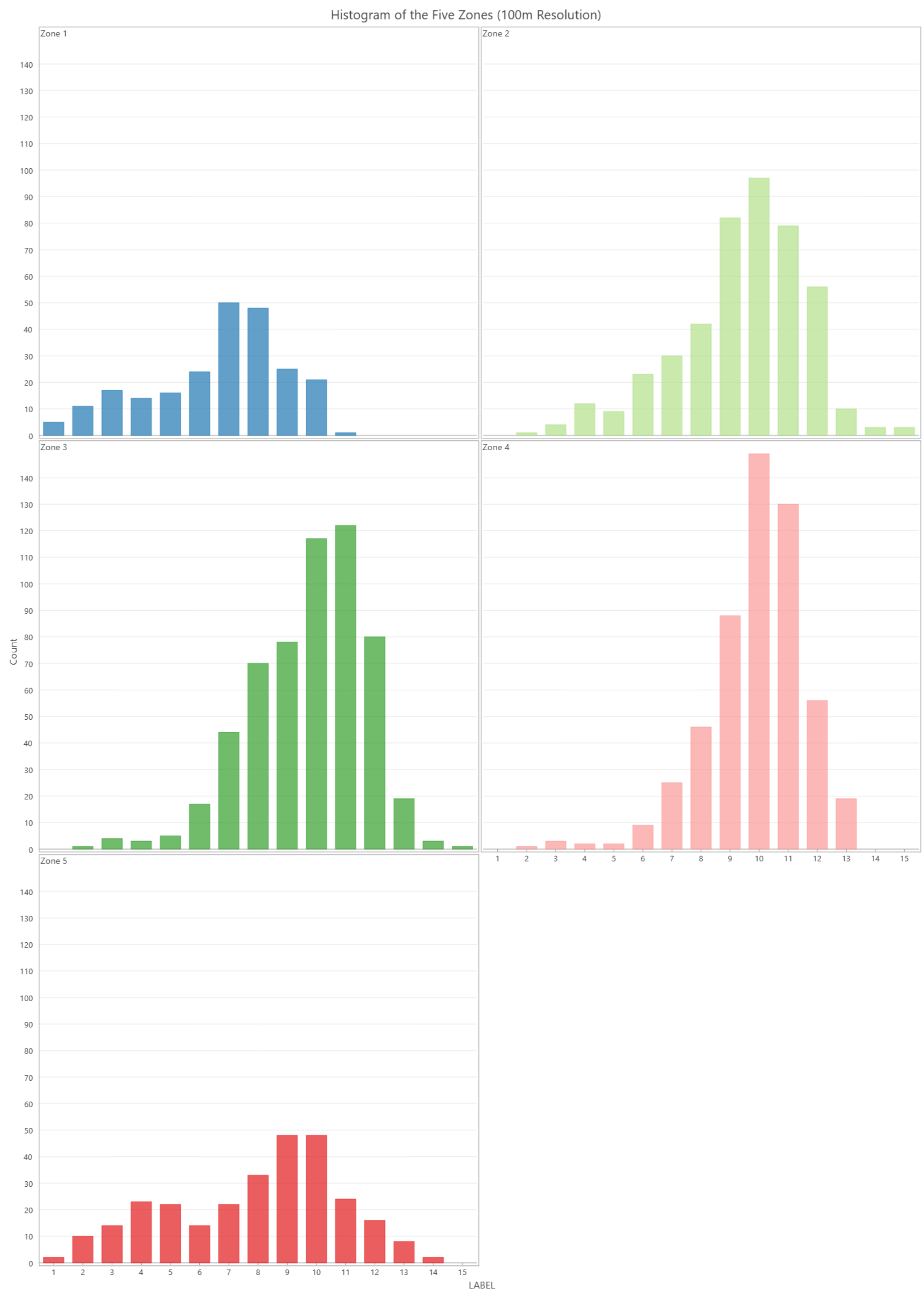


Figure 13: Separate histograms of the slope for each of the five elevation zones of the 100m resolution.