Creating SCS Curve Number Grid using Land Cover and Soil Data

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Objective

The objective of this session is to learn how to generate a raster dataset of SCS Curve Number for any watershed by using land cover and soil data. The SCS curve number method is used in many hydrologic models for computing excess rainfall. Having a curve number grid gives you the utility of extracting curve number for any area in the watershed without performing any calculations.

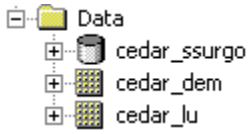
Learning Outcomes

1. Raster operations using ArcGIS spatial analyst
2. Editing attributes of vector features in ArcGIS using field calculator
3. Performing join operations
4. Converting raster data to vector data
5. Creating a map of SCS CN by using land use, soil and CN lookup table

Input Data

The main data that you need for this lab are clipped DEM, Land Cover, and soil data. All of these you have created in your previous labs for Cedar Creek. These datasets are provided in Lab 5 folder on Blackboard or at ftp://ftp.ecn.purdue.edu/vmerwade/download/data/cngrid.zip

Get the data from blackboard or the ftp site, and unzip in your working directory. The ArcCatalog-view of the data folder (or whatever name you gave to your working folder) is shown below:



cedar_ssurgo is the geodatabase with SSURGO spatial and tabular data for cedar creek area. *cedar_dem* is a filled 30m resolution DEM for Cedar Creek obtained from USGS and clipped for the study watershed, and cedar_lu is the 2011 land cover grid from USGS. All datasets have a common spatial reference (NAD_1983_UTM_16).

Note: It is very critical to assign and use consistent coordinate system for all the datasets.

Computer Requirements

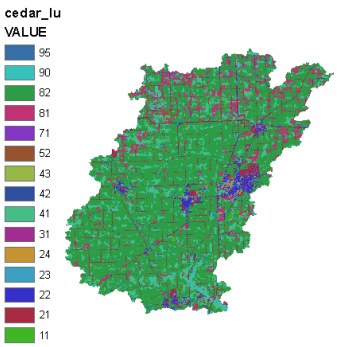
You will need ArcGIS 10.x with spatial and 3D analyst extensions on a windows computer, but the instructions should still work for most part if you are using a different version of ArcGIS. The instructions provided in this exercise do not apply to ArcView 3.x! You will also need the appropriate version of HEC-GeoHMS installed on your computer.

Getting Started

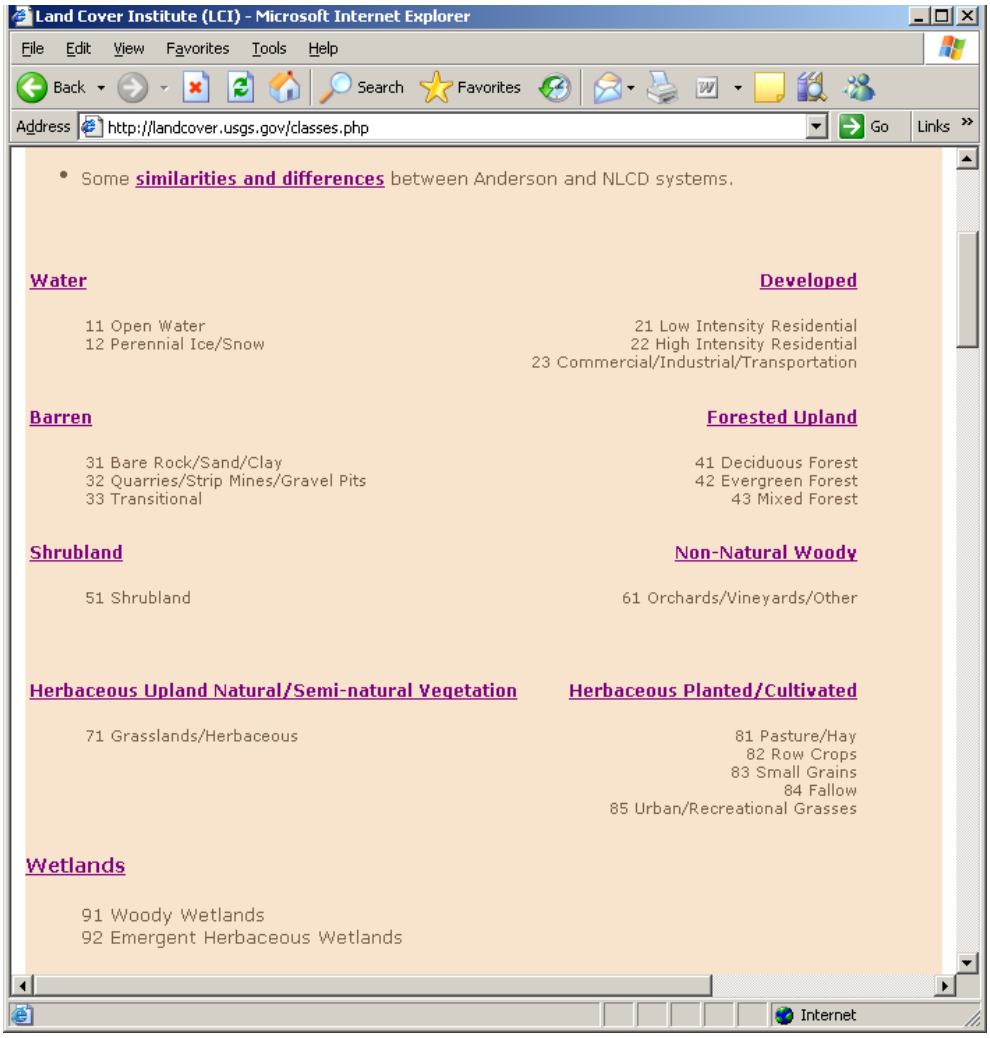
Open ArcMap and save it as cngrid or lab5 Activate the Spatial Analyst by going to *Customize→Extensions*…, and checking the box next to *Spatial Analyst*.

Preparing land use data for CN Grid

Add *cedar_lu* raster to the map document. You will see that the raster is added with a unique symbology assigned to cells having identical numbers as shown below (if your symbology is different just change is by going to properties and selecting Value field for unique values option in symbology):



These numbers represent a land use class defined according to the USGS land cover institute (LCI). A description of some of the land classes and their associated numbers in the grid is shown below by reproducing LCI webpage (http://landcover.usgs.gov/classes.php). You can visit LCI website (publications link) to learn more about how the land use grid is created.

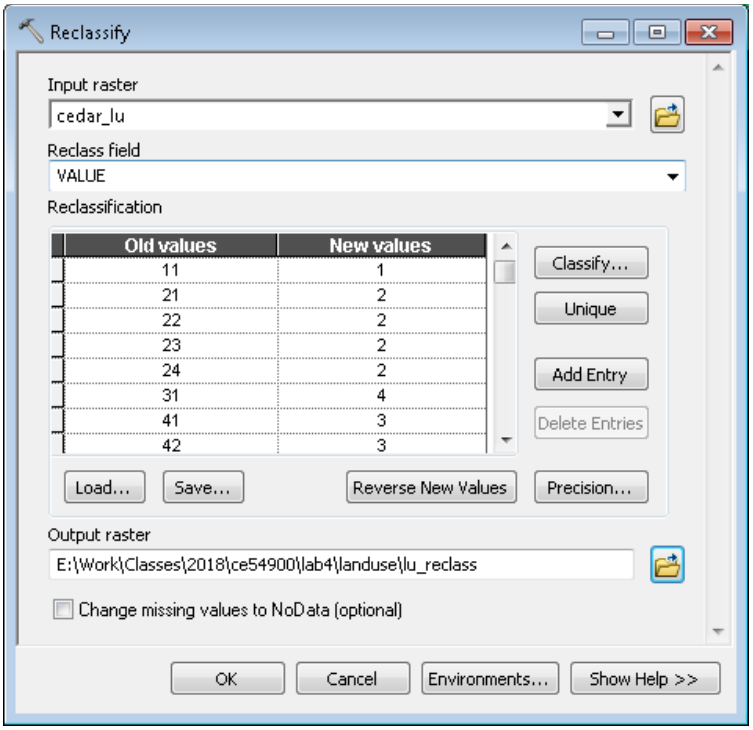


Eventually, we are going to use these land use classes and soil group type, in conjunction with SCS curve numbers, to create the curve number grid. The SCS CN table gives CN for different combinations of land use and soil group. The *cedar_lu* grid has 15 different categories which you can leave unchanged, or reclassify the grid to reduce the number of land use classes to make the task easier. If you open the attribute table of *cedar_lu*, you will see that majority of cells represent grass/crops, followed by forest, developed land, and then water. We will reclassify *cedar_lu* to represent these four major classes. The following table shows how we will accomplish the reclassification of *cedar_lu* (you are free to have more or less classes).

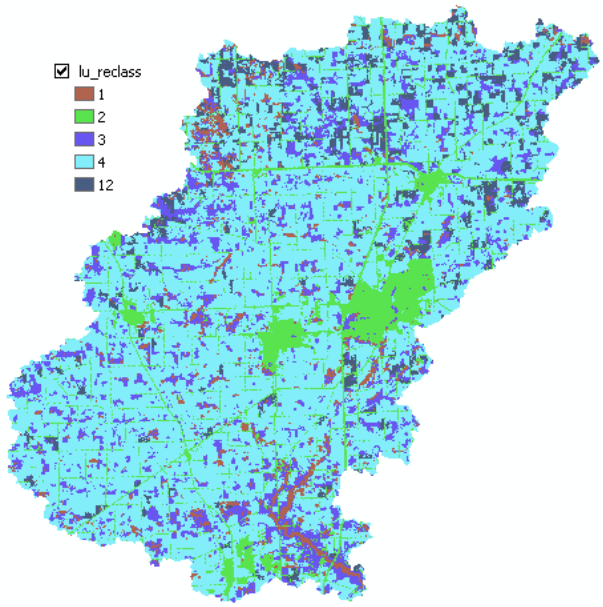
Original NLCD classification		**Revised classification (re-classification)**	
Number	*Description*	*Number*	*Description*
11	Open water	1	Water
90	Woody wetlands		
95	Emergent herbaceous wetlands		
21	Developed, open space	2	Medium Residential
22	Developed, low intensity		
23	Developed, medium intensity		
24	Developed, high intensity		
41	Deciduous forest	3	Forest
42	Evergreen forest		
43	Mixed forest		
31	Barren land	4	Agricultural
52	Shrub/scub		
71	Grassland/herbaceous		
81	Pasture/hay		
82	Cultivated crops		

To implement the above re-classification, use the Spatial Analyst Tools in Arc Toolbox. **Click** on *Spatial Analyst Tools→Reclass→Reclassify*, and then double-click on Reclassify tool.

In the reclassification window, **confirm** the *Input raster* is *cedar_lu*, *Reclass field* is Value, and then manually assign the new numbers based on the above table as shown below (leave NoData option unchanged).



Save the *output raster* as lu_reclass in your working folder, and **click** *OK*. A new grid named *lu_reclass* will be added to the map as shown below (you may not get the same colors in symbology which is OK)



The final step in processing land use data is converting the reclassified land use grid into a polygon feature class which will be merged with soil data later. In ArcToolbox, **Click** on *Conversion Tools→From Raster→Raster to Polygon*. **Confirm** the *Input raster* is lu_reclass, the *Field* is Value, *output geometry type* is Polygon, and save the *Output features* as landuse_poly feature class inside the feature dataset in your soil geodatabase. **Click** *OK*.

You can symbolize the new landuse_poly.shp to match with *lu_reclass* grid or leave it unchanged. **Save** the map document.

Q1. What is the area of each land use type in the new reclassified data? Report your answer in km^2, and write down the steps you implemented to get the answer.

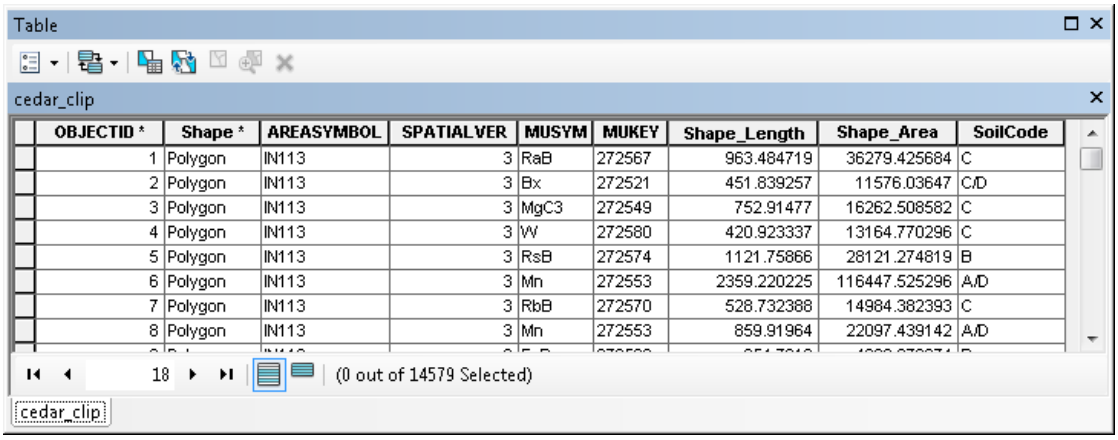
The processing of land use data for preparing curve number grid is over. Now let us prepare soil data.

Preparing Soil data for CN Grid

Add *cedar_soil_clip* feature class from spatial feature dataset within *cedar_ssurgo.mdb*. For extracting CN numbers, we need soil group for each polygon in *cedar_soil_clip* feature class. If you open the attribute table for cedar_soil_clip, you will notice that there is already a populated field called SoilCode that you created when the soil database was created. You will also see that there are lots of rows with "Null" value for SoilCode. If you review the SoilCode field you will see that "C" or "C/D" is the dominant soil group. To keep it simple, let us assign a SoilCode of C for all polygons that do not have soil group associated with them (this is just one way of dealing

with the issue for small number of Null rows. If the number of Null rows is significantly high, you may want to consult other resources before assigning SoilCode to these rows). **Select** the rows in cedar_soil_clip that have <Null> values for SoilCode and **assign** them a value of "C". You can use select by attributes option to do this. Now you should have a SoilCode (soil group) assigned to each polygon in *cedar_soil_clip*.

Q2. What is the area of each soil group (include A/D. B/C, etc.) in the Cedar Creek watershed? Report your answer in km^2 and write down the steps you implemented to get the answer.



Table

cedar_clip

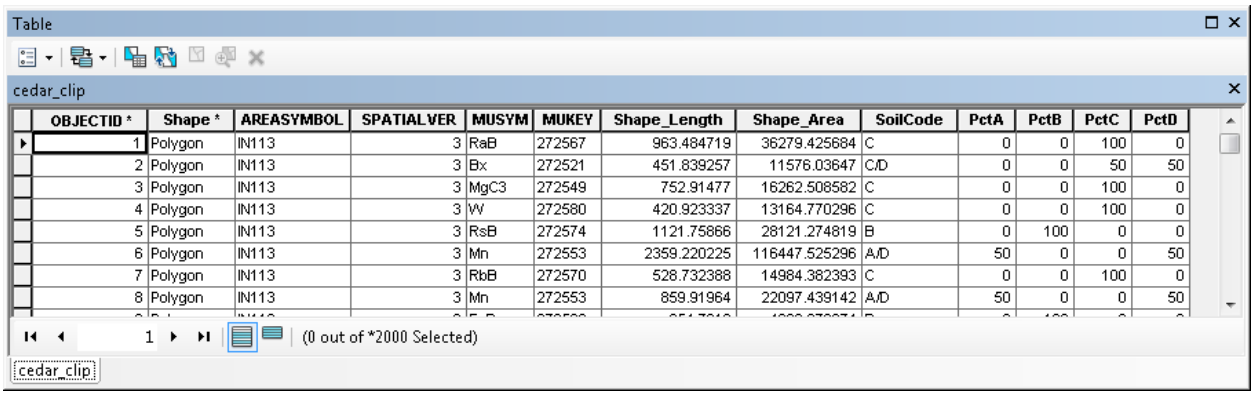
OBJECTID *	Shape *	AREASYMBOL	SPATIALVER	MUSYM	MUKEY	Shape_Length	Shape_Area	SoilCode
1	Polygon	IN113	3	RaB	272567	963.484719	36279.425684	C
2	Polygon	IN113	3	Bx	272521	451.839257	11576.03647	C/D
3	Polygon	IN113	3	MgC3	272549	752.91477	16262.508582	C
4	Polygon	IN113	3	W	272580	420.923337	13164.770296	C
5	Polygon	IN113	3	RsB	272574	1121.75866	28121.274819	B
6	Polygon	IN113	3	Mn	272553	2359.220225	116447.525296	A/D
7	Polygon	IN113	3	RbB	272570	528.732388	14984.382393	C
8	Polygon	IN113	3	Mn	272553	859.91964	22097.439142	A/D

18 (0 out of 14579 Selected)

cedar_clip

Next **create** four more fields named PctA, PctB, PctC, and PctD all of type short integer in cedar_soil_clip feature class. Assign an initial value of "0" for these four fields so you get rid of <Null>.

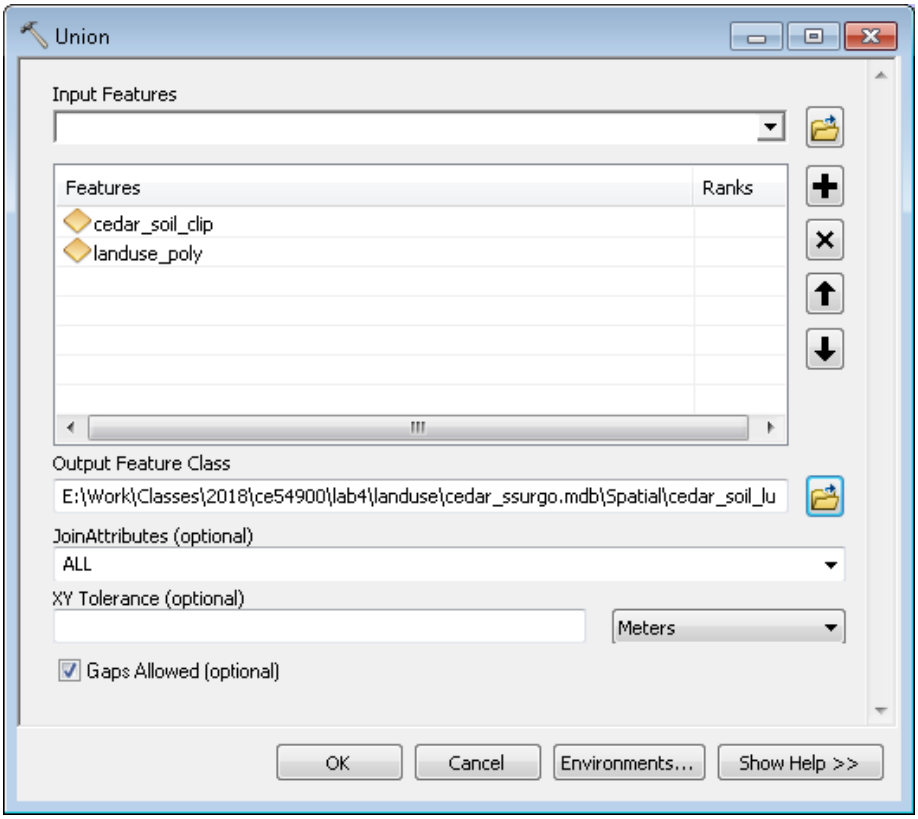
For each feature (polygon) in cedar_soil_clip PctA will define what percentage of area within the polygon has soil group A, PctB will define what percentage of area within the polygon will have soil group B and so on. This is critical when we have polygons with more than one soil group (for eg. A-B-A/D would mean that group A, group B and group A/D soils are found in one polygon; A/D would mean the soil behaves as A when drained and as D when not drained, and so on). If we have classifications such as these, we need to define how much area of a polygon is A/B/C/D. For example, if a map unit has soil group "A", we will assign have PctA = 100, PctB = 0, PctC = 0, and PctD = 0. Similarly for a polygon with soil group A/D, only PctA = 50 and PctD = 50, and other two Pcts are 0. Now **populate** PctA, PctB, PctC and PctD based on SoilCode for each polygon. You can select features based on SoilCode and then use field calculator to assign numbers to polygons. The resulting attribute table should look like below:



The preparation of soil data is over at this point. The next step is to merge/union both soil data and land use data to create polygons that have both soil and land use information. **Save** the map document.

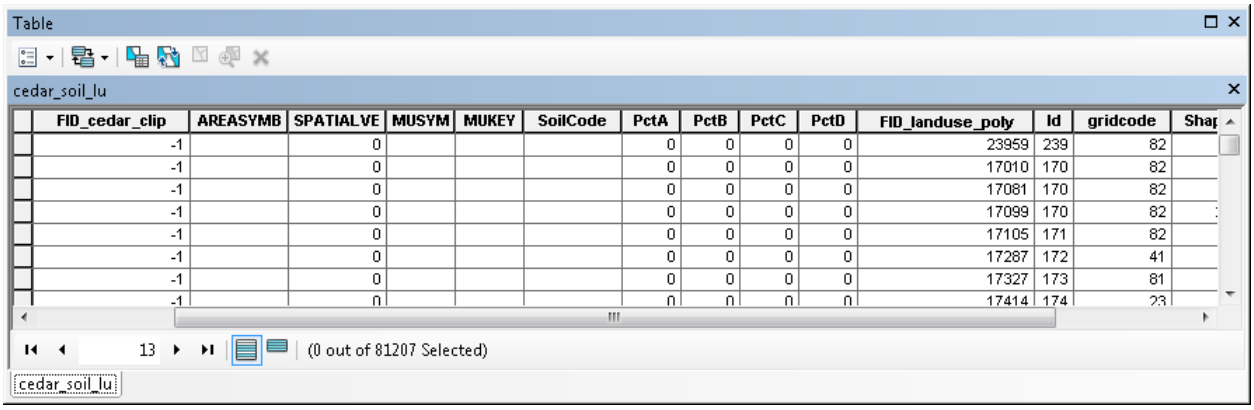
Merging of Soil and Landuse Data

To merge/union soil and landuse data, **use** the *Union tool* in *ArcToolbox* available under *Analysis Tools →Overlay*. **Browse/drag** *cedar_soil_clip and landuse_poly* as input features, name the output feature class as "cedar_soil_lu" in the same geodatabase (cedar_ssurgo.mdb), leave the default options, and **click** *OK* (you can change the cluster tolerance to a small number, but this is not necessary).



This process will take few minutes, and the resulting *cedar_soil_lu* feature class will be added to the map document. **Save** the map document.

The result of union/merge features inherit attributes from both feature classes that are used as input. However, if the outer boundaries of input feature classes do not match exactly, the resulting merged feature class (cedar_soil_lu in this case) usually will have features that will have attributes from only one feature class because the other feature do not exist in this area. These features are usually referred to as "slivers". If you open the attribute table for *cedar_soil_lu*, you will find that there are several sliver polygons in this feature class that have attributes only from *landuse_poly* and the soil attributes are empty, and vice versa as shown below:



In the above table the columns that start with FID_.... give the Object IDs of features from landuse_poly and cedar_soil_clip. A value of -1 for FID_... means one of the feature classes do have features in that area to union with features from other feature classes. Basically a value of -1 for FID_... means that feature is a sliver polygon. You can also verify this by looking at other fields. For example features that have FID_cedar_soil_clip = -1 have attributes only from landuse_poly and all attributes from cedar_soil_clip = 0.

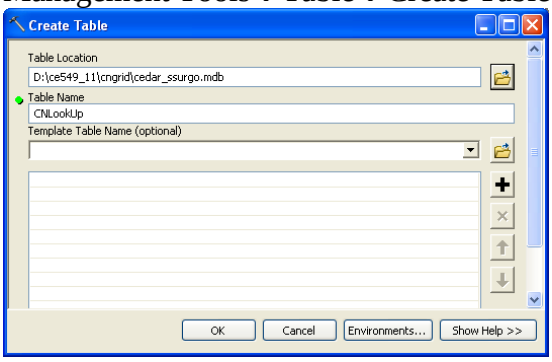
One way to deal with sliver polygons is to assign missing values to all features. Another way (easiest!) is to just delete them. For this exercise we will take the easy route, but you may want to populate these features for other studies depending on your project needs.

Start the *Editor*. **Select** all the features that have "FID_..." = -1 and **delete** them. **Save** your edits, **stop** the *Editor*, and **save** the map document. You will have to do this twice because there are two fields beginning with FID_.

This finishes the processing of spatial data for creating the curve number grid. The next step is to prepare a look-up table that will have curve numbers for different combinations of land uses and soil groups. In this case, we will use SCS curve numbers that are available from literature (SCS reports, or SCS tables from text books). The spatial features in conjunction with the look-up table can then be used to create curve number grid.

Creating CN Look-up table

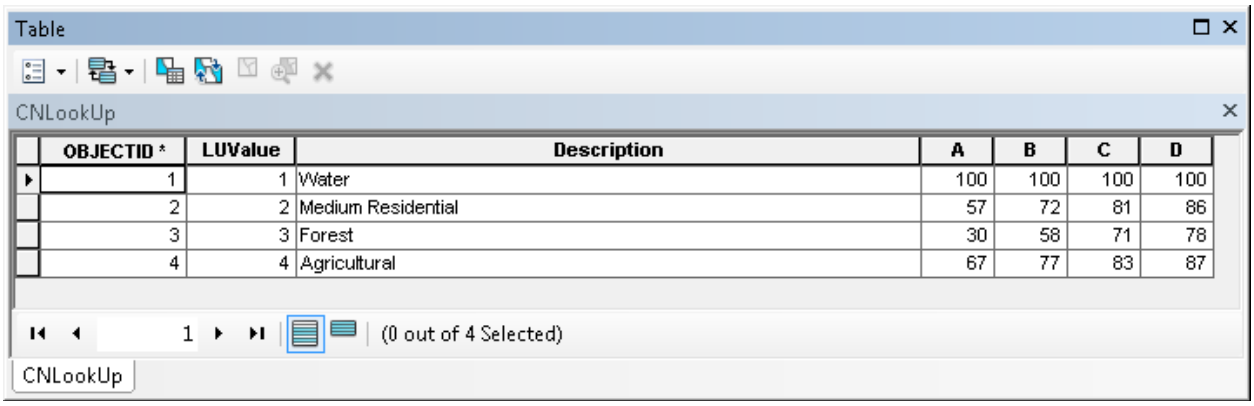
Create a table named "CNLookUp" inside *cedar_ssurgo.mdb*. In ArcCatalog, select Data Management Tools→Table→Create Table.



Once the table is created **create** the following fields in it:

1. LUValue (type: short integer)
2. Description (type: text)
3. A (type: short integer)
4. B (type: short integer)
5. C (type: short integer)
6. D (type: short integer)

Now **start** the *Editor* to edit the newly created CNLookUp table, and **populate** it as shown below.



OBJECTID *	LUValue	Description	A	B	C	D
1	1	Water	100	100	100	100
2	2	Medium Residential	57	72	81	86
3	3	Forest	30	58	71	78
4	4	Agricultural	67	77	83	87

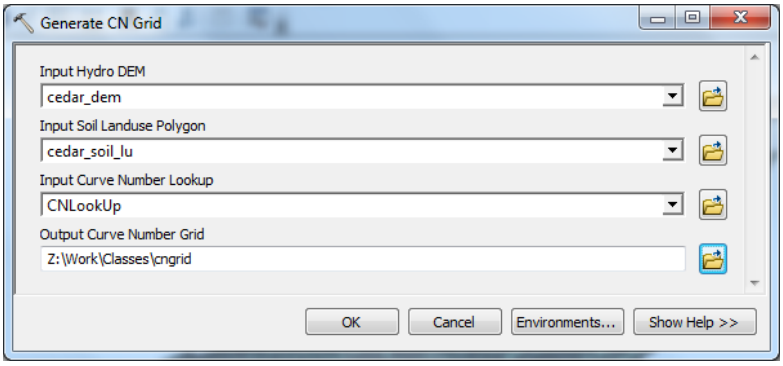
Columns A/B/C/D store curve numbers for corresponding soil groups for each land use category (LUValue). These numbers are obtained from SCS TR55 (1986). **Save** the edits and **stop** the *Editor*. **Save** the map document.

Creating CN Grid

We will use HEC-GeoHMS to create the curve number grid. **Activate** the HEC-GeoHMS Project View toolbar in the same way as ArcHydro toolbar. HEC-GeoHMS uses the merged feature class (*cedar_soil_lu*) and the lookup table (CNLookUp) to create the curve number grid. The format and the field names that we are used in creating the CNLookUp table are consistent with HEC-GeoHMS. Before we proceed, one final step is to create a field in the merged feature class

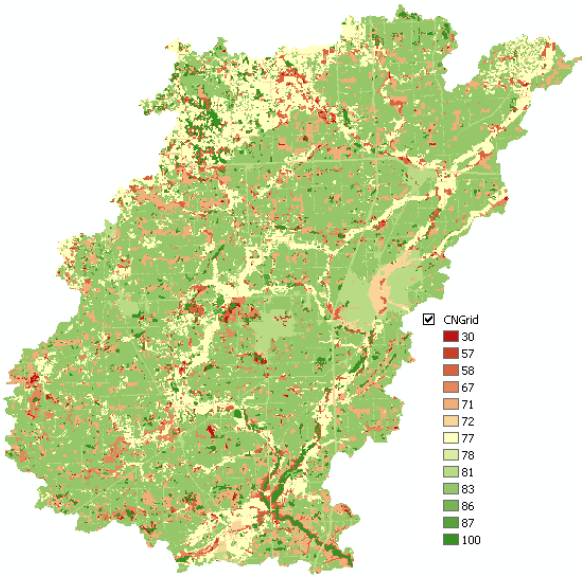
(*cedar_soil_lu*) named "LandUse" that will have land use category information to link it to CNLookUp table. We already have this information stored in GRIDCODE field, but HEC-GeoHMS looks for this information in LandUse field. So **create** a field named LandUse (type: short integer), and **populate** it by equating it to GRIDCODE.

On the HEC-GeoHMS Project View toolbar, **click** on *Utility*→Generate CNGrid. **Choose** the lookup parameter as Curve Number (which is default) in the next window, **Click** *OK*, and then select the inputs for the next window as shown below:



Cedar_dem for *Hydro DEM*, cedar_soil_lu (merged soil and land use) for *Curve Number Polygon*, CNLookUp table for *Curve Number Lookup*, and leave the default CNGrid name for the *Curve Number Grid*.

This process takes a while (actually quite a while!). Be patient and CNGrid will be added to your map document. You can change the symbology of the grid to make it look pretty!



You now have a very useful dataset for use in several hydrologic models and studies. **Save** the map document, and **exit** ArcMap.

OK. You are done!