



Roadkill Reduction with GIS

Learning to Use Layers

What factors influence roadkill densities on our streets and highways? What steps can we take to protect wildlife?

Authors: Elizabeth Bastiaans, PhD candidate and SCWIBLES Graduate Fellow, Ecology and Evolutionary Biology, University of California, Santa Cruz;

Daniel Johnston, Teacher, Environmental Science and Natural Resources Academy, Watsonville High School, Watsonville, CA

Field-tested with: 12th grade students in the Green Careers Course, ESNR Academy, Watsonville High School, Watsonville, CA (Spring, 2010)

Concepts: Geographic Information Systems, Hypothesis Testing, Human Impacts on Wildlife

Skills: Map reading, basic GIS skills, developing and testing hypotheses, linear regression

Module Type: computer lab activity

Duration: 1 2-hour class session

Key materials:

- Computers (minimum of 1 for every 2 or 3 students)
- Internet access & browser
- Google Earth loaded on to computers
- Class set of handouts with background information, protocol, and scaffolding for hypothesis generation and testing
- .kmz file containing roadkill data points for the geographic zone of analysis

Science Education Standards:

National: Science As Inquiry; Science and Technology; Science in Personal and Social Perspectives

California: Biology-Life Sciences: 6b. Ecology (habitat alteration); Investigation and Experimentation: 1a, 1c, 1d, 1h, 1j, 1l, 1m

Overview: Students use Google Earth to learn how Geographical Information Systems (GIS) technology can help solve environmental problems. They also develop and test their own original hypotheses about roadkill, a familiar, local environmental issue.

This project is an opportunity for students to investigate what factors may affect the frequency of roadkill on highways in their area. By combining multiple GIS layers in Google Earth, students develop and test hypotheses about which other landscape features may be correlated with roadkill frequency. They discuss what mechanisms might cause these correlations and what steps they could take to reduce the impact of cars on wildlife. Finally, the students discuss the difference between correlation and causation and what factors might bias their analyses. This module also introduces students to the power and widespread availability of open-source data and data analysis programs.

Background for Teachers

Geographic Information Systems (GIS) include the methods and technology used to analyze data that include spatial locations. Businesses, the military, government agencies, and scientists use GIS technology and methods to answer a huge variety of questions, many of them with important environmental implications.

This module uses GIS to reduce negative human impacts on wildlife. Specifically, this module uses one of the most familiar, accessible representations of GIS (Google Earth) in conjunction with prepared data sets, to ask what factors might influence the frequency with which drivers kill animals on highways. Roadkill is poorly studied, but it probably has an important impact on wildlife. The Humane Society of the United States estimates that 1 million animals are killed every day on American roads.

This module also focuses on critical thinking and problem-solving. By visualizing multiple layers of computer maps, students learn about correlation, and then think critically about what could produce these relationships. They generate and trouble-shoot hypotheses about these correlations, brainstorm possible solutions to diminish roadkill, and present their work afterward.

Science Education Standards Addressed:

This module addresses National Science Education Standards A. Science As Inquiry (p.175-176); E. Science and Technology (p.192-193); F. Science in Personal and Social Perspectives (p.198-199), as well as the following Science Content Standards for California Public Schools:

Biology-Life Sciences, 6. Ecology: Stability in an ecosystem is a balance between competing effects.

b. Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size (p. 54).

Investigation and Experimentation, 1. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing content in the other four strands, students should develop their own questions and perform investigations. Students will:

a. Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.

c. Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.

d. Formulate explanations by using logic and evidence.

h. Read and interpret topographic and geologic maps.

- j.** Recognize the issues of statistical variability and the need for controlled tests.
- l.** Analyze situations and solve problems that require combining and applying concepts from more than one area of science.
- m.** Investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. Examples of issues include irradiation of food, cloning of animals by somatic cell nuclear transfer, choice of energy sources, and land and water use decisions in California.

NSES (<http://www.nap.edu/catalog/4962.html>)

SCSCPS (<http://www.cde.ca.gov/be/st/ss/documents/sciencestnd.pdf>);

Common Student Misconceptions:

When we taught this project, our students often were confused about the difference between determining what factors affect the likelihood animals will be killed on roads, and proposing strategies to protect animals. They also struggled a lot with the idea of calculating “density.” The section of the lab that requires the students to choose five different stretches of road on which to calculate roadkill density and the density of whatever feature they hypothesized might affect roadkill density was particularly challenging. It would help for the instructors to go through the whole lab as an example before asking the students to follow the instructions. (See Appendix for handouts.)

Project Description

Materials:

- Computers with Google Earth installed and access to the internet (enough for students to work in groups of 2-3)
- .kmz file containing roadkill data points (please see Preparation section, below for instructions on how to create this)
- Class set of handouts with protocol and background information (see Appendix)

Preparation:

Teachers will need a list of georeferenced locations (locations with latitude and longitude) where roadkill has been discovered, within a defined geographic area. This can be compiled from the California Roadkill Observation System website (<http://www.wildlifecrossing.net/california/>) or requested from its administrators. In order to access the CROS data, teachers will need to create a user profile, which can be done on the homepage by clicking “Create New Account.” As an extension to the lesson, students may create their own profiles, which will allow them to upload their own roadkill observations if they have access to a GPS receiver. During the in-class lab,

students will likely be most interested in studying a geographic area near where they live, if the appropriate data are available.

The georeferenced locations should be saved in an Excel spreadsheet with three columns: species, latitude, and longitude. Use the .csv (comma separated values) format to save the file, rather than the default (.xls or .xlsx). The data can then be converted to a .kmz file that will open in Google Earth, using the GPS Visualizer website (<http://www.gpsvisualizer.com/>). For further instructions, read the tutorial on converting data files: <http://www.gpsvisualizer.com/tutorials/waypoints.html>. The file should be uploaded to all student computers prior to the activity.

Timeline:

1. Introductory discussion and background reading (15 min.)
2. Teacher explanation and demonstration (10 min.)
3. Hypothesis generation (15 min.)
4. Hypothesis testing (50 min.)
5. Student reporting of results (20 min.)

Procedure:

1. Introductory discussion and background reading

Students read the background information on the handout, "What is GIS? And Why Are There So Many Dead Animals on the Side of the Road?" and discuss the importance of maps and how modern GIS technology expands the kinds of applications for which they can be used. They also discuss the problem of roadkill and what factors might make it more or less likely that animals will be killed on a given street or highway.

2. Teacher explanation and demonstration

Teachers then walk them through the steps of the lab. Please read the handouts included as an appendix for detailed instructions on the laboratory exercise. Depending on the students' level of experience with computers and mathematics, it may be necessary for teachers to demonstrate the entire exercise for the class before asking the students to perform the analysis.

3-4. Hypothesis generation and testing

Students work individually or in small groups to complete the lab. The testing component includes analyzing results, and, if there is time, completing bonus questions in which students examine their assumptions and explore further possibilities about the patterns they found.

5. Students report results

Teachers ask student groups to describe to the rest of the class what hypotheses they tested and whether or not the factors they chose appear to be correlated with roadkill density.

Assessment Methods:

Teachers can evaluate students' answers to the questions in the protocol. This lab could also be used as a starting point for a more involved project, which could incorporate outside research and end with a report or a presentation.

Appendices

Lab Handouts

- Background Reading: What is GIS? And Why Are There So Many Dead Animals on the Side of the Road?
- Hypothesis generation
- Hypothesis testing
- Bonus Questions

What Is GIS? And Why Are There So Many Dead Animals on the Side of the Road?

You may have used websites like Google Maps or Mapquest to look up directions to an unfamiliar address. Or maybe you used a GPS (Global Positioning System) to help you navigate while driving in a car. You might even have a cell phone that can tell you where you are and help you find a great new restaurant for lunch. All these tools are made possible by a field called **Geographic Information Systems**, or **GIS**.

Geographic information systems include the methods and technology used to analyze data that incorporate spatial locations. GIS analysts use maps (both digital and paper), aerial and satellite photos, and **remote sensing** tools like radar or sonar to put information into a useful geographic context.

Businesses, the military, government agencies, and scientists use GIS technology and methods to answer a huge variety of questions, many of them with important environmental implications. For example:

- Where is the best place to construct a new wind farm or solar array?
- What routes do migratory animals (birds, whales, turtles, etc.) use most often, and how can humans avoid disrupting them?
- Which habitats are most important for conserving a certain endangered species?

Today, you'll be using Google Earth, a free, web-based GIS program, to answer some questions about one visible way humans harm wildlife – hitting animals with cars to create roadkill. We'll use data from the California Roadkill Observation System (CROS), a website that collects information about roadkill sightings from volunteer citizen scientists. The Humane Society of the United States estimates that 1 million animals are killed every day on American roads and highways. CROS hopes to reduce those impacts by creating a database that scientists and government agencies can use to understand what factors make encounters between cars and wildlife more likely. Today, you and your classmates will contribute to those efforts by analyzing CROS data for Santa Cruz County.

For more information about Google Earth, visit:

<http://www.google.com/earth/index.html>

For more information about the CROS, visit: <http://www.wildlifecrossing.net/california/>

Hypothesis generation

On the desktop of your computer, you should see a file called "Roadkill Data for Green Careers.kmz." Files with the extension .kmz contain data points with geographic coordinates (latitude and longitude) that can be opened in Google Earth. This file will display all the roadkill data collected by the CROS for Santa Cruz County from September 2009 to January 2011.

1. Double click on the file "Roadkill Data for Green Careers.kmz."

You may see a "Startup Tip," which will tell you something interesting you can do with Google Earth. If so, click "Close." You should now see a satellite image of Santa Cruz County, with black and white squares showing locations where roadkill observations were made. Each square is labeled with the species of animal that was killed.

2. Spend a few minutes exploring Google Earth and the roadkill data.

You can move the map around by using the hand tool to "grab" onto it. Zoom in and out using the sliding bar in the upper right hand corner of the map. Do you see any landmarks you recognize? Can you find your house or school? Do you notice anything right away about how the roadkill data points are distributed? There are more points in some areas than in others. What do you think might cause this?

3. Write down two hypotheses (ideas you might want to test out) for what might explain why there are more roadkill data points in some areas than in others.

Hypothesis 1:

Hypothesis 2:

In the bottom left corner of the map, you should see a menu labeled “**layers.**” **Layers** are an important feature of GIS. Each layer usually contains information that relates to a particular theme, such as rivers, towns, roads, etc. You can think of layers like sheets of transparent plastic that are placed over the map and can be stacked on top of each other to show how elements in different layers are related. Indeed, the roadkill data file you are currently looking at is one example of a GIS layer. We’ll be using some of the other layers included with Google Earth to determine what landscape features may be related to the density of roadkill observations in Santa Cruz County.

4. Turn on the “Roads” layer by clicking on the box to the left of the label.

You should start to see streets, roads, and highways appear on the map. Take a few minutes to zoom in and out and move the map around. See if you can find some streets you recognize.

5. Which roads seem to have the most roadkill data points? Why do you think this might be? Do you have anything to add to your hypotheses from question 3? Answer these questions below.

Hypothesis testing

In order to determine what factors might increase the frequency with which people kill animals with their cars, you’ll be measuring the **density** of roadkill along five different stretches of road. For our purposes, roadkill **density** is defined as:

$$(\# \text{ of animals killed})/(\text{km of road available})$$

To measure distance in Google Earth, you can use the ruler tool. **Click on the picture of the ruler in the bar at the top of the map.** A menu will pop up that allows you to choose the units of measurement and either the “line” or “path” method of measuring distance. Choose “**kilometers**” as your unit of measure (this is a science class, so we’ll be using the metric system!). The “line” method measures the shortest

path between two points, while the “path” method lets you measure the total length of a series of shorter lines. Since most roads aren’t perfectly straight, you should choose the “**path**” method here. Use a series of short lines to approximate curved roads; the more curved the road, the shorter your line segments should be. **Practice measuring a few distances to get the hang of the tool.** Ask for help if you’re having trouble.

6. Choose five different stretches of road, each between 1 and 2 kilometers long. In the table below, record the stretches of road you chose, as well as their lengths. Write down the boundaries of each stretch of road (use cross streets) and use the “path” method described above to measure the lengths. Make sure each of the stretches of road you choose contains at least a few roadkill data points, but try to choose areas with different densities of roadkill.

Boundaries (cross streets)	Length (km)	# of Roadkill Points	Roadkill Density (# of roadkill points/km)

7. Now, count the number of roadkill data points along each stretch of road, and record those numbers in the table.

8. Calculate the density of roadkill along each road using the equation from step 5.

9. Now look back at the hypotheses you wrote in step 2, and then look at the different layers available in the “layers” menu. Do you think any of the available layers might let you test either of your hypotheses? If not, can you come up with any new hypotheses that you could test with the available layers?

10. Choose a layer that you think might contain information that will help explain the differences in roadkill density you saw in the roads you chose above. That is, choose a layer whose data points you think will make it either more or less likely that people will hit animals with their cars. For example, people might be more likely to hit animals near parks, so you could try looking at the number of parks located along the stretches of road you chose.

Name of Layer to Analyze: _____

11. Click on the box next to the layer you've chosen, so that the information it contains appears on the map.

12. Just as you did for roadkill data points above, calculate the density of data points from the layer you chose and write it in the table. Use only those data points that are located right next to the roads.

Boundaries (cross streets)	Length (km)	# of _____ Points	_____ Density (# points/km)

13. Analyze the results. Does it look like your hypothesis was correct? Write a few lines about any patterns you notice in your data:

Bonus Questions:

1. How might this analysis be improved? When you find a correlation between roadkill density and the density of some other element in another layer and then suggest that this means the element causes increased or decreased roadkill frequency, you make several assumptions. Can you describe any of these assumptions? What further information might help you decide if your assumptions are valid?

2. Did you notice any patterns in which species of animals were killed in which places? If so, what do you think might cause these patterns? How might you test your hypotheses?

Reference List

CROS: <http://www.wildlifecrossing.net/california/>

GPS Visualize: <http://www.gpsvisualizer.com/>

Humane Society: <http://www.humanesociety.org/>