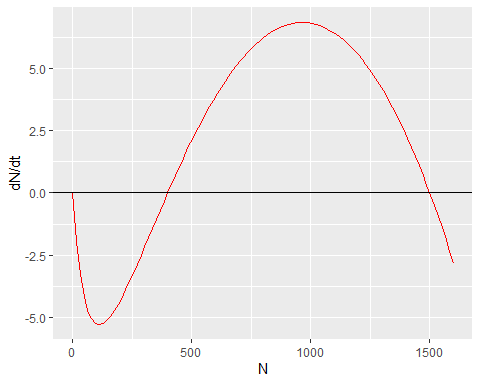
HW2

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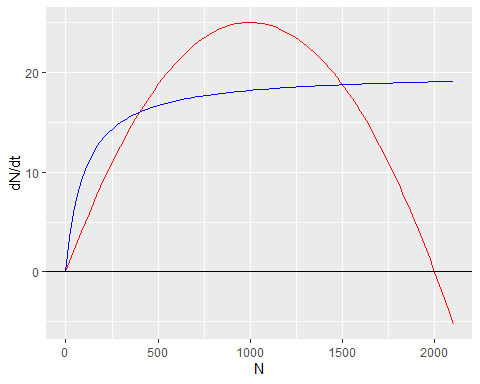
# plotting the function  
  
#loading the variables of the function  
r <- 0.05  
K <- 2000  
P <- 4  
a <- 0.05  
h <- 0.2  
full <- function(N) r \* N \* (1 - N/K) - (P \* (a \* N)/(1 + a \* h \* N)) # Here is defined the function  
f <- function(N) r \* N \* (1 - N/K) #this is the first part of the function defined  
  
  
fun <- ggplot(data.frame(N = 0:1600), aes(x = N)) +  
 stat\_function(fun = full, color ="red") +  
 geom\_hline(yintercept = 0) +  
 ylab("dN/dt")  
  
fun



1. Based on the graph there are three equilibria for this population. There are stable equilibria at population sizes of 0 and 1500. There is an unstable equilibria at a population size of 375.
2. The zero equilibrium is locally stable when P > r/a, but there is always going to be a zero equilibrium for this model. To eliminate the means to eliminate the species hunters would need to be attacking the species at a greater rate than the species intrinsic growth rate (Pa > r).
3. To find the non zero equilibria you need to solve the equation: dN/dt = 0 = rN(1 - N/K) - P((aN)/(1 + ahN)).

5a.

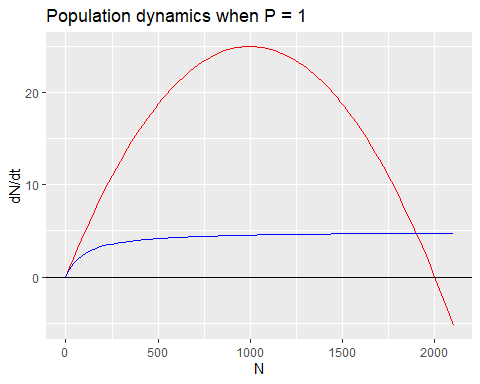
fp <- function(N) P \* ((a \* N)/(1 + a \* h \* N)) #This defines the hunting rate  
  
fun\_p <- ggplot(data.frame(N = 0:2100), aes(x = N)) +  
 stat\_function(fun = f, color ="red") +  
 stat\_function(fun = fp, color = "blue") +  
 geom\_hline(yintercept = 0) +  
 ylab("dN/dt")  
  
fun\_p



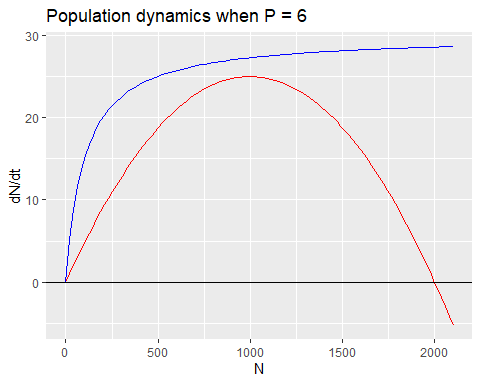
5b. When the hunting rate is greater than the intrinsic growth rate then the population will decline. When the hunting rate is less than the intrinsic growth rate then the population will increase. When hunting rate is equal to the intrinsic growth rate then the population will be in a state of equilibrium.

5c. Where the graphs intersect on this graph is where the graph in problem crosses 0 on the x-axis. This means where the above graphs intersect are locations where the population is at equilibrium.

P <-1 #This will set the P value to 1 for the following function  
  
fun\_p1 <- ggplot(data.frame(N = 0:2100), aes(x = N)) +  
 stat\_function(fun = f, color ="red") +  
 stat\_function(fun = fp, color = "blue") +  
 geom\_hline(yintercept = 0) +  
 ylab("dN/dt") +  
 ggtitle("Population dynamics when P = 1")  
  
fun\_p1



P <- 6 #This will set the P value to 6 for the following function  
  
fun\_p6 <- ggplot(data.frame(N = 0:2100), aes(x = N)) +  
 stat\_function(fun = f, color ="red") +  
 stat\_function(fun = fp, color = "blue") +  
 geom\_hline(yintercept = 0) +  
 ylab("dN/dt") +  
 ggtitle("Population dynamics when P = 6")  
  
fun\_p6

 When the P value is 1 ther are two equilibria, one at 0 and one at approximately 1875. The 0 equilbria is unstable and the 1875 equilibria is stable. When the P value is 6 then there is only one equilibria at 0. This is a stable equilibria.

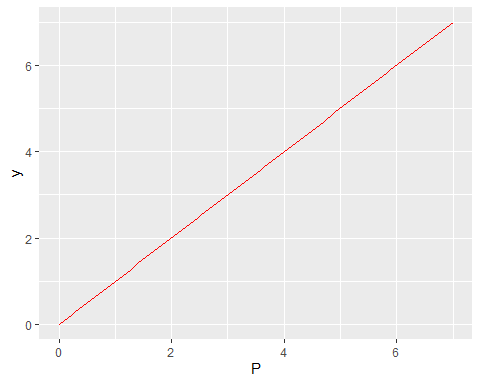
7a. The domain of of attraction for the zero equilibrium is is from zero to the next equilibrium point which is approximately 375 based on the graph. The domain of attraction of the largets equilibrium point is anything above the previous equilibrium point, approximately 375.

7b. If the population of the species was 100 individuals then then 4 hunters would be able to extirpate the species as the hunting rate would be greater than the intrinsic growth rate.

7c. If the population was already at carrying capacity then 4 hunters would not be enough to extripate the species. At this population level the growth rate would grow as the population shrunk until it equaled the hunting rate. Four hunters would cause the population to reach an equilibrium at 1500 individuals.

8a.

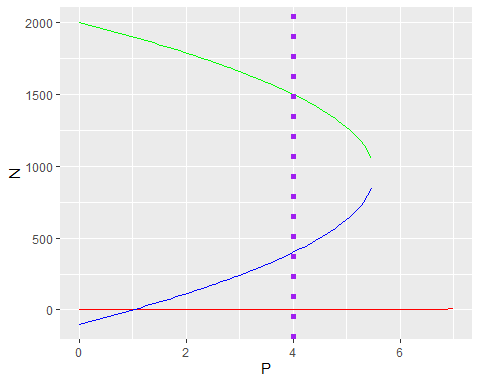
#Finding the equilibrium values based on the number of hunters  
  
#setting the parameters agains for the equations  
r <- 0.05  
K <- 2000  
a <- 0.05  
h <- 0.2  
d <- 1/(a\*h)  
N <- 0  
  
  
fp1 <- function(P) (P \* a)/r  
fp2 <- function(P) (1/2) \* ((K - d) - sqrt((K - d)^2 + ((4\*K\*d)/(r)) \* (r - a \* P)))  
fp3 <- function(P) (1/2) \* ((K - d) + sqrt((K - d)^2 + ((4\*K\*d)/(r)) \* (r - a \* P)))  
  
fun\_fp1 <- ggplot(data.frame(P = 0:7), aes(x = P)) +  
 stat\_function(fun = fp1, color = "red")  
  
fun\_fp1



fun\_fp123 <- ggplot(data.frame(P = 0:7), aes(x = P)) +  
 stat\_function(fun = fp1, color = "red") +  
 stat\_function(fun = fp2, color = "blue") +  
 stat\_function(fun = fp3, color = "green") +  
 ylab("N") +  
 geom\_vline(xintercept = 4, color = "purple", linetype = "dotted", size = 2)  
  
fun\_fp123

## Warning in sqrt((K - d)^2 + ((4 \* K \* d)/(r)) \* (r - a \* P)): NaNs produced  
  
## Warning in sqrt((K - d)^2 + ((4 \* K \* d)/(r)) \* (r - a \* P)): NaNs produced

## Warning: Removed 22 rows containing missing values (geom\_path).  
  
## Warning: Removed 22 rows containing missing values (geom\_path).



8b. The value of P when the equilibrium changes from locally stable to unstable is where the populations equilibrium points are.

8c. This also tells me that the equlibrium formula for the two non zero equilibria are logistic and that the zero equilibria is linear. I am confused as to why the zero equlibrium is a linear graph. It also tells me that 6 hunters will be enough to exterminate the invasive species.