the Creative Learning EXCHANGE

Volume 8, Number 4 - Fall 1999

If a Tree Falls in the Woods, Will Another Replace It?

by Chris Brummer (junior), Adelle Lennox (junior), and Leela Yellesetty (sophomore)
One of the 5 finalist papers from the SyMBowl competition for High School students in Portland, OR

Living in one of the greenest and most picturesque states in the U.S. is something that many people in the northwest take for granted. Oregon's lush forests are filled with evergreens that not only provide the oxygen we all need to survive, but also provide us with a peaceful and beautiful place to relax.

The survival of our forests is important for so many reasons: they are home to thousands of plants and animals, they regenerate our oxygen supply and keep the air crisp and fresh, and the forests are a visible history of the area's first inhabitants. But there are many threats to Oregon's forests, and the timber industry that supplies the Great Northwest with all its timber products is the biggest threat to the millions of trees in Oregon.

Since the survival of our forests is so important, we decided to create a model analyzing Oregon's timber industry and how it affects the forest tree population. We wanted to know if Oregon's forests would be sustained over at least 300 years with the current trends and procedures in the timber industry. The model shows us the rate at which Oregon's harvestable forests are depleting and how drastic or moderate that rate is.

This model is intended for anyone who has an interest or concern in Oregon's forests, though those in the forestry industry will be more interested in such a model than the average person. However, the model was designed to be informative and enlightening for everyone who lives in Oregon, as well as anyone who has ever enjoyed a forest hike, or gone bird watching among the evergreens that surround our state. The more people there are who know and understand our forest ecosystem and its future, the more hope there is for its survival.

***Forest** continued on page 4*

The Fish Pond Story in Rockport, Maine

by Malcolm Brooks, Children's House Montessori School
(based on the work of Richard Tu)

At Children's House Montessori School in Rockport, Maine, fourth & fifth grade students have been studying ecosystems, and some have chosen to run simulations and chart the results. They are discovering how systems drive behaviors and cause events.

The simulations involve Montessori-like tactile activities, combined with computer applications of increasing complexity.

Here's what the children did with "The Fish Pond Story," a simulation proposed by Richard Tu of Taiwan in the *Creative Learning Exchange*, Volume 7, Number 4 - Fall 1998.

A group of 7 students gathered in a circle and made fishing poles out of pencils, strings, magnets and adhesive tape. They decided to start with a fish population of 20 fish (colored paper clips), a fishing season lasting 10 seconds, and a reproduction rate of 1 new fish per 10. They also decided that a "fisherperson" could survive only one season without catching a fish.

One child timed the 10-second seasons on his watch. Aggressively, the children competed to see who could catch the greatest number of fish.

Four times they depleted the pond, four times they started over with a greater number of fish but depleted the pond again.

Then the children decided to stop competing and to try collaborating. They reached an agreement that each fisherperson could catch 1 fish per season. In delight, the children then fished for 18 consecutive seasons (until lunchtime), adding increasing numbers of newborns to the pond.

Through "The Fish Pond Story," the children personally experienced the lesson of the "Tragedy of the Commons." At a later date, when they were working

***Fish Pond** continued on page 14*

UPDATES, etc…

EDITORIAL

Welcome back for the new year. The lead article in this issue is written by a student. In Portland every spring there is a SyMBowl competition with high school students presenting their work in system dynamics. This year the response was overwhelming. As you can see from the one paper we can publish in this issue, the quality of work that high school students can achieve is excellent. It is a constant reminder not to underestimate the ability of our K-12 students!! It is a lot easier for them than it is for us as adults. We have so much to un-learn!

We anticipate a very busy year, culminating in our conference near Portland Oregon, June 25-27. We are looking forward to another stimulating few days of learning and sharing. Please!—anyone who is interested in presenting a session should consider submitting a proposal (see page 3 of this newsletter.)

I hope all of you have a good start to the year! We look forward to hearing from you during the course of the year.

Lees Stuntz (stuntzln@tiac.net)

Australia

I sent out an inquiry to all the people in Australia for whom I have e-mail addresses to ask what was going on in Australia. I got two replies which I would like to share with you here:

Last week I coordinated a Vacation School entitled: Futures in Education-from Fatalism to Foresight. There were 14 participants, mostly secondary teachers.

My individual contribution, which occupied the equivalent of half a day, was loosely titled "Systems Thinking in Education." It involved introducing basic concepts of feedback and associated behaviours, followed by a delicate dance among behaviours, archetypes, causal loop diagrams, and applications. My preference for stock and flow diagrams was subjugated by time constraints and restricted to building small models to generate behaviours linked with the above. What the participants saw were archetypes enhanced by directional arrows with positive and negative signs, and corresponding behaviour-over-time graphs to provide structure-behaviour links. (I probably managed to offend both George Richardson's aversion to CLDs, and John Sterman's suspicions of the use of archetypes!) We looked at a variety of familiar friends, like limits to growth, escalation, shifting the burden, tragedy of commons, etc. Because the interest of the teachers was naturally in terms of infusing their teaching in a variety of subjects we spent some time among examples. For example "escalation" ranged across the cold war, South Africa, Palestine, and the current hotspots of Kosovo, East Timor, and Ireland. What seemed particularly interesting to them was the identification of 3 or 4 different policy responses/outcomes, etc., to situations with a common structure. Things really came alive here.

What happens next of course depends on them as there is no systematic support in the sense of the K-12 initiative.

A second initiative will take place later in the year at an annual conference of mathematics teachers. I have been invited to give a couple of talks on using mathematics to address future oriented issues. I intend to present a tutorial on modeling with Powersim with applications to simple problems of population, spread of infection and ecology—Kaibab might just be reachable. Because they are mathematicians keen enough to attend, it will be possible to move at a reasonable rate, and the intention here is to try to establish a group of participants interested in going on.

Depending on outcomes, this could have longer term potential for development and growth of SD in secondary education. Since many mathematics teachers also teach at least one other subject, wider curriculum possibilities may emerge. We shall see.

Peter Galbraith
Graduate School of Education
University of Queensland
Queensland, 4072
Australia
Ph +61 7 3365 6376
Fax +61 7 3365 7199

I teach at tertiary level in an IT (Comp Sci and Info Systems) School, and find that apart from basic feedback concepts, system dynamics is relatively unknown. I take it from the start in a dedicated final year undergraduate elective unit (using the Roberts *et. al.* text and on line resources, including MIT), and introduce Senge at earlier points in the curriculum at a low level, as an aside, mainly for awareness raising.

Associate Professor John G. Gammack
Head School of Information Technology
Murdoch University
Perth, 6150
Western Australia
Tel: +618 9360 2410
Fax: +618 9360 2941

Updates, etc. *continued on page 12*

COMING TOGETHER AND MOVING FORWARD

Call for Presenters

Are you interested in presenting at the 2000 conference, June 25-27, near Portland, Oregon?

The theme of next summer's conference, "Coming Together and Moving Forward," will emphasize the learning gained from the last 8-10 years of work in K-12 systems education and our thoughts for incorporating more people while moving forward positively. This includes the following topics:

- Getting this progressively less wrong—how have we done it, what are the markers of our failures and triumphs?
- Case studies approach—where is/has SD made a difference both in education and in the world?
- Many people enter systems education through various doors. How do we create paths from those doors? What paths have worked, have not worked?
- How does SD create better questions?
- System Dynamics as a vehicle for collaboration
- Tools for understanding the real world

Please consider presenting a session at next summer's conference if you have something to say on any of the above themes or if you:

- Have an effective piece of curriculum to present.
- Have a story about your progress as a systems educator.
- Have an administrative application of systems tools and techniques.
- Have a progress report on a plan to get systems education implemented in your classroom, school or school district (or all three).
- Have examples of learning achieved by students through systems education.
- Have students who are willing to share insights into their learning through the use of systems.
- Have created a sequence of curricula which seems to work for your grade level in teaching systems concepts.
- Have insights into assessing systems learning.
- Have tools for assessment.
- Have an overview of how systems education fits into a curriculum for a certain grade level and/or discipline.
- Have used systems techniques to create learner-centered learning.
- Have used systems techniques to create interdisciplinary cooperation and curriculum..
- Have an effective way of introducing systems to neophytes.
- Have a good training session for more advanced participants.

Sessions will be approximately one-and a-half hours in length. Special exceptions for appropriate long sessions (3 hours) will be considered, especially for introductory material or games such as Fish Banks.

Process for submitting presentations for sessions:

- **Feb. 1, 1999** – Submission of an abstract which includes the context and history of the topic of the session and the level of participant (introductory or experienced) is due.
- **Mar. 1, 1999 –** All submitters will be notified of acceptance
- **June 1, 1999 –** A final outline/presentation/paper due for incorporation into the conference CD.

The Systems Thinking and Dynamic Modeling Conference will be held June 25-27, 2000, at Skamania Lodge in Stevenson, WA, just 45 minutes east of the Portland, OR International Airport. More information and a registration form will be included in the next newsletter.

The Ecology of a Forest *continued from page 1*

Resources Utilized

Our main source of information was Chris Tercek, a student at Oregon State University who is specializing in the forestry engineering program. Our advisor set up the contact with Mr. Tercek, as she knew him personally. We did not meet with Mr. Tercek in person; instead we sent information and questions through our advisor. We also sent Mr. Tercek rough models to analyze and he gave us feedback and suggestions for additions and improvements.

Various Internet cites also provided background information and some data for the model. The World Forestry Center website gave us a better understanding of how forest ecosystems throughout the world are different and similar. The Oregon Department of Forestry website gave us some background information about Oregon's forests and a few statistics.

Data Sources

Our expert, Chris Tercek, told us what to expect from our model, and explained how the harvestable forest ecosystem works. He said that our model should show equilibrium. Our model does not reach equilibrium, but we believe this is due to some missing components that were left out to keep the model simplistic enough for most people to understand. Aside from not reaching equilibrium, we believe the model is working accurately and realistically and our expert verified that the model is constructed realistically.

Challenges

As with any model, our model presented many hurdles for us to jump over. Our biggest challenge with this model was finding the information we needed for the model. There was no lack of general information on the web or in pamphlets, but specific numbers were hard to come by, until we found our expert. Once we had an expert, we asked him specific, detailed questions that helped us put the finishing touches on the model, as well as verify some of the data we retrieved from Internet sources. Without our expert, our biggest challenge may have become what can we do with a model without data!

Other problems we ran into included discrepancies in information sources, the difficulty finding an expert, and final topic choice. When we first began, we wanted to build a model mainly on rainforest deforestation, but upon creating a trial model, we realized that the model would become too complex and we wouldn't have enough information to make it work realistically. We then altered the topic a few more times, and finally ended with the best choice, analyzing Oregon's harvestable forestland.

Reference Behavior

Our initial expectation of this model was that it would show a decrease in the total acreage of trees in Oregon as time went on and more and more trees were cut down, as it has in the past. However, our expert Chris Tercek informed us that the current planting plans have been designed to provide equilibrium in the forestry cycle for the future. Every step taken to re-plant the forests is supposed to create equilibrium between the cutting down of older trees and the planting of new trees, so that the forest will be sustained.

The "Core" Model

Model Description: Key Variables

The fertile forestland of Oregon is an entity that has influenced our lives for generations, and will determine the future prosperity of our state's wellbeing. Seeing as how the forest is such a powerful instrument that is utilized for economic growth and employment, while creating some of the most diverse ecosystems on the planet, we wanted to pursue the construction of a model that would allow us foresight into the coming years. Therefore, it was imperative that the initial step taken in modeling this vast system be to isolate the most significant factors, or key variables, that affect the health and safety of our trees.

Until a few decades ago, the detriments that clear-cutting placed on the land were unknown. Just a few problems caused by the process include erosion, water run-off, and the inability for trees to naturally regenerate, lacking enough resources and matured trees to produce seeds. After much research and protest for protection, environmentalists were able to convince legislators to put restraints on the timber industries who were consuming the forestland in Oregon. One of the most profound regulations enacted was a requirement that logging companies employ regeneration processes after having harvested a number of acres. This declaration took the form of a "two for one" policy, demanding that for every one tree that was cut down, a number of seedlings be replanted in its place. Currently, on those acres of harvestable forest, industries are planting four seedlings for every one mature tree they fell. Thus, one of the most important variables in our model is the number of trees planted by humans instead of through natural means.

The reason we chose to model Oregon's forests was because of the ongoing concern raised about its ultimate demise caused by human consumption. Thus, we knew right away that the supreme factor in our model would most likely be the rate at which companies are cutting down acreage. However, we first had to see if the methods in use today were actually sufficient for prolonged economic and environmental health.

Model Description: Core Model Flow Diagram

Figure 1 displays the model that we have constructed in an effort to determine how Oregon's forests will fare in their survival over the next three hundred years. When combined, the stocks represent the total tree population in the state.

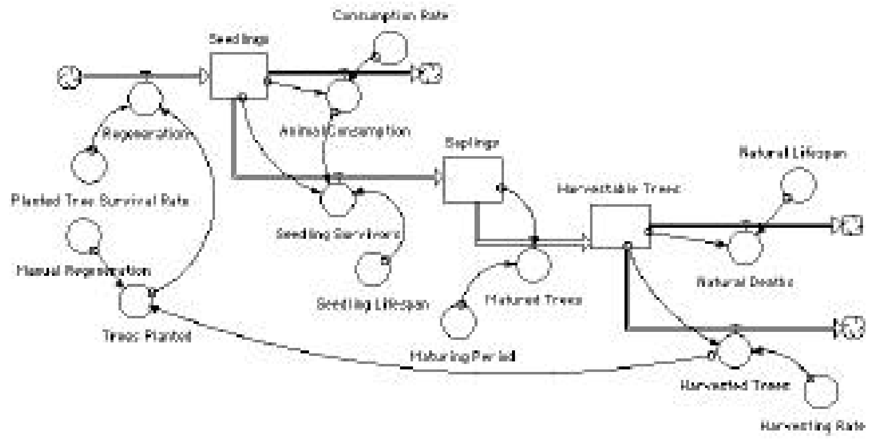

Figure 1: The Core Model

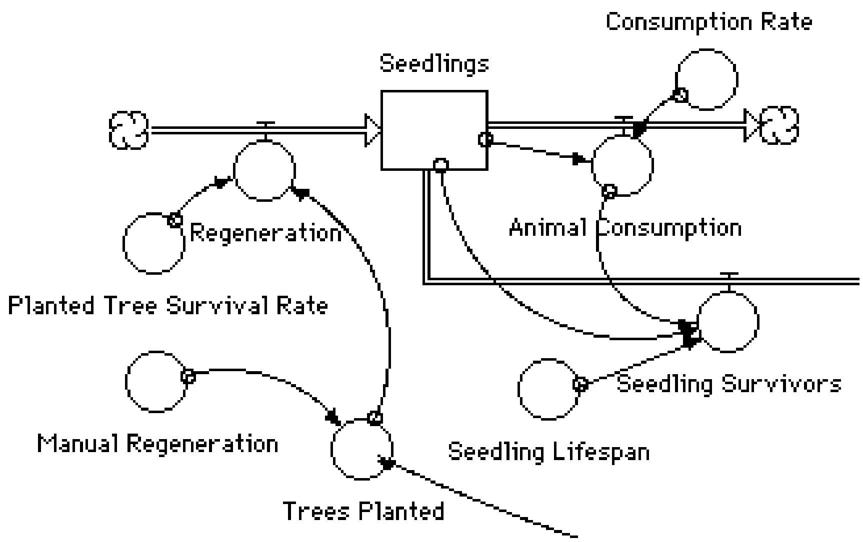

Figure 2: The "Seedling" Section of the model.

Model Description: Core Model Logic and Key Equations

Our deforestation model can be divided into three groups that designate the three periods of life that cultivated trees experience: infancy, adolescence, and harvestable maturity. Each stock is one that contains the total number of trees currently in that growth age for the entire population of harvestable trees in Oregon.

The establishment of select age groups for trees is to allow specific factors to be displayed visually in our diagram, and allow more accuracy in our output. Trees that have just been planted, known as "seedlings," are susceptible to being eaten by animals, and are also subject to a high mortality rate. The model begins with this group of trees, being influenced by the inflow "Regeneration," which is the number of new trees planted. There are two other outflows, "Animal Consumption" and "Seedling Survivors," which show the trees that are eaten by deer and those that are able to survive, moving on to the next stock. Because of clear-cutting, natural regeneration is almost non-existent in a harvested acre, thus, the survival of the trees depends solely upon human intervention. After achieving five years of age, the seedlings that have survived are pushed into the age group (stock) known as "Saplings." Because of the number of years they carry, trees in the "Saplings" stock can now survive a nibble or two from the passing dear or other herbivore, but are not yet large and developed enough to be harvested as timber. We divided the remaining tree population into those trees that have reached the ability to be harvested, the stock "Harvestable Trees," and those that still must grow for another twenty years. The connection between the two latter stocks is the flow "Matured Trees" which allows a stand of 25 years to pass on to the "Harvestable Trees" stock.

After trees have been placed into the final maturity grouping, they wait for death to take them in one of two ways. Either old age or manual labor can bring down timber (shown in the "Natural Deaths" outflow), but death by old age is rare considering that 550 years must pass before a tree will die naturally. Those individual trees that perish due to natural causes decompose and enter back into the ecosystem cycle. Those that are cut affect the future of their kind; here humans determine the number of seedlings to be planted, thereby completing the system.

The "Seedling" section of our model, shown in figure two, can be divided into two subsections: regeneration and survival. Regeneration is that part of the system that deals solely with the trees that are being planted and how they are entered into the "Seedlings" stock. The survival piece defines the percent of planted seedlings that are not immediately eliminated by bug infestation, disease, etc.

***Forest** continued on page 6*

The Ecology of a Forest *continued from page 5*

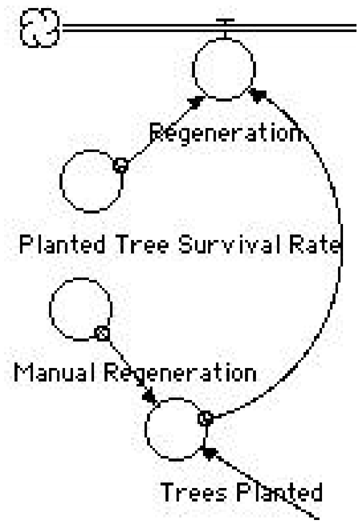

Figure 3: The regeneration subsection.

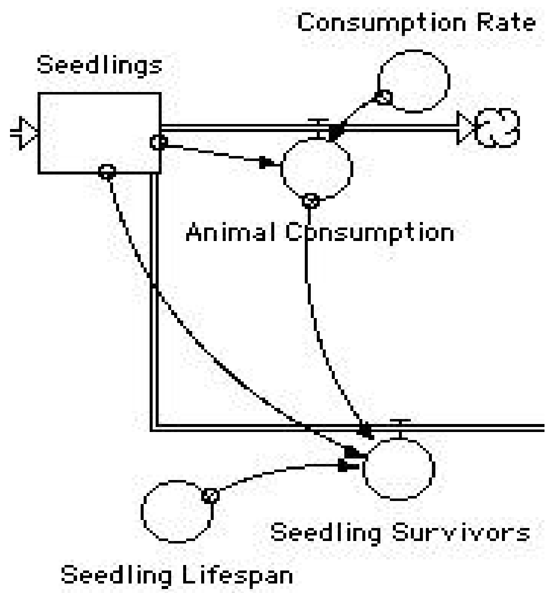

Figure 4: The survival subsection of the model.

After an area of forestland has been clear-cut, the only method that can be used for growth is manual regeneration. The timber industries of Oregon are currently planting four seedlings for every one tree harvested. So, the regeneration piece to our model (see figure three) begins with the planting of new trees in a cleared area, represented by the converter "Trees Planted." This unit is defined as the number of trees that have been harvested multiplied by the converter "Manual Regeneration," which contains a value of four (Trees Planted = Harvested Trees * Manual Regeneration). From here, the seedlings are left in the "care" of climate and conditions.

Clear-cutting is an environmentally degrading process that destroys ecosystems, leaving the land beyond repair. Such harsh conditions are not, by far, the best for nurturing the development of seedlings. As a result, fifty percent of the trees planted by humans will not survive. This mortality rate, called "Planted Tree Survival Rate," is multiplied by the number of trees that are planted each year by humans in the flow "Regeneration" (Regeneration = Trees Planted * Planted Tree Survival Rate). Thus, the model moves on to the survival subsection of the "seedling" model breakdown.

Once a seedling has been able to survive the initial planting into the wild, one threat rises above all else: the food chain. Before reaching the age and maturity of five years, the life of a seedling is in danger of being eaten away by deer. In fact, twenty-five percent of the tiny trees that survive initial mortality rates will be consumed by the four-legged herbivores, and we have accounted for these deaths with the "Animal Consumption" outflow. The "Consumption Rate" converter, defined as "0.25," or the rate at which deaths occur from trees being eaten, is multiplied by the "Seedlings" stock within the "Animal Consumption" outflow (Animal Consumption = Consumption Rate * Seedlings). Therefore, a quarter of the remaining population is left to have a chance at developing to a strength, at which point deer will no longer pose such danger.

The period of time required for a seedling to advance into an "inedible" state is five years. So, we have constructed another outflow called the "Seedling Survivors," that outputs trees of five years of age from the "Seedlings" and into the "Saplings" stock. The aforementioned flow is dependent upon three factors: the "Seedlings" stock, the "Seedling Lifespan," and the "Animal Consumption" flow.

The first part of the "Seedling Survivors" equation involves the removal of eaten trees from the remaining population (Seedlings - Animal Consumption).[1] This value is then multiplied by the reciprocal of the number of years (five) needed before a tree is able to tolerate some damage by predators. The use of the reciprocal allows the number of seedlings in the "Seedlings" stock to be divided into age groups, where the oldest is then transferred to the "Saplings" stock each year.

[1] The software, even with outflow priorities set, does not calculate this flow value correctly unless this subtraction is done here. The animal consumption really should subtract the trees first and survivors should be 20% of those left. But the software would not do that. This modification gives the correct results.

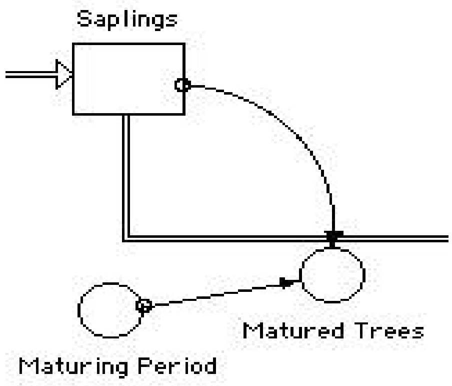

Figure 5: The Sapling section of the model.

After having acquired an age that leaves them no longer susceptible to death by deer, time, approximately twenty years is still needed before any seedlings are evolved enough to supply an adequate harvest. Thus, in order to incorporate the delayed cutting of trees, we introduced the sapling section into our model (figure 5). Here, the stock "Saplings" receives the number of five-year-old seedlings through the "Seedling Survivors" flow. That value is then multiplied by the reciprocal of the number of years remaining ("Maturing Period") before profitable and efficient harvesting of the trees can proceed. The equation (Saplings*(1/Maturing Period) was placed into the flow "Matured Trees," which sends only those properly qualified timbers into the final system fragment of harvesting.

The concern surrounding our state's forests lies in the rate at which we are cutting trees down. The final portion of our model is designed to calculate and record the consumption of trees through harvesting and those that perish due to natural deaths. (See figure 6.)

The stock "Harvestable Trees" receives input from the flow "Matured Trees." As described earlier, "Matured Trees" are those stands that have reached a minimum age of twenty-five years, making them open for the timber industry's use. Once a tree has been placed into this final stock, either a natural death or an end by harvesting can occur. These two processes are demonstrated in the outflows "Natural Deaths" and "Harvested Trees." The lifespan of the average timber tree in Oregon, the Douglas Fir, is 550 years. In order to calculate the number of trees that die annually as a result of old age, we multiplied the "Harvestable Trees" by the reciprocal of the "Natural Lifespan." This equation (Harvestable Trees*(1/Natural Lifespan)) is what we used to define the outflow "Natural Deaths."

"Harvested Trees" is the flow that determines just what its name implies, the number of trees that are felled for human use per year. This outflow is dependent upon the two influences of the "Harvestable Trees" stock and the "Harvesting Rate" converter. At the close of 1998, Oregon was using up forest resources at a rate of just over two-percent annually. That means that in fifty years, if we had no conservation or rejuvenating programs in use, the forests would be eradicated. In any circumstance, we decided to use this rate for inclusion in our model, by defining the converter "Harvesting Rate" as "2.08%." By multiplying the harvestable tree population by the rate at which it is being cut down, we can determine the value for the number of timbers logged. This equation (Harvestable Trees * Harvesting Rate) is what the outflow "Harvested Trees" is defined as, which then goes on to affect the number of seedlings that will be planted for the following year.

Model Description: Identification and Analysis of Feedback Loops

The most important factor in any dynamic system is the presence of feedback loops. It is through feedback that stability or efforts for the institution of stabilization can be made. Occurring in our model are six loops, divided between five local and one universal influence.

The first two feedback loops that are found in our forest system deal with the death of trees. Both animal consumption and, towards the end of the model, old age, work as balancing feedback to reduce forest over-population and free up resources for the remaining plants. Although considerably less striking than its paired feedback loop, the cycle involving the "Natural Deaths" flow and the "Harvestable Trees" stock does have

Forest *continued on page 8*

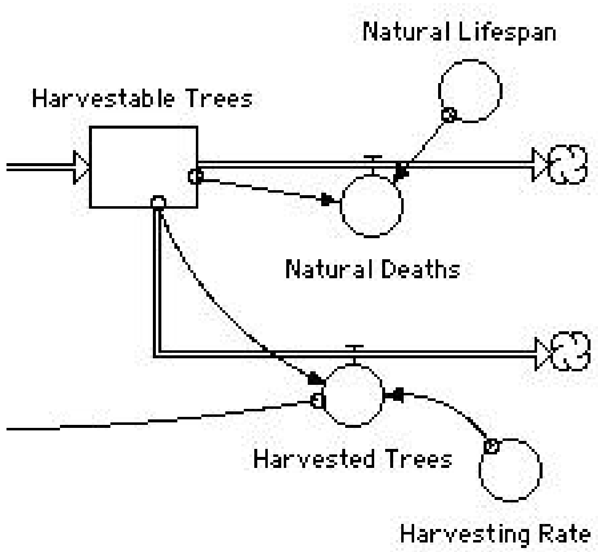

Figure 6: The harvesting section of the model.

The Ecology of a Forest *continued from page 7*

bearing on the behavior of the output. As the number of harvestable trees increases, the number that die from old age rises, if they are not harvested. As the number of deaths increase, the remaining tree population decreases, reducing the number of perished trees for the coming year. Thus, the cycle is a balancing influence.

Also a balancing influence, the "Animal Consumption" feedback loop is responsible for the removal of an entire quarter of planted seedlings from the forest life pattern. As the numbers of seedlings increase in the "Seedlings" stock, deer are able to feed on more plants. This causes more of the infant trees to perish, which decreases the "Seedlings" value in the next year, which, in turn, reduces the eating of the trees in the coming annual period as well. This loop is one of the major contributors to the decline in forest population, seeing as how the seedlings that survive the initial mortality rate are affected only by this threat so early in life.

The remaining three "local" feedback loops are those that involve the removal of trees from the three stocks in the model. The first of these loops is that dealing with "Seedlings" and the "Seedling Survivors." An increase in seedlings will allow more to be transferred to the "Saplings" stock, dropping the number in the "Seedlings" stock, returning to diminish the next year's transferring numbers. The same process is present in the loops including "Saplings" and "Matured Trees," and "Harvestable Trees" and "Harvested Trees." These three loops act to regulate the flow of the timber population as various levels of development take place throughout the life of a tree. The effects that they have on the model's behavior are in the delay of the elimination of the forest's inhabitants.

The last feedback loop, and by far the most important, is the cycle involving the manual re-planting policy. As companies remove lumber from the forests, more seedlings are planted in an effort to sustain profit margins in the future. The increase in seedlings raises the number that will survive animal consumption, while at the same time increasing the number that will die from the same factor. The jump in "Seedling Survivors" will increase the influx of trees into the "Saplings" stock, which, after reaching maturity, will place more into the "Harvestable Trees," allowing more to be cut in the future, and, therefore, completing the reinforcing circle.

One might assume, because of the last feedback loop's over-all implications, that the forest is going to be able to survive inevitably. Not true. Because of the numerous negative loops existing in our system, the forces conflict and reflect their trading of dominance in the final behavior.

Additional Considerations: Major Assumptions

When constructing the model of a system, one must make certain assumptions in order to allow comprehension of the situation at hand. Otherwise, the requirement of detail would make any effort to understand events in the world nearly impossible. Our work was no exception.

Oregon's government is one that is known for its tendency to be protective of the environment. Thus, logging companies may lose some of their lobbying power. The time is almost certain to come when our elected officials will demand more be done about the dwindling timber acres. The initiation of statewide paper recycling programs, corporate harvesting caps, and restoration reform are all possibilities of drastic change that would alter the future of forest life. For our model, we eliminated the idea of political intervention, keeping only current policies intact for the duration of our simulation.

Just as a legislator's opinion can change (or can it?), so too, can the environment of the forest. Recently, for example, in the states bordering those that line the East Coast, an infestation of a southeastern Asian beetle has devoured a large percentage of the trees in native forests. Because events such as infestations, drought, and fire, to name a few, are unpredictable, our model also eliminated their presence from the various forces in play.

Lastly, our model uses the statistics surrounding only the type of tree known as the Douglas Fir. To gain average lifetimes, maturity processes, and such for the vast number of species of trees in Oregon would have consumed a great number of hours. When we discovered that Douglas Fir seedlings were the most commonly used tree for re-planting, because of their relatively low time requirements for harvesting, it seemed both efficient and logical to create a model based on that specie's statistics.

Additional Considerations: Parameter Values

"Consumption Rate," "Manual Regeneration," "Planted Tree Survival Rate," and the "Harvesting Rate" are the four major forces acting to determine the behavior of our model. Another common aspect that these pieces share is that scientists in the fields of forestry, ecology, and environmental engineering have determined all of their defining values. Chris Tercek, a student majoring in forestry engineering, was our expert consultant, who provided us with the data to put together the above-mentioned fragments. However, there was one key aspect that was left unaccounted for by both Mr. Tercek and our self-guided searches, and that was the division of the harvestable forest population between the three different age group stocks of our model.
At first, due to our conception of the Oregon policy on reforestation, we assumed that most of the harvestable forest population would be made up of seedlings. Acting upon our thought, we split the number of total trees in Oregon's forest-

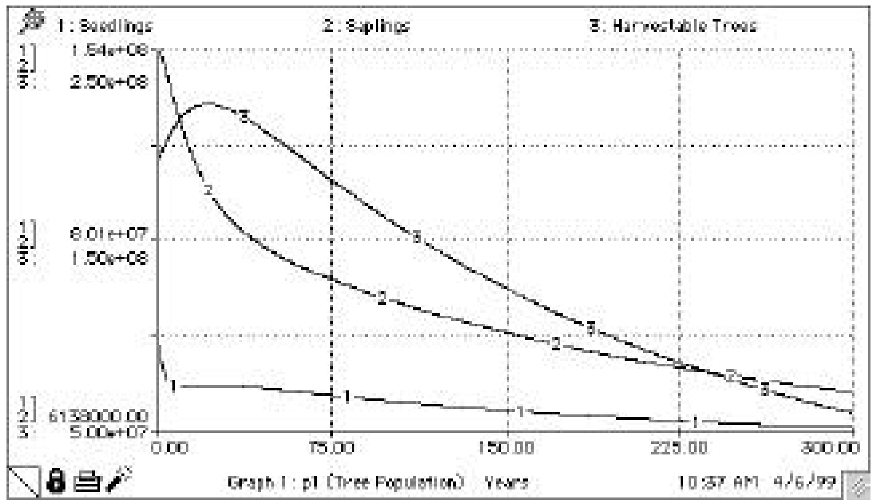

Figure 7: The Final Graph

land (385,000,000) by two, giving us the value 192,500,000. Our next step was simply to place one quarter of the total population into each of the remaining stocks (Harvestable Trees and Saplings). However, when we ran the model and observed the graphs, the seedling population plummeted immediately, while the sapling and mature trees made a steady decline.

In reconsidering our approach, we decided to divide the tree population according to the fraction of the number of years that each group is designated to compared to the average lifespan of a harvested tree (fifty years). Thus, the "Seedlings" stock was given ten percent of the trees in harvestable forests as an initial value (5 years/50 years = 0.1), "Saplings" was given forty percent (20 years/50 years = 0.4), and "Harvestable Trees" was given fifty (25 years/50 years = 0.5). The graph of the model with new initial values provided a much steadier change over time, confirming that we had a reasonable division of the timber stand population.

Additional Considerations: Choice of Time

The harvesting rate of Oregon's forests is calculated annually. Logging companies record their hauls in yearly holdings. Environmental scientists catalogue progress/regression analysis in deforestation, animal observation, and policy enforcement in twelve month increments. Naturally, to allow an easier transfer of data, as well as aligning ourselves with the tradition of the field, we conducted our model in the time units of "Years." Because the harvestable trees require a twenty-five year period before reaching maturity, we wanted to have enough time pass so that a fair number of cycles of growth and harvesting could come about. Therefore, we selected a simulation time of three hundred years, beginning from time zero, as appropriate to our needs. By starting from a time period of zero, sensitivity-specification interpretation could be more illuminating, in that a change in policy or environment would not have to take place on a certain date, as it would if we had entered our beginning and end years calculated from the calendar. As for our integration method, we preferred Runge Kutta's more accurate outputs as opposed to Euler's faster process.

Core Model Results: Graph for the Core Model

The initial stock values for the graph output shown in figure seven are those that were determined and described in the "Parameter Values" section. The "Consumption Rate" is "0.25," the "Manual Regeneration" converter is defined as "4," the "Harvesting Rate" is "2.08%," and the "Planted Tree Survival Rate" is set at "0.5."

Core Model Results: Interpretation of the Graph

The first graph in figure seven represents the behavior of the "Seedlings" stock over a period of three hundred years. As can be observed, there is a sudden drop in the seedling population in the first ten years, a slight rise on the eleventh, and then a gradual decline for the remaining simulation time. We equate the swift drop in the initial figure of the "Seedlings" population with the stock values that we have chosen. However, the slight growth shows the temporary dominance of the manual regeneration feedback loop. The increasing behavior is quickly overcome by the balancing loops of animal consumption of the trees and the harvesting rate, showing that the policy of four trees planted for every one cut needs some changes in order to make the forest last. Because we are still employing the use of clear-cutting, the soil quality deteriorates due to erosion, and competition for resources skyrockets. Soon, no matter how many seedlings one plants, their chance of survival will continue to trickle away.

The second curve on the final graph shows the alteration of the "Saplings" stock for three hundred years. It begins with a sharp, declining slope for the first ten years, due to the "Saplings" behavior, and achieves a much more leveled decrease at the same time that seedlings are leveling out. The graph continues on a downward slope due to its predecessor's (Saplings) actions.

The last curve on the final graph shows the "Harvestable Trees" population. The beginning twenty years appear to be doing very well, with the number of trees available for cutting rising to greater numbers. However, the reason for

***Forest** continued on page 10*

The Ecology of a Forest *continued from page 9*

the growth is due to the drops in the "Seedlings" and "Saplings" stocks. In order for them to decrease, trees must be pushed through the cycle and into the harvestable tree population where they will spend more time than any other. This initial build-up is from the high numbers of trees in first two stocks, which allows great quantities of trees to be pushed forward in the model. The remaining 280 years for the "Harvestable Trees" is spent dying out.

Overall, our model appears to predict a bleak future. Unless there is decisive change in the policies that Oregon currently runs on, we could be looking at our state turning into a wasteland.

Core Model Results: Tabular Output for the Core Model

Years	Seedlings	Saplings	Harvestable Trees
.0	38,500,000.00	154,000,000.00	192,500,000.00
1.0	32,467,541.60	151,646,369.48	195,753,274.31
2.0	28,531,722.75	148,689,865.71	198,801,056.23

Figure 8: The Initial Output

20.0	22,934,497.15	101,273,410.27	221,239,843.61
21.0	22,959,621.37	99,691,799.66	221,259,216.71
22.0	22,975,709.75	98,190,329.33	221,201,974.22

Figure 9: The "Harvestable Trees" ends its increase

Final	6,138,059.58	20,480,954.54	58,275,327.27

Figure 10: The Final Output

Core Model Results: Interpretation of the Table

The table simply numerically verifies our graphic conclusion: reform must occur in order for our forests to survive. The initial outputs found in figure eight point out the specific decline in both "Seedlings" and "Saplings" and the significant gains by the "Harvestable Trees." But, because of the environmental disasters caused by clear-cutting, the planted seedlings are having a harder time each year trying to survive, causing the harvestable trees to level off and begin a down-hill pattern. Figure ten, the final output for our simulation, merely reinforces the message that careful planning, thought, and consideration now, will improve and secure environmental health for our posterity.

Conclusions and Future Plans

With this model we were able to develop an understanding of Oregon's timber harvest and what effect it has upon the harvestable tree population in Oregon. Due to increasingly strict forestland laws, only 15% of Oregon's total forestland is available for harvest. And though the current planting laws are designed to create equilibrium between the planting and cutting down of trees, it is certainly possible that their efforts will prove unsuccessful and that the tree population will begin depleting, as our model suggests. However, as earlier discussed, our lack of equilibrium may be due to other factors that were not considered in this model.

Though creating and modifying a model is a difficult process, the output can be easily explained by taking advantage of the graphs and tables. Since our intended audience was anyone interested in the future of Oregon's forests, the model is appropriate and also informative for the general population. However, voters and politicians will also be interested in such a model. Voters are the people who pass funding measures for forest programs and politicians ratify legislation to protect forests and regulate the timber industry.

Politicians play a key role in the state our forests are in. For example, if our model were entirely accurate and the tree population would really decrease drastically in the next hundred years, then it is up to politicians to support new legislation that would remedy this situation. If the deer population is killing most of the seedlings, then there must be a new plan implemented to compensate for this, or to reduce the number of seedlings that are eaten by deer.

We are also interested in altering the model to show how the change in the harvestable forestland would affect the total forestland in Oregon. Aside from this adaptation, there are many other ways to alter the model to include other factors of Oregon's forests or even all the forestland in one region or on one continent. Deforestation is an ongoing problem that is not going to ease unless there is some miraculous new source of timber designed or found. Realistically, that is not an option. Since deforestation has become such a serious and relevant issue, more research into how to preserve forestland is inevitable. Thus, hopefully, our beautiful forests will remain plentiful long into the future.

This student work can be found in its entirety from the CLE or the Web site, catalogued as SW1999-08IfATreeFalls

✧

Systems Thinking in School Administration: Part II
Budgeting Dynamics

by Matt Hiefield, Sunset High School, Beaverton, Oregon

In a previous article in *The Exchange* (Vol. 8, No. 2 - Spring 1999), I reported on an interview with Rick Miller, principal of Sunset High School in the Beaverton School District, a suburban district west of Portland, Oregon. In that article, we discussed attendance, class size, and staffing issues. This article is a continuation of our discussion, and will focus on some of the dynamics of school budgeting.

Matt Hiefield (interviewer): From a teacher's standpoint, I have seen some strange budget dynamics over the years. For example, many academic departments feel that they have to "spend down" their budget as the money will go away after a certain date. As a result, some purchases (like several hundred boxes of chalk) are made not because that much is needed, but because department heads often feel that their budgets will be cut next year if they don't prove that they need the money.

Rick Miller (principal): Unfortunately, money can't be rolled over to the next year to encourage saving by department, as this is public finance law. One of the reasons for this is that it would be unseemly to keep taxpayer money for the next year.

MH: Well, is there any way to break this spending paradigm?

RM: One aspect of budgeting that I've found important is to (at an appropriate point) let all of the different interests see the overall budget and how people are spending money. Breaking down the budgetary "fiefdoms" is critical. If you can get people to see the big picture and evaluate spending priorities on "what is good for the school," then people are more likely to make wise spending decisions. The department chairs get to the reasoning behind the overall budget and to grapple with equity issues. This forces people to articulate spending decisions to a higher degree.

MH: What other systems issues are there in school budgeting dynamics?

RM: Well, one budgeting strategy that we are working on is the concept of "committed futures". This means that we try to plan ahead for a three year spending plan, and we separate classroom from building expenditures.

MH: Yes, but didn't you state earlier that public finance law doesn't allow funds to be rolled over to the next year? If this is the case, then how can you plan a budget for three years?

RM: Just because money isn't being rolled over and saved in an account somewhere doesn't mean that we can't anticipate future needs. Instead of dividing up money on an equal basis every year, it is important to view the school and specific needs from a more global perspective. This year it might mean taking care of technology in the counseling office, while next year it might mean something else. What we do as department chairs, then, is to articulate future needs and designate when building money will be spent on them. This gives a more global picture to departments and lets people know how money is being spent.

MH: What are some future budgeting challenges?

RM: Anticipating technology purchases and doing so in a thoughtful manner is a very tricky thing and is a significant challenge. Our district purchases some technology for each school, and schools can purchase more if they want to use their own resources. Factors in these decisions include obsolescence, server resources, curriculum planning and course offerings, and software. What we offer as a school with regard to technology education is totally different from what we were offering 5 years ago, and I imagine that classes, software, and hardware will continue to change in the coming years. So, will the software site license that we purchase today be obsolete tomorrow? Is the class being taught to rely on a certain piece of software? As more teachers integrate technology and special programs into their teaching, will we have the resources to support this? Will we have the personnel to teach specific classes if one of our teachers leaves? At first glance, budgeting seems simple, but, to do it right it is important to ask the systemic questions.

* * * * *

In considering budgeting dynamics in a school, it became clear that many forces are at work. The most important aspect, though, is that the major budget players should have access to the big picture, and have the ability to question and explore the spending assumptions of others. Other important aspects include projecting budgetary needs into the future (despite state spending laws) and looking at obsolescence and delay issues.

In sum, effective administrators are systems thinkers and budgeters by nature. They have to be to foster success in such a complex organization. In grappling with these issues, spending assumptions and values become increasingly important, and being able to articulate and test assumptions is essential in the effective allocation of precious resources.

Matt Hiefield is a Social Studies Teacher at Sunset High School in Beaverton, Oregon. He can be contacted via e-mail at Matt_Hiefield@beavton.k12.or.us

This document is available from the CLE or the Web site catalogued as SE1999-08STInAdmin2Budgetng

✧

Updates, etc… continued from page 2

Below is an introduction from the listserve, which illustrates the number of intiatives which are going on out there. Those of you who are not yet contributing to the listserve, be sure to sign up and join our discussions.

The K-12 listserve is a monitored discussion of system dynamics in K-12 education. For past discussions see: <http://sysdyn.mit.edu/k-12sd-email-list/archive/home.html>. Send contributions and all requests to subscribe and unsubscribe to: <k-12sd@sysdyn.mit.edu>.

I am Co-Director of La Salle University's Institute for the Advancement of Mathematics and Science Teaching (named by committee, can you tell?) and Associate Professor of Geology and Environmental Science. I have joined this list because I have just received funding from Pennsylvania to begin a project to train pre-service K-8 teachers to do modeling and then to have those college students do modeling projects with middle school students. (http://www.lasalle.edu/academ/iamst/e-sist.htm). We will begin this summer by training the faculty who run the pre-service science courses and the partnering middle school teachers, and developing the curriculum we will use with the students. In the fall, we will teach the college students modeling in an integrated science course that all K-8 pre-service teachers must take. In the spring, those students, in the second semester of the course, will conduct modeling projects with middle school students here in Philadelphia and in a suburban district. In addition to time-domain modeling with Stella, we will be doing spatial analysis and modeling with the ArcView Geographic Information System. The projects will likely be focused on the local environment (streams, etc).

Personally, I am interested not only in geologic and other natural systems, but also in the social systems that promote or inhibit improvement in education. I'm certainly getting plenty of firsthand knowledge of the latter.

Dave Smith (dsmith@lasalle.edu)

Resources…

I *would love to hear comments on LOGAL Software*. Their web address is http://www.logal.net. They say they have the following:

1.Award-winning interactive simulations.

2.Two new products that will change the way the Internet is used in education:

- new and improved version of our comprehensive educational web site - Logal.net.
- a product that is destined change the way the Internet is used in the classroom. LOGAL's SimPlayer is a groundbreaking approach to using Internet data in a meaningful and dynamic way. With SimPlayer, educators can actually take data from the Internet and use that data to drive a simulation.

There is a new book on the environment with system dynamics modeling: *Modeling the Environment* by Andrew Ford. The back jacket says "Professor Ford has developed a website at http://www.islandpress.org/ford for students and instructors using this book." The book is interesting and instructive, a terrific resource.

What should 9th graders read on systems? This question was posed to the K-12 listserve and the answers were varied. Here are a few of them:

Systems I, An Introduction to Systems Thinking, by Draper L. Kauffman, Jr.
The Art of Systems Thinking : Essential Skills for Creativity and Problem Solving by Joseph O'Connor and Ian McDermott.
"Systems Thinking in 25 Words or Less" by Debra Lyneis
"Systems Thinking: Four Key Questions" by Barry Richmond
"Tips for Behavior-over-Time Graphs" by CFSD (Catalina Foothills School District)
"Tips for Causal Loop Diagrams" by CFSD
"Tips for Stock/Flow Diagrams" by CFSD
Many of the Cross-Curricular materials also would be a good place for 9th graders to get started.

SyMBowl…

The following students and high schools participated in this year's SyMBowl. We commend them all. As is evident by the finalist paper presented in this newsletter, each year the students raise the bar for the standard of excellence.

- *How Can a Plane Fly?* Matvey Adzhigirey, Will Robertson - Franklin High School
- *If A Tree Falls in the Forest, Will Another Replace It?* Chris Brummer, Adelle Lennox, Leela Yellestty - Franklin High School
- *How Did Battle Casualties Affct the Fighting Force of the Union Army?* Eric Anholt, Elizabeth Durham - Franklin High School
- *How Bad will Portland's Traffic Be in 2040?* Ben Andrews and David Roth - Franklin High School
- *Where Does Society Intervene With Child Abuse?* Troy Barnard and Katie Coombs - Franklin High School
- *What Effect Does Raising the Minimum Wage Have on a Business?* Danny Green and Alan Martin - Franklin High School
- *Will the Grizzly Bear Population of North America Survive?* Jonathon Marcus, David Ng, Nicholas Popenuk - Franklin High School
- *Deceleration of the Earth* Leisa Hall, Kristy Stotler, Sunmi Yi - Franklin High School

***SyMBowl** continued on page 14*

New Materials Now Available from the CLE

The following new documents are now available from us or the Web site <http://sysdyn.mit.edu/cle/>

CROSS CURRICULAR

CC1999-08TheFishPondStory **The Fish Pond Story.** Malcolm Brooks and Richard Tu

The sample game developed by Richard Tu in Taiwan and a simple simulation used in Maine based upon that game. [Cross Curricular, Science, Simulation, Elementary School, Middle School] (50¢)

SYSTEMS EDUCATION

SE1999-08STInAdmin2Budgetng **Systems Thinking in School Administration Part II: Budgeting Dynamics.** Matt Hiefield

A continuation of an interivew with Rick Miller, principal of Sunset High School, in Beaverton, OR, focusing on some of the dynamics of school budgeting. [Systems Education, Administration, K-Adult] (50¢)

STUDENT WORK

SW1999-08HowDoesGalaxyEvolv **How Does a Galaxy Evolve?** Carl Anderson and Steven Cottingham

A 1999 SyMBowl finalist paper. This paper discusses a model developed to demonstrate what happens in a galaxy as it goes into stars and eventually into white dwarfs, black holes, and neutron stars. [Student Work, Science, Dynamic Modeling, High School] ($1.00 paper only; $6.00 paper + model on disk)

SW1999-08IfATreeFalls **If a Tree Falls in the Woods, Will Another Replace It?** Chris Brummer, Adelle Lennox, Leela Yellesetty

A 1999 SyMBowl finalist paper. This paper discusses a model developed to analyze Oregon's timber industry and how it affects the forest tree population. [Student Work, Social Studies, Science, Dynamic Modeling, High School] ($1.00 paper only; $6.00 paper + model on disk)

SW1999-08Influenza **Influenza.** Ryan Ivie

A 1999 SyMBowl finalist paper. This paper discusses a model developed to provide a realistic look at how influenza affects a population. [Student Work, Science, Dynamic Modeling, High School] ($2.00 paper only; $7.00 paper + model on disk)

SW1999-08PortlandsTraffic **How Bad Will Portland's Traffic Be in 2040?** Ben Andrews and Dave Roth

A 1999 SyMBowl finalist paper. This paper discusses a model developed to discover the change in the commute time over the next 50 years in metro Portland, OR. [Student Work, Social Studies, Dynamic Modeling, High School] ($1.00 paper only; $6.00 paper + model on disk)

SW1999-08RaisingMinimumWage **What Effects Does Raising the Minimum Wage Have on a Business?** Danny Green and Alan Martin

A 1999 SyMBowl finalist paper. This paper discusses a model developed to demonstrate the future effects, help or harm, to a business if the minimum wage is raised. [Student Work, Social Studies, Dynamic Modeling, High School] ($1.00 paper only; $6.00 paper + model on disk)

New Document Naming and Cataloguing Method

As you will note from the above list of new materials, the CLE models and documents are now named and catalogued in a new manner. On the List of Materials and in the Acrobat Models and Documents folder on both the Web site and the new CD-ROM, the materials are arranged by their date of inclusion, within 8 major headings: Systems Education (SE), Cross Curricular (CC), English (EN), Math (MA), Science (SC), Social Studies (SS), System Dynamics (SD), and a new category, Student Work (SW). Within each heading, the materials are listed by the abbreviation of that heading, followed by the year and month that the item was added to the list, followed by a short version of the title. Thus, the most recent additions to our list will be found at the end of the list for each category. It is our intent that the cataloguing/date-of-inclusion/abbreviated title format will help people find the new materials more readily and contain enough of the complete title to identify the content.

Newsletter Subscription Information

The Creative Learning Exchange Newsletter is available in three different formats:

- On the web page at http://sysdyn.mit.edu/cle/
- As an attached file to an e-mail
- In paper via US mail ($15.00 outside the USA)

Since we vastly prefer electronic distribution to paper because it so much less expensive, please e-mail us at any time when you would like to have an electronic subscription.

<milleras@cle.tiac.net>

SyMBowl continued from page 12

- *Will the Bald Eagle Population Survive?* Peter Nguyen, Andy Waltz - Franklin High School
- *How Does a Galaxy Evolve?* Carl Anderson, Steven Cottingham - Franklin High School
- *What is the Most Effective Dose of Ibuprofen?* Isaac Sterling - La Salle High School
- *What are the Effects of Hunting on Douglas County Cougar and Deer Populations?* Randy Boyd, Ben Jensen, Isaac Van Cleave - Roseburg High School
- *How Can One Minimize the Time it takes to Eat a Bowl of Hot Soup?* Mickey Deagle, Chris Haney, B. J. Mares - La Salle High School
- *Influenza* Ryan Ivie - Wilson High School
- *How do Various Factors Affect Supply and Demand of Computer Sales?* Nat Kuhn, Bob Nelson, Nathan Singer - Roseburg High School
- *Diamond Lake Trout Crisis* Stephen Bennett - Roseburg High School

✧

Fish Pond continued from page 1

on a more complex simulation involving grassland, rabbits, hawks, and coyotes, the students discussed whether predators and prey should collaborate!

Malcolm Brooks, Children's House Montessori School, 205 West St.
Rockport, ME 04856 USA
Tel: 207-236-2911
mbrooks@chms.pvt.k12.me.us

This article has been combined with Richard Tu's description of The Fish Pond Story to create a new document, titled "The Fish Pond Story." It is now available from the CLE or the Web site under the catalog name CC1999-09TheFishPondStory.

✧

"If you want to teach people a new way of thinking, don't bother trying to teach them. Instead, give them a tool, the use of which will lead to new ways of thinking."
Buckminster Fuller

INTERESTED IN INVESTING?

If you would like to invest in our effort here at *The Creative Learning Exchange*, your contribution 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.

Name ____

Address____

____

e-mail ____

Thank you!

***The Creative Learning Exchange*, 1 Keefe Road, Acton, MA 01720**

The Creative Learning Exchange
1 Keefe Road
Acton, MA 01720
Phone 978-287-0070
Fax 978-287-0080

The Creative Learning Exchange is a trust devoted to encouraging exchanges to help people to learn through discovery. It is a non-profit educational institution and all contributions to it are tax deductible.