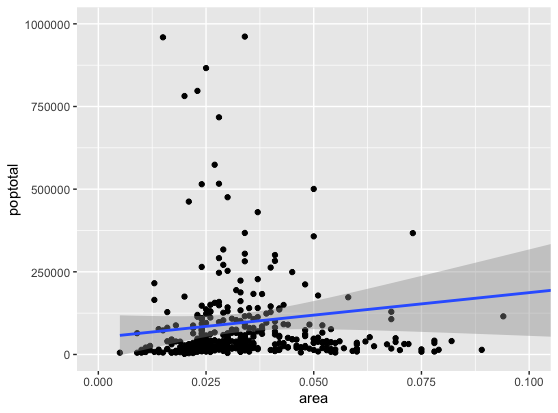
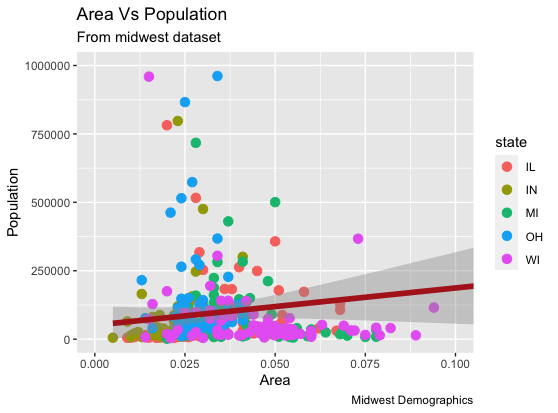
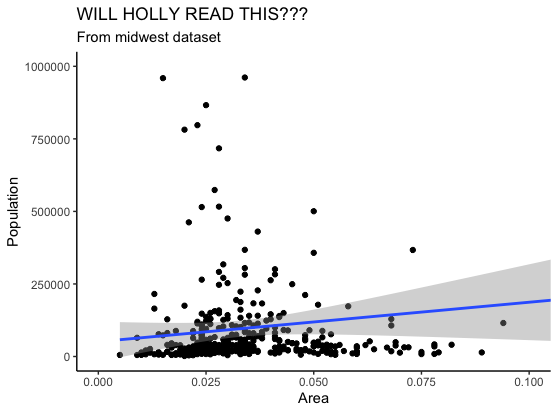
BIOL 772/872 M&S in Life Sciences

Lab 5 Name: Amanda DeVleeschower

1. Link for ggplot tutorials.
   1. <http://r-statistics.co/Complete-Ggplot2-Tutorial-Part1-With-R-Code.html>
   2. Try making the plots shown on new data set
   3. Export 3 plots of your data and insert those images here.





1. Add a third country to our COVID model.
   1. Copy R code here.
   2. Create one plot of Infected population in each country.

rm(list=ls())

require(deSolve)

#----- The differential equations -----

sir <- function(t, x, p) {

with(as.list(c(x,p)),{

#Country 1

dS\_1 <- -S\_1\*(beta\*(I\_1+A\_1)+m12\*beta\*(I\_2+A\_2)) - nu\_1\*S\_1 + w1\*V\_1 + w2\*R\_1

dE\_1 <- S\_1\*(beta\*(I\_1+A\_1)+m12\*beta\*(I\_2+A\_2)) - e\*E\_1

dA\_1 <- mu1\*e\*E\_1 - nu\_1\*A\_1 - gamma1\*A\_1

dI\_1 <- (1-mu1-mu2)\*e\*E\_1 - gamma2\*I\_1 - phi\*I\_1 - delta1\*I\_1

dH\_1 <- mu2\*e\*E\_1 + phi\*I\_1 - gamma3\*H\_1 - delta2\*H\_1

dR\_1 <- gamma1\*A\_1 + gamma2\*I\_1 + gamma3\*H\_1 - nu\_1\*R\_1 - w2\*R\_1

dV\_1 <- nu\_1\*S\_1 + nu\_1\*A\_1 + nu\_1\*R\_1- w1\*V\_1

#Country 2

dS\_2 <- -S\_2\*(beta\*(I\_2+A\_2)+m21\*beta\*(I\_1+A\_1)) - nu\_2\*S\_2 + w1\*V\_2 + w2\*R\_2

dE\_2 <- S\_2\*(beta\*(I\_2+A\_2)+m21\*beta\*(I\_1+A\_1)) - e\*E\_2

dA\_2 <- mu1\*e\*E\_2 - nu\_2\*A\_2 - gamma1\*A\_2

dI\_2 <- (1-mu1-mu2)\*e\*E\_2 - gamma2\*I\_2 - phi\*I\_2 - delta1\*I\_2

dH\_2 <- mu2\*e\*E\_2 + phi\*I\_2 - gamma3\*H\_2 - delta2\*H\_2

dR\_2 <- gamma1\*A\_2 + gamma2\*I\_2 + gamma3\*H\_2 - nu\_2\*R\_2 - w2\*R\_2

dV\_2 <- nu\_2\*S\_2 + nu\_2\*A\_2 + nu\_2\*R\_2 - w1\*V\_2

#Country 3

dS\_3 <- -S\_3\*(beta\*(I\_3+A\_3)+m31\*beta\*(I\_1+A\_1)) - nu\_3\*S\_3 + w1\*V\_3 + w2\*R\_1

dE\_3 <- S\_3\*(beta\*(I\_3+A\_3)+m31\*beta\*(I\_1+A\_1)) - e\*E\_3

dA\_3 <- mu1\*e\*E\_3 - nu\_3\*A\_3 - gamma1\*A\_3

dI\_3 <- (1-mu1-mu3)\*e\*E\_3 - gamma2\*I\_3 - phi\*I\_3 - delta1\*I\_3

dH\_3 <- mu3\*e\*E\_3 + phi\*I\_3 - gamma3\*H\_3 - delta2\*H\_3

dR\_3 <- gamma1\*A\_3 + gamma2\*I\_3 + gamma3\*H\_3 - nu\_3\*R\_3 - w3\*R\_3

dV\_3 <- nu\_3\*S\_3 + nu\_3\*A\_3 + nu\_3\*R\_3 - w1\*V\_3

list(c(

dS\_1, dE\_1, dA\_1, dI\_1, dH\_1, dR\_1, dV\_1,

dS\_2, dE\_2, dA\_2, dI\_2, dH\_2, dR\_2, dV\_2,

dS\_3, dE\_3, dA\_3, dI\_3, dH\_3, dR\_3, dV\_3

))

})

}

beta = 0.00005

nu\_1 = 0.0 # no vaccination in location 1

nu\_2 = 0.001

nu\_3 = 0.001

w1 = 1/90 # assuming vaccine immunity lasts for 90 days

w2 = 1/180 # assuming natural immunity lasts for 180 days

w3 = 1/180 #assuming immunity lasts for 180 days

e = 1/10 # 10 days from exposure to infection

mu1 = 0.25 # percent asymptomatic 15-60% from various sources

mu2 = 0.0002 # percent to hospital from CDC data from Sept 29, 2022

mu3 = 0.0002

gamma1 = 1/9 # guessing same as mild case or less

gamma2 = 1/10 # sick for 7-14 days

gamma3 = 1/50 # sick for 6 weeks or more

phi = 0.00004 # guessing part of hospitalized rates are from here

delta1 = 0.0

delta2 = 0.011/50 # case-fatality divided by length of infection

delta3= 0.0

m12 = 0.0

m21 = 0.0

m31 = 0.0

S\_0 <- 5000.0 # Initial conditions

E\_0 <- 0.0

A\_0 <- 0.0

I\_0 <- 5.0 # initial conditions

H\_0 <- 0.0

R\_0 <- 0.0 # initial conditions

V\_0 <- 0.0

times <- seq(0.0, 1000.0, 0.1) # Time sequence

parms <- c(beta=beta, nu\_1=nu\_1, nu\_2=nu\_2, w1=w1, w2=w2, e=e,

mu1=mu1, mu2=mu2, mu3= mu3, gamma1=gamma1, gamma2=gamma2,

gamma3=gamma3, phi=phi, delta1=delta1, delta2=delta2, delta3=delta3,

m12=m12, m21=m21, m31=m31

)

xstart <- c(S\_1=S\_0, E\_1=E\_0, A\_1=A\_0, I\_1=I\_0, H\_1=H\_0, R\_1= R\_0, V\_1=V\_0,

S\_2=S\_0, E\_2=E\_0, A\_2=A\_0, I\_2=I\_0, H\_2=H\_0, R\_2= R\_0, V\_2=V\_0,

S\_3=S\_0, E\_3=E\_0,A\_3=A\_0, I\_3=I\_0, H\_3=H\_0, R\_3=R\_0, V\_3=V\_0) # Initial conditions

my.atol <- c(1e-16,1e-16,1e-16,1e-16,1e-16,1e-16,1e-16,

1e-16,1e-16,1e-16,1e-16,1e-16,1e-16,1e-16,

1e-16,1e-16,1e-16,1e-16,1e-16,1e-16,1e-16); # Abs. accuracy - remember to add a term for each equation

my.rtol <- 1e-12 # Rel. accuracy

out <- as.data.frame(lsoda(xstart, times,

sir, parms, my.rtol, my.atol)) # Solve the eqns.

#----- Plot the output -------

plot(out$time, out$I\_1, col="black", type="l", lwd=5,

xlab="Time", ylab="Number")

#ylim=c(0,5000), xlab="Time", ylab="Number")

lines(out$time, out$I\_2, col="red", lwd=5)

lines(out$time, out$I\_3, col="blue", lwd=5)

#lines(out$time, out$R, col="blue", lwd=5)

grid(NULL, NULL, lty=1,lwd=1)

