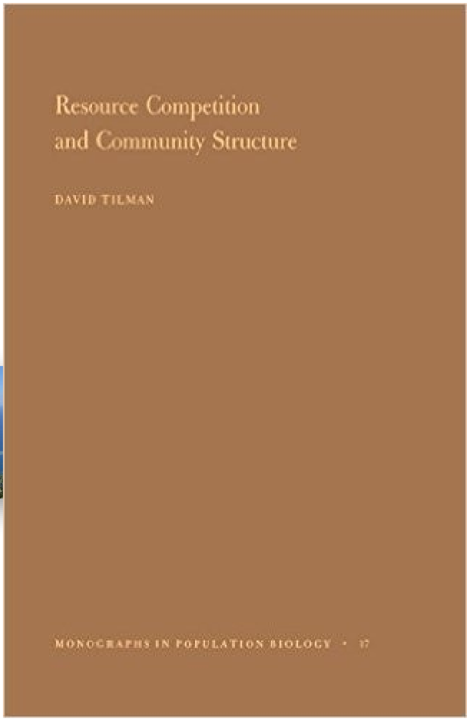
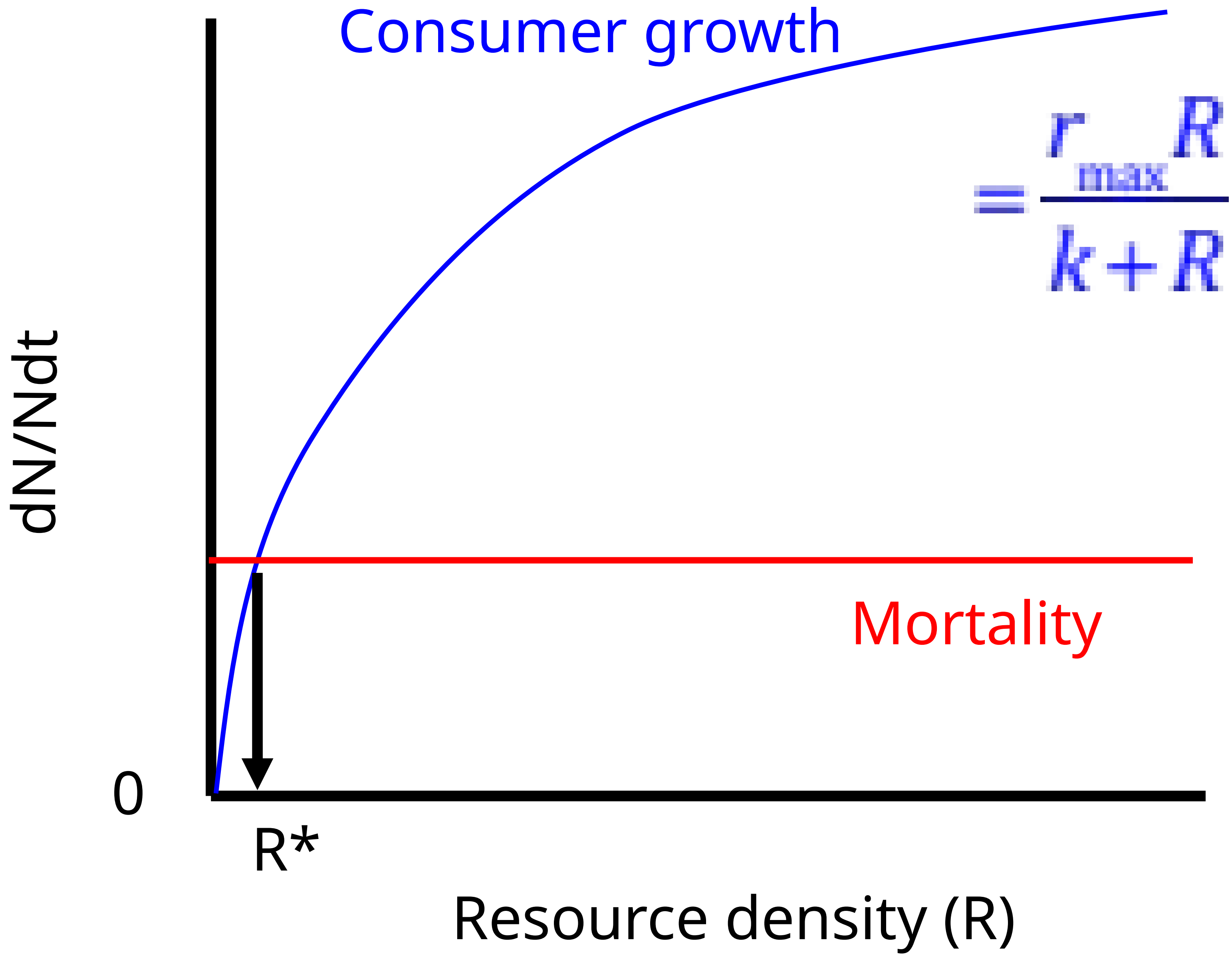
Ecology 8310
Population (and Community) Ecolo



Competition: the R* approach

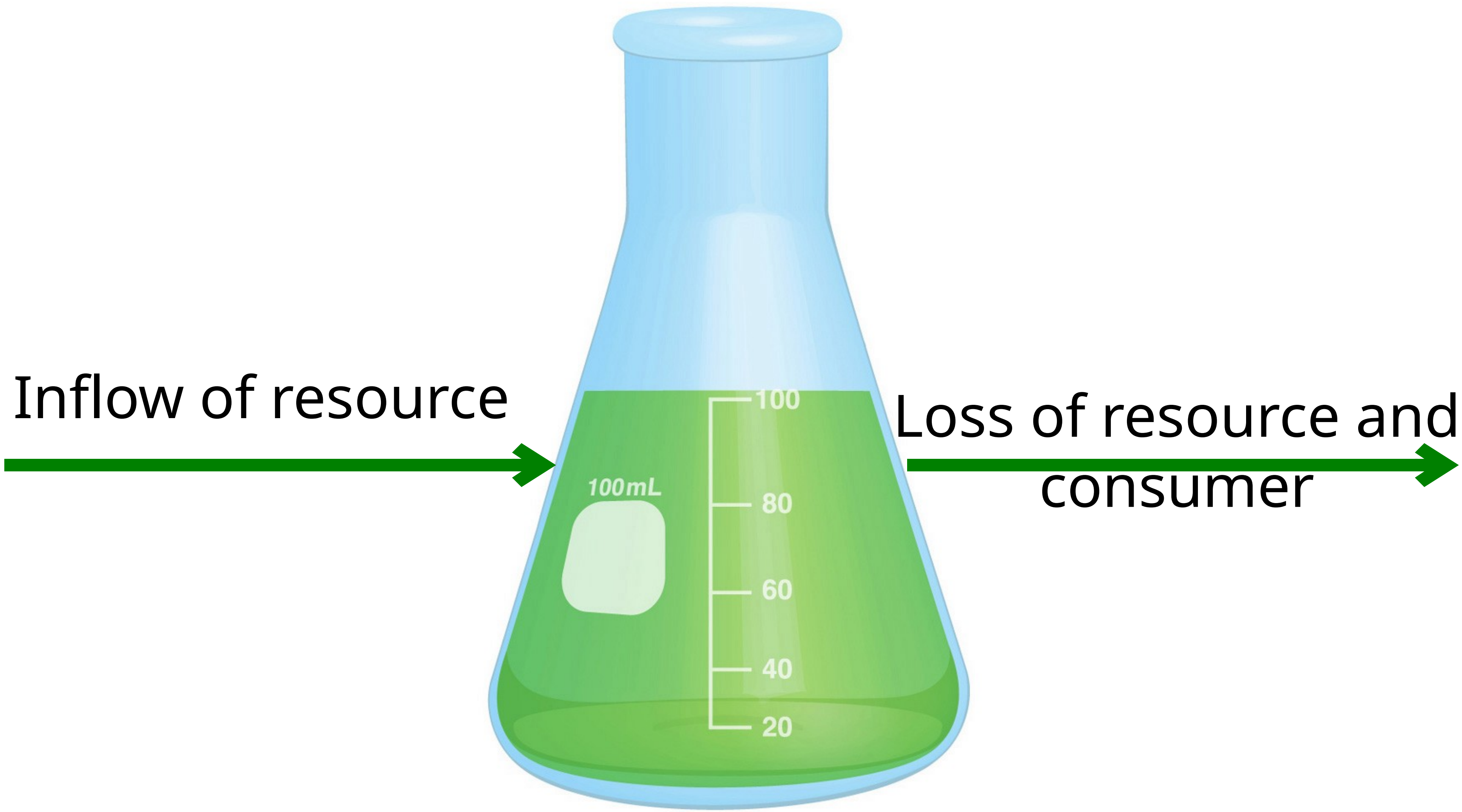
- Consumer and resource dynamics
- A graphical approach
  - ZNGIs
  - Consumption vectors
  - Resource renewal
  - Putting it together
- Tests

The basics:



Consumer growth
$= \frac{r_{max} R}{k + R}$
dN/Ndt
Mortality
0
R*
Resource density (R)

The basics: A chemostat



Write out equations for dynamics of the consumer (N) and resource (R)…

N=concentration of consumer in the chemostat

R=concentration of resource in the chemostat

R_0=concentration of resource in the inflow

F=flow rate into (out of) the chemostat

V=volume of the chemostat

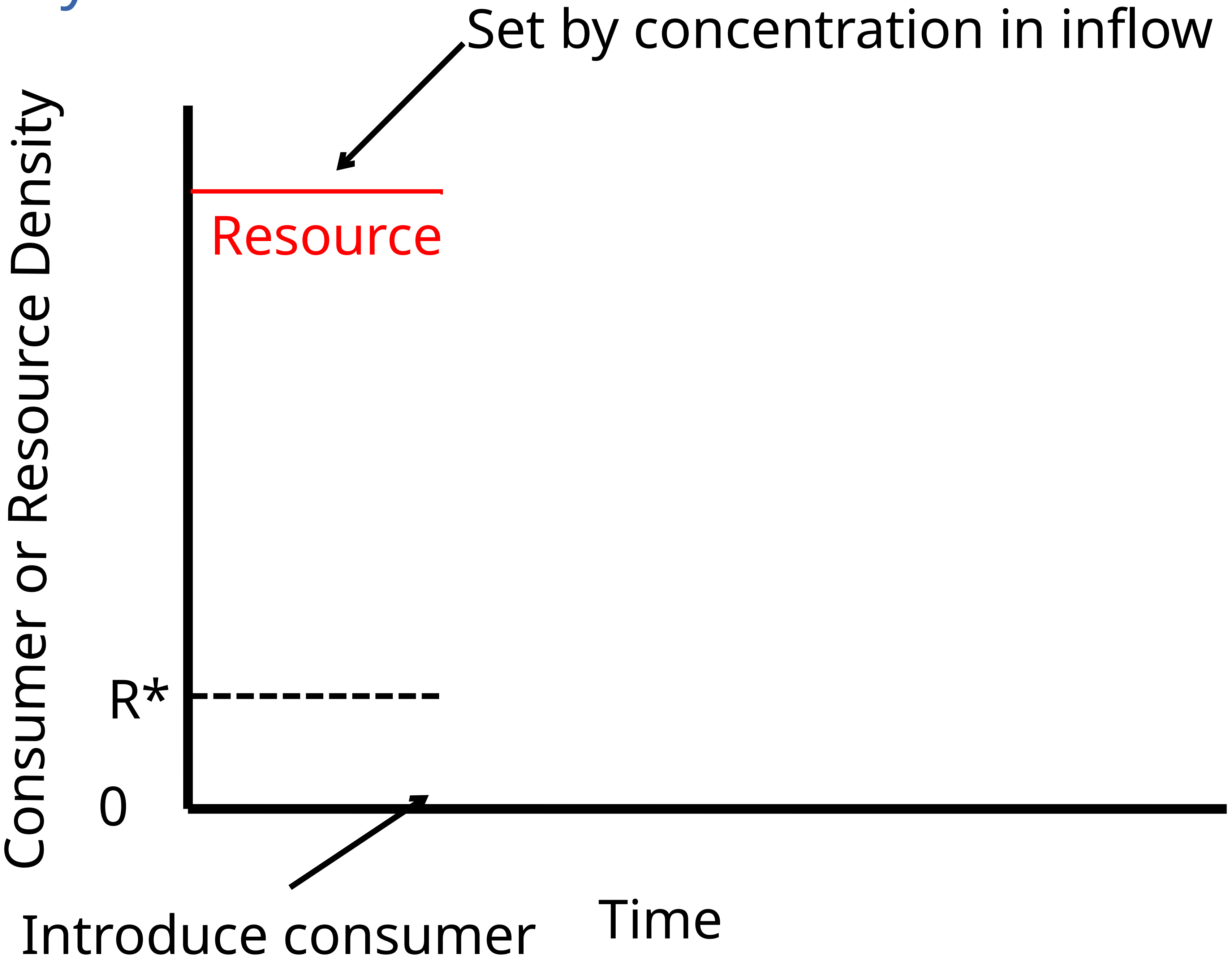
Q=cell quota (resource content / consumer)

Note: be clear about whether you're tracking abundance in vessel or concentration

Notes:

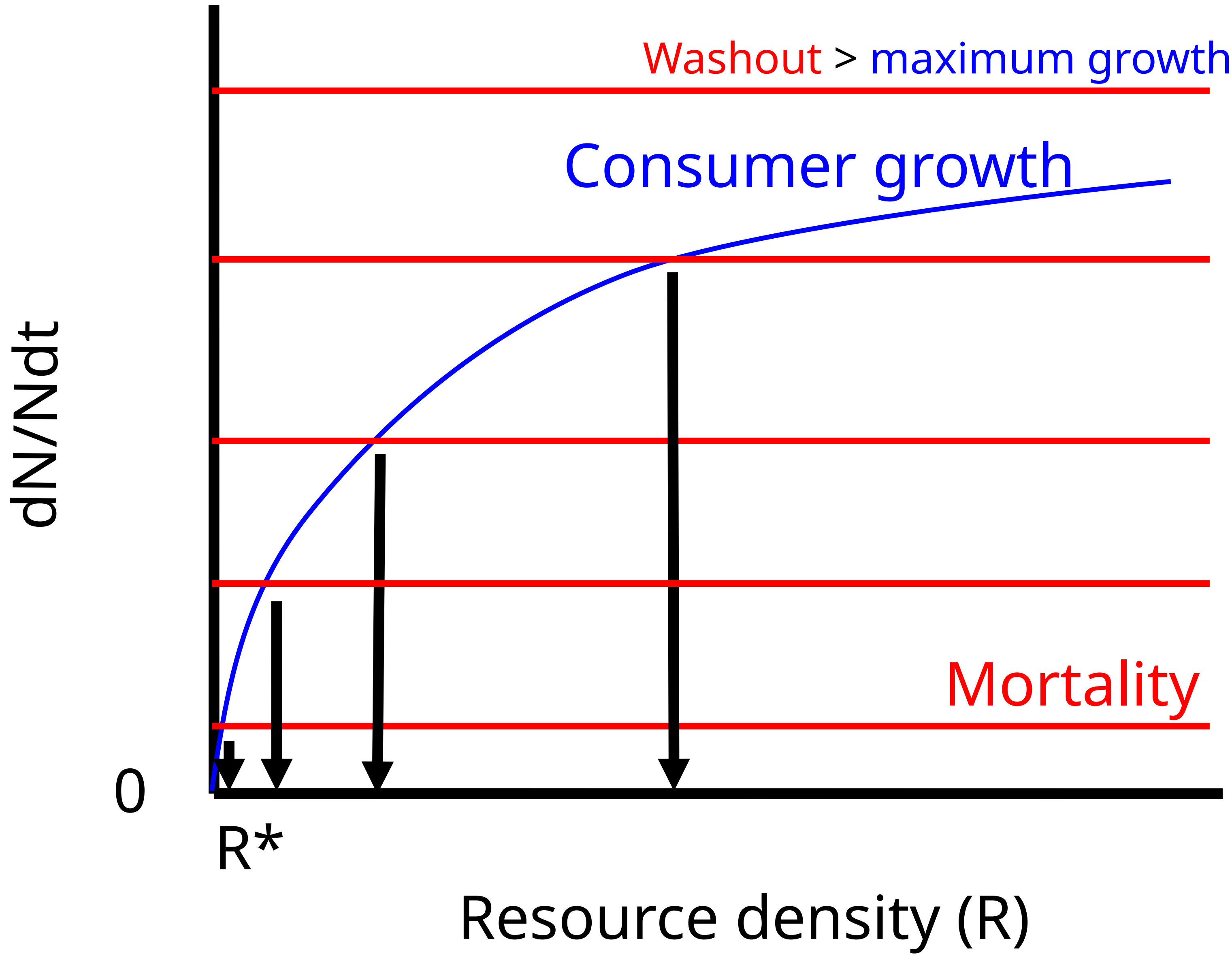
- R,N measured as concentrations
- R is the concentration of free resource (so we can ignore that bound up in the consumer that flows out)
- D = F/V, which is the mortality rate (per capita"wash out" rate)

The dynamics:



What happens to N^* and R^* if we increase the flow?

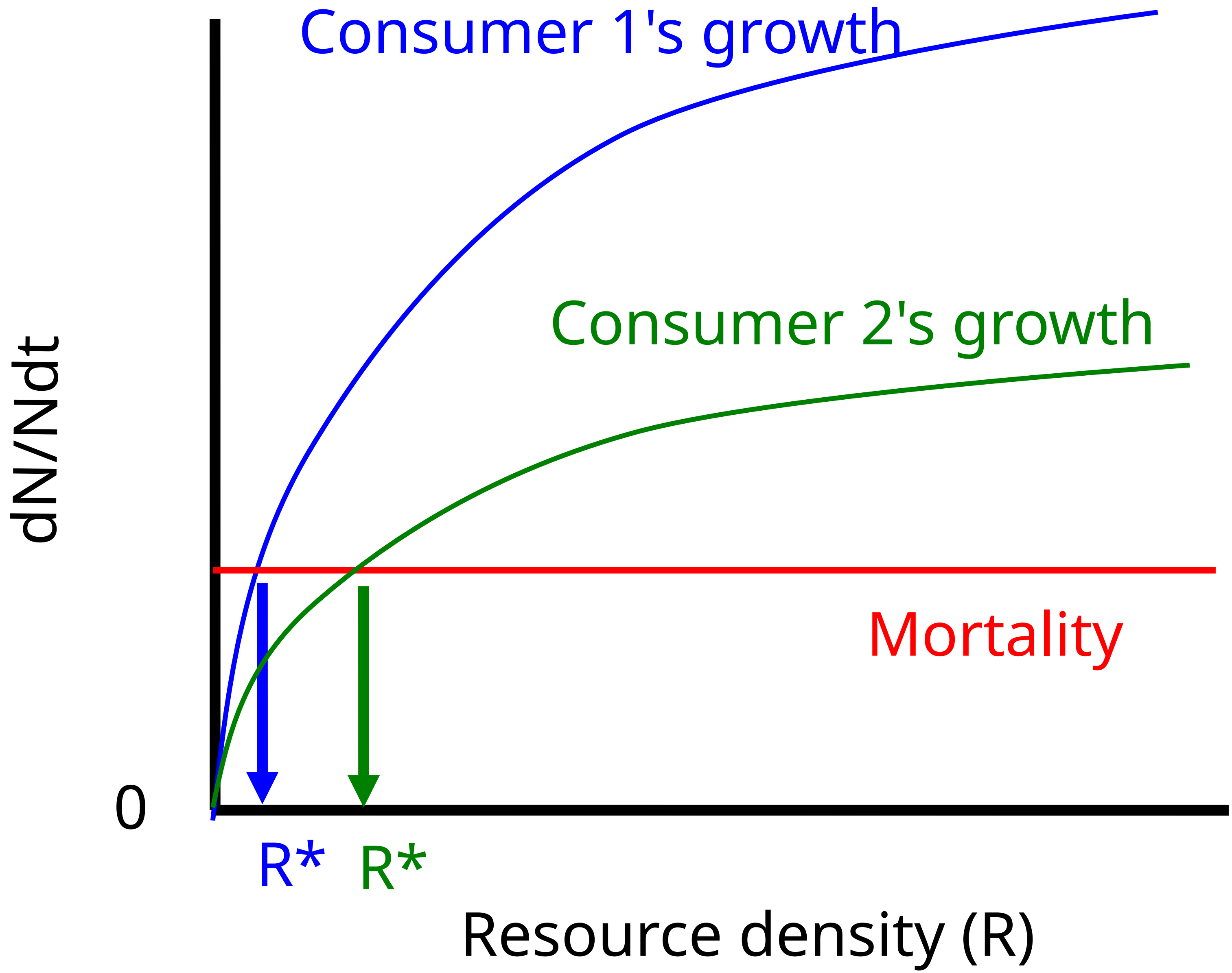
The basics:



Washout > maximum growth
Consumer growth
Mortality
dN/Ndt
0
R*
Resource density (R)

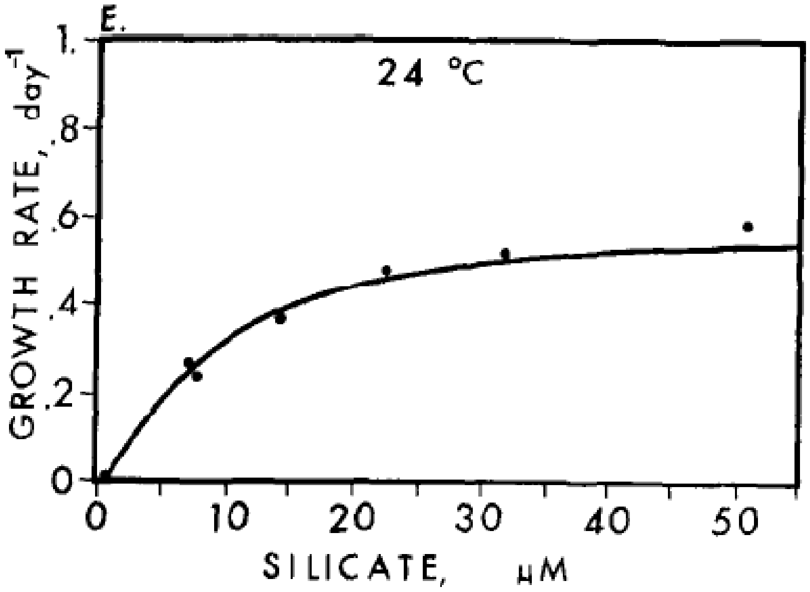
What if we have two consumers?

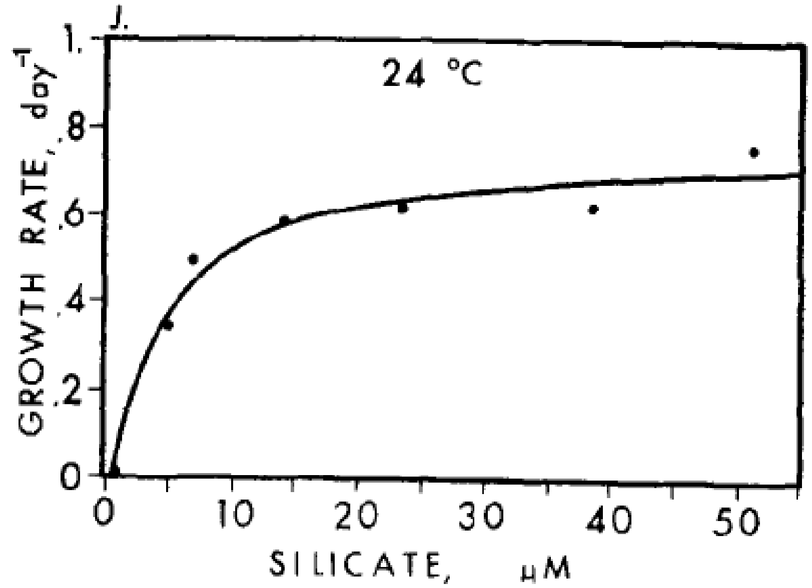
Two consumers:



Asterionella

Synedra





What will happen if we put one (or both) species into a chemostat and silicate is limiting?

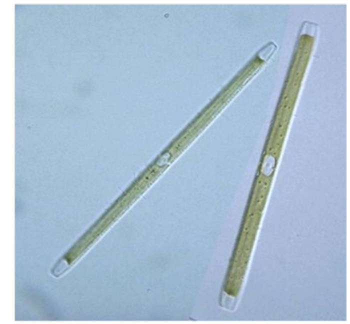
From Tilman et al. 1981 (L&O)

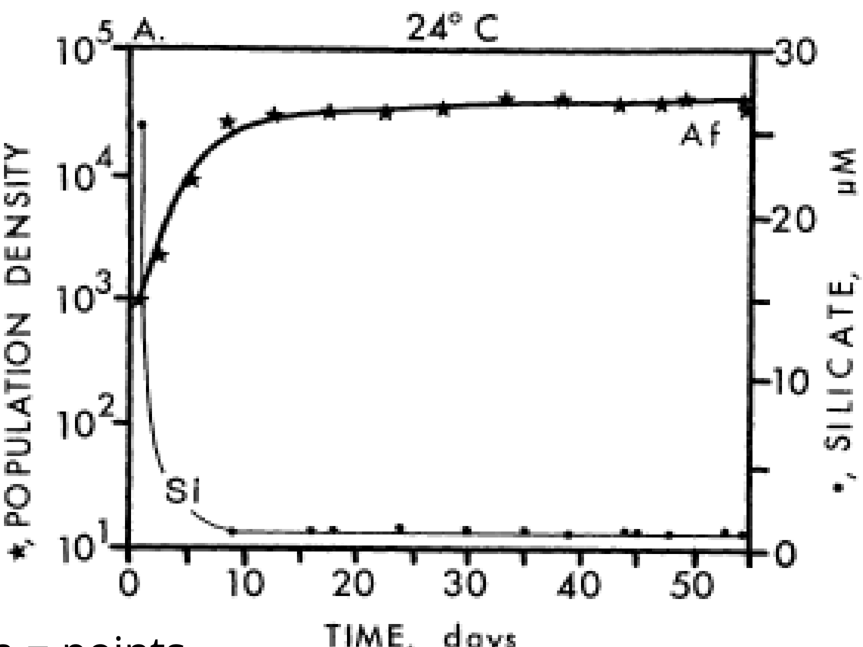
Alone:

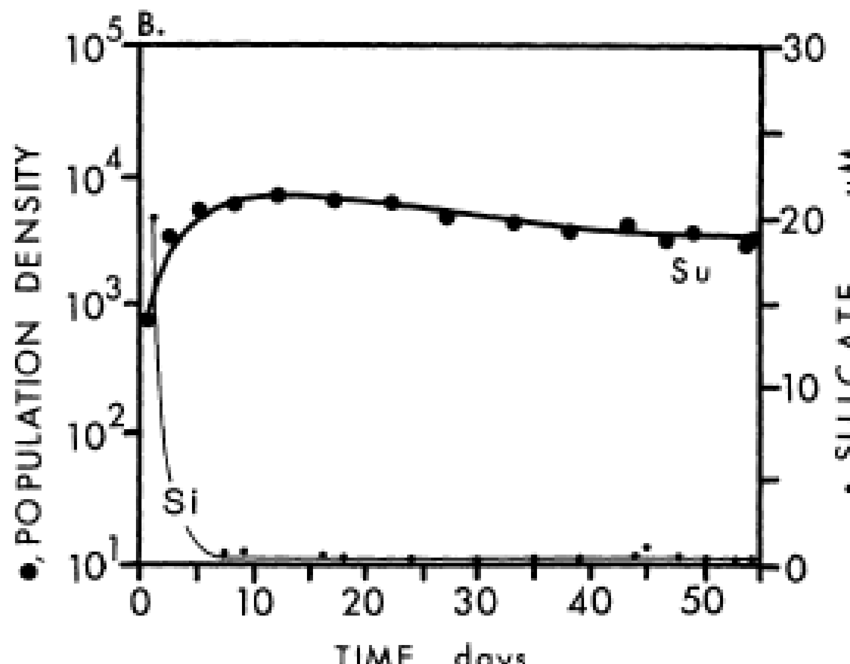
Followed population growth and resource (silicate) when alone:

Asterionella formosa

Synedra ulna





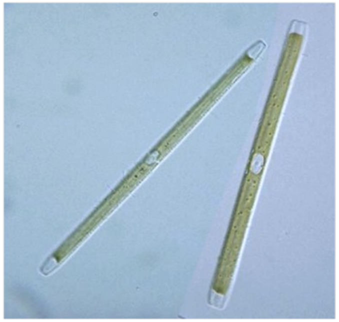


Data = points.
Lines = predicted from model

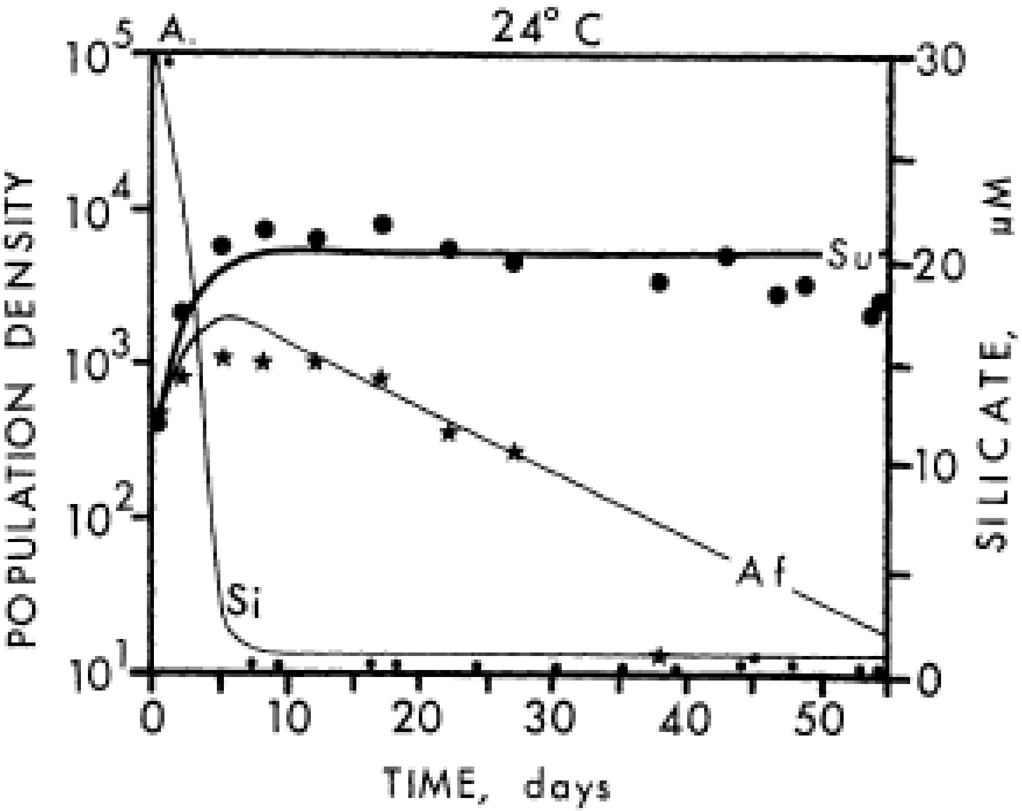
In Competition:

Synedra wins

Synedra ulna



Asterionella formosa

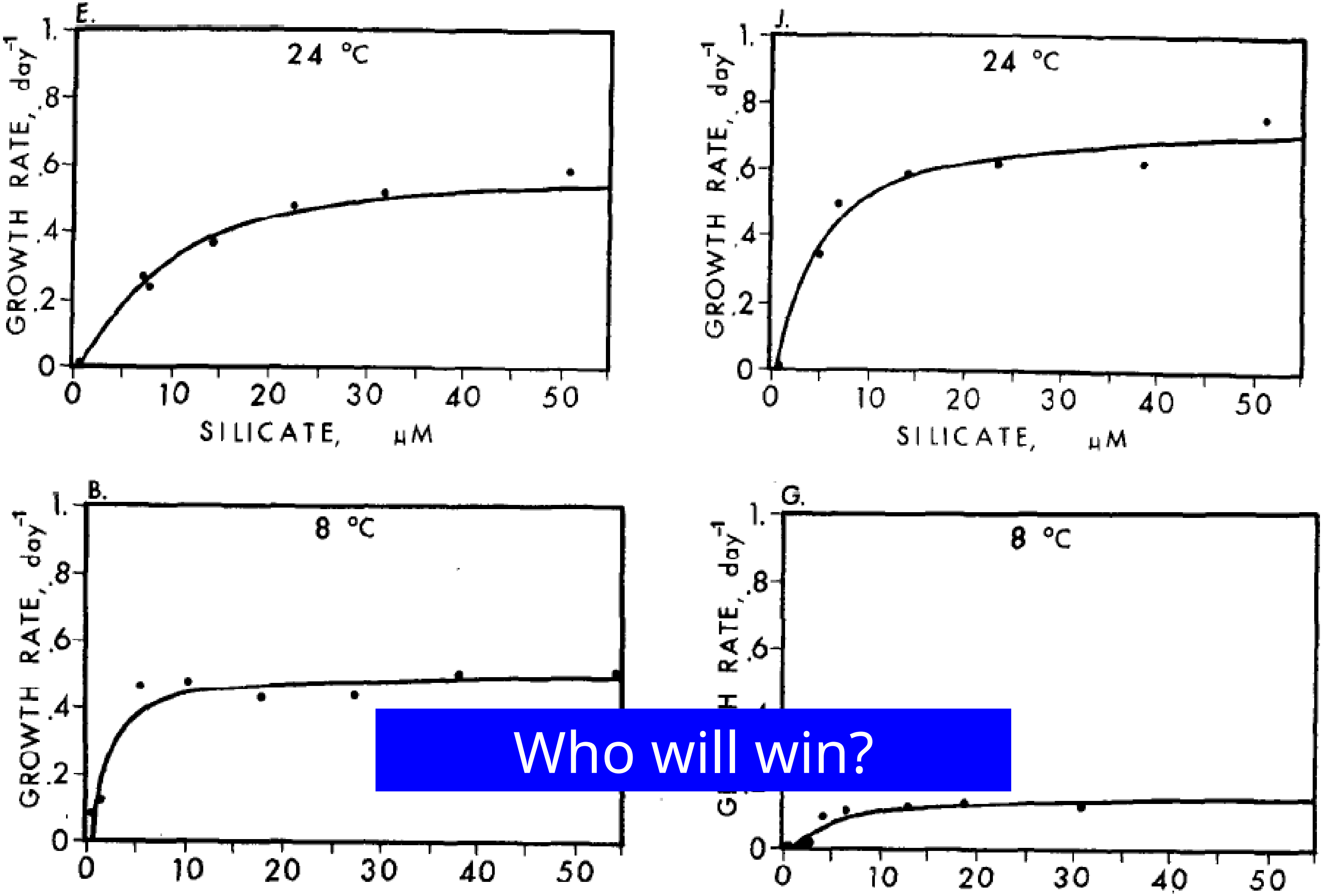


What if we change the environment?

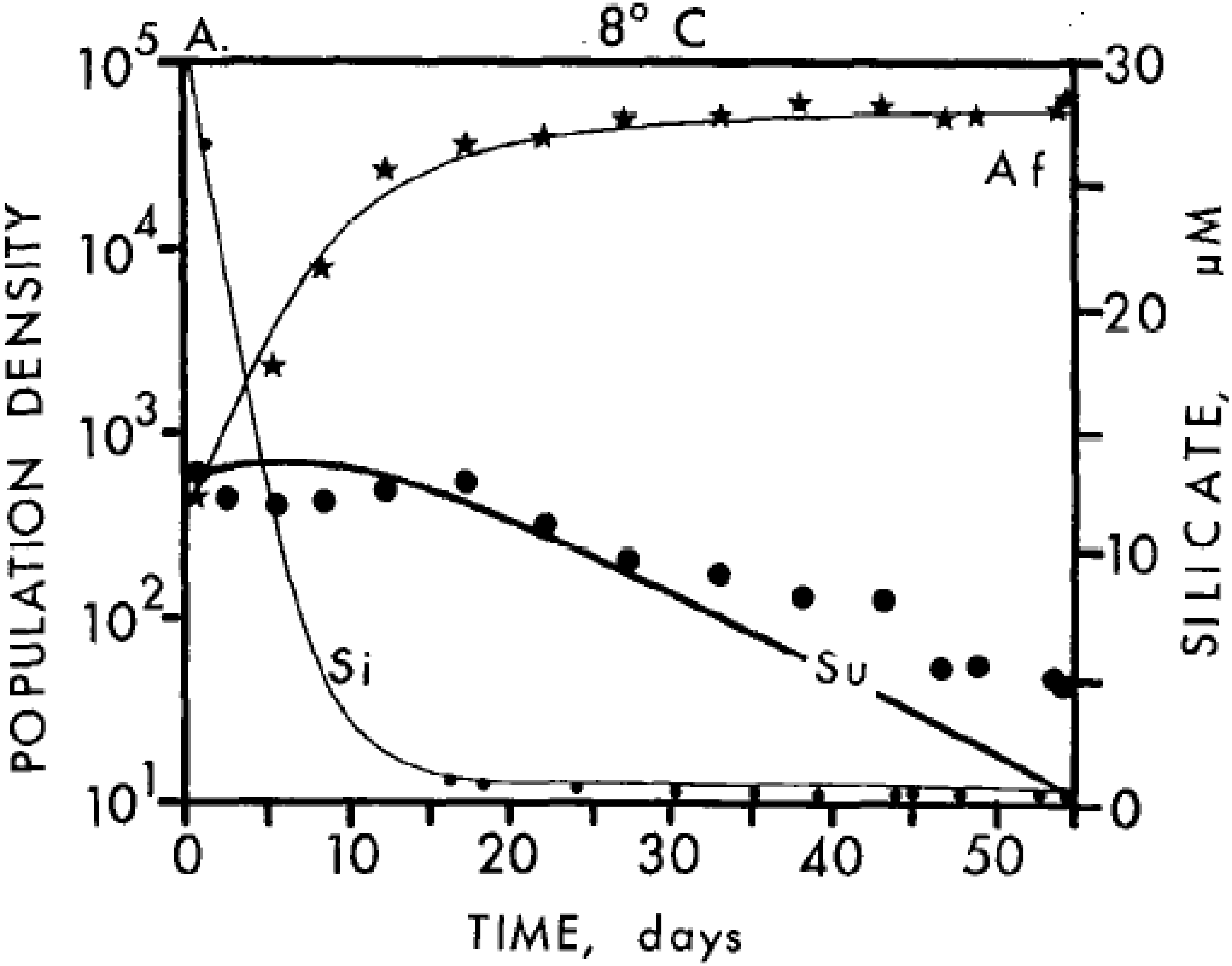
Synedra won at 24^{o}C.

Who will win at 8^{o}C?

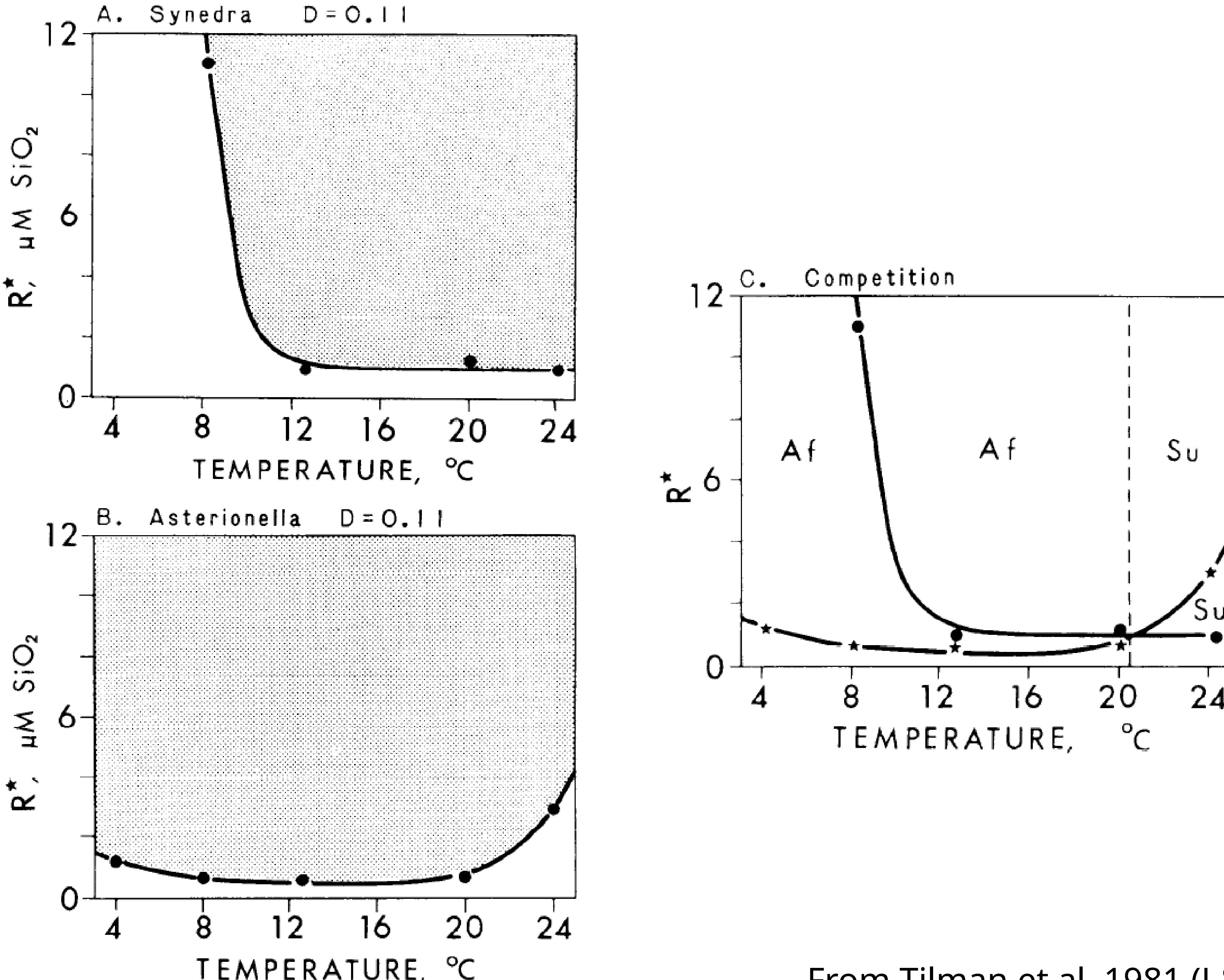
Asterionella   Synedra



From Tilman et al. 1981 (L&O)



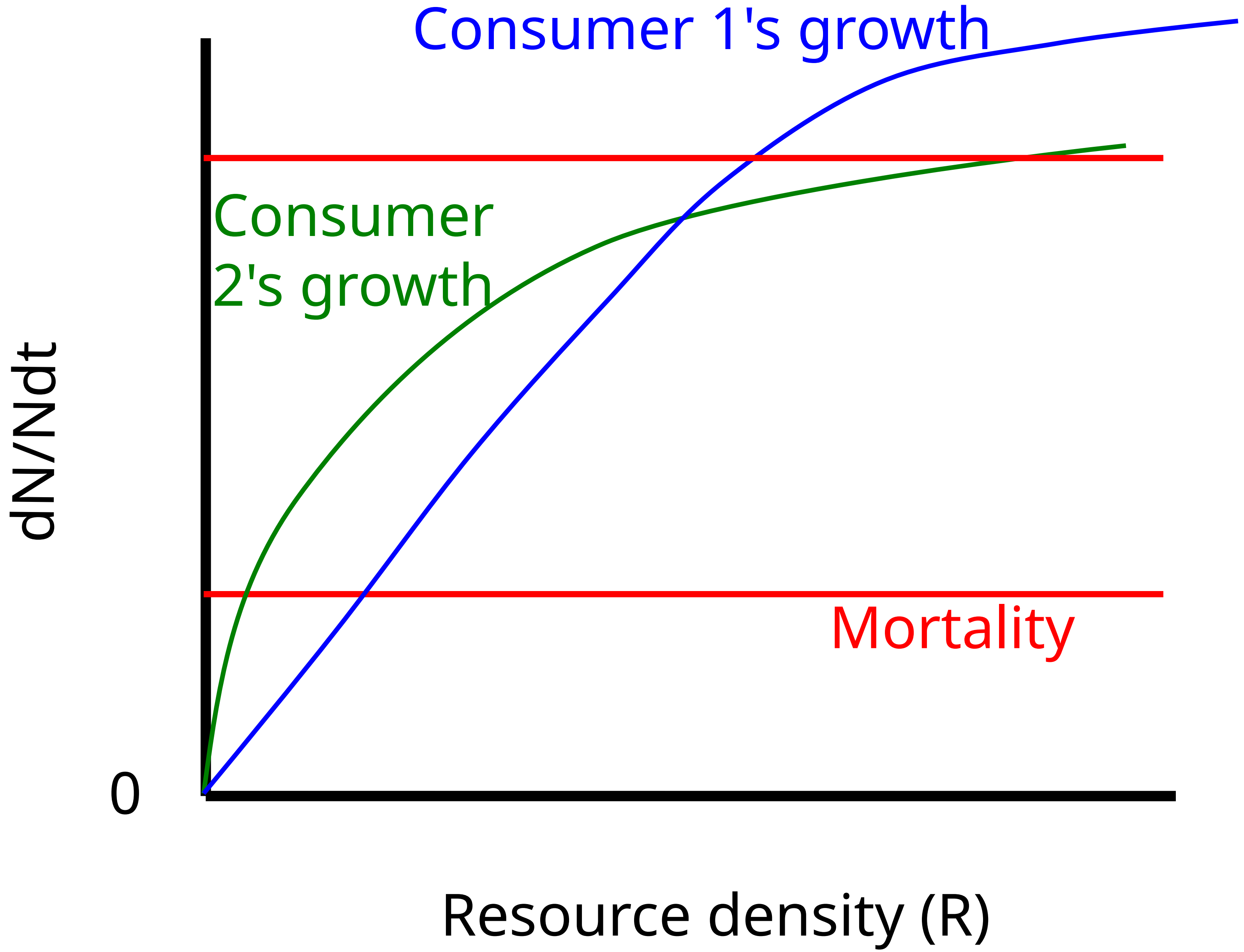
From Tilman et al. 1981 (L&O)



From Tilman et al. 1981 (L&O)

What about changing the mortality rate?

Two consumers:

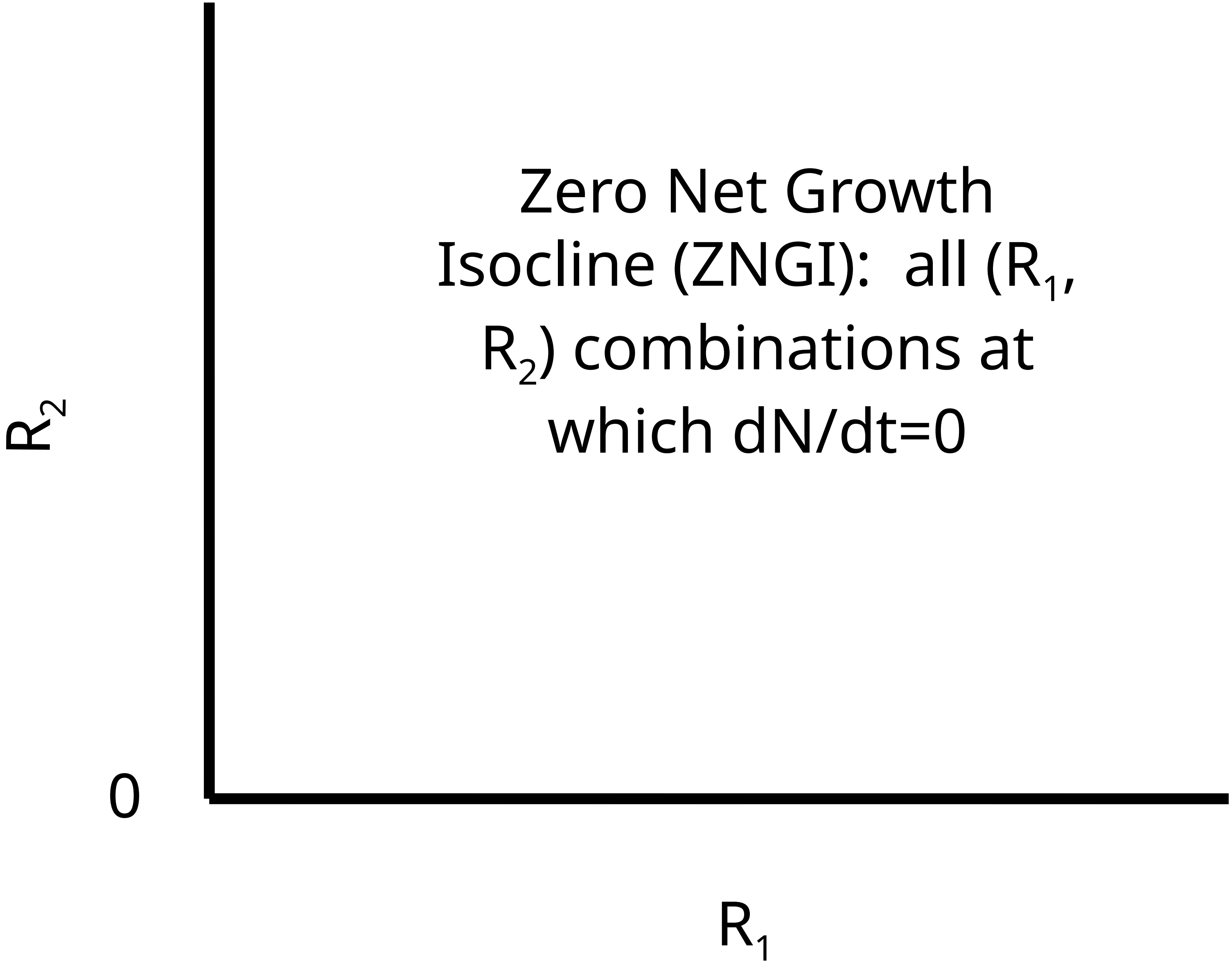


Let's extend this to >1 resource…

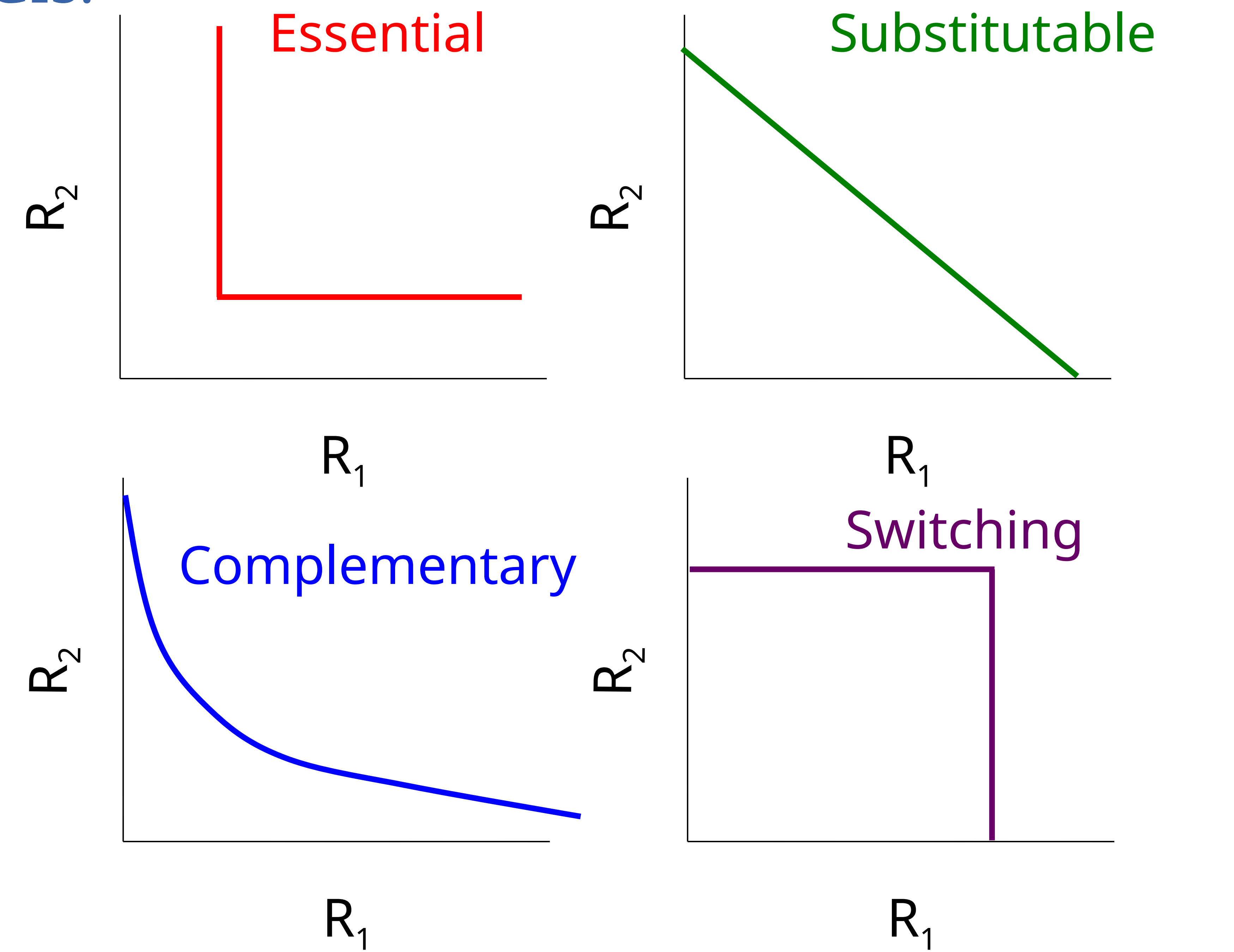
We could approach this mathematically, but Tilman advanced an elegant graphical approach (underlain by explicit math)…

ZNGIs:

Zero Net Growth Isocline (ZNGI): all (R_1, R_2) combinations at which $dN/dt=0$



ZNGIs:


Essential
Substitutable
Complementary
Switching
R2
R1
R2
R1
R2
R1
R2
R1

ZNGI's tell us about the resources densities when the consumer is at equilibrium.

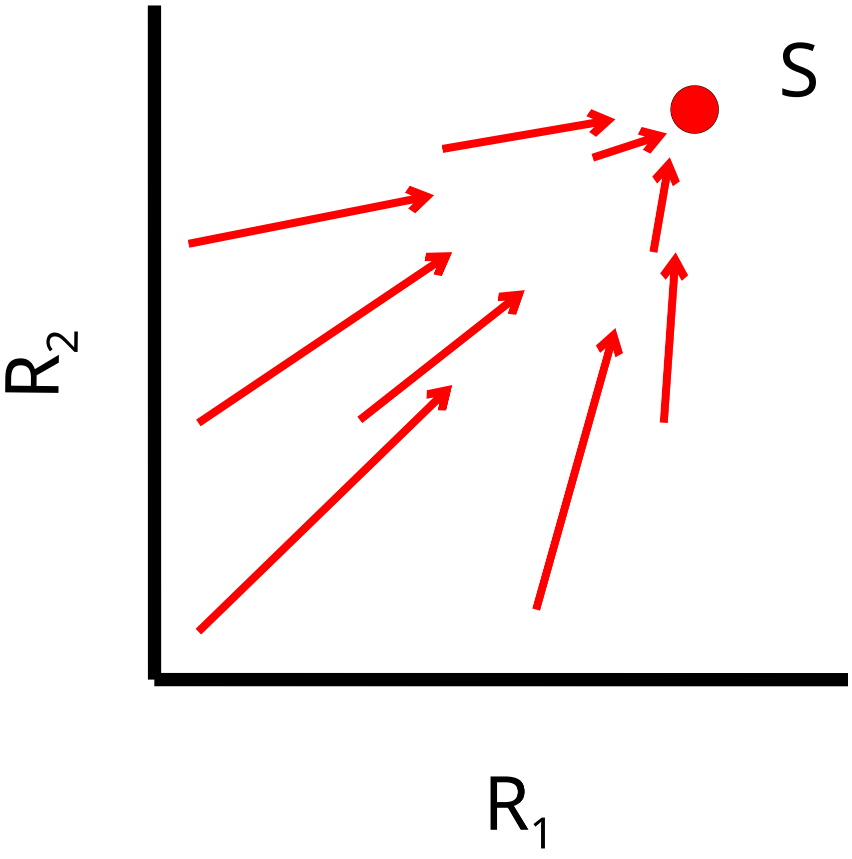
When are the resources at equilibrium?

Resource equilibrium:

Supply = Consumption

Resource supply:
"equable" vs. biotic (logistic) resources

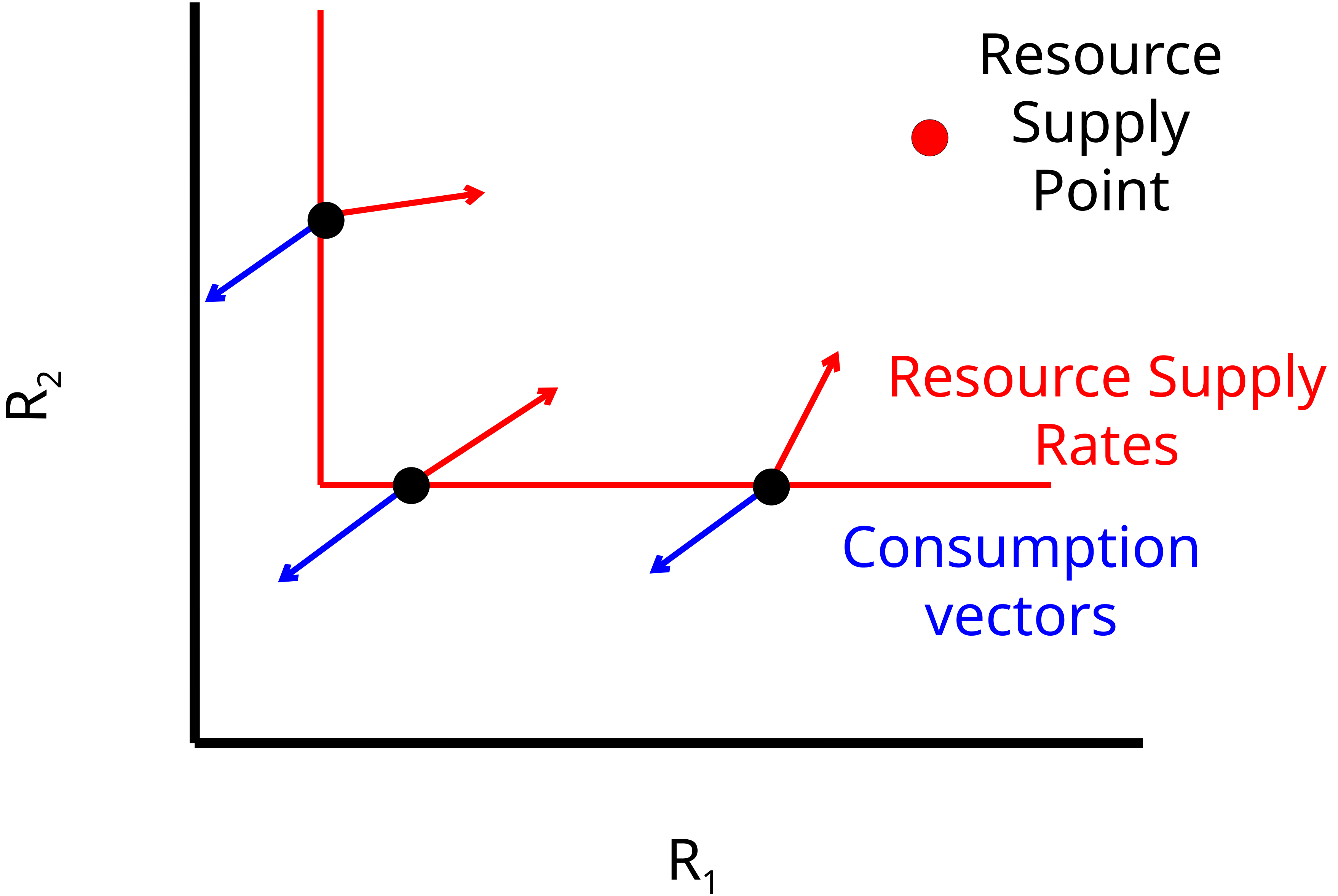
Equable (abiotic)



Resource consumption?

We'll assume: 1) essential resources; 2) fixed stoichiometry (i.e., consumption ratio is constant)

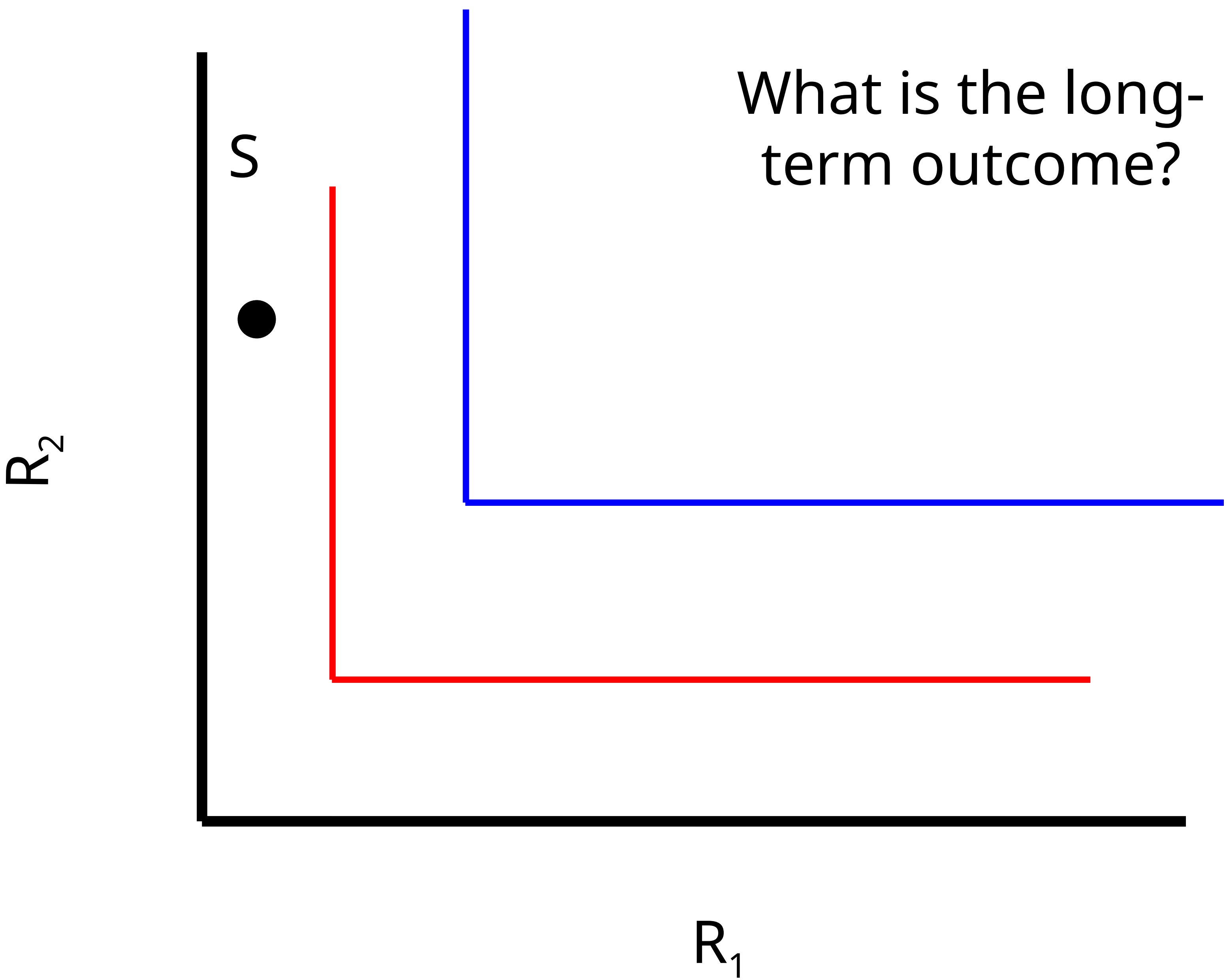
Resource supply:



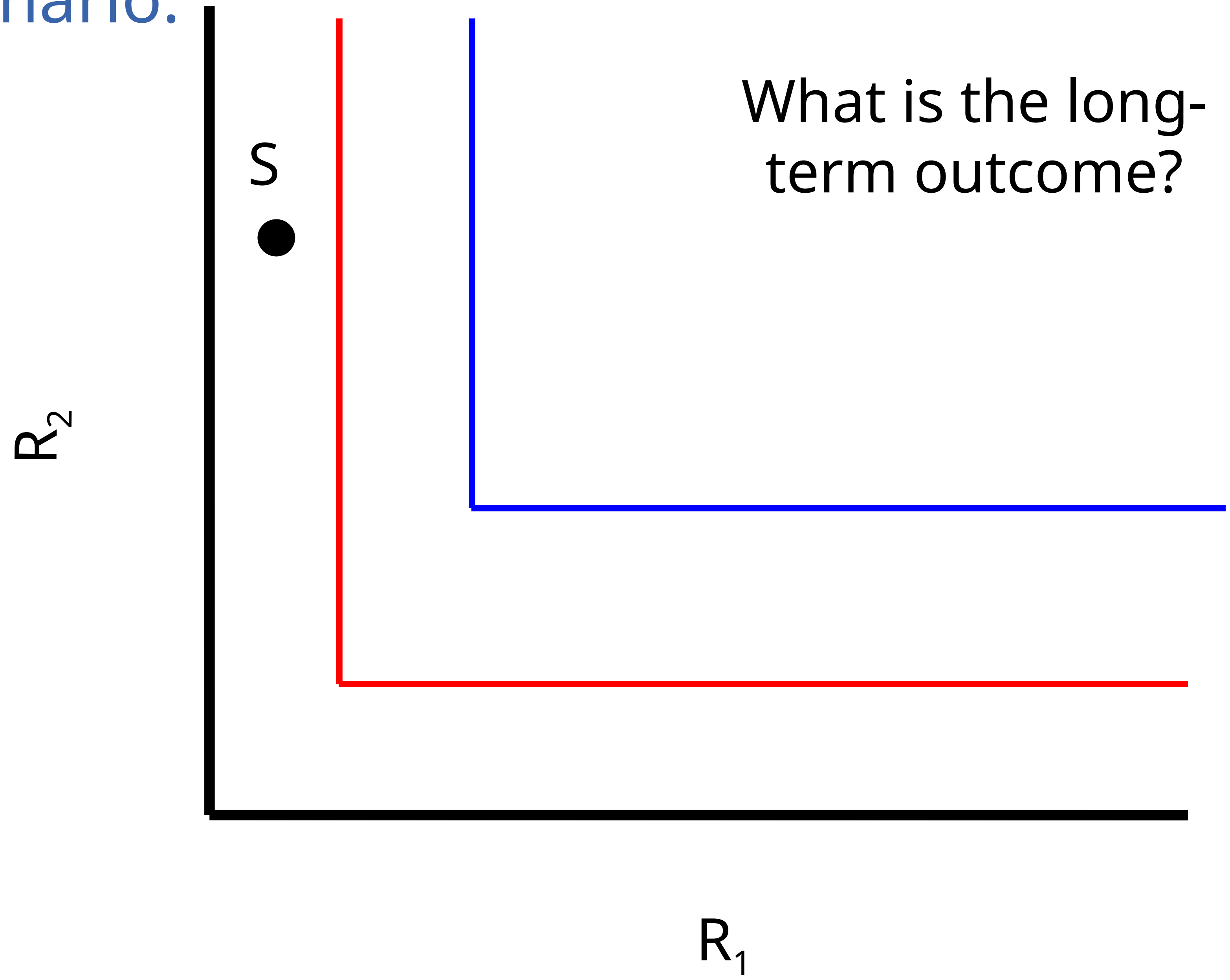
Notice that dynamics of consumer is implicit…

Two consumers…

Competition – one possibility:

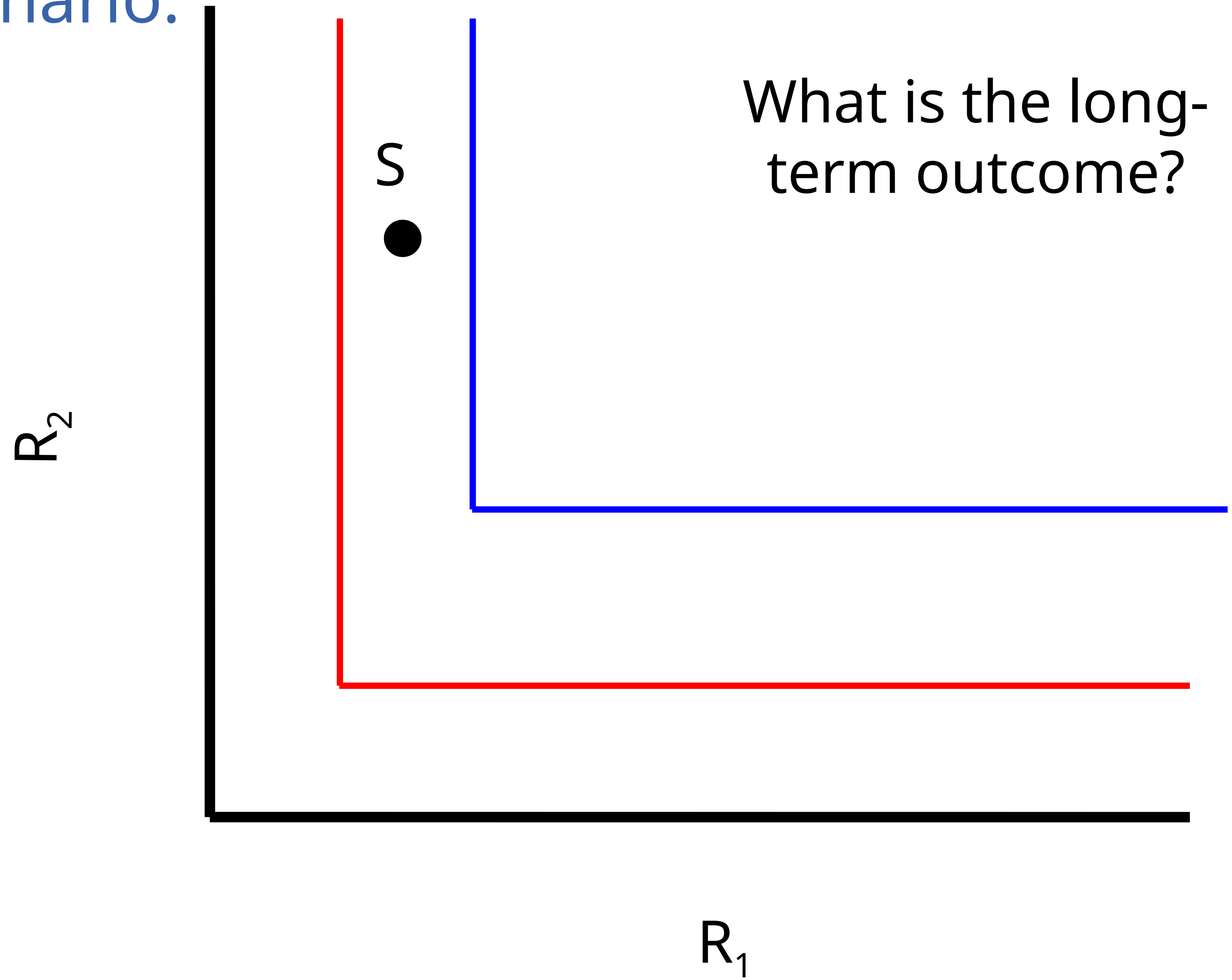


Competition – another scenario:



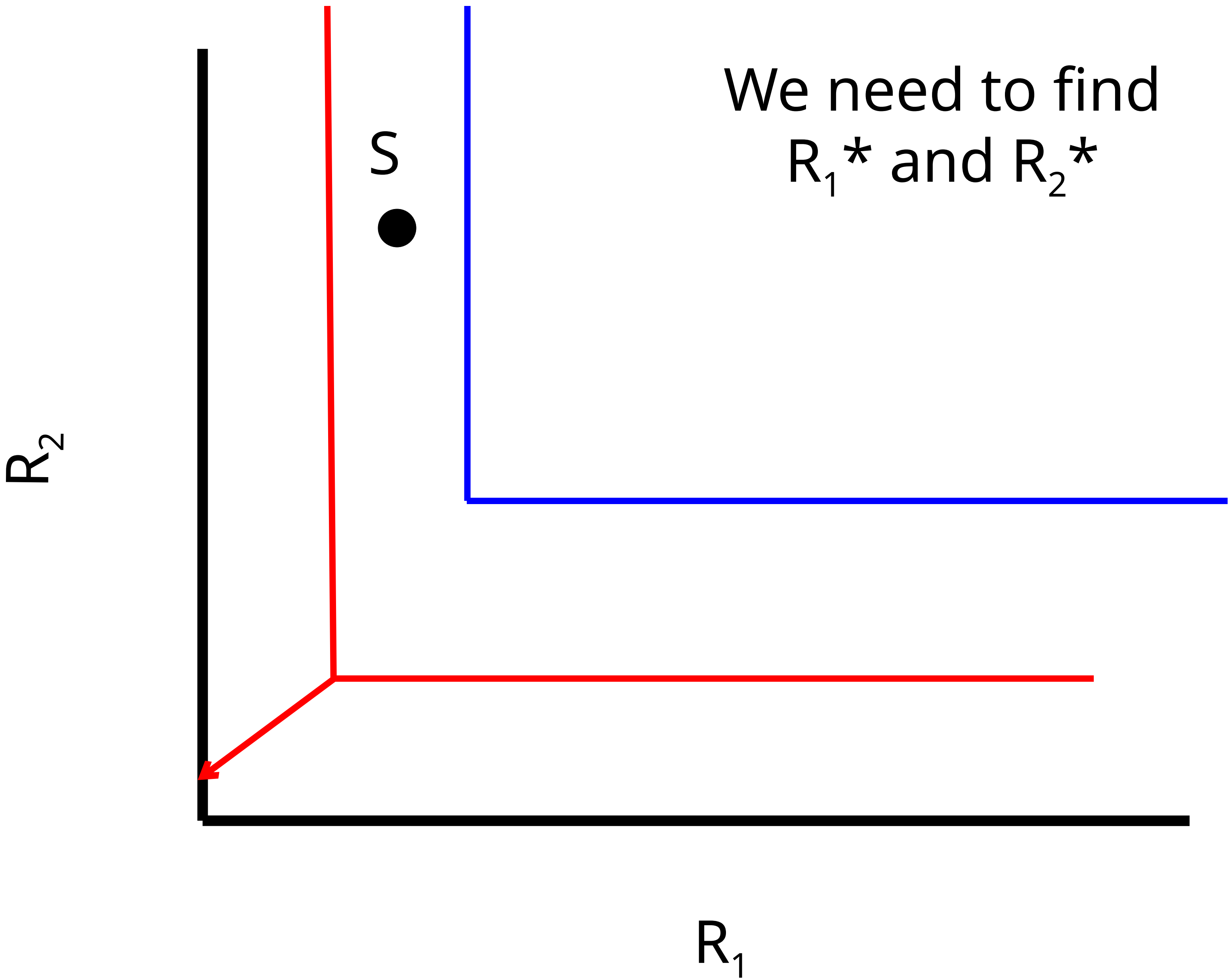
What is the long-term outcome?

Competition – another scenario:

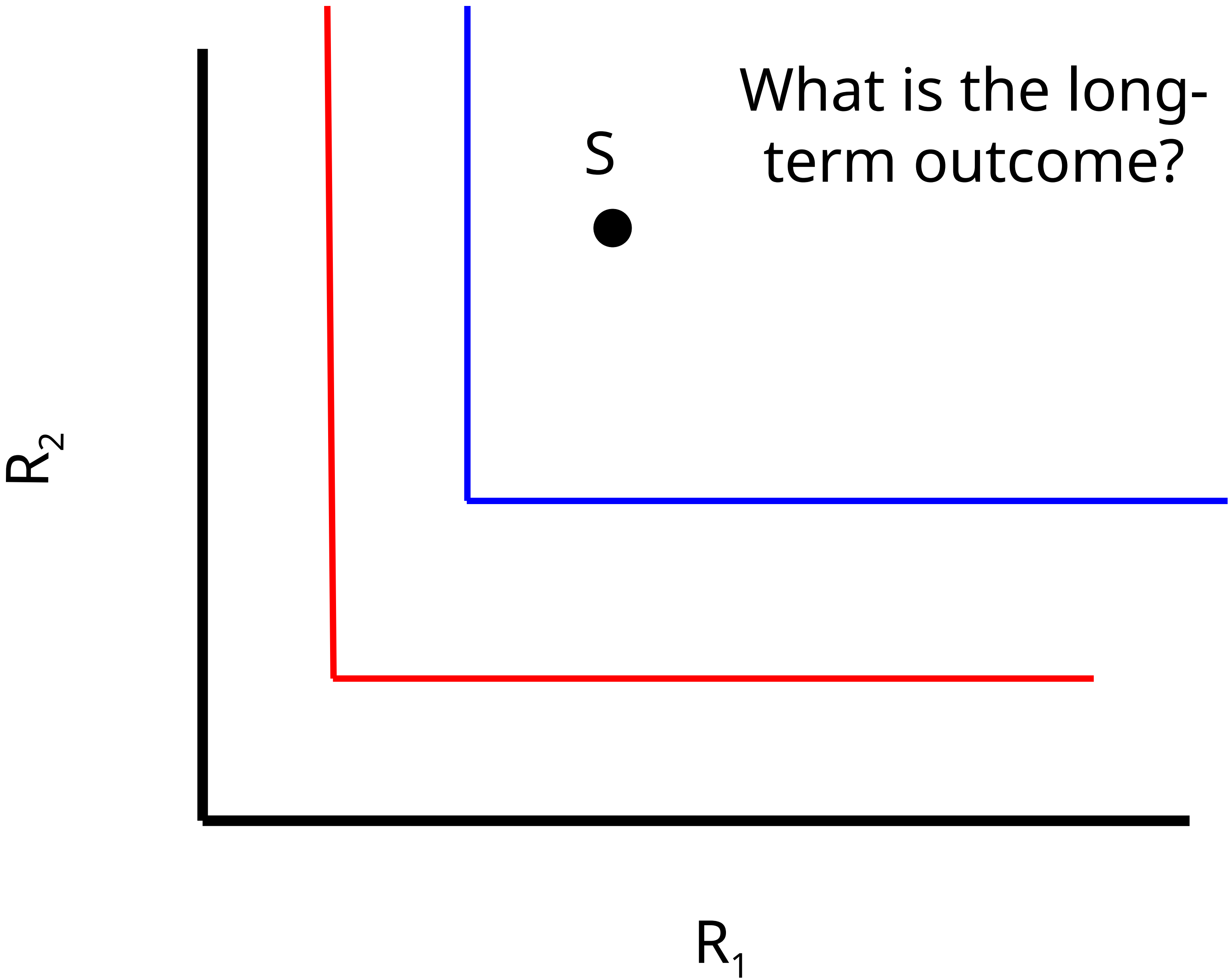


What else do we need to specify?

Finding resource equilibria

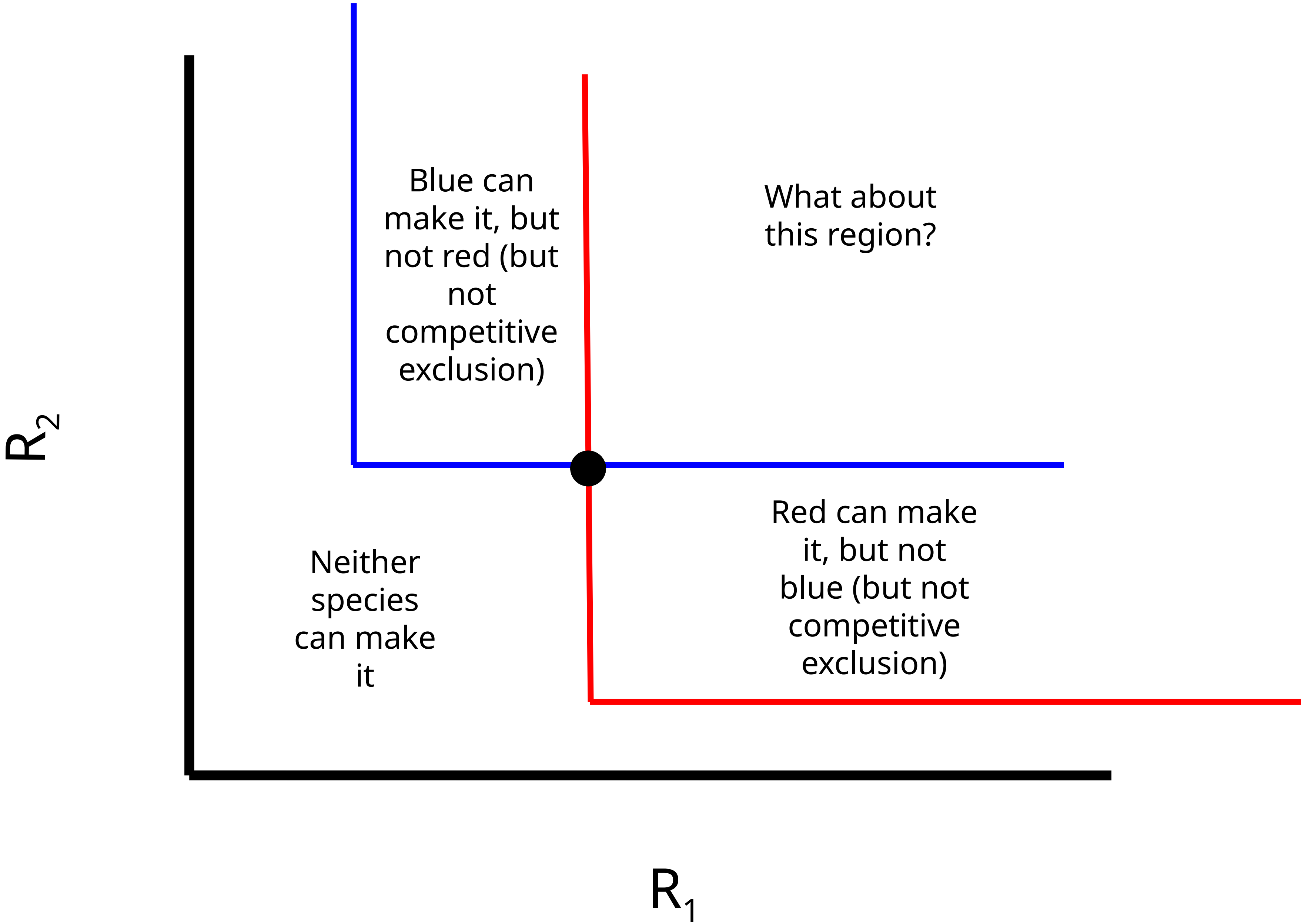


Competition – another scenario:

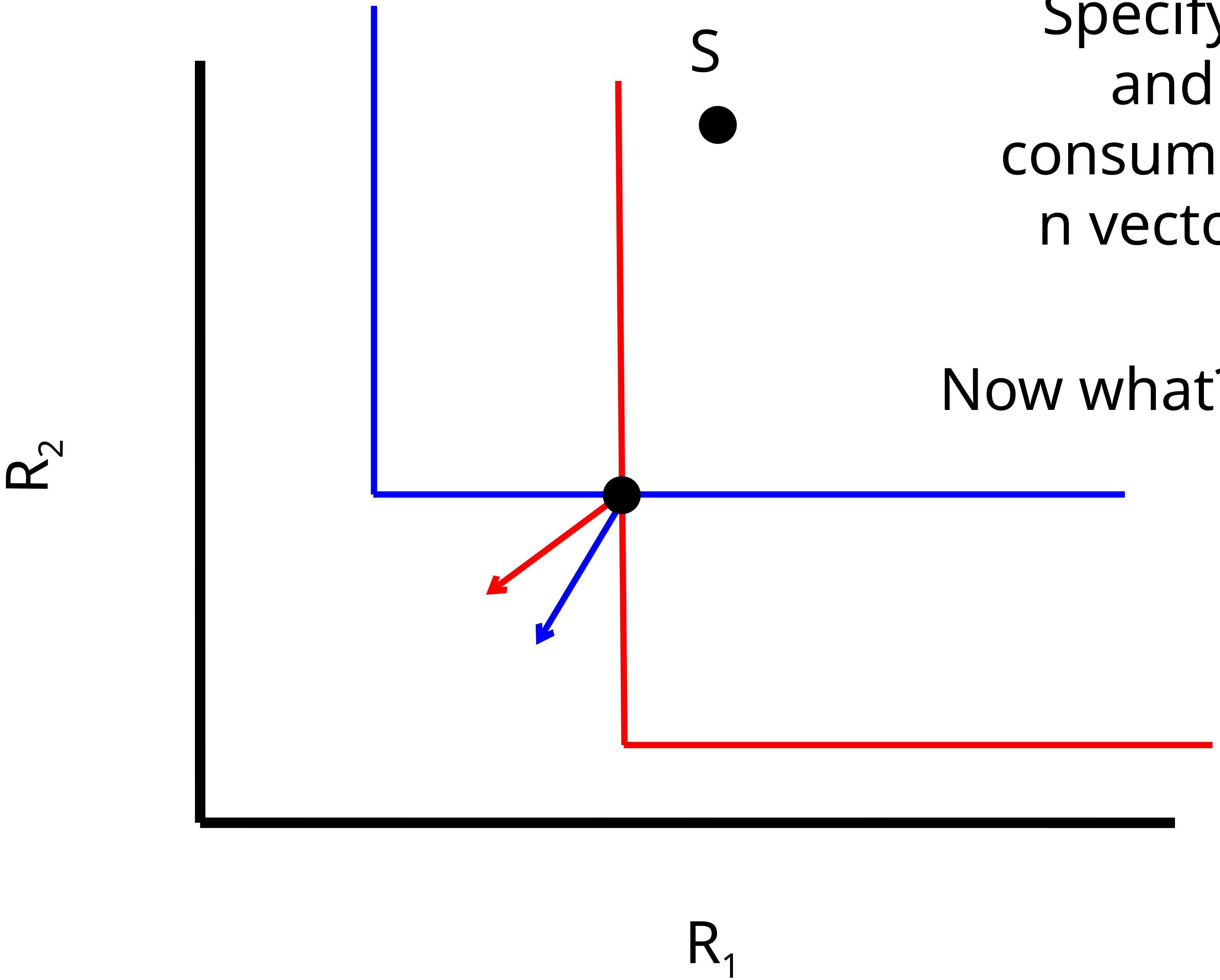


How can we potentially get persistence of both consumers?

Competition – another scenario:



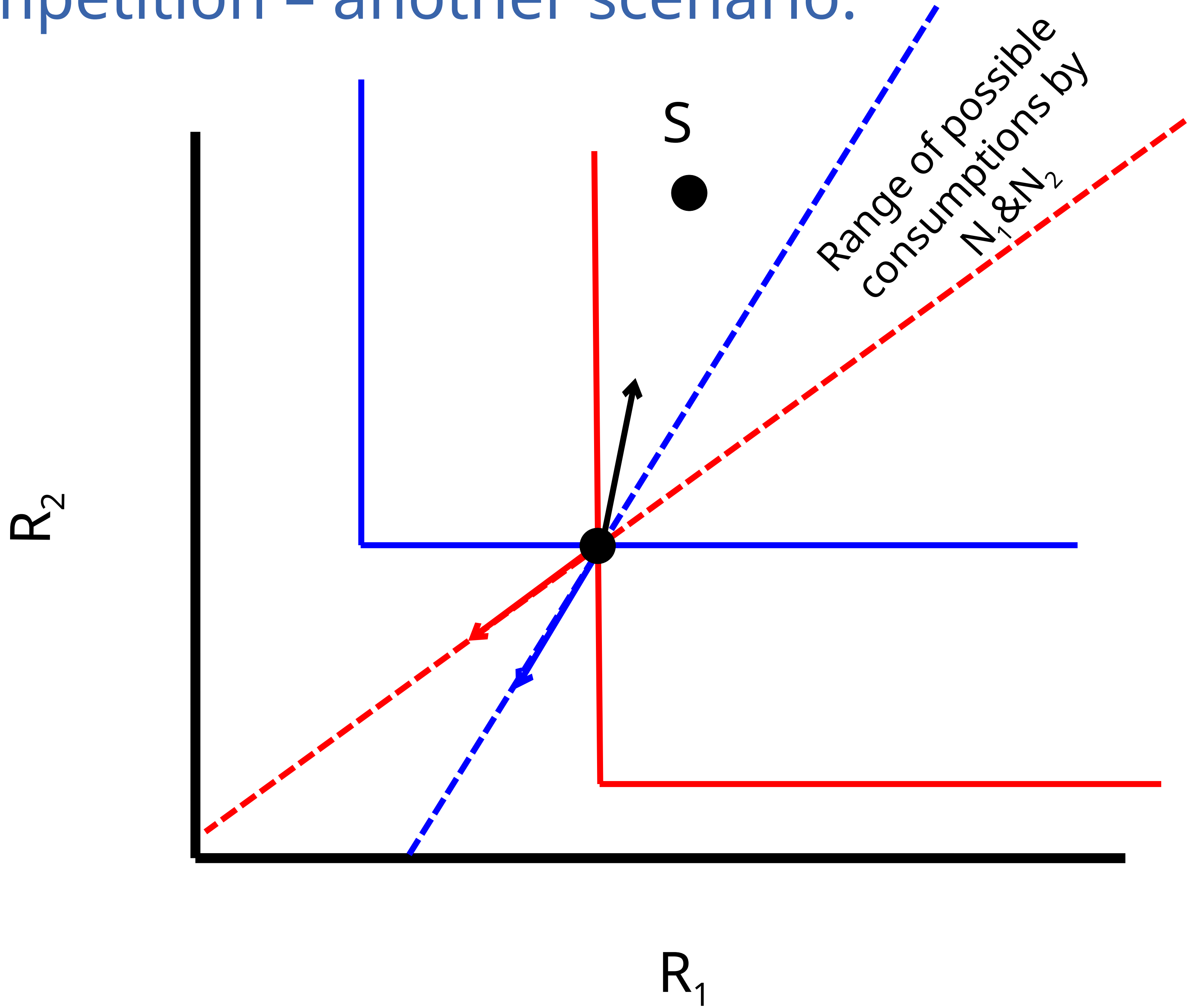
Competition – another scenario:



Specify S and consumption vectors

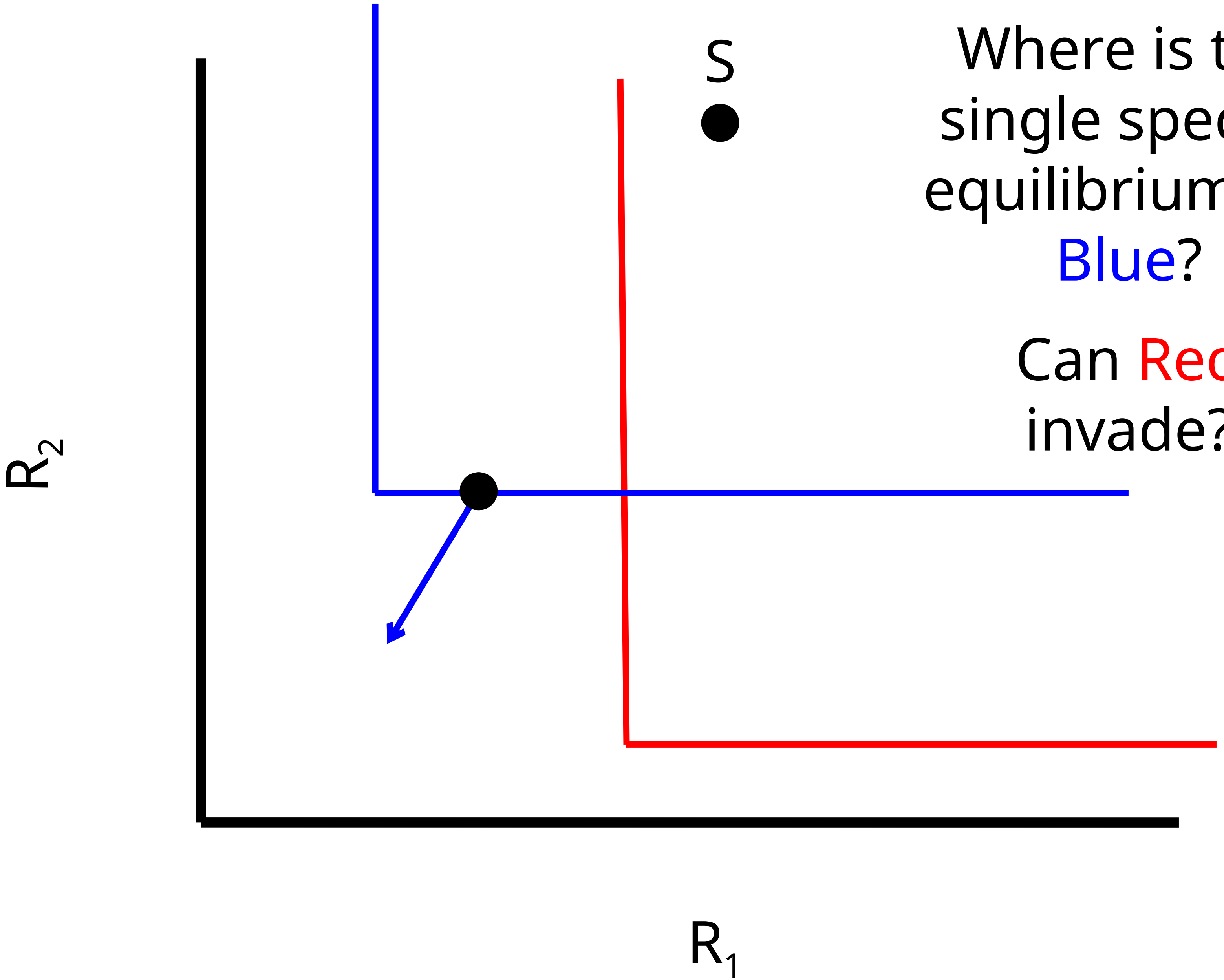
Now what?

Competition – another scenario:



Let's look at invasibility...

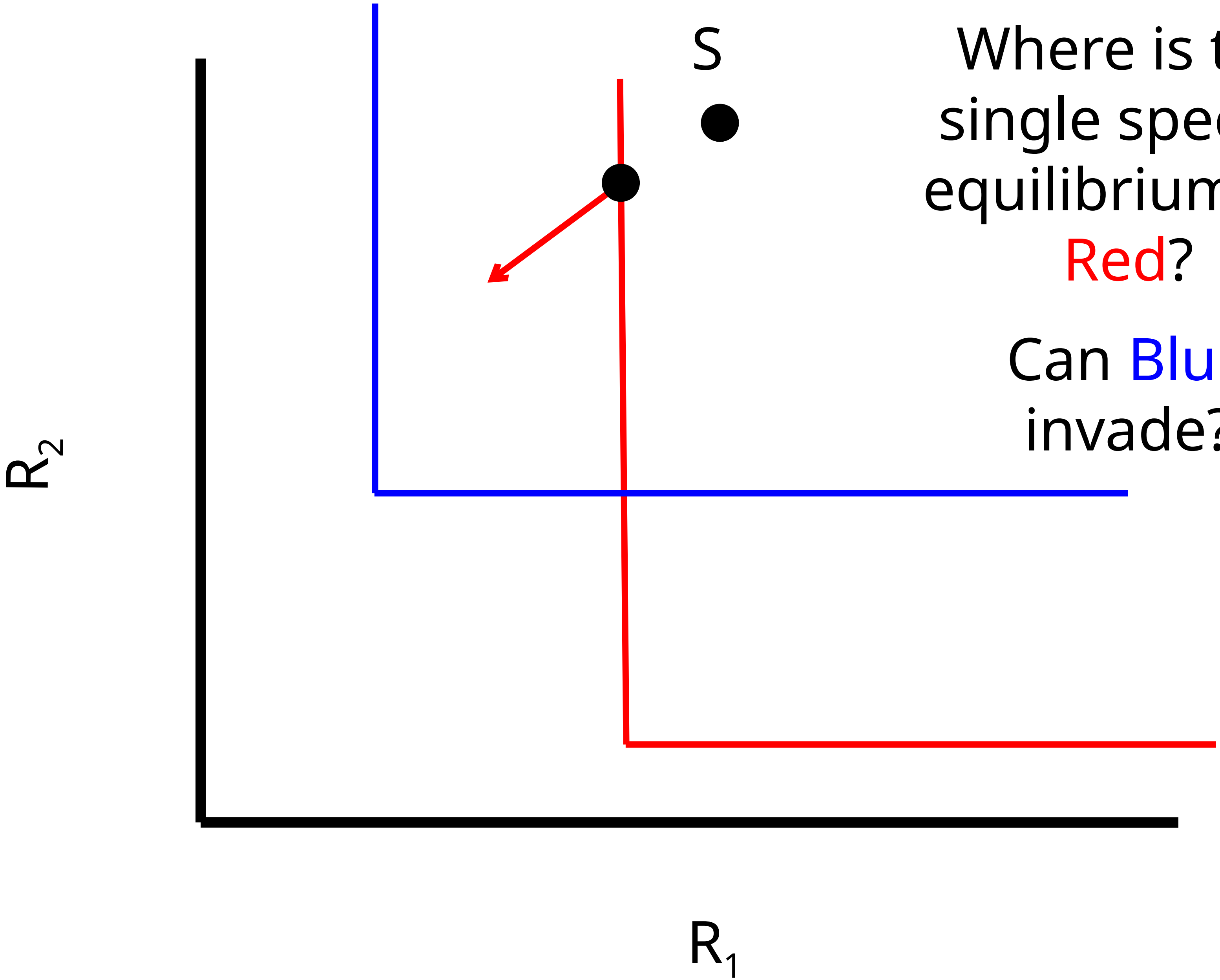
Competition – invasibility?



Where is the single species equilibrium for Blue?

Can Red invade?

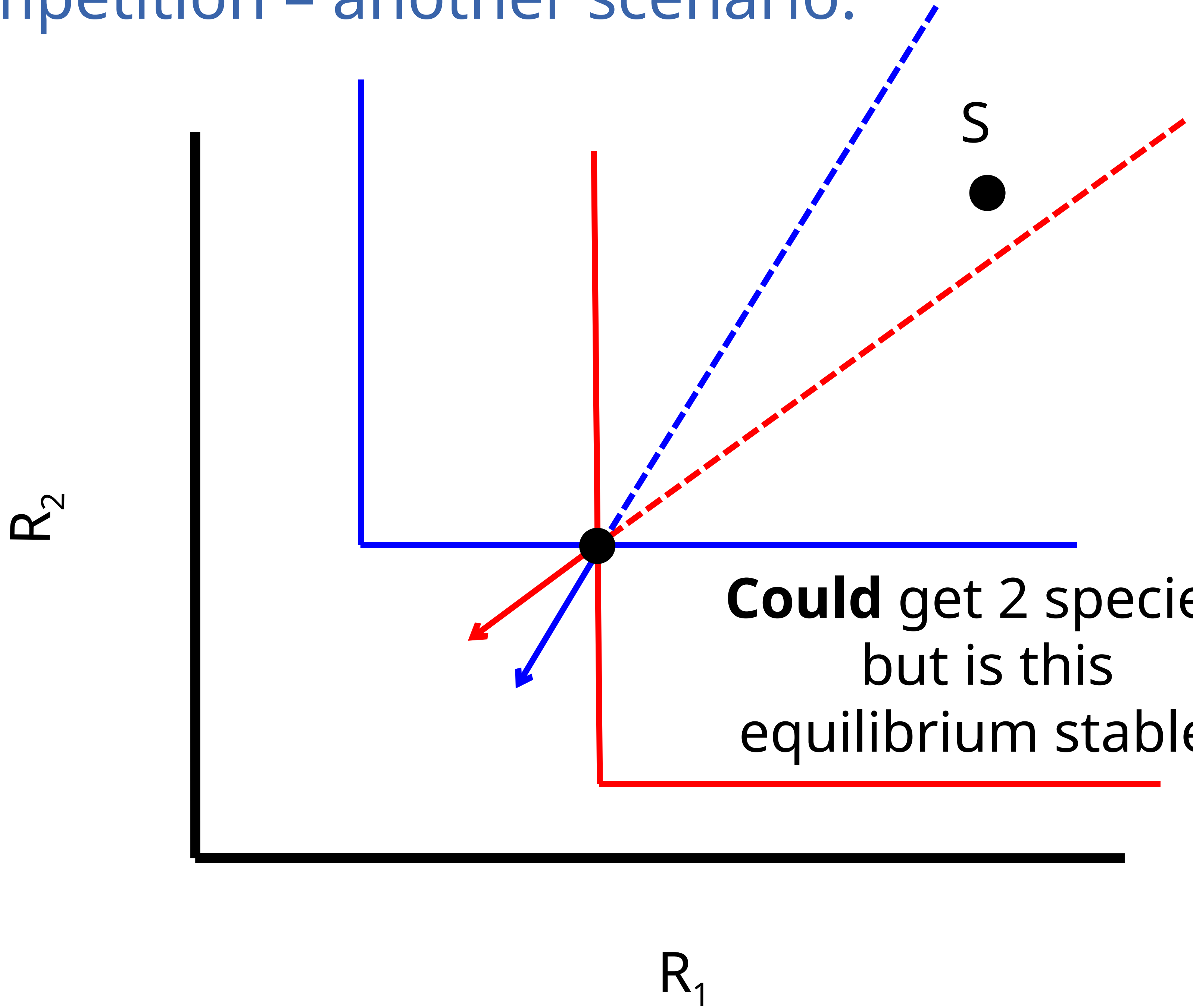
Competition – invasibility?



Where is the single species equilibrium for Red?

Can Blue invade?

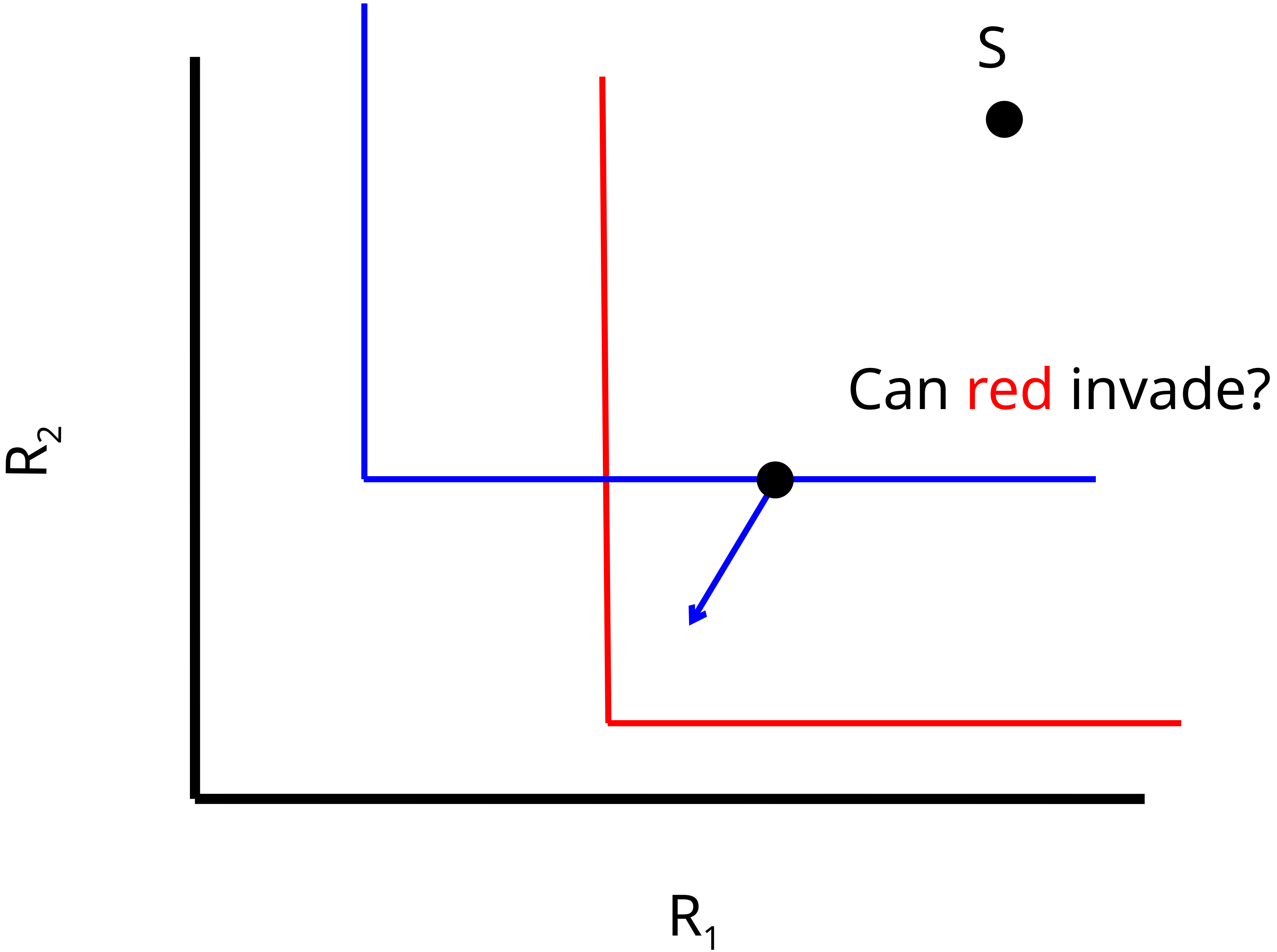
Competition – another scenario:



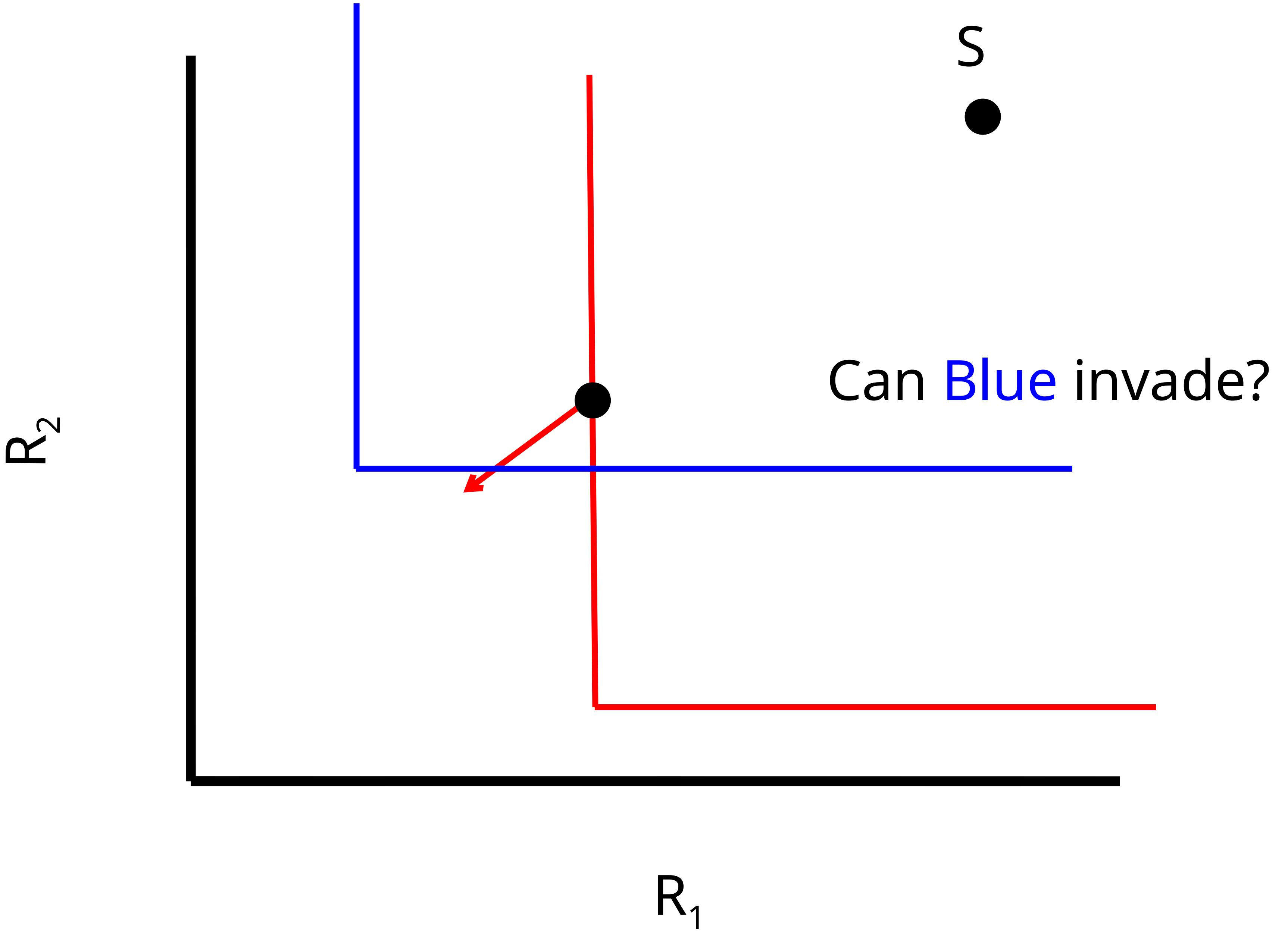
Could get 2 species, but is this equilibrium stable?

Let's look at invasibility...

Invasibility?



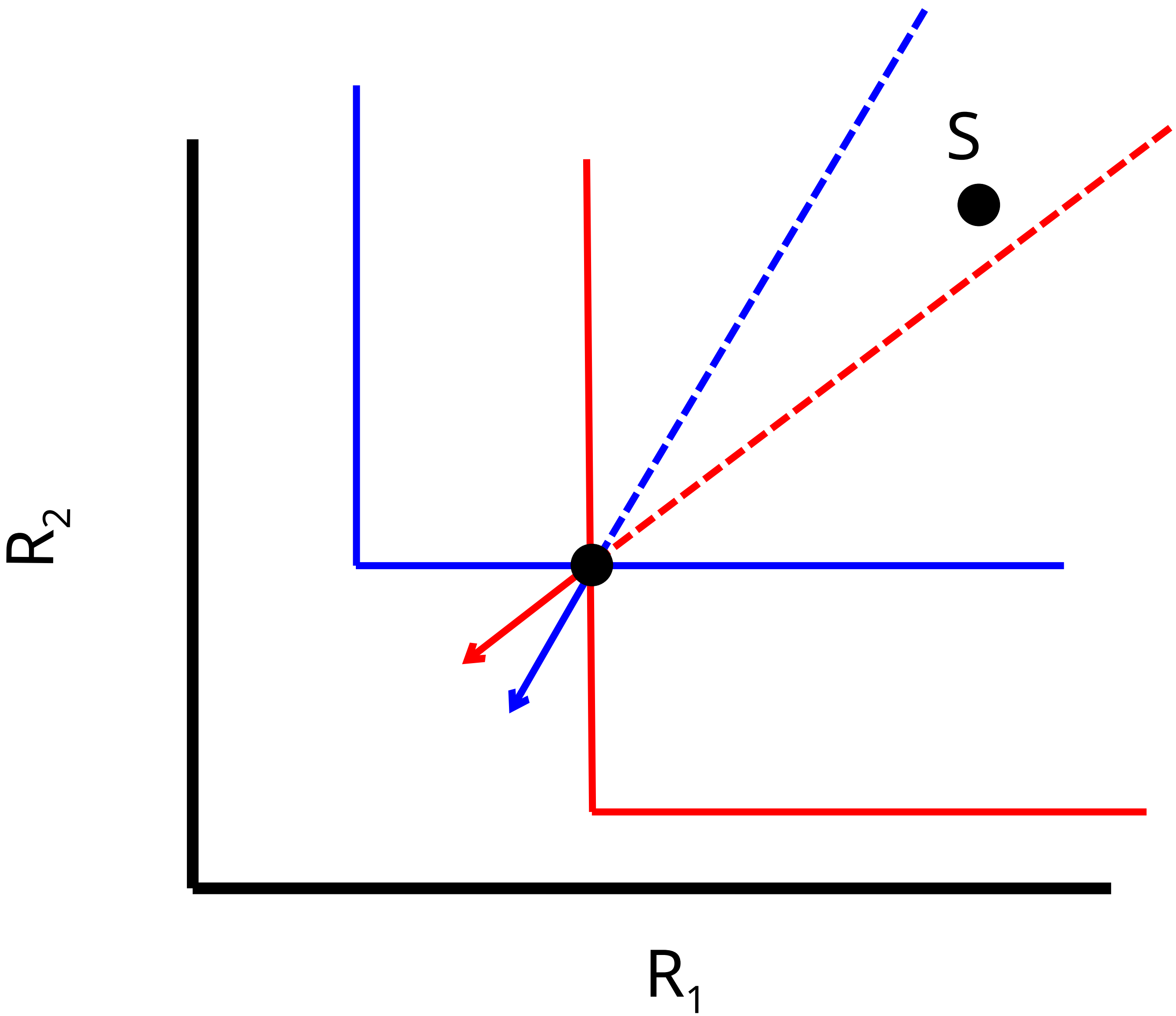
Invasibility:



Mutual invasibility = Co-existence!

Can we interpret the conditions for coexistence?

Resource limitation?



Which resource limits Red vs. Blue?

Which resource is used primarily by Red vs. Blue?

So, "intra vs. inter"?

Ecology (1977) **58**: pp. 338–348

RESOURCE COMPETITION BETWEEN PLANKTONIC ALGAE: AN EXPERIMENTAL AND THEORETICAL APPROACH[1]

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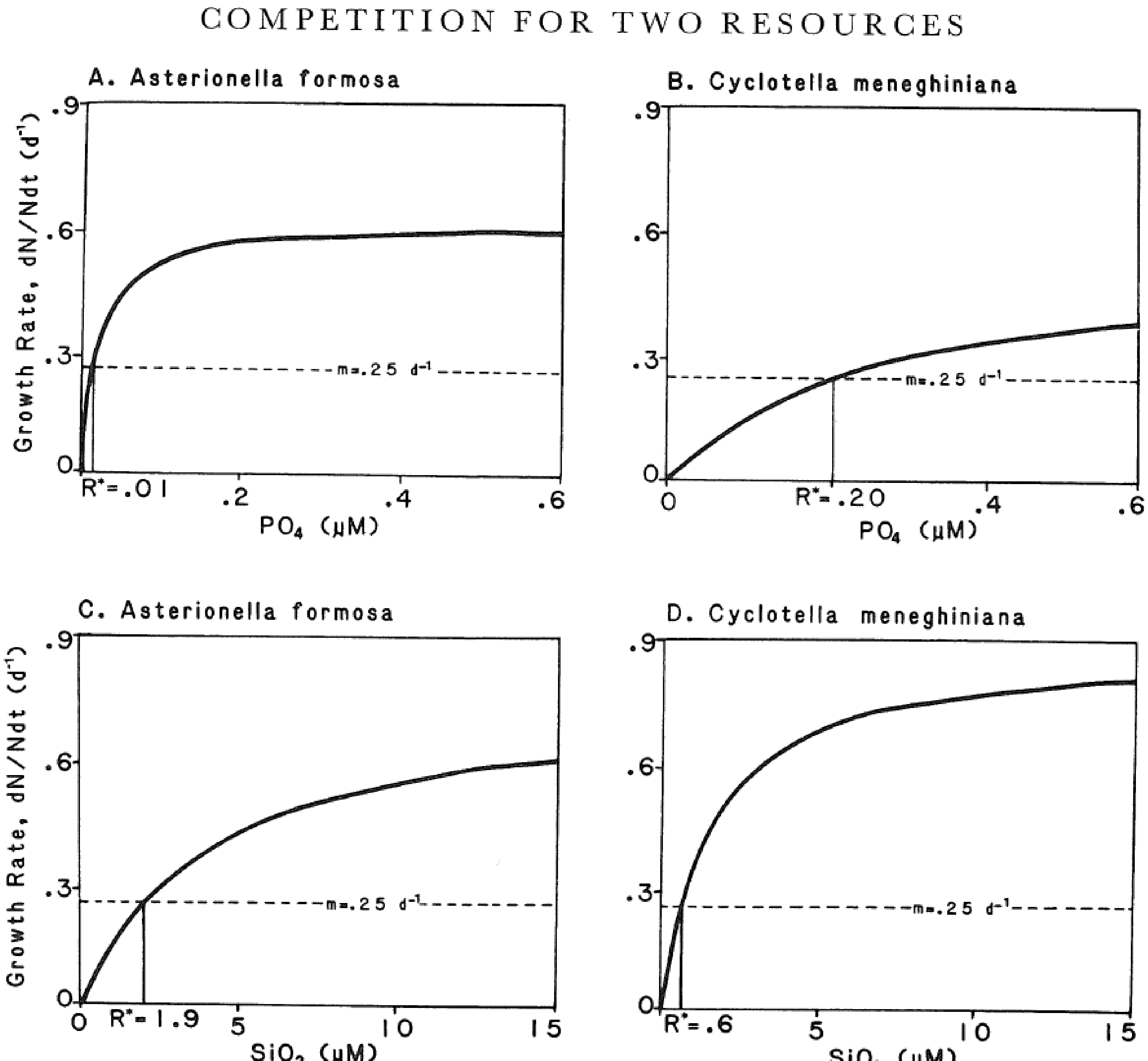
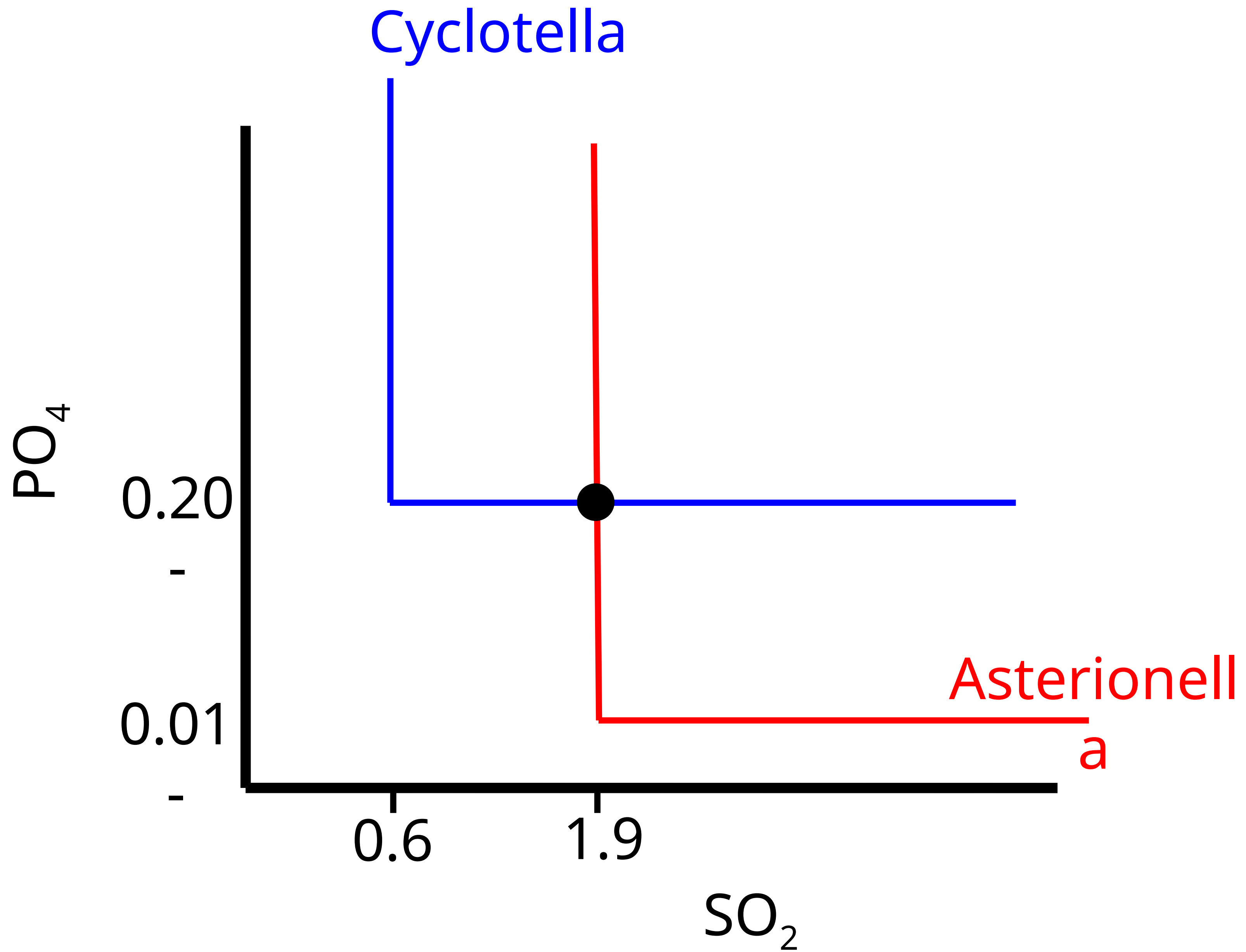


Which species will win?

What if we alter the flow rate of the chemostat?

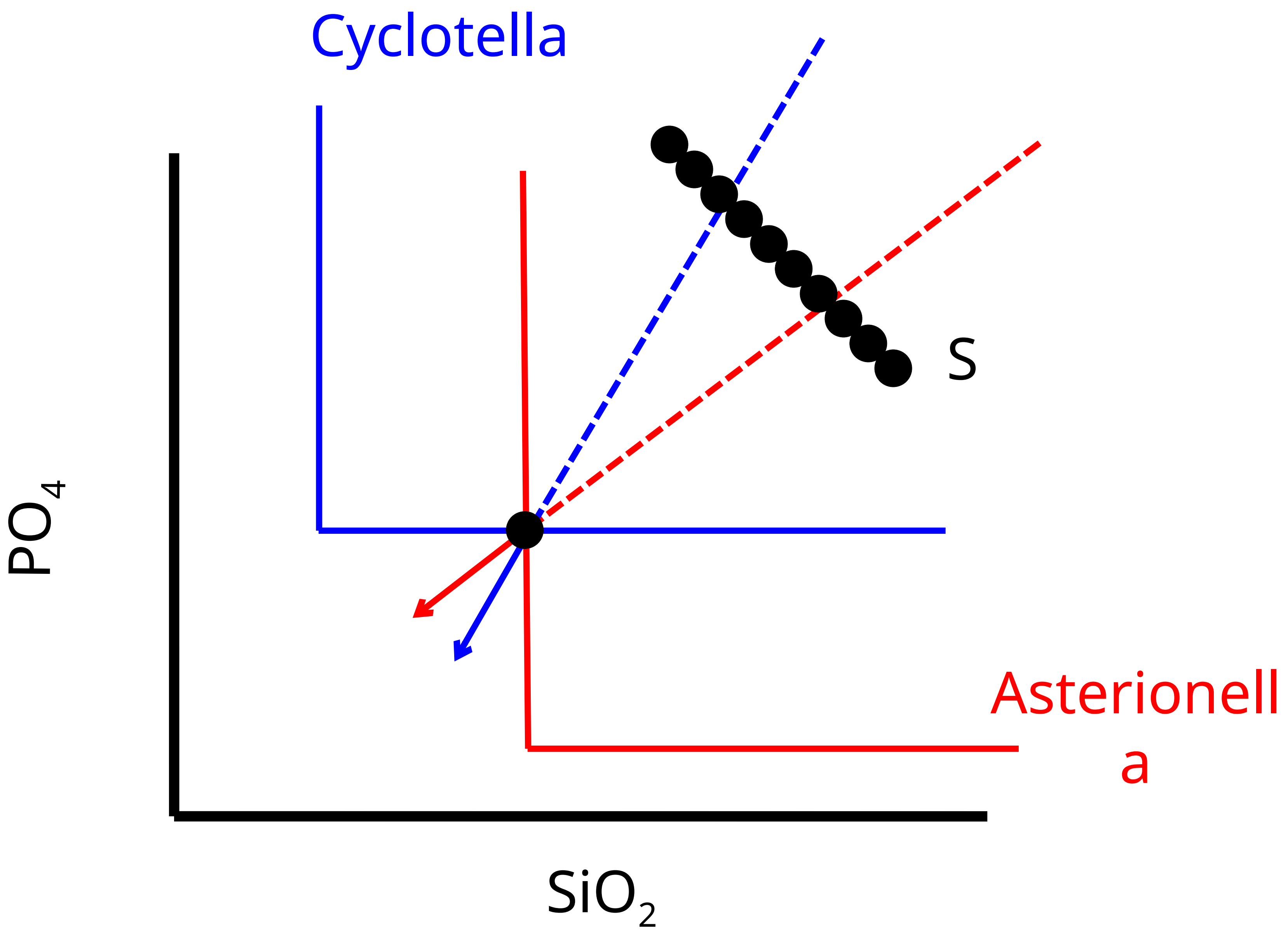
Can we draw the ZNGIs?

Experimental test: vary ratio of resources



What about resource dynamics (consumption and supply)?

Experimental test



Test: vary ratio of nutrients supplied to chemostat

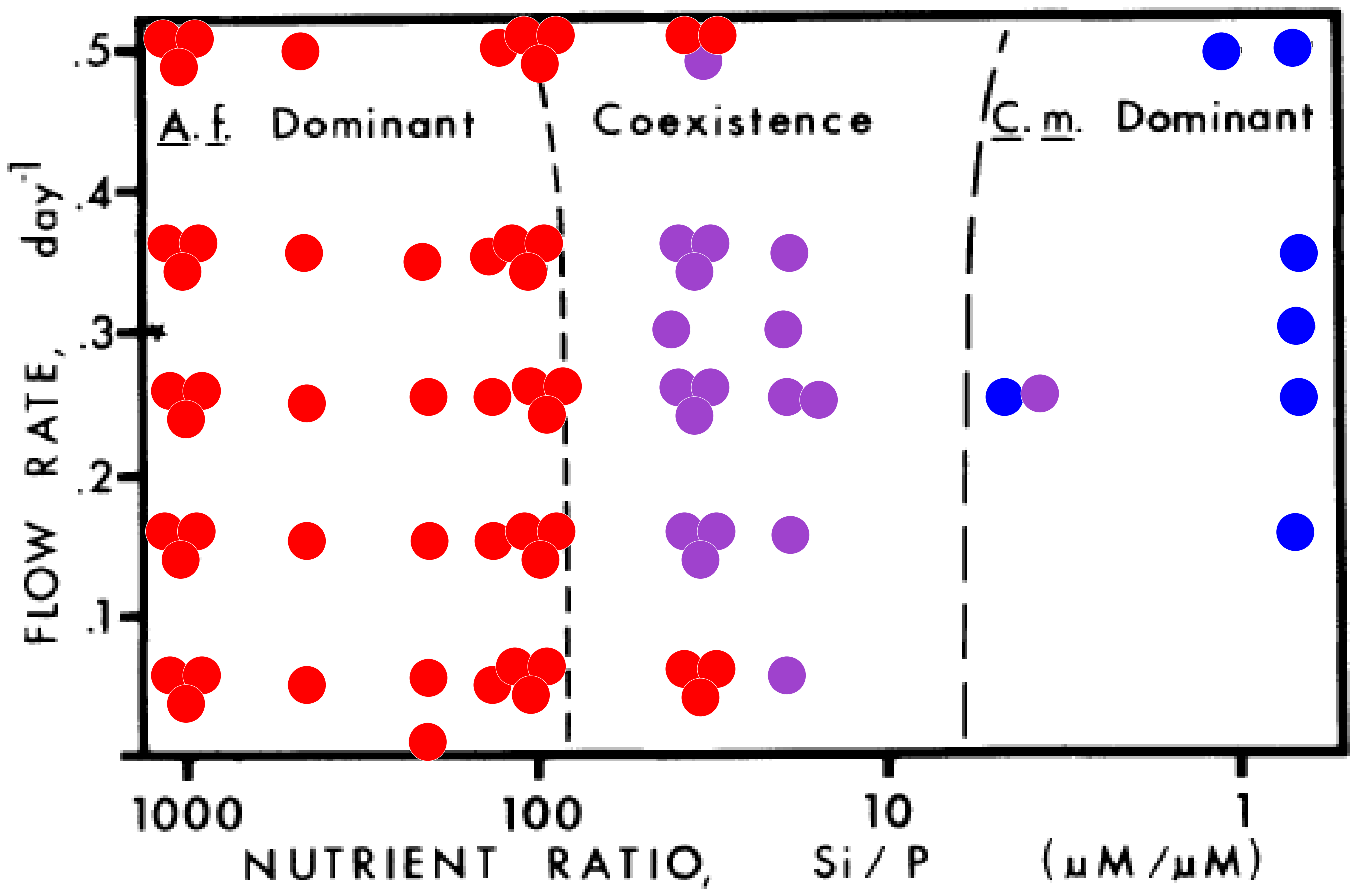
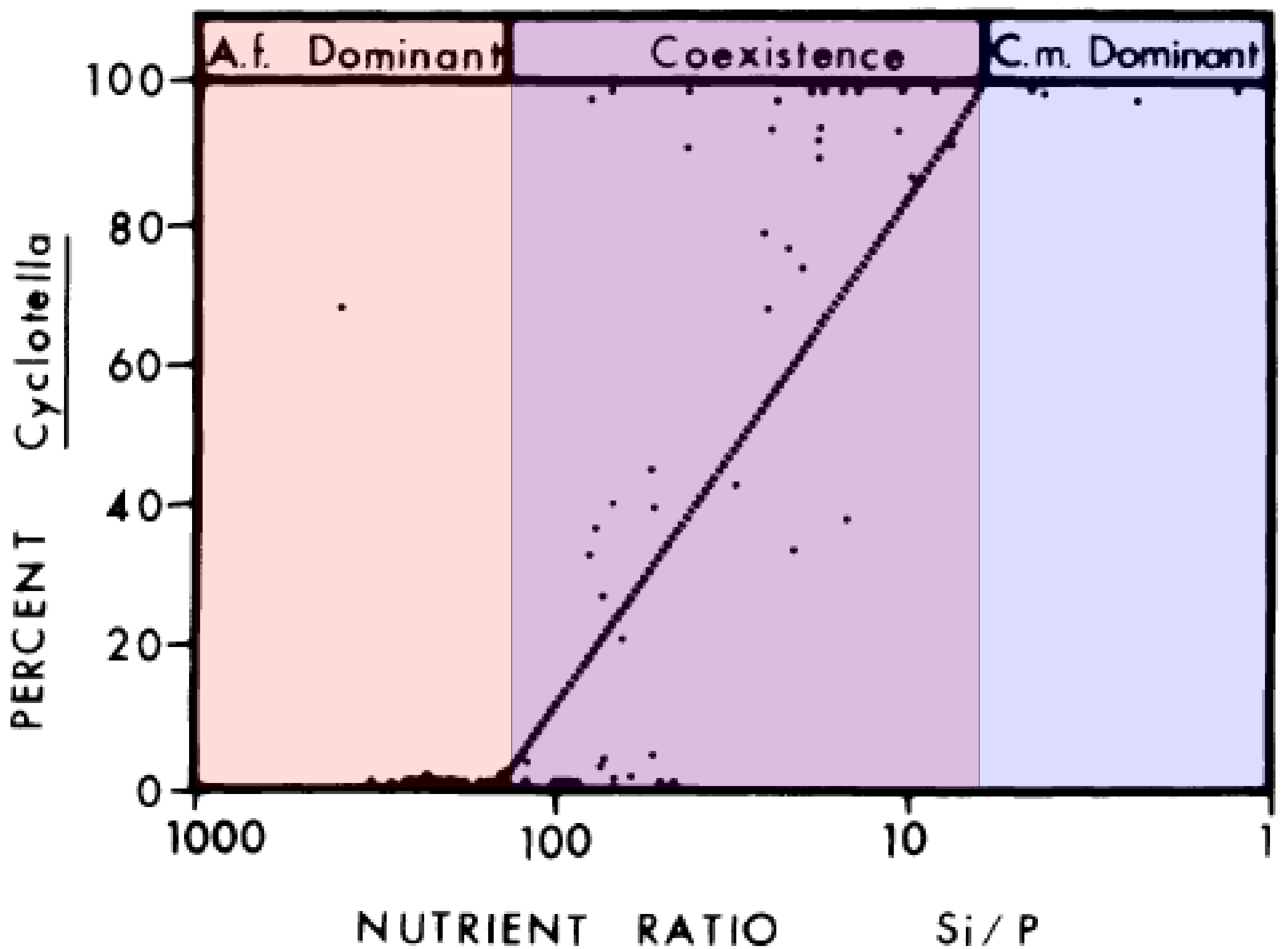


FIG. 12. The steady state results of all 76 long-term competition experiments are compared with the predictions of the Monod model (Model I). Stars represent cultures in which *Asterionella* (*A.f.*) was competitively dominant. Diamonds represent cultures in which *Cyclotella* (*C.m.*) was dominant. Closed circles represent stable coexistence of both species.


A.f. Dominant
Coexistence
C.m. Dominant
PERCENT Cyclotella
100
80
60
40
20
0
1000
100
10
1
NUTRIENT RATIO Si/P

Homework 6