How competition affects evolutionary rescue:

theoretical insight

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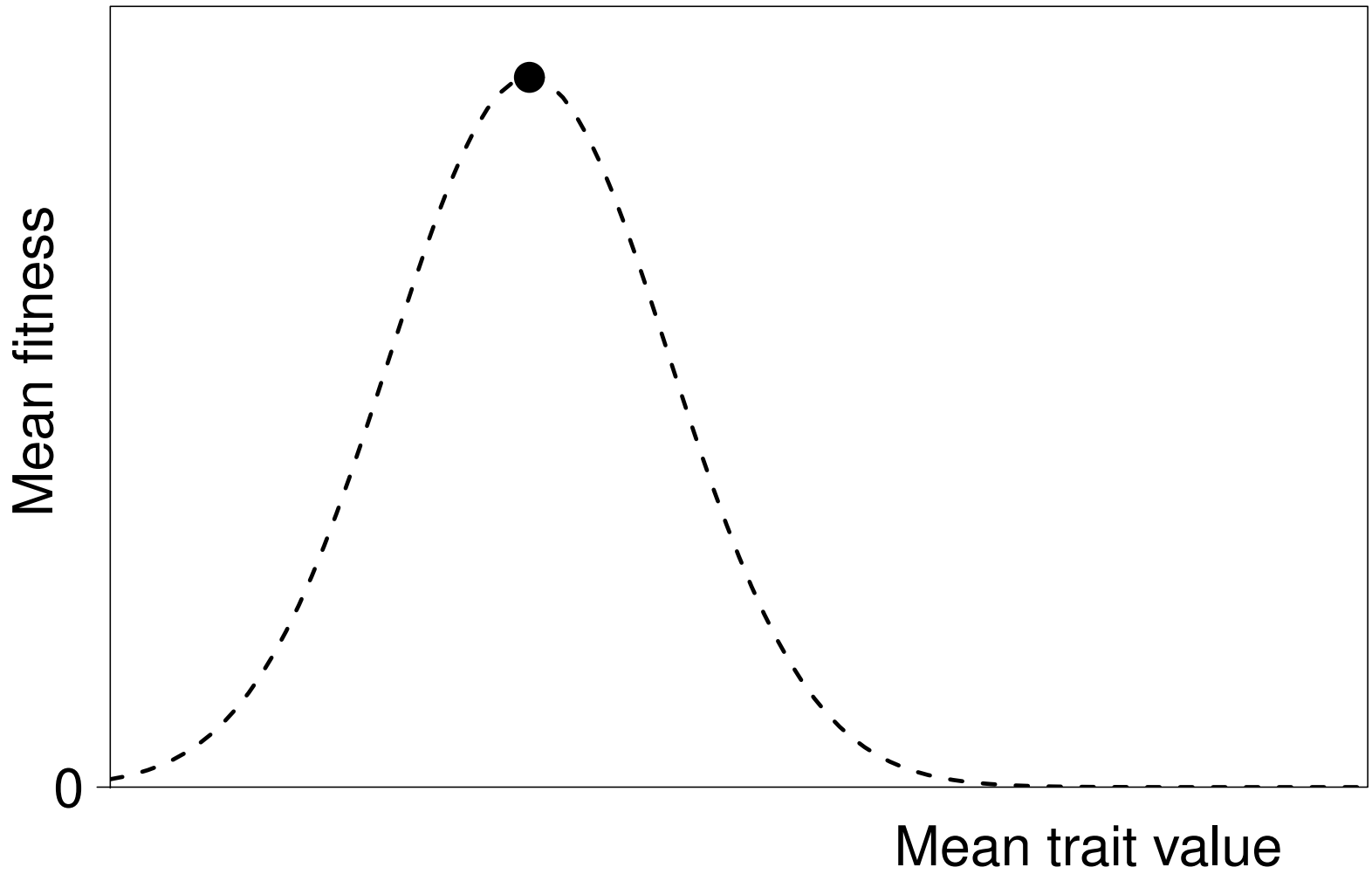
Evolutionary rescue

Evolutionary rescue



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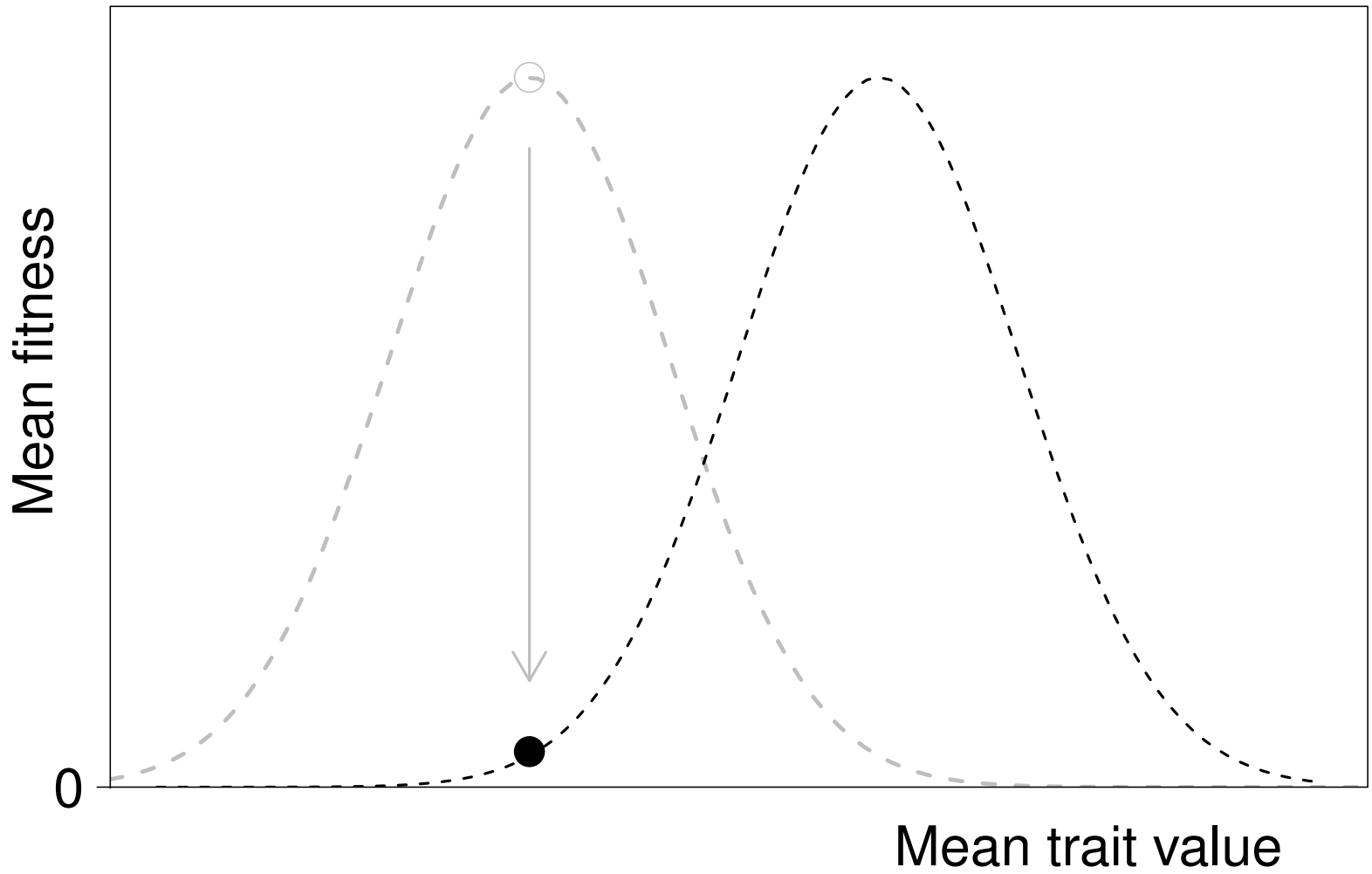
Evolutionary rescue



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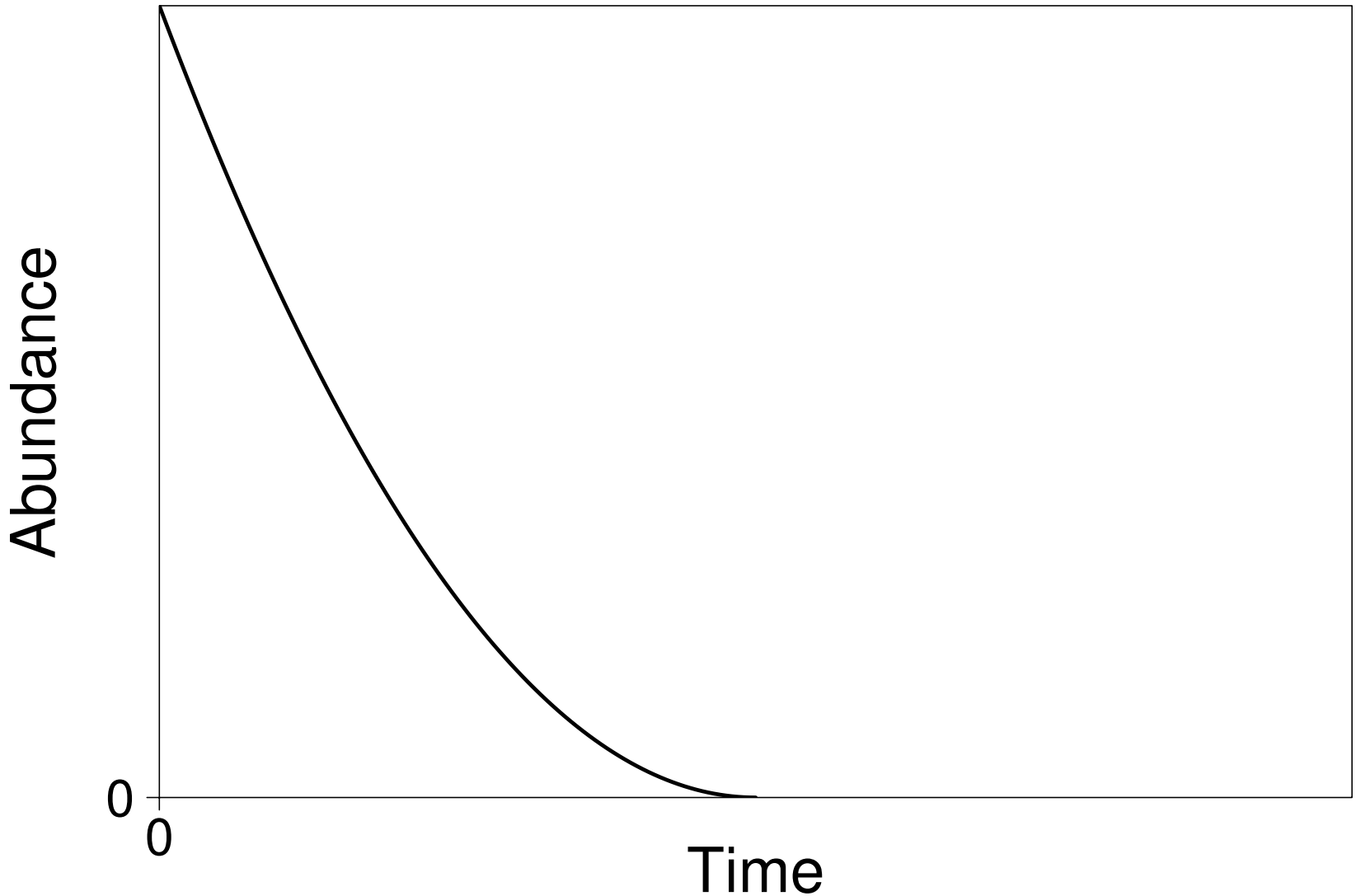
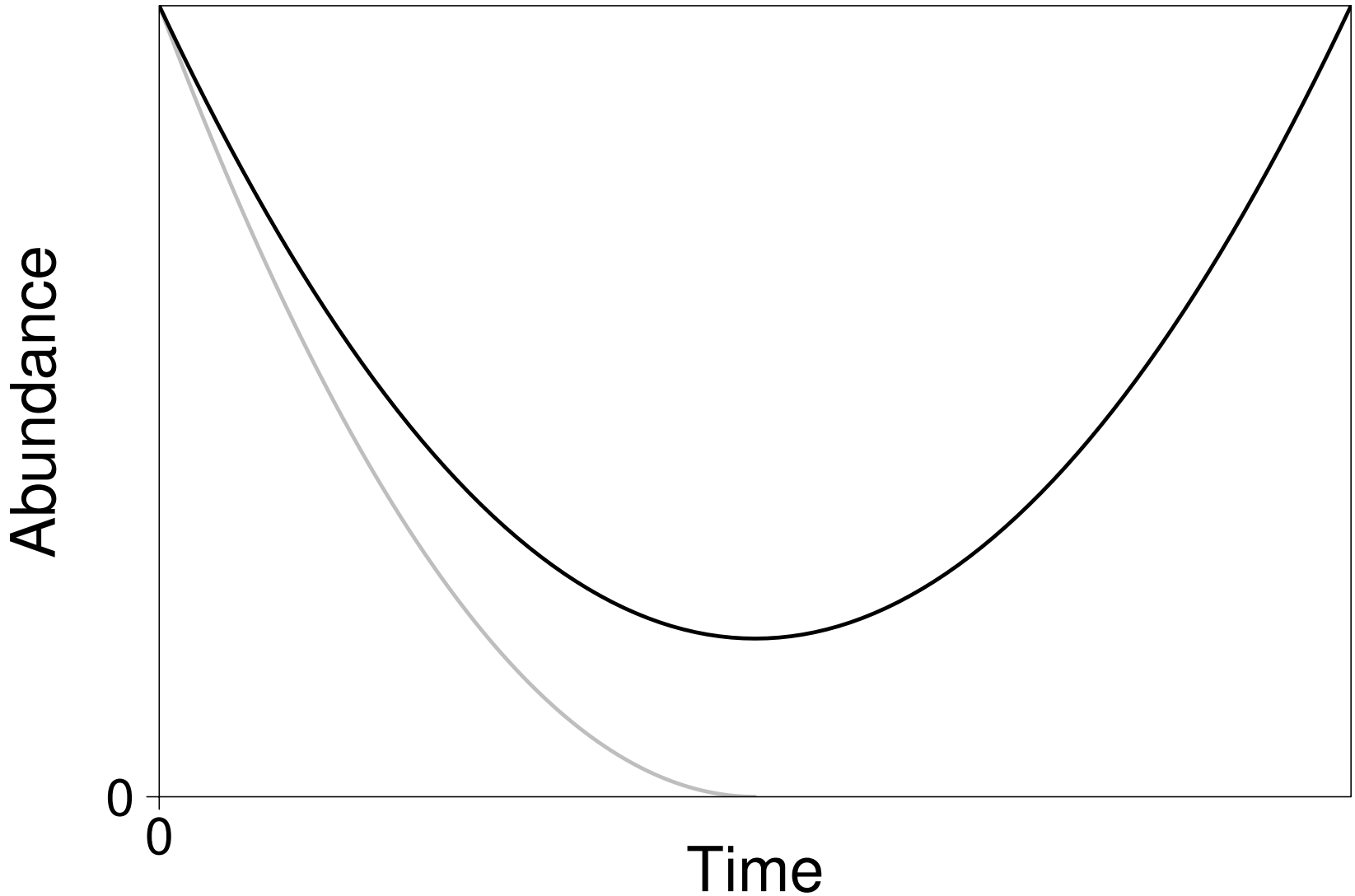
Evolutionary rescue



Evolutionary rescue



Evolutionary rescue

So, which populations are likely to be "rescued" by evolution?

Evolutionary rescue

Likelihood of rescue increases with:

- genetic variation / mutation rate (faster adaptation)
- initial population size (slower extinction)

Gomulkiewicz & Holt (1995), Orr & Unckless (2008), Chevin & Lande (2010)

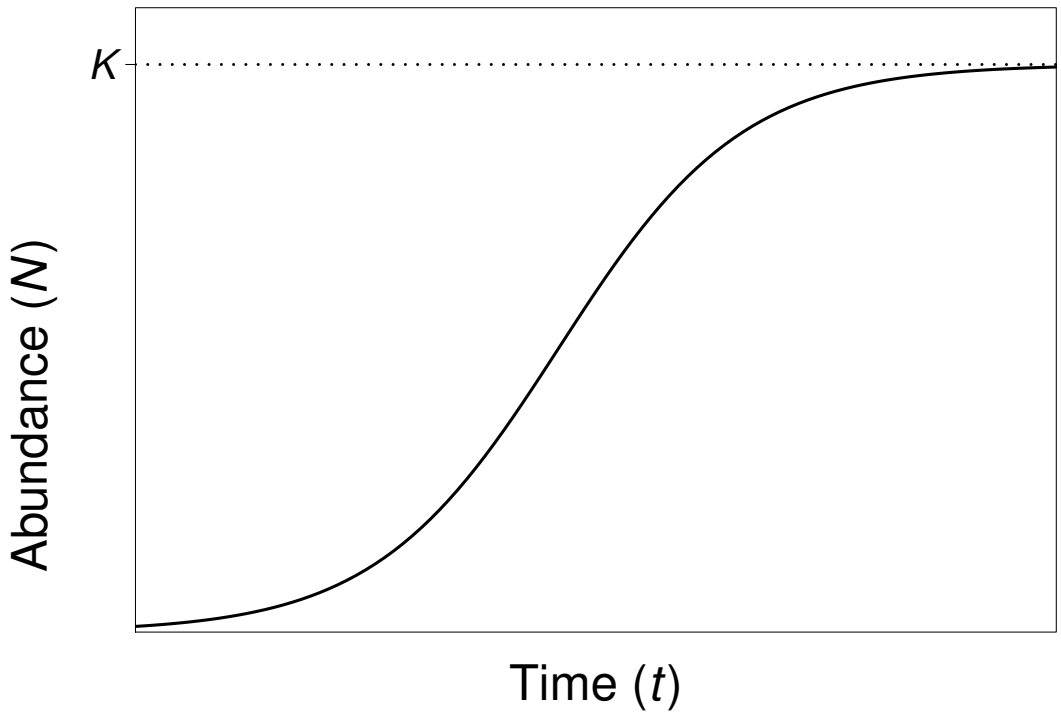
Extending evolutionary rescue

Extending evolutionary rescue: competition

Competition reduces the abundance of a species ...

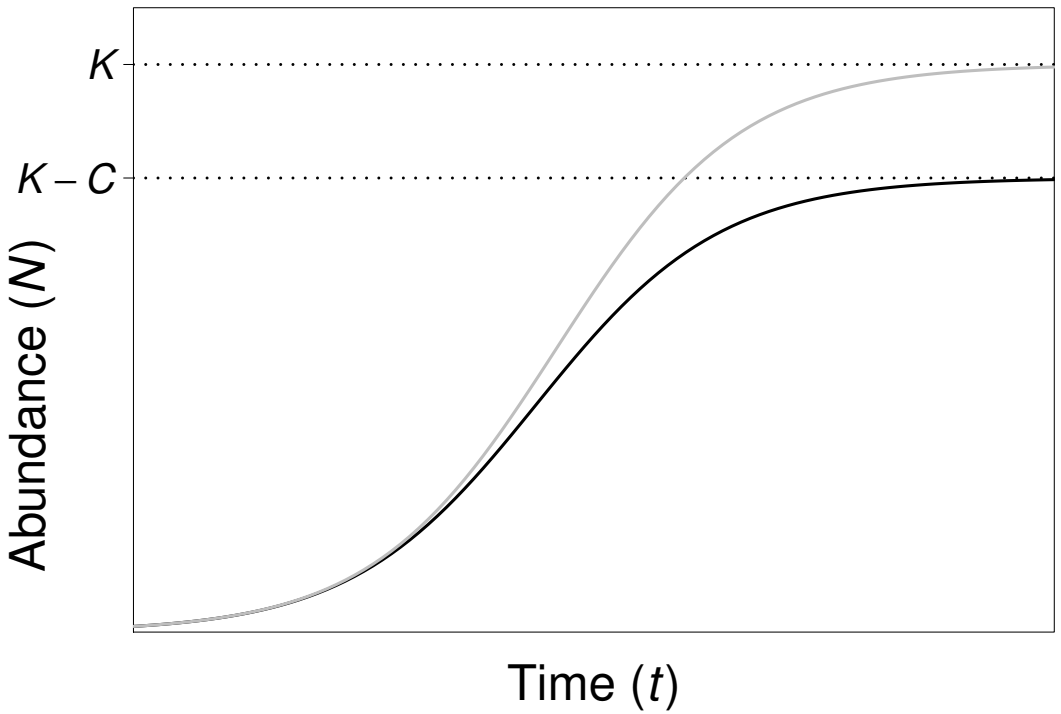
Maynard Smith (1989)

Extending evolutionary rescue: competition



$$\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$$

Extending evolutionary rescue: competition



$$\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$$

$$\frac{dN}{dt} = rN\left(1 - \frac{N+C}{K}\right)$$

Extending evolutionary rescue: competition

Competition reduces the abundance of a species ...

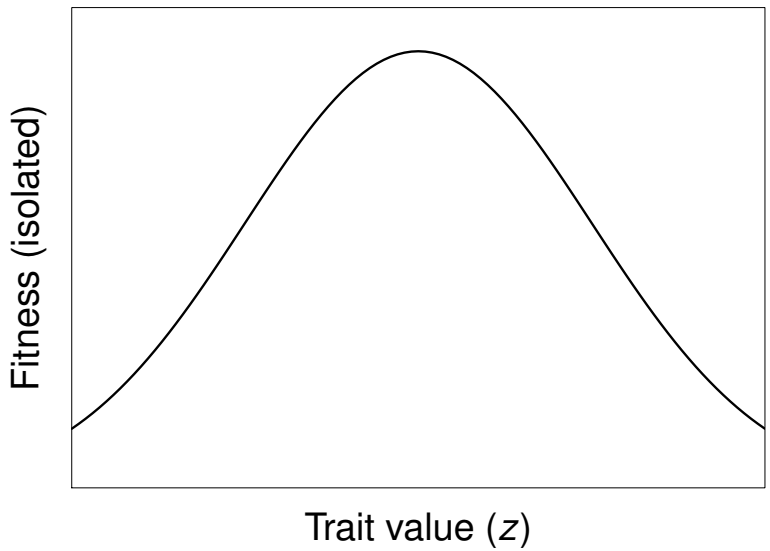
... which must make **extinction more likely**.

Maynard Smith (1989)

Extending evolutionary rescue: competition

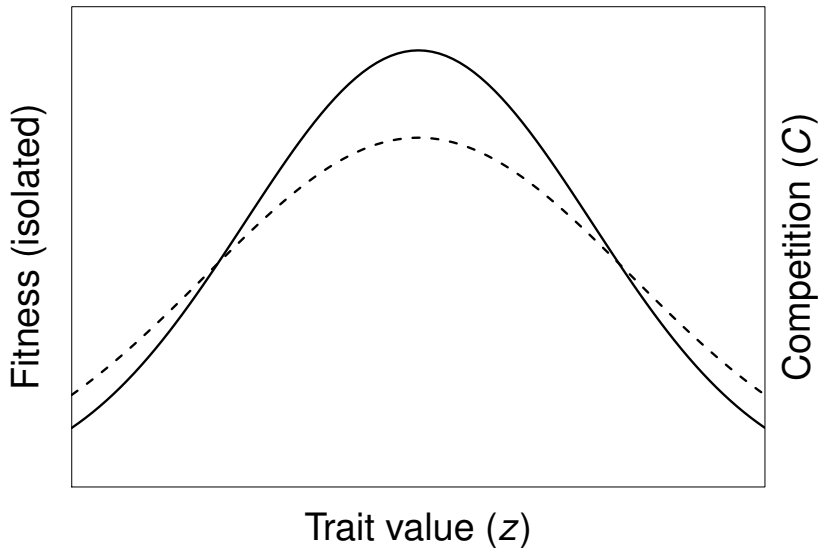
But, competition also influences selective pressures ...

Competition and selection



Fitness (in isolation): ——

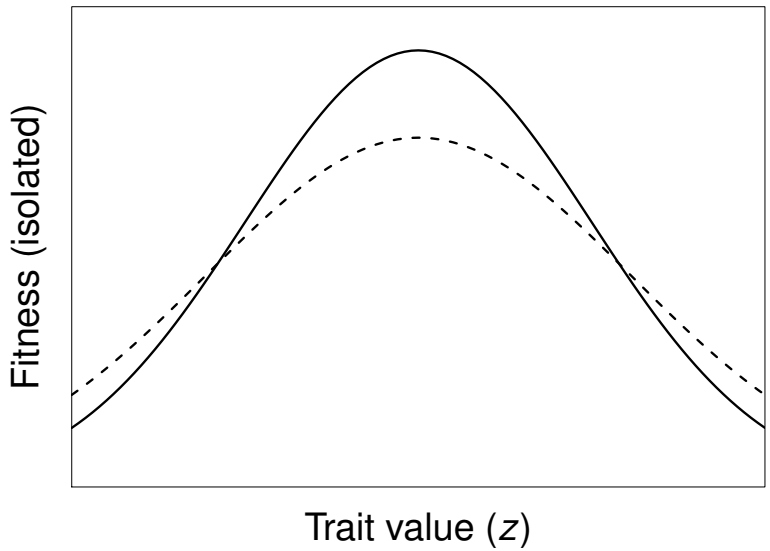
Competition and selection



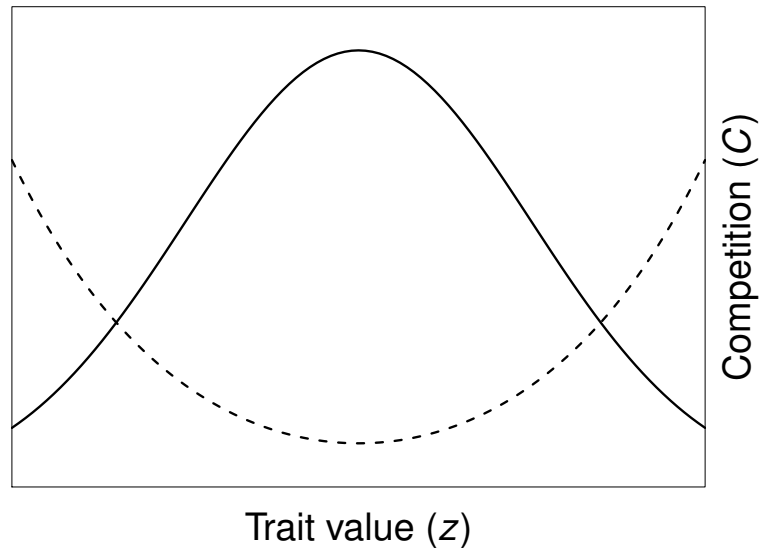
Decreases selection strength

Fitness (in isolation): ———
Competition (C): - - - - - - -

Competition and selection



Decreases selection strength



Increases selection strength

Fitness (in isolation): ———
Competition (C): - - - - - - -

Extending evolutionary rescue: competition

But, competition also influences selective pressures ...

... and selection affects the rate of adaptation.

Extending evolutionary rescue: competition

But, competition also influences selective pressures ...

... and selection affects the rate of adaptation.

So, competition can sometimes help evolutionary rescue?

Adaptive dynamics

- Large asexual population
- All individuals have same phenotype
- Beneficial mutations rare and small

Adaptive dynamics

The rate of evolution:

$$\frac{dz}{dt} = \mu \cdot n(z) \cdot g(z)$$

z: phenotype
μ: per capita mutational input
$n(z)$: abundance
$g(z)$: selection gradient

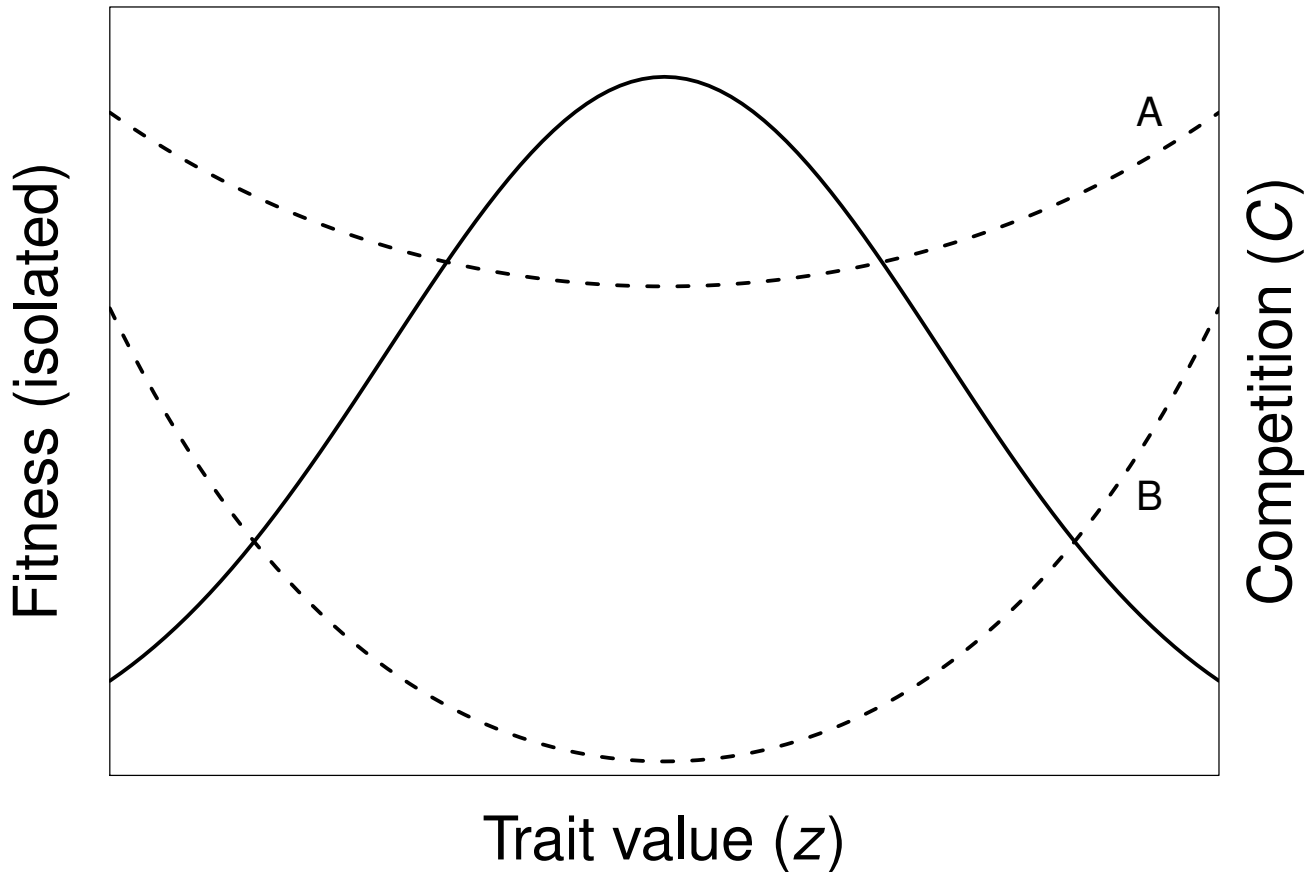
Adaptive dynamics

The rate of evolution:

$$\frac{dz}{dt} = \mu \cdot n(z, \mathbf{C}) \cdot g(z, \mathbf{C})$$

z: phenotype
μ: per capita mutational input
$n(z, \mathbf{C})$: abundance
$g(z, \mathbf{C})$: selection gradient
C: competition

Competition and adaptation



Decline in abundance: **A**>**B**

Increased selection: **A**<**B**

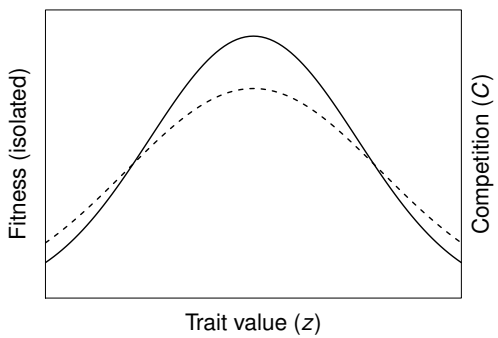
$\Rightarrow$ Rate of adaptation: **A**<**B**

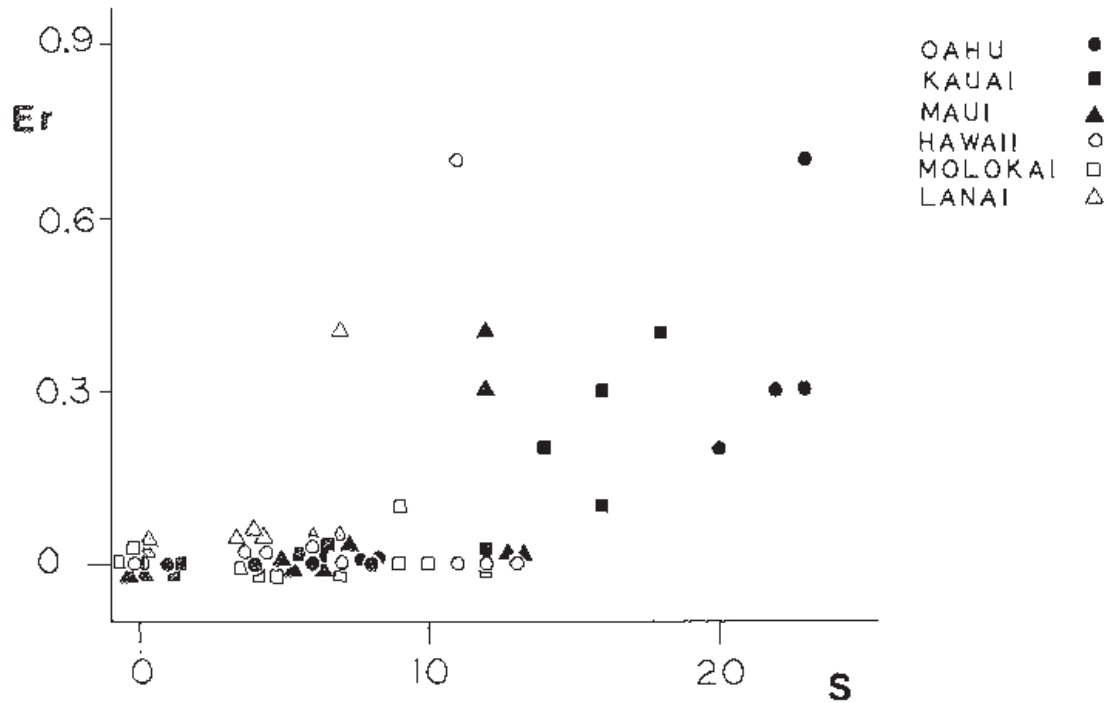
Conclusions

1. Competition lowers abundance, slowing adaptation
2. Competition also impacts selection, potentially speeding adaptation
3. **If selection imposed by competition is strong enough to overcome negative effect on abundance**, competition can help evolutionary rescue

Circumstantial evidence

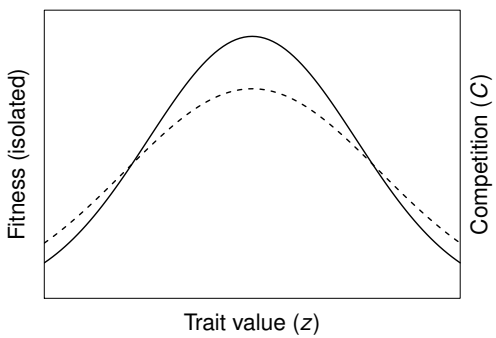
Extinction rate (Er) of birds on islands increases with sqaure of species number, suggesting competition **increases** extinction Moulton & Pimm 1983

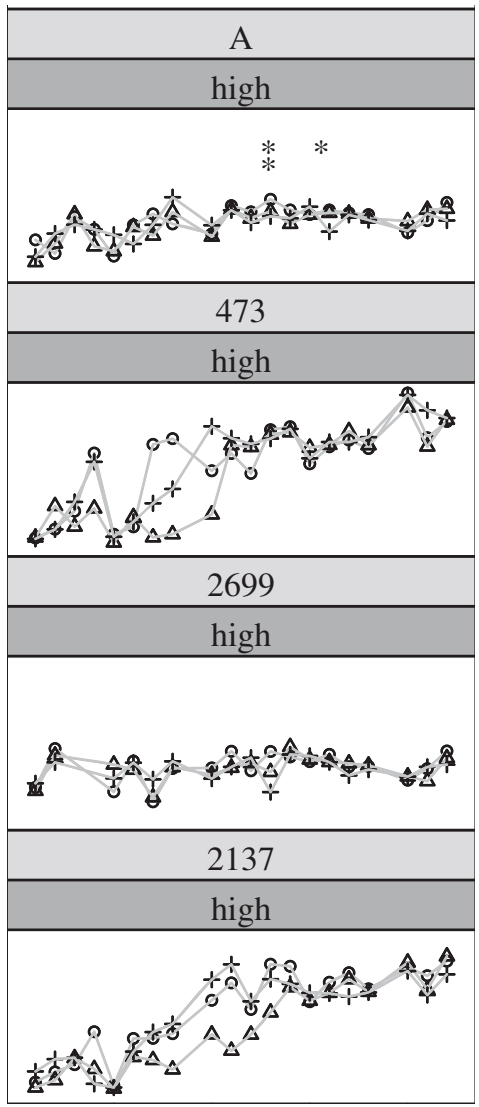




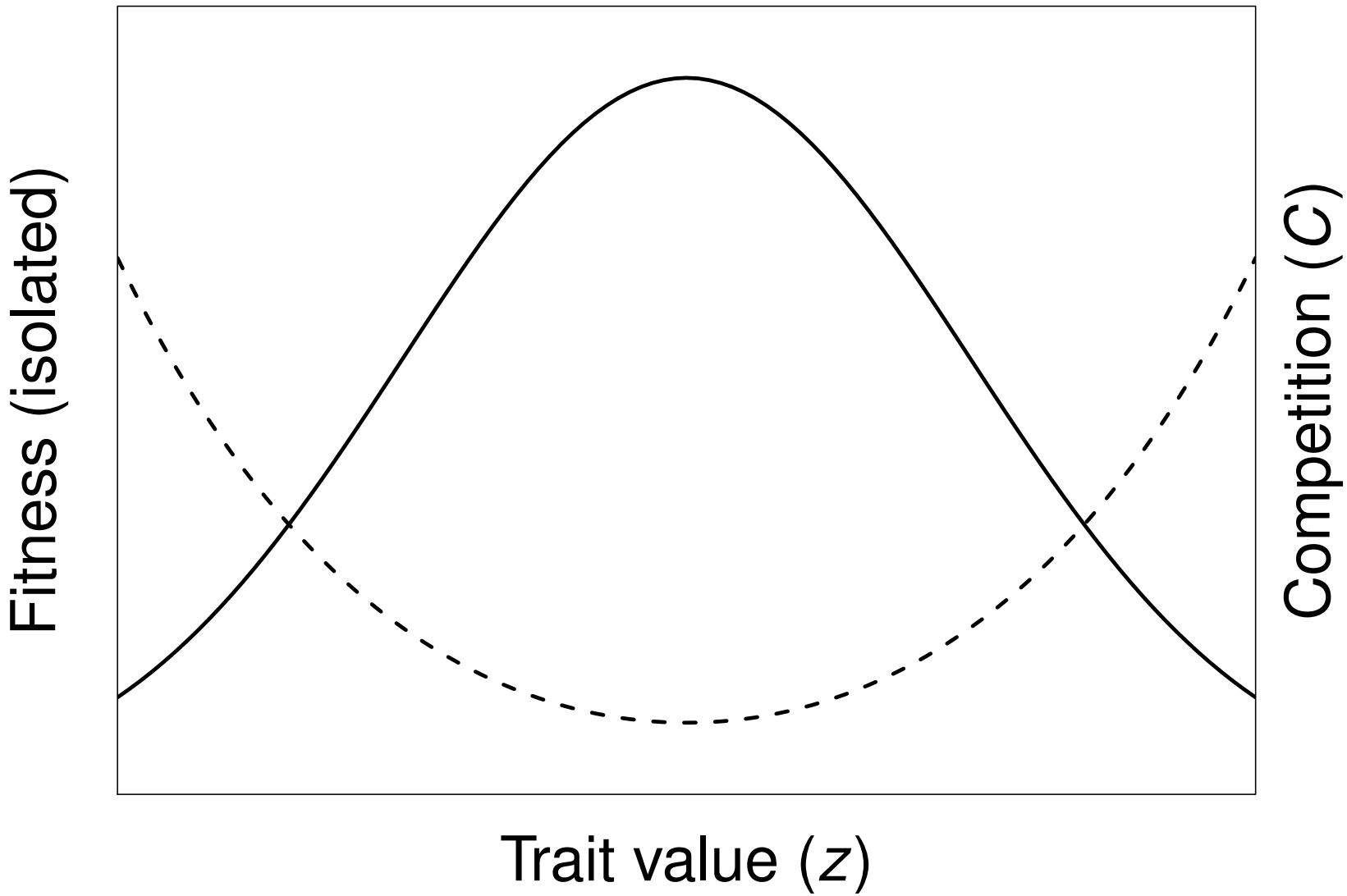
Evidence

Adaptation of algae to increased CO_2 **slowed** by competition Collins 2011





Evidence for ‘helpful’ competition?



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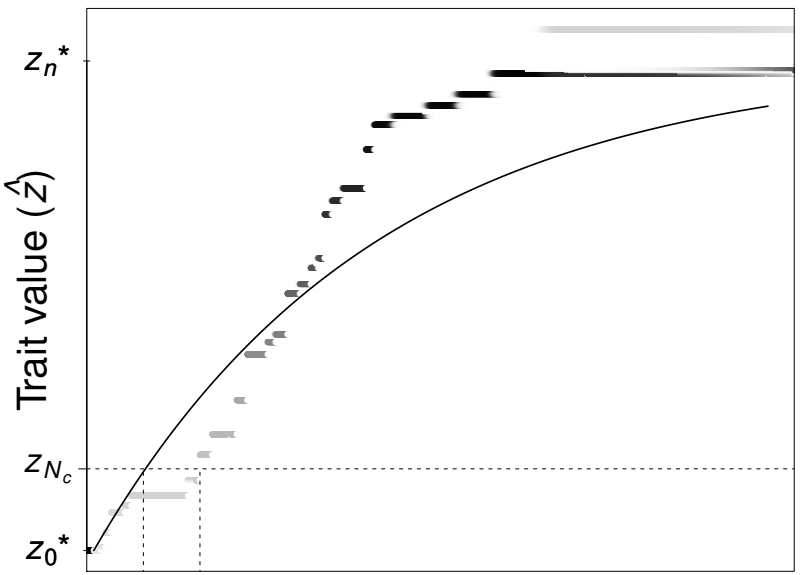
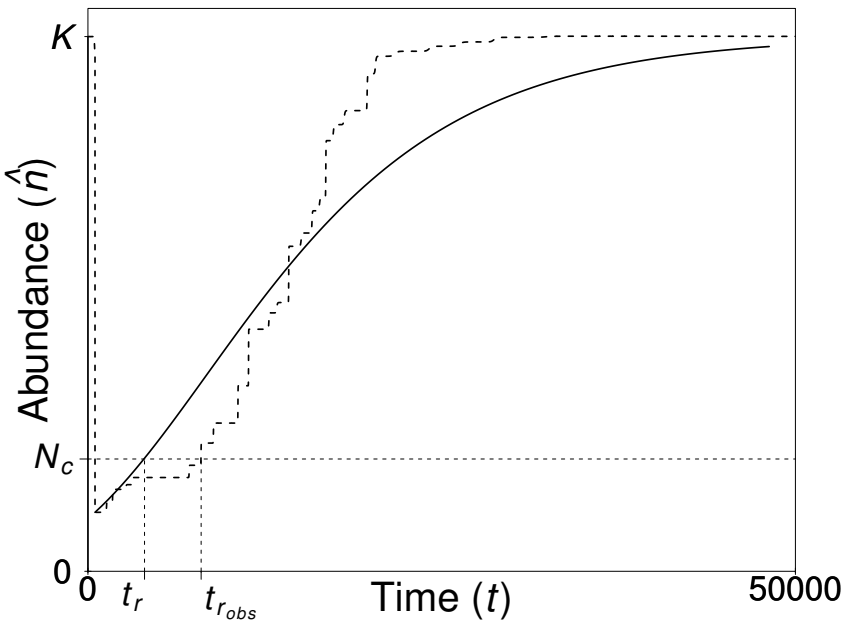
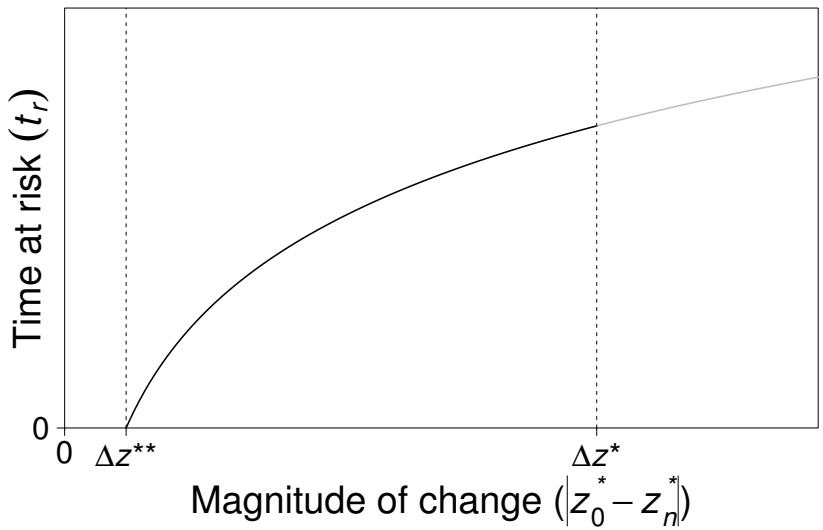
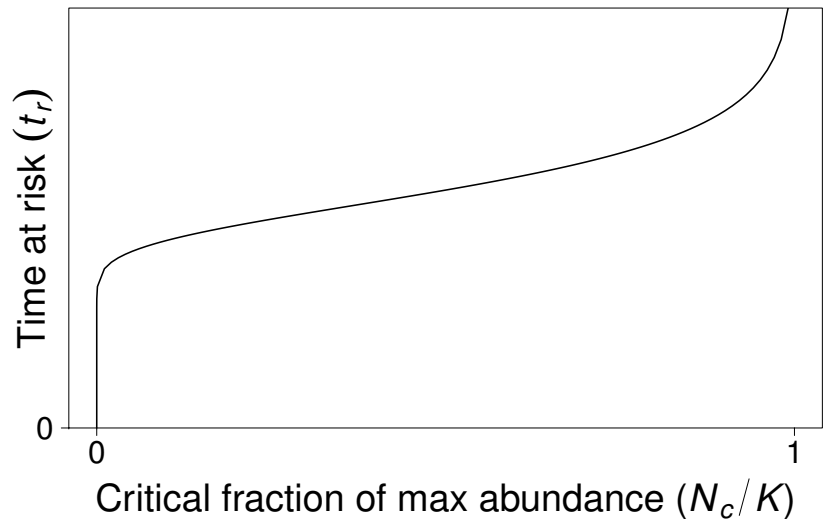
Adaptive response

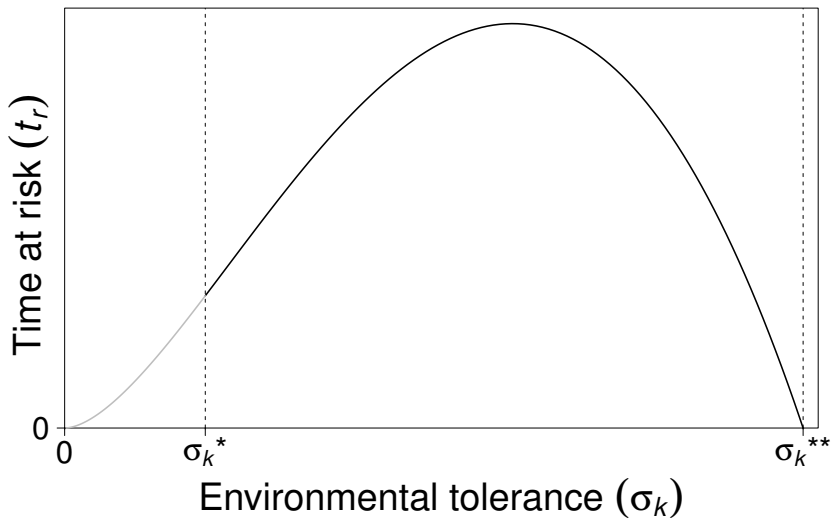


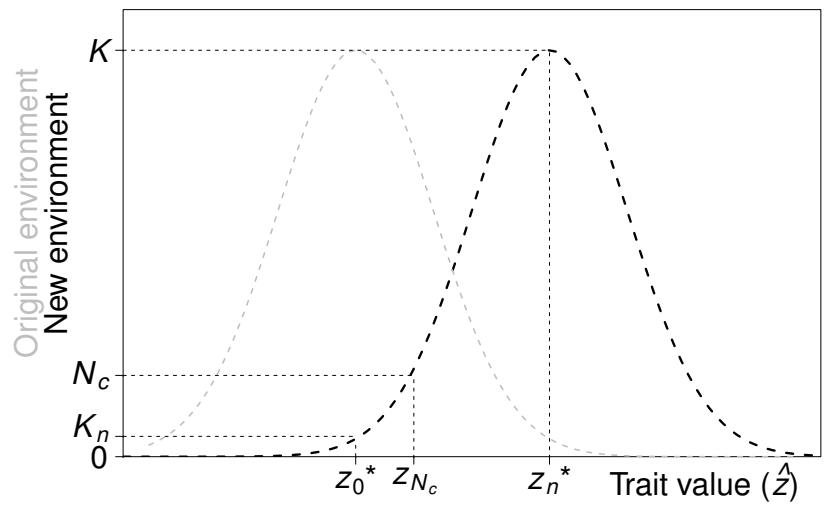


Time at risk influenced by:









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