Risk Assessment for Biological Control Introductions: Will the Ecologists *Ever* Be Satisfied?

Dan Simberloff
Department of Ecology and Evolutionary Biology
University of Tennessee

Euglandina rosea = rosy wolf snail

Risk Assessment for Biological Control Introductions: Will the Ecologists *Ever* Be Satisfied?

Dan Simberloff
Department of Ecology and Evolutionary Biology
University of Tennessee

1) Direct effects on non-targets:

What is the host range?
Is there a population impact?

2) Indirect effects on non-targets

3) Range change of biocontrol agent, target, or non-target

Ann. appl. Biol. (1974), **77**, 201–211
Printed in Great Britain

A strategy for evaluating the safety of organisms for biological weed control

BY A. J. WAPSHERE
CSIRO Biological Control Unit, 335 Avenue Abbé Paul Parguel, 34000 Montpellier, France

Table 1. *Centrifugal phylogenetic method applied to* Chondrilla juncea

Testing sequence	Plants to be tested	Host range determined if plants at that phylogenetic level remain unattacked
1	Other forms of *C. juncea*	Specific to *C. juncea* clone
2	Other *Chondrilla* species	Specific to *C. juncea*
3	Other members of tribe Crepidinae	Specific to genus *Chondrilla*
4	Other members of subfamily Cichoriaceae	Specific to tribe Crepidinae
5	Other members of family Compositae	Specific to subfamily Cichoriaceae
6	Other members of the Order Synantherales. Member of Campanulaceae, Lobeliaceae, etc.	Specific to family Compositae

Larinus planus

Rhinocyllus conicus

For entomophages:

1) systematics often poorly worked out

2) ecological similarity of hosts

3) generally poor knowledge of non-target hosts

cf. Messing 2001

Kuhlmann et al. 2006

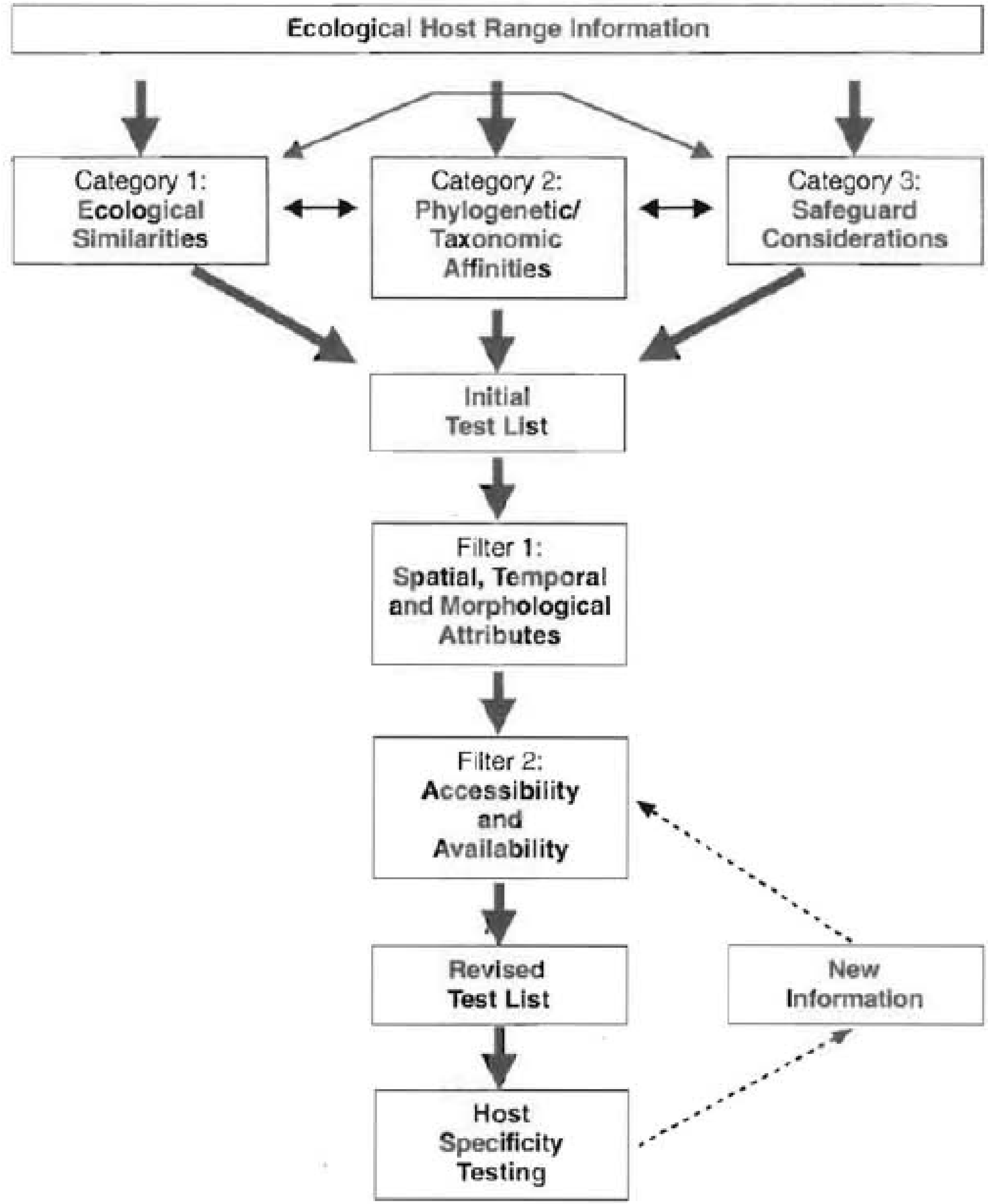
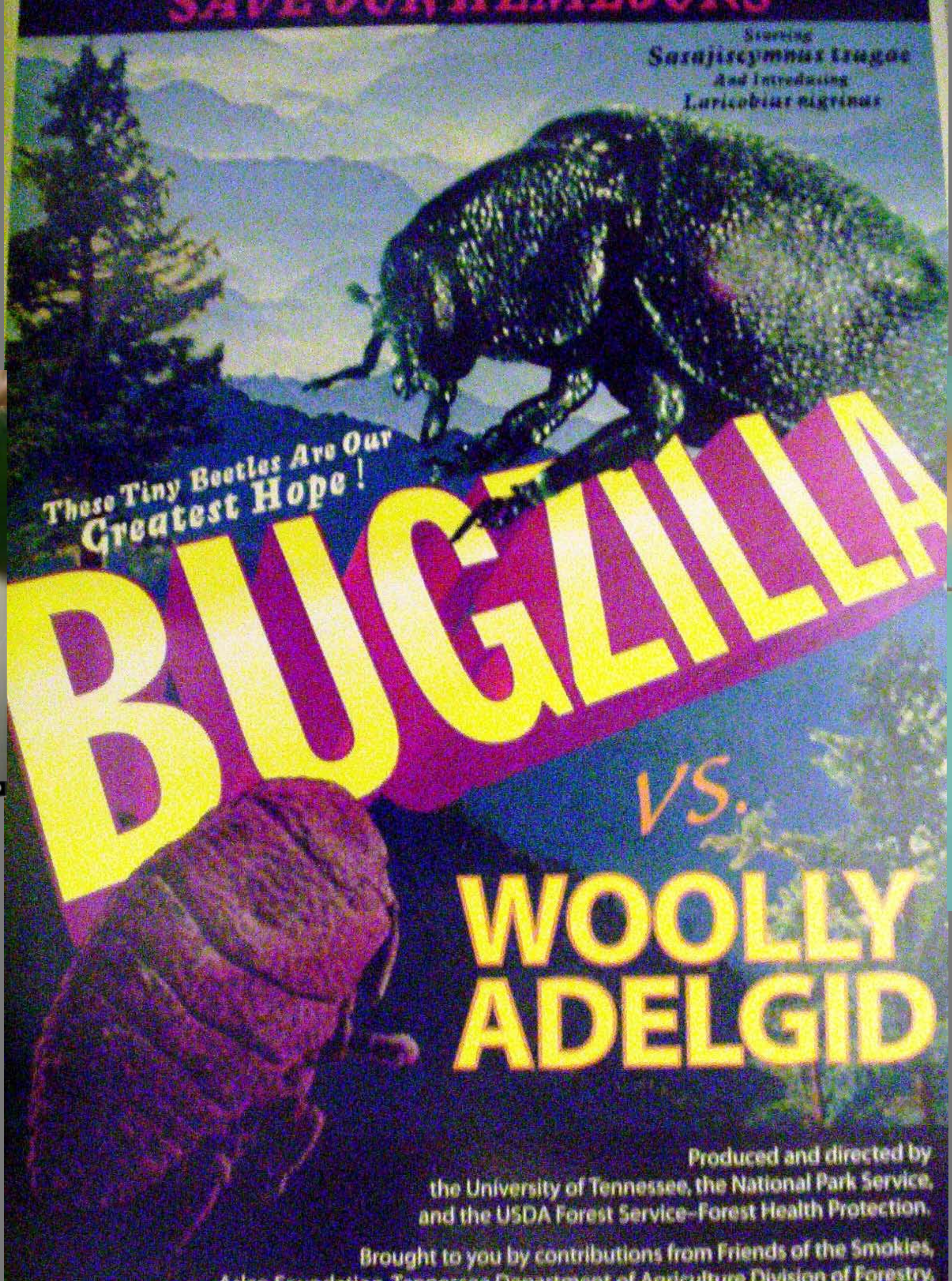


Fig. 2.1. Recommendations for the selection of non-target species for a test list to be applied in host specificity testing of invertebrates for biological control of arthropods.

Sasijiscymnus tsugae



Laricobius nigrinus

Tetrastichus planipennisi

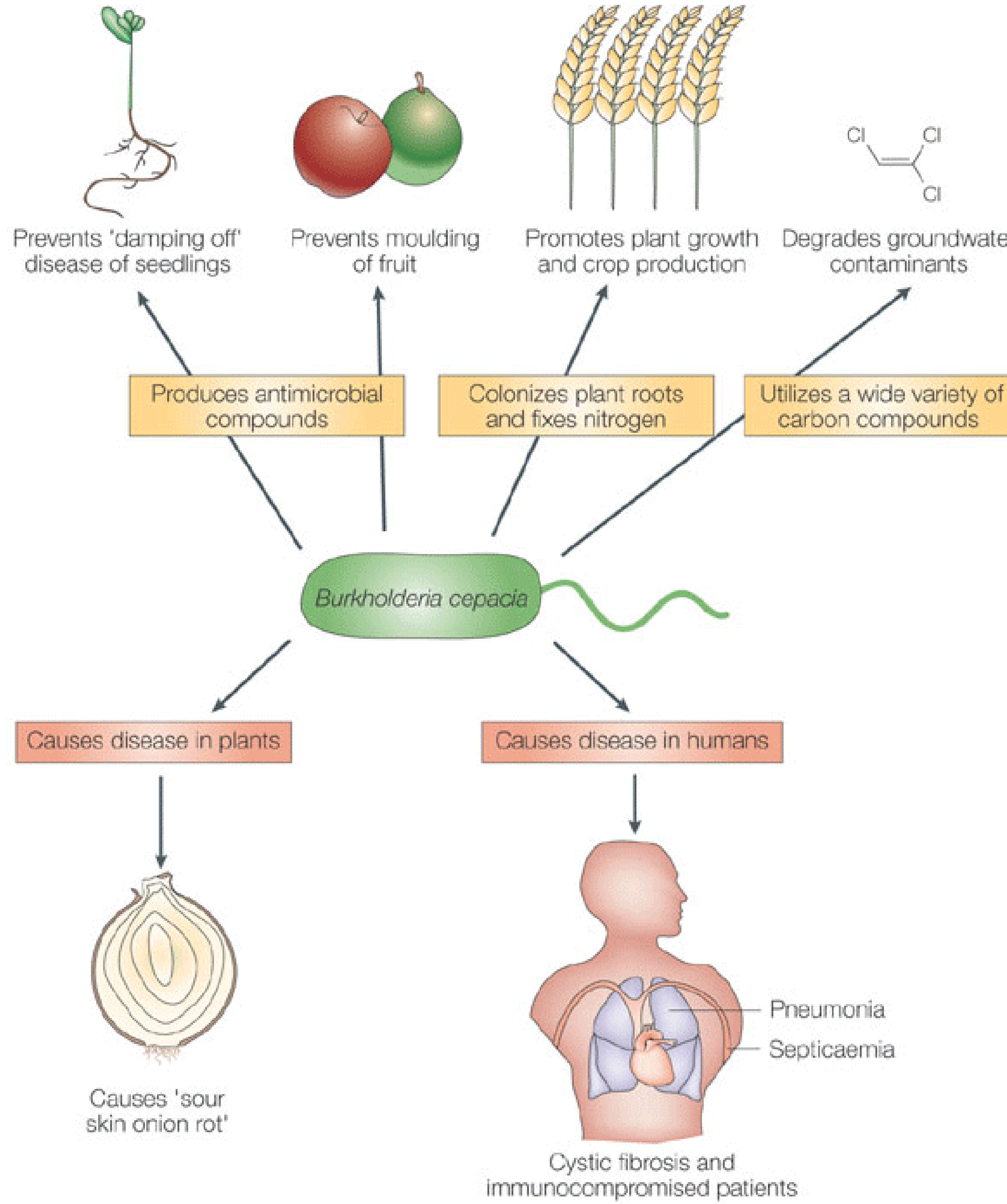
Oobius agrili

Spathius agrili

Lepismadora algodones

Prasinalia imperialis

from E. Mahenthiralingam
et al., 2005



Nature Reviews | Microbiology

Holt and Hochberg 2001

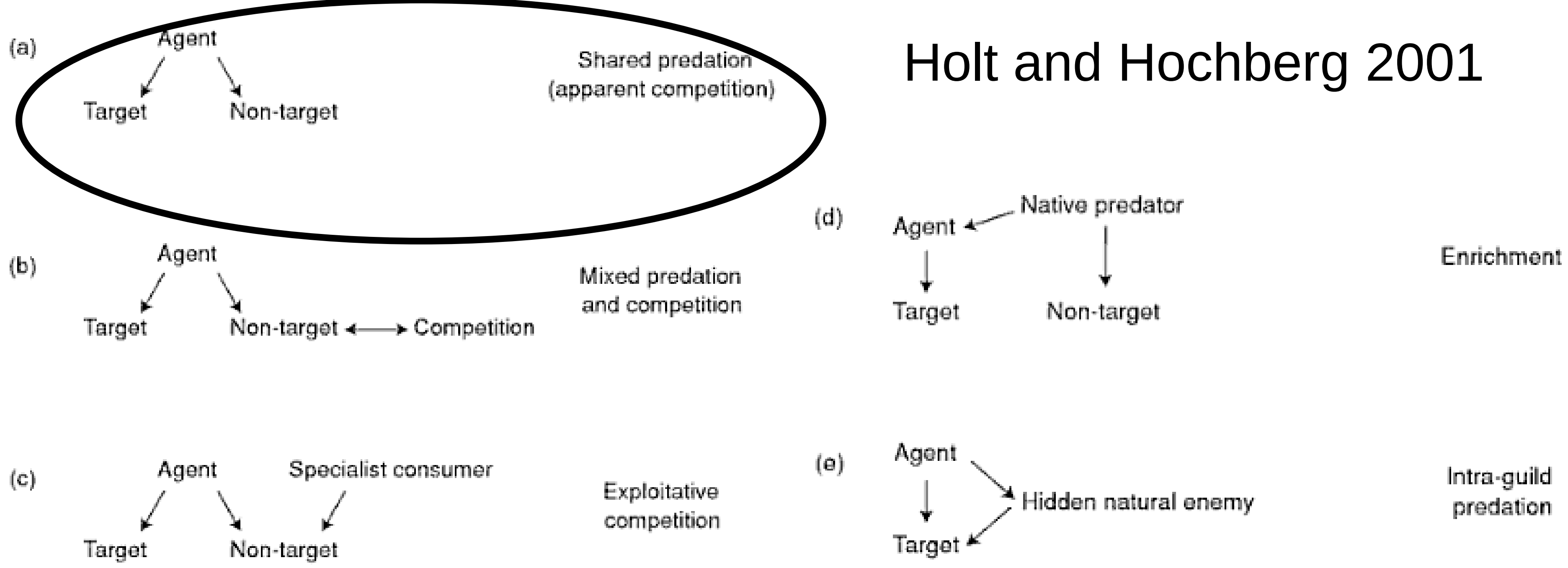


Fig. 2.1. Community modules. The word 'module' refers to a specified structure of interactions among a small number of species. A number of modules are likely to describe indirect impacts of biological control. For simplicity, the lines indicate that two species interact (a more detailed food web diagram would have pairs of arrows and signs, describing reciprocal impacts of each species). (a) Shared predation: impacts upon non-targets reflect interactions between agent and target (as in apparent competition). (b) Mixed predation and competition: impacts upon non-targets are aggravated by the presence of competing species. (c) Exploitative competition: the agent exploits a non-target species which is required by another non-target consumer. (d) Enrichment: introduction of the agent enriches the diet of a native predator, with impacts upon non-target prey (a more elaborate version of the shared predation module). (e) Intra-guild predation: the agent both competes with and attacks a non-target natural enemy.

Holt and Hochberg 2001

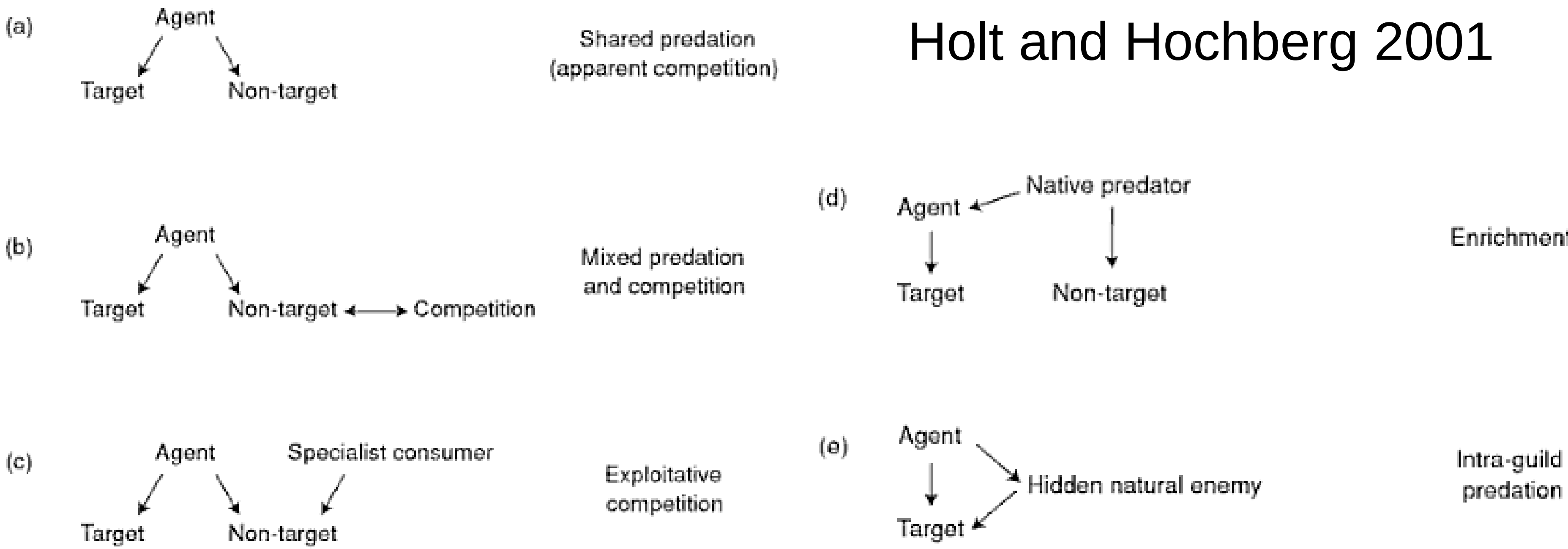


Fig. 2.1. Community modules. The word 'module' refers to a specified structure of interactions among a small number of species. A number of modules are likely to describe indirect impacts of biological control. For simplicity, the lines indicate that two species interact (a more detailed food web diagram would have pairs of arrows and signs, describing reciprocal impacts of each species). (a) Shared predation: impacts upon non-targets reflect interactions between agent and target (as in apparent competition). (b) Mixed predation and competition: impacts upon non-targets are aggravated by the presence of competing species. (c) Exploitative competition: the agent exploits a non-target species which is required by another non-target consumer. (d) Enrichment: introduction of the agent enriches the diet of a native predator, with impacts upon non-target prey (a more elaborate version of the shared predation module). (e) Intra-guild predation: the agent both competes with and attacks a non-target natural enemy.

DE Pearson and RM Callaway, 2003

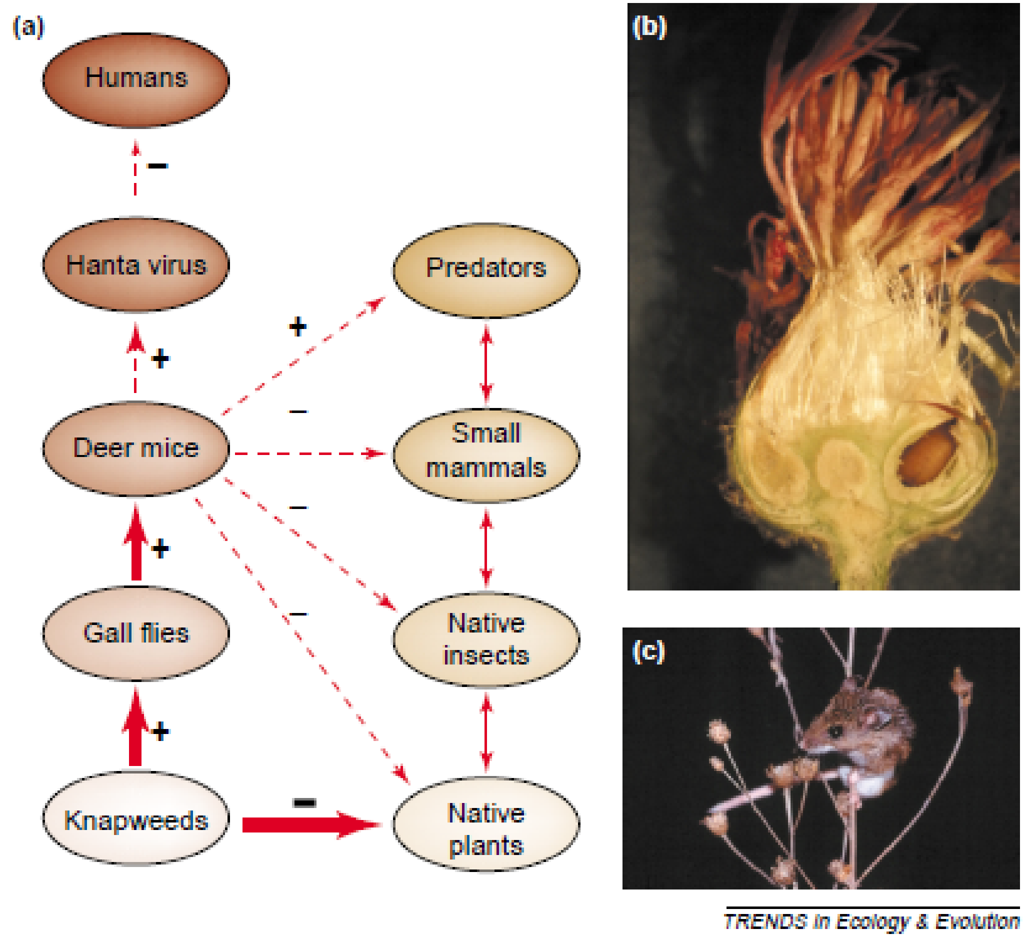


Fig. I. Currently documented (solid lines) and postulated (dotted lines) direct and indirect effects (a) associated with gall fly *Urophora affinis* and *U. quadrifasciata* biocontrol agents introduced for the control of spotted knapweed *Centaurea maculosa* (b). The *Urophora* biocontrol agents exhibit very weak negative top-down effects on *C. maculosa*. Because of their lack of control over the weed, *C. maculosa* exhibits very strong bottom-up effects on the biocontrol agents. The resulting superabundance of the biocontrol has facilitated the bottom-up flow of energy further out into the native system by subsidizing native predators such as deer mice *Peromyscus maniculatus* (c) [19] that are integrated into native food webs. The extent to which this unintended outcome is likely to carry out into the system is a function of the strength of the various interactions. The most important interaction is that between the biocontrol and the native consumer. In the case of the deer mouse, this interaction has proven to be very strong [20], increasing the likelihood that other postulated nontarget indirect effects will follow. Line thickness indicates interaction strength. (c) reproduced with permission from Milo Burcham.

Figure 1. Bridal creeper invasion, Fitzgerald River National Park, W.A.

Asparagus asparagoides from Peter Turner

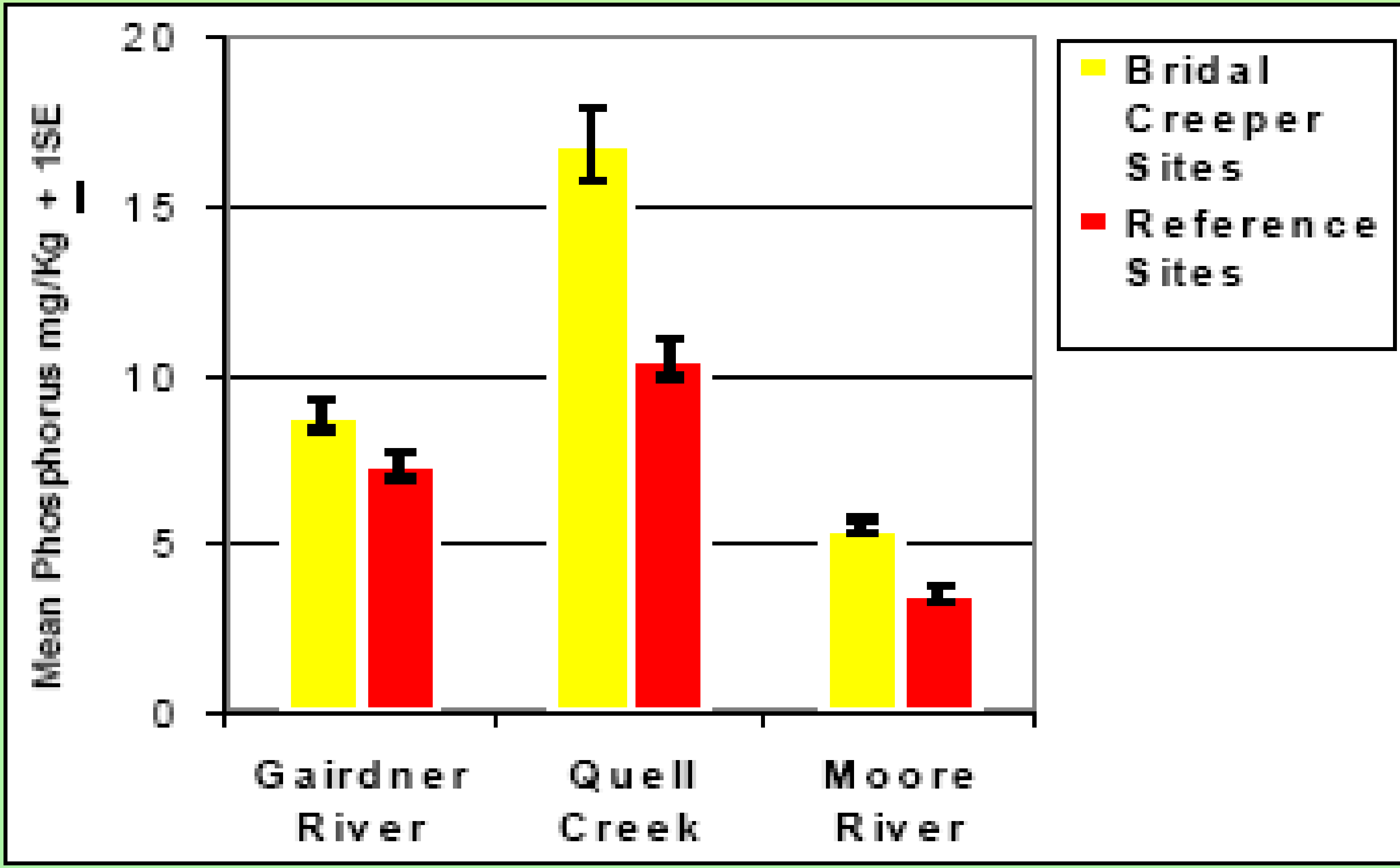
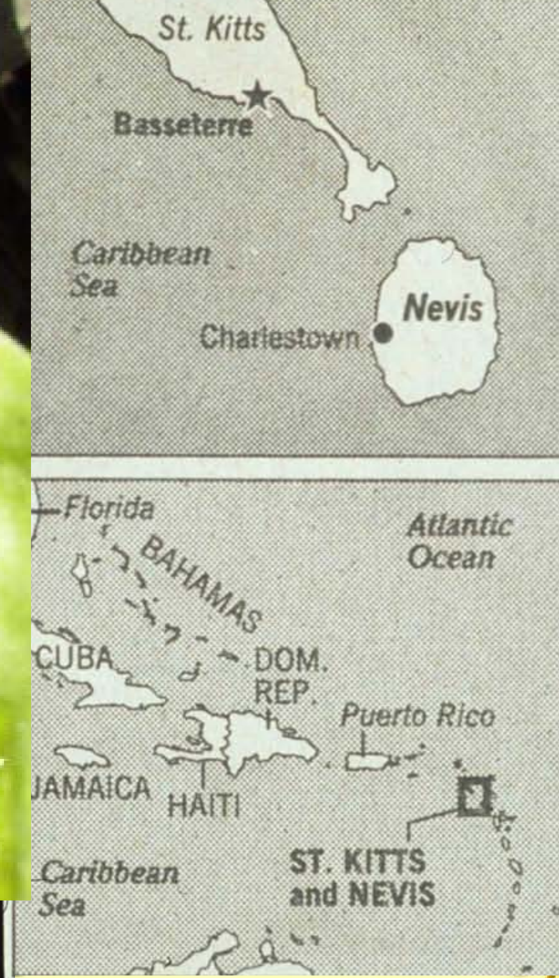


Figure 3. Bridal creeper sites have higher levels of phosphorus available to plants (Colwell method) ($F = 64.87$; d.f. 1,30; $p < 0.001$).

from Peter Turner



Cactoblastis cactorum,
the cactus moth

from Bradley et al. 2010

kudzu

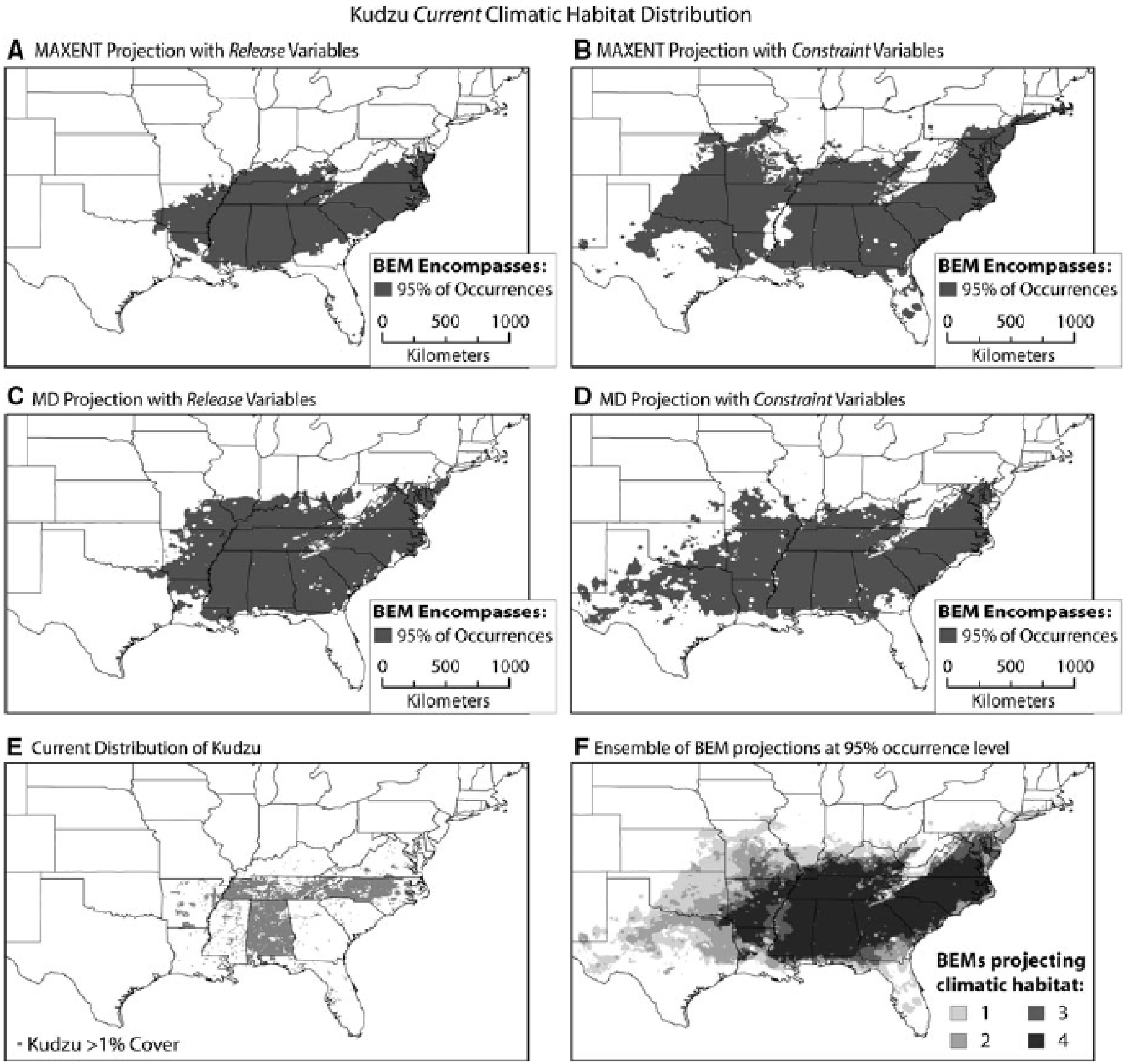


Fig. 1 Kudzu climatic habitat under current climate conditions. **a** Bioclimatic envelope based on the MAXENT model using predictor variables selected based on land area released. **b** Bioclimatic envelope based on the MAXENT model using predictor variables selected based on those that most constrain distribution. **c** Bioclimatic envelope based on the MD model using predictor variables selected based on land area released. **d** Bioclimatic envelope based on the MD model using predictor variables selected based on those that most constrain distribution. **e** ¼ USGS quadrangles with greater than 1% cover of Kudzu in the southeast US based on expert opinion (Marvin et al. 2009). **f** Sum of bioclimatic envelope models **a**–**d**. Areas identified as climatic habitat by all four BEMs are more likely at risk from kudzu invasion

Ecological and Evolutionary Responses to Recent Climate Change

Camille Parmesan

Section of Integrative Biology, University of Texas, Austin, Texas 78712;
email: parmesan@mail.utexas.edu

Annu. Rev. Ecol. Evol. Syst. 2006. 37:637–69

First published online as a Review in Advance on August 24, 2006

The *Annual Review of Ecology, Evolution, and Systematics* is online at http://ecolsys.annualreviews.org

This article's doi:
10.1146/annurev.ecolsys.37.091305.110100

1543-592X/06/1201-0637$20.00

Key Words

aquatic, global warming, phenology, range shift, terrestrial, trophi
asynchrony

Abstract

Ecological changes in the phenology and distribution of plants an
animals are occurring in all well-studied marine, freshwater, an
terrestrial groups. These observed changes are heavily biased in th
directions predicted from global warming and have been linked t
local or regional climate change through correlations between cli

From R.W. Pemberton 1984, Native plant considerations in the biological control of leafy spurge.

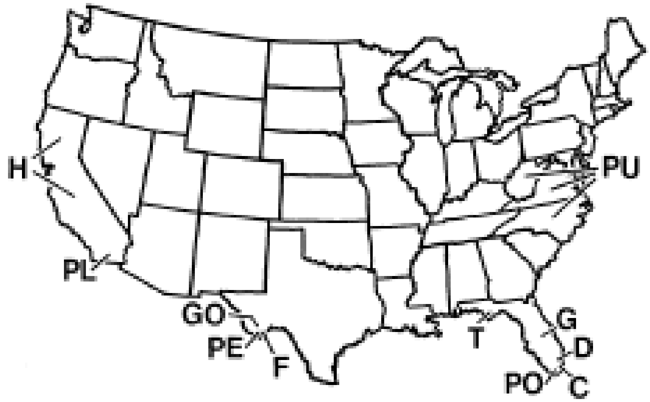


Fig. 4. Distribution of rare spurges which are under review for legal protection as threatened or endangered status. H = *Euphorbia hooveri* L.C. Wheeler, PL = *E. playsperma* Engelm., PE = *E. perennans* (Shinners) Warnock & M. Johnst., GO = *E. golondrina* L.W. Wheeler, F = *E. fenderli* Torr. & Gray var. *triligulata*, T = *E. telephiodes* Chapm., PU = *E. purpurea* (Raf.) Fernald, G = *E. garberi* Engelm. ex Chapm., D = *E. deltoidea* Engelm. ex Chapm., C = *Chamaesyce cumulicola* Raf., PO = *C. porterana* Small.

Fig. 5. Distribution of *Euphorbia spatulata* Lam., a subgenus esula species which could serve as a bridge from leafy spurge to the rare spurges under review.

from Van Nouhuys and Lei 2004, J. Anim. Ecol. 73:526-535

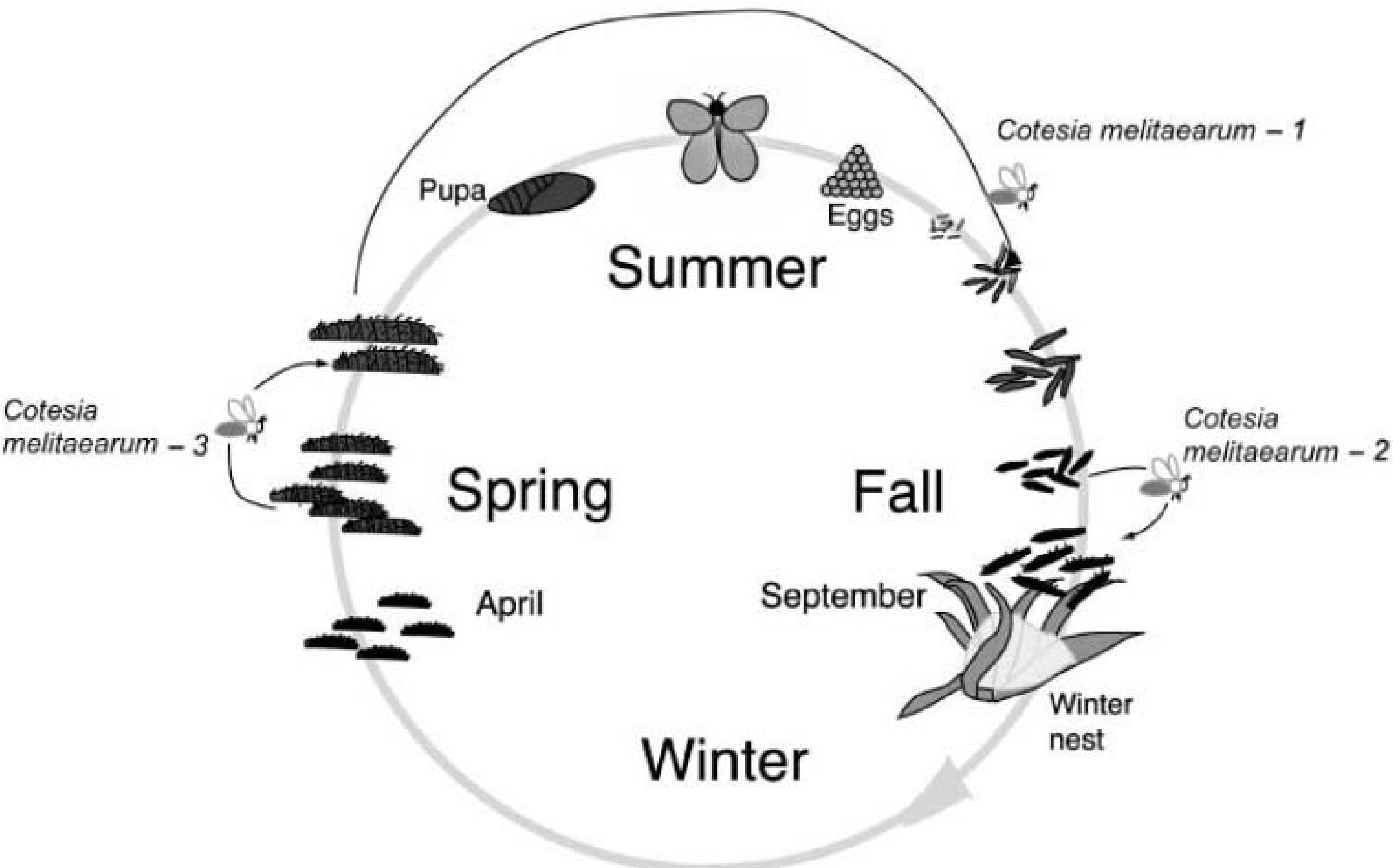


Fig. 1. The life cycle of the butterfly *Melitaea cinxia* and parasitoid *Cotesia melitaearum* in Åland, Finland.

Ecological Entomology (1992) **20**, 237–244

Effects of temperature on phenological synchrony and altitudinal distribution of jumping plant lice (Hemiptera: Psylloidea) on dwarf willow (*Salix lapponum*) in Norway

JANE K. HILL and IAN D. HODKINSON
School of Biological and Earth Sciences, Liverpool John Moores University, Liverpool

from T.M. Bezemer and T.H. Jones, 1998. Oikos 82:212-222

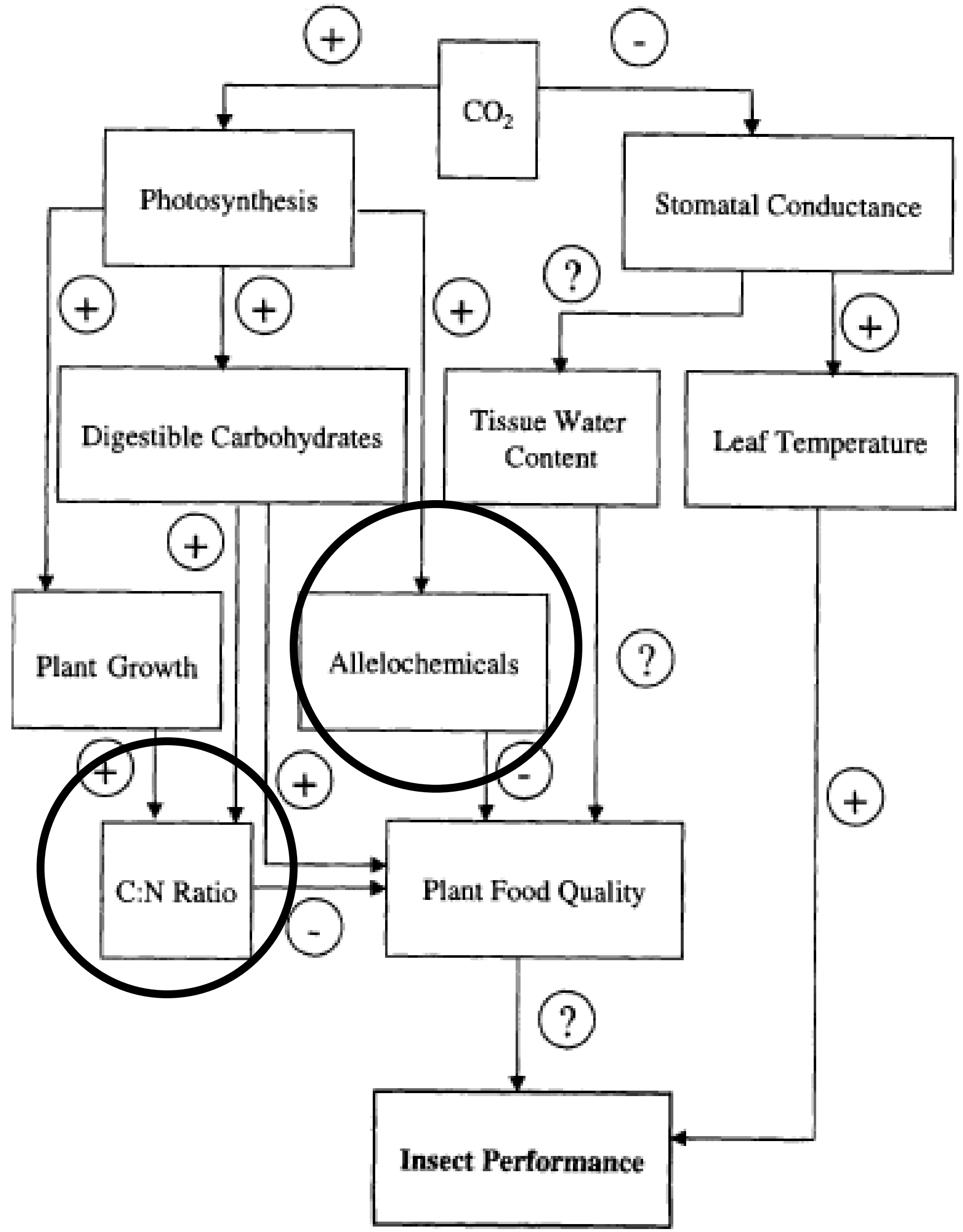
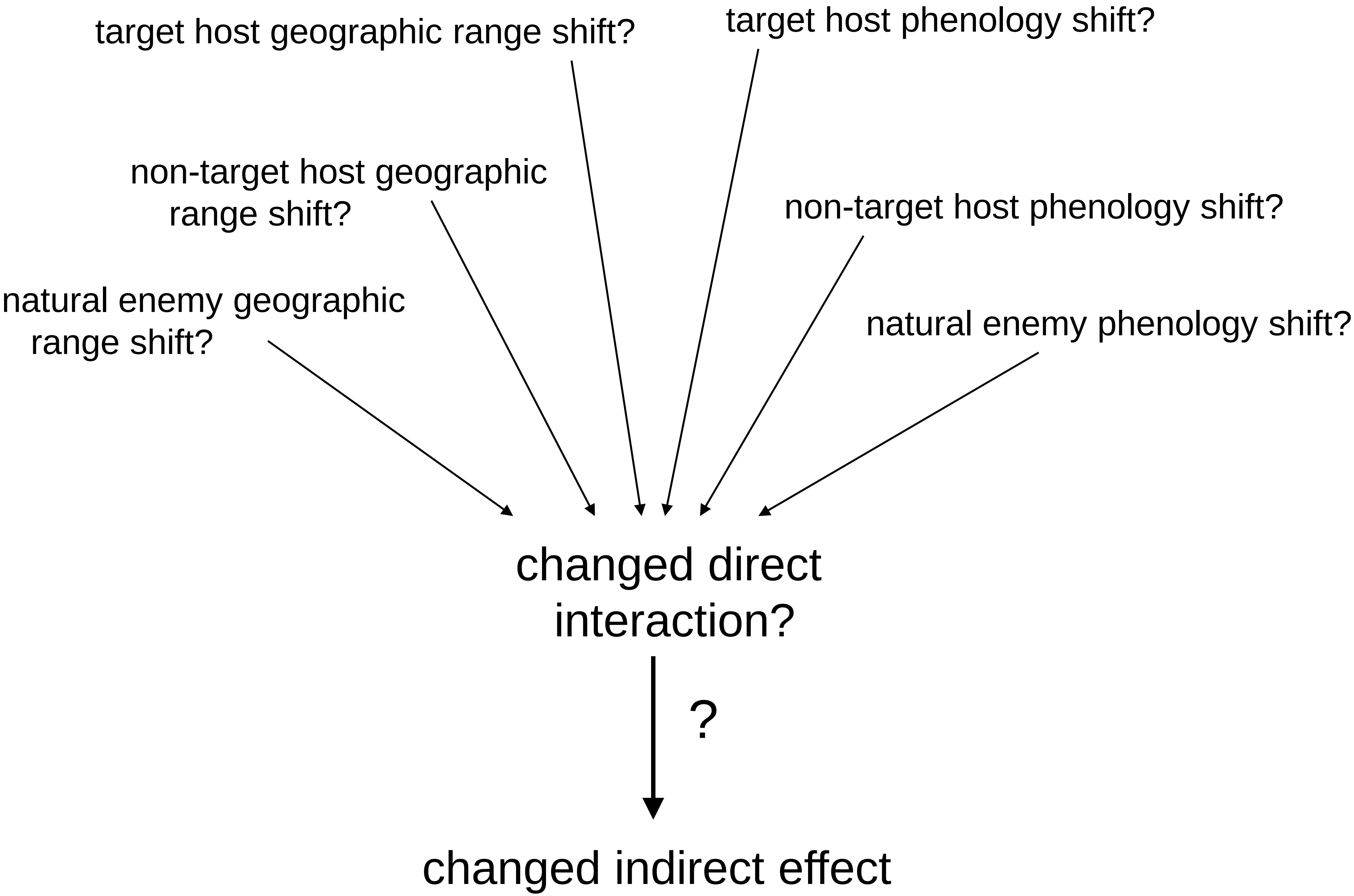


Fig. 1. A conceptual model of possible CO_2-induced changes in plant food quality and how these may affect insect herbivore performance (also see Jones and Coleman 1991).

Agasicles hygrophila
Alligatorweed flea beetle


target host geographic range shift?
target host phenology shift?
non-target host geographic range shift?
non-target host phenology shift?
natural enemy geographic range shift?
natural enemy phenology shift?
changed direct interaction?
?
changed indirect effect

van Lenteren et al. 2003

Table 2. Qualitative scales for likelihood (a), magnitude (b) and level of risk of adverse effects (c) (after Hickson et al., 2000)

(a) **Likelihood**	**Description**
Very unlikely	Not impossible but only occurring in exceptional circumstances
Unlikely	Could occur but is not expected to occur under normal conditions
Possible	Equally likely or unlikely
Likely	Will probably occur at some time
Very likely	Is expected to occur

(b) **Magnitude**	**Description**
Minimal	Insignificant (repairable or reversible) environmental impact
Minor	Reversible environmental impact
Moderate	Slight effect on native species
Major	Irreversible environmental effects but no species loss, remedial action available
Massive	Extensive irreversible environmental effects

(c) **Level of risk of adverse effect**

	Magnitude				
Likelihood	Minimal	Minor	Moderate	Major	Massive
Very unlikely	Insignificant	Insignificant	Low	Medium	Medium
Unlikely	Insignificant	Low	Low	Medium	High
Possible	Low	Low	Medium	Medium	High
Likely	Low	Low	Medium	High	High
Very likely	Medium	Medium	High	High	High

Living organisms, including biological control agents:

1) Disperse

1) Evolve

We are severely limited in our ability to predict the exact trajectory of both processes!

Bigler and Kölliker-Ott, 2006

Table 16.1. Categories of costs and benefits of using invertebrate biological control agents.

Category	Costs	Benefits
Economy		
Applicant/ distributor	Development of agent (research, rearing, dossier for application, marketing)	Sales of agent, profits, sustainable business (estimate potential markets in space and time)
Farmer	Market price of agent and its application	Control of pest with adequate efficacy, higher yield and quality of product, higher revenue
Consumer	Higher prices and apparent lower quality of product (food, fibres, etc.)	Lower prices and apparent higher quality of product (food, fibres, etc.)
Society	Agent costs subsidized by government	Control of pest with no/few risks to humans, animals and environment
Human and animal health	Allergies Stings or bites Nuisance	No hazards (exposure of users and residues in food and feed) from other pest control options (e.g. pesticides)
Environment		
Soil, water, air	No costs	Prevents pollution by alternative control options (e.g. pesticides)
Biodiversity and ecosystems	Adverse effects on plants, animals, microorganisms and on ecosystem functions	Control of pest with no/little effects on plants, animals, microorganisms and their functions
	Introduced species cannot be eradicated if established	Replacement of control options with high impacts on environment