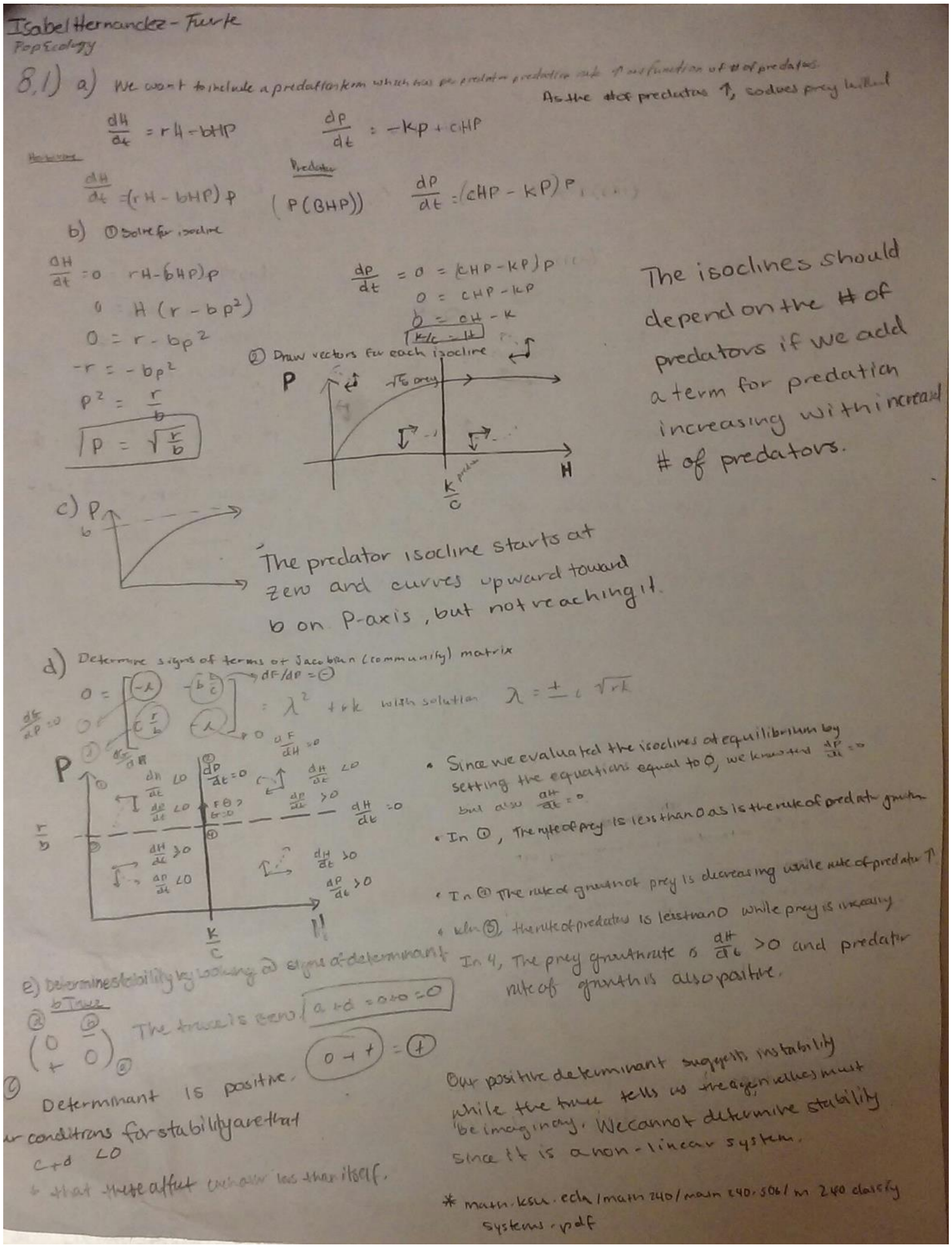
Isabel Hernandez-Fuerte

Population Ecology

HW 5

1. Hastings Problems
    a. 8.1



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Pop Ecology

8.1) a) We want to include a predation term which has per predator predation rate ↑ as function of # of predators.
As the # of predators ↑, reduces prey killed

$\frac{dH}{dt} = rH - bHP$ $\qquad$ $\frac{dP}{dt} = -kP + cHP$

Herbivore $\qquad$ Predator

$\frac{dH}{dt} = (rH - bHP)P$ $\qquad$ $(P(BHP))$ $\qquad$ $\frac{dP}{dt} = (cHP - kP)P$

b) ① Solve for isocline

$\frac{dH}{dt} = 0 \quad rH - bHP)P$

$0 = H(r - bp^2)$

$0 = r - bp^2$

$-r = -bp^2$

$p^2 = \frac{r}{b}$

$\boxed{P = \sqrt{\frac{r}{b}}}$

$\frac{dP}{dt} = 0 = cHP - kP)P$

$0 = cHP - kP$

$0 = cH - k$

$\boxed{k/c = H}$

② Draw vectors for each isocline

P, $\sqrt{b}$ prey, H, $\frac{k}{c}$ predator

The isoclines should depend on the # of predators if we add a term for predation increasing with increased # of predators.

c) P, b

The predator isocline starts at zero and curves upward toward b on P-axis, but not reaching it.

d) Determine signs of terms of Jacobian (community) matrix

$0 = \begin{bmatrix} -\lambda & -b\frac{k}{c} \\ c\frac{r}{b} & -\lambda \end{bmatrix} = \lambda^2 + rk$ with solution $\lambda = \pm i\sqrt{rk}$

$dF/dP = \ominus$ $\qquad$ $\frac{dF}{dH} = 0$ $\qquad$ $\frac{dF}{dP} = 0$

P, $\frac{r}{b}$, H, $\frac{k}{c}$

$\frac{dH}{dt} < 0$, $\frac{dP}{dt} < 0$ $\qquad$ $\frac{dP}{dt} = 0$ $\qquad$ $\frac{dH}{dt} < 0$, $\frac{dP}{dt} > 0$ $\qquad$ $\frac{dH}{dt} = 0$

$\frac{dH}{dt} > 0$, $\frac{dP}{dt} < 0$ $\qquad$ $\frac{dH}{dt} > 0$, $\frac{dP}{dt} > 0$

- Since we evaluated the isoclines at equilibrium by setting the equations equal to 0, we know that $\frac{dP}{dt} = 0$ but also $\frac{dH}{dt} = 0$
- In ①, The rate of prey is less than 0 as is the rate of predator growth
- In ② The rate of growth of prey is decreasing while rate of predator ↑
- In ③, the rate of predators is less than 0 while prey is increasing
- In 4, The prey growth rate is $\frac{dH}{dt} > 0$ and predator rate of growth is also positive.

e) Determine stability by looking at signs of determinant

b Trace

$\begin{pmatrix} 0 & - \\ + & 0 \end{pmatrix}$ The trace is zero $\boxed{a + d = 0 + 0 = 0}$

$(0 - +) = \oplus$

Determinant is positive.

Our conditions for stability are that $c + d < 0$
& that these affect each other less than itself.

Our positive determinant suggests instability while the trace tells us the eigenvalues must be imaginary. We cannot determine stability since it is a non-linear system.

* math.ksu.edu/math240/math240.506/m240 classify systems.pdf

b. 8.3

8.1) f) In some ways, this makes sense. Because in the case of insects, if a tree has certain defenses like toxin release, the predators are kept in control and each individual one has an individual effect on the tree, but at a certain threshold of predators, the effect that each individual predator has on the tree increases due not to its own feeding, but also that this feeding damage is increased by the sheer number of predators available.

8.3)

8.22) $\frac{dH}{dt} = rH\left[1-\frac{H}{K}\right]-bHP$

8.23) $\frac{dP}{dt} = cHP - kP$

Add a term representing effect of pesticide, an add source of mortality (density-dependent)

$$\frac{dH}{dt} = rH\left(1-\frac{H}{K}\right) - bHP - mH$$

$$\frac{dP}{dt} = cHP - kP - mP$$

Adding another mortality term which seems to affect predators as well as the pests decreases the prey of the predators and also decreases predators. Thus, the pests are benefitting from the same food source, but less competition initially as prey is low and then the increased death rate of predators combined allow them to flourish

4) No density dependence

a) Some of the prey are not experiencing predation

$\frac{dH}{dt} = rH\left[1-\frac{H}{K}\right]-bHP$

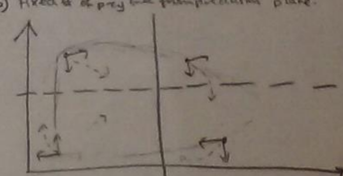
modified $\frac{dH}{dt} = f(rH) + rH\left[1-\frac{H}{K}\right]-bHP$

$\frac{dH}{dt} = f(rH) + rH - \frac{rH^2}{K} - bHP$

$\frac{dH}{dt} = H\left(f(r) + r - \frac{rH}{K} - bP\right)$

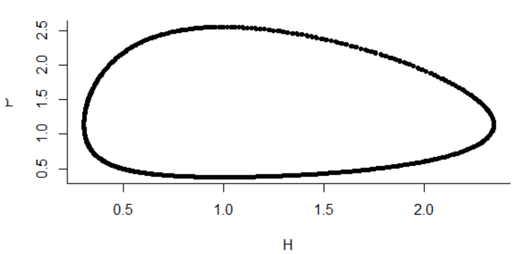
Refuges increase the stability of the models when applied to prey because these populations are less perturbed by the fluctuations in predator numbers. Gause though finds that the dynamics in ecological systems are less stable when looking at changes in predator capture.

b) Fixed # of prey free from predation plane.



Plugged the equation H into R showed a very similar plot except that prey is always reaching higher population peaks.

c. 8.4




```r
library (deSolve)
## Function for pred-prey interaction
pred.prey <- function (t, y, p) {
  H <- y [1]
  P <- y [2]
  with(as.list(p), {
    dH.dt <- r * H - b * H * P + m * r * H
    dP.dt <- c * H * P - k * P
    return(list(c(dH.dt, dP.dt)))
  })
}
## Specify the parameters and initial conditions
p <- c('r' = 1,
       'b' = 1,
       'c' = 1,
       'k' = 1,
       'm' = 0.14)
y0 <- c('H' = 0.5, 'P' = 0.5)
t <- 1:1000

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

## Plot Time Series
plot(H ~ time, data = sim, type = 'l', col = 'darkgreen', bty = 'l', lwd = 2)
points(P ~ time, data = sim, type = 'l', col = 'purple', lty = 2, lwd = 2)

## Plot Phase Space and Attractor
plot(P ~ H, data = sim, type = 'p', bty = 'l', pch = 20)
```

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3. Checked out document.