Rosenzweig-MacArthur Plot Additional Questions

**Questions to Answer:**

**How do the dynamics differ from Lotka-Volterra**

The dynamics of the Lotka-Volterra (LV) and Rosenzweig-MacArthur (RM) models are very closely related, as the RM model is amended version of the LM model. In both models, the dynamics typically follow the dynamic response where as predator populations decrease, prey populations increase. In the LV models shown in the section above, this was always paired with dynamic response in which as prey populations increase, predator populations can increase until reaching a maximum and falling again. These cyclic, oscillatory dynamics applied for all simulations of the LV model. The RM model dynamics differ as a result of the introduction of additional terms. Namely, the RM model accounts for the predator search rate, *w*, intraspecific competition coefficient, α, and the density of prey at which the predator kill rate reaches half its maximum, *d*, but the RM does not account for the predator attack rate, *a*, that the LV model does. The introduction of these terms allows for simulations in which the dynamics are not cyclic, but rather reach a steady-state response. There are some instances of cyclic dynamics between predator and prey populations in the RM model for the cases tested, but the introduction of these terms does not only allow for these lower-order responses.

**What can you say about the “role” of each parameter, especially what causes the dynamics to differ between the L-V and R-M models?**

Below, simulations for the RM model are shown for a variety of parameters. To start, the base case is shown, where the simulation is run for the parameters given in the project problem statement. Then, each parameter (*b*, α, *w, d, e,* and *s*) is isolated in order to evaluate its effect on the dynamic response of the model. For each parameter, all other values are held constant while the parameter value is first tripled and then halved in order to understand how the parameter affects the predator-prey populations over time. Following the plots showing the simulations for each parameter, an analysis of the parameter’s effects on the populations of predator and prey is given, highlighting the differences of the parameters effects between the LV and RM models if applicable. In addition, the relationship between parameter values and predator abundance are given for each parameter value.

In all cases, the predator population is defined by the red line and the prey population is defined by the black line.

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| Base Case for LV Model | Base Case for RM Model |
| C:\Users\Cole\Downloads\LVPlot.png |  |

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| Triple the Prey Birth Rate (b) | Half the Prey Birth Rate (b) |
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The prey birth rate has the most profound effect on the predator prey dynamics at the beginning of the simulation. When the prey birth rate is tripled, there are a lot of new prey born, which allows for higher populations of predators to be sustained. This high predator population is able to level out once the high prey birth rate is balanced out by the rate at which predators kill the prey. At this point, both populations are sustained at much higher values than in the base case. In the case that the prey birth rate is halved, the prey population immediately drops before rising again in dynamics that would suggest steady state response in the far future.

In the LV model, the prey birth rate controls how high the maximum populations of predator and prey are at each of their peaks, as well as the rate of increase or decrease approaching and following those peaks, especially for the prey. This holds true in the RM model at the beginning, as the prey population spikes sharply for the tripled birth rate. In opposition to the LV model, halving the birth rate results in an immediate reduction in prey population. This is due to additional factors *d* and *w* affecting the dynamics. In the LV case, the predator-prey populations were cyclic, but in the RM model for tripled birth rate, the dynamics are not cyclic but reach steady state again. For the halved birth rate RM model, the dynamics may still be cyclic, but at a much lower frequency than for the LV model.

Increasing the birth rate results in a higher steady state predator abundance along with a predator population change rate that is always either positive or zero. Decreasing the birth rate results in a lower steady state predator abundance than the RM base case.

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| Triple the Intraspecific Competition Coefficient (α) | Half the Intraspecific Competition Coefficient (α) |
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The intraspecific competition coefficient determines the degree to which the populations of each species affect the populations of their predator-prey counterpart, and is inversely related to the carrying capacity of the prey. When the competition coefficient is tripled, there is a very high affect between the populations of each species and an end result of very low steady state populations for both predator and prey due to the reduced carrying capacity. When the competition coefficient is tripled, the swings in population occur with much greater magnitude than in the base case since a relatively large increase in prey population tends to not have such a large change on the prey populations ability to sustain itself. Both steady state populations for predator and prey are higher for this halved coefficient case than for the RM base case.

There is no direct analog between the intraspecific competition coefficient in the RM model and any parameters in the LV model, so no effective comparisons can be made between the two with respect to this parameter. Still, halving the competition coefficient for the RM model results in cyclic dynamics between predator and prey that are characteristic of the LV model.

Increasing the competition coefficient results in drastically decreased predator abundance. At a predator population < 1 individual at the end of the simulation, effectively the predators have died out, whereas in the base case the predator population reached a positive steady state value. Decreasing the competition coefficient by a factor of two resulted in more cyclic dynamics of the predator population and a higher peak value of predator abundance than in the RM base case.

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| Triple the Predator Search Rate (w) | Half the Predator Search Rate (w) |
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The predator search rate in unit area per time linearly affects the degree with which the predators are able to find prey, assuming a constant density of predators per unit area. When the search rate for the predators is tripled, the predators have a very easy time finding prey, and nearly wipe out the initial population of prey. After a long period of time, the prey population spikes back up, which can eventually sustain a relatively large population of very effective searching predators, killing off almost all prey again cyclically. When the predator search rate is reduced by a factor of two, the predators have a very hard time finding prey and die off very quickly, allowing the prey to asymptotically approach its carrying capacity population at steady state.

There is no direct analog between the intraspecific competition coefficient in the RM model and any parameters in the LV model, so no perfectly effective comparisons can be made between the two with respect to this parameter. The closest analog to the predator search rate would be the predator attack rate from the LV model. Increasing the predator search rate in the RM model and the predator attack rate in the LV model elicit similar cyclic dynamics where the prey populations are kept relatively low for most of the time as a result of very high frequency predator attacks/effective searches. Decreasing the predator search rate in the RM model and the predator attack rate in the LV model results in much higher maximum prey populations, but the LV model has cyclic dynamics whereas the RM model reaches steady state almost immediately partially as a result of the additional terms in the RM model.

Increasing the predator search rate results in less stable predator abundance than for the RM base case, with high but rare peaks. Decreasing the predator search rate results in a drastic decrease in predator abundance, where the predator population effectively dies out very quickly.

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| Triple density of prey at which the predator’s kill rate reaches half its maximum (d) | Half density of prey at which the predator’s kill rate reaches half its maximum (d) |
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| Triple the Conversion Efficiency of Prey to Predators (e) | Half the Conversion Efficiency of Prey to Predators (e) |
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| Triple the Predator Death Rate (s) | Half the Predator Death Rate (s) |
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