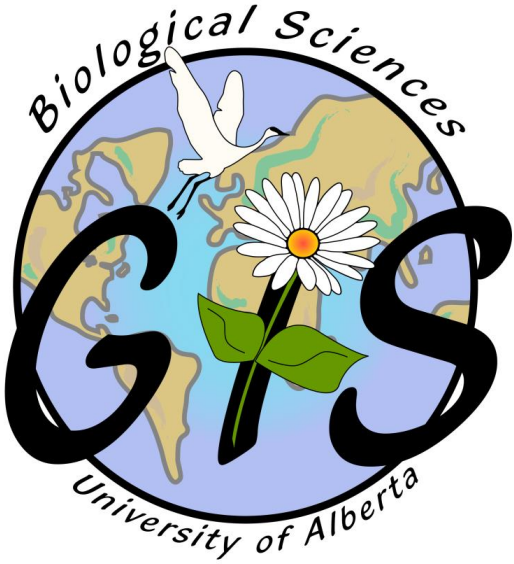
GIS IN ECOLOGY: ANALYZING VECTOR DATA



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This is an applied course on how to use the software. It reinforces working with map documents and layers. It focuses on overlaying, buffering, and other simple analyses involving vector data, with an introduction to geoprocessing using ArcToolbox and ModelBuilder.

For additional suggested reading on GIS theory, fundamentals, and software see: www.esri.com and www.biology.ualberta.ca/facilities/gis/index.php?Page=338#online.

Training courses: www.biology.ualberta.ca/facilities/gis/index.php?Page=484#virtualcampus

- Learning ArcGIS
- Geoprocessing with ArcGIS Desktop

References:

Longley, Paul A., Michael F. Goodchild, David J. Maguire, and David W. Rhind. 2001. **Geographic Information Systems and Science**. John Wiley & Sons, Ltd. Chichester UK.

Mitchell, Andy. 1999. **The ESRI Guide to GIS Analysis. Volume 1: Geographic Patterns and Relationships**. Environmental Systems Research Institute, Inc.

ESRI. 2013. **What is Geoprocessing?**. Online: http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#/What_is_geoprocessing/002s00000001000000/

GIS IN ECOLOGY: ANALYZING VECTOR DATA

Introduction

In this short course you will get familiar with ESRI's ArcGIS software and its basic functions for spatial analyses on data stored in the **vector data model**. Recall that vector data represents features as points (x, y coordinates), lines (sets of coordinates), and polygons (sets of coordinates defining boundaries that enclose areas), and focuses on modeling discrete features with precise shapes and boundaries. Example file types include vector coverages, shapefiles, CAD, etc.

Tools and Functionality for Vector Data

The focus of this short course is on simple vector analyses, such as overlaying and buffering, and also includes instructions on adding x, y coordinate data to a map. **ArcToolbox** contains the majority of the geoprocessing functionality for these analyses.

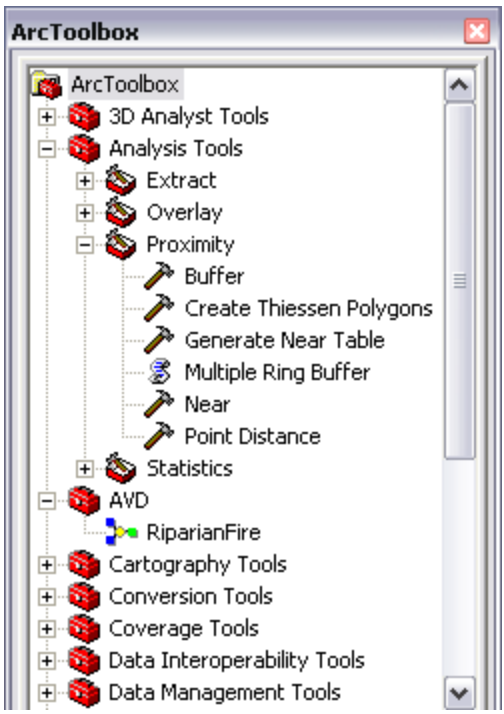
Geoprocessing – One of the basic functions of any GIS is to manipulate geographic information to create new information by applying an operation to existing data. Layers are often combined to generalize, isolate, and determine relationships among features. If you want to process spatial data based on the geography of the features in the layers, then use the geoprocessing tools in ArcToolbox to:

- Dissolve
- Append
- Clip
- Intersect
- Union
- Buffer
- Add XY Data
- and many others

Each ***tool*** is organized in a container called a ***toolset*** within a broader ***toolbox*** category. You may use the tools individually, or combine them in **ModelBuilder** to create a ***model*** that runs the sequence of geoprocessing tools in your

workflow. The ModelBuilder application helps you to streamline your workflow and automate repetitive tasks by stringing processes together. You may then run the model with a single click, set parameters, iterate, and even export and modify as a ***script***, to adapt your model for flexible applications.

Consult the **ArcGIS Desktop Help** for details on these and many other geoprocessing tools.



Course Data Sources

Free spatial data that can be used for GIS analysis in ecological applications have been obtained from the GeoGratis website http://geogratis.cgdi.gc.ca and Alberta SRD www.srd.alberta.ca/Wildfire/WildfireStatus/HistoricalWildfireInformation/SpatialWildfireData.aspx. The following summarizes the metadata for each geographic layer in the course dataset that has been made available to you on the local server \COURSES\GIS-100\2_AVD:

The 1:250,000 scale data have been previously processed, projected in the NAD 1983 UTM Zone 11 spatial referencing (i.e. map units are in meters) and converted to file geodatabase feature classes for NTS map sheet 083J (Whitecourt) in central Alberta.

Name	Description
soil_cmp soil_layer soil_mapunit soil_name	CANSIS soil attribute tables *(Refer to **CANSIS Data Model for Detailed Soil Surveys.mhtml** in the _documentation folder.)*
sites.xls	Locations of field sites
points	Towns and other human point features
access	Roads and other human linear features
streams	Small rivers and streams
boundary	Study area boundary
firehistory	Historic spatial wildfires in study area
forestry	CLI forestry capability
soils	CANSIS soil database
waterbodies	Lakes and major rivers
waterfowl	CLI waterfowl productivity

Copying the Course Dataset

1. Double click on the COURSES shared directory icon on the Desktop
2. Open the "**GIS-100**" folder by double clicking on it
3. Click on the FOLDERS icon along the top menu bar
4. On the left side of the window, click and drag the scroll bar to see "My Computer"
5. Expand "**My Computer**" by clicking the "**+**"
6. Expand "**Local Disk (C:)**" by clicking the "**+**"
7. Click and drag (copy and paste) the "**2_AVD**" folder from the right side of the exploring window to the **C:\WorkSpace** directory on the left side
8. Once all the files have copied over, close the exploring window

Tasks

Creating point data, joining data by attribute or spatial location, tabular calculations, buffering, overlaying, ModelBuilder.

Getting Started

1. Click START MENU >>> PROGRAMS >>> ARCGIS >>> ARCMAP
2. Start with a new blank map
3. Click the CATALOG WINDOW button and dock the window to one side

4. Click the CONNECT TO FOLDER button and navigate to the **C:\WorkSpace\2_AVD** directory
5. Click the "**+**" to expand the folder
6. Click SHOW NEXT VIEW until you can see the catalog tree and the Name windows together

Creating a new empty file geodatabase:

This will be used to contain output files you generate.

7. In the catalog tree, right-click on the 2_AVD folder and select NEW >>> FILE GEODATABASE
8. Rename the new gdb to **Work.gdb**

Adding data from ArcCatalog:

9. In the catalog Name window examine the Whitecourt.gdb to get familiar with the files used in the following exercises
10. Select the **Whitecourt.gdb\soils** polygon features and then click, drag and drop to the data frame
11. Select the following layers from **\2_AVD** folder and then click, drag and drop to the data frame: **Study Boundary.lyr**, **Waterbodies.lyr**, **Streams.lyr**, and **Towns.lyr** (hold the CTRL key for multiple selections)
12. In the Table of Contents (TOC), rename the data frame to "**Soil Sites**"
13. Choose FILE >>> MAP DOCUMENT PROPERTIES >>> DATA SOURCE OPTIONS to "Store relative pathnames"
14. SAVE the map document as **Whitecourt_*date*.mxd**

Adding XY Data, Joining Data, and Calculating Attributes

In this application, some of the many GIS functions available in ArcMap are demonstrated to answer the question: **What are the soil attributes at each site location?** Often, field data collection results in a table of locations (i.e. from GPS units) that have ecological attributes associated with them. For example, telemetry locations and vegetation plot sites can easily be integrated with other GIS layers to map point features of interest.

This XY data may be stored in GIS-ready tables (text, dBase, or INFO), an MS Access database, or an MS Excel spreadsheet that has been explicitly formatted.

The following instructions show how to spatially display sites and spatially join them with digital soil attribute data. However, the soil features are incomplete in that they must be joined to additional attribute tables to obtain important information on soil values. The steps involve:

- Joining attributes from a table
- Adding XY data
- Joining data from another layer based on spatial location

The available data includes tabular point locations and a CANSIS soil survey. (See **CANSIS Data Model for Detailed Soil Surveys.mhtml** for soil relationship information.) Note: You will notice after completing this task that the soils data are incomplete – i.e. several polygons are unclassified. This demonstrates the point that not all data are equal and that you must check your data for errors/omissions prior to use in analysis!

TIP: Using Excel for Tables

1. ArcGIS can only read Excel version 2003 or earlier (**no** .xlsx files)
2. Only one worksheet can be imported at a time
3. Column headings (field names) must be present
4. Do not use spaces or non-alphanumeric characters in column headings
5. No skipped rows anywhere
6. Be aware that date/time values are subject to import errors (a work around is to split the date/time parts in to separate columns)

Joining attributes from a table:

The soils coverage has additional attribute tables that must be joined. Use "MAPUNIT" as the field to base the join to attributes from the soil_cmp.dbf table, and then "SOILTYPE" to join attributes from the soil_name.dbf table.

1. Turn off and collapse all but the soils layer
2. Right click on **soils** and choose JOINS AND RELATES >>> JOIN
3. In the JOIN DATA wizard at step 1: Choose "**MAPUNIT**"
4. At step 2: Click the BROWSE button and navigate to **\2_AVD\Whitecourt.gdb** and select the **soil_cmp** table

5. At step 3: Choose "**MAPUNIT**"
6. Click OK

*Repeat a second join on **soils** using "**SOILTYPE**" to join attributes with **soil_name**. Another way to set an attribute join is in Layer Properties.*

7. Double click on **soils** to access its layer properties
8. In the JOINS & RELATES tab, click on the ADD button
9. At step 1: Choose "**SOILTYPE**"
10. At step 2: BROWSE for **soil_name**
11. At step 3: Choose "**SOILTYPE**"
12. Click OK twice

Making the attribute join permanent:

13. Right click on **soils** and choose DATA >>> EXPORT DATA to save to a new feature
14. Select to Save as type: **File and Personal Geodatabase feature classes**
15. Double click inside **Work.gdb**
16. Specify a new name: **soildata**
17. Click YES to add the new layer to the map document
18. In the SYMBOLOGY tab, show **soildata** categorically by "**ORDER_**"
19. Click OK to apply the symbology and dismiss the Layer Properties dialog
20. Open the **soils** and **soildata** attribute tables to inspect them simultaneously
21. Open the Layer Properties for each and inspect the FIELDS tab

*In the **soils** Fields tab table, the field headings are prefixed by each table name. The permanently joined tables in **soildata** do not have this naming.*

22. Remove all joins by right clicking on **soils** and choosing JOINS AND RELATES >>> JOIN >>> REMOVE JOIN(S) >>> REMOVE ALL JOINS

Adding XY data:

23. In the catalog, double click to open the **sites.xls** file
24. Select the sites worksheet and then click, drag and drop to the data frame
25. In the catalog, click the UP ONE LEVEL button to get outside of the Excel file
26. In the 'List by Source' view of the TOC, right click on the **sites** table and click OPEN
27. CLOSE table when finished viewing

28. Right click the sites table and choose DISPLAY XY DATA
29. Select the appropriate **X** and **Y** fields – *automatically done by ArcMap if the fields are labeled as X and Y or Longitude and Latitude*
30. Click the EDIT button to set the Spatial Reference
31. Click the SELECT button
32. Navigate to select the predefined projected **NAD_1983_UTM_Zone_11** as the coordinate system – *as indicated in the metadata!*
33. Click OK
34. Read the warning then click OK

Read more about XY data in ArcGIS Desktop HELP. Save this event as new spatial data…

35. In the table of contents, right-click on the **sites Event** name
36. Select DATA >>> EXPORT DATA
37. Provide a new name for the feature class; e.g. **\Work.gdb\sites**
38. Click OK
39. Compare the attribute tables and layer properties for the sites Events and sites feature class
40. Right click on the name and REMOVE the sites Events and table from the TOC

Joining data from another layer based on spatial location:

*A spatial join may be used to extract the values from the **soildata** layer that coincide with the **sites** locations.*

41. Right click on **Sites** and choose JOINS AND RELATES >>> JOIN
42. Choose to '**Join data from another layer based on spatial location**' and set the following:
43. Step 1: Select **soildata** as the join layer
44. Step 2: Select 'it falls inside'
45. Step 3: Type in an output file name; e.g. **\Work.gdb\soilsites**
46. Click SAVE and OK
47. Click YES to add the new point layer to your map document
48. Open the attribute table to view each location's soil attribute values
    *The **soilsites** layer represents the spatial coincidence of the sites point locations with the soils attributes.*
49. SAVE your map document

Spatial joins have much power depending on the order (e.g. polygons to points, points to polygons, etc.), and by choice:
POLYGONS TO POINTS:

- 'it falls inside' – this method assigns the attributes of the polygon to the point
- 'is closest to it' – this method assigns a distance value in a new *DISTANCE* field

POINTS TO POLYGONS:

- 'Each polygon will be given a summary of the numeric attributes of the points that fall inside it..." – this method assigns a count value to a new *COUNT* field
- 'Each polygon will be given all the attributes of the point that is closest to its boundary..." – this method assigns a distance value in a new *DISTANCE* field

You can also join points to lines, lines to points, lines to polygons, and polygons to lines!
Remember a spatial join is what you use to get counts, intersect points with other layers, or automatically calculate nearest distance measures between features.

Common Geoprocessing and Summarizing

The following instructions show how ArcToolbox's geoprocessing tools can be used to answer the question: **How much waterfowl habitat is within 250 meters of major roads?**
The steps involve:

- Selecting by attributes for major roads
- Buffering
- Clipping
- Calculating area
- Summarizing area by habitat class

The available data includes a CLI classification on land capability for waterfowl and an access layer including roads. This new analysis will be performed in a new data frame.

1. Choose INSERT >>> DATA FRAME
2. Rename this new data frame: "**Waterfowl Area**"
3. Add the following data by dragging and dropping from the Catalog Name window to the data frame:
   - **Access.lyr**
   - **Waterfowl.lyr**
4. Click to show the ARCTOOLBOX WINDOW button and dock it where you prefer
5. Take a moment to examine the ArcToolbox window

Keep in mind that there are many ways to utilize ArcToolbox: first you will learn how easy it is to interact with your data in ArcMap using the tools one at a time. Remember to click the ***Show Help*** *button to view instructions and tips on how to use the tools.*

Selecting by attributes for major roads:

6. Choose DATA MANAGEMENT TOOLS >>> LAYERS AND TABLE VIEWS >>> SELECT LAYER BY ATTRIBUTES
7. Set **Access** as the layer
8. Click the SQL button
9. Click the appropriate buttons to enter the expression:

```
"FIR_ROADNO" <> ' '
```

Recall what you learned in the "Querying and Creating Maps" course.

10. Click OK twice – *the primary roads are now highlighted*

Buffering:

11. In ArcToolbox, navigate to ANALYSIS TOOLS >>> PROXIMITY >>> BUFFER
12. Double click on the BUFFER tool to open it *(alternatively, right click and choose OPEN)*
13. Click on the SHOW HELP button – *to see helpful information at the right side as you click on each of the parameters on the left side*
14. Reposition the Buffer window so you can see it and the TOC simultaneously
15. Click and drag **Access** from the TOC in ArcMap to the Input Features text box of the Buffer window
16. Specify **C:\WorkSpace\2_AVD\Work.gdb\roadbuffer250** as the Output
17. Enter **250** for the linear distance and select **Meters** for the unit
18. Select **ALL** as the Dissolve Type
19. Click OK
20. CLEAR SELECTED FEATURES
21. Zoom in to examine the new **roadbuffer250** polygon layer

Clipping:

22. In ArcToolbox, navigate to ANALYSIS TOOLS >>> EXTRACT >>> CLIP
23. Double click on the CLIP tool – *read the descriptive text that is displayed in the help panel to learn more about this tool*

24. Drag **Waterfowl** to the Input Features layer
25. Drag **RoadBuffer250** as the Clip features layer
26. Specify **\2_AVD\Work.gdb\ roadhabitatclip** as the output
27. Click OK
28. Zoom in to examine the new **roadhabitatclip** layer

Calculating area:

An attribute table can be treated just like a database table: fields can be added, deleted, and calculated to yield new information about the associated geographic features. In this example, you will update the area field to reflect the actual area of each polygon within the buffers you processed above in preparation for summarizing the data below.

29. SAVE your map document
30. Choose CUSTOMIZE >>> TOOLBARS >>> EDITOR to add it
31. Choose EDITOR >>> START EDITING
32. Select the **\Work.gdb** to edit data from
33. Right click on **roadhabitatclip** and OPEN ATTRIBUTE TABLE
34. Right click on the heading of the "**AREA**" field
35. Click CALCULATE GEOMETRY
36. Select the **AREA** property and **Square Meters (sq m)** as the units
37. Click OK
38. Choose EDITOR >>> STOP EDITING
39. Click YES to save edits

IMPORTANT NOTE: Notice that the AREA field now has the exact same values as the SHAPE_AREA field that is automatically generated for geodatabase feature classes. You may want a previous area to persist in future overlay outputs, so calculating your own distinctive field will help with future proportion calculations, for example. However, when working with shapefiles, the automatic geometry fields are not added/calculated, and you must always calculate the geometry into a new or existing field.

Summarizing area by habitat class:

40. In the attribute table of **roadhabitatclip**, right-click on the "**CLASS_A**" heading
41. Choose SUMMARIZE from the menu
42. Select to summarize **CLASS_A** by **AREA – Sum** (expand and click a check beside Sum)

43. Save to the Work.gdb and specify a name for the output table; e.g. **roadhabitatarea**
44. Click OK
45. Click YES to add the table to the map document
46. In the table of contents' SOURCE tab, open the **roadhabitatarea** table to view the info
47. Optionally, right-click the Sum_AREA heading and click STATISTICS to view Min, Max, Sum (useful for calculating proportions in a new field), Mean, Std Dev

Geoprocessing with ModelBuilder

The following instructions show how ArcToolbox's ModelBuilder can be used to answer: **What is the area of burned riparian forest species for each year?** The steps involve:

- Setting up a model with ArcToolbox's ModelBuilder
- Buffering water features
- Intersecting riparian, forestry and fire history
- Adding a field, calculating area, and summarizing multiple fields
- Running the model

The available data includes streams, water bodies, a CLI classification on land capability for forestry, and fire history layer of polygons indicating the year of burn. This new analysis will be performed in a new data frame

1. Choose INSERT >>> DATA FRAME
2. Rename this new data frame: "**Riparian Fire**"
3. From the Catalog, add the following data from the \2_AVD folder by dragging and dropping to the data frame: **Fire History.lyr**, **Forestry.lyr**, and **Streams.lyr**
4. In the List by Drawing Order view if the TOC, modify the layer drawing order
5. SAVE your map document

Setting up a model with ArcToolbox's ModelBuilder:

To create a model in ModelBuilder, ideally you may create your own custom toolbox in ArcToolbox – there are a few ways to do this, but a good practice is to store it in your working directory for ease of retrieval and sharing.

6. In ArcToolbox, right click on the name ArcTolbox and choose ADD TOOLBOX
7. Navigate to the **\2_AVD** folder and click the NEW TOOLBOX icon

8. Rename Toolbox to "**AVD**"
9. Highlight it and click OPEN
10. Right click on the **AVD** toolbox in the ArcToolbox window and choose NEW >>> MODEL

The ModelBuilder interface is immediately displayed.

11. Choose MODEL >>> MODEL PROPERTIES
12. In the GENERAL tab, specify a Name (no spaces) and Labe (spaces okay)l; i.e. **RiparianFire**
13. Check to 'Store relative path names'
14. Click OK
15. Briefly, examine the ModelBuilder window
16. Click OK and then click the SAVE button
17. Choose HELP >>> ARCGIS DESKTOP HELP
18. Read through '**What is ModelBuilder**' and explore some of the links
19. Minimize the help file when finished – *you will want to refer to it as you work*

Buffering water features:

The first step in your model building is to buffer the water features.

20. In ArcToolbox, navigate to ANALYSIS TOOLS >>> PROXIMITY >>> BUFFER
21. Drag and drop the BUFFER tool to the Model window
22. Double click the BUFFER tool element
    - Specify the input as **Streams**
    - Specify the output as **\Work.gdb\streams_Buffer**
    - Set the Distance linear unit to **500 meters**
    - Dissolve **ALL** and leave all else at their defaults
    - Click OK
23. Click on the AUTO LAYOUT and FULL EXTENT buttons to organize the model elements

You could run the model at this point, but to see just how powerful and timesaving ModelBuilder is, continue with building your model until all processes have been set up.

Intersecting riparian, forestry and fire history:

24. In ArcToolbox, navigate to ANALYSIS TOOLS >>> OVERLAY >>> INTERSECT
25. Drag and drop the INTERSECT tool to the Model window

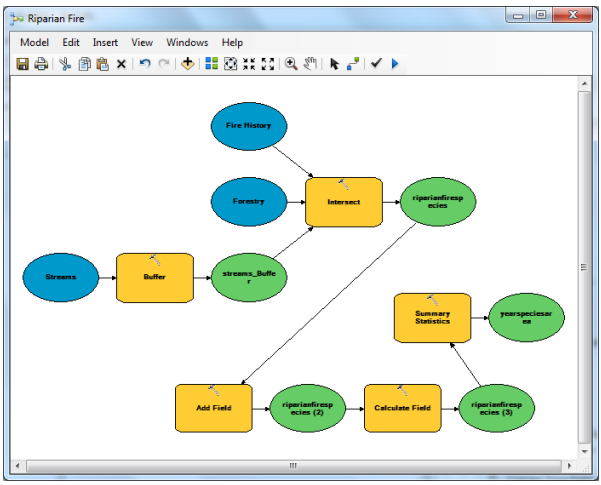
26. Double click on the INTERSECT tool element to open it
    - Specify **Fire History**, **Forestry** and **streams_Buffer** as the input features
    - Change the output name to **\Work.gdb\ riparianfirespecies**
    - Click OK

Adding, calculating, and summarizing fields:

27. Use the SEARCH and/or INDEX tabs in ArcToolbox to ***locate*** the tool you want
28. Locate, drag, and drop the ADD FIELD tool to the Model window
29. Connect the INTERSECT output to the ADD FIELD tool
30. Double click on the ADD FIELD tool element to open it
    - Specify the new Field Name as **I_AREA**
    - Specify the Field Type as DOUBLE
    - Click OK
31. Repeat the locate, drag, and drop for the CALCULATE FIELD tool
32. Double click CALCULATE FIELD to open it
    - Specify the input table as **riparianfirespecies (2)**
    - Specify the new Field Name as **I_AREA**
    - Specify the Expression as **`!shape.area!`**
    - Select the Expression Type as PYTHON_9.3
    - Click OK
33. Repeat the locate, drag, and drop for the SUMMARY STATISTICS tool
34. Double click SUMMARY STATISTICS to open it
    - Specify the input
    - Specify the output table as **\Work.gdb\ yearspeciesarea**
    - Select **I_AREA – SUM** for the Statistics Field(s)
    - Select **BURNYEAR** and **SPECIES_A1** for the Case Field(s)
    - Click OK

Running the model:

Your model should look similar to the following:



It is time to see how your model runs. Hopefully you have set all the connections and parameters appropriately. If not, simply double click on each element to open, examine, and modify as necessary.

35. Click on the SAVE button (*perhaps this is a good time to SAVE the map document, too*)
36. Choose MODEL >>> VALIDATE ENTIRE MODEL – *all model elements should be in color*
37. Choose MODEL >>> RUN ENTIRE MODEL – *or click on the RUN button*
38. After waiting for the processes to complete, examine the log window then close
39. In the ModelBuilder window, right click on the final output **yearspeciesarea** and choose ADD TO DISPLAY

You may examine the intermediate layers by adding them to ArcMap or preview them in ArcCatalog. If you are satisfied with the final output then you may opt to delete all intermediate data.

40. Make any modifications to the model; e.g. UNcheck 'Intermediate' for the **riparian** and **riparianfirespecies** outputs (right click on each to access this)
41. Choose MODEL >>> DELETE INTERMEDIATE DATA
42. Click SAVE and close the ModelBuilder window

Note: For future reference, know that you can set the ARCTOOLBOX >>> ENVIRONMENT working directory and other options.