An in-depth look at scientific solutions to a real-world problem

Wildlife and Highway Management

Lesson 2: How Do We Solve the Problem of Wildlife on Our Roads?

LESSON OVERVIEW

Students use actual scientific data to evaluate the movement of elk. Using this information, they must determine where to build three wildlife bridges or underpasses along the highway as well as develop several cost-saving alternatives. They will write a formal report to present their findings.

SUGGESTED GRADE LEVELS

- 7 – 12

ENDURING UNDERSTANDINGS

- Accurate and reliable data need to be analyzed impartially to develop conclusions.
- Technology has improved data collection for scientists.

OBJECTIVE

Students will:

- Analyze tables and graphs to come to a conclusion.
- Write a report in which their conclusions are supported by facts.

ARIZONA DEPARTMENT OF EDUCATION STANDARDS

Grade	Science	Mathematics	Writing
7	S1-C3-01; S1-C3-05; S1-C4-02; S1-C4-03; S1-C4-05; S3-C1-03; S3-C2-01; S3-C2-02	S2-C1-03; S2-C1-04; S2-C1-05; S2-C1-07; S2-C1-08; S2-C1-09	S2-C1-01; S2-C1-03; S2-C1-04; S2-C2-03; S2-C2-05; S2-C3-02; S2-C3-04; S2-C4-01; S2-C4-03; S2-C5-02; S3-C2-01; S3-C2-03
8	S1-C3-01; S1-C3-05; S1-C4-01; S1-C4-02; S1-C4-03; S1-C4-05; S3-C2-01; S3-C2-02	S2-C1-03; S2-C1-07; S2-C1-08	
High School	S1-C1-01; S1-C4-01; S1-C4-02; S1-C4-03; S1-C4-04; S3-C1-01; S3-C1-03; S3-C1-04; S3-C2-02; S3-C2-03; S3-C2-05	S2-C1-02; S2-C1-08; S2-C1-09; S2-C1-11	S2-C1-03; S2-C1-05; S2-C2-03; S2-C2-05; S2-C3-02; S2-C3-03; S2-C4-01; S2-C4-02; S2-C4-03; S2-C5-03; S3-C2-01

Note: The full text of these standards can be found in Appendix A.

TIME FRAME

- Two to three days (45 minutes each day)

An in-depth look at scientific solutions to a real-world problem

MATERIALS

- *How Do We Stop Wildlife-Vehicle Collisions* worksheet (one per team)
- *Ecology* of *Elk* worksheet (one per team)
- *Elk Movement Research* worksheet (one per team)
- *Research Rubric* (one per team)
- Computers with Internet access (one per team) or copies of various Web sites for research

TEACHER PREPARATION

- Make copies of the *How Do We Stop Wildlife-Vehicle Collisions*, *Ecology of Elk*, and *Elk Movement Research* worksheets and the *Research Rubric* for each team. You might also want to make copies for each student.
- If computer access is not available, preview the Web sites and print out relevant information. You should find specific ways to prevent wildlife-vehicle collisions. Make copies of these for students to use in class.

SUGGESTED PROCEDURES

1. Divide the class into teams and hand out the worksheets.
2. Read the first worksheet, *How Do We Stop Wildlife-Vehicle Collisions*, as a class and review the map of proposed sites.
3. Inform the teams that the remaining worksheets present data on elk ecology and elk movements across the highway. They must analyze the data to determine where to build the bridges or underpasses. They will then use the computers or the printed material to research alternatives to bridges and underpasses and determine if any will work best in this situation. Each team (or each student if you prefer) will then write a research report that explains their conclusions.
4. Be sure to allow sufficient time. This portion of the assignment may take more than one day.
5. When the teams have completed their analyses, assign the research report.

ASSESSMENT

- Research report

EXTENSIONS

- Have students research the work done in Banff National Park along the Trans-Canada Highway and compare it to the plan for State Route 260 in Arizona.

Appendix A: Arizona Department of Education Standards – Full Text

Science Standards

Grade	Strand	Concept	Performance Objective
7	1	3 – Analysis and Conclusions	1 – Analyze data obtained in a scientific investigation to identify trends 5 – Formulate a conclusion based on data analysis
		4 – Communication	1 – Choose an appropriate graphic representation for collected data 2 – Display data collected from a controlled investigation 3 – Communicate the results of an investigation with appropriate use of qualitative and quantitative information 5 – Communicate the results and conclusion of the investigation
	3	1 – Changes in Environments	3 – Propose possible solutions to address the environmental risks in biological or geological systems
		2 – Science and Technology in Society	1 – Propose viable methods of responding to an identified need or problem 2 – Compare solutions to best address an identified need or problem
8	1	3 – Analysis and Conclusions	1 – Analyze data obtained in a scientific investigation to identify trends 5 – Explain how evidence supports the validity and reliability of a conclusion
		4 – Communication	1 – Communicate the results of an investigation 2 – Choose an appropriate graphic representation for collected data 3 – Present analyses and conclusions in clear, concise formats 5 – Communicate the results and conclusions of the investigation
	3	2 – Science and Technology in Society	1 – Propose viable methods of responding to an identified need or problem 2 – Compare solutions to best address an identified need or problem

Science Standards Continued

Grade	Strand	Concept	Performance Objective
High School	1	1 – Observations, Questions, and Hypotheses	1 – Evaluate scientific information for relevance to a given problem
		4 – Communication	1 – For a specific investigation, choose an appropriate method for communicating the results 2 – Produce graphs that communicate data 3 – Communicate results clearly and logically 4 – Support conclusions with logical scientific arguments
	3	1 – Changes in Environment	1 – Evaluate how the processes of natural ecosystems affect, and are affected by, humans 3 – Assess how human activities can affect the potential for hazards 4 – Evaluate how urban development affects the quality of the environment
		2 – Science and Technology in Society	2 – Recognize the importance of basing arguments on a thorough understanding of the core concepts and principles of science and technology 3 – Support a position on a science or technology issue 5 – Evaluate methods used to manage natural resources

Mathematics Standards

Grade	Strand	Concept	Performance Objective
7	2	1 – Data Analysis (Statistics)	3 – Determine when it is appropriate to use histograms, line graphs, double bar graphs, and stem-and-leaf plots 4 – Interpret data displays including histograms, stem-and-leaf plots, circle graphs, and double line graphs 5 – Answer questions based on data displays including histograms, stem-and-leaf plots, circle graphs, and double line graphs 7 – Interpret trends from displayed data 8 – Compare trends in data related to the same investigation 9 – Solve contextual problems using histograms, line graphs or continuous data, double bar graphs, and stem-and-leaf plots

Mathematics Standards Continued

Grade	Strand	Concept	Performance Objective
8	2	1 – Data Analysis (Statistics)	3 – Determine the appropriate type of graphical display for a given data set 7 – Formulate reasonable predictions based on a given set of data 8 – Compare trends in data related to the same investigation
High School	2	1 – Data Analysis (Statistics)	2 – Organize collected data into an appropriate graphical representation 8 – Make reasonable predictions for a set of data, based on patterns 9 – Draw inferences from charts, tables, graphs, plots, or data sets 11 – Evaluate the reasonableness of conclusions drawn from data analysis

Writing Standards

Grade	Strand	Concept	Performance Objective
7 – 8	2	1 – Ideas and Content	1 – Use clear, focused ideas and details to support the topic 3 – Develop a sufficient explanation or exploration of the topic 4 – Include ideas and details that show original perspective
		2 – Organization	3 – Place details appropriately to support the main idea 5 – Construct paragraphs by arranging sentences with an organizing principle (e.g., to develop a topic, to indicate a chronology)
		3 – Voice	2 – Convey a sense of identity through originality, sincerity, liveliness, or humor appropriate to the topic and type of writing 4 – Choose appropriate voice (e.g., formal, informal, academic discourse) for the audience and purpose
		4 – Word Choice	1 – Use accurate, specific, powerful words that effectively convey the intended message 3 – Use vocabulary that is original, varied, and natural
		5 – Sentence Fluency	2 – Create sentences that flow together and sound natural when read aloud

Writing Standards Continued

Grade	Strand	Concept	Performance Objective
7 – 8	3	2 – Expository	1 – Record information (e.g., observations, notes, lists, charts, map labels and legends) related to the topic 3 – Write a process essay that includes: a. a thesis statement b. supporting details c. introductory, body, and concluding paragraphs
High School	2	1 – Ideas and Content	3 – Provide sufficient, relevant and carefully selected details for support 5 – Include ideas and details that show original perspective and insights
		2 – Organization	3 – Place details appropriately to support the main idea 5 – Employ a variety of paragraphing strategies (e.g., topical, chronological, spatial) appropriate to application and purpose
		3 – Voice	2 – Convey a sense of identity through originality, sincerity, liveliness, or humor appropriate to the topic and type of writing 3 – Choose appropriate voice (e.g., formal, informal, academic discourse) for the application
		4 – Word Choice	1 – Use accurate, specific, powerful words and phrases that effectively convey the intended message 2 – Use vocabulary that is original, varied, and natural 3 – Use words that evoke clear images
		5 – Sentence Fluency	3 – Demonstrate a flow that is natural and powerful when read aloud

Writing Standards Continued

Grade	Strand	Concept	Performance Objective
High School	3	2 – Expository	1 – Write a multi-paragraph essay that: a. includes background information to set up the thesis (hypothesis, essential question), as appropriate b. states a thesis with a narrow focus c. includes evidence in support of a thesis in the form of details, facts, examples, or reasons d. communicates information and ideas from primary and/or secondary sources accurately and coherently, as appropriate e. attributes sources of information as appropriate f. includes a topic sentence for each body paragraph g. includes relevant factors and variables that need to be considered h. Includes visual aids to organize and record information on charts, tables, maps, and graphs, as appropriate i. includes an effective conclusion

Appendix B: Worksheets and Overheads

The pages that follow contain the worksheets listed below:

A. *How Do We Stop Wildlife-Vehicle Collisions?* – A handout describing the activity (1 page)

B. *Ecology of Elk* – A brief summary of the history and ecology of elk in Arizona (1 page)

C. *Elk Movement Research* – A summary of the actual data collected on elk movement near State Route 260 (3 pages)

D. *Research Rubric* – One method to evaluate the student report (1 page)

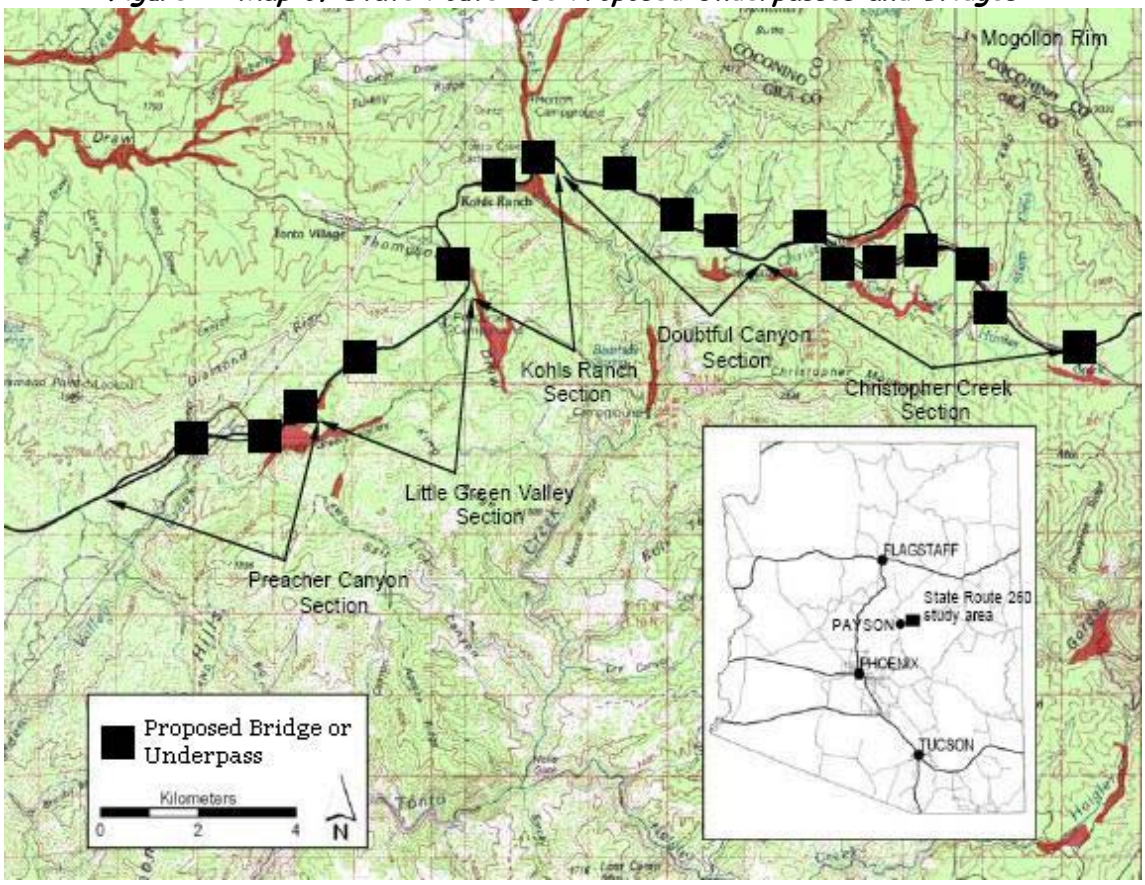
Wildlife and Highway Management

How Do We Stop Wildlife-Vehicle Collisions?

The Arizona Department of Transportation has decided that wildlife-vehicle collisions are a serious issue in Arizona. One main area of concern is Highway 260 east of Payson. This 18.5-mile stretch of highway cuts right through the middle of prime elk habitat but is also experiencing a significant increase in highway traffic.

The proposed plan calls for increasing the size of this road from a two-lane to a four-lane highway while improving wildlife permeability (passage). It would incorporate 11 bridges and 6 underpasses (Figure 1).

Figure 1: Map of State Route 260 Proposed Underpasses and Bridges



The research has been performed and construction is ready to begin. However, concerns have been raised over the cost. Your team has been chosen to analyze the data with two goals in mind:

1. Evaluate and characterize wildlife movements, particularly elk, across State Route 260.
2. Research alternatives to bridges and underpasses that may reduce the costs.

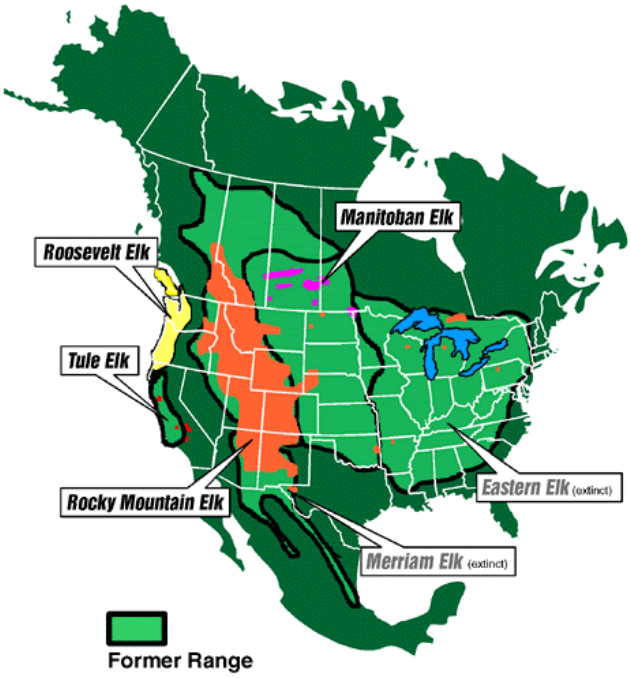
The Arizona Department of Transportation has asked for a formal report in which you describe three ideal locations for bridges or underpasses as well as two cost-saving alternatives.

On the following pages, you will find information and data collected during this research project that is available for you to use as you make your decisions. Good luck!

Wildlife and Highway Management

Ecology of Elk

At one time, elk were the most widely distributed member of the deer family in North America. Their population size was estimated at 10 million. But that was before Europeans arrived. Just as with the buffalo, agriculture and market hunting took their toll on the elk. By 1922, the population had shrunk to 90,000, most of them living in Yellowstone Park, which became a reservoir to preserve them. As the Yellowstone elk reproduced, some were transplanted to bolster or begin herds in other parts of the country. Between 1912 and 1967, more than 13,000 elk were relocated. Eighty-three of them were sent to Arizona, and this small population is responsible for the 35,000 elk now in the state.



Elk have two distinct coats. They grow a heavy winter coat that is primarily dark brown across the head, belly, neck, and legs, and grayish brown on the sides and back. The rump is yellow with a dark brown stripe. They shed this coat in the spring, revealing the summer coat, which is usually a deep red-brown with no undercoat. They shed this coat as fall arrives.

One of the elk's most distinctive features is its antlers, which are shed every year. Adult males (bulls) shed their antlers between January and March, and the new antlers begin to grow soon after. By August, antler growth is complete. During this time of growth, the males have increased nutritional needs.

Most elk cows weigh between 450 and 600 pounds; bulls average 600 to 800 pounds. Some large bulls have been reported to weigh as much as 1,200 pounds. Elk are extremely fast and can run up to 40 miles per hour for short distances and 30 miles per hour for longer ones. They have been known to swim a distance of more than a mile. They can jump 8 to 10 feet into the air. An elk's life span is usually between 14 and 17 years, although some have reached the age of 25.

The elk breeding period is during the months of September and October. One bull elk may breed with as many as 30 females (cows), but the average is around 15 to 20. Calves are born about 8 months later, in late May. The calves weigh approximately 30 pounds. Twins are extremely rare. The mother's nutritional demands increase during gestation (pregnancy) and in the weeks following the birth, when she must produce milk to feed her calf. A few weeks after birth, the calf is able to run and join in the regular activities of the herd. At this time, herds may number in the hundreds.

Information for this article was provided by the Arizona Game and Fish Department and the Rocky Mountain Elk Foundation.

Elk Movement Research

Researchers with the Arizona Game and Fish Department used global positioning satellite (GPS) telemetry to assess the movement of elk within the research area near State Route 260. Elk were captured and fitted with GPS receiver collars. These collars, which had a life of approximately 15 months, were programmed to report a fix (elk location) every four hours. From May 2002 to April 2004, a total of 33 elk (25 cows and 8 bulls) were studied. The scientists collected more than 101,000 GPS fixes. The following tables summarize the data they collected.

Definitions

Crossing – any time an elk moved from one side of the road to another (the crossings are all inferred based on the elk's location between two consecutive GPS fixes)

Weighted Crossing – a number of crossings corrected to reflect the number of different elk that crossed at a given point and the evenness in the distribution of crossings among the different elk

Approach – any time an elk traveled within 0.15 miles of the highway but did not cross (based upon GPS fixes)

Passage Rate – a relationship between the number of times the elk approached the highway and the number of times they crossed (highway crossings/highway approaches)

A Note About the Tables

All of the data included in the following tables were collected from May 2002 to April 2004 along the research area on State Route 260 (see Figure 1).

Elk Movement Data – The following data tables (1 – 5) deal specifically with the movement of elk around the research area.

Table 1: Elk Crossings by Highway Section

Highway Section	# of Miles	# of Elk	# of Elk Crossings	Crossings/Mile	Weighted Crossings	Weighted Crossings/Mile
Preacher Canyon	3.0	13	1298	432.7	1312	437.3
Little Green Valley	2.5	13	132	52.8	193	77.2
Kohl's Ranch	3.4	13	212	62.3	237	69.7
Doubtful Canyon	2.8	8	292	104.3	332	118.6
Christopher Creek	5.0	15	1070	214.0	1451	290.2

Table 2: Average Number of Elk Highway Approaches and Crossings

	Elk Gender		
	All	Cow	Bull
# of Highway Crossings	92.6	112.0	32.1
Highway Crossings/Day	0.22	0.28	0.06
Highway Approaches/Day	0.73	0.83	0.43
Highway Passage Rate	0.35	0.36	0.34

Table 3: Frequency of Elk Fixes Found in Various Habitats

		Proportion of Habitat Area where Elk are Found				
		Chaparral	Pinyon-Juniper	Ponderosa	Mixed Conifer	Riparian
Proportion of Total Habitat Area		0.16	0.12	0.46	0.22	0.04
Elk Gender	All	0.15	0.10	0.39	0.18	0.18
	Bull	0.12	0.07	0.42	0.19	0.20
	Cow	0.14	0.10	0.39	0.19	0.17

Table 4: Highway Crossings and Passage Rates by Month

Month	Bull		Cow	
	Crossing	Passage Rate	Crossing	Passage Rate
Jan	0	0.00	151	0.32
Feb	0	0.00	120	0.26
Mar	2	0.34	257	0.30
Apr	13	0.68	128	0.36
May	16	0.59	142	0.54
Jun	54	0.47	199	0.42
Jul	33	0.27	184	0.31
Aug	61	0.48	230	0.30
Sep	25	0.53	199	0.38
Oct	31	0.49	259	0.52
Nov	3	0.08	201	0.27
Dec	0	0.00	116	0.22

Table 5: Proportion of Highway Crossings by Time of Day

Crossing Time	12am	2am	4am	6am	8am	10am	12pm	2pm	4pm	6pm	8pm	10pm
Proportion	0.14	0.15	0.10	0.18	0.06	0.02	0.01	0.00	0.01	0.07	0.13	0.12

Note: Times represent the midpoint of a 2-hour time interval (i.e., 2am = 1am-3am)

Elk-Vehicle Collision Data – The following tables (6 – 9) deal with comparisons between elk movement and the number of collisions that occur

Table 6: Elk Highway Crossings and Elk-Vehicle Collisions by Highway Section

Highway Section	# of Elk Crossings	# of Elk-Vehicle Collisions
Preacher Canyon	1312	78
Little Green Valley	193	3
Kohl's Ranch	237	39
Doubtful Canyon	332	9
Christopher Creek	1451	98

Table 7: Proportion of Elk-Vehicle Collisions and Highway Crossings by Month

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Proportion of Crossings	0.06	0.05	0.11	0.11	0.06	0.10	0.09	0.12	0.09	0.12	0.08	0.05
Proportion of Collisions	0.06	0.06	0.04	0.07	0.06	0.05	0.08	0.08	0.16	0.20	0.13	0.07

Table 8: Proportion of Elk-Vehicle Collisions and Highway Crossings by Time of Day

Time	12am	2am	4am	6am	8am	10am	12pm	2pm	4pm	6pm	8pm	10pm
Crossing Proportion	0.14	0.15	0.10	0.18	0.06	0.02	0.01	0.00	0.01	0.07	0.13	0.12
Collision Proportion	0.12	0.07	0.08	0.08	0.04	0.01	0.01	0.00	0.00	0.11	0.31	0.16

Note: Times represent the midpoint of a 2-hour time interval (i.e., 2am = 1am-3am)

Table 9: Proportion of Elk-Vehicle Collisions Occurring by Hours Away from Sunrise or Sunset

Hours From Sunrise/Sunset	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
Collisions	0.11	0.23	0.11	0.09	0.07	0.06	0.04	0.04	0.05	0.06	0.06	0.07

Note: Times represent how close the elk crossing occurred to sunrise or sunset (0.5 = half hour before or after sunrise or sunset)

Data Analysis Questions

Use the following questions to help focus your ideas as you develop your report.

1. How much more likely is a female elk to cross the highway than a male elk? Does this make a significant difference in the passage rates of the two genders?
2. In which type of habitat are there more elk than would be expected based upon the area of that habitat?
3. At what time of year are the most elk crossing the highway? Does it vary depending on the gender of the elk? Why are they crossing during this time? Does this match the time when the most elk-vehicle collisions occur? Why or why not?
4. At what time of day do the most elk cross the highway? Does this match the time when the most elk-vehicle collisions occur? Why or why not?
5. Which highway section has the largest proportion of elk-vehicle collisions compared to elk crossings? Is this the same area that has the highest number of elk-vehicle collisions?

Formal Report

You must now use this information to prepare a report for the Arizona Department of Transportation. The report must identify three locations where bridges or underpasses should be built and present any cost effective alternatives to deal with this situation rather than building 18 bridges or underpasses. In this report, you must address the following issues:

1. Describe the movement of elk across State Route 260. Be sure to focus on when and where the elk are moving. Use graphs if necessary.
2. Identify on the map, three locations where bridges or underpasses should be built. Be sure to explain why you selected these locations. Use graphs if necessary.
3. Analyze possible alternatives to bridges and underpasses. If possible, describe where alternatives are currently being used and how effective they are. Use graphs if necessary.
4. Identify two cost-saving alternatives that could be used in place of the bridges or underpasses. Describe how these would be used at these locations. Use graphs if necessary.

Use the links below (or your own Internet search) to find information about alternative solutions:

- Wildlife-Vehicle Accident Prevention Program: *http://www.wildlifeaccidents.ca/*
- Wildlife Crossings Toolkit: *http://www.wildlifecrossings.info/beta2.htm*
- Wildlife Protection – Keeping It Simple: *http://www.fhwa.dot.gov/environment/wildlifeprotection/index.cfm?fuseaction=home.viewTopic&topicID=1*
- Critter Crossings: *http://www.fhwa.dot.gov/environment/wildlifecrossings/index.htm*

Wildlife and Highway Management

Research Report Rubric

The following rubric will show you how your essay will be evaluated. Use it as you write.

CATEGORY	4	3	2	1
Accuracy of Facts (Content)	All supportive facts are reported accurately.	Almost all supportive facts are reported accurately.	Most supportive facts are reported accurately.	NO facts are reported OR most are inaccurately reported.
Adding Personality (Voice)	The writer has developed an academic voice appropriate for the audience.	There is some sense of academic discourse, but it may be inconsistent or weak at times.	The writer occasionally develops an academic voice, but generally it is weak and inconsistent.	There is no sense of voice in the essay.
Sequencing (Organization)	Details are placed in a logical order and the way they are presented effectively keeps the interest of the reader.	Details are placed in a logical order, but the way in which they are presented or introduced sometimes makes the writing less interesting.	Some details are not in a logical or expected order, and may distract or confuse the reader.	Many details are not in a logical or expected order. There is little sense that the writing is organized.
Word Choice	Writer uses appropriate words and phrases, and the placement of the words seems accurate, natural and not forced.	Writer uses appropriate words and phrases, but occasionally the words are used inaccurately or seem overdone.	Writer uses words that communicate clearly, but the writing lacks interest.	Writer uses a limited vocabulary that does not communicate strongly or capture the reader's interest. Jargon or clichés may be present and detract from the meaning.
Flow and Rhythm (Sentence Fluency)	All sentences sound natural and are easy-on-the-ear when read aloud. Each sentence is clear and has an obvious emphasis.	Almost all sentences sound natural and are easy-on-the-ear when read aloud, but 1 or 2 are stiff, awkward or difficult to understand.	Most sentences sound natural and are easy-on-the-ear when read aloud, but several are stiff, awkward or difficult to understand.	The sentences are difficult to read aloud because they sound awkward, are repetitive, or difficult to understand.
Citations	At least three citations are used and all are cited correctly.	At least three citations are used but one is not cited correctly.	Less than three citations are used or more than one is not cited correctly.	There are no citations.