# Geomorphic/Hydrologic Characteristics of Terrain

The TNTmips Watershed process (Terrain / Watershed) models the surface movement of water through landscapes by delineating drainage patterns and watershed boundaries from an input digital elevation raster. Surface water movement plays an important role not only in the hydrologic cycle, but also in soil erosion, sediment yield, and the movement of sediment and other pollutants through watersheds. It also affects the landscape-dependent development of soil properties and is a major factor governing vegetation patterns. In addition to its standard products, the Watershed process can optionally create a number of derived, higher-level raster products that depict cell-by-cell geomorphic and hydrologic characteristics of the terrain that are useful as input to predictive hydrological models and other environmental models. Computation of each of the products described below is activated by a separate toggle button on the General panel of the Watershed Analysis window. Useful hydrologic attributes are also computed for stream lines, catchments (watersheds) and subcatchments (basins) and stored in attached database tables; these attributes are described on the Technical Guides entitled *Terrain Operations: Hydrologic Attributes of Catchments* and *Terrain Operations: Hydrologic Attributes of Flowpaths*.

(1) **Specific Catchment Area** is a raster object depicting for each cell the upslope contributing area per unit flow width perpendicular to the flow direction. The upslope contributing area (in square meters) is derived from the local flow accumulation value and the cell dimensions. The unit flow width (in meters) is computed from the cell dimensions and local flow direction, and varies depending on whether the flow direction is horizontal, vertical, or diagonal (in 2D raster space) through the cell. Specific catchment area is used as a parameter in modeling runoff on slopes and resulting soil erosion (and thus sediment yield).

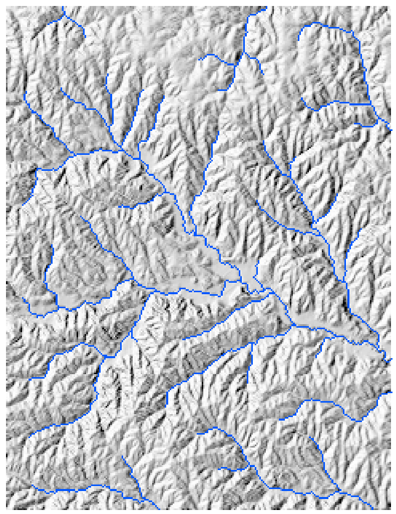
(2) **Slope** is a raster object showing the maximum terrain slope in degrees for each cell. Slope values are computed from the depressionless DEM using the elevation of each cell and that of its four nearest neighbors.

(3) **Length-Slope** is a raster object depicting an approximation of the combined Length-Slope (LS) factor used in computing the Revised Universal Soil Loss Equation (RUSLE) for erosion due to overland flow. In field studies this factor is derived from the slope over the length of a standard test plot, but for GIS use it can be approximated for individual DEM cells. Computation of the Length-Slope raster requires computation of both Specific Catchment Area and Slope rasters, so turning on the Length-Slope checkbox automatically turns on the other two (if not already on).

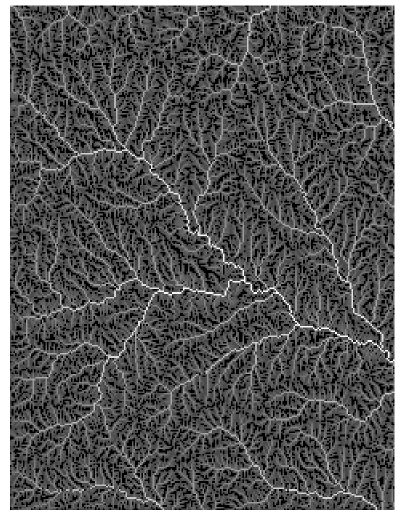
The expression used to compute the Length-Slope raster value for each cell† is as follows:

LS = (specific catchment area / 22.13) ^0.6 *
(sin[slope] / 0.0896) ^1.3

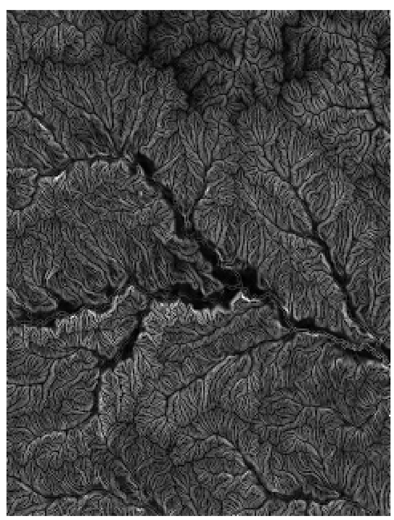
† page 89 in Wilson, J.P. and Gallant, J.C., 2000, Terrain Analyis: Principles and Applications. New York, John Wiley & Sons.



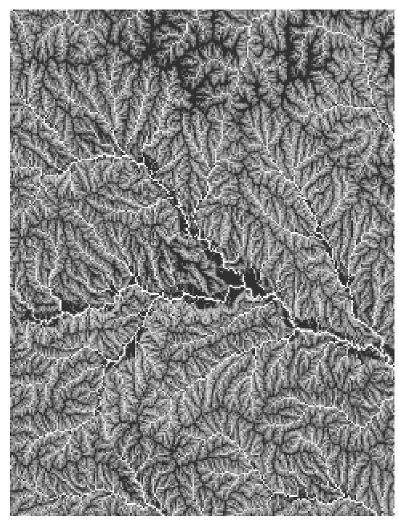
Shaded relief image of sample area with flowpaths computed by the Watershed process.



(1) Specific catchment area raster. Brighter tones indicate larger catchment areas, so brightest tones trace stream channels.



(2) Slope raster. Brighter tones indicate higher slopes. The lowest slope values are on valley floors and ridge tops.



(3) Length-Slope raster computed from specific catchment area and slope. High values occur along major flowpaths due to high values of specific catchment area.

(over)

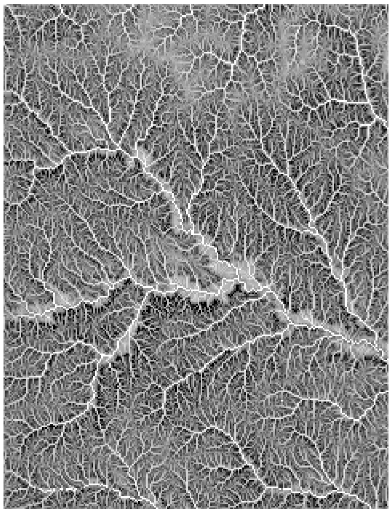
④ **Compound Topographic Index** (CTI) is a raster object that is computed as follows:

CTI = natural log ( Flow Accumulation / tan (slope) ).

CTI, also referred to as a Wetness Index, predicts zones of increased soil moisture where the landscape area contributing runoff is large and where slopes are low, such as at the base of hillsides and in valley bottoms. This property is used in soil landscape modeling and in analysis of vegetation patterns.

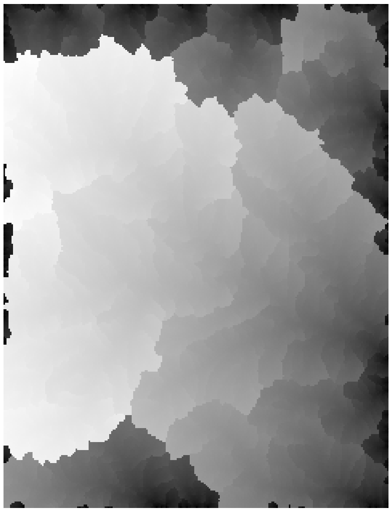
⑤ **Maximum Upstream Flow Distance** is a raster object that records for each cell the longest flow distance from the upstream watershed boundary to the cell. This property can be used in modeling sediment yield and erosion rates.

⑥ **Downstream Flow Distance** is a raster object that maps the flow distance downstream from each cell to the outlet of its watershed. This distance has applications in analysis of downstream dispersal of sediment or other pollutants.



④ Compound Topographic Index (CTI) raster. Brighter areas are more likely to have saturated soils.

⑤ Maximum upstream flow distance raster. Cell value equals the longest flow distance from the upstream watershed boundary to that cell.



⑥ Downstream flow distance raster. Cell value equals the downstream flow distance from the current cell to the watershed outlet.