Layer Variables for RSF-type Modelling Applications

These instructions for ArcGIS 9.x enable you to create expressions for use in Spatial Analyst's Raster Calculator that result in output grids of continuous variables for use in an RSF-type modelling application. The Raster Calculator is highly recommended because it allows you to batch process many output layers at a time... instead of babysitting the graphical user interface (GUI). However, you may adapt these instructions for use in ArcToolbox and Model Builder if you so wish.

> See ArcGIS Desktop Help and Spatial Analyst's Functional Reference for the syntax on the following Map Algebra functions:
> CON()
> FOCALMEAN()
> FOCALMAJORITY()
> FOCALMIN()
> SETNULL()
> EUCDISTANCE()
> Many other functions (e.g. FOCALSTD(), LINESTATS(), etc.) are available...

When creating layers for an RSF, the general plan is to extract ecological variables within a specified area surrounding observed and random point locations. **Neighborhood statistics (a.k.a. focal functions)** are the perfect choice for RSF data layer creation because a 'moving window' or neighborhood is applied to the input raster. The process is comparable to 'buffering' every cell center by a specified distance and shape. A natural neighborhood shape is the **circle** (used in these instructions), but a rectangle, annulus (donut), wedge, or defined polygon may be used.

ORIGINAL DATA

landcover	raster grid of values for land cover classes
dem, aspect, cti, tri	various raster grids of topographic variables

CREATED DATA

decfor, mixfor, ocfor, ccfor, agric, dmherb, saherb, recherb, shrub, wetherb, trbog, rburn, cutunk, cut3, cut14, cutold, water, ice, cloud, bare, urb, proad, sroad	various rasters resulting from the calculation of the proportion of each landcover class
avelev, avcti, avtri, majasp	various rasters resulting from the calculation of topographic variables
distroad	raster grid resulting from the calculation of distance to road classes
avdistrd, mindistrd, distroad	various rasters resulting from the calculation of distance to roads metrics
…many others	see the appendix for additional ecological variables

The example here uses a 30 m raster grid named **landcover**, where the following values are associated with named classes (the abbreviated field is recommended because the output rasters will require short, yet meaningful, names):

VALUE	NAME	ABBREV
110	Deciduous Forest	decfor
120	Mixed Forest	mixfor
131	Open Conifer Forest	ocfor
132	Closed Conifer Forest	ccfor
210	Agriculture	agric
221	Dry/Mesic Herbaceous	dmherb
223	Subalpine Herbaceous	saherb
224	Reclaimed Herbaceous	recherb
230	Shrub	shrub
240	Wet Herbaceous/Wetland	wetherb
241	Treed Bog	trbog
250	Recent Burn	rburn
260	Cutblock (unknown age)	cutunk
261	Cutblock: 0-3 yrs post-cut	cut3
262	Cutblock: 4-14 yrs post-cut	cut14
263	Cutblock: > 14 yrs post-cut	cutold
310	Lake/River	water
313	Ice	ice
314	Cloud	cloud
320	Rock/Bare Soil	bare
330	Urban/Developed	urb
341	Primary Road	proad
342	Secondary Road	sroad

Note: Abbreviations are used to conform to raster grid naming conventions; i.e. no spaces, no illegal characters, and must be under 13 characters long.

Background Information

Landcover Proportions

A useful measure of landscape composition is percent of each class within a specified area. You may nest the CON() and FOCALMEAN() functions to calculate the proportion. The CON() function extracts each particular landcover class as 1, and all else as 0. Adding up 1's and 0's basically counts the number of cells of a specified value that then gets divided by the total number of cells within the moving neighbourhood of FOCALMEAN(). **Choose the circle radius based on whole numbers of cells that fit with the distance you have in mind; e.g. a 500 m radius may be represented as 16 cells (~480 m) or 17 cells (~ 510 m).**

Separately, these functions look like this (a binary grid and a proportion grid):

```
bdecfor = CON(landcover == 110, 1, 0)
decfor = FOCALMEAN(bdecfor, circle, 16, DATA)
```

Nesting them results in one output layer (i.e. no intermediate binary grid for each class):

```
decfor = FOCALMEAN(CON(landcover == 110, 1, 0), circle, 16, DATA)
```

Topography

Elevation and related surface analyses are important habitat components. Slope, aspect, and shaded relief are all readily calculated within the ArcGIS toolset. However, some tried and true indices include Topographic Ruggedness Index (TRI) and Compound Topographic Index (CTI). CTI and TRI must be previously created using AML scripts – these require an ArcInfo license but are free to download from:

http://arcscripts.esri.com/details.asp?dbid=11863
http://arcscripts.esri.com/details.asp?dbid=12435

Average elevation can be calculated using the FOCALMEAN() function:

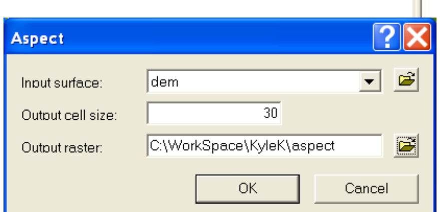
```
avelev = FOCALMEAN(dem, circle, 16, DATA)
```

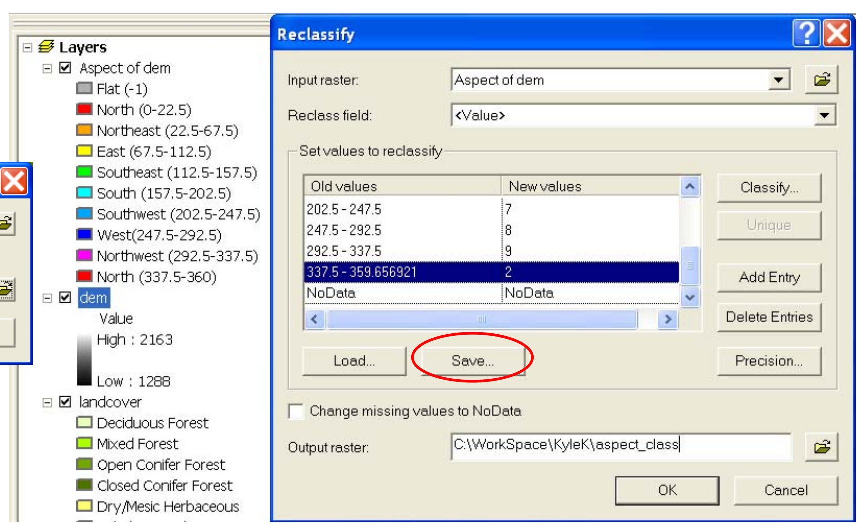
Averages for all other topographic variables are similar:

```
avcti = FOCALMEAN(cti, circle, 16, DATA)
avtri = FOCALMEAN(tri, circle, 16, DATA)
```

ASPECT is a special circular variable that requires reclassifying prior to calculating a meaningful neighbourhood statistic on it (i.e. do not calculate the mean – it is meaningless). When you create aspect from the DEM (using the Spatial Analyst Toolbar GUI interface), ArcMap classifies the cardinal directions as categories in its default symbology. Utilize this by reclassifying aspect into a new grid of classes (e.g. integer values that will allow the FOCALMAJORITY() function to run on it.

```
majasp = FOCALMAJORITY(aspect_class, circle, 16, DATA)
```





How to create aspect_class

Be sure to SAVE the reclassify table – it shows old and new values!

Distance to Roads

Create your distance to roads layers as indicated below*, then run the FOCALMEAN() function:

```
avdistrd = FOCALMEAN(distroad, circle, 16, DATA)
```

* To create the base distance to roads raster (i.e. distroad for use in above), nest the SETNULL() and EUCDISTANCE() functions on the original landcover raster:

```
distroad = EUCDISTANCE(SETNULL(landcover < 340, 1))
```

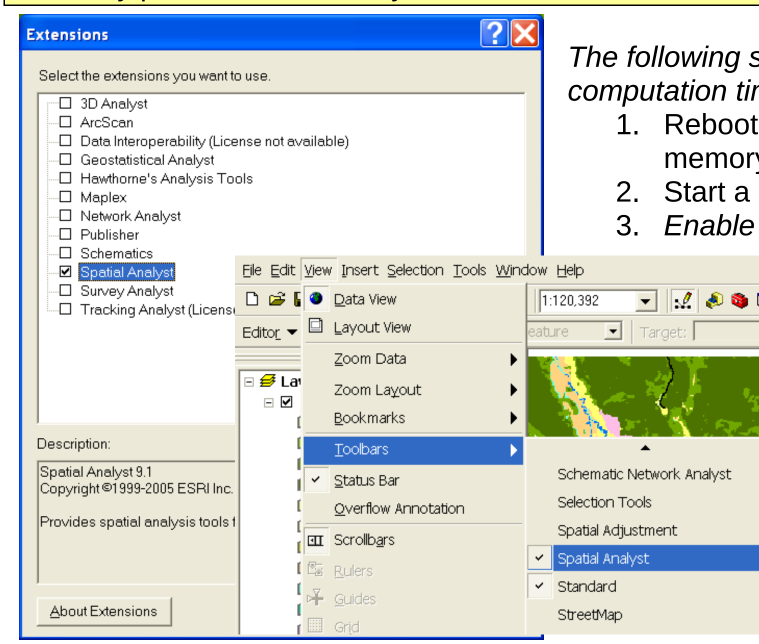
If you have a roads layer in shapefile format, you may nest within the EUCDISTANCE() function the SHAPEGRID() function that converts from shapefile to raster grid (also available through the Spatial Analyst GUI):

```
distroad = EUCDISTANCE(SHAPEGRID(roads.shp, convert, 30))
```

Set Up a New ArcMap Document

All the above statements can be batched in Spatial Analyst's Raster Calculator. Writing multiple, repetitive expressions for Raster Calculator can be a breeze using MS Excel. Please examine the corresponding .xls file to see how to set this up.

IMPORTANT!!! Before starting, set SPATIAL ANALYST >>> OPTIONS Working Directory to the folder that contains your raster grids (ideally all should be in one folder to make computation time quicker). Otherwise, precede all raster layer names with the full directory path for where the data resides or where you wish the output to be created in. There is no need to add the original rasters to the map document when the Working Directory is set and/or you specify the full directory path before each layer name.

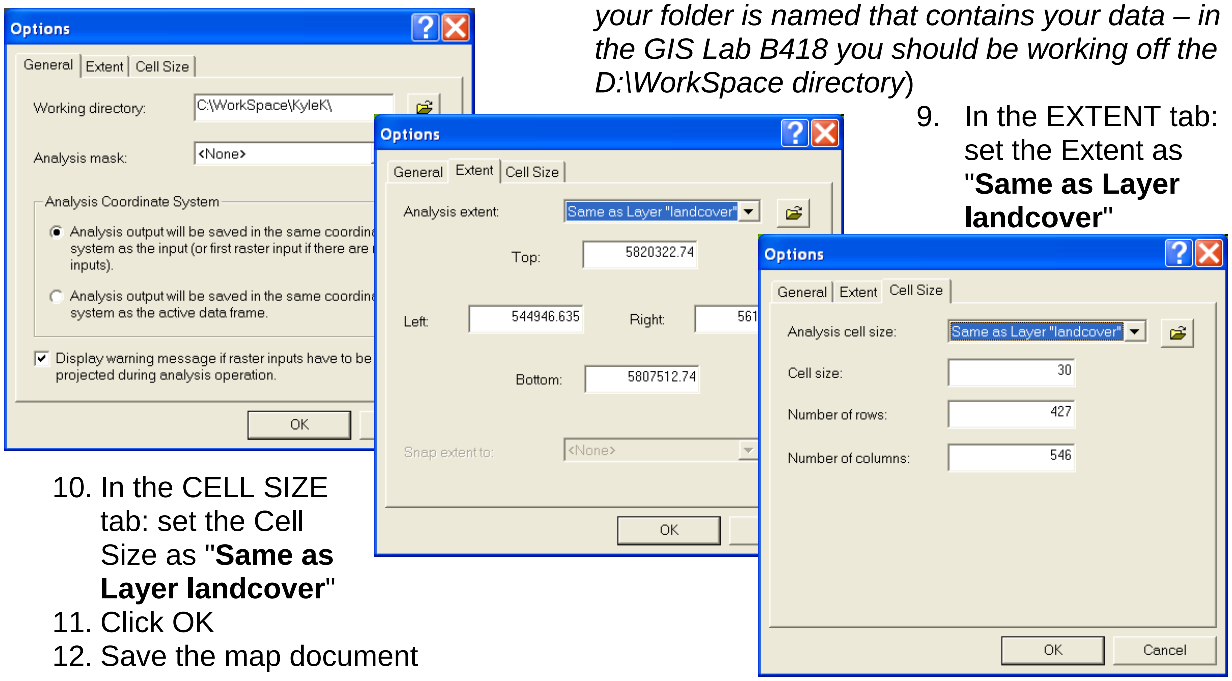


The following steps are performed to optimize computation time and provide proper outputs:

1. Reboot the computer to free up all available memory (this will need to be done periodically)
2. Start a new empty map document
3. *Enable the Spatial Analyst extension*: choose TOOLS >>> EXTENSIONS and place a check in the box beside Spatial Analyst
4. Click CLOSE
5. *Make the toolbar visible*: choose VIEW >>> TOOLBARS and place a check beside Spatial Analyst
6. ADD DATA: add the **landcover** and **dem** rasters to the map document

Set the required analysis options:

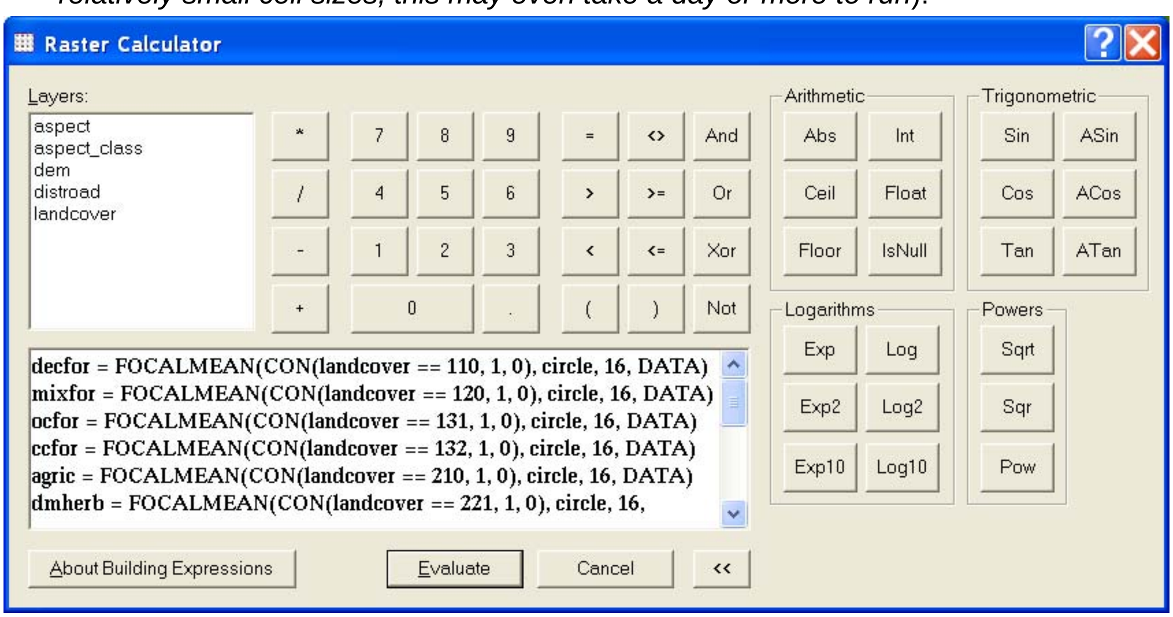
7. Choose SPATIAL ANALYST >>> OPTIONS
8. In the GENERAL tab: set the Working Directory; e.g. **C:\WorkSpace\KyleK** (*whatever your folder is named that contains your data – in the GIS Lab B418 you should be working off the D:\WorkSpace directory*)
9. In the EXTENT tab: set the Extent as "**Same as Layer landcover**"



10. In the CELL SIZE tab: set the Cell Size as "**Same as Layer landcover**"
11. Click OK
12. Save the map document

Evaluate the Expressions in Raster Calculator

13. Choose SPATIAL ANALYST >>> RASTER CALCULATOR
14. Copy and paste the following statements into the expression box (*note: do approximately 10-12 statements at one time; for extremely large study areas and/or with relatively small cell sizes, this may even take a day or more to run*):

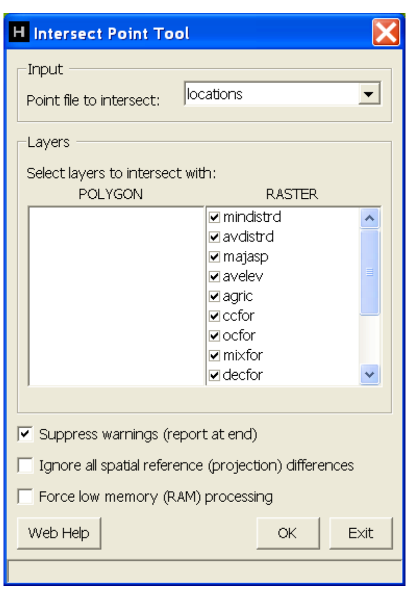


```
decfor = FOCALMEAN(CON(landcover == 110, 1, 0), circle, 16, DATA)
mixfor = FOCALMEAN(CON(landcover == 120, 1, 0), circle, 16, DATA)
ocfor = FOCALMEAN(CON(landcover == 131, 1, 0), circle, 16, DATA)
ccfor = FOCALMEAN(CON(landcover == 132, 1, 0), circle, 16, DATA)
agric = FOCALMEAN(CON(landcover == 210, 1, 0), circle, 16, DATA)
dmherb = FOCALMEAN(CON(landcover == 221, 1, 0), circle, 16, DATA)
saherb = FOCALMEAN(CON(landcover == 223, 1, 0), circle, 16, DATA)
recherb = FOCALMEAN(CON(landcover == 224, 1, 0), circle, 16, DATA)
shrub = FOCALMEAN(CON(landcover == 230, 1, 0), circle, 16, DATA)
wetherb = FOCALMEAN(CON(landcover == 240, 1, 0), circle, 16, DATA)
trbog = FOCALMEAN(CON(landcover == 241, 1, 0), circle, 16, DATA)

rburn = FOCALMEAN(CON(landcover == 250, 1, 0), circle, 16, DATA)
cutunk = FOCALMEAN(CON(landcover == 260, 1, 0), circle, 16, DATA)
cut3 = FOCALMEAN(CON(landcover == 261, 1, 0), circle, 16, DATA)
cut14 = FOCALMEAN(CON(landcover == 262, 1, 0), circle, 16, DATA)
cutold = FOCALMEAN(CON(landcover == 263, 1, 0), circle, 16, DATA)
water = FOCALMEAN(CON(landcover == 310, 1, 0), circle, 16, DATA)
ice = FOCALMEAN(CON(landcover == 313, 1, 0), circle, 16, DATA)
cloud = FOCALMEAN(CON(landcover == 314, 1, 0), circle, 16, DATA)
bare = FOCALMEAN(CON(landcover == 320, 1, 0), circle, 16, DATA)
urb = FOCALMEAN(CON(landcover == 330, 1, 0), circle, 16, DATA)
proad = FOCALMEAN(CON(landcover == 341, 1, 0), circle, 16, DATA)
sroad = FOCALMEAN(CON(landcover == 342, 1, 0), circle, 16, DATA)

avelev = FOCALMEAN(dem, circle, 16, DATA)
avcti = FOCALMEAN(cti, circle, 16, DATA)
avtri = FOCALMEAN(tri, circle, 16, DATA)
majasp = FOCALMAJORITY(aspect_class, circle, 16, DATA)
distroad = EUCDISTANCE(SETNULL(landcover < 340, 1))
avdistrd = FOCALMEAN(distroad, circle, 16, DATA)
```

Note: You may need to reboot computer in between batches to free memory!



Extract the Values to Your Point Locations

15. Once the new rasters have been calculated, add them all to ArcMap (*note: perhaps repeat this for groups of them if you have more than a couple dozen*)
16. ADD DATA: add the point shapefile(s) of your study and random locations
17. Access the Hawth's Tools extension (http://www.spatialecology.com) and apply the INTERSECT POINT tool to extract the data values from each raster variable
18. In the table of contents, right click on the point layer name and choose OPEN ATTRIBUTE TABLE
19. Click on the OPTIONS button and choose EXPORT to save as a .dbf or text delimited table for use in the statistical software package of your choice

APPENDIX

Create Raster Layers for Additional Ecological Variables

ArcGIS Desktop Help has very useful sections on **'The Raster Calculator**' and '**Spatial Analyst Functional Reference**.' Search within these and for help on **Map Algebra syntax**. Some of the functions should NOT be applied to categorical data (e.g. FOCALSTD() or FOCALMEAN() would be meaningless when applied directly to the landcover raster) while others (e.g. FOCALMAJORITY()) can ONLY be applied to integers. All functions begin with the function name, followed by the input (e.g. rasters, features, shapefiles, coverages, or tables) to which the function is to be applied and the necessary parameters, all in parentheses.

Pay attention to the explanations for each parameter, especially since some functions require number of cells versus distance in map units!

Examples

Landscape "richness" (# of classes) in raster format:

```
variety = FOCALVARIETY(landcover, circle, 16, DATA)
```

The Map Algebra syntax in the '**FocalVariety**' help topic shows:
FocalVariety(<grid>, <CIRCLE>, <radius>, {DATA | NODATA})

Density (#/area) of wells in shapefile format:

```
wellden = POINTSTATS(wells.shp, none, 30, npoints, circle, 480)
```

The Map Algebra syntax in the '**PointStats**' help topic shows:
PointStats(<points>, {item}, {cellsize}, {statistic}, {neighborhood})

Edge density (length/area) of water, forest, or roads in shapefile format*:

```
ldwater = LINESTATS(water_edge.shp, none, 30, length, 480)
ldforest = LINESTATS(forest_edge.shp, none, 30, length, 480)
ldroad = LINESTATS(roads.shp, none, 30, length, 480)
```

The Map Algebra syntax in the '**LineStats**' help topic shows:
LineStats(<lines>, {item}, {cellsize}, {statistic}, {radius})

* How to get the polyline features to use in the linear density calculations:

- Use a coverage's polylines
- Convert shapefile polygons to polylines using ArcToolbox
- Convert a reclassified raster to polylines using ArcToolbox
- Apply the GridLineShape() function to a reclassified raster using Raster Calculator

There are too many more possibilities to mention!!! Consult the GIS Analyst for help on calculating your specific variables of interest.