Lotka-Volterra: Models of competition
(1920s and 1930s)

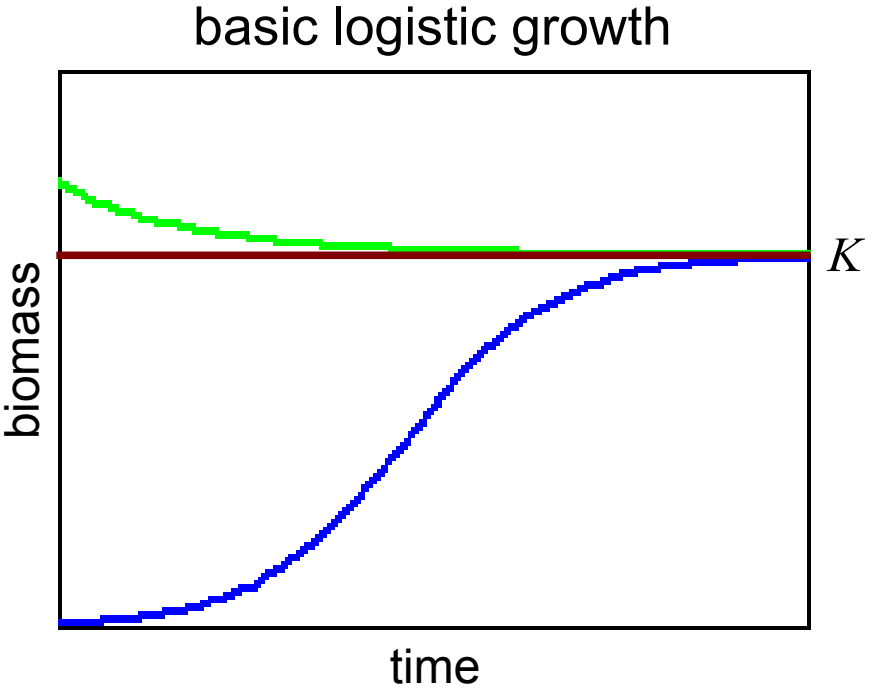
**Assumptions:**
- continuous nutrient regeneration
- constant loss rate (constant predators)

**Basic logistic growth:**

$$\frac{dX}{dt} = r X \frac{K - X}{K}$$

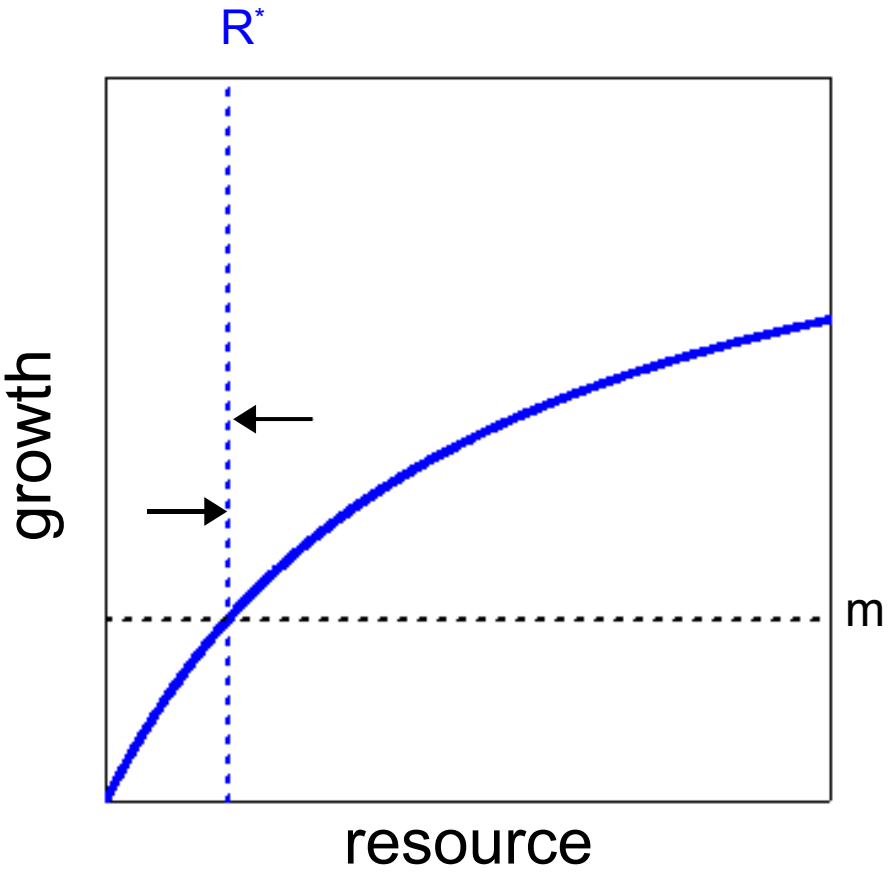
- growth rate r
- carrying capacity K
- intraspecific competition:

X << K ⇒ exponential growth
X = K ⇒ zero net growth
X > K ⇒ negative net growth



Resource limited growth

**Functional response Holling type 2 (Monod):**




$$\frac{dX}{dt} = \mu(R)X - m$$

$$\mu(R) = \mu_{max}\frac{R}{R + k_s}$$

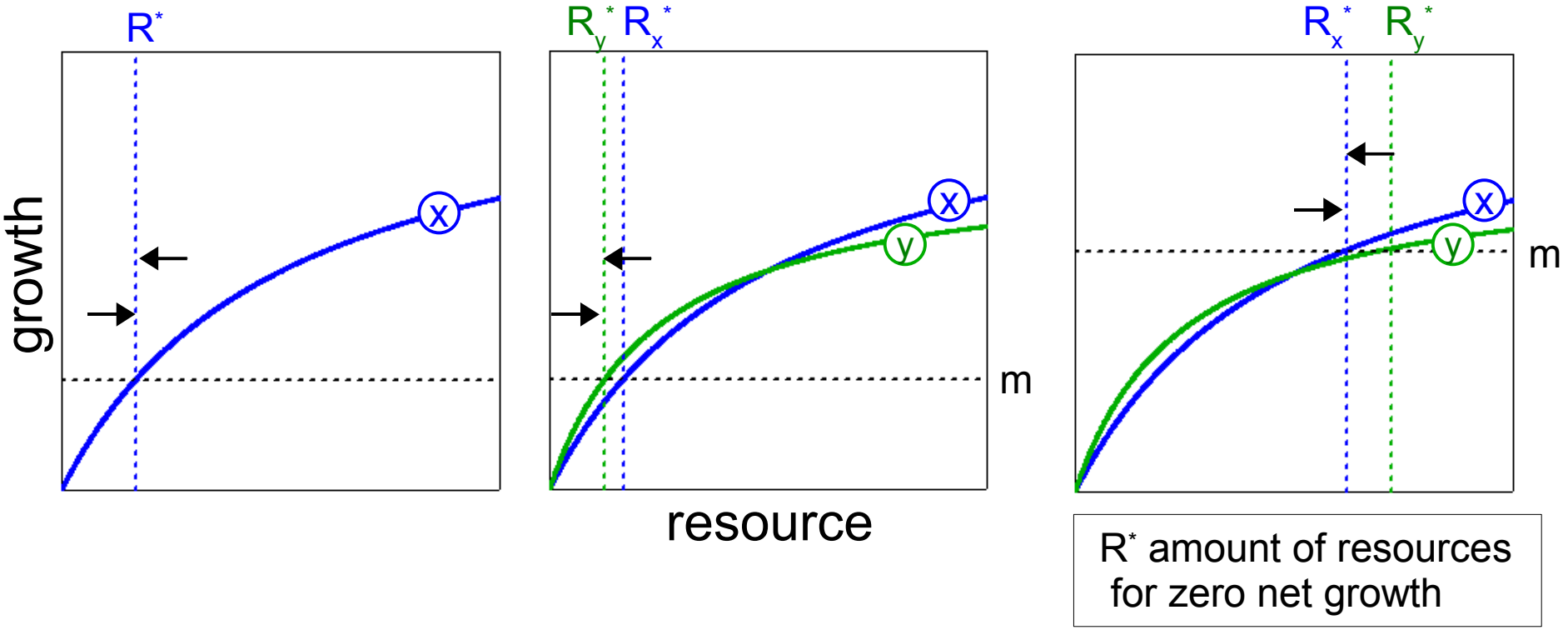
R* amount of resources for zero net growth

Resource limited growth:
Competition for a single resource

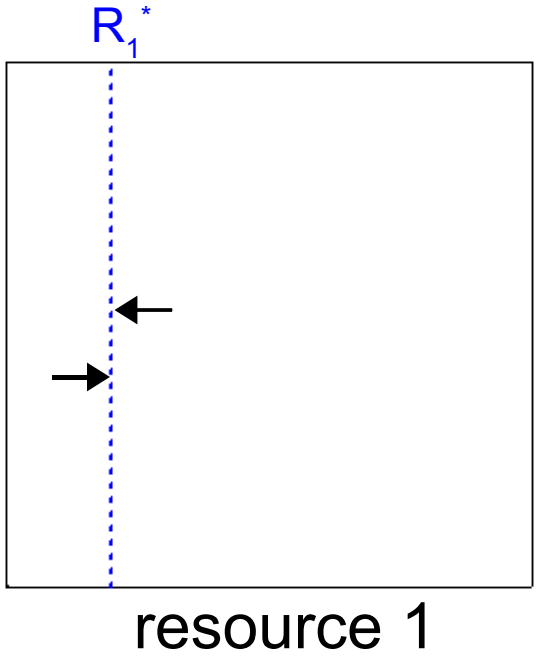
- no competition parameters

- physiological attributes specify the competitiveness

- in a constant environment only one species can survive



# Resource limited growth:
# Competition for two resources

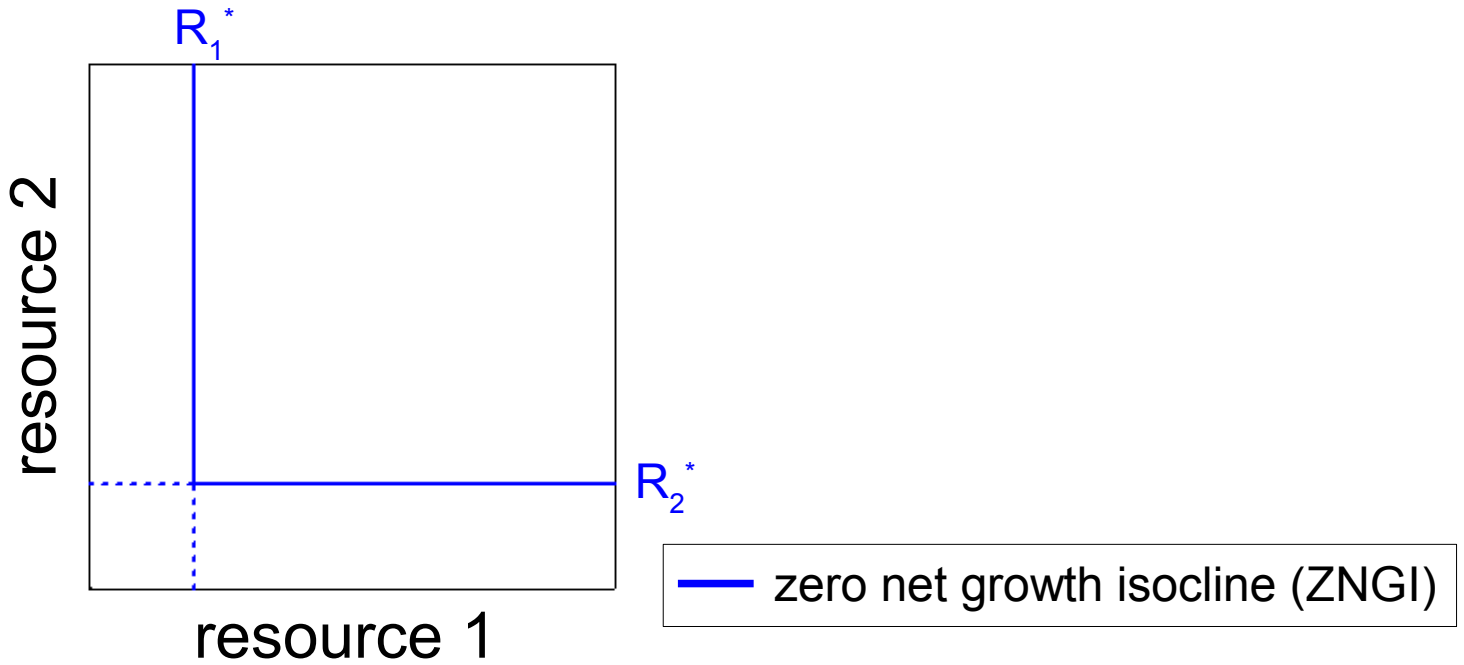


Resource limited growth:
Competition for two resources

- not replaceable resources

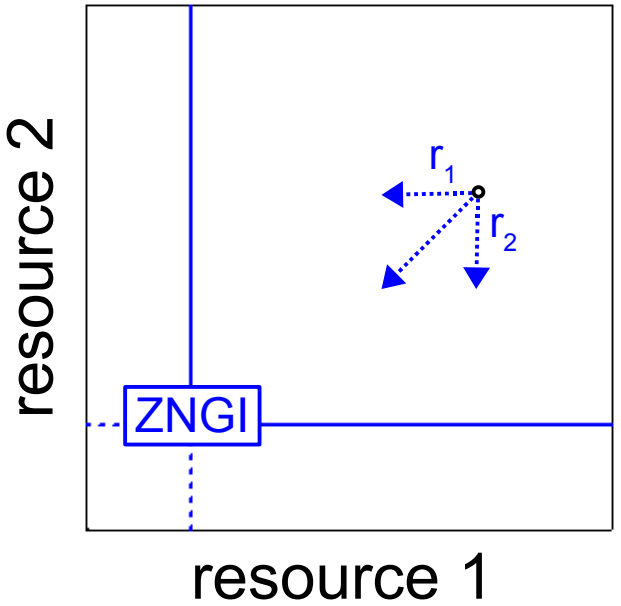
- typical for plants

- Liebig's law



# Resource limited growth: Competition for two resources

consumption vector



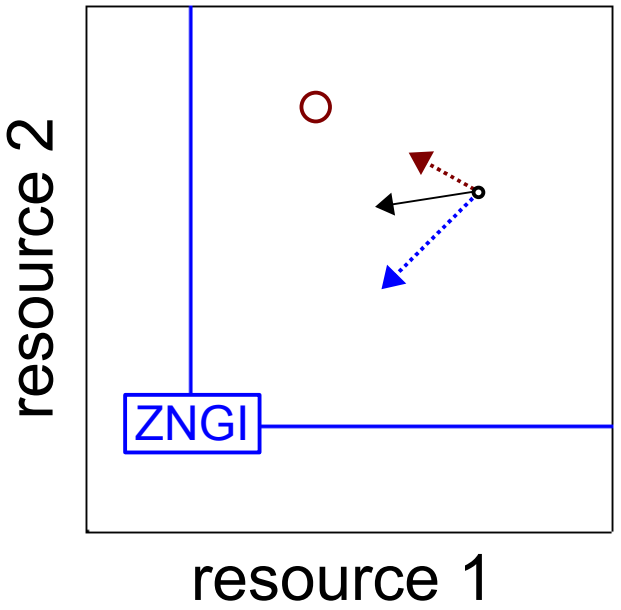
# Resource limited growth:
# Competition for two resources

consumption vector

resulting change of resources

resource supply point

resource supply vector



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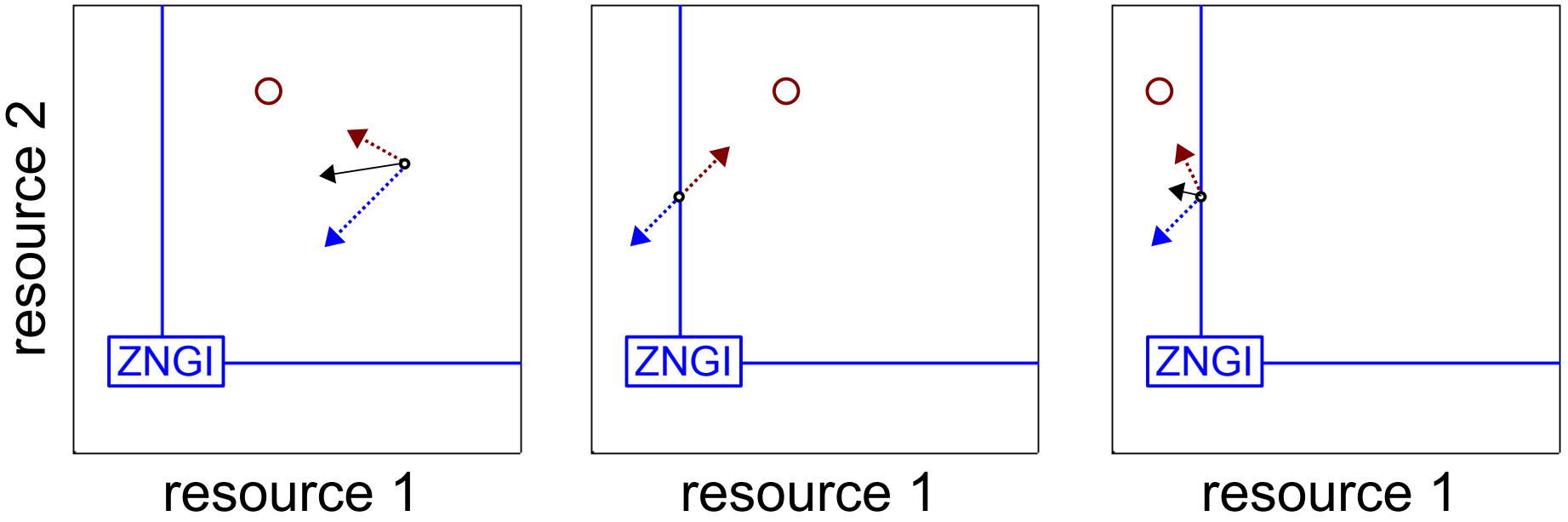

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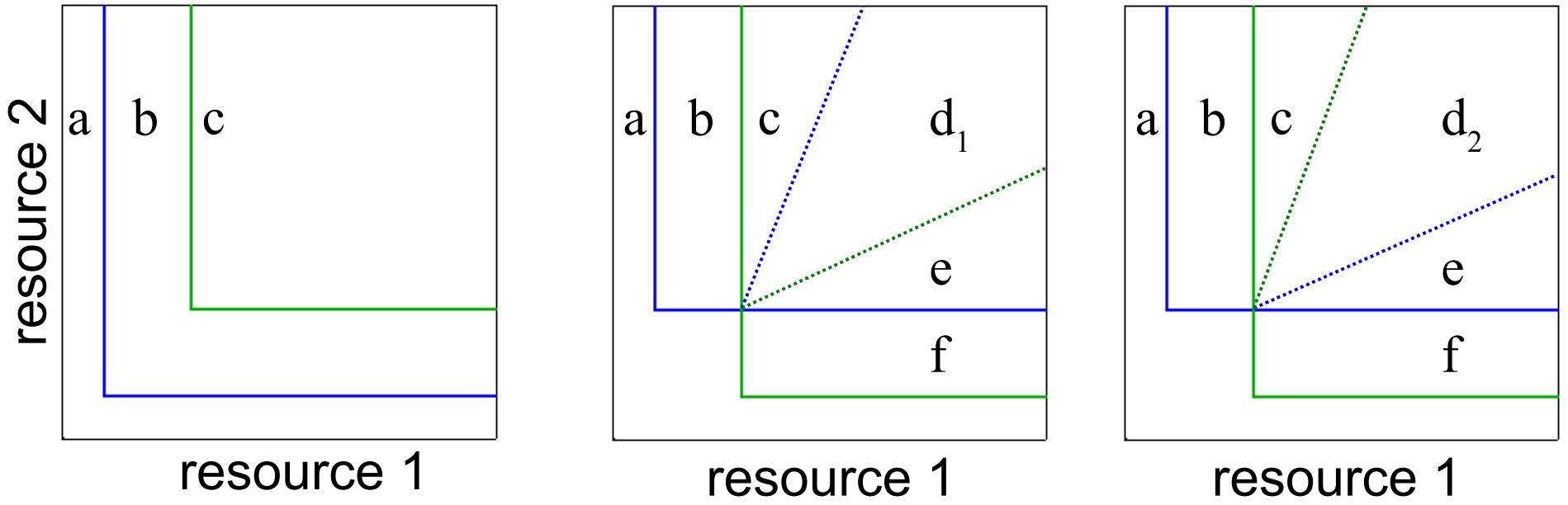
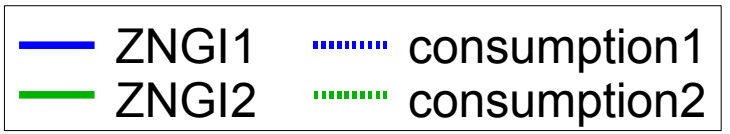
Competition for two resources

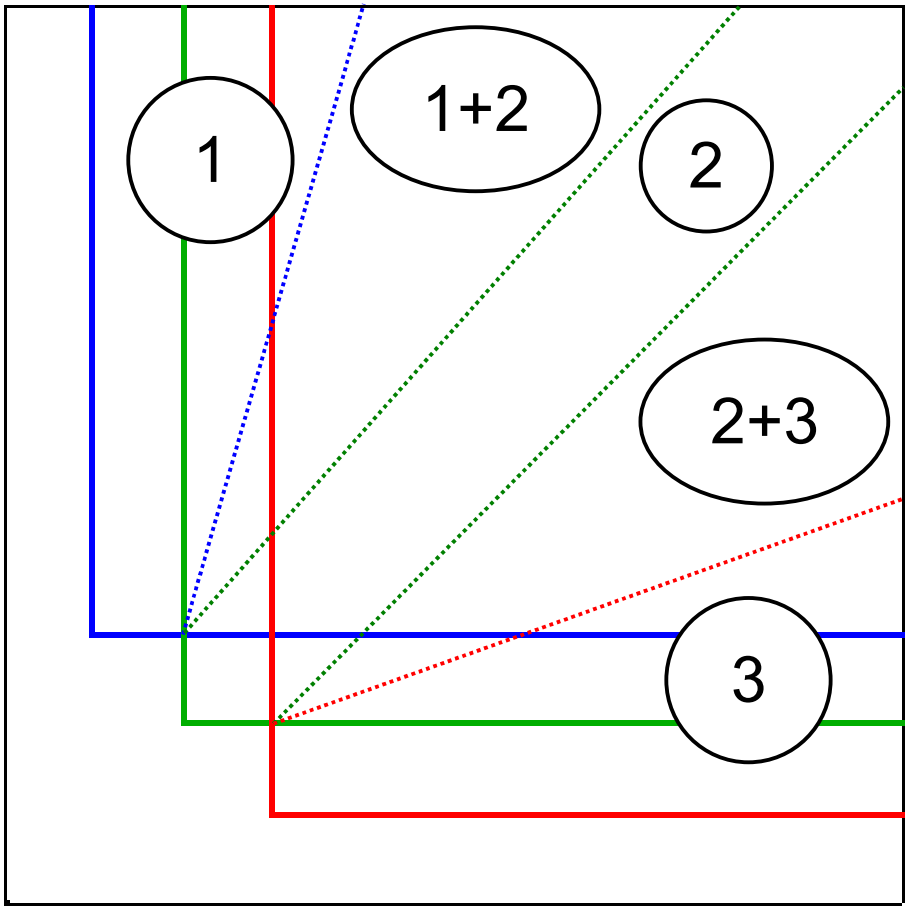



a.) insufficient resources for both
b.) insufficient resources for species 2 / species 1 wins
c.) competitive exclusion of species 2 by species 1
$d_1$.) coexistence
$d._2$) competitive exclusion depending on initial

e.) competitive exclusion of species 1 by species 2
f.) insufficient resources for species 1

# Resource limited growth: Competition for two resources



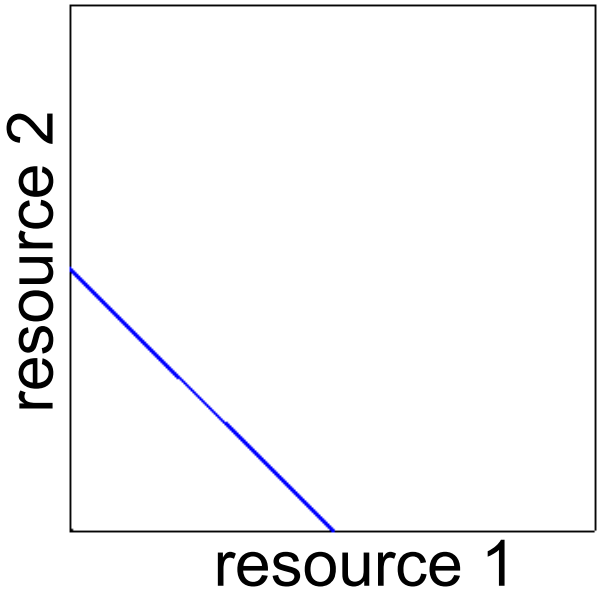

ZNGI species 1
ZNGI species 2
ZNGI species 3

**On n limiting resources a coexistence of not more then n different species is possible.**

# Competition for replaceable resources

- uptake of replaceable nutrient packages

- typical for animals



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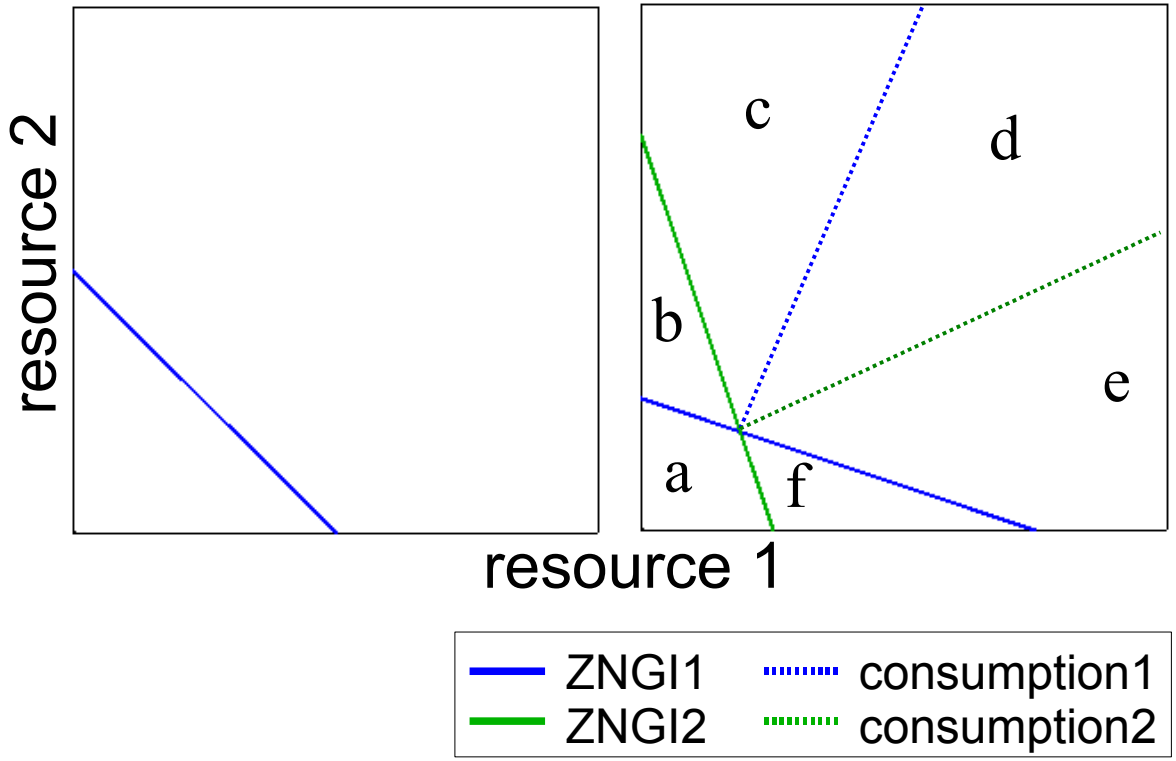
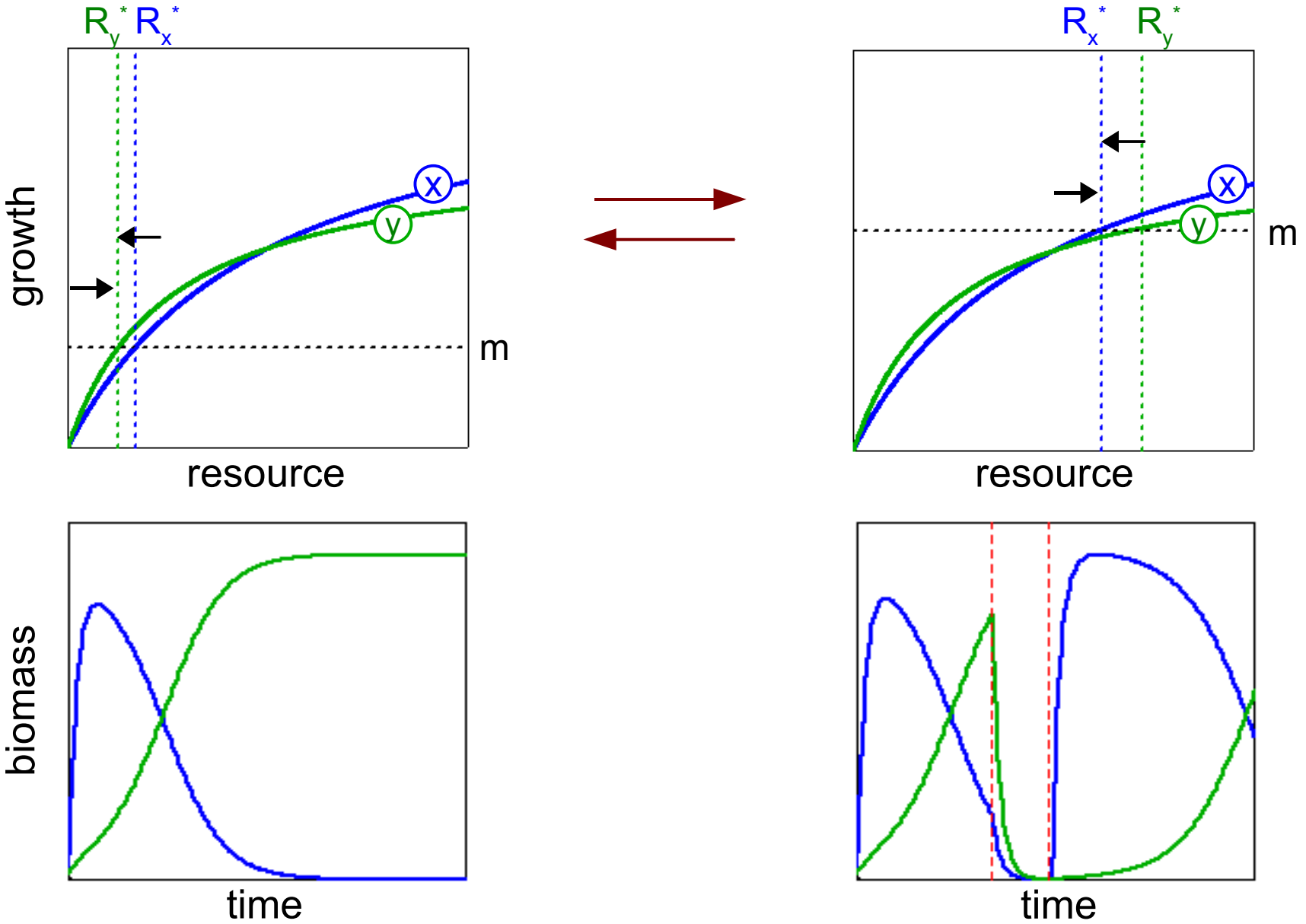


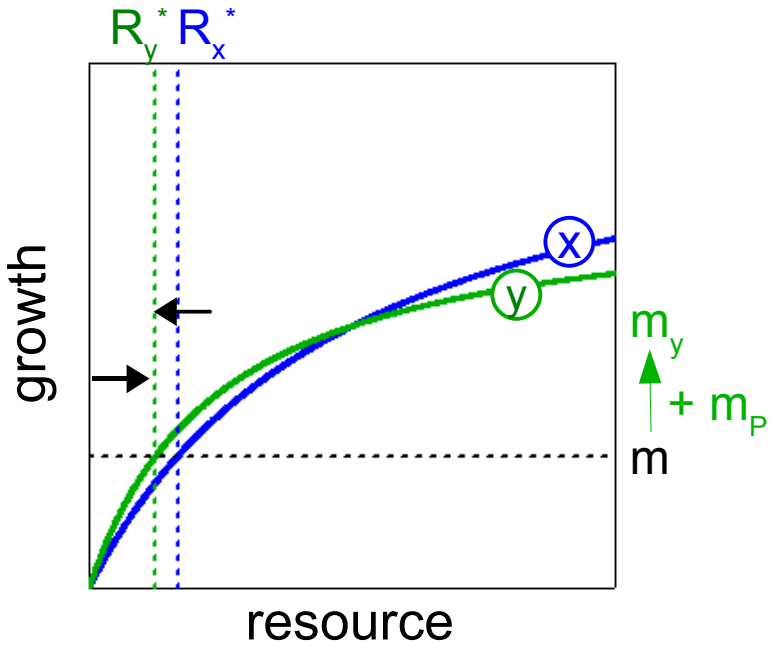

a.) insufficient resources for both
b.) insufficient resources for species 2
c.) competitive exclusion of 2 by 1
d.) coexistence
e.) competitive exclusion of 1 by 2
f.) insufficient resources for species 1

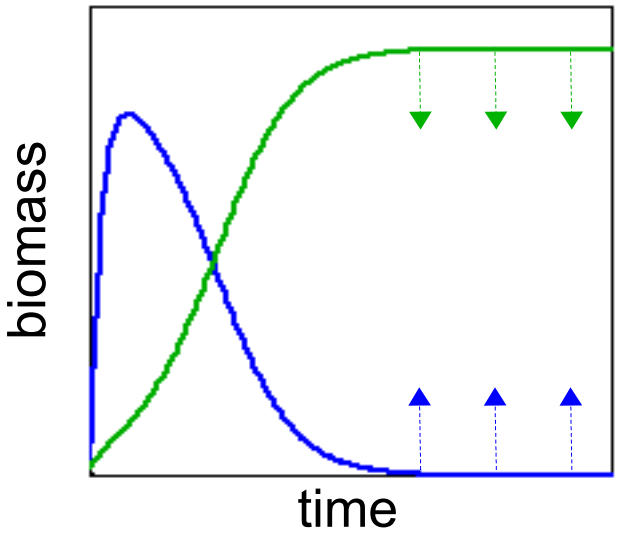
# The factor time: A variable environment

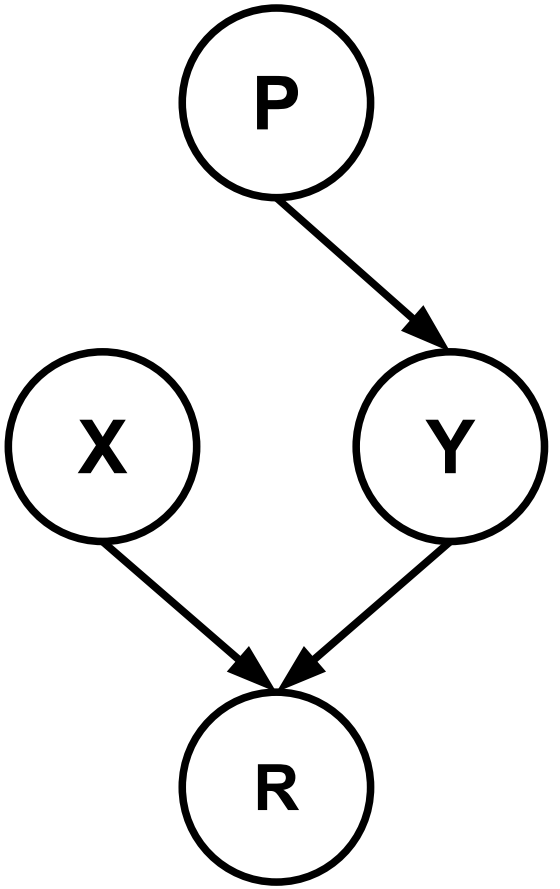
## “Intermediate disturbance hypothesis” (Connel 78)



# Creation of niches by the food web



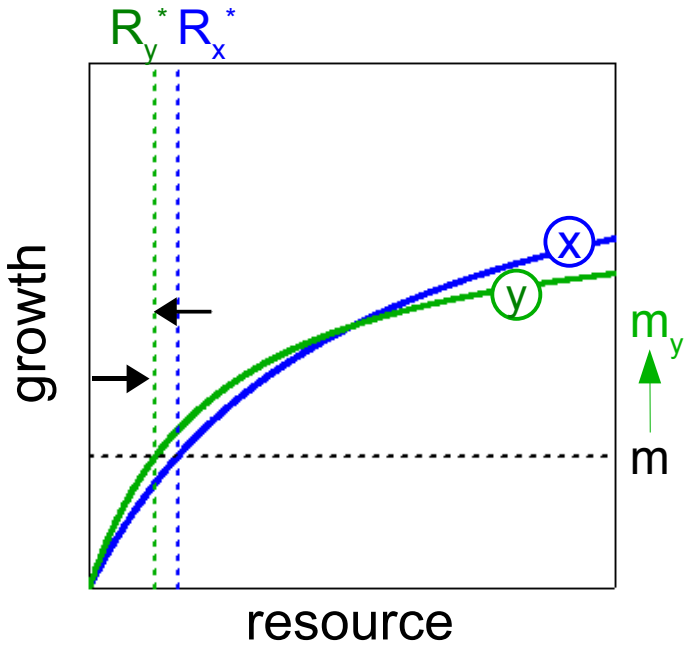



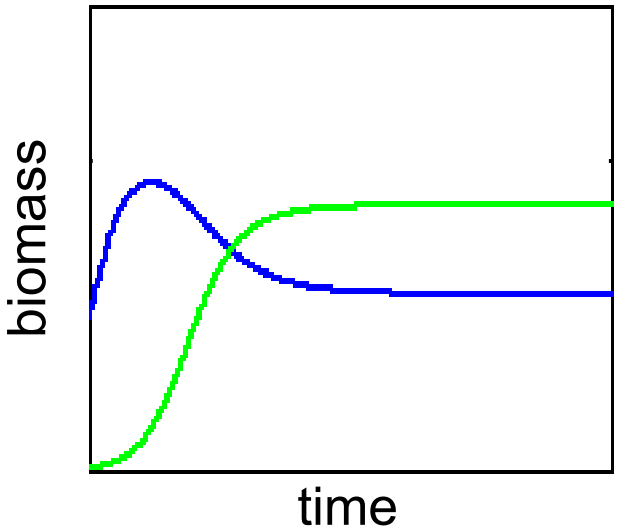

1 predator

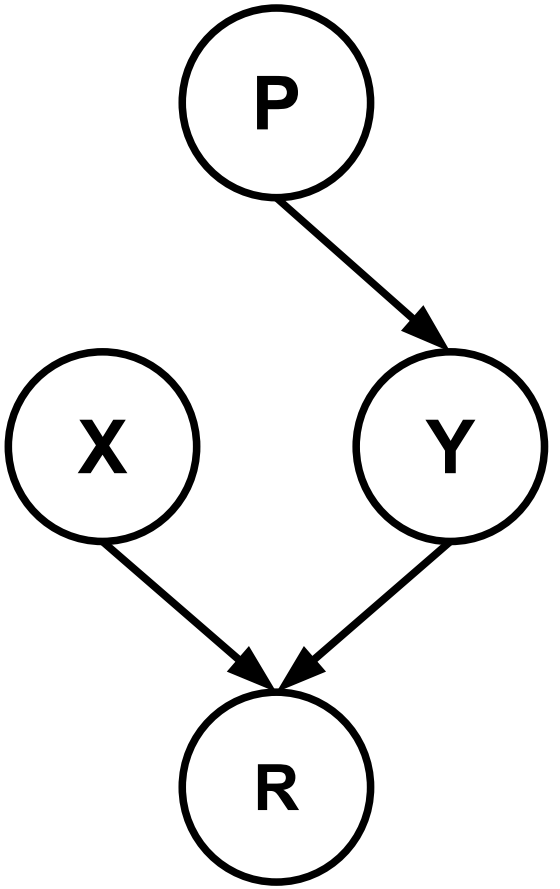
2 coexisting prey species

1 resource

# Creation of niches by the food web

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