**Lesson 5: Eat and Be Eaten: Prey as Predator, Predator as Prey**

### Overview
This model explores a moose and wolf population. A predator/prey relationship is present, as with Lesson 4, but now the moose have a food source, creating a more realistic representation of the ecosystem. Students take on the role of wildlife manager and control hunting policies for both predator and prey populations. The default simulation behavior for prey, predators, and biomass is oscillation. Depending on policy decisions, a variety of results occur.

**Learning Goals:**
- Represent and interpret data on a line graph.
- Compare results for simulation runs.
- Manage a simulated ecosystem, keeping it healthy.
- Identify and explain challenges of being a wildlife manager and meeting specific goals.

### Materials:
- One computer for every 2-3 students
- Handouts (See pages 4-18)

### Curricular Connections:
- Science: Populations, ecosystems, scientific method
- Math: Vary assumptions, explore consequences, and compare predictions with data.*
- Reading: Analyze a complex set of ideas or sequence of events and explain how specific individuals, ideas, or events interact and develop over the course of the text.*

*Common Core Standards

### Key system dynamics concepts and insights:
- Expanding boundaries can provide a bigger picture of how a system works. (Note: this model adds a food supply for the prey.)
- Systems can have conflicting goals, thus making it difficult to manage system results.
- Balancing feedback loops (predator/prey and prey/biomass) keep the system “in check.”

### Student Challenge
Keep the ecosystem healthy while managing related human interests, even in the face of unexpected events such as a drought.

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Figure 1: Title Screen
Lesson Details

Preparation:
1. Create groups of two to three students each.
2. Check computers to make sure you can access the online simulation.
3. Copy each handout double-sided for each student. See the chart below to determine how many copies of each handout you’ll need.

<table>
<thead>
<tr>
<th>#</th>
<th>Page</th>
<th>Handout</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4-6</td>
<td>Introduction</td>
<td>This section includes instructions for assembling a learning portfolio and an assessment rubric. Students then get started on the simulation using step-by-step directions.</td>
</tr>
<tr>
<td>2</td>
<td>7-8</td>
<td>Baseline Run with experimental exploration</td>
<td>Students set up and record the data for a baseline run. They then explore “What if?” questions, recording their data for the best run.</td>
</tr>
<tr>
<td>3</td>
<td>9-13</td>
<td>Challenge Runs</td>
<td>Students work to complete two specific ecosystem challenges.</td>
</tr>
<tr>
<td>4</td>
<td>14 - 15</td>
<td>Debrief</td>
<td>Students step through the debrief and write their reflections.</td>
</tr>
<tr>
<td>5</td>
<td>16 - 18</td>
<td>Recommendation (Official Memo)</td>
<td>Students create a final analysis of the data, make recommendations, and write a summary for the forest director.</td>
</tr>
</tbody>
</table>

4. Optional: You may want to read the background information about the underlying structure of the model. This can be useful as you guide students to understanding the model behavior as it relates to real-world behaviors and the limitations of the model. See, “Predator-Prey-Biomass Model Background Info,” available as a separate file for download.

Lesson Sequence:
1. Introduce students to any specific content knowledge related to ecosystems, animal populations, etc., that you’d like students to have prior to running the simulation. This may include definitions of terms such as: ecosystem, lifespan, area, population density, predator, prey, nutritional needs, and biomass.
2. Have students open the simulation and work through the simulation introduction, runs, and debrief using the guided handouts. Note that the handouts guide students through the simulation in a step-by-step manner. If you’d like to leave the exploration more open, then you may wish to eliminate some of the handouts. Figure 2 shows the control panel screen.
Lesson 5 – Level C • Predator/Prey/Biomass • ©2012 Creative Learning Exchange • 3

**Lesson Details**

**Virtual Populations**

- **Instructions**
  1. Select Sensory inputs.
  2. Set setting level.

**Figure 2: Control Panel**

**Bringing the Lesson Home:**

Discuss these and any other questions that have surfaced about model behaviors.

- How does the addition of a food source for the prey impact the dynamics of the ecosystem?
- Why do the prey start dying from starvation before the biomass is completely gone?
- To what degree should human interests impact ecosystem policy decisions?
- How might differing needs from various parts of the system (animals, plants, hunters, farmers, and residents) make it difficult to manage a system over time?

**Debrief and Assessment:**

1. Using the instructions and rubric, have students assemble their portfolios and write up their recommendations and summary.
2. One option is to ask students to orally present their recommendations within small groups or in front of the class. Peers could ask questions and give feedback to one another using aspects of the same rubric.
3. Debrief the simulation experience as a class, using ideas for bringing the lesson home.

**Assessment Ideas:**

Using a rubric, students assemble a portfolio of their learning. The portfolio includes a recommendation to the park director (the boss) explaining a plan of action and the rationale for choosing it.
Waves of Change: Predator and Prey Dynamics – Introduction

You are a new employee of a major national park and will be in charge of issuing hunting licenses and deciding whether or not to allow predators to be killed if humans or their animals are at risk. In preparation for taking on this role, you will run a simulation to determine how different policies play out over time. You’ll explore the sections (in bold) as indicated. Remember, you can always revisit a section anytime you like.

After running this “Training Simulator,” you will write up a recommendation to your boss (the park director) explaining your plan and your rationale for choosing it. The park director will score your recommendation and portfolio with a rubric (see attached).

At the conclusion of this project, you will need the following items organized into a portfolio.

1. Title page that incorporates the following:
   - Title: Wildlife Management Project Analysis
   - Your name
   - One or more drawings, illustrations, and/or diagrams that illustrate what you learned

2. Your “Official Memo” to the forest director, Rutheforest T. Grove

3. Handouts 1-4, complete and organized neatly in order
   - Handout 1 – Instructions, Rubric, and Introduction
   - Handout 2 – Baseline Run
   - Handout 3 – Challenge Runs
   - Handout 4 – Debrief
## Project Assessment Rubric

<table>
<thead>
<tr>
<th>Category</th>
<th>Novice</th>
<th>Basic</th>
<th>Proficient</th>
<th>Advanced</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Title</strong></td>
<td>Little to no visuals are included.</td>
<td>Visuals are included, but they are not clearly linked to learning.</td>
<td>Visual representations clearly show key learning.</td>
<td>In addition, a diagram clearly shows cause and effect relationships.</td>
</tr>
<tr>
<td><strong>Ecosystem Health</strong></td>
<td>The ecosystem is completely out of balance (e.g., all of the predators are gone).</td>
<td>The ecosystem is somewhat out of balance (e.g., populations have big ups and downs over time).</td>
<td>The ecosystem is stable and healthy.</td>
<td>In addition to having a healthy ecosystem, the hunters, residents, and farmers are satisfied with your job performance.</td>
</tr>
<tr>
<td><strong>Data</strong> (within the simulation handouts and in the recommendation)</td>
<td>Little to no data is included.</td>
<td>Some data is included, but it is not clear or accurately recorded.</td>
<td>The recorded data is relevant, accurate and clearly represented.</td>
<td>In addition to the data, the analysis shows logical connections to the hunter and farmer/resident satisfaction over time.</td>
</tr>
<tr>
<td><strong>Explanations</strong> (within the simulation handouts and in the recommendation)</td>
<td>Little to no explanation of the data is included.</td>
<td>Some explanation of the data is included, but it includes little detail and has some inaccuracies.</td>
<td>Explanations are clear and directly links to the data on the graphs.</td>
<td>In addition, explanations describe trends and inter-connections.</td>
</tr>
<tr>
<td><strong>Recommendations (RECs) and Rationale</strong></td>
<td>RECs are missing or unclear.</td>
<td>RECs are present but not clearly linked to the data analysis.</td>
<td>RECs are clearly linked to the data analysis.</td>
<td>In addition, RECs include subtleties that are not explicitly shown in the data but are inferred from the data.</td>
</tr>
<tr>
<td><strong>Summary and Conclusions</strong></td>
<td>Summary and/or conclusion is missing.</td>
<td>Summary and policy statement are included but are unclear or inaccurate.</td>
<td>Brings together the data and recommendations into a concise summary and a general policy statement.</td>
<td>In addition, includes a rationale for why you will be best able to manage the forest as a new employee.</td>
</tr>
</tbody>
</table>
Introduction
Open web address: http://www.clexchange.org/curriculum/complexsystems/oscillation/
Select the Waves of Change: Predator and Prey Dynamics-Level C simulation and click “Start.”
   a. What is an ecosystem?
   b. What do you think it means to be a wildlife manager?

   Click Read more about your area
   c. Why might an ecosystem be referred to as an island if it isn't surrounded by water?
   d. What are some current concerns relating to the wolf population?
   e. What are some current concerns relating to the moose population?
   f. Define the term “biomass” and explain why it is important within this ecosystem.
   g. What is a “boom and bust” cycle?

Click Menu.
2. Click Experiment with the Model.
You will use the following worksheets to predict and record your virtual experiments.
Run #1: Baseline Run

Click on the ? button for each of the sliders to see what each one does. Input the values shown below onto the simulation screen, but don't run it just yet.

<table>
<thead>
<tr>
<th>Simulation Mode</th>
<th>Experiment freely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prey hunting</td>
<td>0</td>
</tr>
<tr>
<td>Predator hunting</td>
<td>0</td>
</tr>
</tbody>
</table>

Predict: What do you think will happen to the two populations and the biomass?

Draw your general prediction as lines on the graph, showing the predators, the prey, and the biomass in three different colors. Now **click** “Run.”

Analysis:

a. Using the same three colors, create a key, label the appropriate scales on the y-axis with the respective colors, and draw the three lines on the graph below.
Baseline Run (continued)

b. Explain why you think the populations and biomass changed as they did. Make sure to discuss how and why the populations and biomass impacted one another.
Optional: Include a visual representation of the relationships between the predator, prey, and biomass.

c. Continue your exploration, asking “What if?” questions, keeping the model in the “experiment freely” mode. Ask one question at a time, running the simulator until you have a feel for the behavior that is being produced.
Example questions:
Question 1: What might happen if I allow some hunting of prey?
Question 2: What might happen if I allow some predators to be killed?
Question 3: What might happen if I allow both prey hunting and predator kills?
Question 4: What might happen if I allow a very high level of hunting either predators or prey or both?

d. Write a brief summary of what you’ve learned so far.
Challenge Run #1: Can you keep the ecosystem in balance?

Set the simulation mode to “Pause every 5 years.”
Set up your initial hunting for year 0, click “Run,” and then make changes as needed every time the simulation pauses. Record your settings as you go in the table.

<table>
<thead>
<tr>
<th>Year</th>
<th>Prey Hunting</th>
<th>Predator Hunting</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
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<tr>
<td>10</td>
<td></td>
<td></td>
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<tr>
<td>15</td>
<td></td>
<td></td>
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<tr>
<td>20</td>
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<td>25</td>
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<td>30</td>
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<td>35</td>
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<tr>
<td>40</td>
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</tbody>
</table>

Analysis:
a. Using the same three colors, create a key, label the appropriate scales on the y-axis with the respective colors, and draw the three lines on the graph below.
b. What was your general strategy, and how successful were you in achieving stable (flat-line) population levels over time?

c. What changes would you make to improve your results?

Continue running the simulation in pause mode, trying different hunting strategies. Record your best run and explain what you did to achieve those results.

<table>
<thead>
<tr>
<th>Year</th>
<th>Prey Hunting</th>
<th>Predator Hunting</th>
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<tbody>
<tr>
<td>0</td>
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<td>40</td>
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</tbody>
</table>

Analysis:
Using the same three colors, create a key, label the appropriate scales on the y-axis with the respective colors, and draw the three lines on the graph below.
**Challenge Run #2:** Can you keep the ecosystem in balance while meeting the needs of the hunters, residents, and farmers?

Set the simulation mode to “Real-world situations.” Set up your initial hunting for year 0, click “Run,” and then make changes as needed. You can pause whenever you like to make changes. Record the year, messages, and your settings in the table. You can see the year (time) by pointing and clicking on the end of the graph line.

<table>
<thead>
<tr>
<th>Year</th>
<th>Message Issue</th>
<th>Prey Hunting</th>
<th>Predator Hunting</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>None</td>
<td></td>
<td></td>
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</tbody>
</table>

**Analysis:**

a. Using the same three colors, create a key, label the appropriate scales on the y-axis with the respective colors, and draw the three lines on the graph below.
b. What was your general strategy and how successful were you in achieving stable (flat-line) population levels over time?

c. Click the triangle (bottom left on graph pad) to flip to “Page 5.” Looking at this graph that shows the number of prey killed by hunters and the number of prey hunters wanted to kill, how satisfied do you think the hunters are? Draw the graph lines and your perception of the hunters’ satisfaction level (using three new colors).

Prey Killed vs. Desired Prey Killed

Hunter Satisfaction

![Graphs of Prey Killed vs. Desired Prey Killed and Hunter Satisfaction]

d. Based on all three graph lines above, why do you think that the hunters might feel this way?

e. Based on the graph of predators and any messages you received, how do you think the farmers and residents were feeling over time?

f. What changes would you make to improve your results?
Continue running the simulation in “Real-world situations” mode, trying different hunting strategies. Record your best run and explain what you did to achieve those results on a blank sheet of paper.

<table>
<thead>
<tr>
<th>Year</th>
<th>Message Issue</th>
<th>Prey Hunting</th>
<th>Predator Hunting</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>None</td>
<td></td>
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</tr>
</tbody>
</table>

Predators, Prey, and Biomass Graph

Prey Killed vs. Desired Prey Killed  
Hunter Satisfaction
Debrief

Click **Menu** and then **Debrief Central**. You’ll go through each of these sections of the debrief to process what you experienced in the simulation.

**Click A. Behavior Patterns.**
Read and click on **What’s really happening**.
- a. Why is the situation reflected in this graph not an ideal situation for the health of the ecosystem? Make sure to include thoughts about all parts of the ecosystem in your explanation.

**Click Continue.** Read and click on **What’s really happening**.
- b. Why do you or don’t you think this result is successful management?
- c. How would the hunters feel over time? Why?

**Click Menu** and **B. Explore the Model.**
Read “Model as Hypothesis” and answer the following:
- a. How do the three main parts of the ecosystem (predators, prey, and biomass) affect one another?
b. Looking at the map of the system, fill in the following table.

<table>
<thead>
<tr>
<th>Stock</th>
<th>What increases the stock?</th>
<th>What decreases the stock?</th>
<th>How does this stock affect another stock(s)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predator Population</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prey Population</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biomass</td>
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</tbody>
</table>

c. Choose one of the loops, draw it here, and “tell the story” of that loop in your own words.

d. How does that loop relate to the behaviors you saw in the simulation?

Click Menu and then C. Connections.
Click on each of the models and read about the purpose of using a model to better understand predator, prey, and biomass interactions.
List and describe one or more situations that might be better understood with a model.
OFFICIAL MEMO

DATE:

TO: Rutheforest T. Grove, Park Director

FROM:

REGARDING: Official Management Recommendation

Data and Analysis:

Figure 1: Graph of stable simulated ecosystem (predators, prey, biomass)

Actions that led to this result:
### Figure 2: Graphs of acceptable hunting levels for predators and prey

![Graphs of acceptable hunting levels for predators and prey](image)

### Figure 3: Complaints from hunters and farmers/residents

<table>
<thead>
<tr>
<th>Year</th>
<th>Complaint and Issues</th>
<th>Action Taken</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

**Actions that best led to keeping the surrounding community members satisfied, while at the same time keeping the ecosystem healthy:**

...
**Figure 4: Recommendations:**

<table>
<thead>
<tr>
<th>Policy Areas</th>
<th>Recommendations</th>
<th>Rationale (Why this policy is good for the ecosystem and the surrounding community)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1 – Hunting Prey</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#2 - Hunting Predators</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#3 – Responding to Complaints from Hunters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#4 – Responding to Complaints from Farmers/Residents</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Summary and General Conclusions:** (see attached)
Acknowledgements:
Lesson 5 - Level C
Eat and Be Eaten: Prey as Predator, Predator as Prey
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Anne LaVigne
Michael Radzicki
George Richardson
Lees Stuntz
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