Invaders on Daisyworld:
A Computer Simulation of Invasive Species

Jack Hosemans
jmhos3@student.monash.edu

Faculty of Information Technology
Monash University, Clayton, Australia

Keywords: TODO

ABSTRACT GOES HERE TODO

1 Introduction

A healthy ecosystem exhibits homeostatic properties[1] that maintain an environment hospitable to the native species, allowing for a stable system in situations where life may not normally exist. External pressures such as climate change may cause an ecosystem to collapse given there is a large enough change that the system cannot react in time[2]. If the change is not large enough so that the system can adapt, the additional stress of the introduction of a non-native species can cause the adaptation to fail and the collapse of the ecosystem's homeostasis[3].

To explore the extent of which an ecosystem can adapt to a changing environment, a computer simulation of DaisyWorld[4] was developed. This model is *Agent based*[5], where the ecosystem is simulated by aggregation of many simple autonomous agents that perform simple

tasks. By being made up of these agents the system can exhibit complex behaviour through their interactions.

In the original specification of Daisyworld, there are only two kinds of daisies, black and white. These two daisies flourish at the same temperature, only differing by the amount of incident radiation that they absorb. It is this difference in albedo that causes either type of daisy to warm or cool it's local environment. As the local temperature strays from the optimal growing temperature of the daisies, the chance of that daisy dying increases. Hence daisies that cause the temperature to deviate from their optimal temperature die more often, causing the global temperature to converge to the daisies growing temperature.

This paper tests the introduction of a third type of daisy with the same albedo as the "black" variant of daisy, but with a higher optimal temperature. It can therefore warm up it's environment and overtake the two native species in certain conditions, much like an invasive species in real life.

TODO: describe what happens?

TODO: better structure of the document

This paper is split up into the following sections, each discussing different parts of the aforementioned system.

- Method
- Results
- Analysis and discussion
- Future work
- Conclusion

2 Method

This agent based model of daisyworld is implemented on a two dimensional grid, with opposing sides connected to one another (the surface of a torus in 3d space). This grid is split up into tiles, that may or may not contain a daisy. Each tile modifies it's local temperature at each time step based on the albedo of the object at it's location and the current incident radiation. This incident radiation is controlled by a sun object that updates the solar luminosity at each time step.

TODO: figure of the program update flow?

2.1 World

The world is implemented in a two dimensional grid, with opposing sides connected to one another. At each time step the following is calculated:

- The average temperature
- The average albedo
- The expected temperature from the average albedo (TODO Stefan)
- The expected temperature for a lifeless world
- The amount of each type of daisy

These numbers are written to a file for later processing

Then, the following actions are completed:

- Allowing each tile to update it's attributes
- Temperature mixing between adjacent tiles

Temperature mixing is implemented by taking the average temperature of adjacent tiles and adding 20% of the difference to the current tile (TODO REWORD) (TODO REDO?)

2.2 Tiles

2.3 Daisies

2.3.1 Invasive species

2.4 Sun

TODO: Read ODD paper stuff

3 Results

4 Analysis & Discussion

5 Future work

6 Conclusion

TODO: How to conclude?

References

[1] Ernest, S. and Brown, J. (2001). Homeostasis and Compensation: The Role of Species and Resources in Ecosystem Stability. Ecology, 82(8), p.2118.

[2] Barry, G. (2014). Terrestrial ecosystem loss and biosphere collapse. Management of Env Quality, 25(5), pp.542-563.

[3] Rapport, D., Regier, H. and Hutchinson, T. (1985). Ecosystem Behavior Under Stress. The American Naturalist, 125(5), p.617.

[4] Watson, A. J. and J. E. Lovelock, 1983: Biological homeostasis of the global environment: the parable of daisyworld. *Tellus*, **35B**, 284–289.

[5] Gilbert, G. (n.d.). Agent-based models.