***Online Lab focused on Population Genetics, especially Drift, Selection and Conservation Genetics***

**Population Genetics Simulation**

**Introduction**

Population Genetics Simulation can be found here:

<http://flask-env.rnwhymamqf.us-west-2.elasticbeanstalk.com/evo>

This simulation is designed to help you further understand how population size, natural selection and variability in the environment play a role in evolutionary change. This simulation was inspired by field work done on snowshoe hares which are genetically programmed to seasonally change their coat color from white to brown to match the color of the ground as snow melts. Being camouflaged appears to aid survival; field researchers found a 7% reduction in survival for each week a hare’s coat color mismatched its environment.

This simulation starts with a hypothetical population containing 4 equally abundant alleles (A.wk.15, A.wk.24, A.wk.26, A.wk.35). The number in each allele’s name indicates the week of the year a homozygote will switch its coat from white to brown. (For example, A.wk.15 homozygous hare will change from white to brown in the 15th week of the year, or early April. Other alleles will change later in the year.)

The six scenarios in this simulation will allow us to test the importance of population size, natural selection and stability of the climate on the process of evolution. Each run of simulation will track the frequency of the four alleles and therefore the evolution of the population of hares. After each run of the simulation you’ll find a graph presenting the change of allele frequencies over time and a graph presenting the change in the week of snow melt for each year in the simulation. Just like in the biosphere, chance events like random mating and the success of individual animals will play a role in how these simulated populations evolve. Fortunately, because this is a simulation, you can ‘rerun’ 50 years of evolution by simply pressing the button again. Feel free to run each scenario as many times as you want to deepen your understanding of each topic.

Now you will go through the lesson plan for each simulation outlined below to get a better grasp of population genetics. Have fun!

**Part A:  Population Size**

To begin, open the link given above and take a look at the simulation. You’ll find the different scenarios we will test and an empty graph ready for your use. We will initially simulate the population with no natural selection. This allows us to eliminate predators thus making all four alleles equally fit. We will also initially make the climate generally stable, so that the snow tends to melt in week 25 of the 52-week year (the end of June). Although these conditions might seem artificial, beginning in this way allows us to clearly focus on a surprisingly important factor; the effect of population size.

**A1: Large Population with No Selection in a Stable Climate.**

Alright first let’s run Scenario 1; the simulation for a large population with no selection in a stable environment. Check the button next to Scenario 1 and click the “run simulation” button. This will produce a graph underneath showing how the four alleles in the snowshoe hair population change overtime in terms of their frequencies. Make note of the different alleles represented on the graph and how their frequencies change especially if they survive or die out. Play around a bit with the graph: it should be interactive. Note that you can hide a curve(s) from view by clicking on the corresponding colored box(es) in the legend, thereby reducing the number of curves you need to look at. Similarly, you can get a more detailed view of the underlying data by hovering the cursor over a specific point(s) on each a line. Now save an image of your results from running Scenario 1 and paste it below this paragraph.

This graph shows a classic Hardy Weinberg result. Due to the large population, random mating and absence of natural selection, migration, and mutation the frequencies each of the four alleles stays about the same ( around 0.25).

**A2. Small Population with No Selection in a Stable Climate.**

Run Scenario 2; the simulation for a small population with no selection in a stable environment.Capture the graph and compare to these new results to those from A1. Remember that the only difference here is that this population is much smaller. Bear in mind that since there is no natural selection at play; all alleles have an equal chance of transmission in each new generation. Note that although frequencies fluctuated somewhat in large populations, they fluctuate quite a bit more in small populations. Because this process is random rather than due to directional natural selection this is known as **genetic drift**.

Now rerun the simulation repeatedly; (at least 2 more times, depending on your results…). Note that different alleles are ‘fixed’ (reach a frequency of 1.00, taking over the gene pool) in different runs. Capture images for three different alleles reaching a frequency of ‘1’. Paste those three different graphs below:

In the space provided below, explain why these graphs demonstrate that these results are due to drift, NOT natural selection.

**Part B. Natural Selection.**

Now that you’ve observed that small populations an allele can be fixed due to drift rather than superior contribution to fitness, let’s run the scenarios with natural selection. For simplicity, this simulation makes all alleles act as incomplete dominants. Since hare’s are diploid, an animal’s two alleles are averaged to obtain their week of coat color change from white to brown. This week of color change is compared to the week of snow melt for each of the many years 50 modeled in a run. The longer an animal’s week mismatches it’s environment, the higher the chance natural selection will kill that animal and remove its alleles from the gene pool. Let’s look at an example to understand how this would work. Imagine that the climate is stable with the snow melting during week 25 of the year. A heterozygous animal of genotype (A.wk.15/A.wk.35) changes its coat from white to brown in week 25 (e.g. ((15+35))/2)=25) thus would be well adapted for a climate in which snow typically melts in week 25. By contrast, a an animal with two copies of the A.wk.10 would change their coat from white to brown in week 10 ((10+10)/2=10) and be poorly adapted because due to 15 weeks of mismatched coat color.

**B1. Natural Selection with a Large Population.**

Run Scenario 3; the simulation with natural selection in a large population. Save an image of your results and paste it below.

Compare your graph above to the results of A1 (which differs only due to no selection). Run the simulation a four times to see how reproducible the results are. Which alleles tend to win and why? Which are selected against and why? Use the space provided below to answer these questions.

**B2. Natural Selection with a Small Population**.

Run Scenario 4; the simulation with natural selection in a small population. Just like you did for A2, run this simulation four times, comparing the results of each run.

Does population size have on the effectiveness of natural selection? Explain your answer in the space below.

**Part C. Simulating Climate Change**

Now we will run the simulation with climate change. Climate change will tend to move the week of snowmelt earlier in the year as time passes. This means that the snowmelt moves away from week 25 (July) and towards week 12 (April) or even earlier. You’ll find the graph showing the change of the week of snowmelt at the bottom of the page. Use this graph after running each simulation to better understand how climate change impacts the allele frequencies over time.

**C1. Climate Change and Natural Selection in a Large Population.**

Run Scenario 5: the simulation with climate change and natural selection in a large population. Take a look at the lower graph with the weeks of snowmelt to note the impact of climate change as the weeks get earlier and earlier in the year. As above, run the simulation four times and capture images of the results, pasting them below.

Compare the results of the allele frequencies you found for B1. Which alleles tend to perform best? Use the space provided below to answer.

**C2. Climate Change and Natural Selection in a Small Population.**

Run Scenario 6: the simulation with climate change and natural selection in a small population. Run at least four times, and keep running it thereafter until you see at least one case where all four alleles reach a frequency of zero; this represents population extinction. Capture the case of population extinction and paste it below.

Compare these latest results to those you generated for A2 (a small population with no selection or climate change). How does a smaller population perform under the challenging conditions of selection and a changing environment? Why is this scenario the one most likely to show extinction? Under which circumstances is it most likely to results? Use the space provided below to answer these questions.