Social-ecological network dynamics

An analysis of a simple dynamical model of a consumer-resource system with network effects.

Setup

First load the necessary packages. *deSolve* for solving the diffeqs and *phaseR* for the phase plane analyses.

```
library(deSolve)
library(phaseR)
```

Second let's write a convenience function that calls on phaseR under the hood to generate the flow field, nullclines, and sample trajectories for a given system and parameterization.

```
phasePlot <- function(mod, params, xmax = 1, ymax = 1){
  x.lim <- c(0, xmax)
  y.lim <- c(0, ymax)

  y0 <- matrix(c(.5,.5, 1,1, .1,.1),
               ncol = 2, nrow = 3,
               byrow = TRUE)

  flw <- flowField(mod, x.lim = x.lim, y.lim = y.lim, parameters = params,
                   xlab = 'Population', ylab = 'Resource Biomass', add = F)
  nc <- nullclines(mod, x.lim = x.lim, y.lim = y.lim, parameters = params)
  trj <- trajectory(mod, y0 = y0, t.end = 100, colour = rep('black', nrow(y0)), parameters = params)
}
```

Model 1: Simple consumer-resource system with network effects

First, we'll replicate the model of Muneepeerakul and Qubbaj (2012). It's a simple consumer resource system, with parameterized flows of population and resources (i.e. immigration and trade).

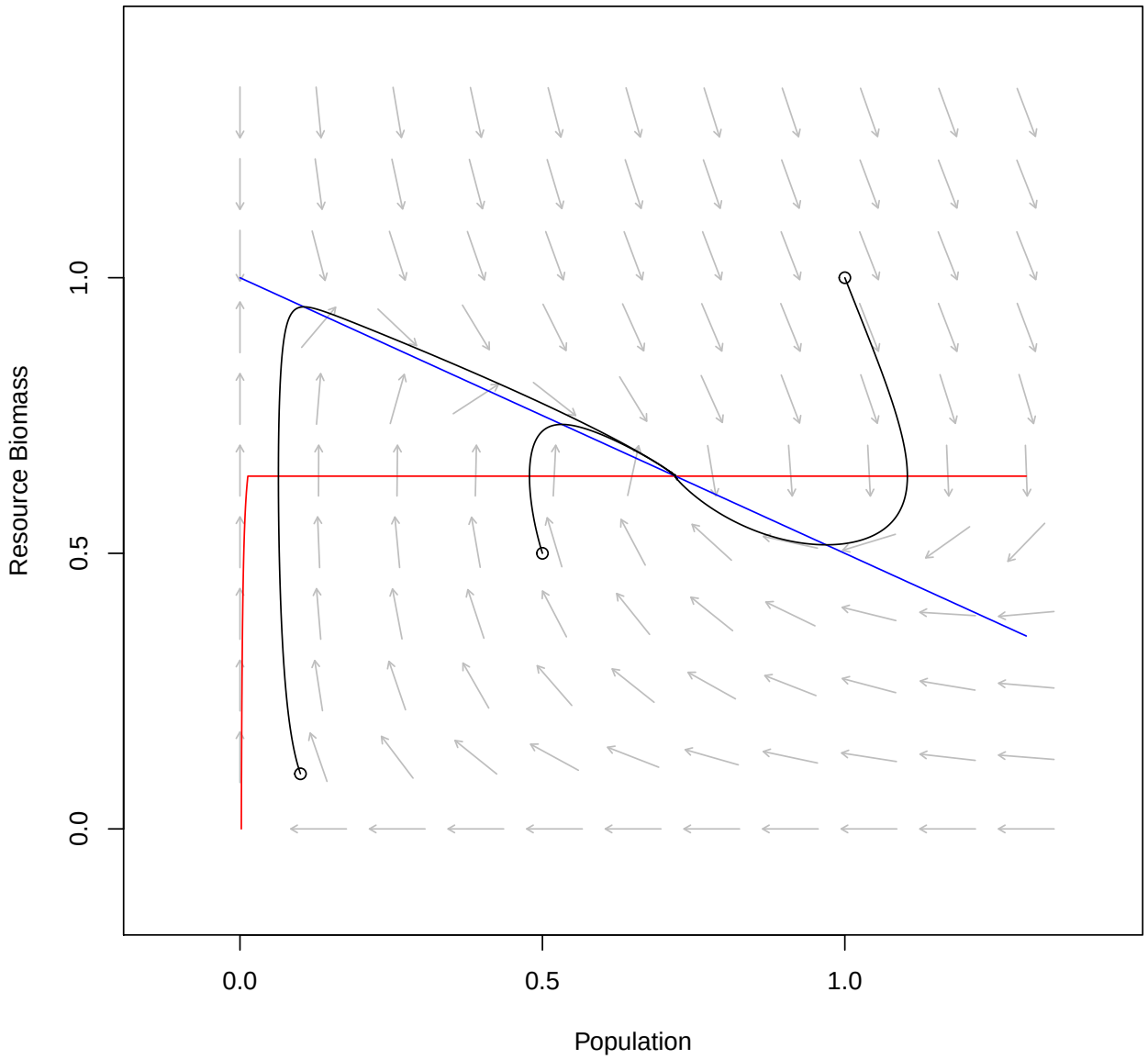
Setup the model.

```
netMod <- function(t, y, parameters){
    H <- parameters[1]
    M <- parameters[2]
    alpha <- parameters[3]
    beta <- parameters [4]
    mu <- parameters[5]
    xi <- parameters[6]

    dy <- numeric(2)
    dy[1] <- H * y[2] * y[1]^beta - M * y[1]^alpha + xi
    dy[2] <- y[2] * (1 - y[2]) - H * y[2] * y[1]^beta + mu
    list(dy)
}
```

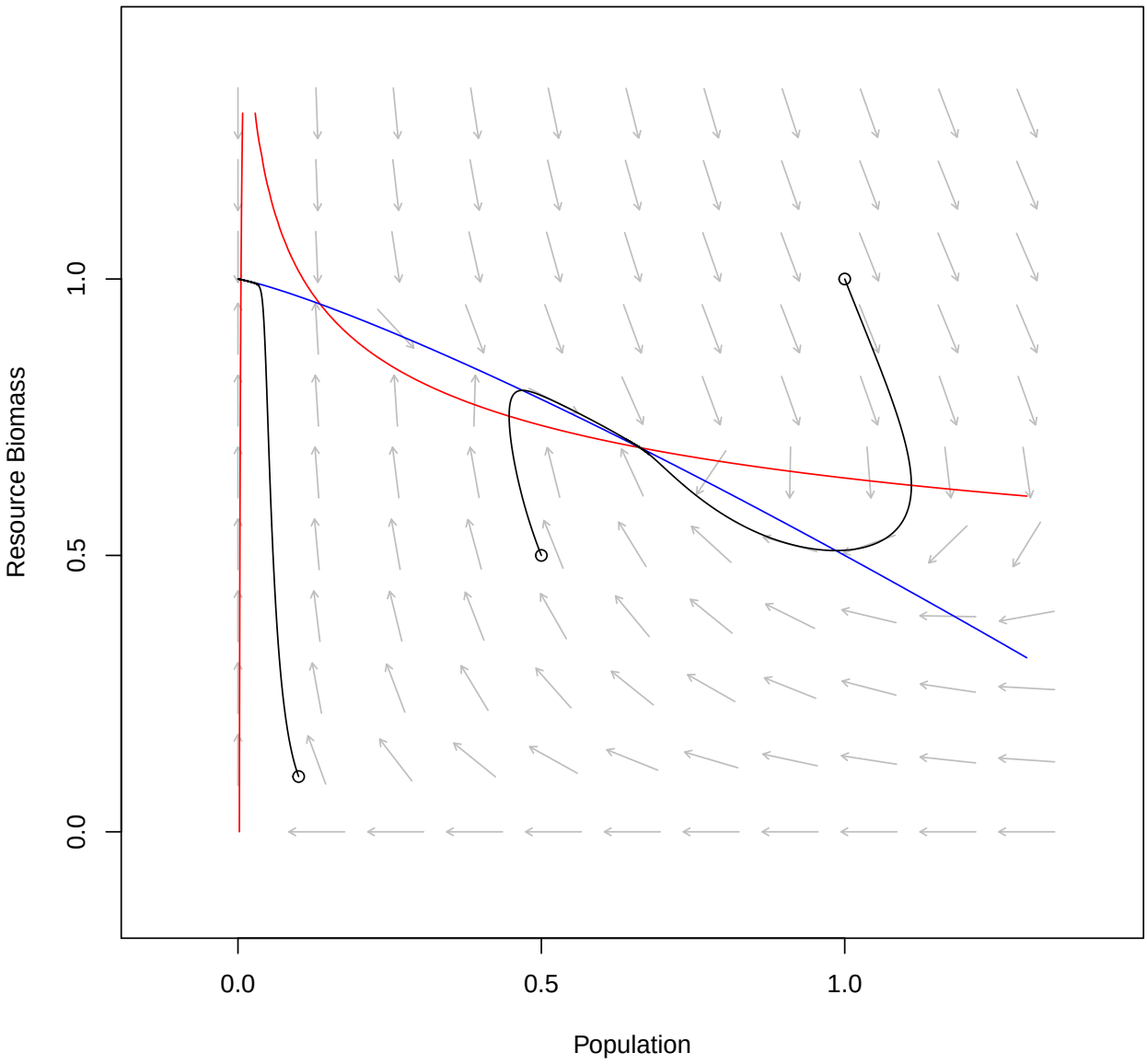
No scaling

```
phasePlot(netMod, c(.5, .32, 1, 1, 0, 0), xmax = 1.3, ymax = 1.3)
```



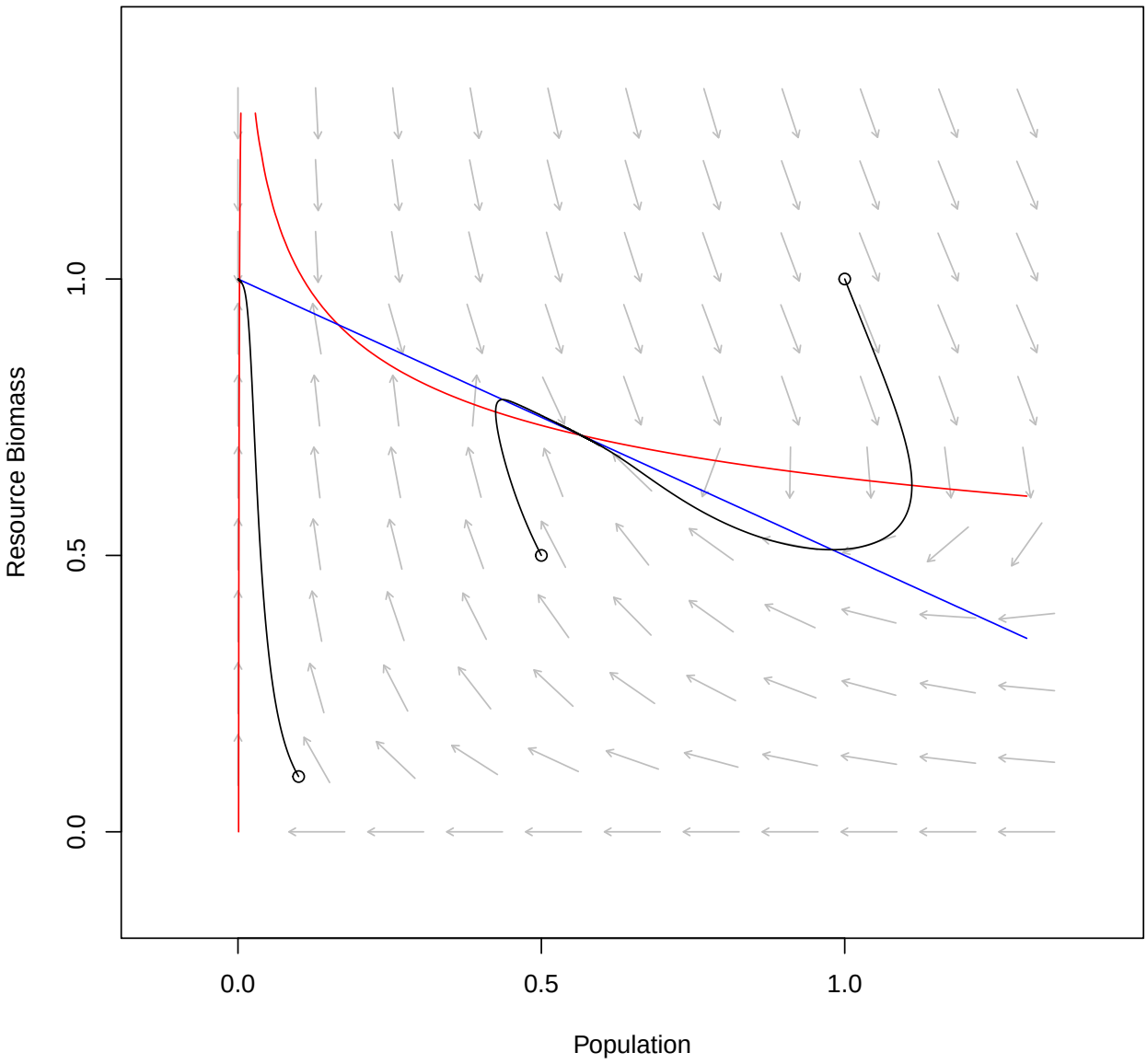
Superlinear scaling of harvest ability

```
phasePlot(netMod, c(.5, .32, 1, 1.2, 0, 0), xmax = 1.3, ymax = 1.3)
```



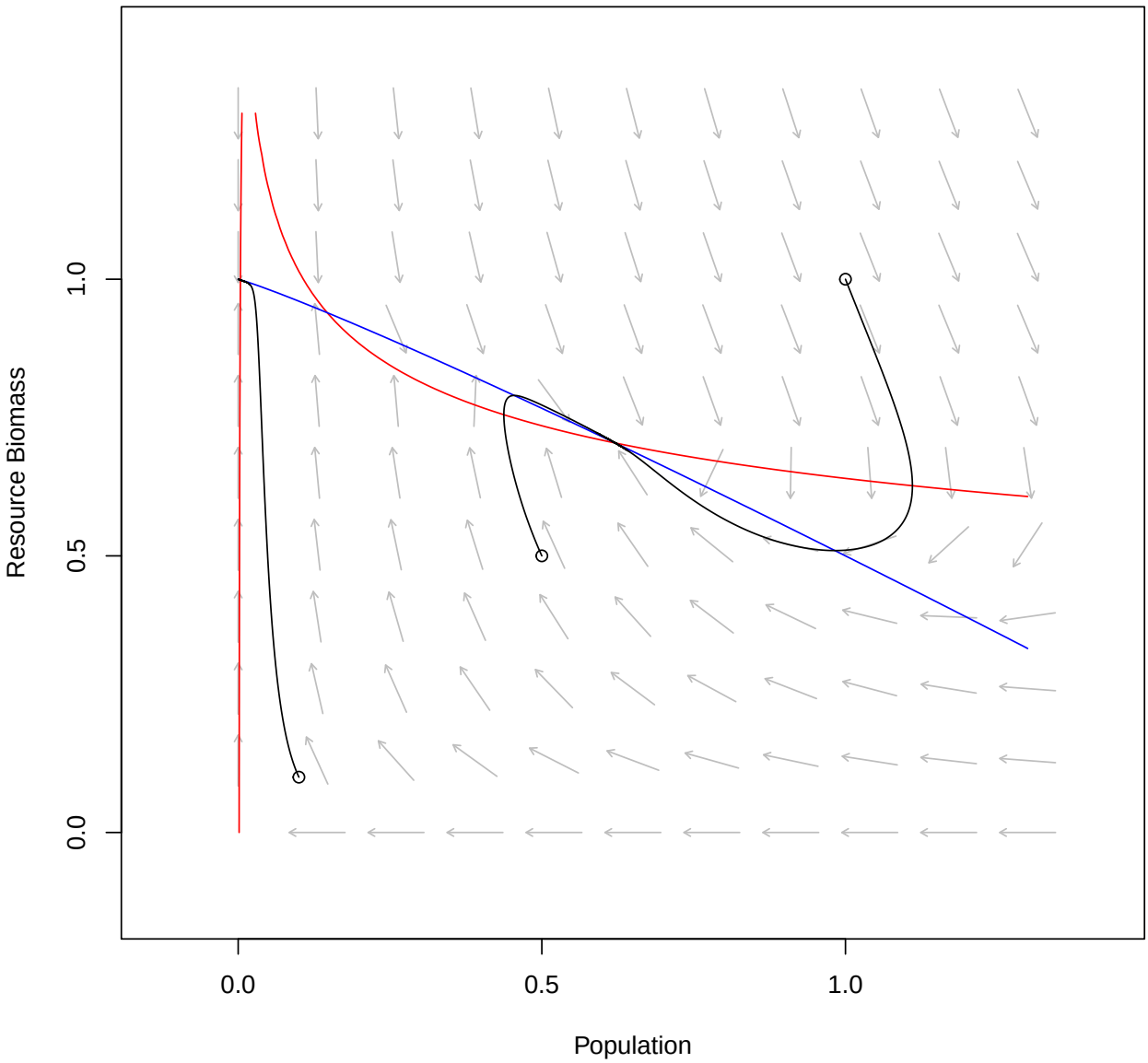
Sublinear scaling of resource conversion efficiency

```
phasePlot(netMod, c(.5, .32, .8, 1, 0, 0), xmax = 1.3, ymax = 1.3)
```



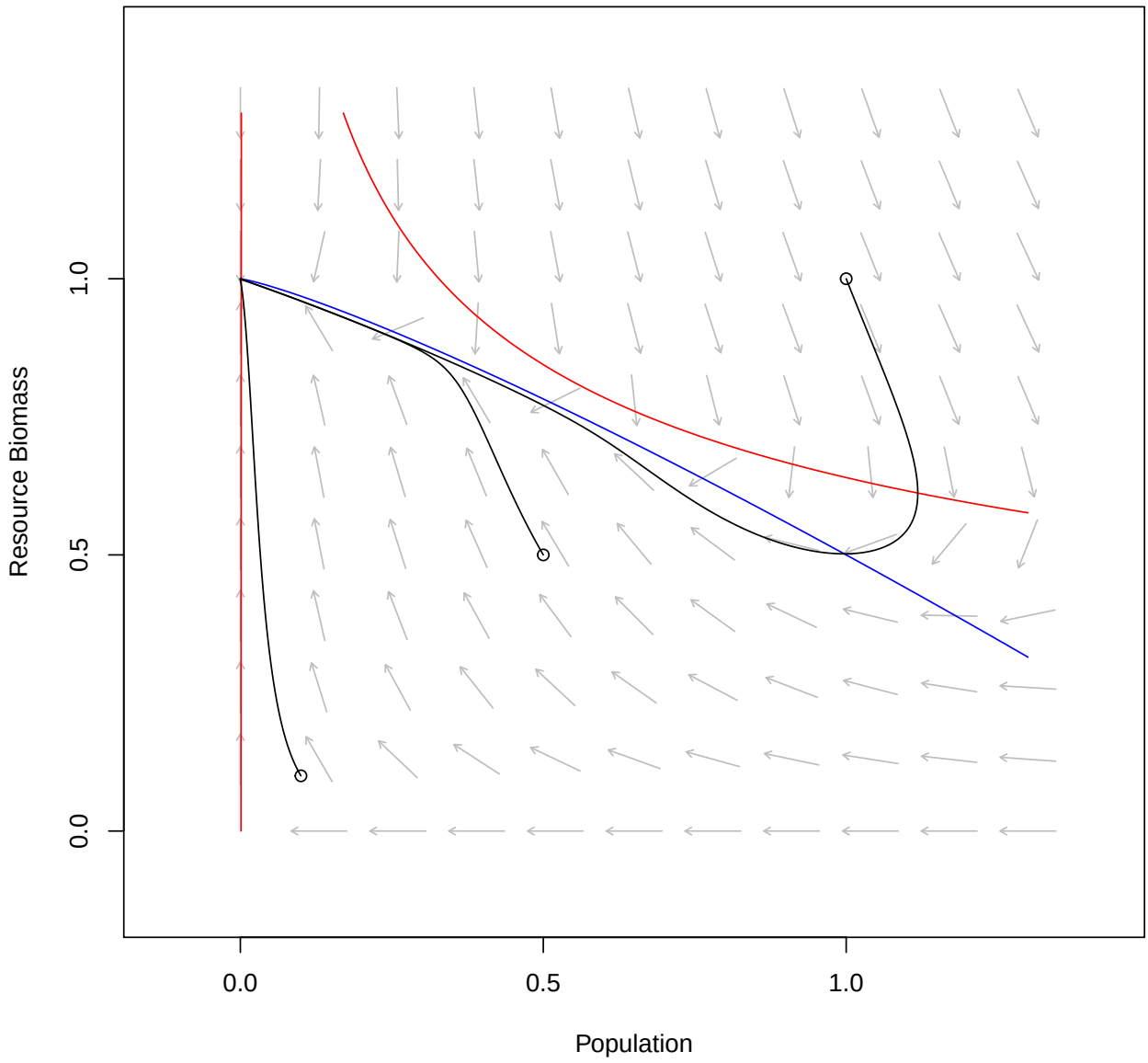
Both scaling processes. lesser scaling

```
phasePlot(netMod, c(.5, .32, .9, 1.1, 0, 0), xmax = 1.3, ymax = 1.3)
```



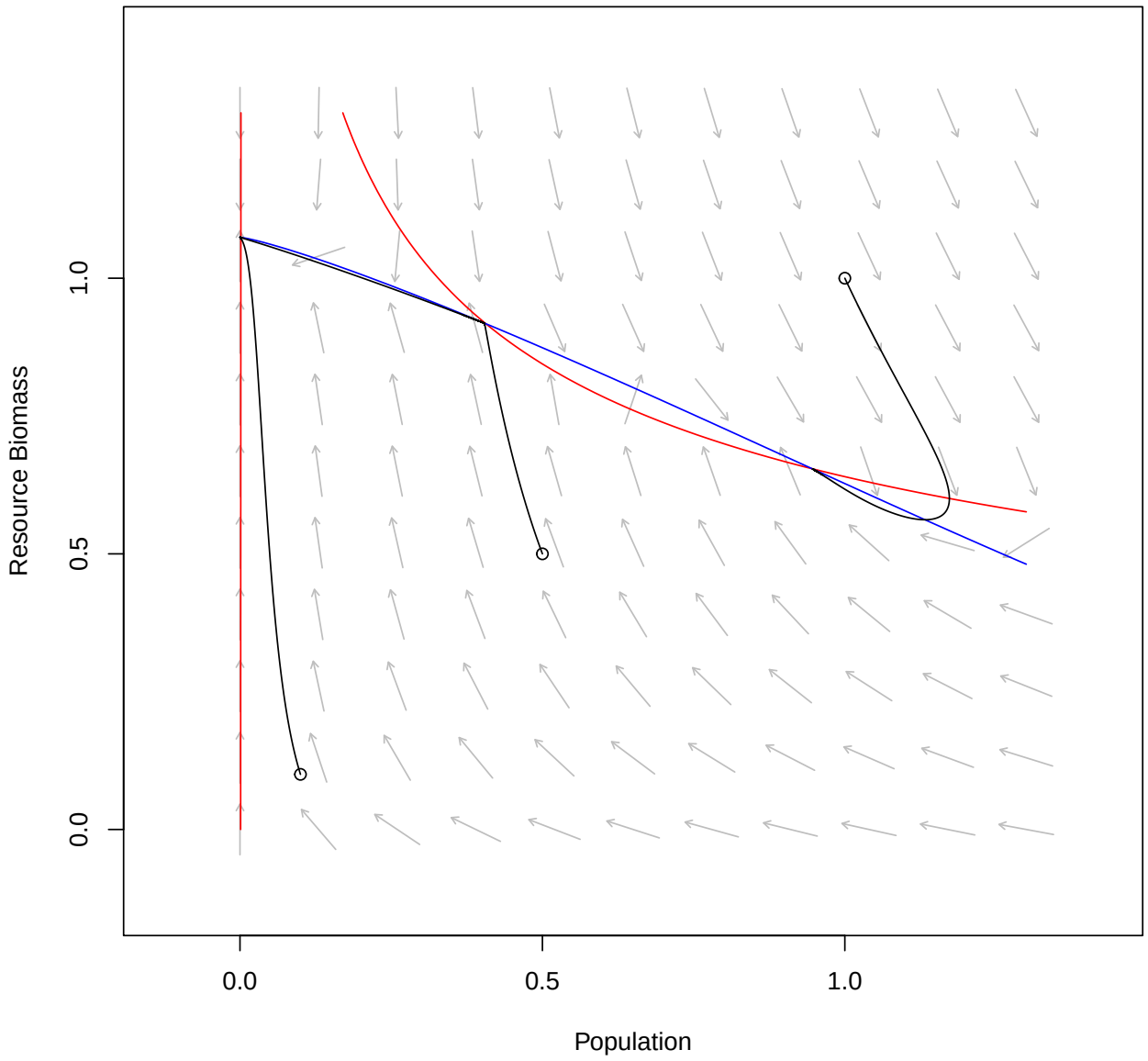
greater scaling

```
phasePlot(netMod, c(.5, .32, .8, 1.2, 0, 0), xmax = 1.3, ymax = 1.3)
```



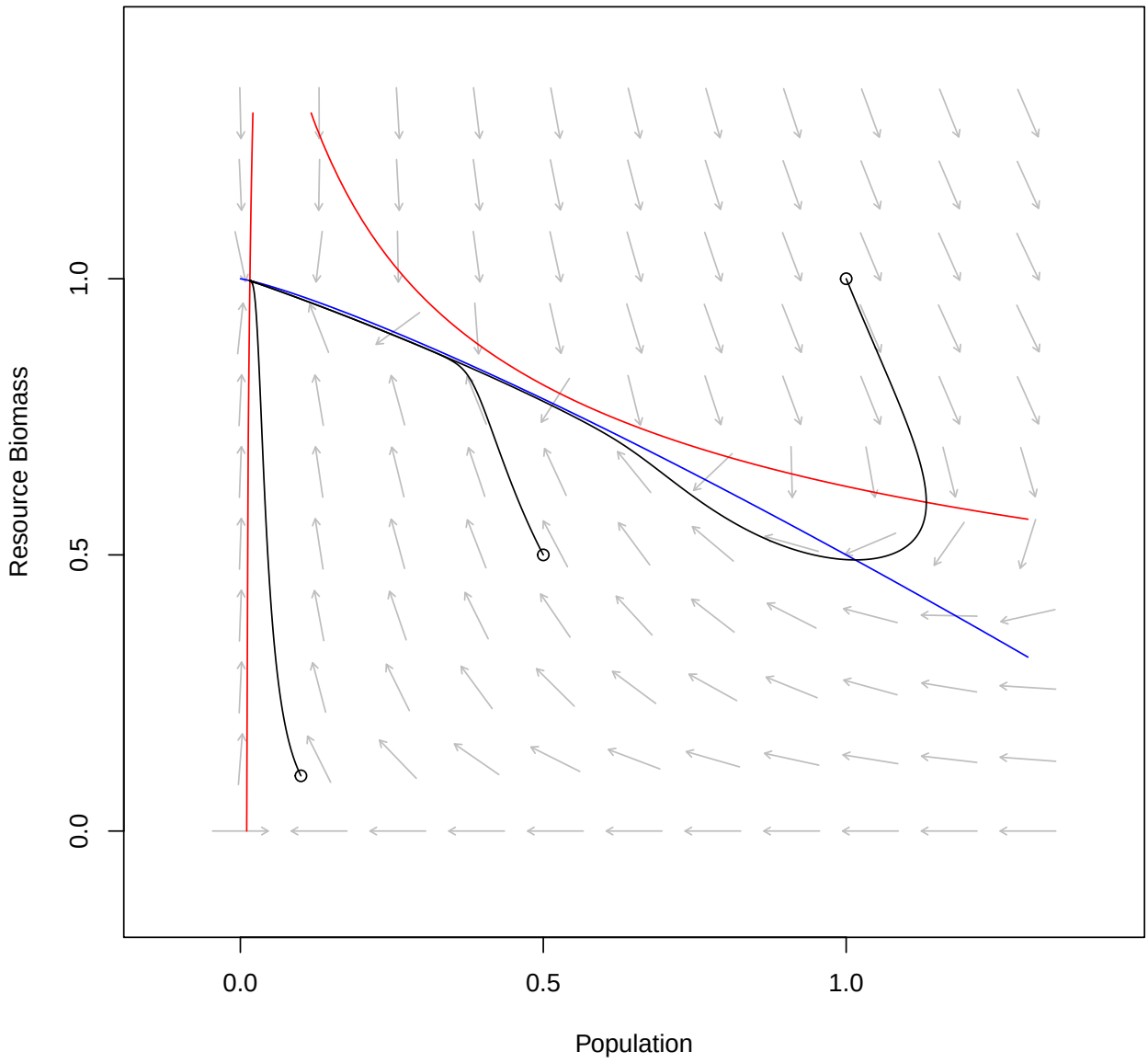
Trade

```
phasePlot(netMod, c(.5, .32, .8, 1.2, .08, 0), xmax = 1.3, ymax = 1.3)
```

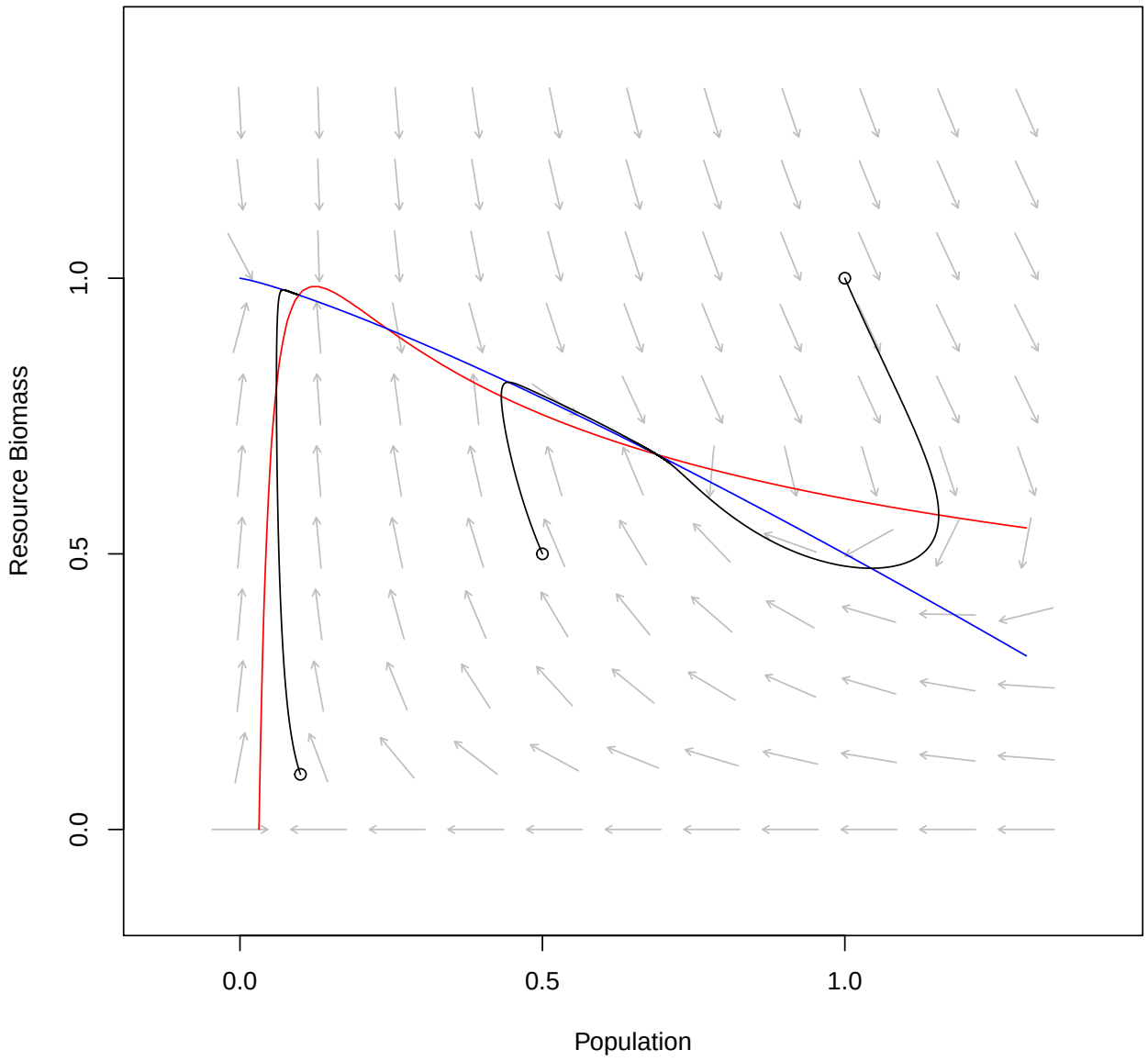


Immigration

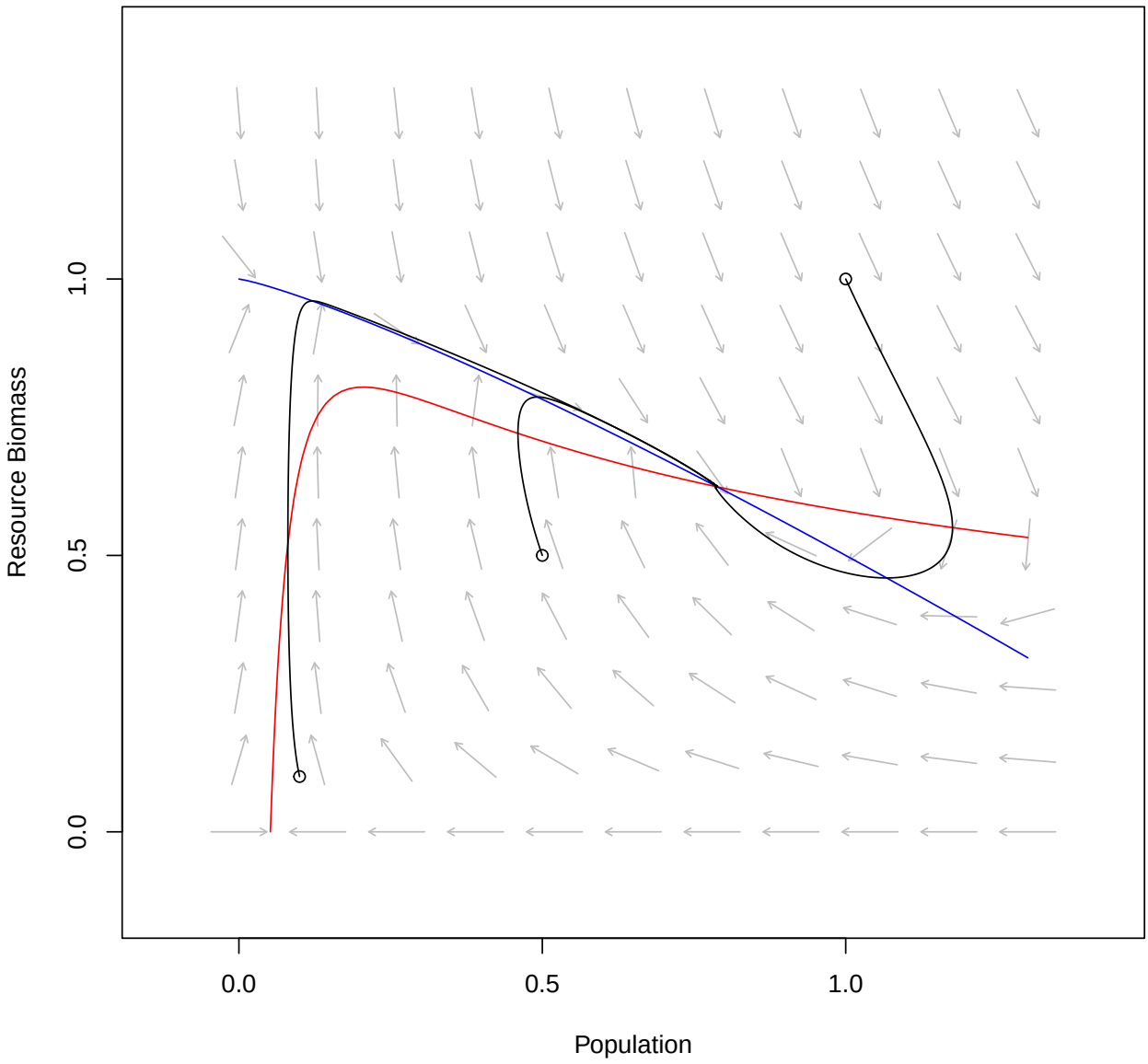
```
phasePlot(netMod, c(.5, .32, .8, 1.2, 0, .008), xmax = 1.3, ymax = 1.3)
```




```
phasePlot(netMod, c(.5, .32, .8, 1.2, 0, .02), xmax = 1.3, ymax = 1.3)
```




```
phasePlot(netMod, c(.5, .32, .8, 1.2, 0, .03), xmax = 1.3, ymax = 1.3)
```


Resource Biomass
0.0
0.5
1.0
0.0
0.5
1.0
Population