MARXAN 101 Course Manual

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THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Applied Environmental Decision Analysis
Commonwealth Environmental Research Facility

Case Study Profile
Case study region: Tasmania, Australia (terrestrial)

Objective: Identify cost-effective areas for acquisition that protect a portion of each biodiversity feature.

Decision support tool: Marxan, of course!

Key reference: This project is a mini version (less data, smaller study region, etc.) of a larger spatial prioritization project that we did under contract to Australia's Department of Environment and Water Resources. The final report for this project is located in the course folder to give you a more complete description of the project, data, and approach:

Klein, C, J. Carwardine, K. Wilson, M. Watts, H. Possingham. 2007. Spatial Prioritization Approaches for the Conservation of Biodiversity in Australia: Considering Conservation Costs, Ecological & Evolutionary Processes, and Large-Intact Areas. Report to the Department of Environment and Water Resources.

Day 1

Getting Started

> **Note: When we refer to drive D:\ in this document, substitute drive C:\ on your computer. For example, D:\Marxan101 should be replaced with C:\Marxan101**

Disclaimer: There are many ways to create and view Marxan files. For the purpose of this class, we present just one method using ArcGIS 9.X. This manual is meant to be used in a Marxan 101 course and not as a stand-alone document. In addition, this manual only covers some of the basic functionalities of Marxan. Additional functionalities are outlined in the Marxan manual (http://www.uq.edu.au/marxan) and are taught in advanced courses.

- Login to the computer: Username: marxan; Password: naxram (in the Geosciplng domain)
- Navigate to S:\other and copy the folder Marxan101 to the C drive.
- Navigate to C:\Marxan101 and double click on Marxan101.mxd to launch the ArcMap project.
- Ensure the Spatial Analyst extension is enabled by clicking on Tools, Extensions, then enabling Spatial Analyst by checking its box
- Explore each data layer so that you have a better understanding of the type of information that you will be working with in this course.

The data layers are:
tas: Tasmania study region
reserve: IUCN reserves in Tasmania
cost: Cost data: Unimproved land value layer to represent acquisition costs at a resolution of local government areas (cost)

Biodiversity features: We provide you with 1) a layer that details the extent of a selection of vegetation types in Australia 2) a layer that details the distribution of one bird species. Each vegetation type will be considered as one conservation feature.
tasinvis: broad vegetation groups (63? total classes)
bird_raster: distribution data for one bird species

Step 1: Creating Planning Units
Planning units refer to the grid or cell size that you will do your analysis on. For example, planning units of 5 x 5 km squares might be appropriate for management scale of terrestrial or coastal environments, while larger cells might be more appropriate for open ocean analyses. Planning units can be squares or polygons. From these planning units, we will then use GIS to calculate the area within each planning unit covered by each species/vegetation distribution, and use these quantities to run our Marxan analysis.

Here we create a square grid for the Tasmania dataset with 5 x 5 km cells (5000 x 5000 m). Note that the GIS data for Tasmania is in main units of metres.

We demonstrate how to create a planning unit layer using a free extension for ArcGIS, called ET GeoWizards. We have pre-installed this extension so you will not need to perform the installation steps. However, we provide the extensions and instructions for installation for use on your home/work computer.

<u>Installing ET GeoWizards to make planning unit grid</u>

Navigate to the folder C:\Marxan101\extensions

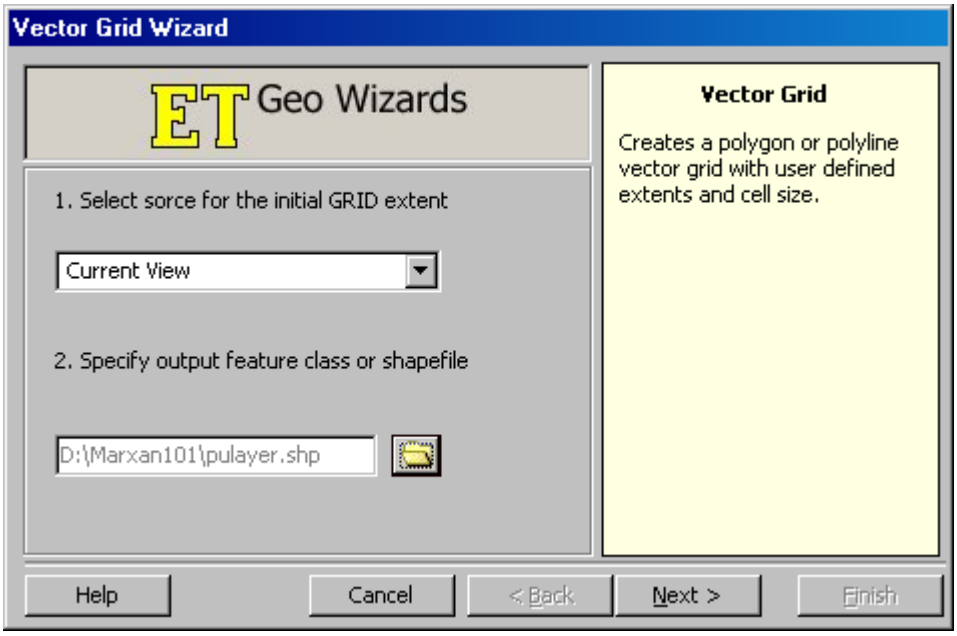
- Run register_ETGeoWizards951_9x.exe
- In ArcMap click the Tools menu and click Customize
- Click Add from file button
- Navigate to the folder where ETGeoWizards951_9x.dll, select it and click open
- In the added objects dialog box there will be a single object - ETGeoWizards, Click OK
- Click the Commands Tab
- There will be new category - ET GeoWizards - click on it
- Drag the ET GeoWizards command to any tool bar or menu (be sure to drag it next to a existing toolbar, and not to the empty space beside the toolbars)

For more information about ET GeoWizards, go to www.ian-ko.com/

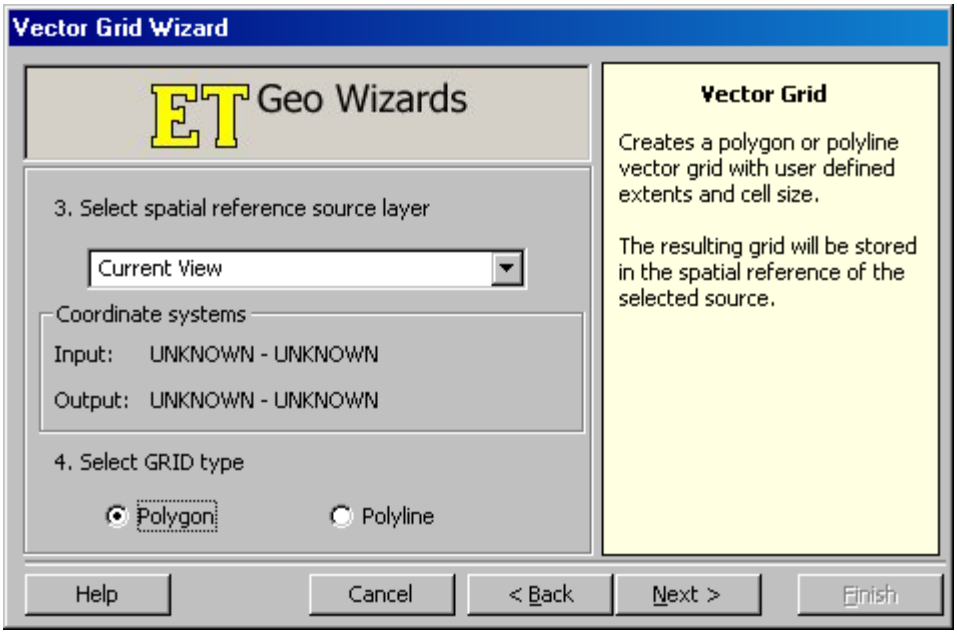
Creating Planning Units using ET GeoWizards

- Click on the yellow button called ET on the ArcMap toolbar
- Click on the basic tab
- Click on Vector Grid
- Click GO

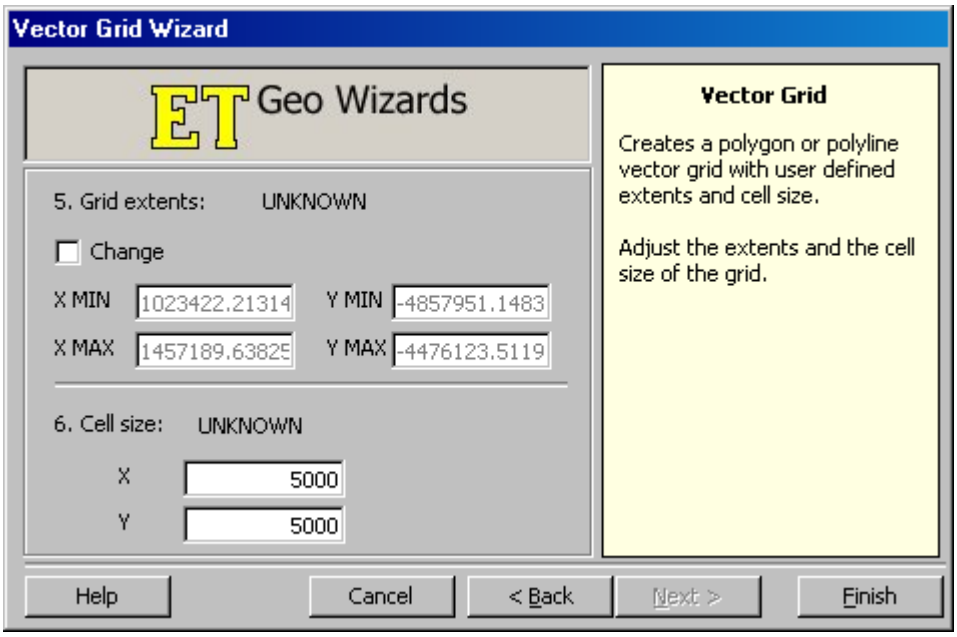
Ensure your Clip window has the following parameters:
You will need to enter the output file name for your planning unit shape file.



Click Next



Click Next



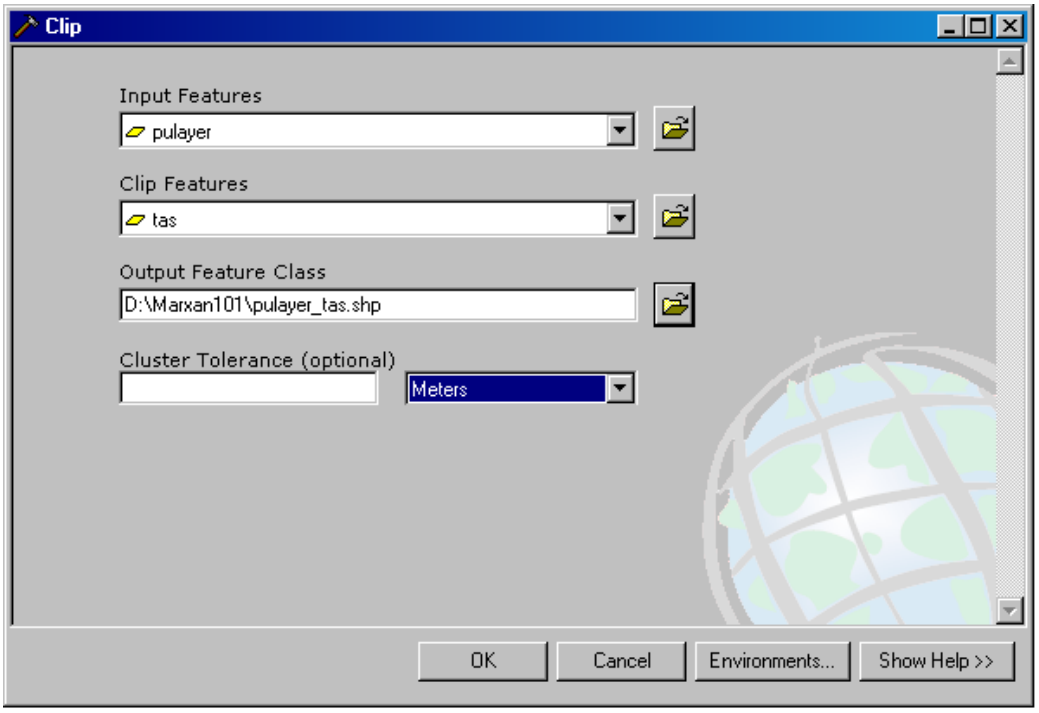
Here each unit in this Tasmania GIS dataset represents 1 m; thus (X=5000, Y=5000) means you are creating a grid of 5 x 5 km cells.
Click Finish

You now have a planning unit grid for the entire extent of your GIS window. In the next steps, we will limit this grid to our study region, Tasmania.

Clipping the planning units to your study region, Tasmania

- To make your ArcToolbox visible, click on red toolbox button.
- Under, Analysis Tools, Extract, click Clip

Ensure your Clip window has the following parameters:



Again, you will need to enter the output file name.
Click OK

Creating planning unit unique ID field
**Marxan requires that each planning unit needs to have a unique identifier. In this exercise you will assign a unique ID to each planning unit.

- Right click on pulayer_tas and open the attribute table
- Click options, then add field
- Name the field PUID and click OK
- Right click on the column title PUID
- Click Field Calculator
- Under Fields, double click on FID and then Click OK
- Delete unnecessary fields by right clicking on the fields: Id, ET_ID, and ET_Index
- Close table

Creating Data Input Files
Step 2: Creating the planning unit file (pu.dat)
**You are creating a Marxan planning unit file that contains the planning unit id, cost, and status (availability for selection).

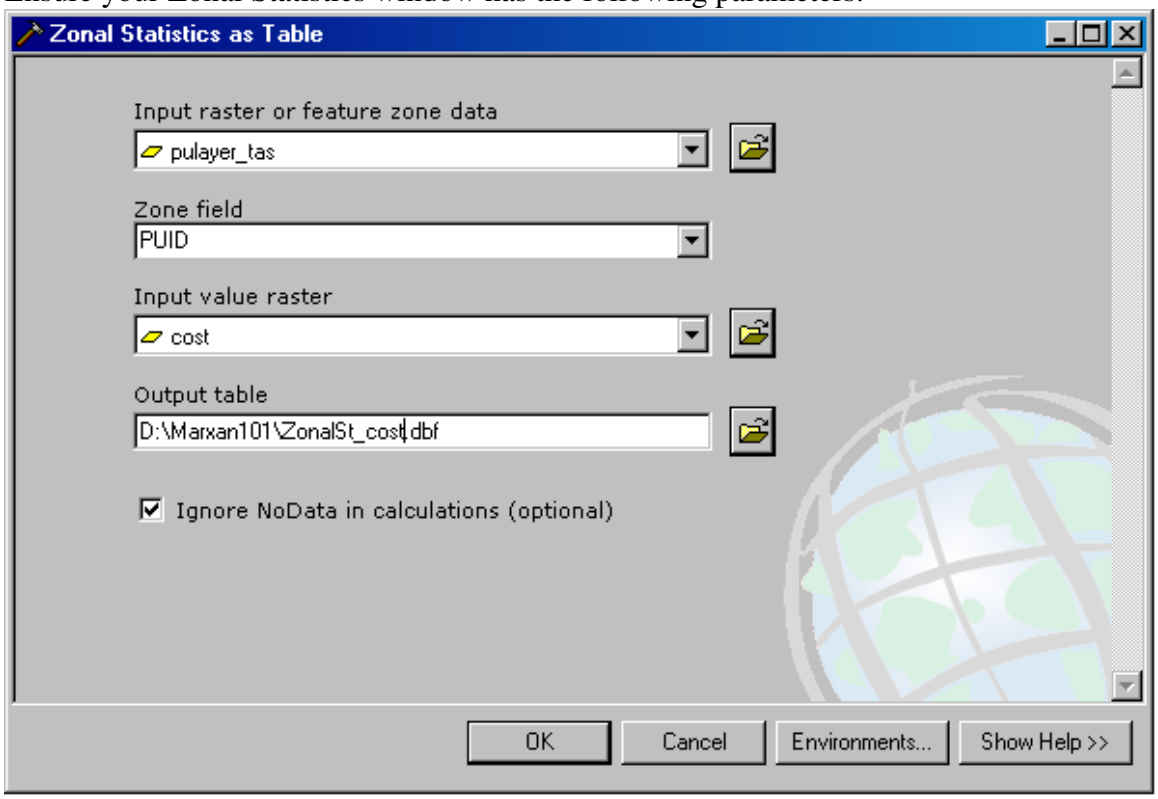
Step 2a: Creating Cost Table
**We have provided a GIS layer that depicts the relative cost of acquiring land in the local government areas of Tasmania. Here, the cost is high if land is near a city, and lower elsewhere. Assuming that you are acquiring land for conservation investment, you will calculate the expected cost of purchasing each planning unit.

Note: Please ensure that the tables for your layers "pulayer_tas" and "cost" do not have any rows selected or the zonal statistics function will not work correctly.

- Under Spatial Analyst Tools, Zonal, click on Zonal Statistics as Table

If you can't get to Spatial Analyst Tools, click on Tools, then Extensions, then click Spatial Analyst Tools to load these tools into your ArcGIS package.

Ensure your Zonal Statistics window has the following parameters:



This will create a table (ZonalSt_cost.dbf) that sums the cost of land within each planning unit (indexed by PUID).

Click OK

Step 2b: Creating Reserved Table

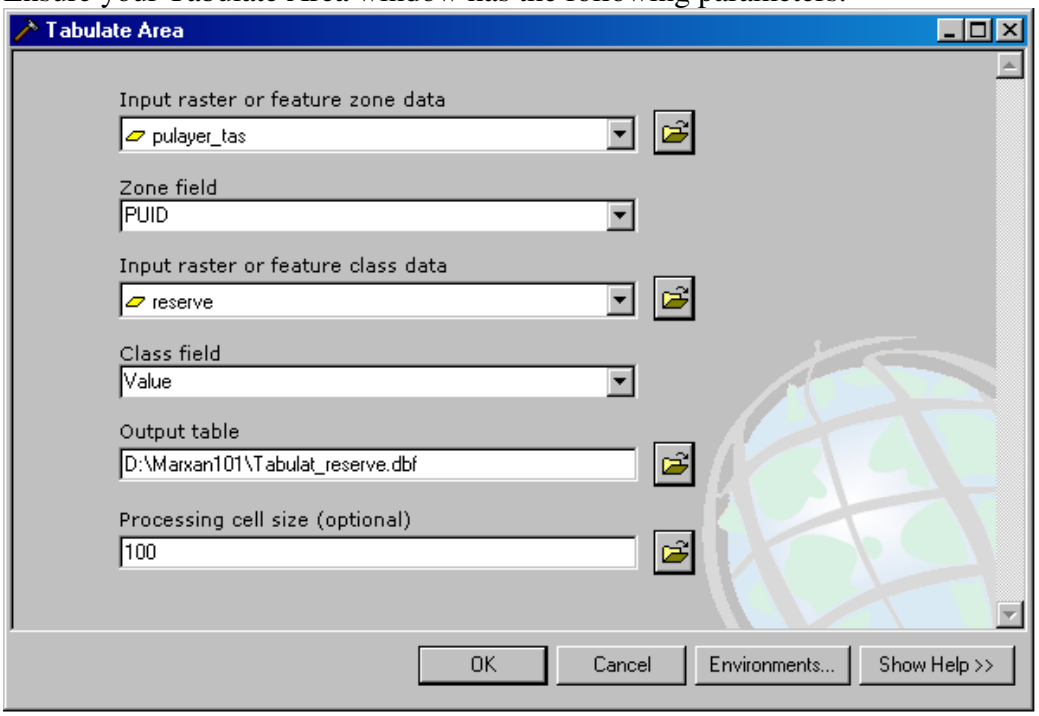
**There are IUCN (I-IV) protected areas in Tasmania. Since these protected areas contribute towards your conservation objectives, you may which to lock them into the final solutions. To do this, the planning unit status must be assigned a 2 in the planning unit file (a status of 0 is available; 3 is locked out; 2 is locked in).

We will determine which planning units are currently protected and lock ones that are greater than 50% protected. 50% is an arbitrary threshold – we encourage users to explore the impacts of setting a threshold to lock in planning units. There are other approaches that can account for currently protected areas; one of these approaches is discussed in the "Day 1 Extra Activities" section.

Note: Please ensure that the tables for your layers "pulayer_tas" and "reserve" do not have any rows selected or the tabulate areas function will not work correctly.

- Under Spatial Analyst Tools, Zonal, click on Tabulate Area

This tool calculates the area within each planning unit that has the feature you specify). Ensure your Tabulate Area window has the following parameters:

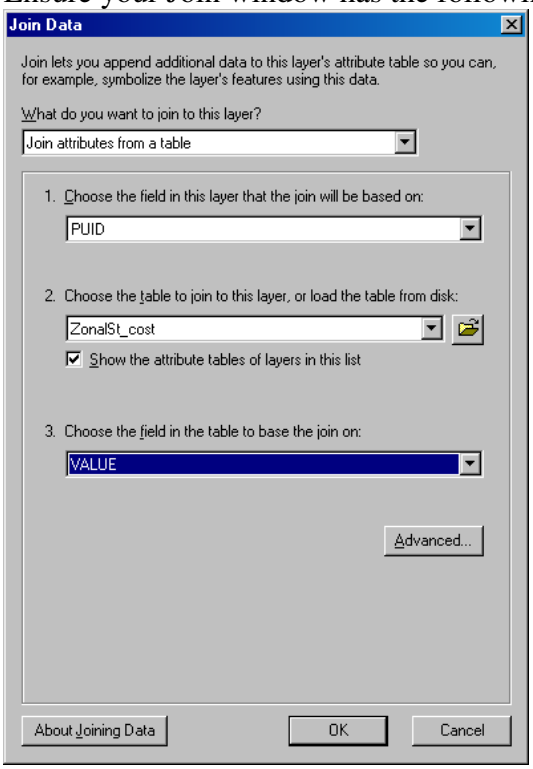


Click OK

Step 2c: Link data layers to create table for export.

- Add the following tables that you just created to ArcMap: tabulate_reserve.dbf (area in reserve of each planning unit), and zonalst_cost.dbf (cost of each planning unit). To do this, click on the yellow + sign, or right click the layers windows and clickAdd Data.
- Now, we will join the information in these two tables to the information in the planning unit file. Right click on pulayer_tas and select Joins and Relates and then Join

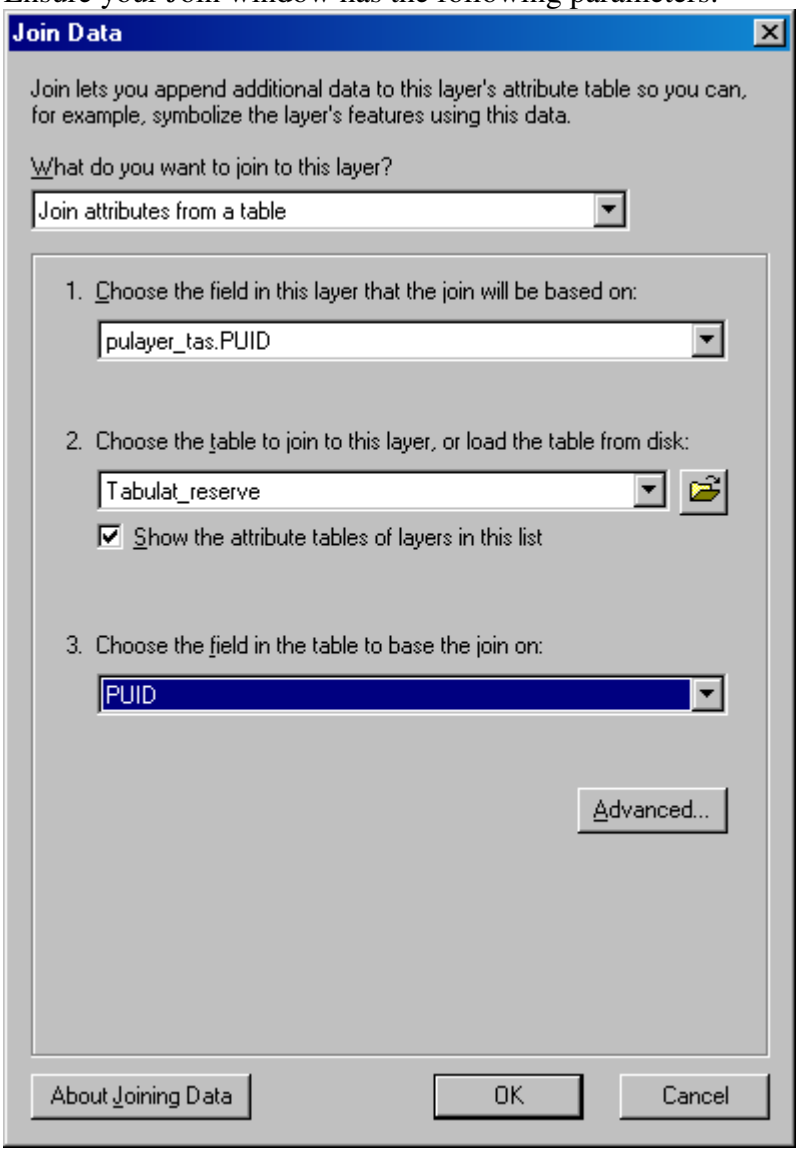
Ensure your Join window has the following parameters:



Click OK

- Click Yes on the Create Index box that appears.
- Right click on pulayer_tas and select Joins and Relates and then Join

Ensure your Join window has the following parameters:



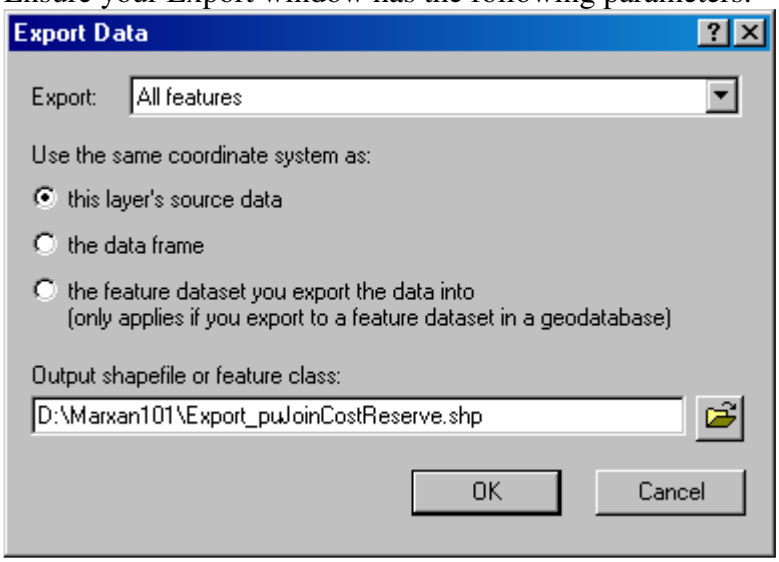
Click OK

- Click Yes on the Create Index box that appears.

Step 2d: Export data to create planning unit file

- You have now linked data on planning unit (PUID), cost, and area in reserve, using the Join tool. This will let you export all 3 columns of information into one file. You will also add one more column to your export data, the total area of each planning unit.
- Now we want to export the data from the planning unit file, cost file, and reserve file to a new table. To do this, right click on pulayer_tas, select Data and then Export Data.

Ensure your Export window has the following parameters:



Click Ok

- Click Yes, add exported data to map as a layer.

Step 2e: Calculate area of each planning unit

We will now calculate the area of each planning unit using ArcGIS, and use this information to determine the status of each planning unit, by comparing the area reserved to the total area in each planning unit in Excel.

- Open attribute table for Export_puJoinCostReserve.
- Click on the **Options** tab
- Choose **Add Field**
- Name it **Aream2**
- For *Type*, choose *Double*
- Don't put anything under *Precision* or *Scale* (i.e. leave default values)
- **OK**
- Right-click the field heading for **aream2**
- *Option 1 : If using ArcGIS 9.2*
  - Click Calculate Geometry
  - Click Yes
  - Under Property, select Area
  - Click Ok

- *Option 2 : If using ArcGIS 9.1*
  - Click Calculate Values.
  - Check the Advanced box.
  - Type the following VBA statement in the first text box (you should be able to copy it from this document and paste it into ArcGIS):

Dim dblArea as double
Dim pArea as IArea
Set pArea = [shape]
dblArea = pArea.area

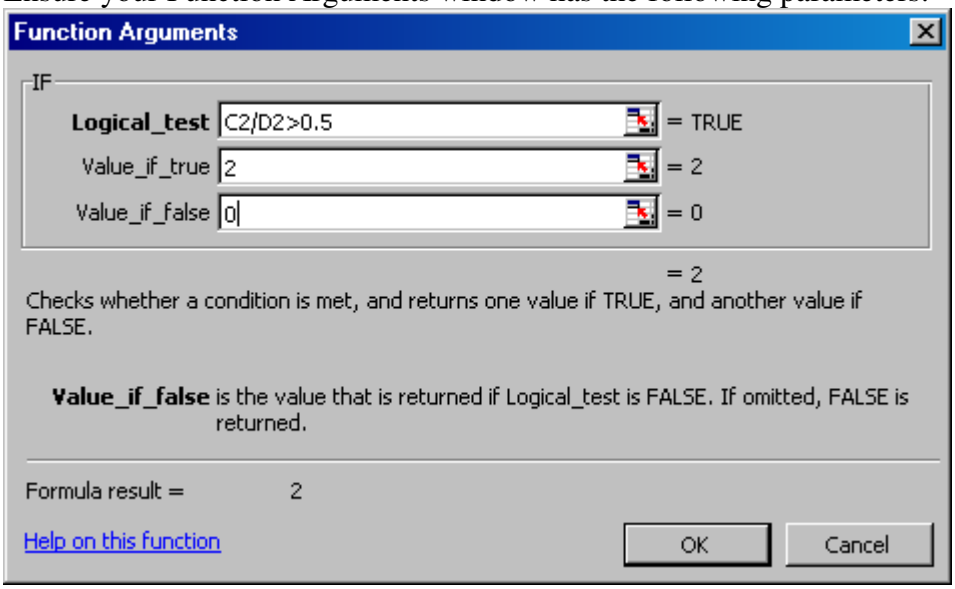
- Type the variable *dblArea* in the second text box (near the bottom of the dialog box) directly under the area field name.
- Click OK

- Remove layer Export_puJoinCostReserve from ArcGIS so we can load the file in Excel.
- Open Export_puJoinCostReserve.dbf in Excel (make sure that you have selected "show all file types" so that the .dbf files are visable)
- Delete all columns EXCEPT: PUID, MEAN, VALUE_1, and AREAM2. These refer to your planning unit index, the cost of each planning unit, the area in each planning unit that is reserved, and the total area in each planning unit. Note that most of AREAM2 column has values of 25 km^2 (which in the table shows up as 25000000 m^2). If a planning unit is on the edge, it will have a smaller area.
- Rename PUID to id (must be in lower case letters), as this is what it must be called for Marxan to run.
- Rename MEAN to cost (must be in lower case letters), as this is what it must be called for Marxan to run (mean is the average cost of each planning unit).

We will now determine in Excel which planning units are more than 50% protected and lock them in by giving them a status of "2". We will also assign planning units that are available for selection a status of "0":

- Click on cell E1 (should be blank if you deleted the correct number of fields), and type status (must be in lower case letters).
- Click on cell E2, and click the fx button (to the left of the formula bar).
- Select IF function.

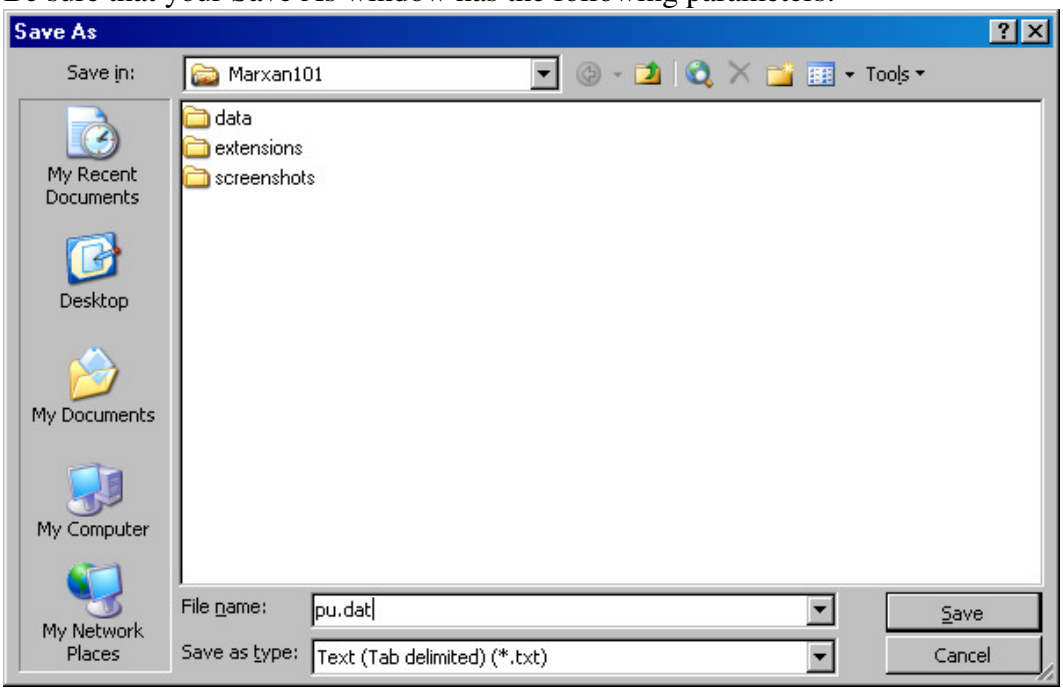
Ensure your Function Arguments window has the following parameters:



Click OK

- In cell E2, double click the bottom right hand corner of the cell to automatically fill this function across the column.
- Select column E (status), copy the column.
- Right click on column E and Paste Special (Values only) in column E (over the top of what is currently in column E). This step is necessary as the Marxan files can not contain formula information.
- Delete VALUE_1 and AREAM2 columns as you only needed this information to determine the planning unit status.
- Autofit the entire table (do this by selecting the entire table and double clicking on the line between columns A and B).
- Click File, Save As, and select Text (Tab delimited) type and rename the file to pu.dat (see next page for screen shot).
-

Be sure that your Save As window has the following parameters:



Click Save

- Click Yes on the pop up dialog box.
- Close the pu.dat file in excel.
- Click No on the pop up dialog box.

Step 3: Creating the species file (spec.dat)

**The species file lists the conservation features/species and the target amount to be included in the reserve system.

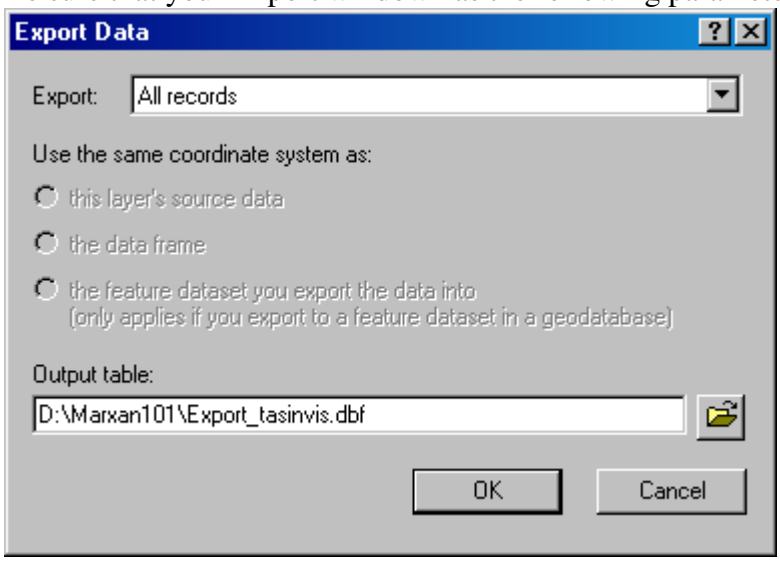
For the Tasmania dataset we will calculate the total area covered by each of the 63? vegetation classes using the *tasinvis* layer, and the one bird species distribution using the *bird_raster* layer. Then we will use these areas to calculate (in Excel) the desired target of 30% protection of each species range/vegetation class.

Step 3a: Export vegetation/species layers to excel

First, we will export the information from tasinvis (vegetation layers) and open it in excel:

- In ArcMap, open the attribute table for tasinvis
- Click Options then Export

Be sure that your Export window has the following parameters:



Click OK and *do not* add layer to the map, when prompted.

You will now create the species file so that each species has a unique id:

- Open Export_tasinvis.dbf in Excel (The values in the first column will be the species id. The values in the second column indicate how many pixels there are for each species in the raster data layer.)
- Delete row which has a value=0 (this is area of no data in the vegetation layer).
- Rename Value to id (must be in lower case letters), as this is what is required in Marxan.

The species file is the file in which you must set a target amount per species to be included in the solution. We will set a target of 30% per species by doing the following steps:

- Click in cell C1 and name it target (must be in lower case letters).

- Click in cell C2 and type =B2*10000*0.3) to set a 30% target on the area of each vegetation type. Where B2 = number of cells containing feature; 10000 is the area of each cell; and 0.3 is the target amount. The vegetation features are based on 100 x 100 m cells (thus total area is 10000 m), and need to be converted to the same units as your Tasmania GIS dataset (metres).
- In cell C2, double click the bottom right hand corner of the cell to automatically fill this function down the column.
- Select column C (target), copy the column.
- Paste Special (Values only) in column C (yes, over the top of the other values). This step is necessary as the Marxan files can not contain formula information and must only contain values.

In the species file, the first column is the id for the species and the second column is the species name. In the name column, you can indicate the actual name of the species or conservation feature. For this exercise, we will make the name equivalent to the id:

- Select column A (id) and copy the column and paste into column B (over count).
- Rename cell in B1 from id to name (must be in lower case letters).

Step 3b: Create species penalty factor

In the species file, you indicate the species penalty factor (spf) for each species (we will discuss the meaning of spf during this course):
For this analysis, we will use a value of '1' for all species/vegetation types.

- Click in cell D1 and name it spf (must be in lower case letters).
- Click in cell D2, type 1 (this will be the spf value for each species), and double click the bottom right hand corner of the cell to automatically fill this function down the column (this is the default value for spf).

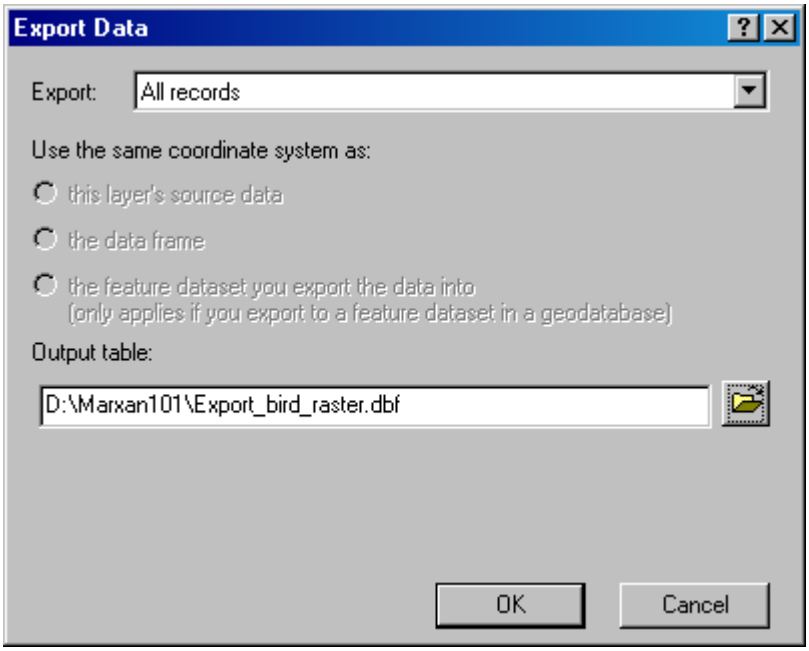
Step 3c: Add bird species layer and associated values to table

You will now need to add information about the bird species to this table. The id and name for the bird species will be 64. At the bottom of your species file, add species 64, name 64, and a spf of 1. Determine the total area and target amount using the bird_raster attribute table information (the steps will be similar to above). Add the target amount for species 64 to your species table. Detailed instructions on computing this target are included below.

Compute the target for the bird species. First, we will export the information from bird_raster and open it in excel:

- In ArcMap, open the attribute table for bird_raster
- Click Options then Export

Be sure that your Export window has the following parameters:



Click OK and *do not* add layer to the map, when prompted.

You will now create the species file so that each species has a unique id:

- Open Export_bird_raster.dbf in Excel (The values in the first column will be the species id. The values in the second column indicate how many pixels there are for each species in the raster data layer.)

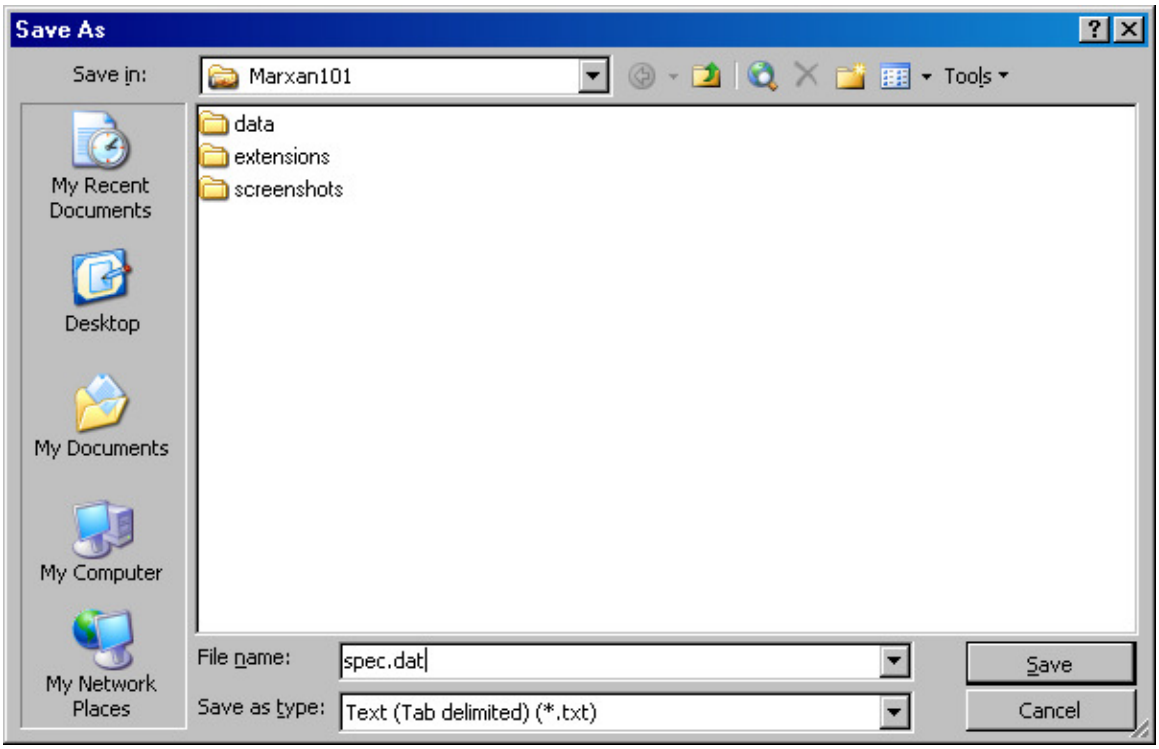
The species file is the file in which you must set a target amount per species to be included in the solution. We will set a target of 30% per species by doing the following steps:

- Click in cell D2 and type =B2*10000*0.3) to set a 30% target on the area of each vegetation type. Where B2 = number of cells containing feature; 10000 is the area of each cell; and 0.3 is the target amount. The bird_raster feature is based on 100 x 100 m cells (thus total area is 10000 m), and needs to be converted to the same units as your Tasmania GIS dataset (metres).
- Cell D2 is the target for our bird species. Copy and paste (special values) the amount into the target field for species 64 in the spec.dat table.

Step 3d: Save completed Marxan species file

- Autofit the entire table (do this by selecting the entire table and double clicking on the line between columns A and B).
- Click File, Save As, and select Text (Tab delimited) type and rename the file to spec.dat (see next page for screen shot).

Be sure that your Save As window has the following parameters:



Click OK and click Yes on the pop up dialog box.

- Close the spec.dat file in excel.
- Click No on the pop up dialog box.

Step 4: Creating the planning unit versus species matrix (puvsp.dat)

In this exercise, we will determine how much of each vegetation type and bird distribution is contained in each planning unit.

**We provide you with 1) a layer that details the extent of a selection of vegetation types in Australia *(tasinvis)* 2) a layer that details the distribution of one bird species *(bird_raster)*. Each of the 63 vegetation type will be a conservation feature. Open up the layers and its table to familiarize your self with the data.

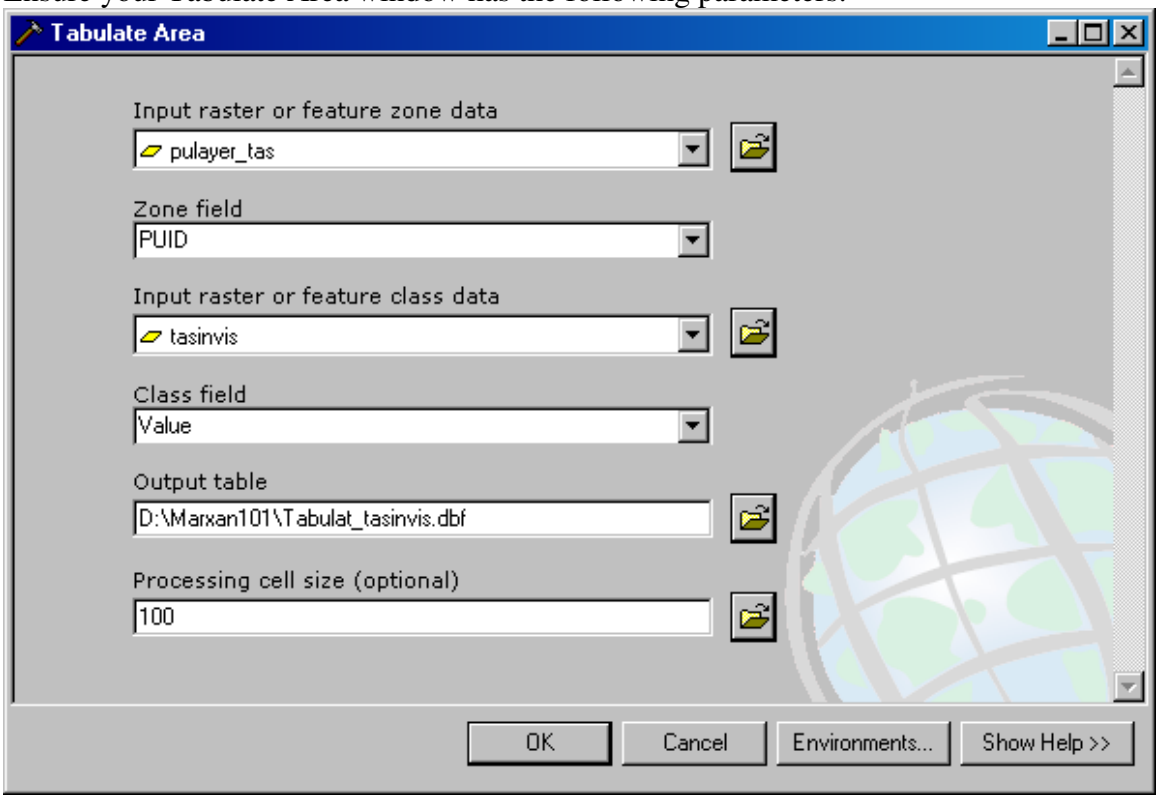
Step 4a: Calculate area in each planning unit covered by each vegetation type

Note: Please ensure that the tables for your layers "pulayer_tas" and "tasinvis" do not have any rows selected or the tabulate areas function will not work correctly.

- In ArcGIS, right click on pulayer_tas, select Joins and Relate then Remove Joins then Remove All Joins
- Under Spatial Analyst Tools, Zonal, click on Tabulate Area

Here you are tabulating the area in each planning unit of each of the vegetation types.

Ensure your Tabulate Area window has the following parameters:



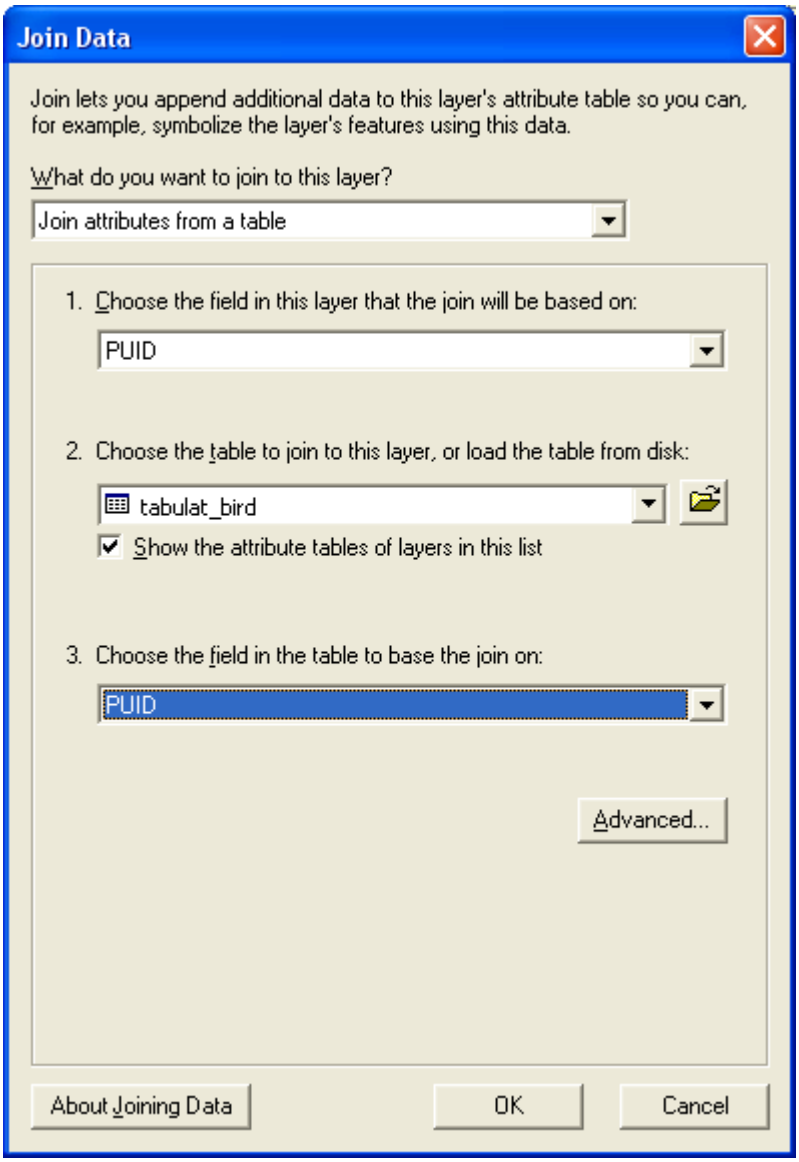
Click OK

Step 4b: Calculate area in each planning unit for the bird species

- Repeat the tabulate area steps above for the bird_raster data. Name this file tabulate_bird.dbf.

Step 4c: Join tables and export to Excel

- Ensure that both tabulate_tasinvis.dbv and tabulate_bird.dbf are added to ArcGIS.
- Join the two tables (tabulate_tasinvis.dbv and tabulate_bird.dbf) so that you know how much of each species is located in each planning unit. To do this, right click on Tabulat_tasinvis, select join, and ensure your Join Data window has the following parameters:



Click OK

Now, we need to export this joined data to a new table. Right click on tabulat_tasinvis, data, and export the table to the Marxan 101 folder. Call it tabulate_nvis_bird.dbf

- Open tabulate_nvis_bird.dbf in Excel and explore results. Each vegetation type and bird species will be listed in the first row and each planning unit will be listed in the PUID field. The area (meters squared) of each vegetation type and bird

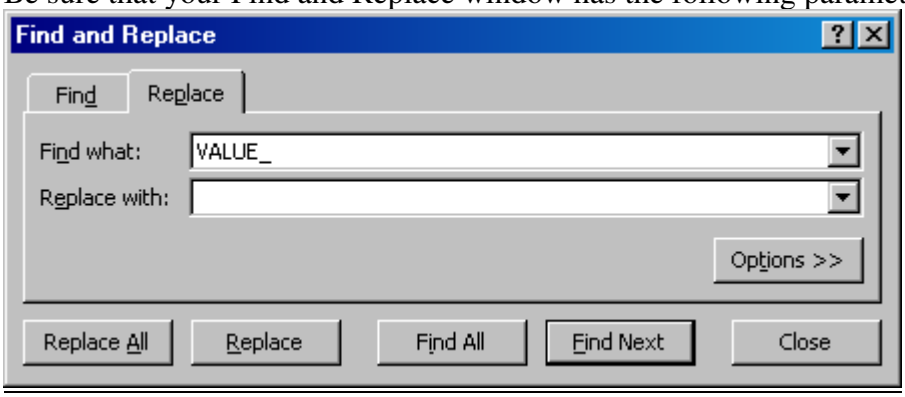
distribution was calculated for each planning unit. If you have time, you can validate the calculation by overlaying the vegetation GIS layer and planning unit layer to check if the results in the table correlate with the spatial data.

If you scroll to column BM, you will notice that this is where the table tabulate_bird was added to tabulat_tasinvis. These last 3 columns in your table represent the information from the bird table you created in GIS. Delete column BM (Rowid_) and BN (PUID_1) as they are not needed. Change the new column BM called from "value_1" to "64" as the bird species id is 64 (see your species.dat file).

To make the vegetation species IDs in this file consistent with the species file, perform the following steps:

- Delete **column** (not row) Value_0 (areas of no data in the vegetation layer).
- Rename PUID to pu (must be lowercase), as this is required in Marxan
- Select row 1
- Click Edit, Replace

Be sure that your Find and Replace window has the following parameters:

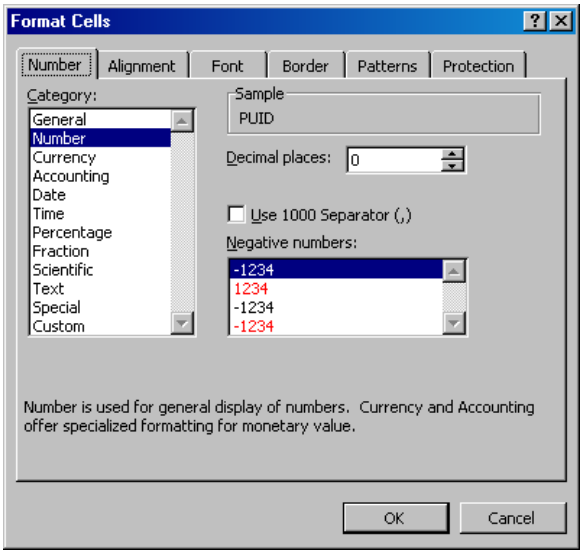


- Click Replace All.

Now, we should get rid of the extra zeros after the decimal place as they are not needed:

- Select the entire tabulate_nvis_bird.dbf table.
- Click Format, Cells

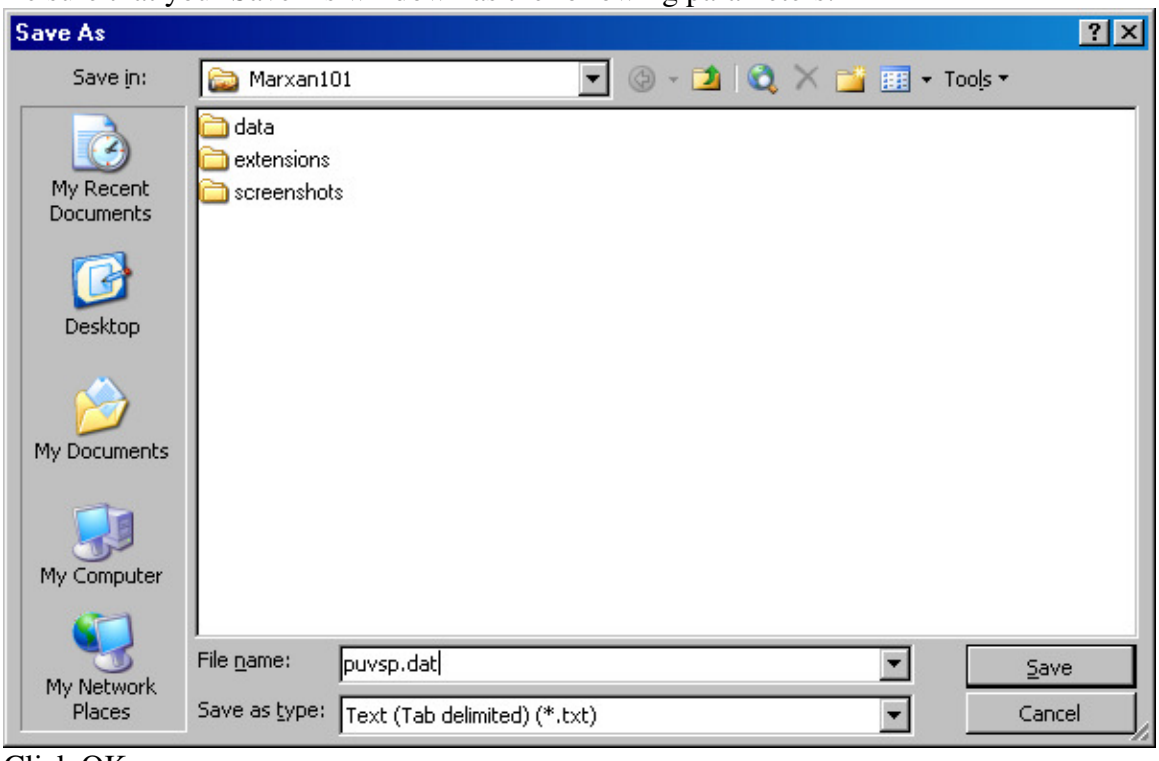
Be sure that your Format Cells window has the following parameters:



Click OK

- Click File, Save As, and select Text (Tab delimited) type and rename the file to puvsp.dat.

Be sure that your Save As window has the following parameters:



Click OK

- Click Yes on the pop up dialog box.
- Close the puvsp.dat file in excel.
- Click No on the pop up dialog box.

Step 5: Creating the bound.dat file

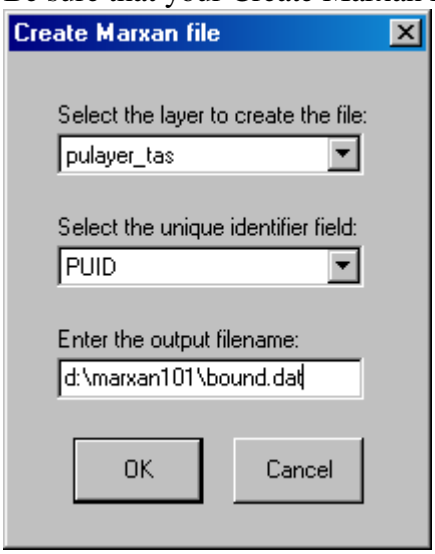
Step 5a: Load boundary maker tool

We have already downloaded a boundary maker tool on this computer. This allows you to use an automated tool to determine boundaries between each of the planning units. However, for use on your personal computer, we have provided you with the files necessary to download this tool.

Step 5b: Create boundary file using Marxan tool.

- To ensure the JNCC toolbar is showing, in ArcMap, click View, Toolbars, JNCC ArcGIS Extensions.
- Ensure that pulayer_tas is the only layer on your layer list (delete all other layers) or the program may not execute (yes, it is picky).
- Click the Create Marxan File button (the toolbar may look different on your computer)

Be sure that your Create Marxan File window has the following parameters:



Click OK

- Browse to the C:\Marxan101 folder and right mouse click on the bound.dat file, selecting Open with Notepad.
- Scroll to the end of the file and delete the blank line as Marxan may not run with this extra blank line.
- Save the file and exit the program.

Note: The boundary maker tool has a sporadic glitch that sometimes results in malformed rows. For example if you see a row in your file that ends in ",5000.", then do a search and replace with notepad to replace "5000." With "5000". In some cases,

Marxan will give an error message when running with a boundary file that contains these malformed rows. The problem here is that there are no zeroes following the decimal place, which confuses the program when it tries to convert the text into a number.

Step 6: Creating the input file (input.dat) file using Inedit

Congratulations. You are done creating the data files with ArcGIS, and will now create the input file for running Marxan.

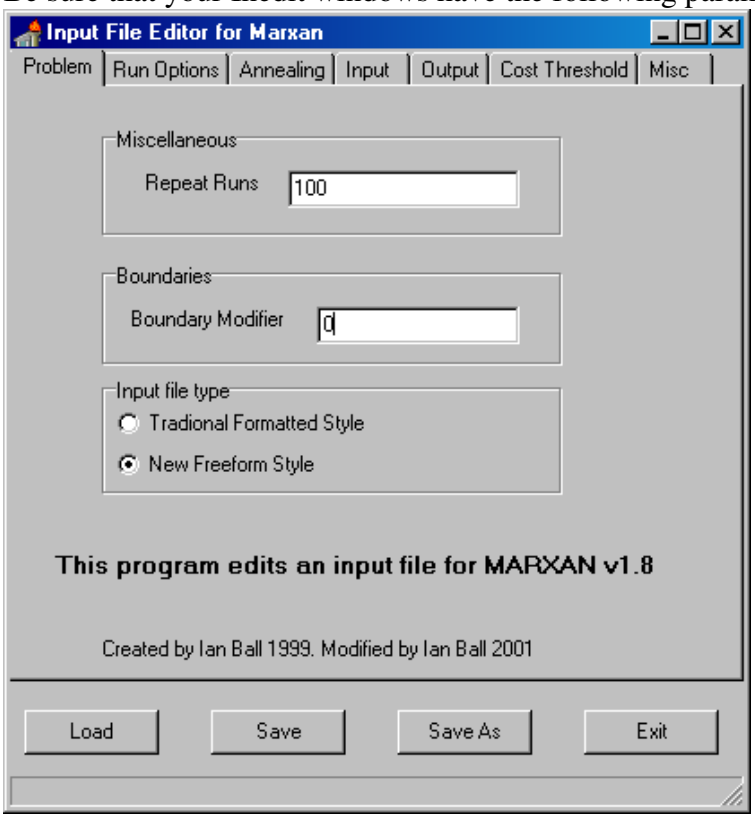
**The input.dat file is where you will indicate the name of your other input files and set several parameters. A description of all files is described in the Marxan manual, which is in the documents section of your course folders. We will not cover all of these parameters in this course.

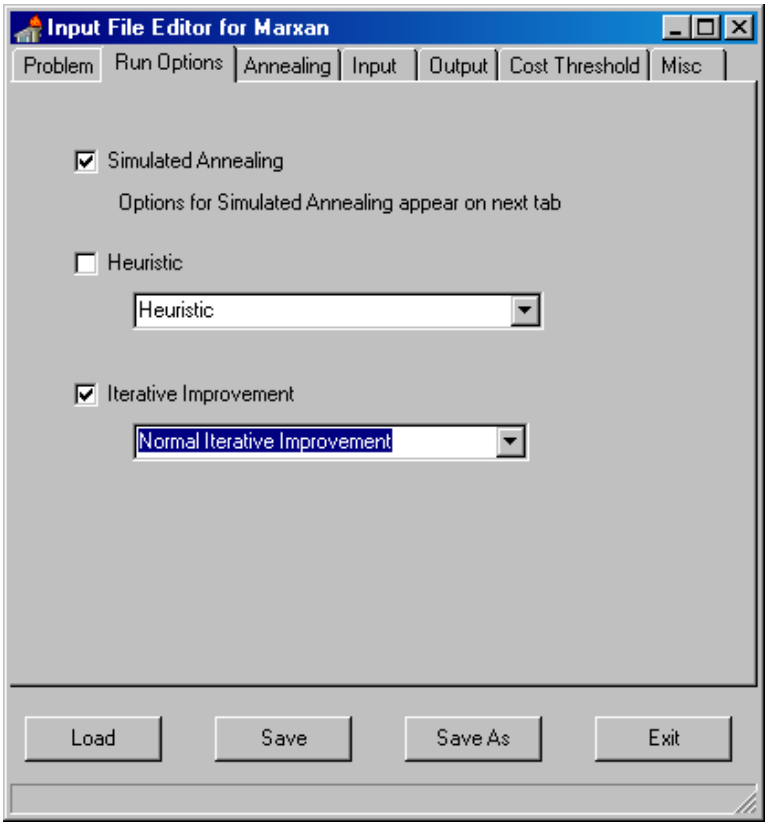
First, you will need to establish a specific structure for your files:

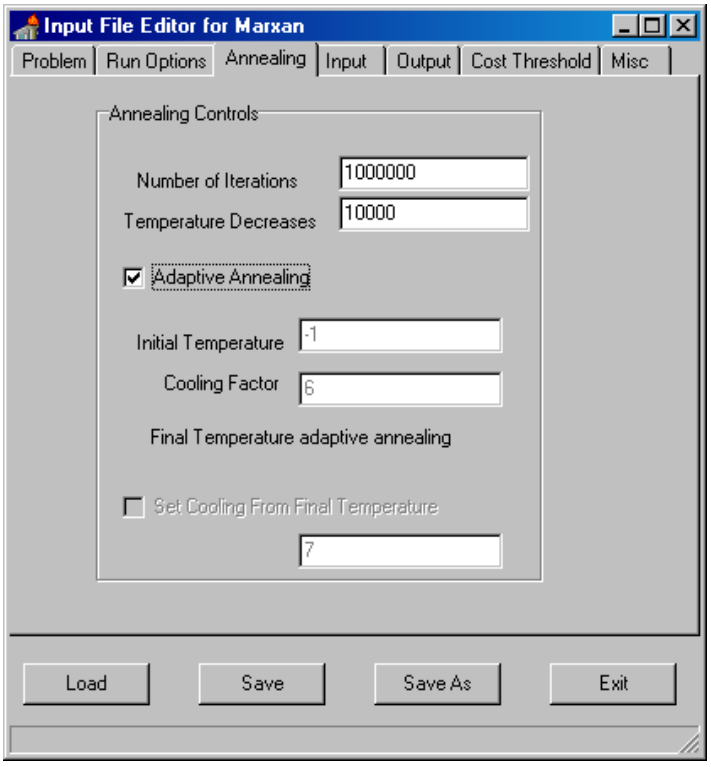
- Browse to the Marxan101 folder, create a new folder and name it Marxan_Database.
- In the Marxan_Database folder, create two new folders called input and output
- Copy the files Inedit.exe and Marxan.exe from the Marxan1_8_10Full folder into the Marxan_Database folder.
- Move the following files into the input folder: bound.dat, pu.dat, puvsp.dat and spec.dat

Then, In the Marxan_Database folder, open Inedit.exe (Ignore the file not found warning by clicking OK)

Be sure that your Inedit windows have the following parameters:

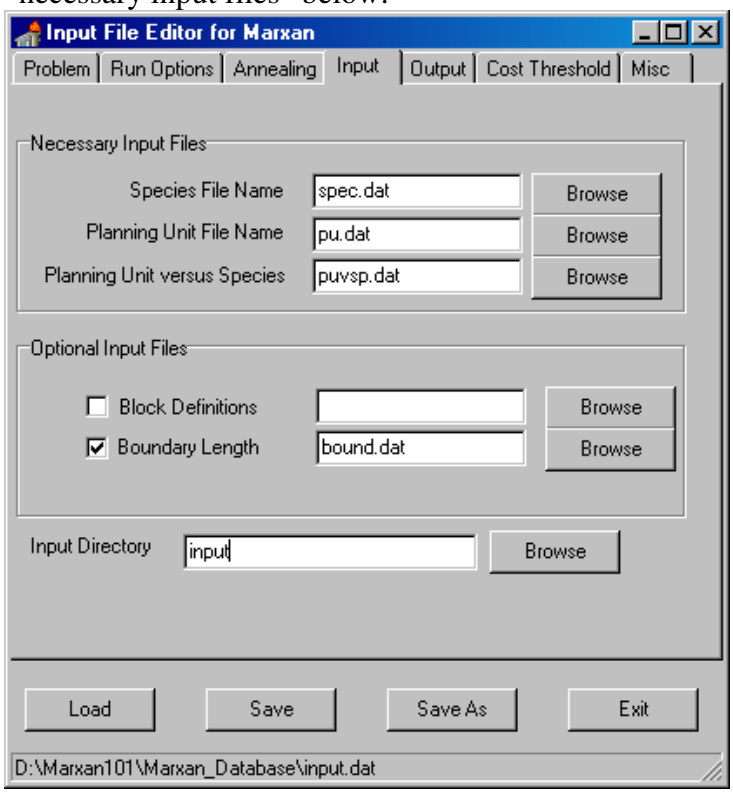


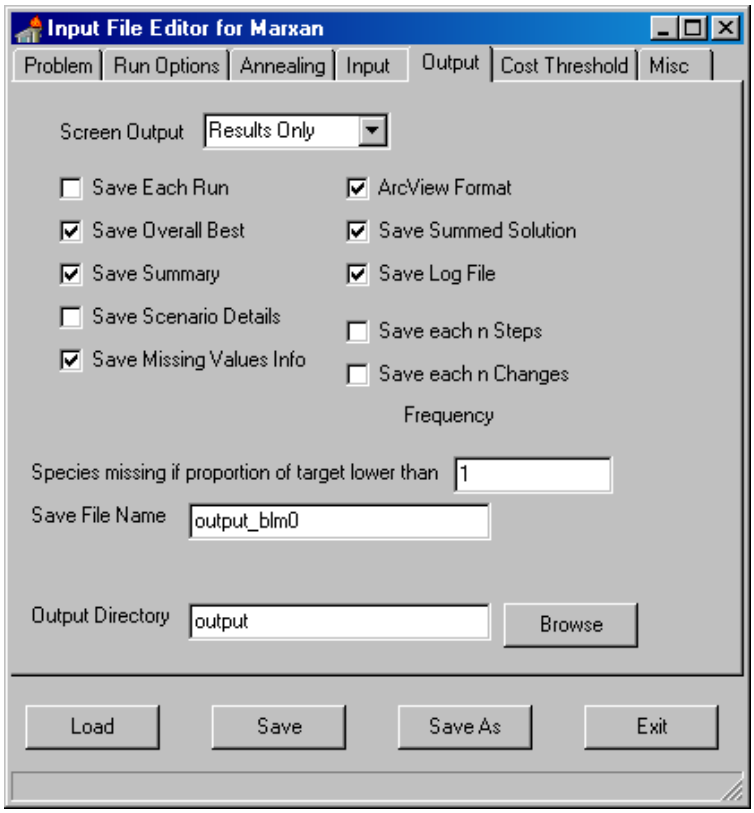


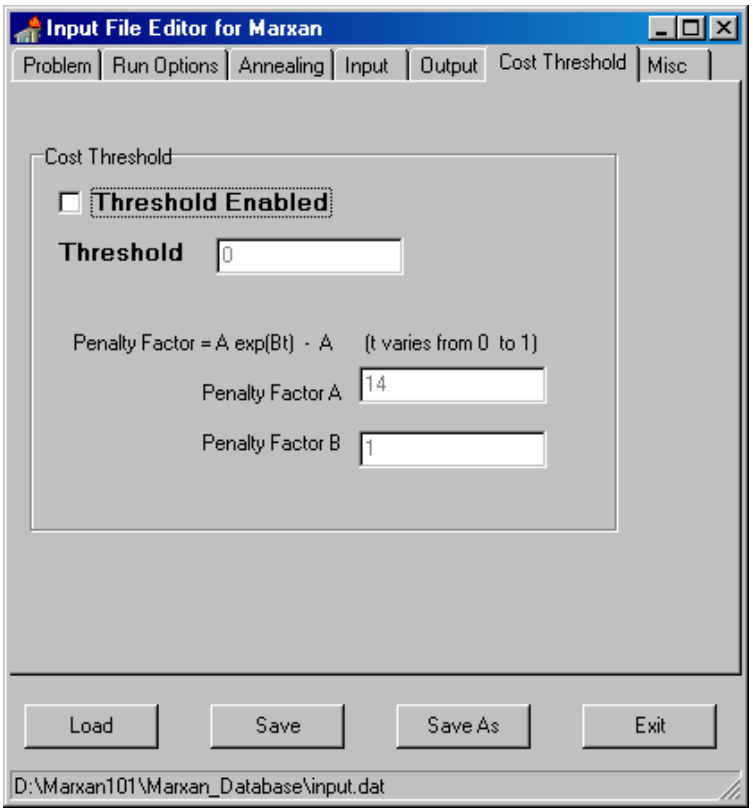


Ignore the floating point overflow message when entering Temperature Decreases.

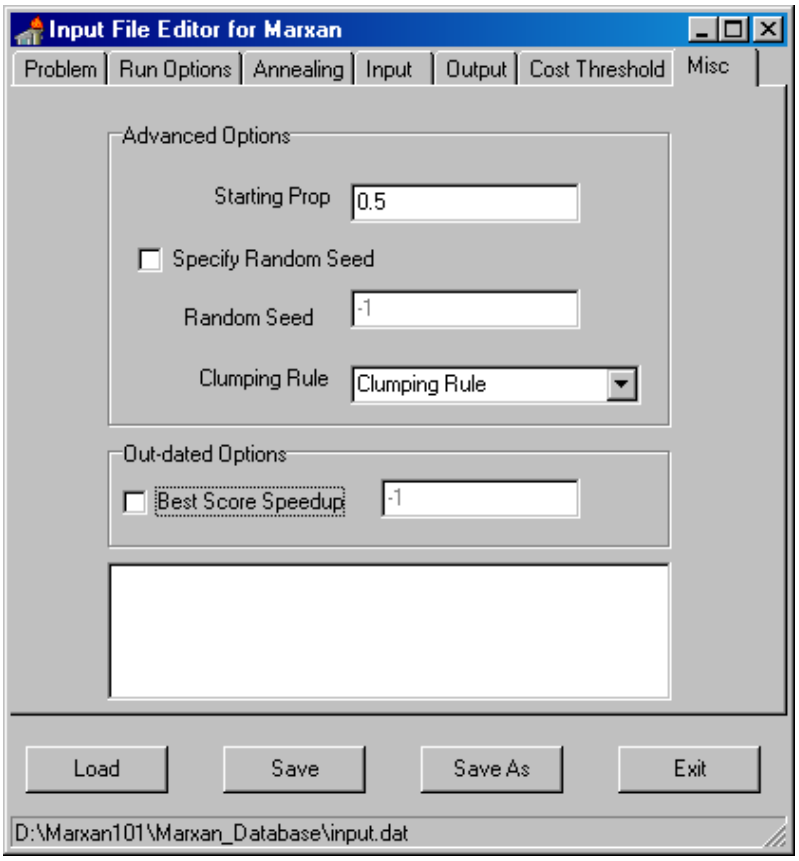
Define the “input directory” first to avoid getting an error message when setting the “necessary input files” below:







Switch threshold on then off to get these parameters.



Press Save and then Exit

Note: On manually editing the input.dat parameter file.

Experienced users of Marxan often use a text editor to edit the input.dat instead of the Input Editor application for convenience. Open the input.dat file that you created using the TextPad text editor, and browse the parameters you have just set with the Input Editor.) and set the VERBOSITY to 1.

Extra Activities

**A few suggested readings are provided to help you get a better understanding of systematic conservation planning and the Marxan software. Additional references are provided in the documents folder in your Marxan 101 folder. In addition, if you need additional practice in making Marxan files, we provide you with additional data and methods to create files.

Suggested Readings

Suggested readings are located in the course folder, extra activities, suggested readings.

Klein, C, J. Carwardine, K. Wilson, M. Watts, H. Possingham. 2007. Spatial Prioritization Approaches for the Conservation of Biodiversity in Australia: Considering Conservation Costs, Ecological & Evolutionary Processes, and Large-Intact Areas. Report to the Department of Environment and Water Resources.

This report features 3 applications of Marxan across the entire continent of Australia. The case study that you are working on today is a mini version (less data, smaller study region, etc.) of this spatial prioritization project. The report will give you a more complete description of the project, data, and approach:

Possingham H.P., Wilson K.A., Andelman S.J. & Vynne C.H. (2006) Protected areas: goals, limitations, and design. In: Principles of Conservation Biology (eds. Groom MJ, Meffe GK & C.R.Carroll), pp. 509-533. Sinauer Associates Inc., Sundaland, MA

This book chapter provides an overview of key concepts in systematic conservation planning.

S*tewart R.R. & Possingham H.P. (2005) Efficiency, costs and trade-offs in marine reserve system design. Environmental Modeling & Assessment, 10, 203-213*

This paper provides a good overview of how Marxan has been applied in the marine environment to design marine reserves, considering the costs of conservation associated with fishing activities.

Suggested Activities

1) Reserve design game - A reserve design game was created by Wayne Rochester and Hugh Possingham to help teach concepts and methods of systematic reserve design. The game allows you to adjust parameters (similar to the ones found in Marxan) and explore how the program selects sites.

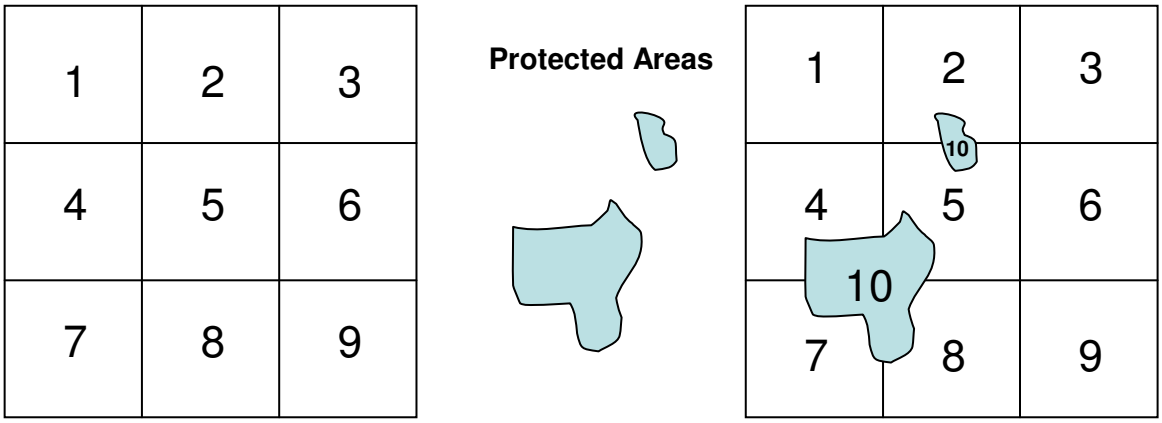
To play the game, go to your course folder, extra activities, “resgame”, and click on “resgame.html”.

2) More Practice - Try building the files with another dataset. In your course file, extra activities, more_practice_california_data, you will find a few marine data layers for California: Depth Zones, Kelp, and Study Region (see metadata for more information on

each layer). Using this study region (California's Central Coast), create new planning units and summarize the conservation features (depth zones and kelp) to these planning units. If you want extra practice, make each Marxan file using this dataset (you will need to make up the cost data as we did not provide any).

3) Make file with the CLUZ user interface – CLUZ is an ArcView 3 GIS interface that allows users to design protected area networks and conservation landscapes. It can be used for on-screen planning and also acts as a user interface for the MARXAN conservation planning software. It is currently being developed at DICE and is funded by the British Government through their Darwin Initiative for the Survival of Species. In your course folder, under extra activities, you will find a folder called "Cluz". Read Cluz_tut.pdf to help you get started with the Cluz tutorials.

4) Planning units - Today, you learned how to lock planning units in so that they are not available for selection but contribute towards achieving the biodiversity goals. In the exercise, you locked planning units in if more than 50% of the planning unit was currently in a protected area. However, this method is not accurate and may not be suitable in all cases. A more accurate way to consider the contribution of protected areas is to modify the planning unit layer. Below, we provide a list of guidelines to do this and encourage you to try this. We do not provide step by step instructions as many methods can be used to accomplish the same goal.



1. Create planning unit grid (above left)
2. Identify protected areas (above center)
3. Intersect the protected areas with your planning unit grid and create one planning unit that comprises the protected areas (above right). Some of the other planning units will now be a different shape from the original grid.
4. Allocate new unique ids for each planning unit
5. You will now have to create a new planning unit versus species table using the same methods used in today's exercise (just with a different planning unit layer).

Day 2

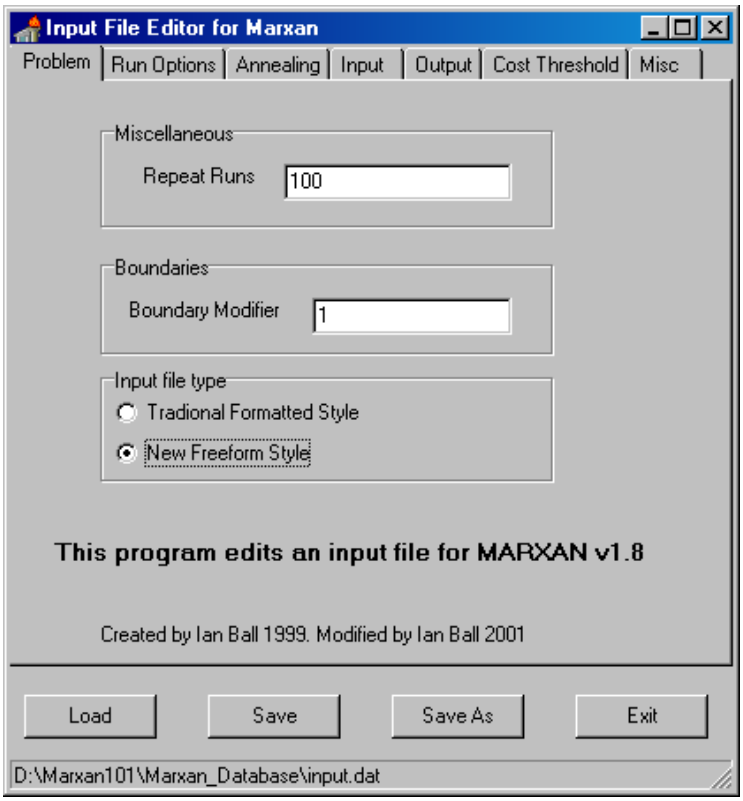
Note: When running multiple Marxan scenarios, it is recommended to have a system for organizing your input and output files. This might be to save the data files and input file in a new directory for each simulation, keeping track of the changes (eg changing spf files) made, and the resulting changes in the output of each simulation. You might just simple change the output name for each scenario as is done in the scenarios below.

1st Scenario: Running Marxan

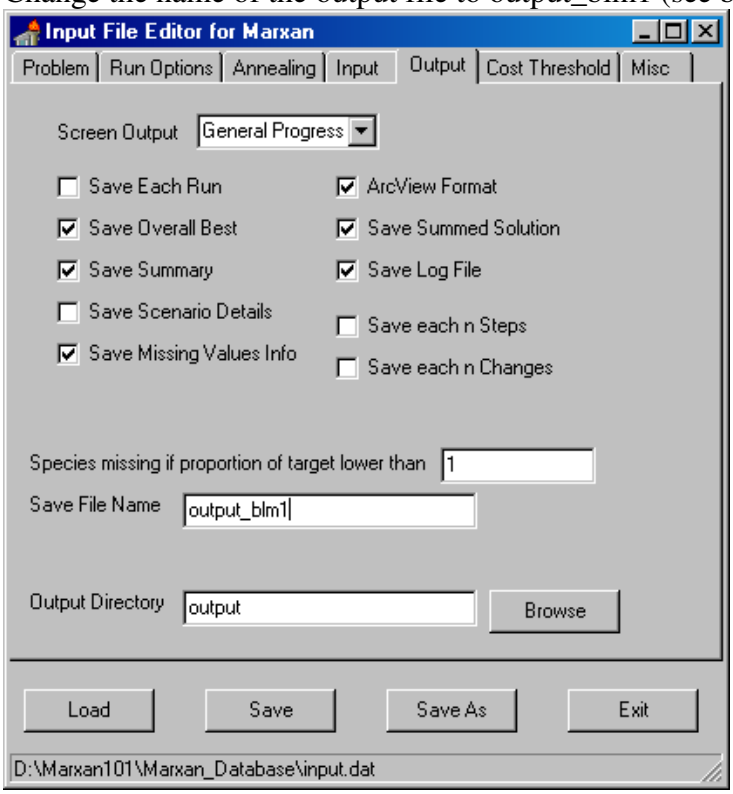
- Browse to the Marxan_Database folder, and double click on Marxan.exe to run Marxan.
- Ignore "Blockdefname" & "highdata" errors (these errors are obsolete and related to old versions of Marxan)
- Sit back, relax, and wait for Marxan to finish.
- Each Marxan run will create 5 output files, e.g., output_blm0_ssoln.txt, output_blm0_best.txt, output_blm0_mvbest.txt, output_blm0_log.txt, output_blm0_sum.txt summarizes data from each simulation. (did I miss any other output files? I can't remember). *ssoln.txt lists the number of runs that chose each planning unit. *best.txt lists all planning units chosen in the 'best' solution from your Marxan run. *log.txt lists information on each run. *sum.txt is similar to *log.txt. *mvbest.txt lists if targets were met for each species in the 'best' run.
- If Marxan crashes or you get other errors messages, common mistakes are having extra lines at the end of the *.txt files that cause Marxan to crash. Check *.txt files in Excel or Notepad and delete extra (blank) lines at the end of each file.

2nd Scenario: Running Marxan with a Boundary Length Modifier

- Open Inedit.exe in the Marxan_Database folder and change the boundary modifier to 1 (see below). In general, increasing BLM reduces fragmentation of your reserve selections; however, too high of a BLM may restrict your reserve options. More details are in the Marxan manual, and you can explore how BLM affects the Tasmania dataset here.



Change the name of the output file to output_blm1 (see below).



Click Save and then Exit.

- Rerun Marxan by clicking on Marxan.exe

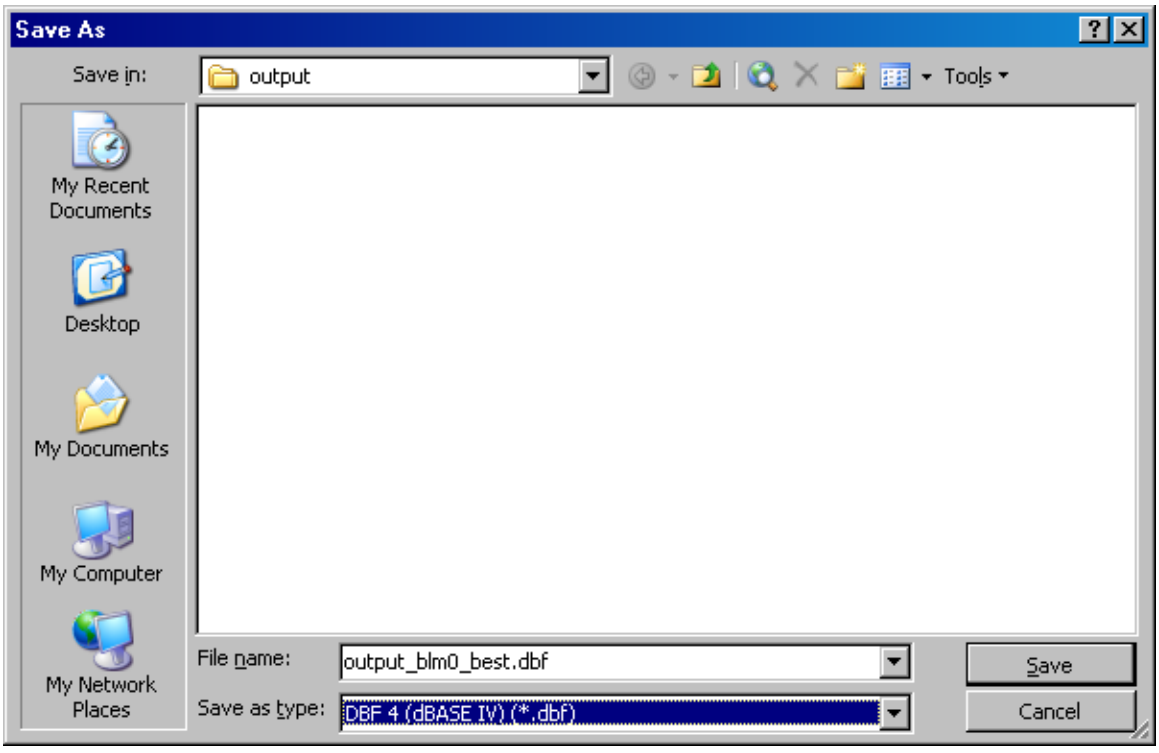
3rd Scenario: Sensitivity Analysis for the SPF (species penalty factor)

- To be sure that all of your species were met in the solution:
- In excel, open the output_blm0_mvbest.txt and output_blm1_mvbest.txt files in the Output folder
- Look at the column called Target Met and note any species not met.
- If a species was not met, you will need to increase the spf value for that species in the spec.dat input file, then run Marxan again.

Linking Output Files with ArcGIS

To map the results of your simulation and see where Marxan chose to place reserves, you must convert the Marxan output files to database files that you can import into ArcGIS.

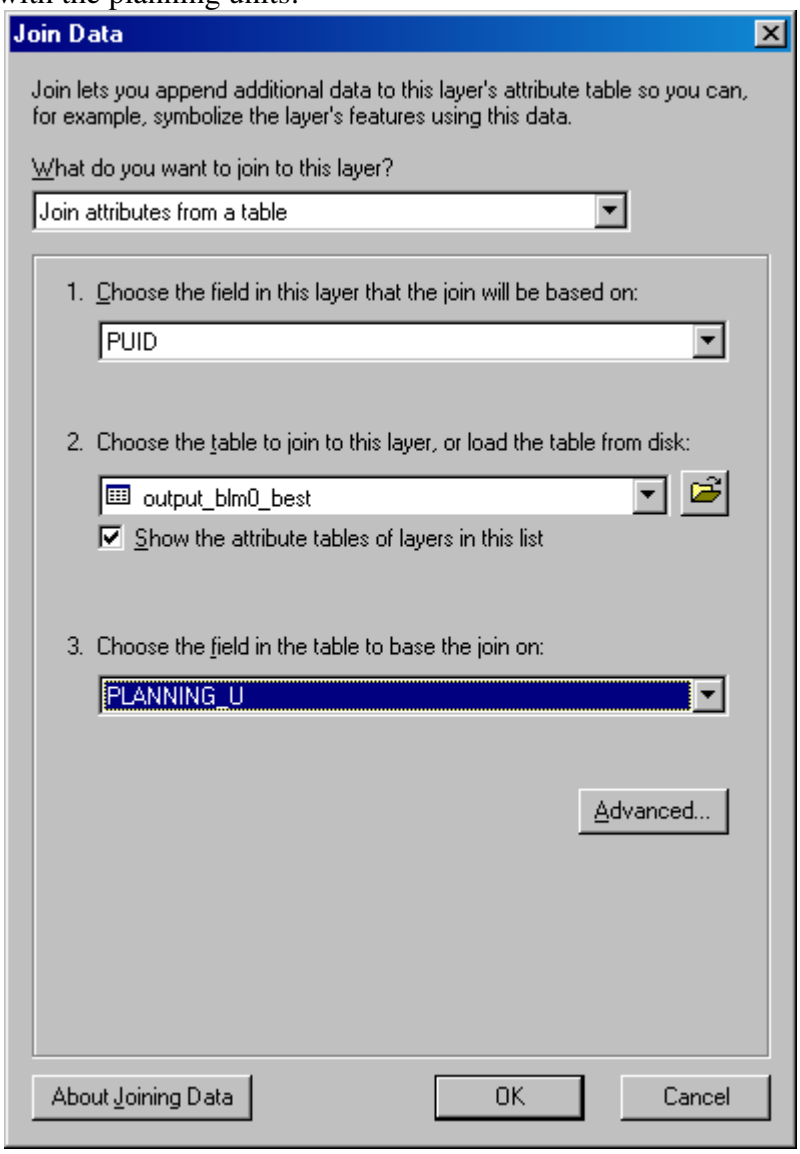
- In Excel, open the output_blm0_ssoln.txt, and output_blm0_best.txt files (both are .csv files). Hint: In the Excel open file dialog, use "Text Files" as the file type, tell excel that the files are "Delimited" and the delimiter is "Comma". After loading the files, you will see the 'best' solution and also the relative proportion of time that different planning units were chosen.
- Auto fit the columns.
- Save files as data base files (*.dbf).



- Click yes in the pop up menu
- Close files in excel.
- Open Marxan101.mxd
- Add the two output tables: output_blm0_best.dbf and output_blm0_ssoln.dbf.

- Right click on the planning unit file pulayer_tas, and select Joins and Relates and then Join.

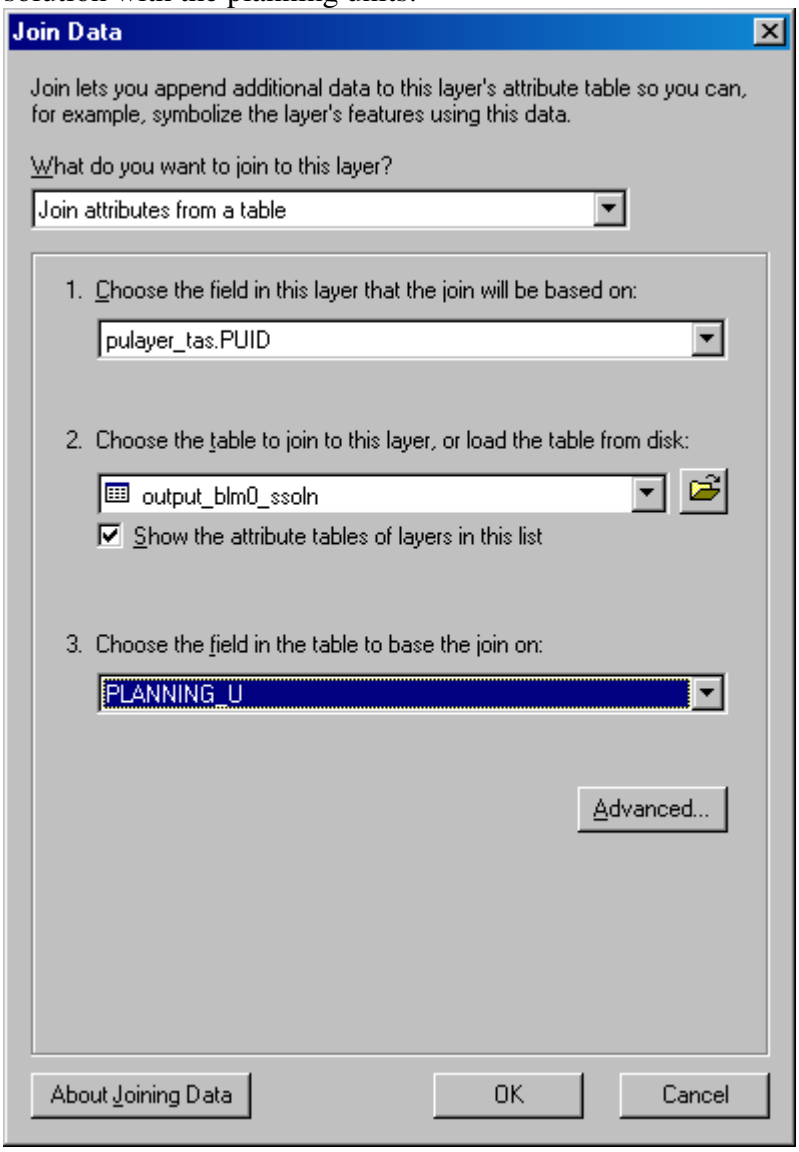
Be sure that your Join Data window has the following parameters to join the best solution with the planning units:



Click OK and when prompted, click Yes to making an index for the table.

- Right click on the planning unit file pulayer_tas, and select Joins and Relates and then Join.

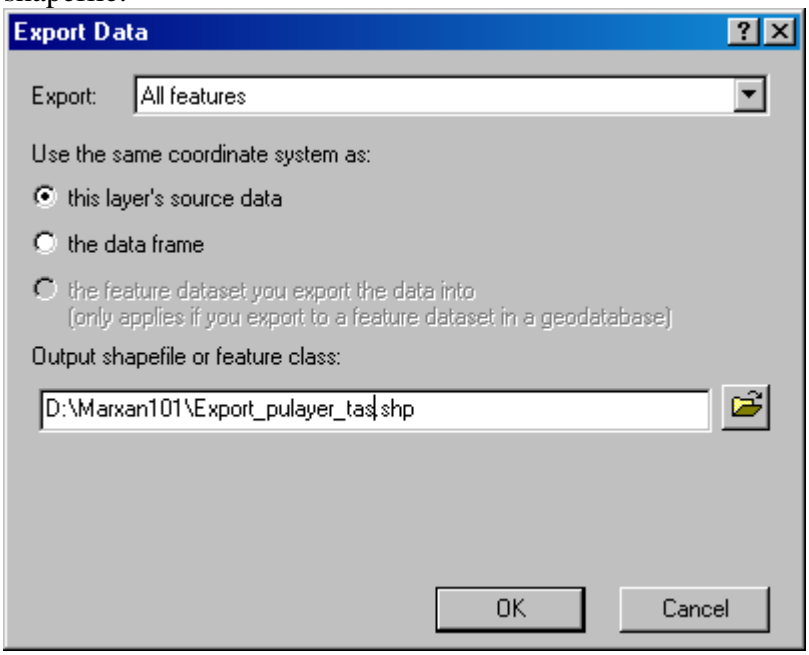
Be sure that your Join Data window has the following parameters to join the summed solution with the planning units:



Click OK and, when prompted, click Yes to making an index for the table.

- Right click on the planning unit file pulayer_tas, and select Data then Export Data.

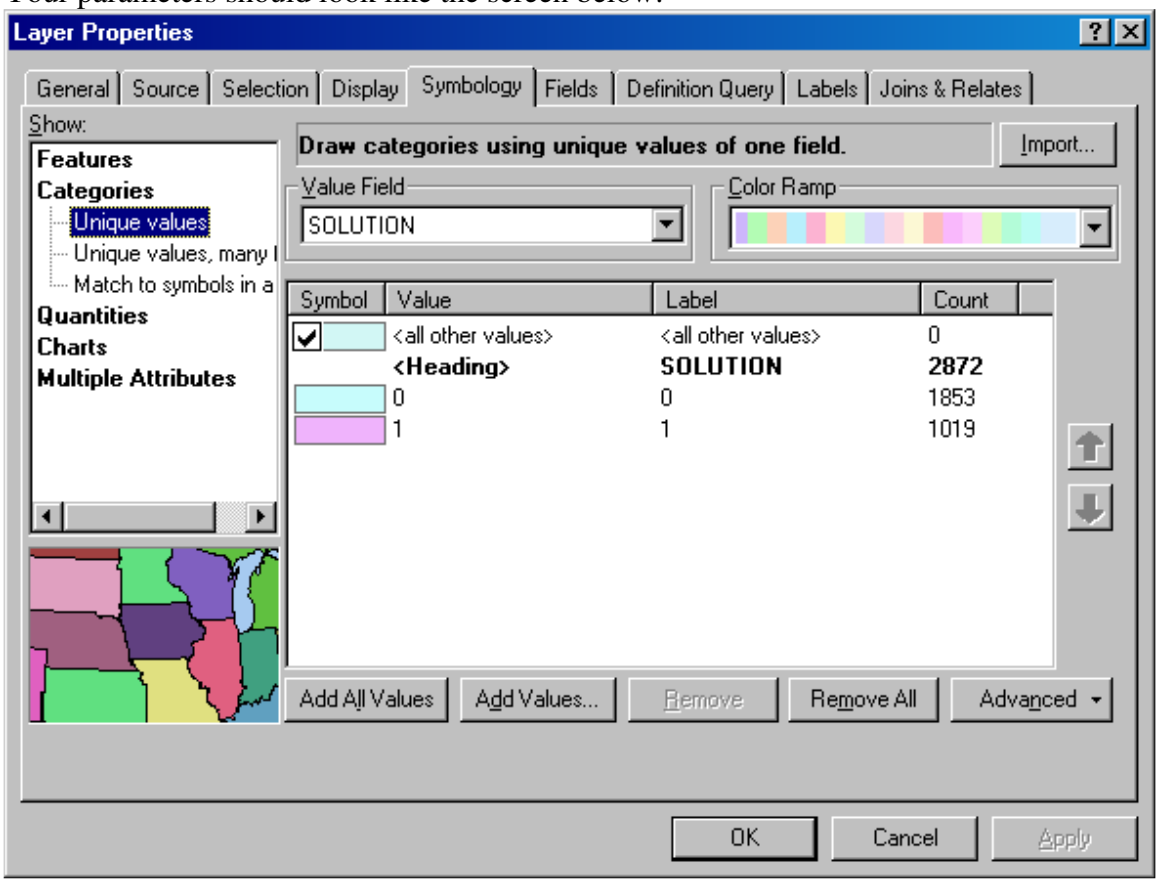
Be sure that your Export window has the following parameters to export the new shapefile:



Click yes to add the layer to the map.

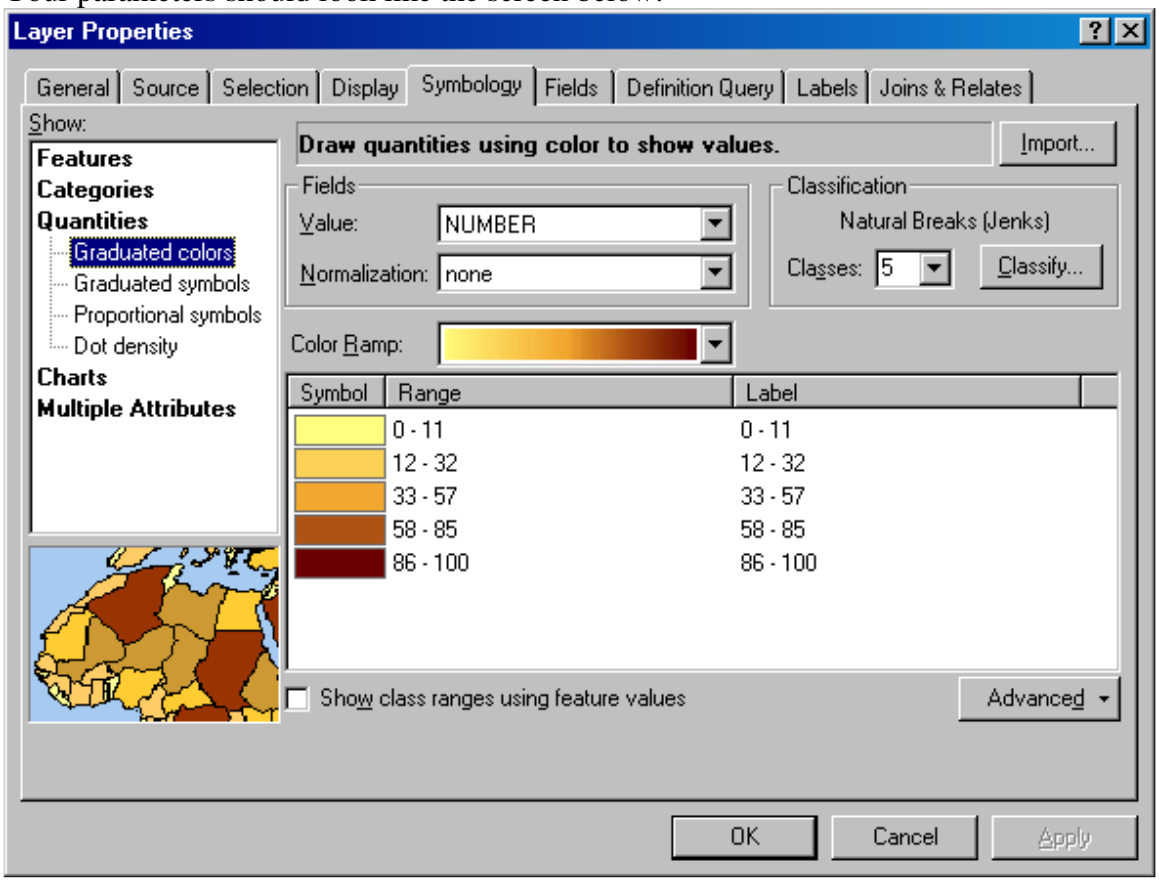
- Create a copy of the new shapefile so that you have two shapefiles in view so you can visualize both the 'best' solution and the relative proportion of time each planning unit was chosen.
- To view the Marxan results, we need to symbolize the shapefile.
- First, change properties of the best solution file to show the 'best' reserve configuration.
- Right click on one of the files Export_pulayer_tas and select Properties
- Click the Symbology tab
- Show Categories
- Select Solution as the value field to display the best solution.
- Click Add All Values
- Click Apply

Your parameters should look like the screen below:



- Then changes properties of the summed solution to show how often each planning unit was chosen.
- Right click on one of the files Export_pulayer_tas and select Properties
- Click the Symbology tab
- Show Quantities
- Select Number as the value field to display the summed solution.

Your parameters should look like the screen below:



Click Apply and then OK

If you finish early, please see the "extra activities" from day 1!

The End