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 – qualitative, quantitative or both? [think about this before

A1. The data in these map layers are a mixture of both quantitative and qualitative (categorical) variables. The percentage tree cover recorded for each polygon is quantitative (because we can say that some parts of the map have greater tree cover than others), whilst the land cover categories are qualitative (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 – qualitative 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 ArcView?

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

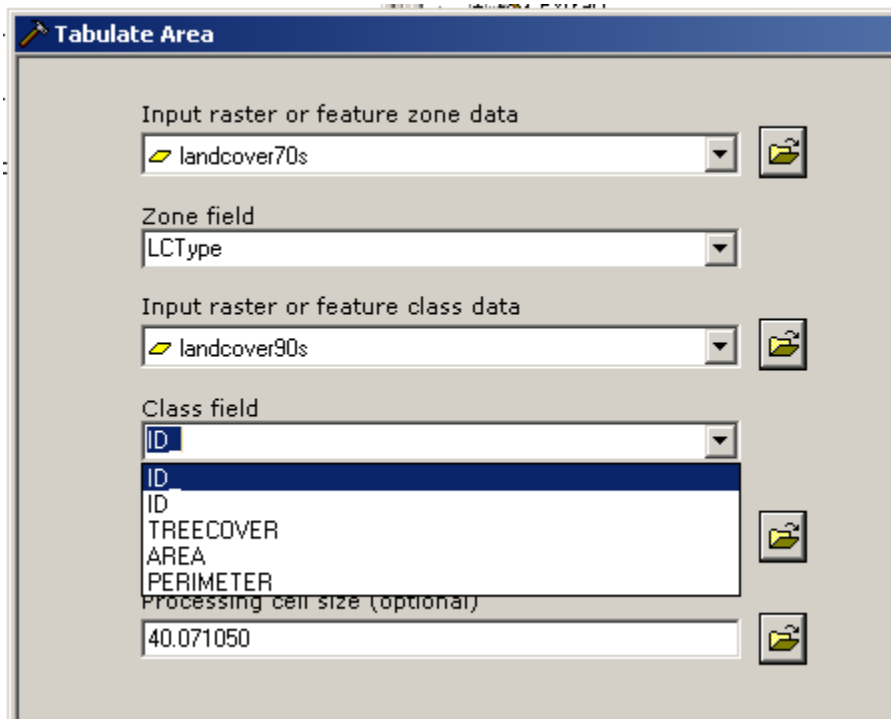
Area converted to agriculture from forest

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 ArcToolBox. 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 ArcToolBox command under *spatial analyst* called *Tabulate Area*. Select this command and enter **landcover70s** as the *input raster or feature zone data*.

This command 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.

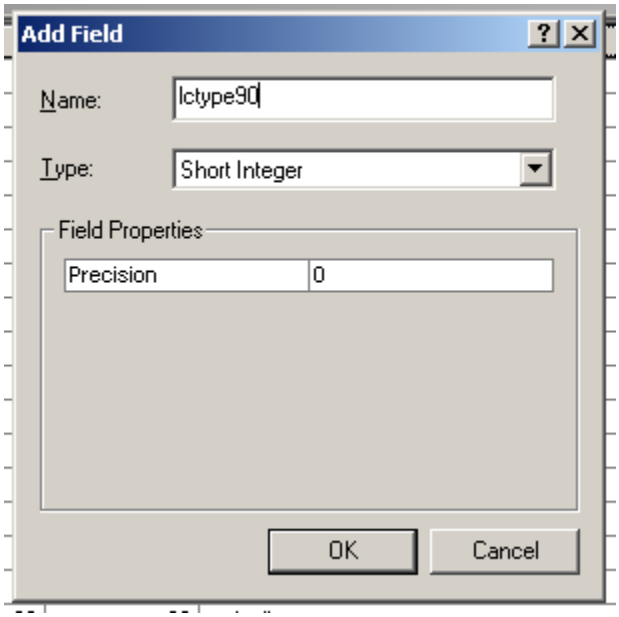
Unfortunately, we have a problem. If you try to enter in the **landcover70s** and **landcover90s** map layers as the two input layers, you will see that ArcView will not let us select our **type** or **landcover** fields – they simply do not appear on the drop-down lists under *zone field* or *class field*. The reason for this is that *tabulate areas* will only work with attributes that are whole numbers (integers) – text such as 'forest' or 'agriculture' is not accepted as an input to the command and therefore text fields do not appear in the drop-down menu.



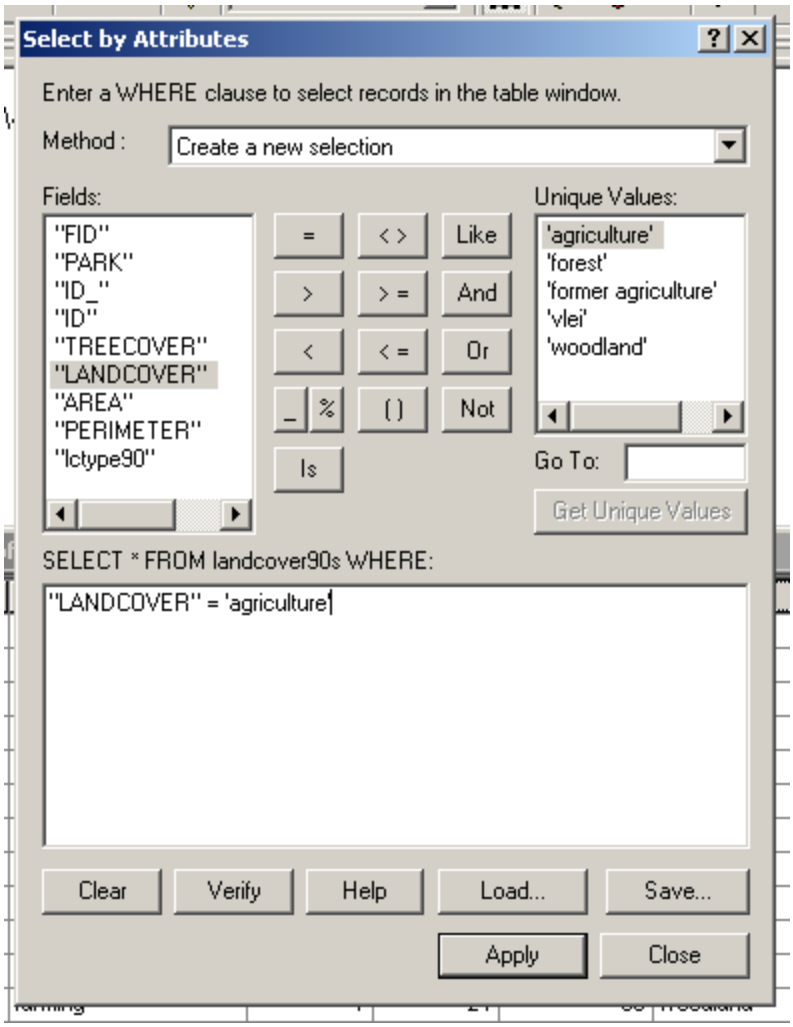
To fix this problem, we need to create a new field for the **landcover90s** map layer that has numeric codes for each land cover type in it. In other words, we need a new column of information for this map layer, just as for the **landcover70s** map layer (i.e. with agriculture = 1; vlei = 2; woodland = 3; and forest = 4).

We can create such a field as follows:

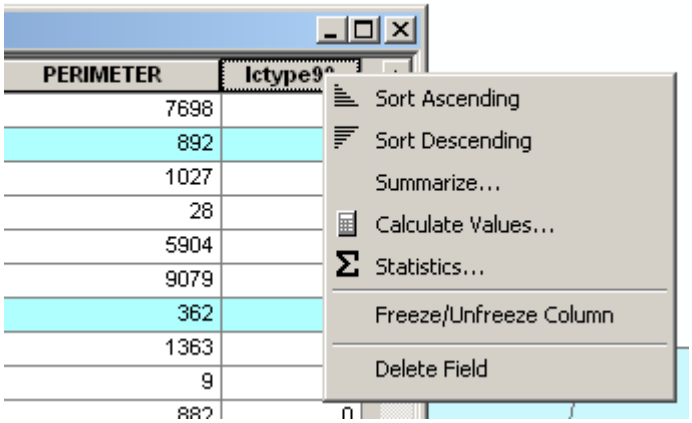
- right-click on the **landcover90s** map layer and choose *open attribute table* from the pop-up menu that appears.
- Click on the *options* button at the bottom of your table and choose *add field*.
- Create a new field called **lctype90,** of type *short integer* (i.e. containing whole numbers less than 256). This will contain our shorthand numeric codes for the different types of land cover.



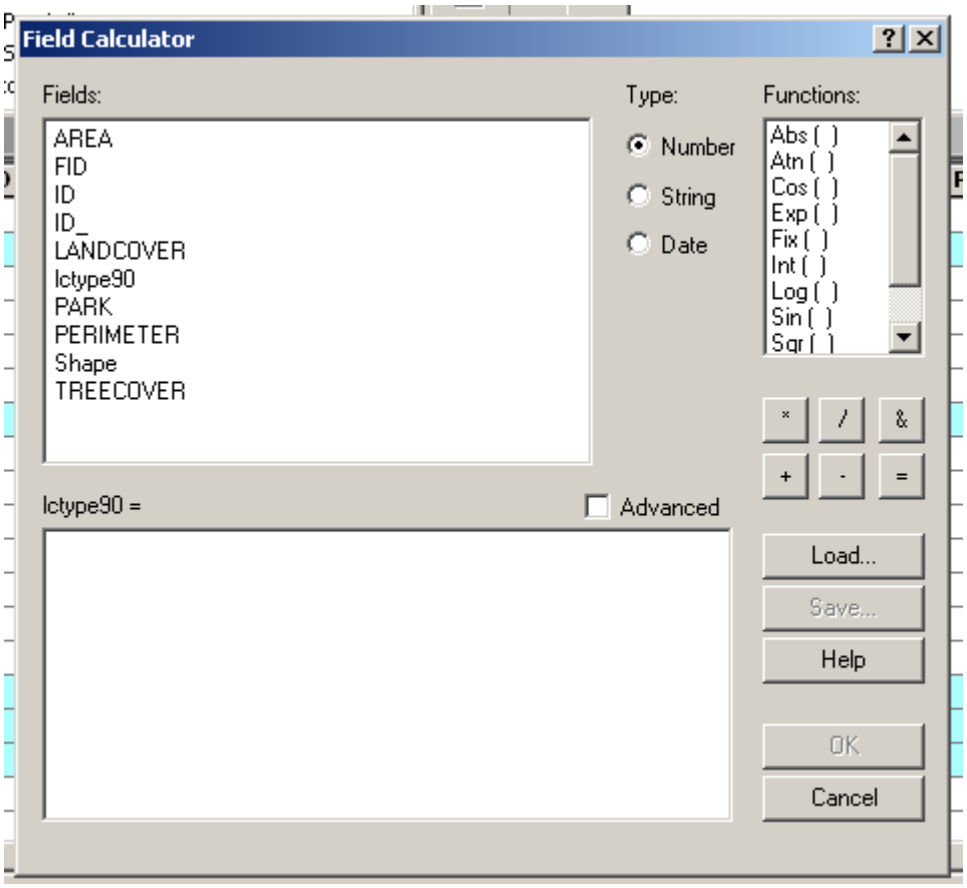
- We now need to add in numeric codes for the main types of land cover into this new field (i.e. agriculture = 1; vlei = 2; woodland = 3; and forest = 4)
- To do this, we will need to select out each land cover type in turn and calculate its numeric code.
- Click on the *options* button again, and this time, choose *select by attributes*.
- Under *fields*, double-click on **landcover** and then double-click on the '=' button in the centre of the screen (see illustration below).
- Click on the *get unique values* button and all of the different entries in the **landcover** field will appear on the right of this dialog box.
- Double-click on the 'agriculture' entry under *unique values*.
- If you now click on *apply*, ArcView should highlight and select out all of the agriculture polygons in our data set.



- We can now add in our code of 1 for agriculture. Right-click on the heading of our new **lctype90** field and a pop-up menu will appear.



- Select *calculate values* and when you receive a warning message about making calculations outside of an edit session, click *yes*.



- Click in the bottom box (under *lctype90* =) and enter a numeric code for agriculture – we will use a code of 1 here.
- Repeat this process for the remaining land cover types. The appropriate codes for **lctype90** for each land cover type are shown in the table below.

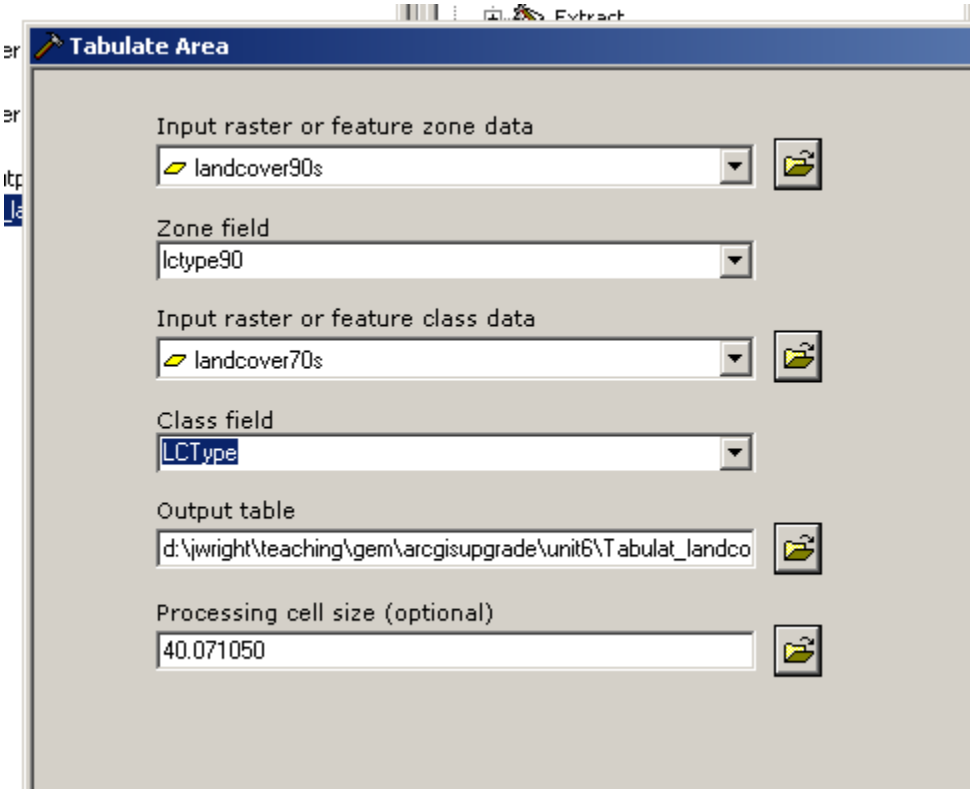
Land cover type	**Numeric code to be entered in lctype90**
Forest	4
Former agriculture	1
Vlei	2
Woodland	3

You should now have a full set of numeric codes in the field **lctype90**, which are a sort of shorthand for the entries in the **landcover** field.

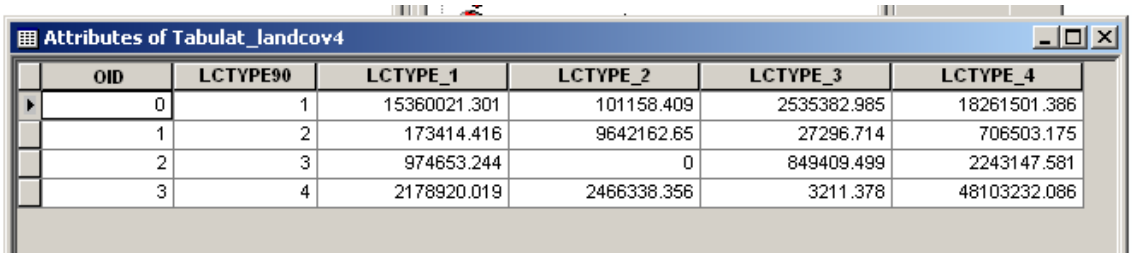
Now we have created a field with whole number (integer) codes for the different types of land cover, we are in a position to go back and run the *tabulate areas* command properly. First of all, though, we need to make sure that we have not inadvertently selected out some of our polygons for analysis. In the same way as *calculate values* only worked on

the table records highlighted in blue, so *tabulate areas* will only work with the polygons in our map layers that are highlighted.

- to deselect any highlighted polygons, right-click on the **landcover90s** map layer, choose *selection*, and then choose *clear selected features* (note: if this option is greyed out, then you have no polygons selected in this map layer and do not need to worry!)
- Now we are finally ready to run *tabulate areas*, so return to the ArcToolBox, select *spatial analyst* and choose this command.
- This time, we have our newly created **lctype90** field to work with, so we are in a position to compare land cover types in the map layers from the 1970s and 1990s.
- Select **landcover90s** and **landcover70s** for the input *feature zone data* and *feature class data* and choose the two fields with the numeric codes for land cover (see illustration below). Choose an appropriate name for your *output table*, such as **landcov_70s90s.**



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 1996 in the rows (the code for each landcover type being stored in the **lctype90** field), and land cover types in 1976 along the columns.



Attributes of Tabulat_landcov4

OID	LCTYPE90	LCTYPE_1	LCTYPE_2	LCTYPE_3	LCTYPE_4
0	1	15360021.301	101158.409	2535382.985	18261501.386
1	2	173414.416	9642162.65	27296.714	706503.175
2	3	974653.244	0	849409.499	2243147.581
3	4	2178920.019	2466338.356	3211.378	48103232.086

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

A3. The 1976 land cover type of 3 (in the columns) represents woodland, whilst the 1996 land cover type of 1 (in the rows) represents 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