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



# **STEP-BY-STEP TUTORIAL:**

How to produce a matrix style legend using both vectors and rasters with open source using QGIS 1.8 and 2.x





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.

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### 1. Introduction

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.

Open Source GIS software can be used to undertake spatial analysis of datasets of relevance to multiple benefits and environmental safeguards for REDD+. Open-source software is released under a license that allow software to be freely used, modified, and shared (http://opensource.org/licenses). Therefore, using open source software has great potential in building sustainable capacity and critical mass of experts with limited financial resources.

This tutorial enables a user to produce matrix style legend in QGIS with vector or raster data in QGIS.

#### 2. Create a map with a matrix style Legend

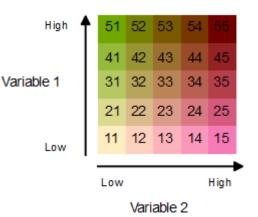
#### 2.1. Technical summary

Displaying two thematic wall-to-wall datasets on the same map can help to visualise 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 QGIS (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. There are different approaches depending on whether the two datasets to be displayed are in vector or raster format. This tutorial covers three approaches:

- using two vector datasets
- using one vector and one raster dataset
- using two raster datasets

The illustration to the left gives an example of a matrix style legend where classified into 5 classes.



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#### 2.2. Matrix legend using two vector dataset (using QGIS 1.8)

Two wall-to-wall vector datasets are needed to create the matrix map. In addition to these, a vector dataset to use as the summary units is required. This could be a vector grid of squares or hexagons of equal area. Each wall-to-wall vector datasets is analysed against the square/hexagon summary units dataset and an attribute is added to the squares/hexagons dataset and the summary value calculated. In the following example one variable is the number of endemic species and the other is the number of threatened species.

#### Pre-processing of the data for the matrix legend

In the example below the summary units file is a grid of hexagons which has been generated using the **QMarxan plugin>>Create Planning Unit Grid** in **QGIS 1.8.** Then the **QMarxan plugin>>Calculate conservation values** has been run on each of the two variables to summarise. The first, a shapefile containing polygons of individual endemic species extent of occurrence and the second a shapefile threatened species extent of occurrence.

An example of the resultant attribute table post analysis is presented below

- unique ID of each hexagon (pu\_id)
- number of endemic species in each hexgon
- > number of threatened species in each hexagon

487 488 489 490 491 492 493 494 495 495 495	1 1 1 1 1 1 1 1 1 1 1 1	0 0 0 0 0 0 0 0 0	1 1 1 1 1 1 1 1 1 1 1 1 1	100000000 100000000 100000000 100000000	117713.238255309 117713.238255309 117713.238255309 117713.238255309 117713.238255309 117713.238255309 117713.238255309 117713.238255309	19618.8730425514 19618.8730425514 19618.8730425514 19618.8730425514 19618.8730425514 19618.8730425514	0 1 1 1 3 3 3 4 4	
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490 491 492 493 494 495 496	1	0 0 0 0 0 0	1 1 1 1 1 1 1	100000000 100000000 100000000 100000000	117713.238255309 117713.238255309 117713.238255309 117713.238255309 117713.238255309	19618.8730425514 19618.8730425514 19618.8730425514 19618.8730425514 19618.8730425514		
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492 493 494 495 496	-	0 0 0 0	1 1 1 1	100000000 100000000 100000000 100000000	117713.238255309 117713.238255309 117713.238255309	19618.8730425514 19618.8730425514 19618.8730425514		
493 494 495 496	1 1 1 1 1	0	1 1 1 1	1000000000 100000000 100000000	117713.238255309 117713.238255309	19618.8730425514 19618.8730425514	3 3 4	
494 495 496	1 1 1 1	0	1	100000000 100000000	117713.238255309	19618.8730425514	3	
495 496	1 1 1	0	1	100000000			4	
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497	1	0	1	100000000	117713.238255309	19618.8730425514	2	
498	1	0	1	100000000	117713.238255309	19618.8730425514	0	
499	1	0	1	100000000	117713.238255309	19618.8730425514	4	
500	1	0	1	100000000	117713.238255309	19618.8730425514	0	
501	1	0	1	100000000	117713.238255309	19618.8730425514	0	
502	1	0	1	100000000	117713.238255309	19618.8730425514	0	
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	500 501 502	500         1           501         1           502         1	500         1         0           501         1         0           502         1         0	500         1         0         1           501         1         0         1           502         1         0         1           503         1         0         1	500         1         0         1         10000000           501         1         0         1         10000000           502         1         0         1         10000000           503         1         0         1         10000000	500         1         0         1         100000000         117713.238255309           501         1         0         1         100000000         117713.238255309           502         1         0         1         100000000         117713.238255309           503         1         0         1         100000000         117713.238255309	500         1         0         1         100000000         117713.238255309         19618.8730425514           501         1         0         1         100000000         117713.238255309         19618.8730425514           502         1         0         1         100000000         117713.238255309         19618.8730425514           503         1         0         1         100000000         117713.238255309         19618.8730425514	500         1         0         1         10000000         117713.238255309         19618.8730425514         0           501         1         0         1         100000000         117713.238255309         19618.8730425514         0           502         1         0         1         100000000         117713.238255309         19618.8730425514         0           503         1         0         1         100000000         117713.238255309         19618.8730425514         0

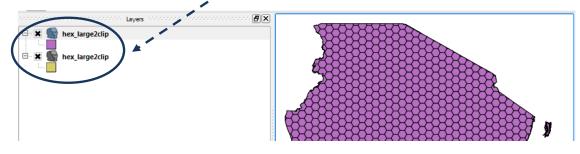
For full instructions of the above procedure, please refer to the tutorial below:

STEP-BY-STEP TUTORIAL: EXTRACTING AND PROCESSING IUCN RED LIST SPECIES DATA USING A VECTOR APPROACH IN QGIS 1.8

Please note: The Qmarxan extension is not yet available for QGIS 2.x

#### Defining class breaks for the matrix legend

a. Add the summary units shapefile (hexagons/squares) which containing the 2 variable summary values into QGIS. e.g. in this example endemic species counts and threatened species counts. Add the layer in twice so that there are 2 copies



**b.** Right click on one of the copies of the dataset and click Open the attribute table and check that there are two columns one for the count of the endemic species and one for the count of the threatened species

🖞 At	tribute table - hex_l	arge2 :: 0 / 1771 fe	ature(s) selected						
	pu_id ∇	pu_cost	pu_status	bnd_cost	area	perimeter	sidelength	endcount	thrcount
487	487	1	0	1	100000000	117713.238255309	19618.8730425514	0	11
488	488	1	0	1	100000000	117713.238255309	19618.8730425514	1	11
489	489	1	0	1	100000000	117713.238255309	19618.8730425514	1	12
490	490	1	0	1	100000000	117713.238255309	19618.8730425514	1	13
491	491	1	0	1	100000000	117713.238255309	19618.8730425514	3	12

**c. Right click >>properties>>Style** on one of the copies of the hexagon dataset. Symbolise the data so that it is displayed in 5 quantiles on the endemic species count column.

🌠 Layer Properties - Hex_I	large2clip   Style
General (	Craduated
Style	
(abc Labels	Sympol Classes 5
Fields	Colo ramp [source]  Invert Mode Quantile (Equal Count)
	Synhool 🗸 Value 🔪 Label
≼ Rendering	0.0000 - 0.0000 0 1.0000 - 5.0000 1 3 5
🥏 Display	6.0000 - 10.0000 6 - 10
	11.0000 - 20.0000 11 - 20
Actions	21.0000 - 37.0000 21 - 37
Joins	
	Classify Add class Delete Delete all Advanced -
💽 Diagrams	
<u>_</u>	▼ Layer rendering
🧃 Metadata	Layer transparency
	Layer blending mode Normal 🔽 Feature blending mode Normal 🗸
	Load Style Save As Default Restore Default Style Save Style
	OK Cancel Apply Help

Change Single Symbol to Graduated style, change column to endcount, change mode to Quantile (Equal count) for other method if preferred), change class to 5 (if you are creating a 5 x 5 matrix). Click Classify then click OK

**d.** Symbolise the second copy of the layer in a similar way so that it is displayed in 5 quantiles on the threatened species count column

11.0000 - 13.0000     13.0000     13.0000 - 15.0000     15.0000 - 59.0000     hex_large2clip     0.0000 - 0.0000     1.0000 - 1.0000     1.0000 - 2.0000     2.0000 - 4.0000     4.0000     4.0000	
--	--

- e. Next add a new column called end5clas of type Whole Number (integer), Width 10
- f. Next add a new column called thr5clas of type
   Whole Number (integer), Width 10
- g. In QGIS 1.8 click on the Advanced tab (or (or in QGIS 2.x the "select features using expression button)

🕺 Add col	umn ? X
N <u>a</u> me	end_5class
Comment	
Туре	Whole number (integer)
	nteger
Width	10
Precision	
	OK Cancel

 Make sql selections for endcount according to the classes in your 5 class quantiles for endemic richness. So for example:-

- if the first class in the quantile for endemics was 0 4 use the SQL endcount <= 4</p>
  - then click the field calculator button and calculate the **end5clas** field to **1**
- if the second class was 5 8 use the SQL
  - endcount > 4 and endcount <= 8

then click the field calculator button and calculate the end5clas field to 2

#### Do this for all 5 classes

i. In QGIS 1.8 click on the Advanced tab (or in QGIS 2.2 the "select features using expression button )

Make sql selections for **thrcount** according to the classes in your 5 class quantiles for threat richness

 j. Then finally click the calculator and calculate a new field call it endthr of type Whole Number (integer), Width 10 using an SQL query to concatenate variable 1 and variable 2 in this example:

#### "end5clas" || "thr5clas"

*Note: the first variable in the concatenation represents the vertical axis on the matrix and the 2nd variable the horizontal axis.* 

💋 Field calculator	? <mark>- × -</mark>
Only update selected features	
Create a new field Update exis	sting field
Output field name endthr	
Output field type Whole number (integer) -	<b>v</b>
Output field width 10 🗣 Precision 0 🜩	
Function List	Selected Function Help
Search	Field
Borna String Borna Geometry <	Double click to add field name to expression string. Right-Click on field name to open context menu sample value loading options.
Expression "end5das"    "thr5clas" Output preview:	OK Cancel Help

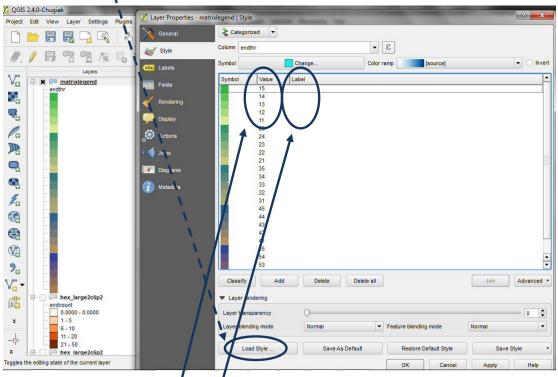
#### The table should now look something like the below.

💋 At	tribu	ute table - hex_large	e2clip :: 0 / 1048 fe	ature(s) selected								
		pu_cost	pu_status	bnd_cost	area	perimeter	sidelength	endcount	thrcount	end5clas 🛆	thr5clas	endthr 📥
233	57	1	0	1	100000000	117713.238255309	19618.8730425514	4	12	4	3	43
234	58	1	0	1	100000000	117713.238255309	19618.8730425514	4	12	4	3	43
235	52	1	0	1	100000000	117713.238255309	19618.8730425514	4	8	4	1	41
236	75	1	0	1	100000000	117713.238255309	19618.8730425514	4	9	4	1	41
237	98	1	0	1	100000000	117713.238255309	19618.8730425514	4	8	4	1	41
238	19	1	0	1	100000000	117713.238255309	19618.8730425514	0	11	1	2	12
239	50	1	0	1	100000000	117713.238255309	19618.8730425514	0	11	1	2	12 🔺
<b>24</b> 0	<b>k</b> 1	1	0	1	100000000	117713 238255300	19618 8730/ 2551/	n	12	1	3	12 V ( )
		1 📰 🔝 🝳	. 🗞 <		Look for						in pu_id	▼ <u>S</u> earch
Sh	ow s	elected only	arch selected only	X Case sensitive						Advanced s	earch ?	Close

The value 11 in the endthr column represents low endemic richness and low threatened species richness and 55 represents high endemic species richness and high threatened species richness.

Formatting the Matrix legend and adding to the map layout

- a. Add the layer into QGIS again and right click on the dataset>>properties
- **b.** Click the **Load Style** button to load in a pre-prepared qml file of choice (provided with this tutorial)



c. Pick one of the custom QML iles of choice of colour scheme provided with this tutorial.

١

Note: The legend is formatted in a specific way so that each block of 5 numbers are sorted in reverse starting with the 10's then the 20's then the 30's then the 40's then the 50's i.e. starting with 15,14,13,12,11

Also note that the **labels** that usually appear next to the legend box **have been removed**. This is necessary in order to generate the square legend.

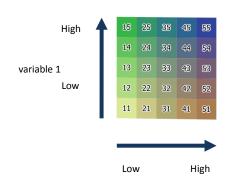
	🧼 « old_desktop 🕨 matrixqml	▼ <sup>4</sup> → Sean	ch matrixqml
Organize	- New folder		:≡ ▼ 🚺
<b>\$</b> ^	Name	Date modified	Туре
	📄 matrix_blue_brown.qml 💙	04/12/2013 17:42	QML File
	matrix_green_blue_brown.qml	04/12/2013 17:59	QML File
	matrix_purple_orange.qml	04/12/2013 18:09	QML File
	raster_matrix.qml	27/11/2013 12:20	QML File
	raster_matrix_car_spec.qml	27/01/2014 12:23	QML File
	raster_matrix_car_spec2.qml	28/01/2014 00:23	QML File
	raster_matrix2.qml	26/01/2014 19:27	QML File
	raster_matrix3.qml	27/01/2014 02:19	QML File
	reds_greybrown.qml	04/12/2013 18:29	QML File
5			
-	•	III	
	File name: matrix_green_blue	brown.gml 👻 OGIS I	Layer Style File (*.qml)

An illustration of the matrix\_green\_blue\_brown.qml file is presented below:-



**d.** The next step is to add the map to a layout and display the legend to look similar to the illustrations right.

(Note: the numbers inside the boxes will not be presented on the final legend, this is just to illustrate how the reverse ordering of values in the step enable the correct ordering of the colours in 5 columns)

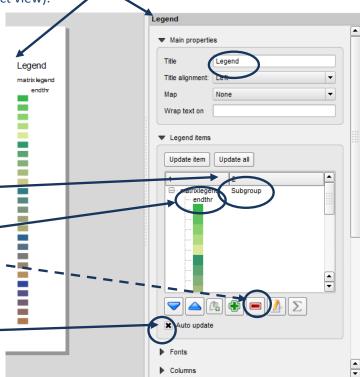


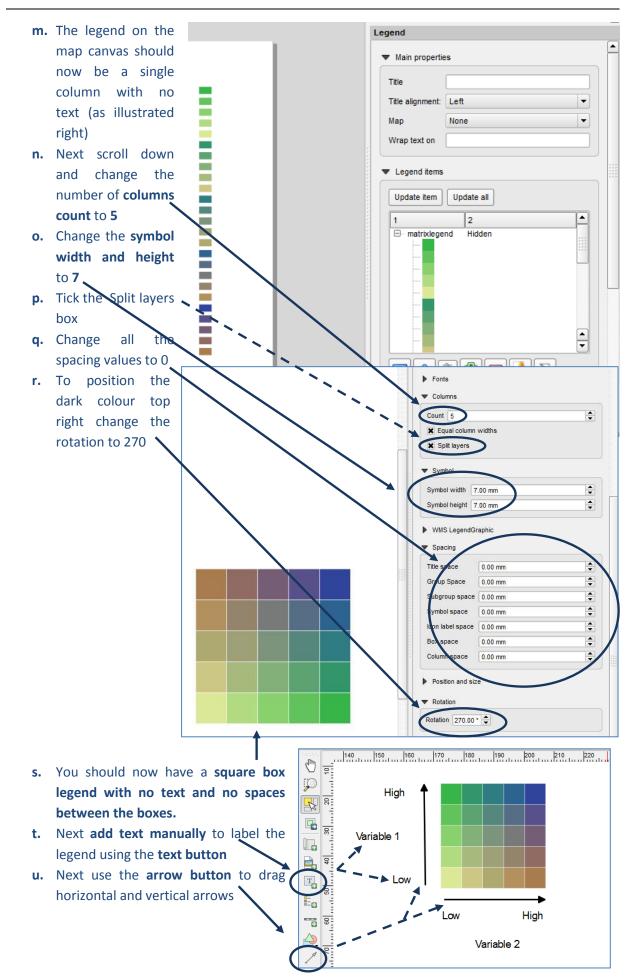
variable 2

- e. From the project menu select project>>New Print Composer
- f. Click on the Add new map icon and then drag a box onto the canvas. The map appears with the layers that were ticked in table of contents in the project view window.
- Composer Edit View Layout Atlas T I 다.다. 🖓 📂 🛃 🖨 🚉 🍇 🤌 🔿 40, 120, 100, 120, 140, 160, 180, 1100, 120, 1 m 20 P 13 G. 0 -Т Eo 0 8
- g. Then click on the legend button and drag a legend onto the canvas. It will appear as a single column.
- **h.** The legend should look similar to the illustration below (if only the matrix layer was ticked in the table of contents in the project view).

🖉 matrix\_legend map

- i. In order to display this legend in a matrix style only include the matrix layer (i.e. highlight each of the other layers in turn and use the red minus button to remove them from the legend). Other layers can be added in a separate legend.
- j. Change the subgroup to hidden
- k. Click on the (e.g. in this example endthr field text) and click the minus button
- Remove the cross from the Auto update (so when new layers are added to the map they are not automatically added to this legend)

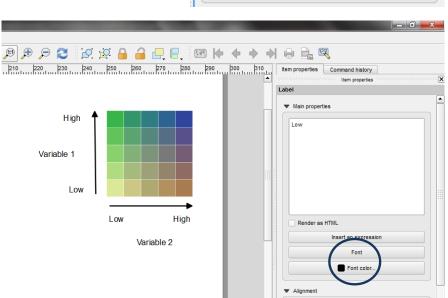




v. Select the arrows and use the item properties to change the thickness of the arrow line and the size of the arrow heads

<ul> <li>Main properti</li> </ul>	es	
	Color	
Line width	0.50 mm	
Line width	0.00 mm	
Arrow head wi	dt 2.00 mm	
	dt 2.00 mm	) SVG
Arrow head wi	dt 2.00 mm	) SVG

 w. Similarly, select the text and use the item properties in the right hand panel to change the size of the text accordingly



The matrix legend and map using two vector datasets is now complete

*If you want to have a go at creating your own matrix colour ramps see guidance in section 2.4* 

#### 2.3. Matrix legend using raster datasets (using QGIS 1.8 or 2.x)

Two wall-to-wall raster datasets are needed to create the matrix map. This illustration will use an example of a raster dataset of Threatened Mammal Species Richness and raster dataset containing Woody biomass values.

For instructions for creating a raster dataset of species richness, please refer to the tutorial:-STEP-BY-STEP TUTORIAL: EXTRACTING AND PROCESSING IUCN RED LIST SPECIES DATA USING A RASTER METHOD IN QGIS 2.X

#### Defining class breaks for the matrix legend

- **a.** Add the Woody biomass raster dataset into QGIS
- b. Right click on the dataset>>properties

- c. Click on Style
- d. Change the rendering type to Singleband pseudocolor, Change the Mode to Equal Area, Change the number of classes to 5

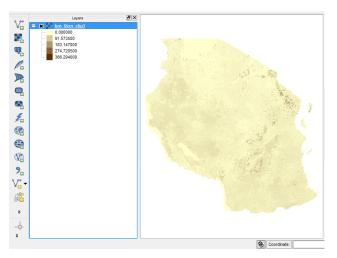
🌾 Layer Properties - bm_5kn	nctip3   Style
Gen al	Band rendering
Style	Render type Singleband pseudocolor
Transparency	Band Band 1 (Gray)
Pyramids	Color interpolation
Histogram	Image: Classes 5         Image: Classes 5<
(1) Metadata	Value         Color         Label           0.000000         0.000000         0.000000           91.573500         91.573500           183.147000         123.147000           274.720500         366.294000           366.294000         366.294000           Cumulative         2.0 ÷ .           98.0 ÷ %         Min / max           0         Min / max           0         Min / max           0         Min / max           0         Win / max           0         Current
	Ctip
	Restore Default Style Save Style Save Style OK Cancel Apply Help
Click on Min/M	ax,
	wer), Click Load, and Click Classify
Show a second lord	

f. Click Apply and then OK

e.

The result may look very washed out (as in the example below) if there is a wide spread of values with a large number for example in the lower classes and a few in the upper classes.

There are no automatic options for displaying the data using other types of class break when using Raster datasets in QGIS. Users can however chose to define class breaks manually or use a processing tool to generate a text file of Quantile class breaks which can then be entered manually. The next steps (g - u) illustrate how to do this.



g. Search for quantile in the processing toolbox (From the main menu click on processing>>toolbox (if you don't already have the toolbox panel open on the right hand side of the QGIS session))

Processing Toolbox
quantile
⊖- Recently used algorithms
🌼 Generate points (pixel centroids) inside polygons
🕰 Step2b - Create Business As Usual Carbon Layer from LUP and Current Carbon
🖻 🖉 GRASS commands [167 geoalgorithms]
⊡ Raster (r.*)
r.quantile - Compute quantiles using two passes.

h. Double click on the r.quantiles GRASS tool. This will generate class breaks where each class will contain approximately the same number of pixels (i.e. each class covering the same area).

#### Click on the Show advanced parameters i.

	Arameters Log Hide ad Input raster layer bm_5km_clip3 [USE Number of quantiles 5 Generate recode rul Yes GRASS region exter 606385.748664,17	Help Us dvanced parameters ER:100002]	Select extent
	Output report		
<u> </u>	[Save to temporary Output text file	/ 1le]	
	C:/Users/corinnar/I	Documents/lastest_tutorials/tmpf/quantile_class_woody_biom	nass.txt 🔽
		0%	
			Run Close

- j. Set the inputIraster layer to the raster layer you want to display in quantile class breaks
  k. Chose 5 for the number of quantiles (if you are creating a 5 x 5 matrix legend)
  l. Change Generate recode rules based on quantile-defined intervals to yes (this is important or it will not generate the required number of class breaks)
- m. Set the Grass region as use layer/canvas extent and pick the raster dataset you are generating quantiles for. Т
- n. Leave the Output report as [save to temporary file]
- o. Change the Output Text file to Save to File and give it a name with a .txt ending.
- p. Click Run.

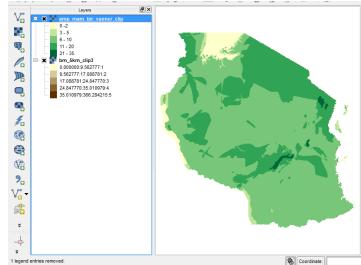
q. Open the text file that was created in a notepad to see the class breaks which have been generated

	quant	ileWB.t	txt - No	otepad	
				<u>V</u> iew	<u>H</u> elp
9. 17 24	5627 088 847	781:2 770:3	.088 4.84 5.01	77:1 781:2 7770: 0979: 94215	3 4

- In QGIS Right click on the dataset again to bring up the layer properties window. Click on Style
- s. Manually alter the class breaks to your own chosen values. Remember to change both the value and label
- t. Change color interpolation to discrete

🏑 Layer Properties - bm_5km	cl p3   Style	x
General General General Transparency Pyramids Histogram Metadata	Band rentering         Render type         Band         Color interpolation         Discrete         Image: Color         Loter         0.000000:9:562777:1         9:562777         17:088781         24.847770         35:010979         366:294000         35:010979:366:294215:5	
	Restore Default Style     Save As Default     Load Style     Save Style       OK     Cancel     Apply     Help	

- u. Click Apply, Click OK
- Repeat steps a-u for the second raster dataset to be used in the matrix legend. e.g. threatened species richness in this example



The next steps generate new raster datasets for the two themes based on the class breaks defined in the previous steps using the r.reclass function in the processing toolbox.

a. First a reclass tables need to be created in notepad using the following syntax. Note the thru mens 'up to' (not including) the second number in the expression

0.000000 thru 9.562777 = 1	quantile_class_woody_biomass_reclass.txt - Notepad
9.562777 thru 17.088781 = 2	<u>File Edit Format View Help</u>
17.088781 thru 24.847770 = 3	0.000000 thru 9.562777 = 1 9.562777 thru 17.088781 = 2 17.088781 thru 24.847770 = 3 24.847770 thru 35.010979 = 4 35.010979 thru 366.294215 = 5
24.847770 thru 35.010979 = 4	24.847770 thru $35.010979 = 435.010979 thru 366.294215 = 5$
35.010979 thru 366.294215 = 5	

Note if the class breaks were generated by the r.quantile process, open the txt file it produced and modify syntax to the above rather than having to type all the numbers.

b. Search for reclass tool in the processing toolbox and double click on the r.reclass GRASS tool. This will create a **new raster dataset** with 5 classes based on the text file above.

Parameters Log Help	1				
(					
Input raster layer					
bm_5km_clip3 [USER:10000	2]			•	
File containing eclass rules					
C:\Users\corinnar\Documen	ts\lastest_tutorials\tmp	of\quantile_class_	woody_biomass_red	class.txt	
GRASS region extent(xmin, >	(max, ymin, ymax)		1		
606385.748664,1796124.96	761,-873348.175131,	326347.020543	1		
GRASS region cellsize (leave	e 0 for default) 🧍		!		
1000.000000	i				<b>.</b>
Output raster layer	Ĩ		i		
C:/Users/corinnar/Documen	ts/lastest_tutorials/tmp	of/bm5km_clip3_50	classquantiles.tif		
X Open output file after run	ning algorithm		1		
			:		
i i i	i	١	;		
1			•		
I	1				
		0%			
	1			Run	Close

- c. Set the input raster layer to the raster layer you want to reclass
  d. Set the File containing reclass rules (from step a above)
- e. Set the Grass region as use layer/canvas extent to the same as the Input Raster
- f. Set the Grass region cellsize (choose according to the minimum resolution of the two rasters to be used in the matrix map) ۱
- g. Change the Output raster layer to Save to File and give it a suitable name. e.g. bm5km\_clip3\_5classquantiles.tif in this example
- h. Click Run

- i. Right click >> properties on the output raster layer that has appeared in the table of contents
- j. Click on the general tab and rename the layer name to it's proper name e.g. bm5km\_clip3\_5classquantiles.tif in this example

🧭 Layer Properties - Outpu	ut raster layer   General	×
General	▼ Layer info	
🥁 Style 🤇	Layer name bm5km_clip3_5classquantiles.tif displayed as bm5km_clip3_5classquantiles.tif	
Transparency	Layer source C/Users/corinnar/Documents/lastest_tutorials/tmp1/bm5km_clip3_5classquantiles.tif Columns: 239 Rows: 241 No-Data Value: 255	
Histogram	Coordinate reference system	
Metadata	USER:100002 - * Generated CRS (+proj=laea +lat_0=-4 +lon_0=24 +x_0=0 +y_0=0 +ellps=WGS84 +units=m +no_defs) Specify	
Ŭ	▼ Scale dependent visibility	
	Minimum (exclusive) (1:100,000,000 Maximum (inclusive) (1:0 current current	
	Thumbnail Legend Palette	4
	Restore Default Style Save As Default Load Style Save Style	
	OK Cancel Apply He	lp

- k. Click on the style tab
- I. Symbolise the data by adding 5 manual classes in the **5 classes** (see that it only has 5 values now)

🌠 Layer Properties - bm5km_	clip3_5classquantiles   Style			? <mark>×</mark>
General	<ul> <li>Band rendering</li> </ul>			
Style Style Pyramids Histogram Metadata	Render tyte Singleband pseudoc Band Color interpolation	Band 1 (Gray)	Mode Equal interval V Classes Min 1 Max E Class	
	··· 3.000000 3.0 ··· 4.000000 4.0	00000	Min / max origin: Exact min / max of full extent. Load min/max values Cumulative 2.0 - 98.0 Min / max Mean +/- standard deviation × 2.00 - Extent • Full Current	
	Clip			Load
	Restore Default Style	Save As Default	Load Style	Save Style
			ОКСа	ncel Apply Help

m. Repeat steps a - I for the second raster datasets. i.e. threatened species richness in this example. BUT Note as the number are whole number in this dataset be careful in step a when creating the text file. If you want values from 0 - 2 (including 2) in the first class for example. Make sure it is defined in the reclass file as 0 thru 3 = 1 (remembering the 'thru' means 'up to').

n. The next step is to combine the two 5-class raster datasets together. In QGIS it is not possible to see the attribute table of raster datasets so this means there is in effect only 'one attribute' called value which is numeric. From the main menu click on Raster>> raster calculator

Raster bands				Result lay	er					
	_5classquantiles. richness_5classI			Output lay	/er	matrix_s	peciesric	hness_biom	nass.tif	
"amp_mam_bir_vuencr_clip@1" "bm_5km_clip3@1"			:	Current	ayer extent					
				X min	606385.7486	6 🗘	XMax	1796124.9	96761	-
				Y min	-873348.175	13 🖨	Y max	326347.02	2054	-
			1	Columns	239	\$	Rows	241		-
				Output fo	rmat	GeoTIFF			-	
				X Add n	esult to projec	:t				
<ul> <li>Operators</li> </ul>										
-	*	eart	ein		٨	3008		(		
+	*	sqrt	sin		•	acos		(		
+	*	sqrt cos	sir asi		^ tan	acos atan		(		
+	*	· · · ·						( ) OR		
		cos	asi		tan	atan		( ) OR		
Raster calculate	or expression		asi	n [	tan >=	atan AND		( ) OR		
Raster calculate	or expression richness_5classI	cos = Manual2.tif@1" = 4	asi	n	tan >=	atan AND	* 44) +	( ) OR		-
Raster calculate (("thr_species_ (("thr_species_ (("thr_species_ (("thr_species_	or expression richness_5classl richness_5classl richness_5classl	cos = Manual2.tif@1" = 4 Manual2.tif@1" = 4 Manual2.tif@1" = 5	asi	n	tan >=	atan AND 	* 44) + * 45) + * 51) +	( ) OR		-
Raster calculate (("thr_species_ (("thr_species_ (("thr_species_ (("thr_species_	richness_5class richness_5class richness_5class richness_5class richness_5class	cos = Manual2.tif@1" = 4 Manual2.tif@1" = 5 Manual2.tif@1" = 5	asi <= 4 and "bms 5 and "bms 5 and "bms 5 and "bms	n	tan >= classquantiles classquantiles classquantiles classquantiles	atan AND s.tif@1" = 4) s.tif@1" = 5) s.tif@1" = 1) s.tif@1" = 2)	* 44) + * 45) + * 51) + * 52) +	( ) OR		-
Raster calculato (("thr_species_ (("thr_species_ (("thr_species_ (("thr_species_ (("thr_species_ (("thr_species_	richness_5classl richness_5classl richness_5classl richness_5classl richness_5classl richness_5classl	cos = Manual2.tif@1" = 4 Manual2.tif@1" = 4 Manual2.tif@1" = 5 Manual2.tif@1" = 5 Manual2.tif@1" = 5 Manual2.tif@1" = 5	asi <= 4 and "bm5 4 and "bm5 5 and "bm5 5 and "bm5 5 and "bm5 5 and "bm5 5 and "bm5	n 5km_clip3_5 5km_clip3_5 5km_clip3_5 5km_clip3_5 5km_clip3_5 5km_clip3_5	tan >= classquantiles classquantiles classquantiles classquantiles classquantiles	atan AND s.tif@1" = 4) s.tif@1" = 5) s.tif@1" = 2) s.tif@1" = 2) s.tif@1" = 4)	* 44) + * 45) + * 51) + * 52) + * 53) + * 54) +	( ) OR		-
Raster calculato (("thr_species_ (("thr_species_ (("thr_species_ (("thr_species_ (("thr_species_ (("thr_species_	richness_5classl richness_5classl richness_5classl richness_5classl richness_5classl richness_5classl	cos = Manual2.tif@1" = 4 Manual2.tif@1" = 4 Manual2.tif@1" = 5 Manual2.tif@1" = 5 Manual2.tif@1" = 5	asi <= 4 and "bm5 4 and "bm5 5 and "bm5 5 and "bm5 5 and "bm5 5 and "bm5 5 and "bm5	n 5km_clip3_5 5km_clip3_5 5km_clip3_5 5km_clip3_5 5km_clip3_5 5km_clip3_5	tan >= classquantiles classquantiles classquantiles classquantiles classquantiles	atan AND s.tif@1" = 4) s.tif@1" = 5) s.tif@1" = 2) s.tif@1" = 2) s.tif@1" = 4)	* 44) + * 45) + * 51) + * 52) + * 53) + * 54) +	( ) OR		
Raster calculato (("thr_species_ (("thr_species_ (("thr_species_ (("thr_species_ (("thr_species_ (("thr_species_	richness_5classl richness_5classl richness_5classl richness_5classl richness_5classl richness_5classl	cos = Manual2.tif@1" = 4 Manual2.tif@1" = 4 Manual2.tif@1" = 5 Manual2.tif@1" = 5 Manual2.tif@1" = 5 Manual2.tif@1" = 5	asi <= 4 and "bm5 4 and "bm5 5 and "bm5 5 and "bm5 5 and "bm5 5 and "bm5 5 and "bm5	n 5km_clip3_5 5km_clip3_5 5km_clip3_5 5km_clip3_5 5km_clip3_5 5km_clip3_5	tan >= classquantiles classquantiles classquantiles classquantiles classquantiles	atan AND s.tif@1" = 4) s.tif@1" = 5) s.tif@1" = 2) s.tif@1" = 2) s.tif@1" = 4)	* 44) + * 45) + * 51) + * 52) + * 53) + * 54) +	( ) OR		

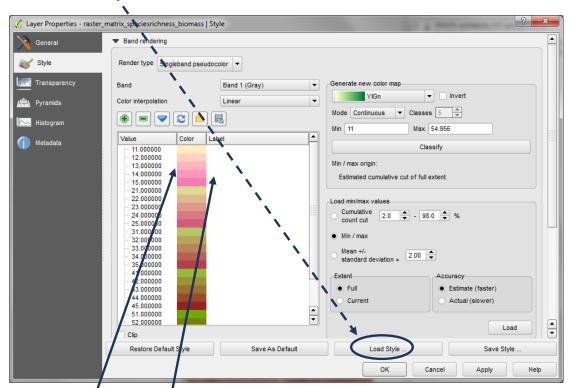
o. In the raster calculator expression box use the following syntax to combine the two raster datasets together. Where raster1\_5class.tif in this example is the species richness and the raster2\_5class.tif is the woody biomass. replace the names with the names of your 5-class datasets but keep the rest of the syntax the same.

```
 (("raster1_5class.tif@1" = 1 and "raster2_5class.tif@1" = 1) * 11) + (("raster1_5class.tif@1" = 1 and "raster2_5class.tif@1" = 2) * 12) + (("raster1_5class.tif@1" = 1 and "raster2_5class.tif@1" = 3) * 13) + (("raster1_5class.tif@1" = 1 and "raster2_5class.tif@1" = 4) * 14) + (("raster1_5class.tif@1" = 1 and "raster2_5class.tif@1" = 5) * 15) + (("raster1_5class.tif@1" = 2 and "raster2_5class.tif@1" = 1) * 21) + (("raster1_5class.tif@1" = 2 and "raster2_5class.tif@1" = 2) * 22) + (("raster1_5class.tif@1" = 2 and "raster2_5class.tif@1" = 3) * 23) + (("raster1_5class.tif@1" = 2 and "raster2_5class.tif@1" = 4) * 24) + (("raster1_5class.tif@1" = 2 and "raster2_5class.tif@1" = 4) * 24) + (("raster1_5class.tif@1" = 2 and "raster2_5class.tif@1" = 5) * 25) + (("raster1_5class.tif@1" = 3 and "raster2_5class.tif@1" = 1) * 31) + (("raster1_5class.tif@1" = 3 and "raster2_5class.tif@1" = 2) * 32) + (("raster1_5class.tif@1" = 3 and "raster2_5class.tif@1" = 2) * 32) + (("raster1_5class.tif@1" = 3 and "raster2_5class.tif@1" = 4) * 33) + (("raster1_5class.tif@1" = 3 and "raster2_5class.tif@1" = 2) * 32) + (("raster1_5class.tif@1" = 3 and "raster2_5class.tif@1" = 4) * 33) + (("raster1_5class.tif@1" = 3 and "raster2_5class.tif@1" = 4) * 33) + (("raster1_5class.tif@1" = 3 and "raster2_5class.tif@1" = 4) * 33) + (("raster1_5class.tif@1" = 3 and "raster2_5class.tif@1" = 4) * 33) + (("raster1_5class.tif@1" = 3 and "raster2_5class.tif@1" = 4) * 33) + (("raster1_5class.tif@1" = 3 and "raster2_5class.tif@1" = 4) * 34) + (("raster1_5class.tif@1" = 3 and "raster2_5class.tif@1" = 4) * 34) + (("raster1_5class.tif@1" = 3 and "raster2_5class.tif@1" = 4) * 34) + (("raster1_5class.tif@1" = 3 and "raster2_5class.tif@1" = 4) * 34) + (("raster1_5class.tif@1" = 3 and "raster2_5class.tif@1" = 4) * 34) + (("raster1_5class.tif@1" = 4) * 34) + (("raster1_5class.tif
```

$(("raster1_5class.tif @1" = 3 and "raster2_5class.tif@1" = 5) * 35) +$
$(("raster1_5class.tif @1" = 4 and "raster2_5class.tif@1" = 1) * 41) +$
$(("raster1_5class.tif @1" = 4 and "raster2_5class.tif@1" = 2) * 42) +$
$(("raster1_5class.tif @1" = 4 and "raster2_5class.tif@1" = 3) * 43) +$
$(("raster1_5class.tif @1" = 4 and "raster2_5class.tif@1" = 4) * 44) +$
$(("raster1_5class.tif @1" = 4 and "raster2_5class.tif@1" = 5) * 45) +$
$(("raster1_5class.tif @1" = 5 and "raster2_5class.tif@1" = 1) * 51) +$
$(("raster1_5class.tif @1" = 5 and "raster2_5class.tif@1" = 2) * 52) +$
$(("raster1_5class.tif @1" = 5 and "raster2_5class.tif@1" = 3) * 53) +$
$(("raster1_5class.tif @1" = 5 and "raster2_5class.tif@1" = 4) * 54) +$
(("raster1_5class.tif @1" = 5 and "raster2_5class.tif@1" = 5) $*$ 55)

#### Formatting the Matrix legend and adding to the map layout

- a. Right click on the new matrix raster dataset>>properties
- **b.** Click the **Load Style** button to load in a pre-prepared qml file of choice (provided with this tutorial)

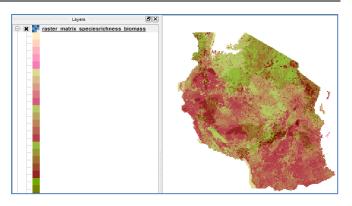


c. Pick one of the custom raster QML files of choice of colour scheme provided with this tutorial.

Note: The legend is formatted in a specific way so that **each block of 5 numbers are coloured in a ramp** which when presented in 5 columns forms a two-way ramp of colours. Also note that the **labels** that usually appear next to the legend box **have been removed**. This is necessary in order to generate the square legend.

🄏 Load layer	r properties from stjle file			x
00-	🕌 « old_desktop 👔 matrixqml	▼ <sup>4</sup> → Searce	h matrixqml	٩
Organize •	New folder		≣ ▼ 🚺	0
<b></b>	Name	Date modified	Туре	Size
-	matrix_blue_brown.qml	04/12/2013 17:42	QML File	
	matrix_green_blue_brown.qml	04/12/2013 17:59	QML File	
1 E	matrix_green_blue_brown_correctorder.q	02/11/2014 21:49	QML File	
	matrix_purple_orange.qui	04/12/2013 18:09	QML File	
	raster_matrix.qml	27/11/2013 12:20	QML File	
	raster_matrix_car_spec.qml	27/01/2014 12:23	QML File	
	raster_matrix_car_spec2.qm	28/01/2014 00:23	QML File	
	raster_matrix_green_pink_brown.qml	03/11/2014 14:25	QML File	
	raster_matrix2.qml	26/01/2014 19:27	QML File	
<b>1</b>	raster_matrix3.qml	27/01/2014 02:19	QML File	
	reds_greybrown.qml	04/12/2013 18:29	QML File	
<b>a</b>				
				÷.
	File name: raster_matrix_green_pink_	brown g 👻 OGIS L	aver Style File (*.gml)	•
			pen Cance	

An illustration of the matrix dataset with the raster\_matrix\_green\_pink \_brown.qml file is presented here.



High

Low

Variable 1

The next step will be to add the map to a layout and display the legend to look similar to the illustrations right.

(Note: the numbers inside the boxes will not be presented on the final legend, this is just to illustrate the final position of the numbers in the 5 columns)

In the example map above Threatened species richness (Variable 1) was combined with Woody biomass (Variable 2).

The definitions of for the combined threatened species/woody biomass field are:

11 Low threatened species richness, low woody biomass
12 Low threatened species richness, medium woody biomass
13 Low threatened species richness, medium woody biomass
14 Low threatened species richness, medium high woody biomass
15 Low threatened species richness, high woody biomass
...

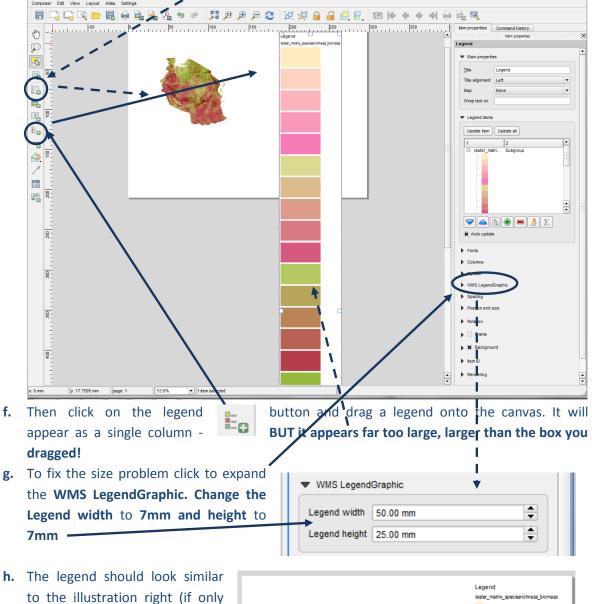
11 Low threatened species richness, low woody biomass
21 Medium Low threatened species richness, low woody biomass
31 Medium threatened species richness, low woody biomass
41 Medium High threatened species richness, low woody biomass
51 High threatened species richness, low woody biomass
51 High threatened species richness, low woody biomass
52 High threatened species richness, medium woody biomass
53 High threatened species richness, medium woody biomass
54 High threatened species richness, medium woody biomass

55 High threatened species richness, high woody biomass

1		51	52	53	54	55
		41			44	45
		31	32	33	34	35
		21	22	23	24	25
		11	12	13	14	15
	۰.					
		Low				High

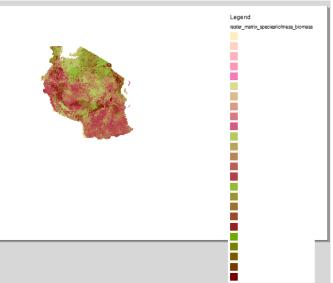
Variable 2

- d. From the project menu select project>>New Print Composer
- e. Click on the Add new map icon appears with the layers that were ticked in table of contents in the project view window.

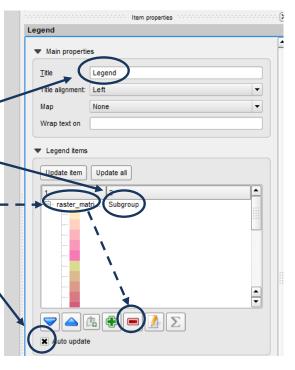


to the illustration right (if only the matrix layer was ticked in the table of contents in the project view).

Note the legend boxes are now a better size



- i. In order to display this legend in a matrix style only include the matrix layer (i.e. highlight each of the other layers in turn and use the **red minus** button to remove them from the legend). Other layers can be added in a separate legend.
- j. Remove the Title Legend
- k. On the matrix layer change the subgroup to hidden
- I. Click on the raster dataset name and click the minus button
- m. Remove the cross from the Auto update (so when new layers are added to the map they are not automatically added to this legend)
- n. The legend on the map canvas should now be a single column with no text (as illustrated below)



- Next expand the Columns tab and change the number of columns count to 5
- p. Tick the Split layers and tick Equal column widths
- q. Expand Spacing
- r. Change all the spacing values to 0

#### s. Expand Rotation

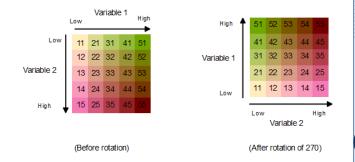
t. Change rotation to **270**. This rotates the legend so that the lightest value is in the bottom left and the darkest colour is in the top right.

u. The legend should now look like this.

The illustration below illustrates the positioning of the values in the



combined matrix dataset and the effect of the rotation on the appearance of the legend.



Columns	λ
Count 5	1
X Equal column	widths
X Split layers	
Symbol	
<ul> <li>WMS LegendG</li> </ul>	Graphic
Legend width	7.00 mm
Legend height	7.00 mm
<u> </u>	$\sim$
<ul> <li>Spacing</li> </ul>	
Title space	0.00 mm
Group Space	0.00 mm
Subgroup space	0.00 mm
Symbol space	0.00 mm
Icon label space	0.00 mm
Box space	0.00 mm
Column space	0.00 mm
h Destina ender	
Position and size	ze
Rotation	
Rotation 270.00	. 🔺
270.00	7

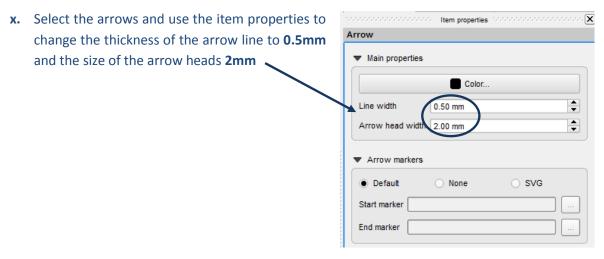
The Next steps will manually add the arrows and legend text. In the illustration above, the numbers inside the legend squares have been added to illustrate how the values in the final matrix raster dataset form the matrix legend. They are not required for the final legend.

v. Click on the add text button

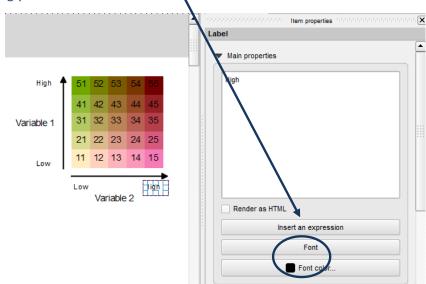
to manually add text to label the legend

w. Next use the **arrow button** it to drag horizontal and vertical arrows

T



y. Similarly, select the text and use the item properties in the right hand panel to change the size of the text accordingly  $\lambda$ 

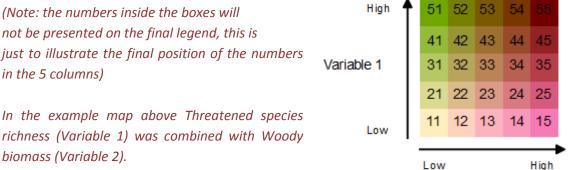


The matrix legend and map using two raster datasets is now complete

#### 2.4. Guidance for creating your own matrix colour ramps

We have generated a few 5x5 class colour ramps for you and saved them as QML files. The notes below give guidance on how to generate your own styles from scratch. The instructions are descriptive rather than full step-by-step instructions. When defining the colours It is probably easiest to use a vector dataset containing 5 x 5 squares whilst working out the colours and then enter them into gml files at the end.

For a five class matrix with **carbon** and **species richness** the values read as follows:



Variable 2

not be presented on the final legend, this is just to illustrate the final position of the numbers *in the 5 columns)* 

In the example map above Threatened species richness (Variable 1) was combined with Woody biomass (Variable 2).

The definitions of for the combined threatened species/woody biomass field are:

11 Low threatened species richness, low woody biomass 12 Low threatened species richness, medium woody biomass 13 Low threatened species richness, medium woody biomass 14 Low threatened species richness, medium high woody biomass 15 Low threatened species richness, high woody biomass ... 51 High threatened species richness, low woody biomass 52 High threatened species richness, medium woody biomass 53 High threatened species richness, medium woody biomass 54 High threatened species richness, medium woody biomass 55 High threatened species richness, high woody biomass

Etc.

The illustrations below help to demonstrate how you go about defining your new colour. The idea is to seamlessly grade the colors in all directions.

a) You will first need to choose colours for:-

- Iow threatened species richness low woody biomass (11)
- Iow threatened species richness high woody biomass (15)
- high threatened species richness low woody biomass (51)
- high threatened species richness high woody biomass (55)

So, for example, you will need to produce a colour ramp from a colour chosen at 11 to the colour chosen at 15:

Chose a starting colour for
the pale yellow for 11 and a
bright pink for the 15. Ramp
between the yellow to pink. Make
a note of the RGB values for 12;
13 and 14

11	12	13	14	15
21	22	23 13	24	25
31	32	33	34	35
41	42	43	44	45
51	52	53	54	55

Similarly you will need to produce a colour ramp from 11 (21,31,41) 51:

Chose the same starting colour for the pale yellow for 11 and a bright green for the 51. Ramp between the yellow to green. Make a note of the RGB values for 21, 31 and 41

51		53		55
41		43		45
		33		
		23		
11	12	13	14	15

and the same for ramping colours from 51 to 55:

Chose the same starting bright green for 51 and a dark browny pink for the 55. Ramp between the yellow to green. Make a note of the RGB values for 52, 53 and 54

_				
51	52	53	54	65
41	42	43	44	45
31	32	33	34	35
21	22	23	24	25
11	12	13	14	15

So we now know RGB values for the top and bottom parts of the matrix and therefore can produce ramps between 12 - 52, 13 - 53, 14 - 54. Make a note of all the RGB values generated so that these can be manually entered into the QML files.

