Ecological Problem Solving

FW 364

Assignment 5

**Due: October 29**

**Learning objectives**: In working through this exercise, we reinforce the distinction between deterministic and stochastic fluctuations in population size, and see density dependence in action. We again apply the concept of risk by estimating risks of extinction and explosion. Note: most of the challenge is in the interpretation.

In this exercise, we will explore how two types of density dependence influence (A) a population's **deterministic** dynamics as well as (B) its **stochastic** risk of extinction/explosion. This will help clarify the distinction between deterministic and stochastic population fluctuations. The interaction between these two types of fluctuations also illustrates the subtle difference between scramble (exploitative) and contest (interference) density dependence and the value of understanding how a particular natural-resource population is regulated.

Part A: Density dependence and deterministic population dynamics

For the first part of the exercise, we will examine **deterministic** trajectories for two populations growing from low density to carrying capacity, as might occur when a species invades a new habitat. We will compare trajectories in habitats of low and high productivity (simulated by using two λmax values for each population). The two populations are characterized by different modes of intraspecific competition: scramble versus contest. To accomplish this part of the exercise, I ran four deterministic simulations (replications set to 0) in the Population Growth module of Ramas EcoLab, using the following set of values for each run: duration = 25, carrying capacity (K) = 50,000, and an initial (single) abundance (N0) of 200. Compare population trajectories using combinations of low and high λmax (2.5 and 6.5, simulating habitats with differing productivities) and scramble versus contest density dependence. You are, therefore, examining four combinations of the two factors (density dependence type crossed with habitat productivity; this is called a 2x2 factorial design).

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| --- | --- | --- |
| λmax | Scramble Competition Time to K=50,000 | Contest Competition Time to K=50,000 |
| 2.5 |  |  |
| 6.5 |  |  |

Make a single plot in Excel with all four trajectories. **Comment** on any qualitative differences in how the populations in each simulation reach carrying capacity. **How does the effect of increasing λmax differ between the two types of density dependence?**

Part B: Next, **plot the density-dependence functions (λ versus density) for each of the four simulations.** Make one graph in Excel that shows the four trajectories of λ versus density (adjust the graphing options to ensure none of the trajectories is covered up). **Looking at the graph, compare the values of λ (the dependent variable) at low and high density (the independent variable) for scramble versus contest. Which is higher/lower? What might these differences mean in terms of how much the population fluctuates?** This comparison will help us to understand one way in which the type of density dependence influences the stochastic risk of extinction/explosion in the next part of the homework.

Part C: Density dependence and stochastic population dynamics

For the second part of the exercise, we will simulate the **stochastic** dynamics of each population **after it has reached carrying capacity**. By introducing random variation in population growth rate (i.e., a stochastic simulation), we will cause the populations to fluctuate randomly about carrying capacity and examine how the type of density dependence and the magnitude of λmax influence each population's risk of rising above (explosion risk) and falling below (extinction risk) certain levels (population thresholds). To accomplish this part of the exercise, we will run 4 stochastic simulations using the following set of values: replications = 1000, duration = 50, K = 50,000, N0 = 50,000, survival rate = 0.90, and **standard deviation of λ** = 0.20 (we are not using demographic stochasticity). Note that by setting the starting population size (N0) at 50,000 (equivalent to K), we can investigate population dynamics at carrying capacity. As before, we ran simulations for each combination of low and high values of λmax (2.5 and 6.5) and scramble versus contest density dependence. Using the data, record the risk of the population **falling below 30,000**, and the risk of the population **exploding above 70,000**.

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| --- | --- | --- | --- | --- |
| λmax | Scramble Risk of Falling Below 30,000 | Contest Risk of Falling Below 30,000 | Scramble Risk of exploding above 70,000 | Contest Risk of Exploding above 70,000 |
| 2.5 |  |  |  |  |
| 6.5 |  |  |  |  |

Compare and contrast the risks of extinction/explosion for the two types of density dependence at low and high values of λmax. Is one or the other type of population more prone to extinction/explosion in habitats with low and high productivity? If there is a difference in the behavior of the two types of populations at low and high productivity, your earlier findings provide any clues as to why (see Part B)? Keep in mind that random fluctuations in population growth rate will push the population away from carrying capacity, at which point the type of density dependence will determine how the population returns to carrying capacity (fast or slow, smoothly or cyclically).