# Exercise 3, Level 3, Problem # 1

# Predation Model: Sheep – Wolves – Grass

**Instructions** (*compiled*):

**D**etermine the rules followed by predator and prey and through that, which parameters you need. Maybe some parameters will be “global” (the same value is used for the whole simulation) or specific to the individuals. Your writeup should include some plots, possibly of the populations over time.

*Explore the behavior of the model as described in previous ABM Predator-Prey problems.*

* *Level 1, Problem #4: Predator Prey*

*Write a program that can implement an ODE solution for the classic Lotka-Volterra Predator-Prey model. Explore and report on how changing the parameters changes the behavior of the solution. Try different time-step sizes. Do your populations ever go completely to 0 then “come back”? If so, can you figure out why? Can you find parameters that achieve stable or stable-oscillating populations? See the Week 4 lecture material for example code, as well as the Sayama book. Your writeup should include plots with different parameters, as well as phase-plots for interesting sets of parameters. For the overall problem, write a paragraph or more about what you found challenging and/or what you learned while working on this problem.*

**Experimentation:**

Batch 1: (Original state): Seems like a stable oscillation.

Batch 2: (Slower growing, richer grass {*increase “Grass Regrowth Time” by +10, Increase “Sheep Gain from Food” by +2, Increase “Wolves Gain from Food” by +1*}) - This is still an oscillation but is less stable.

Batch 3: (Slower growing, richer grass {*increase “Grass Regrowth Time” by +25, Increase “Sheep Gain from Food” by +5, Increase “Wolves Gain from Food” by +2*}) - This appears to set up a secondary oscillation.

Batch 4: (Lower quality, faster growing grass {*Decrease grass quality: Grass regrowth time-15, Sheep Gain from Food-2, Wolves Gain from Food-1*}). - Decreasing the quality of the grass causes an extinction of wolves at t=214. Sheep and grass find homeostasis at sheep ~= 165 sheep, and grass ~= 335 patches.

Batch 5: (*Increase Sheep Reproduction Rate\*3 {12%*}) - At first, sheep numbers go up, and grass amount goes down. Then Wolves go up, sheep go down, and meet in the middle to find stasis. Grass goes up and remains up.

Batch 6: (*Increase Sheep Reproduction Rate\*5 (20%})* - In this run, sheep population goes up at first, and has a much sharper drop, and pendulums down to less than grass and the wolves.

Batch 7: (*Decrease Sheep Reproduction Rate -1 {3%}*) - Suppresses number of wolves all the way through.

Batch 8: (*Decrease Sheep Reproduction Rate -3 {1%}*) - Wolves die out by t=90.

Batch 9: (*Decrease Initial Number of Sheep = Initial Number of Wolves {50}*) - At first wolves nearly die out, then make a comeback to the normal oscillation.

Batch 10: (*Increase sheep reproduction rate +1% {5%}*) - Stable Oscillation

Batch 11: (*Decrease Initial Number of Sheep = (Initial number of Wolves \* 0.5) {25}*) - Wolves are extinct.

Batch 12: (*Decrease Initial Number of Sheep = (Initial number of Wolves \* 0.5) {25}*) - This is the threshold where in one run, wolves make a comeback, and in another they go extinct.

Batch 13: (*Increase Wolves Reproduction Rate +1 {6%}*) - Still the system finds a stasis within an oscillation.

Batch 14: (*Increase Wolves Reproduction Rate +15 {20%}*) - The system is unphased by this increase.

Batch 15: (*Decrease Wolves Reproduction Rate -3% {1%}*) - While slow to recover from the initial dip, the system finds a similar equilibrium.

Batch 16: *(Increase Initial Number of Wolves +200 {250}* - Even this onslaught of predators finally breaks the system at t=90, but it didn’t break until this point. I will run it again to see if I can get a different result. Not by a significant amount after 10 more runs.

Batch 17: (*Increase Initial Number of Wolves +200 {250}*) - 2nd run; It took until t=100, but the wolves made a comeback.

**Conclusions:**

**T**he farther up the food chain you go, the less any changes impact the total system.

**E**very modification of significance is a countdown to extinction for the top of the food chain; be it wolves or humans.

**T**he most sensitive variable array is the grass quality. If you change type of grass or plant food quality to a higher quality, the oscillation of the three populations is strong but stable. If you decrease the grass quality, the wolves die very quickly.

**T**he second most sensitive variable is the Sheep reproduction rate which killed the wolves with a change of -2, followed by a decrease of Initial Number of Sheep to ½ of the value of Initial Number of Wolves.

**F**inally, the least influential, but still of consequence; Increasing the Initial Number of Wolves to (Initial Number of Sheep \* 2.5) caused a slow initial system shock recovery.