What is the definition of the R* value?

R* represents the resource level at which population growth is balanced by population loss (death or biomass loss in plants). At resource levels below the R* population growth is negative.

Maximum growth rate doesn’t influence species coexistence
2 species - one limiting resource
What is the outcome of competition?

Resource level where sp A pop stops growing

Sp A pop stops growing --represents R* for that species
Why should we expect species to differ in their $R^*$ values?

Grime argument: Strong competitor for one resource strong for all.

Tilman argument: Resource allocation trade-offs mean that strong competitive ability for one resource = poor ability for another.
Resource allocation trade-off:

More resources allocated to light capture means less resources available for soil-borne resource capture
Resource level will depend on resource supply and resource consumption rates. Direction of the consumption vector - results from trade-offs in resource uptake (doesn’t necessarily have to do with R* value)
What happens in zone 1 and zone 2?

Which spp survive if resource supply point is in zones 1, 2 and 3?

- Zero Net population growth for sp 1 (ZNPG for sp 2)
- Zone 3
- Zone 2
- Zone 1

Resource 2 availability

Resource 1 availability
Two species coexistence

- Species A consumption vector
- Species B consumption vector
- Species A zero growth
- Species B zero growth
Which species wins in zone 4?
Which sp wins in zone 4?

Species A consumption vector

Species B consumption vector

Answer = A: Because the consumption vector will pass through the sp B zero growth isocline before reaching the species A isocline.

Resource 1 is most limiting to BOTH species.
Answer = A: Because the consumption vector will pass through the sp B zero growth isocline before reaching the species A isocline. Resource 1 is most limiting to BOTH species.
Why do species coexist in zone 6?

Species A consumption vector

Species B consumption vector

Resource 2 availability

Resource 1 availability
Why do species coexist in zone 6?

Answer: In zone 6 the resource most limiting to species A is resource 2. The resource most limiting to species B is resource 1. Each species is limited by the resource for which it has the highest $R^*$ value.
Could the vectors be switched? YES!!

Red arrows show direction of species A consumption from zone 6. Moves resource supply point towards zone 4.
Could the vectors be switched? YES!!

Resource 1 availability

Resource 2 availability

Species B consumption vector

Species A consumption vector

1 2 3 4 5 6
Could the vectors be switched? YES!!

Outcome of competition is conditional on starting conditions
How can \( R^* \) promote multi-species coexistence?

Resource allocation trade-offs mean that a low \( R^* \) for one resource implies a high \( R^* \) for another.

If resource supply rates vary then species with differ \( R^* \) ratios will be favored in different sites.

Species differences in \( R^* \) across gradients of resource availability.
Can $R^*$ promote multi-species coexistence?

Tilman (1988) Fig. 2.10a
What does the big blue ball represent?
Even if initial resource supply rates are high…
Might also account for successional change?
What is the functional response of a predator?

\( \alpha V \) represents the type I **functional response** of the predator (this describes *how the rate of prey capture is affected by prey abundance*).
- **P abundant**
  - **V scarce**
  - **P & V decrease**

- **P scarce**
  - **V scarce**
  - **V recovers**

- **P & V abundant**
  - **P increases**
  - **V decreases**

- **P isocline**
- **V isocline**

- **Numbers of predators (P)**
- **Numbers of victims (V)**
Number of predators ($P$)

$\frac{r}{\alpha}$

$\frac{q}{\beta}$

Numbers of victims ($V$)

$P$ scarce

$V$ scarce

$P$ scarce

$V$ scarce

$P$ scarce

$P$ recovers

$V$ recovers

$V$ increases

$P$ increases

$V$ decreases

$P$ decreases

$V$ decreases

$P$ abundant

$V$ abundant

$P$ scarce

$V$ scarce

$P$ & $V$ decrease

$P$ & $V$ abundant

$P$ & $V$ increase
Prey carrying capacity results in damped oscillations leading to equilibrium predator and prey populations.

**Figure 6.5** The effect of a victim carrying capacity on the victim isocline. The victim isocline slopes downward with a carrying capacity incorporated. The intersection with the vertical predator isocline forms a stable equilibrium point.
Type II or III without carrying capacity are not stable

Why is this unstable?

High P pop
V pop cannot
grow until pop
much lower

Figure 6.9 Victim isoclines incorporating a Type II or a Type III functional response. The intersection of an increasing victim isocline with a vertical predator isocline generates an unstable equilibrium point.
Most appropriate model yields humped prey isocline

*Why humped?*
Inefficient predator: populations oscillate to equilibrium point
Efficient predator: predator drives prey to extinction ("paradox of enrichment")

Greater opportunity for predator to drive down prey density despite increased prey carrying capacity
What will happen to predator and prey numbers if they are not at the intersection of the zero growth isoclines?

$P$ isocline

Number of predators ($P$)

$r/\alpha$

$q/\beta$

Numbers of victims ($V$)
Predator carrying capacity: predator can no longer drive prey to extinction. Stable coexistence.
What happens if a predator has multiple prey?

Outcome will depend on whether prey species cycle in concert.

If prey abundances are *not* strongly positively correlated then as one prey species becomes scarce, the predator can continue to feed and increase its population size.

Unstable equilibrium: predators drive prey to extinction.
Figure 6.15  Effects of clockwise rotation of the predator isocline. As the predator isocline is rotated, the dynamics change from cycles with a neutral equilibrium, to damped cycles, to a stable equilibrium point. Biologically, the three predator isoclines correspond to a predator that is a complete specialist on the victim, to one whose carrying capacity is proportional to victim abundance, to one whose carrying capacity is independent of victim abundance.
Zero growth isoclines - combination of abundances of $N_1$ and $N_2$ at which growth of one species is zero

\[
\frac{dN_1}{dt} = 0 = 1000/0.6
\]

\[K_1/a_{12} = 1000/0.6\]

\[K_1/k_{12} = 1000/0.6\]

\[K_2/k_{21} = 1000/0.6\]

**FIGURE 2.2.** Values of population sizes of two species, $N_1$ and $N_2$, that result in positive, negative, or zero population growth for species interacting according to Equations 2.2a and 2.2b. The zero-growth isoclines are shown as a solid line for species 1 and a dashed line for species 2. This set of isoclines corresponds to $K_1 = K_2 = 1000$, $r_1 = r_2 = 3.22$, $a_{12} = 0.6$, and $a_{21} = 0.5$. 
Individuals of species 2 (green) consume 4 times as much of the resources available to the purple species as does species 1 (purple) itself.

Competition coefficient $\alpha_{\text{purple, green}} = 4$

Read $\alpha_{1,2}$ as effect of species 2 on species 1
Zero growth isoclines - combination of abundances of $N_1$ and $N_2$ at which growth of one species is zero

\[
\frac{K_1}{a_{1,2}} = \frac{1000}{0.6}
\]

$K_1 = 1000$

$a_{1,2} = 0.6$
Zero growth isoclines - combination of abundances of $N_1$ and $N_2$ at which growth of one species is zero

\[ K_1/a_{12} = \frac{1000}{0.6} \]

\[ K_1 = 1000 \]

\[ a_{1,2} = 0.6 \]

No competitor ($N_2$) so population of $N_1$ will stop growing at $K_1$
For any starting value of $N_1$ and $N_2$, what is the predicted equilibrium population sizes?
A. Stable Equilibrium

The graph shows the predicted population sizes denoted by \( dN_1/dt = 0 \) and \( dN_2/dt = 0 \). The predicted population sizes are indicated by 'x' markers.
What is the outcome of competition now?

\[ \frac{K_1}{a_{1,2}} = \frac{1000}{0.5} \]

\[ a_{12} = 0.5 \]
\[ a_{21} = 1.2 \]