Module 3: Ecosystems

Lesson 2: Rabbits and Grass model

50 minutes (1 day)

Lesson Overview (New Learning and Exploration)

In this lesson students will participate in two activities that USE the Rabbits and Grass model. The first activity is a look under the hood at the model to understand what was included and left out of the model (abstraction). In the second activity, students will learn to design and conduct systematic experiments using the model as an experimental test bed. They will instrument their model to collect data, then analyze data and report out on their findings.

Teaching Summary

Getting started – 5 minutes

1. Review of the previous day's lesson and concepts and connection to today's lesson.

Activity 1: Looking under the hood - 20 minutes (New Learning / Discovery)

2. Familiar and New Command Blocks
3. Decoding a model – looking for the parts and interactions between them
4. What calls what? – execution of the program loop

Activity 2: Designing and running experiments - 20 minutes (Guided Practice)

5. Experimental design
6. Running experiments
7. Collecting and analyzing data

Wrap-up - 5 minutes

8. What does computer modeling and simulation allow us to do that would be difficult to do in the real world?

Links to background information and Standards addressed.

Lesson Objectives

The student will:

- ✓ Decode a simple model of a complex adaptive system (LO7)
- ✓ Trace a program's execution (LO8)
- ✓ Ask a question and design an experiment (LO9)
- ✓ Conduct an experiment using a computer model (LO10)
- ✓ Make observations (drawing simple correlations) (LO11)

Teaching Guide

Materials, Resources and Prep

For the Students
- Computers
- Rabbits and Grass base model
- Using a Computer Model to conduct a Scientific Investigation sheet
- New Commands and Concepts sheet

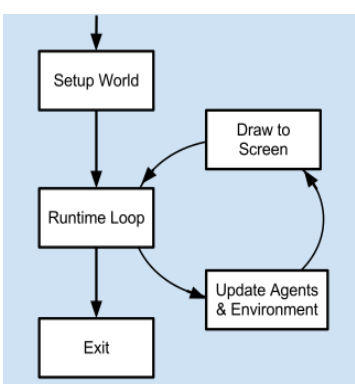
For the Teacher
- Computer and projector
- PPT with simple commands
- Rabbits and Grass base model

Getting started - 5 min

1. Review of previous day's lesson and link to where we are going today.
- What observations did you make while experimenting with the Rabbits and Grass model?
- What do you think is going on in the model? (before looking under the hood)

Activity #1: Looking Under the Hood - 20 min

There are three major abstractions in any agent-based model: agents with rules that they follow, the environment in which they coexist, and time. In StarLogo Nova, the first two are easy to see – the agents are the different turtles and the environment is Spaceland.



Time is harder to see, instead it can be thought of as a series of time slices or "clock ticks". At each tick, all of the agents have a chance to update their position or state. Ticks or time slices are not the same as seconds because it may take more or less than one second to update all of the agents. In StarLogo Nova, the time model is built into the forever buttons and the collision blocks; each time through the "run loop", every agent gets updated.

Whenever we start looking at a new model we should ask how these three elements of a model have been implemented. A simple way to begin to understand a model is to ask "Who are the agents?", "How do they behave?", "What is the environment they live in?", and "What happens each time through the run loop?"

Here's an example of a model observation form:

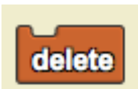
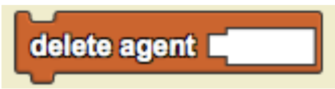
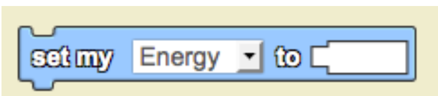
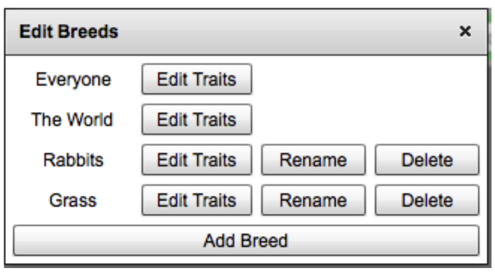
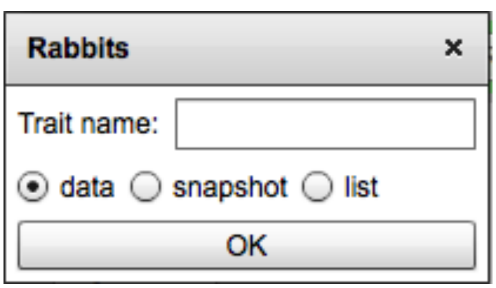
Model observation form

Name(s): ____Date: _____________

Model name: _____Rabbits and Grass______________________________________

Abstractions
Who are the Agents? What is the Environment? What are the Interactions? What do ticks represent? The agents are rabbits and grass. The environment is a meadow. The rabbits move around. When eat the grass. The grass grows new clumps from time to time.
Automation
What happens each time through the forever (or main) loop? Grass grows. Rabbits move, reproduce and die. If rabbits collide with grass, the grass gets eaten.
Assumption(s)
What are the assumptions made in this model? One assumption is that rabbits give birth to one offspring. I don't think this is realistic. Don't rabbits have many babies at a time?
Analysis
What patterns did you observe? Do these patterns occur in real-life? The population of rabbits grows quickly. Sometimes too quickly. The grass can get all eaten up. If there is not enough grass to feed all the new rabbits, the rabbits will all eventually die.

2. **Review Familiar and New Command Blocks**
    - Keep track of familiar command blocks. Students can refer to their StarLogo Nova Command Blocks reference sheets from Module 1.
    - Review what the new command blocks do.

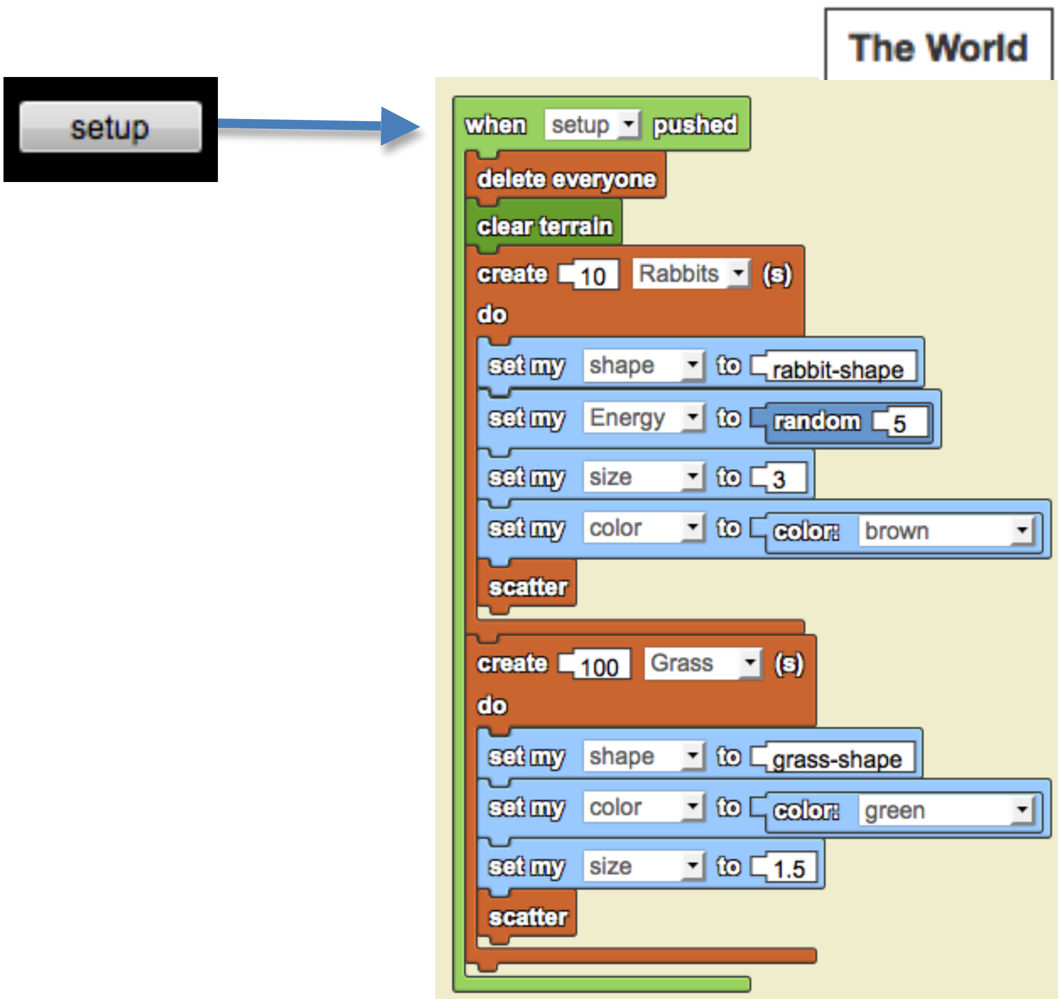
	The delete block deletes the current agent.
	The delete agent block deletes the agent referenced.
	The set my (trait) to (value) block is used to set the current agent's trait to some value. In this case, Energy is a new trait created by the user.
 	The user created the Rabbits trait "Energy" using the Edit Breeds panel. Click on "Edit Breeds" in the Spaceland panel. Then click on the "Edit Traits" button next to Rabbits. From here you can give an agent a new trait by clicking on "Add Trait" Then specify a trait name and type. The type can either be "data", "snapshot", or "list". For Energy, we want to store a value or number, so choose "data" and click OK. In computer science, this is called declaring a variable. The variable in this case is a number variable called "Energy".

3. Assign a part to decode to each pair of students.
- Assign partners to share a computer
- Assign each pair a piece of the model to decode Rabbits, Grass, or World. The detailed description of what an agent's procedures can be added to the model observation form.
- Give the students 5 minutes to decode then ask students to share out

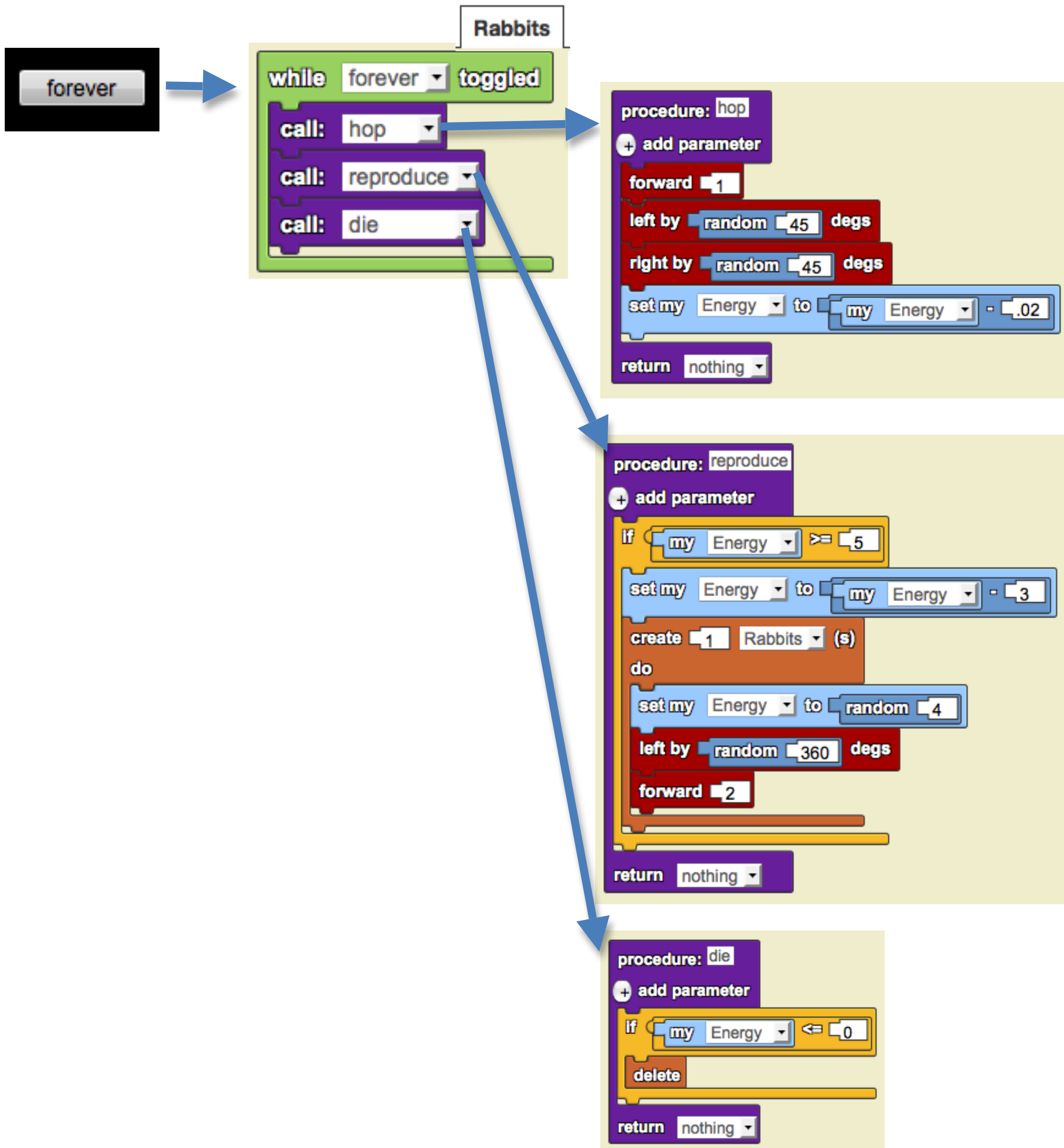
[Notes for the teacher: The base model for this module is a simple ecosystem that consists of rabbits and grass. The grass reproduces at a certain rate and the rabbits randomly move around the world eating the grass. If a rabbit stumbles across a grass, it will eat the grass and gain energy. If a rabbit gains enough energy, it will reproduce (asexually by hatching a baby like itself). If a rabbit wanders around too long without finding any grass to eat, it will die. The “world” agent simply sets up the world in the set up phase.]

4. Program loop and Execution order – what calls what?

- Demonstrate how to trace execution of the program starting with Setup button
- As a group, trace execution of the program starting with Run button

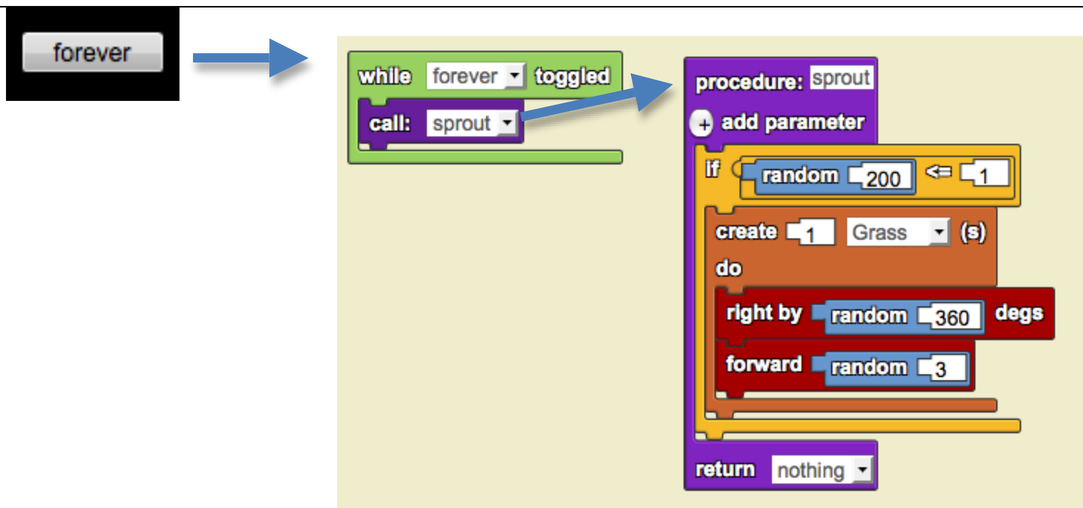
Clicking the setup button in Spaceland causes the execution of this procedure in the World.

First everyone gets deleted and the terrain gets cleared. The 10 rabbits are created with their shape set to “rabbit-shape”, their energy set to a random value between 1 and 5, their size set at 3, and their color set to brown. The rabbits are scattered throughout Spaceland. Next 100 grass agents are created, their shape set to grass-shape, their color set to green and their size set to 1.5. They too are scattered around Spaceland.

Toggling the forever button to its "ON" state in Spaceland causes the execution of this procedure in the Rabbit agents.



In the real world most things happen in *parallel*. That is, all the people move at once. But in the computer we can only move one agent at a time. How does StarLogo Nova make it look like all of the agents are moving at once?

[Notes for the teacher: In StarLogo Nova we simulate parallelism, when each tick starts we give all of the agents a chance to move (each takes a turn) and then say that this tick is now over. Many moves took place one at a time but we say they took place together in one slice of time or tick. We call this method of advancing time “discrete time steps”. In this system of time there is one clock that all of the agents share. The clock has a series of ‘ticks’. During each tick every agent is given a chance to move once. When all agents have been given a turn the clock is moved forward another ‘tick’ and the whole cycle is repeated.]



Teaching Tip *The program execution loop can be diagrammed on the board to give visual clues as to what is happening as time advances in the simulation.*

Teaching Tip *The program execution loop can be acted out with a “clock”. At each tick have each student take their turn, before the clock advances. When the clock advances, take a snapshot of the agents’ positions at that time. Then flip through the snapshots to see what the computer shows us (discrete time slices).*

Activity #2: Experimental Design- 20 min

With these simple agents and behaviors in place, we can observe the system from the global perspective to see the relationship between the amount of grass and the rabbit populations. We can also instrument the model to gain a quantitative understanding of the population dynamics.

5. Experimental Design

- Asking scientific questions
  Use the “USING a Computer Model to conduct a Scientific Investigation” template as a guide and guide students as they develop scientific questions in pairs.

USING a Computer Model to conduct a Scientific Investigation

Name(s): ____Date: _____________

Model name: _____Rabbits and Grass______________________________________

The table below lists scientific practices that you will be using as you conduct a scientific investigation using a computer model. Please provide an example of what you did that matches the practice.

Practices:	Example:
Asking questions and defining problems	I am asking a testable question. The question is "How does increasing the amount of energy gained from eating grass impacts the maximum number of rabbits that can be supported in the ecosystem?"
Develop and use a model	I am using the Rabbits and Grass model that was developed for me. I only need to be able to change the amount of energy a rabbit gains from eating grass.
Plan and carry out an investigation	I am designing an experiment. In my experiment, I will change the amount of energy a rabbit gains from eating grass from 1 to 2 to 3. I will record how the maximum number of rabbits that lived over 1000 ticks. I will run the simulation at each of these values 5 times.
Analyze and interpret data	I will compare the max number of rabbits that lived in each of the trials. I will see if the higher the amount of energy from grass leads to a higher population of rabbits.
Use mathematics and computational thinking	I am looking for relationships between two variables.
Construct explanations and design solutions	
Engage in argument from evidence	
Obtain, evaluate, and communicate information	

- Designing your experiment so the question can be answered

6. Running Experiments
- Which variable will you be changing?
- What range
- How many trials at each setting

See the "USING a Computer Model to do Science" template.

7. Collecting and analyzing data.
- Adding Instrumentation to the model
- Patterns in data

See the "Adding Instrumentation to your model guide"

Wrap-up – 5 min

8. How does experimental design with computer models differ from experimental design without computers?
- What does a computer model enable us to do that would have been difficult or impossible in the real world?
- What might be a danger of trusting a computer model?

Assessment Questions

- Is the Rabbits and Grass ecosystem a complex adaptive system? Why or why not? (LO7)
- What rabbit procedures were called when the forever button was toggled on? (LO8)
- What were the independent and dependent variables in your experimental design (LO9)
- How many times did you have to run your model at each setting? Why? (LO10)
- Give an example of a correlation you observed after running experiments with the model (LO11)

Connections and Background Information

Document: Ecosystems as Complex Adaptive Systems
Document: Feedback loops
Video: Using computer models in scientific inquiry

Standards Addressed

NGSS Performance Expectations

Ecosystems: Interactions, Energy, and Dynamics MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

NRC Disciplinary Core Ideas

Interdependent Relationships in Ecosystems DCI-LS2.A: Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. Growth of organisms and population increases are limited by access to resources.

Ecosystem Dynamics, Functioning, and Resilience
DCI-LS2.C: 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.

In lesson 1 population growth and limits to growth are emphasized. Growth of populations are seen as limited by access to resources. Ecosystems are seen as dynamic (changing) in nature. Populations vary and characteristics can change over time (seen in rabbits and grass model).

NRC Scientific and Engineering Practice Standards

Practice 1: Asking questions and defining problems
1A: Ask questions that arise from careful observation of phenomena, models, or unexpected results.
1B: Ask question to identify and/or clarify evidence and/or the premise(s) of an argument.
1C: Ask questions to determine relationships between independent and dependent variables and relationships in models.

Practice 2: Developing and using models
2A: Evaluate limitations of a model for a proposed object or tool.
2C: Use and/or develop a model of simple systems with uncertain and less predictable factors.
2E: Develop and/or use a model to predict and/or describe phenomena.
2G: Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.

Practice 3: Planning and carrying out investigations
3A: Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.
3B: Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation.
3D: Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.

Practice 4: Analyzing and interpreting data
4A: Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships.
4B: Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships.
4D: Analyze and interpret data to provide evidence for phenomena.

Practice 5: Using mathematics and computational thinking
5B: Use mathematical representations to describe and/or support scientific conclusions and design solutions.
5D: Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems.

Practice 6: Constructing explanations and designing solutions
6A: Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena.
6B: Construct an explanation using models or representations.
6D: Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.

Practice 7: Engaging in argument from evidence
7C: Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

Practice 8: Obtaining, evaluating, and communicating information
8E: Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.

(Practice 1: Asking questions and defining problems)
(Practice 2: Developing and using models)
(Practice 3: Planning and carrying out investigations)
(Practice 4: Analyzing and interpreting data)
(Practice 5: Using Mathematical and computational thinking)
(Practice 6: Constructing explanations and designing solutions)
(Practice 7: Engaging in argument from evidence)
(Practice 8: Obtaining, evaluating, and communicating information)

NRC Crosscutting Concepts

1. Patterns:
1B: Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems.
1D: Graphs, charts, and images can be used to identify patterns in data.

3. Scale, Proportion, and Quantity
3A: Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

4. Systems and Systems models
4A: Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.
4B: Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.
4C: Models are limited in that they only represent certain aspects of the system under study.

5. Energy and Matter:
5B: Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.

7. Stability and Change:
7A: Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale.
7C: Stability might be disturbed either by sudden events or gradual changes that accumulate over time.
7D: Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.

(CCC: Patterns)
(CCC: Scale, proportion, and quantity)
(CCC: Systems and systems models)
(CCC: Energy and matter)
(CCC: Structure and function)
(CCC: Stability and change)

CSTA K-12 Computer Science Standards

CT	Abstraction	2-12	Use abstraction to decompose a problem into sub problems.
CT	Algorithms	3A-3	Explain how sequence, selection, iteration and recursion are the building blocks of algorithms.

CT	Connections to other fields	2-15	Provide examples of interdisciplinary applications of computational thinking.
CT	Data representation	3A-12	Describe how mathematical and statistical functions, sets, and logic are used in computation.
CT	Modeling & simulation	1:6-4	Describe how a simulation can be used to solve a problem.
CT	Modeling & simulation	2-9	Interact with content-specific models and simulations to support learning and research.
CT	Modeling & simulation	3A-8	Use modeling and simulation to represent and understand natural phenomena.
CT	Modeling & simulation	3B-8	Use models and simulation to help formulate, refine, and test scientific hypotheses.
CT	Modeling & simulation	3B-9	Analyze data and identify patterns through modeling and simulation.
CPP	Data collection & analysis	2-9	Collect and analyze data that are output from multiple runs of a computer program.
CPP	Data collection & analysis	3B-7	Use data analysis to enhance understanding of complex natural and human systems.

--

Responsiveness to varied student learning needs:
In Project GUTS, we integrate teaching strategies found to be effective with learners with various backgrounds and characteristics such as economically disadvantaged students (EDS), students from underrepresented groups in STEM (URG) , students with disabilities (DIS), English Language learners (ELL), girls and young women (FEM), students in alternative education (ALT), and gifted and talented students (GAT).

In each lesson we describe the accommodations and differentiation strategies that are integrated in the activities to support a wide range of learners.

Module 3 Lesson 2: Rabbits and Grass model

(EDS)(URG)(ELL) *We ask students to apply what they know, specific to their cultural and/or socio-economic context, when addressing issues related to ecosystems and the realism of models. We can ask what is assumed in this model, what is realistic to the students, and what is not.*
(URG)(DIS) *We use technology to present information in multiple modes of representations. In the StarLogo Nova modeling and simulation environment students can present information as code blocks, text, graphical display of the simulation, and as data in tables and graphs.*
(ELL) *The "place-based" nature of this lesson establishes connections between school science and the students' community and lives.*
(FEM) *Careful planning of partners for the on-computer activity is a strategy that encourages participation for the girls in science.*
(FEM) (URG) *We choose a curriculum topic, Ecosystems, that has relevancy and real-world application, to interest and engage the girls and students from underrepresented groups in STEM in the class.*

Student Activity #1 Guide:

- Model observation form

Student Activity #2 Guide:

- Experimental design form