Are the prey- and ratio-dependent functional responses really extremes along a continuum of predator interference?

$f(N) \longrightarrow f(N/P)$

Christopher X Jon Jensen
Stony Brook University

What is Predator Interference?

- Reduction in the per capita consumption rate as predator abundance increases
- Potential mechanisms:
  - – Time lost bumping into and “handling” other predators
  - – Resource “sharing” over longer intervals of feeding reduces overall consumption rate

Holling Type II:

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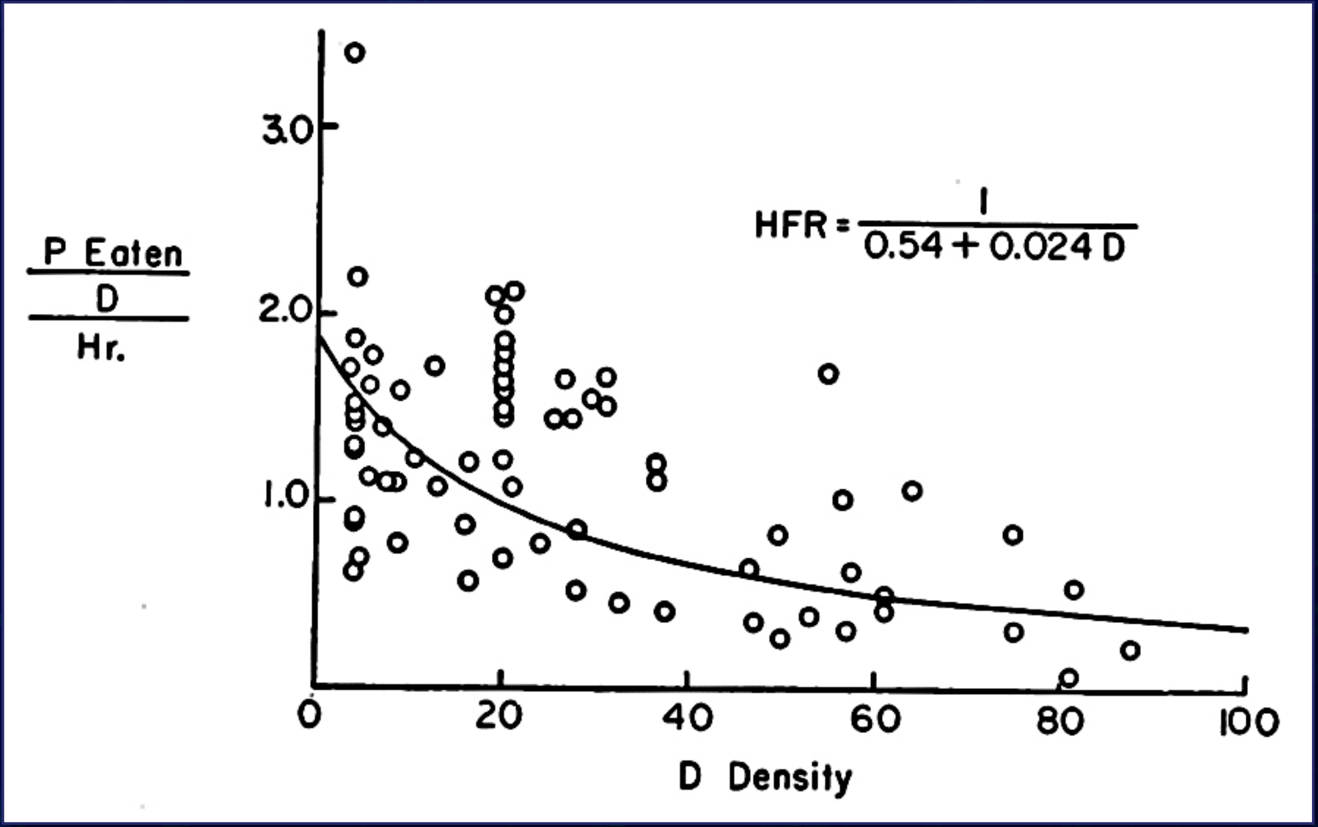
Per Capita Consumption Rate of Predators

Predator Abundance

Predator Interference is Real



(Salt 1974)

Competing Functional Responses

$f\,(N)$ → $f\,(N/P)$

increasing predator interference

Holling Type II
"prey dependent"

Arditi-Ginzburg
"ratio dependent"

Where N is prey density and P is predator density

Competing Functional Responses

$f\,(N)$

Holling Type II
"prey dependent"

$f\,(N/P^m)$

Hassell-Varley-Holling
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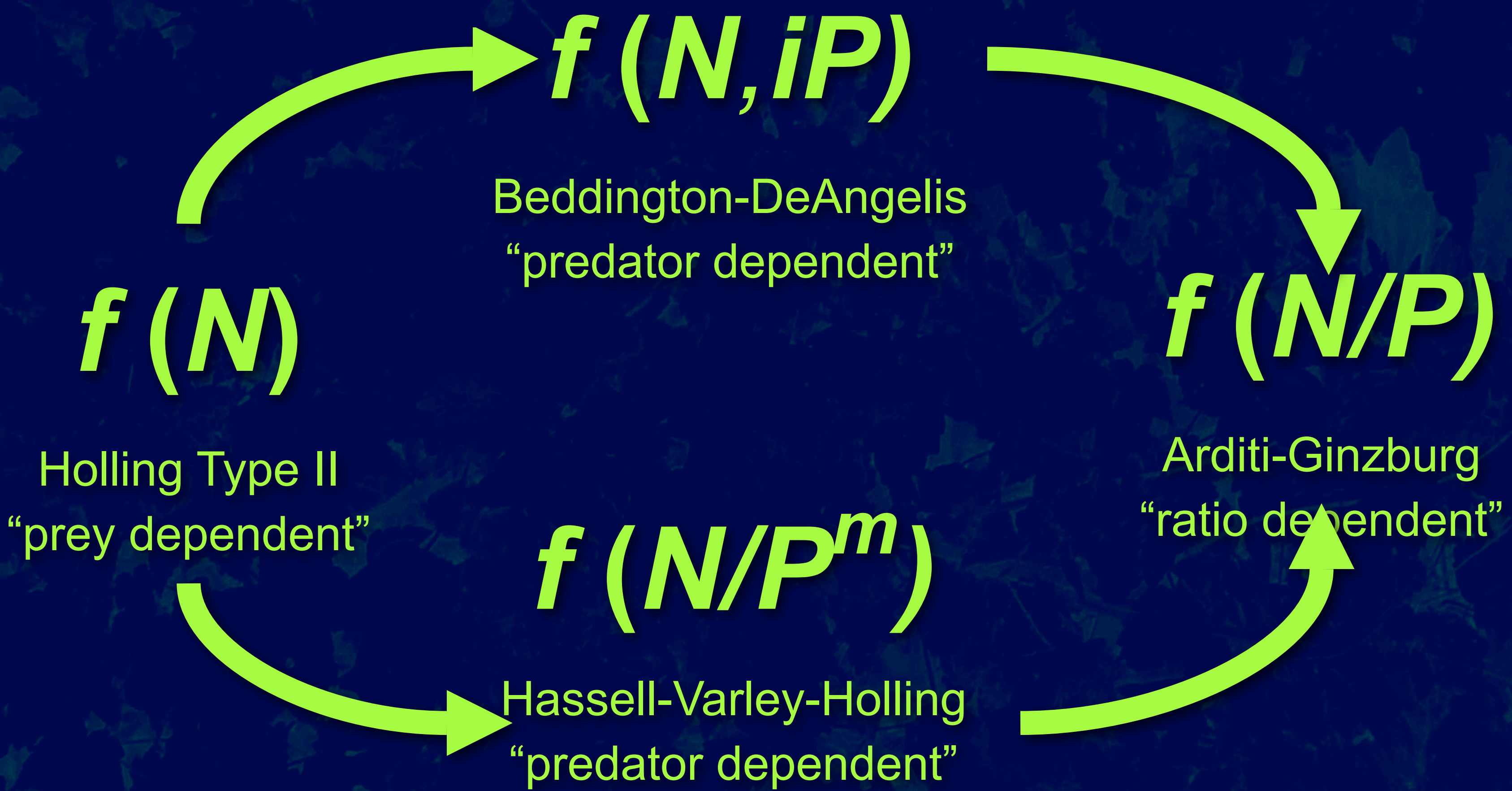
Competing Functional Responses



Where ***N*** is prey density and ***P*** is predator density

Does it matter which form of predator interference is used?

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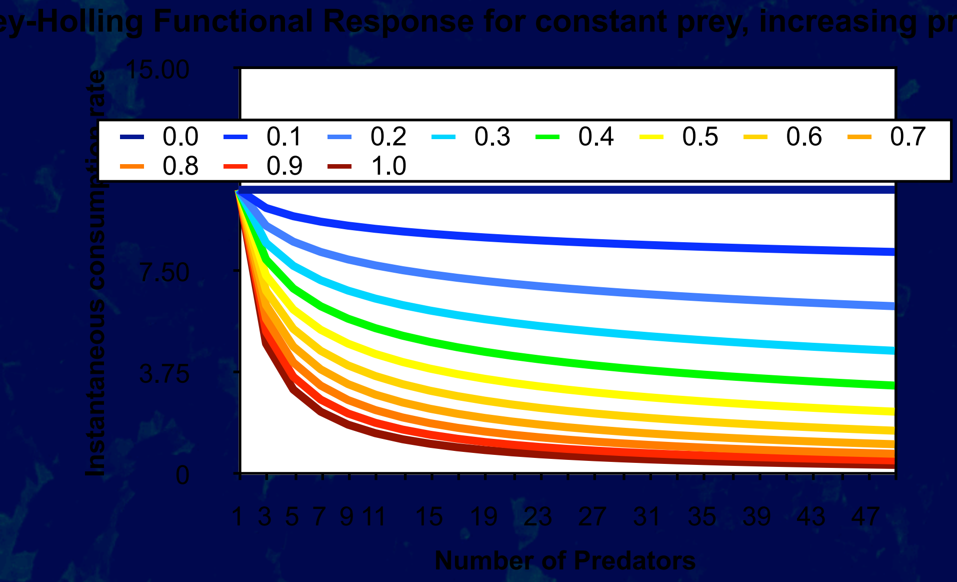
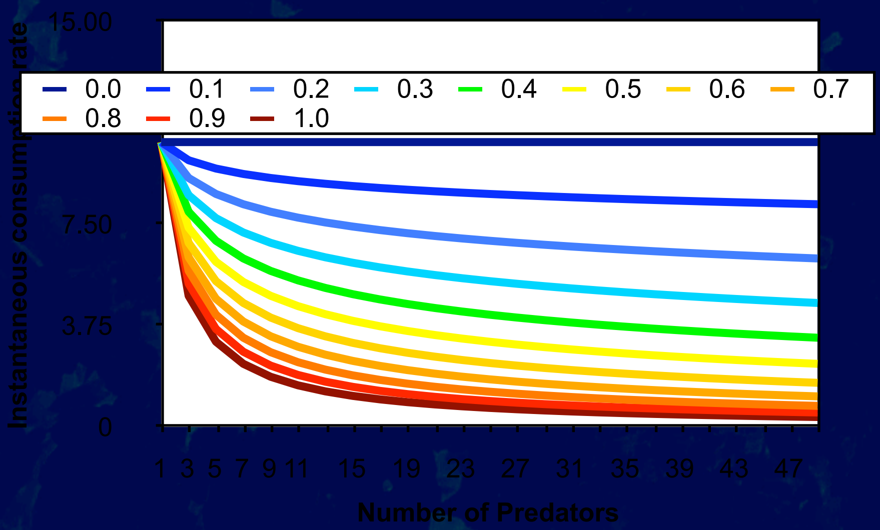
$f\,(N/P^{m})$

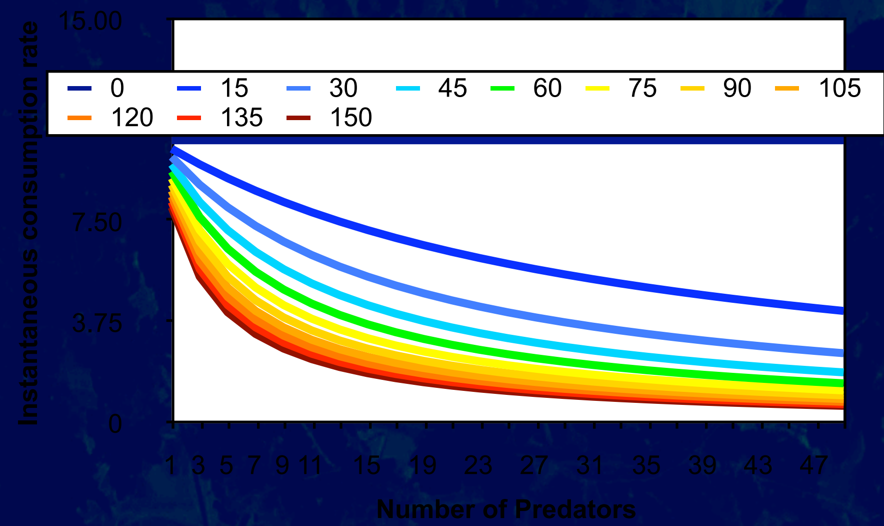


Does it matter which form of predator interference is used?

f (N/P^m)

f (N,iP)





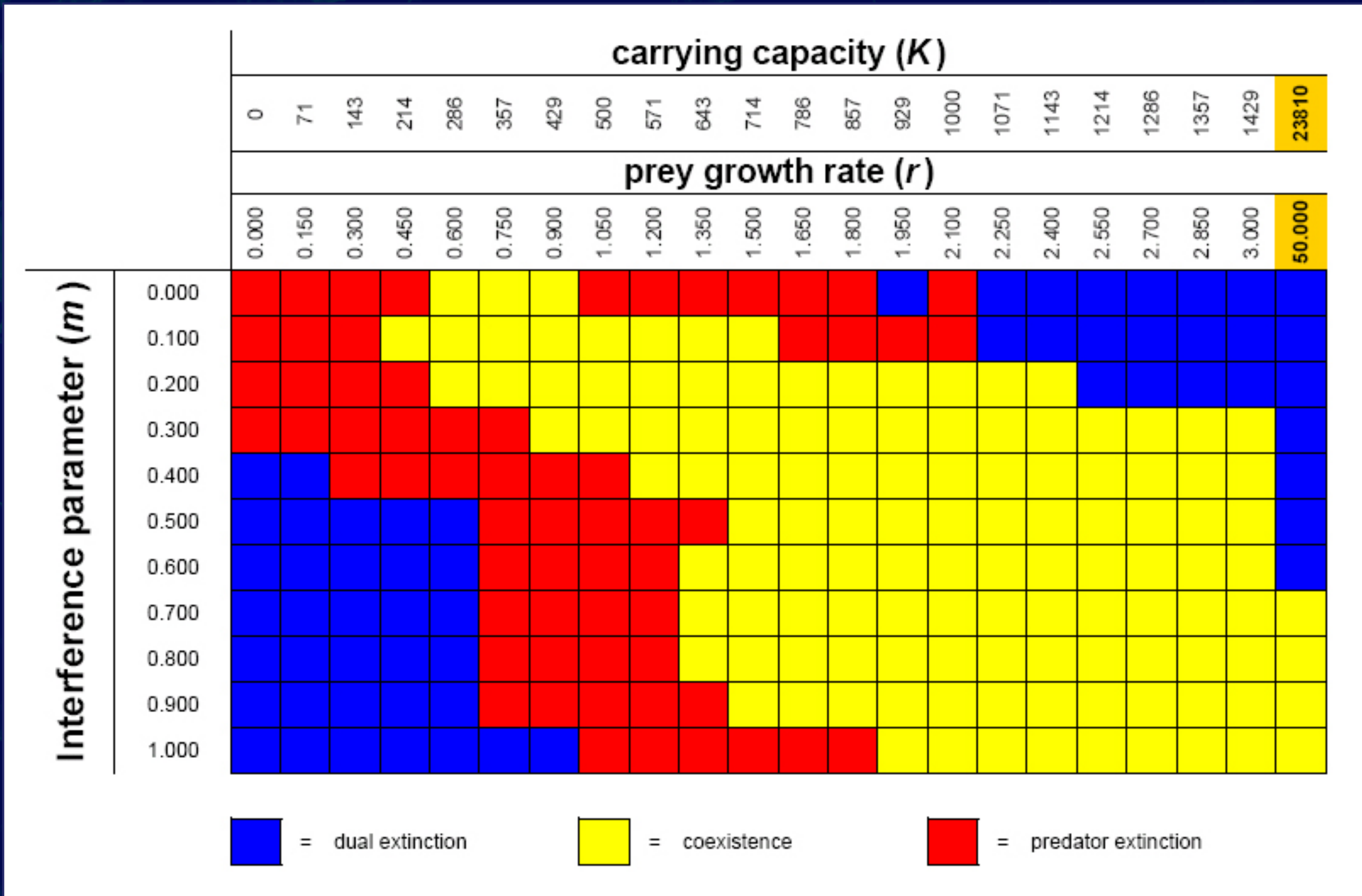
Stability Properties of the Extreme Models:

Change in Parameter	Prey-Dependent Outcome	Ratio-Dependent Outcome
a ↑ (searching efficiency)	Prey Extinction	Prey Extinction
K ↑ (carrying capacity)	Prey Extinction	*no change*
r ↑ (prey growth rate)	*no change**	Prey Persistence
d ↑ (pred. death rate)	Prey Persistence	Prey Persistence
e ↑ (conversion eff.)	Prey Extinction	Prey Extinction
h ↑ (handling time)	Prey Persistence	Prey Persistence

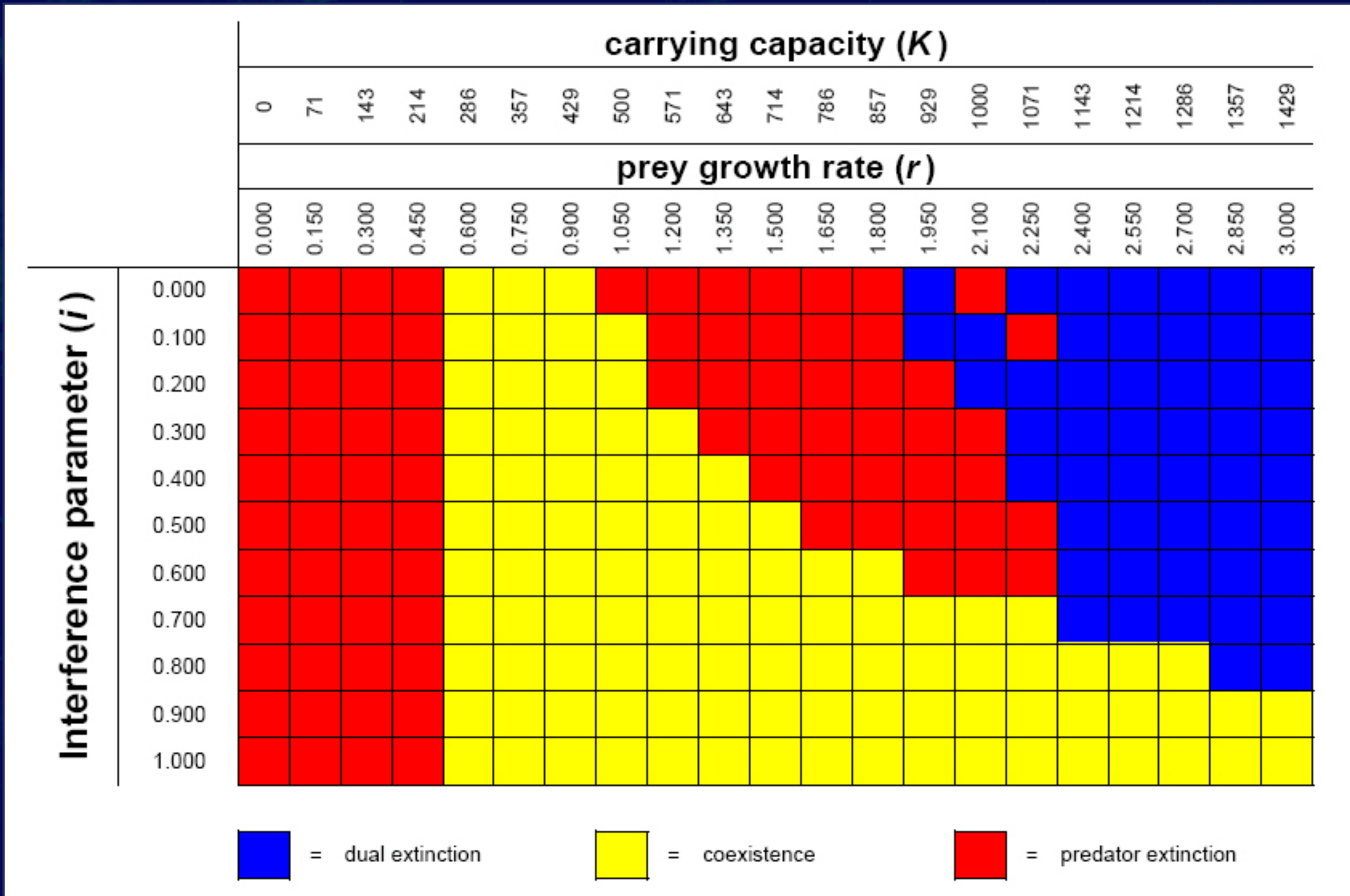
The Simulations:

1. Numerical approximations of differential equations using Populus Software
2. Designed to mimic behaviors of *Didinium-Paramecium* system (parameter values from Harrison 1995)
3. Qualitative outcomes explored over a range of *r/K* values (as planned for my experiments)
4. Parameters *r* and *K* linked
5. Non-deterministic criterion for extinction employed

Hassell-Varley-Holling: $f\,(N/P^{m})$



Beddington-DeAngelis: *f* (*N*, *iP*)



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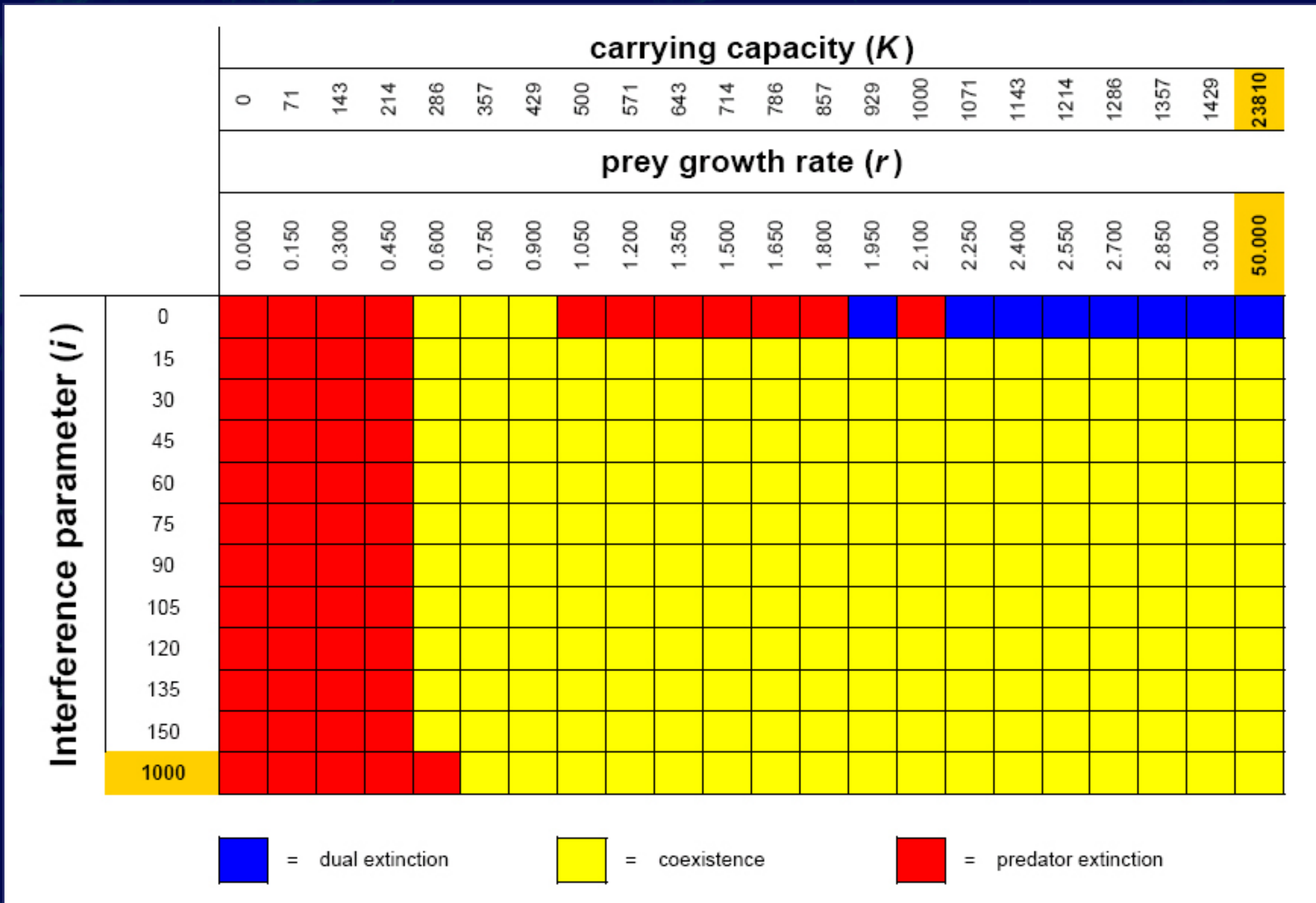

Competing Functional Responses

$f\,(N, iP)$

Beddington-DeAngelis
"predator dependent"

$f\,(N)$

Holling Type II
"prey dependent"

$f\,(N/P)$

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The *Paramecium-Didinium* system:

Paramecium caudatum

Didinium nasutum

Meets major assumptions of simple predator-prey models:

- Closed system
- Can be maintained without heterogeneities/refugia
- Single prey/single obligate predator
- Prey food can be delivered as semi-continuous input

Answers via Experiment:

- What is the magnitude of predator interference?
  - Direct measurement of consumption rate over a range of predator densities
  - Curve fitting to HVH and BD models
- Which model should be used?
  - Microcosm experiments designed to explore the *r*/*K* continuum
  - Detection of characteristic extinction events: low *r*, high *K*

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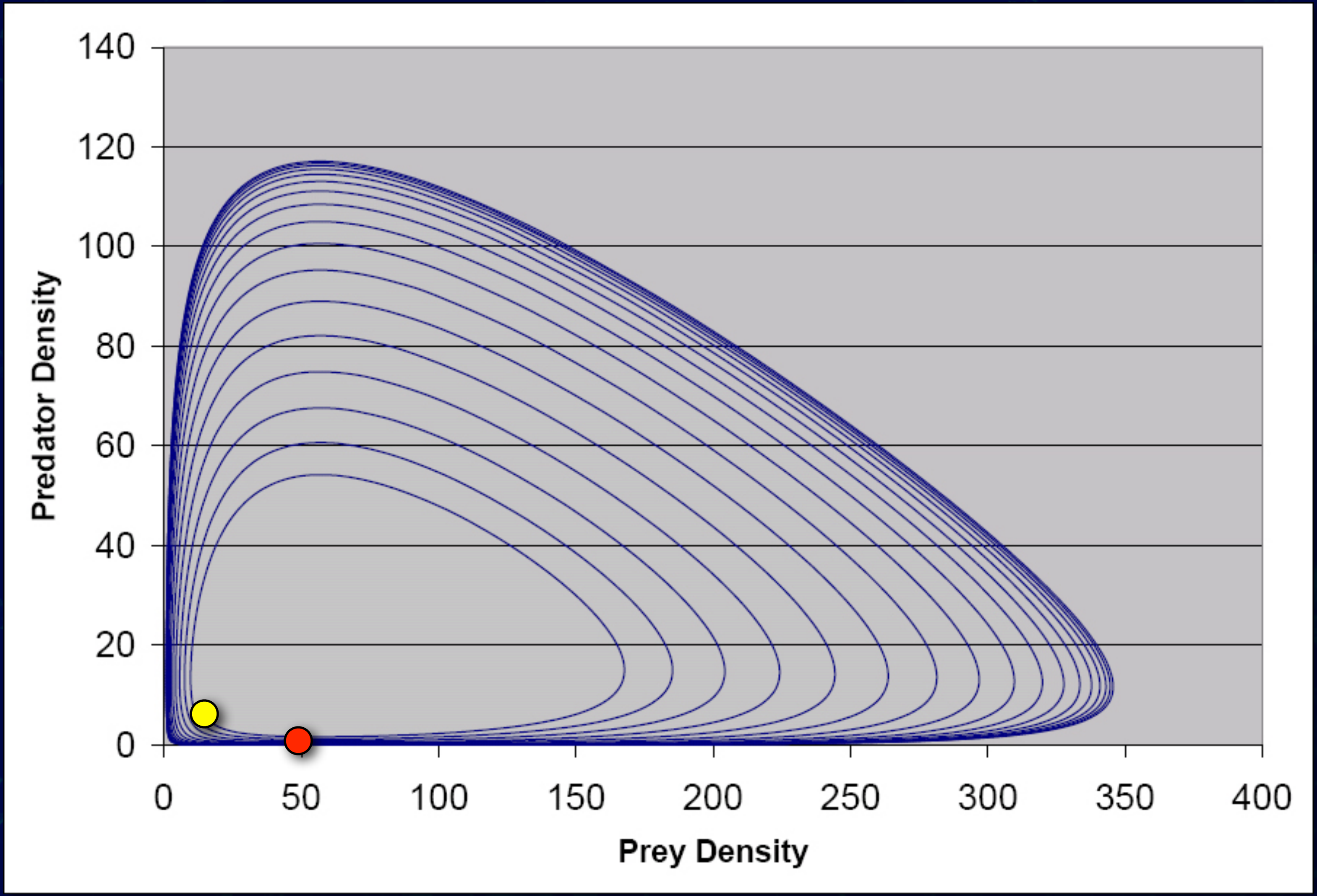
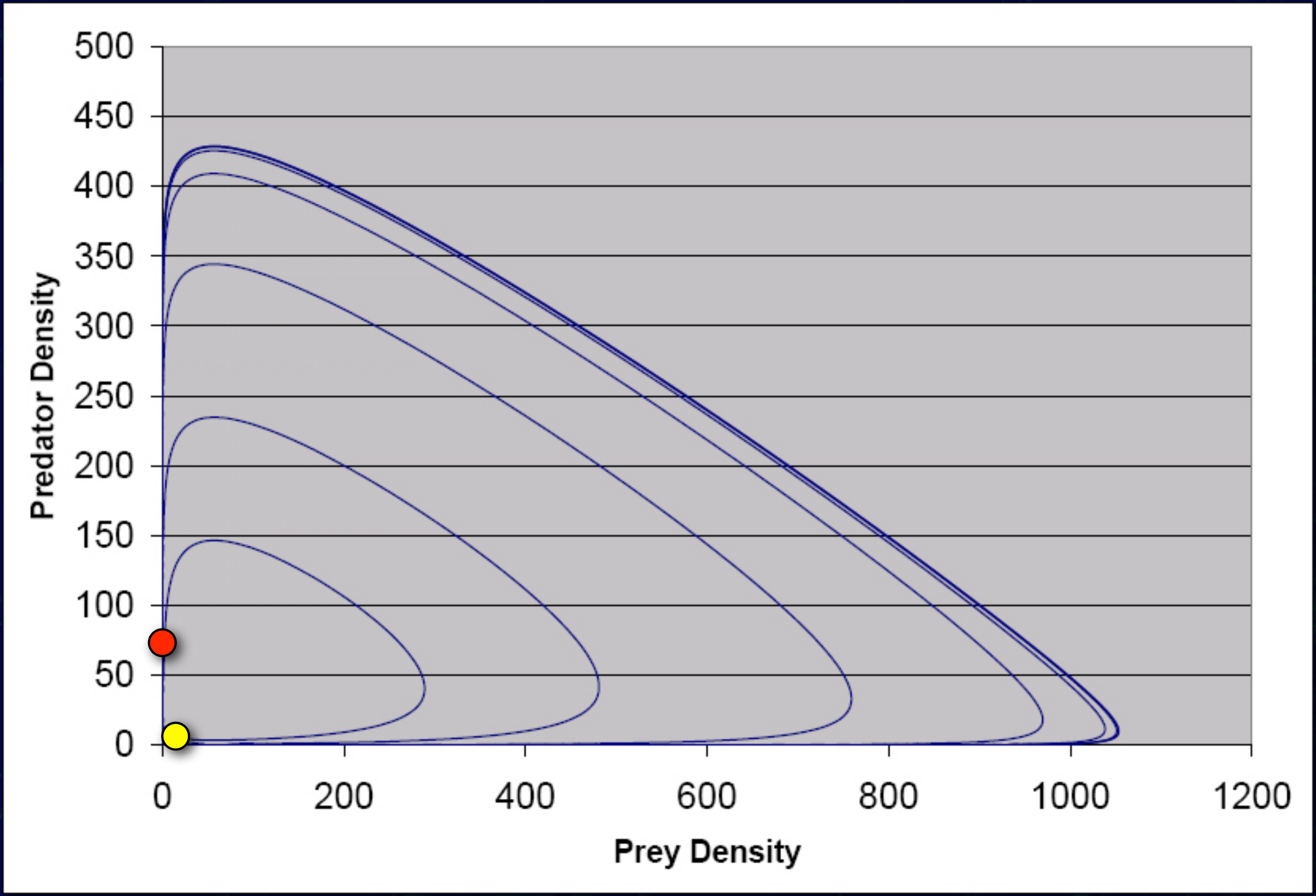
Non-deterministic Predator Extinction



Non-deterministic Dual Extinction



Non-deterministic Extinction Criterion:

- *P* and *N* values represent densities of prey per volume
- In a finite system, a fraction of an individual cannot exist. Threshold extinction density is 1 individual per system
- Threshold extinction as individuals per volume:

$$\frac{\text{Individuals}}{\text{Volume}} = \frac{\text{Individuals}}{\text{System}} \cdot \frac{\text{System}}{\text{Volume}}$$