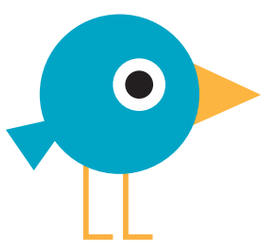
DUCKING RESPONSIBILITY

How Laziness Pays off in Arctic Duck Populations



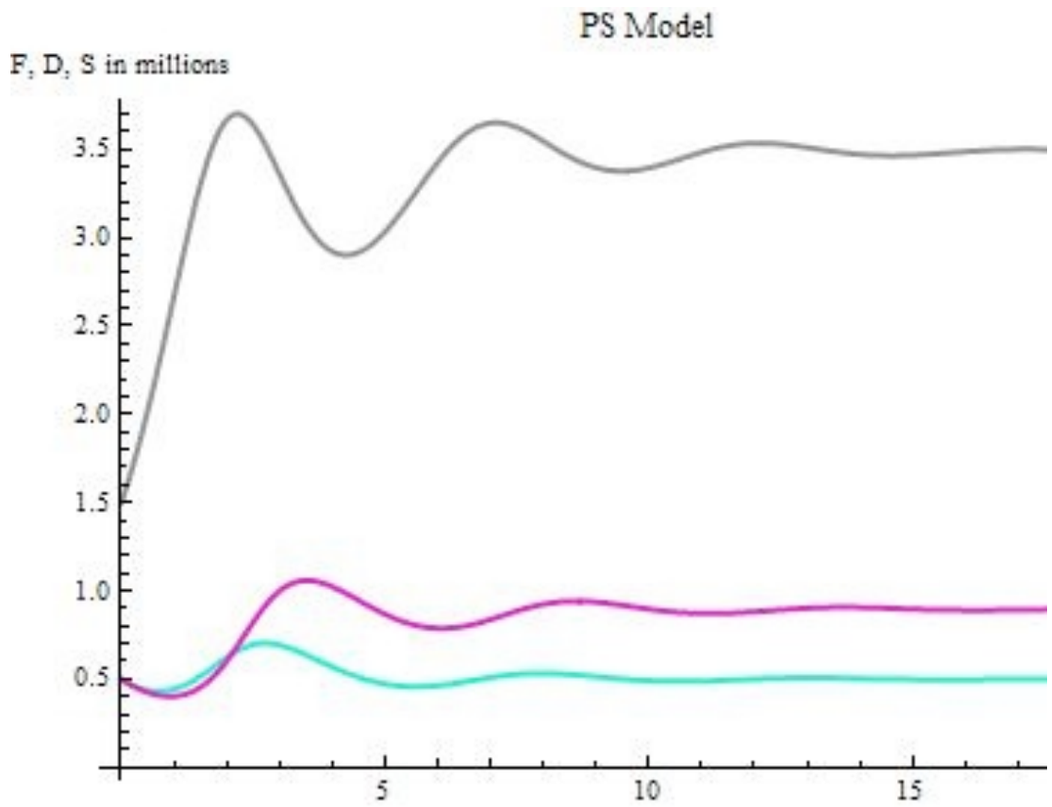
Yu Jin . Alexis Sparko
Smith College

Advisor: Nessy Tania

Producer / Scrounger Behavior

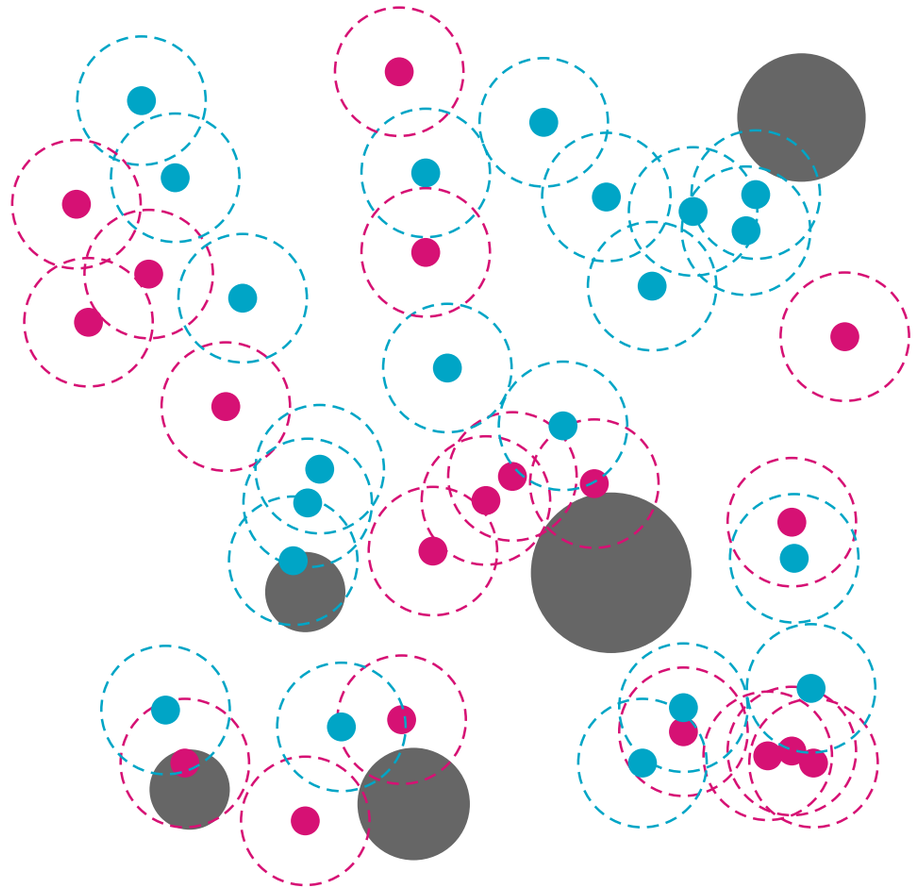
Scarce Food
Patchy Distribution

ODE Model

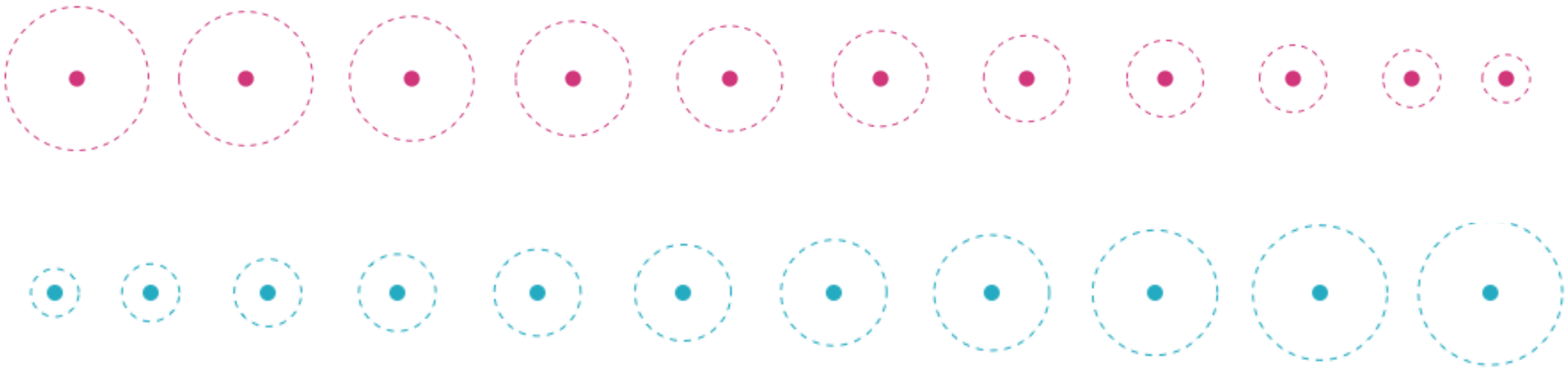


- Observe how populations change over time
- Steady-state analysis

Discrete Model

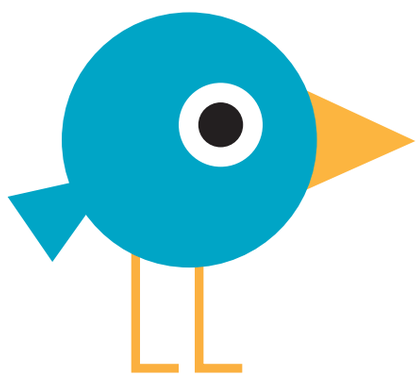


- Spatial reasons for P/S behavior?
- Compare P/S to Predator/Prey
- Measure population success

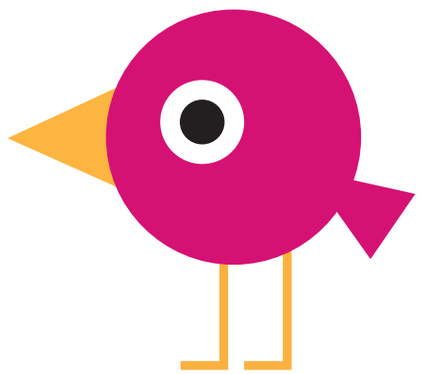


DISCRETE MODEL

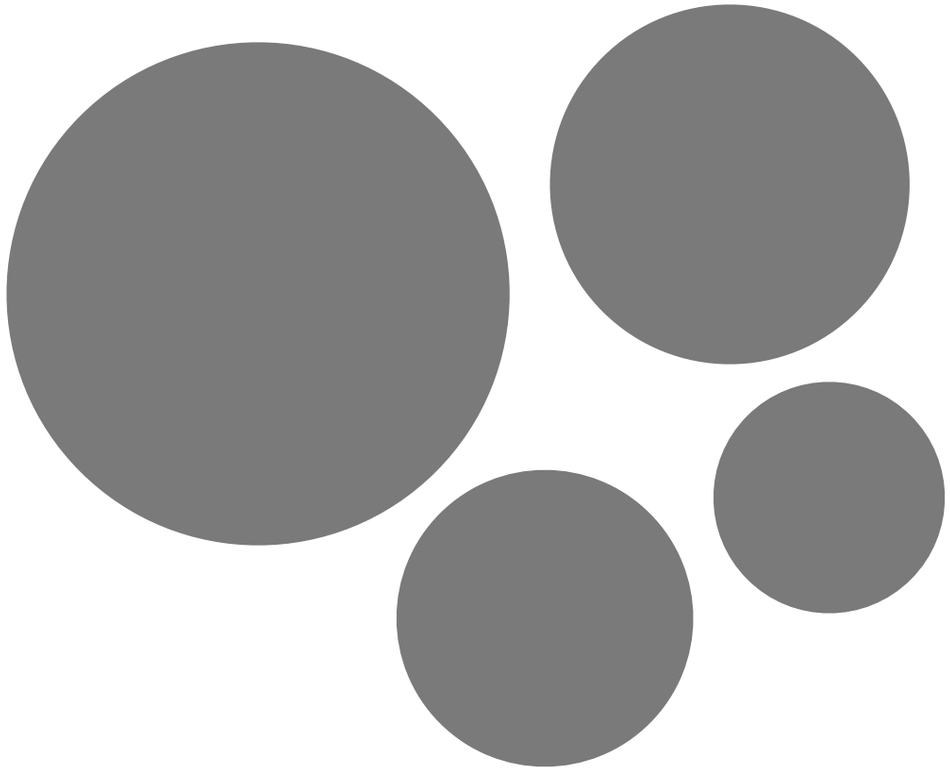
PRODUCERS



SCROUNGERS



FOOD BLOBS



NOTE: DRAWINGS NOT TO SCALE

FOOD BEHAVIOR

FOOD BEHAVIOR

- BLOBS to represent patches of food

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- Random Placement

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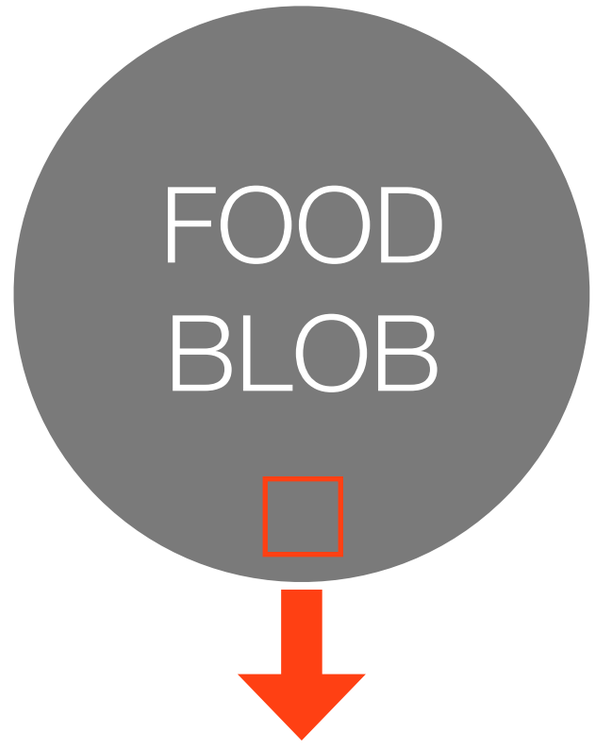
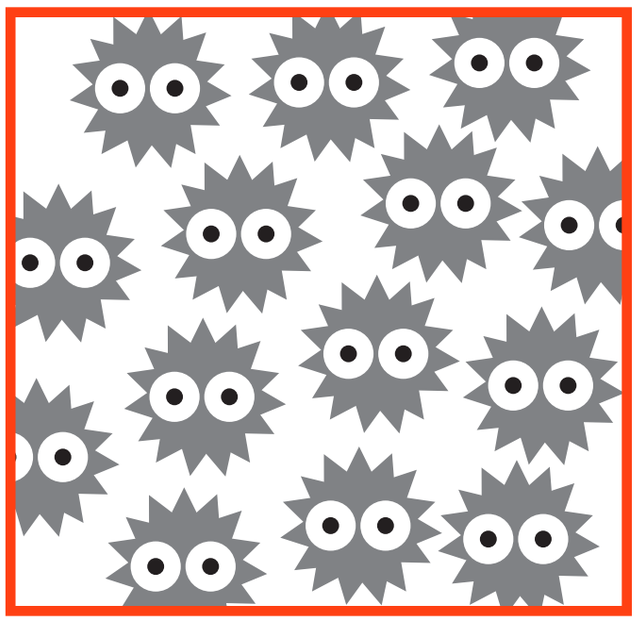


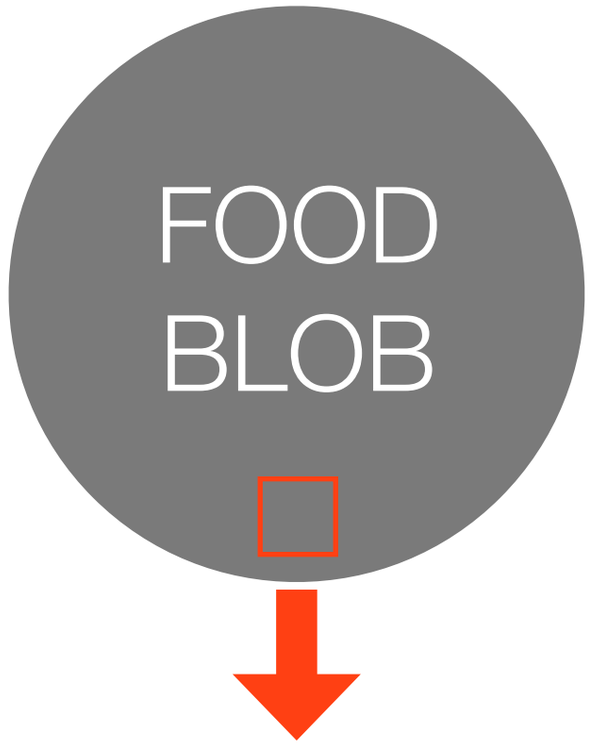
FOOD BEHAVIOR

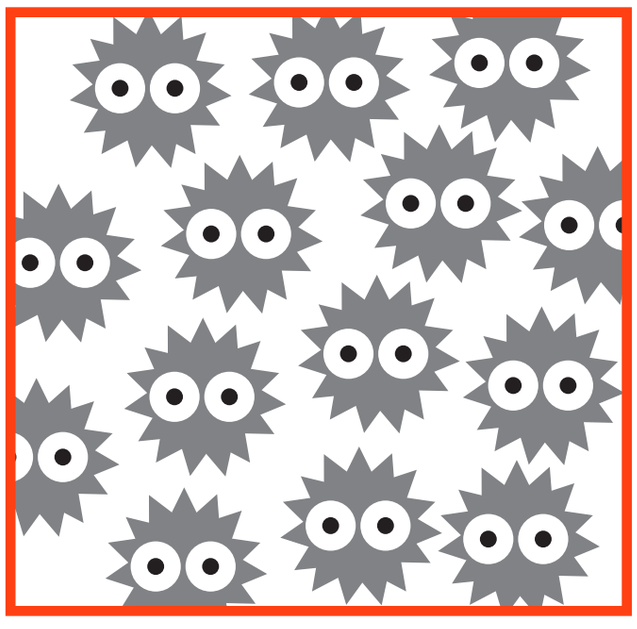
- BLOBS to represent patches of food
- Random Placement
- Comprised of Living Individuals!
- Growth Rate



FOOD BEHAVIOR

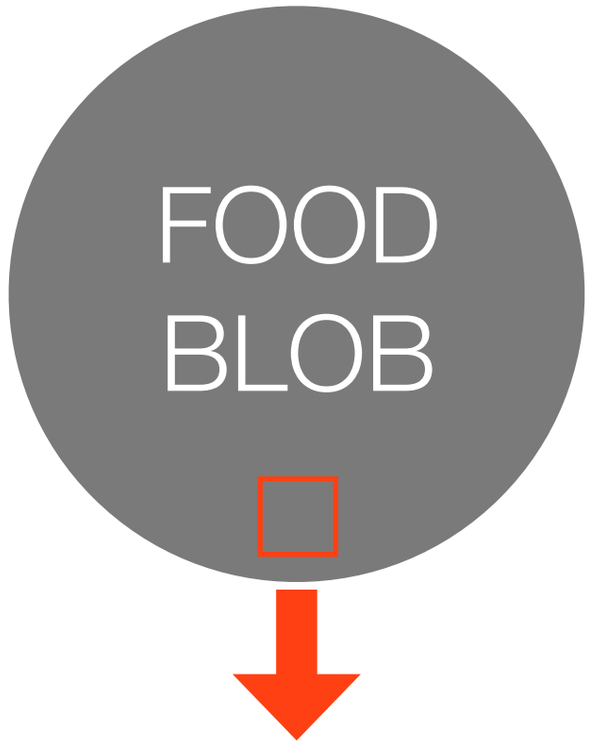
- BLOBS to represent patches of food
- Random Placement
- Comprised of Living Individuals!
- Growth Rate
- Shrink as Eaten

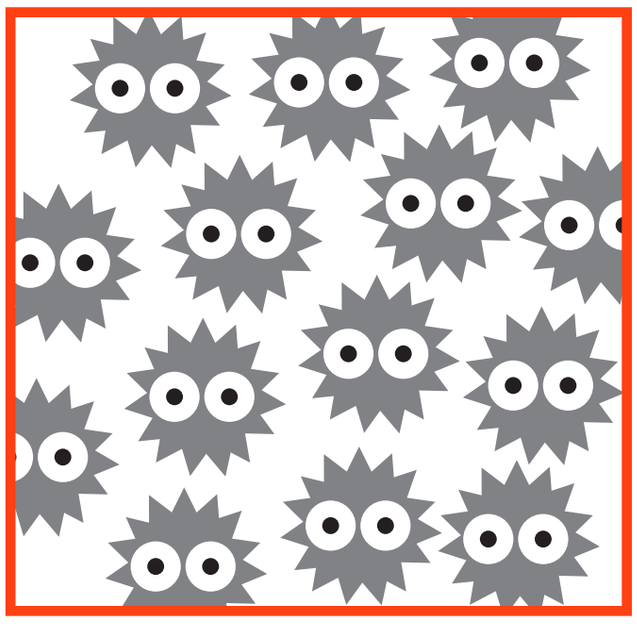




FOOD BEHAVIOR

- BLOBS to represent patches of food
- Random Placement
- Comprised of Living Individuals!
- Growth Rate
- Shrink as Eaten
- Consumed → New





PRODUCER BEHAVIOR

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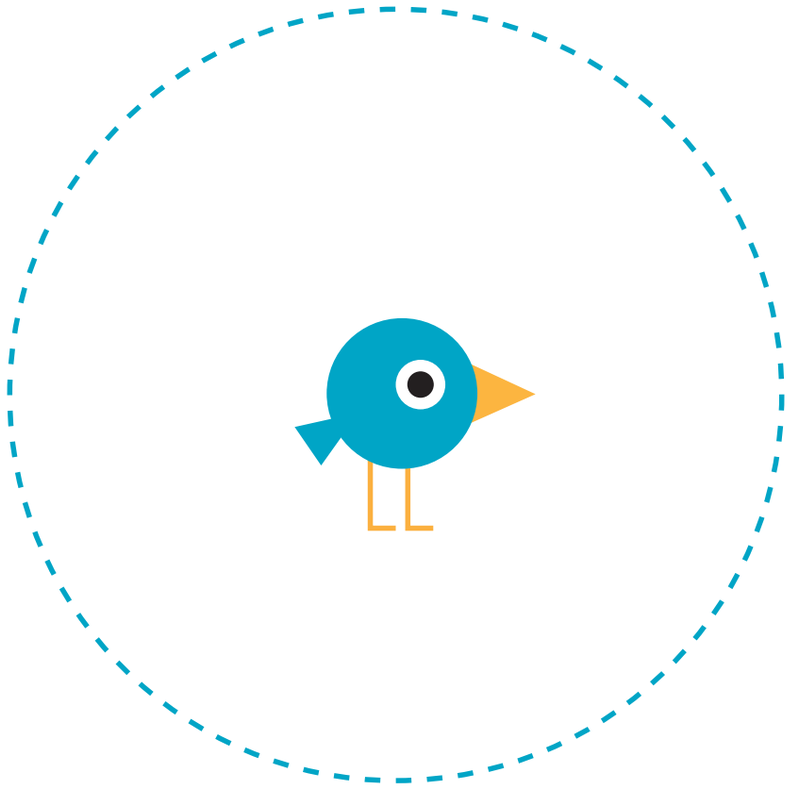
- Move in random direction in search of Food



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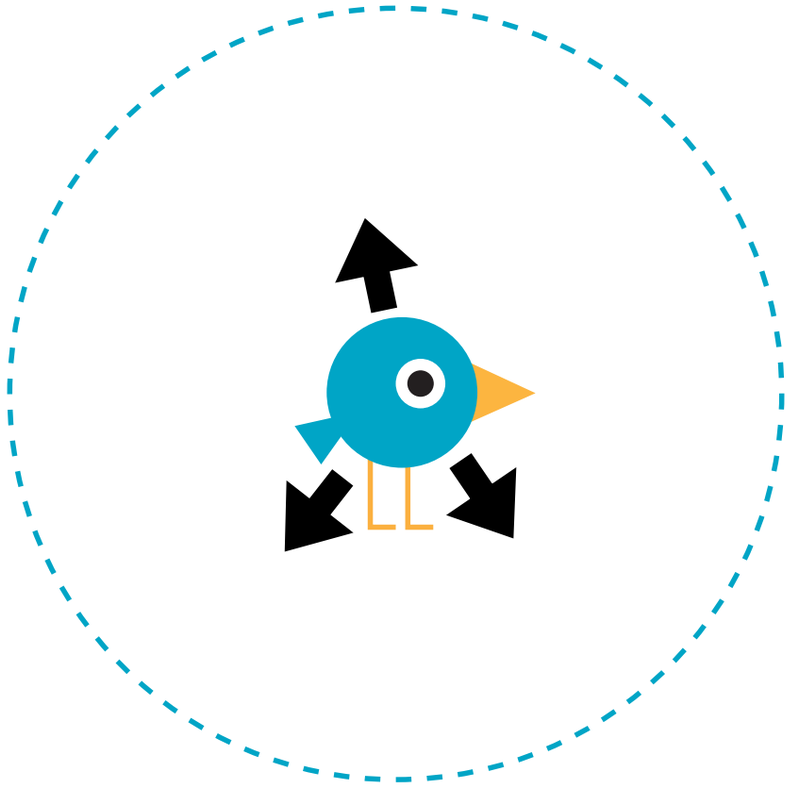
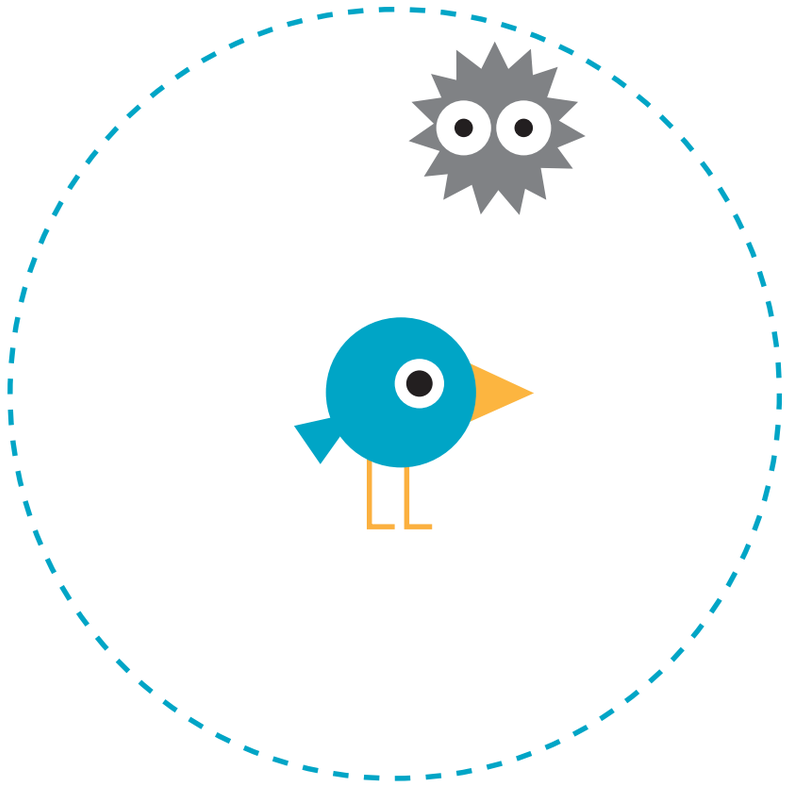


PRODUCER BEHAVIOR

- Move in random direction in search of Food
- Move toward Food if seen



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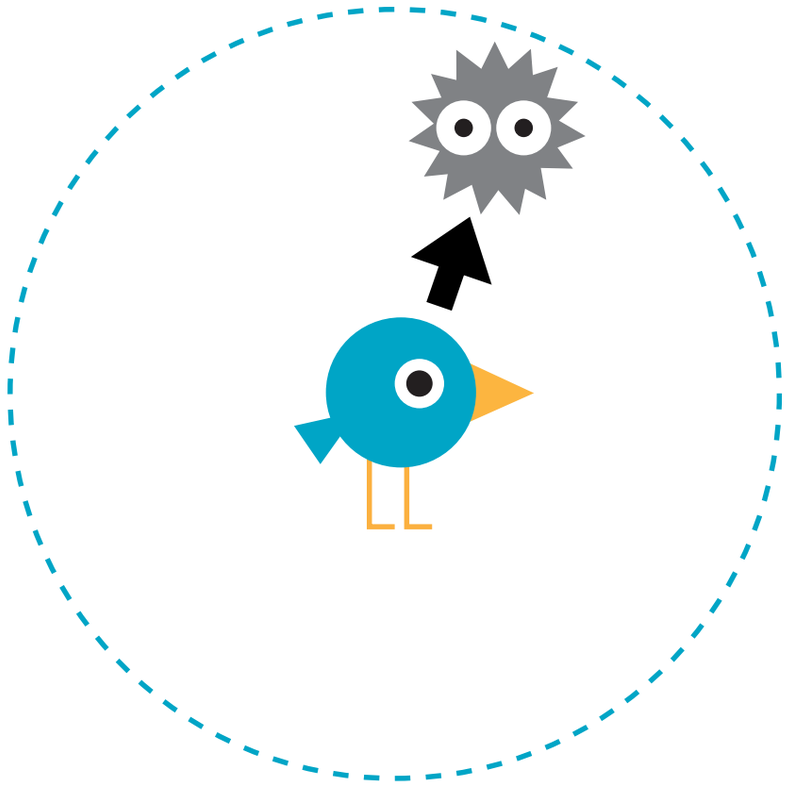
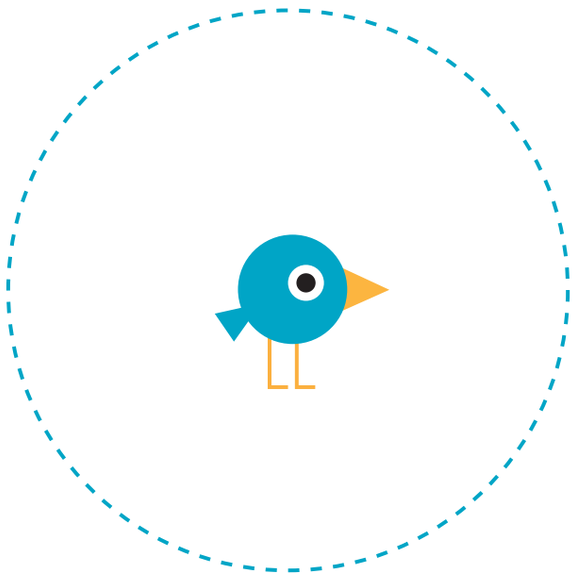


PRODUCER BEHAVIOR

- Move in random direction in search of Food
- Move toward Food if seen
- No Food: Decrease Satisfaction Level



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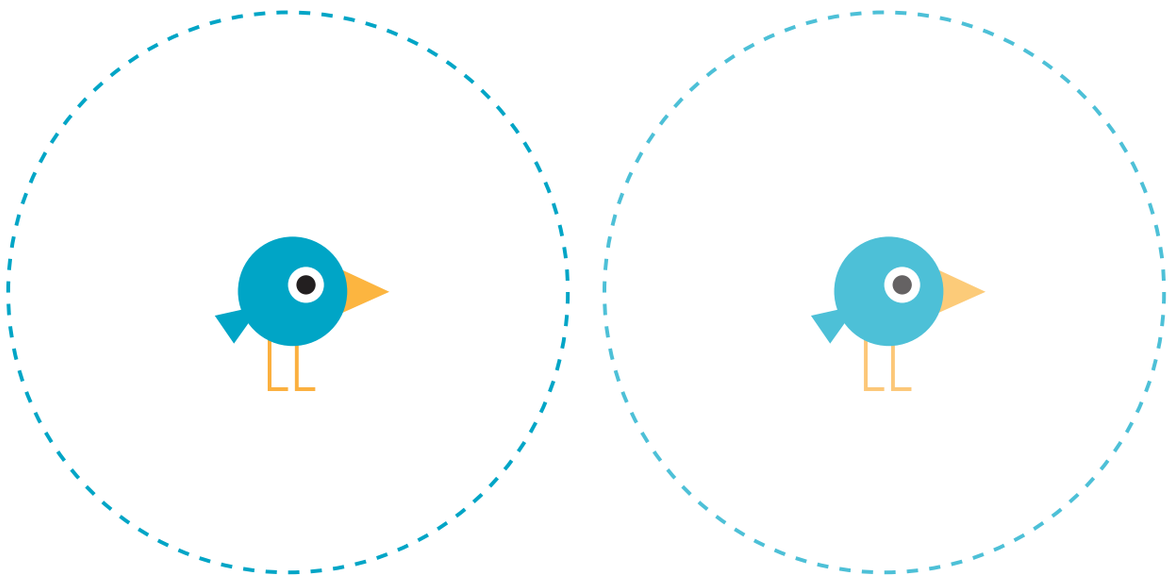

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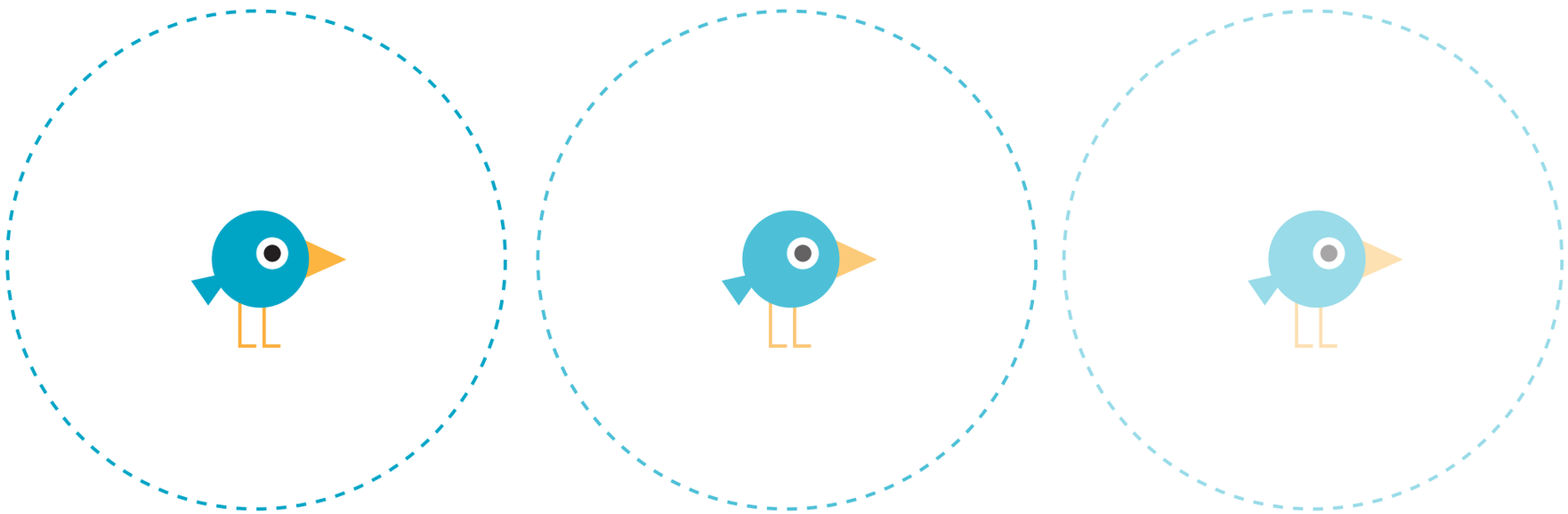

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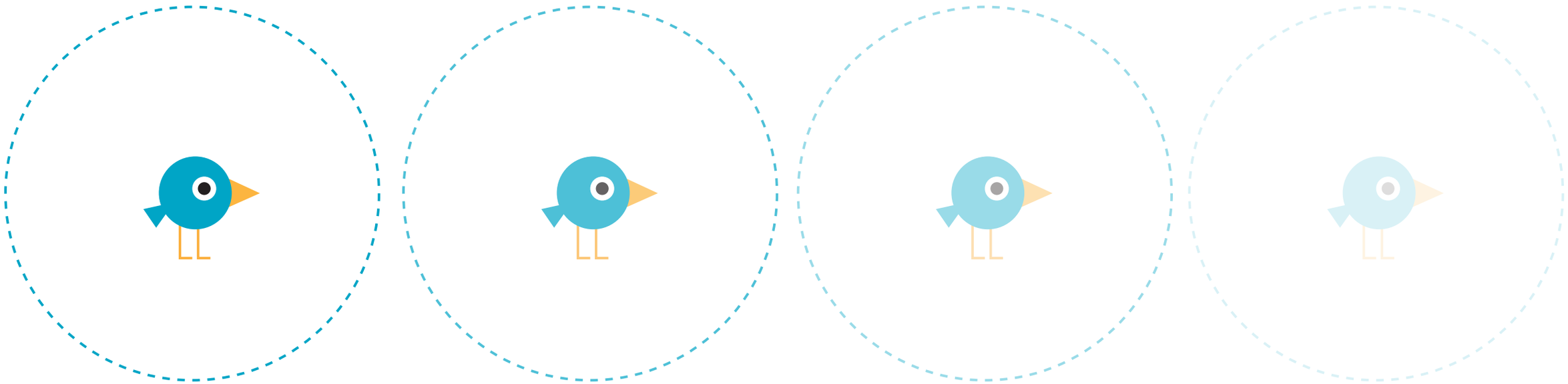

SCROUNGER BEHAVIOR

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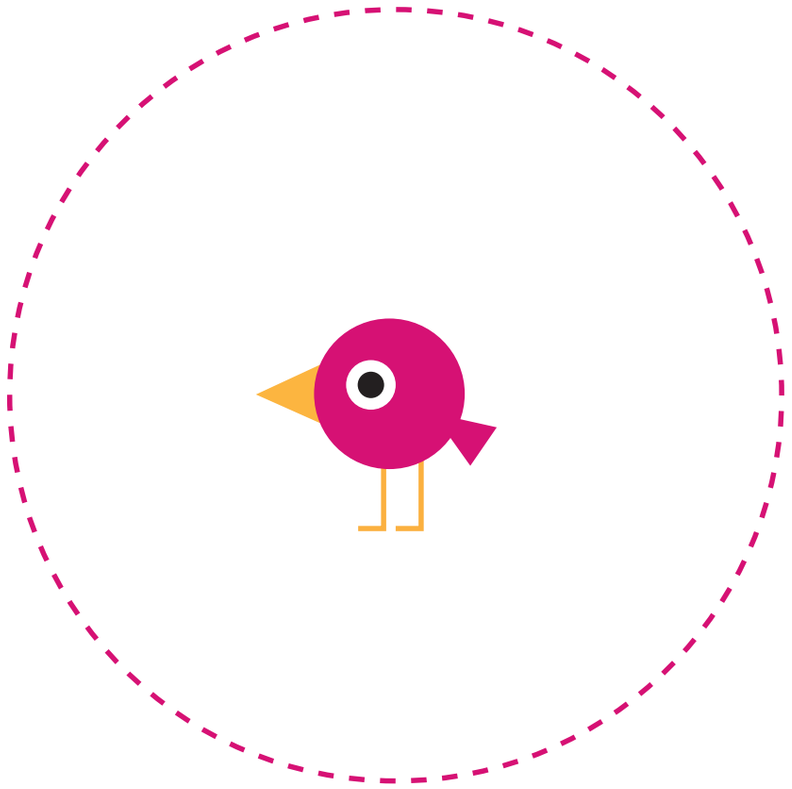
- See nothing: Stay Put



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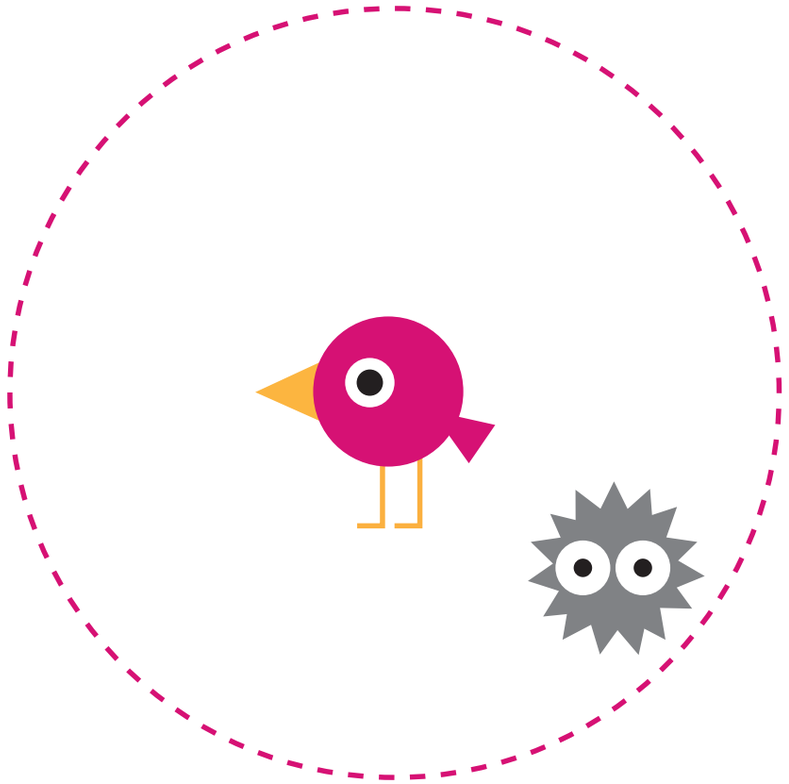

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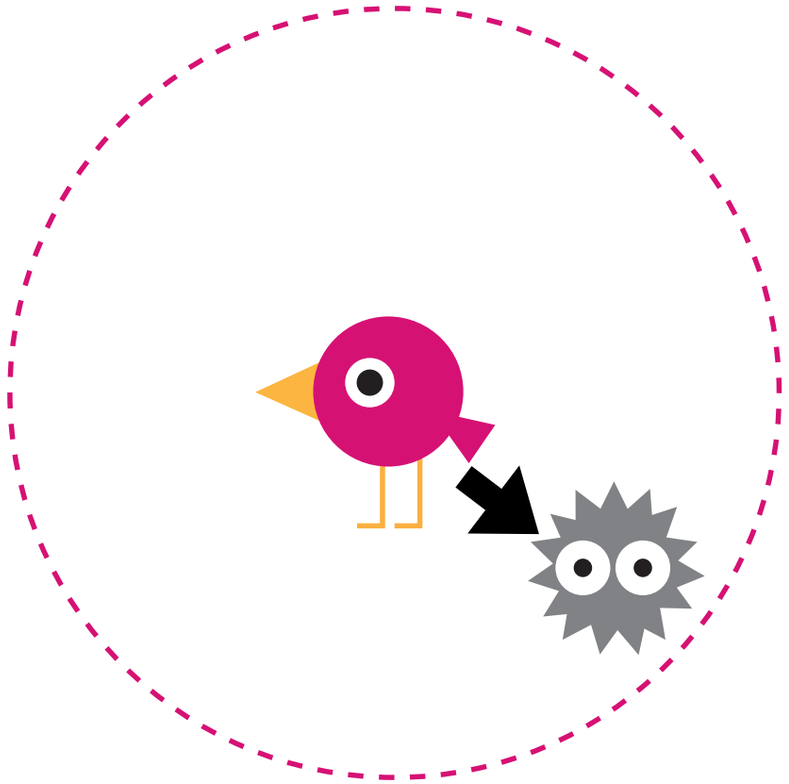
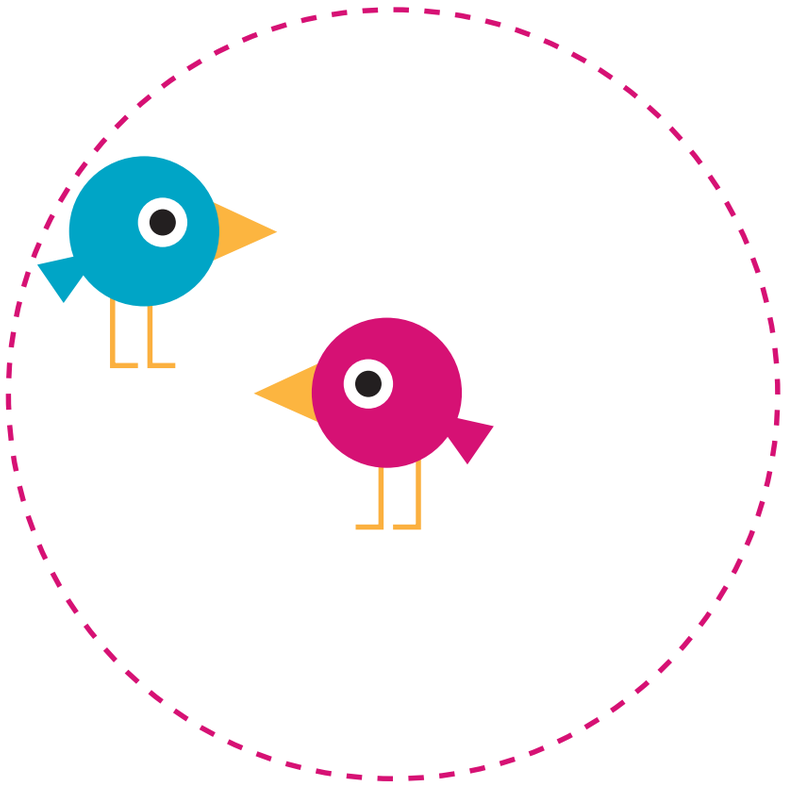


SCROUNGER BEHAVIOR

- See nothing: Stay Put
- Move toward Food if seen
- Move toward Producer if seen



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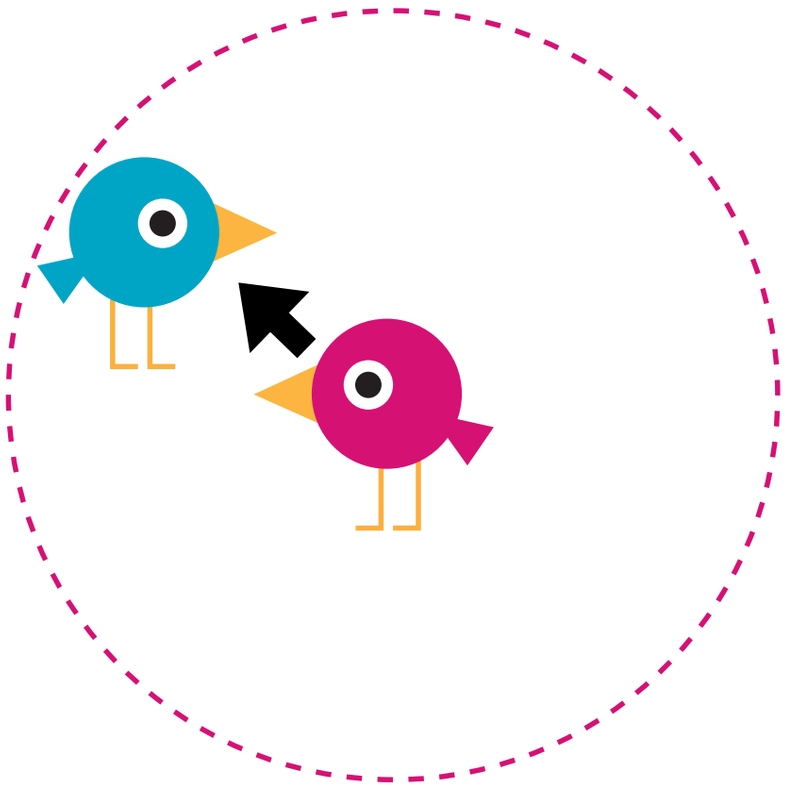

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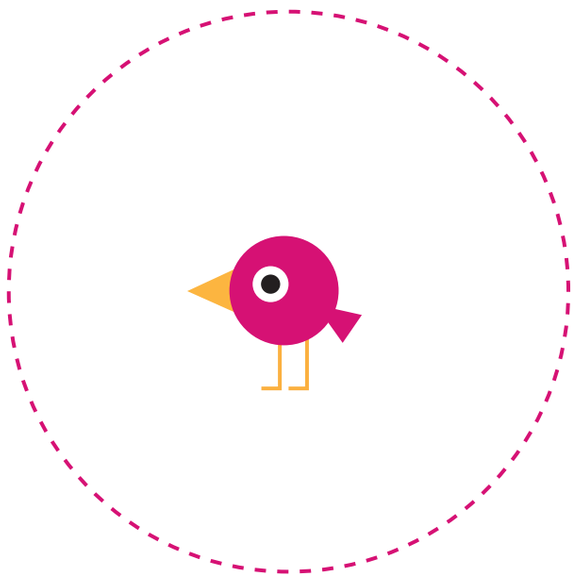

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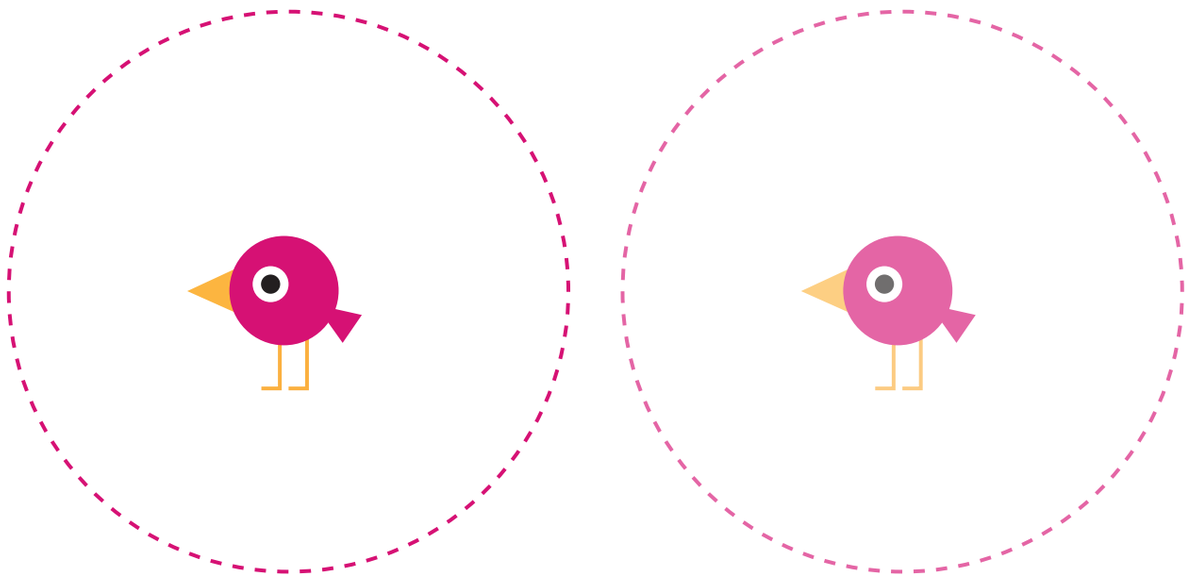

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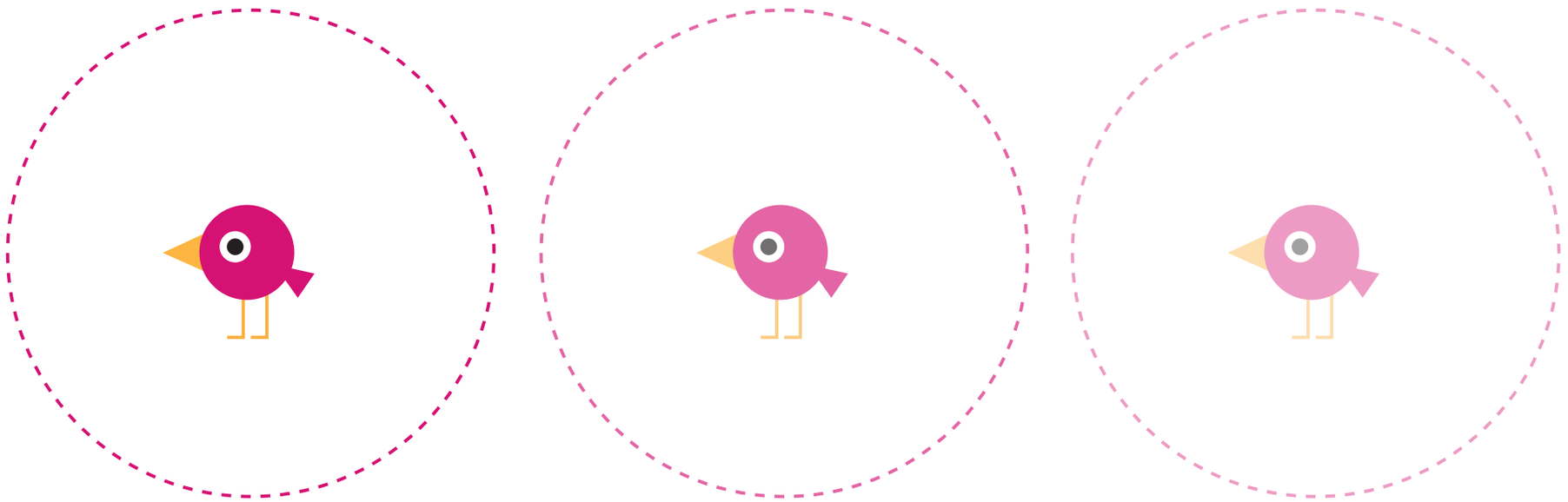

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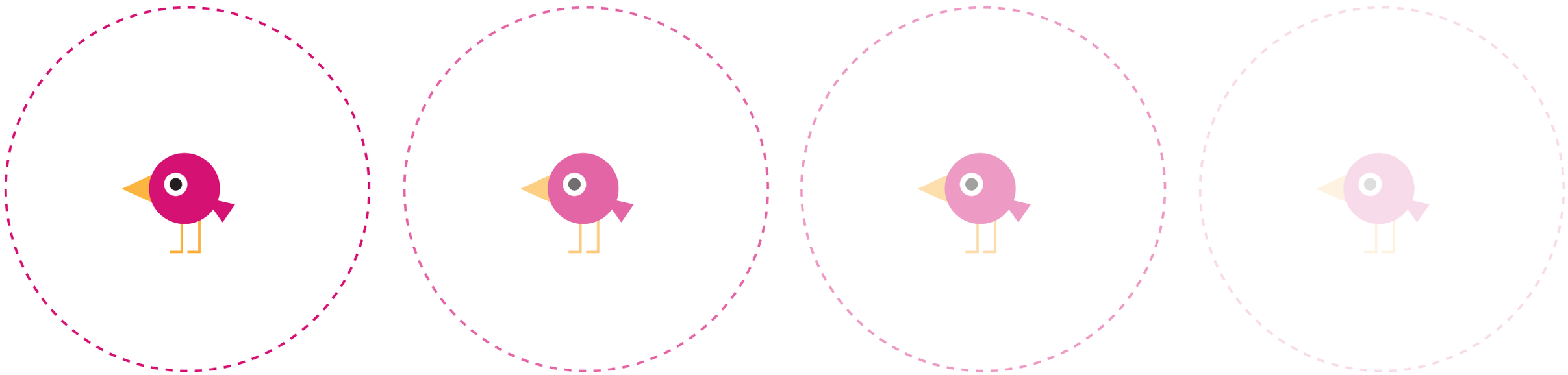
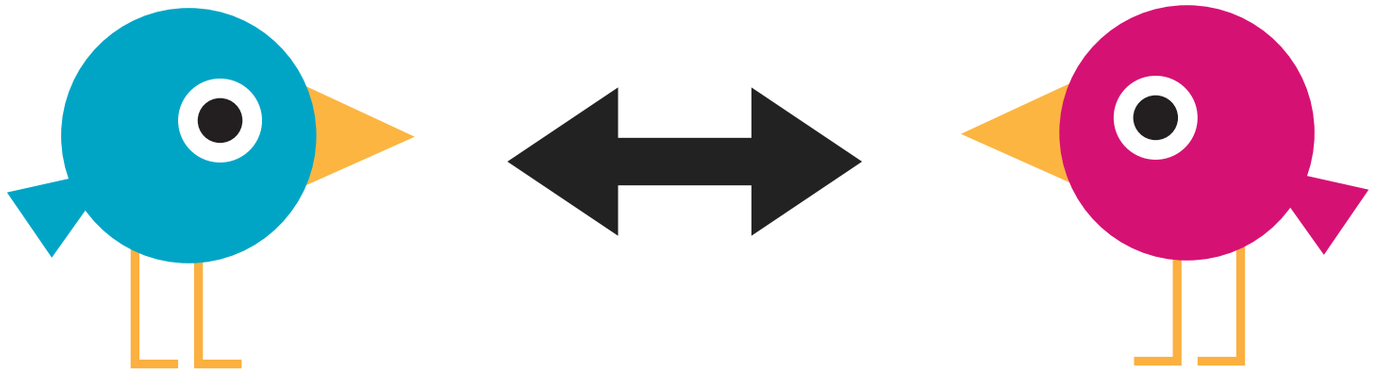
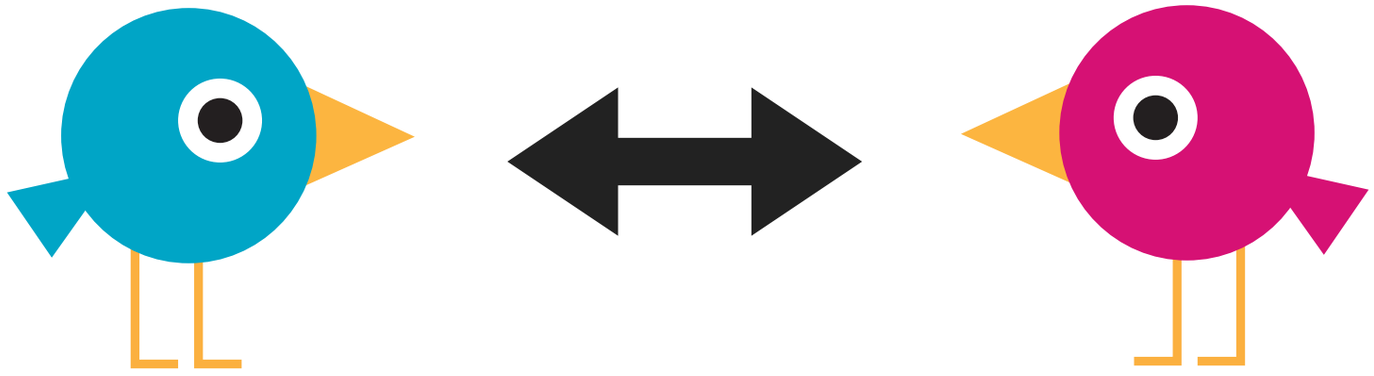


SWITCHING STRATEGIES

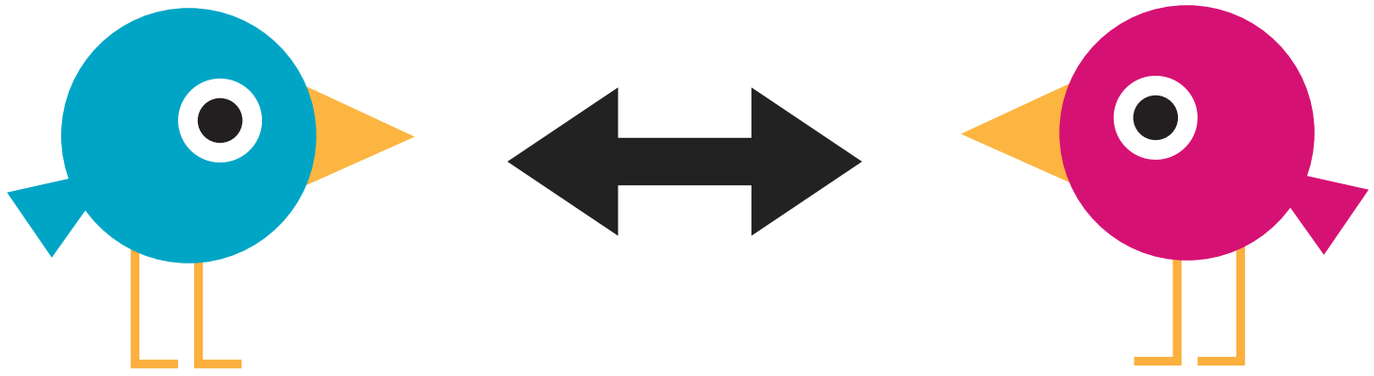


SWITCHING STRATEGIES



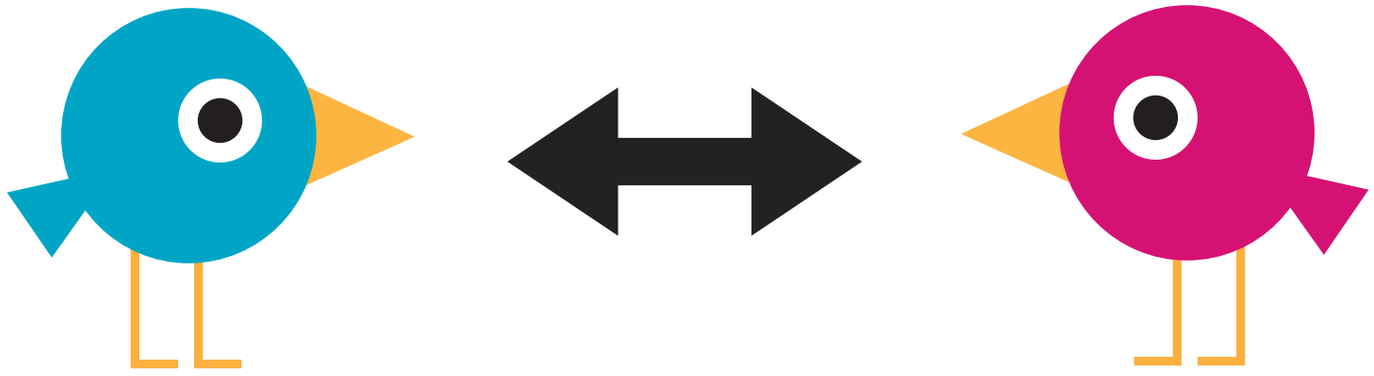
- Every duck assigned a Producing Probability ***p***

SWITCHING STRATEGIES



- Every duck assigned a Producing Probability ***p***
- When satisfaction below a certain threshold, re-select a Foraging Strategy

SWITCHING STRATEGIES



- Every duck assigned a Producing Probability ***p***
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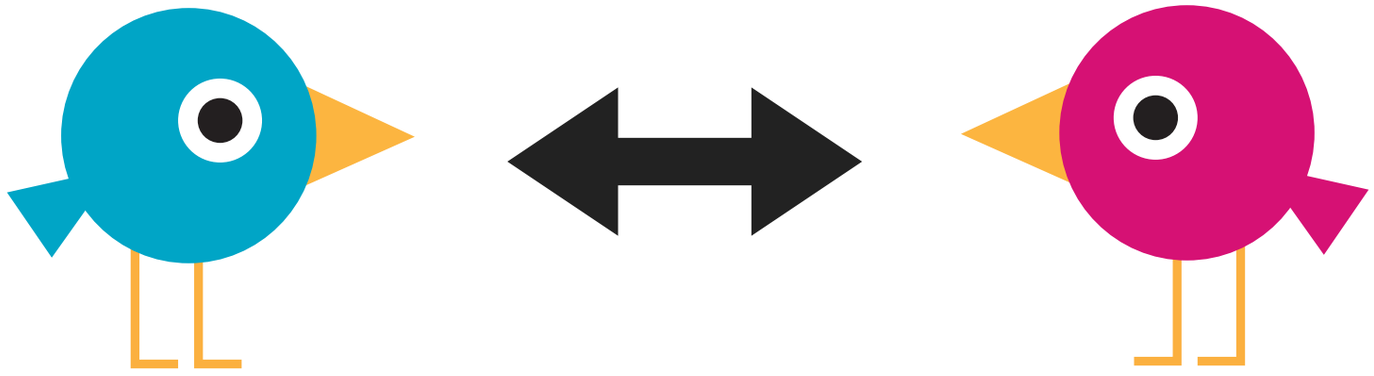
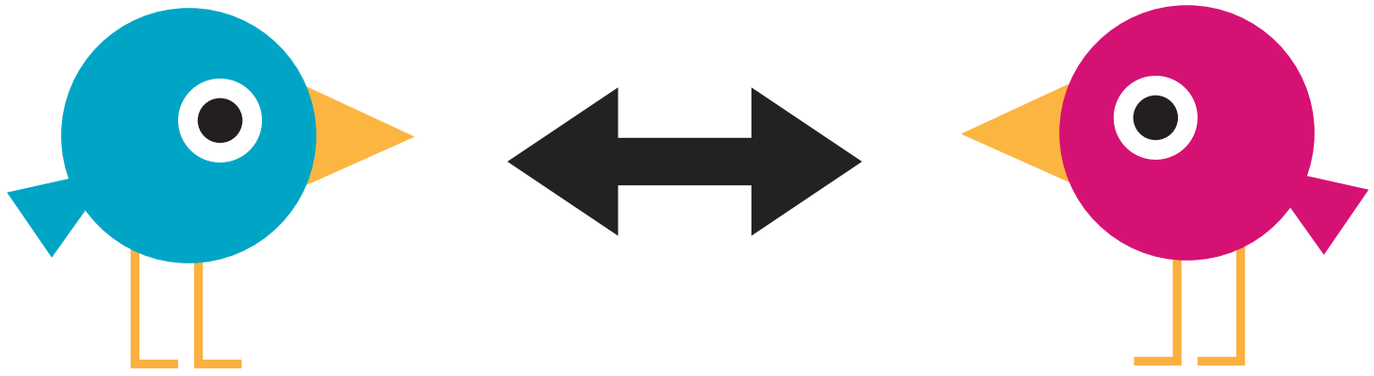
- Bernoulli Trial:

SWITCHING STRATEGIES



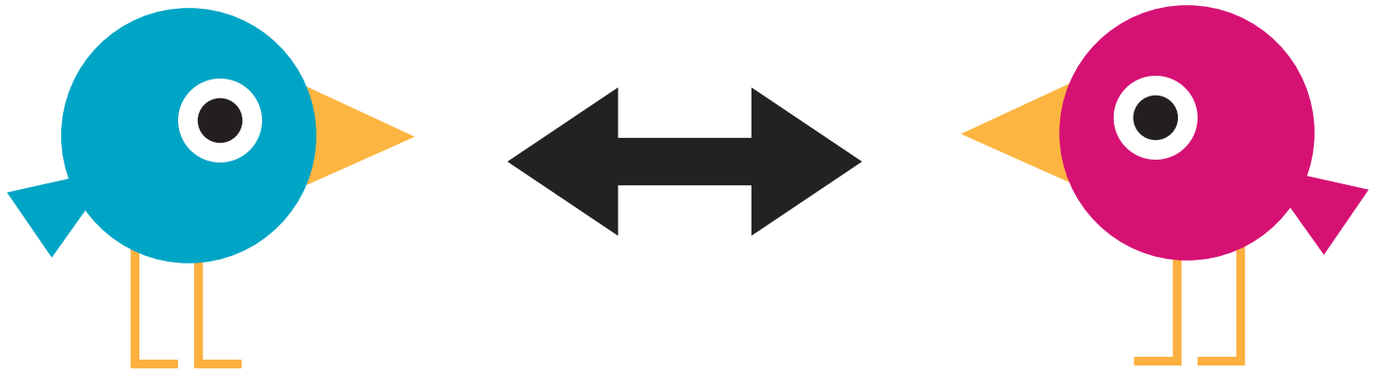
- Every duck assigned a Producing Probability ***p***
- When satisfaction below a certain threshold, re-select a Foraging Strategy
- Bernoulli Trial:
  - Producer with probability ***p***

SWITCHING STRATEGIES



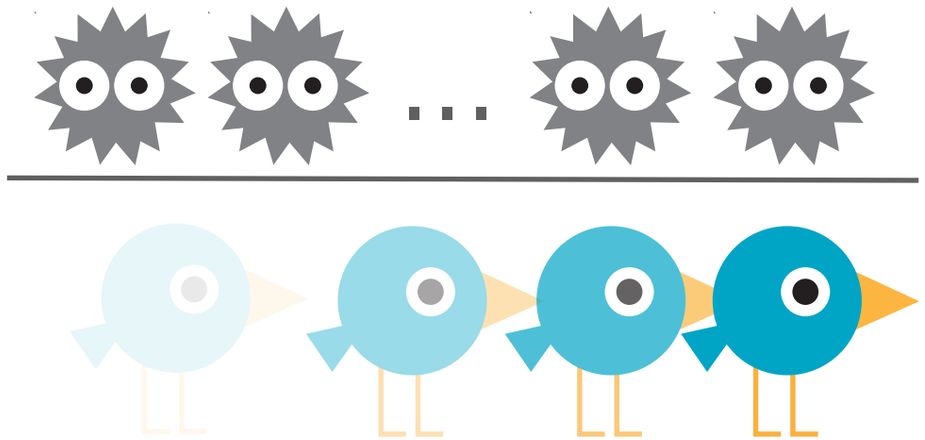
- Every duck assigned a Producing Probability ***p***
- When satisfaction below a certain threshold, re-select a Foraging Strategy
- Bernoulli Trial:
  - Producer with probability ***p***
  - Scrounger with probability ***1-p***

SWITCHING STRATEGIES

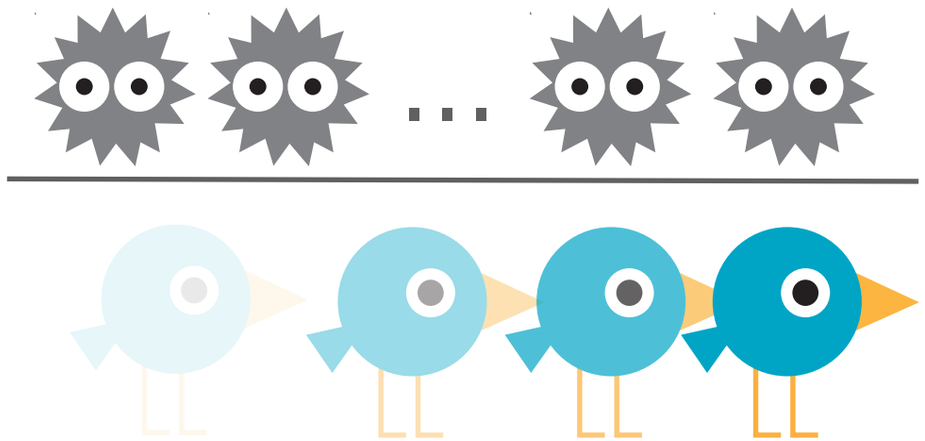


- Every duck assigned a Producing Probability ***p***
- When satisfaction below a certain threshold, re-select a Foraging Strategy
- Bernoulli Trial:
  - Producer with probability ***p***
  - Scrounger with probability ***1-p***
- Model can learn from past population successes

MEASURING SUCCESS

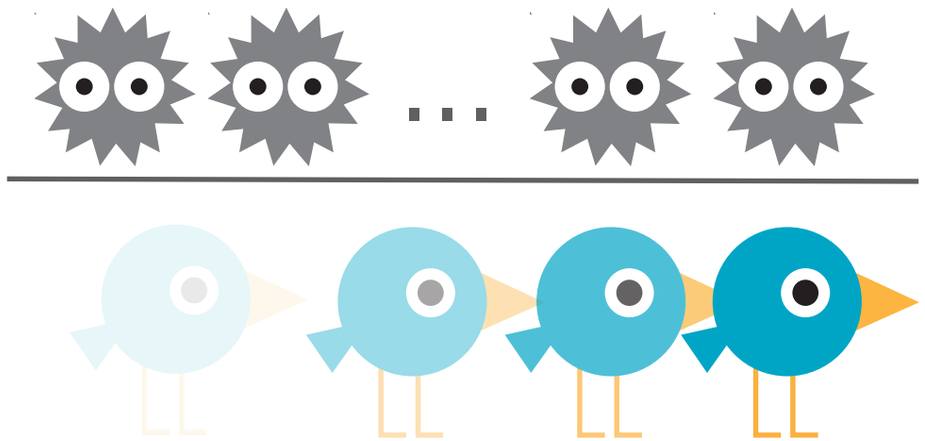


MEASURING SUCCESS



Food Eaten

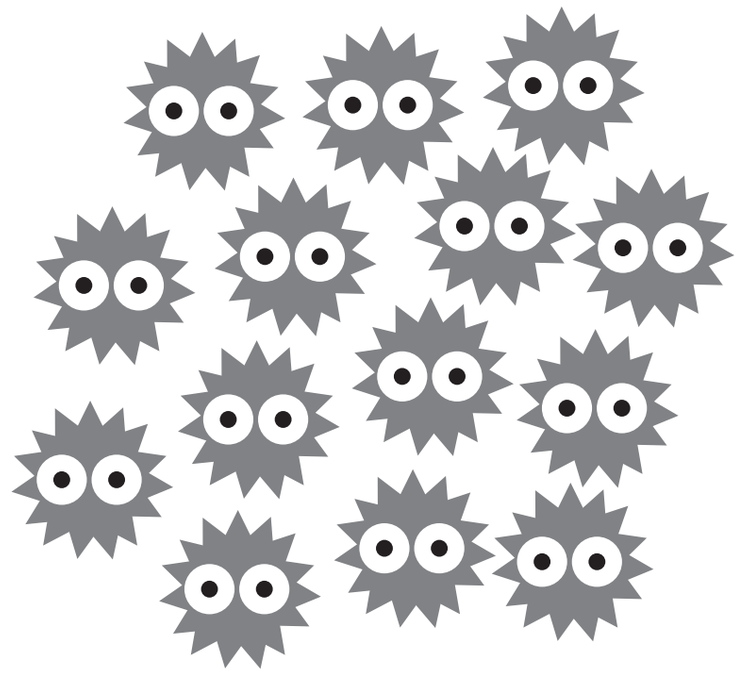
MEASURING SUCCESS



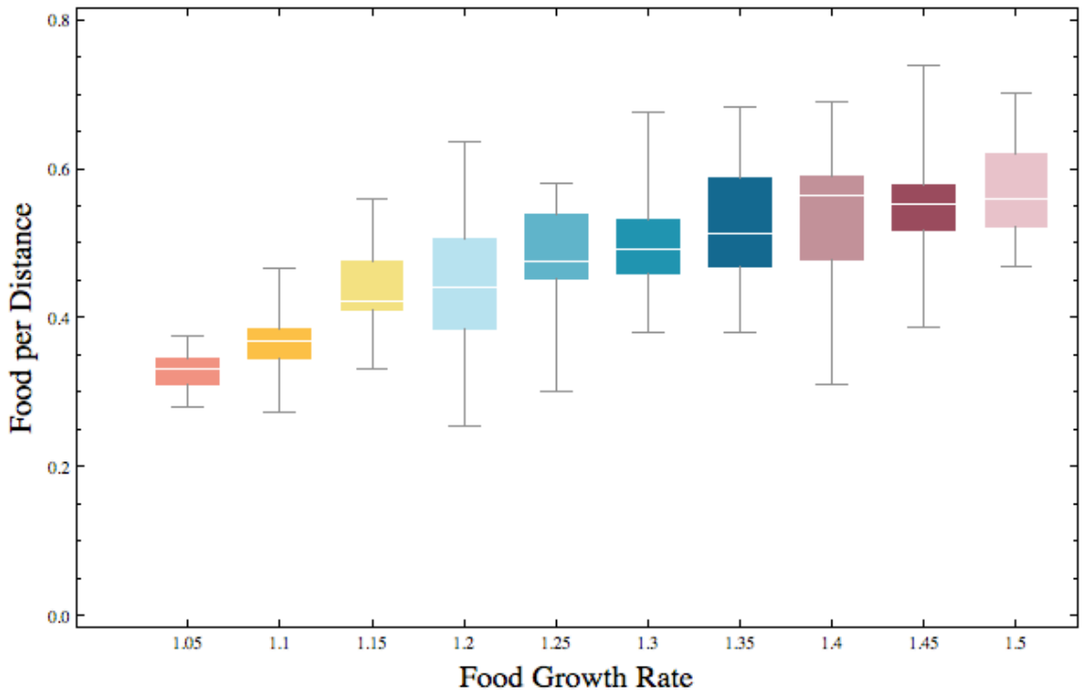
$$\frac{\text{Food Eaten}}{\text{Distance Traveled}}$$

MATHEMATICA SIMULATIONS

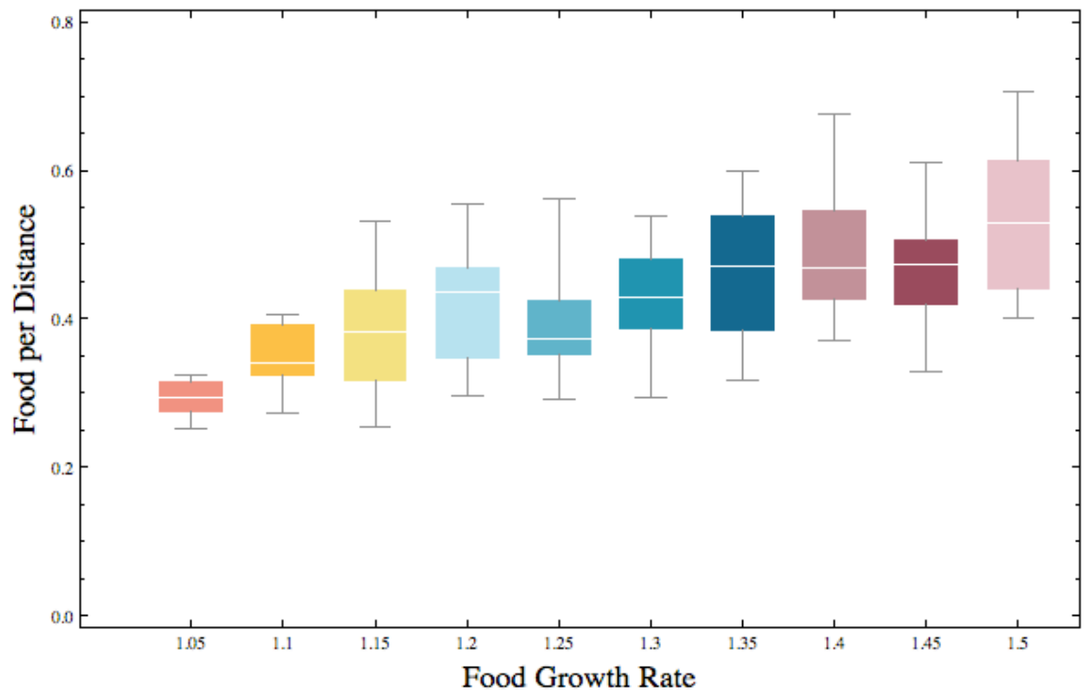
VARYING FOOD GROWTH RATE



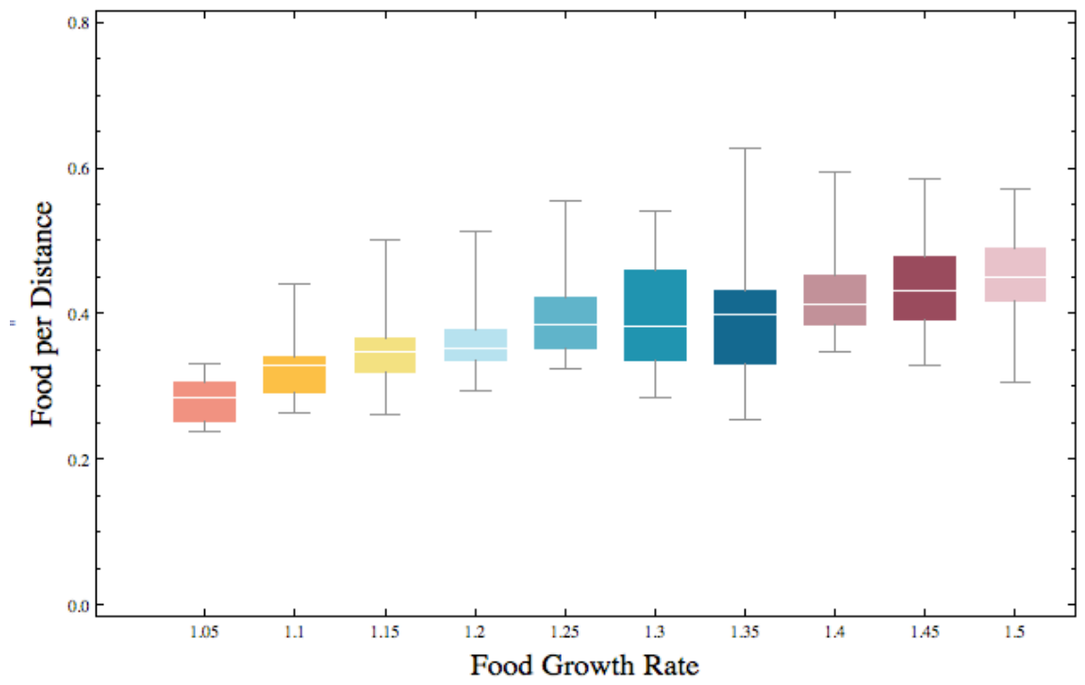
25% PRODUCERS



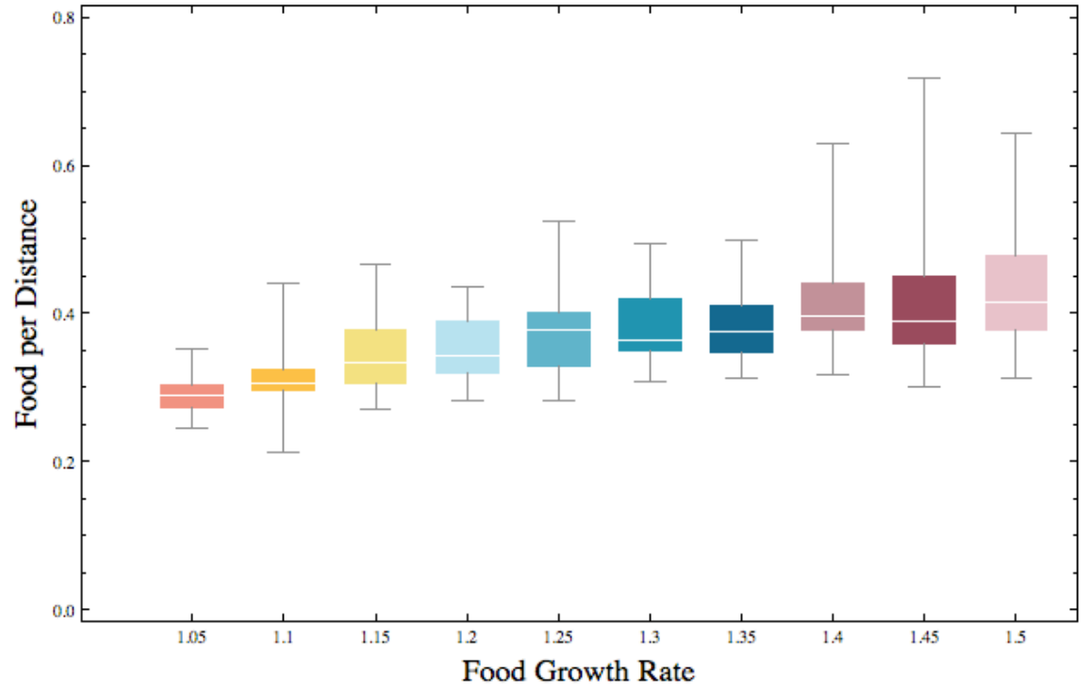
50% PRODUCERS



75% PRODUCERS

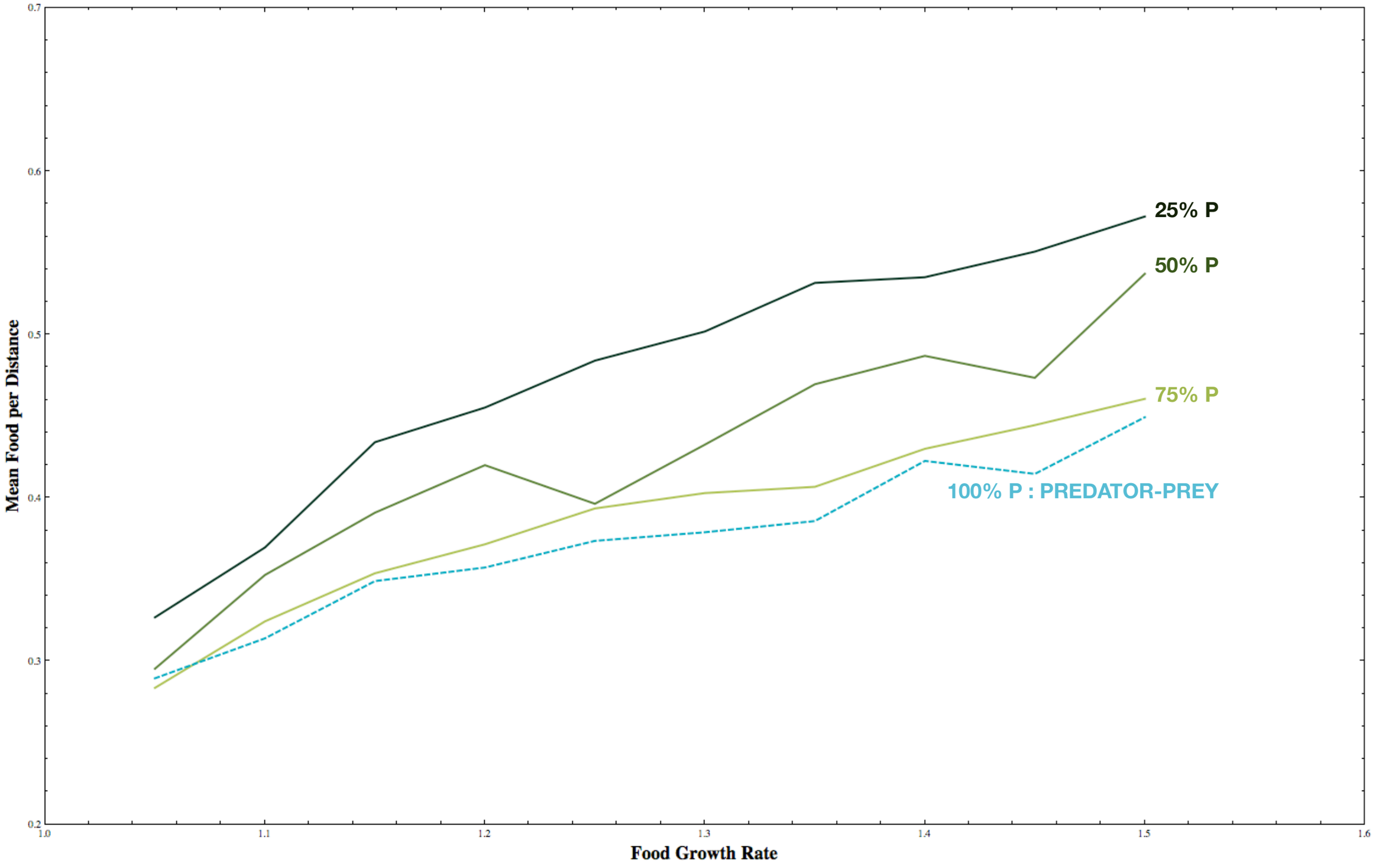


100% PRODUCERS



Constant Population Sizes
Average Food/Distance per 100 Time Steps
Varying Food Growth Rate: 20 Simulations Each

Total Population



Constant Population Sizes
Average Food/Distance per 100 Time Steps
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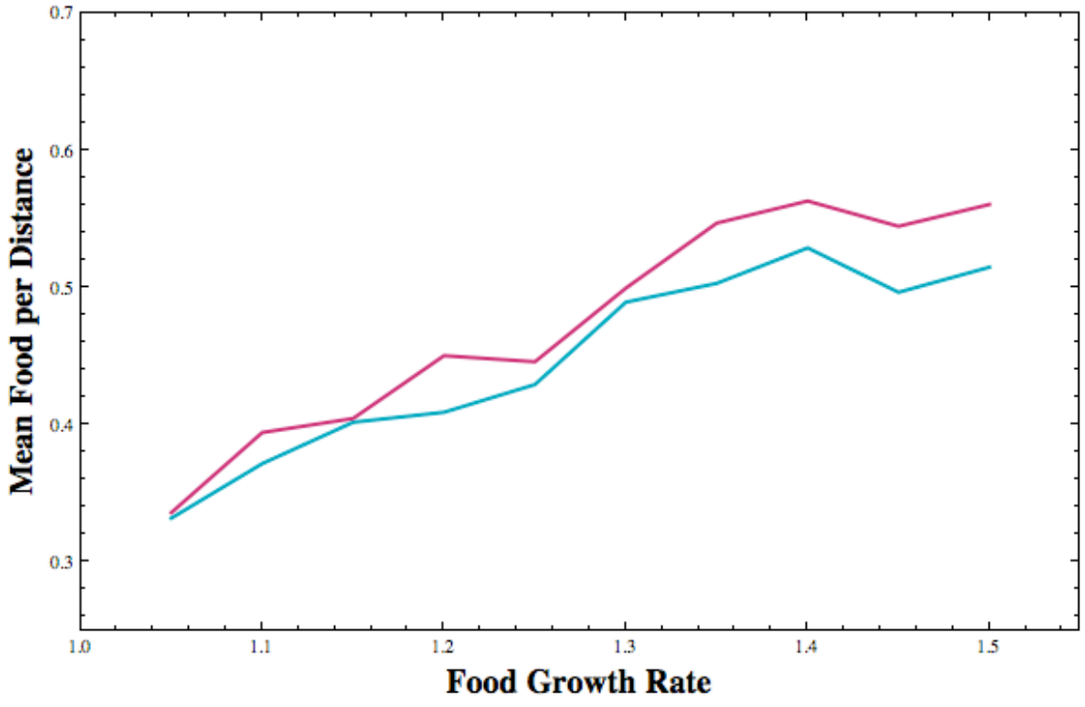
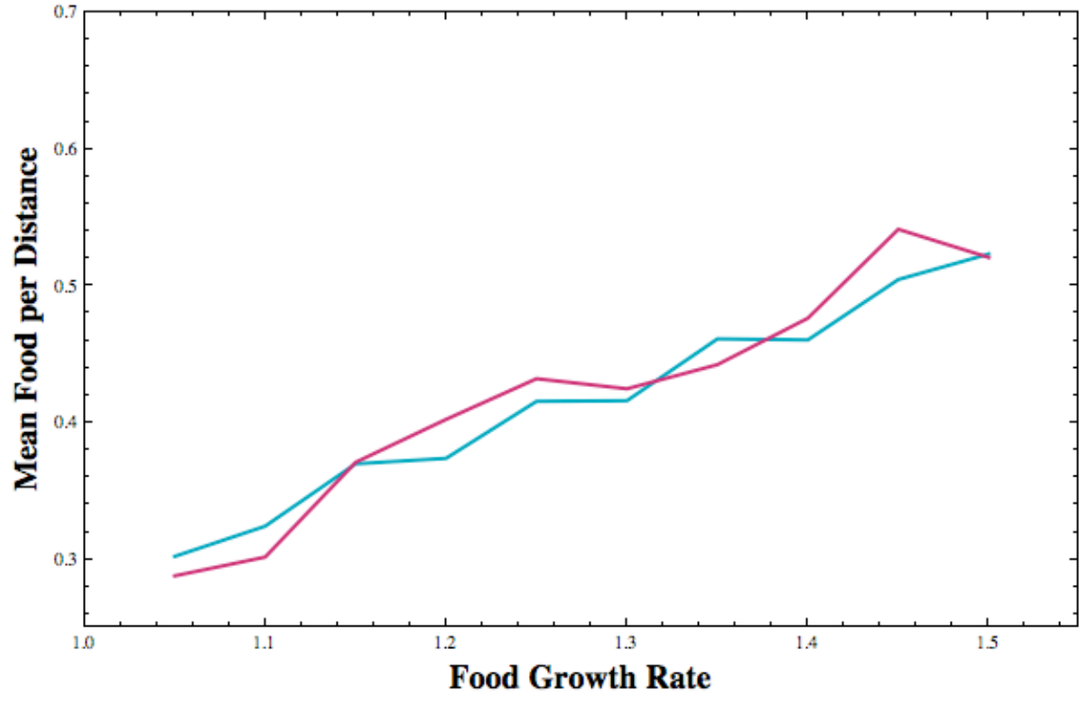
Total Population

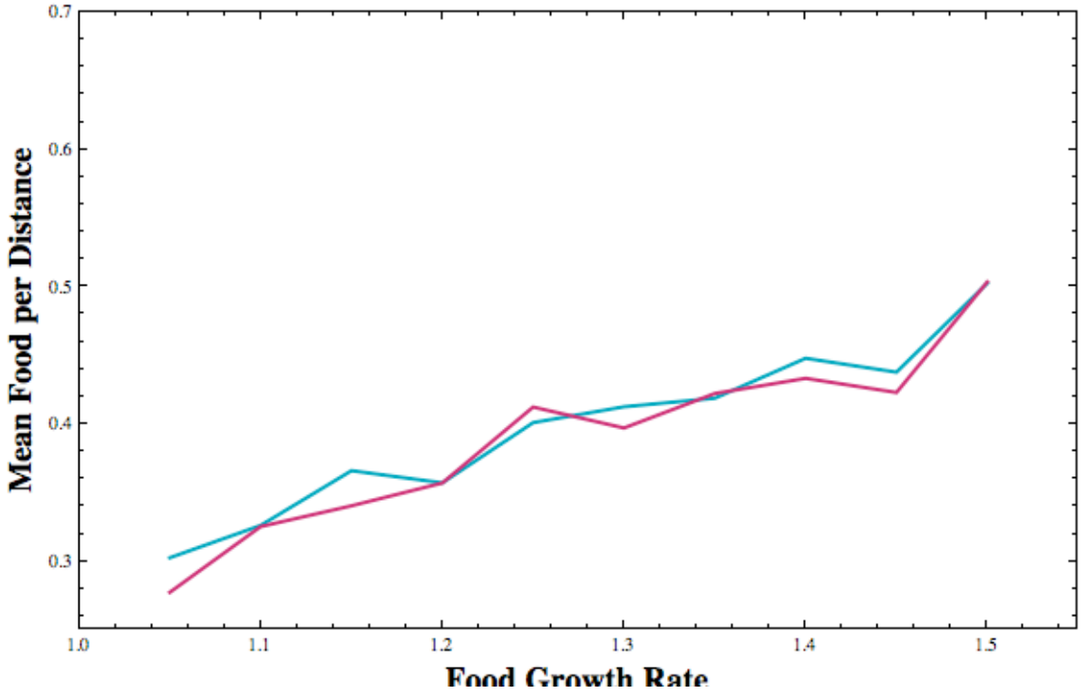
25% PRODUCERS



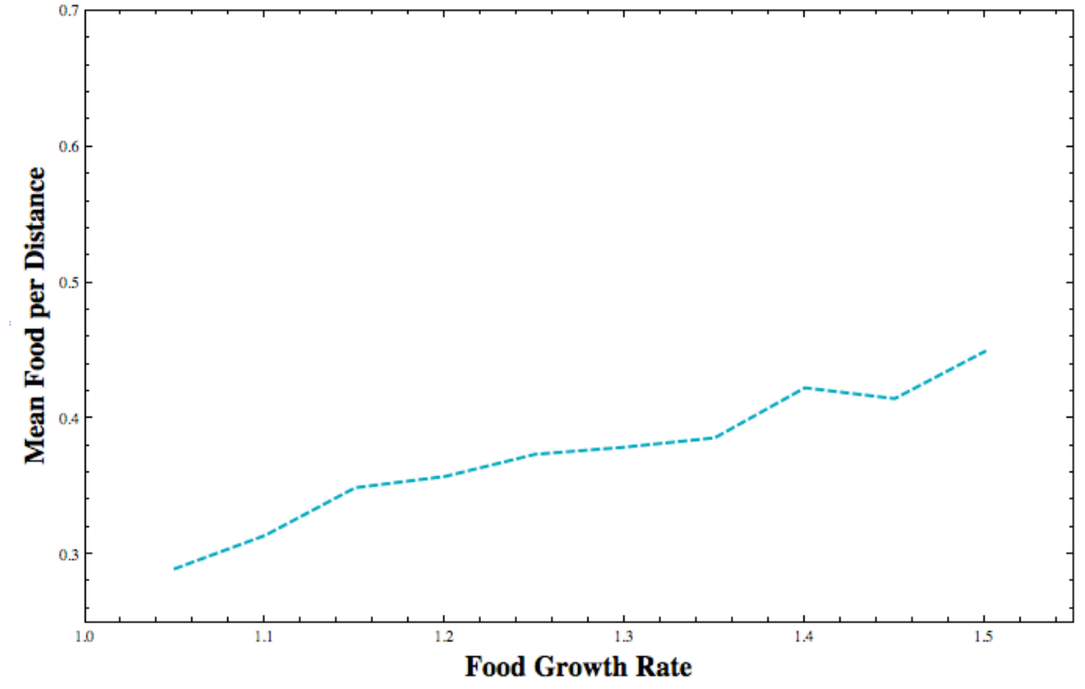
50% PRODUCERS



75% PRODUCERS

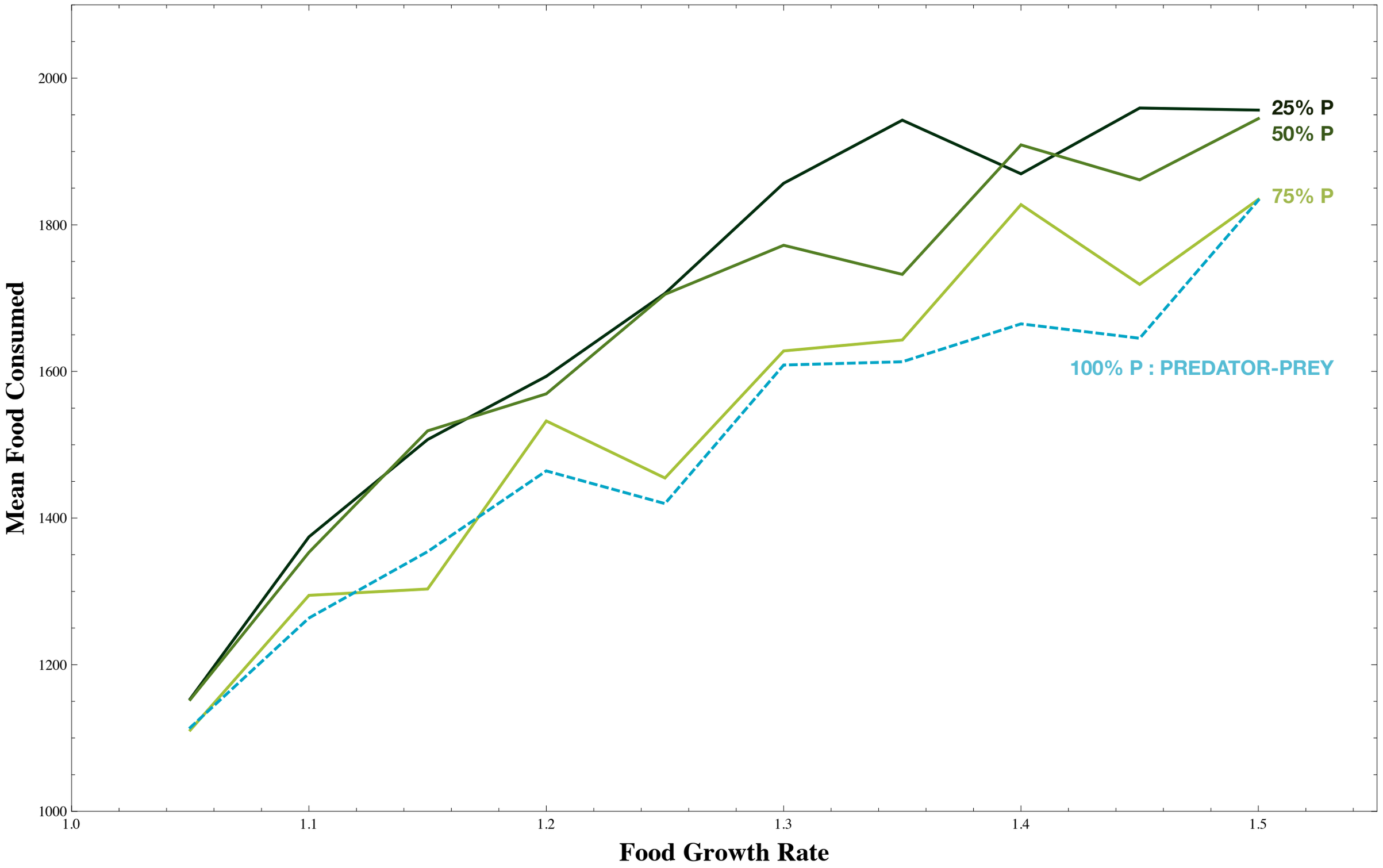


100% PRODUCERS : PRED–PREY



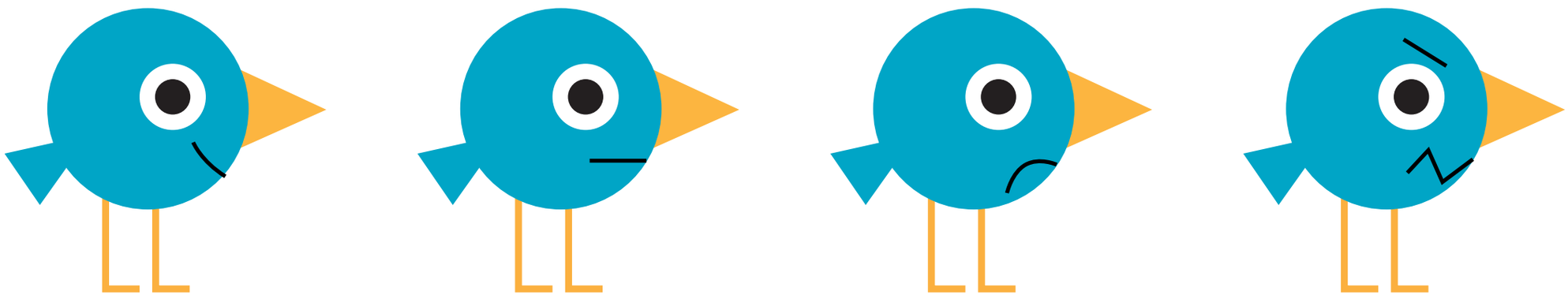
Constant Population Sizes
Average Food/Distance per 100 Time Steps
Varying Food Growth Rate: 20 Simulations Each

Producers Scroungers

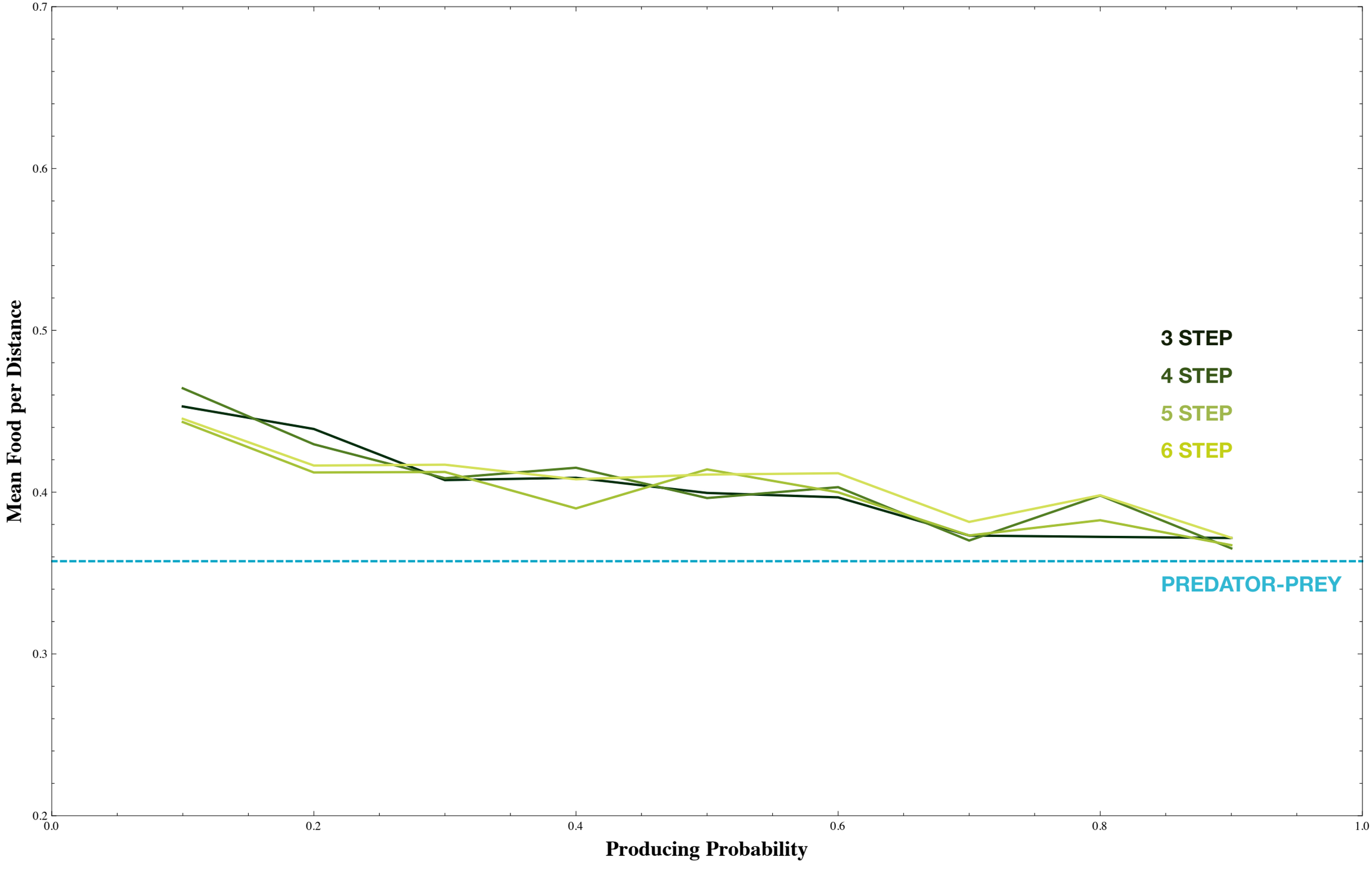


Constant Population Sizes
Average Food per 100 Time Steps
Varying Food Growth Rate: 20 Simulations Each

Total Population

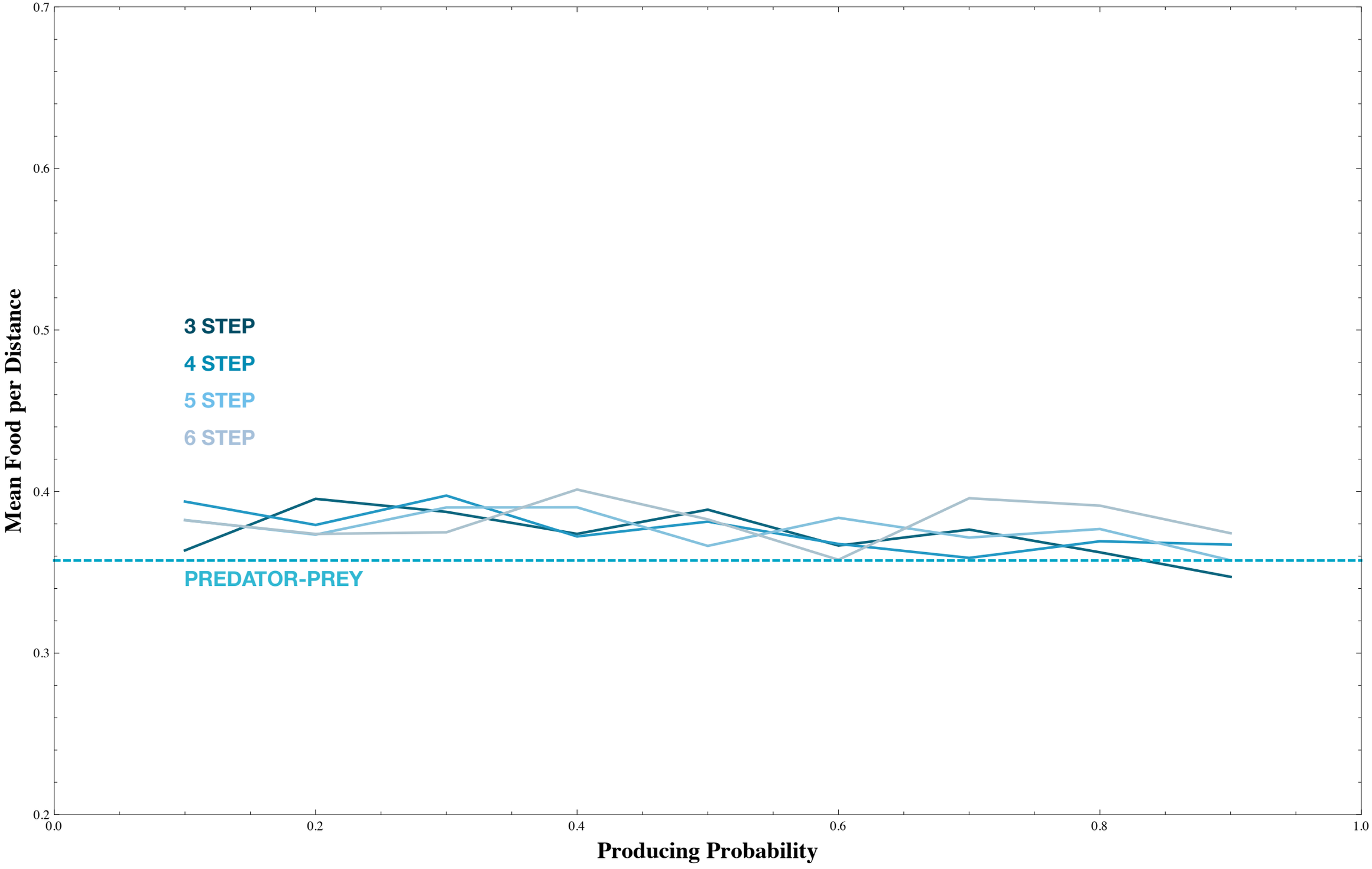


VARYING TOLERANCE THRESHOLD



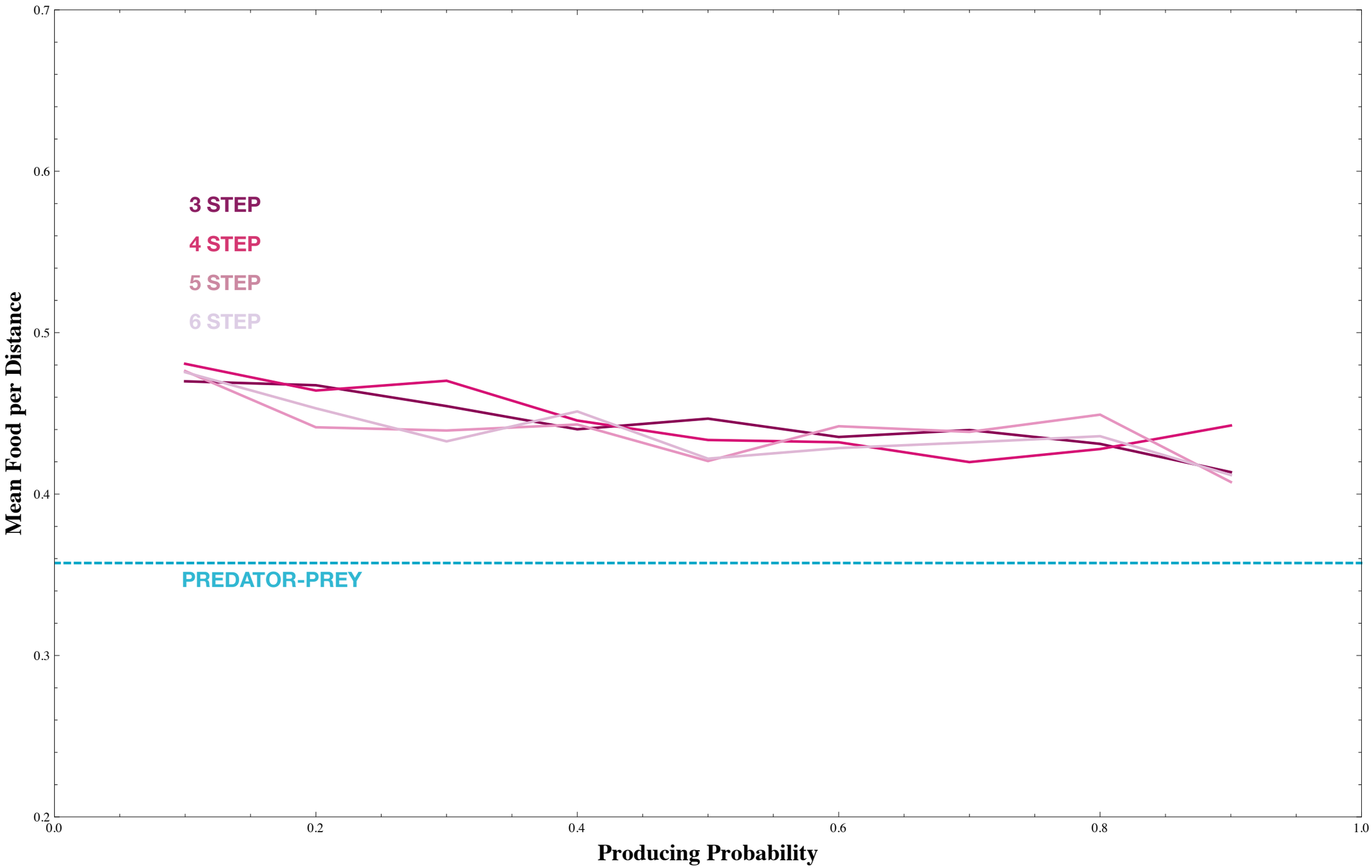
Varying Tolerance Thresholds
Average Food/Distance per 100 Time Steps
Varying Producing Probability: 20 Simulations Each

Total Population



Varying Tolerance Thresholds
Average Food/Distance per 100 Time Steps
Varying Producing Probability: 20 Simulations Each

Producers



Varying Tolerance Thresholds
Average Food/Distance per 100 Time Steps
Varying Producing Probability: 20 Simulations Each

Scroungers

ODE MODEL

Producer-Scrounger Model
Inspired by the Predator-Prey Model

$$\frac{dF}{dt} = aF\left(1 - \frac{F}{L}\right) - b(P+S)F$$

$$\frac{dP}{dt} = -dP + cPF - cPF\frac{S}{S+x_0}$$

$$\frac{dS}{dt} = -dS + cPF\frac{S}{S+x_0}$$

Different Types of Long-Term Behavior

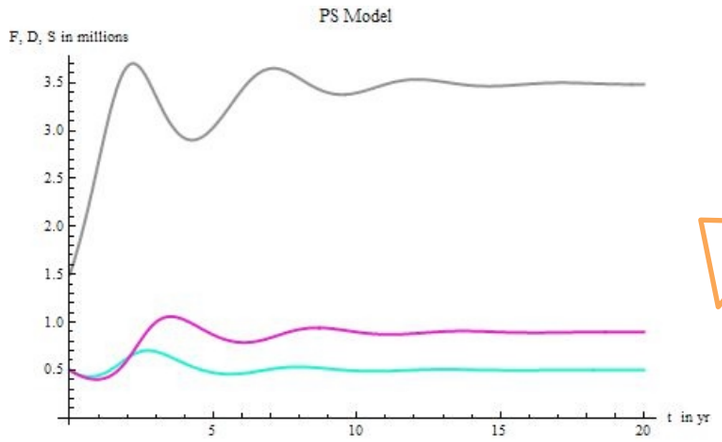
food, producers, scroungers coexist

only food survives

only scroungers die

nothing exists

Different Types of Long-Term Behavior



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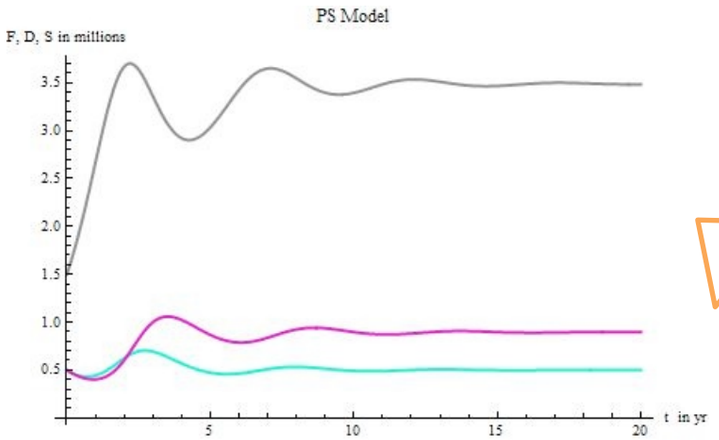

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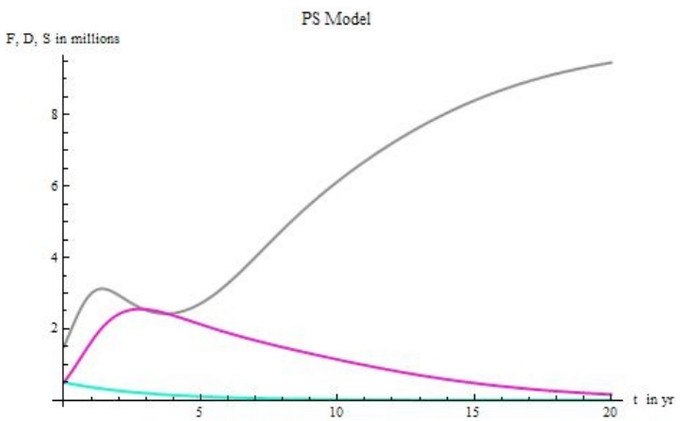

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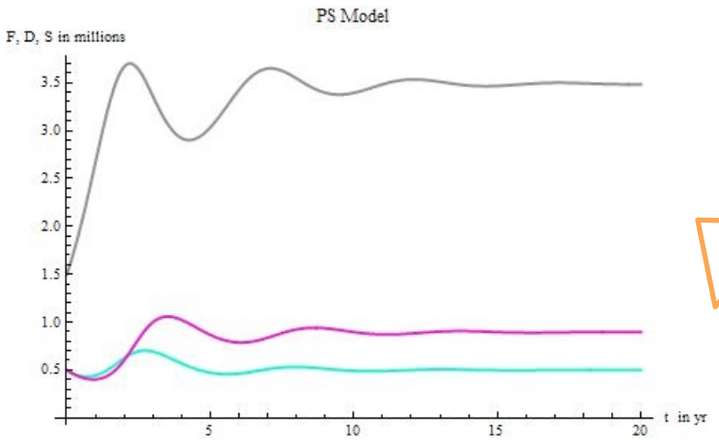
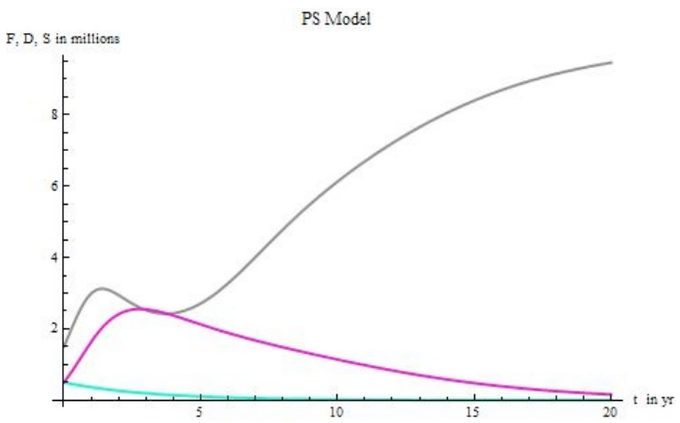
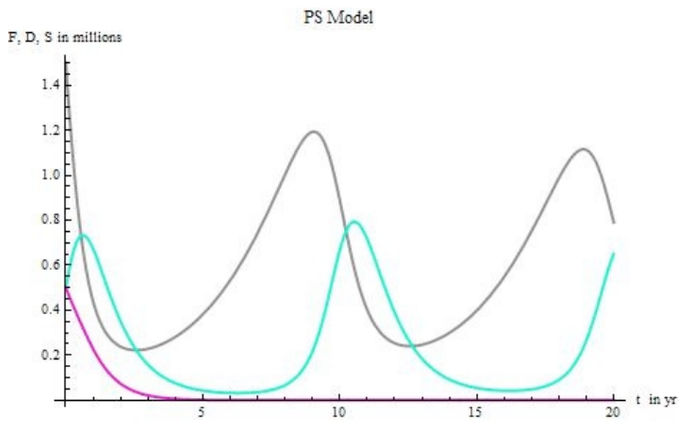
Different Types of Long-Term Behavior



food, producers, scroungers coexist



only food survives



only scroungers die

nothing exists

Summary

- Producer-Scrounger Interaction
  - Patchy, sparse food distribution

- Effect on Population
  - Food eaten/energy expended (Discrete Model)
  - Long-term population levels (ODE Model)

Future Work

- Refining behavior rules
-

Special Thanks To

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