Habitat connectivity can reduce the total population size

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MPDEE 2021

Is fragmentation good or bad for biodiversity?

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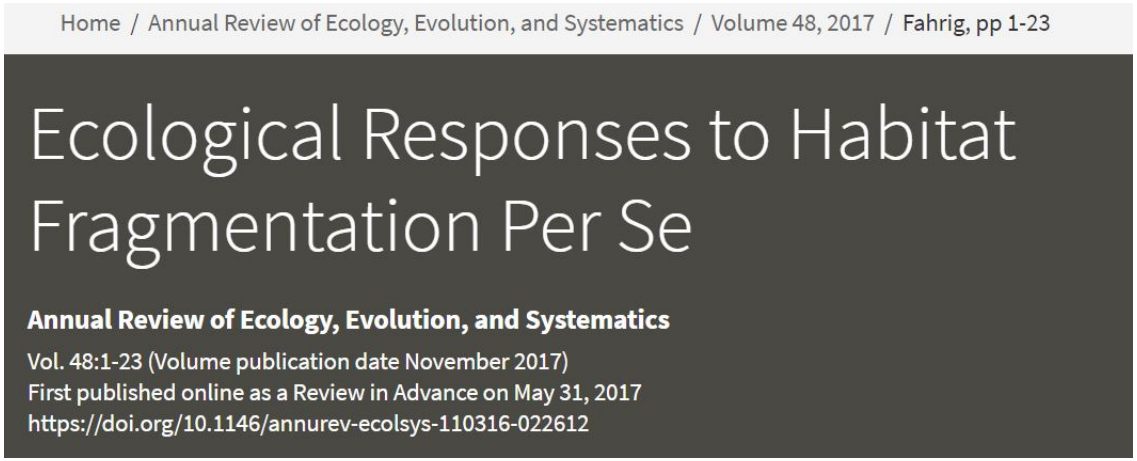
- Biogeography: fragmentation generally reduces biodiversity
- Review by Fahrig (2017): more positive than negative biodiversity responses to fragmentation *per se*



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Ecological Responses to Habitat Fragmentation Per Se

Annual Review of Ecology, Evolution, and Systematics
Vol. 48:1-23 (Volume publication date November 2017)
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ELSEVIER
Biological Conservation
Volume 226, October 2018, Pages 9-15

Perspective

Is habitat fragmentation good for biodiversity?

Robert J. Fletcher Jr [a], Raphael K. Didham [b, c], Cristina Banks-Leite [d], Jos Barlow [e], Robert M. Ewers [d], James Rosindell [d], Robert D. Holt [f], Andrew Gonzalez [g], Renata Pardini [h], Ellen I. Damschen [i], Felipe P.L. Melo [j], Leslie Ries [k], Jayme A. Prevedello [l], Teja Tscharntke [m], William F. Laurance [n], Thomas Lovejoy [o], Nick M. Haddad [p]

ELSEVIER
Biological Conservation
Volume 230, February 2019, Pages 179-186

Perspective

Is habitat fragmentation bad for biodiversity?

Lenore Fahrig [a], Víctor Arroyo-Rodríguez [b], Joseph R. Bennett [a], Véronique Boucher-Lalonde [c], Eliana Cazetta [d], David J. Currie [e], Felix Eigenbrod [f], Adam T. Ford [g], Susan P. Harrison [h], Jochen A.G. Jaeger [i], Nicola Koper [j], Amanda E. Martin [k], Jean-Louis Martin [l], Jean Paul Metzger [m], Peter Morrison [a], Jonathan R. Rhodes [n], Denis A. Saunders [o], Daniel Simberloff [p], Adam C. Smith [q], Lutz Tischendorf [r], Mark Vellend [s], James I. Watling [t]

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Biological Conservation
Volume 232, April 2019, Pages 271-273

Editorial

How does habitat fragmentation affect biodiversity? A controversial question at the core of conservation biology

Abraham J. Miller-Rushing [a], Richard B. Primack [b], Vincent Devictor [c], Richard T. Corlett [d], Graeme S. Cumming [e], Rafael Loyola [f], Bea Maas [g], Liba Pejchar [h]

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Perspective

Is hab

Robert J. Flet
Rosindell [d], R
[k], Jayme A. Pr

Issues: spatial scale and definition of fragmentation

Eliana
Jaeger [i],
[a], Jonathan
ark Vellend [a]

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Fragmentation in the Hambach forest (Germany)

- old forest and habitat for numerous species
- cleared for opencast lignite coal mine

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Research question

What is the effect of habitat connectivity on the population size of a single species?

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Laboratory experiments

Research question

What is the effect of habitat connectivity on the population size of a single species?

Laboratory experiments

ODE model

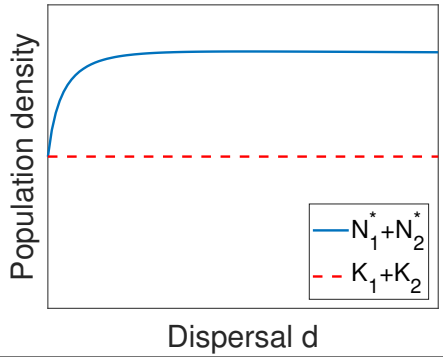
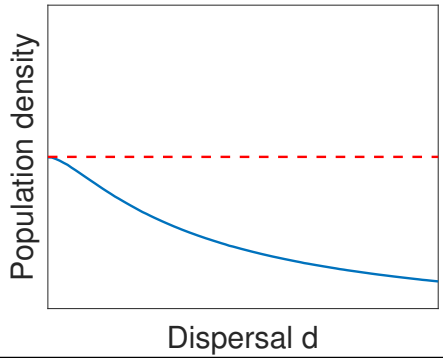
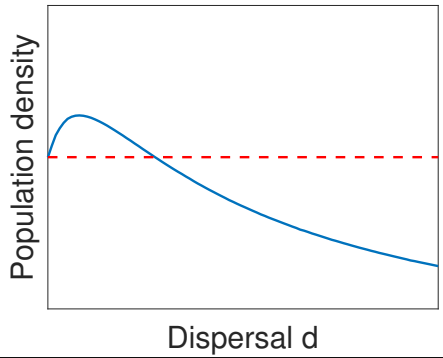
Study system

Study system

Habitat quality:

- productivity (K)
- promote rapid population growth (r)

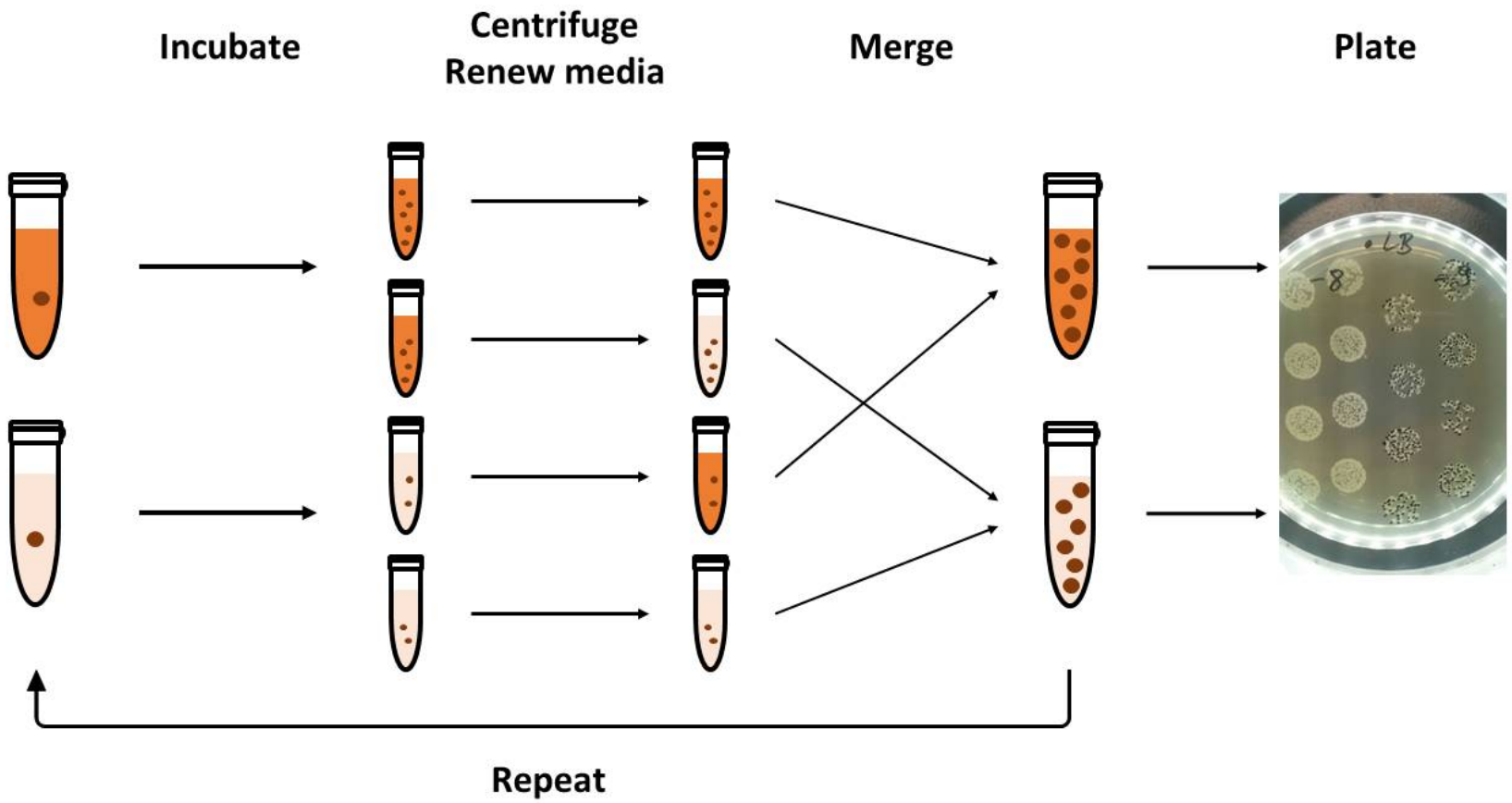
r-K relationship

Positive r-K relationship (rK^+)	$K_i > K_j$	$r_i{=}K_i \quad r_j{=}K_j$	$r_i > r_j$	
Negative r-K relationship (rK)	$K_i > K_j$	$r_i{=}K_i < r_j{=}K_j$	$r_i \quad r_j$	
Negative r-K relationship (rK)	$K_i > K_j$	$r_i{=}K_i < r_j{=}K_j$	$r_i > r_j$	

Arditi et al. (2015), Theoretical Population Biology

Experimental design

- Model organism: *Escherichia coli*
- two growth environments
- Four different dispersal regimes



Spatial Baranyi model

Population growth and dispersal:

$$\frac{dN_1}{dt} = \frac{Q_1}{1+Q_1} r_1 N_1 \left(1 \quad \frac{N_1}{K_1}\right) \quad d(N_1 \quad N_2)$$

$$\frac{dN_2}{dt} = \frac{Q_2}{1+Q_2} r_2 N_2 \left(1 \quad \frac{N_2}{K_2}\right) \quad d(N_2 \quad N_1)$$

With lag phase:

$$\frac{dQ_i}{dt} = r_i Q_i$$

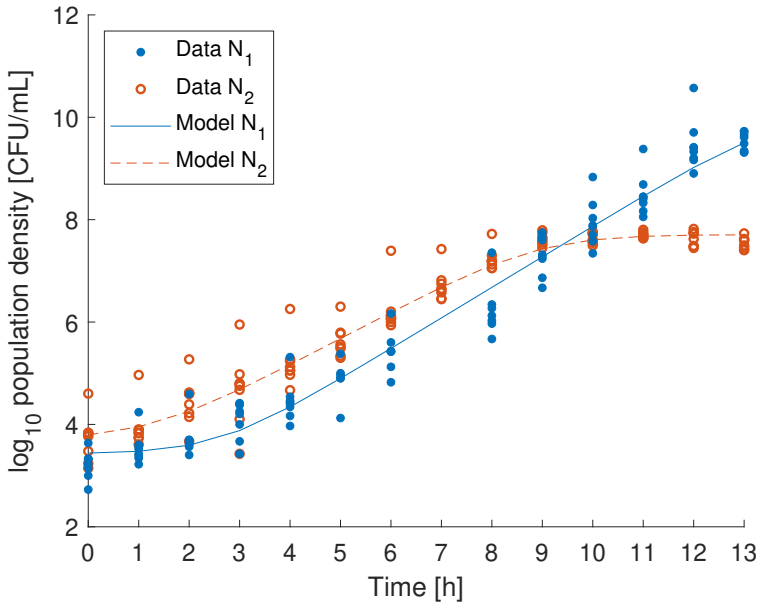


Figure: Model calibration by independent growth kinetics

Result

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- dispersal decreases steady state population density compared to sum of carrying capacities

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- first experimental evidence for negative r-K relationship (r K)

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- dispersal decreases steady state population density compared to sum of carrying capacities
- first experimental evidence for negative r-K relationship (r K)
- generic approach

Implications

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- condition: intraspecific competition stronger in lower quality habitat $!$ lower K (and r)

Implications

- habitat connectivity reduces population size
- condition: intraspecific competition stronger in lower quality habitat *!* lower K (and r)
- r-K relationships in literature review:

  rK^+: 7 (2 strong)
  rK : 6 (4 strong)
  rK : 7 (3 strong)

Back to Hambach forest

- habitat fragmentation generally includes habitat loss, habitat isolation and edge effects
- sometimes conflicting interests, e.g. due to demands for energy, mobility
- then: **site analysis** and **compensation**

Compensating fragmentation effects

- e.g. by afforestation or dispersal corridors

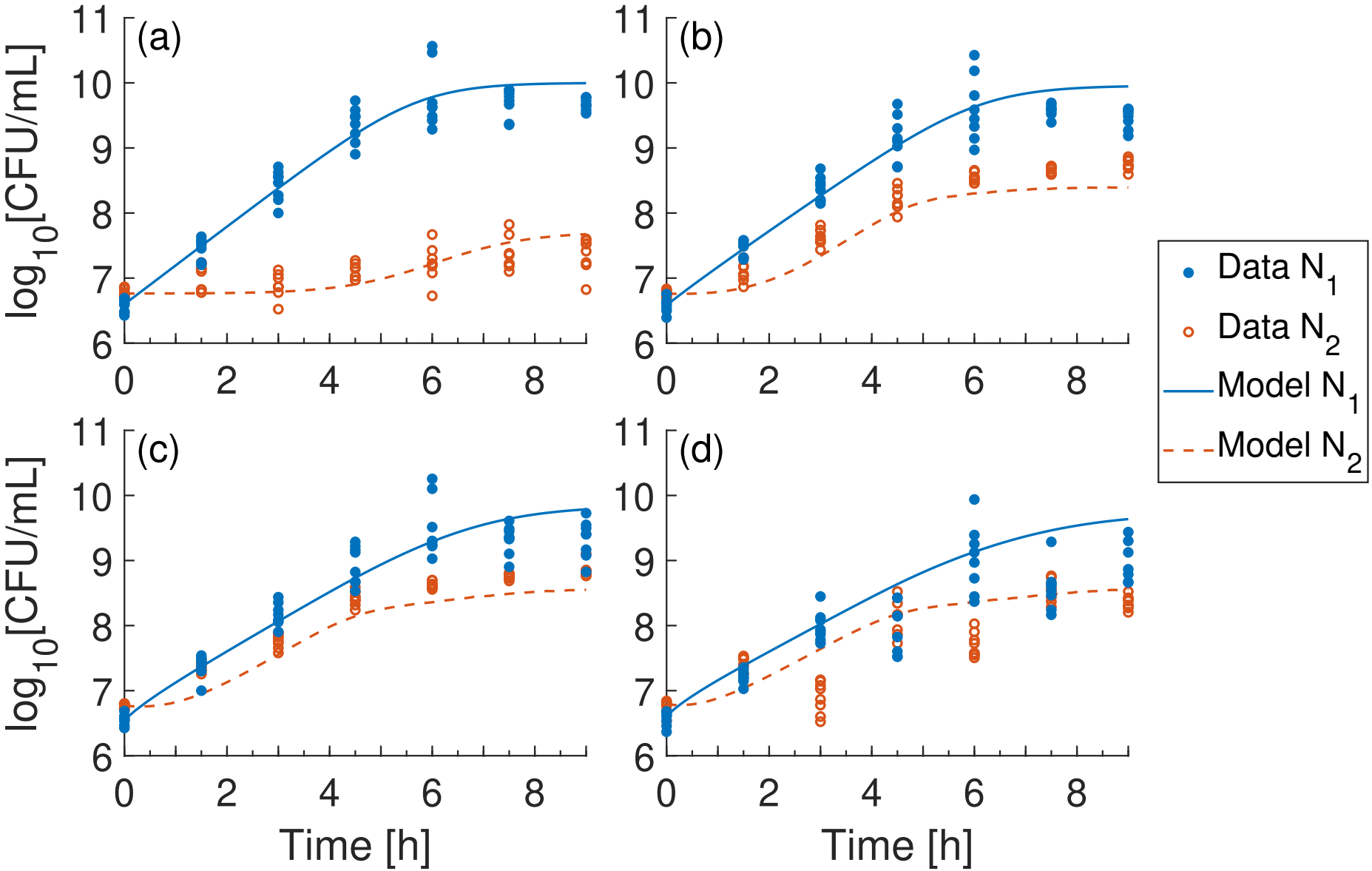
- results question (cost-)effectiveness of dispersal corridors
- r-K relationship is not considered in the conservation literature

THANK YOU!

For further questions and discussion,
let's meet after the last talk for today
(6 PM) in "Le Billard".

Kost Lab team

Time series



Literature review

Table: Empirical evidence for positive r-K relationships (rK^+) and/or negative r-K relationships (rK , rK). x: evidence, **X**: most evidence (more than three times the number of examples or over thirty more examples), otherwise no evidence. Note that studies differ with respect to the number of tested r-K relationships.

Modeled species	**Condition causing heterogeneity**	$\mathbf{rK^+}$	$\mathbf{rK}$	$\mathbf{rK}$	**Reference**
Escherichia coli	Culture medium			x	This study
Nephotettix spp	Temperature	**X**	x	x	*Valle et al. (1989)*
Chlamydomonas	Mineral nutrients	x	**X**	x	*Bell (1990)*
Anuraeopsis fissa	Food density			x	*Dumont et al. (1995)*
Several	Toxin concentration	x	x	**X**	*Hendriks et al. (2005)*
Chaetosiphon fragaefolii	Host plant	x	**X**	**X**	*Underwood (2007)*
Saccharomyces cerevisiae	pH and dissolving oxygen	x	**X**	**X**	*Salari and Salari (2017)*
Saccharomyces cerevesiae	Culture medium	x			*Zhang et al. (2017)*
Tetraselmis tetrahele	Temperature	**X**	**X**	x	*Bernhardt et al. (2018)*