APEC Workshop on Hazard Mapping & Risk and Vulnerability Assessment

Instructions for Day 3 Exercises

Chinese Taipei

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Subject matter experts at the Pacific Disaster Center (contact: Mr. Chris Chiesa, PDC Chief Information Officer, CChiesa@pdc.org) prepared this manual for the Asia-Pacific Economic Cooperation (APEC) organization as part of the APEC Technical Assistance and Training Facility (TATF) program.

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Contents

Introduction

GIS is a useful tool for organizing, displaying and analyzing hazard, asset, vulnerability, capacity and risk information. In the exercises you complete today, you will gain a basic familiarity with some of the ways GIS can be used to support hazard mapping and risk and vulnerability assessment (RVA). You will not be experts in either GIS or RVA by the end of one day. However, the exercises provide illustrations of methods and challenges and introduce you to one commonly used GIS software package: ESRI's ArcGIS Desktop. Data, documents and results are for illustration only and should not be applied in real-world decision making contexts.

Hands-on Exercise: Becoming Familiar with ArcGIS Desktop

GOALS OF EXERCISE 1: BECOMING FAMILIAR WITH ARCGIS

At the end of this exercise, participants should be able to:

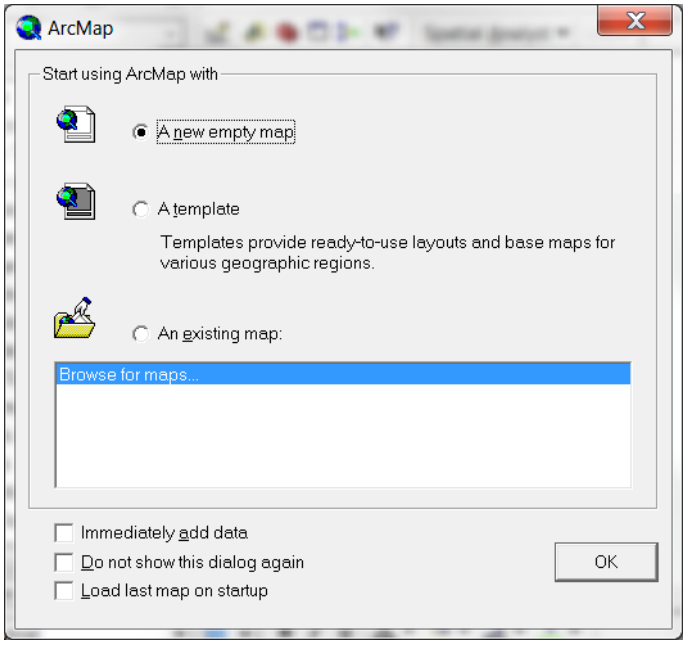
- Create a new project and add data themes to a view
- Use basic tools to manipulate and explore the map
- Locate and explore the attribute table
- Select features
- Open and explore ArcToolbox
- Locate the Spatial Analyst toolbar

OPENING A NEW PROJECT AND ADDING DATA

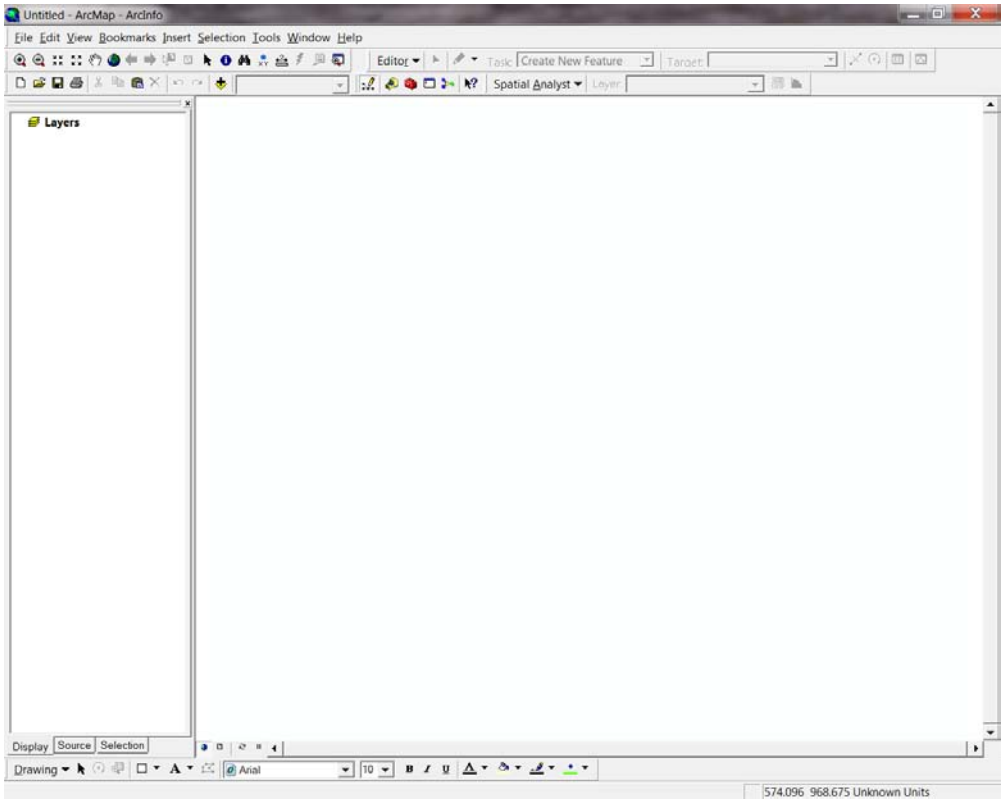
ArcGIS Desktop is made up of three components: ArcMap; ArcCatalog; and ArcToolbox. ArcMap allows you to view data, ArcCatalog allows you to organize and describe data, and ArcToolbox allows you to perform analysis and processing. We will create a project using ArcMap.

First, click on the **ArcMap** icon on your desktop.

When ArcMap opens, a dialog box will appear. Uncheck “Immediately add data” and click on the **OK** button.

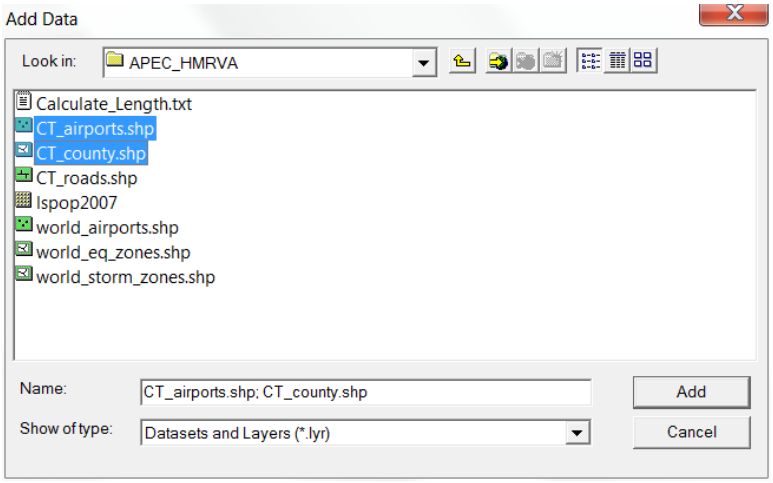


Your screen should look similar to this:

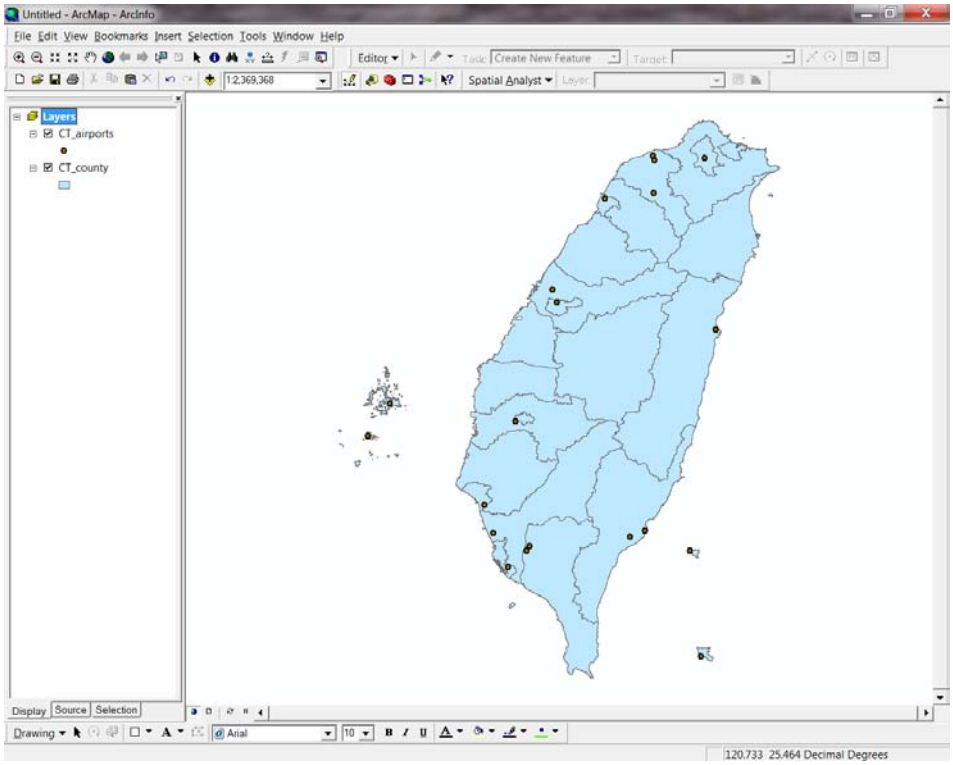


You will now add two GIS datasets (or layers) to the map, which provide information about the counties and airports of Chinese Taipei. First, click on the **Add Data** icon.

In the dialog box, use the drop down menu to navigate to the *C:* drive and open the "*APEC_HMRVA*" folder. Select *CT_county.shp* and *CT_airports.shp*. (*Hint*: You can select more than one data layer by holding down the Ctrl button on the keyboard while you make your selection with the mouse). Click the **Add** button once you've selected the two layers.



The layers appear in the Table of Contents (TOC) on the left side of your screen. ArcMap has assigned each of them a default symbology which we will change later in this exercise.



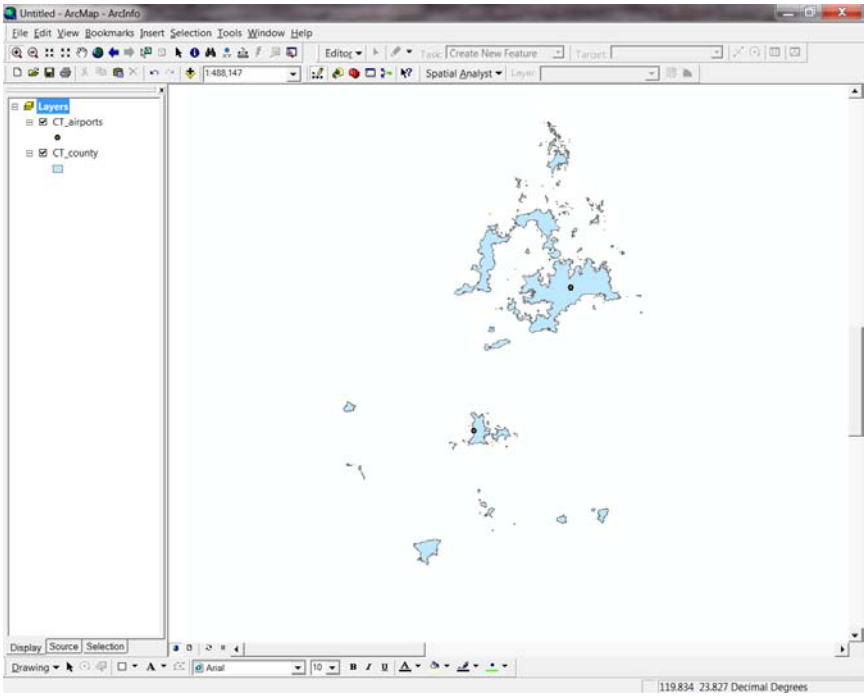
You can make these layers visible or not visible by checking and unchecking the box next to the name of each layer. Try it.

The second way to alter the appearance of features is to move the position of layers in the TOC by dragging that layer above/below another layer in the TOC. As a general rule, points should always be at the top of the TOC, lines below points, and polygon and raster layers at the bottom.

USING BASIC TOOLS

You may want to take a closer look at a particular area. To do so, use the **Zoom In** tool.

Click on the icon, and draw a box around the area of interest using your left mouse button. Once you release the button, the map view will be focused on your area of interest. You may also click once with the left mouse button for a fixed zoom in.



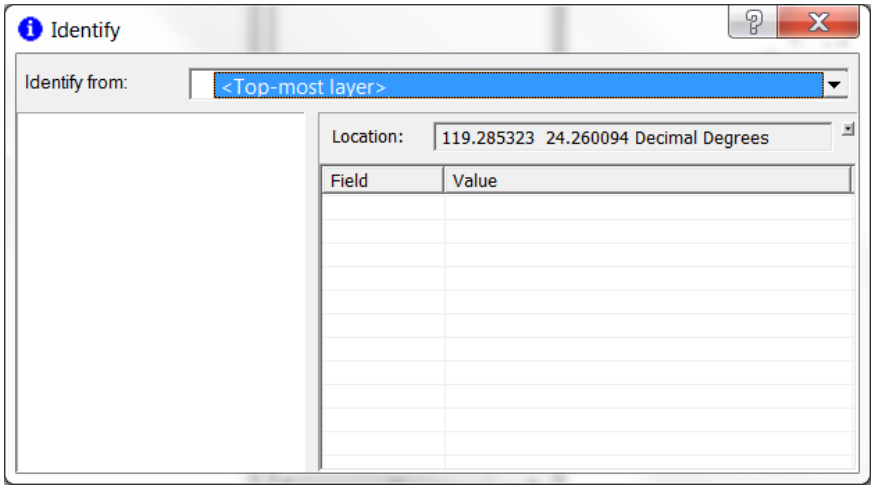
Example of the view zoomed into Penghu County.

Use the **Pan** tool to move around the view. Click and hold the left mouse button down to drag the map to the desired area.

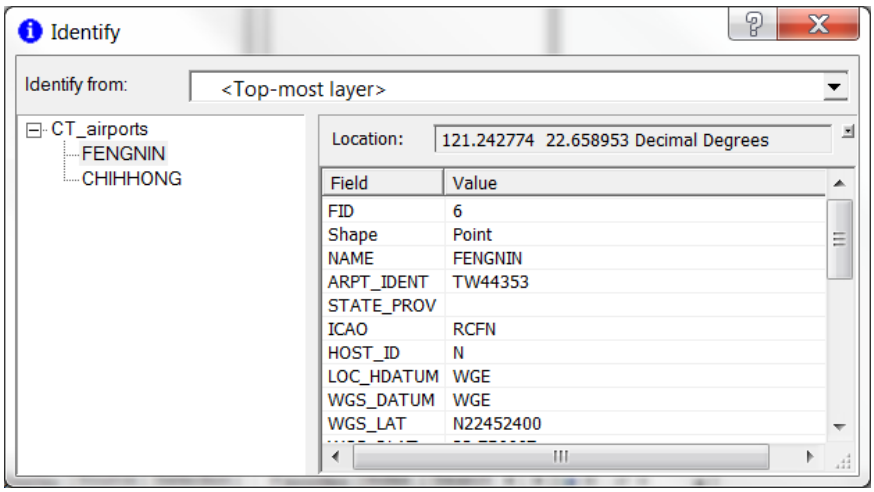
To return to your original view, click on the **Zoom to Full Extent** button located next to the **Pan** tool.

Perhaps you would like to find some information about a particular feature on the map, such as the name. The **Identify** tool allows you to do this.

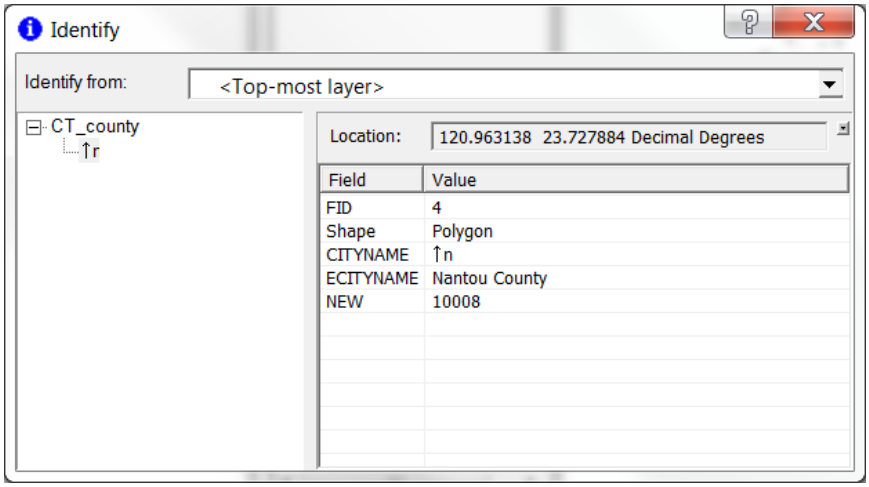
Click on the **Identify** tool. A dialog box will open. As a default, the **Identify** tool will provide information on the layer listed first in the Table of Contents (in this case, the airport layer). However, you can choose your preferred layer or combination of layers in the drop down menu.



You can use the **Identify** tool in a couple of ways. First, you can draw a box around the feature or features that you are interested in. All of the attribute information associated with those features will appear in the dialog box.



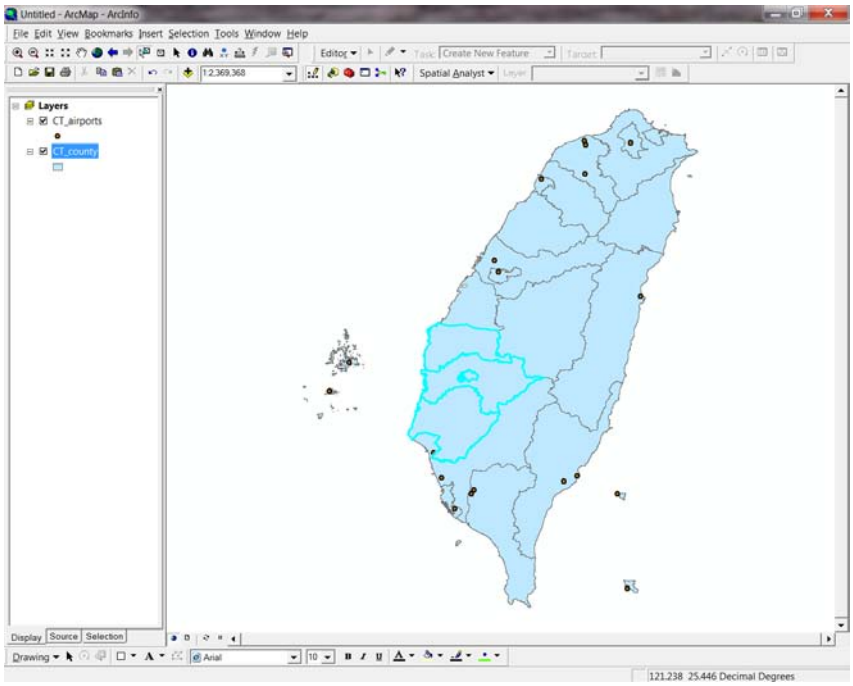
Second, you can click once on the map and the dialog box will display information about the feature you have pointed to. This is more difficult with points, and works better with polygon and line features. Try it.



As with the **Identify** tool, you can select features by either drawing a box or by pointing to them, using the **Select Features** tool.

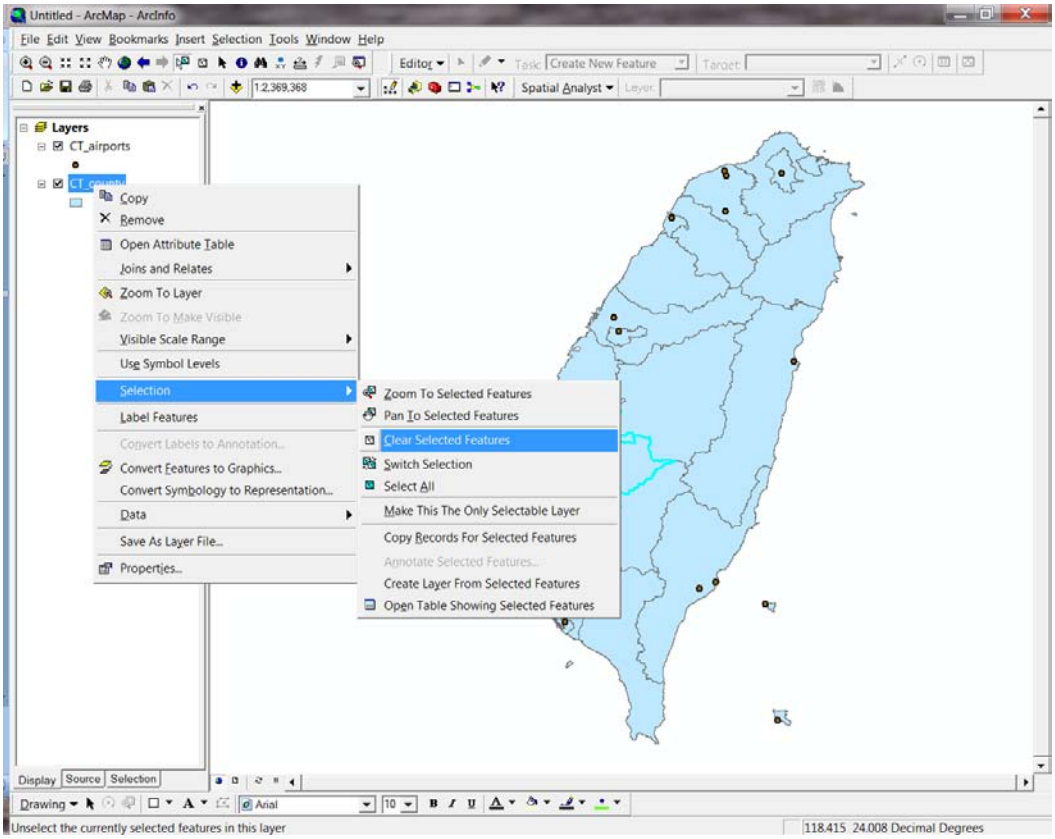
The ability to select data is one of the most powerful tools in GIS. It allows you select a subset of your data either geographically or by attributes (table information). We will see several examples in this, and in the following exercises.

Once selected, the features will be highlighted on the map, and in the attribute table, which we will explore later. In the screen shot below, three counties and Tainan City are highlighted.



As with most GIS tools and analysis steps, there are multiple ways to clear the features you have selected. One option is clicking on the **Clear Selected Features** tool in the toolbar.

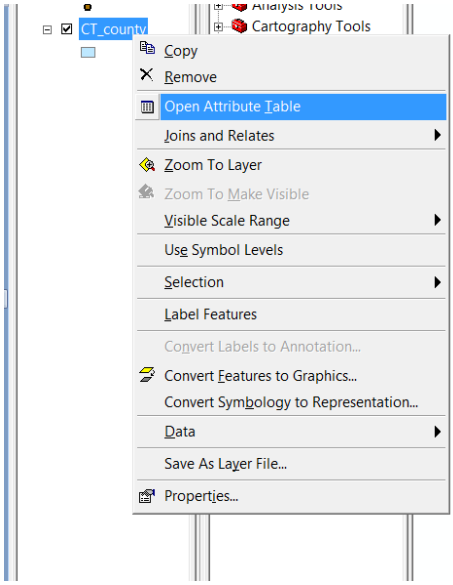
You can also right click on the *CT_county* layer in the TOC, then navigate to "Selection," and left click on "Clear Selected Features."



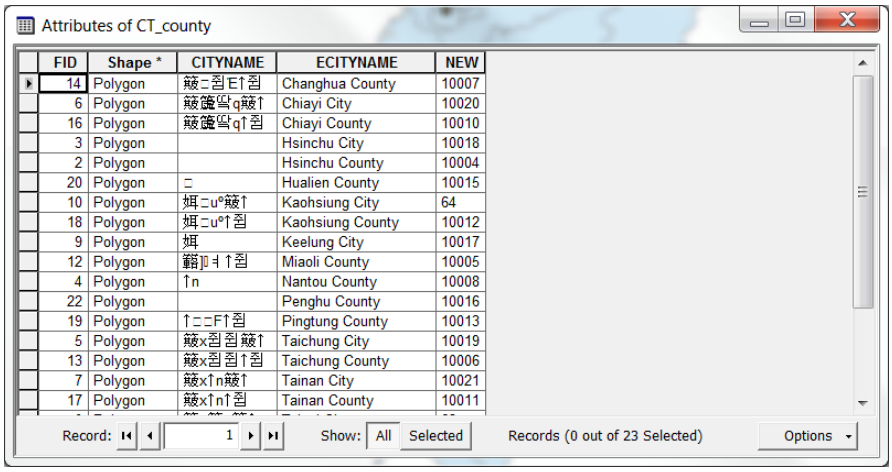
You will notice that right clicking on the layer name in the TOC gives you a variety of options, some of which we will explore.

THE ATTRIBUTE TABLE

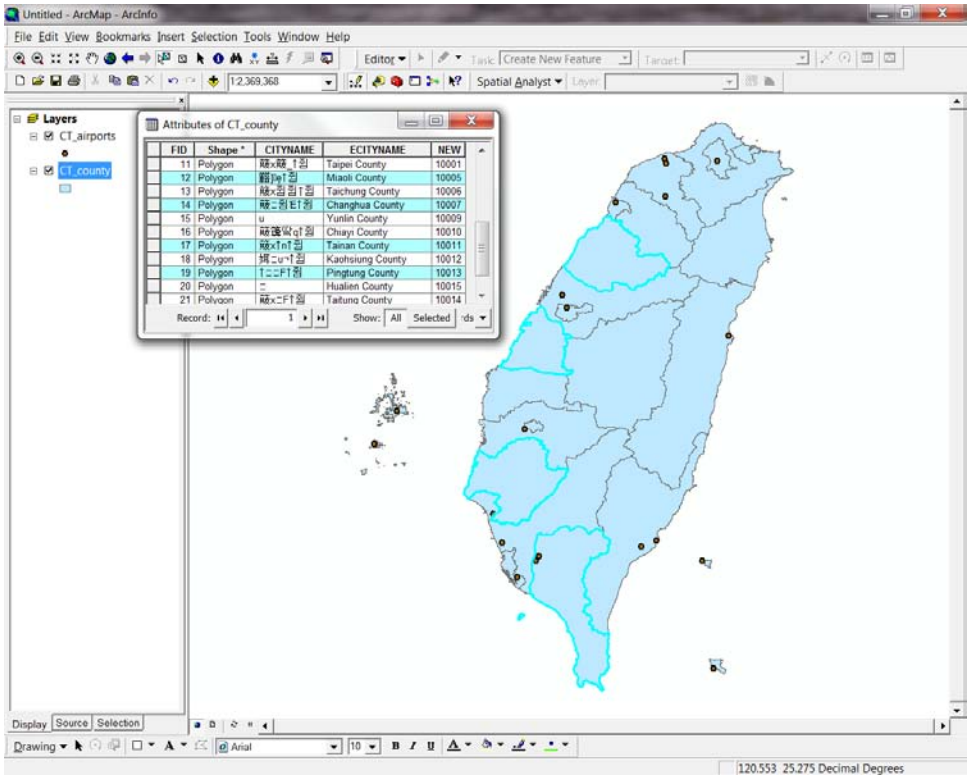
You can access all the attribute information you saw in the "Identify" dialog boxes through the attribute table. The attribute table contains available data for all features and allows a user to manipulate and work with it. The information in the attribute table is linked to the spatial information used to display the features in the viewing window. Open the attribute table of the *CT_county* layer by right clicking on the layer name in the TOC and clicking on "Open Attribute Table."



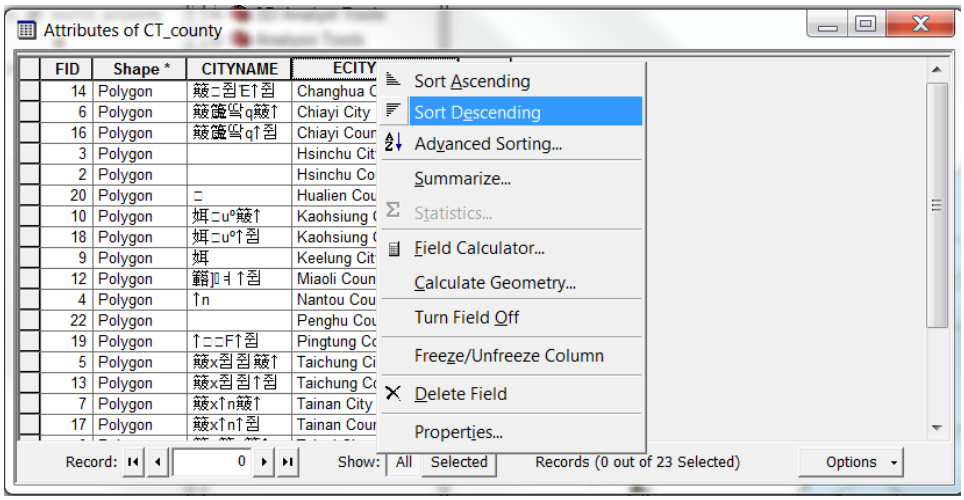
The attribute table will open in a separate window.



You can also make selections using the attribute table by left clicking in the gray box next to a row (left). Select several cases by holding down the Ctrl key as you click. You can see that the selections are highlighted on both the map and in the attribute table. This will be the case regardless of the selection method you use (there are many).

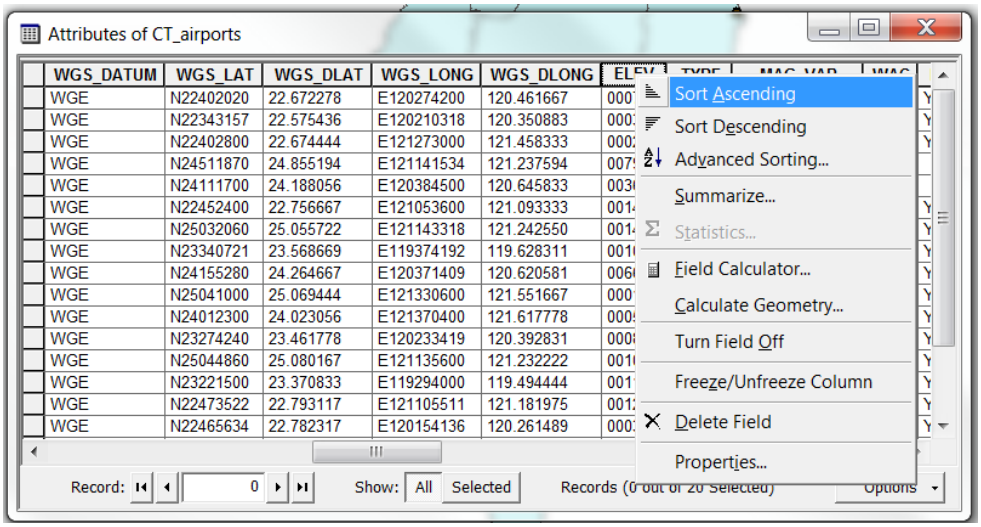


Right clicking on a field name in the attribute table brings up a menu with a variety of options.



Sorting is a useful function. Select “Sort Ascending” to sort the *ECITYNAME* field alphabetically. You can sort in reverse alphabetical order by clicking on “Sort Descending.” Sorting works with letters, numbers and dates.

Open the attribute table for the *CT_airports* layer and sort the *ELEV* field. You will need to scroll to find it. Which airport has the lowest elevation? Which airport has the highest elevation?

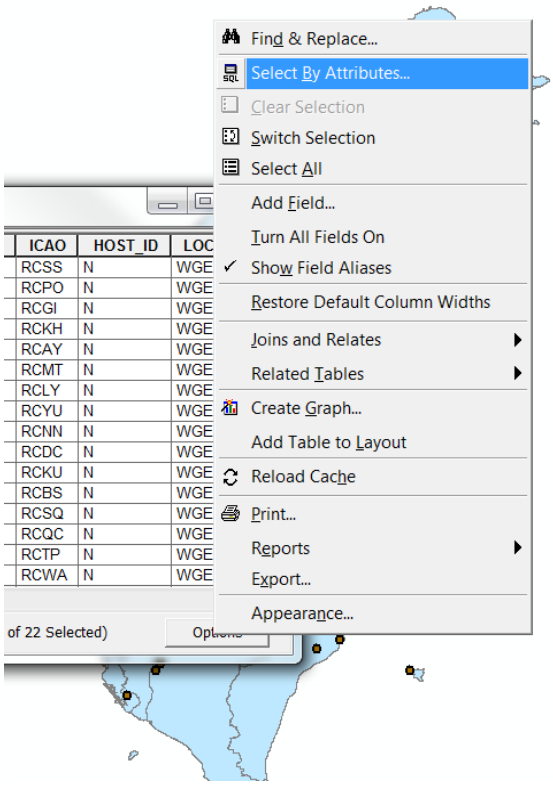


Later in the exercises, you will use the "Summarize" function listed in the menu, which creates a table containing one record for each value of a selected field, along with statistics summarizing any other fields. For instance, if the *CT_airports* layer attribute table included the county each airport was located in, a user could use the summarize function to calculate how many airports were in each county.

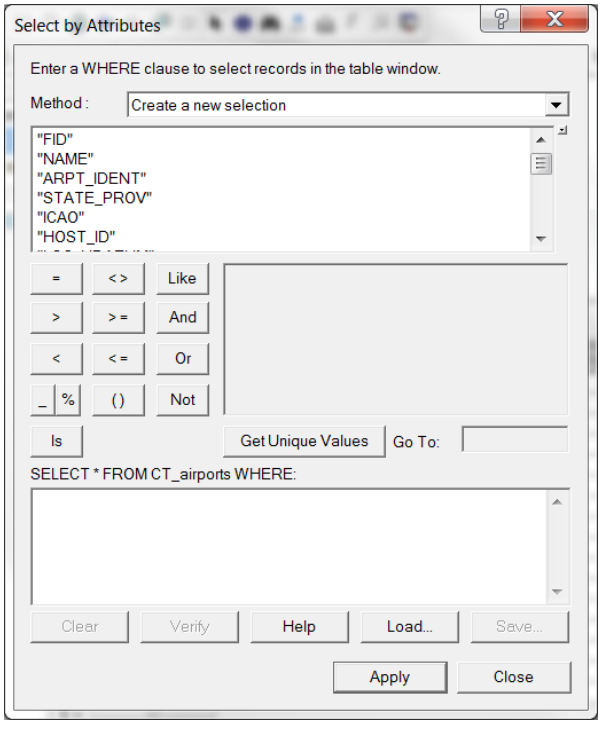
You will also use the field calculator, which allows you to populate fields based on conditions or equations you define.

SELECT BY ATTRIBUTE

You have already learned a few ways to make selections. But, what if you want to locate features that meet certain criteria in large datasets? To find these subsets of the data, we can select based on attribute values. Selection by attribute is a very common step in GIS analysis. Perhaps we want to find out which airports in Chinese Taipei are below 30 feet (since the elevation is recorded in feet here). One way to make this selection is through the attribute table. Click on the **Options** button (at the bottom of the dialog box) and navigate to "Select By Attributes" in the menu.

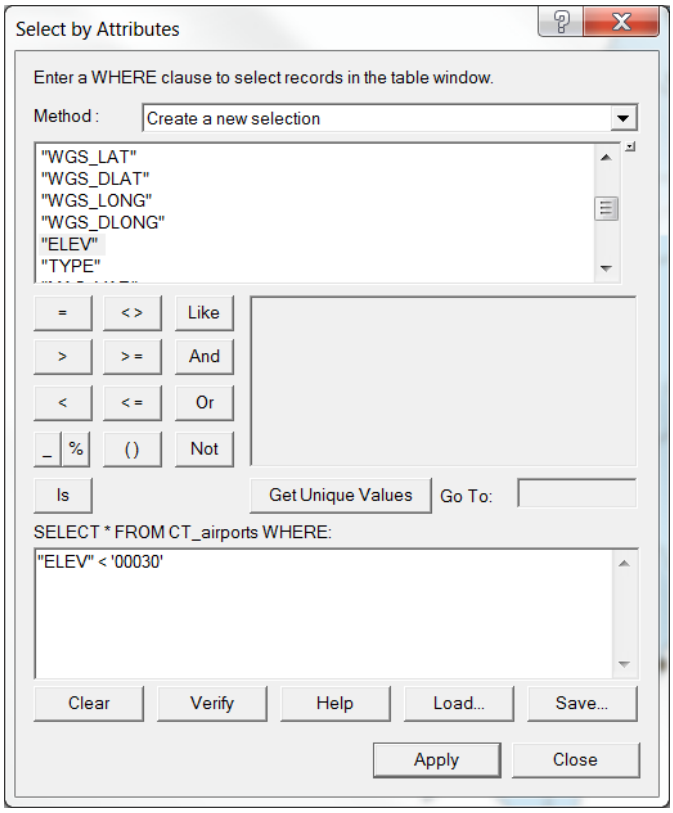


A dialog box will open.

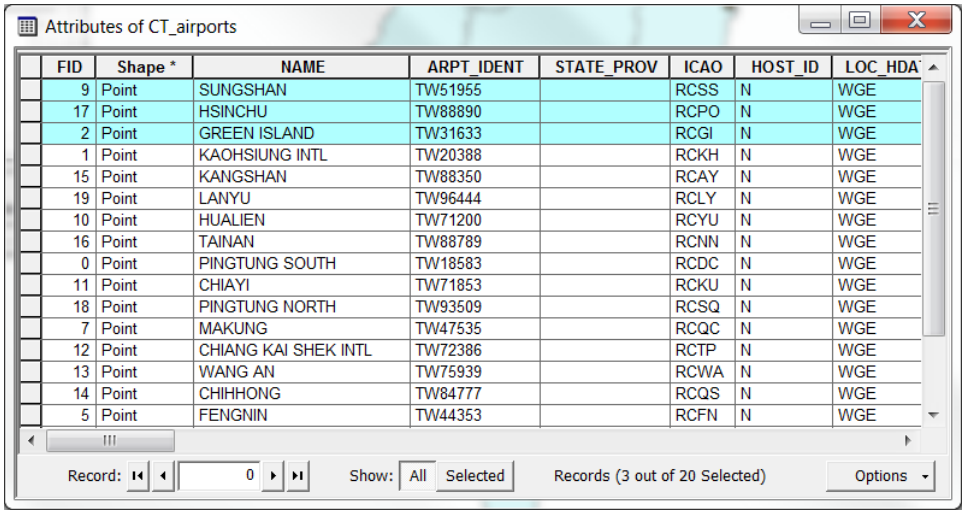


We want to create a new selection from the *CT_Airports* layer. We are looking for airports below an elevation of 30 feet, so we know we'll need to select based on the *ELEV* field. All the fields are listed in the top window. Scroll down till you find *ELEV*. Double click on it. It will appear in

quotation marks in the lower window, which is where you build your conditions. We are looking for airports located below 30 feet, so next click on the “less than” (<) button. Then we will enter our selected value by hitting the space bar and then typing ‘00030’. Make sure you type a space after the < and that you enclose the 00030 in single quotation marks.



Click on the Apply button.



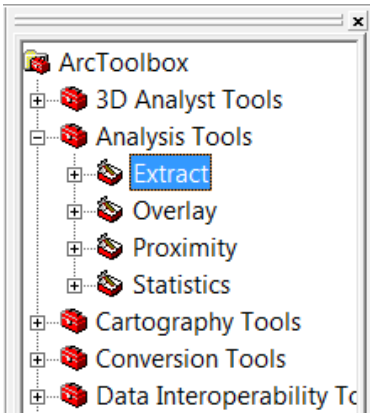
This process is also called a Query. Are any of the selected airports near the coast?

LOCATING TOOLS FOR USE IN ADDITIONAL EXERCISES

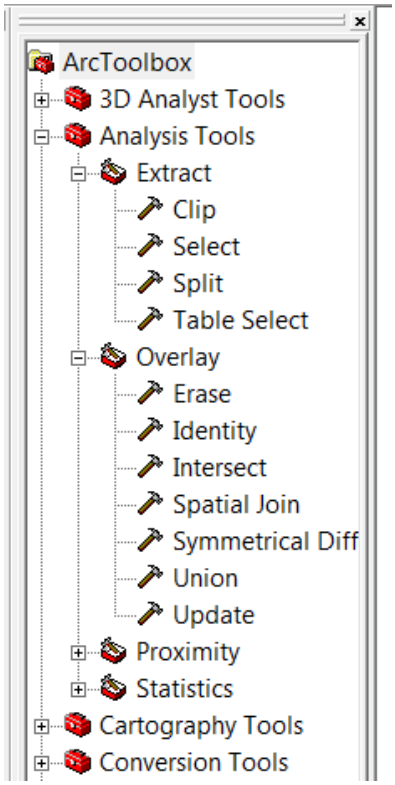
As mentioned before, ArcGIS Desktop consists of three components: ArcMap, ArcCatalog, and ArcToolbox. In exercises 3 and 4 today, you will use tools available through ArcToolbox to perform some analysis steps. You will need to know where to find them.

If ArcToolbox is not already visible on your ArcMap screen, click on the **ArcToolbox** icon.

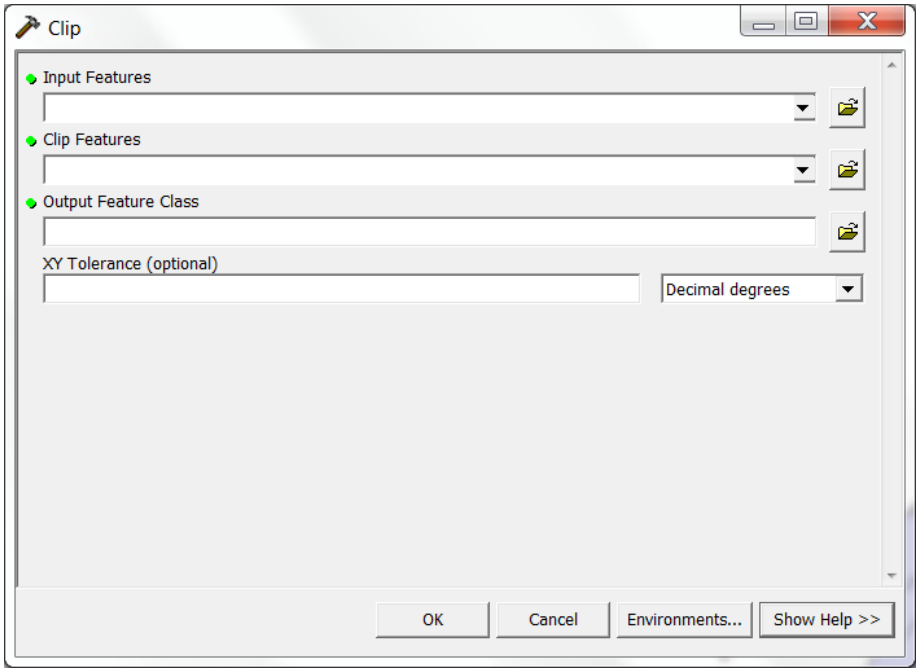
A series of tool sets will be listed in a TOC. Your instructor will provide a general overview of the types of toolsets available. Each toolset includes several individual tools. While the number may be overwhelming, we will be using primarily one toolset for our exercises: **Analysis Tools**. Click on the "+" in the box next to the **Analysis Tools** toolbox.



Though the box contains four categories, we will only be using tools in the first two: **Extract** and **Overlay**. Click on the "+" in the boxes next to "Extract" and "Overlay" to see the available tools. You will notice that you have already been performing a type of extraction through the selections you have made. In addition to selection, the main analysis tools we will use in subsequent exercises include the **Clip** tool, located under the "Extract" heading, and **Intersect**, located under the "Overlay" heading. Both allow you to use information from more than one layer to create new layers.



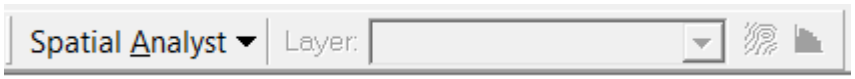
To open the tools, double click on the name of the tool you are interested in. A dialog box will appear. You can access a description of the tool by clicking on the “Show Help” button.



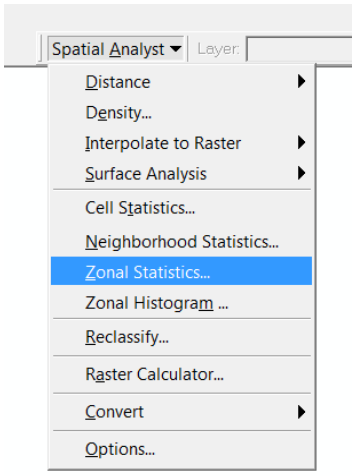
What does a **Clip** do? What happens when you **Intersect** two layers?

You do not need to do so now, but you can fill-out the dialog boxes by either using the drop down menus to select features, or by dragging the appropriate layer names from the TOC into the appropriate boxes.

Because we are using raster data as well as vector data, you will also need to locate the **Spatial Analyst** toolbar.



Click on the arrow to access a drop down menu listing a variety of analysis functions. We will be using the “Zonal Statistics” tool, which will be described in more detail later.

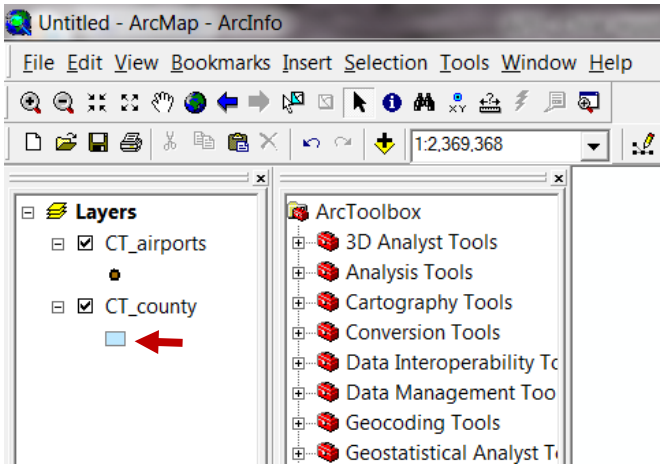


CHALLENGE STEPS

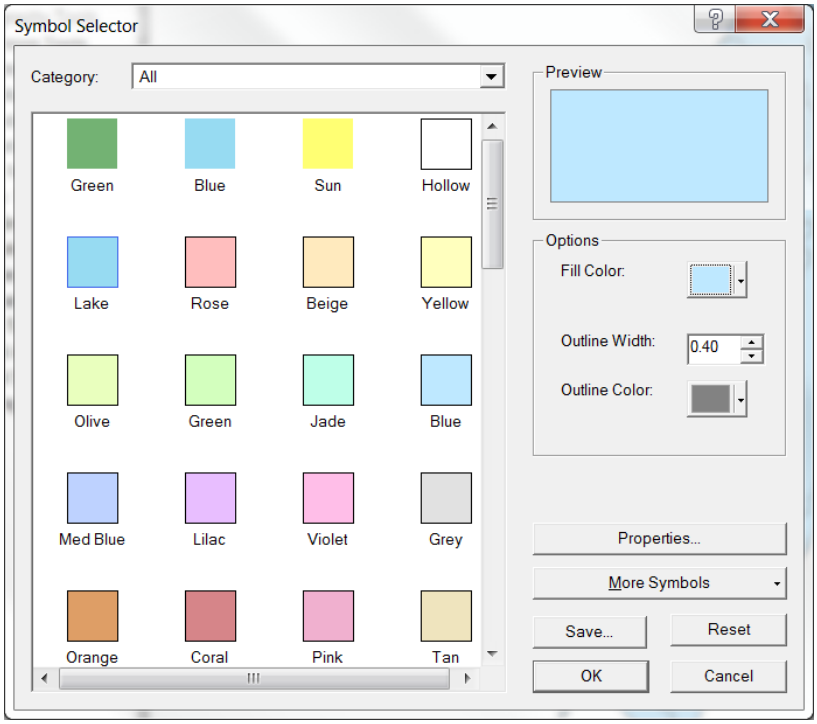
Changing Symbology

Symbology determines how features are represented on a map. Using appropriate symbology can help make communication more effective. You will look at two ways to alter the appearance of features.

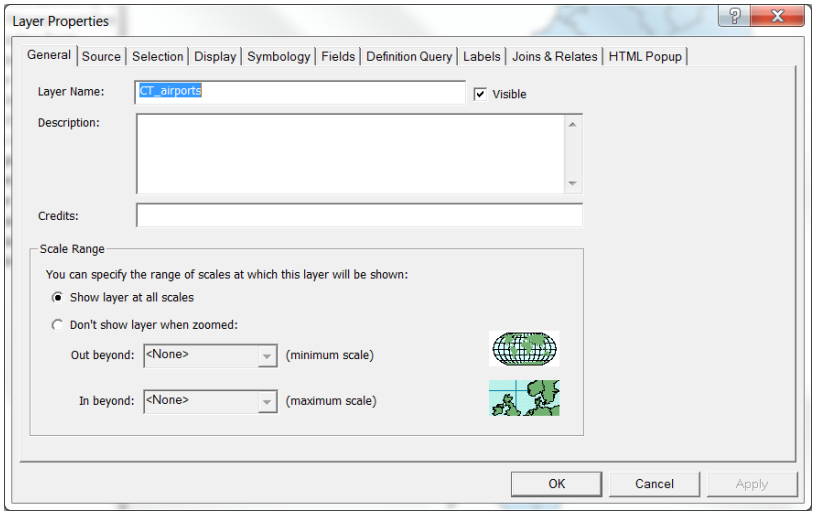
First, when a layer is represented using a single category (e.g. airports), you can change the symbology of the layer by clicking on the **Layers** symbol in the table of contents.



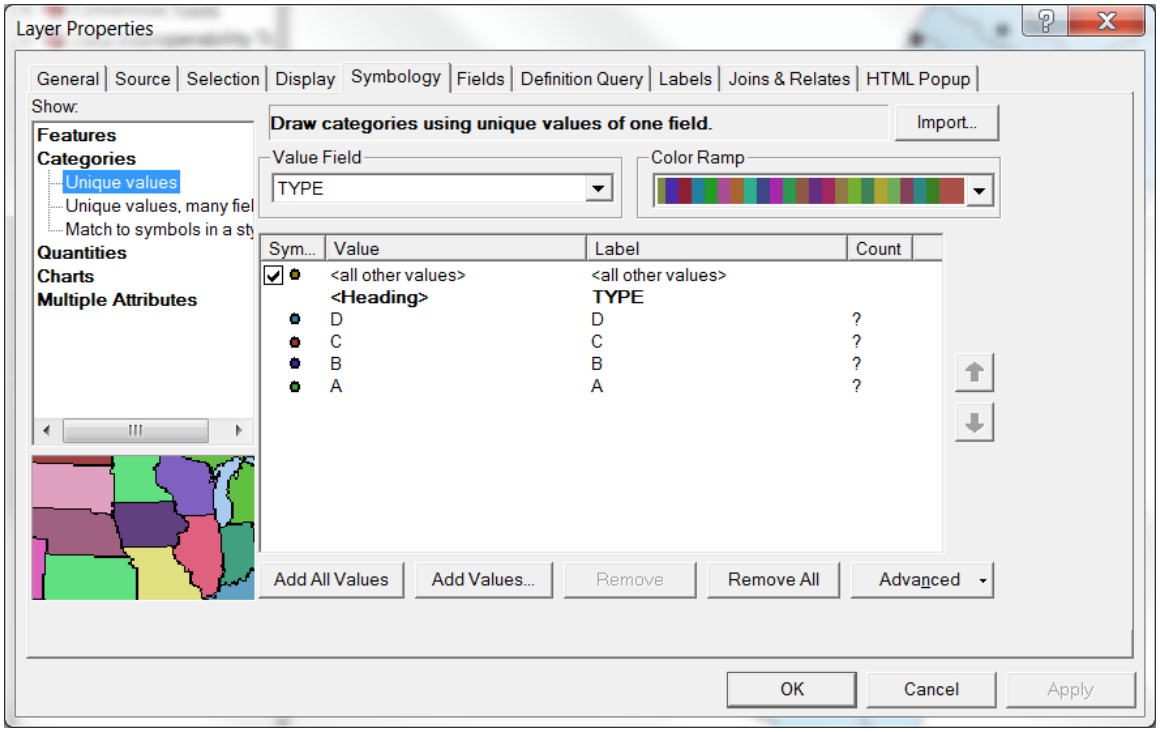
A **symbol selector** box will open. From this box, you can change the color and outlines of polygons (counties), or the size, shape and color of points (airports). Try various actions. Remember, you will need to click "OK" for your changes to take effect.



You can also represent features based on categories or data ranges associated with attribute data. You will need to right click on the layer you want to symbolize (*CT_airports*) to begin the process. Navigate to **Properties** at the bottom of the menu. Click it, and a dialog box will appear.



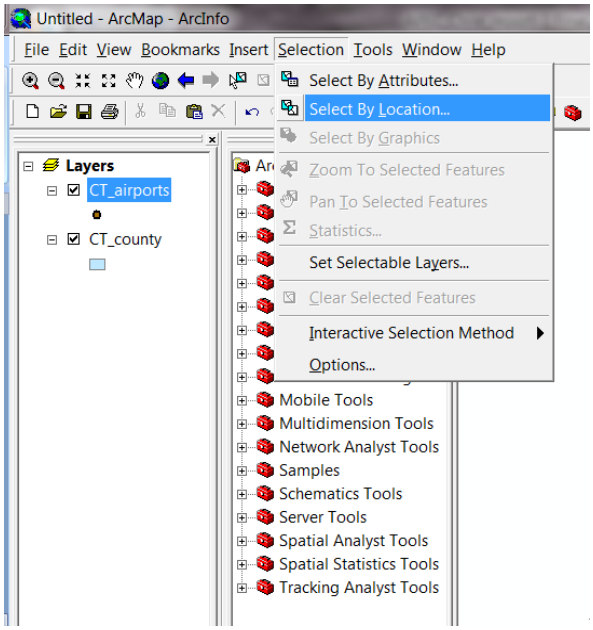
There are many tabs that lead to windows where you can establish settings and find general information about the layer. We are interested in symbology right now, so click on the **Symbology** tab. For instance, you may want to convey the type of airport (you will explore the data in the next exercise, but the TYPE categories relate to the type of organization that operates each airport). Since you are looking at categories, click on "Categories" in the Symbology TOC. Click on "Unique Values." The value field you are interested in is **TYPE**, so select **TYPE** from the drop down menu. Click on the "**Add All Values**" button so all categories are represented. Change the "Color Ramp" if you want. Your window should look similar to the one below. Click "OK."



Your airport layer is now displayed by airport type. Notice changes in both the map and the TOC.

Select by Location

It is also possible to select by location. Explore this option if you have time. You will find this option by clicking on the **Selection** button and navigating to “Select by Location” in the menu.



Hands on Exercise: Data Collection and Preparation

GOALS OF EXERCISE 2: DATA COLLECTION AND PREPARATION

In this exercise we will identify and explore geospatial datasets relevant to disaster management. On day one of this workshop, we learned about aspects of geospatial data management such as types of data, data models, metadata, etc. Over the course of this workshop, we have also identified a variety of ways to collect information. In this exercise, we will use the Internet to search for relevant datasets from global and local sources, and learn more about the datasets that we will use for subsequent exercises.

IDENTIFYING KEY DATA

Before data collection, it is necessary to identify the types of information that support disaster management activities, such as hazard mapping and risk assessment. Key data types have been identified throughout this workshop. It will be useful to refer to your notes as you complete the exercise.

EXPLORING GLOBAL AND REGIONAL DATA AND MAPPING RESOURCES

Next you will identify some global/regional data and mapping resources and the type(s) of information and products they provide. The Internet provides access to a wealth of data. A few resources are listed below. Take the next 25 minutes to briefly visit at least four of the following websites to find out more about what they offer. These links can also be found in the *Favorites* of Internet Explorer on your computer.

- The Global Hazards Information Network (GHIN): http://www.pdc.org/ghin
- United Nations Environmental Programme (UNEP), Project of Risk Evaluation, Vulnerability, Information & Early Warning (PreView): http://www.grid.unep.ch/activities/earlywarning/preview/
- Socioeconomic Data and Applications Center: http://sedac.ciesin.columbia.edu/
- GeoNetwork: http://www.fao.org/geonetwork/srv/en/main.home
- Global Land Cover Facility (GLCF): http://glcf.umiacs.umd.edu/index.shtml
- EM-DAT: The International Disaster Database: http://www.emdat.be/
- ReliefWeb: http://www.reliefweb.int

- Open Street Map: http://wiki.openstreetmap.org/wiki/Main_Page or http://downloads.cloudmade.com/ or http://download.geofabrik.de/osm/

As you explore these sites, consider the following questions:

- In general, what types of information are available?
- Is there a geographic focus?
- What organizations are providing the data?
- How might the data resources provided support RVA and decision making?
- How useful might the site and its data resources be to you and your organization?
- Is the data available for download directly from the site? If so, in what format(s)?

EXPLORING LOCAL DATA AND MAPPING RESOURCES

On the first day of the workshop, you identified some local sources of geospatial information that might be important to your organization and/or your work. Refer to this list now. Take the next 20 minutes to search for each of the listed organizations on the Internet and explore their available information resources. Consider the following:

- What type of information can the source provide?
- How might this information support RVA and decision making?
- Is the data available for download directly from the site? If so, in what format(s)?
- If data is not available through the site, how might you obtain it?
- How useful might this site and its data resources be to you and your organization?

EXPLORING METADATA

We have already learned that metadata is crucial to understanding geospatial data and using it appropriately. Metadata elements include data source, scale, date, use constraints, attribute values, who to contact for more information, and more. Metadata can exist in many formats, such as web pages, text documents or xml files. Listed below are four datasets that we will use in subsequent exercises and links to metadata that describes them. These links can also be found in the *Favorites* of Internet Explorer on your computer.

- Tropical Storm Intensity Zones: http://www.pdc.org/mde/full_metadata.jsp?docId=%7BD5F86ED2-CA65-4114-815D-471A8027D260%7D&loggedIn=false
- Global Earthquake Intensity Zones: http://www.pdc.org/mde/full_metadata.jsp?docId=%7BF732C388-6386-4269-A3BB-5DE18D229657%7D&loggedIn=false
- Global Airports: http://www.pdc.org/mde/full_metadata.jsp?docId=%7BD20FE79B-12B7-4EC8-92B8-913AAC6FB6D1%7D&loggedIn=false
- LandScan Population*:* http://www.ornl.gov/sci/landscan/landscan_documentation.shtml

Take the next 30 minutes to review each of the four metadata records. Answer the following questions for each dataset:

- Who is the originator (creator/owner) of the data?
  _____
- Metadata will often have various dates. For each of the datasets:
  - When was the dataset created?_____
  - When was the dataset published?_____
  - How often is the data updated? _____
- Are there any use or access constraints on the data?
  _____
  _____
  _____
- What is the spatial resolution or scale of the data? _____
- What are the geographic and projected coordinate systems of the data?
  _____
  _____
  _____
- What spatial extent does the dataset cover (e.g., the globe, a particular region)?
  _____
- Who can you contact for more information?
  _____
- How can you obtain this data?
  _____
  _____
  _____

Take some time to understand each dataset, including the attributes. What can the data tell you? For example:

- What does each “zone” represent in the Storm Intensity Zones dataset?
  _____
  _____
- What does each “zone” represent in the Earthquake Intensity Zones dataset?
  _____
  _____

- What information is available in the attribute table for each airport?

  _____

  _____

CHALLENGE STEP

On day one, we briefly discussed data services. Two of the above data sources, GHIN and PreView, offer data as services which can be added to a desktop GIS client. See the following links for more information. These links can also be found in the *Favorites* of Internet Explorer on your computer.

GHIN Geospatial Information Services: http://www.pdc.org/mde/services.jsp
PreView Services: http://preview.grid.unep.ch/index3.php?preview=data&lang=eng

Explore the services available from these two providers. What types of services are available (i.e. what standard)? What data is available via the services?

Participants with more advanced technical skills may want to add one or more of the services to ArcMap and further explore the data. Follow the directions on the sites to do so.

Hands on Exercise: Mapping Hazard and Exposure

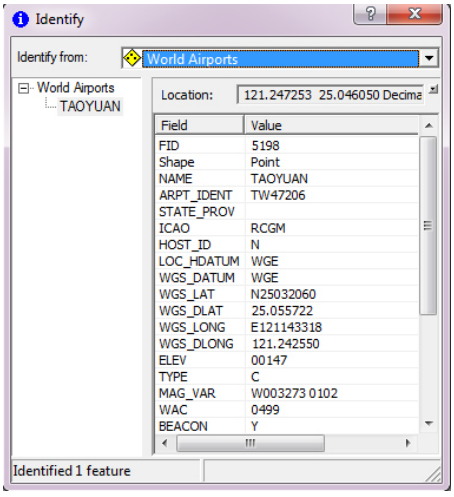
GOALS OF EXERCISE 3: MAPPING HAZARD AND EXPOSURE

Participants will learn to use a set of geospatial processes to estimate exposure of particular assets in Chinese Taipei to tropical cyclones and earthquakes. Participants will learn to map cyclone and earthquake hazards and estimate exposure of airports, roads and population. Below are brief descriptions of the analysis tools to be used in this exercise.

TOOLS USED IN THIS EXERCISE

Identify

When you want information about a feature, you can use the **Identify** tool. The **Identify** tool allows you to see the attributes of your data, and is an easy way to learn something about a location in a map.

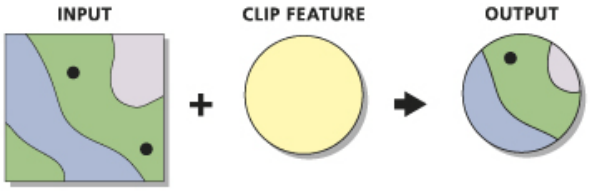


Example of an Identify on the World Airports dataset.

Clip

Clip

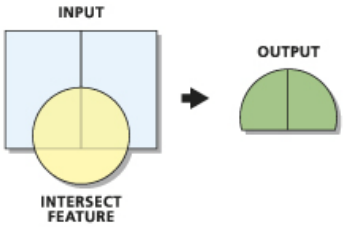
The **Clip** tool is used when you want to cut out a piece of one feature class using one or more of the features in another feature class as a "cookie cutter." This is particularly useful for creating a new feature class that contains a geographic subset of the features in another, larger feature class.



Intersect

Intersect

The **Intersect** tool calculates the geometric intersection of any number of feature classes and feature layers. The features or portion of features that are common to (intersecting) all inputs will be written to the Output Feature Class.



Zonal Statistics

Zonal Statistics summarizes the values of a raster (cell based) dataset within the zones of another dataset and reports the results to a table. We will use this tool to calculate the number of people per storm zone.

TROPICAL CYCLONE HAZARD EXPOSURE

Participants will perform a series of GIS tasks to visualize the probability of particular storm intensities across space and look at how these events might overlap with transportation assets and population.

Transportation: Airports

In this step you will use three datasets in order to answer questions pertaining to airports in Chinese Taipei. This step does not require the use of any ArcToolbox commands.

If not already running, start ArcMap. Then click on the **Open** button  and navigate to the "*C:\APEC_HMRVA"* folder and select the existing *APEC_HMRVA.mxd* map document. Next click **Open** and the ArcMap document will be loaded with the data needed for today's exercise.

If not already done, make the *CT_Airports, CT_County* and *World_Storm_Zone* layers visible by checking the box next to the layer name.

Take some time to explore the datasets in order to answer the following questions. (*Hint:* ArcMap tools that can be used to help answer these questions include **Identify, Select by Attributes** and **Select by Location.** You can also work directly with the data layers' attribute tables—*Open Attribute Table*.)

1. According to this data, how many airports are there in Chinese Taipei? _____
2. How many airports are located in each storm zone?

   Zone 1 _____ Zone 2 _____ Zone 3_____ Zone 4_____ Zone 5_____
3. What storm zone is Taoyuan International Airport located in? _____

Challenge Questions

4. What is the elevation of Kaohsiung International Airport? _____ meters
5. What are the dimensions of the runway at Kaohsiung International Airport?

   _____ meters by _____ meters

Transportation: Roads

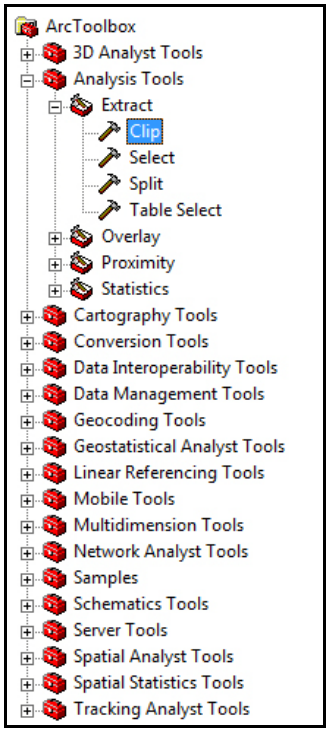
In this task we will calculate the total length of roads in Chinese Taipei that lie within a particular storm zone by performing an overlay analysis. Before the overlay analysis, we'll need to prepare the data. This section has been divided into a *Data Preparation Task* and an *Overlay* and *Summarize* Task.

Data Preparation Task: In this step we will perform analysis needed to prepare the data for the *Overlay* and *Summarize* Task. Reset your ArcMap project so that only the *CT_Roads*, *World_Storm_Zones* and *CT_County* datasets are visible, ensure that you are zoomed into Chinese Taipei, and close any other dialog boxes.

Take a moment to explore the extent of the *CT_Roads* and *World_Storm_Zones* datasets. One dataset has global coverage, while the other covers only Chinese Taipei. Sometimes it is useful to have all of your data cover the same extent. Therefore, we will use the **Clip** tool in ArcToolbox to reduce the extent of the *World Storm Zones* dataset to that of our study area, Chinese Taipei.

If you have not already done so, open ArcToolbox by clicking the following icon in ArcMap: 

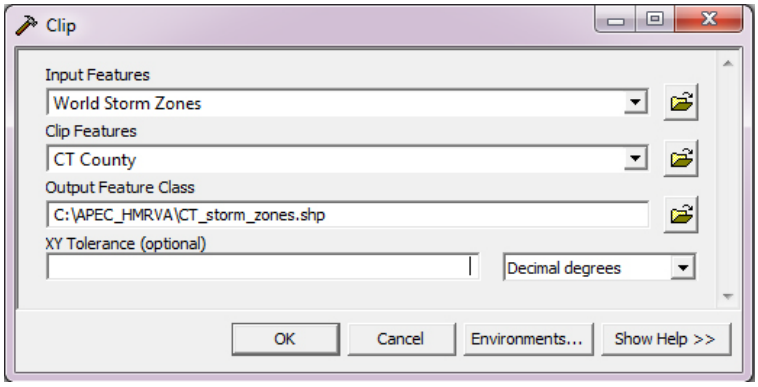
Navigate to *Analysis Tools* → *Extract* and double click on the **Clip** tool.



Use the **Clip** tool to clip the *World_Storm_Zones* layer to Chinese Taipei using the *CT_County* layer. Use the following as tool parameters:

- Input Features: *World_Storm_Zones*
- Clip Features: *CT_County* (*Hint*: Simply select the *Input* and *Clip Features* from the drop down box by clicking on the downward arrow, or you can also drag layers from the TOC into the Clip tool window)
- Output Feature Class: *C:\APEC_HMRVA\CT_storm_zones.shp (Hint*: This name is different than the default.)
- XY Tolerance: Leave blank, you do not need to specify a value for this.

Ensure that your tool parameters are the same as below and click “OK.”



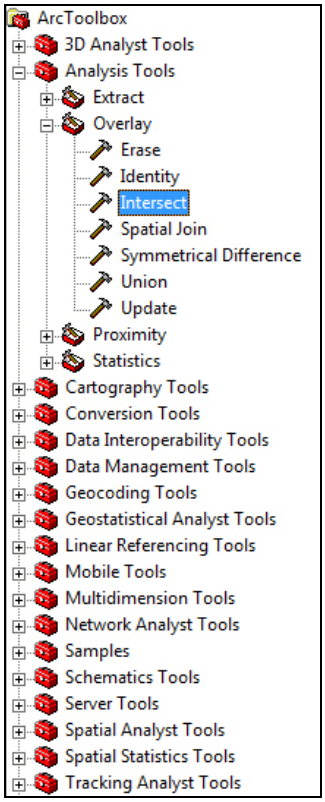
Click **Close** once the tool has completed processing. This may take 30 seconds or more.

You will notice that the new layer has automatically been added to the Table of Contents. Turn off the *World Storm Zones* layer and take a moment to explore the new *CT_storm_zones* layer and symbolize it to match the World layer. (*Hint*: You may choose your own symbology or use the *Import* tool in the Symbology tab of the Layer Properties dialog box to easily import symbology for layers with the same geometry and attributes.)

Overlay and Summarize Task: Now that the data is prepared, we will perform an overlay analysis in order to calculate the number of kilometers of roads in each storm zone. In the first step we will perform an intersect command in order to join together the attributes of the *CT_storm_zones* and *CT_roads* datasets. In the second step we will perform a calculation in order to see the result in the desired units (kilometers), and the third step will summarize all the road segments in a particular zone and provide a total for each.

Storm zones and roads exist as two different datasets. In order to figure out how many kilometers of road are in a storm zone we need to combine these two datasets using an **Overlay** tool. We will use the **Intersect** tool to accomplish this. The resulting roads dataset will have a new attribute associated with it, the storm zone.

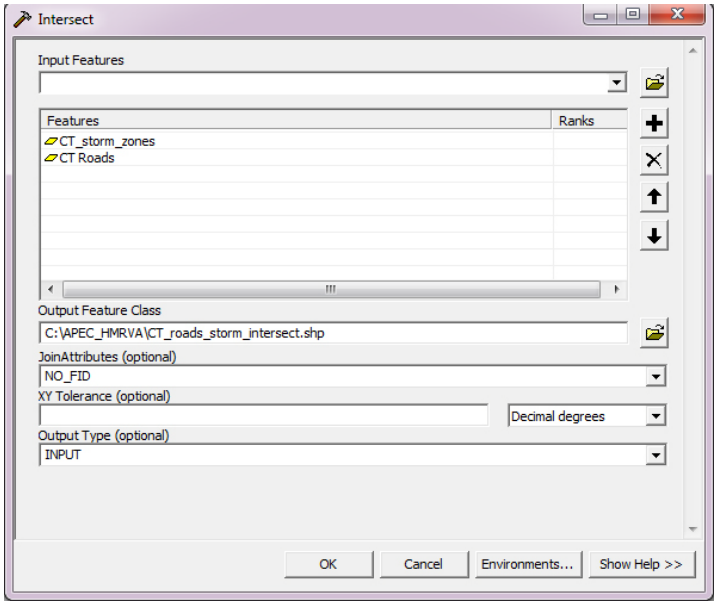
In ArcToolbox choose the **Intersect** tool located in *Analysis Tools* →*Overlay*



Use the following for tool parameters:

- Input Features: Add *CT_storm_zones* and then *CT_roads*. (Note: It is very important that *CT_storm_zones* is the first (top) dataset listed in the features section. See picture below).
- Output Feature Class: *C:\APEC_HMRVA\CT_roads_storm_intersect.shp*
- JoinAttributes (optional): Select *NO_FID*
- Leave all other parameters as default.

Once your **Intersect** tool parameters match those below, click "OK."



Click **Close** once the tool is complete. The new *CT_roads_storm_intersect* layer is added to the map. Explore and symbolize this new layer.

- How is the new *CT_roads_storm_intersect* layer different than the original *CT_roads* layer? (*Hint*: Look at attribute table)

  _____

  _____

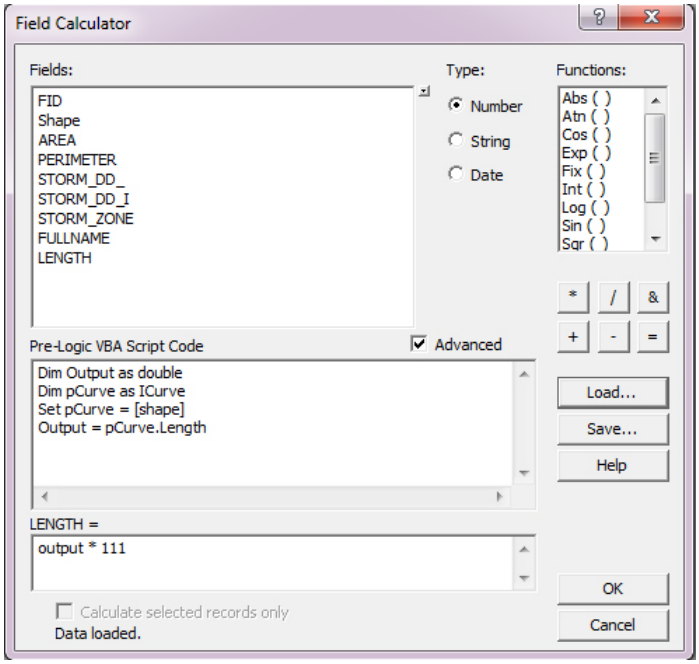
- What new attributes have been added to the *CT_roads_storm_intersect* layer?

  _____

The **Length** attribute in the new *CT_roads_storm_intersect* layer has not yet been calculated. In this step we will perform a calculation on the length attribute of the *CT_roads_storm_intersect* layer using the field calculator tool. The units will be kilometers.

1. Open the attribute table of the *CT_roads_storm_intersect* layer.
2. Right click on the **LENGTH** field (column) and choose *Field Calculator*
3. Click the **Load…** button.
4. Select the *Calculate_Length.cal* file in the *C:\APEC_HMRVA* folder and click "Open."

Your field calculator dialog box should look like the following:

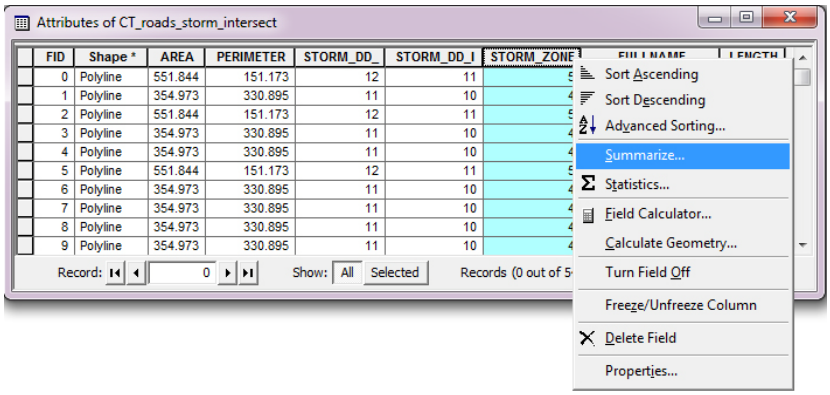


Click “OK” once all parameters have been entered correctly. If you need help ask an instructor to verify that your parameters are correct.

The calculation was completed using Visual Basic code. Now the **LENGTH** column has been updated to include the length of each road segment (i.e. row in the table) in kilometers. Explore a few segments of road to see what the length is.

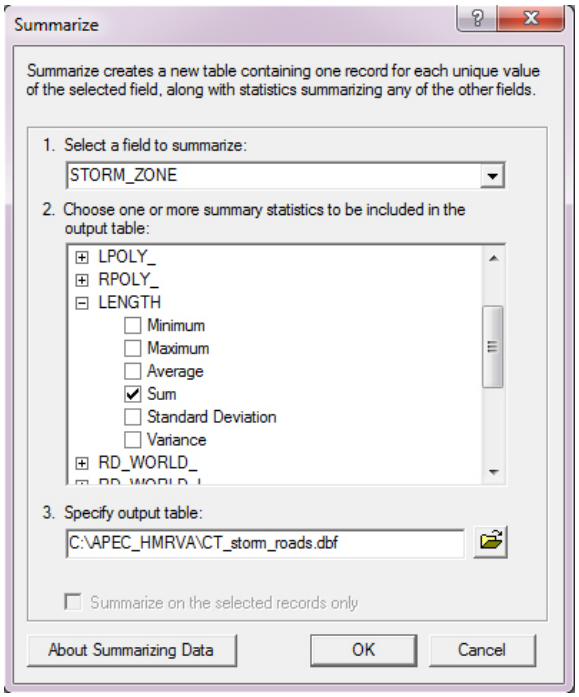
In the next step we will summarize the amount of roads (in km) that are in each storm zone.

1. With the *CT_roads_storm_intersect* attribute table still open, left mouse click on the **STORM_ZONE** field (column). The field will turn blue once selected. Now right mouse click on the same field and choose **Summarize**.



2. In the **Summarize** dialog box, use the following parameters:

    - Ensure that **STORM_ZONE** is selected for step one.
    - For step two, click on the plus sign (+) next to the **LENGTH** option, then check the box next to "Sum."
    - Specify an output path of *C:\APEC_HMRVA\CT_storm_roads.dbf.*
    - Ensure that parameters match those below, and click "OK."



3. Click "Yes" when asked about adding the table to the map.

4. Close the *CT_roads_storm_intersect* attribute table, and open the new *CT_storm_roads* table and explore the data.

The resulting table contains the length of road in kilometers per each storm zone. How many kilometers of road in Chinese Taipei are in each storm zone?

Zone 3_____ Zone 4_____ Zone 5_____

Challenge Question

Later on in this exercise, it will be useful to disaggregate this data by County. For example, how many kilometers of road are in each storm zone for the County of Tainan? Can you think of some ways of accomplishing this? Why might it be useful to know this information?

(*Hint*: Like many processes in GIS, there are multiple ways of accomplishing this task. One way is similar to the Data Preparation task above. Clip the *CT_roads_storm_intersect* layer with a

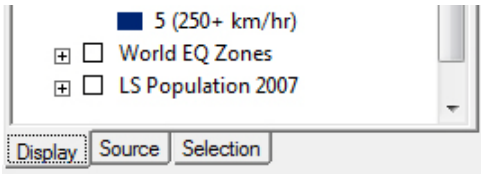
selection [one county] of the *CT_County* layer. Open up attribute table, then summarize the **Zone** field for that selection [one at a time].)

Population

Participants will perform a series of GIS tasks to determine the number of people in Chinese Taipei potentially exposed to tropical cyclones of various intensities. We will use a series of GIS analysis steps to determine how many people live in a particular storm zone.

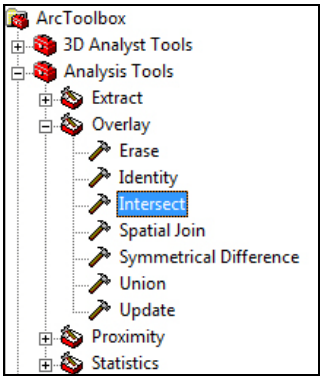
In the first step we will perform an **Intersect** command in order to join together the attributes of the *CT_storm_zones* and *CT_County* datasets. In the second step we will perform a **Zonal Statistics** command in order to summarize the number of people in each zone. A challenge step will be presented at the end to disaggregate this by county.

We will start with a fresh map. Turn off all layers except *CT_storm_zones* and *CT_County*. Ensure that your Table of Contents tab is set to **Display**.



You may also need to move the *CT_County* layer to be positioned above the *CT_storm_zones* polygon layer so that it is visible. You can do this simply by using the mouse to click and drag the layer. (This will be effective because your *CT_County* layer is already set to "hollow.")

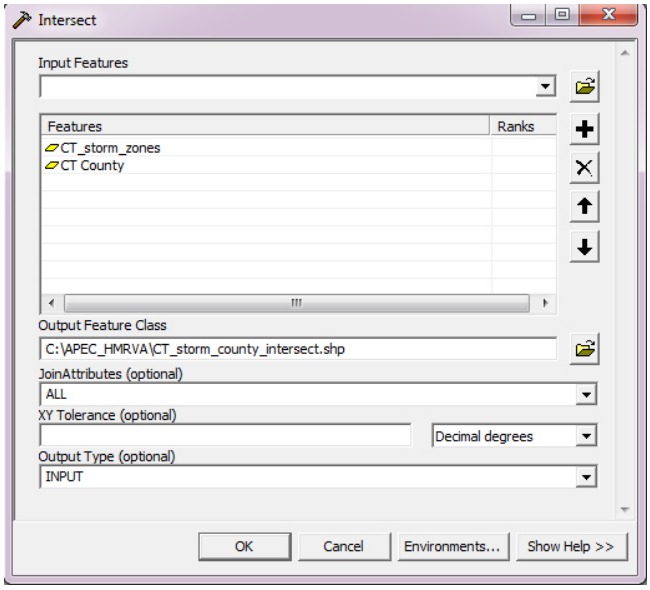
In ArcToolbox choose the **Intersect** tool located in *Analysis Tools* →*Overlay*



Use the following for tool parameters:

- Input Features: *CT_County* and *CT_storm_zones*
- Output Feature Class: *C:\APEC_HMRVA\CT_storm_county_intersect.shp*
- Leave all other parameters as default.

Your **Intersect** dialog box should look like the following:



Click "OK" once all parameters have been entered correctly.

Click "Close" once the tool is complete.

The new *CT_storm_county_intersect* layer is added to the map. Make the layer visible, explore and symbolize this layer.

- How is this layer different than the original *CT_storm_zones* layer? (*Hint*: Look at attribute table)

  _____

  _____

- What new attributes have been added to the *CT_storm_county_intersect layer?*

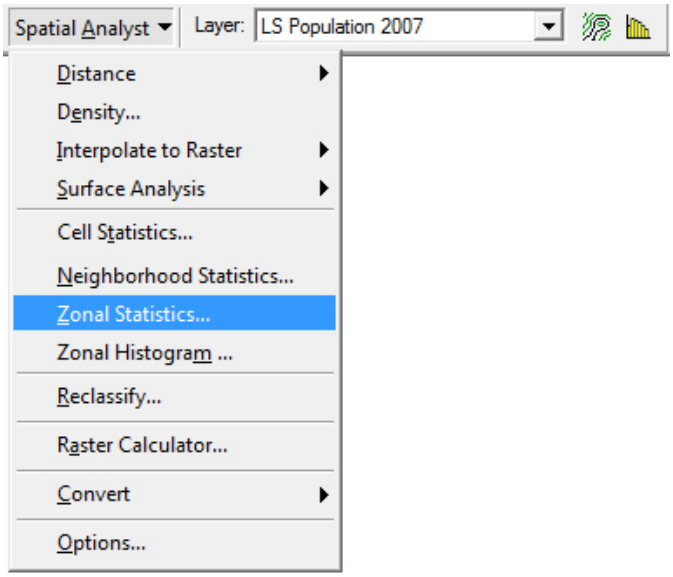
  _____

In the next step we will perform analysis in order to figure out the number of people in each storm zone. We will perform a **Zonal Statistics as Table** command using the data just created and the *Landscan Population 2007* layer.

Take a moment to explore the *Landscan Population 2007* dataset. This is a raster dataset, meaning that the data covers the entire world as same sized cells (or a grid), in this case approximately 1km resolution. Each cell has a population value, (e.g. 1,000 persons per km2). It would be very difficult and time consuming to count each cell in a particular area (e.g. storm zone, county). Instead, we can use the *Zonal Statistics as Table* command to perform this calculation for us.

1. Make *LS Population 2007* the only visible dataset. Take some time to explore the data to understand the values and symbology.

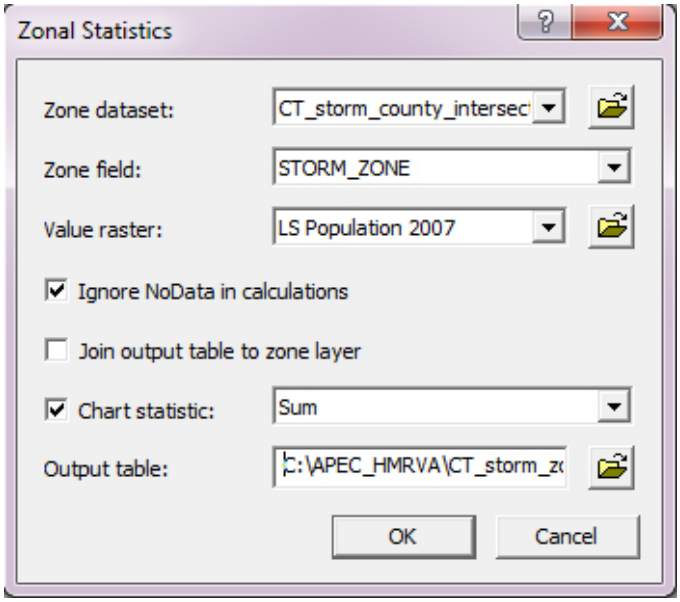
2. Click on the *Spatial Analyst* toolbar and select *Zonal Statistics*.



3. Use the following for tool parameters:

   - Zone Dataset: *CT_storm_county_intersect.*
   - Zone Field: *STORM_ZONE.*
   - Value raster: *LS Population 2007.*
   - The box *Ignore NoData in calculations* should be checked.
   - The box *Join output table to zone layer* should be un-checked.
   - The box *Chart statistic* should be checked. Select *Sum* from the dropdown list.
   - Output Table: *C:\APEC_HMRVA\CT_storm_zone_population.dbf.*

Your *Zonal Statistics* dialog box should look like the following:



Click “OK” once all parameters have been entered correctly

After the calculation is finished, a table and a chart will be displayed. Take some time to review these to answer the following question:

- How many people are present in Storm

  Zone 1_____ Zone 2_____ Zone 3_____ Zone 4_____ Zone 5_____

Challenge Question

How would you get the number of people in each storm zone for one county? (*Hint*: The select tool can be used to select a portion of data [such as one county]. All GIS analysis will then be performed only on the selected data, not the entire dataset.)

EARTHQUAKE HAZARD EXPOSURE

Participants will perform a series of GIS tasks to visualize the probability of particular earthquake intensities across space and look at how these events might overlap with transportation assets and population.

Transportation: Airports

In this step you will use three datasets in order to answer questions pertaining to airports in Chinese Taipei. This step does not require the use of any ArcToolbox commands.

If not already running, start ArcMap. Then click on the *Open* button  and navigate to the *C:\APEC_HMRVA* folder and select the existing *APEC_HMRVA.mxd* map document. Next click *Open* and the ArcMap document will be loaded with the data needed for this exercise. You may skip this step is you still have the project open from the previous exercise.

Make *CT_Airports*, *CT_County* and *World_Earthquake_Zones* the only visible layers..

Take some time to explore the datasets in order to answer the following questions. (*Hint:* ArcMap tools that can be used to help answer these questions include **Identify**, **Select by Attributes** and **Select by Location**. **Location.** You can also work directly with the data layers' attribute tables—*Open Attribute Table*.)

1. How many airports are located in each earthquake zone?

   Zone 0 _____ Zone 1 _____ Zone 2_____ Zone 3_____ Zone 4_____

2. What earthquake zone is Taoyuan International Airport located in? _____

3. Are there any airports that are not listed as being in an earthquake zone? What are some possible reasons for this?

Transportation: Roads

In this task we will calculate the total length of roads in Chinese Taipei that lie within a particular earthquake zone by performing an overlay analysis. Before the overlay analysis, we'll need to prepare the data. This section has been divided into a *Data Preparation Task* and an *Overlay* and *Summarize* Task.

Data Preparation Task: In this step we will perform analysis needed to prepare the data for the *Overlay* and *Summarize* Task. Reset your ArcMap project so that only the *CT_Roads* and *World_Earthquake_Zones* datasets are visible, ensure that you are zoomed into Chinese Taipei and close any other dialog boxes.

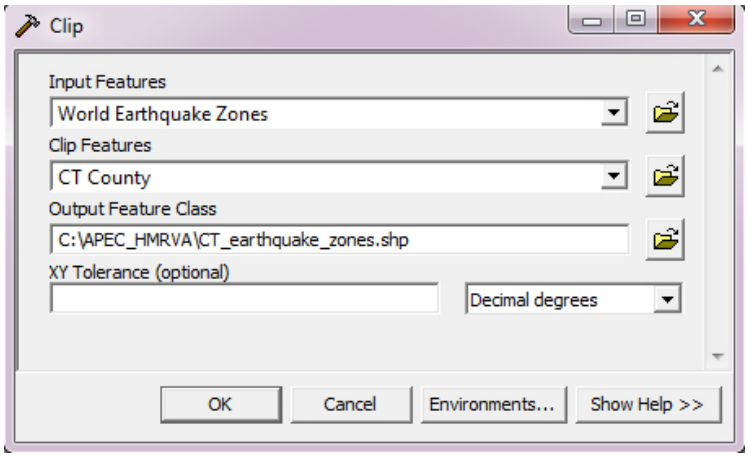
Take a moment to explore the extent of the *CT_Roads* and *World_Earthquake_Zones* datasets. One dataset has global coverage, while the other covers only Chinese Taipei. Sometimes it is useful to have all of your data cover the same extent. Therefore, we will use the **Clip** tool in ArcToolbox to reduce the extent of the *World Earthquake Zones* dataset to that of our study area, Chinese Taipei.

In ArcToolbox, navigate to *Analysis Tools* → *Extract* and double click on the **Clip** tool.

Use the *Clip* Tool to clip the *World_Earthquake_Zones* layer to Chinese Taipei using the *CT_County* layer. Use the following as tool parameters:

- Input Features: *World_Earthquake_Zones* (*Hint*: Simply select the *Input* and *Clip Features* from the drop down box by clicking on the downward arrow, or you can also drag layers from the Table of Contents into the Clip tool window.)
- Clip Features: *CT_County*
- Output Feature Class: *C:\APEC_HMRVA\CT_earthquake_zones.shp* (*Hint:* This name is different than the default.)
- XY Tolerance: Leave blank, you do not need to specify a value for this.

Ensure that your tool parameters are the same as below and click "OK."



Click **Close** once the tool has completed processing. This may take 30 seconds or more.

You will notice that the new layer has automatically been added to the Table of Contents. Turn off the *World Earthquake Zones* layer and take a moment to explore the new *CT_earthquake_zones* layer and symbolize it to match the World layer. (*Hint*: You may choose your own symbology or use the **Import** tool in the Symbology tab of the Layer Properties dialog box to easily import symbology for layers with the same geometry and attributes.)

Overlay and Summarize Task: Now that the data is prepared, we will perform an overlay analysis in order to calculate the number of kilometers of roads in each earthquake zone. In the first step we will perform an intersect command in order to join together the attributes of the *CT_earthquake_zones* and *CT_roads* datasets. In the second step we will perform a calculation in order to see the result in the desired units (kilometers), and the third step will summarize all the road segments in a particular zone and provide a total for each.

Earthquake zones and roads exist as two different datasets. In order to figure out how many kilometers of road are in an earthquake zone we need to combine these two datasets using an

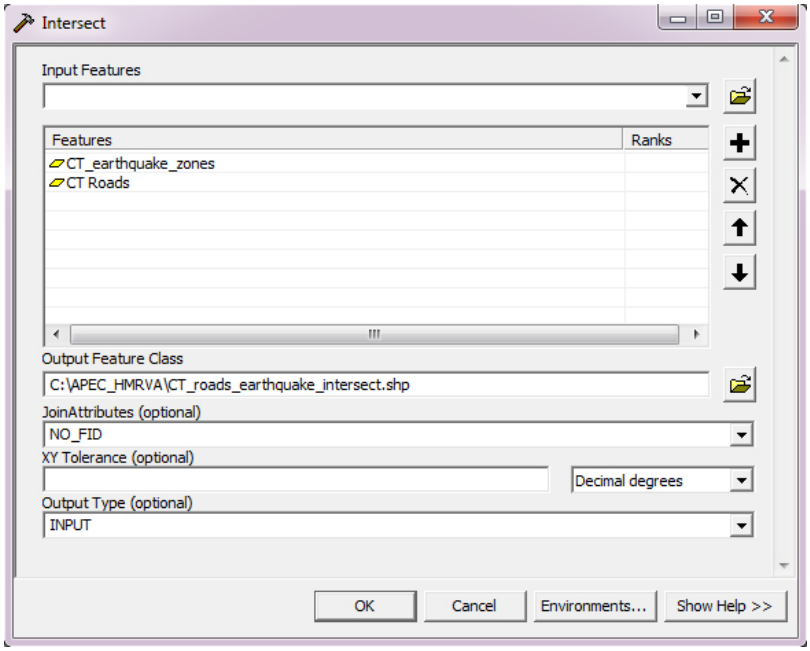
Overlay tool. We will use the **Intersect** tool to accomplish this. The resulting roads dataset will have a new attribute associated with it, the earthquake zone.

In ArcToolbox choose the **Intersect** tool located in *Analysis Tools* →*Overlay*

Use the following for tool parameters:

- Input Features: Add *CT_earthquake_zones* and then *CT_roads*. (Note: It is very important that *CT_earthquake_zones* is the first (top) dataset listed in the features section. See picture below).
- Output Feature Class: *C:\APEC_HMRVA\CT_roads_earthquake_intersect.shp*
- JoinAttributes (optional): Select *NO_FID*
- Leave all other parameters as default.

Once your **Intersect** tool parameters match those below, click "OK."



Click *Close* once the tool is complete. The new *CT_roads_earthquake_intersect* layer is added to the map. Explore and symbolize this new layer.

- Q: How is the new *CT_roads_earthquake_intersect* layer different than the original *CT_roads* layer? (*Hint*: Look at attribute table)

  _____

  _____

- Q: What new attributes have been added to the *CT_roads_earthquake_intersect* layer?

  _____

  _____

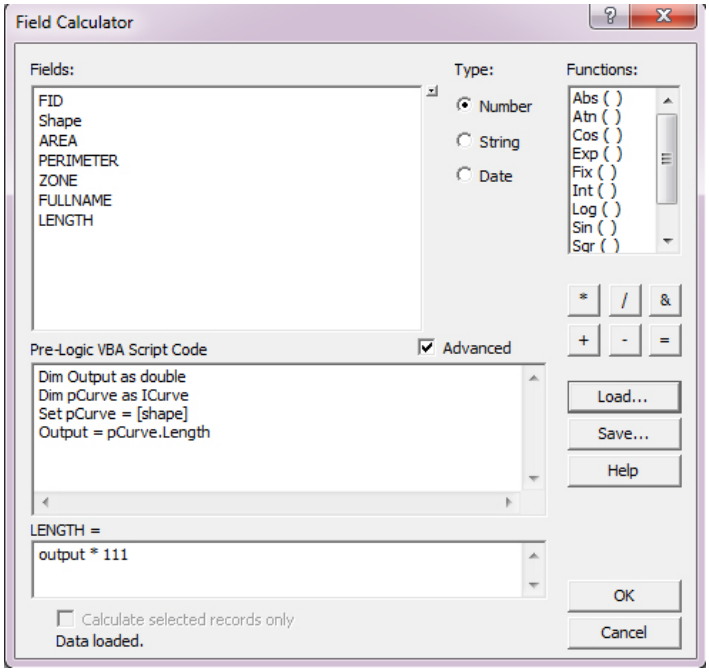
- Q: Are there any problems with this new layer? (*Hint*: Look at the roads on the east side of Chinese Taipei)

_____

The **Length** attribute in the new *CT_roads_earthquake_intersect* layer has not yet been calculated. In this step we will perform a calculation on the *length* attribute of the *CT_roads_earthquake_intersect* layer using the field calculator tool. The units will be in kilometers.

1. Open the attribute table of the *CT_roads_earthquake_intersect* layer.
2. Right click on the **LENGTH** field (column) and choose *Field Calculator.*
3. Click the **Load**… button.
4. Select the *Calculate_Length.cal* file in the *C:\APEC_HMRVA* folder and click "Open."

Your field calculator dialog box should look like the following:

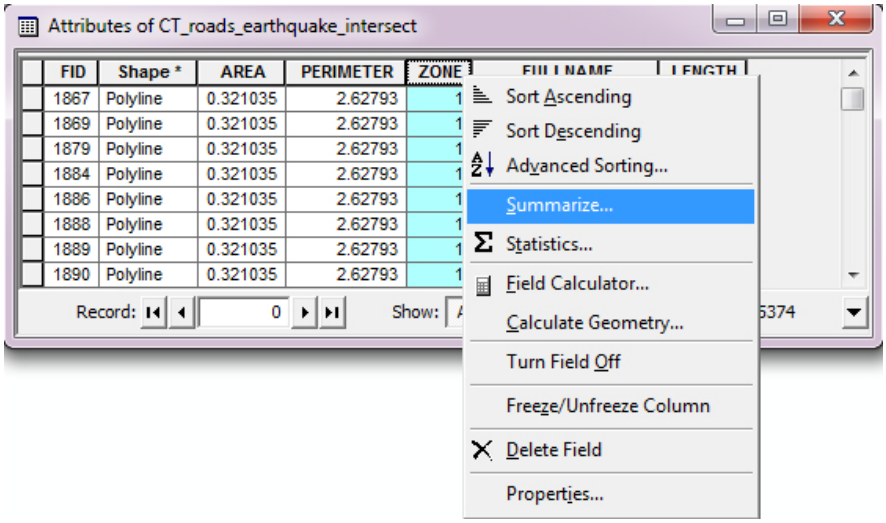


Click "OK" once all parameters have been entered correctly. If you need help ask an instructor to verify that your parameters are correct.

The calculation was completed using Visual Basic code. Now the **LENGTH** column has been updated to include the length of each road segment (i.e. row in the table) in kilometers. Explore a few segments of road to see what the length is.

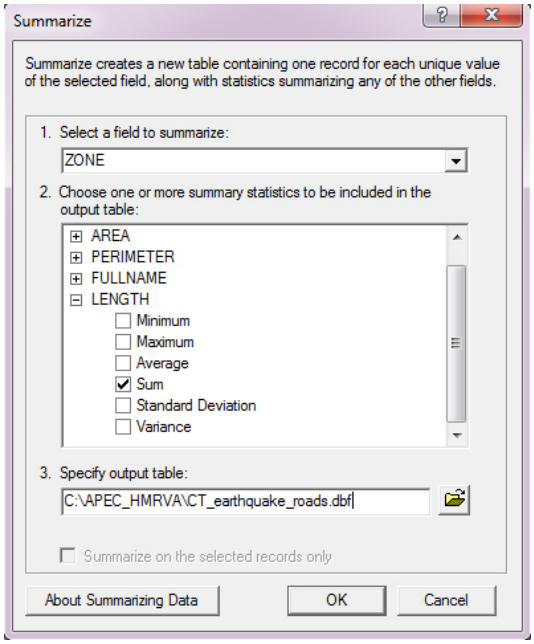
In the next step we will summarize the amount of roads (in km) that are in each earthquake zone.

1. With the *CT_roads_earthquake_intersect* attribute table still open, left mouse click on the ZONE field (column). The field will turn blue once selected. Now right mouse click on the same field and choose Summarize.



2. In the Summarize dialog box, use the following parameters:

    - Ensure that **ZONE** is selected for step one
    - For step 2, click on the plus sign (+) next to the **LENGTH** option, then check the box next to "Sum."
    - Specify an output path of *C:\APEC_HMRVA\CT_earthquake_roads.dbf*.
    - Ensure that parameters match those below, and click "OK."



3. Click “Yes” when asked about adding the table to the map.

4. Close the *CT_roads_earthquake_intersect* attribute table, and open the new *CT_earthquake_roads* table and explore the data.

The resulting table contains the length of road in kilometers per each earthquake zone. How many kilometers of road in Chinese Taipei are in each earthquake zone?

Zone 1_____ Zone 2_____ Zone 3_____ Zone 4_____

Challenge Question

Later on in this exercise, it will be useful to disaggregate this data by County. For example, how many kilometers of road are in each earthquake zone for the County of Tainan? Can you think of some ways of accomplishing this? Why might it be useful to know this information?

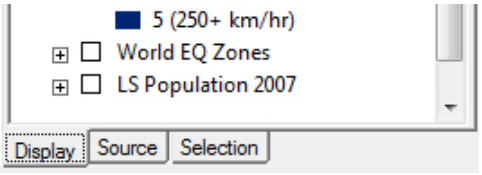
Hint: Like many processes in GIS, there are multiple ways of accomplishing this task. One way is similar to the Data Preparation task above. Clip the *CT_roads_earthquake_intersect* layer with a selection (one county) of the *CT_County* layer. Open the attribute table then summarize the **Zone** field for that selection (one county at a time).

Population

Participants will perform a series of GIS tasks to determine the number of people in Chinese Taipei potentially exposed to earthquakes of various intensities. We will use a series of GIS analysis steps to determine how many people live in a particular earthquake zone.

In the first step we will perform an **intersect** command in order to join together the attributes of the *CT_earthquake_zones* and *CT_County* datasets. In the second step, we will perform a **Zonal Statistics** command in order to summarize the number of people in each zone. A challenge step will be presented at the end to disaggregate this by county.

We will start with a fresh map. Turn off all layers except *CT_earthquake_zones* and *CT_County*. Ensure that your Table of Contents tab is set to **Display**.



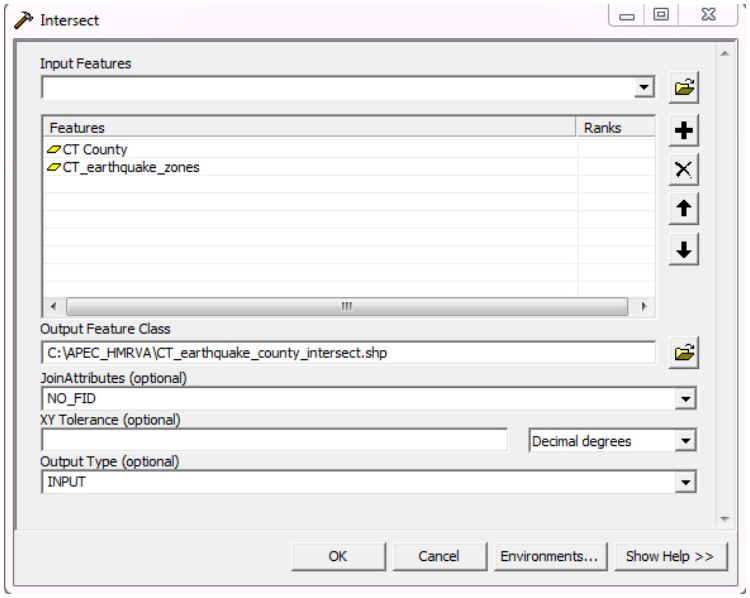
You may also need to move the *CT_County* layer to be positioned above the *CT_earthquake_zones* polygon layer so that it is visible. You can do this simply by using the mouse to click and drag the layer. (This will be effective because your *CT_County* layer is already set to “hollow.”)

In ArcToolbox choose the *Intersect* tool located in *Analysis Tools* →*Overlay*

Use the following for tool parameters:

- Input Features: *CT_County* and *CT_earthquake_zones*
- Output Feature Class: *C:\APEC_HMRVA\CT_earthquake_county_intersect.shp*
- JoinAttributes (optional): Select *NO_FID*
- Leave all other parameters as default.

Your **Intersect** dialog box should look like the following:



Click “OK” once all parameters have been entered correctly.

Click “Close” once the tool is complete.

The new *CT_earthquake_county_intersect* layer is added to the map. Make the layer visible, explore and symbolize this layer.

- Q: How is this layer different than the original *CT_earthquake_zones* layer?

  _____

  _____

- Q: What new attributes have been added to the *CT_earthquake_county_intersect layer?*

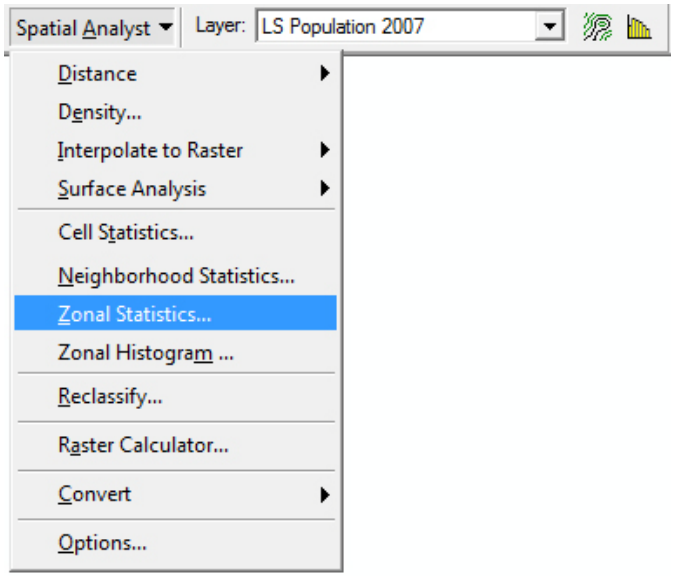
  _____

In the next step we will perform analysis in order to figure out the number of people in each earthquake zone. We will perform a **Zonal Statistics as Table** command using the data just created and *the Landscan Population 2007* layer.

Take a moment to explore the *Landscan Population 2007* dataset. This is a raster dataset, meaning that the data covers the entire world as same sized cells (or a grid), in this case approximately 1km resolution. Each cell has a population value, (e.g. 1,000 persons per km2). It would be very difficult and time consuming to count each cell in a particular area (e.g. earthquake zone, county). Instead, we can use the *Zonal Statistics as Table* command to perform this calculation for us.

1. Make *LS Population 2007* the only visible dataset. Take some time to explore the data to understand the values and symbology.

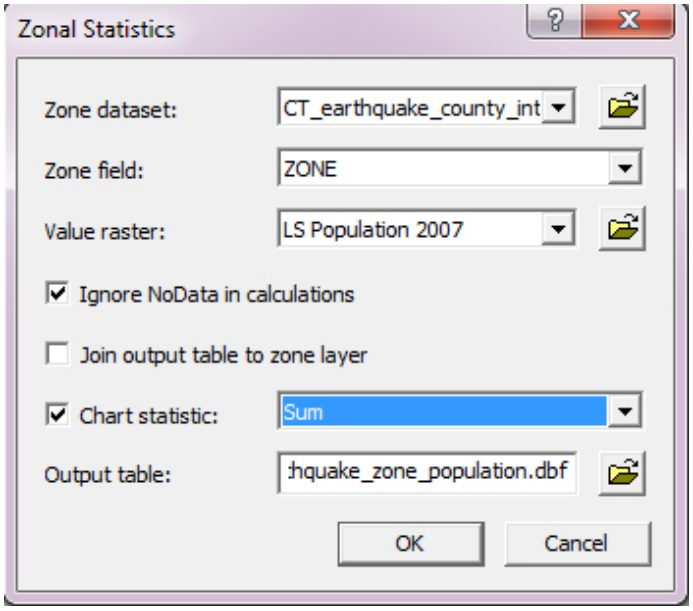
2. Click on the *Spatial Analyst* toolbar and select *Zonal Statistics*.



3. Use the following for tool parameters:

   - Zone Dataset: *CT_earthquake_county_intersect.*
   - Zone Field: *ZONE.*
   - Value raster: *LS Population 2007.*
   - The box Ignore *NoData in calculations* should be checked
   - The box *Join output table to zone layer* should be un-checked
   - The box *Chart Statistic* should be checked. Select *Sum* from the dropdown list.
   - Output Table: *C:\APEC_HMRVA\CT_earthquake_zone_population.dbf*

Your *Zonal Statistics* dialog box should look like the following:



Click "OK" once all parameters have been entered correctly

After the calculation is finished, a table and a chart will be displayed. Take some time to review these to answer the following question:

- Q. How many people are present in each earthquake zone?

  Zone 1_____ Zone 2_____ Zone 3_____ Zone 4_____

Challenge Question

How would you get the number of people in each earthquake zone for one county? (*Hint*: The select tool can be used to select a portion of data (such as one county). All GIS analysis will then be performed only on the selected data, not the entire dataset.)

CHALLENGE STEP

If you have finished this exercise before the allotted time, explore some other data sources from Exercise 2 such as the UNEP PreView and PDC GHIN Services.

- How does the UNEP PreView Tropical Cyclone Frequency dataset compare to the Storm Zones layer we have used here? How are the layers different and when would it be useful to use each one vs. the other?

- From PDC Active Hazards, describe the location and type of some current hazards.

Hands-on Exercise: Assessing Vulnerability and Risk

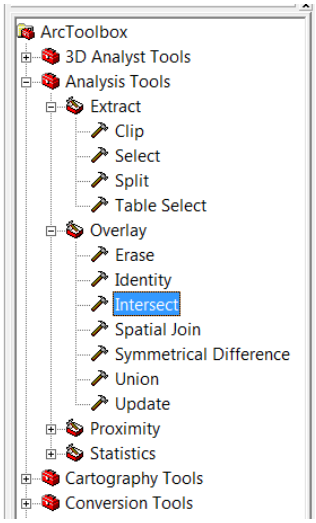
GOALS OF EXERCISE 4: ASSESSING VULNERABILITY AND RISK

This exercise provides examples of two approaches to estimating risk. The first focuses on airports and the second focuses on communities. Throughout the exercises, you will learn how to join tables, practice symbolizing data and calculating fields while gaining a better understanding of the concepts of exposure, vulnerability, capacity and consequence. You will also explore some of the ways these factors can be represented and combined to estimate relative risk.

EXAMPLE 1: AIRPORTS

In the first example, you will use GIS to look at risk associated with airports. As discussed in the lectures on Day 2, one approach to assessing risk, especially related to infrastructure, is to examine the level of hazard an asset is exposed to, the susceptibility to impact from the hazard, and the consequence of that impact on the surrounding community.

In exercise 3, you explored the location of the airports of Chinese Taipei in relation to the tropical cyclone and earthquake hazard zones. In this exercise, we will focus on tropical cyclones. In your TOC, make the *CT_county*, *CT_airports*, and *world_storm_zones* layers visible.



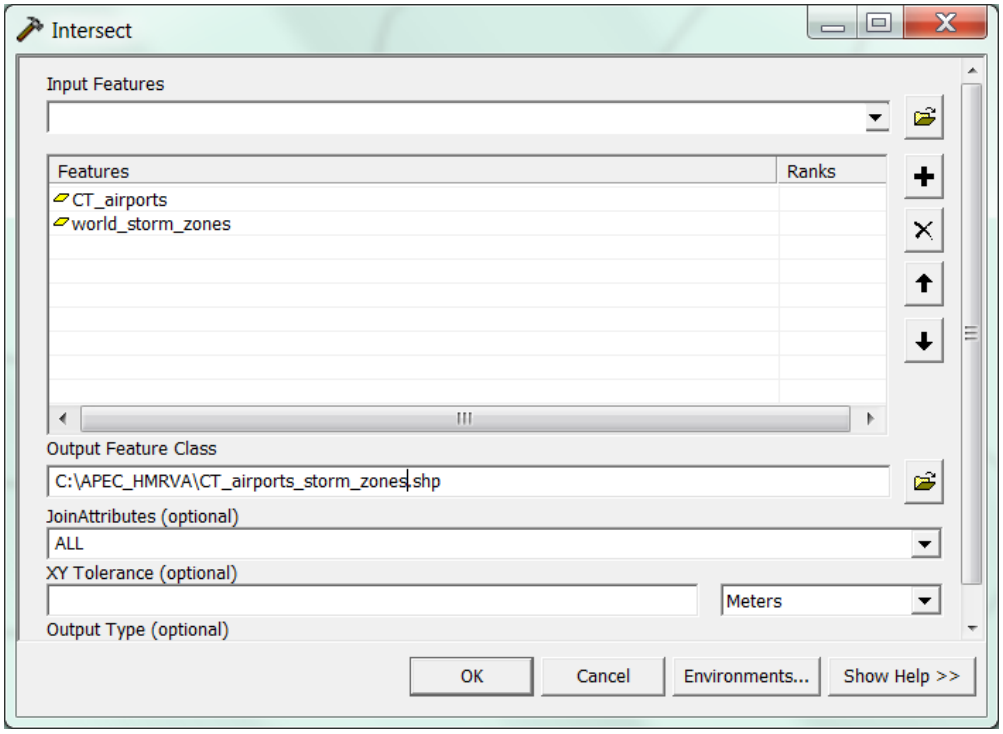
Hazard

In order to assign a storm zone to each airport, you will once again use the **Intersect** tool.

In the dialog box, use the following parameters:

- Input Features: CT_airports; world_storm_zones
- Output Feature Class: C:\APEC_HMRVA\CT_airports_storm_zones.shp
- All other parameters should be left as the default

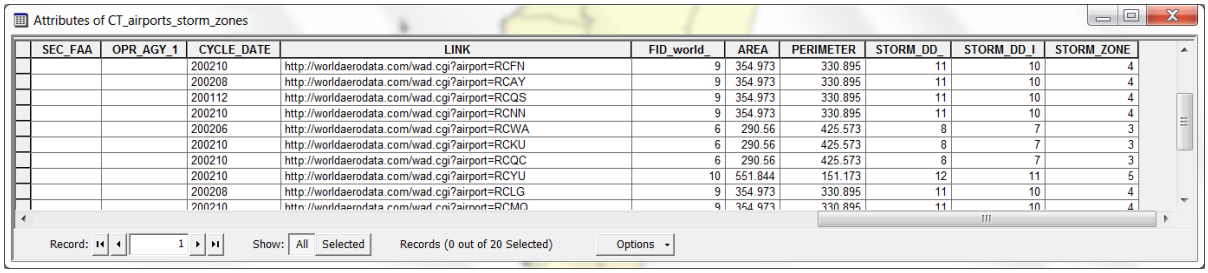
Your dialog box should look like this:



Click “OK” to run the tool. The new layer should have been added to the TOC and the map.

Click off the *CT_airports* and *world_storm_zone* layers.

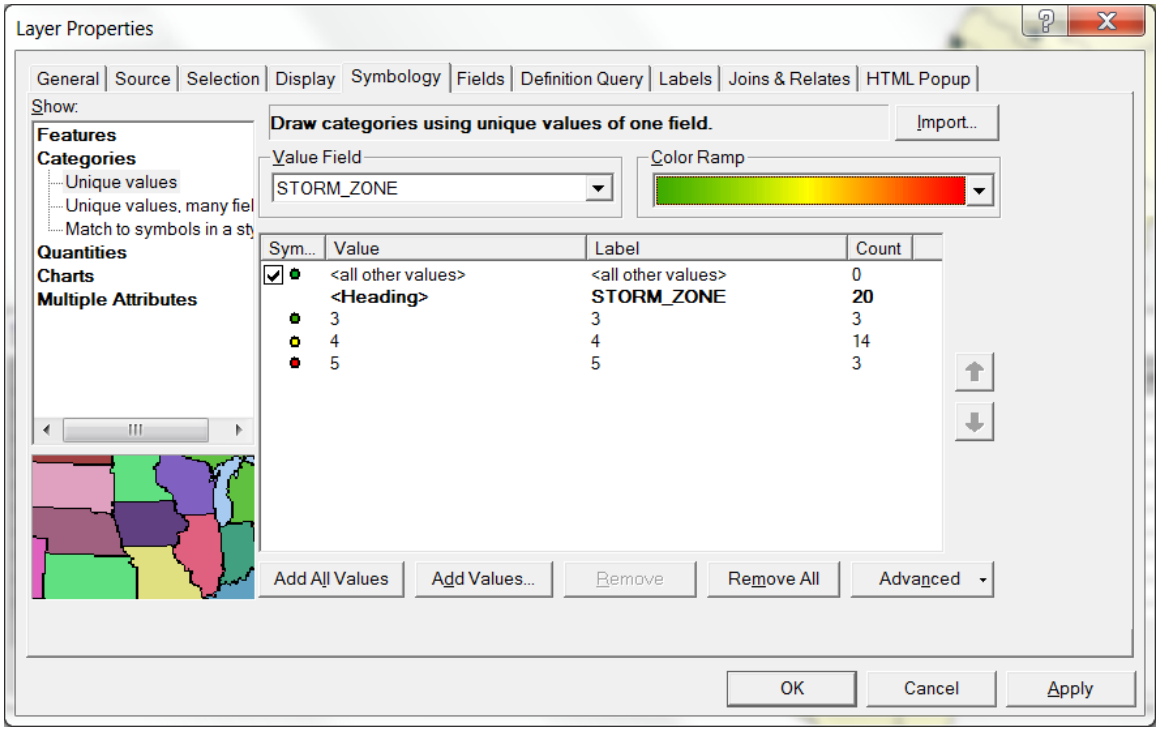
Open the attribute table for *CT_airports_storm_zones* and scroll to find the zone field.



In what storm zone is Hsinchu Airport?

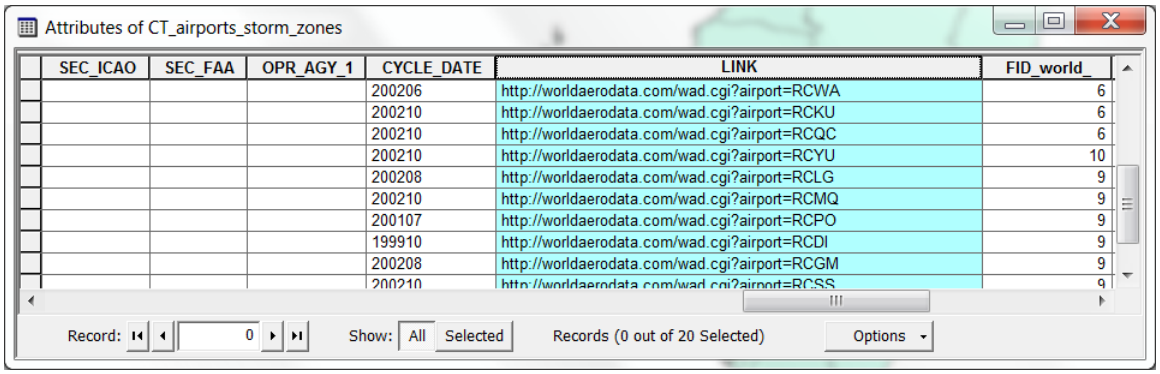
You will now symbolize the airports based on their zone. This represents the level of hazard they are exposed to.

Right click on the *CT_airports_storm_zones* layer and navigate to “Properties.” Click on the Symbology tab. Storm Zones are categories, so click on “Categories” in the Symbology TOC if it is not expanded. Click on “Unique Values.” The value field you are interested in is STORM_ZONE, so select STORM_ZONE from the drop down menu. Click on the “Add All Values” button so all categories are represented. Change the color ramp if you want. Your window should look similar to the one below. Click “OK” when you are done.



Vulnerability

Next we will think about the susceptibility to impact of the airports. If you closed the attribute table of *CT_airports_storm_zones*, reopen it. Scroll to find the links to more information provided by the data source of the airports layer.



Copy one of the links and paste it into your internet browser. Hit “Enter.”

Explore the information on the web page. You may want to follow more than one link. What information might be useful in determining susceptibility of the airport to impact from winds or associated hazards like flooding or storm surge? Why? Make note of your ideas below.

_____

_____

_____

What other factors can you think of that might influence the asset's vulnerability to a tropical cyclone hazard? List at least three factors in the space provided below and give reasons why these factors might be important.

_____

_____

_____

Consequence to Community

When an asset like an airport is damaged, the effects of the impact may spread throughout the surrounding community and region. The consequences may be much greater than the monetary loss associated with repair or replacement.

Look at the map. Think about the location of each airport and its relationship to other airports and elements of interest. What factors might you consider when assessing potential consequence of damage to an airport? Why? Turn on other layers if it helps you to visualize. Record your ideas in the space below.

_____

_____

_____

_____

If you have closed the airport information web pages, reopen one by copying and pasting one of the links from the *CT_airports_storm_zones* attribute table into your Internet browser. Look at the information again. Could any of the data help estimate potential consequences? How? Make note of your answer below.

_____

_____

_____

_____

In your opinion, which airports, if damaged, would be associated with the greatest consequences on the surrounding county or region?

_____

_____

Combining the Components

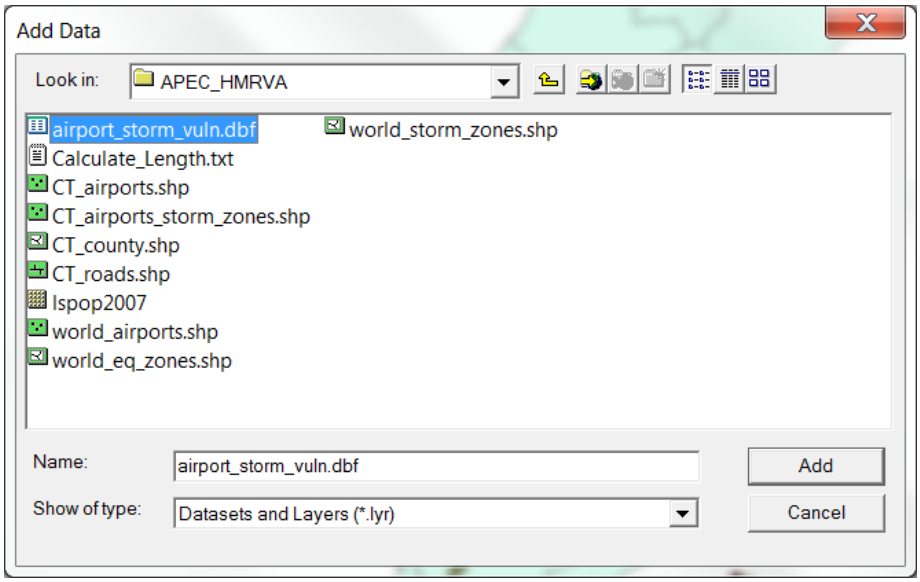
In the previous two steps, you identified factors that you believed might contribute to the vulnerability of an airport to storm impacts and the potential consequences to surrounding communities. Now you will explore the components of hazard, vulnerability and consequence in combination.

In order to map these components, and more easily examine them in combination, one can create categories to represent levels of hazard, vulnerability and consequence based on the information available. The storm zones are one way to represent varying levels of hazard. Five levels were identified.

Next we will look at a representation of levels of vulnerability and potential consequence.

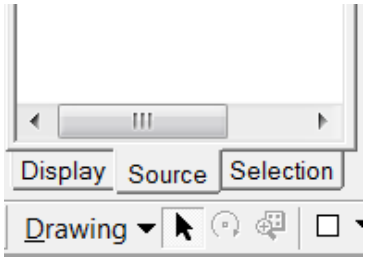
Click on the "Add Data" icon.

Navigate to the *C:\APEC_HMRVA* folder. Click on the *airport_storm_vuln.dbf* file.

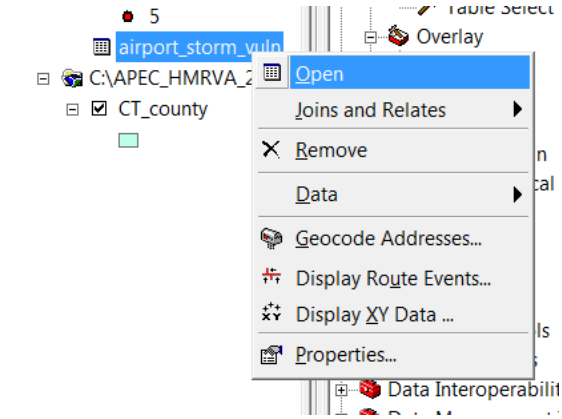


Click on the "Add" button.

The file is a table that includes information on vulnerability and consequence for each airport. The table has been added to your work space. Click on the “Source” tab under your table of contents to find it.



Right click on the table name, and then click “Open.”

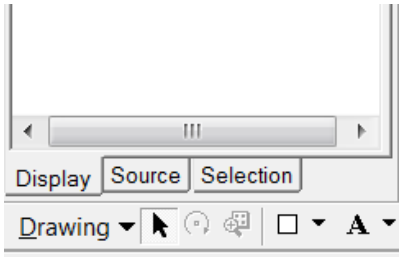


This will open the table. What fields are included?

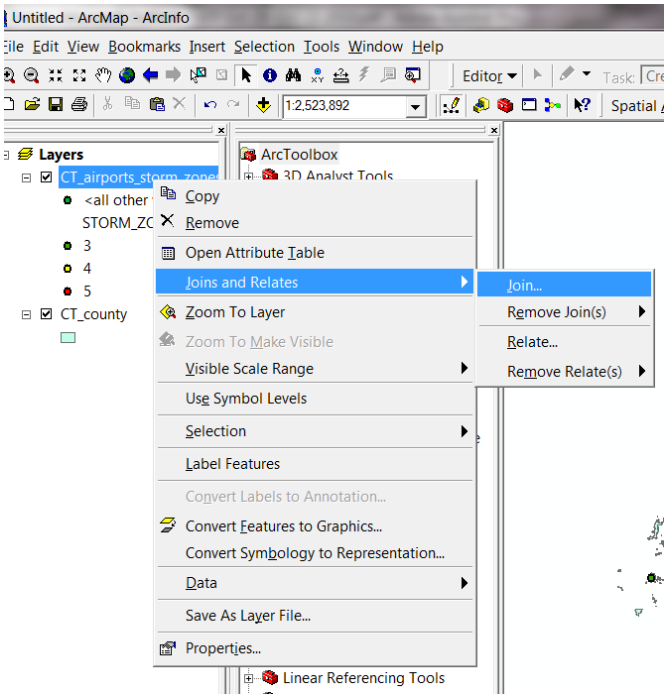
The vulnerability and consequence fields contain numbers ranging from 1 through 5. The number 1 represents relatively low vulnerability or consequence; a 5 represents relatively high vulnerability or consequence. These numbers were assigned based on a very subjective assessment of the limited information you have seen and discussed. THIS DATA IS TO BE USED FOR EXERCISE PURPOSES ONLY.

The attribute information in the table is not yet linked to any spatial information, so it cannot be mapped. However, if there are common field names, the table can be linked to layers in your TOC. We will join the table to the *CT_airports_storm_zones* in order to visualize the information.

Close the table and click on the “Display” tab at the bottom of the TOC.



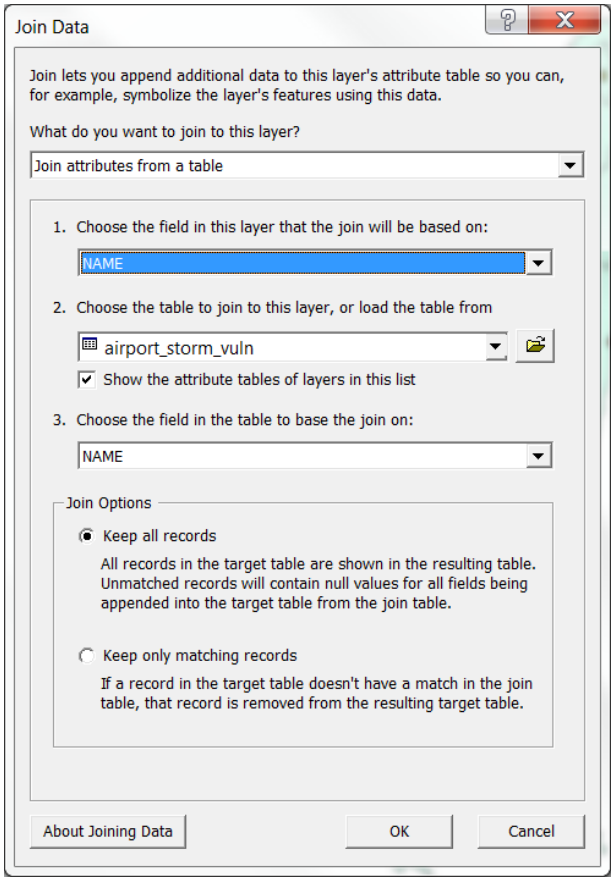
Right click on the *CT_airports_storm_zones* layer and navigate to “Joins and Relates” and click on “Join.”



A dialog box will open. From the drop down menus, select the following parameters:

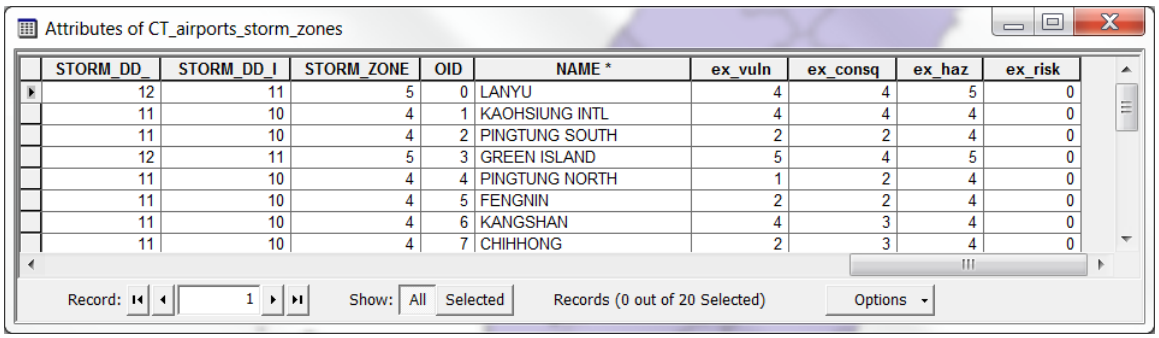
- What do you want to join: Join attributes from a table
- Field the join will be based on: NAME
- The table to join: *airport_storm_vuln*
- Field in the table: NAME
- Join Options: Keep all records

Your completed dialog box should look like this:



Click "OK."

Open the attribute table of *CT_airports_storm_zones* and scroll to the end to find the joined table.



STORM_DD_	STORM_DD_I	STORM_ZONE	OID	NAME *	ex_vuln	ex_consq	ex_haz	ex_risk
12	11	5	0	LANYU	4	4	5	0
11	10	4	1	KAOHSIUNG INTL	4	4	4	0
11	10	4	2	PINGTUNG SOUTH	2	2	4	0
12	11	5	3	GREEN ISLAND	5	4	5	0
11	10	4	4	PINGTUNG NORTH	1	2	4	0
11	10	4	5	FENGNIN	2	2	4	0
11	10	4	6	KANGSHAN	4	3	4	0
11	10	4	7	CHIHHONG	2	3	4	0

Sort the **ex_vuln** field to find out which airports fall into the highest category of vulnerability. List them below.

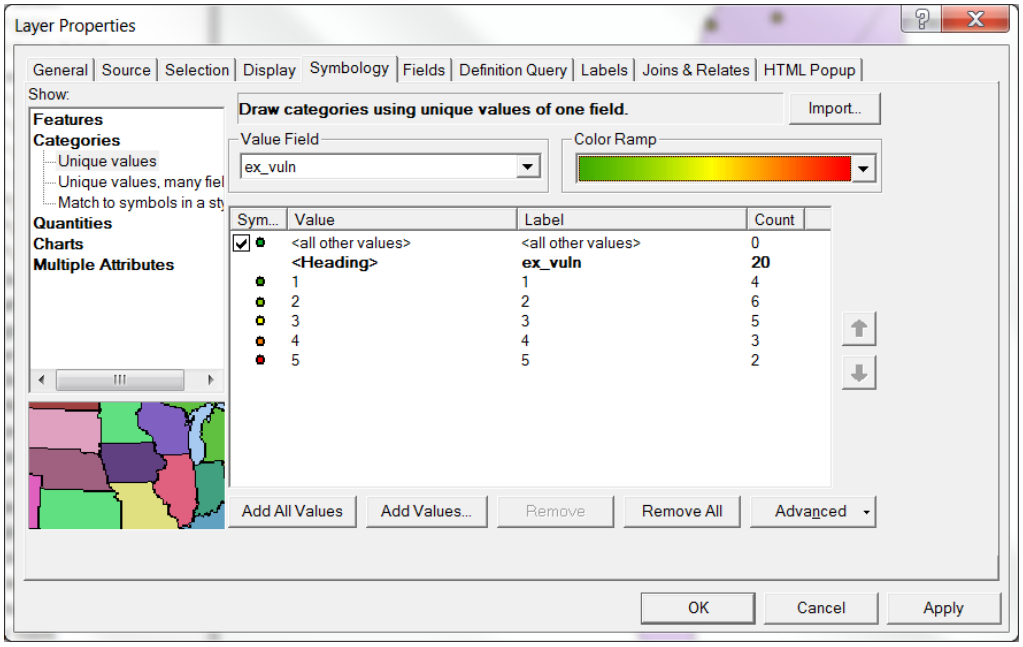
_____

_____

Now, sort the **ex_consq** field to see which airport might have the largest effects if damaged. Write the answer below.

Now, you will symbolize the airports based on estimated vulnerability and consequence. Make the *CT_storm_zones* layer visible to provide hazard context.

Right click on the *CT_airports_storm_zones* layer and click on "Properties." Click on "Categories" under the "Symbology" tab and select "Unique values." Select **ex_vuln** for the Value Field. As you did before, click on the "Add All Values" button. Make sure the colors make sense to you. If they do not, select a different color ramp. Your completed dialog box should look something like this:

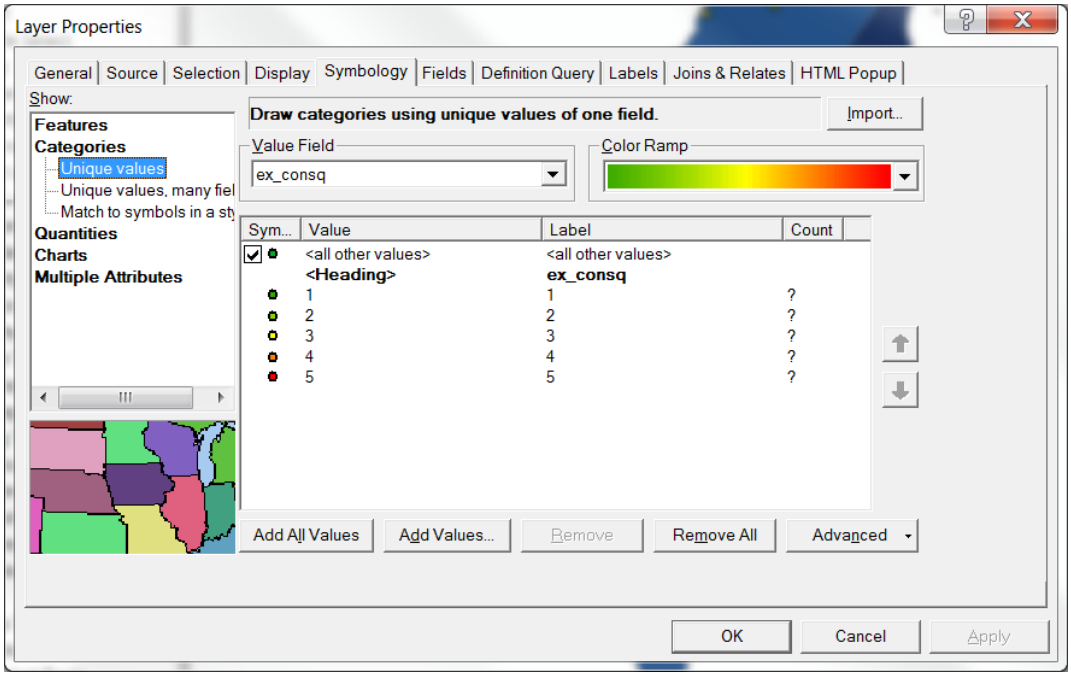


Are any of the airports in the highest vulnerability category located in the highest hazard zone? Which one(s)?

_____

_____

Repeat the process for the **ex_consq** field. Your dialog box will look similar to this:



Does any airport with a consequence value of 5 fall into the highest hazard category?

_____

What about airports with a consequence value of 4?

_____

Based on this quick visual examination, which airports do you think might have the highest and lowest priority when allocating resources?

_____

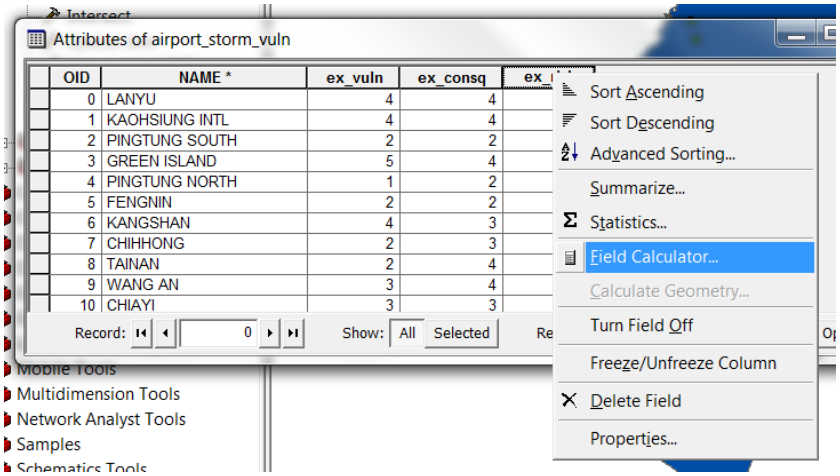
We will now use another method to try to estimate relative risk and establish priorities.

Open the attribute table of the *CT_airports_storm_zones* layer. Scroll to the end.

You will probably have noticed that there is a field called **ex_risk**. We will use the field calculator to combine hazard levels, vulnerability levels, and consequence levels into one measure that can be mapped and sorted.

Click on the source tab and open the **airport_storm_vuln** table.

Right click on the **ex_risk** field and click on “Field Calculator.”



Click “Yes” when the warning box appears. A dialog box will then appear.

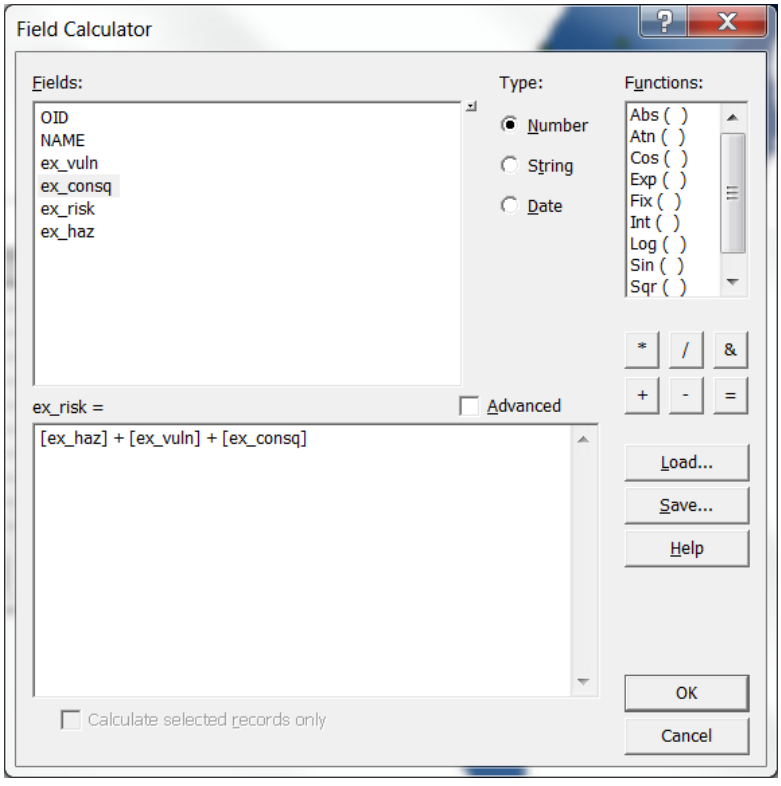
In order to combine them, we are simply going to add the field values for hazard, vulnerability, and consequence.

Double click on **ex_haz**. Then click the “+” button.

Double click on **ex_vuln** and then click the “+” button again.

Double click on **ex_consq**.

Your dialog box should look like this:



Click “OK.”

Your **ex_risk** field should now be filled with numbers.

Close the table. Click on the "Display" tab and then open the attribute table for the *CT_airports_storm_zones* layer. Scroll to the end to find the **ex_risk** field. It should have numbers in it.

Which airport has the highest relative risk based on the exercise data?

_____

Which airport has the lowest relative risk based on the exercise data?

_____

You will now visualize this information. Right click on the *CT_airports_storm_zones* layer and click on "Properties." Open the Symbology tab. Click on "Quantities." You will use Graduated colors to illustrate variation in relative estimated risk. Select **ex_risk** for the value field. Leave the classification as the default. Change the color ramp if you wish.

Which airports fall into the highest category? Are there similarities?

_____

Which airports fall into the lowest category? Are there similarities?

_____

Which airports would you prioritize if you were allocating resources? Why?

_____

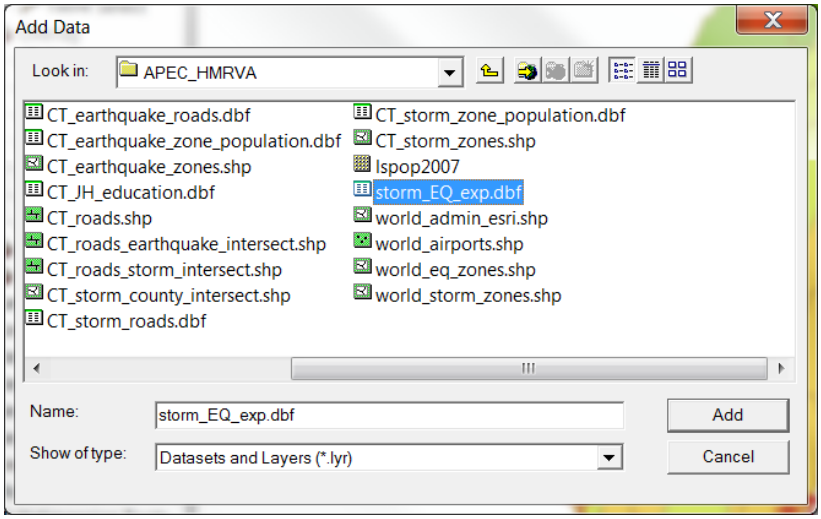
EXAMPLE 2: COMMUNITIES

On days 1 and 2, we also discussed disaster risk related to communities in terms of hazard and exposure, vulnerability and capacity. We will use an abbreviated form of a composite indicator approach to estimate multi-hazard risk. The exercise is intended to provide an example, provoke thought, and increase familiarity with the process. The results should not be used for decision making purposes.

Hazard and Exposure

In Exercise 3, you had Challenge Questions related to finding the number of people and the length of roads in each hazard zone in each county. In this exercise we will focus on exposure of people to the tropical cyclone hazard. The number of people located in each storm zone for each county was calculated prior to the workshop. The results can be found in the *storm_EQ_exp.dbf* file.

Click on the "Add data" icon and navigate to *C:\APEC_HMRVA*. Click on the *storm_EQ_exp.dbf* file. Click "Add."



The file will appear in the "Source" window. Right click on the table name and open the table. You will see two major types of field names. Those beginning with "pop" contain the number of people estimated in each zone for that county. These fields represent raw exposure. Those beginning with "perc" contain the percentage of the county's population that is estimated for each zone for that county. These field names represent relative exposure, discussed during the first two days of the workshop.

Sort the field **pop_Z4**.

Which community has the highest population located in Zone 4? _____

Now sort the field **perc_Z4**.

Do the same communities also have the highest percentage? _____

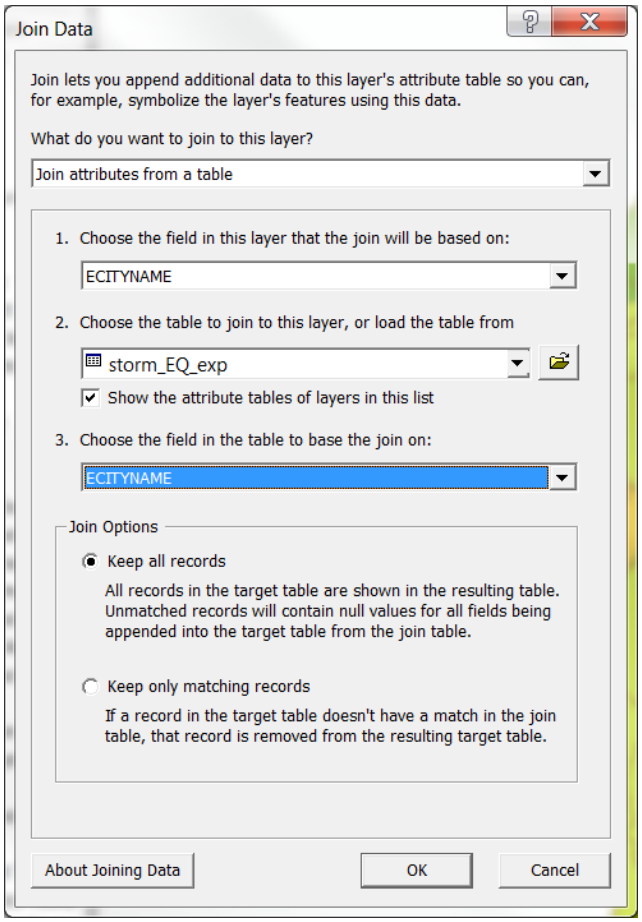
Overall exposure is sometimes considered a combination of raw and relative exposure. In this example, the field **rel_ex** represents relative exposure to varying levels of hazard within a county. The field **pop_ex_level** represents the raw exposure based on the total population of the county. To facilitate the combination of this information with other data, each county was assigned a category of 1 through 5 for both relative and raw exposure. This ensures that the data will have a consistent range. The field **exp** contains levels of hazard exposure estimated as a function of relative and raw exposure for each county.

You can visualize this data by joining the table to a layer in your table of contents. Click on the "Display" tab. Right click on the CT County layer and navigate to "Join…". A dialog box will open.

Select the following parameters from the drop down menus.

- What do you want to join: Join attributes from a table
- Field the join will be based on: ECITYNAME
- The table to join: *storm_EQ_exp*
- Field in the table: ECITYNAME
- Join Options: Keep all records

Your dialog box should look like this:



Click “OK.”

Open the attribute table for the CT County layer. Scroll to the end to locate the joined table. Close the table. You will use this information in a later step.

Vulnerability

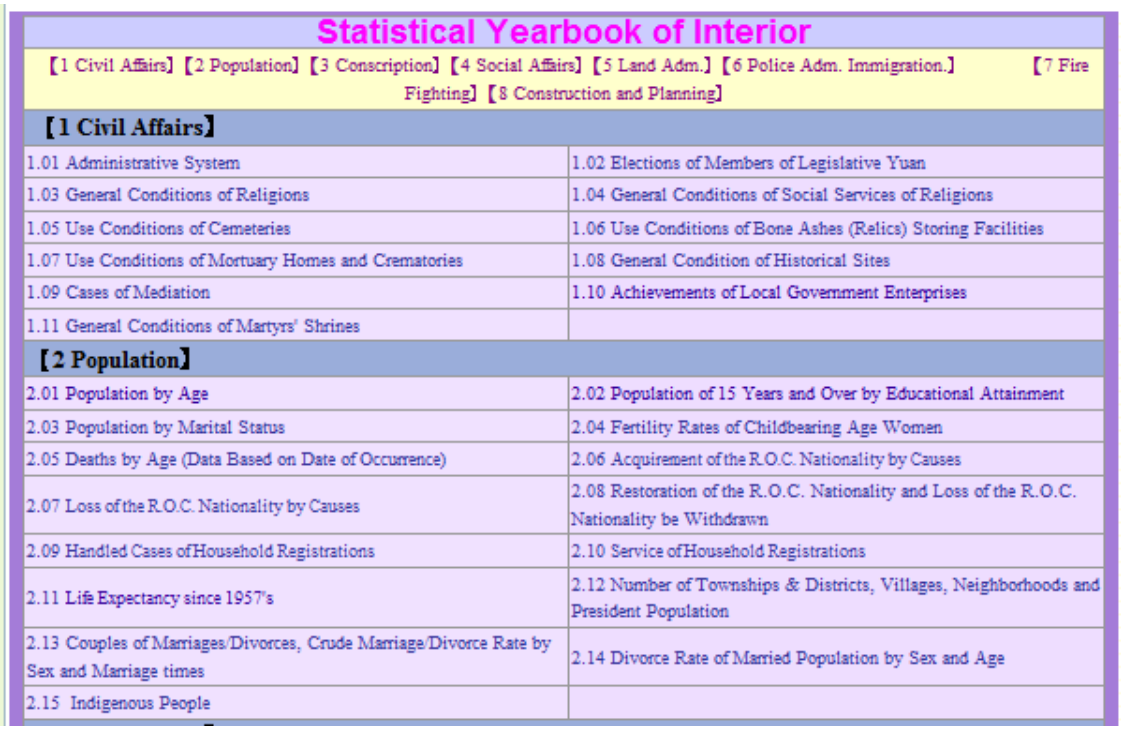
On Day 2, we discussed a variety of ways in which to think about vulnerability. In this section, we will explore some social data that might be used to represent vulnerability.

Chinese Taipei consistently collects and publishes data on a variety of social, economic, and environmental topics. Some of this information is available online. Much of it is disaggregated by gender. We will look at one point of access to data provided through the Ministry of the Interior's Department of Statistics.

The following link will take you to the Statistical Yearbook of the Interior:

http://www.moi.gov.tw/stat/english/year.asp

The data links are organized into 8 categories. Scroll down to the second category, Population.

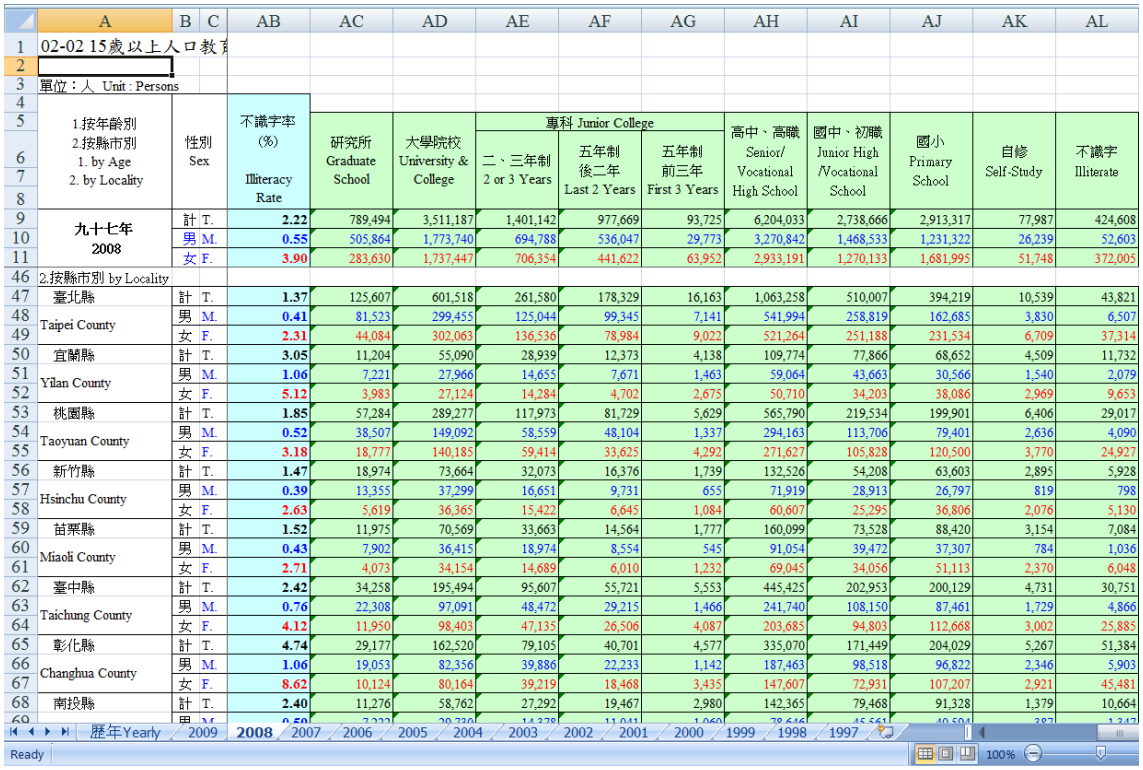


Statistical Yearbook of Interior

【1 Civil Affairs】【2 Population】【3 Conscription】【4 Social Affairs】【5 Land Adm.】【6 Police Adm. Immigration.】【7 Fire Fighting】【8 Construction and Planning】

【1 Civil Affairs】	
1.01 Administrative System	1.02 Elections of Members of Legislative Yuan
1.03 General Conditions of Religions	1.04 General Conditions of Social Services of Religions
1.05 Use Conditions of Cemeteries	1.06 Use Conditions of Bone Ashes (Relics) Storing Facilities
1.07 Use Conditions of Mortuary Homes and Crematories	1.08 General Condition of Historical Sites
1.09 Cases of Mediation	1.10 Achievements of Local Government Enterprises
1.11 General Conditions of Martyrs' Shrines	
【2 Population】	
2.01 Population by Age	2.02 Population of 15 Years and Over by Educational Attainment
2.03 Population by Marital Status	2.04 Fertility Rates of Childbearing Age Women
2.05 Deaths by Age (Data Based on Date of Occurrence)	2.06 Acquirement of the R.O.C. Nationality by Causes
2.07 Loss of the R.O.C. Nationality by Causes	2.08 Restoration of the R.O.C. Nationality and Loss of the R.O.C. Nationality be Withdrawn
2.09 Handled Cases of Household Registrations	2.10 Service of Household Registrations
2.11 Life Expectancy since 1957's	2.12 Number of Townships & Districts, Villages, Neighborhoods and President Population
2.13 Couples of Marriages/Divorces, Crude Marriage/Divorce Rate by Sex and Marriage times	2.14 Divorce Rate of Married Population by Sex and Age
2.15 Indigenous People	

Topic 2.02, "Population of 15 Years and Over by Educational Attainment" links to a table that includes educational information broken down by age, place and gender. It includes the number of people have who completed a variety of levels of schooling. A screen capture of a section of the data table is included here.



02-02 15歲以上人口教育

單位：人 Unit : Persons

1.按年齡別 2.按縣市別 1. by Age 2. by Locality	性別 Sex	不識字率(%) Illiteracy Rate	研究所 Graduate School	大學院校 University & College	專科 Junior College			高中、高職 Senior/ Vocational High School	國中、初職 Junior High /Vocational School	國小 Primary School	自修 Self-Study	不識字 Illiterate
					二、三年制 2 or 3 Years	五年制後二年 Last 2 Years	五年制前三年 First 3 Years					
九十七年 2008	計 T.	2.22	789,494	3,511,187	1,401,142	977,669	93,725	6,204,033	2,738,666	2,913,317	77,987	424,608
	男 M.	0.55	505,864	1,773,740	694,788	536,047	29,773	3,270,842	1,468,533	1,231,322	26,239	52,603
	女 F.	3.90	283,630	1,737,447	706,354	441,622	63,952	2,933,191	1,270,133	1,681,995	51,748	372,005
2.按縣市別 by Locality												
臺北縣	計 T.	1.37	125,607	601,518	261,580	178,329	16,163	1,063,258	510,007	394,219	10,539	43,821
Taipei County	男 M.	0.41	81,523	299,455	125,044	99,345	7,141	541,994	258,819	162,685	3,830	6,507
	女 F.	2.31	44,084	302,063	136,536	78,984	9,022	521,264	251,188	231,534	6,709	37,314
宜蘭縣	計 T.	3.05	11,204	55,090	28,939	12,373	4,138	109,774	77,866	68,652	4,509	11,732
Yilan County	男 M.	1.06	7,221	27,966	14,655	7,671	1,463	59,064	43,663	30,566	1,540	2,079
	女 F.	5.12	3,983	27,124	14,284	4,702	2,675	50,710	34,203	38,086	2,969	9,653
桃園縣	計 T.	1.85	57,284	289,277	117,973	81,729	5,629	565,790	219,534	199,901	6,406	29,017
Taoyuan County	男 M.	0.52	38,507	149,092	58,559	48,104	1,337	294,163	113,706	79,401	2,636	4,090
	女 F.	3.18	18,777	140,185	59,414	33,625	4,292	271,627	105,828	120,500	3,770	24,927
新竹縣	計 T.	1.47	18,974	73,664	32,073	16,376	1,739	132,526	54,208	63,603	2,895	5,928
Hsinchu County	男 M.	0.39	13,355	37,299	16,651	9,731	655	71,919	28,913	26,797	819	798
	女 F.	2.63	5,619	36,365	15,422	6,645	1,084	60,607	25,295	36,806	2,076	5,130
苗栗縣	計 T.	1.52	11,975	70,569	33,663	14,564	1,777	160,099	73,528	88,420	3,154	7,084
Miaoli County	男 M.	0.43	7,902	36,415	18,974	8,554	545	91,054	39,472	37,307	784	1,036
	女 F.	2.71	4,073	34,154	14,689	6,010	1,232	69,045	34,056	51,113	2,370	6,048
臺中縣	計 T.	2.42	34,258	195,494	95,607	55,721	5,553	445,425	202,953	200,129	4,731	30,751
Taichung County	男 M.	0.76	22,308	97,091	48,472	29,215	1,466	241,740	108,150	87,461	1,729	4,866
	女 F.	4.12	11,950	98,403	47,135	26,506	4,087	203,685	94,803	112,668	3,002	25,885
彰化縣	計 T.	4.74	29,177	162,520	79,105	40,701	4,577	335,070	171,449	204,029	5,267	51,384
Changhua County	男 M.	1.06	19,053	82,356	39,886	22,233	1,142	187,463	98,518	96,822	2,346	5,903
	女 F.	8.62	10,124	80,164	39,219	18,468	3,435	147,607	72,931	107,207	2,921	45,481
南投縣	計 T.	2.40	11,276	58,762	27,292	19,467	2,980	142,365	79,468	91,328	1,379	10,664

歷年Yearly 2009 2008 2007 2006 2005 2004 2003 2002 2001 2000 1999 1998 1997

Ready 100%

This data was used to create an educational variable for each county or city to use in this exercise.

How might education affect a person's or community's vulnerability to impact? How might education levels be important to disaster management activities? Make note of your ideas in the space below.

_____

_____

_____

_____

_____

Briefly look at the topics listed in the "Population" category (you do not need to open the data). What other topics might be useful in representing vulnerability? Name one and provide a reason below.

_____

_____

_____

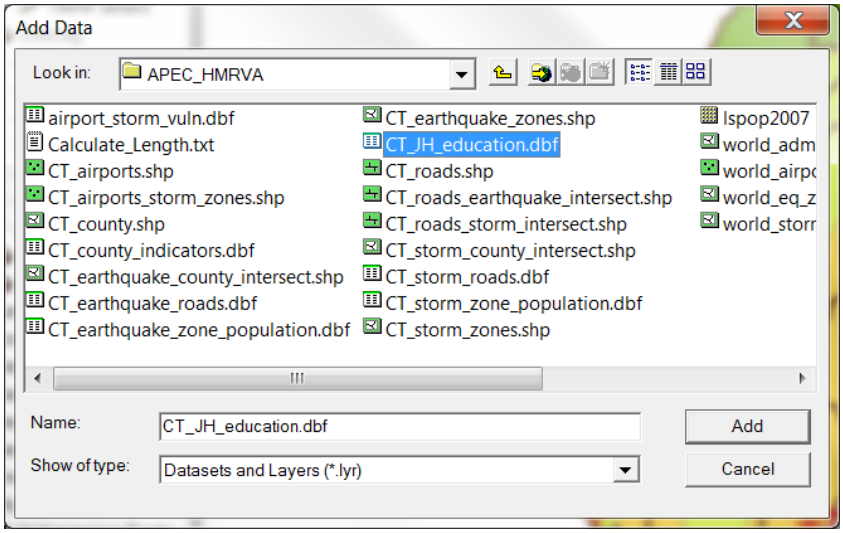
Now look at the topics listed in the fourth category, “Social Affairs.” Identify one topic that might be useful in representing vulnerability and provide a reason below.

_____

_____

In this exercise, vulnerability will be represented by the percentage of the population over 15 of each county or city who have a junior high education or lower.

Click on the “Add data” icon and navigate to C:\APEC_HMRVA. Click on the *CT_JH_education.dbf* file. Click “Add.”



The file will appear in the “Source” window. Right click on the table name and open the table.

Sort the field **PERC_JH_T**, which represents the percentage of all individuals over 15 who have a junior high education level or lower.

Which community has the highest percentage? _____

Which community has the lowest percentage? _____

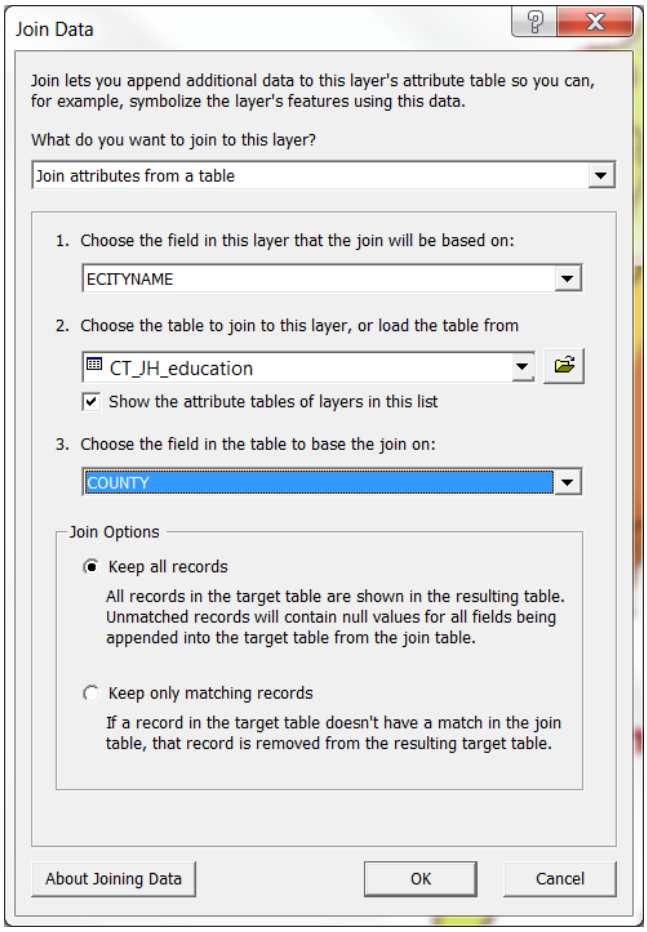
To facilitate the combination of this information with other data, each county was assigned a category of 1 through 5 based on the percentage. This ensures that the data will have a consistent range. The categorization was based on quantiles. However, there are many ways to prepare datasets for combination.

You can visualize this data by joining the table to a layer in your table of contents. Click on the “Display” tab. Right click on the *CT County* layer and navigate to “Join…”. A dialog box will open.

Select the following parameters from the drop down menus.

- What do you want to join: Join attributes from a table
- Field the join will be based on: ECITYNAME
- The table to join: *CT_JH_Education*
- Field in the table: COUNTY
- Join Options: Keep all records

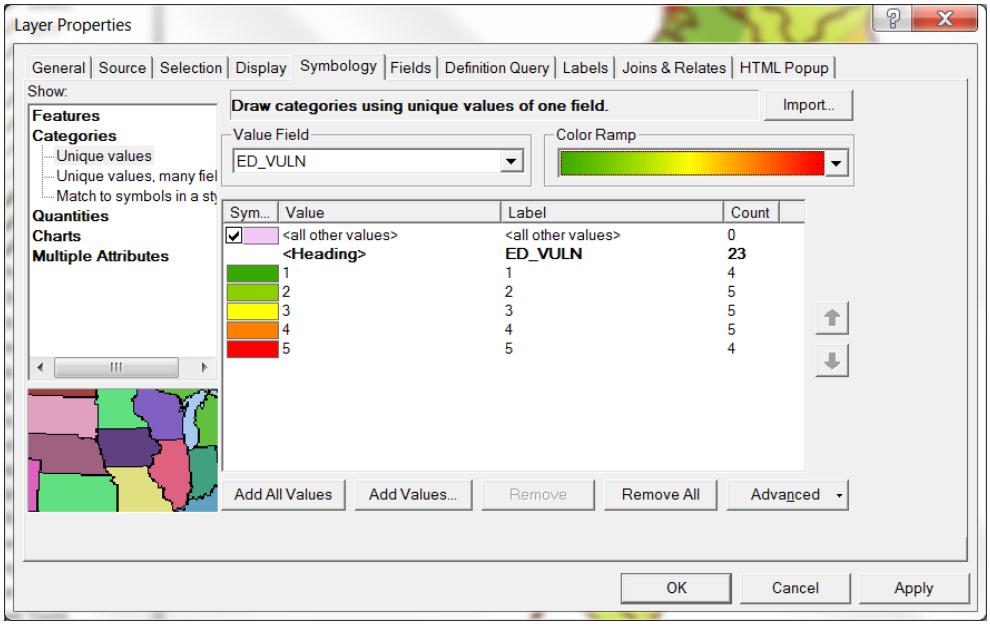
Your dialog box should look like this:



Click “OK.”

Open the attribute table for the *CT County* layer. Scroll to the end to locate the joined table. Close the table.

You will now symbolize the *CT County* layer using the **ED_VULN** field. You will base the symbology on Categories of unique values. Don't forget to "Add All Values." Your dialog box should look something like this:



Click "OK."

Note any spatial patterns. Remember that education level is only one possible indicator used to represent vulnerability. In a real assessment, more dimensions and indicators of vulnerability would be included; the patterns on the map would likely change if additional information were included.

Capacity

You have already looked at the exposure of the road network as a whole. Transportation information can also be used as a measure of coping capacity. Just as you summarized the roads information by storm zone, you can summarize the length of roads by county.

This step has been performed for you. The results (in meters) are included in the file *county_road_cap.dbf*. Add this file to your workspace by using the "Add data" button.

The file will appear in the "Source" window. Right click on the table name and open the table.

Neither the area nor the length of road by themselves indicates capacity. However, road density can. Why? Make note of your ideas below. (*Hint:* Think about transporting goods and people into and out of an area.)

_____

_____

Sort the field **road_D_mkm**, which represents the road density in meters per square kilometer for each county.

Which community has the highest density? _____

Which community has the lowest density? _____

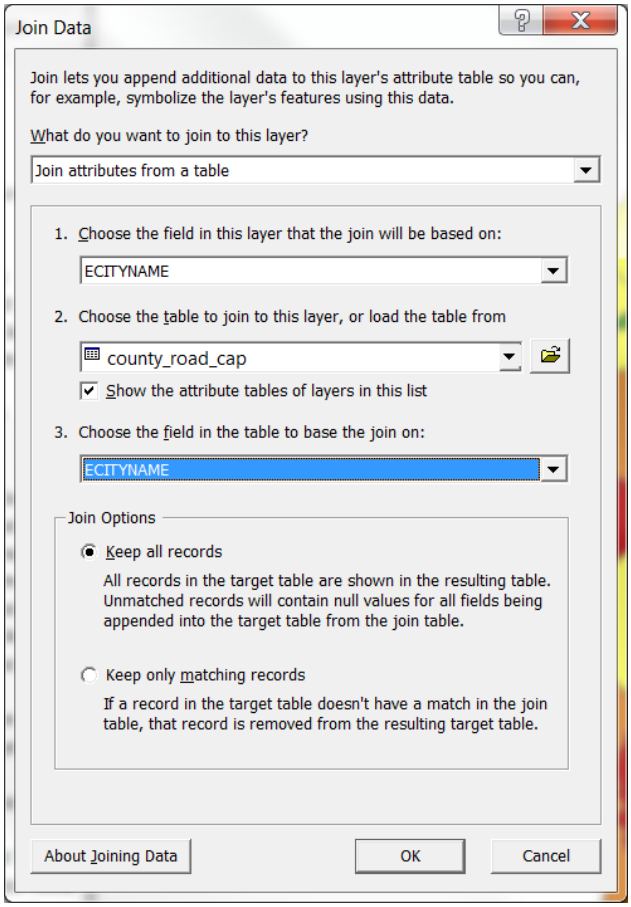
To facilitate the combination of this information with other data, each county was assigned a category of 1 through 5 based on the density. As with the education information, the categorization was based on quantiles.

You can visualize this data by joining the table to a layer in your table of contents. Click on the "Display" tab. Right click on the *CT County* layer and navigate to "Join…". A dialog box will open.

Select the following parameters from the drop down menus.

- What do you want to join: Join attributes from a table
- Field the join will be based on: ECITYNAME
- The table to join: *county_road_cap*
- Field in the table: ECITYNAME
- Join Options: Keep all records

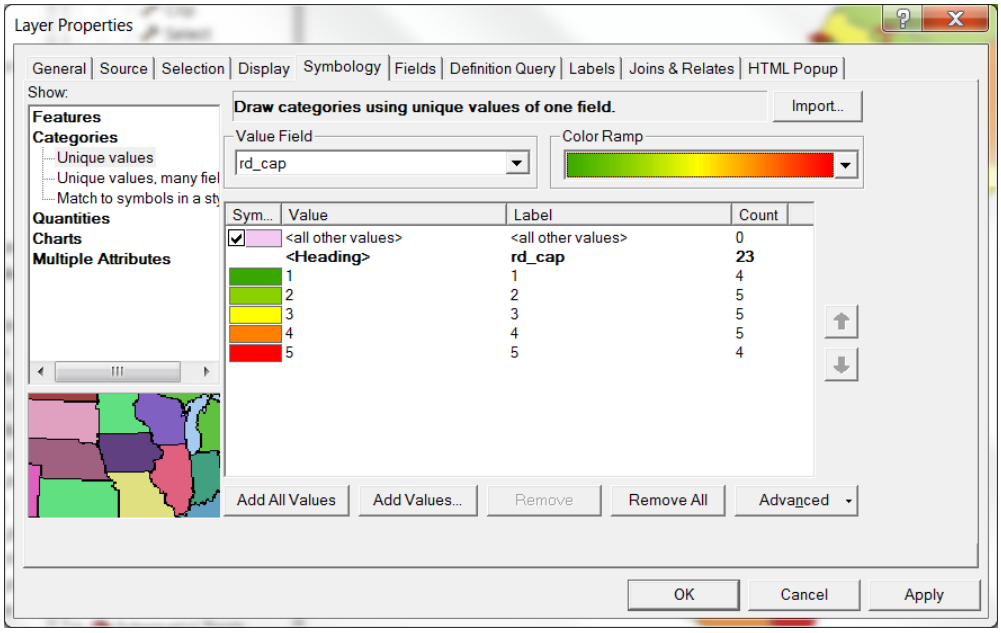
Your dialog box should look like this:



Click “OK.”

Open the attribute table for the *CT County* layer. Scroll to the end to locate the joined table. Close the table.

You will now symbolize the *CT County* layer using the **rd_cap** field. You will base the symbology on Categories of unique values. Don't forget to "Add All Values." Your dialog box should look something like this:



Click "OK."

Note the spatial patterns. How do they differ from the patterns of vulnerability as represented by education level?

_____

_____

Remember that road density is only one possible indicator used to represent capacity. In a real assessment, more dimensions and indicators would be included; the patterns on the map would likely change if additional information were included.

Challenge Question

What other information have you looked at or worked with today that might help represent capacity? Record your thoughts below.

_____

_____

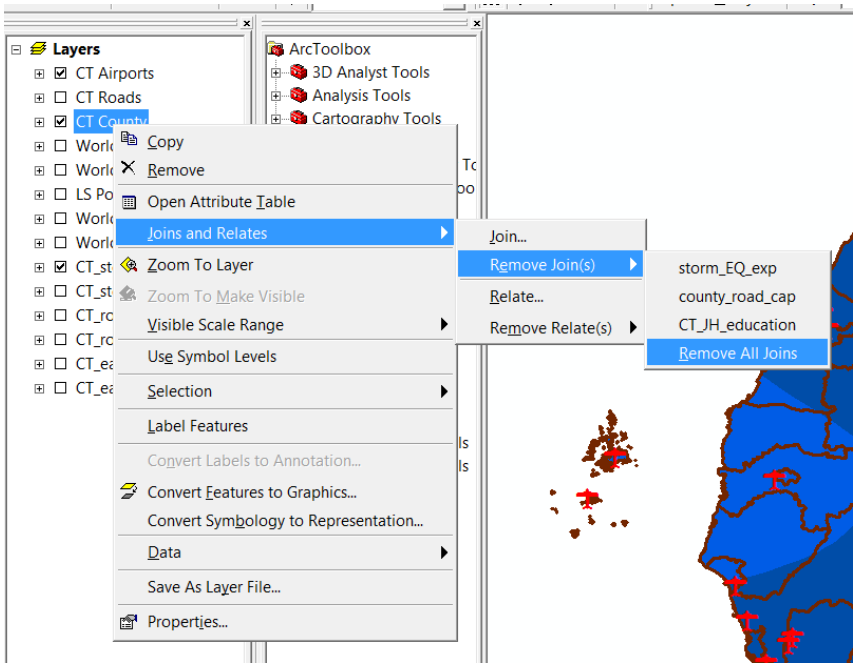
_____

Combining the Components

The *CT County* attribute table now contains all the information you need to estimate risk. Included are measures of exposure related to varying hazard levels, a measure of vulnerability based on education levels, and a measure of capacity based on road density. Keep in mind that these indicators were used as examples in order to illustrate concepts and processes. Results are for exercise use only.

In order to make the attribute table easier to use for calculations, you will remove all the tables currently joined. A file containing the final measures of hazard exposure, vulnerability represented as education level, and capacity represented as road density can be found in *C:\APEC_HMRVA*. You will use this table to make risk calculations.

First, right click on the *CT County* layer. Navigate to Joins and Relates, select "Remove Join(s)," and click on "Remove all joins."



Next, you will add the file *CT_county_risk_comp.dbf* to your work space using the "Add data" button.

The file will appear in the "Source" window. Right click on the table name and open the table.

You will see four fields named **RISK_1** through **RISK_4**. This is where you'll make your calculations. Notice that having the hazard exposure, vulnerability, and capacity measures next to each other helps you to see variation between components within a county. It is the combination of these component scores that will be used to represent risk.

We have focused on tropical cyclones in this example. However, earthquake exposure was also estimated for use in this exercise (**EQ_EXP**). This measure was then combined with the estimated storm exposure to get a multi hazard measure of relative exposure related to earthquakes and tropical cyclones (**MH_EXP**).

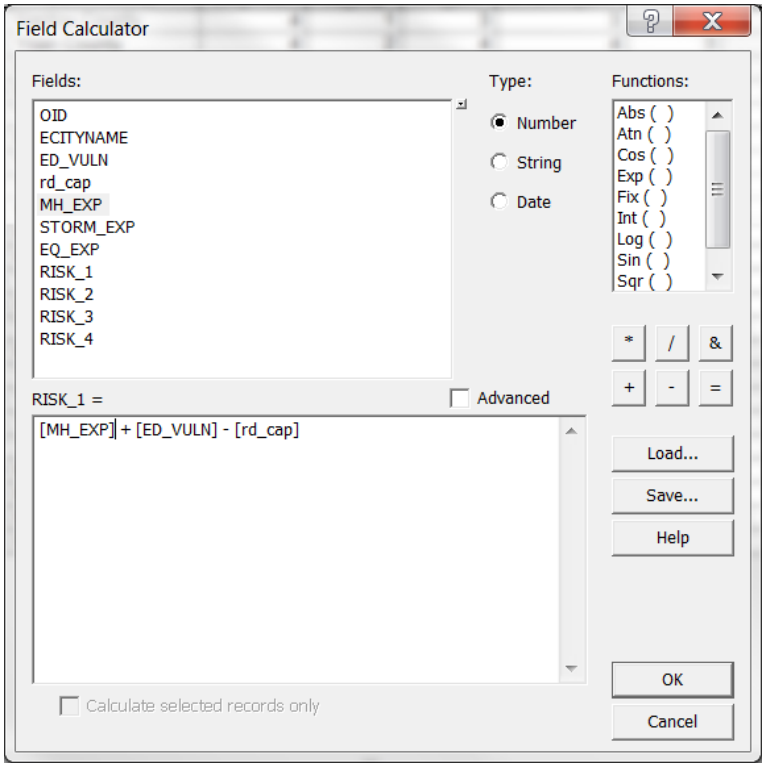
We will begin by using a simple, additive formula to calculate relative risk associated with earthquakes and tropical cyclones within Chinese Taipei. Right click on the field **RISK_1** and select "Field Calculator." A dialog box will open.

Double click on **MH_EXP**. Click the "+" sign.

Double click on **ED_VULN**. Click the "-" sign.

Double click on *rd_cap*.

Your dialog box should look like this:



Click "OK."

Sort the results.

Which counties are estimated to have the highest risk based on the exercise data?

Which counties have the lowest estimated risk based on the exercise data?

Sometimes a multiplicative function is used to represent risk.

Right click on the field “RISK_2” and select “Field Calculator.”

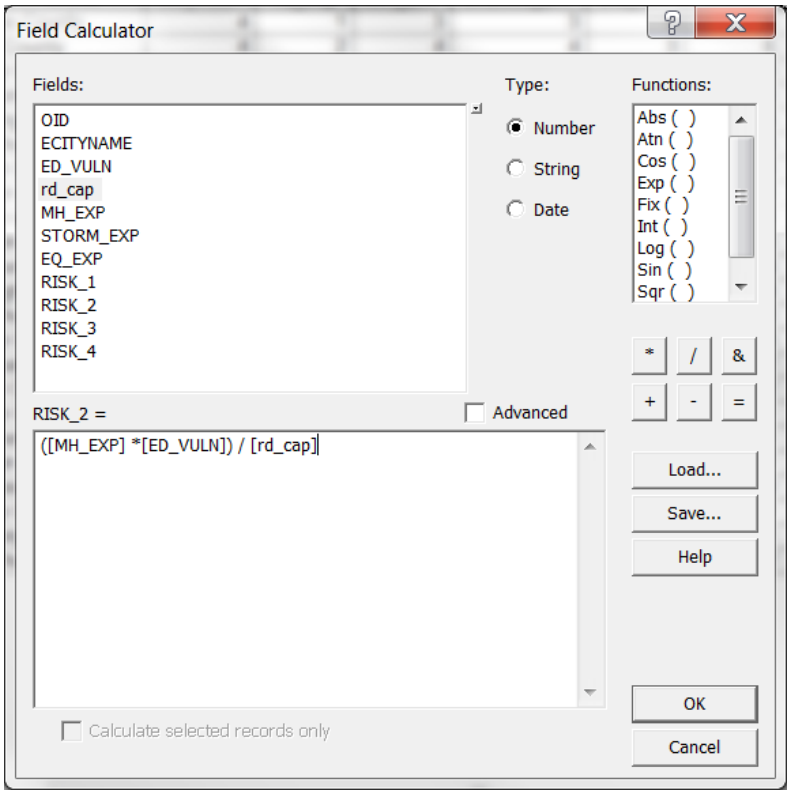
Enter a left bracket, “(“, using the keyboard.

Double click on “MH_EXP.” Click on the “*” sign.

Double click on “ED_VULN.” Enter a right bracket, “)”, using the keyboard.

Click the “\” sign. Double click on “rd_cap.”

Your dialog box should look like this:



Click OK.

Sort the results.

Which counties are estimated to have the highest risk based on the exercise data?

_____

_____

Which counties have the lowest estimated risk based on the exercise data?

_____

_____

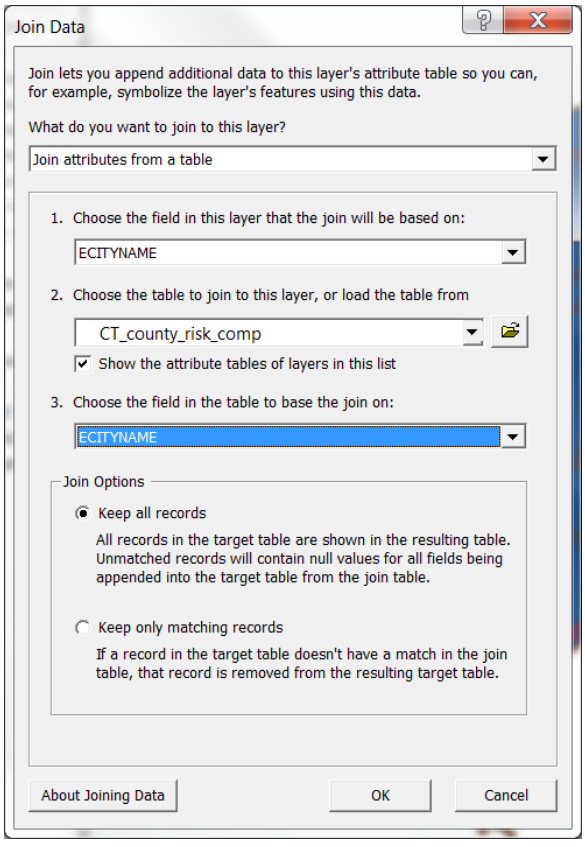
You will now visualize estimated risk using the measures you have just calculated. In order to visualize the information, you first need to join the table to a layer containing spatial information.

Click on the *CT County* layer and choose "Join…"

Select the following parameters from the drop down menus.

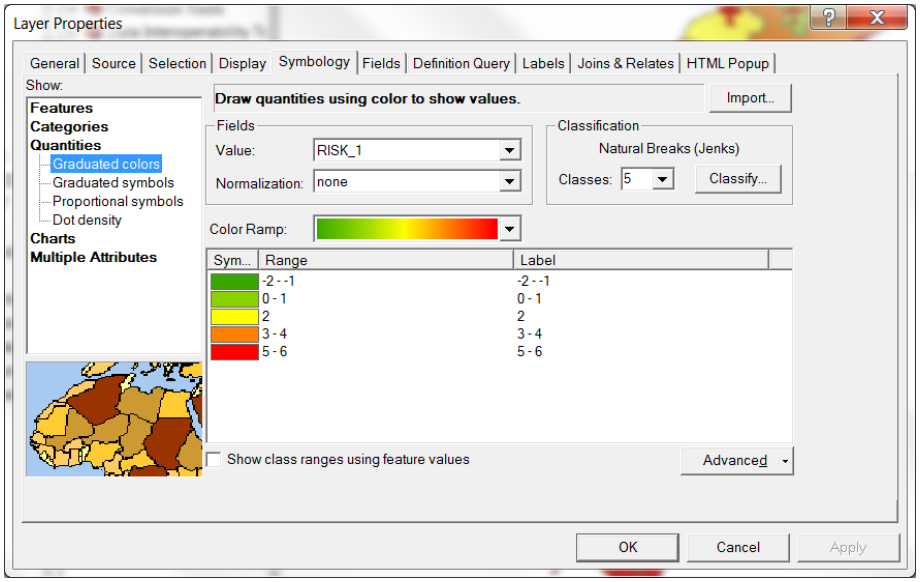
- What do you want to join: Join attributes from a table
- Field the join will be based on: ECITYNAME
- The table to join: *CT_county_risk_comp*
- Field in the table: ECITYNAME
- Join Options: Keep all records

Your dialog box should look like this:



Click "OK."

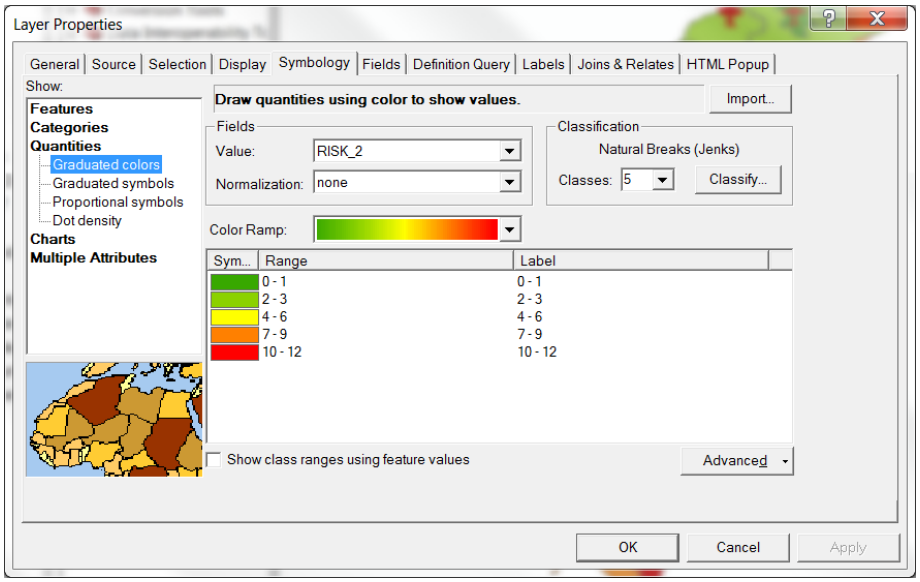
Symbolize the **RISK_1** field using graduated colors and the default classification. Your dialog box should look similar to this:



Note the spatial patterns.

Now symbolize the **RISK_2** field using graduated colors and the default classification.

Your dialog box should look something like this.



Note the spatial patterns.

What are the differences between the maps?

_____

_____

What does the table add to the information conveyed by the maps?

_____

_____

How might this information be applied? Note your ideas below.

_____

_____

_____

_____

Challenge Question

What is another way that you might represent combined vulnerability and capacity? How might you calculate risk based on this measure?

_____

_____

Challenge Step

If you have time, experiment with the calculation of risk and/or the ways in which you symbolize it. To calculate additional measures of risk, you will need to go back to the original table under the “Source” tab. Use the fields RISK_3 and RISK_4 to make new calculations estimating multi-hazard or single hazard risk. Under “Symbology,” you might try different classification mechanisms and numbers of classes. How do changes in symbology affect the way you perceive relative risk?

Hands on Exercise: Estimating Costs and Benefits

GOALS OF EXERCISE 5: ESTIMATING COSTS AND BENEFITS

In this exercise we will start with a hypothetical scenario, and determine the probability of two hazards to a given location by using GIS. We will then identify estimated costs and anticipated benefits for two mitigation projects.

Note: This manual does not include step-by-step instructions for Exercise 5. Worksheets will be handed out instead.

Acknowledgements

APEC Workshop on Hazard Mapping and Risk & Vulnerability Assessment

Instructions for Day 3 Exercises 1–4

- **Contributing Authors**
  - Heather Bell, PhD, Pacific Disaster Center
  - Todd Bosse, Pacific Disaster Center
  - Sharon Mielbrecht, Pacific Disaster Center

- **Published Source Materials**
  - Pennsylvania Spatial Data Access Tutorials pages. (Accessed September 2010) http://www.pasda.psu.edu/tutorials/arcgis.asp
  - Ministry of the Interior, Department of Statistics. Statistical Yearbook of the Interior. (Accessed September 2010) http://www.moi.gov.tw/stat/english/year.asp
  - World Aero Data. Airports in Taiwan. (Accessed September 2010) http://worldaerodata.com/countries/Taiwan.php
  - ESRI GIS.com – Guide to Geographic Information Systems website (Accessed September 2010): http://www.gis.com/
  - ESRI ArcMap ArcGIS Desktop software, version 9.3.1

- **Acknowledgements**
  - The following GIS datasets are from PDC's Enterprise Geospatial Database (EGDb): World Storm Zones, World Earthquake Zones, LS Population 2007, World Airports, CT Airports, World Admin Boundaries.
  - The following GIS datasets were provided by the National Science and Technology Center for Disaster Reduction (NCDR): CT County, CT Roads.
  - The following dataset was obtained from the Ministry of the Interior, Department of Statistics, Statistical Yearbook of the Interior: CT_JH_education.