

# UN-REDD PROGRAMME



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## Marxan Tutorials to Enhance REDD+ Multiple Benefits

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UN-REDD PROGRAMME

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16 December 2013

*This tutorial is an annex to the manual “Using spatial planning software to support REDD+ decision-making: an application of Marxan”*

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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[ccb@unep-wcmc.org](mailto:ccb@unep-wcmc.org).

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<sup>1</sup> I.R. Ball, H.P. Possingham and M. Watts, "Marxan and Relatives: Software for Spatial Conservation Prioritisation," in *Spatial conservation prioritisation: Quantitative methods and computational tools.*, ed. by A. Moilanen, K.A. Wilson, and H.P. Possingham (Oxford, UK: Oxford University Press, 2009), pp. 185–195.

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## Introduction

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Marxan (Ball, Possingham, & Watts, 2009) is a type of spatial planning software, originally designed for spatially planning nature reserves and protected areas. Marxan can also be used for REDD+ planning, in particular to demonstrate where priority areas for REDD+ actions could be implemented when there are too many considerations for the solution to be obvious.

The aim of this document is to give users a step by step guide to prepare data for Marxan and run Marxan for enhancing multiple benefits from REDD+ actions. This is not a document that attempts to give policy advice on Marxan for REDD+, such a document will be released shortly, please contact [ccb@unep-wcmc.org](mailto:ccb@unep-wcmc.org) for more details. There are a wealth of materials available for Marxan that this set of tutorials does not attempt to superceed, these include :

- Marxan user manual: <http://www.uq.edu.au/marxan/index.html?page=77823>
- Marxan online tutorial: <http://www.uq.edu.au/marxan/tutorial/toc.html>
- Marxan best practices guide: <http://www.uq.edu.au/marxan/index.html?page=77823>

This tutorial was prepared for a working session in June 2013 in the DRC, with participants from the Ministry of Environment, Conservation and Tourism (Directorate of Forest Inventories and Directorate of Sustainable Development), the Satellite Observatory of Central African Forests (OSFAC) and the Post-University Regional School for Integrated Tropical Forest Management (ERAIFT). The objective of this workshop was to demonstrate how policy priorities for multiple benefits may be used to identify potential priority areas for REDD+ actions, and to enable participants to carry out this analysis.

Participants of the technical workshop have USB sticks containing all the software relevant to this tutorial, however all this software can be downloaded for free on the following websites:

Essential for this tutorial:

Marxan software: <http://www.uq.edu.au/marxan/marxan-software>

Quantum GIS software: <http://www.qgis.org/>

Quantum GIS software plugin "QMARXAN": <http://aproposinfosystems.com/products/qmarxan/>

Optional for this tutorial:

Ubuntu operating system: <http://www.ubuntu.com/>

Enquires on acquiring datasets, questions, corrections and queries should be sent to [ccb@unep-wcmc.org](mailto:ccb@unep-wcmc.org).

## Chapter 1. Unpacking the USB stick and setting up the environment

### 1.1 Plug in Linux USB stick



### 1.2. Start computer



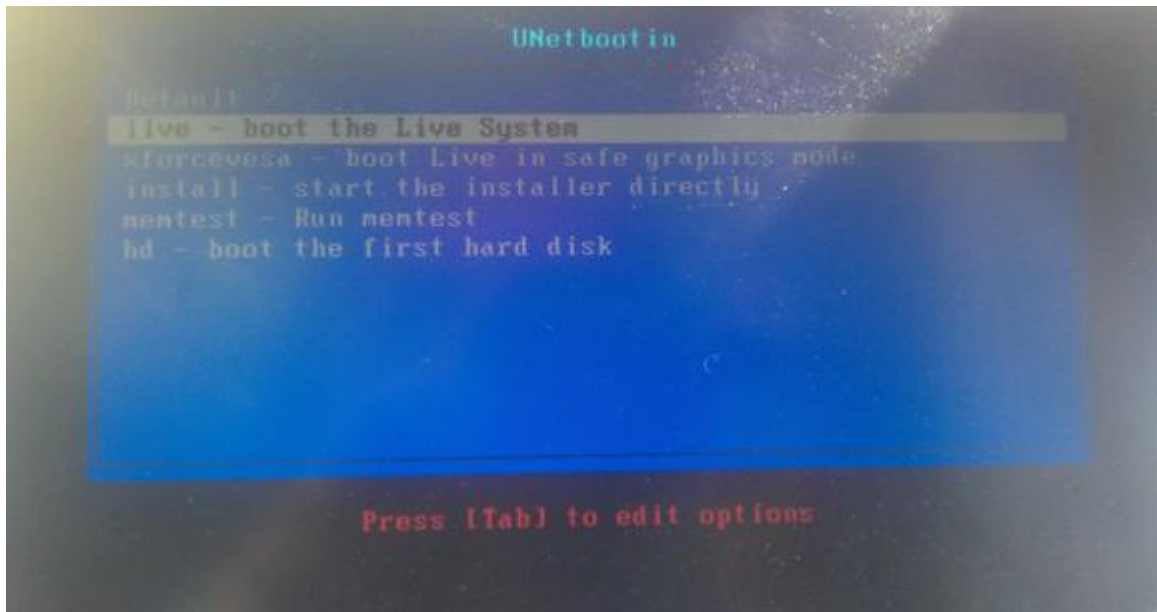
### 1.3. Press F11 on your keyboard or F12 (depending on the computer) immediately and repeatedly



### 1.4. If you see that screen, choose USB Device

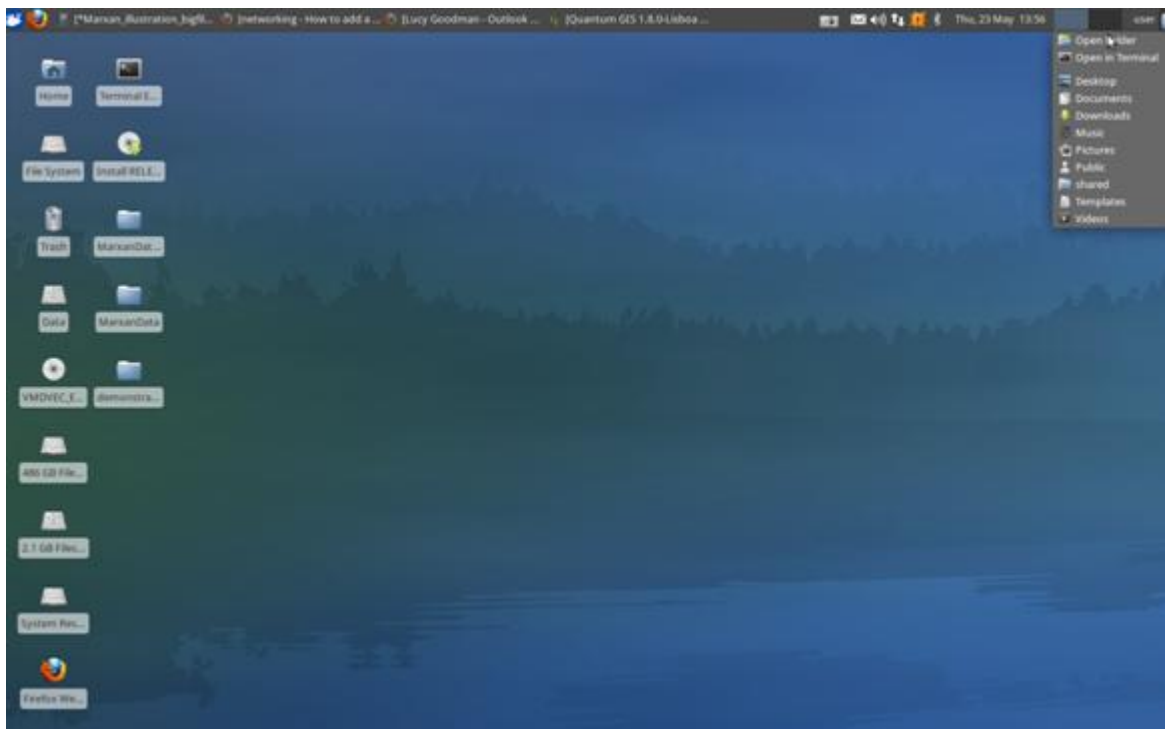


1.5. Use the arrow key to select “live – boot the live system” the second option down and press enter



When the Ubuntu environment has loaded, copy your training files from a USB stick onto the following drive: `computer/media/14363F28363F09EE/`

You can navigate to this folder from the following dropdown menu



1.6. Then by clicking on the folder that has a higher number out of the two file systems, below this is “486 GB filesystem” but it will vary from computer to computer.

Open your folder with training materials, and ensure it has the following folders:

- Documents
- Inputs\_demo
- MarxanData\_unix
- Outputs\_demo
- Qgis\_after
- Qgis\_before
- Targetsdetails



1.7. Then open the folder “Desktop” between the two “filesystem” and open MarxanData\_unix.

Open the folder with the training material and ensure it contains the following folders:

- Input.dat
- MarOpt\_v243\_Linux32
- Inputs
- Outputs



## Chapter 2. Making planning units

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To use Marxan software, it needs to be downloaded first and the environment needs to be set up. This is described in another annex. The illustration below supposes that this steps were undertaken previously.

The next step is to then create planning units, subsequently changing the size and shape of a planning unit is time consuming so that it is important to be clear on the correct size and shape at the beginning. The planning units are areas which will be either selected as priority areas for REDD+ or not selected. Units can be regular or irregular, regular units could be squares or hexagons, irregular units could be districts or communities, see Figure 7-1.



Figure 0-1 example planning unit grid

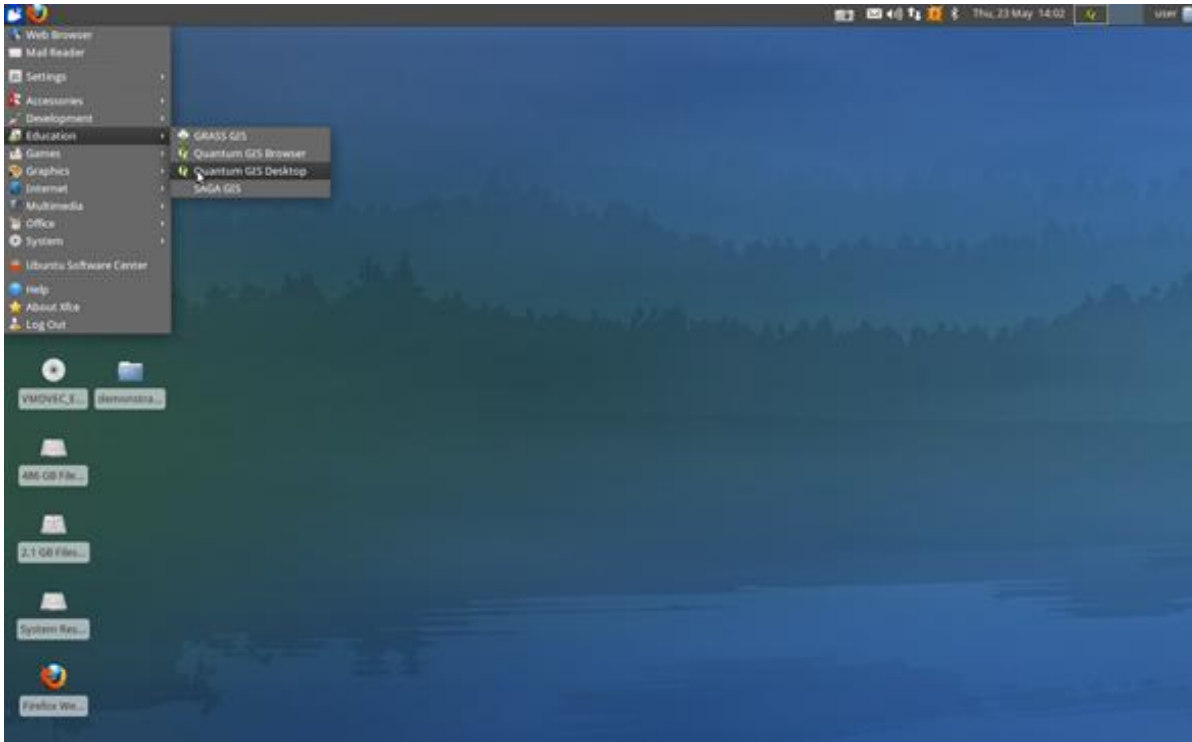
For this illustration, we use squares of 100 km<sup>2</sup>. The resolution should be realistic for planning and the scale of your input layers.

At national scale, analysis and display are much easier in a raster rather than vector planning unit layer, although the software can utilise either format. There are limitations to how many planning units can be produced by software which supports Marxan, we found that planning units of 1km<sup>2</sup> caused the software to crash, and Marxan runs more slowly with more planning units. There is no accepted limit, but a good target number is 10,000 planning units.

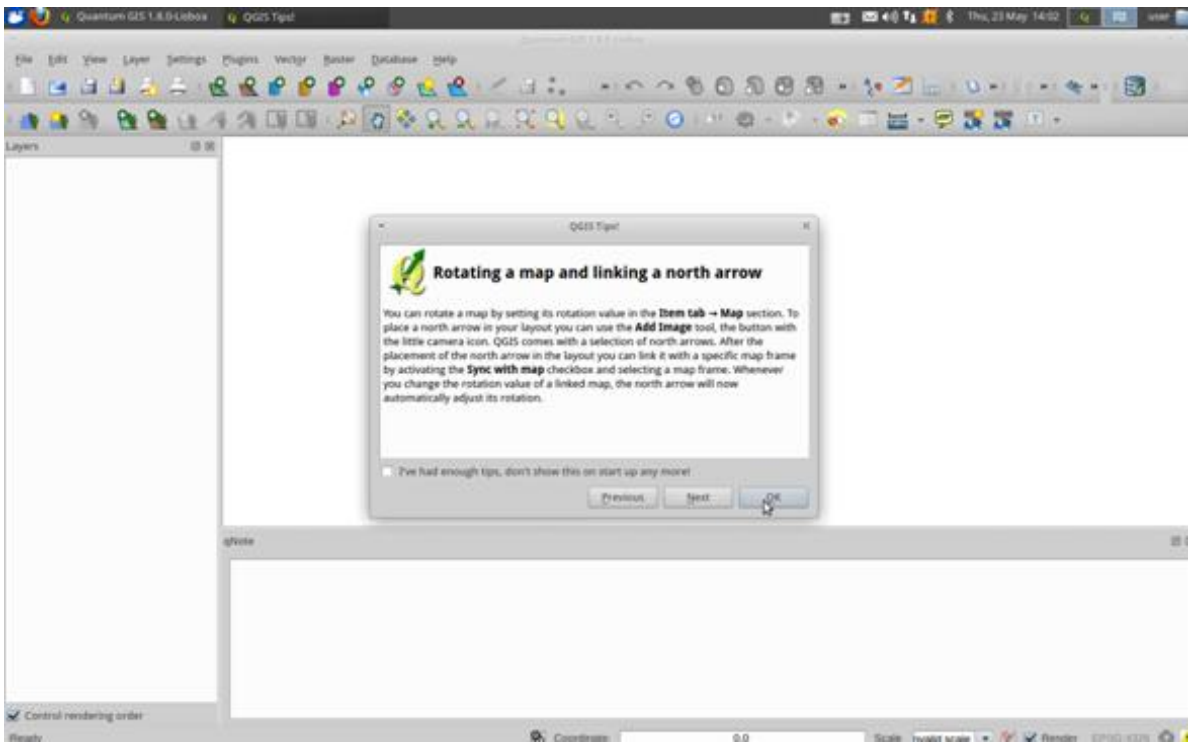
2.1 The first step is to select the layer that is being used to define the boundaries of the area of interest, in this case, it is the DRC.

### 2.1.1 Open QGIS Desktop

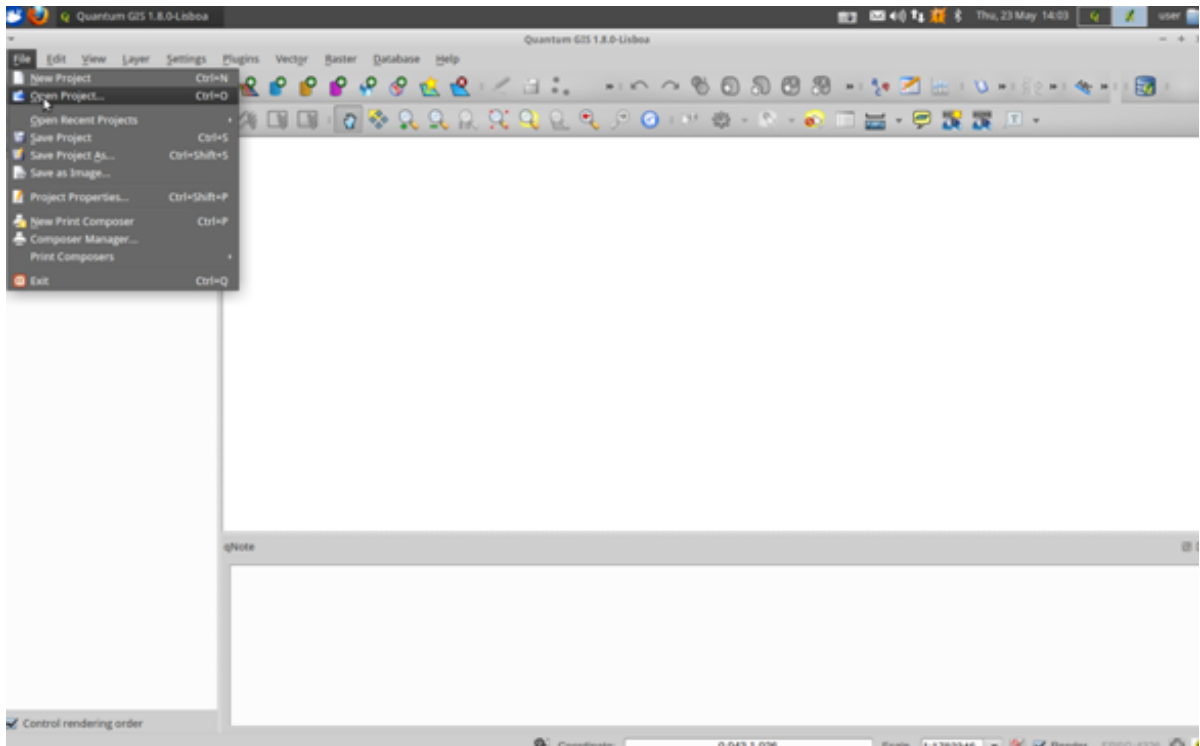




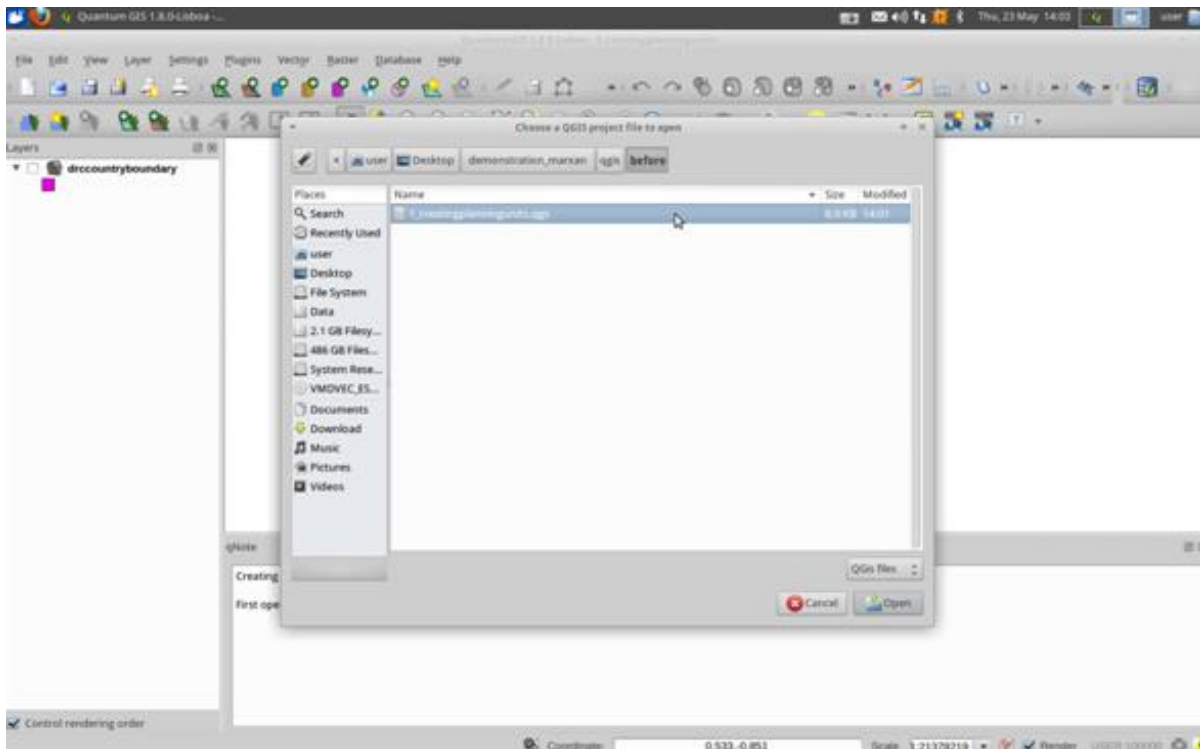
## 2.1.2



### 2.1.3

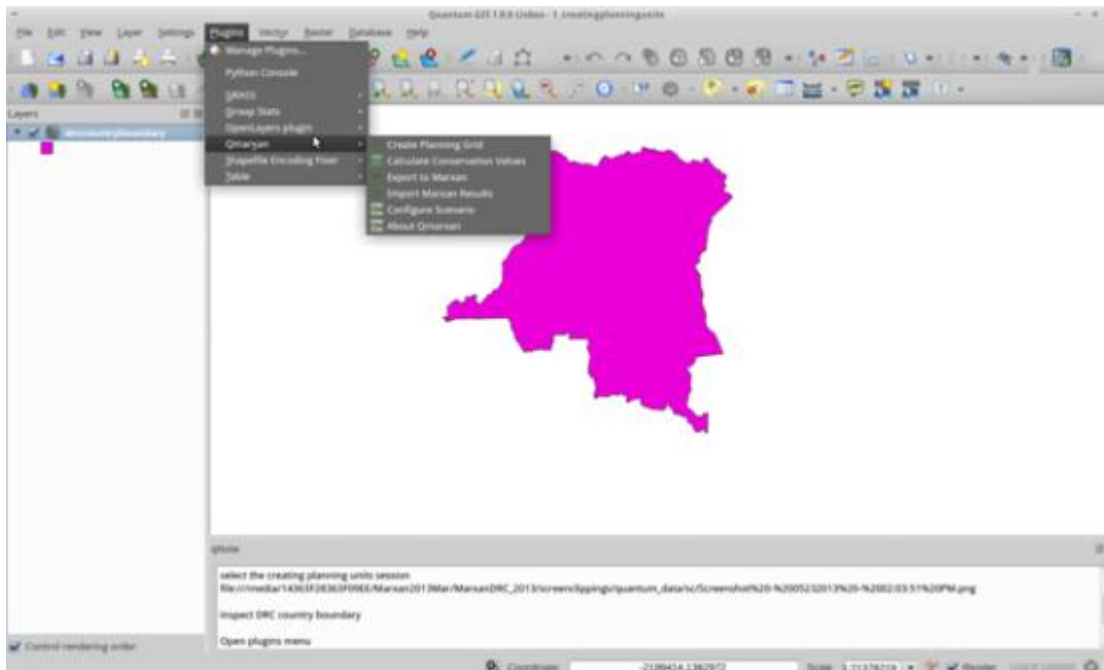


### 2.1.4



### 2.2 Next Open QMarxan

## 2.2.1



## 2.3 Then select "Create Planning Grid"

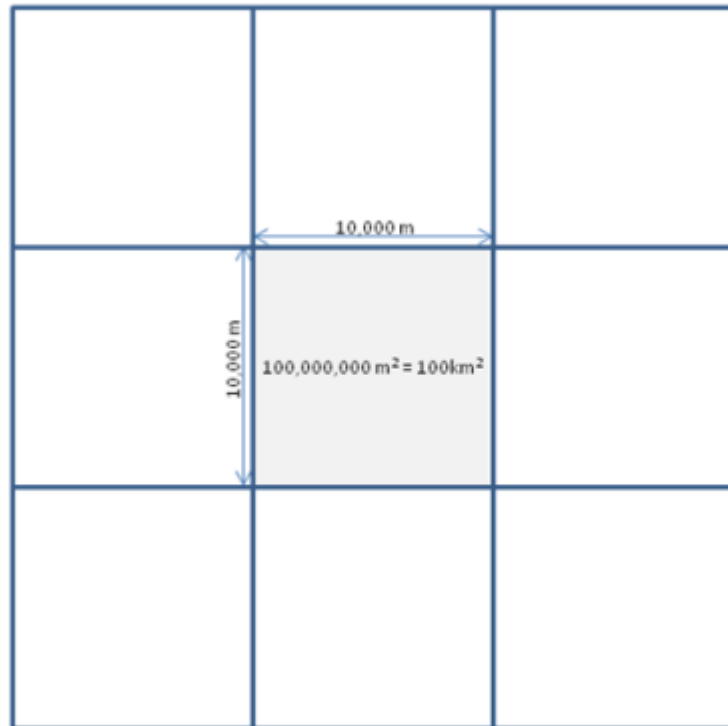
The pop up screen should already have drccountryboundary.shp in the planning grid extent, if not select it from the first drop down menu.

## 2.4 Next click the button "update extents from layer": Scupdateextents

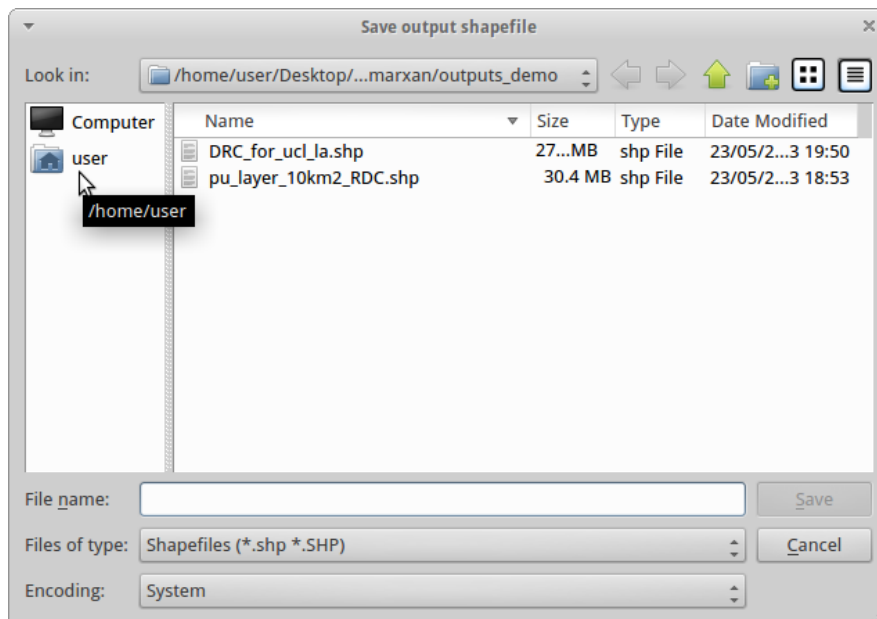


2.5 Ensure that "unit area" is selected under "calculate grid in projection units using" this will mean that the number you enter into "unit area" will represent the total area in metres squared (as the projection of the layer is in metres)

2.6 Type "100000000" in the unit area box, this will make the area of the planning units 100km<sup>2</sup> (see figure below). Ensure that you selected "squares" for the planning grid shape.



Check that the number of units has updated. Under “output shapefile”, click browse.



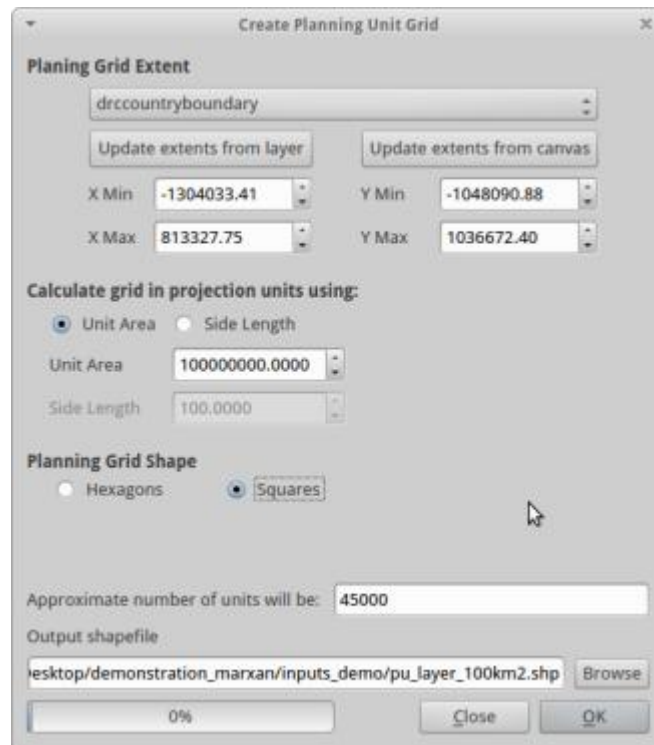
Navigate by double clicking on “computer” then “media” then “14363F283F09EE” then “demonstration\_marxan” then “inputs\_demo”

Under file name, save as pu\_layer\_100km2.shp

The entire filepath should now be:

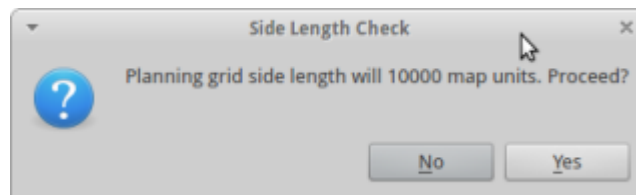
/media/14363F283F09EE/demonstration\_marxan/inputs\_demo/pu\_layer\_100km2.shp

Your window should now look like this:



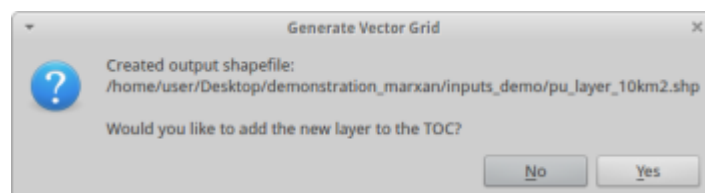
Click ok


You will then get a message asking you to check the side length:

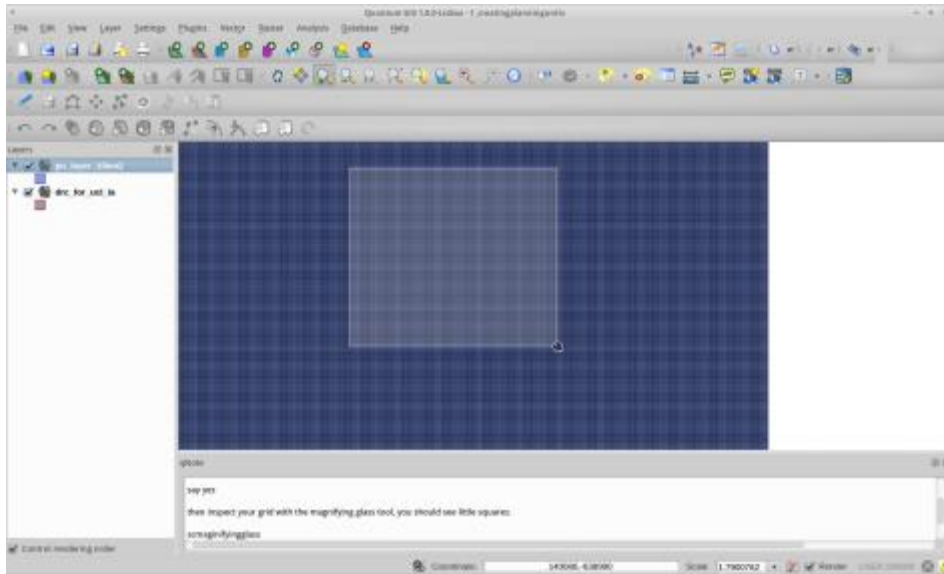


Click ok, but note down the number here \_\_\_\_\_. If you multiply the side length of the planning unit by the side length of the planning unit you will get 100,000,000 m<sup>2</sup>, the total area of the planning unit.

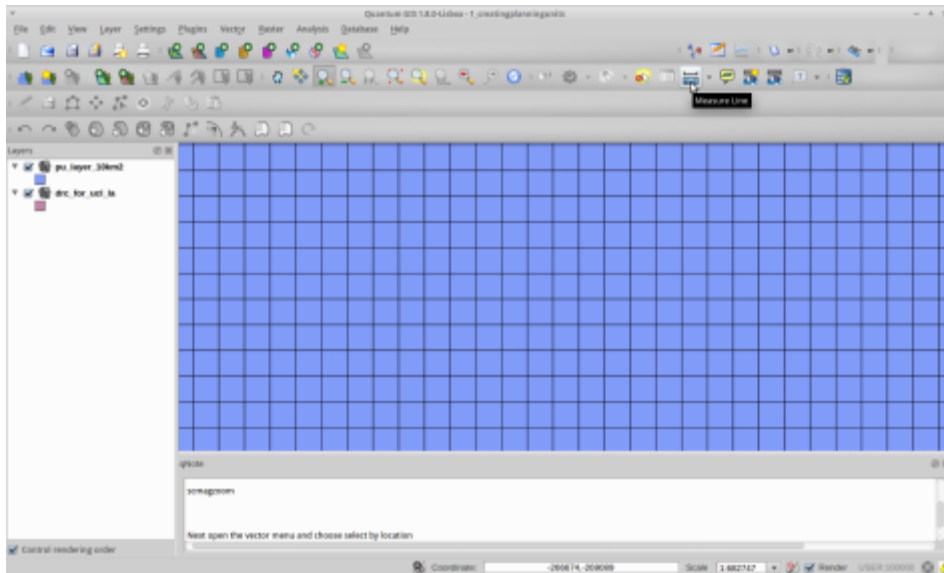
It will then ask you if you want to add this to your table of contents. Click yes.



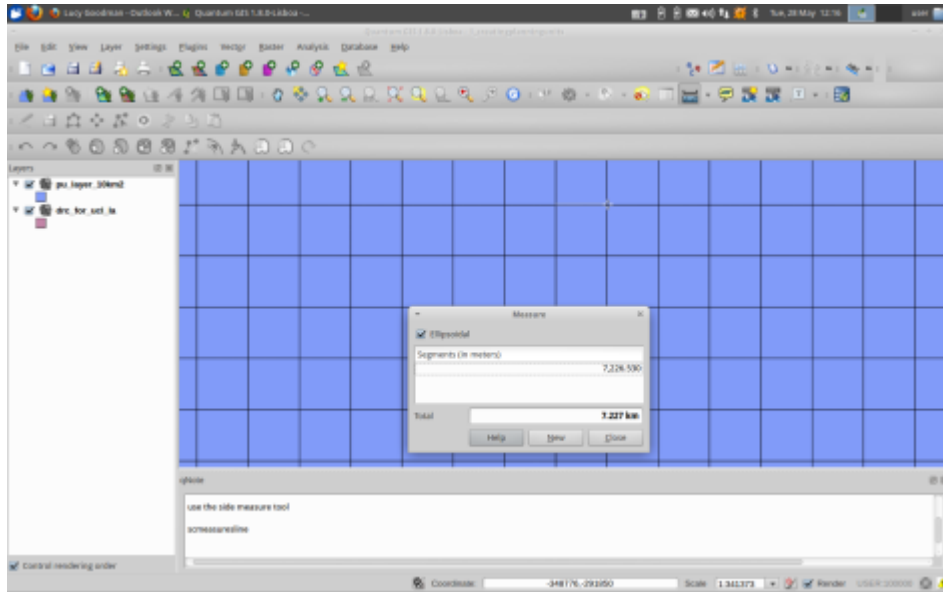
2.7 Then inspect your grid with the magnifying glass tool,  you should see little squares when you zoom in:



Select the side measure tool



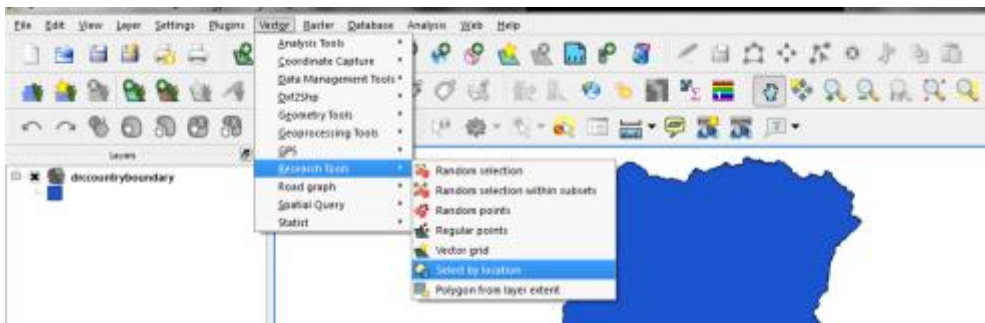
And click and drag to measure the edge of the squares:



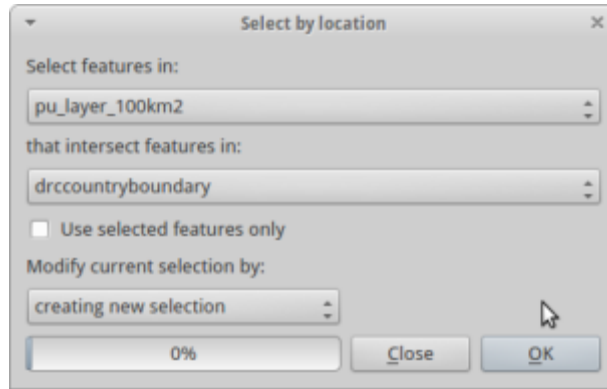
Do these squares have the same side length as recorded above? Write down here\_\_\_\_\_

You will notice that the side length on recorded by the measure tool, and the side length check message were the same.

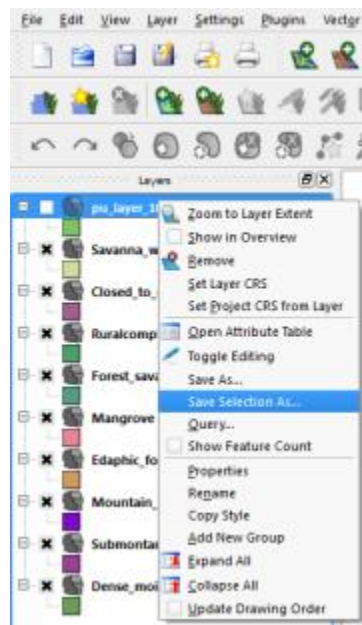
2.8 Next open the vector menu and choose select by location under the “research tools” subheading.



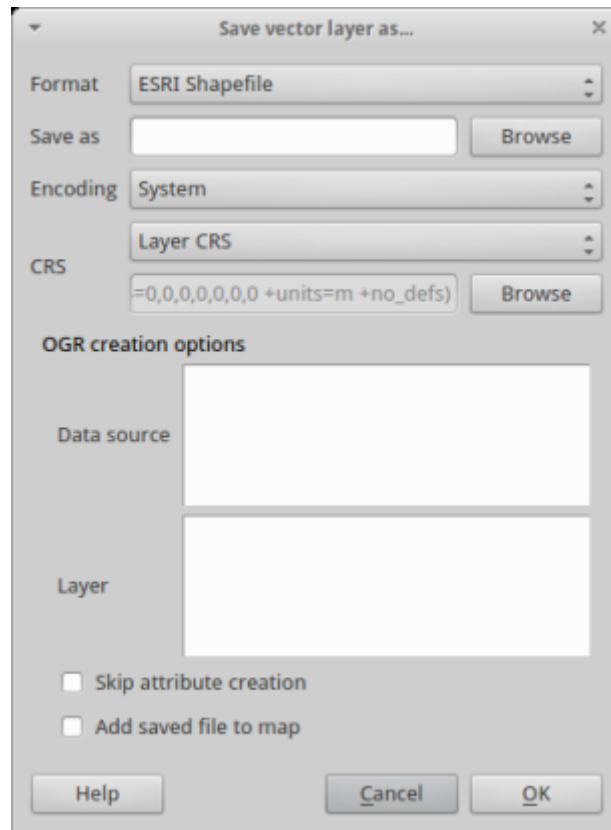
Use the dropdown menus to select the squares in the pu\_layer100km2 by the drccountryboundary



2.9 Next save the selection as a new layer by right hand clicking the pu\_layer\_100km2



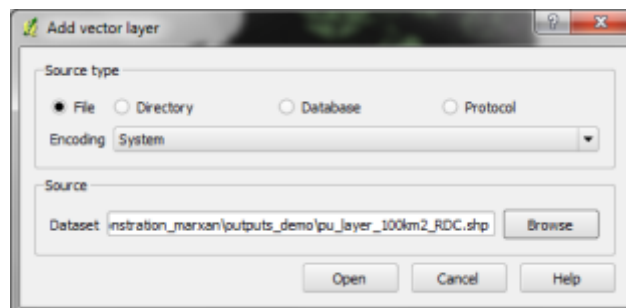




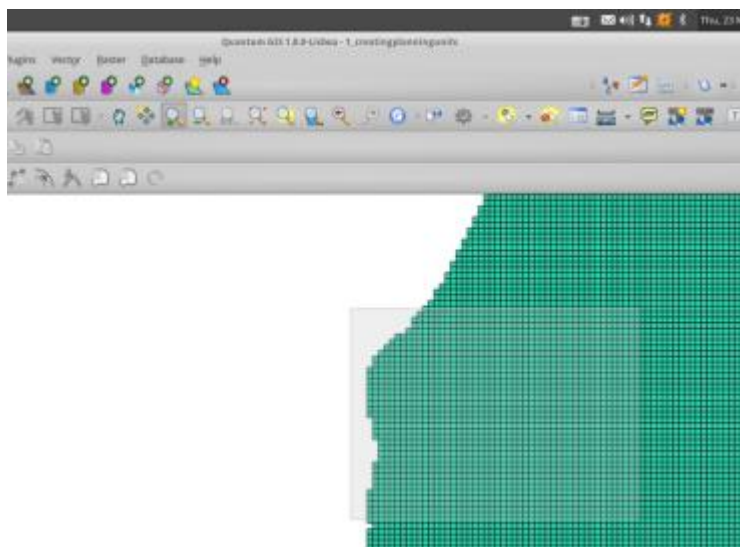
2.10 Click “browse” and change the output To pu\_layer\_100km2\_RDC in the outputs demo folder, the full filepath is:

/media/14363F28363F09EE/demonstration\_marxan/outputs\_demo/pu\_layer\_100km2\_RDC.shp

Next add the new created layer to the session.

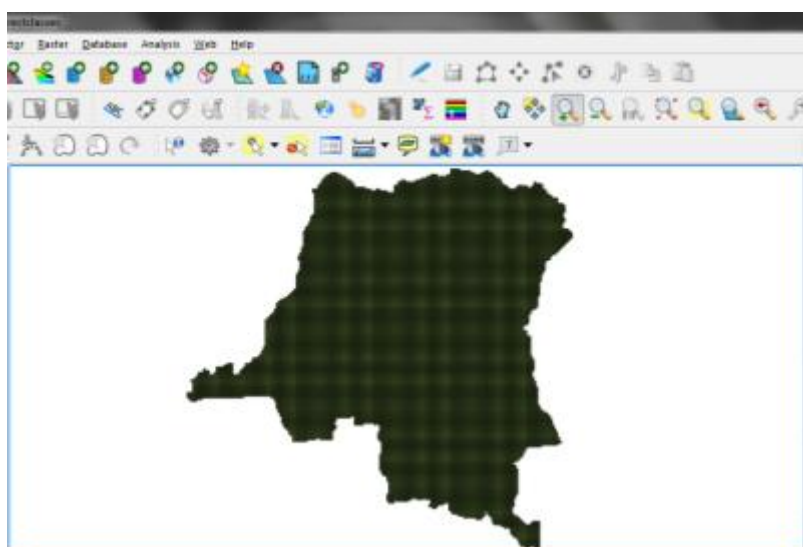


Inspect with the magnifying tool



Note that the squares have not been clipped and are still whole.

You have now finished creating your planning unit layer!



2.11 As a final step, open the attribute table of the layer by right hand clicking on the layer in the table of contents:



Attribute table - psu\_layer\_000km2\_RDC : 0 / 21825 features (1 selected)

	psu_id	psu_cost	psu_status	bed_cost	area	perimeter
0	343	1	0	1	10000000	40000
1	346	1	0	1	10000000	40000
2	347	1	0	1	10000000	40000
3	348	1	0	1	10000000	40000
4	349	1	0	1	10000000	40000
5	357	1	0	1	10000000	40000
6	358	1	0	1	10000000	40000
7	359	1	0	1	10000000	40000
8	360	1	0	1	10000000	40000
9	361	1	0	1	10000000	40000
10	362	1	0	1	10000000	40000
11	363	1	0	1	10000000	40000
12	364	1	0	1	10000000	40000
13	365	1	0	1	10000000	40000
14	366	1	0	1	10000000	40000
15	367	1	0	1	10000000	40000

Write down the 7 column headings below:

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_
7. \_\_\_\_\_

### Chapter 3. Entering cost layer and locking in/locking out

Marxan allows you to factor in the decision process that there is a cost against any conservation action. It assumes that you want to meet your targets but also are constrained by some factor, be it the amount of area that you can conserve or the cost of implementation. In order to do this you need to assign some value to each square of the planning unit layer.



Here, we use the total area to demonstrate associated costs (the larger is the selected zone, the higher is the final cost). However, if a dataset was available, say for agricultural projects, we could create an “opportunity cost layer” of the classification of forests. As the classification of forest prevents from developing agricultural areas, it has an “opportunity cost”, the cost of losing the possibility to cultivate this area. This cost is even higher in an area where agricultural projects were already planned. Planning units covering this area will therefore have a higher relative cost.

1	1	1	1	1
1	1	1	1	1
1	1	1	1	1
1	1	1	1	1
1	1	1	1	1

*Example of a cost layer based on the area (area = cost), with similar-shaped units*

4	1	1	1
	1	1	1
1	1	2	1
1	1	1	1
1	1		3

*Example of a cost layer based on the area with heterogeneous units (e.g. administrative boundaries)*

1x1	1x1	1x1	1x1	1x1
1x1	1x1	1x2	1x2	1x2
1x1	1x1	1x2	1x2	1x2
1x1	1x1	1x2	2x2	
3x1		1x1	1x1	

*Example of a cost layer based on the area with a multiplication based on other spatial data (in yellow an agricultural projects, where opportunity costs are twice as high)*

When you created the planning unit layer in your last exercise you will note that there is a column header called pu\_cost. The default value is 1 and in this exercise you need to modify this to the area of the planning units.

Attribute table - pu_layer_100km2_RD							
	pu_id	pu_cost	pu_status	bnd_cost	area	perimeter	sidelength
0	145	1	0	1	100000000	40000	10000
1	146	1	0	1	100000000	40000	10000

The other thing that you will learn to do in this exercise is to “lock in” certain planning units into the solution. In this case we are working to understand what areas are priorities for « forêts classées », but we already know that forest inside of protected areas are included in forêts classées, so we want them to be included in the solution.

Attribute table - pu_layer_100km2_RD							
	pu_id	pu_cost	pu_status	bnd_cost	area	perimeter	sidelength
0	145	1	0	1	100000000	40000	10000
1	146	1	0	1	100000000	40000	10000
2	147	1	0	1	100000000	40000	10000

You can “lock in” some planning units into the solution by using the pu\_status column in your planning unit layer.

Attribute table - pu_layer_100km2_RD							
	pu_id	pu_cost	pu_status	bnd_cost	area	perimeter	sidelength
	145	1	0	1	100000000	40000	10000
	146	1	0	1	100000000	40000	10000
	147	1	0	1	100000000	40000	10000

The default value of 0 means that the planning unit may or may not be included in the solution. A value of 1 means that the planning unit may be included in the initial reserve but is not guaranteed to be part of the outcome. A value of 2 means the planning unit will definitely be part of the solution.

You can also lock out planning units identified so that they are never included in the areas selected by Marxan. In order to do this, give the planning unit a value of "3" under the pu\_status field.

If you were to take the status of the planning units above planning units 145 and 146 are free to be selected by Marxan. 147, 148, 149 and 357 must be included in the solution, and 358-363 will never be included.

	pu_id	pu_cost	pu_status	bnd_cost	area	perimeter	sidelength
0	145	1	0	1	100000000	40000	10000
1	146	1	0	1	100000000	40000	10000
2	147	1	2	1	100000000	40000	10000
3	148	1	2	1	100000000	40000	10000
4	149	1	2	1	100000000	40000	10000
5	357	1	2	1	100000000	40000	10000
6	358	1	3	1	100000000	40000	10000
7	359	1	3	1	100000000	40000	10000
8	360	1	3	1	100000000	40000	10000
9	361	1	3	1	100000000	40000	10000
10	362	1	3	1	100000000	40000	10000

A graphical representation of this is below:

145	146
147	148
149	357
358	359
360	361

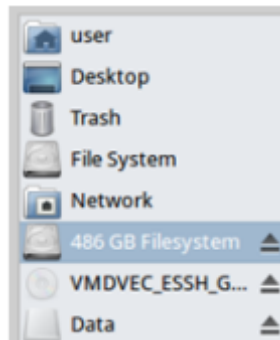
The highlighted numbers relate to the planning unit IDs under the column header pu\_id. The colouring represent whether they are open (no fill) locked in (red) or locked out (grey).

3.1 The first thing to do, is to modify the planning unit cost layer so that it matches the area column. Do this firstly by opening your QGIS

3.1.1 Next add the planning unit layer that you just created from your outputs folder:



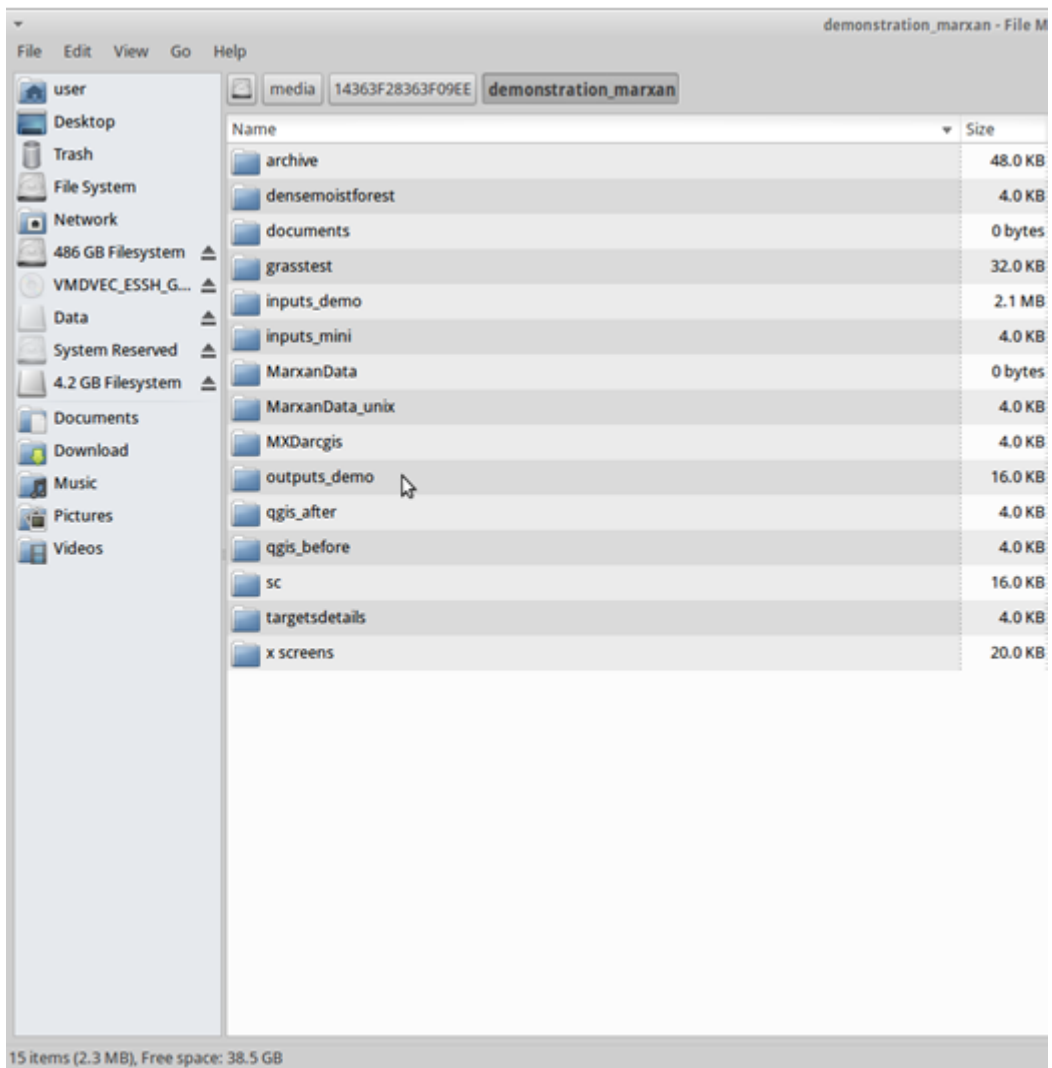
3.1.2 Navigate to the larger disk:



3.1.3 Double click on “demonstration\_marxan”

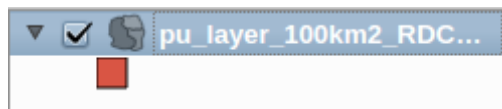


3.1.4 And open your “outputs\_demo” folder.

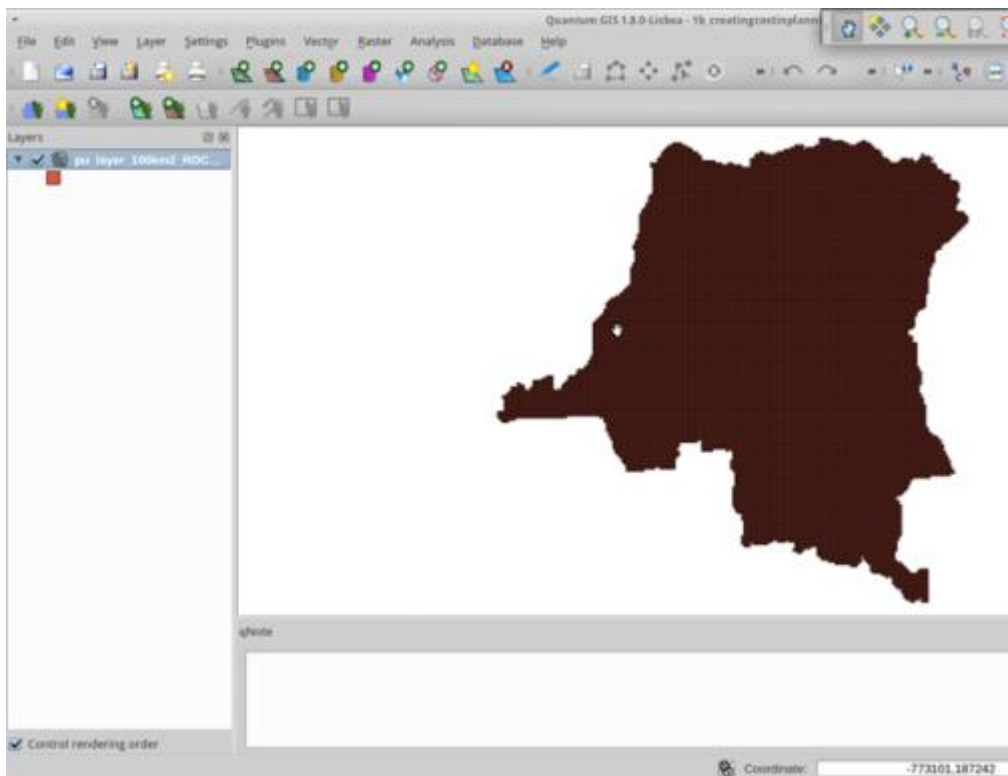


3.1.5 Finally double click on your planning unit layer created in the last session. Note it should have \_RDC as a suffix

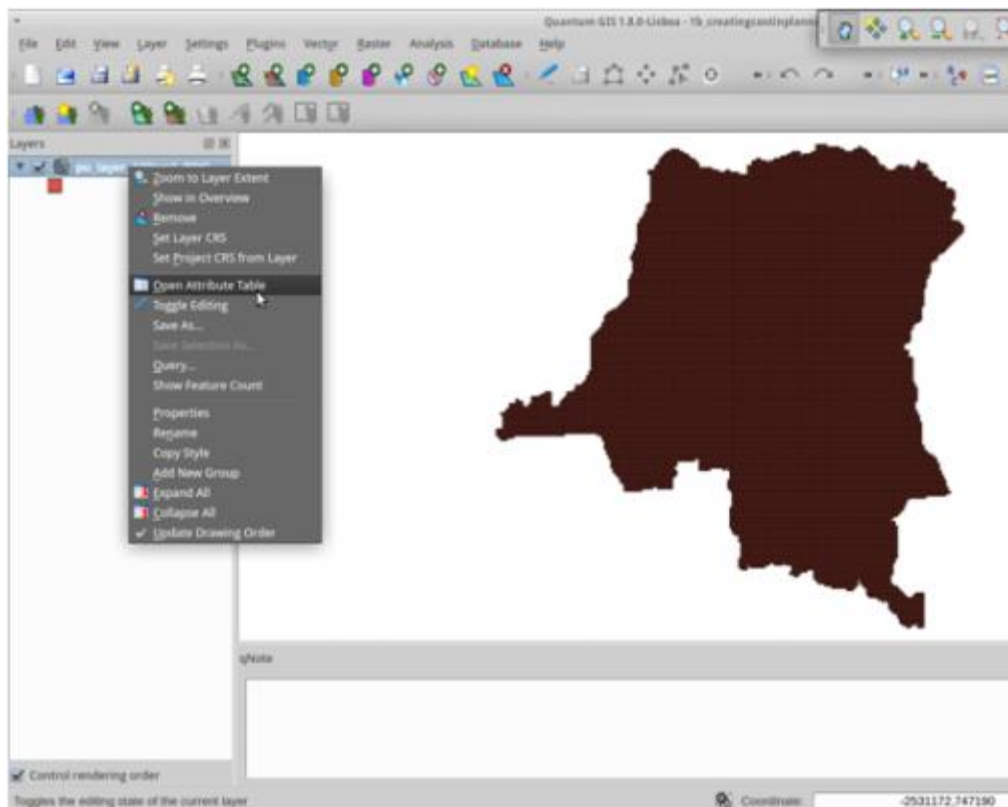
Click the layer on and off:



For the whole country it will look like this:



3.2 Now right hand click on the layer in the table of contents and open the attribute table:



You are going to update the planning unit cost column, pu\_cost, the second column along:



	pu_id	pu_cost	pu_status ▲	bnd_cost	area	perimeter	sidelength
0	145	1	0	1	100000000	40000	10000
1	146	1	0	1	100000000	40000	10000
2	147	1	0	1	100000000	40000	10000
3	148	1	0	1	100000000	40000	10000
4	149	1	0	1	100000000	40000	10000
5	357	1	0	1	100000000	40000	10000
6	358	1	0	1	100000000	40000	10000
7	359	1	0	1	100000000	40000	10000
8	360	1	0	1	100000000	40000	10000
9	361	1	0	1	100000000	40000	10000

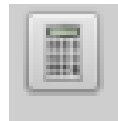
You want to make this column equal to the area column, already calculated by the Qmarxan plugin in the first step of creating the planning units.

3.3 First click within the attribute toolbar at the bottom of the table:



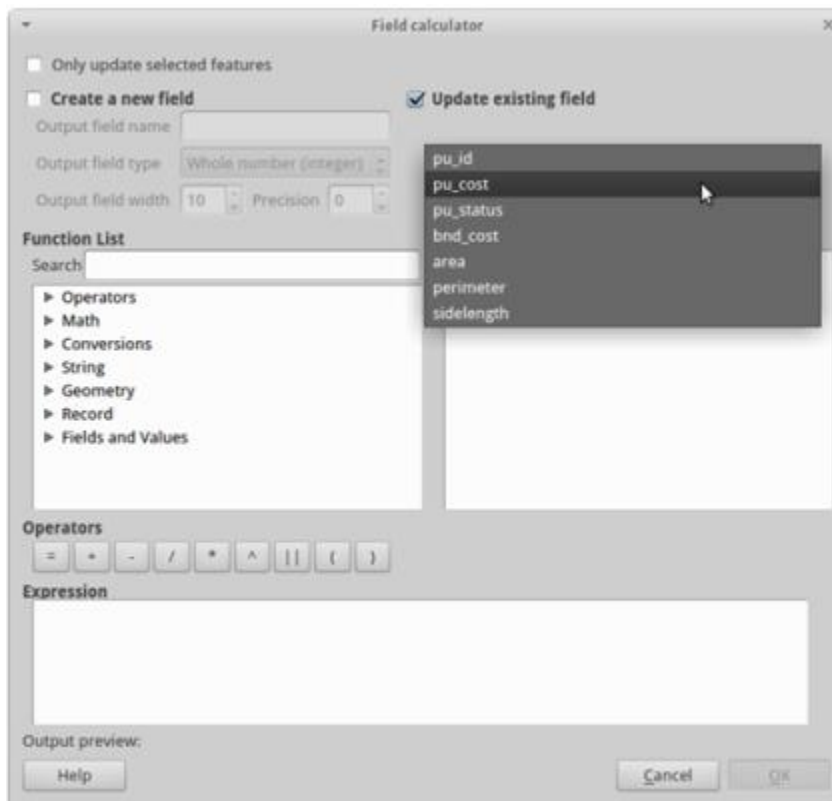
Select the “edit” tool:

Next click on “open field calculator”



Select “update existing field”

And then select pu\_cost from the list of fields to update in the dropdown menu:



3.4 Under the expression box write “area” and click ok. This will make the pu\_cost equal to the area field. Check this.

Attribute table - pu_layer_100km2_RDC_1								
	pu_id ▲	pu_cost	pu_status	bnd_cost	area	perimeter	sidelength	
0	145	100000000	0	1	100000000	40000	10000	
1	146	100000000	0	1	100000000	40000	10000	
2	147	100000000	0	1	100000000	40000	10000	
3	148	100000000	0	1	100000000	40000	10000	
4	149	100000000	0	1	100000000	40000	10000	
5	357	100000000	0	1	100000000	40000	10000	
6	358	100000000	0	1	100000000	40000	10000	
7	359	100000000	0	1	100000000	40000	10000	
8	360	100000000	0	1	100000000	40000	10000	

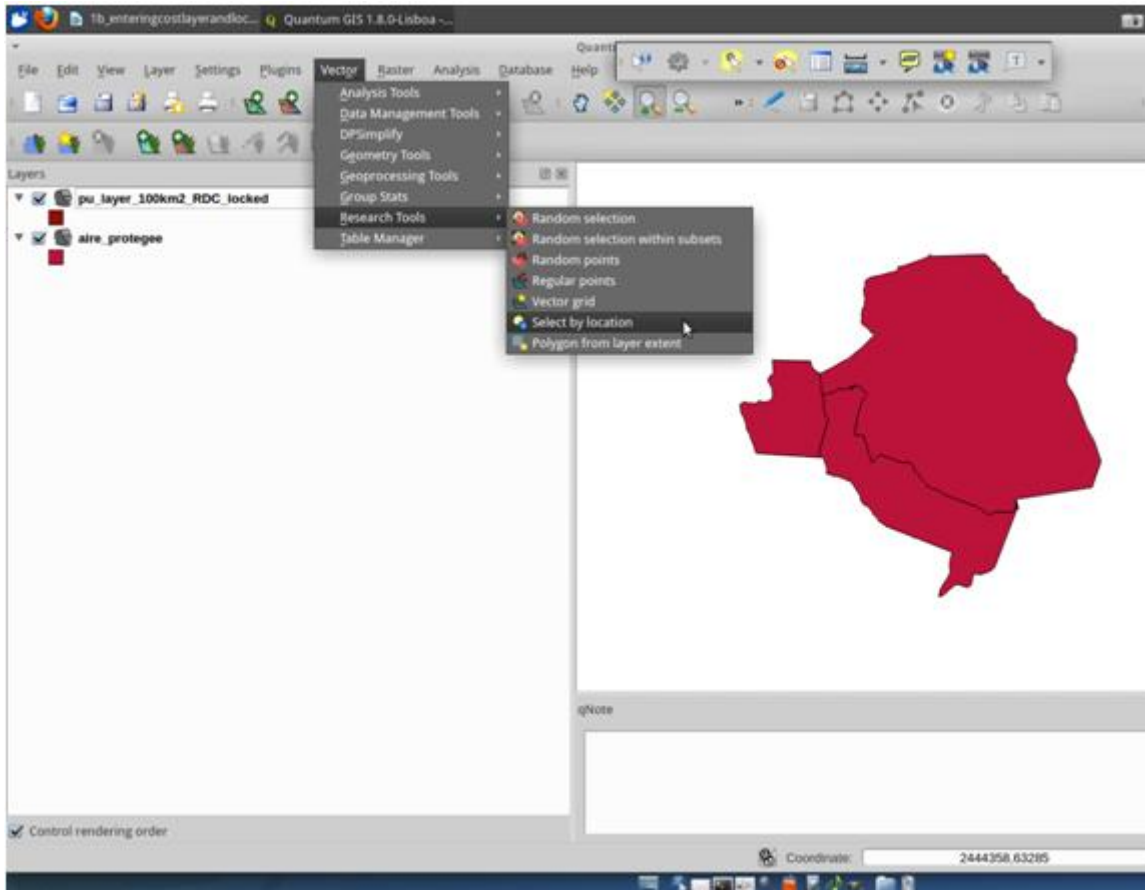
You have now successfully updated your planning unit layer to include a cost function.

Attribute table - pu_layer_100km2_RDC_1								
	pu_id ▲	pu_cost	pu_status	bnd_cost	area	perimeter	sidelength	
0	145	100000000	0	1	100000000	40000	10000	
1	146	100000000	0	1	100000000	40000	10000	
2	147	100000000	0	1	100000000	40000	10000	
3	148	100000000	0	1	100000000	40000	10000	
4	149	100000000	0	1	100000000	40000	10000	
5	357	100000000	0	1	100000000	40000	10000	
6	358	100000000	0	1	100000000	40000	10000	
7	359	100000000	0	1	100000000	40000	10000	
8	360	100000000	0	1	100000000	40000	10000	

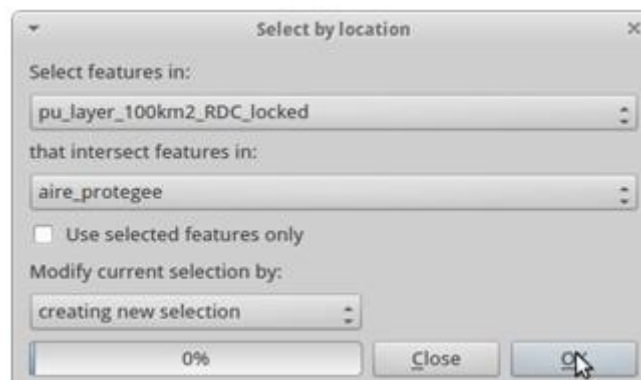
### 3.5 Next you need to create the correct locked in/locked out status.

3.5.1 First open another vector file, and then navigate to your media/demonstration\_marxan/inputs\_demo folder and add outputaire\_protegee.shp. This file comes from WRI

3.5.2 Next select by location:



3.5.3 And select the planning units by the aire\_protegeee. Press OK, then “close”.



3.6 Open the attribute table of the planning unit layer again:

You may need to turn editing on again using the pen symbol if the following options are greyed out.

Click on move selection to the top:



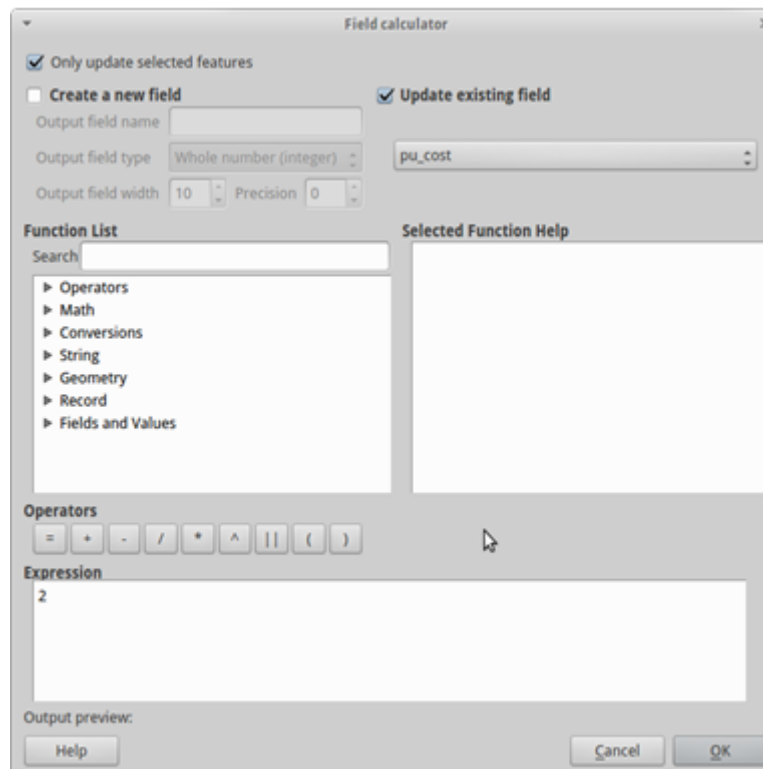
Next click on this button:



Make sure that “only update selected features” and “update existing field” are checked.

In the dropdown menu, select “pu\_status”.

In the expression box, type 2 and then press “OK”.

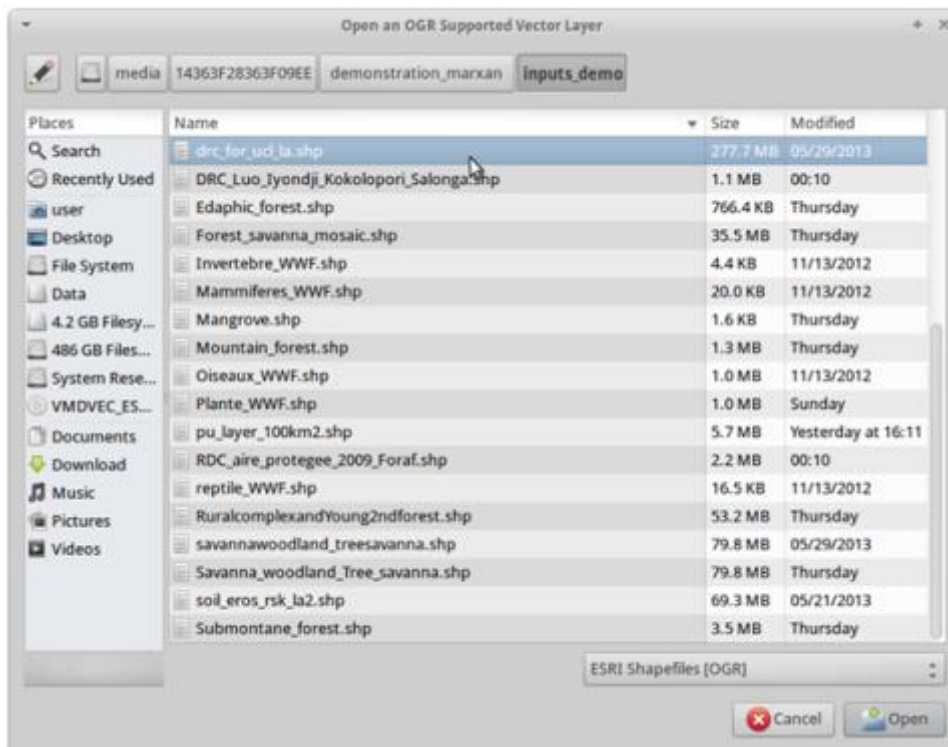


You will see that all the selected records have been updated from 0 to 2.

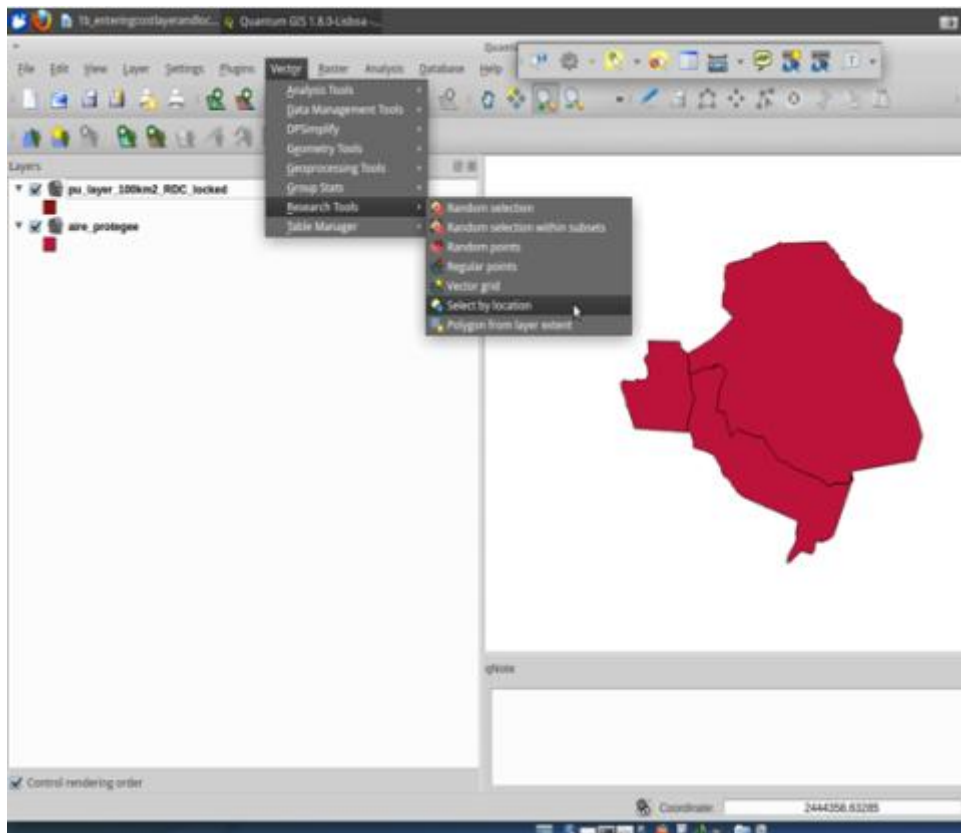
Before closing the attribute table, hold down the control key (ctrl) and press “u” to unselect all the rows. Then close the table using the close button.



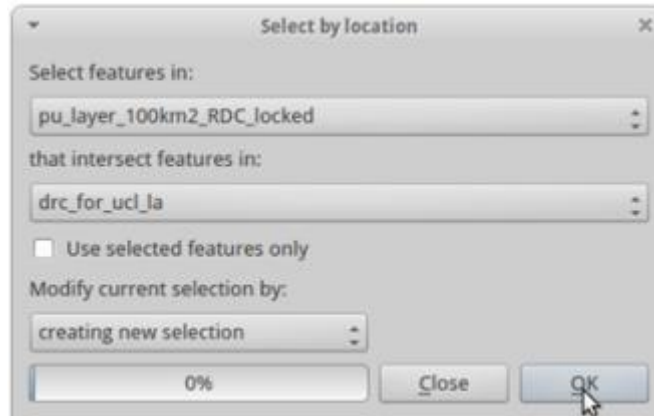
3.7 Next add the forests layer to your selection by clicking on the add vector layer button. this is called drc\_for\_ucl\_la.shp and you can find it in the media/demonstration\_marxan/inputs\_demo folder.



Open the "select by location" tool again:



This time, select your planning units layer by the forest layer “drc\_for\_ucl\_la”:



3.8 Open the attribute table of your planning unit layer by right clicking on the layer in the table of contents and clicking on attribute table.

3.9 Click on invert selection (**very important step!**) by clicking on the invert selection button on the bottom left of the attribute table.



Now all the planning units are selected that are outside of the forests. Because these are outside of areas eligible for forêts classées, we are going to lock them out in the next step.

3.10 Click on the field calculator button. Make sure that “only update selected features” and “update existing field” are checked. In the dropdown menu, select “pu\_status”. And this time in the expression box write “3” before pressing ok.

This will lock out all areas that are not forests.

NB : Marxan assumes that a unit is covered by forest as long as at least one pixel of the forest layer is included in it. So planning units which look at first sight free from forest might be locked in anyway because a very small portion of forest occurs in it (as you can observe with the magnifying tool).

Toggle editing off at the bottom of the attribute table and click on the save button (very important step).

You now only select planning unit layers eligible for forêts classées, and have told the software that forests inside of protected areas are already included in the output. Advanced users may wish to display the symbology of their planning unit layer, using the pu\_status field to do so.

The output will look like this:

Attribute table - pu_layer_100km2								
	pu_id	pu_cost	pu_status	bnd_cost	area	perimeter	sidelength	
0	27326	100000000	3	1	100000000	40000	10000	
1	22024	100000000	3	1	100000000	40000	10000	
2	27327	100000000	3	1	100000000	40000	10000	
3	31366	100000000	3	1	100000000	40000	10000	
4	31367	100000000	3	1	100000000	40000	10000	
5	22025	100000000	3	1	100000000	40000	10000	

## Chapter 4. Upload conservation values

4.1 Open QGIS and add the DRC boundaries layer (drccountryboundary) and the planning unit layer (pu\_layer\_100km2\_RDC) to the session.

Add bonobos range layer to the session (output4\_bonoboranges\_GAA), and then the one of deforestation with a 500m buffer (output2\_facetdef500mbuf).

4.2 Open the attribute table of bonobo range by right-clicking on the layer.

4.2.1 Write the name of a column which is common to all the rows here:

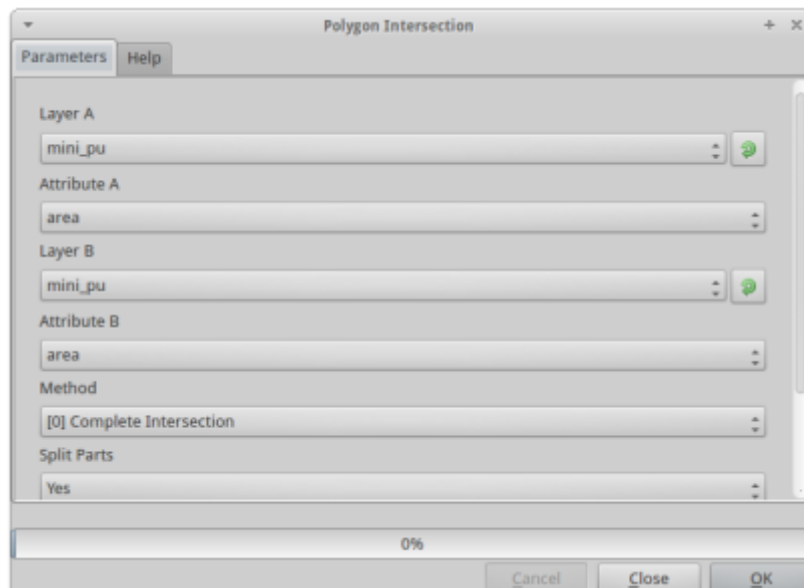
---

4.3 Open the attribute table of the deforestation with 500m buffer layer to the session.

Write down a column which is common to all the rows here:

---

4.4 Open the polygon intersect tool from the saga menu in the sextante tool box:



- Make the layer A the planning unit layer
- Make the attribute A the pu\_id
- Make the layer B the bonobo range
- Make the attribute B the column header you identified as having common rows
- Make the method [1] intersection, and split in parts is yes. It should cut the layer into squares corresponding to the planning units.
- Save the file in your outputs folder, call it int\_bonobos.shp

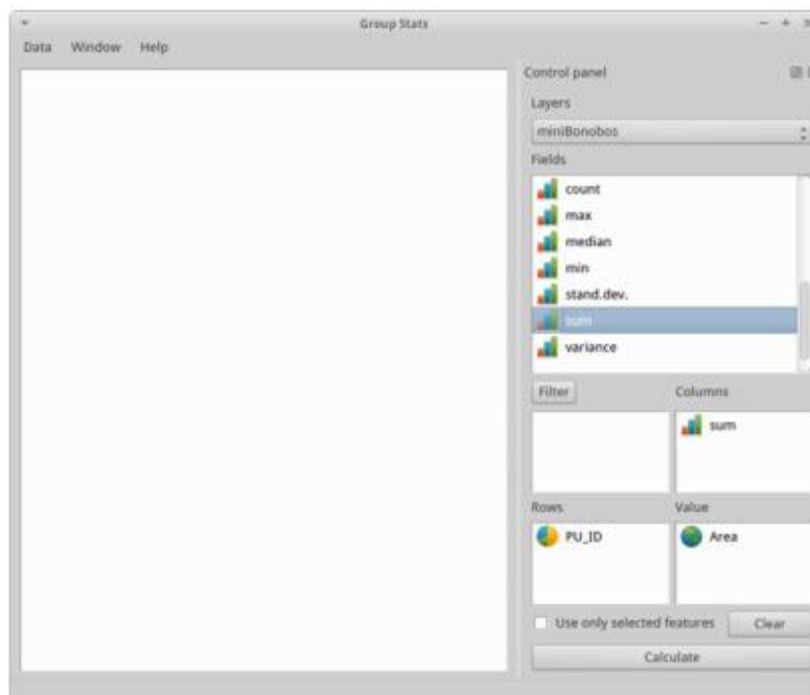


Repeat the steps above for the deforestation 500m buffer file, only save it as int\_def500m.shp

Add the output layers to the session.

#### 4.5 Open Group Stats from the vector menu.

Calculate the intersected area of the bonobo range in each planning unit. Select the following criteria by choosing the layer in the drop-down menu and by dragging the desired properties into the four boxes at the bottom of the window. In this example, you want to calculate the sum of the area of all pieces of the layer selected contained in a given planning unit. In order to get a table to display the result for every planning unit, you need to select "pu\_id" as rows and "area", as long as the function "sum" for columns.



##### 4.5.1 Click on "Calculate"

Write down the area of pu 16171 here: \_\_\_\_\_

Save the group stats by going to data and save it as a csv file in your outputs. Call the file "puvsbonobos".

##### 4.5.2 Do the same for the deforestation layer, this time write down the total area of deforestation 500m buffer in planning unit 14701: \_\_\_\_\_

Save the result in your outputs and call it "puvsdef".

#### 4.6 In file manager, navigate to your csv files in your outputs folder and open them with leafpad.

Change the column heading “sum” to be “bonobos” in the bonobos file and “def” in the deforestation file. Change the column heading “function” in both files to be pu\_id and Save your changes

4.7 Add the two csv files to the session using the add vector tool.

Join the tables to your planning unit layer by opening the properties of the planning unit layer and clicking on the join tab.

Press the green plus button to add the files one at a time. Select to make the target field and join field the pu\_id fields.

Click apply and OK.

4.8 Open the attribute table of the planning unit layer.

4.8.1 Write down the value of planning unit 16171 for bonobos and deforestation:

Deforestation : \_\_\_\_\_

Bonobos : \_\_\_\_\_

4.8.2 Write down the value of the planning unit 14701 for bonobos and deforestation:

Deforestation : \_\_\_\_\_

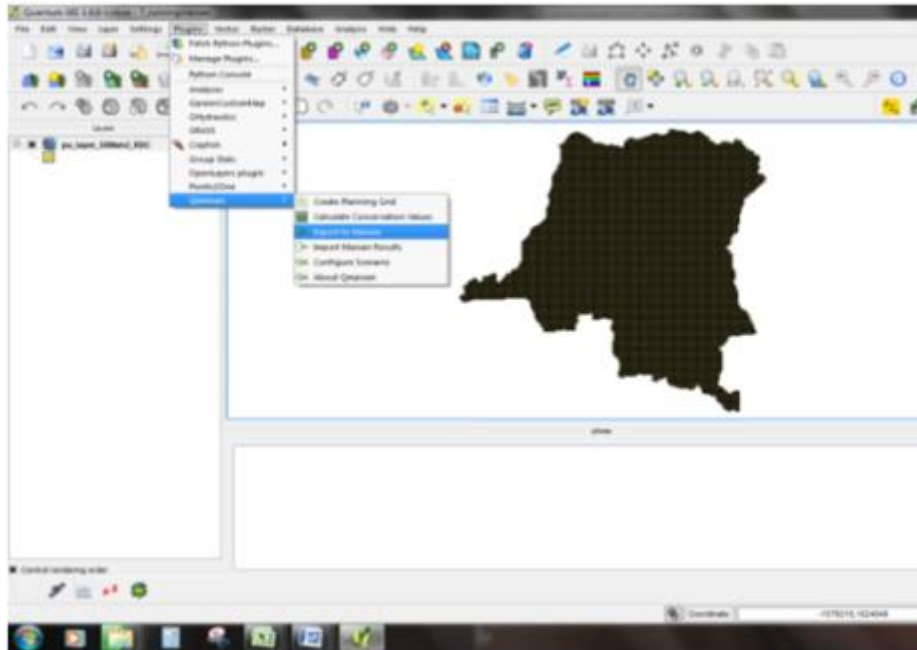
Bonobos : \_\_\_\_\_

4.9 Now save your planning unit layer by right hand clicking on it and going to “save as” put it in your outputs folder and call it pu\_layer\_targets. Open this layer and remove the old planning unit layer. Now select all null values in the bonobo column by putting “bonobos is null” in the search box. Click on “edit” and then on the field calculator.

With SELECTED FEATURES ONLY in the bonobo field make all values 0. Repeat this for the deforestation layer so that all 0's are removed from the target fields.

Your planning unit file pu\_layer\_target should be in the session. If not, add it.

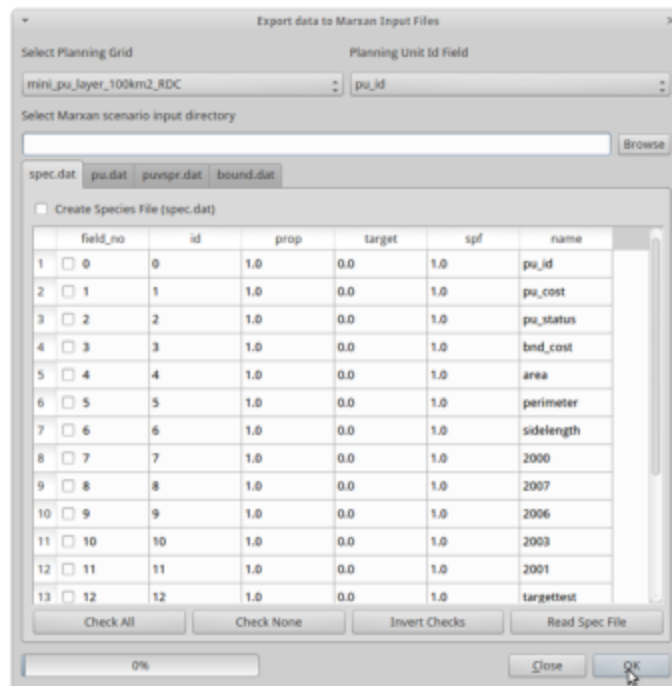
4.10 Now go to the QMarxan plugin and open the export to Marxan plugin.



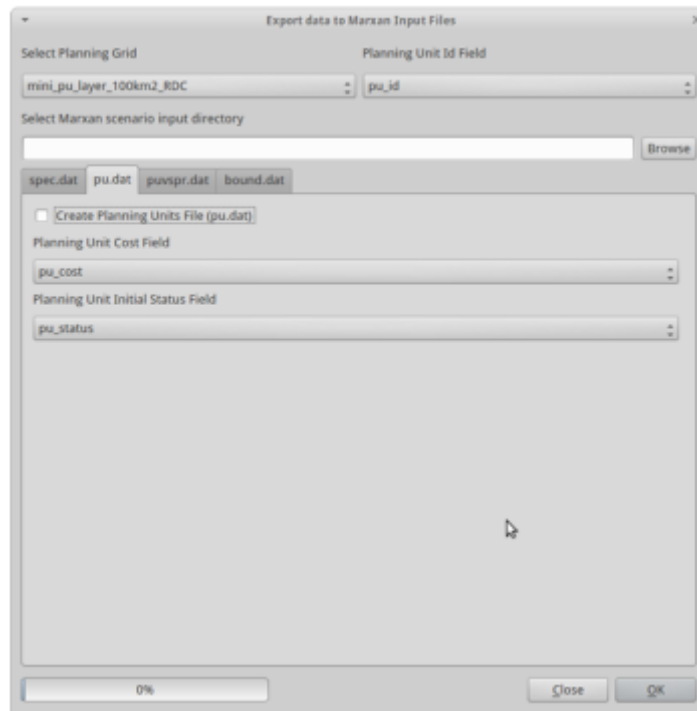
Have a look at each tab of the four tabs of the tool; each relates to one of the input files that Marxan needs.

The four input files are:

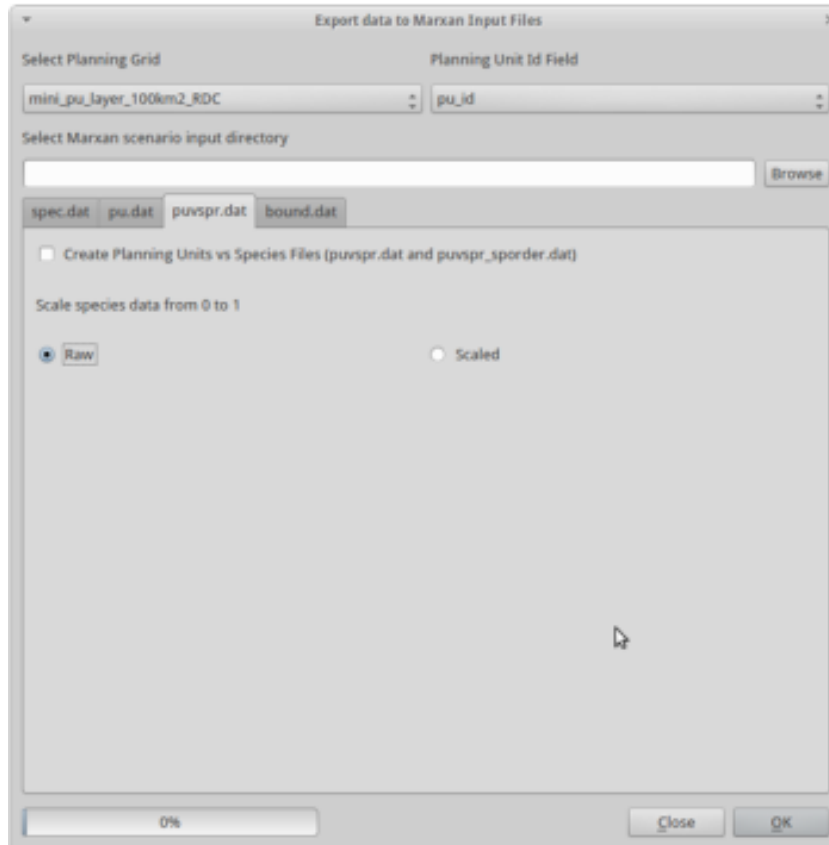
1. spec.dat - This file describes the "species" or conservation factors which you are trying to conserve. In our case, these are related to REDD+ actions and include forest cover types, biodiversity spatial indicators and other relevant layers.



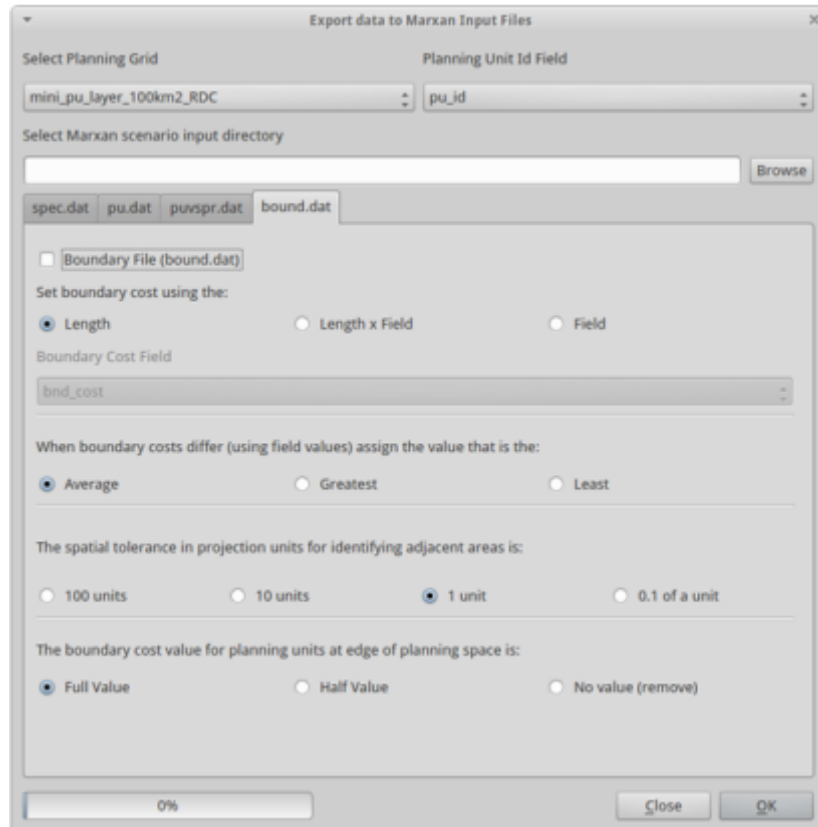
2. pu.dat – This file contains the location, cost, and initial status of planning units. The planning unit file that you have already created contains the correct values for each of these values, and now it needs to export these into a format that Marxan can absorb.



3. puvspr.dat – The species vs planning file contains the amount of each target layers in each planning unit. Zero value units are not included in this file. For example if you have 10000m2 of your edaphic forest in one planning unit, this file will contain the planning unit ID, the id of the target relating to edaphic forests and finally the value “10000”.



4. bound.dat – This file contains the adjacency and boundary cost for each unit. This value is used to control how clumped the output solution is. You do not need to modify this unless you have irregular planning units.



4.11 Next, you need to select your planning unit grid file in the top left of the tool. If you use a grid layer created by Qmarxan, it will attempt to match input fields based on expected names for these fields. On the spec.dat tab, the fields of the planning unit grid layer will be displayed.

At the bottom of the dialog, select the directory where you want to write the Marxan input files. In many Marxan projects this directory would be <marxan\_project\_name>/input, in this instance it is “\Desktop\demonstration\_marxan\MarxanData\_unix\input

It is really important that you open the correct input file!

4.12 Open the spec.dat tab of the tool and inspect the grid of the selected planning grid, there are six columns. The first column on the left is the field number, the next five are values exported to the spec.dat file. The id, prop, target, and spf values can be edited as suits your project. The id field identifies what the input layer is that is being acted on.

The ID numbers for the two target layers you have just produced are highlighted below:

Nom Anglais	Nom Français	Nombre d'entrées pour Marxan
Closed to open deciduous woodland	Bois à feuilles caduques, fermés ou ouverts	2000
Savanna Woodland / Tree savanna	Savanes arborées / bois	2001
Submontane forest	Forêt submontagnarde	2002
Rural complex and Young secondary forest	Complexe rural et jeune forêt secondaire	2003
Mountain forest	Forêt montagnarde	2004
Mangrove	Mangrove	2005
Forest savanna mosaic	Mosaïque forêt-savane	2006
Edaphic forest	Forêt édaphique	2007
Dense moist forest	Forêt dense humide	2008
Threatened forest		3000
Bonobos		4000
WWF birds		5000
WWF mammals		5001
WWF reptiles		5002
WWF plants		5003
WWF inverts		5004

These will become your IDs in the spec.dat file.

The next column is the “prop” field. In this field you are able to specify what proportion of the input layers, in this case the forest types, you want to include in the solution. The proportion we will use for all of these is 0.5. This will mean that Marxan will try and include 50% of bonobo range and 50% of threatened forest in the solution. If my input layer had 100 ha of Bonobo range, by putting in a prop value of 0.5 I'd be trying to get Marxan to find a solution that had 50ha of Bonobo range retained.

**The target field is an alternative to the prop field.** You should only change one or the other and not both. The target field allows you to specify how much of each input layer you want Marxan to try and retain in the solution, in the same units as the input layer itself. So if you inputs are in m2, then your target will also be in m2. So using the example above, if I wanted to protect 50ha of Bonobo range, and my input layer was in area m2, then I would enter a value of 500000 under the target layer. You should either define your target for each input in the target field or the prop field, you should not edit both.

To help with conversions, a correspondence table between m2 and ha and km2 is below:

m2	ha	km2
1	0.0001	0.000001
100	0.0100	0.0001
1,000	0.1000	0.0010
10,000	1	0
100,000	10	0
1,000,000	100	1
10,000,000	1,000	10
100,000,000,000	10,000,000	100,000

### Species Penalty factor

The spf field in the spec.dat file, is the species penalty factor.

This is factored into the “score” that Marxan uses when choosing between different planning units during the simulated annealing process. The score is made up of the following

Cost of the reserve system

+ Score =Boundary length of the reserve system

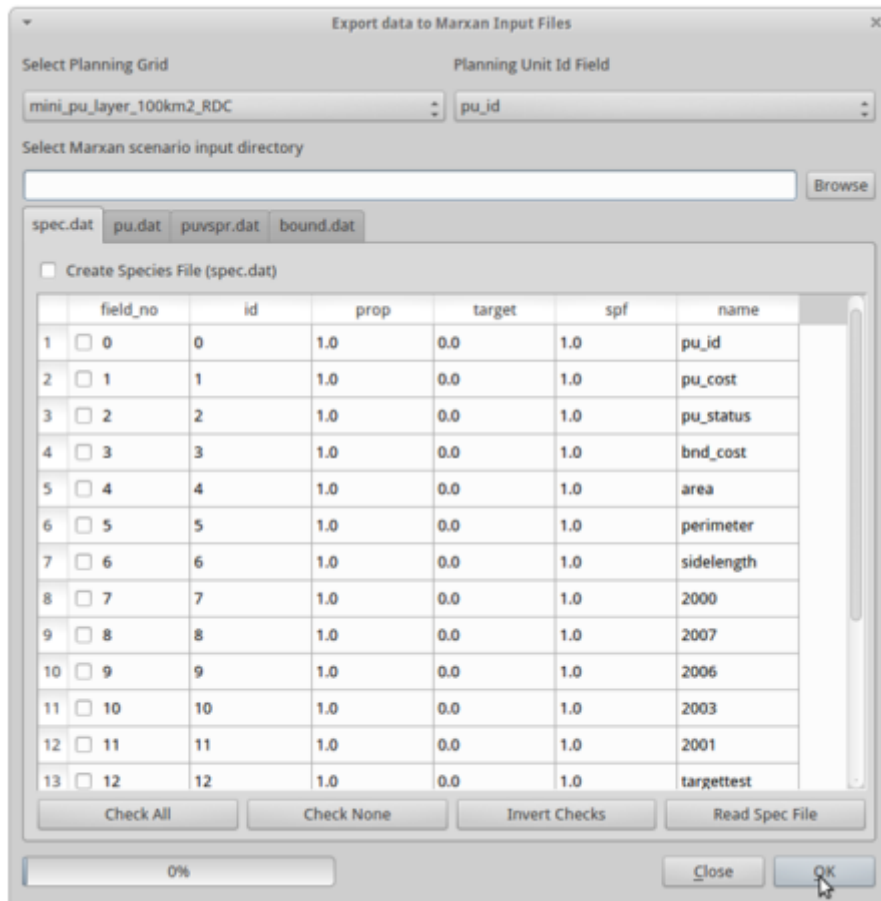
+ Penalty incurred for unmet targets (determined by the spf - species penalty factor)

For each alternative reserve system solution, Marxan calculates whether the target for each conservation feature ('species') is met or not. If a target is unmet, then a user-defined penalty cost - called the **Species Penalty Factor** or **SPF** - is applied. Making the SPF user-defined allows different weightings be given to different feature targets. For example, it may be more important to achieve targets for one forest type over another.

The same SPF can be applied to all input layers (in which case the SPF for feature A = SPF for feature B), or you can set them individually depending on the goals and objectives of your planning process. The higher the SPF, the higher the penalty to results when a conservation feature target is unmet.

The name field cannot be edited as it is used to match existing spec.dat files with the current planning grid. Do not manually alter the value of the spec.dat name field if you wish Qmarxan to read your input.

After selecting the process output (Marxan input) directory, if there is a pre-existing spec.dat file, you can scan and update the Qmarxan export dialog by clicking the "Read Spec File" button and select the "spec.dat" file. This process will scan the spec.dat file for matching field names and adjust their "checked", target, and spf values.



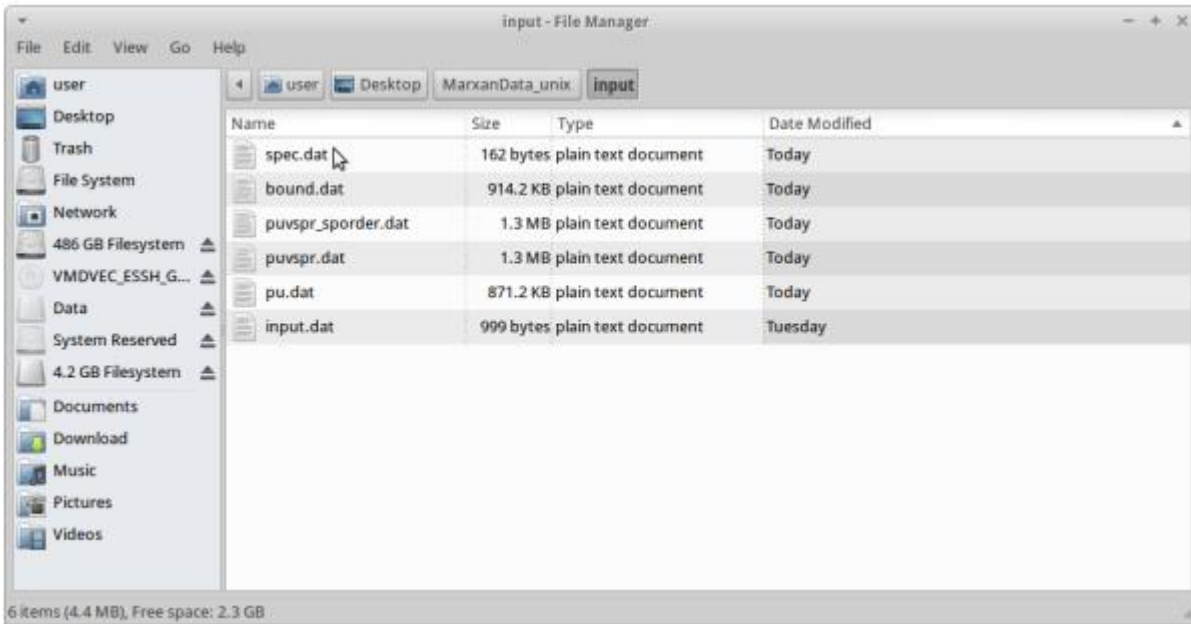
If a field is checked in the grid it will be exported as a "species" and the targets and species penalty factors (spf) associated with it will also be exported. To adjust the target and spf values for a particular field, double click in the grid on the target or spf value in question and edit it appropriately. You do not need to use this function and could edit this spec.dat file by hand, but this is error prone and thus not recommended.

The Species Target option must be checked to create or update a spec.dat file in the selected output to be exported. Check this and then click ok. You will get a message to say that the spec.dat file has been written.

4.13 Now navigate to where you Marxan files are and open the input folder to find the spec.dat file.

To do this Open the file manager from the blue button in the top left corner. Then open accessories and select "file manager".





4.13.1 Then navigate to the folder that contains Marxan. If you are working from a USB stick from UN-REDD, this will be on the Desktop within MarxanData\_unix. Open the input folder and list the names of the files that you find there:

---



---



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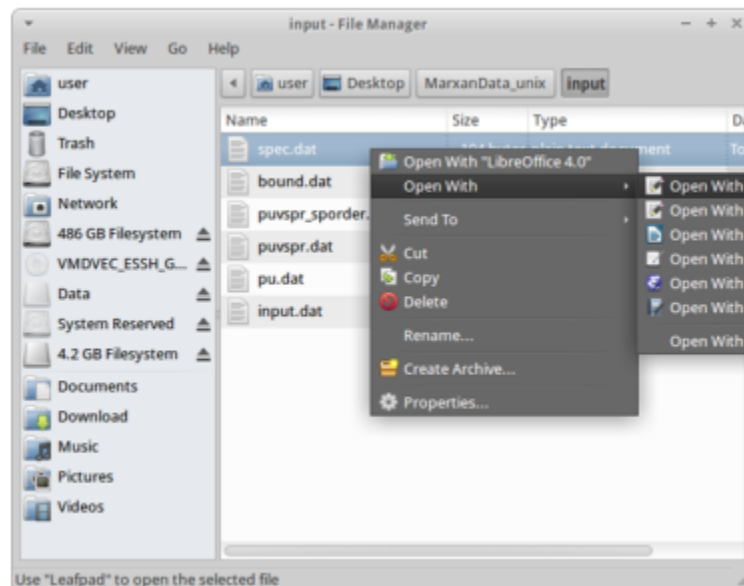


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4.14 Open the spec.dat file by right clicking and opening with leafpad



4.14.1 write down the names of the column headers that you find in this file, and note the first value in each row. **Be careful not to change anything in this file.**

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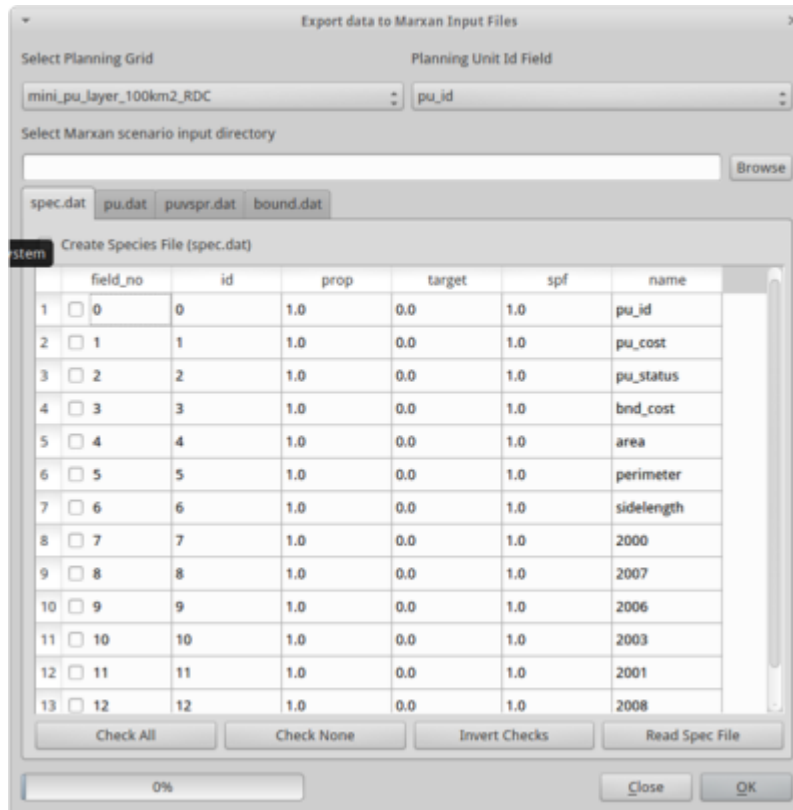


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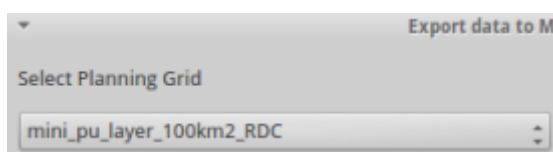


---

Now close spec.dat and look at the spec.dat tab.



Make sure that your planning unit layer is selected in the top of the spec.dat tab.



This should automatically populate the matrix below:

Export data to Marxan Input Files

Select Planning Grid: mini\_pu\_layer\_100km2\_RDC

Planning Unit Id Field: pu\_id

Select Marxan scenario input directory: [Browse]

spec.dat | pu.dat | puvspr.dat | bound.dat

Create Species File (spec.dat)

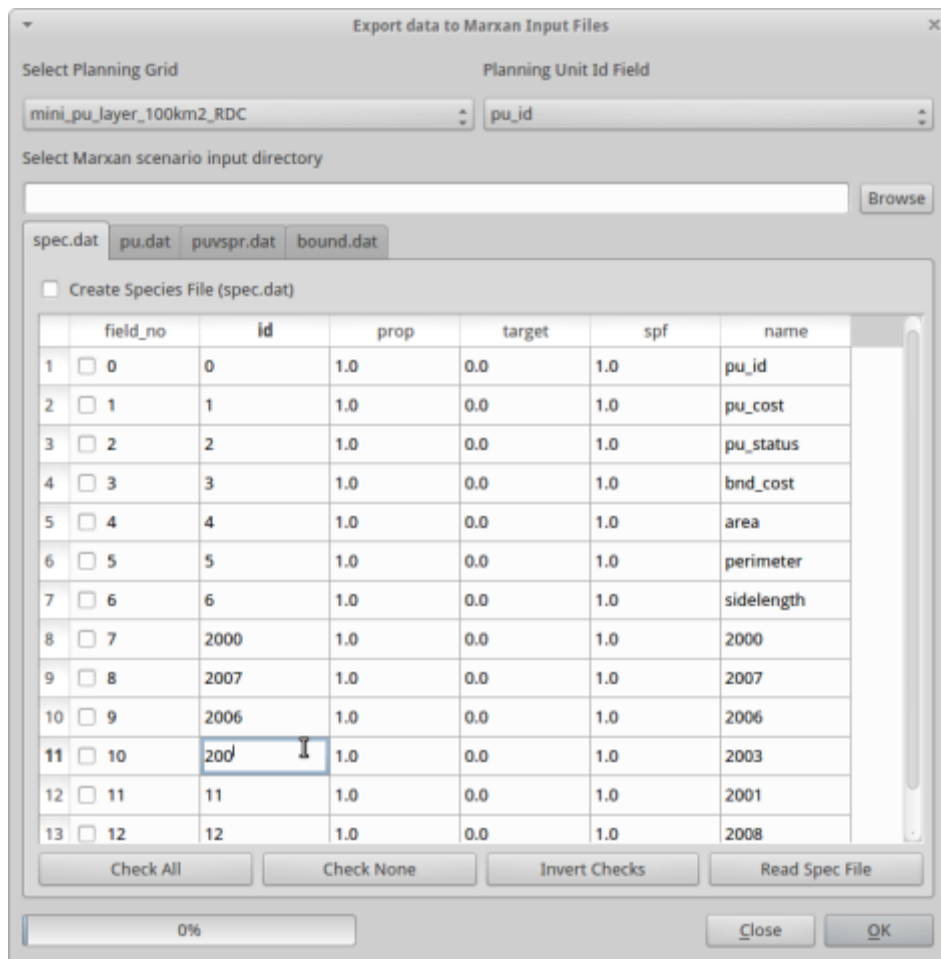
	field_no	id	prop	target	spf	name
1	<input type="checkbox"/> 0	0	1.0	0.0	1.0	pu_id
2	<input type="checkbox"/> 1	1	1.0	0.0	1.0	pu_cost
3	<input type="checkbox"/> 2	2	1.0	0.0	1.0	pu_status
4	<input type="checkbox"/> 3	3	1.0	0.0	1.0	bnd_cost
5	<input type="checkbox"/> 4	4	1.0	0.0	1.0	area
6	<input type="checkbox"/> 5	5	1.0	0.0	1.0	perimeter
7	<input type="checkbox"/> 6	6	1.0	0.0	1.0	sidelength
8	<input type="checkbox"/> 7	7	1.0	0.0	1.0	2000
9	<input type="checkbox"/> 8	8	1.0	0.0	1.0	2007
10	<input type="checkbox"/> 9	9	1.0	0.0	1.0	2006
11	<input type="checkbox"/> 10	10	1.0	0.0	1.0	2003
12	<input type="checkbox"/> 11	11	1.0	0.0	1.0	2001
13	<input type="checkbox"/> 12	12	1.0	0.0	1.0	2008

Check All | Check None | Invert Checks | Read Spec File

0% | Close | OK

4.15 You now need to edit the rows that relate to your input layers. Those rows which contain information about your input layers, will have “Bonobo” and “def” under the name column.

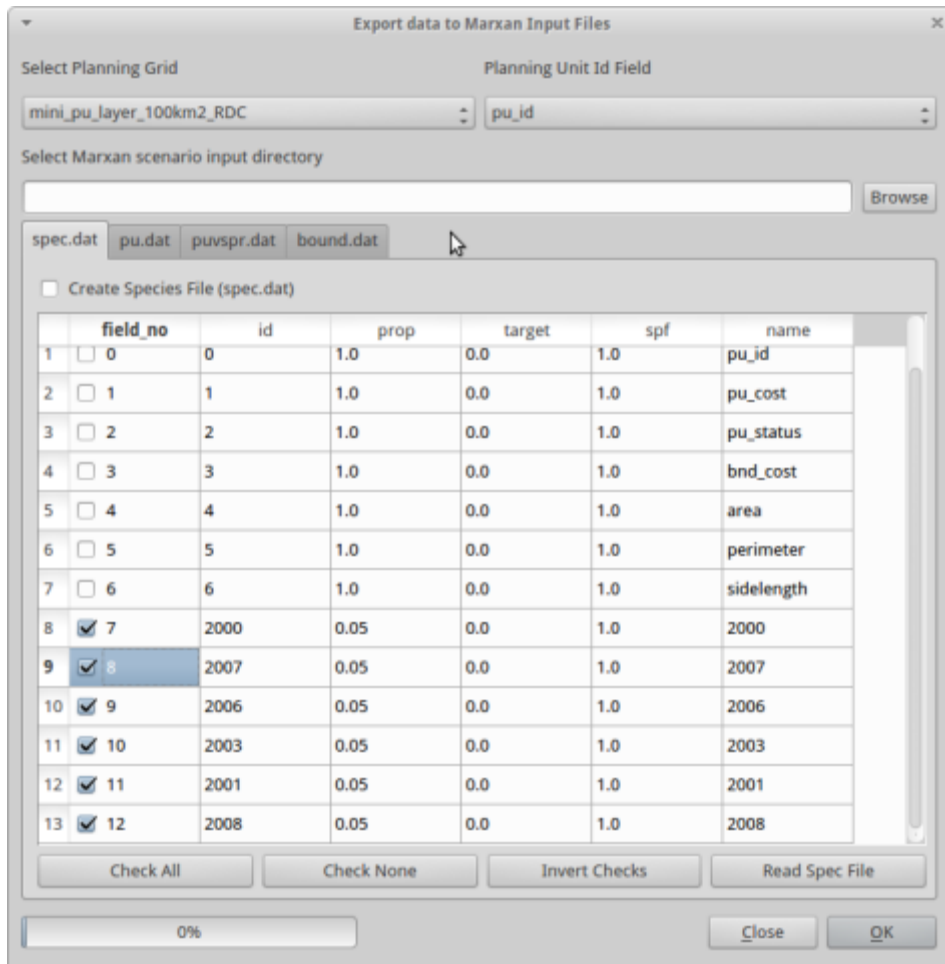
Change the id column to match the table above that contains the target ID numbers, 4000 for Bonobos and 3000 for def.



Now change the proportion column for each input layer to 0.5, change the target column for the Bonobo and Def rows to -1.

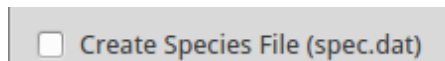
You have now changed the target for Bonobo range and threatened forest to 50%. The programme is now set up to try and select 50% of each Bonobo range and threatened forest.

Now check each of these input layer rows:



Only the checked rows will be outputted into the spec.dat file.

4.16 You are now ready to check the button “create species file”



and hit “OK” in the button right corner of the window. You will get a little message “export to Marxan complete”. Click ok.

4.17 Navigate again to your Marxan folder and open the spec.dat file in Leafpad by right clicking. Write down the column headers and first row of values. Make no changes to the file:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

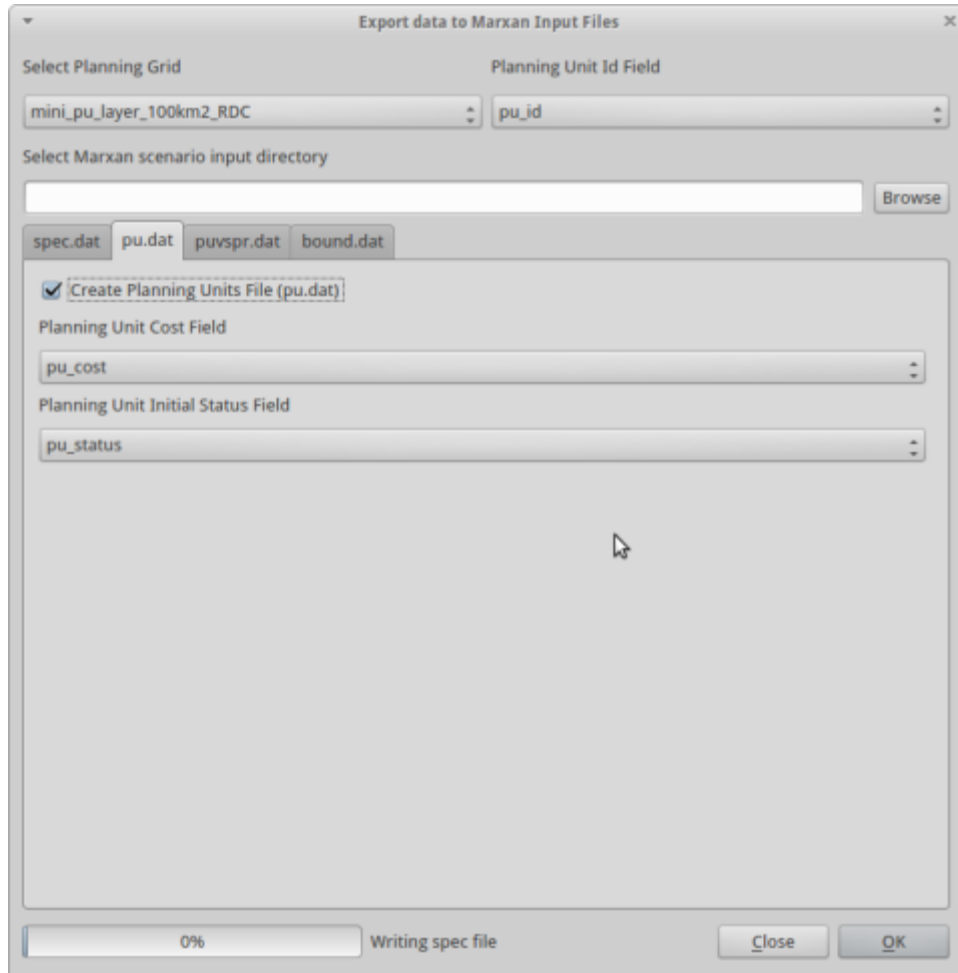
\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Note that using Qmarxan you have updated the spec.dat file.

4.18 Next go to the pu.dat tab in Qmarxan and export the pu.dat file by checking as below:



Click OK to export this file.

4.19 Now go to the puvsspr file check “raw” values. Check the export to puvsspr file and click ok.

As previously, navigate to the Marxan folder and open the puvsspr file in the input folder in Leafpad.

4.19.1 For species 4000 and 3000 write down the amount for the following pu numbers:

Write down the value of planning unit 16171:

Deforestation : \_\_\_\_\_

Bonobos : \_\_\_\_\_

4.19.2 Write down the value of the planning unit 14701:

Deforestation : \_\_\_\_\_

Bonobos : \_\_\_\_\_

This should be equal to the area in m2 that intersects these planning units for these species.

4.20 Finally go to the boundary.dat file, accept the default settings, check the export button and click OK.

Now you need to write your input.dat file.

## Chapter 5. Configure scenario and run Marxan

To edit the file input.dat, go to QMarxan and click on “Configure scenario”.

The configuration of how a scenario is explored using Marxan is done using the input.dat file. There are many fields that can be used for this process and review of the Marxan user manual is required if you are not familiar with all the input configuration options.

Qmarxan presents these options in four panels:

1. **General** - General settings such as BLM and number of runs or times the scenario will be explored.
2. **Run and Annealing** - Configuration of the algorithms used by Marxan. You must read and understand the Marxan user manual before altering these settings
3. **Files and Costs** - Here the input files and directories are specified.
4. **Marxan Output** - Set what will be written to file during the Marxan execution and how it will be formatted and named.

Below the tabs is an edit box with browse button to select the scenario directory where input.dat either exists or needs to be created. Click on browse and select this directory. If input.dat exists in this directory it will be read.

### 5.1 General

The fields you will most likely adjust on this tab are the BLM, MISSLEVEL and NUMREPS values. If you plan on altering the other values please check the Marxan user manual to understand the implication of changing these settings. The General tab is shown below.



## 5.2 Run and Annealing

The Run and Annealing is shown below.

Configure Scenario (input.dat)

Select scenario directory (where input.dat is or needs to be created)

/home/common/development/qmarxan/test/marxan

General **Run and Annealing** Files and Costs Marxan Output

NUMITNS: Number of simulated annealing iterations in each run  
1000000

NUMTEMP: Number of temperature decreases  
10000

RUNMODE: Run mode  
Annealing only

HEURTYPE: Heuristic type  
[Empty dropdown]

ITIMPTYPE: Iterative improvement type  
Normal

STARTTEMP: Starting temperature (-1 for adaptive annealing)  
-1

COOLFAC: Cooling factor for annealing  
1.00

VERBOSITY: Set output verbosity  
Intermediate

0%

## 5.3 Files and Costs

The input and output directories along with all the input files are specified here. The one file that is not included in the Marxan manual is MATRIXSPORDERNAME. This file is the puvspr.dat file sorted in species order. Inclusion of the MATRIXSPORDERNAME file will speed processing on large projects. Qmarxan automatically creates this file when you export the puvspr\_sporder.dat file.

The Files and Costs tab is shown below.

**Configure Scenario (Input.dat)**

Select scenario directory (where input.dat is or needs to be created)

/home/common/development/qmarxan/test/marxan

General Run and Annealing **Files and Costs** Marxan Output

Drop image files here to open them

input  BOUNDNAME: Boundary File (bound.dat) bound.dat

OUTPUTDIR: Output directory (output) output  PUVSPRNAME: Planning Units vs Species (puvspr.dat) puvspr.dat

SPECNAME: Species File (spec.dat) spec.dat  BLOCKDEFNAME: Block definition file (gspec.dat)

PUNAME: Planning Unit File (pu.dat) pu.dat

MATRIXSPORDERNAME: puvspr in species order (puvspr\_sporder.dat) puvspr\_sporder.dat

COSTTHRESH: Cost threshold 0.00000000 Penalty Factor =  $A * \exp(B) - A$

THRESHPEN1: Threshold Penalty A 0.14000000

THRESHPEN2: Threshold Penalty B 1.00000000

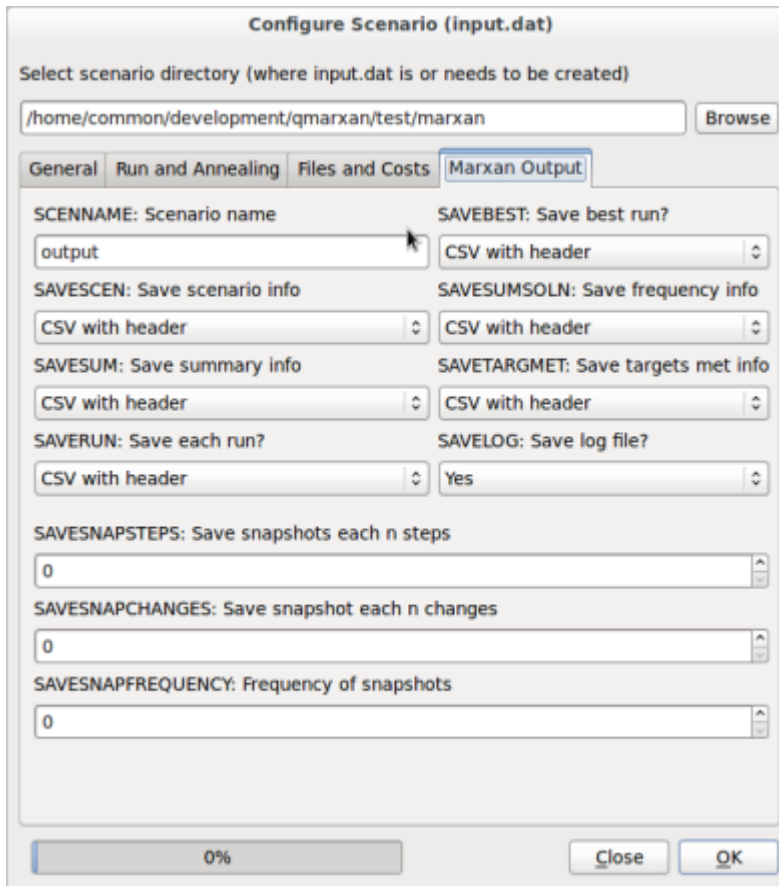
0%

#### 5.4 Marxan Output

The output files created during the Marxan run are edited on this tab. The SCENNAME field is the prefix for all output created by Marxan, so using a meaningful name instead of "output" is recommended to help you keep track of your data files. Please note that no spaces are permitted.

For Qmarxan or ArcGIS to import the results successfully you need to set the Marxan output format to "CSV with header".

The Marxan Output tab is shown below.



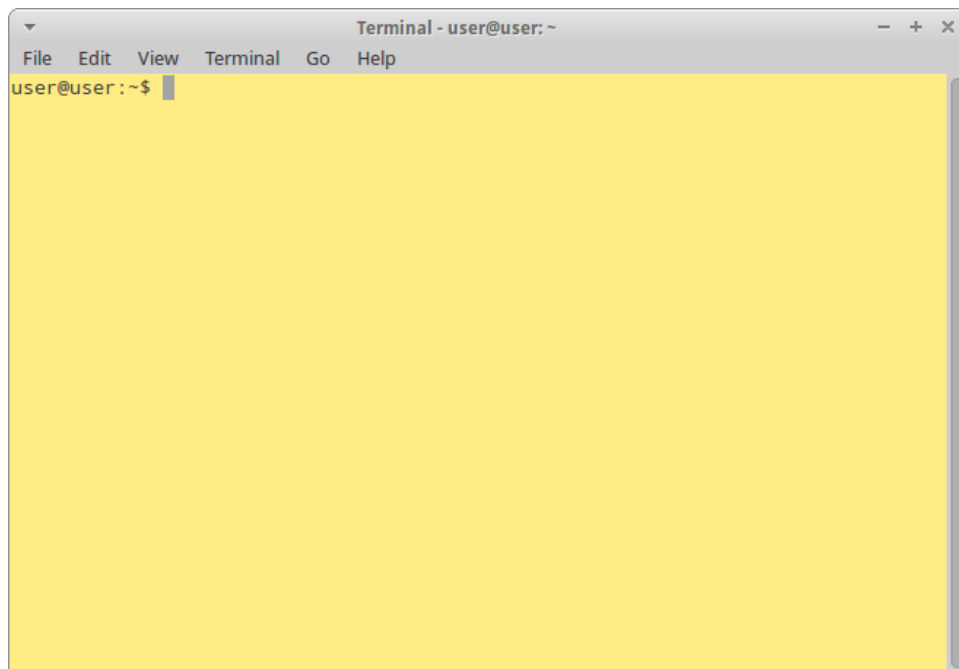
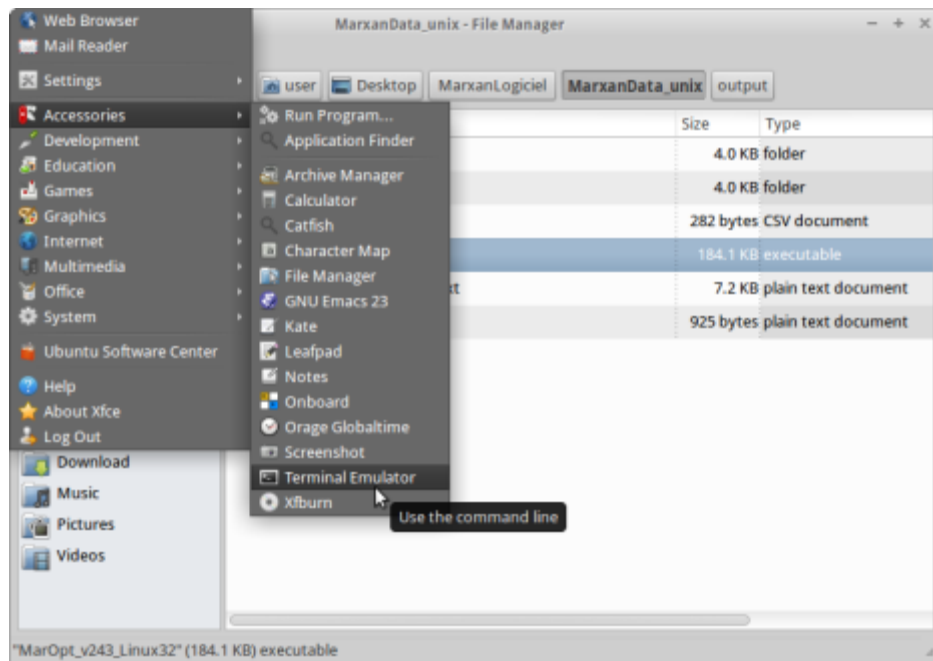
For now the only things that you will change are the input directory, the name of the run and whether the runs are being saved or not.

Click browse and navigate to where the Marxan programme is (Desktop/MarxanData\_unix Next go to the Marxan output tab, and under “save each run” select no. Replace “output” under SCENNAME on this tab with your surname.

Click OK, then on “Close” to close this dialog.

Now you are ready to run Marxan!!!

5.5 Open the terminal emulator from the accessories menu.

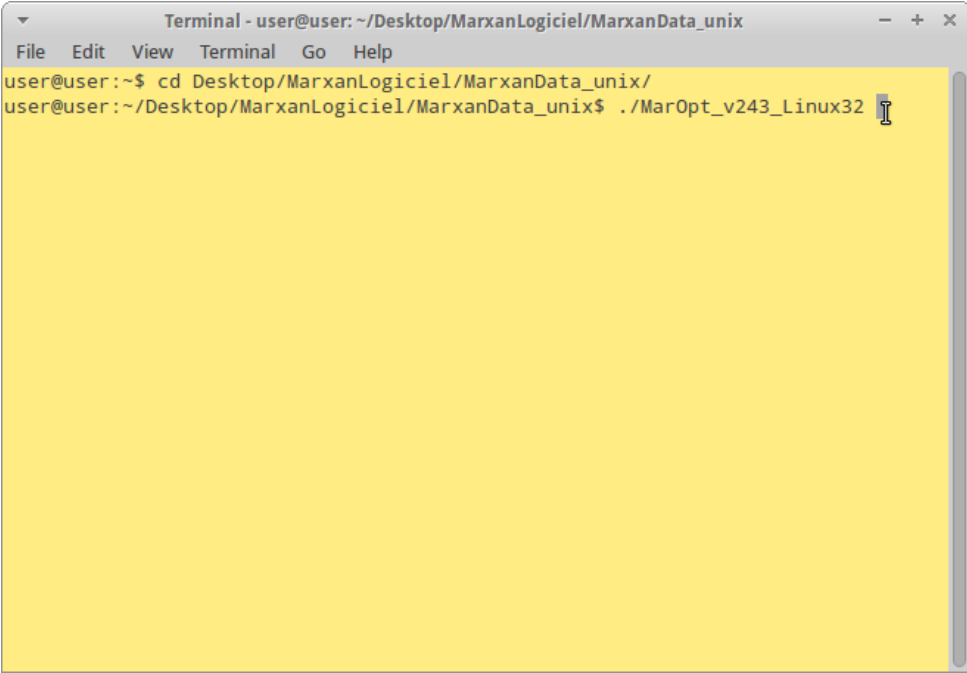


5.5.1 Type `cd Desktop/MarxanLogiciel/MarxData_unix` (note that it is case sensitive) and hit enter.



```
Terminal - user@user: ~  
File Edit View Terminal Go Help  
user@user:~$ cd Desktop/MarxanLogiciel/MarxanData_unix/
```

### 5.5.2 Type “./MarOpt\_v243\_Linux32”



```
Terminal - user@user: ~/Desktop/MarxanLogiciel/MarxanData_unix  
File Edit View Terminal Go Help  
user@user:~$ cd Desktop/MarxanLogiciel/MarxanData_unix/  
user@user:~/Desktop/MarxanLogiciel/MarxanData_unix$ ./MarOpt_v243_Linux32
```

You will subsequently get a stream of text run through the terminal, this is Marxan running, trying to find the best solution.

```

Terminal - user@user: ~/Desktop/MarxanLogiciel/MarxanData_unix
File Edit View Terminal Go Help

ThermalAnnealing:Value 17036486651.1 Cost 17000000000.0 PUs 170 Connection 226
0000.0 Missing 1 Shortfall 32213622.15 Penalty 34226651.1 MPM 1.0

Iterative Improvement:Value 16899724332.4 Cost 16800000000.0 PUs 168 Connectio
n 2240000.0 Missing 1 Shortfall 91750824.18 Penalty 97484332.4 MPM 1.0

Best:Value 16899724332.4 Cost 16800000000.0 PUs 168 Connection 2240000.0 Missi
ng 1 Shortfall 91750824.18 Penalty 97484332.4 MPM 1.0

Time passed so far is 1 secs

Run 10 Using Calculated Tinit = 100040000.0000 Tcool = 0.99976969
Creating the initial reserve

Init:Value 60110460000.0 Cost 60100000000.0 PUs 601 Connection 10460000.0 Miss
ing 0 Shortfall 0.00 Penalty 0.0 MPM 1.0

ThermalAnnealing:Value 17031786774.3 Cost 17000000000.0 PUs 170 Connection 244
0000.0 Missing 2 Shortfall 11194228.87 Penalty 29346774.3 MPM 1.0

Iterative Improvement:Value 17003952736.1 Cost 16900000000.0 PUs 169 Connectio
n 2420000.0 Missing 2 Shortfall 92966554.22 Penalty 101532736.1 MPM 1.0

```

It will run 10 times which was the default number in the input.dat file.

```

Terminal - user@user: ~/Desktop/MarxanLogiciel/MarxanData_unix
File Edit View Terminal Go Help

Time passed so far is 1 secs

Run 10 Using Calculated Tinit = 100040000.0000 Tcool = 0.99976969
Creating the initial reserve

Init:Value 60110460000.0 Cost 60100000000.0 PUs 601 Connection 10460000.0 Miss
ing 0 Shortfall 0.00 Penalty 0.0 MPM 1.0

ThermalAnnealing:Value 17031786774.3 Cost 17000000000.0 PUs 170 Connection 244
0000.0 Missing 2 Shortfall 11194228.87 Penalty 29346774.3 MPM 1.0

Iterative Improvement:Value 17003952736.1 Cost 16900000000.0 PUs 169 Connectio
n 2420000.0 Missing 2 Shortfall 92966554.22 Penalty 101532736.1 MPM 1.0

Time passed so far is 1 secs

Best solution is run 9

Time passed so far is 1 secs

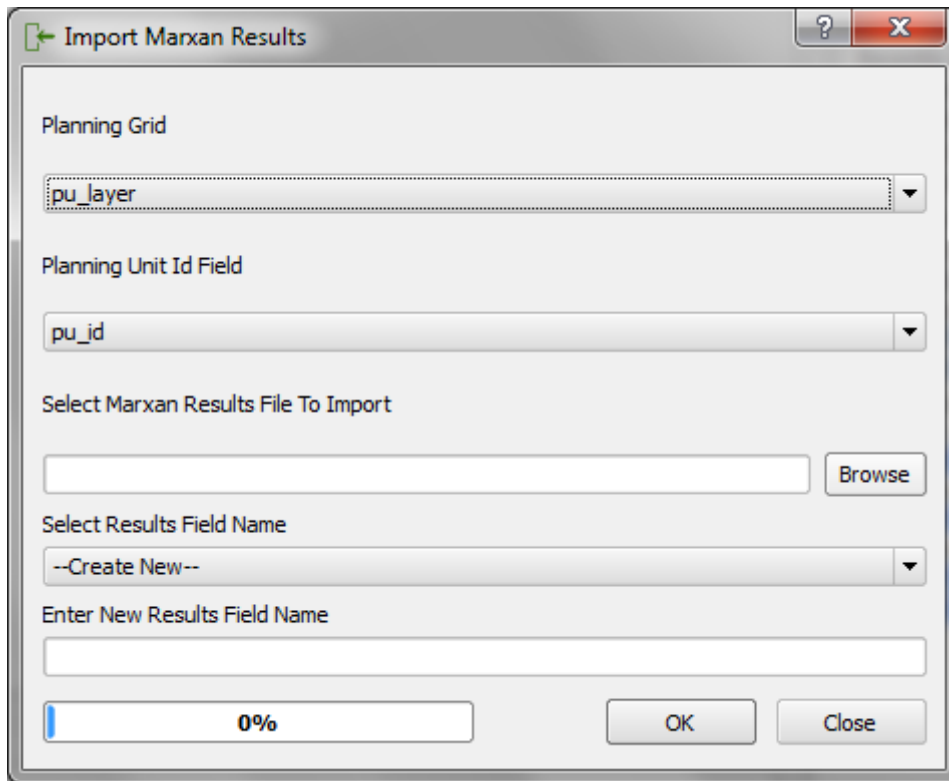
The End
Press return to exit.

```

5.5.3 Press enter when the text stops moving across the screen.

Now you need to import your results.

5.6 Go back to QGIS. Save a copy of your planning unit layer under the name “pu\_layer\_yourname\_display” in a new folder called “display” in your demonstration\_marxan folder. Open the module of the QMarxan folder “import Marxan results”.



- Make the planning grid your planning unit layer, and the planning unit id field “pu\_id”
- In “select Marxan results file to import” browse and navigate to the Marxan output folder in “Desktop/Marxan Data\_unix/outputs” and select the output file yourname\_best.csv or .txt
- Under new results field name write “yourname\_best\_1”

Now display your results by changing the symbology in the properties of that layer. Go to “style” and select “categorized”. Then in “Column” make sure that it is “yourname\_best\_1 selected”. Then click classify, apply and finally OK.

You should now be able to see where Marxan has selected. IT should have 0 where the pu has been selected and 1 where it hasn't been selected.

5.7 Go back to the MarxanData\_unix/outputs folder and open mvyourname\_best.csv in leafpad by right clicking and opening with Leafpad. Copy and paste your results in an excel sheet.

Remember your ID's for your targets are:

targets	File names	ID in Marxan
Threatened forest		3000
Bonobos		4000

Your output text file should look like this:

```

File Edit Search Options Help
mrxRED_mrbest.txt
FConservation Feature", "Feature Name", "Target", "Amount Held", "Occurrence Target ", "Occurrences Held", "Separation Target ", "Separation Achieved", "Target Met", "
10, ,14500051875.853862,1440776051.173264,0,169,0,0,no,0.993635
9, ,365307799.513520,368949406.705800,0.35,0,0,yes,1.000000
8, ,543867921.006852,563192692.063490,0.36,0,0,no,0.998803
4000, ,2858932531.350868,9650703353.082031,0,104,0,0,yes,1.000000
    
```

Description of each column in the file :

Conservation Feature	Number assigned to a given parameter among the different values for conservation (e.g. bonobo will be assigned number 3000 or other)
Feature Name	Name of the parameter given among the values for conservation, e.g. "bonobos"
Target	The amount of a given value for conservation that Marxan tries to include in its output. This amount corresponds to the specified proportion in the spec.dat file, applied to the puvsspr.dat file. This amount is thus an absolute value and not a proportion (e.g. if the proportion in the spec.dat file is 50% and total area for the range of bonobos is 500m <sup>2</sup> , target will be 250m <sup>2</sup> )
Amount Held	Amount of the value for conservation that the software managed to include in its final output, in the same units as in the input file
[...]	
Target Met	"yes" if all the targets are met, otherwise "no"
MPM	Proportion of the target which is met (e.g. if the target is 250m <sup>2</sup> and that the output managed to include only 125m <sup>2</sup> , it would be 0.5). NB: the figure is never higher than 1, even if target is exceeded (even if the output includes 750m <sup>2</sup> it would still be 1).

This file tells you whether or not Marxan has met its targets and if so by how much.

5.8 Write down whether or not Marxan met its target for:

Bonobos : \_\_\_\_\_

Threatened forest : \_\_\_\_\_

5.9 Go back to the QGIS session and run group stats on the bonobos range to calculate its total area.

Écrire le résultat : \_\_\_\_\_



NB : if Group stat cannot operate (if the bonobo file is a txt file for instance), right click on the layer in the TOC and choose Save as. Comma Separated Value (CSV) as a format and save the file in . demonstration\_marxan/outputs\_demo. Open the file in the file manager with LibreOfficeCalc by right clicking on the file. You get a spreadsheet and you can calculate the total area of bonobos by using the SUM function for all the bonobo column.

Multiply this number by 0.5 the proportion that Marxan was trying to reach. Compare this to the target column in your mv\_best file for bonobos. Is it the same? **Yes/No**

What does this mean?

5.10 Now open the export to Marxan sub menu again.

Change the proportion targets to 0.05 for both conservation features and export the file to your MarxanData\_unix/inputs folder. Open the configure scenarios submenu. Change on the Marxan Output tab the name to "yourname\_0.05"

Run Marxan again by opening the terminal emulator and typing ./ MarOpt\_v243\_Linux32 and hitting enter again. Wait until it finishes and import the new best rest in yourname\_0.05\_best.csv again. Add a new field called "yourname\_0.05".

Compare the new results with your last results for 50% proportional targets by changing the display field in the symbology to "youranme0.05".

### Boundary length

5.11 Revert the targets to 0.5 for both threatened forest and bonobos in the spec.dat file under the export to Marxan module. Export another spec.dat file. Open the configure scenario submenu of the QMarxan plugin. Change the field BLM in the general tab from 1 to 0.1 and run Marxan through the emulation terminal. Rerun Marxan and import the results, calling the results field "BLM\_0.1"

Compare your results.