Computational Analysis of Potential Rainforest Monoculture Due to Slash-and-Burn Techniques Phase II

New Mexico

Supercomputing Challenge

Final Report

April 1, 2015

Team 125

School of Dreams Academy

Team Members:

Paige Torres

Taylor Torres

Teacher(s):

Talysa Ogas

Eric Brown

Table of Contents

Executive Summary

As a continuation of last year's project, a technique which is used mostly by farmers, "Slash-and-burn" to rid a desired area of trees by burning the crops/trees down. Farmers use this method so they can grow more trees/crops in that particular, this is good for the soil because when the field is burned it will regenerate the soil from when the trees/crops were burned down originally. Yet it is known that the slash-and-burn effect is having a negative impact on majority of the plants, animals and the biodiversity the rainforests affected. The way it effects animals is when all the trees/crops in an area is burned, the animals are forced to migrate to another location or die there. Animals rely on the ecosystems in which they live in and to have it be burned down is even worse. A monoculture is the arising of a single species over a wide area and for a number of consecutive years with no other species remote in that area. If one of the trees gets sick, then all the trees will get sick becoming a domino effect since there is no other species present. The technique slash-and-burn can lead to a monoculture because an increasing competition will result in a decrease in diversity which is something we don't want to happen.

There are over 16,000 million different types of tree species within the Amazon rainforest. We chose five of the most popular trees from the Amazon rainforest; the Rubber Tree, Walking Palm, Euterpe Precatoria, Huicungo (Astricaryum Murumuru), and Attalea Butyracea and put them as the variables in our model. U.S. ecologist and author Professor Miles Silman, from Wake Forest University, said: "Just like physicists' models tell them that dark matter accounts for much of the universe, our models tell us that species too rare to find account for much of the planet's biodiversity. That's a real problem for conservation, because the species at the greatest risk of extinction may disappear before we ever find them." Our model could be looked at as a version of Conway's game of life, "Patterns can evolve. Life provides an example of emergence and self-organization. It is interesting for computer scientists, physicists, biologists, biochemists, economists, mathematicians, philosophers, generati ve scientists and others to observe the way that complex patterns can emerge from the implementation of very simple rules" (Wikipedia).

In our computer program, we used an agent based modeling program, Netlogo because it gives our project the realistic approach in our stimulation. In our program want to determine the impact that the slash-and-burn technique has on a single species. Having five variables: Rock, Paper, Scissors, Lizard, and Spock (RPSLS) which is represent our five tree variables earlier mentioned. Clicking the setup button, will show the five tree variables randomized each time the setup button is clicked because we can pin point the exact place all the trees are placed in the Amazon Rainforest. This gives our project a real world approach, also we have added the slash-and-burn technique in the program which is white lines randomly placed when the setup button is pressed. When the program is running the slash-and-burn areas are white and the game of RPSLS isn't played in that area because it is dead due to the technique. Our model includes the life cycle of a tree: Seedling → Sprout competing for nutrients → RPSLS → Winner → Mature Tree → Produces Seedling, the entire process being equal to 1 "tick."

Our program in NetLogo works by following a number of steps in which all selections are made at random. The first step is to generate five different random colored dots on a field each representing a tree with a varying degree of competition like in our RPSLS model. One dot will first select another dot that is either directly up, down, left, or right of the original dot. If this new dot is a different color than the original the game will continue, but if the two dots are the same another dot will be selected. Next, these two dots will then randomly select one of the variables from the following list: Rock, Paper, Scissors, Lizard, or Spock. They will play against each other and whoever wins this game will "take over" the other space on the field which is indicated by a change in color. This process will continue until only one color is left. This demonstrates a monoculture. There are also white slashes along our program which are randomly distributed each time the setup button is pressed, just as the multi-colored dots.

Using the program Netlogo to create our stimulation of the Amazon rainforest, eventually playing the game of rock, paper, scissors, lizard, spock with each species of tree seeing which specific species of tree will be dominate. Although there are 16,000 different tree species in the Amazon rainforest, we have selected 5 of the most popular species: the Rubber Tree, Walking Palm, Euterpe Precatoria, Huicungo (Astricaryum Murumuru), and Attalea Butyracea. With these species representing the patches on the interface, a dominant species will arise, forming the outcome. Currently, we are working on adding the slash-and-burn technique to the program, put as a barrier so no living tress will grow in the slash-and-burn areas, this will be randomized.

Problem

We want to determine the number of year that it takes in which a monoculture to arise in the Amazon Rainforest. The environment in which this situation will be conducted is the dots (patches) in the program are represented as trees. The species of trees will vary between five species, including the age of the trees and the weather in the Amazon rainforest. Our expectation is to be able to tell what specific type of trees species which will dominate and the number of ticks on the program will tell us the number of years it will take for a monoculture to form.

Hypotheses

Our NetLogo model will simulate the effect of slash-and-burn in the Amazon rainforest in one of the following three ways:

1. The slash-and-burn method will increase the biodiversity of the affected areas of the rainforest.

2. The slash-and-burn method will decrease the biodiversity of the affected area of the rainforest.

3. The slash-and-burn method will not affect the biodiversity of the affected area of the rainforest.

Materials and Methods

All the data we acquired was from the use of a Behavior Space in NetLogo. While running our computer model in the Behavior Space, all the results were analyzed in Excel.

Materials:

Multiple Computers (to run tests in parallel)

NetLogo 5.1.0 Software

Microsoft Excel

Methods:

1. Run the program multiple times to ensure the proper results.
2. Create an algorithm that properly supports each variable.
3. Set the world size boundaries and topology in the model to various sizes.
4. Clear all plotting history, and check the amount of memory to prevent run-time errors.

5. Analyze the number of ticks in which one game of Rock, Paper, Scissors, Lizard, and Spock (RPSLS) is played. To determine the number of years it takes to create a monoculture.
6. Make sure all programs end with a monoculture where one species will dominate (represented by one color).

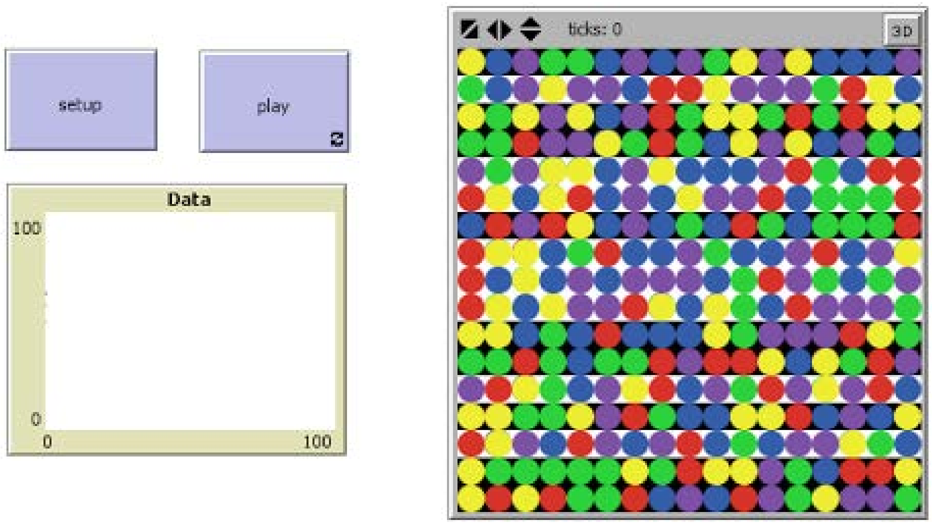

Figure 1. Displays the interface of our NetLogo model when the “setup” button is pressed the patches are randomly dispersed among the field. Each of the five colors represents one of Rock, Paper, Scissors, Lizard, and Spock. The areas in white are the slash-and-burn designated areas, which are randomized each time the setup button is pressed.

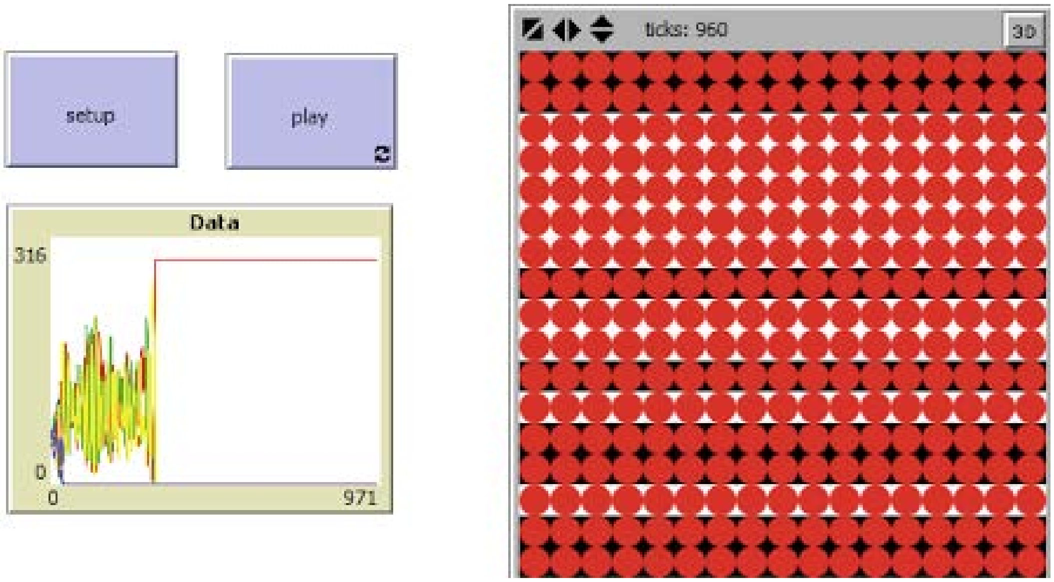

Figure 2. A single color is represented when one of Rock, Paper, Scissors, Lizard, or Spock (RPSLS) creates a monoculture, along with the white spaces representing the slash and burn technique. Notice the areas that are the slash-and-burn areas do not play the game of RPSLS among the tress since that area is dead.

Figure 1

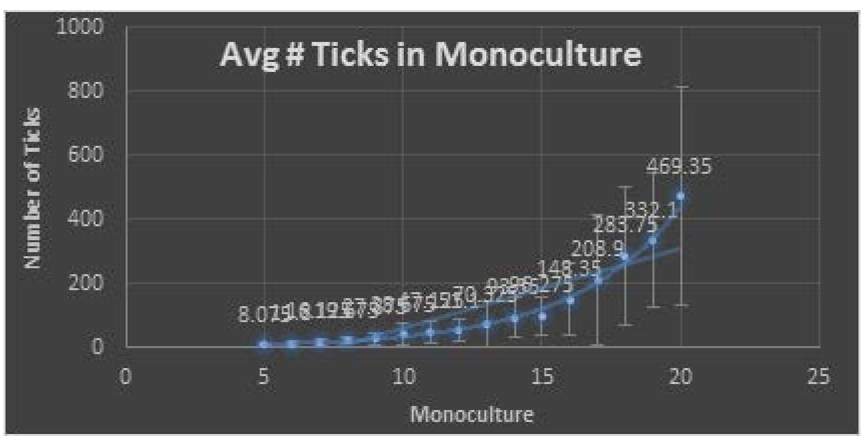

Figure 1. Average number of ticks it takes for a monoculture to form with standard deviation.

Figure 2

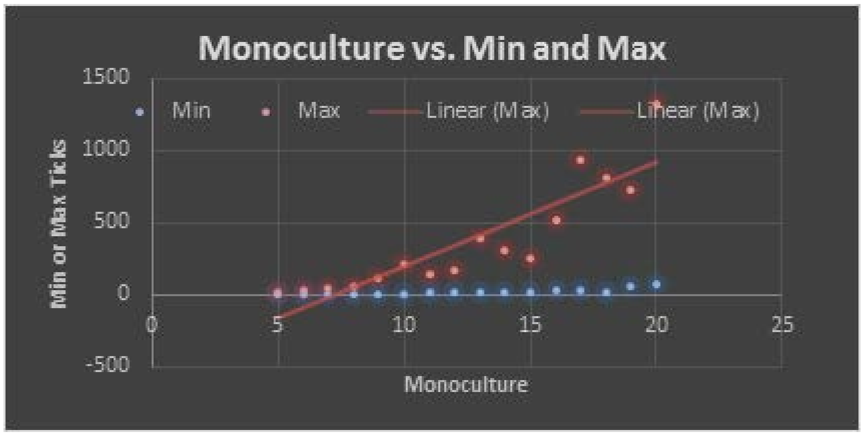

Figure 2. Monoculture vs. minimum world size and maximum world-size

Figure 3

Figure 3. Helicopter view of a monoculture

Figure 4

Figure 4. Satellite view of slash-and-burn method

Figure 5

Figure 5. Stimulation version of RPSLS representing trees: Rubber Tree, Walking Palm, Euterpe Precatoria, Huicungo (Astricaryum Murumuru), and Attalea Butyracea with actual slash-and-burns from figure 4

Results

Figures 1 and 2 display the analyze results from world-sizes 16x16 which is most similar to the plot area of most rainforests in Brazil. Figure 1 shows the average number of ticks with standard deviation it took to develop a monoculture in our stimulation. Figure 2 shows the maximum and minimum number of ticks it took to develop a monoculture. Both figures include the slash-and-burn which are the white areas we added to the program.

Discussion

Our program was run using various world-sizes of 16-25, with the addition of the slash-and-burn added to the variable to see approximately how many ticks it takes for a monoculture to arise. After a long analysis of our statistics, we noticed a pattern in the number of ticks for a monoculture to arise, it takes under 1,000 ticks for world-size 16 (the most realistic world-size in comparison to the Amazon rainforest). Coming to the conclusion, the smaller the world-size, the shorter the number of ticks, even with the addition of the slash-and-burn to the stimulation. We found when the world-size was larger of course it took a longer number of ticks. In relation to the Amazon rainforest, using smaller world-sizes helped us draw to the conclusion of our hypotheses.

We applied our program to the Amazon rainforest because the size of land relates more coherently with our model with using world-size 16 to find the amount of ticks it takes to potentially form a monoculture. In analyzing the results, the slash-and-burn method will decrease the biodiversity of the affected area of the rainforest, which turned out that hypotheses two was our final result drawing us to the conclusion after looking at the data.

Conclusion

The results of our experiment proved Hypothesis 2 to be correct, pending increased world-sizes and the parameters of the Amazon rainforest being set. The slash-and-burn method decreased the amount of biodiversity in which affected certain areas of the rainforest. This is shown in the average number of ticks it takes for the model to reach a monoculture with the obstacles of the slash and burn method. The set world size at 16x16 allowed us to make our similar as real as possible to the size of the amazon rain forest. Continuing this experiment with to discover the exact amount of time a tick is. This data will help us to fore long the approximate amount of time it will take for all biodiversity to be extinct in the rainforest. The overall trends for a monoculture to arise was compared to different world sizes include a neutral correlation amongst the graphs and tables. There was no color that appeared more than any other.

We finished running the final results, and looked at the different life spans of five different tree species and added each of their ages to within the program to get a more accurate result. Appling to reality, we gave each tree an equal chance (randomness was priority) of ending up in a monoculture in the five variables we had. Coming to the conclusion that if and when a monoculture occurs, the regeneration of the trees will be fighting for dominance (playing the

RPSLS game) with their neighbor seeing which tree will take over residency of a particular location in the Amazon rainforest, and turn the color of the victor.

The RPSLS model is applicable to many areas, including political/social influence, contagious diseases, and other biological/ecological systems. First we started with three variables (Rock, Paper, and Scissors) and it seemed almost impossible to come up with a single color as the victor. But, with the three variables in a smaller scale a single color prevailed rather quickly. Then we added two more variables (Lizard and Spock) and within a large scale it is almost impossible for a single-species to dominate, in a small scale it will dominate in less than 200 ticks. The more variables we added the faster a single-species dominated.

Accomplishments

One of our biggest accomplishments is developing our computer model that simulates a realistic model including a set of species of trees competing for dominance in 16x16 area. This model is a strong foundation for other possible scenarios.

Lastly, all members of our team have learned valuable skills in communication, collaboration and teamwork in general. In addition, teamwork is a huge part of this project working together to complete a complex task is both rewarding and a life lesson.

References

"Conway's Game of Life." Wikipedia. Wikimedia Foundation, n.d. Web. 27 Mar. 2015.

"Field Museum Scientists Estimate 16,000 Tree Species in the Amazon."EurekAlert! N.p., n.d. Web. 27 Mar. 2015.