Supplemental Lab. EXTINCTION GAME


A. Introduction

The Extinction board game is designed to illustrate the key processes, i.e., reproduction, migration, mortality, competition, predation, and genetic change, necessary for survival of species. In addition, it illustrates the effects of human-induced changes, such as fragmentation and land-use changes, on population dynamics and extinction of species.

The game consists of several hypothetical animal species competing in an island ecosystem, Darwinia. The island of Darwinia is divided into six habitat types (each a different color). Each species (represented by cubes) competes for occupancy of these habitats. Each player (up to four total) plays one species. Winning Extinction requires that the winner’s species outcompetes all other species on Darwinia, either by being the sole survivor or the most abundant species after a certain period of time.

Throughout the game, each player tries to determine the best competitive strategy of his/her species. Players determine and change the genotypes of their species, which is made of seven different genes each having a variety of different alleles. By changing and improving the species fitness (i.e., genotype), a competitive advantage can be gained. However, gaining a competitive advantage can be difficult because the genotypes of others species change at the same time and the environment encountered by each species changes as the game progresses. The environment can change due to “natural” ecological events (determined by the chance wheel) or due to human activities, such as pollution and habitat fragmentation. These activities can upset the competitive balance between species or can even cause extinction of a particular species.

The Extinction game has several assumptions that make it a simplified version of real ecological processes.

1) Each player has a goal to win. In natural systems, survival or extinction of species is governed by natural selection. Natural populations are made up of individuals with a wide range of different genotypes, produced by the random processes of mutation and genetic recombination. Those genotypes better suited to survive and reproduce under certain environmental conditions will replace those less suited. In the game, the player by changing the genotype to try to best match the environment simulates natural selection.

2) Competition is won by numerical superiority alone. In natural systems, numerical dominance does not guarantee that a species will outcompete its competitors. Rather, species with overlapping ecological niches will most likely compete and one will likely eliminate the other.

3) Predators survive and reproduce at a constant rate regardless of whether they can or cannot find prey. In natural systems, predators rarely eliminate their prey and predation can depend on the density of prey.

4) The schedule of ecological events is random. In natural systems, animals usually breed only at certain times of the year, but they compete and predate more or less continuously.
In addition, survival is often age-dependent with young animals having a higher probability of death than older animals.

5) Human-induced changes do not have as large an impact as in natural systems. In the game, a habitat recovers quickly after disturbance. In natural systems, human-induced changes are widespread and often irrevocable, or recovery occurs on much larger time-scales (100 yr or more).

**B. Description**

1) Habitats
Each habitat type (n = 7) on Darwinia has a color code and is divided into hexagon units. Each player has a set of 20 population cubes of one color. A player occupies a particular habitat hexagon by placing a cube on it. No more than one cube can occupy a given habitat hexagon. The number of dots (from 1-6) uppermost on the cube represents the number of individuals occupying the habitat hexagon. Therefore, the maximum population size of any given species is n = 120 (20 cubes x 6 dots).

1) Genotype
Each player’s species has a genotype made up of seven genes, determining the following attributes:
1. litter size (LITTER SIZE GENE)
2. optimal habitat (HABITAT GENE)
3. mobility (MOBILITY GENE)
4. predator characteristics (PREDATOR TYPE GENE)
5. defense against predators (PREY DEFENSE GENE)
6. ability to cross natural and human-made barriers (BARRIER CROSSING GENE)
7. resistance to environmental changes (ENVIRONMENTAL RESISTENCE GENE)

There are several different forms of each gene, called alleles. In *Extinction* species have only one allele (card) for each gene at one time. Each gene card contains only one allele for a gene, except for the HABITAT and MOBILITY GENES. These two genes are linked and occur on the same gene card. Therefore, a player’s genotype consists of six gene cards.

3) Ecological events
The chance wheel is used to determine the sequence of ecological events in the evolution of a player’s species. The chance wheel is marked off into pairs of the following ecological actions that a player may take:
- reproduce
- migrate
- compete/predate
- change genes
- environmental change
- place barrier
A player must reproduce, change the environment, or place a barrier whenever the spinner lands on these events. All other actions are optional. Because action occurs in pairs on the chance wheel, the player must perform the first listed action first.

4) Barriers
There are five kinds of barriers in the game (2 of each). Three are naturally occurring topographic features: mountains, rivers, and deserts. The other two are human developments: cities and airports. When placed in a habitat hexagon, a barrier can prevent occupation of a hexagon by a species and prevents a population from moving from one part of the island to another.

5) Environmental change
A player draws an environmental change card when the spinner of the chance wheel lands on the “environmental change” space. These changes may be natural or human-induced. In either case, changes can have positive effects but usually have negative effects (eliminating part of all of a population) on the species of the player who draws the card or on all species.

C. How to Play

1) Separate the cards into six gene card piles on one pile of environmental change cards.

2) To start the game, throw any pair of population cubes to determine the order of play. The lowest scorer goes first and play continues clockwise.

3) Each player puts 30 individuals of his/her species on the island as a “founder” population. These 30 individuals are represented by the total number of dots showing on all of the player’s cubes on the board. These individuals can be put into any unoccupied habitat hexagon on the island; however, each hexagon can have only one cube.

4) After each player has colonized the island, each player has the opportunity to relocate his/her 30 individuals relative to those of his/her competitors.

5) Once this second round of play is over, all players draw their first set of alleles, one card from each of the six gene card piles. Then play begins. For each turn, each player spins the chance wheel to determine what ecological actions he/she may take. Each turn consists of the two actions and the one listed first on the space in which the spinner landed must be taken first.

Required Actions

Reproduce. Only those animals in optimal habitats (as specified by the HABITAT AND MOBILITY gene card) can reproduce. To determine the reproductive output of your population, count the number of individuals you have in optimal habitats, multiply this number by the litter size of your species (as indicated on your LITTER SIZE gene card), then divide by 10 (round off to the nearest individual). These newborn animals can be added to you population in two ways: 1) you can increase the number of individual in optimal habitats or 2) you can add new animals.
to hexagons adjacent to reproductive animals in optimal habitats. The player must add as many of the newborn animals to his/her population, even if that means that all the cubes in or adjacent of optimal habitats are turned to six.

**Environmental Change.** A species may be resistant to some environmental changes dependent upon the ENVIRONMENTAL RESISTANCE gene card. Natural environmental changes act only on the species of the player drawing the card. These include famine, pestilence, cold wave, and drought. Famine and pestilence eliminate the player’s species only in hexagons containing 5 or 6 individuals. The player that draws either of these changes must remove all cubes showing 5 or 6 dots. Cold wave and drought are changes that cause 10, 30, or 50 percent mortality in unprotected species. Determine the number of individuals by multiplying you total population size by the percent figure on the card (round off to the nearest individual), and remove them from your population.

Human-induced changes act on more than one species. Fires may burn any of the terrestrial habitats (i.e., woodlands, meadows, or brushlands). Water pollution may affect any of the aquatic habitats (i.e., marshes, lakes, or swamps). These changes eliminate all unresistant individuals in affected habitats. Air pollution affects cities and airports (two barriers), any species not resistant to air pollution in hexagons adjacent to cities or airports are eliminated. No species is able to defend itself against the remaining human-caused changes of the habitats of Darwinia. These include: cutting woodlands and draining swamps for farming, using marshes as landfills, filling lakes for housing developments, and grazing meadows or brushland with cattle. Whenever these changes occur, all species in the stricken habitats are eliminated, but the habitat may be repopulated later.

The third type of environmental changes (e.g., mild season) is positive, allowing a player the chance to take any set of actions on the chance wheel (except for another environmental change). After the player takes the moves of his/her choice, he/she returns to the second of the original moves chosen on the chance wheel.

**Place Barrier.** The player must place one barrier of his/her choice in any hexagon not occupied by a) another barrier or b) the last population cube of a species. Except for b), any individuals in the hexagon are removed. Habitats with barriers cannot be occupied by any species. Once all ten barriers are place on the board, the player must relocate one of the barriers.

**Optional Actions**

**Migrate.** The ability of a species to migrate depends on its MOBILITY GENE. The player may mover his/her species in any combinations of ways such that the number of individuals moved, times the number of hexagons traversed, is no larger than the mobility number on his/her HABITAT AND MOBILITY gene card). The maximum mobility does not need to be used in a turn and migration is always optional. A player may not migrate through habitats occupied by others species or by barriers that cannot be crossed (see your BARRIER CROSSING gene card).

**Compete/Predate.** The player may compete and predate in the same turn; however, he/she can only use each cube once per turn and can only remove rivals from hexagons adjacent to ones he/she occupies. To predate, the player announces his/her predator type (see your PREDATOR
TYPE gene card). Those rivals occupying adjacent hexagons whose PREY DEFENSE gene card defends them against this type of predator must show only that word on their PREY DEFENSE card as proof. Those that are undefended become prey. The predator may then occupy the prey’s hexagon with part or all of his/her animals from an adjacent hexagon. To compete, the player can only displace the adjacent rival with a larger number of animals. Thus if the player has six animals adjacent to a hexagon occupied by three of his/her rivals, the player must use at least four animals to occupy that hexagon. Predation and competition can occur across any barriers which the player’s species can cross (see your BARRIER CROSSING gene card).

Change Genes. A player may change from 0 to 4 genes in a turn. The linked HABITAT AND MOBILITY GENES count as one gene for this purpose. The player may not change any gene more than once in a turn. The player returns unwanted cards to the bottom of the pile before drawing a new card from the top.

D. Winning the Game

Winning Extinction requires that the winner’s species is the sole survivor on Darwinia or the most abundant species after a certain period of time.

If you play a game with a time limit, the final population score of each player is determined as follows: count the individuals on all your cubes showing 1, 2, 3 or 4 dots. The player with the highest score wins. This method of scoring means that sheer abundance will no necessarily win you the game. In nature, overcrowded populations have poorer long-term survival chance than less crowded ones. In the game, hexagons with 5 or 6 individuals are inevitably struck by a famine or pestilence at some time, unless their densities are reduced by other factors. Therefore, they contribute less to the long-term survival of player’s species and are not counted in the final population score.