December 2010

ESA, San Diego

Assessing ecosystem services provided by invertebrates in farmland: A 'bottom-up' approach

Steve Wratten
Bio-Protection Research Centre
Lincoln University

Bio-Protection

What are ecosystem (nature's) services?

Bio-Protection

Ecosystem function + value to mankind = Ecosystem service

e.g. predation (an EF) + value to mankind becomes an ES (biological control)

Bio-Protection

Valuable ecosystem services provided by invertebrates include:

- pollination
- biological control
- nutrient cycling

Bio-Protection

13 years ago, ES globally were worth US$33 trillion/year

(Costanza *et al.)*

Bio-Protection

But Costanza seriously under-valued farmland ES

Bio-Protection

Table 2 Summary of average global value of annual ecosystem services

Biome	Area (ha × 10^6)	Ecosystem serivces (1994 US$ ha^{-1} yr^{-1})																		
		1 Gas regulation	2 Climate regulation	3 Disturbance regulation	4 Water regulation	5 Water supply	6 Erosion control	7 Soil formation	8 Nutrient cycling	9 Waste treatment	10 Pollination	11 Biological control	12 Habitat/ refugia	13 Food production	14 Raw materials	15 Genetic resources	16 Recreation	17 Cultural	Total value per ha ($ ha^{-1} yr^{-1})	Total global flow value ($ yr^{-1} × 10^9)
Marine	36,302																		577	20,949
Open ocean	33,200	38							118			5		15	0			76	252	8,381
Coastal	3,102			88					3,677			38	8	93	4		82	62	4,052	12,568
Estuaries	180			567					21,100			78	131	521	25		381	29	22,832	4,110
Seagrass/ algae beds	200								19,002						2				19,004	3,801
Coral reefs	62			2,750						58		5	7	220	27		3,008	1	6,075	375
Shelf	2,660								1,431			39		68	2			70	1,610	4,283
Terrestrial	15,323																		804	12,319
Forest	4,855		141	2	2	3	96	10	361	87		2		43	138	16	66	2	969	4,706
Tropical	1,900		223	5	6	8	245	10	922	87				32	315	41	112	2	2,007	3,813
Temperate/boreal	2,955		88		0			10		87		4		50	25		36	2	302	894
Grass/rangelands	3,898	7	0		3		29	1		87	25	23		67		0	2		232	906
Wetlands	330	133		4,539	15	3,800				4,177			304	256	106	92	574	881	14,785	4,879
Tidal marsh/ mangroves	165			1,839						6,696			169	466	162		658		9,990	1,648
Swamps/ floodplains	165	265		7,240	30	7,600				1,659			439	47	49		491	1,761	19,580	3,231
Lakes/rivers	200				5,445	2,117				665				41			230		8,498	1,700
Desert	1,925																			
Tundra	743																			
Ice/rock	1,640																			
Cropland	1,400										14	24		54					92	128
Urban	332																			
Total	51,625	1,341	684	1,779	1,115	1,692	576	53	17,075	2,277	117	417	124	1,386	721	79	815	3,015		33,268

Numbers in the body of the table are in $ ha^{-1} yr^{-1}. Row and column totals are in $ yr^{-1} × 10^9, column totals are the sum of the products of the per ha services in the table and the area of each biome, not the sum of the per ha services themselves. Shaded cells indicate services that do not occur or are known to be negligible. Open cells indicate lack of available information.

Therefore, a challenge to ‘invertebrate’ agro-ecologists – to quantify and enhance farmland ES, ideally addressing multiple ES

Bio-Protection

because agriculture is the main cause of biodiversity, and ES loss

Bio-Protection

Bio-Protection

But biological control can be a powerful ES

Bio-Protection

A British monoculture

Bio-Protection

An Australian monoculture

Bio-Protection

A New Zealand monoculture?

Photo: Kevin Judd – with permission

Bio-Protection

Biodiversity loss and reduced ecological resistance in ‘engineered’ landscapes is normal but the consequences of the loss can be difficult to detect

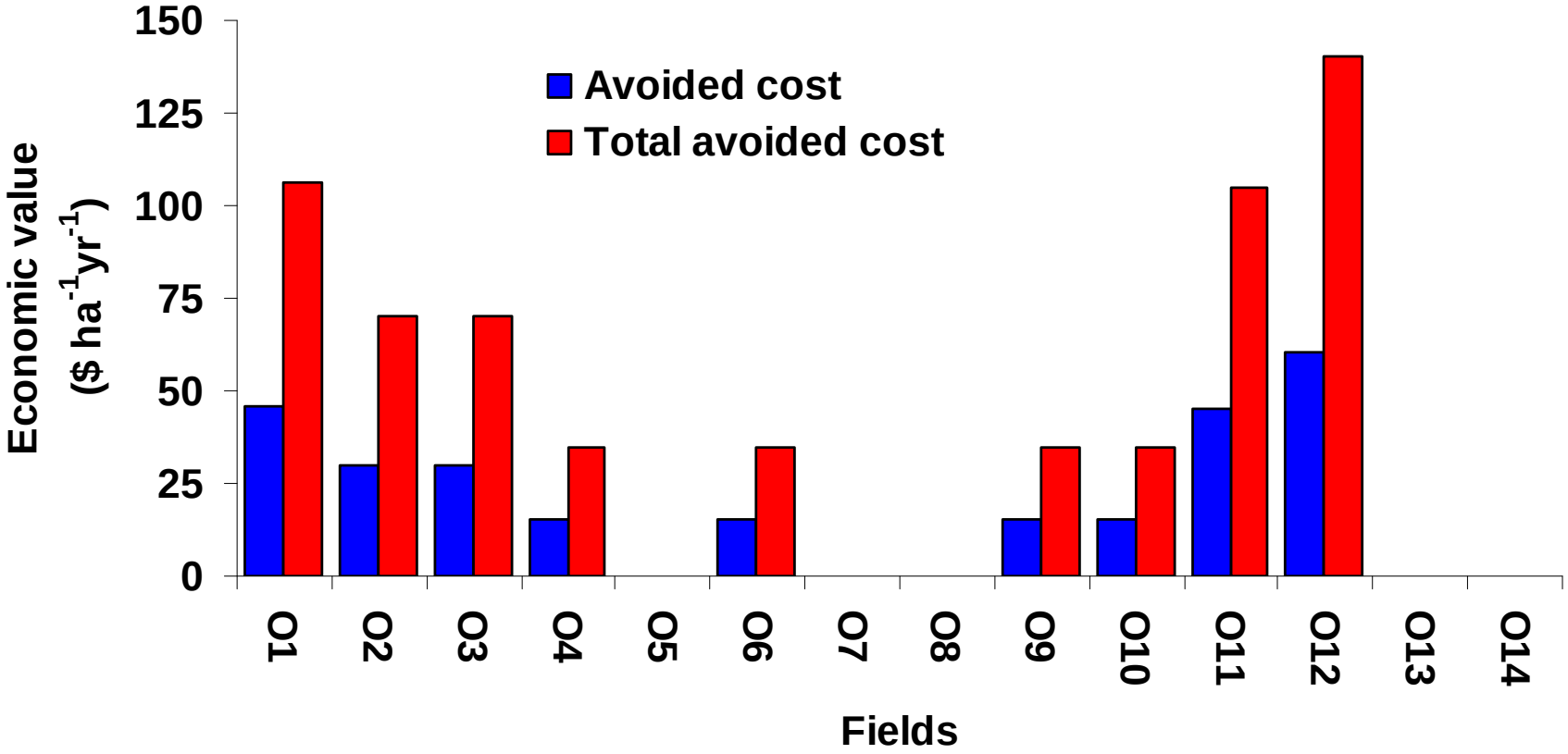
Bio-Protection

So, use prey baits to detect declines in background biocontrol of pests

Bio-Protection

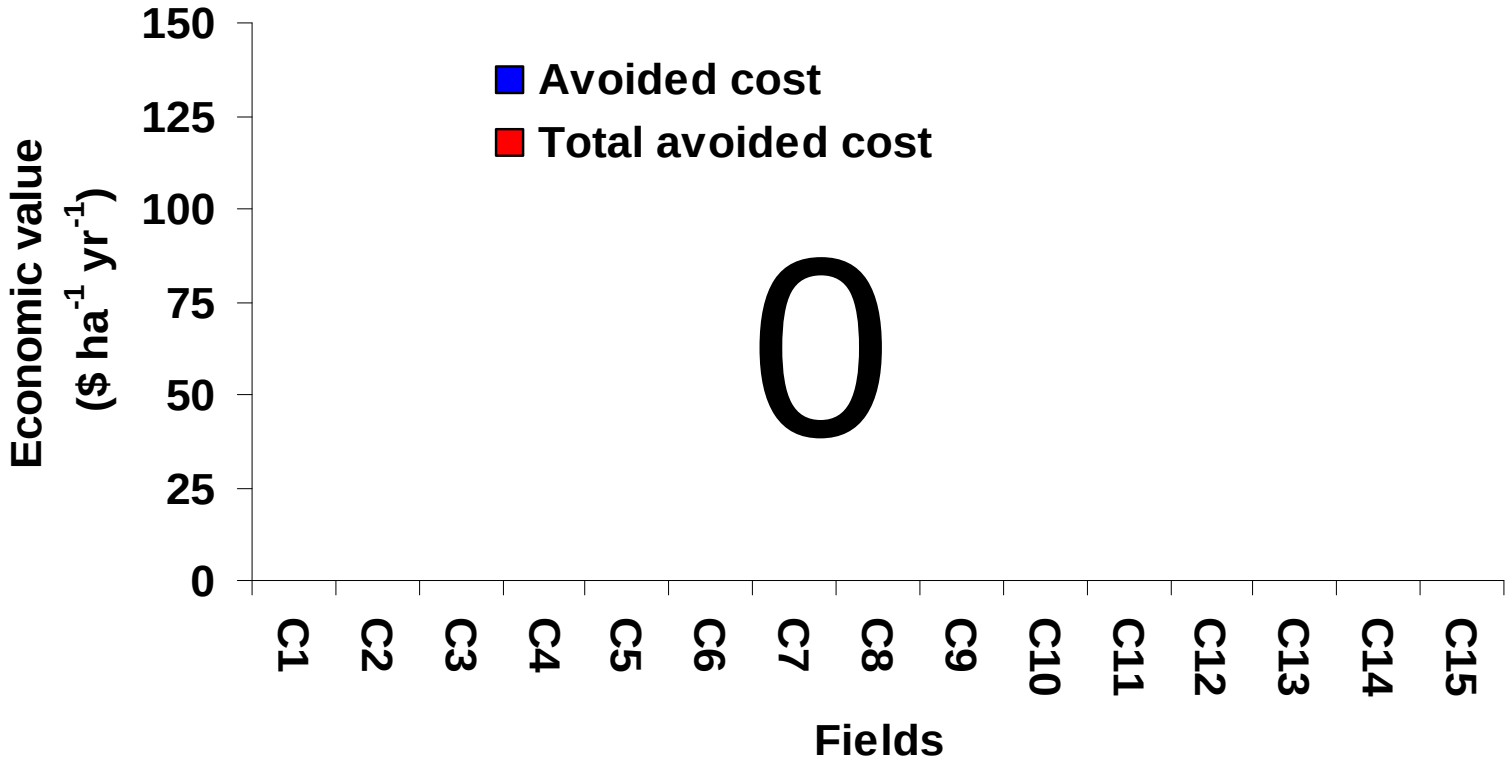

14-7-04 000
20:48:25 L12H

Economic value of biological control of aphids in organic fields



Total avoided cost includes external costs e.g. environment and human health

Economic value of biological control of aphids in conventional fields



Total avoided cost includes external cost

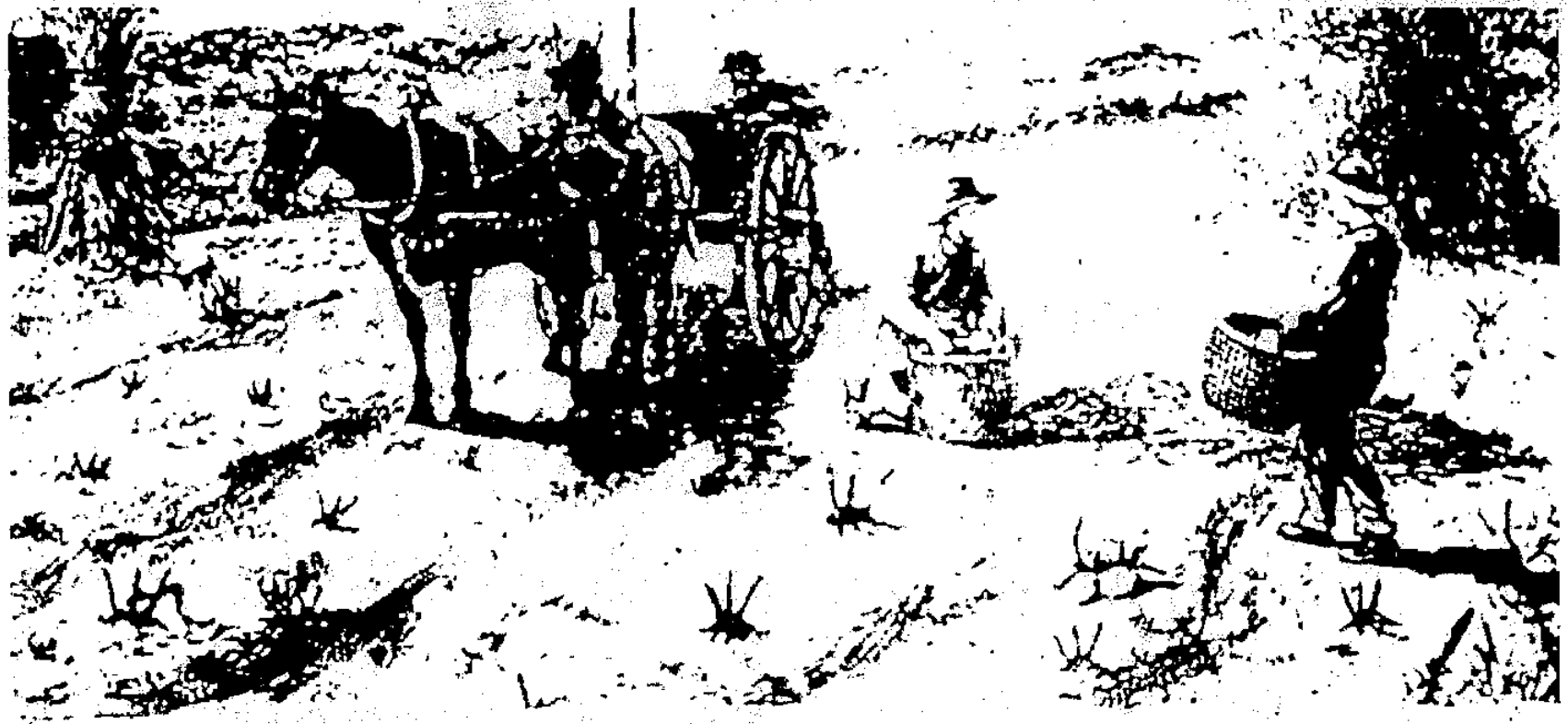
Bio-Protection

But how much biodiversity and what type?

Bio-Protection

And will farmers tolerate it?

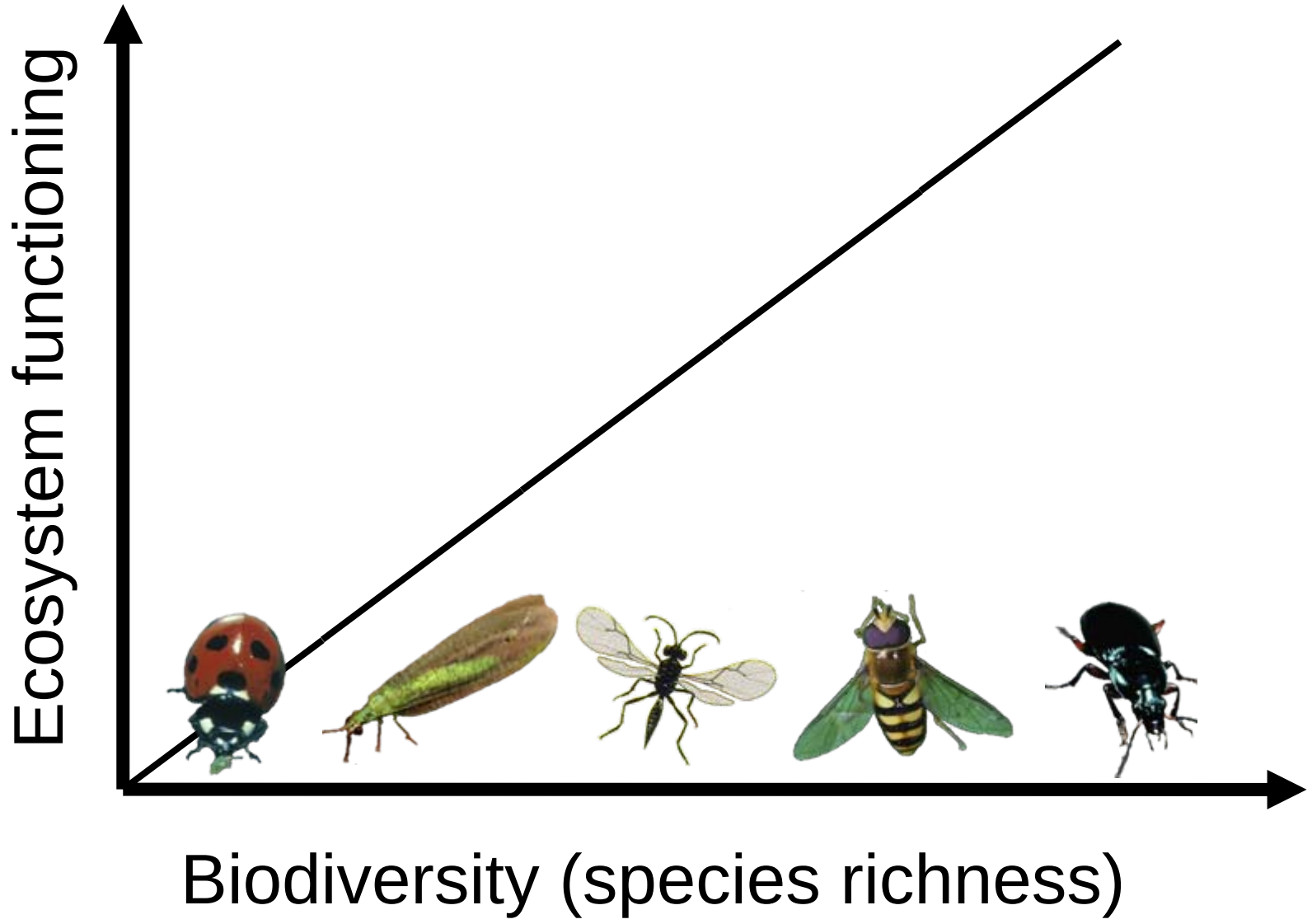
Bio-Protection



Even as a single hair casts a shadow does a weed steal profit from the harvest.

Bio-Protection

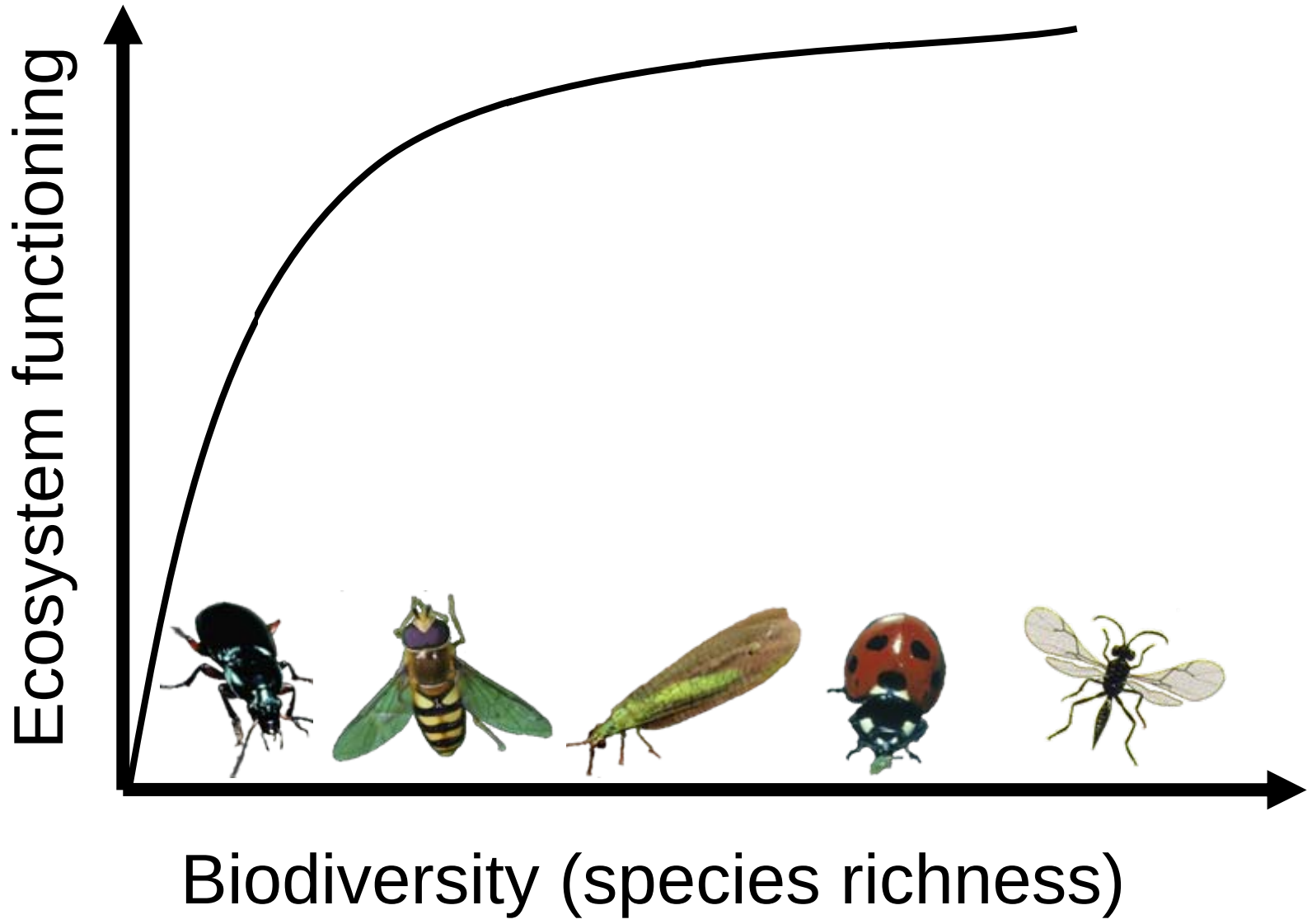
Biodiversity - Ecosystem functioning debate



Cardinale *et al.* 2006 (*Nature*) used a meta-analysis to conclude:

Bio-Protection

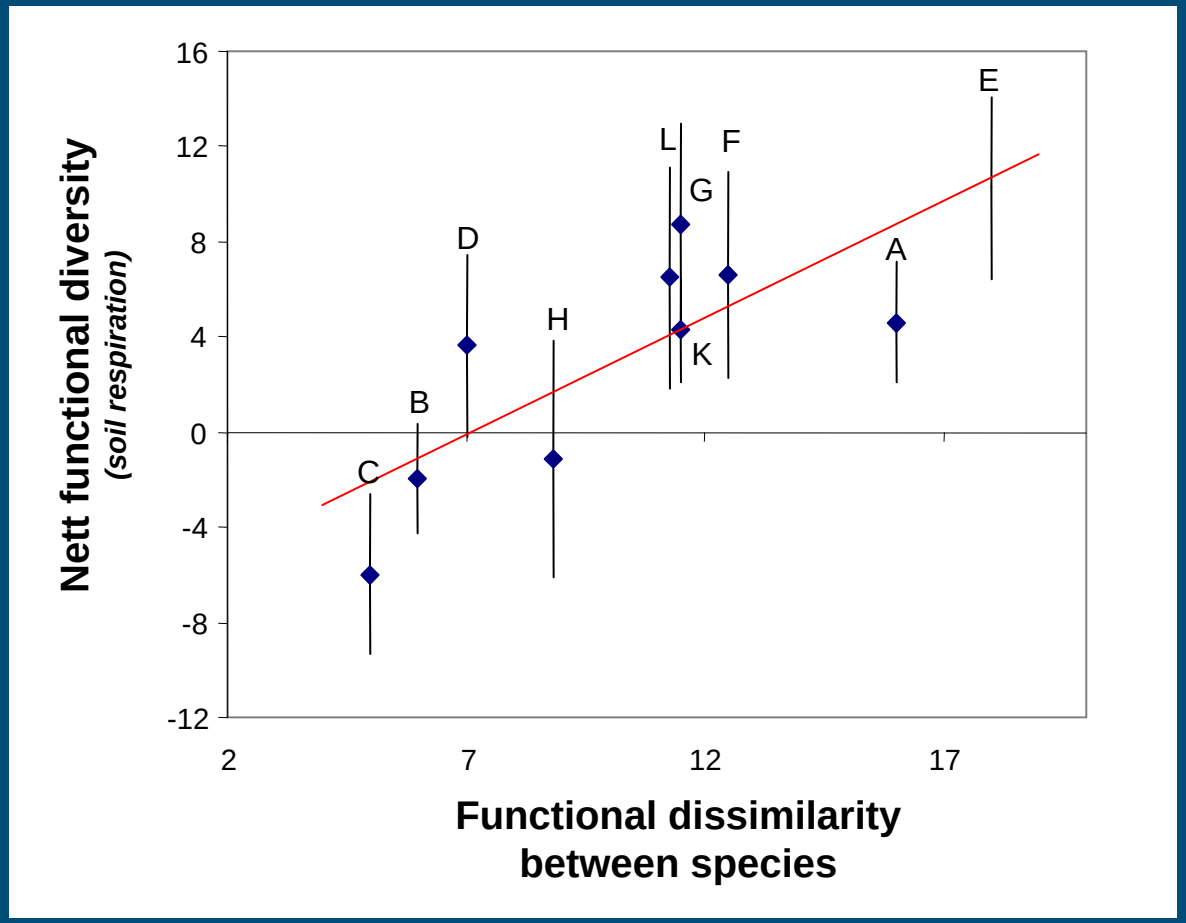
Biodiversity - Ecosystem functioning debate



But Heemsbergen *et al* 2004 (*Science)* said **traits** more important

Bio-Protection

Trait diversity and system functioning



Functioning related to trait diversity

Key species:

Lumbricus rubellus

Foto: Ron de Goede

Heemsbergen et al. 2004

Some practical ES outcomes from the traits idea for conservation biological control of insects

Bio-Protection

Shelter

Nectar

Alternative prey

Pollen

Shelter

Nectar

Alternative prey

Alternative prey

Bio-Protection

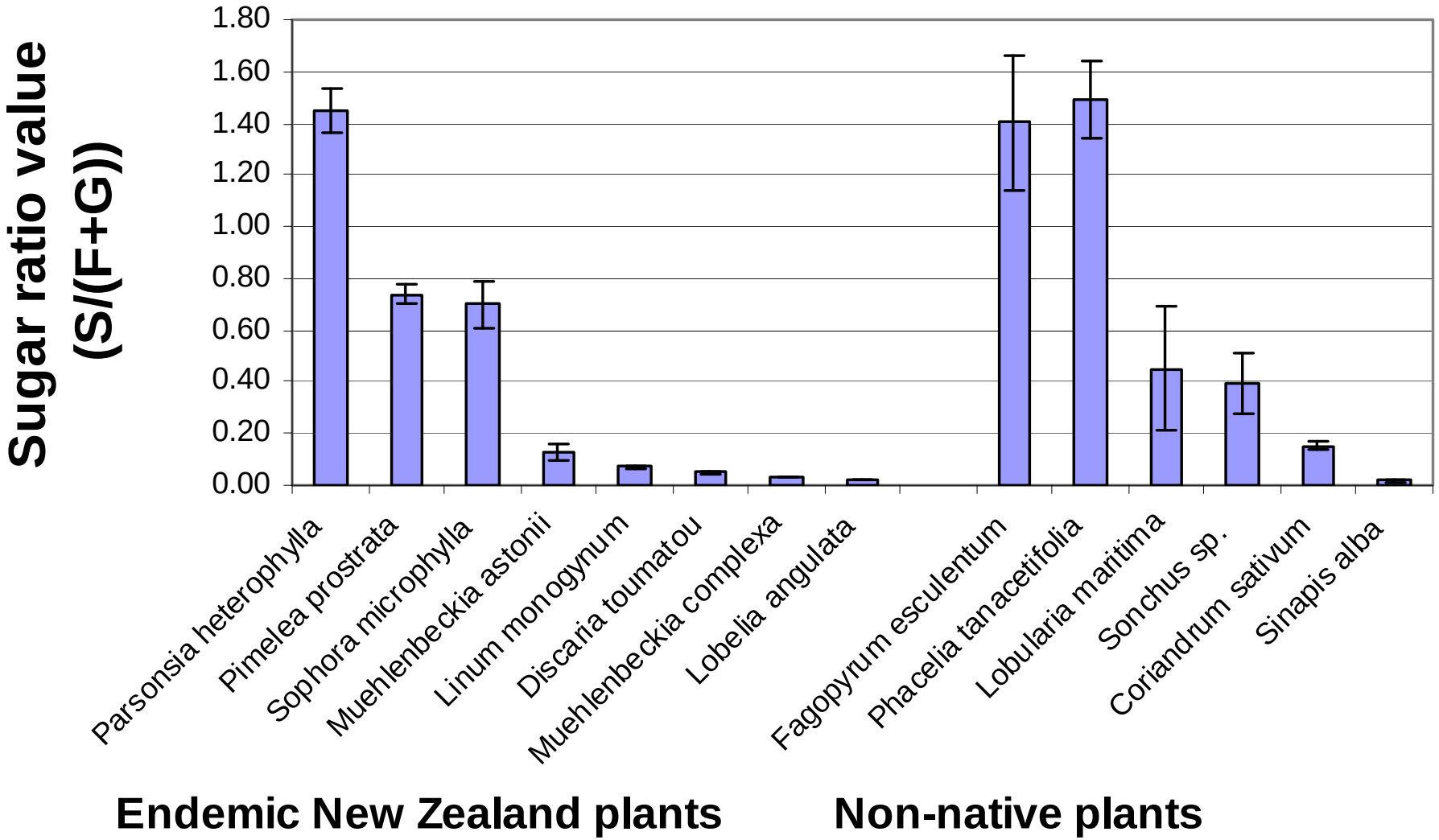
but which plant spp. provide SNAP and which plant traits are most important?

Bio-Protection

Nectar sugar ratios for sNAP?

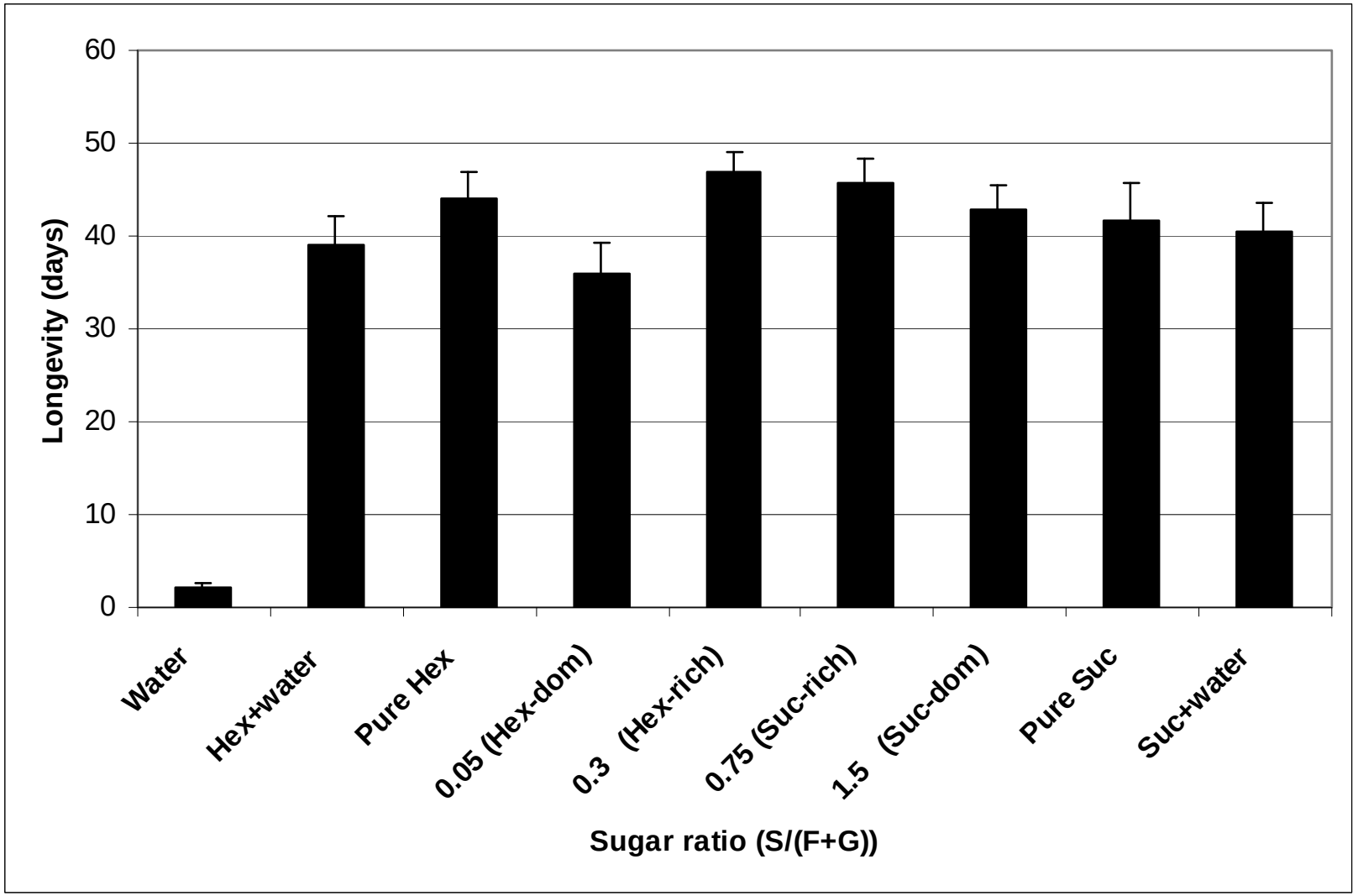
Bio-Protection

Sugar ratio of various plant species



Bio-Protection

Parasitoid longevity on a range of sugar ratios



Bio-Protection

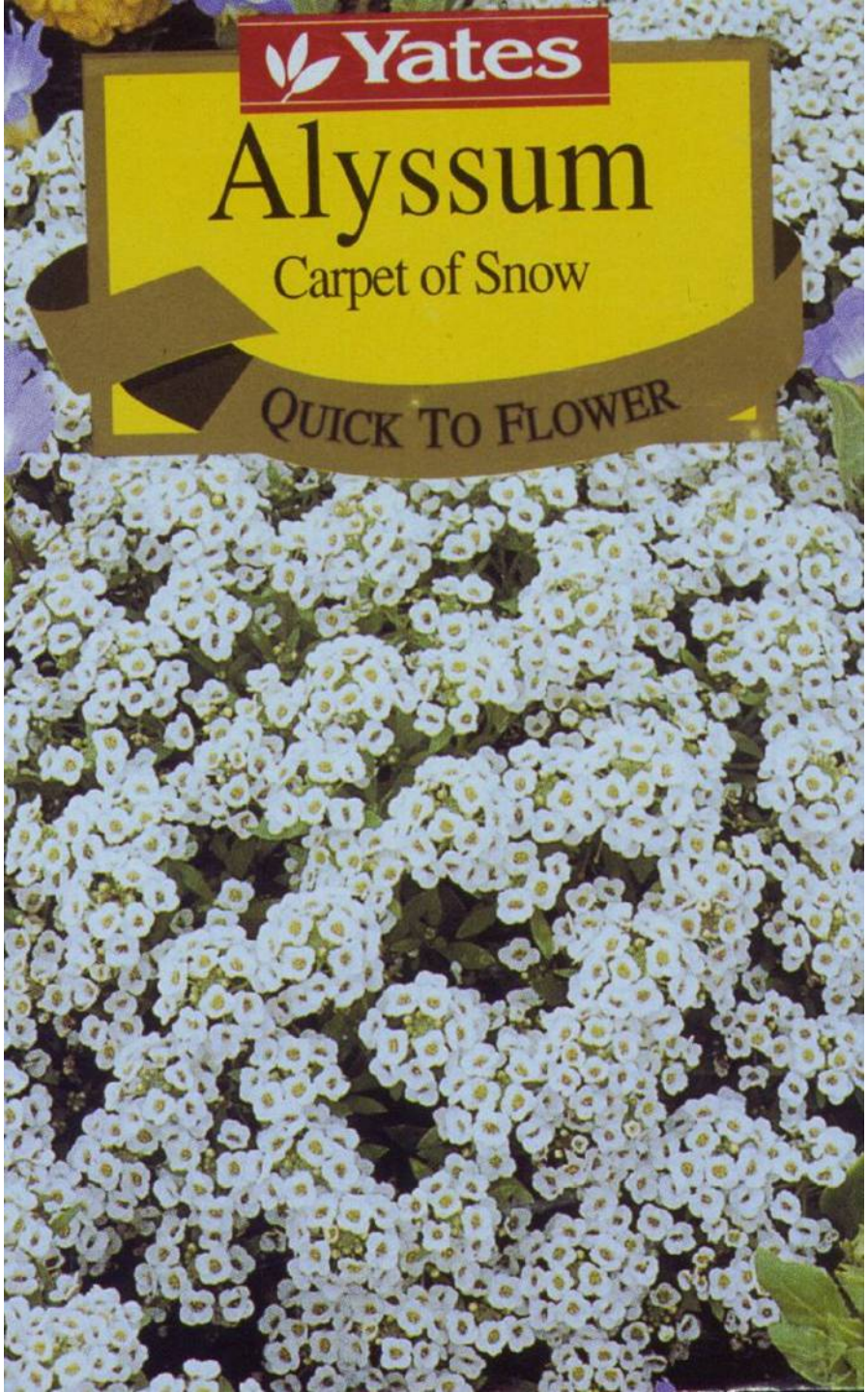
“The great tragedy of Science — the slaying of a beautiful hypothesis by an ugly fact.”

—Thomas Henry Huxley

Bio-Protection

Not eclectic choices of species – lab and field experimentation on traits first

Bio-Protection

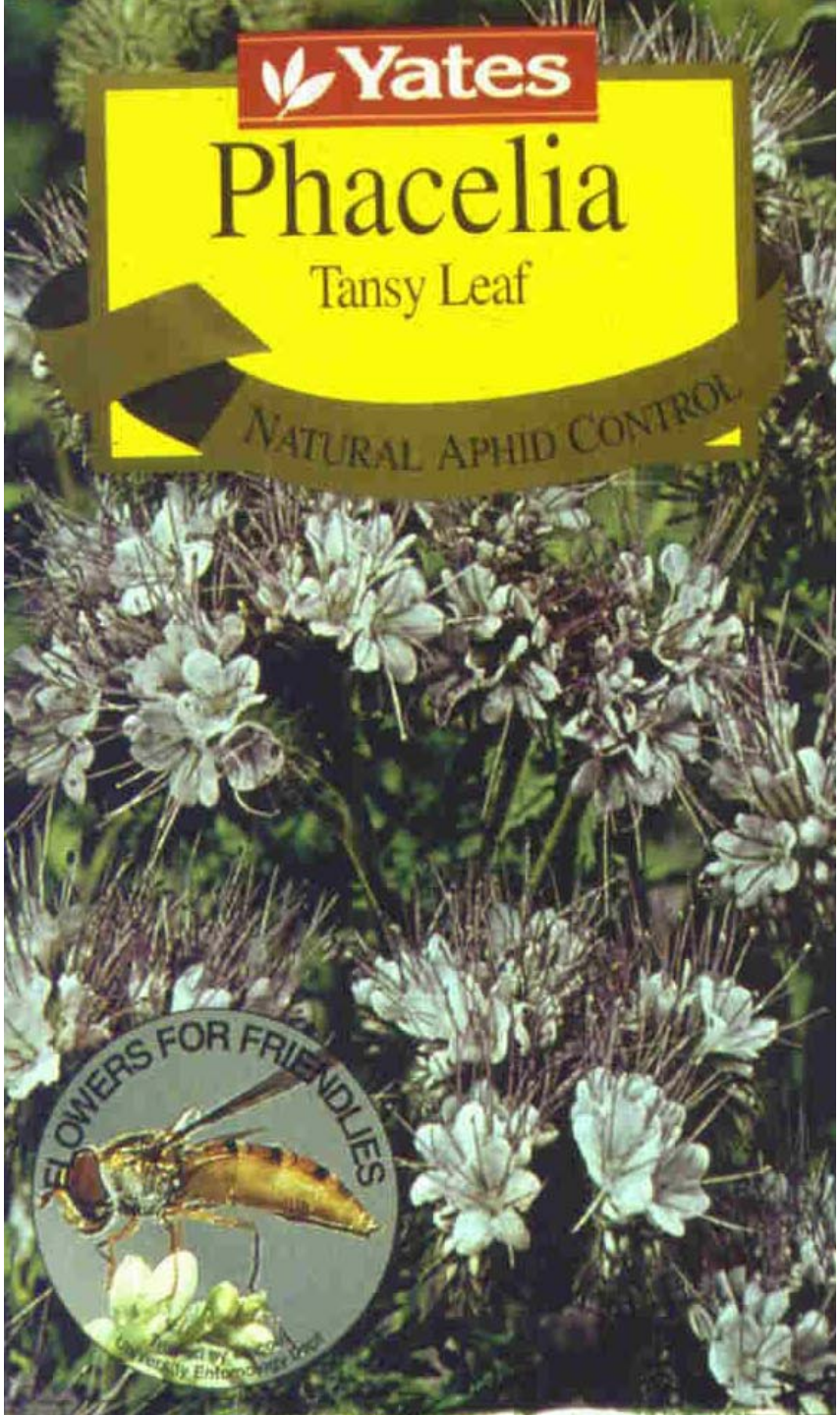


Bio-Protection

Earthbound Farms, Mission Organics, CA: sweet alyssum, *Lobularia maritima* in lettuce crops – an eclectic choice, but it works

Bio-Protection

Bio-Protection



Bio-Protection

and buckwheat

Bio-Protection

Bio-Protection

Bio-Protection

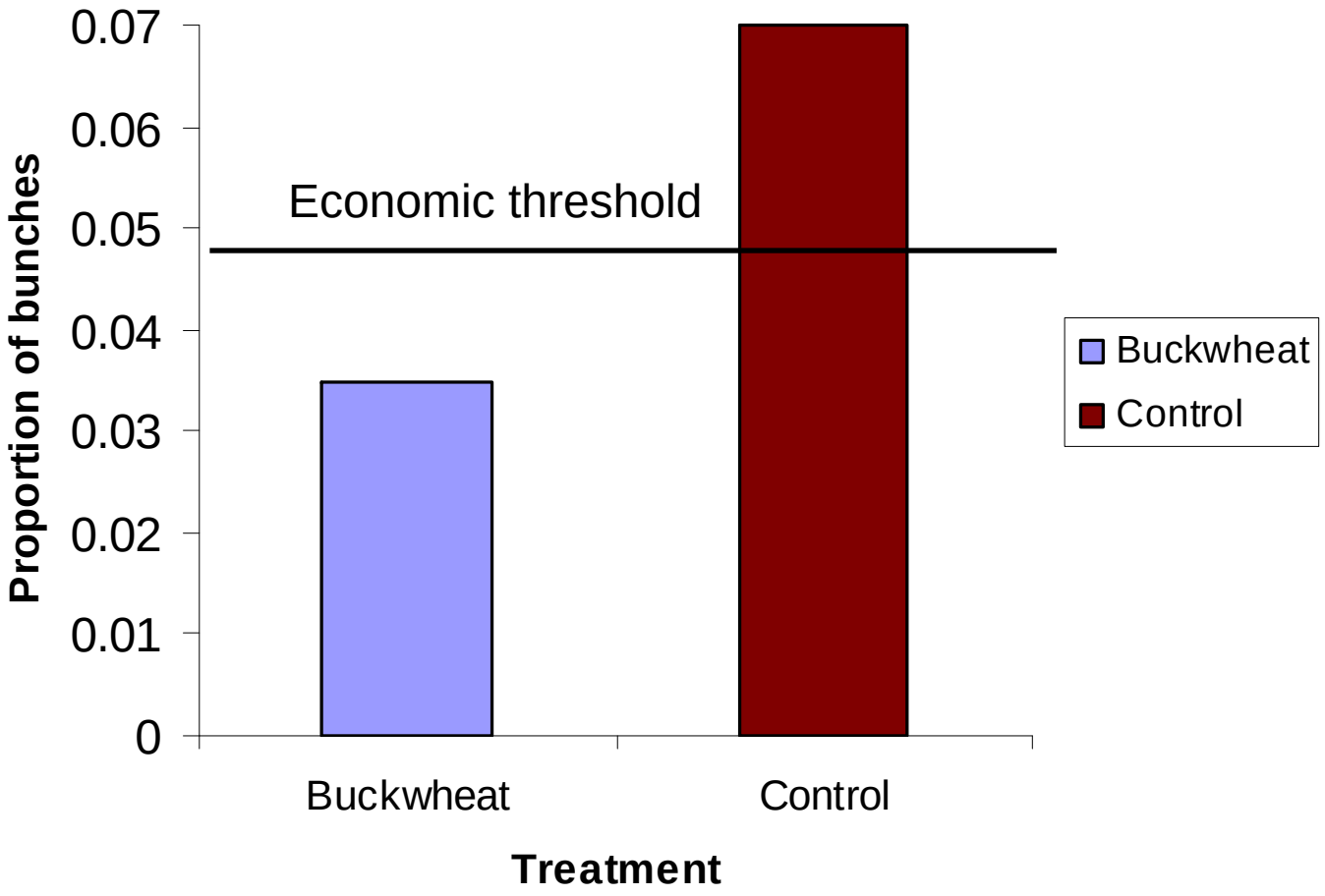
The key biocontrol agents targetted include parasitic wasps

Bio-Protection

Buckwheat in vines also provides SNAP

Bio-Protection

Light brown apple moth *Epiphyas* damage



Proportion of bunches infested with leafrollers.
Economic threshold for leafrollers shown

Bio-Protection

Native plants in NZ vines to provide multiple ES

Bio-Protection

Native plants under grape vines

Bio-Protection

The vineyard landscape of the future?

Bio-Protection

What if we engineered farming for more ES e.g., combined food, energy and ecosystem services (CFEES)?

Bio-Protection

Bio-Protection

CFEES: US$1500/ha/yr in our Denmark work: *Ambio* (2009)

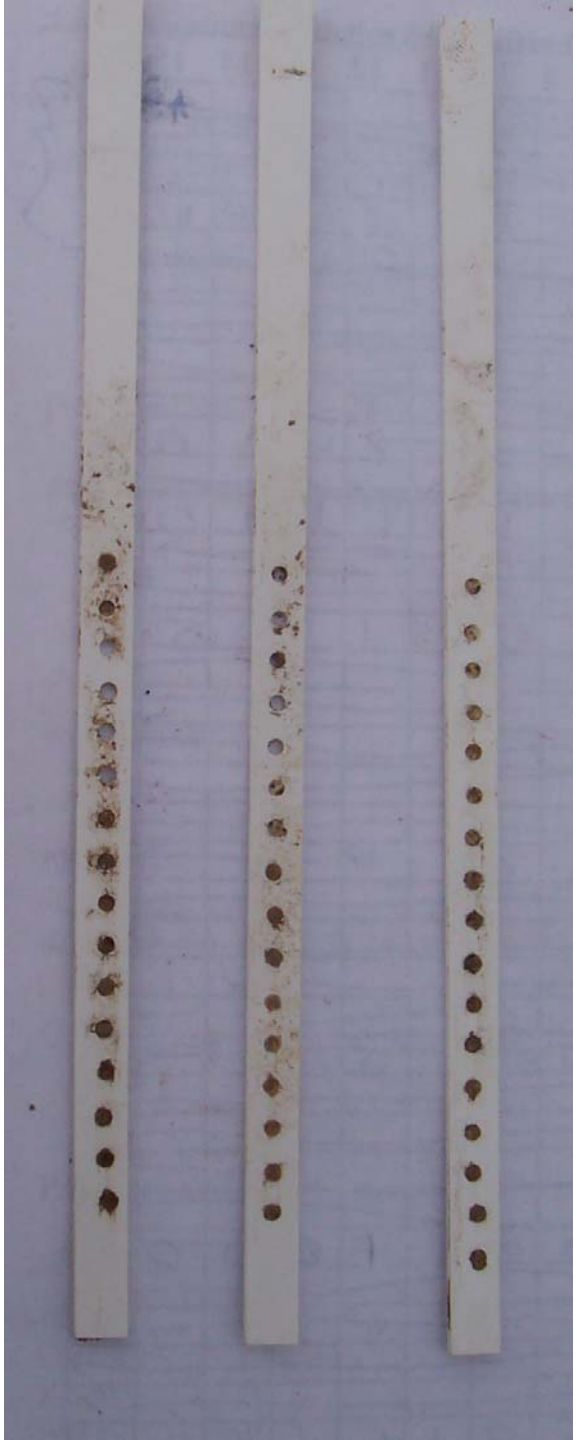
Bio-Protection

Organic/conventional comparison in NZ: two ES: biological control and nutrient mineralisation

Bio-Protection


14-7-04 000
20:48:25 L12H

Bait lamina probes



Bio-Protection

If 25% of EU25 farmland could enhance these two ES to their level in organic farms, their total ES value would be $160 billion pa. EU subsidies are $150 billion p.a., for ‘environmental’ schemes which largely don’t work (Kleijn et al. 2006)

Bio-Protection

Message: enhance invertebrate-driven multiple ES on farmland

Bio-Protection

December 2010

ESA, San Diego

Assessing ecosystem services provided by invertebrates in farmland: A 'bottom-up' approach

Steve Wratten
Bio-Protection Research Centre
Lincoln University

Bio-Protection