

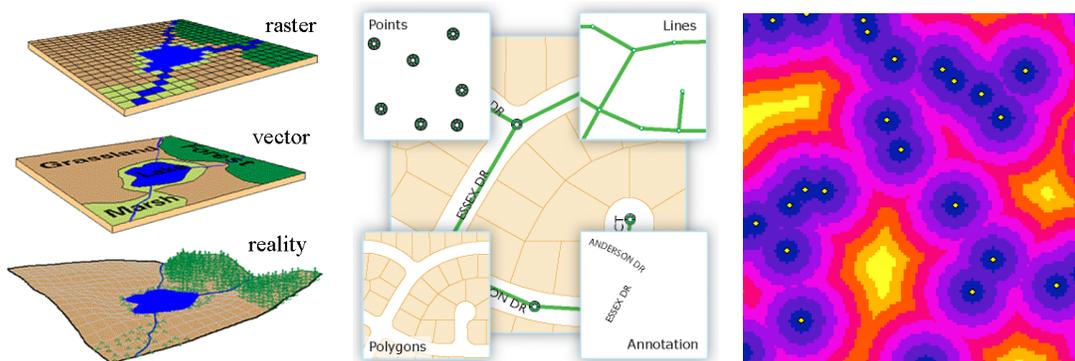
Using the “Map Algebra” ArcGIS Toolbox Function to Identify Criteria Locations

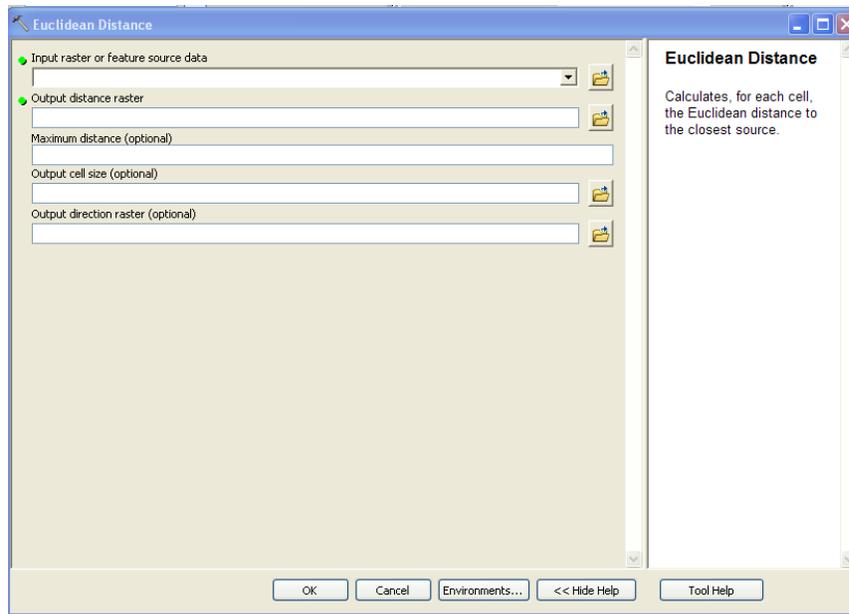
Map Algebra is used when you want to find the places where several layers of data overlap the most. Map Algebra allows the user to use a process called suitability mapping to try to find locations that are “ideal” or “not ideal” for a process or structure. For example, if you want to try to find the best place to locate a sewer, planners have several criteria that they use as places that are ideal and places they want to avoid. Suitability mapping allows them to look at an entire area and weed out locations that are not suitable. The final product is ONLY as good as the criteria. The more criteria you have, the better your suitability map will be.

Steps

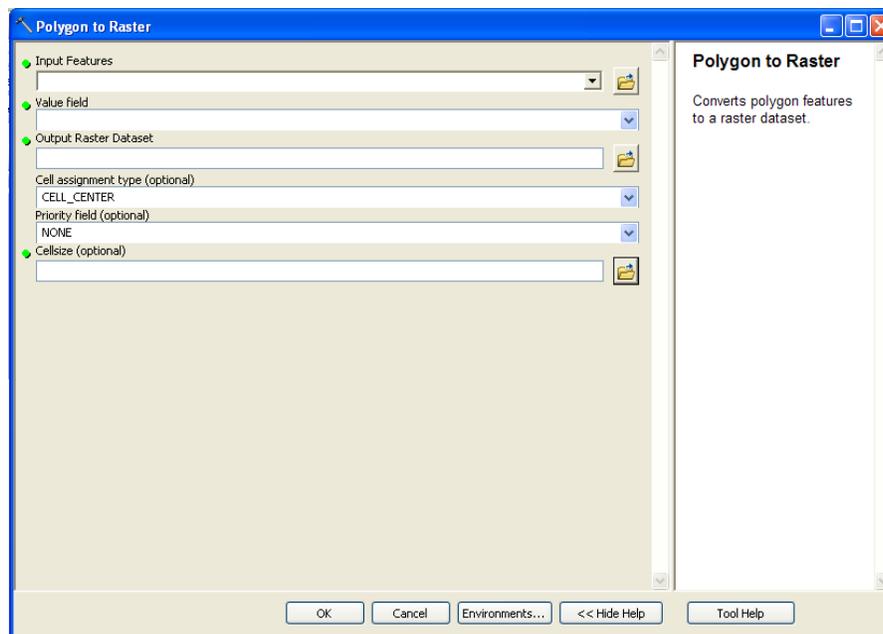
1. Turn on spatial analyst extension.
2. Choose criteria layers and add them to the mxd. Vector layers must be of the **polygon** shapefile type, must already be raster data, or must be able to be converted to raster layers (i.e. line and point shapefiles can be converted to raster data by using the **Euclidean distance** function – last picture shows a Euclidean distance from points).

The Euclidean distance tool is found in Spatial Analyst Tools → Distance → Euclidean Distance. The tool will automatically choose concentric distances or you can put in the maximum distance and it will figure it out. **ALWAYS** click Environments (tab at the bottom) → Processing Extent → Choose the extent of your map. This will fill in all the space. The reason for doing this is the final raster will **ONLY** be the size of your smallest raster extent (e.g. if a layer is 1000 pixels x 1000 pixels and another is 500x500, your final image will be 500x500).





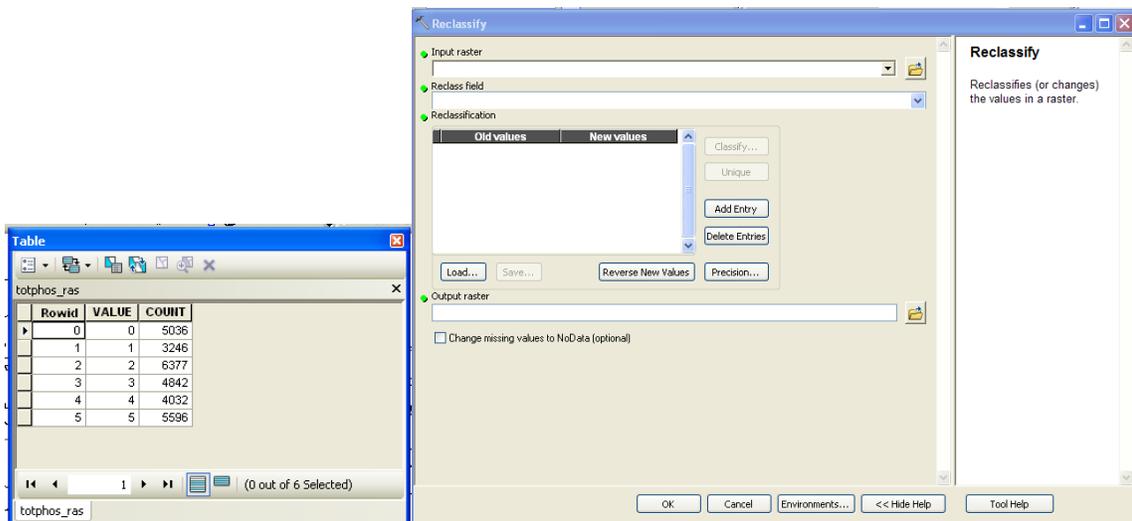
3. Rasterize. All data must be converted to raster layers. All of the **Raster conversion** tools are in Conversion Tools → To Raster → Polygon to Raster. Choose Maximum Combined Area for cell assignment type. Value field is the field you want to rasterize. Names of raster layers must be less than 13 characters.



4. Choose the number of classes and **Reclassify**. Spatial Analyst Tools → Reclass → Reclassify. The scale you set here affects your final map. Typically people use a **1-10 scale** with 1 being NOT ideal and 10 being ideal (and 0 being no data).

In the sewers example you may consider proximity to homes and unsewered areas as two possible criteria. All sewer areas would be a 0 class (known as no data) because you don't want them to be considered at all. Sewer areas would be a 10. But let's say some unsewered areas are not ideal because they have working septic systems. You could say all those with functioning systems are a 5 and those with no septic systems are a 10. Then homes, you would use the **Euclidean distance** tool to where the farther you got away from a home the lower the score, e.g. 0-99 feet from a home is a 10, 100-199 feet is a 9, etc.

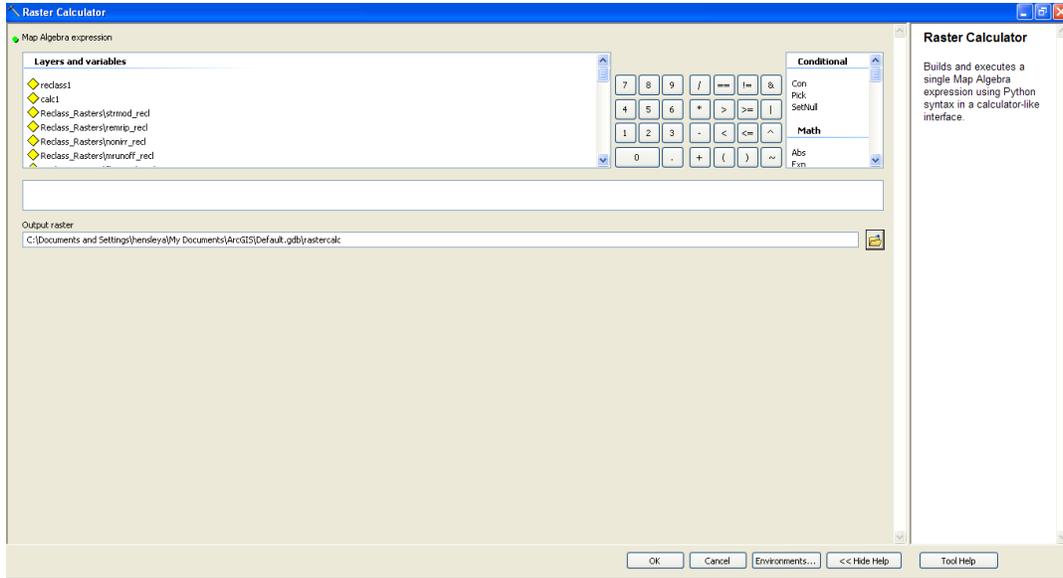
So, not all layers need 10 classes, but all need to have the scale from 1 to 10. Your input is your raster data. The *Reclass field* is the column in the data that you want to reclass. Typically, in raster data, it is the "value" field. You type in your classes in the "old values" and "new values column". You can change the number of classes by clicking "classify". **ALWAYS** click Environments (tab at the bottom) → Processing Extent → Choose the extent of your map. Check "change missing values to NoData" and make no data be 0.



5. Add layers using Raster Calculator. Spatial Analyst Tools → Map Algebra → Raster Calculator. You can add, multiply, divide, subtract. When doing basic suitability mapping, the addition function is the one to use. There are two ways to use the calculator:
 - a. Weight functions now to keep the scale 1-10. The maximum value a cell can have will be 10 if it has every criteria layer. Your function would look like this:
 - i. $1/(X \text{ number of layers}) * \text{Layer1} + 1/(X \text{ number of layers}) * \text{Layer2} + \dots + 1/(X \text{ number of layers}) * \text{LayerX}$
 - ii. For 8 layers – $1/8 * \text{Layer1} + \dots + 1/8 * \text{Layer8}$
 - b. Do not weight functions. The maximum value a cell can have will be: number of layers x highest value on the scale. So if you have 8 criteria layers with a scale 1-

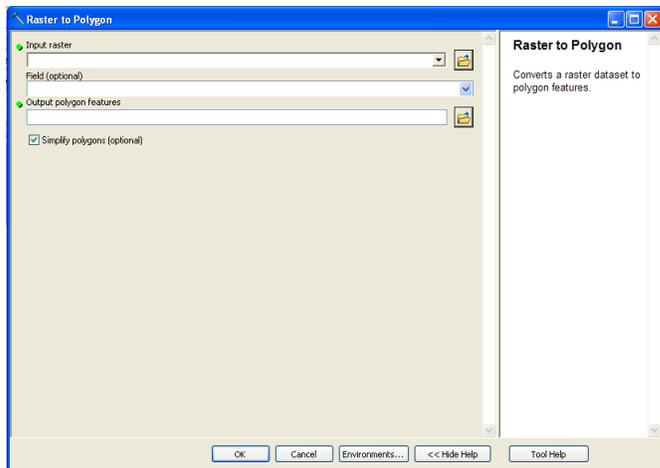
10, then the highest value a cell could have will be 80.

- i. $\text{Layer1} + \text{Layer2} + \dots + \text{LayerX}$
- ii. For 8 layers – $\text{Layer1} + \dots + \text{Layer8}$

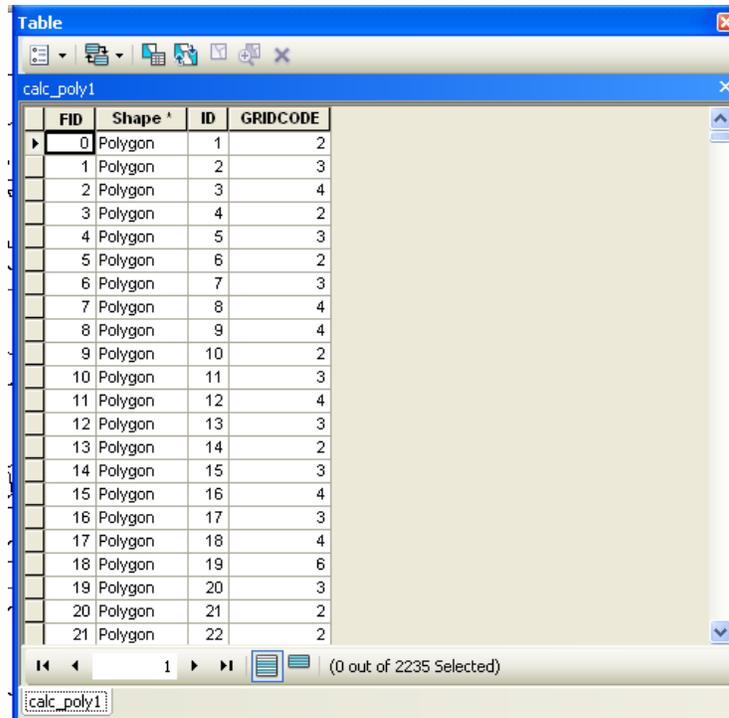


Your end product will be a map where the highest number is “ideal” and the lowest numbers are “not ideal”.

6. **Reclassify** again using the calculated layer. If you chose *method a* in step 5, then you do not need to reclassify. If you chose *method b* in step 5, then you must reclassify to your original scale or some other scale that you would like to use.
7. Convert from **Raster to Polygon**. Conversion Tools → From Raster → Raster to Polygon. The *Field* will be “value”. You can check or uncheck simplify polygons. I usually uncheck it, but to be honest, I am not sure what it does.



You will have data that looks like this:



FID	Shape	ID	GRIDCODE
0	Polygon	1	2
1	Polygon	2	3
2	Polygon	3	4
3	Polygon	4	2
4	Polygon	5	3
5	Polygon	6	2
6	Polygon	7	3
7	Polygon	8	4
8	Polygon	9	4
9	Polygon	10	2
10	Polygon	11	3
11	Polygon	12	4
12	Polygon	13	3
13	Polygon	14	2
14	Polygon	15	3
15	Polygon	16	4
16	Polygon	17	3
17	Polygon	18	4
18	Polygon	19	6
19	Polygon	20	3
20	Polygon	21	2
21	Polygon	22	2

8. Evaluate your data using the “Symbology” tab in “Properties” for that dataset. Properties → Symbology → Unique Values → Value Field → Gridcode → Add all values → uncheck <all other values> → Choose a color scheme that works for your map. Places where you should look first will be the 10s. Places that are unsuitable will be the 1s (or zeros if you kept that separate).

Suitability Mapping Example

Example: You want to find the best places to extend sewer service. We are going to simplify this quite a bit, but you could get very in depth with your assessment.

Layers to use:

- Existing sewers
- Roads
- Watersheds impaired by unsewered areas/septic systems
- Other layers?

9. Turn on spatial analyst extension.

10. Choose criteria layers and add them to the mxd.

11. Rasterize.

- Existing sewers: The best places will be close to sewer lines because service will be easy to pipe, but the worst places will be in sewer areas themselves.
- Roads: Usually sewer and water lines are found along roads, but you will also need to consider that roads provide access to build the lines. Euclidean distance should be used on the roads layer.
- Watersheds impaired: The best places to build sewers will be in watersheds with impairments for unsewered areas or bacteria.

12. Choose the number of classes and **Reclassify**.

- Existing sewers: 10 near sewers, 5 unsewered areas, 0 sewer
- Roads: 1-10 with 10 being closest to road.
- Watersheds impaired: Impaired 10, Not impaired 0.

13. Add layers using Raster Calculator.

- Existing Sewers + Roads + Watershed Impair

14. **Reclassify** again using the calculated layer.

- 1-10 scale

15. Covert from **Raster to Polygon**.

16. Evaluate your data using the “Symbology” tab in “Properties” for that dataset.