How Many Bighorns Can Live in This Forest?

Adapted from Project Wild

Objectives:
Students will be able to describe the food needs of bighorn sheep and identify a limiting factor and define carrying capacity by becoming a "bighorn" and looking for food in this active simulation.

Grade level: 3-8, but could be adapted for younger and older grades
Duration: 1 hour (more with adaptations added)
Group Size: 15-35 students (need to adjust number of tokens based on class size)
Setting: outdoors is best

NGSS Connections:
*See detailed standards and ideas at end of lesson
3-LS4-2, 3-LS2-1 , 3-LS4-3
4-LS1-1
5-LS2-1
MS-LS1-4 , MS-LS1-5 , MS-LS1-6 , MS-LS2-1 , MS-LS4-4 , MS-LS4-5

Background:

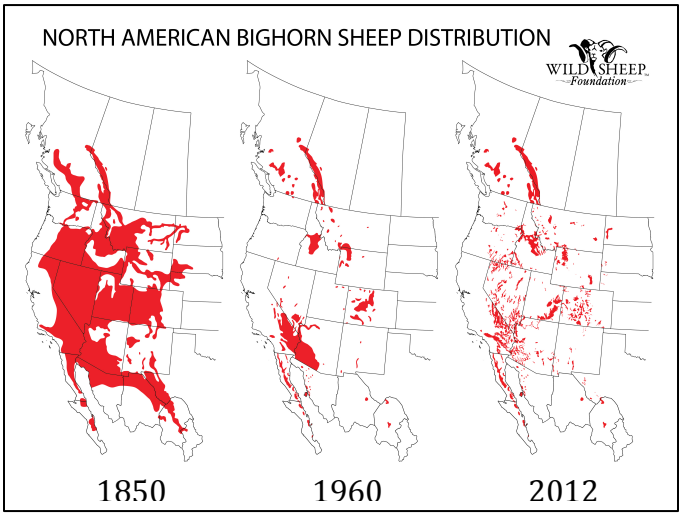
There are four species of wild sheep in North America, broken down into two categories: bighorn and thinhorn. The desert bighorn live in 7 of the western states and parts of northern Mexico, with a population of ~39,000. This sheep can live up to 6 months without drinking water, getting the moisture in needs from plants alone if conditions require. The rocky mountain bighorn live in 14 of the western states including 2 Canadian provinces and include a population of ~48,000. The thinhorns are composed of dall and stone sheep. The dall sheep with its white fur is often considered the most beautiful sheep. The ~90,000 dall sheep live in Alaska and northeast Canada. The ~14,500 stone sheep, with their darker fur live only in two Canadian provinces. This activity will focus on the bighorn.

The male sheep is called a ram while the female is called a ewe. A young sheep is referred to as a lamb.

Sheep have many adaptations that help them survive. Their hairs are hollow, allowing for better insulation, both to keep the cold and heat out. The coloration of their fur helps them camouflage into their surrounding habitat. Bighorn sheep have a double-layered skull honeycombed with bone struts to protect their brains during their impressive head-banging battles. They are ruminants, and like other ungulates (hoofed animals), don't chew their food when first eaten, but instead these "cud chewers" gobble up food fast while in the open, and regurgitate it to chew later while they are relaxed and protected in the safety of cover.

Historically, bighorn lived in every western state. After gold was discovered in California in 1849 and human populations expanded west, bighorns began to be impacted. The 1960s saw the lowest population of bighorns, due to many factors including: habitat loss, diseases from domesticated animals, competition with livestock, and predation.

Efforts to reestablish bighorns into their historic mountain ranges have been occurring for many decades, with the first translocation taking place in 1922. These efforts have really paid off. For example, Nevada had just a remnant of sheep in 1960, but over 11,000 today. One of the biggest issues facing bighorns today is the transfer of bacteria, most often *M. ovipneumoniae (*Movi for short*)*, from domesticated sheep and goats, which results in pneumonia and often death.



Simulation:

This simulation uses data from a research study at Elephant Mountain Wildlife Management Area (WMA) in Texas. The WMA is composed of 93 sq. km (23,000 acres) of which 32 sq. km (8,000 acres) are suitable for bighorn habitat.

The bighorn habitat lies within a transition zone with high desert grasslands and desert scrub and receives 30.5 cm of rain a year. The land for the WMA was donated in 1985 from a private party for the conservation of desert bighorns. In 1987 twenty bighorns were initially transplanted into the area. Recent herd populations are below.

Year	TOTAL			TOTAL
	RAMS	EWES	LAMBS	SHEEP
2015	56	54	16	126
2014	85	63	27	175
2013	64	96	16	176
2012	69	74	13	156
2011	67	64	13	144
2010	47	90	30	167

The activity is based on the following figures that represent the yearly average of a typical desert bighorn from the Elephant Mountain WMA in Texas. The components of an actual bighorn's diet will vary depending on the size of the animal, and the area, season, and year.

Browse.....730 pounds = 50%
Forbs.....511 pounds = 35%
Grasses.....161 pounds = 11%
Succulents.....58 pounds = 4%
Total.....1,460 pounds= 100%

Browse: young twigs, leaves, and shoots.
Forbs: a broad leave plant other than grass.
Grasses: plants that have narrow green leaves.
Succulents: Having thick, heavy leaves or stems that store water (cactus).

Desert bighorn eat an estimated 3-5 pounds of weight vegetation a day, which varies based upon season and availability. For this simulation, 4 pounds of food per day for a total of 1, 460 pounds of food is needed to "survive". Although a sheep *may* survive with a little less, the energy obtained from the vegetation would go directly to staying alive instead of horn growth, strong health, etc.

Materials:

- Large playing field or gymnasium (about 50'x50')
- 4 colors of plastic token, each labeled with appropriate markings (see step 1 procedures)
- envelope for each student
- calculator (optional)

Procedures:

1. If tokens are not previously marked, for a class of 30 mark the tokens as follows (the number after each letter tells how many pounds of that kind of food the token represents):

Number of Tokens Needed

Color	Food	Label	Tokens Per Approximate # of Students			
			10 students	20 students	30 students	40 students
White	Grasses	G-730	5	10	15	20
White	Grasses	G-365	10	25	40	55
Red	Forbs	F-511	5	10	15	20
Red	Forbs	F-256	10	25	40	55
Yellow	Browse	B-161	5	10	15	20
Yellow	Browse	B-81	10	25	40	55
Orange	Succulents	S-58	5	10	15	20
Orange	Succulents	S-29	10	25	40	55

White (grasses)- Mark 15 tokens **G-730** and 40 tokens **G-365**
Red (forbs)- Mark 15 token **F-511** and 40 tokens **F-256**
Yellow (browse)- Mark 15 tokens **B-161** and 40 tokens **B-81**
Orange (succulents)- Mark 15 tokens **S-58** and 40 tokens **S-29**

2. Have each students write his or her name on an envelope. This will represent the student's "shelter" where the bighorn will return to "chew its cud".

3. Scatter the tokens in the playing field. With chalk or rope, mark one side (or a few sides) as the area of the starting line.

4. Have students line up on the starting line, with their envelope at their feet on the ground. Explain that they are bighorn sheep looking for food and that their envelopes represent their shelter. Do not tell them what the colors, letters, and numbers on the tokens represent. Tell them only that the tokens represent various kinds of bighorn food and this simulation represents one year's worth of grazing. You may, or may not, mention to them that since bighorn eat different kinds of food at different times of the year, students should gather different colored tokens to represent a variety of food.

5. Explain to students that they must *walk* because bighorn do not run down their food, they graze for it, usually out in the open. When students find a token, they should pick it up and return to their shelter of the cliffs or forest (their envelope) so predators have less chance of seeing them, and put it in their envelope. (Bighorn would actually eat the food as they find it, but can chew their cud in the safety of shelter.)

6. After students understand what they are to do, have them begin "grazing". When all the food tokens have been picked up, the grazing is over. Ask students to pick up their envelopes containing their food they gathered and return to class.

7. Explain what the colors and numbers represent. Ask each student to add up the total pounds of food he or she gathered and write the amount on his or her envelope.

8. Tell the students that each desert bighorn needs 1,460 pounds (662 kg) of food a year to survive. Is there enough to feed all the sheep?

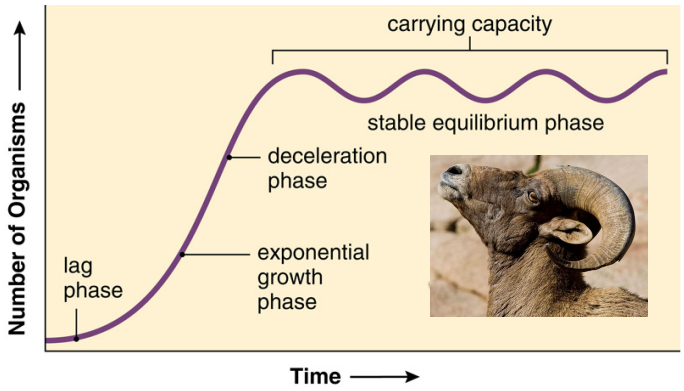
9. Ask each student to tally how many pounds of each of the three categories of food he or she gathered and to convert these numbers into percentages of the total poundage of food he or she gathered.

10. Explain the typical percentages of vegetation eaten throughout a year for a typical desert bighorn (see "Simulation" for info). Ask students to think about how healthy those were that survived. Did they all have around the proper percent of each type of vegetation? Would their sheep have been healthy?

11. Help students calculate a class total for all the pounds of food they gathered. Divide the total by 1,460 pounds needed by an individual desert bighorn to survive in a year, and then discuss the following:

- How many bighorns could the habitat support?
- Why did that number only survive in the activity?
- What percentage of the bighorns survived?
- What percentage would have survived had the food been evenly divided?

13. Discuss *carrying capacity*, which is the maximum number of individuals of a given species that an area's resources can sustain indefinitely without significantly depleting or degrading those resources. What would happen the following year, with the same amount of vegetation (sheep graze only so low on plant so that it grows back the following year) and less sheep now living in the area? (Population would increase and then reach a point that it would decrease again, over and over every few years…reaching the areas carrying capacity for bighorn). See graph at end of lesson plan for showing class.



Evaluation:

What are some of the limiting factors that may affect the survival of desert bighorn?

- Amount of food. Type of food.
- Size of population (too many sheep impacts other sheep)

What is carrying capacity and how did this simulation demonstrate it?

*For more evaluation ideas linked to Next Generation Science Standards (NGSS), see *Next Generation Science Standards (NGSS) Detailed Connection Ideas* at end of lesson plan.

Adaptations and Extensions:

- Do the simulation again, using the same amount of food, but fewer students. Were more able to survive?
- Repeat the simulation again. Add in a ram that wondered from the herd and picked up *M. ovipneumoniae (*Movi for short*)* from domesticated sheep grazing in the summer in the area. This "sheep" walks around coughing and as he or she touches (or sprays with a water bottle, as the bacteria is most likely spread through the air) another sheep, the bacteria are spread. Infected sheep can then impact other sheep. The teacher would randomly call out a few student names as they are about to be infected and tell them

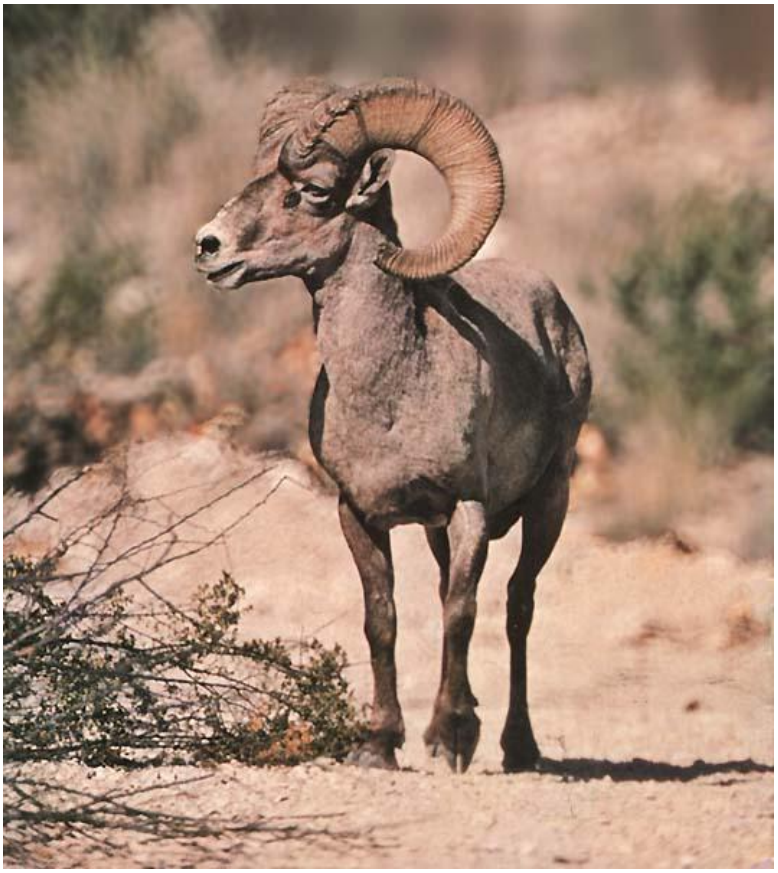
they are immune, as in some individual sheep the bacteria doesn't transform into pneumonia. In reality, individual herd loses can range from 5%-95%.

- Repeat the simulation again, but include a wounded sheep who lost a leg where the student must hop on one leg, and a blind sheep (use a blindfold) who was wounded by either a predator or fighting during the rut.

- Add in a predator, such as a mountain lion, who can prey upon the sheep. For this, the mountain lion must also walk and once captures a student needs to escort him or her off the playing field. Then, count to 20 quickly, representing the week the mountain lion would feed on the dead bighorn, and then return to pursue more sheep.

- Create tri-fold brochures of the Elephant Mountain WMA. Detailed info in available through Texas Parks & Wildlife website.

- Calculate actual percent increase or decrease for the Texas herd using the actual data from the Elephant Mountain WMA each year between 2010 and 2015 (see background info for data).



Next Generation Science Standards (NGSS) Detailed Connection Ideas:

3-LS4-2 **Use evidence to construct an explanation for how the variation in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing** (Could discuss how those more immune to Movi bacteria have greater chance of surviving, how those not crippled have greater chance of getting enough food and escaping predators, lighter or darker fur could help camouflage a sheep better to reduce predation)
3-LS2-1 **Construct an argument that some animals form groups that help animals survive** (Could discuss how herd watches over each other, looking for predators, as they forage for food, then return to more protected area to "chew their cud")
3-LS4-3 **Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all** (Discuss how uneven food distribution could lead to some sheep not getting the amount they need for survival, or even just enough to survive but not a healthy sheep (horns not growing much that year due to energy going only into survival.))
4-LS1-1 **Construct an argument that animals have internal and external structures that function to support survival, growth, behavior, and reproduction** (Discuss their 4-chambered stomach (they are ruminants) that allows them to quickly swallow food while out in the open and then move to more secluded and safe area to regurgitate food, chew their cud, an d then swallow it again. Could discuss more compact horns against their head vs. antlers, which allow them to walk along cliffs easier so they don't knock themselves off.)
5-LS2-1 **Develop a model to describe the matter of movement among plants, animals, decomposers, and the environment** (Could have students draw diagram of suns energy helping plant grow, this energy transferring to sheep when it eats plant, then animal dying and being broken down by decomposers. Could develop food chains involving bighorn.)
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** (Could discuss herding of sheep to protect young, fighting during rut and most dominant males winning chance to mate, etc.)
MS-LS1-5 **Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms** (Discuss how Movi bacteria could be passed on to young in bighorn, with no immunity as in many bacteria, discuss availability of food spread uneven in area could limit some sheep not getting the amount they need as they wander their range. Evidence could be growth of trees and large bushes reducing grass growth)
MS-LS1-6 **Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out 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** (Combine data from food tokens collected. Determine carrying capacity. Determine amount of food needed to sustain the current "herd" of the class)
MS-LS4-4 **Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment** (Could discuss traits leading to larger or

smaller horn growth which could help during rut. Discuss how, genetically, some individuals are faster, which allows some individual sheep to escape predators more easily.)
MS-LS4-5 **Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms** (Discuss efforts to reduce Movi bacteria spread and efforts being done to eliminate it in wild and domestic sheep)

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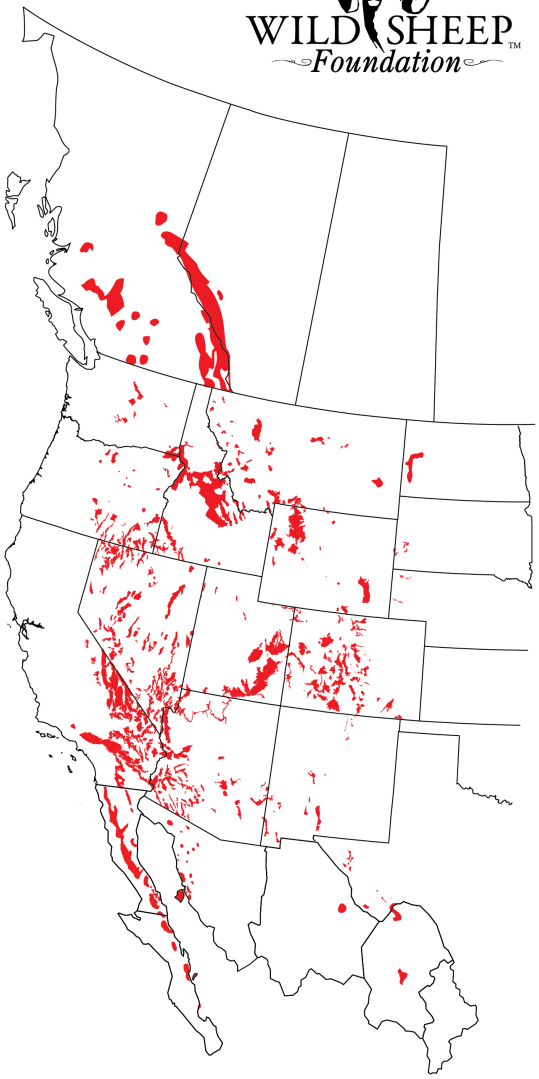

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Carrying Capacity