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Capturing the ecosystem service of pest control: Natural enemy movement between native forests and crops

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Value of Ecosystem Service of Pest Control

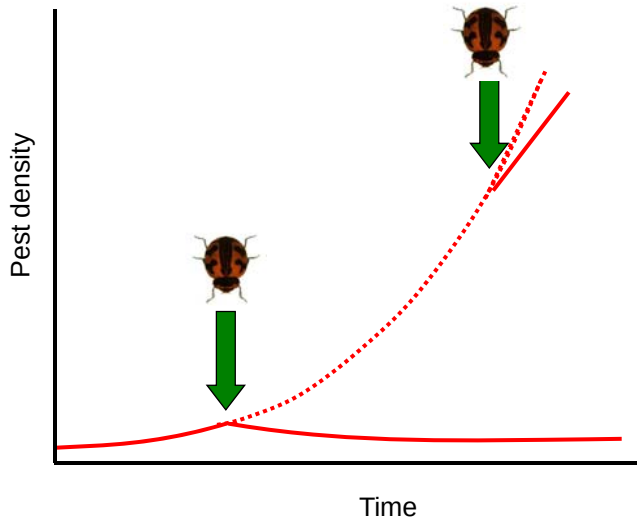
➢US$400 billion / yr

at world wide scale, Costanza *et al* 1997

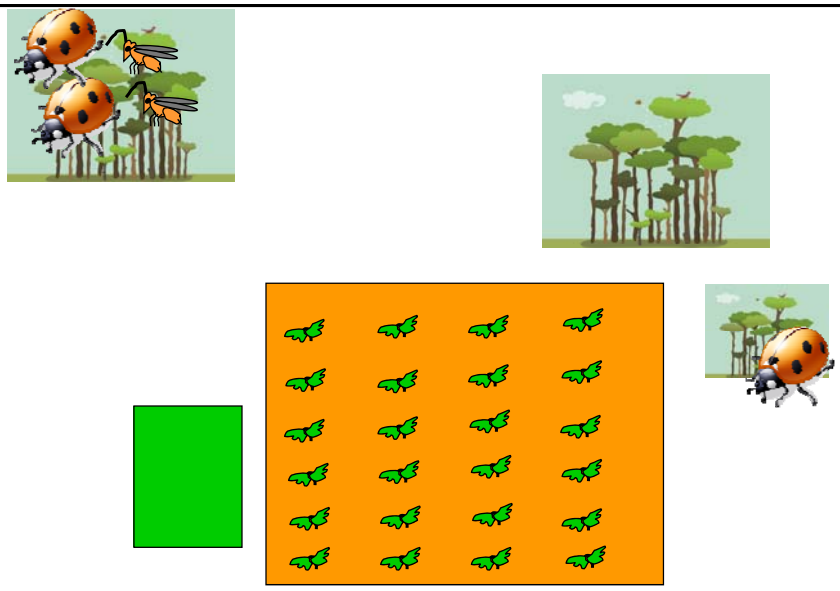
Forest & woody patches in agricultural landscape mosaics provide perennial habitat important for ecosystem services of pest control, Bianchi 2006

Agricultural pest problems need to be considered beyond crop boundary

Timing of natural enemy immigration & colonization is crucial



Settle et al. 1996; Ives & Settle 1997; Landis & van der Werf 1997; Bianchi & van der Werf 2003

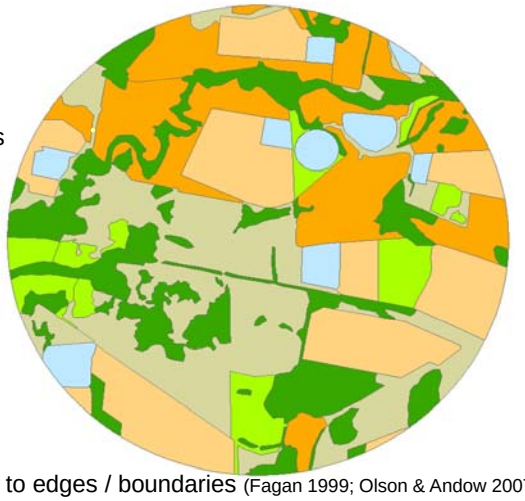


Corbet and Rosenhiem *Environ* Ent 1996, Schellhorn and Andow *Population Ecology* 2005, Schellhorn et al *Aus Jrn Exp Ag* 2008, Bianchi et al *Oikos* 2009

Landscape context influences immigration / colonization

Type of habitats / patches
•Crops
•Grazing Land
•Forests

Ecological Function of habitats
•Sources of immigrants?
•Change over time?



Type of edges
•Crop-Forest
•Crop-Grazing land

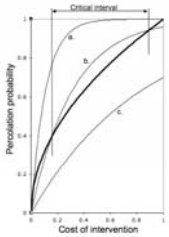
Insects are known to respond to edges / boundaries (Fagan 1999; Olson & Andow 2007)
*community composition (ecotone)
*interaction b/t adjoining patches

Theory

***Meta-population**
***Source-sink dynamics**

***Refining theory - propagating sinks & ephemeral sources**

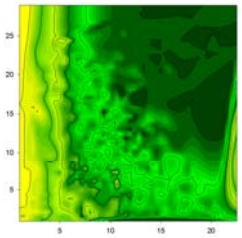
Vandermeer, Perfecto & Schellhorn
***Landscape Ecology* 2010**



Simulation Modelling

***Linking foraging behaviour, spatial distribution of prey, and prey consumption**

Bianchi, Schellhorn & Van der Werf,
***Oikos* 2009**
Bianchi , Schellhorn, Buckley & Possingham
***Ecological Applications* (in press)**



Outcome:
Capture better pest control while maintaining biodiversity conservation

Field Experimentation

Survey

Large scale experimentation

Outline

I. Results from landscape scale studies w/ remnant native forests:

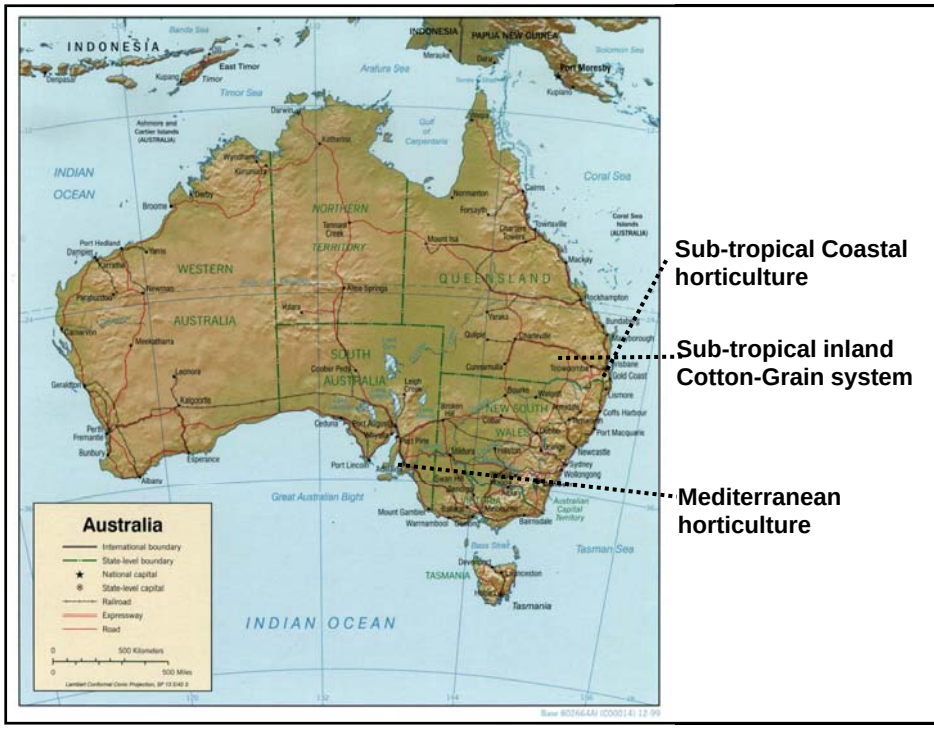
a. natural enemy habitat occupancy & their movement

b. relationship b/t pest suppression & forests

II. Results from revegetation study

III. Conclude with pathway to impact

Link forest habitat function with ecosystem services of pest control in agricultural landscapes



Ex. 1. Do predators occupy different habitats & edges, & do they move between them?

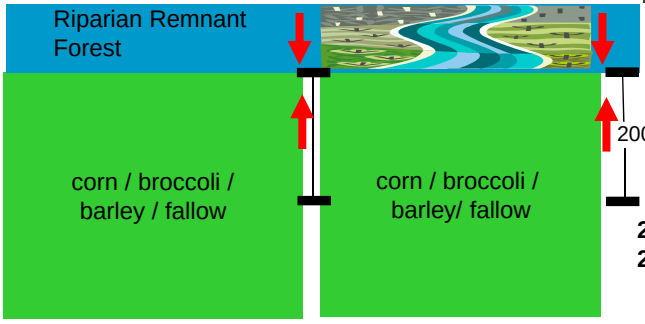
Sub-tropical, coastal horticulture, Lockyer Valley, QLD Australia

Gatton, QLD
Low % Forest < 5%

20 kms apart

Mulgowie, QLD
High % Forest < 70%

Bi-directional Interception Traps



Edge b/t RF & Crop

2 landscapes ('block')
2 treatments
***habitat**
***edge**
Placed on mowed grass

1 year – 7days
bi-weekly
30 dates

15 Species of Predators (most abundant, mostly native & known function)


Micraspis frenata


Diomus notescens.


Melangyna spp.


Sphaerophoria macrogaster


Coccinella transversalis


Harmonia conformis


Simosyrphus grandicornis


Episyrphus viridaureus


Coelophora inaequalis


Hippodamia variegata


Dicranolaius bellulus


Asilidae

X 2


Mallada signata

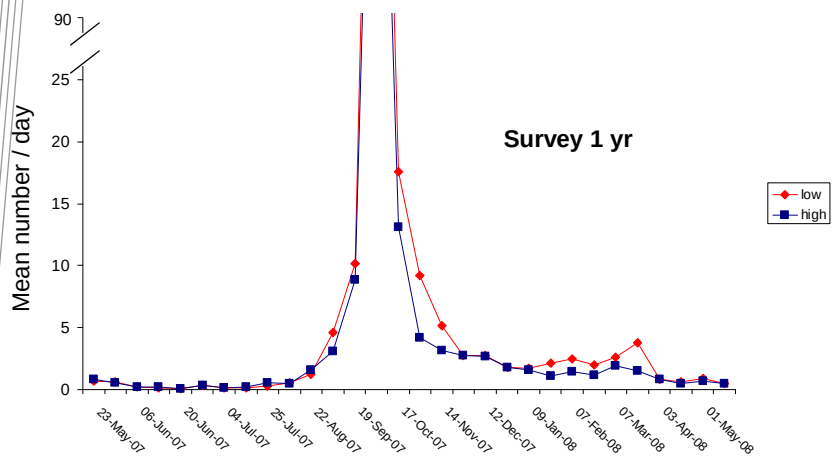

Micromus tasmaniae

***No difference in insect predator abundance b/t the landscapes, occupy all habitats, but there is strong species-specific habitat preference**

***More predators move from riparian remnant forest into the crop than vice a versa – so does a pest!**

***A diversity of forest habitats is important**

Do the landscapes differ in total predator abundance?



F= 0.78, df=1, P=0.3822

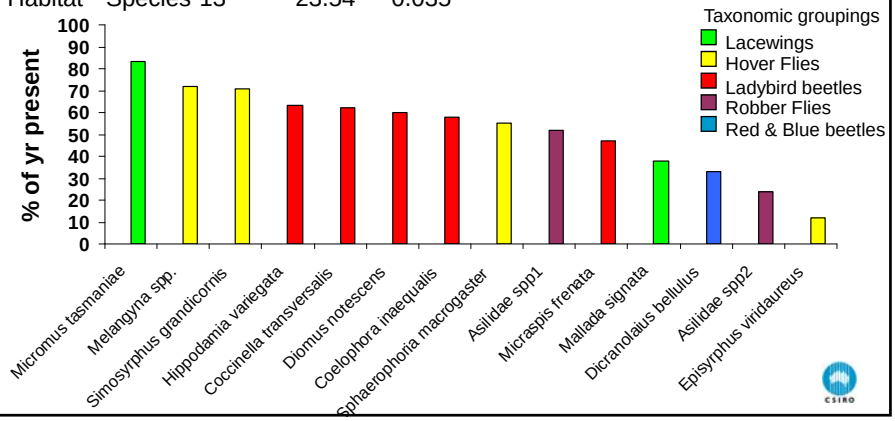
Is the RF edge and crop occupied similarly?

******Harmonia conformis* **only at one site - drop**

***All species occupied both habitat types**

***No difference b/t landscapes**

Source	df	X^2	P
Species	13	89.4	<0.0001
Habitat * Species	13	23.54	0.035



Which species is where when?

Habitat * Species

Occupy Rip Forest Edge More than Crop

X^2=6.89 P=0.009
RFE- 72% vs C- 28%

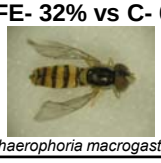
Dicranolaius bellulus

X^2=3.98 P=0.046
RFE- 78% vs C- 22%

Episyrphus viridaureus

Occupy Crop More than Rip Forest Edge

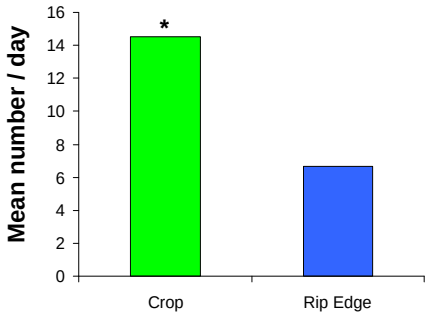
X^2=8.32 P=0.004
RFE- 32% vs C- 68%



Sphaerophoria macrogaster

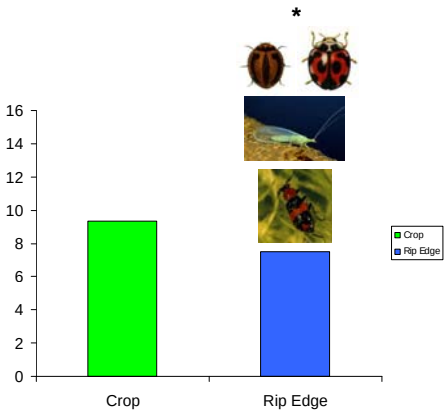
All Predators - Net Daily Immigration

Gatton Site – Low % Forest



3.4 per day; F=2.98, df=1, P=0.087

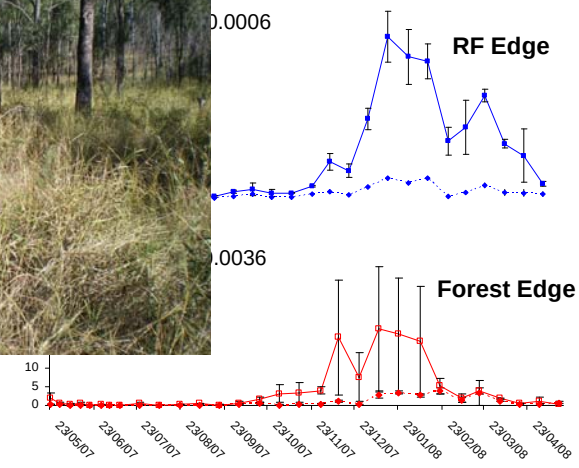
Mulgowie Site – High % Forest

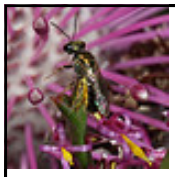


3.7 per day; F=4.24, df=1, ***P=0.043***

Jassid – *C. bimaculata*

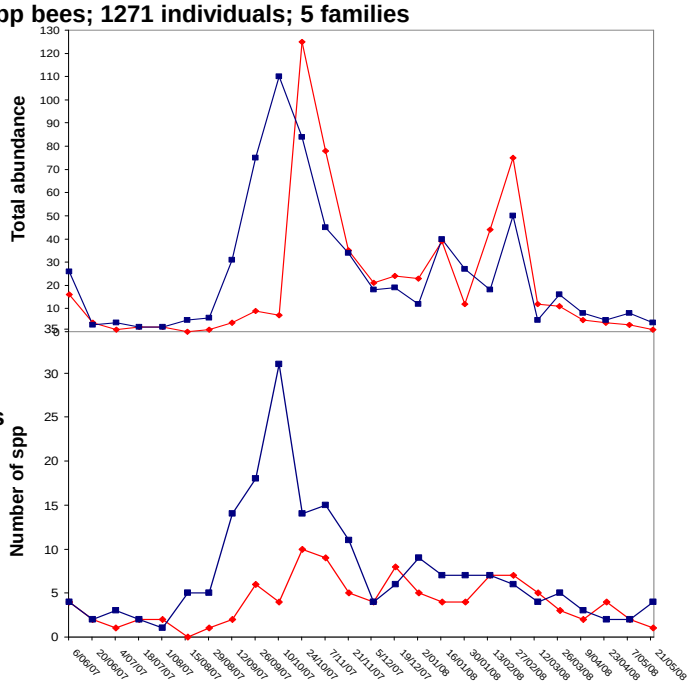
Exotic grass





68 spp bees; 1271 individuals; 5 families

225 spp Ichneumonid parasitoids, & spp from 28 other families

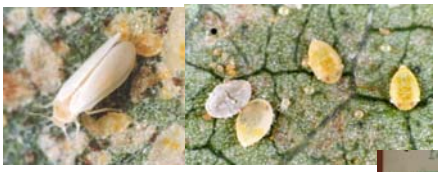


Chris Burwell
Saul Cunningham
Anna Marcora
Michael Bately

Ex. II. How does distance to native forest remnants & composition of landscape influence pest suppression?

Cotton / Grain System, Darling Downs, QLD

Pest



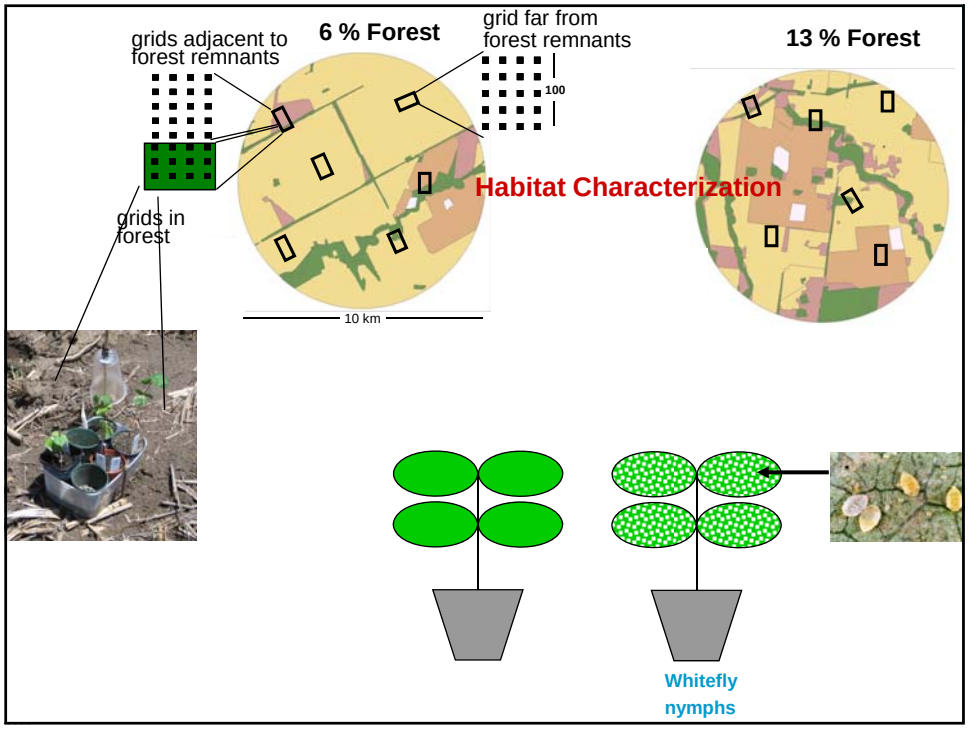
Whitefly adults

Whitefly nymphs

Natural enemy

parasitoids

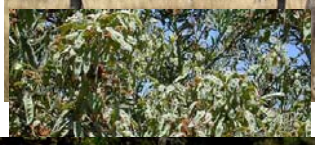
Felix Bianchi



Sampling of native forest

•Popular Box - Eucalyptus

•Acacia



•Salt Bush – Chenopods

2007 ↓ 2008 ↓

J F M A M J J A S O N D J F M A M J J A S O N D

•Suppression of a cotton pest is higher adjacent to native forest remnants

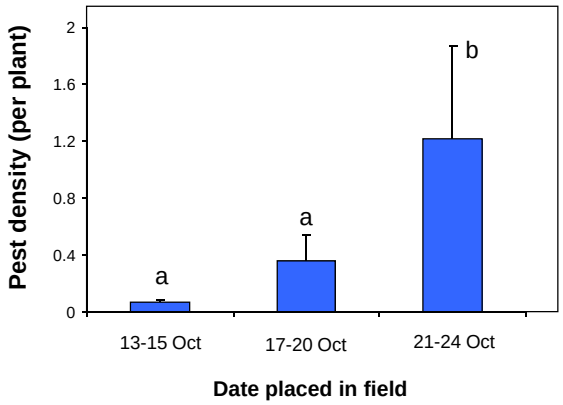
•Native forest remnants:

-are a source of natural enemies for early colonization

-have higher predator : pest ratio than crop

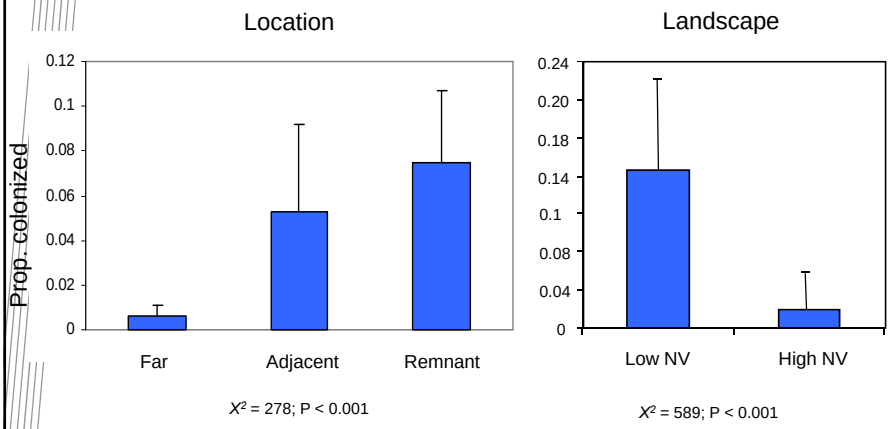
•Natural enemy populations are highly variable in space and time most likely due to the condition of the forest

Rapid increase in early-season pest colonization



$F_{2,36} = 8.12$; $P < 0.001$

Whitefly Parasitism

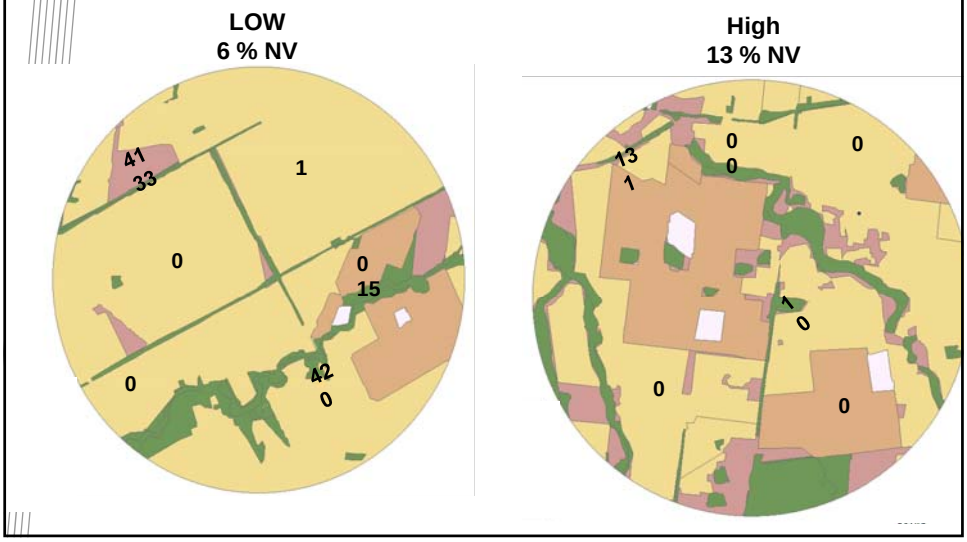


$X^2 = 278$; $P < 0.001$

$X^2 = 589$; $P < 0.001$

Higher whitefly parasitism near native forest, landscape matters

Variability in Habitat Function - Parasitoids



High NV Landscape

Habitat Characterization

Source for Predators and Pests

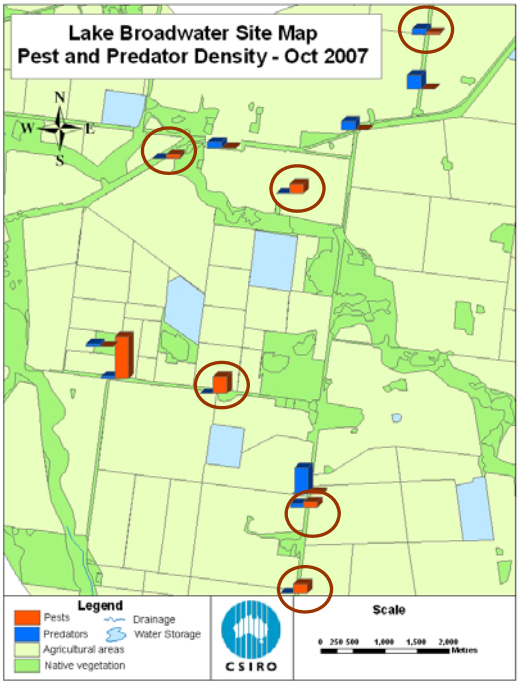
= high pred : pest ratio

= low pred : pest ratio

= crop sample

HIGH Pred : Pest Ratio

Crop	Nat Veg
1 of 6	5 of 6



Ex. III. What's the risk of replacing weeds with native perennial vegetation?

Western flower thrips
Franklinella occidentalis

Tomato Spotted Wilt virus

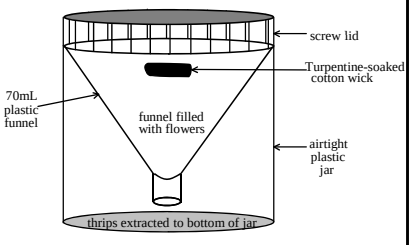
- **$25m crop loss annually**

Approach to problem: bare earth policy

Revegetation by Design

Native perennial vegetation trial and demonstration site,
Northern Adelaide Plains, South Australia

4 pest thrips
Western Flower, *Frankliniella occidentalis*
Tomato, *F. schultzei*
Onion, *Thrips tabaci*
Plague, *T. imaginis*



19 weed species, 13 plant families

13 native perennial plant species, 3 plant families

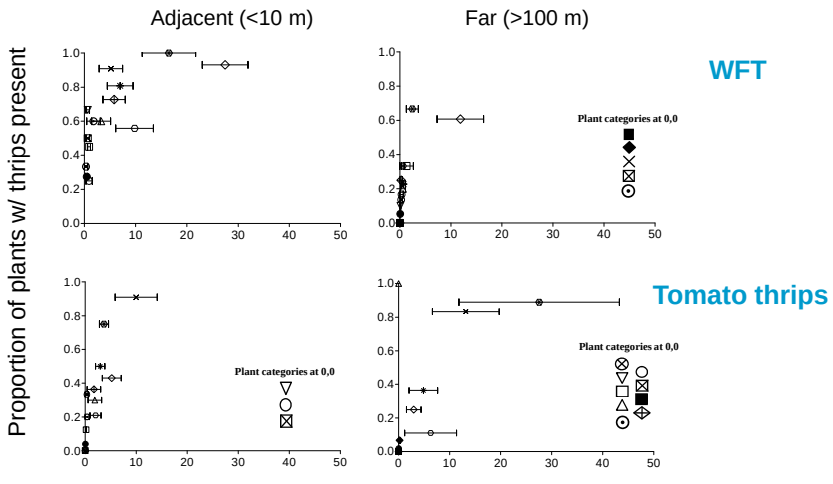
Treatments = adjacent (<10m) or far (>100m) vegetable crops

1 year, 524 samples, 49 dates

*High-risk weeds

*Low risk options for revegetation w/ native plants

*Incentive of better pest control, additional income, reduced pest control costs



Risk of weeds vs native perennial plants

Brassicacea (5)

4.6

Solanaceae (2)

8.0

Asteraceae (3)

0.42

Odds ratios

Native Chenopodeacea

Salt bush

0.08

Native Myrtaceae

0.07

***important reservoir of natural enemies**

***Revegetation 2.5 times cheaper than bare-earth (weed control over 10 yrs)**

***Harvesting of seeds provides income**

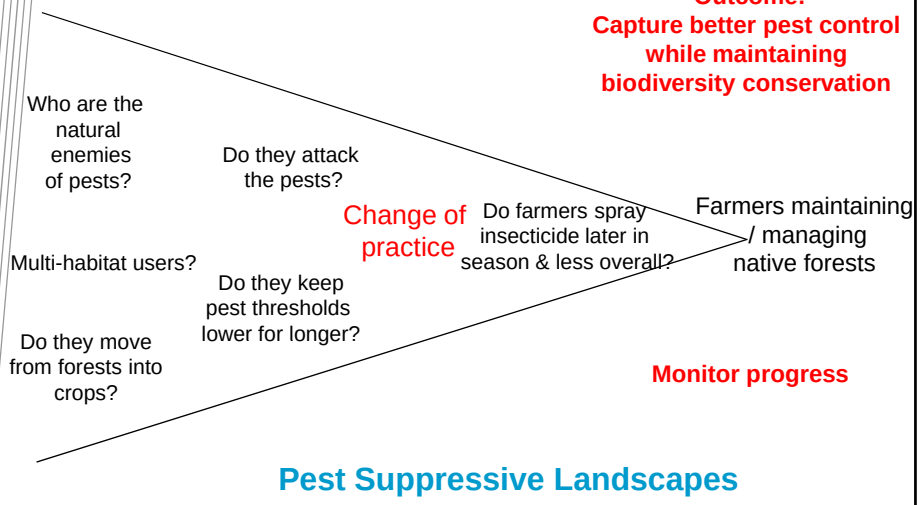
***Low growing, weed suppressive native veg, not trees**

Stephens et al 2006. *Aus J Ent* 45: 176-184
Schellhorn et al 2009 IPM: Innovation-Development Process, Springer Press. Pp. 575-597.
Schellhorn et al 2010 *Bull Ent Res (in press)*

Implications

- **Science**
  - Diversity of forest habitats is important for agricultural ecosystem services
    - *allows flexibility throughout the year & in changing environments (cf climate change)
  - Natural enemies are using forest habitats, moving into crops (pests too)
  - Attacking pests early
- **Industry change of practice**
  - Field-based and on-farm management of pests is only a part of pest management
  - Maintaining / managing native vegetation is a key part of capturing ecosystem services

Pathway to Impact



Pest Suppressive Landscapes

Acknowledgements

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