Day 1

Ecosystems as Complex Adaptive Systems

PACING GUIDE

Getting Started
Introduction to Ecosystems: What are ecosystems, how is energy involved? (Different trophic levels, energy moves through the food web **10 mins**

Activity 1 (New Learning)
Papercatchers Activity: population growth patterns, limits to growth, and carrying capacity **25 mins**

Activity 2 (New Learning)
Previewing the Rabbits and Grass Model (teacher-led demonstration) and challenge (Can you balance the ecosystem? What is a healthy ecosystem?). **10 mins**

Wrap-Up (Reflection)
If you were to study a real-world ecosystem, what kind of data would you want to collect? **5 mins**

LEARNING OBJECTIVES: Students will. . .

Complex Adaptive Systems
Gain a basic understanding of ecosystems as complex adaptive systems.

Disciplinary Core Ideas
Experience population growth and limits to growth through a simulation. Graph different patterns of growth and learn to distinguish them. Learn the ecosystem concept of carrying capacity.

Modeling and Simulation
Setup and run experiments using a computer model. Investigate the parts of a computer model. Speculate as to why computer models can be valuable scientific tools.

ASSESSMENTS OF UNDERSTANDING:

Complex Adaptive Systems
Name two characteristics of a complex adaptive system that exist in ecosystems.

Disciplinary Core Ideas
Describe two patterns you saw in Papercatchers. How would you determine the “carrying capacity” of an environment?

Modeling and Simulation
How many trophic levels were represented in the model?

Day 2

Rabbits and Grass Model

PACING GUIDE

Getting Started
Review of the previous day's lesson and concepts. Connection to today's lesson. **5 min**

Activity 1 (Discovery)
Under the Hood: inspecting the Rabbits and Grass model, variables, looping and execution order. **20 min**

Activity 2 (Guided Practice)
Designing and running experiments: specify your question, write up your experimental design and run your experiments. (Review how to change a parameter, add a slider, a graph, etc). **20 min**

Wrap-Up (Reflection)
How does experimental design with computer models differ from experimental design without computers? What does the computer model enable us to do that would be difficult to do in the real world? **5 min**

LEARNING OBJECTIVES: Students will. . .

Complex Adaptive Systems
Make observations of ecosystems dynamics and change in population sizes over time.

Disciplinary Core Ideas
Growth of organisms and population increases are limited by access to resources. 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.

Modeling and Simulation
Ask a question and design an experiment. Conduct an experiment. Make observations (drawing simple correlations).

Computer Science
Decode a simple model. Trace a program's execution.

ASSESSMENTS OF UNDERSTANDING:

Complex Adaptive Systems
Is the Rabbits and Grass ecosystem a complex adaptive system? Why or why not?

Disciplinary Core Ideas
What are the three different outcomes seen in the rabbits and grass model?

Modeling and Simulation
What variables were we able to manipulate in Rabbits and Grass? Give a good explanation of what happens when a simulation is run. What does it mean if a model produces different outcomes each time I run it?

Computer Science
Diagram an execution loop showing what calls what in the Rabbits and Grass model.

Day 3

Adding a Predator

PACING GUIDE

Getting Started

(Review) Review of the previous day's lessons and concepts; connection to today's lesson. **5 min**

Activity 1 (Guided Practice) Adding a predator, and running an experiment. What is the impact of adding a top predator on the ecosystem? **20 min**

Activity 2 (Guided Practice) Running an experiment. What is the impact of adding a top predator on the ecosystem? **20 min**

Wrap-Up (Reflection) In the real world, what might impact how animals use and gain energy? How can computer models be useful in understanding ecosystems? **5 min**

LEARNING OBJECTIVES: Students will. . .

Disciplinary Core Ideas

Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. 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.

Modeling and Simulation

Design and conduct and experiment. Collect and analyze data to look for patterns.

Computer Science

Modify a simple computer model. Practice Pair Programming and Iterative design, implement and test cycle. Learn CS concepts of userdefined variables and subclasses or breeds.

ASSESSMENTS OF UNDERSTANDING:

Disciplinary Core Ideas

How would you compare the health of the ecosystem with and without a predator?

Modeling and Simulation

What was the impact of adding a predator? How would you describe the distribution of different outcomes?

Computer Science

What is an example of how an IF/THEN was used in this model?

Day 4

Create Your Own Ecosystem Model

PACING GUIDE

Getting Started (Review)
Review of the previous day's lessons and concepts; connection to today's lesson.
5 mins

Activity 1 (New Learning)
Computational Science cycle: Introduction to the Computational Science cycle and defining your computational science project.
20 mins

Activity 2 (Creative/Discovery)
Design and develop your model: Agents and environment, interactions.
20 mins

Wrap-Up (Reflection)
How would you know if your model reflects reality? What research is necessary to ground your model in reality? How will you check to see if your model is realistic? **5 mins**

LEARNING OBJECTIVES: Students will. . .

Disciplinary Core Ideas
Students will learn that organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. Growth of organisms and population increases are limited by access to resources. 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.

Modeling and Simulation
Develop a scientific question that can be answered with data output from running a model. Use abstraction to develop an idea for a model.

Computer Science
Develop a design for a computational science project. Practice Pair Programming and Iterative design, implement, test cycle.

ASSESSMENTS OF UNDERSTANDING:

Disciplinary Core Ideas
Give an example of a three trophic level ecosystem where growth of populations is limited by access to resources.

Modeling and Simulation
State what research question you have chosen to investigate and explain why you chose it. [LO2]

What aspects of the real world did you choose to include in your model? What did you leave out? Why?

Computer Science
What procedures in the model have you built? Choose one and describe how it works.

Day 5

Designing and Running an Experiment and Sharing Your Findings

PACING GUIDE

Getting Started
Review of the previous day's lessons and concepts; connection to today's lesson
5 mins

Activity 1
Finish implementing your model **20 mins**

Activity 2
Running experiments with your model **20 mins**

Wrap-Up
Analyze the results of your experiments and discuss your conclusions. Relate the results back to the bigger issue of Ecosystems as Complex Systems. Prepare your model and results for presentation.
5 mins

LEARNING OBJECTIVES: Students will. . .

Complex Adaptive Systems
Revisit the concept of population growth and feedback loops and come up with a possible feedback loop related to ecosystems. [The more fish there are, the more baby fish they will produce.]

Disciplinary Core Ideas
Gain a deeper understanding of ecosystem dynamics. They will learn that organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. Growth of organisms and population increases are limited by access to resources. Ecosystems are dynamic in nature; their characteristics can vary over time.

Modeling and Simulation
Use their new model as a test bed to run experiments. Learn that the results of their experiments can inform them of ways to further improve their model.

Computer Science
Follow the correct execution of their models and apply debugging techniques to fix their code.

ASSESSMENTS OF UNDERSTANDING:

Complex Adaptive Systems
Describe a feedback loop in ecosystems.

Disciplinary Core Ideas
Describe how adding a predator can impact an ecosystem.

Modeling and Simulation
What experiments did you run in the model and why? What real world information could help you to improve the model? Complete the "Scientific Practices with Computer Modeling & Simulation" document.

Computer Science
Define debugging and give an example of some debugging you had to do in your code [LO6].