Return of the wolves: Isle Royale National Park
"Lessons from the wilderness"
Lesson 1

This lesson is designed to be used after students have viewed Part 1 of the video "Return of the wolves: Isle Royale National Park" and completed the Part 1 student video viewing guide

Lesson Driving Question:

- What factors affect the carrying capacity of moose on Isle Royale?

NGSS Connection:
HS-L2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.

- Primary SEP: Using mathematics and computational thinking
  - Secondary SEP: Constructing Explanations
- Primary CCC: Scale and Proportion
  - Secondary CCC: Patterns

Key Disciplinary Ideas:

- Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support.
- Factors such as boundaries, resources, predation, and space affect the carrying capacity of an ecosystem.
- Some factors have larger limiting effects than others.

Key Practices and Concepts:

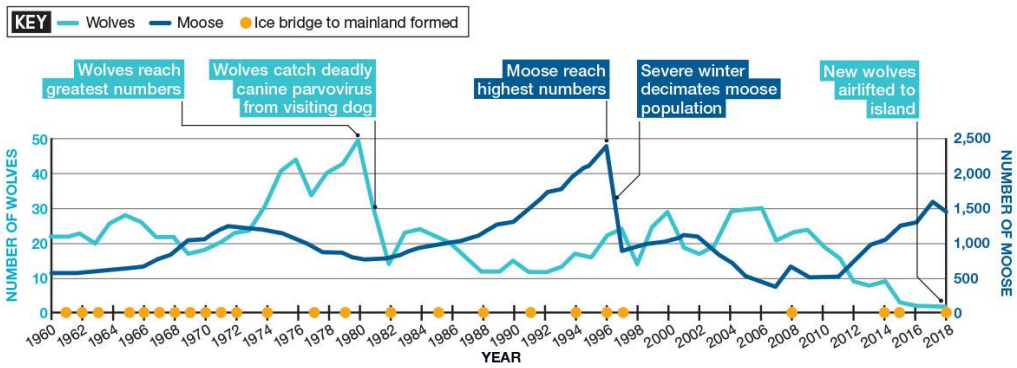
- Mathematical and computational models can be used to support explanations.
- Whether or not a system is considered stable may depend on patterns and trends observed at different scales.

Time: Approximately three class periods.

Materials:

- Computer with internet access for each student or pair of students
- Copies of Appendix A and Appendix B
- Copies of Appendix C as an assessment
- Poster paper or whiteboards and markers for small groups
- Projector for video

Engage	Ask students to evaluate the carrying capacity of students for their school building. Provide them with this information: Our school was designed to hold xx number of students. We currently have xx enrolled. In small groups, they should complete Appendix A, where they will consider these factors: ● What do you need to be comfortable at school? ○ Rank these factors in order of importance ● How would your comfort be affected if your school population doubled? ● Do you think your school currently has about the right number of students, or too few, or too many? Explain your answer. After small groups have discussed and completed Appendix A, the teacher conducts a class discussion to elicit each group's initial ideas about comfortable student population sizes (carrying capacity) and build class consensus about factors that affect a school's carrying capacity.
Explore	Students work alone or with a partner to explore the limiting factors and identify stable population trends in a computer simulation of rabbits, grass, and wolves, following the directions in Appendix B.
Explain	In small groups, students prepare to share their findings using a whiteboard or poster paper. Their poster/whiteboard should list the limiting factors for rabbit populations, ranked from largest effect to smallest effect. (Results of Part A of Appendix B) Their poster/whiteboard should also state their claim and explanation about the pattern and stability of the rabbit population (with adequate grass and no predators) over long periods of time. (Results of Part B of Appendix B) The posters/whiteboards should be arranged for a gallery walk. Students identify commonalities and the teacher facilitates a consensus discussion to decide that: ● Factors that affect rabbit populations include boundaries, space, food, and predators. ● Rabbit populations are most positively affected by a lot of space and few to no predators. ● The carrying capacity for a population in a given ecosystem is based on factors such as resources, predation, and boundaries. ● While the rabbit and grass populations fluctuate constantly at smaller scales, at a larger scale, the population pattern could be considered stable.

Elaborate	Students analyze the Isle Royale wolf/moose population graph from this Scholastic Science World article.  In small groups, students consider these questions: ● What pattern(s) or trends do you see? ● How are these patterns or trends similar or different to the rabbit/grass pattern? ● Would you consider the populations of moose and wolves to be stable over time? Why or why not? ● What evidence is there that the wolves and moose have a predator/prey relationship? ● Which limiting factors of Isle Royale might affect the carrying capacity for wolves? ● Which limiting factors of Isle Royale might affect the carrying capacity for moose? ● Why do you think the presence of an ice bridge is noted on this graph? (We'll find out in the next lesson.) The teacher asks small groups to share their thoughts, conducting a class discussion where consensus is reached that wolves and moose have a predator/prey relationship that the populations were more stable in the past but the wolf population is trending down. From the video, limiting factors for wolves include the boundaries of the island, diseases from dogs, genetic diversity, and amount of moose available. Limiting factors for moose include the availability of food, the number of wolves, deep snow that limits their movements in winter, and disease from ticks. The ice bridge represents an opportunity to expand the island boundary and allow wolves to travel from the mainland to the island.
Evaluate	Students complete Appendix C as a three-dimensional assessment.

Appendix A: HS Lesson 1 Student Worksheet A

Our School's Ecosystem

Our school is a sort of ecosystem, where living and nonliving things interact. Let's think about the population size of the students in our school ecosystem and how that affects the other parts of the system.

What do you, as a student, need to be comfortable at school?	
Rank those factors in order of importance.	
Do you think your school currently has too many, too few, or about the right amount of students? How do you know?	
What would happen if your student population doubled?	

Appendix B: HS Lesson 1 Student Worksheet B

We are going to use a computational model to generate graphs, to evaluate the factors that can affect population sizes in an ecosystem, using a simulation built to represent rabbits and wolves in a forest.

Part A

Before we collect data, make some predictions about **factors in the ecosystem** that might affect the rabbit population over a short period of time.

How will the rabbit population be affected if there is:

An Island Boundary	No Island Boundary (Mainland forest)	More Space	More Predators	Fewer Predators	Less Food

Directions to collect data with the simulation:

- Go to this Rabbits and Wolves simulation website.
- Click on View/Modify Parameters.
    - Choose View/Modify Wolf Parameters.
        - Change Maximum Wolf Age to 25. Save the change.
- Return to the simulator.
- Change the forest size to **Small** and the forest border to **Island.**
- Open View Population Graph.
- Click the Step Simulation button 32 to 34 times. (It can be hard to be exact, that's okay.)
- Open the Cumulative Stats. Record the number of rabbits that are living, died, and were born.
- Make a rough sketch of the shape of the BLUE rabbit population line shown on the population graph. This is the BASELINE data for our island ecosystem.

Change the forest border to **Toroid** (to represent the mainland).

- Reset the simulation.
- Repeat the 32 clicks. Record the rabbit numbers and shape of the blue rabbit population graph. This is the Mainland data.

Change the forest border back to **Island.**
Change the size of the forest to **Huge.**

- Reset the simulation.
- Repeat the 32 clicks. Record the rabbit numbers and shape of the blue rabbit population graph. This is the More Space data.

Change the size of the forest back to **Small.**
Open the View/Modify Parameters window.
Open the Start Up Parameters.
Change the **number of wolves to 15.**

- Reset the simulation.
- Repeat the 32 clicks. Record the rabbit numbers and shape of the blue rabbit population graph. This is the More Predators data.

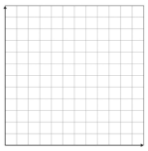
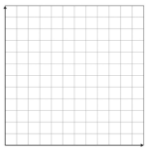
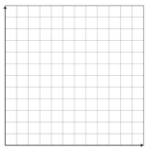
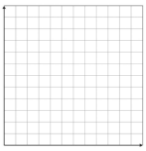
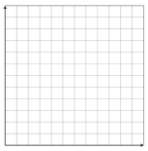
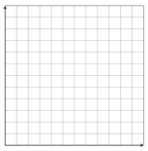
Open the View/Modify Parameters window.
Open the Start Up Parameters.
Change the **number of wolves to 0.**

- Reset the simulation.
- Repeat the 32 clicks. Record the rabbit numbers and shape of the blue rabbit population graph. This is the Fewer Predators data.

Open the View/Modify Parameters window.
Open the Start Up Parameters.
Change the number of wolves back to **5.**
Open the Miscellaneous Parameters.
Change the **Grass to 0.**

- Reset the simulation.
- Repeat the 32 clicks. Record the rabbit numbers and shape of the blue rabbit population graph. This is the Less Food data (grass is not re-growing after being eaten).

Rabbit Population Limiting Factors Data Table

Cumulative Stats: Number of Rabbits after 32 Iterations	Baseline (Small Island Ecosystem)	Mainland	More Space	More Predators	Fewer Predators	Less Food
	Island Small Forest 5 wolves	Toroid (Mainland) Small Forest 5 wolves	Island Huge Forest 5 wolves	Island Small Forest 15 wolves	Island Small Forest 0 Wolves	Island Small Forest 5 Wolves Grass does not regrow
Living						
Died						
Born						
Sketch the shape of the blue line (Rabbits) on the population graph						

Record your current observations below, then compare them to your predictions.

Which limiting factors caused changes in the rabbit population?	
Which limiting factors changed the rabbit population the most?	
In the first five factors, what was the trend shown by the shape of the blue line?	

Does this line shape show a population that is changing, or stable? Explain.	
In the Less Food graph, what was the trend shown by the shape of the blue line?	
Does this show a population that is changing, or stable? Explain.	

Part B

Now let's look at a small island forest, with 20 rabbits and normal grass regrowth at a larger scale (more iterations, over a longer period of time.) We are going to focus on the relationship between the rabbits and the grass, so we will set the wolves to 0.

Make a prediction:

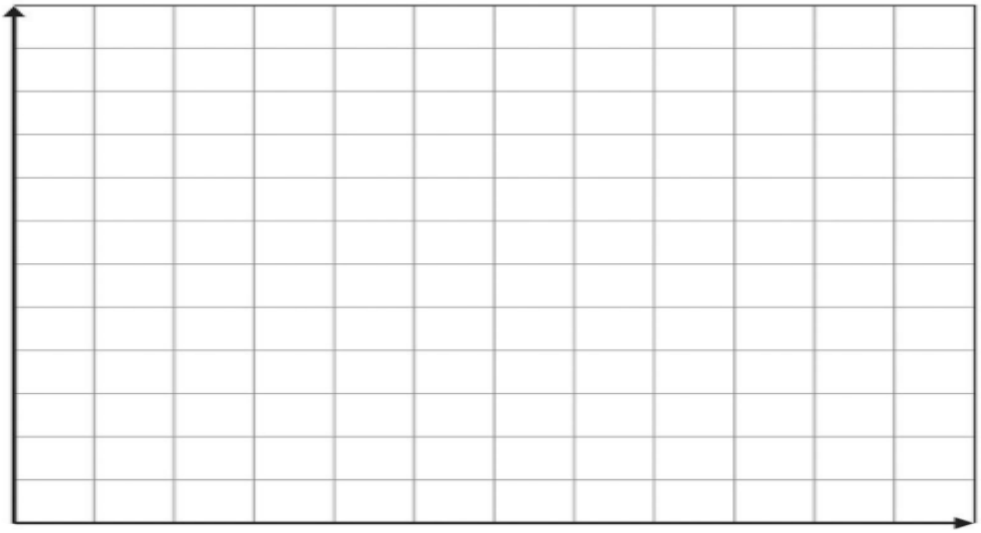
Will the rabbit population continue to increase, or will it stabilize over time? Explain your prediction.	

Return to the simulation here.

- Make sure that you are starting with 0 wolves and 20 rabbits in the Start Up Parameters.
- Make sure you've reset your Grass Growth to 1 in the Miscellaneous Parameters.
- Set your Forest Size to Small and your Forest Border to Island.
- Make sure you Reset the Simulation.

Now, open the Population Graph, and run the simulation for about 400 iterations. (Hint: Use the Run Simulation button - not the Step Simulation button. You can increase the speed.)

Sketch the shape of the pattern you see for rabbits and grass:

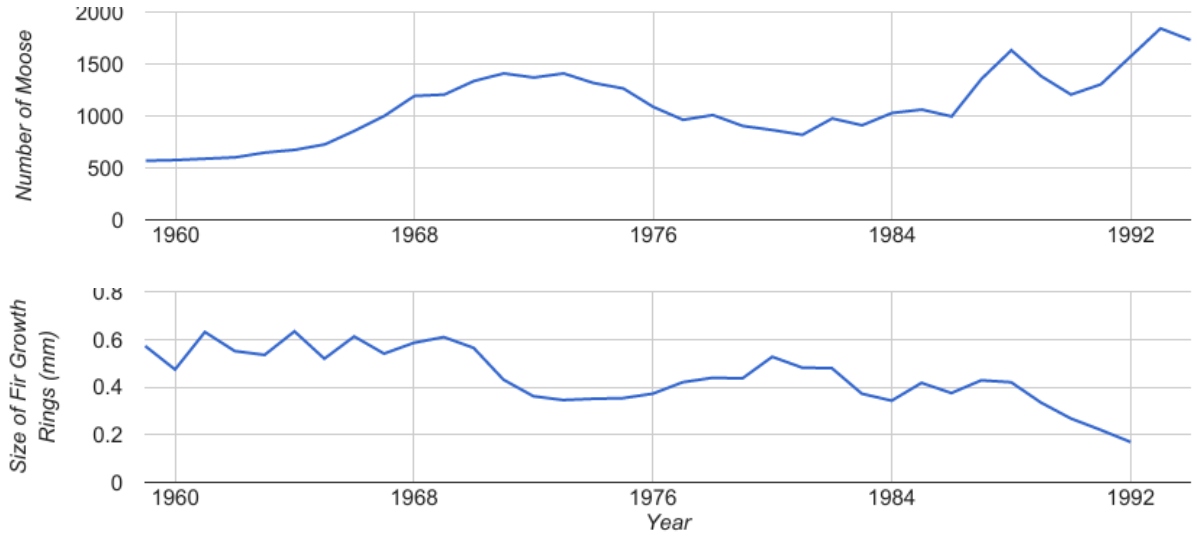


What does this tell you about the relationship between rabbits and grass?	
What is limiting the population of the rabbits?	
Compare this graph to the graphs you sketched in Part A. How does the shape of the graph change over time?	
Would you consider the rabbit population on this graph to be stable, or changing?	

Why?	
By the 400th iteration, would you say the rabbit population is at carrying capacity? Why or why not?	

Appendix C: HS Lesson 1 Student Worksheet C

Below are graphs showing moose population on Isle Royale over thirty years, along with corresponding balsam fir growth data for the same time period. Balsam fir is the primary food source for moose in the winter.



Modified From: McLaren, B. E., & Peterson, R. O. (1994). Wolves, moose, and tree rings on Isle Royale. *Science*, *266*(5190), 1555.

Complete the Claim, Evidence, Reasoning graphic below, using the information given.

Claim: Over time, the carrying capacity for moose on Isle Royale may be affected by the growth rate of balsam fir.	
Scientific Principle: Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support.	
Evidence: (Data)	**Reasoning:** (How does the data, combined with the scientific principle, support your claim?)