Tutorial Set 3: Spatial data analysis

Exercise Site20_3-5 Development of yield productivity management zones

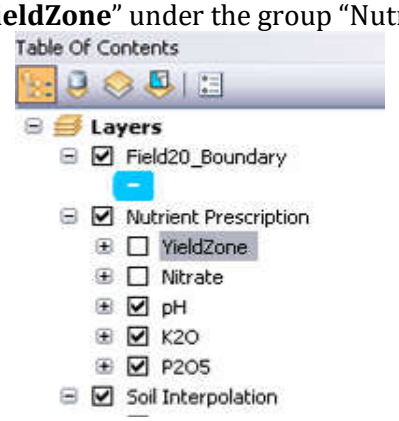
Learning objective: Developing yield-based nutrient management zones according to multi-layer yield history

Techniques: ArcToolbox – Spatial Analyst – Map Algebra – Raster Calculator
ArcToolbox – Spatial Analyst – Neighborhood – Focal Statistics

Data Source: Dataset3

Part 1: Layer management

1. Open the previously saved project.
2. Add a subgroup named "**YieldZone**" under the group "Nutrient Prescription".



Part 2: Creating a map of **Average-Relative Yield**, a map of **Standard-Deviation-Relative Yield,** and a map of **Coefficient of Variability**

1. Understand the formulas.
   Temporal statistics of historical yields:

   Average Yield

$$_{avg}y_{relative} = \frac{y_{relative_{year1}} + y_{relative_{year2}} + \ldots + y_{relative_{yearN}}}{N}$$

   Standard Deviation

$$_{StDev}y_{relative} = \sqrt{\frac{(y_{relative_{year1}} - {}_{avg}y_{relative})^2 + \ldots + (y_{relative_{yearN}} - {}_{avg}y_{relative})^2}{N-1}}$$

   Coefficient of Variation (%)

$$CV = \frac{_{StDev}y_{relative}}{_{avg}y_{relative}} \cdot 100$$

   Class of Yield

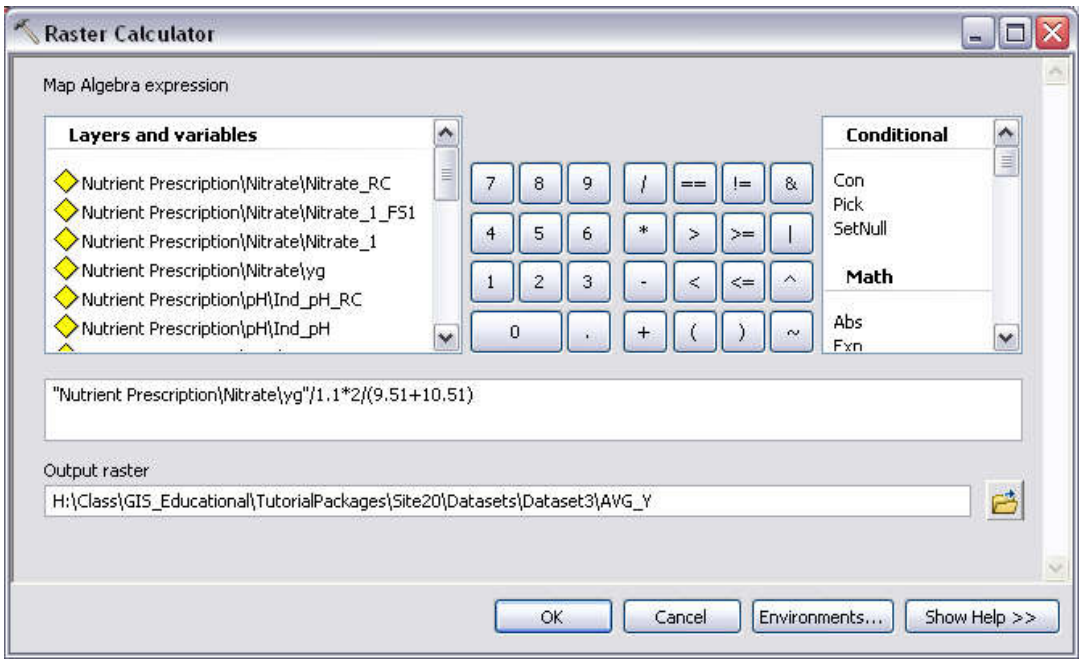
$$CY = \begin{cases} Yield\ Always\ High\ (Nitrogen = -1) & if \quad {}_{avg}y_{relative} - {}_{StDev}y_{relative} > 1 \\ Yield\ Always\ Low\ (Nitrogen = 1) & if \quad {}_{avg}y_{relative} + {}_{StDev}y_{relative} < 1 \\ Yield\ Variable\ Average\ (Nitrogen = 0) & if \quad Otherwise \end{cases}$$

2. Review ***Exercise_Site20_3-4*** to obtain the field average of yield.
   $\overline{Y}_{corn06} = 9.51$; $\overline{Y}_{corn09} = 10.51$; $\overline{Y}_{soybean07} = 4.28$; $\overline{Y}_{soybean10} = 6.29$; $\overline{Y}_{wheat08} = 2.44$

3. Create the map of **Average-Yield**.
   Go to **ArcToolbox** > **Spatial Analyst Tools** > **Map Algebra**> **Raster Calculator**.
   Formulas used:

$$YG = 1.1 \cdot {}_{avg}y_{relative} \cdot \overline{Y_{average_{crop}}}$$

$${}_{avg}y_{relative} = YG \cdot \frac{1}{1.1} \cdot \frac{2}{(\overline{Y}_{corn06} + \overline{Y}_{corn09})}$$



Map algebra expression =

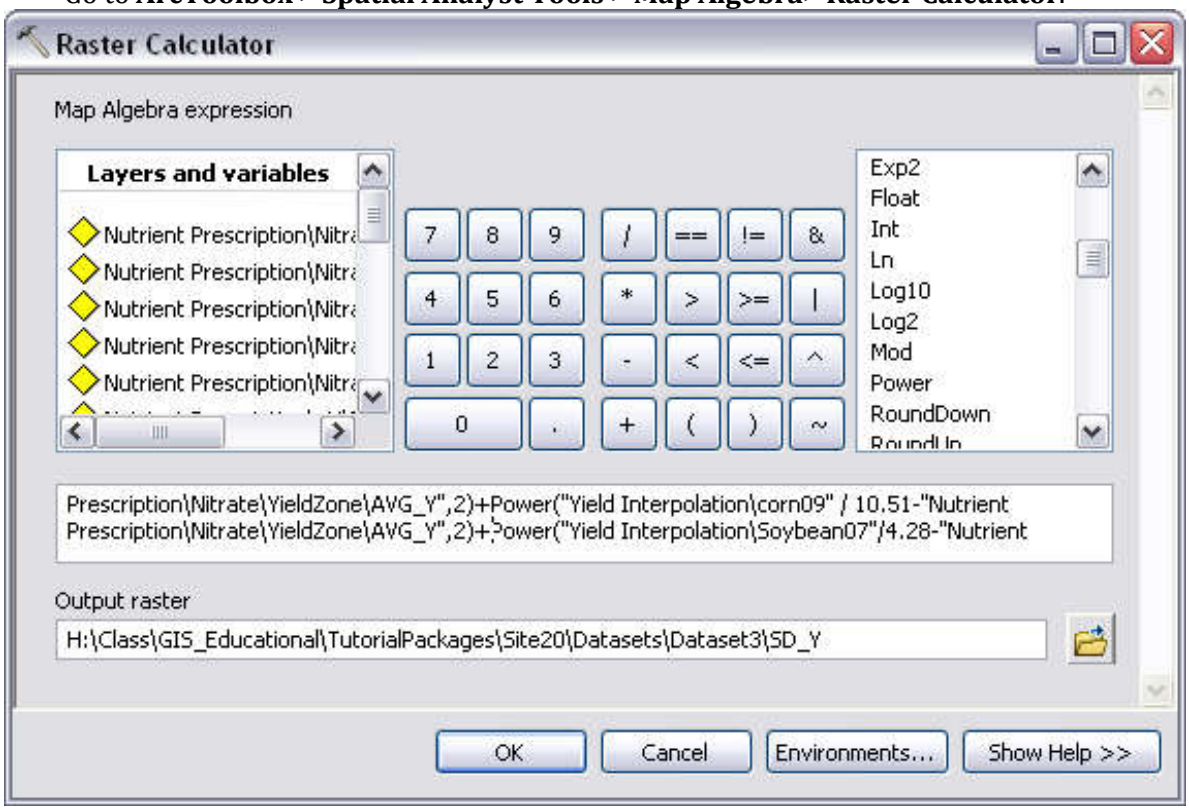
"Nutrient Prescription\Nitrate\yg"/1.1*2/(9.51+10.51)

(*DO NOT directly copy and paste the equation into to Raster Calculator, errors will occur*!!)

Output raster = **AVG_Y**

Click **OK** to proceed.

4. Create the map of **Standard-Deviation-RelativeYield**.
   Go to **ArcToolbox** > **Spatial Analyst Tools** > **Map Algebra**> **Raster Calculator**.



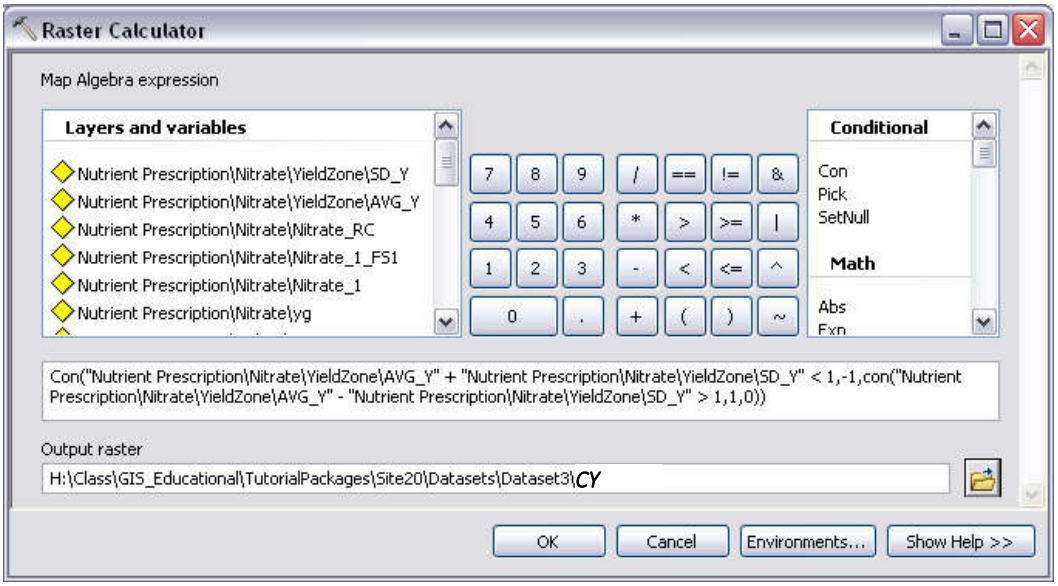
Map algebra expression =

0.5 * SquareRoot(Power("Yield Interpolation\Corn06"/9.51-"Nutrient Prescription\Nitrate\YieldZone\AVG_Y",2)+Power("Yield Interpolation\corn09" / 10.51-"Nutrient Prescription\Nitrate\YieldZone\AVG_Y",2)+Power("Yield Interpolation\Soybean07"/4.28-"Nutrient Prescription\Nitrate\YieldZone\AVG_Y",2)+Power("Yield Interpolation\Soybean10"/6.29-"Nutrient Prescription\Nitrate\YieldZone\AVG_Y",2)+Power("Yield Interpolation\Wheat08"/2.44-"Nutrient Prescription\Nitrate\YieldZone\AVG_Y",2))

Output raster = ***SD_Y***

Click **OK** to proceed.

5. Create the map of Coefficient of Variability using the **Raster Calculator**. Go to **ArcToolbox** > **Spatial Analyst Tools** > **Map Algebra**> **Raster Calculator**. Enter the following map algebra expression. A new raster ***CY*** is added to the **Table of Contents**.

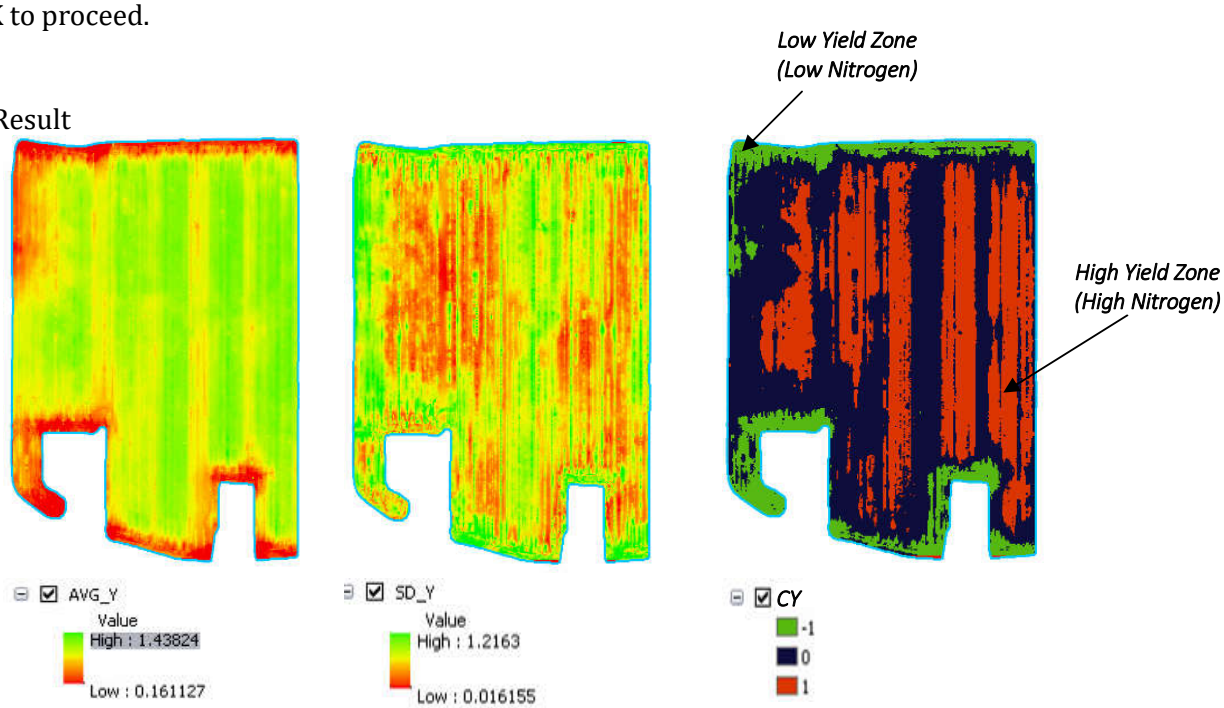


Algebra expression =

Con(("Nutrient Prescription \YieldZone\AVG_Y" + "Nutrient Prescription \YieldZone\SD_Y") < 1,-1,Con(("Nutrient Prescription \YieldZone\AVG_Y" - "Nutrient Prescription \YieldZone\SD_Y") > 1,1,0))

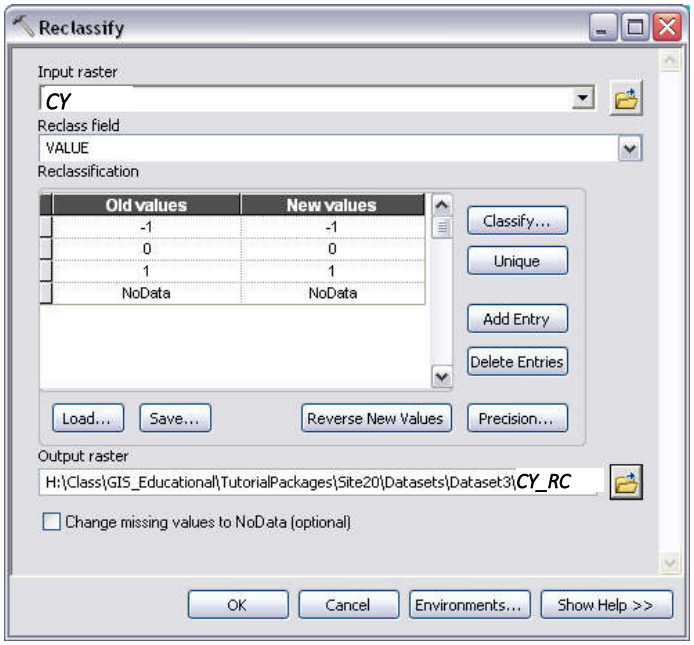
Output raster = ***CY***
Click **OK** to proceed.

6. Result

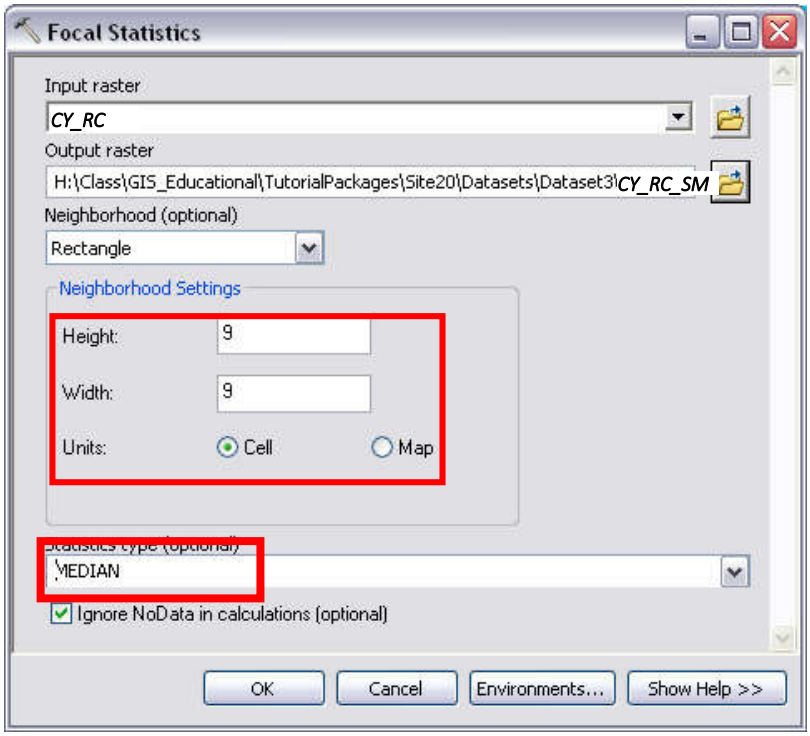


Part 3: Converting raster to vector (e.g., polygon)

1. Reclassify the raster layer ***CY*** to a new raster in which pixels with the same values are merged. Go to **ArcToolbox** > **Spatial Analyst Tools** > **Reclass** > **Reclassify**. Set the parameters as follows and then save the new raster to ***CY_RC***. Click OK, and then the new layer ***CY_RC*** is added to the **Table of Contents**.

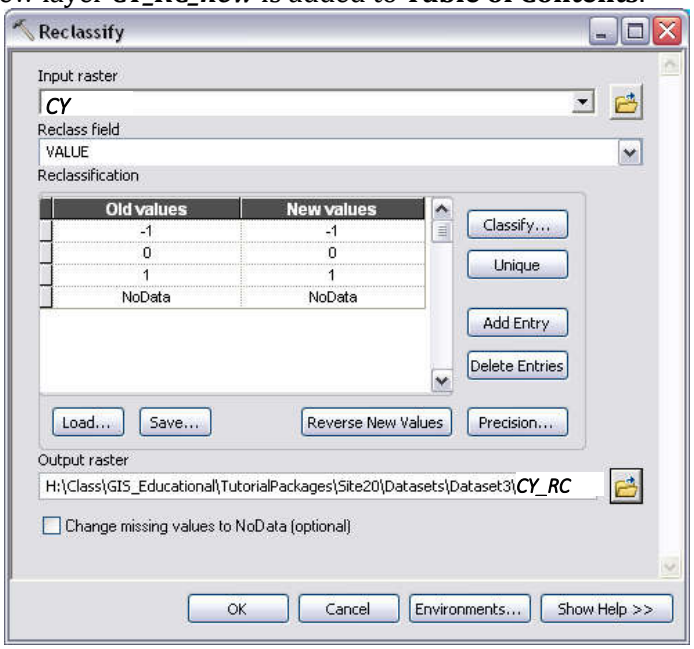


2. Use the **Focal Statistics** tool to smooth the layer ***CY_RC***. Go to **ArcToolbox** > **Spatial Analyst Tools** > **Neighborhood** > **Focal Statistics**. In **Focal Statistics** dialog window, set the parameters as follows. Click **OK**, the smoothed layer ***CY_RC_SM*** is added to **Table of Contents.**

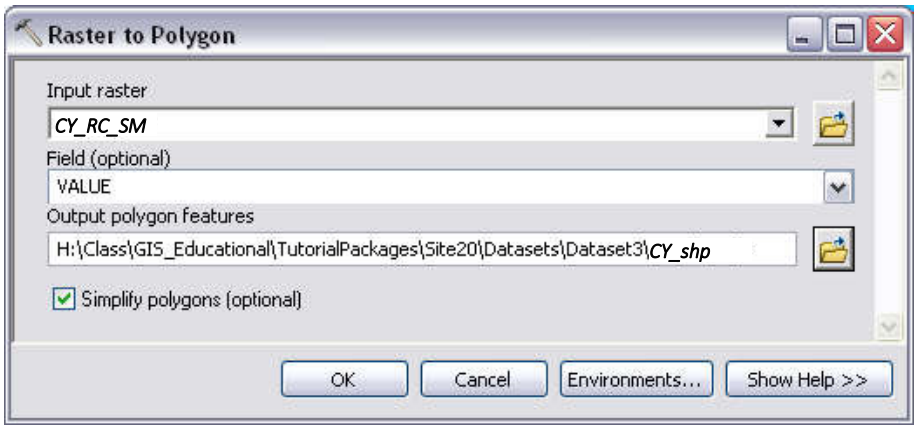


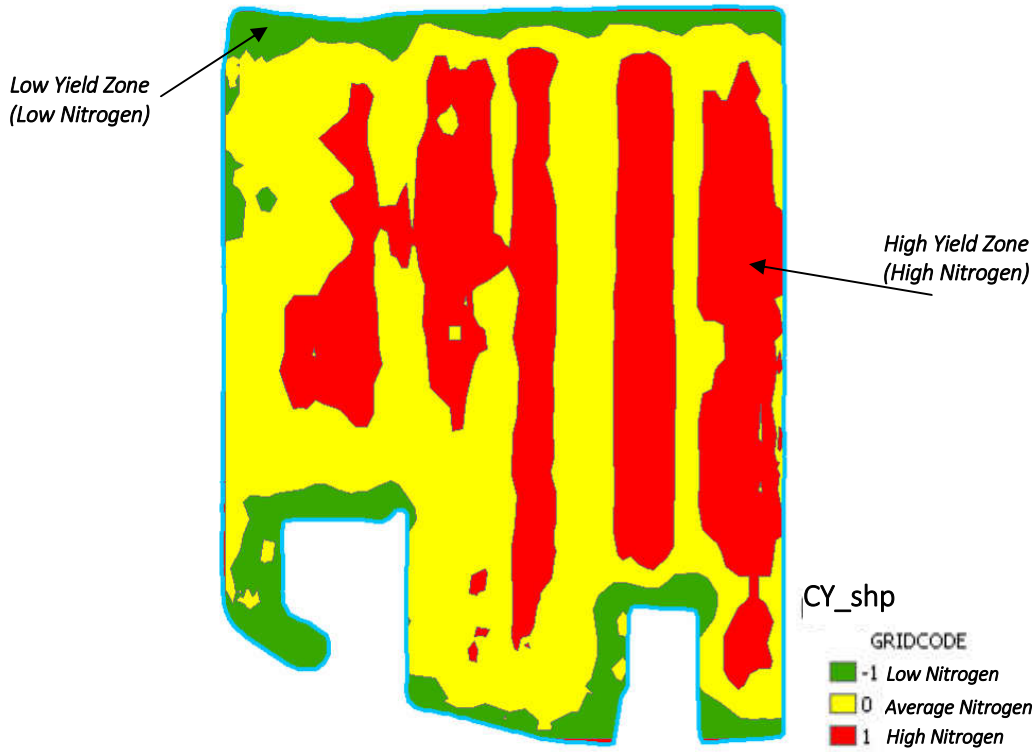
Other smoothing options could be attempted as well. The benefit of the median filter is that it does not reduce the spread of the data, but simply allows the most frequently apparent values to be assigned to the neighbor pixels.

3. Reclassify the raster layer ***CY_RC_SM*** again, as after performing the **Focal Statistics** the new raster contains non-integer values. Go to **ArcToolbox** > **Spatial Analyst Tools** > **Reclass** > **Reclassify**. Set the parameters as follows and then save the new raster to ***CY_RC_new***. Click OK, and then the new layer ***CY_RC_new*** is added to **Table of Contents**.



4. Convert the smoothed and reclassified raster layer ***CY_RC_SM*** to a polygon shapefile.
   Go to **ArcTookbox** > **Conversion Tools** > **From Raster** > **Raster to Polygon**. A new layer ***CY_shp*** showing zones of nitrate prescription is added to the **Table of Contents**.





Here is the final polygonal nutrient management zone map

5. Save the project.