Homework 4: Life History Evolution

1. Invasion fitness
In class we used an adaptive dynamics approach to study the evolution of carrying capacity in the logistic model K. Let's do the same for demographic traits in the Beverton-Holt model of growth. From homework 2 we have that the population dynamics in the Beverton-Holt model are given by:

$$N(t+1) = \lambda N(t) \frac{1}{1+\alpha N(t)}$$

A. Start by assuming the $\alpha(z) = z$. Use an adaptive dynamics approach to determine whether evolution should favour an increase or decrease in α.

B. Repeat part A but now for other demographic trait λ (assuming α is constant).

C. Propose functions $\alpha(z)$ and $\lambda(z)$ that may give you a finite evolutionary singular strategy. You need not show that it does.

2. Mutation Accumulation

In class we considered the evolution of an antagonistic-plieotropic allele that have fitness benefits and young ages and deleterious effects at older ages. A non-mutually exclusive explanation for the evolution of senescence is that deleterious mutations are under less selection at older ages and hence obtain higher frequencies.

A. Propose a model of mutation-selection balance in a non-age structured population. Consider a life cycle of Census->Mutation->Selection->Reproduction. Assume that the mutation is deleterious

$$W_{AA} = (1-2s), W_{Aa} = (1-2s), \text{ and } W_{aa} = 1$$

and that mutations from A->a and a->A occur at the same rate μ.

What is the equilibrium allele frequency of the mutation and how does it depend on s and μ?

B. Suppose that in the absence of mutation the death rate is d_0 with the probability of survival being $M = 1 - d_0$. The mutation increases death rate.

$$d_{AA} = d_0(1+2s), d_{Aa} = d_0(1+s) \text{ and } d_{aa}(a) = d_0$$

Consider a model with three age classes and an age-independent fecundity of F. Calculate the expression for the quasi-equilibrium and young-only approximations for the fitness of a mutant. Compare these fitnesses to the analogous fitnesses in the wild-type population.

C. Analyzing a Leslie matrix numerically (assume $d_0 = 0.3$, $F = 1$, $s = 0.1$) compare the stable age distribution of the mutant and the wild-type.

3. Seed Dormancy with seedling survival
In perennials newly germinated seeds have a different probability of survival than adult plants (e.g., raspberries). To incorporate this into our perennial model of seed dormancy evolution let's introduce a environmental-dependent juvenile survival s_{Ji}.

A. Propose a recession equation for this system.

B. Calculate the long-term growth rate. Characterize numerically under what conditions does the population grow? Assume $\bar{s}_J < \bar{s}_A$.

C. Use a combination of analytical and numerical methods to explore how juvenile survival impacts the evolution of seed dormancy. You will have to make assumptions about correlations between environmental-dependent components– justify your choices.