# Multi-Criteria Analysis for Prioritization

In this exercise, you will gain experience working with weighting methods and the compromise programming ranking algorithm. You will work with a dataset of watersheds and evaluation criteria to determine the highest ranked areas for brook trout habitat integrity.

**Part A. Criteria Weighting**

The first part of the exercise requires you to work in groups of three to four students. The objective is to determine the appropriate importance weights that should be used to rank areas for brook trout habitat integrity. For the first two questions, I would like you to reach consensus on the weights using the point allocation method, and one of the ranking methods of your group's choice. Question three requires you to work through the pairwise comparisons as a group. You will then use your pairwise comparisons to calculate weights using an excel spreadsheet that I have provided as a guide. It is located in the data/MCA folder and is called PC-template.xls

The evaluation criteria to consider for ranking areas for brook trout habitat integrity are: *(from Williams et al., 2007)*

- Land stewardship
- Watershed connectivity
- Watershed conditions
- Water quality
- Flow regime

**Question 1**. Reach consensus on the weights that should be allocated to each of the criteria using the point allocation method. Refer to the lecture notes if you are unsure of this method.

Rating method: Point allocation

| WEIGHT | CRITERIA |
|---|---|
| | Land stewardship |
| | Watershed connectivity |
| | Watershed conditions |
| | Water quality |
| | Flow regime |

**Question 2**. Reach consensus on the weights that should be allocated to each of the criteria using one of the three ranking methods. Refer to the lecture notes if you are unsure of this method. Make sure to specify the ranking method you choose and show all calculations in the space below.

Ranking method you chose:_______________

| WEIGHT | CRITERIA |
|---|---|
| | Land stewardship |
| | Watershed connectivity |
| | Watershed conditions |
| | Water quality |
| | Flow regime |

**Question 3**.
Use the pairwise comparison table below to complete each comparison.

Mark the preferred criteria for selecting areas for brook trout habitat integrity.

| | strongly prefer | prefer | somewhat prefer | equal | somewhat prefer | prefer | strongly prefer | |
|---|---|---|---|---|---|---|---|---|
| Land stewardship | O | O | O | O | O | O | O | Watershed connectivity |
| Land stewardship | O | O | O | O | O | O | O | Watershed condition |
| Land stewardship | O | O | O | O | O | O | O | Water quality |
| Land stewardship | O | O | O | O | O | O | O | Flow regime |
| Watershed connectivity | O | O | O | O | O | O | O | Watershed condition |
| Watershed connectivity | O | O | O | O | O | O | O | Water quality |
| Watershed connectivity | O | O | O | O | O | O | O | Flow regime |
| Watershed condition | O | O | O | O | O | O | O | Water quality |
| Watershed condition | O | O | O | O | O | O | O | Flow regime |
| Water Quality | O | O | O | O | O | O | O | Flow regime |

Next, transfer the comparisons to the pairwise comparison spreadsheet found in the data/MCA folder. Once completed, fill in the weights below

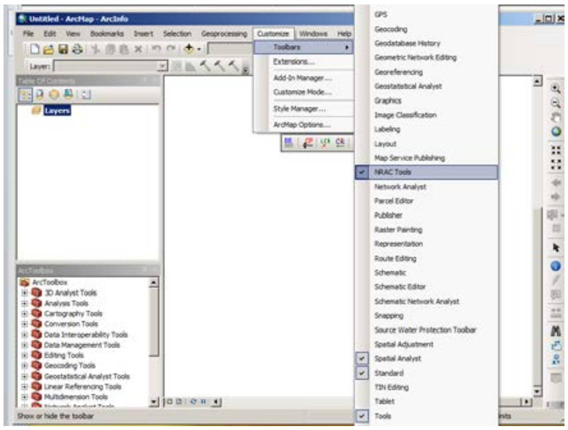
| WEIGHT | CRITERIA |
|---|---|
| | Land stewardship |
| | Watershed connectivity |
| | Watershed conditions |
| | Water quality |
| | Flow regime |

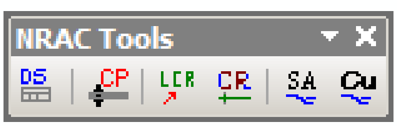
**Question 4**.
Were the pairwise comparisons your group developed consistent? Why or why not?

**Part B. Compromise Programming Ranking Algorithm**

Now that you have weights for each of these criteria using three methods, you will now use them in the compromise programming ranking algorithm.

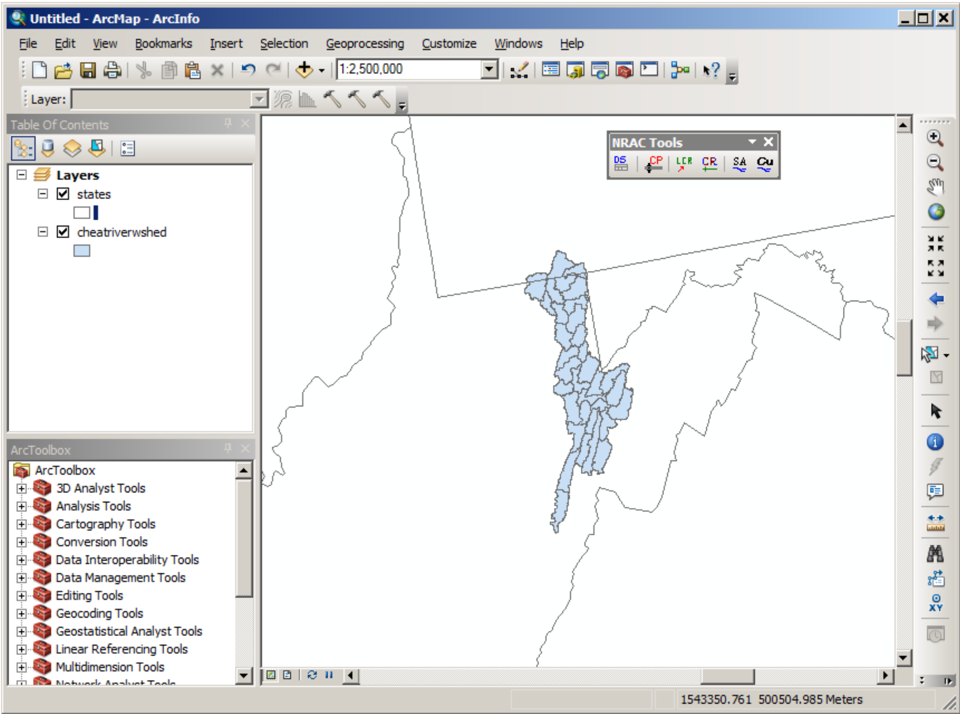
- First, make sure that you have the NRAC Tools toolbar turned on in ArcMap. It can be turned on by Customize -> Toolbars -> checking NRAC Tools






- To use the toolbar, we need to add data to the table of contents. Use the add data button and navigate to the data/MCA directory. Select the cheatriverwshed.shp and add it to the ArcMap display.

Displayed are 12-digit coded hydrological regions for the Cheat River Watershed in WV. To reference yourself on where this watershed is located, you may also add the states shapefile also found in the data/MCA folder.




Located in the attribute table for the cheatriverwshed shapefile are values assembled for each of the subwatersheds. The ones we will focus on for this exercise are the last five Land stewardship (land), Watershed connectivity (wconnect), Watershed condition (wcond), Water quality (wq), and Flow regime (flow).

Table

cheatriverwshed

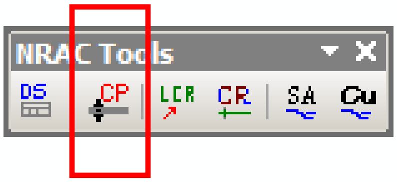
| SO4_MEAN | ELEV_MIN | ELEV_MAX | ELEV_MEAN | EXOTICS | land | wconnect | wcond | wq | flow | HU_12_NAME |
|---|---|---|---|---|---|---|---|---|---|---|
| 24 | 465 | 775 | 637.6 | 0 | 1 | 1 | 2 | 1 | 3 | Fike Run-Little Sandy Creek |
| 24 | 438 | 703 | 552.8 | 0 | 1 | 4 | 2 | 1 | 3 | Middle Big Sandy Creek |
| 24 | 471 | 844 | 602.8 | 0 | 1 | 4 | 2 | 1 | 3 | Upper Big Sandy Creek |
| 24 | 277 | 806 | 568.3 | 0 | 1 | 4 | 1 | 1 | 2 | Lower Big Sandy Creek |
| 24 | 236 | 806 | 423.7 | 0 | 1 | 1 | 2 | 1 | 2 | Cheat Lake-Cheat River |
| 24 | 442 | 943 | 621.3 | 1 | 1 | 1 | 2 | 1 | 1 | Beaver Creek-Little Sandy Creek |
| 24.3 | 255 | 733 | 542 | 0 | 1 | 4 | 1 | 1 | 2 | Bull Run-Cheat River |
| 24.5 | 349 | 952 | 649.2 | 0 | 1 | 1 | 1 | 1 | 5 | Muddy Creek |
| 24.8 | 275 | 727 | 566.5 | 0 | 1 | 5 | 3 | 2 | 5 | Greens Run-Cheat River |
| 25 | 349 | 955 | 644.7 | 0 | 1 | 1 | 1 | 1 | 5 | Roaring Creek-Cheat River |
| 25 | 377 | 898 | 597.7 | 0 | 1 | 4 | 1 | 1 | 1 | Pringle Run-Cheat River |
| 25 | 420 | 922 | 676.9 | 0 | 1 | 1 | 1 | 1 | 1 | Salt Lick Creek |
| 25.2 | 432 | 996 | 729 | 0 | 1 | 1 | 1 | 1 | 1 | Wolf Creek |
| 25.2 | 415 | 884 | 635.4 | 0 | 1 | 4 | 1 | 1 | 1 | Flag Creek-Cheat River |
| 25.9 | 476 | 1120 | 738.1 | 0 | 5 | 4 | 1 | 1 | 5 | Horseshoe Run |
| 26 | 423 | 961 | 637.3 | 0 | 5 | 4 | 1 | 1 | 1 | Licking Creek-Cheat River |
| 26 | 464 | 1115 | 666.4 | 0 | 5 | 5 | 3 | 2 | 5 | Minear Run-Cheat River |
| 25.5 | 723 | 1242 | 1007.4 | 0 | 5 | 1 | 5 | 4 | 1 | Middle Blackwater River |
| 26 | 510 | 1122 | 941.1 | 0 | 5 | 4 | 1 | 1 | 5 | Lower Blackwater Fork |
| 25.3 | 944 | 1333 | 1026.7 | 1 | 5 | 1 | 5 | 4 | 1 | Upper Blackwater River |
| 26 | 466 | 948 | 685.4 | 0 | 5 | 1 | 1 | 1 | 4 | Clover Run |
| 26 | 489 | 1257 | 836.1 | 0 | 5 | 5 | 3 | 2 | 5 | Dry Fork-Black Fork |
| 26 | 489 | 1220 | 726.2 | 0 | 5 | 4 | 1 | 1 | 4 | Haddix Run-Shavers Fork |
| 25 | 651 | 1470 | 1100.9 | 0 | 5 | 1 | 5 | 4 | 1 | Red Creek |

(0 out of 34 Selected)

cheatriverwshed

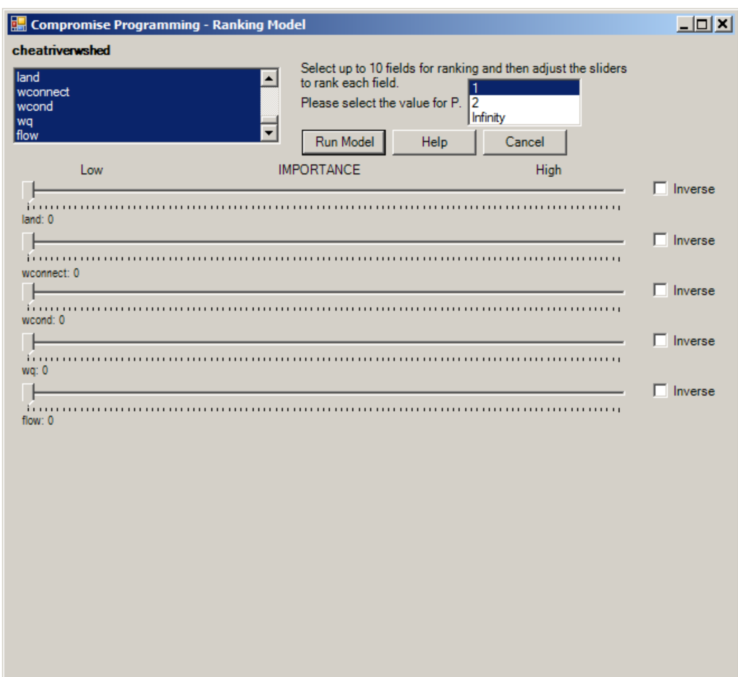
Note that these last five fields before the Hu_12_name range in value from 1 to 5 as a scored rating for each subwatershed. You will now use the compromise programming ranking model with the weights from your previous work on this exercise.

- Select the “CP” button on the ranking toolbar.




A window appears which allows you to select up to ten fields in the attribute table.

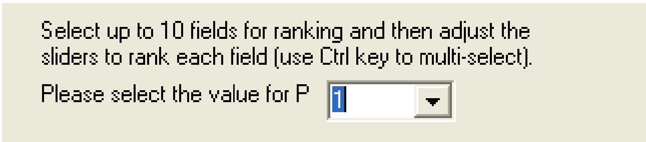
- Since we have weights for Land stewardship, Watershed connectivity, Watershed condition, Water quality, and Flow regime, select the land, wconnect, wcond, wq, and flow fields by holding down the CRTL and clicking on them with your cursor.




You will now see that the criteria now show up at the bottom ready for us to apply a slider bar weight.

- Move the slider bars so that they reflect the weight set from Question 1. Be careful and make sure your values sum to 100. Since a greater score for each of these five criteria is preferred, we don’t have to take the inverse of any of the values.

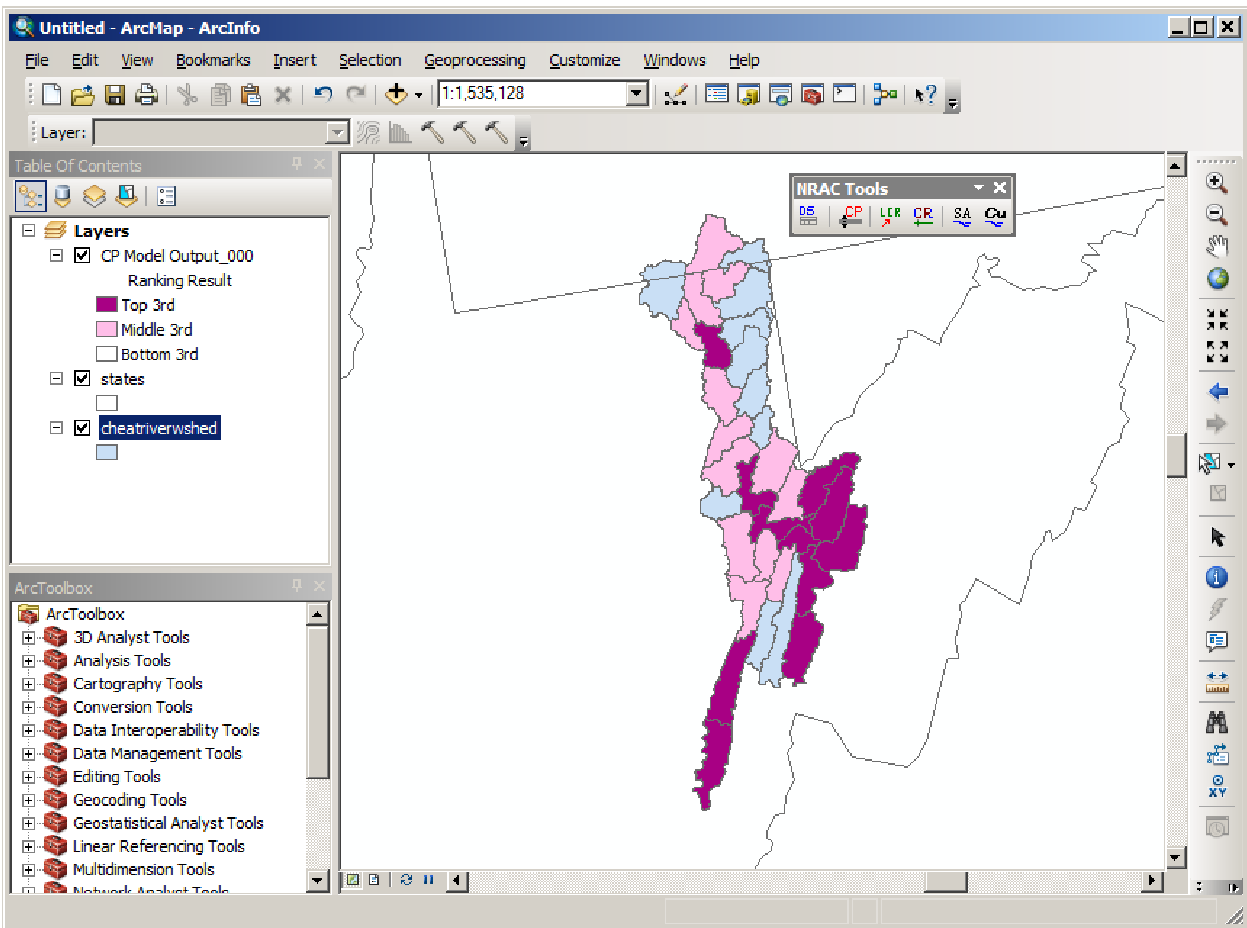
- Select a value for P of 1




- When all ready to go select "Run Model"

The compromise programming model will take a few seconds to run.

The output will be a ranking of the watersheds as a new shapefile with color coded ranking areas as high, medium, and low. The high ranking areas are those watersheds with the highest habitat integrity for brook trout habitat.




You open the attribute table to get a list of the highest ranking subwatersheds.

Table

CP Model Output_000

| HU_12_NAME | score01 | score02 | score03 | score04 | score05 | score06 | score07 | score08 | score09 | score10 | totalScore | totalRank |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Horsecamp Run-Dry Fork | 0 | 0.25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.25 | 1 |
| Minear Run-Cheat River | 0 | 0 | 0.24 | 0.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0.54 | 2 |
| Dry Fork-Black Fork | 0 | 0 | 0.24 | 0.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0.54 | 2 |
| Big Run-Dry Fork | 0 | 0 | 0.24 | 0.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0.54 | 2 |
| Red Run-Shavers Fork | 0 | 0 | 0.24 | 0.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0.54 | 2 |
| Greens Run-Cheat River | 0.46 | 0 | 0.24 | 0.3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 |
| Middle Blackwater River | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 |
| Upper Blackwater River | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 |
| Red Creek | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 |
| Gandy Creek | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 |
| First Fork-Shavers Fork | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 |
| Horseshoe Run | 0 | 0.25 | 0.49 | 0.46 | 0 | 0 | 0 | 0 | 0 | 0 | 1.2 | 4 |
| Licking Creek-Cheat River | 0 | 0.25 | 0.49 | 0.46 | 0 | 0 | 0 | 0 | 0 | 0 | 1.2 | 4 |
| Lower Blackwater Fork | 0 | 0.25 | 0.49 | 0.46 | 0 | 0 | 0 | 0 | 0 | 0 | 1.2 | 4 |
| Haddix Run-Shavers Fork | 0 | 0.25 | 0.49 | 0.46 | 0 | 0 | 0 | 0 | 0 | 0 | 1.2 | 4 |
| Otter Creek | 0 | 0.25 | 0.49 | 0.46 | 0 | 0 | 0 | 0 | 0 | 0 | 1.2 | 4 |
| Outlet Glady Fork | 0 | 0.25 | 0.49 | 0.46 | 0 | 0 | 0 | 0 | 0 | 0 | 1.2 | 4 |
| Taylor Run-Shavers Fork | 0 | 0.25 | 0.49 | 0.46 | 0 | 0 | 0 | 0 | 0 | 0 | 1.2 | 4 |
| Middle Big Sandy Creek | 0.46 | 0.25 | 0.36 | 0.46 | 0 | 0 | 0 | 0 | 0 | 0 | 1.53 | 5 |
| Upper Big Sandy Creek | 0.46 | 0.25 | 0.36 | 0.46 | 0 | 0 | 0 | 0 | 0 | 0 | 1.53 | 5 |
| Lower Big Sandy Creek | 0.46 | 0.25 | 0.49 | 0.46 | 0 | 0 | 0 | 0 | 0 | 0 | 1.66 | 6 |
| Bull Run-Cheat River | 0.46 | 0.25 | 0.49 | 0.46 | 0 | 0 | 0 | 0 | 0 | 0 | 1.66 | 6 |
| Pringle Run-Cheat River | 0.46 | 0.25 | 0.49 | 0.46 | 0 | 0 | 0 | 0 | 0 | 0 | 1.66 | 6 |
| Flag Creek-Cheat River | 0.46 | 0.25 | 0.49 | 0.46 | 0 | 0 | 0 | 0 | 0 | 0 | 1.66 | 6 |
| Clover Run | 0 | 1 | 0.49 | 0.46 | 0 | 0 | 0 | 0 | 0 | 0 | 1.95 | 7 |
| Laurel Fork | 0 | 1 | 0.49 | 0.46 | 0 | 0 | 0 | 0 | 0 | 0 | 1.95 | 7 |

1 (0 out of 34 Selected)

CP Model Output_000

In my case above, the Horsecamp Run – Dry Fork was the top ranking with the rest viewable by sort ascending on the totalRank field.

**Question 5.**

I would like you run the compromise programming model three times (one for each of the criteria weight set of point allocation, rank method, and pairwise comparison) and determine how the top five ranked watersheds change positions. How sensitive are your watersheds ranking based on weights and/or weighting method?