STUDENT PAGES
Asiatic Black Bears: Conservation in Taiwan

INSTRUCTIONS FOR ANALYZING DATA

By now, you should have already developed hypotheses and corresponding predictions. So, it's time for Step 5 of the Scientific Process!

1. Develop Hypotheses
2. Use hypotheses to develop predictions
3. Design a scientific study to rigorously evaluate predictions
4. Collect data
5. Analyze and evaluate data
6. Use results from data evaluation to draw conclusions, and to inform new hypotheses
7. Share findings with peers, scientists, and the public

Because we have **2 different hypotheses** to evaluate, we'll provide **2 different sets of instructions for you**.

Hypothesis 1, we'll provide Instructions for GIS Analyses. For Hypothesis 2, we'll provide Instructions for Habitat Use Analyses.

Let's get started with the GIS instructions.

Instructions for Hypothesis 1: GIS Analyses

1. Open ArcMap

If your school has a SCHOOL CAMPUS LICENSE for ESRI products, then you already have the necessary software at school required to use this lesson plan. If your school does not have a SCHOOL CAMPUS LICENSE for ESRI products, then you can download the software "ArcGIS for desktop" for a free 60-day trial. http://www.esri.com/software/arcgis/arcgis-for-desktop/free-trial

1. In the getting started window click **New Maps** on the left side. With **Blank Map** chosen, hit **OK**.

2. Add Data

1. Click **Add Data** in the toolbar. All of the spatial layers are pre-loaded in the folder called **ABBGIS_Spatial Data**. This folder is available through Bear Trust International; your teacher will give you instructions on how to access this folder. When you have the folder **ABBGIS_Spatial Data,** click on the following files to load them into your map. Make sure you load only these files in the following order.

    1. **FA7.shp**
    2. **MA11.shp**
    3. **MA13.shp**
    4. **MA8.shp**
    5. **MS6.shp**
    6. **YNP.shp**

2. Examine the **Table of Contents** that now has the layers for your map. Notice that each of the layers has a button to expand or minimize its data symbology and a box to uncheck/check to make the layer invisible/visible.

3. Now load the next set of files.

    LOOK -> Some of the following files are projected in a different geographic coordinate system than the previous shape files. For some layers you might see this warning: "Geographic Coordinate Systems Warning". When you see this, click **Transfomrations**. **Convert from** "GCS_WGS_1984" **Into** "GCS_TWD_1967". Click **OK**. Click **Close**. This will transform data layers on the fly into the coordinate system in which the previous set of files is already projected, which is important to ensure all the data are correctly displayed.

    1. **countries.shp**
    2. **TWN_roads.shp**
    3. **TWN_water.shp**
    4. **species_22824.shp**
    5. **N23E120.hgt**
    6. **N23E121.hgt**

3. Asiatic Black Bear Distribution

1. Uncheck and minimize all the layers except for **countries.shp** and **species_22824**.
2. Right click on the layer **countries.shp** and then click on **label features**. This provides the names of the countries.
3. Make sure that **species_22824.shp** is listed above the **countries.shp** layer in the table of contents. The layer's visibility depends on their order in the table of contents, top to bottom. Here's how you move layers: click the button on the far left under the "table of contents". This button is called "List by drawing order". Then right click on a layer and drag the layer to a new position in the table of contents.
4. Right click on the layer **species_22824**. When its toolbar opens up, scroll down and click **Zoom To Layer**. This moves the map display to show the full extent of the data in this particular layer.

The data in this layer are from the ICUN Red List of Threatened Species. It is the species distribution of Asiatic black bears and when you open it up you will see several pale blue polygons. Let's symbolize this layer differently to get a better understanding of the data.

5. Right click again on the layer **species_22824** and click **Open Attribute Table**. Examine the table and notice how similar the attribute table is to an excel file. Scroll to the right to the column called **LEGEND**. It holds the data that explains the differences in the pale green polygons. Okay, now click the **X** in the top right corner to close the table.

6. Right click again on the layer **species_22824** and scroll down to click on **Properties**.
   a) Under the **General** tab, change **Layer Name** to: **Asiatic Black Bear Distribution**.
   b) Let's symbolize the different categories of data from the IUCN Red List. Under the **Symbology** tab, Choose **Categories** in the **Show** column to the left. Keep it on **Unique Values** and change the **Value Field** to **LEGEND,** and click **Add All Values** below it. The columns explain the different values from the field **LEGEND**, as well as what each Label is on the map, the count of occurrences, and the color of the symbology.
   c) Unclick the row for the **<all other values>** because their count is 0. (This is a simple way to remove unneeded data from the map display without removing it from the data.)
   d) Change the **Color Ramp** to any option with at least four distinctly different colors.

e) Click **OK** when done. Examine the map.

Note: when choosing colors for a map, be aware of your audience. Choosing colors based on personal preference may not be best for displaying differences on a map. Choose a wide array of colors in the same spectrum or hue. Be aware that clashing colors might be distracting.

f) To examine the different categories for any layer, click the **Identify Tool** on the toolbar (blue circle with an i). Then click on a point in the map to see its properties.

4. Yushan National Park

1. Uncheck the layer **Asiatic Black Bear Distribution** and **countries.shp**, and check the layer **YNP.shp** to make it visible.

2. Under the **General** tab, change **Layer Name** to: **Yushan National Park**.

3. Zoom to the layer **Yushan National Park.shp.** This layer represents the boundary of the Yushan National Park.

4. Find the **Measure** tool in the toolbars above or to the left. Its icon is a ruler. Clicking on it open the measure window that explains the process of measuring a distance, area, or feature.
   a) **Measure the feature** (the + icon) , the **Yushan National Park** layer.
   b) Change the **units** by clicking on the first downward facing arrow to the right of the + icon. You can change the units measured for the area and distance into kilometers, miles, acres, etc.

5. We need to easily view the boundary of the park. Change the symbology by using a shortcut: double click on the symbol of the layer in the Table of Contents. This opens up the **Symbol Selector** window and gives easy access to changes in color and outline.
   a) Change the **Fill Color** to no color
   b) Change the **Outline Width** to 6
   c) Change the **Outline color** to Black
   d) Click **OK** when done.

6. Check the box in the table of contents to make visible **TWN_roads**. **TWN_roads** actually includes roads and trails so let's change the name of this layer to **Taiwan Roads and Trails** (hint, use the **General** tab). We also need to use symbology to

distinguish between roads and trails. Right click on **Taiwan Roads and Trails** and click properties.

a) Under the **Symbology** tab, Choose **Categories** in the **Show** column to the left. Keep it on **Unique Values** and change the **Value Field** to **F_CODE_DES,** and click **Add All Values** below it. The columns explain the different values from the field **F_CODE_DES**, as well as what each Label is on the map, the count of occurrences, and the color of the symbology.

b) Unclick the row for the **<all other values>** because their count is 0. (This is a simple way to remove unneeded data from the map display without removing it from the data.)

c) Find the box with the column headers:

Symbol Value Label Count

Double click on "Road". Scroll down and click on "Major Road", color black, size 1.5. Click OK.

In the same box, now double click on "Trail". Scroll down and click on "Dashed 2:2", color orange, size 2.

d) Click **OK** when done. Examine the map.

7. Check the box in the table of contents to make visible **TWN_water**. Change the name to **Taiwan Water**. Using the steps from #5 above, change the **water** layer to be bright blue , Size:2 These are all the rivers and streams in the Yushan Mountains.

5. Elevation

1. Uncheck and minimize all layers except **Yushan National Park, N23E120.hgt, and N23E121.hgt**. The two new layers are elevation levels for the **longitude North 23** and the **latitudes East 120 & East 121**.
2. Different vegetation is associated with different elevations. For this bear study, Dr. Hwang correlated different bear foods with different elevations. Let's symbolize the elevation ranges to represent different vegetation zones. Go to the **Symbology** tab in Properties for either of the layers.

a) Explore the four options for Show: Unique values, Classifies, Stretched, and Discrete Color by clicking each and then Apply.

b) Choose the option **Classified**. Change the **Classes** to **8** and click **Classify**.

c) Change the **break values** to the following starting at the top: **500, 1000, 1500, 2000, 2500, 3000, 3500**, leaving the maximum elevation the same. It is easiest to begin with the 3500 and work your way up. Click **OK** when done. (hint: make sure the values you entered are correct, you might have to redo some values).

d) Change the **Color Ramp** to a hue or shade of 1 color. Make sure 8 discrete colors are seen easily.

e) To get rid the many 0000"s off the end of the Label, click on **Label** then **format Labels**. Change the rounding to **Number of decimal places** instead of Number of significant digits. Click **OK** when done.

f) Click **Ok** when finished with the layer and **do the same for the other Elevation layer. Make sure the color ramp is the same as well.**

6. Bears

1. Each bear has a unique set of location data (GPS and radio telemetry data). In the following steps, you will be creating Minimum Convex Polygon home range boundaries for each of the 5 research bears that we will evaluate from this study.

   The 5 bears are:

   MS6 (Male subadult)
   MA8 (Male adult)
   MA11 (Male adult)
   MA13 (Male adult)
   FA7 (Female adult)

Before you create home ranges for each bear, here's some important information about home ranges:

Animal home ranges can be estimated using several statistical methods. The simplest way to create the boundaries of a home range is to draw the smallest possible convex polygon around the locations. This is called the minimum convex polygon (MCP) method. Because this method tends to exaggerate the size of home ranges (e.g., the animal may not use all the spaces between the location points), other more complex mathematical tools have been developed. When data are available, most wildlife biologists also use other methods to calculate home ranges (example: Kernel Home Range, etc), but the MCP is useful as an introductory and comparative method and is the method we will use for the Formosan black bears.

Okay, let's make a home range for each bear individually. Ladies first:

- FA7
  a. Turn off all the layers except **FA7.shp**
  b. Change the color of FA7s points. Properties -> Symbology ->Double click on the symbol-> select Octagon 1, Size 4, color bright pink.

c. Go to the toolbar **Geoprocessing** at the top of the program. Click **Search for Tools.** Search for **minimum bounding geometry** and click it.

i. In the box, make the **Input Feature:** FA7, the **Geometry Type:** CONVEX_HULL, **Group Option**: LIST, and **Group Field**: check the box Bear_id

ii. Hit **OK** when done. It will take a few minutes to process but it will make a polygon around the bear's data points, giving you a rough scope of its home range.

iii. Once the new layer **FA7_MinimumBoundingGeometry** is in the table of contents, change the name of it to **FA7 Home Range** and open its **Properties**.

iv. Change the symbology so the minimum bounding polygon has a fill color that matches the bear's GPS points. Then hit **OK**.

- MA8, MA11, MA13, MS6:

a. Individually, make minimum convex polygon home ranges using **minimum bounding geometry** for each of the male bears using the steps described above for FA7.

2. Time to look at time. You can evaluate bear movements by date to get a better understanding of where AND when bears moved. Let's evaluate the bear MA8 first.

a) Remove all layers except: **Yushan National Park.shp** and **MA8.shp** (this is the file for the original data points for MA8, not the home range). For **MA8.shp**, go to Properties and the tab **Labels**. Click the box: **Label features in this layer**, and change the Label Field: **Date**. Click **OK**. Examine the bear's points in relation to the date to get a timeline of when and where it traveled.

b) Use the same process to evaluate movement for each of the other 4 bears individually.

c) Zoom to **Yushan National Park.shp**. Add all 5 bear home ranges. Did any bears leave Yushan National Park?

3. Let's measure each bear's home range. Use the **Measure Tool** and **Measure By Feature**. Measure each home range in km^2 and perimeters in km. Place answers in the Questions section of the Student Pages.

4. Let's see what elevations each bear used. Make **FA7.shp** visible. Click on table attributes. Right click on the elevation column and click Statistics. This will give you a statistic summary and graph.

7. Make a map layout

You will be making a poster about your findings from this study (look at STUDENT PAGES: Questions and Poster Presentations for details).

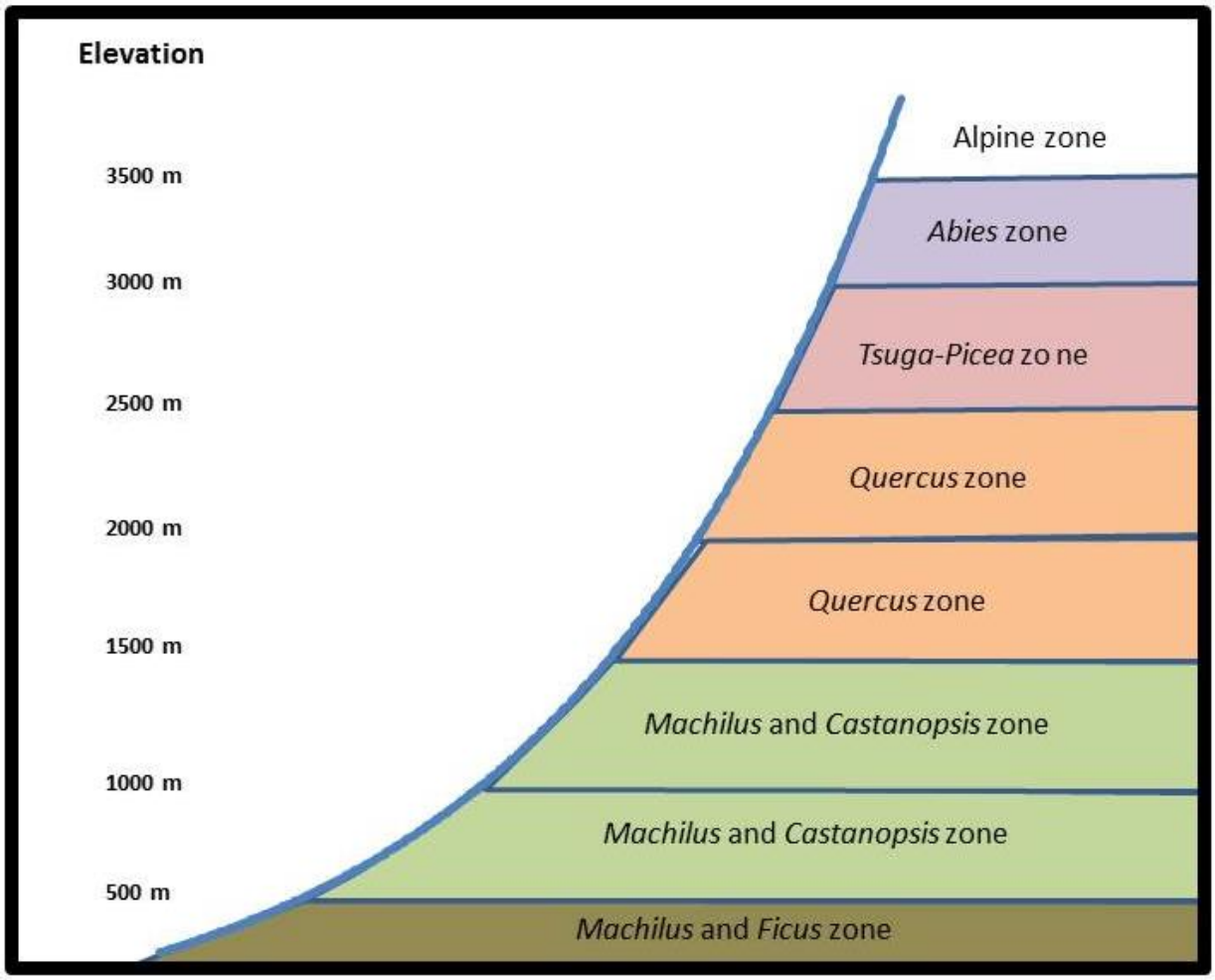
Let's make an example of a map layout that you might include in your poster.

- For this map example, make the following layers visible: **Taiwan Roads and Trails,Taiwan Water, the elevation layers, home ranges for all 5 bears, Yushan National Park.**
- **Right click Yushan National Park** in the table of contents, and click zoom to layer
- Go to the **View** tab at the top of the program and click **Layout View**. A skinny layout window will pop up. Click the **Change Layout** button (the last button to the right has two little pages with an arrow). Under the **Architectural Page Sizes** tab choose **ARCH A landscape.mxd**.(8x12in) Click **Finish**.
- Go to the **Insert** tab at the top of the program and click **Legend**. Have the Legend items only contain **Home ranges, Yushan National Park, Taiwan Water and Taiwan Roads and Trails**. Click **Finish**. Move the legend to the bottom left of the map but not on the white border.
- Double click on the **Legend**. In the Frame tab make the **Background Color**: white and the **Gap X & Y:** 2. Under the **General** tab **unclick Show** for the title. Under the **Items** tab click on **Bears** and then click **Style** below it. Scroll down the list to find the option called " **Horizontal Single Symbol Layer Name and Label**" Click it and then **Ok**. Click **OK** when finished
- Under the **Insert** tab click **Title** and name your map " **Asiatic Black Bears in Yushan National Park**." Click **Ok** when done.
- Double click the title and change symbol to make the **Text Size** 24 and **Font** Arial Black. Click **Ok** when done.
- Now your map is complete! Go to File: Export Map. Name it and keep it as a JPEG. Save it to folder you can find again.
- To go back to the data view with the table of contents and all your layers, go to the **View** tab and click **Data View**. Make another map of your choosing!

Instructions for Hypothesis 2: Habitat Use

By now you should have completed the GIS analyses to evaluate Hypothesis 1.

Let's move on to Hypothesis 2. Go back and look at Hypothesis 2 again. We need to evaluate habitat use by bears for different elevation ranges. Remember during your GIS work that you classified the elevation ranges into 8 classes? Dr. Mei Hwang did the exact same thing because she wanted to correlate elevation classes with different vegetation zones. In Taiwan, here's the general correlation between elevation and vegetation:



Step 1: Before we move on, it would be good to figure out the common names for each of the scientific names of plant species found in each zone. Do a little research to figure that out and place results below:

Machilus species: _____

Ficus species: _____

Castanopsis species: _____

Quercus species: _____

Tsuga species: _____

Picea species: _____

Abies species: _____

What plants are normally found in alpine zones? _____

Asiatic black bears in Taiwan consume mainly succulent vegetation in spring (like young shoots of grasses), soft fruits in summer, and hard mast (e.g., acorns and nuts) in fall and winter. Based on this information, which elevation zones do you think bears will use? When do you think they will use these different elevation zones?

_____

_____

_____

Which zones do you think Asiatic black bears might not use? Why?

_____

_____

_____

Step 2: Let's take a look at some data that Dr. Hwang collected. Below, you will find Table 1.

Table 1. Seasonal differences in use of elevation zones (n = 220 locations) of Formosan black bears in Yushan National Park, 1998-2001.

FEBRUARY-MAY **Elevation zone (m)**	**Proportion of bear locations SPRING**
0-500	9.5
501-1000	33.2
1001-1500	38
1501-2000	13
2001-2500	4.8
2501-3000	0
3001-3500	0
3501-4000	0
JUNE-SEPTEMBER **Elevation zone (m)**	**Proportion of bear locations SUMMER**
0-500	3.3
501-1000	15.4
1001-1500	40.5
1501-2000	39
2001-2500	10.2
2501-3000	1
3001-3500	0
3501-4000	0
OCTOBER-JANUARY **Elevation zone (m)**	**Proportion of bear locations FALL/WINTER**
0-500	0
501-1000	1.7
1001-1500	71
1501-2000	20.5
2001-2500	1.6
2501-3000	1.3
3001-3500	0
3501-4000	0

The light green part of Table 1 shows the percentage of all bear locations found in each elevation zone during summer. The light purple part shows the percentage of all bear locations found in each elevation zone during summer. The light gray part shows the percentage of all bear locations found in each elevation zone during fall. For this analysis, locations for ALL 10 bears in this study were combined (instead of evaluating each bear individually). For our home range analyses using GIS, we only evaluated 5 of these 10 bears, but for this analysis we included habitat use by all 10 bears.

GRAPH IT! Use the data in Table 1 to make 1 bar graph that shows differences in bear locations in different elevation zones during the 3 seasons.

Step 3: Now, let's take a swing at evaluating habitat selection for elevation zones by Formosan black bears. When wildlife scientists evaluate habitat selection, they include estimates of both HABITAT USE and HABITAT AVAILABILITY. Looks like we'll need some additional data to determine whether or not Formosan black bears in Taiwan SELECTED different elevation zones.

Before we do that, it's important to remind you that the data set on Formosan black bears you will be using is small relative to many data sets from research studies on bears in the US and Europe (e.g., American black bears, brown bears, polar bears). For the study that you are evaluating, Dr. Hwang and her crew were able to capture 15 bears. For 5 of these bears, Dr. Hwang was not able to collect adequate location data for analyses. Dr. Hwang was able to use bear location data from 10 bears for her analyses. You will evaluate 5 of those 10 bears. Many North American scientists strive to collect data on at least 30 individuals of a population to meet statistical assumptions. In this particular study, Dr. Hwang and her crew were limited by several constraints:

1) the Formosan black bears have a very low population density so it is difficult to even find them
2) the Formosan black bears are very wary so it's difficult to catch them
3) the rugged terrain makes it very difficult to hike into bear habitat and then track bears when they are collared

What does this mean for you? It means that your conclusions will be somewhat limited because there's a lot of uncertainty when sample sizes are small (sample size for this study = the number of bears collared). For this analyses, the sample size = 10 bears.

We can still evaluate habitat selection, we just need to be careful with the strength of our conclusions. Let's take a look at a different table.

This second table is a bit more involved, so we've placed it in an excel file for you.

- Open the data file named "Data for students"
- Look at the columns and rows. Notice that some data are missing
- **It is your job to fill in these missing cell values in the excel table**

You will notice that you need to complete the values for "Ivlev's Electivity Index" (Ivlev 1961), modified to make it symmetrical with respect to zero. This is an index of habitat selection. It does not include estimates of error, like 95% confidence intervals. In her analyses, Dr. Hwang DID evaluate habitat selection using Chesson selection indices, and she DID estimate confidence intervals for each value (i.e., estimates of error), but that type of analysis is beyond the scope of this lesson plan. For our purposes, calculating Ivlev's Index will provide results that are qualitatively similar to the results that Dr. Hwang found.

The Ivlev's Index provides an index of habitat selection. Here's the equation:

$$\text{Ivlev's Index}_i = \frac{2 \times (\text{Habitat Use}_i - \text{Habitat Availability}_i)}{1 + (\text{Habitat Use}_i + \text{Habitat Availability}_i)}$$

For our analyses, the following terms are defined as:

Ivlev's Index_i = habitat selection for habitat "i"
Habitat Use_i = the proportion of total bear locations in elevation zone "i"
Habitat Availability_i = the proportion of the total study area in elevation zone "i"

When Ivlev Index = 1, this means the elevation zone was used in proportion to its availability. When the value = 1, then bears neither selected nor avoided this zone.

When Ivlev Index > 1, this means that the elevation zone was used more than it was available. Bears selected this zone. The higher the number, the more bears selected the zone.

When Ivlev Index < 1, this means that the zone was used less than it was available. Bears avoided this zone. The lower the number, the more bears avoided the zone.

Okay! You have enough information now to complete the cells in Table 2. When you are done, move on to the "Student Pages: Questions and Posters".

Citations:

IVLEV, V. S. 1961. Experimental ecology of the feeding of fishes. Yale University Press, New Haven, Connecticut.

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