# Group 17

## Agent-based Modelling (ABM)

## Simulating Societal Collapse in Multi-Generational Space Travel

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# Existing Literature

… about space settlements and survival:

- “Computing the minimal crew for a multi-generational space travel towards Proxima Centauri b”
  Marin & Beluffi (2018)
- “Minimum Number of Settlers for Survival on Another Planet”
  Salotti (2020)
- “Should and could humans go to Mars? Yes, but not now and not in the near future”
  Szocik (2019)
- “Can Deep Altruism Sustain Space Settlement?”
  Haqq-Misra (2019)

*“… shows that ethical and social virtues, not current technological and medical threats, are the biggest risk for success of the mission.”*
by Haqq-Misra (2019) cited in Szocik (2019)

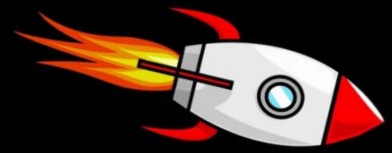
# Motivation

- Observe: complex social behaviour.
- Complex task: sustaining a society with limited resources for multiple generations
- Consider: social / human factors

Take Examples from Lecture:

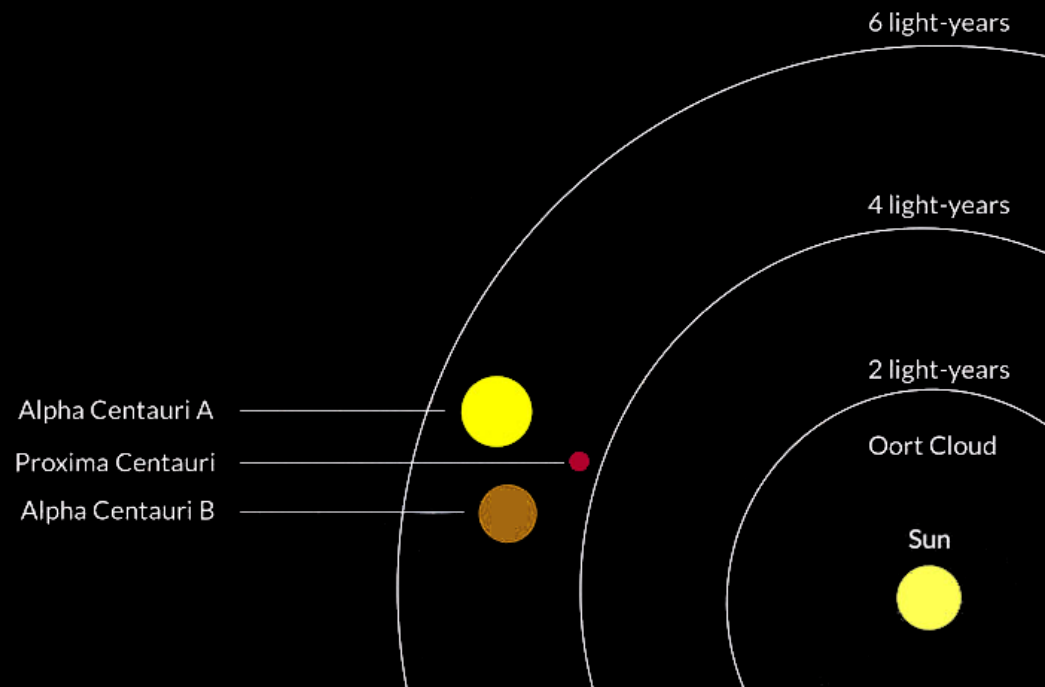
- *Dating Choice Model* by Kalick and Hamilton (1986)
- *Simulating Irrational Human Behavior to Prevent Resource Depletion* by Sircova, Karimi, Osin, Holme, Strömbom (2015)
- Granovetter Threshold Model (1978)
- Opinion Dynamics

# Base Model



Found ABM model with mating logic but without any selectiveness (apart from simple checks) or irrational behaviour:

- Model initially based on an astrophysics paper [1]
- ABM approach based on Netlogo model [2]
  - Simulation of long-distance space flight
  - contains realistic data
  - parameters set based on research

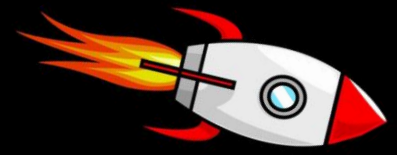




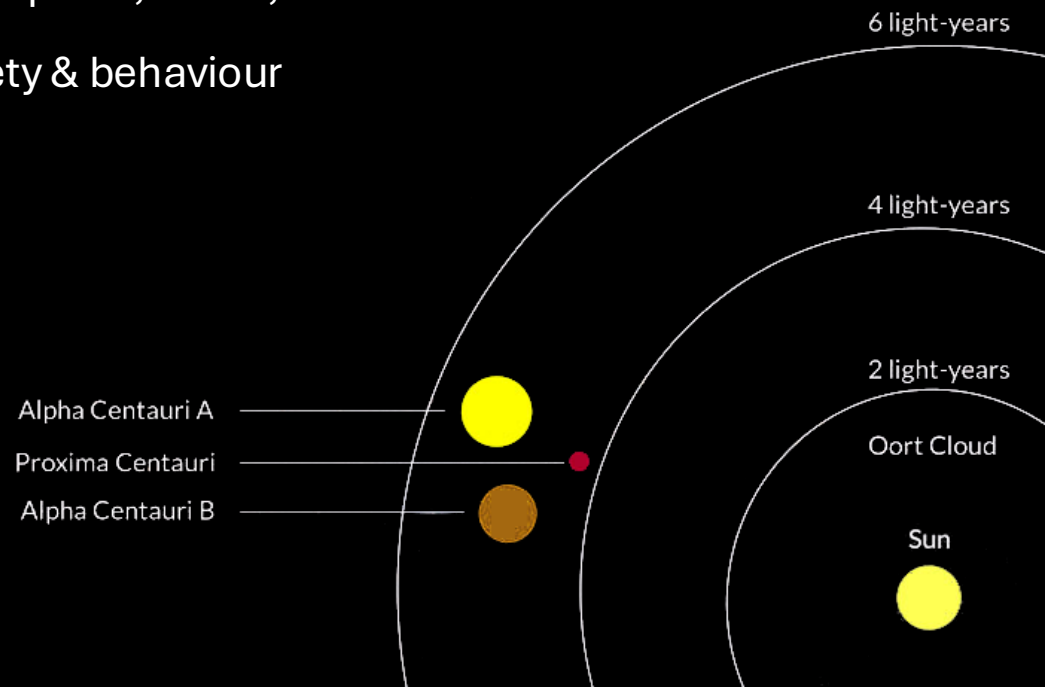
[1] *"Computing the minimal crew for a multi-generational space travel towards Proxima Centauri b"* by Marin & Beluffi (2018)

[2] "*Simulation of a long-distance space flight*" by Sommer & Thorsten (2019)

# Base Model

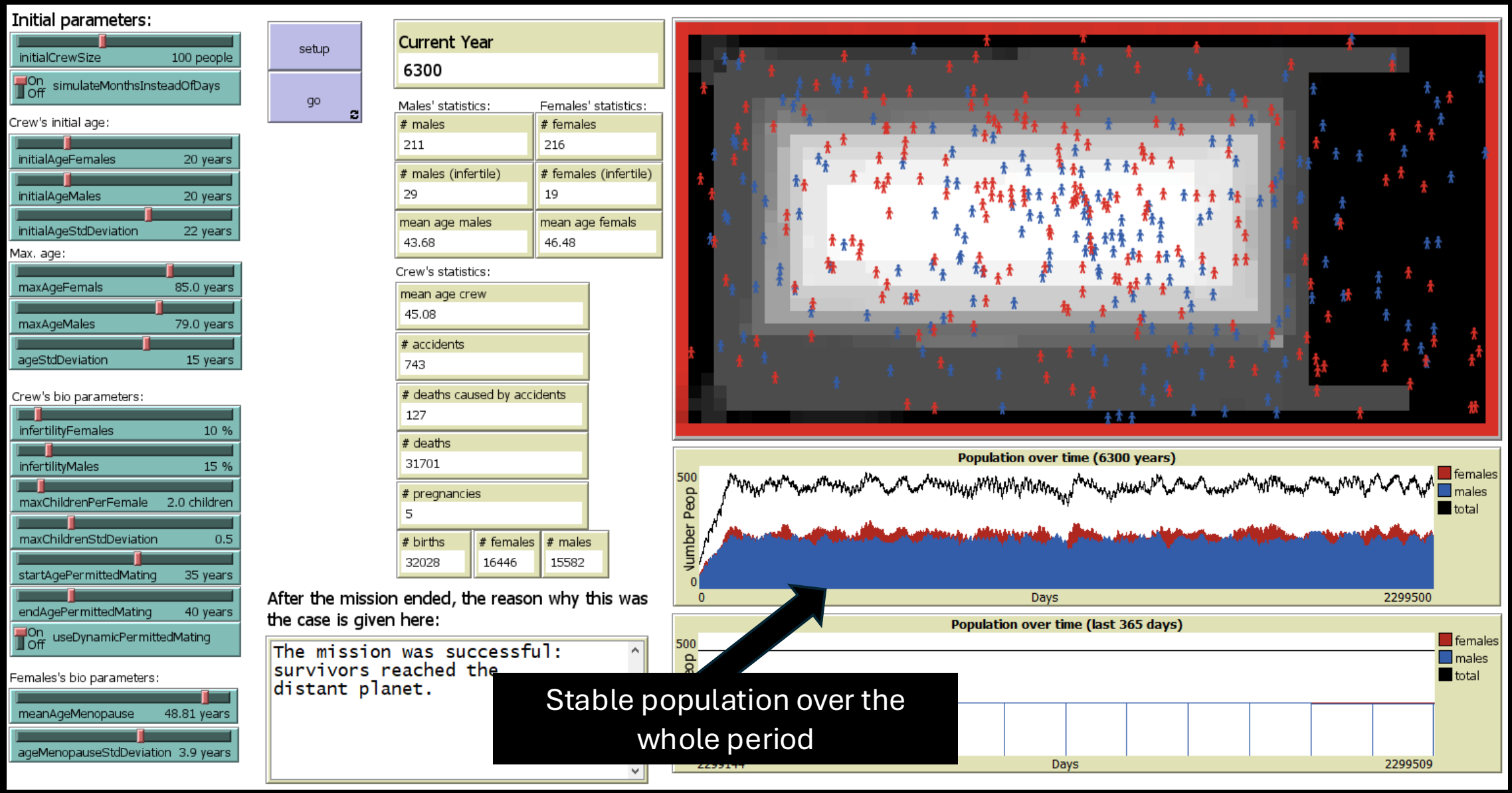


- Base Model simulates life on spaceship
- Agents: male & female, movement, mating, pregnancy
- Parameters: crew size, fertility, age, mating behaviour
- Observation mechanics: population over time, accidents, crew demographics, births, deaths
- Assumptions: infinite resources, no maintenance needed, simple society & behaviour
- Environment: safety zones on ship, accidents occur
- Mission Completion Check:
  - Year 6,300 is reached
  - overcapacity
  - or extinction



# Analysis 1

Base Model (society survives with default parameters)



# Extended Model: with Selectiveness logic

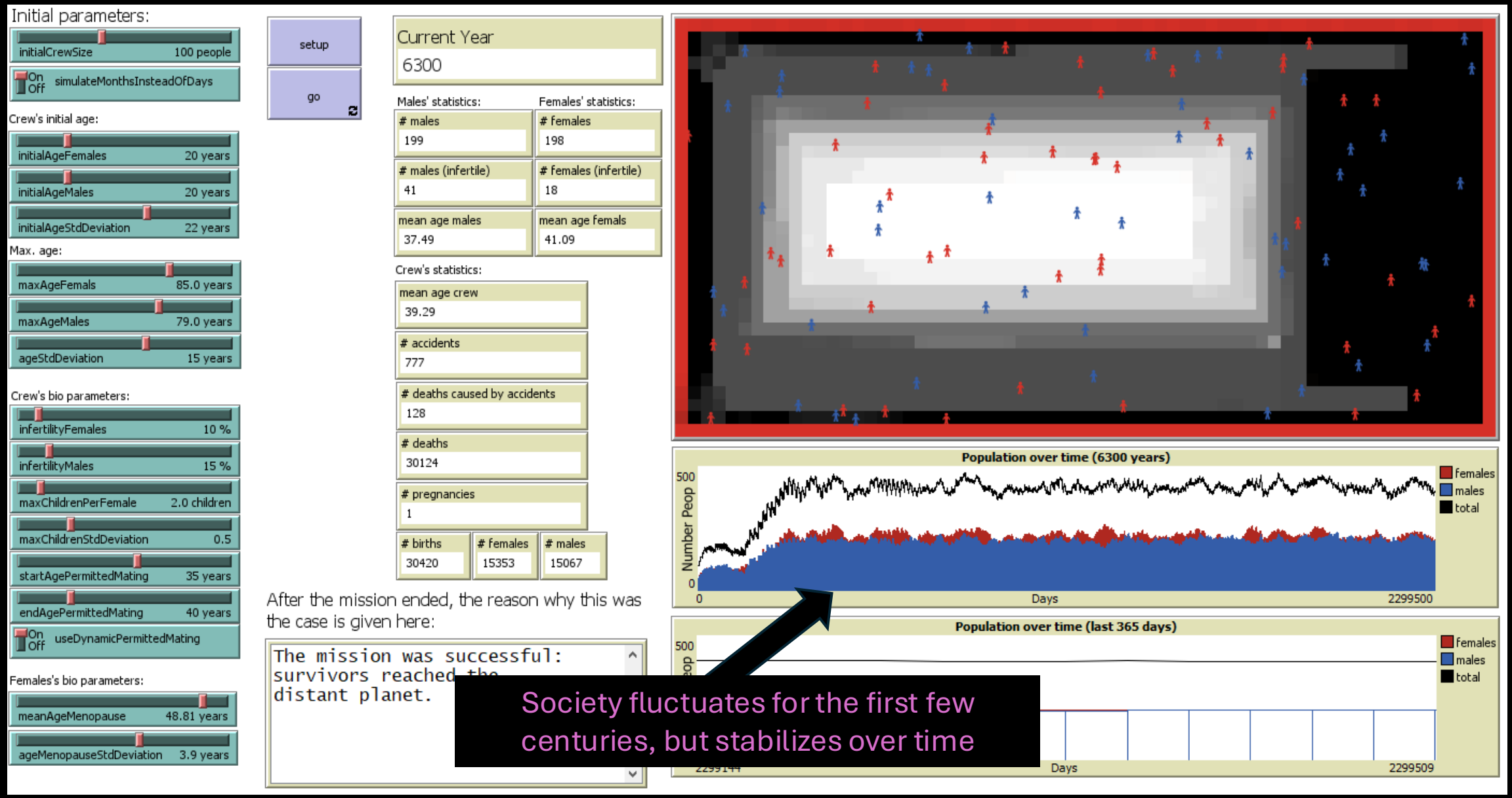
- NEW: Determine the probability of mating
- Process simulates a more realistic social interaction
- Attractiveness-based mate selection simulates mutual consent
- Attractiveness value assigned randomly
  - at birth of each agent (random 0-10)
- When two agents meet:
  - calculate individual differences in values
  - The smaller the difference, the higher the accept probability (%)
  - If attractiveness difference is large, the probability of mating decreases, leading to more rejections.

*Research Question:*

*After the introduction of selective dating preferences, at what difference threshold in polarizing view values does the society go extinct because it cannot sustain itself any longer?*

# Analysis 2

Extended Model: Base Model that includes selectiveness




Society fluctuates for the first few centuries, but stabilizes over time

# Extended Model: with Polarizing View logic

Representative for opposing views:

religious,
political,
ethical,
national,
moral,
etc.

NEW: Killing possible based on polarizing view differences

- Each agent: born with random pv value between 0-10
- if two agents meet outside the safety-zone (white) on ship
  - check differences of polarizing view
  - if values are too far from each other: one of the two agents can get killed

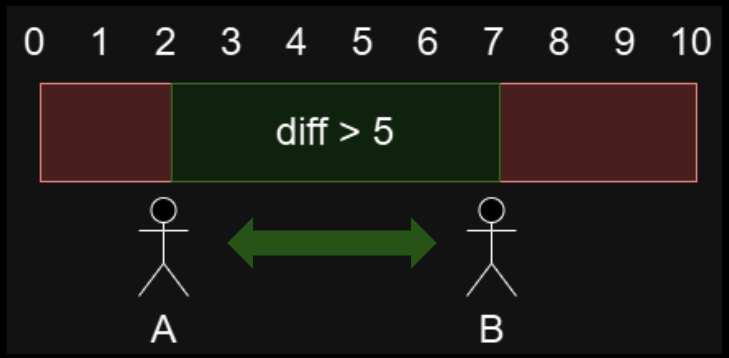
Example: Agent A has pv value of 2

Depending on threshold of pv difference:

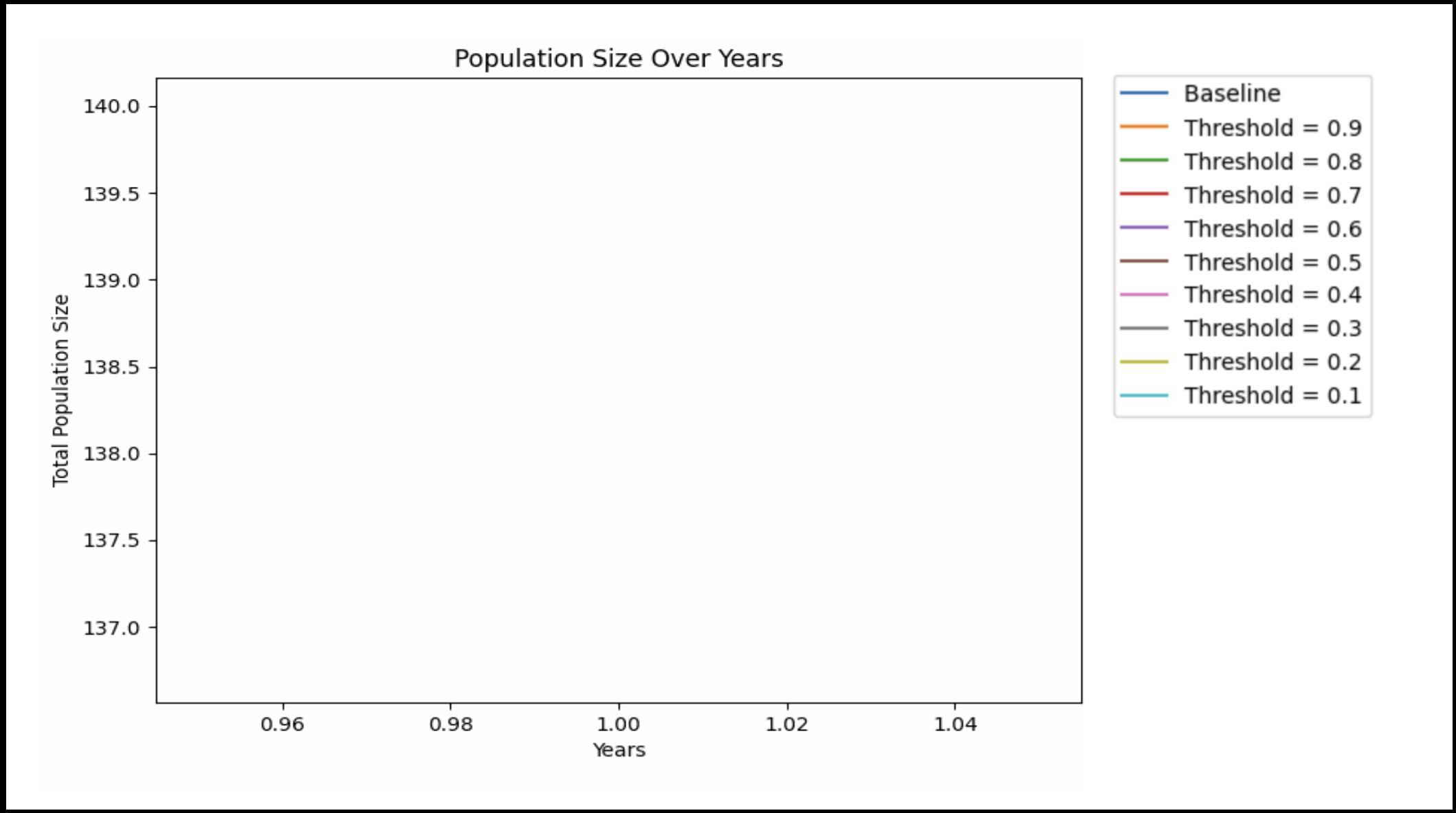
- A and B will try to kill each other if the difference is too big

We want to test these diff_thresholds in the remaining slides!

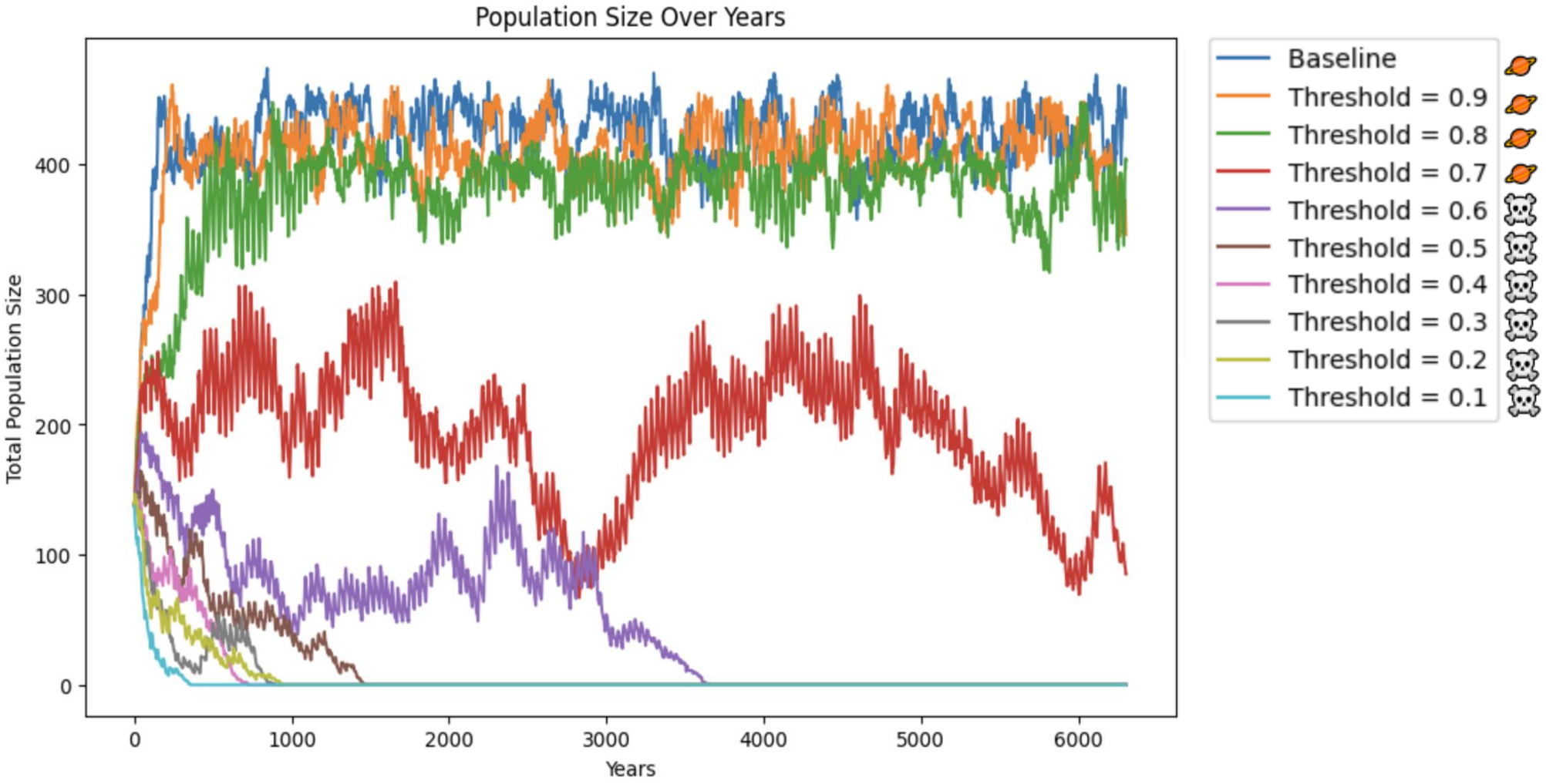




# Simulating Populations with Different Thresholds

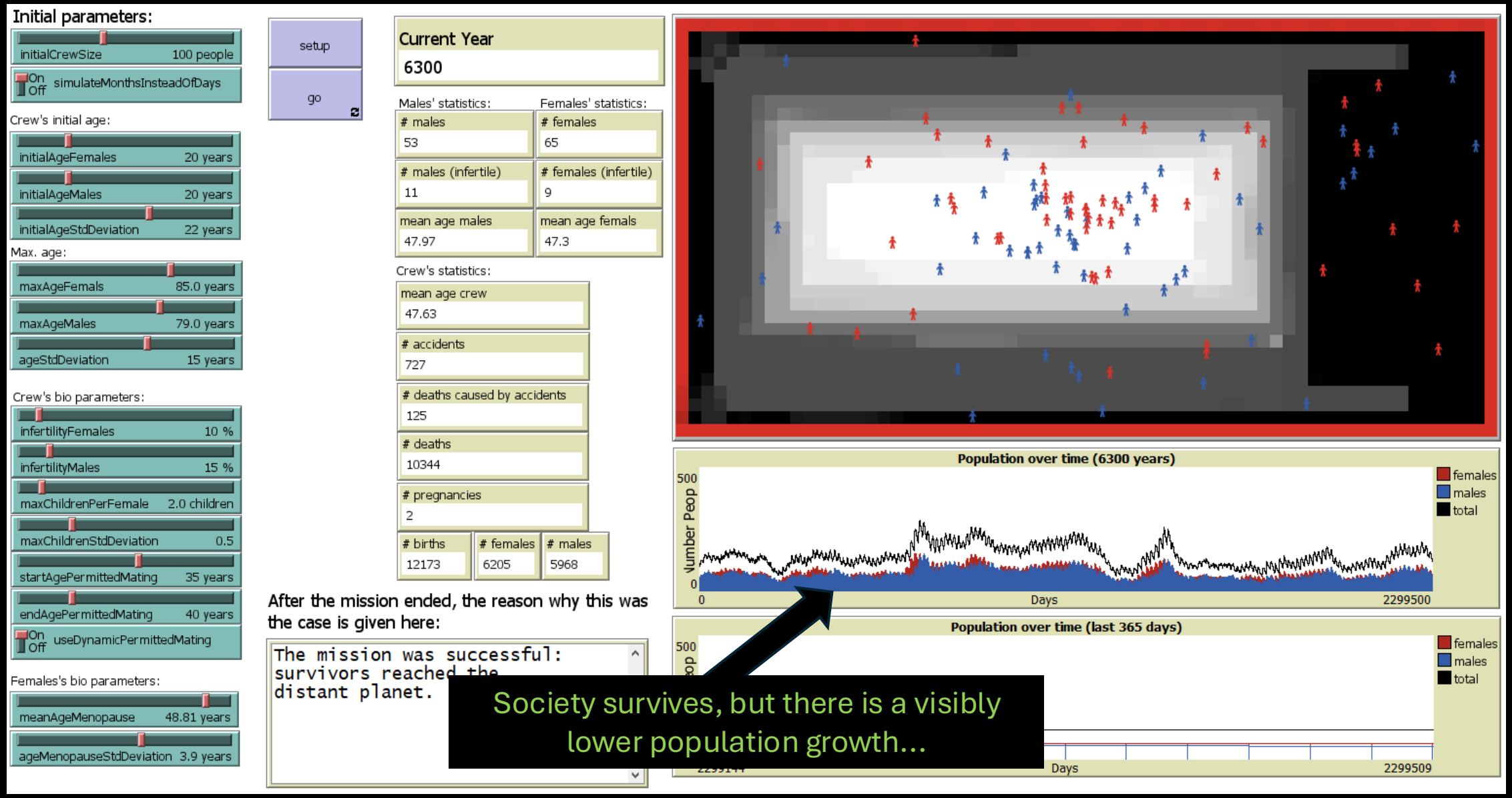


# Simulating Populations with Different Thresholds



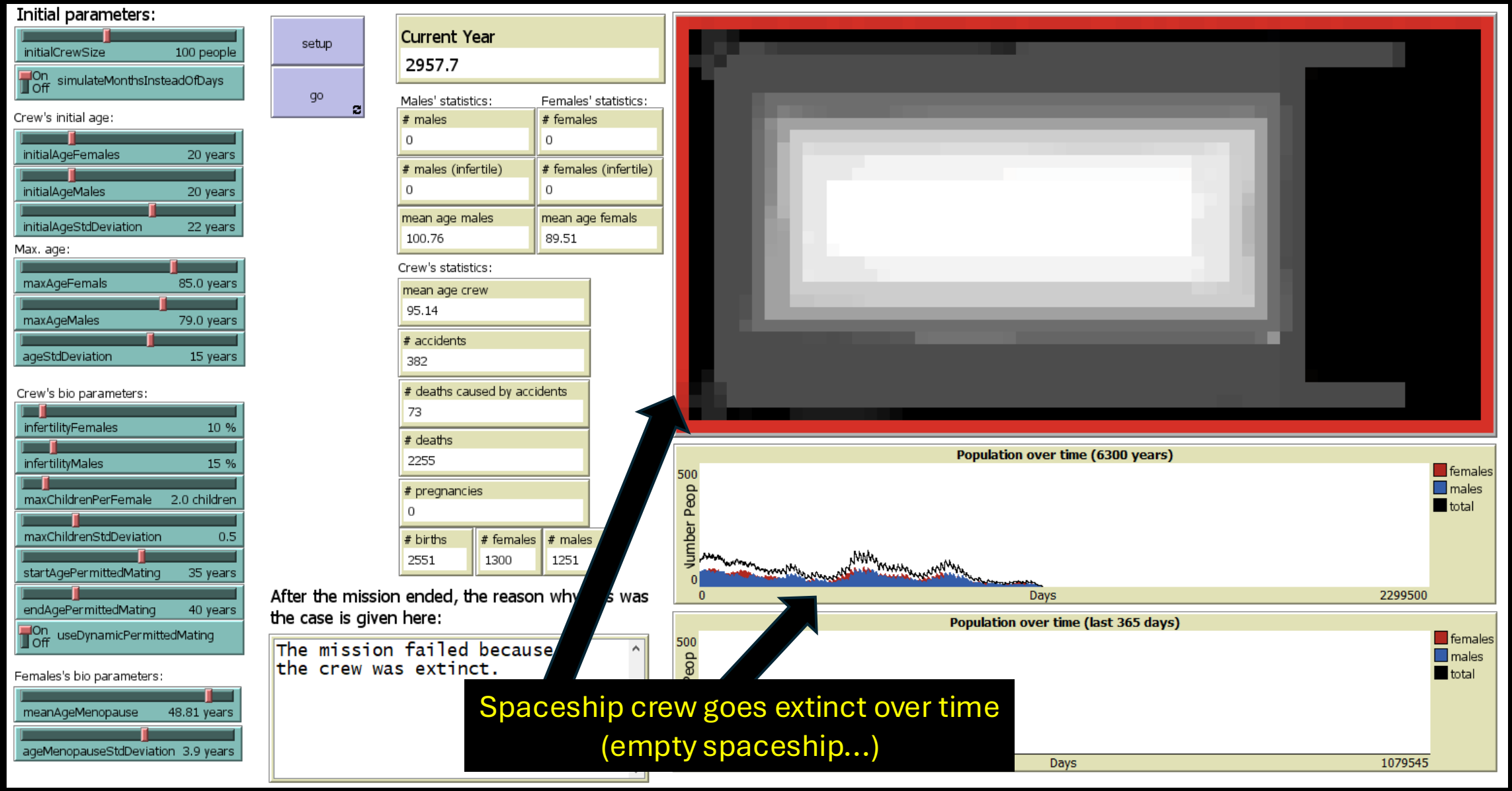
# Analysis 3

Extended Model: includes selectiveness & homicide caused by polarizing views (at view_difference > 7)



# Analysis 4

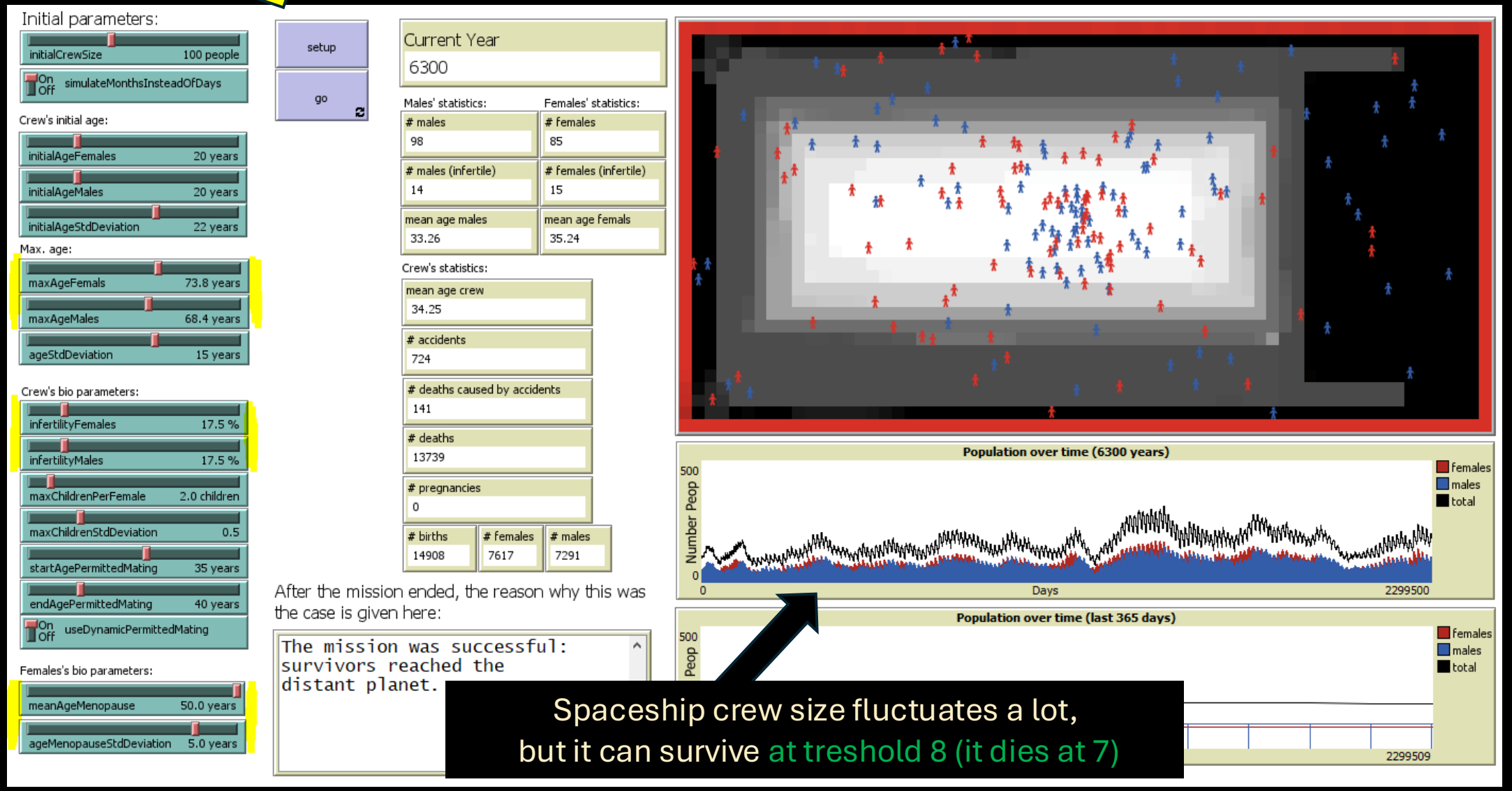
Extended Model: includes selectiveness &
homicide caused by polarizing views (at view_difference > 6)



# Analysis 5

Extended Model: includes selectiveness & homicide caused by polarizing views

Alternative: with our own parameters (based on background research)




Spaceship crew size fluctuates a lot,
but it can survive at treshold 8 (it dies at 7)

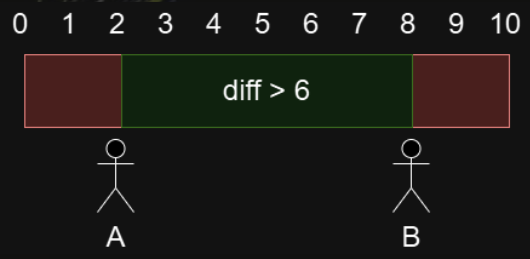
# Conclusion

*After the introduction of selective dating preferences, at what difference threshold in polarizing view values does the society go extinct because it cannot sustain itself any longer?*

- Selective mating preferences have an influence on the crew size over time
- Extended model incl. attractiveness and polarizing view:
  - Tested with default parameters:

    view_difference extinction threshold is between 6 and 7
  - Tested with our own parameters: survival requires more tolerance.

    view_difference extinction threshold is between 7 and 8




# Limitations & Future Research

- Computational intensity restricts options
- Trying different distributions
  - of attractiveness
  - of polarizing view
- Different model for mating preferences
  - e.g. maximizing attractivity
- Examining the unique impact of individual variables
- ABM modelling of a society is a complex process

# Thank you for your attention!

# Group 17

## References


[1] Github: Simulation of a 6,300-year intergalactic journey
https://github.com/SommerEngineering/Simulation-of-long-distance-space-flight?tab=readme-ov-file

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[3] Sommer, Thorsten (2019). Simulation of a 6,300-year intergalactic journey. DOI: 10.17504/protocols.io.676hhre

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[9] Haqq-Misra, J., Wolf, E. T., Welsh, W. F., Kopparapu, R. K., Kostov, V., & Kane, S. R. (2019). Constraining the Magnitude of Climate Extremes From Time-Varying Instellation on a Circumbinary Terrestrial Planet. *Journal of Geophysical Research: Planets*, *124*(12), 3231–3243. https://doi.org/10.1029/2019JE006222

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[11] Haqq-Misra, J. (2019). Can Deep Altruism Sustain Space Settlement? In K. Szocik (Ed.), *The Human Factor in a Mission to Mars* (pp. 145–155). Springer International Publishing.
https://doi.org/10.1007/978-3-030-02059-0_8