# Creating SCS Curve Number Grid using HEC-GeoHMS

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## Introduction

SCS curve number grid is used by many hydrologic models to extract the curve number for watersheds. The objective of this tutorial is to use soil and land use data to create a curve number grid using HEC-GeoHMS (ArcGIS 10 version).

## Computer Requirements

You must have a computer with latest windows operating system, and the following programs installed:

1. ArcGIS 10 (ArcView)
2. Hec-GeoHMS for ArcGIS 10

You can download the HEC-GeoHMS version from the following link:
http://www.hec.usace.army.mil/software/hec-geohms/download.html

You will need to have administrative access to install Arc Hydro and HEC-GeoHMS.

## Data Requirements and Description

This tutorial requires the following datasets:
(1) DEM for the study area
(2) SSURGO soil data
(3) 2006 land cover grid from USGS

The DEM and land cover grid from USGS and SSURGO data for Cedar Creek in northeast Indiana are provided as zip file at the end of this paragraph. The SSURGO soil data that will be used is provided in a geodatabase (cedar_ssurgo.mdb) that is created in the "Downloading SSURGO Soil Data" tutorial available at: (http://web.ics.purdue.edu/~vmerwade/education/download_ssurgo.pdf). You can look at the SSURGO download tutorial if you want to learn how this dataset is processed. Also, if you are interested in downloading the DEM and land cover data by yourself, instructions are available in the following tutorial: http://web.ics.purdue.edu/~vmerwade/education/ned_nhd.pdf

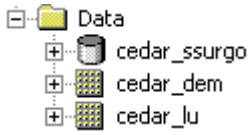
It is highly recommended that you go through these exercises of downloading the data to make yourself aware of the procedure involved.

(**Notes:**

1. The DEM, land use and soil data used in this tutorial are already clipped to the Cedar Creek study watershed
2. This tutorial uses the SSURGO soil data, which is the highest resolution soil data available in public domain from NRCS. This can be replaced by STATSGO data as long as you know how to interpret STATSTO to follow the steps provided in this tutorial)

**Download** the data from ftp://ftp.ecn.purdue.edu/vmerwade/download/data/cngrid.zip

**Unzip** *cngrid.zip* 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 the raw 30 DEM for Cedar Creek obtained from USGS and clipped for the study watershed, and cedar_lu is the 2001 land cover grid from USGS. All datasets have a common spatial reference (NAD_1983_UTM_16).

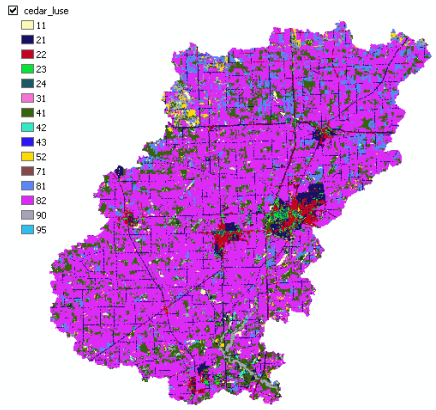
**Note:** It is very critical to assign and use consistent coordinate system for all the datasets.

## Getting Started

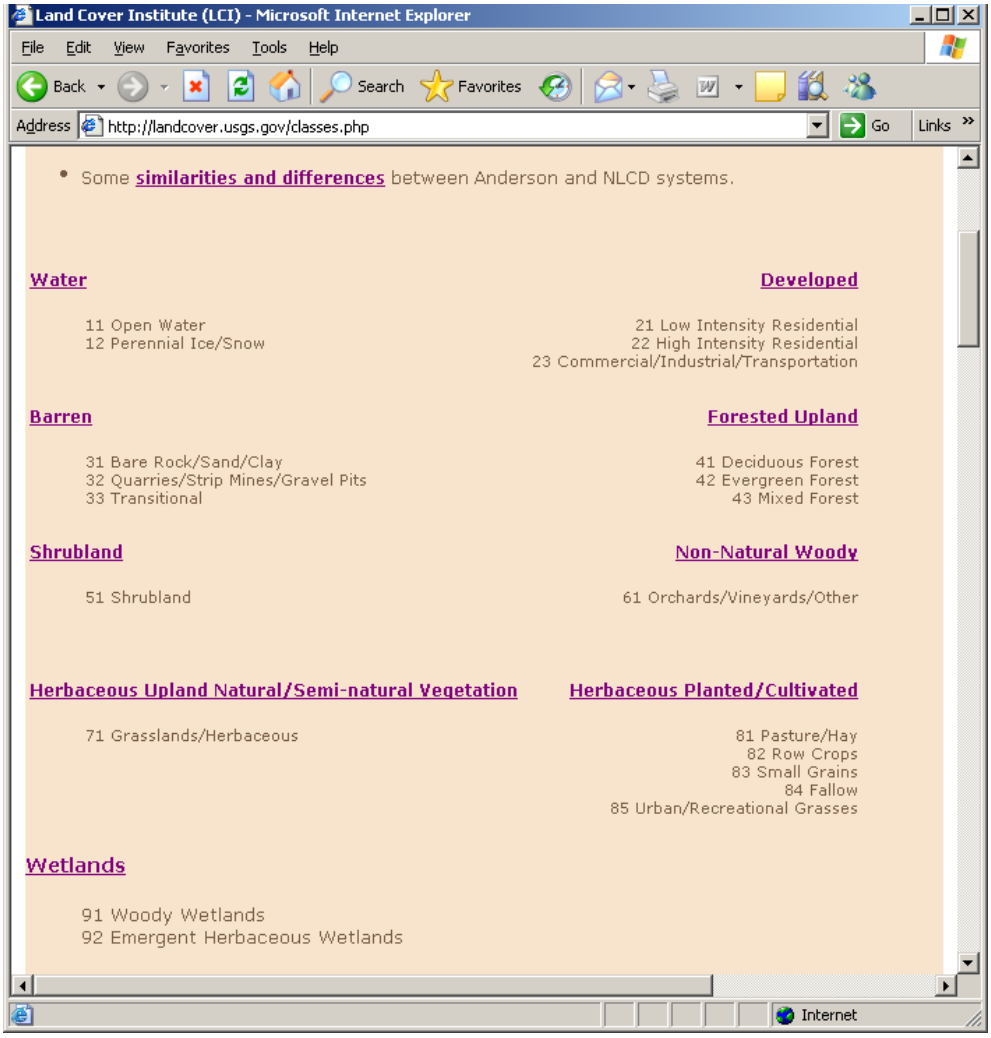
**Open** ArcMap. Create a new empty map, and save it as *cngrid.mxd* (or any other name). Add **Spatial Analyst extension and** activate **it by** *clicking* **on *Customize→Extensions…*, and** checking **the box next to *Spatial Analyst.***

## Preparing land use data for CN Grid

**Add** *cedar_luse* grid to the map document. You will see the grid is added with a unique symbology assigned to cells having identical numbers as shown below:




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.

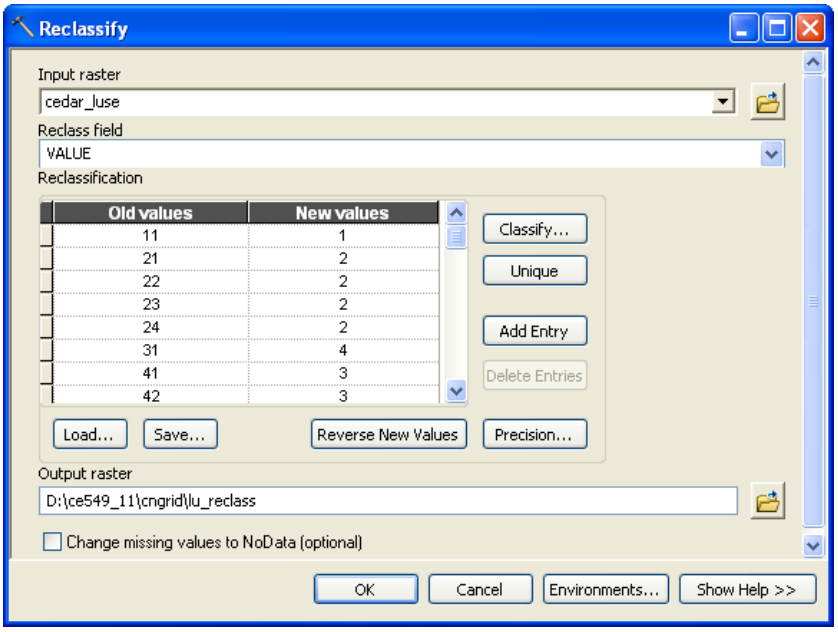


Eventually, we are going to use these land use classes and soil group type, in conjunction with SCS curve numbers, to create the curve number grid. The SCS CN table gives CN for different combinations of land use and soil group. The *cedar_lu* grid has 15 different categories which you can leave unchanged, 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).

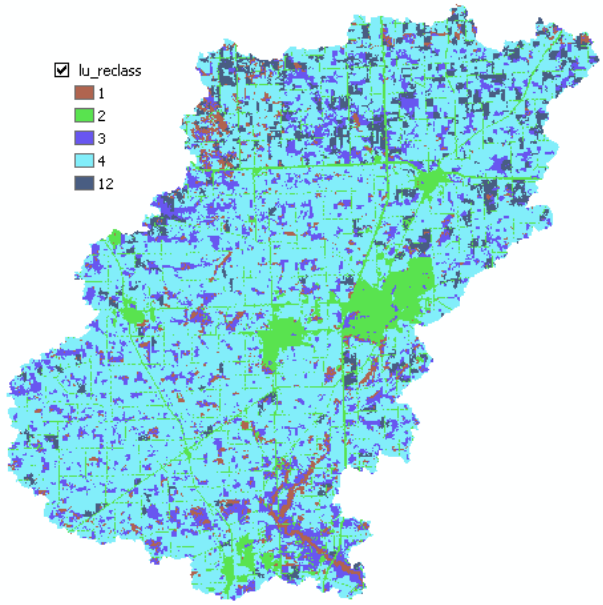
| **Original NLCD classification** | | **Revised classification (re-classification)** | |
|---|---|---|---|
| *Number* | *Description* | *Number* | *Description* |
| 11 | Open water | 1 | Water |
| 90 | Woody wetlands | | |
| 95 | Emergent herbaceous wetlands | | |
| 21 | Developed, open space | 2 | 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.

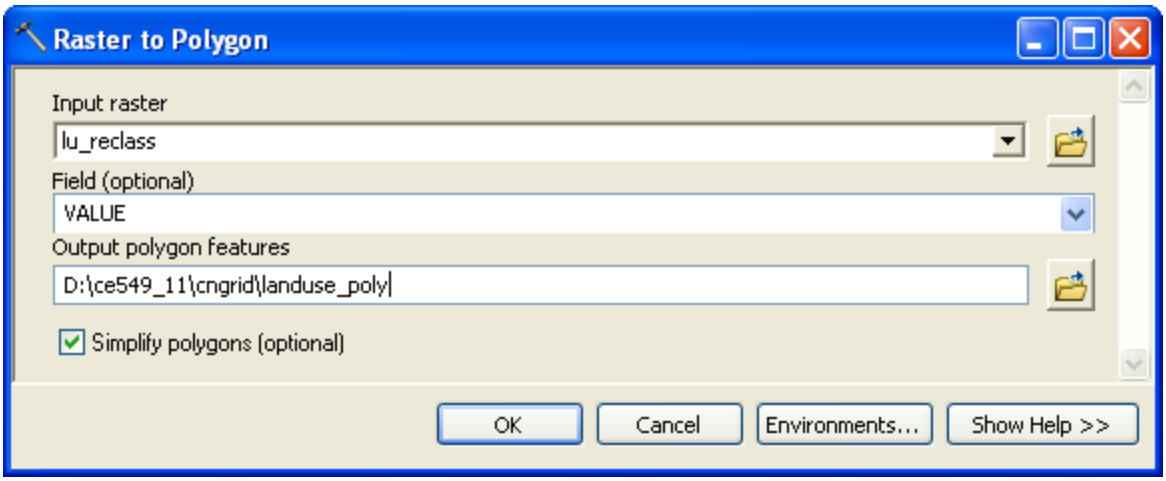
In the reclassification window, **confirm** the *Input raster* is *cedar_lu*, *Reclass field* is Value, and then manually assign the new numbers based on the above table as shown below (leave NoData unchanged).




**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.shp in your working directory (this output is saved only as a shapefile without any other options). **Click** *OK*.



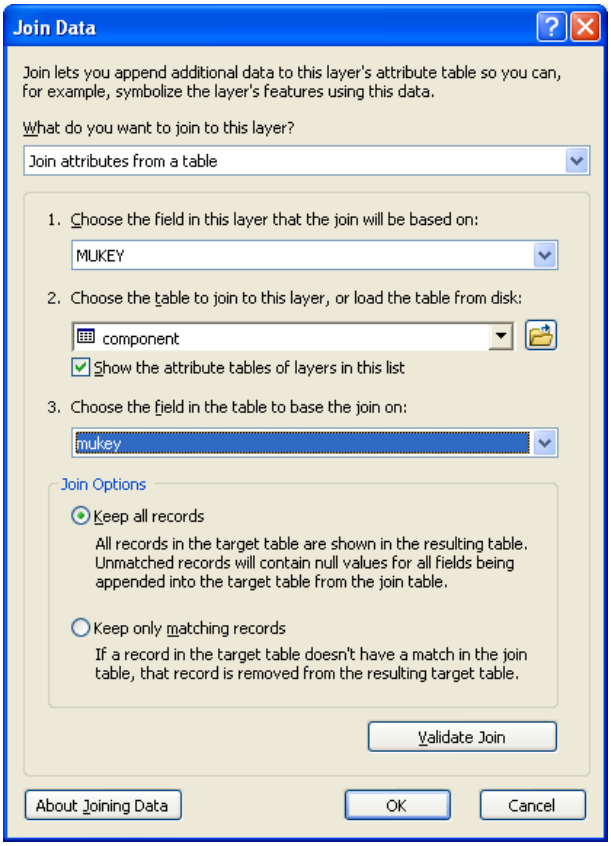

You can symbolize the new landuse_poly.shp to match with *lu_reclass* grid or leave it unchanged. Also, you can export landuse_poly.shp to cedar_ssurgo.mdb to keep all the data in a single geodatabase. **Save** the map document.

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

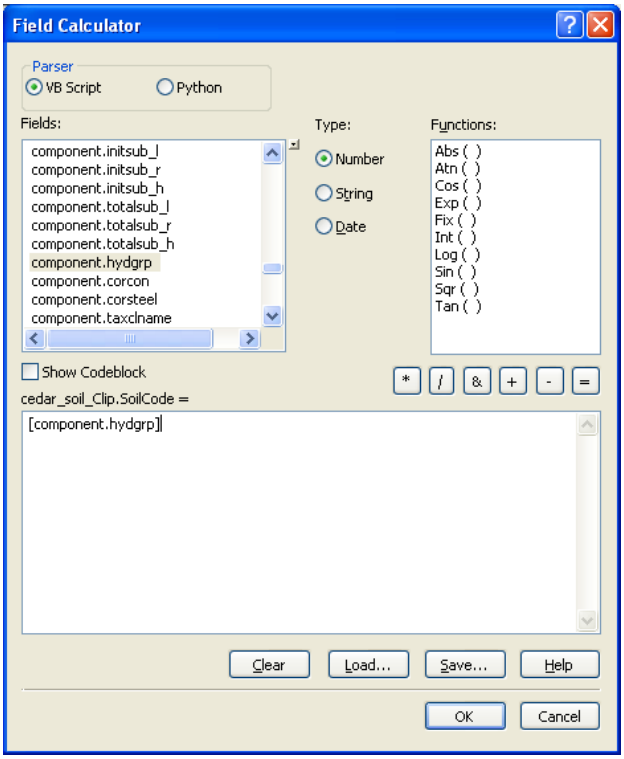
## Preparing Soil data for CN Grid

**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 no field for storing soil group (you can refer to SSURGO tutorial to understand the meaning of each field in cedar_soil_clip). So the first step is creating an empty field for storing soil group data. **Create** a field named "SoilCode" (type: Text) in *cedar_soil_clip*.

The soil group data are available in the component table (in hydgrp field) so **add** the *component* table from *cedar_ssurgo.mdb* to the map document. The polygon features in cedar_soil_clip are related to component table through mukey field**. Right click** on *cedar_soil_clip* in the ArcMap table of contents, and **click** on *Join and Relates→Join* …. Join component table to cedar_soil_clip by using the common mukey field as shown below:

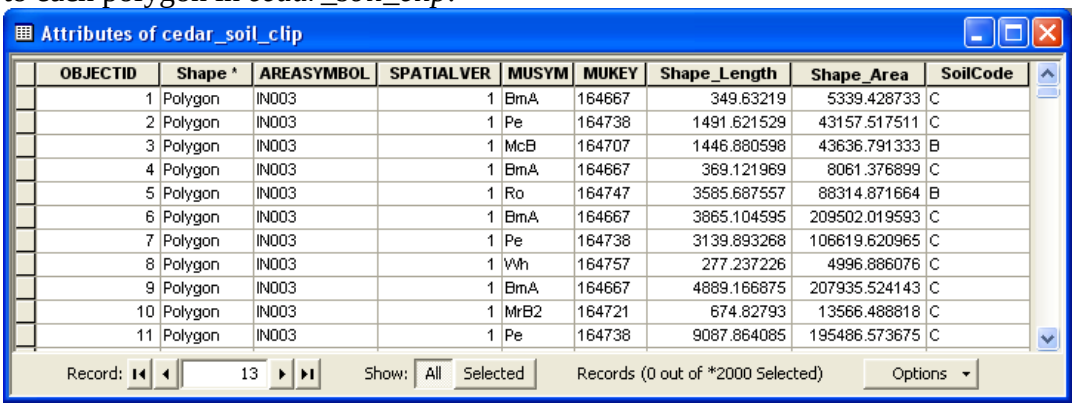



**Click** *OK*. You may get a message asking you to index fields. You can respond to this message by selecting either yes or no - it does not matter in this exercise because we will join the table only once. After you create the join, **open** the attribute table for *cedar_soil_clip*, and you will see that the fields from component table are now available in *cedar_soil_clip* feature class. Now populate the SoilCode (or cedar_soil_clip.SoilCode) field in cedar_soil_clip by equating it with component.hydgrp field. With the attribute table open, **right click** on *SoilCode* field to open the field calculator and then equate SoilCode to component.hydgrp as shown below:



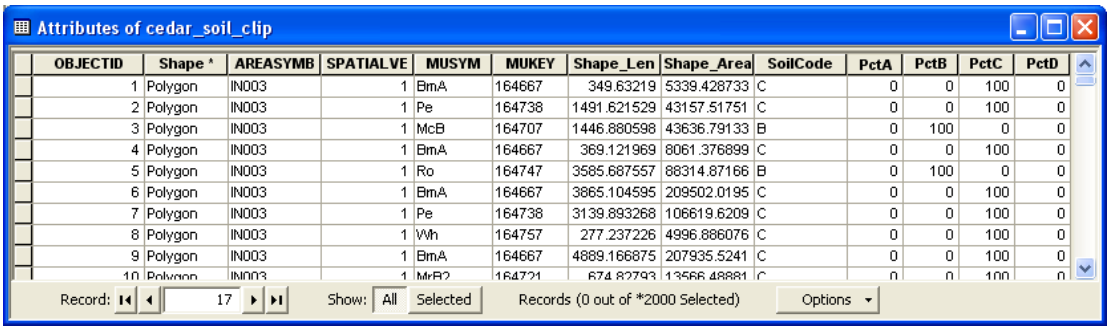

**Click** *OK*. If there are rows in component with "Null" values (which is the case for this dataset), you may get an error message saying the values are too large for the field. Just ignore this message and continue. After the calculations are complete, you should see cedar_soil_clip.SoilCode populated with letters A/B/C/D. Now **remove** the join and **save** the map document.

Before we proceed, let us deal with <Null> rows for SoilCode field. Review the SoilCode field, and you will see that most polygons have "C" soil group so 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*.




| OBJECTID | Shape * | AREASYMBOL | SPATIALVER | MUSYM | MUKEY | Shape_Length | Shape_Area | SoilCode |
|---|---|---|---|---|---|---|---|---|
| 1 | Polygon | IN003 | 1 | BmA | 164667 | 349.63219 | 5339.428733 | C |
| 2 | Polygon | IN003 | 1 | Pe | 164738 | 1491.621529 | 43157.517511 | C |
| 3 | Polygon | IN003 | 1 | McB | 164707 | 1446.880598 | 43636.791333 | B |
| 4 | Polygon | IN003 | 1 | BmA | 164667 | 369.121969 | 8061.376899 | C |
| 5 | Polygon | IN003 | 1 | Ro | 164747 | 3585.687557 | 88314.871664 | B |
| 6 | Polygon | IN003 | 1 | BmA | 164667 | 3865.104595 | 209502.019593 | C |
| 7 | Polygon | IN003 | 1 | Pe | 164738 | 3139.893268 | 106619.620965 | C |
| 8 | Polygon | IN003 | 1 | Wh | 164757 | 277.237226 | 4996.886076 | C |
| 9 | Polygon | IN003 | 1 | BmA | 164667 | 4889.166875 | 207935.524143 | C |
| 10 | Polygon | IN003 | 1 | MrB2 | 164721 | 674.82793 | 13566.488818 | C |
| 11 | Polygon | IN003 | 1 | Pe | 164738 | 9087.864085 | 195486.573675 | C |

Next **create** four more fields named PctA, PctB, PctC, and PctD all of type short integer in cedar_soil_clip feature class. 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 Cedar Creek area we have only one soil group assigned to each polygon so a polygon with soil group "A" will have PctA = 100, PctB = 0, PctC = 0, and PctD = 0. Similarly for a polygon with soil group D, only PctD = 100, and other three 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:


Attributes of cedar_soil_clip

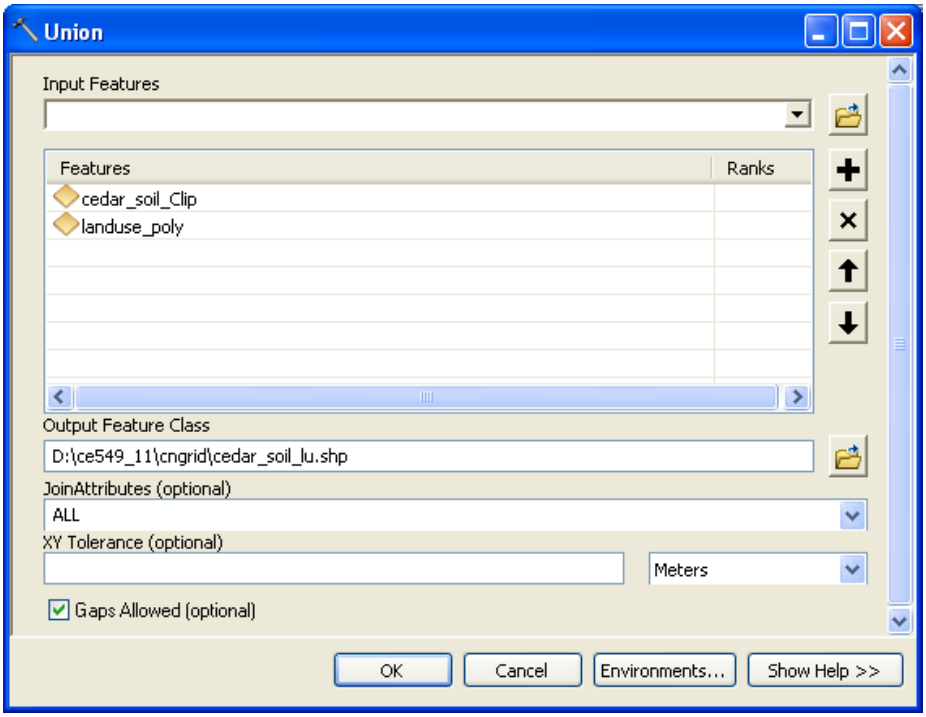
| OBJECTID | Shape * | AREASYMB | SPATIALVE | MUSYM | MUKEY | Shape_Len | Shape_Area | SoilCode | PctA | PctB | PctC | PctD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Polygon | IN003 | 1 | BmA | 164667 | 349.63219 | 5339.428733 | C | 0 | 0 | 100 | 0 |
| 2 | Polygon | IN003 | 1 | Pe | 164738 | 1491.621529 | 43157.51751 | C | 0 | 0 | 100 | 0 |
| 3 | Polygon | IN003 | 1 | McB | 164707 | 1446.880598 | 43636.79133 | B | 0 | 100 | 0 | 0 |
| 4 | Polygon | IN003 | 1 | BmA | 164667 | 369.121969 | 8061.376899 | C | 0 | 0 | 100 | 0 |
| 5 | Polygon | IN003 | 1 | Ro | 164747 | 3585.687557 | 88314.87166 | B | 0 | 100 | 0 | 0 |
| 6 | Polygon | IN003 | 1 | BmA | 164667 | 3865.104595 | 209502.0195 | C | 0 | 0 | 100 | 0 |
| 7 | Polygon | IN003 | 1 | Pe | 164738 | 3139.893268 | 106619.6209 | C | 0 | 0 | 100 | 0 |
| 8 | Polygon | IN003 | 1 | Wh | 164757 | 277.237226 | 4996.886076 | C | 0 | 0 | 100 | 0 |
| 9 | Polygon | IN003 | 1 | BmA | 164667 | 4889.166875 | 207935.5241 | C | 0 | 0 | 100 | 0 |
| 10 | Polygon | IN003 | 1 | MrB2 | 164721 | 674.82793 | 13566.48881 | C | 0 | 0 | 100 | 0 |

Record: 17 Show: All Selected Records (0 out of *2000 Selected) Options

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.

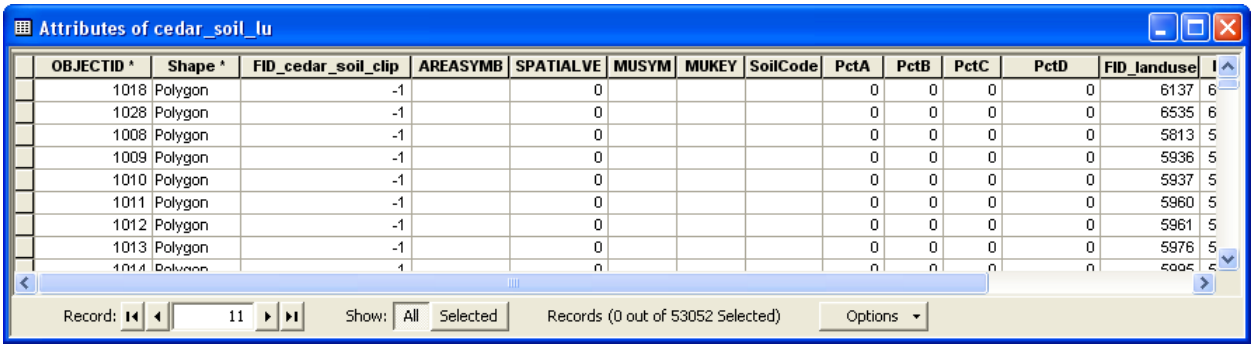
## Merging of Soil and Landuse Data

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.

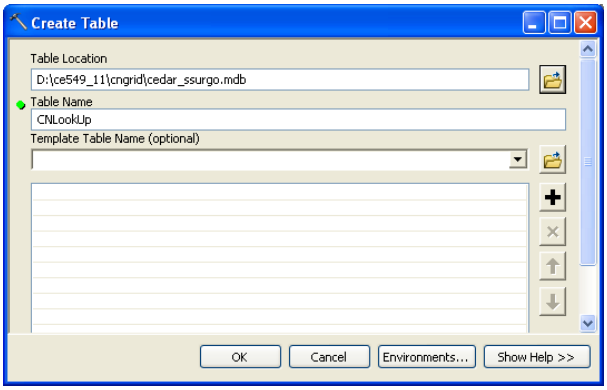
One way to deal with sliver polygons is to assign missing values to all features. Another way (easiest!) is to just delete them. For this exercise we will take the easy route, but you may want to populate these features for other studies depending on your project needs.

**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.

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.

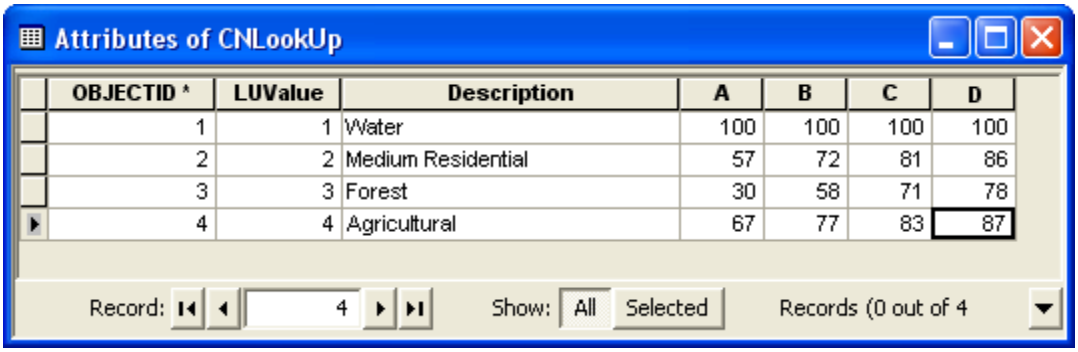
## Creating CN Look-up table

**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.

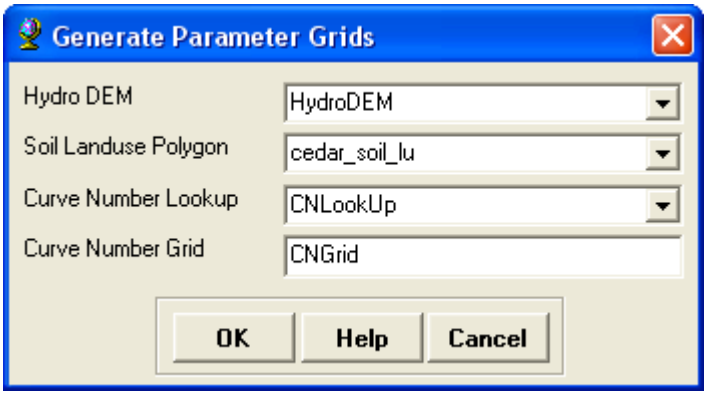



Columns A/B/C/D store curve numbers for corresponding soil groups for each land use category (LUValue). These numbers are obtained from SCS TR55 (1986). **Save** the edits and **stop** the *Editor*. **Save** the map document.

## Creating CN Grid

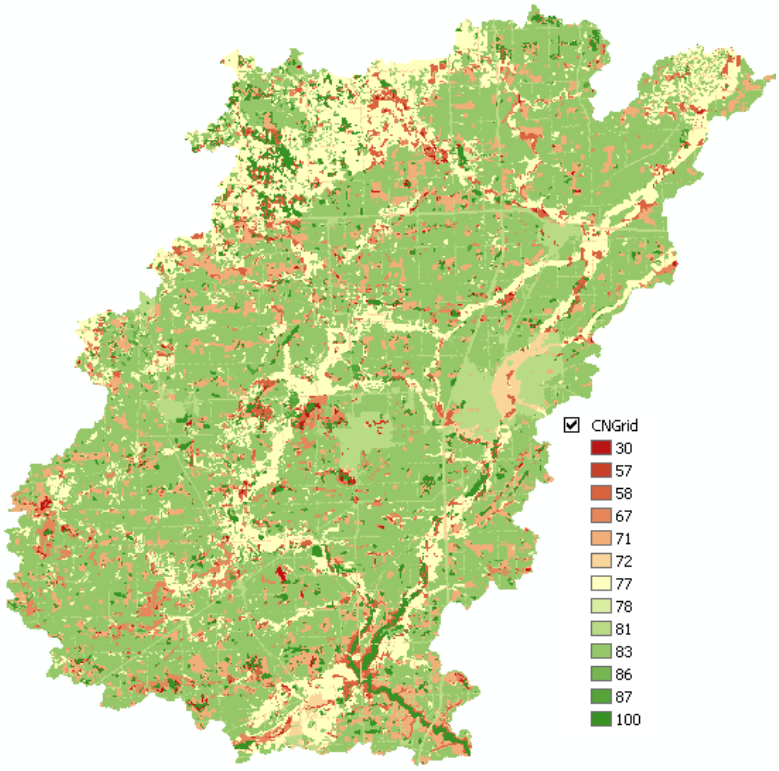
We will use HEC-GeoHMS to create the curve number grid. **Activate** the HEC-GeoHMS Project View toolbar in the same way as ArcHydro toolbar. HEC-GeoHMS uses the merged feature class (*cedar_soil_lu*) and the lookup table (CNLookUp) to create the curve number grid. The format and the field names that 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→Create Parameter Grids*.. **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:




HydroDEM 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!