GIS 4 Geomorphology

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

Welcome ! Ask a Question Maps I Make

Drainage Density

There are several ways to determine Drainage Density.

A Few Quick Notes:

If you have a shapefile of your stream network, then simply calculate the total number of linear kilometers (total li length in a new field in attribute table; use the Field Calculator) and divide by the area of your watershed, project boundary, etc. (use a regular calculator). Most countries have a GIS website with streamlines available (i.e., in the USA it is the "NHD" dataset), though these are often created at too coarse of a scale for use on student researc projects.

If you do not have a stream network shapefile (or need a finer resolution stream network than what is available), then you need to create it yourself from a DEM. To do this, follow the instructions for Watershed Delineation thro Step #14. These instructions assume you are looking for drainage density inside a watershed boundary.

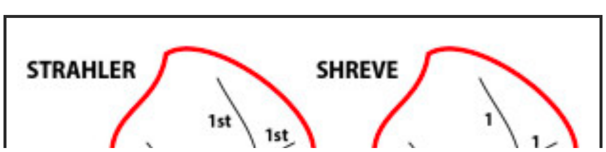
If you have a stream layer shapefile, but your study area is not a watershed (you want to calculate drainage dens for a study area polygon), then run through the Watershed Delineation lesson Steps #1 through #6, then Steps # through #18. In Step #14, substitute your study area polygon for the watershed boundary and clip out the strea network inside it.

DRAINAGE DENSITY CALCULATION METHODS

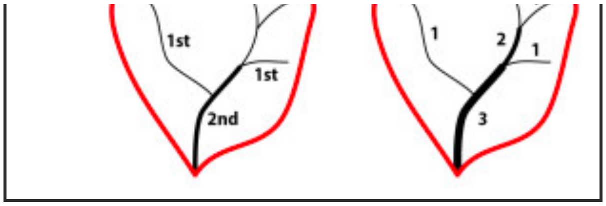
A.) **Stream Frequency**

Stream frequency is the count of all stream segments per unit area of a basin. It describes the texture of a strea network and strongly reflects bedrock properties (strength, fracture density, infiltration, mass wasting tendencies and/or those of surficial material properties if thick (i.e., deep till deposits). Comparisons of basin stream frequen can be made for basins that are underlain by different bedrock types.

– Order the stream network (Stream Order tool) to break network into segments defined by confluences, see Ste #11 in Watershed Delineation lesson. Be careful to examine the network carefully. Places where the channel is represented by clusters of pixels (rather than as a string of single pixels) may be receive their own order. These should be subtracted from the segment count.



– Count streams segments between confluences.



— The 2 methods of ordering streams in a watershed: Strahler and Shreve.

Segment length is not figured here, only the numb of stream segments and the total basin area.

– Basin area is found by multiplying number of pixe in the *watershed* layer (Step #10 Watershed Delineation) by the area of a single pixel (Properties Source tab).

– Stream count per square kilometer is commonly reported.

F = N/A

F = Stream frequency (total number of channels per unit area)

N = Number of channels of all stream orders

A = Basin area

B.) **Drainage Density**

Drainage density of a basin is the total line length of the stream network divided by basin area. 2D length (planimetric length) or 3D length (slope length) may be used. A high density may indicate one or more of the following: a “mature”, well developed channel system exists, surface runoff moves rapidly from hillslopes (overlar flow) to channels, thin/deforested vegetation cover, basin rocks/soils/surface has generally low infiltration rate (highly impervious geology or abundant impervious manmade surfaces). It also describes the texture of a stream network.

– In ArcGIS, begin with a polyline shapefile of the stream network.

– Add a new field to the attribute table named Length_km (Float format).

– Calculate Geometry for length to populate the field.

– Right-click on field name (header row) > Statistics > Sum. Sum is the total length of the network in kilometers.

– Basin area is found by multiplying number of pixels in the *watershed* layer (#10 Watershed Delineation) by the area of a single pixel (Properties > Source tab).

DD = sum(L) / A

DD = Drainage density

L_C = Length of channel

A = Basin area

C.) **NHD Method**

Download hydrography shapefiles from National Hydrography Dataset website (comes as a geodatabase, .gdb) The Flowline layer is an “official” network of larger streams, which will differ from networks generated from flow accumulation rasters. Recall that flow accumulation raster delineates channels, depending on initiation thresholc

DEM resolution, etc.), more channels many of which do not see flow. The streamlines are segmented at confluences. Select and clip streams to basin margin. Use Attribute Table to sum the flowline segment lengths fo the basin. Use this value in Frequency or Density calculation.

D.) **Pixel Method using only a DEM**

An index of Drainage Density can also be derived from a reclassified flow accumulation raster (Step #6 Watershe Delineation). Each “channel” pixel in the reclassified raster represents an area. Recall that reclassification involves grouping the flow accumulation values into 2 classes (channel pixels and hillslope pixels) and changing their respective values (1=channel pixels and NoData = hillslope) using a channel initiation threshold value of your choosing. This method demands that we assume the channel is just one pixel wide. This is likely not the case fo 30m DEM, but go with it. If you have access to LiDAR data, true channel widths could be found.

– Start with a raster containing only channel pixels for the watershed.

– Find the total number of pixels in the network (Properties > Symbology > choose the Classified method on left sidebar > click Classify button > see Sum in Summary Statistics box). Record this value.

– Convert to an area by multiplying pixel count (Sum) by area of a single pixel (find in Properties > Source tab).

– Watershed area (km2) is found by multiplying number of pixels in the *watershed* raster (#10 Watershed Delineation) by the area (km2) of a single pixel (find in Properties > Source tab).

– Divide the channel network area by the watershed area. You end up with an area/area number. If the pixel met is used, it must be used for all basins you compare.

Interpretation of Drainage Density Values

Drainage density is related to runoff erosivity and vegetation resistivity, which vary with climate. Relief and chann concavity may play a role as well (Collins & Bras, 2010). These authors found that equilibrium between vegetatic dominated and runoff-dominated sediment flux occurred at Central Plains Experimental Range (CPER), a portior Pawnee National Grasslands. The CPER is not a mountain landscape, rather it is a semi-arid shortgrass steppe (100-500mm MAP, 1254mm ET) located far south of the glacial margin in NE of Fort Collins, CO (Great Plains/Colorado Piedmont physiographic province). Sediment flux occurs through rilling and gullying. Low draina density, high relief, and low channel concavity conditions are present in their study area.

Refs

Collins and Bras (2010) Water Resources Research 46

Rinaldo et al. (1995)

Moglen et al (1998)

Tucker & Bras (2000)

Schumm (1958)