Roya de café: Informando la intuición con la ecología teórica

John Vandermeer
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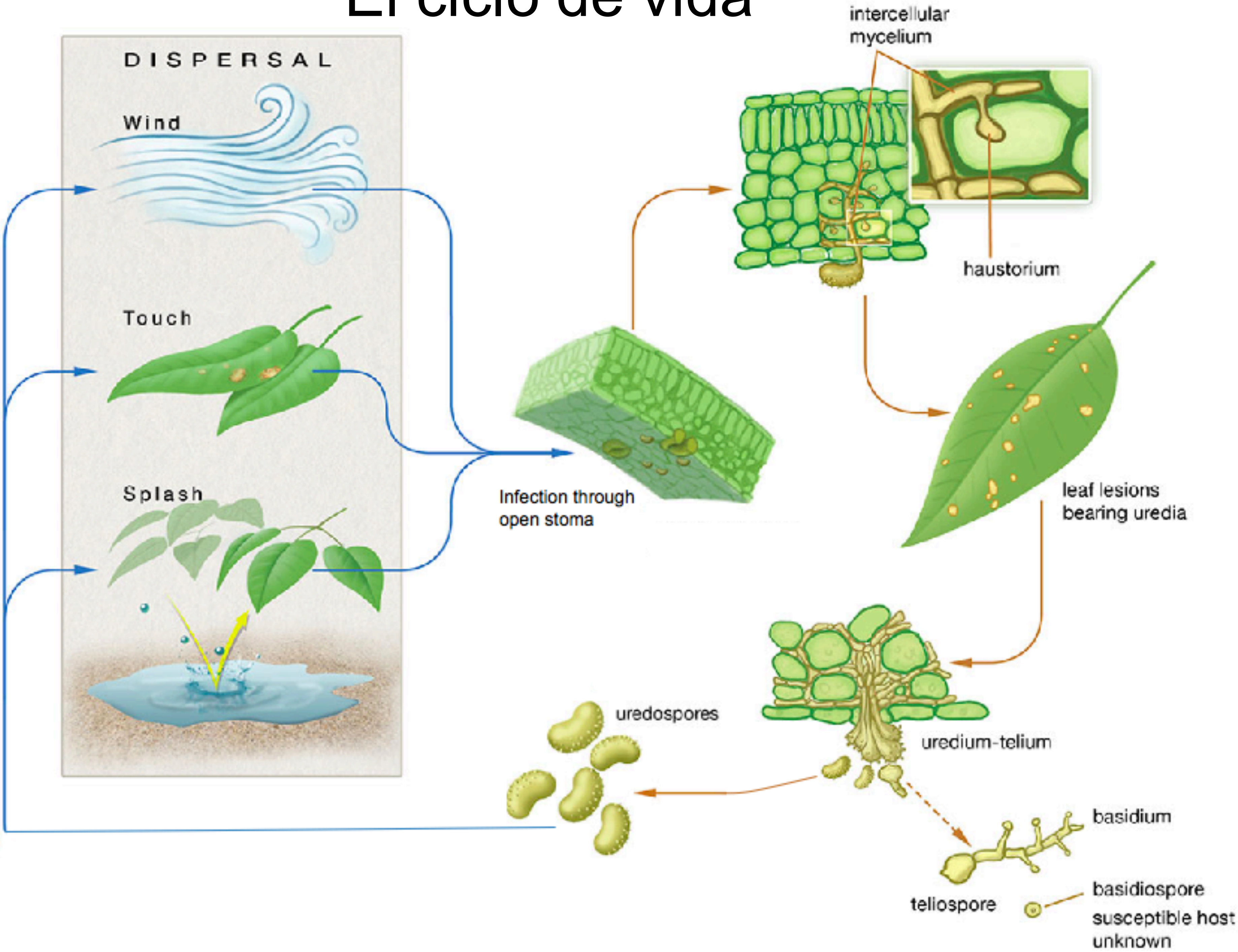
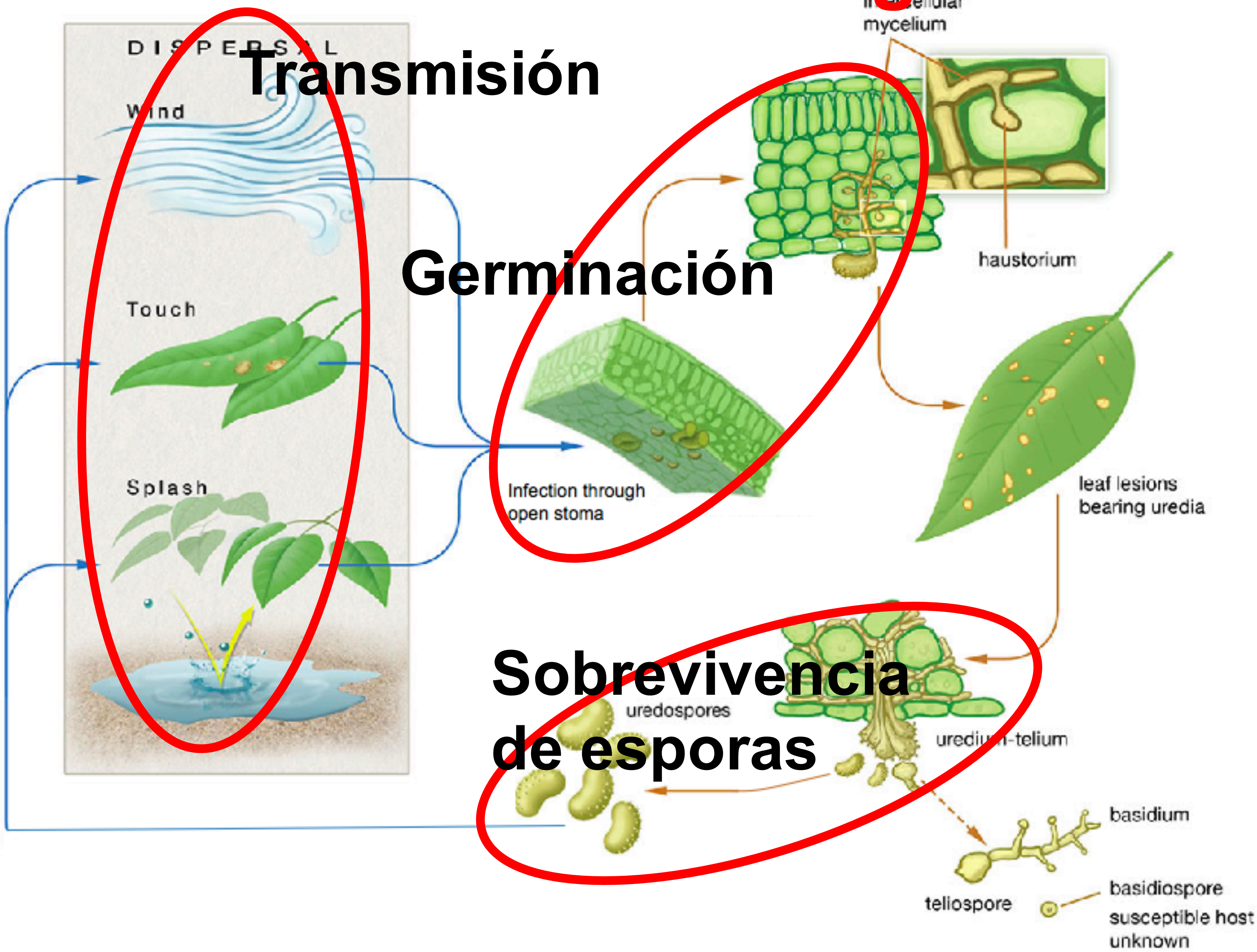
Ann Arbor, MI, EEUU

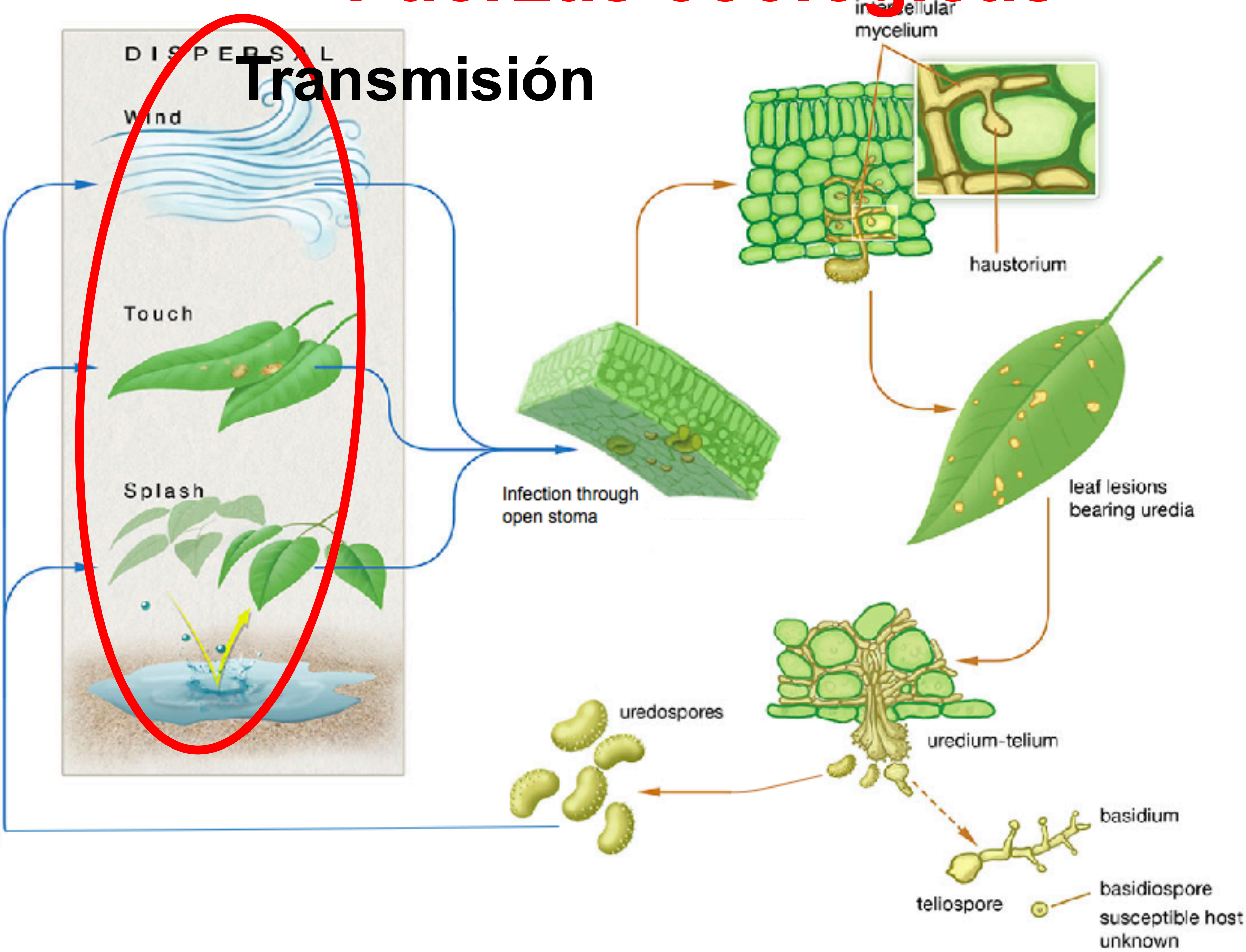
El ciclo de vida



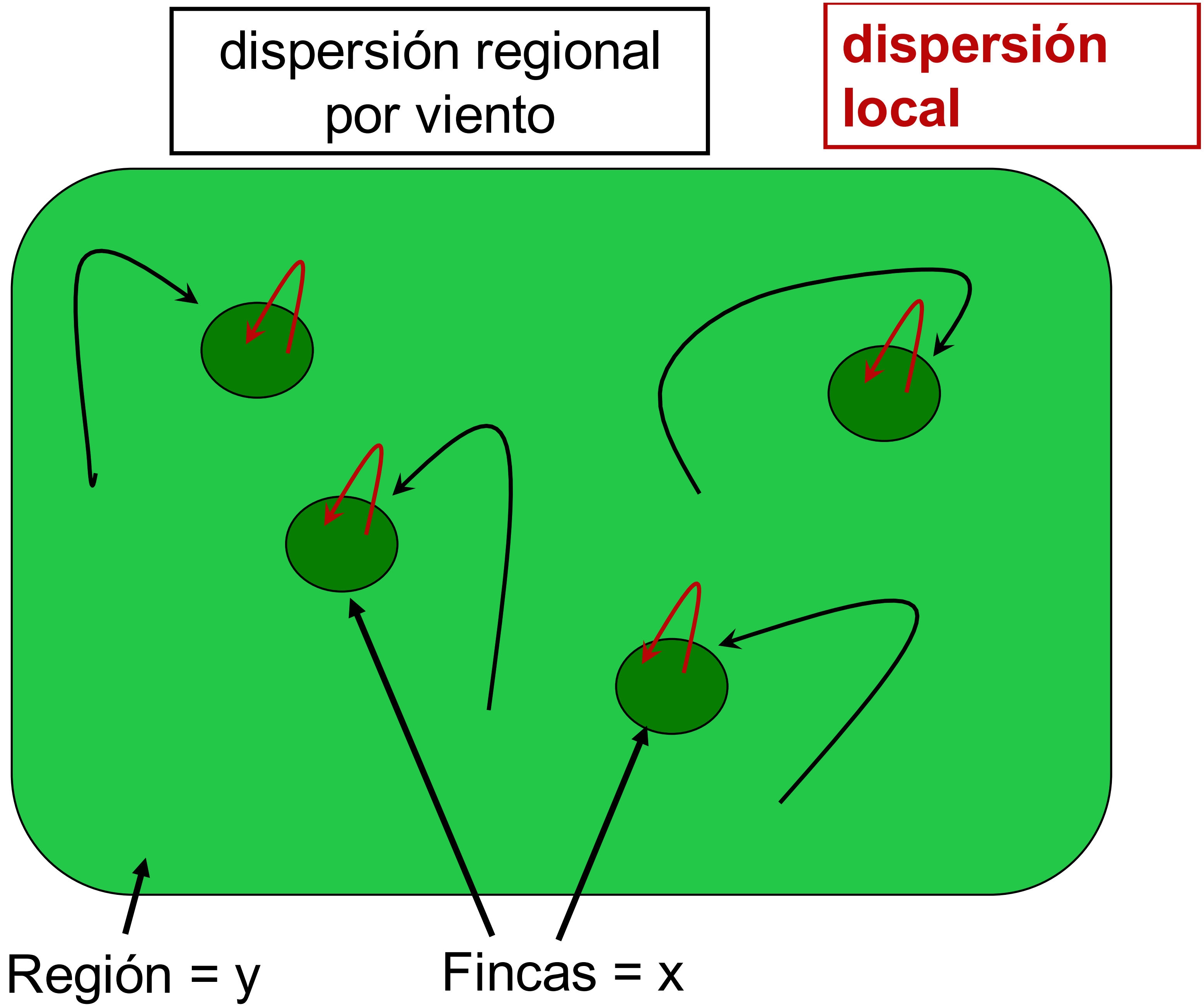
Fuerzas ecológicas



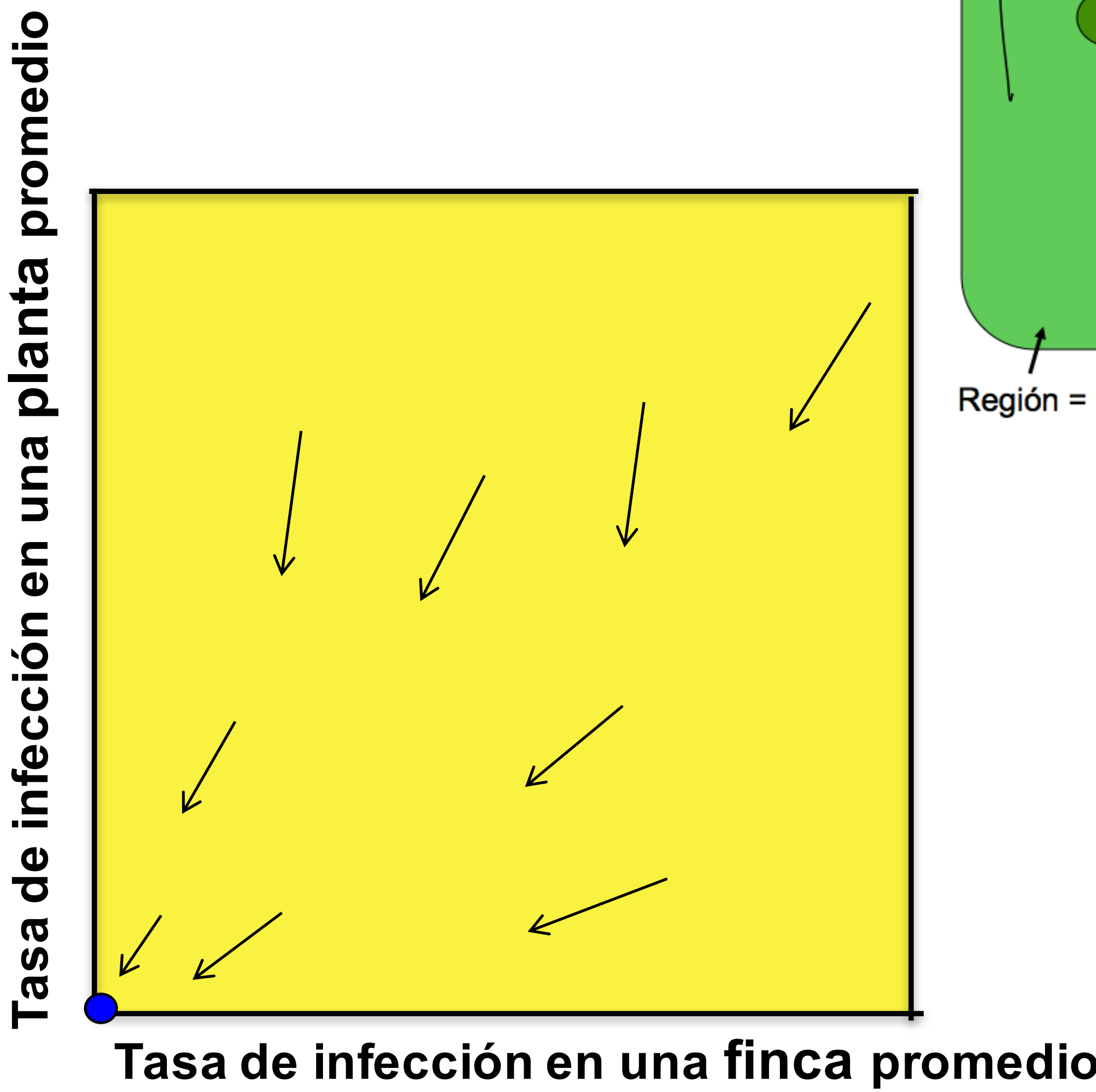
Fuerzas ecológicas

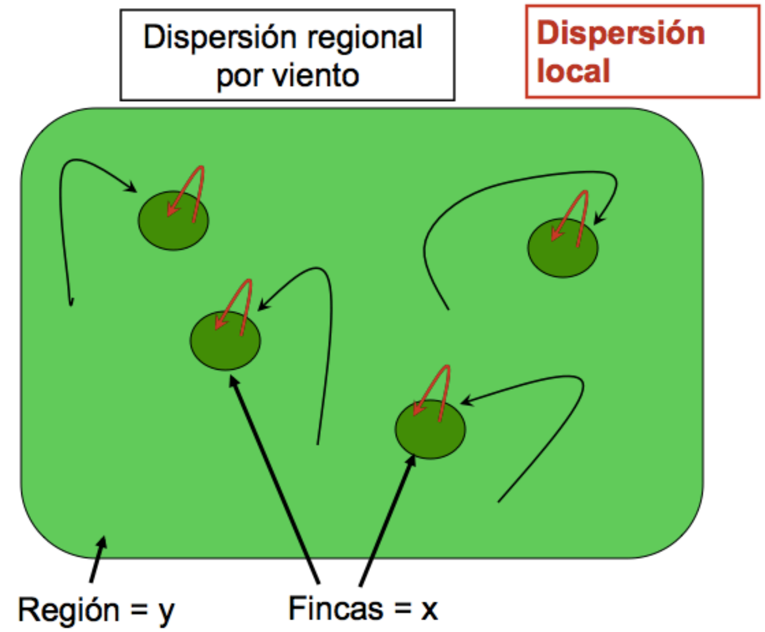


Sistema de manejo



Vandermeer and Rohani (2014) http://arxiv.org/abs/1407.8247


Tasa de infección en una planta promedio
Tasa de infección en una finca promedio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Dispersión local
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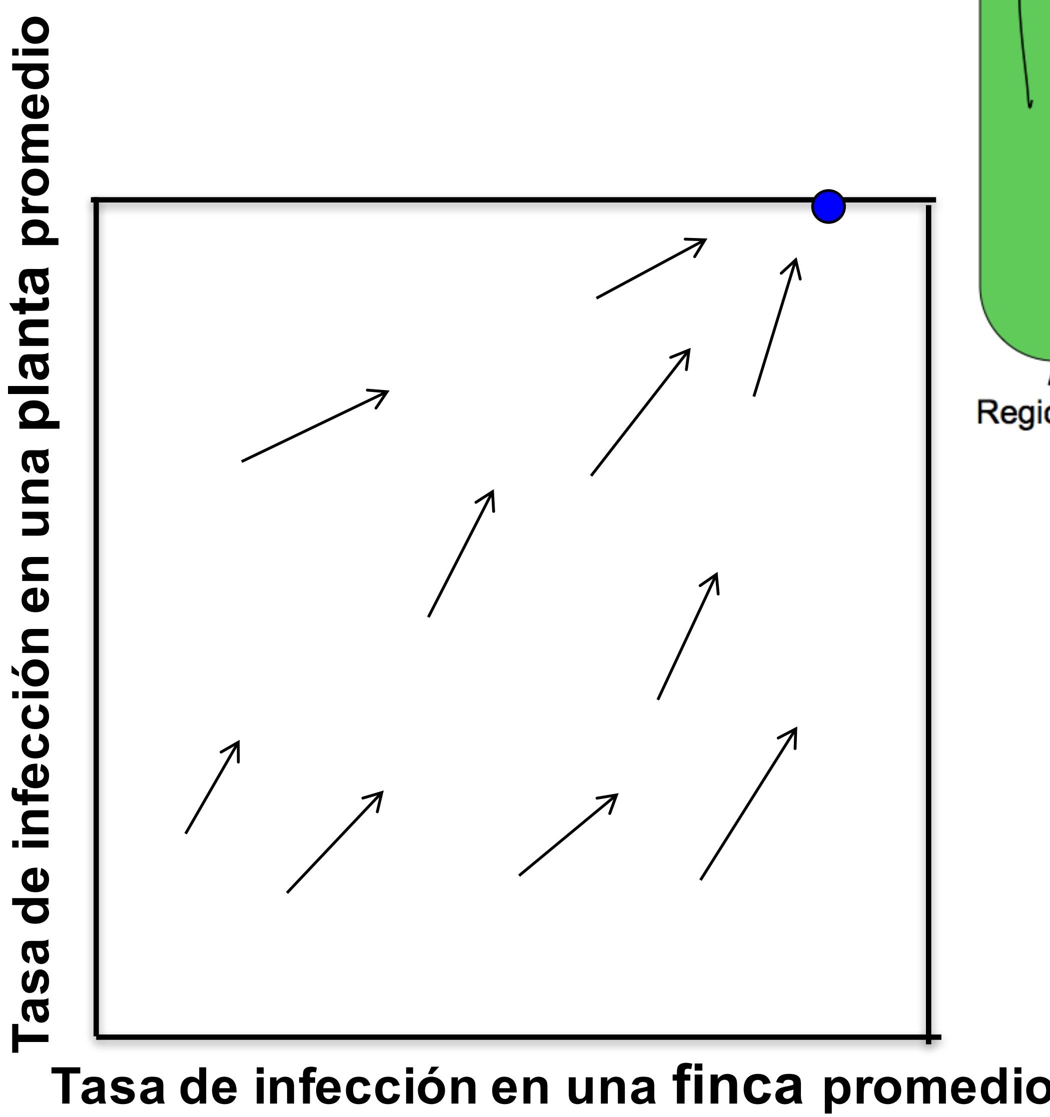
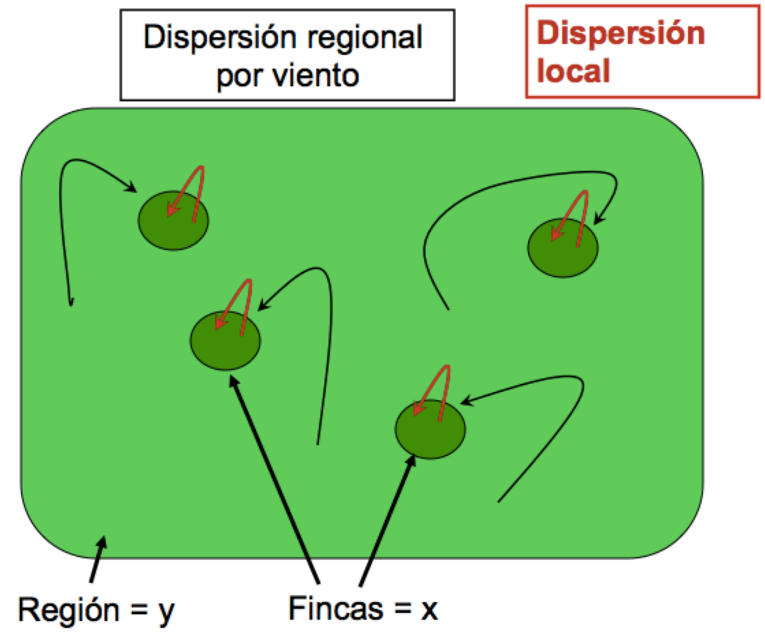
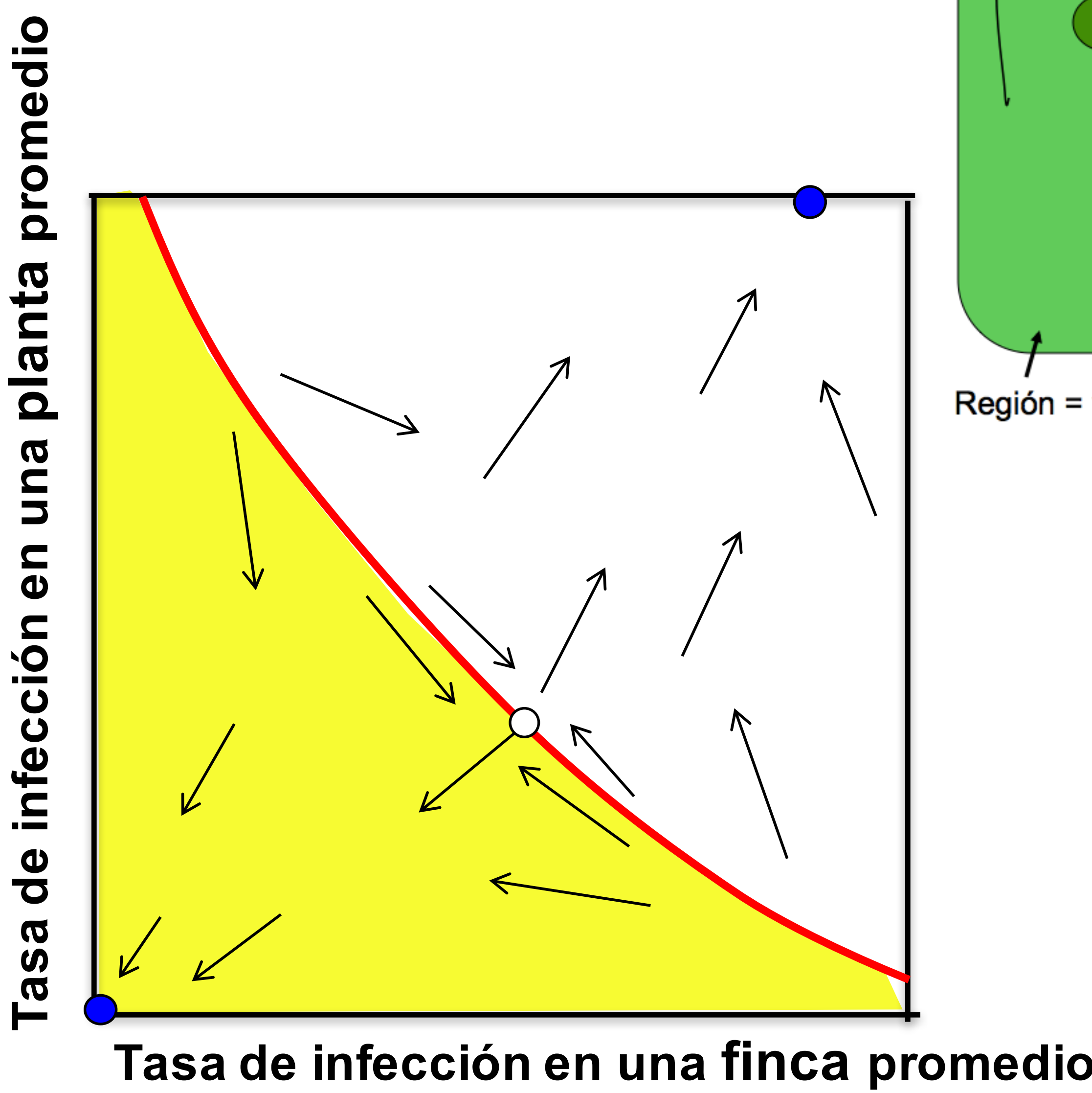
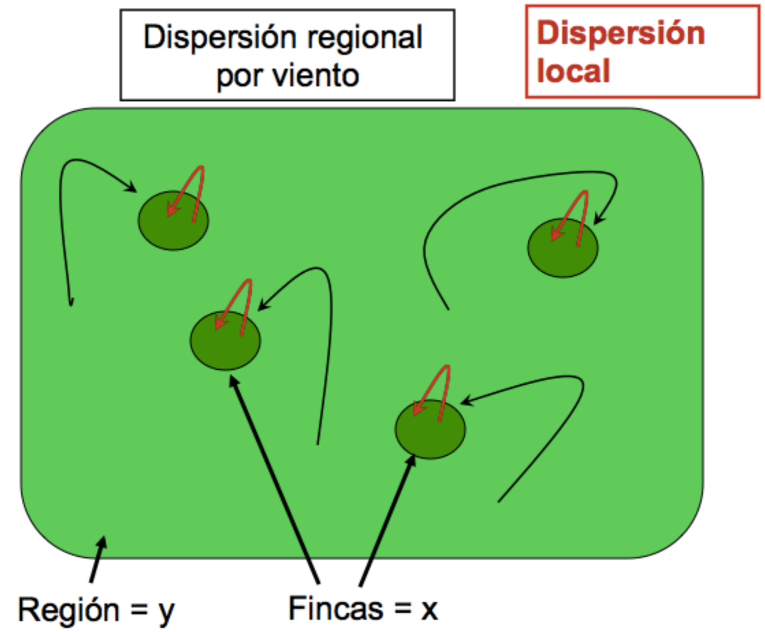
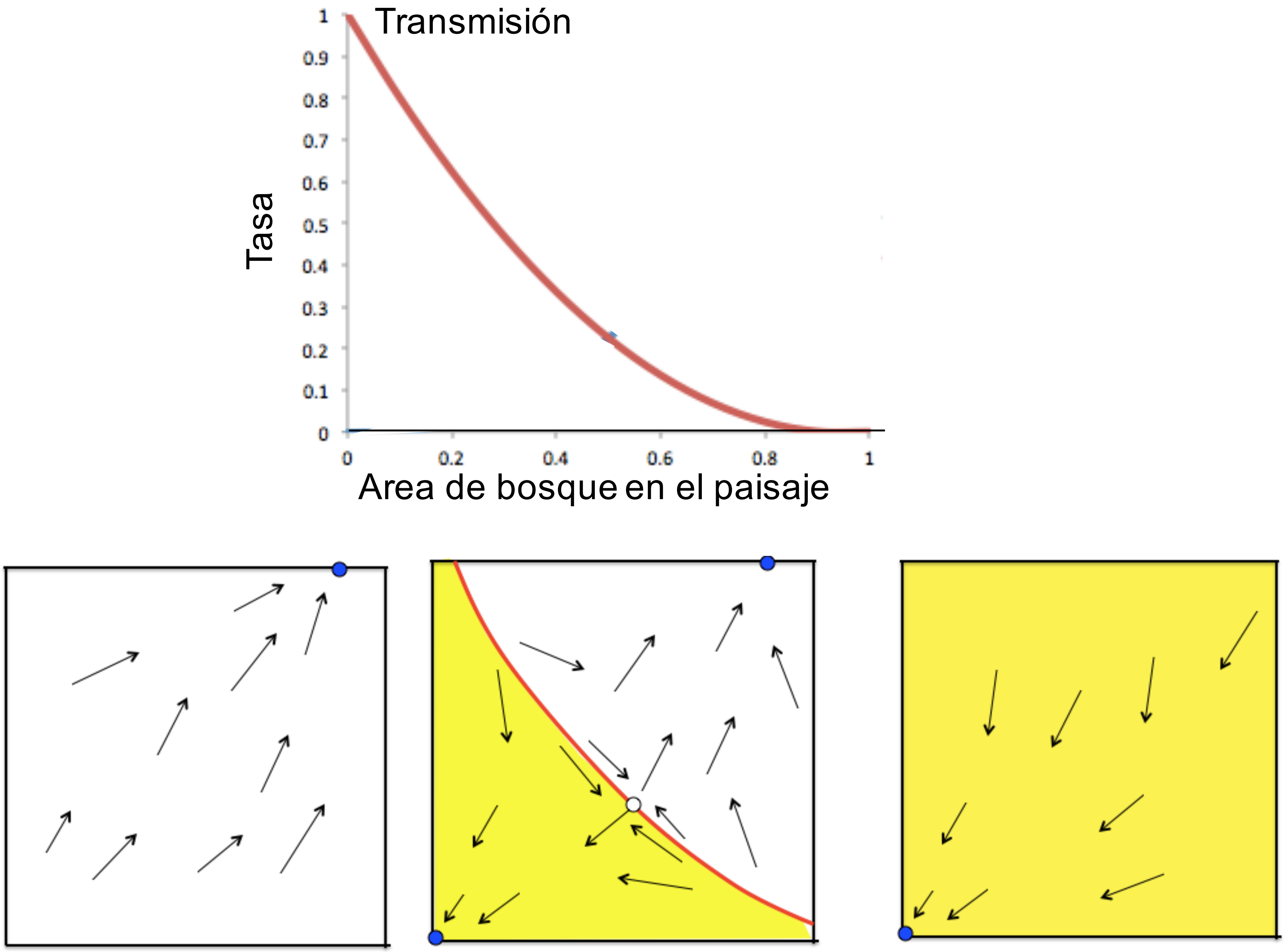
Fincas = x

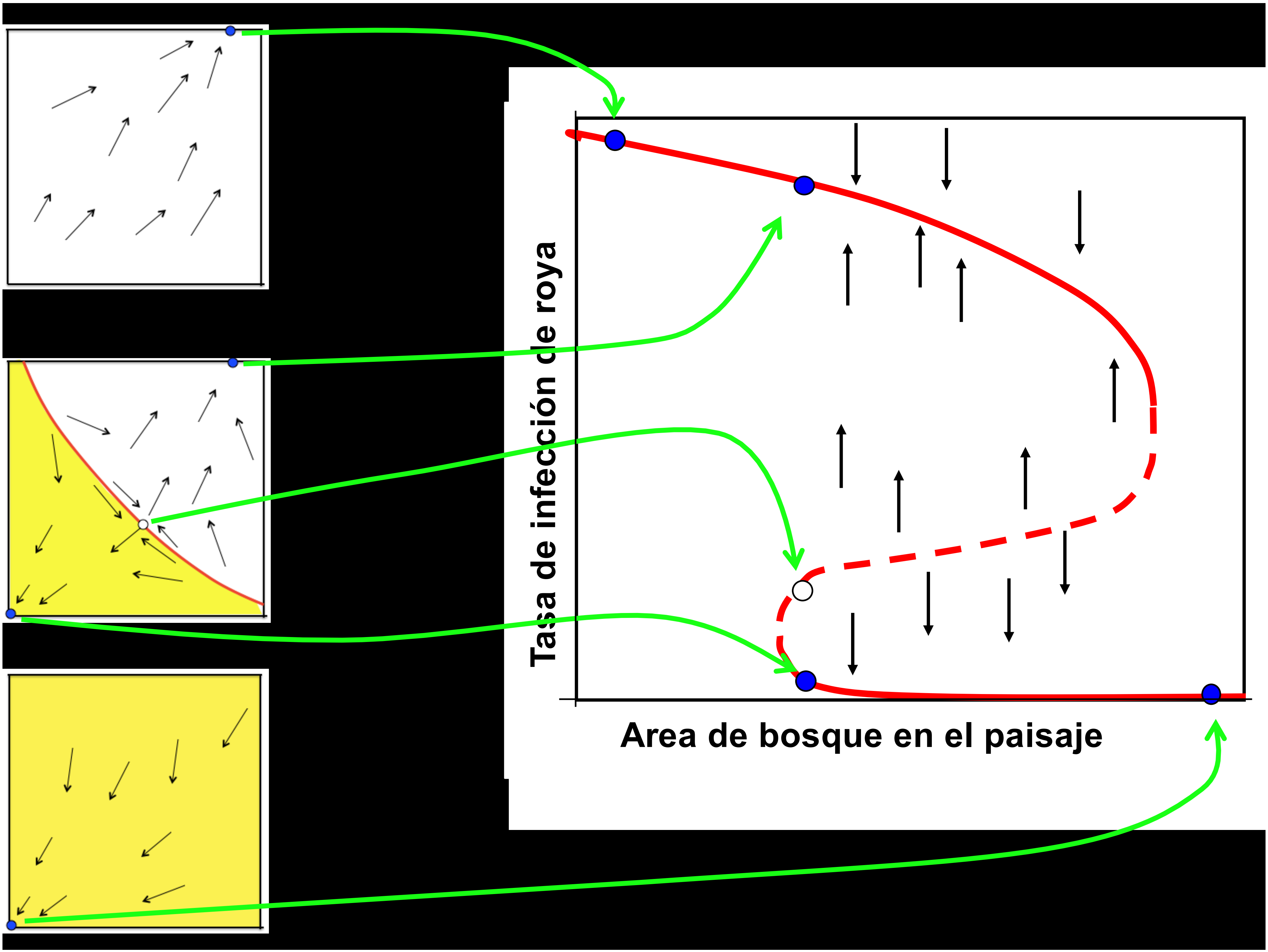

Tasa de infección en una planta promedio
Tasa de infección en una finca promedio


Dispersión regional por viento
Dispersión local
Región = y
Fincas = x

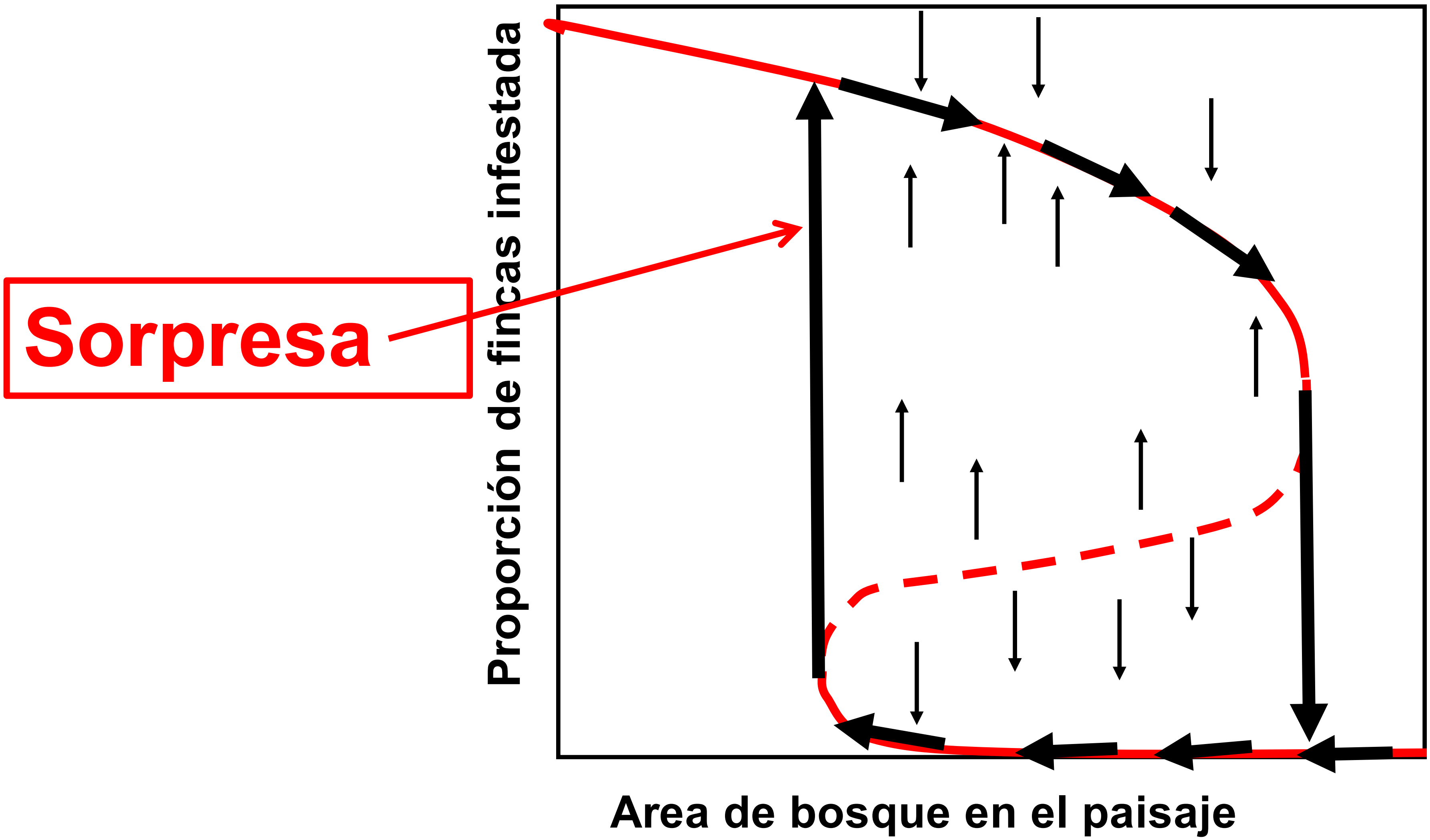

Tasa de infección en una planta promedio
Tasa de infección en una finca promedio

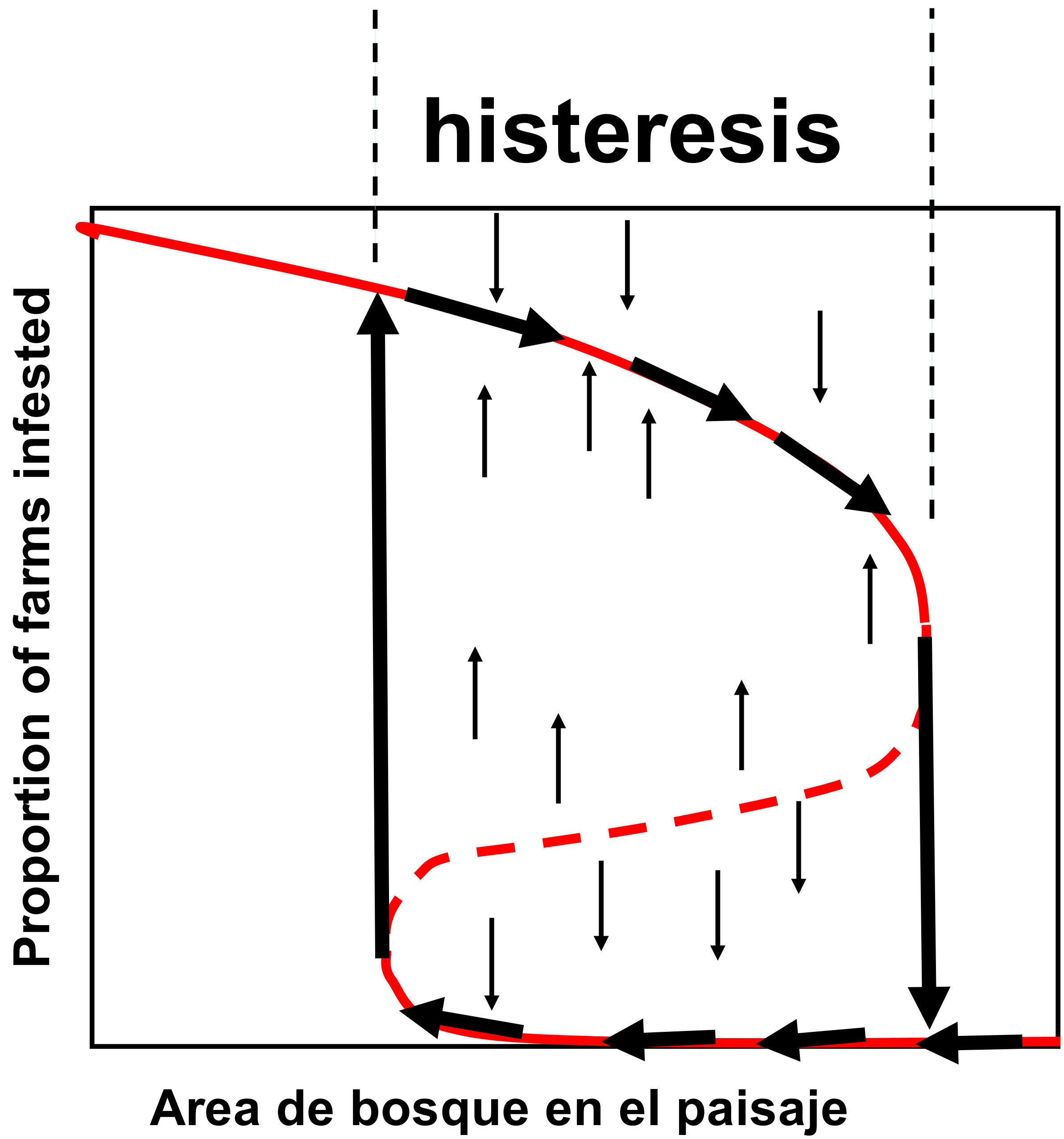

Dispersión regional por viento
Dispersión local
Región = y
Fincas = x

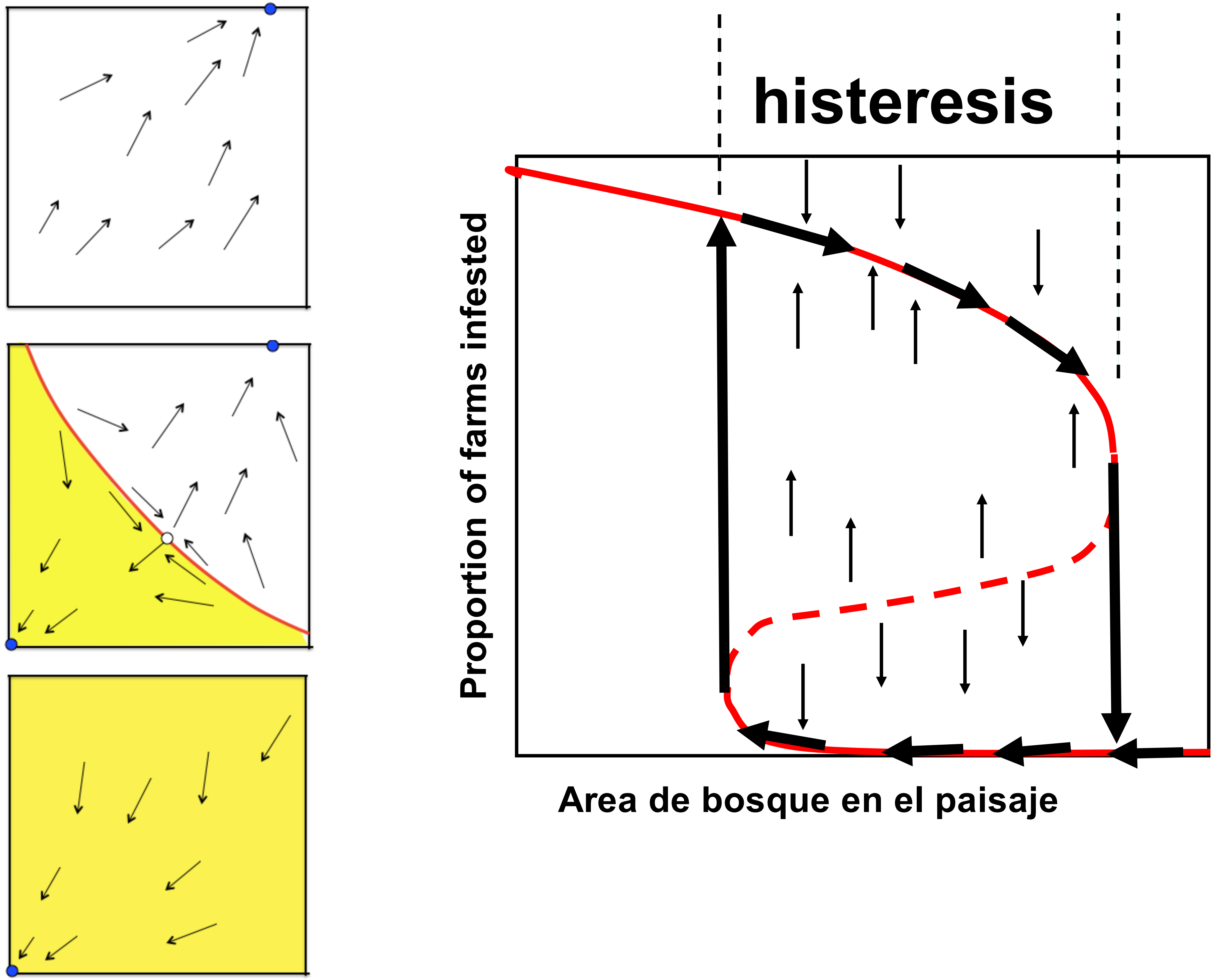

Transmisión
Tasa
Area de bosque en el paisaje
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
0.2
0.4
0.6
0.8
1



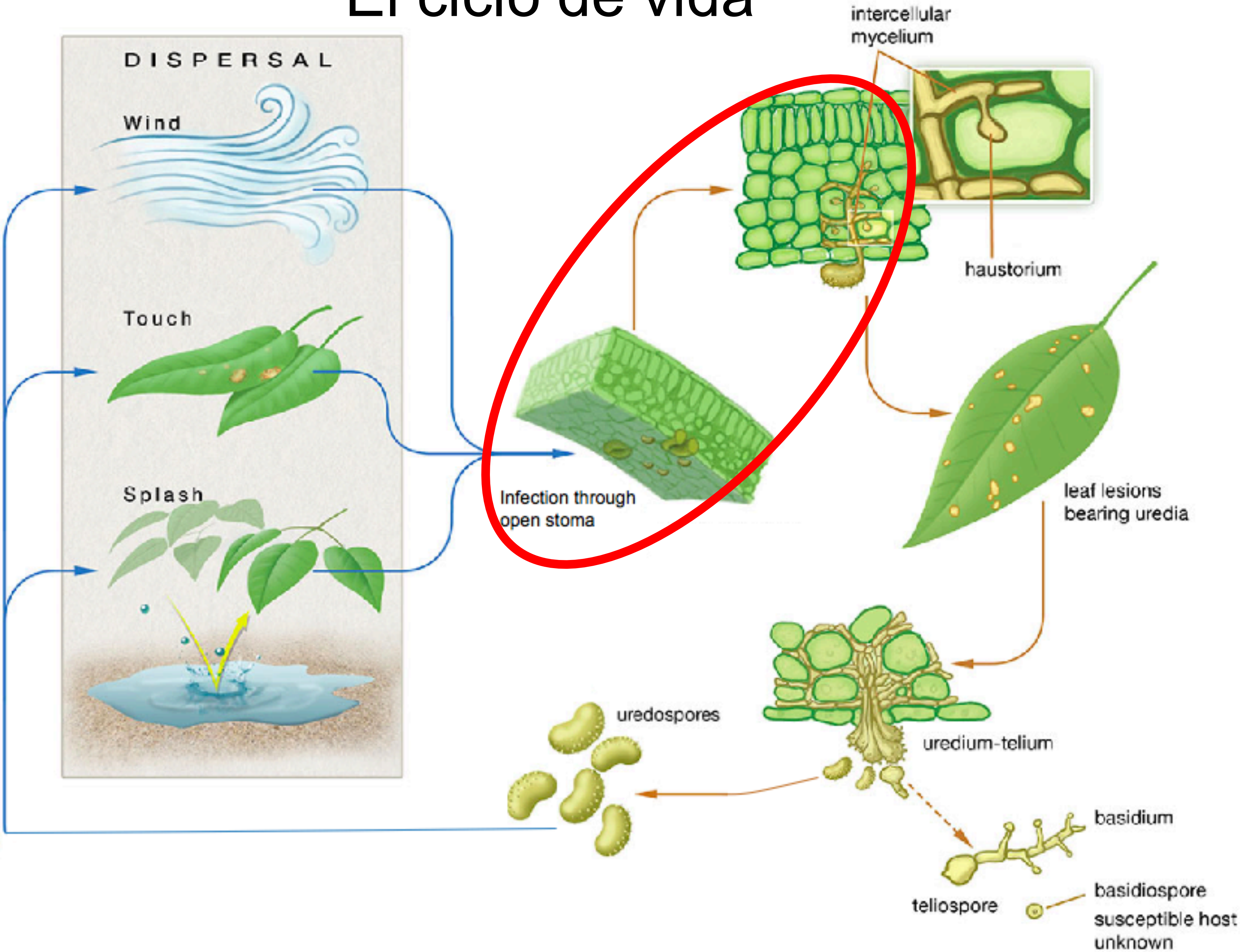
Tasa de infección de roya
Area de bosque en el paisaje


Sorpresa
Proporción de fincas infestada
Area de bosque en el paisaje

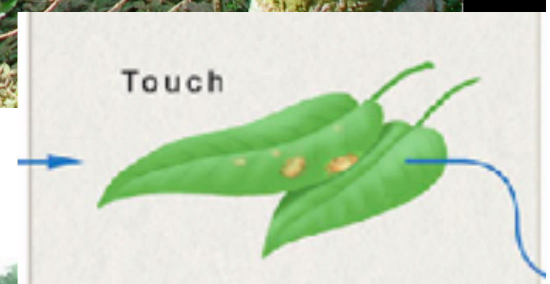

histeresis
Proportion of farms infested
Area de bosque en el paisaje

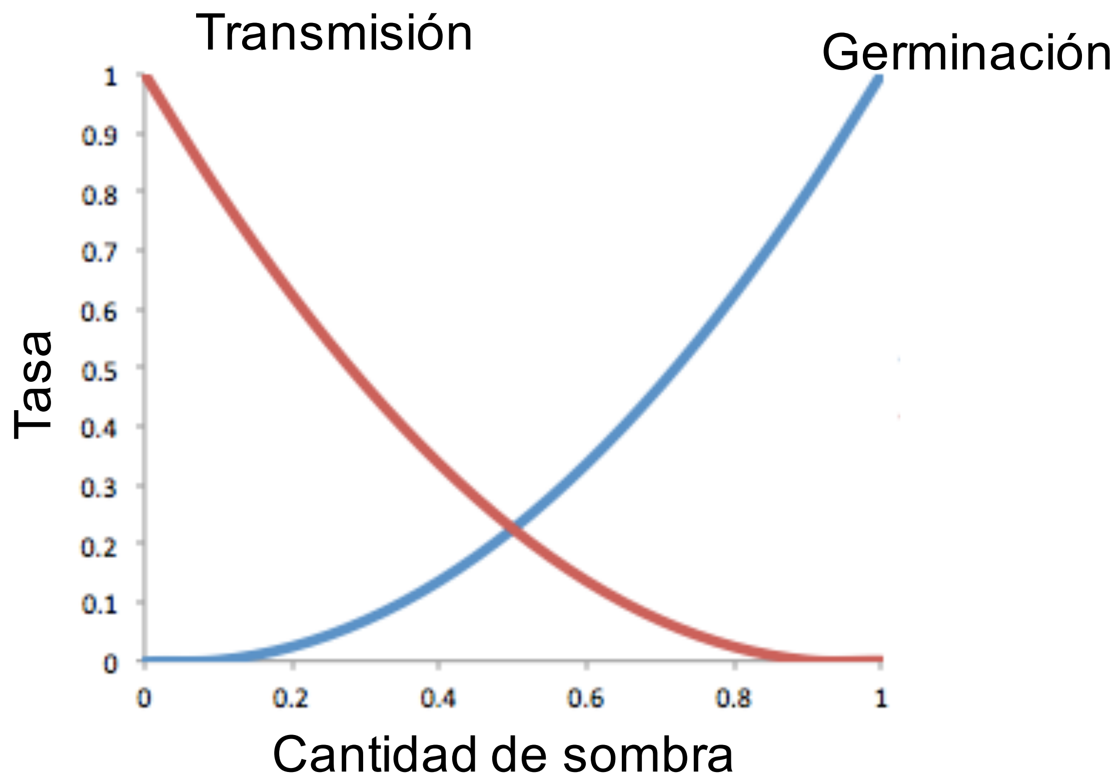

histeresis
Proportion of farms infested
Area de bosque en el paisaje

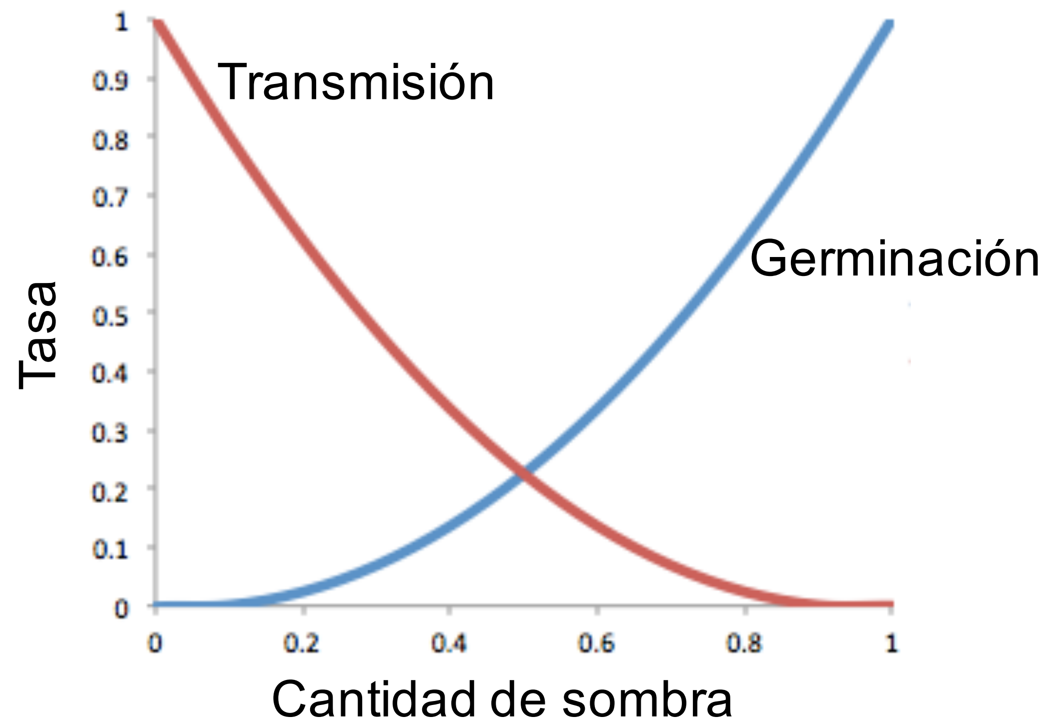
El ciclo de vida



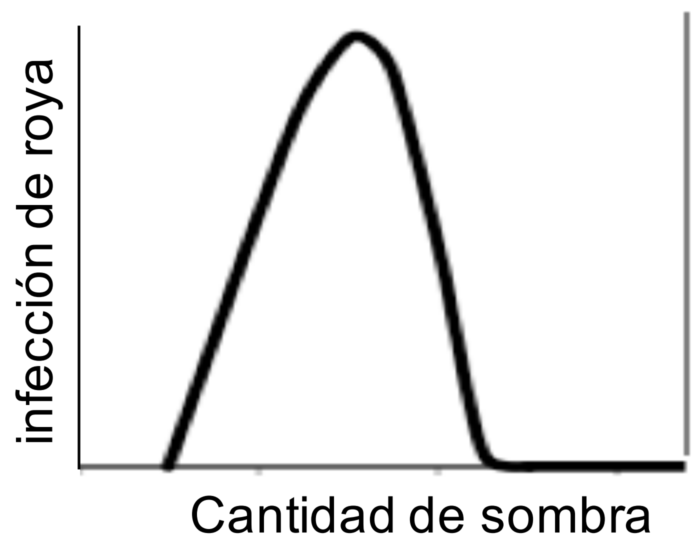
Sistema de manejo



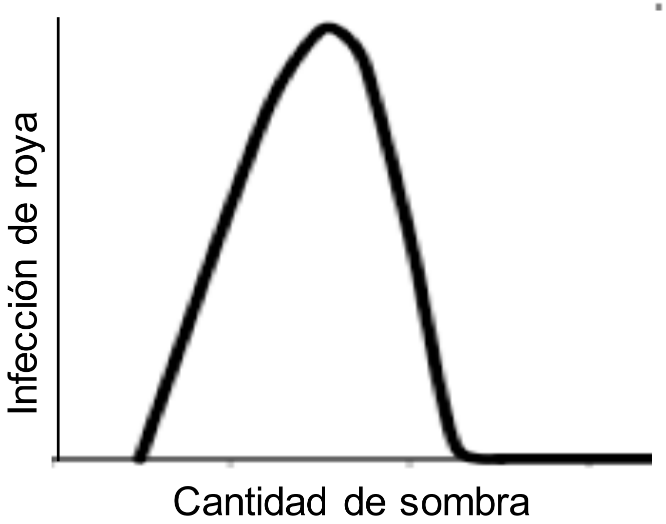

Transmisión
Germinación
Tasa
Cantidad de sombra
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
0.2
0.4
0.6
0.8
1

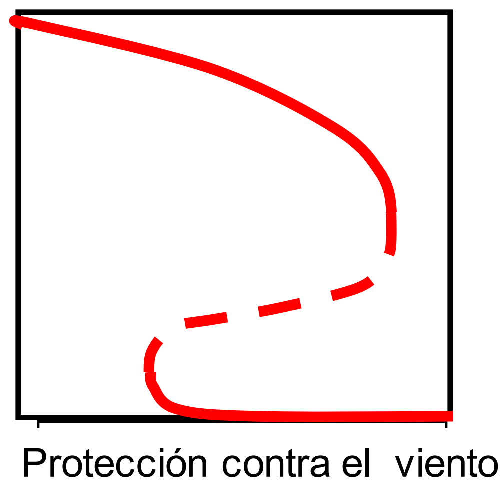


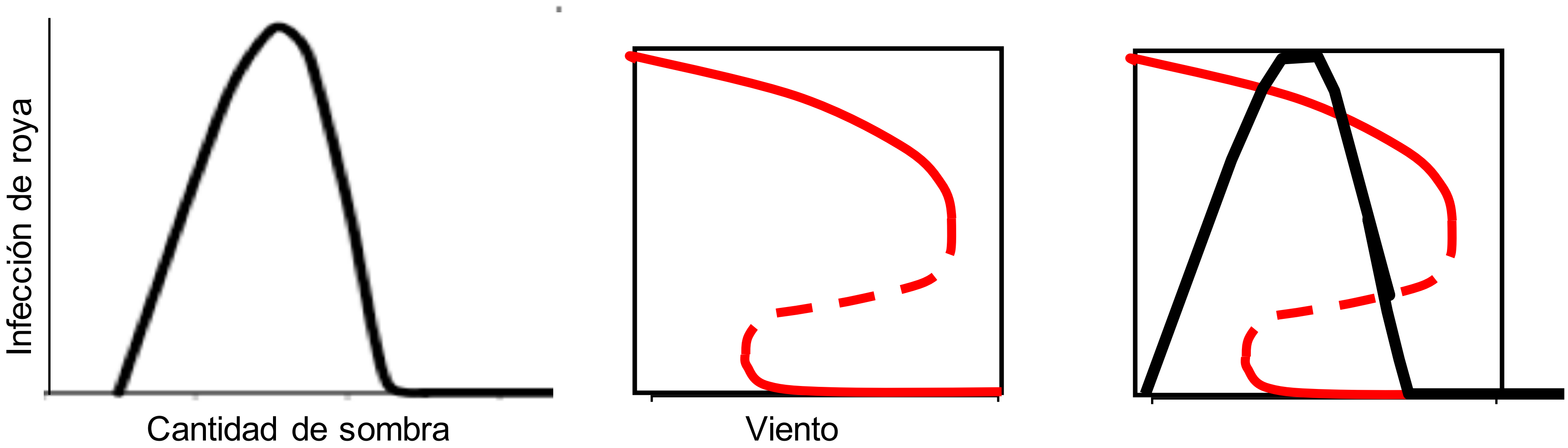
Transmisión
Germinación
Tasa
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.2
0.4
0.6
0.8
1
Cantidad de sombra

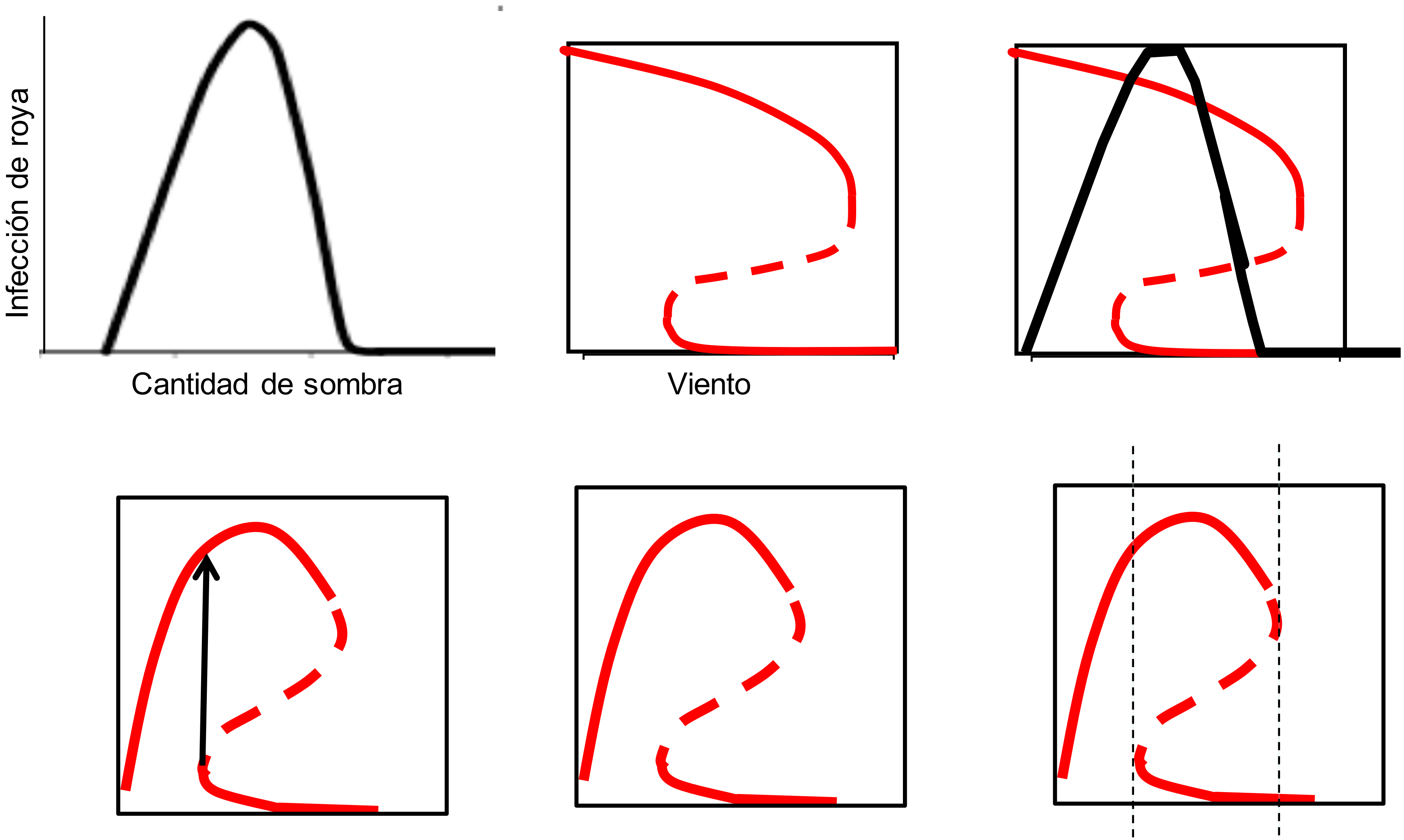


infección de roya
Cantidad de sombra


Infección de roya
Cantidad de sombra


Protección contra el viento


Infección de roya
Cantidad de sombra
Viento



Vandermeer et al., (2015) http://arxiv.org/abs/1510.05849

Fuerzas ecológicas

Fuerzas ecológicas

POTENTIAL FOR BIOLOGICAL CONTROL OF PLANT DISEASES ON THE PHYLLOPLANE

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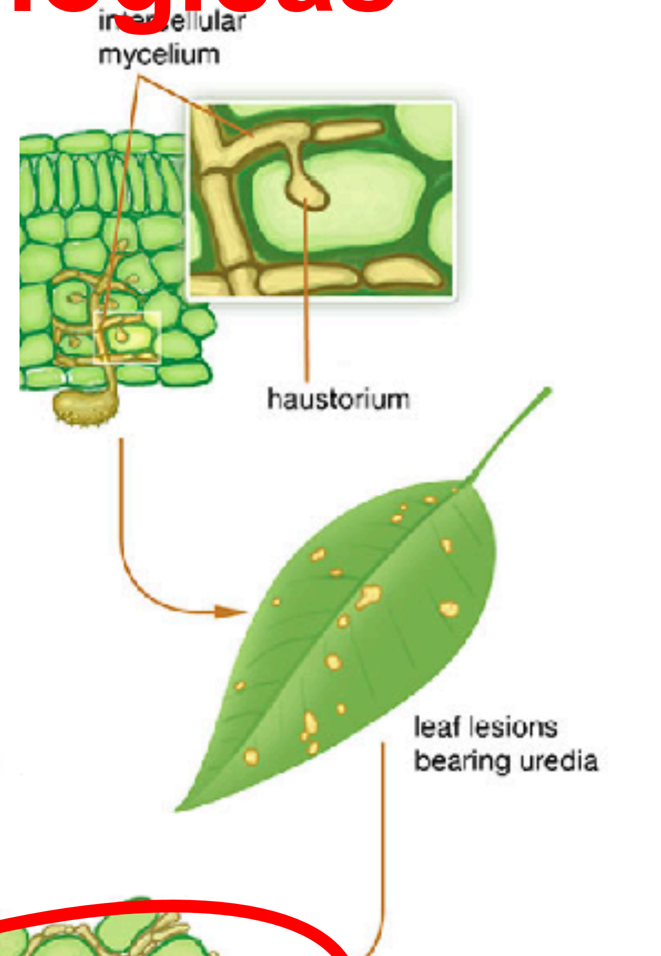
N. J. Fokkema

Phytopathologisch Laboratorium "Willie Commelin Scholten," Javalaan 20, 3742 CP Baarn, the Netherlands

Ann. Rev. Phytopathol. 1982. 20:167–92



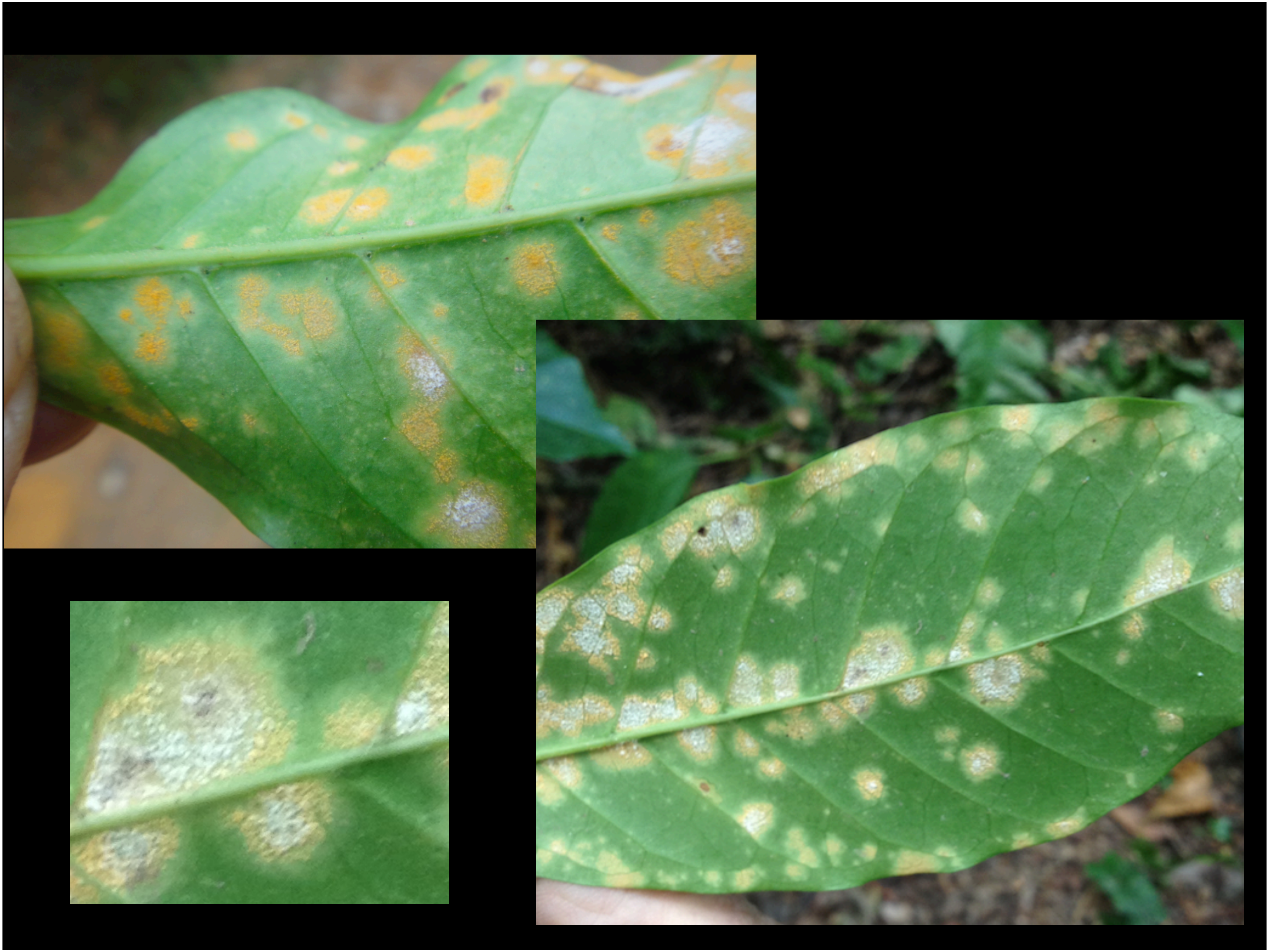
Sobrevivencia de esporas

Azteca sericeasur

Azteca atendiendo escamas

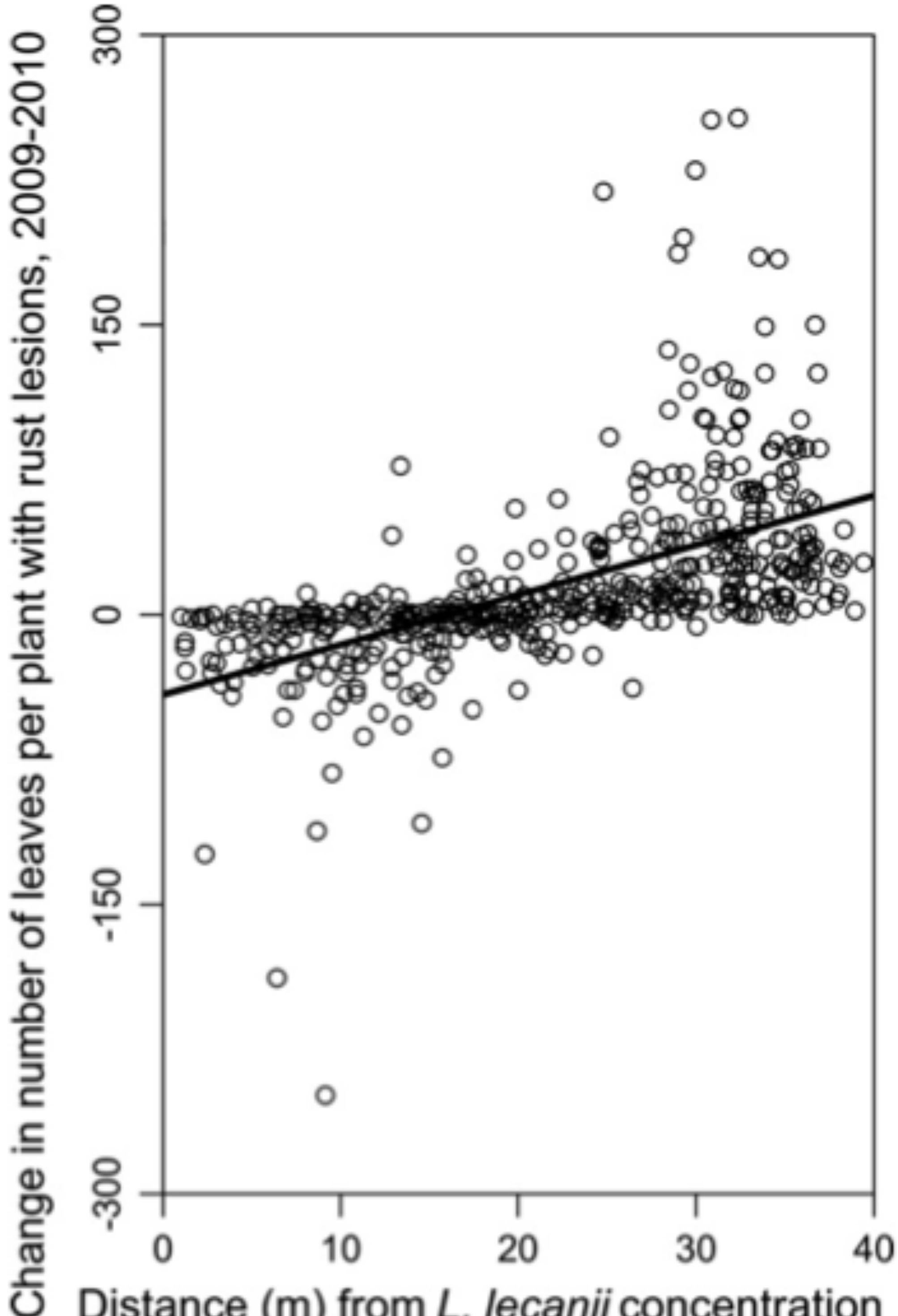
Vandermeer et al., (2008) Nature, 451:457-459.

Lecanicillium lecanii: hongo blanco

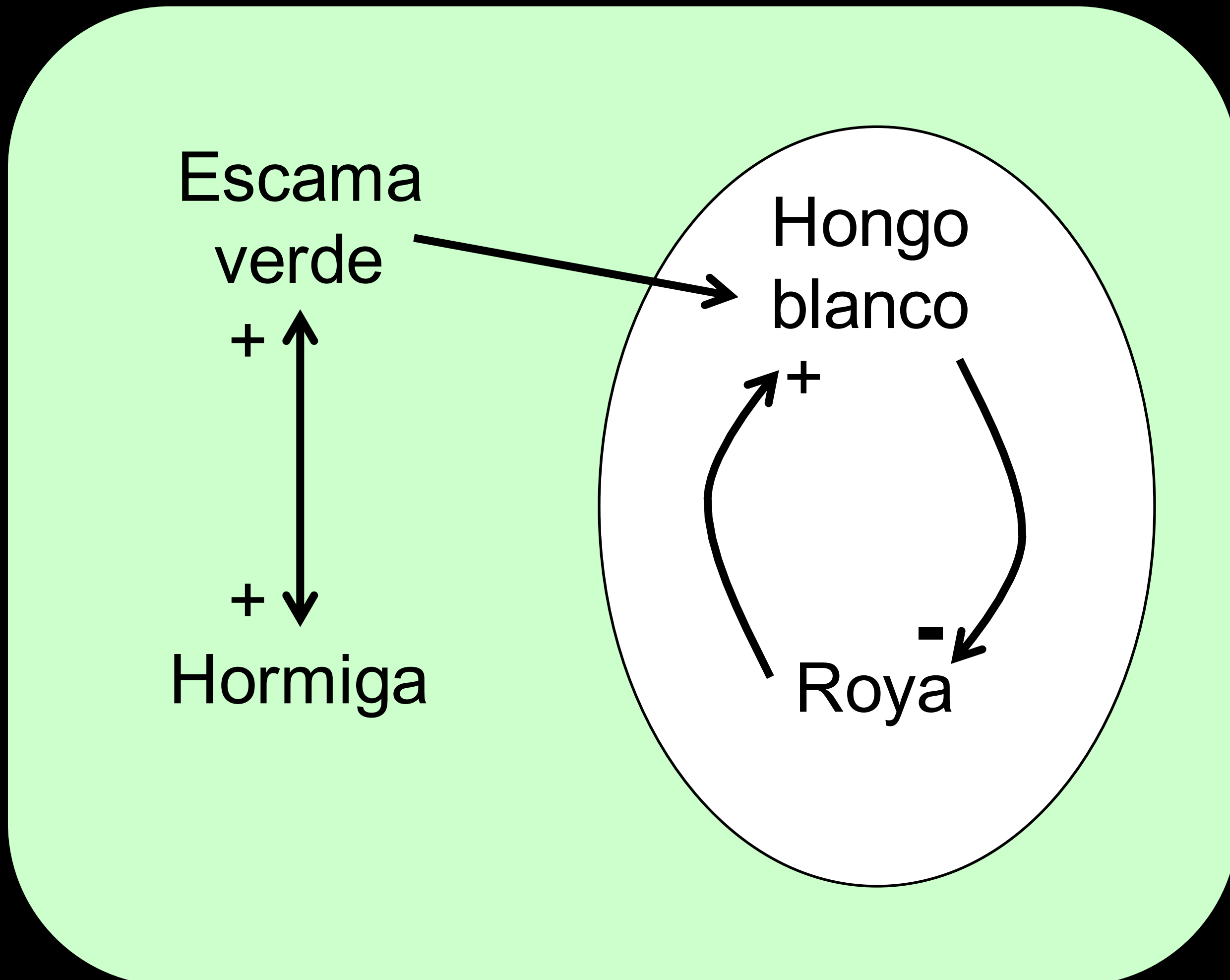


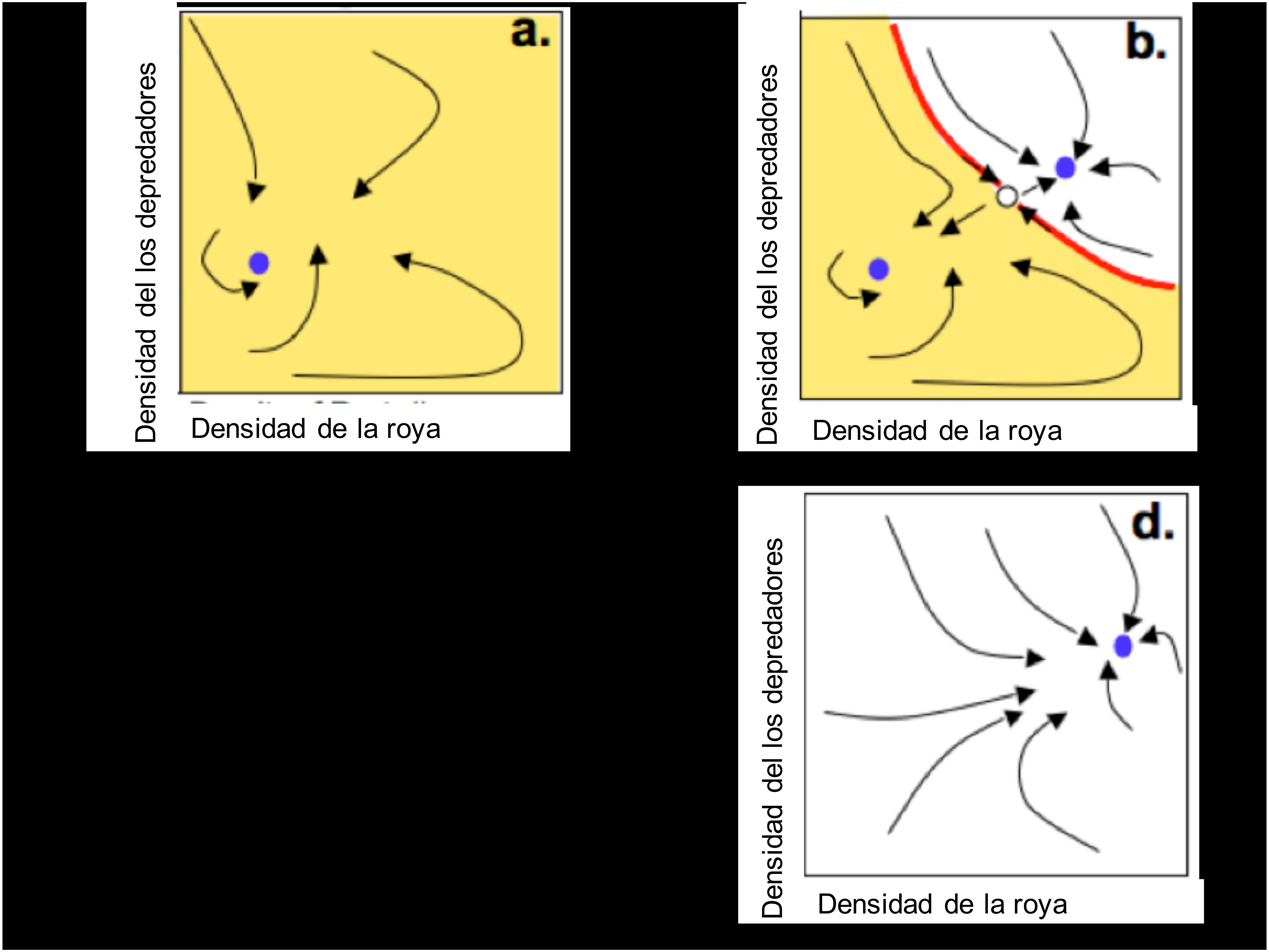
Enfermedad de escamas y roya

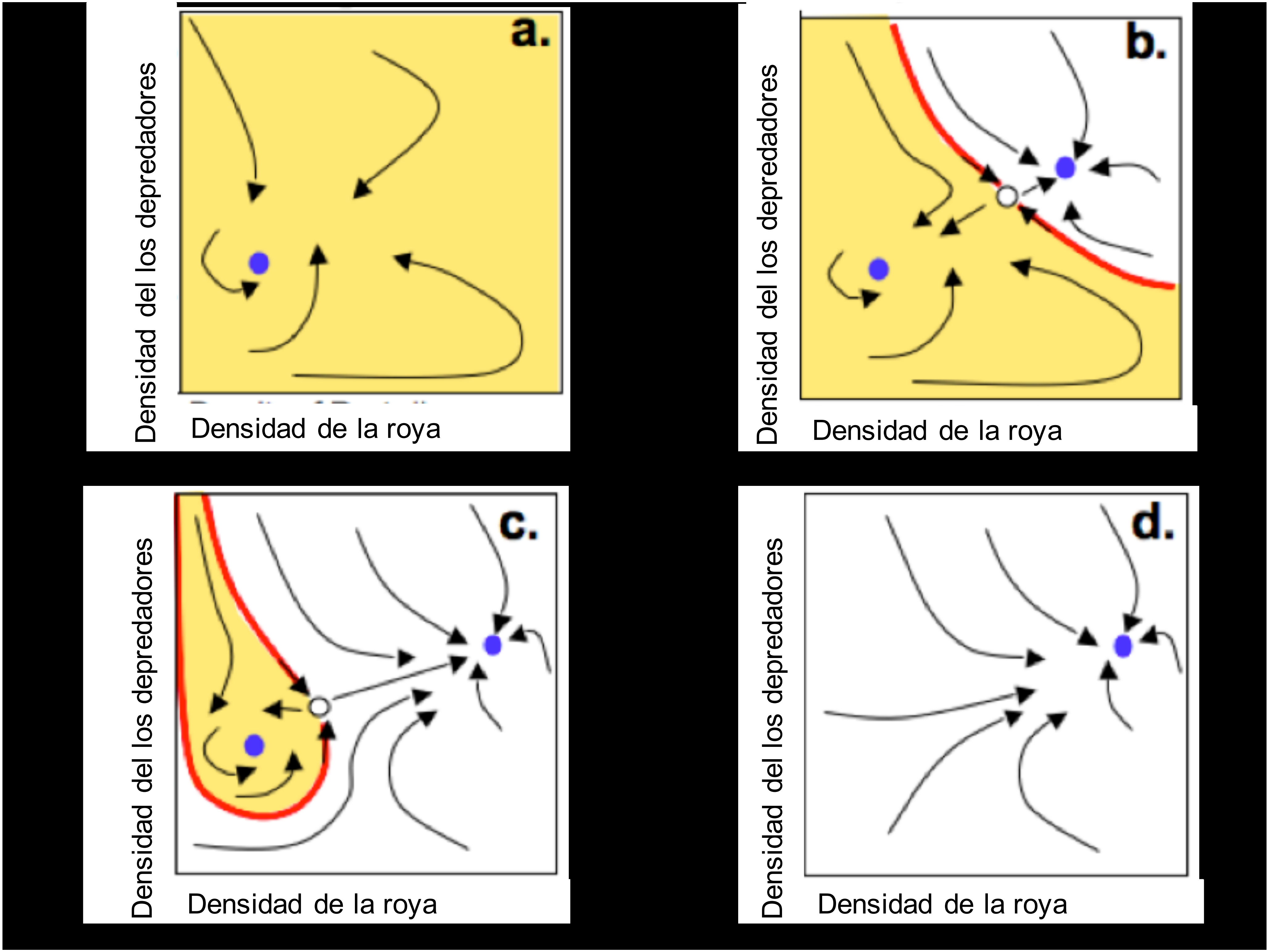
Vandermeer et al., (2008), *Plant Pathology* 58:636-641

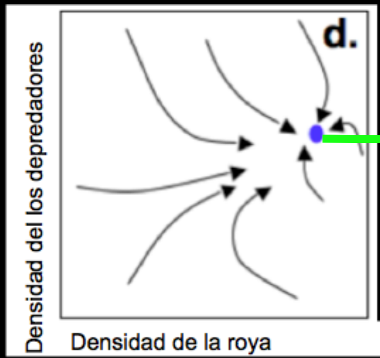


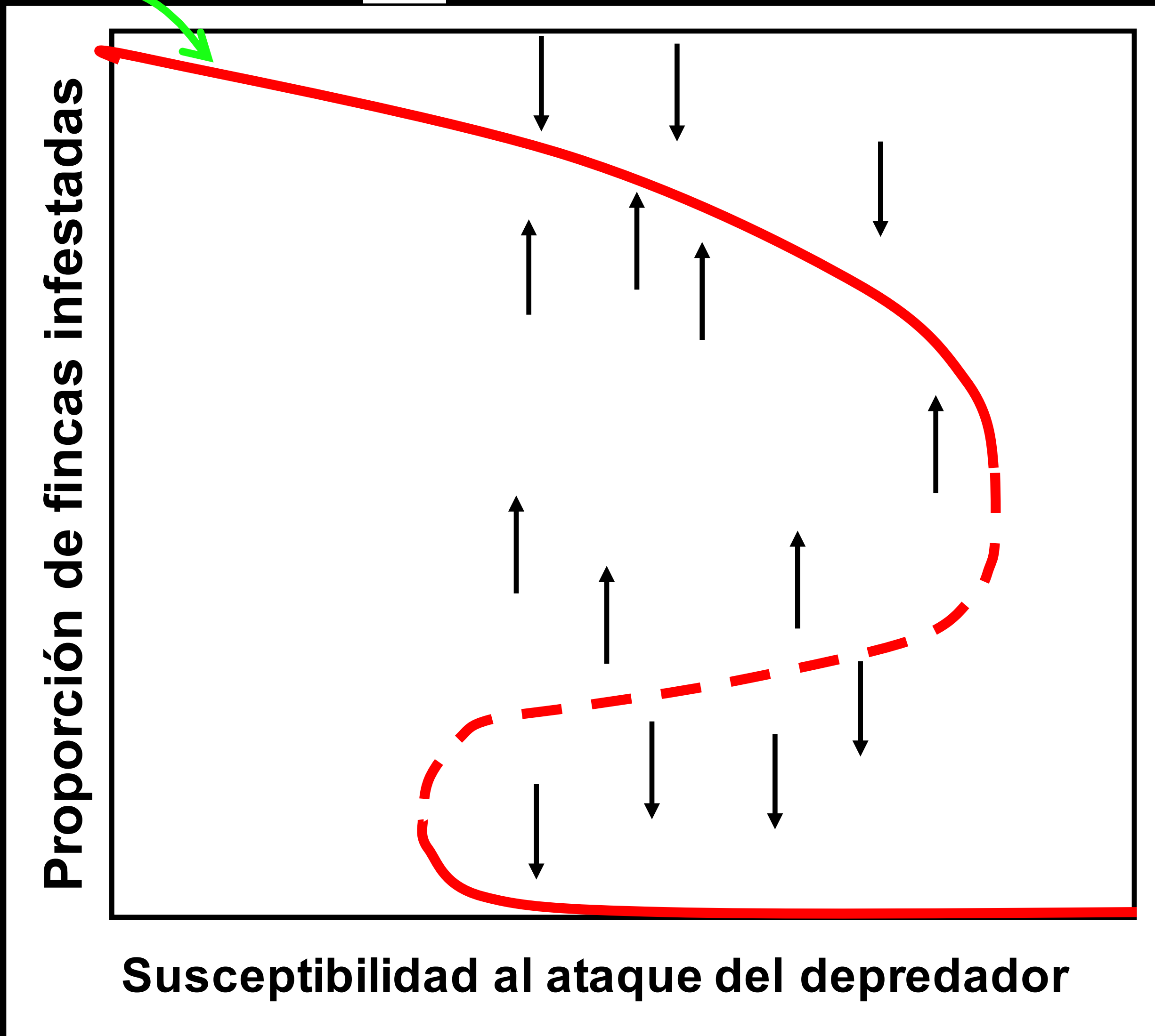
Jackson et al., (2012) Biological Control.


Escama
verde
+
+
Hormiga
Hongo
blanco
+
-
Roya

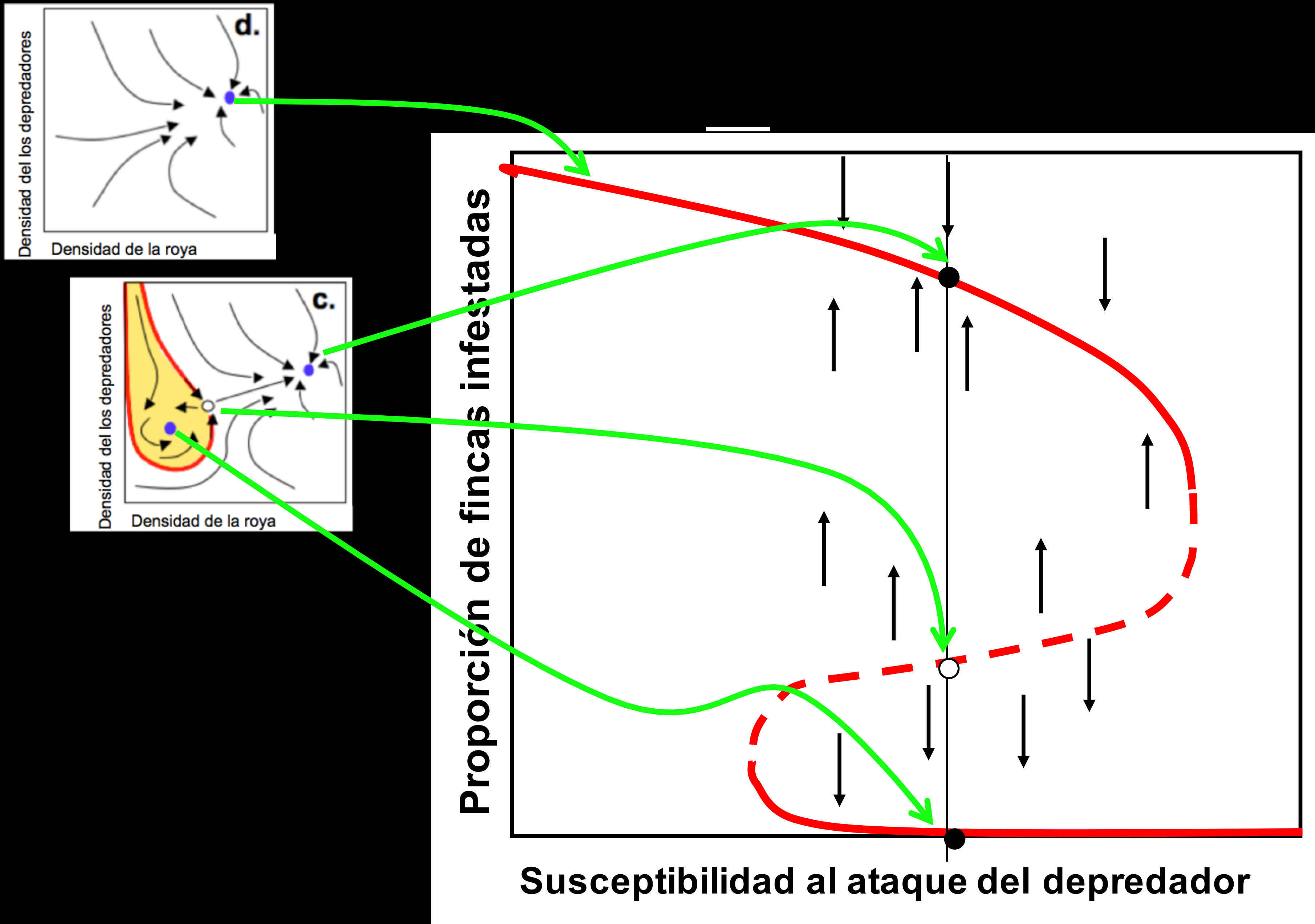

a.
Densidad del los depredadores
Densidad de la roya
b.
Densidad del los depredadores
Densidad de la roya
d.
Densidad del los depredadores
Densidad de la roya


a.
Densidad del los depredadores
Densidad de la roya
b.
Densidad del los depredadores
Densidad de la roya
c.
Densidad del los depredadores
Densidad de la roya
d.
Densidad del los depredadores
Densidad de la roya

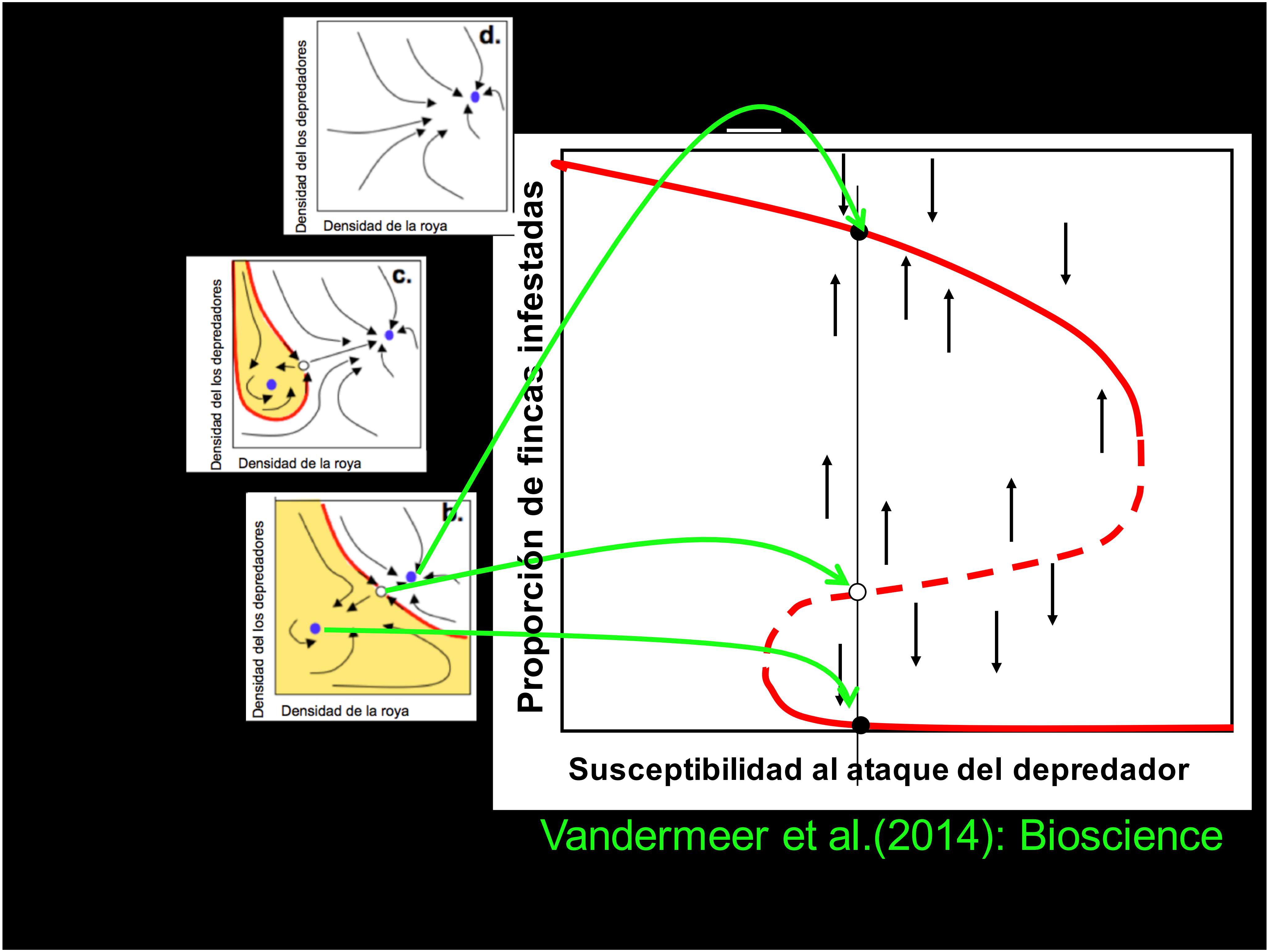


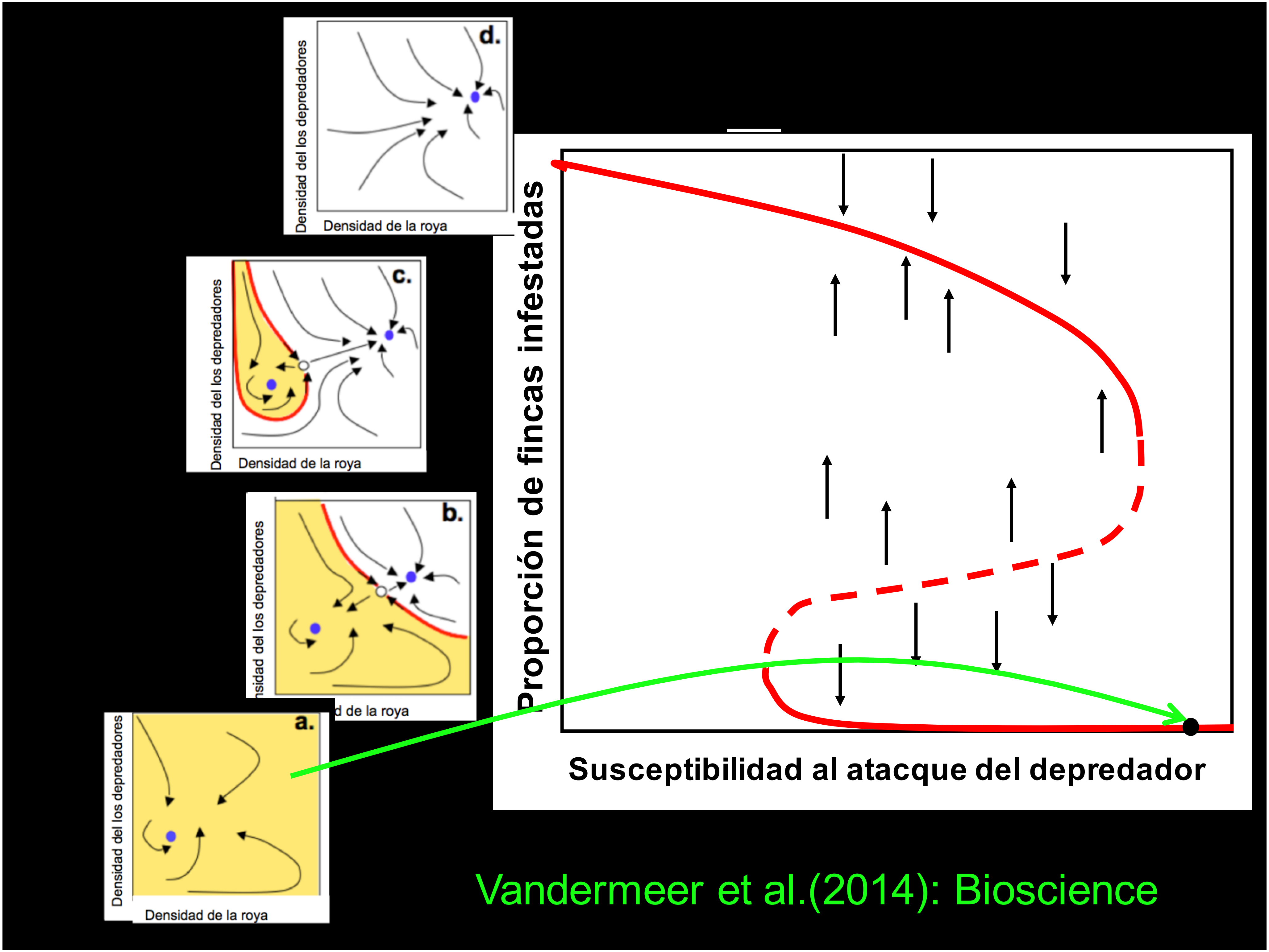


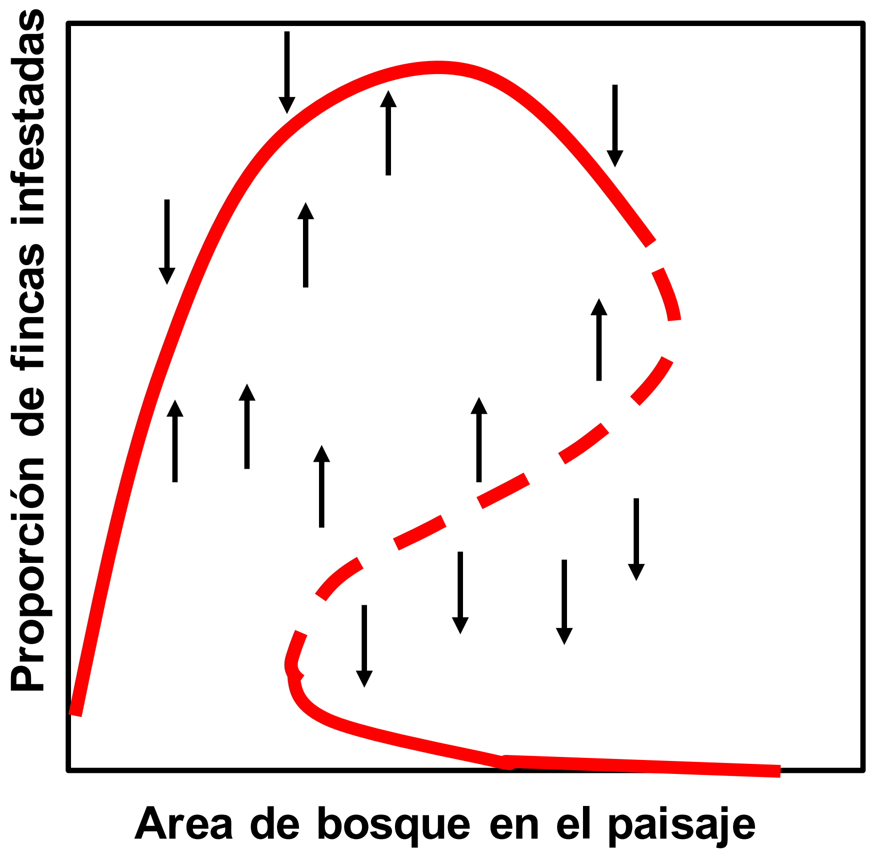
Vandermeer et al.(2014): Bioscience



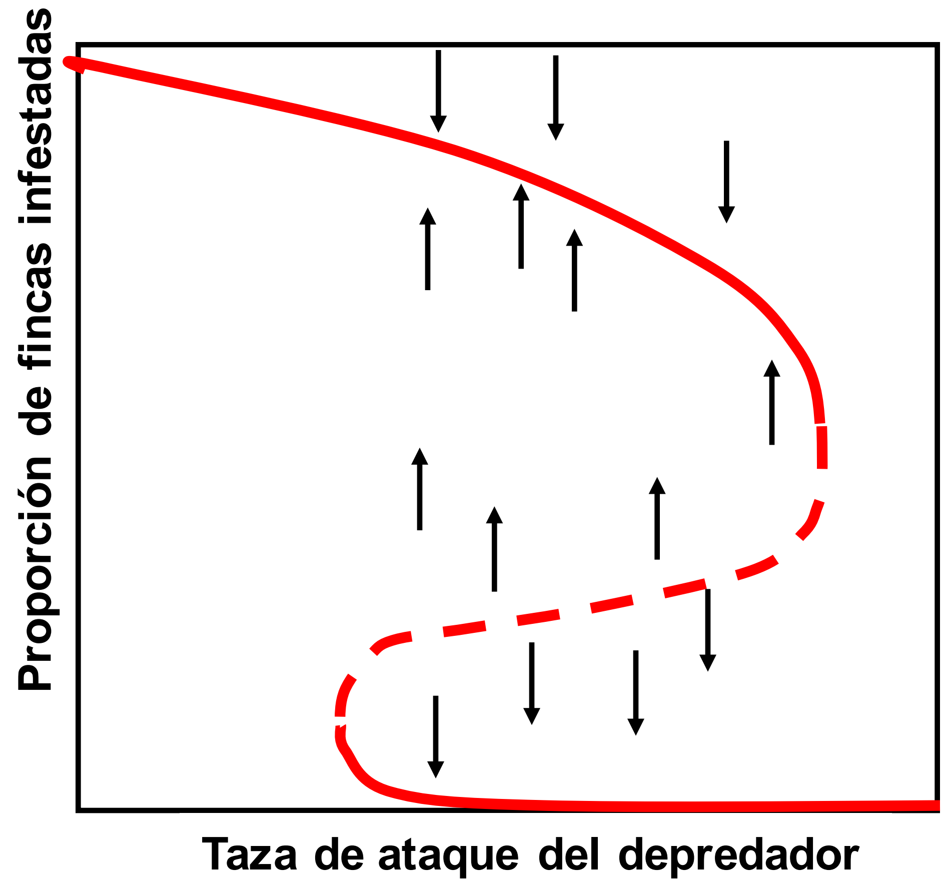
Vandermeer et al.(2014): Bioscience


d.
c.
b.
Densidad del los depredadores
Densidad de la roya
Proporción de fincas infestadas
Susceptibilidad al ataque del depredador
Vandermeer et al.(2014): Bioscience

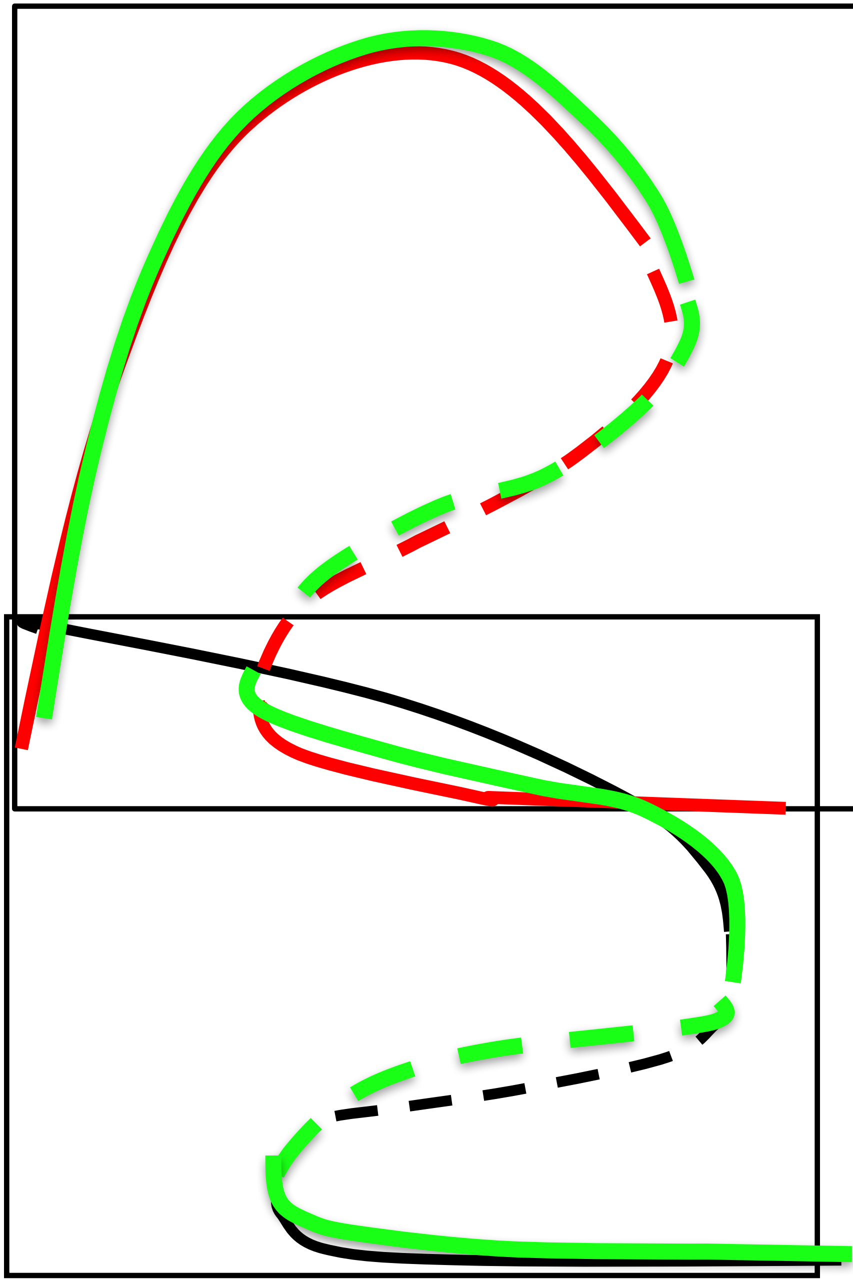

d.
Densidad del los depredadores
Densidad de la roya
c.
Densidad del los depredadores
Densidad de la roya
b.
Densidad del los depredadores
Densidad de la roya
a.
Densidad del los depredadores
Densidad de la roya
Proporción de fincas infestadas
Susceptibilidad al atacque del depredador
Vandermeer et al.(2014): Bioscience



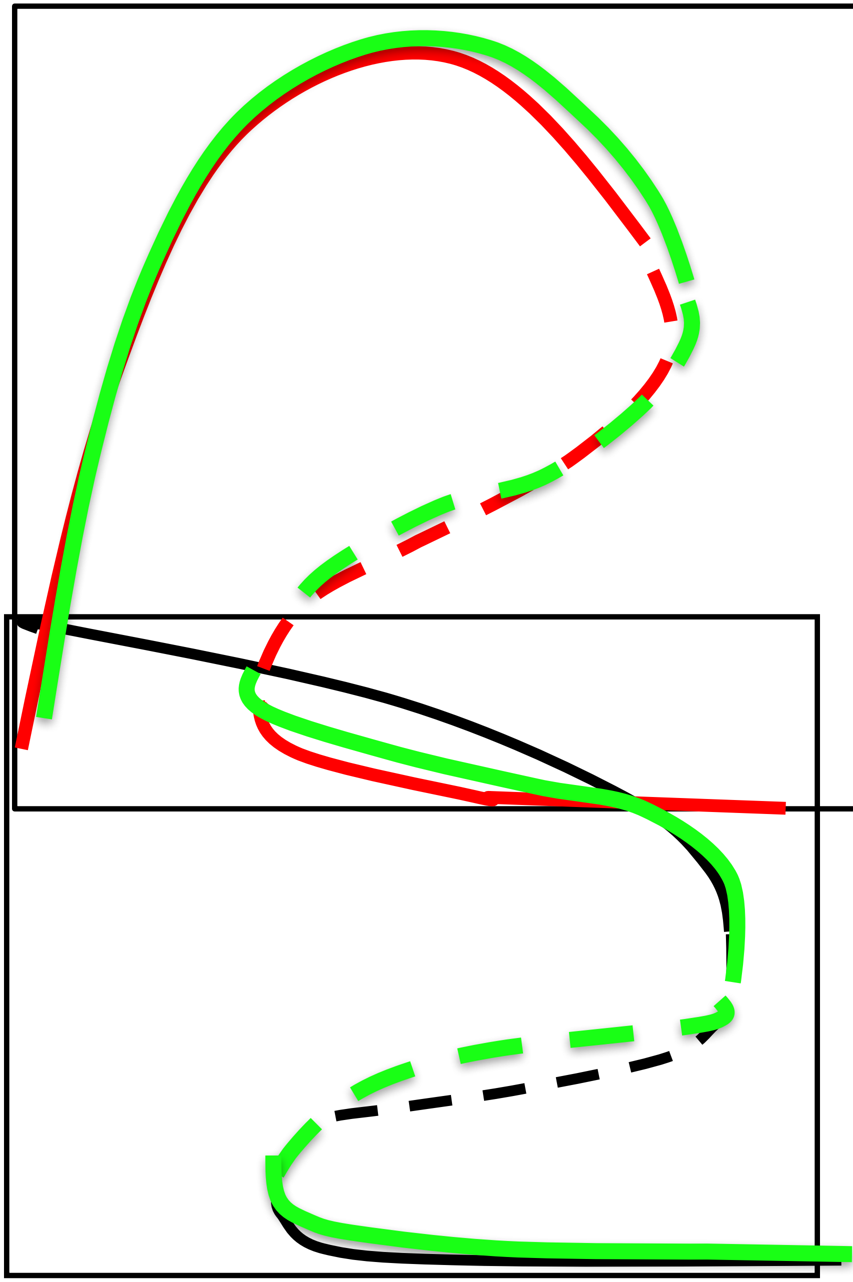
Proporción de fincas infestadas
Area de bosque en el paisaje

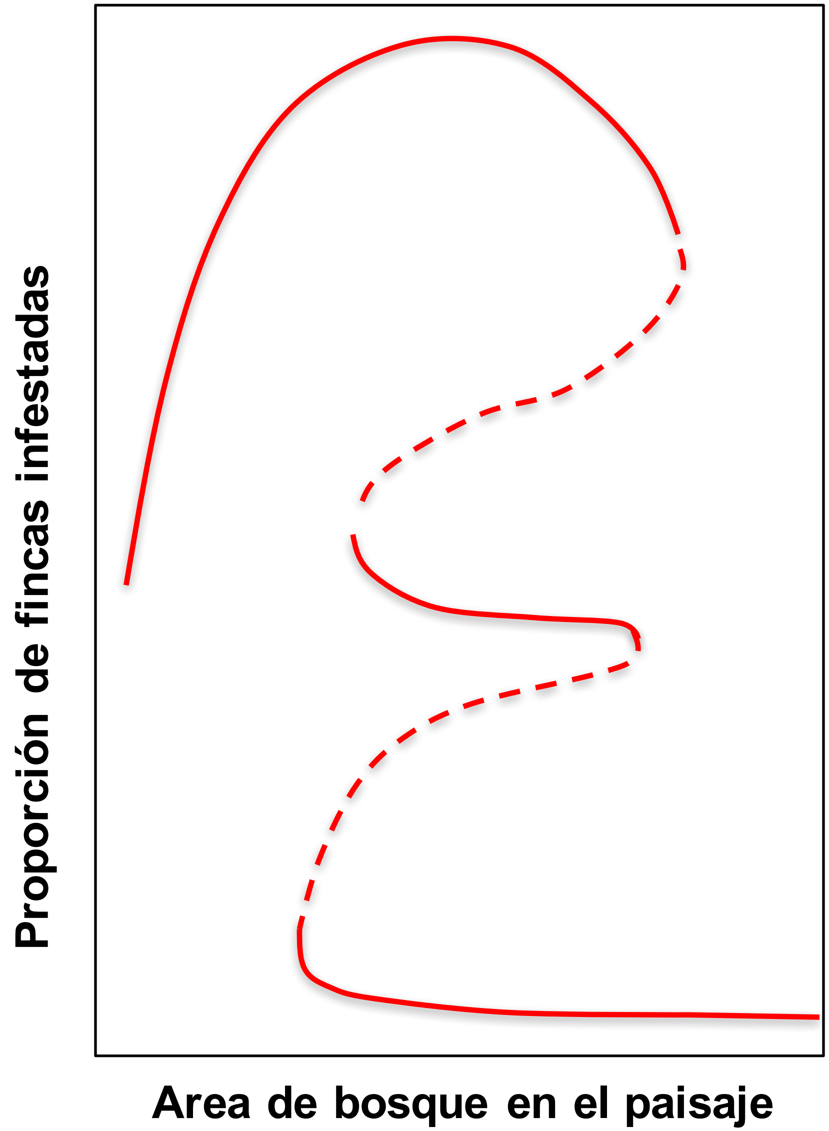


Proporción de fincas infestadas
Taza de ataque del depredador

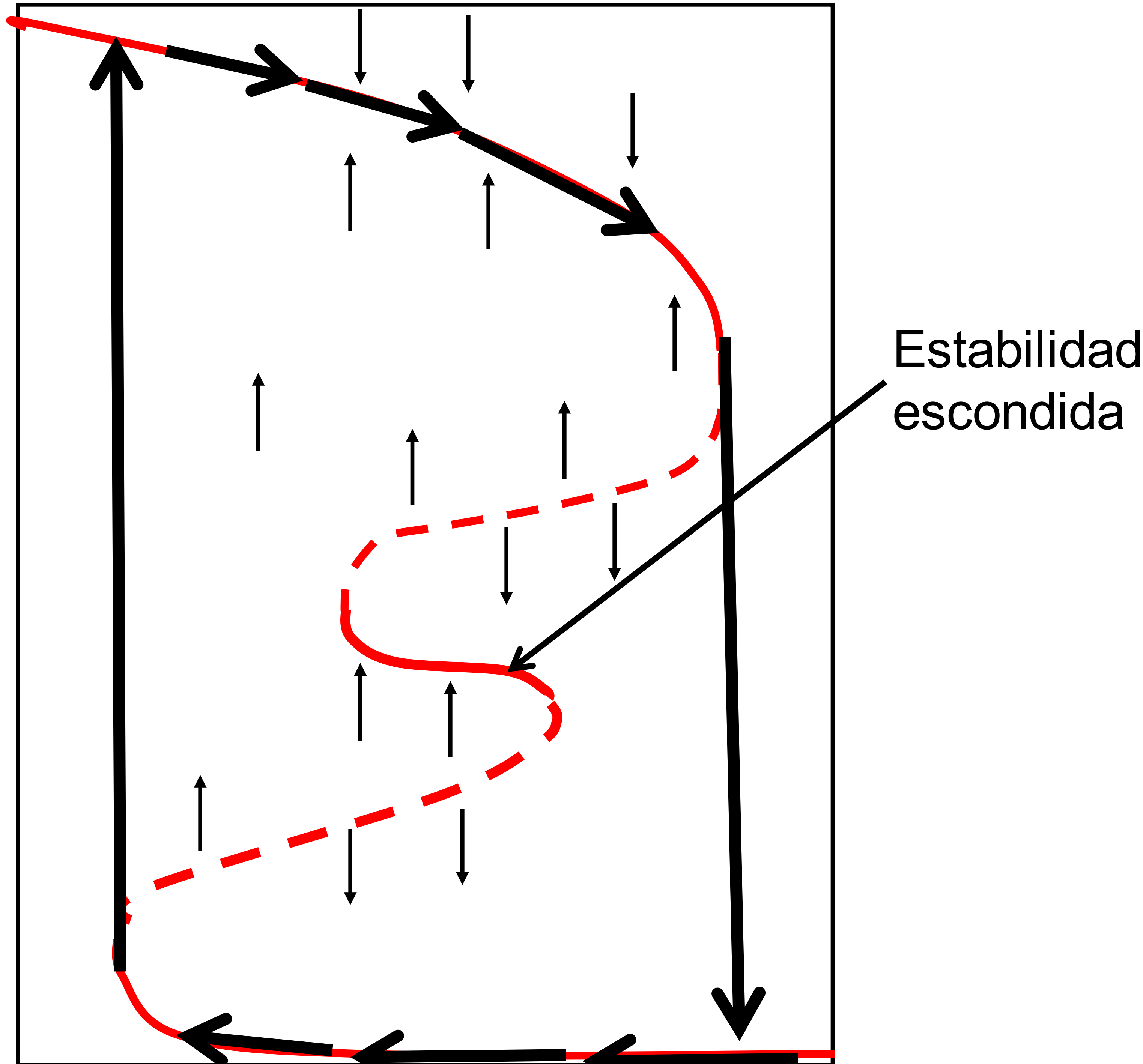


Vandermeer et al., (2015) http://arxiv.org/abs/1510.05849



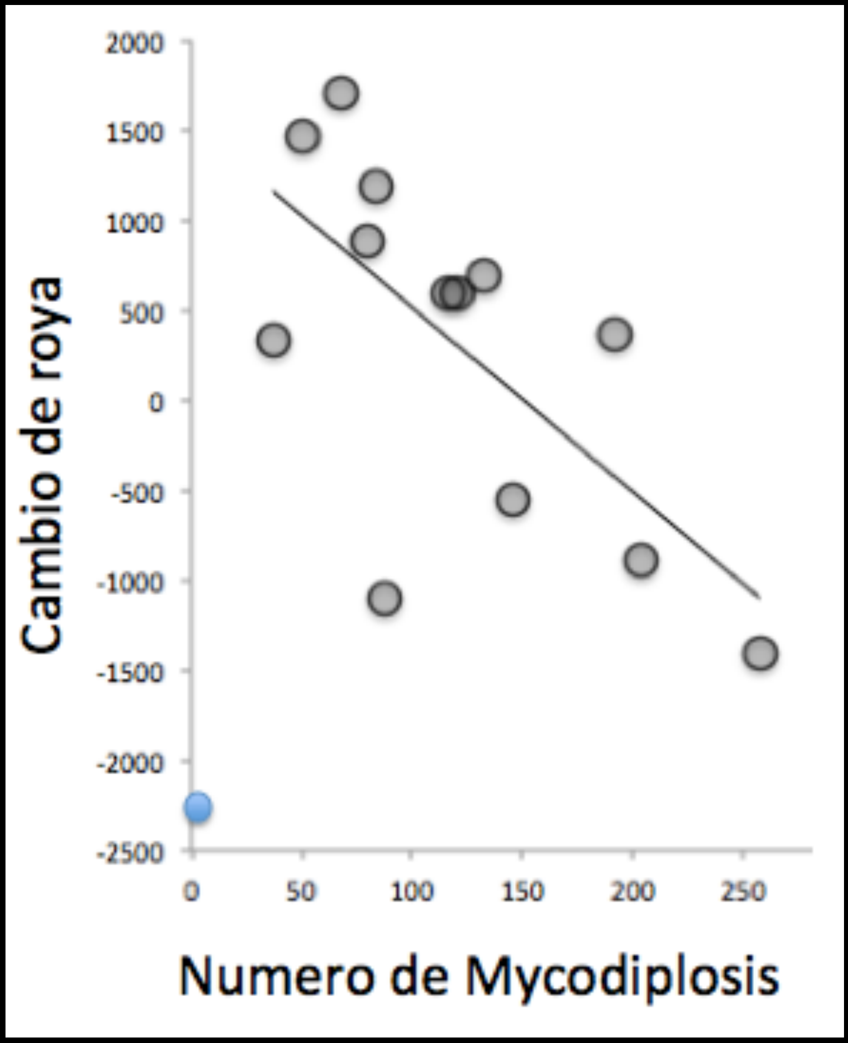


Vandermeer et al., (2015) http://arxiv.org/abs/1510.05849



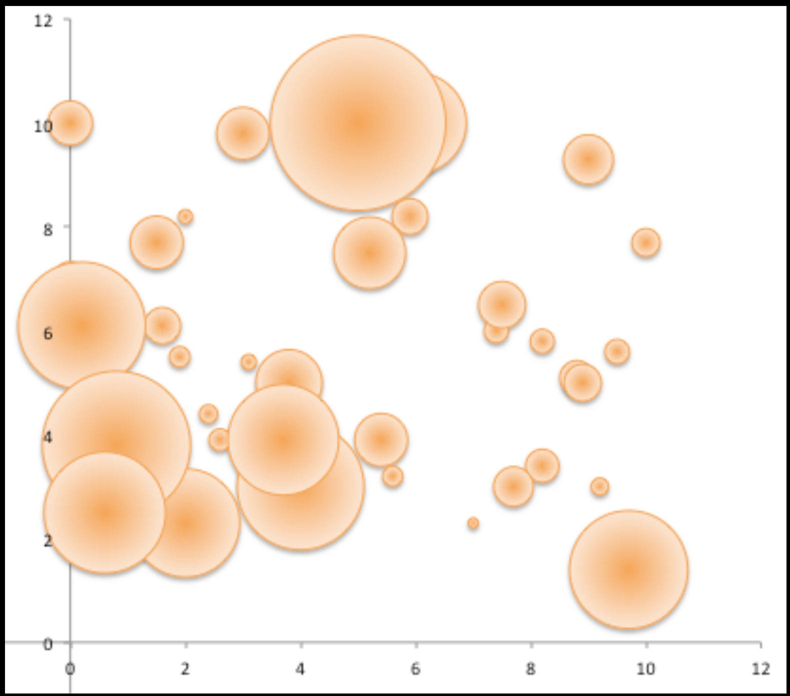
Area de bosque en el paisage

13 semanas en una planta en México

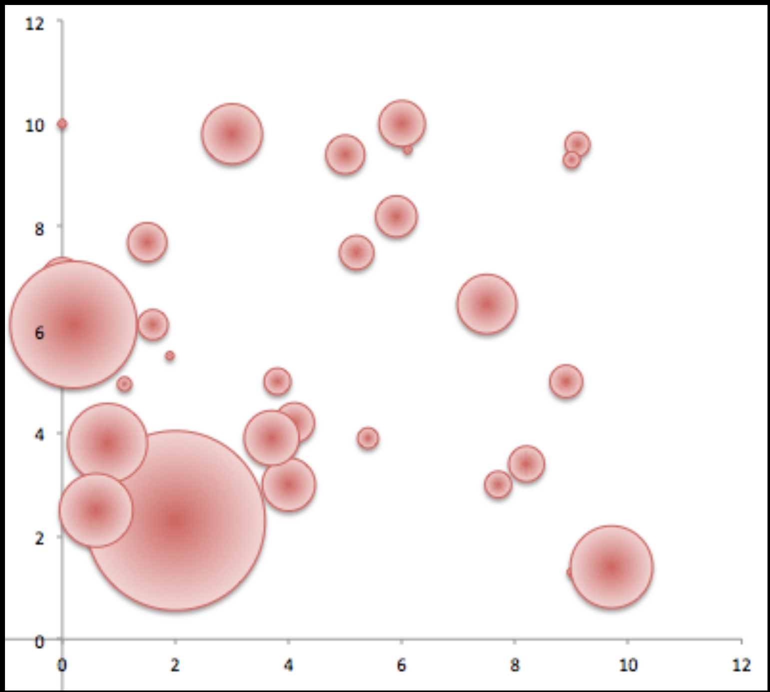


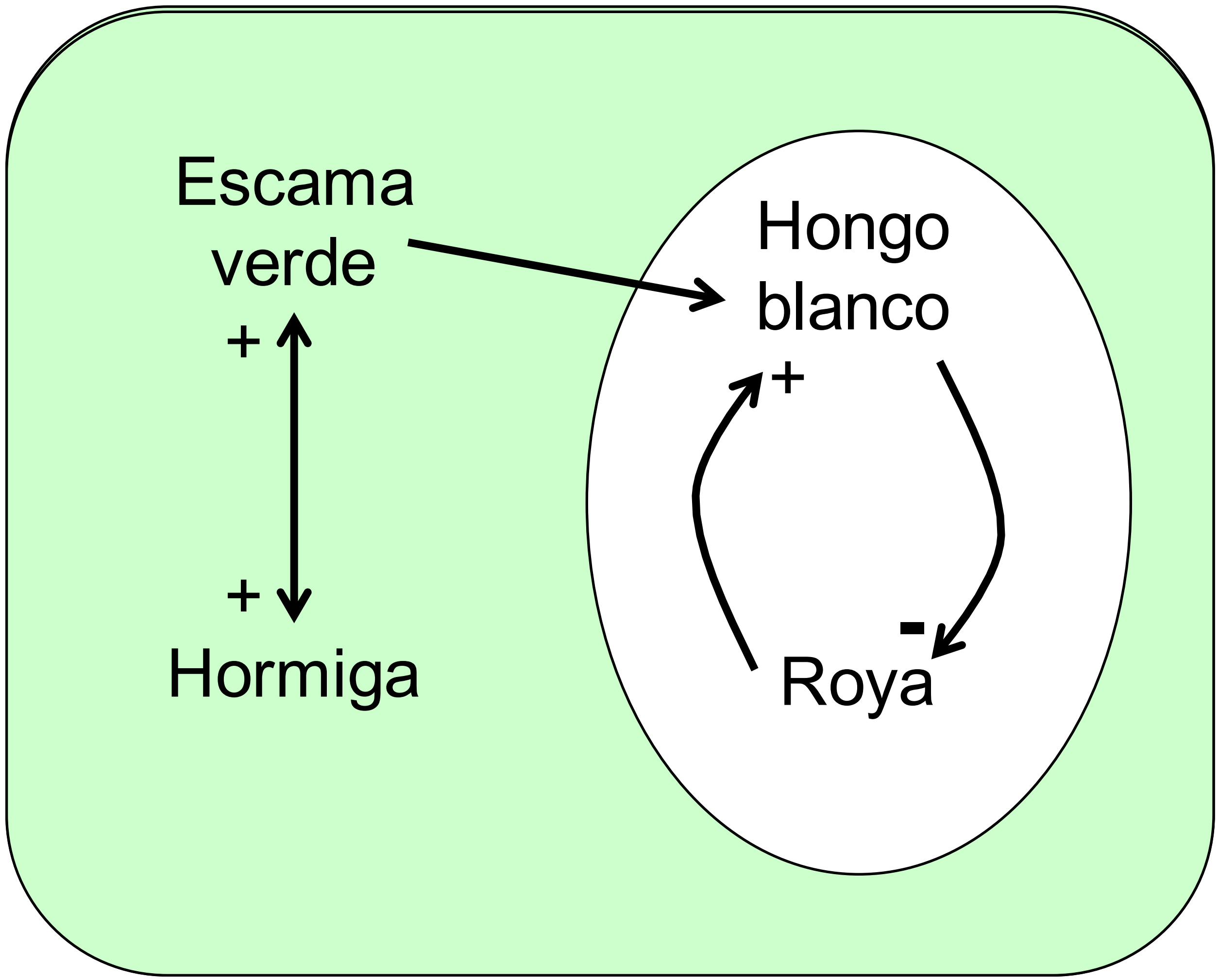
Una parcela en Puerto Rico

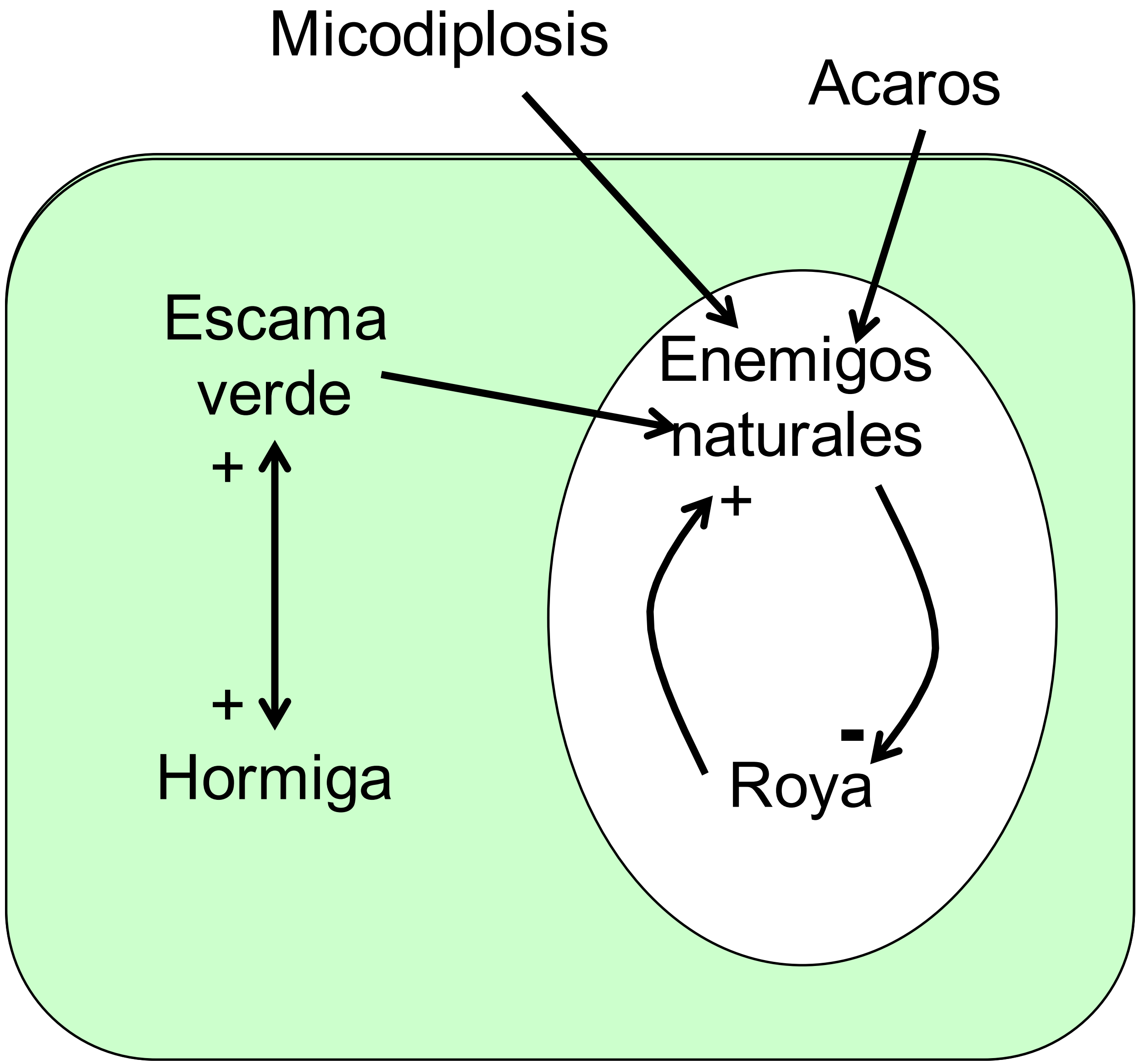
La Roya



Mycodiplosis




Escama
verde
+
+
Hormiga
Hongo
blanco
+
-
Roya



Micodiplosis
Acaros
Escama verde
Enemigos naturales
+
+
+
Hormiga
-
Roya

Proc. Natl. Acad. Sci. USA
Vol. 94, pp. 12243–12248, November 1997

Perspective

A total system approach to sustainable pest management

W. J. Lewis†, J. C. van Lenteren‡, Sharad C. Phatak§, and J. H. Tumlinson, III¶*

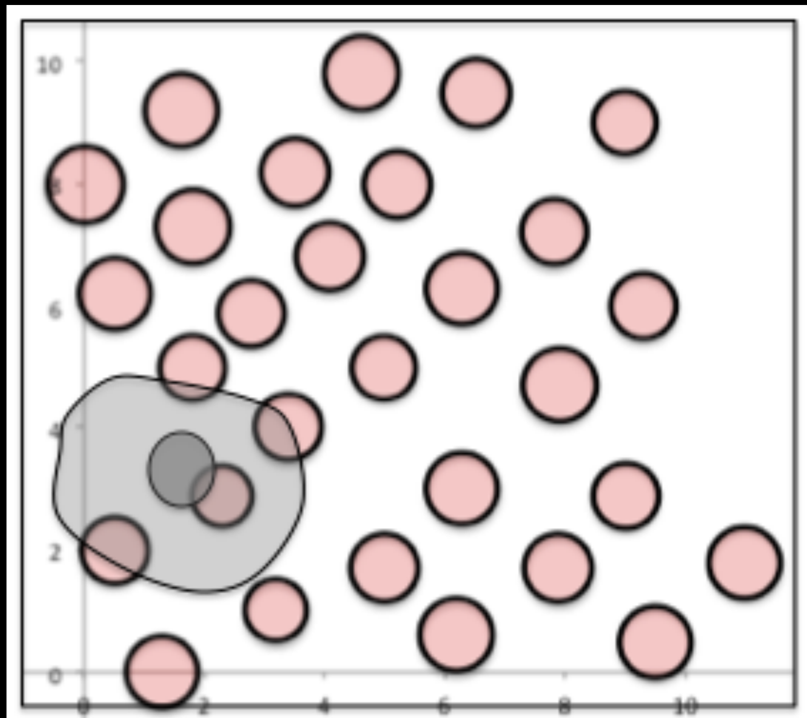
**Insect Biology and Population Management Research Laboratory, Agricultural Research Service, United States Department of Agriculture, P.O. Box 748, Tifton, GA 31793; ‡Department of Entomology, Agricultural University, P.O. Box 8031, 6700 EH Wageningen, The Netherlands; §Department of Horticulture, Coastal Plain Experiment Station, University of Georgia, P.O. Box 748, Tifton, GA 31793; and ¶United States Department of Agriculture-Agricultural Research Service, Center for Medical, Agricultural, and Veterinary Entomology, P.O. Box 14565, Gainesville, FL 32604*

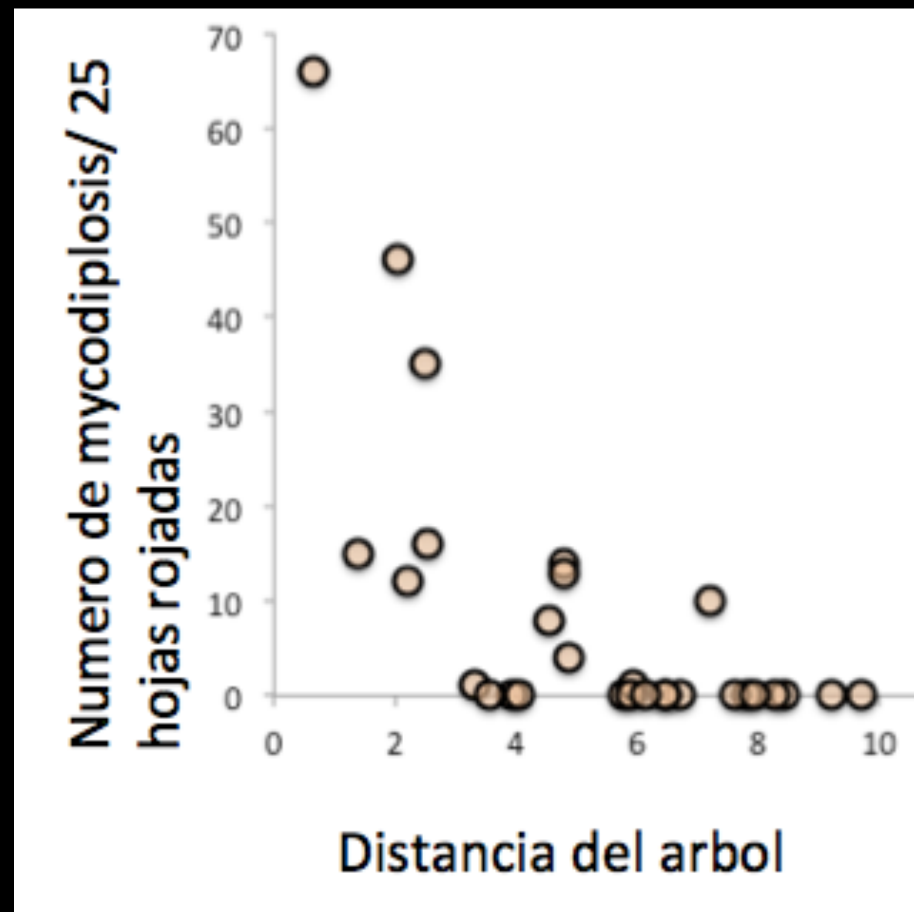
Contributed by J. H. Tumlinson, III, August 13, 1997

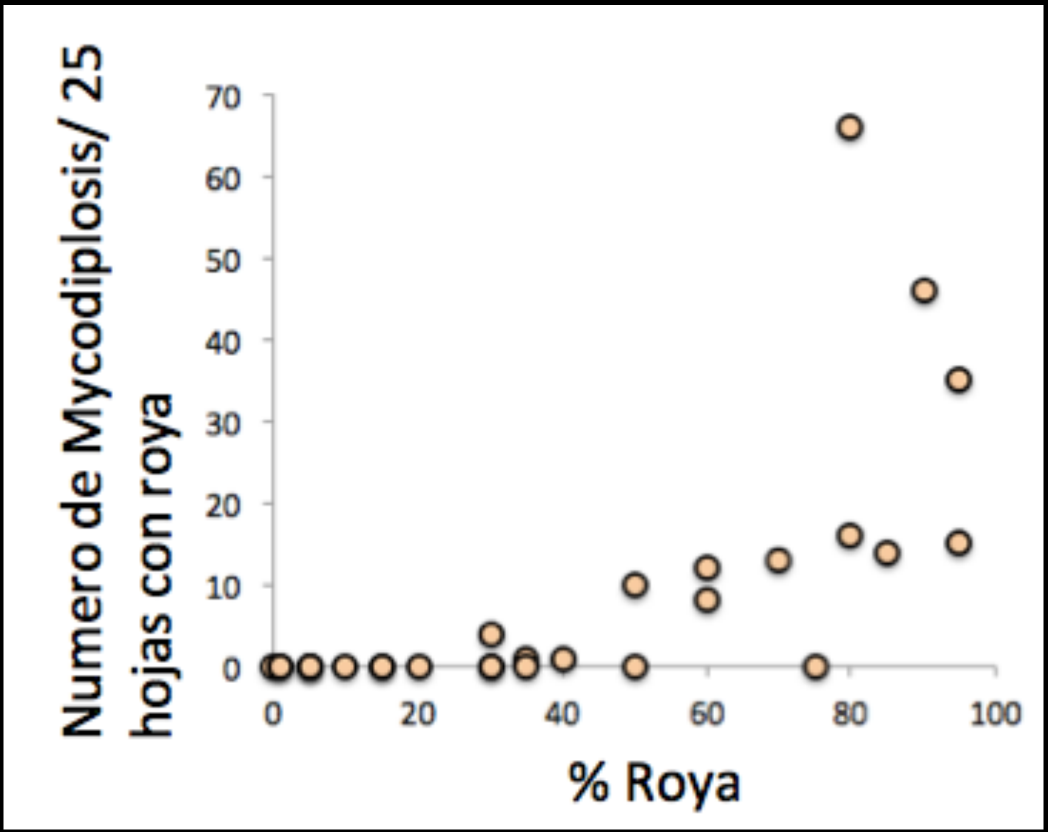
Conclusiones

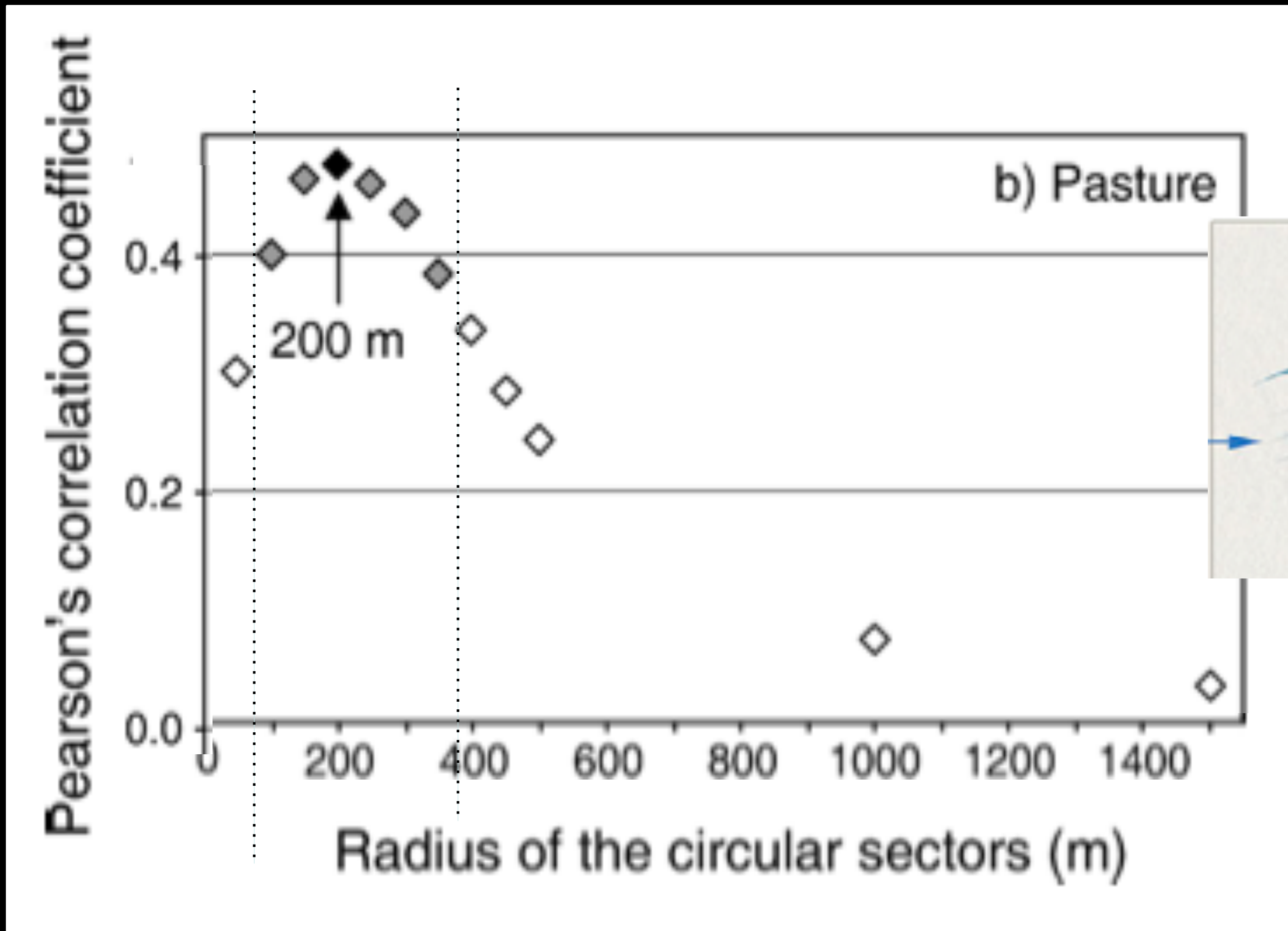
1. Transmisión por viento en escalas distintas, resuta en histeresis y transiciones crítcas – sorpresas inevitables
2. El efecto de sombra en transmisión y germinación fortalesa el patrón de histeresis.
3. Micoparásitos y depredadores son comunes, aunque son bastante variables en espacio.
4. La combinación de transmisión a diferentes escalas y enemigos naturales pueden resultar en complicaciones inesperadas, como, por ejemplo, histeresis y estabilidades escondidas.
5. El “estilo” de manejo de la finca, y especialmente el paisaje, puede minimizar la roya mediante el control autónomo de transmisión y control autónomo biológico.

Gracias


10
6
2
0
0
2
4
6
8
10


Numero de mycodiplosis/ 25 hojas rojadas
70
60
50
40
30
20
10
0
0
2
4
6
8
10
Distancia del arbol


Numero de Mycodiplosis/ 25 hojas con roya
70
60
50
40
30
20
10
0
0
20
40
60
80
100
% Roya



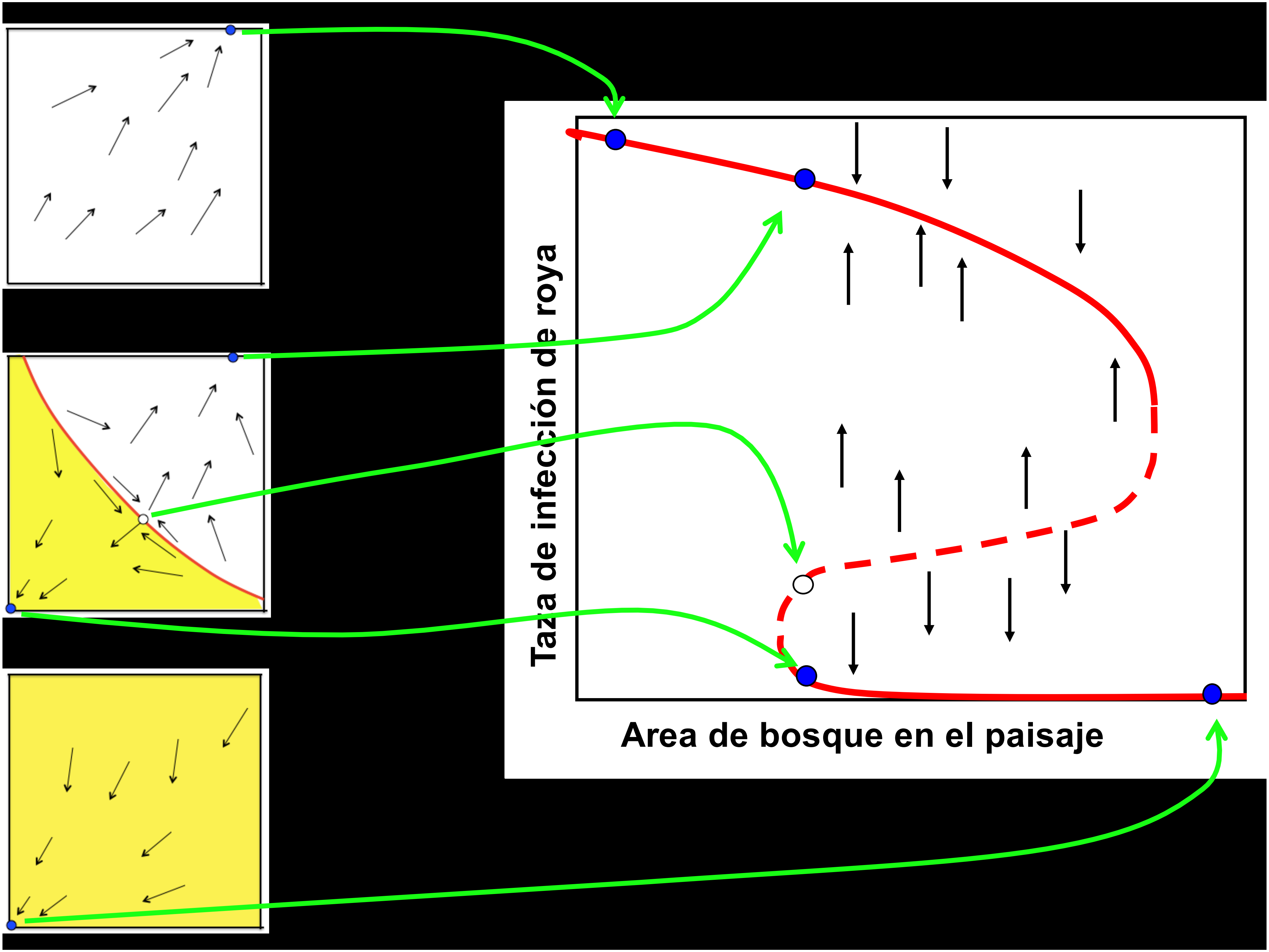
Avelino et al., (2012). Ecological Applications.

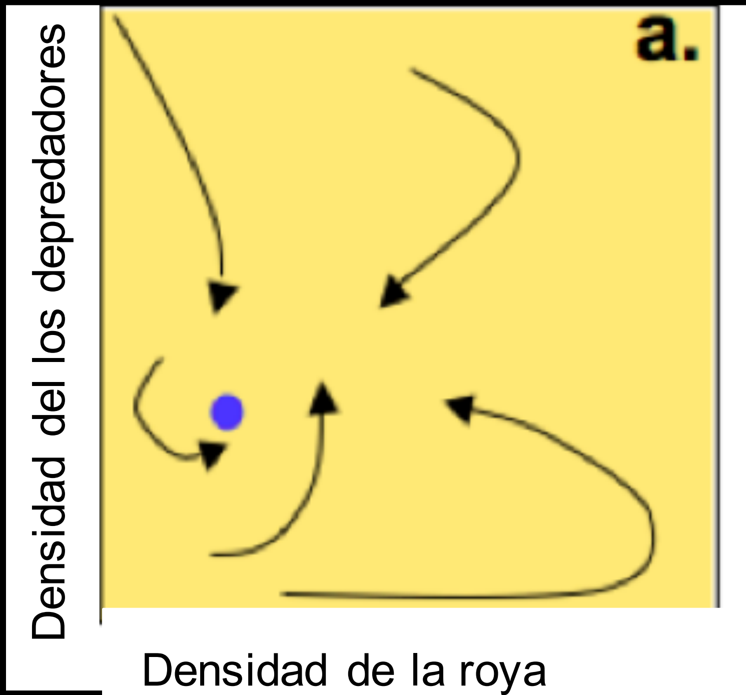
Table 1 Classified summary of the number of literature references to host density effects on disease incidence expressed as the proportion of diseased plants[a]

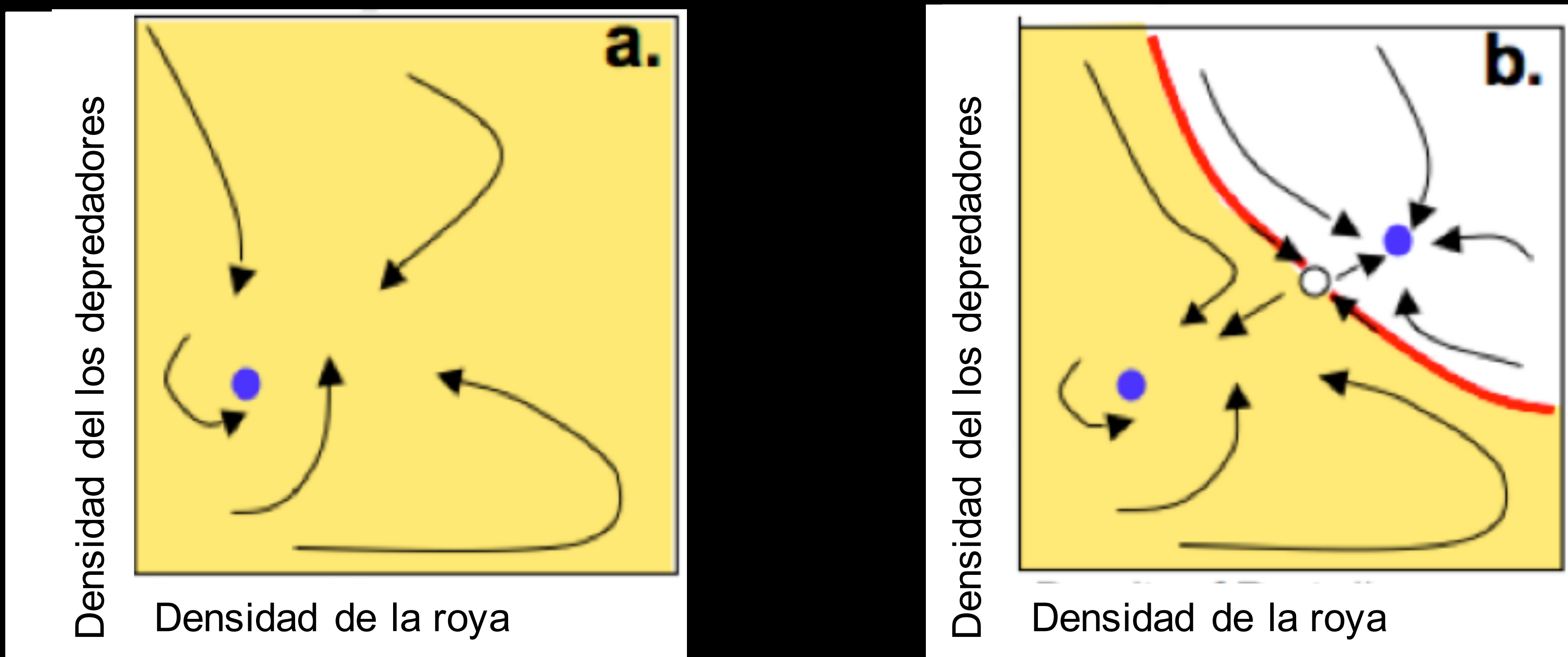
Time scale	Type of pathogen	Correlation between host density and disease incidence			Refer
		Positive	Nil	Negative	
Short term	Fungus	1 (1)	0	2 (2)	21, 31, 47
	Virus	1 (1)	0	13 (5)	1, 2, 14, 16, 38, 44, 48, 61, 62, 64, 77, 97, 113
Medium term	Fungus	32 (23)	5 (4)	5 (3)	4–6, 9, 13, 15, 18, 22, 23, 28–30, 32, 33, 36, 49, 53, 54, 57, 60, 65, 67, 68, 70, 72, 73, 78, 79, 81, 82, 86, 88, 89, 95, 96, 98, 101, 102, 108, 115–117
	Virus	5 (3)	0	0	12, 39, 40, 92, 105
Long term	Fungus	0	1 (1)	4 (2)	76, 80, 91, 100, 110
	Virus	0	0	0	
Totals		39 (28)	6 (5)	24 (12)	

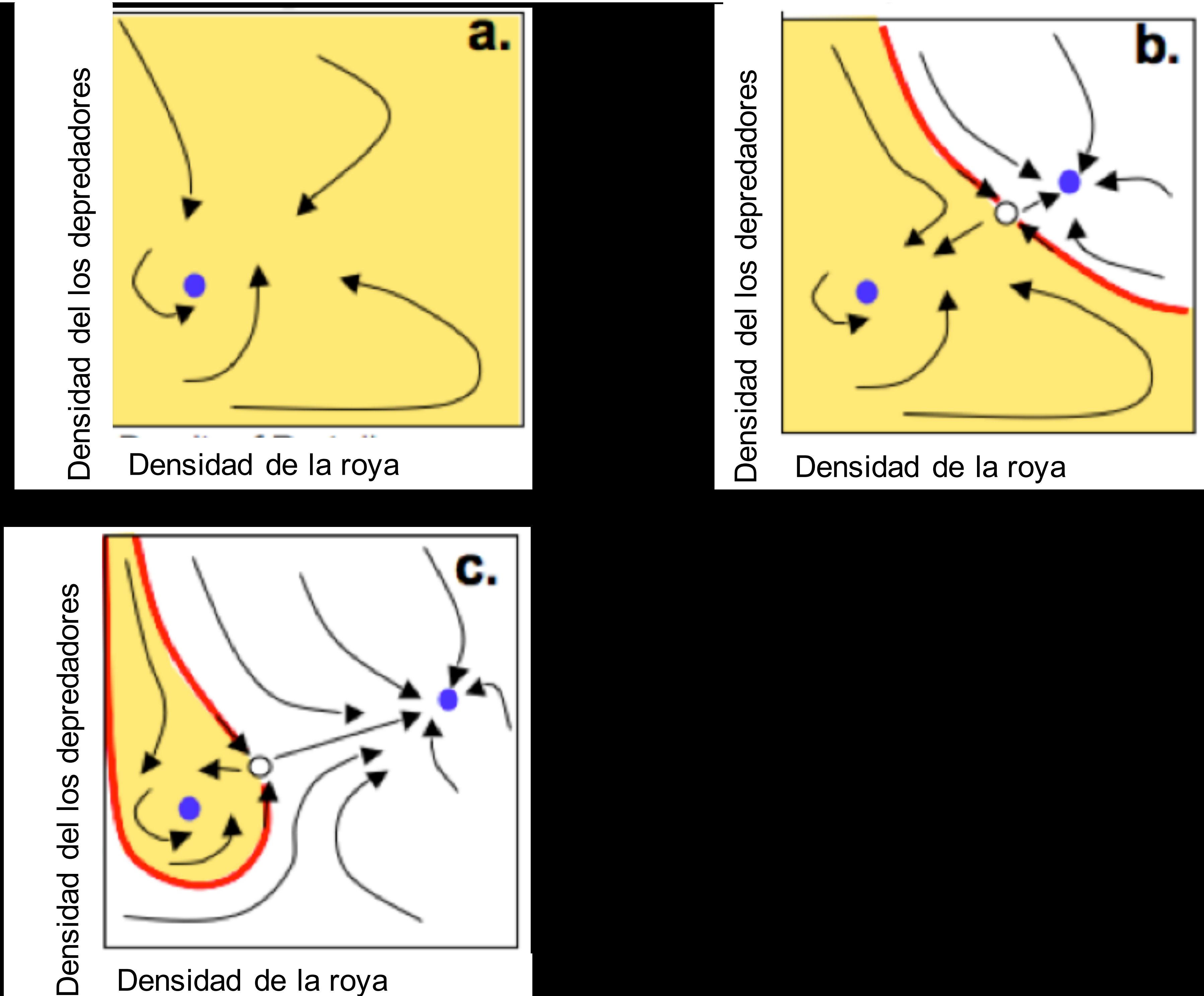
[a] Figures in parentheses give the number of different host-pathogen combinations represented.

Burdon and Childers, (1982). Ann Rev Phytopathology

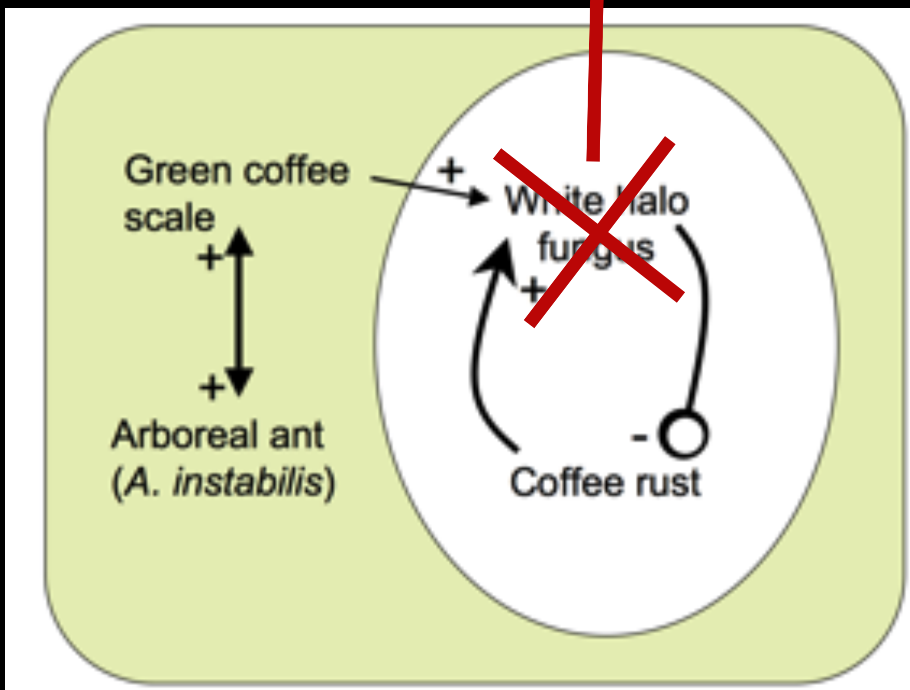

Taza de infección de roya
Area de bosque en el paisaje

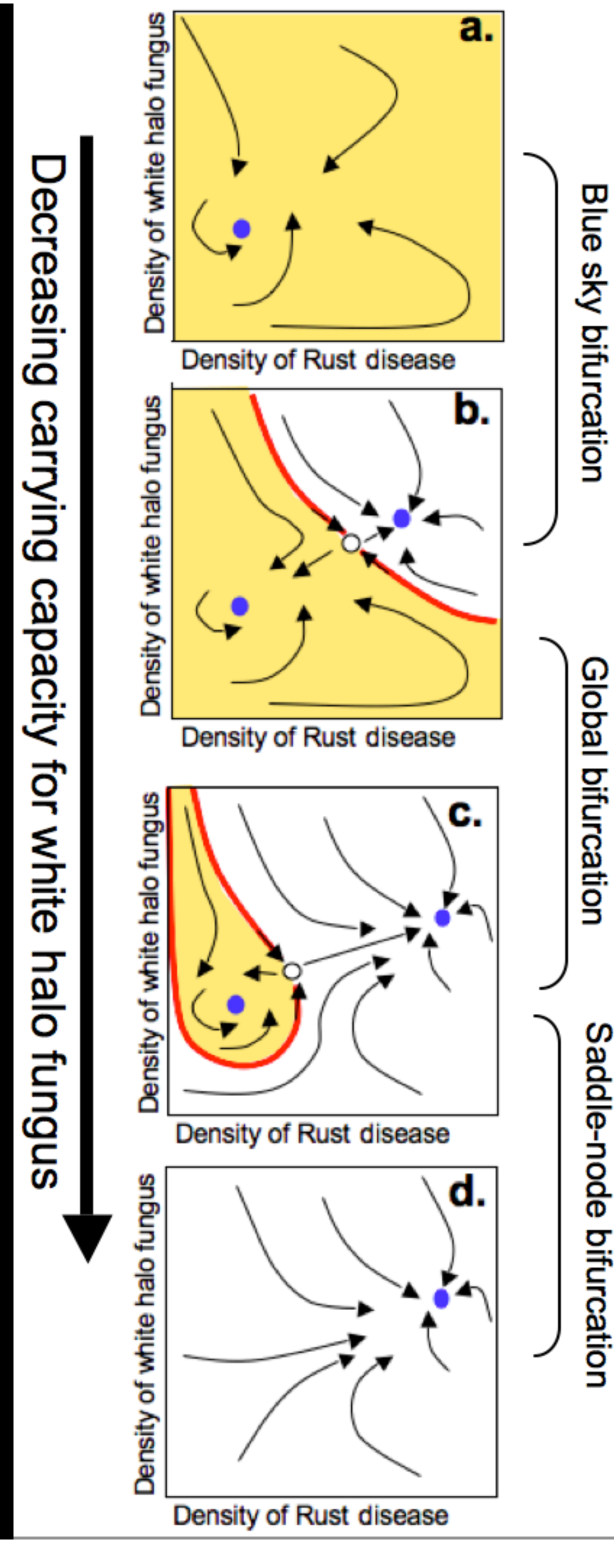

a.
Densidad del los depredadores
Densidad de la roya

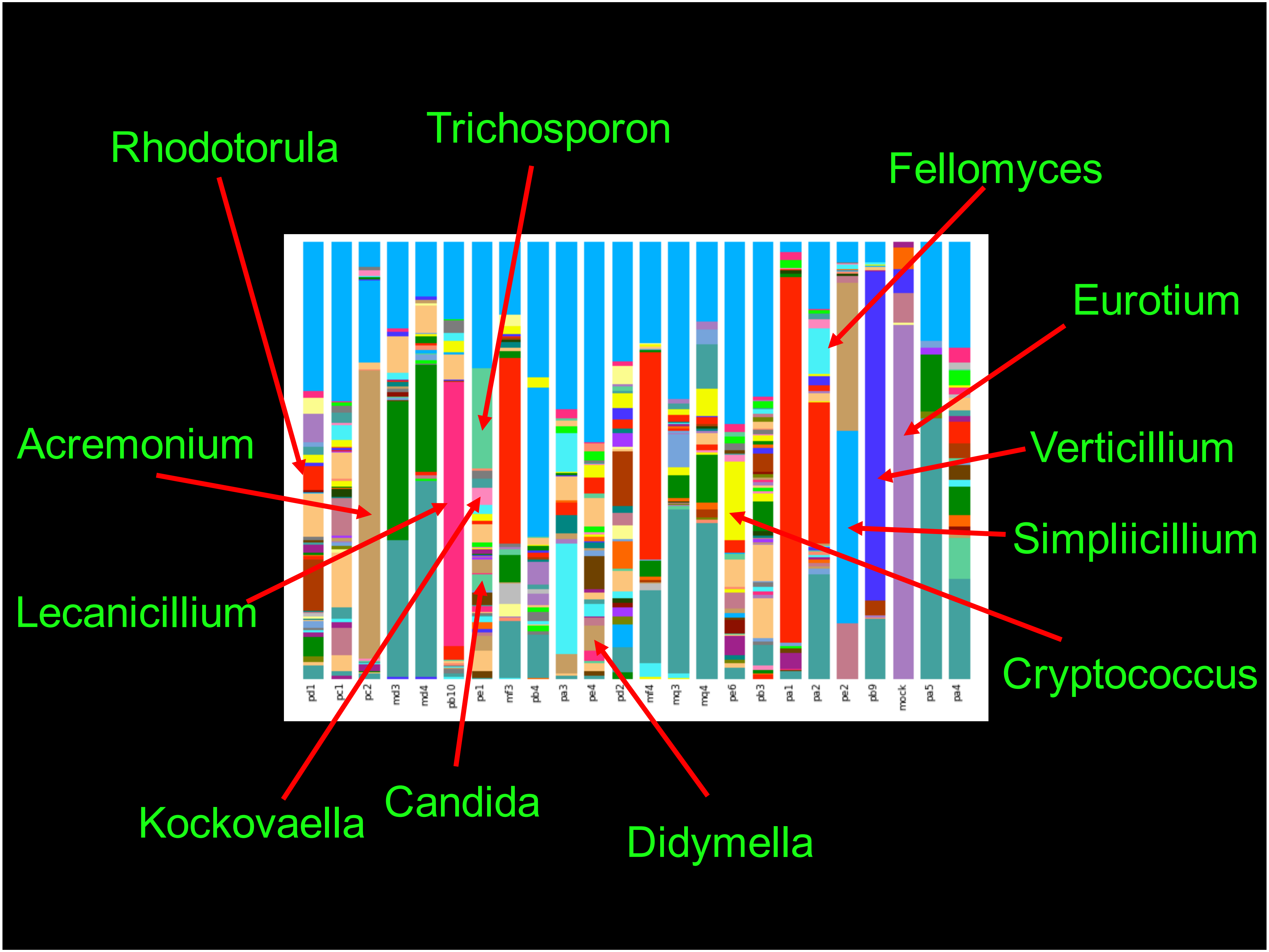

a.
Densidad del los depredadores
Densidad de la roya
b.
Densidad del los depredadores
Densidad de la roya

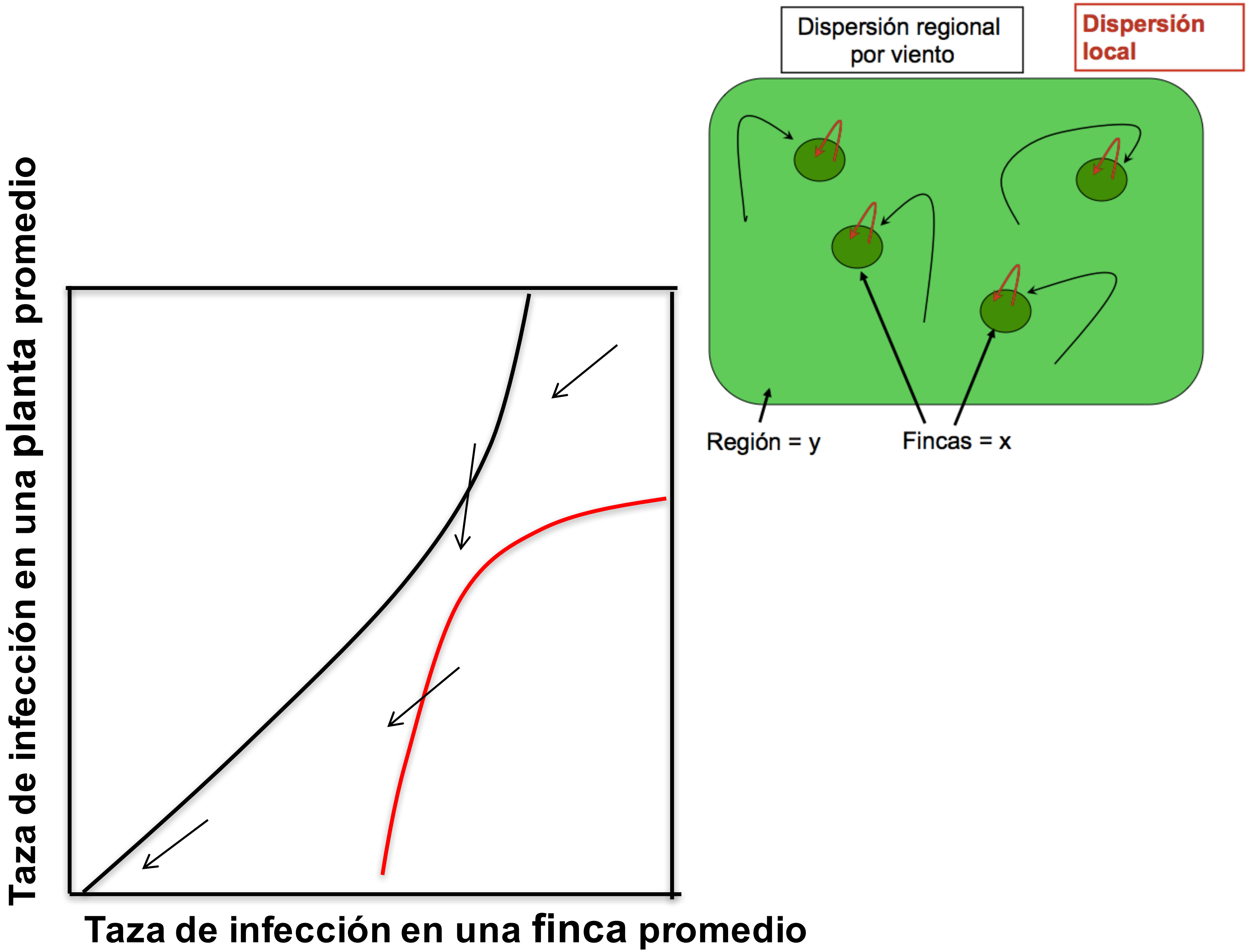

a.
Densidad del los depredadores
Densidad de la roya
b.
Densidad del los depredadores
Densidad de la roya
c.
Densidad del los depredadores
Densidad de la roya

La comunidad de micoparásitos

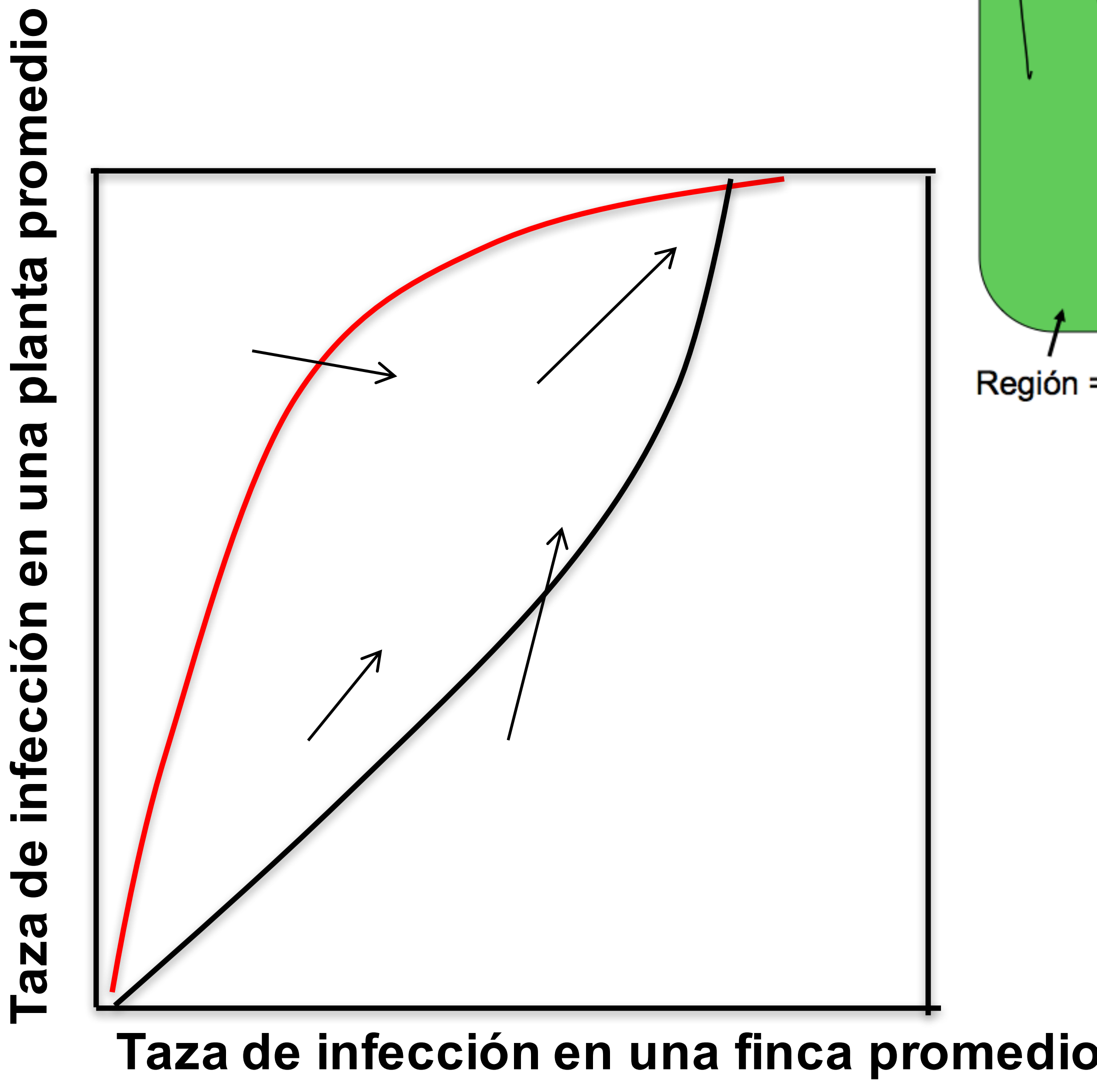


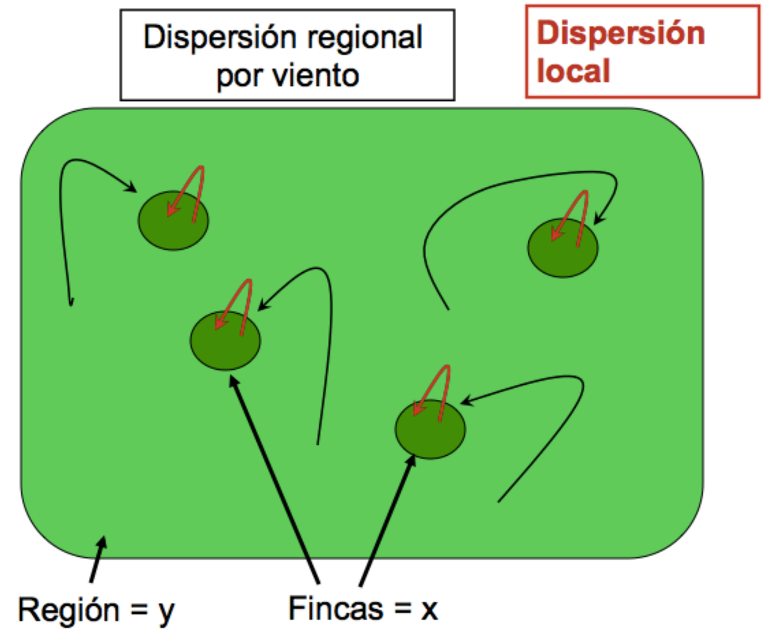


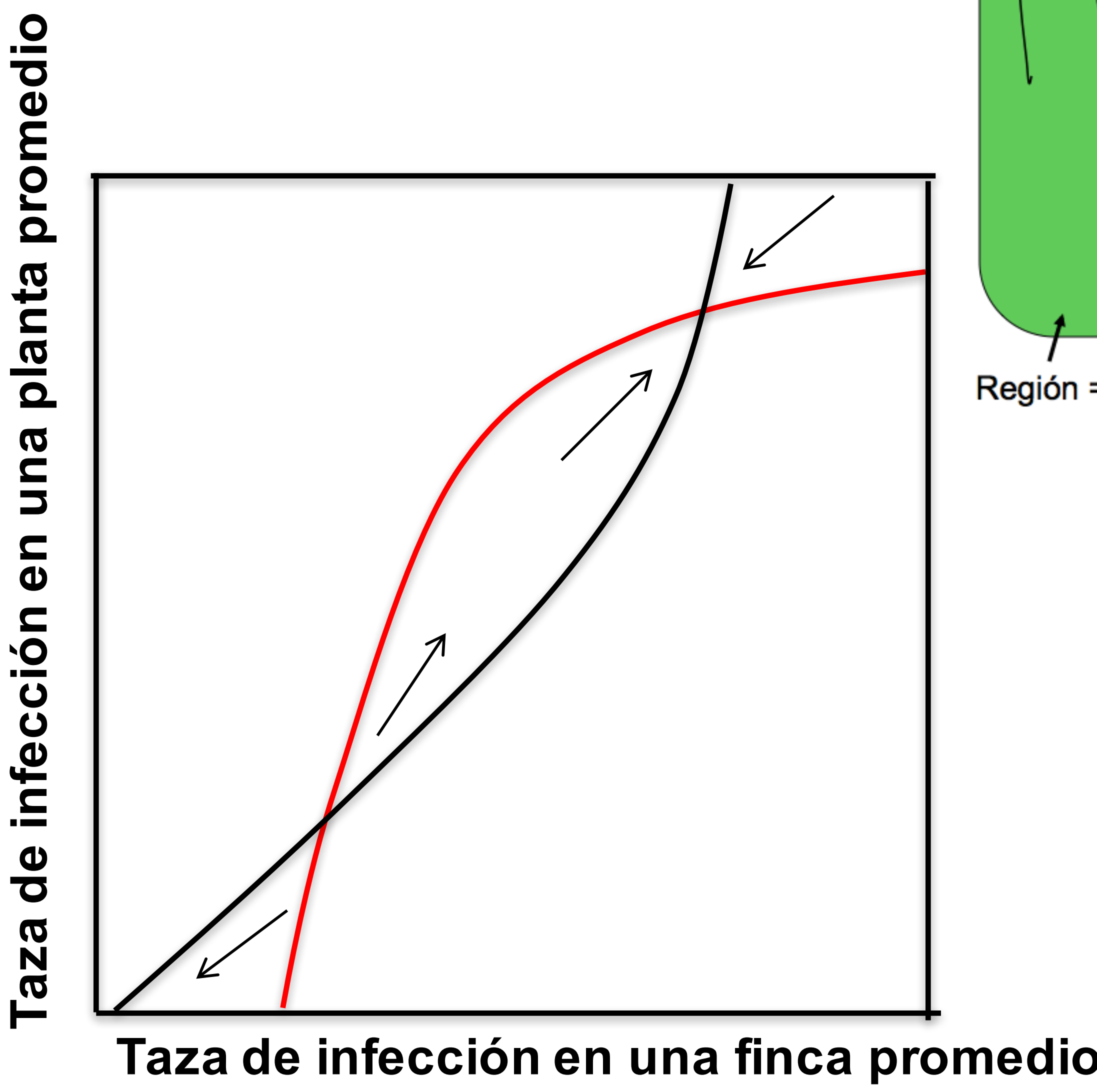

Rhodotorula
Trichosporon
Fellomyces
Eurotium
Acremonium
Verticillium
Simpliicillium
Lecanicillium
Cryptococcus
Kockovaella
Candida
Didymella
pd1
pc1
pc2
md3
md4
pb10
pe1
mf3
pb4
pa3
pe4
pd2
mf4
mq3
mq4
pe6
pb3
pa1
pa2
pe2
pb9
mock
pa5
pa4

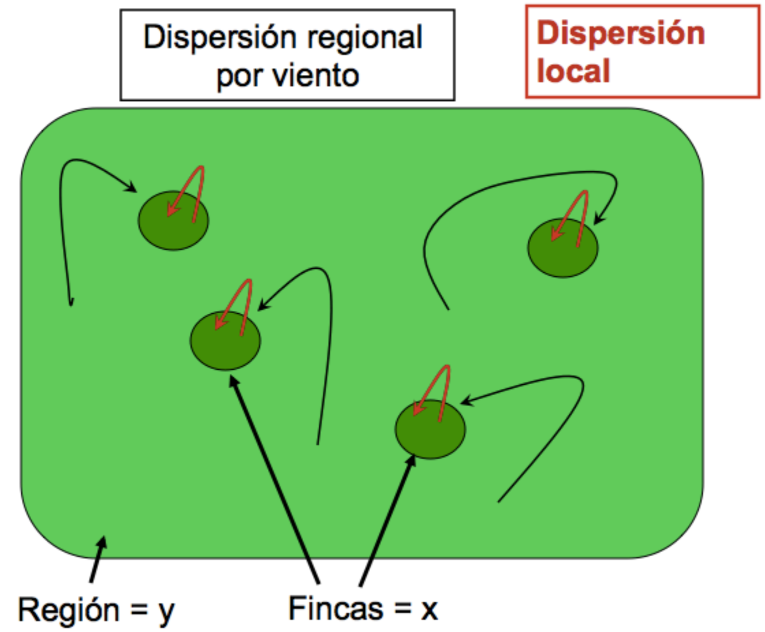


Dispersión regional
por viento
Dispersión
local
Región = y
Fincas = x
Taza de infección en una planta promedio
Taza de infección en una finca promedio

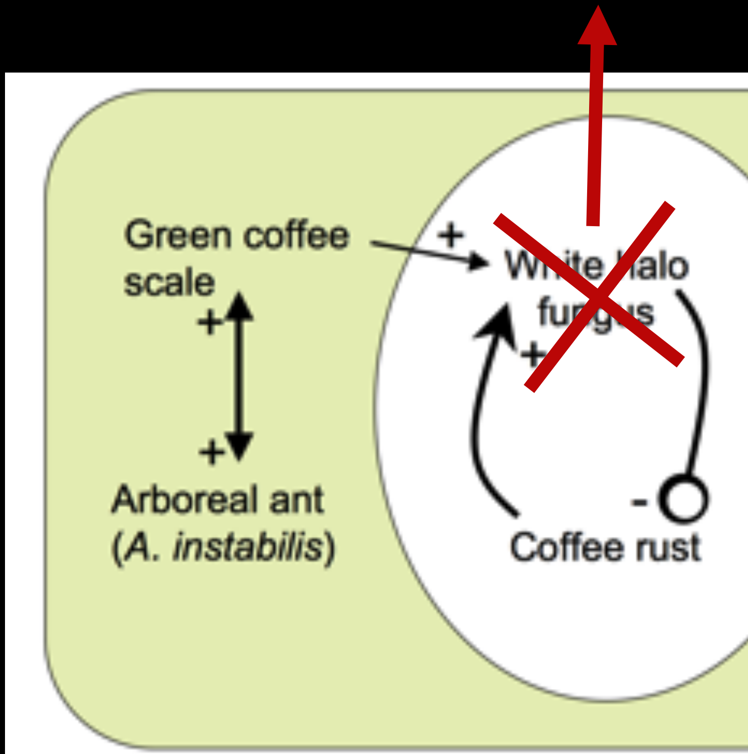

Taza de infección en una planta promedio
Taza de infección en una finca promedio

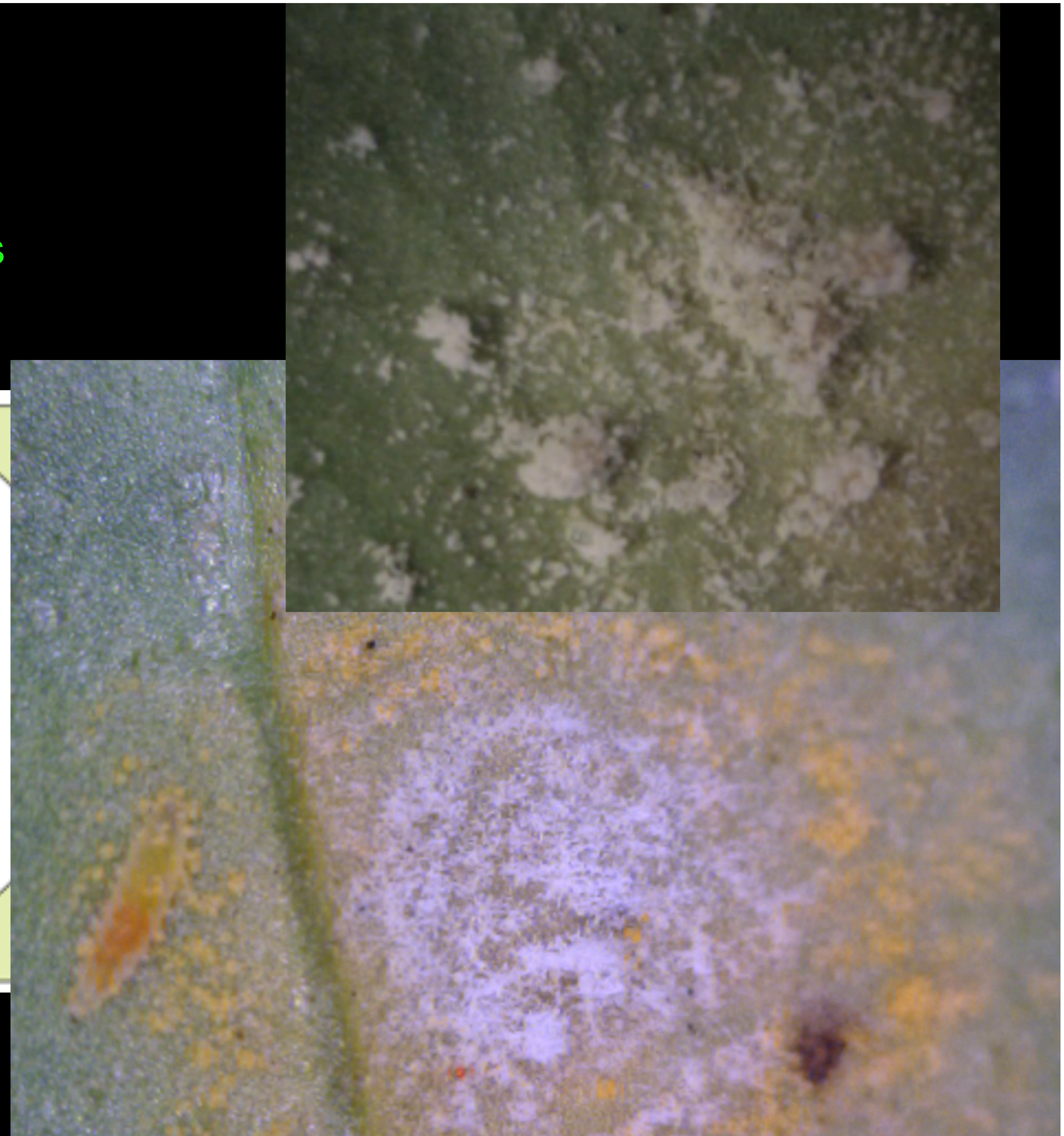

Dispersión regional por viento
Dispersión local
Región = y
Fincas = x


Taza de infección en una planta promedio
Taza de infección en una finca promedio

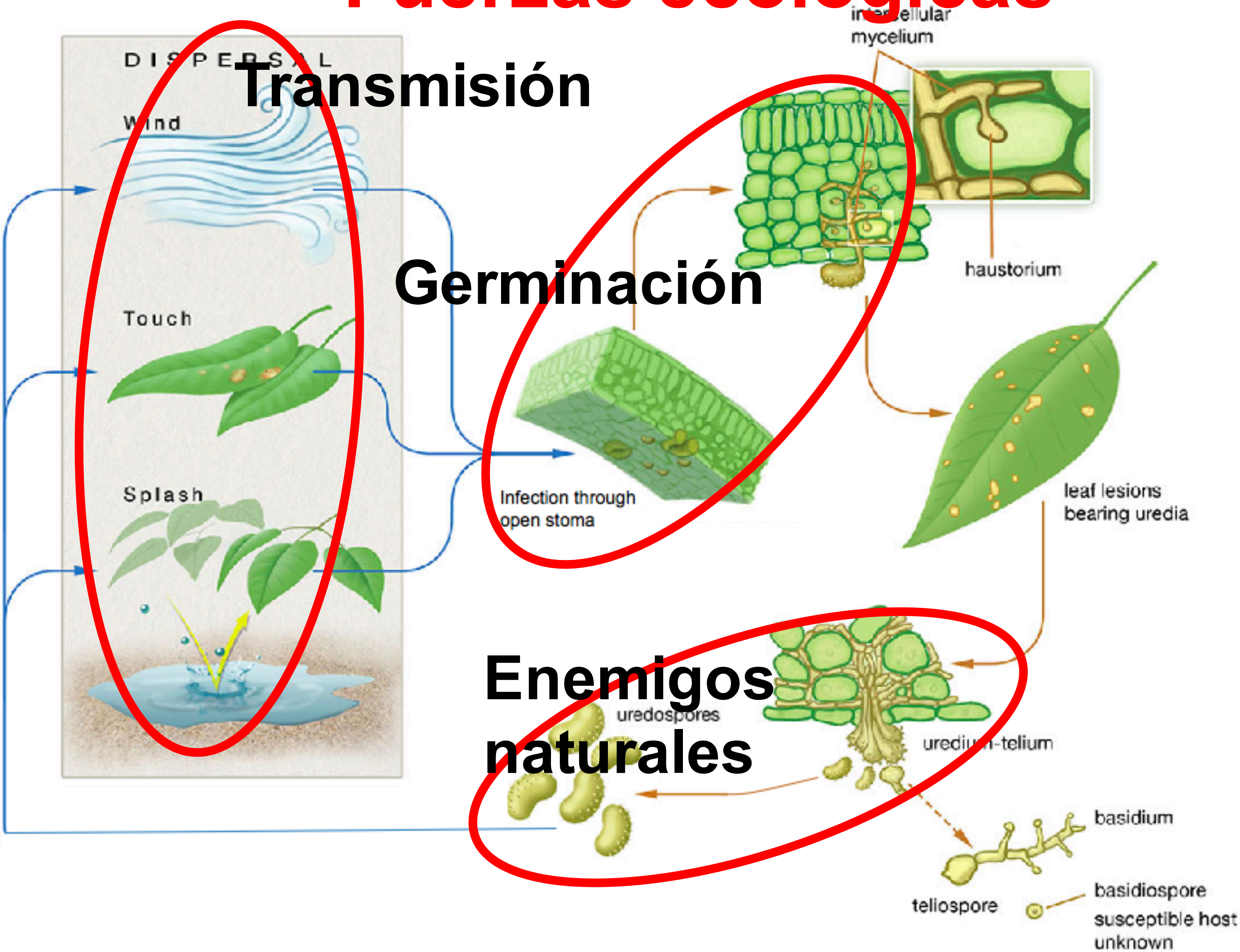

Dispersión regional por viento
Dispersión local
Región = y
Fincas = x

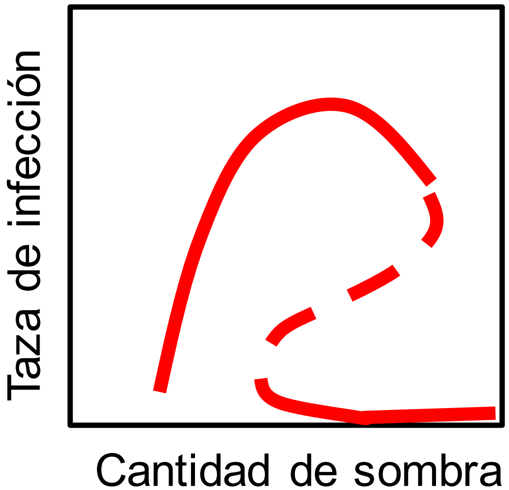
Los enemigos naturales

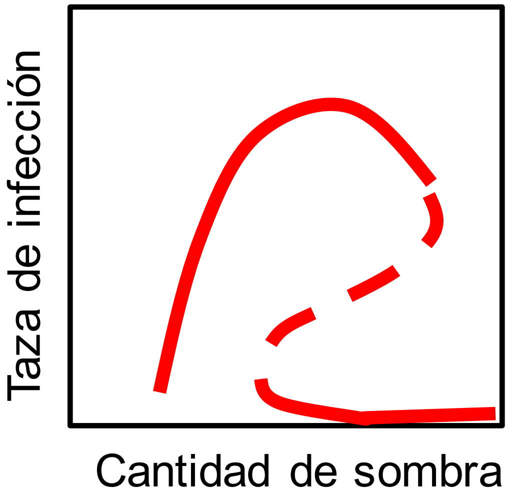


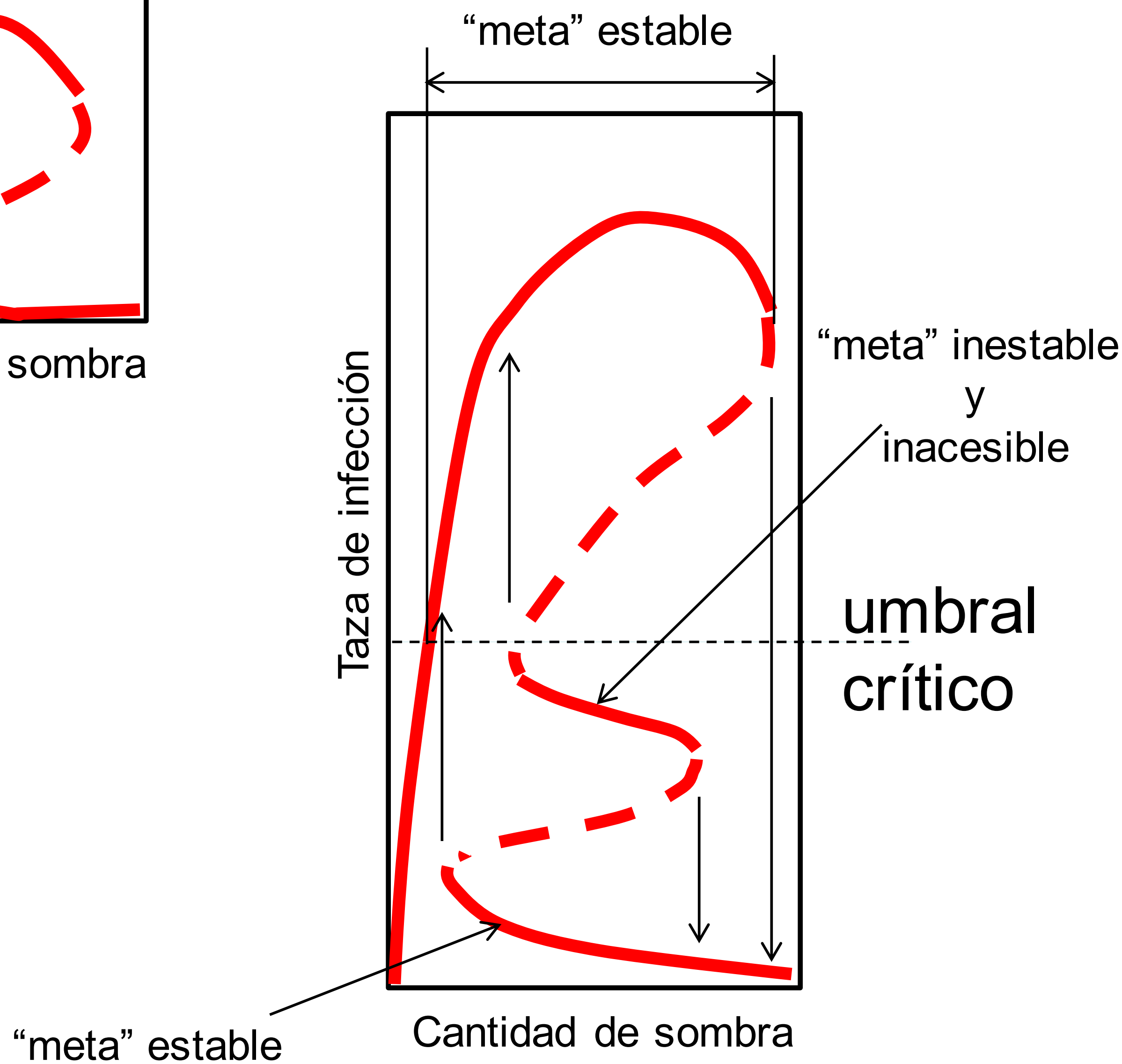


Fuerzas ecológicas




Taza de infección
Cantidad de sombra


Taza de infección
Cantidad de sombra


"meta" estable
"meta" inestable
y
inacesible
umbral
crítico
Taza de infección
Cantidad de sombra
"meta" estable

Finca Irlanda

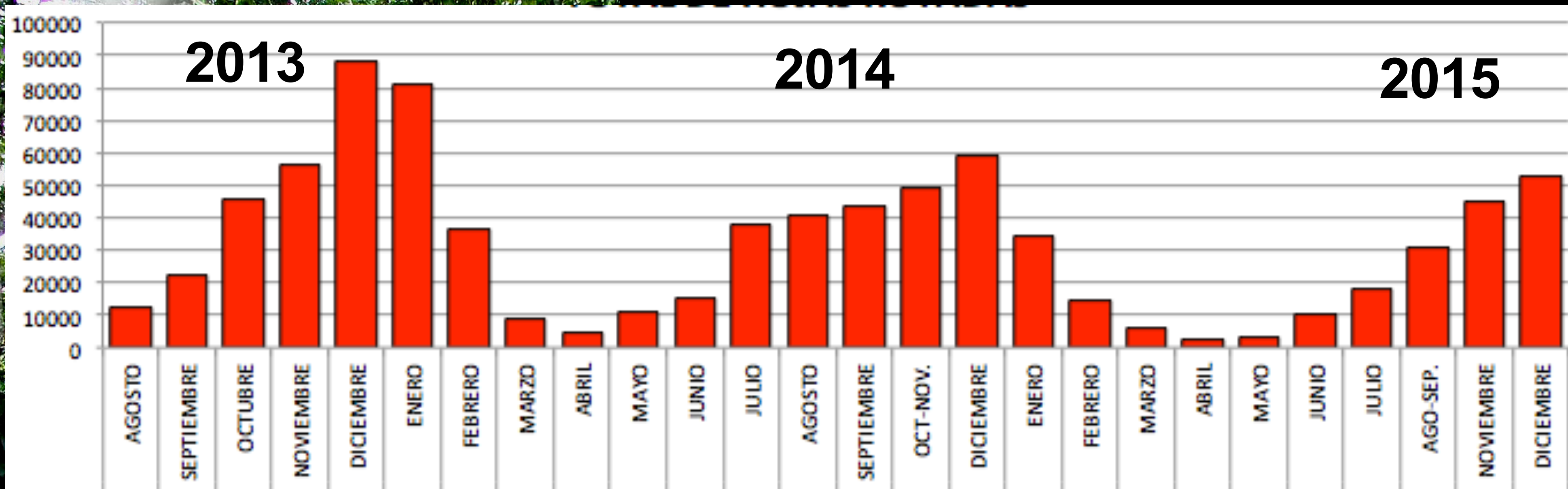
Finca Guaraguao

México

Puerto Rico

	Número de *Mycodiplosis* por hoja	Proporción de lesiones de roya con *Lecanicillium*
Mexico	**0.89**	**0.06**
Puerto Rico	**2.84**	**0.24**

Finca Irlanda



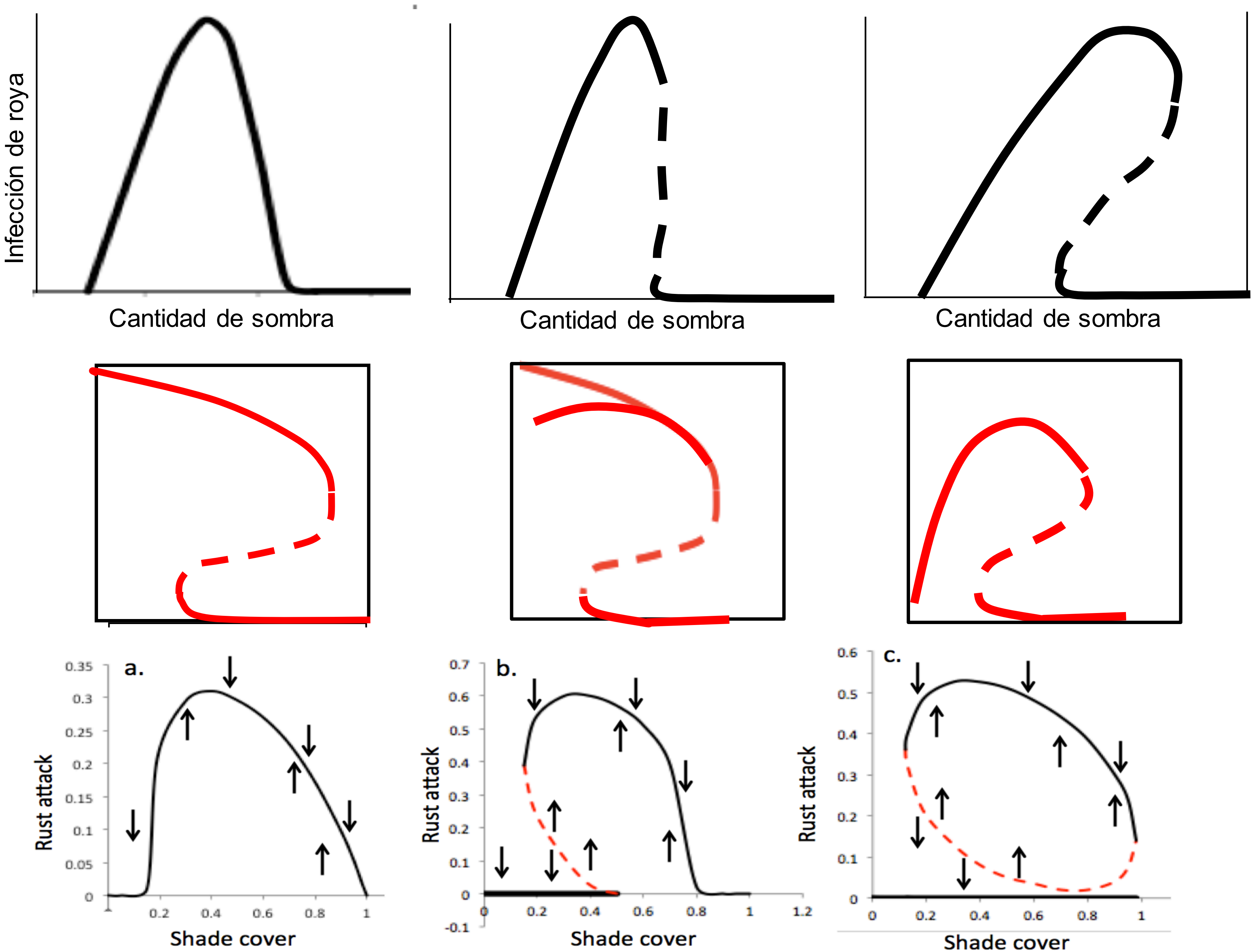
Finca Guaraguao

Table 1 – List of variables describing coffee plots

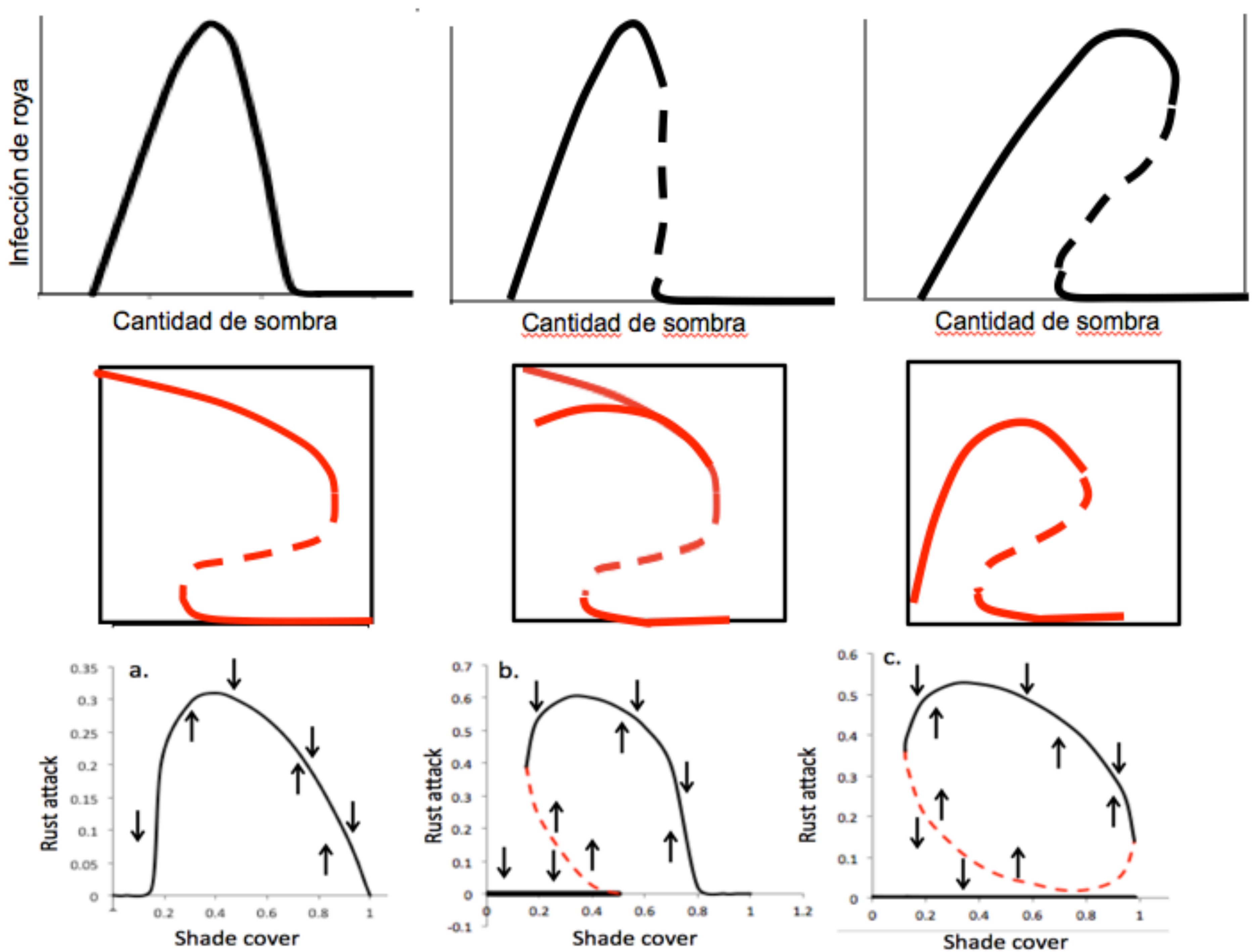
Kind of variable	Variable	Code	Unit
Coffee rust	Maximum annual incidence of coffee rust (maximal percentage of young leaves infected in the year)	R	–
Climate	Altitude	Alt	m
	Annual rainfall	Rain	mm
Soil	pH	–	–
	K	–	C mol$^{(+)}$/kg
	Ca	–	C mol$^{(+)}$/kg
	Mg	–	C mol$^{(+)}$/kg
	Al	–	C mol$^{(+)}$/kg
	P	–	mg/kg
	Fe	–	mg/kg
	Cu	–	mg/kg
	Mn	–	mg/kg
	Zn	–	mg/kg
	Organic matter	OM	% dry weight
	Sand	–	% dry weight
	Silt	–	% dry weight
	Clay	–	% dry weight
Cropping practices	Variety[a]	Var	–
	Distance between rows	Dro	m
	Distance between plants on the row	Dpl	m
	Density of coffee trees per hectare	De/ha	Plants ha^{-1}
	Number of coffee trees per hole[a]	Pl/Ho	–
	Presence of cut down coffee trees[a]	Cut	–
	Shade percentage	Shp	–
	Shade type[a]	Sht	–
	Annual number of shade pruning operations[a]	Psh	–
	Annual number of coffee trees pruning operations[a]	Pcof	–
	Annual number of foliar fertilisations only[a]	Ffert	–
	Annual number of soil fertilisations[a]	Sfert	–
	Annual number of soil improvement activities[a]	Simp	–
	Annual number of fertilisations[a]	Fert	–
	Annual number of physical weeding rounds[a]	Pwee	–
	Annual number of chemical weeding rounds[a]	Cwee	–
	Annual number of weeding rounds[a]	Wee	–
	Annual number of fungicide sprays[a]	Fsp	–
	Annual number of insecticide sprays[a]	Isp	–
	Annual number of pickings[a]	Pic	–
Coffee tree productive characteristics	Coffee tree age	Age	Year
	Circumference of the trunk at ground level	Cir	m
	Height of the coffee tree	Hei	m
	Height of the coffee tree/circumference of the trunk at ground level	Hei/Cir	–
	Number of fruiting nodes per plant	Fnod	–
	Foliage density (number of young leaves per branch at the beginning of the rainy season)	Fdens	–
	Fruit load (number of cherries related to the number of young leaves counted at the beginning of the rainy season)	Fload	–

[a] The initial nature of the variable is qualitative. Others variables are quantitative.

Avelino et al., 2006. Ecol. Modelling



Infección de roya
Cantidad de sombra
Cantidad de sombra
Cantidad de sombra
a.
Rust attack
Shade cover
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.2
0.4
0.6
0.8
1
b.
Rust attack
Shade cover
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
0
0.2
0.4
0.6
0.8
1
1.2
c.
Rust attack
Shade cover
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.2
0.4
0.6
0.8
1



Vandermeer et al., (2015). arXiv at: http://arxiv.org/abs/1510.05849

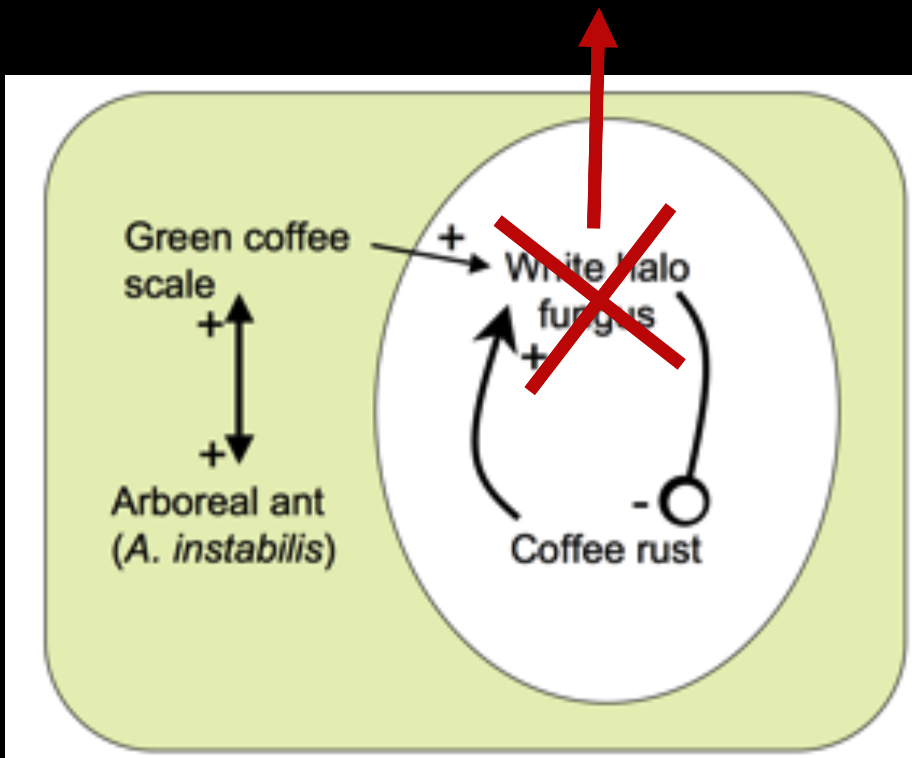

Finca Irlanda
Control biológico

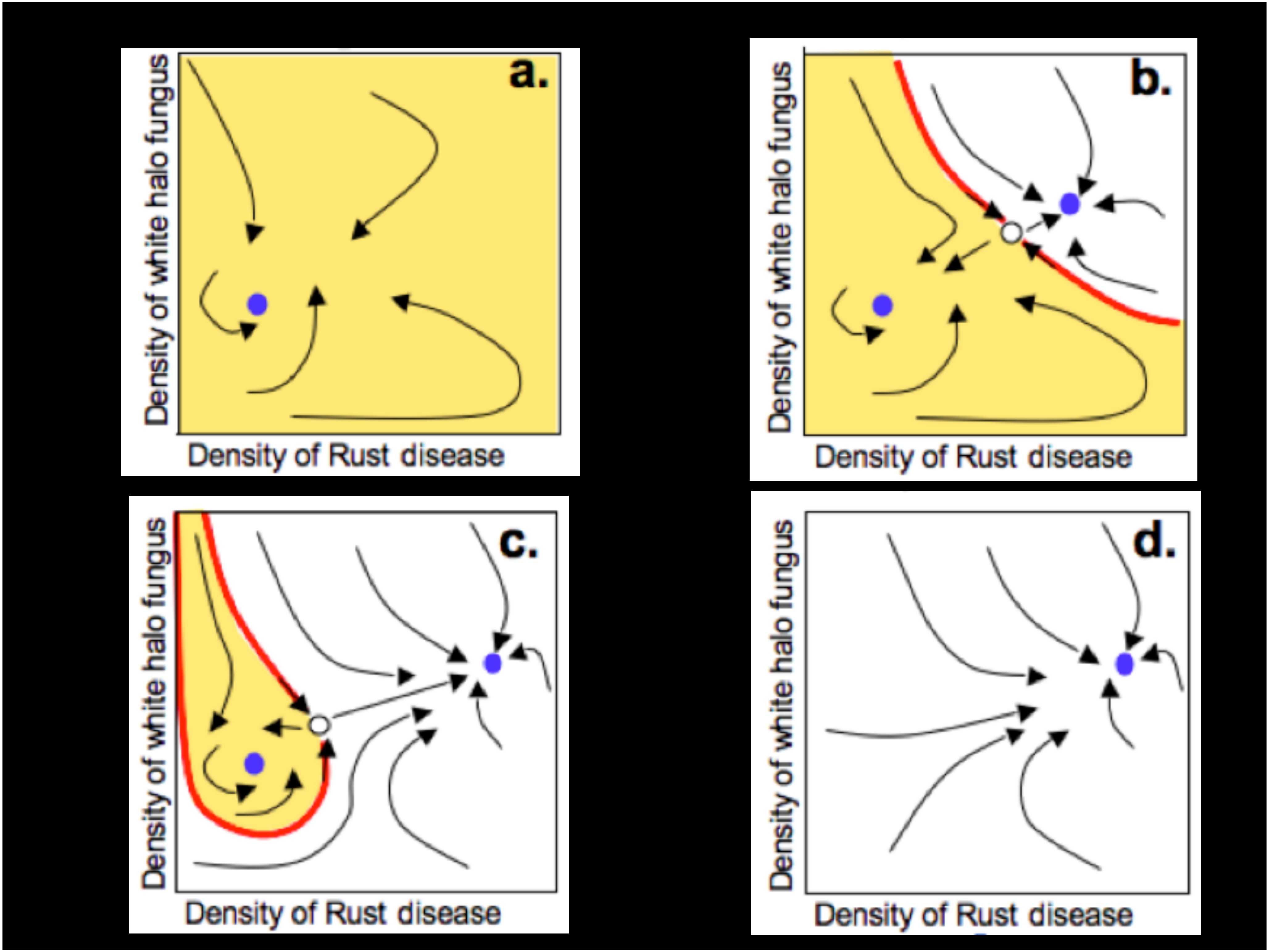
Finca Irlanda

Viento

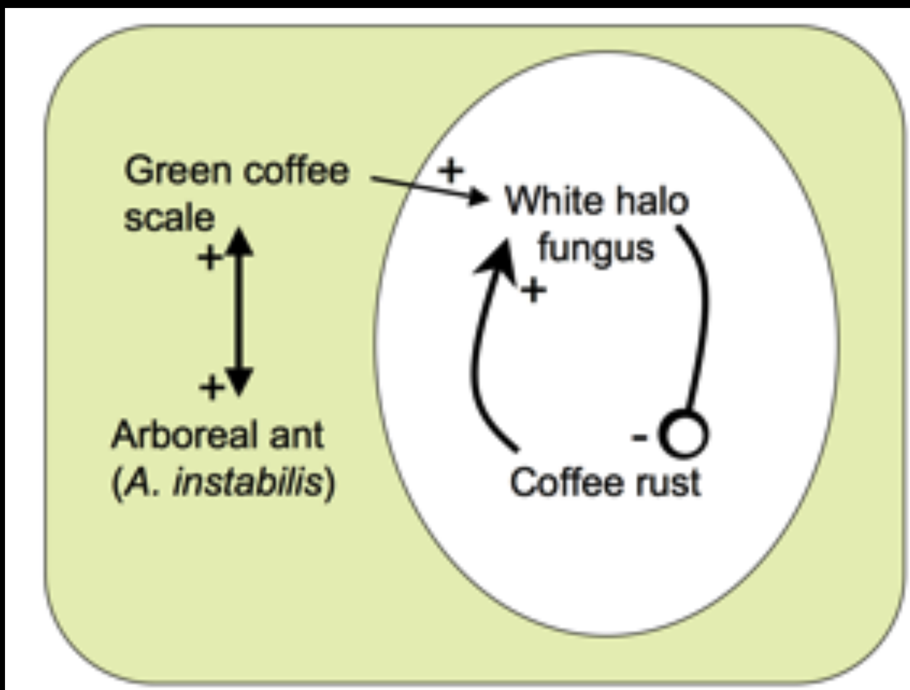
Finca Guaraguao

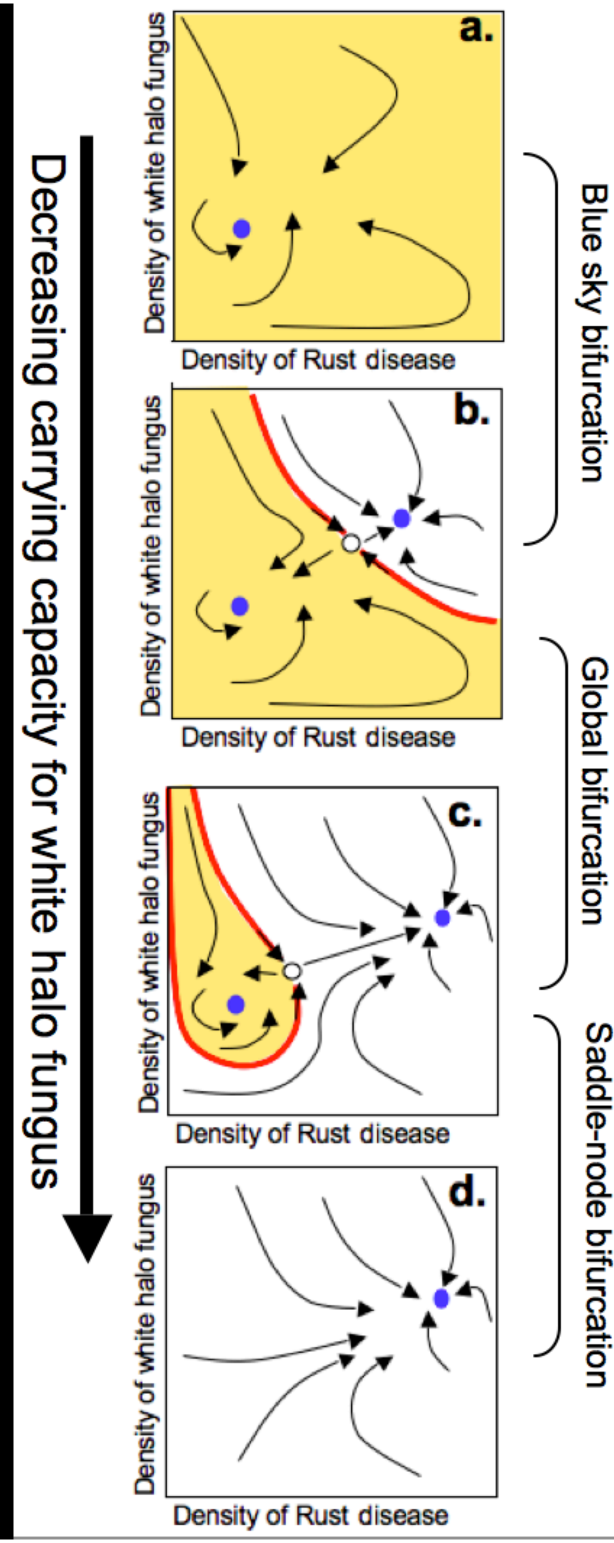
La comunidad de micoparásitos

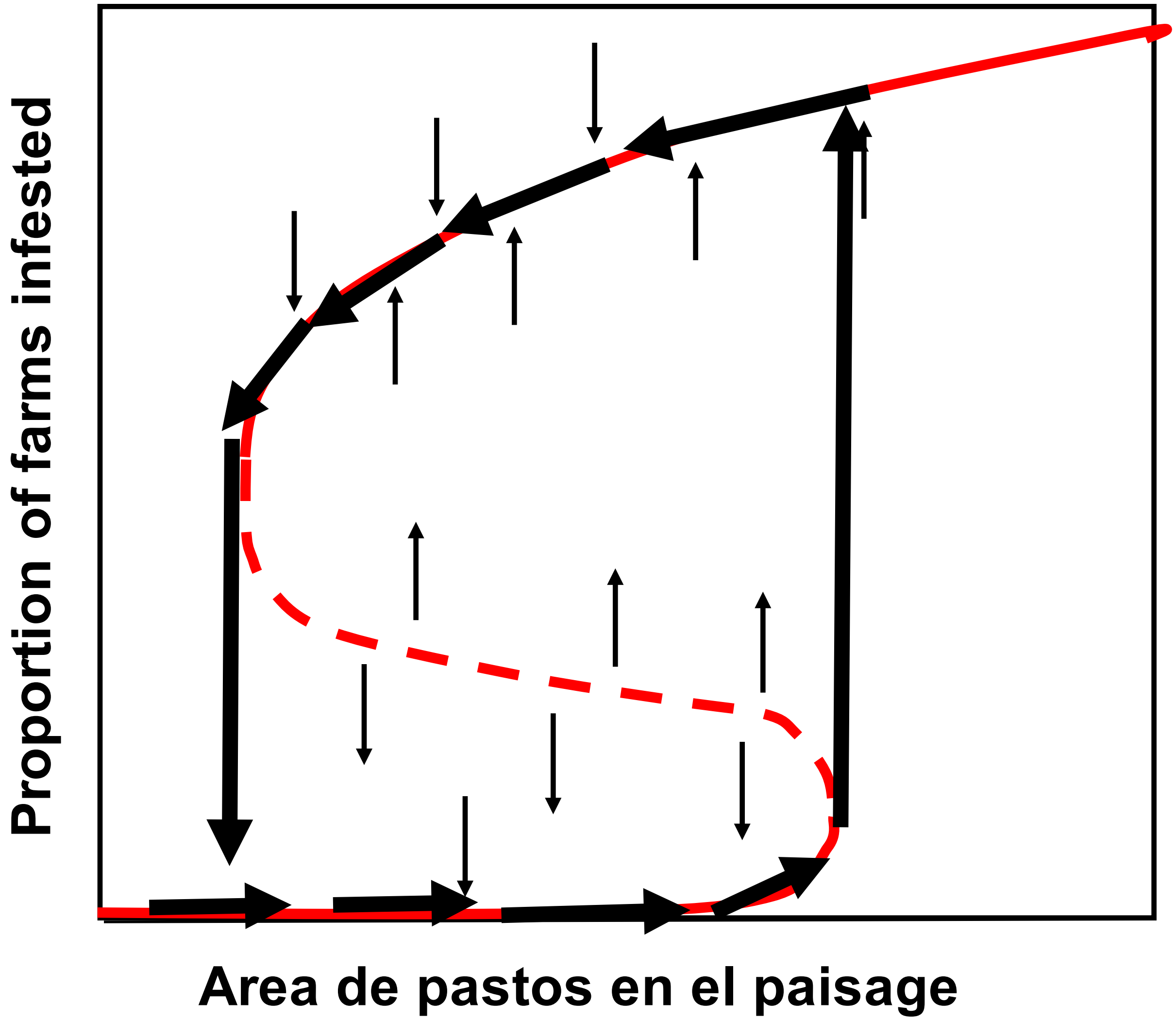


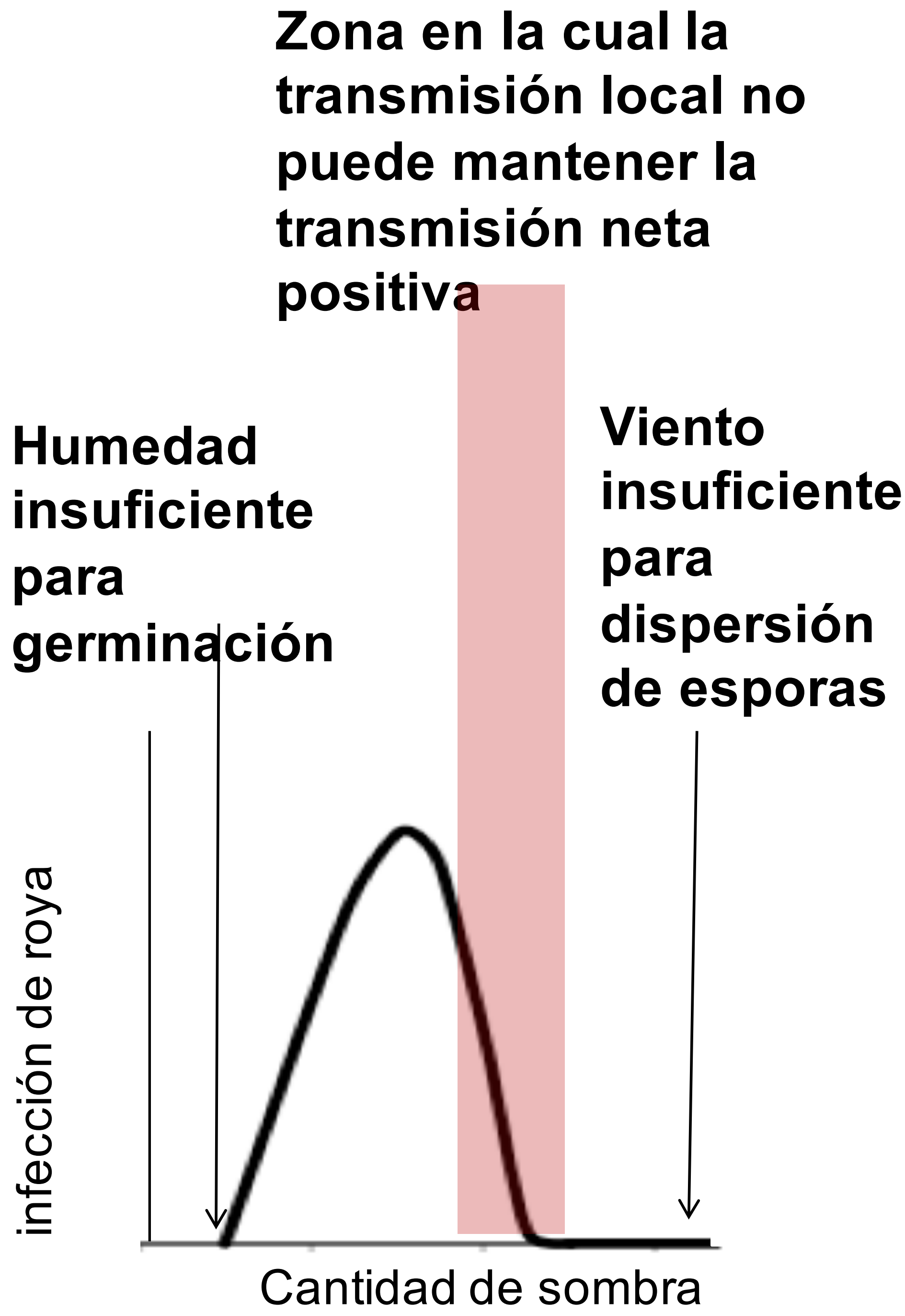


a.
Density of white halo fungus
Density of Rust disease
b.
Density of white halo fungus
Density of Rust disease
c.
Density of white halo fungus
Density of Rust disease
d.
Density of white halo fungus
Density of Rust disease


Green coffee scale
+
+
White halo fungus
+
+
Arboreal ant (*A. instabilis*)
-
Coffee rust


Decreasing carrying capacity for white halo fungus
a.
b.
c.
d.
Density of white halo fungus
Density of Rust disease
Blue sky bifurcation
Global bifurcation
Saddle-node bifurcation


Proportion of farms infested
Area de pastos en el paisage


Zona en la cual la transmisión local no puede mantener la transmisión neta positiva
Humedad insuficiente para germinación
Viento insuficiente para dispersión de esporas
infección de roya
Cantidad de sombra

Lecanicillium