Creating CN Grid in QGIS from NLCD Landuse and SSURGO Soil data

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Introduction

The objective of this exercise is to process the National Land Cover Dataset landuse and SSURGO soil data to create curve number (CN) raster using QGIS. Curve number is used in many hydrologic models for computing rainfall losses using the SCS method.

Learning Outcomes

- Processing of raster and vector data in QGIS
- Performing attribute query and other field operations on vector data
- Classifying raster and performing mathematical operations on raster

Computer Requirements

You must have a computer with windows operating system, and QGIS version 3.2 installed.

Input Data

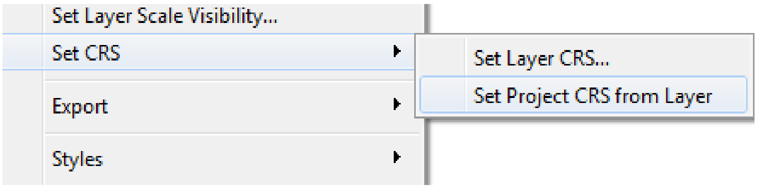
The input data needed to create the CN raster is available at ftp://ftp.ecn.purdue.edu/vmerwade/download/data/qcngrid.zip. This data is for a small watershed in northeast Indiana, USA. The input data contains the following:

1) Landuse.tif (Landuse raster)
2) Soil.shp (Soil polygon shapefile)
3) Boundary.shp (shapefile with watershed boundary)
4) class_table.txt (Landuse classification table in a comma separated file)
5) comp.txt (Component table with soil properties in a comma separated file)
6) cnquery.txt (Raster query expression in a text file)

Copy and save the data in your working folder.

Getting Started

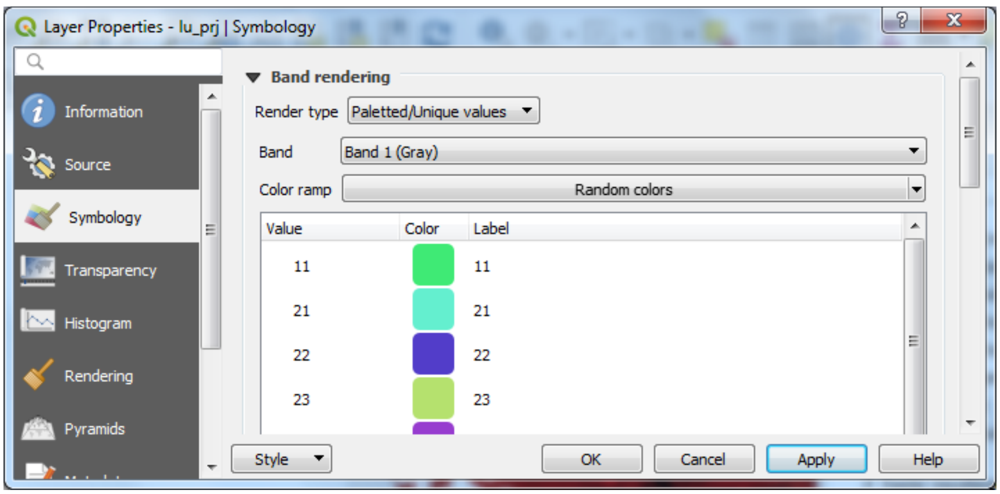
Open a QGIS project and save it as cngrid. Add landuse.tif to the project by going to Layer→Add Layer→Add Raster Layer.. (ctrl+shift+R) . Next, set the CRS (Coordinate Reference System) of the project file to landuse.tif. Setting the CRS can be done by right clicking the layer and set CRS→Set Project CRS from Layer.



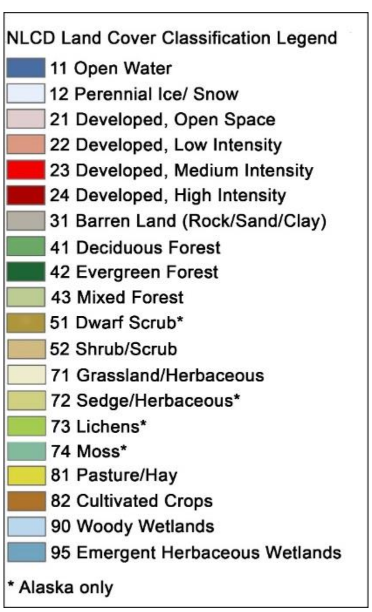
Having all the layers and the project to have the same CRS is very important otherwise some of the processing results may end up with a different CRS.

Landuse Processing

Change the symbology (right click on the layer→Properties→Symbology) of the landuse layer to use Paletted/Unique values so you can see the different landuse with unique colors



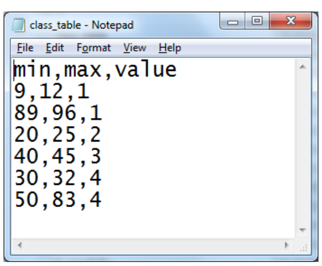
You will see different landuse types with a unique number ranging from 11 to 95. Each number represents a landuse type, and the correspondence between these numbers and landuse types is shown below.



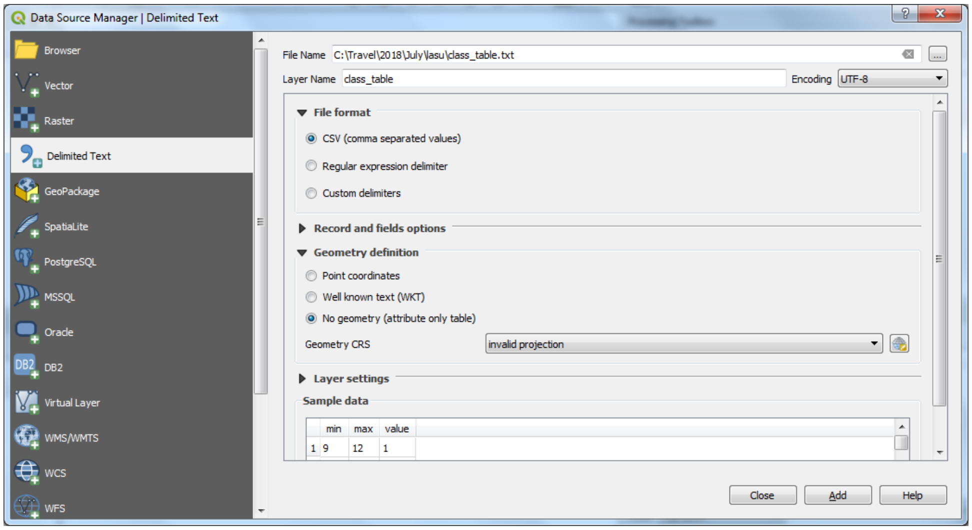
As you know, the landuse data provided to you have many land use categories which you can leave unchanged, or reclassify the grid to reduce the number of land use classes to make the task easier. If you look at the data visually, you will see that most of the area includes grass/crops, followed by forest, developed land, and then water. We will reclassify landuse to represent these four major classes. The following table shows how we will accomplish the reclassification of the landuse raster (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/scrub		
71	Grassland/herbaceous		
81	Pasture/hay		
82	Cultivated crops		

The above reclassification is given to you in a text file which you can open and see. This format is compatible with the tool that you will use in QGIS. Go ahead and look at the text file as shown below. A range is given and that range is replaced with a unique value. This table will have to change if you use a classification different than what is shown in the table above.

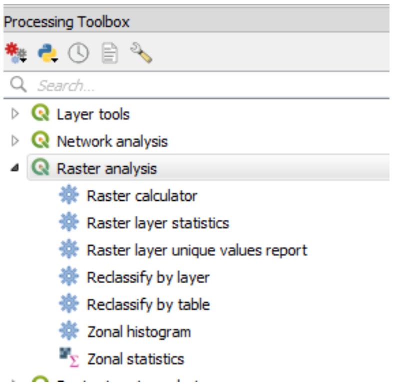


Add the text file (class_table.txt) to the QGIS project by going to Layer→Add Layer→Add Delimited Text Layer. Browse to the class_table.txt file. Make sure you select the "CSV" option for the file format and "No geometry" for the geometry definition as shown below.

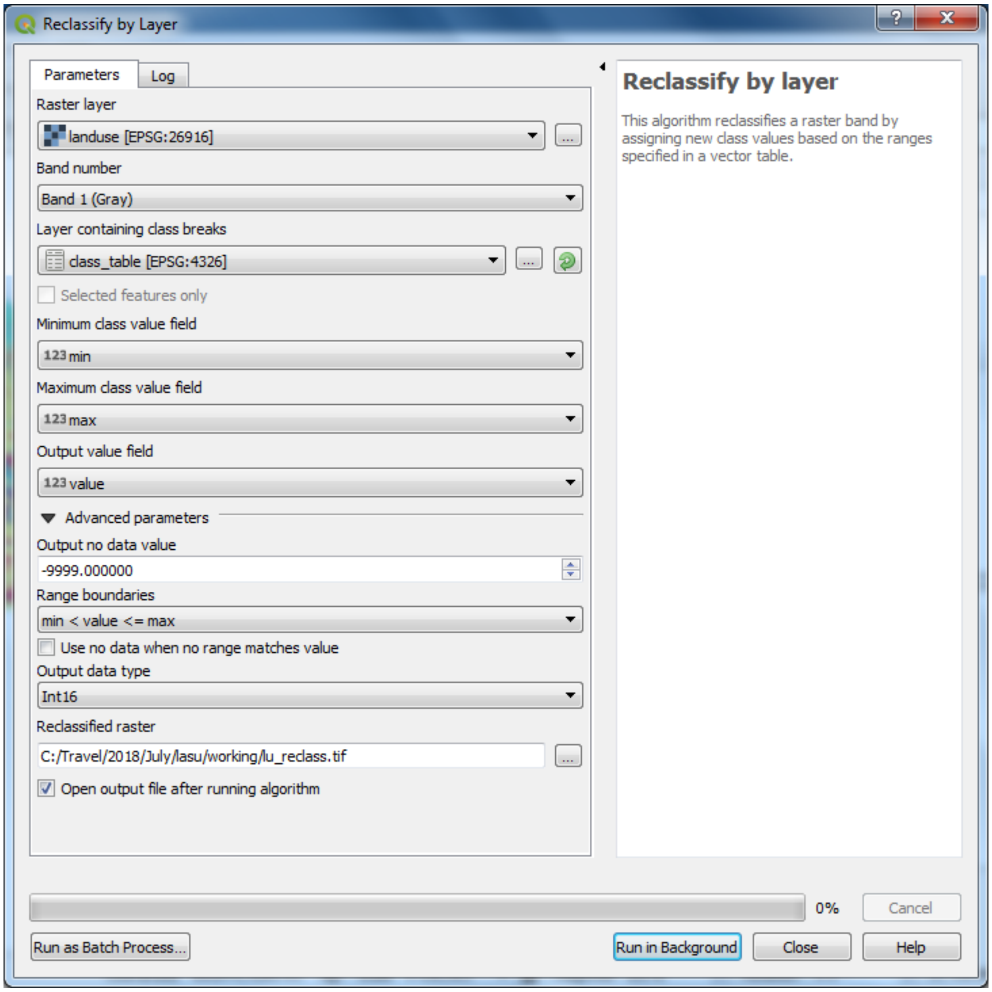


Once this text file is added to the project, you have all the information to reclassify the land use raster.

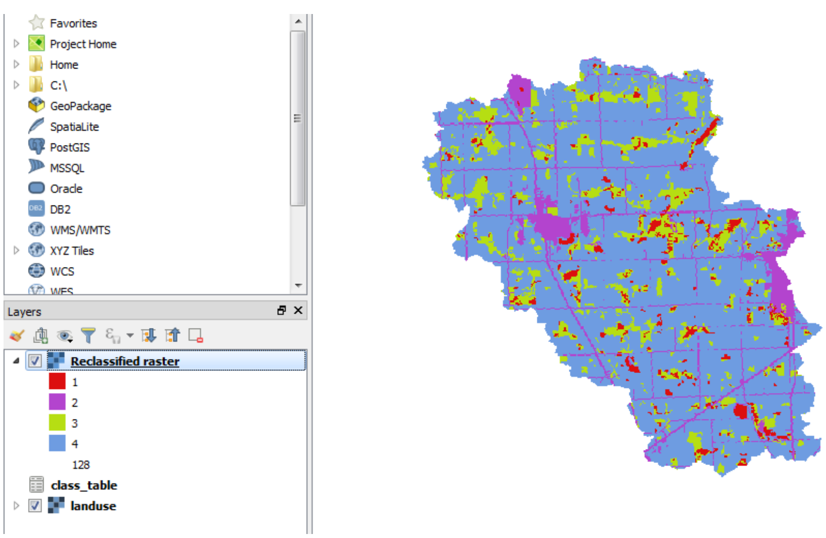
To reclassify the landuse raster, select the Reclassify by layer tool from the Raster analysis menu in the Processing Toolbox.



In the Reclassify by Layer window, select the raster layer as lu_prj and the class_table layer as the layer containing class breaks. Pick the appropriate fields for minimum, maximum and target values, choose the output data type as an integer and save the output as lu_reclass.tif in your working folder as shown below.



Push Run in Background and the reclassified raster will be added to the project after the processing is complete. You will now have only four landuse types in the reclassified raster as shown below. You may see a value of 128 for all cells outside the given boundary so change the color of 128 to white. This completes the landuse processing for creating the Curve Number.

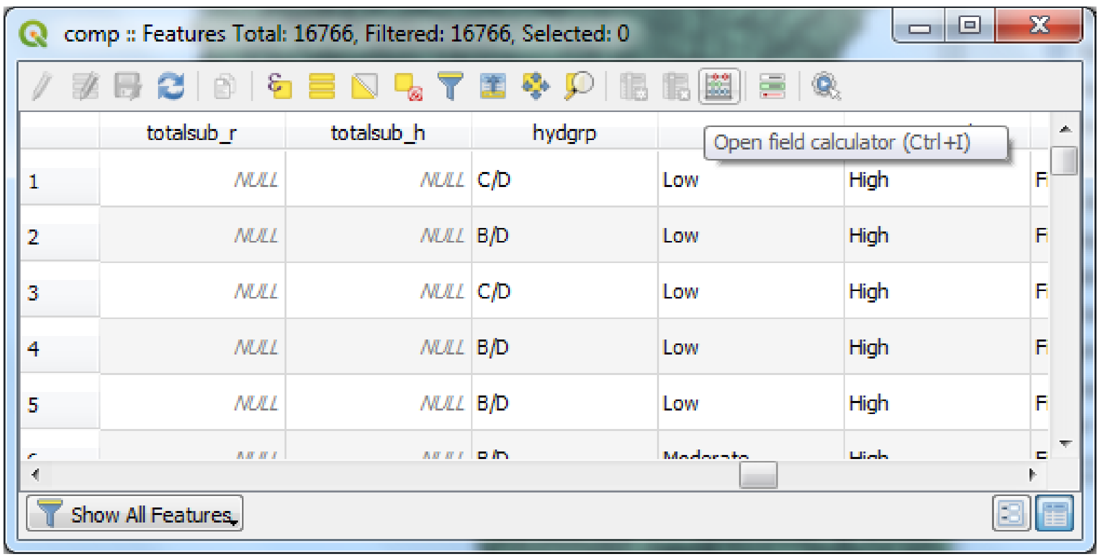


Note: The use of text file to do the classification is not necessary. You can use the "Reclassify by table" tool and create a table in that window with min, max and target values.

Soil Data Processing

Add soil polygon layer (soil.shp) to the project. Check the CRS of this layer (right click on the layer→Properties→Information) to make sure it matches with the project CRS (NAD 1983 UTM Zone 16N). Generating CN requires the knowledge of hydrologic soil group. Open the attribute table and look at the attributes for the soil layer. You will see that there is no attribute for the hydrologic soil group. Some datasets have this information stored as attributes, and some have this information stored in a separate table. The SSURGO vector database that is used in this exercise stores the spatial and tabular information separately. The hydrologic soil group information is stored in a component table, which is also provided to you. Go ahead and add the table (comp.txt) by using the Layer→Add Layer→Add delimited text layer.

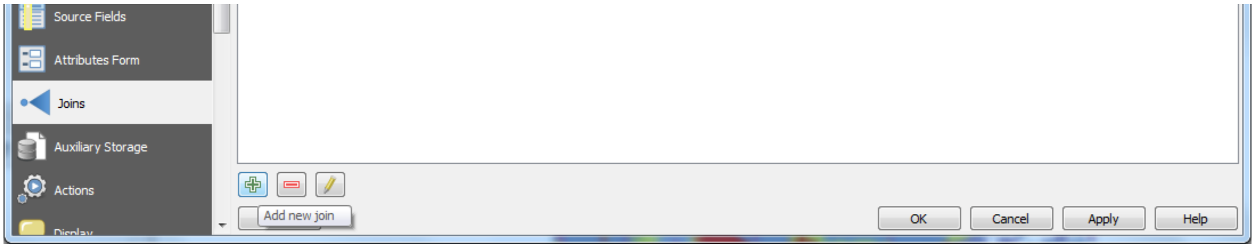
Open the attribute table for the comp table, and find the hydgrp field where the hydrologic group is stored.



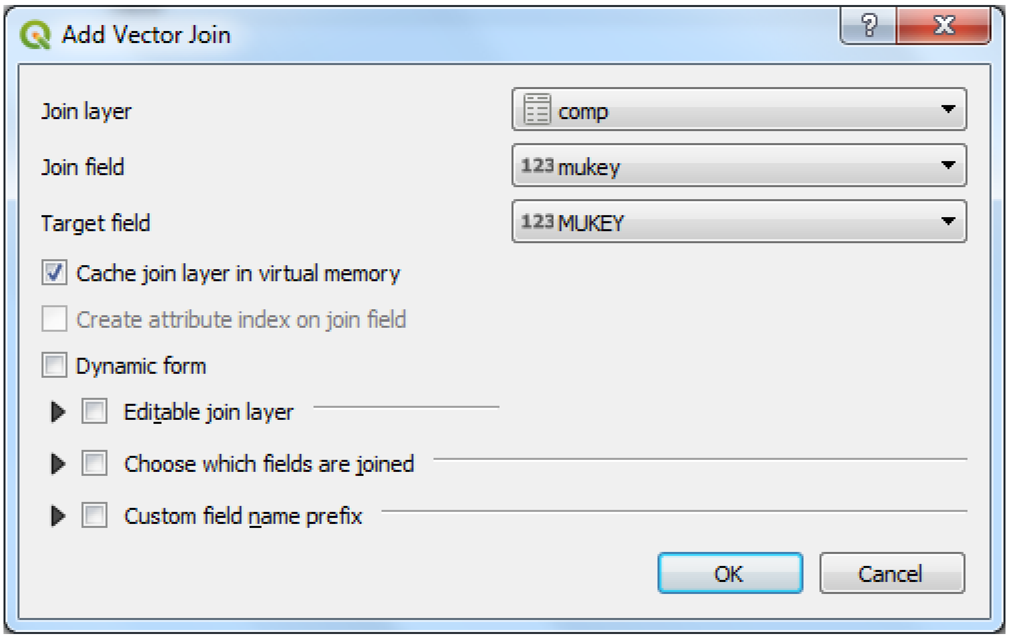
Our goal is to get this information transferred to the soil spatial layer. To accomplish this, we will create a new field in the soil layer called "SoilCode" and store the hydrologic group information in this field.

<u>Joining Layer with Table</u>

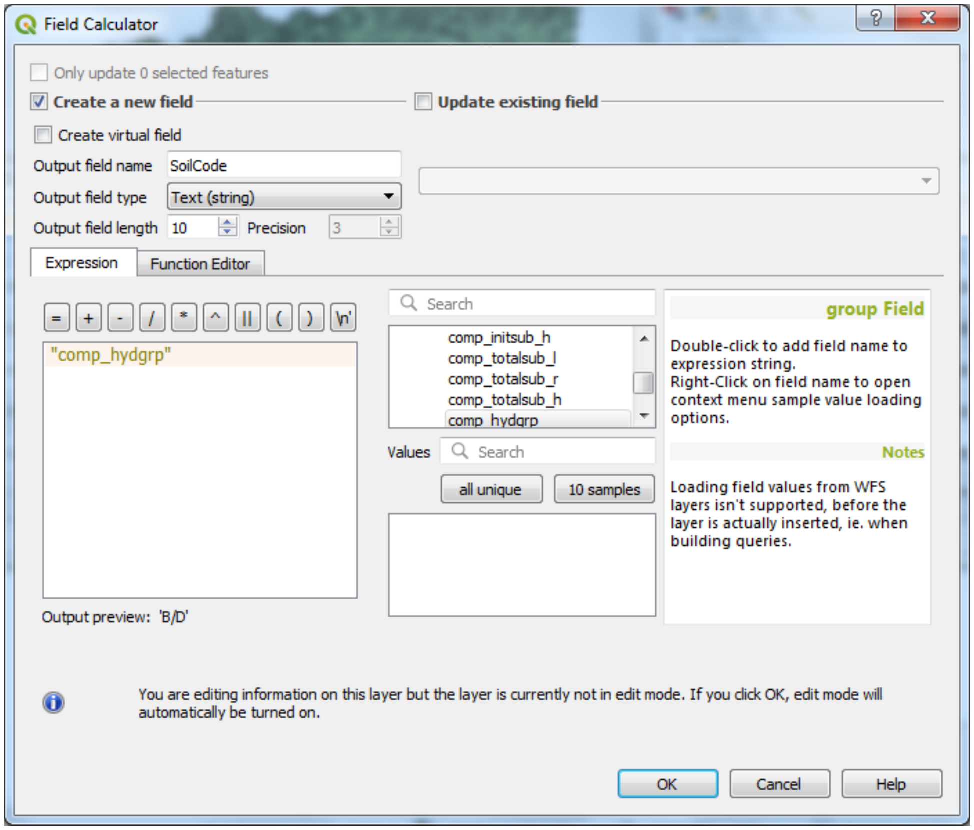
Right click on the soil layer→Properties and the select the Joins tab, and then push the "+" button to add a new join as shown below.



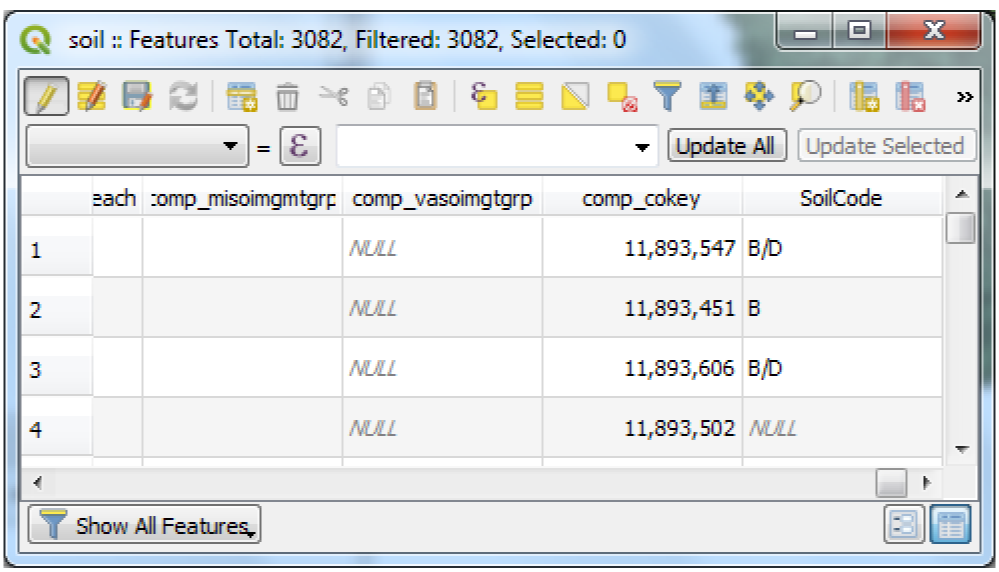
In the join window, select comp as the join layer, and mukey for both the join field and the target field. For the join to work, make sure that both fields have the same data type (i.e., both store either text or numeric data). In this case, MUKEY is a numeric field. Remember the names of the two fields do not need to match even though the names match in this case. What is important is that the information stored in these fields should match. Click OK and Apply to create the join.



Once the join is created, you will see that the attributes of the comp table are now linked, with a comp_" prefix, to the soil attribute table for rows with identical mukey values for both the soil and comp features. Now lets transfer the hydrologic soil group values from the hydgrp field in comp to the soil layer by using the field calculator. With the soil attribute table open, select the field calculator button  (ctrl + I). In the field calculator, use the default "Create new field" option, name the new output field as "SoilCode" and the type for output field as "Text(String). Now we want the SoilCode field to have values from the hydgrp field, which is temporarily named as comp_hydgrp in the joined layer. In the search window of the field calculator, expand the Fields and Values" option, and scroll to "comp_hydgrp" field and double click on it. You will see that the "comp_hydgrp" will be visible in the expression window as shown below.



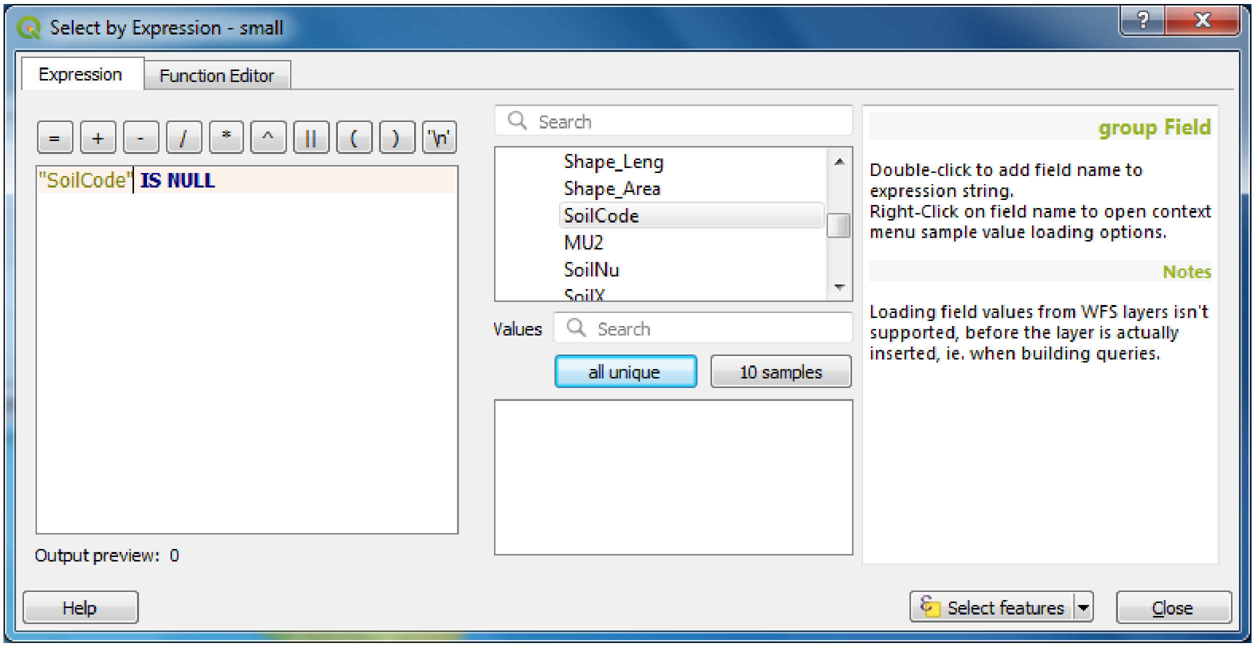
Click OK to create the SoilCode field. Once the process is complete, check that the SoilCode field is created and it has the hydrologic soil group values as shown below.



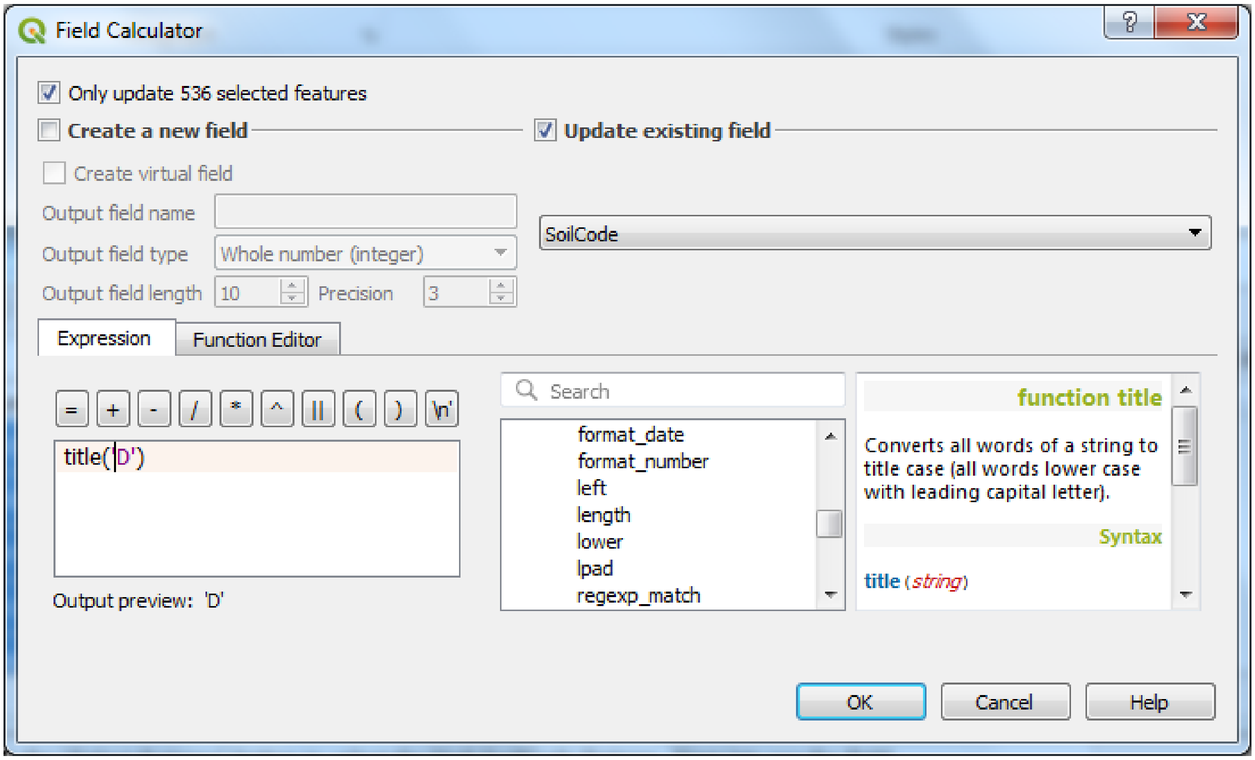
If you think the process worked, remove the join by going to properties of the layer→Joins, and the remove the join by using the "-" button.

In the attribute table for the soil layer, you will see that there are lots of rows with "Null" value for SoilCode. If you review the SoilCode field you will see that D is the dominant soil group. To keep it simple, let us assign a SoilCode of D for all polygons that do not any 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).

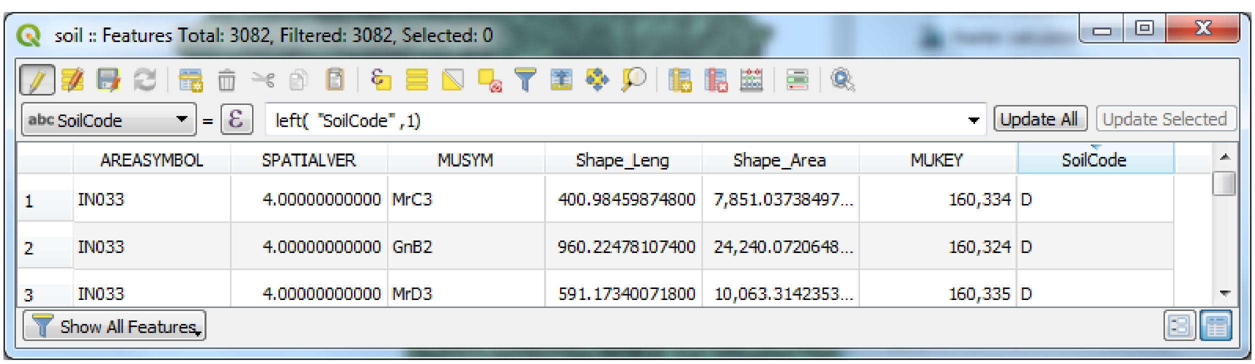
First select all the rows that have Null value for SoilCode. This selection can be done manually by sorting the row and selecting, or by using the Select by Expression button . Push this button, and build an expression ("SoilCode" IS NULL) as shown below by double clicking the "SoilCode" field from the middle box under "Fields and Values" to bring it to the expression box.

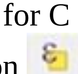


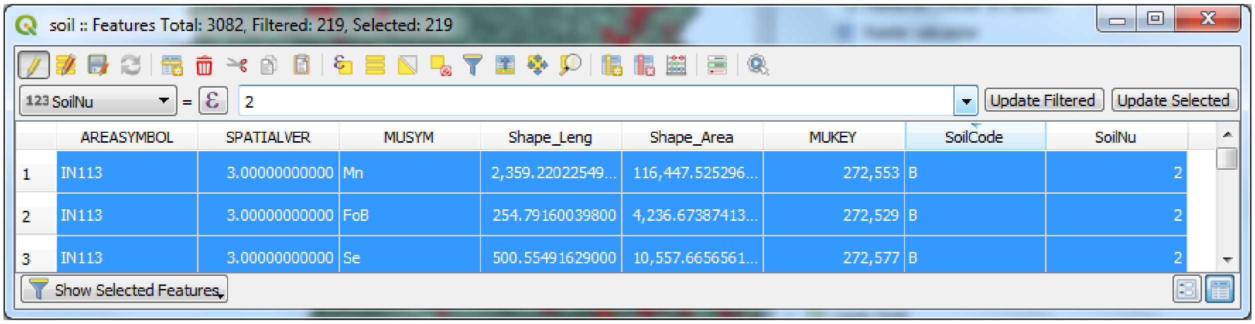
Push the "Select features" button to select the Null SoilCode features. Next lets use the field calculator button as earlier to change the Null values to D. Select the field calculator, but instead of creating a new field, you will now use the Update existing field as shown below. You are updating the SoilCode field and make sure that only selected features are updated with the expression title('D')



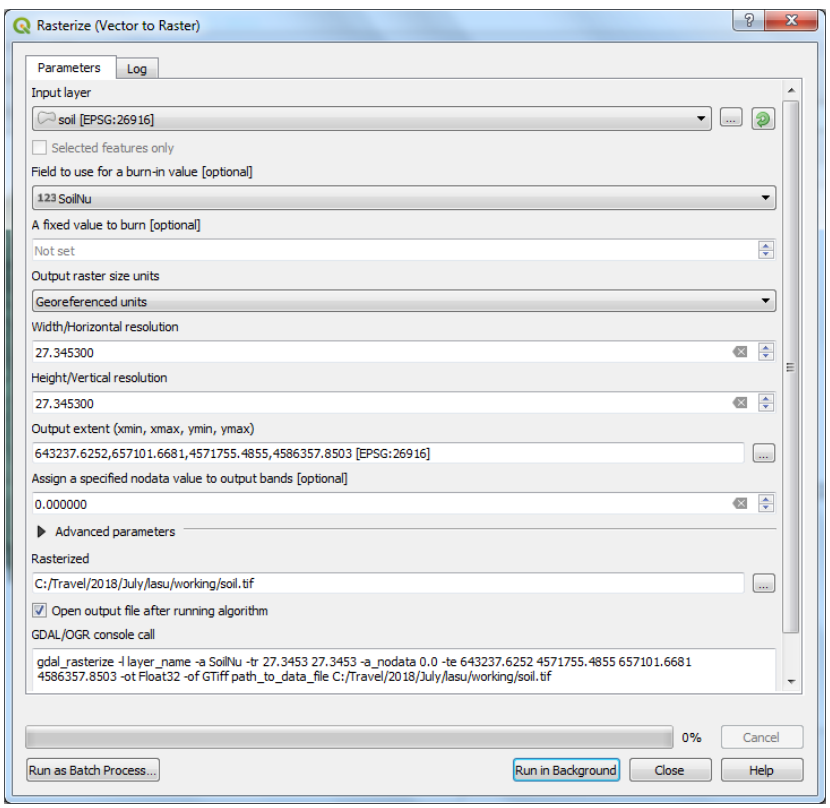
Once the NULL features are updated. Next, lets assign a unique hydrologic group for each soil polygon. For example, hydrogologic group A/B means that some part of the polygon is A and the other part is B. Now, there are ways to use this information in generating the curve number, but to keep the analysis simple, we will assign only one hydrologic group to a soil polygon. Basically, we will keep only the first letter (starting from left) and get rid of anything after that. Earlier, we used field calculator to update a field. You can do that again, but this task can also be accomplished in the attribute table window itself by using the expression bar as shown below. The expression is built by using the "left" function from the string operators. Push the Update All button, and you will see that the SoilCode field now has only one letter.



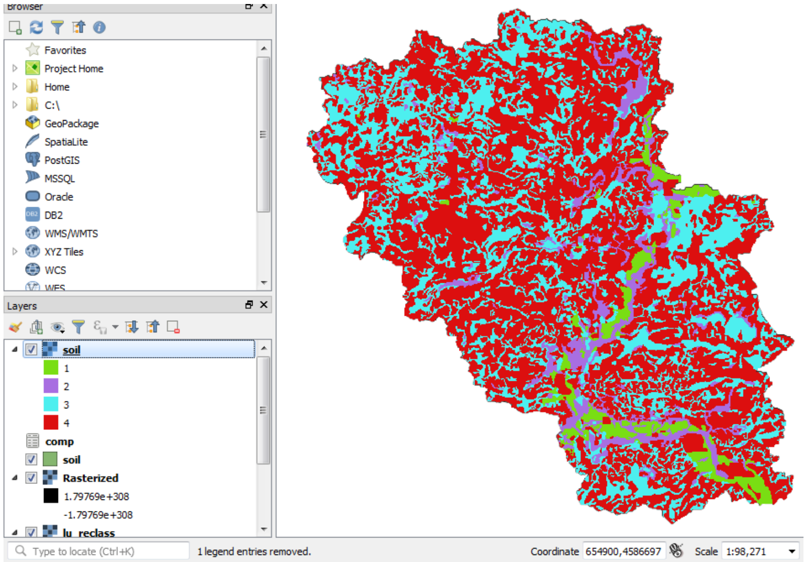
Because we want to create a soil raster, we will assign a number to each of the soil code as A=1, B=2, C=3, and D=4. To do this, we will first create a field called "SoilNu" to store integer values with a default value of "1". Next, you need to select all features with SoilCode = B, and the assign a SoilNU=2. Next assign a soilNu = 3 and SoilNu=4 for C and D features, respectively. You can either select the features using the expression button  or manually. Once the rows are selected, you will update the field with appropriate number using the field calculator. For example, the figure below shows how the SoilNu field is updated after SoilCode = B is selected by using the update selected button.



Repeat this for C and D. Save your edits! Once we have a SoilNu assigned to each soil polygon, the last step is to convert the polygon layer to a raster so both landuse and soil raster can be used to create a CN grid. From the processing tools, search or select the Rasterize (vector to raster tool). Use your soil polygon layer as input, SoilNu for the burn-in value field, and use georeferenced units for the raster output units. The horizontal and vertical resolution of this raster must match with the land use raster, which is 27.3453m in this case. Use the extent of the landuse or lu_reclass layer for the output extent, and leave the default value of zero for the no data cells. Push the Run in Background button to create the soil raster. Once the layer is added to the display, and if you are satisfied with the output, you can save it in your working directory by giving an appropriate name (soil.tif).



After the process is complete, the soil raster will be added to the map document. You can change the symbology to make it look nicer as shown below.



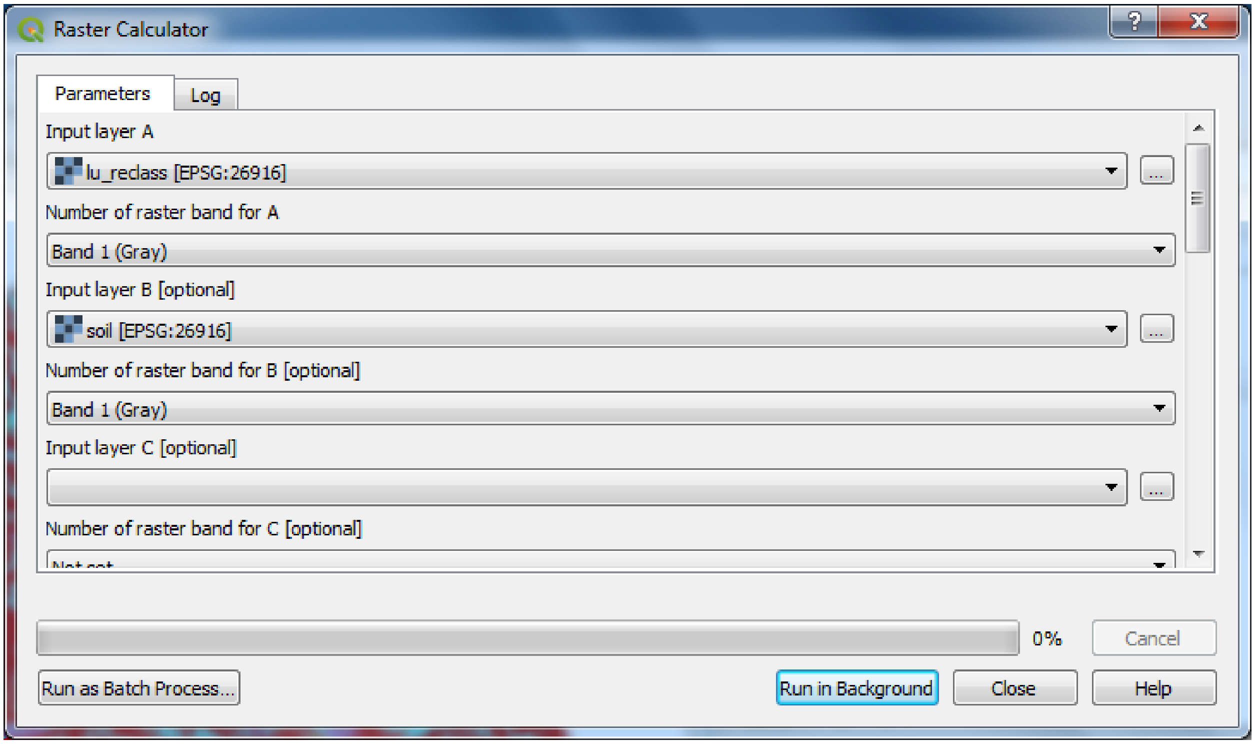
Before proceeding, make sure that the extent, cell resolution and the number of row/columns match for both soil and lu_reclass raster. This is important for the next step. If the extent or the number of rows/columns do not match between the two for some reason, use the smaller dataset to clip the other.

Creating CN Grid

Now, you have two rasters, one for landuse and the other for soil. The next step is to query each cell of these raster and assign a CN value based on the published CN tables. Below is a customized form of the CN table for the current scenario.

Land Use (LU) Description	LU value	Soil Hydrologic Group			
		A(1)	B(2)	C(3)	D(4)
Water	1	100	100	100	100
Medium Residential	2	57	72	81	86
Forest	3	30	58	71	78
Agricultural	4	67	77	83	87

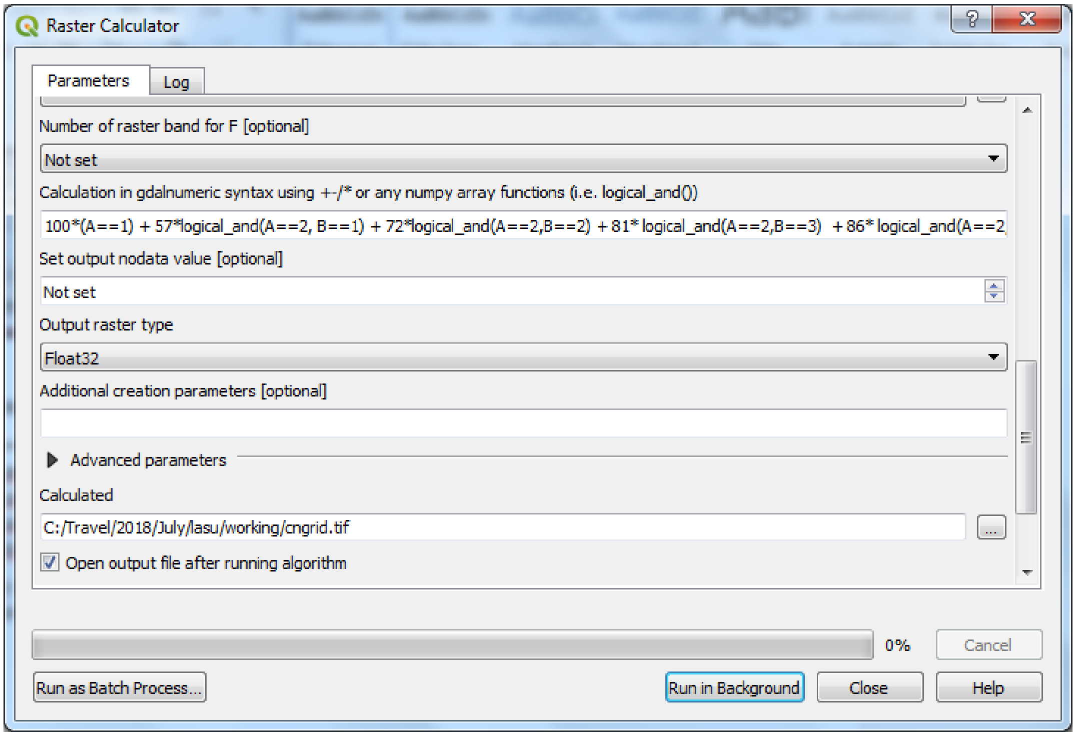
We will use this information and the raster calculator to query each cell in the soil and land use grid to create the CN raster. The query is slightly long and is provided to you in the cnquery.txt file. QGIS has multiple raster calculators, we will be using the GDAL Raster Calculator. In the GDAL raster calculator, make sure you use lu_reclass raster for Layer A and soil raster for Layer B. This is critical because the query is based on A layer for land use and B layer for soil. Specify the number of bands as 1 for both rasters as shown below. Leave other layers blank.



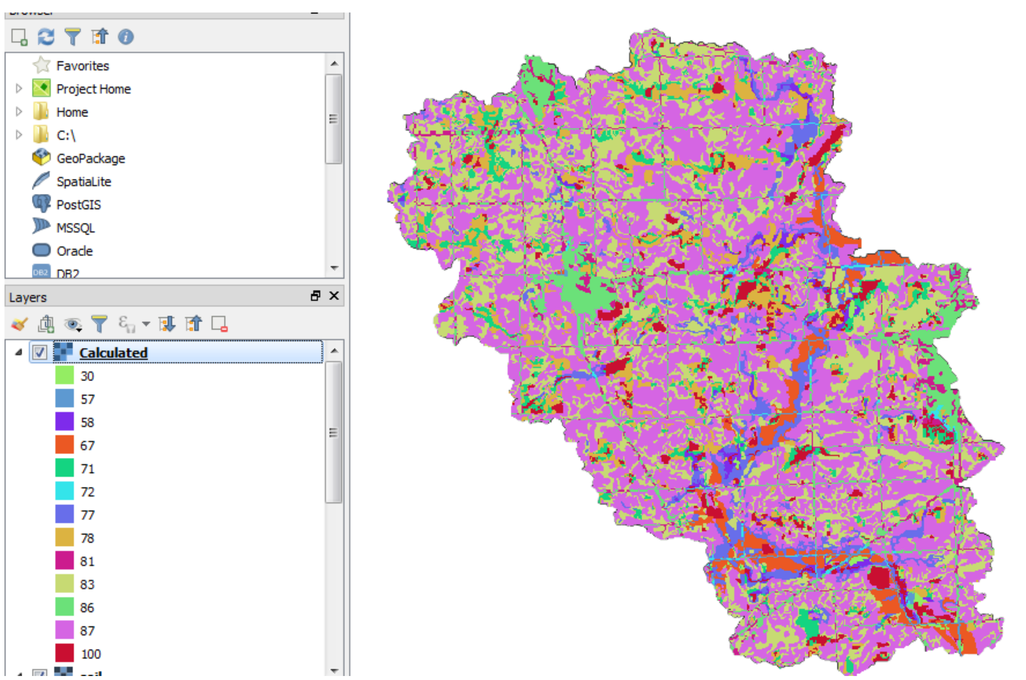
Next open cnquery.txt and copy the query.

100*(A==1) + 57*logical_and(A==2, B==1) + 72*logical_and(A==2,B==2) + 81* logical_and(A==2,B==3) + 86* logical_and(A==2,B==4) + 30*logical_and(A==3, B==1) + 58*logical_and(A==3,B==2) + 71* logical_and(A==3,B==3) + 78* logical_and(A==3,B==4) + 67*logical_and(A==4, B==1) + 77*logical_and(A==4,B==2) + 83* logical_and(A==4,B==3) + 87* logical_and(A==4,B==4)

Basically it is a if-else type of query. Paste the query in the syntax box in the GDAL raster calculator interface and save the output as cngrid.tif as shown below



Push the Run in Background button. After the process is complete, the CN raster will be added to the display. You may change the symbology of the layer to make it look nicer.



Save your QGIS project and you just finished creating an important dataset for hydrologic modeling!