Coevolution in ecological networks

BIO365 – Ecological Networks

Leandro G. Cosmo
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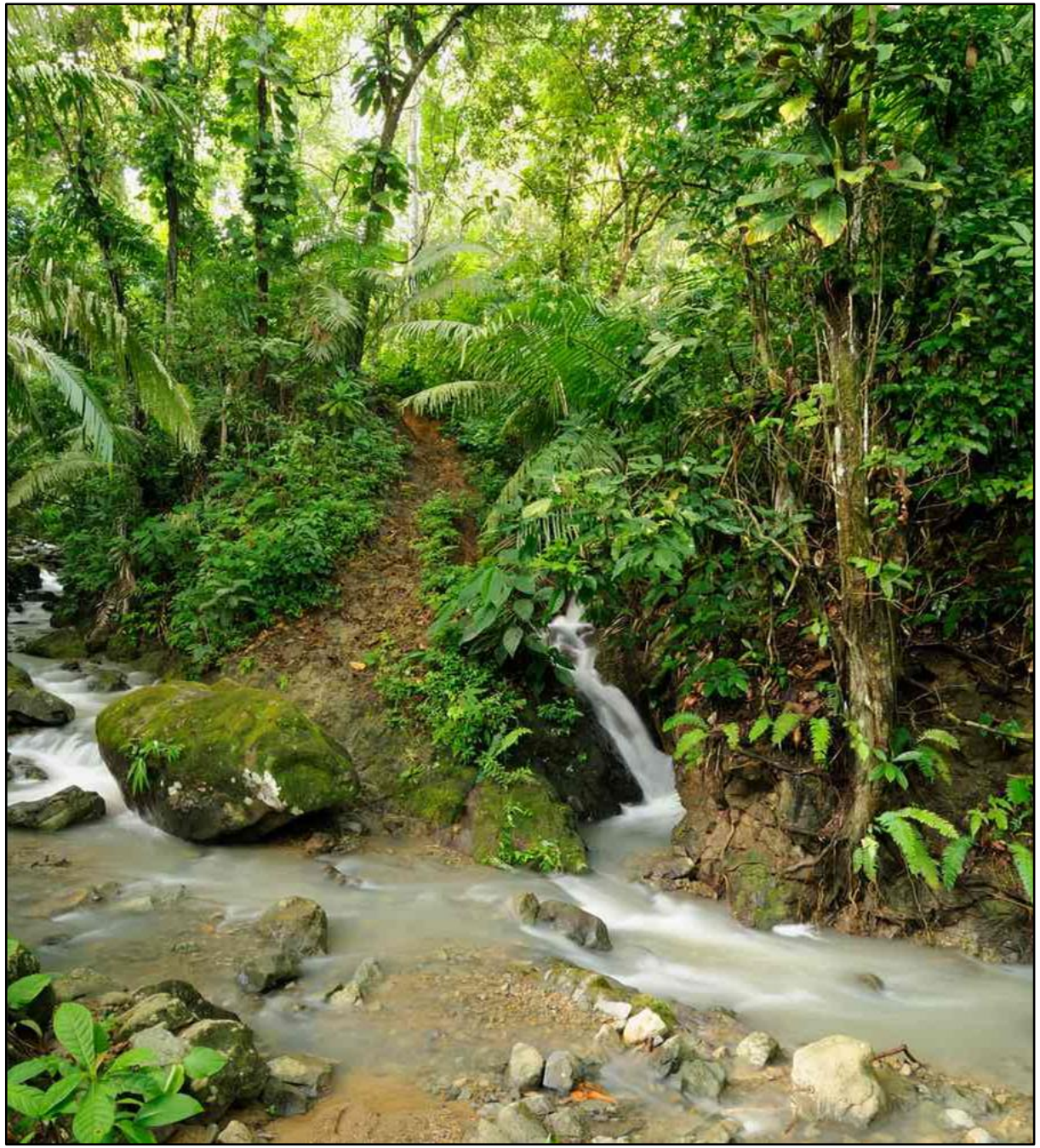
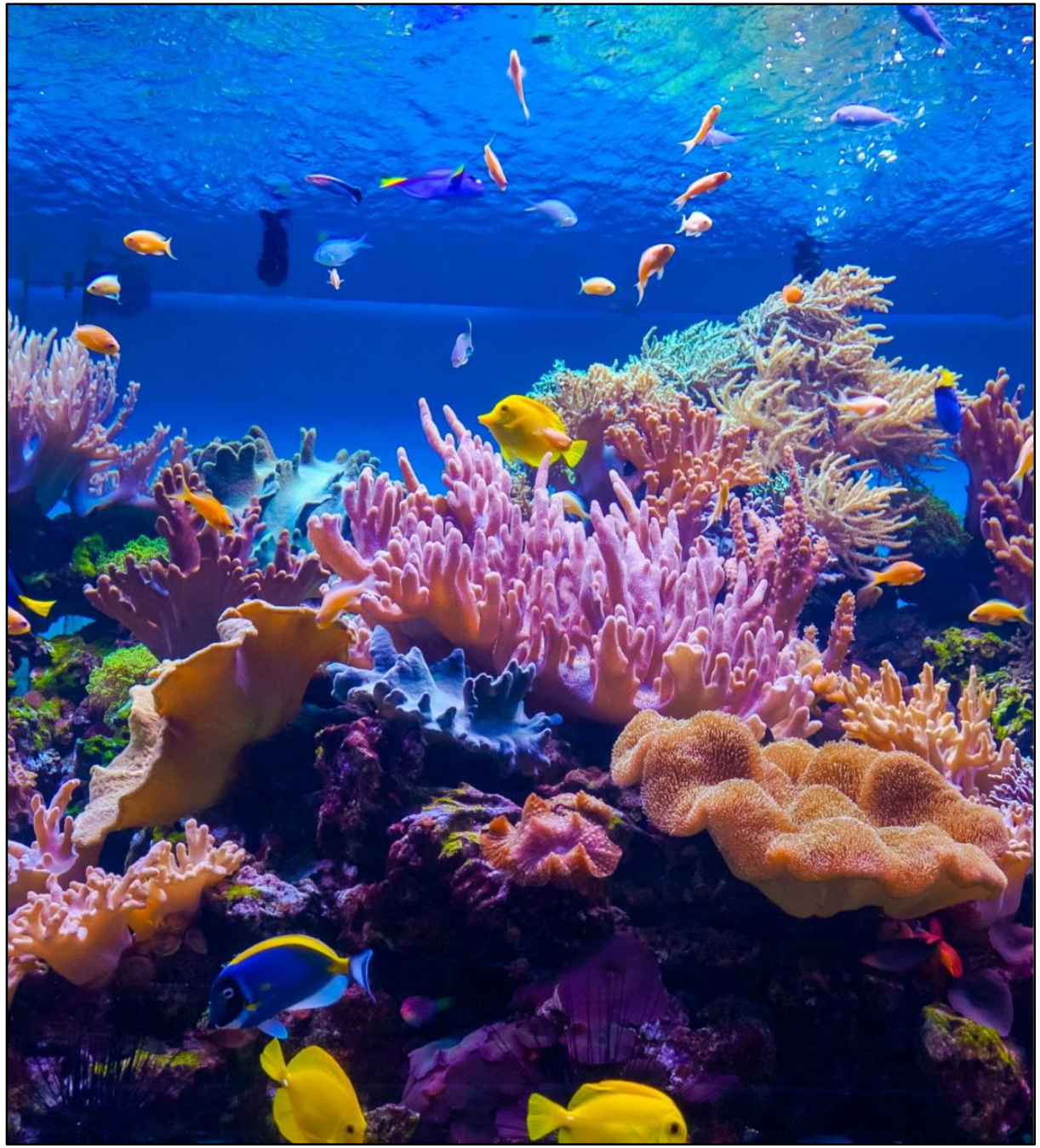
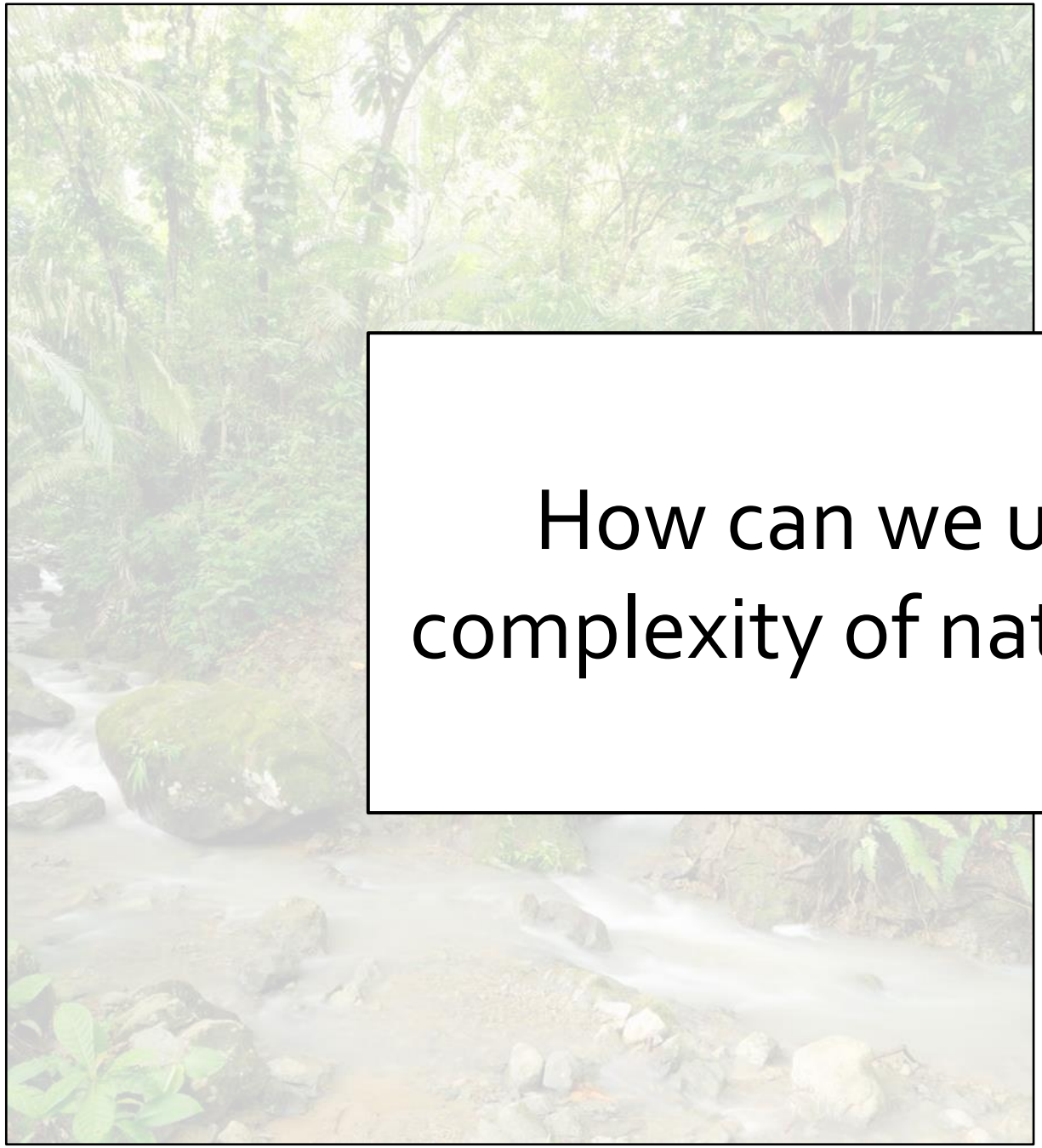
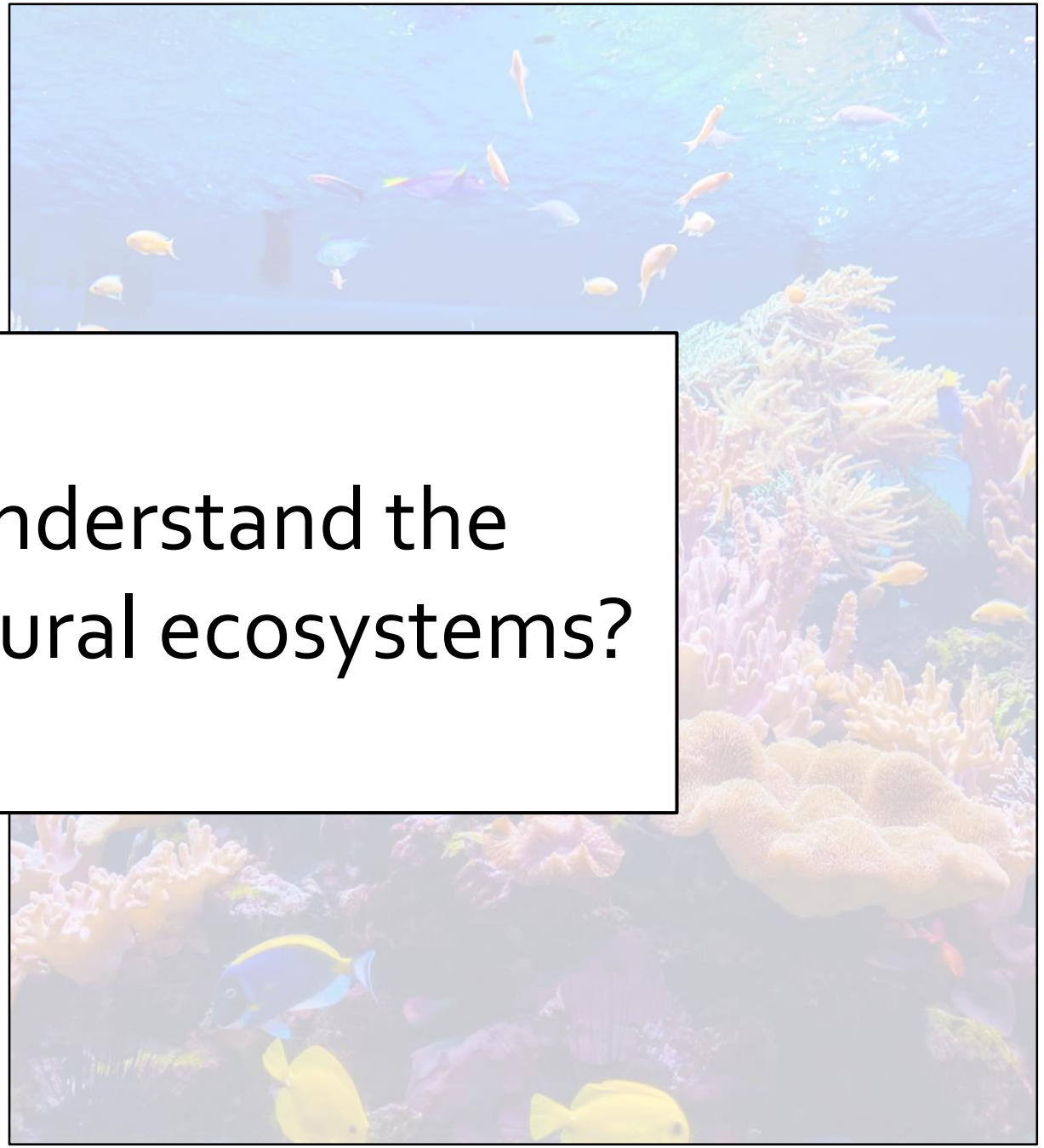
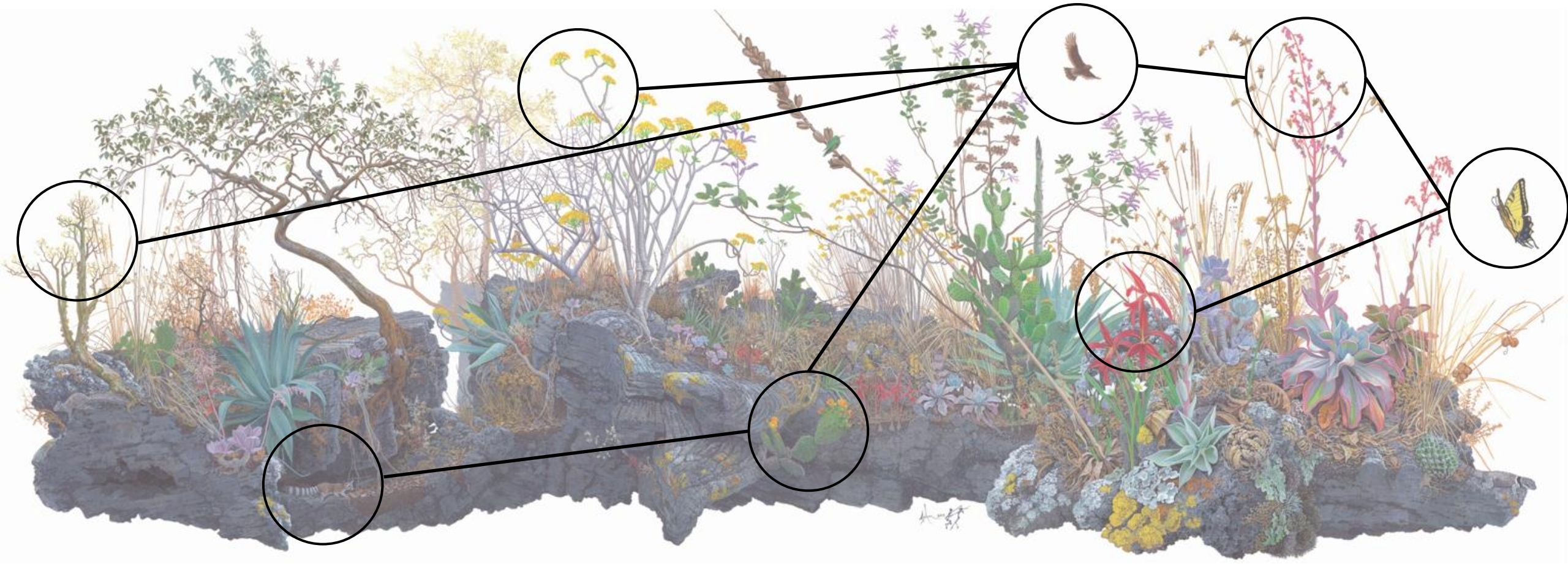


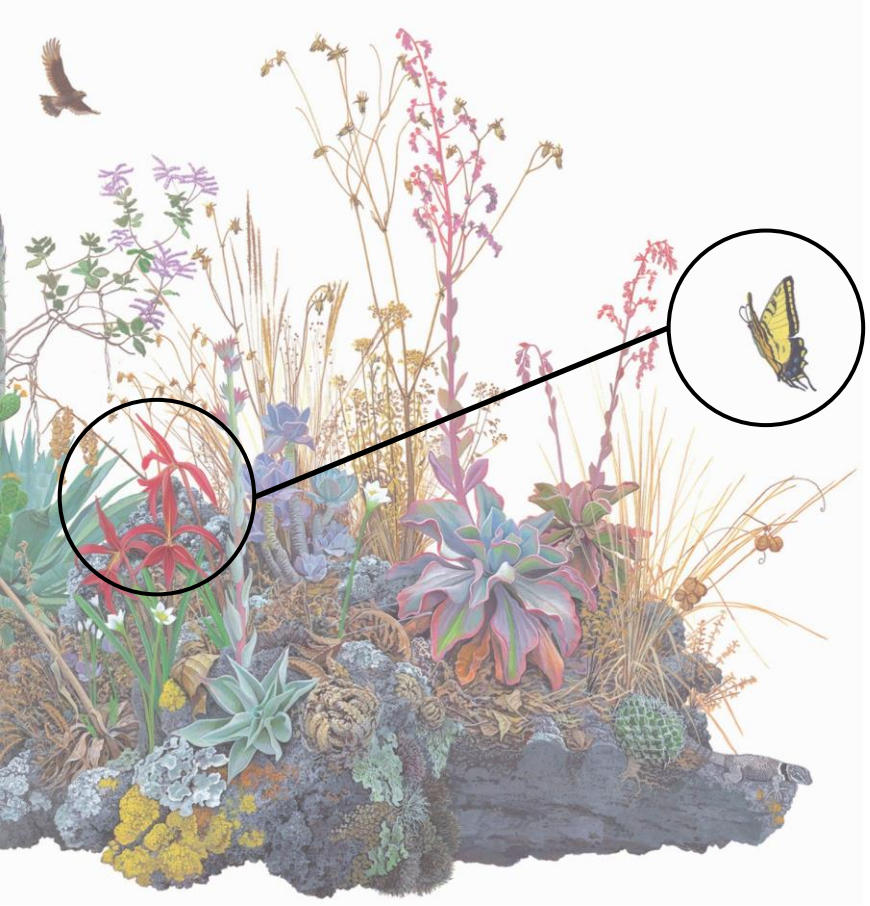




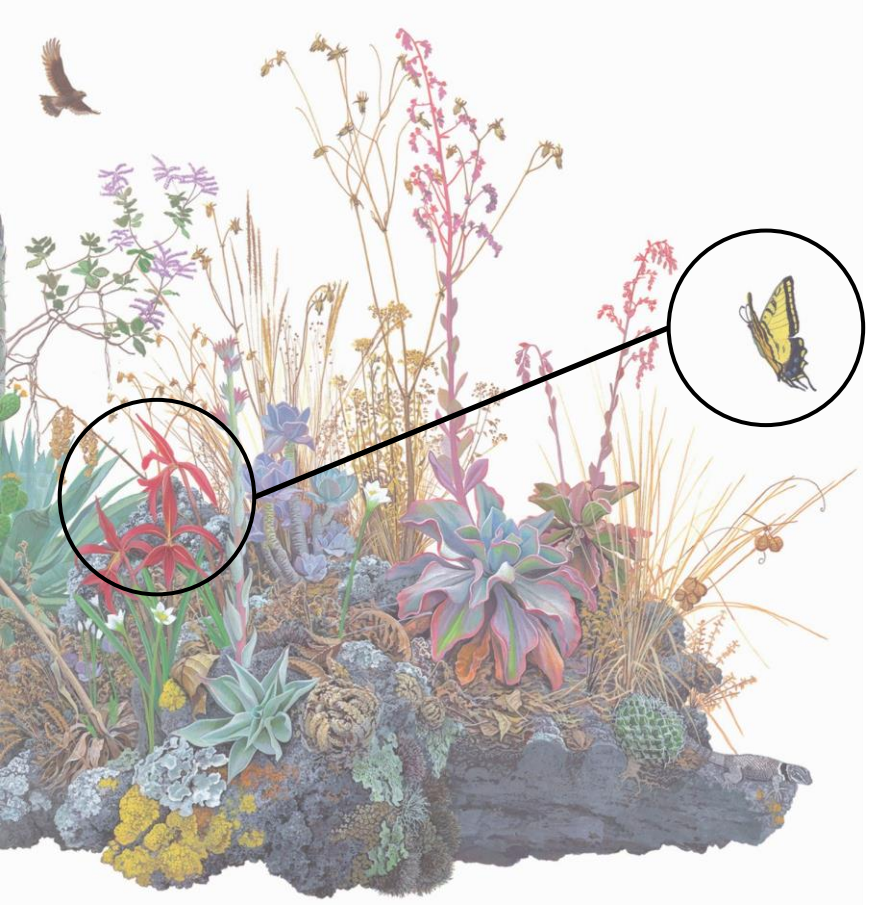


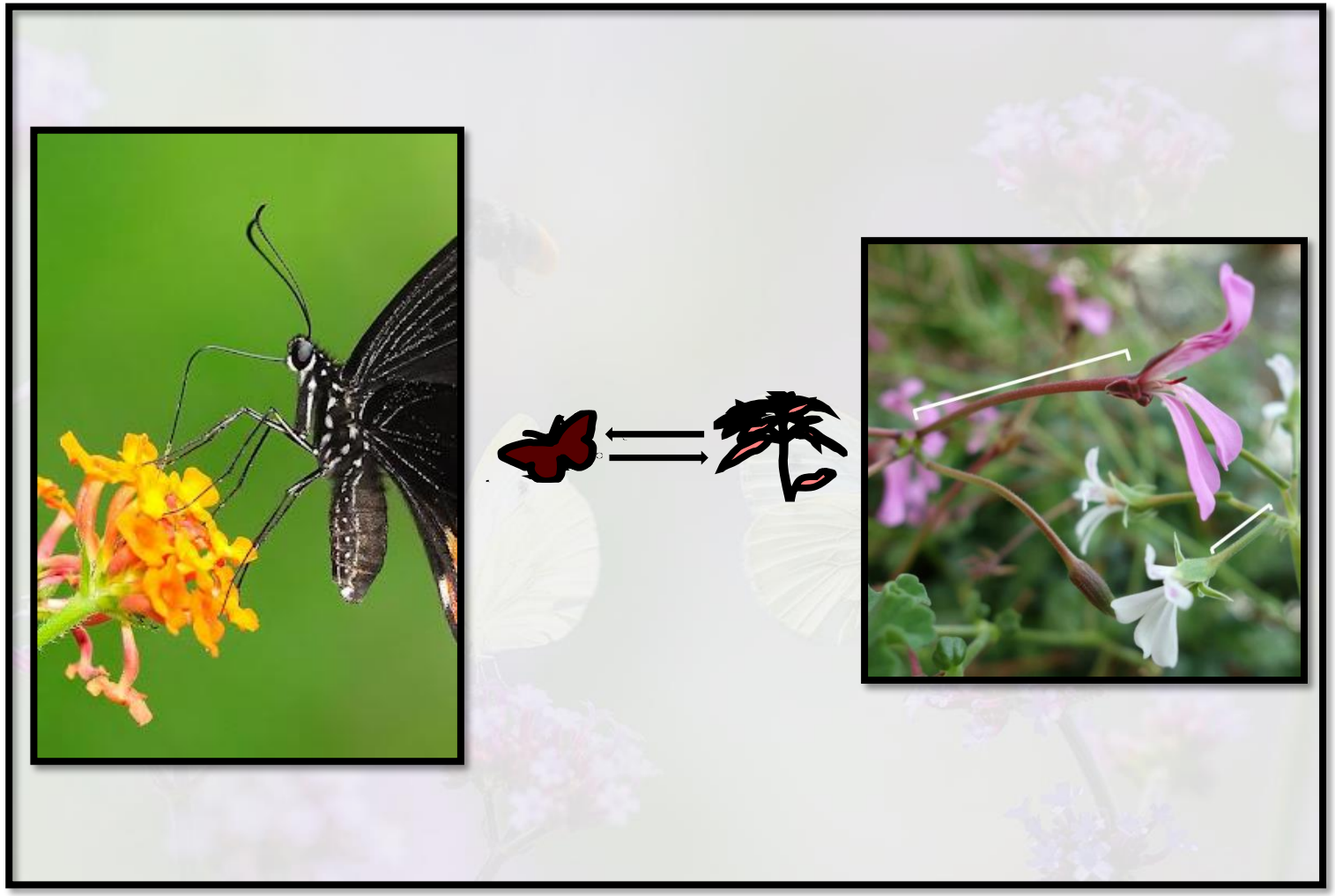
How can we understand the complexity of natural ecosystems?



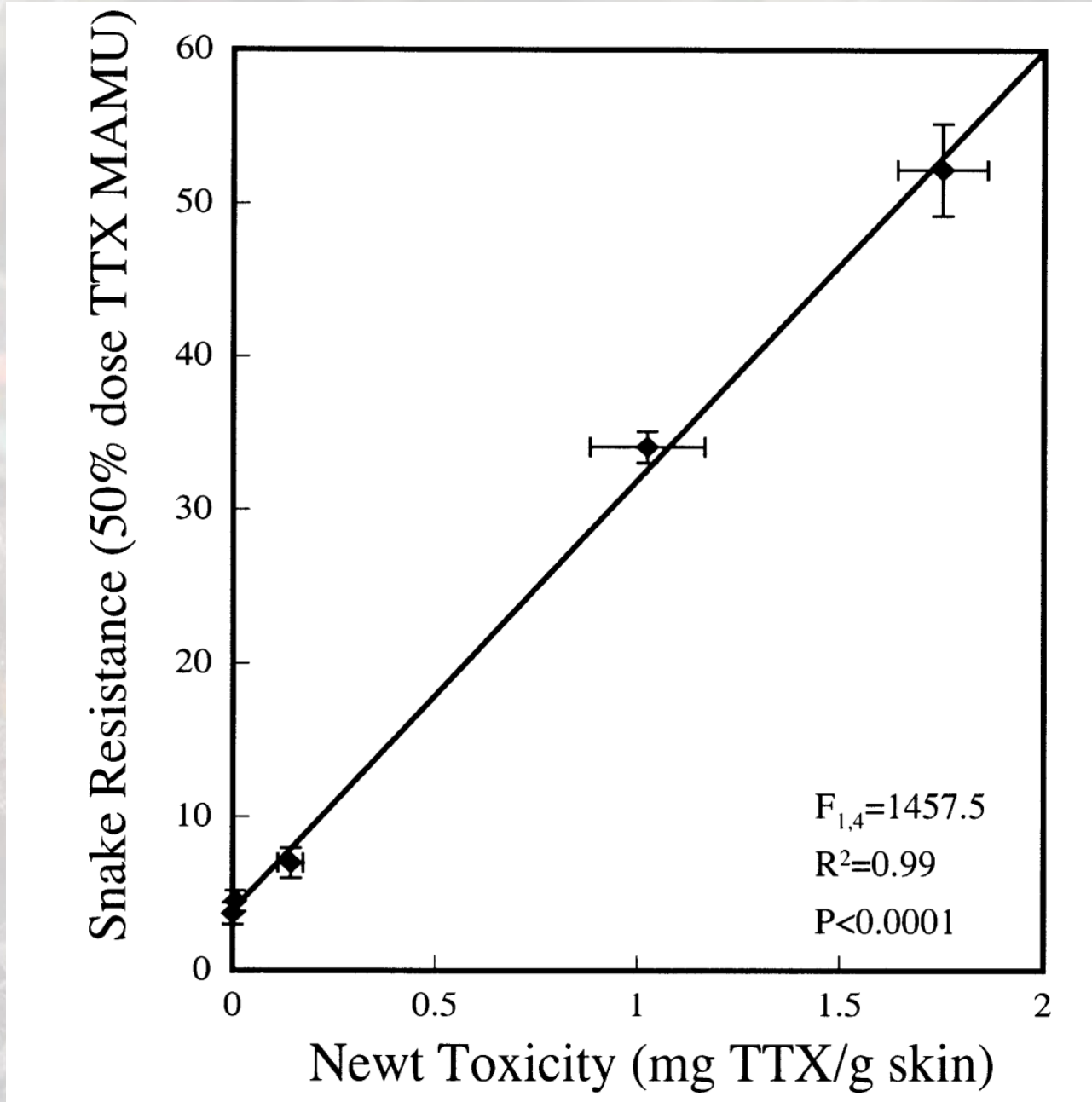


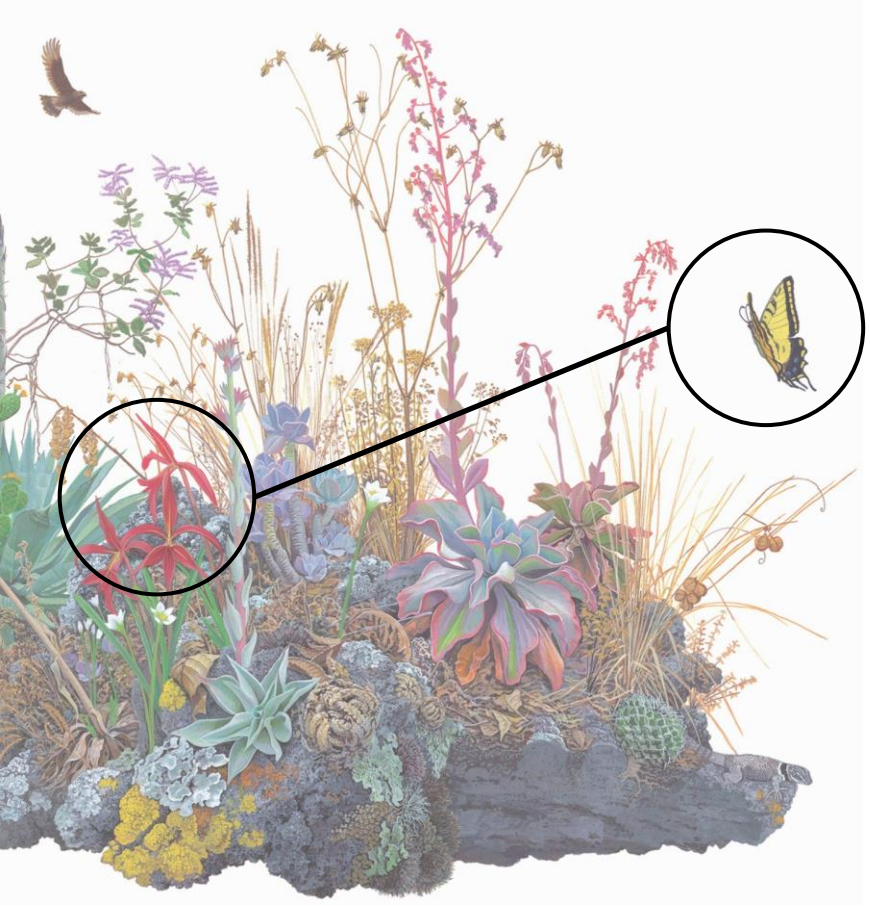
What mediates ecological interactions?

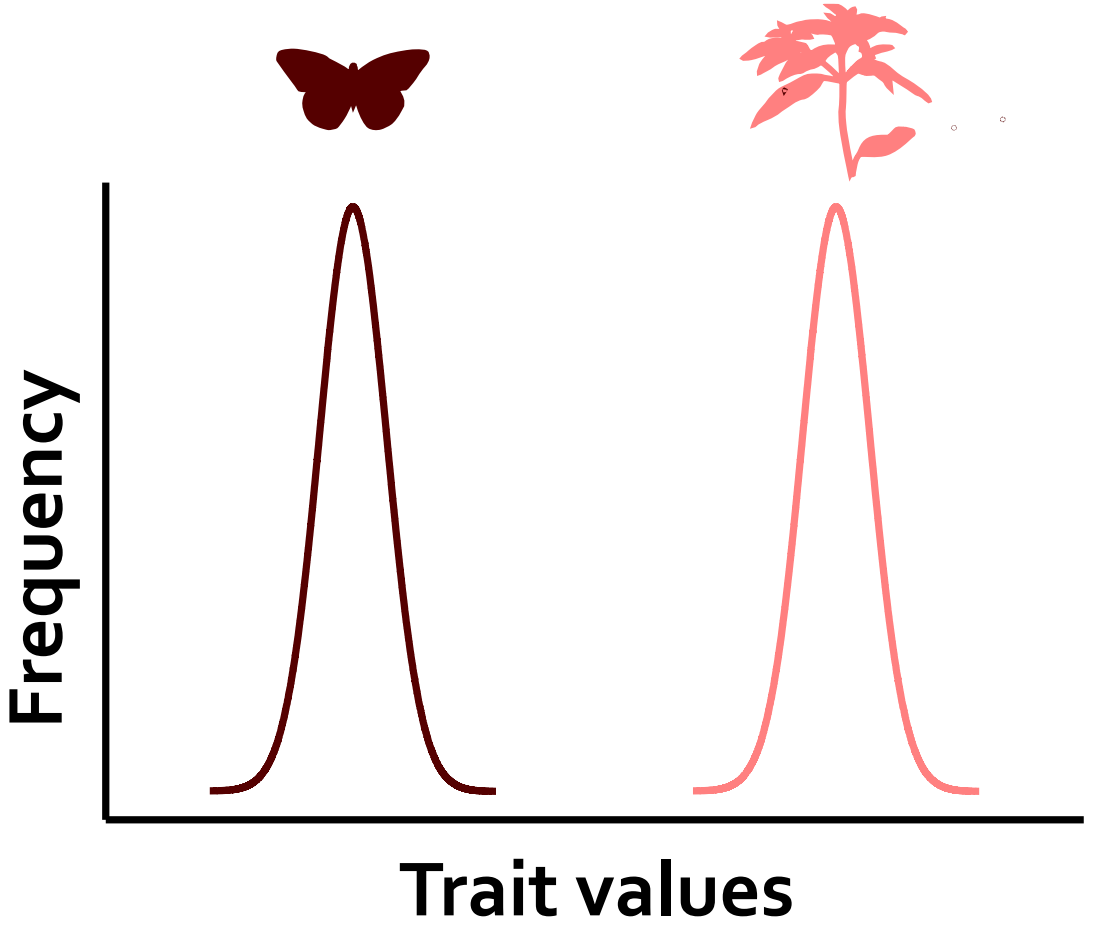




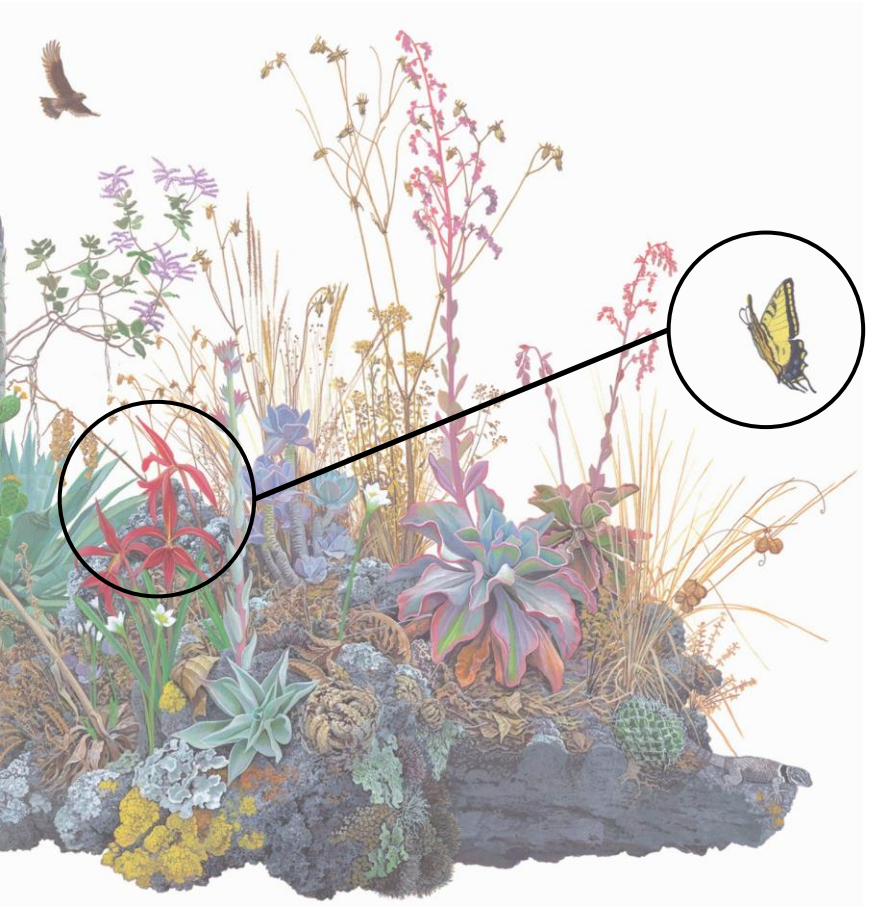
The outcome of interactions depend on species traits!

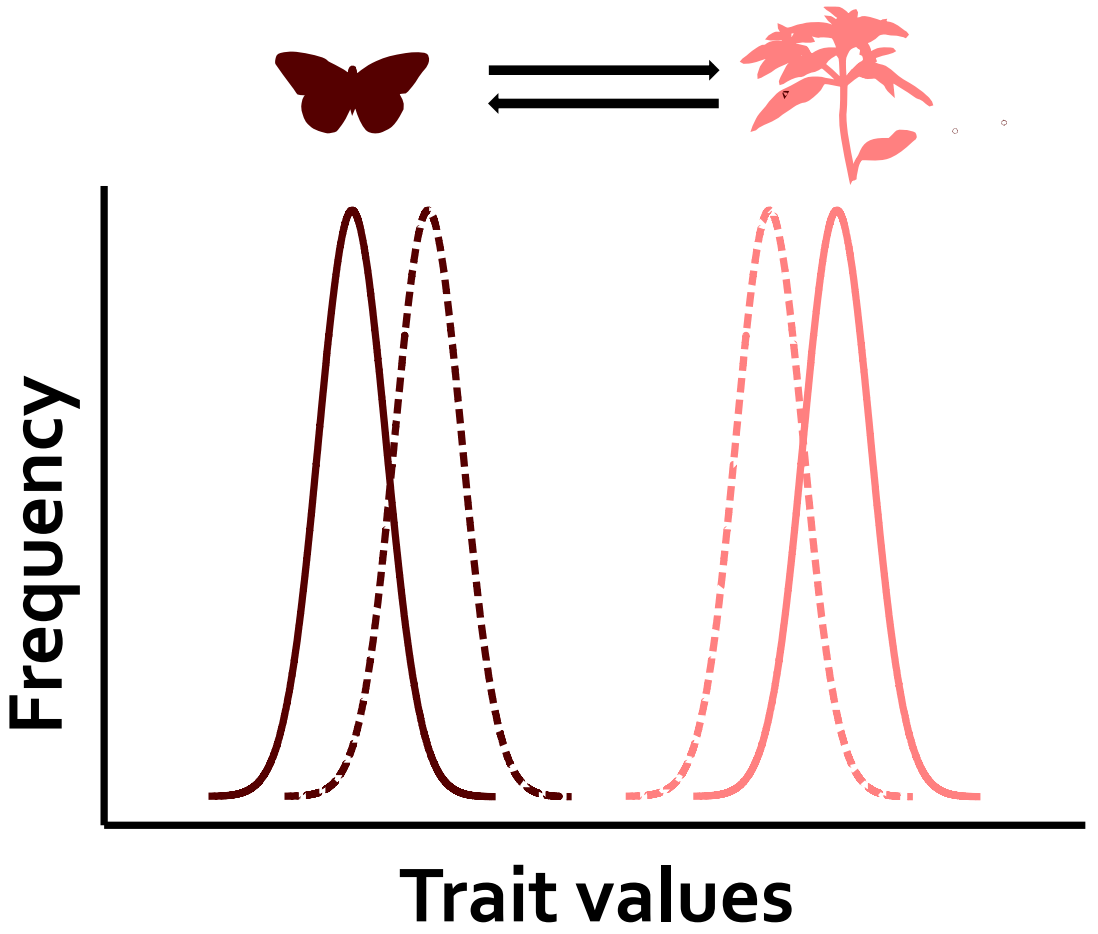

Snake Resistance (50% dose TTX MAMU)
60
50
40
30
20
10
0
0
0.5
1
1.5
2
Newt Toxicity (mg TTX/g skin)
$F_{1,4}$=1457.5
R^2=0.99
P<0.0001



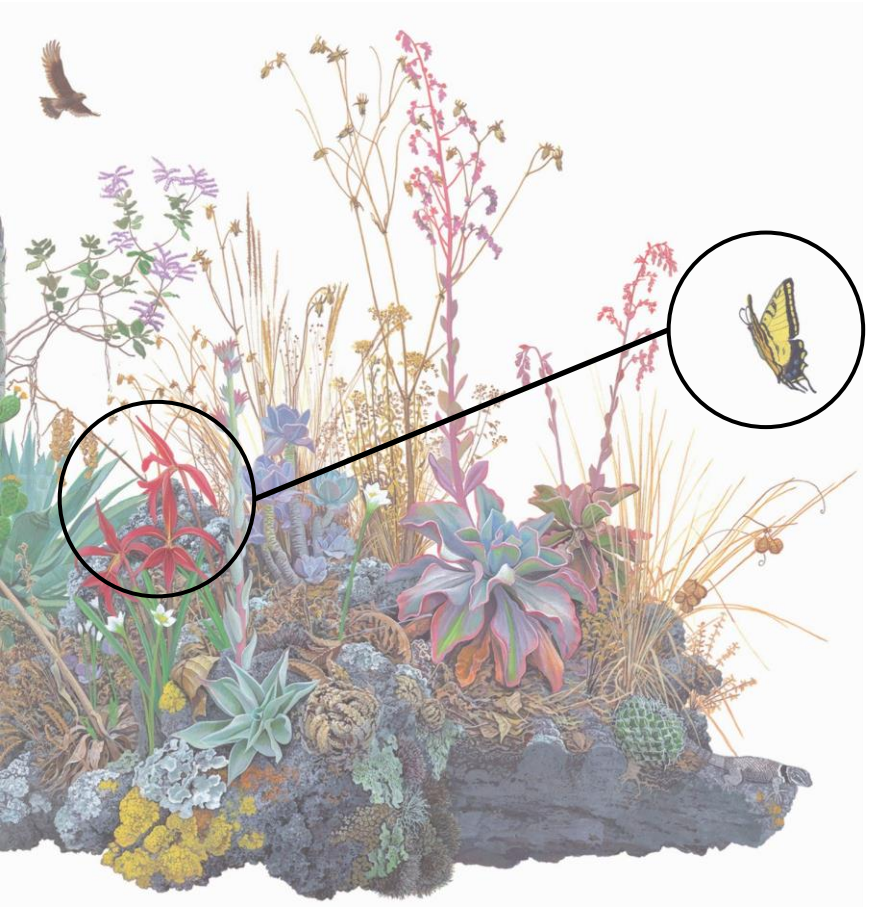


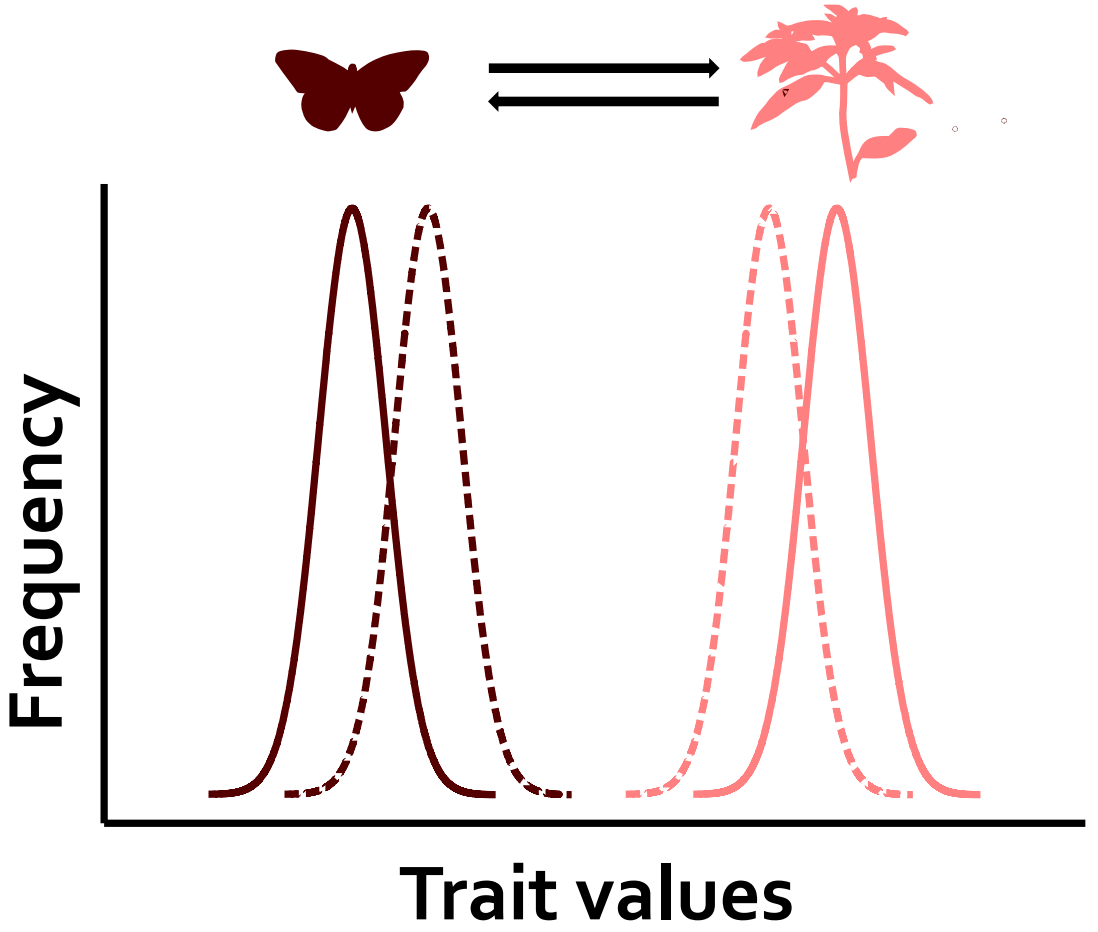
Ecological interactions can be a source of selective pressures that drive the evolution of species traits



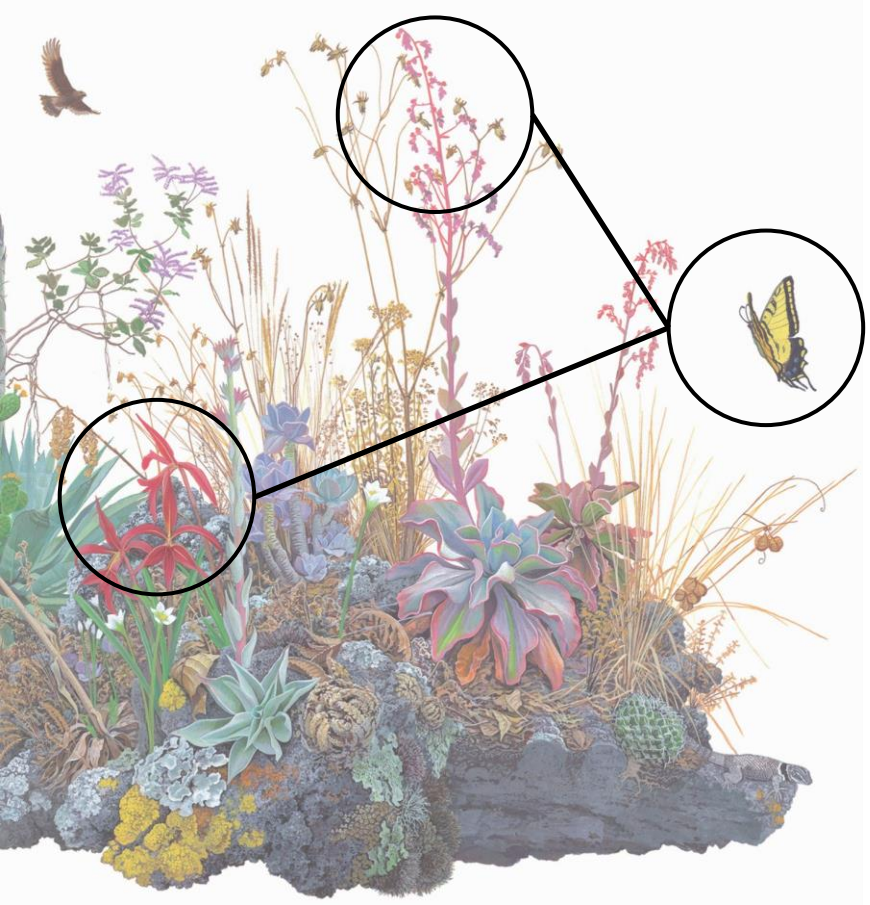


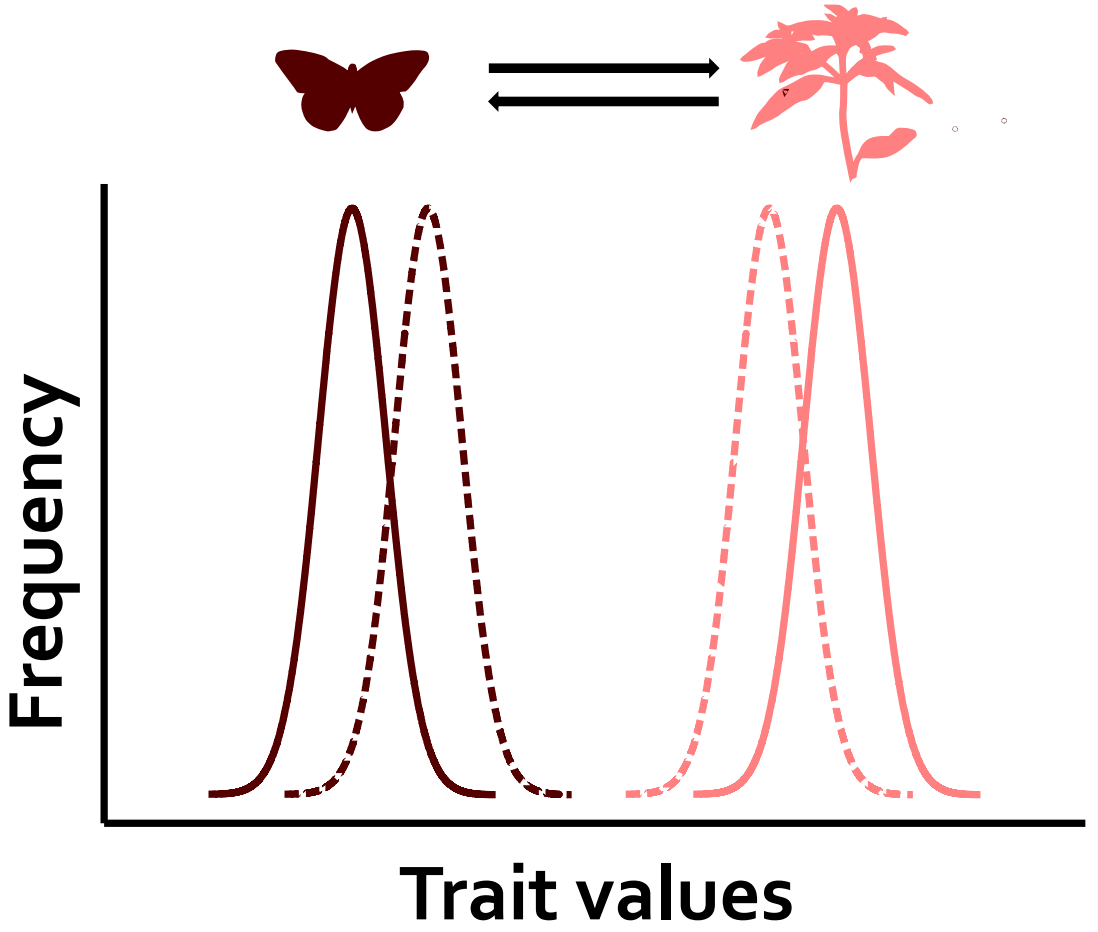
Reciprocal evolutionary changes between interacting species:
coevolution!



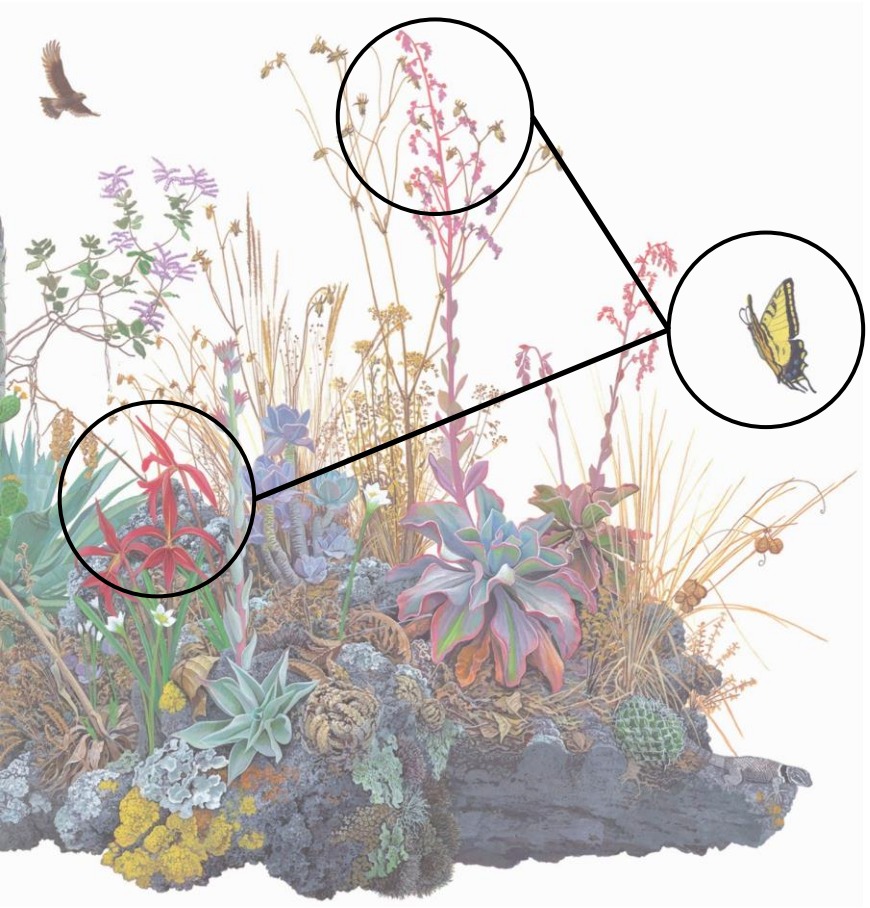


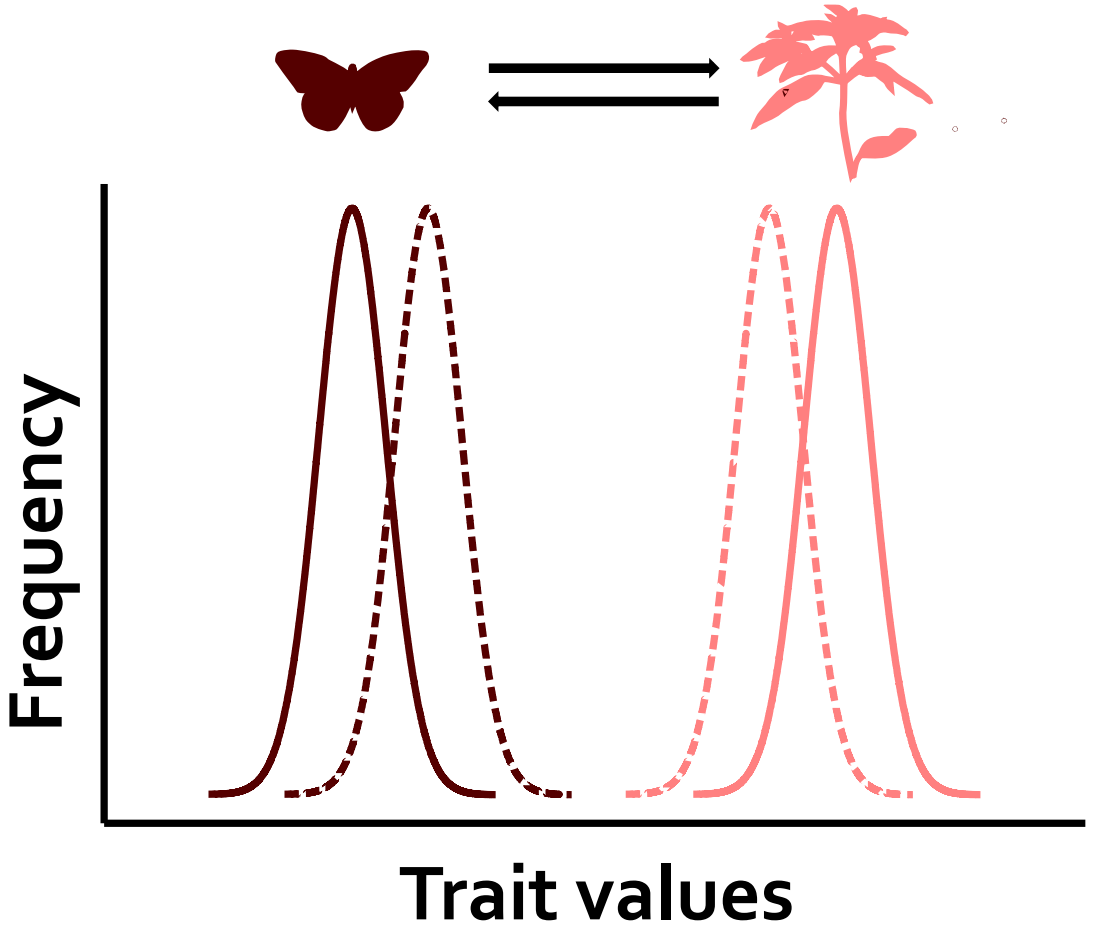
But...



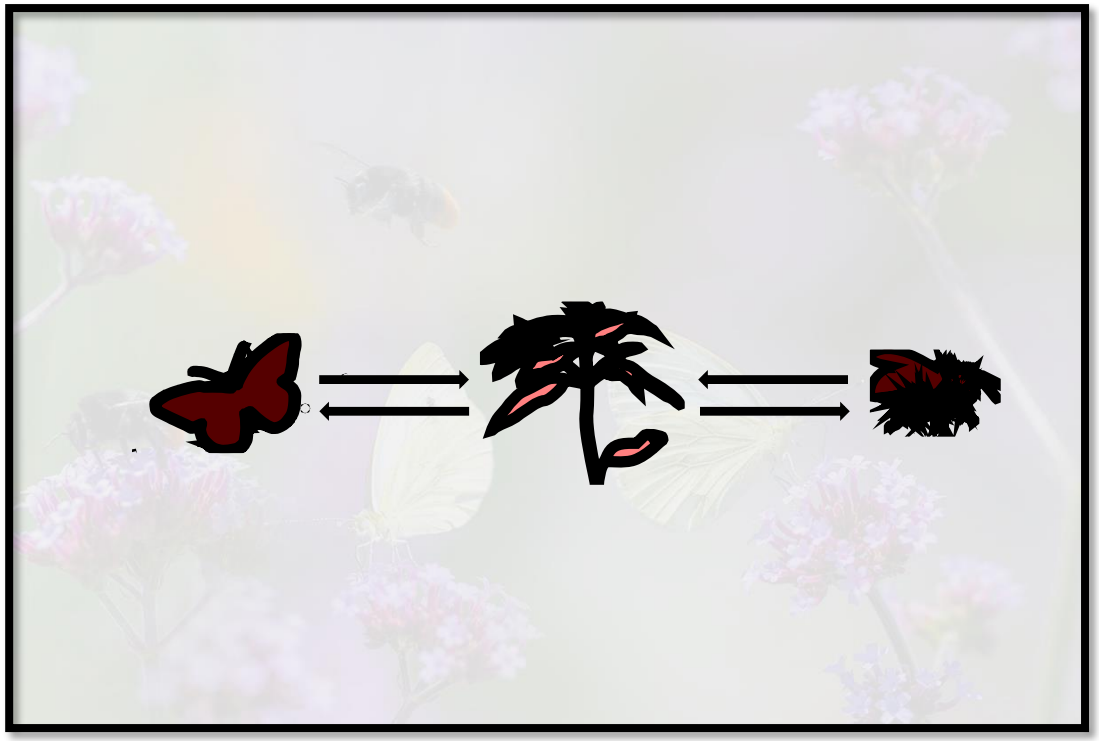


What happens when we have a third interacting species?





How the structure of ecological networks shape coevolution?



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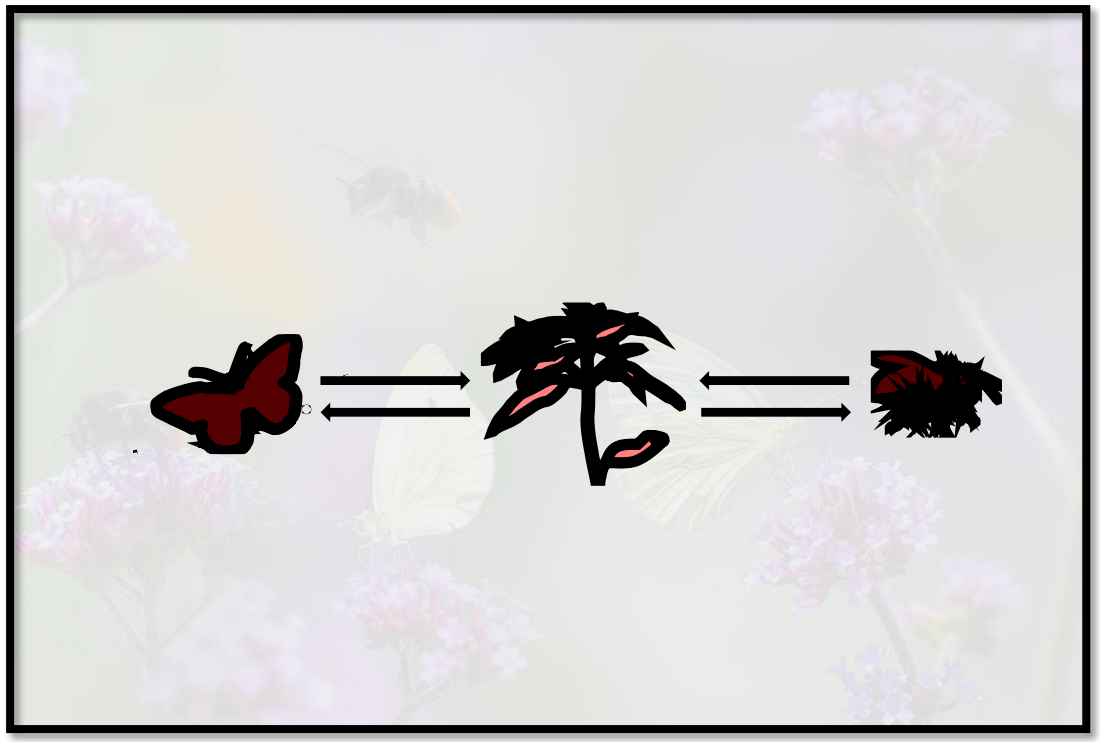

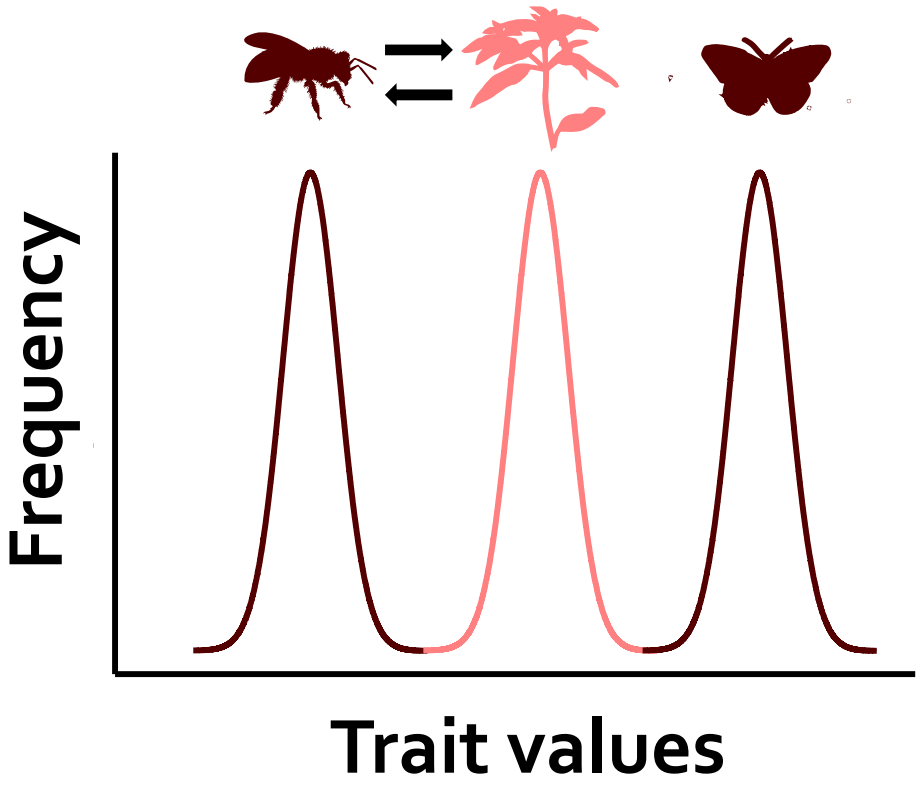

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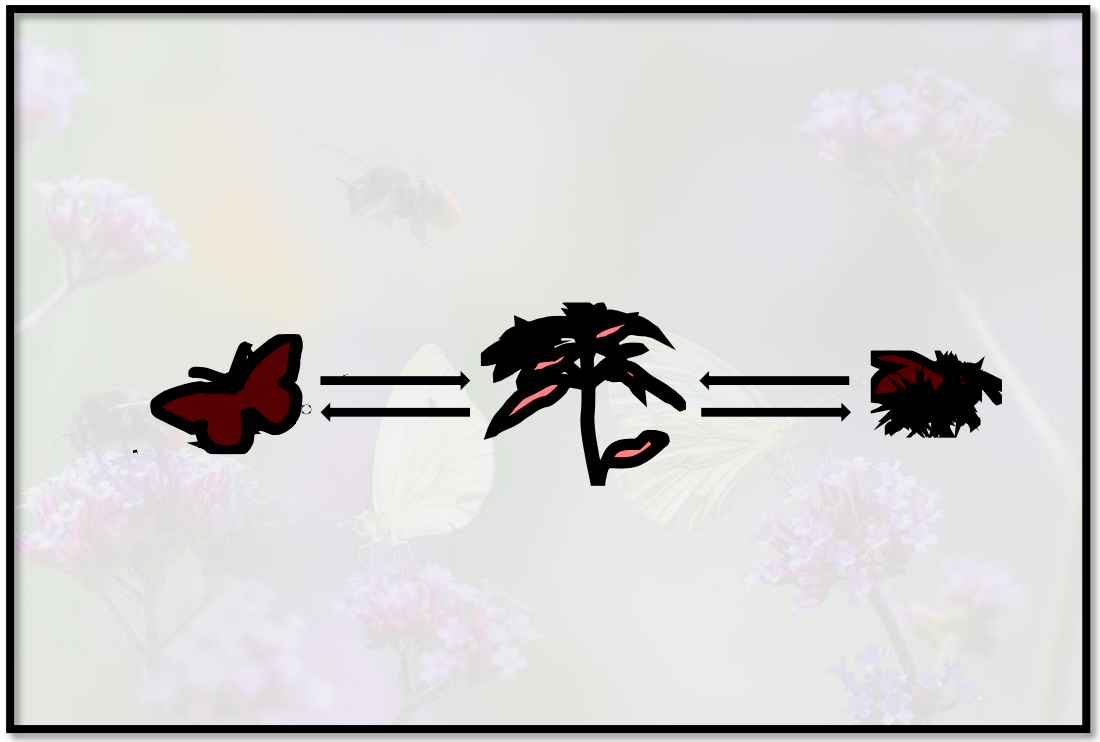
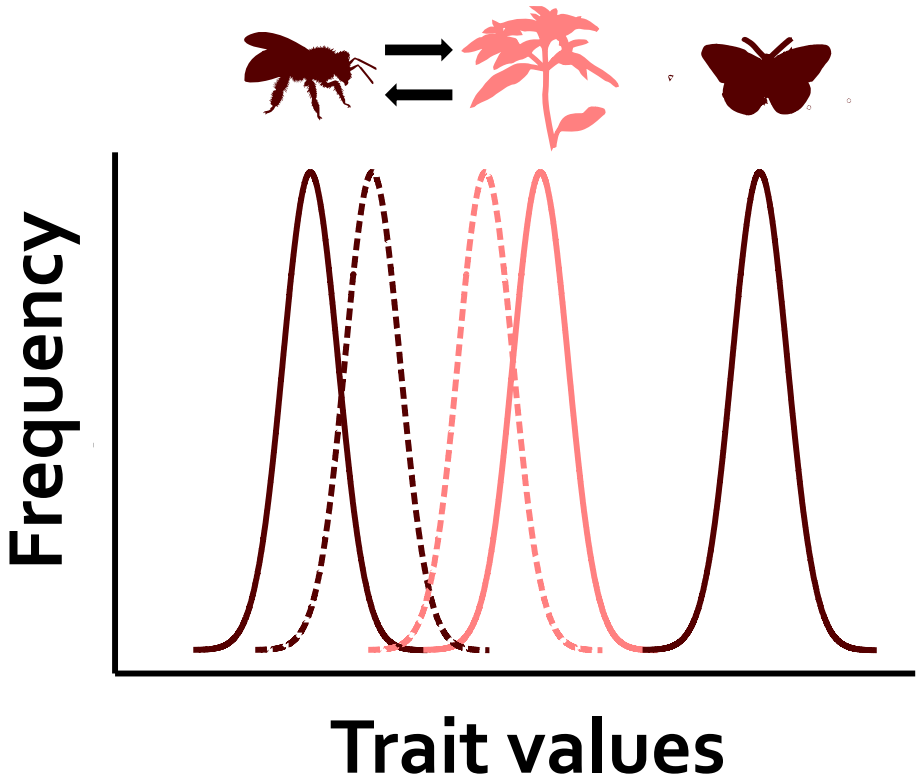
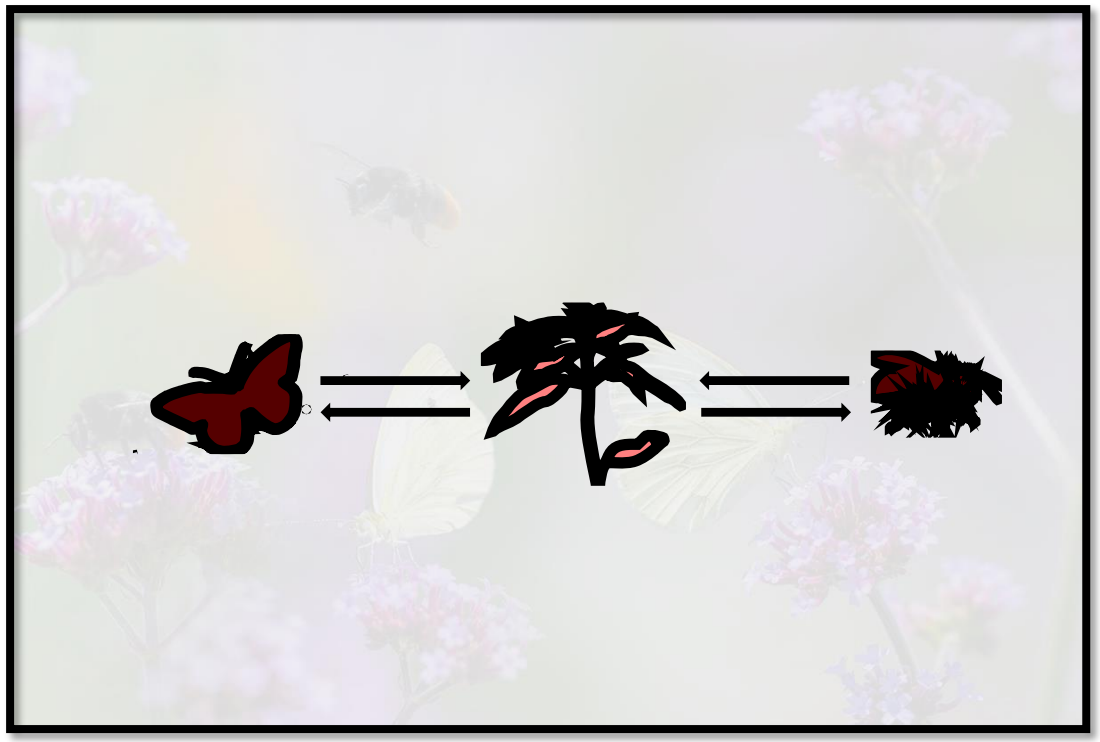
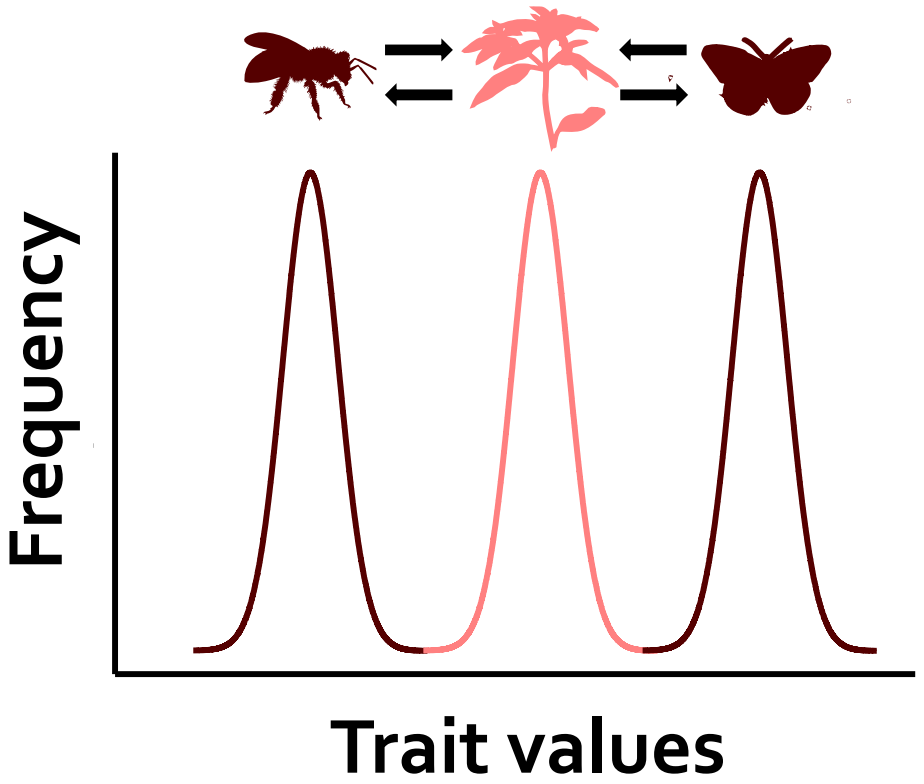


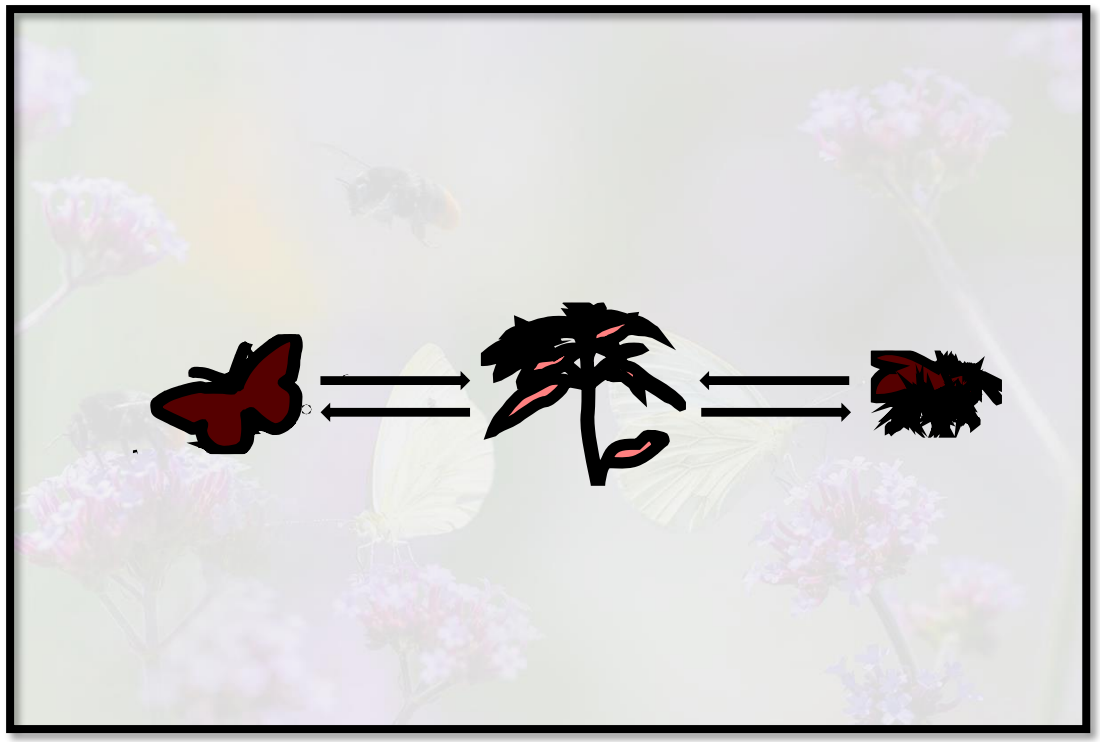


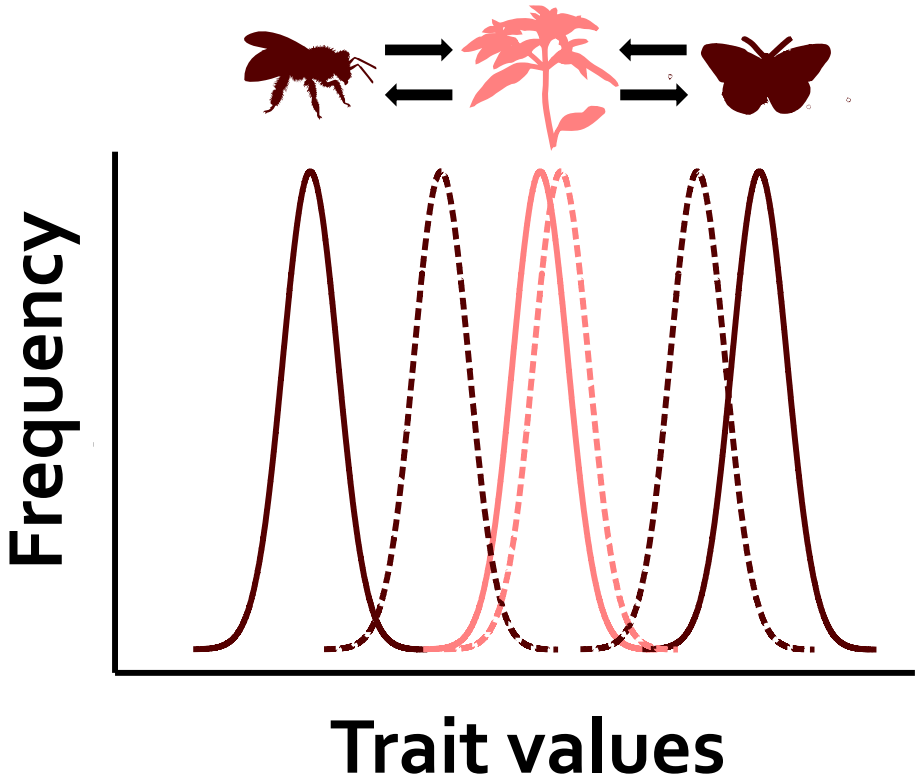
Pairwise interactions: changes in the trait matching between two interacting partners





What are the consequences of coevolution among three or more species?





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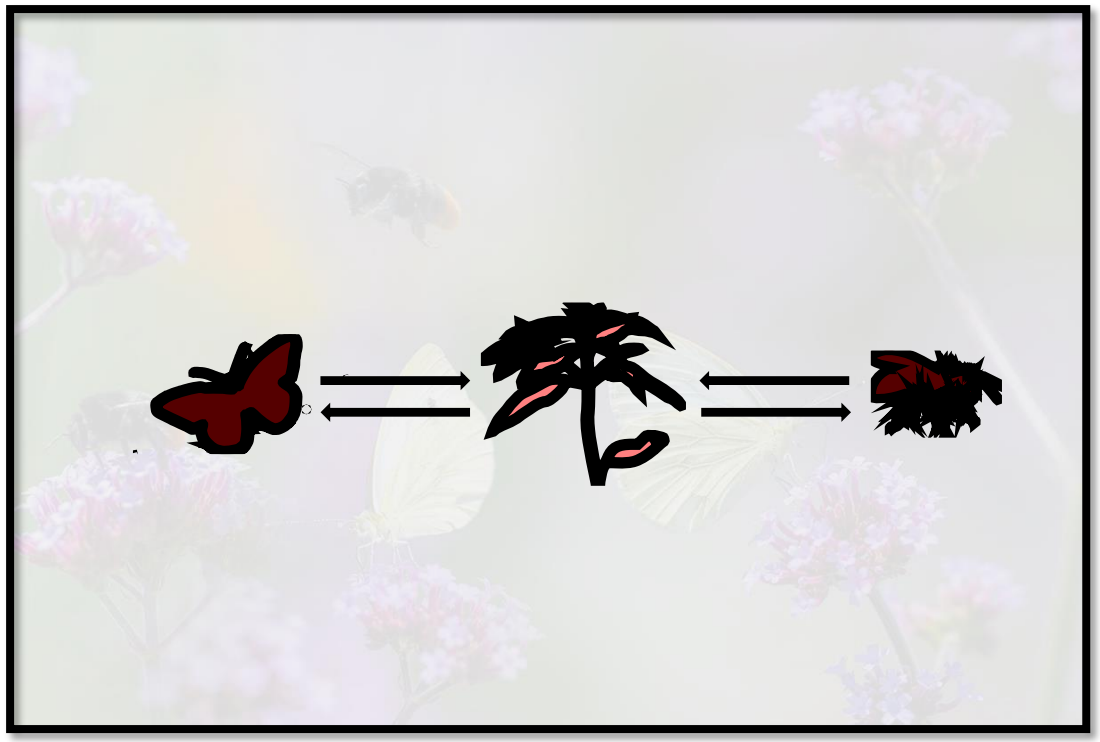
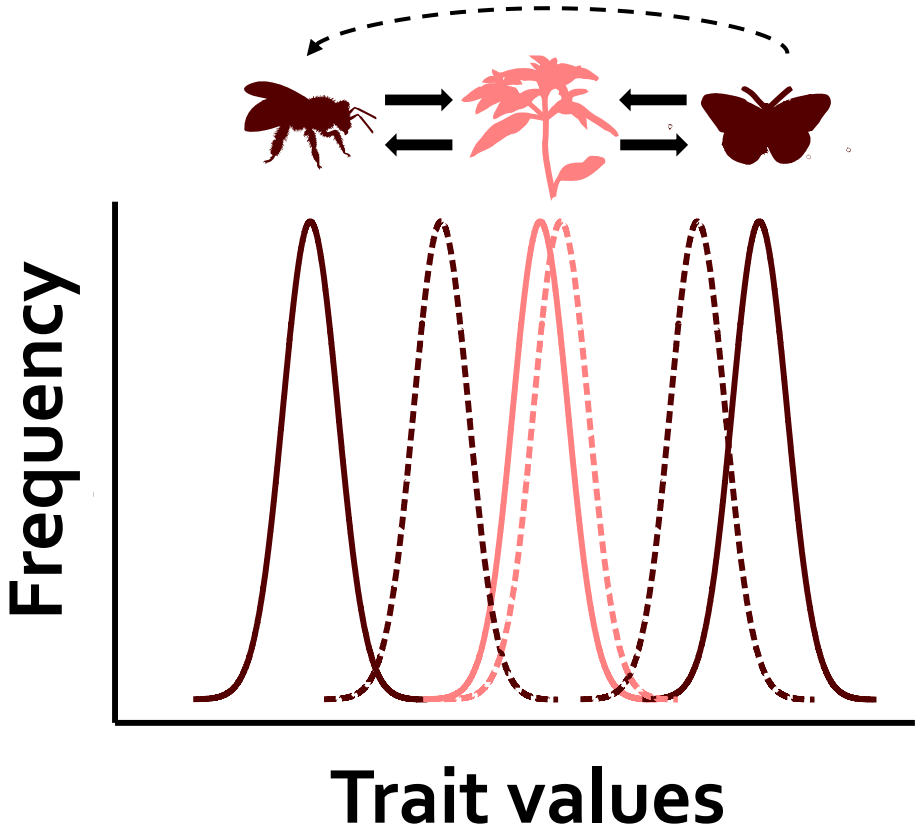
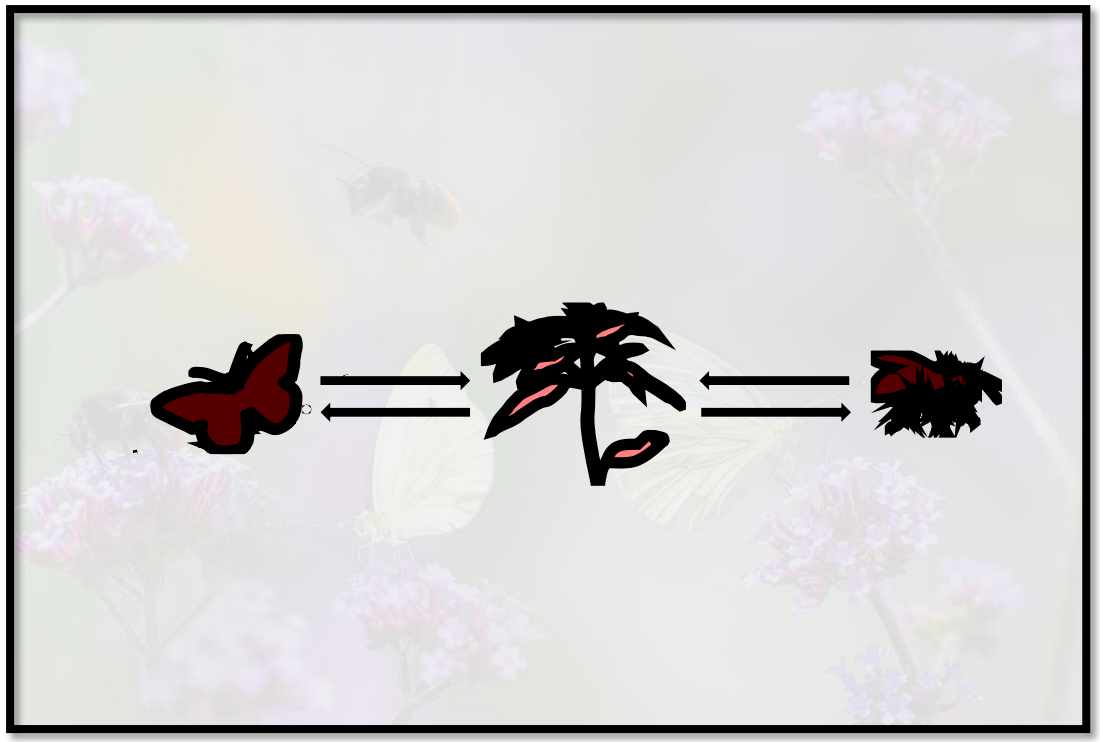
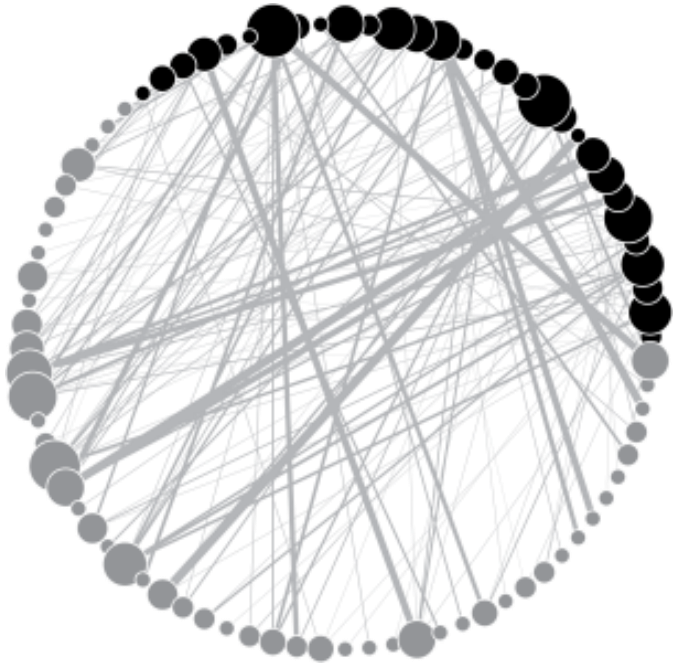




In networks, species can affect each other indirectly: indirect evolutionary effects





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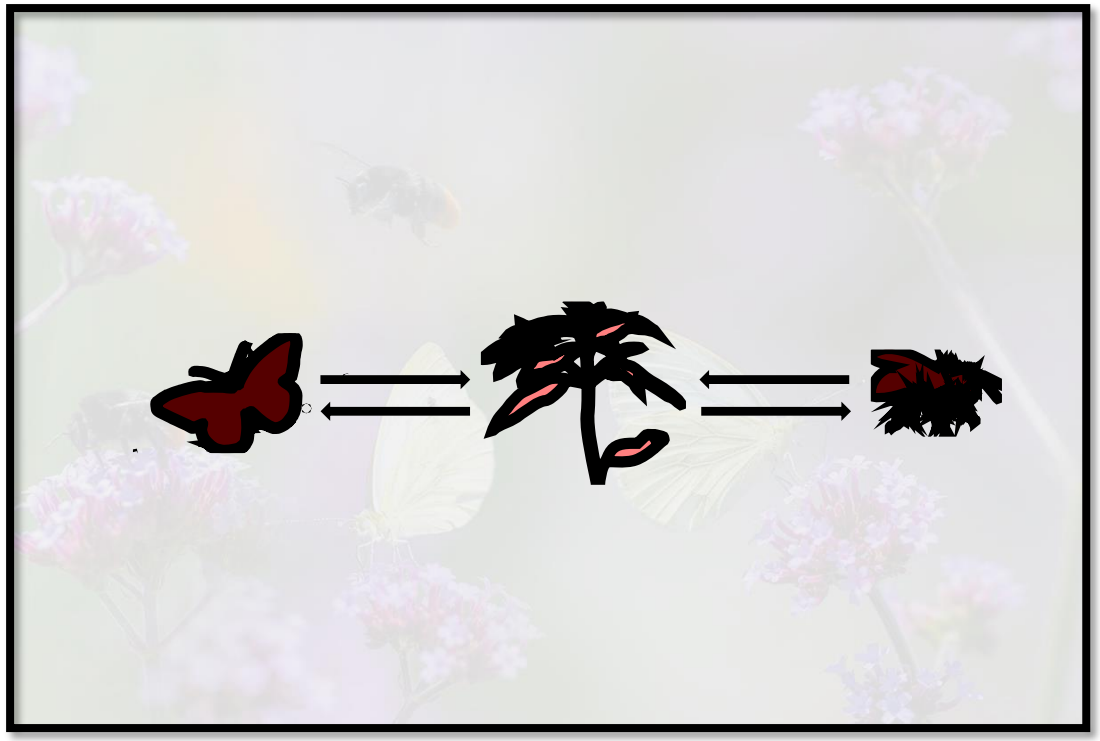

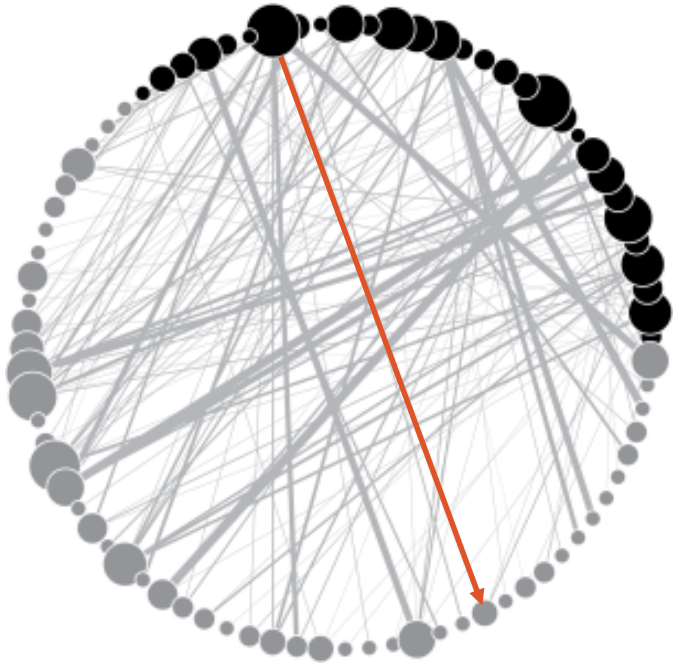

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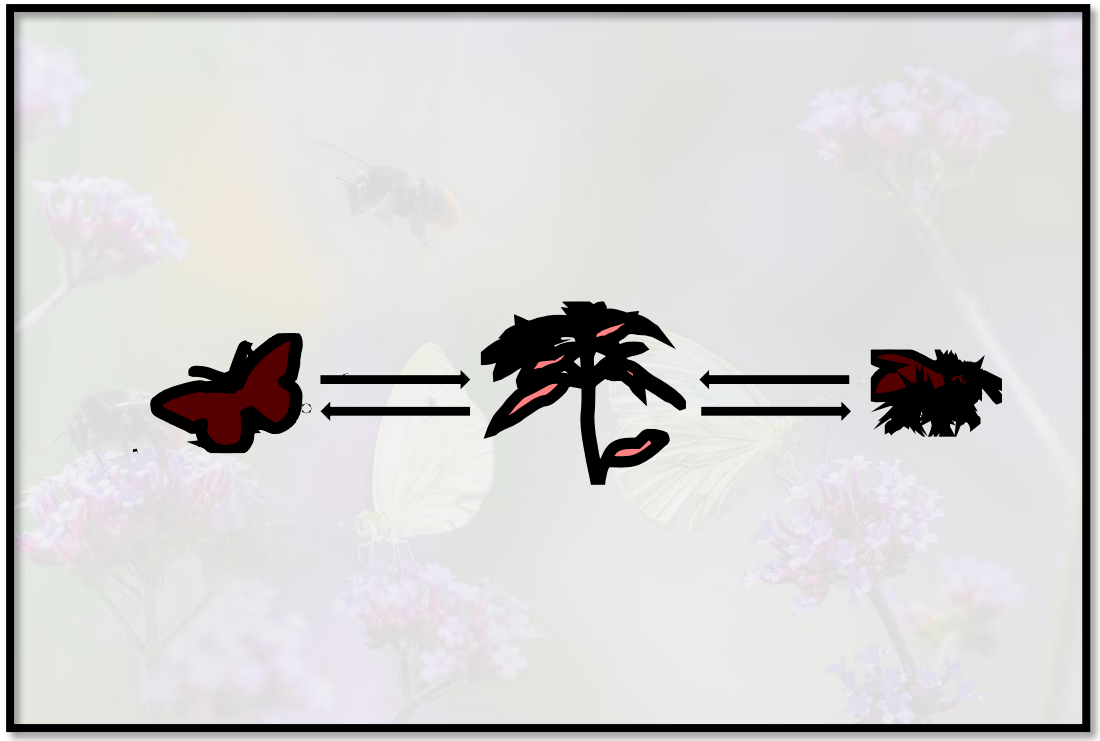

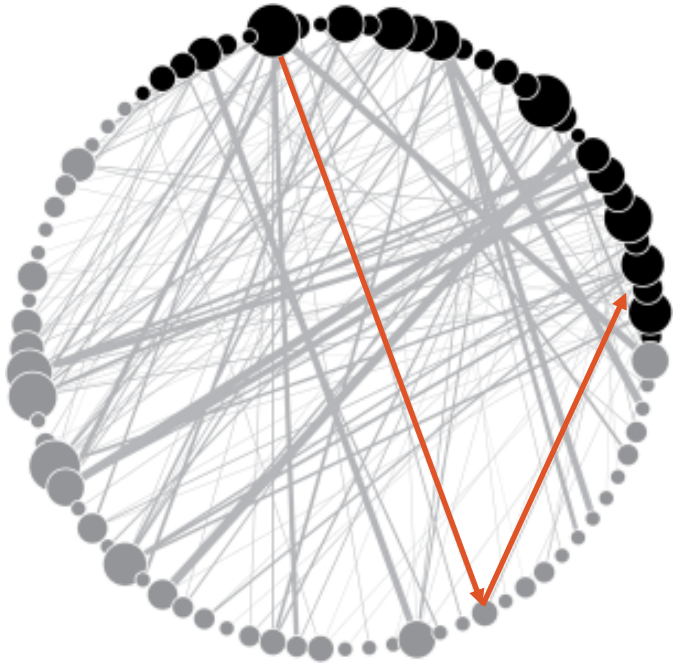

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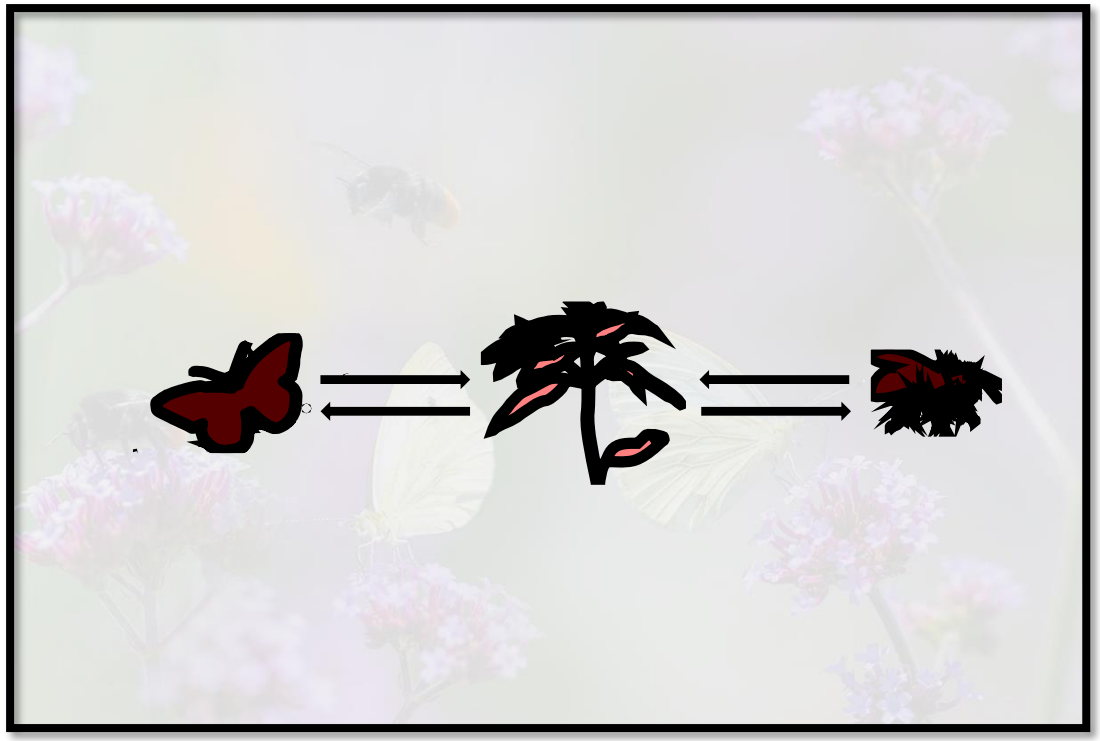

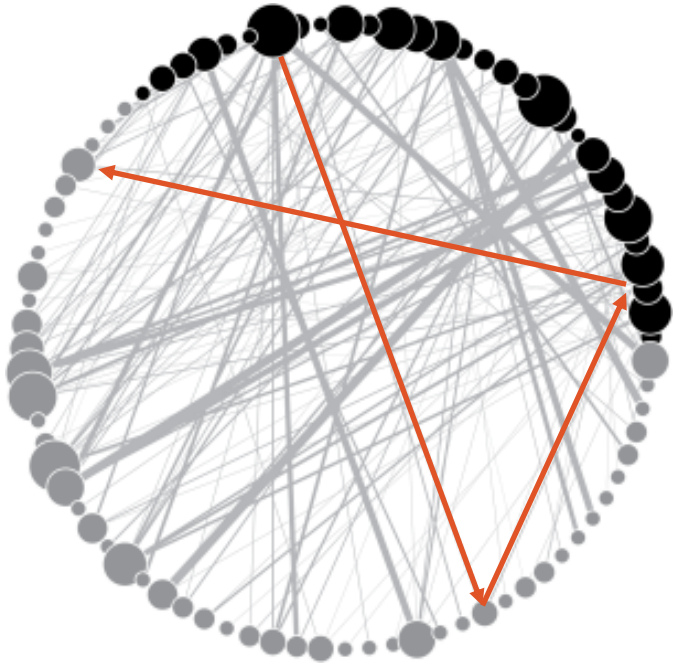

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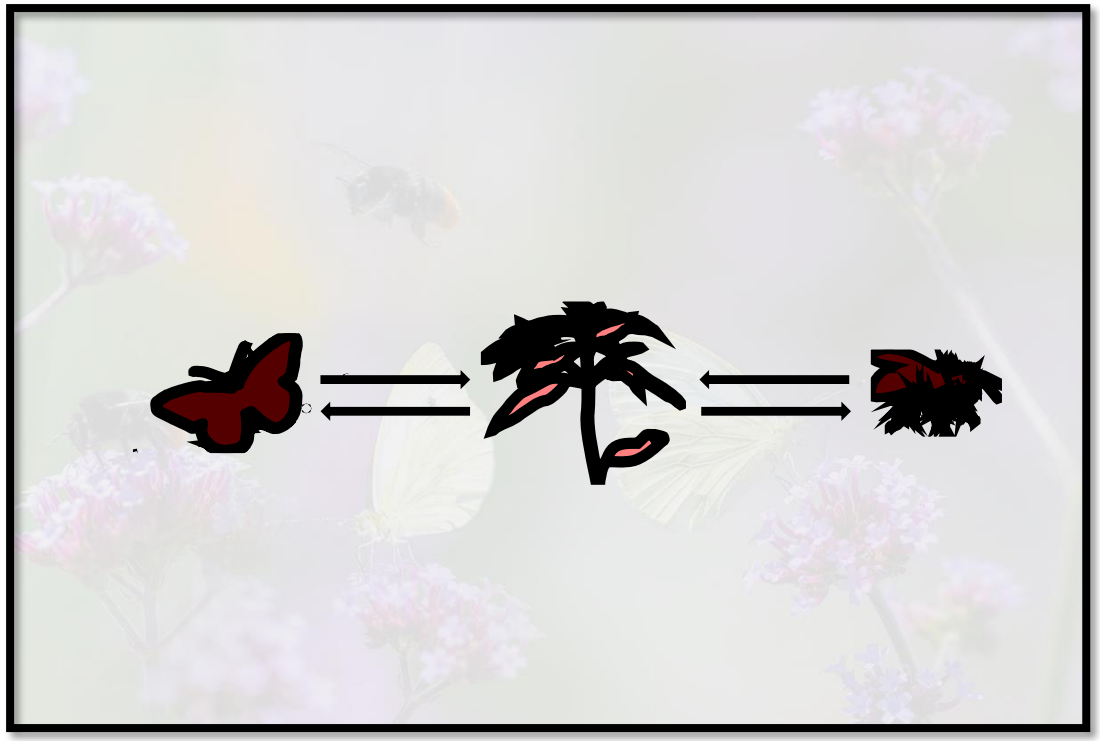

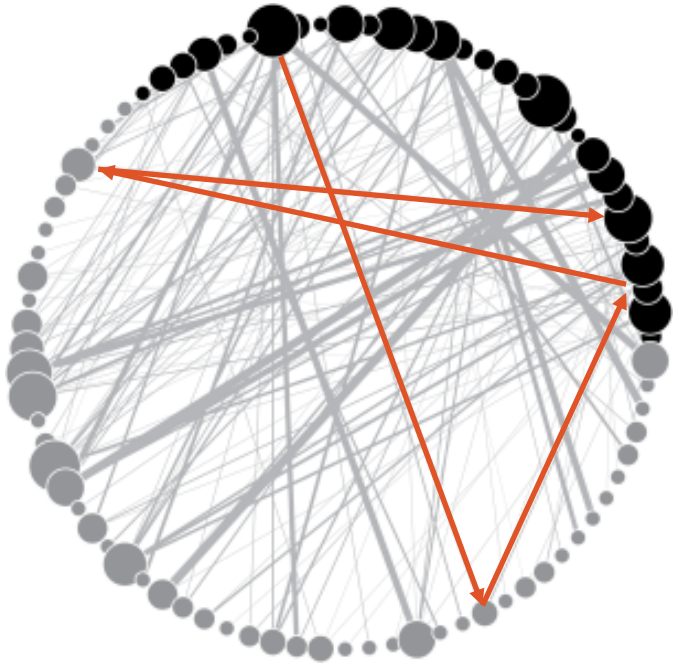

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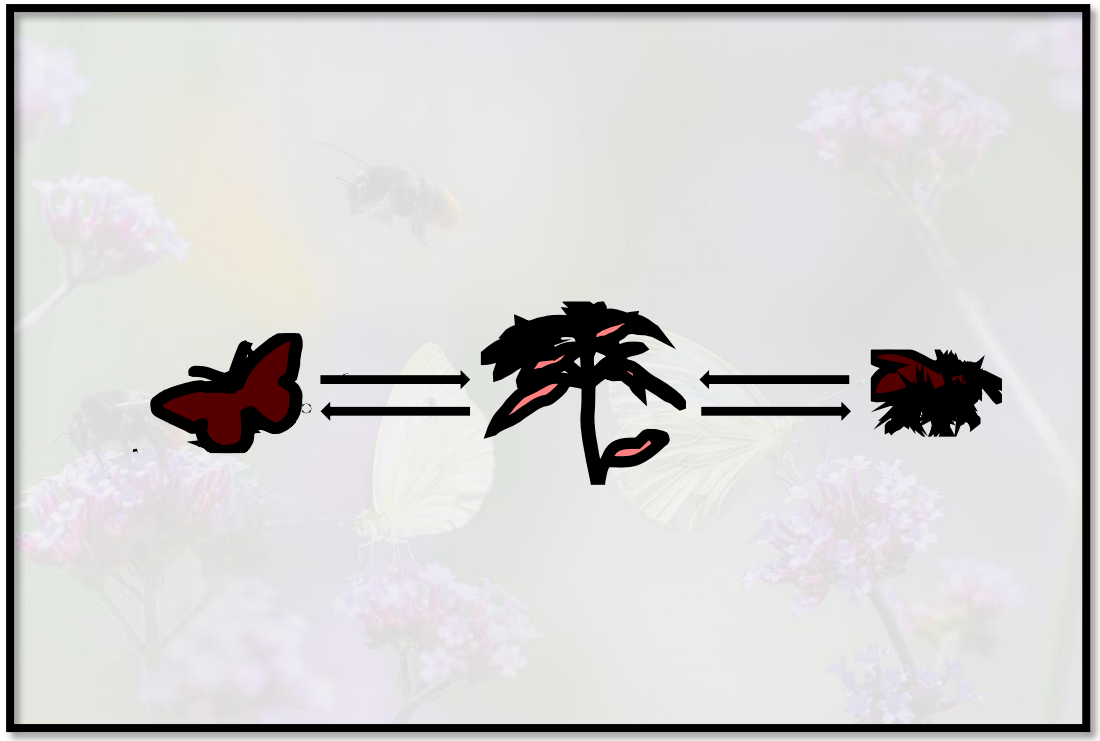

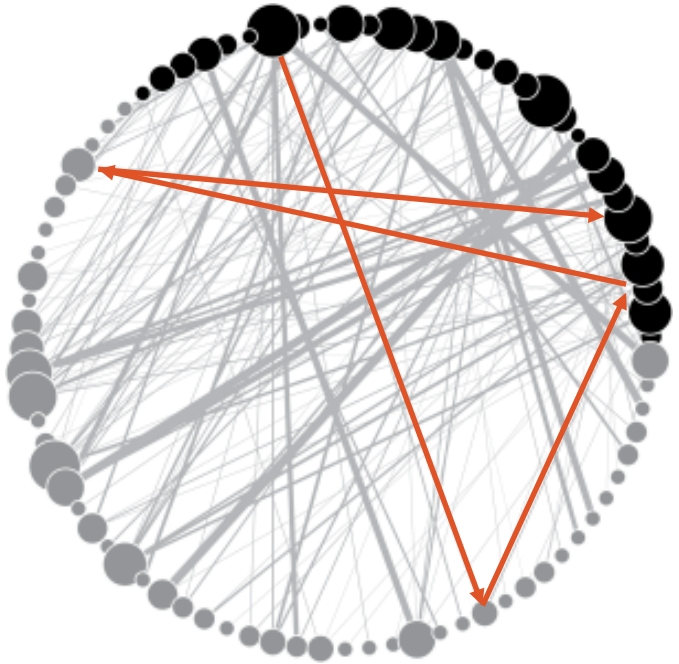

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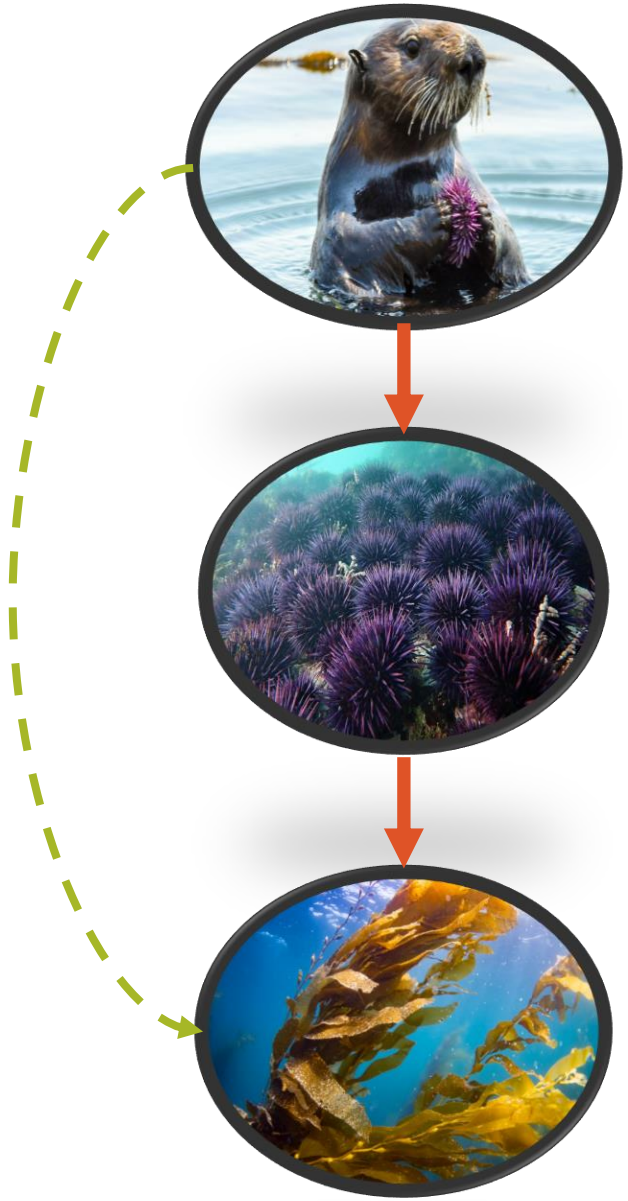

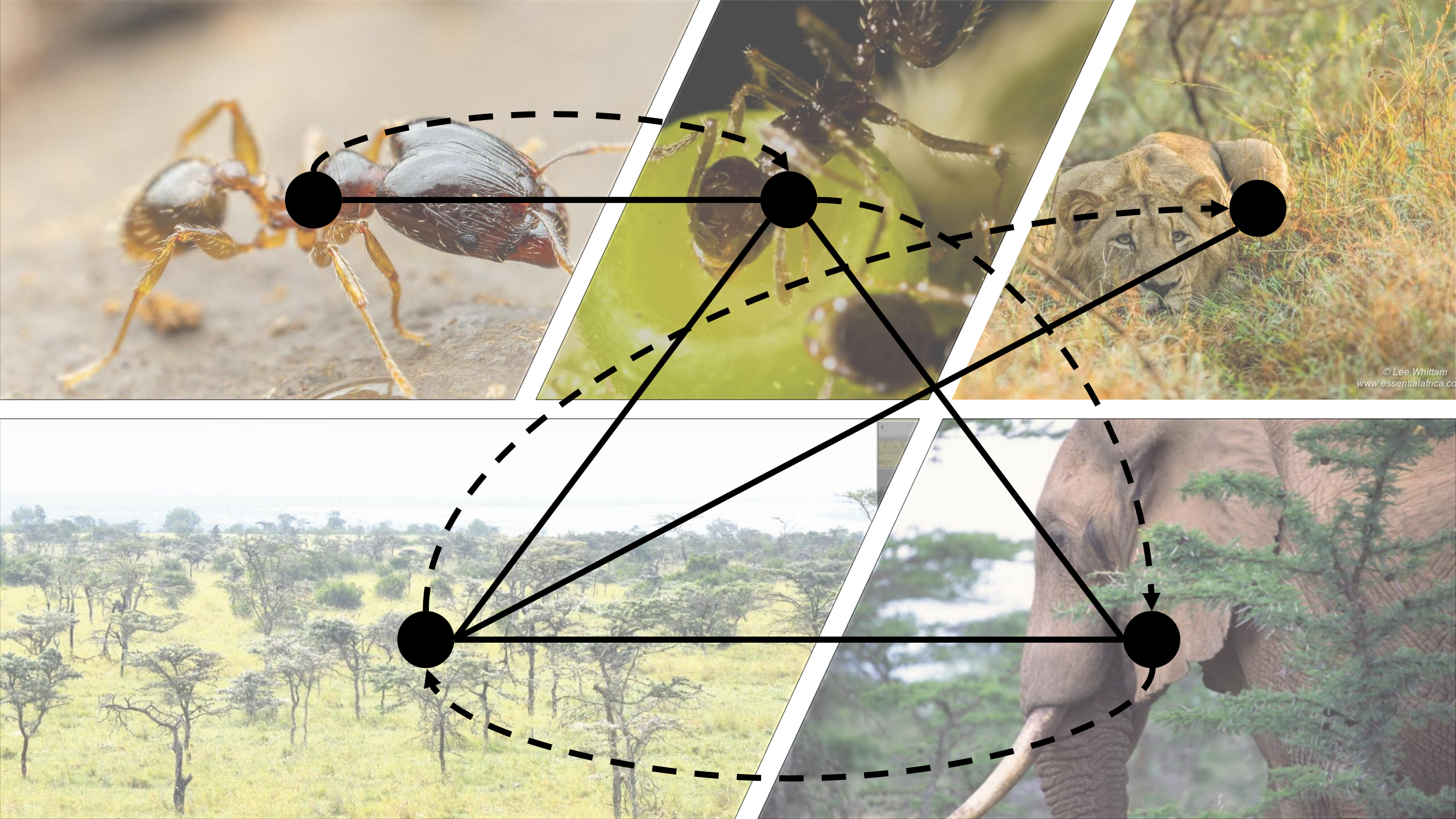
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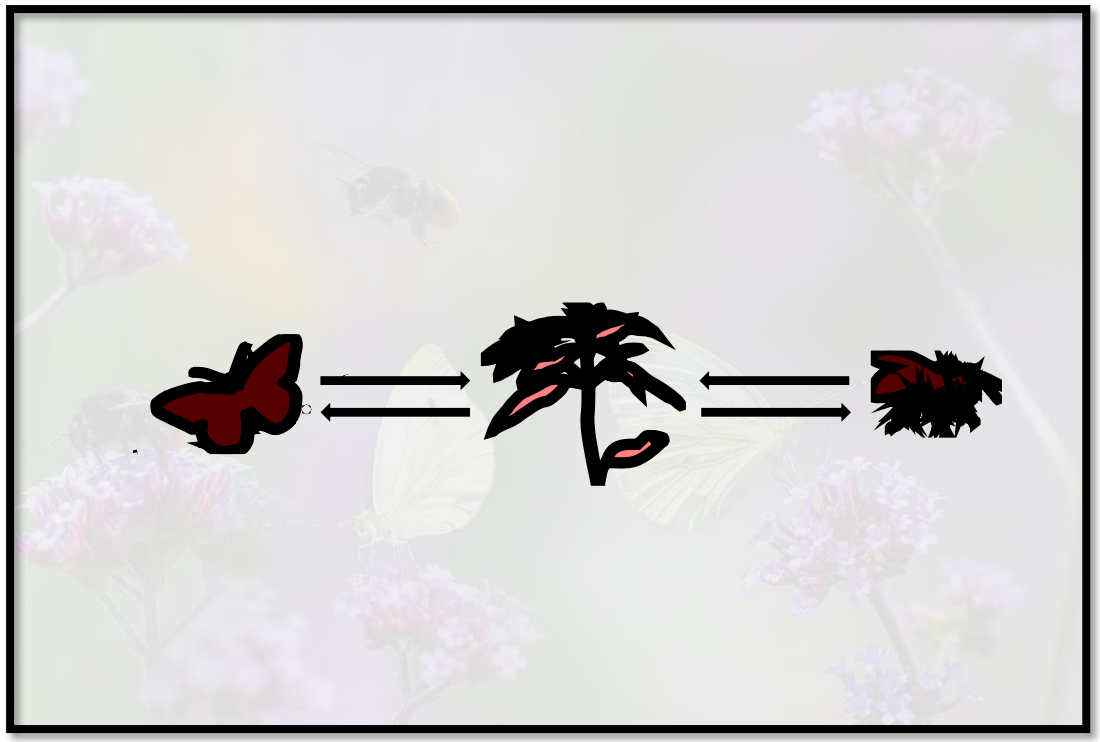
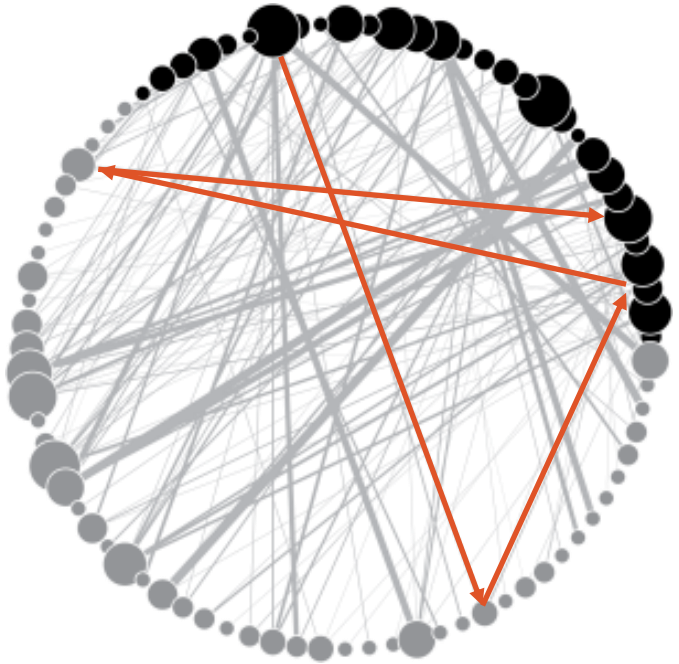
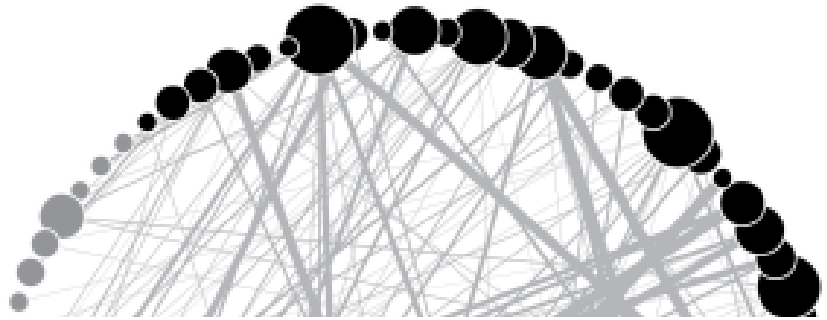




How much indirect effects can shape coevolution?



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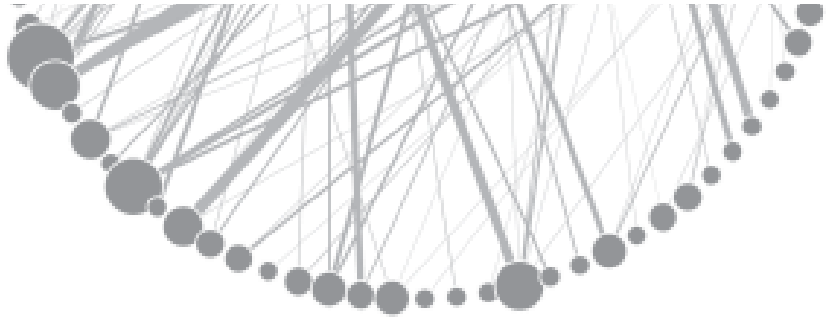
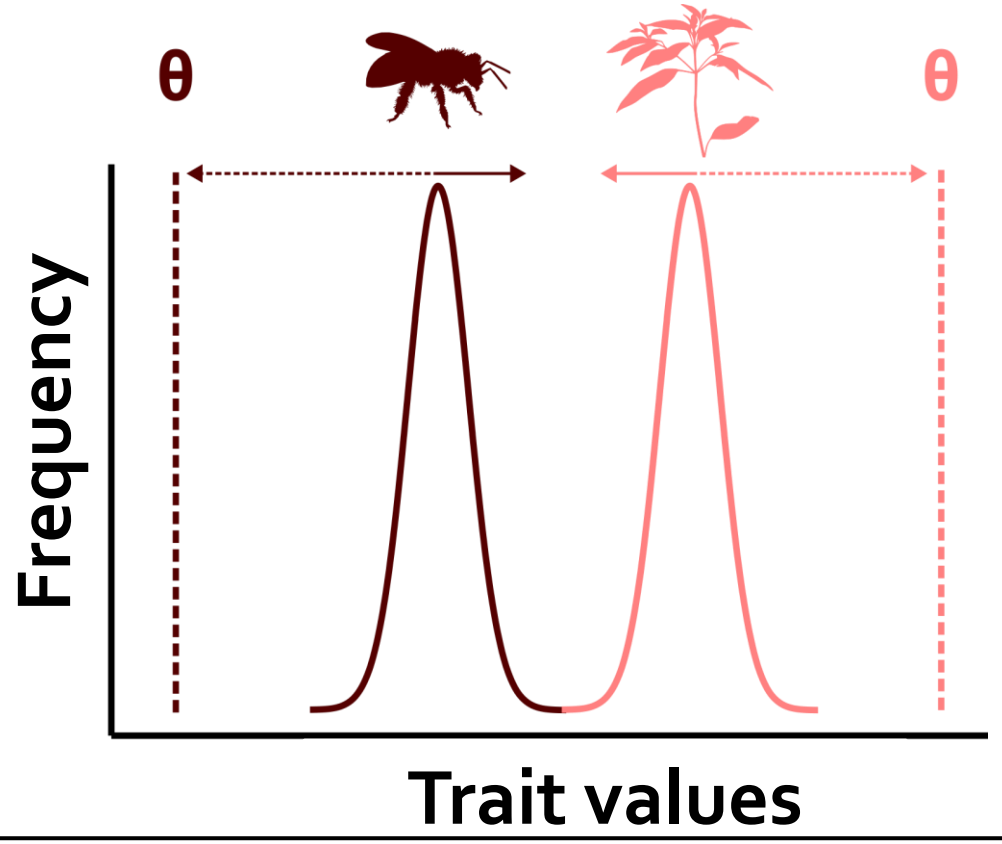


$$\Delta\bar{z}_i = h_i^2 \sigma_i^2 \frac{\partial\, ln\left(\bar{w}_i^{(t)}\right)}{\partial\, \bar{z}_i^{(t)}}$$



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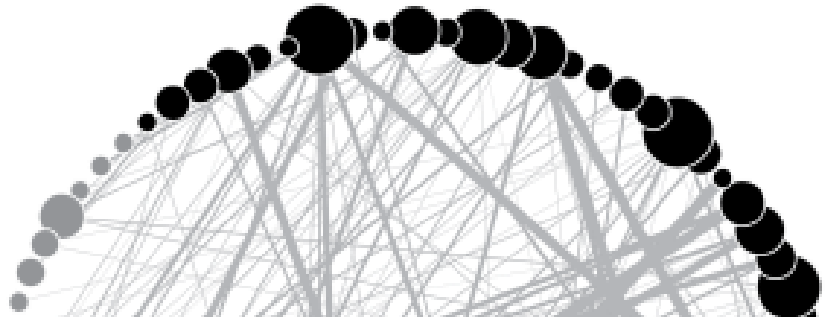

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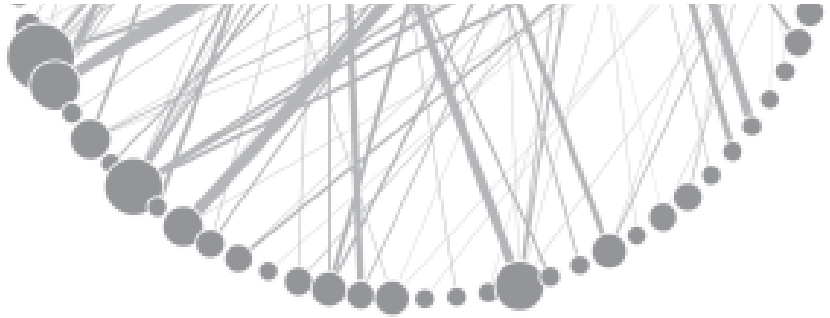

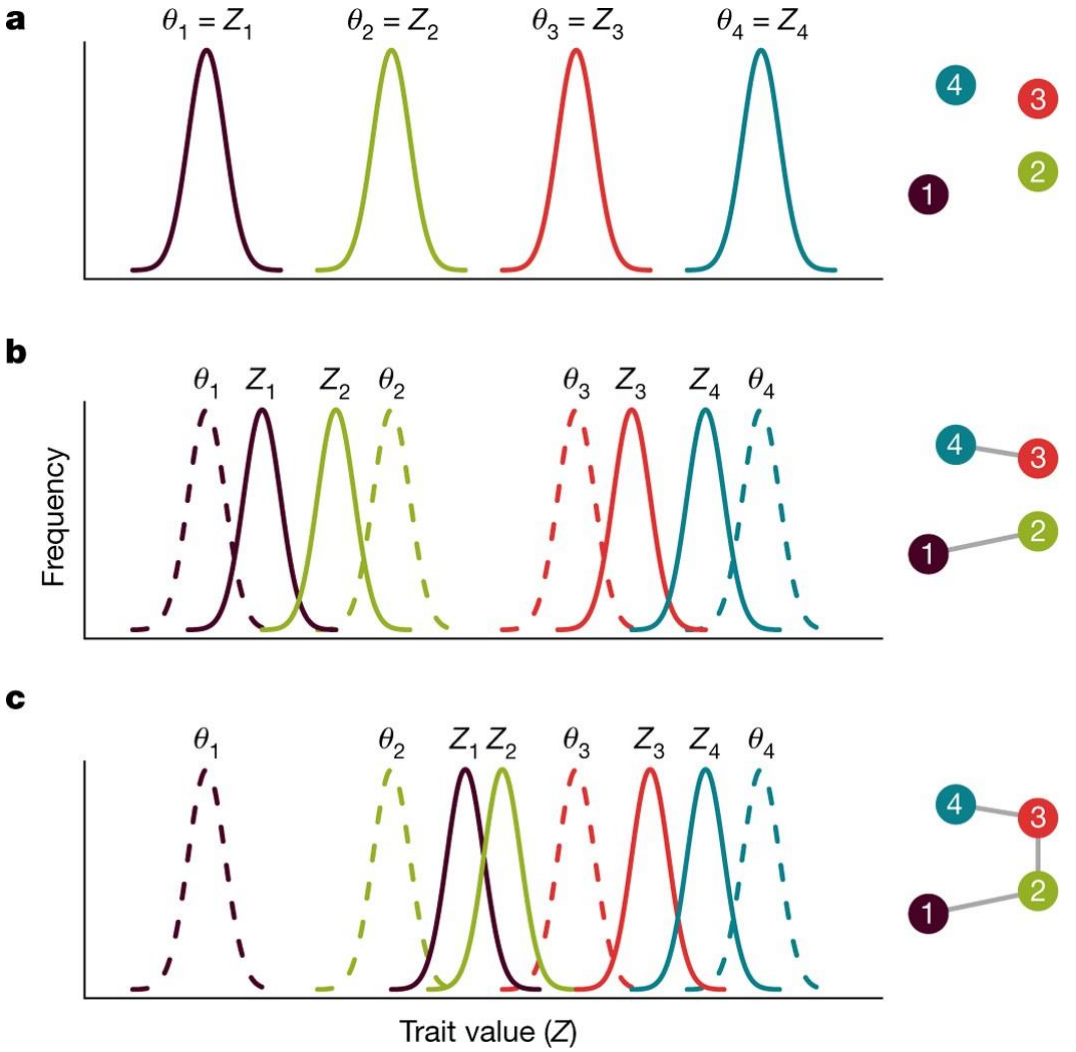

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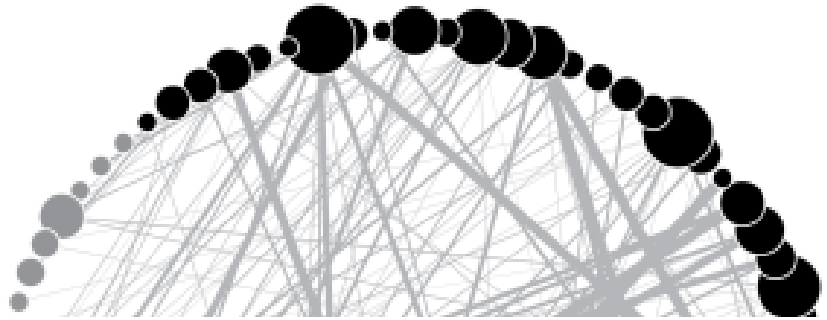

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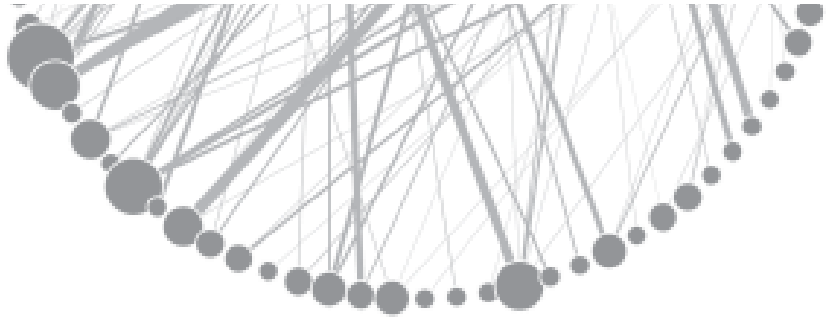
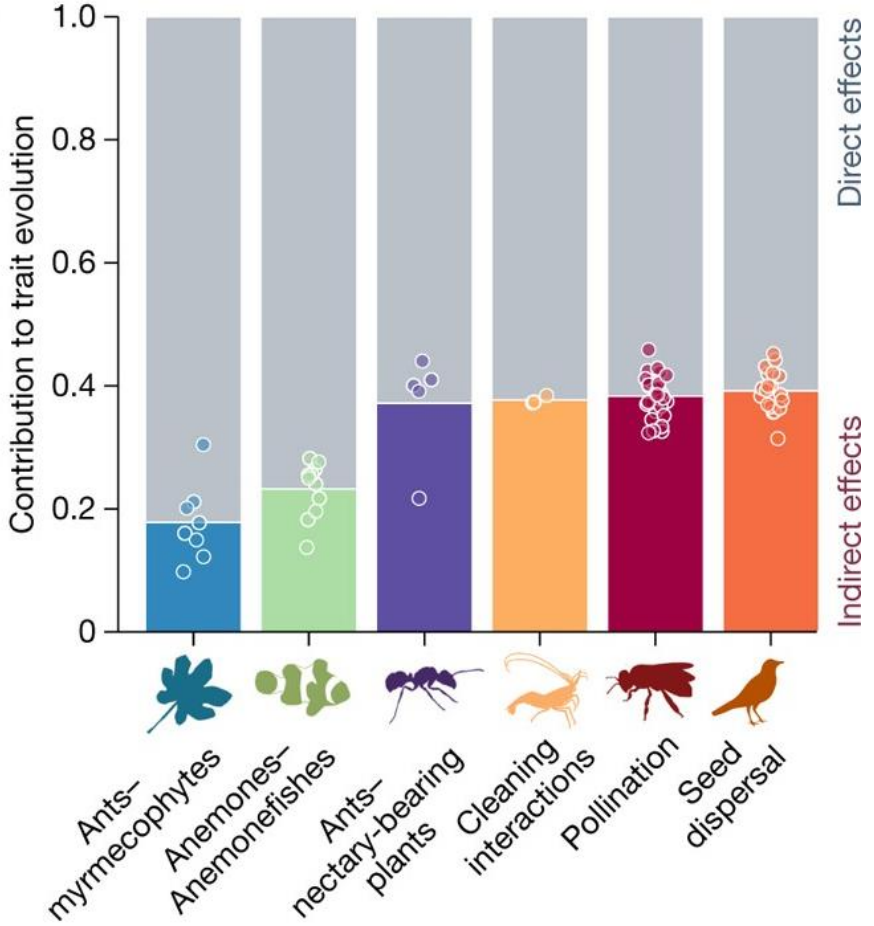
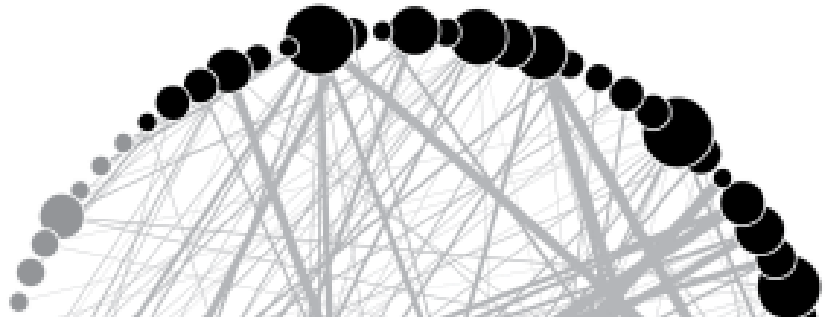




Indirect effects can contribute as much as direct ones to coevolution



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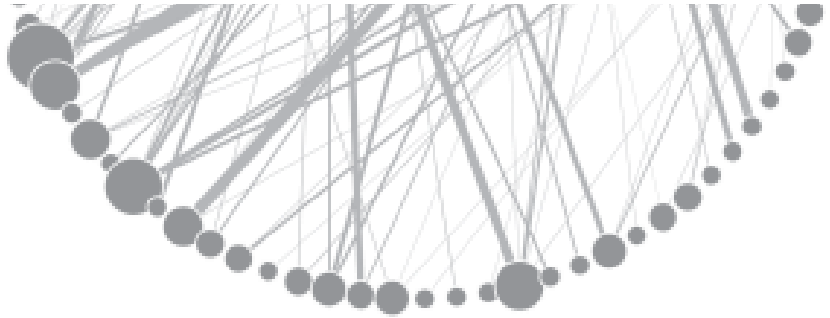
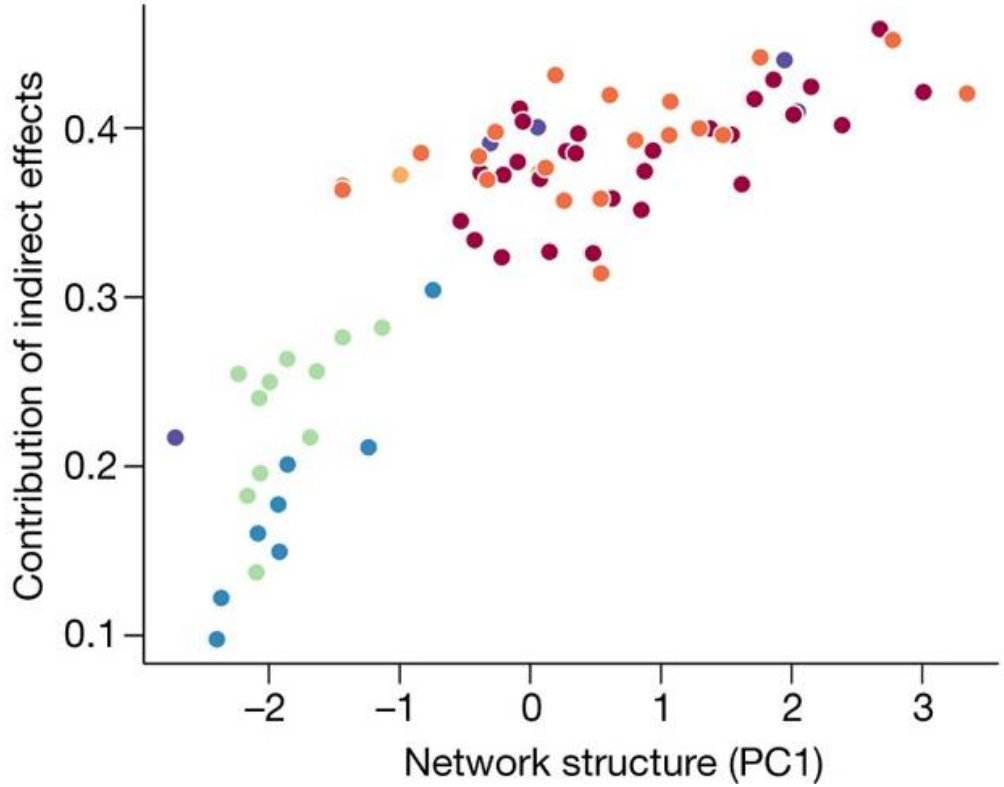
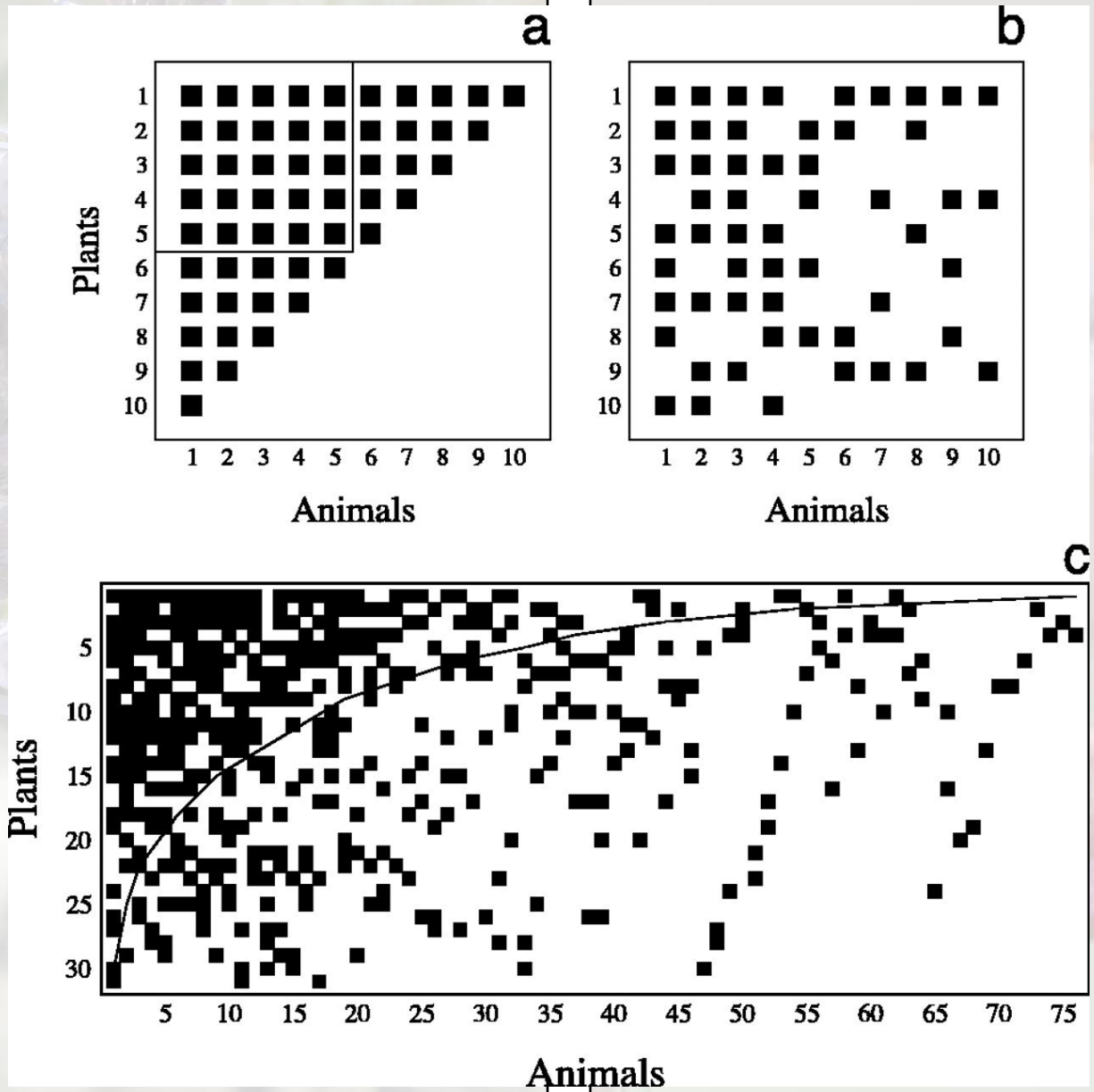


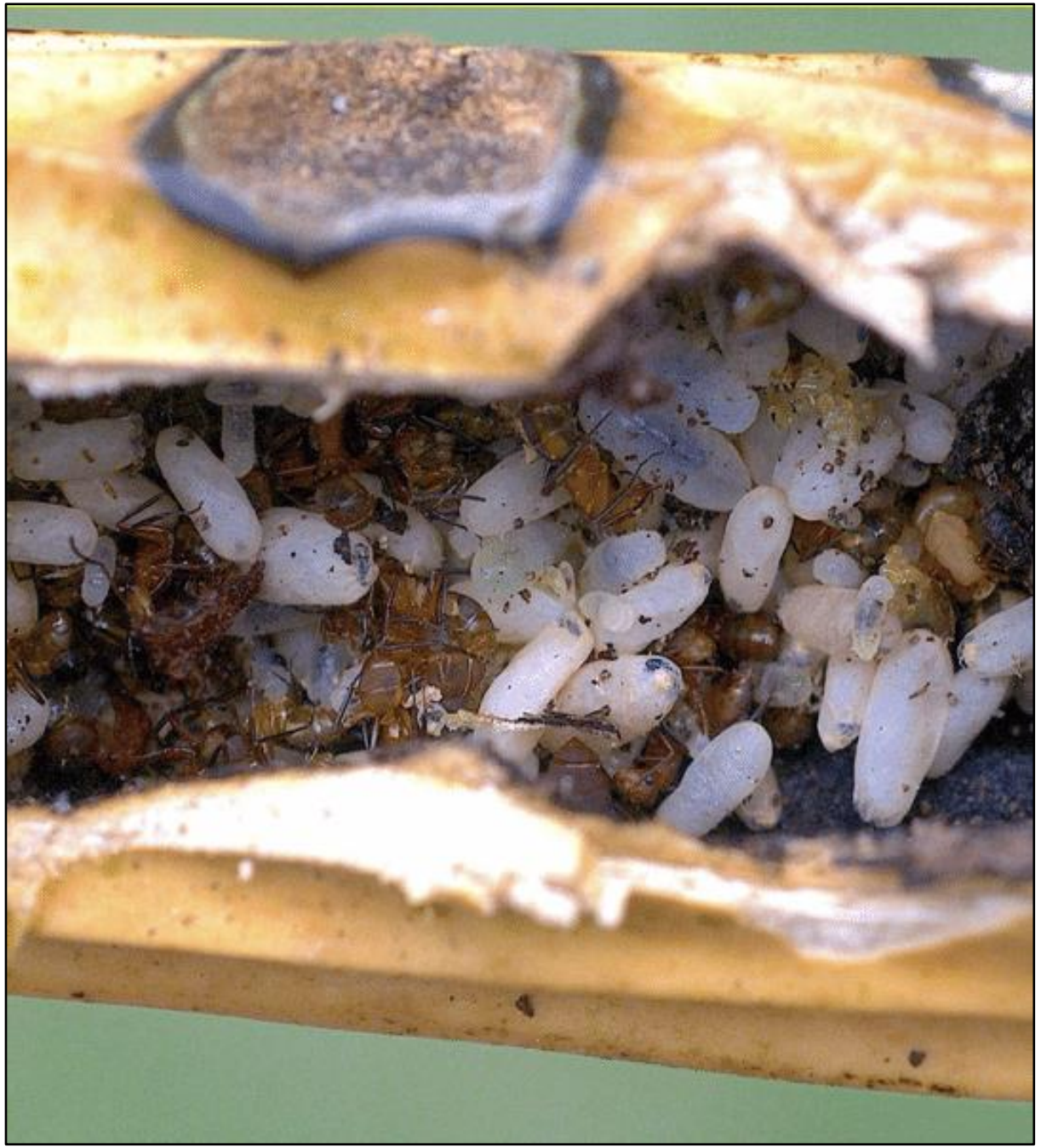


The structure of ecological networks can favor or hinder indirect effects



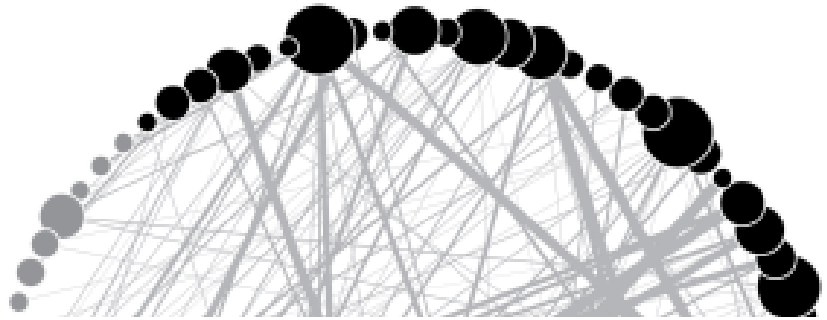
(Bascompte *et al.* 2003)


00129405 © Mark Moffett / Minden / naturepl.com



MYRMECOPHYTES & ANTS	*Cecropia purpuracens*	*Cecropia concolor*	*Cecropia distachya*	*Cecropia ficifolia*	*Pouruma heterophylla*	*Hirtella myrmecophila*	*Hirtella physophora*	*Duroia saccifera*	*Cordia nodosa*	*Cordia aff. nodosa*	*Tococa bullifera*	*Maieta guianensis*	*Maieta poeppiggi*	*Tachigali polyphylla*	*Tachigali myrmecophila*	*Amaioua aff. guianensis*
Camponotus balzanii	11															
Azteca alfari	1															
Azteca isthmica	1	1	1	1												
Azteca aff. isthmica	1			2												
Allomerus D					23											
Allomerus prancei							5									
Allomerus aff. octoarticulata						3	70	27								
Solenops A							3	1								
Allomerus auripunctata								2		2						
Crematogaster B								1	1	1						
Azteca HC										3						
Azteca G										24	11	2				
Crematogaster D										3	2					
Azteca CO										1						
Pheidole minutula											1	93	28			
Crematogaster A							1				7	7	1			
Azteca TO											1					
Crematogaster C											3		3			
Azteca schummani														2	1	
Pseudomyrmex nigrescens														7	16	
Pseudomyrmex concolor														16	18	
Azteca D															1	
Azteca polymorpha															2	
Crematogaster E										1					1	
Azteca Q																3
Unoccupied plants	14	0	0	0	0	0	3	8	0	31	0	5	5	6	5	0

(Fonseca & Ganade *1996*)



Indirect effects drive coevolution in mutualistic networks

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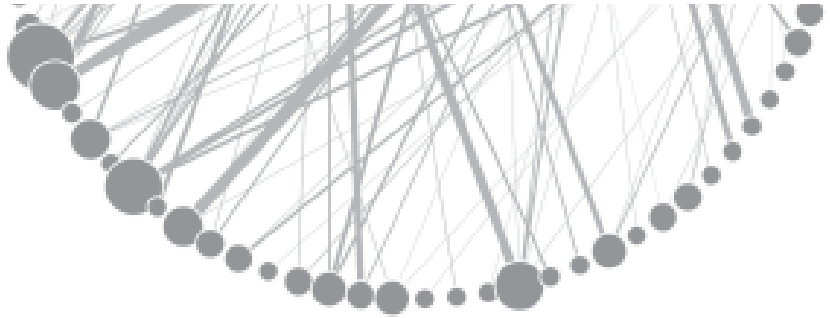
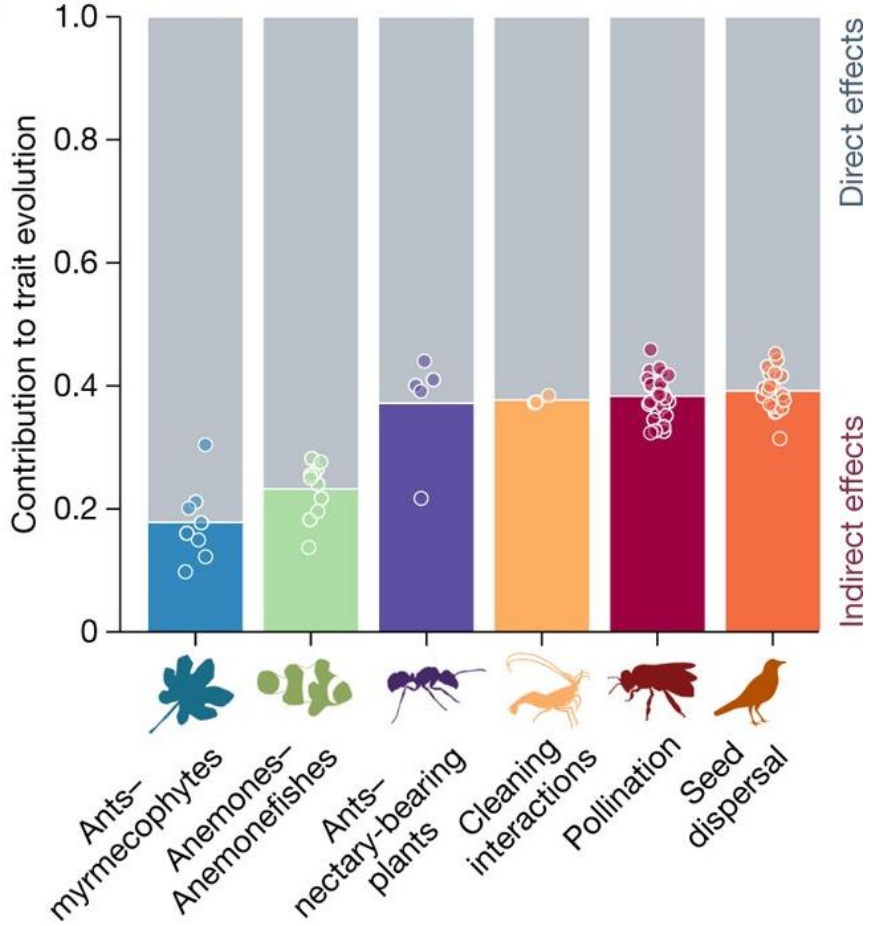
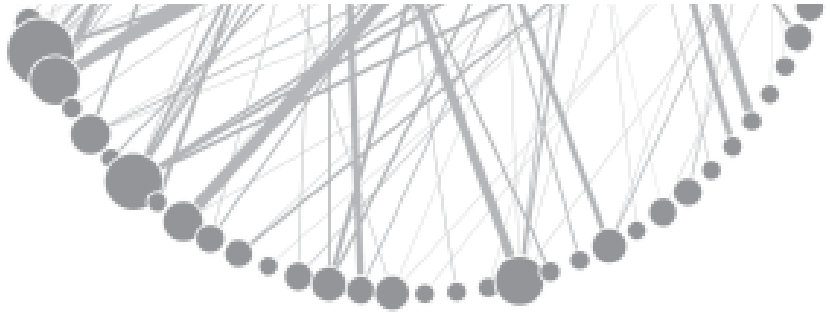




What are the consequences of these indirect effects?

The Role of Indirect Effects in Coevolution along the Mutualism-Antagonism Continuum

Fernando Pedraza,[1,*,†] Hanlun Liu,[1,2,†] Klementyna A. Gawecka,[1,†] and Jordi Bascompte[1]



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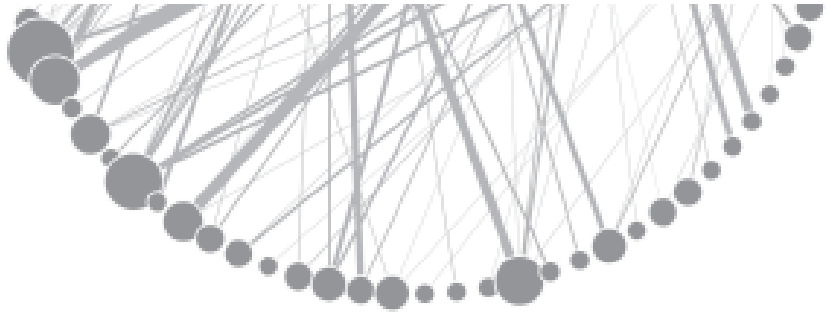

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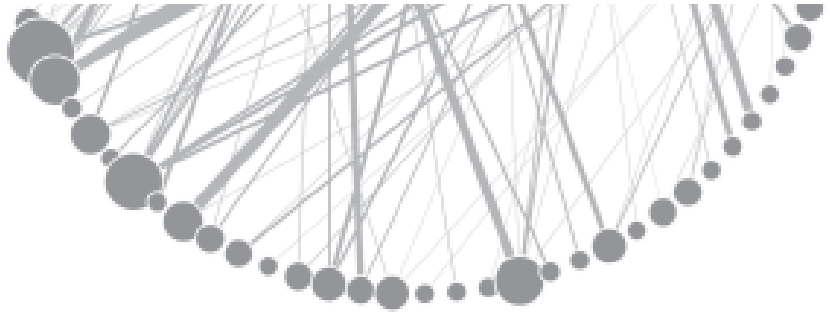

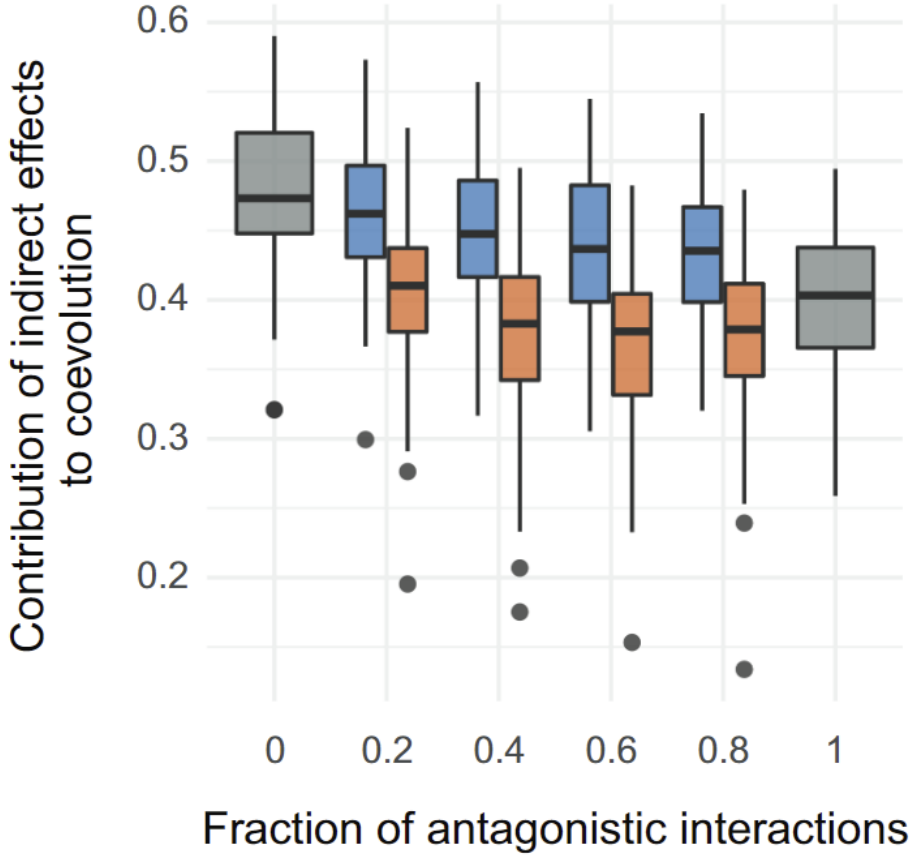

It depends: nature of the interaction and the overall structure of the network

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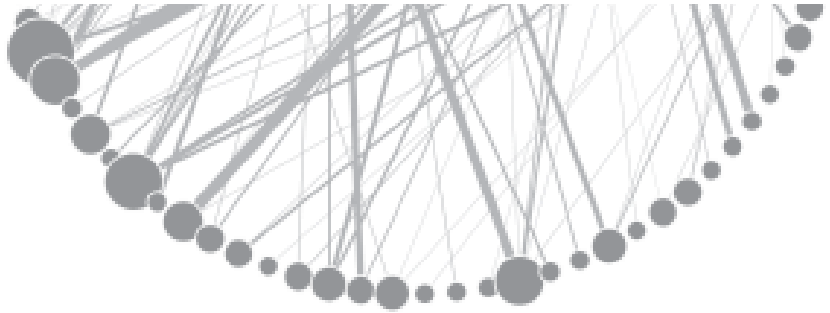

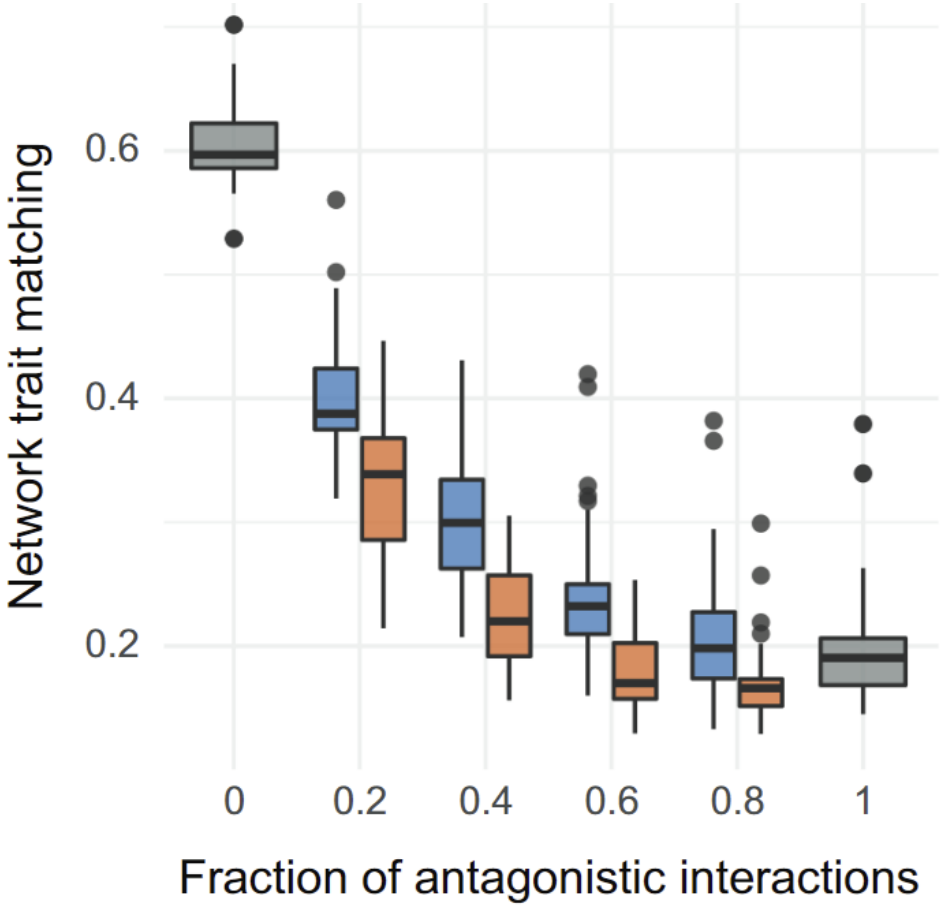

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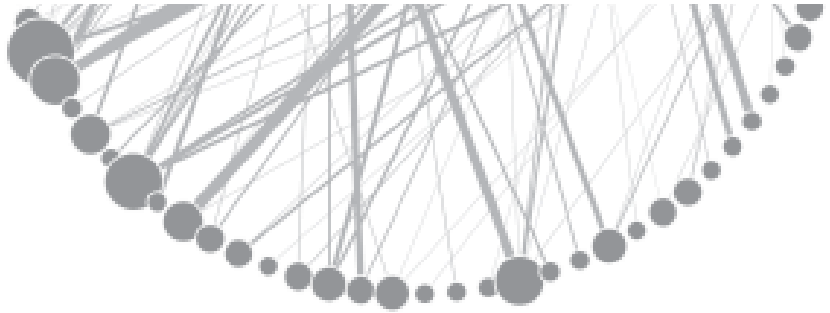

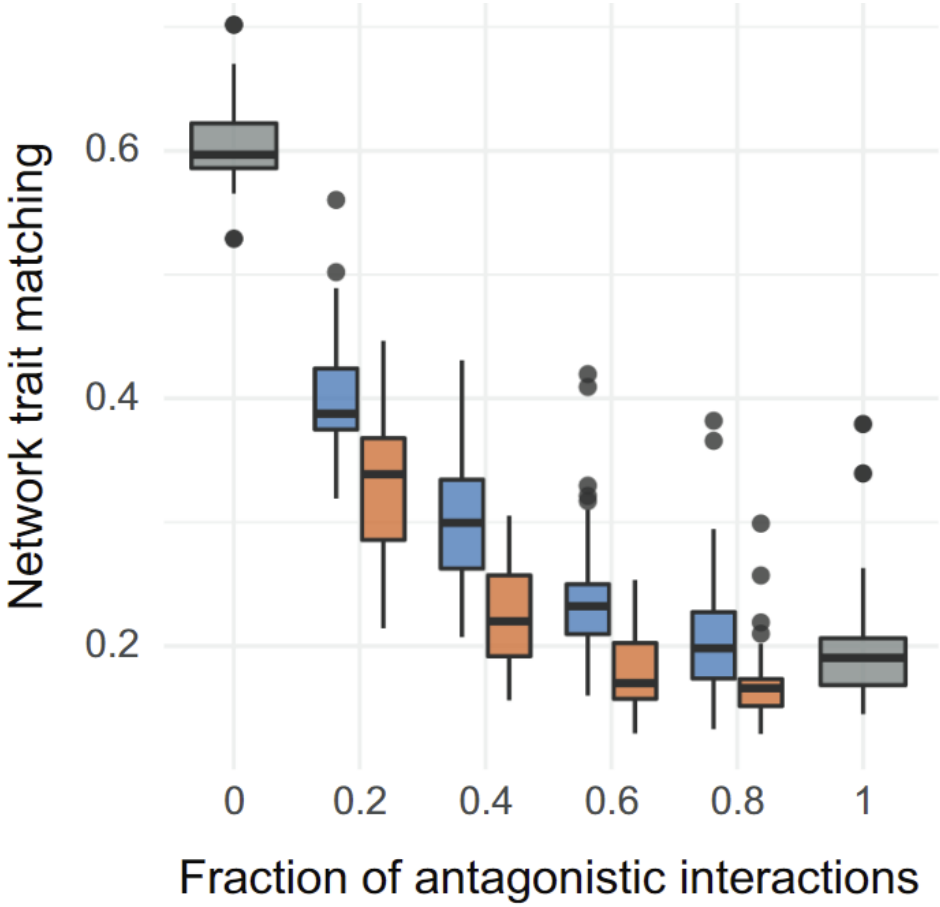

Indirect effects shape trait matching at the network scale

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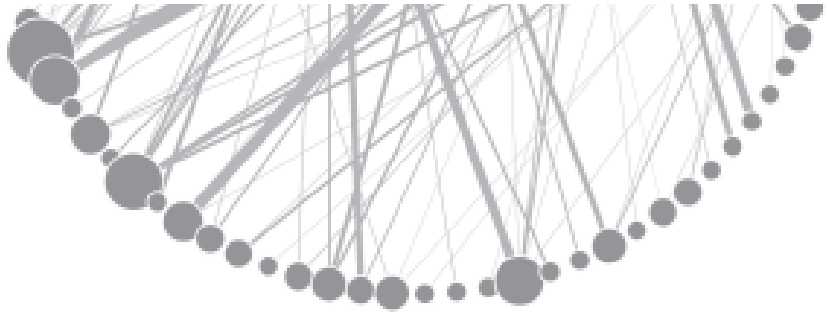
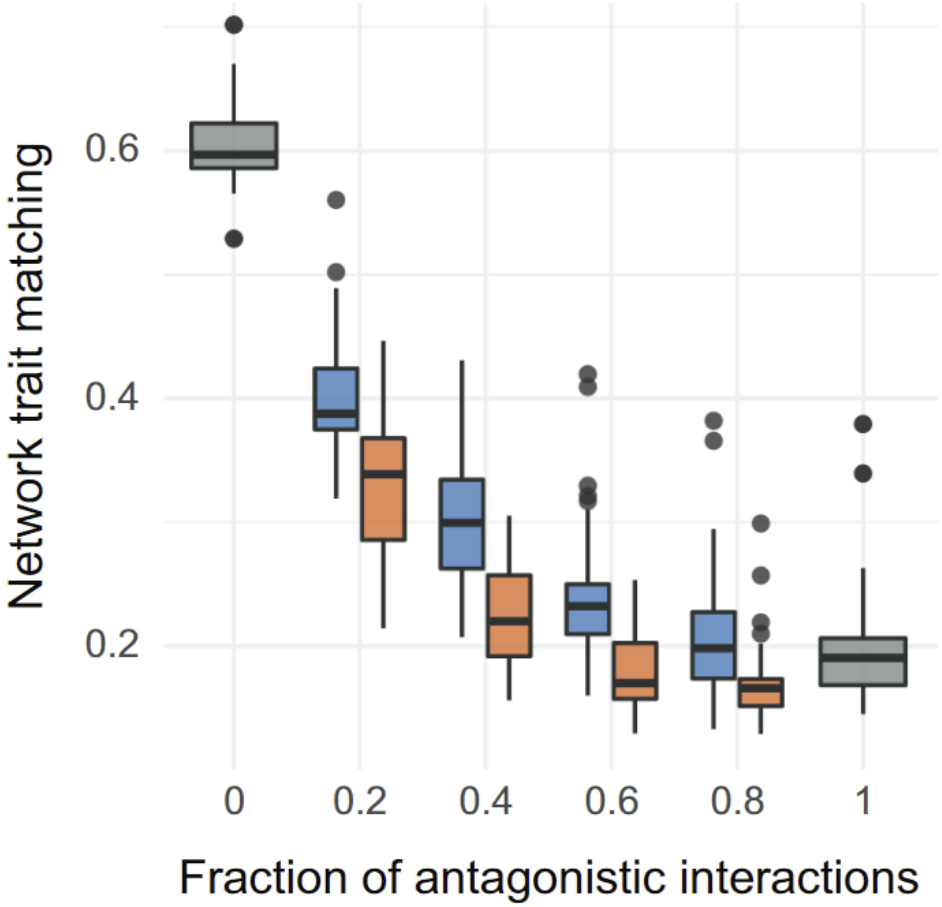
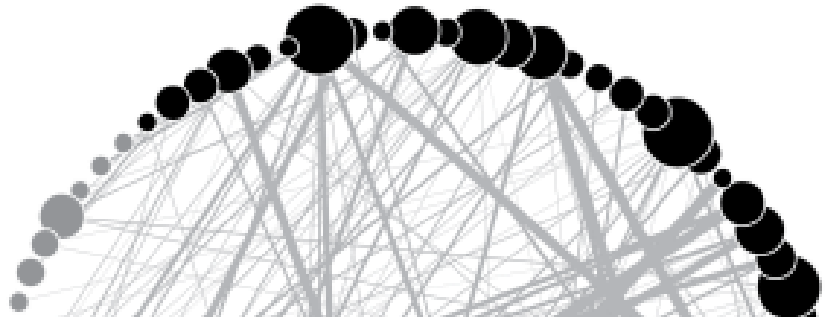




How these indirect effects shape adaptations and the fitness of species?



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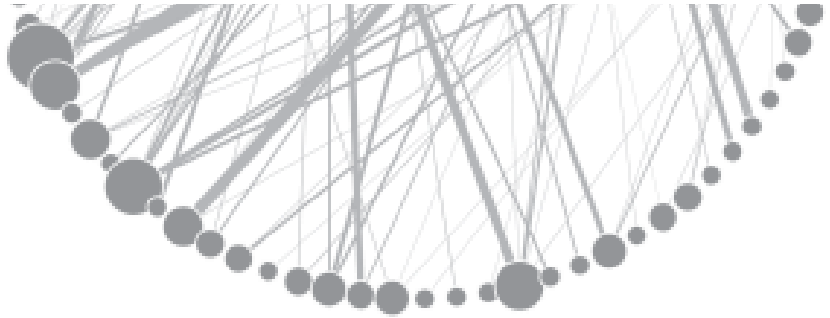

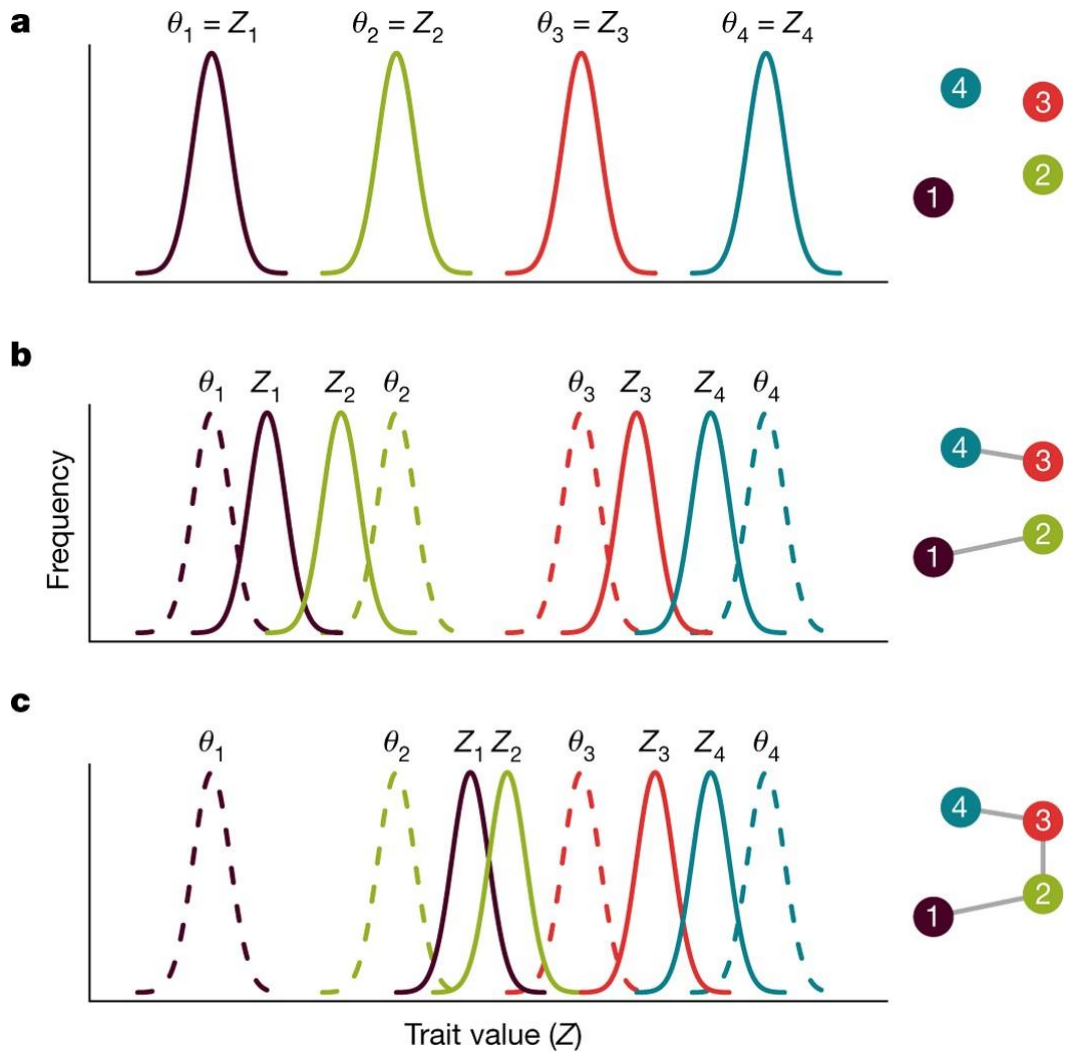

How these indirect effects shape adaptations and the fitness of species?

Indirect effects shape species fitness in coevolved mutualistic networks

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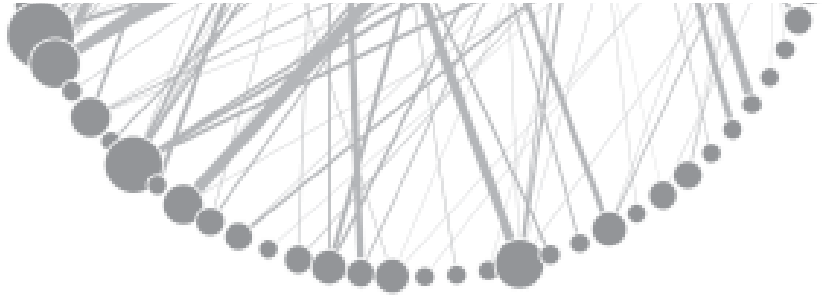

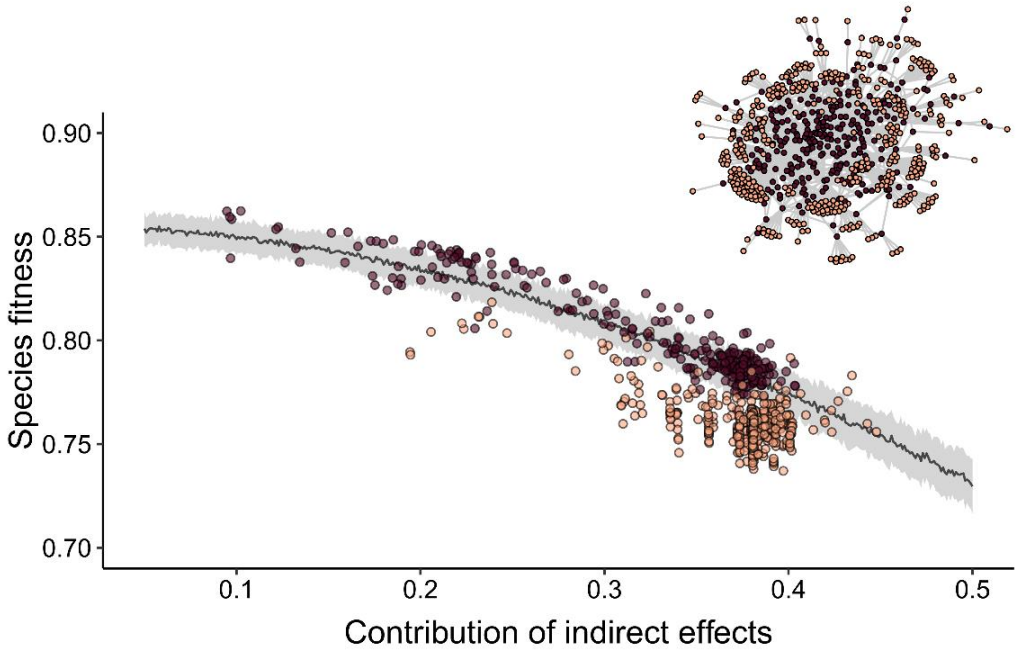

Indirect effects can hinder the ability of species to adapt to direct partners – decreases in fitness

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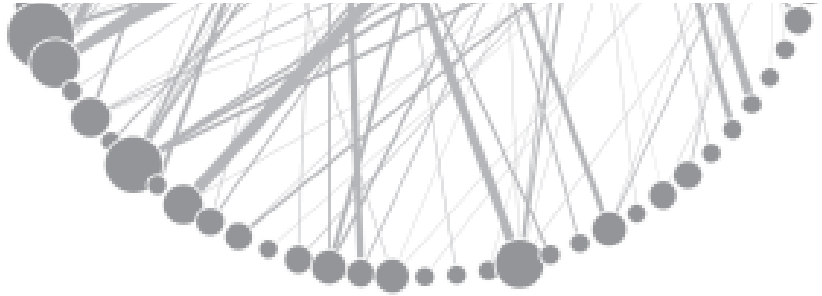
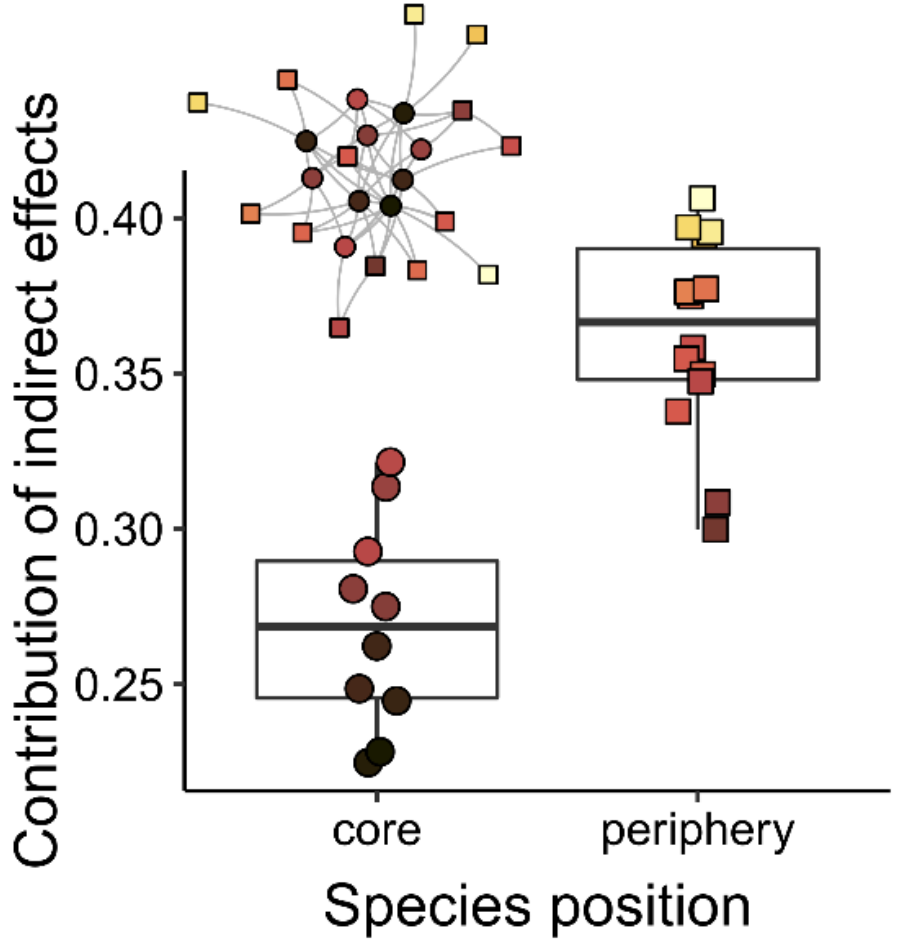
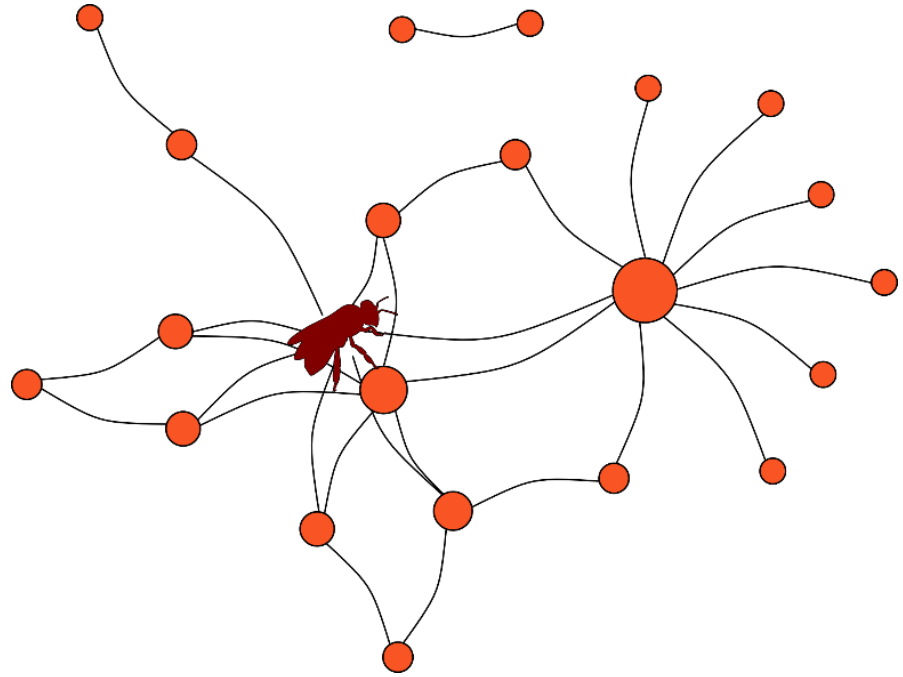
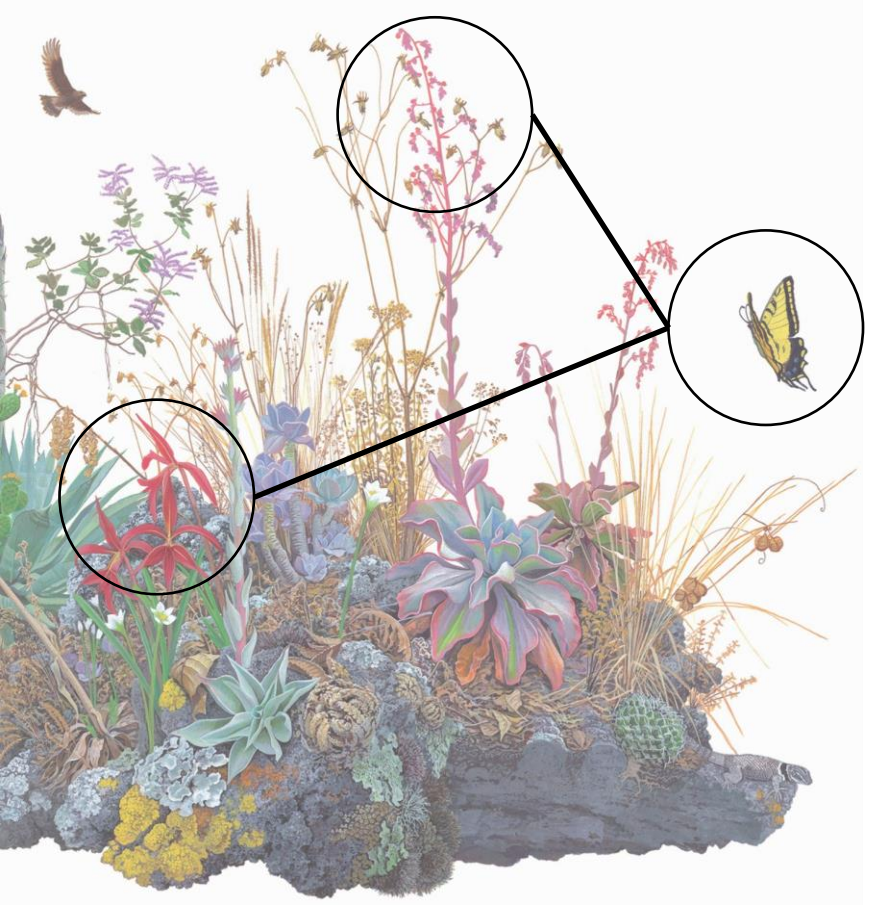


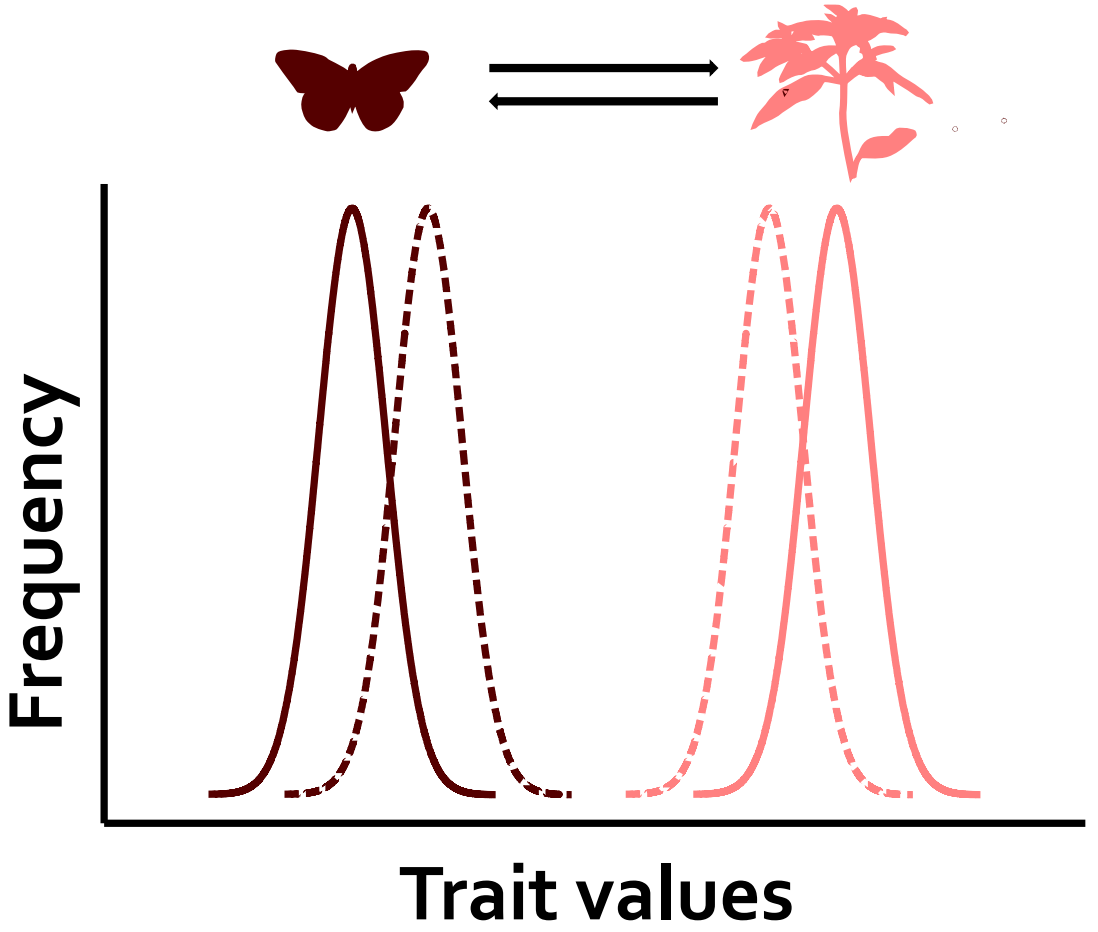


Specialists receive more indirect effects and have higher decreases in fitness

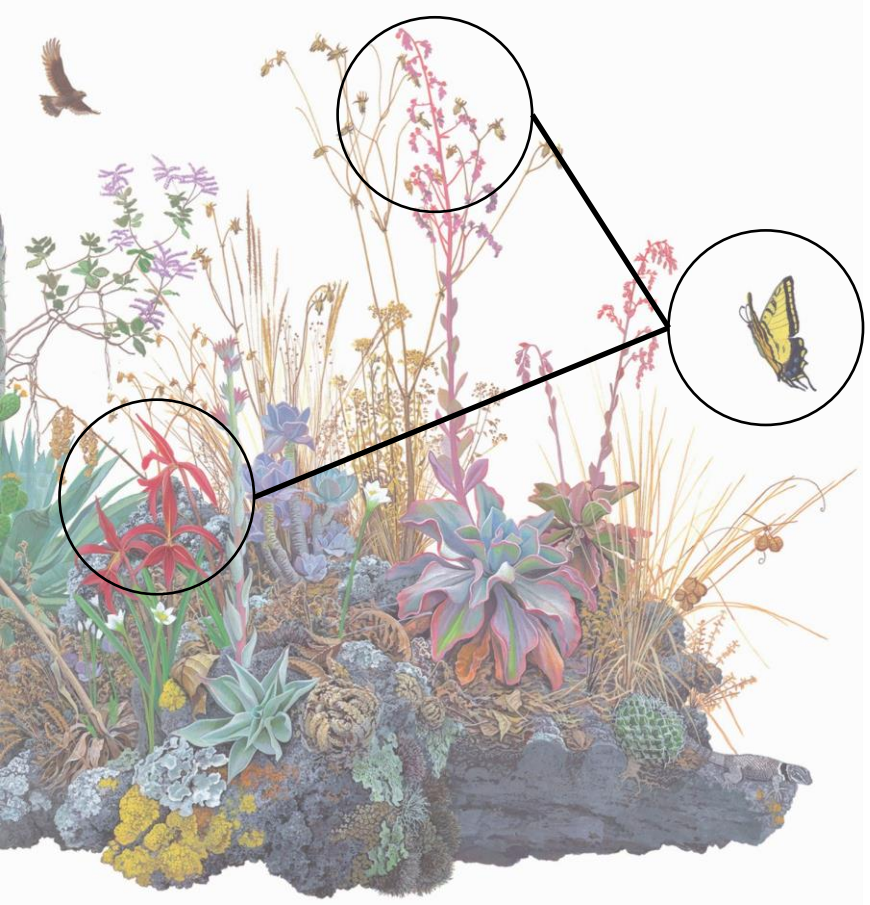


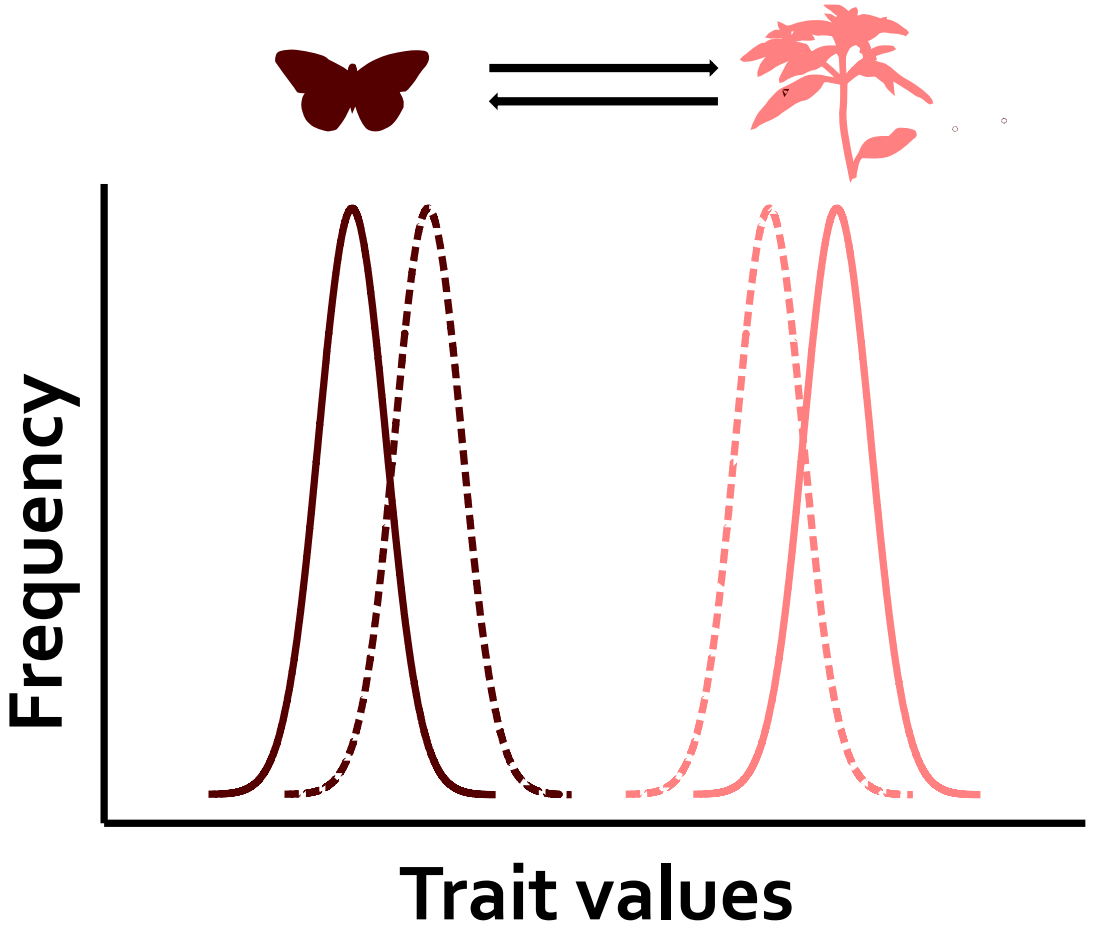
Invasive species can boost indirect effects and decrease the fitness of many other species through coevolution



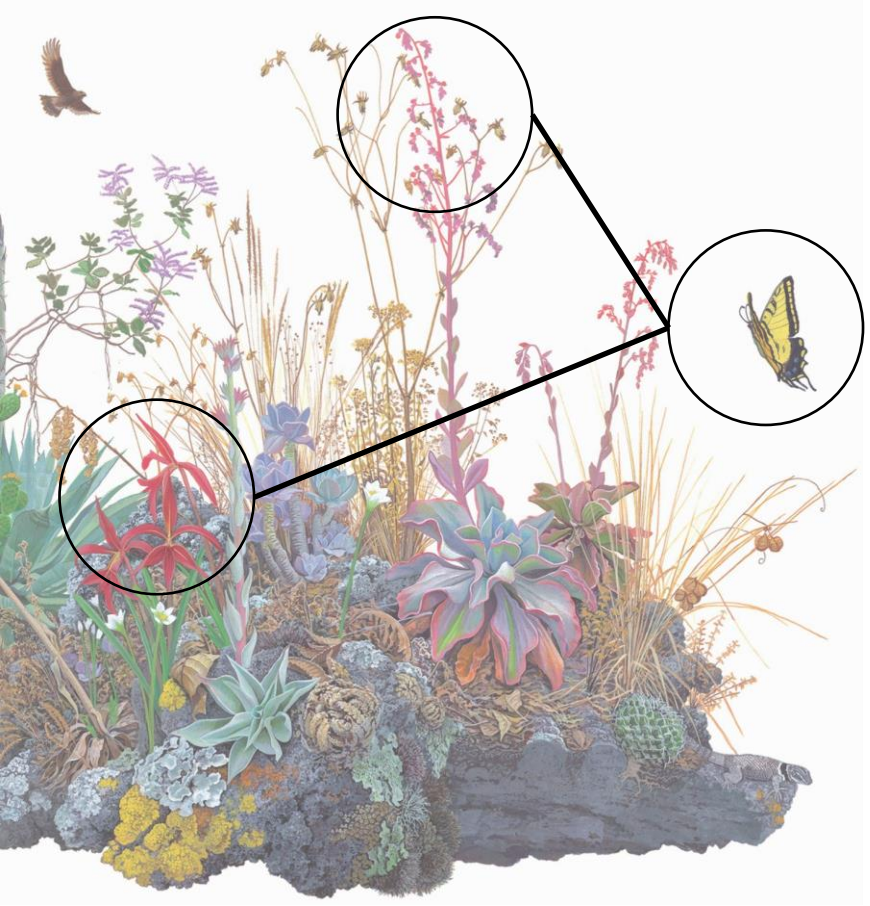


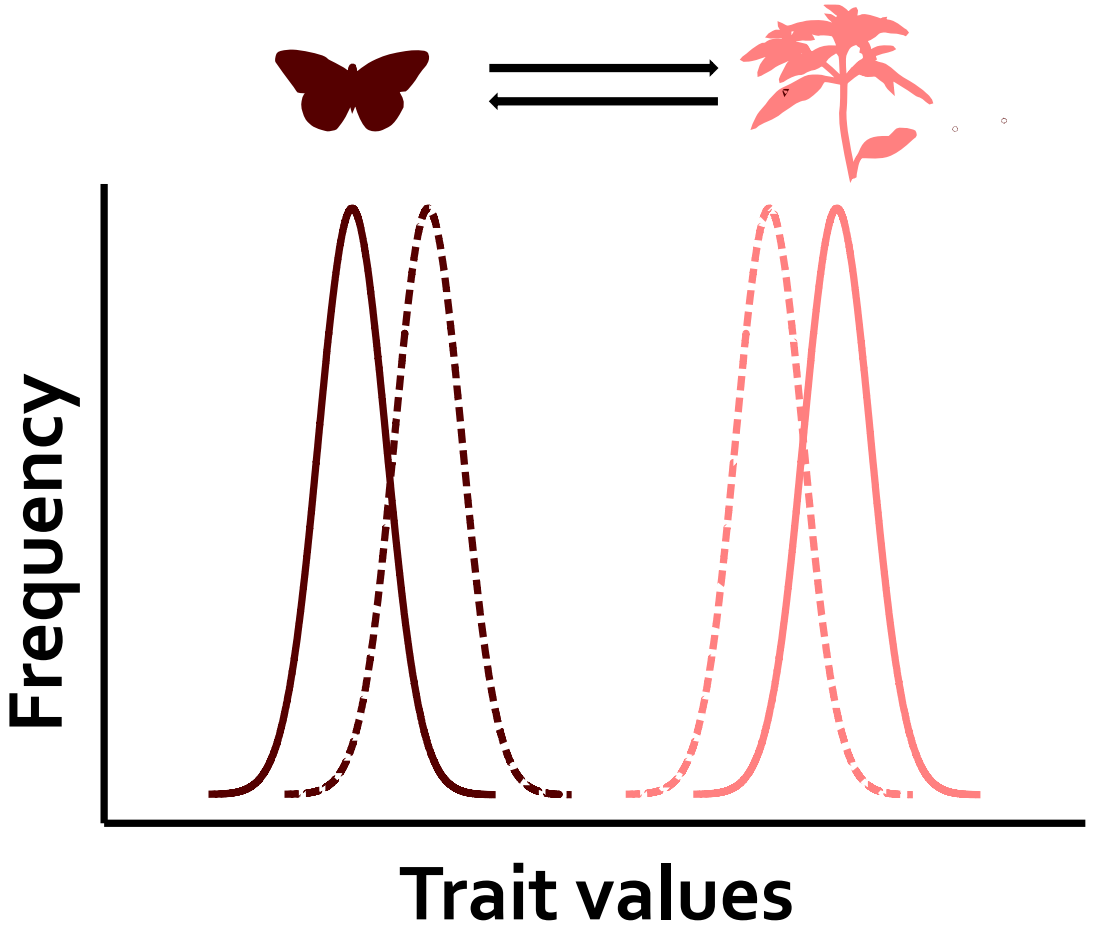
How the structure of ecological networks shape coevolution?



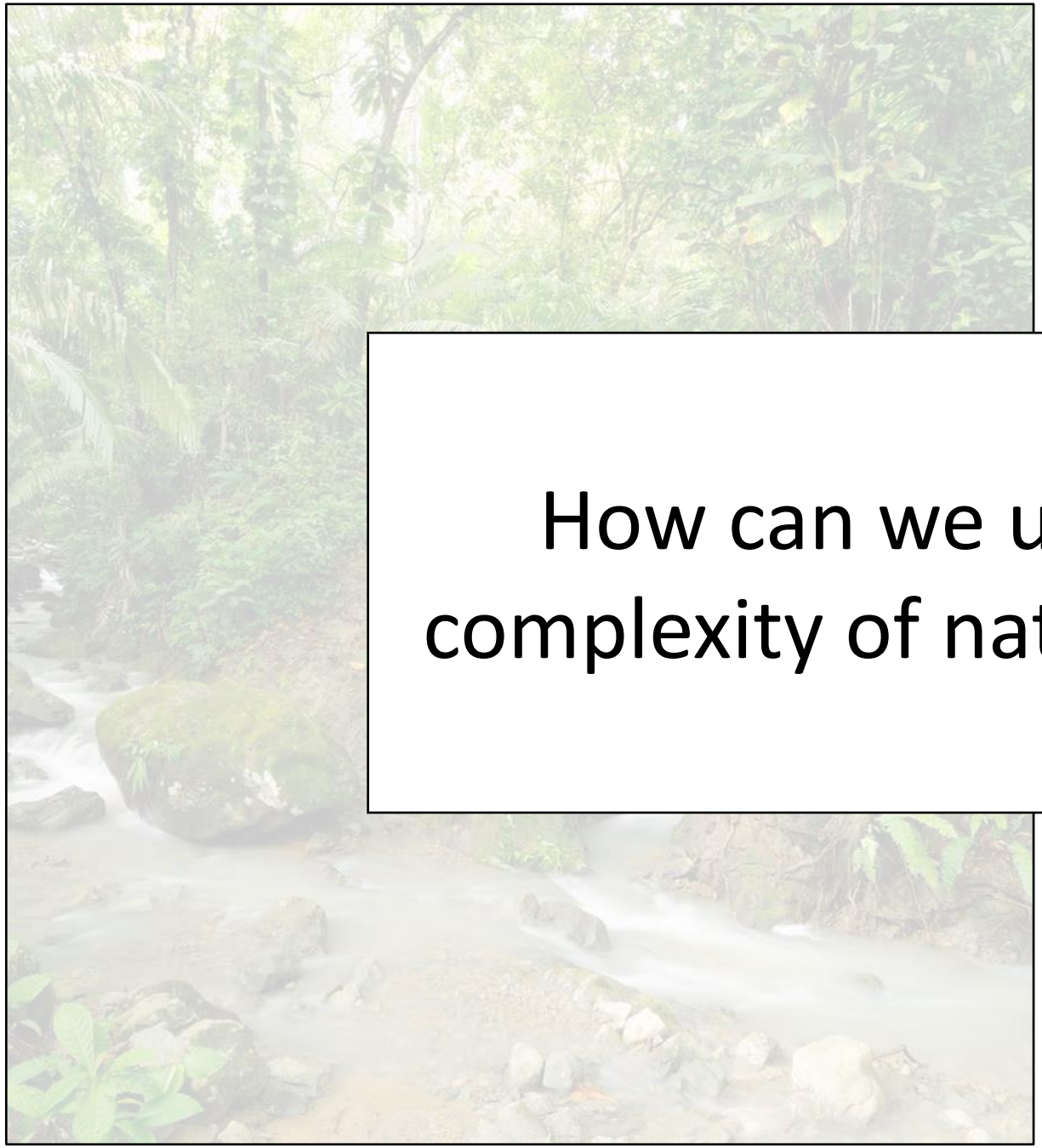


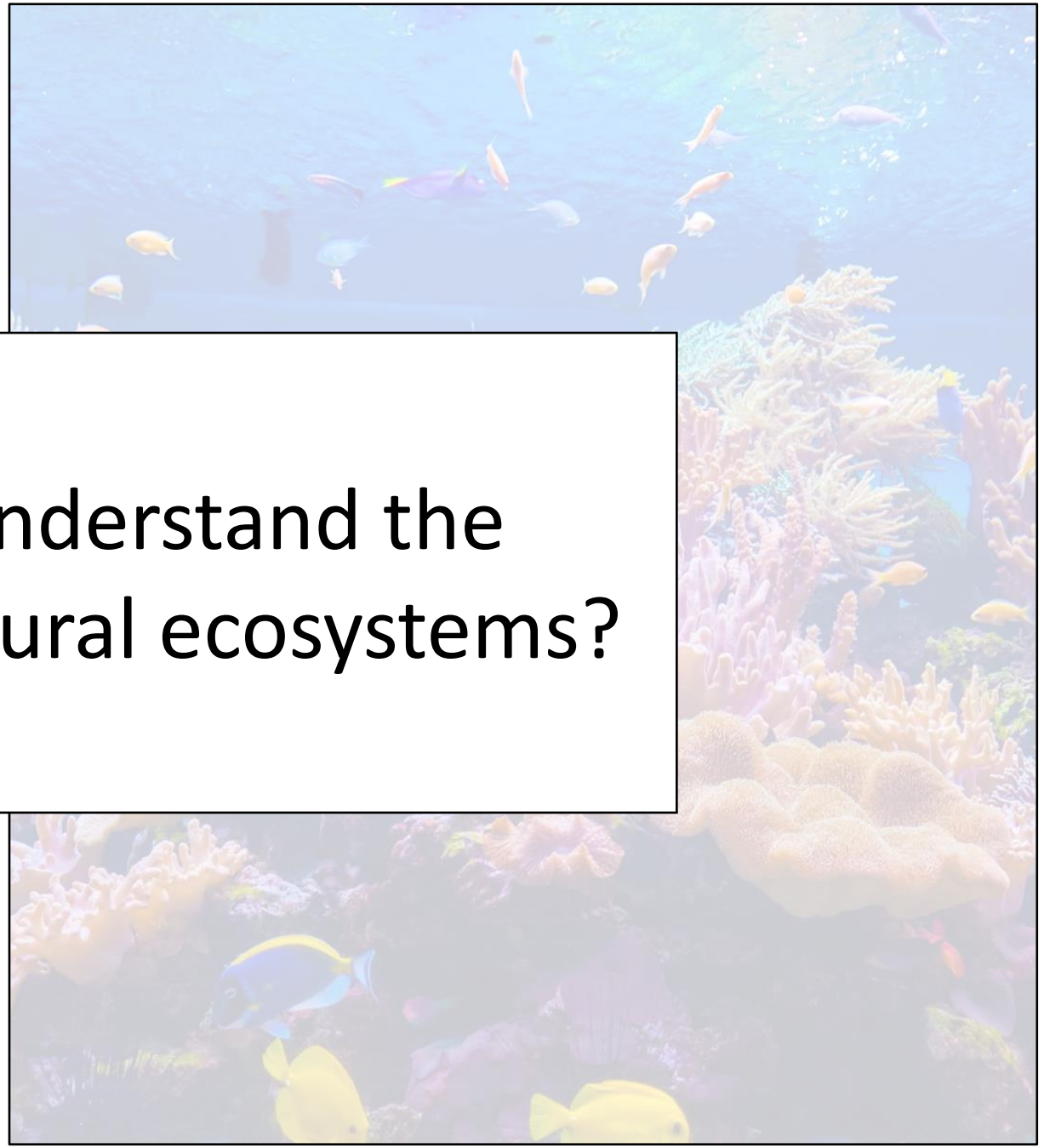
In ecological networks species can indirectly affect each other





These indirect affects modify the outcome of coevolution, shaping trait matching, the efficiency of interactions and fitness



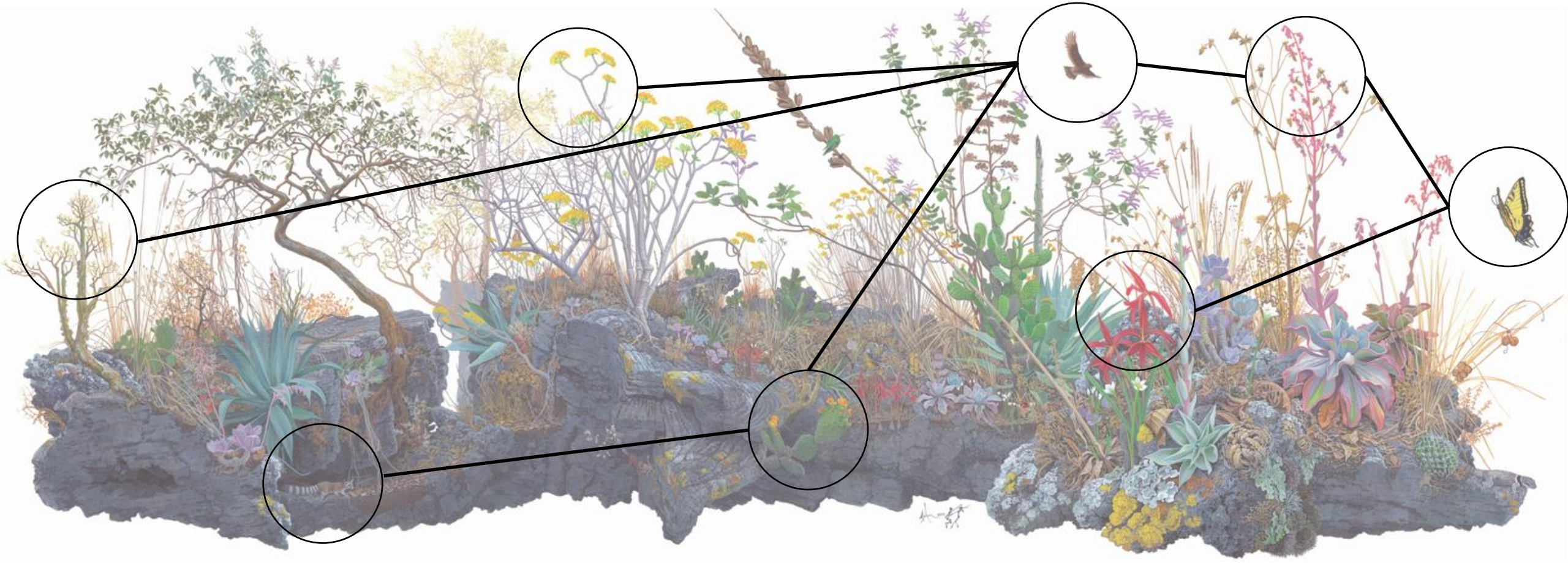


How can we understand the complexity of natural ecosystems?

Depict natural systems as networks, from genetic to spatial networks

Quantify and describe patterns of interactions

Understand the implications of these patterns of interactions for the ecology and evolution of species



"It really boils down to this: that all life is interrelated. We are all caught in an inescapable network of mutuality... ...whatever affects one directly, affects all indirectly."

Martin Luther King Jr.