Do Underpasses Really Work?

In this activity, you will have the opportunity to design your own experiment to see if underpasses and bridges are actually successful in reducing the potential for wildlife-vehicle collisions on the highway. The following article will give you some basic background information you can use to help you design your experiment. With this information as your starting point, you will be asked to develop your own scientific question that can be answered with the data collected. Just as in all science, however, much more information is provided here than you will actually need. It is your responsibility to sift through the data to find relevant information. Good luck.

INTRODUCTION

Wildlife underpasses and bridges are being constructed across the country (Figure 1). The structures, built specifically for animals to use when crossing from one side of a major road to the other, connect a habitat fractured by highways. Transportation agencies, such as the Arizona Department of Transportation, invest money in these projects in order to build safer, more environmentally friendly roads.

Figure 1: Underpass under construction

In the past, these structures were typically focused on a single species of concern in a region. Today, however, governments want more "bang for their buck." They want multiple species to use these structures on a regular basis. But how do we know that animals, whether one species or many, will actually use the underpasses and bridges?

Since it is impossible for anyone to watch these structures all the time, and wildlife movements can be unpredictable, monitoring the use of bridges and underpasses has always been difficult. Usually it has consisted of indirect physical evidence, such as footprints or scat, that animals leave near the structures. The advent of motion-sensitive cameras and infrared lighting, however, has revolutionized this field. Now large amounts of direct evidence can be collected and analyzed with minimal effort by the researcher. But, is the promise of this technology more than the actual payoff? Can it be used to determine whether or not elk and other animals are using the underpasses along the highway?

Scientists with the Arizona Game and Fish Department are working hard to answer these questions. In fact, the 18.5-mile length of State Route 260 east of Payson, Arizona, is one of the first areas in the world to fully implement this technology.

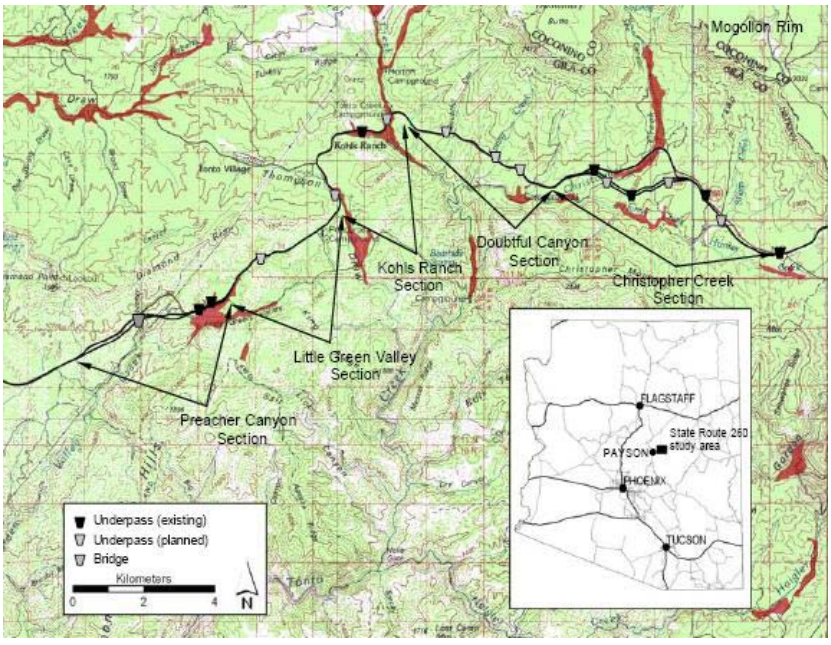

Figure 2: Map of State Route 260 research area

Table 1: Phased Construction Initiation and Completion Dates

Highway Section	Construction Upgrade Dates	
	Begun	Completed
Preacher Canyon	1999	2001
Christopher Creek	2002	2004
Kohl's Ranch	2003	2005
Little Green Valley	Control	
Doubtful Canyon	Control	

PHASED CONSTRUCTION

The original plan of construction along State Route 260 calls for an upgrade from a two-lane to a four-lane highway to accommodate increased traffic volume in the region. The plan has been designed in five phases. This phased construction has three main advantages. First, it is easier to secure funding for five smaller projects than for one large project—individual sections can be upgraded as funds become available. Second, because some sections are upgraded and others are not, researchers can make comparisons between them. By monitoring animal behavior at completed sections, at sections under construction, and at sections where construction has not yet started, researchers can analyze the impact of major roadway construction projects on Arizona's wildlife. This leads to the third advantage: adaptive management. Monitoring completed sections of the highway gives engineers the opportunity to change the plans for future sections, if necessary. So, if they discover that animals avoid certain types of bridges or underpasses, they can remove these from the remaining projects.

When the monitoring project began, the section known as Preacher Canyon had already been completed, the Christopher Creek and Kohl's Ranch sections were being upgraded, and the Little Green Valley and Doubtful Canyon construction had not yet begun (Figure 2 and Table 1).

Figure 3: Preacher Canyon underpasses

UNDERPASS USE AND PREFERENCE BY WILDLIFE

Since the Preacher Canyon section of State Route 260 had already been completed, researchers began there. This section has two underpasses within 750 feet of each other (Figure 3). Because they are so close, the same type of vegetation surrounds them. The dense forest to the north and the small grassy valley to the south are ideal habitats for numerous animals, especially elk. But despite their similarities, the bridges do have some distinct differences in their physical characteristics (Table 2).

To try and maximize wildlife use of the underpasses, 8-foot high fencing was installed along the highway between the two bridges and extended beyond the ends of the bridges 330 feet to the west and 1,000 feet to the east. Since the animals cannot go over the fence, access to the other side of the road is limited. They can either go through one of the underpasses or go to the end of the fence and cross on the highway. The use of video surveillance (described below) should allow the researchers to determine which method the animals prefer.

The video cameras have another advantage: scientists can

monitor an animal's behavior as it approaches and uses an underpass. Previously, only indirect signs, such as tracks, could be used to estimate the number of animals that approached an underpass compared to the number that went through it. This method is not reliable and does not give us the reason an animal turned around. Videos may provide that evidence.

Table 2: Physical Characteristics of Preacher Canyon Underpasses

Characteristic	East Underpass	West Underpass
Construction Type	Open I-beam span	Open I-beam span
Distance[1]	124 feet	124 feet
Height	22 feet	38 feet
Atrium[2]	36 feet	36 feet
Width	30 feet	50 feet
Length[3]	173 feet	360 feet
Side Construction	Sloped earth	Concrete walls

[1] The distance that cars travel on the bridge
[2] The width of the opening between the eastbound and westbound lanes of the highway
[3] The distance that animals must cross to make it from one side to the other

MULTIPLE SPECIES CORRIDORS

Highway upgrades like the ones described here can be quite expensive. Currently, one underpass can cost between $1.5 million and $2 million. Although most of the past research has centered on elk because they provide the greatest potential for damage to vehicles (an elk can weigh nearly 1,000 pounds), the immense monetary investment has the government calling for crossing structures to be designed to accommodate numerous animals. Since elk are among the larger animals found in this region, any underpass that is large enough for elk should be large enough for other species. Here is a way that video surveillance can once again help scientists.

Most animals are instinctively wary of humans. By remotely videotaping any animal that uses the underpasses, researchers can identify a species without being near it. Although an animal can often be identified by its tracks, the video allows for more accurate data collection. After all, tracks may not be left behind in all circumstances. Video cameras can record every animal that passes by, as well as when it passes. Scientists can also monitor underpasses to see if predators are using them to "trap" their prey.

VIDEO SURVEILLANCE

To gather the most useful data, a complex video surveillance system was set up at both underpasses in the Preacher Canyon section. Each underpass was monitored with four black-and-white video cameras on the north side. Two cameras were mounted on trees approximately 100 feet from each underpass to record approaching animals. One camera was positioned in each underpass to record the animals entering and crossing. The last camera faced the highway to record traffic. Special infrared lights, which the cameras could detect but most animals could not, were installed to provide adequate lighting for the cameras at night. To prevent the cameras from recording hours of useless footage and to preserve battery life, numerous infrared beams, positioned at less than two feet above the ground, served as triggers. When an animal crossed through a beam, all of the cameras began filming and continued to film for two minutes.

In addition to the system monitoring the underpasses, another system was installed at the eastern end of the fence. A single camera was triggered to record for one minute any time an animal attempted to cross the highway.

The video cameras have allowed researchers to collect a large amount of data that previously could not be captured. Researchers recorded the date, time of day, total time animals spent in the area, species, gender, number of animals, number of animals approaching and crossing through underpasses, direction of travel, behavior, and number of vehicles on the highway. In many cases, they were also able to determine the age and gender of the animals.

Experiment Planning and Comprehension

The background information on monitoring wildlife use of underpasses has been described to you. Now you must determine what types of questions can be answered from the data that will be made available to you. There are a lot of possibilities, so be creative. Use the questions below to focus the information from the reading and to guide your thinking.

1. What are some examples of indirect physical evidence scientists have used to determine if animals are using underpasses?

2. Why are these considered indirect?

3. What are the advantages of upgrading the highway in phases?

4. What is adaptive management?

5. What was the first section to be completed? When was it completed?

6. What is a control? Why are Little Green Valley and Doubtful Canyon considered controls?

7. Compare and contrast the East and West underpasses in the Preacher Canyon section.

8. Why have elk been the primary focus of this research?

9. Draw a diagram of the camera setup at one of the underpasses.

10. Why have scientists put a camera at the end of the fence?

11. Write a question that you can probably answer based on the data that will be collected in this experiment.

12. Write a hypothesis for your question.

Analyzing the Data

Below you will see a lot of the data that have been collected from video surveillance of the two underpasses in the Preacher Canyon section as well as some additional data that may be significant. Look through all the tables and locate data that are relevant to your research question.

Table 1: Total Animals Approaching and Crossing Preacher Canyon Underpasses

Wildlife Species	East Underpass			West Underpass		
	Approached	Crossed	Passage Rate	Approached	Crossed	Passage Rate
Elk	1,883	1,400	0.74	752	392	0.52
Whitetail Deer	123	5	0.04	59	5	0.08
Coyote	49	8	0.16	9	2	0.22
Gray Fox	15	7	0.47	6	5	0.83
Mountain Lion	4	0	0.00	0	0	N/A
Mule Deer	2	0	0.00	9	0	0.00
Raccoon	1	1	1.00	0	0	N/A
Black Bear	1	1	1.00	0	0	N/A
Ringtail	0	0	N/A	1	0	0.00
All Species	2,081	1,426	0.68	853	415	0.49

Table 2: Total Animals Caught by End-of-Fence Camera

Wildlife Species	# of Animals Crossing at Fence	Ratio of Animals Crossing at Fence : Crossing at Underpasses
Whitetail Deer	283	28.3:1
Elk	110	0.06:1
Mountain Lion	1	N/A
All	394	0.22:1

Table 3: Proportion of Elk Displaying Various Behaviors Near Underpasses

Elk Behavior	East Underpass	West Underpass
No Delay in Crossing[1]	0.57	0.55
Minor Delay in Crossing[2]	0.21	0.19
Obvious Delay in Crossing[3]	0.19	0.25
Would Not Cross[4]	0.26	0.46
Enter Underpass and Retreat[5]	0.11	0.17
Alarmed Flight[6]	0.13	0.25
Feeding in Area[7]	0.22	0.42
Standing/Milling About[8]	0.44	0.46

[1] Crossed within 10 seconds
[2] Crossed within 11 – 30 seconds
[3] Took more than 30 seconds to cross
[4] Left without crossing
[5] Entered the underpass and then left
[6] Approached or entered underpass and left rapidly
[7] Fed within about 150 feet of underpass
[8] Stood within about 150 feet of underpass

Table 4: Crossing and Approach by Construction Phase

Phase	Approaches/Day	Crossings/Day	Passage Rate
Control	0.87	0.22	0.40
Under Construction	0.60	0.26	0.45
Completed	0.81	0.27	0.21

Table 5: Average Number of Elk-Vehicle Collisions per Year by Construction Phase

Highway Section	Before Construction	During Construction	After Construction
Preacher Canyon	7.7	8.0	7.0
Little Green Valley	0.3	N/A	N/A
Kohl's Ranch	5.8	6.0	N/A
Doubtful Canyon	0.6	N/A	N/A
Christopher Creek	7.6	19.7	N/A

Table 6: Number of Elk-Vehicle Collisions by Highway Section and Year

Highway Section	2001	2002	2003	2004	Average
Preacher Canyon	10	13	10	14	11.8
Little Green Valley	3	0	2	1	1.5
Kohl's Ranch	9	7	7	6	7.3
Doubtful Canyon	1	2	5	4	3.0
Christopher Creek	7	18	19	56	25.0
Total	30	40	43	81	48.5

FORMAL SCIENTIFIC REPORT

Now that the experiment is complete, it is time for the next step. Your research must be shared with your fellow scientists. You will do this by writing a formal report that may appear in a scientific journal. Follow the format below (or any other that your teacher recommends).

Title The name of your project indicating exactly what you studied.

Abstract A paragraph summary of your research that should include a statement of your research problem, a brief description of the experimental procedures used, the results, and a concluding statement explaining the results.

Introduction Give background information about your research and identify your problem and hypothesis.

Methods Describe how the research was performed. Be sure to include the materials that were used. Although you did not perform the research, you can summarize how it was done.

Results Present the data in tables and charts. You do not interpret the data at this point, only describe the observations and data.

Discussion Explain what the data mean, describe any trends, make comparisons to other research, and determine if your hypothesis has been supported. In addition, discuss future research ideas that can now be studied based on these results.

References If you used any resources, such as Internet sites, books, or articles, you need to list them here.

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 distractingly 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.