Creating a Soil Topographic Index
• A procedure for generating maps of soil topographic index (STI) from TI maps and soil data. The procedure for generating a topographic index (TI) map from DEM is described in “Creating TI map”.
**STI** grids are soil topographic index grids, derived from digital elevation models (DEM) and SSURGO soils data. This grid incorporates SSURGO soils data into the index class in the form of the soil transmissivity (depth x conductivity). Thus it may better capture distributed landscape flow processes, and correctly predict saturated areas where the soil is shallow, or has a low conductivity in addition to the topographic position. In basins where the **TI** predicts saturated areas well, the **STI** generally provides better predictions of saturated areas unless soils are uniform.
There are several variants of STIs described in the literature. Below are several:

\[
\lambda_i = \ln\left(\frac{\alpha_i}{T_i \tan \beta_i}\right) = TI_i - \ln(T_i)
\]

(1)

where: \(\lambda_i\) is soil topographic index of grid cell \(i\) of the watershed, \(\alpha_i\) is the upslope contributing area per unit length of contour, \(T_i\) is soil transmissivity of the soil surface layer of grid cell \(i\) of the watershed, and \(\beta_i\) is the topographic slope of the cell.

Soil transmissivity is defined as the product of soil depth and saturated hydraulic conductivity of the soil.
Another version considers the value of $T_i$ scaled to the watershed-average value (Sivapalan et al., 1987). Given multiple watersheds, this STI could be used to compare or combine them into a single watershed:

$$
\lambda_i = \ln\left(\frac{\bar{T} \alpha_i}{T_i \tan \beta_i}\right) = TI_i - \ln\left(\frac{T_i}{\bar{T}}\right) = TI_i - \ln(T_i) + \ln(\bar{T})
$$

(2)

where: $\bar{T}$ is average soil transmissivity of the watershed

Note that if $\bar{T}$ is the geometric mean of $T_i$ over the watershed (i.e., equivalent to the arithmetic mean of $\log(T_i)$), then the average value of STI is the same as the average value of TI (without transmissivity). We will use the TI map of Townbrook created in an earlier exercise watershed as an example:
TI map
First, we need to download the soil data from the USDA-NRCS Soil Data Mart website (http://soildatamart.nrcs.usda.gov/):
To download the STATSGO soil data, click on “US General Soil Map”, enter email address, and click on “Submit Request”. A FTP address for downloading the requested soil data will be sent to the email address. To download the SSURGO soil data, click on “Select State”, select desired state, click on “Select Survey Area”, select desired survey area, and click on “Download Data”. Since SSURGO data are distributed on the county basis, downloading all the desired soil data may take a long time if the watershed is large. Another website for downloading soil data is USDA Geospatial Data Gateway (http://dataqateway.nr.cs.usda.gov/):
We need to extract two soil parameters, soil depth and saturated hydraulic conductivity, from downloaded soil data. This can be done through Soil Data Viewer, which can be downloaded from http://soildataviewer.nrcs.usda.gov/download51.aspx:

This program is installed as an ArcGIS extension, and you will see a new menu button after it is installed:
Clicking on the button will open the Soil Data Viewer. Before opening the Soil Data Viewer, however, a soil database for the downloaded soil data needs to be constructed using Microsoft Access. The downloaded soil data have (1) a “spatial” folder containing spatial dataset such as ArcGIS shapefiles, (2) a “tabular” folder containing tables of soil parameters such as soil depth and saturated hydraulic conductivity, and (3) a Microsoft Access template file (such as “soildb_US_2002.mdb”), which is used to create a soil database.

You need to enter the path name for the folder containing the tabular data, e.g., “F:\SSURGO\gsmsoil_ny\tabular”. After the soil database will be constructed, close the Microsoft Access. Now you are ready to open the Soil Data Viewer. First, start the ArcGIS program and open the soil map stored in the “spatial” folder (e.g., “soilmu_a_ny025”).
Clicking on the Soil Data Viewer button will open the Soil Data Viewer:
• Note that the “Database” should be selected as the soil database created using the Microsoft Access (see above).
• To create a map of saturated hydraulic conductivity, click on “Soil Physical Properties” and select “Saturated Hydraulic Conductivity (Ksat)” at the surface layer with the “weighted average” aggregation method:
Clicking on “Map” will create the map (Shapefile) of saturated hydraulic conductivity (in $\mu$m/s):
The map of soil depth can be created in a similar way, by clicking on “Soil Qualities and Features” and selecting “Depth to Any Soil Restrictive Layer” with the “weighted average” aggregation method:

Again, clicking on “Map” will create the map of soil depth (in cm):
After generating these maps, they should be merged as necessary and clipped using watershed boundary map. Finally, they should be converted to rasters with the same resolution as the original TI map. An example below shows the maps of saturated hydraulic conductivity and soil depth for the Townbrook watershed:
Soil transmissivity (in m$^2$/day) is defined as the product of soil depth (in cm) and saturated hydraulic conductivity (in µm/s). To generate the map of soil transmissivity, use the Raster Calculator to multiply these two maps with the unit conversion factor of 0.000864 ($= (1/10^6) / (1/60/60/24) * (1/100)$):

The resulting soil transmissivity raster for Townbrook is shown below:
Let's first create a STI using Eq. 1 (the more common method). We need to bring in the $\alpha$ and $\beta$ rasters that we created in past exercise. To create a STI use the raster calculator:

The STI
We will now generate the STI map using the equation (2) above. To do this, we need to know (arithmetic mean of T). Open the original TB_Trans, right-click on the new map name “Calculation” and select “Properties…”. The “Layer Properties” window will be opened, and you can find the mean of $T_i$ at the “Source” tab:

Copy the value into the clipboard. Now we are ready to use the Raster Calculator to type in Equation (2):
Notice that in Townbrook normalizing by the average $T$ does not change the result much at all.
References: