Fuel for our Future

New Mexico

Supercomputing Challenge

Final Report

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Team number 22

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Executive summary

Algae are unicellular organisms that grow in clusters on the shores of beaches, lakes, or even dog bowls. As technology has advanced, we have realized algae’s potential. It could help humanity in fields such as agriculture, medicine, and as a biofuel. Even though some companies are using algae as a biofuel today, it’s because of the limiting factors because algae haven’t yet seen much large-scale commercial use. Limiting factors like predators contaminating the algae farms stop production and make growing algae more expensive. To help solve this problem I created a simulated model in NetLogo that grows at the same rate as the nannochloropsis oculata that we grew with different amounts of salinity in its nutrients solution. The program has further applications in the field of algae and it could be improved upon to better simulate the algae in different conditions. I hope to increase the efficiency of this simulation so we could better experiment on how we grow our algae to better optimize our money to conduct more experiments with algae.

Introduction

Algae was once thought of as a nuisance unicellular organism that grows in clusters on the shores of beaches, lakes, or even dog bowls. Over the last few years, we have found uses for algae that could be used to help humanity such as in the agricultural, medical, and energy fields.

One strain has been found to help with chemotherapy treatments. Through genetic engineering, the algae biomineralized silica (the brown algae commonly found growing in fish tanks) is attached to the chemotherapy drugs.[4] It then attaches itself only to the cancer cells and doesn't touch any other cell. Algae could be used in agriculture to help enriches the compost with nutrients without any alterations because algae are rich in nitrogen.[2] Algae is used as a biofuel because algae stores energy in the form of oil and it could easily be converted for the use of engines. [3]

Algae has many applications that could help humanity with new applications being discovered today. The main reason why algae haven't been implemented for commercialized uses is that it is expensive to grow and maintain from predators contaminating the algae. [5]

Method

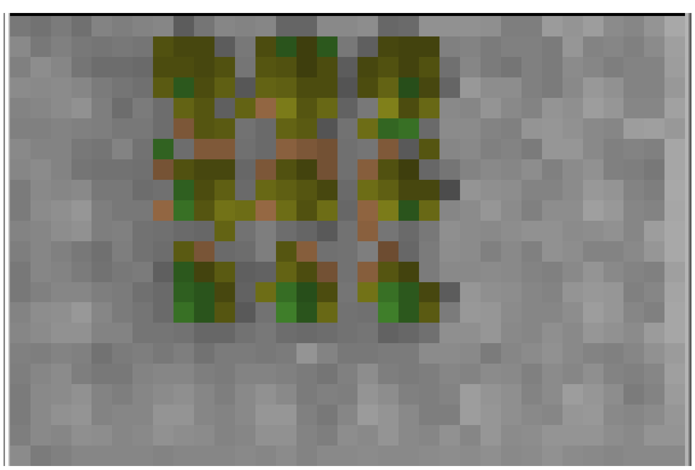
The goal of this project is to create a simulated model of algae that changes its growth depending on the salinity of the nutrient solution. We grew a strain of algae called nannochloropsis oculata, this is a strain of algae that could be used as a biofuel. [1] It usually takes 30 days for algae to grow to when the algae reach its peak,[7] but with nannochloropsis oculata in a temperature of twenty degrees Celsius it should peak at day eight,[6] but because we are growing an older and less healthy strain we will grow it for fourteen days instead of the eight days in a room at twenty-one degrees Celsius. The algae were grown in a 24, 2-milliliter plate or wells with one milliliter of algae and one milliliter of the nutrient solution. The nutrients contain 100 milliliters of distilled water, 1/1000 of hydro algal fertilizer and a salinity that varies by intervals of eight PPT (parts pers thousandths) of salt starting at eight PPT and ending at forty PPT. The algae are grown under T5 lights about 50 cm away from the algae. The algae are grown at the same time on an orbital shaker, they are shaken eighty RPMs for ten minutes twice a day. Pictures of the algae are taken every day in the same location with a white paper at the backdrop. We take the pictures using a Kyocera Dual Force Pro phone on top of a tissue box. Each algae different salinity will have three trials to verify the results.

In NetLogo, we check the average color of the algae using a program created in NetLogo. After three trials of each different nutrients solution, we then place the data into a graph and find the average colors between each graph. We then used the data to create a simulation that is close to how the algae grow by keeping the algae grow between the max peak and minimum peak of the algae and adjust the formula when it doesn't match with the data.

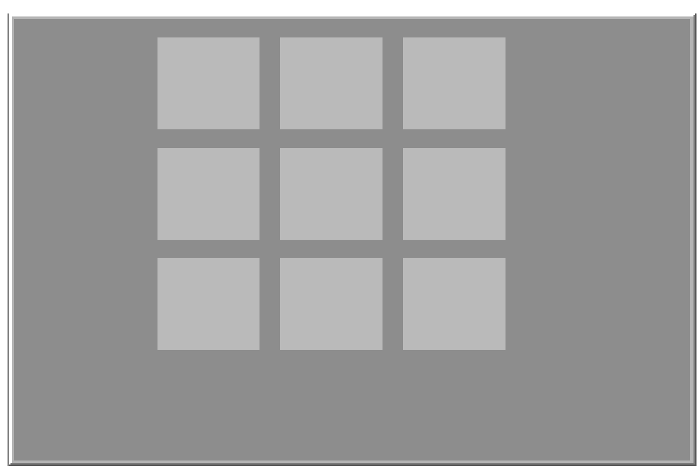
Code

Using the data collected from the trials, we created a base model that was similar to how the algae are set up in the pictures when they are imported into NetLogo as shown in the screenshots below

Original imported image



Setup for simulation model



The images slightly differ because some wells blend with the neighboring wells, but they roughly are in a 5 by 5 square box. Then we used a mathematical equation to simulate the growth of the algae, with each color having its own range of numbers before it was classified under a certain different color. This value is determined by the patch's own energy values as seen in the code below.

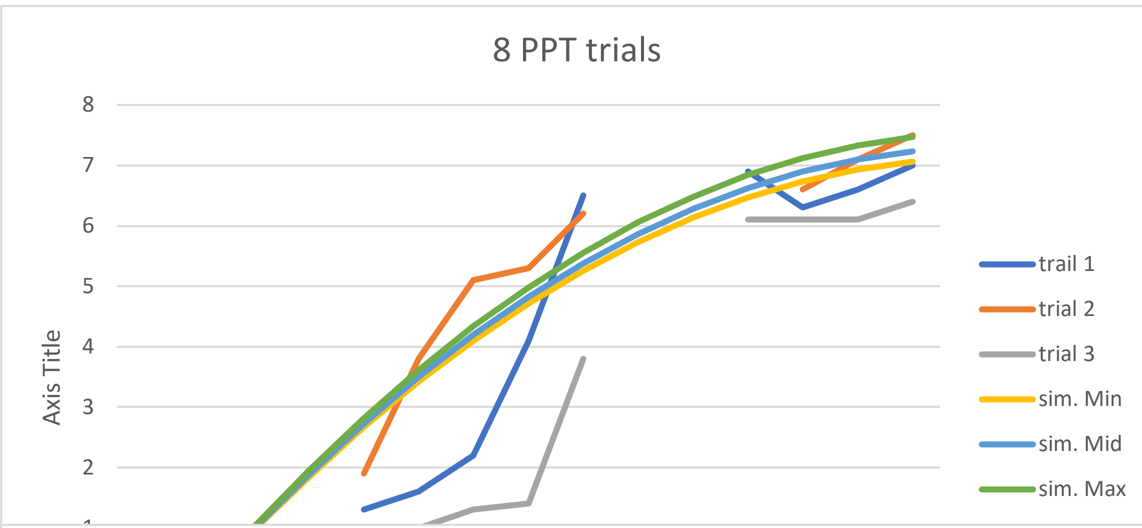
```
to daysgoneby
if ticks < 30
[
ask patches
[
if salt > 0
[
set energy((-.00003825 + (0.00003825 * (((PPT * edge) / 40))) * ticks ^ 3) + ((-.038625 + (.007625 * ((PPT * edge) / 40))) * ticks ^ 2) + ((1.111488 - (.243488 * ((PPT * edge) / 40))) * ticks))
change
]
]
tick
]
end
```

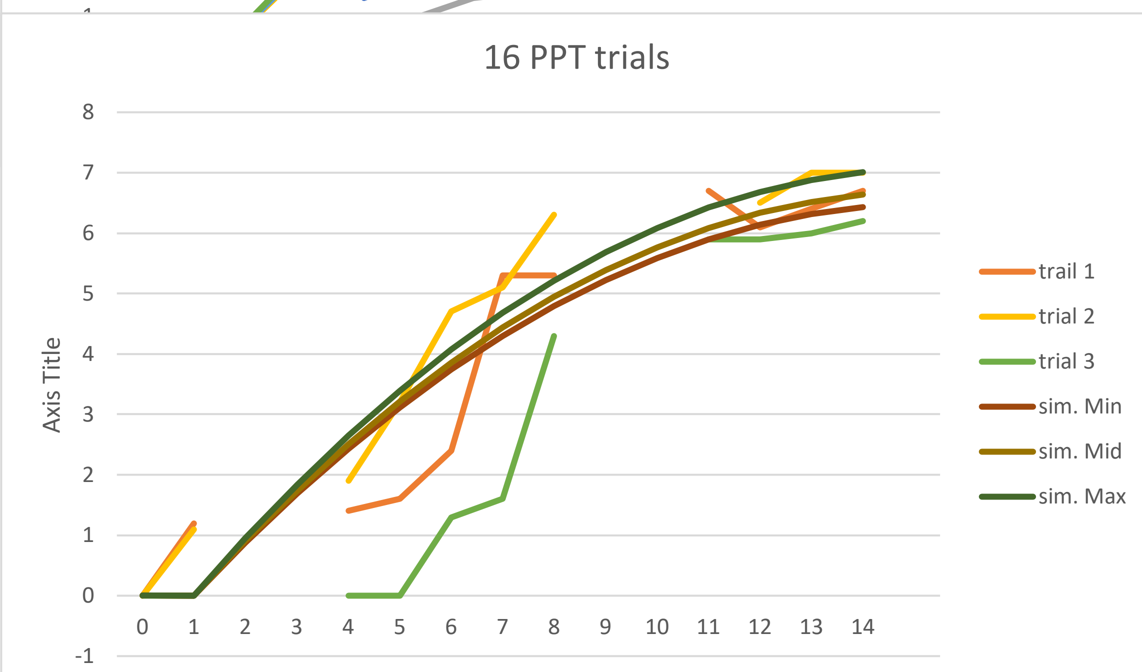
The mathematical equation is meant to grow the algae between the minimum and maximum growth values on day 14. Each patch has its own different growth rate to simulate how random algae grow because one section could be darker than the rest of the well or it could be lighter, but it doesn't change its overall average as much.

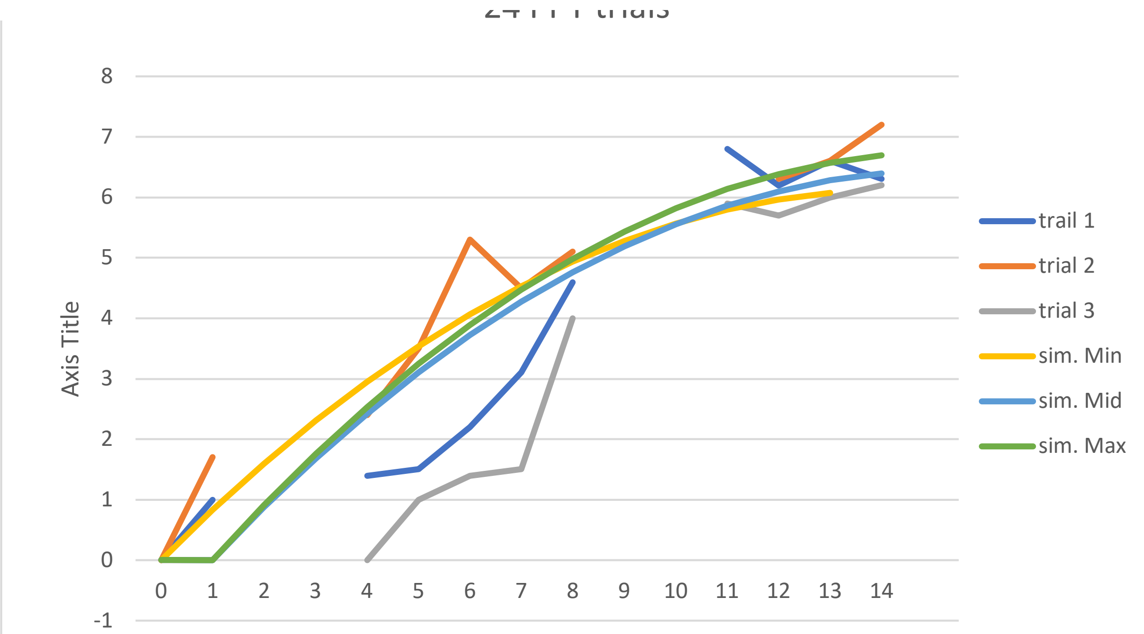
The salt value is meant for the code to identify the patches that are being analyzed and which aren't. The edge values are in the equation to make the edges of the algae lighter like in the pictures, but patches not on the edge have an edge value of 1 instead. The energy is the patch's own value that determines the patch's color. The PPT value is to represents the parts per thousandths of salt in the algae's nutrients solution. The change value changes the color of the patches depending on their own energy value.

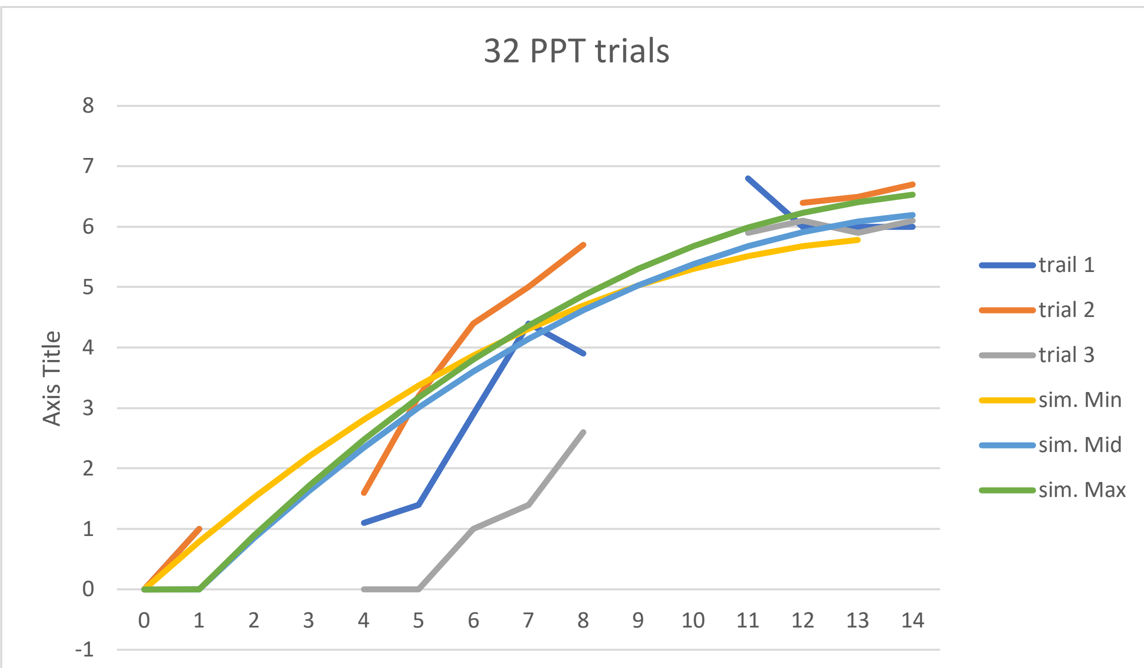
Results

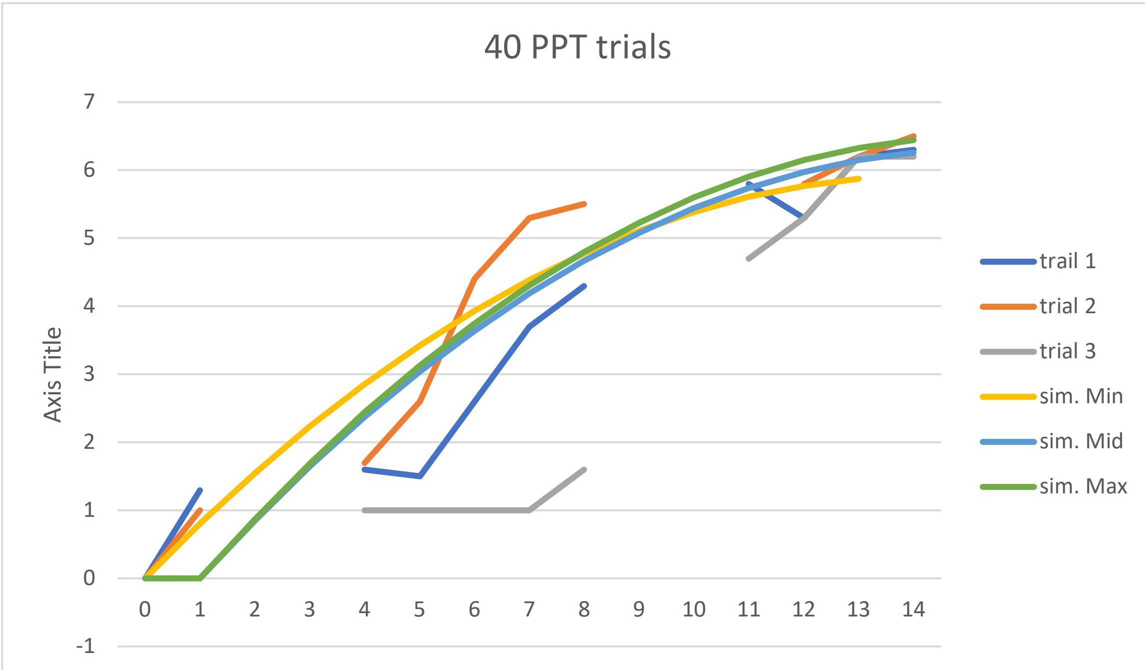
Graphs






24 PPT trials
Axis Title
8
7
6
5
4
3
2
1
0
-1
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
trail 1
trial 2
trial 3
sim. Min
sim. Mid
sim. Max


32 PPT trials
Axis Title
8
7
6
5
4
3
2
1
0
-1
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
trail 1
trial 2
trial 3
sim. Min
sim. Mid
sim. Max



Average color table

	Trial 1	Trail 2	Trail 3	Simulation model min	Simulation model max
8 PPT	4.35	4.94	3.22	4.14	4.37
16 PPT	4.31	4.75	3.12	3.76	4.11
24 PPT	3.97	4.73	3.17	3.56	3.92
32 PPT	3.95	4.5	2.9	3.39	3.83
40 PPT	3.86	4.33	2.8	3.45	3.78

This table shows the average overall pigment value and color of the algae in all the trail and overall. It shows how similar the simulated models are with the trials.

Color Values	Color names	Colors
0-1.4	Green smoke	
1.5-2.4	Asparagus Green	
2.5-3.4	Highball Green	
3.5-4.4	Olive Drab	
4.5-5.4	Dark Olive	
5.5-6.4	Green Kelp	
6.5-7.4	Verdun Green	
7.5-8.4	Dark Green	

The table shows the values of each color from the lightest having a lower number and the darkest having a higher number.

Conclusion

Overall the simulated model does stimulate the growth of the algae, but with a little bit of tweaking, it will be accurate enough to fully simulate the growth of this strain of algae. The model does simulate the growth of some trails of algae such as the algae with 8, 16, and a little bit of 24 PPT of salt, it could be changed to more accurately simulate the 32 and 40 PPT concentrations of salt in the algae's nutrient solution. The reason why the nutrient solutions with the concentrations of 8, 16, and 24 PPT of salt in the algae's nutrient solution is because the minimal and maximum average is close to the minimal and maximum simulated average even though they are in less than the averages.

Significant Achievement

Our significant achievement is creating this simulation because it tested my coding skills in NetLogo and showed me how to use my resources effectively. This program when tweaked could be used to stimulate the growth of the algae to find a more efficient way of growing it with variables such as the amount of sunlight the algae receive or the risk of bacteria growing in the algae.

Acknowledgments

We would like to acknowledge Anne Loveless and Creighton Edington for helping us improve our analysis program in NetLogo and giving us the idea to create this program. We would also like to acknowledge Abe Anderson for helping me by teaching me how the algae grow and for checking our work during the experimental phase. He also got us the supplies to use the experiment and assess to use the science lab.

References

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