Sympatric Speciation in Space and Time

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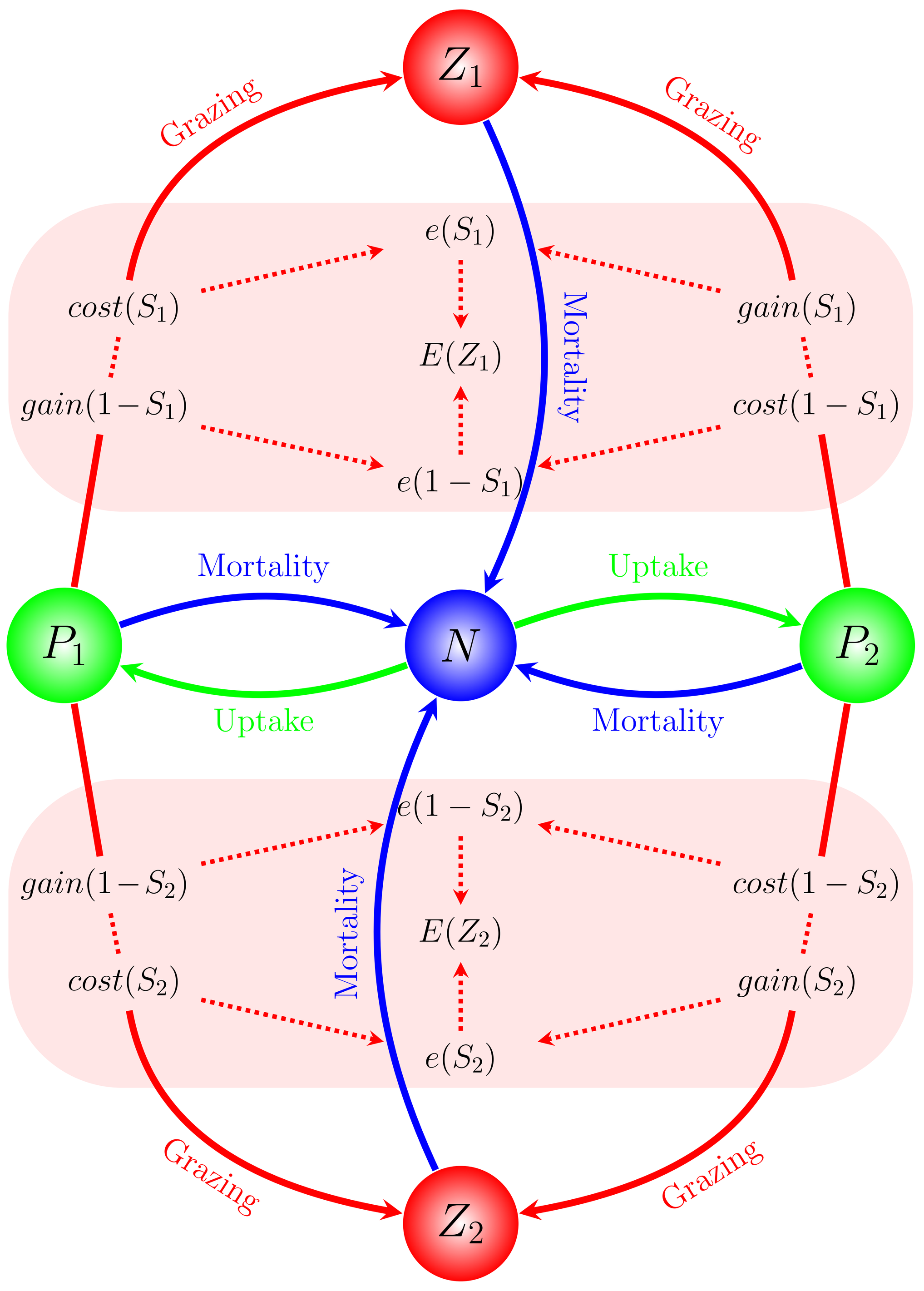
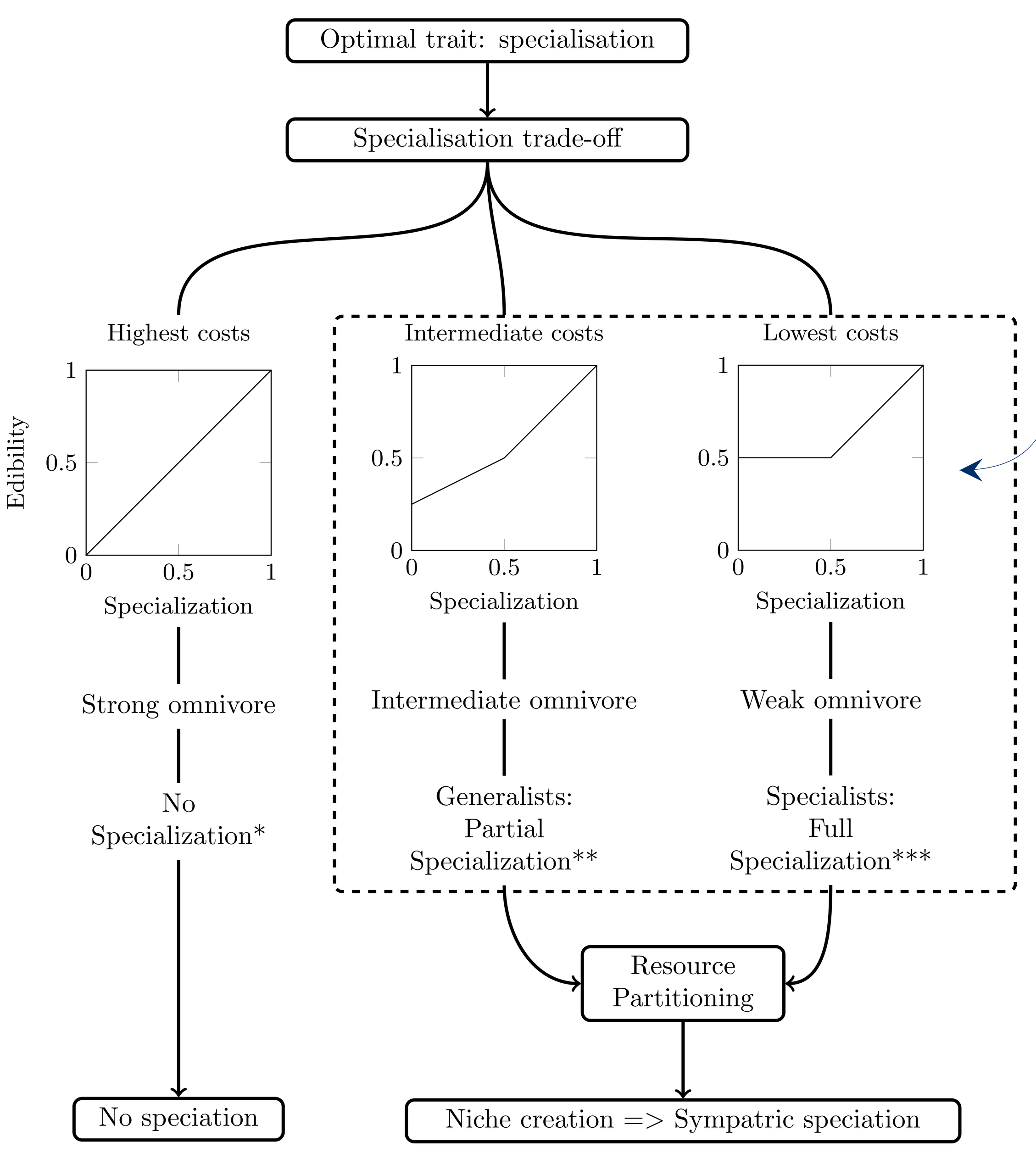
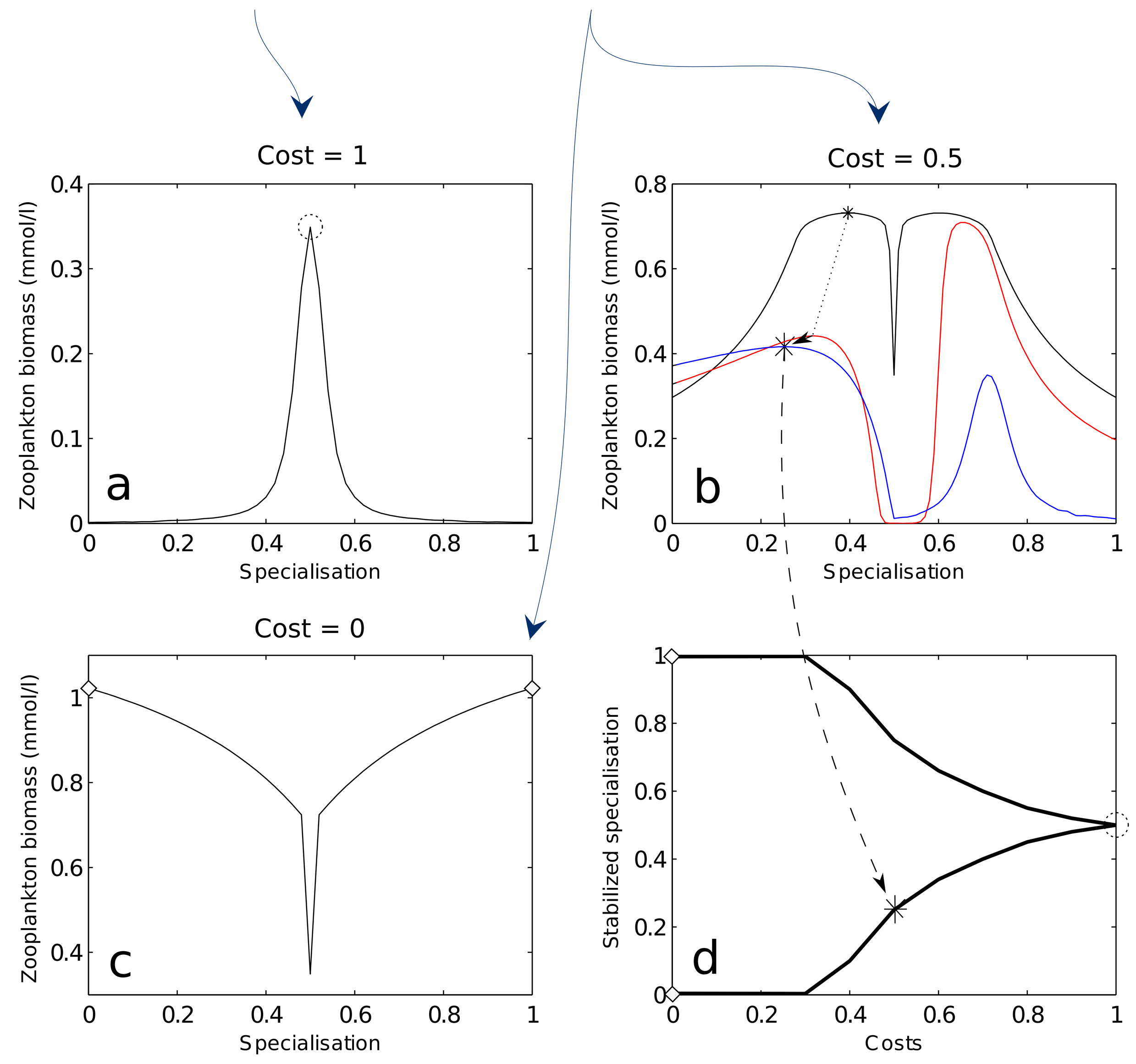
Concept: similar prey



Mechanism of Sympatric Speciation





- Arrows in b and d show the niche stabilisation process.

Problem

- sympatric speciation, i.e., **without geographic isolation**, is controversial and intriguing. However, concrete mechanisms of sympatric speciation remain unknown.
- we present a concept of **Speciation space**, defined as the range of conditions allowing speciation

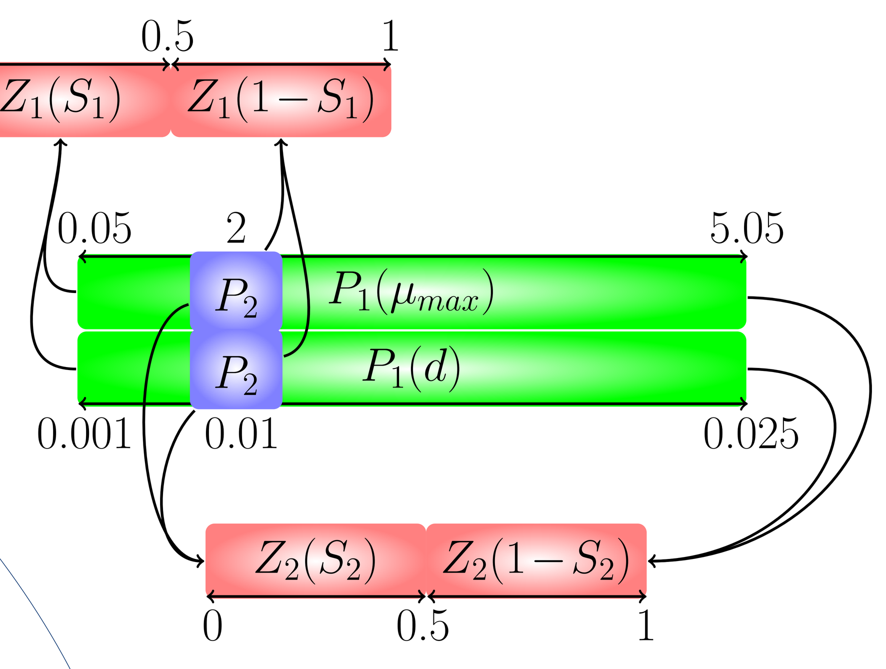
Solution

- we combine optimality-based and trait-based approaches and treat **specialisation as a trait** (S) (top right):
  - S = 0 (specialising exclusively on one prey)
  - S = 1 (specialising exclusively on the other prey)
  - S = 0.5 (omnivory: no specialisation)
- specialisation is assumed to affect **predator's foraging efficiency** (E, ability to capture and eat the prey)
- we define a **specialisation trade-off** between the improved ability to eat the preferred prey ($e(S)$) and the reduced ability to eat the less-preferred prey ($e(1-S)$)
- costs are quantified with the help of the **cost coefficient** $\zeta_S \in [0;1]$
  - $\zeta_S = 1$ - any gain in foraging efficiency of the preferred prey is offset by an equal loss in foraging efficiency of the non-preferred prey
  - $\zeta_S = 0$ - the foraging efficiency of the non-preferred prey is not affected by specialisation
- **evolution of traits** in phytoplankton (top right)
  - maximum specific growth rate $\mu_{max}(P_1)$
  - specific mortality rate $d(P_1)$

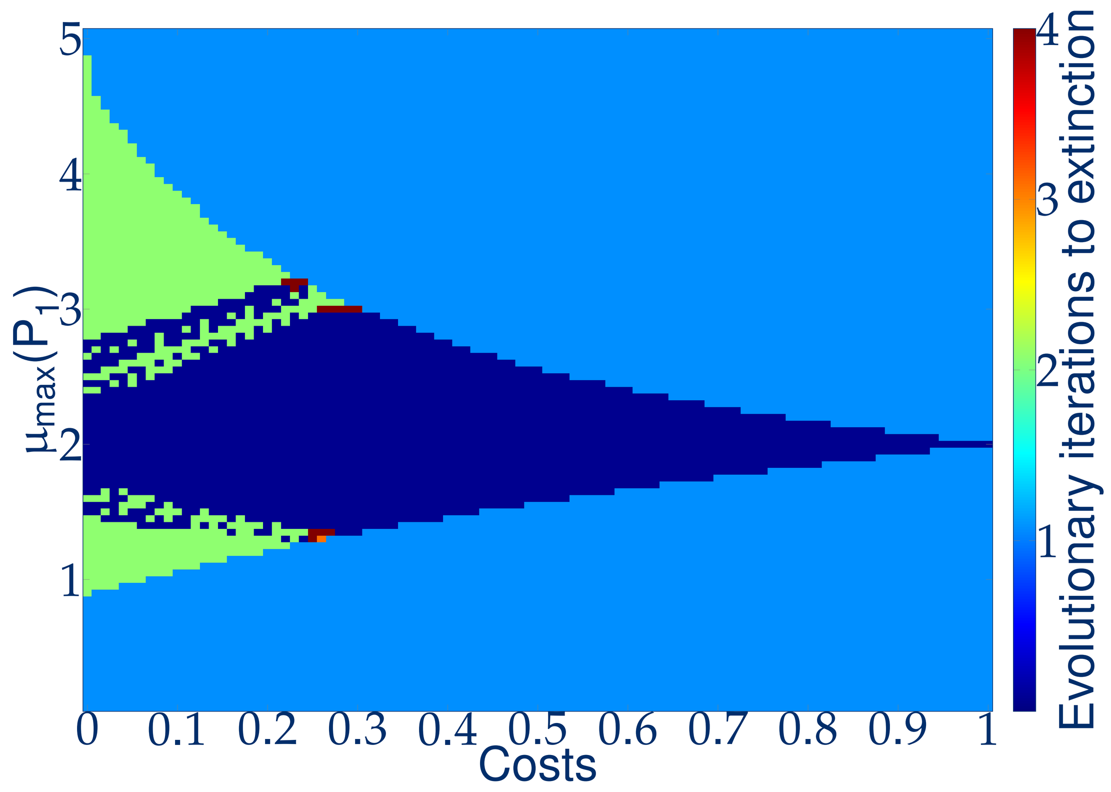
Conclusion

- we use the **Optimal Trait Approach** as a tool for discovering mechanisms of speciation
- the model generates generalists and specialists (bottom left and bottom right)
- our model explains sympatric speciation via top-down control (bottom left)
- range of prey's traits allowing speciation in the predator allows to determine the speciation space for predators
- speciation thresholds (the boundary of the speciation space) show hillocks in the phytoplankton fitness landscape and valleys in the zooplankton fitness landscape (bottom-up control)
- prey equality area (is a part of the speciation space, where both prey species have identical biomass but different trait values) indicates bottom-up control
- evolution closes the cycle by bringing the control back to predators as soon as one of predators goes extinct
- the specialisation landscape shows the change in the predator's adaptive trait along:
  - specialisation gradient itself (Z axes)
  - cost gradient (X axes)
  - trait gradient (Y axes)

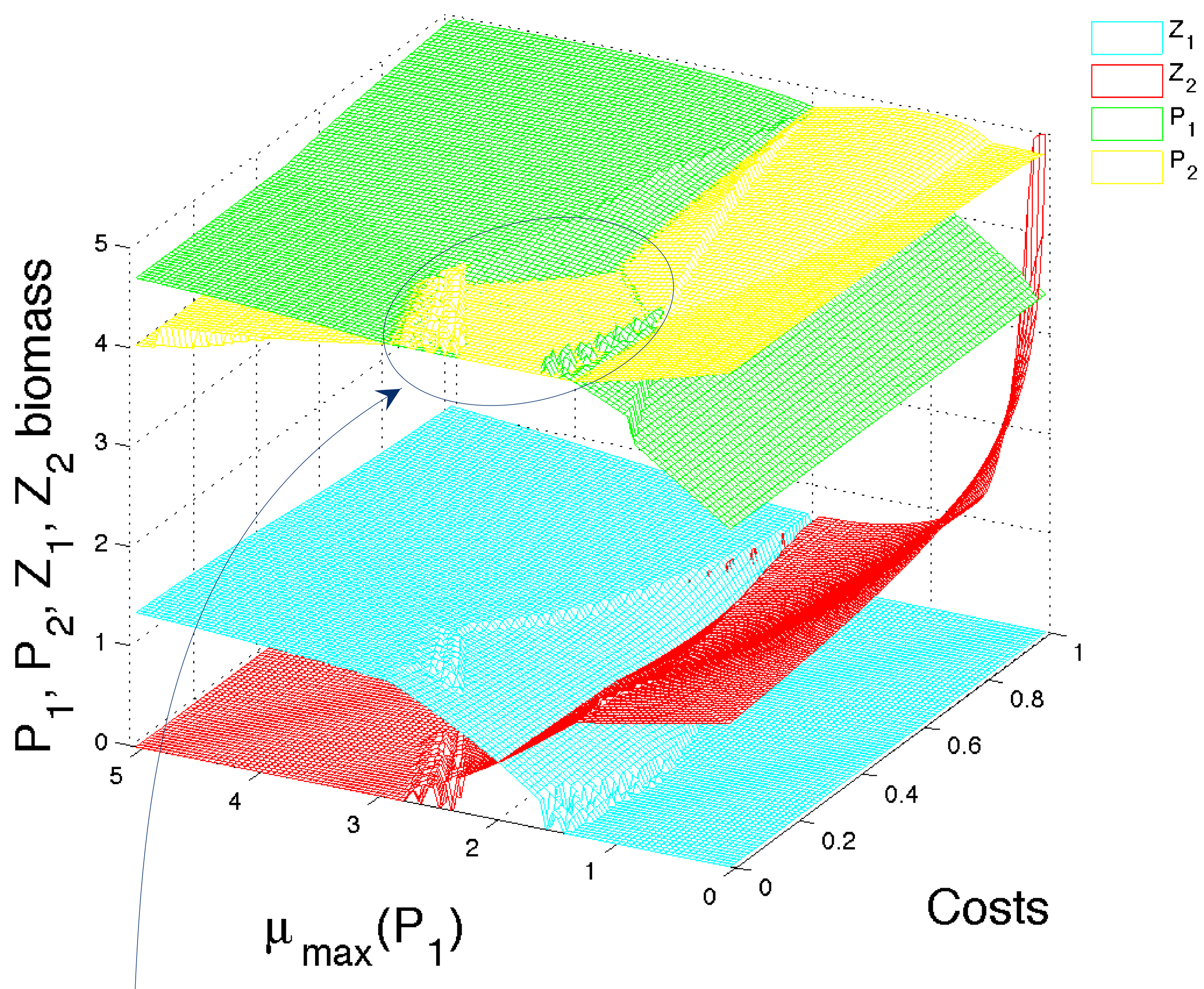
Concept: different prey



Speciation space



Fitness landscapes



Specialisation landscapes