

Wolves of Yellowstone

Ecosystem Interactions

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Grade Level	6th – 8th Grade	**Time Frame**	5-10 class period(s)
Subject	Science	**Duration**	300 minutes

Essential Question

In what ways does a change to one population affect an entire ecosystem?

Summary

Students develop questions about the phenomenon of wolf reintroduction into Yellowstone National Park. They explore published data to explain how different organisms interact to change the entire park ecosystem. Using this data, students take the role of a community member to engage in a role-play and provide a written explanation of which reintroduction plan their community member would support.

Snapshot

Engage

Students watch the first segment of the “Wolves of Yellowstone” video, make observations, and brainstorm questions about it.

Explore

Students use scientific data to answer their Engage questions and create and evaluate models of the Yellowstone National Park ecosystem.

Explain

The class constructs an understanding of how a single population can affect many others in an ecosystem through interactions which produce a "trophic cascade."

Extend

Students are assigned the role of a community member in the reintroduction decision. They research viewpoints to understand their community member’s perspective. From this research, they will construct a written explanation for their community member’s preferred reintroduction plan.

Evaluate

In a “community forum,” students role-play as their community member and advocate for the wolf management plan they selected. They must justify their choices with their understanding of both their social perspective and the ecosystem effects the reintroduction plan could produce.

Standards

Next Generation Science Standards (Grades 6, 7, 8)

MS-LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Oklahoma Academic Standards (7th Grade)

7.LS2.2 : Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
7.LS2.2.1: Predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.
7.LS2.3 : Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
7.LS2.3.1: Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem.
7.LS2.4 : Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
7.LS2.4.2: Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.

Attachments

- Advanced Topic Resources—Wolves of Yellowstone.pdf
- Community Member Cards—Wolves of Yellowstone.pdf
- PBS LearningMedia Derivative Work License.pdf
- Performance Expectation Checklists—Wolves of Yellowstone.pdf
- Wolf Reintroduction Plan—Wolves of Yellowstone.pdf

Materials

- Wolf Reintroduction Plan handout (attached; one per student)
- Community Member Cards (attached)
- Advanced Topic Resources (attached)
- Performance Evaluation Checklist (attached)
- Wolves of Yellowstone Video: http://bit.ly/2gbHoy3
- Yellowstone Ecosystem publication: http://bit.ly/2gbWyOT
- Trophic cascades in Yellowstone: The first 15 years after wolf reintroduction http://bit.ly/2hbv7Hj
- Yellowstone Wolf Project Reports https://www.nps.gov/yell/learn/nature/wolfreports.htm
- Access to internet-connected devices for small group research

Engage

Teacher's Note: Content Source, Licensing, And Funding

This material is based on work supported by the National Science Foundation under Grant No. IIA-1301789. Any opinions, findings, and conclusions expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation or Oklahoma State Regents for Higher Education. Materials and methods used in the Extend and Evaluate portions of this lesson have been heavily modified from the student role-play activity found in the PBS/Nature Conservancy lesson of the same name. Licensing information is included in the Facilitator Resources section.

Teacher's Note: Class Time Required For This Lesson

This lesson spans 5-10 class periods. The time your classroom requires depends on prior student knowledge and access to technology. If your class uses this lesson to learn about evaluating patterns in data or constructing models from data, you might require more time. If students do not have adequate access to technology outside of school, class time may be necessary for students to complete the Extend section of this lesson.

Play the “Wolves of Yellowstone” video to the 0:40 mark: http://bit.ly/2gbHoy3

This initial clip briefly outlines the story of the wolves of Yellowstone National Park, and serves to spark interest and provide context for the lesson. Pay specific attention to the wolves' reintroduction and how it affected Yellowstone's ecosystem. After the clip, ask students to independently brainstorm ideas and questions about the clip using the “I Notice, I Wonder” strategy. Replay the clip another time to give students opportunities to pick up additional details they missed. Allow 2-3 minutes for students to write. Then, the class should engage in a whole-group discussion about their "I notice..." to build a shared understanding of the video.

Possible Student Observations

Given the short video clip length, student observations may include general information about Yellowstone, identifying organisms, the shape of the landscape, the specific impact of the wolves, Yellowstone's ecosystem before wolves were extinct, or why the wolves were hunted to extinction.

Follow this up with a second discussion based on students' "I Wonder" summaries. To support student engagement and a collaborative culture, all students’ ideas, observations, and/or questions should be part of the conversation. Use the best strategy for your classroom. The Think-Pair-Share strategy, for example, is a good way to ensure each student has a way to share their own observations and learn new ideas from their peers. With a full class discussion, be sure to record all shared information on a whiteboard or similar space —these questions form the basis of the Explore activity.

Teacher's Note: Checking Student Understanding

Dedicate some time to helping students develop testable questions from their ideas, but be sure **not to correct misconceptions** at this time. Students' investigations in the Explore phase should address any misguided questions. Other misconceptions will be clarified in the Explain discussion.

Students' questions may span a variety of topics. They may also be beyond the scope of the data in this lesson. To narrow the scope of the objective, consider assigning specific questions to designated groups, or narrowing down the list of questions to help students find focus in their upcoming explorations. Let the questions you focus on be guided by the objectives below in data exploration:

- Students predict what the post-reintroduction ecosystem in Yellowstone looks like.
- Students propose a causal explanation for the post-reintroduction ecosystem structure.
- Students answer their Engage questions.

Explore

During this phase of the lesson, keep the whiteboard space from the Engage displayed. Students should be able to reference the questions they generated.

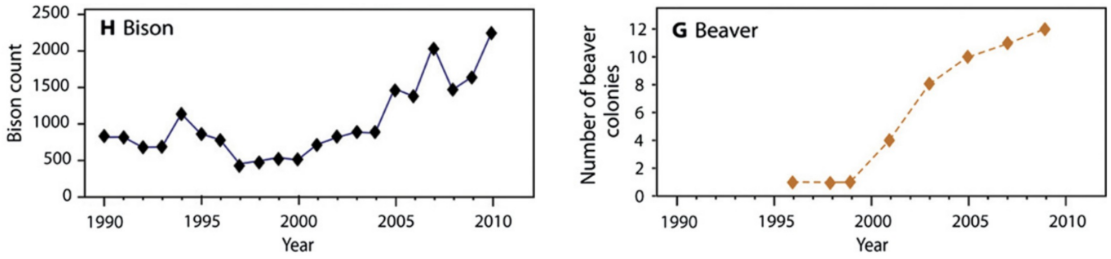
Provide the class with a variety of data sets showing changes in the population sizes of organisms found in Yellowstone—elk, beavers, flowering shrubs, et al. Suggested data sets can be found in the Resources section of this lesson. Other data sets can also be used.

- Gray Wolf (National Park Service)
- Yellowstone After Wolves
- Wolves, Elk, Bison, and Secondary Trophic Cascades in Yellowstone National Park
- Trophic Downgrading of Planet Earth
- History of Wolves in Yellowstone (see "Further Reading" for direct links to data and publications from Yellowstone)

Teacher's Note: Data Literacy

The suggested data sets come from a variety of scientific publications, including Yellowstone annual wolf reports. Yellowstone's reports provide data in the form of written reports, tables, and figures. Consider asking students to glean information from written reports before using tables and figures—if they have never done so before, this presents an excellent opportunity to teach close reading skills and text analysis. Several additional data sets are provided in the Materials section.

Have students work in small groups. Ask each group to search for patterns between data sets where one population's change in size affects, or is affected by, another population. Consider scaffolding this activity with extra guidance if students have little experience finding or evaluating patterns in data



Even though the data in these charts vary, students should be able to identify the overall patterns as an increase in bison and beaver colony numbers over time.

Ask students to use data to create their own models showing how the populations of Yellowstone have changed over time.

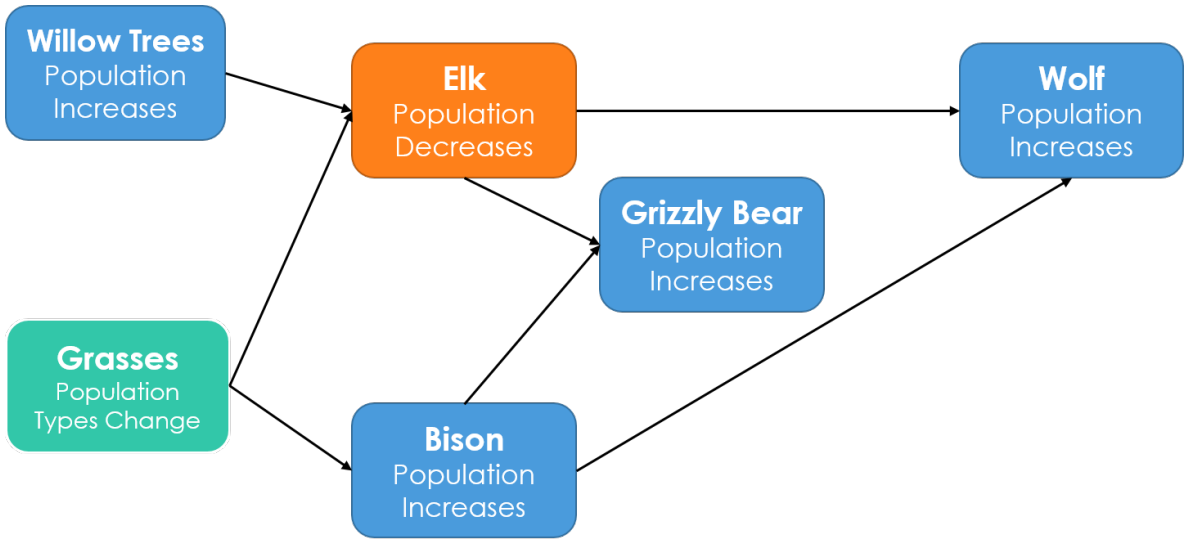
As each group analyzes data for patterns, each individual student should construct an individual model. If students wish to create a model with their group, consider allowing the group to record identical models. As students add organisms into their model of data patterns, ask them to show the relationships between population sizes in a way that expresses how they would visualize data for the entire ecosystem.

Prior Student Knowledge On Ecosystem Models

Students may be compelled to construct their ecosystem models as food webs, with which they likely have prior experience. **However, this format is not a requirement for the lesson!** Students may choose to model Yellowstone's ecosystem differently. Let them construct their knowledge in whatever way makes sense to them, rather than directing them to food webs.

As students work, circle the room to mediate. As students incorporate more data, check that ecosystem-level patterns start becoming clear. Look for patterns like a series of connected populations decreasing in size, or one population increasing as others decrease. For students who are struggling to identify patterns, consider asking questions like:

- Why did that population change?
- What will happen to this population if the other population increases in size? What if it decreases?
- How would you describe what is happening to this (animal, plant, or organism)?



Above is one example of a model students might construct. Colors indicate the change in the individual population size or composition. Arrows indicate the flow of energy among the organisms.

Have students return to their Engage questions. Using their models, ask students to record answers to those questions. Before moving on, show the class the next part (0:40-2:38) of the Wolves of Yellowstone video (link). This clip describes Yellowstone's ecosystem during 100 years without wolves. This ecosystem *does not* match the models students have developed. To work towards facilitating a deeper analysis, ask the class to create a second model of the ecosystem as described in the video. Use a whiteboard space to create this model with student input. To create the model, ask students to identify how organisms in the video were interacting and whether their populations were increasing or decreasing. If students do not have experience with food web models, consider modeling a food web here.

Optional: Food Web Models

As students identify relationships between populations, prompt them to think about how the matter and energy are moving between the organisms. Do matter and energy move between organisms in the food web? In what direction? Students have likely developed similar models of matter moving through ecosystems in 5th grade (5-LS2-1). Build on this prior experience to help students reach the conclusion that energy follows the same patterns as matter. When students conclude that energy and matter move **from** the prey/producer **to** the predator/consumer, draw an arrow from the prey to the predator. Help support students' use of *matter* and *energy* correctly in their explanations.

Once the class has a food web model of the video ecosystem, give them time to compare their personal wolf-present models to the wolf-absent class model. Invite students to assess whether the relationships among organisms are consistent between the wolf-present and wolf-absent conditions and whether the population changes in the video would make sense if they removed wolves from their personal models.

Teacher's Note: Teaching Standards & Disciplinary Core Ideas

This lesson does not cover the entire Performance Expectation (PE) components of each of these standards, but it does directly address these following specific Disciplinary Core Ideas (DCI): "Predatory interactions may reduce the number of organisms or eliminate whole populations of organisms" (MS-LS2-2). "Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem" (MS-LS2-3). "Ecosystems are dynamic in nature; their characteristics can vary over time; disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations" (MS-LS2-4).

Explain

Ask for volunteers to share their groups' answers for selected class questions from the Engage phase. Students should reference the data they used to support their answers. This discussion should be flexible, depending on student questions and discussion. However, the entire class should construct an understanding of the cause and effect changes within the Yellowstone ecosystem, as well as the differences between the models they made and the ecosystem web from the video. This part of the discussion extends students' individual analysis to help the entire class see how the wolves changed the ecosystem.

Optional: Food Web Models

The time during which students compare models is a great time to talk about the strengths and weaknesses of food web models. For example, food web models do not include the environment or all organisms present (a weakness), but they make it easier to sort out complex relationships in an ecosystem (a strength).

Modify or redraw the class ecosystem model as students share out their answers and explain the effects of the wolves' absence and reintroduction. Emphasize explanations that demonstrate student understanding of (1) the broad impacts of relatively minor or major changes within an ecosystem and (2) the potential causes of these impacts. Ask students to think about what their models are missing from what the video mentioned (for example, riverbank erosion). Use student examples to reinforce the idea that the environment is part of the ecosystem, though some models may not include it.

Ask questions to support student understanding. Clarify misunderstandings, especially those related to the effects generated by specific relationships within the ecosystem. Some questions might include:

- What effect did (this interaction) have on each population?
- Based on patterns in the data, why do you think the (*organisms*) experienced those effects?
- How does (*an effect or interaction*) differ from the park ecosystem without wolves?
- What other organisms are affected by (*this interaction*)?
- Do these interactions (*direct versus indirect*) cause the same magnitude of change in the ecosystem? Why/why not?
- How would the populations change if (*low impact event*) happened to (*organisms*)? In what ways would the entire ecosystem be affected by it?
- Thinking about the whole ecosystem, including the environment, what other factors might have caused (*these effects*)? What data would we need to evaluate that claim?

Teacher's Note: Terminology

The *Wolves of Yellowstone* video uses the term *trophic cascade*, but this term is not a necessary vocabulary word outside of that context. The use of alternative phrasings like *domino effect* or *chain reaction* during the discussion may help students make sense of the observed ecosystem effects more clearly than *trophic cascade*.

Wrap up this discussion by asking students to create two rules, or scientific ideas, which describe:

1. How different parts of an ecosystem can affect others (generally).
2. How specific types of organisms (e.g., predators, consumers) interact to produce changes in an ecosystem.

After the discussion, show the remaining clip (2:38 to the end) from the Wolves of Yellowstone video (link) to support students' guided analyses and discussion.

Extend

To extend their understanding, ask students to begin thinking about the intersection of biological systems, society, and scientific progress. In terms of societal and scientific progress, the reintroduction of wolves remains a controversial issue today and affects a variety of people and systems. Ask students to reference the attached **Community Member Cards** and choose a specific community member's role, or depending on classroom needs, assign roles or have students draw at random.

Pass out the attached **Wolf Reintroduction Plan** graphic organizer for students to fill out. This graphic organizer helps students organize and synthesize what they've learned in order to apply it to the next activity.

Before they begin the graphic organizer, pass out to each student a copy of their Community Member Card and a copy of the **Yellowstone Ecosystem** publication linked in the Materials list. Students should also reference the ecosystem models they made individually and as a class. For research purposes, give students access to an internet-enabled device.

Each row of the Wolf Reintroduction Plan graphic organizer contains one of three plans with a brief description. In the columns, students evaluate:

1. Chain reactions (trophic cascades) that may occur with a given plan
2. Good consequences, or positive effects, of the plan including evidence
3. Bad consequences, or negative effects, of the plan including evidence
4. Specific concerns their given community member would have with each plan—this requires students to put aside their own views and roleplay

Optional Aside: The Nature Of Science

Consider sharing all or part of the article "Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards," linked here. Share with students the idea that science is a human endeavor—all scientific progress is filtered through the lens of personal experience and abilities. Due to their profession, scientists use intellectual skills like logic and creativity to conduct research. However, scientists come from a variety of cultures and experiences which also shape their worldview and their research approach. In this way, science is shaped by society and vice versa. The following activities expand on these ideas and invite students to step into a different role with different views.

Allow students time to fill out the organizer, including researching their roles and formulating concerns accordingly. Students should search online for briefs, reports, blogs, and opinion essays that support their given role's opinions on the wolves and their reintroduction to Yellowstone. If your classroom has multiple students with the same community member role, those students might work together to gather this information.

Optional Technology Integration

This activity may present a good opportunity to develop or modify an existing Digital Breakout activity for students to use.

Once students have completed their organizers, ask them to choose the reintroduction plan they believe their community member would support. Invite students to independently explain why they chose the plan for their community member, structured as a Claim-Evidence-Reasoning (CER) statement. Each explanation should include both social and biological evidence for how the plan would affect the following:

- Chain reactions (trophic cascades) in Yellowstone's ecosystem
- Services of Yellowstone's ecosystem
- The community surrounding the student's role

Remind students to use specific evidence by referencing students' in-class work *and* research resources. Students should address the pros and/or refute the cons of the plan. Remind students to stay focused on explaining effects specific to a wolf-present or wolf-absent ecosystem. As students now understand the ecosystem's chain reaction involving wolves, ask them to consider what effects each reintroduction plan might produce in the ecosystem.

Evaluate

Invite students to engage in a forum with their peers. Before the forum begins, give students time to turn their CER statement into an argument. Remind students to focus on the effects of wolves in Yellowstone's ecosystem as they construct their arguments.

Teacher's Note: Methods Of Creating A Forum

For this phase of the lesson, students use their research and CER statement to hold a community forum. Consider in advance what discussion style would best suit your classroom. A few options for your consideration are Town Hall Circle, for less structured and more open dialogue; or for larger classes, the Fishbowl or Socratic Seminar strategies may suit your needs.

To begin the forum, ask students to act as their community members and argue for the wolf management plan they chose. Students should stay "in character" by including the social, cultural, and environmental details that justify their position. Consider asking students to vote on their preferred plan before the community forum starts, in order to compare voting numbers after the forum has ended.

During the forum, consider asking a student with the role of U.S. Fish and Wildlife community member to volunteer as the facilitator (or, if it would suit your classroom needs, you as the teacher may prefer to act as facilitator).

After the forum has ended, ask students, acting as their community members, to vote on the plan they believe they would be most persuaded towards. If the class also voted on a plan before the forum began, knowing whether or not students were persuaded by other students' arguments can be used at the end of the discussion as students evaluate their arguments and reflect on their learning.

Now, ask students to independently reflect on their experience from the beginning of the lesson—watching the Wolves of Yellowstone clip and constructing their first ecosystem diagram—to the end. When asking students to reflect, consider the following questions:

1. How did you use accurate scientific information in your arguments?
2. How did you stay "in character" to argue your community member's opinions instead of your own?
3. What were the strengths and weaknesses of your personal argument?
4. Did you personally agree with your community member?
5. What did you learn from other community members in the forum?
6. What are the most important things you took away from this lesson?

Resources

- Estes, J. A. et al. (2011). Trophic Downgrading of Planet Earth. *Science*, 333, 301–306. doi: 0.1126/science.1205106
- Facing History And Ourselves. (n.d.). Fishbowl. https://www.facinghistory.org/resource-library/teaching-strategies/fishbowl
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