Avoiding Disaster by Design:

Designing and Maintaining Landscapes for Ecologically-Sound Pest Management

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COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

The ornamental landscape as an ecosystem: implications for pest management

Herms et al. (1984) *J. Arbor.* 10:303-307.

"Understanding the ecological interactions between the biotic and abiotic factors within a landscape enables more effective management of pests."

Raupp, M.J., P.M. Shrewsbury, and D.A. Herms (2010) Ecology of herbivorous arthropods in urban landscapes. *Annual Review of Entomology* 55:19-38.

Raupp, M.J., P.M. Shrewsbury, and D.A. Herms (2012) Disasters by design: outbreaks along urban gradients. P. Barbosa, D.K. Letourneau, and A. Agrawal (eds.), *Insect Outbreaks Revisited*. Wiley-Blackwell, Chichester, West Sussex, UK.

Mike Raupp

Paula Shrewsbury

Taxa that outbreak most commonly in urban environments

(analysis of 50 studies; Raupp et al. 2010)

Spider mites

Scales (soft and armored)

Lace bugs

Adelgids

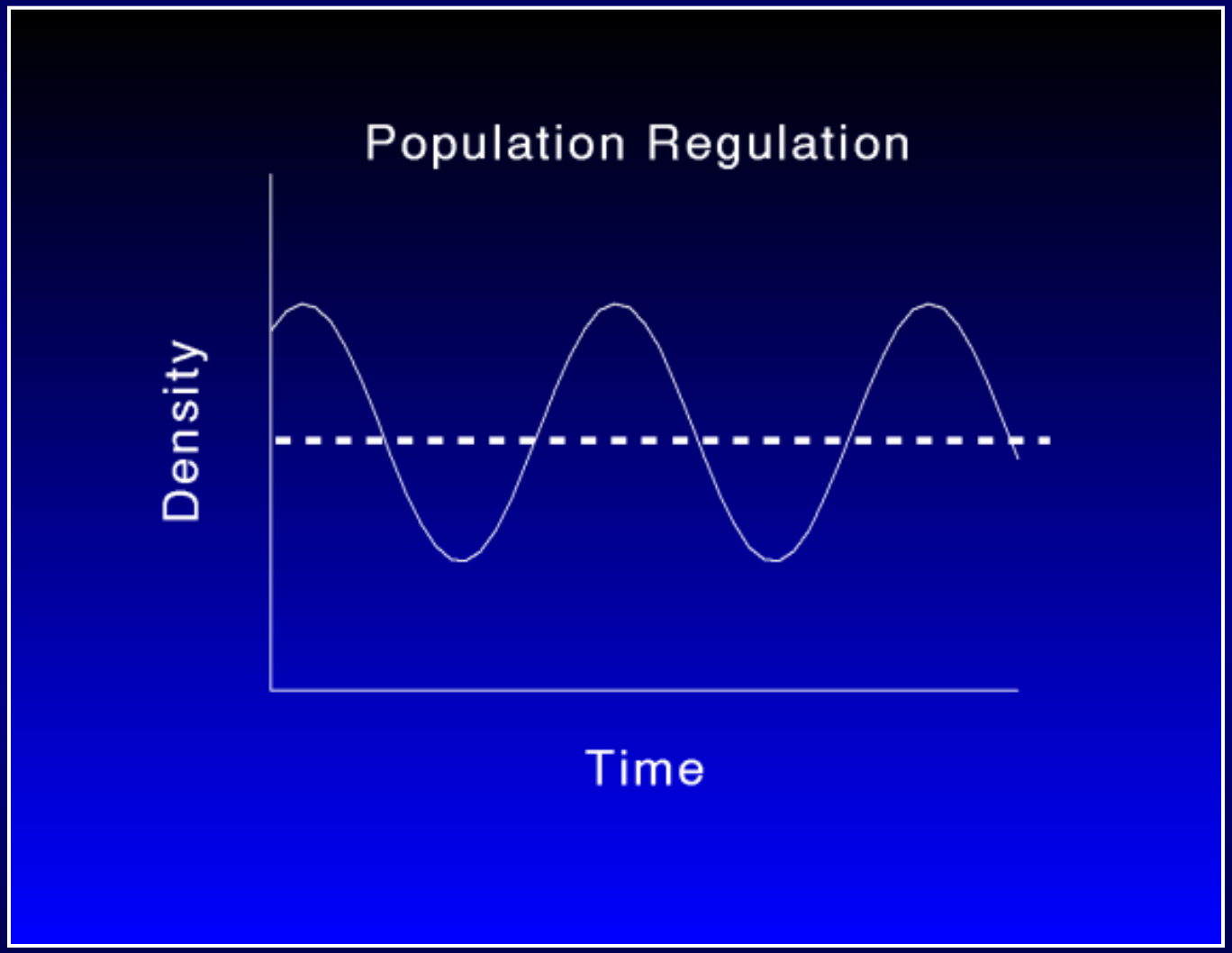
Gall midges and wasps

Leafminers

Specialized; limited mobility; multiple generations on same host plant

Spatial scales of outbreaks vary:

Population Density and Stability



Urbanization and insect population dynamics: top-down and bottom-up effects

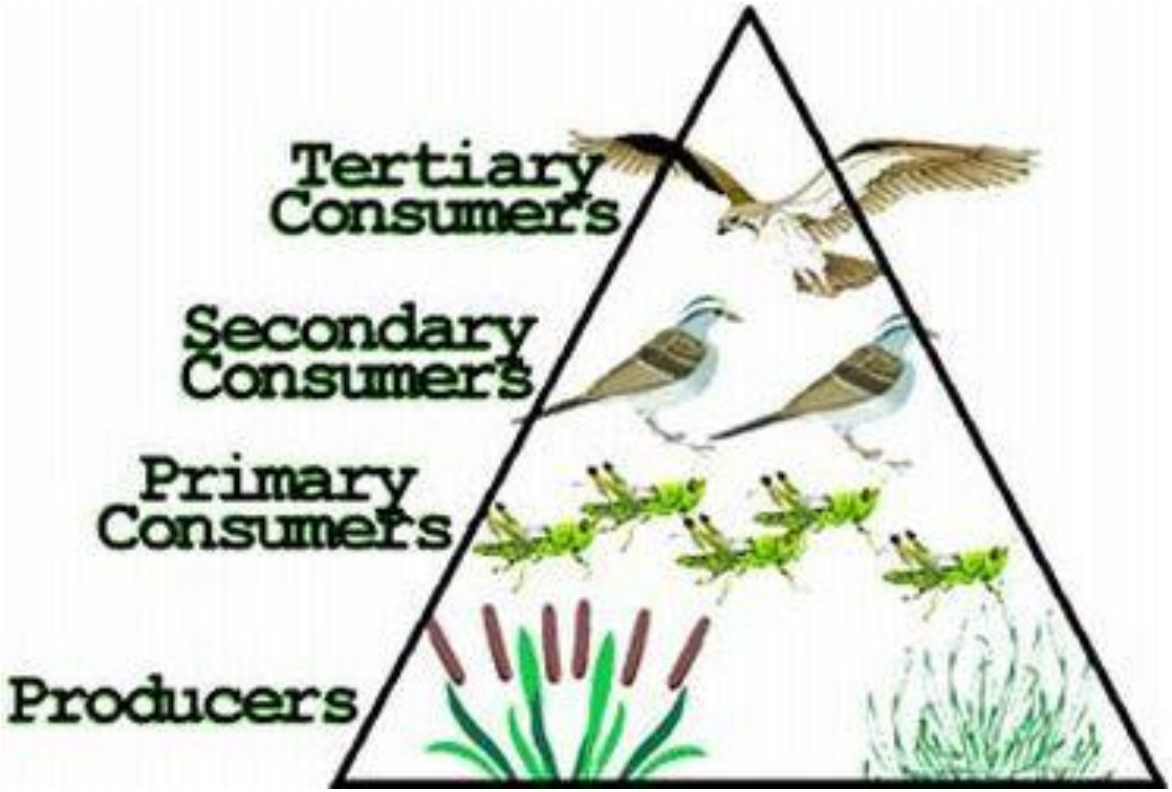
Bottom up effects: host quality

- genetics
- evolutionary history
- environmental stress and cultural practices.

Top down effects: natural enemies

- ecosystem complexity
- evolutionary history
- nontarget effects of pesticides

Trophic Pyramid



http://maggiessciencеconnection.weebly.com

Biotic and abiotic traits of managed environments affecting insect and mite populations:

Community composition and structure (design):

- Plant diversity and natural enemies
- Coevolutionary relationships (and lack thereof).

Abiotic environment

- Stress: Impervious surface, heat islands
- Habitat fragmentation / isolation
- Anthropogenic inputs (pollution, nutrients, pesticides)

Biotic and abiotic traits of managed environments affecting insect and mite populations:

Community composition and structure:

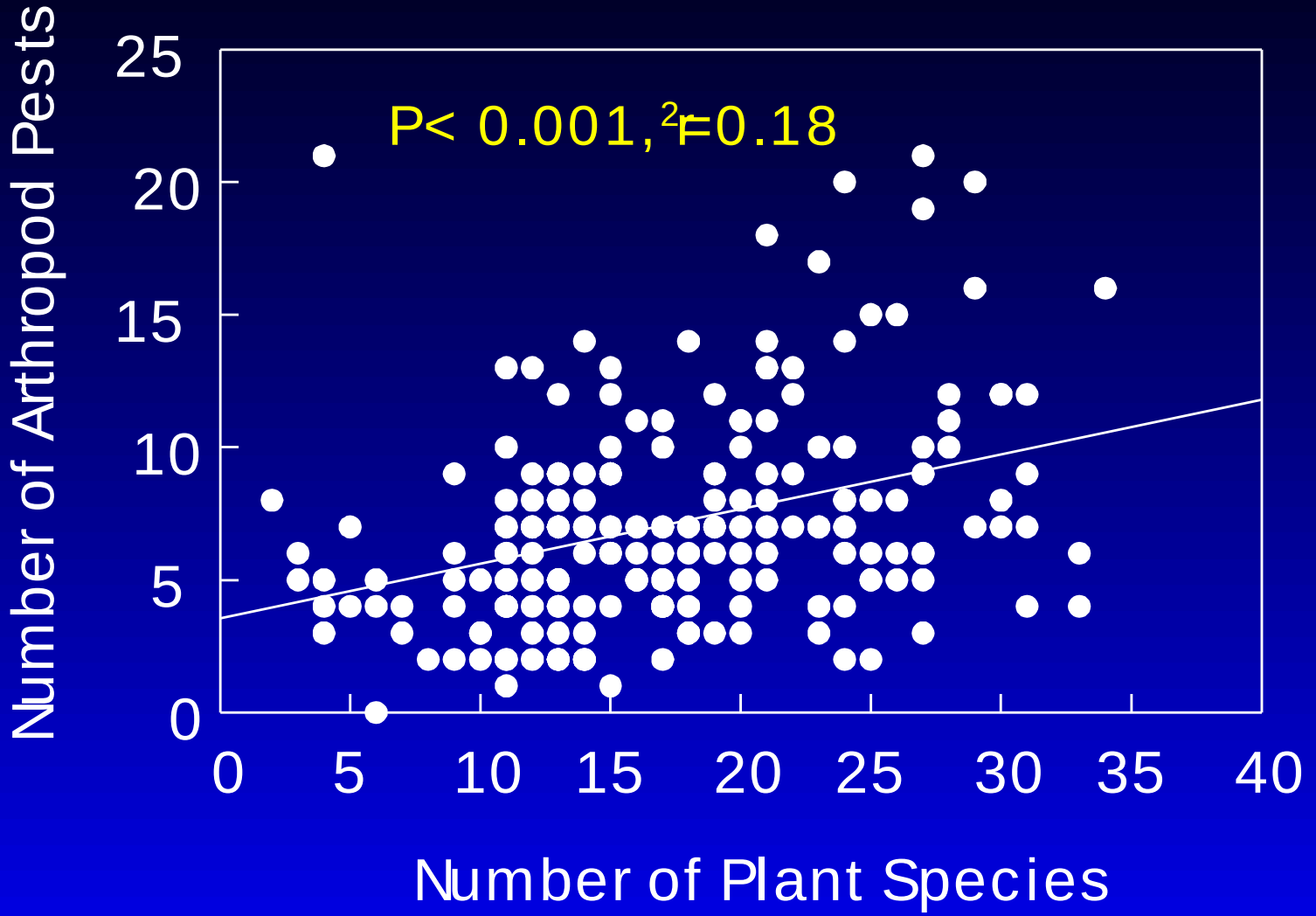
- Plant diversity and natural enemies

What is the relationship between plant abundance and diversity and the diversity of arthropod pests in residential landscapes? We examined 212.

Low diversity n = 3 species

High diversity n = 34 species

Relationship Between Plant Species and Number of Arthropod Pests

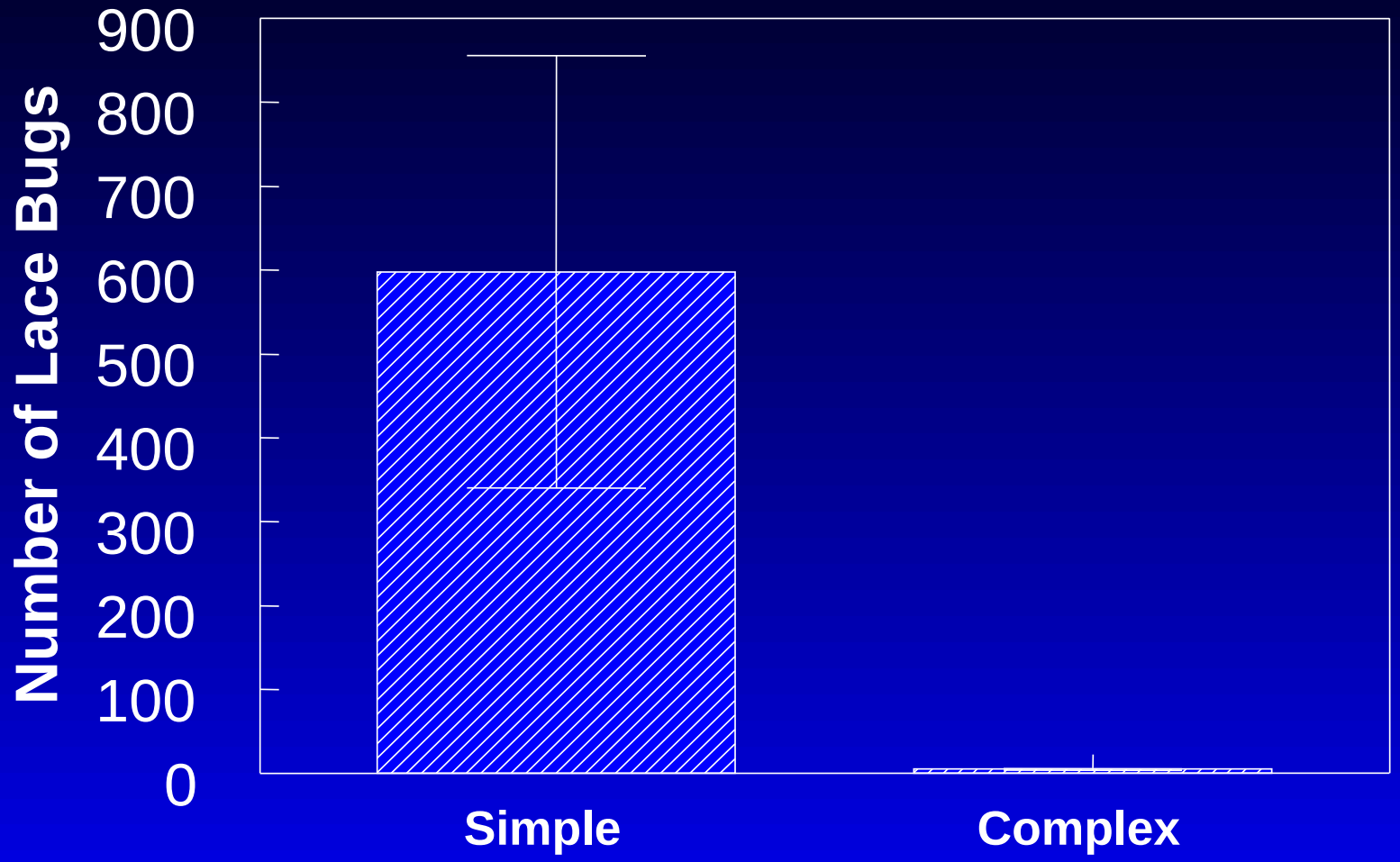


Raupp and Shrewsbury 2000

Azalea Lace Bug

Stephantis pyrioides

Abundance in simple and complex landscapes



Shrewsbury and Raupp 2005

Predator group or taxa	Simple	Complex	*P*
Generalist predators	13.1 ± 2.6	21.8 ± 2.6	0.0273
Spiders	24.7 ± 5.2	40.6 ± 5.4	0.0467
Anyphaenidae	4.93 ± 1.1	25.0 ± 2.5	0.0001
Thomisidae	1.58 ± 1.1	8.31 ± 2.9	0.0029
Theridiidae	9.28 ± 3.7	2.63 ± 0.7	0.0799
Oxyopidae	3.64 ± 2.2	0.68 ± 0.2	0.1111
Salticidae	3.97 ± 1.2	2.31 ± 1.0	0.2976
Phalangidae	0.38 ± 0.2	1.32 ± 0.4	0.0612
Gryllinae	1.36 ± 0.7	6.63 ± 1.8	0.0010
Oecanthinae	0.27 ± 0.2	1.73 ± 0.6	0.0139
Forficulidae	1.14 ± 0.5	1.24 ± 0.3	0.8720
Formicidae	4.72 ± 1.5	6.44 ± 1.4	0.4185
Miridae	0.27 ± 0.1	0.02 ± 0.0	0.0140

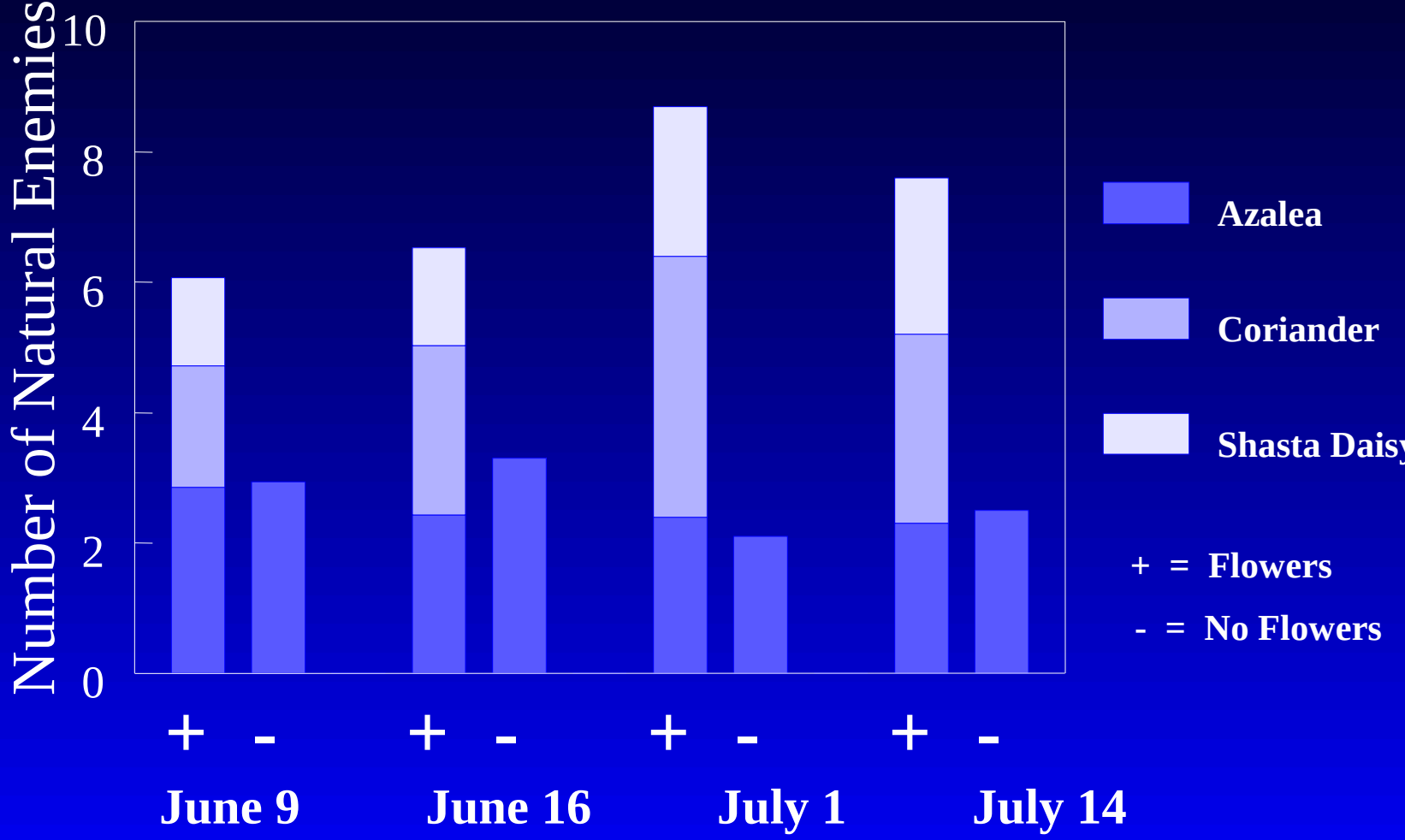
Spiders can be extremely abundant


overstory
understory
shrubs
ground cover or turf
herbaceous plants

Add flowers

to landscapes

Effect of Flowers on Natural Enemy Abundance

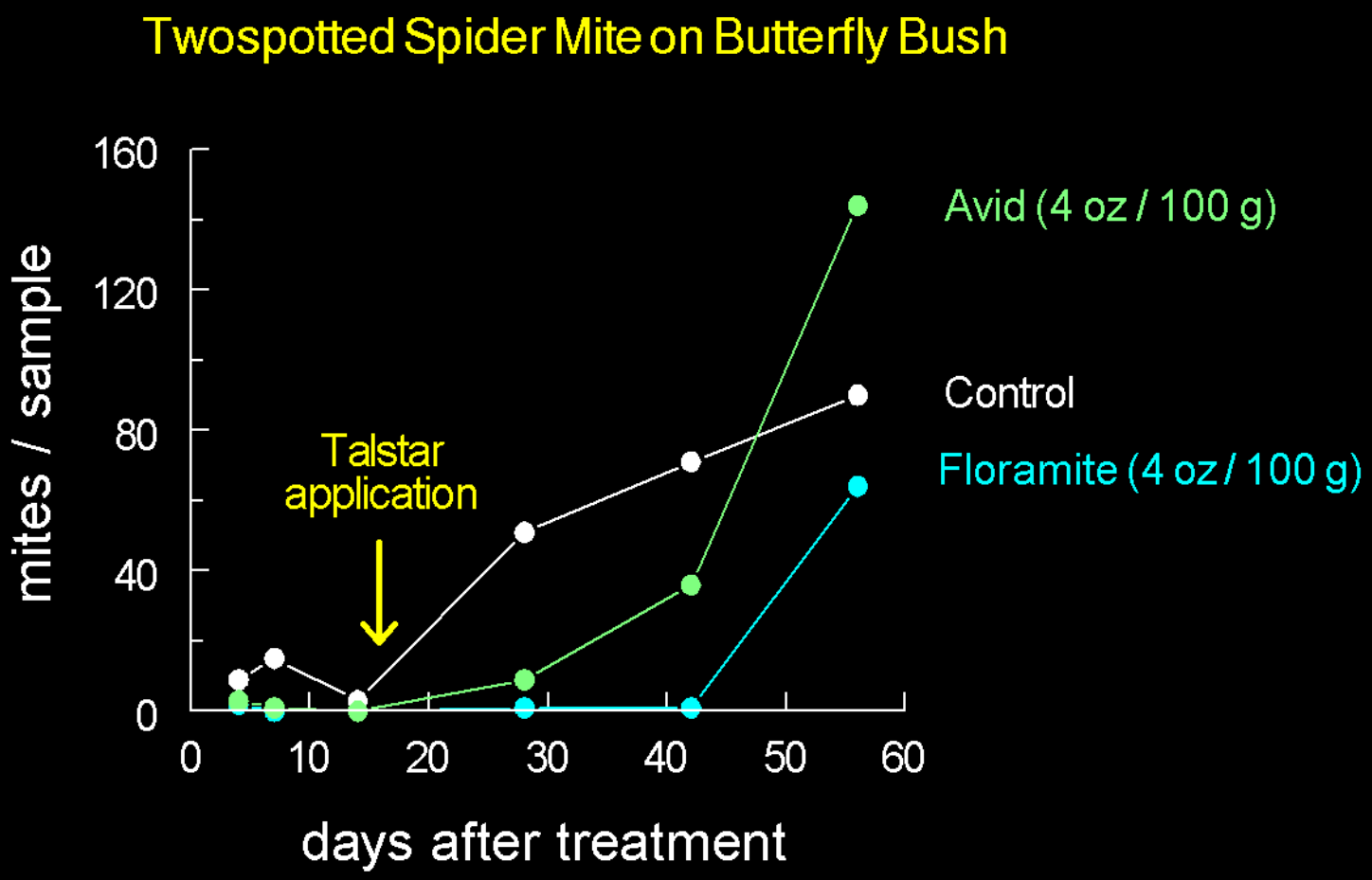


IPM Tactic: Biocontrol

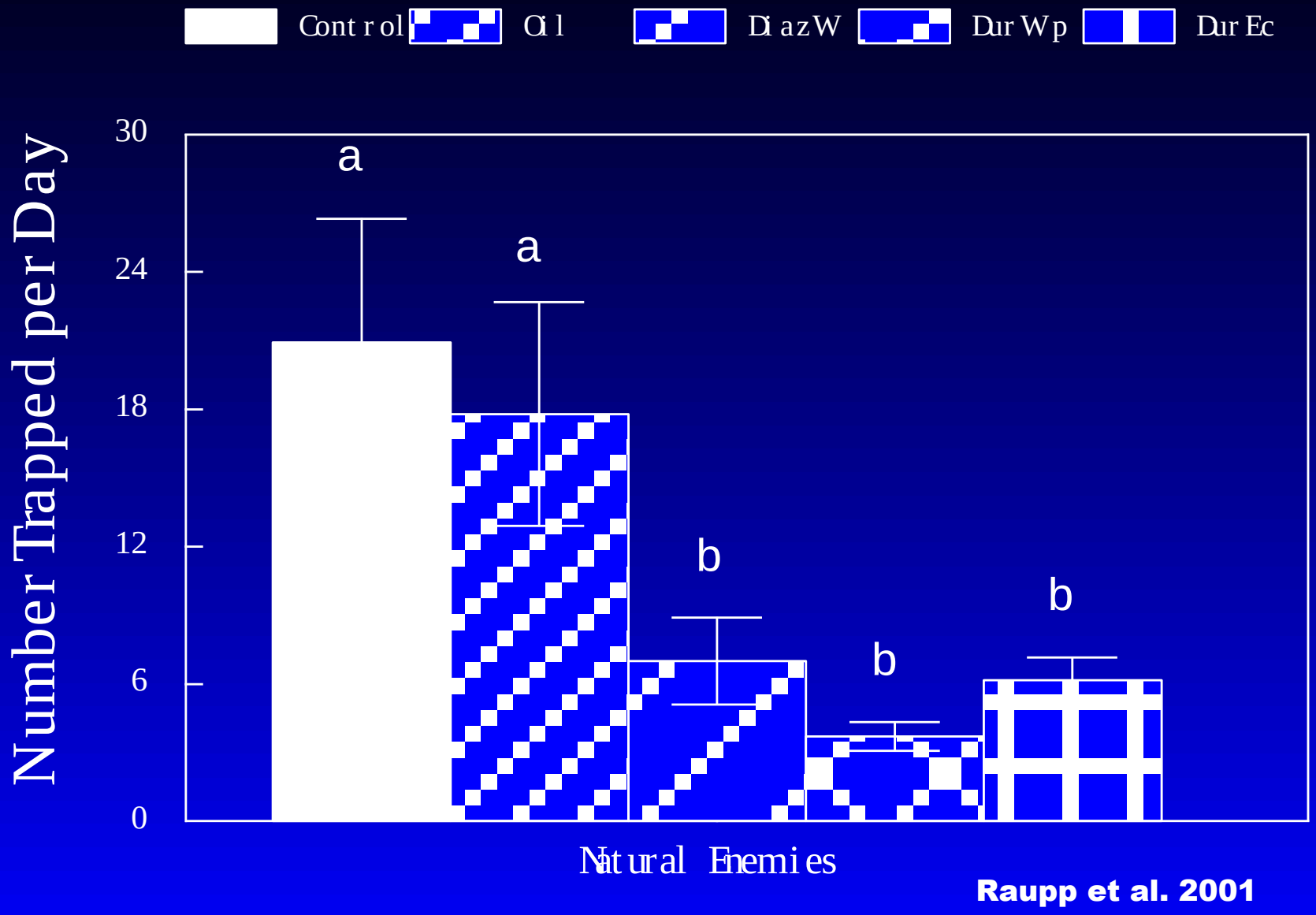
Conservation: protect natural enemies

Augmentative: introduce natural enemies.

Pest Resurgence



Effects of Oil, Diazinon, and Dursban on Natural Enemies over Six Weeks



Raupp et al. 2001

Augmentative Biological Control

Spider Mites

Predatory mite

www.3countieshydroponics.co.uk

Biotic and abiotic traits of managed environments affecting insect and mite populations:

Coevolutionary matrix:

- Native plants / native insects (stable)
- Exotic plants / exotic insects (enemy release)
- Exotic plants / native insects (community simplification; defense free space)
- Native plants / exotic insects (enemy release; defense free space)

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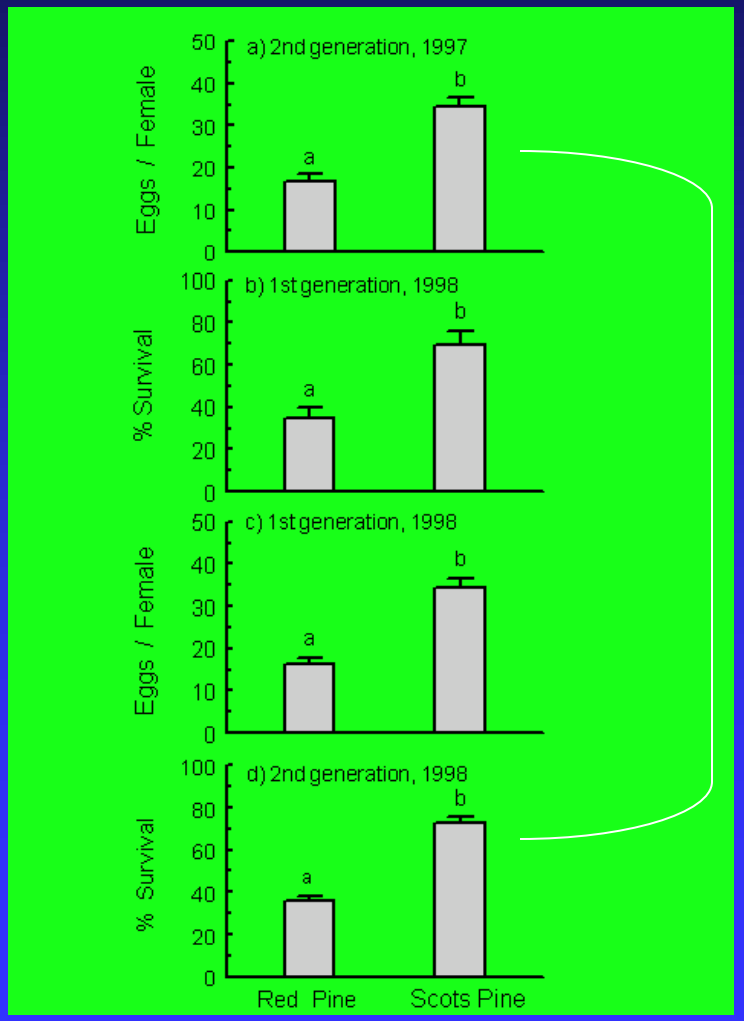
Native plants / native insects (stable)

Comparing N.A. Pine Needle Scale, *Chionaspis pinifoliae*, Performance on Exotic Scots and N.A. Red Pines (Glynn and Herms 2004)



Biotic and abiotic traits of urban environments affecting insect and mite populations:

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- Exotic plants / native insects (community simplification; defense free space)
- Native plants / exotic insects (enemy release; defense free space)

Exotic plants / exotic insects (lack of natural enemies)

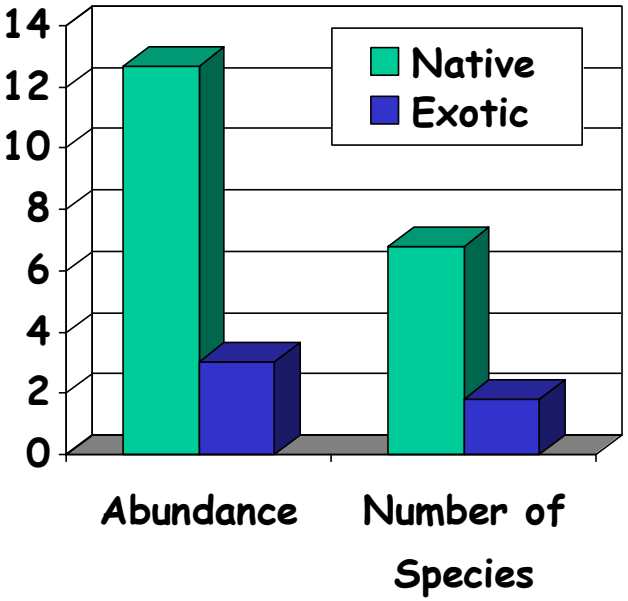
Biotic and abiotic traits of urban environments affecting insect and mite populations:

Coevolutionary matrix:

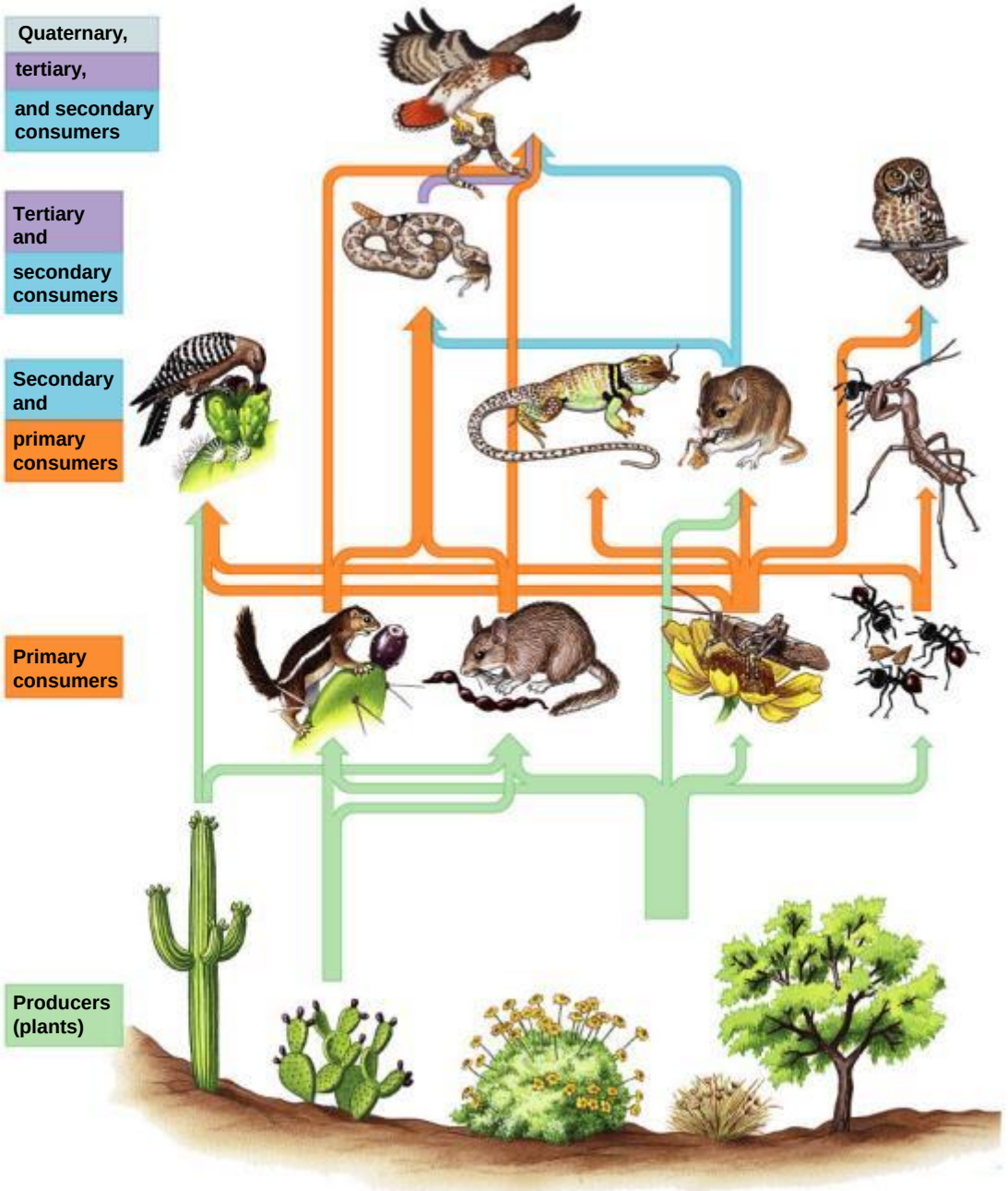
- Native plants / native insects (stable)
- Exotic plants / exotic insects (enemy release)
- Exotic plants / native insects: community simplification
- Native plants / exotic insects (enemy release; defense free space)

Some exotic plants support few or no insects

Greater biodiversity associated with native plants.



Burghardt et al. 2009




overstory
understory
shrubs
ground cover or turf
herbaceous plants

BRINGING NATURE HOME

How Native Plants Sustain Wildlife in Our Gardens

DOUGLAS W. TALLAMY

Biotic and abiotic traits of urban environments affecting insect and mite populations:

Coevolutionary matrix:

- Native plants / native insects (stable)
- Exotic plants / exotic insects (enemy release)
- Exotic plants / native insects: defense free space
- Native plants / exotic insects (enemy release; defense free space)

Some exotic plants are highly susceptible to native insects: Birch resistance to bronze birch borer

Interspecific Variation in Resistance of Asian, European, and North American Birches (*Betula* spp.) to Bronze Birch Borer (Coleoptera: Buprestidae)

DAVID G. NIELSEN, VANESSA L. MUILENBURG, AND DANIEL A. HERMS[1]

Department of Entomology, Ohio Agricultural Research and Development Center, The Ohio State University, 1680 Madison Avenue, Wooster, OH 44691

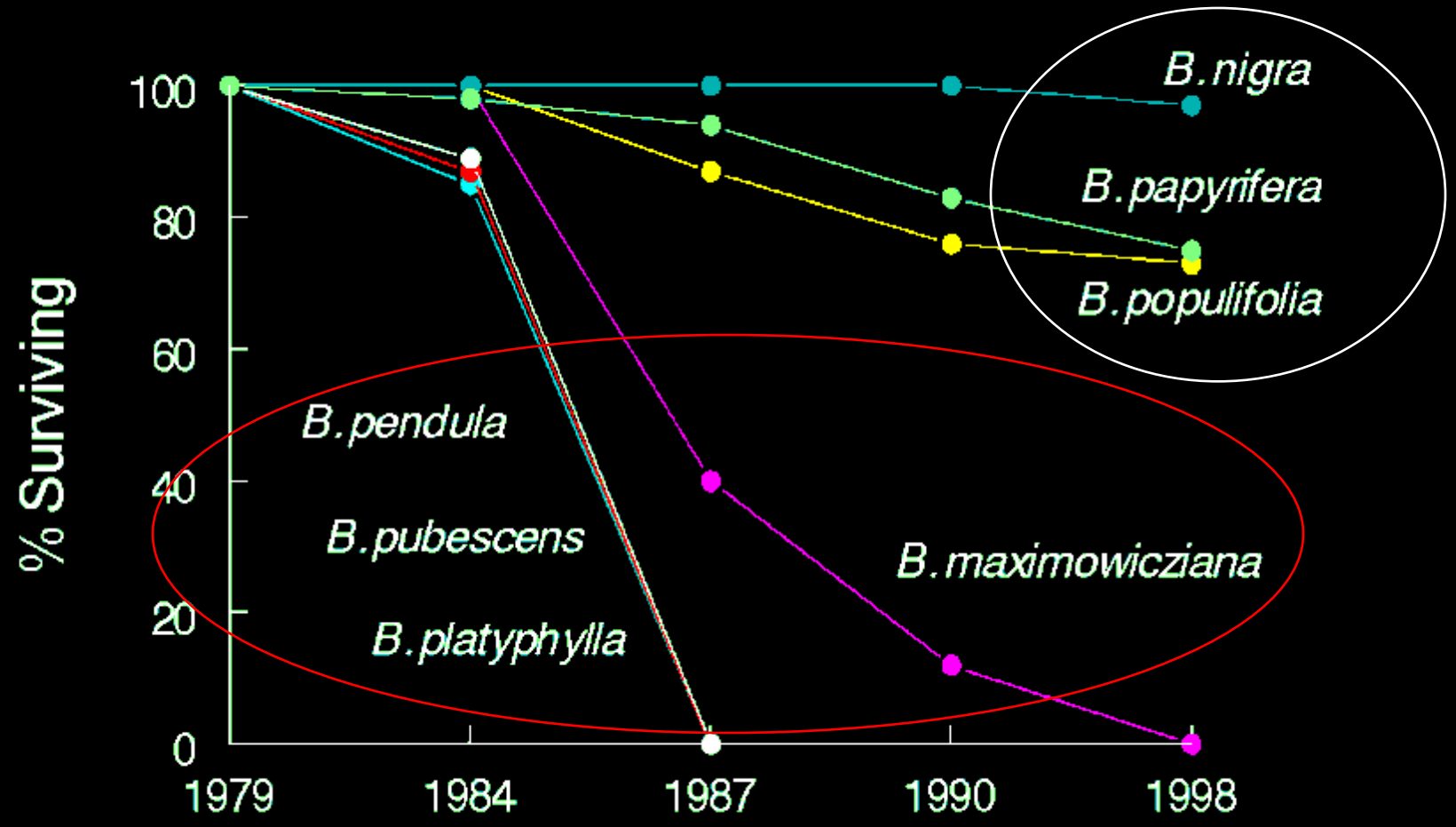
Environ. Entomol. 40(3): 648–653 (2011); DOI: 10.1603/EN10227

20 year study of variation in birch resistance to bronze birch borer

Nielsen, Muilenburg, & Herms (2011) *Environ Entomol.*

7 species, 200 reps / species, 1400 trees total:

Native species:	Exotic species:
B. nigra	*B. pendula*
B. papyrifera	*B. pubescens*
B. populifolia	*B. platyphylla*
	B. maximowicziana


20 Year Record of Birch Mortality from Bronze Birch Borer
% Surviving
100
80
60
40
20
0
1979
1984
1987
1990
1998
B. nigra
B. papyrifera
B. populifolia
B. pendula
B. pubescens
B. platyphylla
B. maximowicziana

Birch survival after 20 years:

North American species:	
B. nigra	97%
B. papyrifera	73%
B. populifolia	75%

Exotic species:	
B. pendula	0%
B. pubescens	0%
B. platyphylla	0%
B. maximowicziana	0%

Conclusion: no evolutionary history, no resistance.

High proportion of exotic plants:

Creates “enemy free space” that allows exotic pests to outbreak on exotic plants.

Uncouples native herbivores from plants, which can collapse food web.

Creates defense free space, which allows native pests to outbreak on exotic plants.

Biotic and abiotic traits of urban environments affecting insect and mite populations:

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Emerald ash borer: hundreds of millions of dead ash trees (and counting)

June 2006

August 2009

Projected Economic Impacts:

$10.7 billion in 25 states for treatment, removal, and replacement of more than 17 million ash on developed land (Kovacs et al. 2010. *Ecol. Econ.* 69:569-578).

$5.2 billion to remove and replace public and private ash trees in Ohio's communities (Sydnor et al. 2007. *Arbor & Urban For.* 33:48-54).

Healthy Asian ash surrounded by declining North American ashes

PLANT–INSECT INTERACTIONS

Interspecific Variation in Resistance to Emerald Ash Borer (Coleoptera: Buprestidae) Among North American and Asian Ash (*Fraxinus* spp.)

ERIC J. REBEK,[1,2] DANIEL A. HERMS,[3] AND DAVID R. SMITLEY[1]

Environ. Entomol. 37(1): 242–246 (2008)

Resistance genes and biological invasions:

Documented examples of low host resistance where coevolutionary history is lacking

- Bronze birch borer and Eurasian birches
- Pine needle scale and Eurasian pines
- Emerald ash borer and N.A. ashes
- Hemlock wooly adelgid and N.A. hemlocks
- Balsam wooly adelgid and N.A. firs
- Beech bark scale and N.A. beech
- Viburnum leaf beetle and NA viburnums
- Redbay ambrosia beetle and NA redbay
- Black walnut and thousand cankers disease
- American chestnut and chestnut blight
- Dutch elm disease and N.A. elms

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- American chestnut and chestnut blight
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Diversity Dilemma
Street Tree Diversity in Eastern North America

Emerald ash borer

Asian longhorned beetle

Ann Arbor, Chicago, Florence, Gastonia, Kansas City, Lincolnshire, Marion, Mt. Ranier, New York, Toledo, Toronto, Wilmington – Raupp et al. 2006

Abiotic traits of managed environments affecting pest populations:

- Stress: Impervious surfaces, heat islands
- Habitat fragmentation / isolation
- Anthropogenic inputs (pollution, nutrients, pesticides)

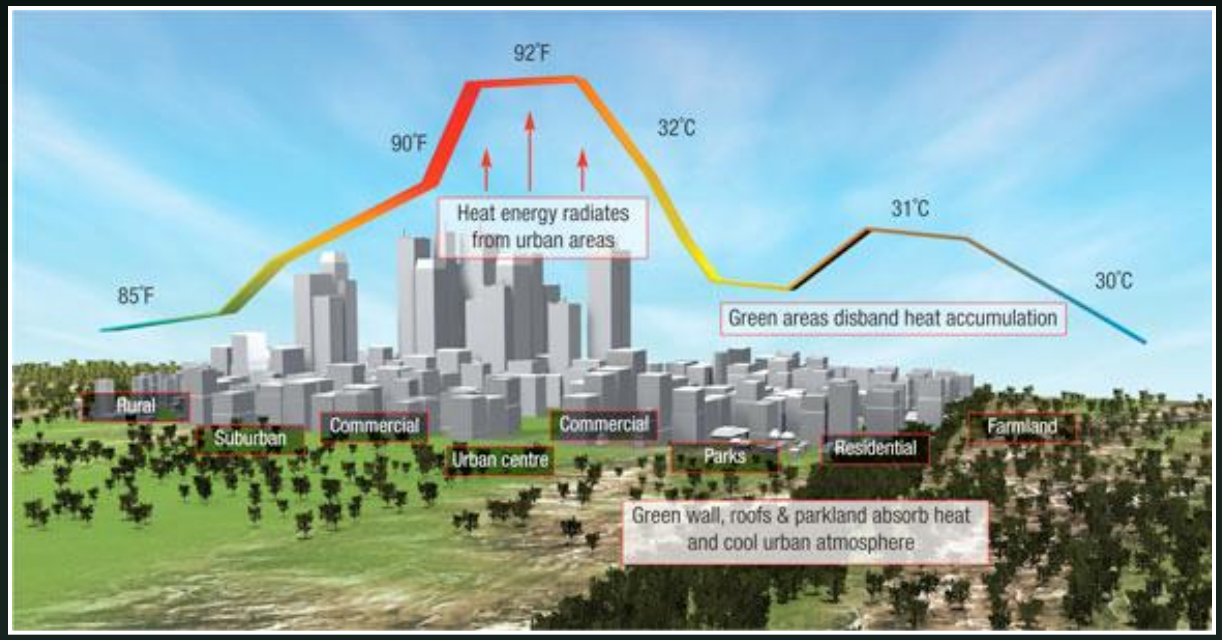
Impervious surfaces:

Drought can weaken tree defenses. Especially true for wood-borers, canker fungi, and vascular wilts.

Different patterns of resource allocation and acquisition work in different environments

Urban stress

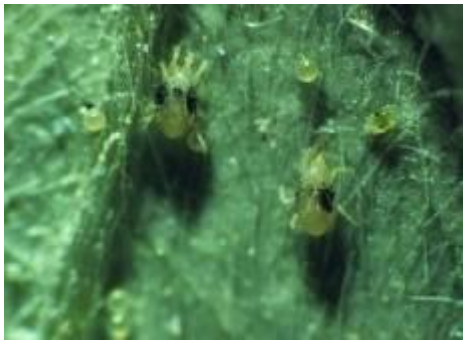
Urban Heat Islands and Pests



- Cities can be 10º warmer than surrounding natural areas.
- Decreased cooling from evapo-transpiration.
- Increased radiant heat.

Developmental times (days) for *Tetranychus utricae – two-spotted spider mite*

Developmental stage**						
Temp. C	Egg	Larva	PN	DN	PQ	Total
15	14.3	6.7	5.3	6.6	3.5	36.3
20	6.7	2.8	2.3	3.1	1.7	16.6
30	2.8	1.3	1.2	1.4	0.6	7.3



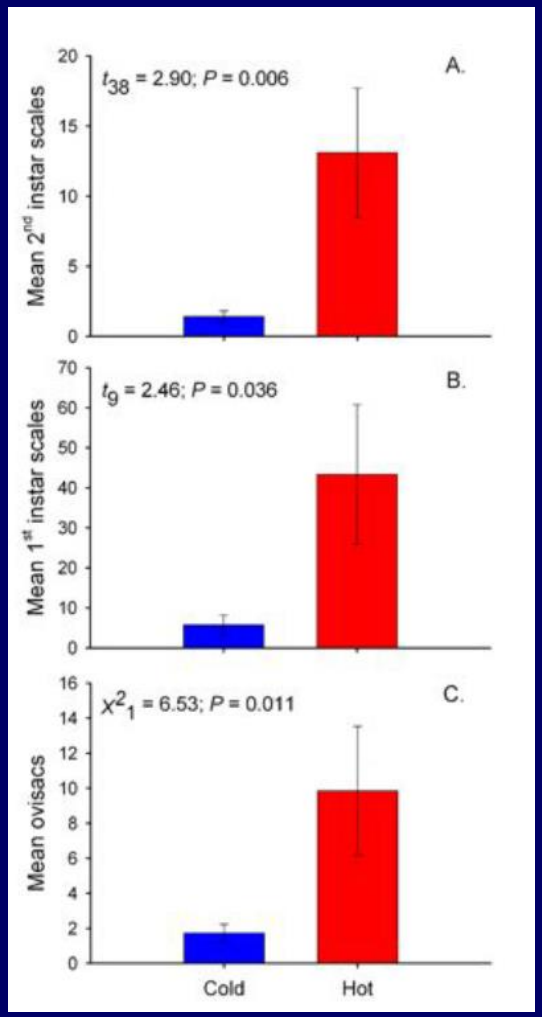
Source: http://mrec.ifas.ufl.edu/lso/spmite/b853a3.htm#Table1

OPEN ACCESS Freely available online

PLOS ONE

Urban Warming Drives Insect Pest Abundance on Street Trees

Emily K. Meineke[1]*, Robert R. Dunn[2], Joseph O. Sexton[3], Steven D. Frank[1]

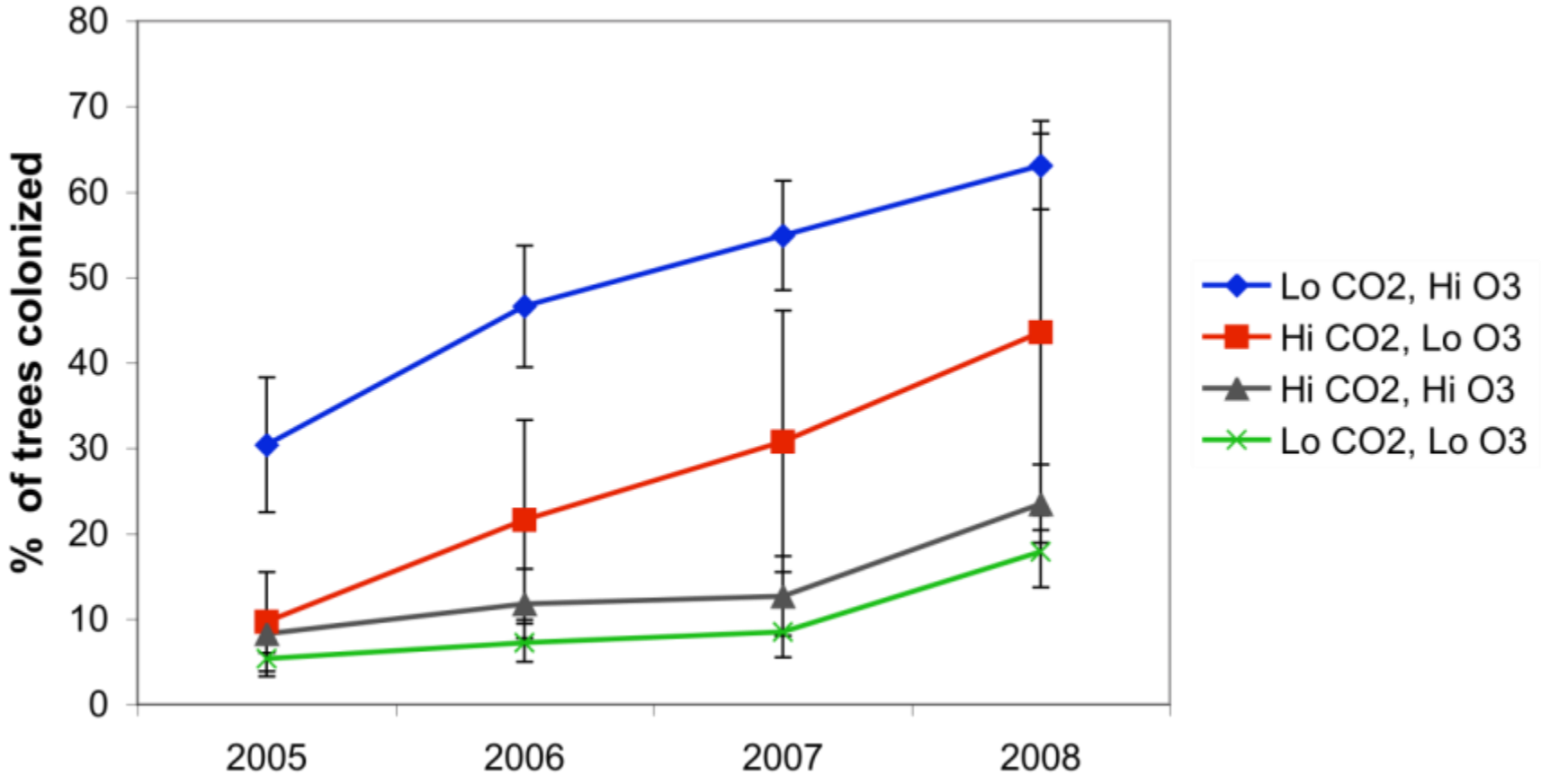


James Solomon

Oak lecanium 13X more abundant on willow oaks in hot vs cooler urban areas

Vanessa Muilenburg

% of Trees Colonized by Bronze Birch Borer

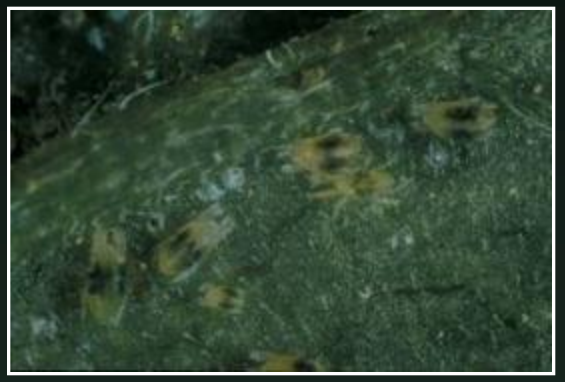


Abiotic traits of managed environments affecting insect and mite populations:

Abiotic environment

- Stress, Impervious surfaces, heat islands
- Habitat fragmentation / isolation
- Anthropogenic inputs (pollution, nutrients, pesticides)

Pests spatially isolated from natural enemies.



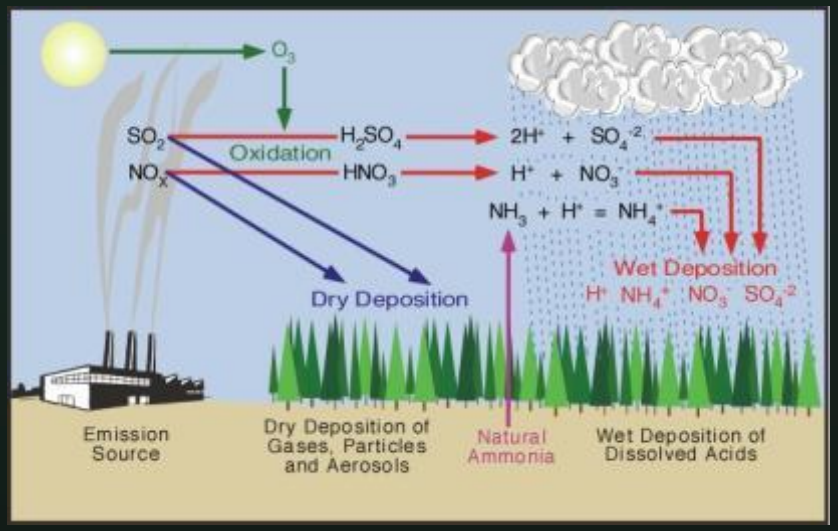
Biotic and abiotic traits of urban environments affecting insect and mite populations:

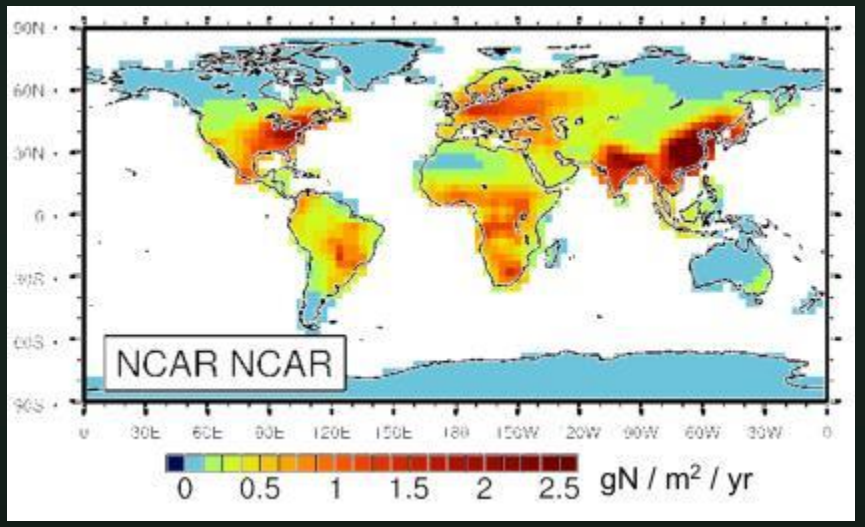
Abiotic environment

- Stress: Impervious surfaces, heat islands
- Habitat fragmentation / isolation
- Anthropogenic inputs (pollution, nutrients, pesticides)

Chronic anthropogenic nitrogen deposition in urban ecosystems:

Up to 30 kg / ha / yr (0.6 lb / 1000 ft^2)





ANSI 300 recommended fertilization rates for trees:

ANSI A300: 2 - 6 lbs N / 1000 ft^2 / yr

(90 – 270 lbs N / acre / yr)

Table 2: Suggested nitrogen rates (lb/A) for irrigated corn, as related to NO_3-N in the soil and soil organic matter content, calculated from the algorithm.

ppm NO_3-N in soil*	Soil organic matter, %		
	0 - 1.0	1.1 - 2.0	> 2.0
0 - 6	210	185	165
7 - 12	160	135	115
13 - 18	110	85	65
19 - 24	60	35	15
> 24	10	0	0

*Average weighted concentration (ppm) in the tillage layer and the subsoil layer to 2 feet.

Note: Credits for N in manure, irrigation water, or previous legumes should be subtracted from the above N rates.

Do trees really need more fertilizer than corn?

Soil fertility and insect resistance:

“Properly fertilized trees are better able to ward off both insect and disease damage."

“Fertilizing landscape plants promotes their general health and vitality, making them more resistant to insect and disease attack."

“Fertilization promotes vigorous growth, disease, and insect resistance, and stress tolerance.”

FORUM

Effects of Fertilization on Insect Resistance of Woody Ornamental Plants: Reassessing an Entrenched Paradigm

DANIEL A. HERMS[1]

Department of Entomology, The Ohio State University, Ohio Agricultural Research and Development Center, 1680 Madison Avenue, Wooster, OH 44691

Environmental Entomology (2002) 31:923-933.

- Fertilization decreased insect resistance of woody plants in almost every study.
- No study showed increased resistance.

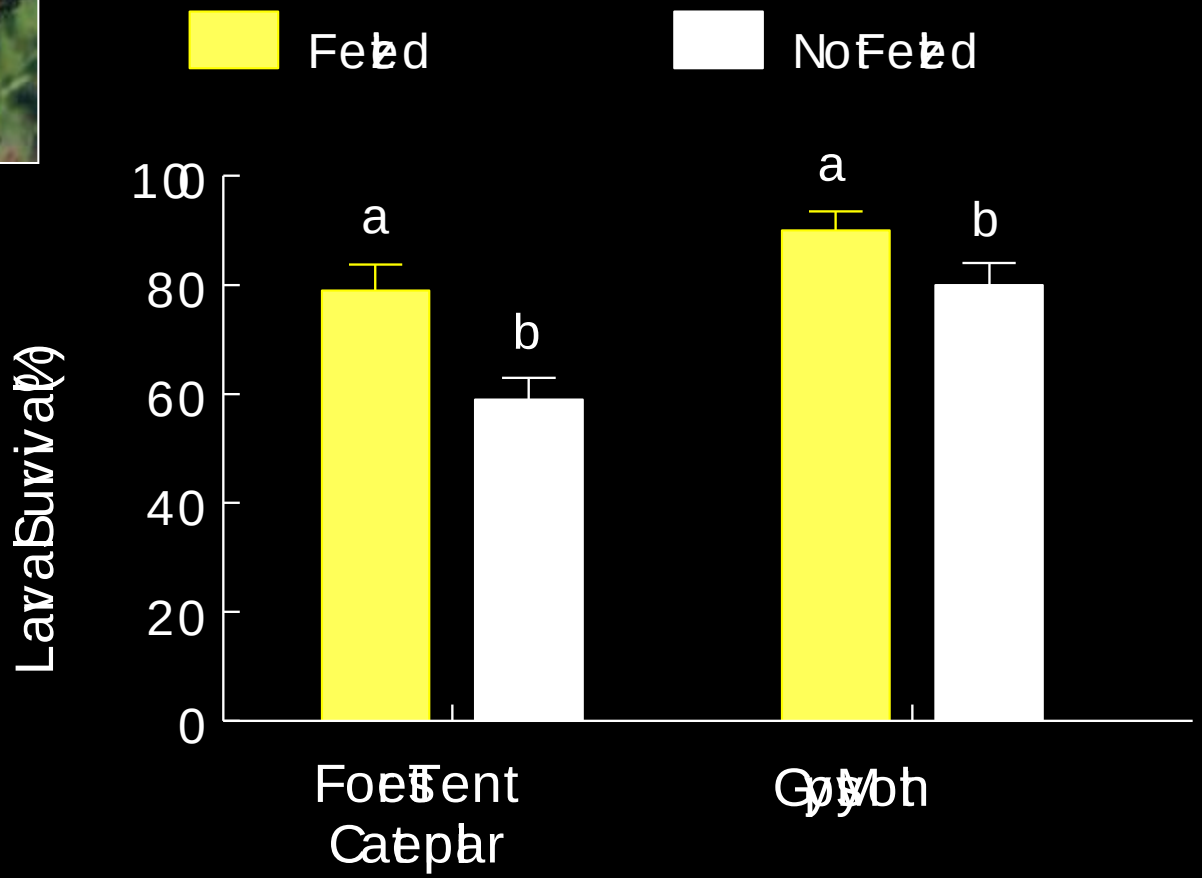
Field Studies: Effects of fertilization on paper birch and red pine

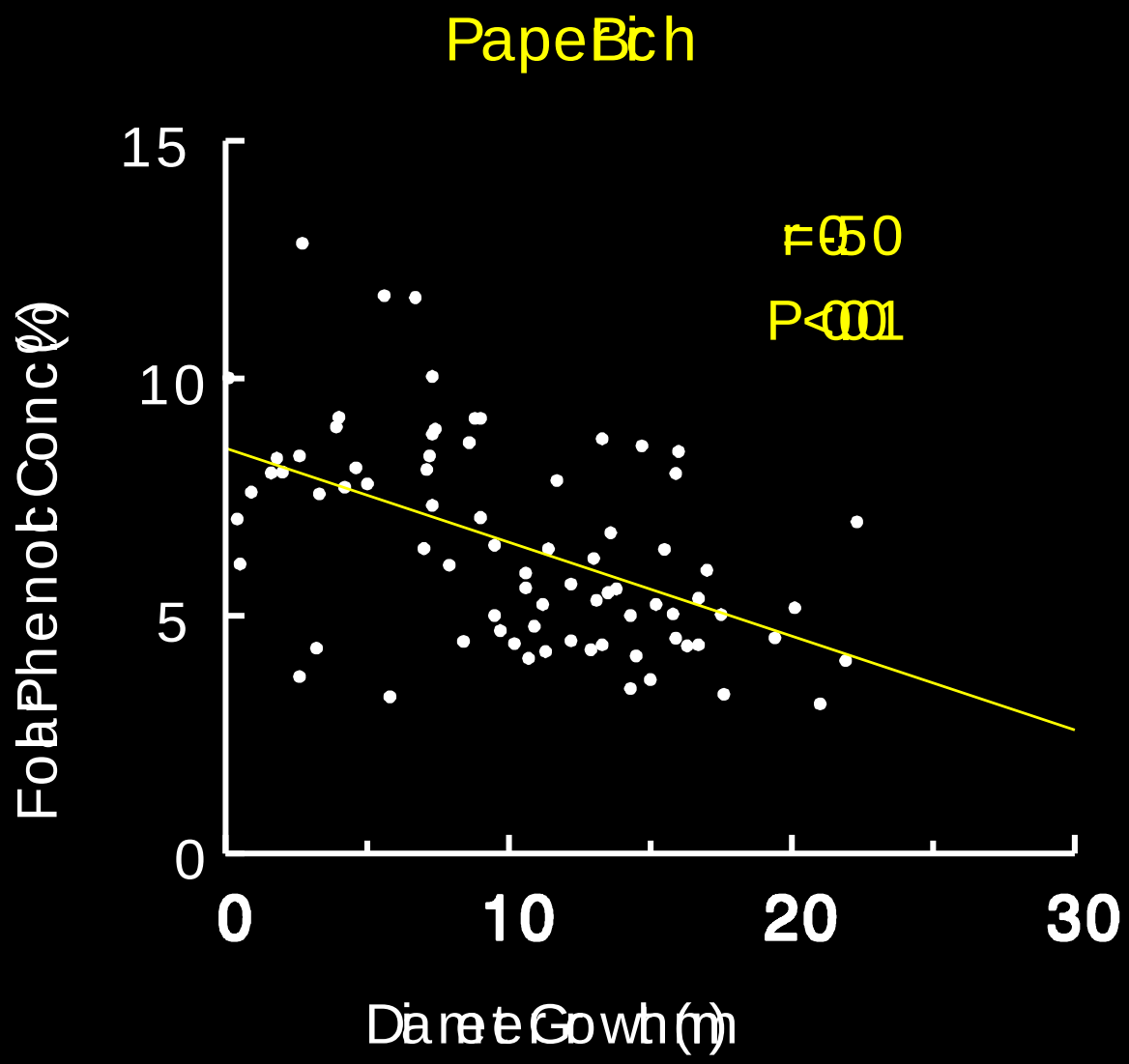
Fertilizer Treatment (ANSI standard):

Rate: 4.1 lb N / 1000 ft^2 / yr
200 kg N / ha / yr
178 lb N / acre / yr

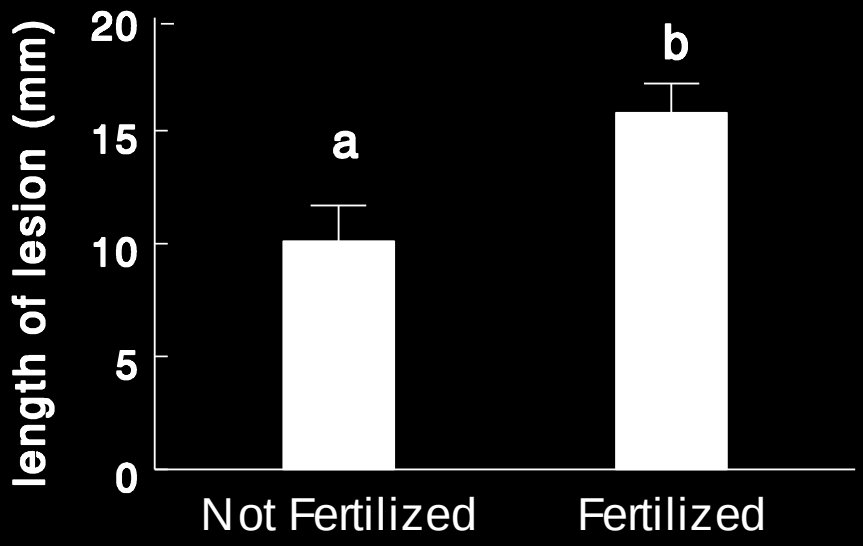
Formulation: 18:5:4 NPK (56 % N slow release)

Timing: early May and mid-Sept (split application)


Fed
Not Fed
Larval Survival (%)
100
80
60
40
20
0
a
b
a
b
Forest Tent Caterpillar
Gypsy Moth


Pape Birch
r=-0.50
P<0.001
Foliar Phenolic Conc (%)
15
10
5
0
0
10
20
30
Diameter Growth (mm)

Fertilization increased growth of Diplodia tip blight lesions by 50%



Blodgett et al. 2005. *Forest Ecology and Management* 208:273-382.

https://sharepoint.cahnrs.wsu.edu/blogs/urbanhort/

Bert Cregg, MSU

"So where does all this leave me on my homeowner recommendation?

"At this point, I'm leaning toward a simple visual assessment – Do the trees / shrubs look healthy and have acceptable color? (check yes/no). If 'yes', don't fertilize. If 'no' add 1-2 lbs N/ 1000 sq ft."

Insecticides and secondary pest outbreaks:

Imidacloprid and spider mite outbreaks

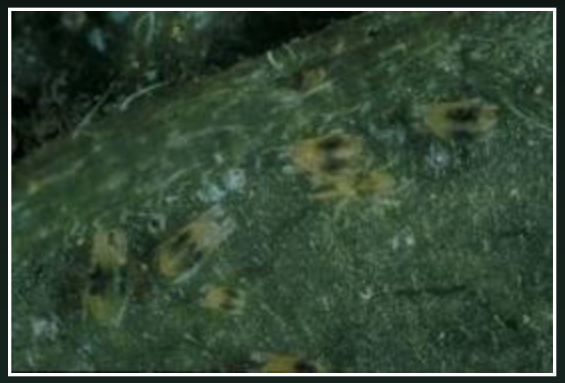
OPEN ACCESS Freely available online

PLoS one

Neonicotinoid Insecticide Imidacloprid Causes Outbreaks of Spider Mites on Elm Trees in Urban Landscapes

Adrianna Szczepaniec[1*¤a], Scott F. Creary[1¤b], Kate L. Laskowski[1¤c], Jan P. Nyrop[2], Michael J. Raupp[1]

1 Department of Entomology, University of Maryland, College Park, Maryland, United States of America, **2** Department of Entomology, Cornell University, Ithaca, New York, United States of America



ECOTOXICOLOGY

Fecundity in Twospotted Spider Mite (Acari: Tetranychidae) is Increased by Direct and Systemic Exposure to Imidacloprid

DAVID G. JAMES[1] AND TANYA S. PRICE

Department of Entomology, Washington State University, Irrigated Agriculture Research and Extension Center, 24106 North Bunn Road, Prosser, WA 99350

J. Econ. Entomol. 95(4): 729–732 (2002)

Spider mite outbreak at elms treated with imidacloprid

Photo: Mike Raupp

Design and Management Affect Pest Populations:

Community composition and structure:

- Plant diversity and natural enemies
- Coevolutionary relationships (and lack thereof).

Abiotic environment:

- Drought and heat stress
- Habitat fragmentation / isolation
- Anthropogenic inputs (pollution, nutrients, pesticides)

herms.2@osu.edu

Google “Dan Herms Lab”

http://oardc.osu.edu/hermslab/

Extension / Presentations