

Empirical and theoretical opportunities in host-symbiont community ecology

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github.com/mbjoseph/esa2015

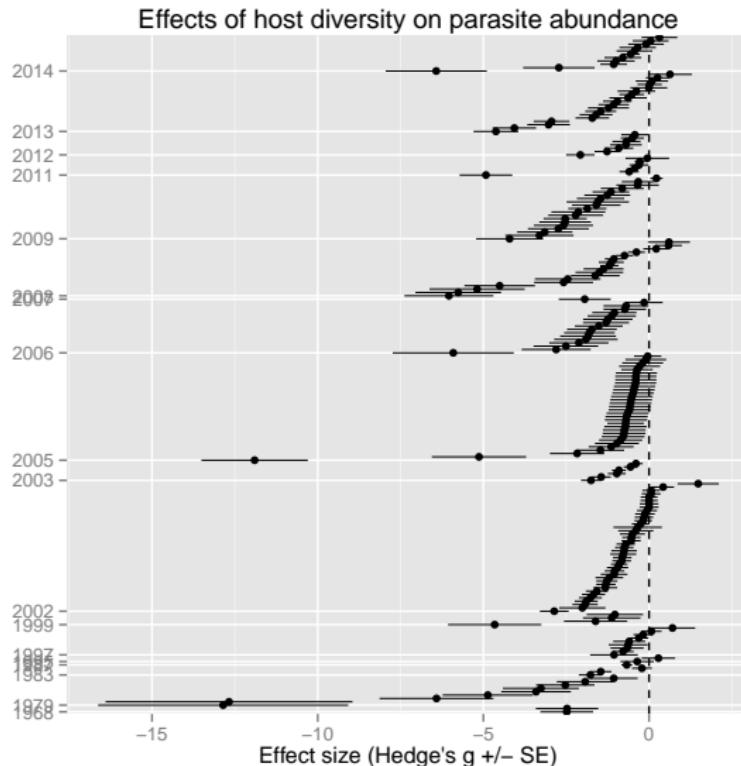
Dilution effect: biodiversity reduces disease risk

Amplification effect: biodiversity increases disease risk

A simple enough question

What is the generality of the dilution effect?

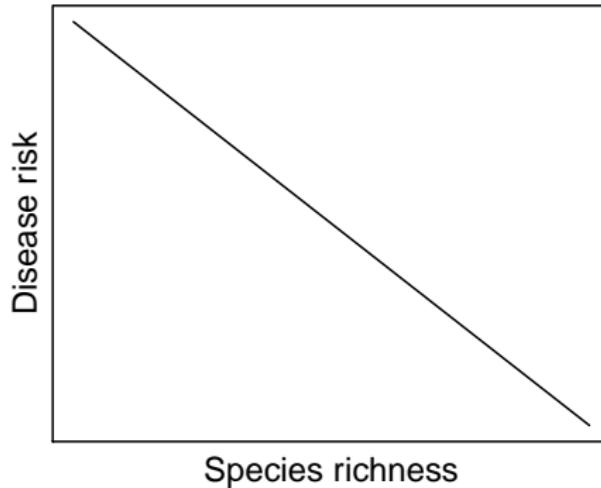
Civitello et al. 2015



Thought experiment

Assume that we know $\mu_{\beta_{diversity}} < 0$

i.e. biodiversity reduces disease risk on average



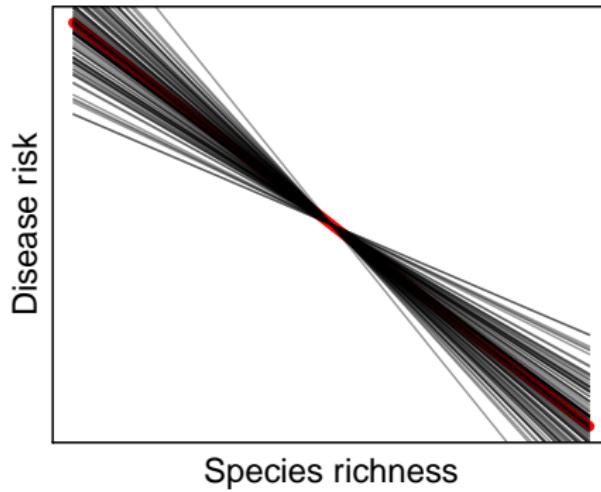
Assume that we know $\mu_{\beta_{diversity}} < 0$

- effects vary across systems

$$\beta_i \sim N(\mu_{\beta_{diversity}}, \sigma)$$

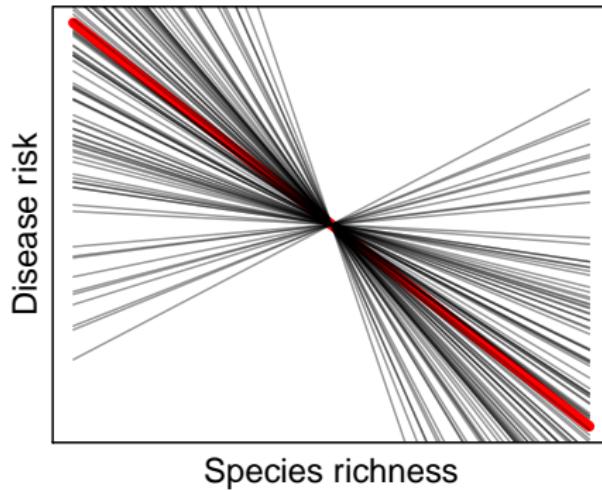
$\beta \sim N(\mu_\beta, \sigma)$

$\mu_\beta < 0, \sigma$ low



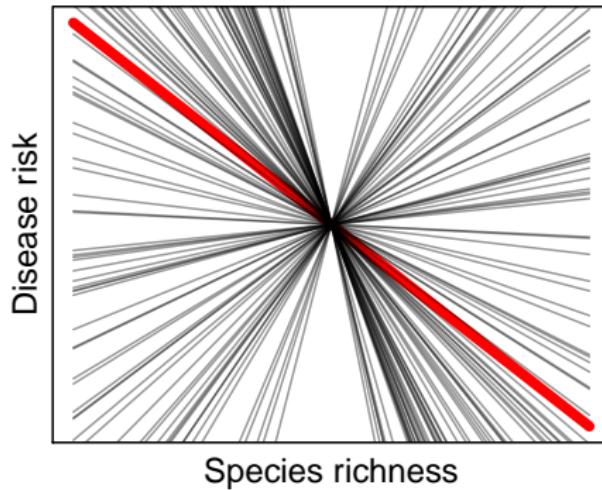
$$\beta \sim N(\mu_\beta, \sigma)$$

$\mu_\beta < 0, \sigma$ medium



$$\beta \sim N(\mu_\beta, \sigma)$$

$$\mu_\beta < 0, \sigma \text{ high}$$



Regardless of the mean effect,

- ① We all care about variation

Regardless of the mean effect,

- 1 We all care about variation
- 2 Explaining the variation should be a common goal

① Thinking beyond the mean effect

- What explains the variance?

- ① Thinking beyond the mean effect
- ② Transmission dynamics

Density-dependent:

$$\beta SI$$

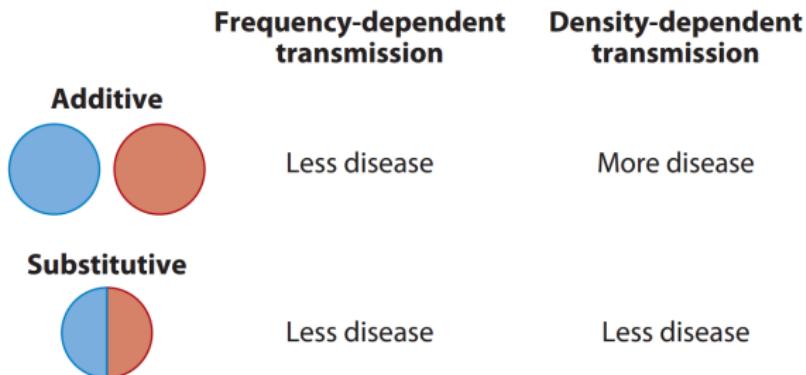


Frequency-dependent:

$$\beta SI/N$$

Contact rate independent from N

Transmission dynamics, diversity, and disease



Ostfeld and Keesing 2012

Rudolf and Antonovics 2005

Dobson 2004

Joseph et al. 2013

Mihaljevic et al. 2013

Constant risk:

$$\beta S$$

Power law:

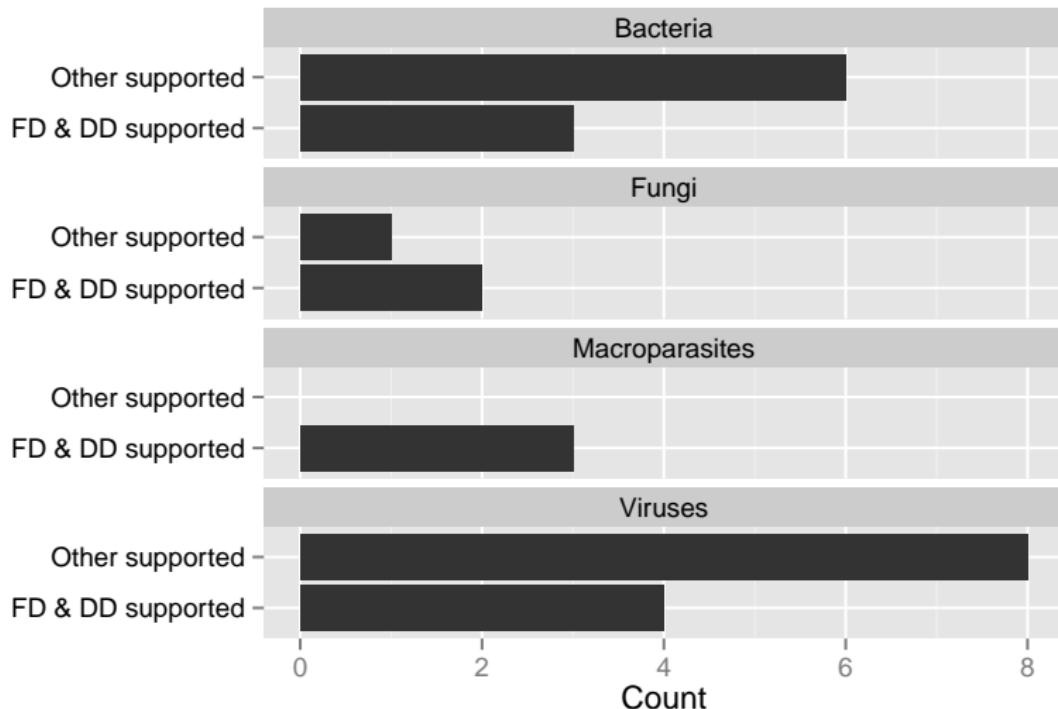
$$\beta S^p I^q$$

Negative binomial:

$$kS \log\left(1 + \frac{\beta I}{k}\right)$$

Support for other transmission functions

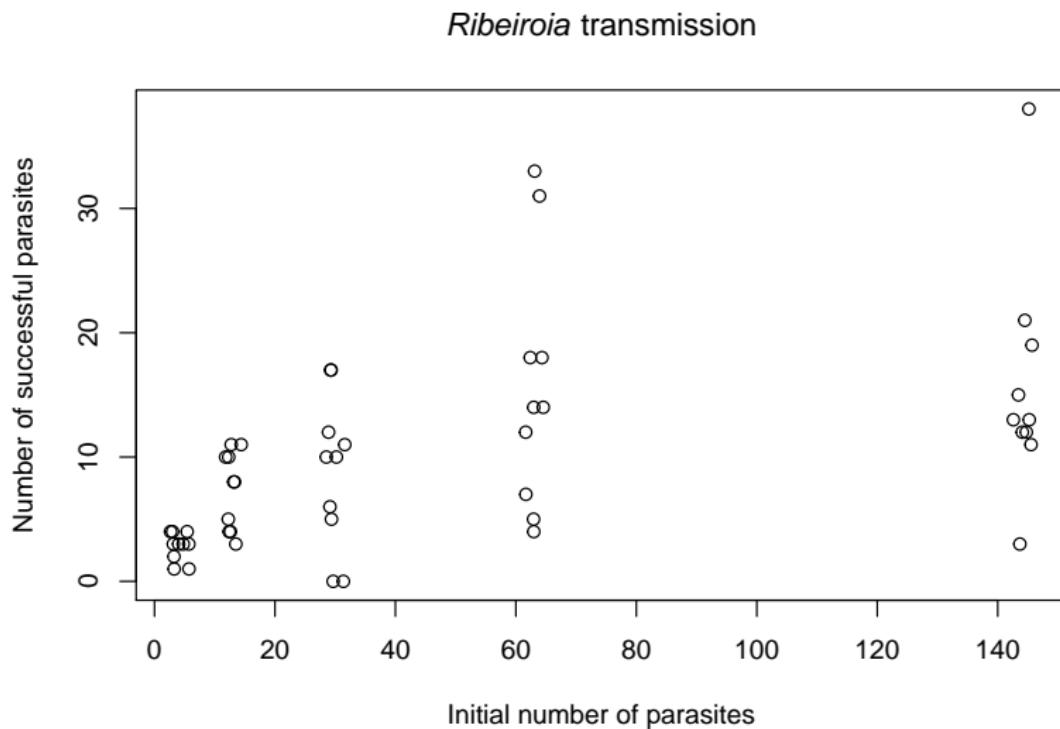
(Orlofske, Joseph, et al. *in prep*)



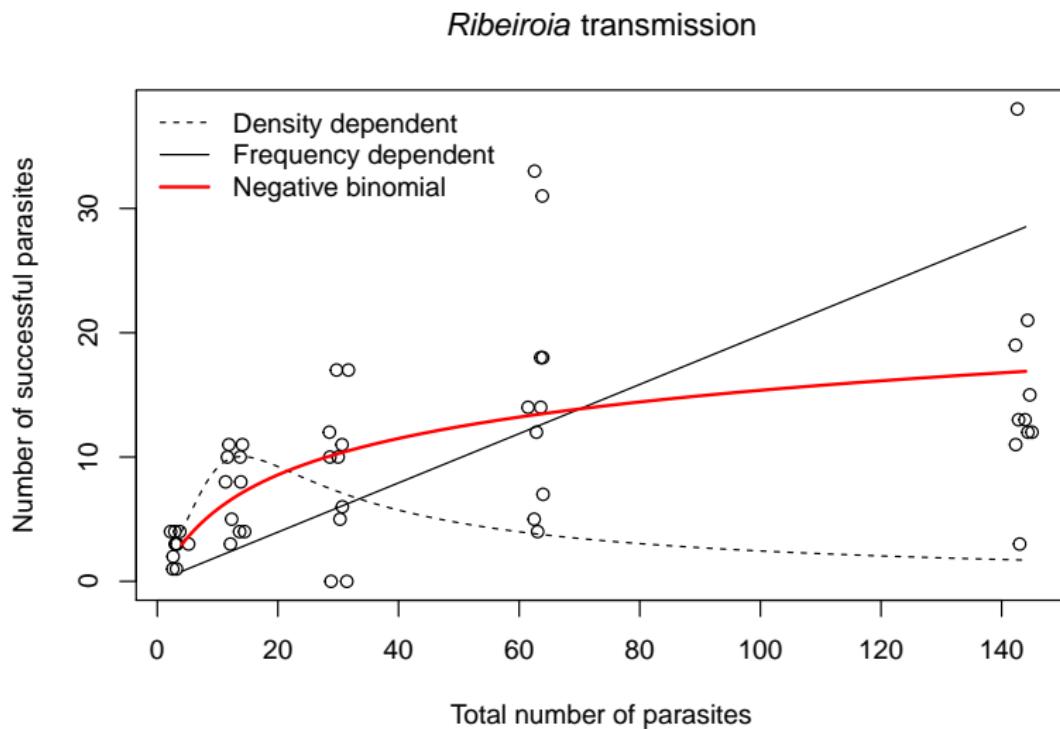
Evaluating support for different models

- 1 Build set of transmission functions (DD, FD, etc.)
- 2 Design experiments varying:
 - P : number of parasites
 - H : number of hosts
 - t : exposure time
 - $\frac{P}{v}$: parasite density
- 3 Fit models, evaluate support with information theoretics

Evaluating support for different models



Evaluating support for different models



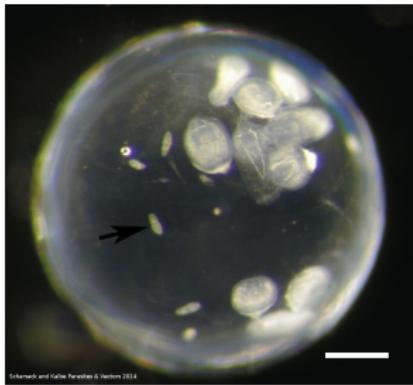
Ribeiroia:

- P : neg. binom.
- H : power law
- t : power law
- $\frac{P}{v}$: uninformative



Diplostomum spathaceum (Karvonen et al. 2003):

- $\frac{P}{v}$: neg. binom. and power law
- P : power law



Centrocestus armatus experiments (Paller et al. 2007):

- $\frac{P}{v}$: neg. binom.
- P : neg. binom.

Modes of transmission, diversity, and disease

- What transmission functions are supported empirically?
- What else might we expect theoretically?

- 1 Thinking beyond the mean effect**
- 2 Transmission dynamics**

- What models have empirical support?
- How do theoretical expectations change?

- ① Thinking beyond the mean effect
- ② Transmission dynamics
- ③ Biodiversity and symbionts

Questions:

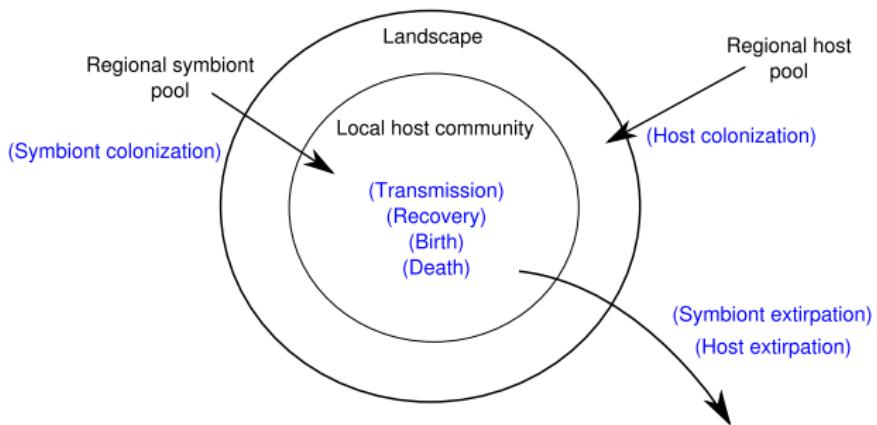
① What is effect of host diversity on:

- symbiont diversity
- symbiont transmission

Questions:

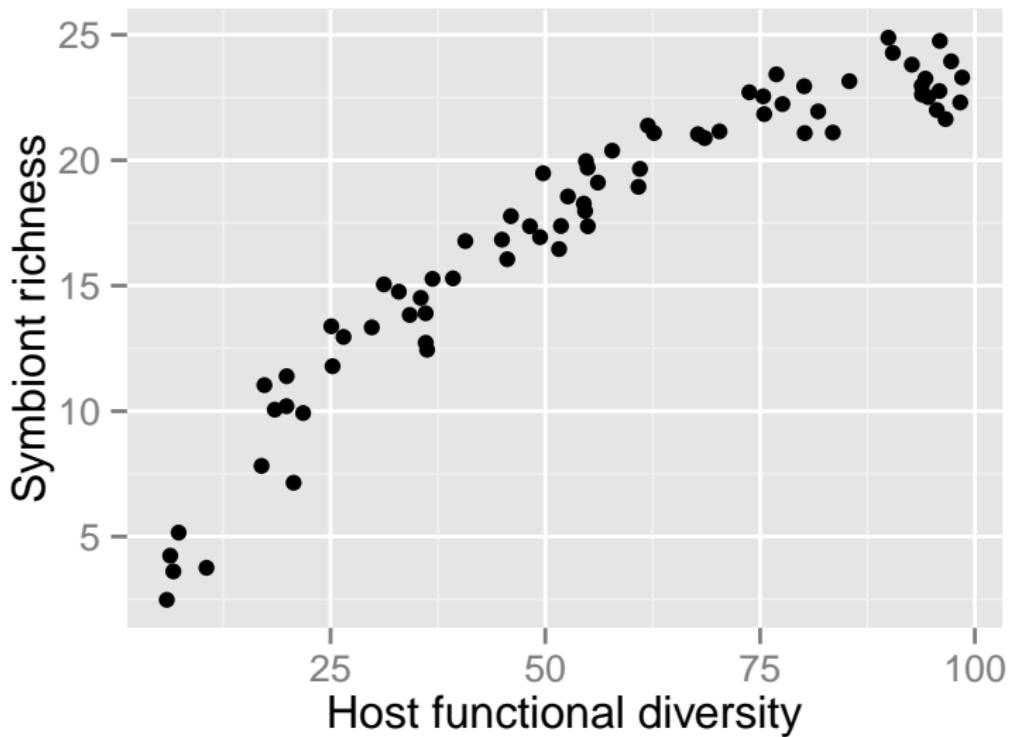
- ① What is effect of host diversity on:
 - symbiont diversity
 - symbiont transmission
- ② What role does parasitism play?

Model structure

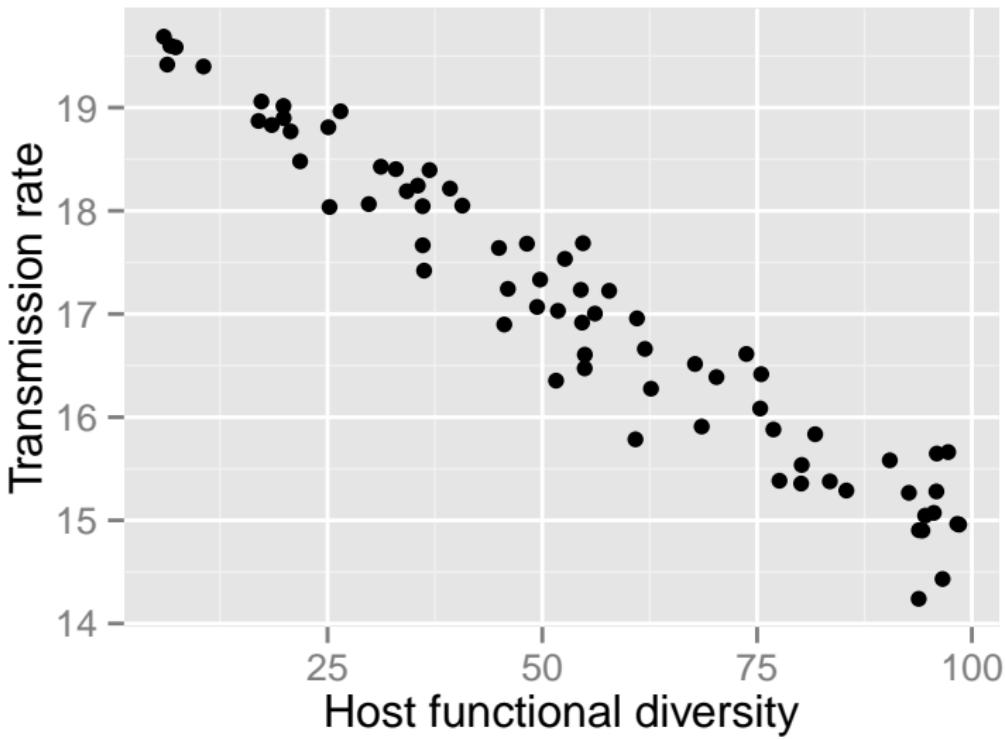


github.com/mbjoseph/abm

Model predictions: diversity begets diversity



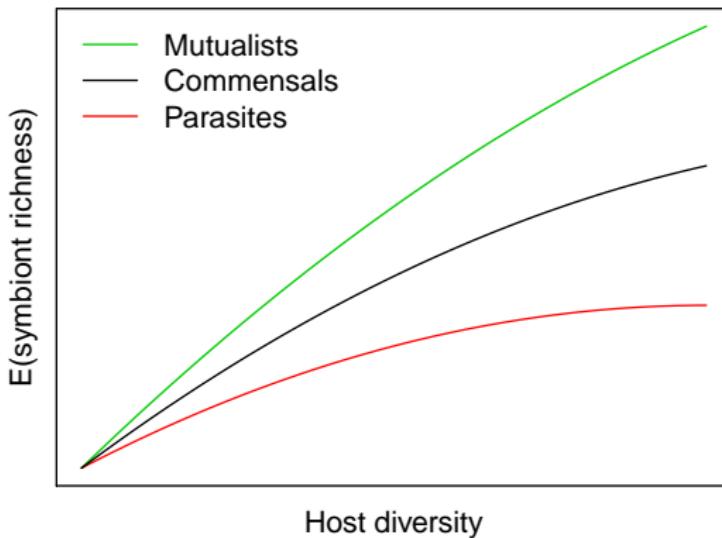
Model predictions: diversity reduces transmission



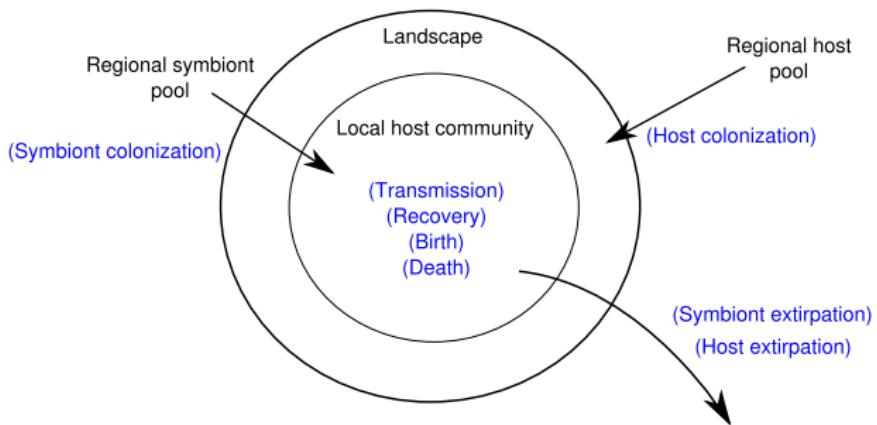
Does disease matter?

A priori expectations

$$R_0 \propto v^{-1}$$

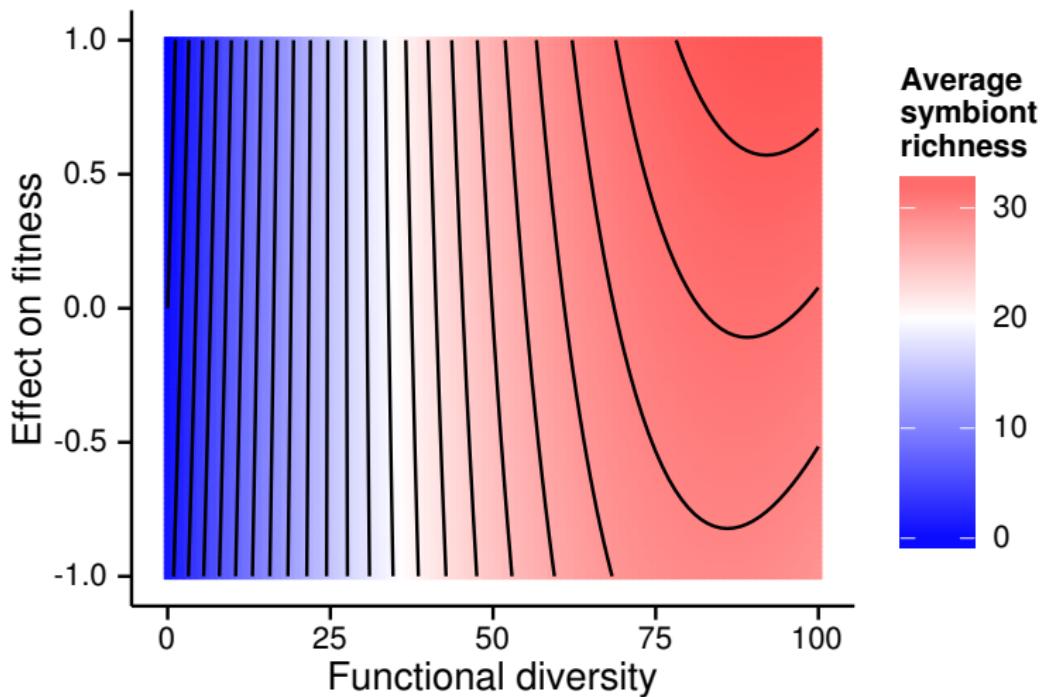


Model structure

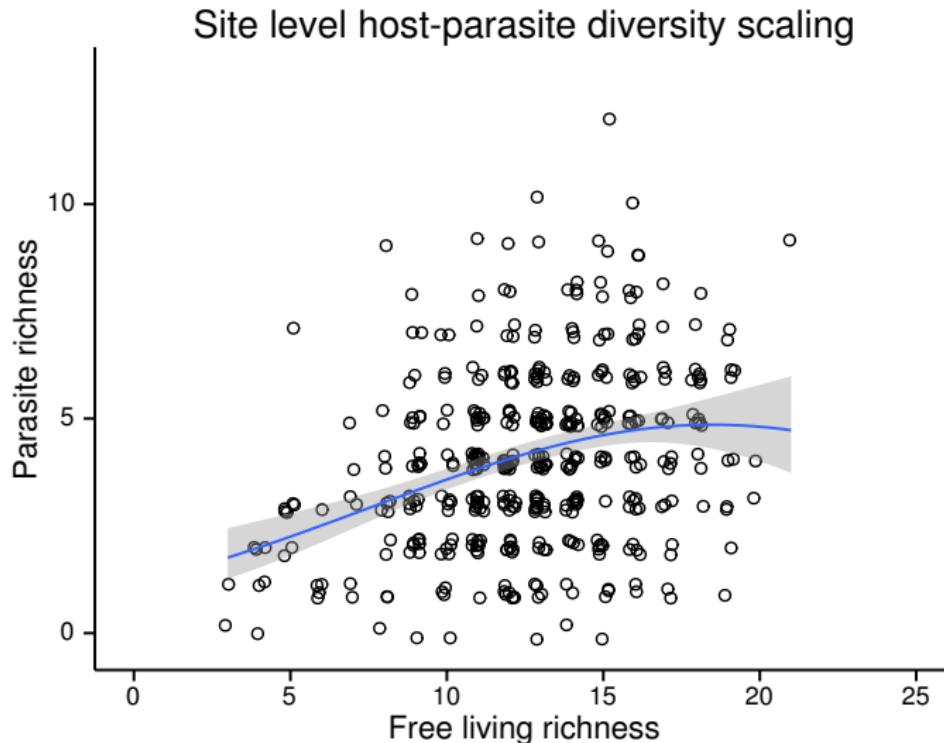


github.com/mbjoseph/abm

Model predictions



San Francisco Bay Area amphibian parasites



Why symbionts in general?

- More data
- Many parasites are facultative
- Broader class of species interactions

-/-	-/0	-/+
0/0	0/+	
+/+		

- ① **Thinking beyond the mean effect**
- ② **Transmission dynamics**
- ③ **Biodiversity and symbionts**

- Relationships between host and symbiont diversity
- Parasites, commensals, and mutualists
- Interplay b/t host diversity and symbiont transmission

- ① Thinking beyond the mean effect
- ② Transmission dynamics
- ③ Biodiversity and symbionts
- ④ Scale transitions

Local dynamics



Local dynamics → regional dynamics



Scale transitions: theoretical results

Local dynamics \neq regional dynamics if

- local dynamics are non-linear
- densities vary spatially
- conditions vary spatially

(Chesson et al. 2005)

- ① Thinking beyond the mean effect
- ② Transmission dynamics
- ③ Biodiversity and symbionts
- ④ Scale transitions
 - is the existing theory useful?

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Chelsea Wood

Sarah Orlofske

Dan Preston

EBIO QDT

Support from: NSF GRFP, CU Research Computing

slides: github.com/mbjoseph/esa2015

symbiont model: github.com/mbjoseph/abm

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Lots of theory (but see Roche et al. 2012): instantaneous rates

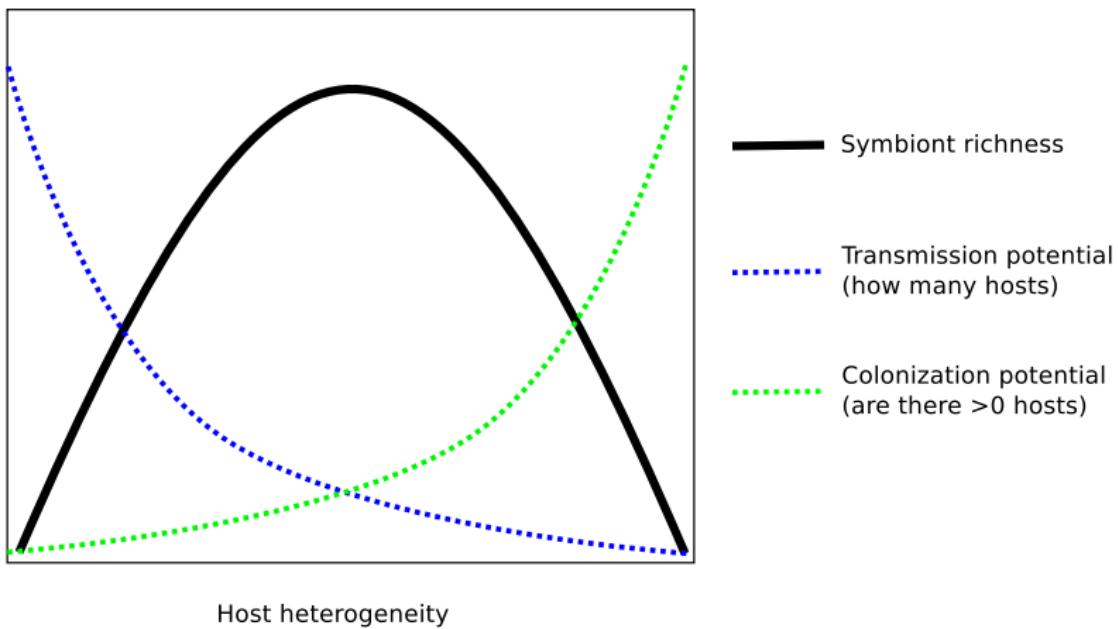
- transmission
- R_0
- force of infection

Most data: integrated quantities

- prevalence
- seroprevalence
- density of infected hosts

Biodiversity and symbionts

Similar to habitat area-heterogeneity trade-off in free living species

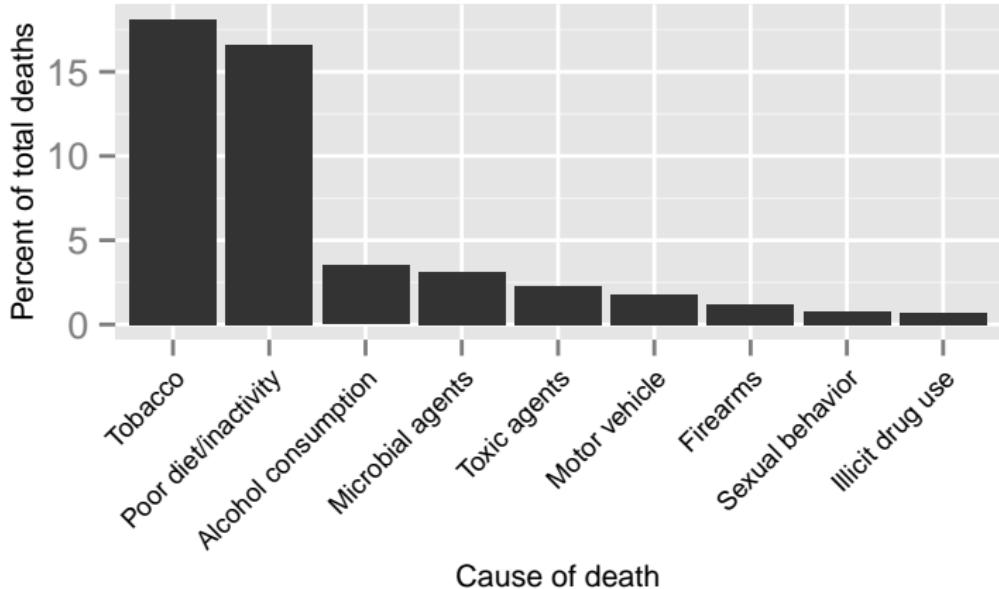


Points of contention

- 1 generality
- 2 justification for conservation

If we knew biodiversity was good for our health,
would we conserve biodiversity?

Actual causes of death in the U.S.



Mokdad et al. 2004.