Insects in fragmented farming landscapes

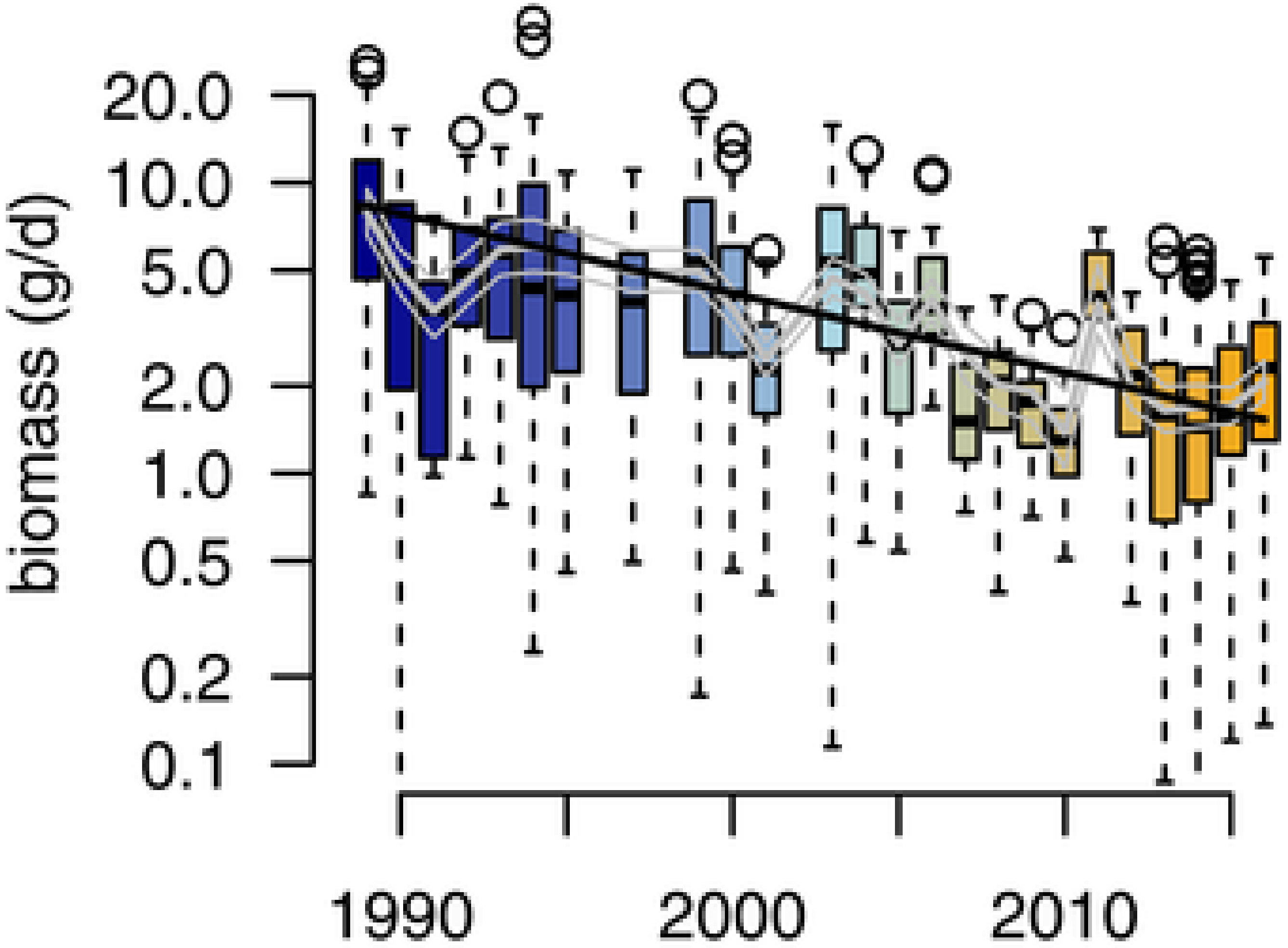
Professor Don Driscoll
Deakin University

Key Points?

Insects are in trouble around the world….

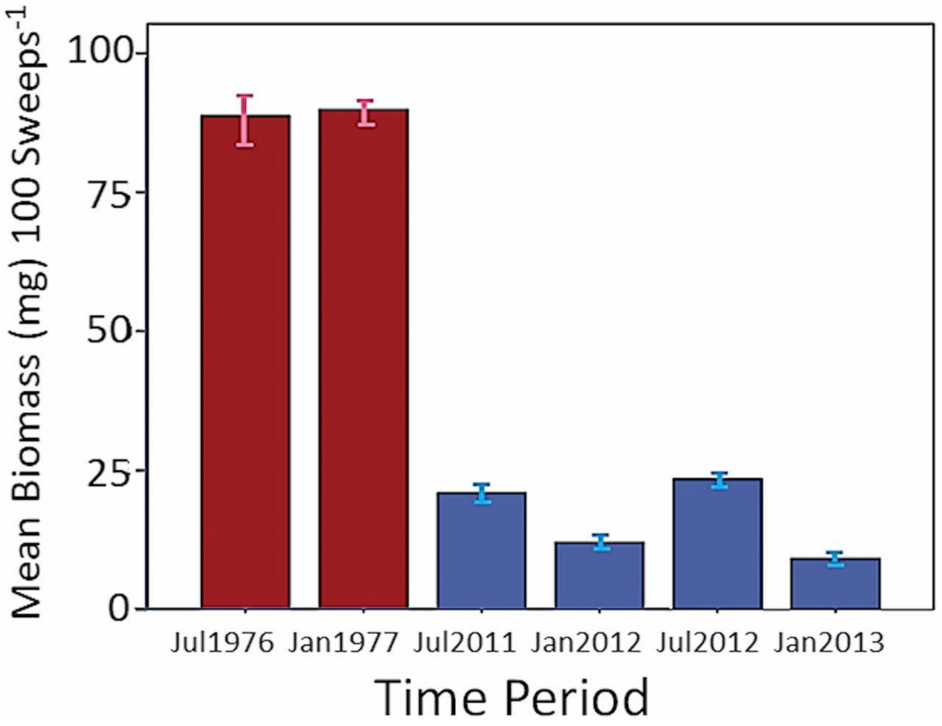
Germany
Flying insects
63 reserves
27 years

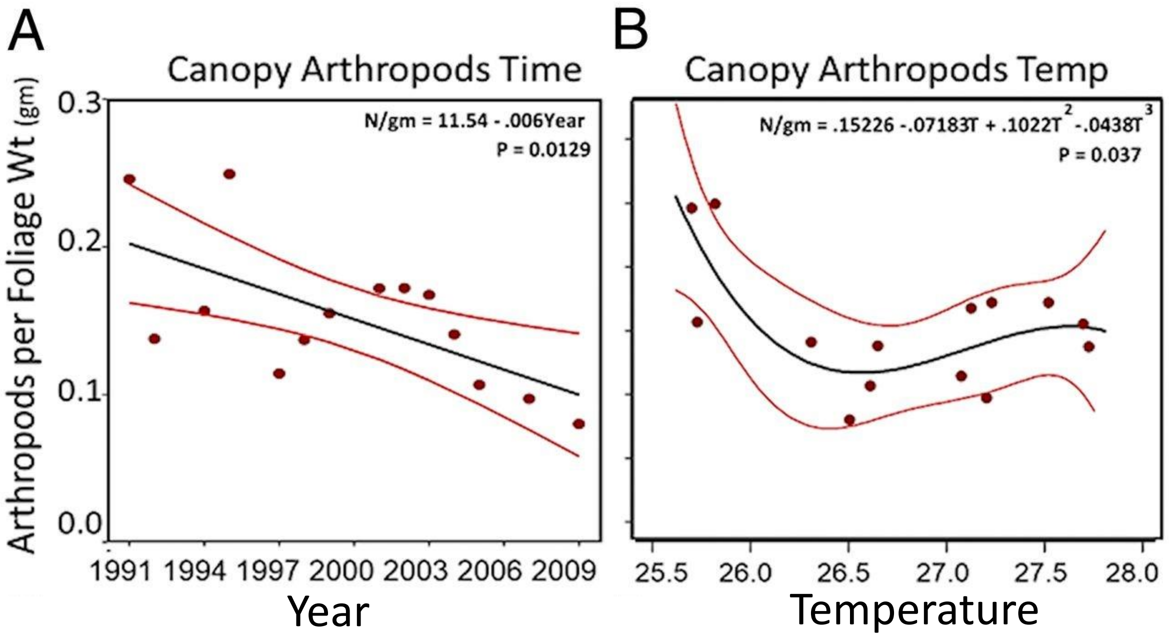
76% decline in biomass



Hallmann C. A., Sorg M., Jongejans E., Siepel H., Hofland N., Schwan H., Stenmans W., Muller A., Sumser H., Horren T., Goulson D. & de Kroon H. (2017) More than 75 percent decline over 27 years in total flying insect biomass in protected areas. *Plos One* ***12, 21.***

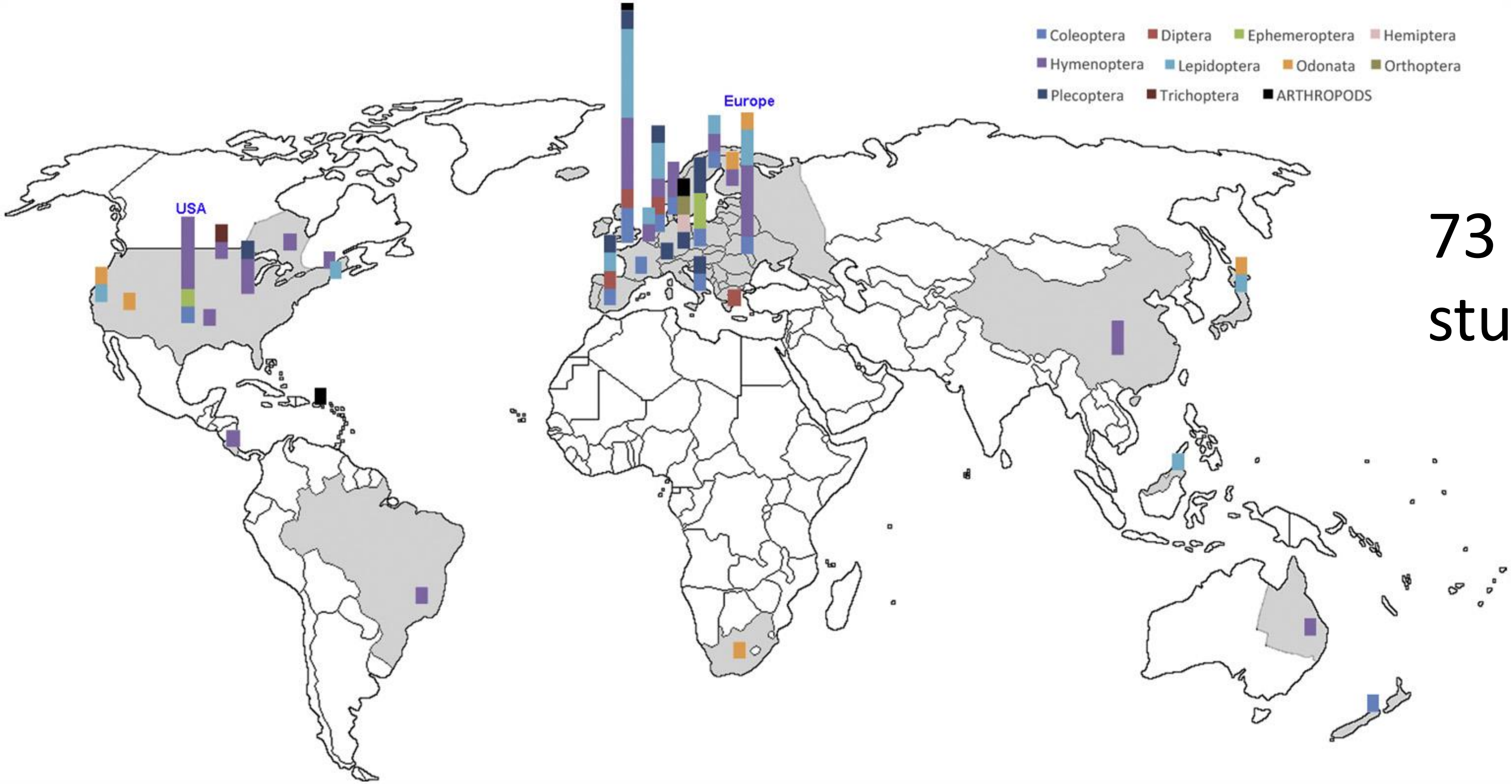
Puerto Rico’s Luquillo rainforest
Arthropod no.s 1976 - 2012
2 sites
mean temperature increased 2.0 °C





Lister B. C. & Garcia A. (2018) Climate-driven declines in arthropod abundance restructure a rainforest food web. *Proceedings of the National Academy of Sciences* ***115, E10397-E406.***

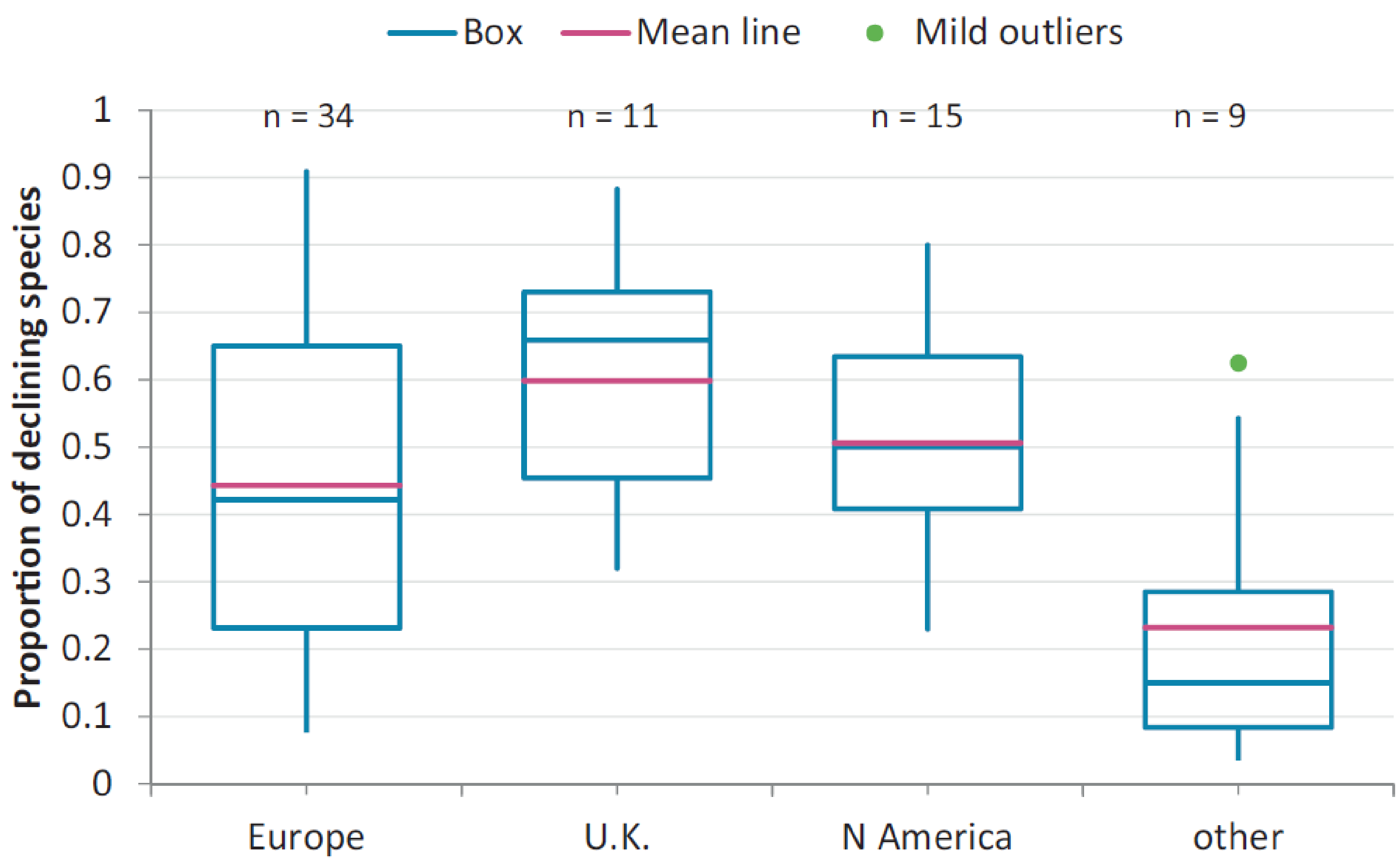
Insect declines around the world



73 long-term studies (> 10 years)

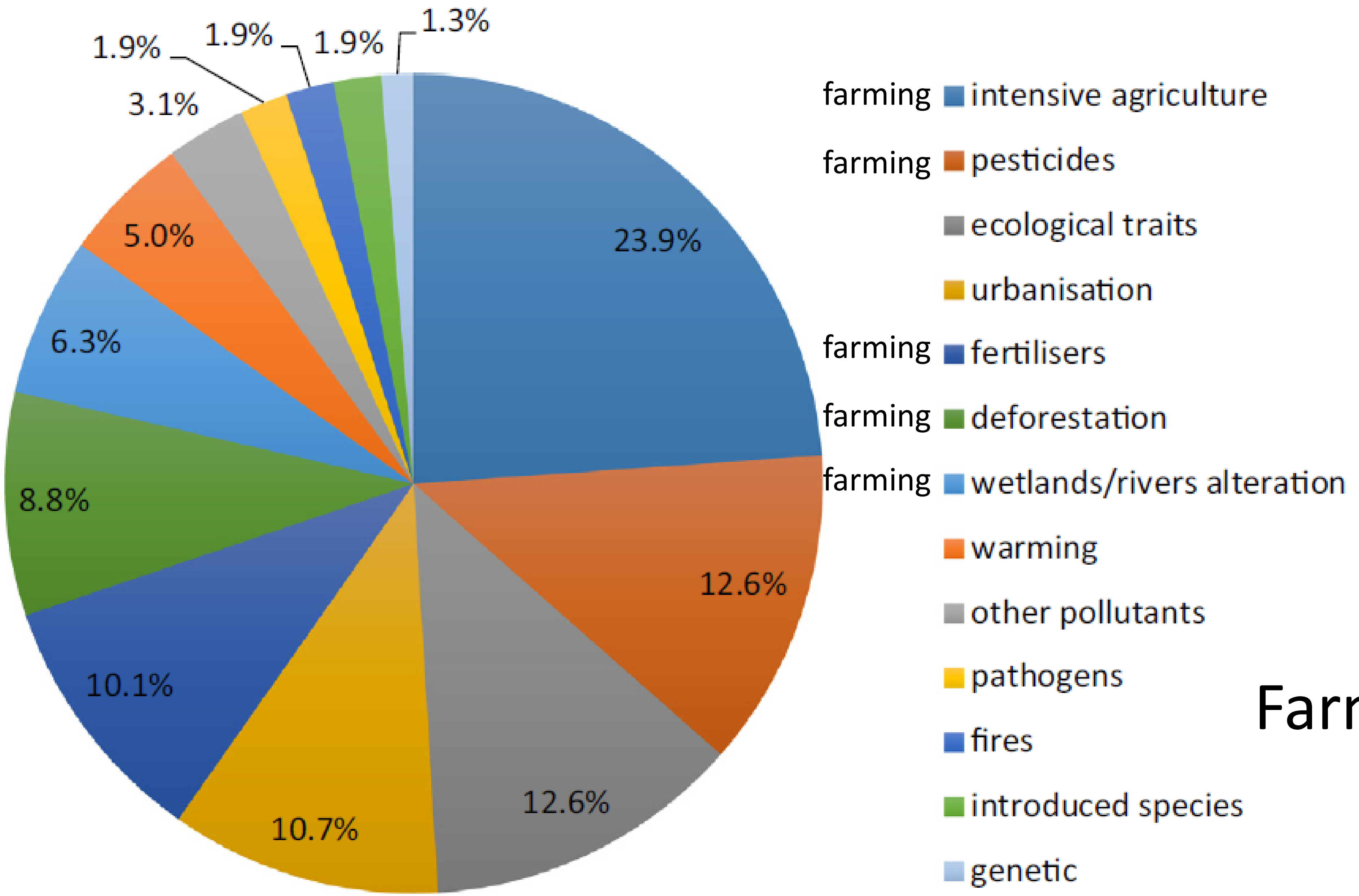
Sanchez-Bayo F. & Wyckhuys K. A. G. (2019) Worldwide decline of the entomofauna: A review of its drivers. *Biol. Conserv.* ***232, 8-27.***

Taxon	Declining (%)	Threatened (%)	Annual species declines (%)
Insects	41	31	1
Vertebrates	22	18	2.5



Sanchez-Bayo & Wyckhuys (2019)

Main factors associated with decline



Farming: 61.7%

Sanchez-Bayo & Wyckhuys (2019)

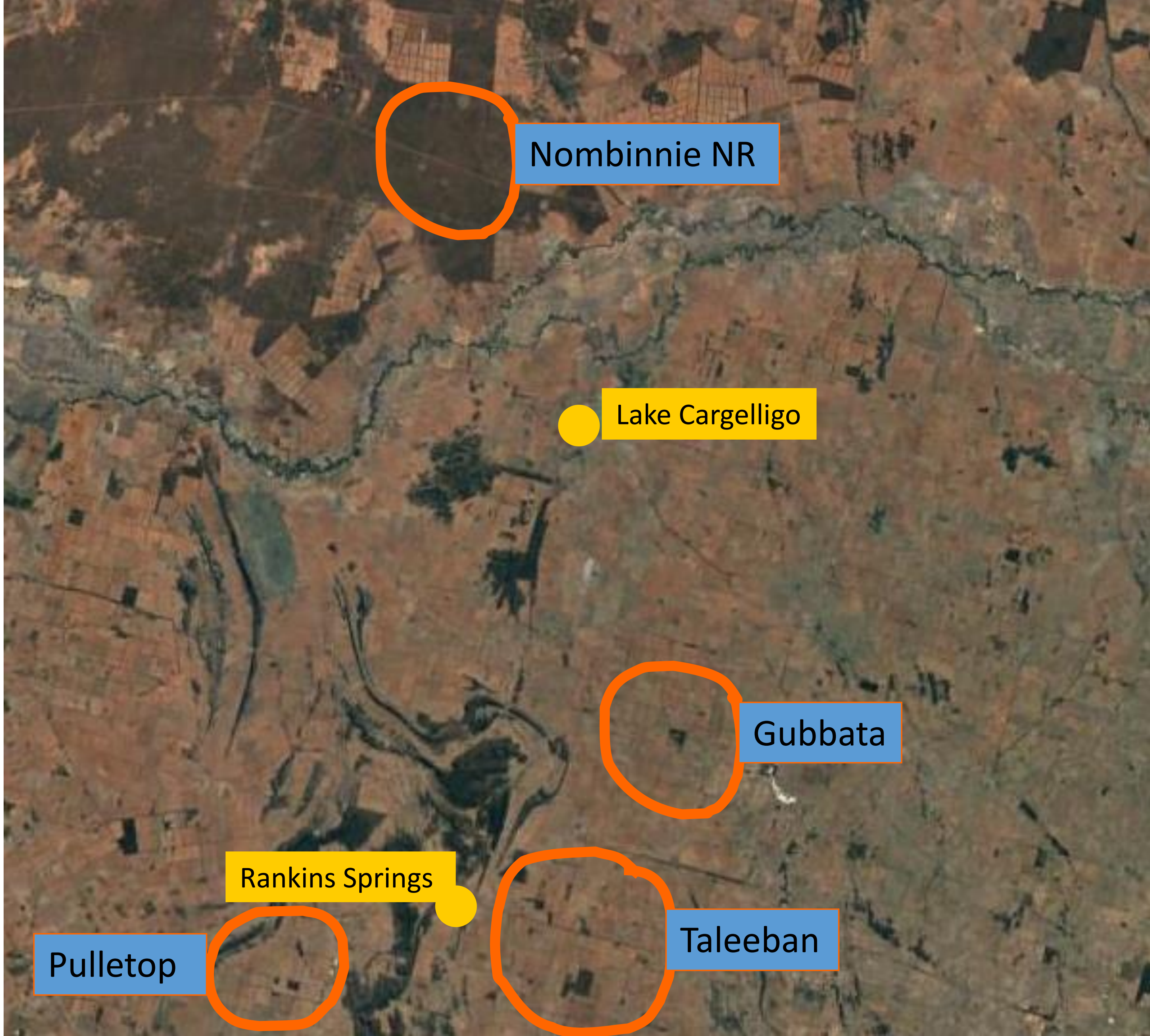
Beetles in Agricultural Landscapes

Australian case studies

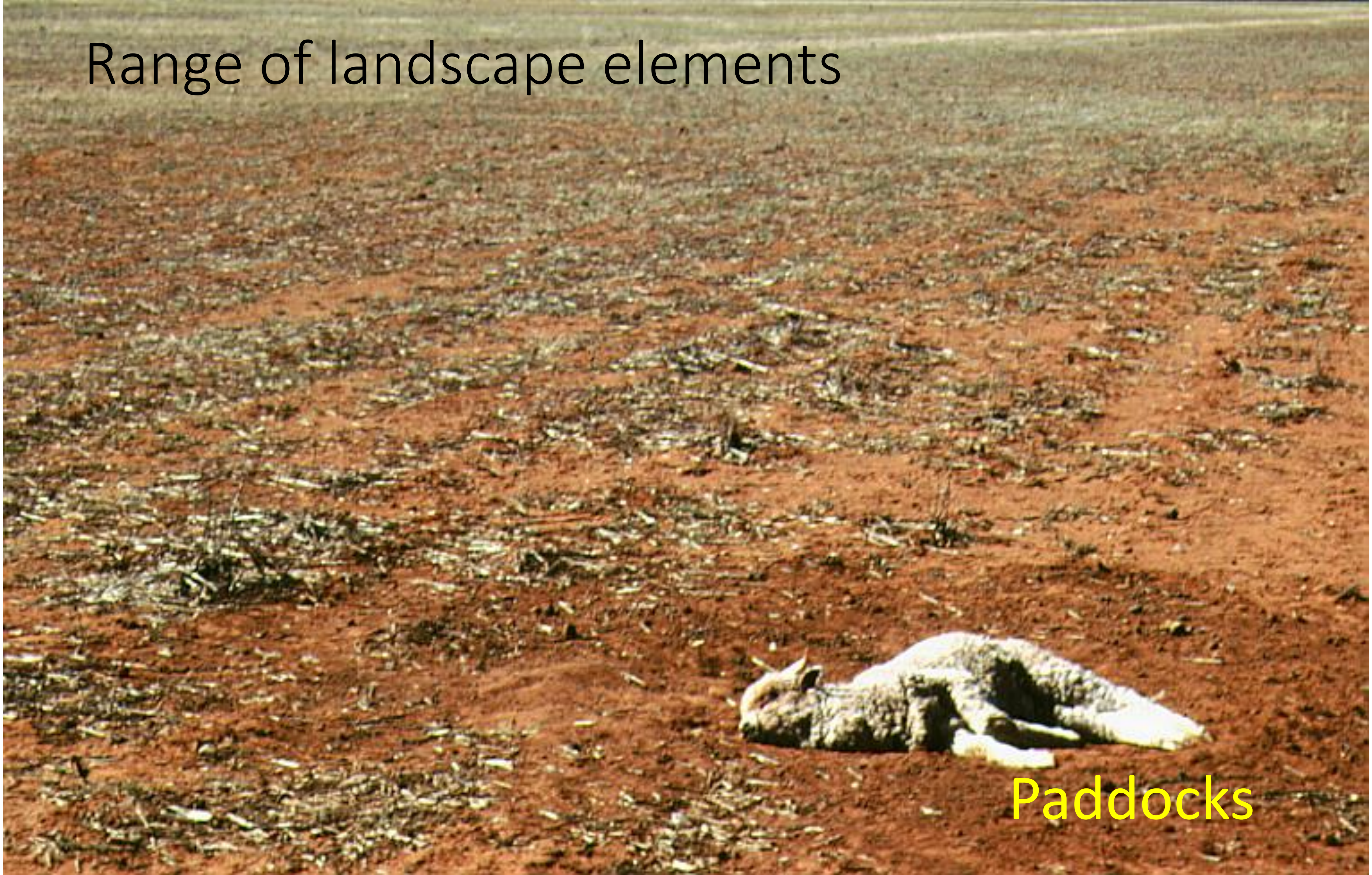
Mallee remnants, NSW- species characteristics influence decline
Pine-Farmland landscapes, Tumut NSW- pine matrix and homogenisation
Benalla/Wimmera, Victoria- total loss of habitat specialists?
Box-cypress woodlands, NSW- the matrix and seasonal effect of cropping
SW Tasmania- dispersal and species interactions
Ivory Coast- Ecosystem interactions

Beetles in Central Western NSW

Driscoll D. A. & Weir T. (2005) Beetle responses to habitat fragmentation depend on ecological traits, remnant condition and shape. *Conserv. Biol.* ***19*, 182-94.**

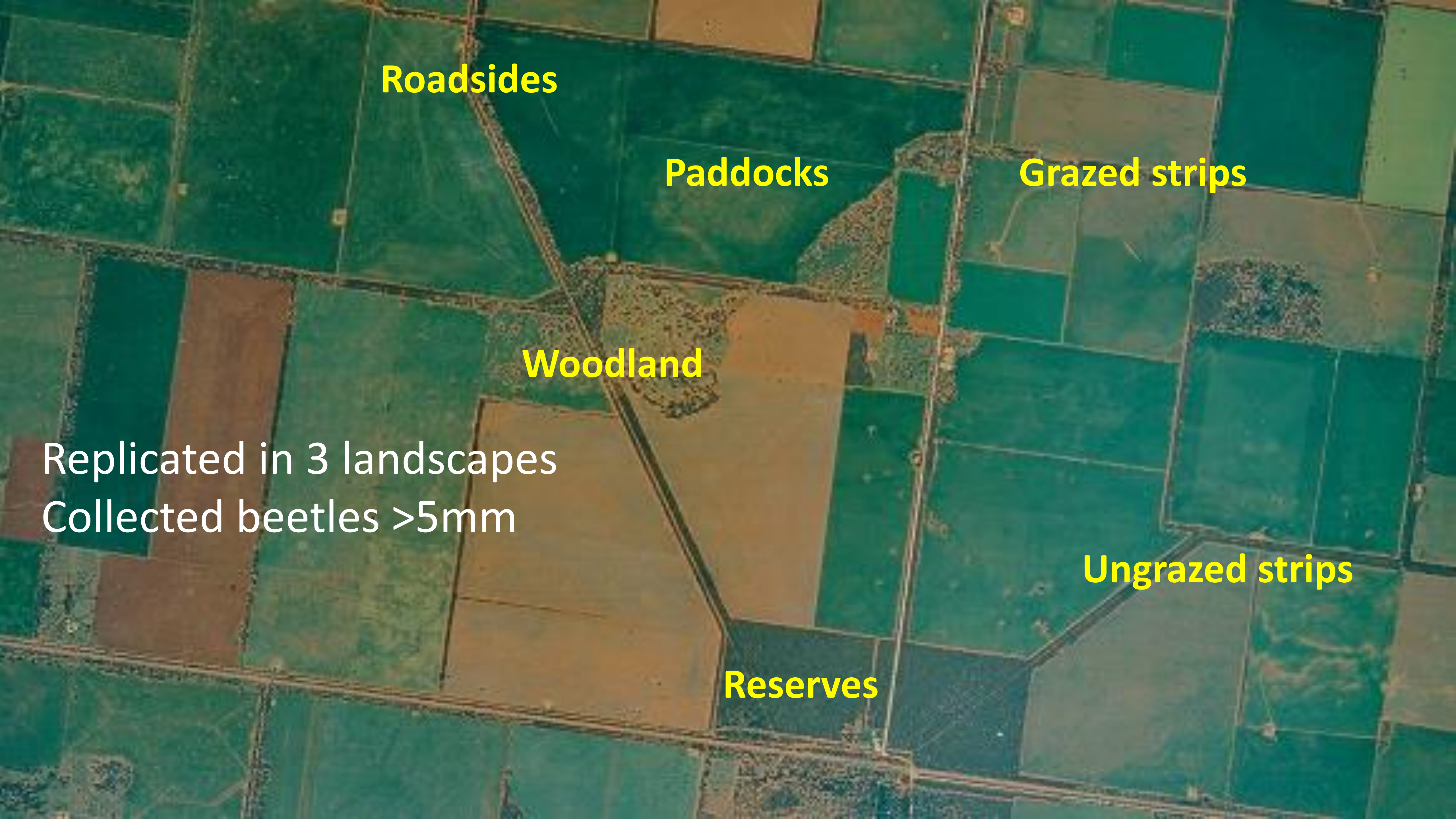


Range of landscape elements




Grazed Strip
Ungrazed Strip

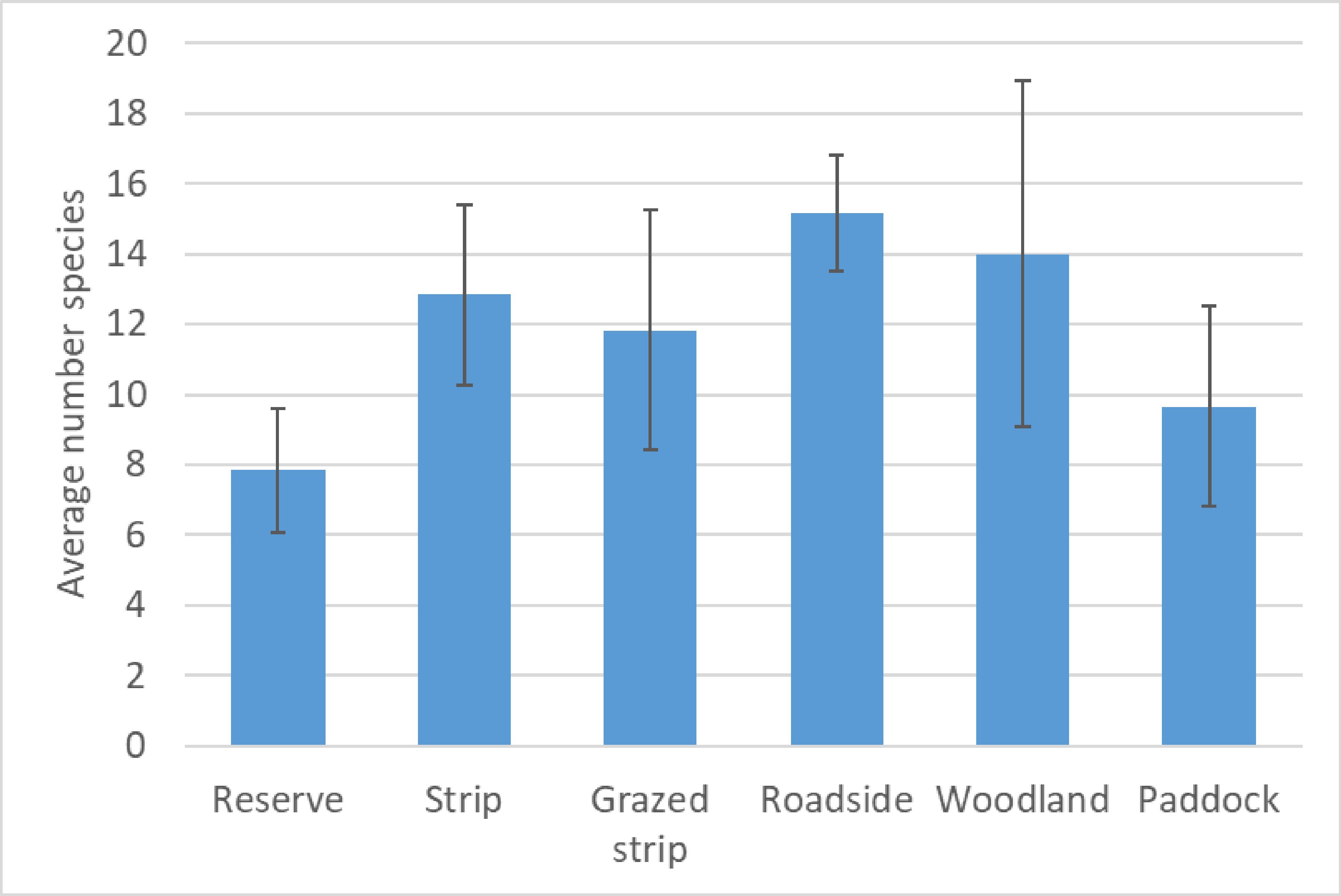

Roadsides


Roadsides
Paddocks
Grazed strips
Woodland
Replicated in 3 landscapes
Collected beetles >5mm
Ungrazed strips
Reserves

Significantly more beetle species in linear remnants than in reserves

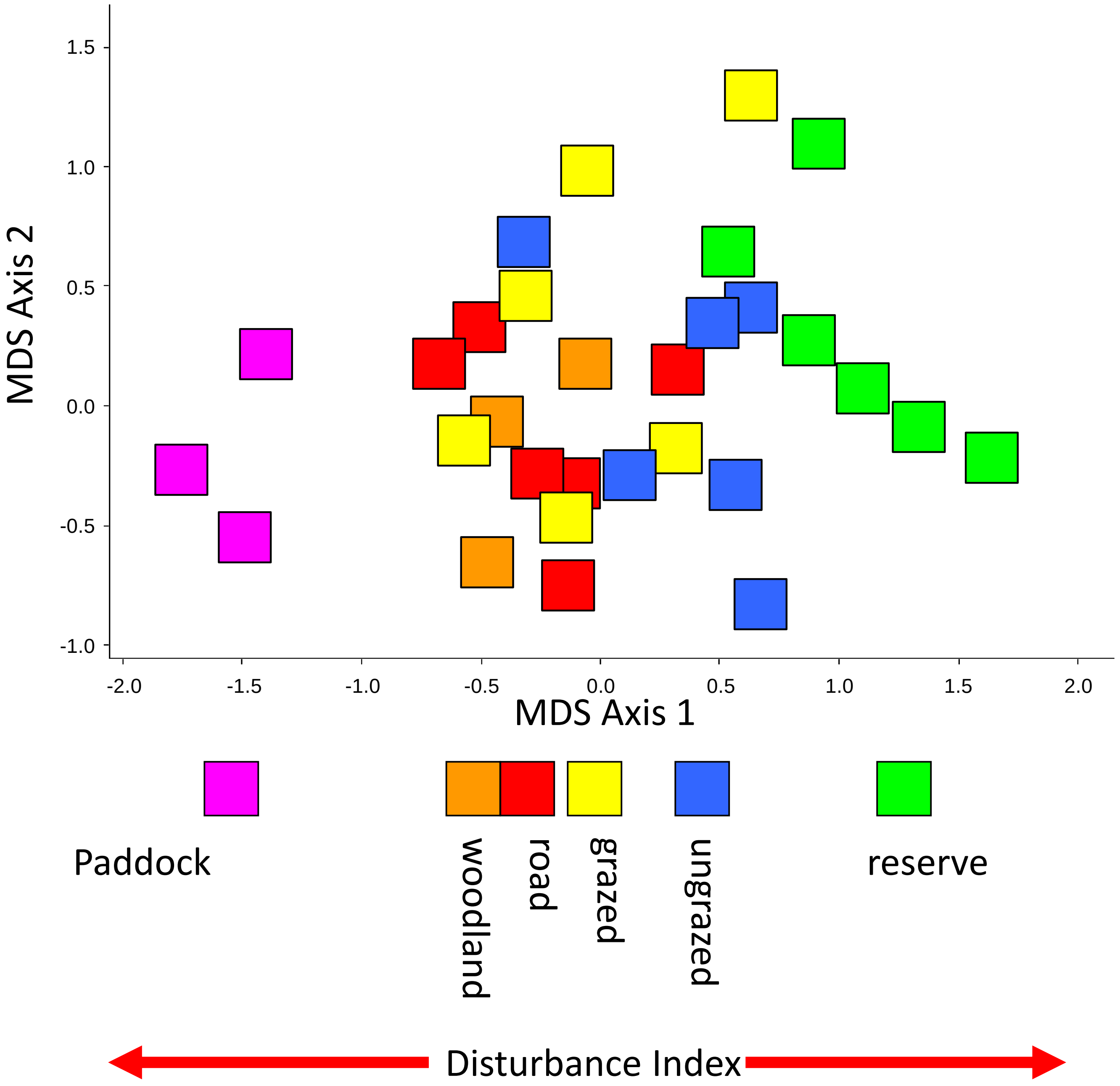
Similar number in paddocks as reserves

Average number of species per site



2017 Data; Linear strips have higher N and P!

Composition varies in relation to disturbance



Do characteristics of beetles influence their response to the disturbance gradient?

Beetle Character Traits

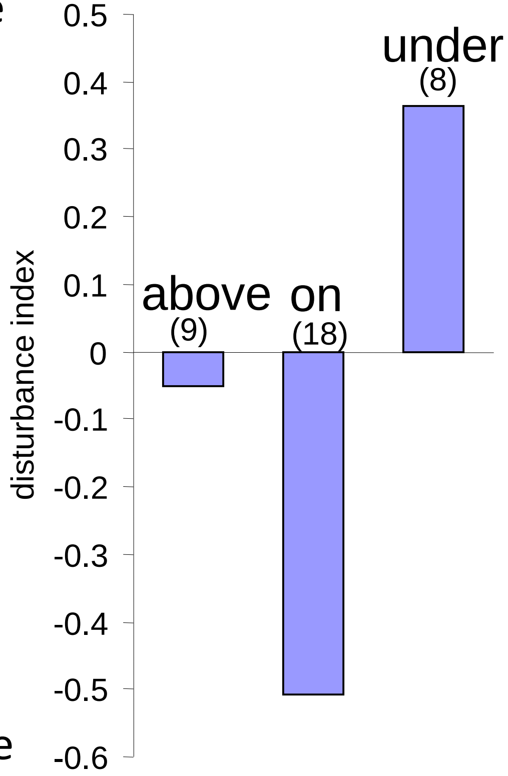
- **Flight** (yes/no)
- **Position** (above/on/below ground)
- **Trophic Group** (predator/ herbivore/ omnivore/ scavenger)
- **Size** (<10mm, 10-20mm, >20mm)

DO CHARACTER TRAITS INFLUENCE RESPONSE TO LAND CLEARING?

Disturbance index Vs Traits

Burrowing species prefer least disturbed sites

Low disturbance

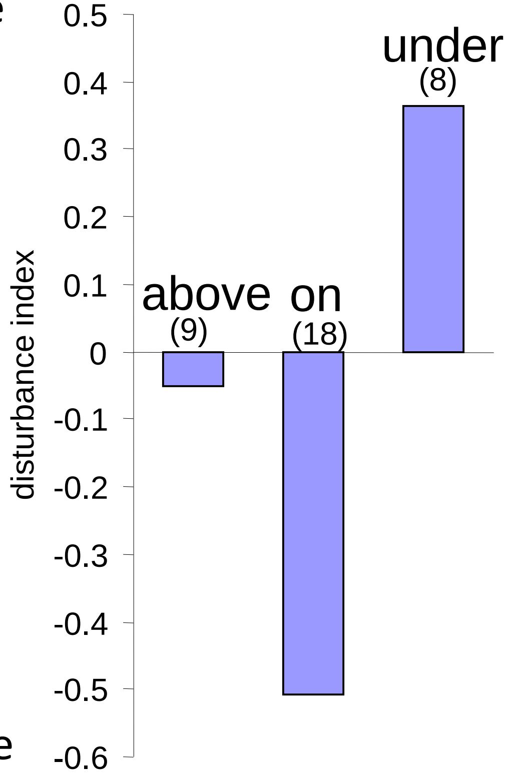


High disturbance

Disturbance index Vs Traits

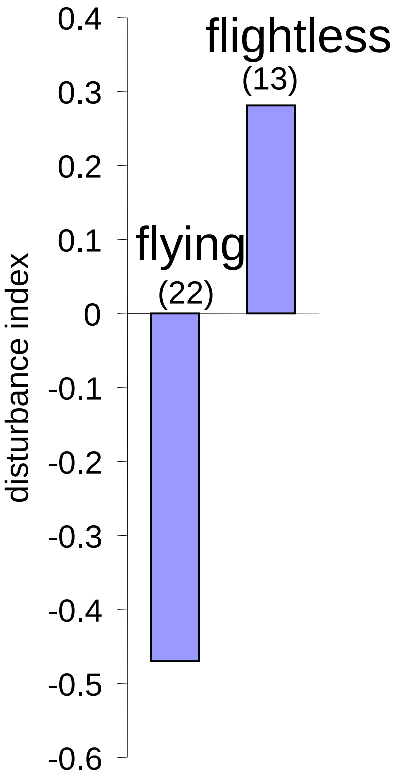
Burrowing species prefer least disturbed sites

Low disturbance



High disturbance

Flightless species prefer least disturbed sites



Species Responses Depend on Combinations of Traits

Flight/Position	Trophic Group	Size	Reserve Bias	Strip Bias	Road Bias	Paddock Bias
Flying-On						
	carnivore	small	-	2	2	-
	carnivore	medium	-	-	-	2
	carnivore	large	-	-	-	1
	omnivore	small	-	-	-	2
	omnivore	medium	-	-	-	1
	scavenger	small	-	-	-	2

Trajectories

24% (8 of 34 species) most abundant in paddocks

Survivors

15% (5) most abundant in reserves

6% (2) most abundant in strips

21% likely at risk of local extinction

Proportion Declining from Cleared Landscapes

26% Reptiles	Mallee
21% Beetles	Mallee
27% Birds	WA Wheatbelt
33% Mammals	North American Wheatbelt
42% Birds	Mt Lofty Ranges

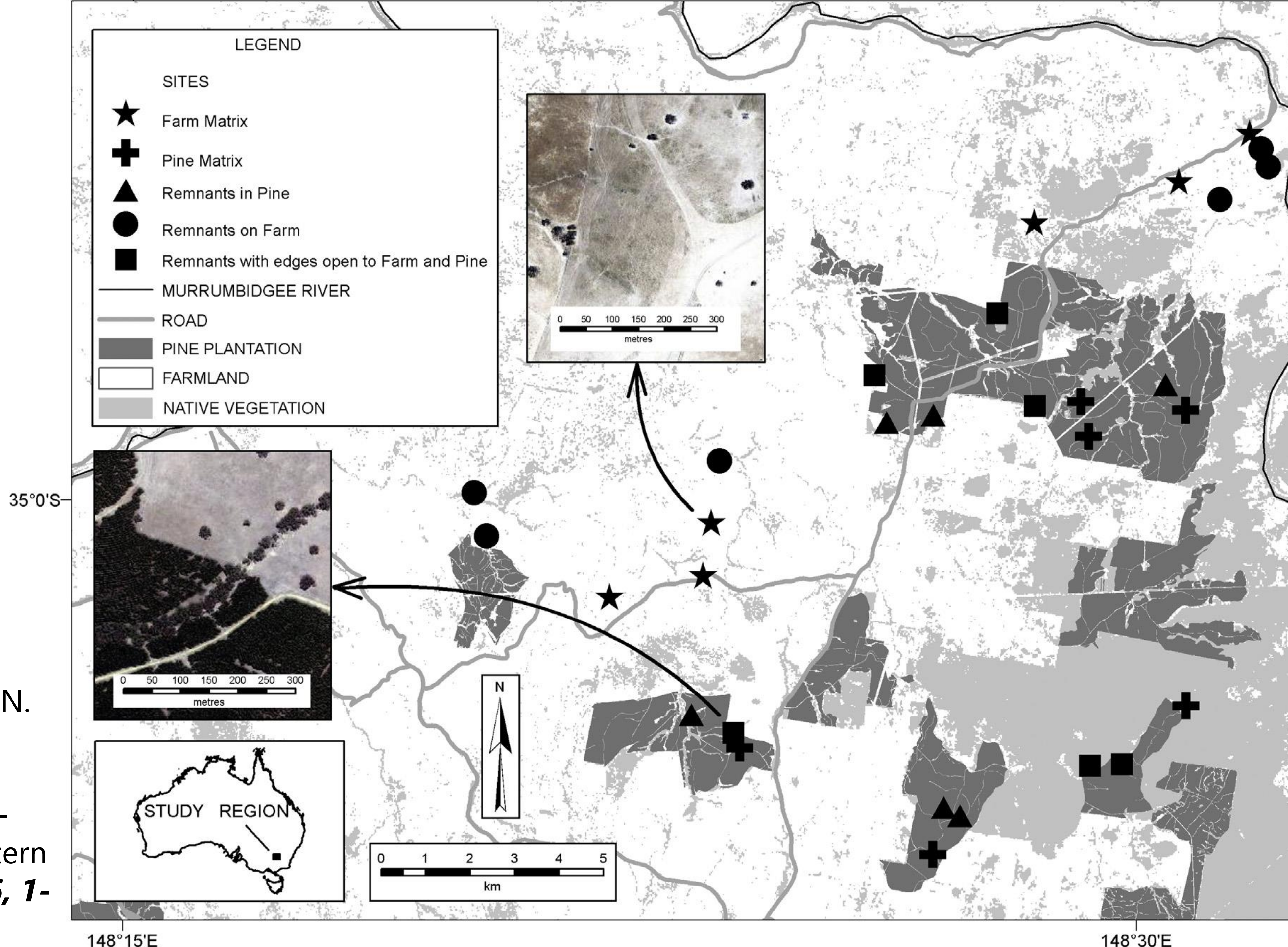
Extreme impacts on beetle communities

Homogenisation

Loss of sensitive species

Tumut region
NSW

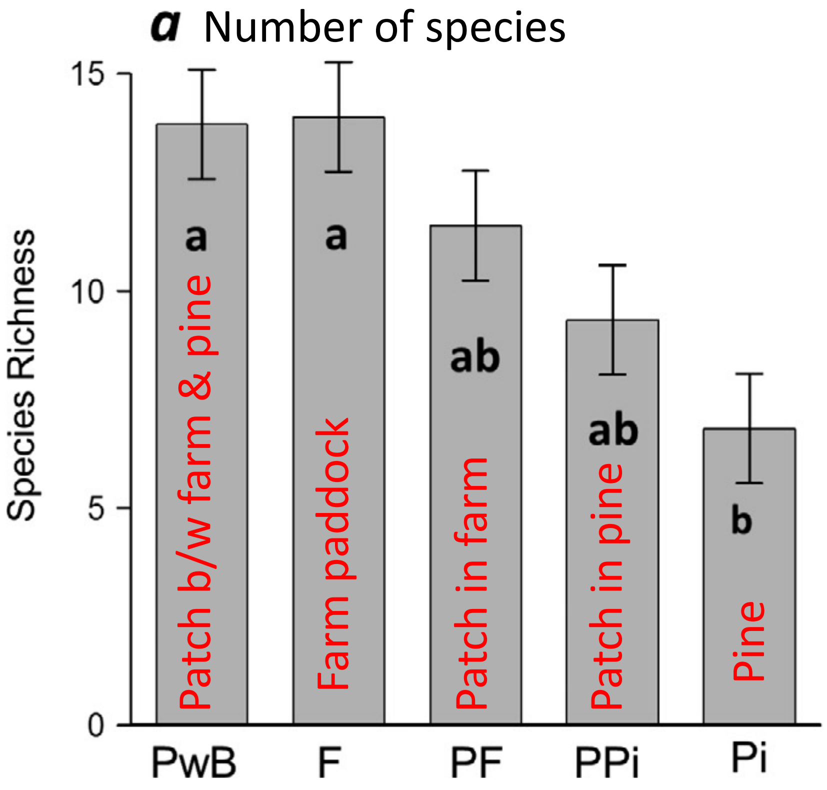
Sampled Beetles
with pitfall traps

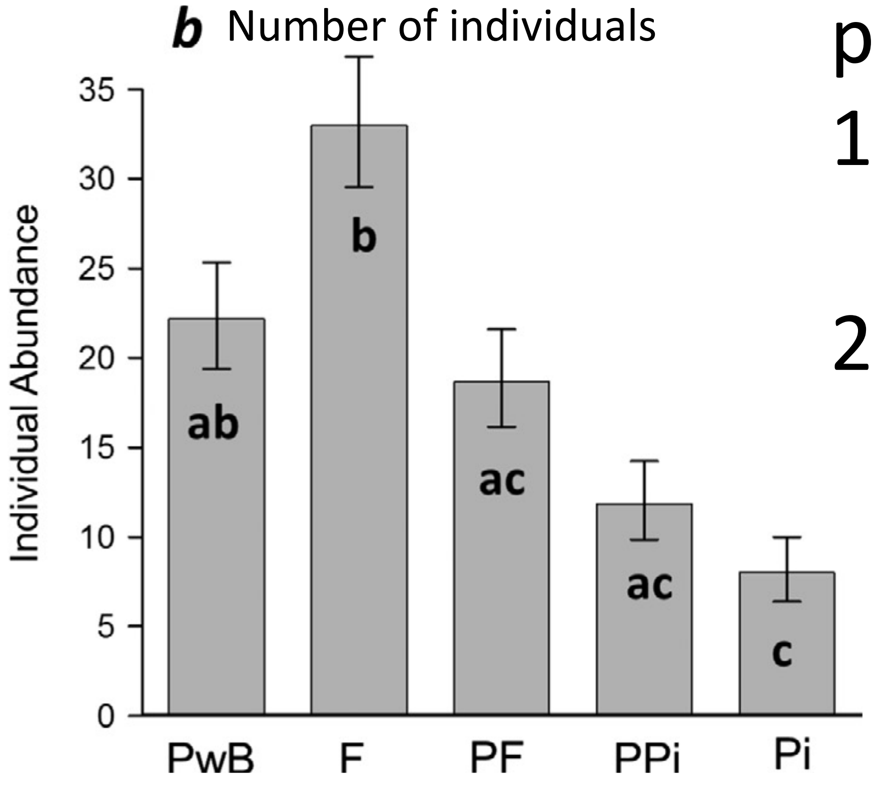


Sweaney N., Driscoll D. A., Lindenmayer B. D. & Porch N. (2015) Plantations, not farmlands, cause biotic homogenisation of ground-active beetles in south-eastern Australia. *Biol. Conserv.* ***186, 1-11.***

Farms and patches adjacent to pines and farms have most species

Highest beetle abundance in paddocks

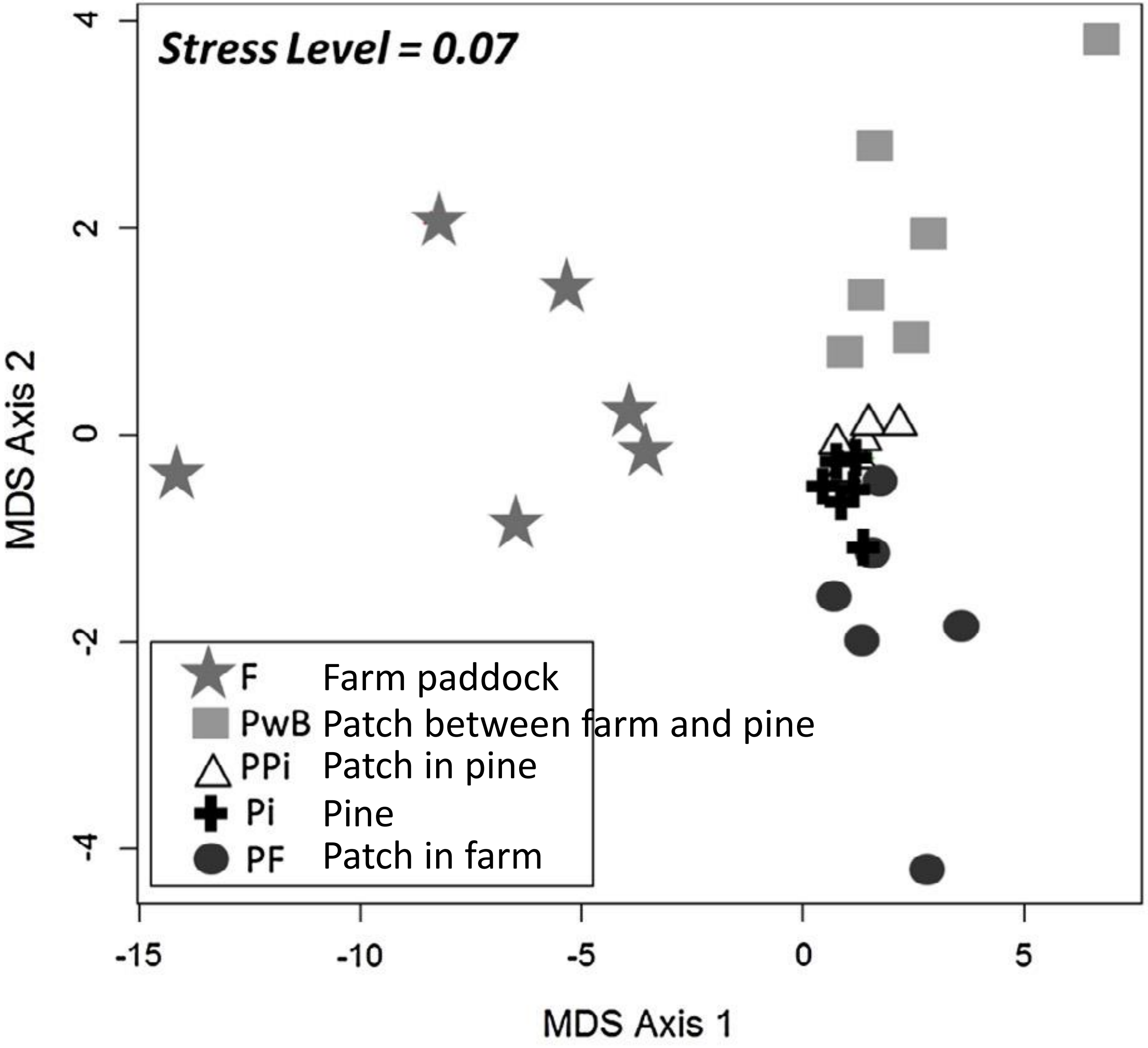




Conversion of farm to plantation

1. Reduced no. species
2. Reduced abundance

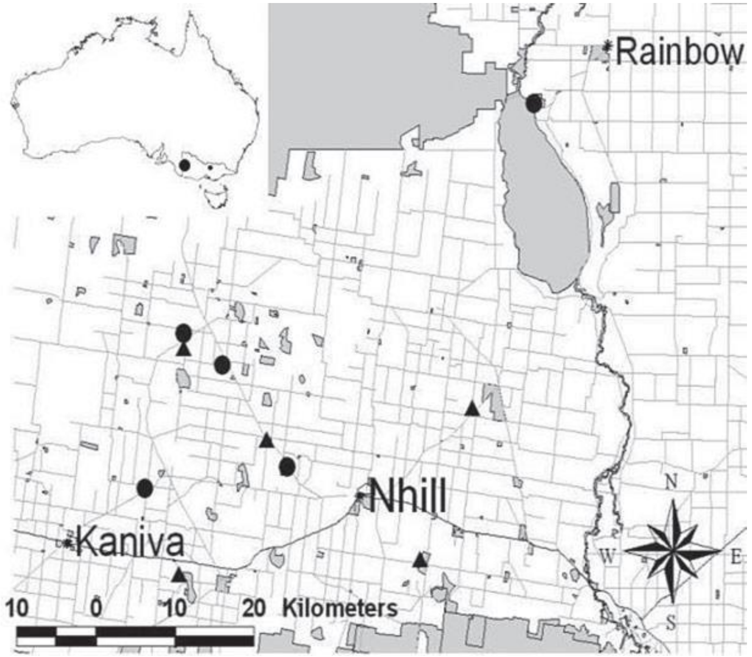
Sweaney N., Driscoll D. A., Lindenmayer B. D. & Porch N. (2015) Plantations, not farmlands, cause biotic homogenisation of ground-active beetles in south-eastern Australia. *Biol. Conserv.* ***186, 1-11.***

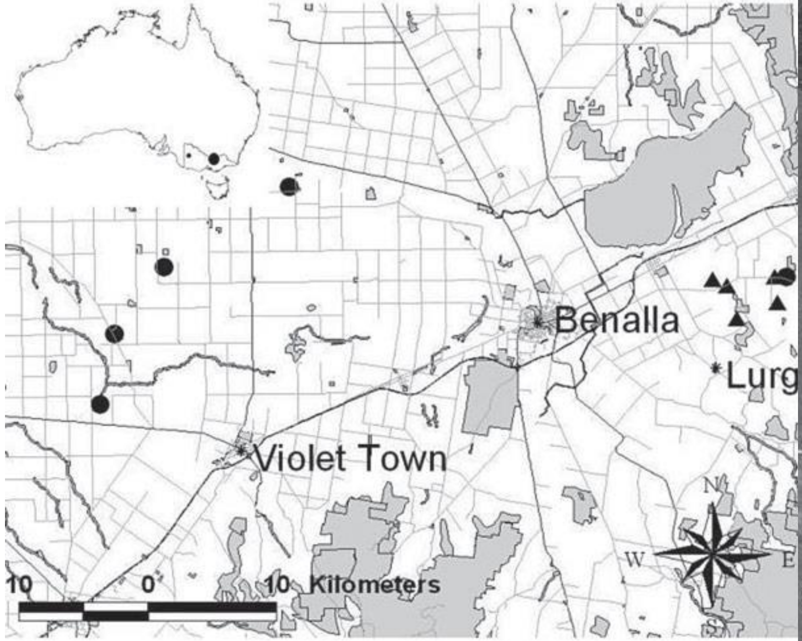


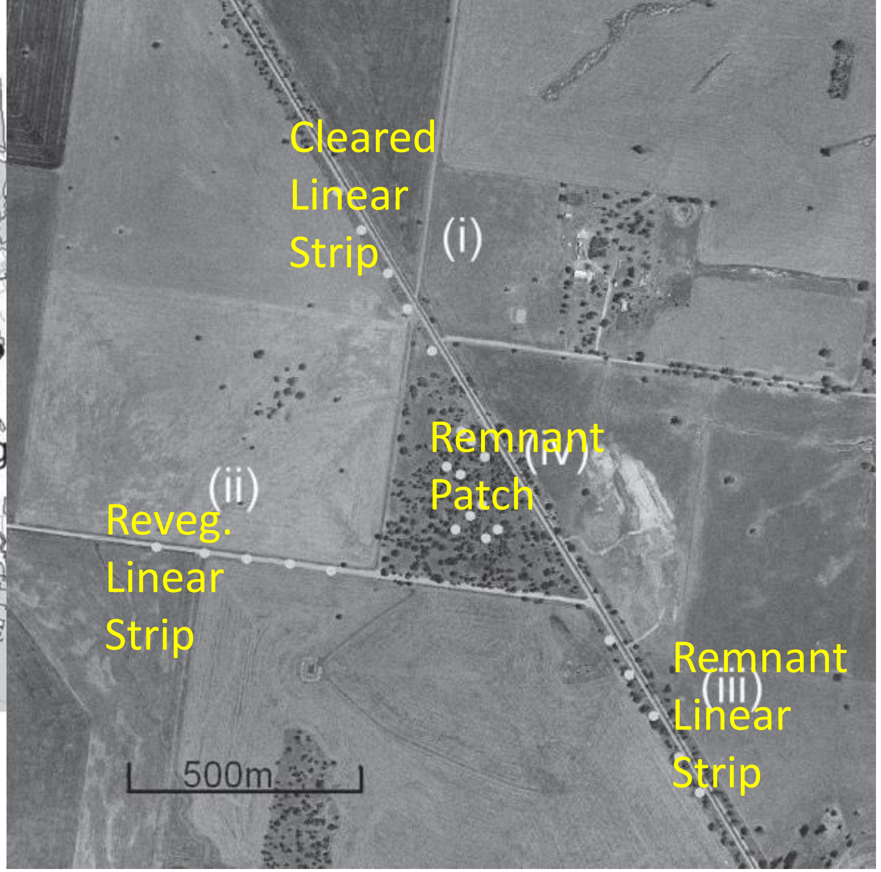
Distinct beetle fauna in each landscape element

Pines and Patches in Pines homogenised

Sweaney N., Driscoll D. A., Lindenmayer B. D. & Porch N. (2015) Plantations, not farmlands, cause biotic homogenisation of ground-active beetles in south-eastern Australia. *Biol. Conserv.* ***186, 1-11.***





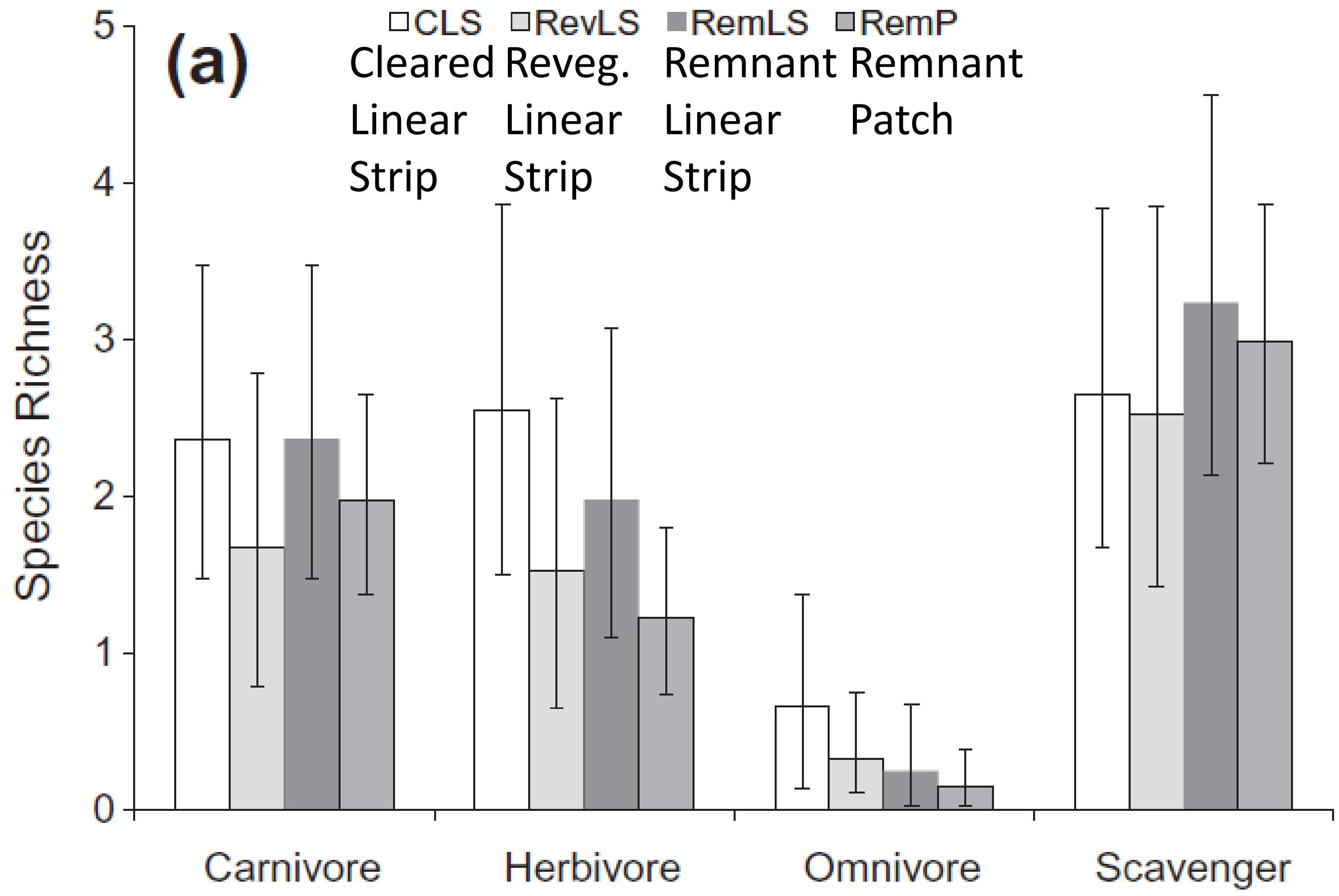


Benalla and Wimmera, Victoria

Sampled Beetles with pitfall traps

Four landscape elements

Jellinek S., Parris K. M. & Driscoll D. A. (2013) Are only the strong surviving? Little influence of restoration on beetles (Coleoptera) in an agricultural landscape. *Biol. Conserv.* ***162, 17-23.***



Error bars represent 95% credible intervals.

Jellinek S., Parris K. M. & Driscoll D. A. (2013) Are only the strong surviving? Little influence of restoration on beetles (Coleoptera) in an agricultural landscape. *Biol. Conserv.* ***162, 17-23.***

No species richness differences across landscape elements

No substantive community differences

Patch-dependent species already lost?

Recommends reintroduction alongside plant restoration

Millennial drought

How do different kinds of paddock affect beetles?

Matrix effects.

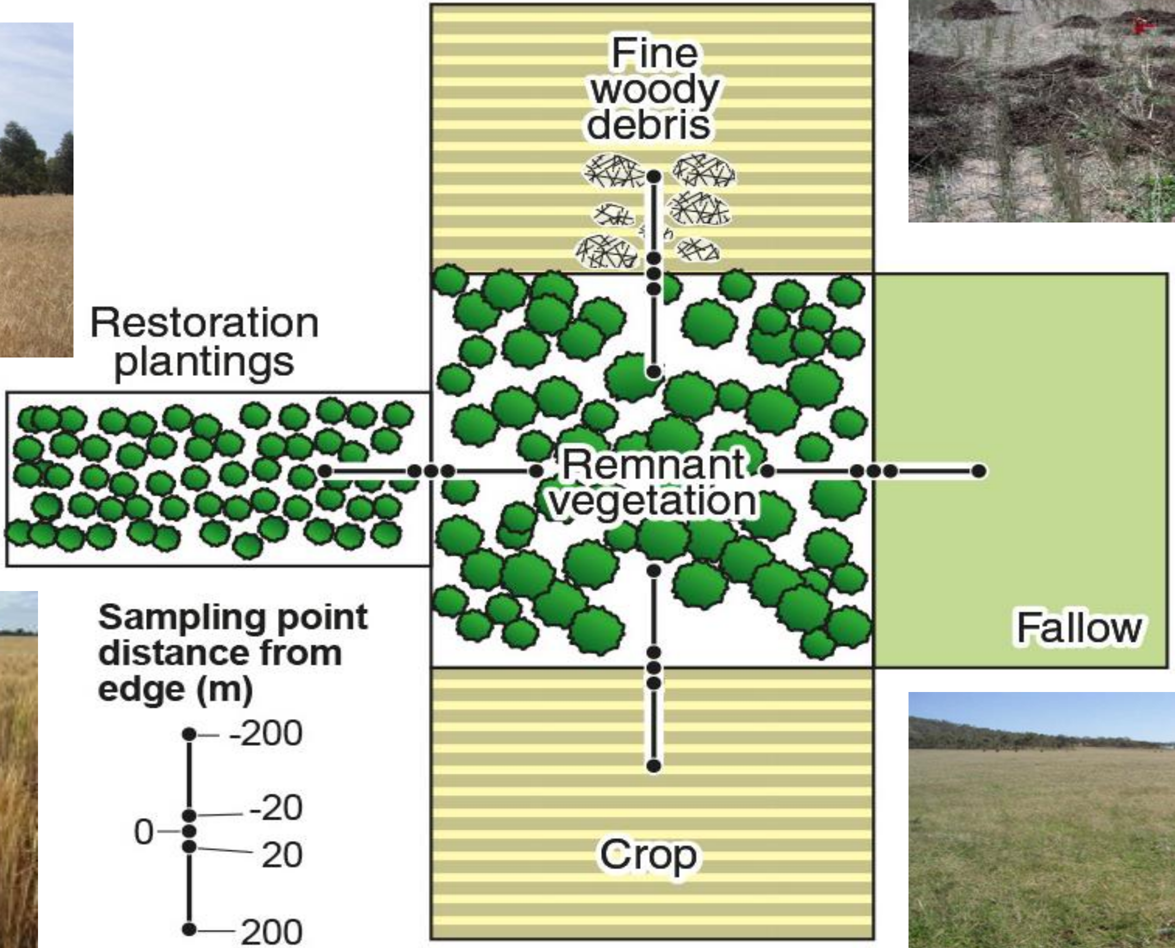
Study sites

- Katharina Ng's PhD
- 11 sites in NSW Lachlan catchment (200 km span)
- Mixed cropping-grazing land.

Methods: Study design

3. Plantings <10 years, 30m wide

4. Fine woody debris (euc-based), 20m wide

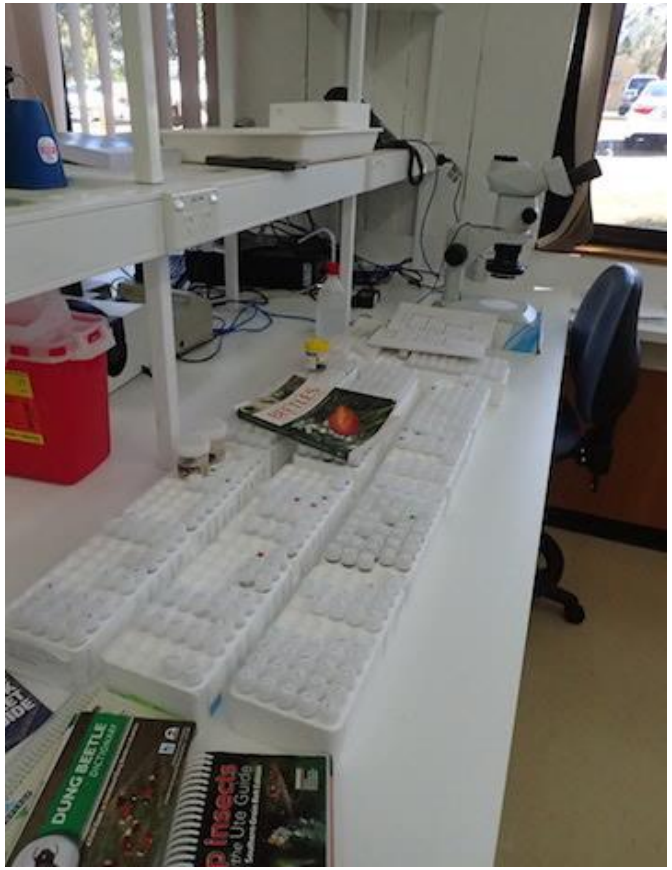


1. Crop

2. Fallow

Methods: Year-long lab work!

- 11,360 individuals, 495 species, 53 families of beetles

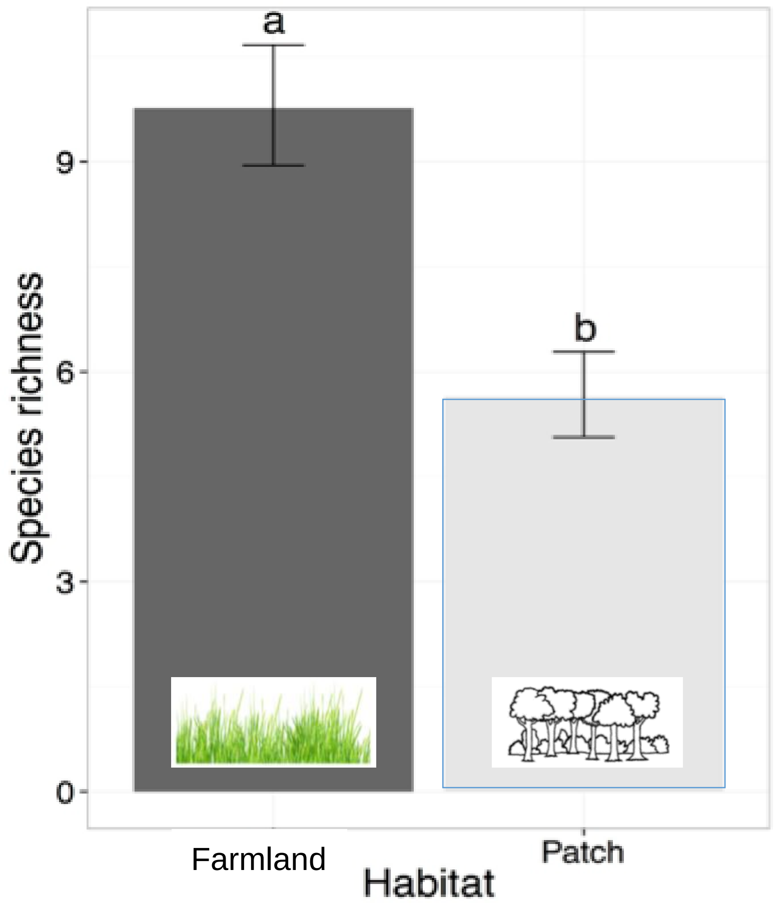


Beetle morphospecies
reference collection

Pinning & labelling
specimens *correctly* is
time consuming!

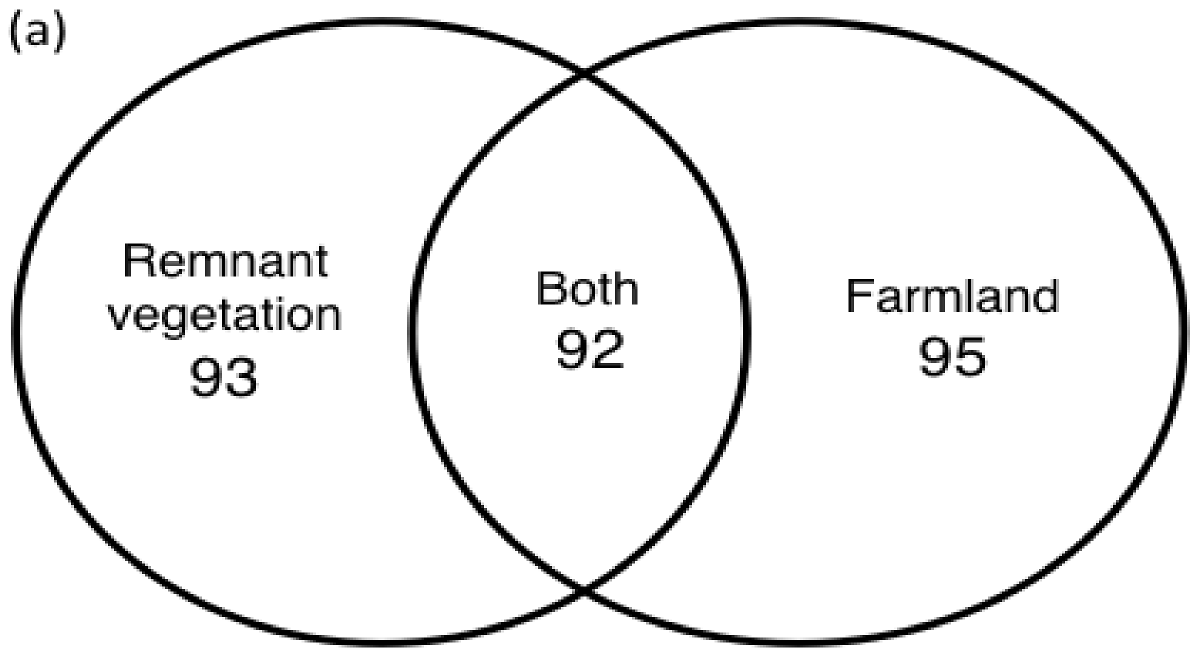
Species richness

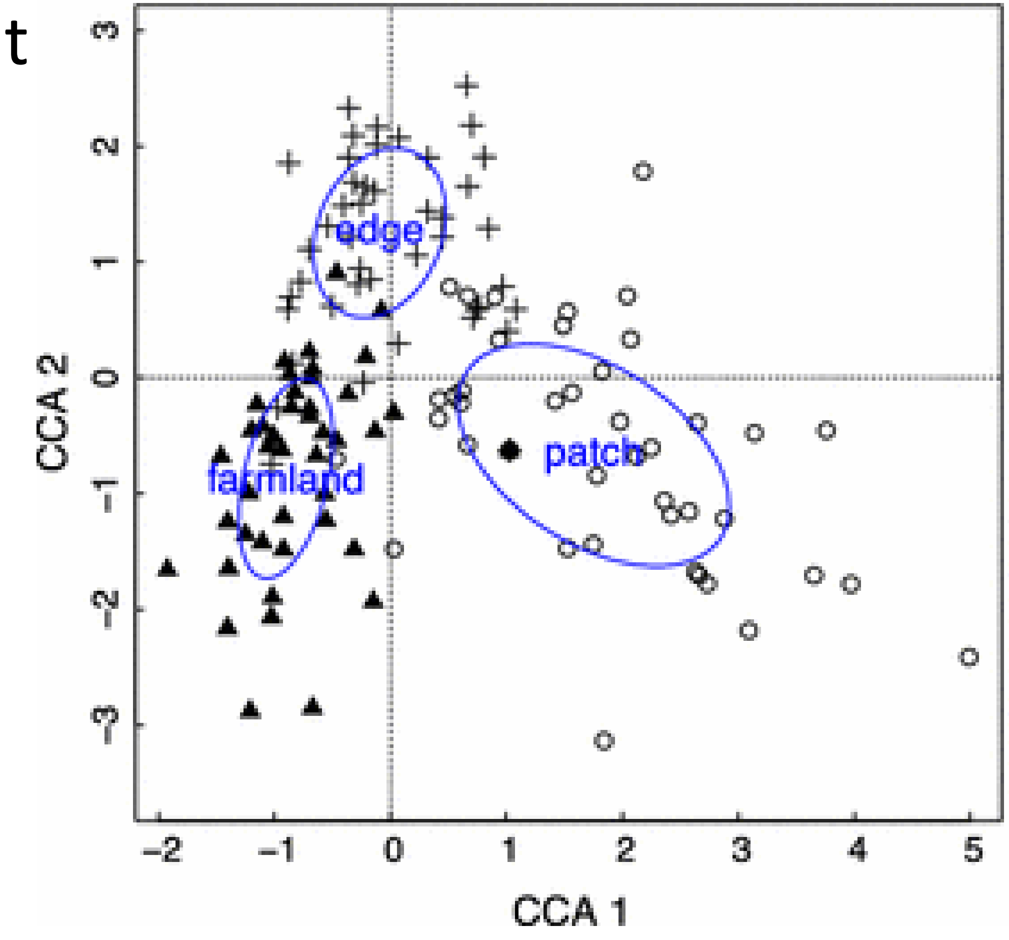
Higher species richness in farmland than remnant patch



Species composition

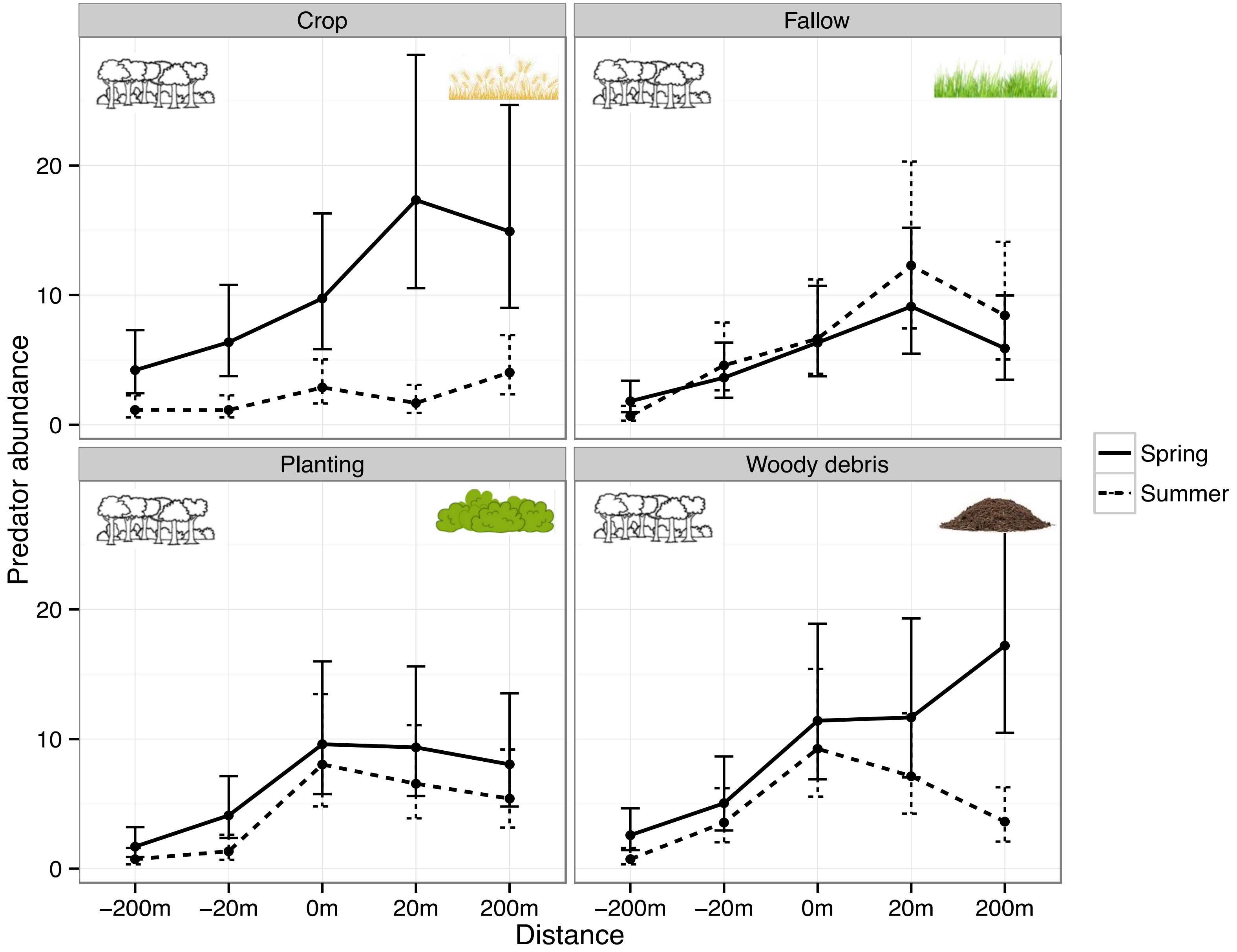
- Significantly different species between remnant patch & farmlands





Ng K., McIntyre S., Macfadyen S., Bartona P. S., Driscoll D. A. & Lindenmayer D. B. (2018) Dynamic effects of ground-layer plant communities on beetles in a fragmented farming landscape. *Biodivers. Conserv.* ***27, 2131-53.***

Predator abundance vs distance

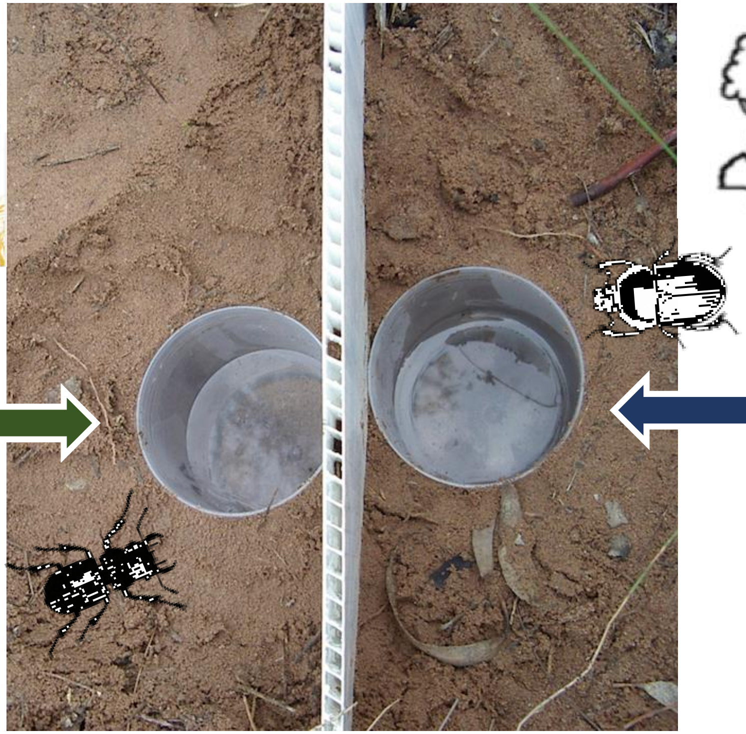


Lower abundance in reserve

Big reduction in crops spring-summer

Movement direction

- Specify direction at each trap point
- 3 possible classifications

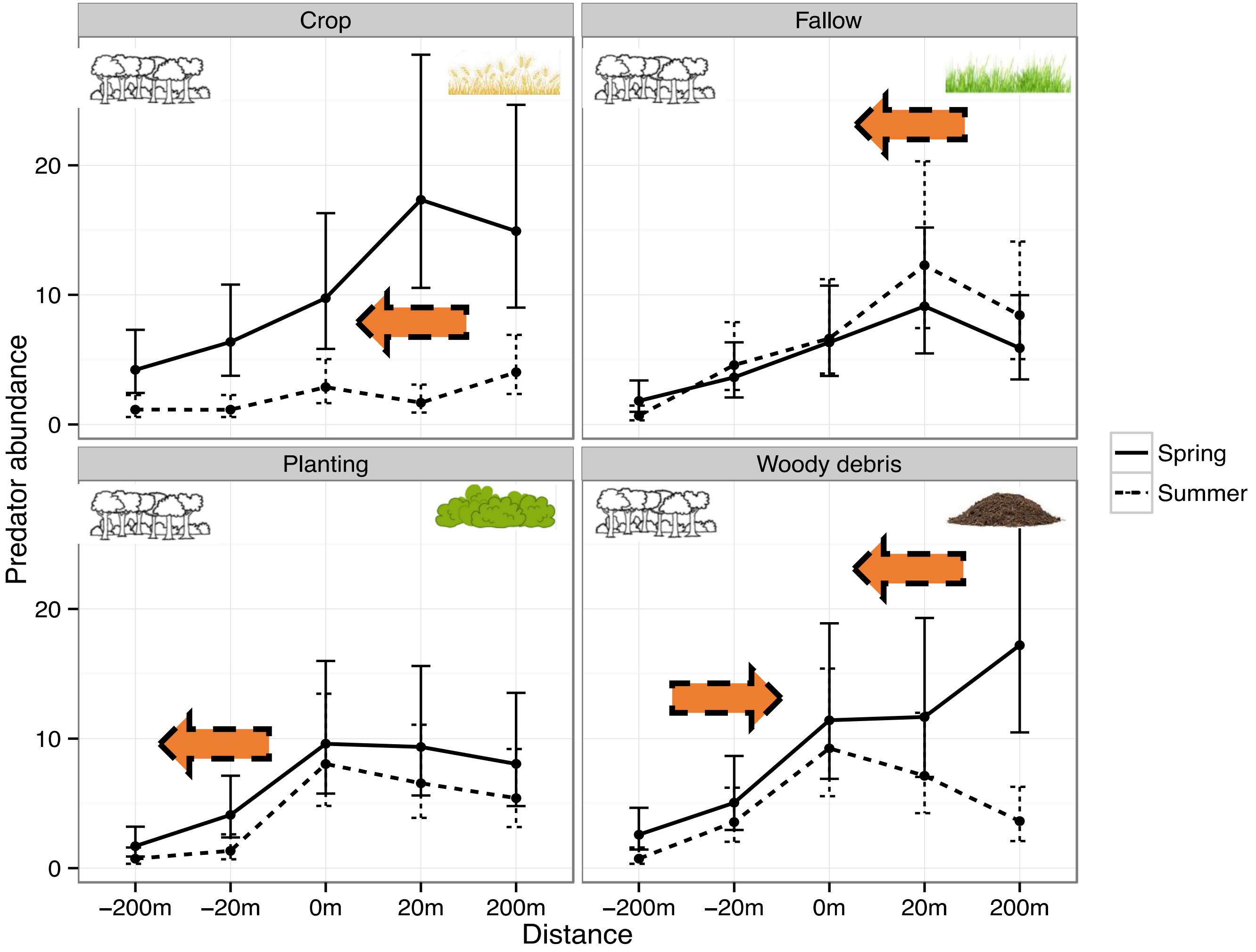


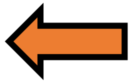
1. To remnant woodland patch

2. To farmland

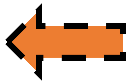
3. No directional preference

Predator movement





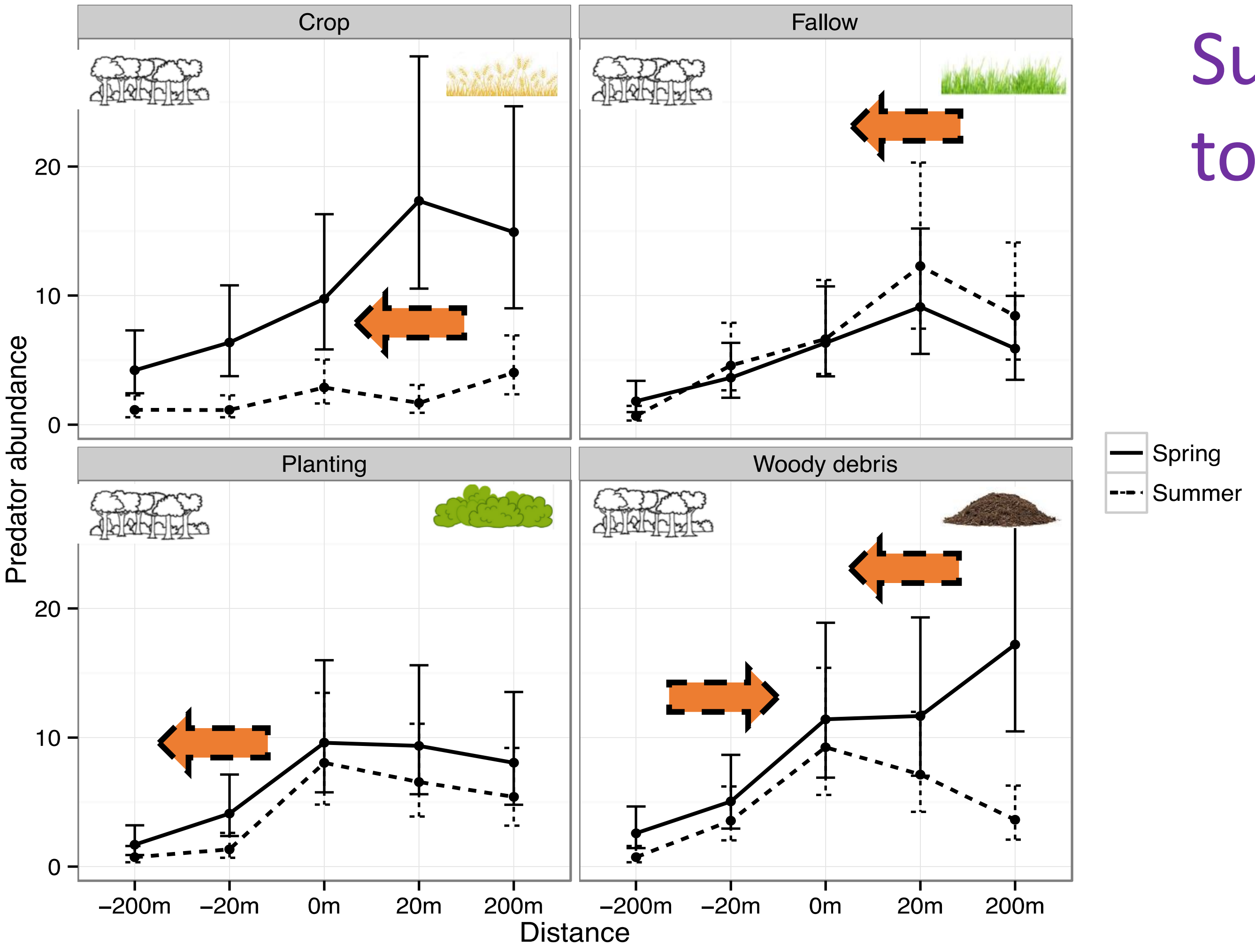
Spring movement direction*



Summer movement direction*

(*) Arrows derived from directional traps per trap point

Predator movement



Summer movement towards edge

- from 20m
- not in planting
- from both directions in woody debris

- Predatory beetles have high abundance in crops, but may emigrate to patch edges after harvest (spillover into remnants)
- Woody debris maintained higher beetle numbers after cropping including attracting beetles from remnant
- No emigration from plantings in summer but movement away from planting edge…..

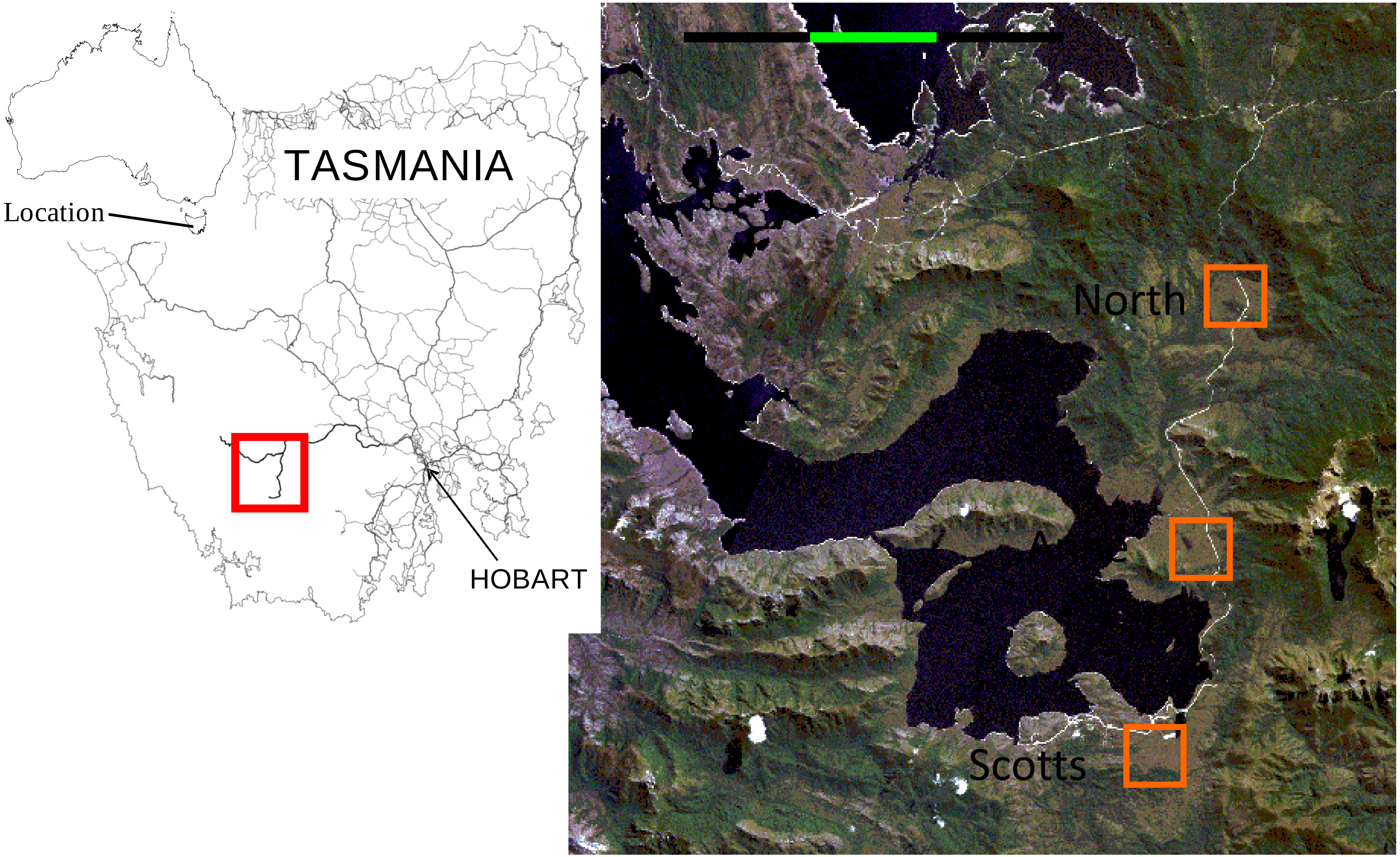
Species interactions

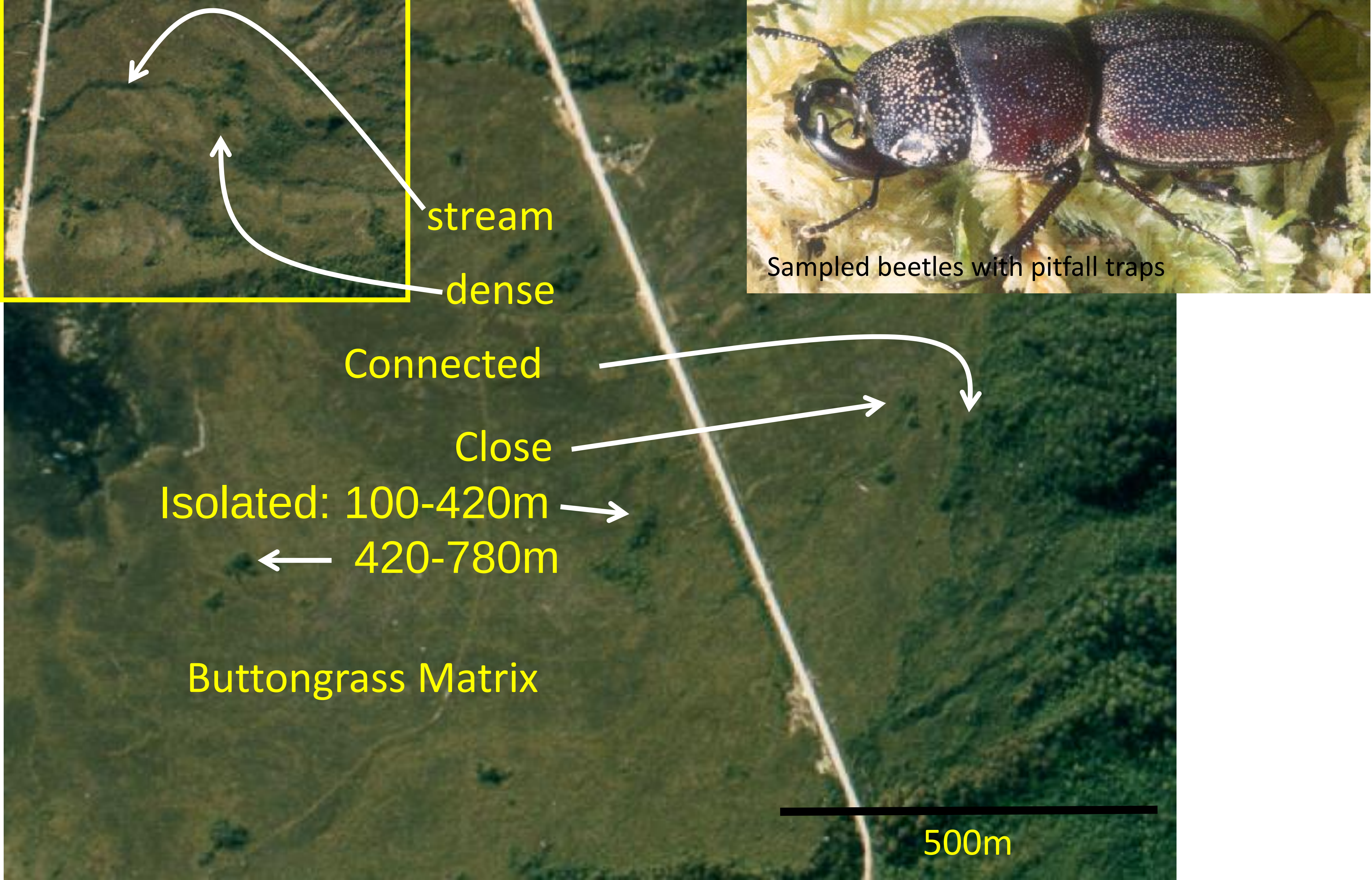
How does patch size, shape and isolation influence the beetle community?

Driscoll D. A. (2008) The frequency of metapopulations, metacommunities and nestedness in a fragmented landscape. *Oikos* ***117, 297-309.***


Eucalypt patches in a buttongrass matrix, Tasmania

3 replicate landscapes



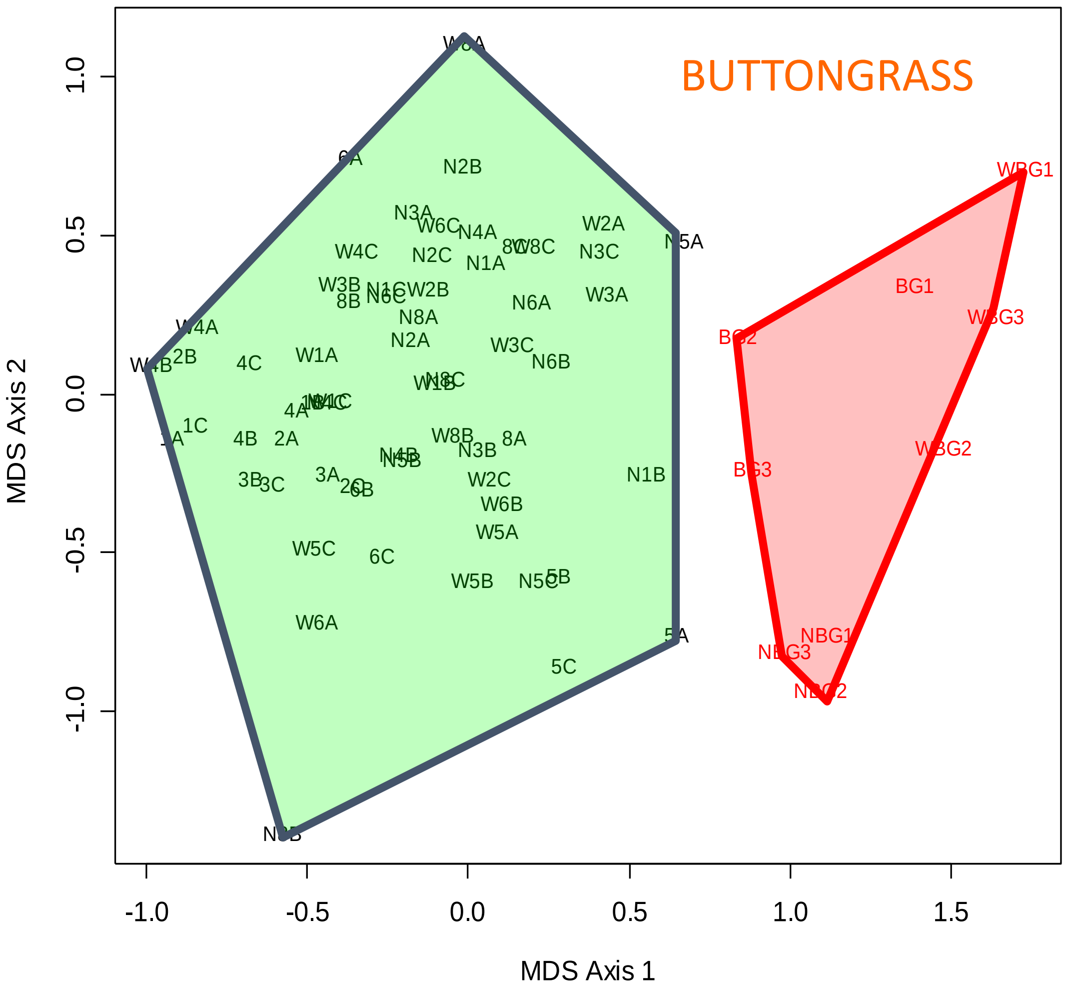

stream
dense
Connected
Close
Isolated: 100-420m
420-780m
Buttongrass Matrix
500m
Sampled beetles with pitfall traps

Buttongrass Fauna is very different from bush fauna

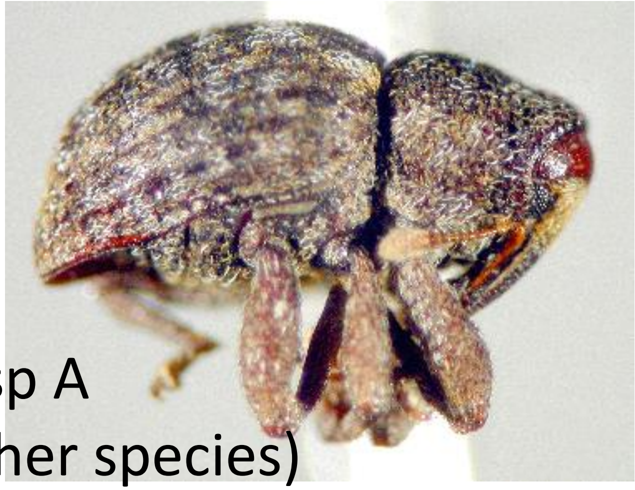
2 species only in buttongrass

88 only in bush

21 in both

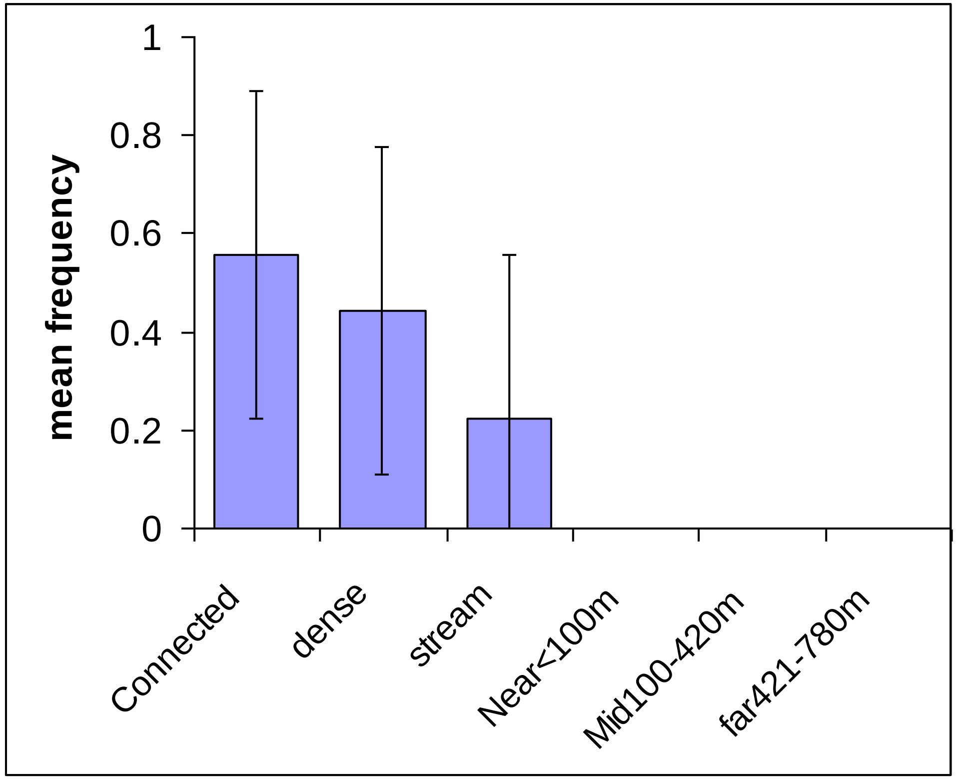


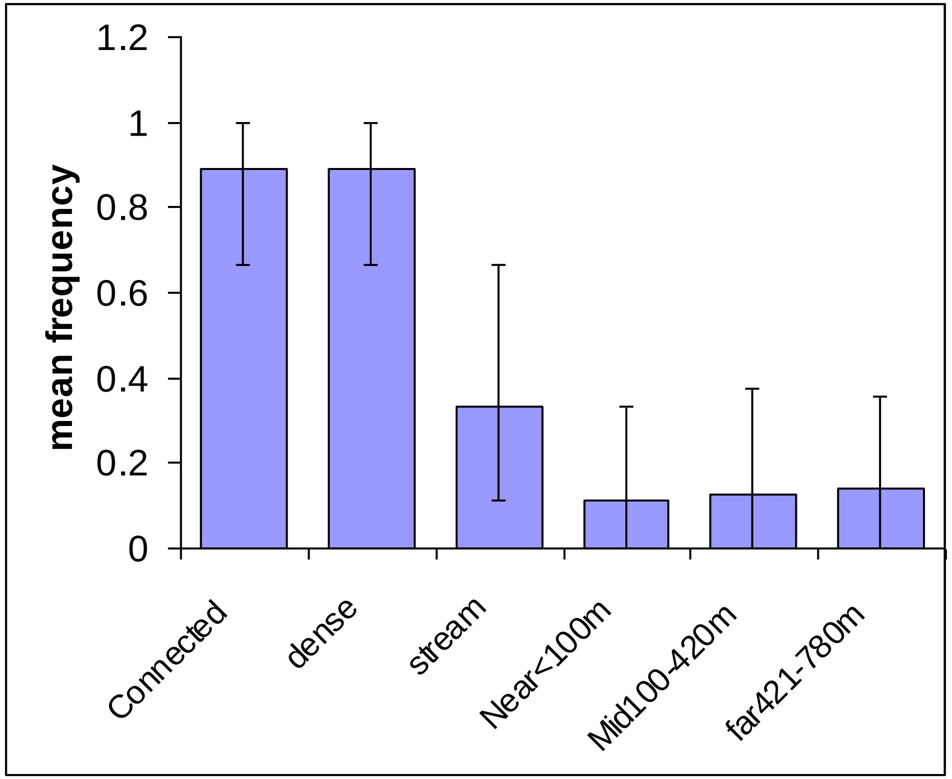
Patch isolation limits species occurrence



Decilaus sp A
(plus 4 other species)

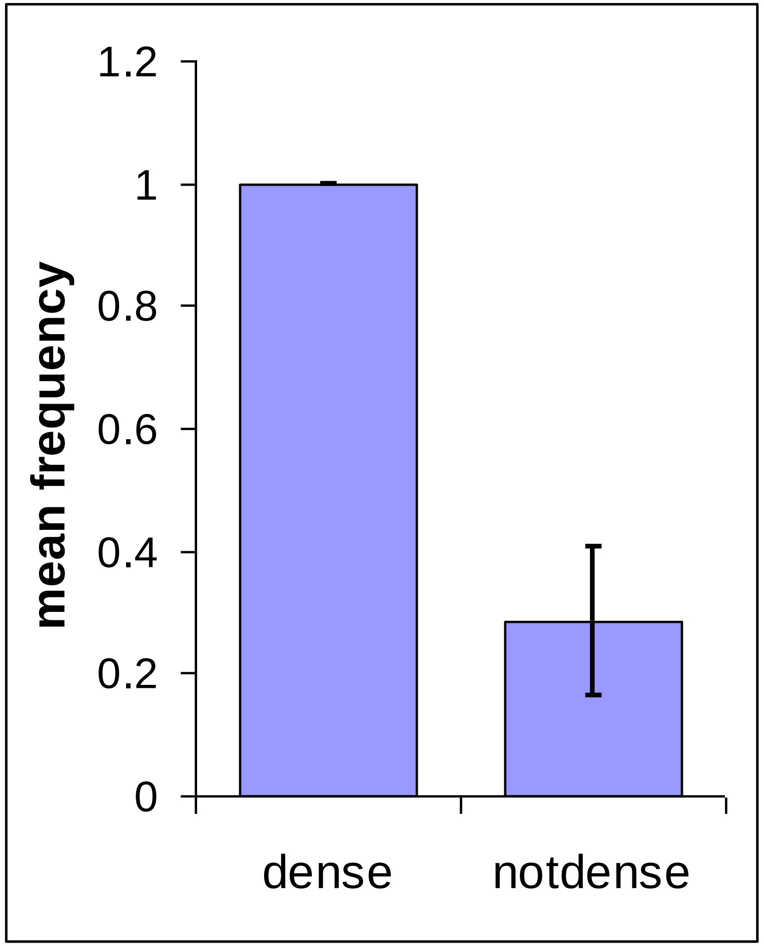
Chylnus ater (plus 3 other species)





Variation on the isolation effect……

Sloaniana tasmaniae



70% less frequent in more isolated AND more connected sites

Distance limited plus exclusion from connected sites

Dispersal limited species

9 (22%) species were limited by distance

7/9 (77%) are flightless

(and the 2 flyers are probably poor flyers)

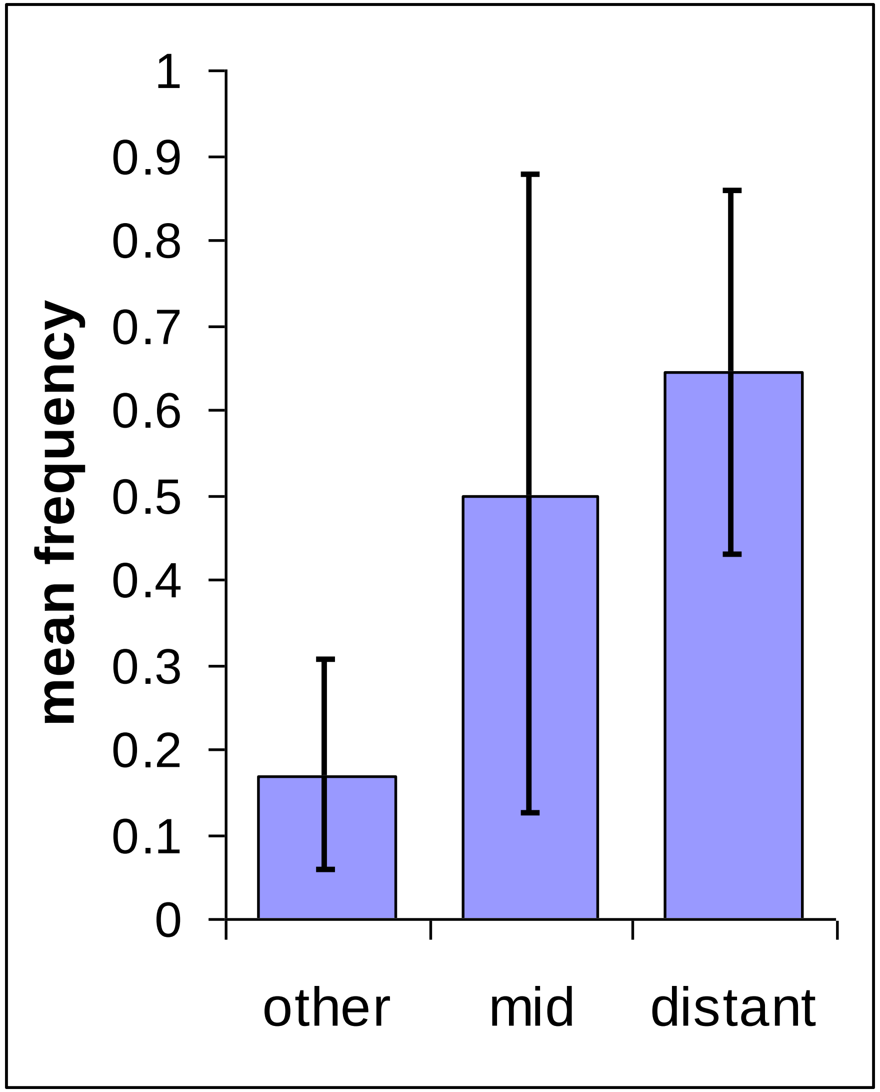
Compared with beetles in all other response categories 4/32 (12.5%) are flightless

Inverse-dispersal limited!!

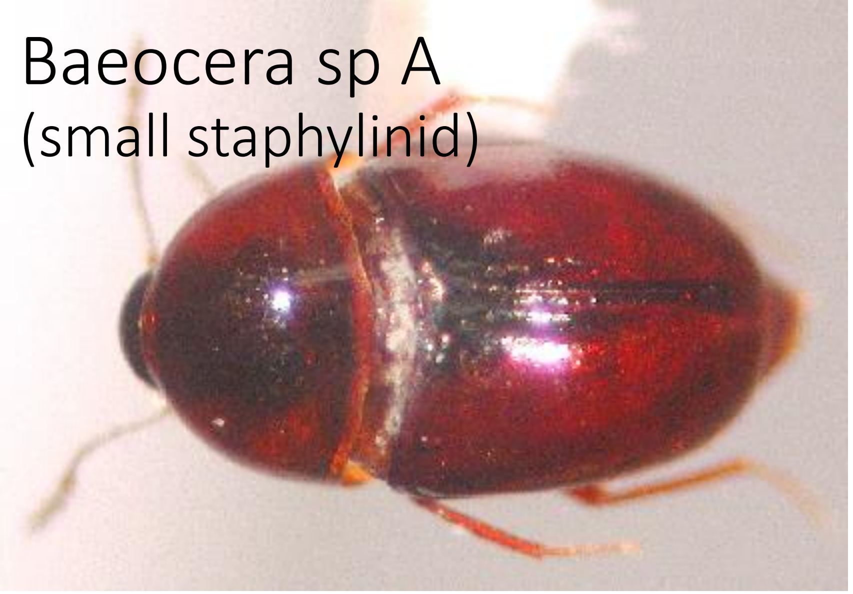
7 (17%) species increased with distance

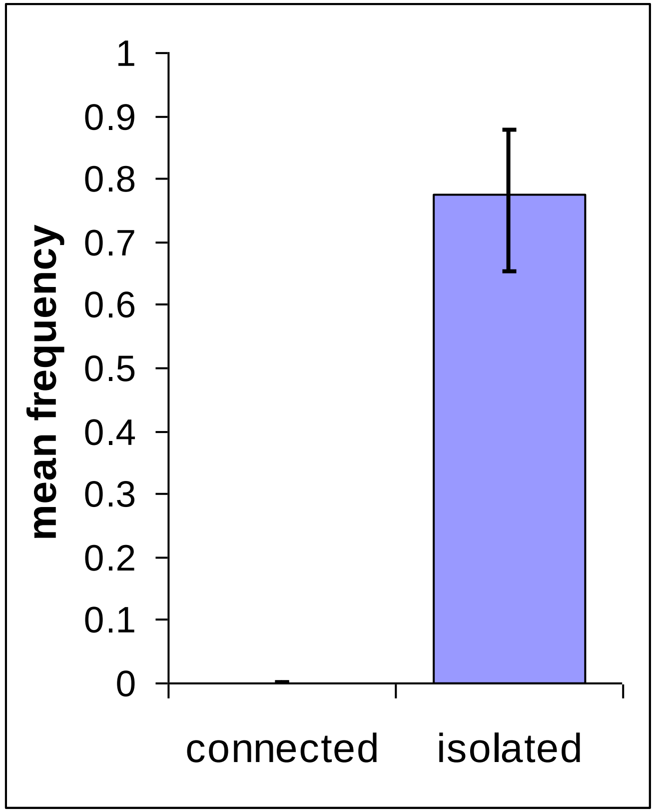
6/7 could fly

Galerucinae sp A
(Chrysomelidae)

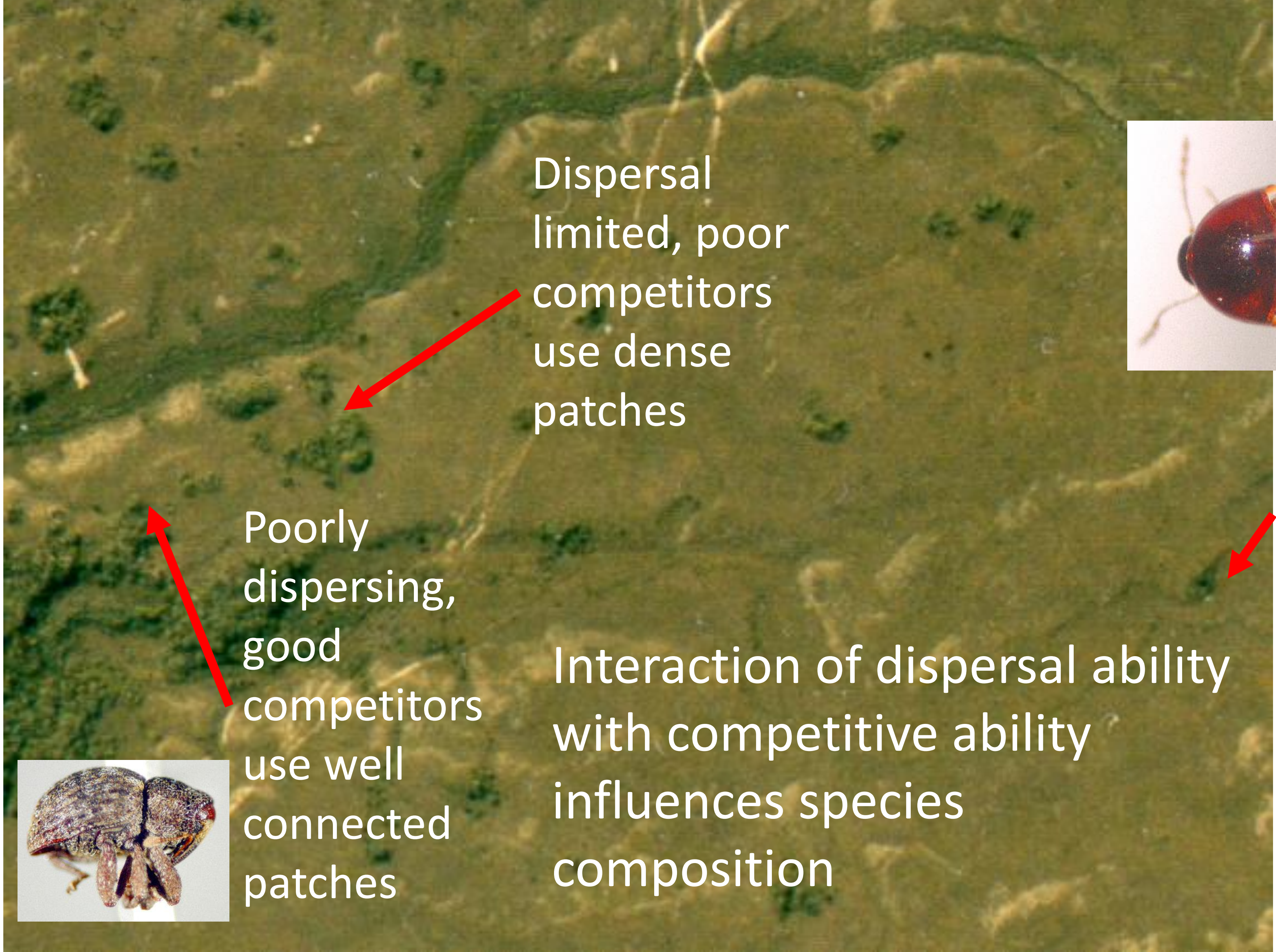


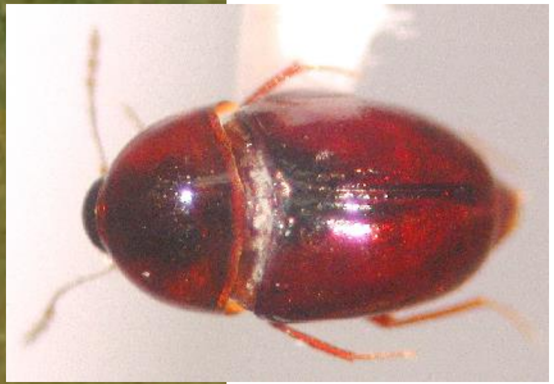
4 species
(of the 7 that increase with distance)
not in buttongrass
could fly





3 species
(of the 7 that increase with distance)
were in buttongrass
2 could fly





Dispersal limited, poor competitors use dense patches

Poorly dispersing, good competitors use well connected patches

Flying, poor competitors use isolated patches

Interaction of dispersal ability with competitive ability influences species composition

IT'S AN ECOSYSTEM OUT THERE………

INSECTS IN ECOSYSTEMS

Above and below ground impacts of terrestrial mammals and birds in a tropical forest

Amy E. Dunham

Dept of Ecology and Evolutionary Biology, Rice University Houston, Texas.

Oikos 117: 571-579, 2008

Ivory Coast
West Africa

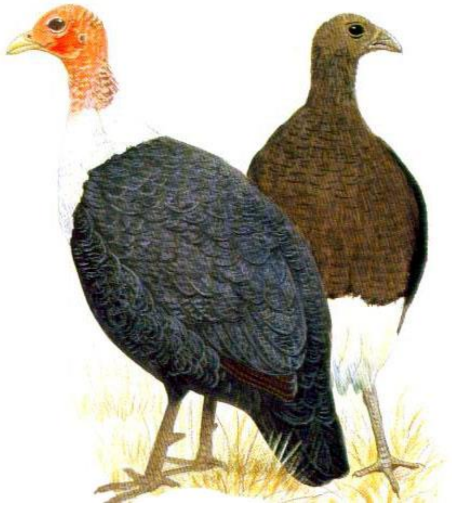

Habitat fragmentation
Ivory Coast, West Africa

The palm oil company PALM-CI has just begun destroying this 6,000 hectare forest to convert it to oil palm plantations (to supply Unilever)

If the forest is destroyed, three primate species as well as many plant species will almost certainly become globally extinct.

Insectivorous birds and mammals decline after fragmentation

Buff-spotted fluff tail



White breasted Guinea-fowl

Latham's Francolin

How does the loss of terrestrial insectivores influence the rest of the ecosystem?

Cusimanse Mongoose

Liberian Mongoose

White Toothed Shrew

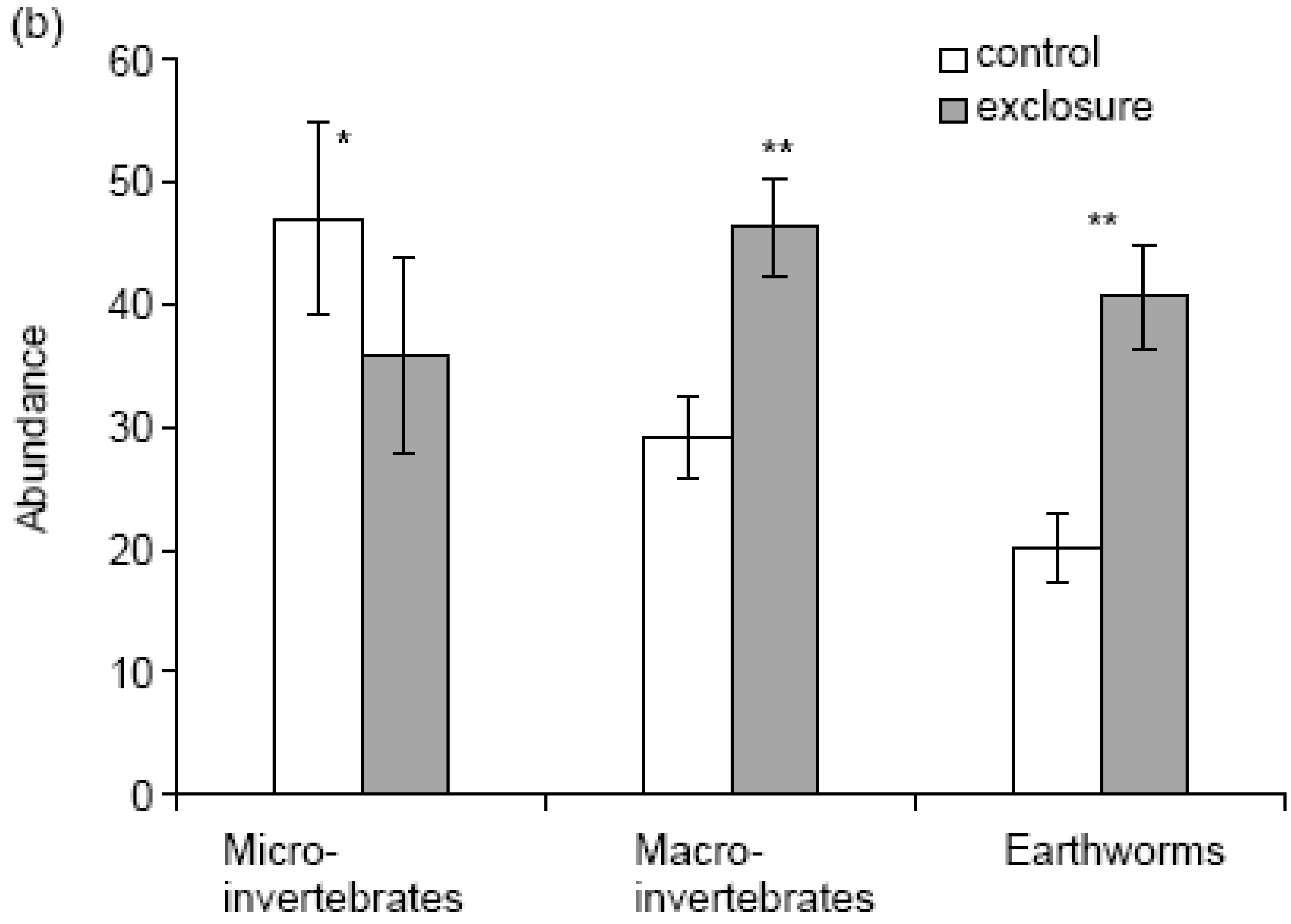
Methods

- Taı¨ National Park
- Seven Sites
- Each with control and caged plot (3 x 3m)
- cage excludes insectivores)

Measured (mostly after nine months):

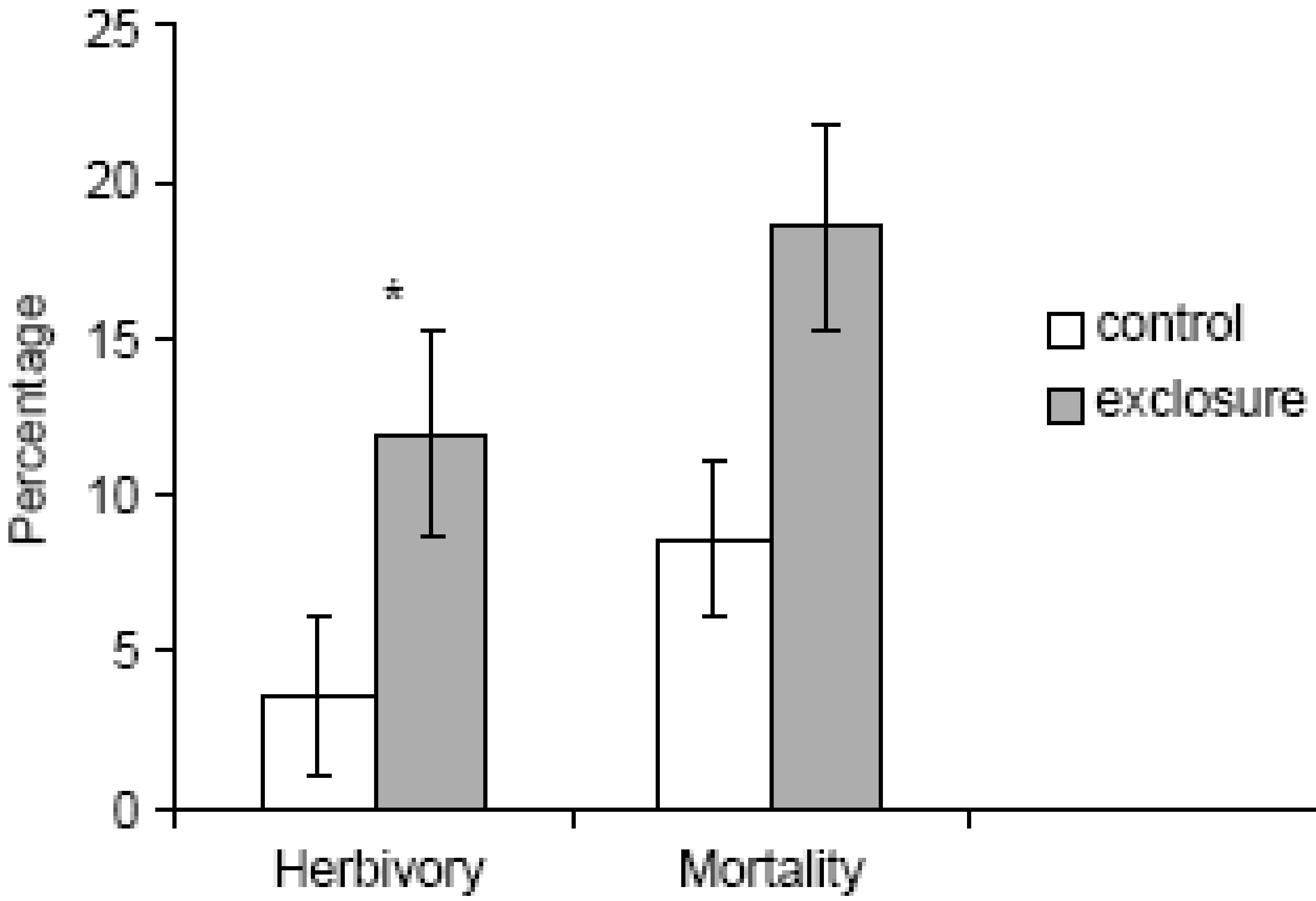
- Macro-invertebrates (>5mm)
- Micro-invertebrates (too small for vertebrates to eat)
- Earthworms
- Herbivory
- Nutrient Cycling

Invertebrate responses to insectivore exclusion

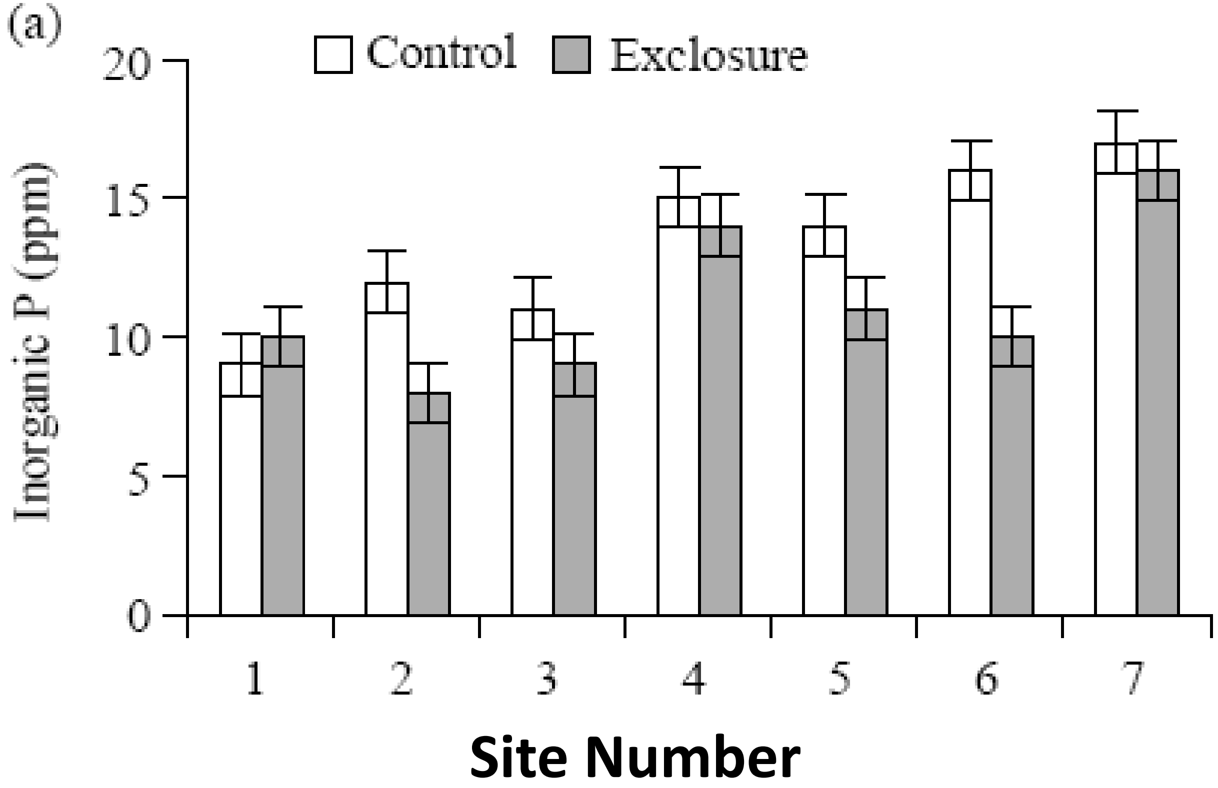


Error Bars = SE, * P < 0.05, ** P < 0.01

Herbivory and plant mortality



Phosphorus availability



Available Phosphorus 20% lower in exclosures

Path Analysis

Insectivore presence

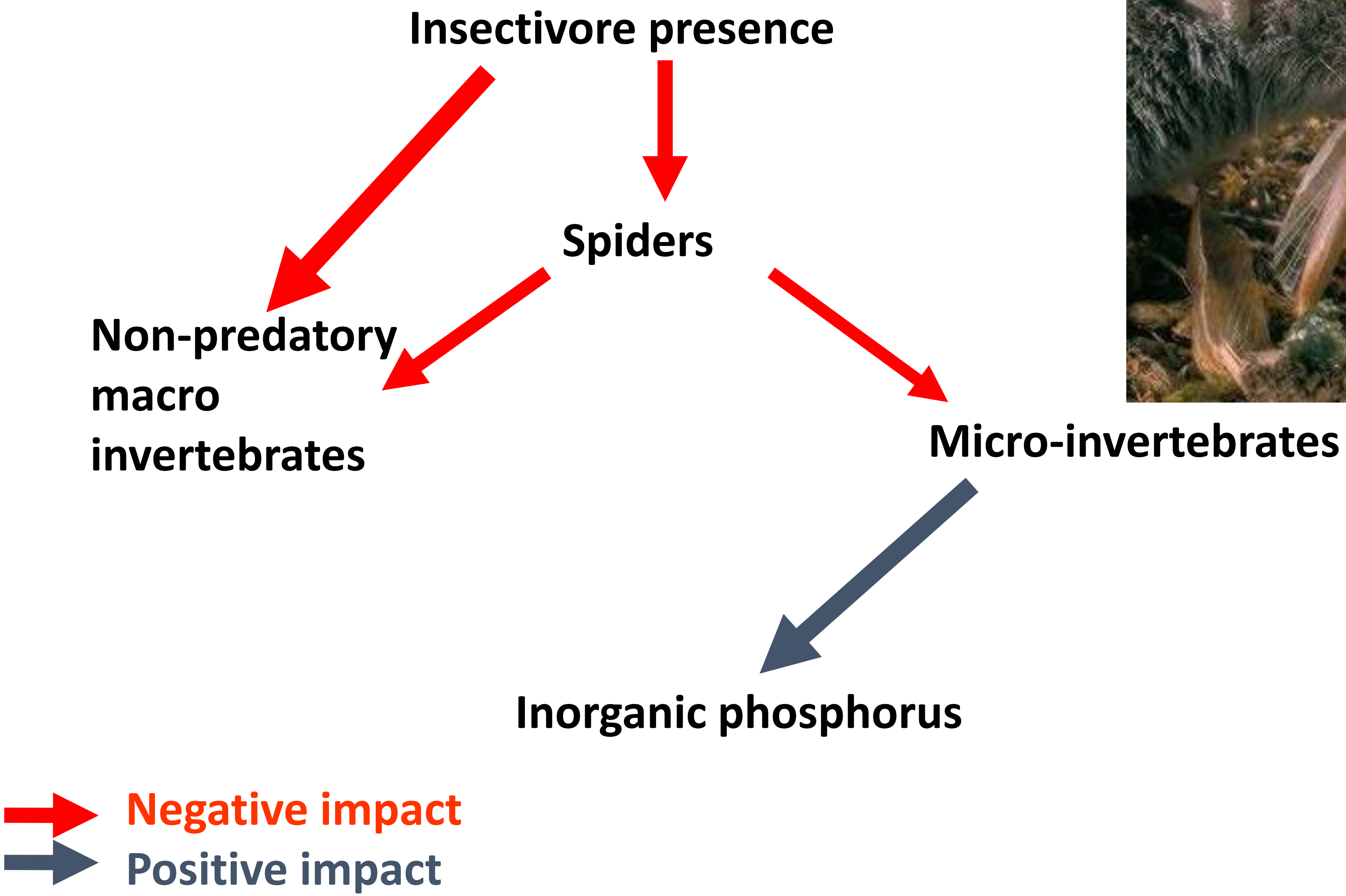
Spiders

Non-predatory macro invertebrates

Micro-invertebrates

Inorganic phosphorus

Path Analysis



Revegetation worst case hypothetical scenario

- **Habitat loss and fragmentation exterminated insectivores**
- **Cascading effects through invertebrate community**
- **High herbivory exterminates many plant species**
- **Some plant species fail to thrive due to low nutrients**
- **Revegetation remains in degraded state, unsuitable for vertebrate insectivores**

Implications for restoration……

- need to discover which species are missing from fragmented landscapes and plantings
- need to know how strongly those species interact with other species
- need to attempt to restore strongly interacting species to reduce impacts of habitat loss, and for restoration to be successful.

Key Points?