II Southern-Summer School on Mathematical Biology

Filling the stomach of the enemy: how does seed masting work?

Group #1

Claudia Buss
Lloyd Sanders
Marcelo Awade
Nicolas Seoane
Tomas Aquino
Willian Silva

- Introduction

  What is seed masting?
  Types of masting.
  Hypotheses for masting.

- Methods

  Variables
  Models
  Simulations

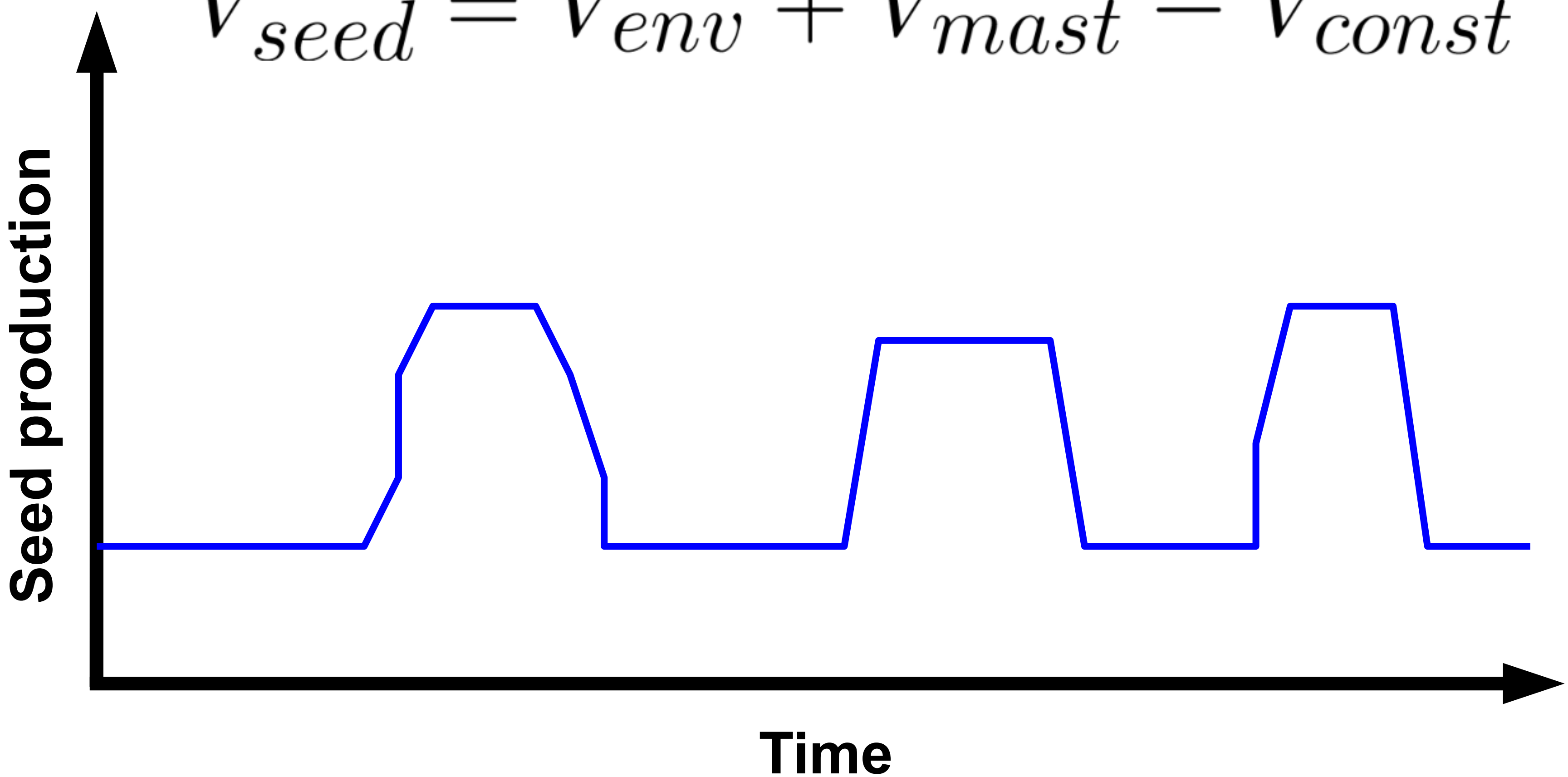
- Results

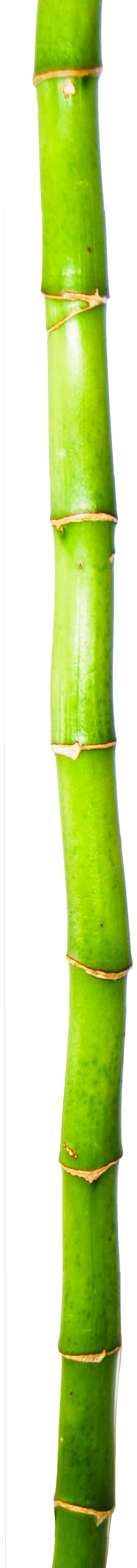
- Conclusion

What is mast seeding?

Masting is the intermittent synchronous production of seeds at long intervals by a population of plants.

$$V_{seed} = V_{env} + V_{mast} - V_{const}$$





Types of masting

Strict masting

- Bimodal seed output with **no** overlap between tails.
- When highly synchronized, mast years can be objectively distinguished.
- Shown only for highly synchronized monocarps, e.g. bamboo and *Strobilanthes*.

Types of masting

Normal masting

- Bimodal seed output **with** overlap between tails (statistically significant bimodality).
- Statistical identification of mast years is sample-size dependent.
- Example: genus *Quercus*.

Types of masting

Putative masting

- Seed output varies greatly but no evidence for switching.
- Not really masting, unless bimodality or switching is shown.
- Example: most published papers on masting.

Types of masting

Strict masting

- Bimodal seed output with **no** overlap between tails.
- When highly synchronized, mast years can be objectively distinguished.
- Shown only for highly synchronized monocarps, e.g. bamboo and *Strobilanthes*.

Normal masting

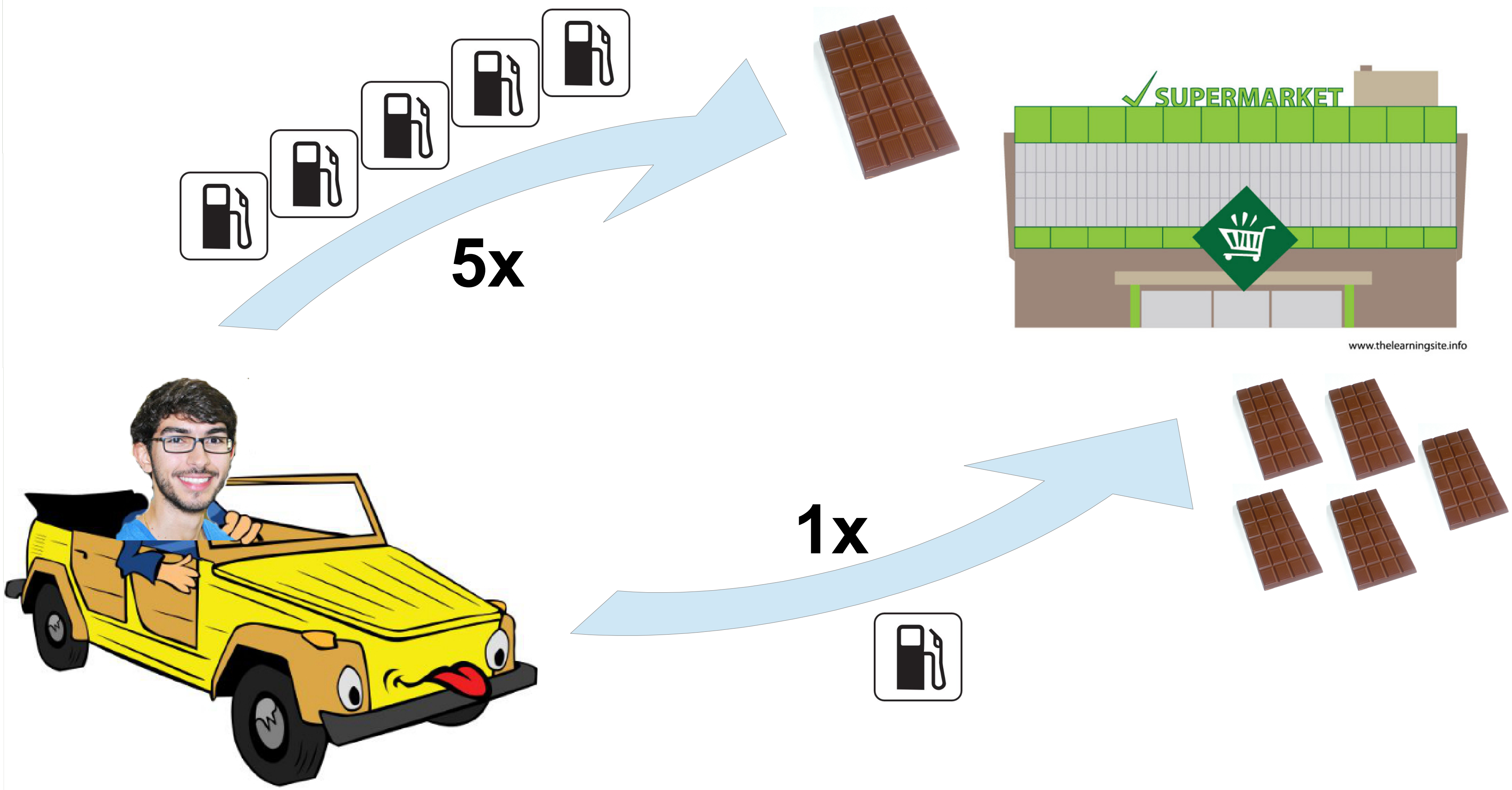
- Bimodal seed output **with** overlap between tails (statistically significant bimodality).
- Statistical identification of mast years is sample-size dependent.
- Example: genus *Quercus*.

Putative masting

- Seed output varies greatly but no evidence for switching.
- Not really masting, unless bimodality or switching is shown..
- Example: most published papers on masting.

Possible ecological advantages of masting

"Economies of scale" = larger reproductive efforts are more efficient, favouring occasional large efforts rather than regular smaller ones.



Possible ecological advantages of masting

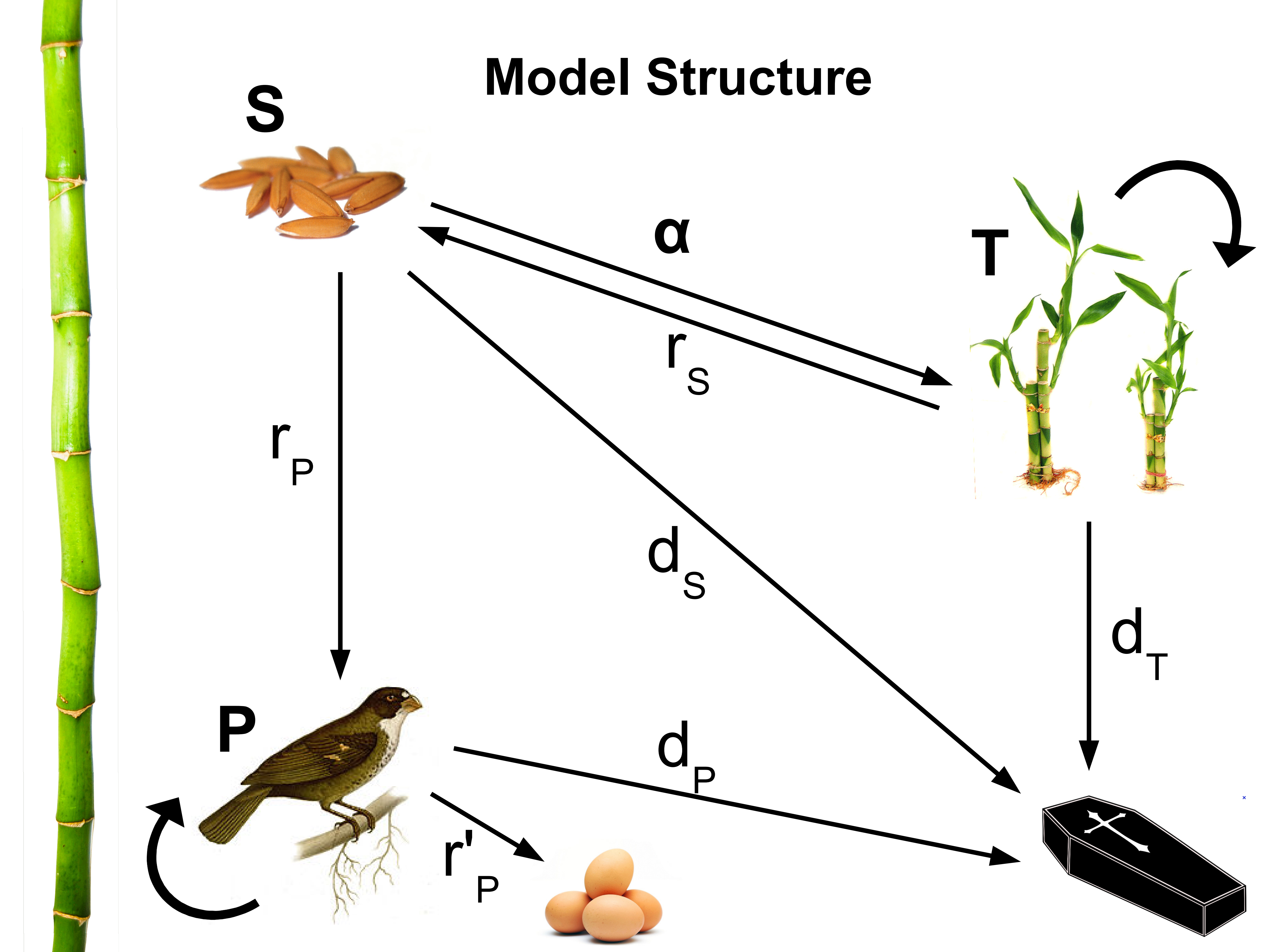
"Economies of scale" = larger reproductive efforts are more efficient, favouring occasional large efforts rather than regular smaller ones.

- Wind pollination
- Animal dispersal
- Resource matching
- Accessory costs
- Large seed size
- Environmental prediction
- Animal pollination
- Predator satiation

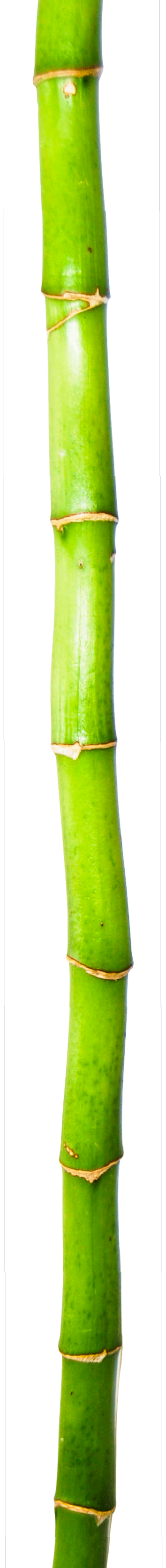
Possible ecological advantages of masting

"Economies of scale" = larger reproductive efforts are more efficient, favouring occasional large efforts rather than regular smaller ones.

Predator satiation


Model Structure
S
T
P
α
r_S
r_P
d_S
d_T
d_P
r'_P

Is masting a good strategy?



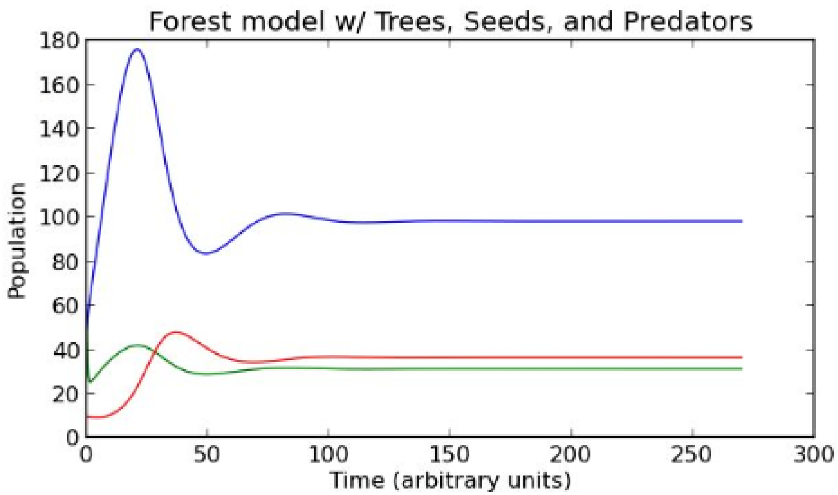
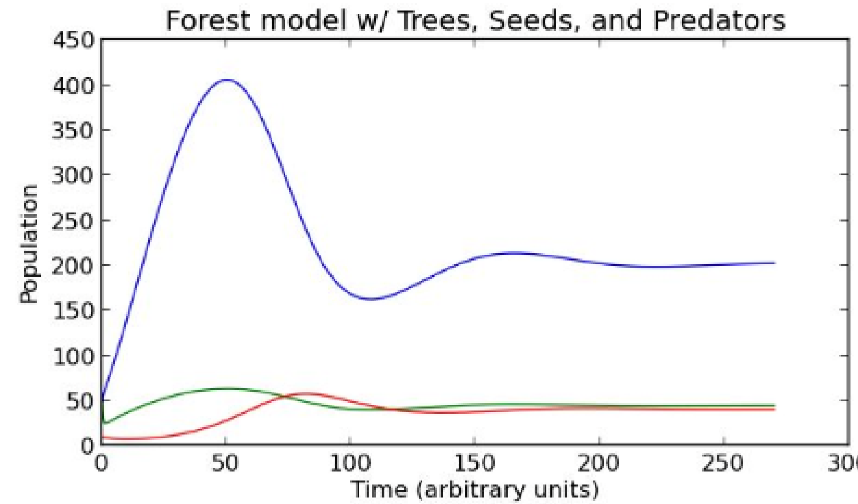
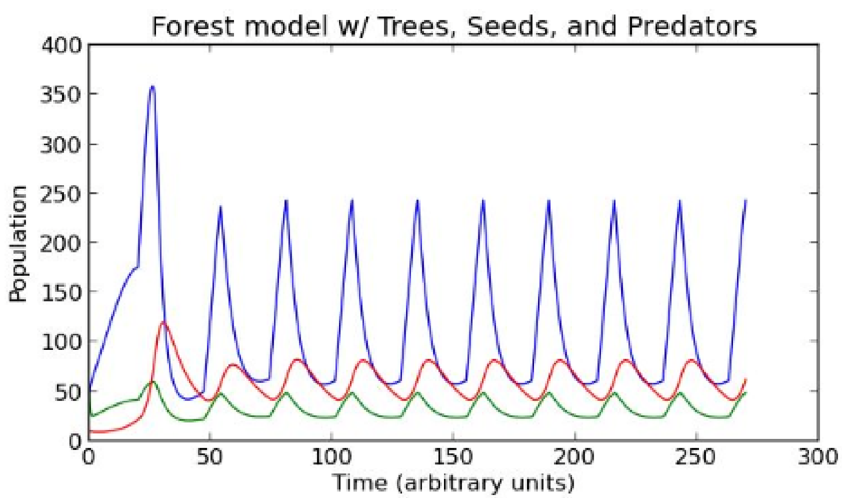
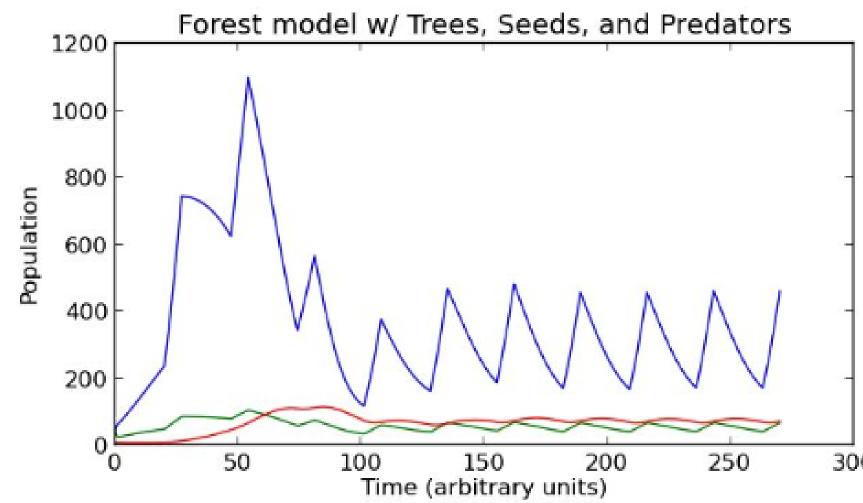
Single-Species Model

$$\frac{\mathrm{d}T}{\mathrm{d}t} = \alpha S - d_T T - \frac{T^2}{K_T}$$

$$\frac{\mathrm{d}S}{\mathrm{d}t} = r_S T - r_P \frac{SP}{f + \gamma S} - d_S S - \alpha S$$

$$\frac{\mathrm{d}P}{\mathrm{d}t} = r'_P \frac{SP}{f + \gamma S} - d_P P - \frac{P^2}{K_P}$$

Single-Species Model - Results

	- Satiation	+ Satiation
- Masting		
+ Masting		

Two-Species Model

$$\frac{\mathrm{d}T_1}{\mathrm{d}t} = \alpha S_1 - d_T T_1 - \frac{T_1(T_1 + T_2)}{K_T}$$

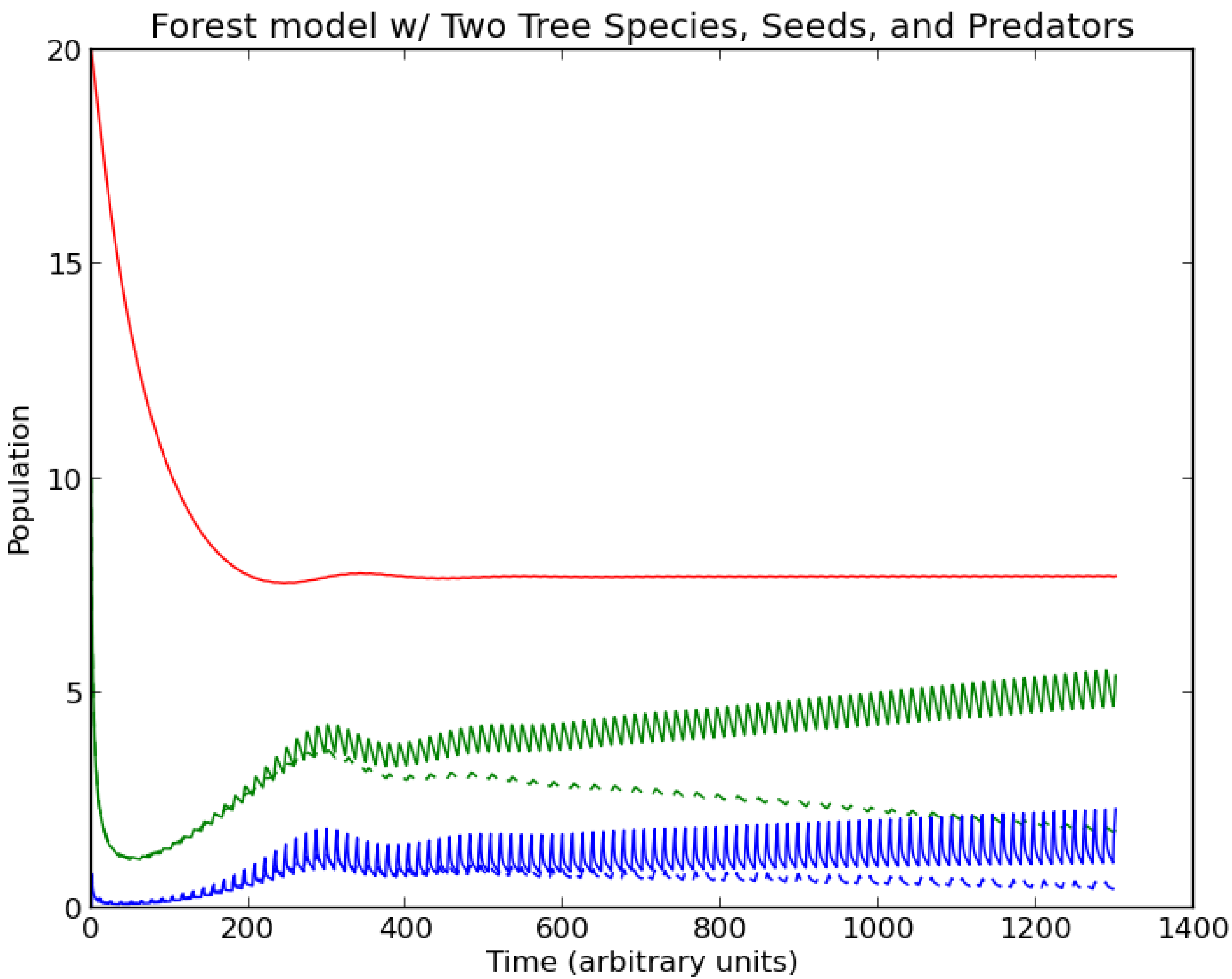
$$\frac{\mathrm{d}T_2}{\mathrm{d}t} = \alpha S_2 - d_T T_2 - \frac{T_2(T_1 + T_2)}{K_T}$$

$$\frac{\mathrm{d}S_1}{\mathrm{d}t} = r_{S_1} T_1 - r_P \frac{S_1 P}{f + \gamma(S_1 + S_2)} - d_S S_1 - \alpha S_1$$

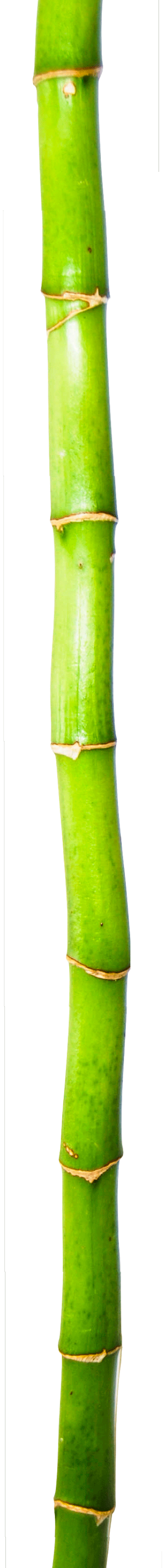
$$\frac{\mathrm{d}S_2}{\mathrm{d}t} = r_{S_2} T_2 - r_P \frac{S_2 P}{f + \gamma(S_1 + S_2)} - d_S S_2 - \alpha S_2$$

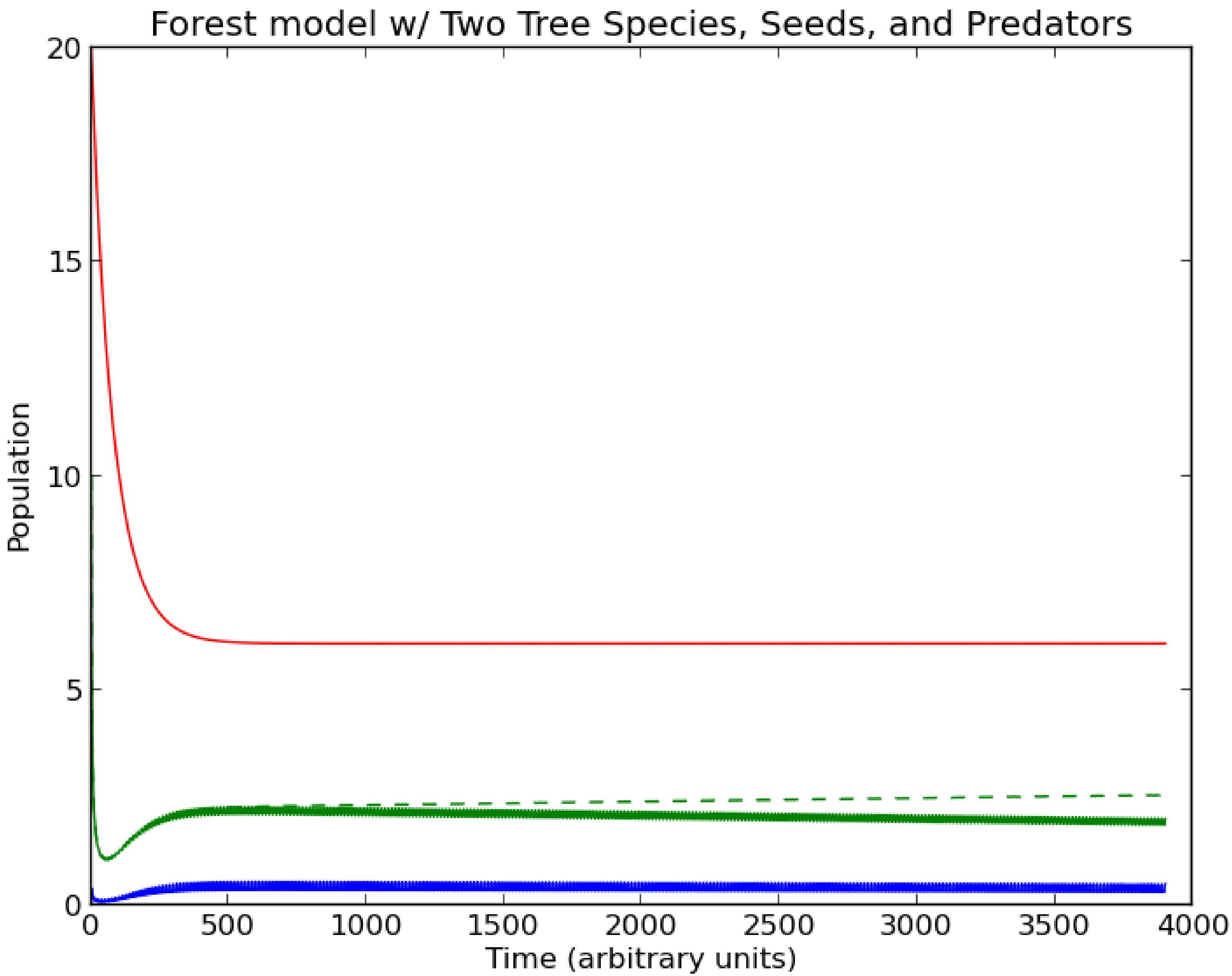
$$\frac{\mathrm{d}P}{\mathrm{d}t} = \widetilde{r_P} \frac{(S_1 + S_2)P}{f + \gamma(S_1 + S_2)} - d_P P - \frac{P^2}{K_P}$$

Two-Species Model - Results

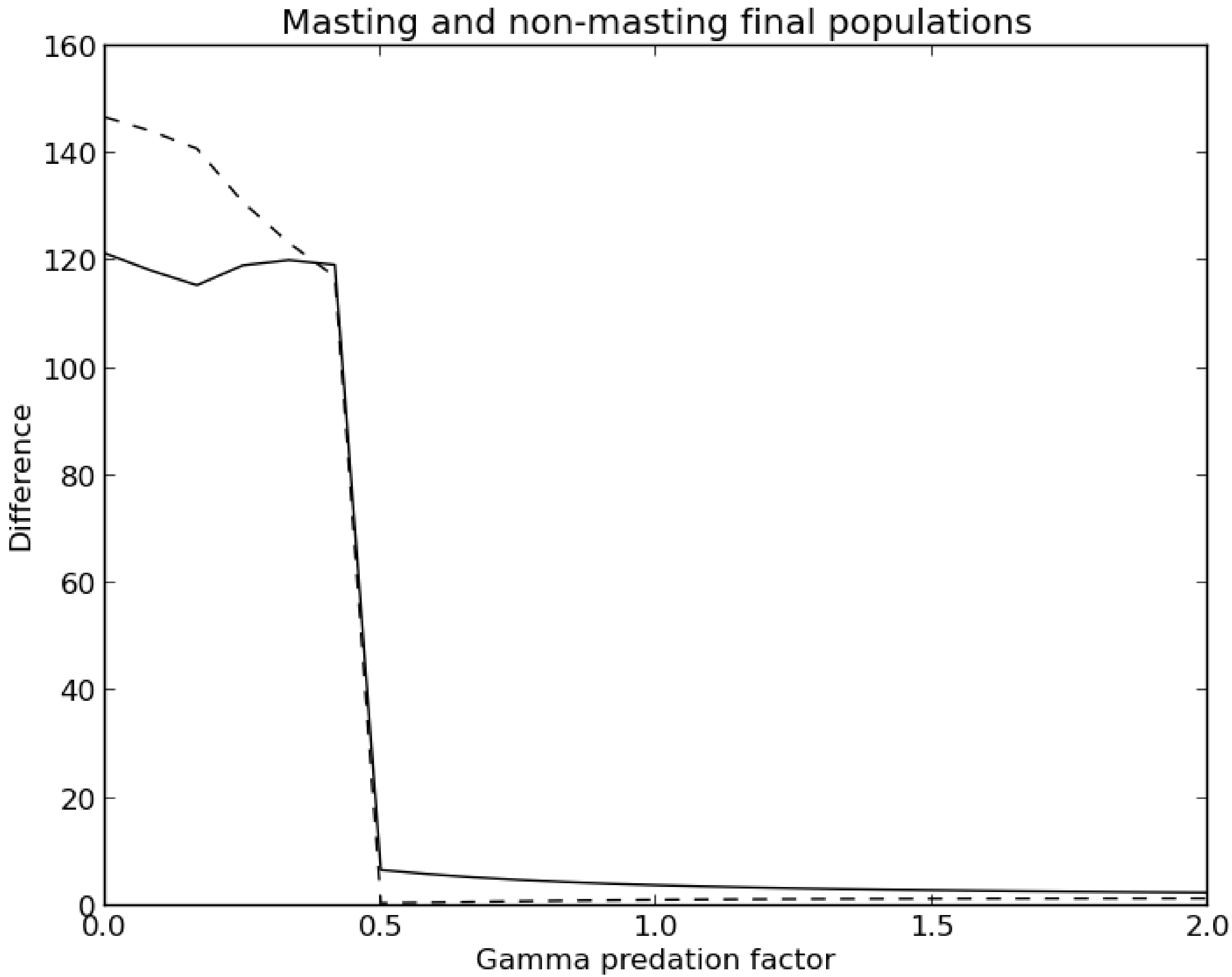


Two-Species Model - Results





Two-Species Model - Results



Conclusion

The single-species model is not enough to show the evolutionary advantage of masting over non-masting.

When predator satiation is amplified and there is competition for the same carrying capacity, masting is more advantageous than not masting, which leads to the extinction of the non-masting population.

Limitations

- Time delay (maturation)
- Dispersal/migration
- Specialist predators
- Random cycles
- Semelparity/iteroparity
- Stochasticity.

Thank you!