Is evolution a driver or passenger of biological invasions?

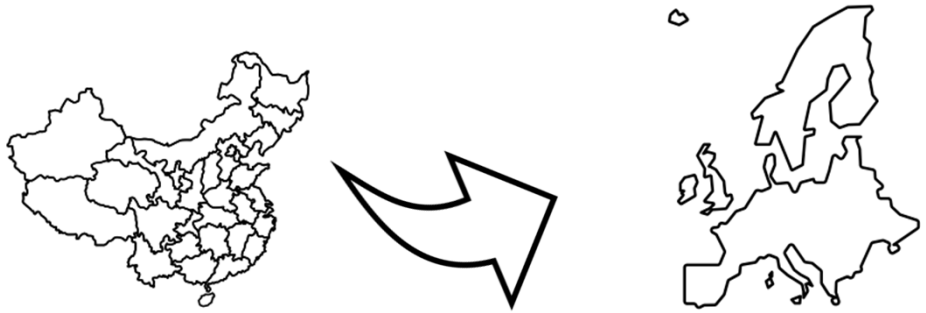
Ruth Hufbauer

Colorado State University

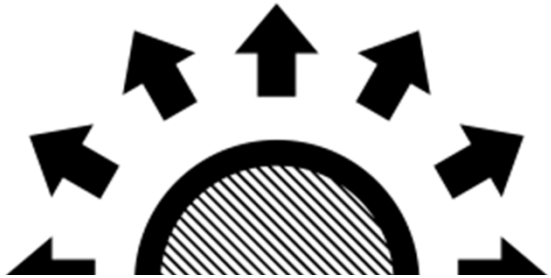
Fort Collins, CO

Evolution as a driver

- Adaptation



- Range expansion dynamics



Megan Vahsen

Marianna Szűcs

Range Expansion:
Evolution with
and without
spatial structure

Brett Melbourne

Topher Weiss-Lehman

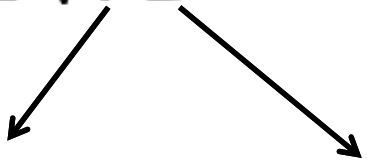
Adaptation:
Evolution in a
novel habitat
vs. **no evolution**

Adaptation as a driver

- Does response to selection lead to
  - –higher densities?
  - –faster spread?

Adaptation as a driver

- Selection in a novel habitat
  - Higher growth rate
  - Higher carrying capacity
- Expansion speed $\approx 2\sqrt{rD}$ (Fisher 1937)



growth rate

mean dispersal distance (diffusion)

The model system

- *Tribolium castaneum*

myrmecos/Alex Wild

http://www.flickr.com/photos/jbe/2499396559/sizes/z/cc b emery

The model system

- *Tribolium castaneum*

Tribolium life cycle in the lab

:

95:5

reproduction

development

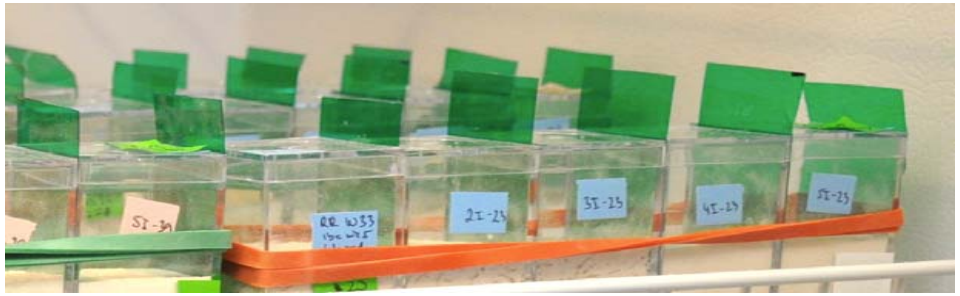
1 day

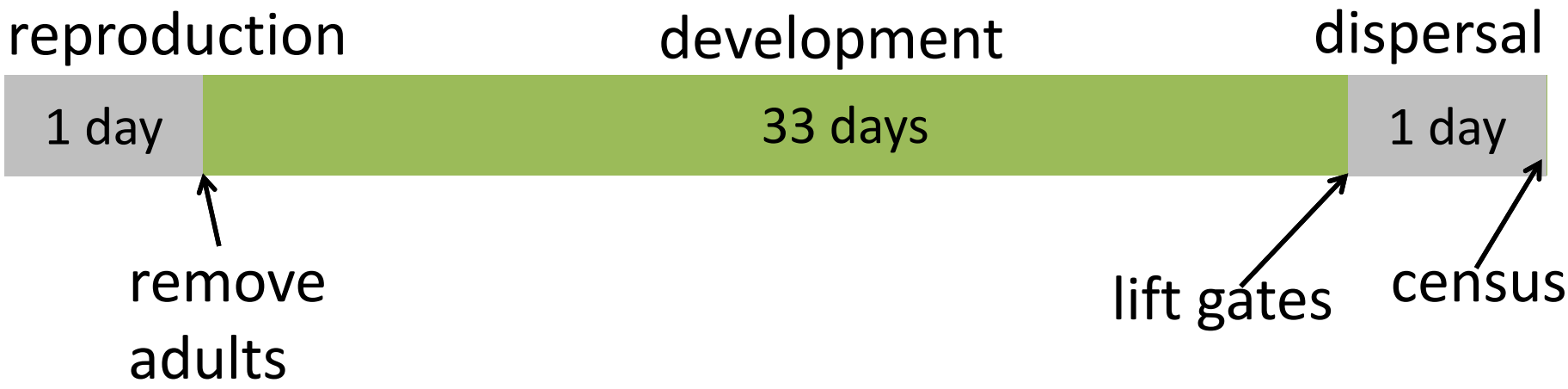
34 days

remove adults

census

Adaptation to novel environment during range expansion





Novel Environment

:

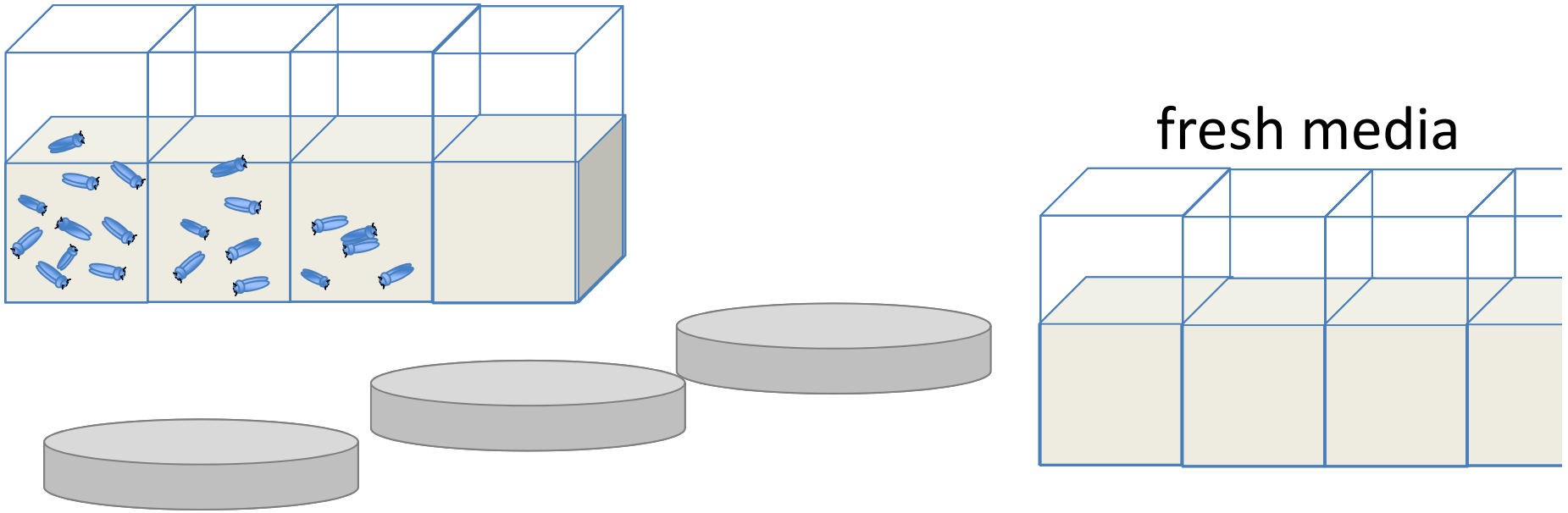
98.8 : 1.2

Evolution Treatments

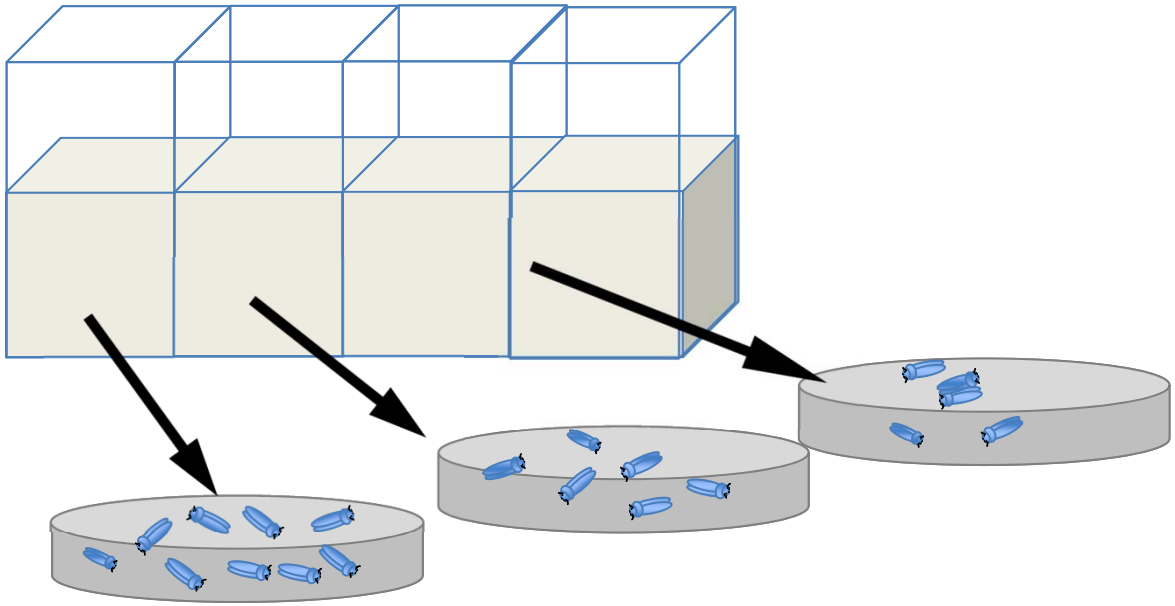
Evolving: continuous populations

Non-evolving: one-for-one replacement each generation

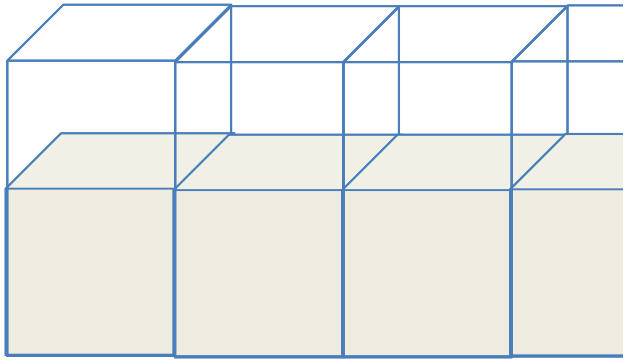
Evolving



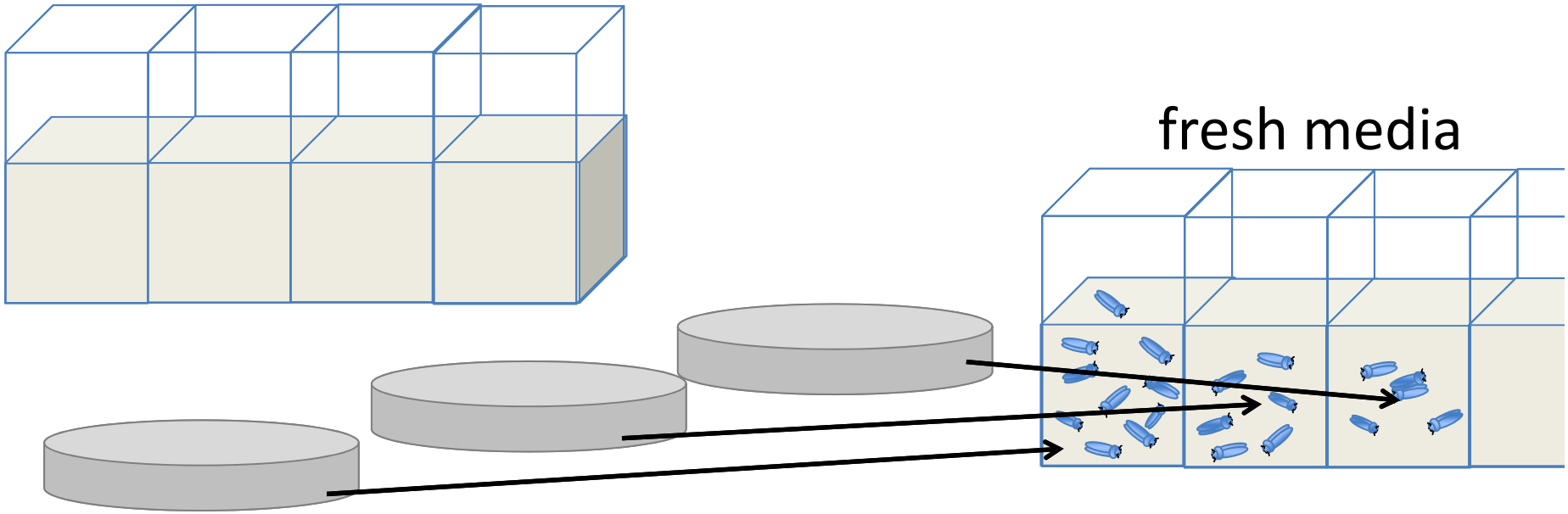
Evolving



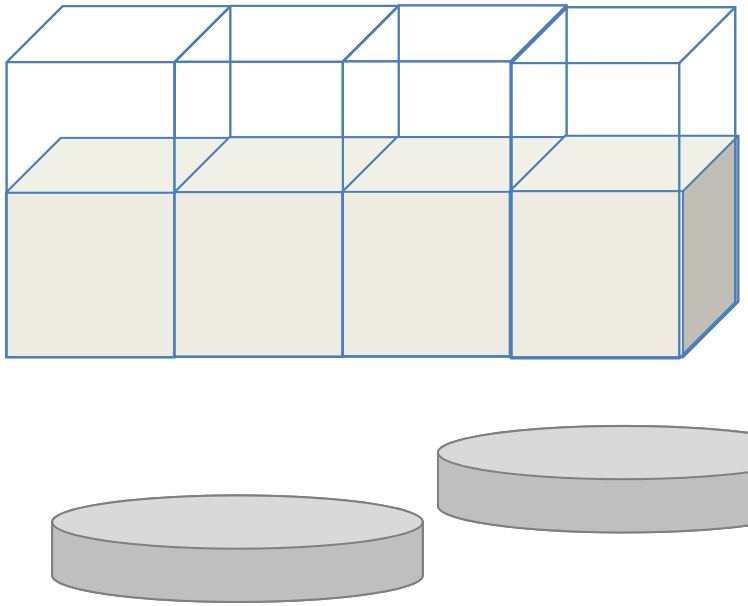
fresh media



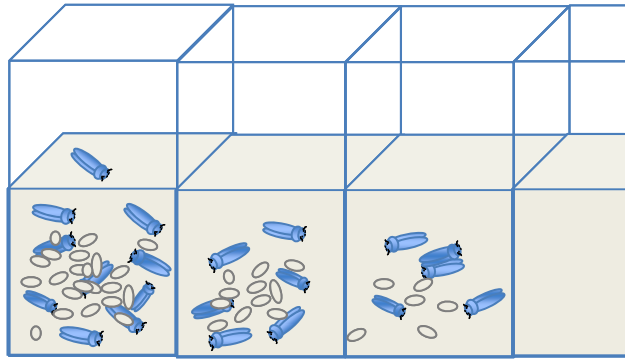
Evolving



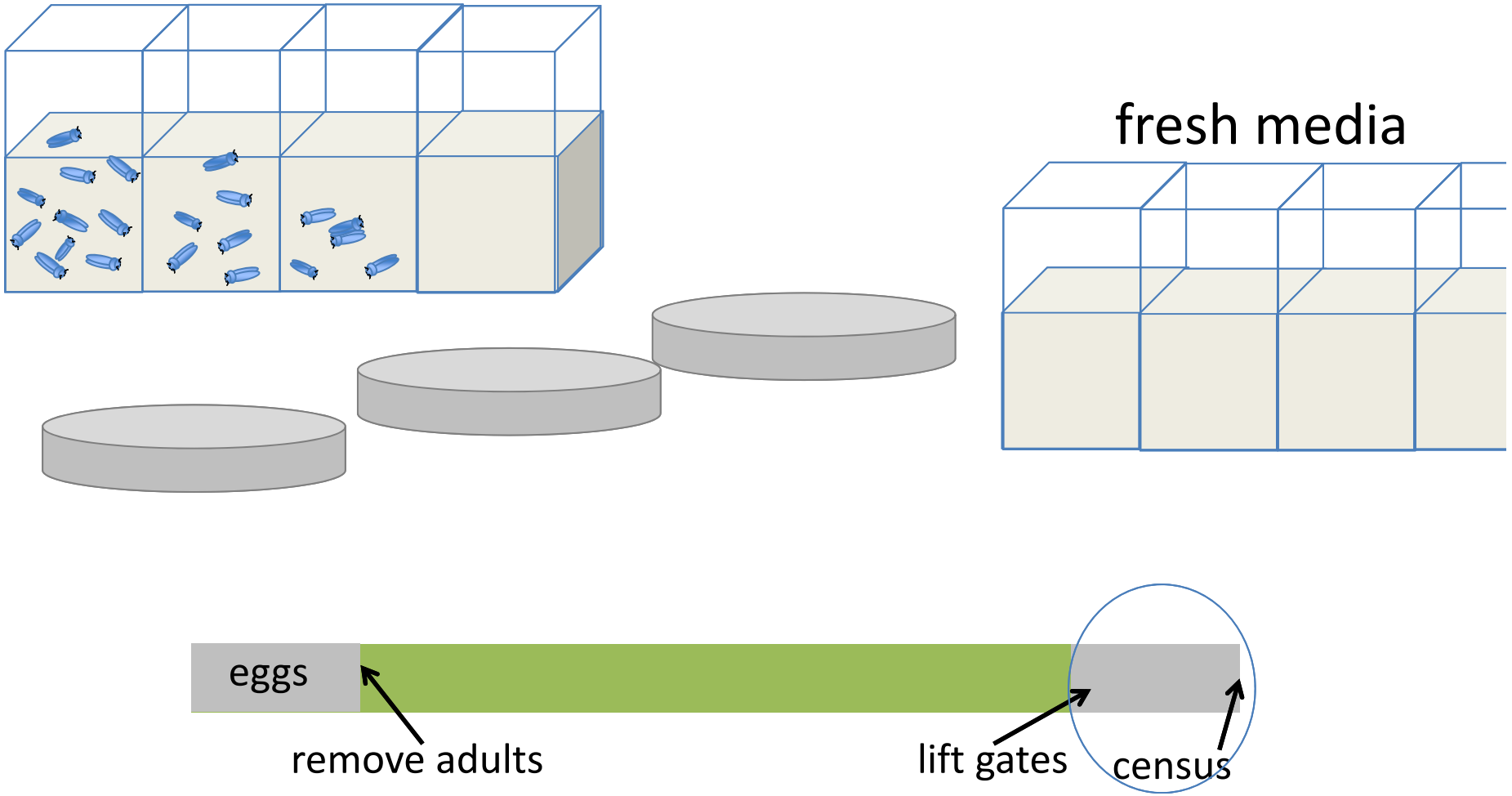
Evolving



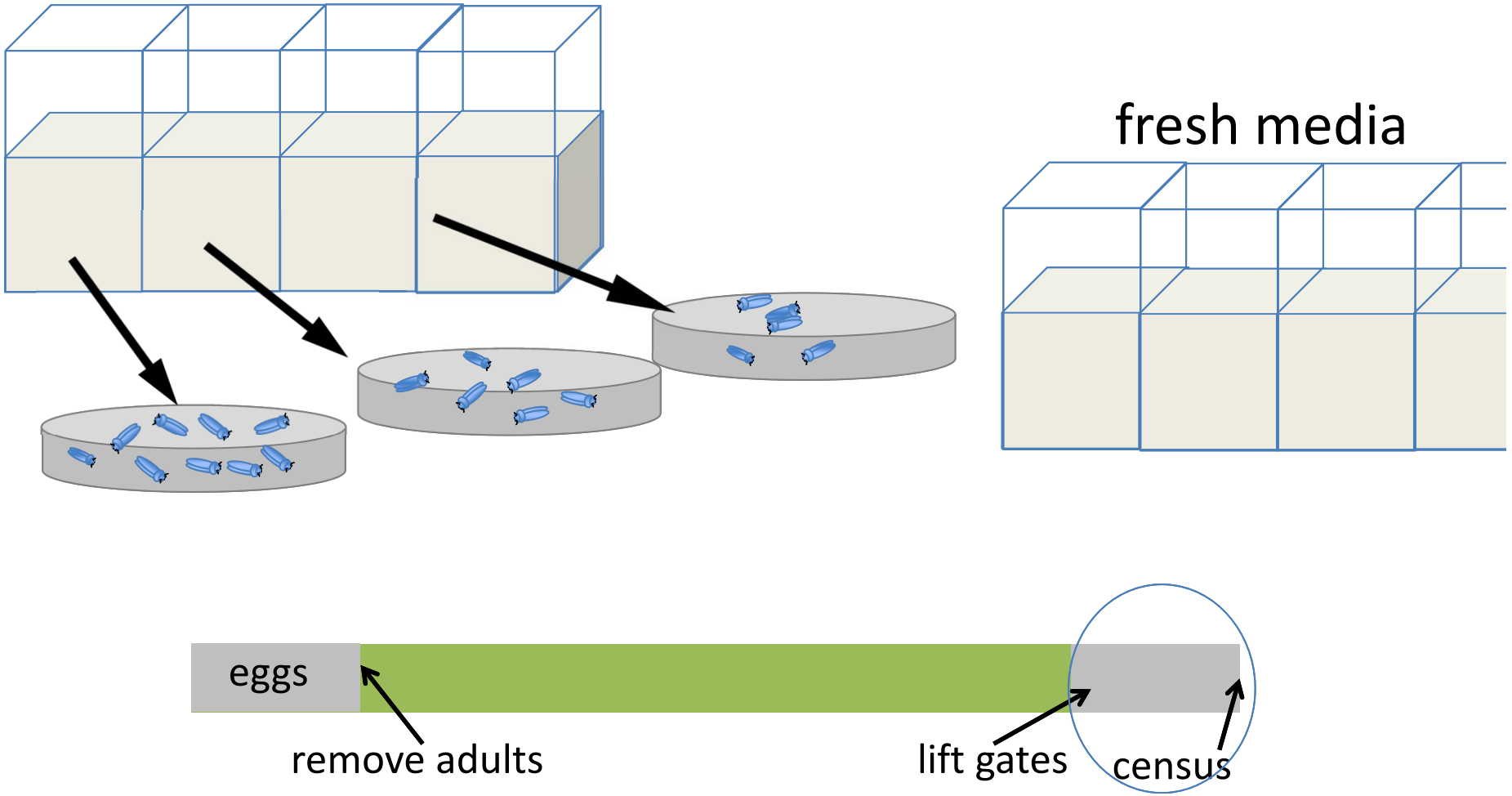
fresh media



Non-Evolving



Non-Evolving



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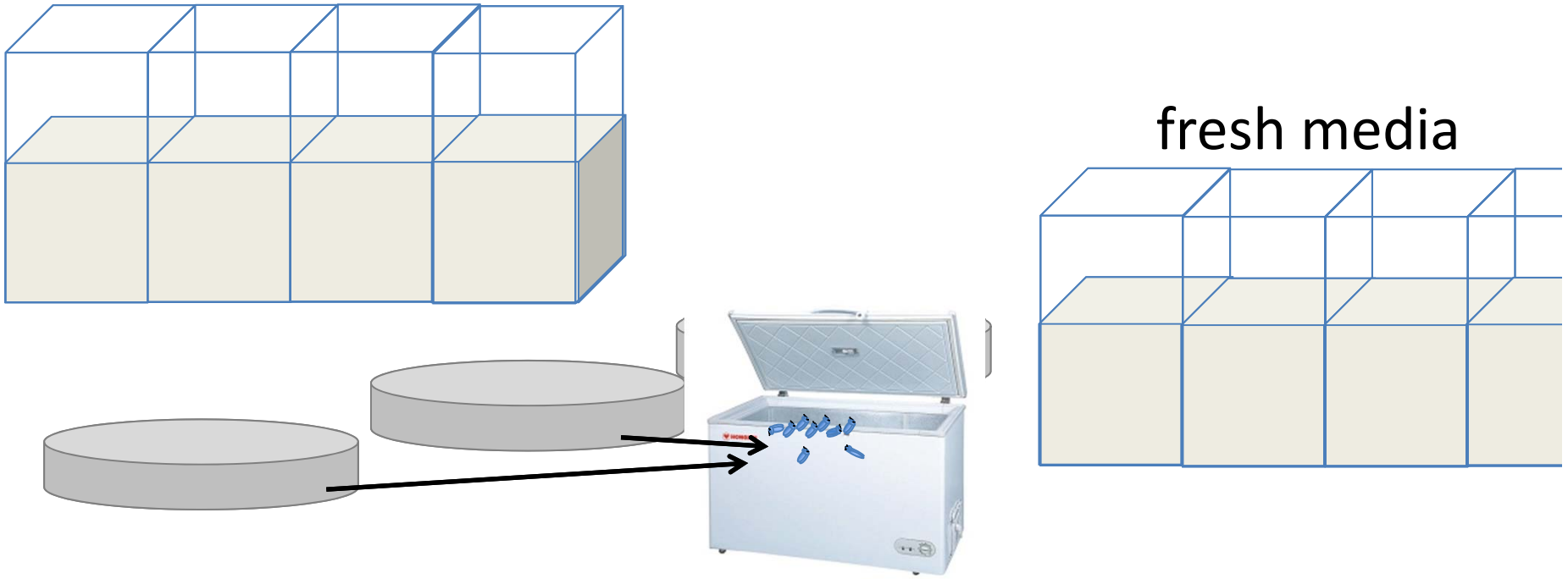
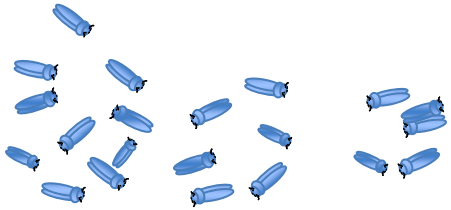
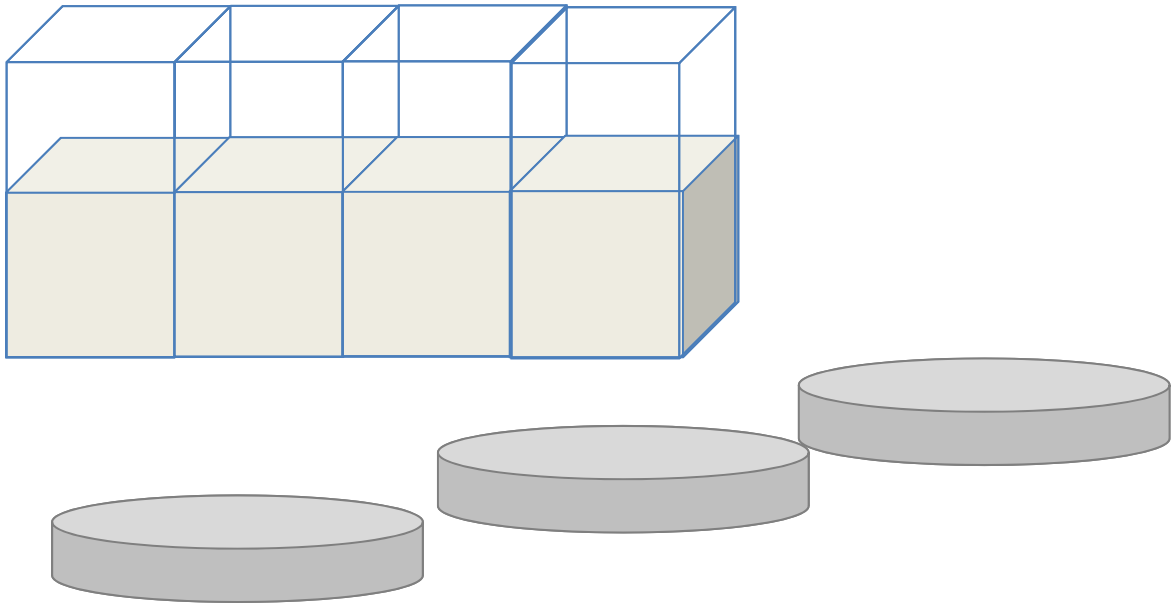
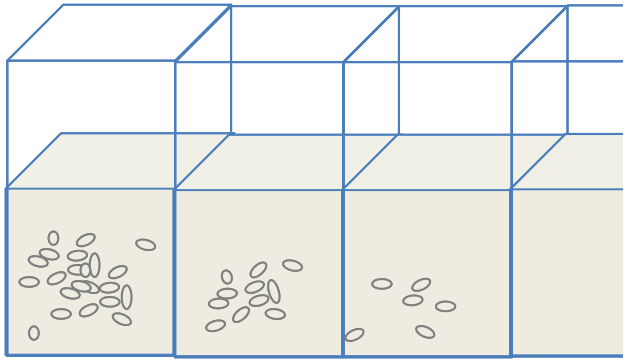


Non-Evolving

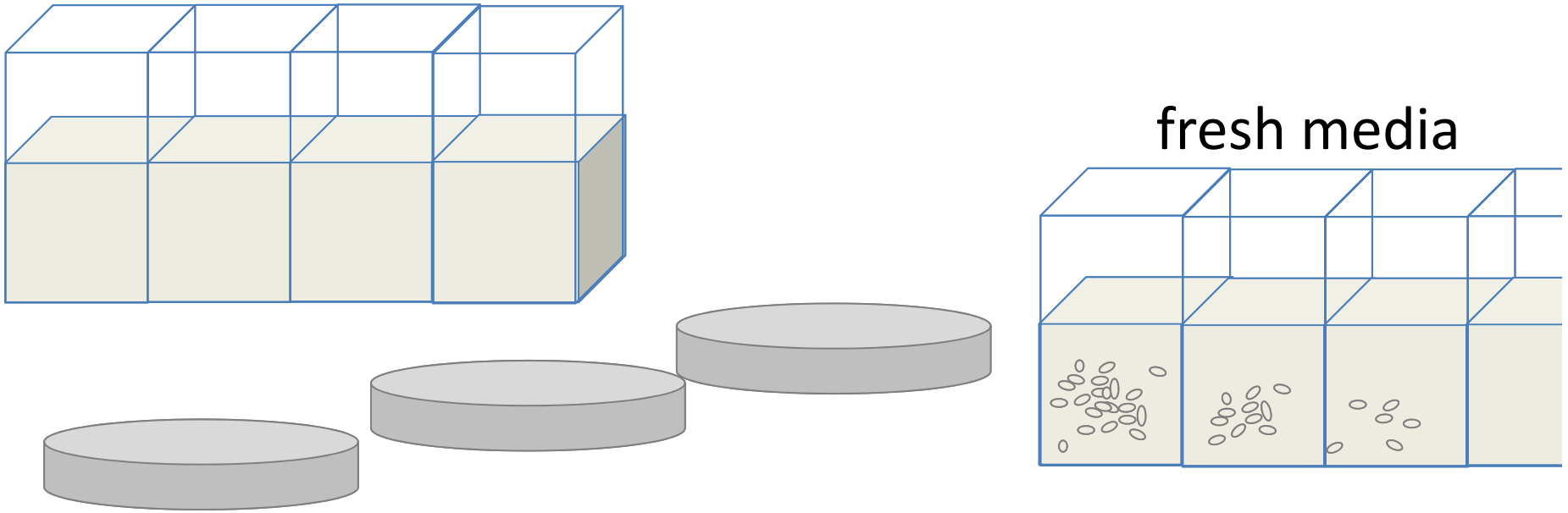




fresh media



Non-Evolving



Non-Evolving

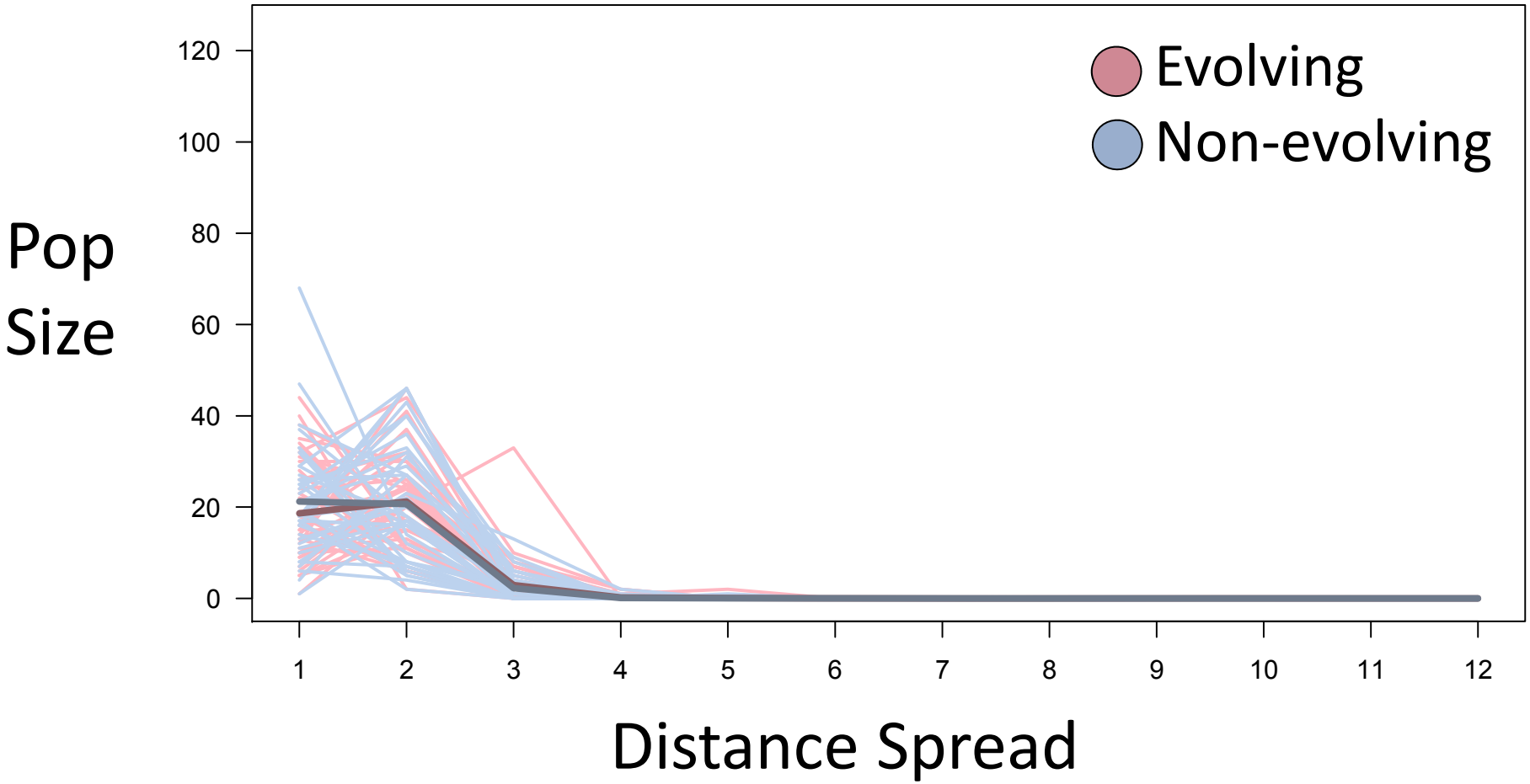
From large colony on wheat flour
minimal drift
minimal inbreeding
no adaptation to corn

Data

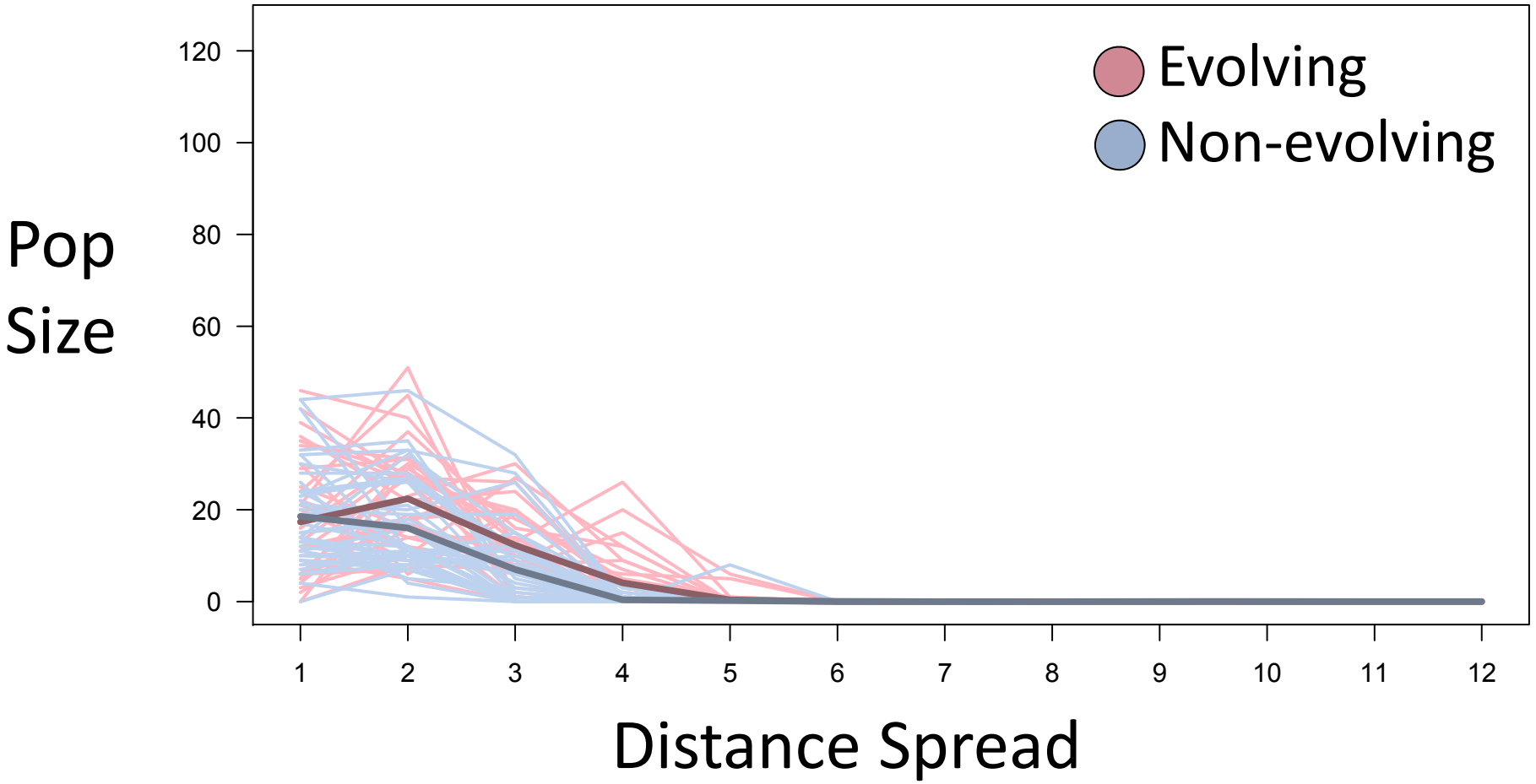
- 6 generations of censuses
  - # of individuals by patch in a landscape

- “common garden” experiment
  - growth rate of evolving and non-evolving in novel environment
  - dispersal from low and higher density patches

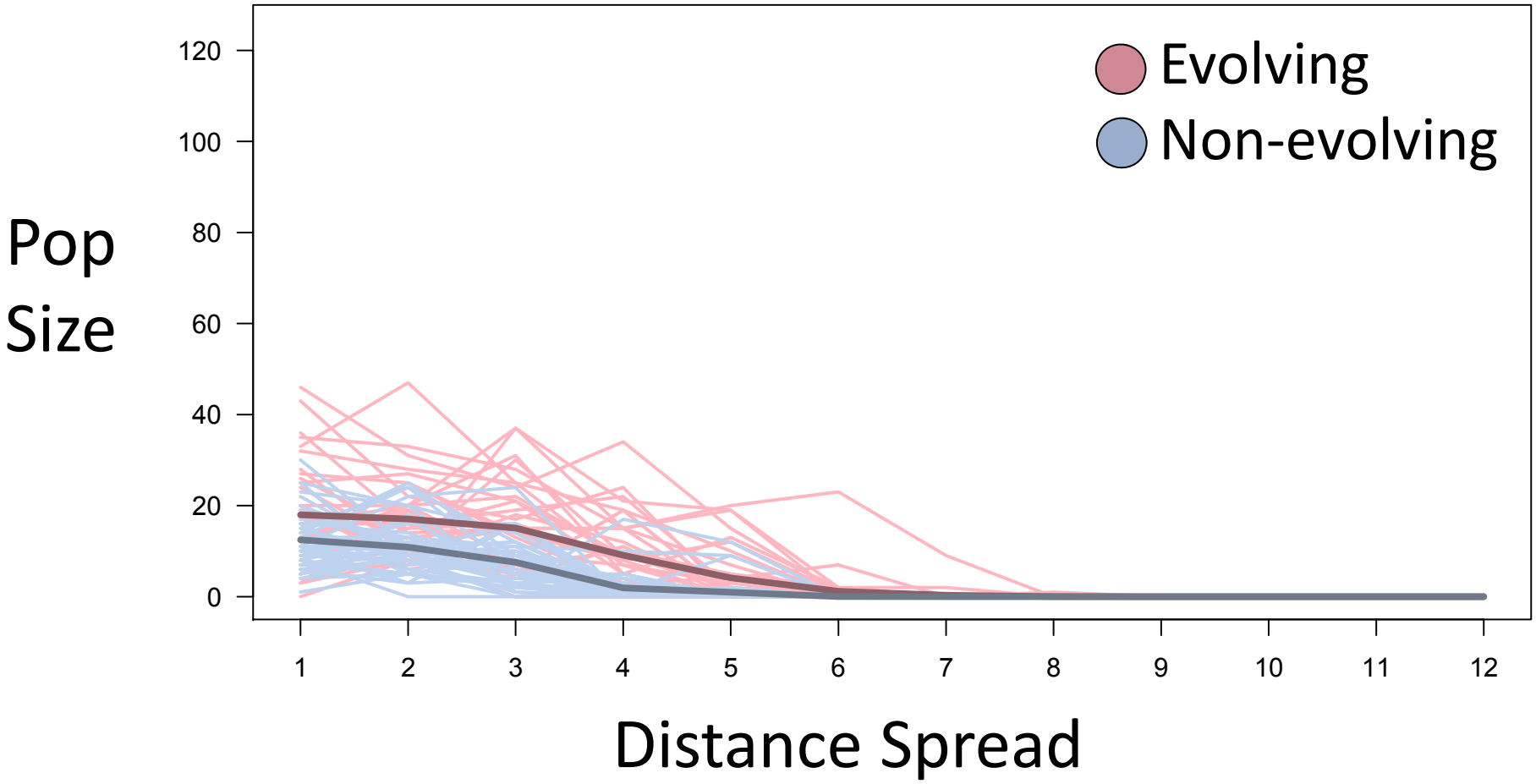
Generation 1



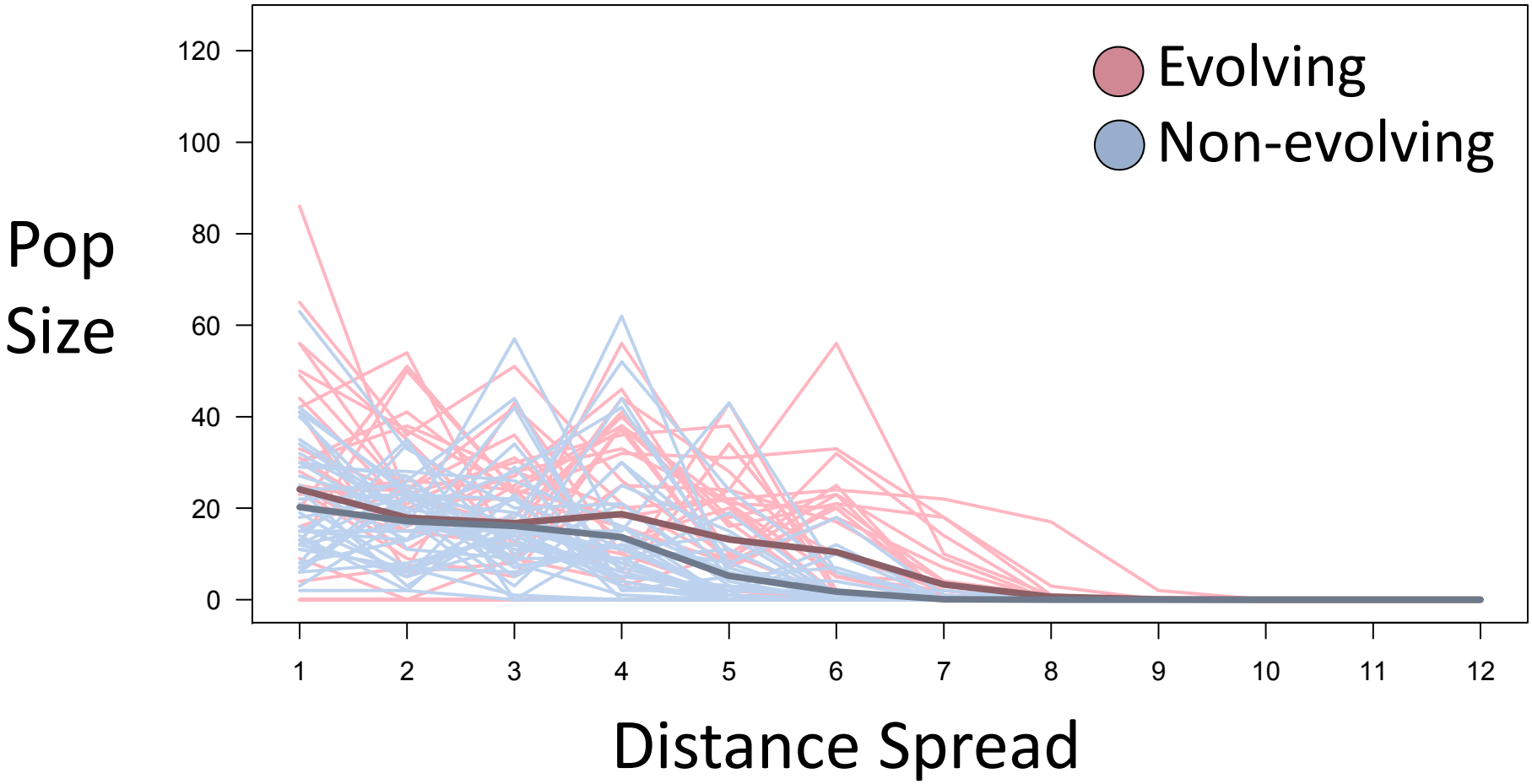
Generation 2



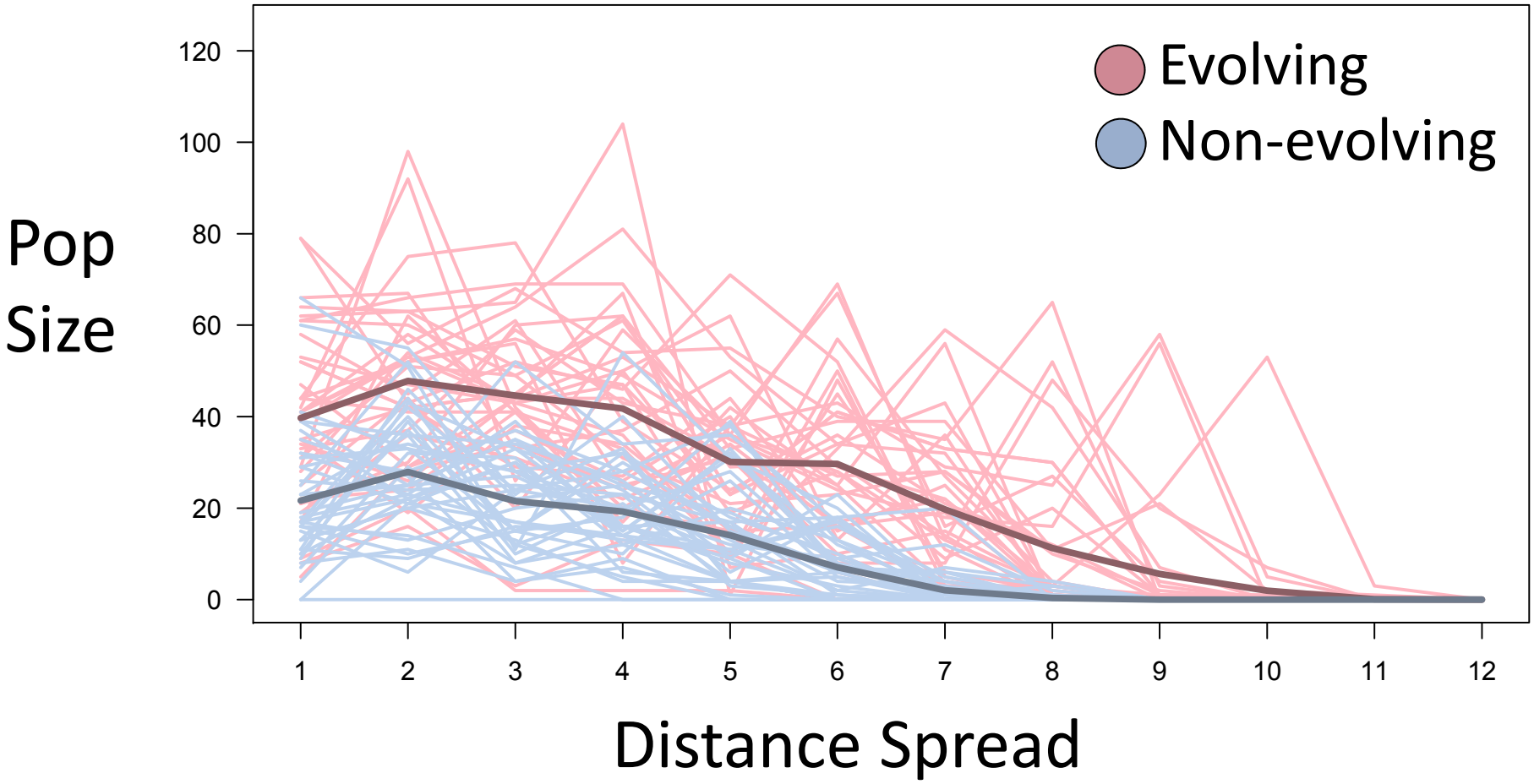
Generation 3



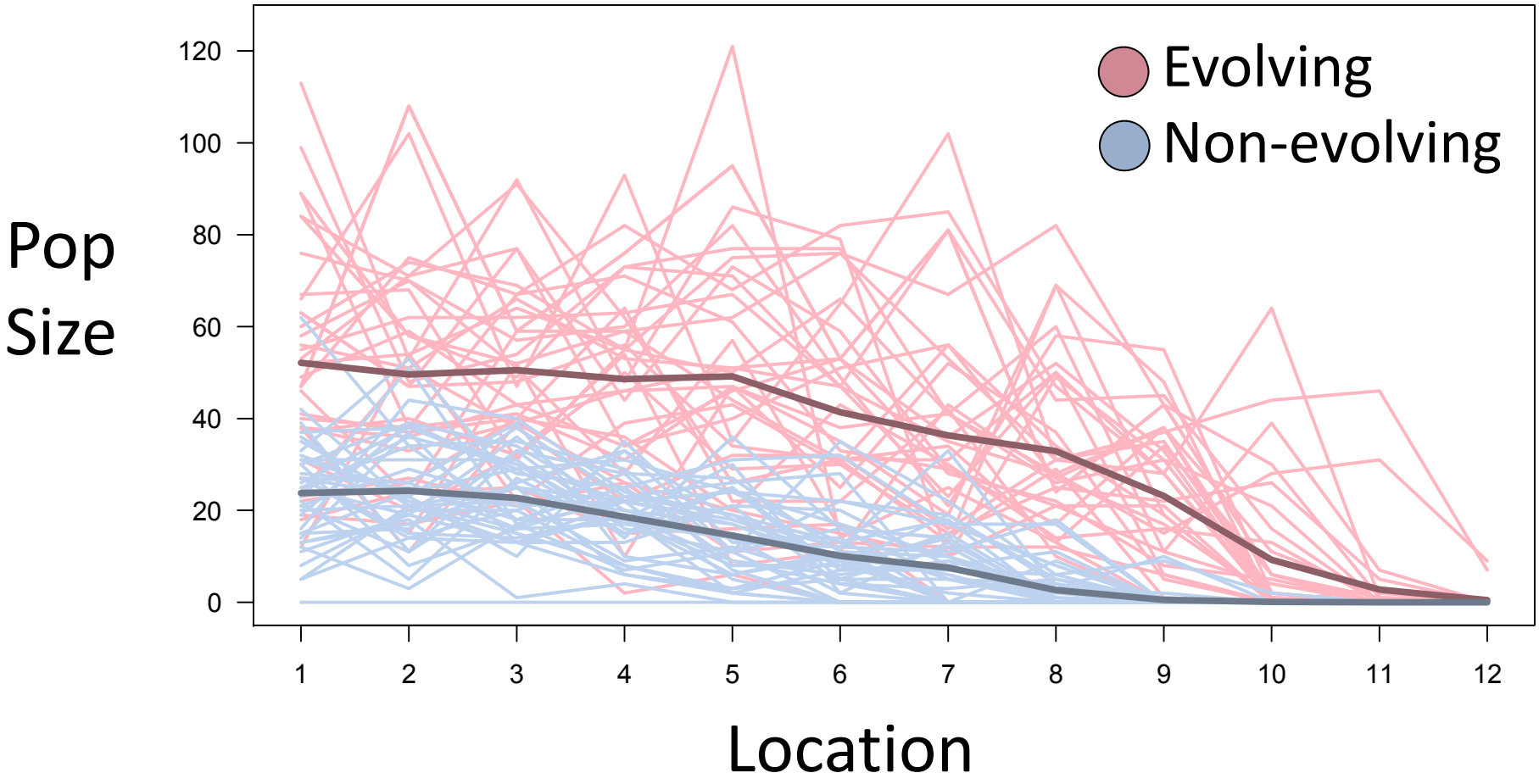
Generation 4

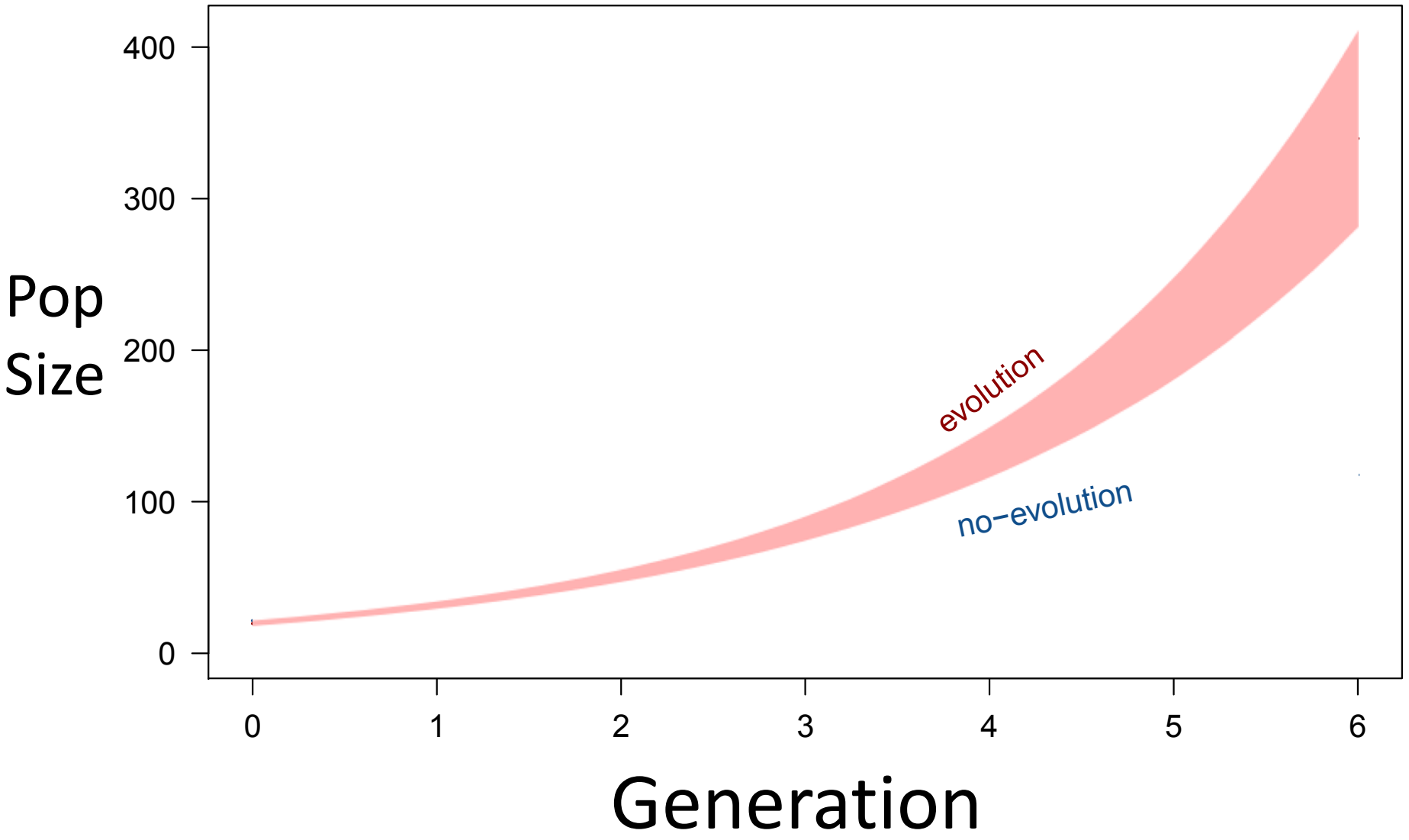


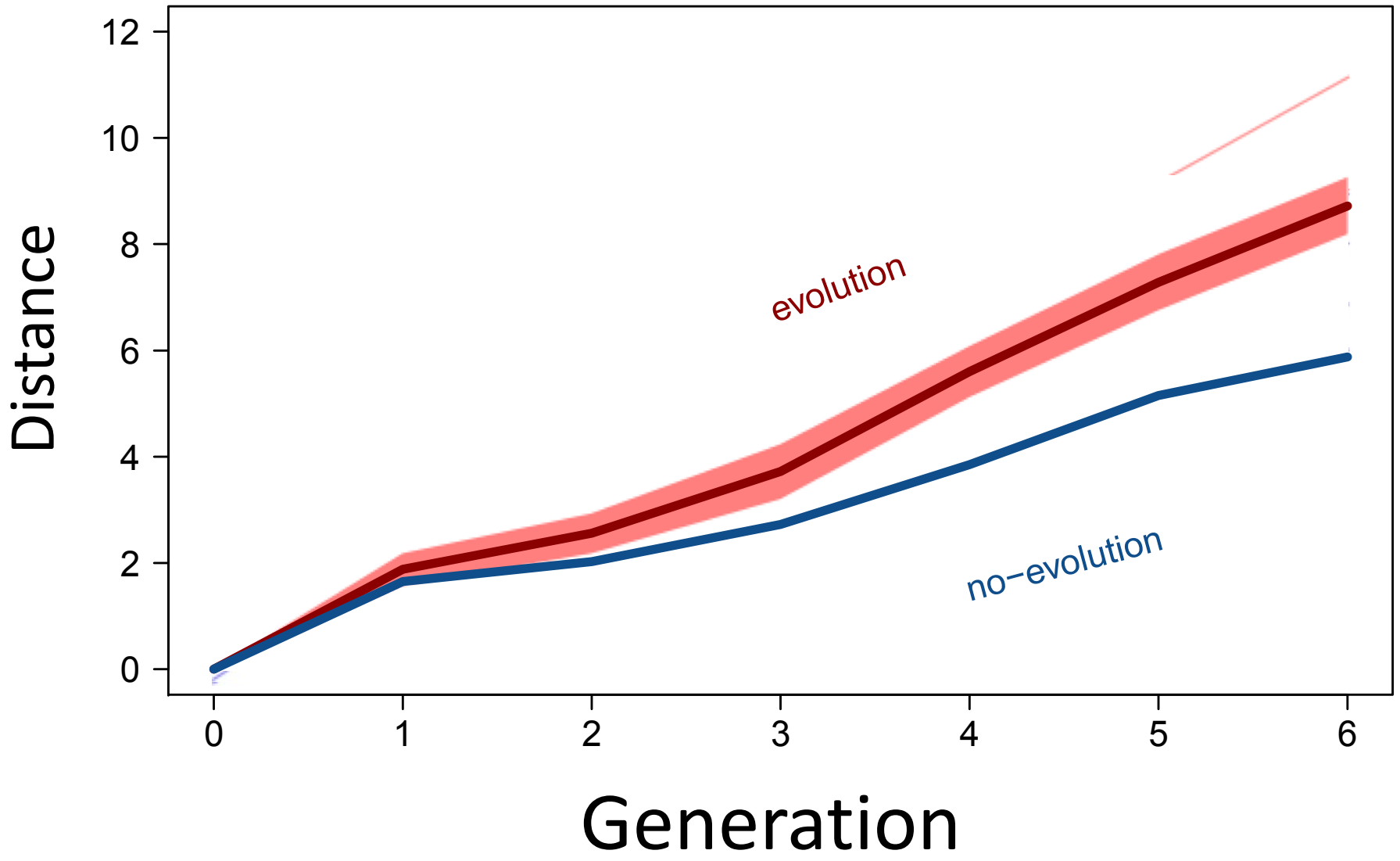
Generation 5



Generation 6



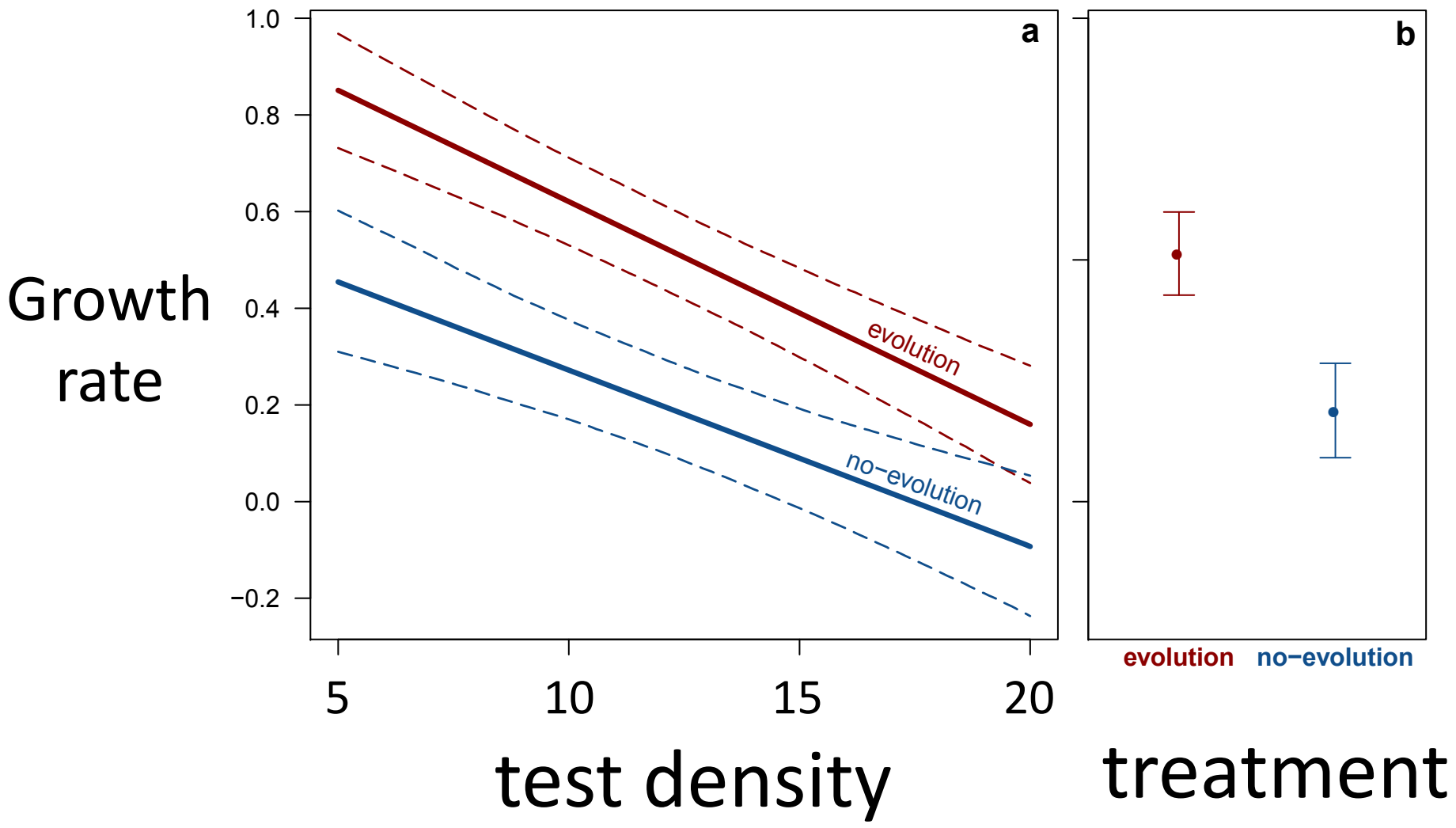

Pop
Size
400
300
200
100
0
evolution
no−evolution
0
1
2
3
4
5
6
Generation

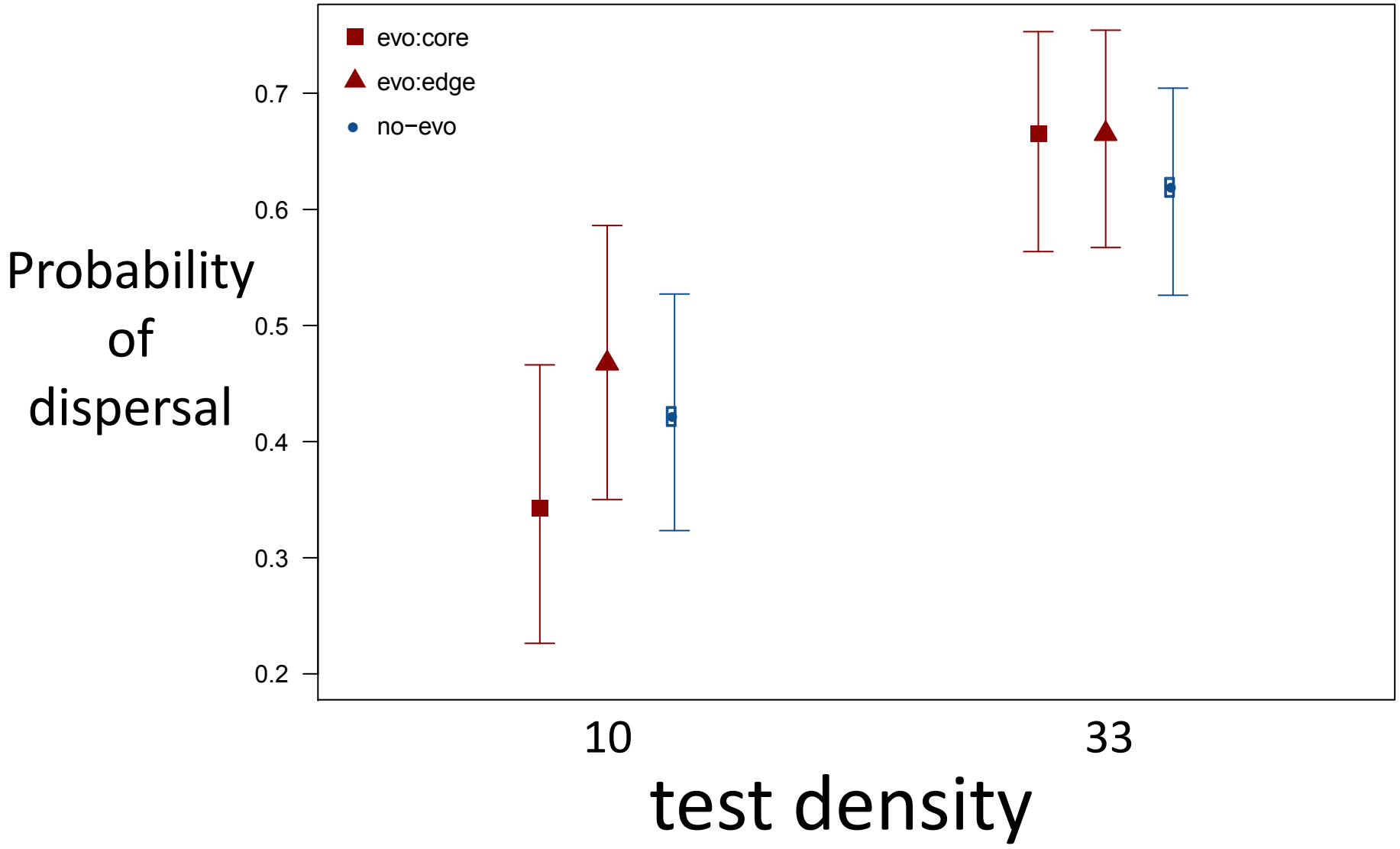

Distance
12
10
8
6
4
2
0
evolution
no−evolution
0
1
2
3
4
5
6
Generation

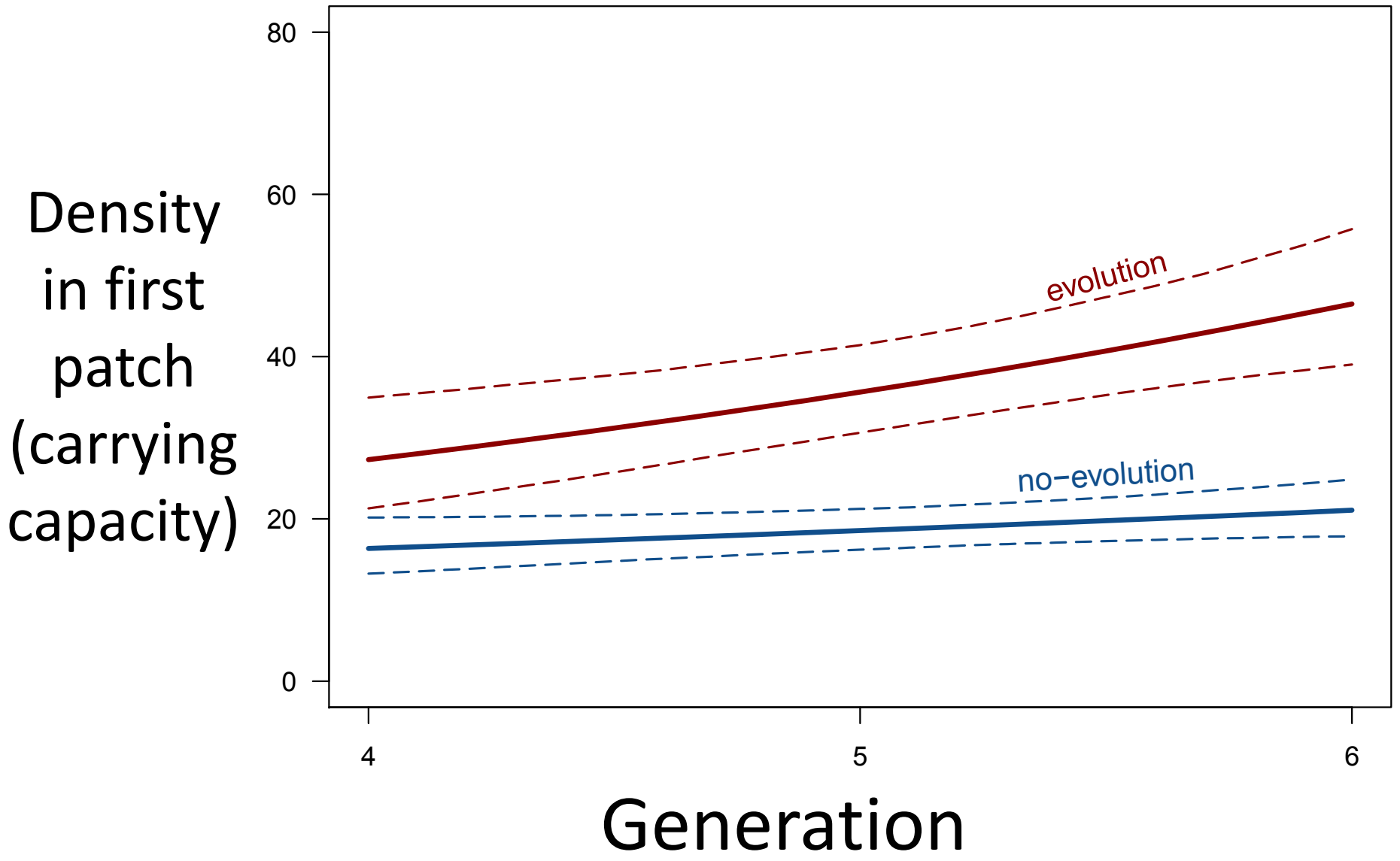
Data

- 6 generations of censuses
  - # of individuals by patch in a landscape

- “common garden” experiment
  - growth rate of evolving and non-evolving in novel environment
  - dispersal from low and higher density patches

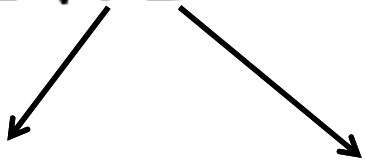

Growth rate
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
a
evolution
no−evolution
5
10
15
20
test density
b
evolution
no−evolution
treatment


evo:core
evo:edge
no−evo
0.7
0.6
0.5
0.4
0.3
0.2
Probability of dispersal
10
33
test density


Density in first patch (carrying capacity)
80
60
40
20
0
evolution
no−evolution
4
5
6
Generation

Adaptation as a driver

- Selection a novel habitat
  - Higher growth rate ✔
  - Higher carrying capacity ✔
- Expansion speed $\approx 2\sqrt{rD}$ (Fisher 1937)

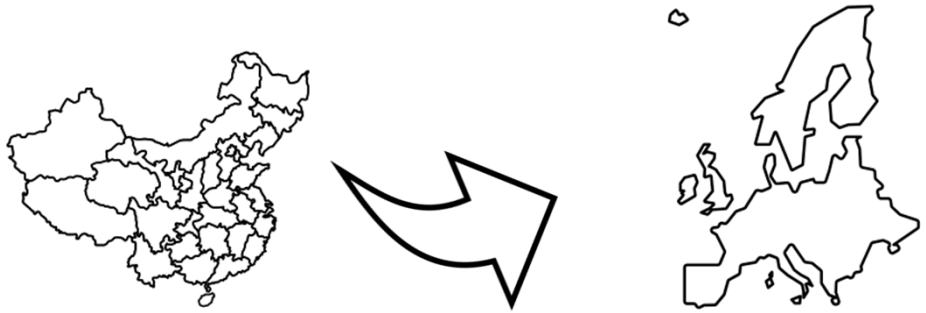


growth rate

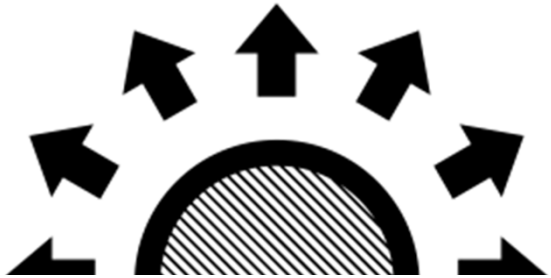
positive density dependent dispersal ✔

Evolution as a driver

- Adaptation

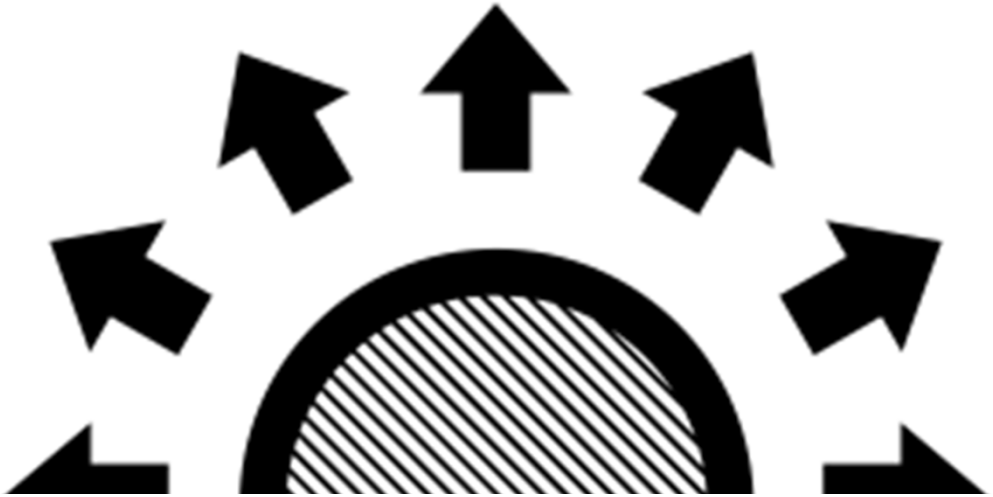


- Range expansion dynamics



Evolution as a driver

- Evolution across a range expansion
  - Evolution of growth rate differences from core to edge
  - Higher dispersal rate



Ben Phillips, Rick Shine

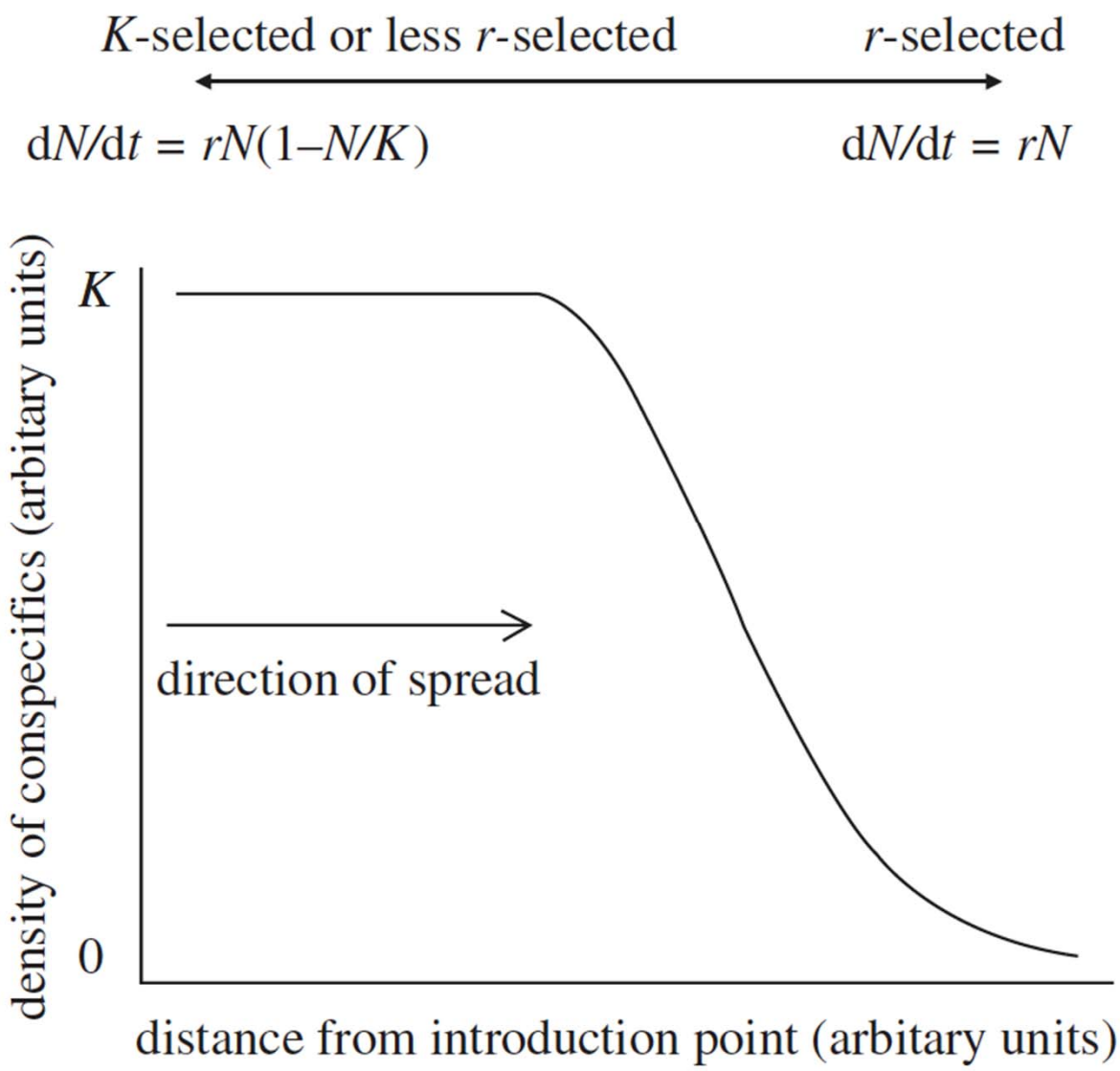
density-driven selection for

"*K*" in core

(fewer offspring, lower growth rate)

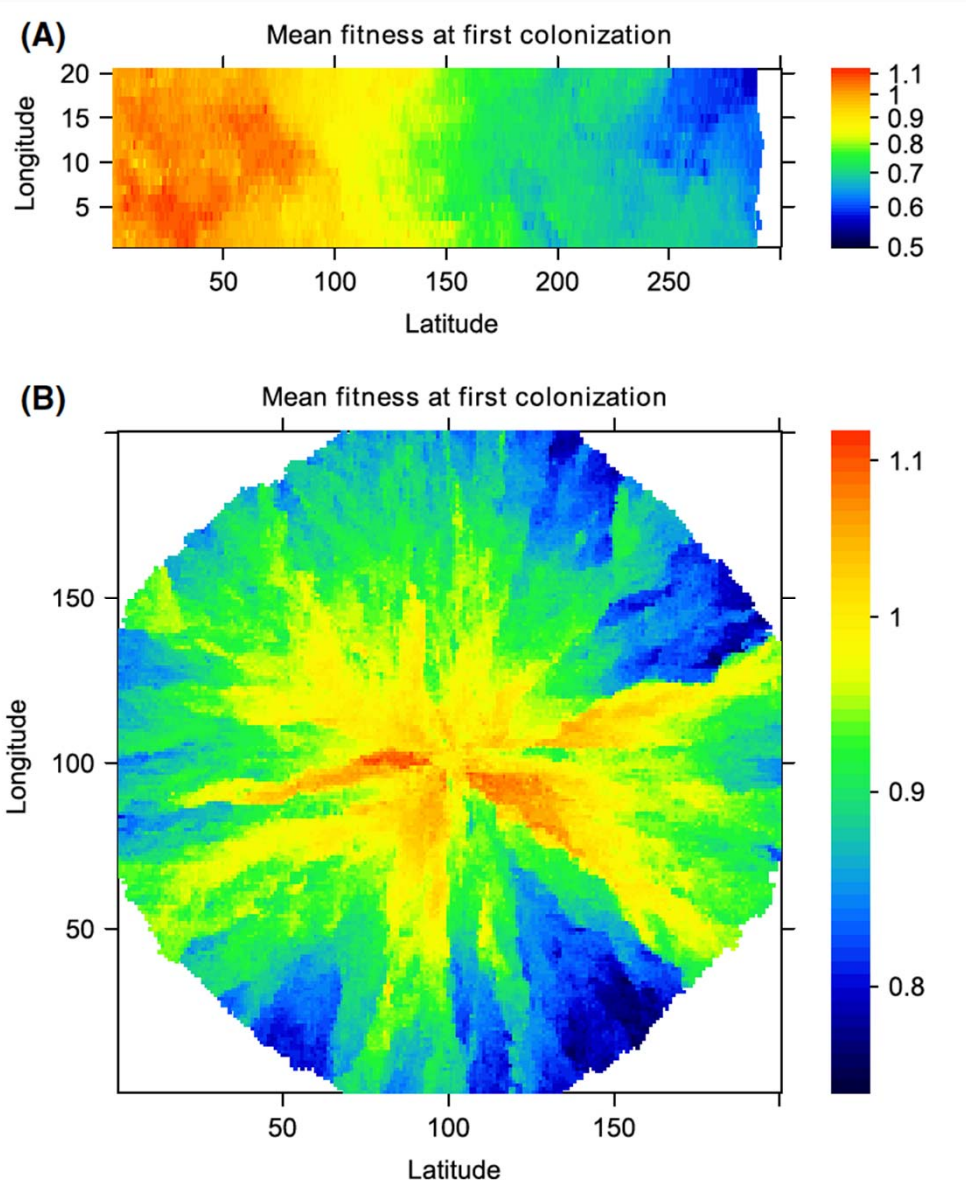
"*r*" in edge

(more offspring, higher growth rate)



Phillips 2009

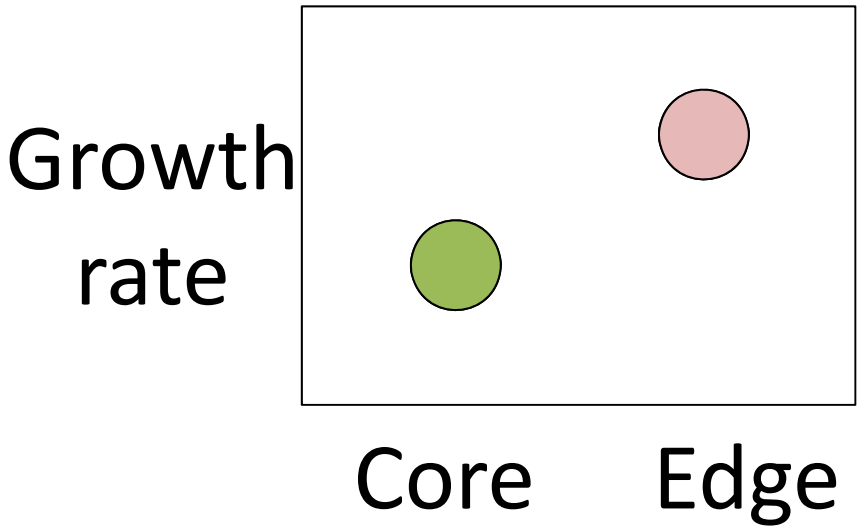
surfing of deleterious alleles at the expansion front



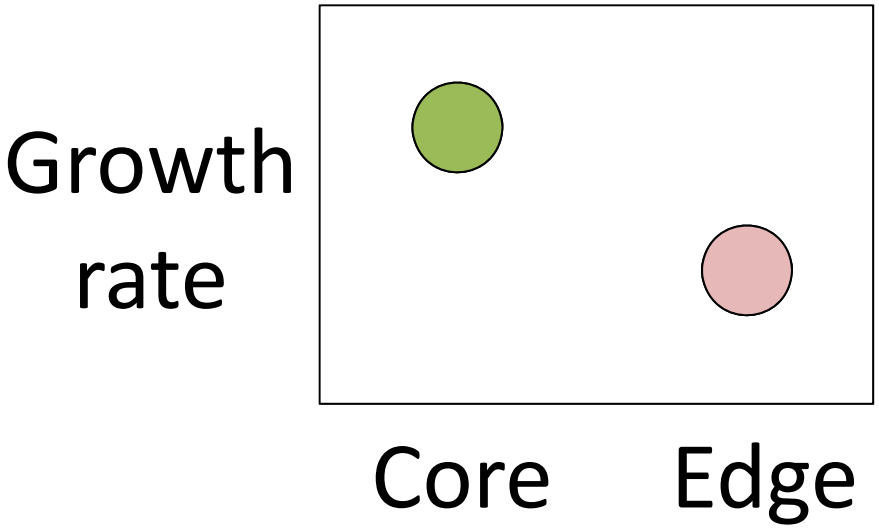
Peischl et al. 2013

Contrasting predictions

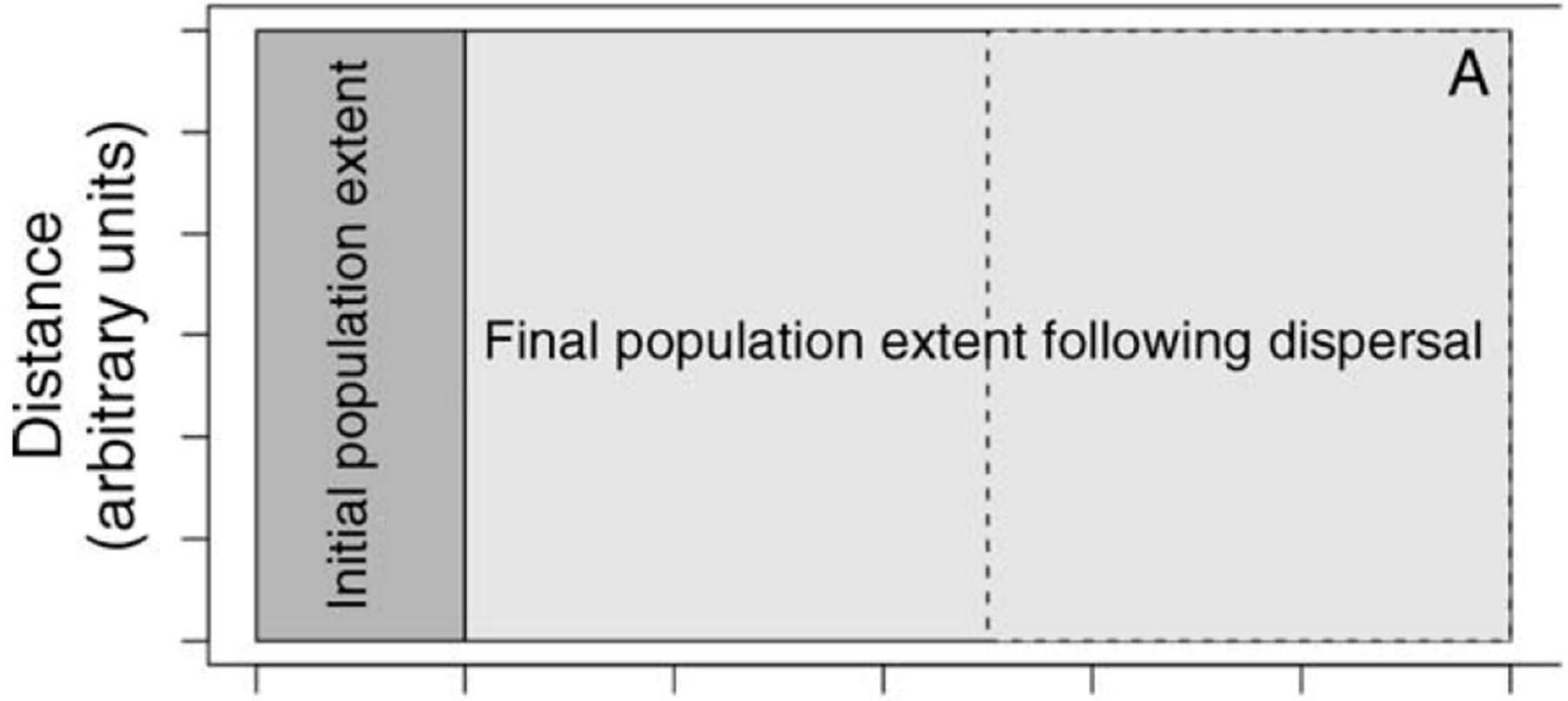
Phillips and co:
density-driven selection



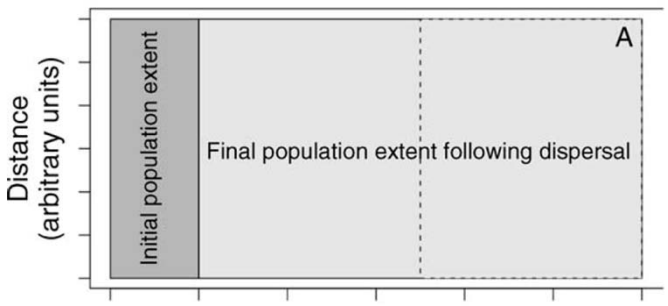
Peischl and co
gene surfing/expansion load

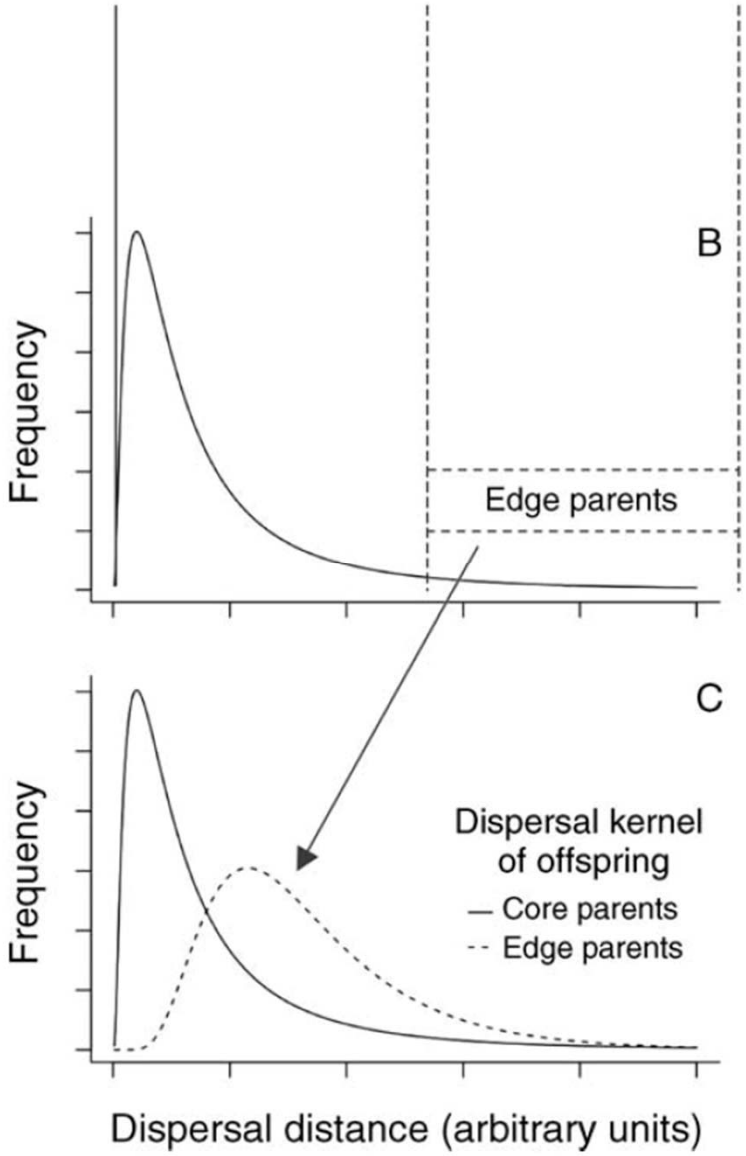


Dispersal



Phillips et al. 2010



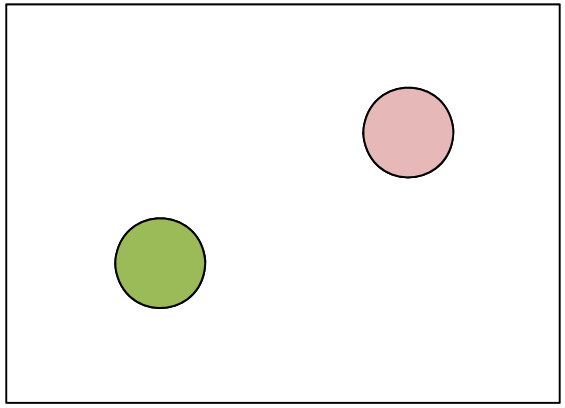


Phillips et al. 2010

Prediction

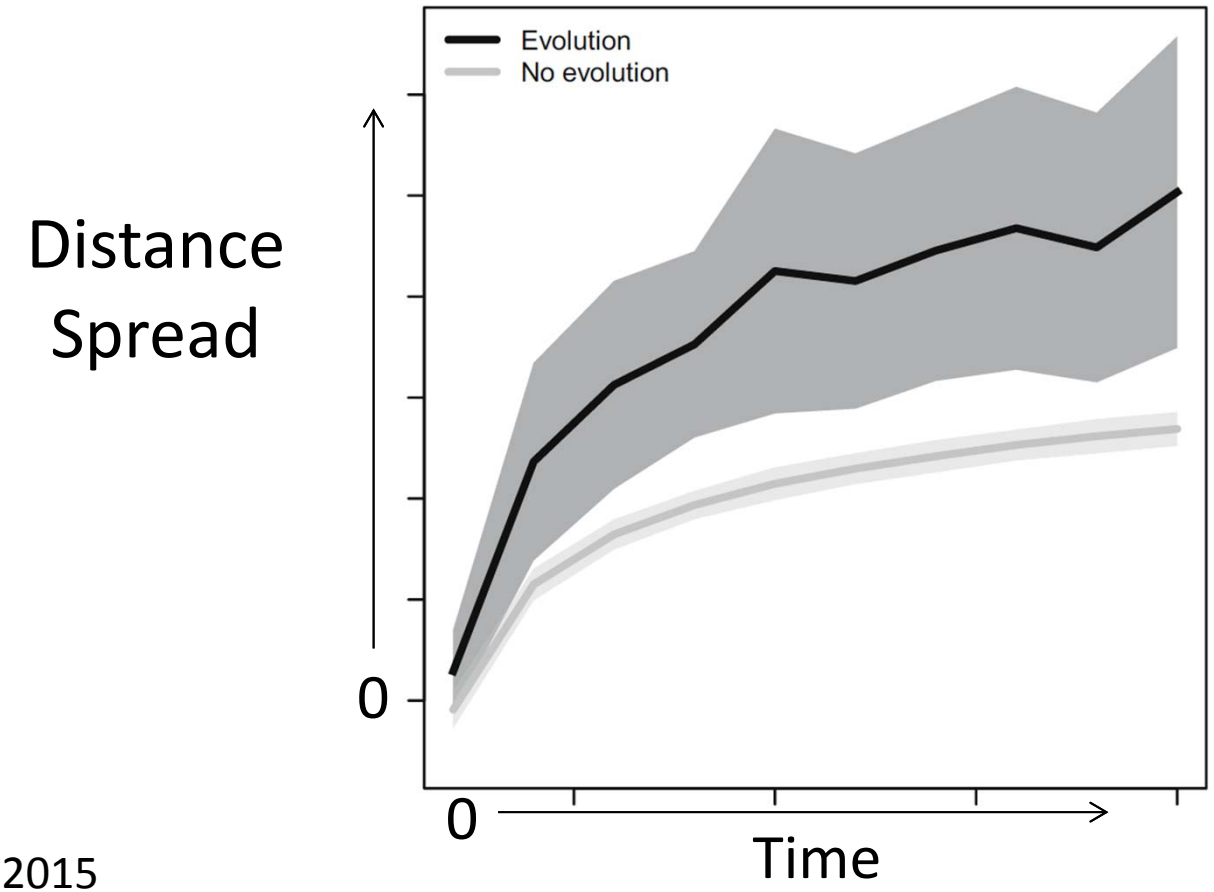
Phillips and co:
spatial selection for dispersal

Dispersal



Core Edge

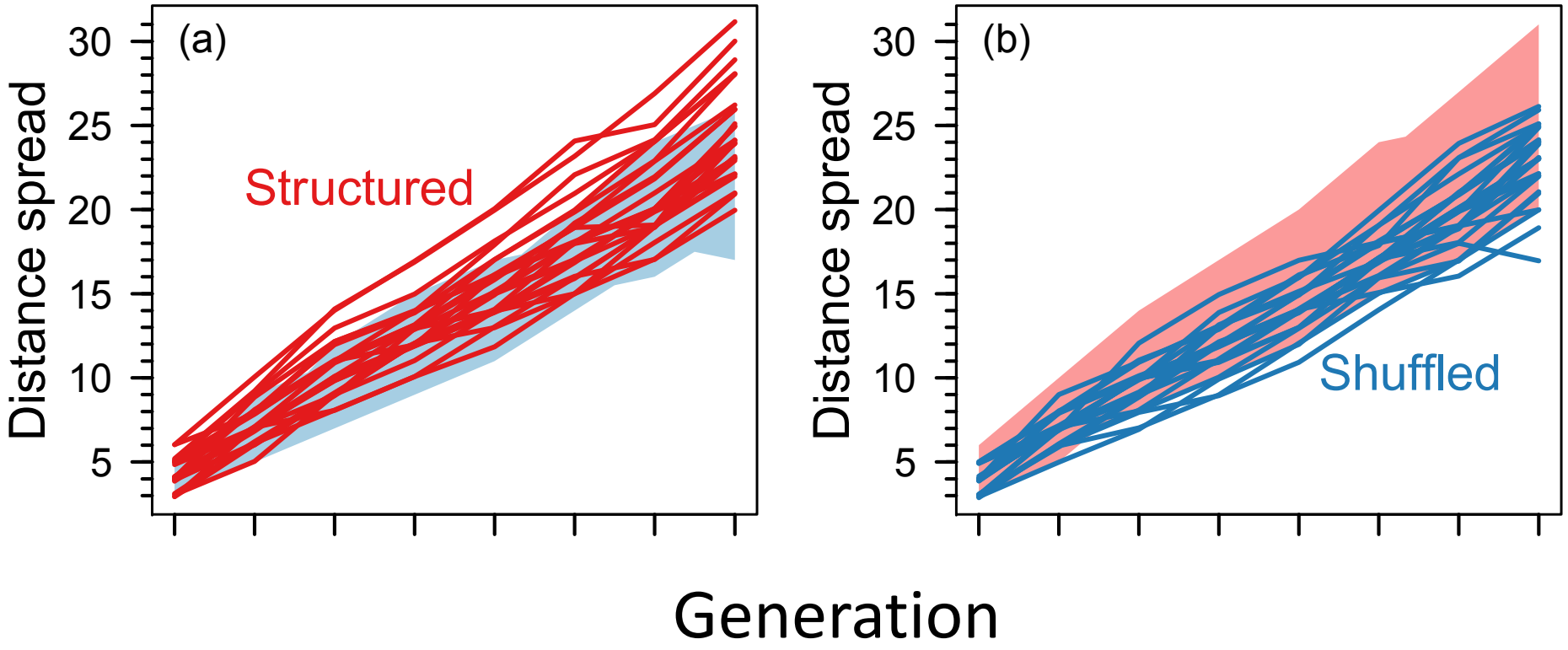
Expansion distance and predictability



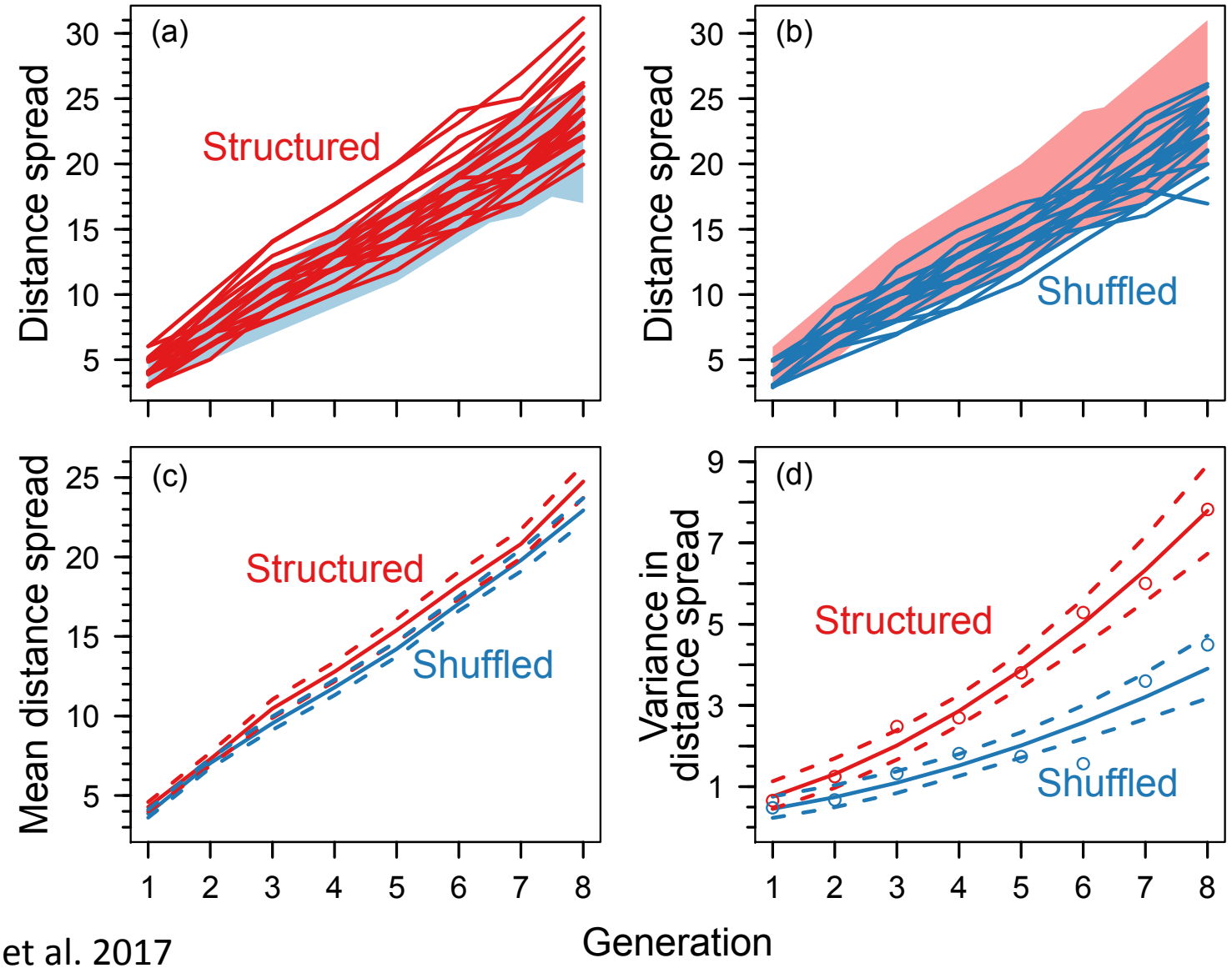
Phillips et al. 2015

Spread experiment

- No novel habitat
- Structured
  - evolving normally with spatial structure
- Shuffled each generation
  - no evolution of spatial structure
  - demographic structure maintained



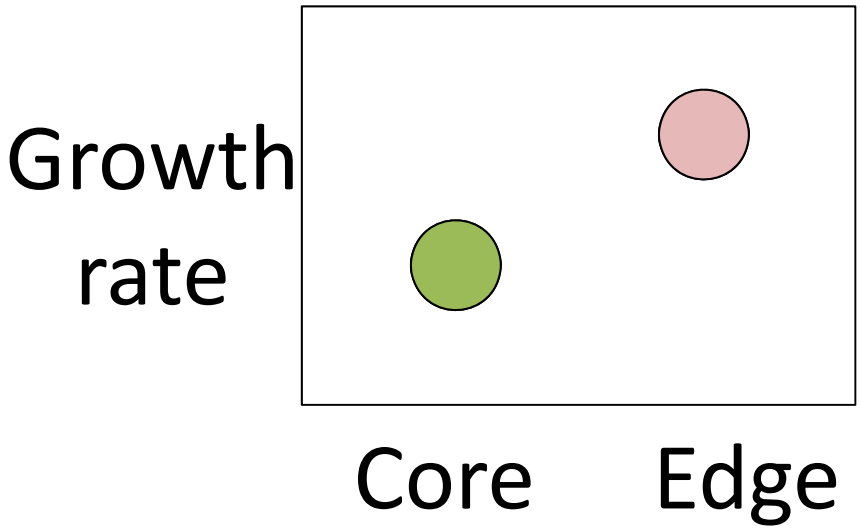
Weiss-Lehman et al. 2017



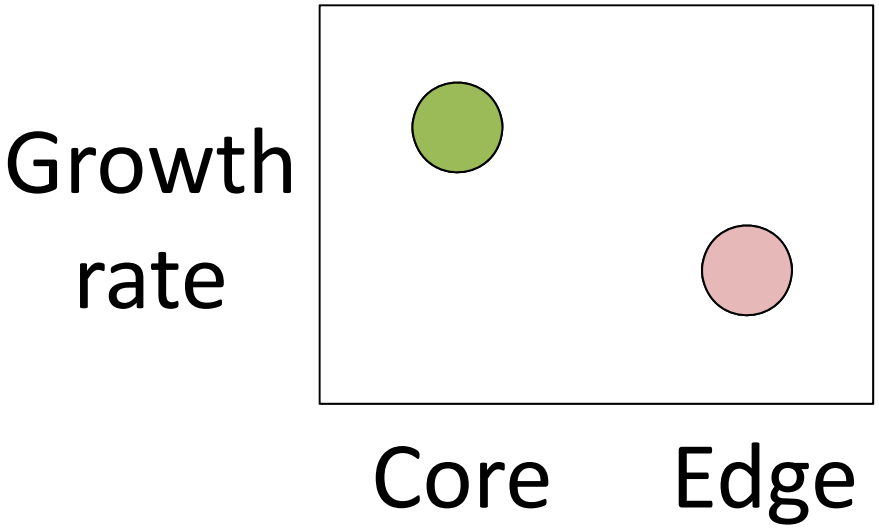
Weiss-Lehman et al. 2017

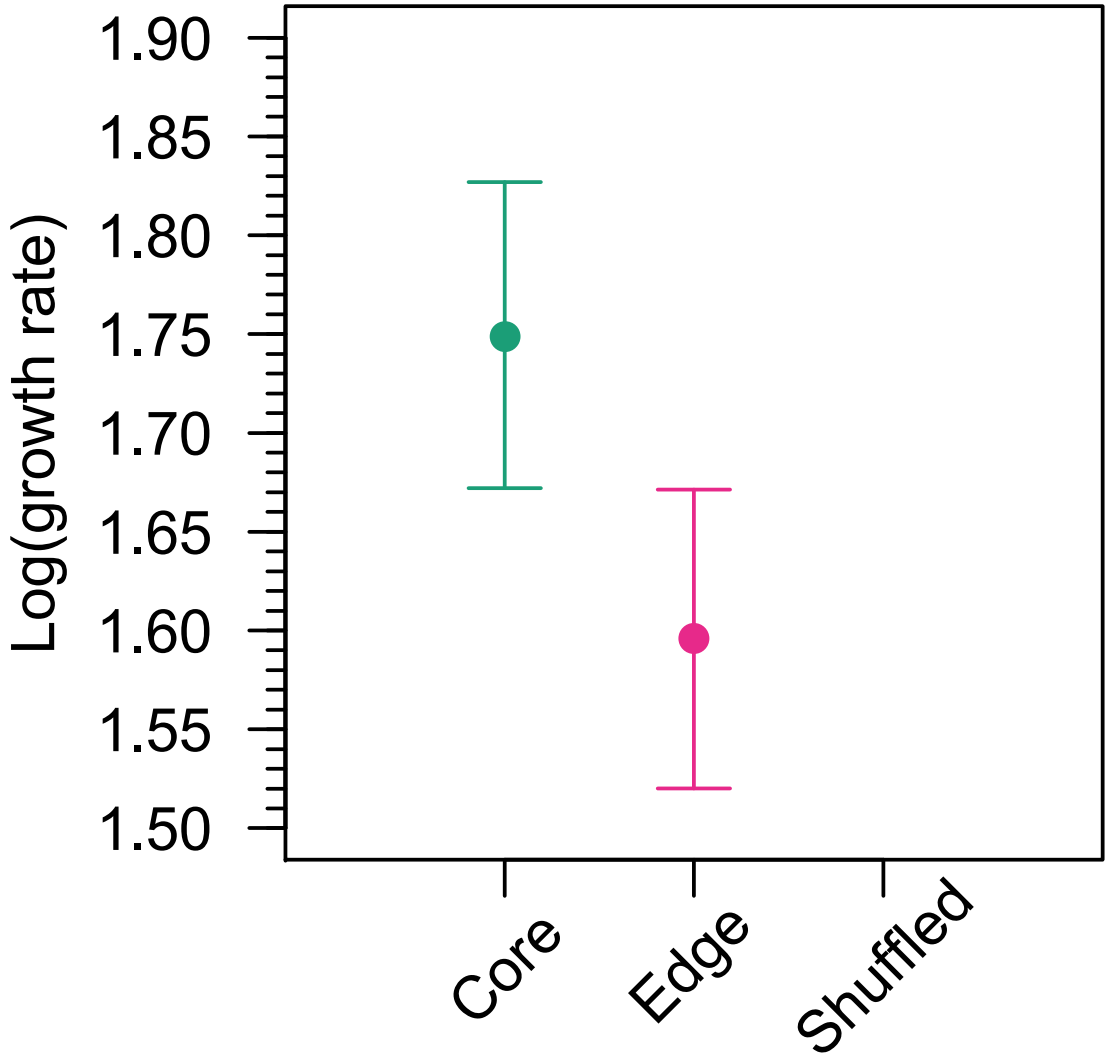
Contrasting predictions

Phillips and co:
density-driven selection



Peischl and co
gene surfing/expansion load



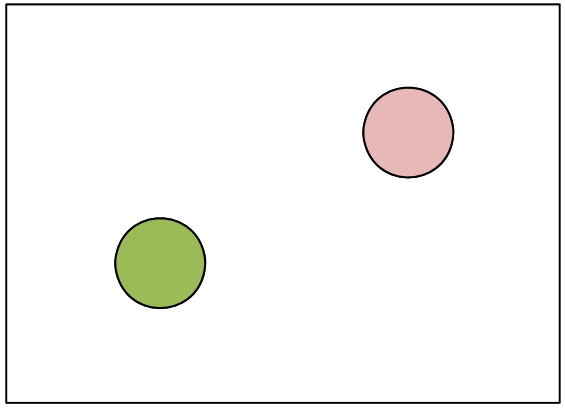


Weiss-Lehman et al. 2017

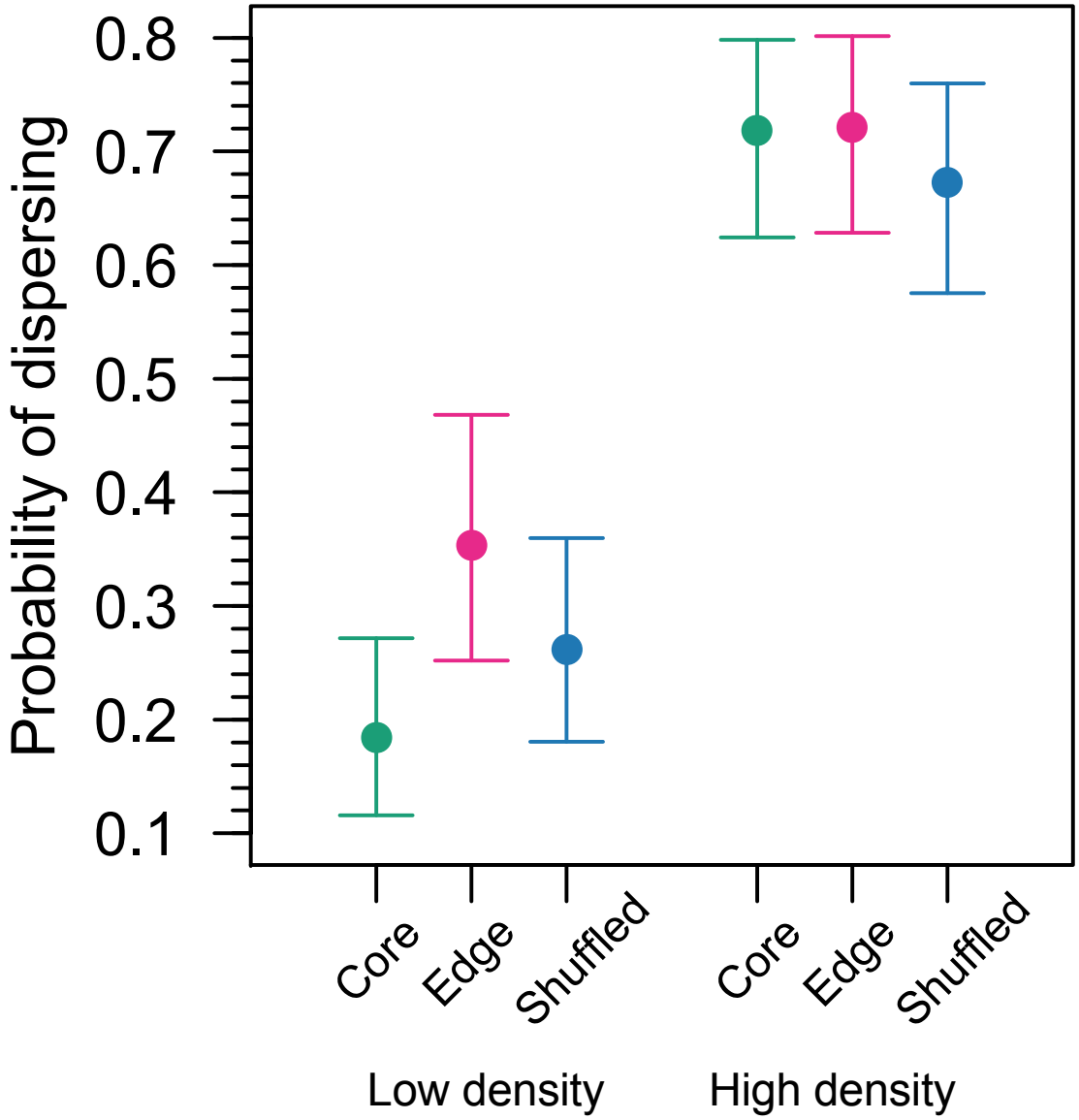
Prediction

Phillips and co:
spatial selection for dispersal

Dispersal



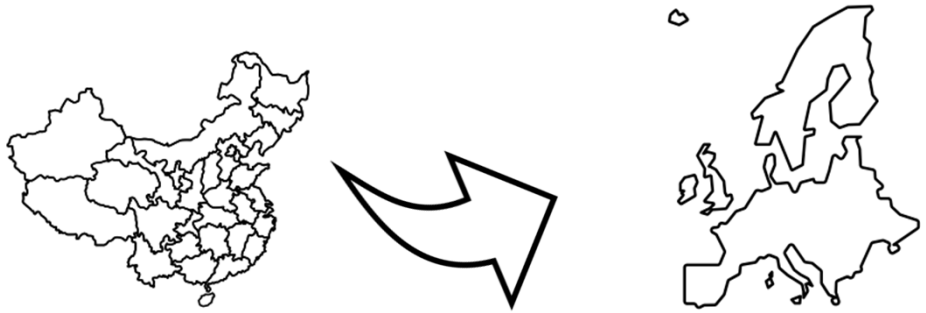
Core Edge



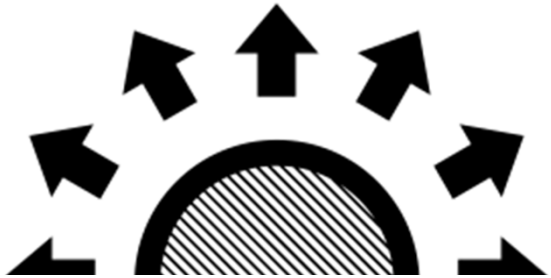
Weiss-Lehman et al. 2017

Evolution as a driver

- Adaptation



- Range expansion dynamics



What next?

- First experiment – have beetles from core, edge and non-evolving frozen (~30) (but no $$)

- Second experiment – have pool seq data (20 beetles)
  - 22 structured (founders, core & edge at gen 8)
  - 15 shuffled landscapes (founders, gen 8)

What next?

- Can we detect signals of adaptation or gene surfing in genomic data?

- Is that even an interesting question to ask??