System Simulations

Project 3

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For this project I considered weights of predator(Insects) and prey (Grass) as constants and the remaining four parameters are used to analyze the predator-prey model using Factor Analysis. we get total 16 (i.e.., $2^k = 2^4 = 16$) factors .So by using first and second order factor analysis we get total 11 combinations . By using these 11 combinations, the results are plot as follows.

Factor 1 :Birth rate of grass

Factor 2:Death rate of grass

Factor 3:Birth rate of insects

Factor 4 : Death rate of insects

TASK 1:

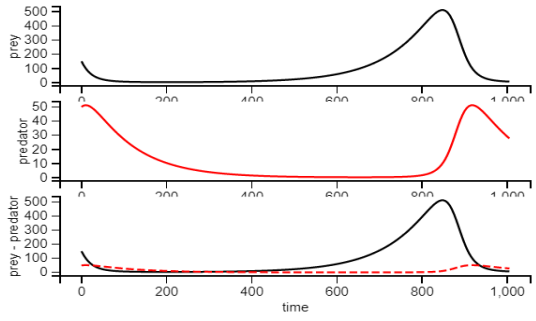
	Prey Birth Rate	Prey Decrease rate	Predator Birth Rate	Predator Decrease Rate
Low-0	0.01	0.001	0.0001	0.01
High-1	0.09	0.008	0.0009	0.2

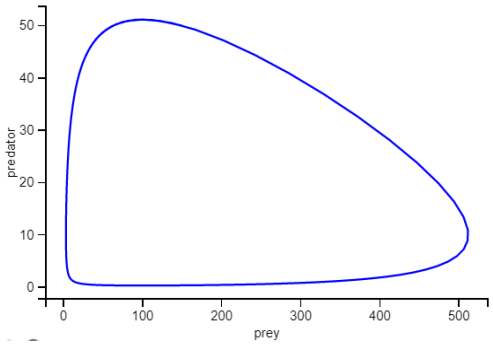
Table 1. High and low values used for four parameters.

Single Factor Analysis:

1.Prey Birth Rate = Low , Prey Decrease rate = Low , Predator Birth Rate =Low ,

Predator Decrease Rate = Low (0000)



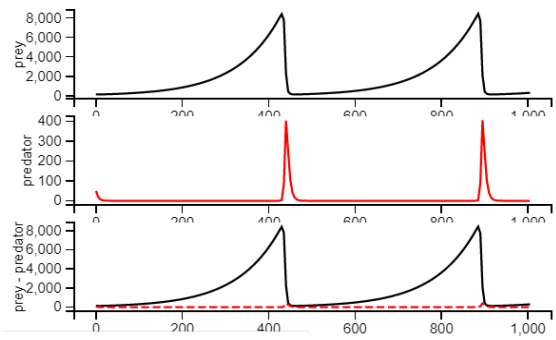


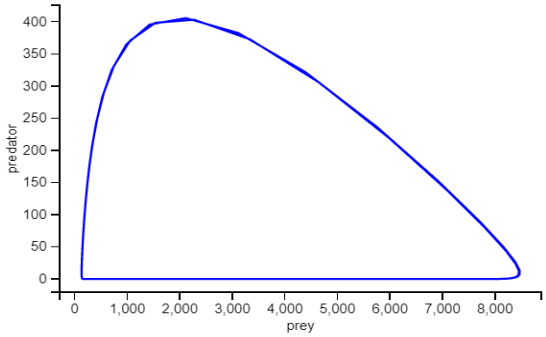
The above diagrams obtained by taking four factor values as low values . We can observe that prey graph is left skewed that means the population is growing slowly and decreasing fastly and predator graphs are right skewed that means the population is growing fastly and decreasing slowly. The growth rate of grass is high when compared to insects and also for more growth of grass we have less growth of insects. The frequency of grass and insect's population is limited to only one circle due to the making changes in respective parameters .

The phase diagram is egg shape with smooth edges .The phase diagram is degenerating quickly when the grass population falling below 100 approximately .

2.Prey Birth Rate = Low , Prey Decrease rate = Low , Predator Birth Rate =Low ,

Predator Decrease Rate = High (0001)

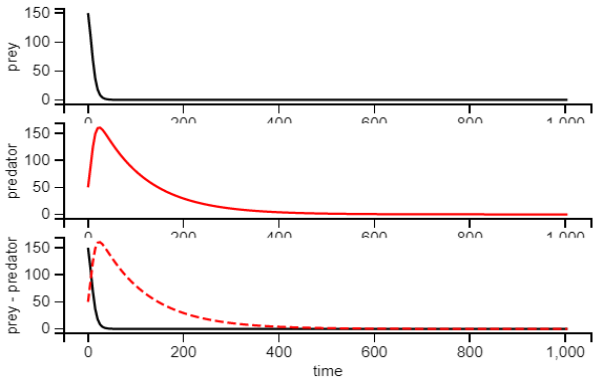


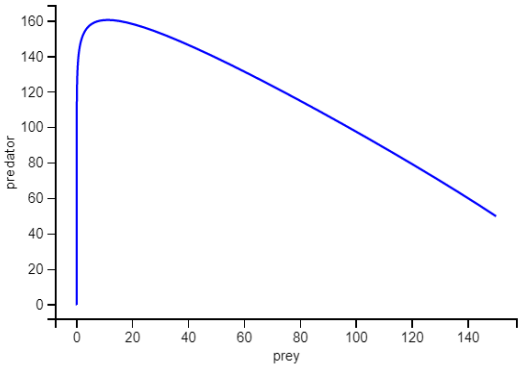


By considering death rate of insects as high and the other parameters as low value the above two graphs are obtained. Here the population of the grass is negatively skewed that means the population is increasing slowing and decreasing rapidly whereas insect's population graph is symmetric that means the population is rapidly increasing and rapidly decreasing. The phase diagram is of egg shape with one sharp edge and two soft edges with less frequency .The phase diagram is degenerating slowly towards zero with the decrease in prey population.

3.Prey Birth Rate = Low , Prey Decrease rate = Low , Predator Birth Rate =High ,

Predator Decrease Rate = Low (0010)



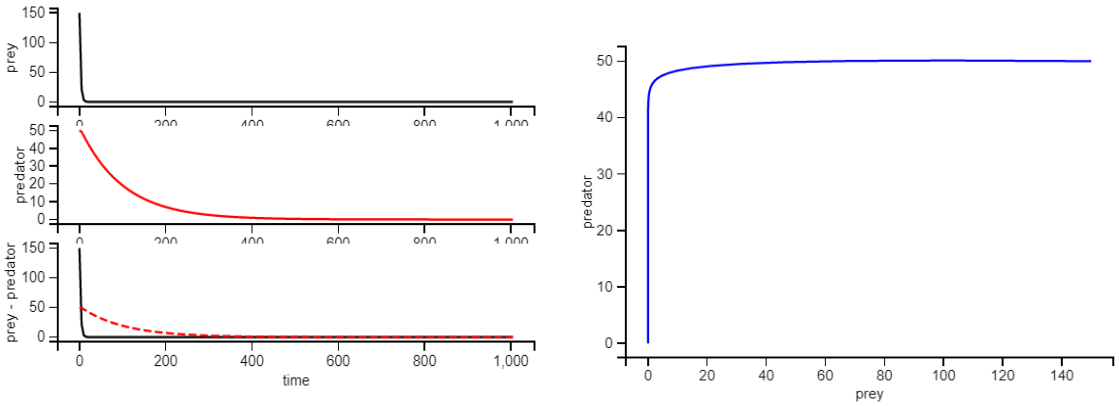


By considering birth rate of insects as high and the other parameters as low value the above two graphs are obtained. With the increase in growth rate of insect's, grass population decreased drastically and frequency of occurring the pattern is very limited ,in this case there is no complete cycle. In this scenario we can observe that the phase diagram is not completed even a single cycle

that means this process requires much time to increase the growth of grass. The phase diagram is degenerating rapidly towards zero when the prey population reaches less than 15 approximately.

4.Prey Birth Rate = Low , Prey Decrease rate = High , Predator Birth Rate = Low,

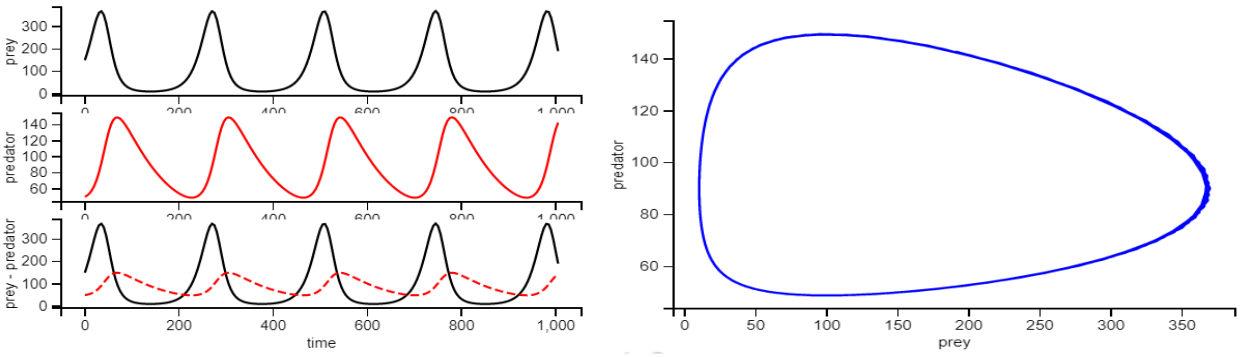
Predator Decrease Rate = Low (0100)



By considering death rate of grass as high and the other parameters as low the above two graphs are obtained. Grass population decreased drastically and there is no further increase of population in this time period and with the decrease in population of grass insects also decreased. The phase diagram is incomplete, and it is degenerating very drastically with the decrease in prey population to 10 approximately.

5.Prey Birth Rate = High , Prey Decrease rate = Low , Predator Birth Rate = Low,

Predator Decrease Rate = Low (1000)

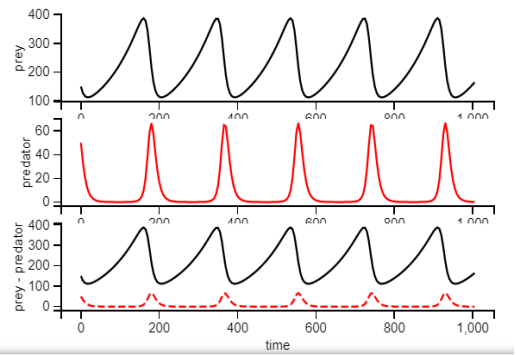


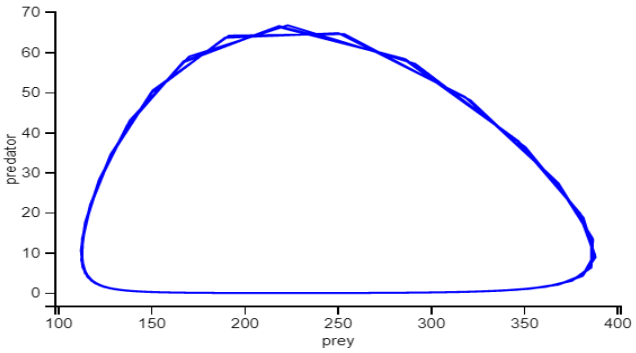
By considering birth rate of grass as high and the other parameters as low the above two graphs are obtained. We can observe the graphs of prey and predator are symmetric and the frequency is increased when compared to previous parameter settings. Predators are growing fast and dying slowly whereas prey is growing slowly and decreasing slowly. The phase diagram is egg shaped with much concentrated lines at the edge (right hand side) . The phase diagram is degenerating slowly based on the population of grass.

Two level Factor Analysis :

6.Prey Birth Rate = Low , Prey Decrease rate = Low , Predator Birth Rate = High,

Predator Decrease Rate = High (0011)

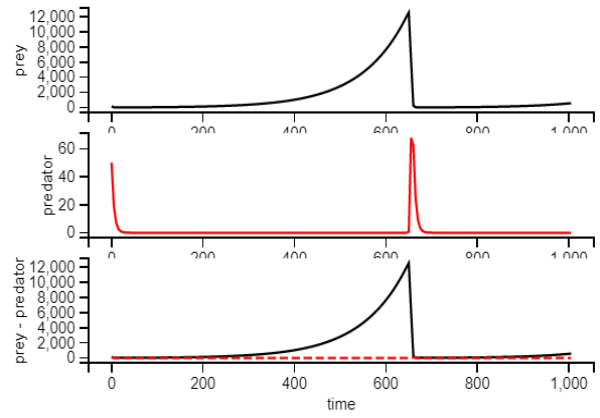


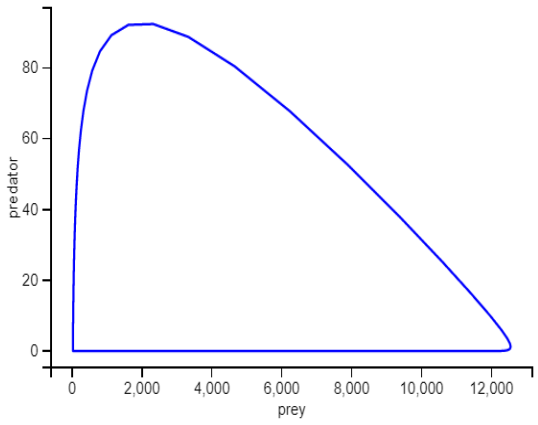


By considering birth rate and death rate of insects as high and the other parameters as low value the above two graphs are obtained. The prey curve is slightly skewed towards left whereas predator is symmetric throughout the time period . The phase diagram is semi-circle in shape with soft edges . The phase diagram is degenerating slowly based on the population of grass.

7.Prey Birth Rate = Low , Prey Decrease rate = High , Predator Birth Rate = Low,

Predator Decrease Rate = High (0101)

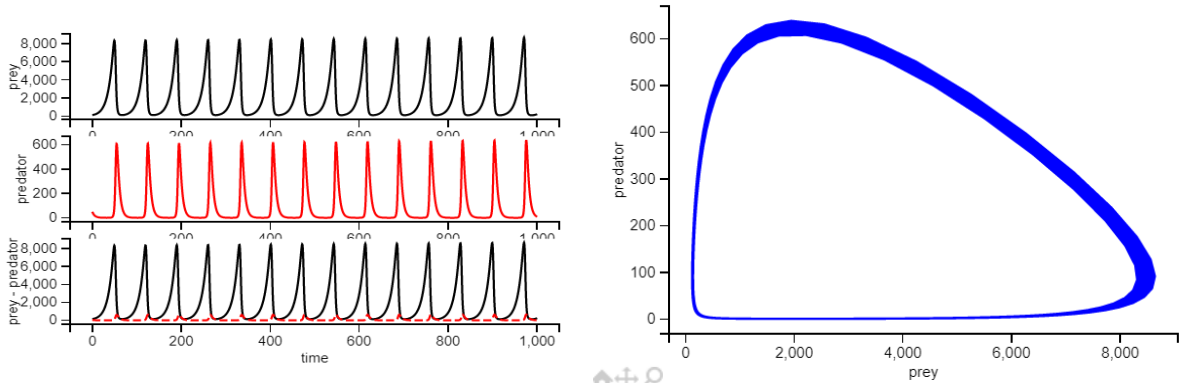




By considering death rate of grass and death rate of insects as high and the other parameters as low value the above two graphs are obtained. The prey curve is skewed towards left and predator curve is symmetric. The frequency of occurring the pattern is limited to only one time. The quantity of grass has increased in large amounts when compared to others. The phase diagram is a triangle in shape with only one sharp edge. At very low values of prey the graph is degenerating drastically toward zero.

8.Prey Birth Rate = High , Prey Decrease rate = Low , Predator Birth Rate = Low,

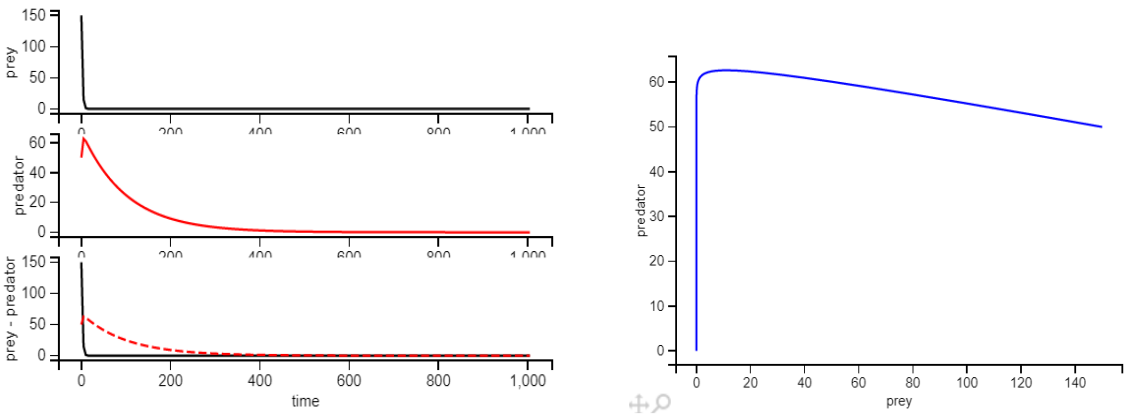
Predator Decrease Rate = High (1001)



By considering birth rate of grass and death rate of insects as high and the other parameters as low value the above two graphs are obtained. The prey and predator graphs are symmetric and rightly skewed little bit .The frequency of change in population for grass and insects is very high when compared to other graphs. The phase diagram forms solid curves with smooth edges. The phase diagram is degenerating slowly with decrease in grass population.

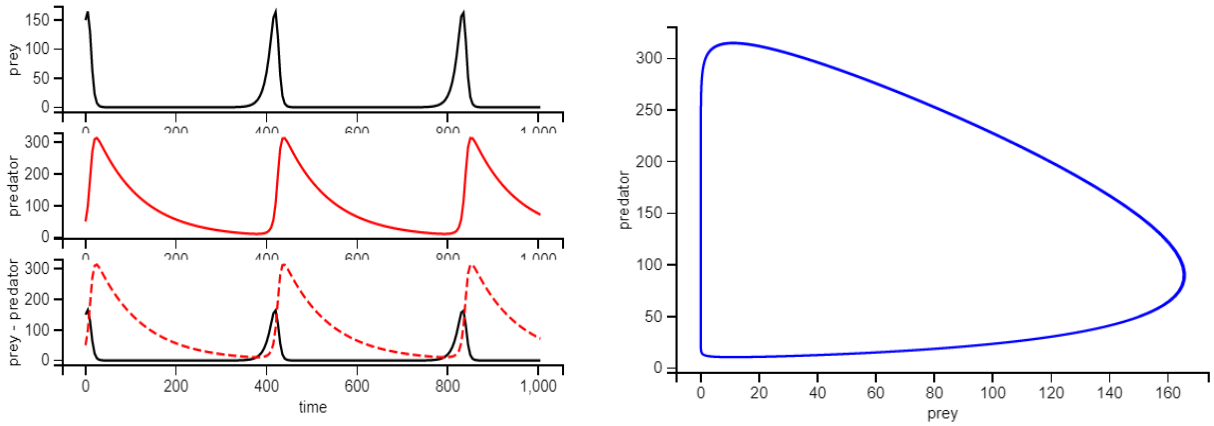
9.Prey Birth Rate = Low , Prey Decrease rate = High , Predator Birth Rate = High,

Predator Decrease Rate = Low (0110)



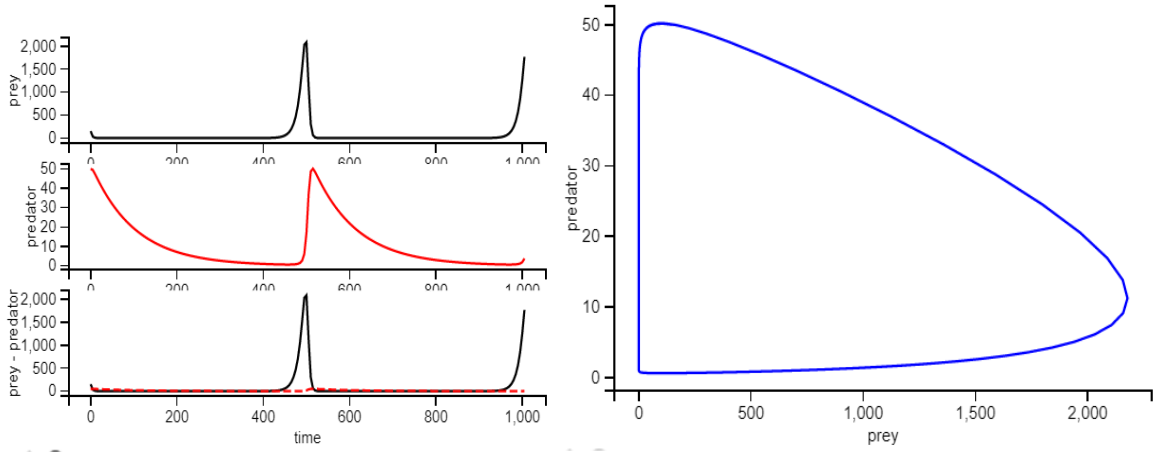
By considering death rate of grass and birth rate of insects as high and the other parameters as low value the above two graphs are obtained .Here we can observe that there is decrease in population for prey and predator. No kind of frequencies are observed. The phase diagram does not form even a single cycle and it deceases drastically when the prey reaches below 10 approximately.

10.Prey Birth Rate = High , Prey Decrease rate = Low , Predator Birth Rate = High, Predator Decrease Rate = Low (1010)



By considering birth rate of grass and birth rate of insects as high and the other parameters as low value the above two graphs are obtained. We can observe a smaller number of frequencies occurred during the time considered . The prey graph is symmetric, and the predator graph is skewed toward right and also we can observe that the peak value of predators is more when compared to prey. The phase diagram is egg shaped with smooth edges and predator population decreases rapidly when prey population is decreased below 15 count nearly.

11.Prey Birth Rate = High , Prey Decrease rate = High , Predator Birth Rate = Low, Predator Decrease Rate = Low (1100)



By considering birth rate of grass and death rate of grass as high and the other parameters as low value the above two graphs are obtained. Prey graph is symmetric and predator graph is skewed towards right that means the predator population is increasing fast and decreasing slowly. The phase diagram is egg shaped with one sharp edge and also has only one complete cycle which is

equal to the number of frequencies observed in the left-hand side graphs .The phase diagram is degenerating quickly with the decrease in population of prey below 100 nearly.

Summary : By considering the above results we can observe that a small change in birth and death rates of insects causes large change in the population of grass . The effective solution in order to yield high population of grass is to maintain high death rate of insects. We can also observe that the prey-predator model is parameter sensitive for any small change in the population we can observe a lot of change in population of the species. In phase diagram , we can observe that there is a drastic down fall of insects when the population of grass is very less whereas grass population is slowly increasing even though the population of insects decreased drastically.

TASK 2:

For the above predator-prey model I am adding pesticide as an additional factor in order to kill insects.

The updated equations are :

For pesticide the equation is :

$$dP / dt = P - \delta p * T \qquad \text{-- Eq 1}$$

P = Total initial quantity of the pesticide

δ_p = The decaying rate at time T

T= Time

The changed Grass and Insects equations are:

$$dG/dt=\beta_g \cdot G(t) - \delta_g \cdot G(t) \cdot I(t) * \gamma_g * (dP/dt) \quad \text{--- Eq 2}$$

$$dI/dt=\beta_i \cdot G(t) \cdot I(t) - \delta_i \cdot I(t) * \gamma_i * (dP/dt) \quad \text{--- Eq 3}$$

Where γ_g = decrease rate of grass when pesticide is applied

γ_i = decrease rate of insects when pesticide is applied

dP/dt = The mass pesticide present at that particular time

β_g:Birth rate of grass , δ_g :Death rate of grass , β_i :Birth rate of insects

δ_i : Death rate of insects , $G(t)$: weight of grass , $I(t)$: weight of insects. T= delta (T)

Equations 2 and 3 (Eq 2 , Eq 3) are obtained by assuming that , applying pesticides kills some amount of insects and grass and the effect is proportional to the mass of the pesticide that is remaining at any time instant.

For this task I considered weights of predator(Insects) and prey (Grass) as constants and the remaining six parameters are used to analyze the predator-prey model using Factor Analysis. we get total 64 (i.e.., $2^k = 2^6 = 64$) factors .So by using first ,second and third order factor analysis I picked some meaningful combinations and analyzed the results as below.

Factor 1 :Birth rate of grass , Factor 2:Death rate of grass , Factor 3:Birth rate of insects

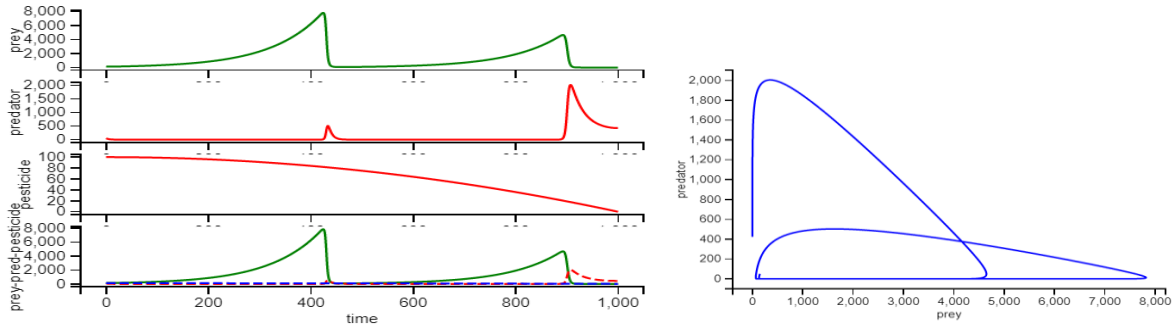
Factor 4 : Death rate of insects , Factor 5 : Pest rate on grass, Factor 6:Pest rate on insects.

	Prey Birth Rate	Prey Decrease rate	Predator Birth Rate	Predator Decrease Rate	Pest rate on grass	Pest rate on insects
Low-0	0.01	0.001	0.0001	0.01	0.01	0.2
High-1	0.09	0.008	0.0009	0.2	0.05	0.5

Table 2 . High and low values used for six parameters.

1.Prey Birth Rate = Low , Prey Decrease rate = Low , Predator Birth Rate = Low,

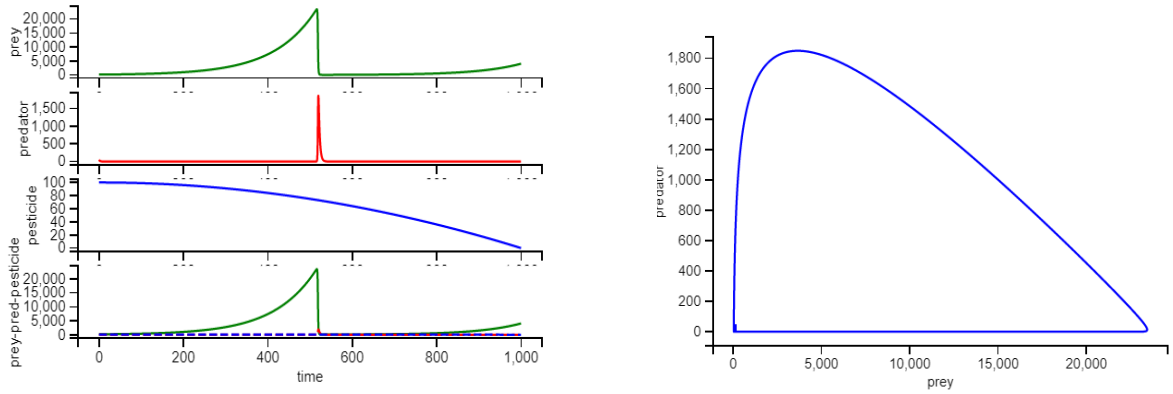
Predator Decrease Rate = Low , Pest rate on grass = Low , Pest rate on insects = Low (000000)



From the graph(left side) we can observe that ,the prey (grass) population graph is left skewed ,predator(insects) graph is right skewed and the pesticide graph is decreasing constantly with time . we can also observe that with the decrease in pesticide quantity the population of grass is decreasing, and population of insects are increasing . And also we can observe the population of insects increased rapidly with the decrease in pesticide quantity. The phase diagram is in egg shape with smooth edges . From the phase diagram we can observe that with the decrease in pesticide quantity the maximum population of grass per cycle is decreasing whereas the population of insects are increasing . Therefore, by adding pesticide we can improve population of grass .

2.Prey Birth Rate = Low , Prey Decrease rate = Low , Predator Birth Rate = Low,

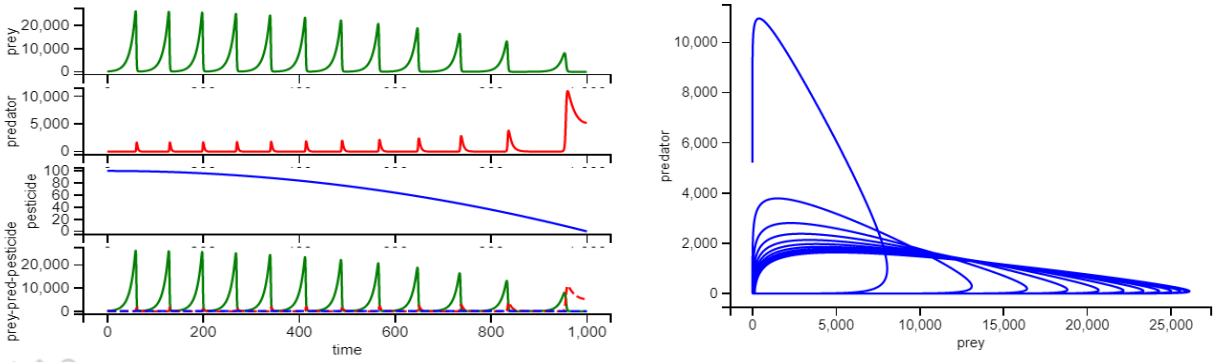
Predator Decrease Rate = Low, Pest rate on grass = Low , Pest rate on insects = High (000001)



From the graph(left side) we can observe that ,the prey (grass) population graph is left skewed ,predator(insects) graph is symmetric and the pesticide graph is decreasing constantly with time . we can also observe that with the decrease in pesticide quantity the population of grass is decreasing, and population of insects are increasing .The phase diagram is in triangle shape with one sharp edge and two smooth edges .The total population of grass is increased with the increase in killing rate of pesticides on insects when compared to the initial condition (i.e.., 000000 scenario).

3.Prey Birth Rate = High , Prey Decrease rate = Low , Predator Birth Rate = Low,

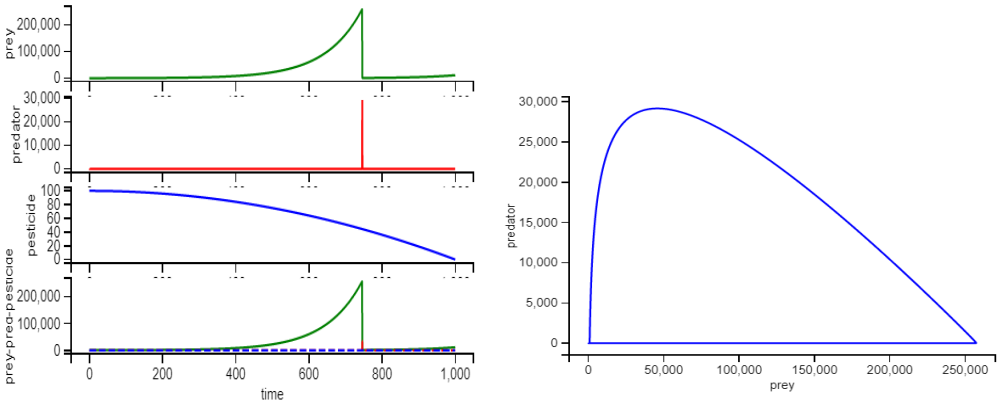
Predator Decrease Rate = Low, Pest rate on grass = Low , Pest rate on insects = High (100001)



From the graph(left side) we can observe that ,the prey (grass) population graph is left skewed , predator(insects) graph is right skewed and the pesticide graph is decreasing constantly with time. We can also observe that with the decrease in pesticide quantity the population of grass is decreasing, and population of insects are increasing .The phase diagram is in triangle shape with two smooth edges and one sharp edge .The total population of grass is increased with the increase in killing rate of pesticides on insects when compared to the initial condition (i.e.., 000000 scenario).

4.Prey Birth Rate = Low, Prey Decrease rate = Low , Predator Birth Rate = Low,

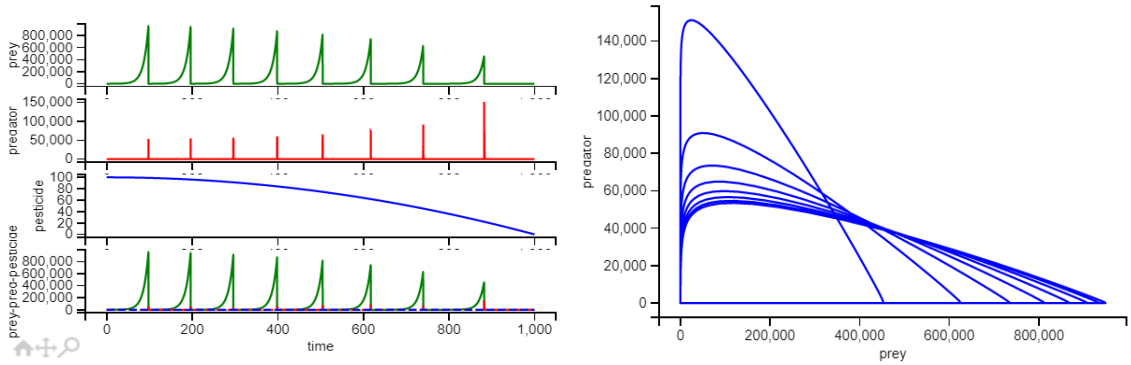
Predator Decrease Rate = High , Pest rate on grass = Low , Pest rate on insects = High (000101)



From the graph(left side) we can observe that ,the prey (grass) population graph is left skewed ,predator(insects) graph is symmetric and the pesticide graph is decreasing constantly with time . we can also observe that with the decrease in pesticide quantity the population of grass is decreasing, and population of insects are increasing .The phase diagram is in triangle shape with one smooth edge and two sharp edges .The phase graph is degenerating slowly with the decrease in prey population .

5.Prey Birth Rate = High , Prey Decrease rate = Low , Predator Birth Rate = Low,

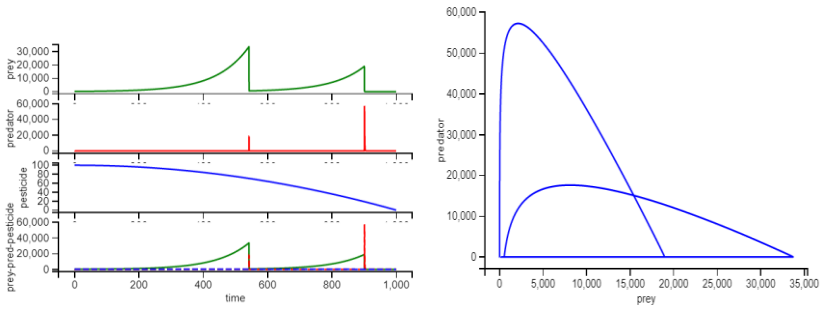
Predator Decrease Rate = High , Pest rate on grass = Low , Pest rate on insects = High (100101)



From the graph(left side) we can observe that ,the prey (grass) population graph is left skewed ,predator(insects) graph is symmetric and the pesticide graph is decreasing constantly with time . we can also observe that with the decrease in pesticide quantity the population of grass is decreasing, and population of insects are increasing .The phase diagram is in triangle shape with one smooth edge and two sharp edges .The phase graph is degenerating rapidly with the decrease in prey population . In this case the population of grass and insects yields highest among all cases.

6.Prey Birth Rate = Low, Prey Decrease rate = Low , Predator Birth Rate = High ,

Predator Decrease Rate = High , Pest rate on grass = Low , Pest rate on insects = High (001101)



From the graph(left side) we can observe that ,the prey (grass) population graph is left skewed ,predator(insects) graph is symmetric and the pesticide graph is decreasing constantly with time . we can also observe that with the decrease in pesticide quantity the population of grass is decreasing, and population of insects are increasing .The phase diagram is in triangle shape with one smooth edge and two sharp edges .The phase graph is degenerating rapidly with the decrease in prey population .

SUMMARY :

By observing first scenarios in both the tasks (i.e.., 0000 and 00000 scenarios) , including pesticides has effect in prey and predator populations. By adding pesticides, the population of insects got decreased and grass population got increased. By changing the pesticide parameter from low to high we can observe even more population growth of grass but with less frequency . In all the cases we can observe that the phase graphs are decreasing in relatively large amounts when the population of grass is very less .Also, the population of grass decreasing with the decrease in amount of pesticide which in turn resulting in the increase in population of insects . From the observations we can get a better solution if we set parameters of birth rate of grass , death rate of insects and effect of pesticides on insects to high values. Therefore, we can conclude that there is a strong correlation between these parameters and the created prey -pred model is parameter sensitive. Thus ,by including pesticides the golf course owner can yield good amount of grass.