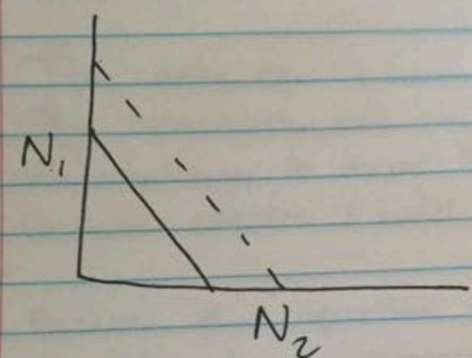
7.1)

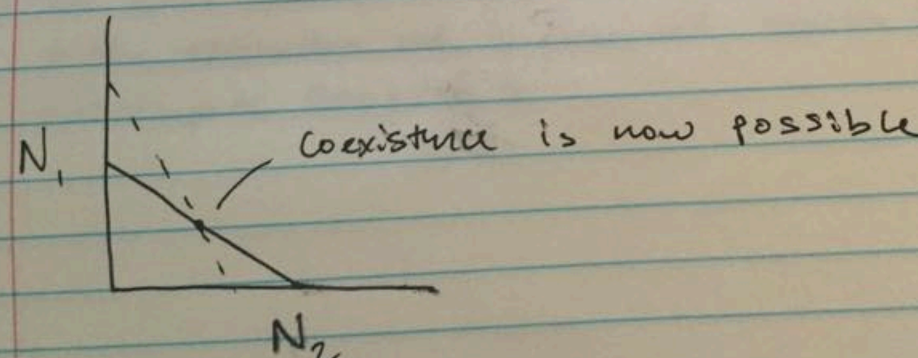
$$\frac{dN_1}{dt} = r_1 N_1 (1 - a_{11}N_1 - a_{12}N_2) - mN_1$$

$$\frac{dN_2}{dt} = r_2 N_2 (1 - a_{21}N_1 - a_{22}N_2) - mN_2$$

Without the additional term:



By adding the new term mN_i, it would change the intercepts which would change the trajectory of the isoclines.



7.2)

a) $\frac{dp_1}{dt} = m_1 p_1 (1-p_1) - e p_1 = 0$ $p_1 = 0$

$1 - p_1 = 0$ or $p_1 = 1$

$p_1 = 1$ To be positive $p_1 < 1$

b) $\frac{dp_2}{dt} = m_2 p_2 (1 - 1 - p_2) - m_1 \cancel{p_1} p_2 - e p_2 = 0$ $p_2 = 0$

The only equilibrium for p_2 is 0 given these conditions. The colonization rate must be greater in species 2 for coexistence to occur. Yes, it makes ecological sense because species 1 will typically replace species 2.

c) Because the equation for species 2 has two negative terms opposed to 1 in the equation for species 1 I predict that as the extinction rate is increased, species 2 would be eliminated first.

d) If both species have positive equilibrium levels & the extinction rate is increased, species 1 will outcompete species 2.

7.4)

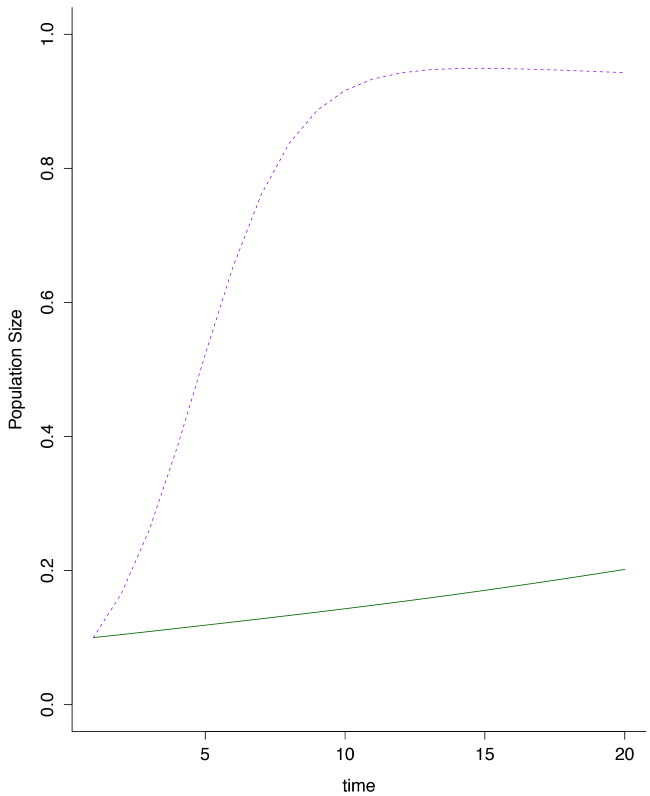
A) Detecting competition in a laboratory and field setting will likely differ. In a laboratory the interaction effects denoted by the term alpha will be easier to determine. Also, the experimenter will be able to control the conditions to limit outside influences. In the field, estimations of the alpha variable may be less accurate due to unaccounted effects, such as a change in weather.

B) Two species grown together would make it easier to detect competition if one has a clear effect on the other. If one species survives while the other doesn't, it's likely that it outcompeted the other species. However, to understand fully how the simultaneous growth of the species affects the outcome of the experiment, you must first observe their growth separately.

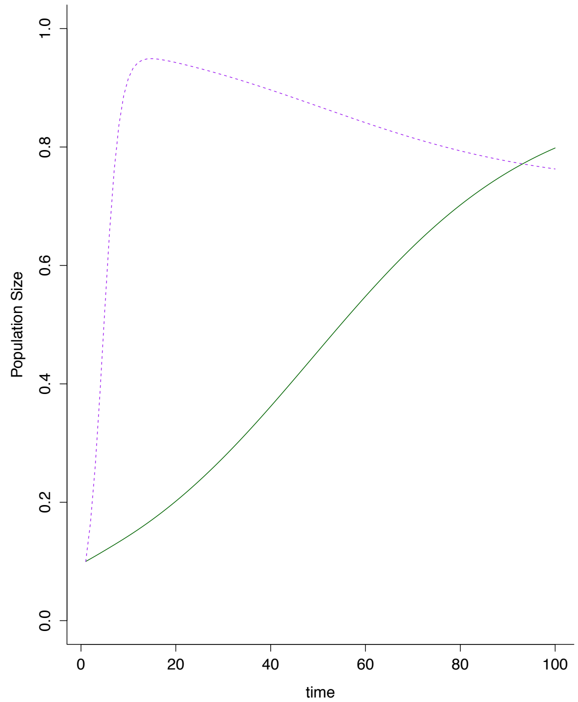
C) Competition does not always happen directly. It can occur putatively in the case of two species that share a resource. They may not directly interact with each other but the use of the same resource will negatively impact the other species, resulting in competition. If space is thought of as a resource then the work done by Connell, studying zonation in the intertidal zone, could be an example of an overlap in resource use by competitors.

D) Experimental field manipulations of populations may be the most difficult to clearly detect competition. In a field setting there are so many variables that you must account for or control. It could be completely possible that you determine that one species is in competition with another but later find that there was another factor affecting the growth rates of the two populations. Perhaps, the presence of absence of a mutualist that could have gone undetected. However, with good controls and enough replication, field manipulations can yield amazing results.

2. In the first simulation with t = 0:20, species 2 reaches their carrying capacity in about 10 days, while species 1's population is still increasing.



However, if the simulation is run for 100 time series, species 1 is still increasing and hasn't reached carrying capacity yet, while species 2 has a declining population that is less than the population size of species 1.




```
library(deSolve)

comp <- function(t, y, p) {
 N1 <- y[1]
 N2 <- y[2]
 with(as.list(p), {
  dN1.dt <- (r1 * N1 / K1) * (1 - N1 - a12 * N2)
  dN2.dt <- (r2 * N2 / K2) * (1 - N2 - a21 * N1)
  return(list(c(dN1.dt, dN2.dt)))
 })
}

p <- c('r1' = 0.1, 'K1' = 2, 'r2' = 0.6, 'K2' = 1,
    'a12' = 0.15,
    'a21' = 0.3)
y0 <- c('N1' = 0.1, 'N2' = 0.1)
t <- 1:20

sim <- ode(y = y0, times = t, func = comp, parms = p, method = 'lsoda')
sim <- as.data.frame(sim)

plot(N1 ~ time, data = sim, type = 'l', col = 'darkgreen', ylim = c(0, 1), bty = 'l',
ylab='Population Size')
points(N2 ~ time, data = sim, type = 'l', col = 'purple', lty = 2)
```