

The Tree Game For Primary Students (Grades K-3)

Anne LaVigne with Lindsey Weaver

adapted from *The Shape of Change* by Rob Quaden, Alan Ticotsky and Debra Lyneis

Illustrated by Nathan Walker

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In *The Tree Game*, students explore what happens to the number of trees in a forest over time as a forester plants and a lumberjack harvests a certain number of trees each year. While playing the game, the class tracks the number of trees over time. Students can see trends and discuss what's happening to the forest and why, connecting it to real-world needs and desires for lumber and paper products. They can then run and discuss a second scenario that shows how that trend can be reversed.

Connection to Standards

The Tree Game connects to standards in math, science and ELA. Related contexts include resource management, ecology, computation, data representation, and graphing. Example standards include:

Common Core Math – Example Standards

- Count to tell the number of objects. (Grade K)

- Represent and solve problems involving addition and subtraction. (Grades 1 and 2)
- Work with addition and subtraction equations. (Grade 1)
- Model with mathematics. (K-3)
- Look for and make use of structure. (K-3)
- Represent and interpret data. (Grades 1 - 3)

National Science – Example Standards

- Systems have boundaries, components, resources flow (input and output), and feedback. (all levels)
- Resources are things that we get from the living and nonliving environment to meet the needs and wants of a population. (K-4)
- Some resources are basic materials, such as air, water, and soil; some are produced from basic resources, such as food, fuel, and building materials; and some resources are nonmaterial, such as quiet places, beauty, security, and safety.
- The supply of many resources is limited. If used, resources can be extended through recycling and decreased use. (K-4)
- Changes in environments can be natural or influenced by humans. Some changes are good, some are bad, and some are neither good nor bad. (K-4)

Common Core for ELA – Example Standards

- Ask and answer questions about key details in a text read aloud or information presented orally or through other media. (Grade 1)
- Add drawings or other visual displays to descriptions when appropriate to clarify ideas, thoughts, and feelings. (Grade 1)

How It Works

Students play a game that simulates the growing and harvesting of trees. The game is set up so students manipulate the stock of trees. Each year a forester plants and a lumberjack harvests a certain number of trees.

Each scenario follows a different plan for planting and harvesting. In Scenario 1, the forester always plants 3 trees. The lumberjack starts by harvesting 1 tree in the first year, followed by 2 in the second year, 3 in the third year, and so on. This scenario shows what can happen to a resource given an ever-increasing demand for a product. The second scenario reverses the rule, so students can explore what might happen if the demand were to drop over time. A third scenario allows the class to make a new rule.

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The CLE has been a busy place over the past months. We are working hard to finish two major curricular projects: the Oscillation Units for the Characteristics of Complex Systems Project, and the second module of our personal finance curriculum, *Dollars and Sense: Our Interest in Interest*. Most of the Oscillations units are accessible on line. Please look for the Finance units in early 2013, as they are posted.

There has also been work on lessons created by teachers. We are always looking for these! E-mail Lees if you are working on one.

In this issue, we present our general overview of the oscillation curriculum units in the Characteristics of Complex Systems in K-12 Education Project. Be sure to check out the complex systems units on the web: <http://www.clexchange.org/curriculum/complexsystems/oscillation/>

We also present a version of *The Tree Game Lesson* from *The Shape of Change*, modified for a younger age group by a teacher, Lindsey Weaver, with Anne LaVigne.

I hope that the holiday season proves peace-filled and joyous for all of you as 2012 draws to a close, and I look forward to keeping in touch with you in 2013.

Take care,
Lees Stuntz
stuntzln@clexchange.org

Fighting Crime with System Dynamics

For those who ask the question, "...and how IS system dynamics used?", here is a good answer. Eric Pruyt has developed a number of small models and simulations for his courses at Delft University of Technology in the Netherlands on current topics that involve the students in real situations and problems.

Marleen Ribbens (Innovation Programme Leader at the Dutch Police) and Erik Pruyt (Assistant Professor at Delft University of Technology) have won the "Stop the Robber" Award (and €50,000.00) for jointly developing a System Dynamics simulation model to fight high priority crimes. The model is currently used during meetings of Chiefs of Police to support their decision-making with regard to real-world police interventions. It allows them to discover intended and unintended consequences of these interventions in the virtual world, i.e., in the model through an online interface. The same simulation model is used at Delft University of Technology to test the effectiveness of suggested interventions under deep uncertainty, i.e., given tens of thousands of plausible scenarios, as well as to identify real-world pilot studies that would be desirable to reduce the uncertainty regarding the effects of some police interventions. The System Dynamics model and a coupled spreadsheet application will also be used to monitor and compare the effectiveness of both real-world interventions and virtual interventions in order to improve the formal model and mental models regarding the real-world system. It is hoped that the simulator will also be used one day to train all Dutch policemen and to develop their systems thinking skills. Marleen and Erik will use the prize money to further develop the System Dynamics model and Forio simulator, extend their work to other priority crimes, and implement this approach in other Dutch police districts.

C-ROADS Update

The latest versions of our C-ROADS desktop application (<http://climateinteractive.org/simulations/C-ROADS>) and C-Learn web-based simulation (<http://forio.com/simulation/climate-development/index.htm>) have just been released.

C-ROADS was developed by a team from Climate Interactive, Ventana Systems, and MIT. The name "C-ROADS", stands for "Climate Rapid Overview and Decision Support" simulator. C-ROADS is easily used by non-modelers, and runs in less than 0.1 second on a laptop computer.

C-ROADS is one of the best tools available to quickly analyze the long-term effects of different combinations of country and regional climate change mitigation proposals. In this latest version, we've updated the model with the latest data, given you even more graphs and controls, and resolved a few minor bugs that have surfaced. We've even made a video about the updates:

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Characteristics of Complex Systems in K-12 Education Project

“The intuitively obvious ‘solutions’ to social problems are apt to fall into one of several traps set by the character of complex systems.”

Jay W. Forrester, *World Dynamics*

What are the characteristics of complex systems referred to by Dr. Forrester in the above quotation?

1. Cause and effect are not closely related in time or space.
2. Action is often ineffective due to application of low-leverage policies (treating the symptoms, not the problem).
3. High-leverage policies are difficult to apply correctly.
4. The cause of the problem is within the system.
5. Collapsing goals results in a downward spiral.
6. Conflicts arise between short-term and long-term goals.
7. Burdens are shifted to the intervener.

Project goals

Led by a partnership between MIT Professor Emeritus Jay W. Forrester and the Creative Learning Exchange, the goal of the project is to create online curricula for ages five and above that will illustrate the characteristics of complex systems. In exploring the nature of complex social systems, the curricula address questions such as – why do such systems resist policy changes? Why are short-term and long-term responses to corrective action often at odds with each other? How can leverage points be applied to bring about desirable change in social systems?

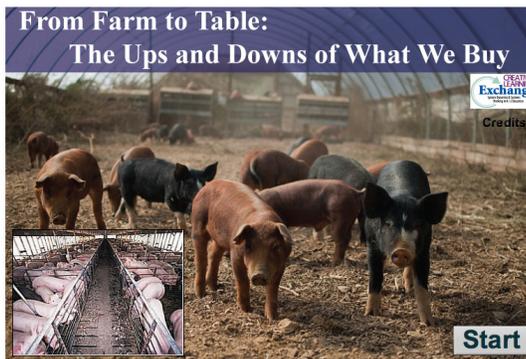
The goals of the project are grounded in the belief that an abstract level of understanding of social systems will help prepare future citizens to actively shape their society.

Lessons and simulations

The lessons and simulations are based upon the fourth characteristic of complex systems, the cause of the problem is within the system.

Five interdisciplinary areas are covered in this series of lessons,

utilizing a family of models that all generate oscillation. Oscillation in real-world systems is often considered problematic rather than a consequence of system structure. This progression of lessons helps students understand that undesirable behavior can be a consequence of system structure and not a result of outside, uncontrollable influences. In other words, a system that oscillates does so because it has an inherent tendency to do so. See the next page for a visual representation of the project components.

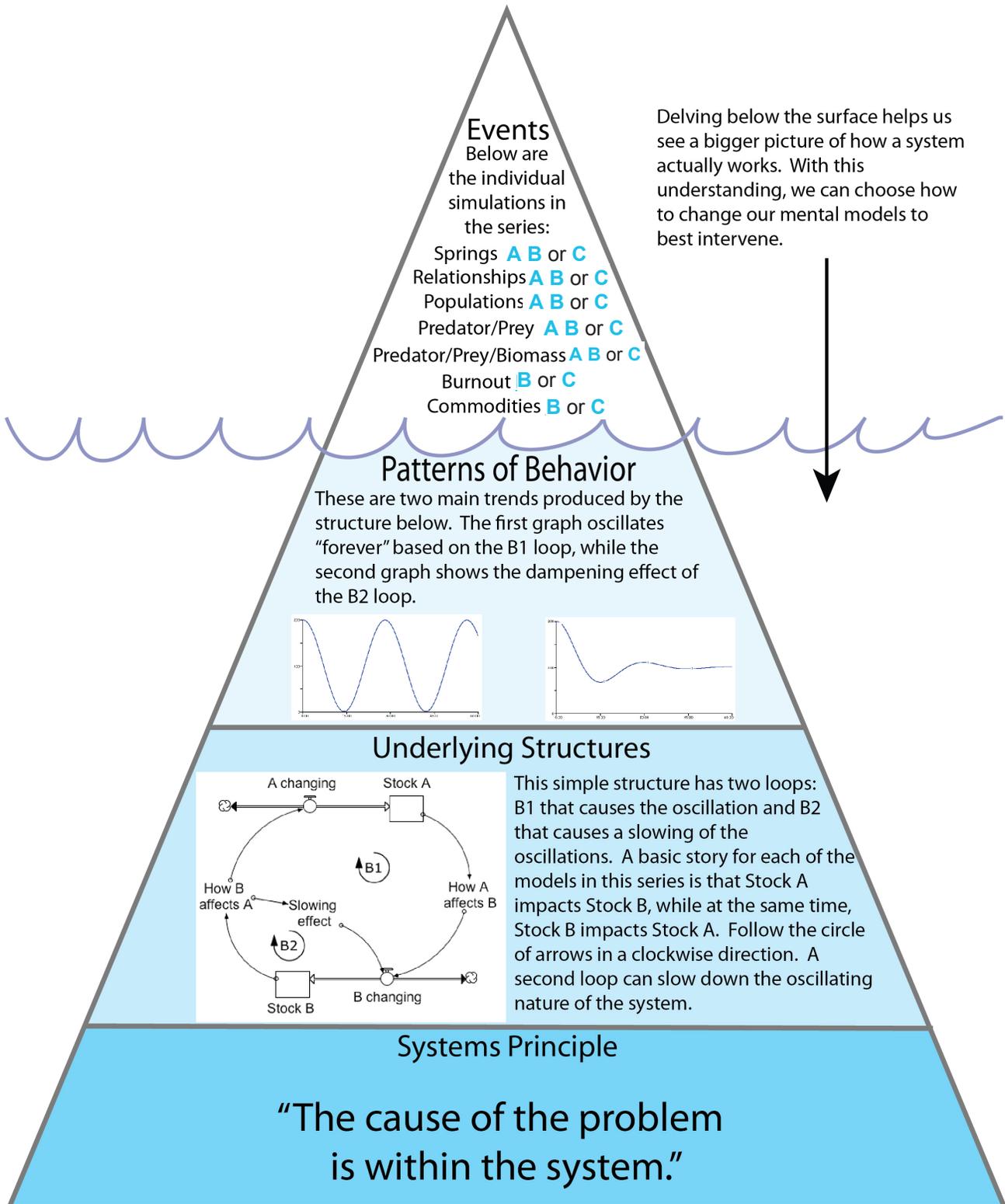


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Thinking about Complex Systems using an Iceberg Visual



Simulation Use

Levels and intended audiences

The main topics for the simulations in this series are:

- Spring Dynamics
- Interpersonal Relationships
- Population Dynamics
 - Logistic Growth
 - Predator/Prey Interactions
 - Predator/Prey/Biomass Interactions
- Burnout
- Economics of Commodities

Most simulations in the series have three possible levels of use: Level A (ages 5+), Level B (ages 9+), and Level C (ages 13+). Note that these age recommendations are in no way absolute, but, generally speaking, the Level A simulations are intended for younger students, while the Level C simulations are intended for older students. That said, it is also possible to use multiple levels of a simulation for differentiation purposes. Students who need material at a higher or lower reading level could use a different version of the simulation along with its accompanying handouts.

Setting up the simulation

Each simulation level has a standardized **menu system**. Levels A and B simulations have button menu systems; Level C simulations have a hyperlink system.

Level A Menu



Level B Menu



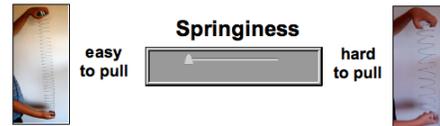
Level C Menu Example

- 1. Introduction - Spring Dynamics**
- 2. Experiment with the Model**
- 3. Debrief Central - Expand your Knowledge**
 - A. Behavior Patterns**
 - B. Explore the Model**
 - C. Connections**
 - D. Learn More - Additional Resources**

Every screen has a “Home” button available. This button returns the user to the front title screen of the simulation.



Slidebars are one method for manipulating the settings for a simulation. Some of the slidebars are based on a general range, with no values showing. Here’s one example within the Level A – Spring simulation.



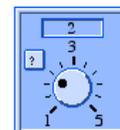
Other simulations have slidebars that include numerical settings. The lesson might call for the student to set a slider to a particular number.



- Setting a slider is as simple as moving the little rectangular lever to the right or left to select higher or lower settings.
- Slidebars that have visible numerical values can also be set by clicking on the value in the middle and typing in the desired number.
- Slidebars must be set according to the indicated minimum and maximum values. For example, if a range is 0—2000, the user will be unable to type in a value that exceeds 2000.
- Slidebars must be set by certain increments, depending on the variable. For example, if a range is 0—2000, then the increments may go up or down by increments of 100.

Most of the Level C simulations contain one or more knobs on the control panel screen. These are manipulated in a fashion similar to slidebars, with minimum and maximum values.

A **knob** is set by moving the black dot around to the desired setting.



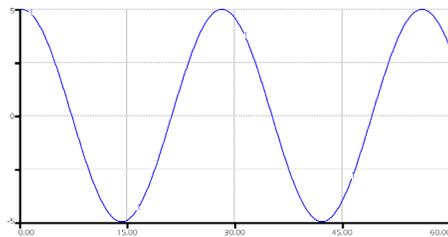
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Characteristics of Complex Systems in K-12 Education Project

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Buttons are used throughout a simulation for different purposes, including navigation among the pages of the simulation, initiating a new simulation run, and resetting the simulation graphs. Depending on the level of the simulation, these buttons may be rectangular images or resemble links on a webpage.

Graphs show the simulation results as a behavior-over-time graph. Graphs are also covered in the next section on visual tools.

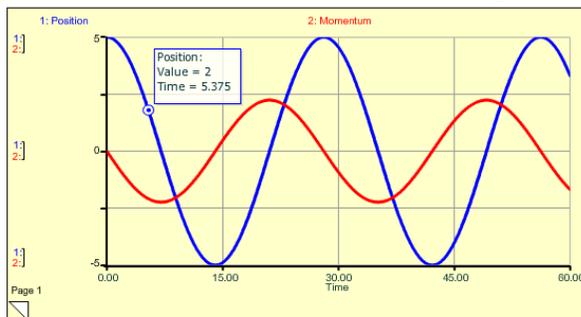


The simulation lesson handouts for the B and C levels (but not the A levels) presume that students know how to create, title, label, and create a key for a line graph.

Some graphs may have multiple pages. To see the additional graphs,

click on the tab  at the bottom, left of the graph pad. Each time you click, the next graph appears. After clicking through all the graphs, you'll return again to the first one.

To see the actual values at any point on a graph line, click and hold the mouse arrow right on the line at the point you'd like to check. A box will appear showing the value at a particular point in time.



Lesson Use

Unless indicated otherwise, handouts are formatted for double-sided printing. Some handouts are optional, depending on prior student experience. For example, one lesson includes an optional handout based on having read a particular book.

The lessons, particularly for Level C, are designed so students can work as independently as possible while moving through the simulations. For other levels, especially Level A simulations, students may need instruction to guide them through the procedures of setting up and running the simulation. Depending on student ages, reading levels, and ability to be self-directed, you may choose to eliminate some of the more guided handouts. Creating an environment in which students can explore the simulation in an organic fashion is an option. Consideration should then be given to developing alternate methods to have students demonstrate understanding of the embedded concepts.

Key elements embedded within handouts include having students make predictions prior to viewing results, and then comparing those predictions to actual graphical data. These tasks, in addition to being strongly connected to multiple curricular standards, are key to enhancing the ability of students to think deeply about what is causing particular results.

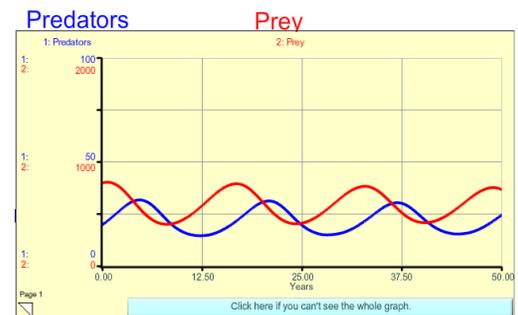
Although example student responses to some handout questions are included in lesson plans, no official answer keys are provided. Most questions are written to allow for multiple "correct" answers. Some questions are

seeking an opinion or an interpretation, along with evidence. These questions by their very nature do not lend themselves to the creation of a discrete set of answers.

About the Visual Tools

- **Behavior-over-time graphs**

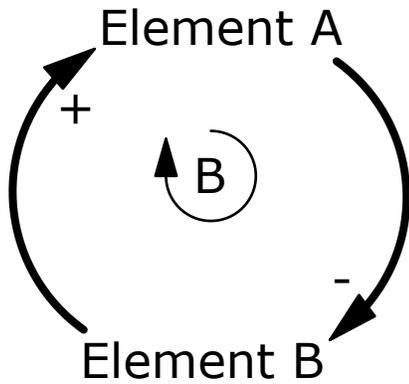
The variable being measured is always on the y-axis of the graph. Time is displayed on the x-axis. Depending on the context, the time frame could be short (measured in seconds) or long (measured in years). Most of the models in this series produce a variety of oscillatory behaviors, although other trends are also possible. See the simulation background documents for additional information about typical behavior patterns.



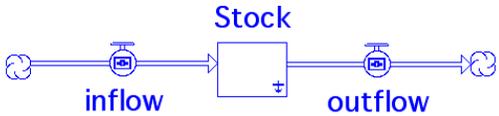
- **Causal loops**

A causal (or feedback) loop diagram is another visual tool that shows the structure of a system. A feedback loop tells a story about how a system operates. Any given system may have multiple interconnected loops. Arrows between any two elements indicate a cause-and-effect relationship: if the first element rises, then it causes the second element either to rise or fall. Depending on the relationship, different symbols are used. See the loop on the next page, along with the key explaining the different symbols.

- + indicates a direct or additive relationship between the two elements.
- indicates an indirect or subtractive relationship between the two elements.
- R in the middle indicates that the loop reinforces.
- B in the middle indicates that the loop balances.

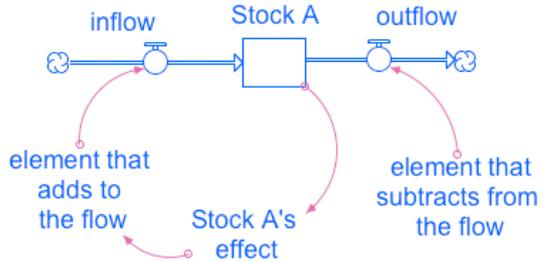


• Stock/flow maps



A stock/flow map represents the structure of the system. The parts of the map along with the underlying mathematical assumptions define the nature of the interdependent relationships among the parts. This structure is based on assumptions about how the system (whether it be a spring or relationships on the playground) really works.

In its simplest form, a stock represents an accumulated amount and the flow (or flows) represent the rate at which the stock goes up or down. Other elements impact one or more flows, either adding to or subtracting from a stock.



• Background documents

Each simulation has an accompanying background document. These documents give the teacher more detail on the model structure and its resulting behaviors, including limitations of the model and ideas for discussion.

C-ROADS Update

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<http://climateinteractive.org/videos/c-roads-cp-video-tutorials-1/video-8-c-roads-new-features-v3.008.030>

With the latest round of the ongoing international climate negotiations less than two months away, we hope these updates will leave you primed to take up the most ambitious course of action to address climate change in whichever sector you work. To get C-ROADS,

you can request a login to download it: <http://climateinteractive.org/C-ROADS%20download> or, if you are already a registered user, you can log in and navigate to the download page to get the updated version.

C-Learn, our web-based climate simulation, is similar to C-ROADS in many ways, but is slimmed down to suit educational settings. With this

latest update, we have configured the C-Learn interface so that it can be easily used with our World Climate Exercise (<http://climateinteractive.org/simulations/world-climate>), which puts groups in the seats of climate negotiators as they try to negotiate a global climate agreement.

The Tree Game

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Materials

- Approximately 60 wooden craft sticks (Popsicle® sticks) for the class or an equivalent number of manipulatives to represent individual trees.
- Computer, projector, and whiteboard (regular or interactive) with scenario spreadsheet open. (optional)
- One copy each of three worksheets for each student:
 1. Forest Inventory Table
 2. Forest Inventory Graph
 3. Forest Stock/Flow Handout

Procedure

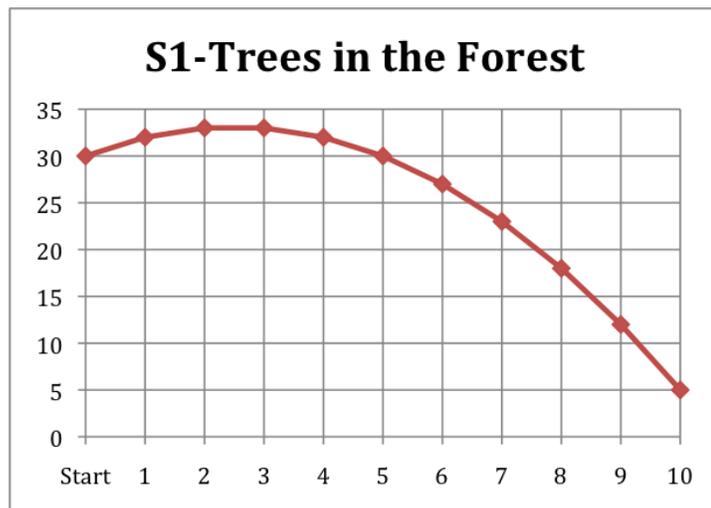
Note: This procedure was tested with a group of first grade students. The specific steps can be adjusted for different grades. Although three scenarios are described, all three do not need to be done, given time constraints. It is important to debrief the experience by having the students think about how the simulation structure created the patterns and trends.

Work through Scenario 1

- Select one student to be a lumberjack and one student to be a forester (tree-planter).
- Explain that each stick represents 1 tree in the forest.
- The forester gives each student 1 or 2 sticks (which represent trees in the forest). Hand out a total of 30 trees.
- Project the spreadsheet onto a whiteboard or just draw it on a board.
- Each year the lumberjack and forester plant/cut the indicated number of trees. For example, in

the first round, the forester will plant 3 trees and the lumberjack will cut 1. Always have the forester plant first and the lumberjack cut second.

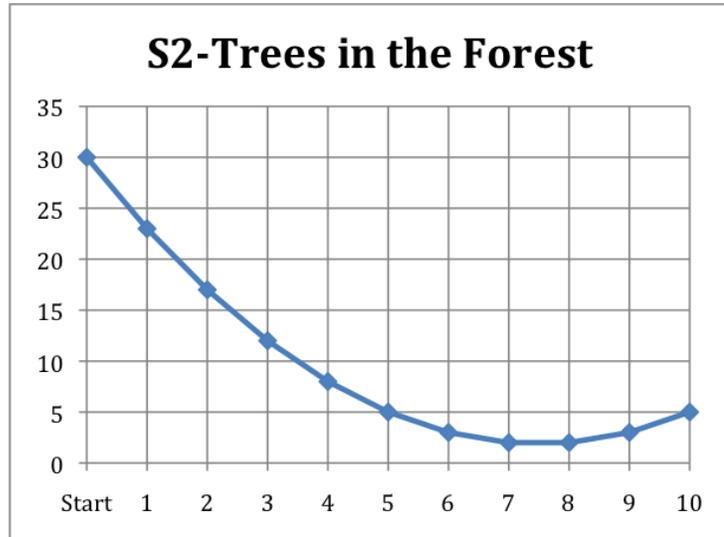
- Together, out loud, count the trees in the forest. For older students, determine the number of trees through an addition/subtraction equation, e.g., 30 trees + 3 planted – 1 cut = 32 trees for the coming year.
- As each round progresses, enter the number of trees into the spreadsheet. Students can also enter the data on their own individual table and/or graph, depending on their age and desired outcomes (See Handouts 1 and 2).
- Record the new number of trees in the table for that year. The forest should have 5 trees left by year 10. See example S1 graph and table on this page.



Year	S1-Trees in the Forest	Trees That Grow	Trees We Cut
Start	30	3	1
1	32	3	2
2	33	3	3
3	33	3	4
4	32	3	5
5	30	3	6
6	27	3	7
7	23	3	8
8	18	3	9
9	12	3	10
10	5		

Process Scenario 1

- What would happen if we did one more round?
- Why did the forest go down?
- Why did it go up at first and then start going down?
- What happens if we cut more than we plant?
- Did the forest ever have the same number of trees for two years in a row? Why did this happen?



Work through Scenario 2

- Scenario 2 shows the demand for trees going down over time. It produces the trend in the example at right.
- Ask, "What might happen if people wanted fewer and fewer trees over time?"
- Have students predict how the graph would look.
- Simulate Scenario 2

Year	S2-Trees in the Forest	Trees That Grow	Trees We Cut
Start	30	3	10
1	23	3	9
2	17	3	8
3	12	3	7
4	8	3	6
5	5	3	5
6	3	3	4
7	2	3	3
8	2	3	2
9	3	3	1
10	5		

Process Scenario 2

- Is it practical that people would choose to cut fewer and fewer trees?
- What would they do if they needed writing paper or building supplies?
- How could we stop the forest from going down at all?
- How could we get the forest to go up?

- Create a simple stock/flow map of the forest, showing what causes the trees to increase and decrease (Handout 3). The basic stock/flow icon structure is shown below, but younger students may choose to create images. The stock might be a drawing of a bunch of trees together. The flows might show pictures of seedlings and an axe. Other pictures could represent other elements, e.g., a lumberjack, a forester, a calendar.

Decide on a new rule and create a new scenario.

Bringing the Lesson Home

- Compare the graphs for different scenarios. How are they similar and different?

Basic forest stock/flow icon structure

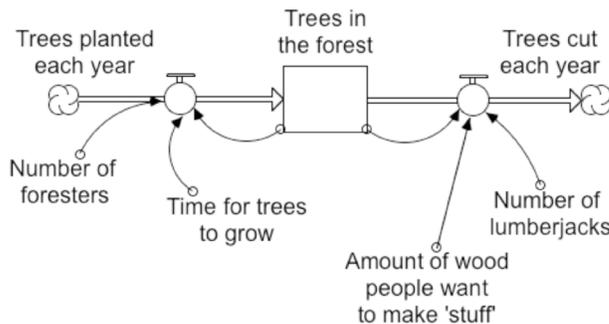


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The Tree Game

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Forest stock/flow with possible connections students might generate



Optional Extensions

- Have a “set up” for students to independently create their own simulation (during free choice or station time), keeping their forest of “sticks” in a cup.
- Try an online simulation.
 - *Tree Game* Simulator that allows students to extend the learning of the *Tree Game* lesson experience at http://www.clexchange.org/curriculum/shapeofchange/soc_6_treegame.asp
 - Animated Forest Simulator by SEED (<http://www.planetseed.com/home>) at <http://www.planetseed.com/files/flash/science/features/earth/climate/en/forest/index.htm?width=740&height=450&popup=true>
 - Fishing Game by SEED at <http://www.planetseed.com/files/flash/science/features/earth/climate/en/toc/index.htm?width=750&height=580&popup=true>

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Your contribution to invest in our effort here at *The Creative Learning Exchange* would be appreciated.. You may donate any amount you wish; perhaps \$50.00 is a reasonable amount for a year. All contributions are tax-deductible.

Enclosed is _____ to *The Creative Learning Exchange* to help invest in the future of K-12 systems education.

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