Density Dependence

Today's Agenda:

- Quiz
- Project 2: Species Interactions
- Population growth
- Density Dependence

Project 2: Species Interactions: Due Feb 28

Step 1: Select type(s) of species interactions relevant for your study system

Step 2: Find and read 10-20 relevant papers

Step 3: Write around 3 pages about it (double spaced)

~ Pages 1-2: Focus on interactions

~ Page 3: Focus on impact of interactions on diversity patterns

Introduction format, references don’t count against page limit

Project 2: Species Interactions: Due Feb 28

Potential things to include:

- Predation
- Competition
- Mutualism
- Coexistence (with linkages to e.g., predation, competition, etc.)
- How things are tested
- Gaps in our knowledge
- Spatial variation in interaction strength

Project 2: Species Interactions: Due Feb 28

Grade Breakdown:

● At least ten papers were referenced in the text	30%
● One or more interaction types were discussed	30%
● Impact of the interaction on diversity patterns was discussed	20%
● One or more additional aspects (e.g., testing, competition) discussed	10%
● Writing quality	10%
● Up to 10% will be deducted for excessive length	-10%

Project 2: Species Interactions: Due Feb 28

Questions?

Population Growth

Population Growth

Thomas Malthus

- Economist who is critical for ecology and evolution

Population Growth

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- Focused on population growth

Population Growth

Thomas Malthus

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- Focused on population growth
- Inspired the Exponential (a.k.a. Malthusian) Growth Model

$$N_t = N_0 e^{rt}$$

Population Growth

Thomas Malthus

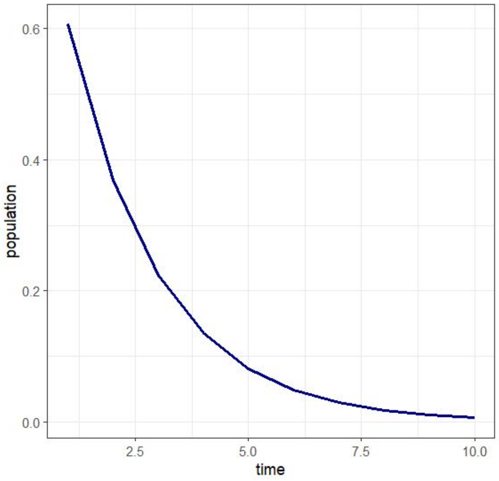
- Economist who is critical for ecology and evolution
- Focused on population growth
- Inspired the Exponential (a.k.a. Malthusian) Growth Model

$$N_t = N_0 e^{rt}$$

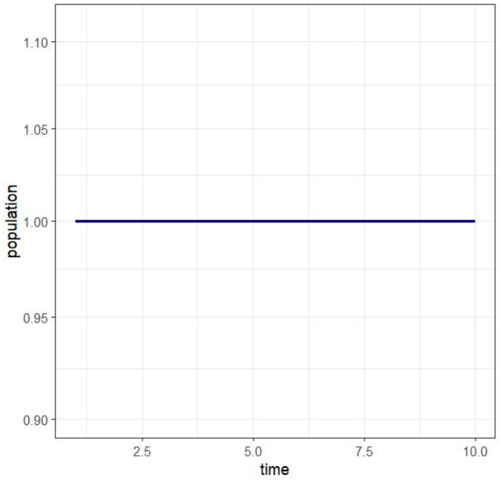
N_t = # at time t,
N_0= initial population size,
r = intrinsic population growth rate
t = time

Exponential Growth

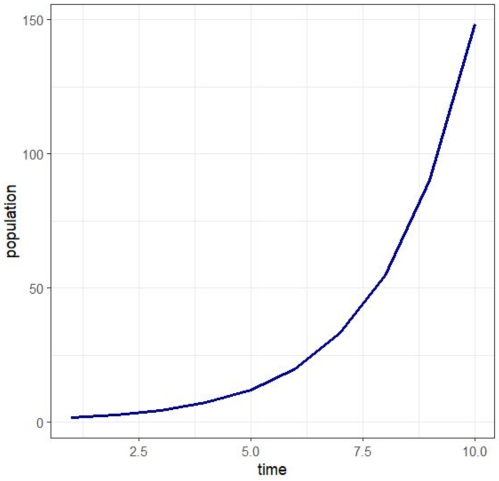
$N_t = N_0e^{rt}$



r = -0.5



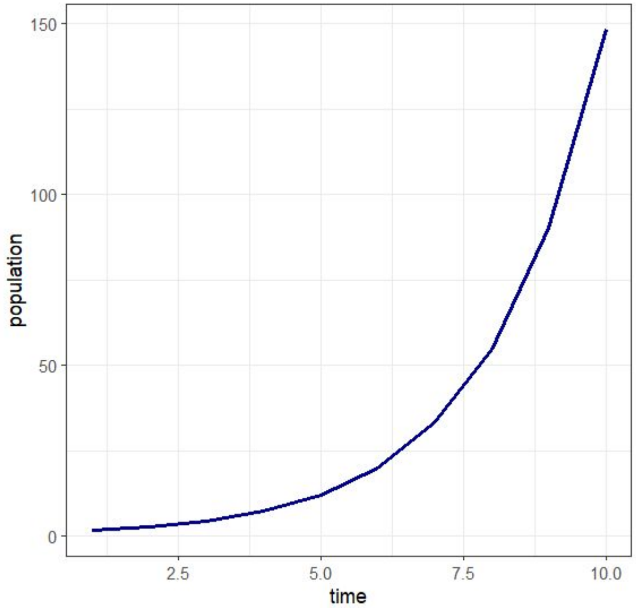
r = 0.0



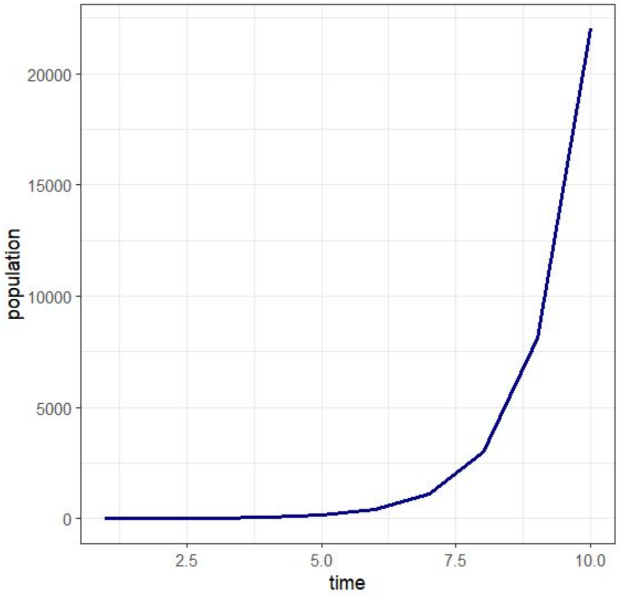
r = 0.5

Exponential Growth

$N_t = N_0 e^{rt}$



r = 0.5



r = 1

Exponential Growth

What is the growth rate for a population that doubles every 20 years?

$N_t = N_0 e^{rt}$

Exponential Growth

What is the growth rate for a population that doubles every 20 years?

$N_t = N_0 e^{rt}$

$2=1*e^{r*20}$

Exponential Growth

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$N_t = N_0 e^{rt}$

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$\ln(2)=20r$

Exponential Growth

What is the growth rate for a population that doubles every 20 years?

$N_t = N_0 e^{rt}$

$2=1*e^{r*20}$

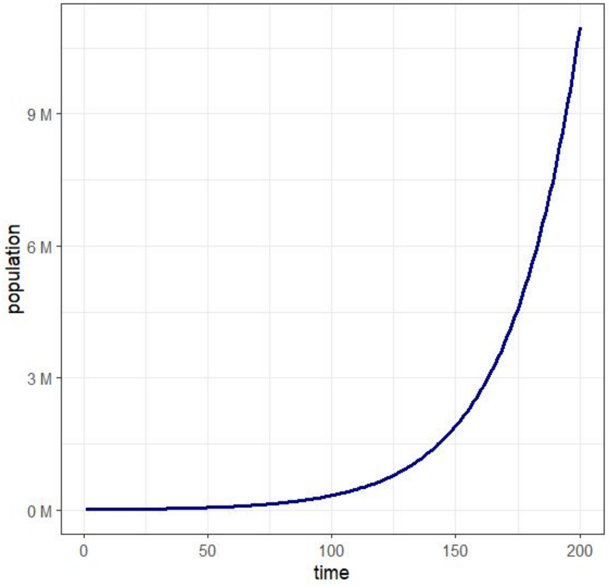
$\ln(2)=20r$

$r = \ln(2)/20 = 0.03465736$

Exponential Growth

Our book gives 20,000 humans as an estimate for 70k bce

Assuming populations doubled in ~ 20 years…



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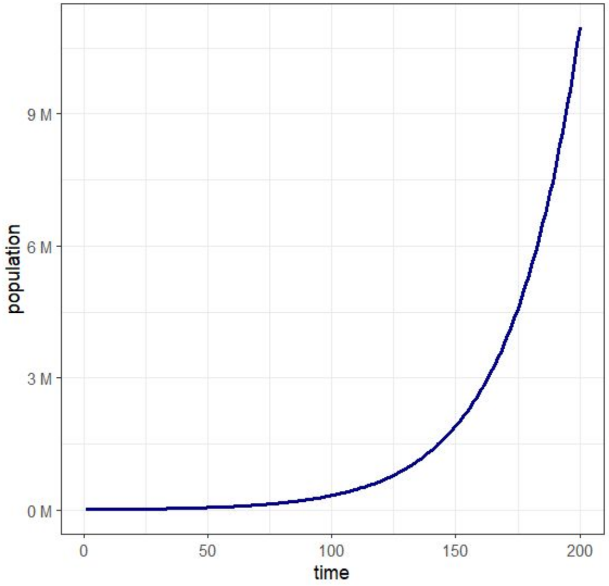

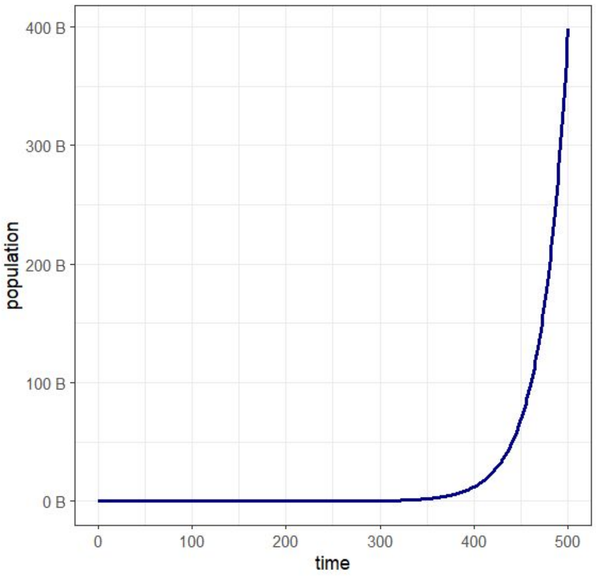

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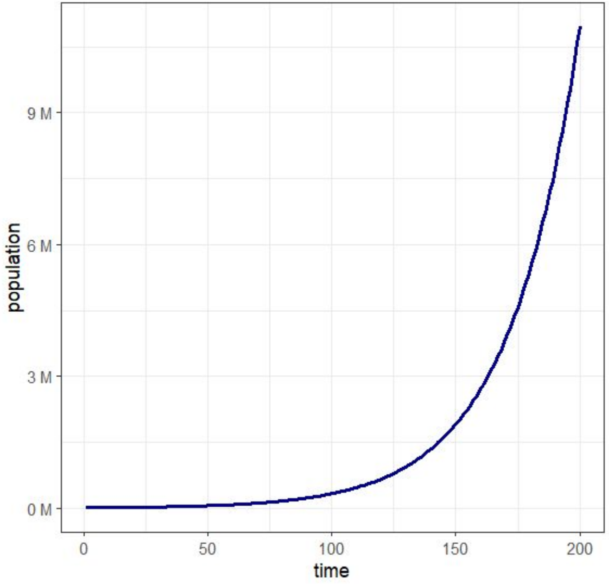

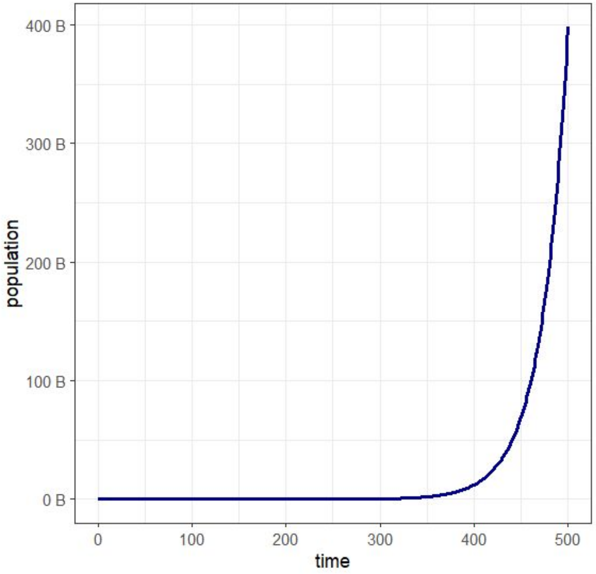

Obviously, 400 billion humans is unrealistic…

Density Dependence

As populations increase, growth rates decrease

- What factors drive this?

Density Dependence

As populations increase, growth rates decrease

What factors drive this?

- Competition
- Aggression
- Disease
- Predation
- Accumulation of waste

Density Dependence

As populations increase, growth rates decrease

- Creates a feedback between population size and growth rate
- Often modelled using a logistic growth model

Logistic Growth

$$N_t = N_0 \frac{K}{(K - N_0)e^{-rt} + N_0}$$

N_t = # at time t,
N_0= initial population size,
r = intrinsic population growth rate
t = time

K = carrying capacity

Logistic Growth

$$N_t = N_0 \frac{K}{(K - N_0)e^{-rt} + N_0}$$

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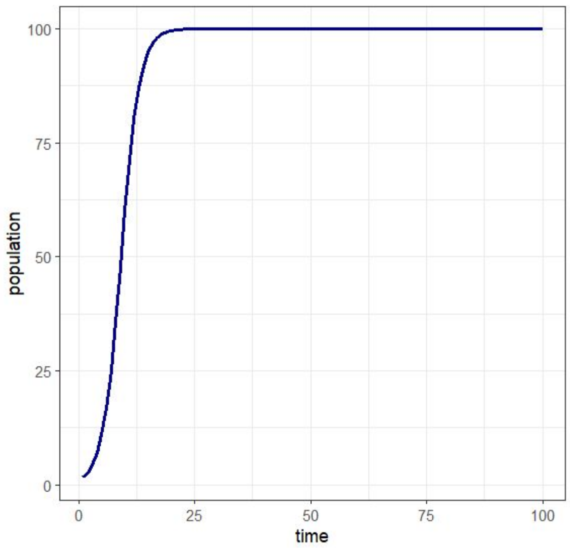
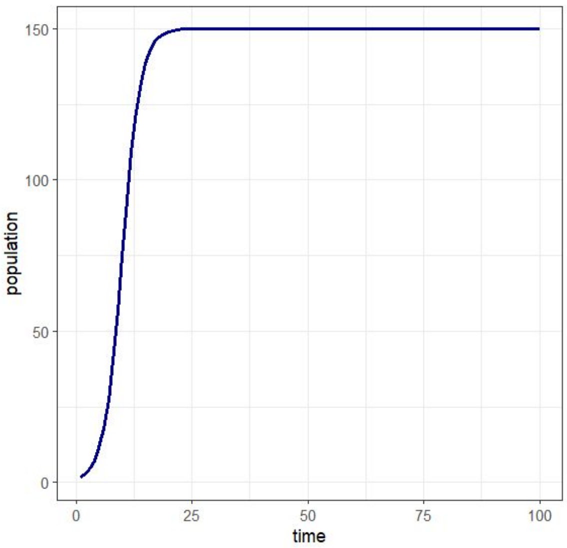
Logistic Growth

$$N_t = N_0 \frac{K}{(K - N_0)e^{-rt} + N_0}$$



K = 100
r = 0.5

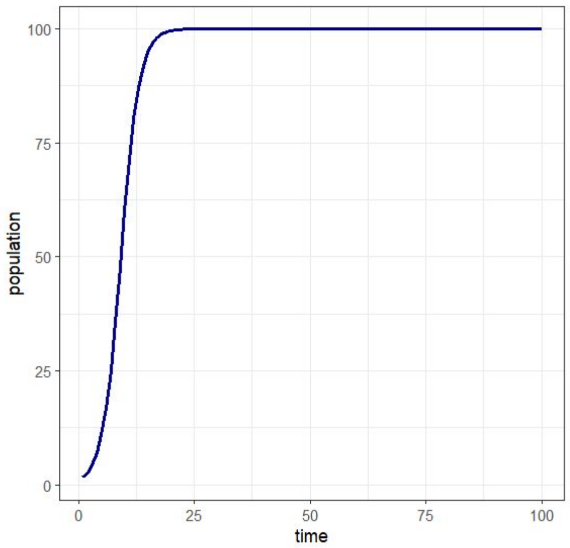


K = 150
r = 0.5

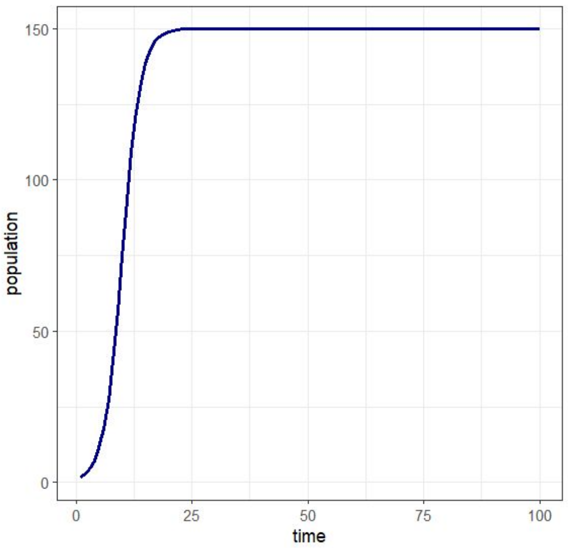
N_t = # at time t,
N_0= initial population size,
r = intrinsic population growth rate
t = time
K = carrying capacity

Logistic Growth

$$N_t = N_0 \frac{K}{(K - N_0)e^{-rt} + N_0}$$



K = 100
r = 0.5



K = 150
r = 0.5

N_t = # at time t,
N_0= initial population size,
r = intrinsic population growth rate
t = time
K = carrying capacity

K controls maximum population size, that is, the carrying capacity

Assumptions of Logistic Growth

Makes some assumptions, which are unlikely to hold:

1) Per capita growth rate is a linear function of the number of individuals
2) Changes to growth rate are instantaneous
3) External environment doesn’t matter (e.g., resources, climate)
4) All individuals are equivalent

Why use logistic growth?

Given the unrealistic assumptions, why use it?

- Good starting point
- Can add other features to it
- Often best to start with a simple model and only add parameters as needed
- Useful as a tool for thinking about population dynamics

Causes of Density dependence

Earlier we discussed some factors that could lead to density dependence.

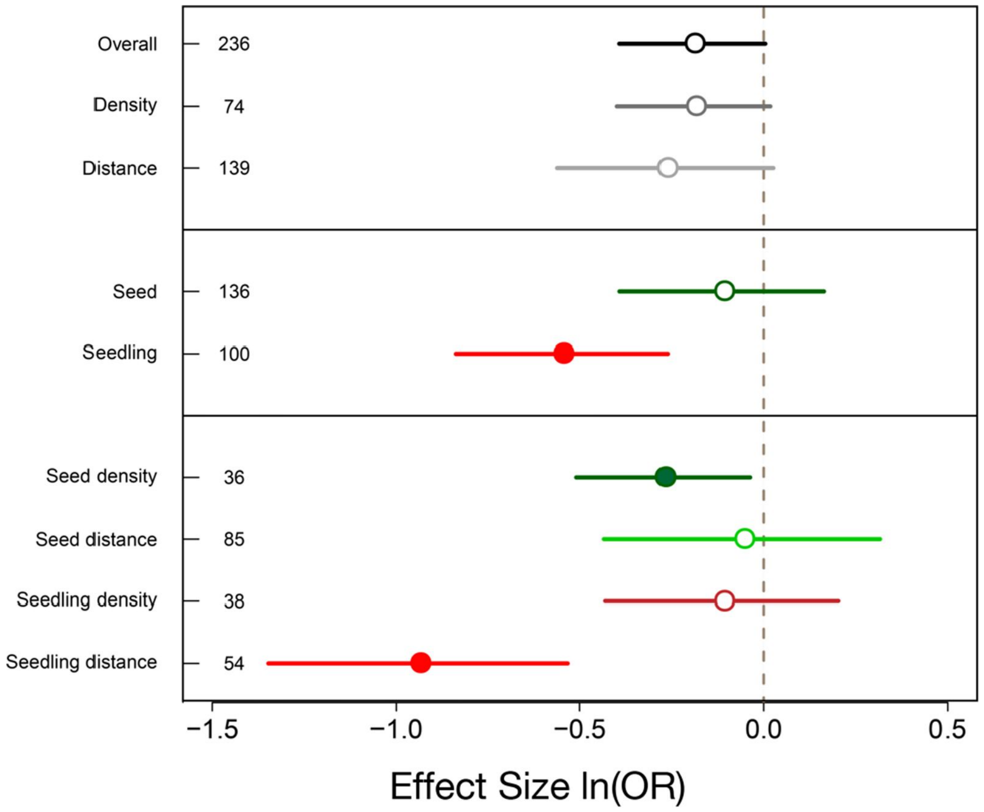
Lots of focus on competition

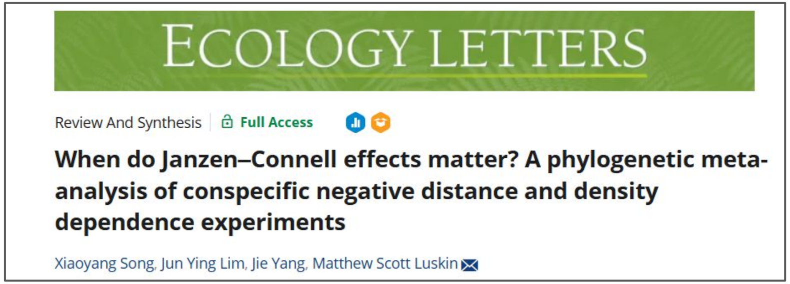
But, as we discussed, other factors can play a role!

Janzen-Connell Hypothesis

- Focuses on specialist natural enemies (e.g., herbivores, pathogens)
- The impact of enemies is related to distance to others of your species
- So, as an area fills up, there are fewer places free of enemies
- Thus, populations are kept in check by enemies

Janzen-Connell Hypothesis





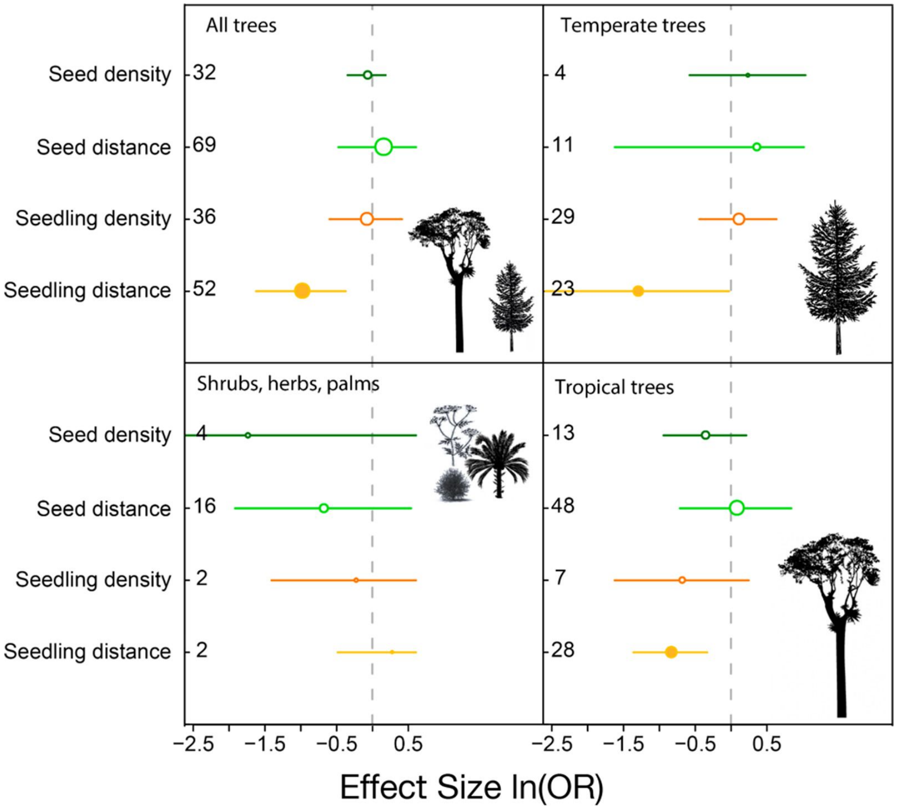
ECOLOGY LETTERS

Review And Synthesis | Full Access

When do Janzen–Connell effects matter? A phylogenetic meta-analysis of conspecific negative distance and density dependence experiments

Xiaoyang Song, Jun Ying Lim, Jie Yang, Matthew Scott Luskin

Janzen-Connell Hypothesis



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Positive density dependence?

Why might the growth rate of a species INCREASE with population size?

Positive density dependence?

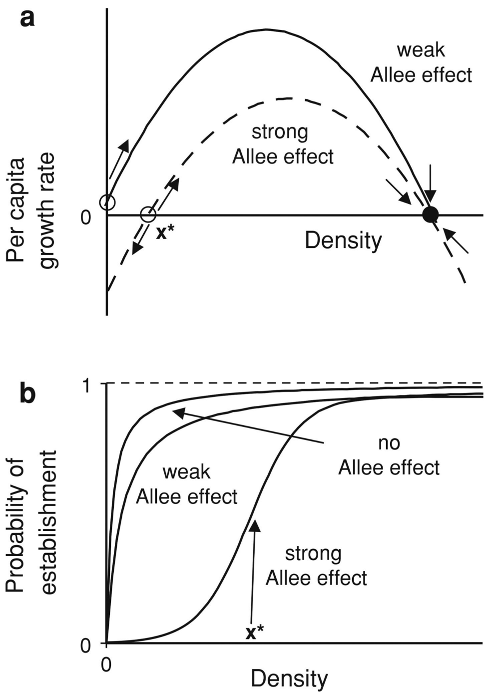
Why might the growth rate of a species INCREASE with population size?

- Ease of finding a mate
- Predator defense
- Offspring survival
- Greater foraging efficiency
- Environmental modification

Some of these are particularly important for social species

Allee Effects

Positive relationship between growth rate and population size




Population Ecology

Special Feature: Review | Full Access

The evidence for Allee effects

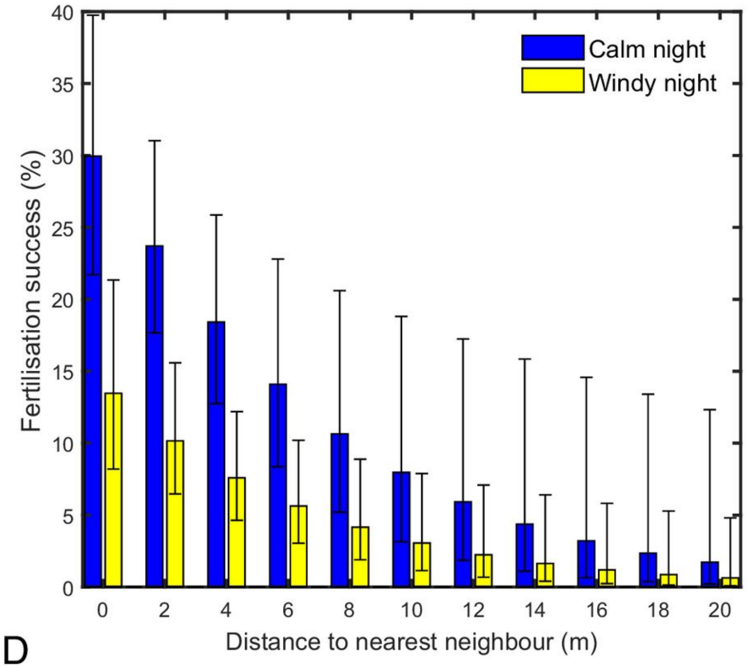
Andrew M. Kramer, Brian Dennis, Andrew M. Liebhold, John M. Drake

First published: 18 April 2009 | https://doi.org/10.1007/s10144-009-0152-6 | Citations: 384

Allee Effects

Positive relationship between growth rate and population size

B



D

PNAS RESEARCH ARTICLE | ECOLOGY OPEN ACCESS

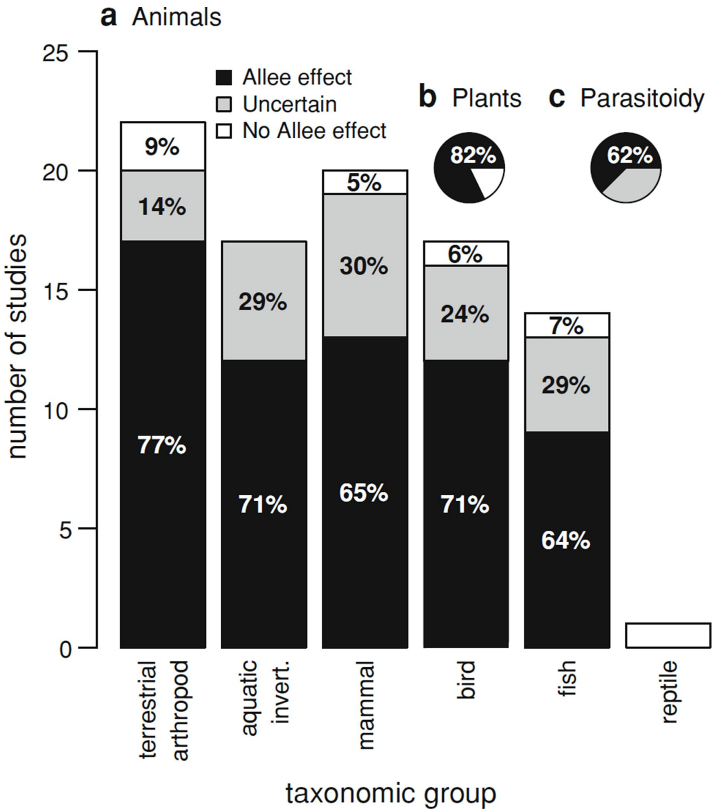
Allee effects limit coral fertilization success

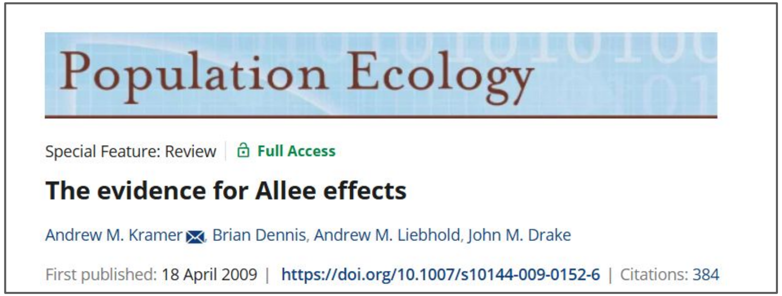
Peter J. Mumby[a,b,1], Greta Sartori[b], Elizabeth Buccheri[a,c], Cinzia Alessi[b], Hannah Allan[a,c], Christopher Doropoulos[c], Geraldine Rengiil[b], and Gerard Ricardo[a,c]

Edited by Mark Hay, Georgia Institute of Technology, Altanta, GA; received September 8, 2024; accepted October 24, 2024

December 16, 2024 | 121 (52) e2418314121 | https://doi.org/10.1073/pnas.2418314121

Allee Effects





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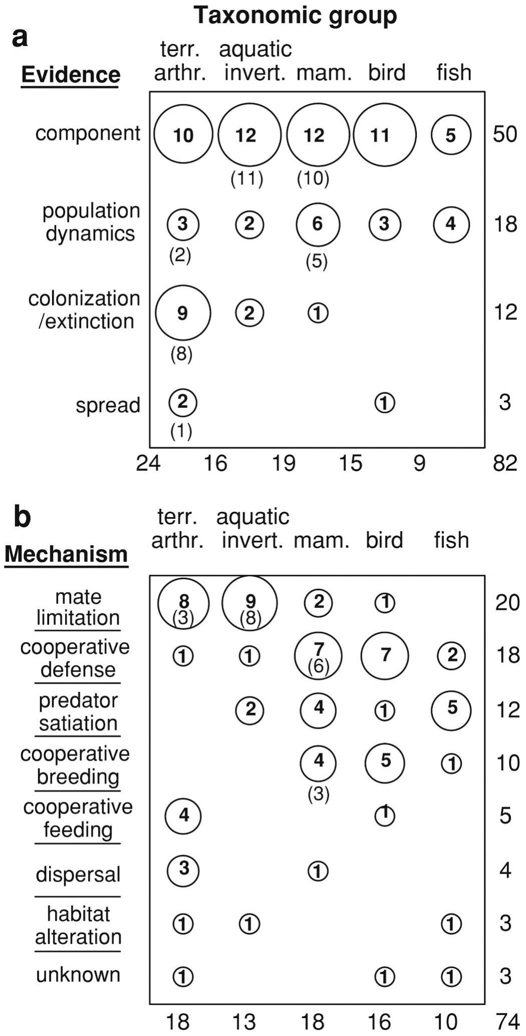

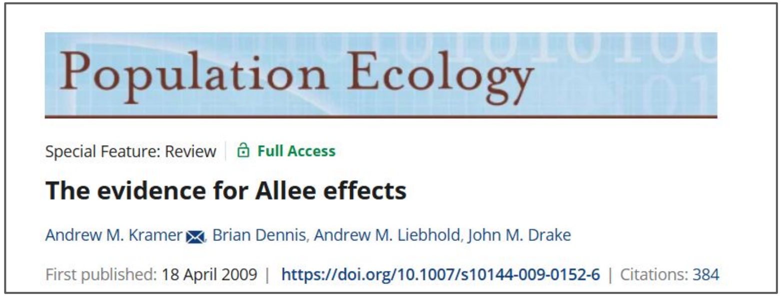
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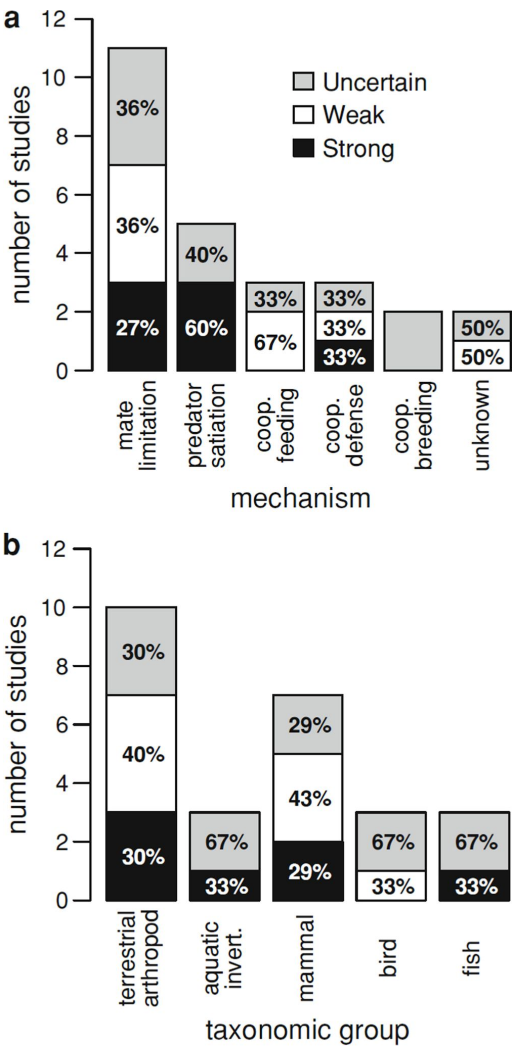

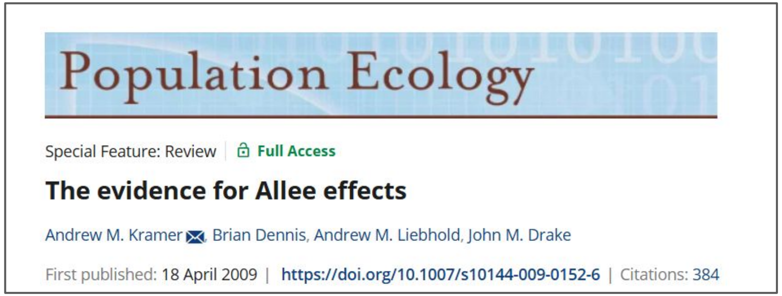

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Density Dependence and Rarity

Remember SADs?

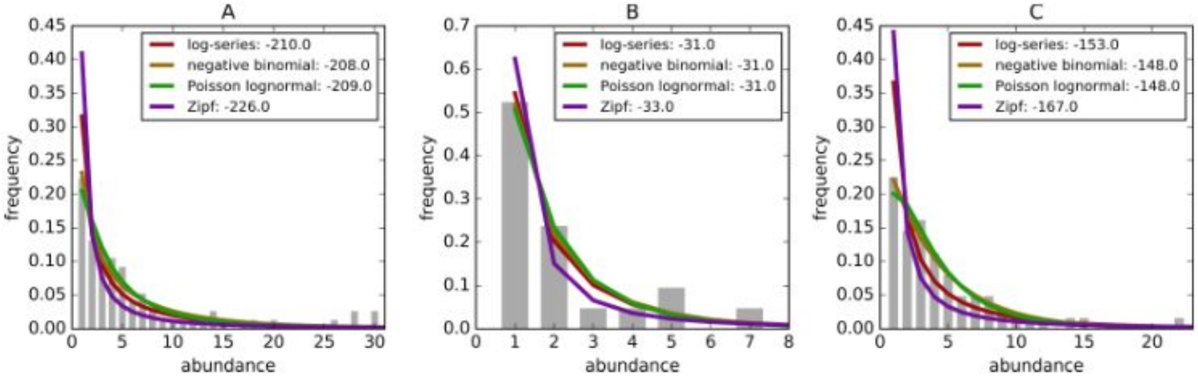

Figure 1 Example species-abundance distributions including the empirical distributions (grey bars) and the best fitting log-series: maroon, negative binomial: brown, poisson lognormal: green, and Zipf: purple. Distributions are for (A) Breeding Bird Survey—Route 36 in New York, (B) Forest Inventory and Analysis—Unit 4, County 57, Plot 12 in Alabama, and (C) Gentry—Araracuara High Campina site in Colombia. Log-likelihoods of the models are included after the colon in the legend.

An extensive comparison of species-abundance distribution models

Elita Baldridge[1,2], David J. Harris[3], Xiao Xiao[1,2,4,5] and Ethan P. White[1,2,3,6]

[1] Department of Biology, Utah State University, Logan, UT, United States
[2] Ecology Center, Utah State University, Logan, UT, United States
[3] Department of Wildlife Ecology and Conservation, University of Florida, Gainesville, FL, United States
[4] School of Biology and Ecology, University of Maine, Orono, ME, United States
[5] Senator George J. Mitchell Center for Sustainability Solutions, University of Maine, Orono, ME, United States
[6] Informatics Institute, University of Florida, Gainesville, FL, United States

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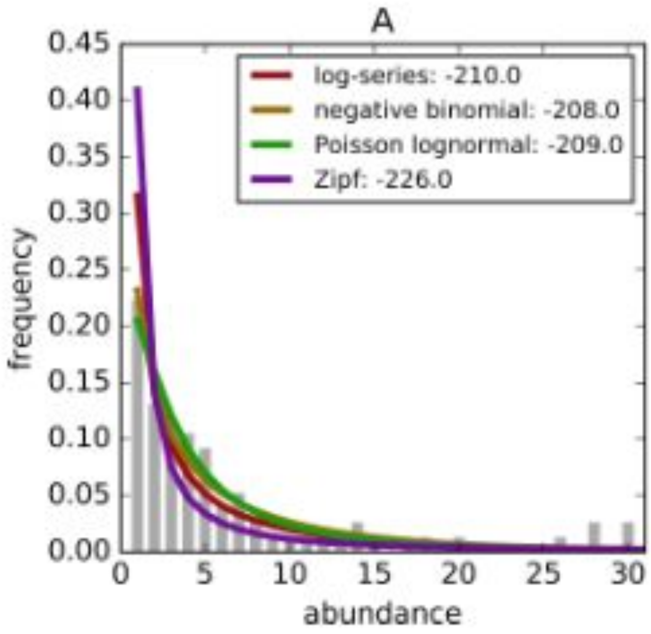

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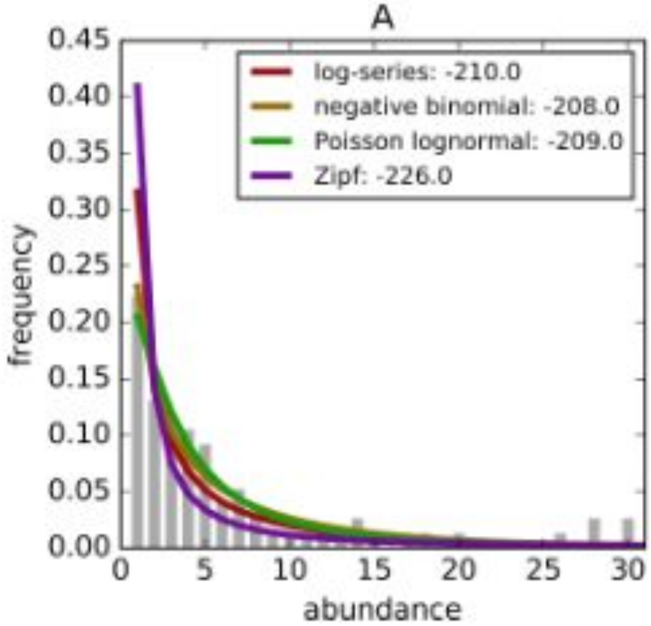
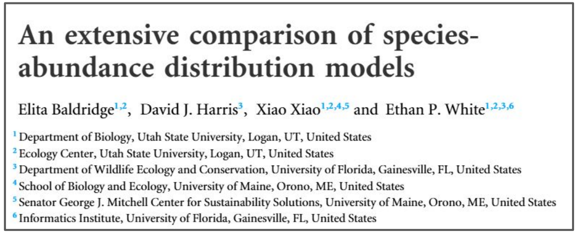
Density Dependence and Rarity

Remember SADs?

Differences driven by density dependences?





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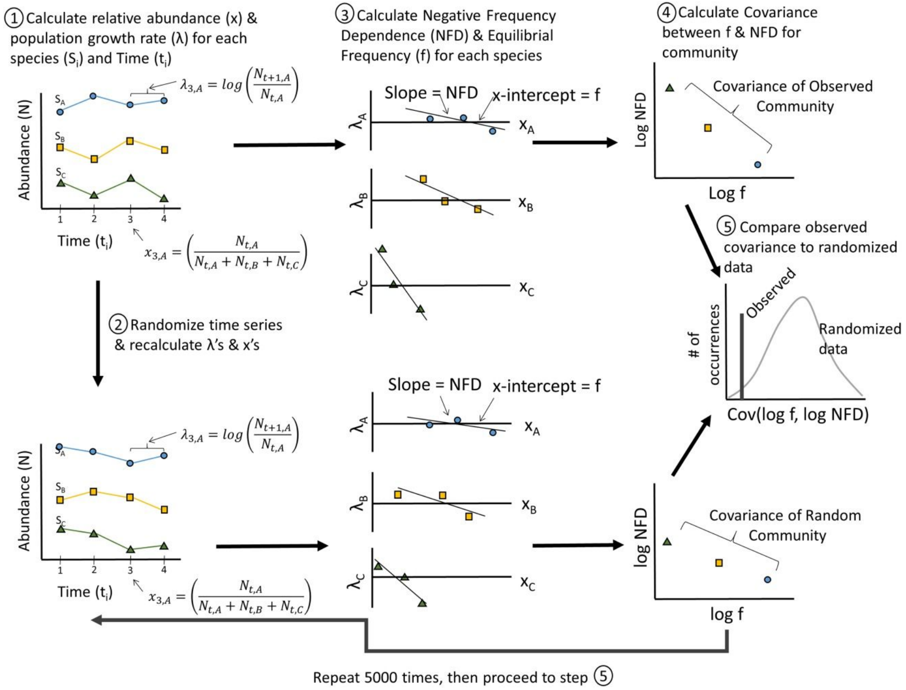
Density Dependence and Rarity

- Rare species should experience stronger density dependence than common species



Global Ecology and Biogeography

A Journal of Macroecology

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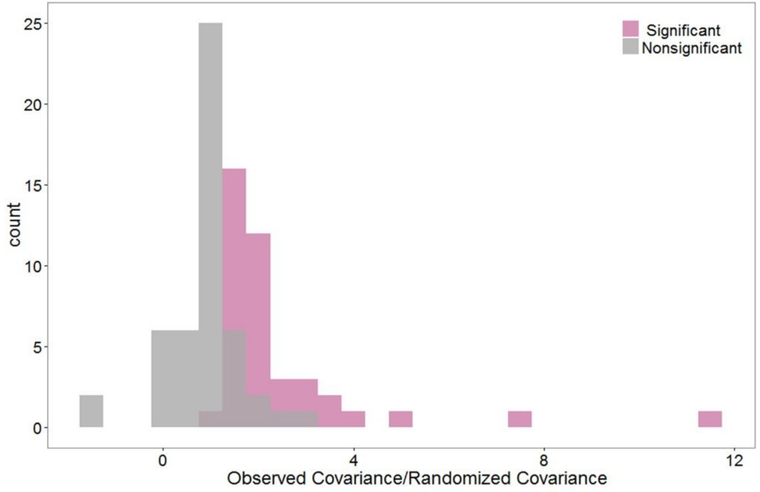
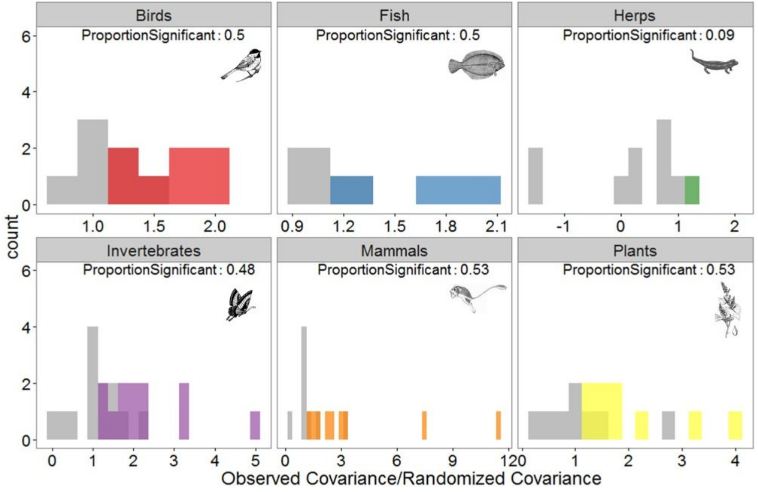
Do persistent rare species experience stronger negative frequency dependence than common species?

Glenda Yenni, Peter B. Adler, S. K. Morgan Ernest

Density Dependence and Rarity

- Rare species should experience stronger density dependence than common species





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Do persistent rare species experience stronger negative frequency dependence than common species?

Glenda Yenni, Peter B. Adler, S. K. Morgan Ernest

Density Dependence and Rarity

Hypothesized that differences in density dependence may help buffer rare species

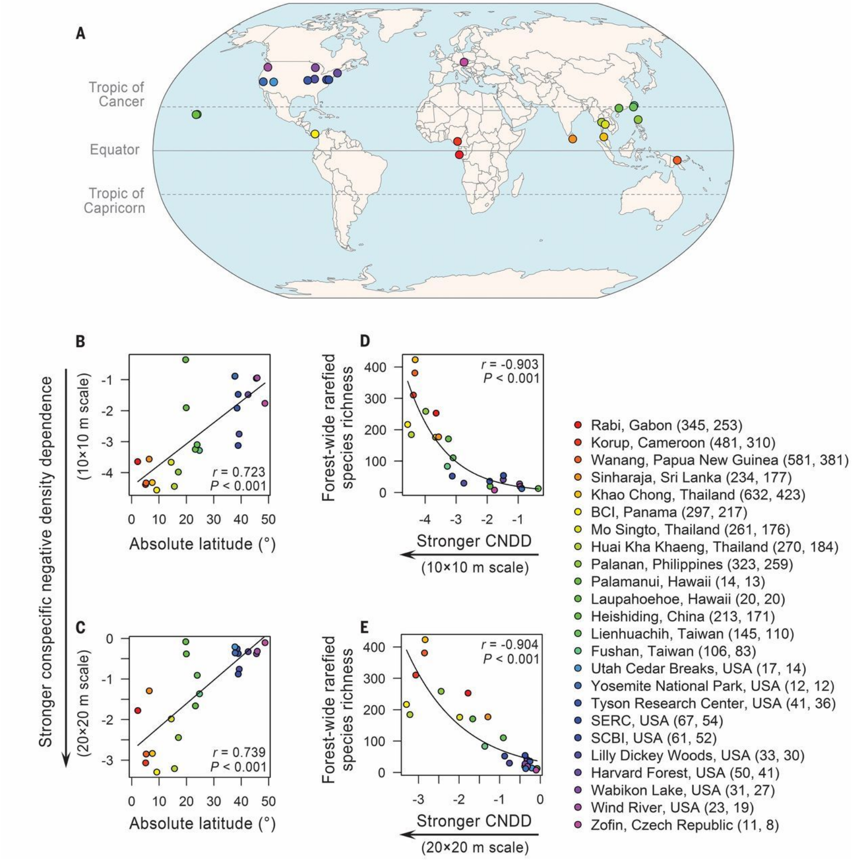
- Essentially improve growth rates when rare
- Small drop in population size is a big increase in growth rate

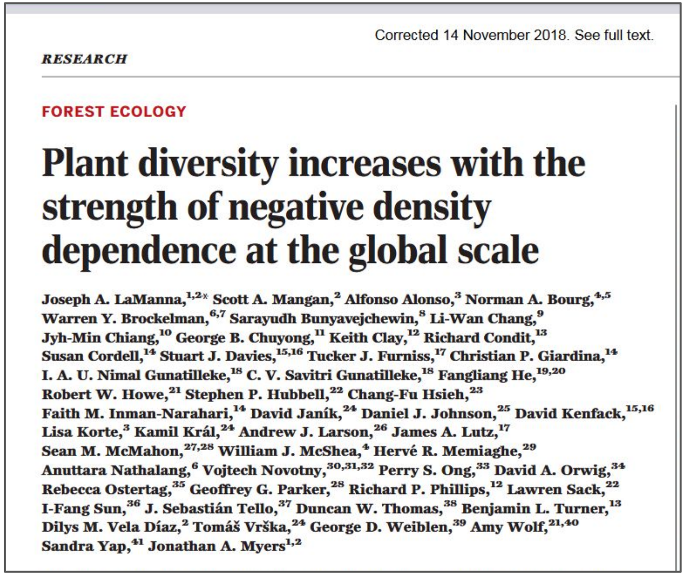
Density dependence and richness

If there is variation in density dependence, does this impact richness?

- More DD, smaller populations
- Smaller populations, more species

Density dependence and richness





Corrected 14 November 2018. See full text.

RESEARCH

FOREST ECOLOGY

Plant diversity increases with the strength of negative density dependence at the global scale

Joseph A. LaManna,[1,2*] Scott A. Mangan,[2] Alfonso Alonso,[3] Norman A. Bourg,[4,5] Warren Y. Brockelman,[6,7] Sarayudh Bunyavejchewin,[8] Li-Wan Chang,[9] Jyh-Min Chiang,[10] George B. Chuyong,[11] Keith Clay,[12] Richard Condit,[13] Susan Cordell,[14] Stuart J. Davies,[15,16] Tucker J. Furniss,[17] Christian P. Giardina,[14] I. A. U. Nimal Gunatilleke,[18] C. V. Savitri Gunatilleke,[18] Fangliang He,[19,20] Robert W. Howe,[21] Stephen P. Hubbell,[22] Chang-Fu Hsieh,[23] Faith M. Inman-Narahari,[14] David Janík,[24] Daniel J. Johnson,[25] David Kenfack,[15,16] Lisa Korte,[3] Kamil Král,[24] Andrew J. Larson,[26] James A. Lutz,[17] Sean M. McMahon,[27,28] William J. McShea,[4] Hervé R. Memiaghe,[29] Anuttara Nathalang,[6] Vojtech Novotny,[30,31,32] Perry S. Ong,[33] David A. Orwig,[34] Rebecca Ostertag,[35] Geoffrey G. Parker,[28] Richard P. Phillips,[12] Lawren Sack,[22] I-Fang Sun,[36] J. Sebastián Tello,[37] Duncan W. Thomas,[38] Benjamin L. Turner,[13] Dilys M. Vela Díaz,[2] Tomáš Vrška,[24] George D. Weiblen,[39] Amy Wolf,[21,40] Sandra Yap,[41] Jonathan A. Myers[1,2]

Next class: Predator-Prey Interactions