

# 15.879 S04 Predator Prey Model

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## Equilibrium

The system is

$$\begin{aligned}\frac{dX}{dt} &= \alpha XY - \beta X \\ \frac{dY}{dt} &= \delta YZ - \gamma XY - \epsilon Y \\ \frac{dZ}{dt} &= \zeta Z - \eta YZ - \theta Z\end{aligned}$$

where  $X$ : Predator Population,  $\alpha$ : Predator Fractional Birth Rate,  $\beta$ : Predator Fractional Death Rate,  $Y$ : Prey Population,  $\delta$ : Prey Fractional Birth Rate,  $\gamma$ : Prey Fractional Predation Death Rate,  $\epsilon$ : Prey Fractional Non Predation Death Rate,  $Z$ : Vegetation,  $\zeta$ : Vegetation Fractional Restoration Rate,  $\eta$ : Vegetation Fractional Consumption Rate,  $\theta$ : Vegetation Fractional Death Rate.

The equilibrium condition is then

$$\begin{aligned}X^* &= \frac{\delta Z^* - \epsilon}{\gamma} \\ Y^* &= \frac{\beta}{\alpha} \text{ and } Y^* = \frac{\zeta - \theta}{\eta} \\ Z^* &= \frac{\gamma X^* + \epsilon}{\delta}\end{aligned}$$

The parameter values set in simulation are

$$\alpha = 0.1, \beta = 0.5, \delta = 0.3, \gamma = 1.4, \epsilon = 0.2, \zeta = 5.1, \eta = 1, \theta = 0.1$$

which makes equilibrium values

$$(X^*, Y^*, Z^*) = (2, 5, 10)$$

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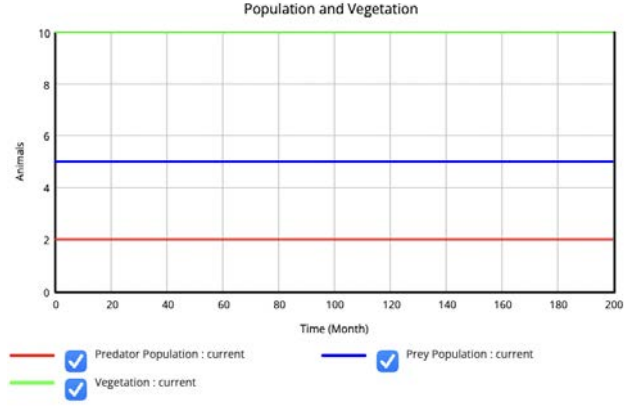


Figure 1: Predator population, prey population and vegetation in equilibrium



Figure 2: Fractional birth, death, restoration, and destruction rates in equilibrium

## Deforestation

Deforestation shock is implemented with PULSE function so that the Vegetation Fractional Death Rate ( $\theta$ ) jumps from  $0.1/Month$  to  $1.0/Month$  from month 12 to 60.

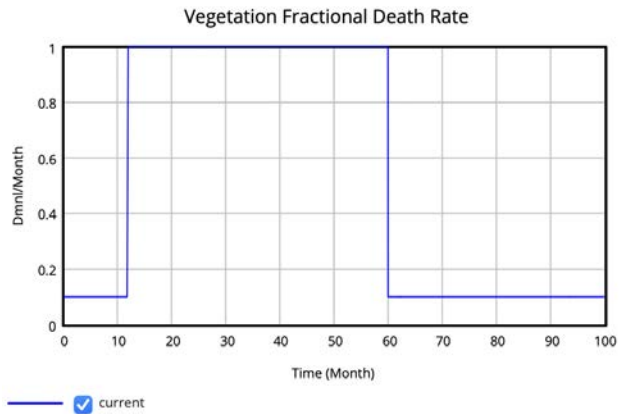


Figure 3: Deforestation shock on vegetation fractional death rate

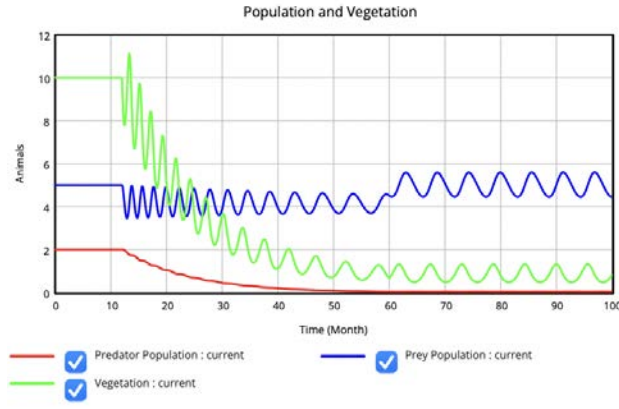


Figure 4: Predator population, prey population and vegetation with deforestation shock

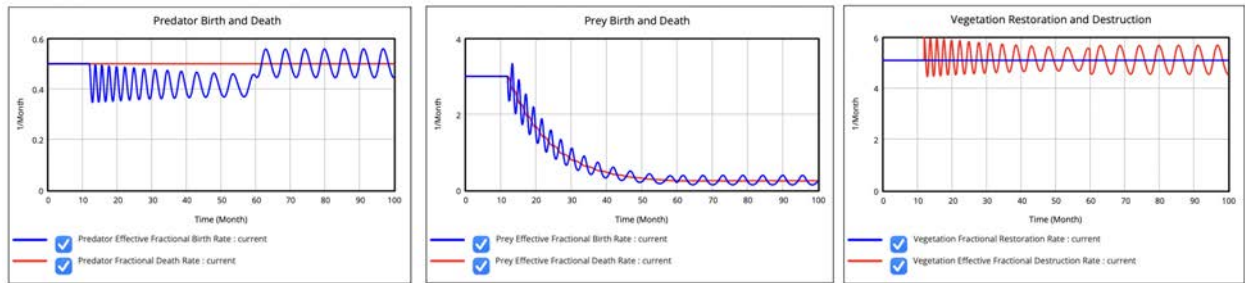


Figure 5: Fractional birth, death, restoration, and destruction rates with deforestation shock

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