Can we manage *Bsal*?

Finding evidence-based amphibian conservation strategies in an emergency

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@can_essay

Making management decisions

We want to **achieve** something

We have some **options** available

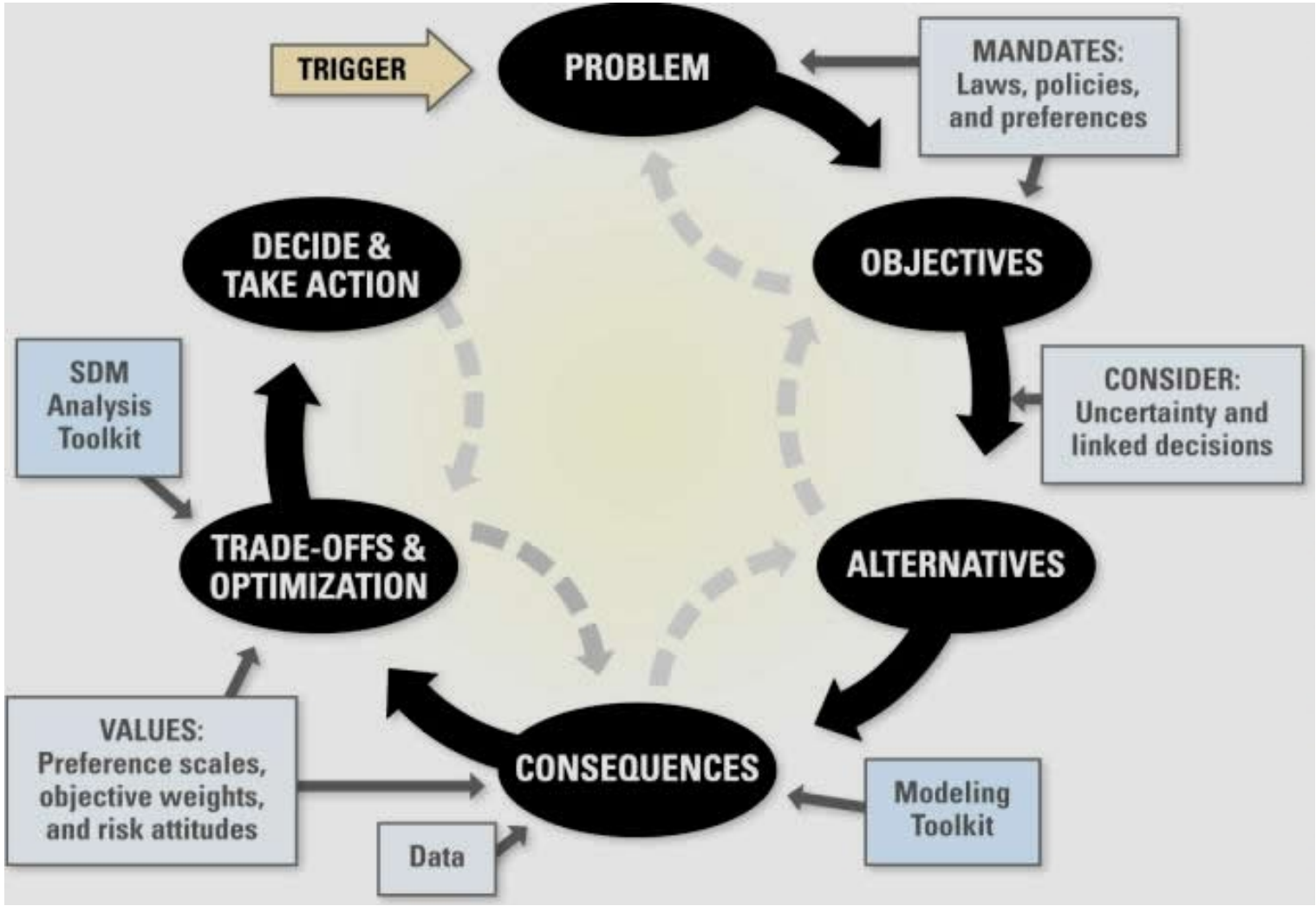
We choose the one we **expect** to work best
(or a combination thereof)

We might need to make **trade-offs**:
cost/benefit, adverse effects

Science has a precise role:
provide rigorous expectations, solve trade-offs

Common approach in many fields
Increasingly applied in conservation
but reliance on «feeling» is still widespread

Change in perspective:
From: *what science offers*
To: *what management needs*



From Cochrane, 2011

What happens in an epidemic?











S
S
Susceptibles
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S
S
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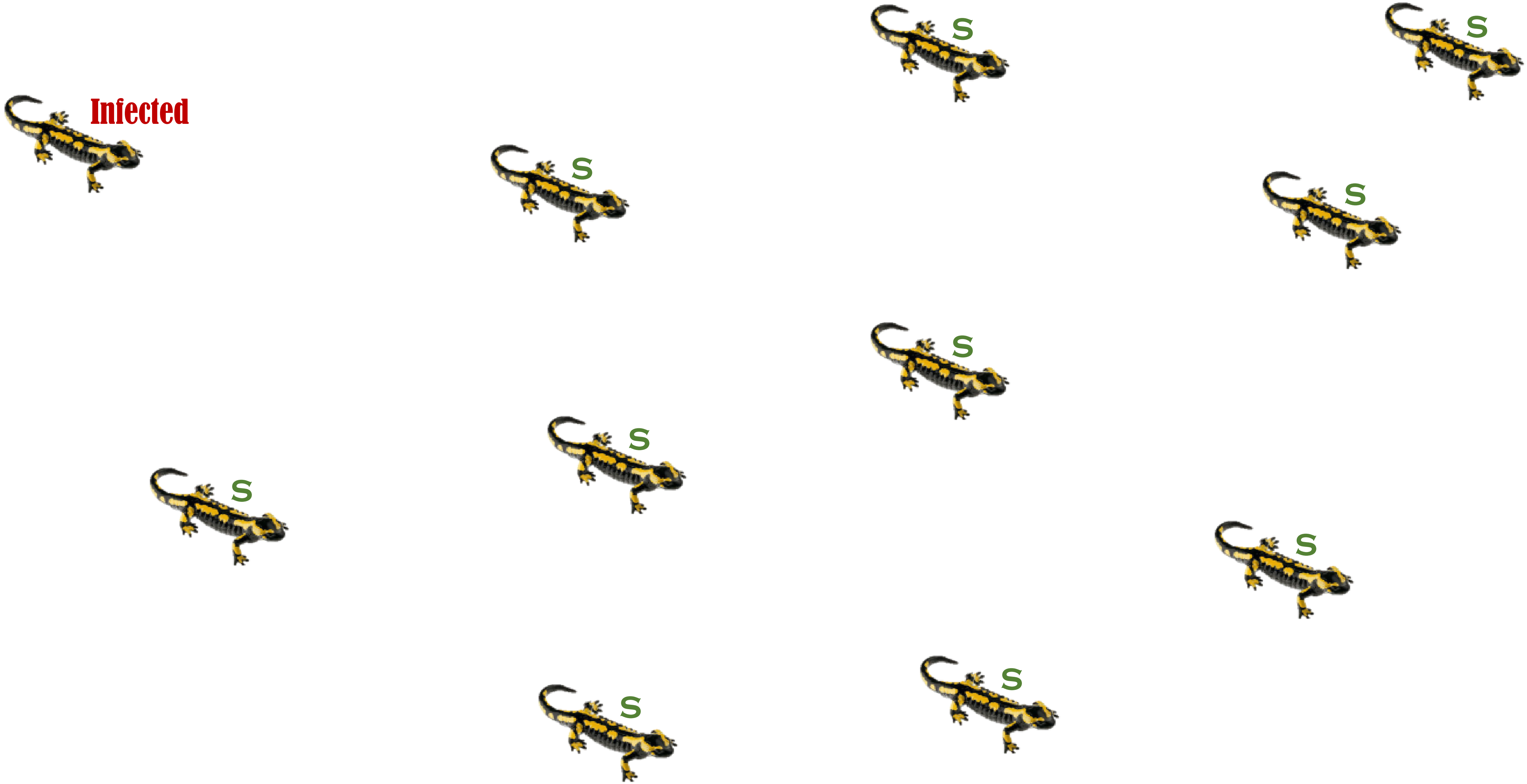
S


Infected
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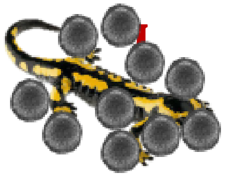

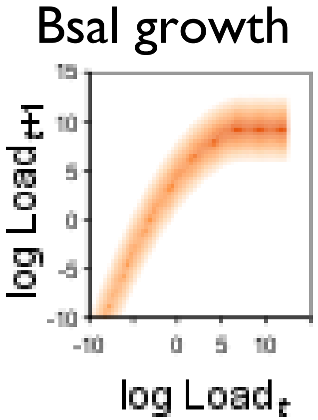
Bsal growth
log Load t+1
log Load t
15
10
5
0
-5
-10
-10
0
5
10


S
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S
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S
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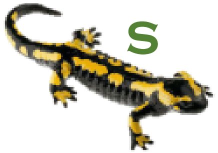
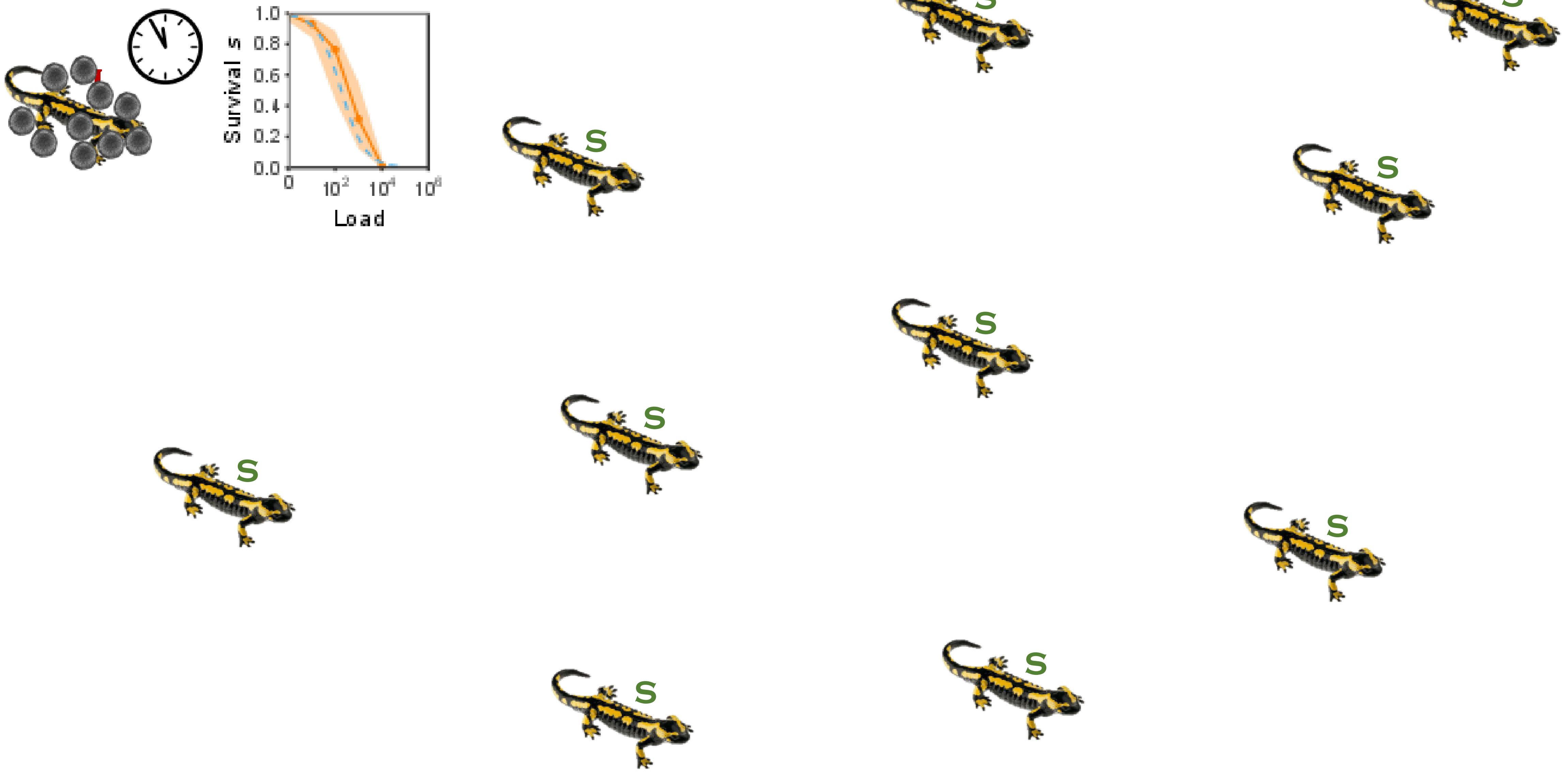
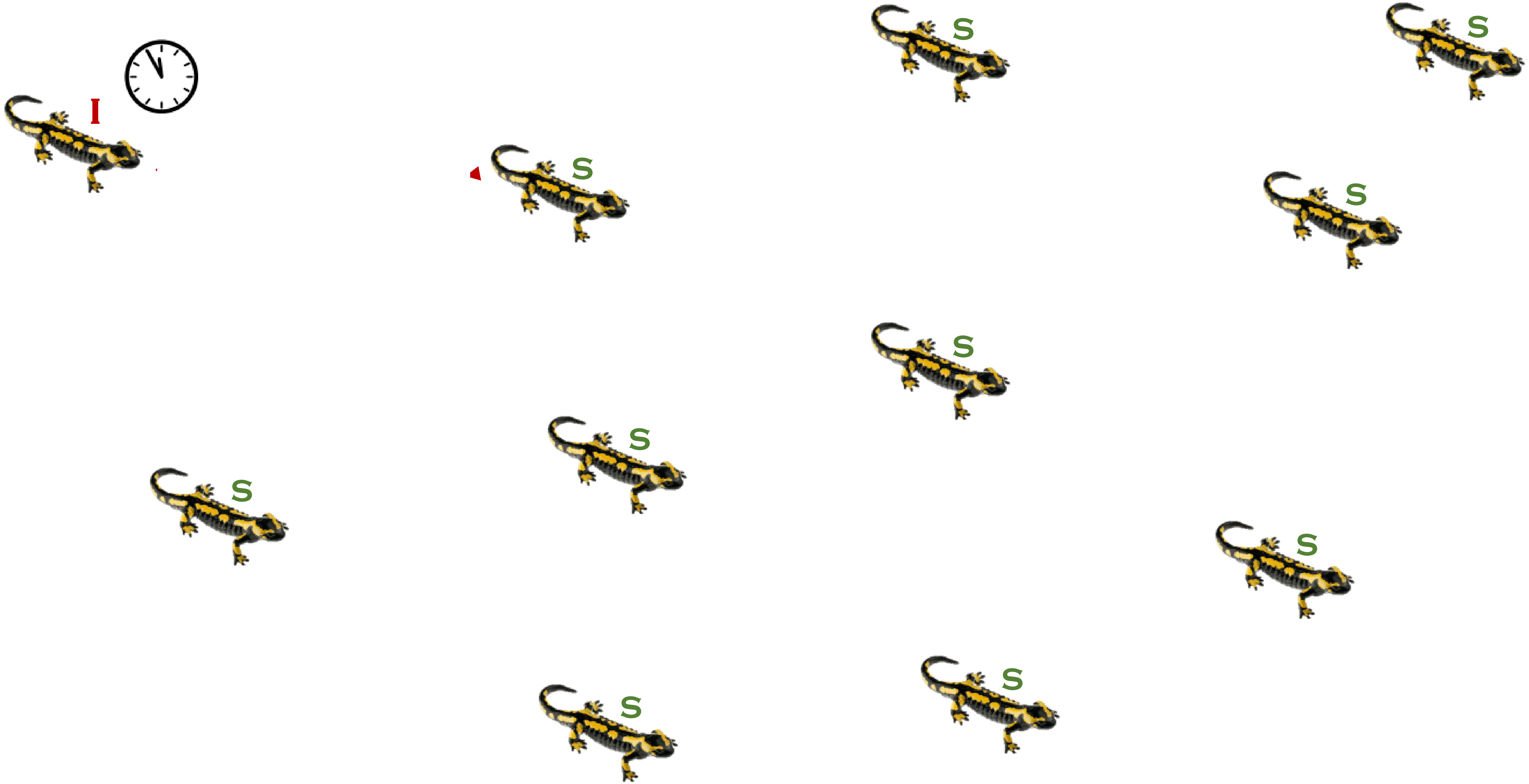

S

Survival

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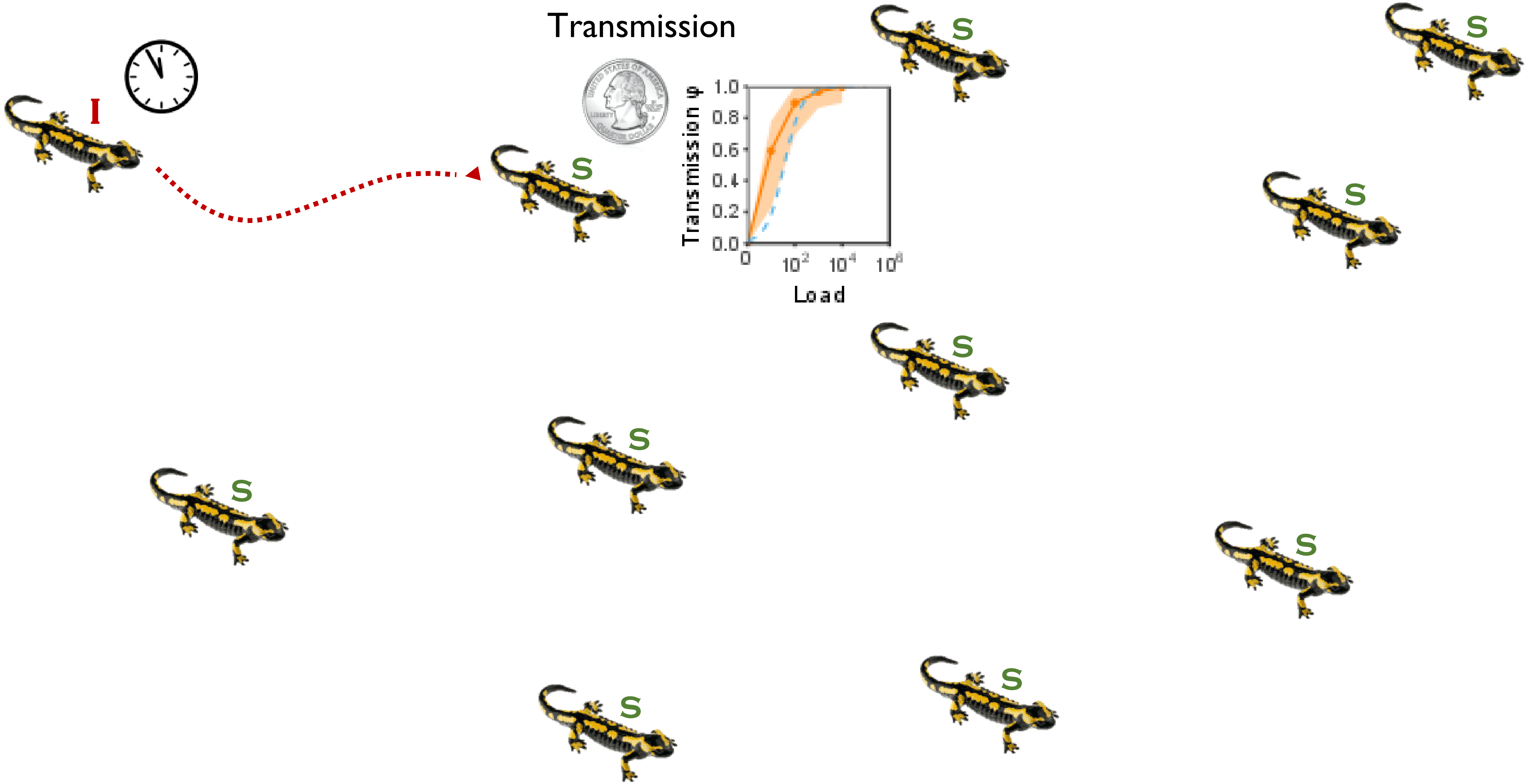
Transmission
I
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S
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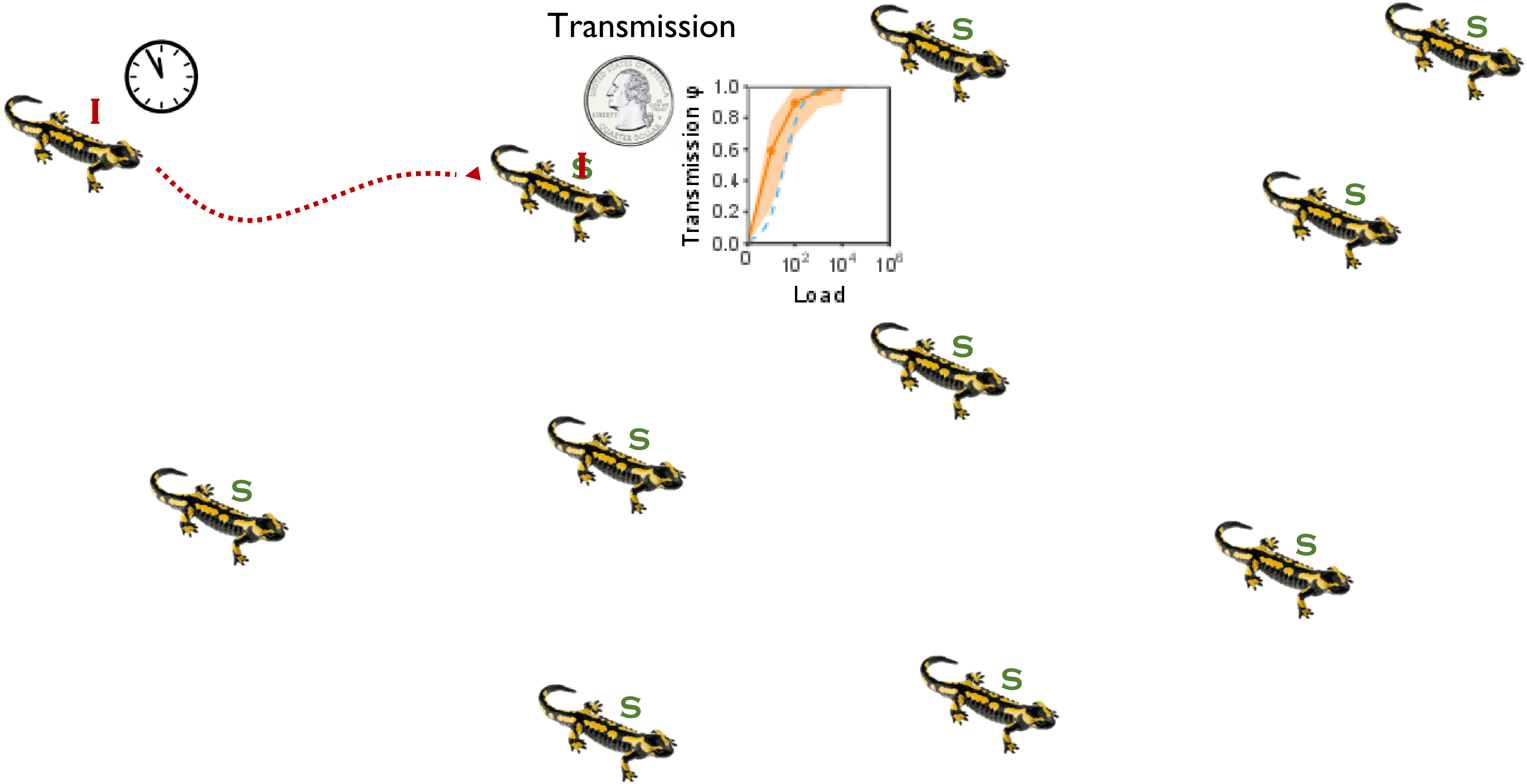
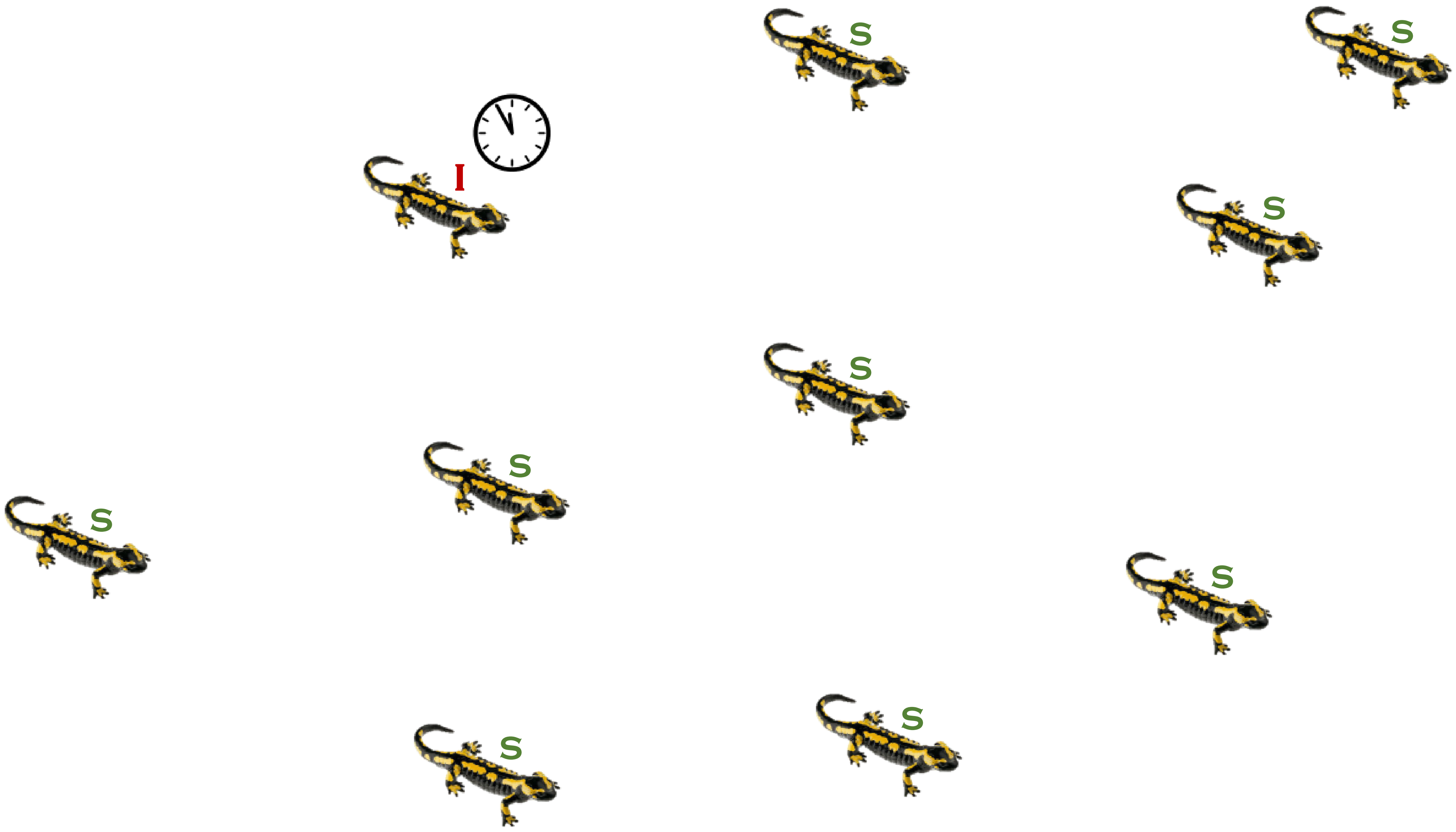
S
S
S
S
S
S
Transmission φ
1.0
0.8
0.6
0.4
0.2
0.0
0
10²
10⁴
10⁶
Load

Transmission




S
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S

What happens in an epidemic?

Animals go from **susceptible** to **infected**

Survival

- For susceptible animals is a normal process
- For infected animals depends on pathogen load

Transmission

- Depends on frequency of contacts
- Which in turn depends on density
- And also on how heavily infected the carrier is

Pathogen growth

- Host-pathogen relationship
- Also external conditions

Clearance

- Not found in fire salamanders

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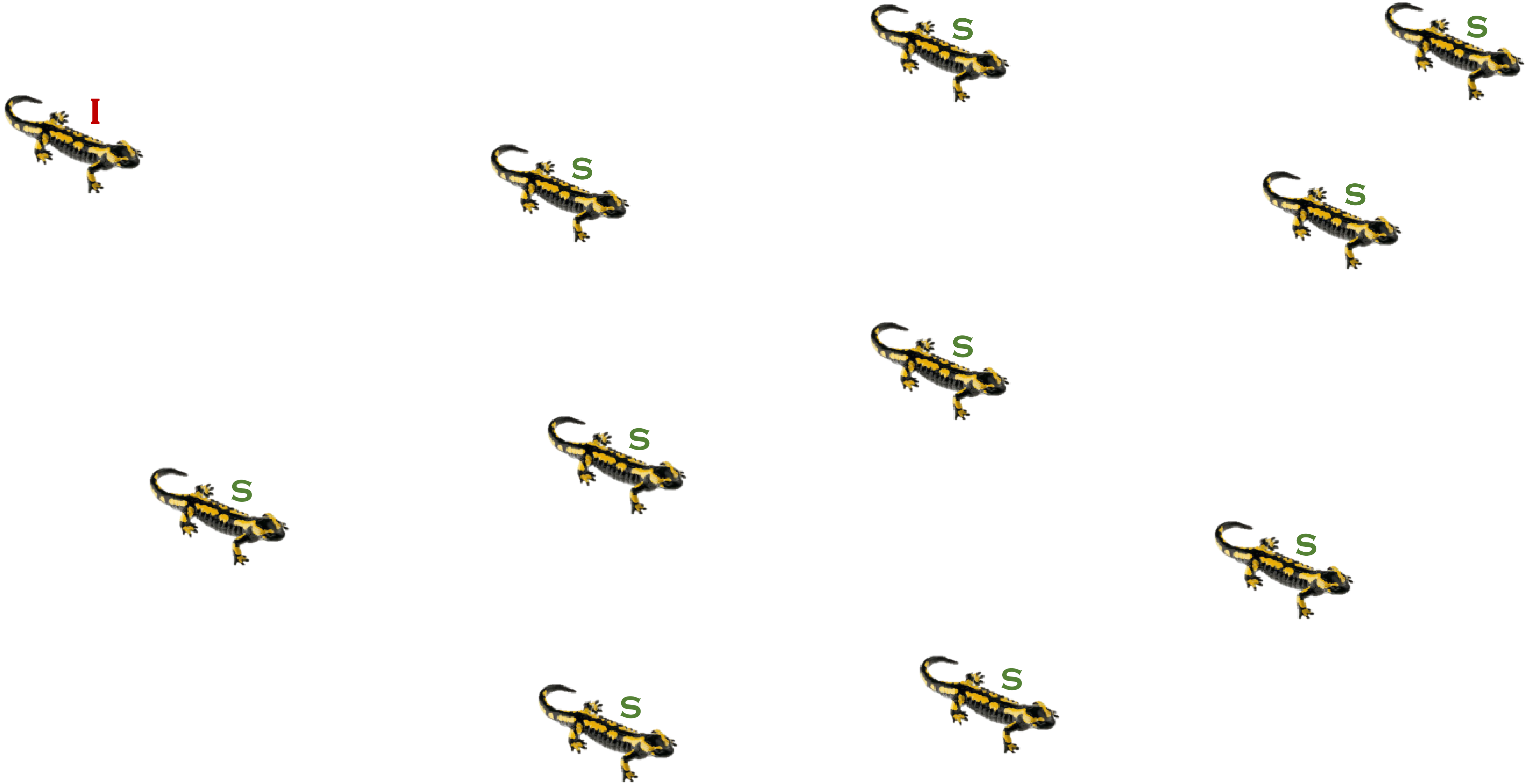
Integral projection model

Canessa et al., J. Appl. Ecol., *under review*

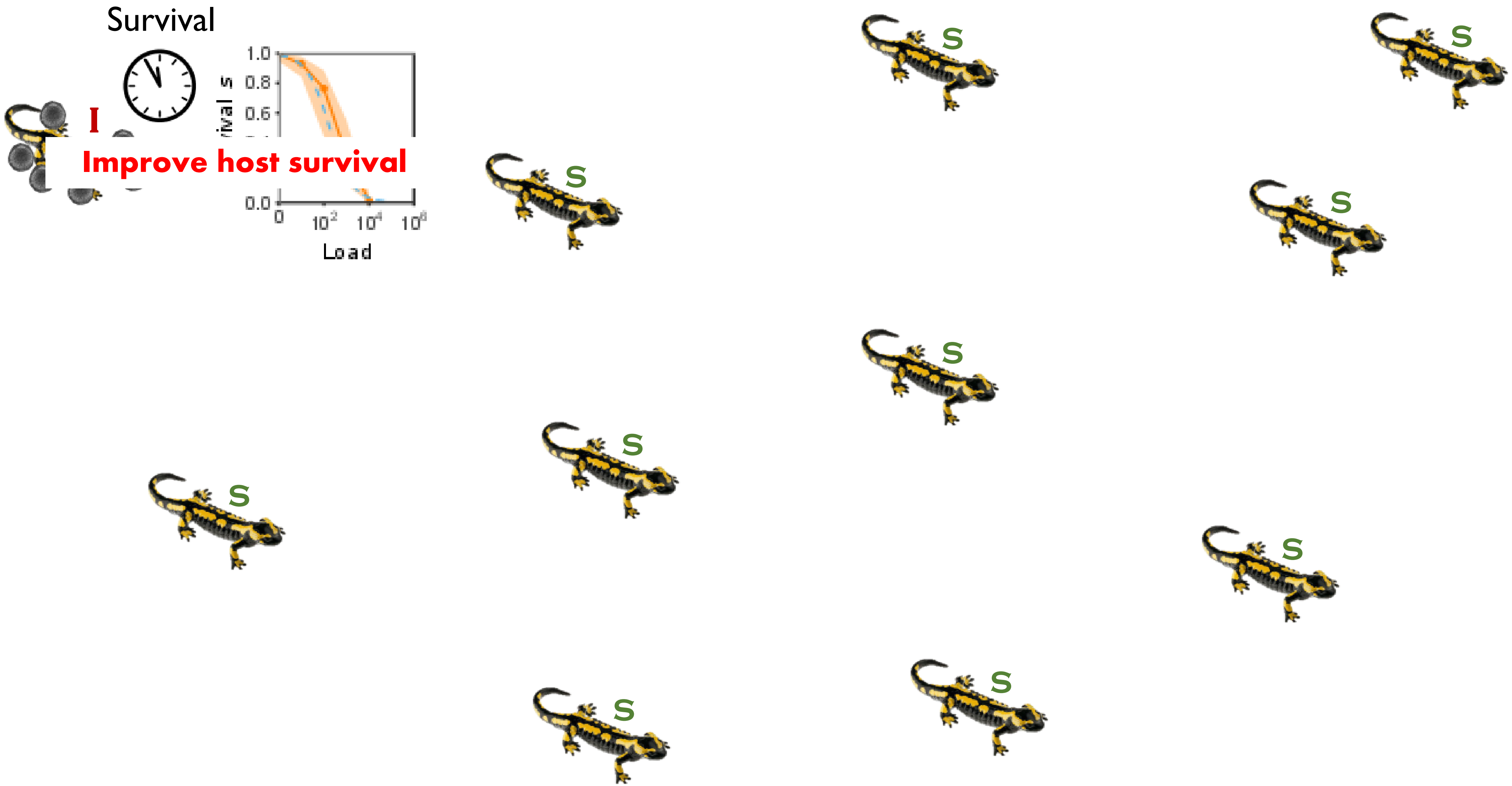
What do we hope to achieve with management?

- Eradicate *Bsal*
  - Useful metric: R0
  - R0 = basic reproduction number: number of individuals infected by each infected individual
  - R0<1: eradication
- Save the infected population
  - Avoid extinction or massive decline
  - Proportion of (healthy) individuals left at the end of the epidemic
  - No «natural» target, and what if *Bsal* is still there?
- Minimize chance of spread to other populations
  - Distance moved by infected individuals
  - Extreme values may be more relevant than averages

How can we manage this system?



Slow down or interrupt *Bsal* growth


Survival
I
Improve host survival
1.0
0.8
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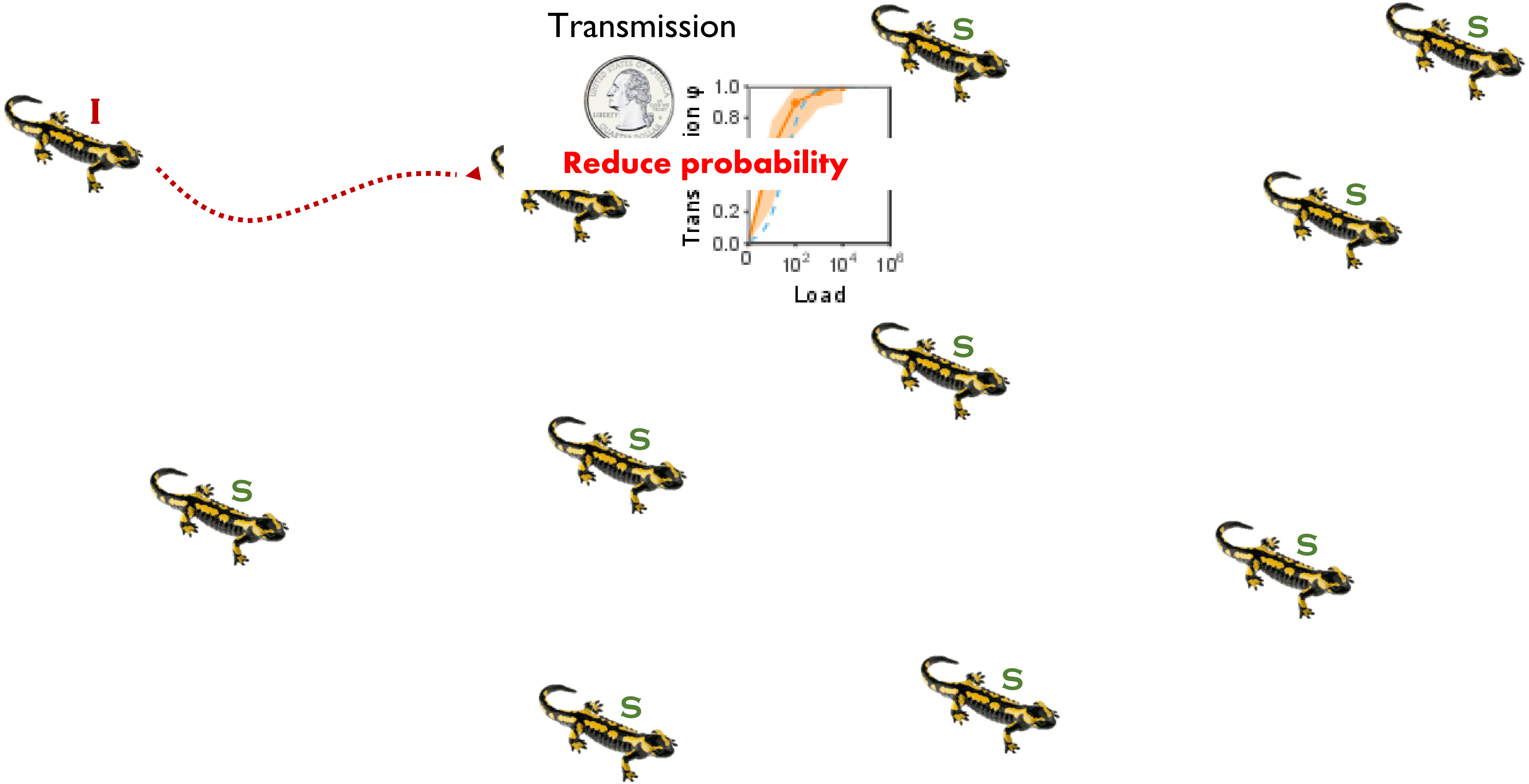
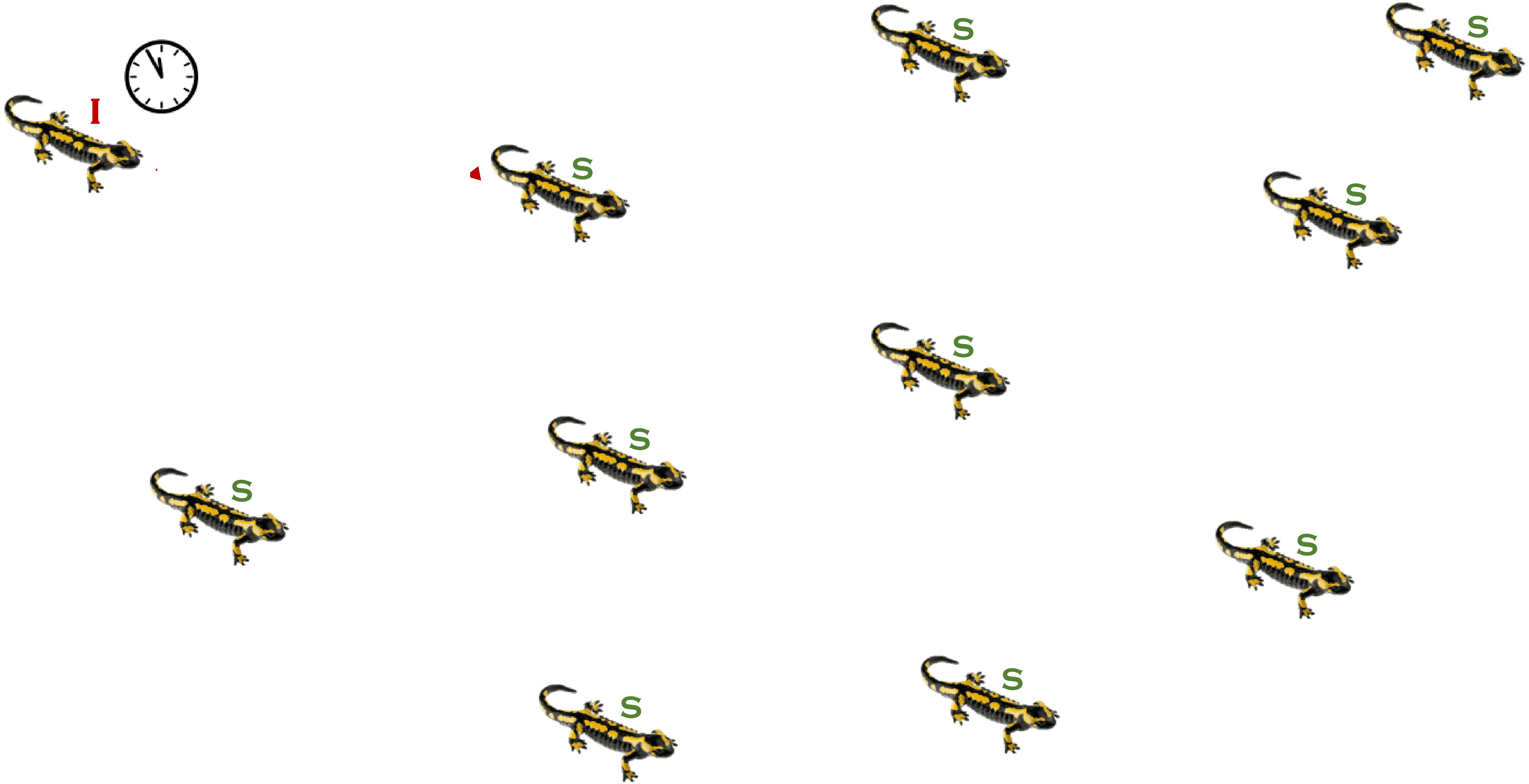
S



Transmission
I
S
S
S
S
S
S
S
S
S
Reduce probability
1.0
0.8
0.2
0.0
0
10^2
10^4
10^6
Load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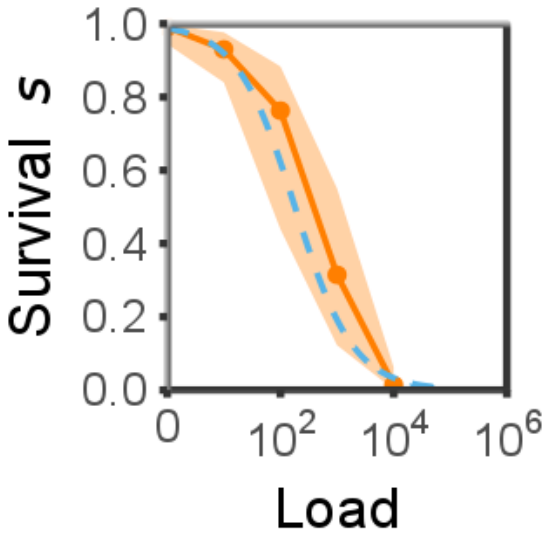
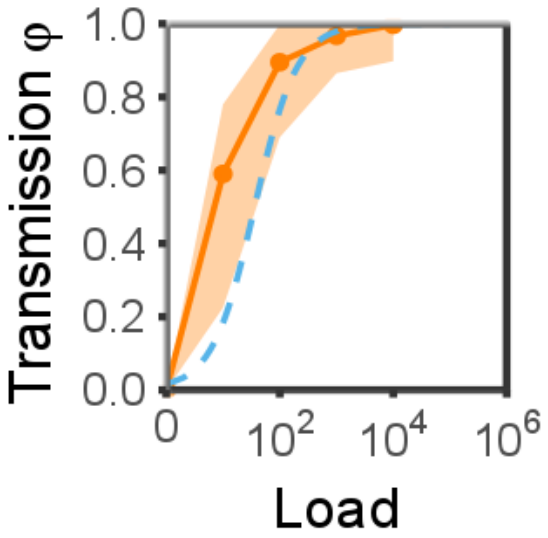
S

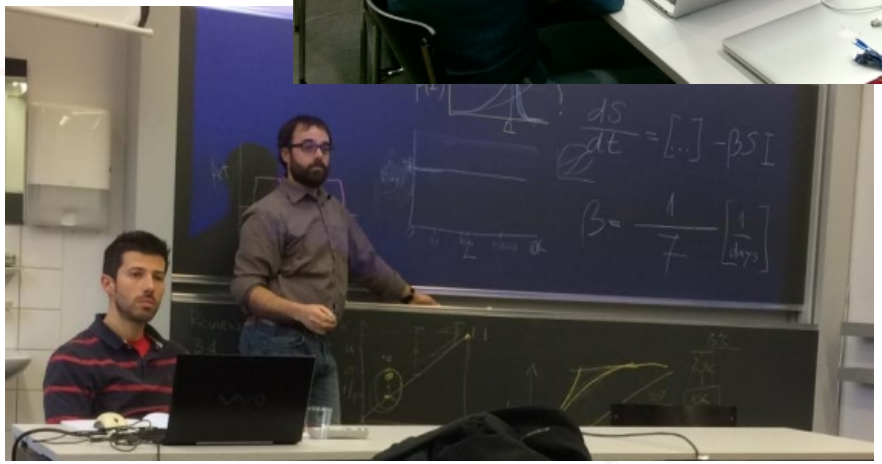
Reduce density ("thinning")
before or after entry of *Bsal*

What can we actually do, and what do we expect?

- Expert collaboration: four day workshop
- Fill the model with best available information
- Recognise what we know and what we don't know
- Brainstorm possible management ideas
- Simulate their outcomes using the model



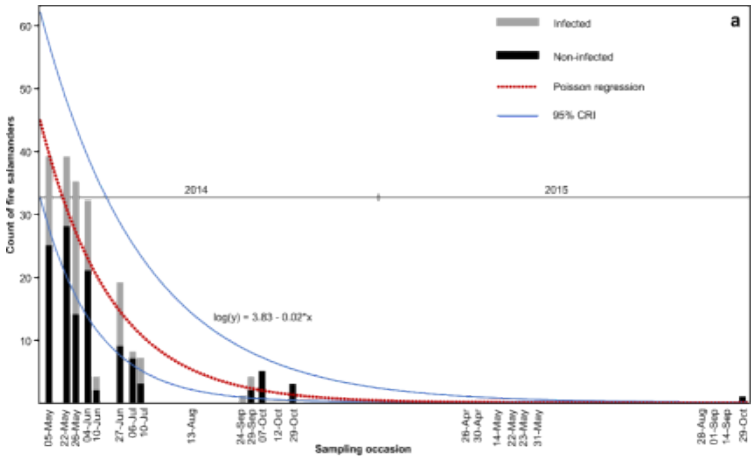




Action	Description	Modelling
No action	Unmitigated course of Bsal outbreak in a population	–
Improve body condition	Increase resistance to infection at low load by 50%	$0.5 * \beta(z)$ for $z \leq 100$ GE
Probiotic treatment	Pre-emptive treatment of susceptible individuals (a) Increase resistance to infection at low loads by 50% (b) slow Bsal growth once infected by 80%	(a) $0.5 * \beta(z)$ for $z \leq 100$ GE (b) $\lambda = (\sqrt{0.2} * data)^3$
Antifungal treatment, perfect coverage	Treatment of both susceptible and infected individuals (a) Increase the resistance to infection by 98% (b) Slow Bsal growth once infected by 80%	(a) $(1 - 0.98) * \beta(z)$ (b) $\lambda = (\sqrt{0.2} * data)^3$
Antifungal treatment, incomplete coverage	Treatment of both susceptible and infected individuals (a) Increase the resistance to infection by 98% (b) Only 80% of individuals treated at each time step (c) Slow Bsal growth once infected by 80%	(a-b) $(1 - 0.80 * 0.98) * \beta(z)$ (c) $\lambda = (\sqrt{0.2} * data)^3$
Pre-emptive removal, light thinning	Removal of 50% of individuals prior to entry of *Bsal*	$0.5 * S_0$
Pre-emptive removal, heavy thinning	Removal of 90% of individuals prior to entry of *Bsal*	$0.1 * S_0$
Post-detection removal	Removal of 90% of all individuals (per time step) after detection of Bsal, i.e., imposing an additional mortality probability of 90%.	$0.1 * s(z)$

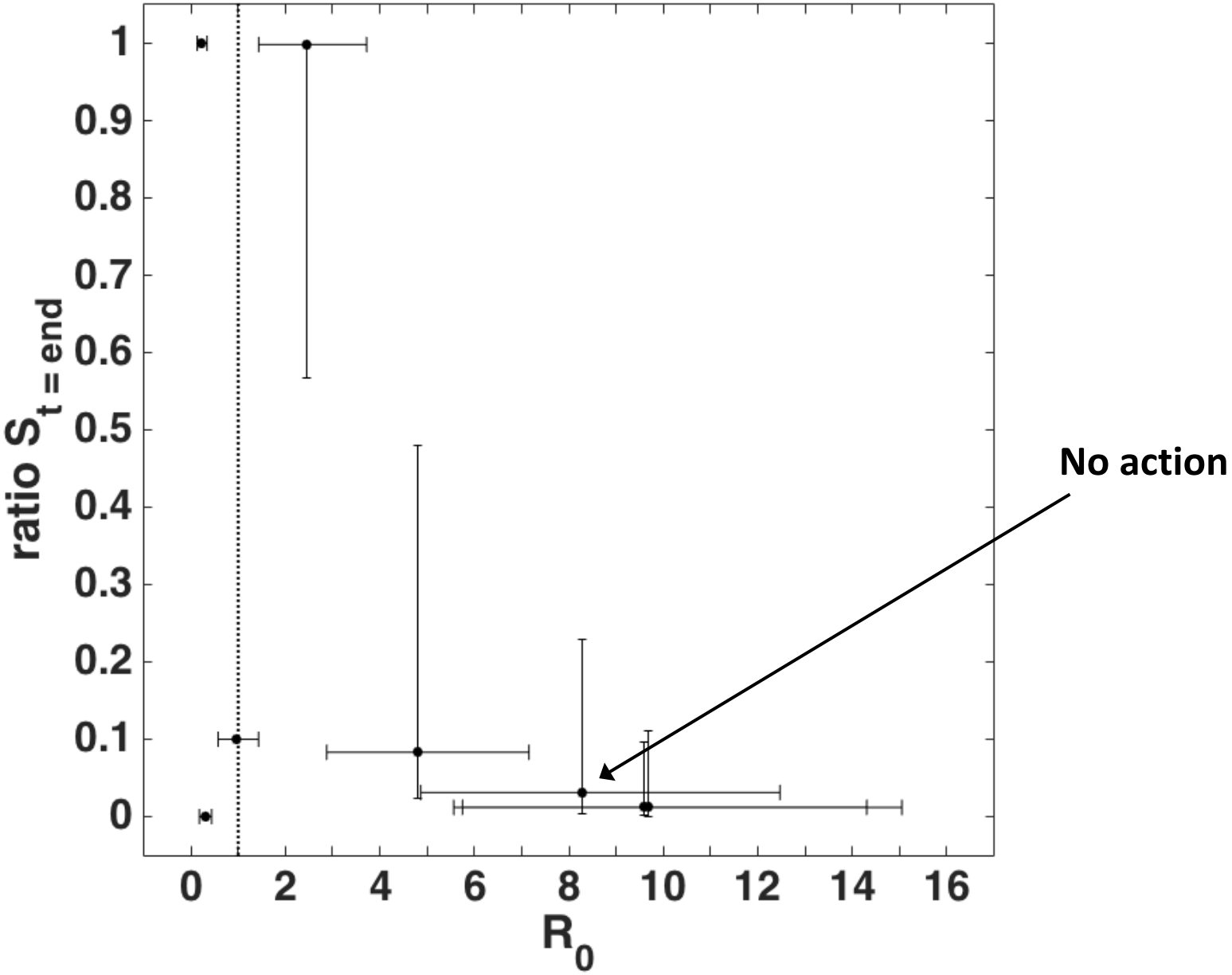
Results of mitigation actions

(3 month period)



How much has the population declined?

0=extinction
1=no damage



Has Bsal been eradicated? R0<1 yes, R0≥ 1 no

Canessa et al., J. Appl. Ecol., *under review*

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(3 month period)

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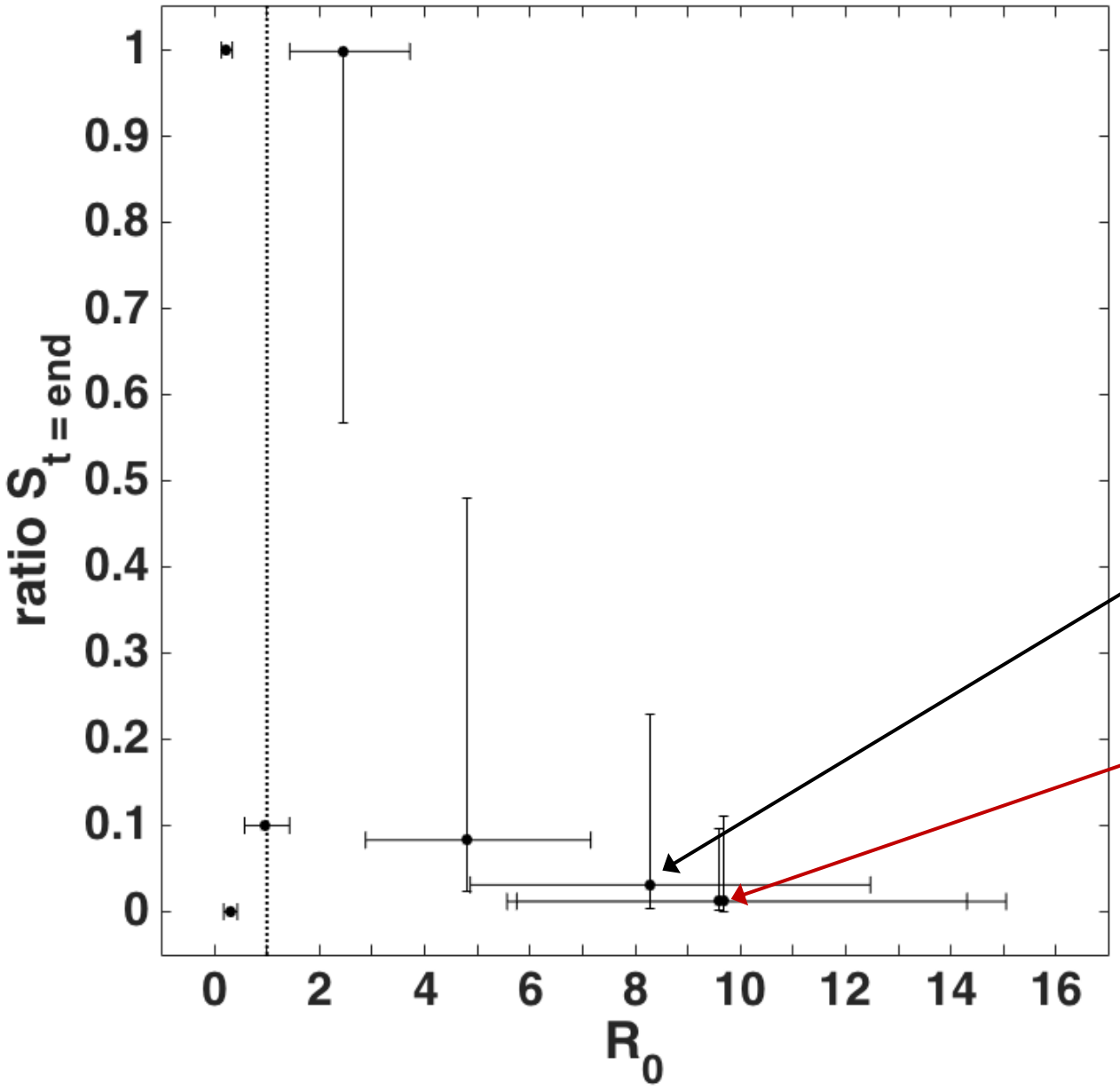

No action

Slowing *Bsal* growth makes things worse

Has Bsal been eradicated? R0<1 yes, R0≥ 1 no

Canessa et al., J. Appl. Ecol., *under review*

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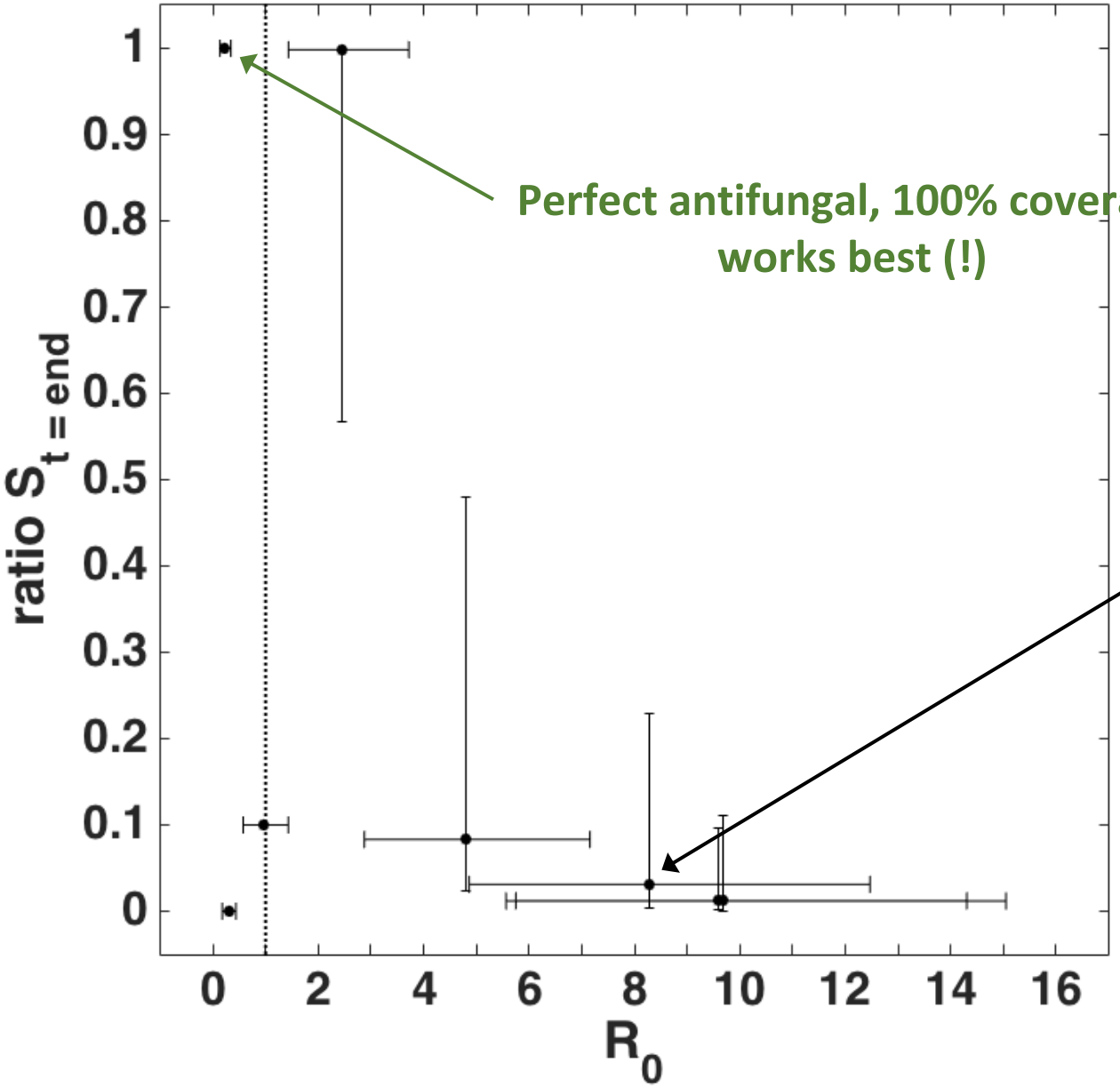

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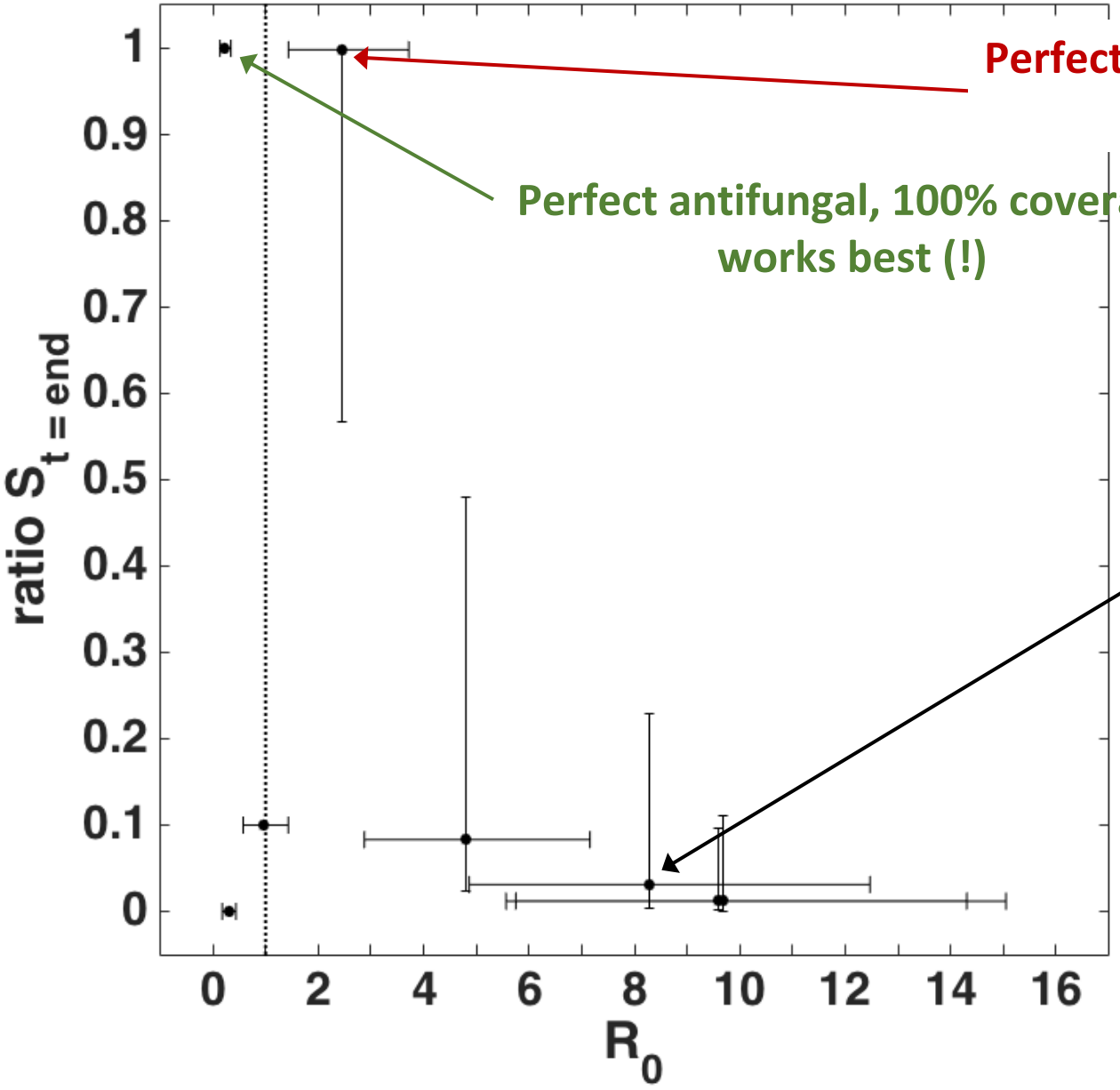

Perfect antifungal, 80% coverage already insufficient

Perfect antifungal, 100% coverage works best (!)

No action

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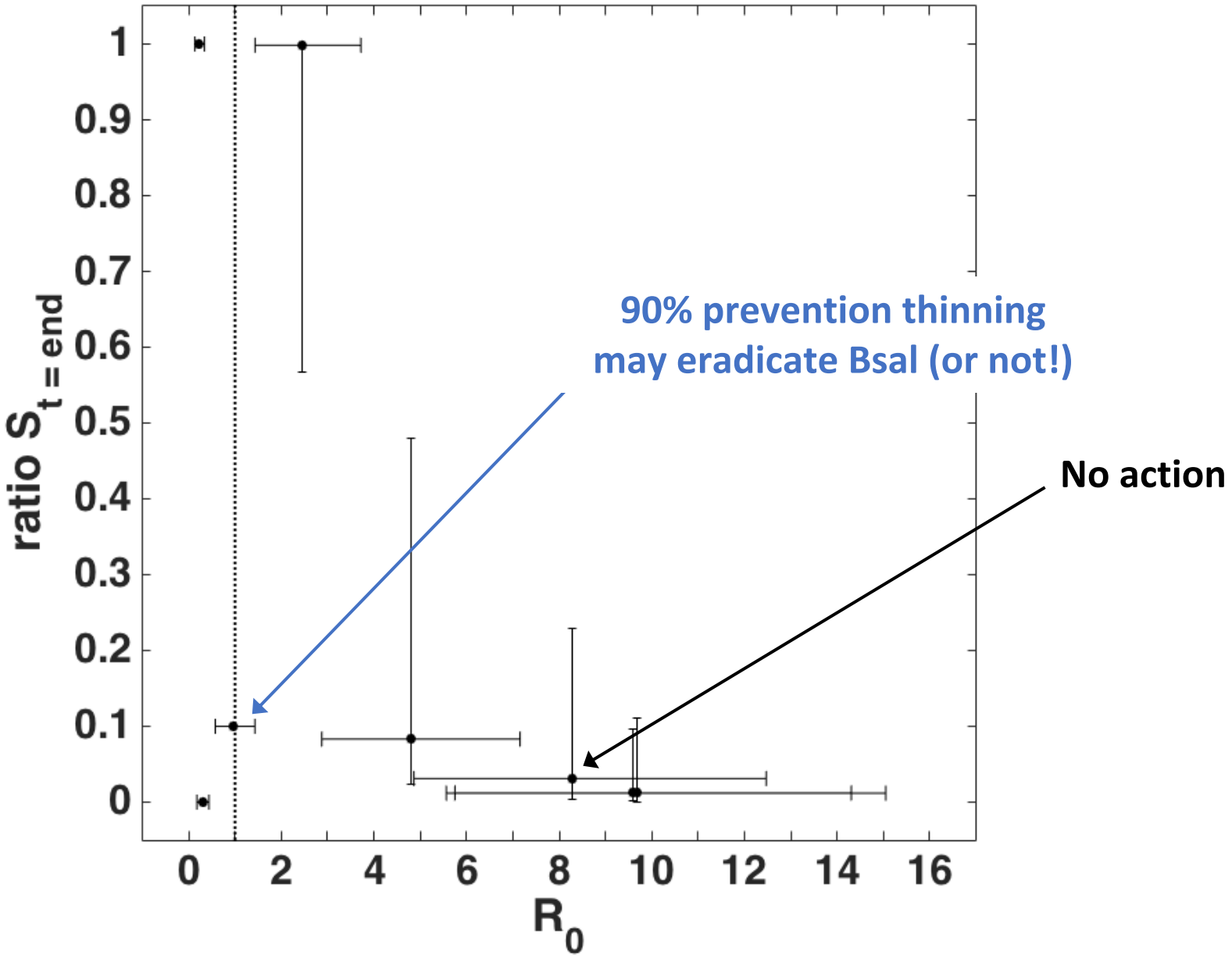

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Results of mitigation actions

(3 month period)

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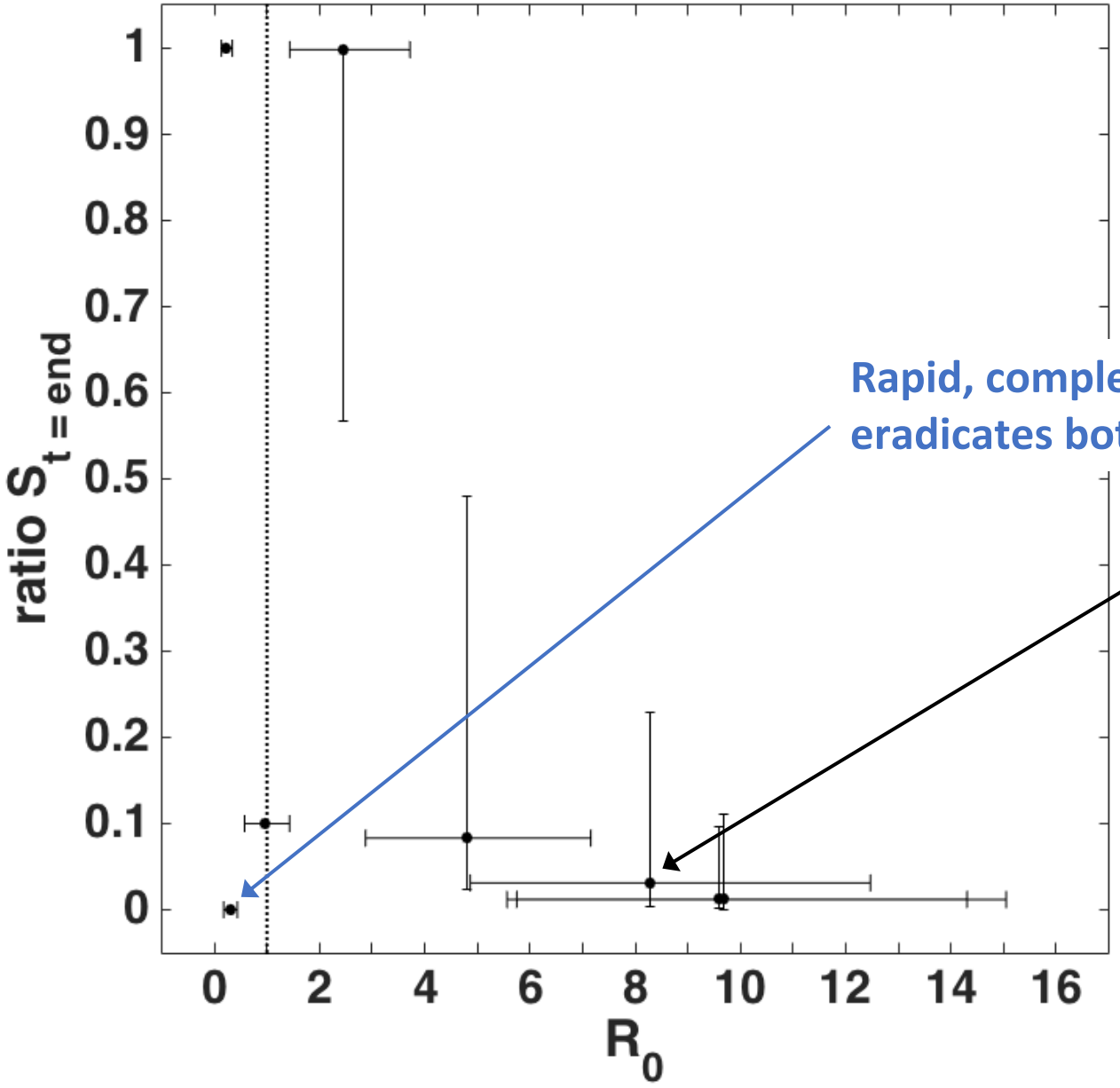


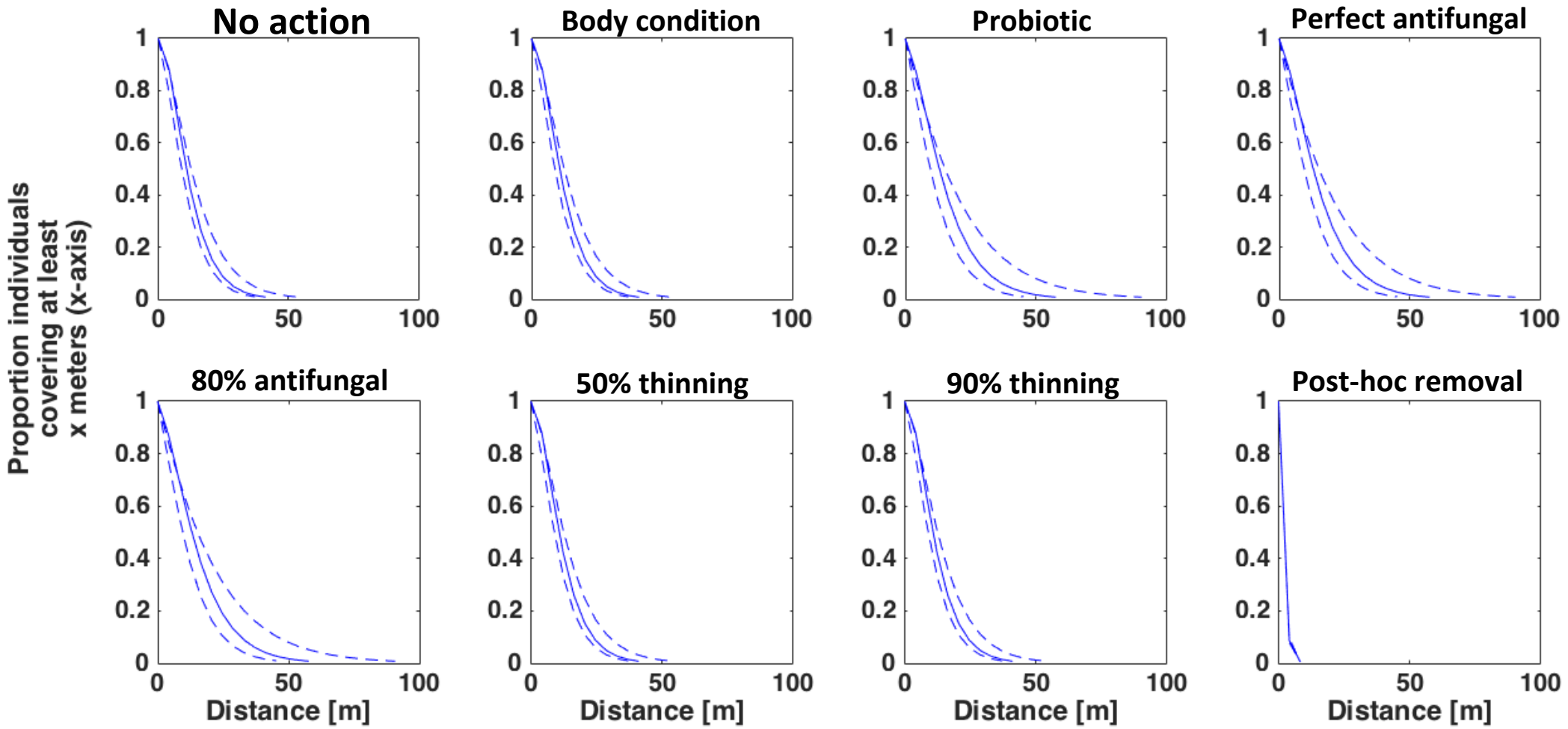
Rapid, complete removal of population eradicates both Bsal and salamanders

No action

Has Bsal been eradicated? R0<1 yes, R0≥ 1 no

Canessa et al., J. Appl. Ecol., *under review*

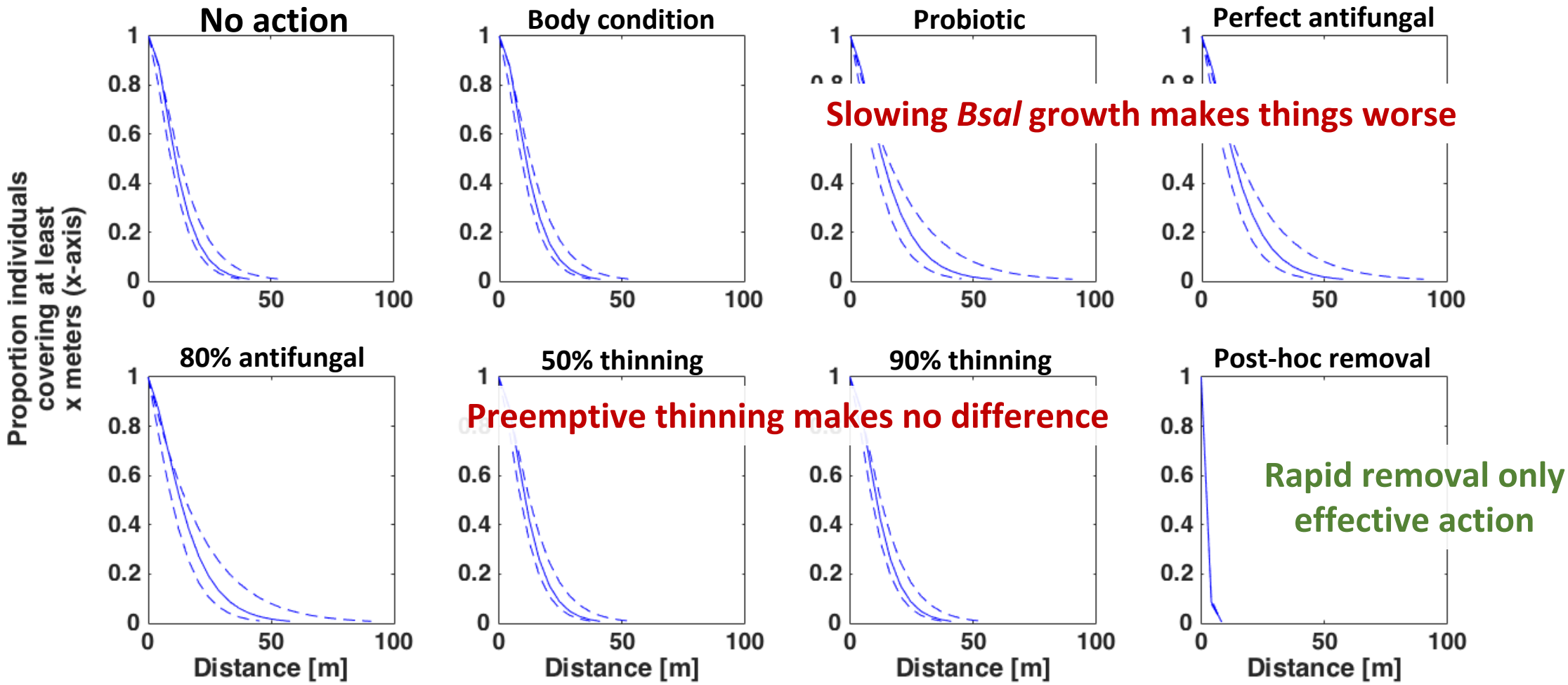
Results of mitigation actions: dispersal of infected individuals



How much do infected animals move? (less is better)

Canessa et al., J. Appl. Ecol., *under review*

Results of mitigation actions: dispersal of infected individuals



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Canessa et al., J. Appl. Ecol., *under review*

Conclusions

- Management of a *Bsal* epidemic in a susceptible species is very unlikely
- Any treatment (probiotic, antifungal) will need to be almost perfect
- Increasing survival without cutting transmission only makes things worse
- More extreme removal actions may block spread, but at an obvious cost
- Role of reservoirs to be clarified (probably makes everything worse)
- Spatial ecology of host species a research priority

Conclusions (II)

- Our model is not the truth – it's current knowledge of a complex system
- Analysis can help us look at mitigation options rationally
- Important to recognise uncertainty: we don't and can't know everything
- What does management need?
- To translate into real practice: who makes decisions about salamander conservation?

Thank you

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wildlife analysis

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FNSNF

fwo Research Foundation Flanders Opening new horizons

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