| Title | **Wyoming Bighorn Sheep:  On the Edge?** |
|---|---|
| | Adapted by the National Bighorn Sheep Center (www.bighorn.org) from Bear Trust International |
| OBJECTIVES | Students will…<br>1. Actively participate in the process of scientific discovery, using real-world data and case studies on bighorn sheep<br>2. Outline possible factors affecting the conservation of bighorn sheep and evaluate whether bighorn sheep are "on the edge" of survival<br>3. Create a concept map of bighorn sheep needs and hazards<br>4. Explain that effective conservation of bighorn sheep requires cooperation among scientists, wildlife managers, and owners of domestic sheep and goats<br>5. Predict that regulated hunting is important to bighorn sheep conservation and that hunting organizations and state wildlife agencies have worked collaboratively to reestablish bighorn sheep herds throughout the west<br>6. Define habitat and describe which resources are important for bighorn sheep survival and reproduction |
| DURATION | 60-90 minutes |
| MATERIALS | 1. PowerPoint slide show, "*Wyoming Bighorn Sheep: On the Edge?" Parts I & II*<br>   a. Email Karen@bighorn.org for Part II<br>2. For Each Student:<br>   a. Worksheet "Wyoming Bighorn Sheep:  On the Edge?"<br>   b. Graph paper<br>   c. Ruler<br>   d. Pencil with eraser<br>3. Space on dry erase board for the concept map |

| | |
|---|---|
| **ADVANCE PREPARATIONS** | 1. Preview PowerPoint program, student worksheets, sample concept map<br>2. Decide whether the class will work individually or in groups for the graphing exercise.<br>3. Decide whether you want students to make a line graph or bar graph.<br>4. Copy student worksheets and graph paper |
| **APPENDIX** | 1. Background information about bighorn sheep<br>2. Example concept map of bighorn resources and harmful factors<br>3. Wyoming Science Curriculum Standards which are met with this lesson |

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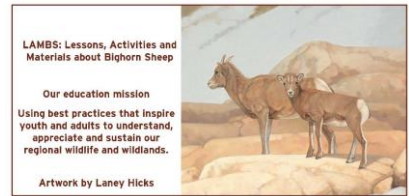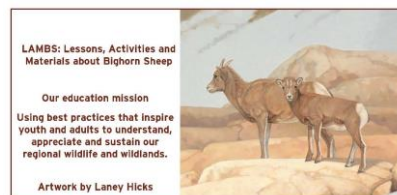| VOCABULARY | |
|---|---|
| | 1. **CARRYING CAPACITY** <br> The maximum population size of a species that the environment can sustain indefinitely, given the food, habitat, water, and other necessities available in the environment. In population biology, carrying capacity is defined as the environment's maximal load. <br><br> 2. **ENDANGERED SPECIES** <br> A species of organisms facing a very high risk of extinction <br><br> 3. **LIVESTOCK GRAZING ALLOTMENTS** <br> An area of land that is designated and managed for grazing of livestock. It may include private, state, and public lands *under the jurisdiction of the Bureau of Land Management* (BLM) and/or other federal agencies. The Bureau of Land Management administers about 245 million acres of public lands and manages livestock grazing on 155 million acres of those lands, as guided by federal law. The BLM administers nearly 18,000 permits and leases held by ranchers who graze their livestock, mostly cattle and sheep, at least part of the year on more than 21,000 allotments under BLM management. Permits and leases generally cover a 10-year period and are renewable if the BLM determines that the terms and conditions of the expiring permit or lease are being met. <br><br> 4. **HABITAT** <br> The place an animal lives, which includes all the resources an animal needs to survive and reproduce <br><br> **SUBSPECIES** <br> A taxonomic subdivision of a species consisting of an interbreeding, usually geographically isolated population of organisms |

# Instructional Sequence

| | |
|---|---|
| **ENGAGE** | **WHAT IS A BIGHORN SHEEP?**<br><br>1. Ask students how they would describe a bighorn sheep to someone who had never seen one.<br><br>2. They will likely list physical traits. You can guide them toward behavioral and physiological traits by encouraging them to consider the kinds of "things they do" and "how their body's work." |
| **EXPLORE** | **CONCEPT MAP**<br><br>1. Tell students we want to look more closely at things that bighorns need and things that might be harmful to them.<br><br>2. Using the dry erase board, guide students in creating a concept map of bighorn sheep resources and things that are harmful to bighorns. Appendix 2 is an example concept map. Their map does not have to look exactly like the example. It will depend on what types of things they think of with some guidance from you. Start with a circle in the middle labeled "bighorns" and a circle on the left and right of the "bighorns" circle. Ask questions such as:<br><br>  a. What are some things that bighorns need to survive?<br>    i. They will likely list food, water, shelter, etc, first. Draw circles for each of these attached to the blank circle to the right of the "bighorns" circle. Other things they may list are space, habitat, escape terrain, cover.<br>    ii. Ask what these things are called and they should think of the word "resources". Fill in the blank circle next to the "bighorns" circle with the word "resources".<br>    iii. Ask them for examples of bighorn foods. Answers could include grasses, forbs (flowers) and brushes. List these on lines next to the "food" circle.<br>    iv. If applicable, ask for examples of other items they thought of that are resources for bighorns.<br>  b. What are some things that might be harmful to bighorns?<br>    i. They may start by listing mountain lions, wolves, coyotes, bears or golden eagles. Ask what those animals could be called as a group. If they don't think of the word "predator" right away, ask them the term for |

|  | animals that eat other animals. Draw a circle attached to the blank circle to the left of the "bighorns" circle and write "predator" in that circle then list the examples on lines connect to the "predator" circle. |
|  | ii. Ask what other things can be harmful to bighorns. They may think of accidents, disease, overhunting/poaching or others. Draw circles for each of the things they list attached to the blank circle to the left of the "bighorn" circle. If applicable, ask for examples of each of the harmful items they listed. An example of a disease that affects bighorns is pneumonia. An example of an accident is a car hitting a bighorn on the road. |
|  | iii. Ask what term could be used to fill in the circle to the left of the "bighorn" circle that would describe all the things they listed to the left. Possible answers include hazards, harmful, detrimental, bad, etc. Write the word they agree on in the blank circle to the left of the "bighorns" circle. |
| **EXPLAIN I** | **POWERPOINT PART 1**<br>1. Tell the students they will now view a PowerPoint that looks a little deeper at ideas they came up with to create the concept map.<br>2. Show your students Part I of the PowerPoint slide show: "Wyoming Bighorn Sheep: On the Edge?" |
| **Explain II** | **Changes in Population Estimates Over Time**<br>1. Tell students that, now that they know some basic information about bighorns, they will be looking more closely at population estimates for the Whiskey Mountain and Jackson herds as well as how and why the populations change over time.<br>2. Hand out student worksheets.<br>3. Have the students look at the population estimate numbers for each year and ask what they observe. If you must guide them, ask if the numbers increase every year. Do they decrease some years?<br>4. Ask them what might cause the increases and decreases. If necessary, encourage them to recall some of the resources and harmful factors from the concept map and PowerPoint. |

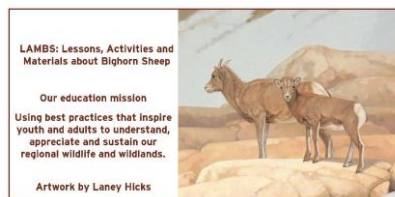| | |
|---|---|
| **ELABORATE** | **Students Graph Data - Bighorn Sheep Population Estimates**<br>1. Tell the students that they will now use the population estimate data from the worksheet and graph paper to create population graphs. Inform them to make either bar graphs or line graphs.<br>2. If you are dividing students into groups, do so now.<br>3. Instruct the students to read the background information and then use the data to create their graphs. |
| **EVALUATE** | **Students Use Graph to Answer Questions**<br>Once the students have completed the graphs, tell them to use the graphs to answer the questions on the worksheet. |
| **WRAP-UP** | **POWERPOINT PART 2**<br>1. Inform the students that they will now watch Part II of the PowerPoint slide show in order to compare their own graphs and responses to questions to those from biologists.<br>2. Show Part II of the PowerPoint slide show: "Wyoming Bighorn Sheep: On the Edge?".<br>3. Ask a few students to summarize what they learned in this lesson. |

## Appendix 1: Bighorn Sheep Background Information

It is estimated that over 2 million wild bighorn sheep roamed many parts of the west in the 1800s. With European settlement, the number of bighorn sheep plummeted to an estimated 15,000 sheep and bighorn sheep were extirpated throughout much of their historic range.  The decline was due to *unregulated* hunting (which differs significantly from regulated hunting), habitat loss, predation, disease transfer from domestic sheep and goats to wild bighorns, and competition for food resources with domestic animals.
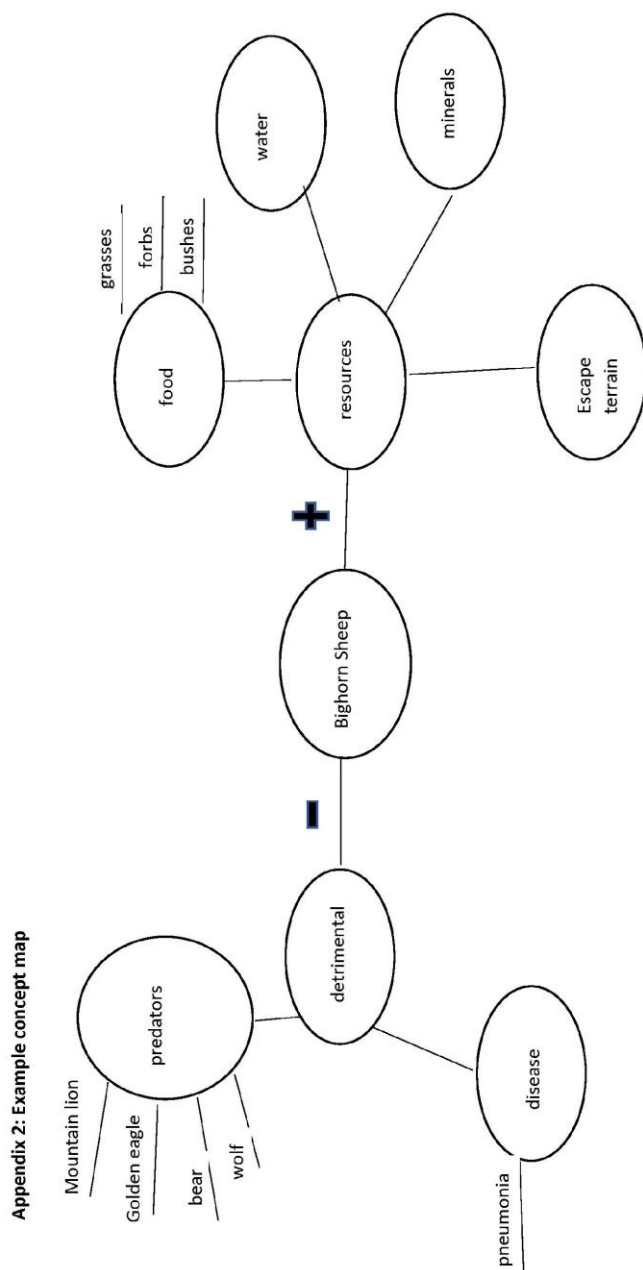
Thanks to efforts by conservation organizations like hunting groups and state wildlife agencies, the number of wild bighorn sheep has increased to about 70,000 sheep throughout the west.  As part of this conservation effort, managers used transplant programs, where individual sheep from healthy herds are trapped and moved to different areas to re-establish formerly inhabited areas or to supplement small existing herds.

Currently, there are three subspecies of wild bighorn sheep: 1) Rocky Mountain bighorn sheep, 2) Desert bighorn sheep, and, 3) Sierra Nevada bighorn sheep. Of the three subspecies, the Sierra Nevada bighorn sheep is most limited in population size and range. In fact, the Sierra Nevada bighorn sheep subspecies was federally listed as an endangered species under the Endangered Species Act (ESA) in 1999.  Predation by mountain lions was the primary factor that led to the severe decline of this subspecies.  By 1995, there were only about 100 Sierra Nevada bighorn sheep anywhere in the world. Since it was listed as endangered and federally protected, this subspecies has grown to about 400 individuals today.

In the US, the Rocky Mountain bighorn sheep is the most widely distributed subspecies. This subspecies is the focus of the activities that are included in this lesson. Specifically, students will use real-world data and information from case studies on different herds of Rocky Mountain bighorn sheep that live in Wyoming.

![National Bighorn Sheep Center, Dubois, WY]
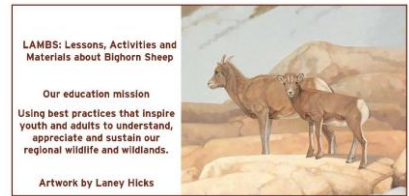
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# Appendix 2: Sample Concept Map



**Appendix 2: Example concept map**

# Appendix 3: Wyoming Science Curriculum Standards
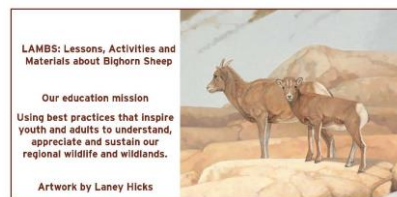
**Middle School**

- MS-LS1-4. Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.
- MS-LS1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
- MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
- MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
- MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
- MS-LS4-4. Construct an explanation based on evidence that describes how genetic variations of traits in a population affects individuals probability of surviving and reproducing in a specific environment.
- MS-LS4-6. Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.
- MS-ETS2-2. Develop a model defining and prioritizing the impacts of human activity on a particular aspect of the environment, identifying positive and negative consequences of the activity, both short and long-term, and investigate and explain how the ethics and integrity of scientists and engineers and respect for individual property rights might constrain future development.

**High School**

- HS-LS2-1. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.
- 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 the claims, evidence, and reasoning that the complex biotic and abiotic interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may results in a modified ecosystem.

- HS-LS2-7. Evaluate and assess impacts on the environment and biodiversity in order to refine or design a solution for detrimental impacts or enhancement for positive impacts.
- HS-LS2-8. Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.
- HS-LS4-6. Create and/or use a simulation to evaluate the impacts of human activity on biodiversity.
- HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
- HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

National BIGHORN SHEEP CENTER — DUBOIS, WY

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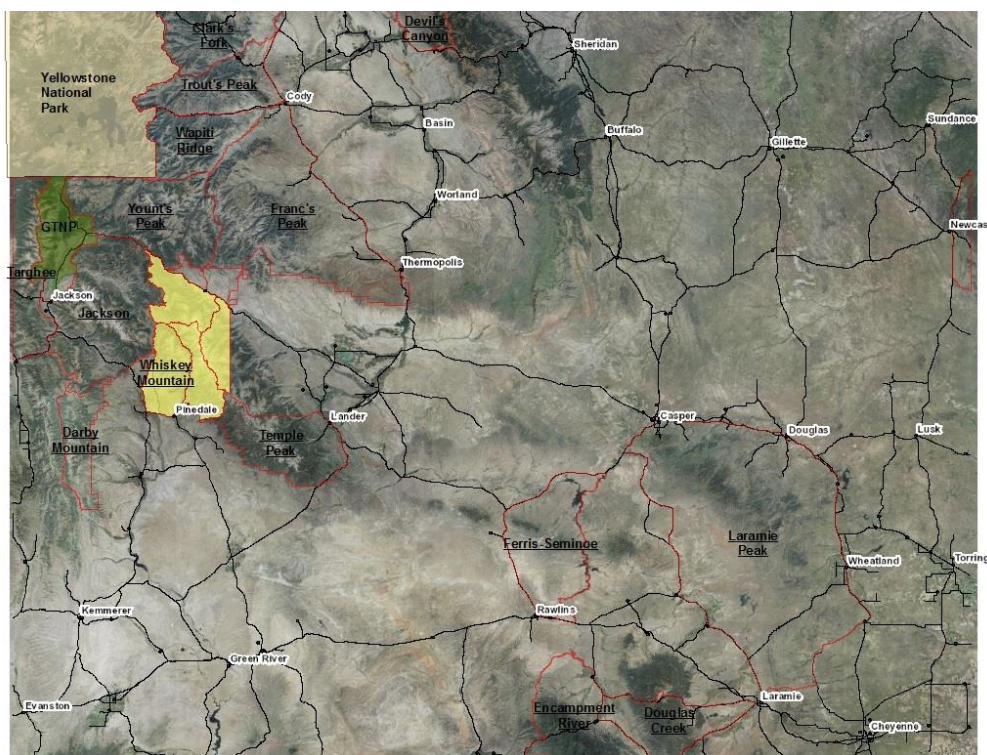
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# Student Worksheet
# Wyoming Bighorn Sheep: On the Edge?
## Case Study 1: Whiskey Mountain Bighorn Sheep Herd

**Instructions for this Activity**

Individually, read through this page of background information thoroughly before creating your graphs. After you have graphed the data, answer the questions that follow.

**Background Information**



The Wyoming Game & Fish Department has a population objective of 1,350 bighorn sheep for this herd. The 2018 postseason population estimate is 700 sheep. The herd has been below objective for over two decades following a pneumonia related die-off in 1991. The population continues to fall below objective primarily due to persistent lamb pneumonia. The same bacteria thought to be responsible for the large die-off in 1991 are believed to be the cause of many lamb deaths.

The Whiskey Mountain bighorn sheep herd occupies the northern Wind River Mountain Range. Much of the sheep habitat is located in wilderness areas and remains undisturbed. Despite protection from development and disturbance, the condition of key winter range throughout this herd is still subject to change based on environmental
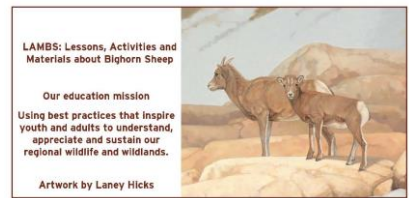
conditions. In 2012 and 2013, sheep range throughout the herd was impacted by extreme drought.

The primary management challenge for this herd is to identify the specific causes of the persistent pneumonia in the population. Managers then must determine how to prevent the spread of pneumonia causing bacteria. If that happens, it is likely the sheep population will grow quickly and present managers with a new challenge of how to maintain a stable population that does not increase above the management objective and result in overcrowding on the limited amount of winter range.

**Whiskey Mountain Bighorn Sheep Herd Population Data**

Use the following table to create a graph (bar or line graph) showing the population estimate of bighorn sheep each year. Put "Year" on the x-axis and "Population Estimate" on the y-axis.
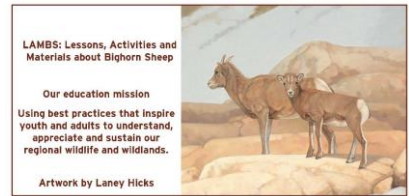
| Year | Population Estimate |
|------|---------------------|
| 1988 | 1340 |
| 1990 | 1480 |
| 1992 | 1000 |
| 1994 | 930 |
| 1996 | 920 |
| 1998 | 890 |
| 2000 | 810 |
| 2002 | 660 |
| 2004 | 623 |
| 2006 | 745 |
| 2008 | 891 |
| 2010 | 825 |
| 2012 | 1010 |
| 2014 | 1044 |
| 2016 | 841 |
| 2018 | 700 |

{Data were provided by bighorn sheep biologist, Greg Anderson, who works for Wyoming Game and Fish.}
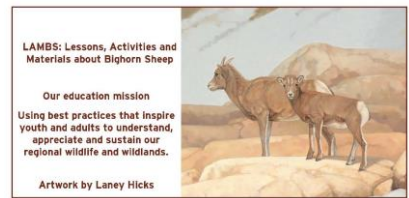
## QUESTIONS

1. In which two years do you see the largest decreases in numbers of bighorn sheep due to pneumonia?

2. Based on the data you graphed for the population estimate, would you say that this herd has recovered from what happened in 1991? Explain.

3. How many bighorn sheep do managers strive to maintain in this herd each year?

4. Do you think that the number of sheep that managers strive to maintain each year represents carrying capacity for this herd? Why or why not?

5. During which year was the number of bighorn sheep highest?

6. Did the number of bighorn sheep increase or decrease from 2010-2012?
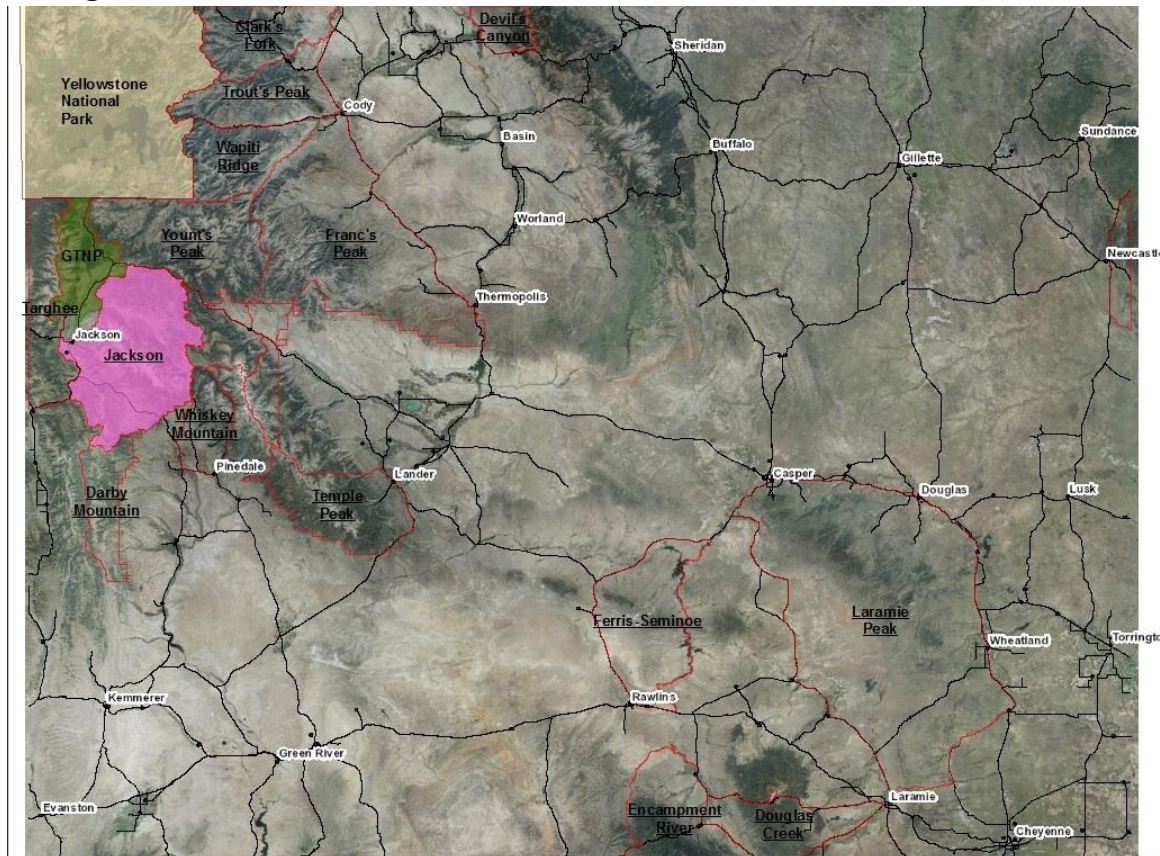
# Student Worksheet
# Wyoming Bighorn Sheep: On the Edge?
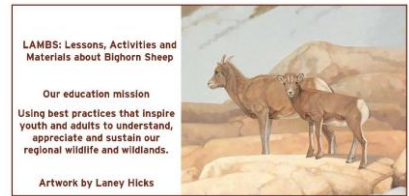## Case Study 2: Jackson Bighorn Sheep Herd

**Instructions for this Activity**

Individually, read through this page of background information thoroughly before creating your graphs. After you have graphed the data individually, work as a group to answer the questions.

**Background Information**



The Jackson bighorn sheep herd experienced a pneumonia-related die-off in 2001-2002 in which approximately 50% of the population died. In 2011 and 2012, an estimated 30% of the population died from another pneumonia outbreak. Lamb survival rebounded within a couple of years after both outbreaks, leading to relatively quick herd recoveries. The population objective (goal) for this herd is 500 animals. In February 2016, a total of 375 sheep were observed. Currently, the population is increasing due to
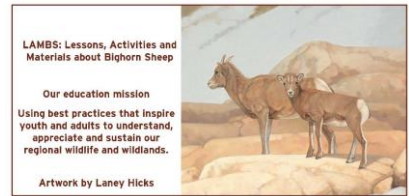
relatively high birth rates and may approach the objective of 500 within 2-3 years. Past trends seem to indicate that pneumonia outbreaks occur when the population reaches 500-600 animals. Therefore, the public and managers should monitor the herd closely and anticipate another pneumonia outbreak in the near future.

## Jackson Bighorn Sheep Herd Population Data

Use the following table to create a graph (bar or line graph) showing the population estimate of bighorn sheep each year. Put "Year" on the x-axis and "number of bighorn sheep" on the y-axis.

| Year | Population Estimate |
|------|---------------------|
| 1986 | 289 |
| 1988 | 353 |
| 1990 | 384 |
| 1991 | 446 |
| 1992 | 400 |
| 1993 | 183 |
| 1994 | 297 |
| 1996 | 390 |
| 1998 | 436 |
| 2000 | 503 |
| 2002 | 227 |
| 2004 | 132 |
| 2006 | 183 |
| 2008 | 309 |
| 2010 | 299 |
| 2012 | 350 |
| 2014 | 330 |
| 2016 | 366 |
| 2018 | 363 |

{Data were provided by bighorn sheep biologist, Aly Courtemanch, who works for Wyoming Game and Fish.]

**QUESTIONS**

1. In which two years do you see the largest decreases in numbers of bighorn sheep due to pneumonia?

2. If the current trend continues, when will the number of bighorn sheep be above 500?

3. During which year was the number of bighorn sheep lowest?
4.

5. Based on the data you graphed for the number of total sheep observed, would you say that this herd has recovered from what happened in 2001-2002? Explain.

6. How many bighorn sheep do managers strive to maintain in this herd each year?

7.  Do you think that the number of sheep that managers strive to maintain each year represents carrying capacity for this herd?  Why or why not?