

# GIS 4 Geomorphology

Geomorphometry of Mountain Landscapes &  
Upland Watersheds...a little Wildlife, too

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## Landforms I: Hammond

Hammond-type macro landform mapping is accomplished using a DEM and the Spatial Analyst extension. Hammond's method was created for region-scale landform delineation. The steps below were reworked from Morgan et al. (2005). You should have this paper handy. I have retained Morgan's workflow, but modified the size and shape of their focal statistics neighborhood operator (changed from a 20×20 pixel radius to a 50×50 pixel rectangle), clarified reclassification routines, and updated language to match that used by ArcGIS Desktop. Input and output filenames are in quotes. We'll do the Hammond/Dikau landform model here. Look for the [MORAP landform model](#) in its own lesson. Instructions revised May 2016.

### LANDFORM = SLOPE + RELIEF + PROFILE

#### Tools You Will Use:

*Focal Statistics: Spatial Analyst tools > Neighborhood > Focal Statistics*

*Reclassify: Spatial Analyst tools > Reclass > Reclassify*

*Slope: Spatial Analyst tools > Surface > Slope*

*Raster Calculator: Spatial Analyst tools > Map Algebra > Raster Calculator*

*Project Raster: Data Mgmt tools > Projects and Transf > Raster > Project Raster*

*Clip: Data Management tools > Raster > Raster Processing > Clip*

#### SET UP

1.) Acquire a 30m DEM from EarthExplorer ([earthexplorer.usgs.gov](http://earthexplorer.usgs.gov)) or see [DEM Data Sources](#).

2.) Project DEM = "NED". For example: GCS\_NAD83 to NAD83\_UTM\_Zone12.

3.) Change Viewframe display coordinate system to NAD83\_UTM\_Zone12 (View > Data Frame Properties > Coordinate System tab > Select...)

#### SLOPE INPUT PARAMETER

4.) Create Slope raster, percent rise. Output raster name = "slope\_p".

5.) Reclassify Slope raster to delineate areas with slopes less than 8% from areas with slopes greater than 8%. I

the slope raster as the input. Use the Reclassify tool to create 2 classes (lump Old Values into 2 groups, 0% – 8% and 8% – maximum%) to create New Values. Set the class Break values at 8% and the maximum slope value in the distribution (usually the default value). Break values always represent the upper value for the range of values to be classified. Set the New Values of 0 for pixels with slopes less than 8%. Set a New Value of 1 for slopes less than 8%. Name the output raster “slope\_reclass”.

*This is raster reclassification. Reclassification involves chopping up the histogram and assigning new values (grouping pixels into classes, each of which will get a new value). The goal of this step is to identify flat areas at the resolution of the DEM – a preliminary step in the landform delineation process. You start with the histogram of pixel values in your raster. Determine the number of classes needed (in this case 2). Determine what the range of pixel values will be included in each (identify break value). The break value here is 8. Now assign all the pixels in the first class the value of 0 and the second a value of 1. The original slope values go away and you are left only with values of 0 (nearly level pixels) and 1 (steeper pixels).*

6.) Save .mxd.

7.) “Map6” = Focal Stats, input = slope\_reclass, 50x50 cell, rectangle, sum.

*This step smooths the slope raster using a 50 pixel neighborhood, which produces a more coherent, less noisy map.*

8.) “Map7” = Open attribute table for slope\_reclass raster. Calculate percentage of class 0 pixels. Write this down. This is the percentage of “nearly level land” in your project area.

*This step should probably go before the Save Your Work step (Step #6), since the input is slope\_reclass. Anyways, the goal here is to simply determine how many pixels constitute each class (0=nearly level land, 1=steeper areas). In the example...*

*Example:*

*Nearly Level Land = Class 0 = 89,635 pixels = 14% of total pixel count*

*Steeper = Class 1 = 549,990 pixels = 86% of total pixel count*

*Total pixel count for the raster = 639,625 pixels*

*So, for this example dataset, you would write down 89,635 pixels (14%) for Nearly Level Land.*

9.) “Map8” = Reclassify, input = Map6, 4 classes, toggle to show break values where the default maximum is 100; if you do not toggle to get correct values (the little button with % on it), you will regret it. Use Break Values = 20, 50, 80, 100 corresponding to the New Values = 400, 300, 200, 100 (<– these 4 New Values may be listed in reverse order; I’m checking original source papers by Hammond and Morgan et al.. Thanks for the heads up, Mateus!).

*This step reclassifies the smoothed slope raster into 4 classes, where smoothed slope pixels (old values) get assigned new values based on the 4 break values...*

*(old values) 0 to 20 → 400 (new value)*

*(old values) 20 to 50 → 300 (new value)*

*(old values) 50 to 80 → 200 (new value)*

*(old values) 80 to 100 → 100 (new value)*

**RELIEF INPUT PARAMETER**

- 10.) "Map9" = Focal Stats, input = projected DEM, 50x50 cell, rectangle, max.
- 11.) "Map10" = Focal Stats, input = projected DEM, 50x50 cell, rectangle, min.
- 12.) "Map11" = Raster Calculator equation -> "Map9"- "Map10"
- 13.) "Map12" = Reclassify, input = Map11, 6 classes, BVs = 30, 90, 150, 300, 900, max value, New Values = 10, 20, 30, 40, 50 60.

**PROFILE INPUT PARAMETER**

- 14.) "Map13" = Raster Calculator "Map11"/2.
- 15.) "Map14" = Raster Calculator equation -> "Map10"+ "Map13"
- 16.) "Map15" = Raster Calculator equation -> "Map14"- "NED"
- 17.) "Map16" = Reclassify, input = Map15, 2 classes, BVs = 0, max value, New Values = 1, 2.  
*Note: When setting Break Values, toggle the "%" button to find the correct value range to classify (there are two choices). Otherwise, your break values won't make sense. The correct one has a minimum value that is a negative number. Values greater than zero are "lowlands". Values less than zero are "uplands".*
- 18.) "Map17" = Reclassify, input = Map16, BVs = 1, max, New Values = 1, 0.
- 19.) "Map18" = Raster Calculator equation -> "Map17"\*\*slope\_reclass"
- 20.) "Map19" = Focal Stats, input = Map18, 50x50 cell, rectangle, sum.
- 21.) "Map20" = Raster Calculator equation -> Float("Map6")
- 22.) "Map21" = Raster Calculator equation -> "Map19"/"Map20"
- 23.) "Map22" = Raster Calculator equation -> "Map17"\*\*Map21"
- 24.) "Map23" = Reclassify, input = Map22, 3 classes, BVs = 0, 75, 100, New Values = 0, 2, 1.
- 25.) "Map24" = Reclassify, input = Map16, Bvs = 1, max value, New Values = 0, 1.
- 26.) "Map25" = Raster Calculator equation -> "slope\_reclass"\*\*"Map24"
- 27.) "Map26" = Focal Stats, input = Map25, 50x50 cell, rectangle, sum.
- 28.) "Map27" = Raster Calculator equation -> "Map26"/"Map20"

29.) "Map28" = Raster Calculator equation -> "Map24"\*\*"Map27"

30.) "Map29" = Reclass, input = Map28, 3 classes, BVs = 50, 75, 100, New Values = 0, 3, 4.

31.) "Map30" = Raster Calculator equation -> "Map23"+"Map29"

32.) "Map31" = Reclass, input = Map30, 2 classes, BVs = 0, maximum, New Values = 0, 1.

33.) "Map32" = Raster Calculator equation -> "Map8"+"Map12"

*Note: This is the Hammond Landform raster.*

### LANDFORM MODEL

34.) "Map33" = Raster Calculator equation -> "Map32"+"Map31"

35.) Reclassify landform map according to Dikau's landform codes. New Values and BVs are below:

11 411-414

12 421-424

13 311-321

14 321-324

21 433-434, 333-334

22 443-444, 343-344

23 453-454, 353-354

24 463-464, 363-364

31 431-432, 331-332

32 441-442, 341-342

33 451-452, 351-352

34 461-462, 361-362

41 211-214

43 231-234

44 241-244

45 251-254

46 261-264

51 111-114

52 121-124

53 131-134

54 141-144

55 151-154

56 161-164

37.) "Map35" = Focal Stats, input = Map34, 5x5 cell, rectangle, majority.

*Note: Majority filter removes small contrasting areas (noise). I've changed this from an 8x8 to a 5x5 neighborhood.*

*Thanks Frank!*

38.) Create a rectangle to use as a clipping boundary (or use an existing shapefile).

39.) "FinalMap" = Clip, input = Map35, output extent = clipping box shapefile, check the box "Use Input Features...".

40.) Add a labels field to the attribute table for FinalMap to and type in labels:

- 11-Flat or nearly flat plains
- 12-Smooth plains with some local relief
- 13-Irregular plains with low relief
- 14-Irregular plains with moderate relief
- 21-Tablelands with moderate relief
- 22-Tablelands with considerable relief
- 23-Tablelands with high relief
- 24-Tablelands with very high relief
- 31-Planis with hills
- 32-Plains with high hills
- 33-Plains with low mountains
- 34-Plains with high mountains
- 41-Open very low hills
- 42-Open low hills
- 43-Open moderat hills
- 44-Open high hills
- 45-Open low mountains
- 46-Open high mountains
- 51-Very low hills
- 52-Low hills
- 53-Moderate hills
- 54-High hills
- 55-Low mountains
- 56-High mountains

40.) "FinalPolys" = Convert FinalMap to vector (polygons) with ArcToolbox > Conversion Tools > Raster to Polyg

41.) Change symbology/color scheme.

42.) Create a hillshade raster, drag it to top of stack, change transparency to ~60%.

### Refs:

Hammond (1964a,b)

Morgan et al., (2005) Developing Landform Maps Using ESRI's ModelBuilder, ESRI User Conf. Proc, 11 pgs. [PDF](#)