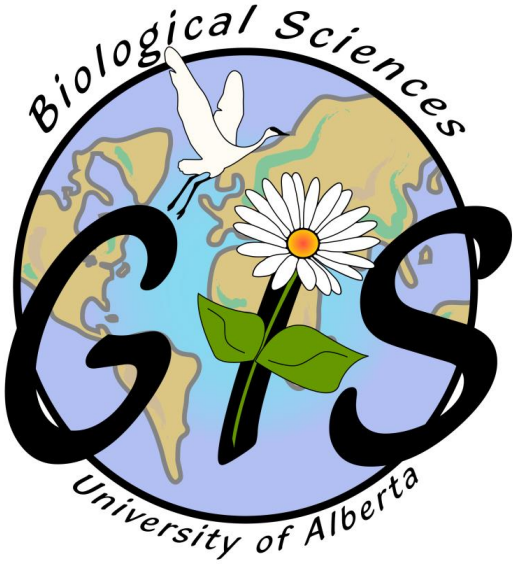
GIS IN ECOLOGY: MANAGING SPATIAL DATA



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GIS IN ECOLOGY: MANAGING SPATIAL DATA

Introduction

This is an applied course for those with previous experience using ESRI's ArcGIS software who want to acquire and manage spatial data available from Canadian online sources; e.g. Framework, CanVec, CDED, Landcover, etc. GIS project development issues relevant to working with digital spatial data in ArcGIS are examined. Hands-on exercises in the "**Tasks**" section include finding, preparing (e.g. converting, combining layers, and projection issues), and managing data efficiently. You will learn tips and tricks that you can readily apply when creating your own custom spatial database.

In a typical GIS analysis project, you need to identify the objectives of your project, create a project database containing the data you need to solve the problem, do any necessary preprocessing to get the data into useable format for the task at hand, use GIS functions to create an analytical model to solve the problem, and finally interpret and present your results. Acquiring and processing the data can take more time than necessary (upwards of 80% of GIS project development) if you don't have the appropriate skills to import files, work with various projections, and basically get all your data "ducks" lined up on a row. And to make matters more challenging, some of the spatial data you obtain may not be GIS-ready or easily interpretable.

Data Acquisition

Tips to keep in mind

- Copy the website address for future reference (e.g. documenting metadata)
- Look for readily useable, or easily imported, file formats
    - See the ArcGIS Desktop Help topics
    - Common formats shown in the table below (and may be zipped archives *.zip)
- Check for projection information – it is very important that you know the exact datum and parameters; the data may not be explicitly defined in the GIS, but with the proper knowledge you can remedy this
- Download (or ask for) metadata – this may be a simple readme.txt file, MS Word document *.doc, Excel spreadsheet *.xls, Adobe Acrobat *.pdf, or *.XML file
- In the absence of formal metadata, save (or print to image or *.pdf) the web page details

File formats

GIS files come in a variety of formats. Common file types supported by ArcGIS include:

VECTOR
Geodatabase
ESRI Shapefile
ArcInfo coverage
PC ARC/INFO coverage
TIN
DXF, DWG, DGN

RASTER
Geodatabase Raster
ESRI GRID
ERDAS Imagine (.IMG)
Windows Bitmap (.BMP)
JPEG File Interchange Format, JIFF (.JPG)
LizardTech MrSID (.SID)
Tagged Image File Format, TIFF (.TIF)

TABLE
Geodatabase Table
Text file (.TXT, .CSV)
DBASE file (.DBF)
INFO table

The most frequently imported data formats supported in ArcGIS include the following:

INPUT FORMAT	**OUTPUT FORMAT**
Atlas Geo file (.AGF) MapInfo Interchange Format (.MIF)	ESRI Shapefile
ArcInfo export interchange file (.E00) Spatial Data Transfer Standard SDTS Point Profile (.TVP)	ArcInfo coverage
Spatial Data Transfer Standard SDTS Raster Profile (RSDF, LDEF)	ESRI GRID

ASCII
US Digital Terrain Elevation Data (DTED)
USGS Digital Elevation Model (.DEM)

Data Management

Once you acquire your digital data, maintaining an organized database is key to effective analysis. Getting your data "ducks" lined up in a row may involve several activities in both the management and preparation (next section). The following are some recommendations for managing GIS data file structures, specifically naming conventions, backup suggestions, and metadata practices:

HANDY TIP

Always keep a notebook with you beside your computer to jot down notes on sources (e.g. website) of your data, informal metadata, details on any processing you perform, information on useful help files, step-by-step instructions on the analyses you execute to answer your research question(s), etc.

Naming conventions

- Decide on a concise (short), descriptive (but not too long) naming convention in the beginning, and stick to it; this may include:
  - Using general common sense names or specialized names as appropriate
  - Study area abbreviations as prefixes – it may be hard to keep track of multiple streams or roads datasets when combining data from different geographic regions
  - Projection abbreviations as suffixes – when starting out with managing GIS data, sometimes you may want to adopt the 'over-kill' practice of suffixing _nad83z12 at the end of your datasets, just to keep it all straight
  - Date worked on – for example, use yyyymmdd as the prefix or suffix of a dataset, especially when digitizing a complete coverage that may take several days to complete
  - Version – add this to the end of the filename if you're carrying out multiple edits throughout the day
- Do NOT use spaces in any of the file names – including the directory paths (this is mostly a consideration when working with raster data, but it's just a good rule of thumb) – instead use the underscore character "_"

Backup suggestions

Be sure to keep your current work readily available (in case of the dreaded hard drive crash or errors in

processing that may be found days later) by backing it up to an alternate storage device; e.g. server, secondary/external hard drive, CD/DVD or at minimum a separate location on your single hard drive. The following are two suggestions for doing so:

- Backup Method 1: Create a new working directory/gdb each day you work on your database
  - Name with today's date and the project name; e.g. yyyymmdd_projname1
  - Copy ALL files from the previous day's work into the new directory/gdb
- Backup Method 2: Use an archiving program to ZIP each day's work into a new file
  - At the end of each working day, zip up the entire working directory and save it using a filename with today's date and the project name; e.g. yyyymmdd_projname1.zip
  - Continue working on the main directory/gdb, but create new zip at the end of each day

Delete previous backup files from several days ago to "declutter" your drive.

Metadata practices

- Document your data files from the moment you acquire them!
- ArcCatalog can facilitate this very nicely. Use the built-in metadata editor to write in the important characteristics of each dataset so that future use (by you or others) will know the history and particulars about the data.
- Some useful references on metadata include the following:
  - ArcGIS Desktop Help topic: **Working with metadata**
  - Federal Geographic Data Committee (FGDC): http://www.fgdc.gov/metadata
  - ESRI Profile of the Content Standard for Digital Geospatial Metadata: http://downloads.esri.com/support/whitepapers/ao_/**GeospatialMetadataProfile_J8709_3-03.pdf**
  - Metadata and GIS: http://downloads.esri.com/support/whitepapers/ao_/**metadata-and-gis.pdf**

Data Preparation Issues

Projecting to matching coordinate systems – ArcMap has the ability to reproject on-the-fly allowing different layers to line up. However, some tools and operations may yield unexpected results when you use them. It is always a good idea to have all your layers in the same coordinate system and defined (e.g. *.prj for shapefiles).

Aggregating similar features – Some datasets (e.g. CanVec) contain a wealth of spatial information in multiple layers. Combining them into single layers based on similar geographic features (points, lines, polygons) makes them easier to work with, especially when symbolizing and reprojecting.

Exploring and symbolizing **layer files** – Getting to know the attributes associated with your layers helps you to unleash the power of the geospatial data. Think of the GIS as a database that understands geometry. Tables of data can be linked together and joined to feature classes or raster datasets if they share a common attribute or ID. Through symbology, you can communicate specific attributes of your geographic information by making the map look more visually appealing and convey more meaningful information. ArcMap has several ways to spruce up legend styles to help describe how the data is displayed. You can then conveniently save everything about the layer (symbology, labels, classification) as a layer file (i.e. *.lyr) that when added to another map document will reference the data source and tell ArcMap to draw it exactly as it was saved.

Documenting metadata - Metadata is the all-important ancillary information associated with a GIS layer or coverage that characterizes the data set content, quality, condition and other characteristics, and generally includes: date of production, name of creator, data type (raster or vector), instrument type, coordinate system: projection and datum (very important), subject content, attributes (a.k.a. database fields), minimum mapping unit or cell size (scale/resolution), and much more… A helpful practice is to always document this information in a standardized way so that at a later date you or someone else can make sense of it all and know how to appropriately use the data for GIS analyses. You may take advantage of ArcCatalog's metadata tools or implement your own system using commonly available software, such as MS Excel or MS Access.

Tasks

Your overall goal is to ***set up a GIS project database for the Milk River area in southern Alberta*** where you may be researching a particular plant community, aquatic system, wildlife phenomenon, or other ecological question.

Copying the Course Dataset

1. Double click on the COURSES shared directory icon on the Desktop
2. Open the “GIS-100” folder (double click on it)
3. Select and copy the “**7_MSD**” folder (right click and choose Copy)
4. Click on the FOLDERS icon along the top menu bar
5. On the left side of the exploring window, click and drag the scroll bar until you can see “My Computer”
6. Expand/open “My Computer” and “Local Disk (C:)” by clicking on the “**+**”s
7. Paste in the **C:\WorkSpace** (right click and choose Paste)
8. Once all the files have copied over, close the exploring window
9. To use the ArcGIS Online base map and imagery service, you will need to AUTHENTICATE for internet access

Creating the Database

There are three basic steps for acquiring pre-existing GIS data:

❶ Establish required data needs (where/what)

❷ Find and order/download

❸ Make all the data ‘GIS-ready’ (unzip/import)

Initiating the database

Create two new file geodatabases for storing your intermediate and final data files:

1. Start ***ArcCatalog*** and navigate to the C:\Workspace **\7_MSD** folder
2. SHOW ArcToolbox, if needed
3. In ArcToolbox, click DATA MANAGEMENT TOOLS >>> WORKSPACE >>> CREATE FILE GDB
   - Specify the File GDB Location: **\7_MSD**
   - Type File GDB Name: **Work** - *this will store your intermediate work*
   - Click OK
4. REPEAT to create the **MilkRiver**.gdb - *this will store your final data layers*
5. Explore the various folders of available files

A great starting point in acquiring your digital data is to determine the geographic extent. From there you can brainstorm on the nature of data needed to address your research/mapping needs. Index maps provide a useful search 'tool' when identifying your region of interest because they provide the often needed information for when you order/download your files.

> For more information on the **National Topographic System (NTS)** see: http://maps.nrcan.gc.ca/topo101/index_e.php
> NTS map sheets are defined by up to three elements:
> - a number (1:1,000,000)
> - one of 16 letters (1:250,000)
> - a number 1 to 16 (1:50,000)

Determining your study area

6. Start a new empty ***ArcMap*** map document
7. SHOW ArcToolbox, if needed
8. Click the ADD DATA button
9. Navigate to \7_MSD**IndexMaps.gdb** and add the following feature classes:
   - **nts_snrc50k**
   - **utm**
10. Navigate to \7_MSD**Framework1M** and add ALL layer files
11. Navigate to \7_MSD**ArcGISOnline** and add the following layers:
    - World_Imagery.lyr
    - World_Physical_Map.lyr
    - World_Street_Map.lyr
    - **World_Topographic_Map**.lyr

    TIP: Use the layers in \Framework1M and \ArcGISOnline folders for your own research!
12. ZOOM IN on southern Alberta and locate the Milk River study area through

visualization and inspection of the attributes for the various reference layers

13. In the table of contents, turn on/off each of the layers to view
14. Use the IDENTIFY tool and OPEN ATTRIBUTE TABLE for each to learn which NTS map sheets and UTM zones include the Milk River
    How many 1:50,000 NTS map sheets cover the study area? How many UTM zones?
15. When viewing attribute tables, click the SELECTED button to show those records
16. Set the DATA FRAME >>> COORDINATE SYSTEM tab to an appropriate projection for the study area (*HINT: NAD 1983 UTM Zone ?)*
17. Use the SELECT FEATURES tool to interactively select the 1:50,000 scale NTS index map tiles that completely cover the Canadian portion of the river basin
18. In the table of contents, right-click **nts_snrc50k** and choose DATA >>> EXPORT DATA
    - Click to Use the same coordinate system as the data frame
    - Save the Selected Features as **\Work.gdb\nts_utm12**
19. Optionally, in the attribute table view click OPTIONS >>> EXPORT to save the table to a file that can be opened in a text editor or MS Excel (*this is handy for future transfer of information, say listing the map sheets you need to download/order, or passing on to a government agency that may be providing you with additional data*)
    Now, prepare a study area extent polygon to be used for clipping other data layers.
20. In ArcToolbox, choose DATA MANAGEMENT TOOLS >>> GENERALIZATION >>> DISSOLVE
    - Input Features: **nts_utm12**
    - Output Features: **extent**
    - Click OK

Optionally, create an extent polygon in the original geographic coordinate system. You never know if you'll need a study area layer that's unprojected! Once you have established where and what types of data you need, check out the various free online web resources and also contact the UofA Library staff knowledgeable about academic licensed spatial data services. Contacting government agencies may also be needed.

Acquiring selected data sources

Use the lists of index map identifiers to help you locate and download/order your data. For a listing of useful Alberta & Canada websites, please see:
www.biology.ualberta.ca/facilities/gis/?Page=2980
Specific data files already downloaded for this short course are as follows (NOTE: original downloads of data are stored in the \DATA folder, and selected metadata have been saved to the _documentation folder):

DATA FILES	WEB SOURCE
IndexMaps.gdb	http://geogratis.cgdi.gc.ca/geogratis/en/download/topographic.html C:\Program Files\ArcGIS\Reference Systems\utm.shp
\Framework1M	http://geogratis.cgdi.gc.ca/geogratis/en/download/framework.html
\ArcGISOnline	http://help.arcgis.com/en/arcgisonline/agolbasemaps.html World_Imagery.lyr, World_Physical_Map.lyr, World_Street_Map.lyr, World_Topographic_Map.lyr
\DATA\CanVec	http://geogratis.cgdi.gc.ca/geogratis/en/download/topographic.html
\DATA\CDED	http://www.geobase.ca/geobase/en/data/cded/
\DATA\GSC	http://geoapps.nrcan.gc.ca/applications
\DATA\NLWIS	http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1227635802316&lang=eng

TIP: The NLWIS Landcover product covers the agricultural region of Canada. Other land cover and classification products for Canada can be accessed through GeoGratis, GeoConnections, or SAFORAH (e.g. CFS EOSD landcover is useful for forested study areas).

See the Appendix on FTP – this is a most efficient method for mass downloading! Upon receiving the files, examine each of the data products to help you decide if they are indeed appropriate for your research. If you cannot immediately view the data then you must import or convert them to the proper formats.

Unzipping

To unzip files is a cinch using ZipGenius/WinZip or similar utility. First look at the original files in Windows Exploring and then determine which needs extraction by unzipping:

1. Start ***Windows Exploring***
2. Navigate to the **C:\WorkSpace\7_MSD** directory

3. Explore each of the sub-folders to see what they contain
4. Extract the archived data files as demonstrated – *write down notes!*
5. Consult the HELP if you are unfamiliar with this utility
6. **Unzip ALL *.zip files** into their respective originating folders then inspect/examine them
   Make note of the file format (coverage, shapefile, raster), geographic extent, subject matter, projection information (especially datums) and other important metadata for each of the datasets. You'll need to know where to quickly find this info when processing the various datasets. Also, inspect and examine the files from within ArcCatalog where you can explore and visualize the data, and then directly address any processing requirements using ArcToolbox (next sections below).
7. In ***ArcCatalog***'s catalog tree, navigate to **C:\WorkSpace\7_MSD\DATA**
8. Click the "**+**" to expand each of the folders
9. Select any one of the layers and click on the PREVIEW tab to preview the GEOGRAPHY and TABLE (see drop-down list below the display window)
10. Right click on one of the layers
11. Choose PROPERTIES
12. Review the information contained here and close the window when done
13. Right Click on another layer select Item Description and examine the METADATA - do all layers have 'complete' information here?
14. PREVIEW all the other data layers in the subfolders of C:\WorkSpace\7_MSD
15. Go back to the CONTENTS tab for the **\7_MSD\GSC** directory

Importing an interchange file (.E00)

Select ArcToolbox - Conversion Tools – To Coverage, Select Import from E00 and double click. Each tool is a wizard-driven interface in which you select the input file, specify the output name, and enter any associated parameters. The import tools work in similar ways.

16. Click on the browse button (looks like an opening folder)
17. Navigate to the input file and select one; e.g. **\7_MSD\DATA\GSC\GEO1880A.E00**
18. Click OPEN

19. Click on Output Folder and select the GSC directory, click Add
20. In the Output name space type ***geo1880a***
21. Click OK – *you will now have a vector coverage named* ***geo1880a***

Projecting

Data often need to be projected to your study area coordinate system, and it may take more than one step depending on the original and target systems. All data seem to be in the GCS NAD1983 coordinate system, except: CanVec (GCS_North_American_1983_CSRS), NLWIS (GCS_WGS_1984), and GSC. The latter data requires an intermediate projection and a transformation:

1. In ***ArcToolbox*** choose DATA MANAGEMENT TOOLS >>> PROJECTIONS AND TRANSFORMATIONS >>> FEATURE >>> PROJECT **geo1880a\polygon** to NAD 1927 UTM Zone 12 and save as \Work.gdb**geo1880a_n27**
2. PROJECT geo1880a_n27 to NAD 1983 UTM Zone 12 (*remember the NTV2 transformation*) and save as \Work.gdb**geo1880a_n83**

NOTE: You already did some projecting when you created your nts_utm12 polygon!

Preparing/Customizing Data

Topographic Features from CanVec

CanVec is a digital database of topographic features developed for all of Canada. ArcGIS can directly read and analyze the available GIS-ready file formats, which in this course are the ***shapefiles*** (i.e. required extensions ****.shp***, ****.shx***, ****.dbf***). Each geographic feature comes in its own shapefile. Aggregating the similar types (points, lines, polygons) greatly facilitates management and symbolizing of this data.

1. Start a new empty ***ArcMap*** map document
2. In ArcCatalog, navigate to **\7_MSD\DATA\CanVec**
3. While ArcCatalog is also open and both ArcMap and ArcCatalog windows are viewable onscreen, select **ALL** shapefiles from each subfolder
4. Click and drag to add to the ArcMap data frame (select all, then click and drag from each subfolder in ArcCatalog to the Data

View window [*NOT the table of contents!*] in ArcMap)

5. In ArcCatalog, click on the CanVec folder and then choose VIEW >>> REFRESH
6. Minimize ArcCatalog

Notice how ArcMap automatically organizes the layers by feature type – points, lines polygons. When working with numerous shapefiles like this, it is more convenient to group the layers by feature type (points, lines, polygons) and then move them to their own data frames to facilitate merging into well-ordered themes.

Notes about CanVec

- Both 1:250,000 and 1:50,000 data are available
- Individual NTS mapsheet tiles are available as shapefiles
- Entire provinces or country are available as file gdb!

7. Holding the CTRL key, click any of the checks (within a check box in table of contents)
8. Select all the ***point*** feature layers (click on the first one then while holding the SHIFT key, click on the last one)
9. Right click on one of the highlighted layers
10. Choose **GROUP**
11. Rename this layer as "**points**"
12. Collapse the group layer by clicking the "**-**"
13. REPEAT the grouping for the "**lines**" and "**polygons**" (and rename the grouped layers as indicated and collapse)
14. Optionally, save each grouped layer as a layer file

While they are not symbolized in any special way, the advantage of having the grouped features as layer files gives you the flexibility of adding the layer files to a new map document for future work (and in the event of a computer crash) without having to add from each of the individual folders again.

15. INSERT two new data frames – choose INSERT >>> DATA FRAME
16. Click and drag the "**lines**" grouped layer to one of the new data frames
17. Remove the original from the first data frame
18. Click and drag the "**polygons**" grouped layer to the other new data frame
19. Remove the original from the first data frame

This might seem overboard in the organization department, but it certainly beats having to pick through all feature types when you want to merge certain layers in the next few steps. You may also go one step further and save as layer files.

20. Optionally, double click on EACH data frame and set the COORDINATE SYSTEM to NAD 1983 UTM ZONE 12 (*set the correct transformation method, too*)
21. SAVE the map document; e,g, CanVecGroups.mxd
22. Right click on the data frame containing "**points**" and choose ACTIVATE

*Explore some of the data layers to get a feel for what can be combined and what you want kept separate. For example, the *_TO_*.shp files should be combined with only each other to create a complete coverage across all map sheets. All other point features can be aggregated and then symbolized/selected by the THEME field. READ the files in the _documentation folder to learn more about what the names and attributes mean. Don't you agree that using numeric codes is pretty smart for a bilingual country?*

READ the documentation - CanVec_feature_catalogue_en.pdf - to learn more about what the names and attributes mean.

Now, to keep all output layers in the same coordinate system as the one chosen for your study area, it's more efficient to set this as a global environment setting.

23. Click on Geoprocessing in the menu and choose ENVIRONMENTS
24. In the ENVIRONMENT SETTINGS category:
    - Set the workspaces to the **\Work.gdb**
    - Set Output Coordinate System to 'As Specified Below' >>> **NAD 1983 UTM Zone 12**
    - Set the transformation to **NAD_1983_To_NAD_1983_CSRS_3**
    - Click OK
25. Choose DATA MANAGEMENT TOOLS >>> GENERAL >>> MERGE
26. Select ALL ***_TO_*.shp** files - *easiest to select in the TOC and drag to the input window*
27. Type an output name; e.g. \Work.gdb**toponames**
28. Click OK

29. Remove the old ***_TO_*.shp** files from the group layer
30. Repeat the MERGE for all other point features to create a new **\Work.gdb\points** *– the THEME field can be used for future mapping and analysis queries*
31. ACTIVATE the data frame containing "**lines**"
    *The **water** features and **contours** should also be kept separate from other entity types when merged. Human access features – roads, rail, pipelines, etc. – may be combined. Remove each set of layers after they have been merged to help with the next selection of layers to process. Read the documentation to learn more about what the names and attributes mean. TIP: The CanVec_Codes_v1_1 table, available in the \IndexMaps.gdb, is similar to CanVec_EntitiesCodesFileNames_EntitesCodesNomsDeFichier_v1_1_0.xls.*
32. MERGE each theme for the various linear features, save all to **\Work.gdb**, and remember to remove the highlighted layers from the table of contents each time (*this reduces the number of files to sort through*):
    - all single line watercourses (HD) and name it **watercourses**
    - all contour lines (FO_1030009) and name it **contours**
    - all human linear types (everything else) and name it **linear** – highlight one of the **TR_1760009** layers and click the UP ARROW button to set this as the topmost input layer; this will require the output to retain all the road attributes, which is more numerous than the other line features
33. ACTIVATE the data frame containing "**polygons**"
34. Save all polygon outputs to **\Work.gdb**
35. MERGE each theme for the various linear features, save all to **\Work.gdb**, and remember to remove the highlighted layers from the table of contents each time (*this reduces the number of files to sort through*):
    - all hydro polygon files (HD_1480009) into \Work.gdb**waterbodies_Merge**
    - all wetland polygon files (SS_1320049) into \Work.gdb**wetlands_Merge**
    - aggregate one or two others of interest; e.g. wooded_Merge (VE_1240009)

Because ArcToolbox's global environment was set to output the same coordinate system as

the display (data frame), the merge output is automatically reprojected to NAD83 UTM. Now you have newly created feature classes projected in the coordinate system of choice to analyze and map for the Milk River project database. Note: Merging polygons is not always a good idea because the merge operation results in a "sandwich" layer effect of overlapping polygons. You must carefully consider the input order or opt to use union instead when aggregating polygon features! The next step is to generalize the data between the map sheet edges.

36. ACTIVATE the data frame containing "**polygons**"
37. Choose DATA MANAGEMENT TOOLS >>> GENERALIZATION >>> DISSOLVE
    - Select **waterbodies** as the input features
    - Specify **\Work.gdb\waterbodies** as the output feature class
    - Check both **THEME** and **PERMANENCY** as the Dissolve Fields
    - Uncheck 'Create multipart features'
    - Click OK
38. REPEAT dissolving by THEME (*check for any other fields?*) for the wetlands, vegetation, etc. and save in the **\Work.gdb**
39. Reset ArcToolbox's ENVIRONMENTS to default values - *a very good idea, especially when switching between projects*

Canadian Digital Elevation Data

You can download national coverage DEMs in 1:250,000 (~90 meter) and 1:50,000 (~20 meter) scales. ***Canadian Digital Elevation Data (CDED)*** is digital terrain data available in USGS DEM format from Natural Resources Canada (NRCan). ArcGIS can read, import, and export the single file type (****.dem***). The following procedures outlines the steps necessary for mosaicking and reprojecting (DO take a closer look at the help for each of the parameters and pay attention to the # of bands and bit depth):

1. In a new empty ***ArcMap***, add all the *.dem files to visualize how the tiles appear
2. In ArcToolbox, choose DATA MANAGEMENT TOOLS >>> RASTER >>>RASTER DATA SET>>> MOSAIC TO NEW RASTER
    - Select ALL available rasters as the Input Rasters

- Specify Output Location: \7_MSD**Work.gdb**
- Type the Raster dataset name: **dem_gcs**
- Click OK

Now it is time to project the data into the study area's chosen map projection:

3. Choose DATA MANAGEMENT TOOLS >>> PROJECTIONS AND TRANSFORMATIONS >>> RASTER >>> PROJECT RASTER
4. Specify the:
   - Input raster: **dem_gcs**
   - Output raster: **dem_utm**
   - Output coordinate system: **NAD_1983_UTM_Zone_12N**
   - Output cell size: **20**
5. Click OK

You now have one seamless layer of CDED data projected to NAD 1983 UTM Zone 12. You may wish to choose a different coordinate system to suit your particular study area when applying these instructions to another dataset, or even "clip" your data to fit a smaller study area boundary.

Surficial geology from GSC

The ***Geological Survey of Canada (GSC)*** data is at a 1:5,000,000 scale and is useful for practicing the tasks of joining attribute tables, projections, and clipping. This particular dataset is a digital version of the surficial geology of Canada map. You have already projected it, now you will populate the attribute table and subset to the study area extent.

1. Start a new empty ***ArcMap*** map document
2. ADD the projected **geo1880a_n83** from the \Work.gdb (*NAD 1938 UTM Zone 12*)
3. OPEN ATTRIBUTE TABLE for geo1880a_n83
4. In ***Windows Exploring***, locate the information (*HINT:* _*documentation*) you need to interpret the codes in the GEOPOLY field
5. Back in ***ArcMap***, ADD DATA: geopolye.xls
6. Double click on geo1880a_n83 polygon to access its Layer Properties
7. In the JOINS & RELATES tab, click ADD in the Joins frame (left side)
8. Choose to join the GEOPOLY field to the geopolye.xls table's GEOPOLY field
9. Click OK twice

10. Examine the joined attribute table and optionally, symbolize using one of the joined fields
11. In the Layer properties' FIELDS tab, check off any of the unwanted fields (e.g. click the CLEAR ALL button and check on **GEOPOLY**, **GEOMOD**, **Label**, and **Description**
12. Click OK and view the table with its reduced number of columns
13. ADD DATA: **extent** from the Work.gdb
14. Open the CLIP tool and specify the following parameters:
    - Input Features: **geo1880a_n83**
    - Clip features: **extent**
    - Output Feature Class: \Work.gdb**surfgeol**
15. Click OK

Take a few moments to reflect on all the processing performed and notice the few minor tricks incorporated (join by attributes, turn unwanted fields off) to extract the desired data for the study area. NOTE: This 1:5M scale data is likely too coarse for this study area.

Landcover from NLWIS

The ***National Land and Water Information System (NLWIS)*** is part of Agriculture and Agri-Food Canada. Their thematic land cover map was produced through remote sensing classification of Landsat satellite imagery from circa 2000. The 30 meter data cover the Milk River study area.

1. In a new empty map document or data frame, ADD DATA from \Work.gdb: **extent**
2. ADD DATA from the \DATA\NLWIS folder: **lcv_utm12_aafc_30m_2000_v11.tif**
3. CLIP / EXTRACT BY POLYGON / EXTRACT BY MASK the landcover layer to just the study area extent subset and save as \Work.gdb**landcover**
4. CHALLENGE: Assign descriptive names/labels to the subset raster attribute table

More data?

If time, examine the metadata and files for the NRN and SLC directories to process, subset to extent, and add these datasets to the study area database.

Copy to Final Database

1. Import/export/copy all the final layers (*feature classes and rasters that have been aggregated, projected to NAD 1983 UTM Zone 83, and/or subsetted by clip/extract*) in to the **MilkRiver.gdb**
   - Use ArcCatalog to right-click on MilkRiver.gdb and choose IMPORT >>>
   - Or in ArcToolbox choose CONVERSION TOOLS >>> TO GEODATABASE >>> … (multiple)
2. CHALLENGE: Use ArcCatalog or MS Excel/MS Access to create ***metadata*** documentation describing the original data files, the processing you performed, and properties of your final dataset layers in the **\MilkRiver.gdb** directory

*For example, in MS Excel/MS Access set up column headings for a table that indicate the original input layers complete with descriptions of content, file format, file location, extent, scale, coordinate system/datum, source, etc., and the final output layers complete with the same information, along with the processing details that generated them. See Chapter 9 in the **Using_ArcCatalog.pdf** for documenting metadata in ArcGIS. Metadata is very useful!!!*

What next?

What you do with your data depends on your research objectives. To get you this far, you already determined what kinds of data were needed to meet your objectives as identified by your GIS project development. Now that you've completed the acquisition and preparation you are ready to apply the appropriate GIS functions and methods to analyze the data and produce the output products you need. Other tutorials and short courses can help you address these issues.

Appendix A: Brief Notes on Scale, Accuracy, and Precision

You may have noticed the spatial differences among the various data sets – this is due to the variation in source methods and scale. The producers of each dataset created the data for specific purposes, which may have required

generalization of features to fit the appropriate scale of mapping/analysis (as well as other sources of error). This leads to an interesting issue regarding **scale** as a property of the digital database. The definition of scale (ratio of distance in the computer map to distance on the ground) makes no sense to digital data because how can there be distances in a computer? When scale is quoted for a digital database it usually means the scale of the map that formed the source of the digital data.

Box 5.3 The many meanings of scale

Unfortunately the word *scale* has acquired too many meanings in the course of time. Because they are to some extent contradictory, it is best to use other terms that have clearer meaning where possible.

Scale is in the details. Many scientists use scale in the sense of spatial resolution, or the level of spatial detail in data. Data are fine-scaled if they include records of small objects, and coarse-scaled if they do not.

Scale is about extent. Scale is also used by scientists to talk about the geographic extent or scope of a project: a large-scale project covers a large area, and a small-scale project covers a small area. Scale can also refer to other aspects of the project's scope, including the cost, or the number of people involved.

The scale of a map. Geographic data are often obtained from maps, and often displayed in map form. Cartographers use the term scale to refer to a map's *representative fraction* (the ratio of distance on the map to distance on the ground – see Section 3.7). Unfortunately this leads to confusion (and often bemusement) over the meaning of *large* and *small* with respect to scale. To a cartographer a large scale corresponds to a large representative fraction, in other words to plenty of geographic detail. This is exactly the opposite of what most other scientists understand by a large-scale study. In this book we have tried to avoid this problem by using *coarse* and *fine* instead.

Scale is often integral to the trade off between the level of spatial resolution and the degree of attribute detail that can be stored in a given application – as in the trade off between spatial and spectral resolution in remote sensing (Section 10.2.1).

For an extensive discussion of these and other meanings of scale (e.g. the degree of spectral or temporal coarseness), and their implications, see Quattrochi and Goodchild (1996). The scale at which data from different sources are usually made available is discussed in Section 10.4.

The scale of data capture (digitizing, remote sensing, GPS, etc.) influences the **accuracy** of the data. When you display the national-level data with the 1:50,000 data, the generalization of the large regional scale is readily apparent: Milk River appears jagged and doesn't conform to the gentle meanders visible in the finer data. Another important point to remember is that the earth is not a perfect sphere, is in constant motion, and is subject to minute movements from seismic, drift, and wobbling; therefore, accurate measurements on the earth's surface are inherently uncertain. Do not confuse accuracy with **precision**, which is often referred to as the repeatability of and number of digits used to report measurements.

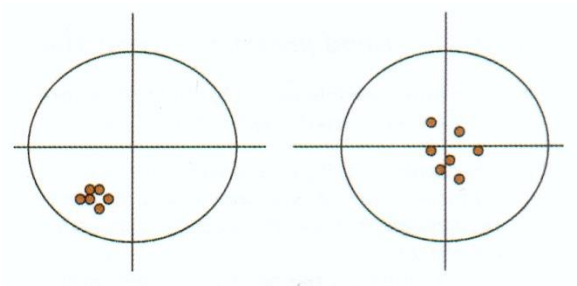


Figure 15.2 The term *precision* is often used to refer to the repeatability of measurements. In both diagrams repeated measurements have been taken of the same position, represented by the center of the circle. In (A) successive measurements have similar values (they are precise), but show a bias away from the correct value (they are *inaccurate*). In (B), precision is lower but accuracy is higher

To add to the complexity of scale issues, ***spatial*** scale (e.g. grain size, extent, representative fraction, minimum mapping unit, etc.) is not the only matter to be concerned with when establishing your GIS project database. Scale also includes temporal and spectral characteristics. The timing of data capture affects the ***temporal*** scale – very significant when analyzing time-sensitive phenomena or for just preserving a proper time frame among the various data sources (e.g. you wouldn't want an airphoto from 1972 when your research will be performed next summer). In the case of remote sensing data, ***spectral*** scale defines the wavelengths of electromagnetic radiation – very affective when differentiating among earth features (e.g. healthy green vegetation greatly reflects in the near-infrared wavelengths and absorbs in the red and blue wavelengths).

Of course, this brief discussion is only the tip of the iceberg where scale is concerned when compiling your GIS database. Excellent selected references for further reading are listed below:

Environmental Systems Research Institute, Inc. 1995-2010. **ArcGIS Desktop Help**.

Environmental Systems Research Institute, Inc. 1995-2010. ***ESRI Virtual Campus***. http://campus.esri.com/

Lillesand, T.M. and Kiefer, R.W. 2000. **Remote sensing and Image Interpretation**. John Wiley & Sons, Toronto, Ontario.

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

National Center for Geographic Information and Analysis (NCGIA). 2007. ***GIS Core Curriculum***. http://www.ncgia.ucsb.edu/education/curricula/cctp/Welcome.html

…and so many more…

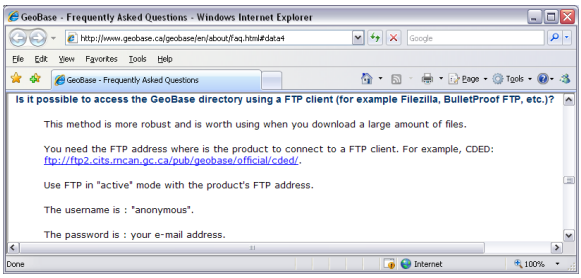
Note: When "mixing" datasets of various scales, your output will only be as spatially accurate as the coarsest scale!

Appendix B: FTP Information

When you need to download many files in many directories, it is more efficient to use a File Transfer protocol application, such as the following highly recommended free and open source:

http://filezilla-project.org

You may also use the AICT provided clients, which have online documentation on their use, from here: http://helpdesk.ualberta.ca/storage/filetransfer.html



Log on as ***anonymous*** with your ***email*** for the password.

The main hosts are **ftp2.cits.rncan.gc.ca** and **ftp.geogratis.gc.ca** and **ftp.agr.gc.ca**:

Typically, inside the \pub directory are all the publicly available spatial data products from NRCan. You may need to type in the subdirectory (subfolder) name; e.g. \geobase\cded.

You can expand your local site and navigate to the directory folder you wish to download files to – and also create new directories within. Then simply select, click, and drag from the remote side (NRCan directories) to your local hard drive!

Appendix C: Very Useful ArcGIS Online Resources

http://**support**.esri.com

http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html

http://resources.arcgis.com/content/**product-documentation**?fa=viewDoc&PID=17&MetaID=1003 (PDFs of older manuals)

http://**resources**.arcgis.com/en/home/