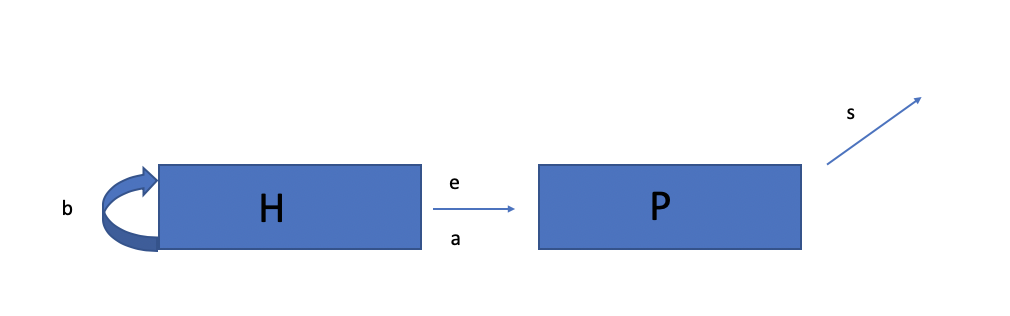
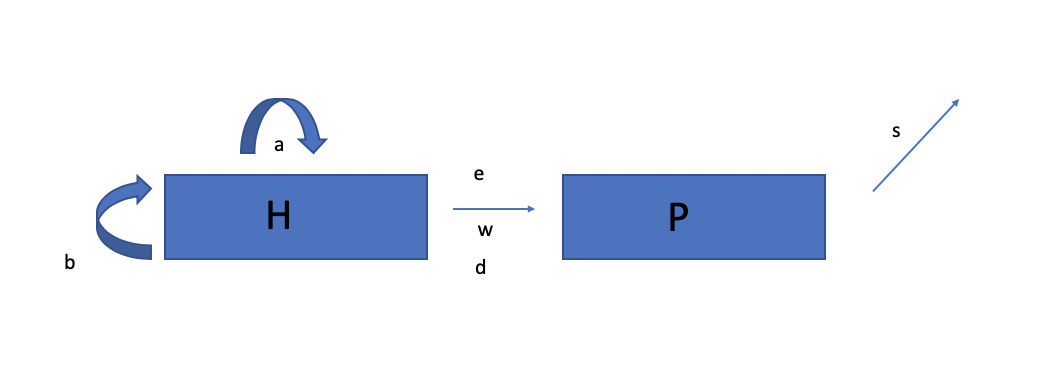
Andrew MacKinnon

Megan Hartle

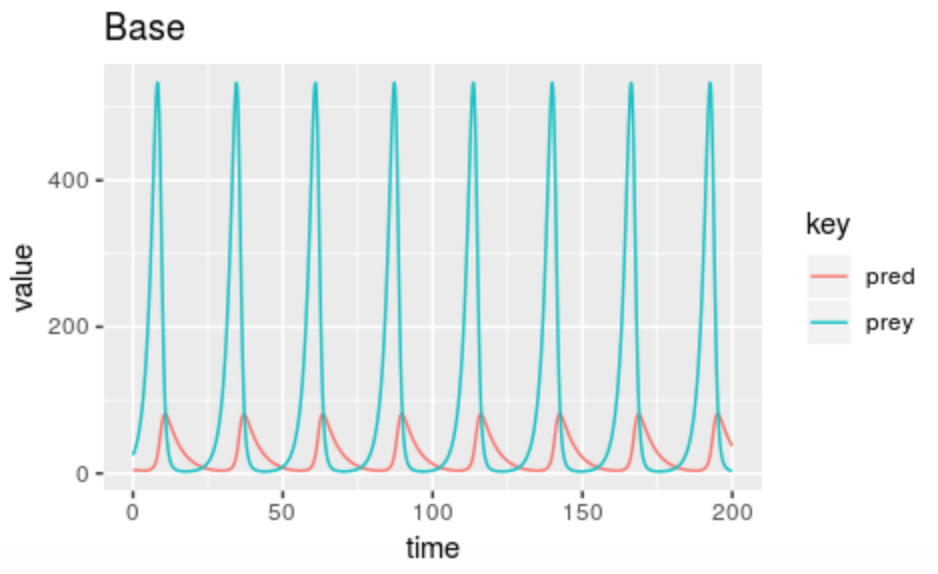
Gabriel Tauro

Dynamic Modeling Project

**Lotka Volterra vs. Rosenzweig MacArthur**

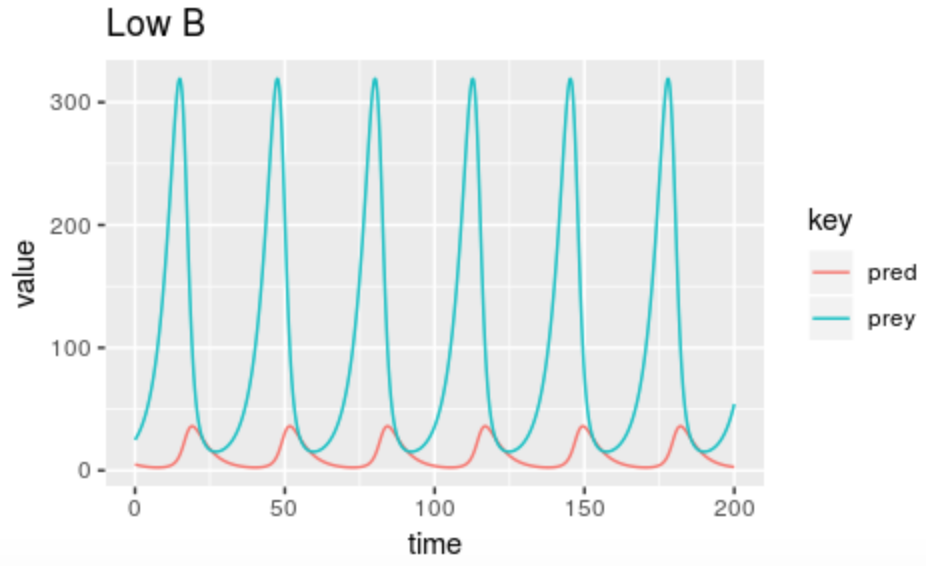
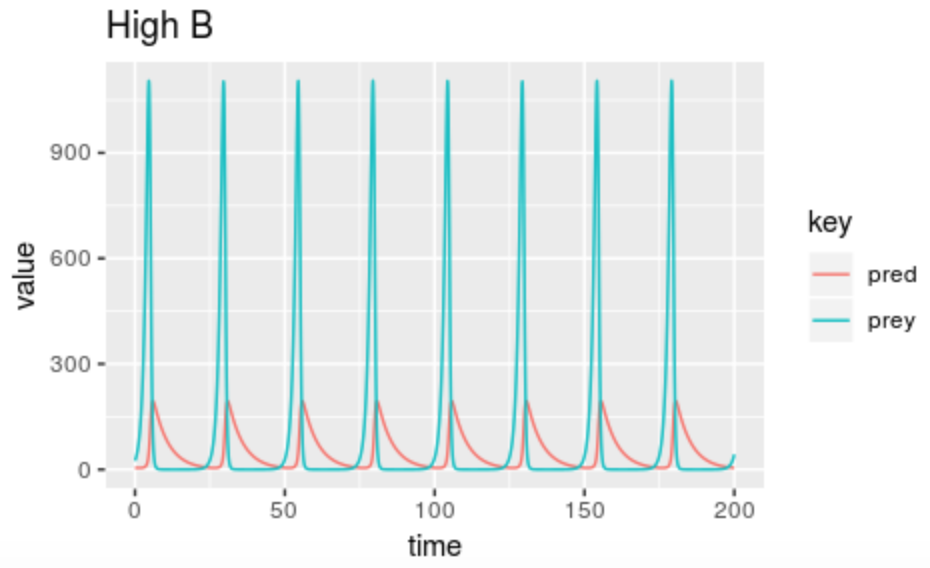


**LV Model Questions:**



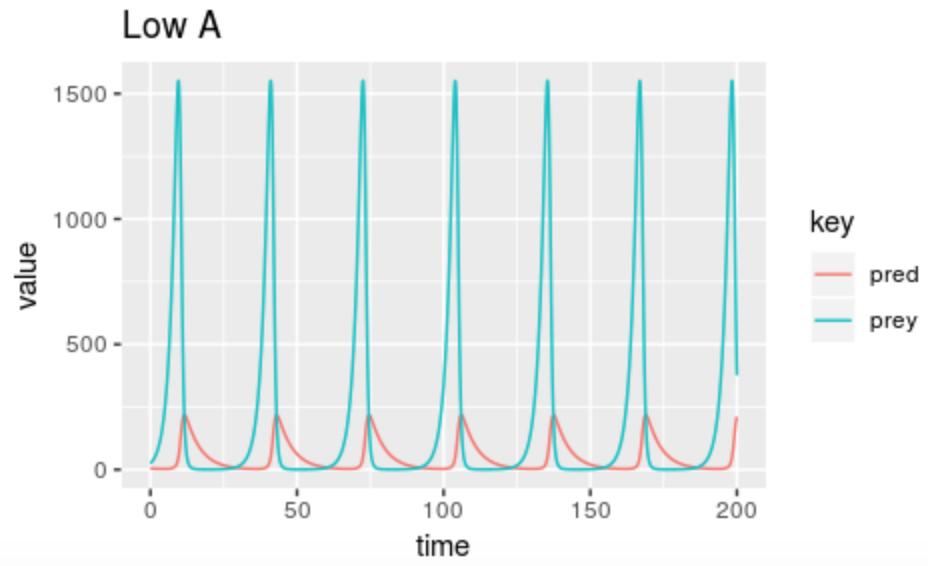
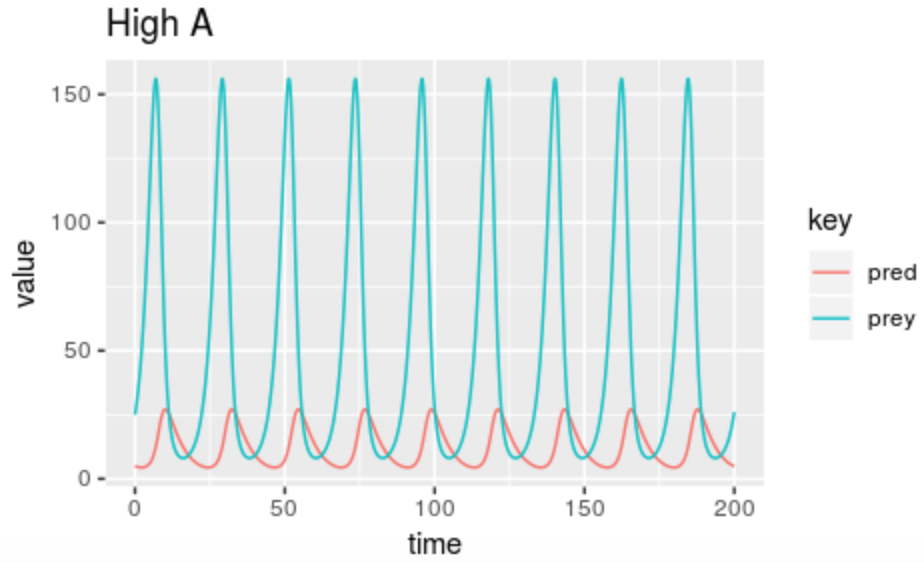
This is the baseline graph where b = 0.5, a = 0.02, e = 0.1, and s = 0.2. In each of the following simulations, the “high” value is equal to the original parameter doubled in value, and the “low” value is equal to the original parameter cut in half. For example: High b is when b = 1, Low b is when b = 0.25.

**What can you say about the “role” of each parameter?**



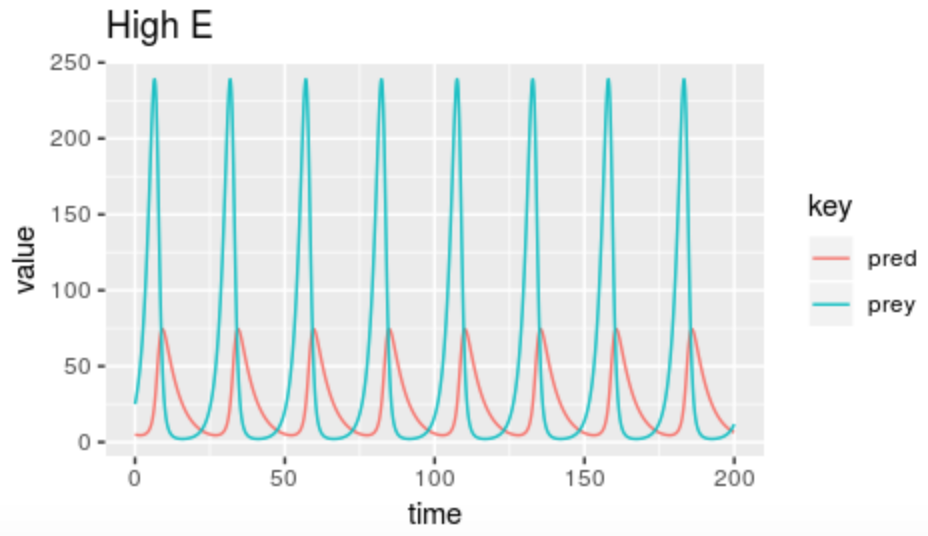
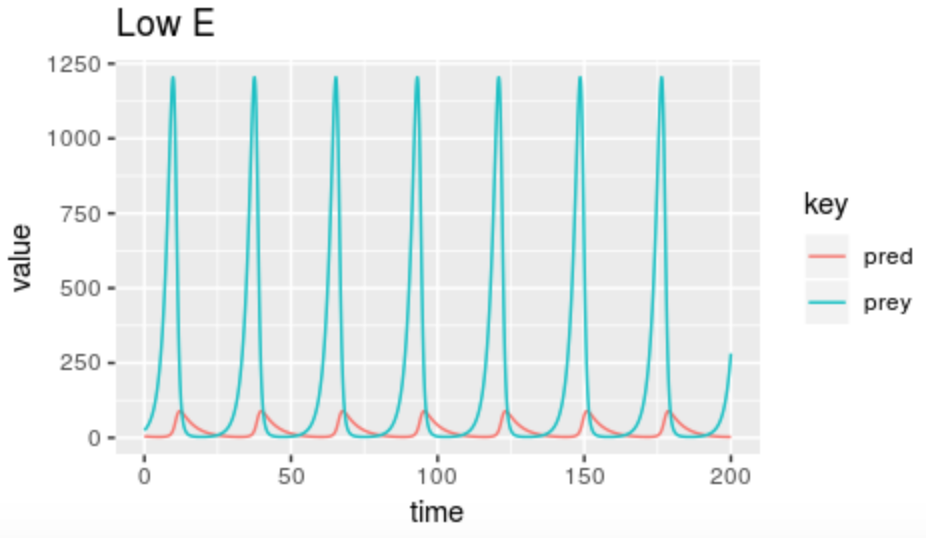
“b” = Prey birth rate

Higher values of “b” increase the amount of prey by more than triple the value, it also increases the value of predators but not nearly as much. As the predator value spikes, the prey value drives to close to 0 immediately. When there is a lower value of “b”, the values of prey always stay above the values of predators. This may be due to the fact that there are less prey available for predators to survive on, so more predators die off quicker.

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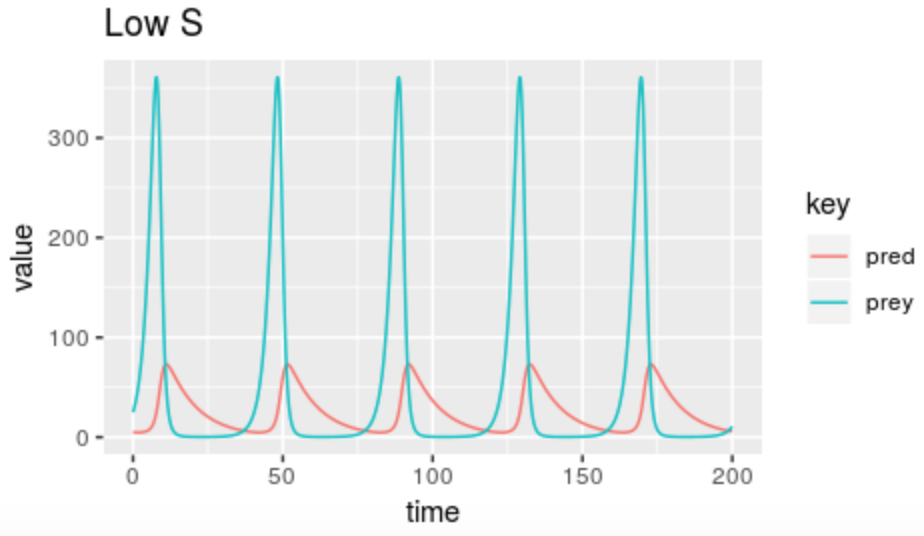
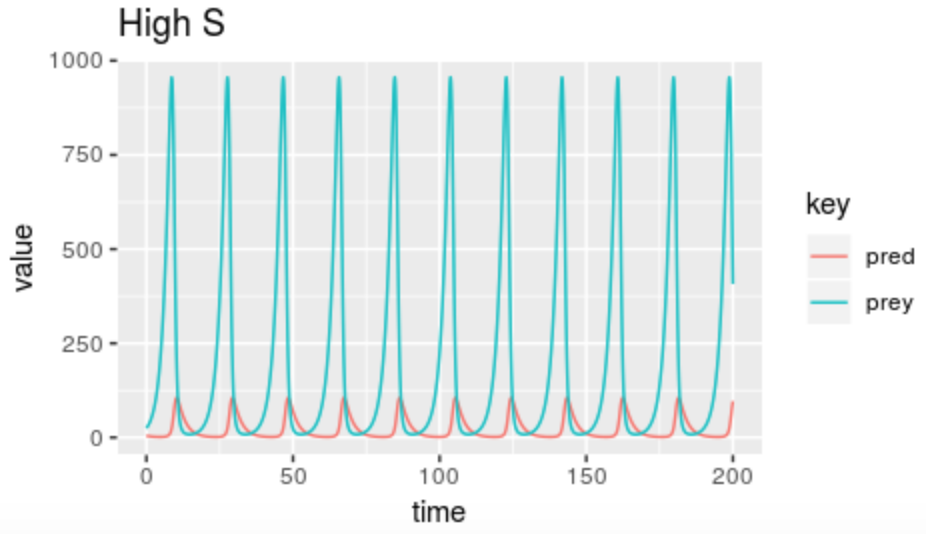
“a”: Intraspecific competition coefficient, or predator attack rate

Lower values of “a” leads to an increase in prey and predator values by ten-fold. This makes logical sense because “a” is the rate at which predators attack and kill prey. So, when this rate value is small, there are more prey that survive due to less predators attacking and therefore driving the values of prey down.



“e” = Conversion efficiency of prey to predators

Higher values of “e” leads to smaller amounts of prey, which makes sense because “e” stands for the conversion efficiency. This conversion efficiency is related to the biomass, not strictly the amount of prey turning into predators. The more efficient the rate is, lower the value of prey there is, and therefore higher value of biomass that was converted.



“s” = Predator death rate

Higher values of “s” leads to a significant increase in the value of prey. This makes sense because with more predators dying, this allows for prey populations to increase. In addition, the slope of the predator cycle is much steeper. This also makes sense because when the predator death rate is high, the amount of predators decreases much faster than normal. When the value of “s” is lower, the slope of predator cycles is not as sharp, and the number of prey is smaller relative to the higher “s” graph.

**What can you say about the role of predators in the simulation?**

The role of predators in this simulation serves as a driving force for the actions of the model as a whole. Prey values depend on the different parameters explained above. All of the parameters relate to predators except prey birth rate. In this case, prey are their own enemy and limit their own survival as a result of increased population size. In testing parameter values, it can be seen that predators are the dominant force in this simulation. This is consistent with the role of predators in relation to prey in their rankings on the food chain.

**What is the relationship between parameter values and predator-prey cycle length?**

a: Lower values of “a” leads to shorter prey cycles and longer predator cycles. This makes logical sense because with lower interspecific competition, predators will live longer, and will drive down the prey populations faster as a result. Lower values of “a” also lead to a lower frequency of both predator and prey cycles.

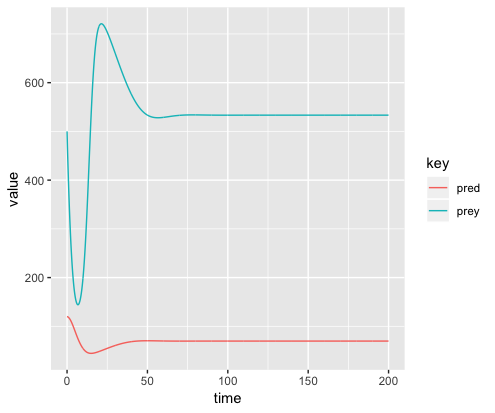
b: The prey cycle is extremely short with higher values of “b”, which makes sense because they are all typically born around the same time, and thus compete for resources and many die quickly. The predator cycles extend longer which makes sense because there is more prey available and predators will survive longer as a result.

e: Higher values of “e” don’t change the frequency of the cycles of predators and prey, but higher “e” values shortens the cycle length of predators. In addition, when e is low, the predator cycle slope is constant and stays relatively flat, whereas higher “e” values lead to a more dramatic predator cycle slope. This is consistent because the biomass is shifting to predators at a much more dramatic rate when the value of “e” is high.

s: Higher values of “s” significantly increases the frequency of both predator and prey cycles. This makes sense because predators are dying faster, so the cycle is short, and re-starts in a much shorter amount of time. The length of each of the life cycles for the prey increases with higher values of “s”, whereas the length of the predator cycle decreases with higher values of “s”. This makes sense because with higher values of “s” that means there is a higher predator death rate so predator cycles decrease, whereas the opposite occurs for prey because they are able to live longer without being killed.

**RM Questions**

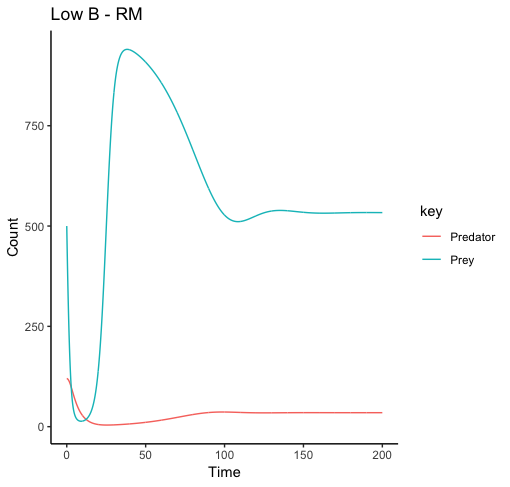
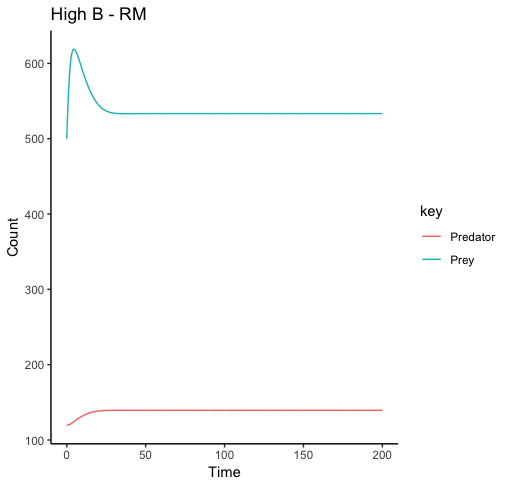
Base RM Simulation. All “High” and “Low” designations refer to a doubling and halving of the respective parameter from this simulation, where b=.8, a=.001, w=5, d=400,e=.07 and s=.2



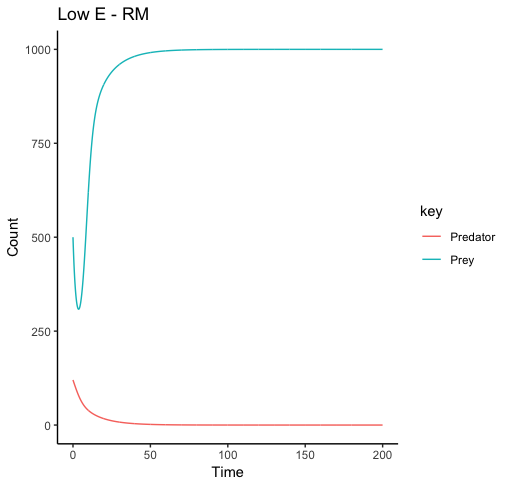
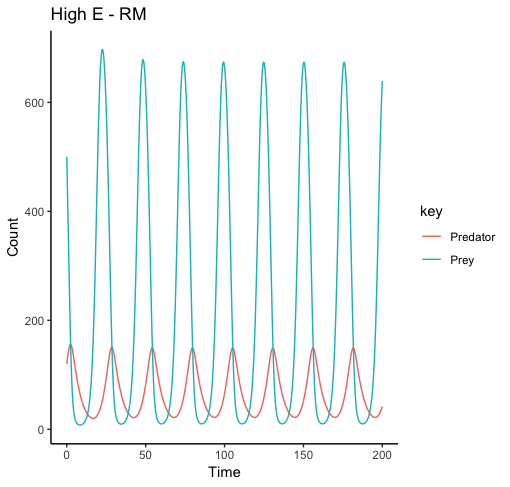
**How dynamics different from Lotka-Volterra**

The Lotka Volterra and Rosenweig MacArthur models are different because the Rosenweig-Macarthur model includes a carrying capacity for the prey and limits the amount of prey that the predators can kill per unit time. The positive factor of prey growth is represented by bH(1- αH), rather than simply bH in the Lotka-Volterra. In the Rosenweig-Macarthur model, the birth rate is multiplied by the prey population, times one minus the current prey population divided by the carrying capacity. The RW model also replaces the simple attack calculation “a\*H” in the LV model with w(H/d+H). “w” replaces “a” and (H/d+H) replaces H. As H becomes very large then this quotient increases closer and closer to 1.

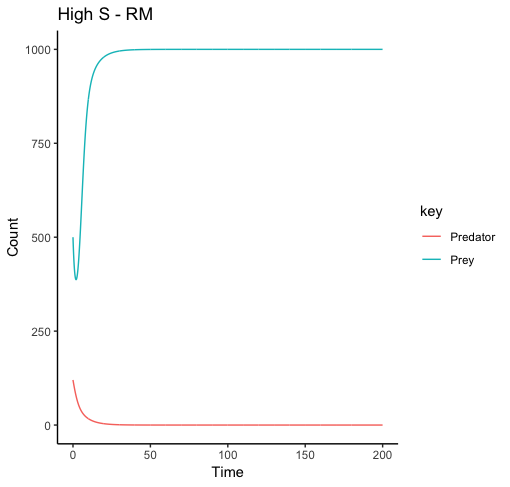
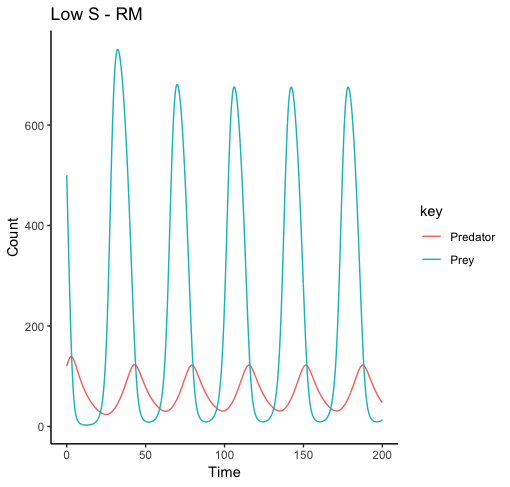
**Role of each parameter, what causes different between L-V, R-M**

“b” is the birth rate for the herbivores. A high birth rate allows prey growth to outpace prey death from predators immediately, a low birth rate causes prey to decrease before rebounding when predators become low enough. “b”’s effect is not limited by carrying capacity in the LV model. “b\*H” is multiplied by zero when H = k in the RM model.

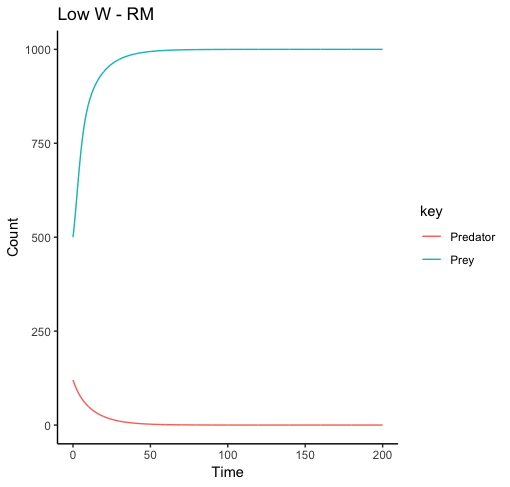
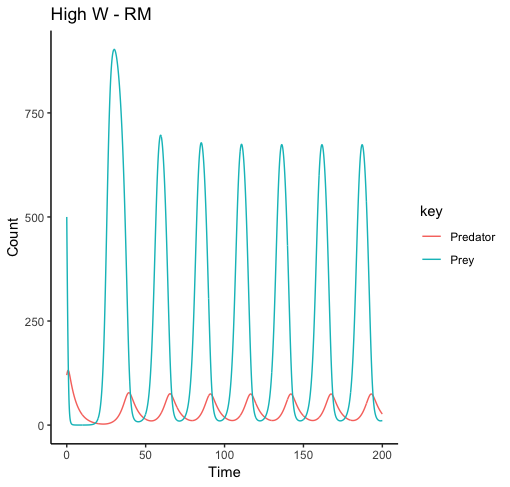
“e” is the conversion efficiency from herbivores to predators. High “e” allows the predator population to recover cyclically as herbivore population increases in the RM model, vs. low “e” causes decrease to 0. “e”’s effect is limited by the limit of predator response via (H/d+H), which is different from the L-V model. High E causes very fast predator-prey cycles, with prey peaking close to 600 and predators peaking around 200. Low E allows causes prey to reach equilibrium around 100 quickly, and predators to reach equilibrium close to 0.



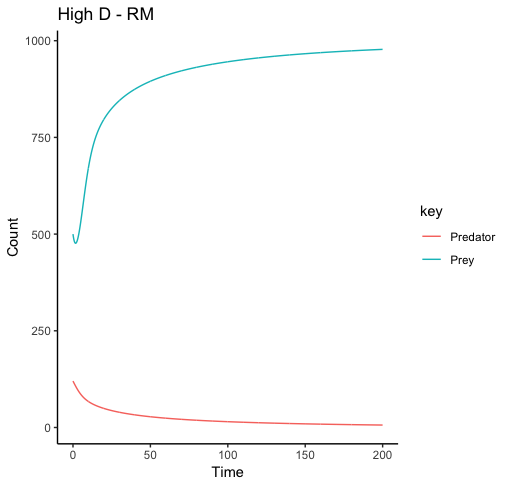
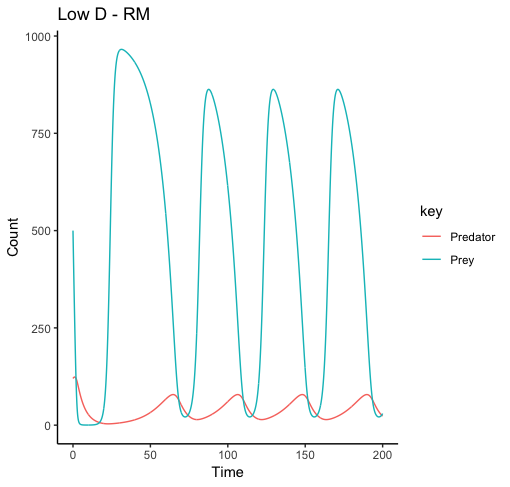
“s” is the predator death rate. It functions identically in both models, having a negative effect on predator growth rate. A high “s” causes predators to reach an equilibrium close to zero quickly, while prey increase quickly and reach an equilibrium close to 1000. A low “s” creates cyclical changes with predators increasing during prey peaks.



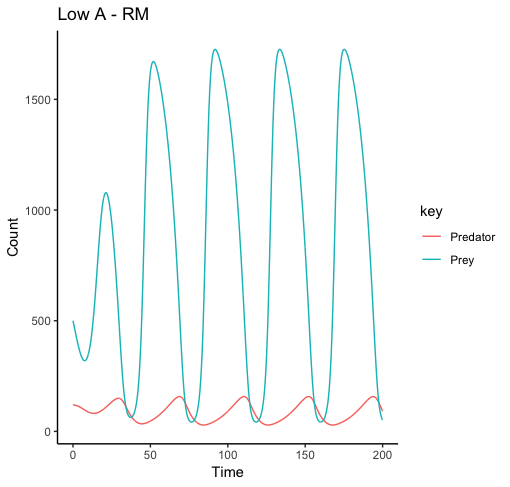
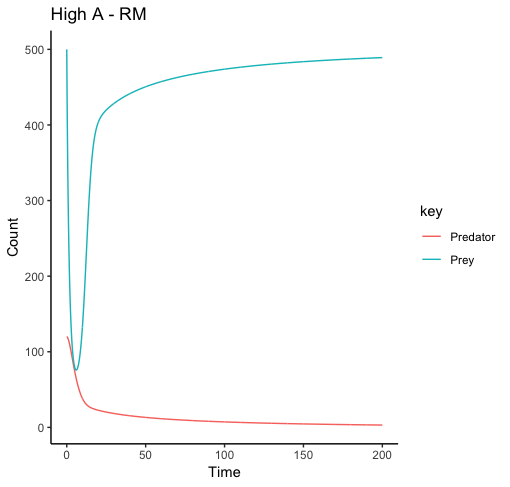
“w” is the substitute for the “a” predator attack rate. Unlike in the LV model, the “w” is also affected by the (H/d+H) factors, which approaches 1 as H gets very large. A high “w” creates cyclical changes for prey and predators, with predators increasing as prey peak. A low “w” makes prey increase quickly to an equilibrium around 1000, while predators decrease and reach a low equilibrium close to zero.



“d” modifies the predator attack rate along with the prey population. This plays a big factor in the difference between the LV and RM models. A high D reduces the growth of predators that caused by the attack rate and the growth of prey. Prey reach an equilibrium between 750 and 100 quickly and predators reach an equilibrium close to 0. A low D increases the influence of the attack rate and conversion efficiency on the dynamics - (H/d+H) gets closer to 1 - and results in prey cycles with large amplitudes peaking close to 1000 and predator cycles with a smaller amplitude peaking around 100.



“α” is 1/k, or the inverse of the carrying capacity. Α limits the growth caused by prey birth rate. When H = α, bH(1-αH) = 0. This carrying capacity factor does not exist in the LV model, acting as a big source of differentiation. A high “α” means a low carrying capacity, and prey reach an equilibrium around 500 while predators declines below ~50. Low A allows prey to reach higher levels and initiate cyclical changes in prey and predator populations.



**Relationship between parameter values and predator abundance**

High “b” is beneficial for predator abundance, increasing the amount of prey available for the conversion expression or prey to predator.

High “e” is beneficial for predator abundance, controlling how well predators able to grow given a certain number of prey

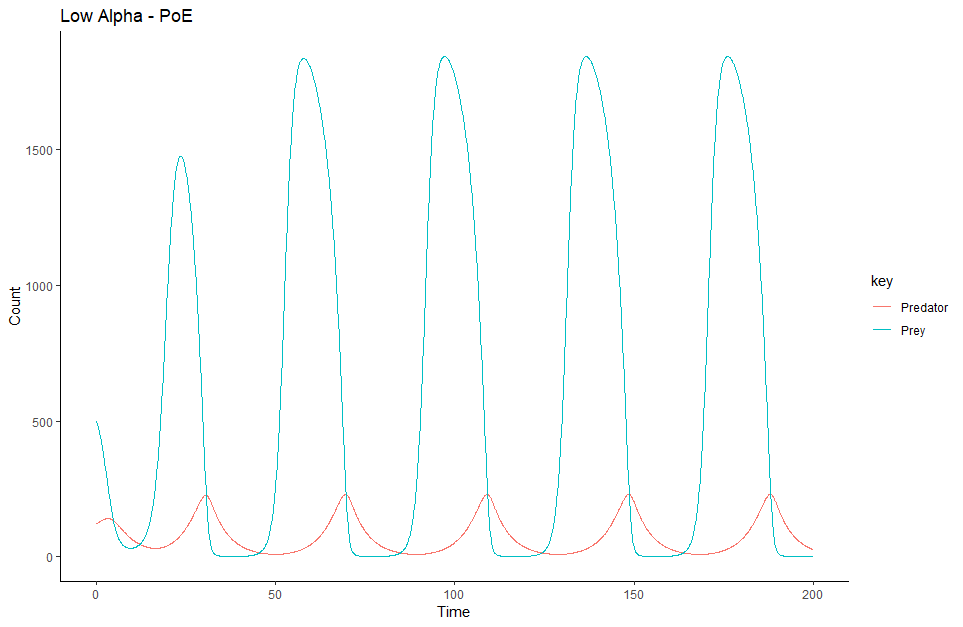
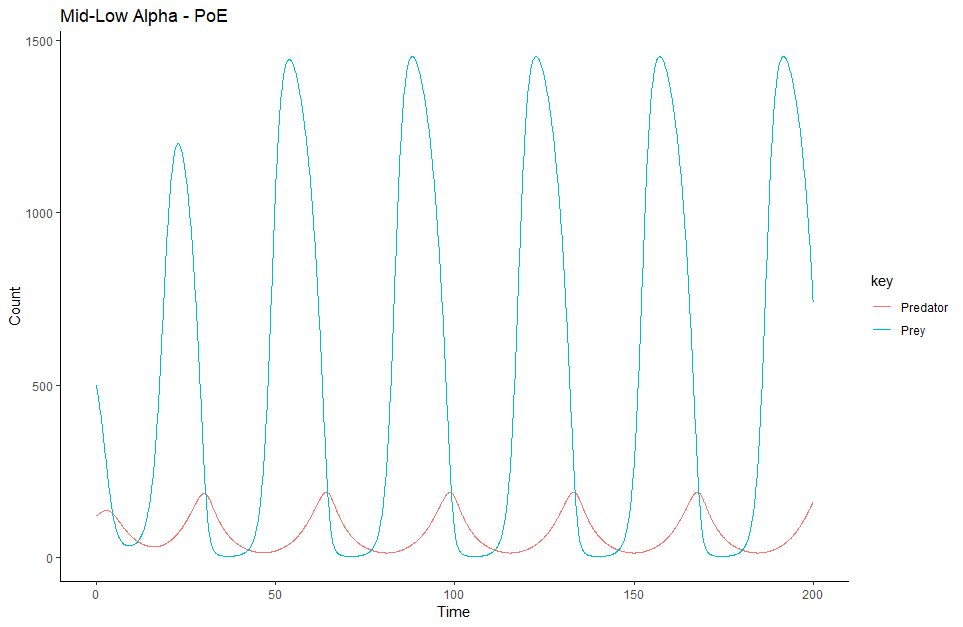
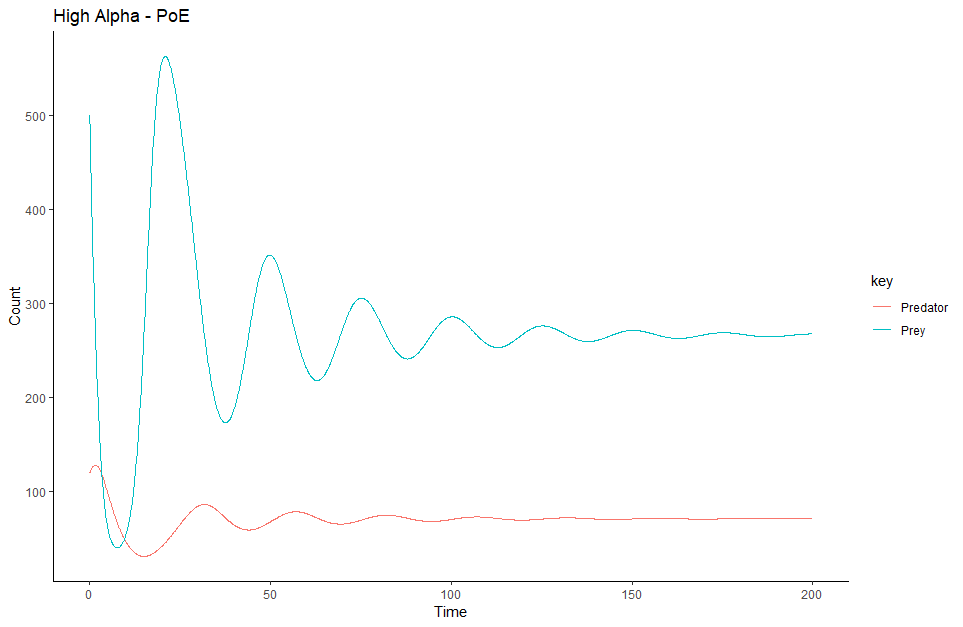
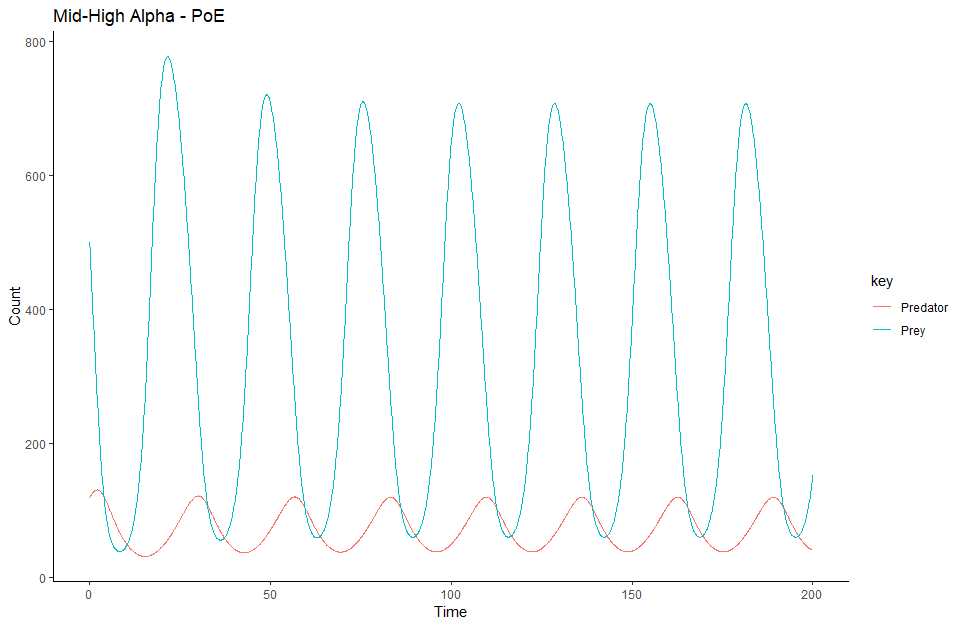
High “S” is harmful for predator abundance, increasing the rate at which they die off.

High “w” is beneficial for predator abundance, increasing attack frequency, allowing predators to grow and recover when prey increase

High “d” is harmful for predator abundance. As “d” gets larger, it reduces the growth of predators associated with the attack rate, conversion efficiency and population of prey.

Low “a” is beneficial for predator abundance. “a” is the inverse of carrying capacity, and a high carrying capacity allows enough prey growth to allow to conversion to predator population

**Paradox of Enrichment Questions:**

**What happens as carrying capacity increases?**

As carrying capacity increases (with a decrease in the alpha variable of the RM model), the prey population grows incredibly rapidly. However, as a result, the predator population also experiences unbounded growth until it reaches its maximum density. This causes both the upper bound of the prey population and the time between each cycle (wavelength) to increase.

**Why do you think we see the Paradox of Enrichment**

An increase in carrying capacity for prey simply allows for predators to gain greater resources. If the prey population is allowed to grow unchecked, the predator population is essentially given free reign to attack and eat, knowing that they have an overabundance of available prey. One predator can take down way more than a single prey (essentially unlimited), so increasing the amount of prey doesn’t affect their “appetite.”