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S222 MATH 20D A00
9/2/2022

Mathematical Modeling of an Outbreak Zombie Infection

1. Summary of Section 2

There are three basic classes in which we will categorize people by.

- Susceptible (*S*) = people who may die through (natural causes) non zombie deaths (δ).
- Zombie (*Z*) = people who became zombies from:
    1. From the *R* class who were resurrected (ζ).
    2. From *S* who lost their encounter with a zombie and became one through transmission (β).
       **Z* may die from an encounter with a susceptible person if they lose (α).
- Removed (*R*) = people who died, from either natural causes or zombie attack.

Parameters (Pi, Alpha, Beta, Zeta, Delta):
Π: Birth rate, assumed to be a constant.
α: Destruction of a zombie accomplished by removing the head or destroying the brain.
β: Transmission parameter for when susceptibles encounter zombies.
ζ: Parameter for *R* to resurrect and become a zombie.
δ: non-zombie related deaths.

2. Model figure 2 and 3 setting initial population to 1000 and time to 15.

Figure 2 on next page (to prevent text from becoming too small and therefore unreadable):
The case of no zombies.

ryoandrewonozuka ▸ Documents ▸ MATLAB

Editor – /Users/ryoandrewonozuka/Documents/MATLAB/zombies.m

erad.m | eradode.m | zombies.m | +

```
function [ ] = zombies(a,b,ze,d,T,dt)
% This function will solve the system of ODE's for the basic model used in
% the Zombie Dynamics project for MAT 5187.  It will then plot the curve of
% the zombie population based on time.
% Function Inputs: a - alpha value in model: "zombie destruction" rate
%                  b - beta value in model: "new zombie" rate
%                  ze - zeta value in model: zombie resurrection rate
%                  d - delta value in model: background death rate
%                  T - Stopping time
%                  dt - time step for numerical solutions
% Created by Philip Munz, November 12, 2008
%Initial set up of solution vectors and an initial condition
N = 1000;        %N is the population
n = T/dt;
t = zeros(1,n+1);
s = zeros(1,n+1);
z = zeros(1,n+1);
r = zeros(1,n+1);
s(1) = N;
z(1) = 0;
r(1) = 0;
t = 0:dt:T;
% Define the ODE's of the model and solve numerically by Euler's method:
for i = 1:n
    s(i+1) = s(i) + dt*(-b*s(i)*z(i));  %here we assume birth rate = background d
    z(i+1) = z(i); %+ dt*(b*s(i)*z(i) -a*s(i)*z(i) +ze*r(i));
    r(i+1) = r(i) + dt*(a*s(i)*z(i) +d*s(i) - ze*r(i));
    if s(i)<0 || s(i) >N
        break
    end
    if z(i) > N || z(i) < 0
         break
    end
    if r(i) <0 || r(i) >N
        break
    end
end
hold on
plot(t,s,'b');
plot(t,z,'r');
legend('Suscepties','Zombies')
```

Figure 1

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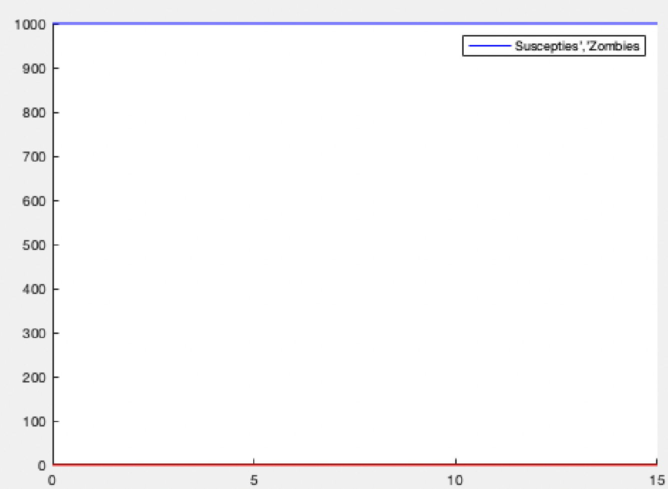

use parentheses.

rical

```
>> zombies(0.005,0.0095,0.0001,0.0001,15,0.1)
>>
```

Figure 3:

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erad.m | eradode.m | zombies.m

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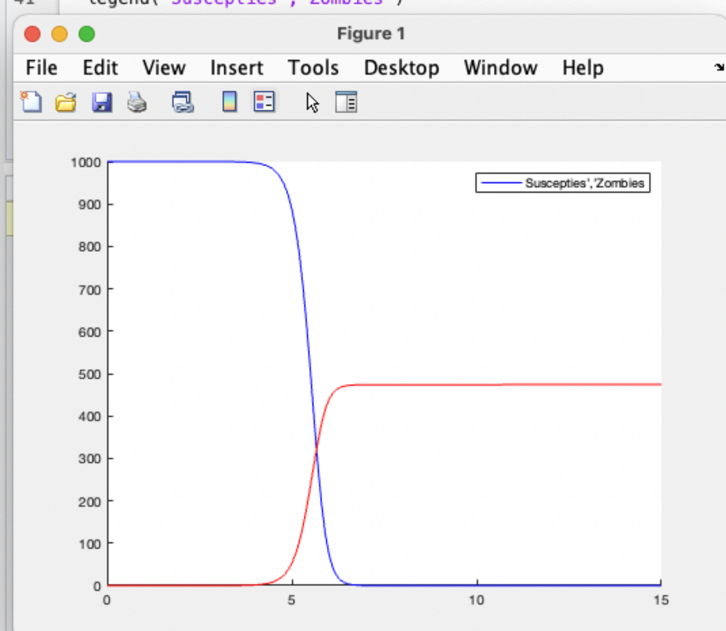
    if s(i)<0 || s(i) >N
        break
    end
    if z(i) > N || z(i) < 0
         break
    end
    if r(i) <0 || r(i) >N
        break
    end
end
hold on
plot(t,s,'b');
plot(t,z,'r');
legend('Suscepties','Zombies')
```



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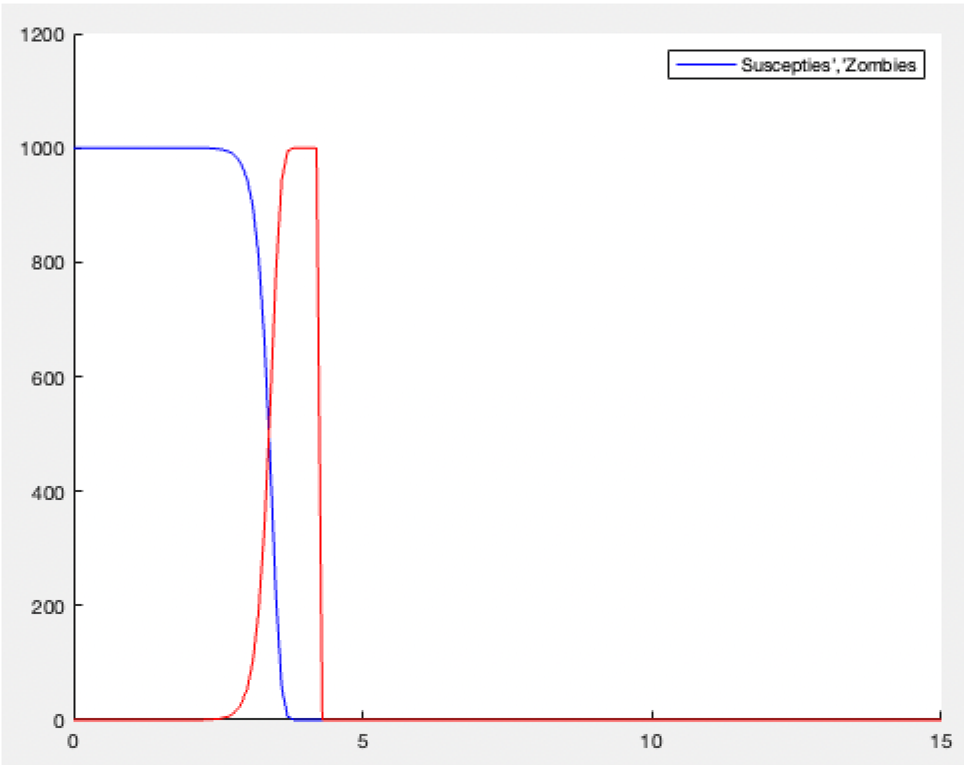
rical

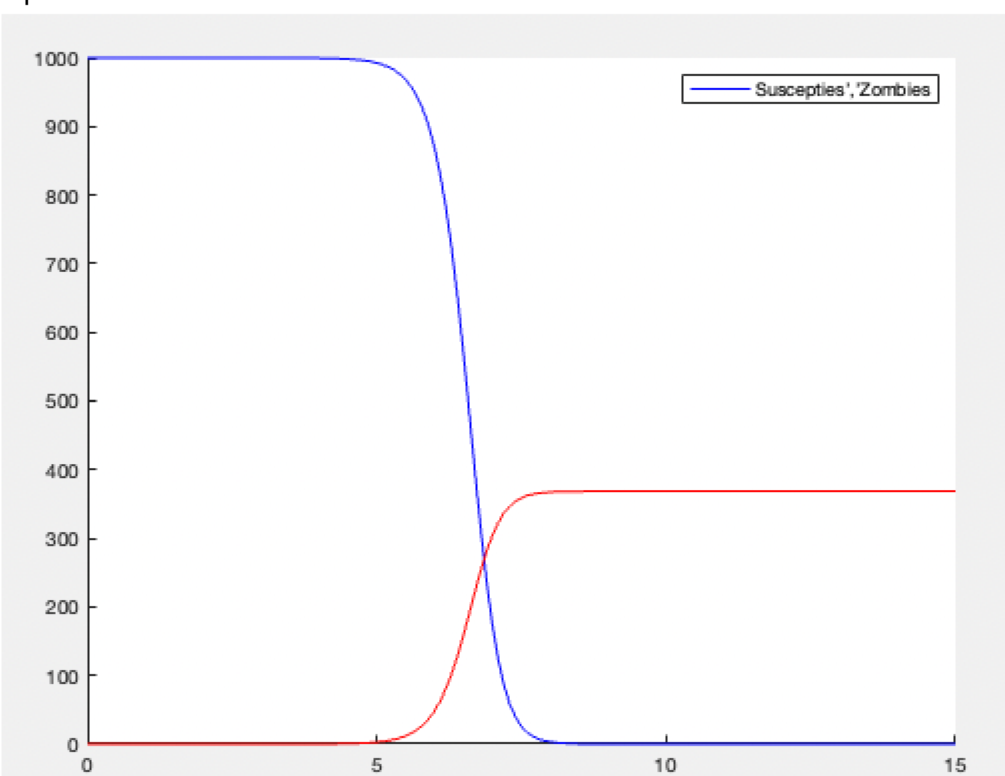
```
>> zombies(0.005,0.0095,0.0001,0.0001,15,0.1)
>>
```

3.

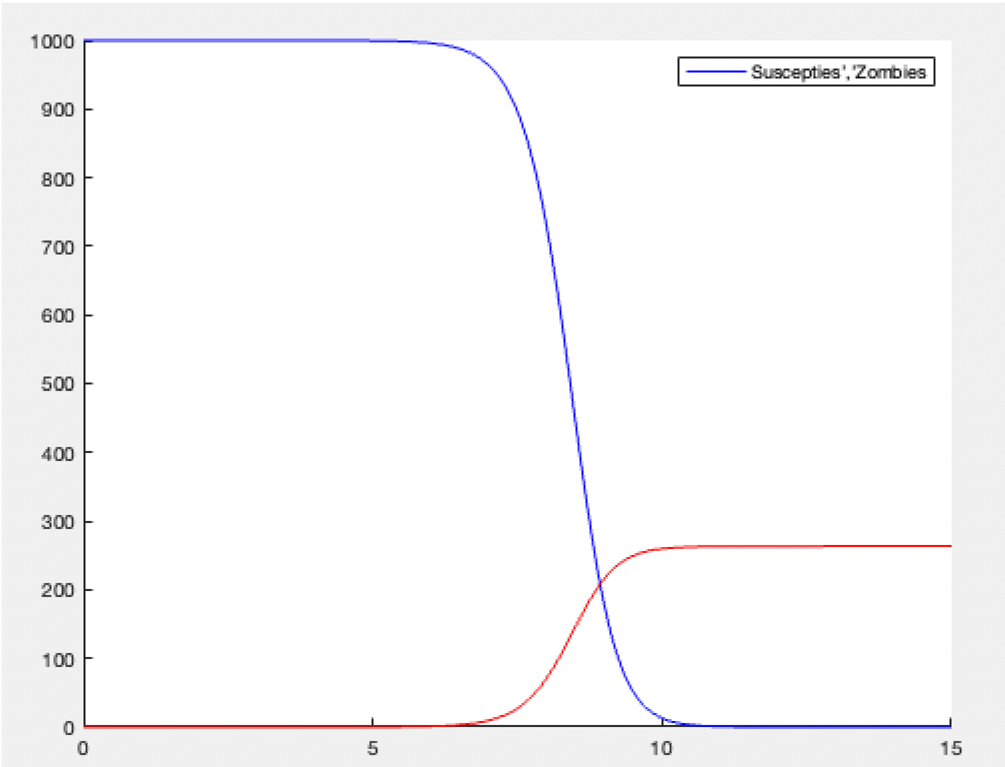
All other variables remain the same, alpha set to 0. It looks like susceptibles and zombies mutually go extinct.



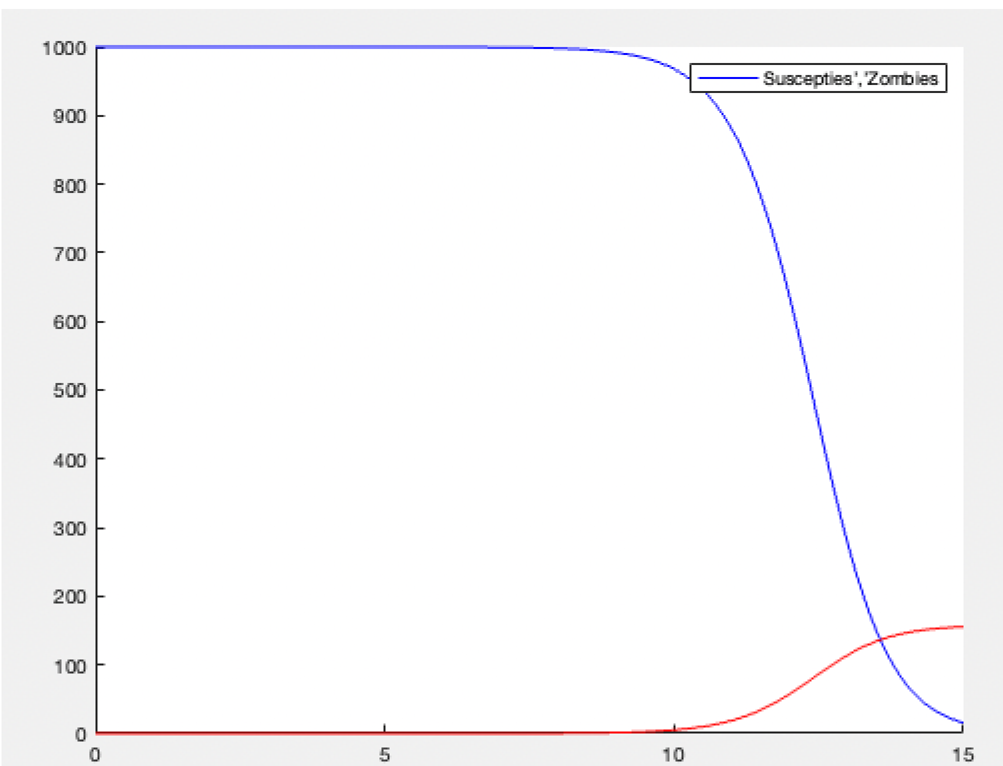
Alpha set to 0.6



Alpha set to 0.7

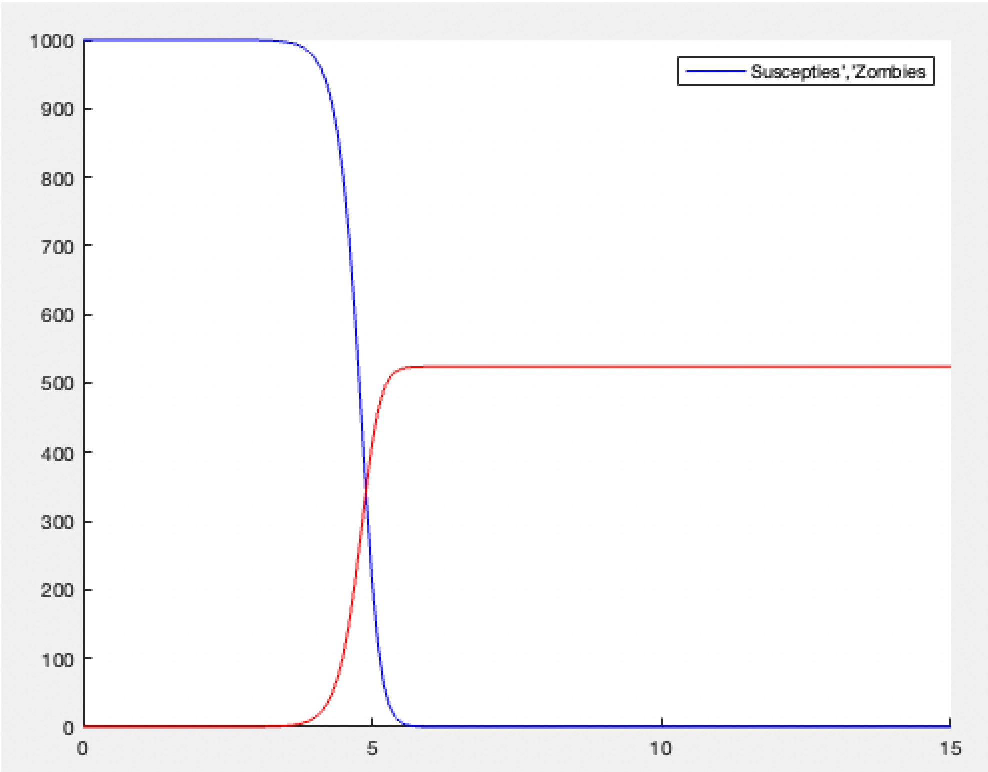


Alpha set to 0.8

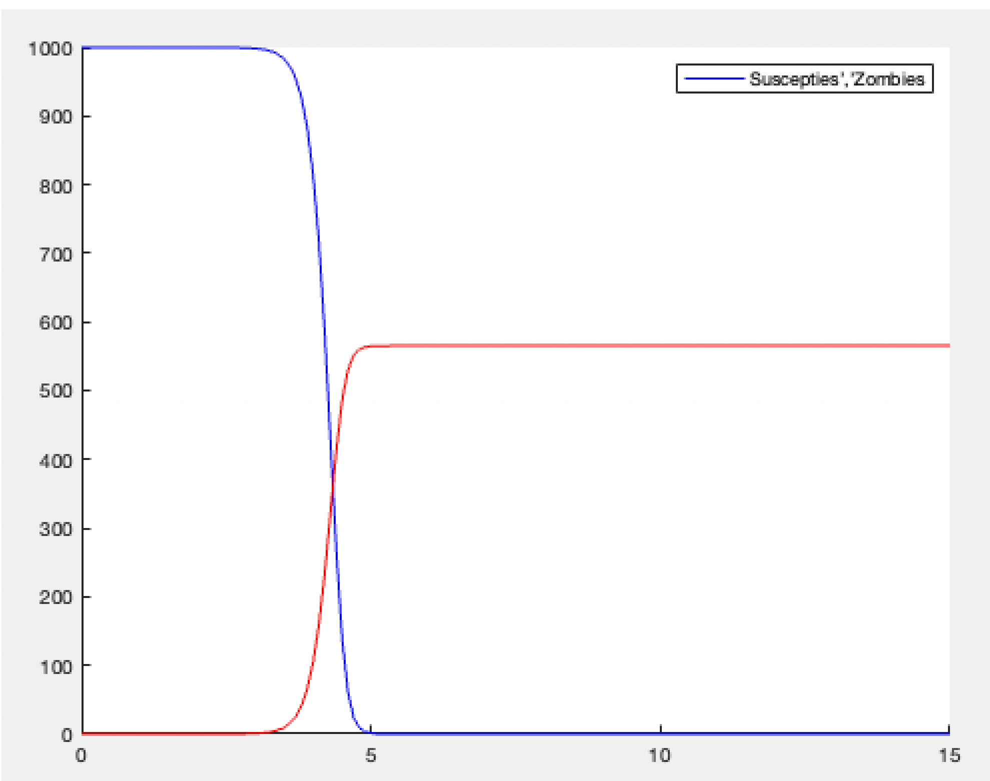


Increasing alpha leads to holding off the zombies longer, but is not a permanent solution since susceptibles will still inevitably go extinct. Decreasing alpha speeds up the extinction rate.

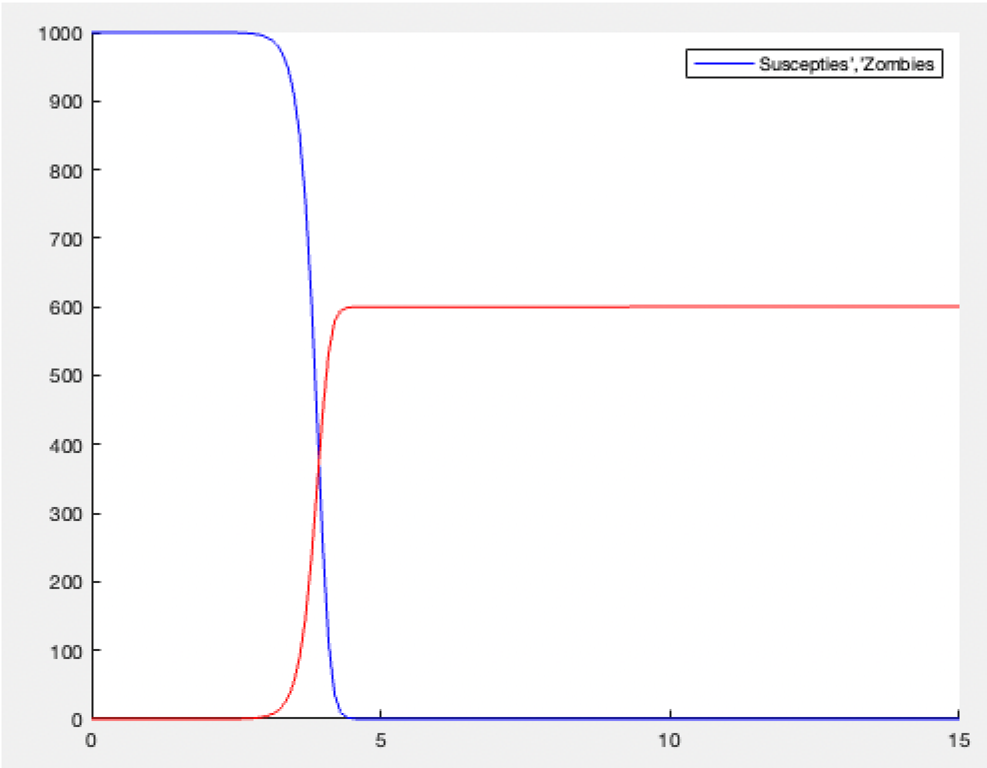
Beta set to 0.0105



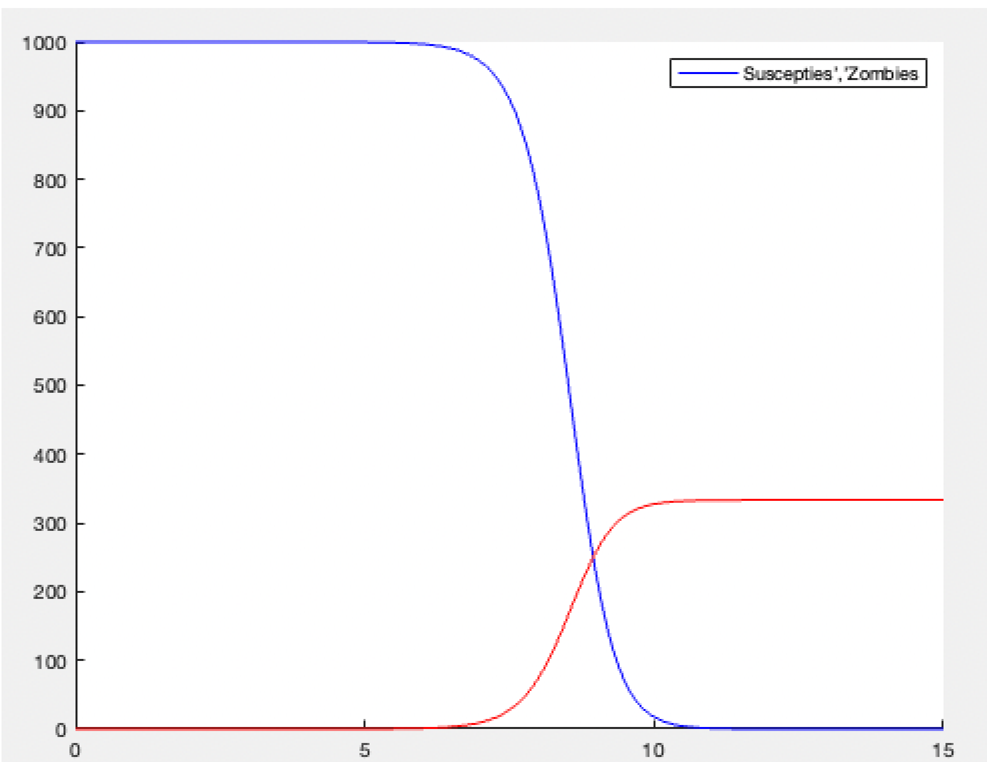
Beta set to 0.0115



Beta set to 0.0125



Beta set to 0.0075



While decreasing Beta helps to buy more time and leads to a slower transmission rate, it does not change the long term outcome. This is consistent with the findings of the paper as well as our answer on part 4, since without a way to eradicate zombies extremely quickly, the future extinction is inevitable.

4.

As we can see in the original PDF, it is almost impossible to survive a zombie outbreak if it is not initially contained aggressively. Quarantine will still lead to extinction, and the best bet is to focus on a treatment - therefore allowing people to continue to survive - while eradicating zombies as quickly as possible. As the report details, even then it would be humans coexisting with zombies. Definitely an interesting and scary topic to think if it were reality.