

Manual for biodiversity modelling on a national scale

Using GLOBIO3 and CLUE methodology to calculate current and future status of biodiversity

Case study area: Zambia

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1. Introduction

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1.1.

Preparation base dataset

All maps should be in the same projection. Polygon and shape files have to be converted into grids with a grid cell size of 1000 * 1000 meter. Choose an equal area projection in order to get grid cells of similar size. For the Zambia case the Transverse_Mercator projection is chosen with the WGS_1984 Geographic Coordinate System.

Projection

Projection: WGS_1984
Spatial reference: WGS_1984_Transverse_Mercator
Linear unit: Meter (1.000000)
Angular unit: Degree (0.017453292519943299)
False Easting: 550000
False Northing: 10000000
Central meridian: 27
Scale factor: 0.9996
Latitude of origin: 0
Datum: D_WGS_1984

Window Extent Zambia

Top: 9092372.78958
Left: 7403.55075589
Right: 1284403.55076
Bottom: 8001372.78958

Grid cell size

Cell size: 1000 x 1000m
Number of rows: 1277
Number of columns: 1091

Mask Zam_rast

General tips for data management in ArcGis:

- Do not use spaces in your file names and limit the length of your filenames to maximum 13 characters. ArcMap can not handle spaces in names or names with more than 13 characters and will return errors in your calculations.
- **Only use the Arc Catalog to move, copy or delete files.**
If you do not use Arc Catalog but for instance your file explorer, your ArcMap files get corrupt.
If an ArcGis map seems to be corrupt first try to restart ArcGis. If that does not help close ArcGis and try to delete the .aux and .rrd files (now in a normal file explorer outside Arc Catalog) with the same name as the corrupt map. Restart ArcGis again.
- Keep always copies of your original files. They might be very helpful in case files get changed or get corrupt.
- Use simple and logic filenames and **work in separate directories per theme** (e.g. Land_use, Infrastr, Nitrogen etc.). Clean up temporary and or erogenous files by deleting them in Arc Catalog before you start a new session.
- Switch on the Spatial Analysis extension in the *Tools\Extensions* menu and put your Spatial Analyst submenu on the screen by tagging-on the *Spatial Analysis* box in the *View\Toolbars* menu.
- Note that ArcMap does use the projection of the first layer file that you load to the map display. When you add a layer file to the map with a different projection, ArcMap tries to show it in the current view with the projection of the first layer file, but it does not actually change the projection. When you try to change the projection of a layer file with a different projection as shown in the map view, a datum conflict may occur. To avoid errors open the layer file that you want to give a different projection in a new empty map view.

Impact calculation per pressure:

- Because some of the pressure impact maps are dependent on the output from calculations that are carried out for other pressures, there is a hierarchical order in the calculations. Start with the Land use pressure calculation. The second pressure calculation should be infrastructure. The other pressure calculations can be carried out after these.

- Since the total Mean Species Abundance map is calculated by a multiplication of all pressure impact raster maps, be sure that each map has the same extent, cell size, and contains only values between 0 and 1. Note that a zero value in one of the maps will always result in a zero value in the final impact map and a null value in one of the maps will return a null value in the final output map. In order to use the same land area in all maps we will use a mask file (*mask*) as a sort of cookie cutter for the final output maps per pressure.

Base data set for calculation of current status biodiversity

- **Land use map**
Global GLC2000 map (see: <http://www-gvm.jrc.it/glc2000/>) For global or regional applications with GLOBIO3, land cover & land use classes can be reclassified into the following categories:
 - Forestry:
 - Natural forests
 - Light used forests
 - Secondary forests and
 - Plantations
 - Agriculture:
 - Extensive agricultural lands,
 - Intensive agricultural lands
 - Irrigated intensive agricultural lands,
 - Area used for perennials and woody bio fuels
 - Agro forestry lands
 - Grazing:
 - Natural grass and shrub lands,
 - Man made pastures and
 - Livestock grazing area
 - Natural bare, rock and snow
 - Lakes, rivers and streams
 - Build up area

These categories are chosen because relations have been found in scientific literature between them and the Mean Species Abundance (MSA) on a global scale. In general these global relations are not detailed enough for straightforward application on national scale. For a proper calculation of the land use impact on biodiversity on national scale local species abundance information is needed per land use type. Since this information is often not yet available the global MSA values can be used as reference for assigning local MSA values to the classes of the national land use map.

- **Road map**
National road map with main roads.
If no detailed road map is available you can use the Digital Chart of the World road map (see: <http://www.maproom.psu.edu/dcw/>).
- **Patches of natural area**
Derived from Land use map and road map. Nature areas are fragmented by roads that dissect them. See further for the
- **Climate change information**
Mean temperature increase from 1970: 0.569° C for the year 2000. If no mean temperature information is available on a national scale, map input (on a 1 * 1 degree resolution) can be derived for different scenarios from the global IMAGE model (contact: Netherlands Environmental Assessments Agency: <http://www.mnp.nl/en/index.html>)
- **Nitrogen Deposition and Critical load map**
Since Zambia has so significant nitrogen deposition this map is not necessary.
(In case needed: Exceedance of the critical load of nitrogen deposition. (IMAGE) If no nitrogen deposition or critical load information is available on a national scale, map input (on a 1 * 1 degree resolution) can be derived for different scenarios from the global IMAGE model. Contact: Netherlands Environmental Assessments Agency: <http://www.mnp.nl/en/index.html>)
- **Ecosystem map**
Global WWF Biomes, Eco-regions. The map can be downloaded from the WWF site: <http://www.worldwildlife.org/science/data/terreco.cfm> This map represents the potential vegetation that can be used for referencing land use classes with the help of a land use / biome matrix table and is also used for allocating climate correction factors.
- **Protected areas**
National protected area map. If not available you can download the global protected area map from the UNEP WCMC website: <http://www.unep-wcmc.org/wdpa/download.cfm>

Impact on biodiversity per pressure

1. Landcover / landuse impact

In this exercise we will calculate the impact of land use on the remaining biodiversity. Land use is by far the most important factor that reduces biodiversity at local, regional and global scales.

In our GLOBIO3 based biodiversity model the Mean Species Abundance (MSA) is calculated as indicator for the remaining biodiversity. For the calculation of the impact of Land use on MSA we distinguish 4 forest use classes, 5 cropland classes, 3 grassland classes, 1 natural bare class and 1 urban area class. Presently Globio3 calculates only MSA values for the land based area. Therefore marine and inland water classes are left out of the calculations.

Table1.1 Biodiversity value per land use

Biodiversity class name	Generic MSA value	For each of these classes a generic MSA value will be applied (See table1.1 <i>Biodiversity value per land use</i>) The MSA values for these land use classes are based upon extensive literature research. However, because the intensity of use is a gradual process, interpretation and assigning of intermediate classes is allowed. This Procedure is described in Appendix I.
Primary forests	1	<p>In this exercise we will use GLC2000 map of Zambia and will reclassify the LuLc classes into Land use classes with a biodiversity value that can be derived from the generic MSA values. Since biodiversity loss by land use is dependent of the original vegetation, an eco-regions map can be used to improve the reclassification. For instance if the original vegetation for an area belongs to the Tundra biome, a low density forest land cover class from the present land cover map will be classified as the GLOBIO3 primary forest class with a MSA of 1 (100%), since forest cover in this biome is . However, if the low density forest belongs to the biome ‘Tropical Moist Broadleaf Dryland forest’, than one can conclude that the present low density forest does not represent the original vegetation and therefore should not be reclassified into the GLOBIO3 primary forest class. The GLOBIO3 class ‘Secondary forest’ with a lower MSA value will be more likely (MSA = 0.5, or 50%).</p> <p>In order to reclassify the LuLc map of Zambia we will overlay it with the WWF-Ecoregions map. This procedure can be easily be carried out by putting the LuLc classes and the Ecoregion classes</p>
Light used primary forests	0.7	
Secondary forests	0.5	
Forest plantations	0.2	
Agro forestry	0.5	
Extensive agriculture	0.3	
Perennials & bio fuels	0.2	
Intensive agriculture	0.1	
Irrigated intensive agriculture	0.05	
Natural grass & shrub lands	1	
Livestock grazing	0.7	
Man made pastures	0.1	
Natural bare, rock & snow	1.0	
Natural inland water	-	
Artificial water	-	
River/stream	-	
Built up areas	0.05	

in a matrix table and then reclassifying each combination by hand into the GLOBIO3 land use classes.

The resulting GLOBIO3 classes can be ‘parsed’ into columns and used to make a new GLOBIO3 raster Land use map. Since each GLOBIO3 class has its own MSA value, the new Land use map can be reclassified into an Final Remaining MSA_lu map.

Exercise

Input data:

- Local land use / land cover shapefile map (*GLC_zam*)
- Ecoregions polygon map WWF/MNP (*Zam_ecopr*)
- Biodiversity value table (*Biodiversity value table.xls*)

Intermediate output:

- Land use / Landcover – Ecoregion matrix table (*Landuse_ecoregion matrix.xls*)
- Land use / Landcover – Ecoregion raster map (*GLC_ecoregion*)

Final Output:

- Land use impact map (Impact_lu gridmap) (*MSA_Lu*)

Steps:

Preparing Ecoregion map

1. Check if your Biome map has a known projection.
If not define the projection by using The *Define Projection* option in the Data Management menu in your ArcToolbox (ATb). Select the predefined *Geographic Coordinate Systems\WGS 1984.prj*
2. Cut out window SE Asia from biome map *Ecoregions* to reduce map size and calculation time
 - A. You can draw on the screen a window with the extent you want with the help of by the Arc Catalog program and the Editor in ArcMap. First start Arc Catalog and add a new file in your Land use directory via the menu: *File\New\Shapfile*. Give the shapefile a name and select *Polygon* as feature type. Now go back to ArcMap and add the new file to your map with the *Add Data* option. Be sure that the new file is selected and open the editor in the *Tools>Edit Toolbar* option. Start drawing the window over SE Asia on top of your Ecoregion map by using the Start Editing option. After finalising the square window double click and save your edits.

B. Now make a subset of the Ecoregions map with your new window extent.
First set the extent of your operations to the extent of your new window file by selecting 'same as your layer "Windowfile" in the Analysis Extent option of the menu *Spatial Analysis\Options\Extent*.
Now open the *Clip* menu in the ArcToolbox and clip the *Ecoregion* polygon map to your desired subset. Use *Ecoregion* polygon map as *Input features*, your new window file as *Clip Features*. Rename the output file name e.g. to ***Ecoreg_clip*** in the relevant directory. You do not have to use a specific Cluster Tolerance.
3. Transform the *Ecoreg_clip* map into the correct projection
We will use the Albers Equal Area Conic Projection (see above) as the common projection for all GMS countries. Go to the *Project* option from the *ArcToolbox\Data Management Tools\Projections and Transformations\Feature* menu. Select the *Ecoreg_clip* as input dataset and give an output filename for the projected file, e.g. *Ecor_proj*. Select *New\Projected* in the Output Coordinate System option. A *New Projected Coordinate System* window will show up. Select in the Name box *Albers* as projection type and fill in the parameters as described above. Respectively press ok, apply and ok and the ***Ecoreg_proj*** map will be created in the new projection.
4. The next step is to rasterize the *Ecoreg_proj* polygon map into a raster with 1000*1000m cells within a fixed window.
 - A. Set up the correct raster cell size and extent for all future analysis operations with grid files in the *Spatial Analysis\Options* menu. For the *Extent* use the *As specified below* option with the following values: *Top: 2700000, Left: 2000000, Right: 3000000* and *Bottom: 900000*. Keep the *Snap extent to* option <none>. You can check with your cursor in your *Ecoreg_proj* map if this is a correct extent that includes all GMS countries. Use also the *As specified below* option for the *Select Cell* option and fill in *1000* (m). The number of rows and columns will show up automatically.

B. Now go to the *Convert\Features to Raster* option in the *Spatial Analysis* menu and use *Ecoreg_proj* as *Input feature*. Select the *Eco_id* as field for rasterization with an output cell size of *1000* m. Give the output file an appropriate name, e.g. ***ecoreg_ras***.

Prepare Land use / Land cover map

5. Change the projection of the Land use / Land cover shapefile map *Rung93_g_region* into the described Albers Equal Area Conic projection.
This exercise is described in step 3.
6. Rasterize the shapefile map *Rung93_proj* for the Type field with help of the *Features to Raster* option in the *Spatial Analysis* menu with the correct extent and cell size.
This exercise is described in step 4. Output file example data: ***GLC_zam***

Prepare Land use / Landcover – Biome matrix table

7. Export the land use / Land cover (LuLc) classes from the *GLC_zam* map and classes from the *Zam_ecopr* map to a table.
Export all classes from the attribute tables from their feature maps and open them in Excel.
For extensive class numbers you could use the pivot option in Excel to get the classes sorted into unique classes.
8. Put the LuLc classes and Ecoregion types into matrix table
Put the LuLc classes in the first column of an excel spreadsheet. Copy the *Ecoreg_ras* classes and put them into the first row with the *Copy* and *Paste Special\Transpose* commands.

9. Fill the matrix table with likely Biodiversity-classes of the *Biodiversity value table.xls*
 For this exercise you have to use common sense. For instance the LuLc class *Broadleaf deciduous open forest* is likely to be *Secondary forest* (i.e. class 12 in Biodiversity value table) in Moist Tropical Forest Biomes. But the same LuLc class is more likely to be *Primary forest* (class 10 in Biodiversity value table) in Biomes such as *Zambeziian Cryptosepalum dry forests, Zambeziian flooded grasslands, Southern Miombo woodlands and Western Zambeziian grasslands*. Try to fill in the complete table. For the LuLc class *water bodies* no biodiversity values is known and therefore they will get a 1 value so that they will not affect the biodiversity loss calculation.

Parse the matrix table into a table with unique MSA values per LuLc class per Ecoregion class

10. A. Create a table with three column headers: GLC, Luza_ecoreg, Bd_class
 Start with the first GLC class (=1) by putting this class number in front of each Ecoregion class. Use the *Copy* and *Paste Special\Transpose* commands to put the biome classes under each other in the new table. This will look like:

GLC	Luza_ecoreg
1	0
1	1
1	3
1	4
..	..
1	26
2	0
2	1
..	..

Do the same for the Biodiversity_class numbers in the third column. This will result in a table like:

GLC	Luza_ecoreg	Bd_class
1	0	10
1	1	10
1	3	10
1	4	10
..
1	26	10
2	0	10
2	1	10
..

- B. Add MSA values that belong to each Biodiversity_class number with the help of a look-up table

Bd_class	MSA value
10	1.0
11	0.2
12	0.5
..	..
70	0.05

Use LOOKUP function in Excel to add MSA values.

Example: =LOOKUP(C2,\$F\$2:\$G\$19 The result will look like the following example:

GLC	Luza_ecoreg	Bd_class	MSA
1	0	10	1.0
1	1	10	1.0
1	3	10	1.0
1	4	10	1.0
..
1	26	10	1.0
2	0	10	1.0
2	1	10	1.0
..

Save the table e.g. as *Landuse_ecoregion matrix.xls*

Combine the GLC map and the Ecoreg map to unique raster map

11. Overlay the Ecoregion map (*Zam_ecopr*) with the GLC map (*GLC_zam*) to get one raster map with unique values. Use the Raster calculator, e.g. like: $GLC_ecoreg = 1000 * [GLC_zam] + [Zam_ecopr]$
The GLC classes can be discriminated as values of 1000 and the Ecoregion classes as nrs between 1000 and 22026. For instance the new class 20026 consists of LuLc class 20 and Ecoregion class 26.
12. Make an Ascii lookup table in order to reclassify the unique raster map *GLC_ecoreg*
 - A. Make two new columns in the *MSA.xls* table, one being the unique combined value of LuLc and Biome (similar with the values of *Luvn_ecoreg* map), and the other with the MSA values.
The combined value can be calculated by multiplying the LuLc value with 1000 and adding the biome value. Because the Reclass function in Ascii can only be used for integer values, the non-integer MSA values can be multiplied with e.g. 100 so that the values vary between 1 and 100.

The resulting table will look like:

<i>GLC_ecoreg</i>	<i>MSA</i>
1000	100
1001....	100
1103....	100
..	..
22026	5

B. Copy the two columns in a text editor, e.g. in Notepad

The correct syntax for an Ascii Reclass table (*ArcToolbox\Spatial Analyst Tool\Reclass by Ascii*) are two columns divided by space : space (See next example)

1000 : 100

1001 : 100

etc.

Give the Ascii table a name (e.g. *GLC_Eco_rc.txt*)

Reclass the unique GLC/Ecoregion raster map (*Luvn_ecoreg*) with the Ascii Lookup table into a MSA map

13. Reclass the *Luvn_biome* map with the *Luvn_biome.txt* lookup table.
Use the *ArcToolbox\Spatial Analyst Tool\Reclass by Ascii* option with
Input raster file *GLC_ecoreg*
Ascii table *GLC_Eco_rc.txt*
Output raster file *MSA_Lu100*

14. Make the final LuLc impact map

You only have to divide the Reclassified *MSA_Lu100* map values by 100

Since the output needs to be non-integer or floating, divide the values by 100.0 with the help of the *Raster Calculator*: $msa_lu = MSA_Lu100 / 100.0$

Realize that the lakes and rivers will have a value of 0

Final output biodiversity impact by Land use MSA_LuLc : *MSA_Lu*

Impact on biodiversity per pressure

2. Impact by Infra structure

Human civilization is characterized by the presence of utility corridors to connect our villages, towns and cities. These corridors take the form of roads, railroads and canals. Of these, roads are the most prominent ones because they are so abundant. It is obvious that roads have an impact on biodiversity and they do so in different ways.

First of all, roads need to be constructed. This is a smaller impact than it may seem, because even in more densely populated areas (but outside settlements) roads take up less 0.1% of the land area. In some areas, however, the simple presence of the road is already an impact. In densely forested areas, the construction of roads creates two edges in the forest, on either side of the road. Along these edges more light and wind penetrates into the forest and the forest will therefore become drier. This may force certain species to move deeper into the forest, away from the road. The traffic on the road has a similar effect in that its noise and dust drives species away from the road.

Secondly, the road forms a physical barrier when trying to cross from one side to the other. Many animals are killed by the traffic when hit. In addition, the road surface tends to be very hot and dry compared to the forest (floor). There may be a barrier in the middle of major roads to keep vehicles in their lanes, but they also prevent animals from crossing. For other animals the road is simply too wide to cross, particularly for insects and smaller reptiles.

Thirdly, roads give humans access to previously inaccessible areas. This process has the most important impact on biodiversity related to infrastructure. People will enter via roads and clear a piece of land for agriculture, enter the forest for hunting or extraction of forest products, start fires, etc.

In this exercise you will look at a way to incorporate the diverse effects of roads on biodiversity.

Exercise

Input data:

- Local land use / land cover layer (*GLC_zam*)
- Road feature map (*Roads_pr*)
- *MSA_Infra* table; Impact zones per UNEP Land cover type

Intermediate output:

- Nature / Non-Nature raster (*nm*)
- Road buffer raster (*Rdbuffer* or *Rd_dist100*)

Final Output: Infrastructure impact raster (*MSA_Infra*)

The Mean Species Abundance (MSA) is affected in different ways as a function of distance to the nearest road and the land use type and population density.

baseline growth	1								
	cropland	grassland	boreal forest	temp. deciduous	tropical forest	semi-deserts/ deserts	wetlands	arctic tundra	Ice and snow / barren
relative impact per ecosystem	1	0.75	1.25	1.75	1.75	0.5	1	0.75	0.25
distance slope	0.1614	0.1614	0.1614	0.1614	0.1658	0.1614	0.1614	0.1658	0.1614
distance bias	0.8134	0.8134	0.7309	0.7309	0.6214	0.8134	0.8134	0.6214	0.8134
factor mineral deposit < 50 km	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
factor population density 0-10 / km ²	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
factor population density 10-50 / km ²	1	1	1	1	1	1	1	1	1
factor population density >50 / km ²	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
factor distance to coast < 50 km	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
factor mineral deposit < 50 km	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

2000	Zone in km								
Impact 1 (standard, MSA = 0.5)									
with population density 0-10 / km2	0.500	0.500	0.300	0.300	1.000	0.500	0.500	1.000	0.500
with population density 10-50 / km2	0.250	0.250	0.150	0.150	0.500	0.250	0.250	0.500	0.250
with population density >50 / km2	0.500	0.500	0.300	0.300	1.000	0.500	0.500	1.000	0.500
	0.750	0.750	0.450	0.450	1.500	0.750	0.750	1.500	0.750
Impact 2 (standard, MSA = 0.75)									
with population density 0-10 / km2	1.500	1.500	0.900	0.900	3.000	1.500	1.500	3.000	1.500
with population density 10-50 / km2	0.750	0.750	0.450	0.450	1.500	0.750	0.750	1.500	0.750
with population density >50 / km2	1.500	1.500	0.900	0.900	3.000	1.500	1.500	3.000	1.500
	2.250	2.250	1.350	1.350	4.500	2.250	2.250	4.500	2.250
Impact 3 (standard, MSA = 0.9)									
with population density 0-10 / km2	5.000	5.000	3.000	3.000	10.000	5.000	5.000	10.000	5.000
with population density 10-50 / km2	2.500	2.500	1.500	1.500	5.000	2.500	2.500	5.000	2.500
with population density >50 / km2	5.000	5.000	3.000	3.000	10.000	5.000	5.000	10.000	5.000
	7.500	7.500	4.500	4.500	15.000	7.500	7.500	15.000	7.500

Table 1 Infra zone impact table (infra_bufferwidth.xls)

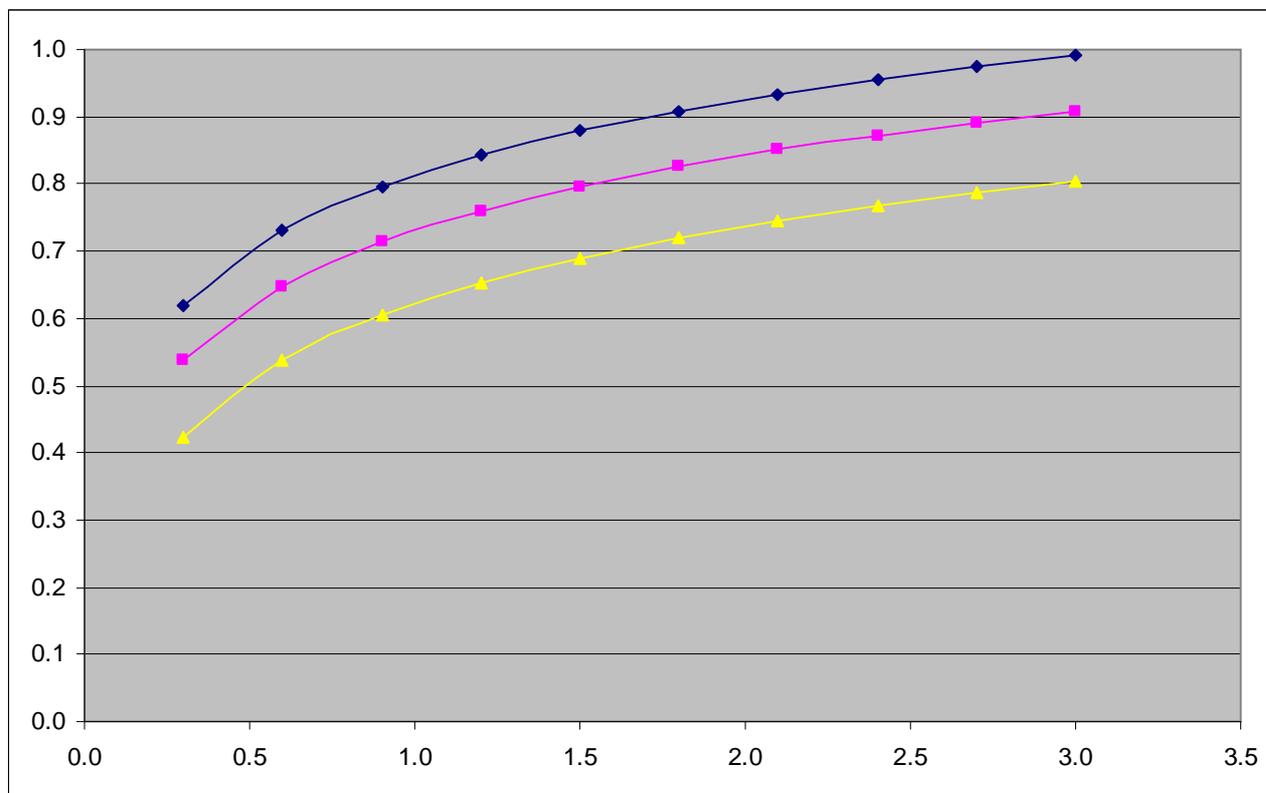


Figure 1: Graph of relation between distance from road and MSA for the land cover classes: cropland (blue/1st line), Boreal forest (pink, 2nd line) and tropical forest (yellow/3^d line)

As you can see from Figure 1 and Table 1, impacts are high (low MSA value) close to the road and they are lower (high MSA value) farther away from the road. At a certain distance the roads have no impact anymore (MSA = 1). Some types of land use have no biodiversity impact values associated with them, so the MSA value is always 1.

In addition, the population density near the roads also affects the pressure on the MSA. This relation is shown in table 1 for three population pressure classes; population 0-10 persons/km², population 10-50 persons/km² and population >50 persons/km². The higher the population, the wider the impact zones will be.

In ArcGIS the analysis without taking the population pressure in account, is fairly easily performed by buffering the roads, selecting the pixels that fall into each cell in the table above, and then combining those individual selections in a final raster. There are actually two ways that you can approach this: (1) You can build 9 polygons around the roads by buffering with the distances indicated and then selecting pixels that fall into each (set of) buffer(s); or (2) you can calculate the distance to the roads for every individual pixel and then select the pixels using that raster.

However, if you want to include the population effect also in the analysis, it becomes a bit more complicated. Therefore an Infrastructure script (*Infrastructure.py*) has been written in Python to simplify the calculation.. Python is the script language of ArcGis. This Infrastructure script assumes a natural logarithmic relation between MSA and the distance to the road (so, in other words, it does not look into only a few impact zones but gradually increases the impact with the distance).

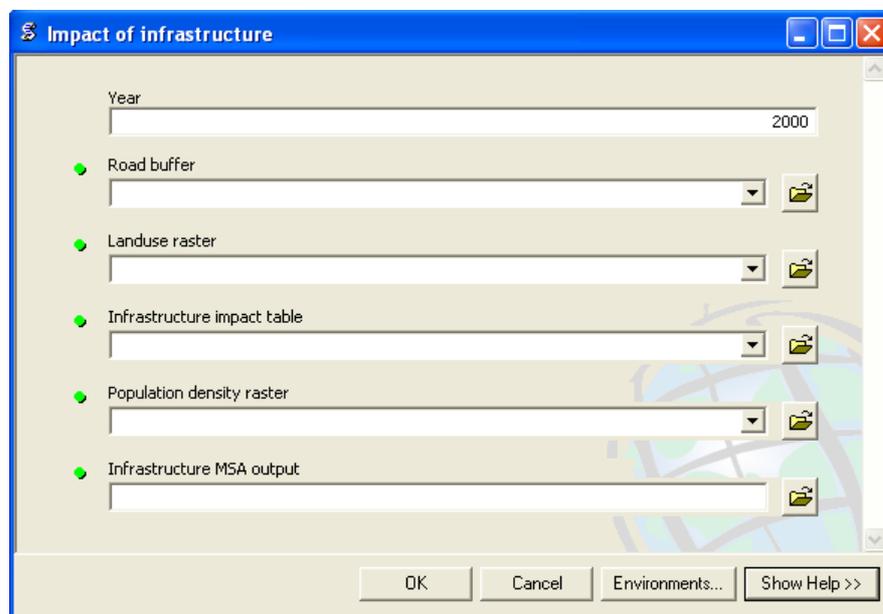
GLOBIO-3 GIS MODULAR: THE "IMPACT OF INFRASTRUCTURE" TOOL

In order to facilitate multiple runs of individual impact calculations (for instance, when you are developing multiple multi-year scenarios) an ArcGIS tool was developed for automated calculation of individual pressures on total MSA. This tool works like any other tool in the ArcGIS toolbox.

In order to run the *Infra_impact* Python script in your ArcMap Toolbox you should first create the following directory: *C:\Zambia_course\GIS\Infra*. This will allow to put temporary files on this location.

Once the *Globio.tbx*, *Infra_Impact.dbf* and *InfraImpact.py* files are in the *C:\Zambia_course\GIS\Infra* directory you add the script in ArcMap as a new Toolbox. Open first the Toolbox window in ArcMap. Right-click on the Toolbox and select Add new Toolbox. The Toolbox consists of one model and one script (lower one). Now, right click on the script icon and go to Properties / Source and edit the path to where the script is situated (*C:\Zambia_course\GIS\Infra*)

You can open the script by double clicking. The following Window should appear.



The following parameters should be supplied:

Parameter	Description
Year	The year for which the impact is to be calculated. This should be a value between 2000 and 2050.
Road buffer (<i>Rd_dist100</i>)	A raster representing the road buffer. This buffer can be prepared by running Spatial Analyst / Distance / Straight line. The resolution should be 100 meter.
Landuse raster (<i>Lu_infra</i>)	A raster with landuse/cover classes that correspond to the 9 classes defined for infrastructure impact by GloBio. Each land use class of the GLC_zam map has to be reclassified into one of the following 10 class numbers: 0= urban, water, other, 1= cropland, 2= grassland, 3= boreal forest, 4= temp. deciduous, 5= tropical forest, 6= (semi-)desert, 7 = wetlands, 8= Arctic tundra, 9= Ice and snow/barren. You can prepare this raster by running Spatial Analyst / Reclass / Reclassify. Values that are outside of the range 1-9 will get a NODATA value in the output (e.g. class 0).
Infrastructure impact table (<i>Infra_Impact.dbf</i>)	A table <i>Infra_Impact.dbf</i> is supplied with this tool. That table contains the constants for the analysis procedure. Locate that DBF file in this variable.
Population density raster (<i>Pop_rast</i>)	A raster with the number of persons per square kilometer.
Infrastructure MSA output (<i>MSA_infra_all</i>)	This is the output of the analysis: MSA due to the impact of infrastructure. Specify a proper location and name.

The theoretical procedure of the tool is as follows:

1. The Landuse raster is reclassified three times using the *Infra_Impact.dbf* table resulting in three temporary rasters: *SlopDist*, *BiasDist*, *TempSens* (these are not visible and deleted upon completion).

2. Then the following formula is applied:

$$\text{Temp} = ([\text{SlopDist}] * \text{Ln}([\text{Road_buffer}] + 10) * 0.001 / \text{Pow}((1 + (0.000001 * [\text{TempSens}] * (0.0221 * [\text{Pop}] + 0.373))), ([\text{Year}] - 2000))) + [\text{BiasDist}] * 0.0001$$

This formula is derived from relationships developed for GloBio-2. You can see these formulas also (in different form) in the Excel table on infrastructure fragmentation.

3. In a last step the values from the previous step are bracketed to the MSA range of 0.05 to 1:

$$\text{MSA} = \text{Con}([\text{Temp}] < 0.05, 0.05, [\text{Temp}] > 1, 1.0, [\text{Temp}])$$

After running the script the output will be a map with the MSA impact zones around roads (*MSA_infra_all*).

However, the impact of infrastructure should only be calculated for roads that are situated in nature areas. The impact of roads is already included in the biodiversity value for non nature classes. For the Zambia exercise, the following three land use classes of the GLC_zam map are classified as nature: broadleave evergreen, broadleave deciduous closed and regularly flooded shrub /herbaceous cover.

Making a Nature / Non-Nature raster

The classes from the Zambian Land use / Land cover raster have to be reclassified into a raster with nature raster cells and non-nature raster cells. For using the Reclass by Ascii option in Spatial Analyst, open your Excel table with the LuLc values and add a column for the Nature values. Give every natural class value 1 and the other non nature classes value 0. The table will look like:

GLC_zam	Nature	
1	1	Copy the two columns into a text editor and make the Reclass Lookup table as described in paragraph 12B in The Land cover / Land use chapter. Use the Reclass by Ascii option. You can also the direct reclassification option in the Spatial Analyst menu / Reclassify
2	1	
3	1	
12	0	
etc	etc	Output raster: <i>nn</i>

Now select only the *MSA_infra* zones that are situated in nature areas and create the final *MSA_infra* map:

1. Select the nature areas using the conditional function on the *nn* raster and assign the value of the calculated MSA value and the value 1 elsewhere (non-nature areas, so no MSA impact from infrastructure). In the **Raster calculator**:

$$\text{MSA_infra} = \text{Con}([\text{nn}] == 1, [\text{MSA_infra_all}], 1)$$

3. Impact by Fragmentation

Each species has a minimum area requirement to support a minimum viable population. Based on extensive literature review of the minimum area requirement for a representative number of animal species, MSA values are determined for different patch sizes. Table 3 shows the relation between MSA and patch size.

Table 3: The relationship between patch size and MSA

Area in km ²	MSA
1	0.55
10	0.75
100	0.85
1000	0.95
More than 10000	1.00

In order to calculate fragmentation first the land use / land cover map needs to be reclassified into a nature – non nature map. The natural classes include forests, grasslands, scrublands, ice and deserts. The non nature areas include cropland, artificial pastures and urban areas. There are different kinds of nature patches; nature areas surrounded by artificial areas with different land use, and natural areas that are disconnected internally by large roads, rail roads or channels.

Small roads with little traffic will have a minor fragmentation impact than large roads with more traffic.

In our exercise we will consider nature areas dissected by large roads as separate fragmented nature areas for which we will calculate their individual areas. Unpaved tracks and paths will be excluded from calculation.

A more complicated procedure will be to consider the distance between patches and thus also consider the connectivity aspect of fragmentation. Because of the complexity of the connectivity procedure we will not include this aspect in our calculation.

Input data:

- Nature / Non-Nature map (*nn*)
- Road through nature areas feature map (*Roads_pr*)
- Fragmentation impact table (*Fragmentation.xls*)

Intermediate output:

- Roads in nature grid map (*Roads_zam_n*)
- Fragmented nature area map (*Zam_area*)

Final Output: Fragmentation impact map (*MSA_fragm*)

Steps:

In order to get a detailed raster map with nature areas that are fragmented / disconnected by roads you will analyze the landscape at a fine resolution, e.g. 100m.

Set the appropriate options for Spatial Analyst. Set the Extent to the area of Zambia we used before (*Zam_rast*) and the Cell Size to 100m. Set the working directory to the folder GIS\Fragm.

Make a raster of the main roads through nature area map with a cell size of 100*100m

1. Use the Convert *Features to Raster* option of the *Spatial Analyst* menu. To select only the main roads and not the paths, select all primary and secondary roads of the feature road map Use the Projected Road file that you made in the Infrastructure module (*Roads_zam*).

First you have to add a unique numeric field to the attribute tables of the feature road layer (*Roads_pr*), e.g. the field *Grid* with the value 1 for all the roads: Open the Attribute map of the feature road layer (*Roads_pr*)

Select the *Options* menu in the table and Add Field. Fill in the *Name* of the field, e.g. *Grid* and use the defaults for Short integer and a precision of 0. Now go with your cursor to one of the column headers and right click: *Select Calculate Values*. Press OK on the edit warning and use *Grid = 1* in the Expression window to add the value 1 to each buffer polygon.

Now make a raster of the Road feature layer:

Input features: *Roads_pr*
Field: *Grid*
Output cell size: 100
Raster: *Roads_zam*

Make an overlay raster map of the road and nature raster maps

2. Use the Raster Calculator in the Spatial Analyst menu and add the road and nature raster maps. Since the Road grid map contains Null values, these will have to be changed in order to add both maps. This can be done with the help of a conditional statement with the Isnull function:

$$\text{Roads_zam_n} = \text{con}(\text{Isnull}([\text{Rds_VN_grid}], 1, 0) * [\text{nn}])$$

This operation will put the nnn value (nature or non-nature) where there are no roads (NULL value in the raster) and a 0 if they are within a nature area. The output values are 0 (non-nature or road) and 1 (nature).

Make a fragmented nature area map

You can do this by making clusters of gridcells with a certain value that are not disconnected by gridcells with another value. This can be realized with the **Regiongroup** function. This function looks to the connectivity of grid cells. Each cluster of grid cells that is not disconnected by grid cells with another value, is given a unique cluster value. The first cluster gets the value of 1, the second 2, etc.

3. Select the Region Group option in the *ArcToolBox\Spatial Analyst Tools\Generalization* menu
Input raster: *Roads_zam_n*
Output Raster: *Reg_n_rd_zam*
Number of neighbours: *Eight*
Method: *Within*
Excluded value: *0*

4. You can use the **.count** function to reclassify the nature area clusters values by Area values

$$\text{Zam_area} = [\text{Reg_nat_rdVN}].\text{count} / 100$$

Every pixel this new raster contains the area of the cluster that it belonged to, in km² (because you divide by 100).

Make the Fragmentation impact map.

You have to reclassify the fragmented nature area cluster Area values by biodiversity impact values. For the reclassification you can make a lookup table with Area classes and corresponding fragmentation impact classes. Use the *Fragmentation.xls* table

A. Make a Fragmentation lookup table

5. Since Reclassify does not work with floating values multiply the *MSA_frag* value with 10,000. Make an Ascii lookup table in Notepad with the following structure:

0	1	:	5500	<i>NB: Use spaces between each column and before and after the : sign.</i>
1	2	:	5829	
2	3	:	5829	
..	..	:	..	

Lookup table: *Fragmentation.txt*

B. Reclassify the *Zam_area* raster with the Fragmentation lookup table

6. Use the *Reclass by Ascii file* option in the *Spatial Analyst Tools\Reclass* Menu. The Output raster file: *Imp_frag10000*
7. Where there is nature you should divide the output raster file (*Imp_frag10000*) by 10000 in order to get the correct *MSA_impact* values. Non-nature areas should get the value 1 (no impact on MSA from fragmentation). Use the Raster calculator and use the value 10000.0 with a decimal in order to get floating results.

$$\text{Imp_fragm} = \text{con}([\text{nn}] = 1, [\text{Imp_frag10000}] / 10000.0, 1)$$

8. Use the Aggregate function in *Spatial Analyst Toolbox\Generalization* menu, to reduce the resolution to 1km. Use a Cell Factor of 10 and an Aggregation Technique of MEAN. Call the final output ***MSA_fragm***.

4. Impact by Nitrogen deposition

Nitrogen deposition occurs in areas that are situated near areas with concentrated use of artificial or natural Nitrogen containing fertilizers. Prevailing winds carry Nitrogen and cause Nitrogen deposition in nature areas.

NOTE: Since Nitrogen deposition is very low in Zambia this pressure map does not have to be calculated.

The impact of Nitrogen deposition on biodiversity will be calculated in our model for nature areas. Crop areas are excluded in the calculation because the impact of Nitrogen deposition is limited in compared with the use of fertilizers for crops.

Different ecosystems have different thresholds for the amount of Nitrogen deposition that they can cope with. When the Nitrogen deposition in a natural area exceeds the so called ‘critical load’ level of this natural area, the biodiversity will decline. If the Nitrogen deposition is lower than the critical load, there will be no significant impact on biodiversity. Table 4 shows the regression equations for the relation between Nitrogen exceedance and the MSA_nitrogen value.

Table4. Regression equations for the relation between Nitrogen deposition exceedance (NE) above Critical loads for three ecosystems.

Ecosystem	Equation*	Applied for land cover classes
Arctic-Alpine ecosystem	$MSA = 0.9 - 0.05 * NE.$	Ice
Boreal coniferous forest	$MSA = 0.8 - 0.14 \log_e (NE)$	Forest
Grassland ecosystems	$MSA = 0.8 - 0.08 * \log_e (\text{Nitrogen exceedance})$	Grassland and shrub

Nitrogen exc. = Nitrogen exceedance defined as N- deposition minus mean Critical load

Both the Nitrogen deposition and the Critical load map are provided for this exercise.

The final nitrogen deposition impact map can be made by combining the N-exceedance map with the land cover map and applying the regression equations from table 4.

Exercise

Input data:

- Local land use / land cover raster map
- N-Deposition map (*Ndep_int*)
- N-Critical load map (*Critl_int*)
- Nitrogen exceedance (or overload) regression equations table (*Ecoreg.xls \Worksheet Nitrogen*)

Intermediate output:

- Nitrogen Exceedance raster map (*Exceed*)
- Nitrogen impact on forests map (*Nimp_forest*)
- Nitrogen impact on grass lands map (*Nimp_grass*)

Final Output: Nitrogen impact map (*Impact_ndep1*)

Steps:

Make a forest and a grasslands raster map based on the Local Land use / Land cover map.

1. Reclassify the Local land use / land cover raster map in a forests and a grasslands map. First make two Ascii lookup tables, one *N_forests.txt* table with a LuLC and a Forests column (forest = 1), and the second table, *N_grass.txt* with a LuLC and a Grasslands column (Grass = 0).

The tables will look like:

GLC_zam	Forest	GLC_zam	Grass
1	1	1	0
2	1	2	0
..
..

2. Use the *Reclass by Ascii file* option in the Spatial Analyst Tools\Reclass\ Menu.

The Input file is:

The Reclass table: *N_forests.txt* (resp. *N_grass.txt*)

Output raster file: *N_forest* (resp. *N_grass*)

Change the projection of the Nitrogen deposition and Critical load map

3. Use the Project Raster option in the ArcToolBox\Data Management Tools\Projections and Transformations menu. If you want to project a file, first open an empty map and add the file(s) you want to project. Otherwise a datum conflict may occur if files that are already on your screen have different projections. Use the Import option to automatically select the right projection parameters of the already converted raster file.
4. Output files: *XXndep* and *XXcritl*
NB Do not yet set the optional cell size to 1000m in the Project Raster menu. ArcMap has a problem doing this. After you created the projected file set your window extent back to the normal extent(see preparation chapter) and cell size (1000m) for Zambia.

Create the Nitrogen Exceedence raster map

The Exceedence is calculated by subtracting the Critical load map from the Nitrogen Deposition map. Both Nitrogen deposition and Nitrogen Critical load input maps are expressed in g/km². In the calculation of the Exceedence you have to convert this unit to kg/km². Convert the negative values into 0 with the SetNull command.

5. Use the Raster calculator to calculate the Nitrogen Exceedence values.
To get from g/km² to kg/km² you have to divide the values by 1000. Give the 1000.0 one additional decimal in order to get an output map with floating values. Use the conditional statement with the Setnull command in order to give all negative values the value 0.

$$\text{Exceed} = \text{Setnull}([\text{VNdep}] < [\text{VNcrtl}], ([\text{VNdep}] - [\text{VNcrtl}]) / 1000.0)$$

Create Nitrogen impact maps for forests and grasslands

Use the Nitrogen exceedence regression equations (*Ecoreg.xls \Worksheet Nitrogen*) to calculate the impact of Nitrogen exceedence for forests and grasslands. For tropical forests no exact relation is known but it will be close to the relation of Boreal coniferous forests. Therefore we will use for the countries forests the equation of the Boreal coniferous forests.

6. Use the Nitrogen exceedence regression equations in the *Raster calculator* to create the N-forest and N-Grasslands impact maps

$$\text{Nimp_for} = \text{con}([\text{N_forest}] > 0, 0.8 - 0.14 * \ln([\text{Exceed}], 0)$$

$$\text{Nimp_grass} = \text{con}([\text{N_grass}] > 0, 0.8 - 0.08 * \ln([\text{Exceed}], 0)$$

Create the Nitrogen impact map

The total Nitrogen impact map can be created by combining the Nitrogen Forest impact map with the Nitrogen Grassland impact map. Since grassland raster cells can not be forest raster cells, the output raster map can be created by adding the two input maps. Because the input maps have values slightly above 1 (max Nimp_for = 1.3 and max Nimp_grass = 1.1), the output values above 1 will have to be reclassified as 1 (= no impact).

7. Use the Raster calculator to add the N-forest impact map with the N-grassland map and use the conditional statement to reclassify the values > 1 to 1:

$$\text{Impact_ndep} = \text{con}([\text{Nimp_for}] + [\text{Nimp_grass}] > 1, 1, [\text{Nimp_for}] + [\text{Nimp_grass}])$$

$$\text{Impact_ndep0} = \text{con}(\text{IsNull}([\text{Impact_ndep}], 1, [\text{Impact_ndep}])$$

8. Now set 0 values to 1 and use the *XX_outl* raster map to set the values outside theZambian border to Null. You can do this by multiplying the Nitrogen impact map (*Impact_ndep*) with the Zambian outline map (*XX_outl*) in the *Raster calculator*:

$$\text{Impact_ndep1} = \text{con}([\text{Impact_ndep0}] == 0, 1, [\text{Impact_ndep0}]) * \text{XX_outl}$$

Impact on biodiversity per pressure

5. Impact by Climate change

The world is currently experiencing a period of rising temperatures. This change in climate will, over time, have an enormous impact on biodiversity locally. With rising temperatures the local patterns of rainfall (amount, distribution during the year) will change as well. This means that species will be driven out their old habitats and having to find new habitats. It has already been noted that certain tree species are “moving up the mountain”, where conditions are now more favourable due to the increased temperature. A similar trend is visible globally, where species are moving to higher latitudes to find conditions that are optimal for them.

Researchers all over the world have tried to quantify these trends and still much work needs to be done. On the basis of previous work MNP derived simple regression models (see background paper). In this exercise you shall adopt such a simple regression that relates predicted temperature rise to impacts on MSA for different biomes.

In this exercise you will use the predicted temperature rise of 0.569 degrees Celsius for the year 2000 with the sensitivity to temperature rise at biome level. The relationship is: $MSA_{cc} = 1 - Sens * \Delta Temp$. Sensitivity values, also called Slopes in mathematical regression equations, are given in the *Climate.xls* spreadsheet for all biomes, so you can easily calculate the effect on MSA for the individual biomes there. You can then import those values into ArcGIS and make a map of the climate change effect on MSA values.

As a result you will get a raster map that indicates for each pixel the impact of climate change. You will combine this map with the other impact maps and produce a final map of impact on MSA.

Input data:

- Ecoregion raster map (*Zam_ecopr*)
- Biome regression slope table (*Climate.xls*)
- Temperature change per year table (*Climate.xls*)

Final Output: Climate change impact map (*MSA_clim*)

Steps:

Reclassify the Biome raster values by creating a Ascii Lookup table

A relation of the impact of temperature change on biodiversity in Biomes has been determined. This relation can be expressed by the following linear regression equation: $MSA_{cc} = 1 - Slope * \Delta Temperature$.

The temperature change for a specific year can be calculated by climate change models. For instance the Image model calculates for each year a temperature depending on the selected scenario. For a baseline scenario of the OECD, Image calculated a delta T of 0.569 degrees Celsius for the year 2000. We will use this figure in our model.

1. Create the Biome raster map.
Use the projected *ecoreg_proj* feature map that you made in the Land use module. Rasterize the layer on the *Biome_rivm* field. Call the output file *Zam_ecopr*.
2. Make in Excel a table with the following columns: Biome, $\Delta t^{\circ} 2000$, Slope $^{\circ}C$, MSA_{cc}
The MSA_{cc} values can be calculated with the expression: $MSA_{cc} = 1 - Slope * \Delta Temperature$
The resulting table will look like:

ecoregion code	$\Delta t^{\circ} 2000$	Slope $^{\circ}C$	MSA_{cc}
0	0.569		1
1	0.569	0.039	0.977809
3	0.569	0.039	0.977809
4	0.569	0,039	0.977809
8	0.569	0.193	0.890183
..			

Create a Lookup table

3. Because the Reclassify by Table can not calculate floating values, you first have to make the MSA_cc values integer. You can do this by multiplying the MSA values with 10000.
Create an Ascii Lookup table with two columns with the values for respectively Biome and MSA_10000
Copy the two columns in Notepad and separate them by spaces and the : symbol
Output: *eco_msa10K.txt*

Reclassify the biome map to a climate impact map

4. Use the *Reclass by Ascii file* option in the *Spatial Analyst Tools\Reclass*. Menu.
The Input file is: *Zam_ecopr*
The Reclass table: *eco_msa10K.txt*
Output raster file: *MSA_clim10K*

Create the Final Climate change impact map

5. Use the Raster calculator and divide the integer climate impact map by 10000.0 to get the MSA_cc impact map.
In order to set the values outside the Zambian border to Null multiplying the input map with the Zambian outline map.

$MSA_clim = [MSA_clim10K] / 10000.0 * [Zam_rast]$

MSA total

6. Total Impact map:

Mean Species Abundance map of the remaining biodiversity in Zambia

The final MSA is now calculated by multiplying the MSA maps for land use, nitrogen deposition, infrastructure, fragmentation and climate:

$$MSA_i = MSA_{LU_i} * MSA_{I_i} * MSA_{F_i} * MSA_{N_i} * MSA_{CC_i}$$

Input data:

- Land use impact map (*msa_lu_fin*)
- Infrastructure impact map (*msa_infr_fin*)
- Fragmentation impact map (*msa_frag_fin*)
- Nitrogen deposition impact map (*msa_nitr_fin*)
- Climate change impact map (*msa_clim_fin*)

Final Output: MSA map Zambia 2000 (*msa_tot*)

Steps:

Create the total remaining biodiversity map or MSA map for Zambia 2005

Use the Raster calculator to calculate the impact of all pressures on the Biodiversity by multiplying their impact raster maps according to the following equation:

$$MSA_{tot} = MSA_{LU_i} * MSA_{I_i} * MSA_{F_i} * MSA_{N_i} * MSA_{CC_i}$$

Note that there should be no zero's (0) or Null values in the Zambia land area for each map

However, the area outside Zambia should be Null for each map. You can achieve this by multiplying the map with the Zambia_outl map which contains only the value 1 for the land surface.

Calculation in the raster calculator:

$$Impact_{tot} = [msa_lu_fin] * msa_infr_fin * msa_frag_fin * [msa_nitr_fin] * [msa_clim_fin]$$

Spatial Aggregation: MSA shares per pressure and unit

If you want to calculate the MSA for a region and you have the MSA maps per country you can aggregate the data according to the following formula:

Where:

U = upper level

i = local level

A = area

$$MSA_U = \frac{\sum_i MSA_i * A_i}{\sum_i A_i}$$

Calculating MSA loss shares per pressure type

If you are interested in the individual share of biodiversity loss per pressure type you have to disaggregate the MSA_{total}. This process is a bit more complicated than the above mentioned spatial aggregation because a correction factor needs to be calculated in order to calculate all shares as a percentage of 1.

In the following example the MSA loss of pressure type x is calculated manually:

- $MSA = MSA_{LUC} * MSA_{CC} * MSA_N * MSA_I * MSA_F$
 $MSA_{LUC} = 0.8; MSA_{CC} = 0.99; MSA_N = 0.95; MSA_I = 0.97; MSA_F = 0.99$
 $MSA = 0.8 * 0.99 * 0.95 * 0.97 * 0.99 = 0.7225$
- Calculate $MSA-loss_x = 1 - MSA_x$ and sum all $MSA-loss_x$
 $MSA-loss_{LUC} = 0.2; MSA-loss_{CC} = 0.01; MSA-loss_N = 0.05; MSA-loss_I = 0.03; MSA-loss_F = 0.01$
 $MSA-loss_{sum} = 0.2 + 0.01 + 0.05 + 0.03 + 0.01 = 0.3$

Note: $MSA-loss_{sum} \neq 1 - MSA$ because of multiplication procedure! Correction with correction factor needed!

→ $1 - MSA = 1 - 0.7225 = 0.2775 \neq 0.3$

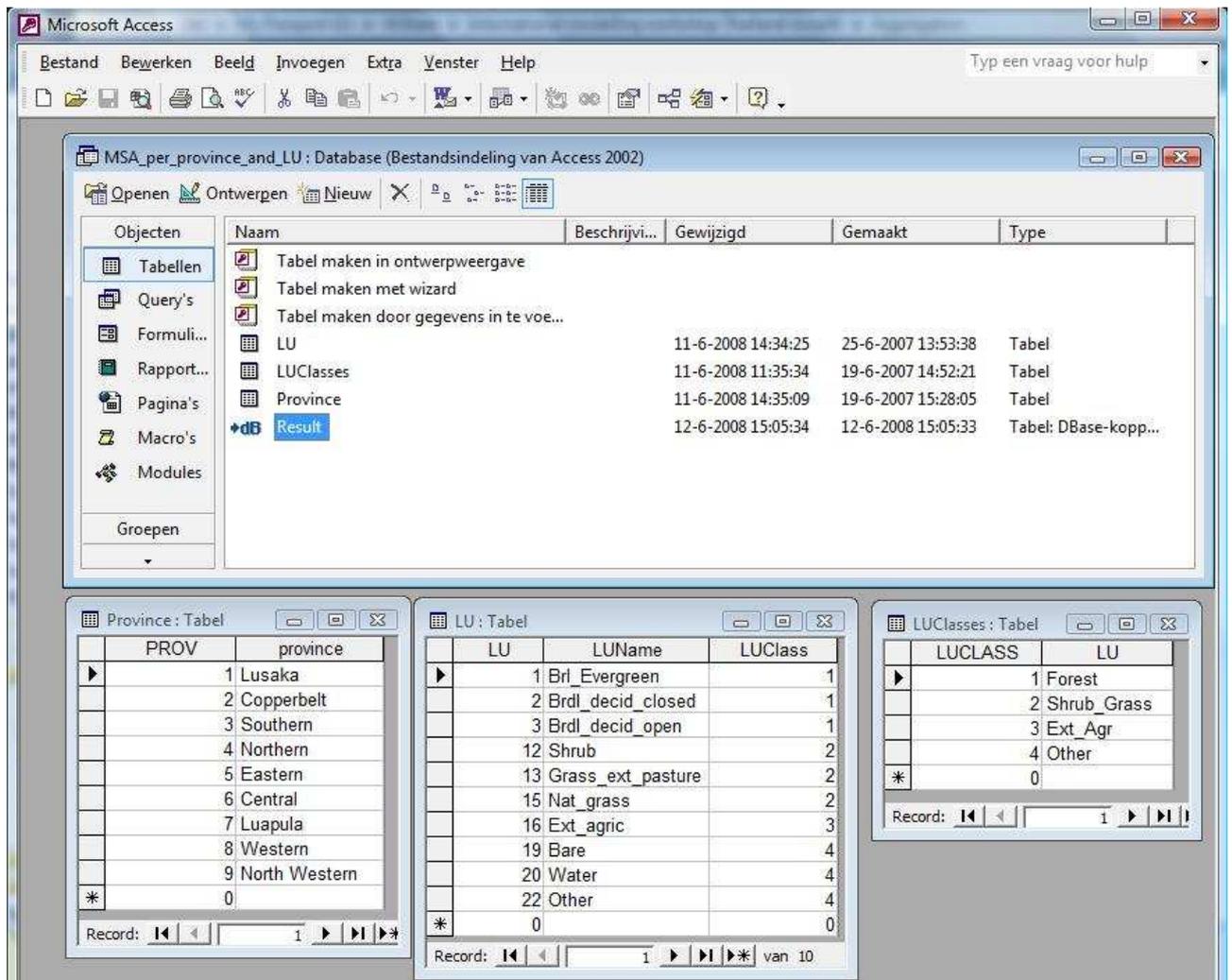
- Calculate correction factor $cf = (1 - MSA) / MSA-loss_{sum}$
 $cf = 0.3 / 0.2775 = 0.9249$
- $MSA-loss'_x = cf * MSA-loss_x$
So the biodiversity loss share for all pressure types are:
- $MSA-loss'_{LUC} = 0.1850; MSA-loss'_N = 0.0092; MSA-loss'_I = 0.0462;$
 $MSA-loss'_I = 0.0277; MSA-loss'_F = 0.0092$

Running the (dis-)aggregation query in Access

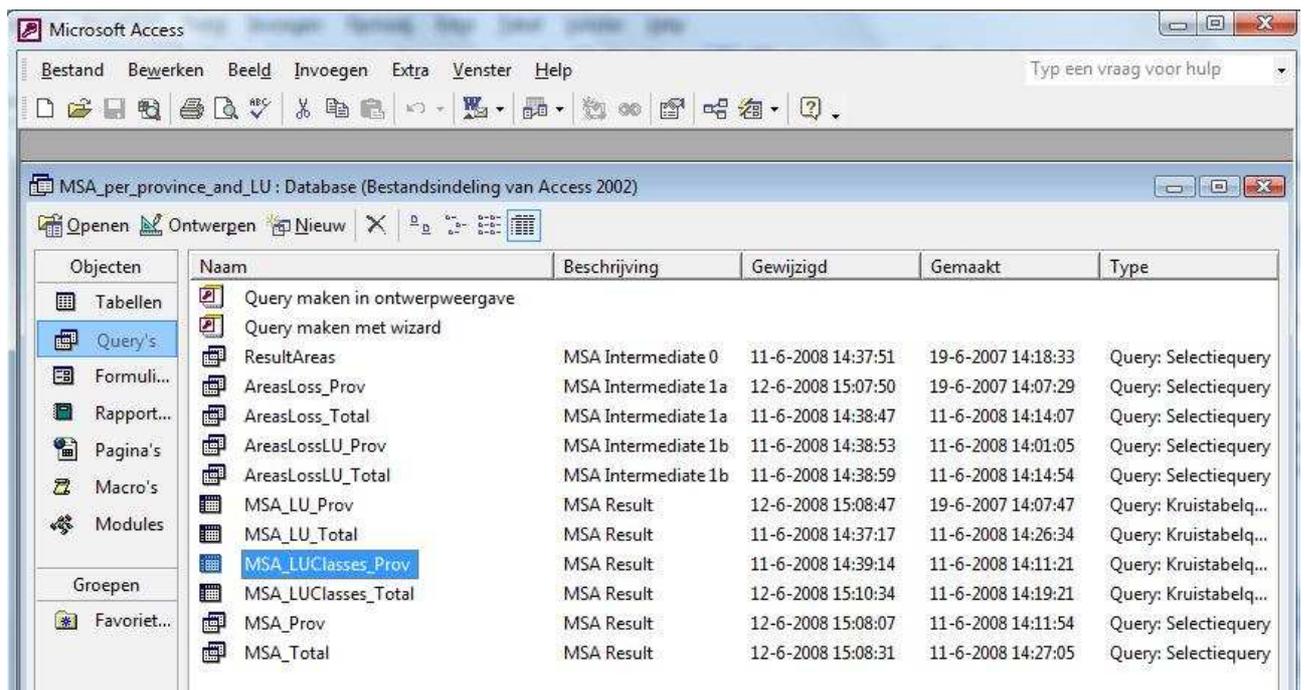
An access database (*MSA_per_province_and_LU.mdb*) has been made to simplify the disaggregating process. By using this tool you let the computer disaggregate your data in a split second. The database together with an example of a combined table (*Result.dbf*) can be acquired freely from the Netherlands Environment Assessment Agency.

Before you can start running the Access query be sure that the syntax of all headers is exactly the same as the headers in the Result.train example dbf table.

1. Make a copy of the database ...*MSA_per_province_and_LU.mdb* to the directory where you saved your Result.dbf table.
2. Open the database (mdb)
3. Update the old Result.dbf with the new Result.dbf table that you just made. You can do this by either:
A: Delete the existing (old) Result.dbf table (select on linked dB table and delete) and Import the new table (right click on Tables menu left of window and select *Import*).
B: **OR** by updating the content of the old Result.dbf with the new Result.dbf table (by right clicking on Tables menu left of window and select *link Tables*) Select the new Result.dbf and *always prompt for new location*.
4. Update the new Result.dbf (Right click on linked dB table and select *Linked Table Manager*)
5. Now edit you province table with the provinces and codes of your own province map (Province).
6. Also edit the LU table with the codes (LU) and names (LUName) of your own LU map.
7. You can regroup your LU classes by giving group codes (LUClass)



8. Now run a query by first opening the Query window and then by double clicking on the MSA result query that you want (MSA total or disaggregated to province and LU type).



9. Export the query result to an Excel table (*File/Export ... Type/Excel*)

Graphical output

In addition to the output table of the MSA results per province and Lu type you can also illustrate your results with graphical output that makes the information better interpretable for policy makers. In general colourful maps and graphs are more appealing to many people than tables or text.

Figures examples

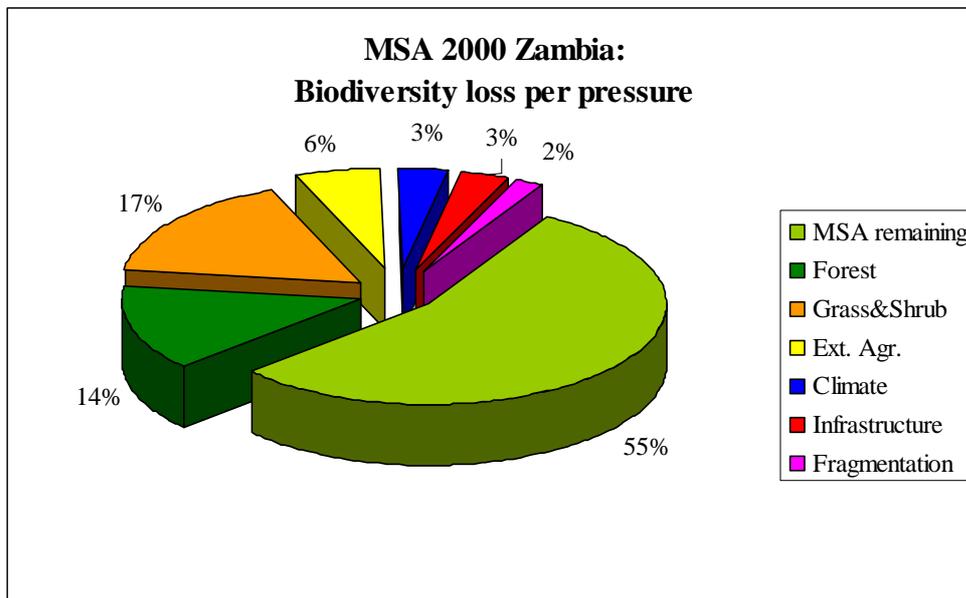
- Pie chart of pressures in one year and region
- MSA loss bars
- Stack bars of pressures for multiple regions/years
- MSA change in time

In Excel edit your query result tables in a format that can be read by the Chart Wizard (*Insert/Chart*), e.g. sort the exported (Excel) output from the Query 'MSA_LUClasses_Prov' in the following structure:

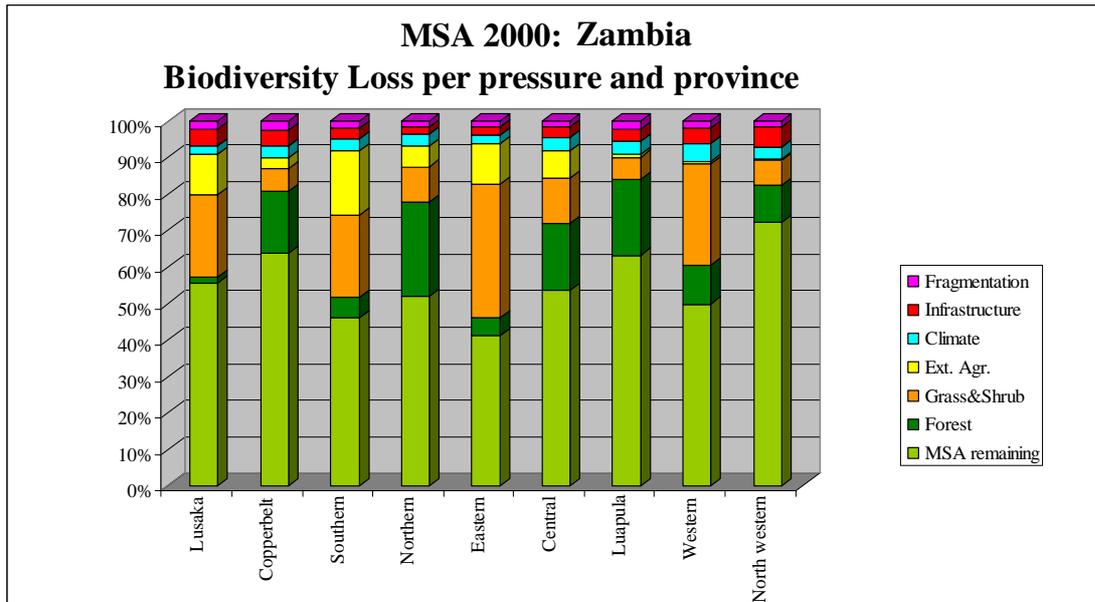
	MSA remaining	Forest	Grass&Shrub	Ext. Agr.	Climate	Infrastructure	Fragmentation
Lusaka	0,54751	0,01713	0,22140	0,11045	0,02278	0,04588	0,02126
Copperbelt	0,63110	0,16803	0,06211	0,02979	0,03181	0,04448	0,02426
Southern	0,45951	0,05779	0,22392	0,17606	0,03255	0,03076	0,01935
Northern	0,52089	0,25612	0,09731	0,05774	0,03206	0,01909	0,01679
Eastern	0,41301	0,04711	0,36839	0,11000	0,02167	0,02353	0,01628
Central	0,53458	0,18393	0,12403	0,07714	0,03552	0,02837	0,01623
Luapula	0,63248	0,20714	0,06100	0,00910	0,03538	0,03274	0,02213
Western	0,49835	0,10552	0,27963	0,00714	0,04643	0,04258	0,02035
North western	0,72320	0,10117	0,06819	0,00239	0,03348	0,05494	0,01664

Now you select the type of chart type that you want (e.g. Pie or Column)

Pie chart example for one country in one year

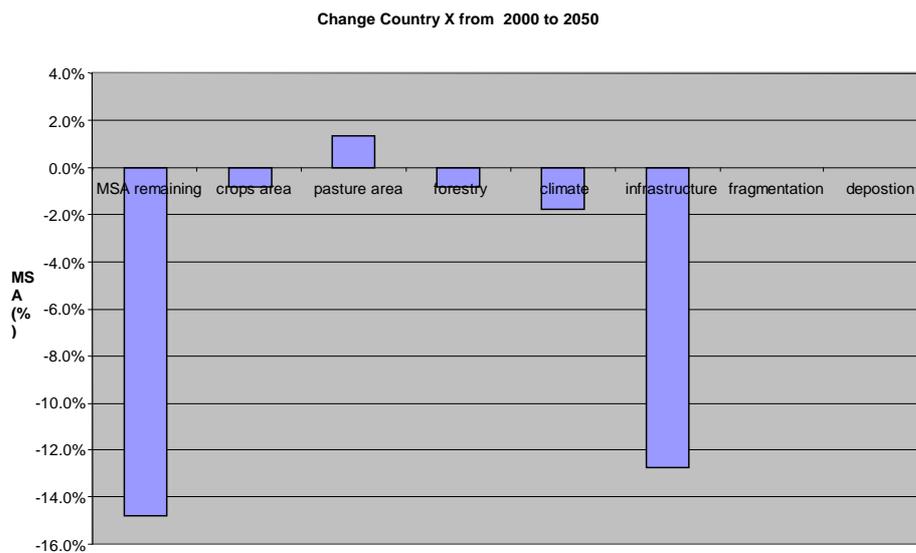


Stack bars example of pressures for multiple regions (provinces)

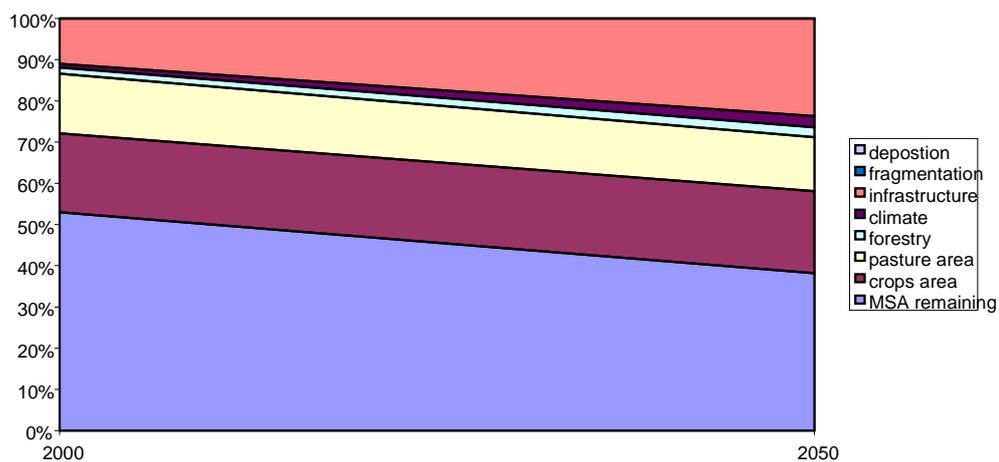


MSA change in time

MSA loss bar



MSA development for country X from 2000 to 2050



Appendix I: Assigning MSA values to a National Land Use map

National Land use maps often contain more detailed information than the Global Land Cover maps (GLC). A lot of detail can be lost with grouping unique land use classes from your national land use map into generic land use classes as shown in Table 1.1. To avoid this information loss biodiversity values can also be estimated for the unique land use classes directly.

The biodiversity value of a land use/cover class can be estimated based on an interpolation of the generic Globio3 MSA values by experts who have some knowledge about the composition and biodiversity level of specific land use classes.

Table I.1 Globio3 MSA values the generic forest classes of the Global model

Biodiversity class name	Generic MSA value
Primary forests	1
Light used primary forests	0.7
Secondary forests	0.5
Forest plantations	0.2

Underneath the example is given for land use classes of the FIPI2002 land use map of Vietnam. For this example forestry experts ranked the 19 forest classes according to their biodiversity level and compared each class with the biodiversity values for the generic Globio3 forest classes (table I.1). Then they assigned a biodiversity value to each unique forest class by interpolation of the MSA values of the generic Globio3 forest classes. By this method the land use MSA values are not determined by extensive research but by interpolation of known MSA values for generic land use classes. Of course the best results would be achieved if the actual MSA value per land use class is determined by extensive field work. But since inventories of species abundance for species groups per land use type are in general lacking the interpolation method will improve the overall result. During the biodiversity assigning process it is essential that the experts do not only look at the generic values but also compare the biodiversity of the unique land use type with that of the original vegetation at each location.

Code	FIPI original (2002)	Interpolated MSA value *
10	Natural Timber Forest	0.90
11	Rich Forest	1.00
12	Medium Forest	0.80
13	Poor Forest	0.60
20	Young Forest	0.55
21	Reforestation Rich	0.45
22	Reforestation Medium	0.40
23	Young forest with volume	0.55
24	Young forest with no volume	0.45
31	Dipterocarp forest (deciduous)	0.95
32	Semi- deciduous forest	0.95
41	Natural conifer forest	0.95
42	Mix forest (Broad leaf and conifer forest)	0.80
51	Bamboo forest	0.45
52	Mix forest (Timber+bamboo forest)	0.55
60	Mangrove forest	0.80
70	Plantation forest	0.20
71	Speciality forest	0.90

Interpolations have also been made for the other land use classes of the FIPI2002 land use map:

80	Bare land (Without distinction)	0.10
81	Grassland	0.15
82	Shrubland	0.20

83	Scattered tree	0.25
91	Rocky mountain with tree	1.00
92	Rocky mountain with no tree	1.00
101	Forest garden	0.50
102	Nursery	0.15
103	Industrial trees	0.20
104	Fruit trees	0.40
110	Agriculture land	0.10
111	Paddy, subsidiary crop	0.05
112	Milpa/upland	0.30
121	Residential land	0.05
122	Specialized land (cemetery, army land,...)	0.05
123	Sand-bank	0.10
130	Other land (undefined)	0.10
141	Swamp	1.00
142	Rivers, Lakes, Streams	1.00

* The interpolation has been carried out by a few specialists for training purpose.