Is there a home on the range for bison?

An exploration of the relationships between people and bison through current management strategies and conservation efforts – High School Life Science

Bison restoration is an incredibly complex and contentious issue in the state of Montana, and many of your students may come in with strongly-held beliefs about bison—running the spectrum from viewing bison as necessary for the health of their communities to viewing bison as a threat to their way of life. As such, this issue is not something we expect you will be able to "solve" with your students within a couple of class periods.

This lesson focuses on current practices and provides students with an understanding of the complexity of managing and restoring wild bison in Montana rather than *Who is right?* and *What should be done?* The lesson should guide students in examining their beliefs about bison in light of state and federal management structures and ongoing bison research. The larger goal of the population dynamics lab is to help students understand that the factors limiting the Yellowstone bison population—and the populations of wild bison throughout the state of Montana—are more political and human-interest influenced than they are ecologically- or biologically-based. And that the management process is a political process, driven largely by cultural attitudes and stakeholder values. That is to say, the research National Park Service (NPS) biologists undertake to gain a better understanding of these population dynamics and the traditional knowledge held by the tribes do play a role in guiding management decisions, but they are ultimately only two pieces of this larger management puzzle.

This three-part lesson, which may take four-five class periods depending upon how much time is incorporated for meaningful and respectful class discussion, contains an introductory background knowledge building and self-reflection activity, a bison population ecology lab that meets Montana Math and Science Content Standards, and a conclusion providing additional information and final reflection. This lesson will provide students with a broader understanding of why and how research of the Yellowstone bison population is culturally important to different groups, including American Indian tribes, and how to contextualize this research within the current management landscape.

The *introductory background knowledge building and self-reflection activity* will engage students' prior knowledge and beliefs about bison using a mind map. The mind map will be revisited after watching the videos and engaging with the focus questions to see if any of their perspectives have shifted. The preliminary mind map activity is to be immediately followed by three short videos, twenty minutes, six minutes, and three minutes respectively. The first video is *In This Together, We Are One* with middle school students in the town of Poplar on the Fort Peck Reservation and how they are learning about their tribes' relationship with bison. This is followed by a short video documenting the bison's return to the Wind River Reservation in Wyoming, home of the Eastern Shoshone and Northern Arapaho tribes. Finally, there is a three-minute segment of Jason Baldes (Eastern Shoshone) discussing tribal

Indian Education for All Unit
opi.mt.gov Montana Office of Public Instruction

ECOLOGY PROJECT INTERNATIONAL

This lesson is a special collaborative endeavor between the Montana Office of Public Instruction Indian Education for All Unit and Ecology Project International and made possible through Indian Education for All grant funding.

governance in regard to the bison's return on his reservation. The purpose is to have student listen carefully to these perspectives in the videos and to evaluate whether new information may have been presented that shifted students' perspectives on bison.

In the *bison population ecology lab*, students will use current management documents to create population models for the Yellowstone bison herd and explore some of the limiting factors—human and ecological—that are at play in controlling and influencing the population of this large, culturally and ecologically important species.

Finally, in the *conclusion and reflection*, students will read and discuss a number of excerpts and articles describing current restoration efforts and making connections between the Yellowstone bison herd and tribal restoration efforts throughout Montana.

NOTE: While "bison" is technically the more accurate name for the Plains Bison (Bison bison bison) that is the subject of this lesson, we use "buffalo" and "bison" interchangeably, as is commonly the case in both Native and settler communities throughout Montana.

Montana Science Content Standards (NGSS HS-LS2-1 and HS-LS2-7)

HS-LS2-1 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

HS-LS2-1. **Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.** [Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] [*Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical and/or computational representations of phenomena or design solutions to support explanations.	LS2.A: Interdependent Relationships in Ecosystems Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.	Scale, Proportion, and Quantity The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

Connections to other DCIs in this grade-band: N/A

Articulation of DCIs across grade-bands:
MS.LS2.A and **MS.LS2.C**; **MS.ESS3.A** and **MS.ESS3.C**

HS-LS2-7 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

HS-LS2-7. **Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.** [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	LS2.C: Ecosystem Dynamics, Functioning, and Resilience Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. LS4.D: Biodiversity and Humans Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). *(secondary)* Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. *(secondary) (Note: This Disciplinary Core Idea is also addressed by HS-LS4-6.)* ETS1.B: Developing Possible Solutions When evaluating solutions, it is important to take into account a range of constraints including cost, safety, reliability, and aesthetics and to consider social, cultural and environmental impacts. *(secondary)*	Stability and Change Much of science deals with constructing explanations of how things change and how they remain stable.

Connections to other DCIs in this grade-band:
HS.ESS2.D ; **HS.ESS2.E** ; **HS.ESS3.A** ; **HS.ESS3.C**

Articulation of DCIs across grade-bands: **MS.LS2.C** ; **MS.ESS3.C** ; **MS.ESS3.D**
Common Core State Standards Connections: *ELA/Literacy -* **RST.9-10.8** Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. **RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. **RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. **WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. *Mathematics -* **MP.2** Reason abstractly and quantitatively. **HSN.Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

Indian Education for All Essential Understandings

Essential Understanding 3: Oral histories are as valid as written histories and inherently include tribal worldviews and the retention of spiritual beliefs and traditions

The ideologies of Native traditional beliefs and spirituality persist into modern day life as tribal cultures, traditions, and languages are still practiced by many American Indian people and are incorporated into how tribes govern and manage their affairs.

Additionally, each tribe has its own oral histories, which are as valid as written histories. These histories predate the "discovery" of North America.

KEY CONCEPTS

- The term spirituality within a cultural context can be limiting and misconstrued. Spirituality to Indigenous peoples generally refers to one aspect of their worldview in which all things are connected. Spirituality in this context does not necessarily equate to nor denote religion.
- A complex history of pre-Columbian tribal migrations and intertribal interactions, European colonization and Christianization efforts, and federal assimilation policies have contributed to the broad range of spiritual beliefs held by American Indians today.
- Despite this history, Native people have retained their spiritual beliefs and traditions – tribal languages are still spoken, sacred songs are still sung, and rituals and ceremonies are still performed.
- It is not important for educators to understand all the complexities of modern day American Indian cultures; however, they should be aware of their existence and the fact they can influence much of the thinking and practice of American Indians today.
- Humor plays an important role in American Indian cultures, there was no "stoic" Indian.

- Tribal oral traditions, ideologies, worldviews, and the principles and values associated with them, are as valid as other such traditions from around the world and should be accorded the same respect and standing.
- Educators should be aware that portions of these principles and values are private and are to be used and understood by certain individuals, groups, or the entire tribe. Tribal culture bearers, experts, and others can assist educators in navigating these situations.

Essential Understanding 4: Tribal territories were inhabited, utilized, and stewarded for millennia and were not "given" to tribes by the U.S. Government

Though there have been tribal peoples living successfully on North American lands for millennia, reservations are lands that have been reserved by or for tribes for their exclusive use as permanent homelands. Some were created through treaties while others were created by statutes and executive orders. The principle that land should be acquired from tribes only through their consent with treaties involved three assumptions: Both parties to treaties were sovereign powers. Indian tribes had some form of transferable title to the land. Acquisition of Indian lands was solely a government matter not to be left to individual colonists or states.

KEY CONCEPTS

- Reservations are lands that have been reserved by tribes or for tribes for their exclusive use as permanent homelands.
- Some reservations are the remnants of a tribe's original land base while others were created by Congressional statute or executive order for the resettling of Indian people forcibly relocated from their homelands.
- Original Indian title to land was acknowledged by tribes and European nations, as well as the United States.
- Indian tribes fought to protect their lands and resources including actively utilizing American courts and the Indian Claims Commission.
- Today, there are 326 reservations in the United States, seven of which are located in Montana.
- There are two main treaties that affected Montana tribal lands:
    - The Fort Laramie Treaty, 1851, 1868
    - The Hellgate Treaty of 1855
- After Congress officially ended treaty-making with tribes in 1871, the federal government used other means to further reduce Indian landholdings on reservations.

Essential Understanding 7: Indian nations possess sovereign powers

American Indian tribal nations are inherent sovereign nations and they possess sovereign powers, separate and independent from the federal and state governments. However, under the American legal system, the extent and breadth of self-governing powers are not the same for each tribe.

KEY CONCEPTS

- Tribal sovereignty stems directly from the fact that tribal nations constitute distinct political communities that have the right to determine their own laws and form of government.
- Tribal self-governing powers predate the existence of the United States and are not delegated powers granted by Congress or any other entity; they are inherent powers of sovereign nations that have never been extinguished.

- Some limitations have been placed on tribal sovereignty throughout the past two centuries by Supreme Court rulings and Congressional statues, which is why tribes are sometimes referred to as "limited" sovereigns today.
- In general, tribes are free to exercise any of their sovereign powers unless Congress has specifically limited or modified them in some way.
- The extent and breadth of self-governing powers is not the same for every tribe.
- Despite the complex evolution of tribal sovereignty in America, it remains one of the most important attributes of tribal independence.

Learning Objectives

Students will:

- consider and analyze their own conceptions and biases about bison;
- listen to and consider multiple perspectives, including tribal perspectives about bison;
- use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales;
- evaluate solutions for reducing the impacts of human activities on the environment and biodiversity.

Background Information and Current Events

Bison coming back to Rocky Boy

Restoring Bison to Tribal Lands

Fort Peck Bison Restoration video [4:54]

The Return [15:56] (DVD provided by Montana Office of Public Instruction Indian Education Division to all Montana public high school libraries)

Iinnii-Buffalo Spirit: The Return of the Buffalo (Blackfeet Nation) [9:41]
More information Blackfeet Nation Iinnii Buffalo Spirit Center

The Montana Experience: Restoring an Icon [12:18]

FAQ on Tribal Treaty Hunting Rights and Bison

Blackfeet to join bison hunt outside Yellowstone

The buffalo hunt

Bison Tearing Up Private Property Where Do the Buffalo Roam?

Ranchers Say Cattle and Bison Don't Mix

Bison restoration: Critics can calm their fanciful fears

Threshold Podcast *Oh Give Me a Home: The Story of American Bison* [7 episodes/~30 min each]

PBS The Buffalo War: The Disease

Montana Indians Their History and Location

Essential Understandings Regarding Montana Indians

Bison Restoration Lesson (great resources in this lesson)

Smithsonian lesson on Intertribal Bison Council

Yellowstone Bison: conserving an American Icon in modern society (full text)

Yellowstone Issues and Resources Handbook: Bison (p. 193-203, refer to page numbers at the bottom)

Materials (all student materials provided at the end of the lesson)

Internet for watching videos

Bison mind map worksheet (1 per student)

Bison video focus questions (1 per student)

YNP Bison Population Dynamics Student Worksheet (1 per student)

Reading passages for students

Procedure

Part One: Engage: Introductory background knowledge building and self-reflection activity

Pass out a copy of the bison mind map to each student. Have students fill them in. Encourage students to symbolically and/or briefly answer each question. Let students know they will be returning to this activity, so they should leave room to add additional information. The page is divided into the following four quadrants:

- Personal Importance
  What is my connection to bison? What interactions have I had with bison? How are bison important, or not important, to me?
- Cultural Importance
  How are bison important, or not important, to Montanans as a whole? What are different cultural perspectives on bison?
- History of Bison
  Over the past 200 years, how have bison populations and their relationships to people living in Montana changed? What caused these changes? What is bison's ecological role in Montana landscapes?
- Current Conservation Efforts
  What is the current status of bison in Montana? What groups have a stake in bison conservation in Montana?

Allow students ten to fifteen minutes to fill in the mind map. They might write a few words or make drawings to represent their current knowledge of and feelings toward bison, but they should be prepared to explain to their peers, if called on, why the wrote or drew what they did. Provide each student with the video focus questions.

Watch:

In This Together, We Are One: The Buffalo Unity Project [20:05]

Shoshone Buffalo Return [6:15]

Tribal Self-Governance with Jason Baldes [3:57]

After the videos have been watched, have students take another five to ten minutes to add to their bison mind maps. It is recommended students use a different color pen so they can more easily track what they wrote in response to the films versus what they wrote down before viewing the films. Open a discussion regarding their answers to the video focus questions.

Discuss as a class what students saw in the videos that surprised them. The D.I.C.E. method would be a great strategy to use:

- What **D**isturbed you about what you saw or heard in any of the videos?
- What did you hear or see that **I**nterested you?
- What do you find **C**onfusing about this issue?
- What information did you find **E**xciting to learn about that you would want to share with someone else?

What coincided with their own prior knowledge about bison and what was new?

NOTE: If students need a little more context to understand the land dispossession dynamics and how that affects tribes and bison as discussed in the videos, and the historical and current land bases of Montana tribes, you can use the Tribal Territories in Montana map provided at the end of this lesson and the "FAQ on Tribal Treaty Hunting Rights and Bison" to explore these subjects in more depth.

Part Two: Bison population ecology lab

Read the introduction (pp. vii-viii) to the executive summary of *Yellowstone Bison* and/or the NPS History of Bison Management in Yellowstone. (see **Whole Class Reading 1**)

Instruct students to complete the Yellowstone National Park bison population lab. The students should receive instruction as to how to use the formulas provided.

Once students have completed the lab sheet, read as a whole class the attached excerpt about management in the northern range and bison population dynamics (pp. 78-80; 90-95) from *Yellowstone Bison.* (see **Whole Class Readings Two and Three**)

Discuss the following as a class:

- According to "Yellowstone Bison," what is the main concern regarding the bison population in Yellowstone National Park?

- What are the main limiting factors for the bison population? Put yourself in the shoes of someone responsible for managing a herd of bison for conservation, ecological, and/or cultural purposes.
- Why would it be important to understand the population dynamics of the herd—trends in numbers over the years, ratios of male to female bison, proportions of the herd that are young (under two years old)?
- What information do these numbers give you and how can they help to inform management decisions?
- What other information would you want to have when making decisions about bison restoration or managing a particular population of bison?

Part Three: Conclusion and final reflection

Split the students up into small reading and discussion groups. Assign one of the following readings (*all readings provided at the end of the lesson after the student worksheets*) to each group to read aloud within their group:

READING GROUP 1 (Longer passage, four pages – good for larger group)

Slow drip Bison quarantine creating path from Yellowstone to Fort Peck from the Bozeman Chronicle (*proficient level reading*)

READING GROUP 2

Recommendations for Future Management (pp. 165-174) from *Yellowstone Bison* (*above proficient level reading*)

READING GROUP 3

Tribal Involvement (pp. 37-39) from Fish Wildlife and Park's *Plains Bison Ecology, Management and Conservation* (*proficient level reading*)

READING GROUP 4

Conclusion (pp. 175-176) to *Yellowstone Bison* (*proficient level reading*)

Optional online readings:

Rancher Perspective: Farm bill spending pits Yellowstone bison against Montana beef (proficient level reading)

Visit the Intertribal Buffalo Council and read about the council's history and current activities.

Visit the National Park Service to read more about current management strategies and challenges in Yellowstone.

Each group should discuss the following questions after they read their assigned passage:

- What voices or perspectives are represented?

- Which groups are mentioned as having a stake in bison conservation efforts? Are they involved in decision-making processes? Is there anyone missing from the table?
- What are the hopes and goals for bison conservation the authors mention?
- What challenges do they describe regarding bison conservation?
- What opportunities for future bison conservation efforts does this passage or article mention?

Once they have compared notes in their small groups (10-15 min), have students group up with other students who read the same resources as they did, if there are multiple groups assigned the same passages. In these, "expert groups" ask them to share what they thought the main points and takeaways from their assigned article regarding bison conservation (10 min).

Come together as a whole class (10 min) to share reflections on bison and bison management students have after watching the videos, exploring Yellowstone bison herd population dynamics, and discussing the readings about current management of bison. The overarching questions here are: "What are the many, diverse relationships Montanans have with bison?" and "What pathways forward do you see for bison restoration in the state?"

Assessment

As a final assessment of students' main takeaways from the lesson, have them again spend some time adding to their bison mind maps, using a third color of ink. Ask them to reflect on what new knowledge and understandings they have gained during the bison population lab and reading activity. How have their opinions changed (or not changed)? How has their understanding of bison's cultural significance deepened? What do they know now about bison—their history and their conservation—they didn't at the beginning of the lesson?

Bibliography

Adams, S.M. and A.R. Dood. *Background Information on Issues of Concern for Montana: Plains Bison Ecology, Management, and Conservation*. Bozeman, MT: Montana Fish, Wildlife, and Parks, 2011.

The Decolonial Atlas. "Extermination of the American Bison." March 7, 2015.

Geremia, Chris, Lauren McGarvey, and P.J. White. "Status Report on the Yellowstone Bison Population, October 2019." Yellowstone National Park: Yellowstone Center for Resources, 2019.

Intertribal Buffalo Council. "Who We Are: Our History."

MAPS Media Institute. "In This Together, We Are One: The Buffalo Unity Project." Video, 20:05. October 27, 2019. Video, 20:05.

National Park Service. "History of Bison Management."

National Park Service. "Bison Management."

White, P.J., R. L. Wallen and D. E. Hallac, eds. *Yellowstone Bison: Conserving an American Icon in Modern Society.* Yellowstone National Park, WY: Yellowstone Association, 2015.

White, P.J., R. L. Wallen and D. E. Hallac, eds. *Yellowstone Bison: Conserving an American Icon in Modern Society. Executive Summary.* Yellowstone National Park, WY: Yellowstone Association, 2015.

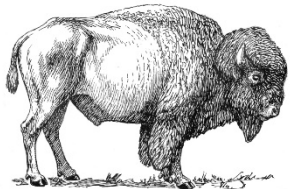
Wright, Michael. "Slow drip: Bison quarantine creating path from Yellowstone to Fort Peck." *Bozeman Daily Chronicle,* December 8, 2019.

Personal Importance

What is my connection to bison? What interactions have I had with bison? How are bison important, or not important, to me?

Cultural Importance

How are bison important, or not important, to Montanans as a whole? What are different cultural perspectives on bison?



Plains Bison (*Bison bison bison)* or Buffalo

History of Bison

Over the past 200 years, how have bison populations and their relationships to people living in Montana changed? What caused these changes? What is bison's ecological role in Montana landscapes?

Current Conservation Efforts

What is the current status of bison in Montana? What groups have a stake in bison conservation in Montana?

Video Focus Questions

In This Together, We Are One: Buffalo Unity Project Focus Questions

1. Did tribal members ever hunt buffalo alone? How were buffalo hunted?

2. What are some of the ways buffalo hold significance and importance to tribal members?

3. How would the extinction of buffalo in North America affect tribes?

4. How long was the buffalo gone from the Assiniboine-Sioux lands?

5. Have you ever been scared to be who you are? (A yes or no answer is acceptable unless you would like to share your story.)

6. How can the buffalo help heal the people now?

7. What are at least two lessons one can learn from buffalo?

8. What are your thoughts after watching this video?

9. What are your questions after watching this video?

Shoshone Buffalo Return Focus Questions

1. How long had it been since the Shoshone had seen bison roaming freely on their lands?

2. What caused the bison's near extinction in North America?

3. What are three steps the tribe took to address neighboring ranchers' concerns?

4. Are bison managed as a wildlife species in Wyoming? Why do you think this is the case? What is your opinion? Is this a reasonable strategy? Why or why not?

Tribal Self-Governance Focus Questions

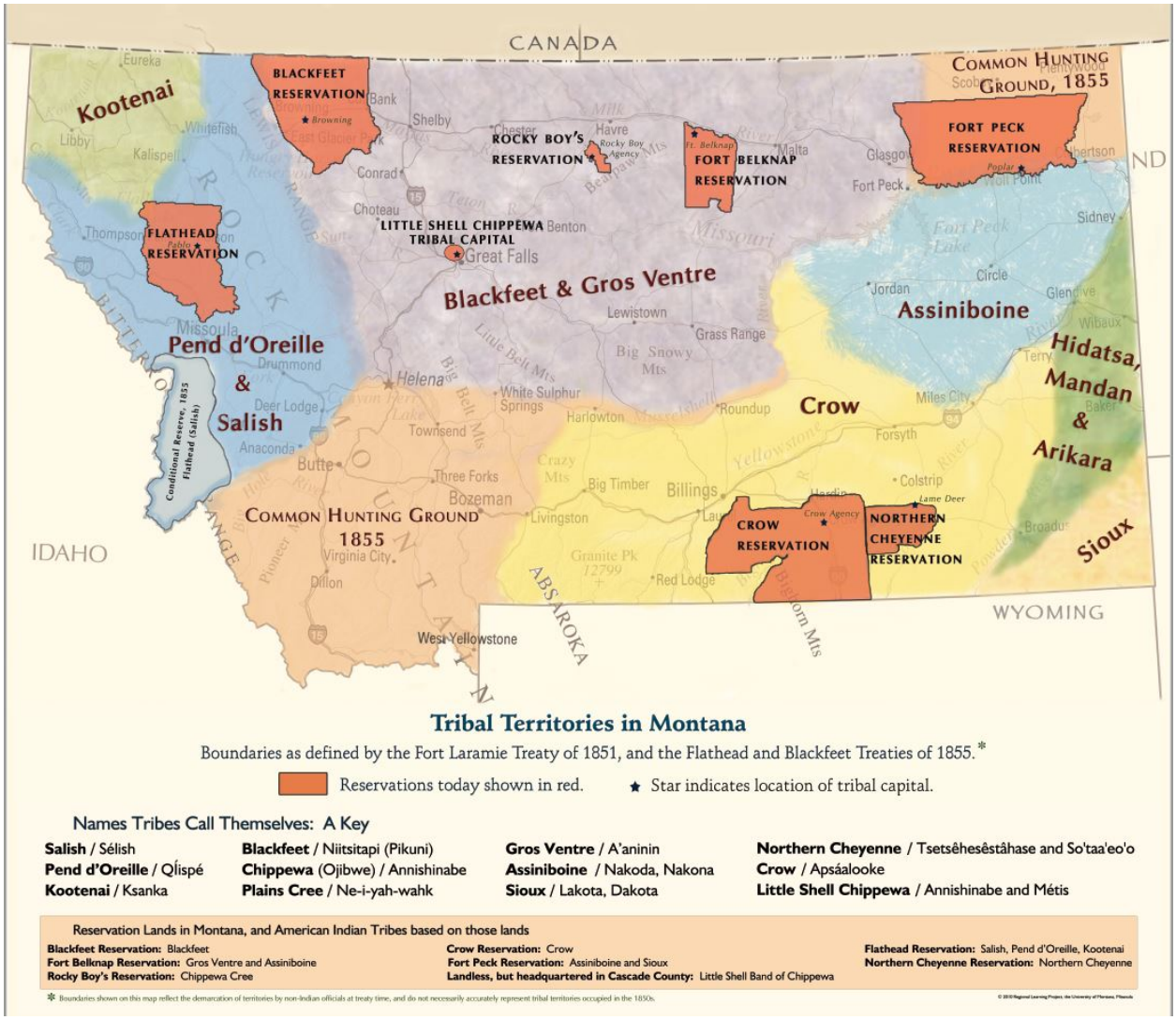
1. What is similar for both bison and American Indian tribes?

2. When did American Indians become citizens of the United States? What do you think about that?

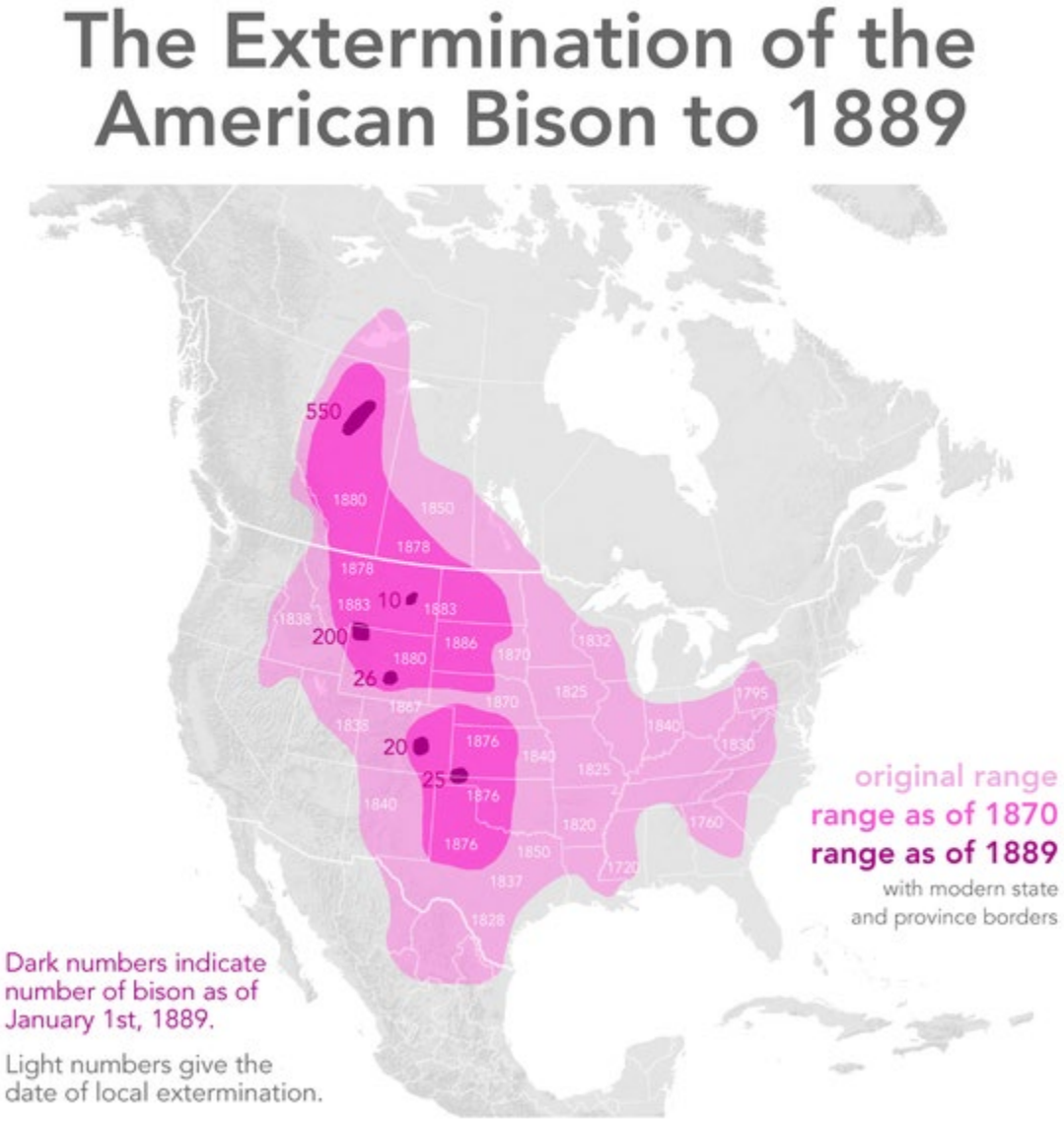
3. What are some of the things that have been lost because of the way American Indians have been treated by the U.S. government?

Readings and Lesson Resources for Students

RESOURCE ONE - Tribal Territories in Montana



RESOURCE 2 - The Extermination of the American Bison to 1889.



Student Yellowstone Bison Population Lab

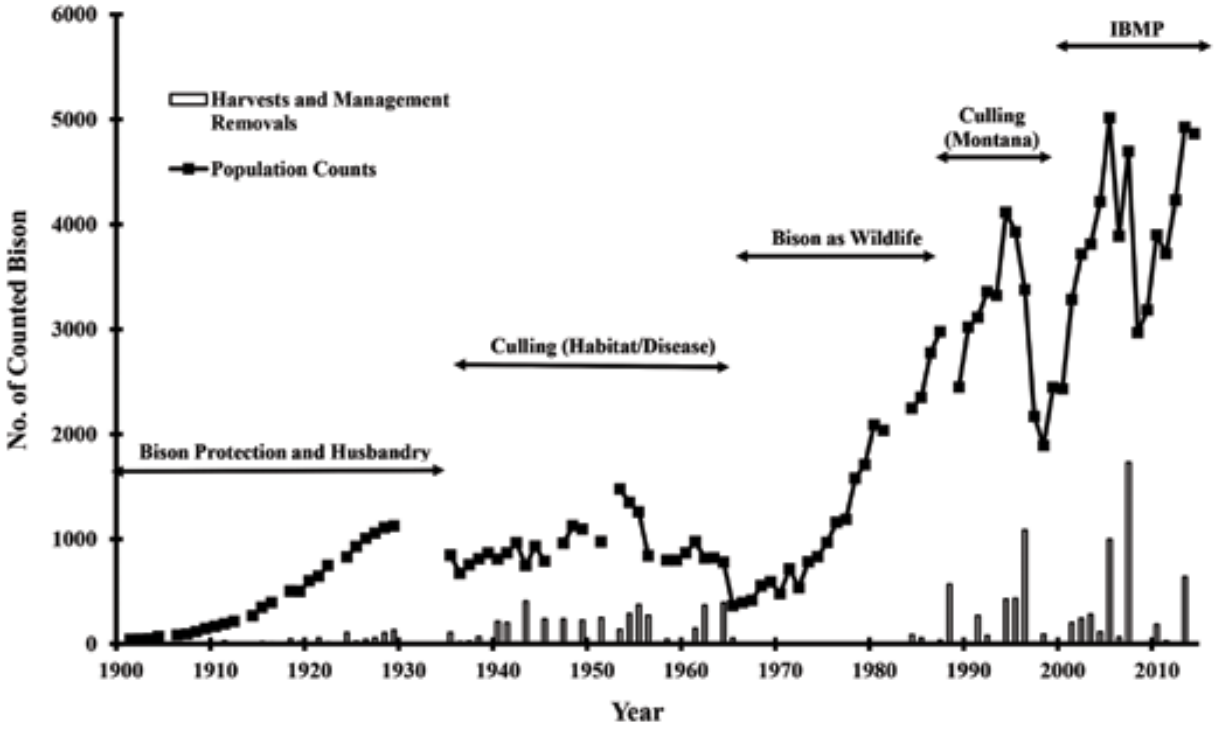


Figure 1.3. Counts and removals of bison in Yellowstone National Park and nearby areas of Montana during 1901 through 2014. IBMP refers to the Interagency Bison Management Plan. (From National Park Service's *Yellowstone Bison: Conserving and American Icon in Modern Society* (p. 15). Used with permission.)

Since bison restoration efforts began in 1902, the numbers of wild, genetically pure bison living in Yellowstone National Park have fluctuated in response to different management strategies. In the early years, bison were treated more like livestock—initially they were given hay in the winter and penned in the floor of the Lamar Valley and were not allowed much room to roam. Since then, they have significantly increased in numbers, habitat, and mobility. Yellowstone's bison are currently managed under the Interagency Bison Management Plan, a group of stakeholders representing state agencies, federal agencies, and Native American tribes (including the InterTribal Buffalo Council, which represents seven Montana tribes). Bison are still mostly limited in their mobility to areas within the park, though there are some efforts to expand "tolerance zones" for bison past park boundaries.

1. **What patterns do you see in the above graph? Where was the population relatively stable? Where was it unstable? What management decisions, ecological events or human actions caused this stability or instability?**

According to recent aerial counts conducted in the late summer of 2019, there are a total of 4,908 bison living in Yellowstone. Based on observations and population models, National Park Service (NPS) researchers have estimated that 1,925 of these are adult males (over two years old, sexually mature), 1,668 are adult females (over two years old, sexually mature), 580 are adolescents (between one and two years old) and 735 are calves, in their first year.

2. **What is the ratio of adult females to adult males? What proportion of the population are young animals (less than two years old)? Why are these metrics important to understand the health of the population?**

3. **Bison managers aim for a ratio of 1 to 1 between male and female animals. And they aim for 30% of the population to be young animals? Based on these numbers, is this a healthy population?**

4. **The NPS has estimated survival rates, defined as the percentage of individuals in this age category who will survive until the next fall, as follows: 90% survival for young/calves, 95% survival rate for adult males and females.* Why do you think survival rates be different for juveniles/calves and adults?**

5. **The NPS has also estimated fertility, defined as the number of calves per reproductively mature female (older than two years) who will survive their first summer, as 51%. Using this fertility rate, how many new calves, born next spring, would you estimate will survive through next fall?**

6. **Bison ecologists use the following equation (and the above numbers and survival and fertility rates) to estimate the Yellowstone bison population in following years. Use this equation to calculate the population in the summer of 2020:**
   N(2020) (the population in 2020) = (# of adult males x male survival rate) + (# of adult females x female survival rate) + (# of young and calves x juvenile survival rate) + (# of adult females x fertility rate)

** These survival rates do not include the hunt and the bison cull, which are the two main management activities used to manage the bison population.*

7. **We can then determine the growth rate of the Yellowstone bison population by dividing N(2020) by N(2019). What is the growth rate of the Yellowstone bison population?**

Now that we know the growth rate and the starting population, we can build a model for what could happen to the bison population over the next five, ten, fifteen, and even twenty years. The formula to calculate the bison population in future years is:

$N_t = N_0 \times e^{rt}$

Notes on how to use this formula:

- N_t is the bison population at any time **t** years after 2019. So, 2020 would be described as N_1 because 2020-2019 is **1**.
- N_0 is our starting bison population in 2019, so N_0 for our purposes will always be **4908**.
- **e** is a constant. We will not get too deep into the reasons for using **e** (which get quickly into calculus). For our purposes it is just important to know that **e** always equals approximately **2.71828**
- **r** is the growth rate, which in our case we assume is constant at **.11**
- **t** (as mentioned above) is the number of years since 2019. So, when calculating for 2020, **t** is **1**. When calculating for 2025, **t** is **6** (2025-2019). And so on and so forth.

8. **Using the above formula to calculate the bison population in future years, fill out the table below:**

Year	***Population***
2019	*4,908*
2020	
2021	
2025	
2030	
2035	
2040	

9. **Represent these points on a graph. How would you describe the population growth represented in this chart? Is this reasonable to expect the population to grow in this way? Why or why not?**

The population of Yellowstone bison are limited mainly by intensive human management, rather than by abiotic or biotic factors within and around the park. There is low tolerance for bison outside the park boundaries, especially herds of females and young during the breeding and birthing season (April through September). To limit outmigration during these times and manage the risks of negative interactions between bison and people/property as well as limiting the possibility of brucellosis transmission to cattle, park biologists manage the bison population in Yellowstone for an abundance of approximately 4,500 animals. They do so through partnerships with state and tribal officials, who manage bison hunting outside the park boundaries, and through large culls of bison where hundreds of bison are rounded up and slaughtered.

10. **On the same graph as above, draw an estimate of what the growth curve would look like, taking into account the ideal population of 4,500 animals and the intensive human management practices outlined above. How would you expect the population growth curve to look different or similar to the original line you drew in response to question 8?**

Whole Class Reading 1

--From the Executive Summary of *Yellowstone Bison: Conserving an American Icon in Modern Society,* and the chapter on Bison's Ecological Role (pp. vii-viii). Used with permission.

Introduction

The plains bison (*Bison bison*), also commonly known as buffalo, once numbered in the tens of millions and ranged across much of North America, from arid grasslands in northern Mexico, through the Great Plains and Rocky Mountains into southern Canada, and eastward to the western Appalachian Mountains. Plains bison are symbolic of the American experience because they are an inherent part of the cultural heritage of many American Indian tribes and were central to national expansion and development. Only a few hundred plains bison survived commercial hunting and slaughter during the middle to late 1800s, with the newly established (1872) Yellowstone National Park providing refuge to a relict, wild, and free-ranging herd of less than 25 animals. This predicament led to one of the first movements to save a species in peril and develop a national conservation ethic by a few visionary individuals, American Indian tribes, the American Bison Society, the Bronx Zoo, and federal and state governments. Bison numbers increased rapidly after protection from poaching, reintroduction of bison to various locations, and husbandry.

Today, more than 400,000 plains bison live in conservation and commercial herds across North America. Despite this success, several scientists recently concluded that plains bison are ecologically extinct because less than 4 percent (20,000) are in herds managed for conservation and less than 2 percent (7,500) have no evidence of genes from inter-breeding with cattle. Most bison are raised for meat production, mixed with cattle genes, protected from predators, and fenced in pastures. As a result, wild bison no longer influence the landscape on the vast scale of historical times by enhancing nutrient cycling, competing with other ungulates, creating wallows and small wetlands, converting grass to animal matter, and providing sustenance for predators, scavengers, and decomposers.

Yellowstone bison comprise the largest conservation population of plains bison and are one of only a few populations to have continuously occupied portions of their current distribution. Perhaps more importantly, Yellowstone bison are managed as wildlife in multiple large herds that currently move across extensive portions of the landscape within and near Yellowstone National Park. Bison exist on this landscape with a full suite of native ungulates and predators, while being exposed to natural selection factors such as competition for food and mates, predation, and survival in challenging environmental conditions. As a result, Yellowstone bison have likely retained adaptive capabilities that may be diminished in other bison herds across North America that are managed like domesticated livestock in fenced pastures with human-induced seasonal movements among pastures, no predators, selective culling of older bulls to facilitate easier management, and selection for the retention of rare alleles—the function and importance of which have not been identified. Yellowstone bison also provide meat for predators, scavengers, and decomposers, and allow visitors to observe this symbol of the American frontier in a wild, unfenced setting.

Whole Class Reading 2

--From the National Park Service's *Yellowstone Bison: Conserving an American Icon in Modern Society,* (pp. 78-80). Used with permission.

Large annual migrations of bison to low-elevation winter ranges north and west of Yellowstone National Park highlight the importance of these areas (Plumb et al. 2009; Geremia et al. 2011). Most bison migration into Montana occurs in late February and March across the north boundary, and in April and May across the west boundary, as new grass begins to grow on lower-elevation ranges (Thein et al. 2009; Geremia et al. 2014b). Bison migration back to interior park ranges typically occurs during April through June, following the wave of growing vegetation from lower to higher elevations (Thein et al. 2009; Wilmers et al. 2013).

If migration by bison into Montana is constrained by hazing animals back into the park, then bison numbers will be ultimately determined by food availability within the park. As a result, substantial winter-kill could occur after bison reach high densities (Coughenour 2005; Plumb et al. 2009; White et al. 2013b). To date, the total number of bison in Yellowstone has not reached the estimated food-limited carrying capacity of approximately 5,500 to 7,500 bison during winter (Coughenour 2005; Plumb et al. 2009). However, the population is prolific and still growing despite annual harvests and culling (White et al. 2011). . . .

An alternative to constraining bison within Yellowstone National Park or artificially maintaining low numbers is to tolerate bison in nearby areas of Montana, but manage them when they encroach on cattle ranches, highways, and local communities (Treanor et al. 2013; White et al. 2013b). Movements of bison to the northern and western boundary areas of the park are affected by different dynamics, and as a result, require different management prescriptions (Geremia et al. 2014b). Large numbers of bison move across the western park boundary each year and these movements correspond with the calving season when bison are most likely to transmit brucellosis. Thus, space-and-time separation of bison and cattle is needed to reduce the risk of brucellosis transmission, which can be accomplished by fencing livestock and/or moving bison to suitable habitat away from livestock (Treanor et al. 2013; Geremia et al. 2014b).

In contrast, the timing and extent of bison movements across the northern park boundary depend on snow conditions, available forage, and the density of bison in the park (Geremia et al. 2011, 2014b).

Large numbers of bison can rapidly move to the northern boundary when conditions severely reduce foraging efficiency, but relatively few bison exit the northern boundary when conditions are mild (Geremia et al. 2011, 2014b). When numbers of bison exceed 1,500 to 2,500 bison in both the central and northern regions of Yellowstone, there is a significant chance that more than one-half will migrate to the northern boundary under severe snow conditions. With similar numbers and average snow conditions, only one-third of the bison are predicted to migrate to the northern boundary; fewer than 200 bison are predicted to move when snow conditions are below average (Geremia et al. 2011, 2014b). If hunting in Montana is used to manage numbers of bison leaving the park, then bison numbers in northern Yellowstone may fluctuate widely over time because few bison are harvested during years when migration is minimal (Geremia et al. 2014b). As a result, it may at times be necessary to capture and remove some bison to meat processing, quarantine, or research facilities to moderate fluctuations in bison numbers (Geremia et al. 2013).

Whole Class Reading 3

--From the National Park Service's *Yellowstone Bison: Conserving an American Icon in Modern Society,* (pp. 90-95). Used with permission.

Causes of Mortality

Since 1985, more than 6,000 bison have been removed from the population by humans, primarily through capture and shipment of bison to meat processing facilities and secondarily through hunting (White et al. 2011). Overwhelmingly, these removals have been the principal causes of bison mortality. Winter-kill can be a significant cause of mortality during winters with severe snow pack (Fuller et al. 2007b; Geremia et al. 2009). Also, predation is becoming a larger factor following wolf restoration and grizzly bear recovery . . . .

. . . An isolated population of wildlife that adapts to local environmental conditions and reproduces faster than individuals die will generally increase in abundance. Because habitat for many wildlife species is limited in modern society, these types of populations often exhibit boom-and-bust cycles with rapid population growth punctuated by sizeable mortality events (e.g., starvation, culling) when food, other resources, or human tolerance become scarce (Caughley 1970). This is the situation in which Yellowstone bison currently exist because: (1) there is a limited amount of winter range and forage for bison inside Yellowstone National Park, (2) there is limited space in Montana where bison are allowed to migrate and disperse, (3) predation removes relatively few bison, and as a result, has limited effects on population abundance, (4) under-nutrition (starvation) only contributes to high mortality when bison abundance is high and/or snow pack is above average, and (5) most bison migrate to lower elevation areas in response to such severe weather events—which eventually brings them into conflict with agriculture and residential development.

Managers could allow the Yellowstone bison population to continue boom-and-bust cycles, and implement episodic, large removals when population abundance is high (e.g., more than 4,500 animals). These removals would reduce migrations outside of the park for several years as a substantially smaller population again increases in size. Alternatively, managers could attempt to regulate the bison population within a range where enough animals exit the park annually to implement harvests and smaller management removals that offset growth. The target range should be defined by ecological conditions that may vary over time, but under current conditions is near an end-of-winter population of 3,000-4,000 bison (Geremia et al. 2014a). However, this approach necessitates tolerance for bison outside of the park, especially during years when severe winter weather increases numbers of migrating animals.

READING GROUP 1 **(Longer passage, four pages – good for larger group)**

--From Bozeman Daily Chronicle, “Slow drip: Bison quarantine creating path from Yellowstone to Fort Peck.” Used with Permission.

Robbie Magnan is seeing signs of progress.

The Fish and Game manager for the Fort Peck Tribes has watched 60 bull bison enter his quarantine pens so far this year — five in February and 55 in August. The program is meant to produce brucellosis-free bison that can enhance other herds or start new ones, and he’s overseeing the final round of testing at the tribal corrals. One of the bulls that arrived in February died, but the other four cleared the final hurdle, graduating the quarantine process. They’ve been released to join the reservation’s main bison herd.

The other 55 have a few months to go, but Magnan has already been taking calls from Native American tribes that want them when they’re ready.

For now, they’re doing OK out on the prairie. “They’re really picking up weight,” Magnan said. “They’re looking real nice.”

More bison may soon be on the way. The Animal and Plant Health Inspection Service (APHIS) has a group of bison in corrals near Corwin Springs it hopes can go north soon. Yellowstone National Park has 24 in its pens near Gardiner and park officials will trap even more this winter. Maybe as many as 110 could enter quarantine next year, assuming the park can capture enough to make that happen.

The plan for this winter represents the immediate future of bison quarantine, with federal officials agreeing to fill double-fenced corrals with animals that could go through the program. APHIS and Yellowstone both have space to fill between the park’s bison trap and APHIS’ Corwin Springs facility, and they want to fill it.

“We’re collaboratively maximizing space for quarantine,” said Tim Reid, Yellowstone’s bison program manager.

This inertia suggests quarantine will become a regular feature in the management of Yellowstone bison, a somewhat consistent alternative that spares some bison from the slaughterhouse. All the government officials involved have confidence that the process works and that it doesn’t increase the risk of spreading brucellosis, a disease feared by the livestock industry because of the potential economic consequences of its spread.

Jay Bodner, executive vice president of the Montana Stockgrowers Association, said his group has followed quarantine closely and has been concerned about it. But so far, it seems to be working OK.

“I think the process that we have laid and put in place is working to a certain degree,” Bodner said.

There are still critics, most prominently the Buffalo Field Campaign, which has opposed quarantine for years. Stephany Seay, a spokesperson for the group, said quarantine doesn’t end the slaughter of bison. She called it a “tool of the oppressor,” saying the years bison spend in corrals take their wildness from them.

“It’s a livestock paradigm, plain and simple,” Seay said. “Instead of quarantine, we feel buffalo should be allowed to migrate.”

A number of other conservation groups are cheering this progress along, however, as it comes after years of conflict over the process. Chamois Anderson, of Defenders of Wildlife, said at a meeting of bison managers last week that this year’s shipments of bison show an improvement in relations between the various officials involved.

“We’ve come a long way,” Anderson said.

The entire idea of quarantine begins with brucellosis, a disease that can cause animals to abort. It’s known to exist in the elk and bison of the Yellowstone ecosystem. The disease can infect humans and cause undulant fever and was once considered a major public health risk, though that risk has been dulled.

Ranchers still worry about the spread of the disease. They worry it could lead to Montana losing its brucellosis-free status. Bodner said losing that status could cause other states to restrict cattle imports from Montana and make life harder for ranchers.

That fear is why controlling brucellosis is one of the stated reasons for the Interagency Bison Management Plan, which restricts where bison can go and calls for population reduction through hunting and ship-to-slaughter.

Critics of the plan, like Seay and the Buffalo Field Campaign, think that reason for restricting bison is bogus, arguing the same restrictions aren’t forced upon elk. There has never been a documented case of bison passing brucellosis to cattle in the wild. Meanwhile, elk have spread the disease.

“This isn’t really about brucellosis. It’s about the grass and who gets to eat it,” Seay said.

Ryan Clarke, a senior veterinarian with APHIS, said it’s not as simple to put the same restrictions on elk because they are harder to track and control. He also said bison have other characteristics that make them a concern.

“They’re a social animal that will interact with cattle and will actually breed with cattle,” Clarke said.

People involved in bison management have long seen quarantine as a potential way to erase the disease risk. It involves keeping the animals in groups separate from wild animals and testing them repeatedly for the disease. After a certain time of testing negative, they can be considered disease free.

Keith Aune, who worked for Montana Fish, Wildlife and Parks for three decades, said quarantine was talked about in the 1990s during the negotiations on the management plan, but that it was never the top priority.

“It was kind of put on the back burner,” he said.

In the early 2000s, though, he and other scientists tasked with answering a crucial question: Would quarantining bison actually work?

Beginning in 2005, scientists ran a bunch of bison at Corwin Springs through the testing protocols prepared by animal health experts. They proved that bison that repeatedly test negative for the disease would stay that way, meaning quarantine worked.

The animals put through those tests got new homes elsewhere, but that study didn't lead to a formal future for quarantine. Clarke said it took time to put together the quarantine study's results and to decide what should come next.

Quarantine got moving again in 2016, when Yellowstone proposed establishing a quarantine program at Fort Peck. The tribes had built a facility they believed would comply with federal standards, and they were eager for bison.

Initially, legal and political conflicts got in the way. Agriculture officials wanted the bison certified as disease free before they left the "designated surveillance area" — a term for the area around Yellowstone where brucellosis is known to exist.

In 2017, Yellowstone turned two pens at its bison trap near Gardiner into quarantine corrals, which require two layers of fencing to prevent contact with animals outside the enclosure. Once the work was done, park officials went back-and-forth with APHIS for months before getting their corrals OK'd for quarantine.

Meanwhile, the park had been holding some bison to get the program started. They'd been in the pens for months by January 2018, when vandals cut the fences and set them free, creating yet another hiccup. In response, Yellowstone beefed up security at the corrals and caught more bison, determined to make something happen.

That spring, regional National Park Service officials formally signed off on a final quarantine plan. More than anything, it represented agreement between NPS and APHIS. Included in the deal were dozens of bison being held at the APHIS corrals at Corwin Springs. The bison were part of a study that had been discontinued and could now enter quarantine.

Quarantine happens in three parts. First, Yellowstone traps bison and tests them for brucellosis. Bison that test negative can go into quarantine.

Next, the animals go through a series of regular tests before being certified as disease free. For bulls, this period lasts a year. For females, the process is longer and more complex — they have to calve during quarantine. For mature females, the process lasts 1.5 years. For immature females, it's 2.5 years.

Those two parts can only happen at Yellowstone's corrals or at Corwin Springs. The last part, called assurance testing, can happen at Fort Peck. It's one more year in isolation with two more tests. Then, it's over.

A year-and-a-half removed from the park service's formal approval, government officials are happy with how things have worked.

"I think that the quarantine process is on the right foot," said Marty Zaluski, Montana's state veterinarian.

The process will evolve over time. The science already has. The third stage of quarantine lasted five years when scientists were first studying the process. Now it's one year.

It's possible other terms will shorten, too, like the amount of time for bull bison to be in quarantine, Clarke said.

"Over a matter of years, all the testing history and experiments that we accumulate may help us shorten the interval that animals spend inside quarantine," Clarke said.

Advocates for the program have said there needs to be more space for it. Yellowstone and APHIS are committed to taking in bison for quarantine for as long as possible, but that's only so many animals. Adding 110 animals this year — if it happens — would leave less space available for additional animals next year.

Reid said expansion is a complicated endeavor. A new facility would require land and someone to run it. So for now, it will be about maxing out what's available.

"It's just kind of a twisting of the spatial Rubik's Cube," Reid said.

A solution some see to this problem is letting the Fort Peck Tribes conduct the second round of testing, the longest part of quarantine. Tribal officials have lobbied for that, but APHIS has thus far been opposed to that happening outside the surveillance area. Lyndsay Cole, an APHIS spokesperson, said in an email that the conversation is "still active" but that no change is expected in the immediate future.

"We are still early in the development of this process and have to ensure the program develops and works for the bison and all parties involved to ensure brucellosis-free bison are being shared outside of the park and to the nations (sic) tribal lands," Cole wrote.

Magnan is hopeful that will change, but he's used to slow progress. He said he'd been working since 2008 to get quarantine going on the reservation. Now that it is, he thinks his program will prove itself.

"Once we keep getting more and more out of here, we can show that we can do this," Magnan said.

For now, he's thinking about how best to use what he's got. He plans to split his two pens into four. There would still be enough land for each to be at least 60 acres.

He's also looking forward to getting some females and calves, a change that brings him family groups of bison, something he's looking forward to sharing with other tribes.

"Now we can look at having organizations starting out with family units," Magnan said. "So, they'll get a little group of a family unit to start a herd."

READING GROUP 2 **(Longer passage, three pages – good for larger group)**

--From the National Park Service's *Yellowstone Bison: Conserving an American Icon in Modern Society,* (pp. 165-174). Used with permission.

Recommendations for Future Management

Objectives—Biologists at Yellowstone National Park have recommended the following demographic, ecological, and genetic objectives for Yellowstone bison:

- Maintain 2,500 to 4,500 bison and average at least 3,000 to 4,000 over decades to preserve genetic diversity and reduce large-scale culls;
- Minimize the effects of selective culling on bison and allow numbers in the central and northern regions of the park to vary depending on dispersal rates and natural selection;
- Maintain similar proportions of males and females and an age structure of about 70 percent adults and 30 percent juveniles to facilitate competition for mates;
- Sustain ecological processes such as predation, migration, dispersal, and competition in the park and other agreed-upon conservation areas; and
- Restore the contributions of bison to herbivore-grassland dynamics, the predator-prey-scavenger association, and many other relationships in the ecosystem (Plumb et al. 2009; Gross et al. 2010; Pérez-Figueroa et al. 2012; White and Wallen 2012; Frank et al. 2013; Geremia et al. 2013; White et al. 2013c; Geremia et al. 2014a).

These objectives are consistent with the recommendations from recent reviews of ungulate management in national parks, but should be reassessed periodically based on new information and changed circumstances . . .

Brucellosis Containment—Given current technology and existing conditions, intrusive human actions such as vaccination or fertility control are unlikely to substantially decrease brucellosis infection in wild bison and elk…In the meantime, the best alternative for suppressing brucellosis transmission is to maintain separation between bison, elk, and cattle during the transmission period from February to June (Keiter 1997; Bienen and Tabor 2006; Nishi 2010; Cross et al. 2013; Godfroid et al. 2013; Treanor et al. 2013; White et al. 2013c).

Tolerance—Allowing migratory bison to occupy public lands in Montana until most calving is completed by early June would reduce stress on pregnant or lactating females and newborn calves (Jones et al. 2010). It would also reduce the cost, duration, extent, and intensity of hazing needed to return bison to Yellowstone National Park each spring or early summer. This tolerance would not significantly increase the risk of brucellosis transmission to cattle because management maintains separation between bison and cattle (Jones et al. 2010; Schumaker et al. 2010; Aune et al. 2012; MFWP 2013). One of the most vexing problems for the management of Yellowstone bison is the lack of available lower-elevation habitat in the Gardiner basin and southern Paradise Valley north of Yellowstone National Park. The valley bottoms in this area have more accessible forage and less snow

than surrounding mountains during winter, but are already used for agricultural and residential development . . . Managers should continue to work with landowners to identify areas with suitable habitat for bison and develop strategies to resolve conflicts with livestock, human safety, and private property.

Hunting—About 322 bison were harvested by public and treaty hunters during the winter of 2014, most of which were shot near the boundary of Yellowstone National Park and along roads. Increasing this harvest will require increased tolerance (e.g., year-round in some areas) for bison in Montana, better access for hunters, creative harvest strategies during non-traditional seasons, and commitments by hunters to adjust harvest methods in response to bison habitat use patterns (White et al. 2011). State and tribal managers are discussing strategies that would allow bison to migrate into more dispersed areas across the landscape. They are also attempting to coordinate the overall harvest of bison by age, breeding area (central, northern), and sex. However, additional consultation is needed to effectively incorporate tribal subsistence hunts into current management strategies. . . . Ongoing discussions are focusing on how to effectively support tribal treaty harvests, while respecting the concerns of other stakeholders about bison conservation, concentrations of gut piles near roads and residences, and human safety issues. . . .

. . . there is a need for further consultation between the federal government and American Indian tribes associated with Yellowstone National Park to discuss recurring questions about potential hunting rights inside the park and whether Yellowstone bison should be managed as trust resources for the benefit of one or more specific tribes. One question is whether any tribes that signed treaties and land purchases/sales reserved the right to hunt bison within the park. To answer this question, it may be necessary to evaluate (1) whether the tribes understood the treaty agreements to mean that they retained the right to hunt in the ceded lands that now encompass Yellowstone National Park, and (2) whether Congress abolished these rights when it created the park in 1872 or passed the National Park Protective Act of 1894 that specifically prohibited hunting in the park (Molloy 2000).

A separate question is whether the U.S. Department of the Interior has a trust responsibility to consult with tribes that have recognized treaty rights for hunting bison on open and unclaimed federal lands in Montana before removing Yellowstone bison to meat processing, research, or quarantine facilities. A few tribes have asserted that such removals could affect the number of bison available for harvest by tribal hunters because fewer bison will migrate outside the park (Whitman 2012; YNP 2012). Two related questions are: (1) should tribes with recognized treaty rights in Montana be preferentially provided with meat, hides, and other products from Yellowstone bison that are shipped to meat processing facilities over tribes that do not have treaty rights but are associated with Yellowstone National Park, and (2) should all brucellosis-free Yellowstone bison that complete quarantine be relocated to open and unclaimed federal lands in Montana where tribes with recognized treaty rights can hunt them (in lieu of relocating them elsewhere; YNP 2012)?

Capture and Culling—In some winters, several hundred bison may need to be captured and culled at boundary facilities to regulate population size (Geremia et al. 2013). Managers should cull animals in a non-selective manner to avoid potential adverse demographic and genetic consequences that could compromise population viability (Halbert et al. 2012; Treanor et al. 2013). Culling bison in proportion to their availability in the population may mimic natural mortality events and help maintain an age

structure close to historical distributions . . . If necessary, large removals of 500 or more bison could be implemented during severe winters and/or at high bison densities when large numbers of bison naturally migrate to lower elevations (Geremia et al. 2013).

Quarantine Facilities and Terminal Pastures—The ecological and adaptive value of Yellowstone bison merits efforts to relocate animals testing negative for brucellosis exposure to quarantine facilities for further testing and eventual release elsewhere (Treanor et al. 2013). Quarantine facilities could be paired with terminal pastures so any animals that test positive for brucellosis could be killed for food. These paired facilities could reduce the frequency of large shipments of bison to meat processing facilities when females are late in pregnancy, while enhancing bison conservation and the cultural heritage and nutrition of American Indian tribes. . . . There is significant interest by federal and state agencies, American Indian tribes, non-governmental organizations, and private entities in receiving brucellosis-free Yellowstone bison and/or constructing and operating a quarantine facility on their lands (NPS, YNP and the Bureau of Indian Affairs 2012; Associated Press 2014). . . .

Public Engagement—Most stakeholders are not satisfied with the level of involvement provided by the partners of the Interagency Bison Management Plan, which primarily amounts to comment periods at public meetings. Rather, stakeholders want substantive input into the decision-making process to influence management strategies before they are adopted and implemented. As a result, managers should consider alternate forms of public involvement such as stakeholder workshops with presentations and discussion that allow information and ideas to be transferred and deliberated between managers, scientists, and the public (Bidwell 2010; Berger and Cain 2014). Management committees comprised of all interested stakeholders could be formed and sustained to develop ideas and recommendations similar to the Citizens Working Group on Yellowstone Bison (2011) and the model used for managing the Book Cliffs and Henry Mountains populations (Utah Department of Natural Resources 2014).

Scientific monitoring and research has greatly increased knowledge regarding bison, brucellosis, and elk in the Greater Yellowstone Area. Gaining this knowledge was a critical step for bison conservation, but also highlighted that human dimensions have a large influence on policy changes when it comes to tolerance for large wildlife such as bison outside national parks and refuges (Berger and Cain 2014). Therefore, additional information is needed on political and socioeconomic factors such as: (1) comparative costs and public preferences for various management alternatives, (2) non-market values of wild bison, (3) the demand for bison removed from the population, (4) traditional knowledge from American Indians and local communities, and (5) public attitudes, behaviors, and knowledge of bison, brucellosis, and management (Nishi 2010; National Research Council 2013). . . .

READING GROUP 3 (one page)

– From *Background Information on Issues of Concern for Montana: Plains Bison Ecology, Management and Conservation*, Montana Fish, Wildlife & Parks. (pp. 37-40). Used with permission.

Tribal Involvement in Bison

Bison are and have been an essential and highly valued element of the rituals and traditions of many Native American cultures. Historically these tribes depended on bison for numerous materials and as a main food source. "The total array made the buffalo a tribal department store, a builder's emporium, furniture mart, drugstore, and supermarket rolled into one-a splendidly stocked commissary for the needs of life" (McHugh, 1972, pp. 109). Krech III (1999) notes that for many tribes, "from a purely material standpoint, it would have been virtually impossible to be out of sight, touch, or smell of a product fabricated from bison at any time of day or night" (pp. 128).

Historically bison were also an essential element of the spiritual and religious customs of numerous native tribes of Montana and surrounding regions. Verbicky-Todd (1984) notes that the following tribes had a strong dependence on bison: Assiniboine, Arapaho, Blackfeet, Cheyenne, Comanche, Crow, Gros Ventre, Kiowa, Kiowa-Arapaho, Plains Cree, Sarcee, and Teton Dakota. Though bison still hold cultural significance for many tribes, there is now the recognition that bison have a strong commercial value and pragmatic use as a food source, as the establishment of tribal herds would enable "control over food production and land, food security, tribal sovereignty, and decreasing reliance on outside sources for food" (Gates et al., 2010, pp. 11).

Increased concern over the high rate of diabetes on reservations has led to a movement toward returning to a more traditional bison-based diet. The value of bison meat as an addition to the diet of many Native American cultures is reflected in the Blackfeet use of the term natapi waksin, which means "real food," referring to bison meat, and kistapi waskin, which means "nothing food," for all other food (Zontek, 2007). . . .

In order to facilitate and coordinate the return of bison to tribal reservations, the InterTribal Bison Cooperative, which is now the InterTribal Buffalo Council (ITBC) was formed in 1990 (ITBC, 2011). The goal of the ITBC is "reestablishing buffalo herds on Indians lands in a manner that promotes cultural enhancement, spiritual revitalization, ecological restoration, and economic development" (ITBC, 2011). As of 2011 the ITBC has a membership of 57 tribes and maintains a collective herd of over 15,000 bison (ITBC, 2011).

The manner in which the individual herds are managed varies. Some tribes maintain their bison with limited management, while others have more strictly managed herds.

Tribal herds are maintained on six of the seven Native American reservations in Montana. The herds range in size and in degree of management. In 2010 there were approximately 2,348 tribal herd bison, including the 400 bison on the National Bison Range, which is co-managed by the Confederated Salish and Kootenai Tribes of the Flathead Reservation and the USFWS. The majority of the tribes have expressed interest in expanding their herds if feasible, and many offer limited bison hunting opportunities. Some of the tribes are also in the process of exploring the potential to create separate cultural herds, which would be managed for different purposes and values than production herds.

READING GROUP 4 (one page)

--From the National Park Service's *Yellowstone Bison: Conserving an American Icon in Modern Society,* (pp. 175-176). Used with permission.

Conclusion

The overriding issue regarding the conservation of Yellowstone bison and plains bison elsewhere in North America is whether the public will support wild bison living outside preserves (Lott 2002; Franke 2005; Bailey 2013). Arguments against tolerance for Yellowstone bison, or their restoration elsewhere, are generally presented in terms of disease, protection of property, and human safety concerns—even though elk have similar effects yet are tolerated without intrusive management because they are economically valuable for hunting. However, there are also underlying issues about grass (i.e., competition with cattle), political control (i.e., state versus federal rights), and the continuing transition of communities from traditional rural occupations and lifestyles such as ranching to tourism and the enjoyment of natural amenities (i.e., locals versus outsiders; Haggerty and Travis 2006; Bailey 2013). While these characterizations are overly simplistic, disease regulators and livestock interests have certainly perpetuated misperceptions regarding the risks posed by bison for decades (Robbins 2006; Bidwell 2010). Even today, these misperceptions strongly influence the management of bison and severely limit their conservation and distribution across the landscape (Bidwell 2010).

The reluctance to allow Yellowstone bison onto more public lands in the Greater Yellowstone Area can no longer be justified solely based on brucellosis risk to the cattle industry. There is recognition by both disease regulators and wildlife managers that the risk of brucellosis transmission from bison to cattle is minute compared to elk which are generally free to roam (Bienen and Tabor 2006; Kilpatrick et al. 2009; Schumaker et al. 2010). Also, the economic consequences of occasional brucellosis outbreaks in cattle are greatly reduced since the Animal and Plant Health Inspection Service changed its regulations in 2010 to deal with outbreaks on a case-by-case (rather than state-wide) basis, and designated surveillance areas for brucellosis were established . . . Furthermore, studies in Wyoming have clearly demonstrated that the costs of measures to prevent brucellosis transmission from elk to cattle are exorbitant compared to the costs of an occasional outbreak in cattle (Roberts et al. 2012; Kauffman et al. 2013).

Current conditions in the Greater Yellowstone Area present an opportunity to manage bison similar to other wildlife . . . Tourism and recreational activities have a large and growing influence on the economy, and the vast majority of visitors and hunters to the area enjoy seeing bison move across the greater landscape in large numbers. . . . Furthermore, American Indian tribes have become more engaged with the management of bison in the area, sharing their traditional knowledge, restoring bison to tribal lands, and renewing subsistence hunts to improve their cultural, nutritional, and social well-being (Plumb and Sucec 2006; Hatfield et al. 2013). As a result, efforts to respect the presence of bison as wildlife on the larger landscape will be welcomed by native peoples and the majority of the local, national, and international public. . . . Acceptance of bison as wildlife in some areas outside parks and refuges will enhance bison restoration, enrich visitor experience, improve public and treaty hunting opportunities, boost local and state economies, and hopefully, elicit regional and national pride in this tremendous conservation accomplishment. The time is right to recover bison, the iconic symbol of power and strength in our nation, as wildlife in appropriate locations of the Greater Yellowstone Area and elsewhere.

RESPONSE GUIDE FOR TEACHER

YNP Bison Population Numbers – Student Worksheet Response Guidance

1. What patterns do you see in the above graph? Where was the population relatively stable? Where was it unstable? What management decisions, ecological events or human actions caused this stability or instability?
   Answers can vary, as long as students are connecting what they see in the graph to their understanding of different management strategies and the historical context that was part of the introductory lesson.

2. What is the ratio of adult females to adult males? What proportion of the population are young animals (less than two years old)? Why are these metrics important to understand the health of the population?
   Male to Female Ratio: 1,925: 1,668 or 1.15:1
   Young animals as a proportion of the total population: 1,668/4,908 or 34%
   They are important because they help to determine the reproductive viability of the bison population.

3. Bison managers aim for a ratio of 1 to 1 between male and female animals. And they aim for 30% of the population to be young animals? Based on these numbers, is this a healthy population?
   Yes, close to management goals.

4. The NPS has estimated survival rates, defined as the percentage of individuals in this age category who will survive until the next fall, as follows: 90% survival for young/calves, 95% survival rate for adult males and females. Why do you think survival rates be different for juveniles/calves and adults?
   Many answers are possible here. In general, juveniles are more susceptible to predation and disease and cold/environmental conditions.

5. The NPS has also estimated fertility, defined as the number of calves per reproductively mature female (older than two years) who will survive their first summer, as 51%. Using this fertility rate, how many new calves, born next spring, would you estimate will survive through next fall?
   Number of adult females times .51. 1,668 * .51 = 851 new young of the year

6. Bison ecologists use the following equation (and the above numbers and survival and fertility rates) to estimate the Yellowstone bison population in following years. Use this equation to calculate the population in the summer of 2020.
   N(2020) (the population in 2020) = (# of adult males x male survival rate) + (# of adult females x female survival rate) + (# of young and calves x juvenile survival rate) + (# of adult females x fertility rate)
   N(2020) = (1925 x .95) + (1668 x .95) + (1315 x .9) + (1925 x .51) = 5449 bison

7. We can then determine the growth rate of the Yellowstone bison population by dividing N(2020) by N(2019). What is the growth rate of the Yellowstone bison population?
   5449/4908 = 1.11. Growth rate is 11% or .11

8. Using the above formula to calculate the bison population in future years, fill out the table below:

Year	***Population***
2019	*4,908*
2020	*5,479*
2021	*6,116*
2025	*9,496*
2030	*16,456*
2035	*28,527*
2040	*49,445*

9. Represent these points on a graph. How would you describe the population growth represented in this chart? Is this reasonable to expect the population to grow in this way? Why or why not?
   Students should talk about exponential growth.
   No. Answers should include a variety of factors that influence carrying capacity and population growth—limiting factors such as food, disease, predation, spatial distribution, and competition with other ungulates.
   Students may also talk about human limitations—hunting and culling—on bison populations.

10. On the same graph as above, draw an estimate of what the growth curve would look like, taking into account the ideal population of 4,500 animals and the intensive human management practices outlined above. How would you expect the population growth curve to look different or similar to the original line you drew in response to question 8?
    New curves should show logistic growth, that is the curve should grow until it hits 4500 animals, or just above, and then stay relatively constant, though it shouldn't just be a straight line across at 4500 because there will still be some fluctuation from year-to-year, with the population being cut back below 4500 in the spring every year and then growing out above 4500 later that spring/summer as new calves are born.