USING SPATIAL INFORMATION TO SUPPORT DECISIONS ON SAFEGUARDS AND MULTIPLE BENEFITS FOR REDD

STEP-BY-STEP TUTORIAL:

HOW TO PRODUCE A MATRIX STYLE LEGEND WITH RASTER DATA USING ARCGIS 10

UN-REDD PROGRAMME

FAO FIAT PANIS UNDP Empowered lives. Resilient nations. UNEP

The UN-REDD Programme is the United Nations Collaborative initiative on Reducing Emissions from Deforestation and forest Degradation (REDD) in developing countries. The Programme was launched in September 2008 to assist developing countries prepare and implement national REDD+ strategies, and builds on the convening power and expertise of the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP).

The United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) is the specialist biodiversity assessment centre of the United Nations Environment Programme (UNEP), the world's foremost intergovernmental environmental organisation. The Centre has been in operation for over 30 years, combining scientific research with practical policy advice.

Prepared by Julia Thorley and Corinna Ravilious

We welcome comments on any errors or issues. Should readers wish to comment on this document, they are encouraged to get in touch via: ccb@unep-wcmc.org.

Citation: Thorley, J. and Ravilious, C. (2015) Using spatial information to support decisions on safeguards and multiple benefits for REDD+. Step-by-step tutorial: How to produce a matrix style legend with raster data using ArcGIS 10. Prepared on behalf of the UN-REDD Programme. UNEP World Conservation Monitoring Centre, Cambridge, UK.

Acknowledgements: With thanks to support provided by IUCN.

These training materials have been produced from materials generated for working sessions held in various countries to aid the production of multiple benefits maps to inform REDD+ planning and safeguards policies using open source GIS software.

Contents

1. Introduction

Reducing Emissions from Deforestation and Forest Degradation (REDD) is an effort to create a financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. "REDD+" goes beyond deforestation and forest degradation, to include the role of conservation, sustainable management of forests and enhancement of forest carbon stocks. This will involve changing the ways in which forests are used and managed, and may require many different actions, such as protecting forests from fire or illegal logging or rehabilitating degraded forest areas.

REDD+ has the potential to deliver multiple benefits beyond carbon. For example, it can promote biodiversity conservation and secure ecosystem services from forests such as water regulation, erosion control and non-timber forest products. Some of the potential benefits from REDD+, such as biodiversity conservation, can be enhanced through identifying areas where REDD+ actions might have the greatest impact using spatial analysis.

GIS software can be used to undertake spatial analysis of datasets of relevance to multiple benefits and environmental safeguards for REDD+. This tutorial enables a user to produce matrix style legend in ArcGIS using raster data.

2. Creating a map with a matrix style legend

Displaying two thematic wall-to-wall datasets on the same map can help to visualize the relationships between two datasets. This graphical technique of creating a two-dimensional legend was first developed by Paul Williams at the Natural History Museum in the UK in a piece of software called WorldMap where it was used to display the spatial relationship of species richness between different groups of species (Williams et al, 1998). (See http://www.nhm.ac.uk/research-curation/research/projects/worldmap/rarity/index.html).

It is not possible to automatically create a 2-way matrix style legend in ArcGIS (or in any of the other GIS software that we are aware), therefore this tutorial takes users through a series of simple steps to manually prepare the data for display in a matrix format.

This tutorial will demonstrate the following example: Biomass carbon and threatened species richness

2.1. Select datasets for which to map with a matrix legend

a. Choose two themes to map.
At this stage it is important to note that some of the data may be in raster format and some are vector. The analysis will be undertaken as a raster analysis.

In this example:
The **carbon** is a **raster dataset** showing **above and below ground biomass carbon density** in tonnes/ha (in 500m resolution cells).

The **threatened species** dataset is a **vector** dataset of hexagons with an attribute indicating the **number of threatened species.**

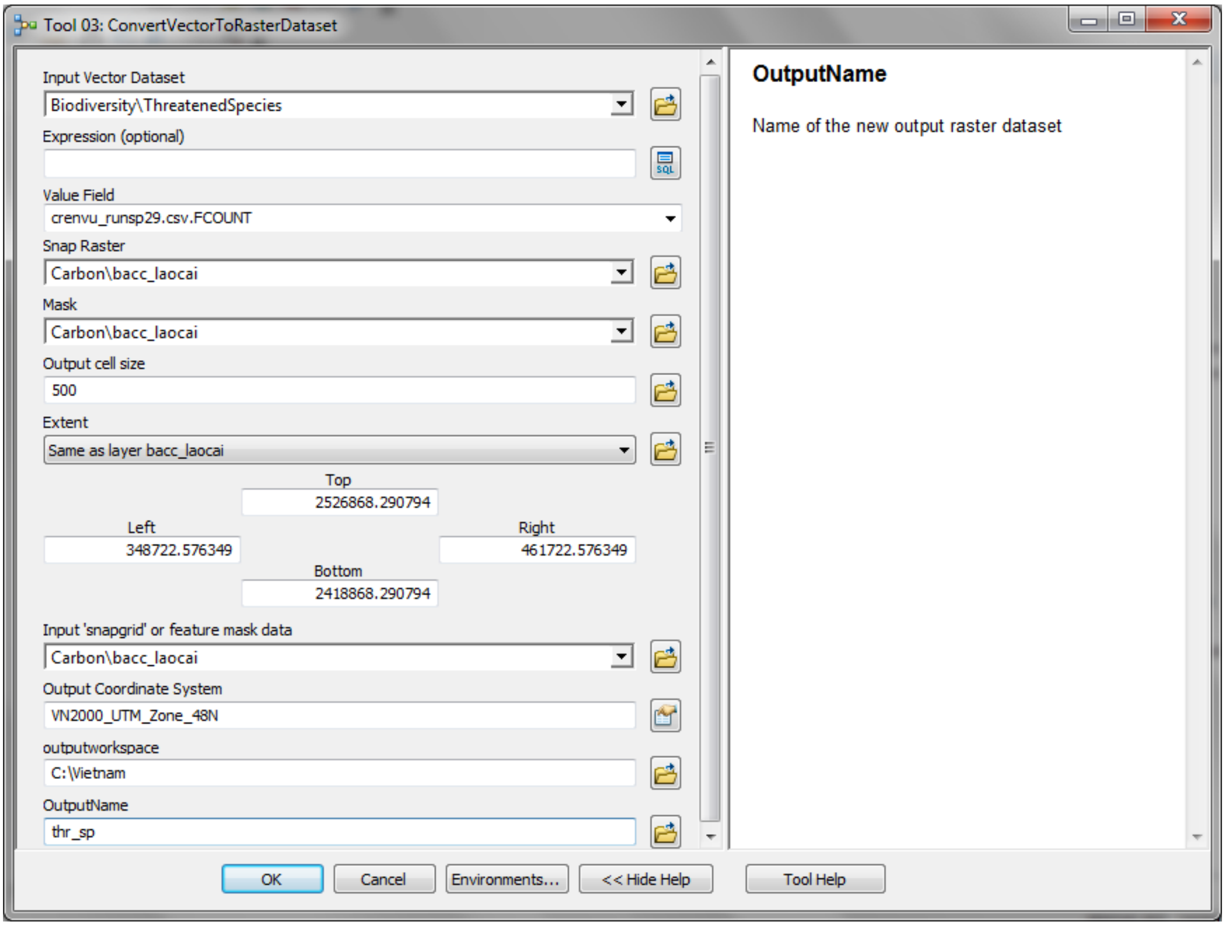
The **X axis of the matrix** will be the **biomass carbon** and the **Y axis of the matrix** will be the **threatened species richness**.

b. Double click on **Tool 3** in the **ExploringMultipleBenefits toolbox** to run the tool to convert the vector data to raster. **A dialogue window will open.** Note that there are various environment setting that need to be filled out (namely Snap Raster, Mask, Output Cell Size and Extent).

If one of the datasets being used for the matrix legend is already a raster you will make use this for the environment settings to ensure the new raster you are creating aligns correctly to it. If both of the datasets are vectors you will first need to run Tool1a to create a Snap Raster from a vector boundary file and then use that for the environment settings.

c. Fill out all the parameters in the white boxes (as in the example below)

In this example, the biomass carbon raster will be used for the environment settings **Snap Raster, Mask, Output Cell Size and Extent**. Set the output coordinate system to an equal area projection e.g. in this example **VN2000 UTM Zone 48N.**

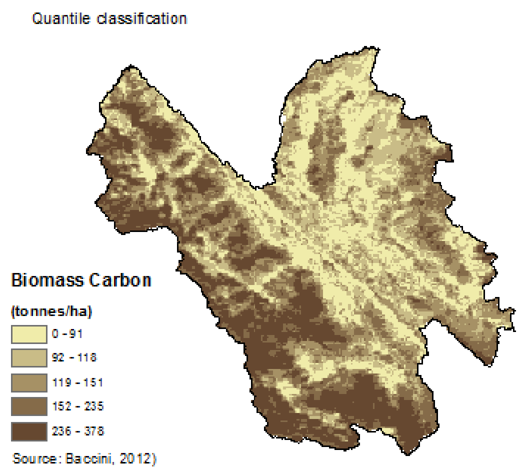


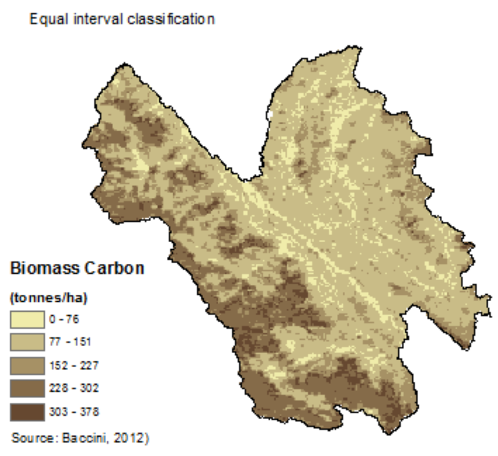
2.2. For the each raster dataset display the data in 5 class breaks

In order to create a 5 by 5 matrix the two datasets need to be **grouped into classes**. Remember in this example, the first dataset that will be displayed along the **X axis of the matrix** is the **biomass carbon** and the second dataset that will be displayed along **the Y axis of the matrix** is **threatened species richness**.

***It is important to note that the consideration of the classification scheme applied to group your dataset is important as different ways of partitioning data can lead to vastly different maps. ***

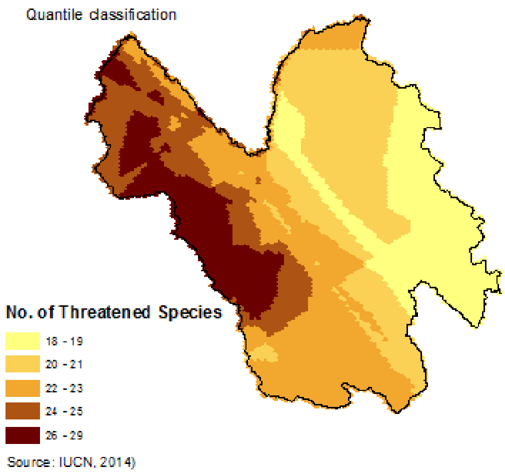
In the **quantile classification method**, each class contains the same number of pixels. Quantiles are best suited for data that is linearly/evenly distributed-; i.e. this means that the classes cover the same amount of area on the map. There can be a disproportionate number of features with a similar value in the dataset - class break values are determined by trying to have about the same area of each class covering the map. In the **equal Interval classification method**, each class has an equal range of values; that is, the difference between the high and low value is equal for each class. The equal interval method divides the range of attribute values into equal sized sub-ranges. Then the features are classified based on those sub-ranges.

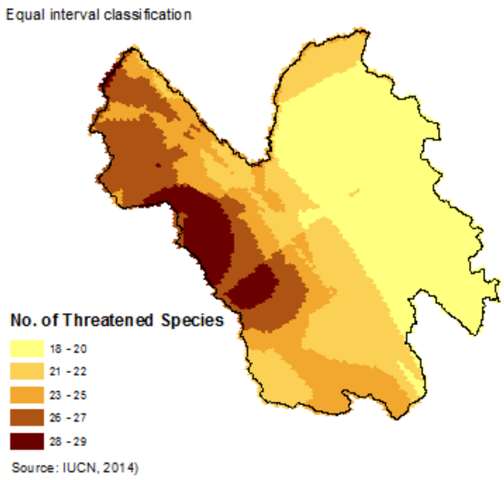




a. **Add** the dataset to be used for the **x-axis** into ArcMap i.e. in this example the **biomass carbon dataset.** Decide on a classification scheme and symbolise the data into 5 classes. The **quantile** is often the best method to show the variation in pattern of carbon distribution (see maps above).

b. **Add** the dataset to be used for the **y-axis** data into **ArcMap** i.e. in this example the threatened species richness dataset. Decide on a classification scheme and symbolize the data into 5 classes (see maps below, different classifications will alter the result)

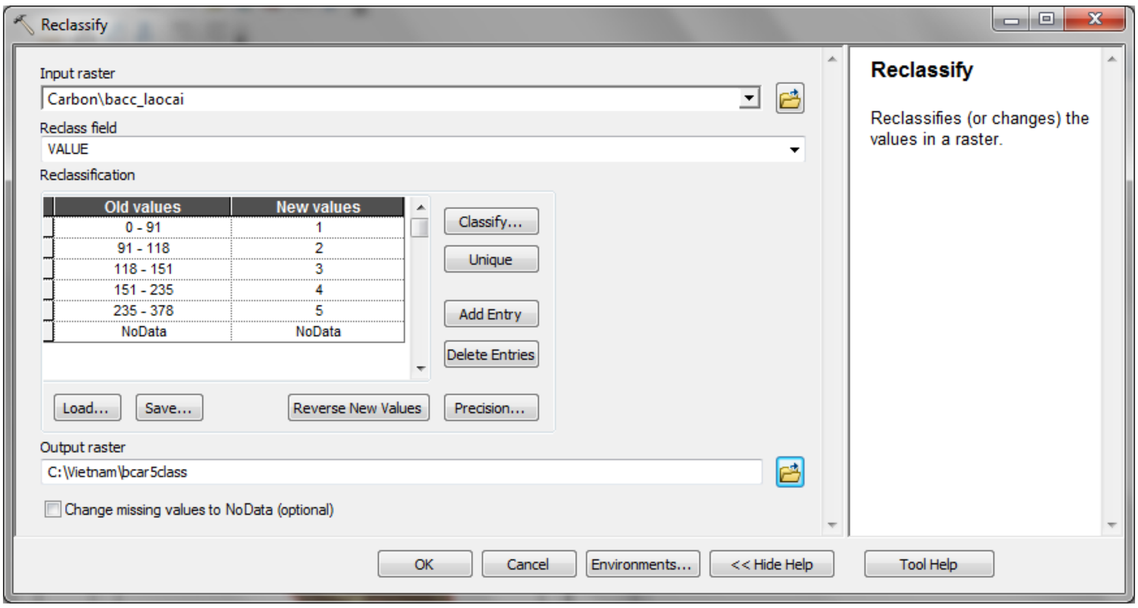




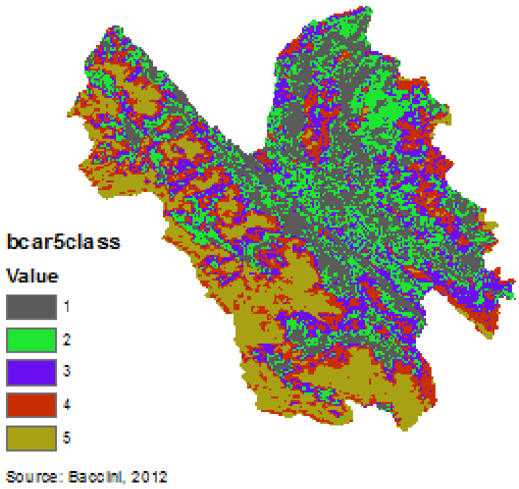
2.3. Create two new simplified raster datasets based on the chosen class breaks

In order to map the two dataset on an x and y axis, it is necessary to simplify each dataset based on the class breaks defined in step 1.

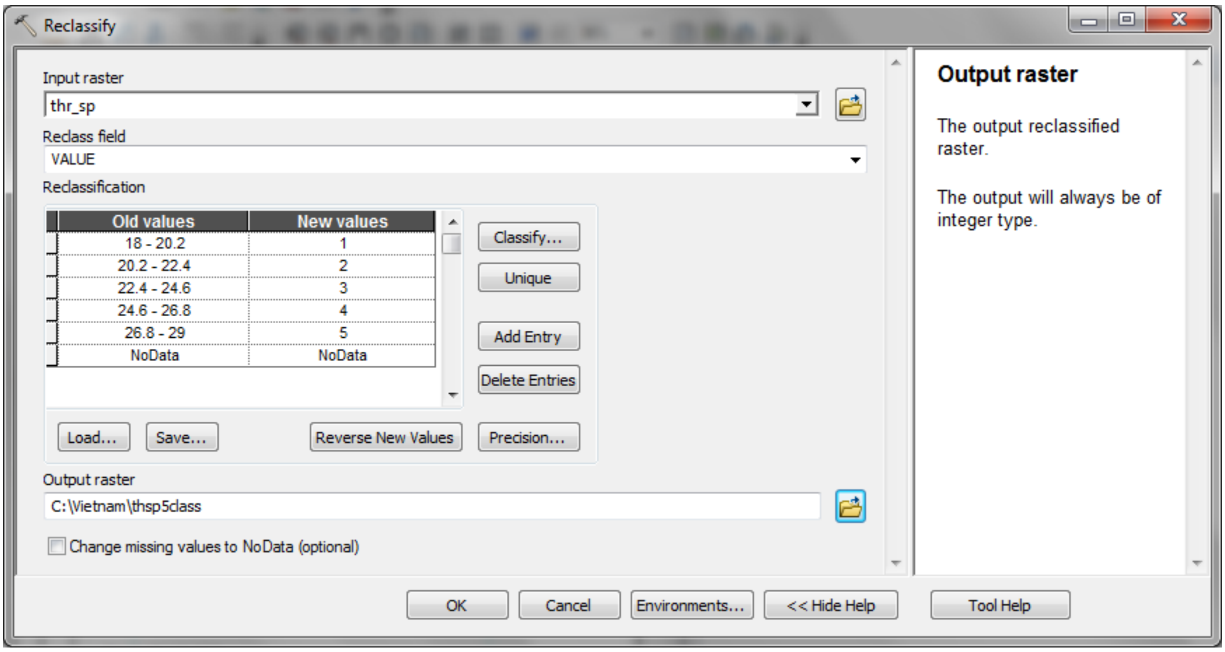
a. Run the **Reclassify tool** in the standard ArcGIS toolbox to reclassify the **x-axis** dataset (i.e.in this example, biomass carbon). Save the new output raster with a name that reflects the new classes e.g. bcar5cl.

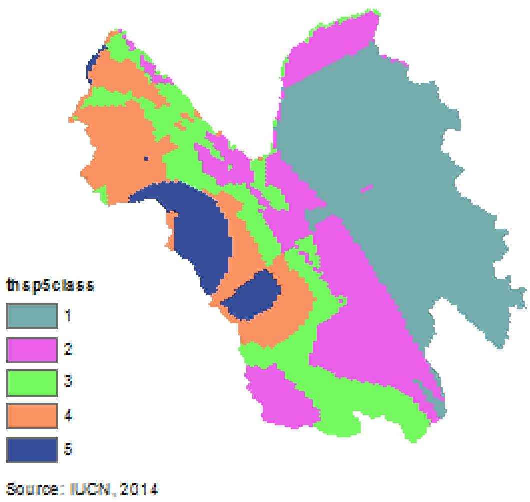


The Result of reclassification of biomass carbon is presented here: Each of the classes has been assigned a new value from 1 – 5.



b. Run the **Reclassify tool again** but this time to reclassify the **y-axis** dataset (i.e.in this example, run the tool for the **threatened species richness**. Save the new output raster with a name that reflects the new classes e.g. thsp5class





The Result of reclassification of threatened species richness is presented here: Each of the classes has been assigned a new value from 1 – 5.

2.4. Combine two 2 simplified datasets together

Now that the two datasets both have only 5 values the next step is to combine the two new rasters together.

a. Double click on **Tool 05: OverlayRastersForMapOutputsAndStatistics in the ExploringMultipleBenefits toolbox** to run the tool.

This tool the **ArcGIS COMBINE function** to combine multiple raster input datasets to produce an output dataset containing a unique combination of the inputs. The output raster contains a VALUE and COUNT field and two extra individual fields for each of the VALUE fields from the input datasets, these fields are given the name of the original input datasets.

Usage Tips
Before running this model, ensure that all datasets have been checked and that 'Tool 3' has been used to convert any "nodata" values to 0. If any of the dataset have "nodata" values within the analysis extent, those cells will be excluded from the analysis.
After running the model check the Output Raster in ArcMap.
The combine function will only keep the Value and Count Fields from the Raster datasets being combined. After this tool has run it may be necessary to join on any missing attributes (see Tool 06).

b. **In the dialogue box** which appears (see below), **fill in the white boxes (parameters)** accordingly as specified below. Make the **snap raster, mask and cellsize** the **same as** one of the input rasters e.g. **bcar5class**.

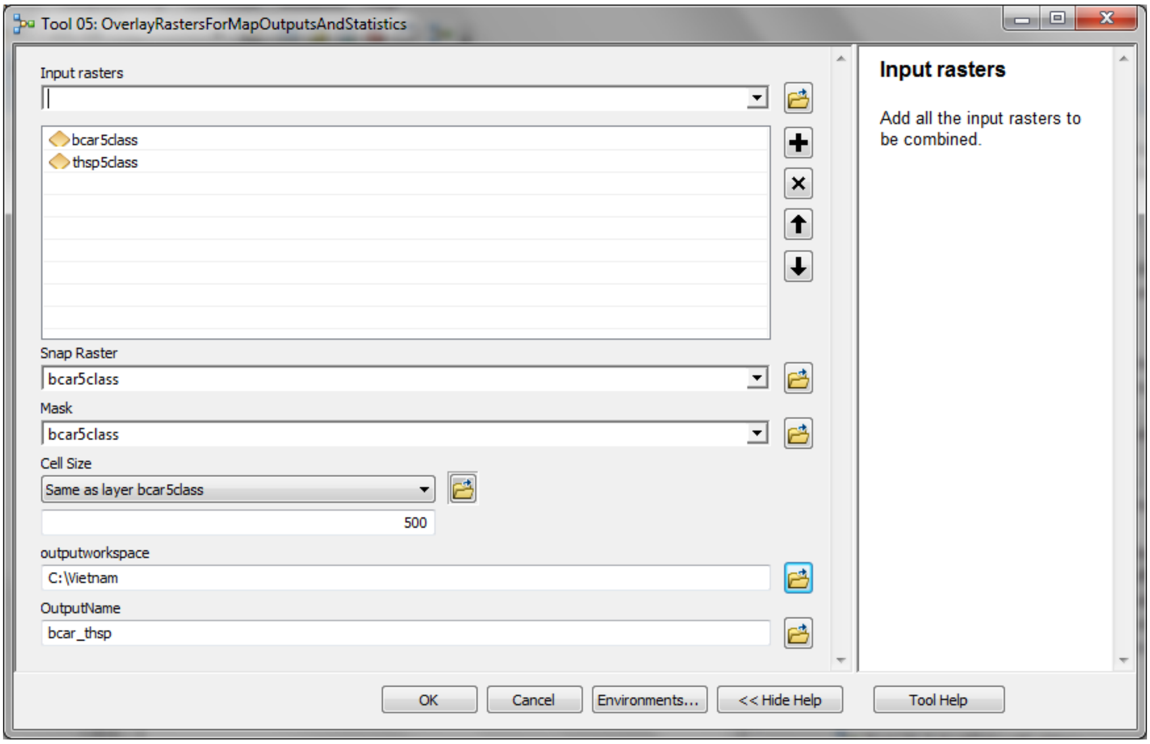
These parameters are environment setting which are usually hidden under the environments tab on the standard ArcGIS tools. These are set to make sure the cells in the output raster are the same size as and align with the cells in the specified input raster. When each is clicked on, explanations/help appear in the panel on the right. The parameter descriptions are also described in the box below.

Parameter Descriptions

Expression	Explanation
<Input_rasters>	Add all the input rasters to be combined
<Snap_Raster>	The snap raster is used to ensure that the cell alignment of the output raster matches to a chosen existing raster. Set the Snap Raster to be the same as the Mask_Raster
<Mask>	The mask will be used to Identify those cells within the analysis extent that will be considered. Set the analysis mask to ensure that processing will occur on all the cells within the analysis extent. Set the mask to be the same as the Snap_Raster
<Cell_Size>	Specify the output cell size to be used for the analysis (this will be the same as the Snap Raster)
<outputworkspace>	Workspace in which to save the output Raster
<OutputName>	Name of the new output raster dataset

c. In the **Input rasters, select** the two 5 class input rasters to be combined i.e in this example, **bcar5class and thsp5class.**

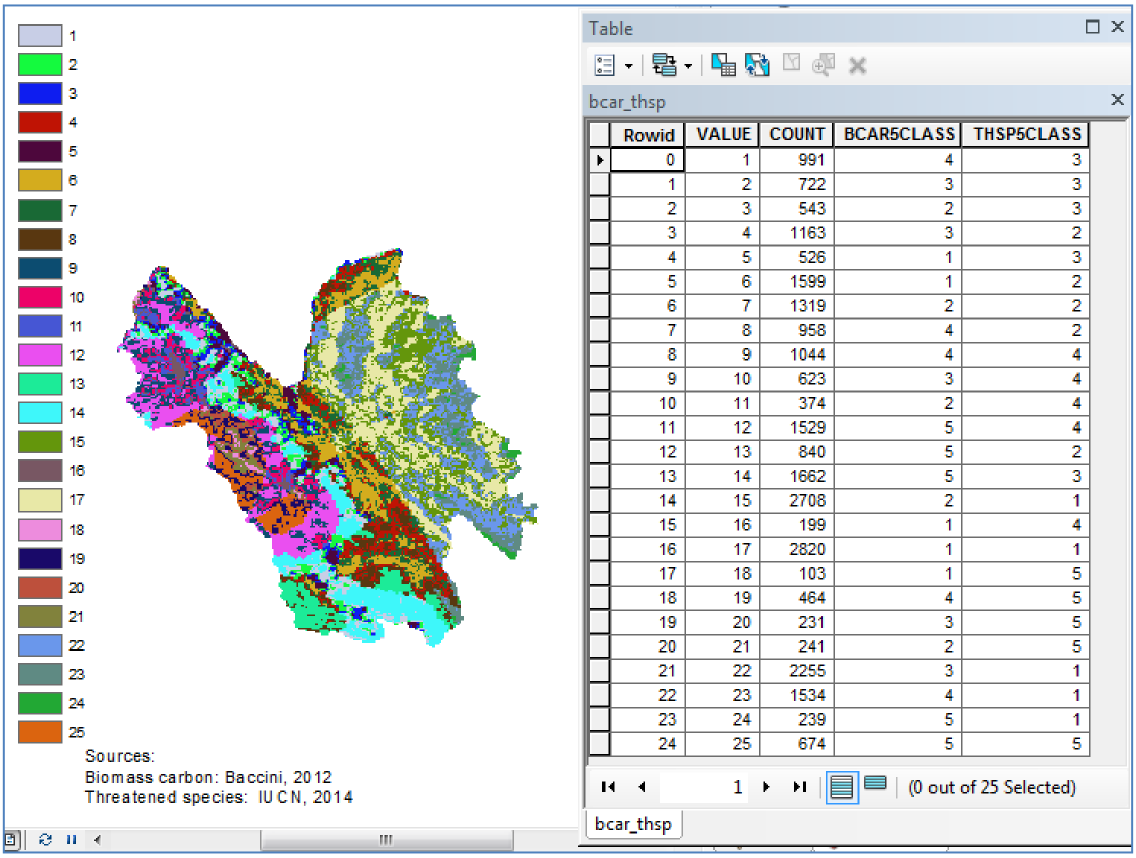
d. Give the **new raster a name to reflect the order of the combination** i.e. In the name specify the **X-axis first** and the **Y-axis second** (e.g**. bcar_thsp**).



e. Click **OK** to run the tool.

f. The new raster **does not automatically add to map** so navigate to the output workspace and **add the new raster to the ArcMap session**.

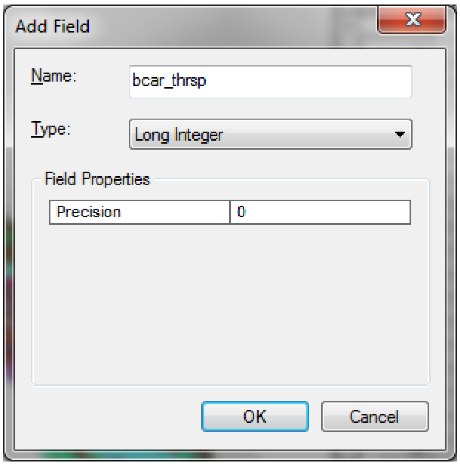
g. The combined output raster with 25 possible classes. Open the attribute table and see that it contains a VALUE and COUNT field and individual fields for each of the VALUE fields from the input datasets, and that these fields are given the name of the inputs.

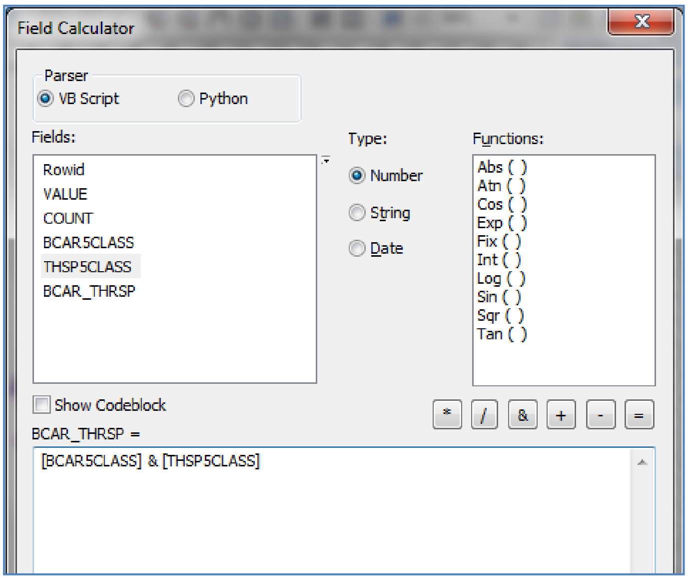


Rowid	VALUE	COUNT	BCAR5CLASS	THSP5CLASS
0	1	991	4	3
1	2	722	3	3
2	3	543	2	3
3	4	1163	3	2
4	5	526	1	3
5	6	1599	1	2
6	7	1319	2	2
7	8	958	4	2
8	9	1044	4	4
9	10	623	3	4
10	11	374	2	4
11	12	1529	5	4
12	13	840	5	2
13	14	1662	5	3
14	15	2708	2	1
15	16	199	1	4
16	17	2820	1	1
17	18	103	1	5
18	19	464	4	5
19	20	231	3	5
20	21	241	2	5
21	22	2255	3	1
22	23	1534	4	1
23	24	239	5	1
24	25	674	5	5

2.5. Create new field in attribute table to contain combined matrix value

a. Add a field to the attribute table of your new raster produced as a result of the combine, named **bcar_thsp** of type **Long Integer**





b. Calculate **bcar_thsp** to equal **[bcar5class] & [sp5class]**

See the result of the calculation in the table below. See for example, where **bcar5class is 4** and **thsp5class is 3** the combined field **bcar_thsp becomes 43**.

The definitions of numbers for the combined species/carbon field [BCAR_THRSP] are:

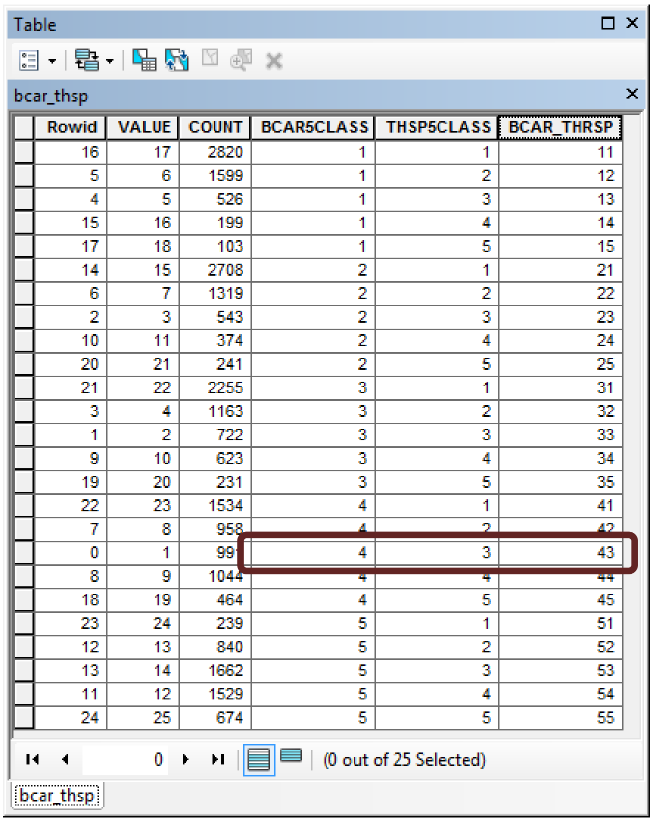
11 Low carbon, low species richness
12 Low carbon, medium low species richness
13 Low carbon, medium species richness
14 Low carbon, medium high species richness
15 Low carbon, high species richness

21 Medium low carbon, low species richness
22 Medium low carbon, medium low species richness
23 Medium low carbon, medium species richness
24 Medium low carbon, medium high species richness
25 Medium low carbon, high species richness

31 Medium carbon, low species richness
32 Medium carbon, medium low species richness
33 Medium carbon, medium species richness
34 Medium carbon, medium high species richness
35 Medium carbon, high species richness

41 Medium high carbon, low species richness
42 Medium high carbon, medium low species richness
43 Medium high carbon, medium species richness
44 Medium high carbon, medium high species richness
45 Medium high carbon, high species richness

51 Very High carbon, low species richness
52 Very High carbon, medium low species richness
53 Very High carbon, medium species richness
54 Very High carbon, medium high species richness
55 Very High carbon, high species richness



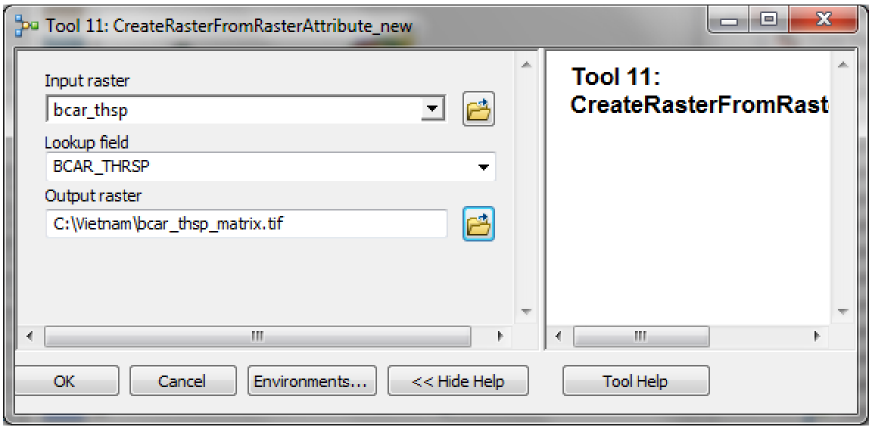
Rowid	VALUE	COUNT	BCAR5CLASS	THSP5CLASS	BCAR_THRSP
16	17	2820	1	1	11
5	6	1599	1	2	12
4	5	526	1	3	13
15	16	199	1	4	14
17	18	103	1	5	15
14	15	2708	2	1	21
6	7	1319	2	2	22
2	3	543	2	3	23
10	11	374	2	4	24
20	21	241	2	5	25
21	22	2255	3	1	31
3	4	1163	3	2	32
1	2	722	3	3	33
9	10	623	3	4	34
19	20	231	3	5	35
22	23	1534	4	1	41
7	8	958	4	2	42
0	1	99[illegible]	4	3	43
8	9	1044	4	4	44
18	19	464	4	5	45
23	24	239	5	1	51
12	13	840	5	2	52
13	14	1662	5	3	53
11	12	1529	5	4	54
24	25	674	5	5	55

2.6. Create new raster from combined values field

Run Tool 11: CreateRasterFromRasterAttribute_new which uses the ArcGIS **LOOKUP** tool to create a new raster by looking up values found in another field in the table of the input raster.

a. **For the** Input raster **select the** combined biomass carbon and threatened species richness **i.e. in this example the combined raster called** bcar_thsp
b. **For the** Lookup Field **select the field containing the** combined biomass carbon and threatened species richness **values** bcar_thrsp

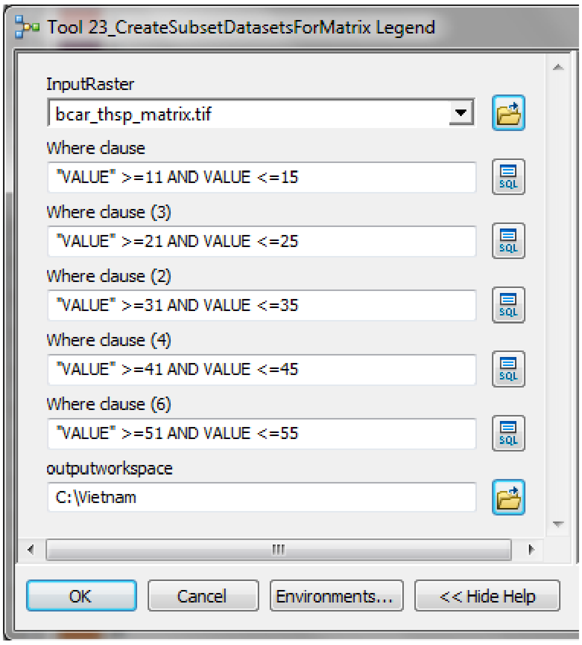
c. For the **Output raster** navigate to an output workspace and save the new raster as a **.tif file** with the **same name as the Input file with the ending _matrix.tif** i.e. in this example **c:\Vietnam\bcar_thsp_matrix.t**



2.7. Create 5 subsets of the combined layer for the Matrix Legend

a. Next Double click on the tool **'Tool 23_CreateSubsetDatasetsForMatrix Legend**. This will split the 25 class matrix.tif into 5 new subsets which can easily be shaded as individual colour ramps to produce the matrix style legend.

b. Click OK to run the tool.

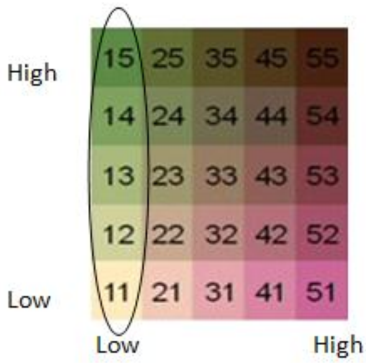


2.8. Example results and guidance on creating the matrix colour ramps

This section describes the example results from Tool 23 and provides detailed guidance on symbolizing the mapped data using the matrix colour ramps. The illustration below helps demonstrate how you will need to define the colour ramps.

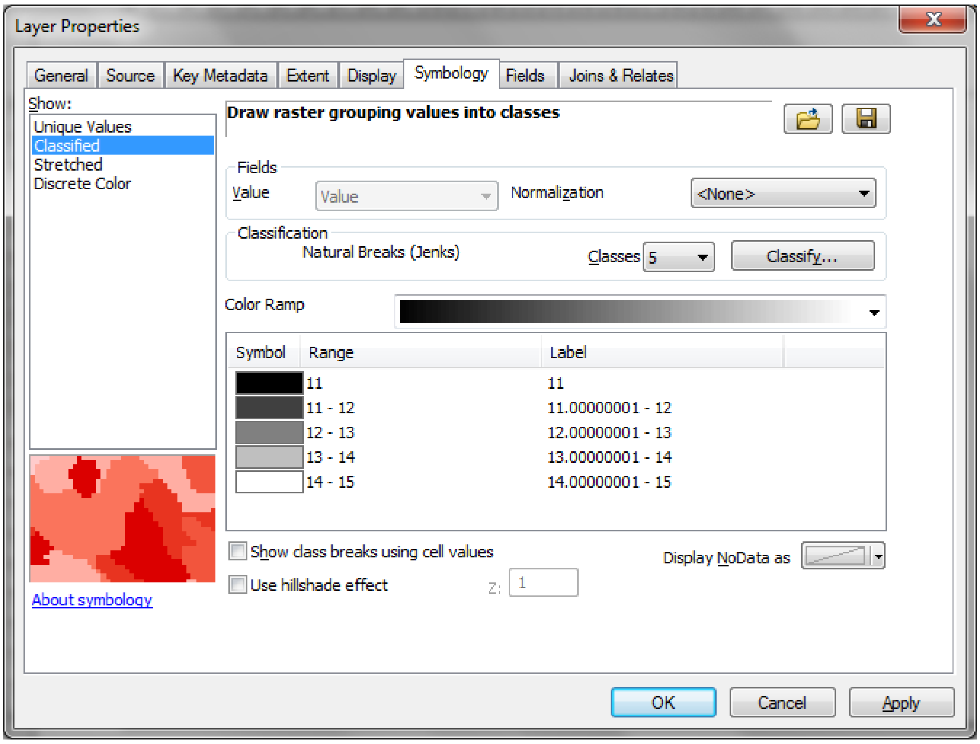
Upon running the Tool, **each 'where clause'** produces a raster **each with 5 classes**. The first raster that is created using the 'where clause' "VALUE" >=11 AND “VALUE” produces a raster containing values 11,12,13,14 and 15. This shades the first column of the matrix legend as illustrated below from 11-15, representing:

Low species richness - low carbon (11) to **high species richness – low carbon (15)**



a. **Double click** on the layer **bcar_thsp_matrix11_15.tif** to open the layer properties.

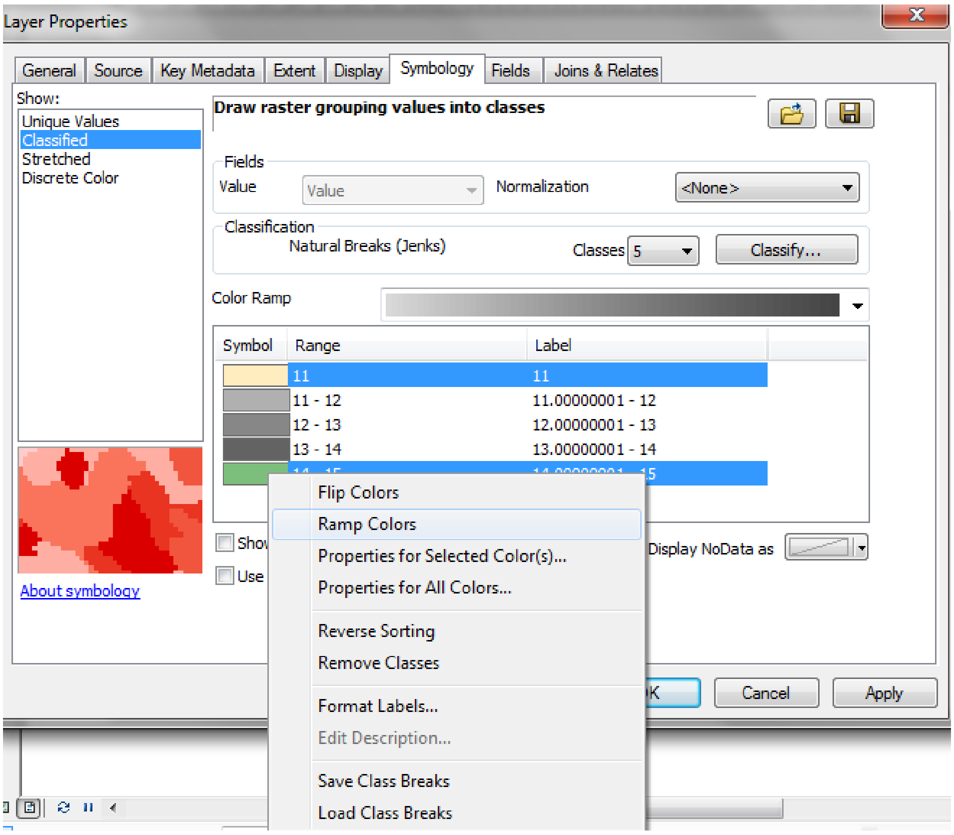
b. **Change** the classification to **Classified** and **5 classes.**



c. Click **OK.**

d. To produce a colour ramp, first choose **a colour to represent low species richness - low carbon** (11), and one to represent **high species richness – low carbon** (15).

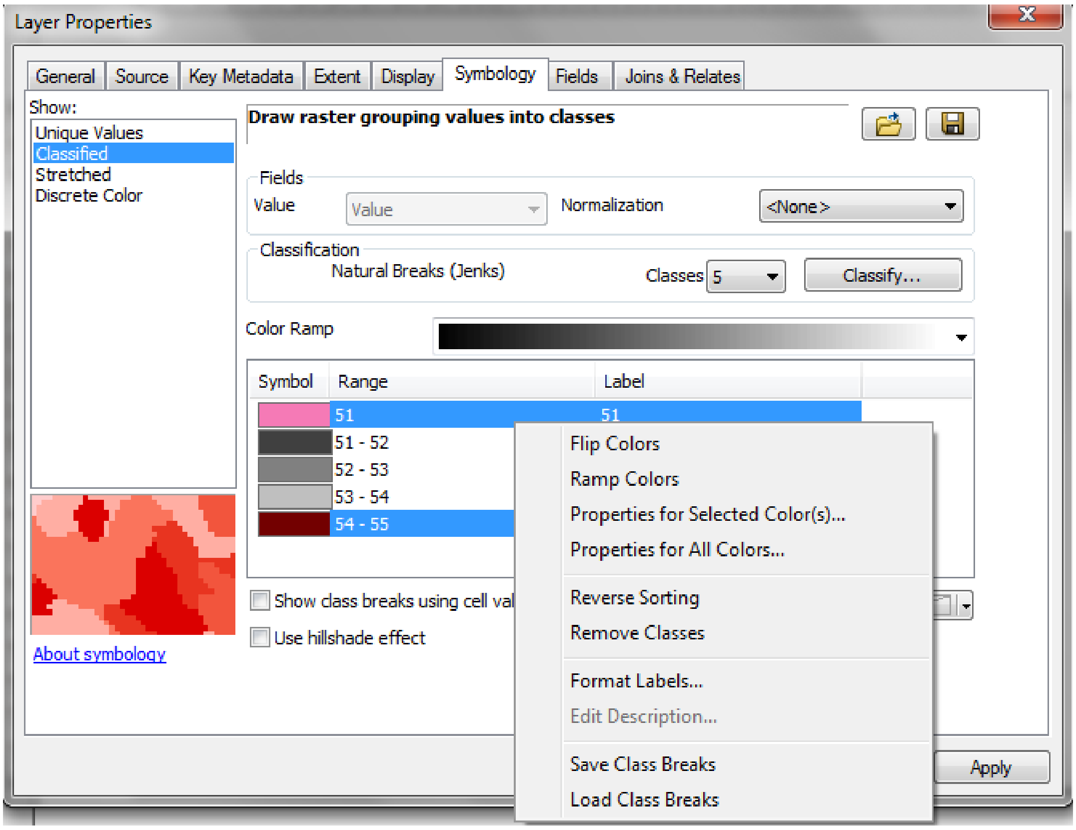
e. Once you have selected these colours, **hold down the Ctrl key** and **select category 11** and **select category 15**, then **right click and select ramp colours.**



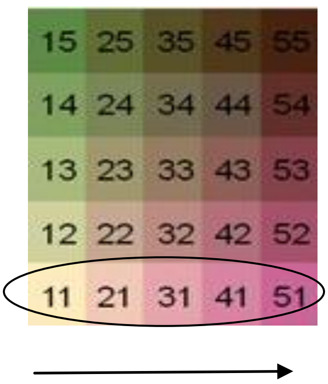
Next you will repeat steps a to d for each your 51-55 category raster to ramp low species richness – high carbon (51) and high species richness – high carbon (55). Therefore, choose a colour to represent low species richness – high carbon (51), and one to represent high species richness – high carbon (55).

f. Double click on the layer **bcar_thsp_matrix51_55.tif** to open the layer properties

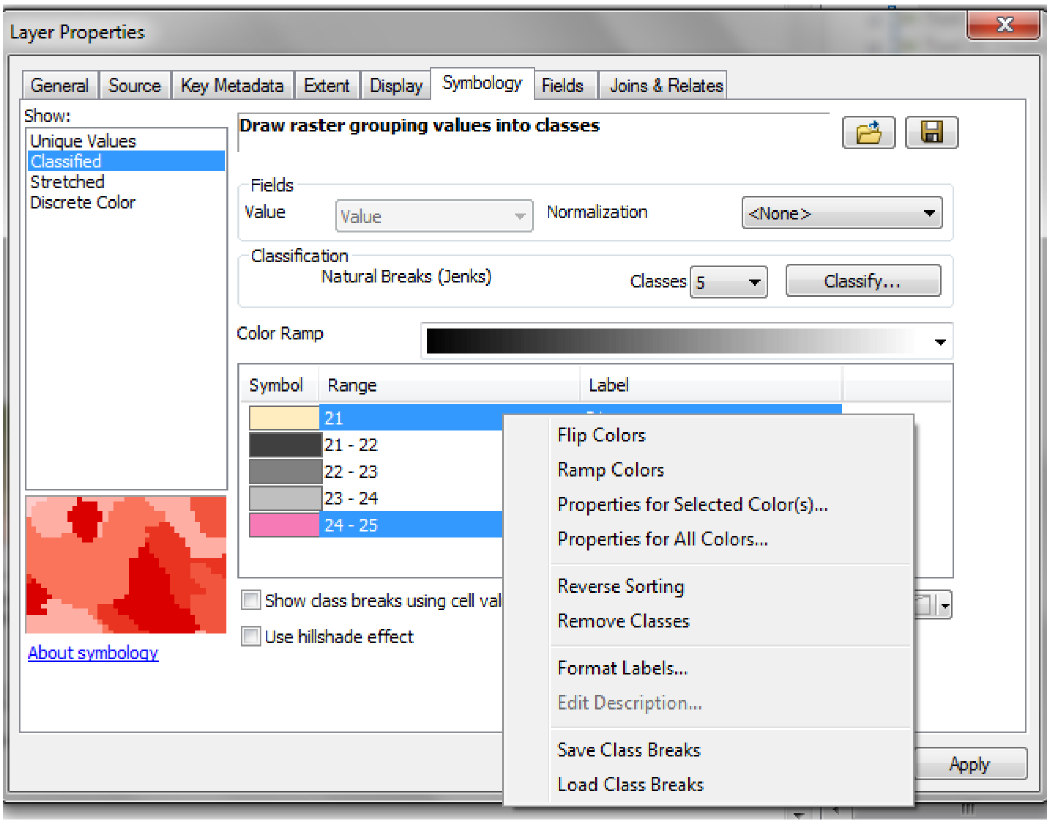
g. Change the classification to **Classified** and **5 classes**

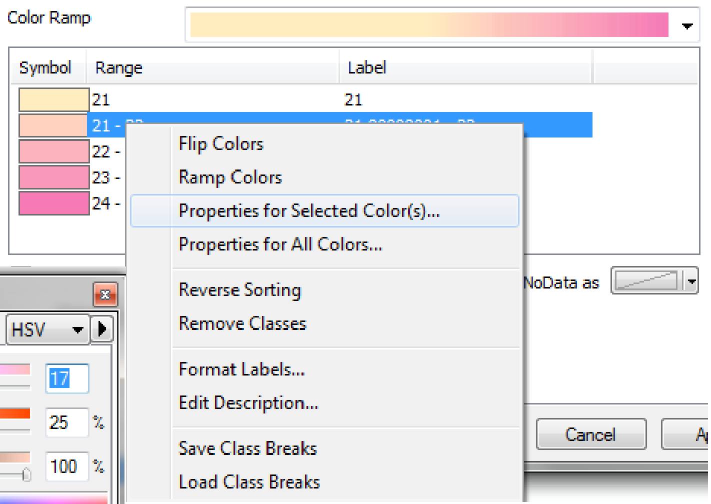


You will then need to create your ramps for 21 – 25 ; 31 – 35 and 41 – 45. To do this, you will need to create some temporary colour ramps between the colours you have chosen to represent codes 11, 15, 51 and 55:



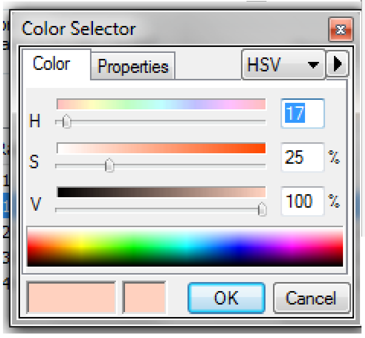
h. Use your 21 – 25 category raster to create a temporary ramp between the colour you chose to represent number 11 and number 51.





i. **Right click** on the **colour box**, and click **properties for selected colours**... **More colours**... then you will be shown a box with the **HSV colour codes** in it.

j. **Write down these numbers** – this will be **your code for box 21.**

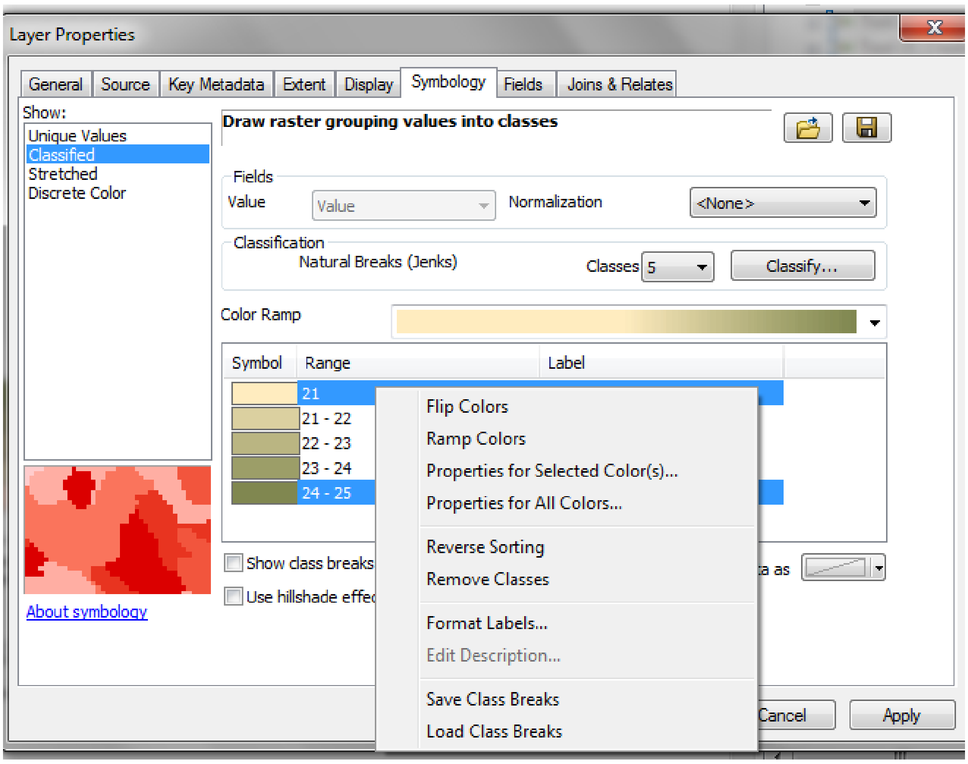


k. **Repeat this process** and **make a note of the codes in boxes 22, and 23**. These will be your colour **codes for the beginning of your ramp in boxes 31 and 41.**

l. **Use the same 21 – 25 category raster** to create a **second temporary ramp between the colour you chose to represent number 15 and number 55**. Again, make a note of the HSV colour codes shown in boxes **22, 23 and 24. These will be your colour codes for the top of your ramp in boxes 25, 35 and 45.**

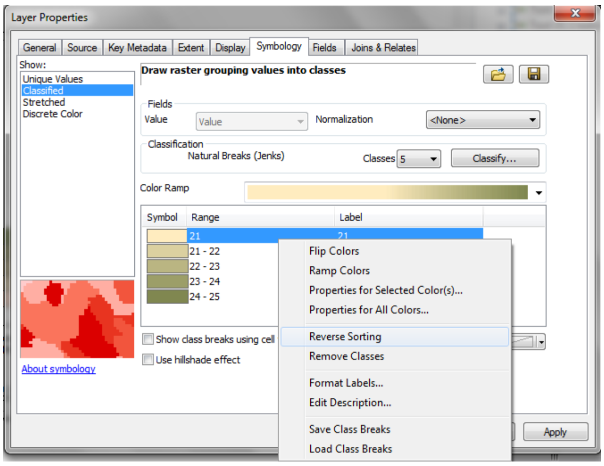
m. Once you have the **HSV codes that represent the colours at the top and bottom of your ramps for boxes 21 and 25; 31 and 35; 41 and 45** you can make the remaining colour ramps.

Enter the colour codes manually by clicking **properties for selected colours** … **More colours**… and then **right click** and **ramp colours**.



n. Once ramps have been created for all 5 datasets, in order to display the colours ramping from light to dark necessary for the legend, all of the colour ramps need to have the option of **reverse sorting** applied to them.

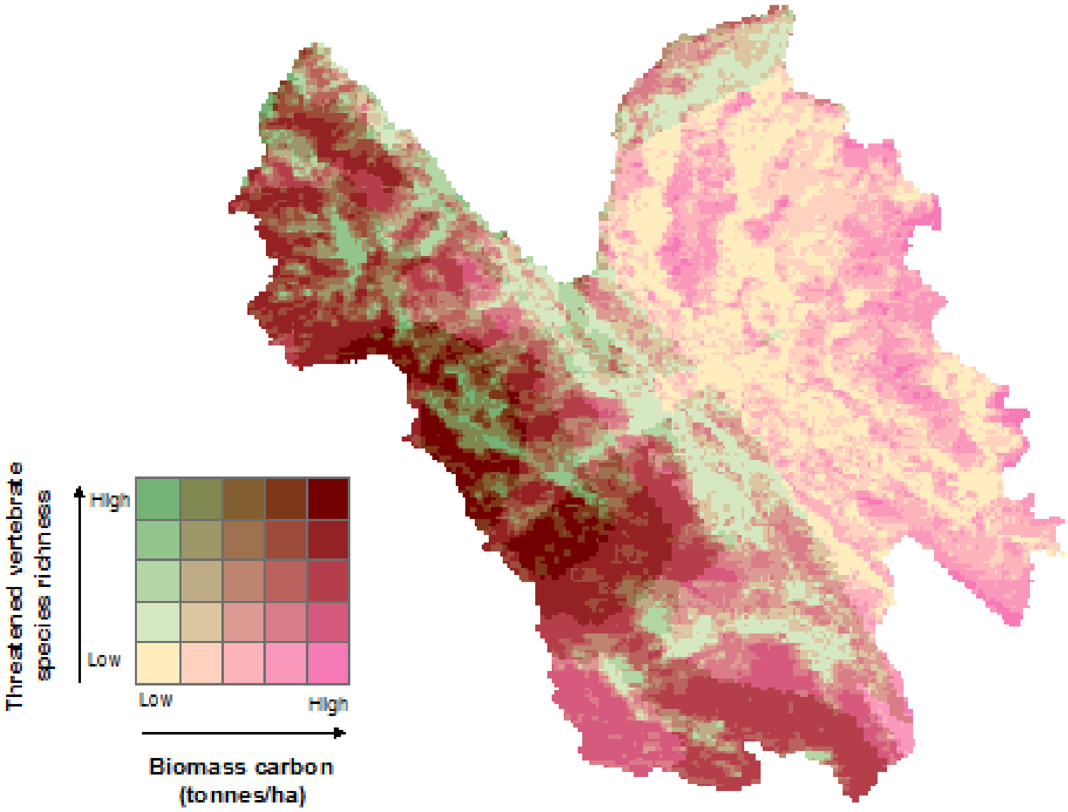
In the **Layer Properties** box, **Right Click** and **select Reverse Sorting**



o. Once the reerse sorting has been applied to all 5 ramps format the legend to a into a square legend by:

i. Standardise the size for all the boxes to 8 by 8 pt.
ii. Clicking on the option to place each legend item into a new column.
iii. Clicking on the options to put no space between rows or columns.

p. The final map and legend should look similar to the example below:



Sources:
Biomass carbon: Baccini, 2012
Threatened species: IUCN, 2014

Annex: Two Predefine colours schemes for the matrix legend colour ramps

When creating a matrix colour legend, it is advisable to use colours that contrast yet work well together. Below are some codes for matrix ramps that have been used frequently in our maps and work fairly well. The notes in the main document should be followed if you want to generate a new matrix colour ramp from scratch.

Matrix colour codes: (HSV values)

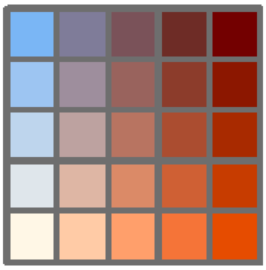
11: 42, 25, 100
15: 120, 35, 70

21: 17, 25, 100
25: 68, 41, 53

31: 353, 29, 99
35: 33, 62, 51

41: 339, 39, 98
45:18, 81, 49

51: 331, 50, 96
55: 0, 100, 45



11: 41, 10, 100
15: 211, 50, 96

21: 25, 35, 100
25: 246, 19, 60

31: 21, 58, 100
35: 350, 33, 48

41: 19, 77, 96
45: 5, 65, 43

51: 20, 100, 90
55: 0, 100, 45