Coding A Balanced Ecosystem Simulation

New Mexico

Supercomputing Challenge

Final Report

April 3rd 2019

Team #86

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Executive Summary

My project is going to focus on Invasive Fish species. It will be a multi-year project, this year I am focusing on getting a grip on the code. Next year when I have a good understanding on how to balance ecosystems I will apply real data to it. Invasive fish such as the Rusty Crayfish can be very real problems, they can dismantle entire ecosystems due to the fact that they have no natural predator when introduced into a different environment. In a recent article from Global Change Biology (https://onlinelibrary.wiley.com/doi/full/10.1111/gcb.14527) the Rusty Crayfish has been identified as one of eight species that pose the greatest threat to biodiversity in Europe. But selective fish breeding and carefully inserting certain fish into the environment could help combat this issue. For my experiment I created a simulation of an ecosystem, this ecosystem has been plagued with the Rusty Crayfish. I need to successfully program and edit the simulation to a point where the ecosystem is balanced so that the Rusty Crayfish, Normal Fish, Shrimp, and Bass all live in harmony together without any artificial help. No one fish dominates or dies off. Now that I have an understanding of the code I can now implement real data to it, without wasting time trying to fix the simulation.

Acknowledgements

I would like to thank Mr. Edington for help with understanding some of the code. I would also like to thank my Mom and Dad for motivational support.

Introduction

I wanted to create a simulation based on invasive fish species, specifically the Rusty Crayfish. The Rusty Crayfish is an invasive fish in New Mexico. I used Netlogo to code because it is a good starter program that I am learning about in school. At the moment, my numbers in the simulation are arbitrary numbers because I am learning to code and also learning how to balance an ecosystem in the simulation. This will be a multi-year project. This year I am dedicating this project to actually learning how to code and to edit the simulation with ease. Once I have gotten a good grip on the code, I am going to apply accurate data about how much each fish travels, eats, breeds, and how long they live. I have applied many actual statistics to my simulation. The simulation itself is based on Conchas Lake which is 9600 acres. Each patch represents one acre. My model is 80 * 120 patches which is equivalent to the size of Conchas Lake. The Rusty Crayfish is a voracious eater that basically eats everything, so I made the Rusty Crayfish eat lots of fish in the simulation. When I apply accurate data I will be able to formulate a counter to invasive fish species.

Main Problem

The main problem I want to tackle is an invasive fish species known as the Rusty Crayfish. The Rusty Crayfish is an invasive species of crayfish that originated from Illinois. It has been used by fisherman as bait allowing it to spread throughout most of North America. Rusty Crayfish can take over a river or lake very quickly due to the fact that a female can lay 80-575 eggs at a time. Due to their high metabolism Rusty Crayfish are able to eat twice as much as other crayfish and eat pretty much anything it can find. They eat fish, important plants, fish eggs, other crayfish, and bacteria. The Rusty Crayfish can destroy entire rivers and lakes. Another problem was that I had no knowledge about coding, so I decided to make this a multiyear project. This year is dedicated to learning how to code a balanced ecosystem simulation that would always reach homeostasis.

Method

For my simulation I incorporated 4 fish: Bluegill, Black Bass, Rusty Crayfish, and Brown Shrimp. Each fish has different predators, prey, and food. Bluegill feeds on grass and Brown Shrimp. Brown Shrimp feeds on just grass. Rusty Crayfish feeds on Bluegill, Brown Shrimp, and grass. Bass feeds on Rusty Crayfish and Bluegill. When creating the simulation, I began by adding Bluegill and Rusty Crayfish. The Bluegill would be killed off in less than 100 days, and the Rusty Crayfish would overpopulate, eating all the plants quicker than they could grow, causing them to die off. The only way of balancing this ecosystem was by artificially helping them by removing the energy threshold for fish breeding if the population got too low, which was not ideal. Bass was added as a natural way to counter the Rusty Crayfish. Rusty Crayfish uses its claws to scare off bigger fish, and opts for smaller fish to eat. Bass is capable of eating Rusty Crayfish, without any opposition from them. When I first added the Bass, they died off very quickly because they ate so many Rusty Crayfish that they ran out of food. When the Bass died off, the few surviving Rusty Crayfish repopulated.

I changed the amount of energy required for a Bass to breed, which kept it from overpopulating. The problem with tweaking the numbers in an ecosystem is that the tiniest change can completely break the ecosystem, requiring lots of trial and error. Eventually, I got the simulation to a point where no matter how many Crayfish, Bass, or Bluegill there were, they would balance out, and keep each other in check forever. Then I added the Brown Shrimp, which immediately broke the balance. The Brown Shrimp would eat too much grass, causing the Bluegill to die off. I tweaked the amount of energy the Brown Shrimp got from eating. The difficulty was finding the amount of energy where they would not eat too much grass, but eat enough grass to survive. I eventually got it fixed, and the ecosystem was balanced again.

Verification

When I ran my model I would run it for 2 million ticks. 1 tick equals one real life day. The reason I would run my simulation for so many ticks is that even at 1 million ticks something could go horribly wrong and the entire simulation could fall apart. When a species would die off, I would check my graph and look for what exactly went wrong like a fish could be gaining too much energy from grass, or a fish might not have enough energy to breed often. I would go into the code and edit the code, and then would run the simulation again. If all the fish survived for 2 million ticks, without having any major drops or rises, than I would say it was balanced. When I do this project next year I am going to get real data from multiple reputable sources such as New Mexico Game And Fish. I will check with multiple sources and people who work in the field to get the most accurate data.

Results

In my work, and research, I have learned a lot about coding and I am ready to apply real data to it. Even though I had many roadblocks during coding I was able to fix the simulation and get every single species of fish to homeostasis. The Rusty Crayfish is a problem that I want to solve. This year I learned how to code, so I won't be wasting time trying to figure out why the code is breaking when I implement real data into it. I will be able to run simulations quicker and more effectively. The real data will be translated accurately into the simulation.

Conclusion

In conclusion, my simulation turned out great. Adding each fish would break the ecosystem, but I was able to get it balanced every time. Balancing it was tough, the problem with tweaking the numbers in an ecosystem is that the tiniest change can completely break the ecosystem, requiring lots of trial and error. Eventually I got the simulation to a point where no matter how many Crayfish, Bass, Shrimp, or Fish there were, they would balance out, and keep each other in check forever. Balancing an ecosystem involves lots of minor adjustments, mainly having to do with the fishes' food sources, breeding rate, predators and prey, and many other factors.

My Greatest Achievement

My greatest achievement of this project was learning to code in the first place, and not only that, but being able to code an ecosystem simulation. This is my first time coding ever, and I am so happy that I was able to make a proper functioning ecosystem, and now I am capable of coding.

References

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