Using data to make decisions

Are There Too Many Elk?

LESSON OVERVIEW

Students read an article that describes a data collection protocol used by wildlife managers. Then, using this information, they must analyze real data and make recommendations regarding the management of elk in Arizona.

SUGGESTED GRADE LEVELS

- 7 – 12

ENDURING UNDERSTANDINGS

- Decisions regarding the management of wildlife must use valid scientific data.

OBJECTIVES

Students will:

- Read and understand a scientific article.
- Analyze data to come to a conclusion.

ARIZONA DEPARTMENT OF EDUCATION STANDARDS

Grade	Science	Mathematics
7	S1-C3-01; S1-C3-05; S1-C4-03; S1-C4-05; S4-C3-04	S1-C2-10; S2-C1-07; S2-C1-08
8	S1-C3-01; S1-C4-03; S1-C4-05	S1-C2-09; S2-C1-08
High School	S1-C4-03; S1-C4-04; S3-C1-05; S3-C2-05	S2-C1-09; S2-C1-11

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

TIME FRAME

- Two days (45 minutes each day)

MATERIALS

- *Forage Monitoring and Utilization* (one per student)
- *Forage Monitoring Comprehension Questions* (one per student)
- *Forage Monitoring Data* (one per group)

TEACHER PREPARATION

- Make copies of the *Forage Monitoring and Utilization* article and the *Comprehension Questions* for each student, and copies of *Forage Monitoring Data* for each group.
- Divide the class into groups of three to four students.

SUGGESTED PROCEDURES

1. Explain to students that the Arizona Game and Fish Department is responsible for managing Arizona's wildlife. As such, the department must sometimes prevent wildlife species from becoming overpopulated and causing harm to the environment. For game species (animals that are legally hunted), the department can reduce the size of their populations by recommending an increase in hunting opportunities. For nongame species, methods such as trapping and releasing animals into less populated areas can be used. Ask the students: how do you think wildlife managers monitor and "count" wildlife populations? Responses can be made in a journal or a class discussion.
2. Write some of the student responses on the board and discuss them.
3. Explain that these are all valid answers and are probably used in some way. Today, we are going to look at one method that the department uses to help make management decisions.
4. Hand out the *Forage Monitoring and Utilization* article and the *Forage Monitoring Comprehension Questions*. The students must read the article and answer the questions.
5. Give students time to work. If necessary, allow them to take the assignment home to finish.
6. When all students have completed the assignment, discuss their answers. It is important that the students have a good understanding of forage monitoring before moving on. *If you wish, your students can try forage monitoring for themselves. This requires a little more time and additional materials. See Appendix B for an explanation*.
7. Divide the class into their groups.
8. Explain that they will now have the opportunity to use their knowledge of forage monitoring to make recommendations regarding elk populations in eastern Arizona.
9. Hand out the *Forage Monitoring Data* form to each group. Instruct students to examine the data, make necessary calculations, and develop recommendations regarding the status of the populations in each Game Management Unit.
10. When all groups have finished, they must now present their findings to the rest of the class. Discuss their recommendations. Were there differences? If so, why would that be if all groups were using the same data?

ASSESSMENT

- Responses to *Forage Monitoring Comprehension Questions*
- Group presentations

EXTENSIONS

- Encourage students to research other methods that are used to manage animal populations. They may use the Internet or interview an expert in the field.

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	3 – Communicate the results of an investigation with appropriate use of qualitative and quantitative information 5 – Communicate the results and conclusion of the investigation
	4	3 – Populations of Organisms in an Ecosystem	4 – Evaluate data related to problems associated with population growth and the possible solutions
8	1	3 – Analysis and Conclusions	1 – Analyze data obtained in a scientific investigation to identify trends
		4 – Communication	3 – Present analyses and conclusions in clear, concise formats 5 – Communicate the results and conclusions of the investigation
High School	1	4 – Communication	3 – Communicate the results clearly and logically 4 – Support conclusions with logical scientific arguments
	3	1 – Changes in Environment	5 – Evaluate the effectiveness of conservation practices and preservation techniques on environmental quality and biodiversity
		2 – Science and Technology in Society	5 – Evaluate methods used to manage natural resources (e.g., reintroduction of wildlife, fire ecology)

Mathematics Standards

Grade	Strand	Concept	Performance Objective
7	1	2 – Numerical Operations	10 – Calculate the percent of a given number
	2	1 – Data Analysis (Statistics)	7 – Interpret trends from displayed data 8 – Compare trends in data related to the same investigation
8	1	2 – Numerical Operations	9 – Calculate the missing value in a percentage problem
	2	1 – Data Analysis (Statistics)	8 – Compare trends in data related to the same investigation

Using data to make decisions

Mathematics Standards Continued

Grade	Strand	Concept	Performance Objective
High School	2	1 – Data Analysis (Statistics)	9 – Draw inferences from charts, tables, graphs, plots, or data sets 11 – Evaluate the reasonableness of conclusions drawn from data analysis

Appendix B: Forage Monitoring in the Field

Below are simplified procedures to give your students the opportunity to try forage monitoring firsthand.

Materials Needed

- Scissors, paper bag, a copy of the *Forage Monitoring Record* data sheet, and a 44-inch length of strong wire for each group
- A scale for weighing cuttings

Making the Plot Ring

This experiment requires the students to use a plot ring, which can be made by forming a loop out of a 44-inch length of strong wire. If done correctly, you will have a loop with an area of 0.96 square feet. If you do not use the correct size ring, the calculations will not be correct. Other materials, such as rope can be substituted for wire, but the circle will not be as accurate. You might want to have your students make their own rings by calculating the necessary size using the equations for the area and circumference of a circle:

$$\text{Area} = \pi r^2$$
$$\text{Circumference} = 2\pi r$$

Doing the Work

1. Take the students outside to the schoolyard or a nearby park.
2. Give a plot ring, a pair of scissors, and a paper bag to each group.
3. Each group must choose a separate location to place their ring. For best results, groups should choose areas that have different vegetative types.
4. Inform the groups that they are to use their scissors to cut away any plants growing within the circle and place the cuttings in the bag. To minimize damage, limit cuttings to green vegetation (leaves, grass, etc.).
5. Each group then weighs their cuttings on the scale, records the data, and completes the calculations on the *Forage Monitoring Record* sheet. Remind students that they need to subtract the weight of the bag to get accurate results.
6. The groups repeat these procedures for two more locations nearby and then average the results.
7. Display the results on the board so students can review the data that each group has collected. What conclusions can they draw?

Although students will not likely get results related to animal foraging, they may be able to compare the types of vegetation and their relative frequency in your region.

Going Beyond

It is possible to establish a long-term research project using this technique. Students choose a location near the school that has been disturbed by animals or people. Then, they place a fence around a small portion of this area. After a few months, they can compare cuttings from the fenced-in area to cuttings from outside the fence. Does this location appear to be overly used by animals or humans? If so, can they come up with ways to solve this problem?

Appendix C: Worksheets and Overheads

The pages that follow contain the worksheets listed below:

A. *Forage Monitoring and Utilization* – An article to introduce students to the process of forage monitoring (4 pages)

B. *Forage Monitoring Comprehension Questions* – A way to determine if the students understood the reading (1 page)

C. *Forage Monitoring Data* – Data collected from forage monitoring in Arizona that students can analyze (2 pages)

D. *Forage Monitoring Record* – Data sheet to allow students to do forage monitoring (2 pages)

Forage Monitoring and Utilization[1]

INTRODUCTION

The Arizona Game and Fish Department serves the people of Arizona as steward of the state's wildlife. Basically, this means that the department must manage Arizona's wildlife populations to keep them at a size that is of greatest benefit to the animals and their habitats, as well as to humans. For example, some animals, like the bald eagle, need protection to help them increase their population size, while other animals, like the cactus wren, do well without any special considerations. Then there are the animals that challenge the department just to keep their population in balance. Elk are a perfect example.

Elk are beautiful animals whose bugling calls can be heard up to a mile away. They are an important part of Arizona's natural landscape. However, their voracious appetites can get them into trouble. When an elk herd gets too large, their grazing behavior can severely damage sensitive grassland and riparian ecosystems. It is the department's responsibility not only to ensure that elk endure in our state, but also to keep them from harming their habitat. To succeed, the department must take into account numerous political, social, scientific and economic factors, as well as all the laws that apply to public lands (e.g., national forests and parks) and private lands (e.g., ranches and golf courses). For example, how do you increase opportunities for hunters, wildlife watchers, and other outdoor recreationists without harming the various habitats? And how do you work with local landowners to make sure habitats remain healthy?

With so much depending on the outcome, the department must have reliable data to use when making such important management decisions. To provide reliable data, the department's biologists must be able to measure elk population levels as accurately as possible, which can be difficult when you're working with an animal that can range across miles in a day. Fortunately, biologists have developed a method to indirectly measure the population of elk, at least in one part of the state.

PROGRAM DESCRIPTION

To improve elk management decisions, the department has developed a method for measuring how much forage elk are eating. The method is called the "forage utilization monitoring program." Its purpose is to estimate elk population levels by measuring the amount of vegetation elk consume. This information helps the department determine if an elk population is too large, too small, or at just the right level. Forage utilization can be measured in several ways, each appropriate to a particular locale. In the department's Region 1 (located in eastern Arizona), grasses, sedges and other forage species are collected and measured following specific procedures to assure consistency in results. The resulting data are used to evaluate habitat impacts and improve recommendations regarding elk management.

The first step in the monitoring process is to define the habitat that needs to be measured. Some plants are not grazed because they are unpalatable to elk. Habitats that contain these plants are not as important to measure. Therefore, monitoring is based on

the "key area" concept. With this approach, key areas are selected that represent the habitats that produce the most palatable and abundant vegetation, and consequently receive the heaviest grazing pressure by elk. If forage utilization is within acceptable limits in the key areas, it is assumed that it will also be acceptable in areas that produce less palatable or less abundant forage.

A typical key area monitoring site is a vegetative community such as a riparian or wet meadow area, a dry meadow or grassland, or an opening in a forest or woodland. For monitoring purposes, the area must be larger than five acres to ensure that elk will use it without fear or hesitation. To evaluate the effect of elk grazing on the total vegetative community, cages are placed on specific plots to keep elk away from them. Forage production is obtained by measuring the undisturbed herbaceous growth within the cage. Forage utilization is calculated by comparing the grazed area (outside the cage) to the ungrazed area (inside the cage). Cages are moved every year so that only the current year's forage is measured.

Careful consideration must be given to the construction and placement of the cages to protect the plants they enclose and minimize the impact of data collection. Cages should be square, they should cover a minimum of one square meter of area, and they should be tall enough to prevent grazing by elk. They also need to have an open-mesh design to ensure that microclimate conditions (e.g., shading effect, moisture retention, etc.) within the cage are not affected.

All palatable perennial plants are measured. Non-native species are included because many key areas are dominated by non-native species that are heavily foraged by elk. When a key area contains several types of vegetation (e.g., grasses, sedges, forbs, etc.), a sample is required for each "dominant" type (those that cover at least 10 percent of the area). Some key areas may require as many as three cages to obtain samples of all the types of vegetation present. A cage is placed over a sample of each type of vegetation at a location that will provide an average representation of forage diversity, density and vigor. For best results, cages should not be placed in areas where cattle graze, because there will be no way to find out if the forage usage is the result of elk or cattle.

Arizona is a large state with a wide diversity of habitats. To simplify wildlife management, the department has divided the state into six regions, each comprised of smaller areas called Game Management Units (GMUs). Elk inhabit a number of these GMUs. Because their population size, behaviors and impacts on resources vary from unit to unit, management decisions will also vary. Key areas need to be identified and monitored in each GMU to assure that these decisions are based on valid data. Each GMU should have from 10 to 15 monitoring sites.[2] If any sites are compromised during the year (e.g., a cage is removed or destroyed) and the total number falls below seven, the data cannot be used in making management decisions because the small sample size can affect validity. The data will still be collected, however, to track population trends.

DATA COLLECTION PROTOCOL

The protocol below was established to guarantee valid results. All data are to be recorded on the Forage Monitoring Record.

1. Identify a number of key areas within the GMU.
2. Identify the dominant herbaceous forage species present in each vegetation type within each key area.
3. Select a representative site for each dominant vegetation type within the key area. Place a cage around each of these sites.

4. Establish a permanent photo point within the key area to provide a photo record of overall forage production and utilization conditions during the monitoring period. Use a rebar stake or fence post to mark the photo point location. Photos will be taken from the photo point during each subsequent monitoring period.
5. Photograph each cage using a chalkboard or dry-erase board to display the cage number and date.
6. Use a Global Positioning System (GPS) unit to accurately determine the location of each cage.
7. Include a sketch of the key area that illustrates the location of the dominant vegetation types, cages and photo points.
8. Estimate and record the percent of each vegetation type sampled within the key area.
9. At each site, remove the cage and place the plot ring (0.96 square foot) over a representative sample of the protected forage.
10. Using scissors, clip perennial forage species of grasses, grass-like plants and forbs within the ring that are palatable to elk. Clip as close to the ground as elk can graze. Clip only the current year's growth. Avoid clipping when the plants are wet.
11. Place clippings in a paper bag marked with the appropriate cage location and date.
12. Repeat the clip procedure for a plot of unprotected forage outside the caged area. Conditions should be as similar as possible to those within the cage (e.g., species diversity, soils, slope, etc.). Avoid clipping within 15 feet of the cage since elk are often attracted to the cages and tend to graze more heavily near them. If possible, the same person that clips inside the cage should also clip outside the cage.
13. Use an oven to dry the clippings for three days at 105°.
14. Use a laboratory scale to weigh the dry clippings. Be sure to subtract the weight of the bag from your measurements.
15. Calculate the percent utilization for each vegetation type sampled, combined production within cage, combined production outside cage, combined forage grazed, and combined utilization (see Data Calculations below).

MANAGEMENT IMPLICATIONS

These procedures will result in numbers representing total elk grazing in the various GMUs. But, what do the numbers mean? How do they help in the management of elk? In order to make comparisons from year to year and develop management guidelines, the department has established some "usage thresholds," which are the maximum amount of grazing that habitats can sustain. Biologists look at how much the animals are eating (intensity) as well as how much of the area is being grazed (extent). If both the intensity and the extent of the grazing are too high, the population may be too large.

The table below describes the threshold values. In most areas, if more than half of the monitored sites within a GMU have more than 25% use, the elk population should be reduced. Unfortunately, this decision is not always so cut and dried. Some areas of the state are also legally grazed by cattle. To account for increased grazing pressure by domestic livestock, the intensity threshold has been lowered to 13% in these "obligated" areas.

Table 1: Management Guidelines for All Key Areas Based on Utilization Intensity and Extent

Utilization Intensity	Utilization Extent	Management Guidelines
< 15%	> 50% of the monitored sites	Consider population increase
15 – 25%	> 50% of the monitored sites	Consider maintaining current population
> 25%	> 50% of the monitored sites	Consider population decrease

Before issuing final population management recommendations, there are other factors that biologists need to consider. Is the ratio between male and female elk adequate to continue supporting a population? Do there seem to be enough new calves born to maintain the species in the region? Each of these factors is evaluated to develop the final population guidelines for that year. For some GMUs, biologists may see a need to decrease elk populations through hunting; for others, they may see a need to restrict activity until the population size can recover.

DATA CALCULATIONS

$$\% \text{ Utilization} = \frac{(\text{Total weight inside cage} - \text{Total weight outside cage})}{\text{Total weight inside cage}} \times 100$$

$$\text{Combined Production (lbs/acre)} = (\text{weight}_1 \times \% \text{ of area}_1) + (\text{weight}_2 \times \% \text{ of area}_2) + (\text{weight}_3 \times \% \text{ of area}_3)$$

$$\text{Combined Forage Grazed (lbs/acre)} = \text{Combined Production (inside)} - \text{Combined Production (outside)}$$

$$\text{Combined Utilization (\%)} = \frac{\text{Combined Forage Grazed}}{\text{Combined Production (inside)}} \times 100$$

Notes:

[1] Based on the original report, "Herbaceous Forage Production and Utilization Monitoring Program for Consideration in Elk Management in Region I," published by the Arizona Game and Fish Department in October 1997.

[2] Prior to 2004, the number of key areas within a GMU was between seven and ten. Be advised that the data used in this activity were collected in 2003, so the smaller range should be used.

Forage Monitoring Comprehension Questions

Answer the following questions in complete sentences.

1. Describe the key area concept in your own words.

2. What is forage production? How does the Arizona Game and Fish Department measure it in Region 1?

3. What is forage utilization? How does the Arizona Game and Fish Department measure it in Region 1?

4. Why is open-mesh fencing used to enclose the vegetative plot?

5. Why might it be necessary to use more than one cage in a key area?

6. Explain why one site in a Game Management Unit is not enough.

7. What are the advantages of adding more sampling areas? What are the disadvantages?

8. Below is representative data from a Game Management Unit somewhere in the state. Based on the criteria outlined in the article, would you make the recommendation to increase the elk population, decrease the population, or keep it at its current levels? Why?

Site #	Combined Production (Inside Cage)	Combined Production (Outside Cage)	Combined Utilization
A	1000	350	65%
B	400	325	19%
C	550	475	14%
D	2250	1625	28%
E	900	300	67%

9. Is forage utilization the only factor considered when looking at elk management? If so, explain why this is or is not an effective way to manage elk in the state? If not, describe other factors that must be considered.

Forage Monitoring Data

The Arizona Game and Fish Department collected the data shown below from six Game Management Units in 2003. Use your knowledge of forage monitoring to make recommendations for elk management in each GMU.

GMU 1

Site	Plot 1			Plot 2			Plot 3		
	Vegetation In	Vegetation Out	% of Site	Vegetation In	Vegetation Out	% of Site	Vegetation In	Vegetation Out	% of Site
1	1340	540	10	540	290	40	1160	320	50
2	510	400	20	1190	1190	80			
3	1480	1480	90	340	290	10			
4	400	250	100						
5	2040	2040	70	1820	1510	30			
6	4570	4570	40	780	570	60			
7	2730	1620	20	730	560	80			
8	3310	2860	20	3080	1140	20	1300	970	60
9	2940	2450	40	1140	960	60			

GMU 3B

Site	Plot 1			Plot 2			Plot 3		
	Vegetation In	Vegetation Out	% of Site	Vegetation In	Vegetation Out	% of Site	Vegetation In	Vegetation Out	% of Site
1	1380	140	100						
2	1350	170	100						
3	1170	1060	100						
4	3080	2240	100						
5	670	610	100						

GMU 3C

Site	Plot 1			Plot 2			Plot 3		
	Vegetation In	Vegetation Out	% of Site	Vegetation In	Vegetation Out	% of Site	Vegetation In	Vegetation Out	% of Site
1	1160	1160	10	1110	930	90			
2	1190	850	100						
3	1870	1440	75	1760	1690	25			
4	610	530	100						
5	250	250	100						
6	320	310	100						
7	1860	1790	100						
8	1830	1660	100						
9	580	470	100						
10	1850	1710	100						

GMU 4A

Site	Plot 1			Plot 2			Plot 3		
	Vegetation In	Vegetation Out	% of Site	Vegetation In	Vegetation Out	% of Site	Vegetation In	Vegetation Out	% of Site
1*	540	540	40	1130	550	60			
2*	490	380	80	1650	140	20			
3*	1130	540	30	370	240	60	260	240	10
4*	680	290	100						
5*	860	560	100						
6**	2200	1500	100						
7**	930	110	100						
8**	1840	810	100						
9**	1030	1030	100						

* Obligated site

** Unobligated site

GMU 27

Site	Plot 1			Plot 2			Plot 3		
	Vegetation In	Vegetation Out	% of Site	Vegetation In	Vegetation Out	% of Site	Vegetation In	Vegetation Out	% of Site
1	1900	1850	50	1090	360	50			
2	1070	1030	100						
3	550	550	100						
4	3940	3900	50	3530	3390	50			
5	1600	1600	45	1950	1340	20	390	340	35
6	1610	1130	100						
7	2760	2280	100						
8	2010	1970	100						

Forage Monitoring Record

Location: _____ Key Area Type: _____ Date: _____
Observers: _____ GMU: _____
Comments: _____
_____

VEGETATION TYPE 1

N

MARK CLIP LOCATION INSIDE CAGE

Cage#: _____ Vegetation Type: _____ % of Key Area: _____
Species Present: _____
_____
Green Weight (Cage) _____ grams X 100^2 = _____ lbs/acre
Average Green Weight[1] (Out) _____ grams X 100^2 = _____ lbs/acre
Forage Utilization = _____%
Dry Weight (Cage) _____ grams X 100^2 = _____ lbs/acre
Average Dry Weight (Out) _____ grams X 100^2 = _____ lbs/acre
Forage Utilization = _____%

VEGETATION TYPE 2

N

MARK CLIP LOCATION INSIDE CAGE

Cage#: _____ Vegetation Type: _____ % of Key Area: _____
Species Present: _____
_____
Green Weight (Cage) _____ grams X 100^2 = _____ lbs/acre
Average Green Weight[1] (Out) _____ grams X 100^2 = _____ lbs/acre
Forage Utilization = _____%
Dry Weight (Cage) _____ grams X 100^2 = _____ lbs/acre
Average Dry Weight (Out) _____ grams X 100^2 = _____ lbs/acre
Forage Utilization = _____%

VEGETATION TYPE 3

N

MARK CLIP LOCATION INSIDE CAGE

Cage#: _____ Vegetation Type: _____ % of Key Area: _____
Species Present: _____
_____
Green Weight (Cage) _____ grams X 100^2 = _____ lbs/acre
Average Green Weight[1] (Out) _____ grams X 100^2 = _____ lbs/acre
Forage Utilization = _____%
Dry Weight (Cage) _____ grams X 100^2 = _____ lbs/acre
Average Dry Weight (Out) _____ grams X 100^2 = _____ lbs/acre
Forage Utilization = _____%

[1] Average of multiple clips
[2] 0.96 ft^2 clipping ring

GREEN WEIGHT
Combined Production (cage):
[(wt_1 X % area) + (wt_2 X % area) + (wt_3 X % area)] = _____ lbs/acre

Combined Production (outside):
[(wt_1 X % area) + (wt_2 X % area) + (wt_3 X % area)] = _____ lbs/acre

Combined Forage Grazed:
Combined Production (cage) – Combined Production (outside) = _____ lbs/acre

Combined Utilization:
Combined Forage Grazed / Combined Production (cage) = _____ %

DRY WEIGHT
Combined Production (cage):
[(wt_1 X % area) + (wt_2 X % area) + (wt_3 X % area)] = _____ lbs/acre

Combined Production (outside):
[(wt_1 X % area) + (wt_2 X % area) + (wt_3 X % area)] = _____ lbs/acre

Combined Forage Grazed:
Combined Production (cage) – Combined Production (outside) = _____ lbs/acre

Combined Utilization:
Combined Forage Grazed / Combined Production (cage) = _____ %

SKETCH OF KEY AREA
Include location of major vegetation types, monitoring cages, photo point, and direction of photo.