Asiatic Black Bears
Conservation in Taiwan
Teacher's Guide

STEM Lesson Using Real-World GIS Data

By design, this lesson does not require teachers to know anything about Asiatic black bears or GIS. The spatial component of this lesson plan is designed for beginner GIS students.

This lesson has been aligned with Next Generation Science Standards, Common Core State Standards, NSES National Science Standards, and NCTM National Math Standards. For a complete description of standards, please see the end of this Teacher's Guide.

Lesson Synopsis

This lesson uses the flipped learning model where teachers don't stand before the class and lecture. Instead, students become Asiatic black bear scientists and "discover" the answers to real-world research questions through scientific inquiry.

Using the scientific method, real-world GIS data, and ArcView GIS software, students map location data for wild bears, create home ranges, graph data about bear habitat use, calculate habitat selection, interpret data, and answer real-world questions that have conservation implications for endangered wild black bears living in Taiwan. Students may share their scientific findings globally by participating in Bear Trust's VIRTUAL POSTER SESSION.

Grade Level: 9-12

Next Generation Science Standards: HS-LS2-2, HS-LS2-6; HS-LS2-7; 12 Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts
Common Core State Standards: MATH: CCSS.Math.Content.HSS-ID.B.5; ID.B.6; IC.B.6; IC.B.9; IC.1; IC.4; IC.5;IC.6;N-Q.1;N-Q.2; Q.A.2; IF.B.4; IF.C.9
LITERACTY: CCSS.ELA Literacy.RST.9-10.1; 9-10.2; .9-10.3;.9-10.4; .9-10.5, .9-10.6, .9-10.7, 9-10.8,.9-10.9,**NSES National Science Standards:** A 1-6, C, and G; **NCTM National Math Standards:** 4, 5 & 6

A complete list of standards are available at the end of this Teacher's Guide

Subjects: Science, Math, Technology

Duration: Approximately 3 class periods

Materials for lesson:
-Video: "Asiatic Black Bears: Conservation in Taiwan"
-Student Pages: Background, Hypotheses, and Predictions
-Student Pages: Instructions for Analyzing Data
-Student Pages: Questions & Poster Presentations
-Excel file "Habitat Use and Selection Data"
-Zipped file "ABBGIS_Spatial Data"
-ArcGIS
This software is free. See Special Instructions in Lesson Materials in Teacher Guide for details.
-Excel software OR calculators and graph paper
-2 Answer Keys
-Teacher Guide

All materials are available for free download at: www.beartrust.org

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Photo image of bear in this Teacher Guide provided courtesy of Shutterstock

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Lesson Objectives

1. Students will actively participate in the process of scientific discovery, using real-world data from research done on wild Asiatic black bears in Taiwan.

2. Students will develop hypotheses, develop predictions, analyze predictions using real data, interpret analyses, draw conclusions, and share findings with their peers.

3. Students will analyze and interpret data, using models and digital tools.

4. Students will learn and use GIS technology skills to estimate home ranges for wild research bears and answer the real-world question, "is the biggest reserve in Taiwan large enough to support the endangered subspecies of Asiatic black bears?"

5. Students will use mathematics and computational thinking to calculate habitat selection (using Ivlev's Electivity Index; equation provided) and habitat use by wild bears. Students will create bar graphs and critically evaluate/interpret graphs and tables.

6. Students will use mathematical representations of phenomena to support explanations.

7. Students will construct explanations supported by multiple and independent student-generated sources of evidence.

8. Students will use equations (all equations are provided) and real-world data to calculate missing information in tables, graph the data, and analyze/interpret results.

9. Students will hone skills in communication as they engage in a range of collaborative discussions.

10. Students will present findings to their peers(via in-class presentations and discussions, and through a virtual poster session), emphasizing important facts with relevant evidence.

11. Students will work individually and cooperatively as they solve problems, construct explanations, hone critical thinking skills, and design solutions.

12. Students will learn that poaching and habitat degradation are the two most important issues facing the conservation of Asiatic black bears.

Acknowledgements

Special thanks to Dr Mei-Hsiu Hwang for sharing some of her research data with Bear Trust International and for her dedication to the conservation of wild Asiatic black bears.

Lesson Materials

All lesson materials are available for free download on Bear Trust International's website: **www.beartrust.org**

- Introductory video: ***"Asiatic Black Bears: Conservation in Taiwan"***
- Teacher Guide (i.e., the guide you are reading)
- "Student Pages: Background, Hypotheses, and Predictions"
- "Student Pages: Instructions for Analyzing Data"
- "Student Pages: Questions and Poster Presentations"
- Excel Data File: "Habitat Use and Selection Data"
- Spatial Data File: "ABBGIS Spatial Data" (zipped for easy download)
- Answer Keys
    - "ANSWER KEY: Habitat Use and Selection", an excel file which provides all graphs and missing cell values in the excel data set about habitat use and selection
    - "ANSWER KEY to Student Questions", a word document
- Excel graphing software, or graph paper and calculators for each student
- SPECIAL INSTRUCTIONS:
    - If your school has a SCHOOL CAMPUS LICENSE for ESRI products, then you already have the necessary software 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
    - If you are a **Montana school** you already have permission to use ArcMap for education at no cost. Contact Melissa Reynolds-Hogland for instructions on how to access it.

Background Information for Teachers

There are 8 species of bears worldwide: American black bear, Asiatic black bear, brown bear, giant panda bear, polar bear, sloth bear, spectacled bear, and sun bear. Of these 8 species, 6 are listed as Endangered or Vulnerable (not endangered, but facing high rate of extinction in the wild) by the International Union for Conservation of Nature (IUCN). Only the American black bear and brown bear are considered species of Least Concern globally.

For this lesson plan, your students will be using real-world data from the **first** bear capture study ever done in Taiwan on wild Formosan black bears (*Ursus thibetanus formosanus*), an endangered subspecies of the Asiatic black bear (*Ursus thibetanus*). During 1998-2000, Dr. Mei-Hsiu Hwang and her research team trapped, collared, and tracked wild Formosan black bears to determine whether or not Yushan National Park, the largest national park in Taiwan at the time of this study, was large enough to support the resident Formosan black bears. Dr. Hwang also wanted to evaluate habitat use by these wild bears.

In Taiwan, protected areas are considered critical to conserving endangered species like the Formosan black bears. Yushan National Park is an ecologically protected area where hunting is not permitted. Very little human activity occurs inside the Park. Although it is illegal to hunt Formosan black bears anywhere in Taiwan, bears that travel outside the boundaries of Yushan National Park face relatively greater risk of mortality due to poaching.

Before Dr. Hwang did her research, no one really knew if Yushan National Park was big enough to support the endangered bears. Protected areas will only be effective if they can provide the habitat and spatial needs of the animals you are trying to conserve. In this particular case, if Yushan National Park did not provide all the resources that Formosan black bears needed, then bears might travel outside the park where mortality risk is higher due to poaching.

Major Threats to Asiatic Black Bears: Illegal hunting and trade of bear parts, along with habitat degradation, are the two primary threats to the persistence of these bears. Although it is illegal to hunt, capture, or kill these bears in most places, it's difficult to enforce regulations owing to lack of funding, lack of conservation commitments among some managers and the public in some areas, and low accessibility of bear habitat for patrolling.

SIZE OF THE DATA SET

It's important to mention that the data set on Formosan black bears your students 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). Research funding for bear species found in US and in Europe, and for giant panda bears, has been relatively more abundant than that for bear species like Asiatic black bears, spectacled bears, sun bears, and sloth bears. The four latter bear species are all listed as vulnerable owing to fragmented, small population sizes and decreasing numbers due to continuous human-caused threats. For most vulnerable species, their populations occur in low densities, animals are wary, and they live in remote places that are difficult for scientists to access. For these reasons, it is extremely difficult to collect data on most vulnerable species, including the Formosan black bears in Taiwan.

For the study that your students 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. Why? Several reasons, including possible collar breakage, possibility of bears moving out of receiver range, and possibility of mortality by illegal hunting.

Dr. Hwang was able to use bear location data from 10 bears for her analyses. Your students 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

The bottom line is this: it is extremely difficult to capture and track Formosan black bears. Just to hike into the study area took 3-4 days. That Dr. Hwang captured any bears at all is an amazing feat!

Conservation of vulnerable and endangered species for which populations are very small and difficult to track is complex. Dr. Hwang is dedicated to the conservation of Asiatic black bears. To this aim, one of her goals is to use the best science available to learn about habitat needs of these bears. The hope is that if we better understand habitat and spatial needs, we will be better able to conserve these amazing animals.

Lesson Procedure

1. Show your students the Introductory Video called ***"Asiatic Black Bears: Conservation in Taiwan"***

You can either present the short video to the entire class, or assign it as homework.

2. At the conclusion of the video, tell your students that they are now Asiatic black bear scientists using real-world data and GIS. Assure them that they don't need to know anything about GIS to successfully complete this task. All the instructions are provided for them.

Tell your students that they need to work through the entire scientific process to answer the question, "is Yushan National Park big enough to support the Asiatic black bear population?". Tell them that they will also be evaluating habitat use and habitat selection by the wild bears.

Because your students will be scientifically evaluating the real-world data collected by Dr. Hwang and her field crew, they will need to use the scientific process, which includes at least the following steps:

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

You can tell them, "Unfortunately, we don't have time to design field studies, determine statistical estimators, and tromp around in the mountains of Taiwan to collect these data. Dr. Mei-Hsiu Hwang and her research team already did that fun stuff! Lucky for us, Dr. Mei has shared her data with you, so your students can participate in Steps 1, 2, 5, 6, and 7".

3. Hand out " Student Pages: Background, Hypotheses, and Predictions" to each student. If your students have experience developing hypotheses and corresponding predictions, then this step will take about 2 minutes. If your class does not have experience with hypothesis and prediction development, you may need to spend a little time helping them come up with appropriate hypotheses and predictions that they can test with their data.

4. When students have completed the Hypothesis and Prediction pages, hand out the "Student Pages: Instructions for Analyses" AND the Student Pages "Questions and Poster Presentations". Tell them they will be working on Hypothesis 1 first and provide them the data file called "ABBGIS Spatial Data". Provide them access to ArcMap (to download for free see "special instructions" in the "materials needed" section above). Tell them to work independently, following the instructions for the GIS analyses. The GIS instructions are designed for beginner GIS users. Your students should have a lot of fun!

Go around to each student and make sure they are on the right track. You have all the answers to the GIS questions in your answer key.

5. When students have completed the GIS Analyses, make sure they have answered the corresponding questions relative to their GIS analyses in their "Student Pages: Questions and Poster Presentations".

6. When students have completed answering their GIS questions, tell them to begin working on analyses for Hypothesis 2. Give your students access to the excel data file to your students called "Habitat Use and Selection Data". For this activity, students will be using real-world data in a table to create a graph showing habitat use by bears. They will also be using an equation and real-world data to calculate estimates of habitat selection.

Go around to each student and make sure they have created the correct graph and completed the habitat selection table correctly (look in the excel file "Habitat Use and Selection Answer Key", which provides the graph and completed table with correct equation values). If their graphs or tables are not correct, help them complete them to ensure they have the correct results from which to draw conclusions and present findings.

7. When students have completed the Analyses for Habitat Use and Selection, make sure they have answered the corresponding questions relative to their analyses in their "Student Pages: Questions and Poster Presentations".

8. Next, tell your students that the last step in the scientific process is to share findings with peers and the public. One way that real scientists share findings is at scientific conferences and meetings, during which scientists give presentations and participate in scientific poster sessions. You can hold a classroom scientific conference, where your students share their posters. In addition, you can ask you students to share findings beyond the classroom via the Bear Trust Virtual Poster Session. In their "Student Pages: Questions and Poster Presentations", students are provided instructions on what they should include in their posters.

Send completed posters for the Virtual Poster Session to: melissa@beartrust.org

9. As a wrap up to this lesson, you can have your students engage in a discussion about this real-world conservation topic. Discuss the answers to their questions from their "Student Pages: Questions and Poster Presentation". Several of the questions in the Student Pages make great jumping off points for in-depth classroom discussions. Remember, you have all the answers to these questions in your Answer Key.

Some additional potential guiding questions include:

- What did you learn about Asiatic black bears?
- What are the 2 most important conservation issues facing this species?
- What can we do to help conserve these wild bears?
- Is the Yushan National Park big enough to support the resident Asiatic black bears that live in/near the Park?
- What implications does your findings have for the conservation of these bears?
- What limitations did Dr. Mei Hwang face with her field research?
- Why was she able to collar and track only 10 bears for this work? What implications does this small sample size have for the conclusions?
- What additional information might you need to make stronger conclusions about findings from your analyses?
- If you were to design a field study on wild bears anywhere, what questions would you ask and how would you design your study?

Note: this lesson is specifically designed using the flipped learning model. Rather than asking teachers to lecture, we ask students to discover the answers and share findings. As such, most of the informational content (including definitions and explanations) are included in the Student Pages and in the Datasets. For example, in the excel data set, definitions are provided for column headings and for other terms.

Next Generation Science Standards: High School

Performance Expectations:

HS-LS2-2: Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales

HS-LS2-6 : Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem

HS-LS2-7: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity

Science and Engineering Practices:

Asking questions and Defining Problems

Developing and Using Models

Using Mathematics and Computational Thinking

Constructing Explanations and Designing Solutions

Engaging in Argument from Evidence

Scientific Knowledge is Open to Revision in Light of New Evidence

Analyzing and Interpreting Data

Disciplinary Core Ideas:

Interdependent Relationships in Ecosystems

Developing Possible Solutions

Ecosystem Dynamics, Functioning, and Resilience

Crosscutting Concepts:

Cause and Effect

Systems and System Models

Common Core State Standards: Math

CCSS.Math.Content.HSS-ID.B.5: Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.

CCSS.Math.Content.HSS-IC.B.6: Evaluate reports based on data.

CCSS.Math.Content.HSS-IC.B.9: Distinguish between correlation and causation.

CCSS.Math.Content.HSS-IC.1: Understand statistics as a process for making inferences about population parameters based on a random sample from that population.

CCSS.Math.Content.HSS-IC.4: Use data from a sample survey to estimate a population mean or proportion; develop a margin of error through the use of simulation models for random sampling.

CCSS.Math.Content.HSS-IC.5: Use data from a randomized experiment to compare two treatments; use simulations to decide if differences between parameters are significant.

CCSS.Math.Content.HSS-IC.6: Evaluate reports based on data.

CCSS.Math.Content.HSS- N –Q1: Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

CCSS.Math.Content.HSS-N-Q2: Define appropriate quantities for the purpose of descriptive modeling.

CCSS.Math.Content.HSN-Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

CCSS.Math.Content.HSF-IF.B.4: For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship

CCSS.Math.Content.HSF-IF.C.9: Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions).

Common Core State Standard Connections: Literacy

CCSS.ELA-Literacy.RST.9-10.1: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

CCSS.ELA-Literacy.RST.9-10.2: Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.

CCSS.ELA-Literacy.RST.9-10.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text

CCSS.ELA-Literacy.RST.9-10.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context

CCSS.ELA-Literacy.RST.9-10.5: Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., *force, friction, reaction force, energy*).

CCSS.ELA-Literacy.RST.9-10.6: Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.

CCSS.ELA-Literacy.RST.9-10.7: Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

CCSS.ELA-Literacy.RST.9-10.8: Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.

CCSS.ELA-Literacy.RST.9-10.9: Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.

NSES National Science Standards

Standard A: Science as Inquiry 1-6

1. Identify questions and concepts that guide scientific investigations (STEM)
2. Design and conduct scientific investigations (STEM)
3. Use technology and mathematics to improve investigations and communications (STEM)
4. Formulate and revise scientific explanations and models using logic and evidence (STEM)
5. Recognize and analyze alternative explanations and models (STEM)
6. Communicate and defend a scientific argument (STEM)

Standard C: Life Science 6; Students will understand the behavior of organisms (STEM)

National Math Standards NCTM

Standard 4: Measurement (STEM)

a. Understand measurable attributes of objects and the units, systems and the processes of measurement (STEM)

Standard 5: Data Analysis and Probability

a. Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them

b. Select and use appropriate statistical methods to analyze data

c. Develop and evaluate inferences and predictions that are based on data

Standard 6: Process

- Build new mathematical knowledge through problem solving
- Solve problems that arise in mathematics and in other contexts
- Apply and adapt a variety of appropriate strategies to solve problems
- Monitor and reflect on the process of mathematical problem solving

Reasoning and Proof

- Make and investigate mathematical conjectures
- Develop and evaluate mathematical arguments and proofs
- Select and use various types of reasoning and methods of proof

Communication

- Organize and consolidate their mathematical thinking through communication
- Communicate their mathematical thinking coherently and clearly to peers, teachers, and others
- Analyze and evaluate the mathematical thinking and strategies of others;

Connections

- Recognize and use connections among mathematical ideas
- Understand how mathematical ideas interconnect and build on one another to produce a coherent whole
- Recognize and apply mathematics in contexts outside of mathematics

Representation

- Create and use representations to organize, record, and communicate mathematical ideas
- Select, apply, and translate among mathematical representations to solve problems

- Use representations to model and interpret physical, social, and mathematical phenomena