

# Dynamic Complex Ecosystems

## TJHSST Senior Research Project Proposal

### Computer Systems Lab 2009-2010

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#### **Abstract**

Ecosystems are based on the multiple interactions between the many parts of a whole. In order to effectively evaluate changes on an ecosystem and to evaluate individual objects in an ecosystem, the ecosystem must be examined as a whole. This requires many species and many interactions and many variables - too many to be done by simple equations or algorithms. The ecosystem must be run/simulated in order to be modeled by a computer. Major inside changes in an ecosystem include evolution, adaptation, population fluctuation - chance events that effect the existing population, based on the existing ecosystem. On the other hand, major outside changes to an ecosystem include natural disasters, invasive species, new species - chance events that do not come from the existing population that do effect the ecosystem. How will these events effect an ecosystem?

**Keywords:** ecosystem, modeling, simulation, adaptation, evolution, population, species, disasters

## **1 Introduction**

### Problem Statement and Purpose

The purpose of my research project is to create a simulation of a many-species, non-static, many-variable ecosystem. According to user preferences, many desired ecosystem simulations will be able to be run. This means that

the simulation will include hypothetical situations, which will be applicable to real-life, but not necessarily a real-world model. This simulation will use a chance-based predator/prey ecosystem (for predation rates), reproduction algorithms for evolution, adaptation algorithms, trait accumulation, new species, and natural disasters. This will first be done in NetLogo to facilitate display/debugging/testing, then will be moved into Python for a more applicable and general programming language.

## 2 Background

Provide enough information in a technical document to allow your reader to understand the specific problem being addressed and to provide a context for your own document. This background information may include (1) a historical summary of the problem being addressed; (2) a briefsummary of previous work on the topic, including, if appropriate, relevant theory; and (3) the specific reasons the document is being written.

Types of research include:

### 1. Applied Research

- Research which studies the relationship and/or applicability of theories or principles to the solution of a problem for the purpose of producing results that may be applied to real world situations.
- Research used to answer a specific question, determine why something failed or succeeded, and solve a specific, pragmatic problem.

### 2. Operations Research and Modeling

- Application of mathematical models to study or plan a process designed to determine the most efficient way to do something. Often used to analyze complex real-world situations.

### 3. Primary (or original) research and Modeling:

- Original research in which new data is actually collected from the natural world (via experiments, naturalistic observation, case studies, etc.) conducted to answer a research problem. Secondary research draws information from books, publications, or expert opinion.

- Primary research requires: 1. knowing what has already been discovered on a subject (background) and 2. formulating a method to find out what you want to know.

#### 4. Qualitative research

- Concerned with understanding the processes which underlie various behavioural patterns through loosely structured, mainly verbal data rather than measurements. Analysis is interpretive, subjective, impressionistic and diagnostic.
- An exploratory study, to explore an unknown sector, identify the main dimensions of a problem, draw assumptions, understand motivations. Or an operational study based on in-depth analysis of interviewee responses.

#### 5. Quantitative research

- Examines phenomenon through the numerical, projectable representations of observations and uses statistics to analyze results in an attempt to establish general laws and principles.
- The numerical representation and manipulation of observations for the purpose of describing and explaining the phenomena that those observations reflect. Used in a wide variety of natural and social sciences, including physics.

#### 6. Research and development

- Aimed at discovering new knowledge in hopes that such activity will be useful in developing or creating research findings into new and improved prototypes, processes or services.

#### 7. Secondary research

- Finding out what others have discovered through original research and trying to reconcile conflicting viewpoints or conclusions, find new relationships between normally non-related research, and arrive at your own conclusion based on others' work.

#### 8. Opensource development; Open Learning and research labs MIT

### **3 Goal**

The goal of my project is to provide a working simulation that will use many variables in order to simulate a dynamic complex ecosystem.

### **4 Design Criteria**

In order for my program to achieve its working goals, it must implement at least a base set of variables that can be manipulated to the user's needs. The most basic of all my variables will be species - there will be producers, consumers, omnivores, etc. Ideally, it will be able to control the number of these species to a certain degree (5 species is the desired amount) and also control the populations. Next, expansion will occur by introducing a trait factor for each of the species. According to the theory of natural selection, this will (like a real-world ecosystem) continually improve the existing populations because those with unfavorable traits would become nonexistent. The trait passing algorithm will be based upon the Punnett square (a simple matrix). Next, a factor for species mutation and new species invasion or creation will be implemented. This will be created by a random chance for the program to take a number of ghost classes and change them in accordance to the new species or mutated species. Last but not least, various natural disasters will be implemented, along with population characteristics. Natural disasters are the catastrophic events that effect the ecosystem, and the characteristics of the different species will mean that different natural disasters affect each species differently.

### **5 Procedure**

Using NetLogo, which will likely be turned into Python given time, I will be programming from the bottom, and expanding on the simple variables in order to create more complex variables. Eventually, there will be a complex dynamic ecosystem with a large amount of variables for optimum user control and definition of the ecosystem. At the end, the program (NetLogo) will be able to store data in a spreadsheet using the BehaviorSpace method.

## 6 Scope

I will validate success or failure when I have an accurate program for modeling while this might not follow the standard equations, at least I will have some type of imaginary ideal world simulation where the rules are the same as the ones I have programmed. I will try to make the modeling program as realistic as possible, but with so many factors, it will be difficult. By the end of the 2nd quarter, I will probably have implemented my evolutionary reproduction system. There will be mutations, adaptations, developments, new species, etc. By the end of the 3rd quarter I expect my goals to be finished. Hopefully, this will be in python.

## 7 Expected Results

The expected behavior / results of my simulation will probably be indicative of the normal standards of population behavior, when certain stresses or variables are predominant (for example, the theory of natural selection).

What contributions can these results give to future researchers (next year's seniors who would like to do a similar project, for example)? This will make it easier for future researchers to expand upon my project and add variables, change variables, and hopefully make it more realistic.

What time frame do you think you will need to accomplish the identified tasks and subtasks? I expect to be finished at the end of the 3rd quarter, the expected time frame.

## References