Competition

BIOL/BOT 160 – Ecology

Delivered by Dr. Lawrence Uricchio

Slides adapted from Dr. Scott Shaffer's lecture

Suggested website to review this material

- http://www.tiem.utk.edu/~gross/bioed/bealsmodules/competition.html

Learning objectives

Students should be able to

- Explain why intraspecific competition may result in distinct patterns from interspecific competition
- Define the Lotka-Volterra competition equations
- Given the parameters of a Lotka-Volterra competition equation for two species, analyze the possible outcomes of competition
- Graph the zero-growth isoclines of the Lotka-Volterra competition model

Definition

- According to Smith and Smith

"Competition is any interaction that is mutually detrimental to both participants."

Detrimental in what way?

Anything that decreases FITNESS

Major driver of evolution through selection

What are we fighting for?

Variety of ‘resources’ may be the center of competitive interactions

- Plants
  - Nutrients, sunlight, water may be important for plants
  - Access to pollinators
- Animals
  - Water, food, mates, shelter
  - Roosting, nesting, breeding, displaying sites

Major Types of Competition

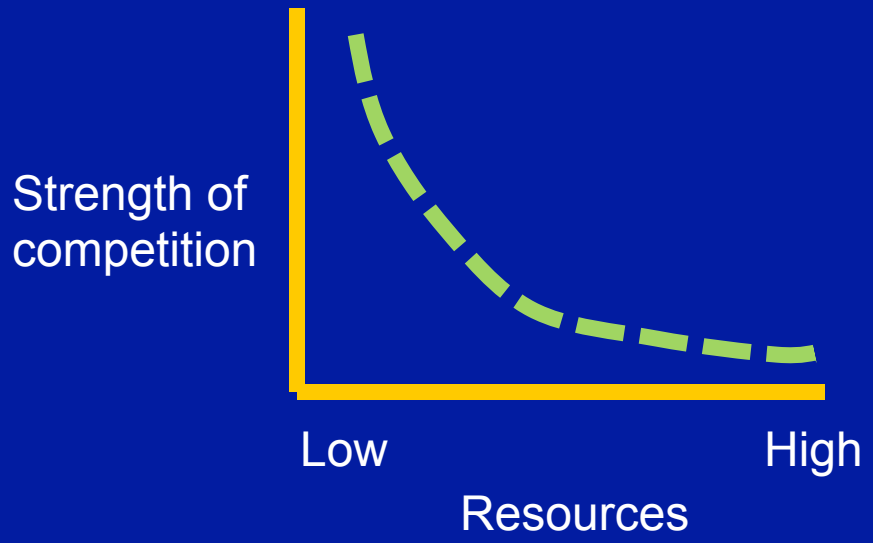
- Intraspecific – among individuals in the same population
  - Often members of the same sex
- Interspecific – among different species
  - Can involve multiple species

In what way do species compete?

- Resource Competition
  - Scramble or exploitative competition
  - Use same resources
  - All individuals equally affected
  - May be no winners or losers
- Interference Competition
  - Contest competition
  - One seeking resource harms the other in process even if resources are not in short supply
  - Definite winners and losers

Strength of competitive interaction

- Depends on the degree to which shared resources are in short supply
  - If resources are scarce competition is greater
  - If resources are abundant, competition is minimal

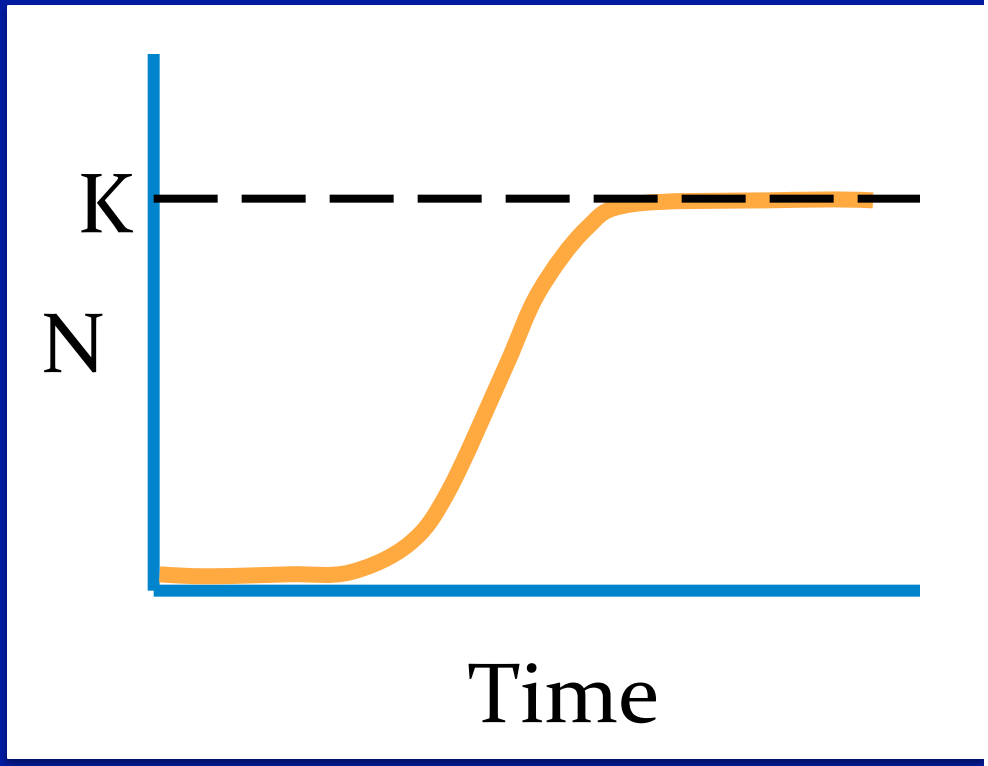


Competition

- Competitors are not always visible to each other
  - Noctural and diurnal competitors
- Many or most of the organisms that a species sees are not competitors
- Competition in plants is often different from mobile animals

Modeling Competition

- Alfred Lotka (American, 1920) and Vittora Volterra (Italian, 1926) independently came up with the same model based on the logistic growth

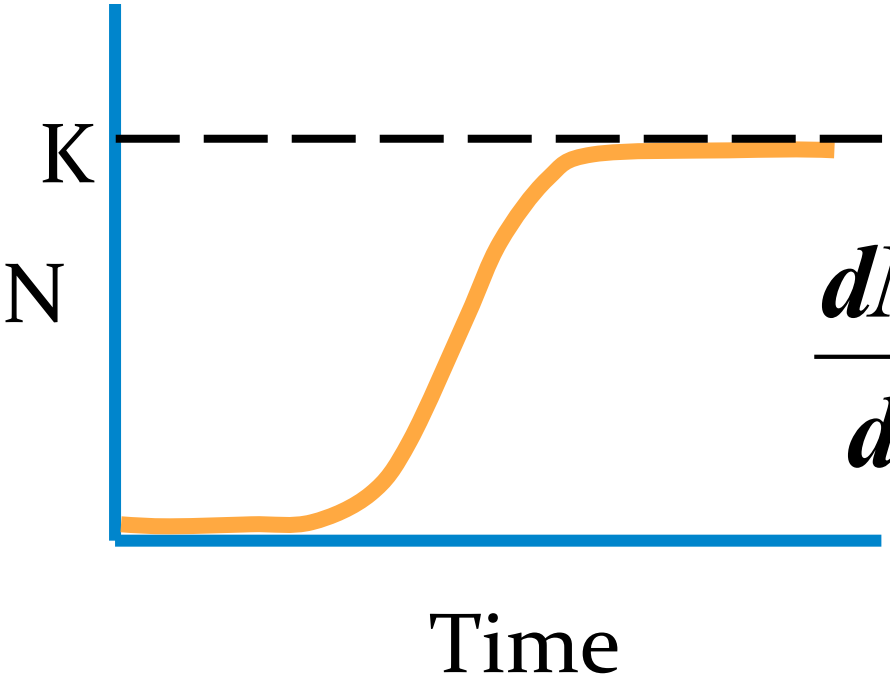


Lotka-Volterra competition models

- Population model framework used during the past century for studying competition
- Illustrate two things:
  - Link between species interactions and population processes
  - How to study the outcome of competition
- Aim is to see how competition affects whether species coexist or exclude each other

Lotka-Volterra model

- Model for two competing species
  - Based on Logistic Growth curve
  - Let's start with one species



$$\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)$$

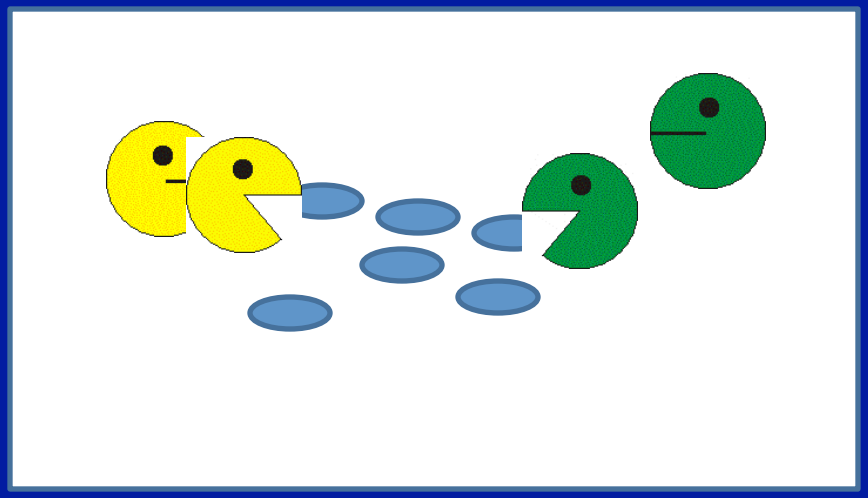
Lotka-Volterra model

- Species A
  - Abundance = N_A
  - Intrinsic growth rate = r_A
  - Carrying capacity = K_A

$$\frac{dN_A}{dt} = r_A N_A \left(\frac{K_A - N_A}{K_A} \right)$$

Lotka-Volterra model

- How many individuals of species A are displaced by species B?
  - Assume 1 Species A needs 2 food pellets
  - Assume 1 Species B needs 1 food pellet

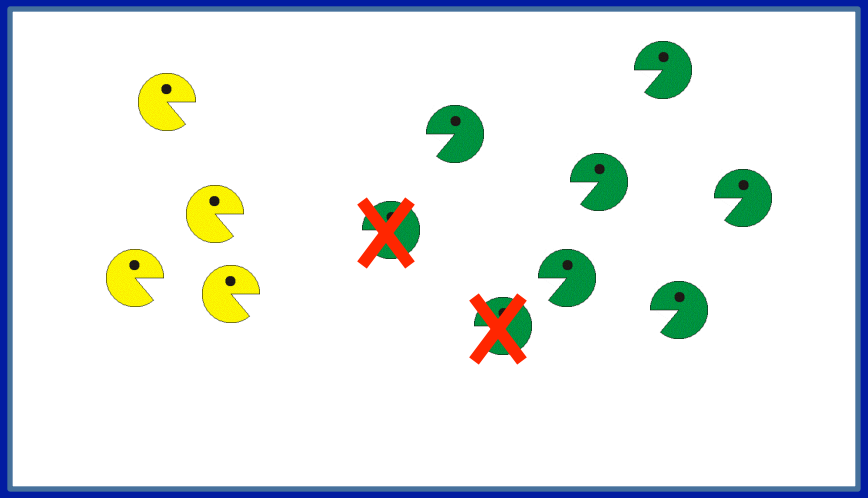


  - The rate of consumption of Species B is 0.5 units relative to Species A

Competition coefficient for Sp B = α = **0.5**

Lotka-Volterra model

- How many individuals of species A are displaced by species B?
  - In other words every two Species B will replace one of Species A



Competition coefficient for Sp B = α = **0.5**

Lotka-Volterra model

- The competitive effect of Sp B on Sp A is

Rate which an individual of Species B can use up resources needed by Species A

# of Species A displaced by Species B

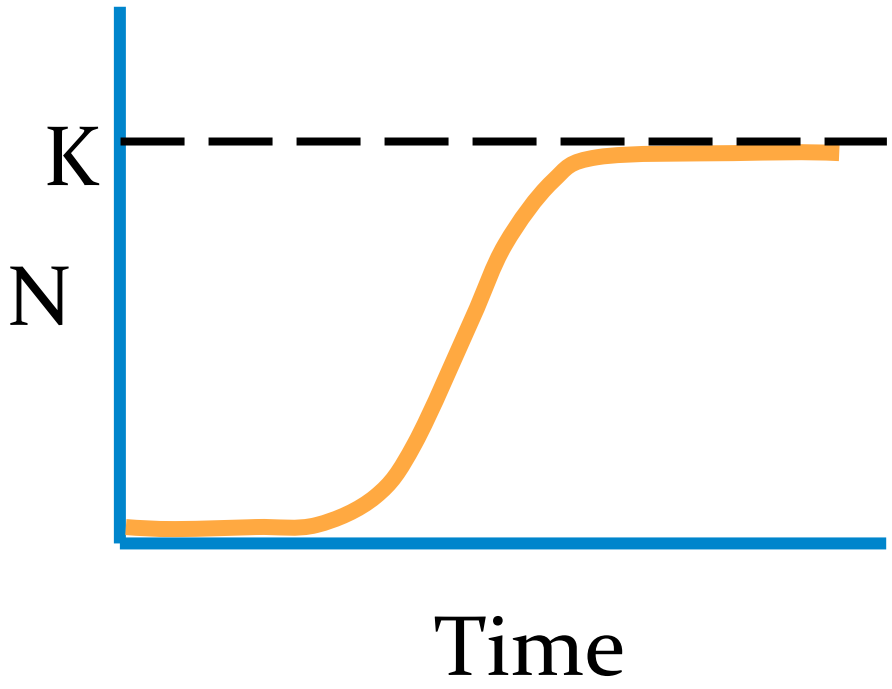
$$= \alpha * N_B$$

Population size of Species B

Model for Species A with the competitive effect of Species B

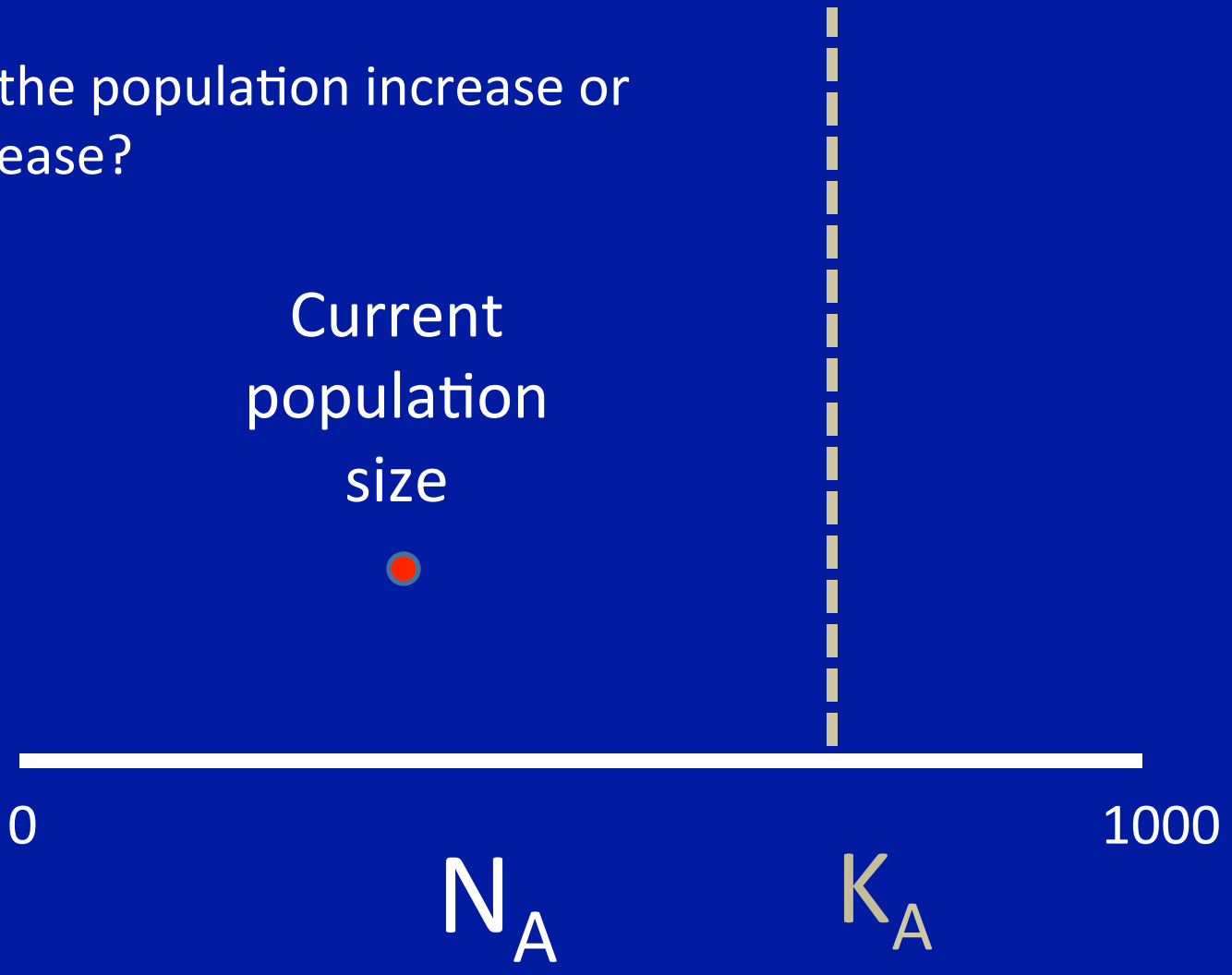
$$\frac{dN_A}{dt} = r_A N_A \left(\frac{K_A - N_A - \alpha N_B}{K_A} \right)$$

Intraspecific Competition only



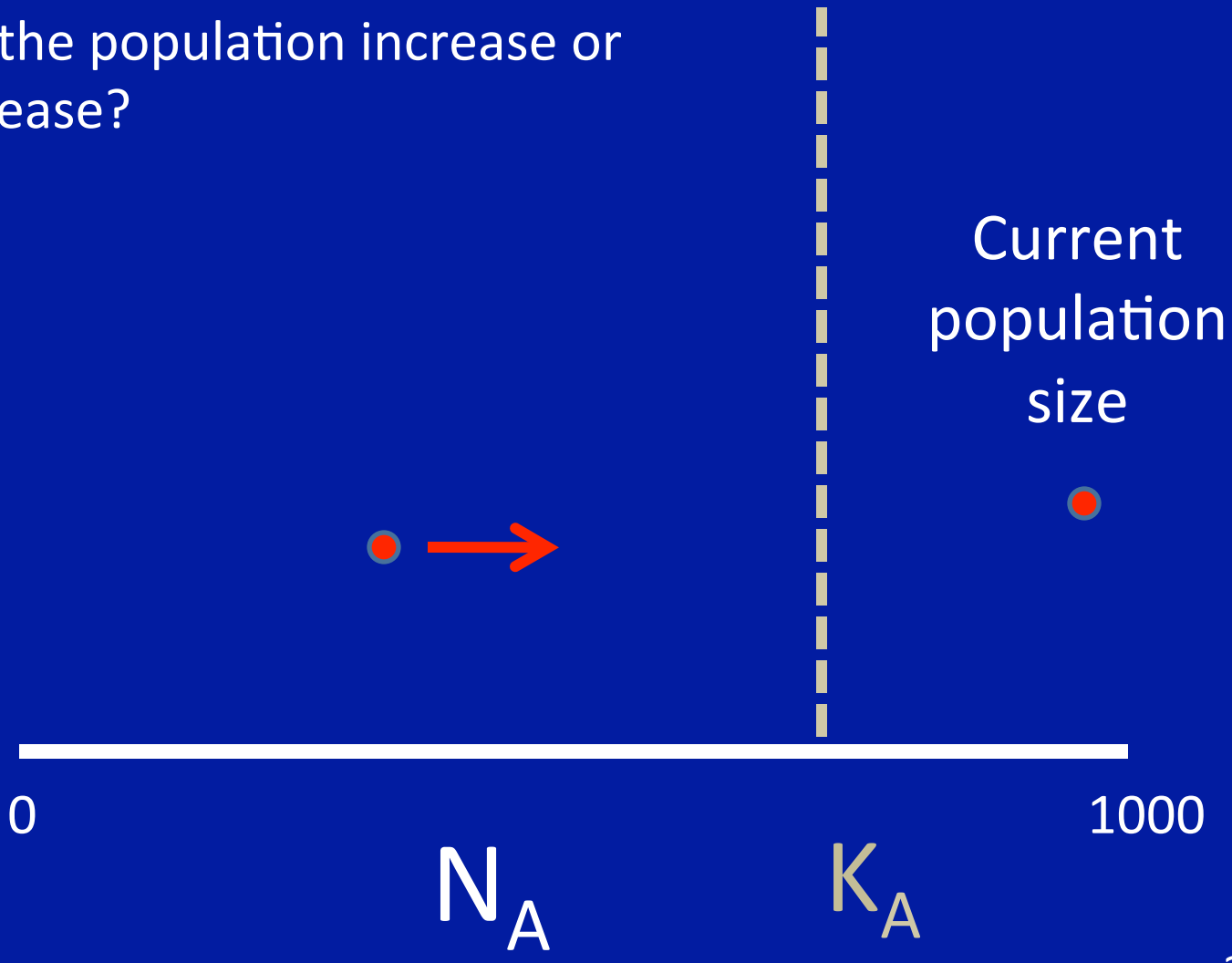
Vector Plot – Species A

Will the population increase or decrease?



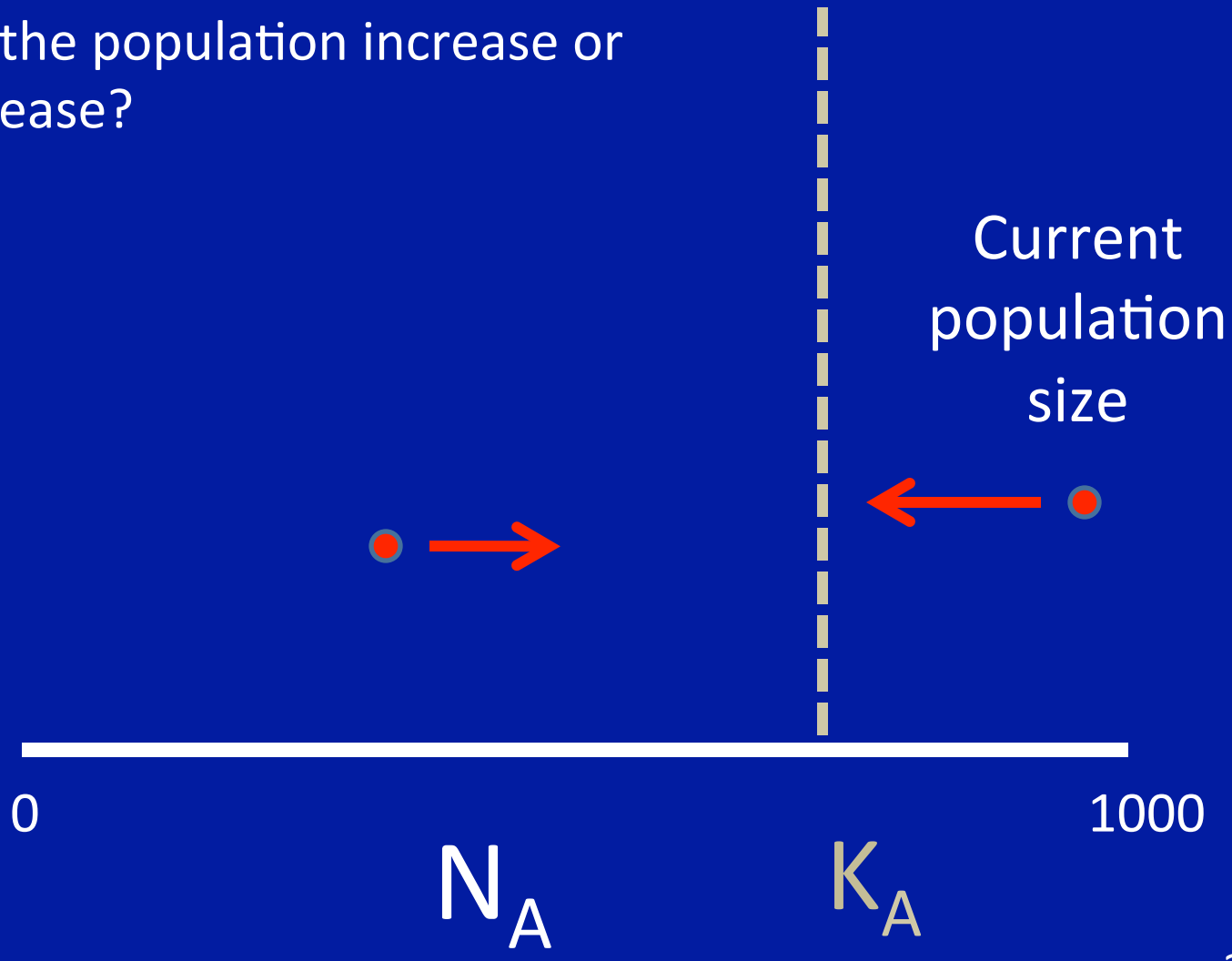
Vector Plot – Species A

Will the population increase or decrease?



Vector Plot – Species A

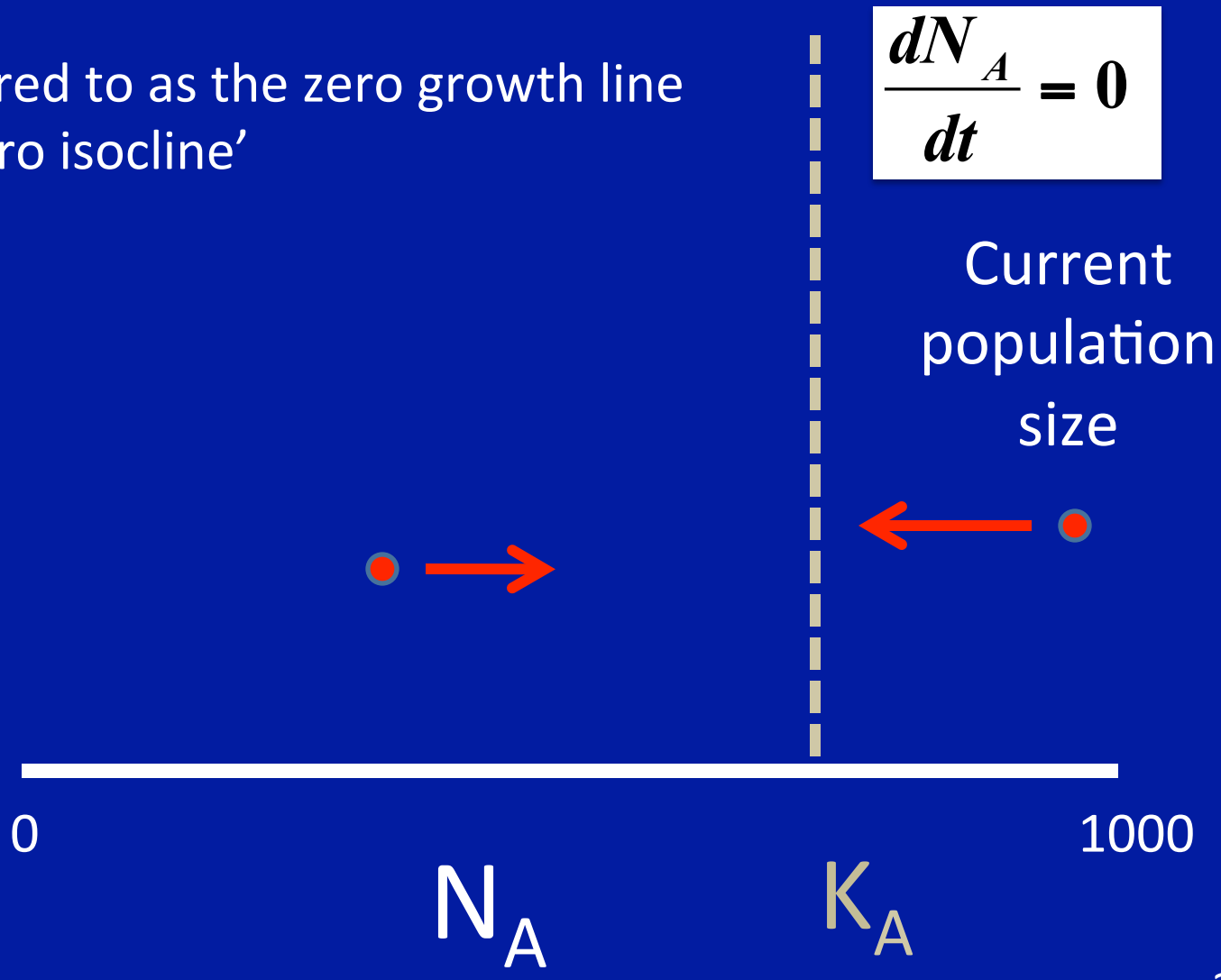
Will the population increase or decrease?



Vector Plot – Species A

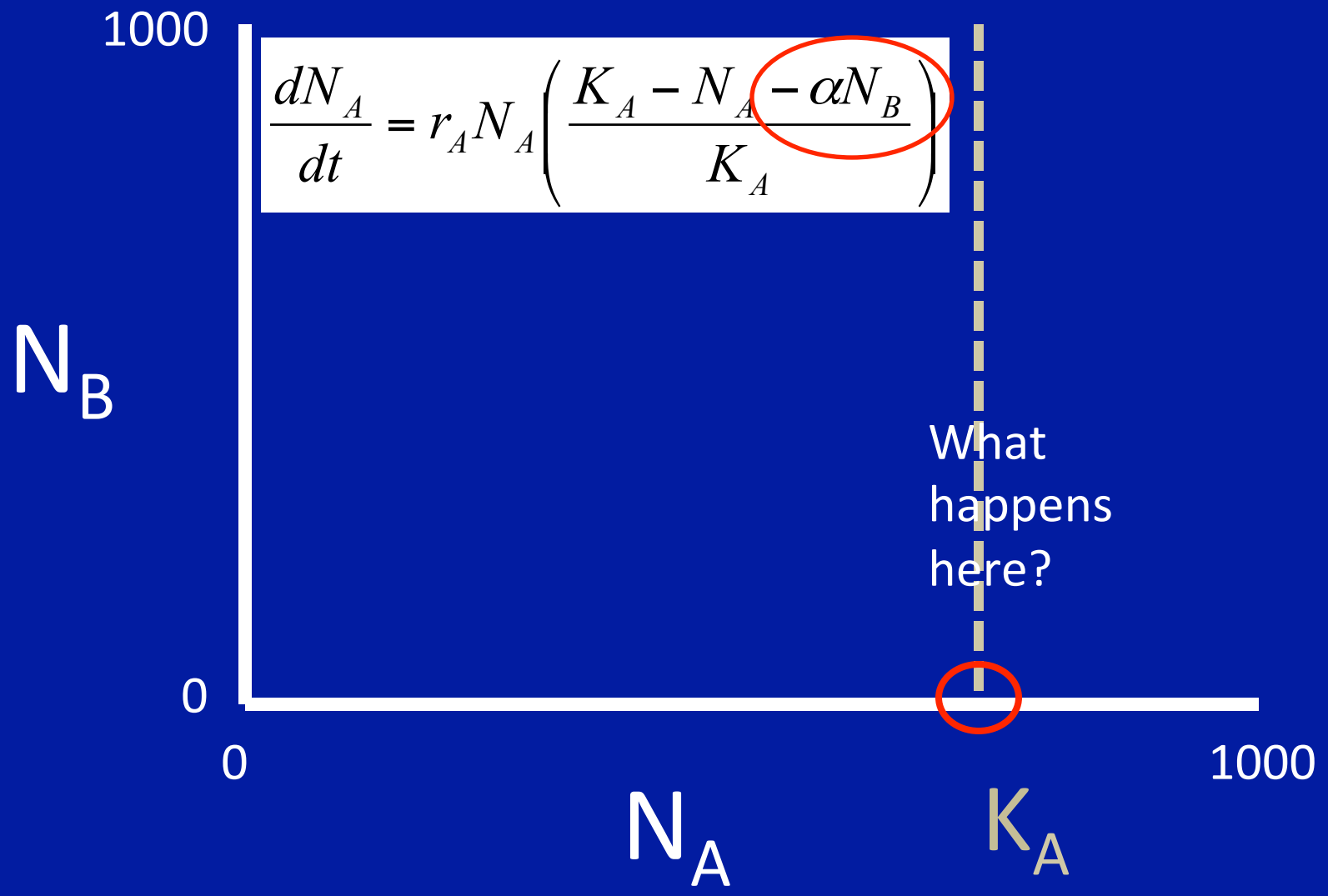
Referred to as the zero growth line or 'zero isocline'

$$\frac{dN_A}{dt} = 0$$



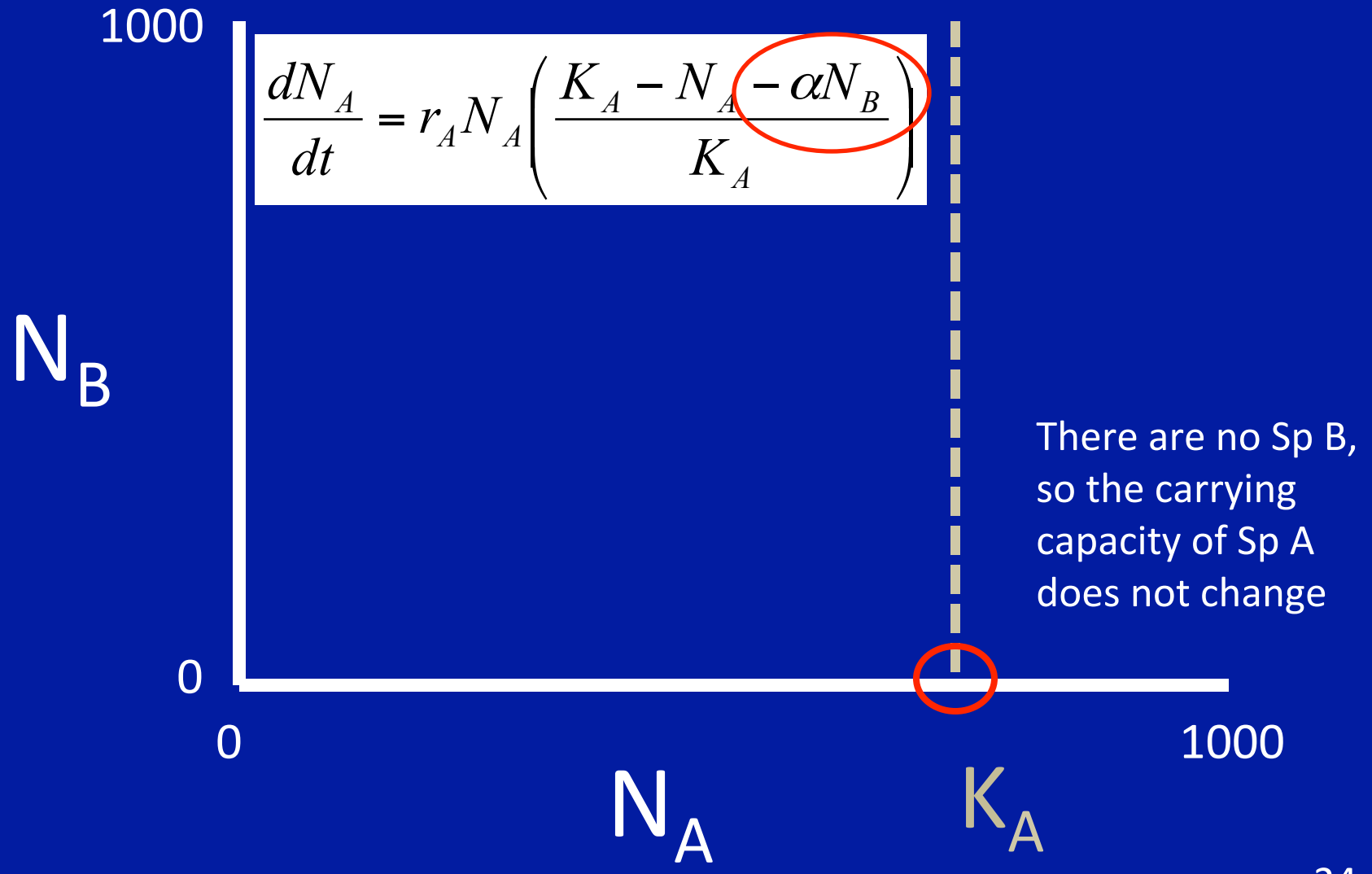
Vector Plot

Let's add in the effect of adding Sp B



Vector Plot

Let's add in the effect of adding Sp B

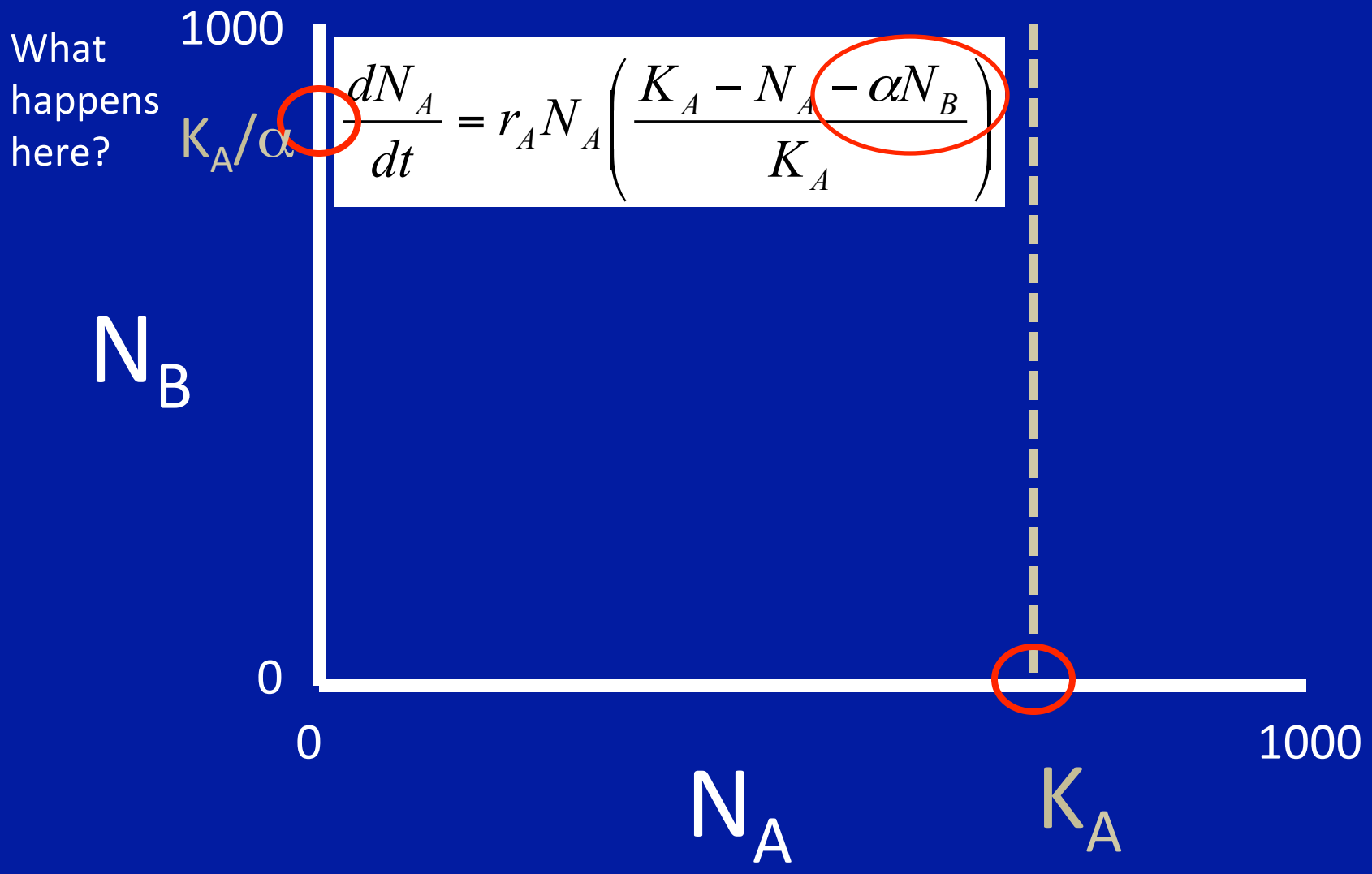


There are no Sp B, so the carrying capacity of Sp A does not change

Vector Plot

Let's add in the effect of adding Sp B

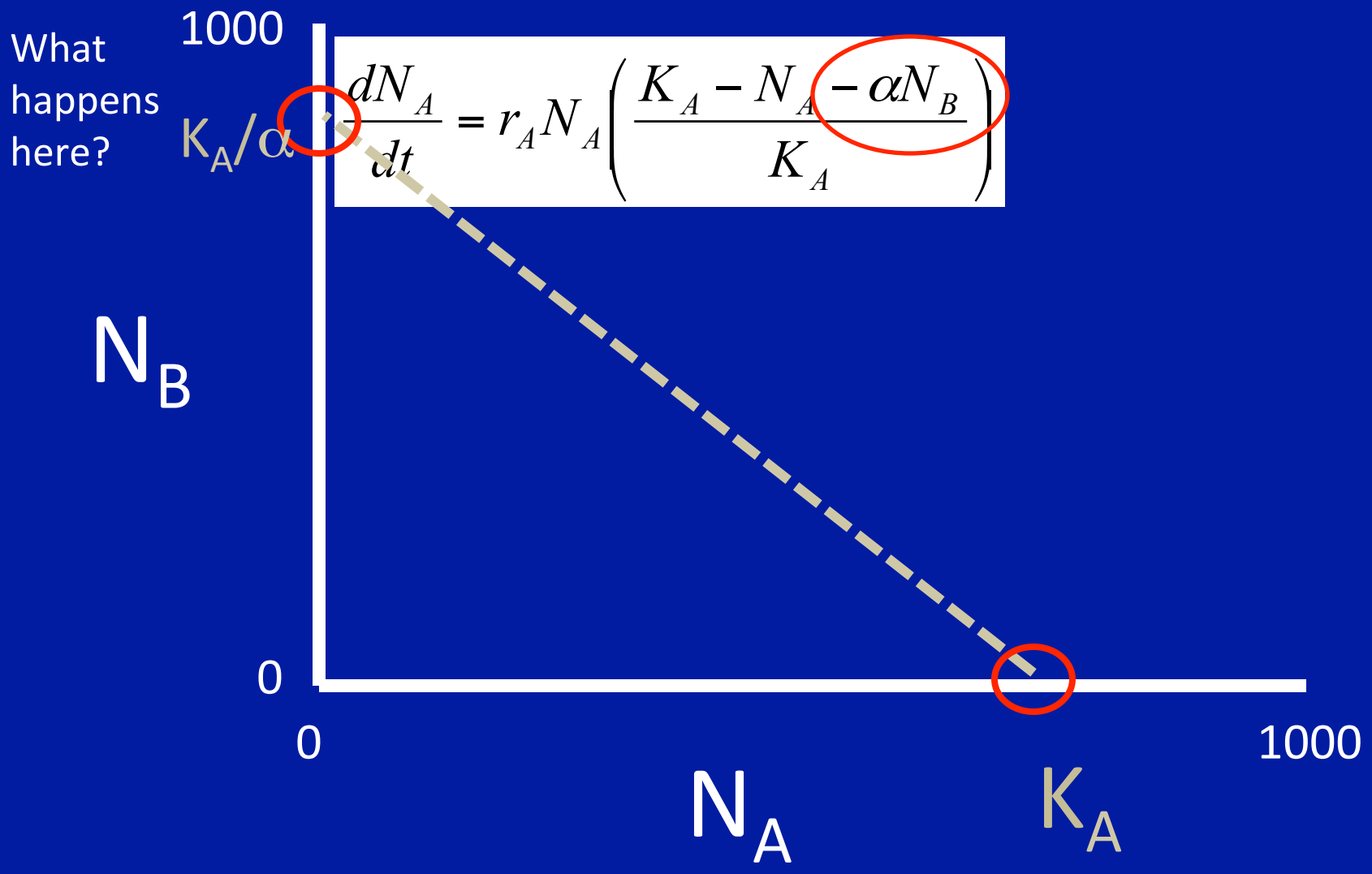
What happens here?



Vector Plot

Let's add in the effect of adding Sp B

What happens here?

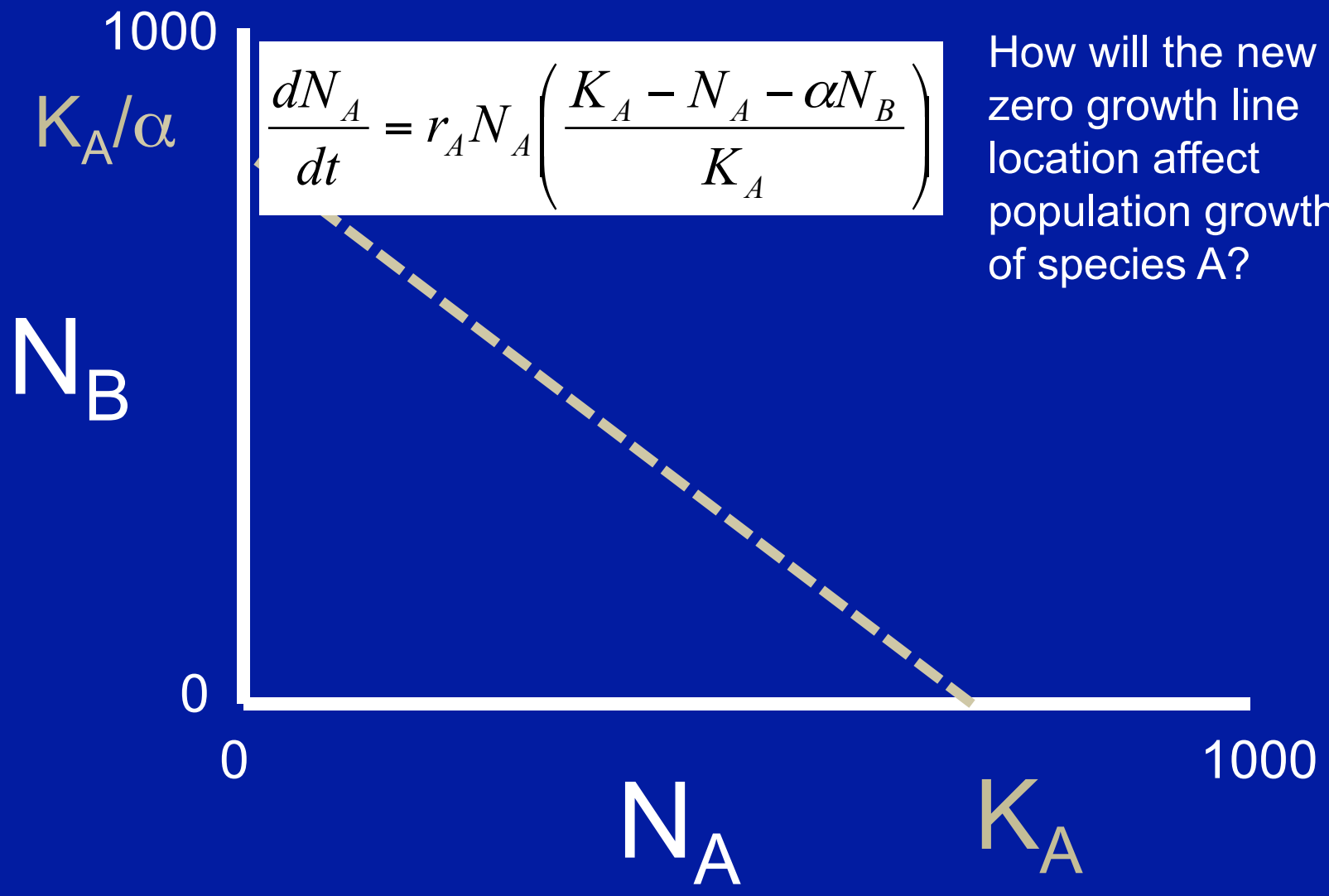


Vector Plot

Let's add in the effect of adding Sp B

$$\frac{dN_A}{dt} = r_A N_A \left(\frac{K_A - N_A - \alpha N_B}{K_A} \right)$$

How will the new zero growth line location affect population growth of species A?

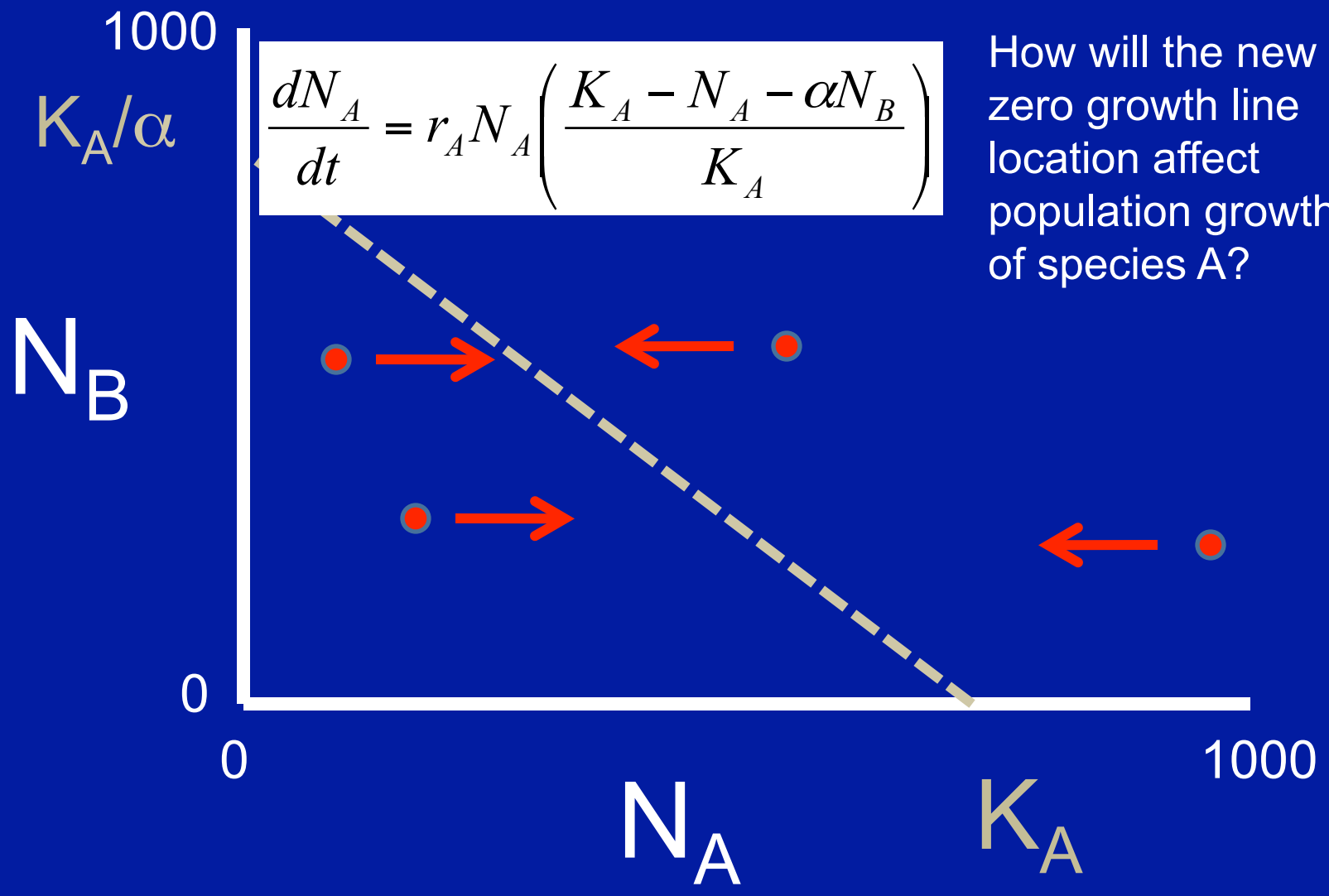


Vector Plot

Let's add in the effect of adding Sp B

$$\frac{dN_A}{dt} = r_A N_A \left(\frac{K_A - N_A - \alpha N_B}{K_A} \right)$$

How will the new zero growth line location affect population growth of species A?

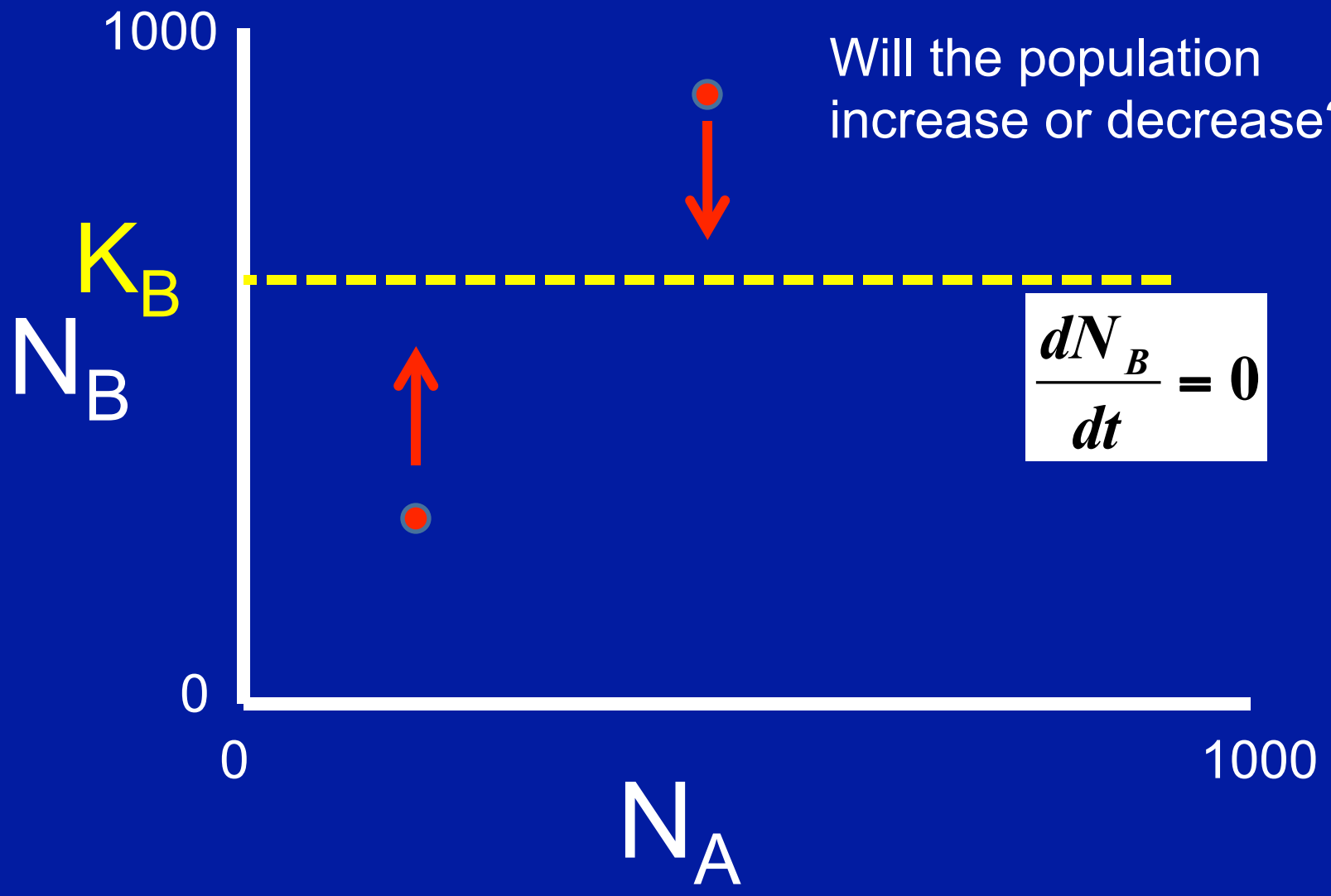


We can do the same thing for Species B

$$\frac{dN_A}{dt} = r_A N_A \left(\frac{K_A - N_A - \alpha N_B}{K_A} \right)$$

$$\frac{dN_B}{dt} = r_B N_B \left(\frac{K_B - N_B - \beta N_A}{K_B} \right)$$

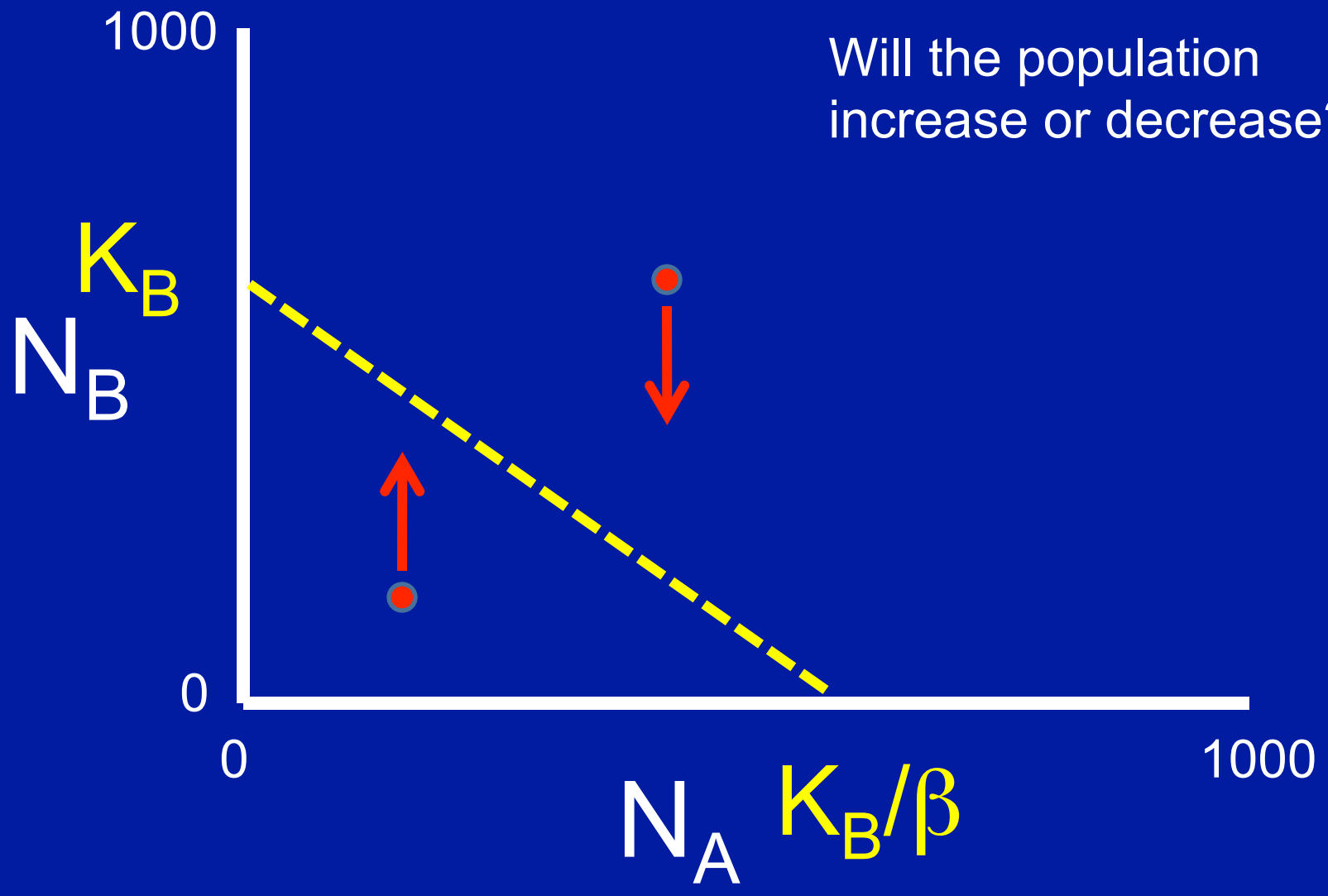
Vector Plot – Species B



Will the population increase or decrease?

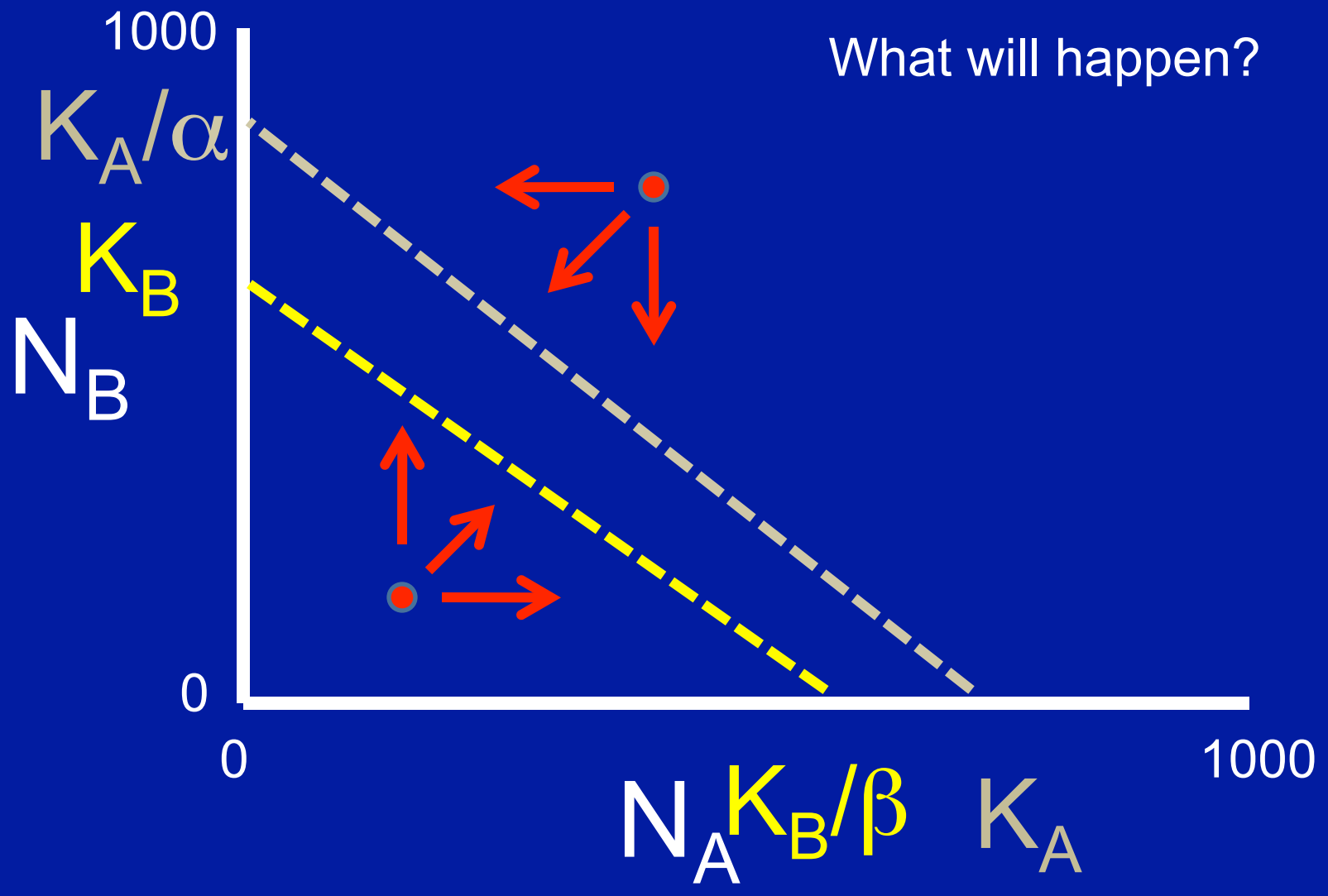
$$\frac{dN_B}{dt} = 0$$

Vector Plot – Species B



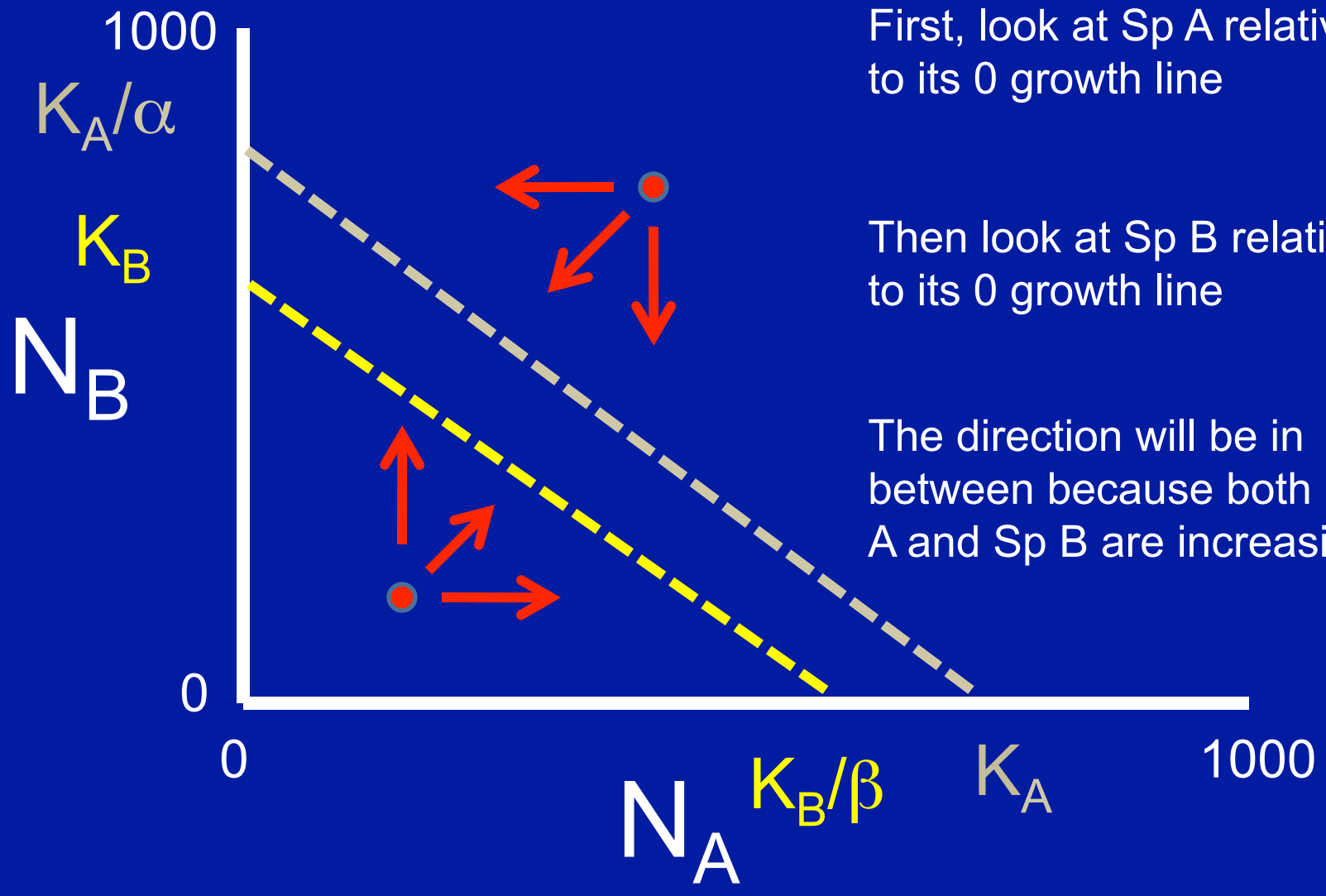
Will the population increase or decrease?

Vector Plot – Combine the plots



What will happen?

Vector Plot – Combine the plots

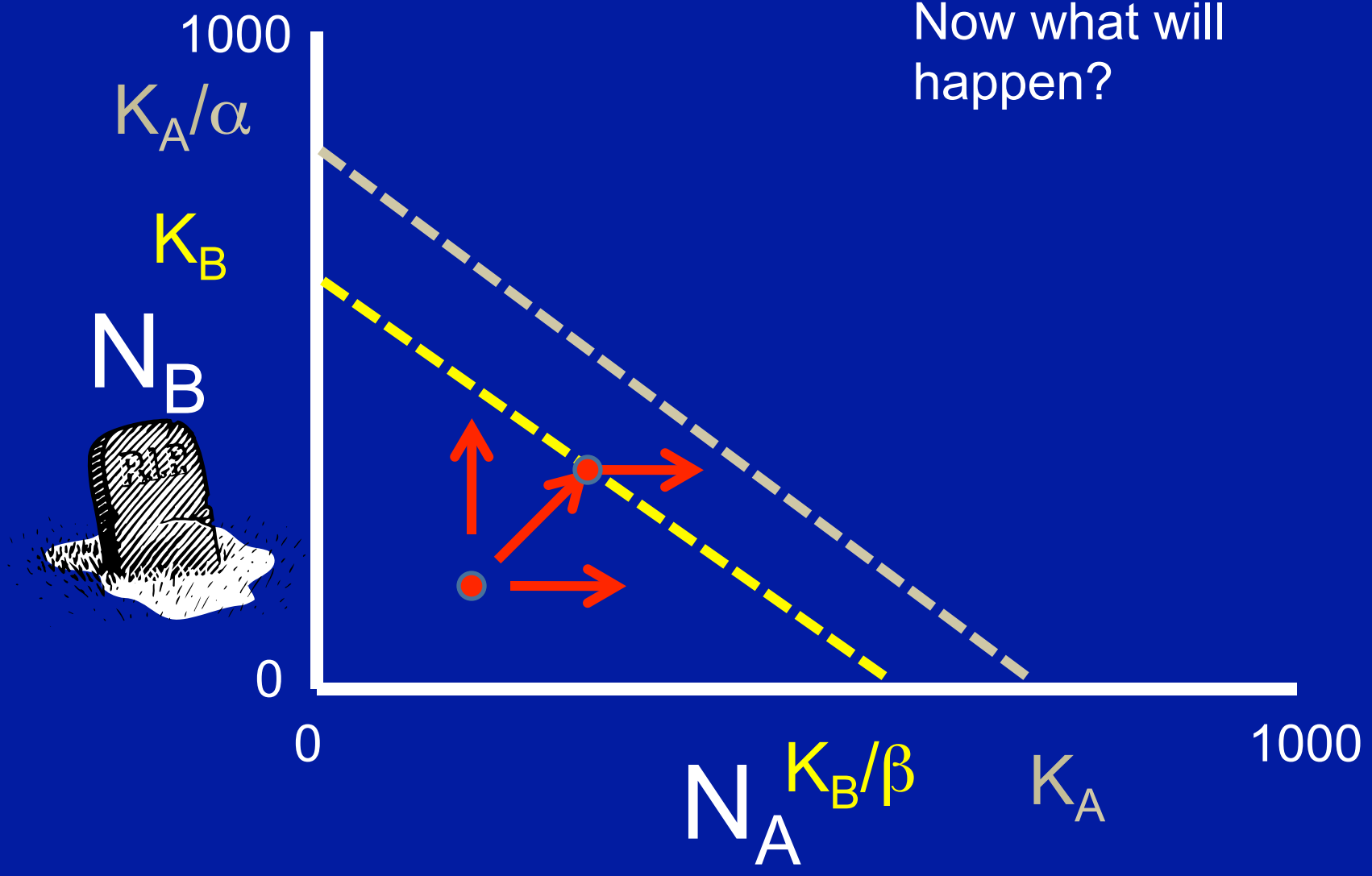


First, look at Sp A relative to its 0 growth line

Then look at Sp B relative to its 0 growth line

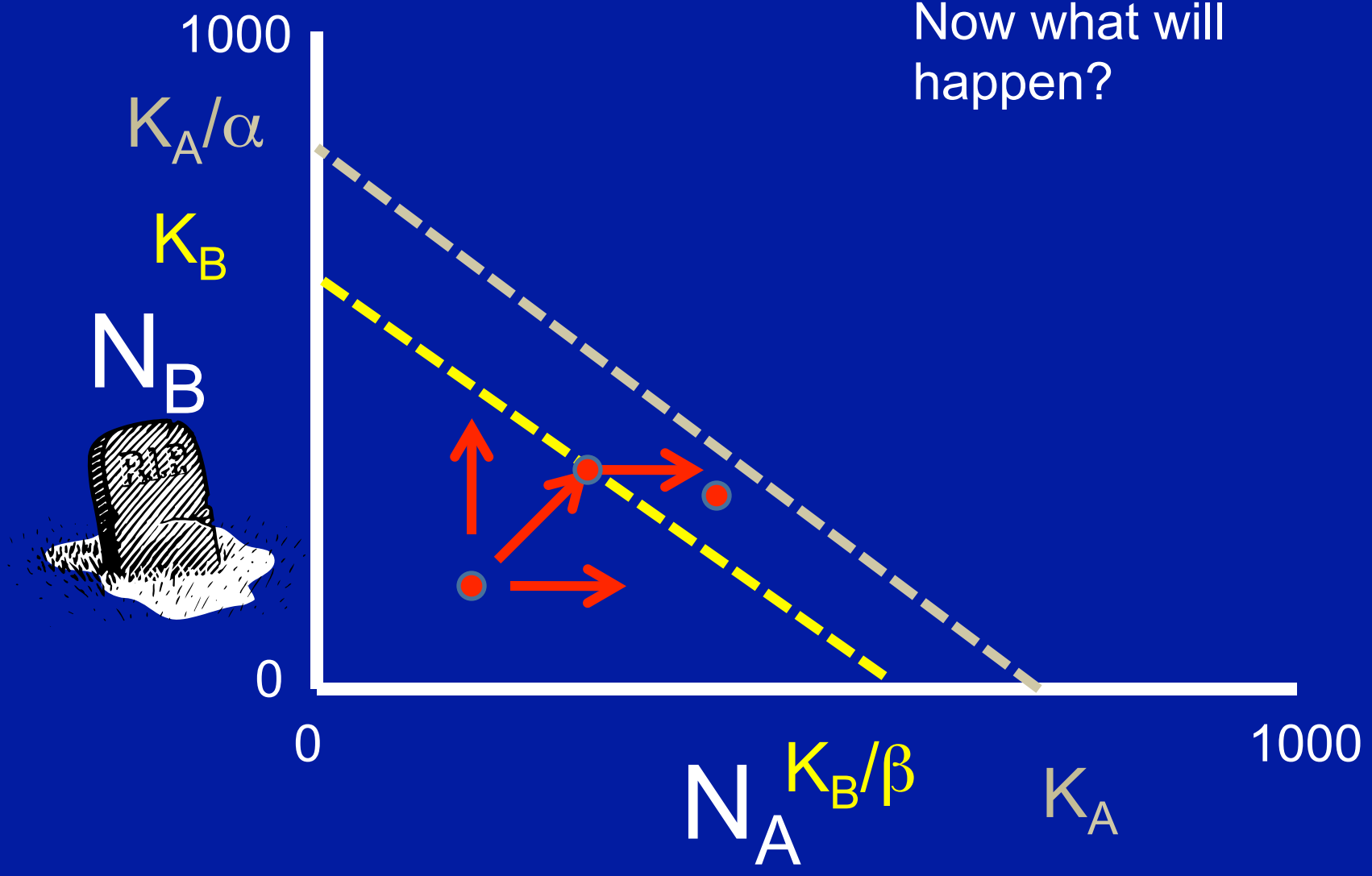
The direction will be in between because both Sp A and Sp B are increasing

Vector Plot – Lets see where the dot will end up

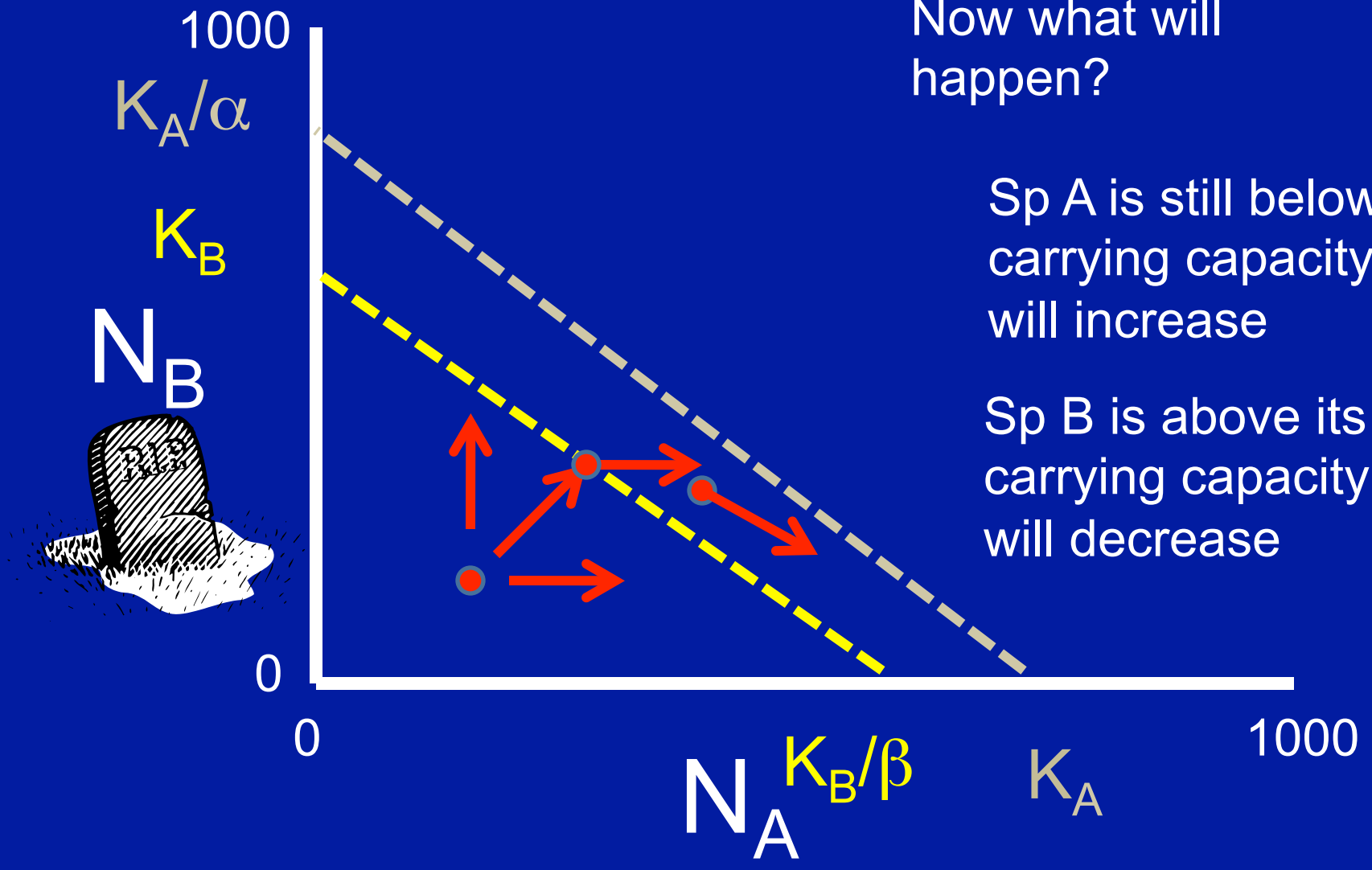


Now what will happen?

Vector Plot – Lets see where the dot will end up



Vector Plot – Lets see where the dot will end up

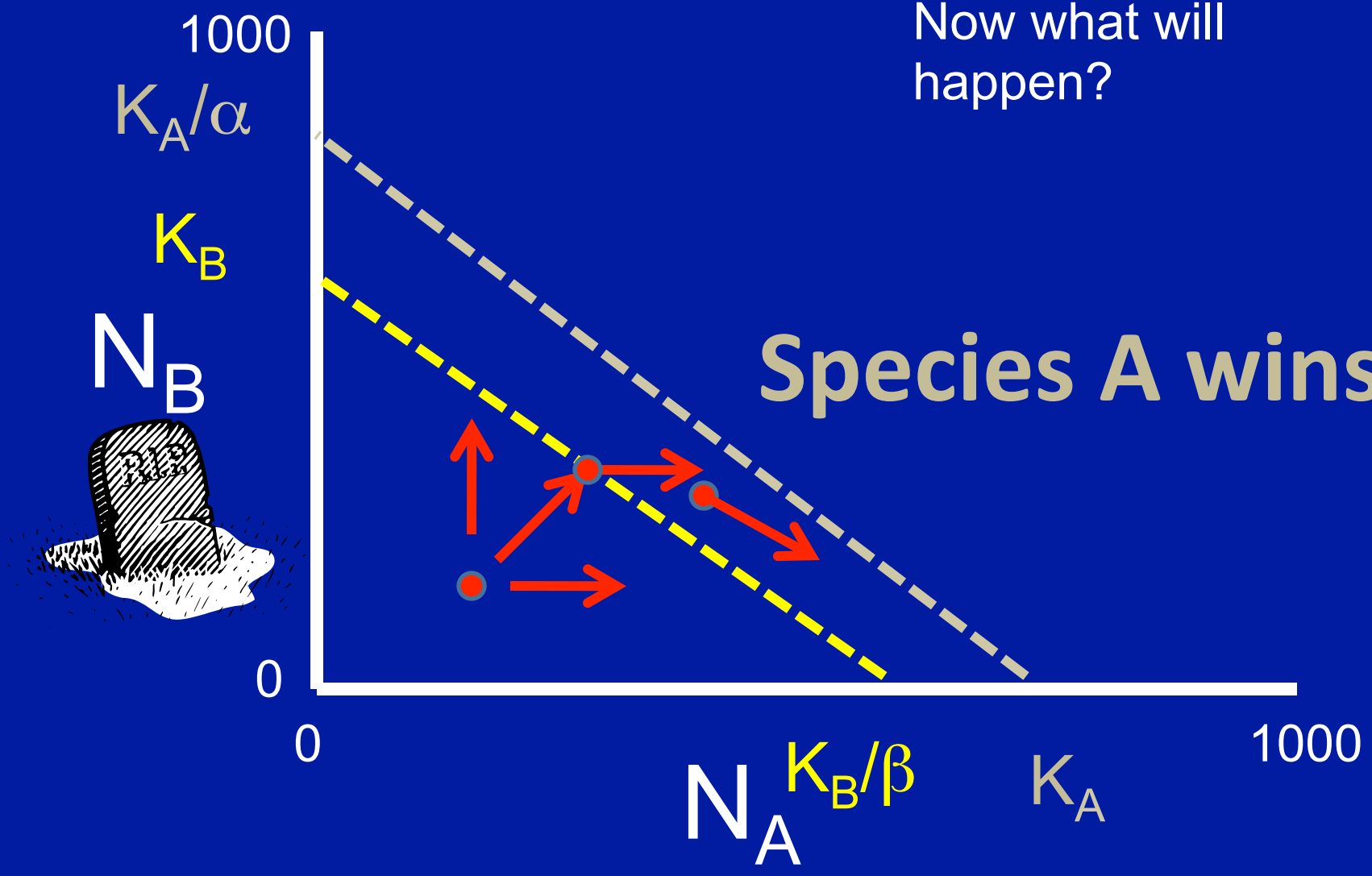


Now what will happen?

Sp A is still below its carrying capacity so it will increase

Sp B is above its carrying capacity so it will decrease

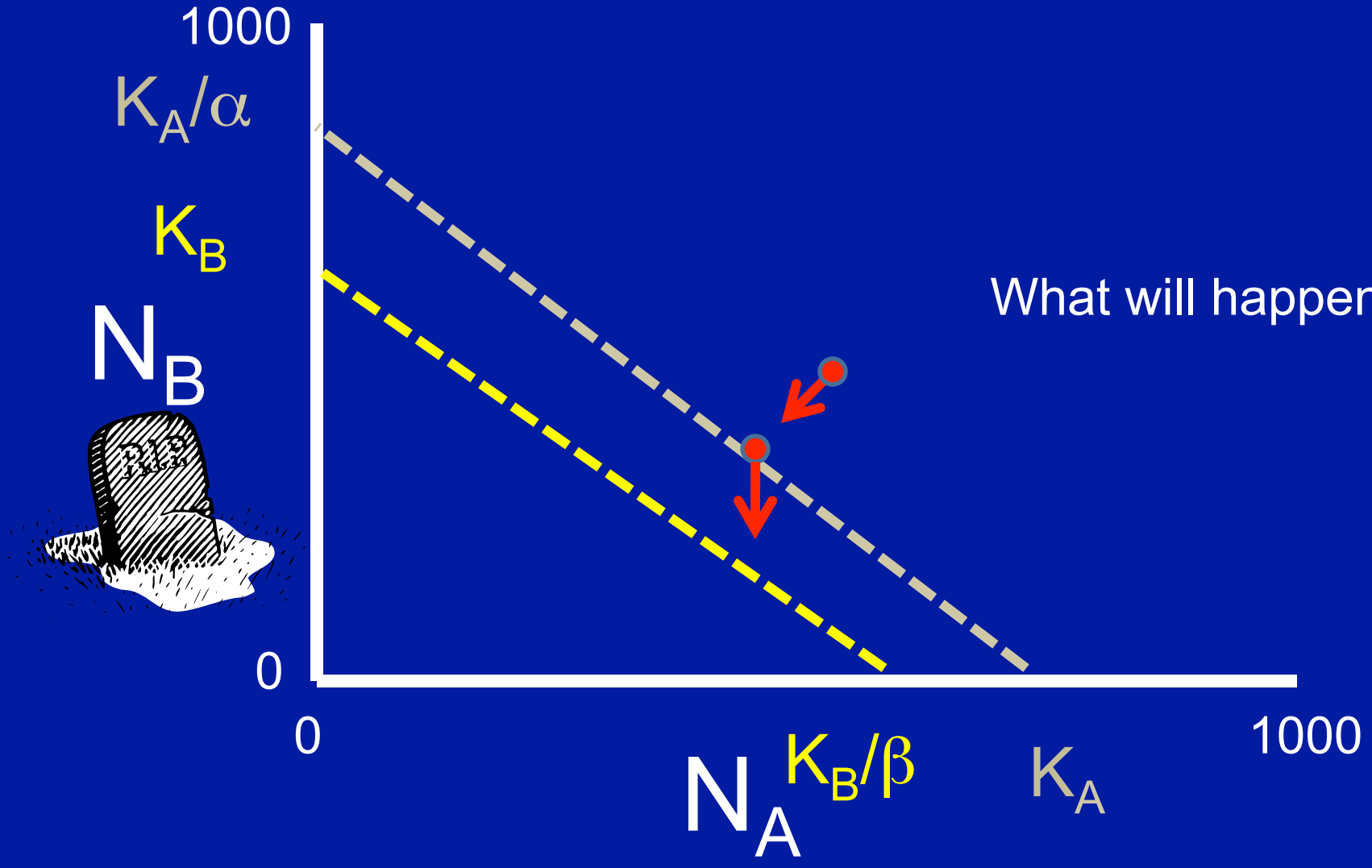
Vector Plot – Lets see where the dot will end up



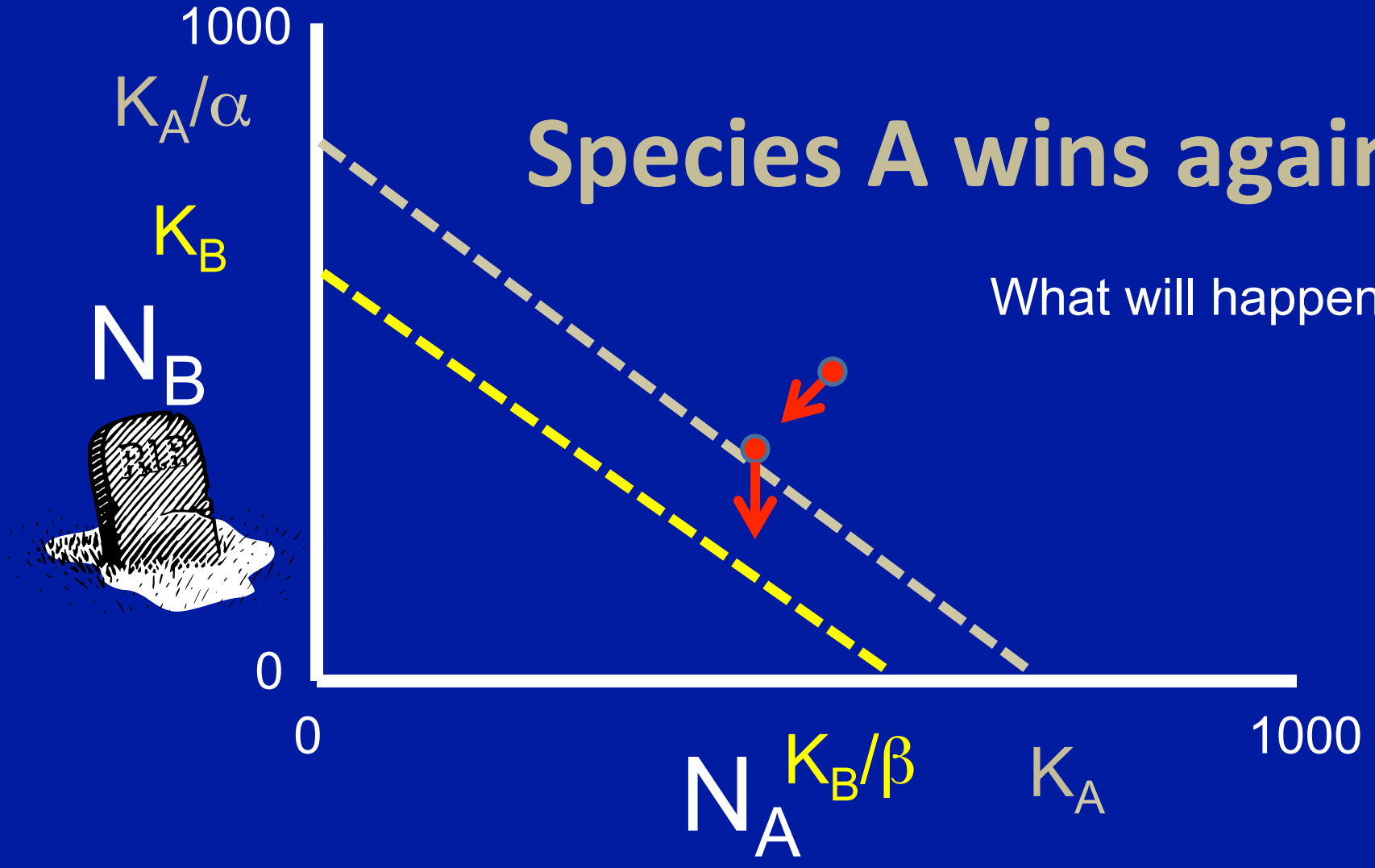
Now what will happen?

Species A wins!

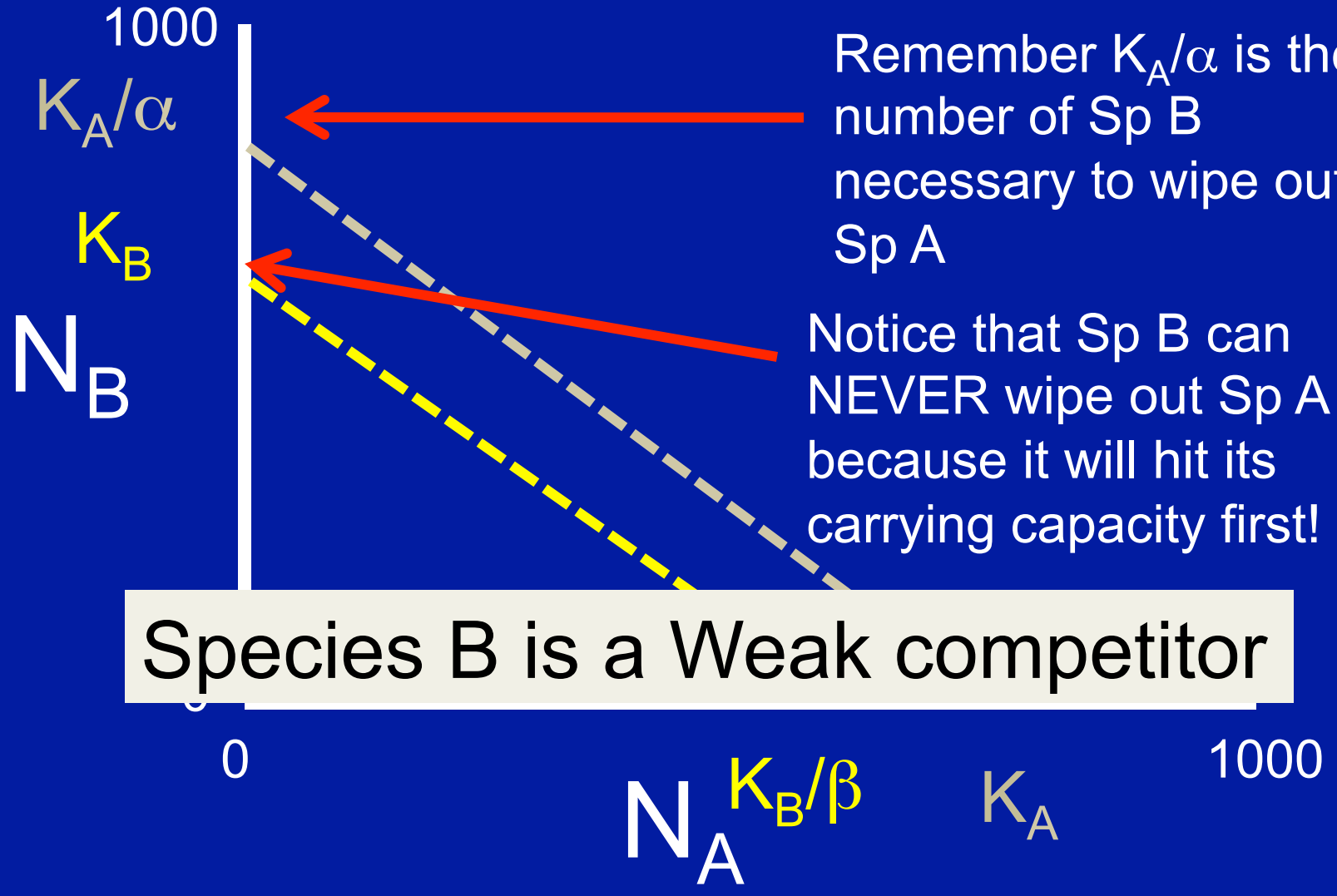
Vector Plot – Lets see where the dot will end up



Vector Plot – Lets see where the dot will end up



Vector Plot – Why does Sp A Win?

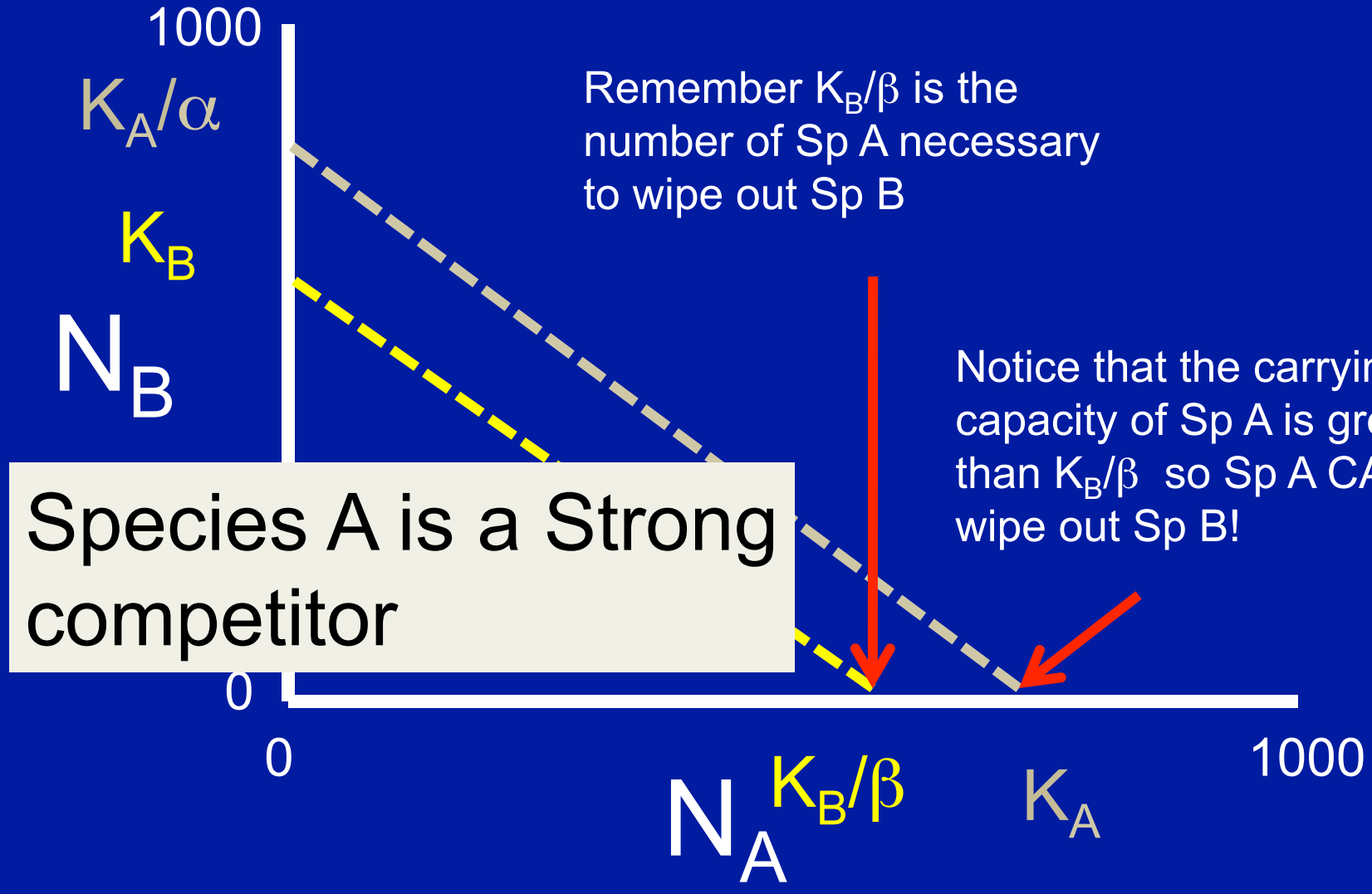


Remember K_A/α is the number of Sp B necessary to wipe out Sp A

Notice that Sp B can NEVER wipe out Sp A because it will hit its carrying capacity first!

Species B is a Weak competitor

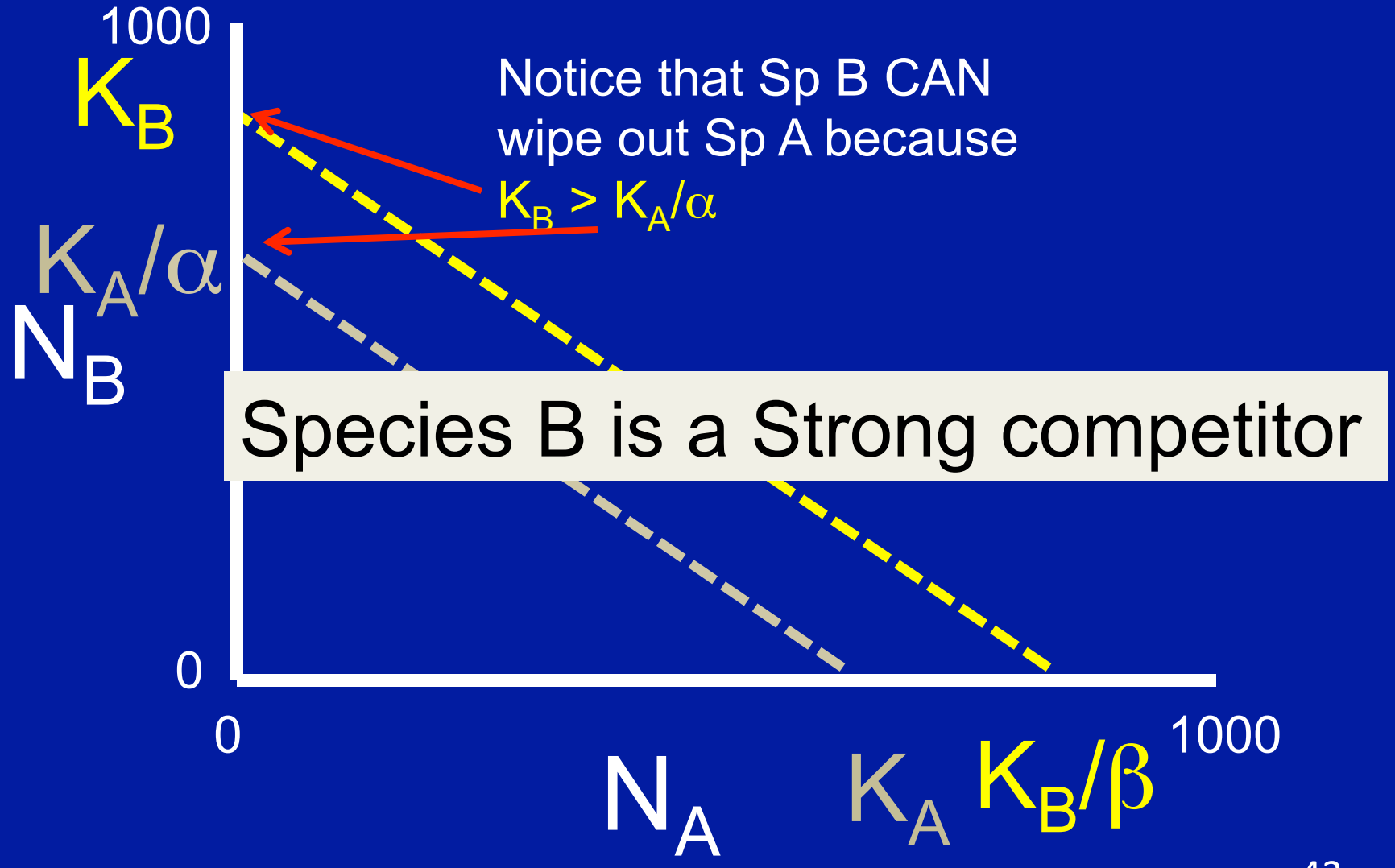
Vector Plot – Why does Sp A Win?



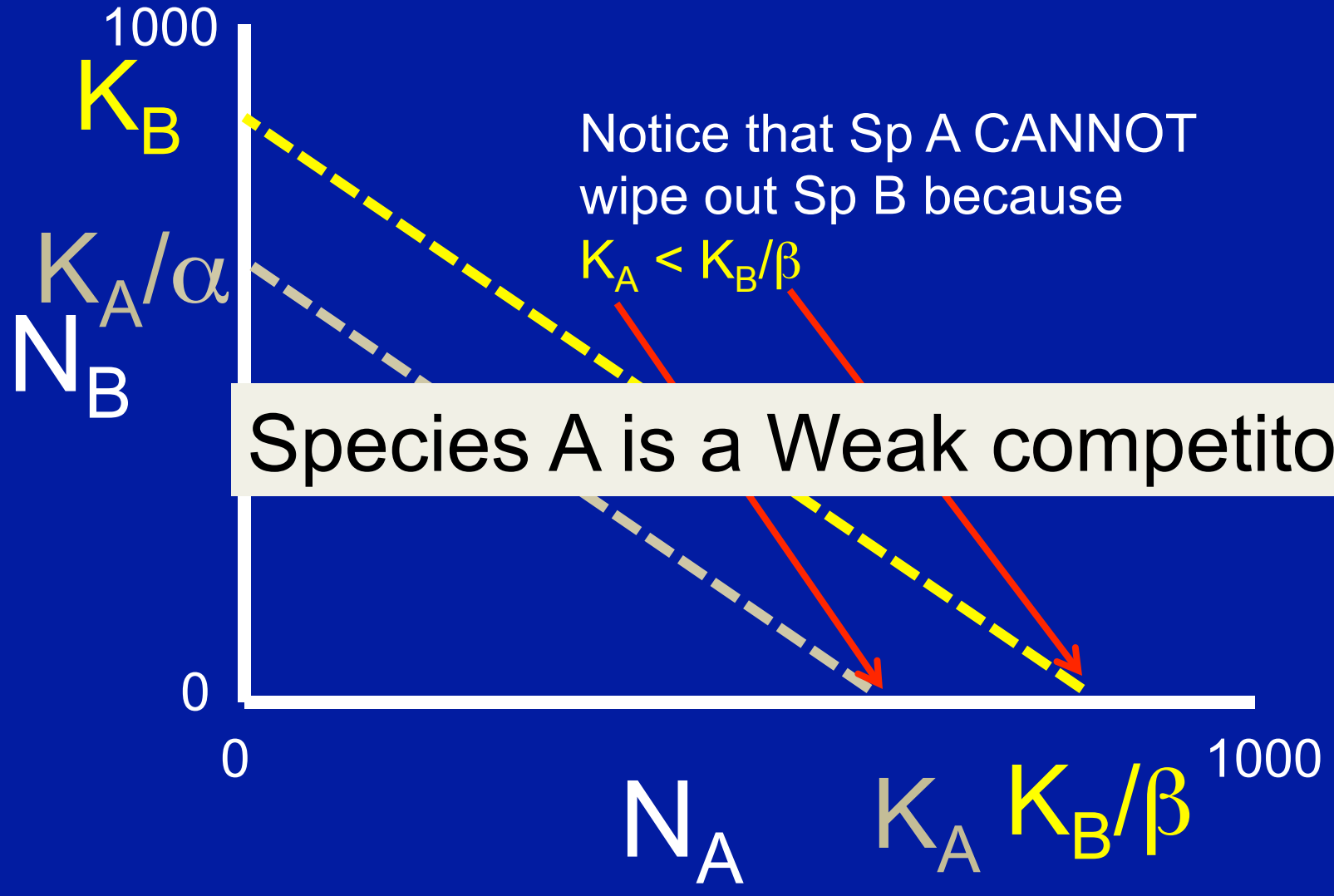
So let's look at what would happen if:

- Sp B was the Strong competitor
- Sp A was the Weak competitor

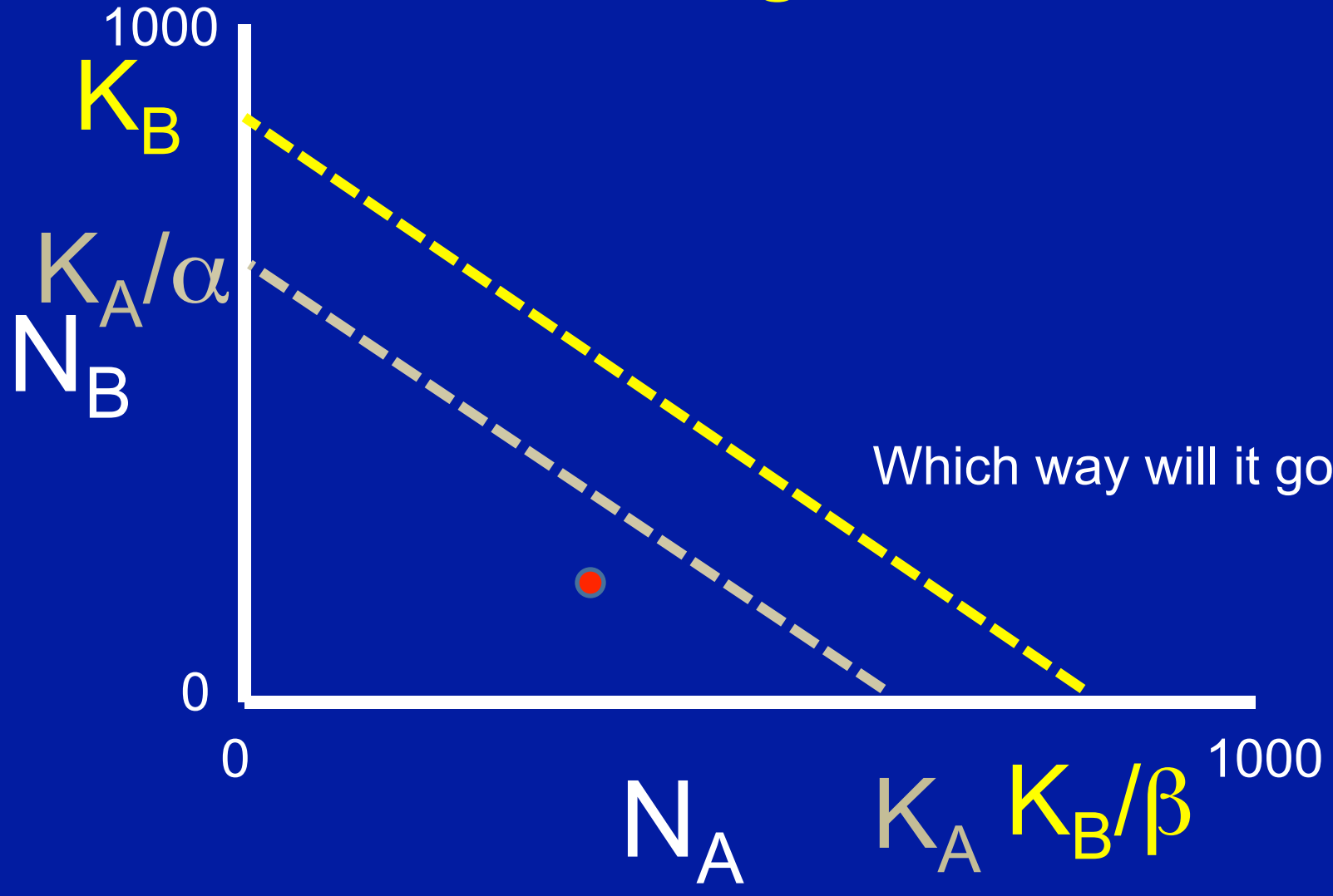
Vector Plot


1000
K_B
Notice that Sp B CAN wipe out Sp A because $K_B > K_A/\alpha$
K_A/α
N_B
Species B is a Strong competitor
0
0
1000
N_A
K_A
K_B/β

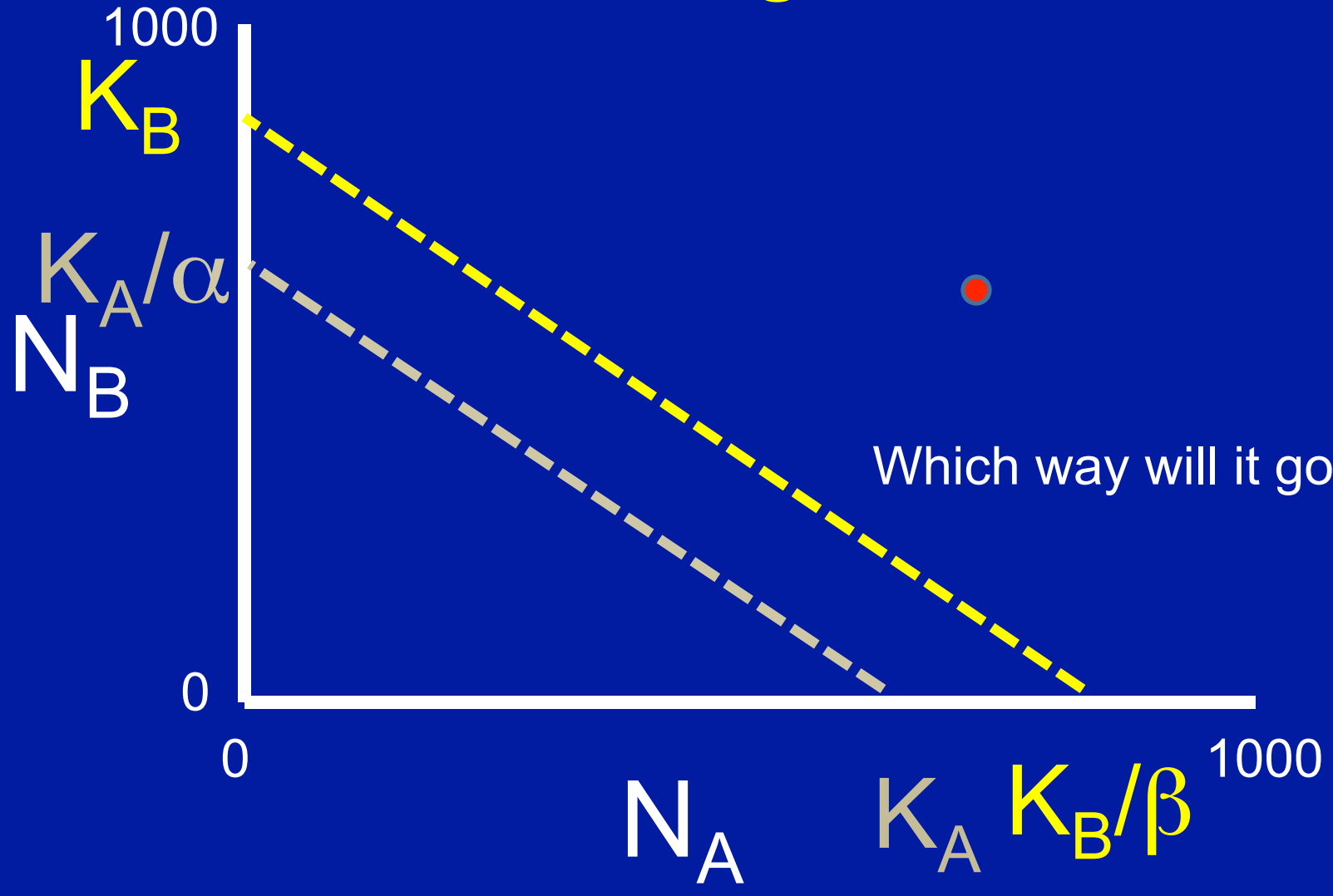
Vector Plot


1000
K_B
K_A/α
N_B
Notice that Sp A CANNOT wipe out Sp B because $K_A < K_B/\beta$
Species A is a Weak competitor
0
0
1000
N_A
K_A
K_B/β

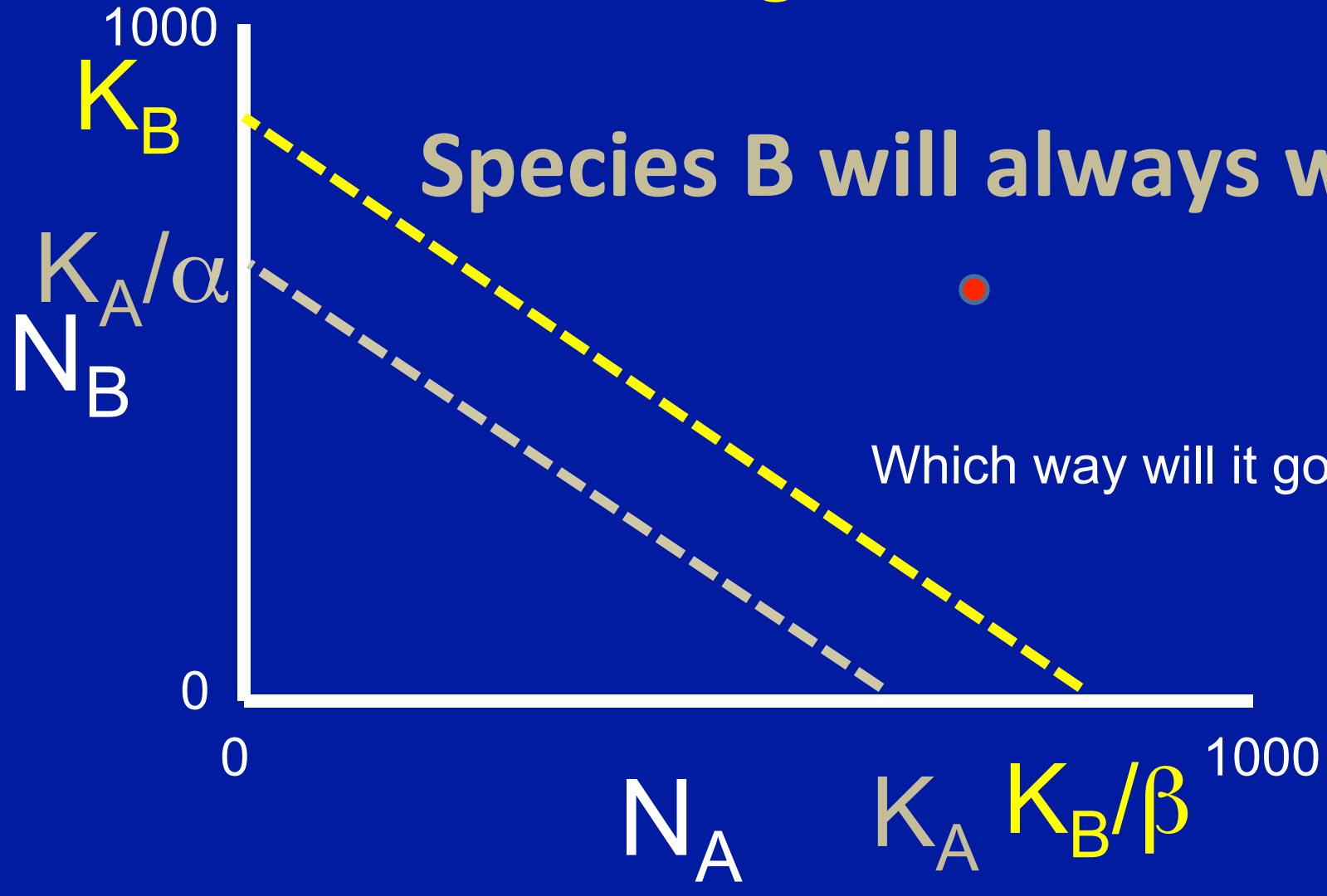
Vector Plot - Sp A weak and Sp B strong



Vector Plot - Sp A weak and Sp B strong



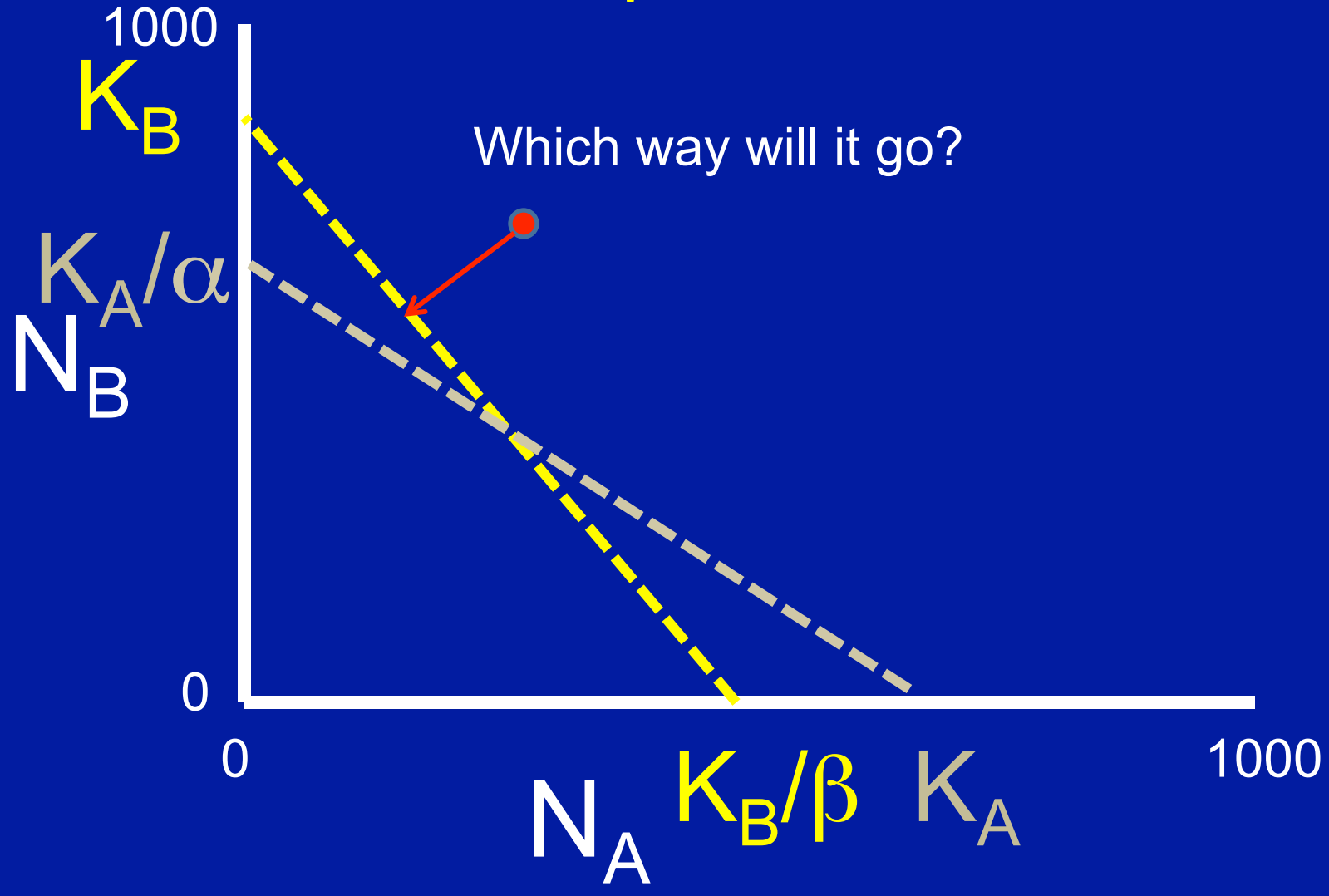
Vector Plot - Sp A weak and Sp B strong



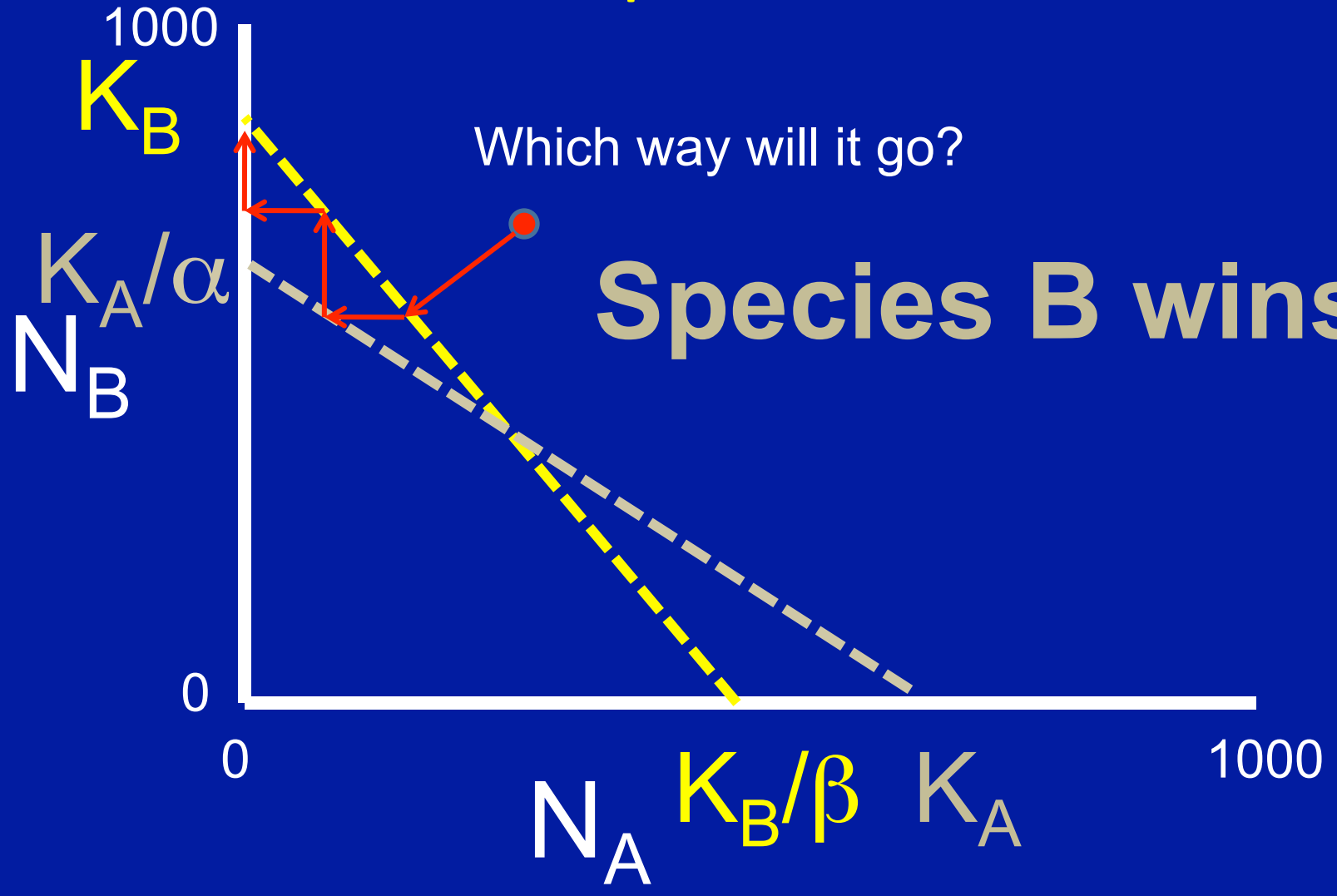
Species B will always win!

Which way will it go?

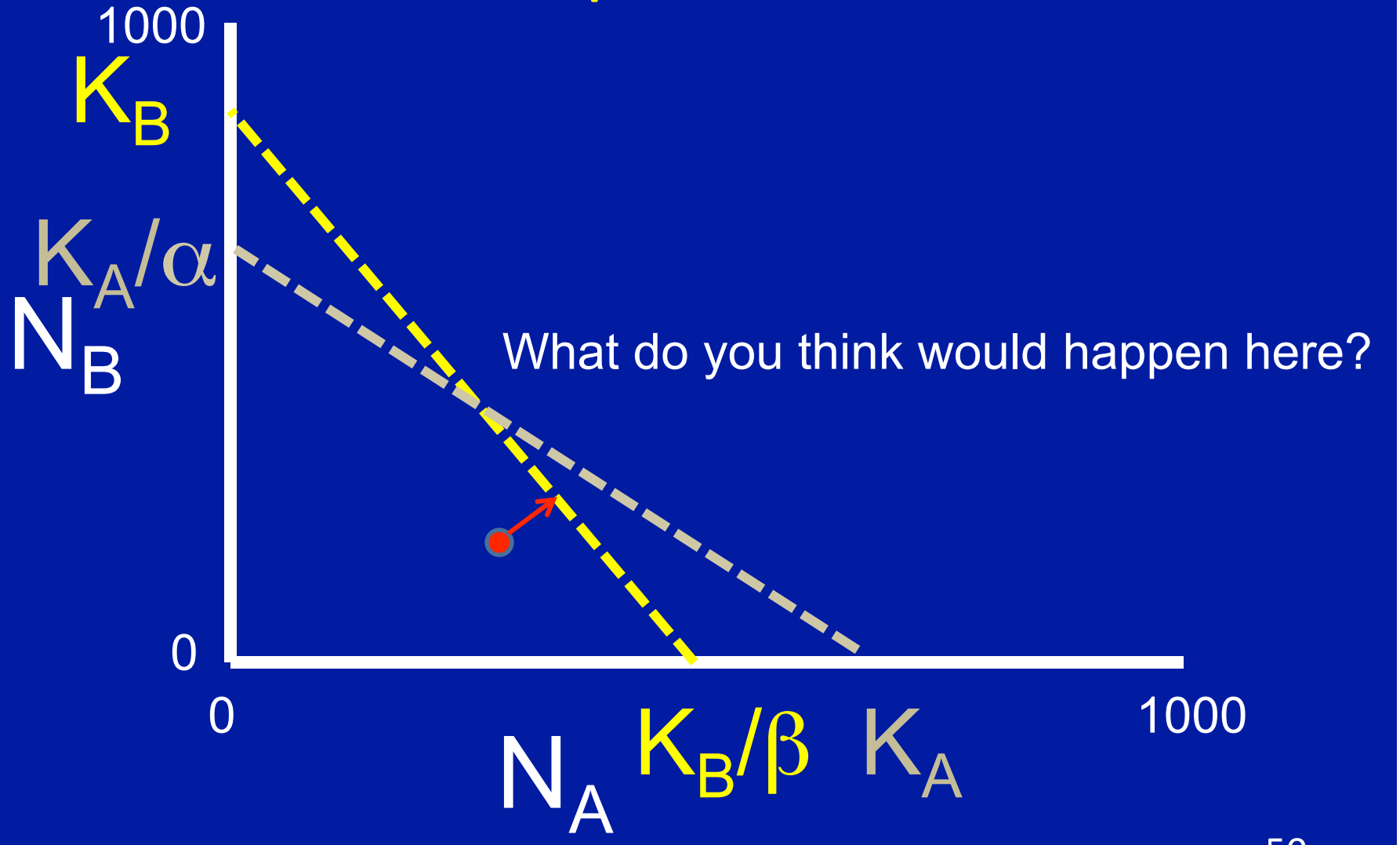
Vector Plot - Let's look at two strong competitors



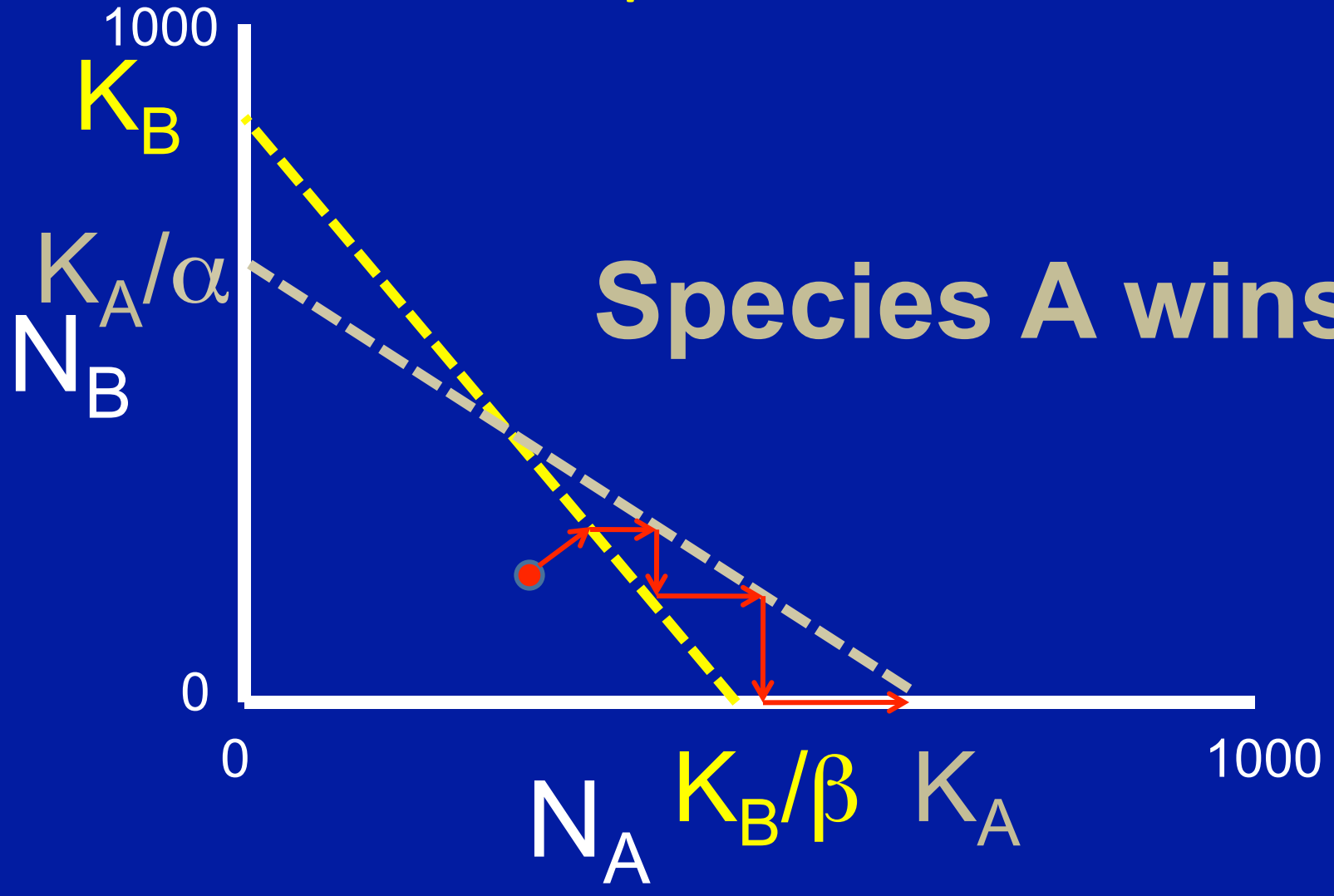
Vector Plot - Let's look at two strong competitors



Vector Plot - Let's look at two strong competitors

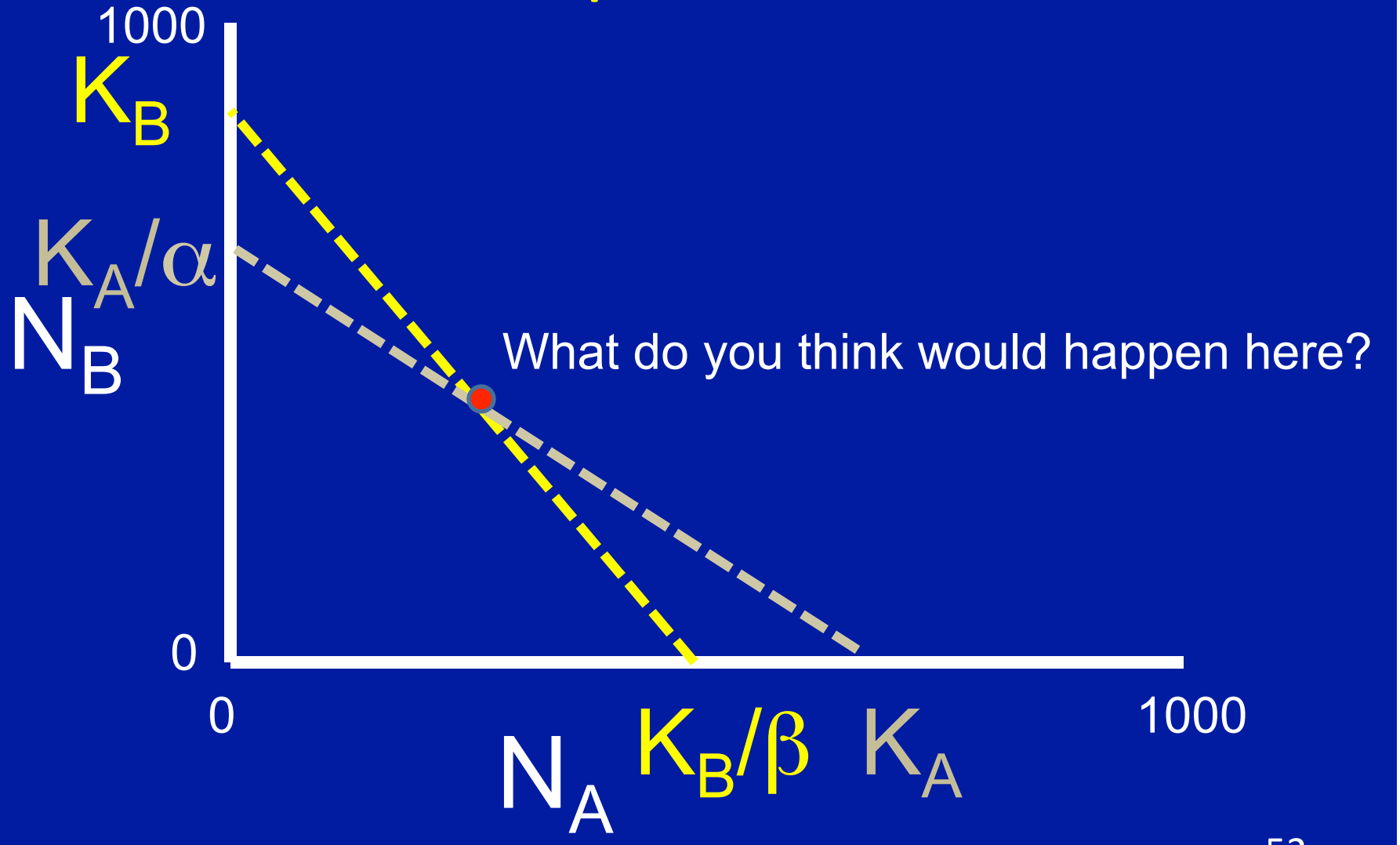


Vector Plot - Let's look at two strong competitors

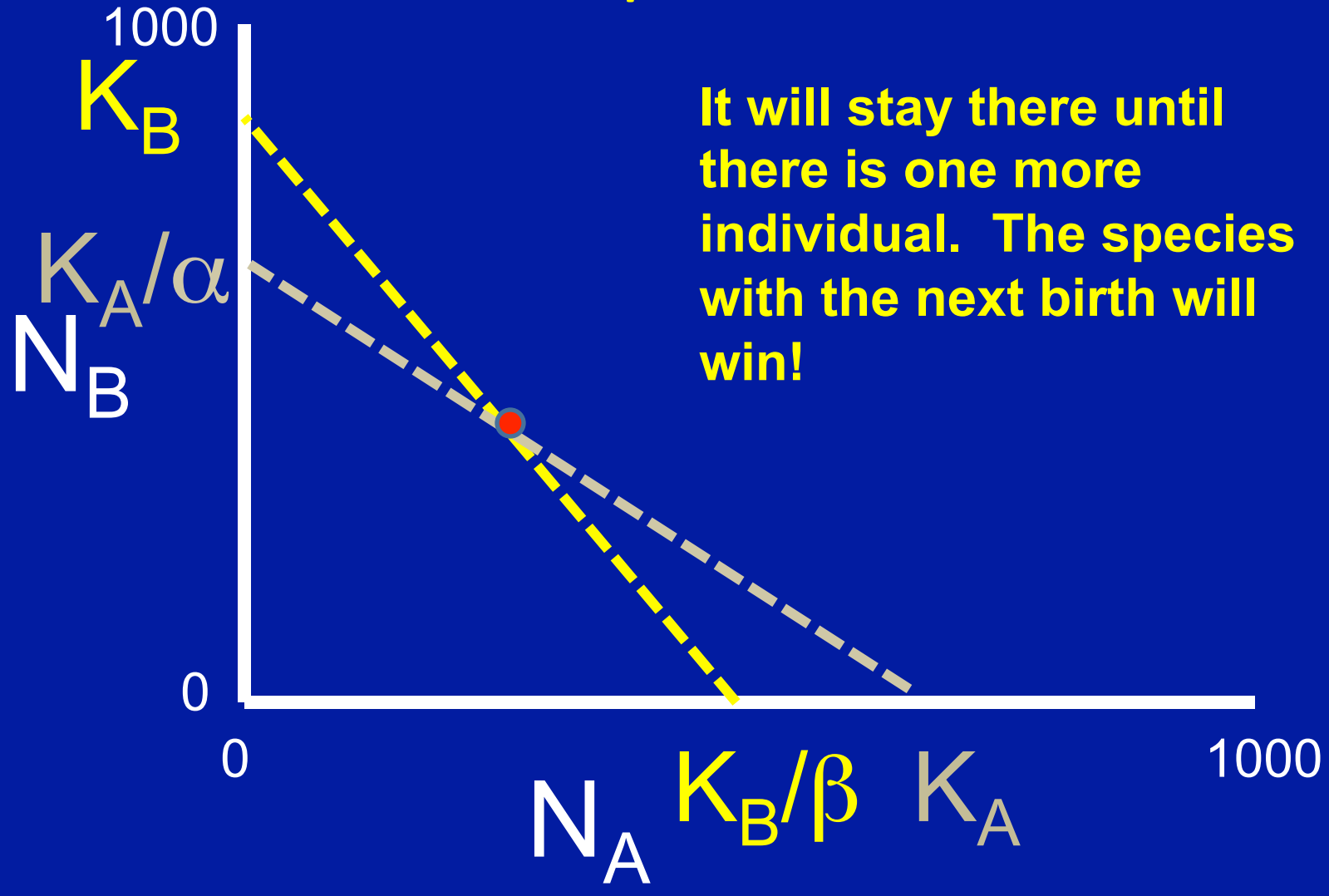


Species A wins!

Vector Plot - Let's look at two strong competitors



Vector Plot - Let's look at two strong competitors



It will stay there until there is one more individual. The species with the next birth will win!

Why did we go through this exercise?

- Interspecific competition can lead to distinct outcomes from intraspecific
- In the intraspecific model (the logistic), the population size always goes to *K*, the carrying capacity
- In interspecific competition, we can get competitive exclusion of one species
- Suggested exercise: what happens when there are 2 weak competitors?

Learning objectives

Students should be able to

- Explain why intraspecific competition may result in distinct patterns from interspecific competition
- Define the Lotka-Volterra competition equations
- Given the parameters of a Lotka-Volterra competition equation for two species, analyze the possible outcomes of competition
- Graph the zero-growth isoclines of the Lotka-Volterra competition model