Lecherous Logging

New Mexico

Supercomputing Challenge

Final Report

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Team 54

Los Alamos High School

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Summary:

Studying the population of a keystone species in ecosystem can show the health of the ecosystem. This model shows how selective logging affects the ponderosa pine forest ecosystem by examining the size of the population of goshawks that the forest can support. Logging 10% or more of the old growth and mature trees in a forest resulted in an unsustainable decrease in the population, which would be indicative of the harm done to the health of the ecosystem. Logging less than 10% of the old growth and mature trees showed that the decrease in goshawk population was not so large that the forest could not recover easily.

Problem:

As the global population grows and resources become scarce, many industries are forced to look for compromises between harvesting the resources the world needs to continue building and harvesting those resources sustainably in order to protect the environment. One such compromise is the use of selective logging. Selective logging is considered environmentally friendly because, unlike clear cutting, it removes a small number of trees that are randomly scattered through out a forest, rather than removing all the trees from a forest. While selective logging is definitely better for the environment than clear-cutting it can still have a large impact on the health of a forest ecosystem. Studying the effects of selective logging has on a keystone species can give an idea of the effects it has on the forest ecosystem as well.

As an important predator in a ponderosa pine forest, the goshawk serves as both a keystone and indicator species in the ecosystem of a ponderosa pine forest. The health and size of a goshawk population in the forest shows how much wild life the forest can support as the number of trees decreases. This model looks at how selective logging affects the health of a ponderosa pine forest ecosystem through observing the size of the goshawk population the forest can support.

Method:

Factors:

As with any problem, before we could solve ours we needed to identify the important factors. For the forest, the percent of the total area covered by trees, and the percentages of the covered area that was saplings or middle-aged ponderosas versus old growth, turned out to be the only important numbers. Nesting and territory requirements—what ages of trees and how much total space for each bird—are important factors for the birds. The mortality and birth rates are not addressed in the model, due to the assumption that in a perfectly balanced ecosystem their population would be stable. The logging factors are how many trees would be cut down annually, what age of tree the logging would remove, and what type of logging is being used— there are different methods that produce varied results in the forest. After determining the factors it was just a matter of fighting with Netlogo's coding language to get them all put in properly.

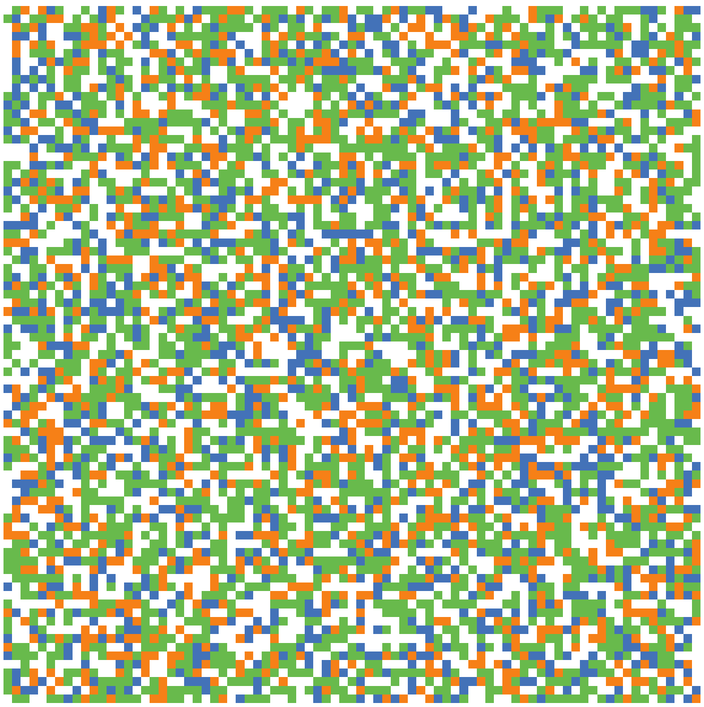
Code:

Netlogo was the coding language chosen for two main reasons: first, it is relatively easy to use, being a language meant for beginners. Second, it is an agent-based modeling system, which makes it a good choice for our project as we are trying to show the effect of logging on a forest from the interaction between the forest and the goshawks. We needed a pretty simple language because no one on the team has very much experience coding.

Originally, we thought that the forest needed to grow, so we created a code to do so. This first code created ten trees each year, using one tick as the equivalent to one month. The trees grew and changed color to show their age, and died when they reached a certain age determined to be the extent of their lifespan.

However, we soon realized that as birds were primarily being modeled and not trees, they should be the focus. To show the effect on the goshawks, ten years was decided on as a good timeframe. This amount of time is short enough that the trees are not really going to be affected, and therefore the forest does not need to actively grow and change. Following this logic, the next step was to create a new code in which a representative forest was created in the setup.

We looked on the Internet for studies to help us decide what would make up a representative forest, as well as asking Brian Jacobs, the botanist at Bandelier National Monument. Our forest type is ponderosa pine, which has a lot of open space between the trees in a healthy forest—because the canopies of old-growth trees do not touch—so a third of our forest was set to open space. Of the two-thirds that is forested, half is saplings, a quarter is trees older than saplings but not yet mature, and the last quarter is a combination of mature and old growth trees. Having decided that the goshawks were the only really dynamic part of the model, we changed the trees from agents to patches in order to make the later coding for the birds easier. Green patches now represent saplings, blue shows trees older than saplings but not yet mature, and orange is both mature and old growth trees. Blank space is represented by white patches.



This is the model forest, before birds enter and before any logging has taken place. This is what appears at setup

In our current code, after the setup creates the described forest, the model begins running through a sequence of days over and over. Each tick represent one hour, and the code goes through one day creating a certain number of birds each tick, and then for the next couple of days the birds fly around and look for a place to nest. Currently, the requirements for nesting are at least one old growth or mature tree and two or more middle-aged trees, along with the condition that there is no bird already nesting within a six patch radius because the birds are very territorial. In order to make our model work with a reasonable number of birds, we changed each patch from representing one tree to representing an acre of trees made up mainly of the type of tree that the color of the patch represents. On the last day of the loop, all the birds disappear, and logging takes place. This day represents the entire portion of the year that the goshawks are gone, with the logging that takes place being a cumulative of what would be logged in all those months.

Results:

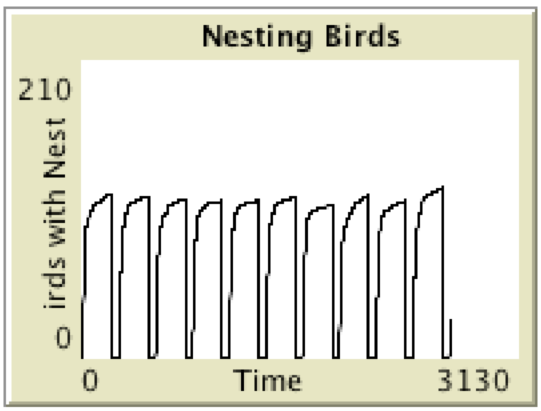
As the rate at which trees were logged increased, the goshawk population decreased faster. When the logging rate is below 10%, the goshawk population also decreases at a rate lower than 10%. We found an average 3.22% decrease in the goshawk population at a 5% logging rate and an average 8.66% decrease at a 7.5% logging rate. But when the logging rate is above 10%, the bird population decreases much faster and we got a 13.3% decrease at a 10% logging rate, a 24.55% decrease at a 15% logging rate and a 41.88% decrease at a 20% logging rate. When he model runs with the logging rate set at 0, there is an average .83% increase in the goshawk population.

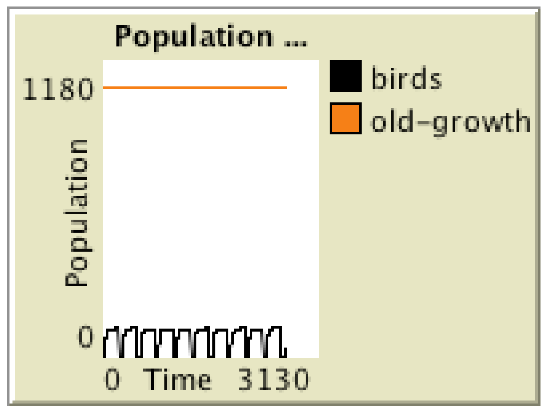
When the logging rate was less than 10%, the goshawk population was consistently lower than the initial population after ten years. However, the final population was still above or at the lowest population recorded when the log rate was set at 0%.

Tree Logging Rate	0%	5%	7.5%	10%	15%	20%
Percent Decrease in Goshawk Population	.83% increase	3.22%	8.66%	13.31%	24.55%	41.88%

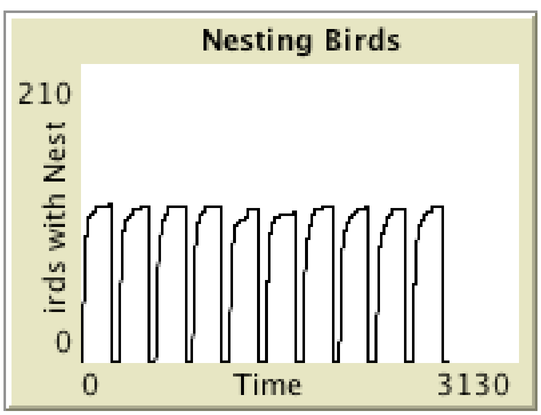
Percentage decrease in the goshawk population was calculated by running the model and recording the initial and final goshawk populations, then finding the percent decrease. The percent decrease of ten trials was then averaged to get these percentages.

These graphs show how the populations of goshawks and old-growth trees changed over a ten-year period. Because goshawks are migratory, they leave the forest for several months and return to it to nest. That is why the graph drops to zero between nesting seasons.

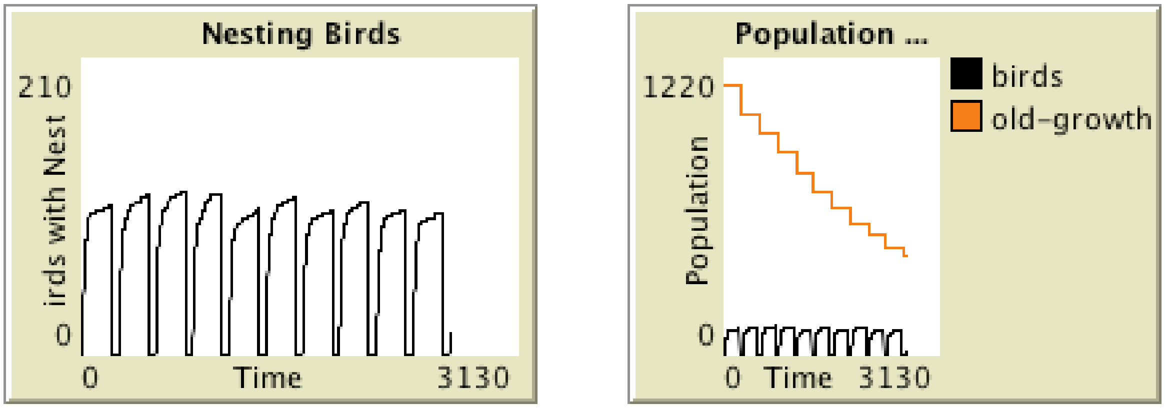




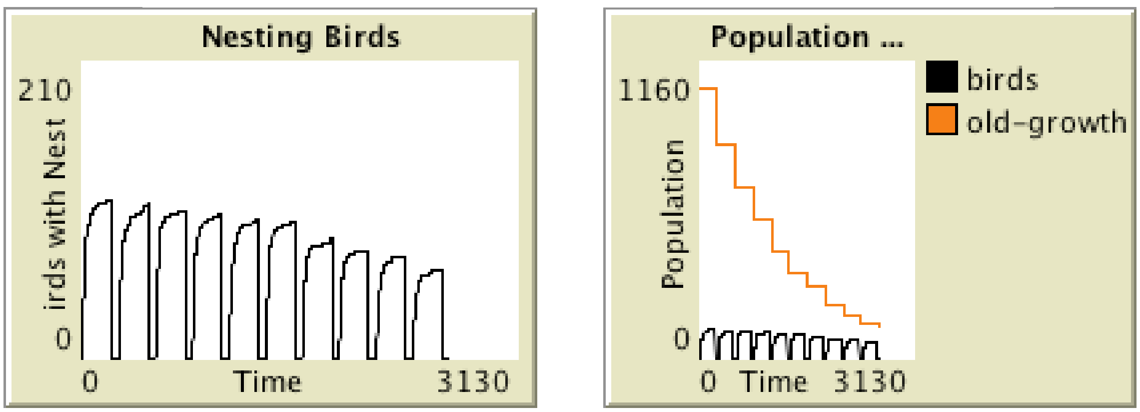
0% Logging Rate



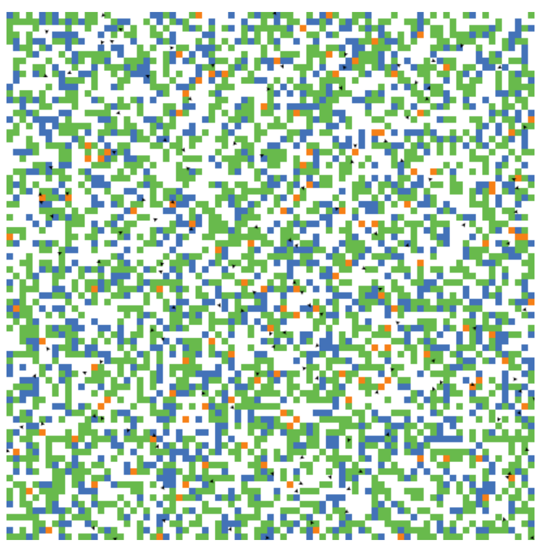
5% Logging Rate



10% Logging Rate



20% Logging Rate



This is the forest after it has undergone a 20% logging rate for 10 years.

Conclusion:

From this data we can conclude that selective logging anywhere above a 10% logging rate is detrimental to the health of a ponderosa pine forest. The changes in the goshawk population show this because the goshawk is a keystone species in a ponderosa pine forest ecosystem. This means that it is an indicator of the health of the forest because, as a top predator, it relies on the other species living in the ecosystem and their health affects its health.

Logging trees at a rate below 10% does decrease the population but the final population size we recorded was frequently above the minimum population in a forest with no logging. This is a decrease that the population and forest can recover from because, although our model does not show it, after ten years a significant amount of immature trees would have grown into mature trees. They would then be attractive to the goshawks for nesting.

Logging trees at a rate at or above 10% decreases the population size by 13% or more. This large of a drop in population is a serious problem for the goshawk and forest and is not easy to recover from even with new nesting trees becoming available. Over time, the population would die out because this forest would no longer have the trees needed to support the goshawk.

Achievements;

Our purpose was to discover how environmentally friendly selective logging is and if there is a rate at which trees can be logged that is sustainable. We have created a realistic forest ecosystem that, for a short amount of time accurately shows how logging can exists without harming the ecosystem. Below a 10% logging rate, it is possible to selectively log without killing such a large number of organisms that the forest cannot recover in a short amount of time. We do not know if this is profitable for logging companies but logging at this rate is definitely profitable for the environment.

Possible Future Work:

If we have time, we may extend the time scale of the model in order to see if there is a certain level of logging at which the goshawk population would be truly sustainable. To do this, the forest would need to grow and change, so we would put back into the model code to simulate the changing ages of the trees over time.

We may also look at the effect of a kind of logging other than selective on the forest, such as strip cutting. Clear cutting would be rather pointless as it is pretty clear the goshawk population will decrease if all the trees disappear.

Acknowledgements:

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We would also like to thank Jorge Roman for being a great mentor and answering all our questions about our model, helping us to focus our ideas and write a code that runs.