Monitoring and measuring environmental change – agricultural encroachment in southern Africa

Scenario

Many areas of southern Africa used to be unsuitable for agriculture because of the disease trypanosomiasis, which affected both cattle and humans. In the past few decades, the tsetse fly that spread trypanosomiasis has been eliminated from large tracts of land, leading to a rapid expansion in agricultural cultivation. Large tracts of semi-natural vegetation have been affected by this expansion, which some have dubbed an 'ecological disaster' (see Reid et al, 1997 for more details).

As a GIS analyst working for an international conservation charity, your task is to determine the extent and pace of land cover change since the 1970s.

The Data

The data set consists of three shape files called landcover70s, landcover80s and landcover90s. These are all map layers of different land cover categories at the Mafungabusi forest reserve in Zimbabwe and the immediately surrounding area of smallholder agricultural land. The map layers are all in the UTM Zone 35 (south) projection and the WGS1984 datum. Each represents a different year (1976, 1985, and 1996) and was produced from 1:50,000 scale aerial photographs.

As well as the area, perimeter, and unique identifier for each object, two further fields of data are available:
Treecover: estimated percentage tree cover, based on the aerial photographs
Landcover (called type in 1976): the main land cover class for the polygon (e.g. forest, farmland, vlei [riverine grassland]), etc.

For the 1970s map layer only, a further field called lctype has been created, which has numeric codes for the main land cover types (agriculture = 1; vlei = 2; woodland = 3; and forest = 4).

Practical activity

Q1. How would you describe the data in these 3 map layers – categorical, ordinal or ratio or both? [think about this before reading further]

A1. The data in these map layers are a mixture of both categorical and ratio variables. The percentage tree cover recorded for each polygon is ratio (because we can say that some parts of the map have greater tree cover than others and the figures are measured in percent, so we can meaningfully divide one percentage by another and say for example that one area has twice the tree cover of another). The land cover categories are categorical (the land cover categories in themselves cannot be ordered from highest to lowest).

The rest of this practical explores the ways that we can use the land cover fields – categorical data.

Q2. You wish to produce a summary table, showing the area covered by each type of land cover in 1976 in the columns and the type of land cover in 1996 in the rows (see the table below as an illustration). Can you think of how you might do this using ArcGIS Pro?

Rows: land cover in 1976	Columns: land cover in 1996			
	Woodland	Forest	Agriculture	Vlei (riverine grassland)
Woodland				
Forest				
Agriculture				
Vlei (riverine grassland)				

Area covered by woodland in both years

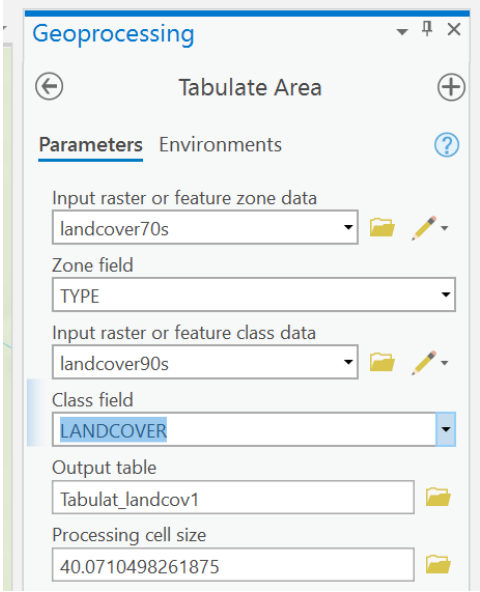
Area converted to agriculture from forest

A2. There are several ways that this could be done. One way would be to overlay the map layers for 1976 and 1996. We could, for example, do this using *Analysis Tools* / *Intersect* in the geoprocessing toolbox. The resultant map would tell us what each polygon's land cover map was in each year – but it still would not give us an overall summary table like the one described on the previous page. We could probably create such a table (e.g. using Excel), but it might take some time.

A quicker way of producing a table like this is to use the geoprocessing tool from the *spatial analyst* extension called *Tabulate Area*. Create a new map template using ArcGIS pro, then head for the *project* menu and *licensing*. Choose *configure your licensing options* to activate the spatial analyst licence. After leaving the *project* menu, head for the *Analysis* menu, choose *tools* and then search for 'tabulate'. Select and run this tool and enter **landcover70s** as the *input raster or feature zone data*.

This tool will create a table such as the one shown on the previous page, using categories drawn from two different map layers. As shown in the illustration below, it uses as inputs some *raster / feature zone data* (the categories that end up in the rows in the output table) and some *raster / feature class data* (the categories that end up in the columns in the output table). For each of these two map layers, we also choose a field from among their attributes that contains the categories that we want.

If you enter in the **landcover70s** and **landcover90s** map layers as the two input layers, you should be able to select the **type** and **landcover** fields as the *class* and *zone field* respectively:



Notice that the tool rasterises both vector layers in making this calculation, which is why a *processing cell size* is needed (automatically calculated as approximately 40 x 40 metres based on study area extent, though you could enter your own value here).

When you run the command, you should find that the command will create a table similar to the one below. This has land cover types in 1976 in the rows (the code for each landcover type being stored in the **TYPE** field), and land cover types in 1996 along the columns.

tabulat_landcov1

Field: Add Calculate | Selection: Zoom To Switch Clear Delete Copy

Rowid	TYPE	FOREST	AGRICULTURE	VLEI	WOODLAND	FORMER_AGRICULTU
1	Agriculture	1143250.592331	11644456.875821	16056.890342	958596.353401	2809955.809802
2	Woodland	0	11239.823239	0	0	0
3	Forest	48103232.085749	17945180.645915	706503.175036	2243147.580739	316320.739732
4	agriculture	28902.402615	696869.040831	0	16056.890342	0
5	woodland	3211.378068	2524143.16172	27296.713581	849409.499077	0
6	Vlei	1774286.382761	40142.225854	9595597.668217	0	48170.671025
7	poss encroach	1006767.024426	0	157357.525349	0	208739.574442
8	Vlei margin	692051.973728	0	46564.981991	0	12845.512273
Click to add new row.						

Q3. What's the area of woodland that became agriculture between 1976 and 1996? (answer on next page!)

Commented [JW1]: Why are there multiple rows labelled woodland?

Rows = 1970s; columns = 1990s.

A3. The 1976 land cover type of woodland (in the rows) occupies two rows because of slight spelling differences (there is one row for "woodland" and another for "Woodland"). We therefore need to add together the values in these two rows for the column headed with the 1996 land cover type of "agriculture". The amount of woodland converted to agriculture is therefore 2,535,383 m^2

Q4. You wish to establish whether the pace of land cover change was quicker in the period 1976-85 or in the period 1985-1996. How might you go about deciding which period saw the greatest rate of change on an objective basis (i.e. based on summary statistics or figures and not simply by eyeballing the map)? Post a brief message with any ideas that you have to the course discussion board. If you are unsure, also post a message to the discussion board.

References:

These data are described in more detail in the following article:

Mapedza E, Wright JA, and Fawcett R (2003): 'An investigation of land cover change in Mafungautsi Forest, Zimbabwe, using GIS and participatory mapping'. *Applied Geography* **23**: 1-21.
More details of the use of GIS to look at land cover change following tsetse eradication are given in:
Reid RS, Wilson CJ, Kruska RL, et al. (1997): Impacts of tsetse control and land-use on vegetative structure and tree species composition in south-western Ethiopia. *Journal of Applied Ecology* **34** (3): 731-747