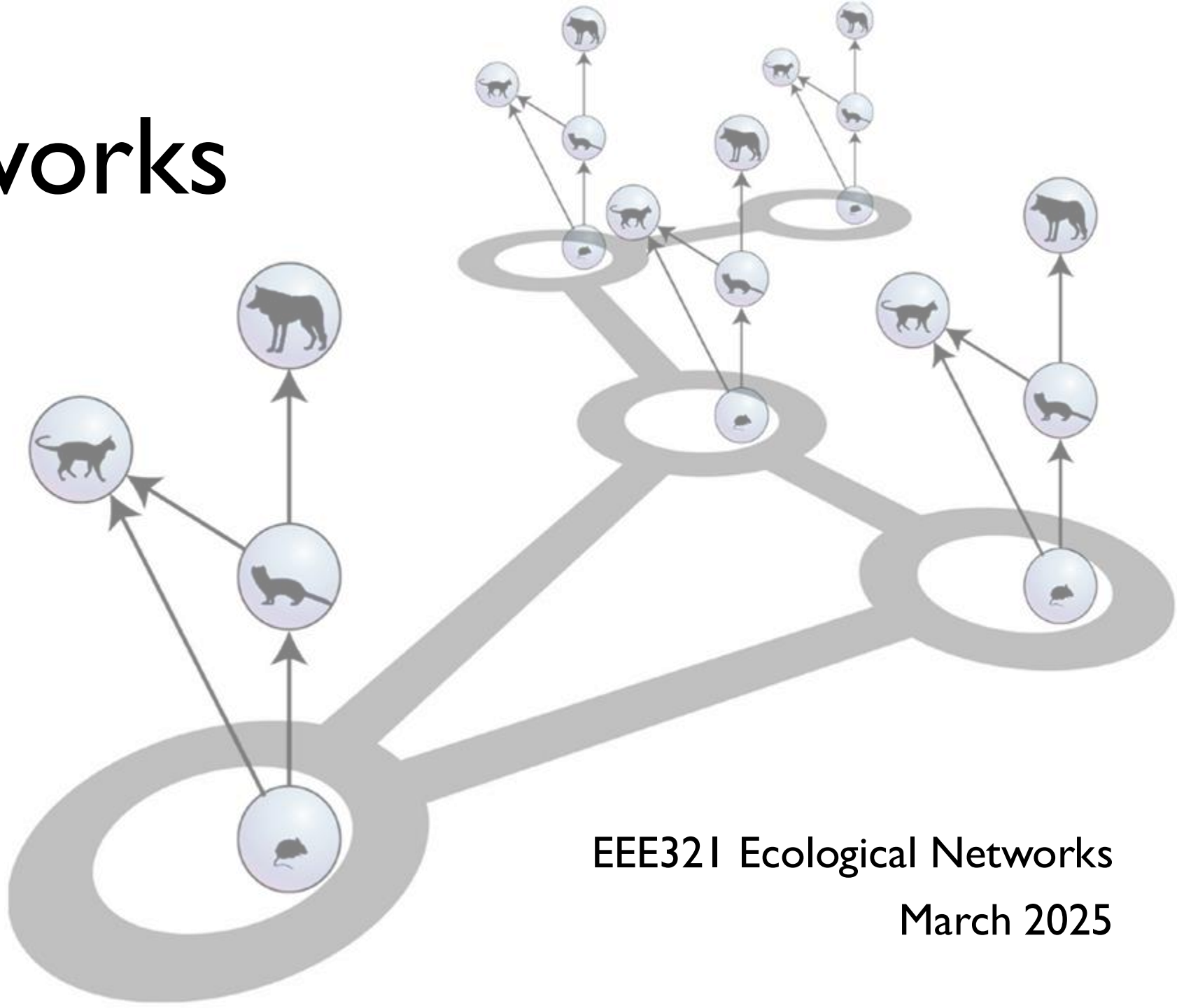
Spatial Networks



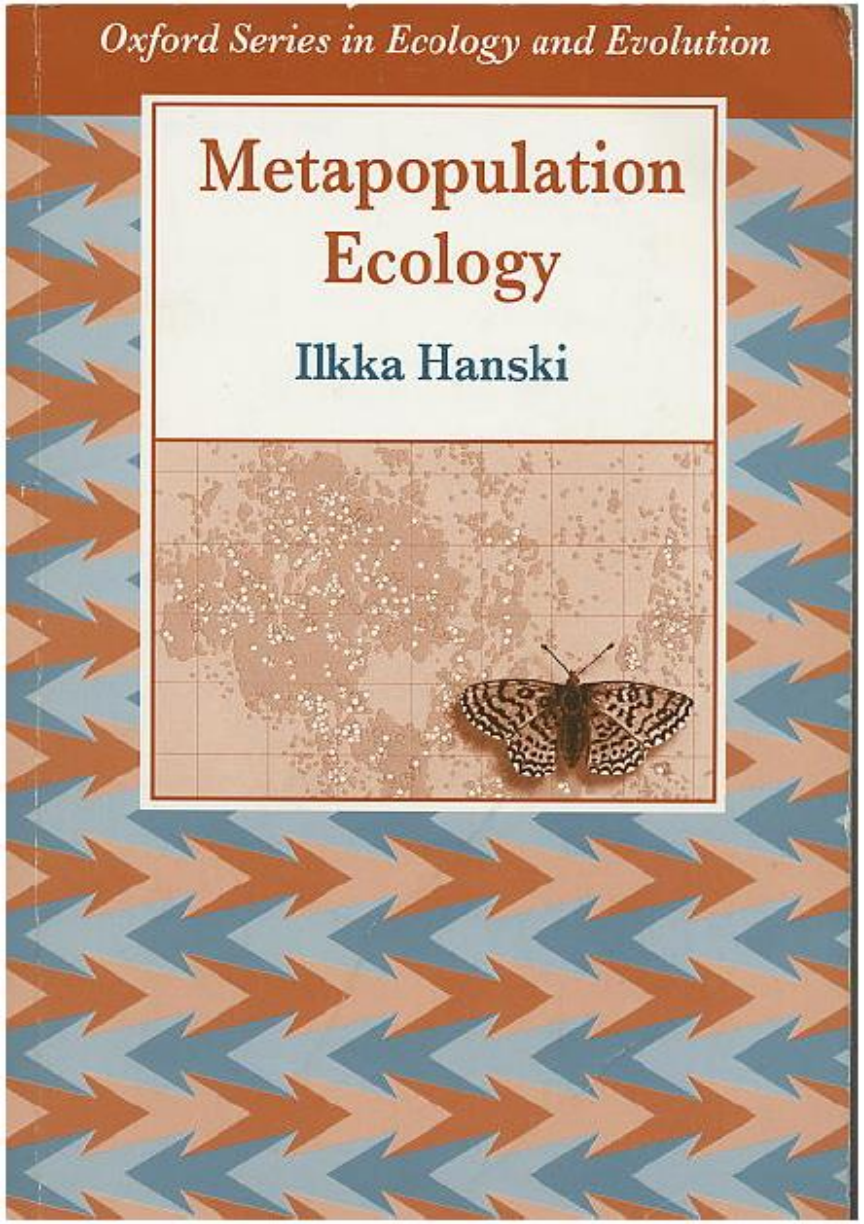
Miguel Román

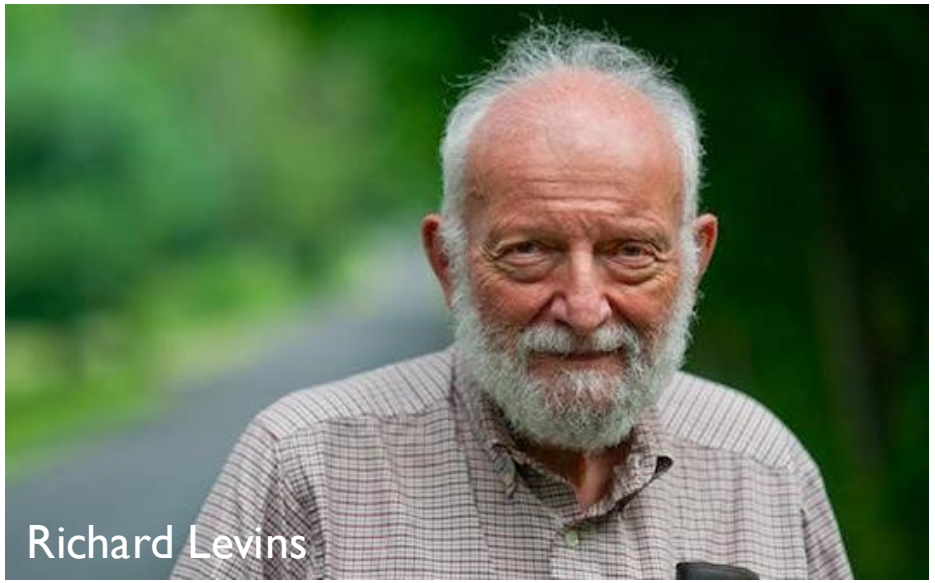
miguel.romansanchez@uzh.ch

(slides by Klementyna Gawecka)

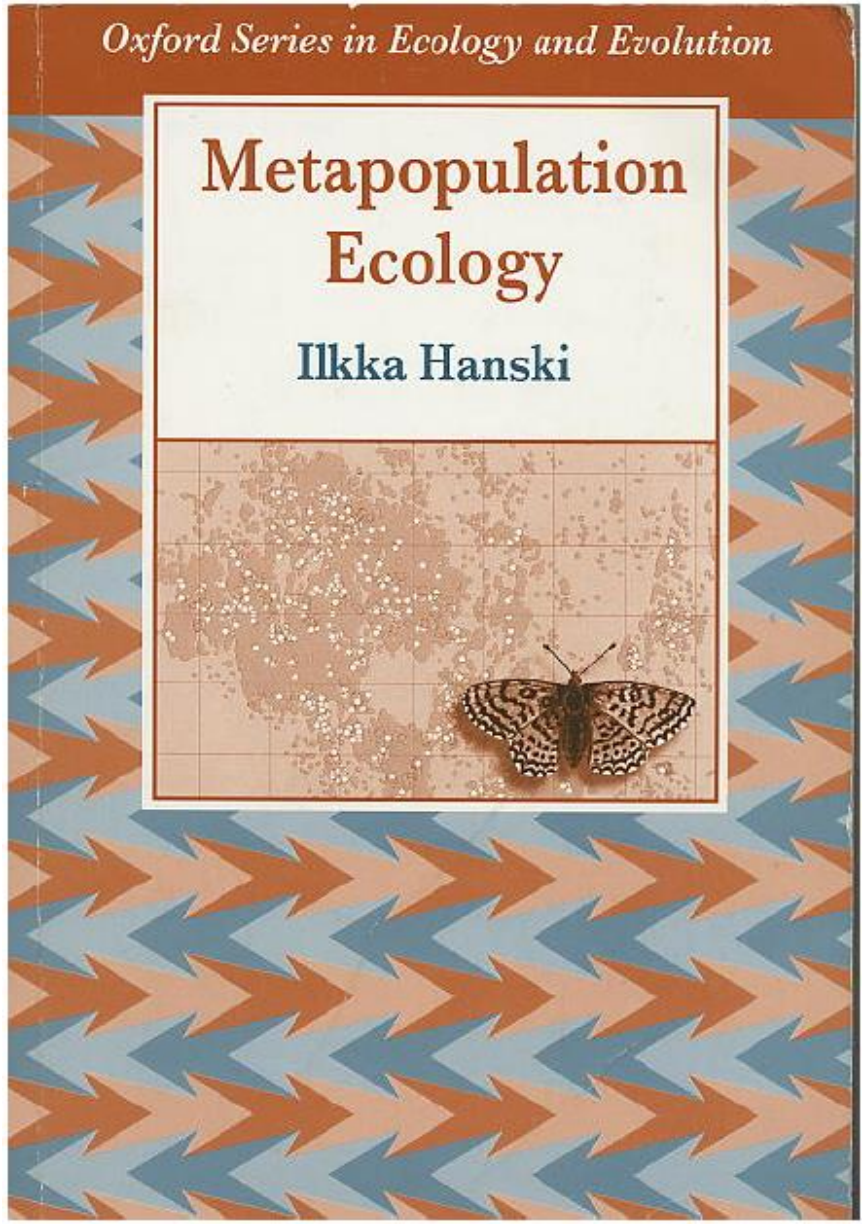
EEE321 Ecological Networks

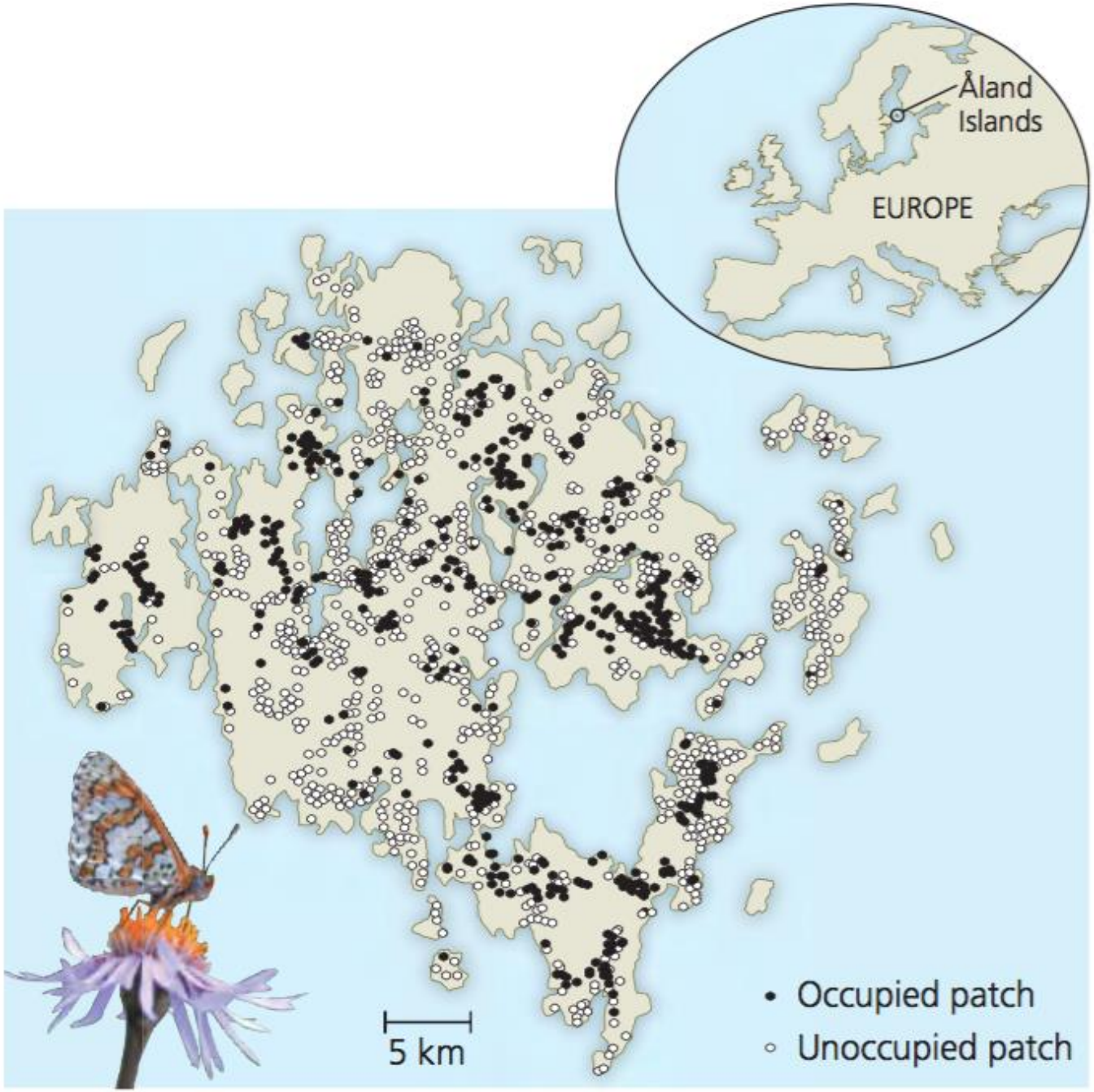
March 2025


Oxford Series in Ecology and Evolution
Metapopulation Ecology
Ilkka Hanski


Richard Levins

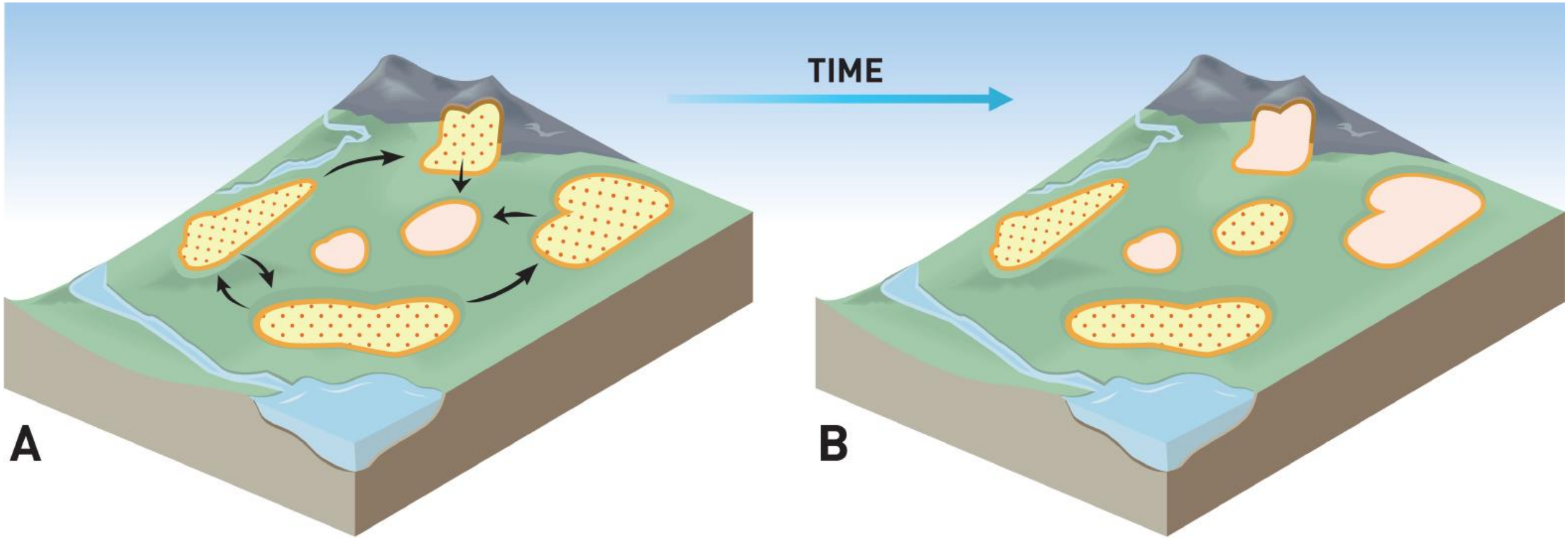
Ilkka Hanski



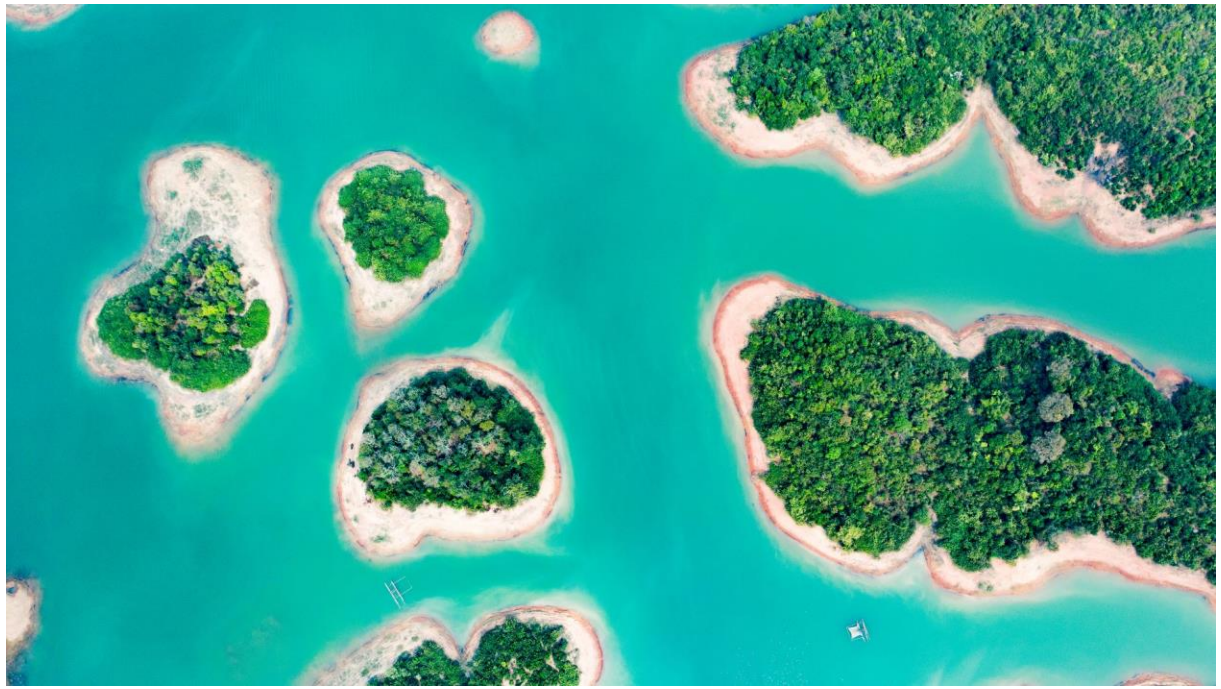


Glanville fritillary butterfly

Metapopulation dynamics

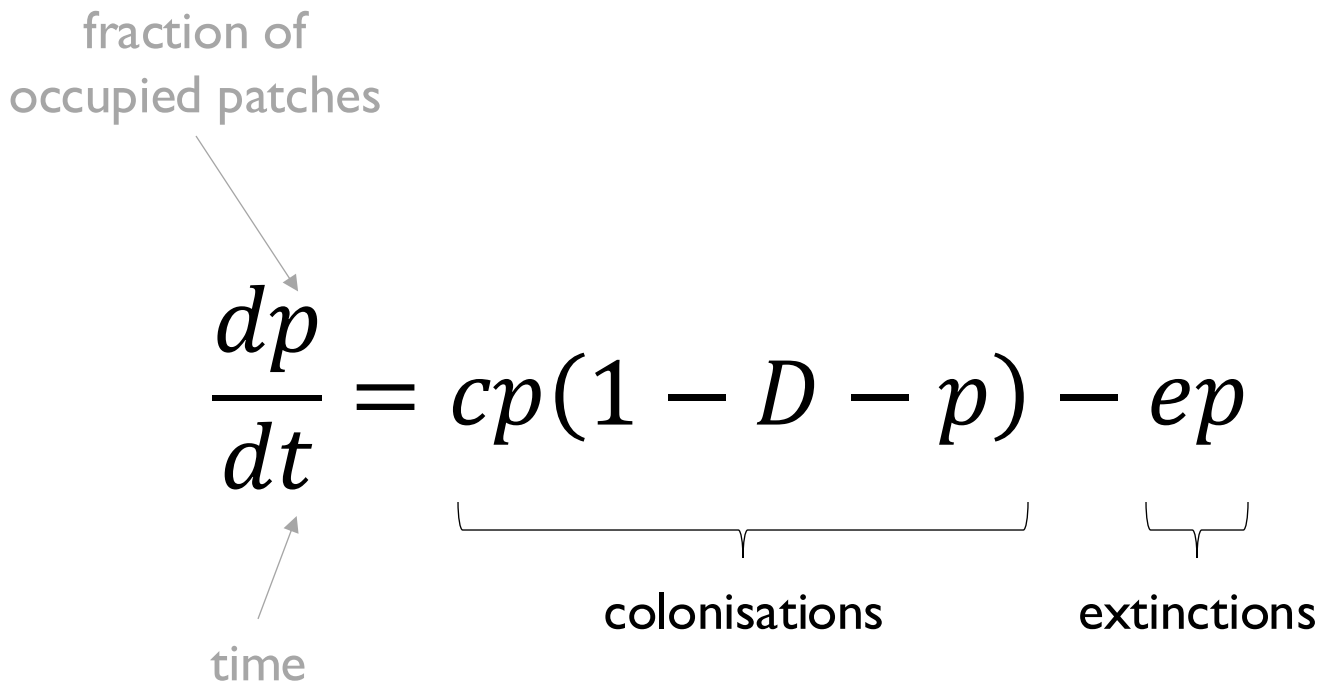


credit: Jimmy Blomqvist, Royal Swedish Academy of Sciences



Habitat loss and extinction thresholds

Levins' model:



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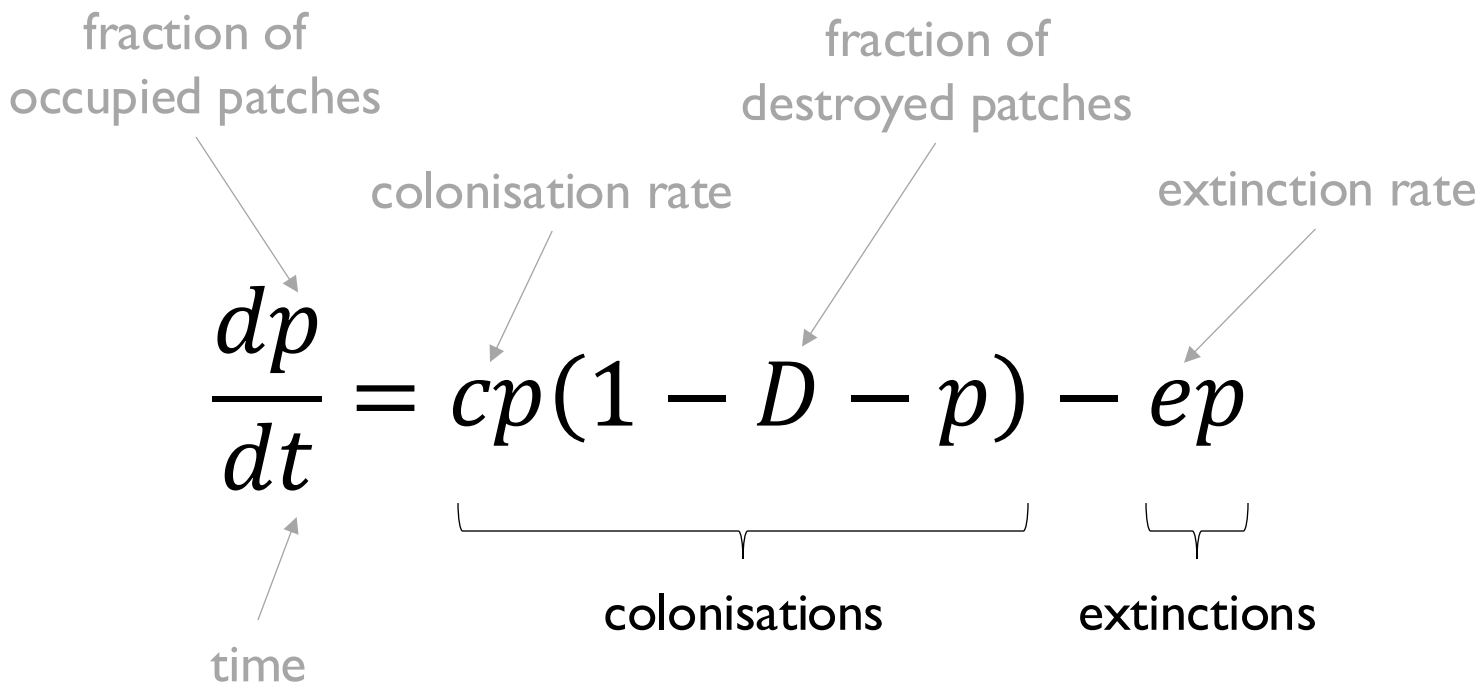
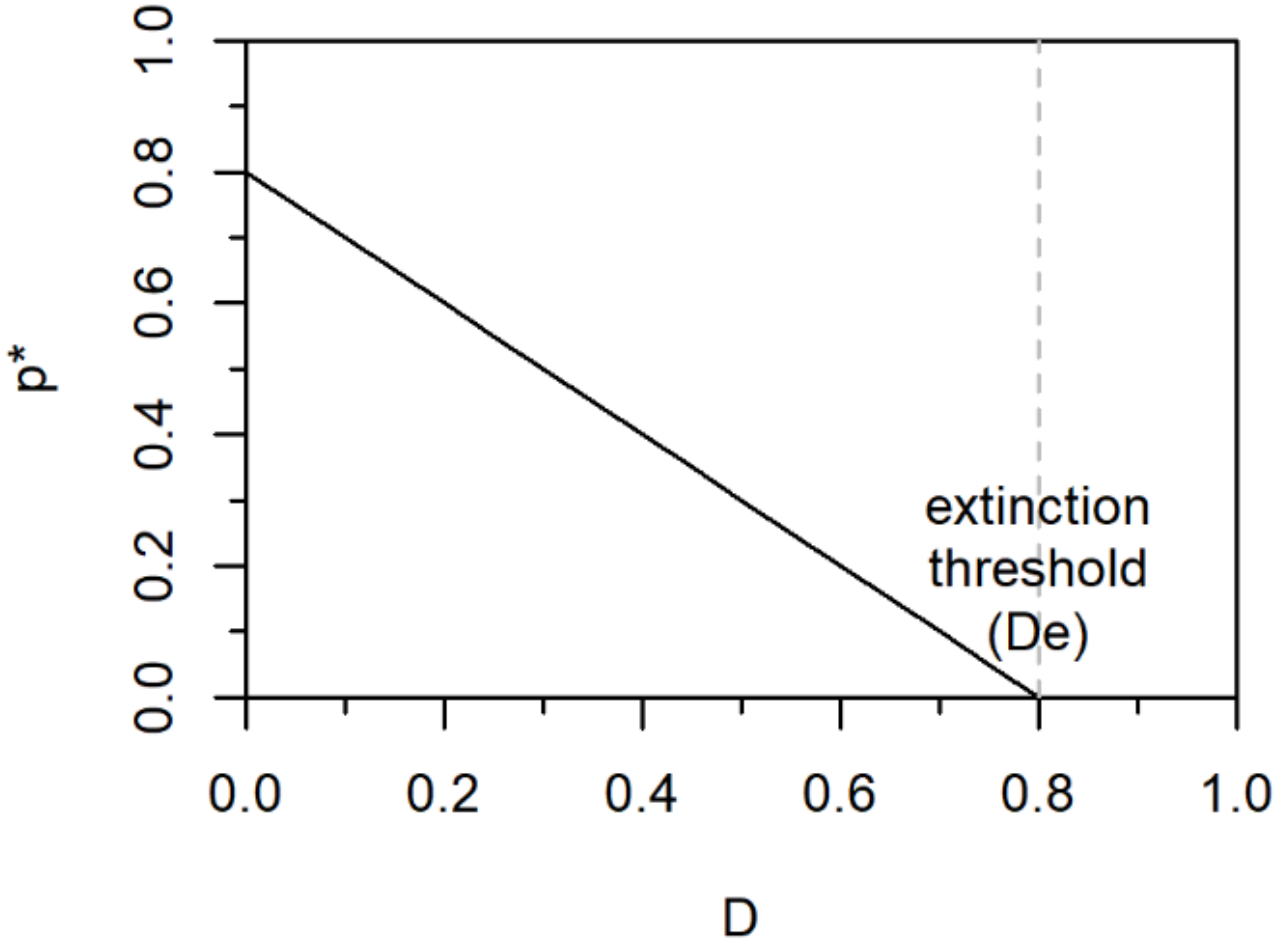


Habitat loss and extinction thresholds

$$p^* = \begin{cases} 1 - D - {}^{e}/_{c} & if\ D < D_e \\ 0 & if\ D \geq D_e \end{cases}$$

$$D_e = 1 - {}^{e}/_{c}$$



Vol. 130, No. 4 The American Naturalist October 1987

EXTINCTION THRESHOLDS IN DEMOGRAPHIC MODELS OF TERRITORIAL POPULATIONS

RUSSELL LANDE

Northern spotted owl

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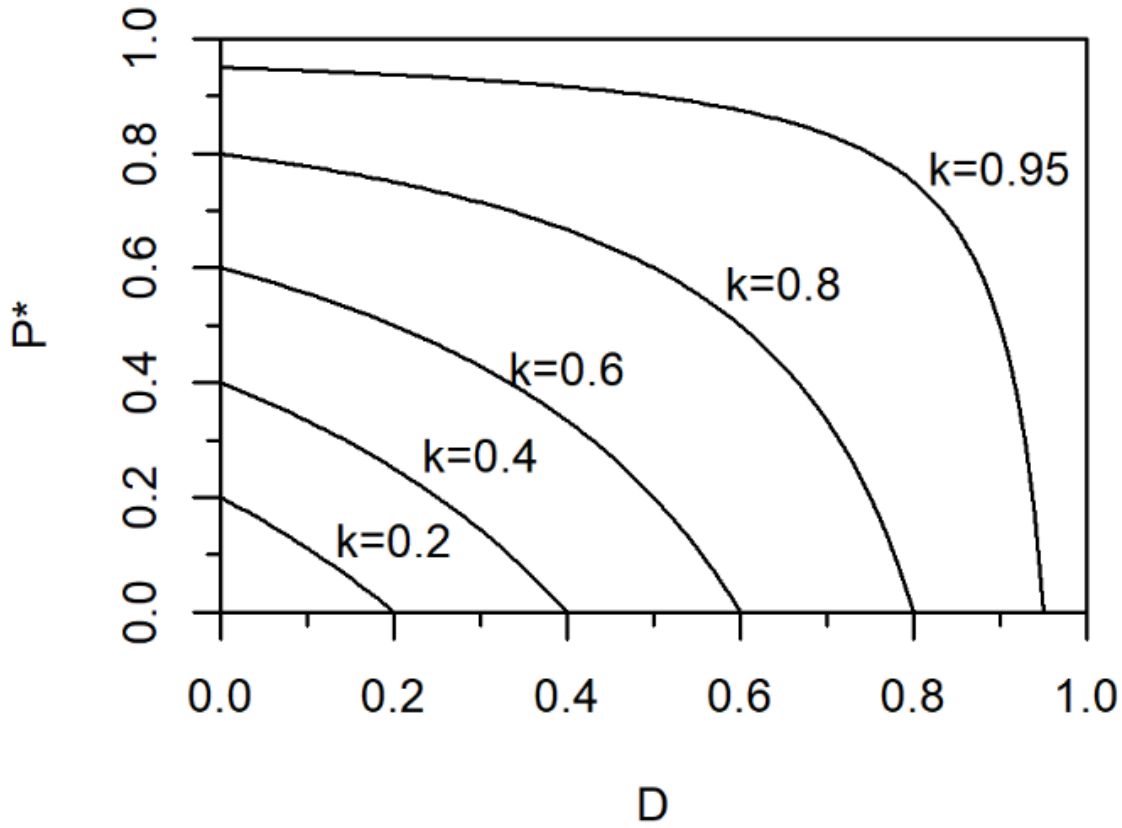
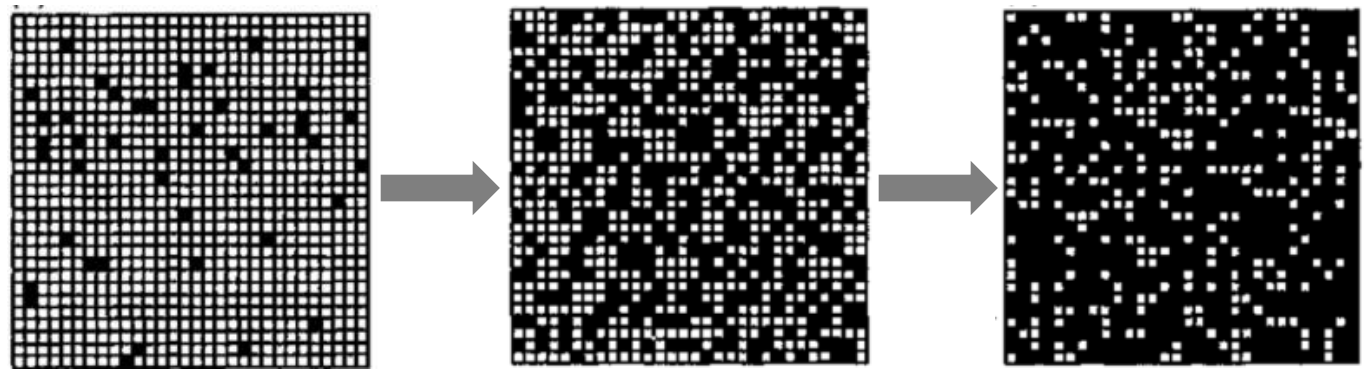


Northern spotted owl

Journal of Animal Ecology 1996, **65**, 465–473

Habitat fragmentation and extinction thresholds in spatially explicit models

JORDI BASCOMPTE*‡ and RICARD V. SOLÉ†



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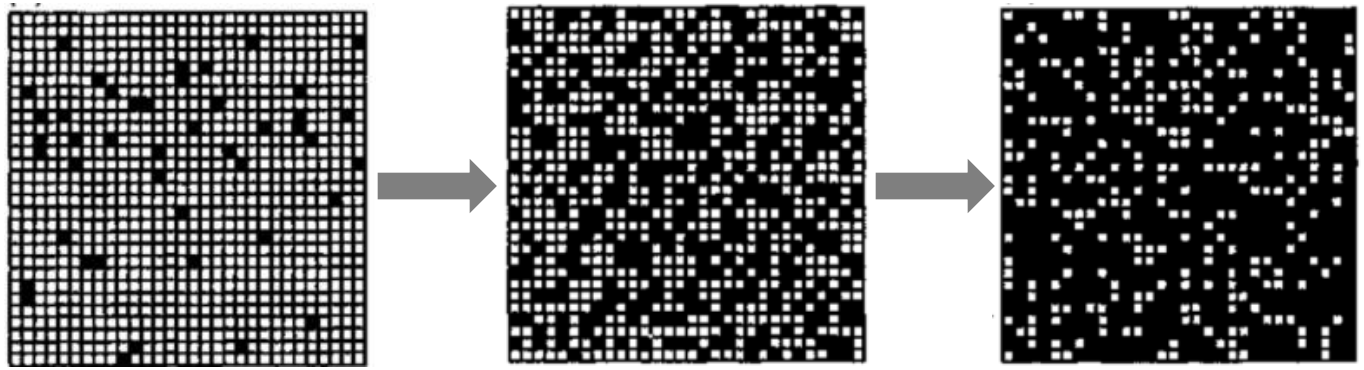

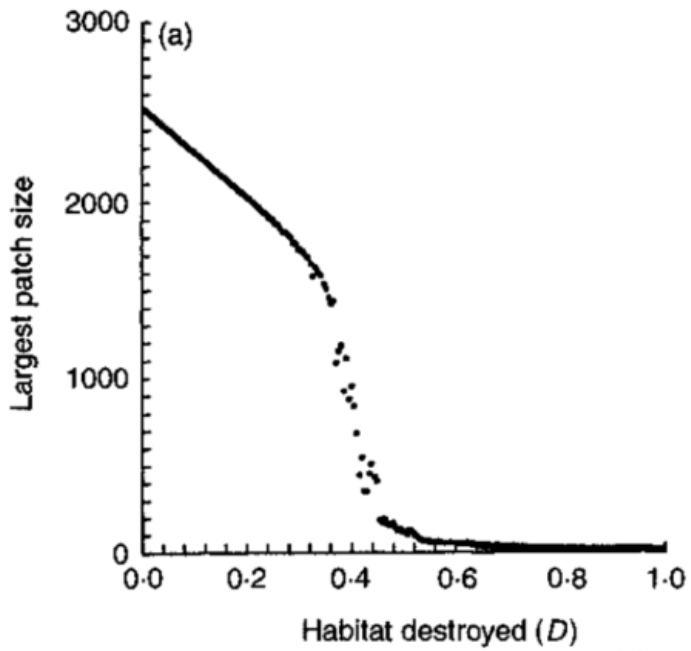

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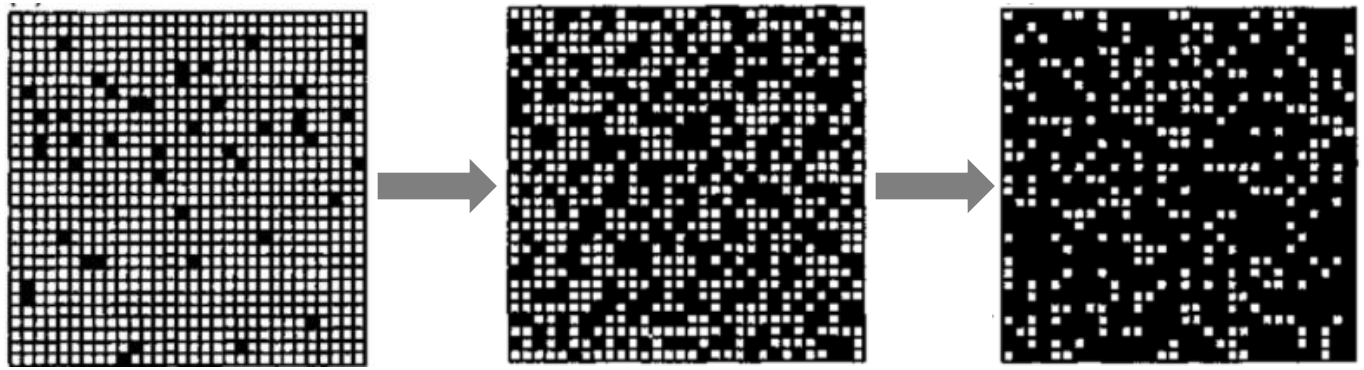
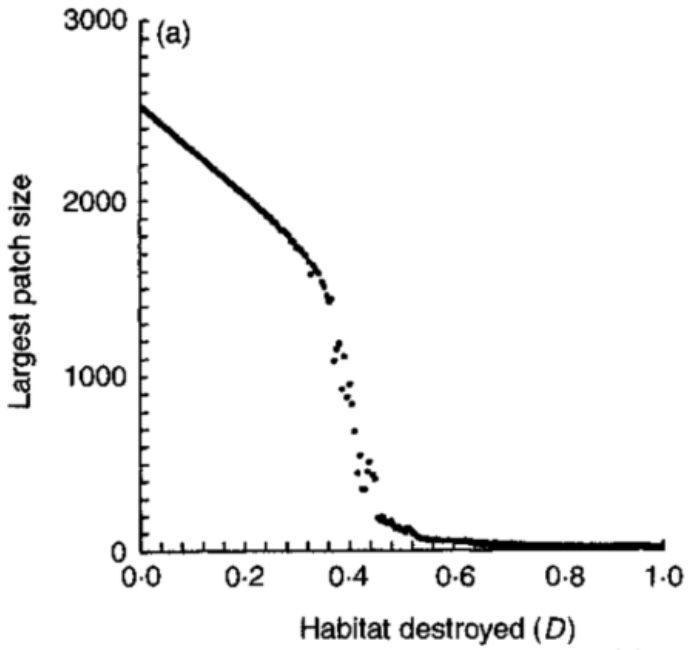
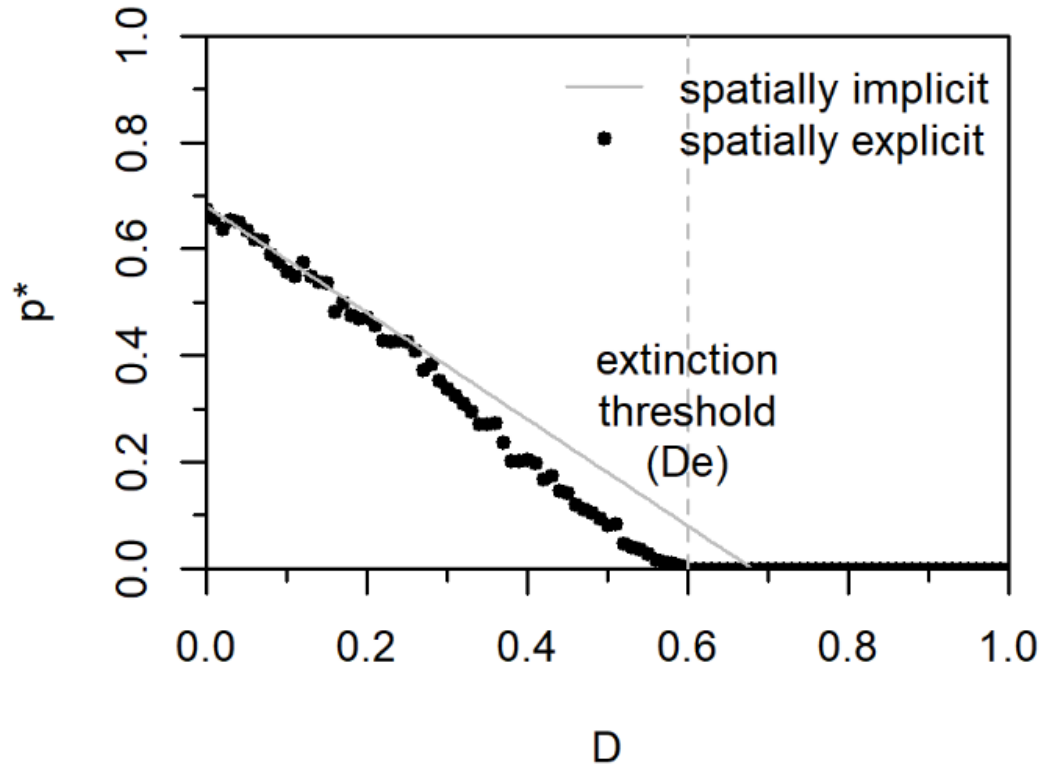
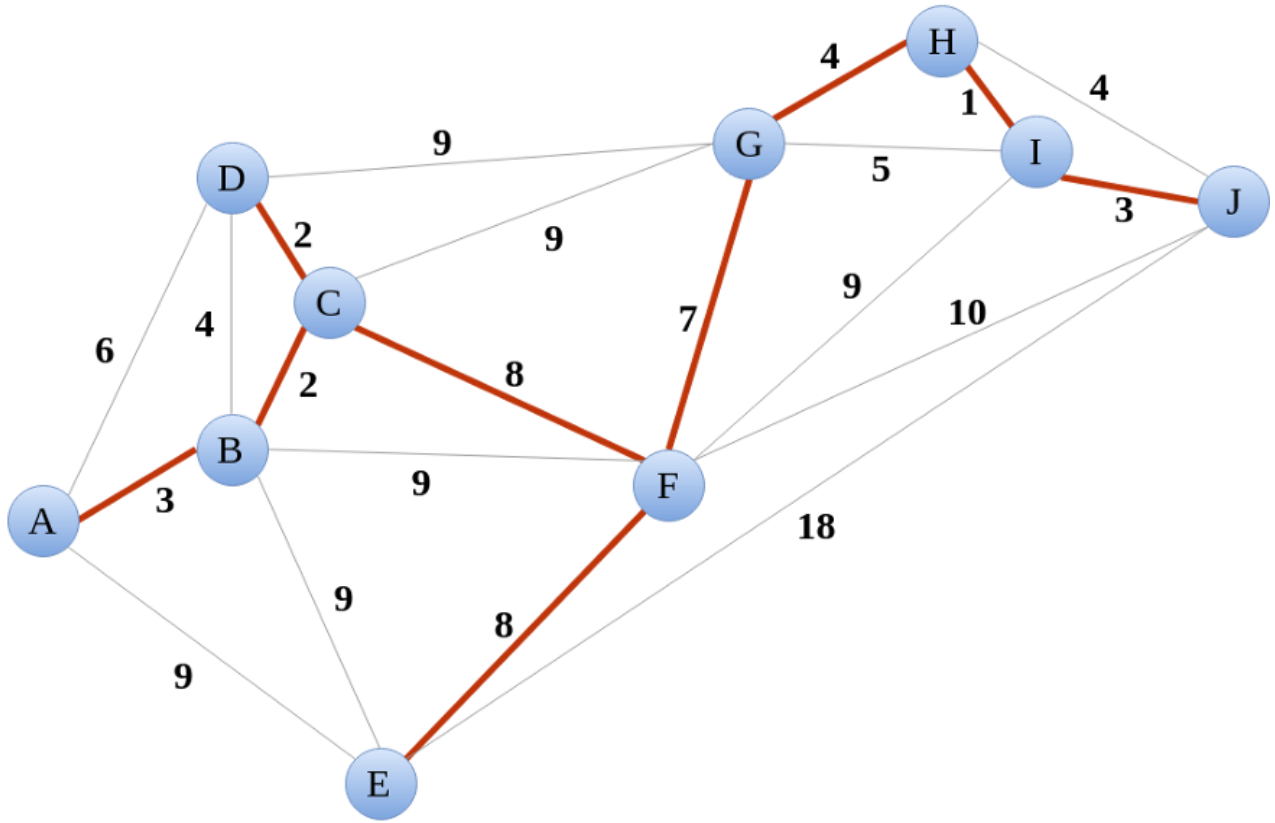






Spatial networks



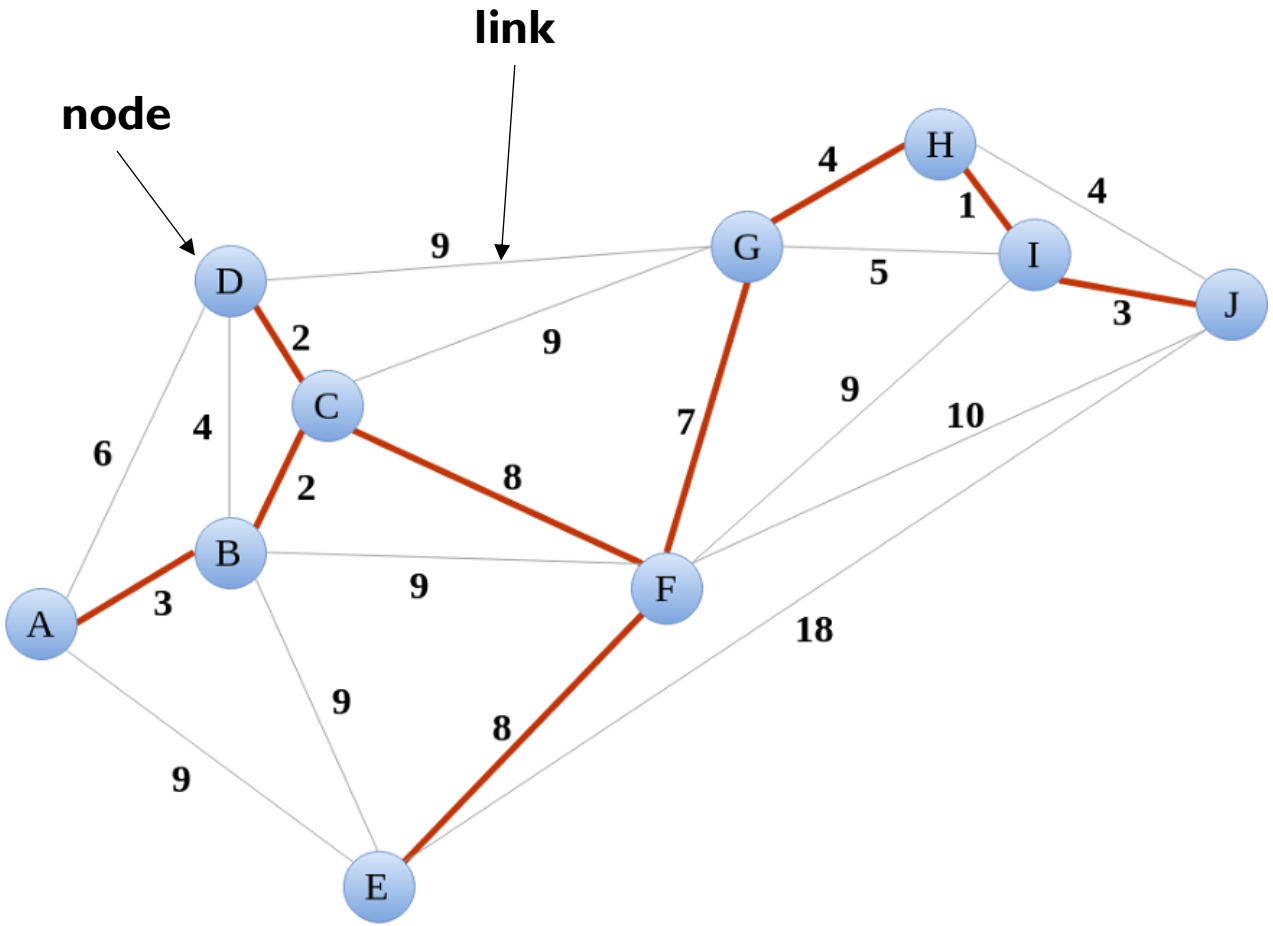
Spatial networks

path
sequence of nodes such that nodes are visited only once

spanning tree
path that includes every node only once

minimum spanning tree
spanning tree with the shortest length

connected graph
graph where a path between each pair of nodes exists



Spatial networks

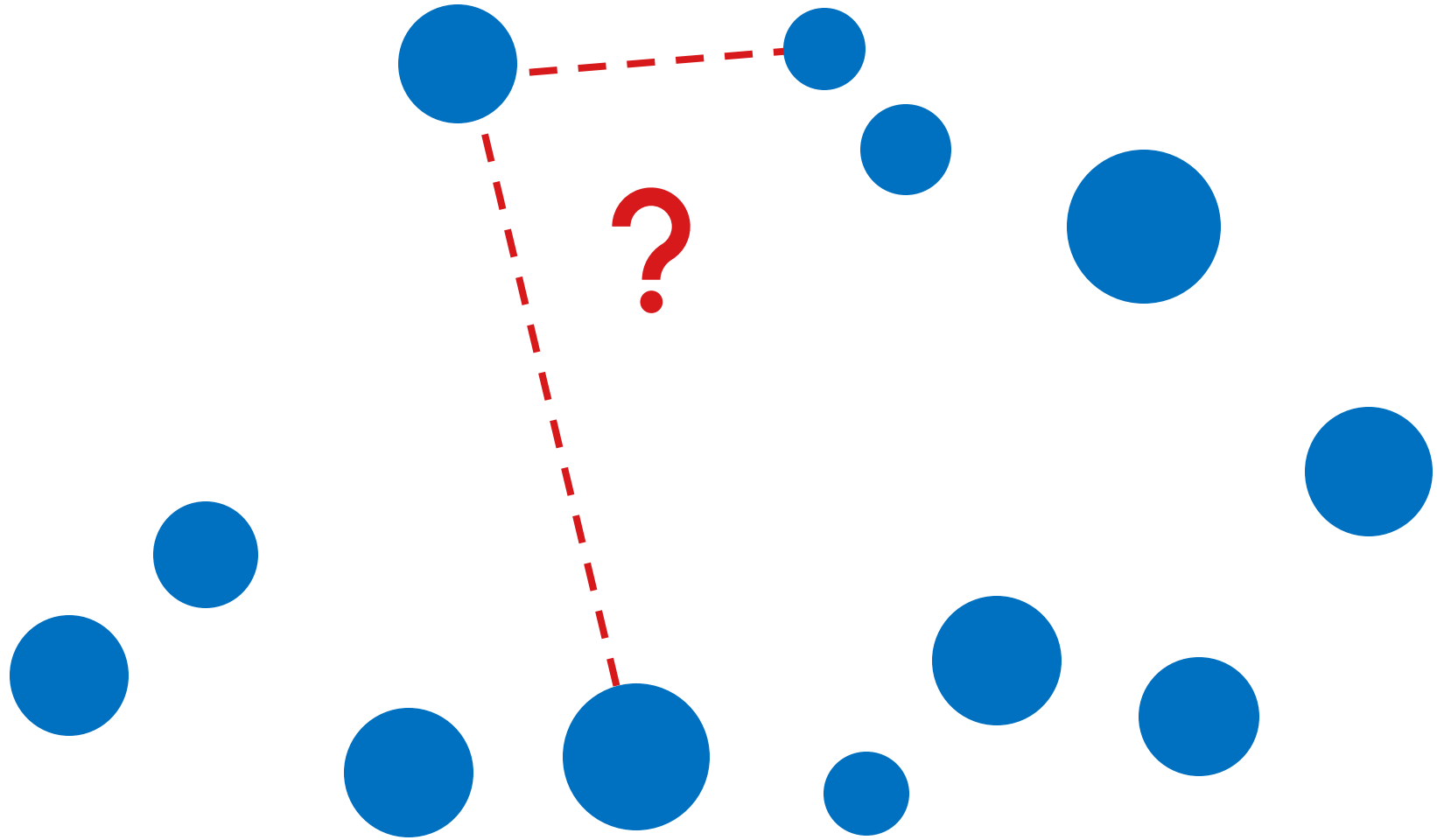
1. Identifying nodes

Spatial networks

2. Connecting nodes

- Nearest neighbours
- Minimum spanning tree
- Connected graph
- …

- Threshold distance
- Dispersal probabilities
- Least-cost paths
- …



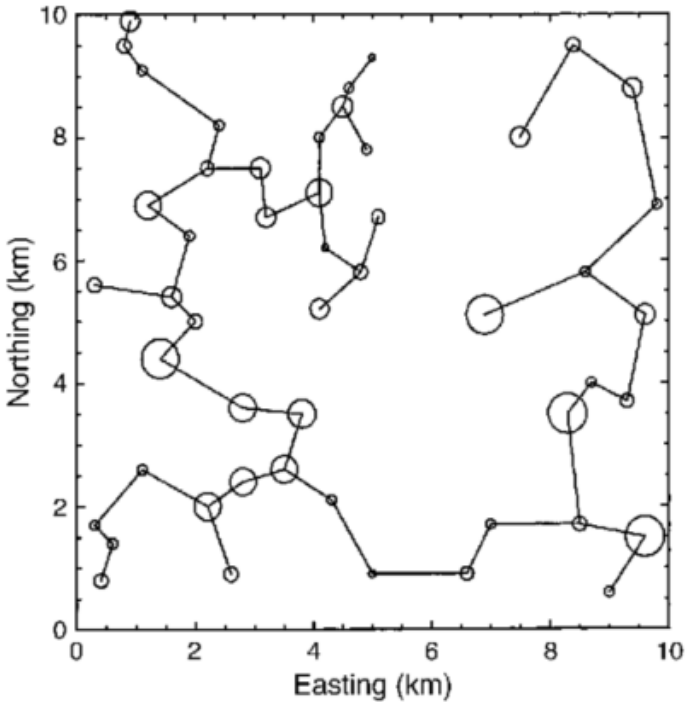
Spatial networks

2. Connecting nodes

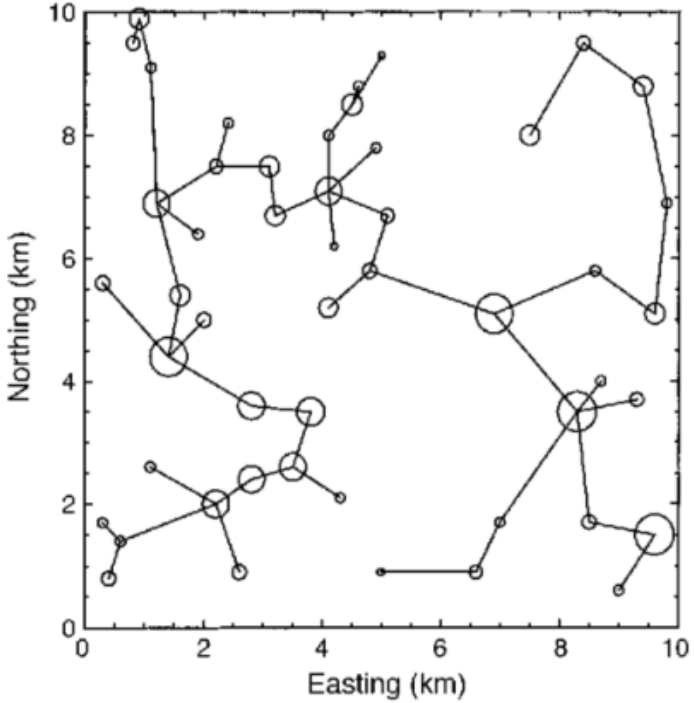
- Nearest neighbours
- Minimum spanning tree
- Connected graph
- …

- Threshold distance
- Dispersal probabilities
- Least-cost paths
- …

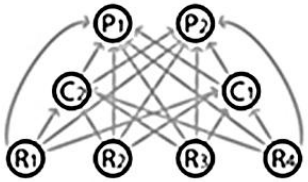
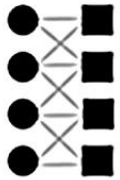
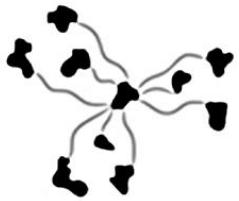
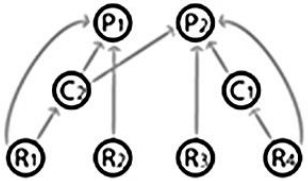
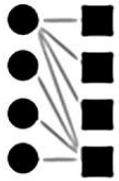
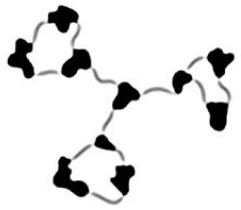
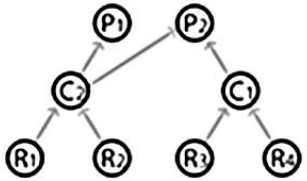
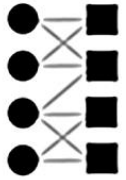
minimum spanning tree



area-weighted dispersal probabilities



Spatial networks

	spatial network	food web	mutualistic network
connectance			
nestedness			
modularity			

Ecology, 82(5), 2001, pp. 1205–1218
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LANDSCAPE CONNECTIVITY: A GRAPH-THEORETIC PERSPECTIVE

DEAN URBAN[1,3] AND TIMOTHY KEITT[2,4]

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LANDSCAPE CONNECTIVITY: A GRAPH-THEORETIC PERSPECTIVE

DEAN URBAN[1,3] AND TIMOTHY KEITT[2,4]

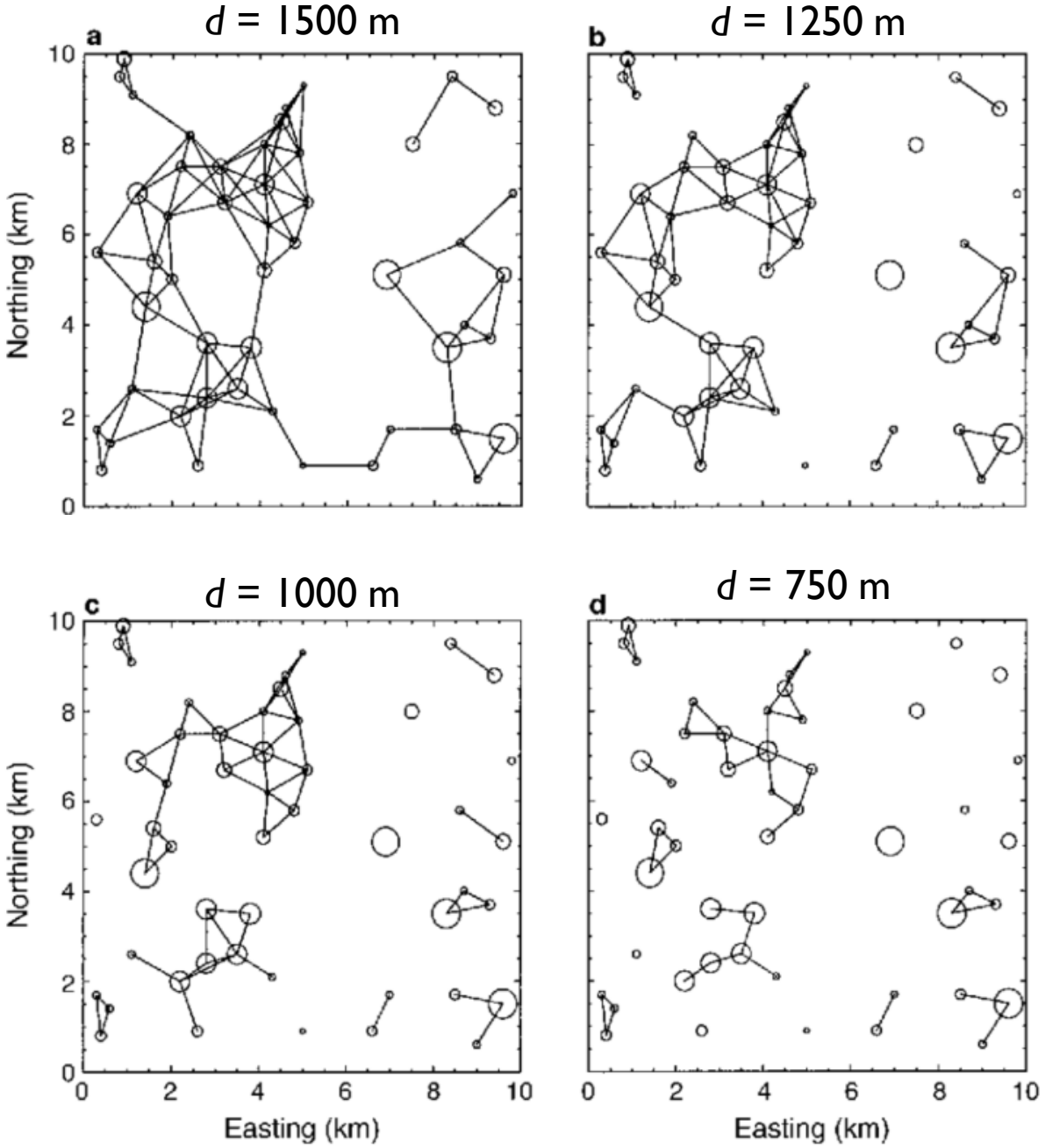
link removal

Is there a relationship between the connectivity of a graph and the number of links removed?

How should corridors be preserved to maintain overall connectivity of the habitat mosaic?

At what threshold distance (*d*) does the graph become unconnected?

How does this distance compare to dispersal capabilities of species of concern?



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LANDSCAPE CONNECTIVITY: A GRAPH-THEORETIC PERSPECTIVE

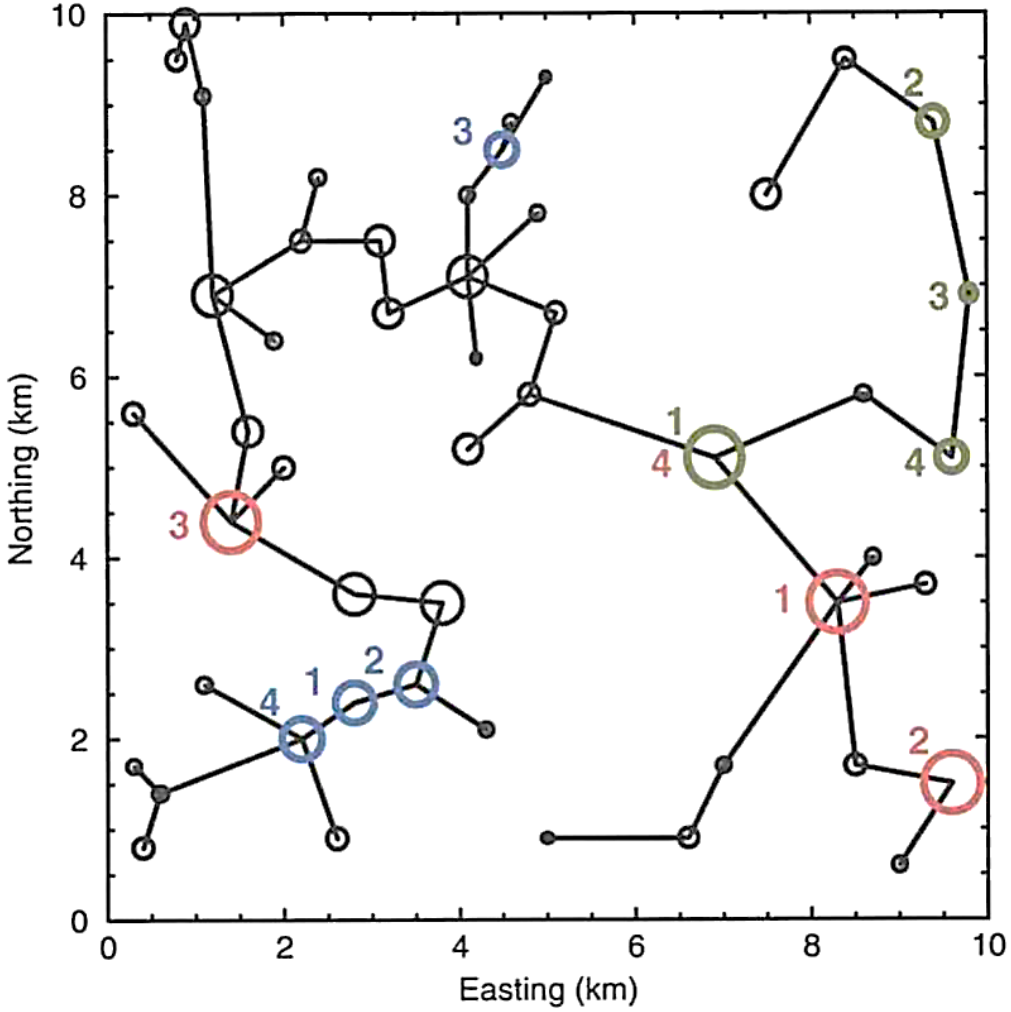
DEAN URBAN[1,3] AND TIMOTHY KEITT[2,4]

node removal

Which nodes are most important for preserving the graph's structure?

Which habitat patches have most influence on metapopulation processes within the landscape?

Which patches should be prioritised for monitoring / protection / restoration?



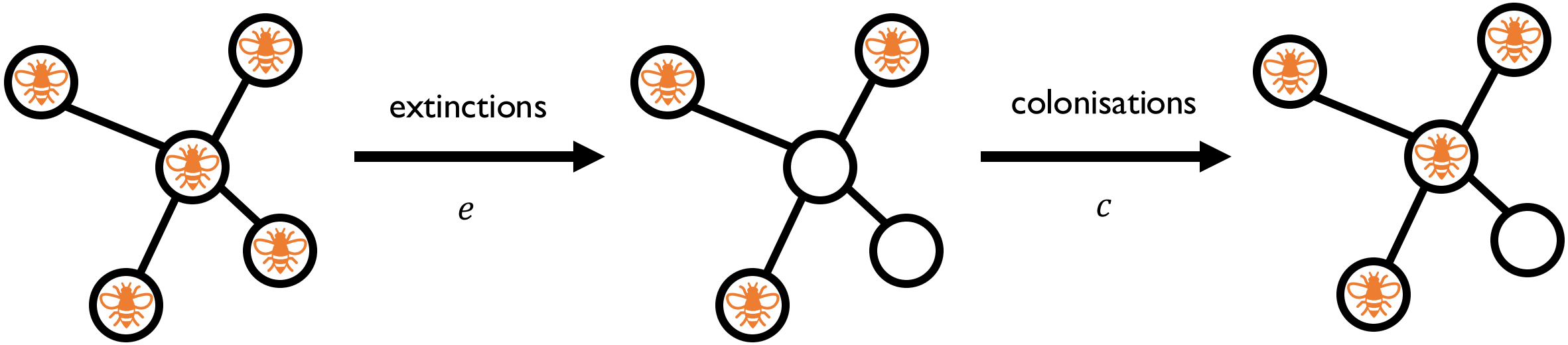
4 most important patches for:

recruitment potential

dispersal flux

traversability

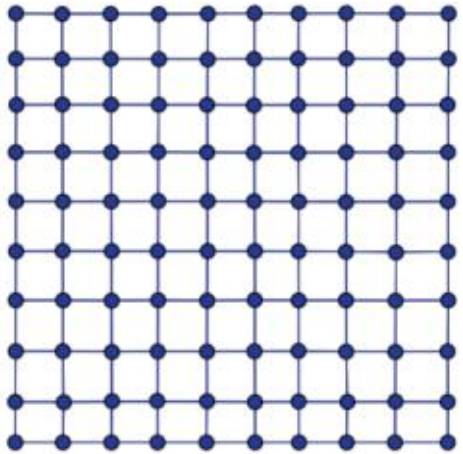
Spatial networks and metapopulations



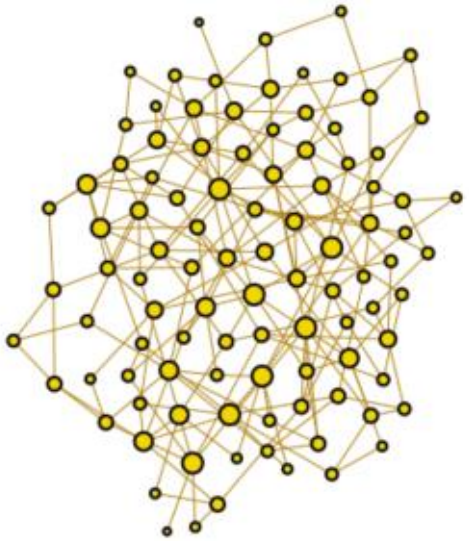
Journal of Theoretical Biology 297 (2012) 11–16

Spatial network structure and metapopulation persistence

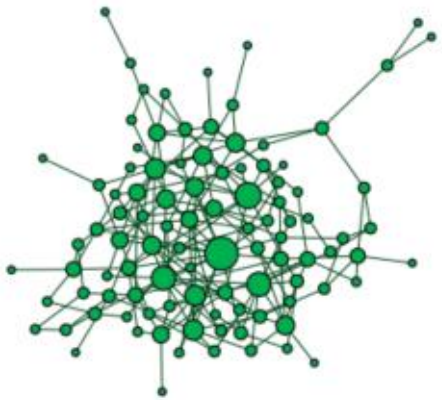
Luis J. Gilarranz*, Jordi Bascompte



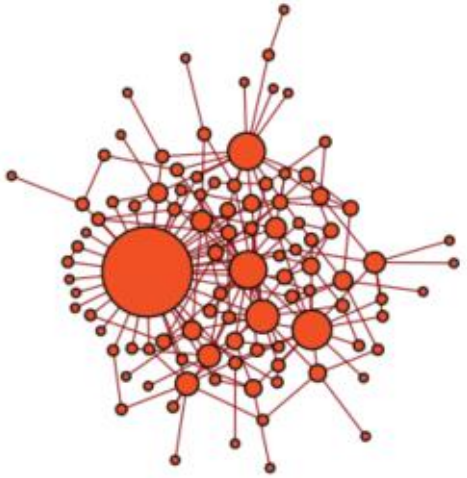
regular



random



exponential



scale-free

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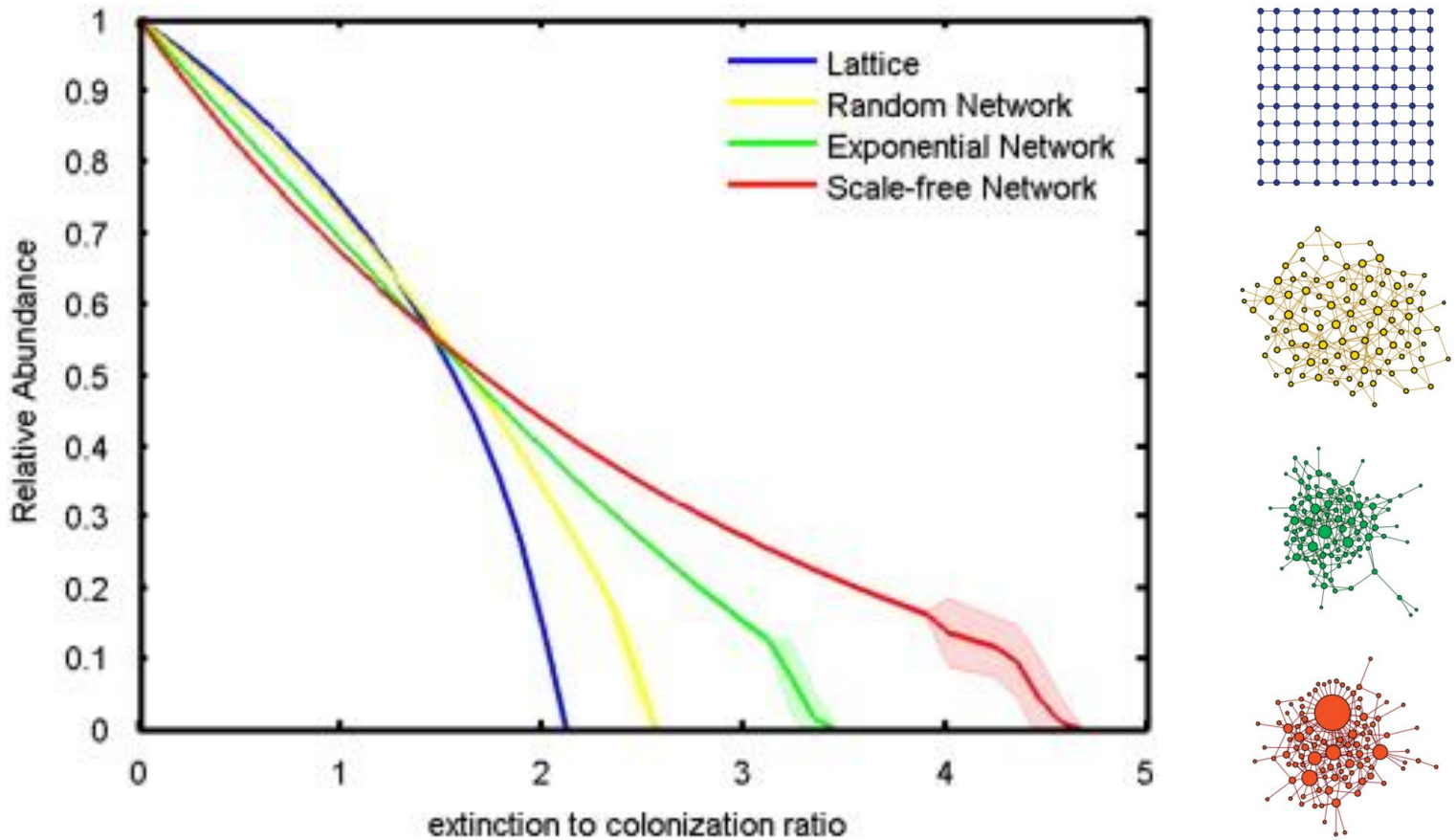
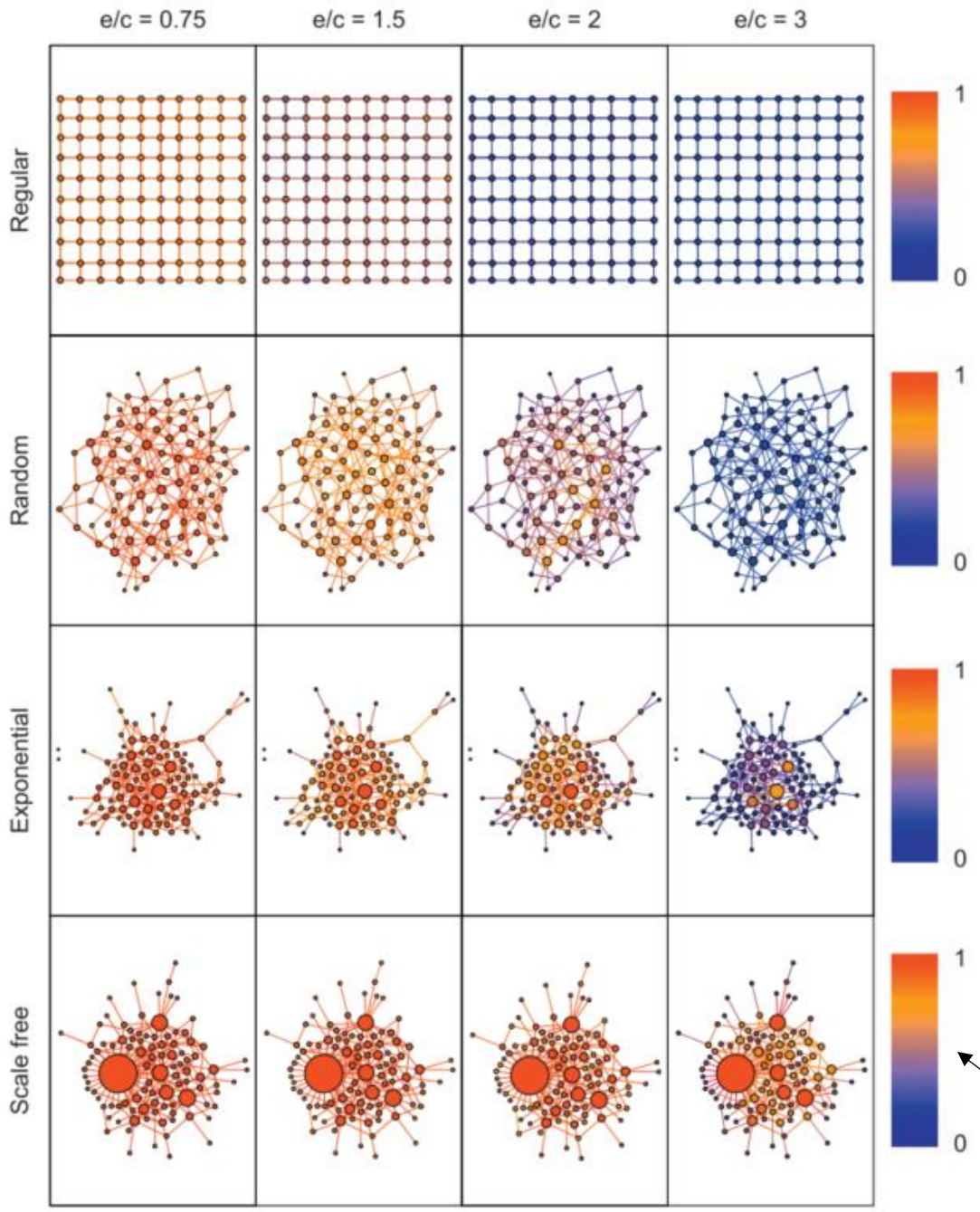
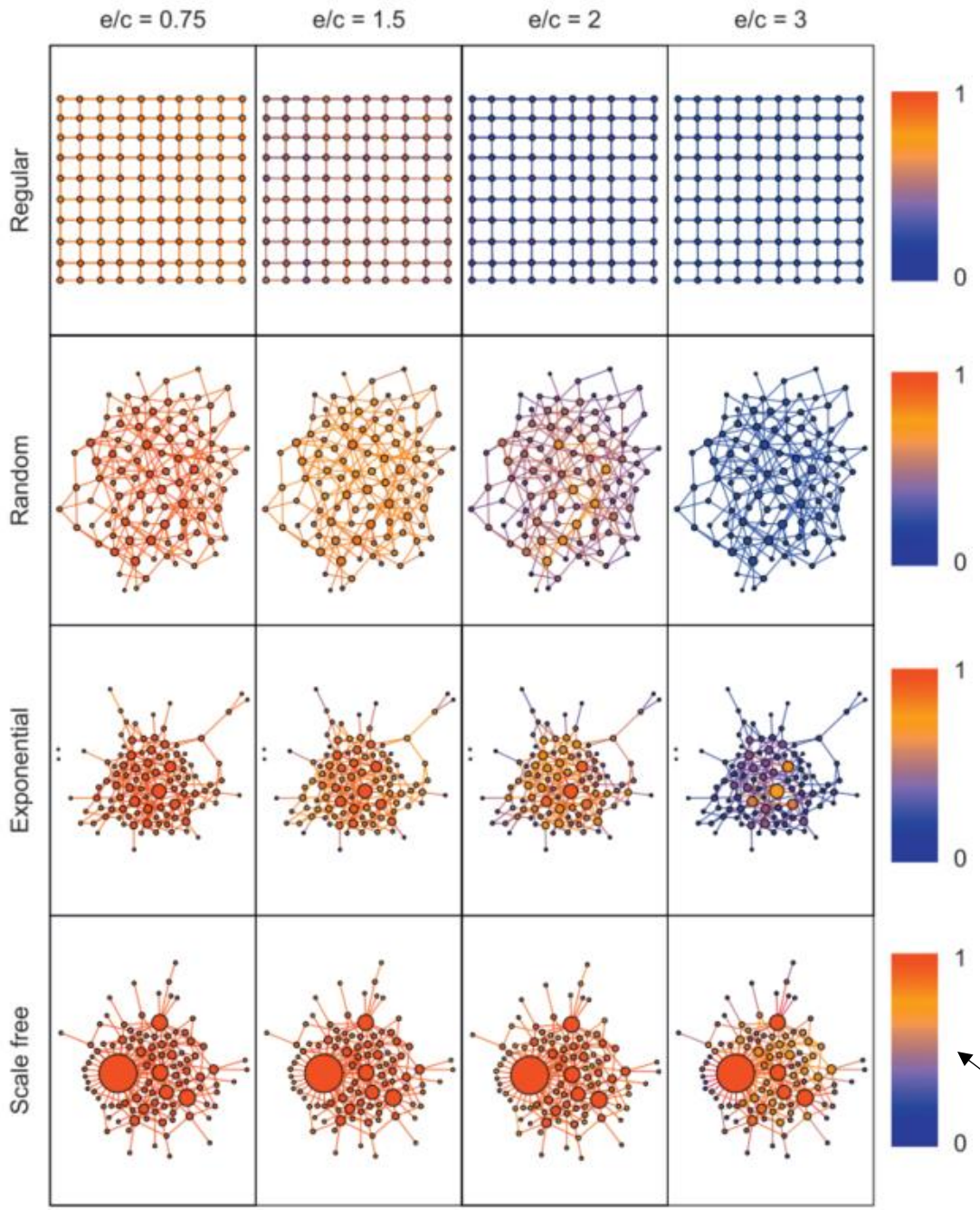
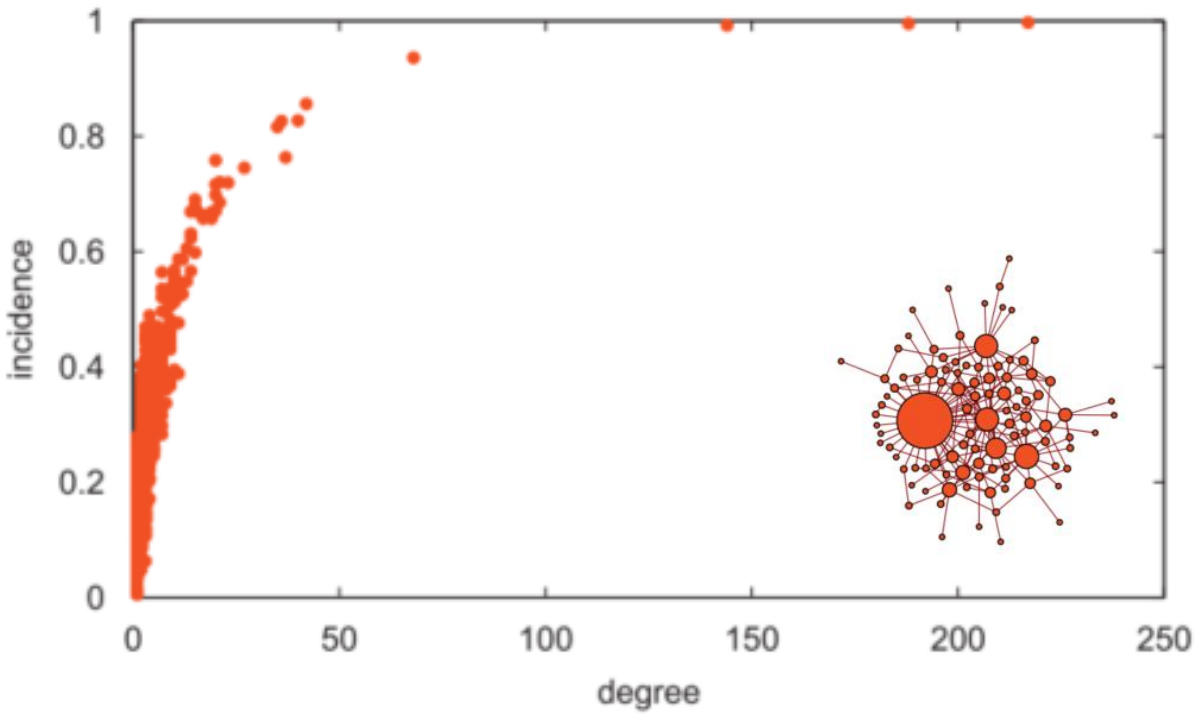




incidence – proportion of time steps a node is occupied



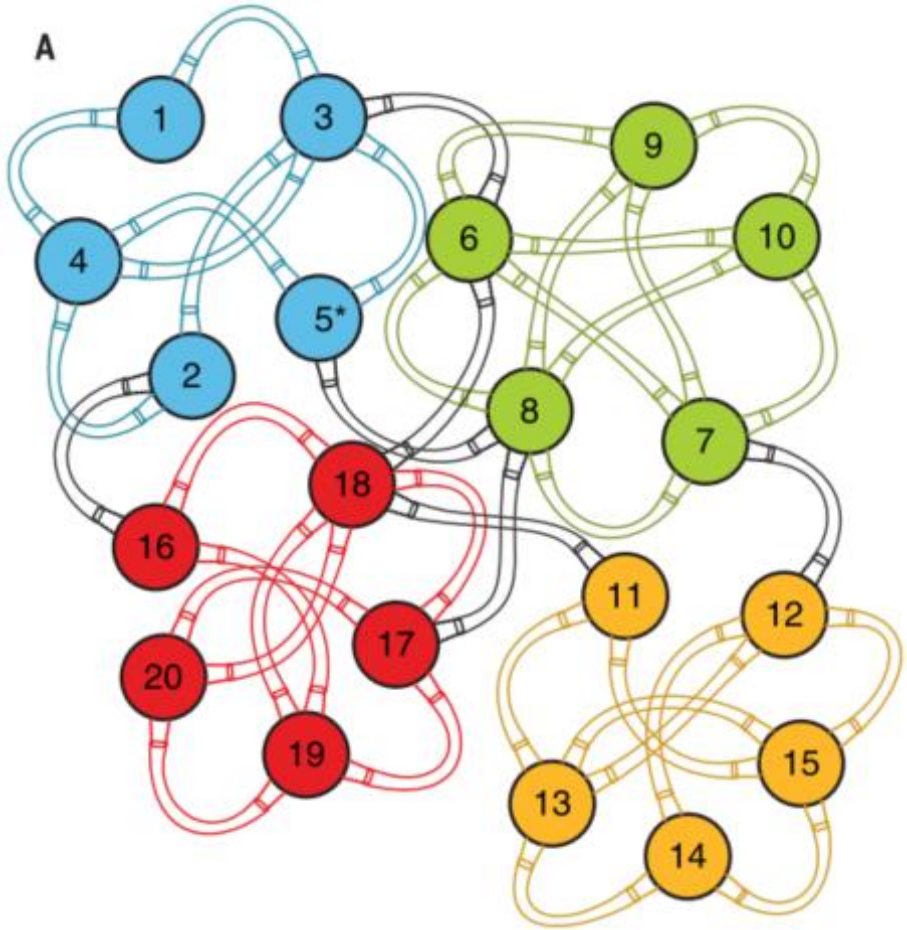


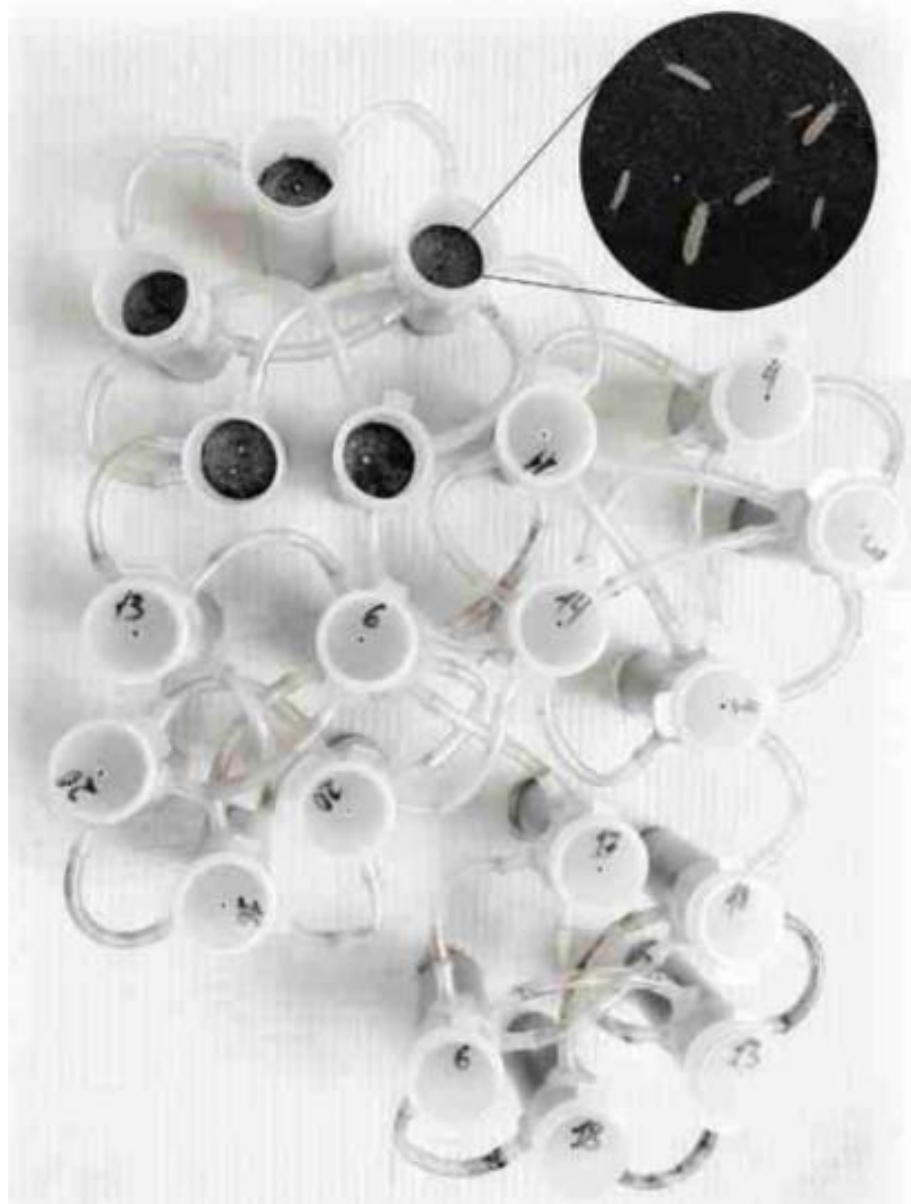
incidence – proportion of time steps a node is occupied

Effects of network modularity on the spread of perturbation impact in experimental metapopulations

Luis J. Gilarranz,[1,2] Bronwyn Rayfield,[3] Gustavo Liñán-Cembrano,[4] Jordi Bascompte,[1,2] Andrew Gonzalez[3]*

Science **357**, 199–201 (2017)





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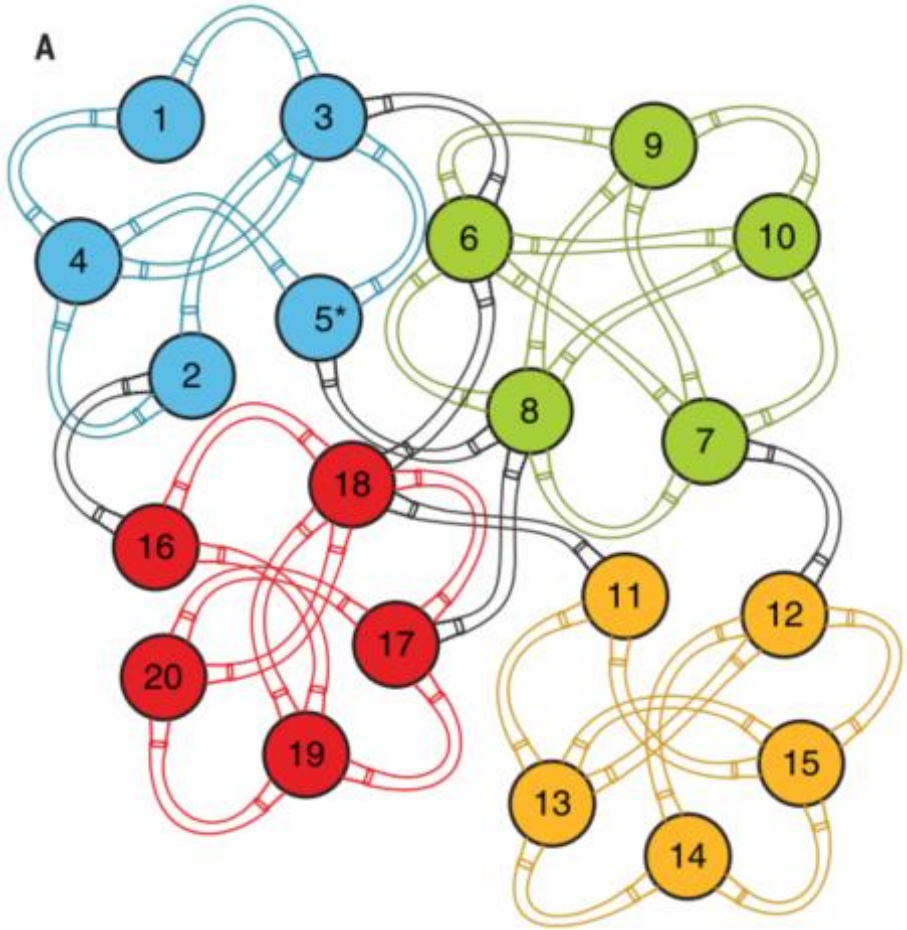
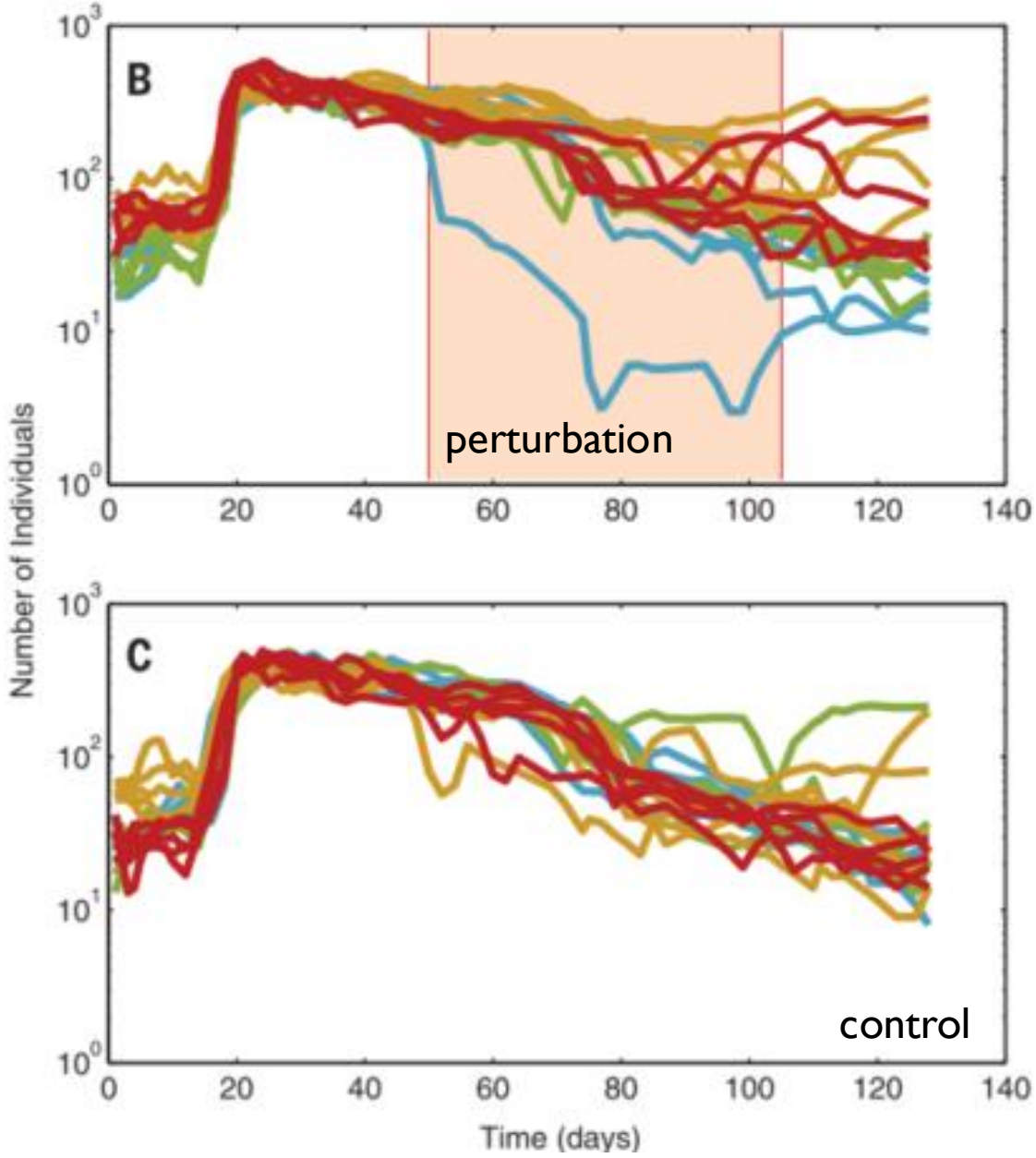
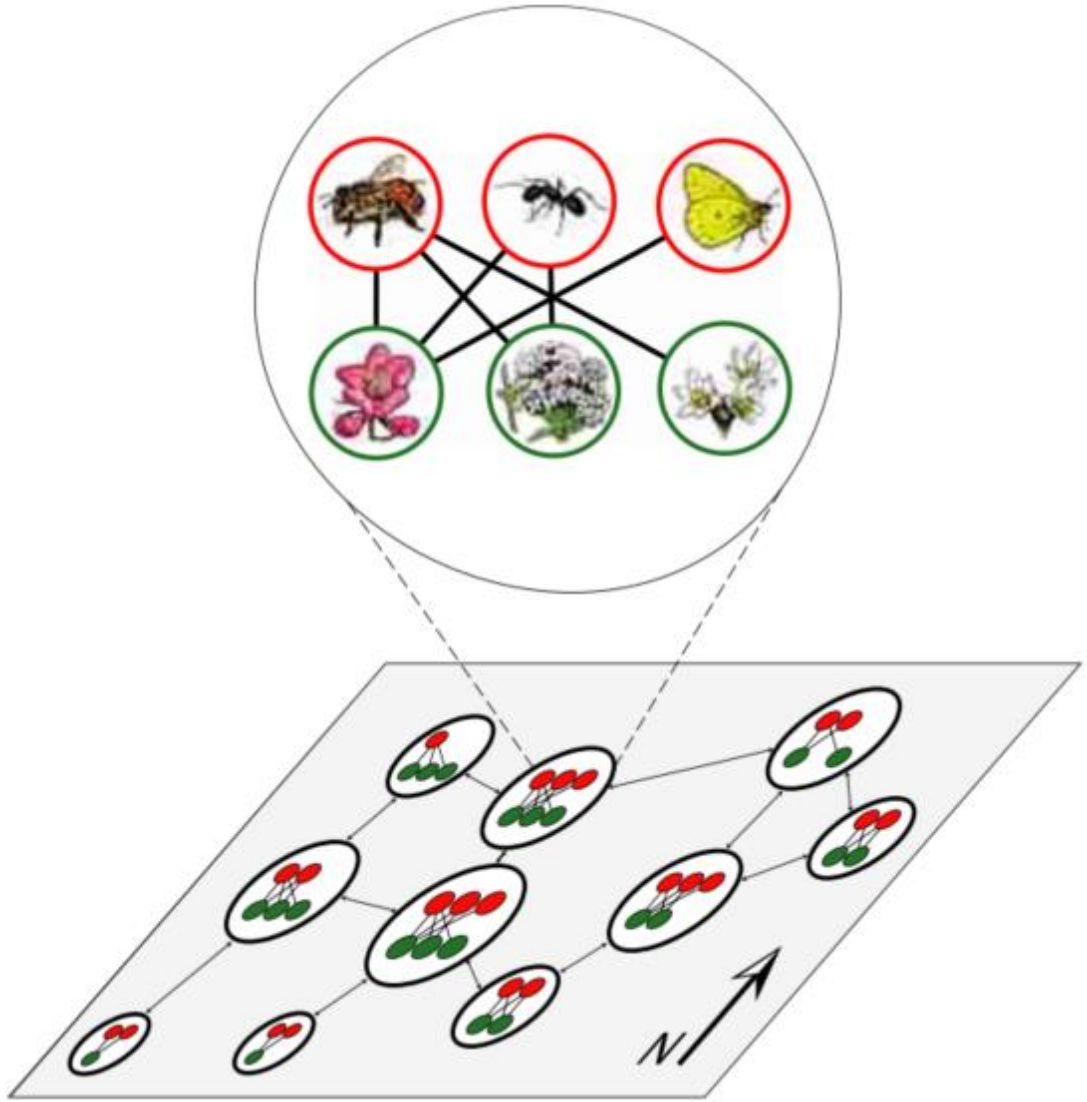




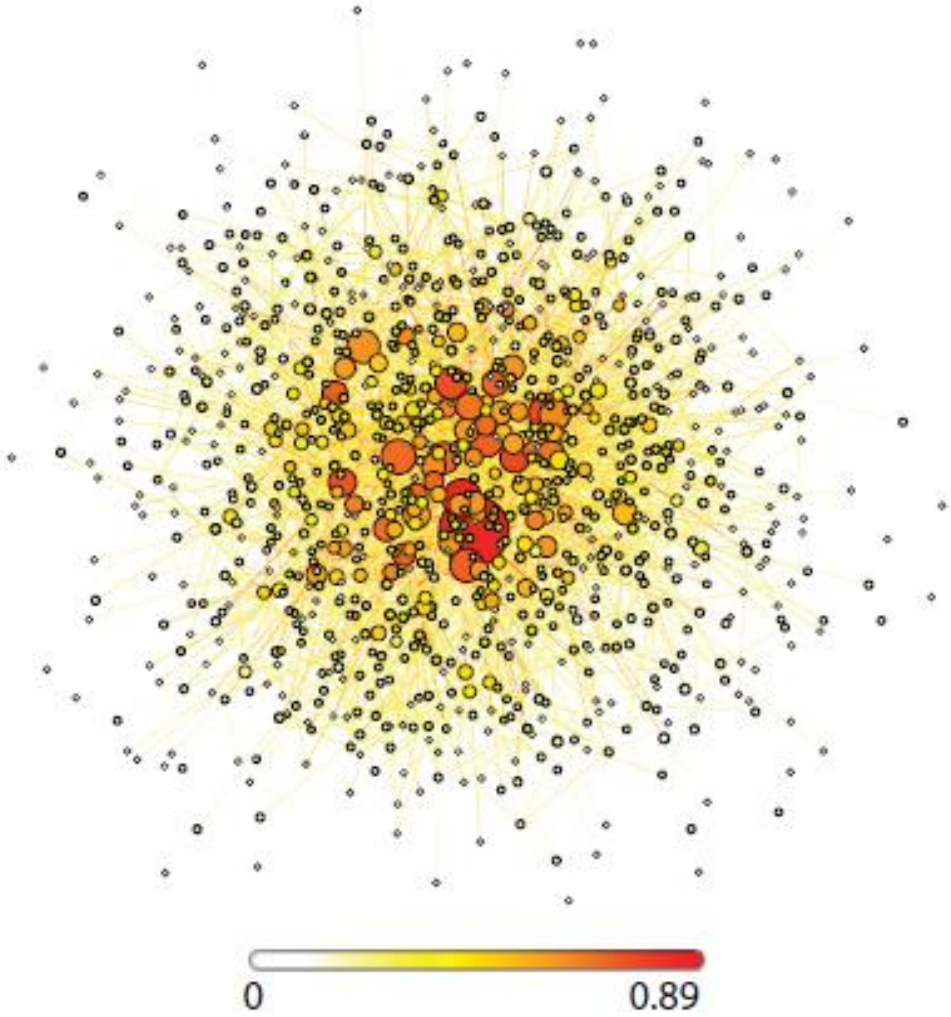
Spatial networks and metacommunities



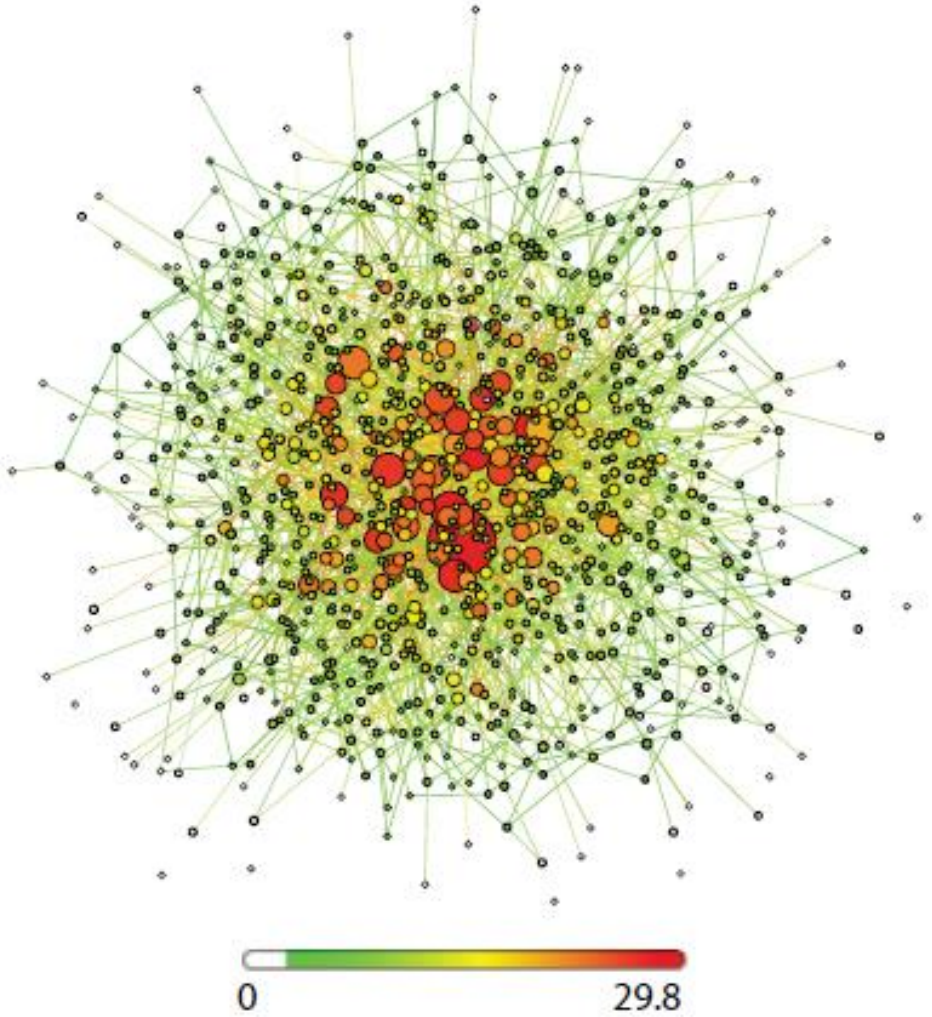
Journal of Animal Ecology 2015, **84,** 407–413 doi: 10.1111/1365-2656.12304

Hot spots of mutualistic networks

Luis J. Gilarranz[1,*], Malena Sabatino[2,3], Marcelo A. Aizen[2] and Jordi Bascompte[1]



number of interactions

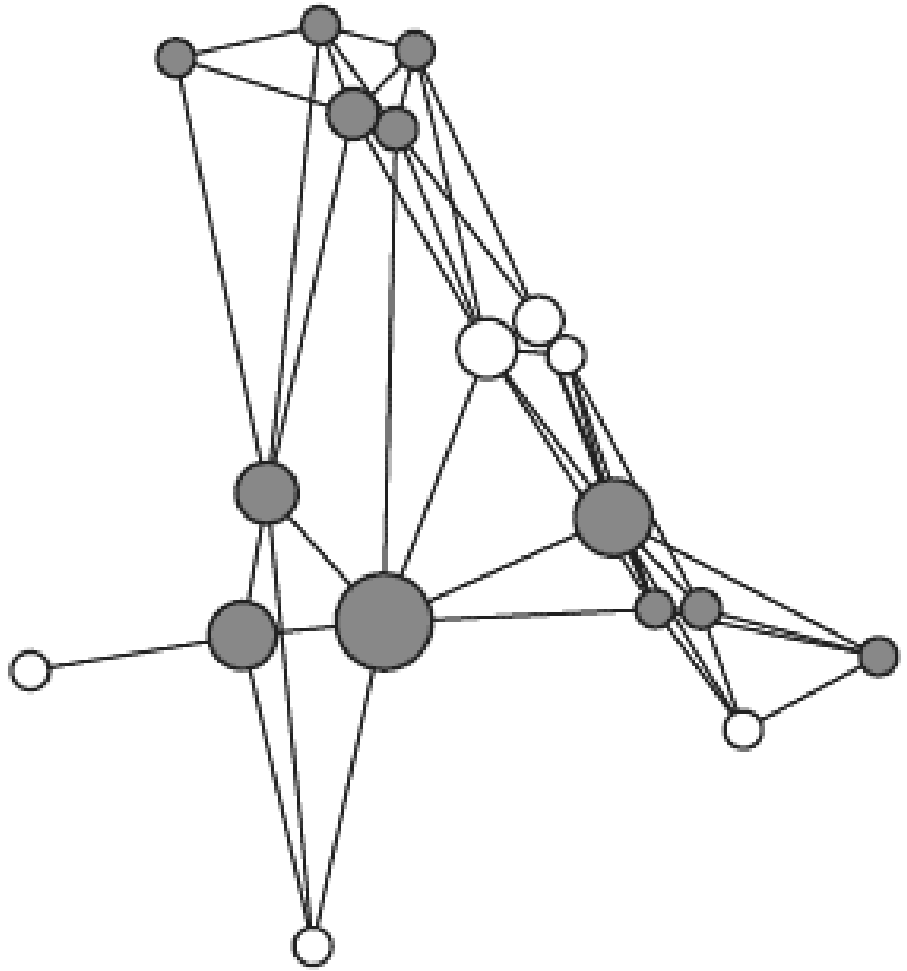


nestedness

Journal of Animal Ecology 2015, **84,** 407–413 doi: 10.1111/1365-2656.12304

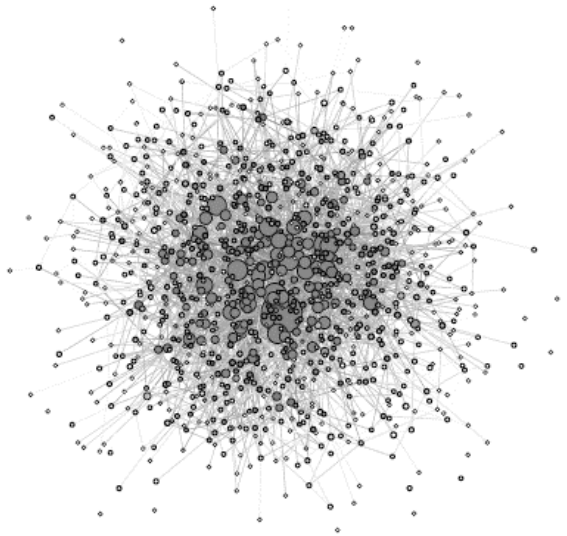
Hot spots of mutualistic networks

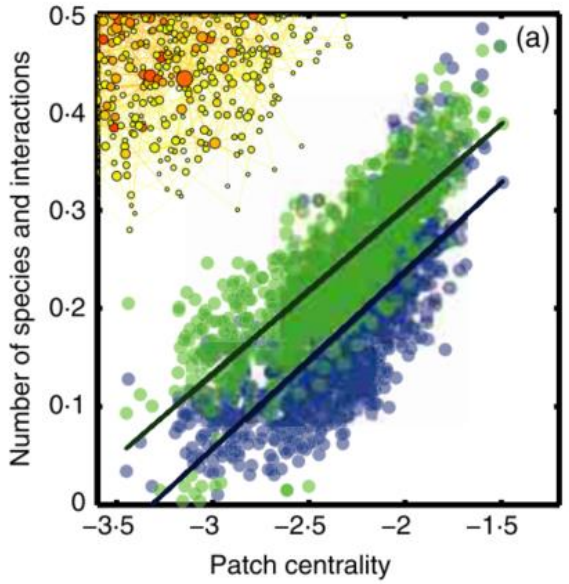
Luis J. Gilarranz[1,*], Malena Sabatino[2,3], Marcelo A. Aizen[2] and Jordi Bascompte[1]

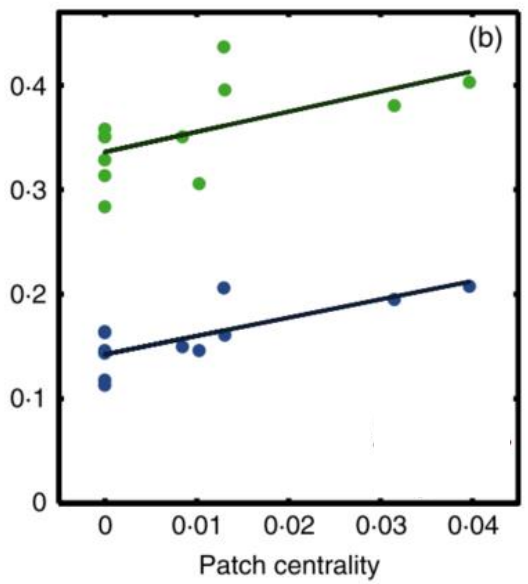


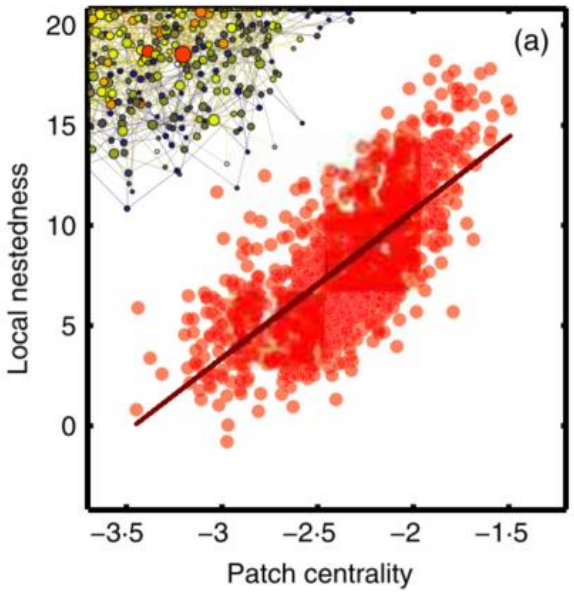
THEORY

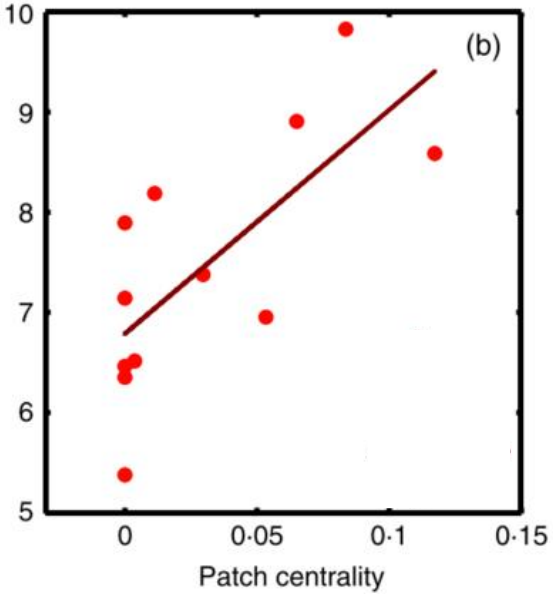
FIELD DATA

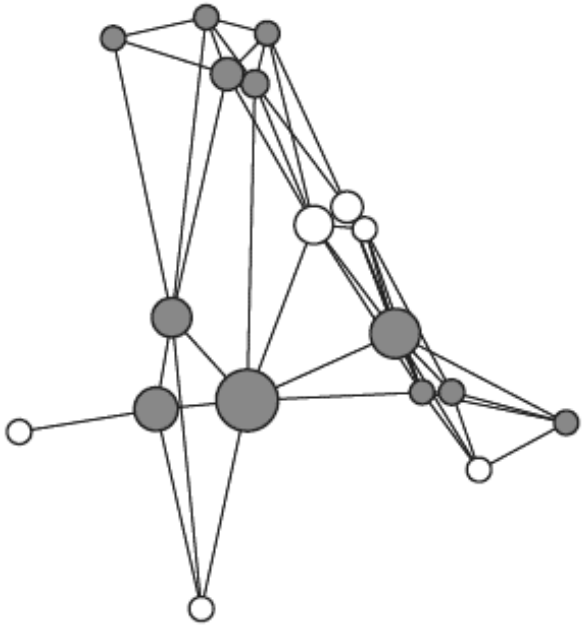












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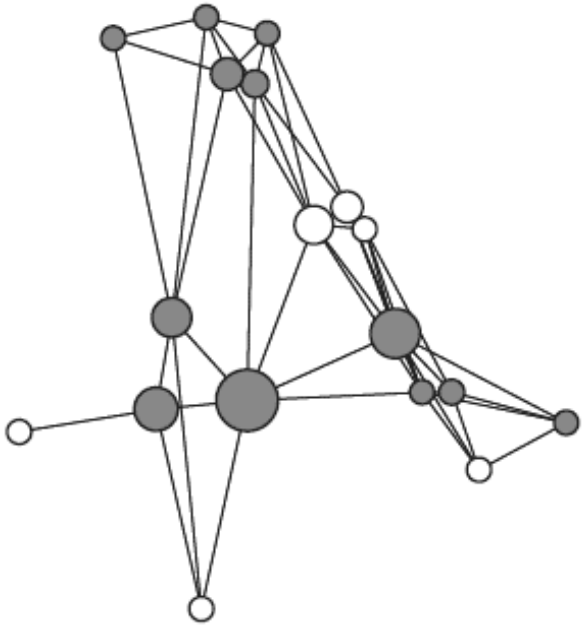
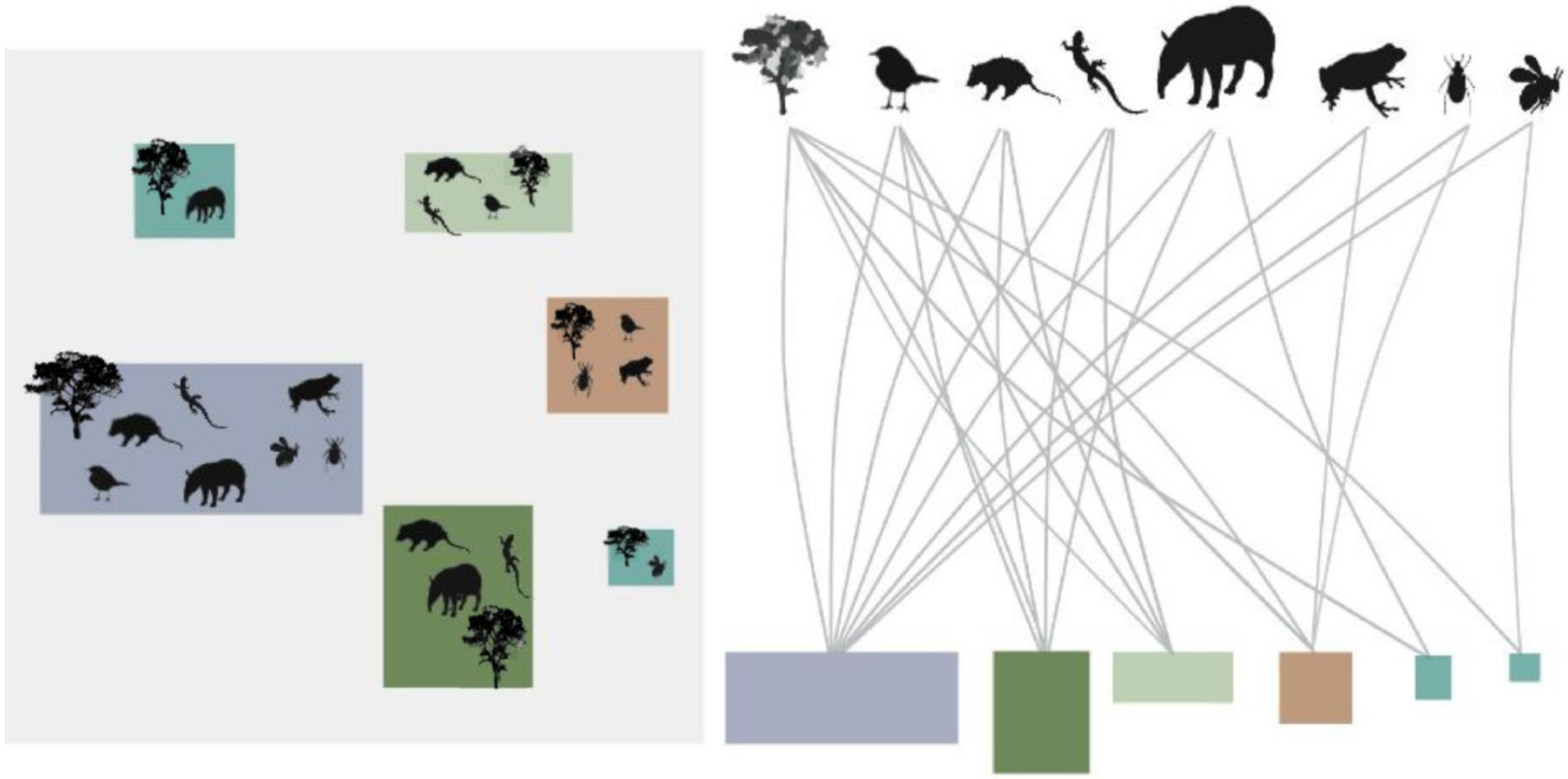
	number of species	number of interactions	nestedness
patch centrality	0.66	0.67	0.75
patch area	0.37	0.12	0.09

centrality is a better predictor than area



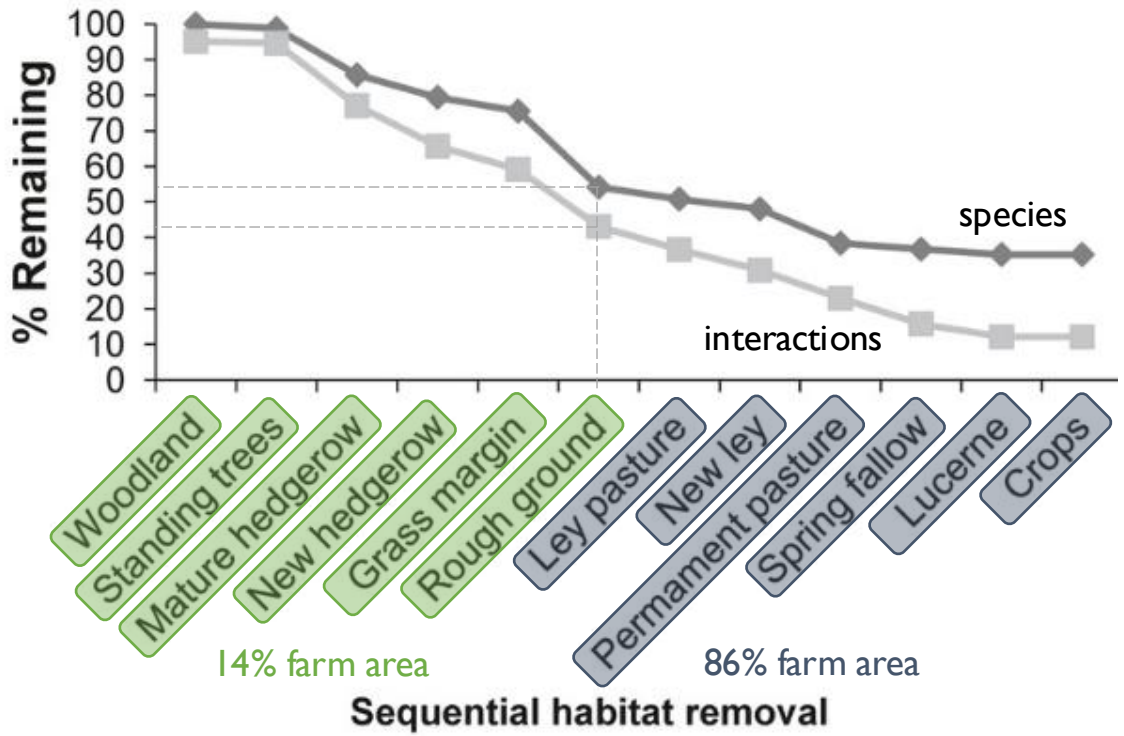
Species-habitat networks



Ecology Letters, (2013) **16**: 844–852 doi: 10.1111/ele.12117

The robustness of a network of ecological networks to habitat loss

Darren M. Evans,[1,2]* Michael J. O. Pocock[1,3] and Jane Memmott[1]



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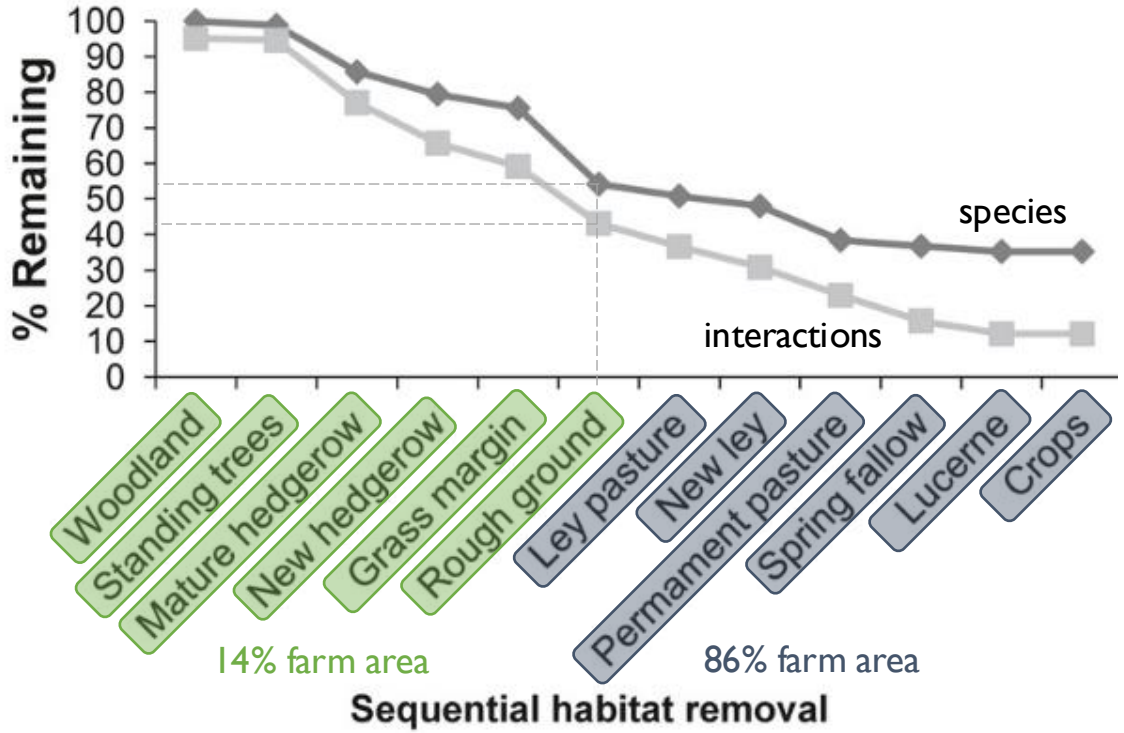
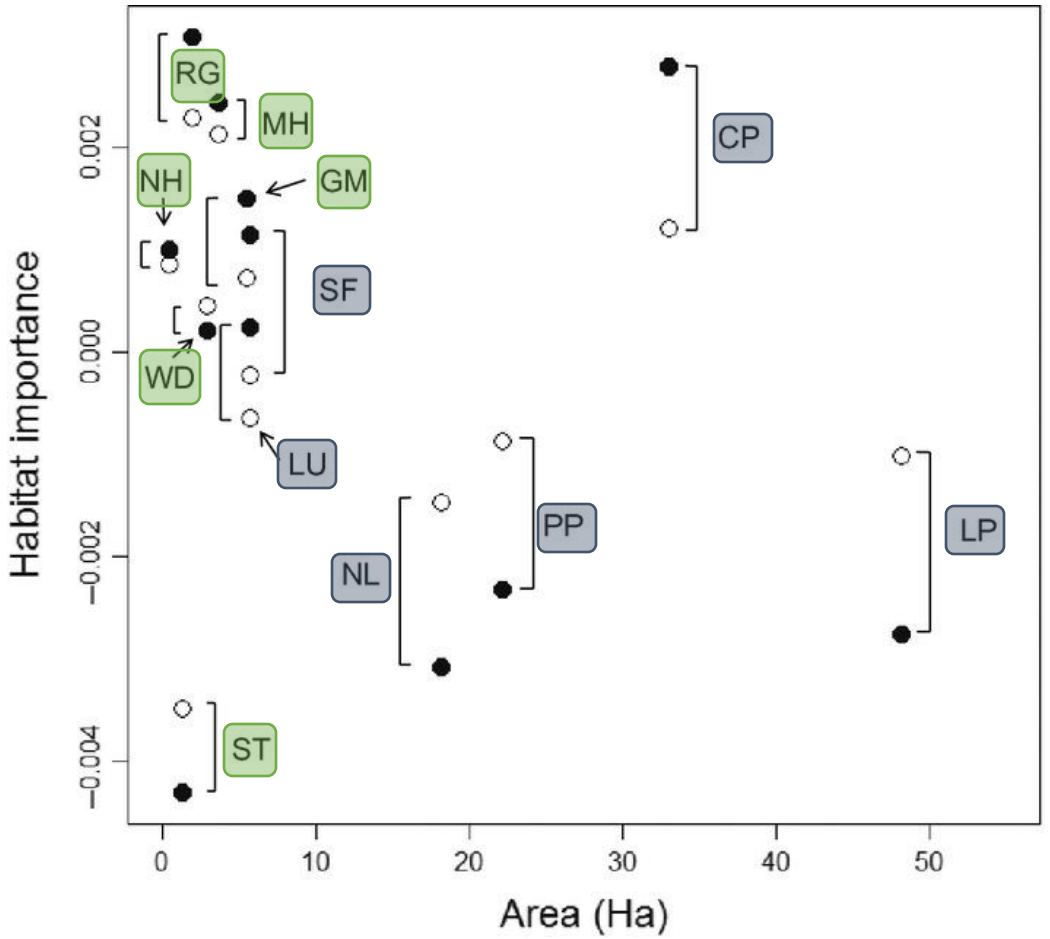
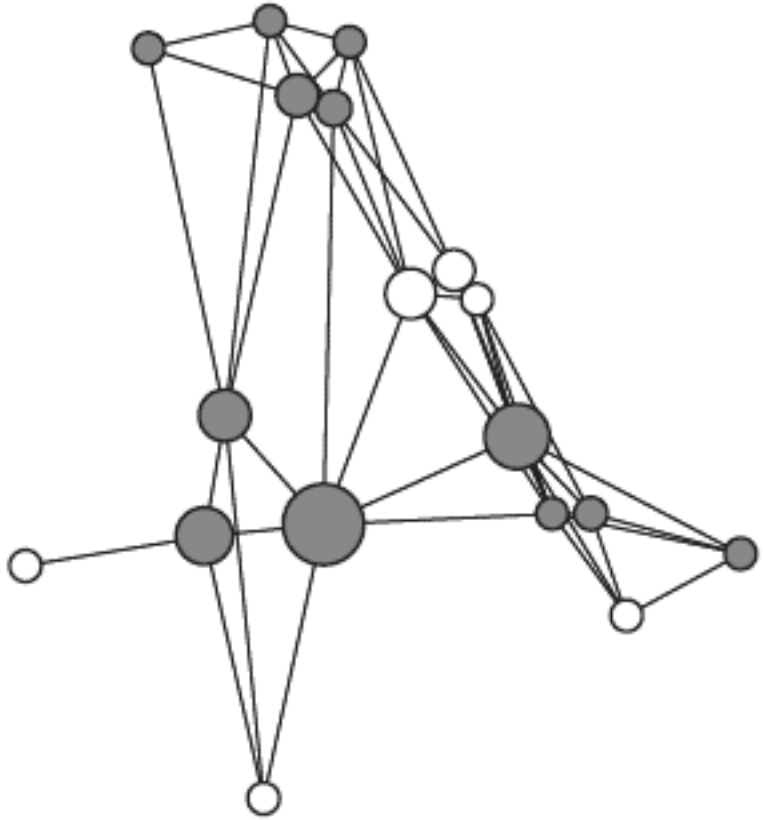




Afternoon

Comparing Networks in Space



Miguel Roman (slides by Klementyna Gawecka)

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EEE321 Ecological Networks

March 2025