Polar Warming

New Mexico Supercomputing Challenge

Final Report

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Team 55

Los Alamos High School

Team members:

- Shelby Anderson
- Emily TenCate

Teacher:

- Diane Medford

Project Mentors:

- Mark Anderson
- James TenCate

Executive Summary:

Polar bears in the Arctic face a number of serious threats to their existence, the two most substantial being global warming and humans. Polar bears depend on Arctic ice for their survival, and ice is melting more rapidly every day. It is obvious that any simulation of this situation will show a dramatic decrease in the polar bear population. However, what if it were possible to increase the amount of ice in the Arctic, or at least prevent any further melting? Would the polar bear population be able to renew itself?

A simple computer program was developed to model the Arctic environment and the results of global warming upon polar bears. The StarLogo programming environment was chosen to implement the algorithm, since StarLogo allows many agents to be acting independently but at the same time. This feature correlates well with an ecosystem. The basic model elements were polar bears and their food source (StarLogo "turtles") and Arctic ice (StarLogo "patches"). The polar bears were able to breed and feed upon the food agents, according to the size of the ice floe. The ice floe was able to change size, according to the temperature.

Each polar bear could roam the ice floe at will. Polar bear attributes included color (corresponding to health status), age, and gender. The program was baselined with one set of parameters, then temperatures, melting rates, initial amounts of polar bears, and the original size of the food source was varied systematically. For each set of initial conditions, 5 to 10 simulations were run. The output of each simulation was the size of the polar bear population at the end of one cycle, which correlated to approximately 10 years.

Simulation results showed a wide distribution of potential outcomes, but general trends were apparent. The first half of the program created results that were similar to today's situation – a collapsing polar bear population. When the ice stopped melting, the polar bear populations were able to revive their numbers from most cases. Only when the numbers had decreased so severely that the bears could not breed were they unable to survive. Potential refinements and applications were identified.

Introduction:

Global warming is having bad effects on polar bears in the Arctic. Their habitats are melting, food supplies are dwindling, and the bears can't survive in climates and water above certain temperatures. The situation in the Arctic is truly a disastrous one, and everything that can be done to prevent the extinction should be done.

The loss of polar bears' habitats is the greatest threat to their continued existence. Polar bears are totally dependent on Arctic sea ice for their livelihood. They are not good swimmers, and all feeding and mating is done upon ice[1]. As the media is making it more and more clear, ice is melting at a greater rate than ever before. In fact, over 65,000 square miles of Arctic ice can melt in less than one week[2].

It is obvious that any computer model simulating this situation would result in total destruction of the polar bear species.

But what if it were possible to replenish the ice in the Arctic, or at least to prevent any further melting? Would the polar bear populations be able to recover? This is the goal of this model: to discover whether polar bear populations could renew themselves if the Arctic ice were to stop melting.

Problem:

After analyzing previous studies regarding the fate of polar bears, it becomes obvious that a model simulating the global warming crisis, no matter what the parameters, will ultimately result in the total destruction of polar bears. This would likely be accurate of the Arctic, several decades from now.

However, simply knowing that the polar bears will be extinct in about thirty years is useless. It is far more practical to model suggested solutions, and see how the polar bear populations react. Efforts at preventing ice melting, after all, would become a waste of time should it turn out that polar bears are already too far gone for any hope of salvation.

Expected Results:

From this simulation, we expect to see a correlation between decreasing polar bear populations and loss of their habitat due to global warming. We hope that by stopping the melting of ice, perhaps showing human involvement, the polar bears can recover and repopulate the area. We believe that the polar bears will be able to recover from various states of degeneration, according to the state of the devastation wrought by global warming. We believe that when the ice melt stops, the bears will in fact regenerate themselves, and thrive.

Programming Method:

This simulation was designed to model what would happen should the ice simply stop melting. Temperatures would decrease slightly, and the melting of the ice would merely not occur. This is not perfectly realistic, but it does provide a fairly accurate representation of the polar bear population's ability to recover itself.

An ecosystem is an extremely complex environment. As such, the programming was done in layers and stages, to accommodate the complexity of the environment and provide the least possible amount of errors.

First, the polar bear agents were developed. To be as realistic as possible, each bear was assigned attributes: color (correlating to health status, which represented how recently the bear had eaten), age, and gender. The bears were able to breed once they had reached an age of 2, which corresponds to about five years of age. The gender assignments created a more realistic breeding pattern. When the health status reached a certain low point, the bear would die.

The food source was developed next. It was assumed that the food source was preyed upon by only polar bears, and that the food source was not affected by habitat. A basic predator-prey simulation was developed between the polar bears and the food source, ignoring habitat and temperature. When the predator-prey part of the simulation was running properly – populations rising and falling accordingly, it became possible to include another element of the Arctic ecosystem.

Habitat related ratios were put into the equation. Now, it was assumed that polar bears could only survive if they were supported by at least 20 patches of sea ice. This correlates to the actual domain of a single polar bear – about 500 kilometers squared[3]. When the amount of ice grew too small, a polar bear randomly died – representing a fight between polar bears that resulted in death.

Temperature was introduced next. The temperature rose at a rate designated during the setup of the program, and the ice melted directly in relation to the temperature. Higher temperatures, obviously, caused the ice to melt at a greater speed. The program ran a loop, with polar bears living, feeding, and breeding, temperature increasing, and ice melting, until the temperature reached another point, also assigned at the beginning of the program. At this point, data was gathered. This temperature was considered the peak, and after this temperature was reached, the ice stopped melting – essentially representing human involvement.

Various sets of initial conditions were created – varying the starting temperature, the initial amount of polar bears, the peak temperature, etc., systematically. Each set of initial conditions was run three to five times. The output for each run of the simulation included two things: the number of polar bears at the peak temperature (before the ice stopped melting), and the number of polar bears at the end of the cycle (after "human intervention"). These two values were compared so as to realize the amount of population recovery after the ice stopped melting.

See Appendix 1 for the simulation window.

Results:

When the initial food source was small, the polar bears were not able to recover as quickly, and in some cases, could not recover at all. The polar bear populations were able to recover from most states of devastation. Even when the amount of remaining bears at the peak temperature was less than thirty, it was still possible for the bears to renew their population. Due to the absence of a well-defined time element in the model, however, it was impossible to determine how long such recoveries could take.

Also, the populations were only able to recover as much as their remaining habitat would allow. For instance, when most of the ice had been depleted during the melting phase, the polar bears had difficulty recovering. When enough ice had been depleted, it was impossible for the polar bears to recover.

Conclusion:

This model shows that it is not too late to help the Arctic ecosystem, as well as polar bears and other Arctic animals that suffer from habitat loss. As evidenced in the results, polar bears can recover from some seriously devastating population declines.

However, results also show that the polar bears have more and more trouble recovering as the temperature increases and the habitat declines. If humans do not try to assist the climate now, it will soon be too late for Arctic mammals. By getting the message across that polar bear populations will be affected more severely as more time goes by, perhaps simulations such as these can convince people to take action soon.

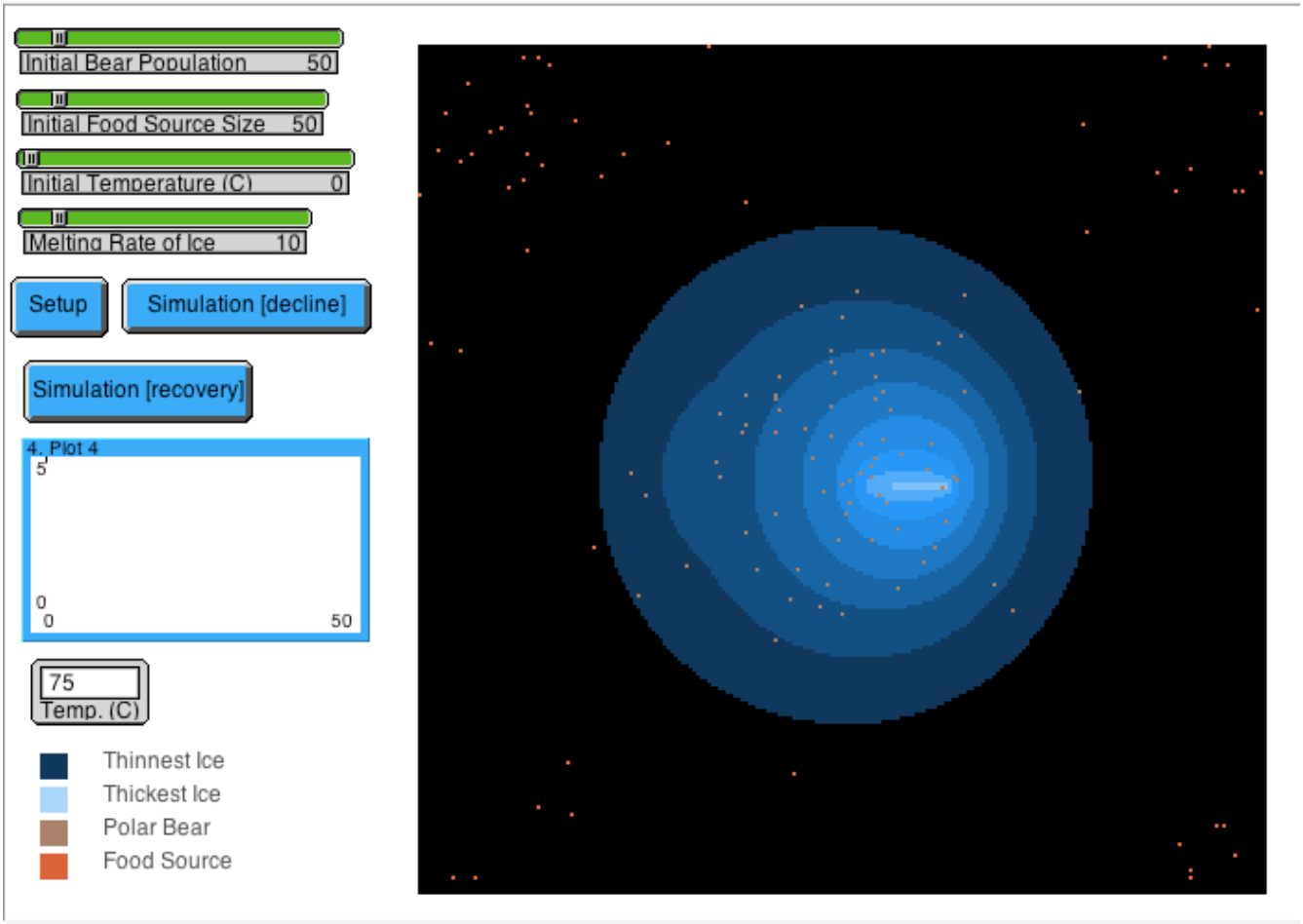
Refinements and Future Work:

In very extreme cases, the numbers tended to decrease so that only males or only females survived, creating an unrealistic situation that did not allow breeding. This is due to the element of randomness worked into the model – the polar bears die randomly when the habitat grows too small.

References:

1. Owen, Megan. On Thin Ice? ZooNooz - San Diego Zoo; April 2008.
2. Sandell, Clayton. Arctic Ice Continues Record Melting. ABC News; September 10, 2007. <http://abcnews.go.com/Technology/GlobalWarming/story?id=3582433>
3. S.H Ferguson, M.K Taylor, E.W Born, A Rosing-Asvid, F Messier (1999) Determinants of Home Range Size for Polar Bears (*Ursus maritimus*) Ecology Letters 2 (5) , 311–318 doi:10.1046/j.1461-0248.1999.00090.x

Appendix 1



The blue circle in the center of the screen represents the ice floe upon which the bears are living. The thickest ice is white, and the thinnest ice is dark blue. The thinnest ice melts first, and the other ice changes colors accordingly. Orange dots represent fish – the food source – and the brown dots on the ice floe represent polar bears. The sliders to the left represent the variables that can be altered.