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

STEP-BY-STEP TUTORIAL V1.0: EXTRACTING AND PROCESSING IUCN RED LIST USING ARCGIS 10.0

UN-REDD PROGRAMME

Food and Agriculture Organization of the United Nations

UNDP Empowered lives. Resilient nations.

UNEP

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

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

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

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

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Contents

1. Introduction

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

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

This tutorial demonstrates how a species richness grid could be created using species range data from the IUCN Red List (IUCN, 2013). It provides full instructions of how to select and analyze and export information from the non-spatial species data on the IUCN Red List website and how to further analyze the information along- side the IUCN spatial data using ArcGIS 10.x.

2. Using IUCN Red List species data and generating species richness maps

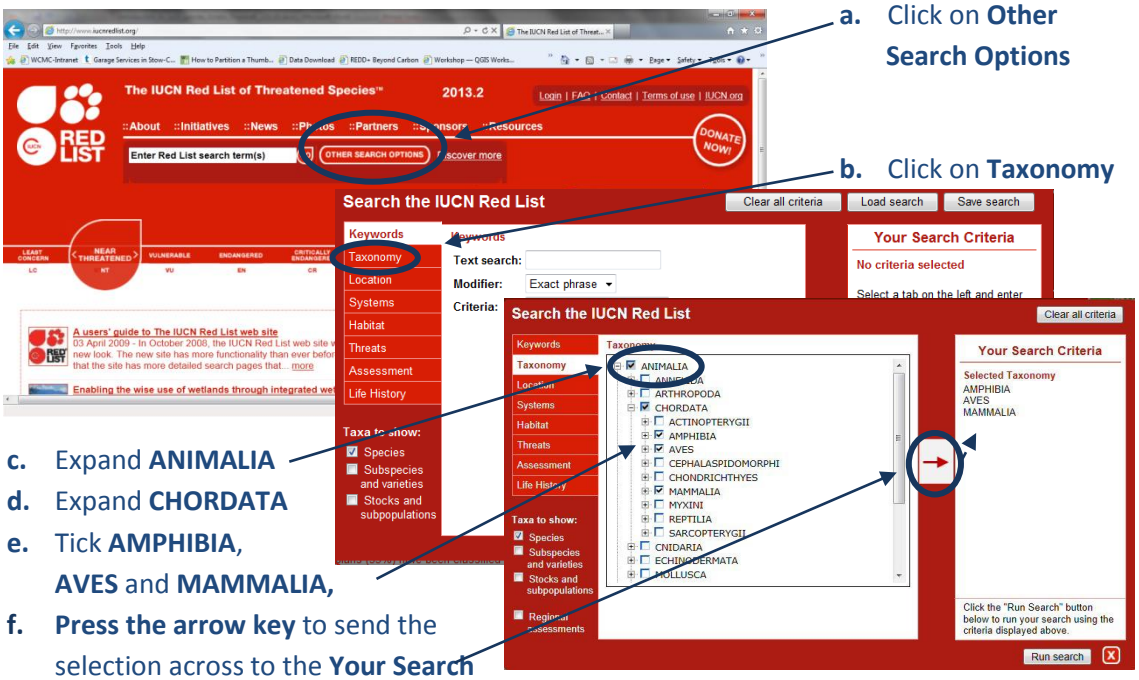
2.1. Selecting and downloading species data from the IUCN Red List website

The IUCN Red List of Threatened Species website allows users to search for and extract tabular information (in comma separated values (CSV) file format) on the status of threatened species. The website provides a user friendly interface and gives the user flexibility to customize searches based on a range of criteria. Users must register with the website to save and export customized searches.

2.1.1. Searching for non-spatial data

Open a web browser and go to the IUCN Red List website at http://www.iucnredlist.org/.

This search below is an EXAMPLE search for Mammals with threat status of Critically Endangered (CR) and Endangered (EN).



a. Click on **Other Search Options**

b. Click on **Taxonomy**

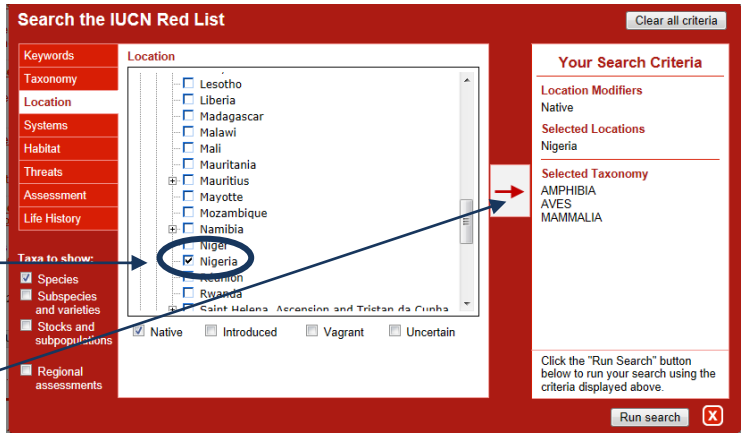
c. Expand **ANIMALIA**

d. Expand **CHORDATA**

e. Tick **AMPHIBIA, AVES** and **MAMMALIA,**

f. **Press the arrow key** to send the selection across to the **Your Search Criteria** panel

You may want to limit the search to a single location e.g. a single country or group of locations only.



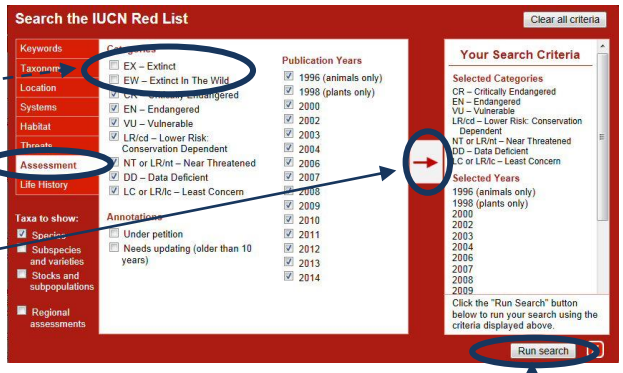
g. Click on **Location,** expand **land regions,** expand and tick the **country of interest**

h. **Press the arrow key** to send the selection across to the **Your Search Criteria** panel

i. Next Click on **Assessment**

j. Untick categories not required i.e. in this example **unticking EX and EW** and keeping the rest.

k. **Press the arrow key** to send the selection across to the **Your Search Criteria** panel

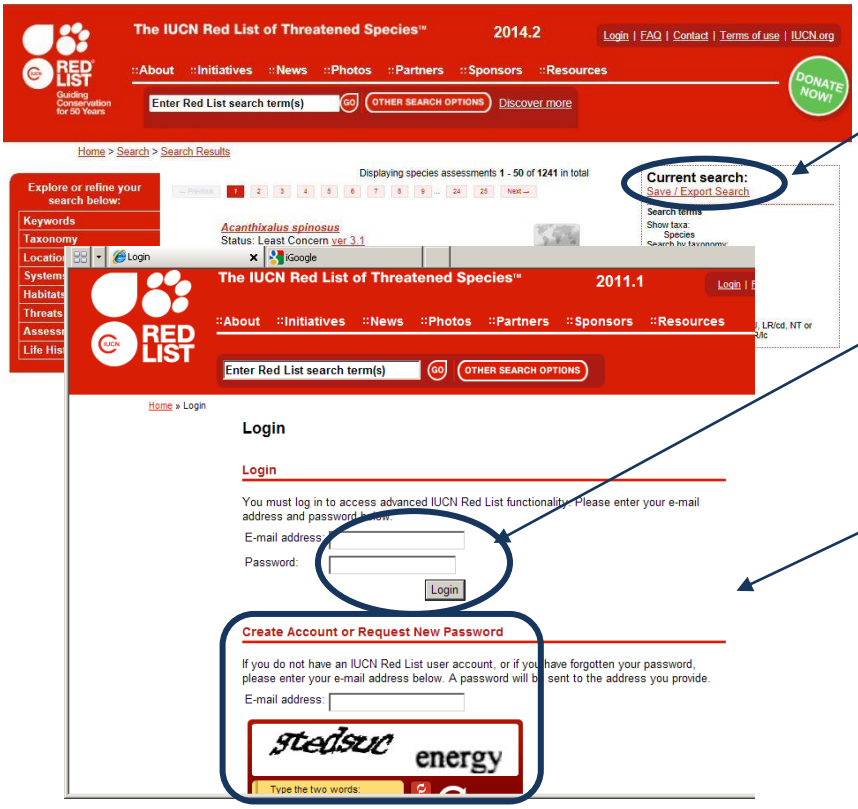


l. Click **Run search**

This search will result in a list of species within the AMPHIBIA, AVES and MAMMALIA taxonomic groups that have critically endangered, Endangered, Vulnerable, Lower Risk: Conservation Dependent, Near Threatened, Data Deficient or Least Concern Red List status. The search will produce in a list of species containing and additional attribute data, including the threat status of each of the species.

There are other criteria that you may want to include. For example, to limit the search to species dependent upon a particular habitat type you would click on Habitat, the expand and tick the relevant habitat type and send that across to the search criteria panel.

2.1.2. Save the search and exporting to CSV format



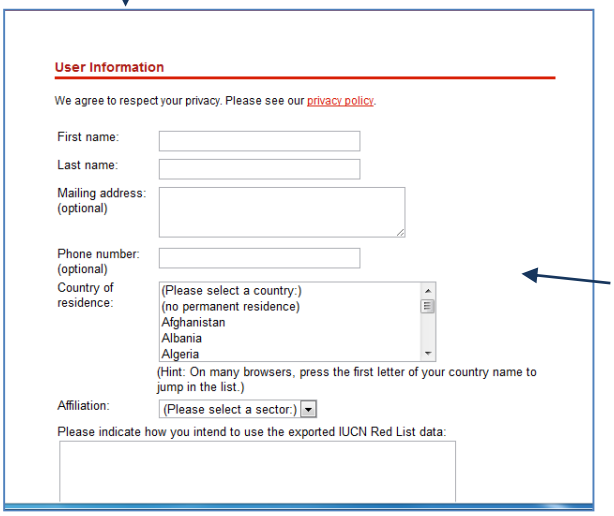
a. Click **Save/Export Search**

b. If already registered, **fill in your email address and password** and click **login**

c. If you have not yet registered, you need to **create an account (see box below)**

An account is needed in order to save and export the search results.

d. New users will be asked to fill out the details in the box below

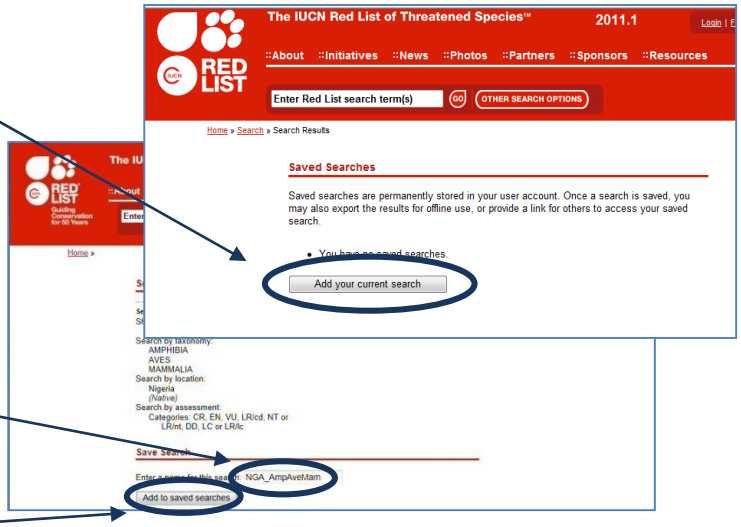


The first time new users export a search, they are required to fill out some information about themselves and the intended use of the data

Click on **Supply your information** and fill in the requested details

Click on **Submit**

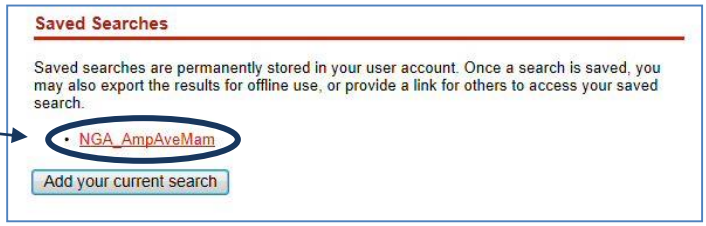
e. Once registered and/or logged in, Click on **Add your currentSearch**

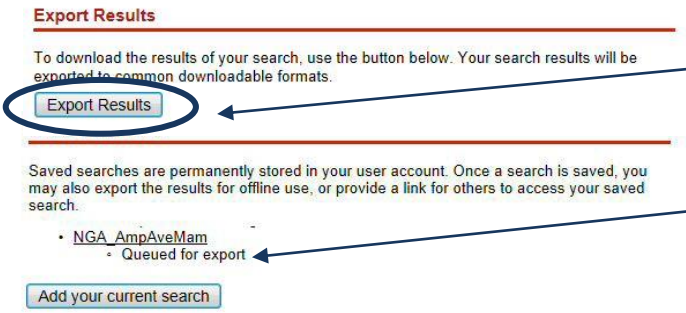


f. Give the search a name e.g. **NGA_AmpAveMam** in this example

g. Click **add to saved searches**

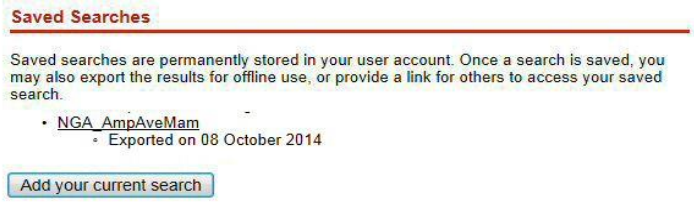
h. Click on the **saved search** e.g. **NGA_AmpAveMam** in this example





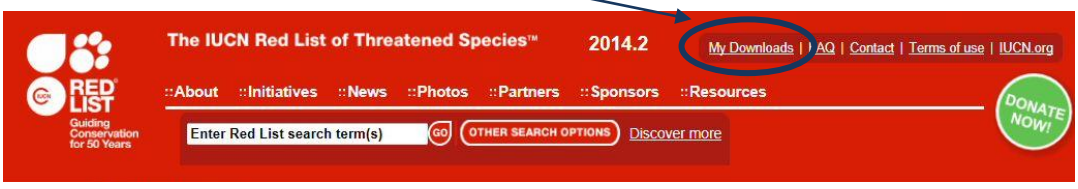
i. **Scroll down to Export results** and click on **Export results**

The dataset will then give a status of Queued for export.

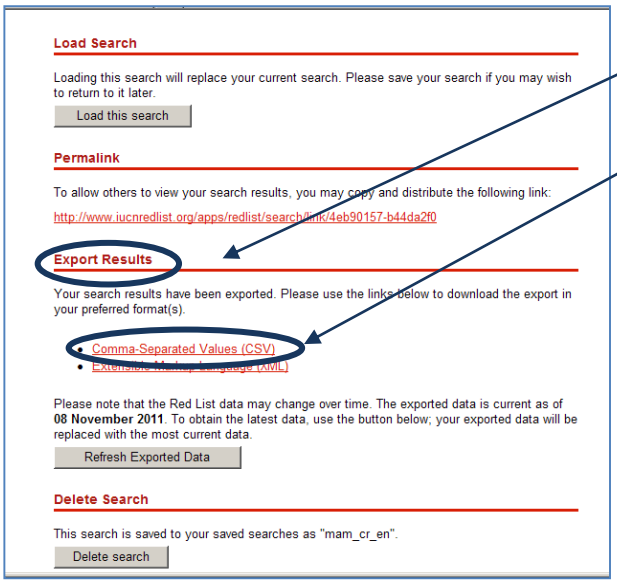


An email will be sent to you once it has been exported. This is usually within minutes but may take hours for large searches).

j. **Refresh the browser** to see the status change to show the export is complete or if it is taking a long time log out and once the **email has been received**, log back in to the Red List website and click on the **My Downloads** Tab to get back to your saved searches.



k. Click on the **exported search** e.g. **NGA_AmpAveMam** in this example



l. **Scroll down** to the **Export results**

m. Click on **Comma-Separated Values (CSV)** and the zip file will download

n. If the download has placed the file in a general download folder move the zip file to a more suitable location e.g. in a project folder

o. **Rename** the zip file to somthing sensible e.g. **NGA_AmpAveMam.zip** in this example

p. **Right click on zip folder**, extract the csv file

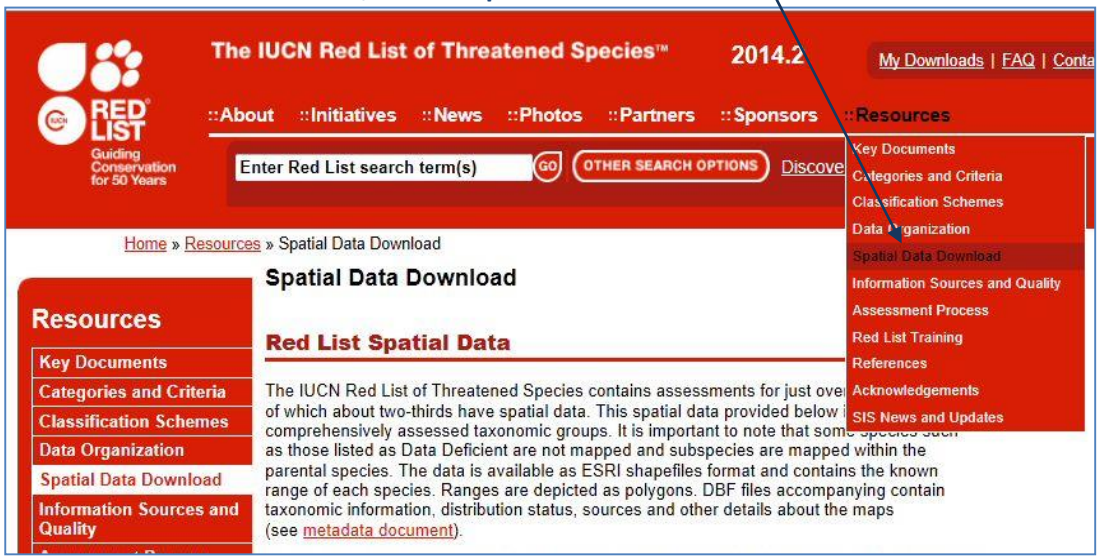
q. **Rename** the csv file e.g. **NGA_AmpAveMam.csv** in this example

2.1.3. Download the IUCN Red List spatial data layers

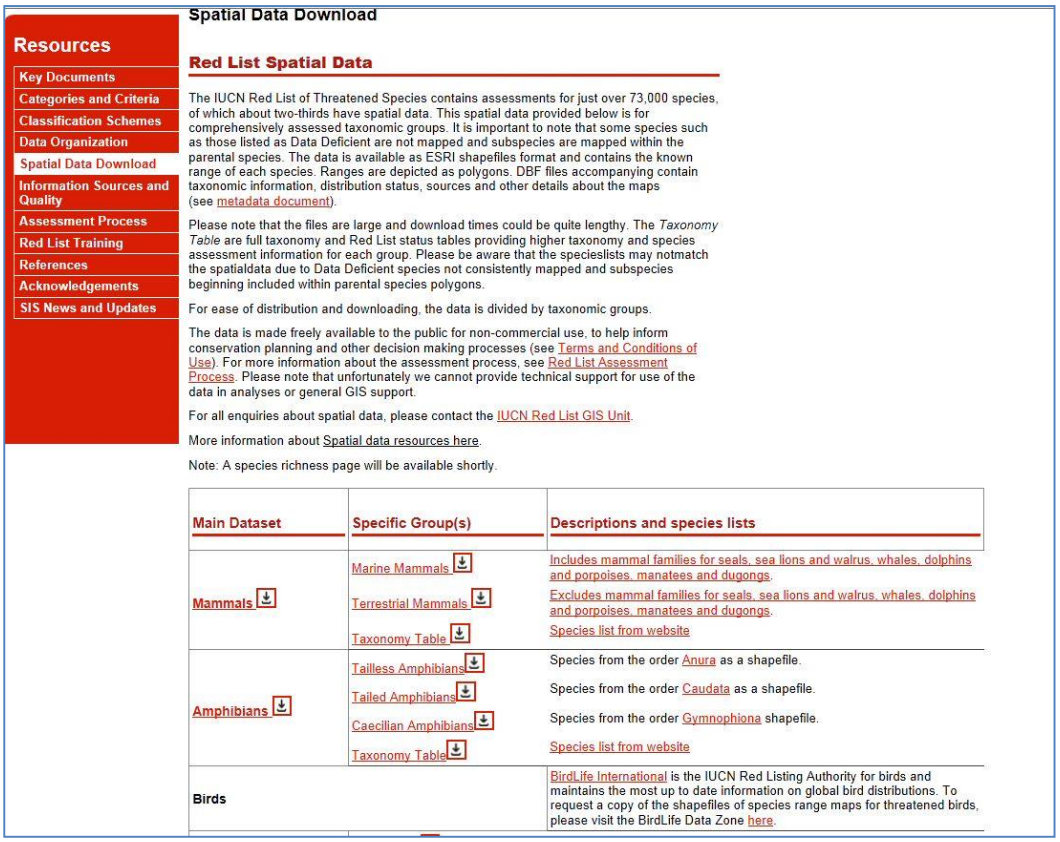
The next steps are for downloading spatial data. It is only possible to download the whole global dataset. It is not possible to filter by county prior to download. It is important to note that some of the spatial datasets are very large. If you have received the spatial data directly from IUCN you can skip this section.

a. Open a web browser and go to the IUCN Red List website at http://www.iucnredlist.org/

b. From the **Resources tab,** click on **Spatial Data Download**



c. **Scroll down** on the Spatial Data page to the **Datasets table**



Spatial Data Download

Resources

- Key Documents
- Categories and Criteria
- Classification Schemes
- Data Organization
- Spatial Data Download
- Information Sources and Quality
- Assessment Process
- Red List Training
- References
- Acknowledgements
- SIS News and Updates

Red List Spatial Data

The IUCN Red List of Threatened Species contains assessments for just over 73,000 species, of which about two-thirds have spatial data. This spatial data provided below is for comprehensively assessed taxonomic groups. It is important to note that some species such as those listed as Data Deficient are not mapped and subspecies are mapped within the parental species. The data is available as ESRI shapefiles format and contains the known range of each species. Ranges are depicted as polygons. DBF files accompanying contain taxonomic information, distribution status, sources and other details about the maps (see metadata document).

Please note that the files are large and download times could be quite lengthy. The *Taxonomy Table* are full taxonomy and Red List status tables providing higher taxonomy and species assessment information for each group. Please be aware that the specieslists may notmatch the spatialdata due to Data Deficient species not consistently mapped and subspecies beginning included within parental species polygons.

For ease of distribution and downloading, the data is divided by taxonomic groups.

The data is made freely available to the public for non-commercial use, to help inform conservation planning and other decision making processes (see Terms and Conditions of Use). For more information about the assessment process, see Red List Assessment Process. Please note that unfortunately we cannot provide technical support for use of the data in analyses or general GIS support.

For all enquiries about spatial data, please contact the IUCN Red List GIS Unit.

More information about Spatial data resources here.

Note: A species richness page will be available shortly.

Main Dataset	Specific Group(s)	Descriptions and species lists
Mammals	Marine Mammals	Includes mammal families for seals, sea lions and walrus, whales, dolphins and porpoises, manatees and dugongs.
	Terrestrial Mammals	Excludes mammal families for seals, sea lions and walrus, whales, dolphins and porpoises, manatees and dugongs.
	Taxonomy Table	Species list from website
Amphibians	Tailless Amphibians	Species from the order Anura as a shapefile.
	Tailed Amphibians	Species from the order Caudata as a shapefile.
	Caecilian Amphibians	Species from the order Gymnophiona shapefile.
	Taxonomy Table	Species list from website
Birds		BirdLife International is the IUCN Red Listing Authority for birds and maintains the most up to date information on global bird distributions. To request a copy of the shapefiles of species range maps for threatened birds, please visit the BirdLife Data Zone here.

d. **Click the links** to navigate to each dataset and download the following global datasets:

- Mammals
- Amphibians
- Birds (via the link to the BirdLife Data Zone)

(Leave Reptiles for now as assessment is not yet complete for all species)

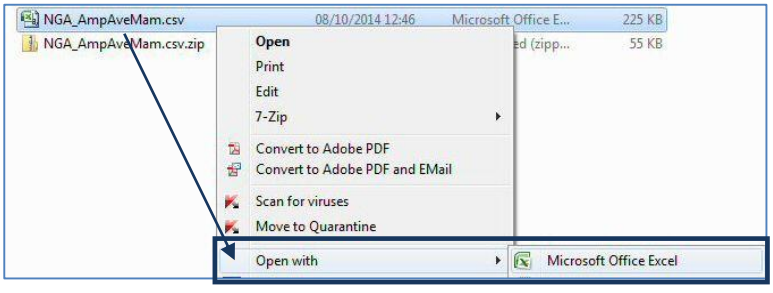
These files are all stored in geographic coordinate system (EPSG: 4326). Be aware the files are very large and will take some time to download.

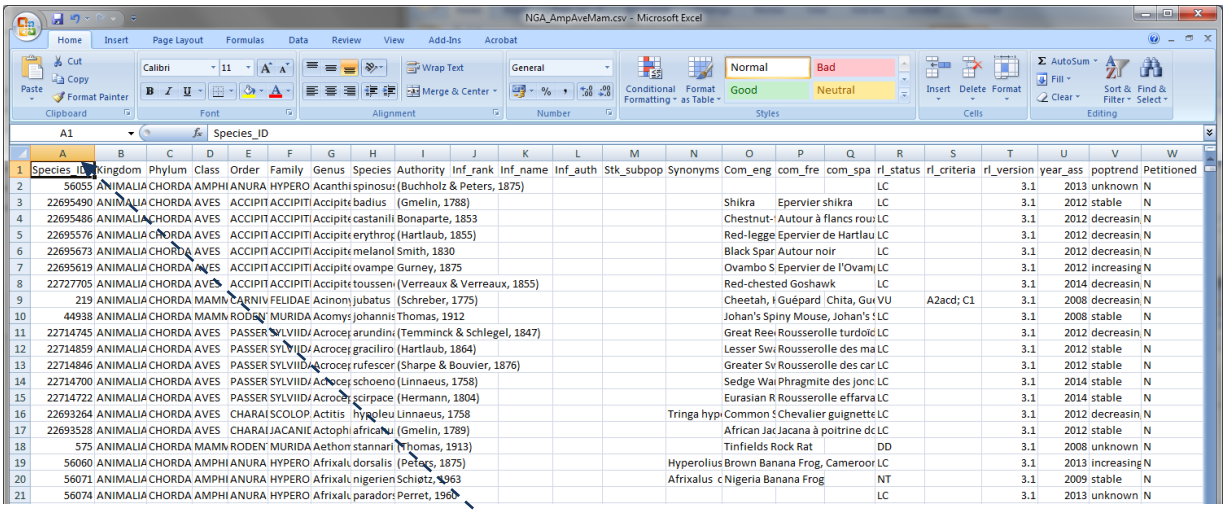
Note: If you have received the spatial data directly from IUCN they may have delivered as a single geodatabase containing all taxa in a single feature class rather than as separate files.

2.2. Vector Spatial Data Selection and Preparation

2.2.1. Format species CSV file in preparation for querying the spatial data

a. Open the 'exported search' results csv file (that was downloaded in section 2.3 step m) e.g. **NGA_AmpAveMam.CSV in this example. Open the file Excel** (or if using completely open source software in **Gnumeric or Libre Office Calc)** (The Screengrab examples below use Excel.





Species_ID	Kingdom	Phylum	Class	Order	Family	Genus	Species	Authority	Inf_rank	Inf_name	Inf_auth	Stk_subpop	Synonyms	Com_eng	com_fre	com_spa	rl_status	rl_criteria	rl_version	year_ass	poptrend	Petitioned
56055	ANIMALIA	CHORDA	AMPHI	ANURA	HYPERO	Acanthi	spinosus	(Buchholz & Peters, 1875)									LC		3.1	2013	unknown	N
22695490	ANIMALIA	CHORDA	AVES	ACCIPIT	ACCIPIT	Accipite	badius	(Gmelin, 1788)						Shikra	Epervier	shikra	LC		3.1	2012	stable	N
22695486	ANIMALIA	CHORDA	AVES	ACCIPIT	ACCIPIT	Accipite	castanili	Bonaparte, 1853						Chestnut-	Autour à flancs rou		LC		3.1	2012	decreasin	N
22695576	ANIMALIA	CHORDA	AVES	ACCIPIT	ACCIPIT	Accipite	erythrop	(Hartlaub, 1855)						Red-legge	Epervier de Hartlau		LC		3.1	2012	decreasin	N
22695673	ANIMALIA	CHORDA	AVES	ACCIPIT	ACCIPIT	Accipite	melanol	Smith, 1830						Black Spar	Autour noir		LC		3.1	2012	decreasin	N
22695619	ANIMALIA	CHORDA	AVES	ACCIPIT	ACCIPIT	Accipite	ovampe	Gurney, 1875						Ovambo S	Epervier de l'Ovam		LC		3.1	2012	increasing	N
22727705	ANIMALIA	CHORDA	AVES	ACCIPIT	ACCIPIT	Accipite	toussen	(Verreaux & Verreaux, 1855)						Red-chested Goshawk			LC		3.1	2014	decreasin	N
219	ANIMALIA	CHORDA	MAMM	CARNIV	FELIDAE	Acinony	jubatus	(Schreber, 1775)						Cheetah, F	Guépard	Chita, Gue	VU	A2acd; C1	3.1	2008	decreasin	N
44938	ANIMALIA	CHORDA	MAMM	RODEN	MURIDA	Acomys	johannis	Thomas, 1912						Johan's Spiny Mouse, Johan's S			LC		3.1	2008	stable	N
22714745	ANIMALIA	CHORDA	AVES	PASSER	SYLVIID	Acrocep	arundina	(Temminck & Schlegel, 1847)						Great Ree	Rousserolle turdoid		LC		3.1	2012	decreasin	N
22714859	ANIMALIA	CHORDA	AVES	PASSER	SYLVIID	Acrocep	graciliro	(Hartlaub, 1864)						Lesser Swa	Rousserolle des ma		LC		3.1	2012	stable	N
22714846	ANIMALIA	CHORDA	AVES	PASSER	SYLVIID	Acrocep	rufescer	(Sharpe & Bouvier, 1876)						Greater Sv	Rousserolle des car		LC		3.1	2012	stable	N
22714700	ANIMALIA	CHORDA	AVES	PASSER	SYLVIID	Acrocep	schoeno	(Linnaeus, 1758)						Sedge Wa	Phragmite des jonc		LC		3.1	2014	stable	N
22714722	ANIMALIA	CHORDA	AVES	PASSER	SYLVIID	Acrocep	scirpace	(Hermann, 1804)						Eurasian R	Rousserolle effarva		LC		3.1	2014	stable	N
22693264	ANIMALIA	CHORDA	AVES	CHARAI	SCOLOP	Actitis	hypoleu	Linnaeus, 1758					Tringa hyp	Common S	Chevalier guignette		LC		3.1	2012	decreasin	N
22693528	ANIMALIA	CHORDA	AVES	CHARAI	JACANI	Actophi	african	(Gmelin, 1789)						African Jac	Jacana à poitrine dc		LC		3.1	2012	stable	N
575	ANIMALIA	CHORDA	MAMM	RODEN	MURIDA	Aethom	stannari	Thomas, 1913)						Tinfields Rock Rat			DD		3.1	2008	unknown	N
56060	ANIMALIA	CHORDA	AMPHI	ANURA	HYPERO	Afrixalu	dorsalis	(Peters, 1875)					Hyperolius	Brown Banana Frog, Cameroor			LC		3.1	2013	increasing	N
56071	ANIMALIA	CHORDA	AMPHI	ANURA	HYPERO	Afrixalu	nigerien	Schiøtz, 1963					Afrixalus c	Nigeria Banana Frog			NT		3.1	2009	stable	N
56074	ANIMALIA	CHORDA	AMPHI	ANURA	HYPERO	Afrixalu	paradox	Perret, 1960									LC		3.1	2013	unknown	N

b. Scroll along the **column headings** of the table. Some will need to be changed as GIS software such as ArcGIS will not accept them. **Change the ones listed below in red**

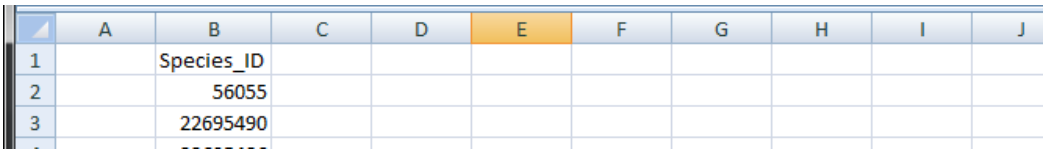
OLD Field Name		New Field Name
Species ID	=	Species_ID
Kingdom	=	Kingdom
Phylum	=	Phylum
Class	=	Class
Order	=	Order
Family	=	Family
Genus	=	Genus
Species	=	Species
Binomial	=	Binomial
Authority	=	Authority
Infraspecific rank	=	Inf_rank
Infraspecific name	=	Inf_name
Infraspecific authority	=	inf_auth
Stock/subpopulation	=	stk_subpop
Synonyms	=	Synonyms
Common names (Eng)	=	com_eng
Common names (Fre)	=	com_fre
Common names (Spa)	=	com_spa
Red List status	=	rl_status
Red List criteria	=	rl_criteria
Red List criteria version	=	rl_version
Year assessed	=	year_ass
Population trend	=	poptrend
Petitioned	=	Petitioned

c. Click **File> Save** to save the file (keeping the file format as csv). If it asks if you want to keep the file in this format **click yes**

Keep the CSV file open as it will be used in section 2.6 where we will use the 'species_id' column to prepare an SQL query to be used in ArcGIS.

The next steps will prepare an SQL query which will be used in ArcGIS to select out the polygons from the large spatial dataset which are in the species list. This method is being used rather than using a 'join' to join the species list to the spatial data because the join function often fails or causes errors on this very large spatial dataset.

d. Go back to the 'species list csv file. e.g. **NGA_AmpAveMam.CSV**
Then **copy and paste** the Species_ID column into **column B** a **new** excel worksheet



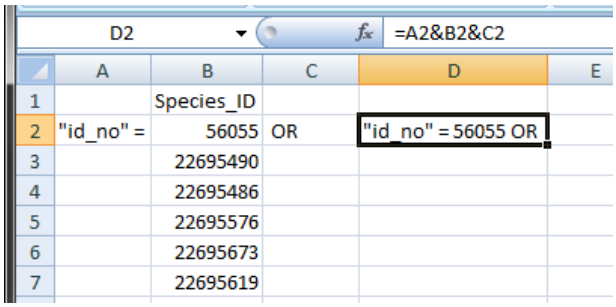
	A	B	C	D	E	F	G	H	I	J
1		Species_ID								
2		56055								
3		22695490								

e. In **row 2** of **column A** type **"id_no" =** (make sure you put a space after the equals sign as this is important for the SQL syntax we are creating

f. **In row2** of **column C** type an **OR** (this time make sure you put a space **before** the OR as this is important for the SQL syntax we are creating.)

g. **In row 2** of **column D** type **=A2&B2&C2**

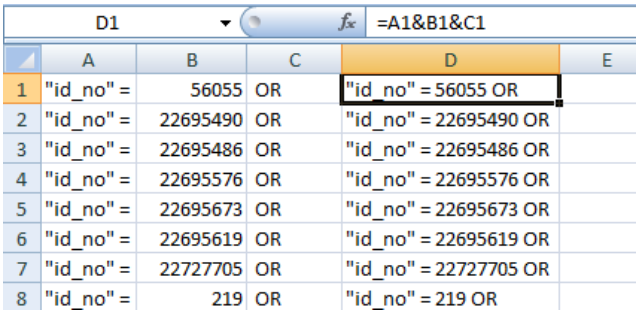
h. Next **fill Columns A, B, C and D** by double clicking on the bottom right hand corner of **each cell in row 2**



D2 =A2&B2&C2

	A	B	C	D	E
1		Species_ID			
2	"id_no" =	56055	OR	"id_no" = 56055 OR	
3		22695490			
4		22695486			
5		22695576			
6		22695673			
7		22695619			

i. Delete the entire first row so that the file now looks similar to the illustration below



D1 =A1&B1&C1

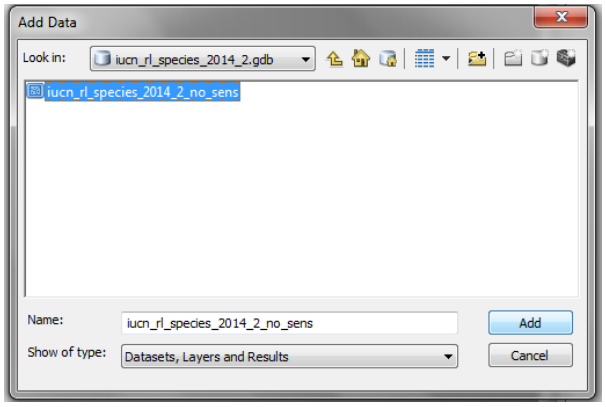
	A	B	C	D	E
1	"id_no" =	56055	OR	"id_no" = 56055 OR	
2	"id_no" =	22695490	OR	"id_no" = 22695490 OR	
3	"id_no" =	22695486	OR	"id_no" = 22695486 OR	
4	"id_no" =	22695576	OR	"id_no" = 22695576 OR	
5	"id_no" =	22695673	OR	"id_no" = 22695673 OR	
6	"id_no" =	22695619	OR	"id_no" = 22695619 OR	
7	"id_no" =	22727705	OR	"id_no" = 22727705 OR	
8	"id_no" =	219	OR	"id_no" = 219 OR	

j. **Save** the worksheet for later to a **new file** e.g. in this example called **formatted_for_SQL_query.xlsx** and **close**

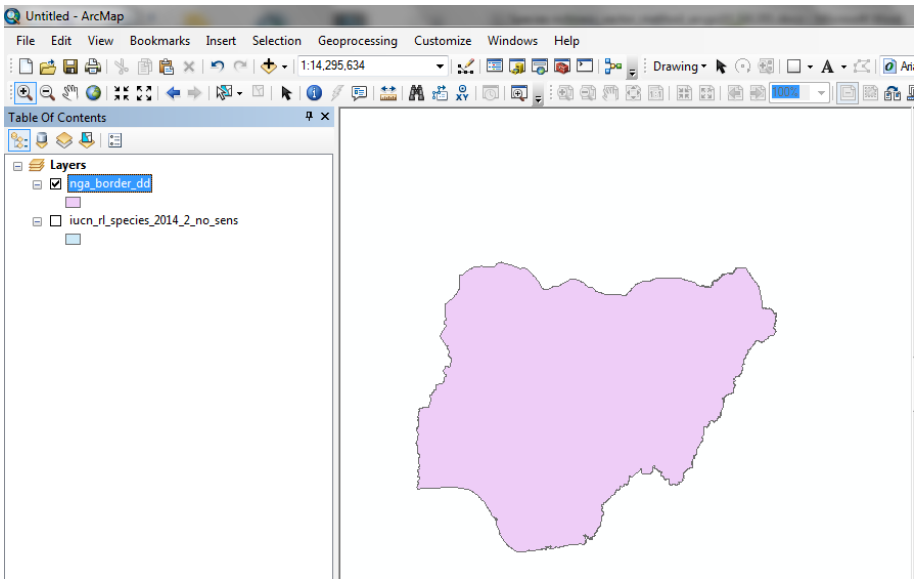
2.2.2. Use SQL query to select species of interest from spatial dataset

The next section prepares the spatial data ready for analysis. The IUCN spatial dataset is a complex dataset as it contains many overlapping polygons for each species for the entire world. Even subsetting the dataset for your area of interest can be problematic so these set of instructions are important steps to make sure the analysis runs as smoothly as possible and to reduce the risk of errors in processing.

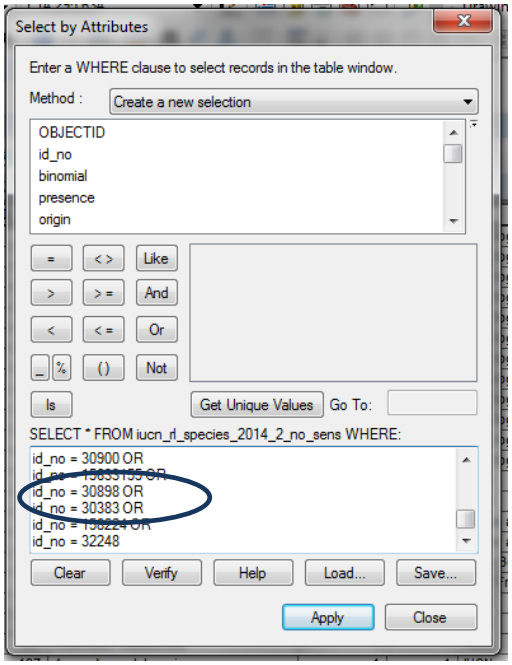
a. Open **ArcGIS**
b. Add in the **IUCN Species spatial dataset(s)** (the data are in geographic coordinate system (i.e. WGS84)



c. **Untick** the dataset in the table of contents to stop it drawing
d. **Add** in a polygon dataset of the area of interest (e.g. country boundary). e.g. in this example **nga_border_dd.shp.** Make sure the dataset is in geographic coordinate system (i.e. WGS84) to match the coordinate system of the IUCN spatial data
e. **Click** on the IUCN spatial dataset in the table of contents to make it the active layer e.g. in this example **iucn_rl_species_2014_2_no_sens**



f. Right click on the IUCN spatial dataset and Click **Open attribute table.** Click on the top left button, and click **select by attributes.**

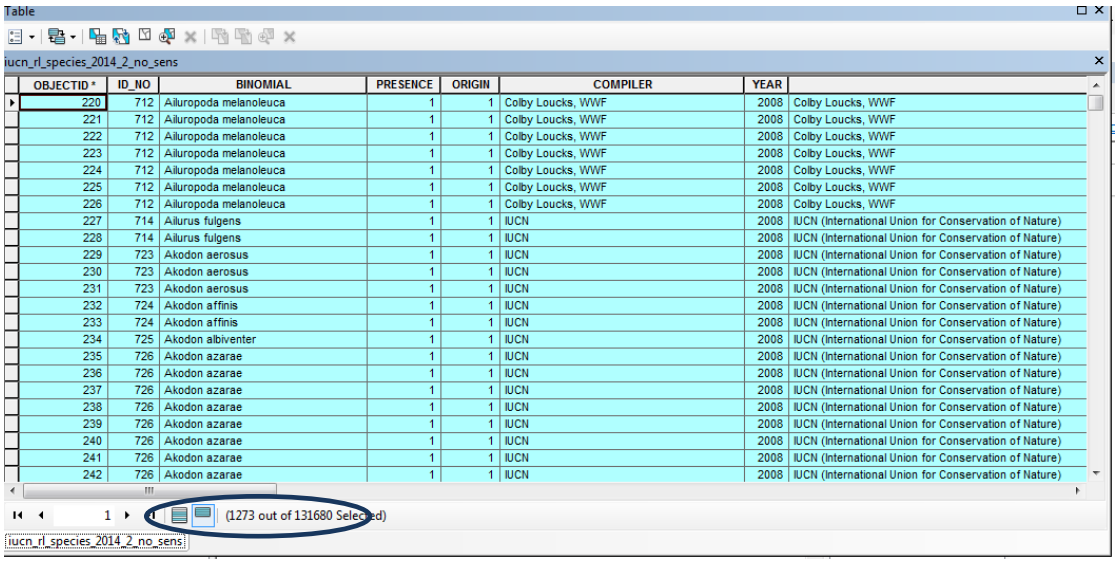


g. A Query window appears**. Copy and paste** into the Query window **the SQL query** that you created earlier. This will select out only those species present in the exported species list

h. **Remove** the **OR** from the last row and click **Verify** to check you got the syntax correct. This may take 5 - 10 minutes or longer depending on how many records are being selected.

i. **Click Apply** to apply the filter to the IUCN spatial dataset. This may take 5 - 10 minutes or longer depending on how many records are being selected.

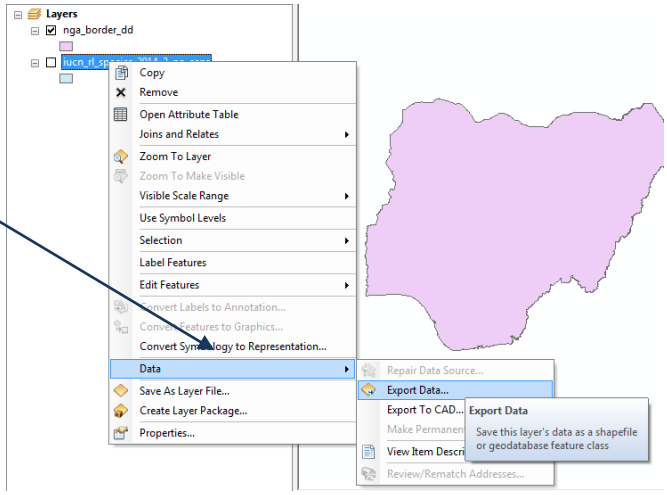
j. The attribute table will show the filtered records highlighted in blue, and the number of records that have been selected.

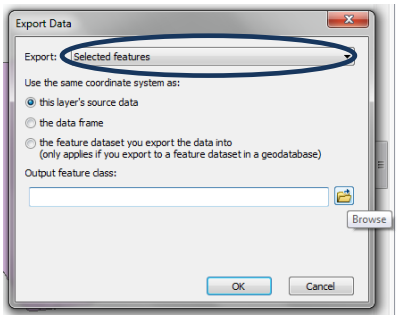


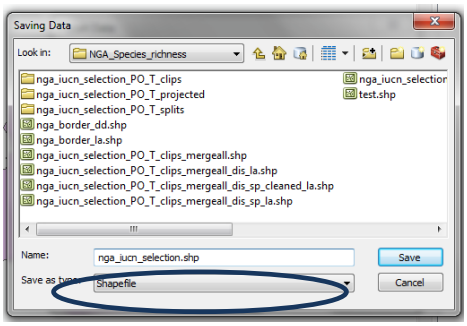
OBJECTID *	ID_NO	BINOMIAL	PRESENCE	ORIGIN	COMPILER	YEAR	
220	712	Ailuropoda melanoleuca	1	1	Colby Loucks, WWF	2008	Colby Loucks, WWF
221	712	Ailuropoda melanoleuca	1	1	Colby Loucks, WWF	2008	Colby Loucks, WWF
222	712	Ailuropoda melanoleuca	1	1	Colby Loucks, WWF	2008	Colby Loucks, WWF
223	712	Ailuropoda melanoleuca	1	1	Colby Loucks, WWF	2008	Colby Loucks, WWF
224	712	Ailuropoda melanoleuca	1	1	Colby Loucks, WWF	2008	Colby Loucks, WWF
225	712	Ailuropoda melanoleuca	1	1	Colby Loucks, WWF	2008	Colby Loucks, WWF
226	712	Ailuropoda melanoleuca	1	1	Colby Loucks, WWF	2008	Colby Loucks, WWF
227	714	Ailurus fulgens	1	1	IUCN	2008	IUCN (International Union for Conservation of Nature)
228	714	Ailurus fulgens	1	1	IUCN	2008	IUCN (International Union for Conservation of Nature)
229	723	Akodon aerosus	1	1	IUCN	2008	IUCN (International Union for Conservation of Nature)
230	723	Akodon aerosus	1	1	IUCN	2008	IUCN (International Union for Conservation of Nature)
231	723	Akodon aerosus	1	1	IUCN	2008	IUCN (International Union for Conservation of Nature)
232	724	Akodon affinis	1	1	IUCN	2008	IUCN (International Union for Conservation of Nature)
233	724	Akodon affinis	1	1	IUCN	2008	IUCN (International Union for Conservation of Nature)
234	725	Akodon albiventer	1	1	IUCN	2008	IUCN (International Union for Conservation of Nature)
235	726	Akodon azarae	1	1	IUCN	2008	IUCN (International Union for Conservation of Nature)
236	726	Akodon azarae	1	1	IUCN	2008	IUCN (International Union for Conservation of Nature)
237	726	Akodon azarae	1	1	IUCN	2008	IUCN (International Union for Conservation of Nature)
238	726	Akodon azarae	1	1	IUCN	2008	IUCN (International Union for Conservation of Nature)
239	726	Akodon azarae	1	1	IUCN	2008	IUCN (International Union for Conservation of Nature)
240	726	Akodon azarae	1	1	IUCN	2008	IUCN (International Union for Conservation of Nature)
241	726	Akodon azarae	1	1	IUCN	2008	IUCN (International Union for Conservation of Nature)
242	726	Akodon azarae	1	1	IUCN	2008	IUCN (International Union for Conservation of Nature)

k. **Close** the attribute table

l. **Right click** on the IUCN spatial dataset and **Click Data > Export Data**

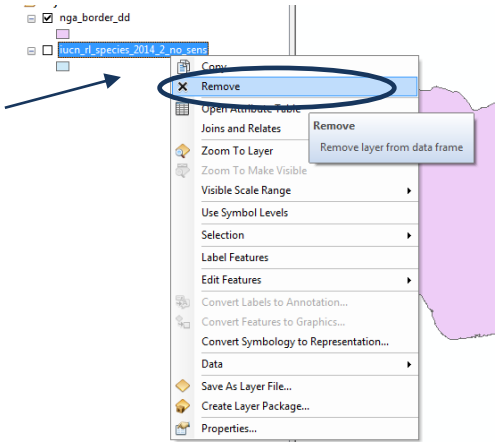






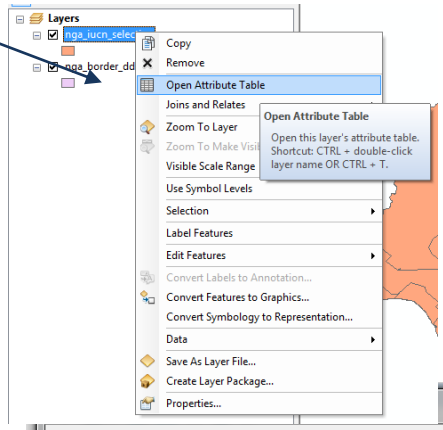
m. Ensure that you are exporting the **selected features,** then **save** the file with a new name, **e.g. nga_iucn_selection.shp** (as file type shapefile) in this example and **Click OK.** It will ask you if you would like to add the new file to dataframe. **Click OK.**

n. **Right click and Remove** the IUCN spatial dataset in the table of contents e.g. in this example remove **iucn_rl_species_2014_2_no_sens**



2.2.3. From the previous selection select out the current native species range

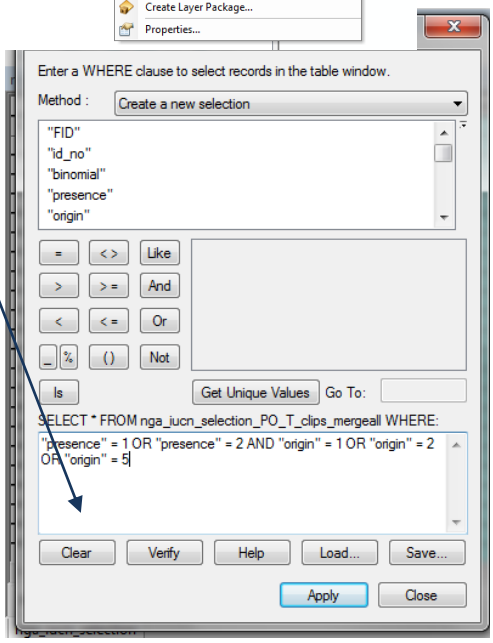
a. Right click on the newly added subset species layer **e.g. nga_iucn_selection.shp** in this example and and click **Open attribute table.** Click on the top left button and click **Select by Attributes.**



b. To only include categories as advised by IUCN Presence - 1 (extant); 2 (probably extant); 6 (presence uncertain) Origin – 1 (native); 2 (reintroduced); 5 (origin uncertain)

Put the following expression into the Select by Attributes window:-

("presence" = 1 OR "presence" = 2 OR "presence" = 6) AND ("origin" = 1 OR "origin" = 2 OR "origin" = 5)



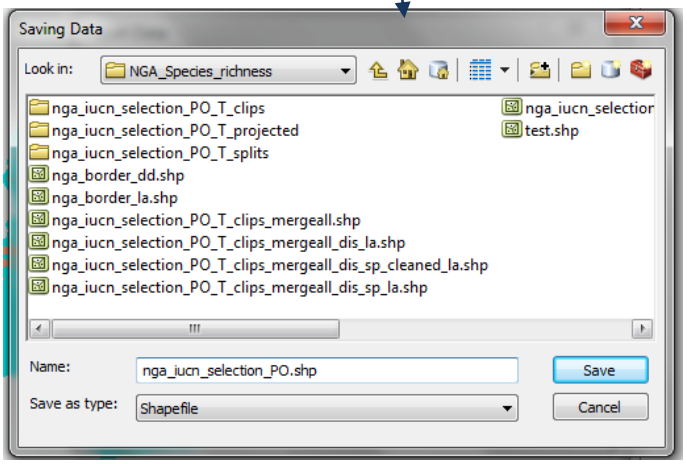
c. Click **Apply**

d. Click **Close** to close the Select by Attributes window.

e. As per step 2.2.2. (j), the attribute table will show the filtered records highlighted in blue, and the number of records that have been selected.

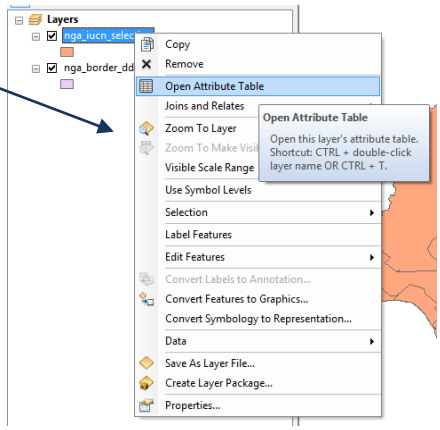
f. Close the attribute table. **Right click** on the IUCN spatial dataset e.g. **nga_iucn_selection.shp** in this example and **Click Data > Export Data.**

g. Ensure that you are exporting the **selected features,** then **save** the file with a new name, **e.g. nga_iucn_selection_PO.shp** (as file type shapefile) in this example and **Click Save.** It will ask you if you would like to add the new file to dataframe. **Click OK.**

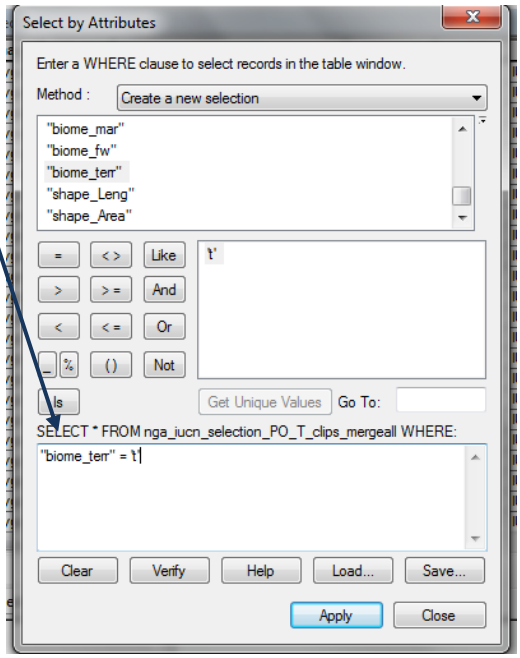


2.2.4. From the previous selection select out terrestrial species ranges

a. Right click on the **newly added subset species layer e.g. nga_iucn_selection_PO.shp** in this example and and click **Open attribute table.** Click on the top left button and click **Select by Attributes.**



b. To only include species which are terrestrial put the following expression into the Select by Attributes window: **"biome_terr" = 't'**



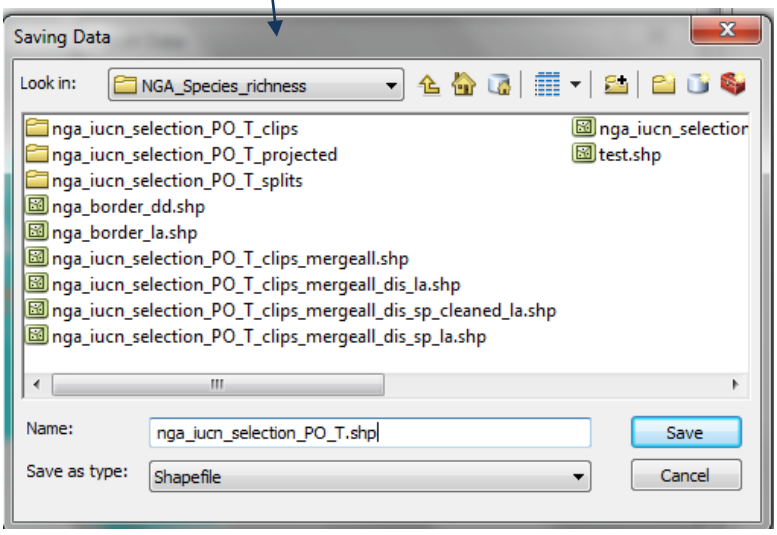
c. Click **Apply**

d. Click **Close** to close the Select by Attributes window.

e. As per step 2.2.2. (j), the attribute table will show the filtered records highlighted in blue, and the number of records that have been selected.

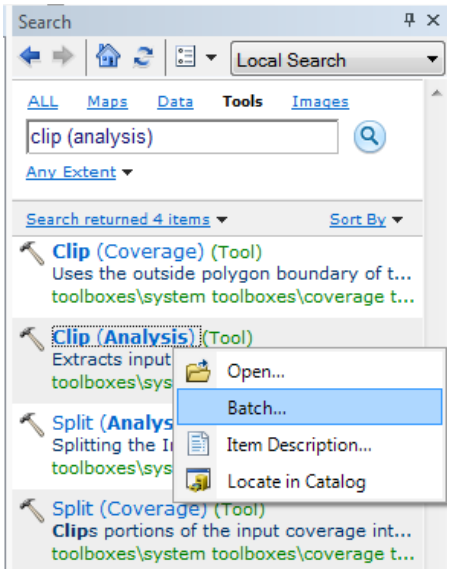
f. Close the attribute table. **Right click** on the IUCN spatial dataset e.g. **nga_iucn_selection.shp** in this example and **Click Data > Export Data.**

g. Ensure that you are exporting the **selected features,** then **save** the file with a new name, **e.g. nga_iucn_selection_PO_T.shp** (as file type shapefile) in this example and **Click Save.** It will ask you if you would like to add the new file to dataframe. **Click OK.**

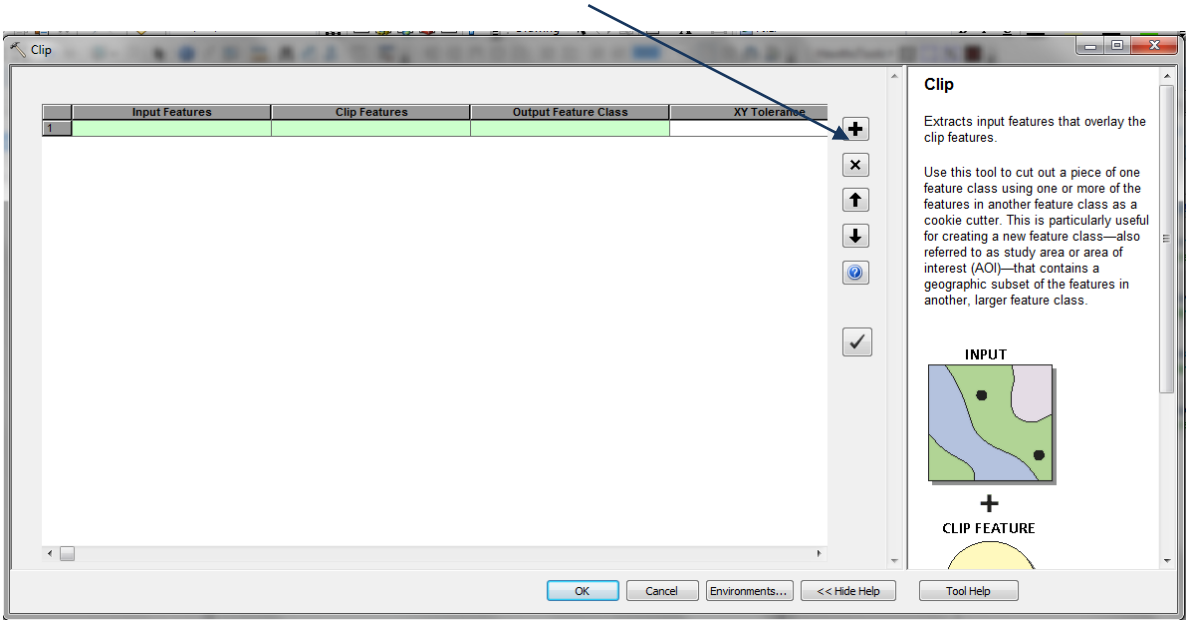


2.2.5. Batch clip the separate species datasets to area of interest

a. In ArcGIS go to the Search > Tools > Clip (analysis). **Right click** on **Clip** and choose **Batch.**

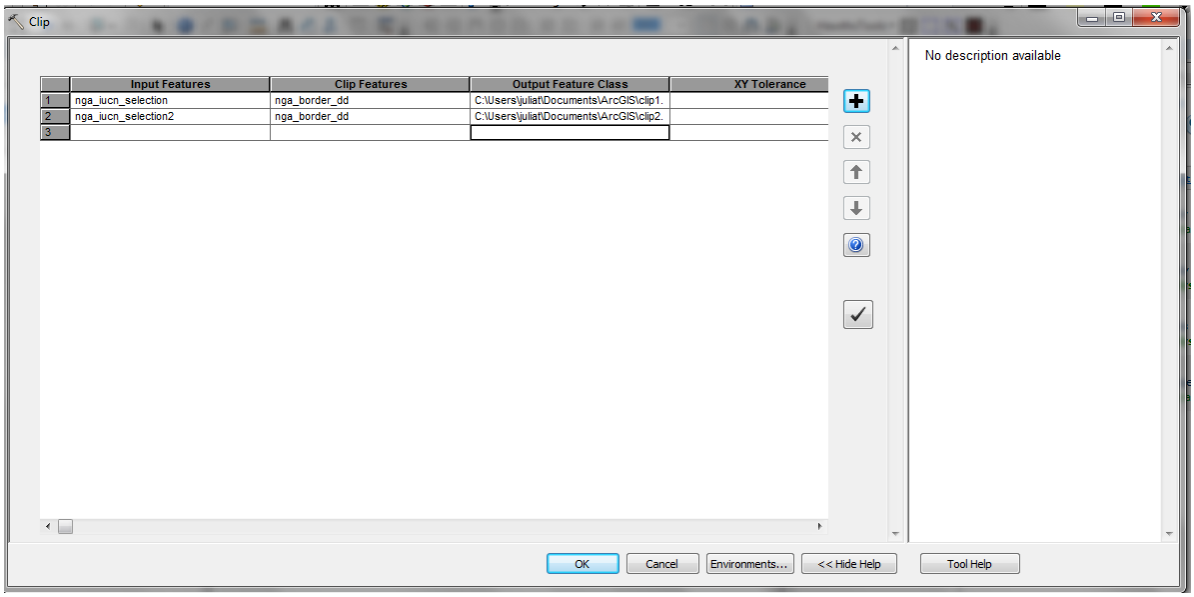


b. Click on the **"Input Features"** and select the first of the species range files that you want to clip. Click on the + symbol to add extra lines, and therefore add multiple datasets.



c. In the "**Clip Features"** column, select the **vector boundary file** covering your area of interest.

d. **In the "Output Feature Class"** column, right click and select **Browse.** Select the location to store your clipped files, and type a new name for each dataset e.g. clip_1.shp; clip_2.shp. Leave the XY Tolerance column blank.



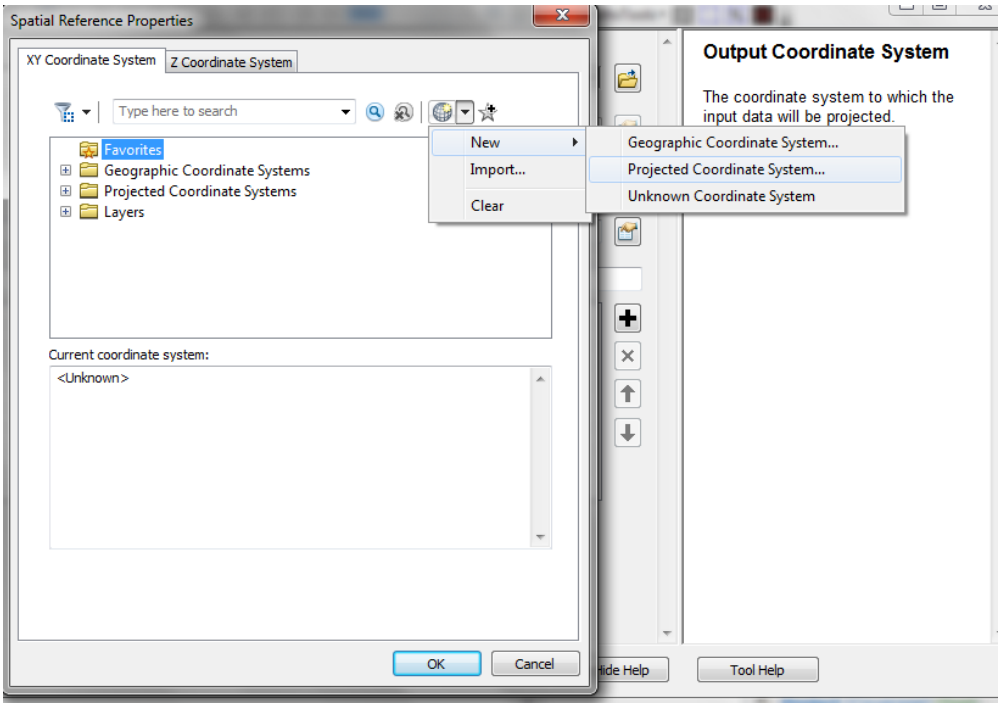
e. Click **Ok**. This may take some time to run, depending on the number of species ranges in the input files being processed. Add the clipped species files to the ArcMap session.

2.2.6. Reproject to an equal area projection

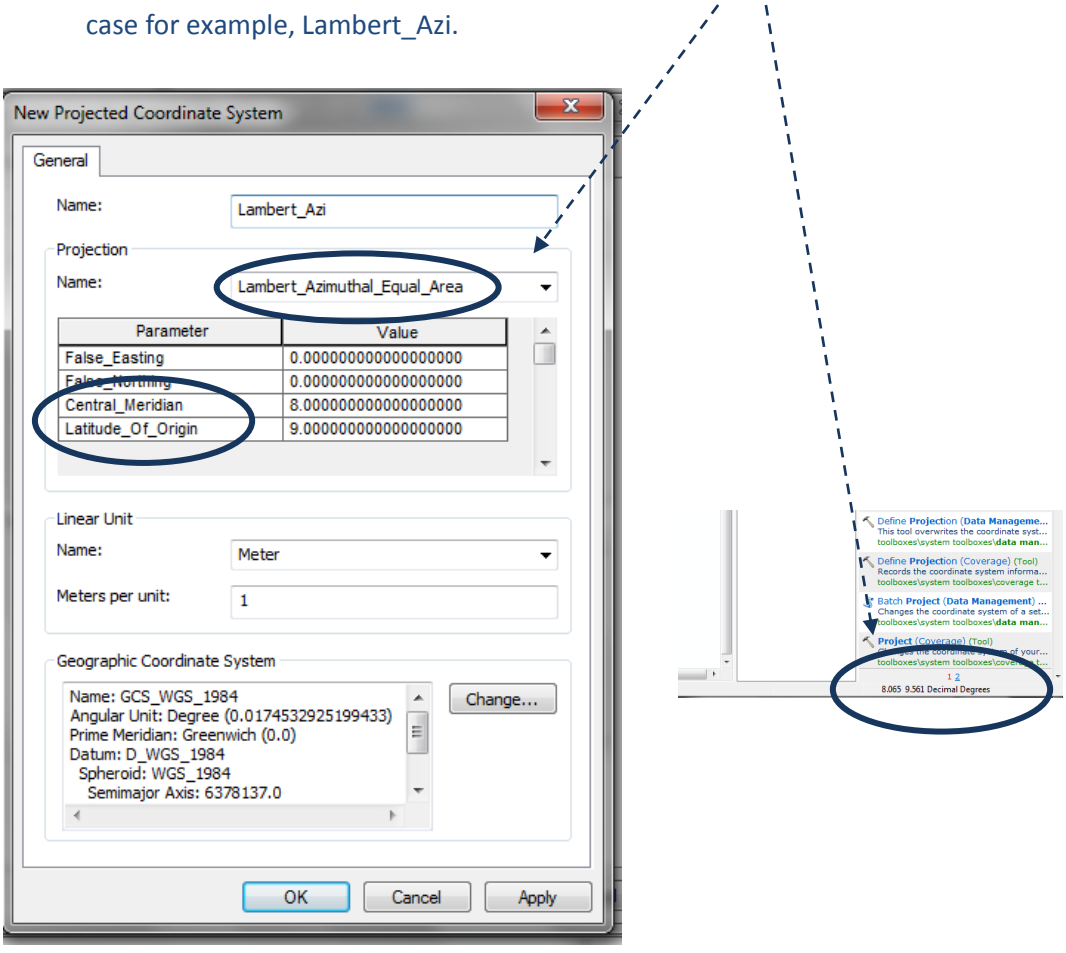
In subsequent steps a planning unit layer of **hexagons or squares** will be generated in order to **summarise the species range data to create a species richness map**. The species range and the hexagon or square layer must be projected to an equal area projection (e.g. Lambert Azimuthal Equal Area). Using an equal area projection allows the true area of the species ranges in each planning unit to be calculated. Whichever projection is chosen, both the species ranges and the planning units **must** be in exactly the same projection.

In this example, the data are in WGS84 (a geographic coordinate system with units in decimal degrees). In order to generate a planning units dataset of hexagons with a specific area, the data need to be projected into an equal area projection with units of meters. In the following example Lambert-azimuthal-equal-area projection is used.

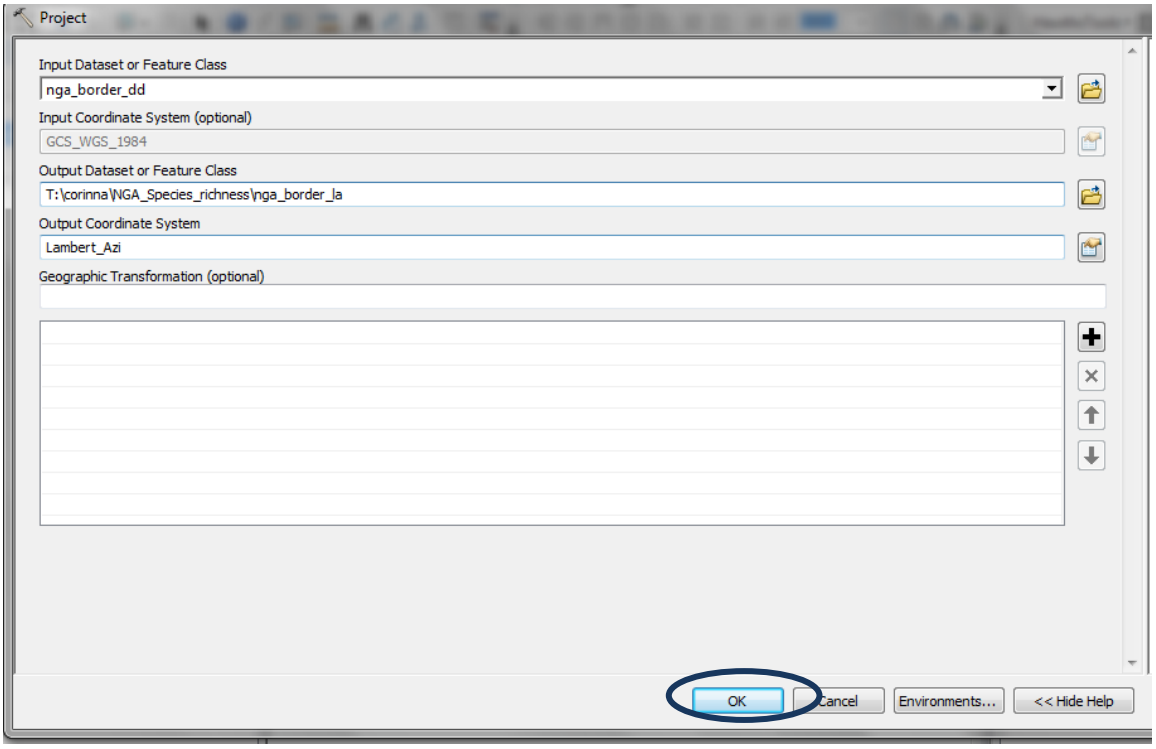
a. In ArcGIS go to the Search > Tools > Project (data management)
b. In the **Input Dataset or Feature Class** select the vector boundary file covering your area of interest.
c. In the **Output Dataset or Feature Class** select the location to store your projected file, and type a new name for the dataset, in this example nga_border_la.shp.
d. Under **Output Coordinate System**, click on the button to the right to set the projection.
e. Click on the Globe symbol and select **New** > **Projected Co-ordinate System**



f. From the drop down menu, choose Lambert -azimuthal-equal-area. Set the **Central Meridan** and **Latitude of Origin** according to the centre point of your vector area of interest..(You can check the co-ordinates at the bottom right hand side of the main ArcGIS screen, and make a note of these). Give the projection a new name, in this case for example, Lambert_Azi.

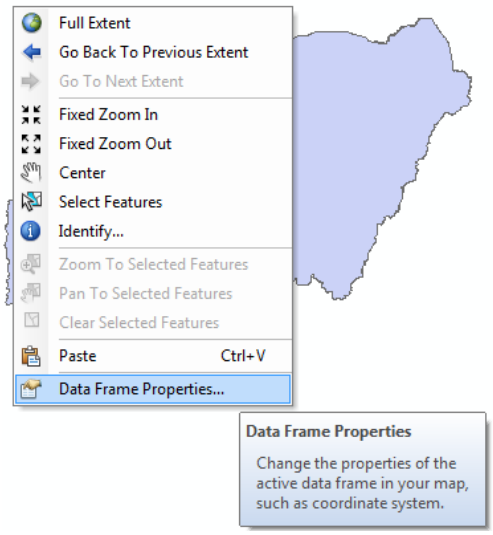


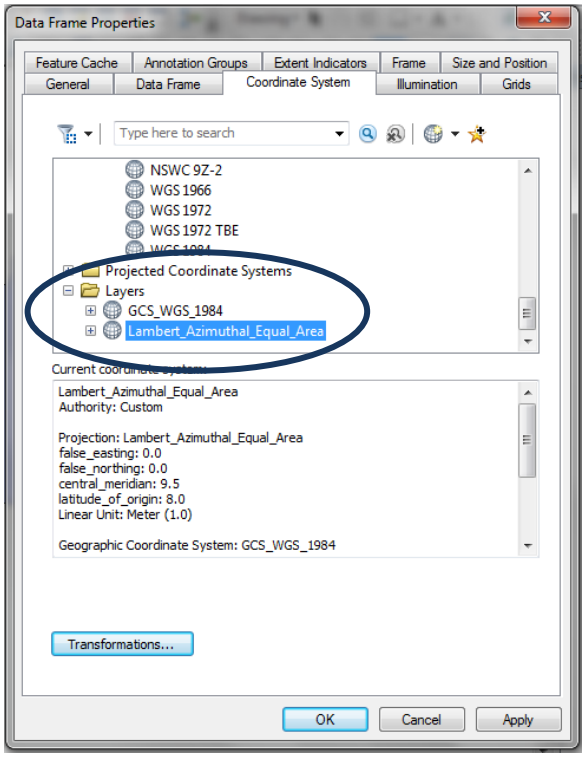
g. **Click OK** and then **OK** again, to set the projection. **Click OK** to run the Project tool.



h. Add the projected vector boundary nga_border_la.shp into the dataframe.

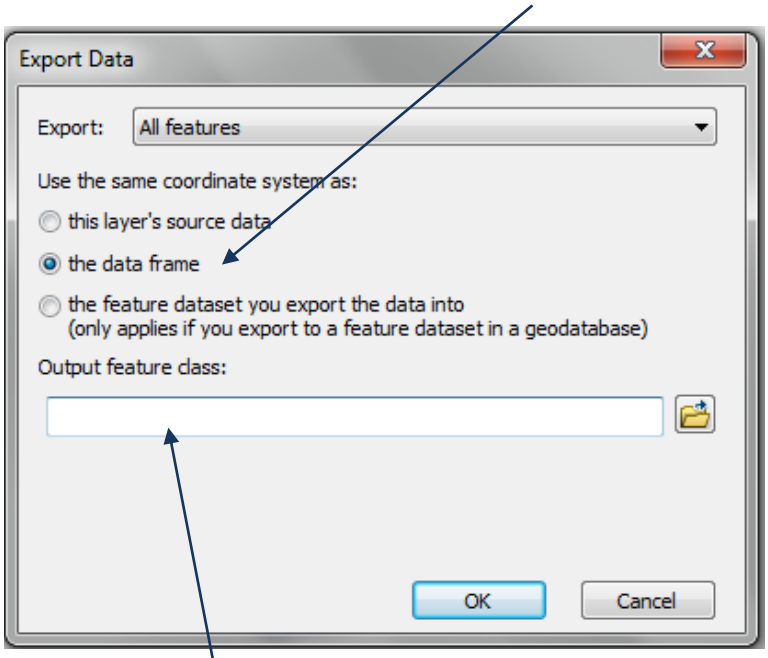
i. Right click on the dataframe and select **Data Frame Properties.**





j. Click on the "Layers" folder and you will see the custom projection that was created for the vector boundary. Highlight the **Lambert_Azimuthal_Equal_Area** and click ok to set the dataframe from Geographic to Lambert - Azimuthal-Equal-Area.

k. Right click on the one of the **clipped IUCN species** datasets in the data viewer and click **Click Data > Export Data.** Ensure that you are saving **All Features and then click "Use the same coordinate system as the data frame".**



l. Save the output file with a new name, **e.g. nga_iucn_selection_mammal_la.shp** (as file type shapefile) in this example and **Click Save.** It will ask you if you would like to add the new file to dataframe. **Click OK.**

m. Repeat this step for the remaining species clipped files. Save each projected output file with a new name, and add these projected layers to the dataframe.

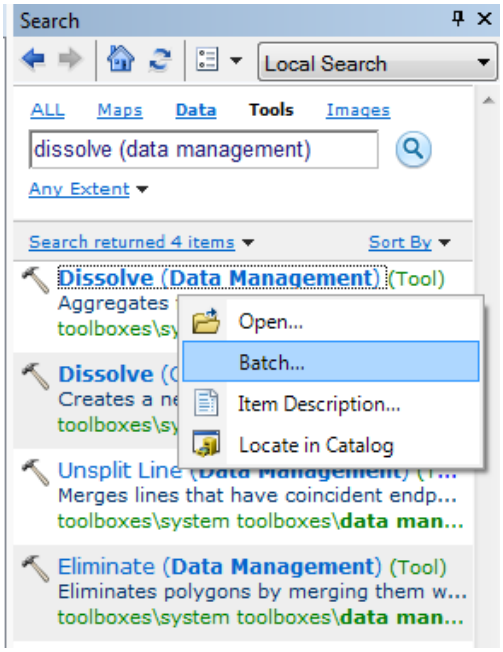
n. Remove the Geographic versions of the datasets from the ArcMap project to reduce confusion.

There should now be the following files in the project :-

- *Area of interest shapefile in projected CRS (e.g. TZAcountry_la.shp)*
- *Clipped species shapfile in projected CRS (e.g. Mam_la.shp)*

2.2.7. Batch dissolve and convert to single part features

a. Use the **Dissolve** tool to dissolve the IUCN species range dataset based on the species id or binomial field. In ArcGIS go to the Search > Tools > Dissolve (data management). **Right click** on **Dissolve** and choose **Batch.**



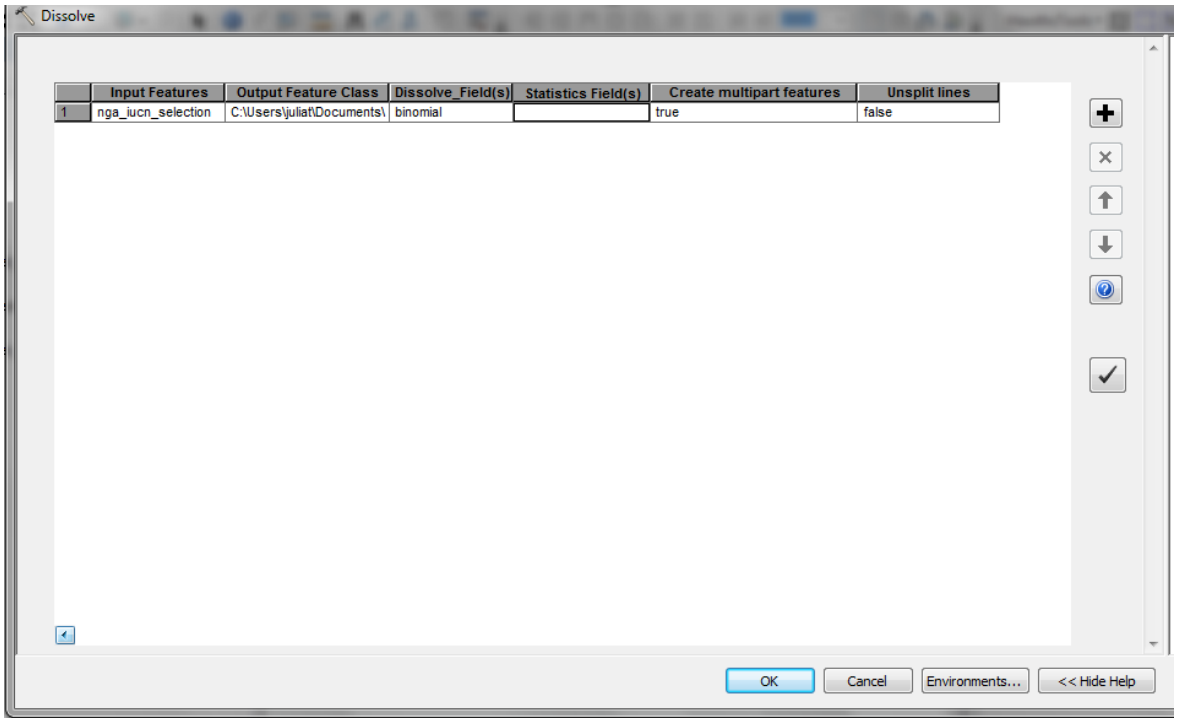
b. Click on the **"Input Features"** and select the first of the species range files that you want to dissolve. Click on the + symbol to add extra lines, and therefore add multiple datasets.

c. **In the "Output Feature Class"** column, right click and select **Browse.** Select the location to store your clipped files, and type a new name for each dataset e.g. **nga_iucn_selection_mammal_la_dis.shp**

d. In the **Dissolve Field(s)** select binomial

e. In **Create multipart features** select True

f. Leave the remaining fields as they are.



g. The output datasets attribute tables should contain one attribute row per species e.g:

Table

nga_iucn_selection_la_dis

FID	Shape *	binomial
0	Polygon	Acinonyx jubatus
1	Polygon	Agelastes niger
2	Polygon	Alopochen aegyptiaca
3	Polygon	Anas acuta
4	Polygon	Anas capensis
5	Polygon	Anas sparsa
6	Polygon	Anomalurus derbianus
7	Polygon	Aonyx capensis
8	Polygon	Arctocebus calabarensis
9	Polygon	Arthroleptis palava
10	Polygon	Arvicanthis niloticus
11	Polygon	Aythya ferina
12	Polygon	Aythya fuligula
13	Polygon	Aythya nyroca
14	Polygon	Buccanodon duchaillui
15	Polygon	Bycanistes albotibialis
16	Polygon	Bycanistes subcylindricus
17	Polygon	Campethera caroli
18	Polygon	Campethera nivosa
19	Polygon	Campethera punctuligera
20	Polygon	Caracal aurata
21	Polygon	Ceratogymna atrata
22	Polygon	Chlorocebus tantalus
23	Polygon	Coturnix coturnix
24	Polygon	Coturnix delegorguei
25	Polygon	Crocidura virgata
26	Polygon	Dendrocygna bicolor
27	Polygon	Dendrocygna viduata
28	Polygon	Dendropicos elachus
29	Polygon	Dendropicos fuscescens
30	Polygon	Dendropicos lugubris

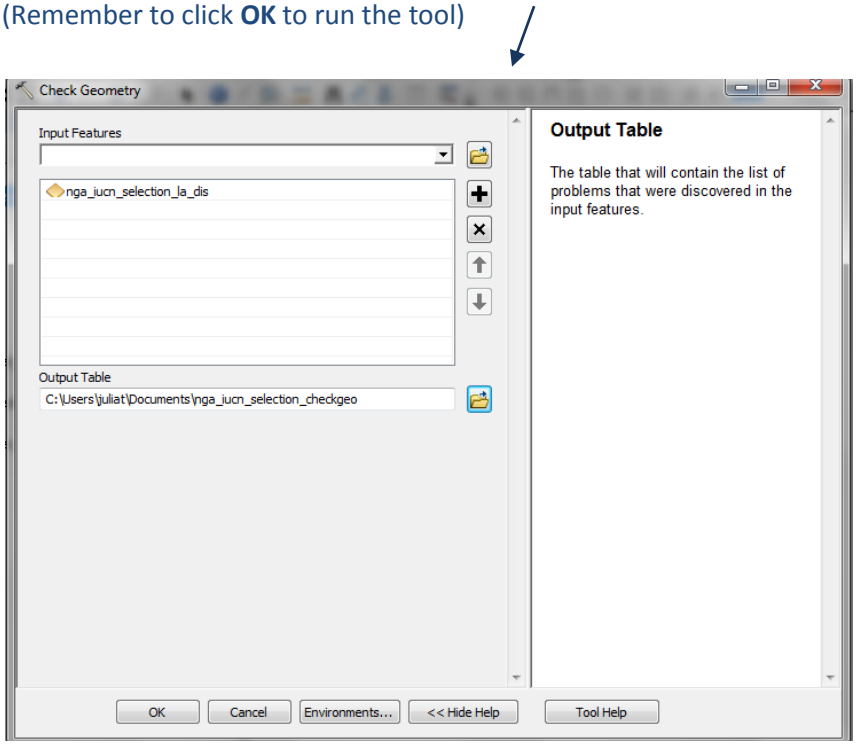
1 (0 out of 197 Selected)

nga_iucn_selection_la_dis

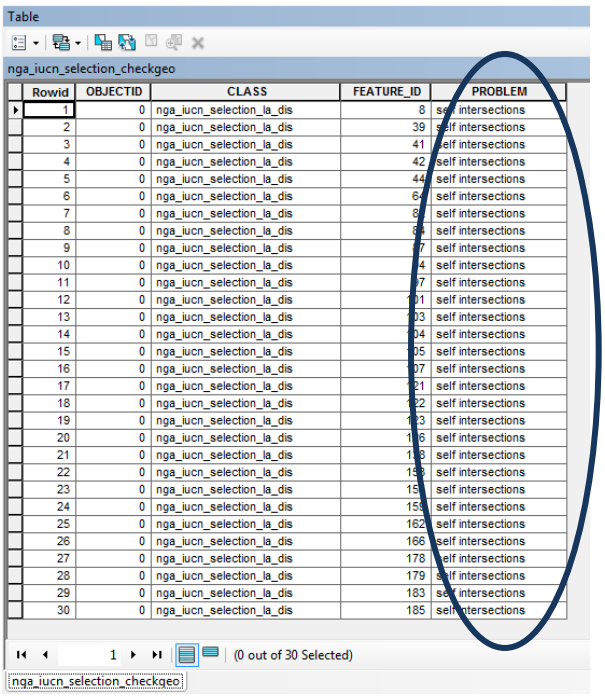
2.2.8. Check the clipped and projected IUCN species range data for topological errors

Check for topological errors in the projected IUCN and the country boundaries shapefiles data as these could prevent the subsequent analysis tools from working correctly.

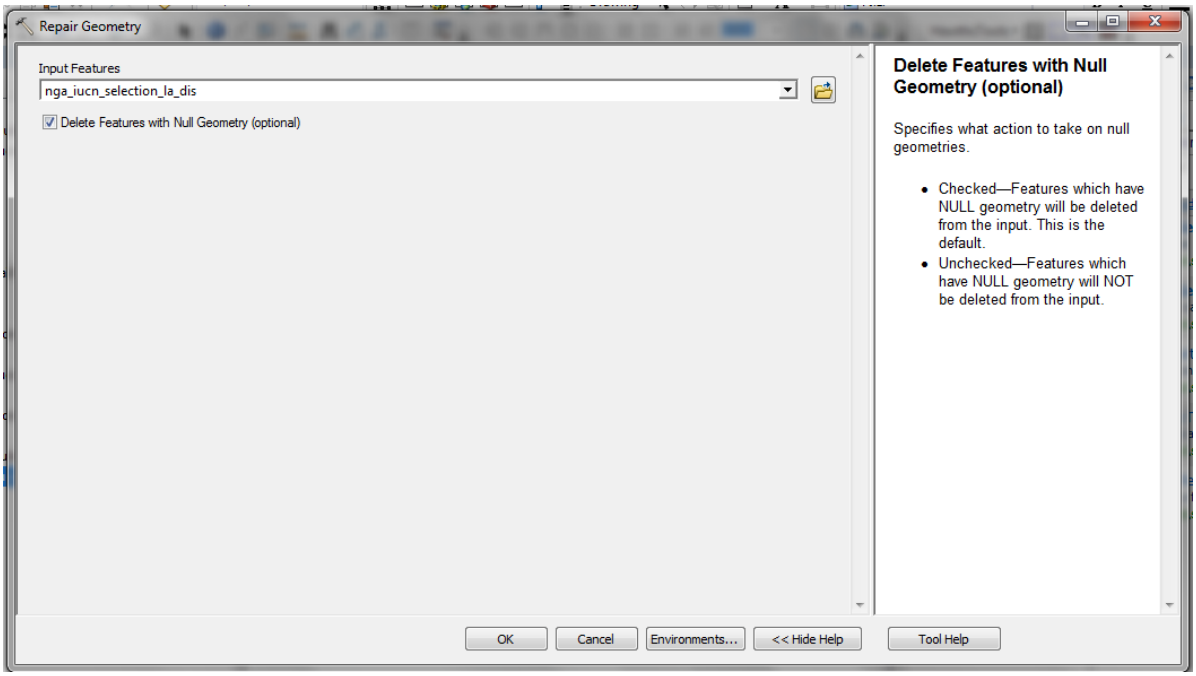
a. In ArcGIS go to the Search > Tools > **Check Geometry**. Run for **each** dataset. (Remember to click **OK** to run the tool)



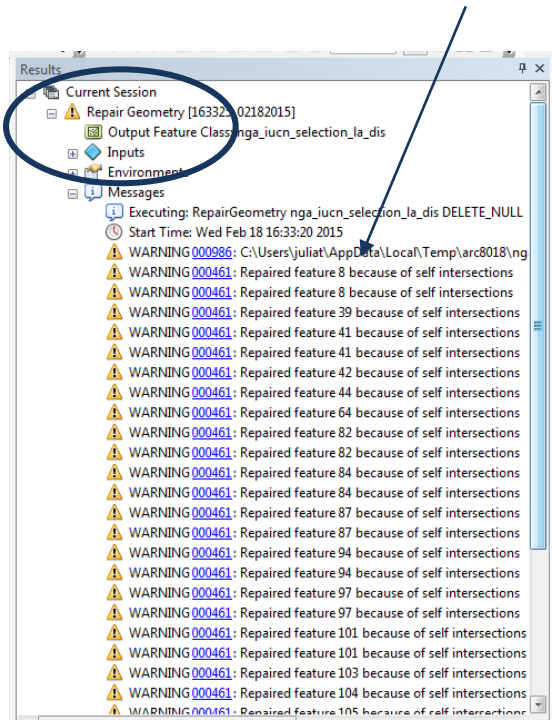
b. A table will be produced which reports the errors in each of the files. In this example the species ranges polygons have some errors:



c. For each file in which there are geometry errors reported, go to Search > Tools > **Repair Geometry.** This tool inspects each feature in a feature class for geometry problems. Upon discovery of a geometry problem, a relevant fix will be applied, and a one line description will be printed identifying the feature as well as the problem encountered. The tool will continue to run through all records until geometry errors are resolved.



d. Under the **Geometry tab > Results**, open the results of the ArcMap session. By **expanding the results** of the Repair Geometry tool, you can see the errors encountered in the data and the fix applied by the tool.



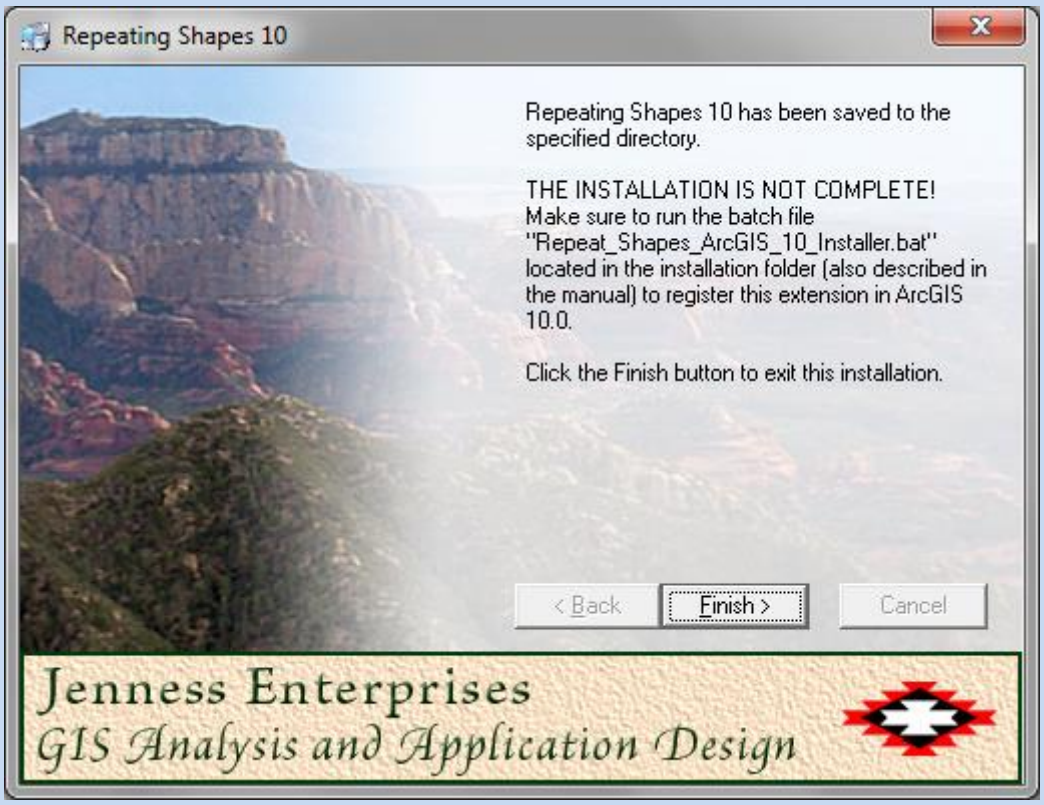
Run the check and repair geometry tools on **each** of the vector files so that all geometry errors are resolved.

3. Generate a dataset of hexagons or squares

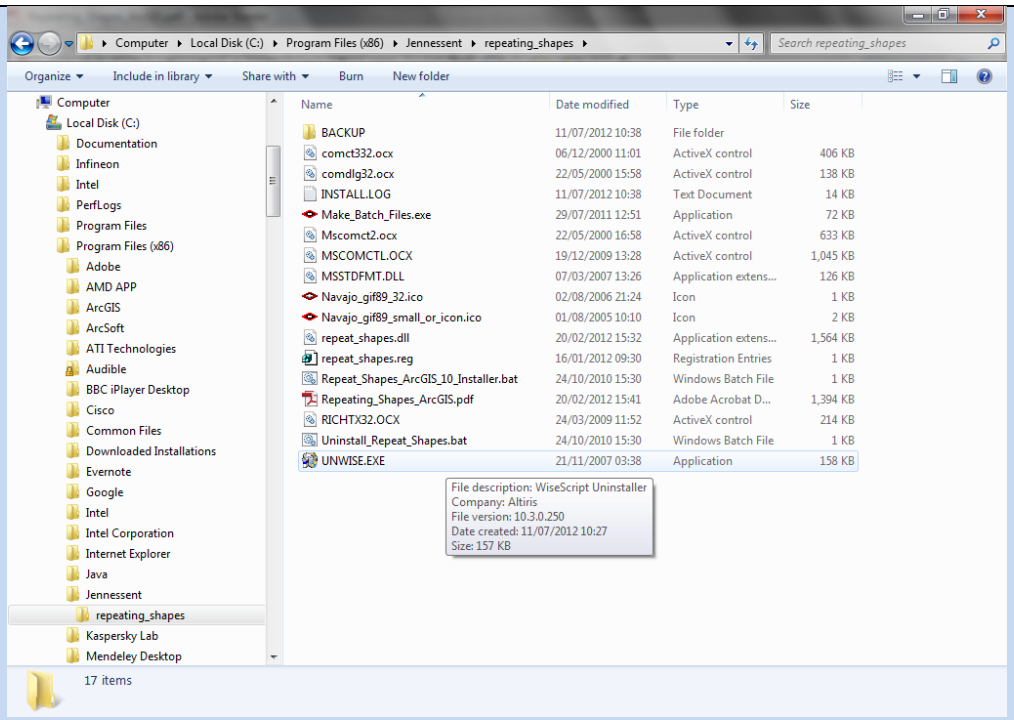
a. **Download** the Repeating shapes 10 tool from http://www.jennessent.com/arcgis/repeat_shapes.htm and follow their instructions for installation.

Make sure you don't have any ArcGIS applications open on your machine while installing. Install on your machine by double clicking on repeat_shapes_10.exe

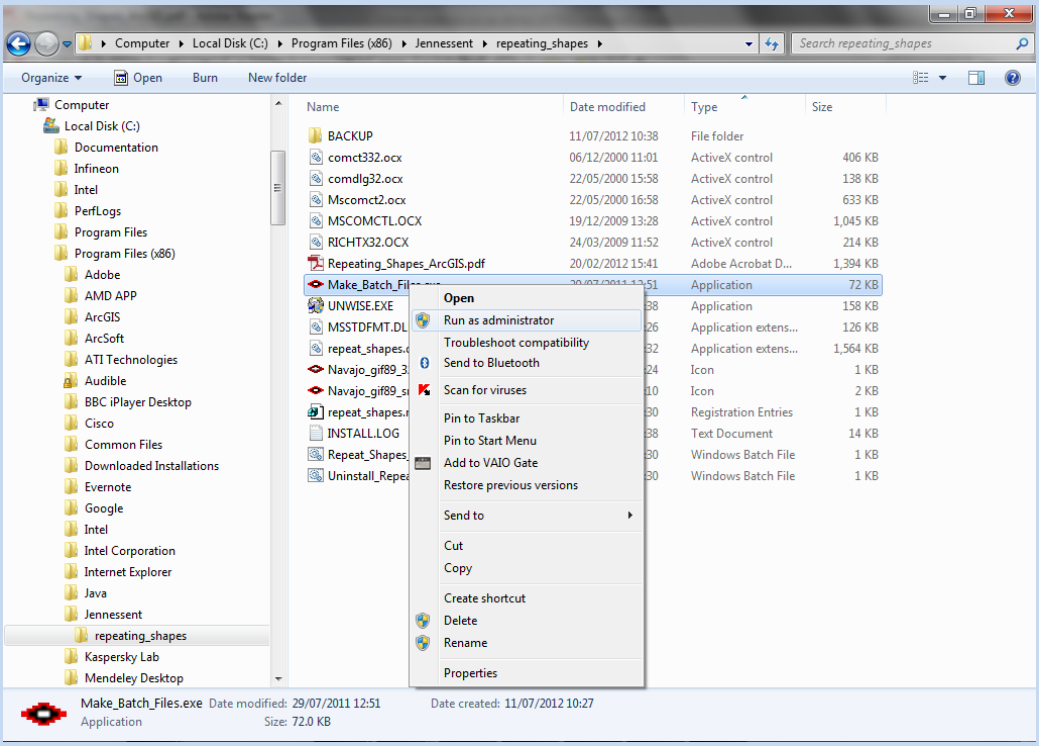
If it fails the first time (as in the dialog below)

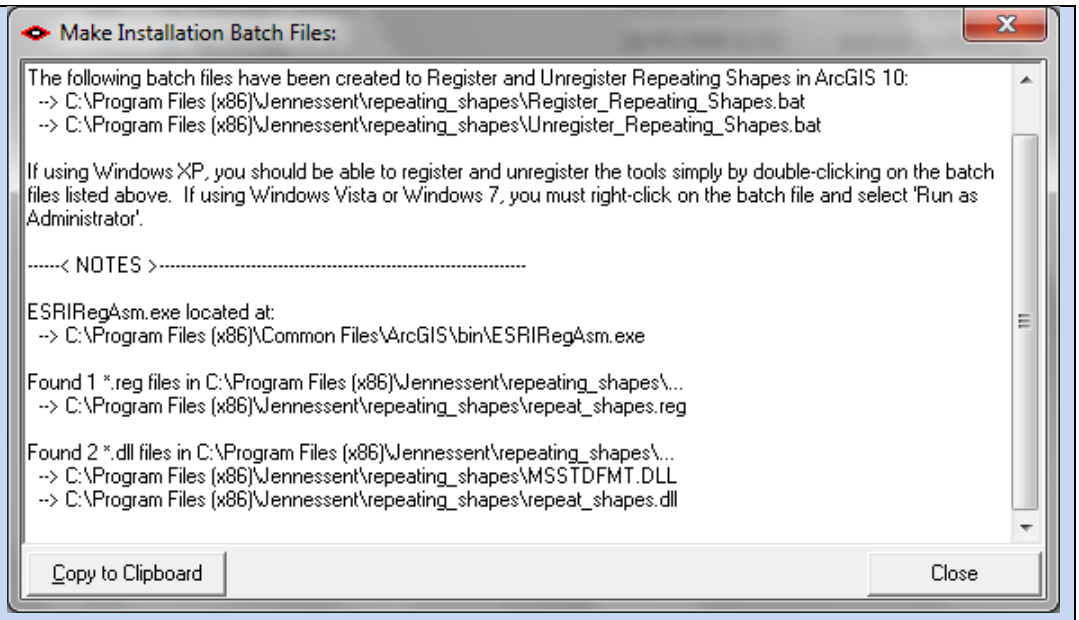


- Go to your installed folder in your programme folder.



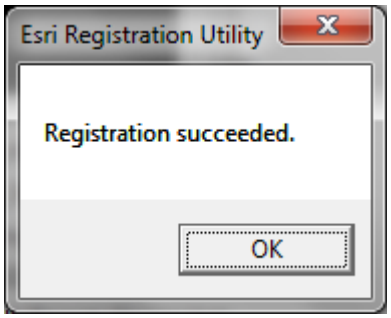
➢ Right click on Make batch files.exe and run as administrator.





- Once you have done this,new files have been created one of which is Register_Repeating_Shapes.bat, double click on it.
- Now go to **step c** and to try adding the tool to ArcMap. This time you should be able to see it.

b. You should see:

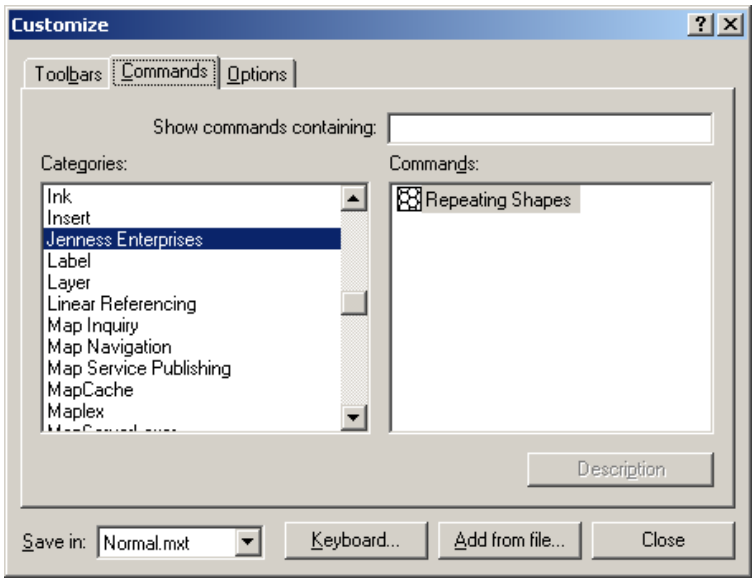


c. Open ArcMap.

d. If you cannot see the **Repeating shapes** tool, click on **Customize > Toolbars > Customize.**

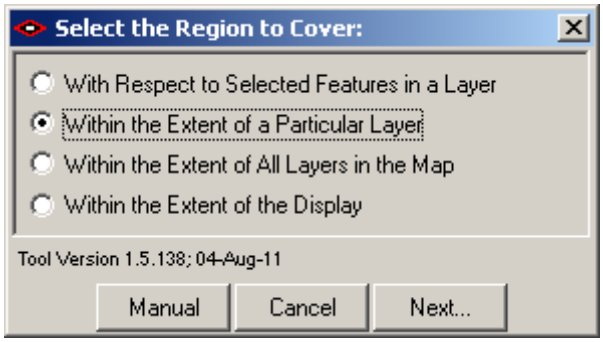
e. Click on **Commands.**

f. Scroll down and **click on Jenness Enterprises.**



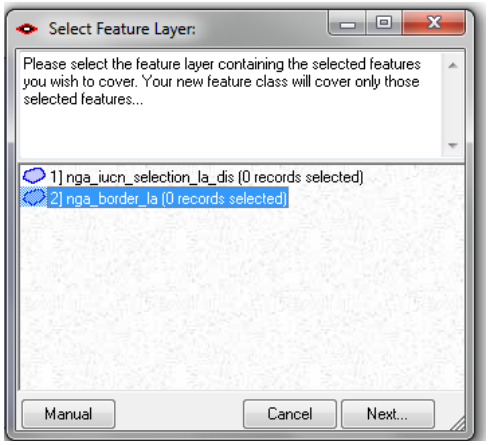
g. Drag the repeating shapes tool and place it somewhere on your toolbars.
h. Click Close.

i. Click on the repeating shapes tool button.



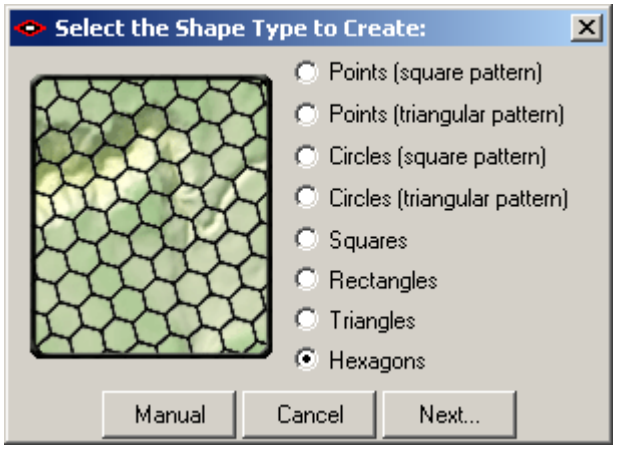
j. Click the extent of a particular layer.

k. Click Next.



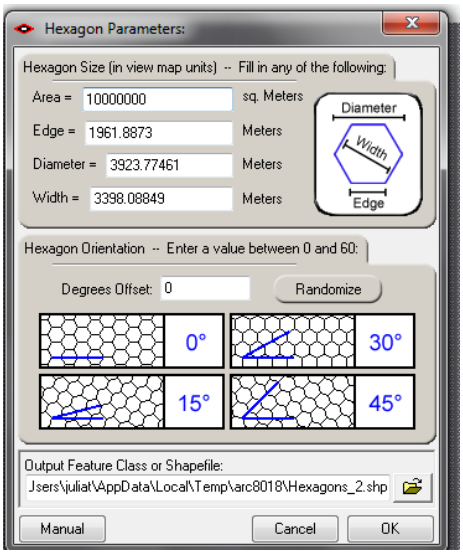
l. Click on the vector file of the country boundary e.g. nga_border_la (i.e. the one that you saved in the equal area projection), so that it is highlighted in blue.

m. Click **Next.**

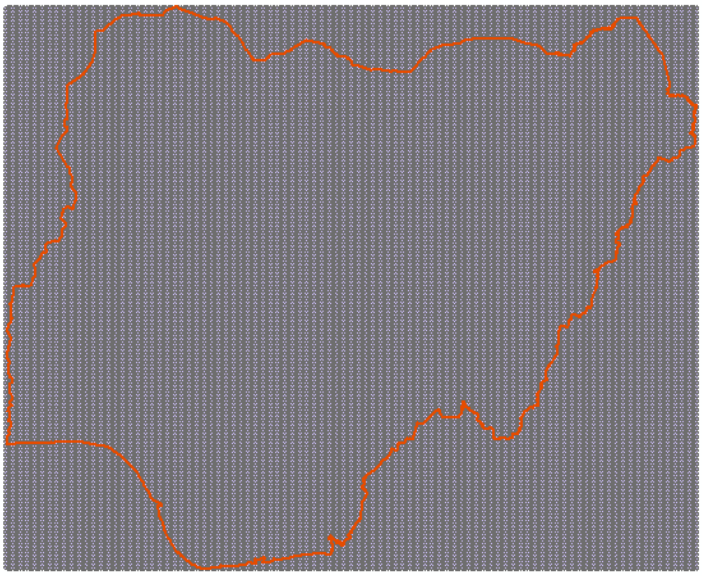


n. **Choose** the shapes you want to use **e.g. hexagons.**

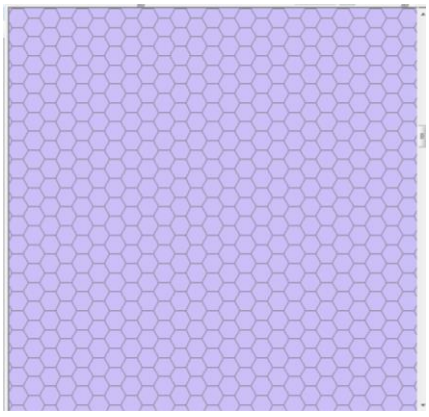
o. Choose **size of hexagons (the units will be in map units i.e. meters)** e.g. area **10000000** (for 10km^2 dataset).



p. Click **OK. The tool will run and generate a grid of hexagons over the full extent of the specified input file**. If it generates a grid that covers beyond the extent of the vector boundary, as in the example below, then simply clip the hexagon file to the vector boundary using the **Clip** tool.



** Zoom into the Hexagons layer to see the shapes:



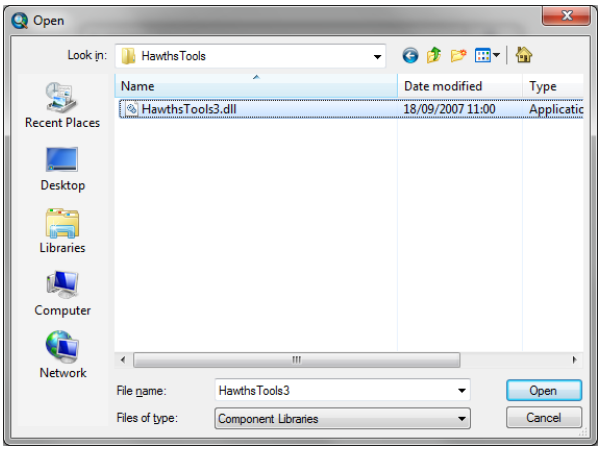
3.1. Use Hawths Analysis tools to generate species richness

a. Download Hawths Analysis tools from http://www.spatialecology.com/htools/tooldesc.php

*****IMPORTANT NOTE: the documentation for Hawths tools states that it will not work for ArcGIS 10.x. However it will work. Install the tool as instructed. At the end it will say that it has not installed correctly. Ignore this message and continue to step b.**

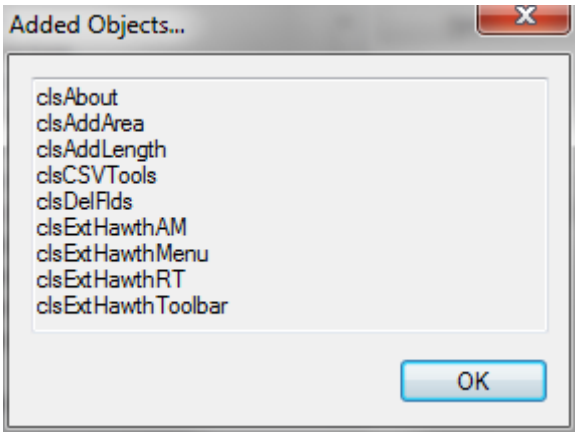
b. Click on **Customize - Toolbars – Customize.**

c. Click on **Add from file** and navigate to **C:\Program Files\HawthsTools.**



d. Click on **Hawthstools3.dll** and click **open.**

e. Say **yes** to any messages asking if you want to allow it to install. You should then see following screen.

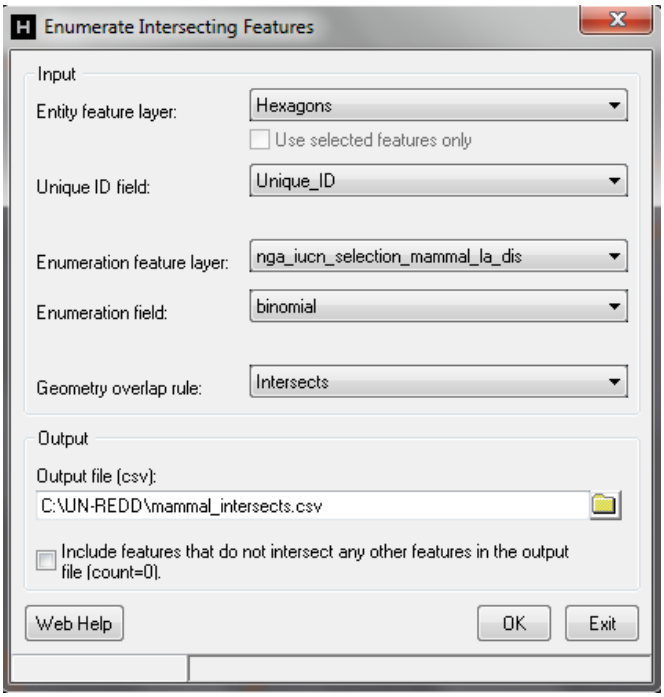


f. Click **OK.**

g. Click **Close.**

h. Click **Customize > Toolbars > Hawths Tools.**

i. From the **Hawth's tools menu bar,** Click on **Hawthstools > Analysis Tools > Enumerate Intersecting Features**.



j. The entity layer is the **hexagons shapefile.** Select **"Unique_ID"** under the **Unique ID field.**

k. The **Enumeration feature layer** is the final **species spatial data in equal area projection** that has been checked and cleaned for geometry errors. e.g. **nga_iucn_selection_mammal_la_dis.shp.** The **Enumeration field** is the binomial**.**

l. Select Intersects as the geometry overlap rule.

m. Choose the **output location and new name** for the output **.csv** file.

n. Chose whether to tick to **include hexagons containing 0 features** or exclude them.

o. Click **OK.**

Be patient! - ***This will likely take a long time to run*** *(dependent upon the size of the study area, and number of species) but will eventually produce a new* ***output .csv*** *file containing a list of hexagon unique id's, the number of species it has intersected and which species these are.*

p. The **output .CSV file** can be opened in **Excel**.

q. Make a copy of the sheet which just includes the Unique_ID and number of species.

r. Save as a **new .xlsx file** and close Excel.

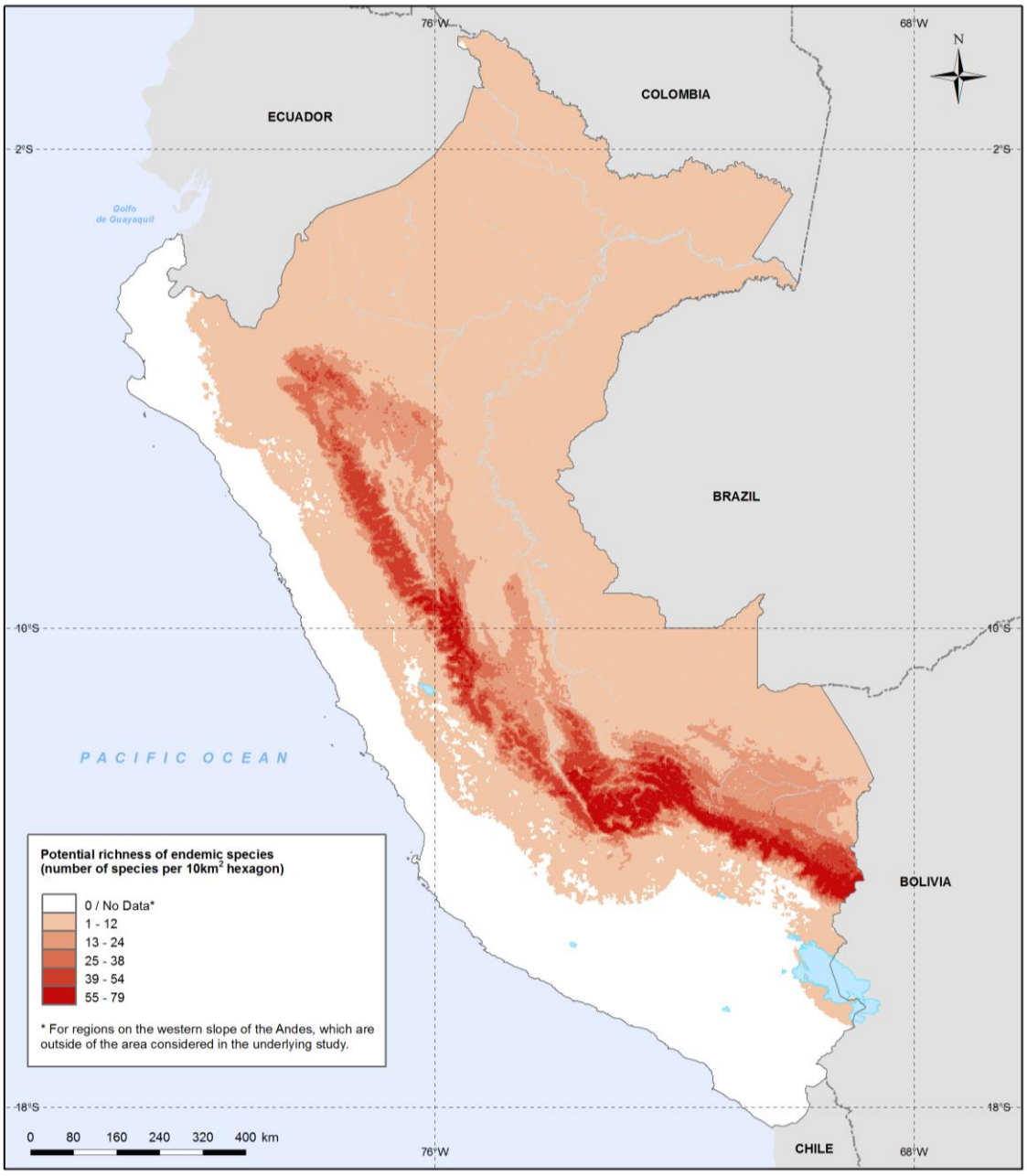
s. **Add new .xlsx** to your **ArcMap** session and **join onto the hexagons dataset by Unique_ID**, by right clicking the dataset, clicking **Joins and Relates > Joins**

t. You can now **export the hexagons to a new shapefile to make the join permanent**, by right clicking on the dataset and **clicking Data > Export Data**.

You should now be able to shade the hexagons by species number in the new exported file.

The dataset can then be symbolized and placed in a map layout as in the example below

Example Map



Methods and data sources:
Endemic species distribution (amphibians, mammals and birds): Young, BE, Beck S, Córdova J, Embert D, Franke I, Hernandez P, Herzog S, Pacheco V, Timaná M, Tovar C, and Vargas J. 2007. Digital distribution maps of species endemic to the east slope of the Andes in Peru and Bolivia. NatureServe, Arlington, Virginia, USA.
Data provided by NatureServe in collaboration with the Centro de Datos para la Conservación (CDC) of the Universidad Nacional Agraria La Molina, the Museo de Historia Natural de la Universidad Mayor de San Marcos, and many participating natural history museums and herbaria. See: http://www.natureserve.org/conservation-tools/data-maps-tools/modeled-distribution-maps-species-endemic-east-slope-andes-peru