Applied Farmscape Ecology in the Mid-Hudson Valley: Preliminary Thoughts.

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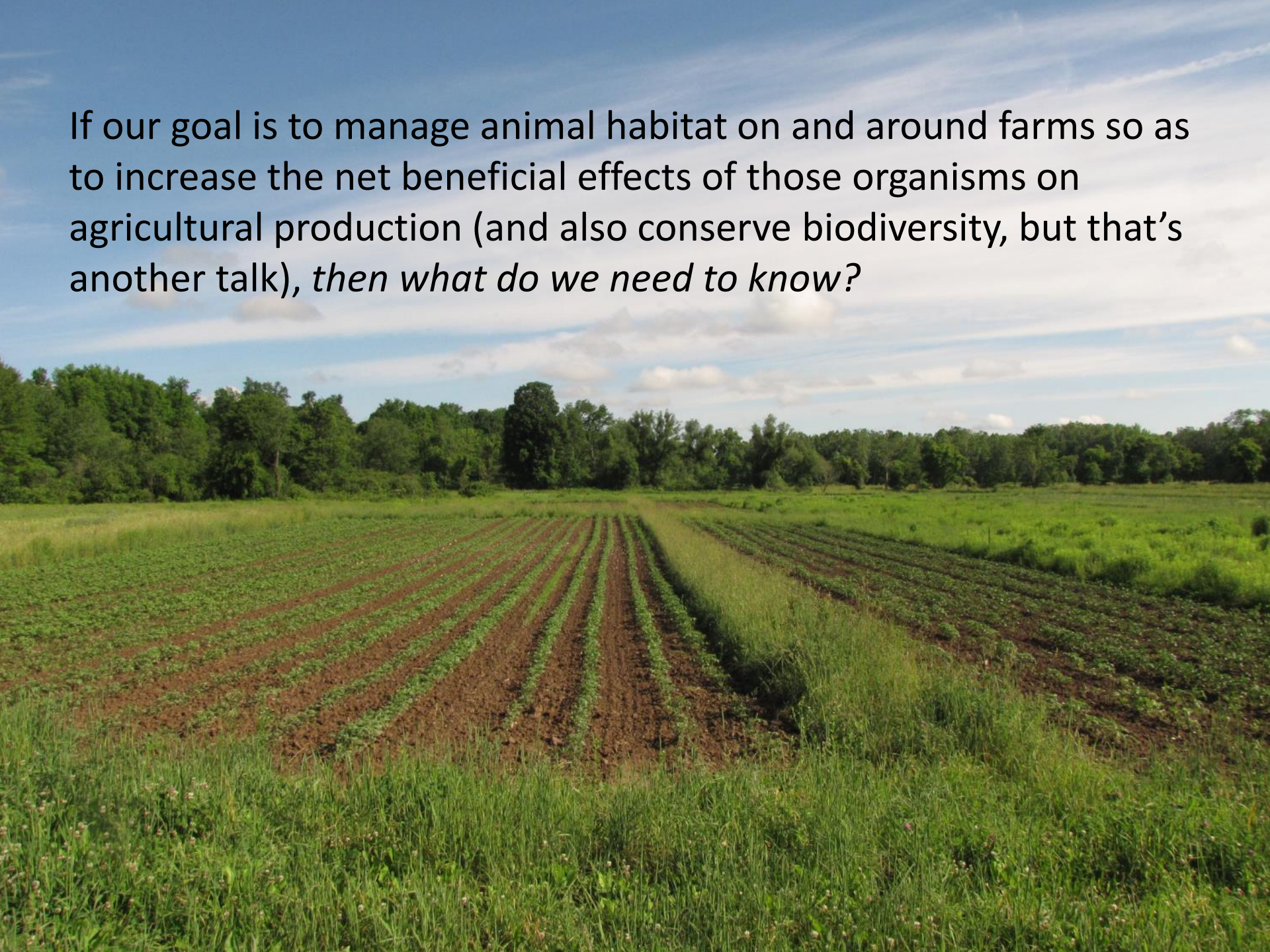
If our goal is to manage animal habitat on and around farms so as to increase the net beneficial effects of those organisms on agricultural production (and also conserve biodiversity, but that's another talk), *then what do we need to know?*



Who are the creatures of interest?

(brief photo review)

Syrphids = Flower Flies = Hover Flies


Lady Beetles

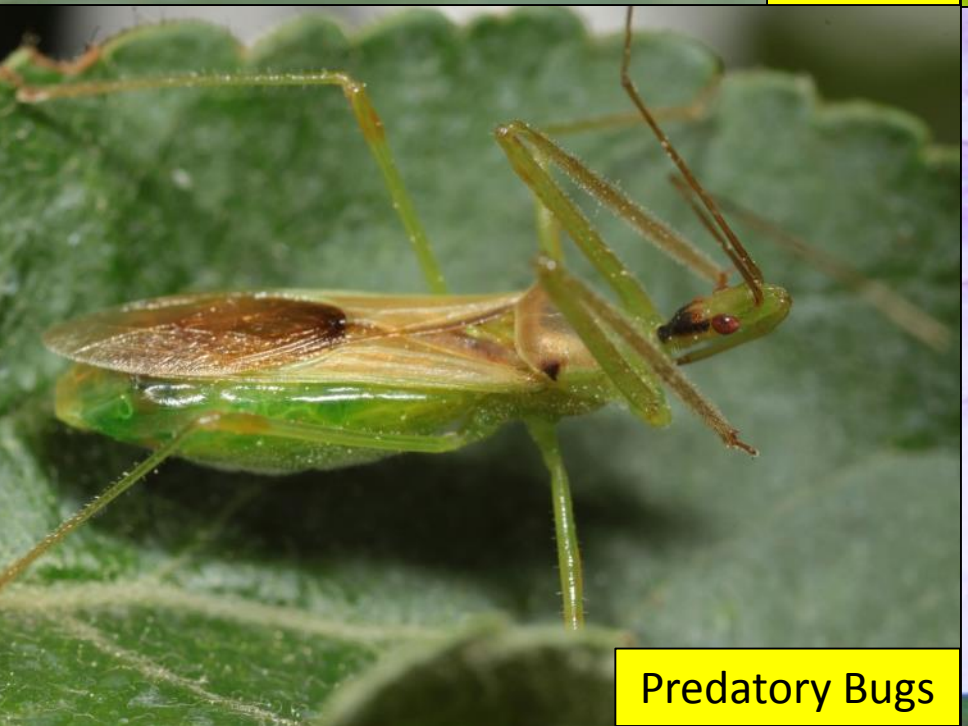

Spiders


Ground Beetles (at Least 45 species at the Hub)


Lacewing Larvae

Wasps

Long-legged Flies



Predatory Bugs

Native Bees (at least 41 species at the Hub)

Which habitats around the Farm do those creatures of interest use?

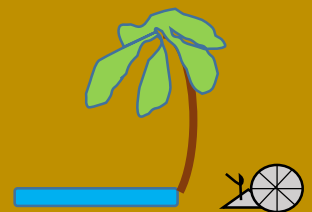
Spider Spa

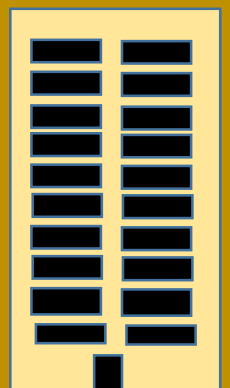
Wasp Wohnung

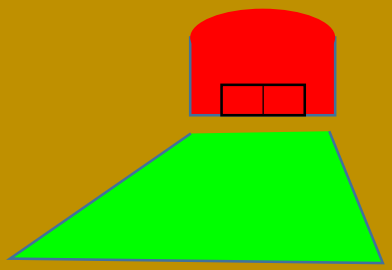
The Farm

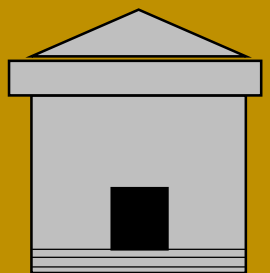
Beetle Bank

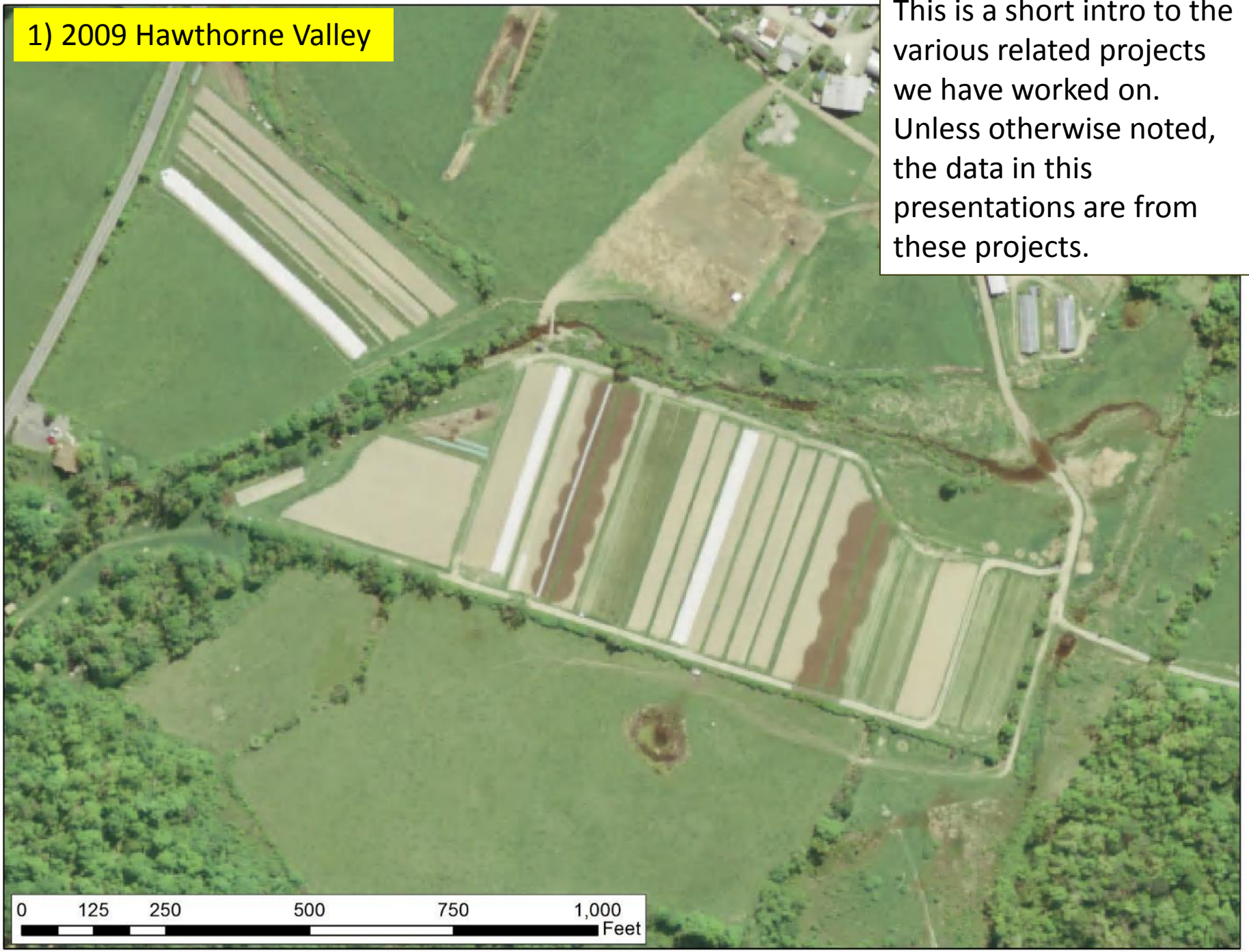
Bee Bar

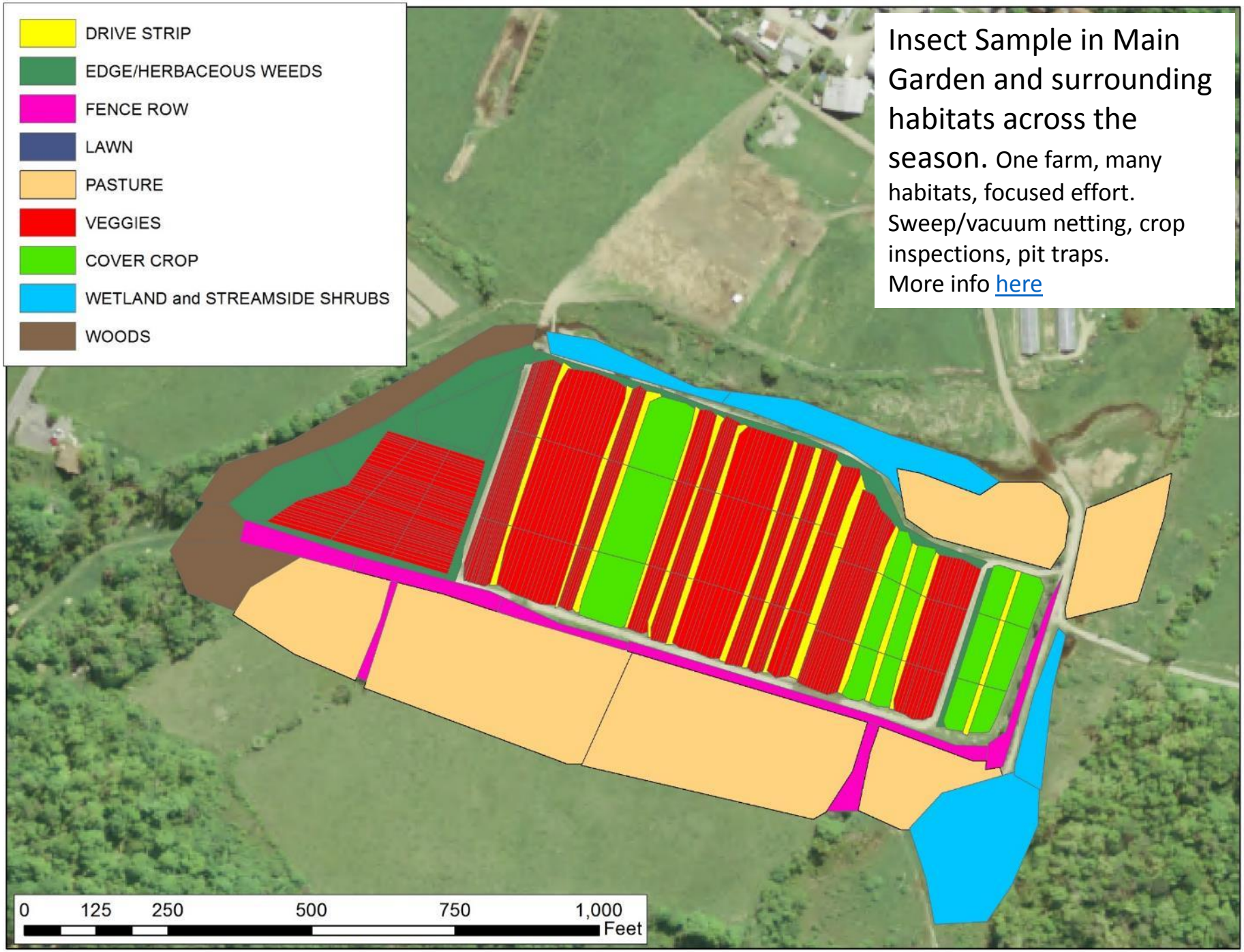








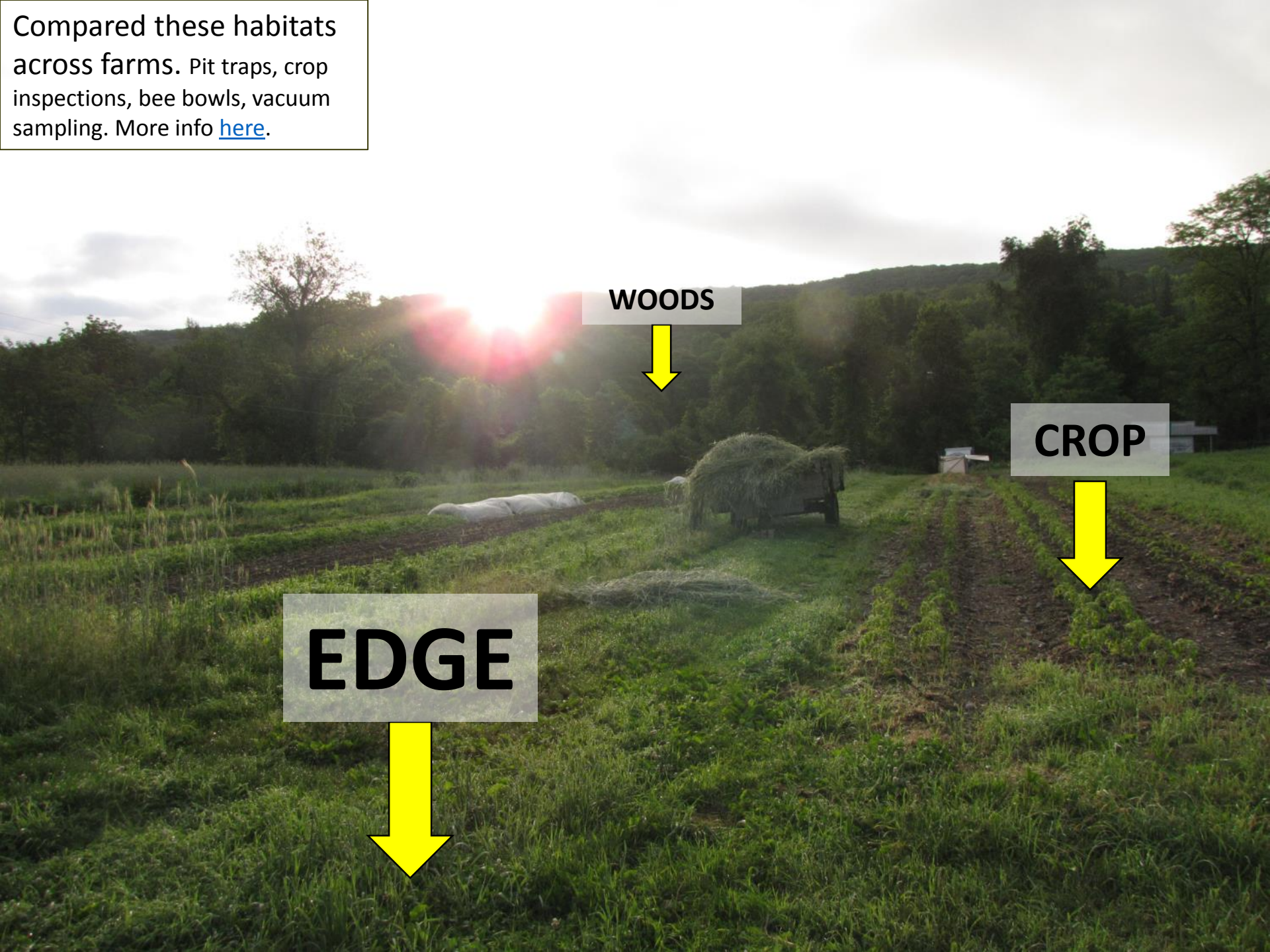

1) 2009 Hawthorne Valley
This is a short intro to the various related projects we have worked on. Unless otherwise noted, the data in this presentations are from these projects.
0
125
250
500
750
1,000
Feet

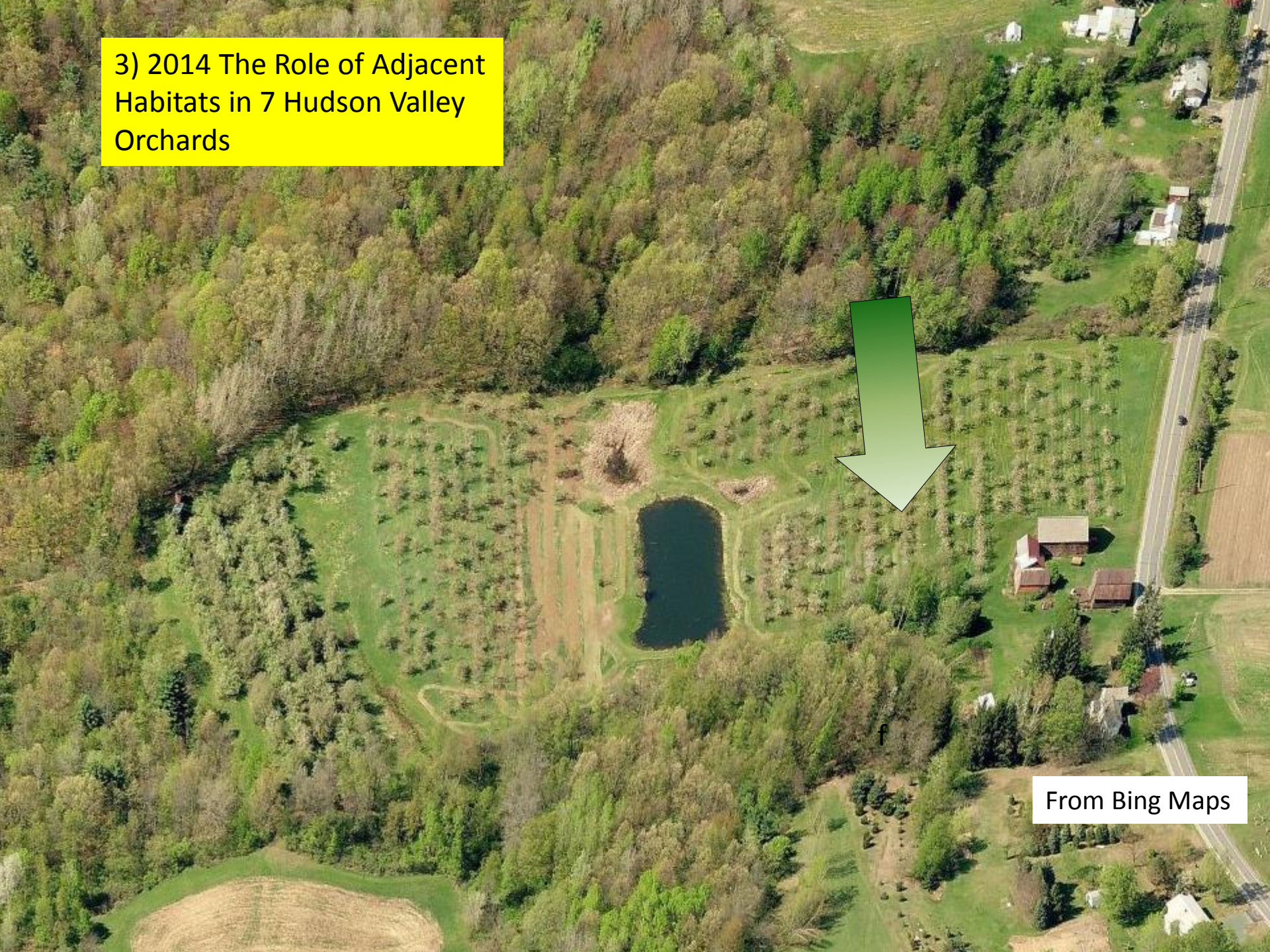


Insect Sample in Main Garden and surrounding habitats across the season. One farm, many habitats, focused effort. Sweep/vacuum netting, crop inspections, pit traps.
More info here

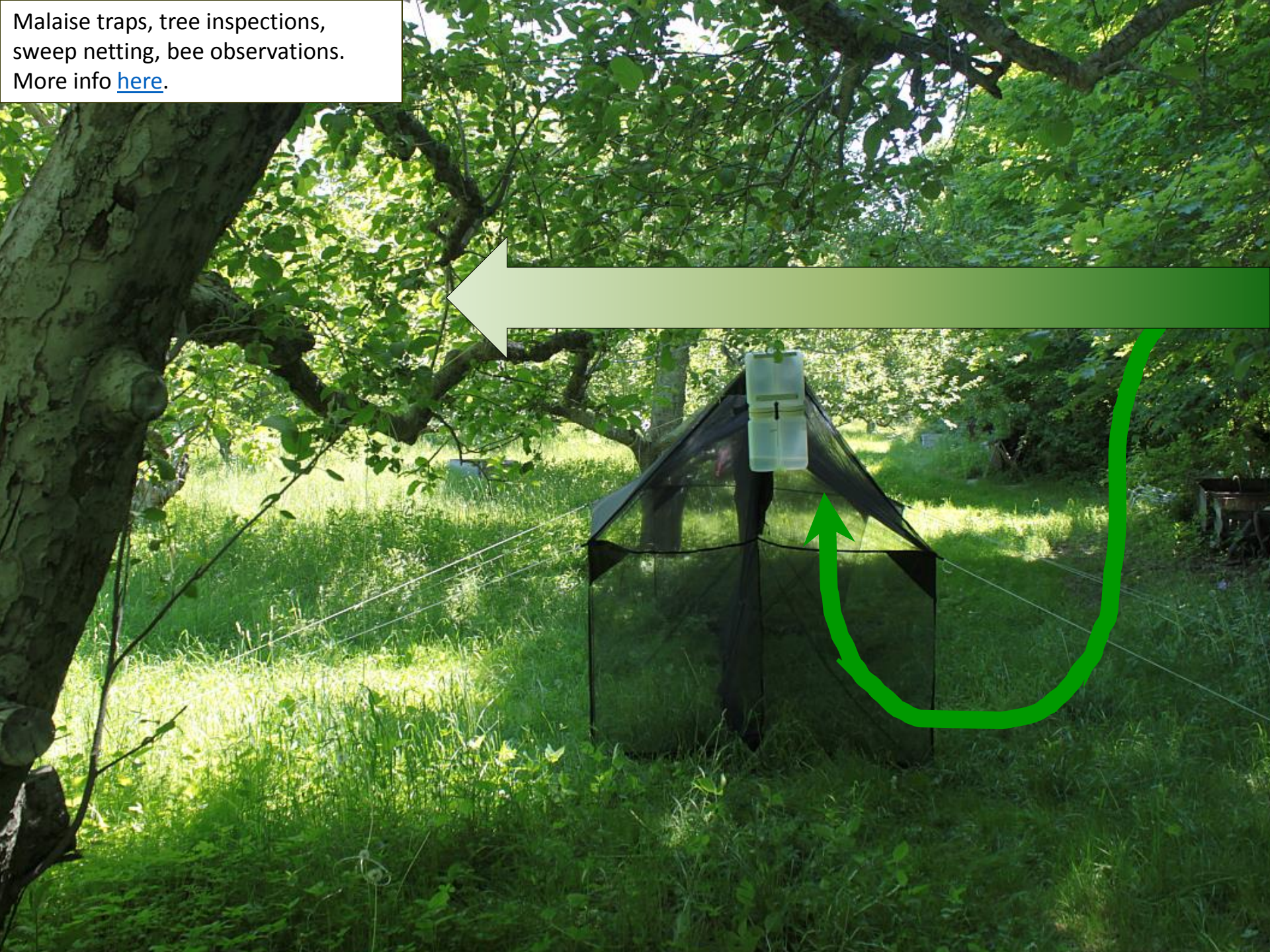
2) 2010 on 19 Columbia County Veg Farms, focus on tomatoes and surroundings

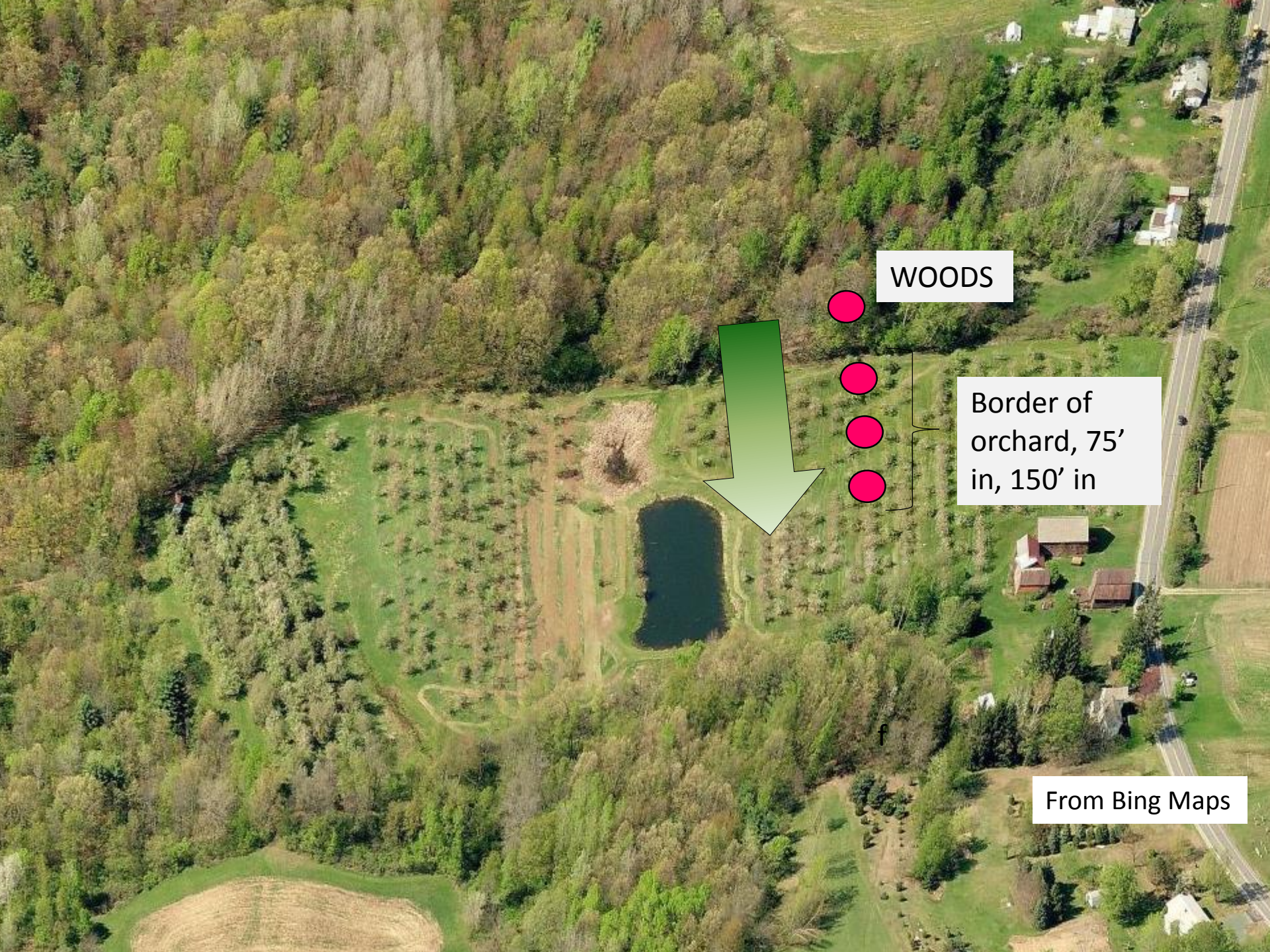
Compared these habitats across farms. Pit traps, crop inspections, bee bowls, vacuum sampling. More info here.




3) 2014 The Role of Adjacent Habitats in 7 Hudson Valley Orchards
f
From Bing Maps

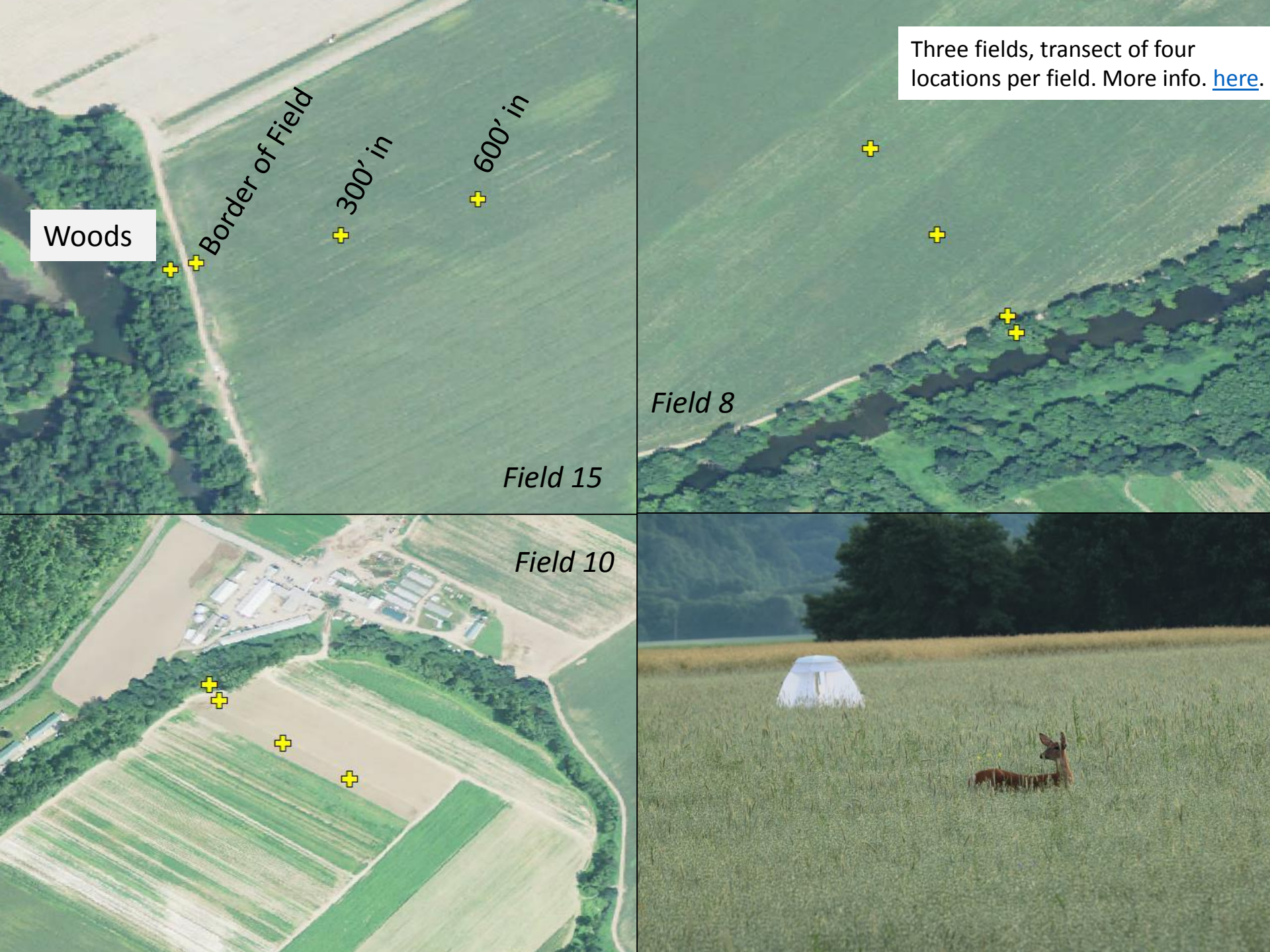
Malaise traps, tree inspections, sweep netting, bee observations. More info here.



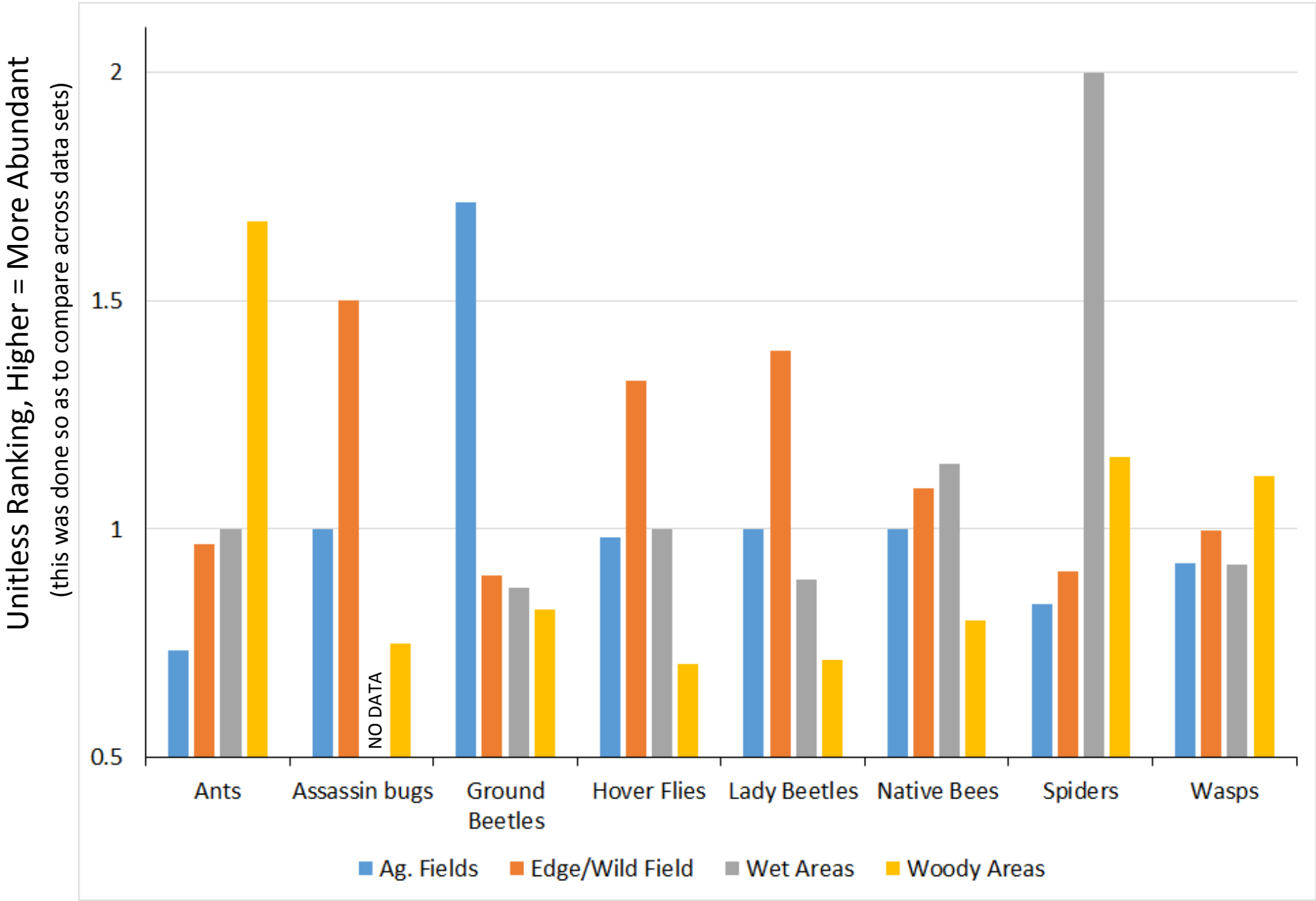

WOODS
Border of orchard, 75’ in, 150’ in
From Bing Maps


4) In 2012-2014, we compared the insect communities of wild meadows and landscape native-plant meadows.
Sweep netting, misc. other observations, more info. here.

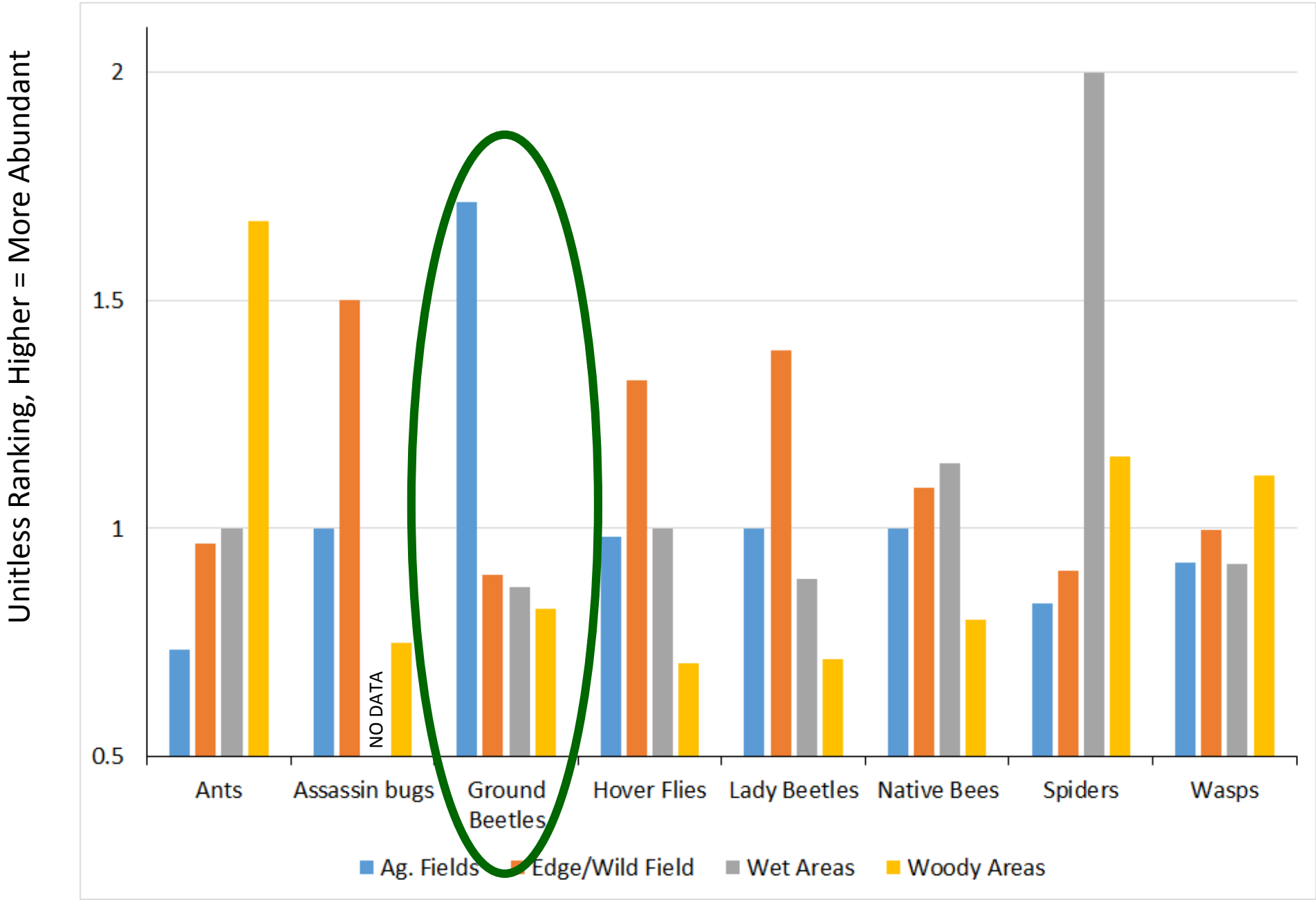

5) 2016 Farm Hub.


Woods
Border of Field
300’ in
600’ in
Field 15
Three fields, transect of four locations per field. More info. here.
Field 8
Field 10

Summary of our Data (3-10 data sets per species group), let's start with beneficials



Looking at the ground beetle data in a different way…..




Suppose one took this landscape….


… coded its habitats…
Ag
Edge/Wild Fields
Wet Areas
Woody (Shrubs and Trees)

And then plotted those relative abundances.

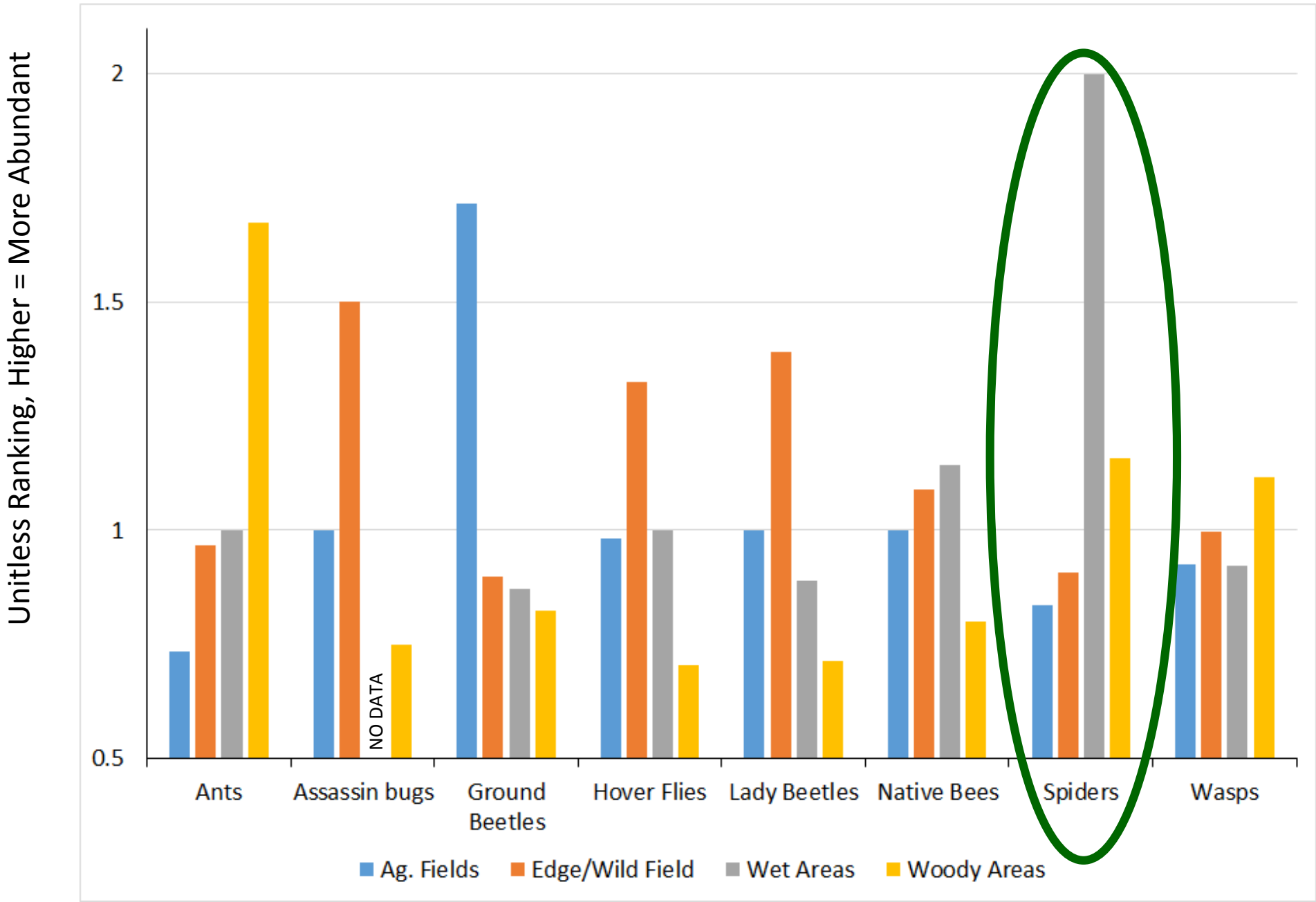
Hypothetical Habitat Use
Ground Beetles

MANY

MEDIUM NUMBERS

FEW

Or….


Unitless Ranking, Higher = More Abundant
2
1.5
1
0.5
NO DATA
Ants
Assassin bugs
Ground Beetles
Hover Flies
Lady Beetles
Native Bees
Spiders
Wasps
Ag. Fields
Edge/Wild Field
Wet Areas
Woody Areas

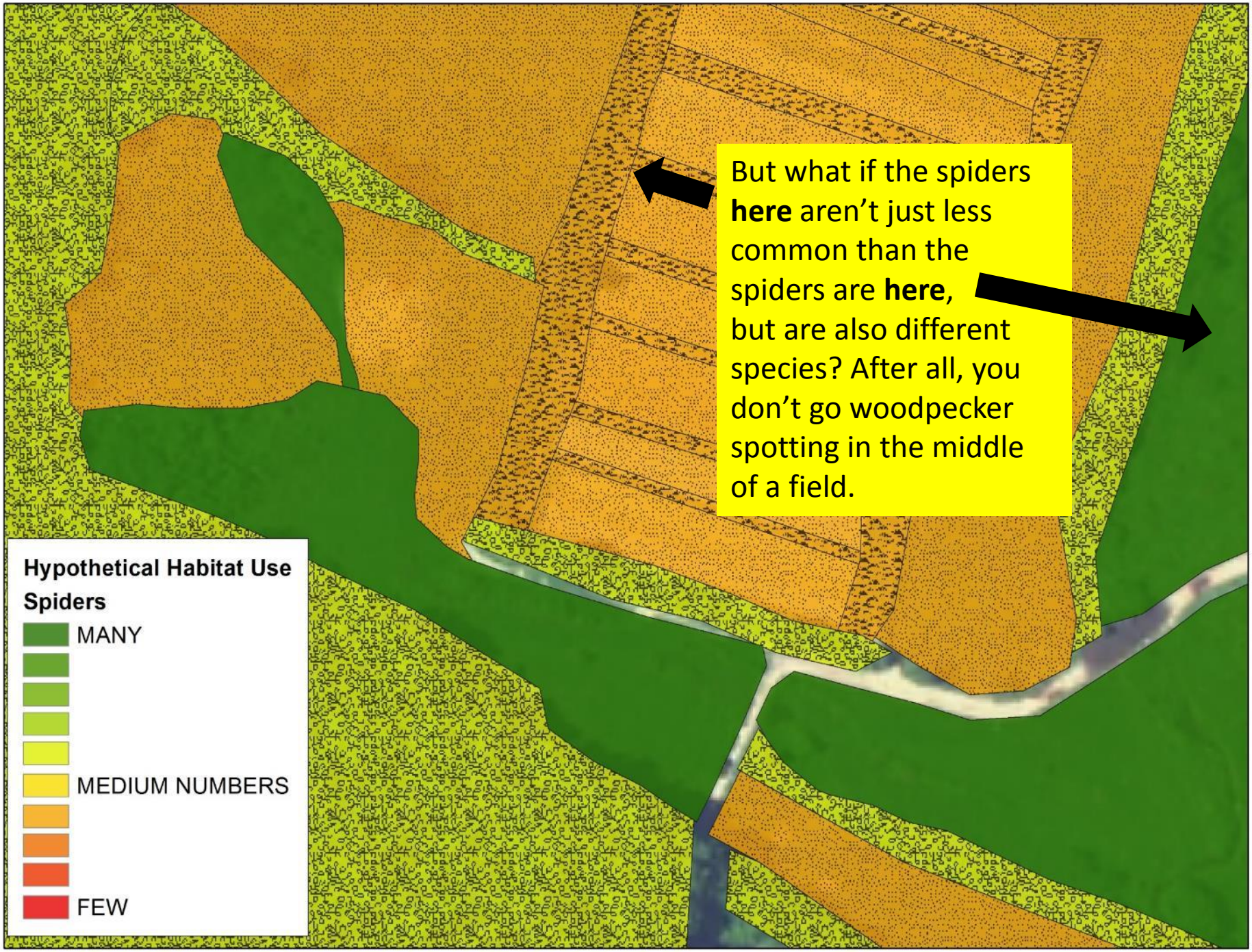

Same approach but for spiders….

Hypothetical Habitat Use
Spiders
MANY
MEDIUM NUMBERS
FEW

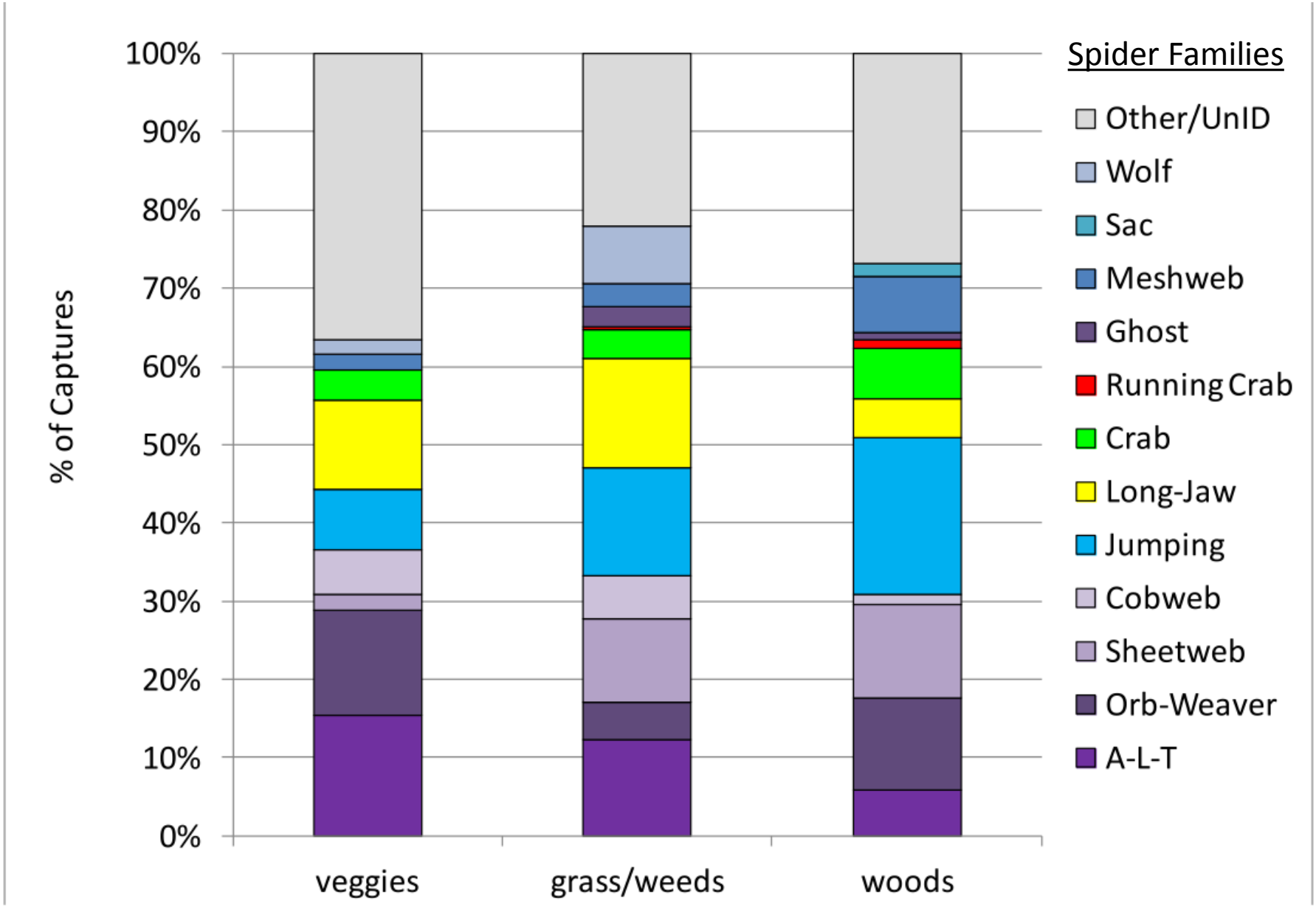
R.o.T. (Rule of Thumb) #1:

Different types of habitat are important for different groups of beneficials. One size does not fit all.


But I am assuming that a high density area can serve as a source of beneficials to a low density area.
Hypothetical Habitat Use
Spiders
MANY
MEDIUM NUMBERS
FEW


But what if the spiders **here** aren't just less common than the spiders are **here**, but are also different species? After all, you don't go woodpecker spotting in the middle of a field.
Hypothetical Habitat Use
Spiders
MANY
MEDIUM NUMBERS
FEW

This is as far as we have gotten with spiders. At this level, there does appear to be some similarity among the spider communities



We hope to do more with spiders this year, but we've gotten further with Ground Beetles, so let's look at them…

The Distribution of a Ground Beetle across a Field.

Anisodactylus sanctaecrucis

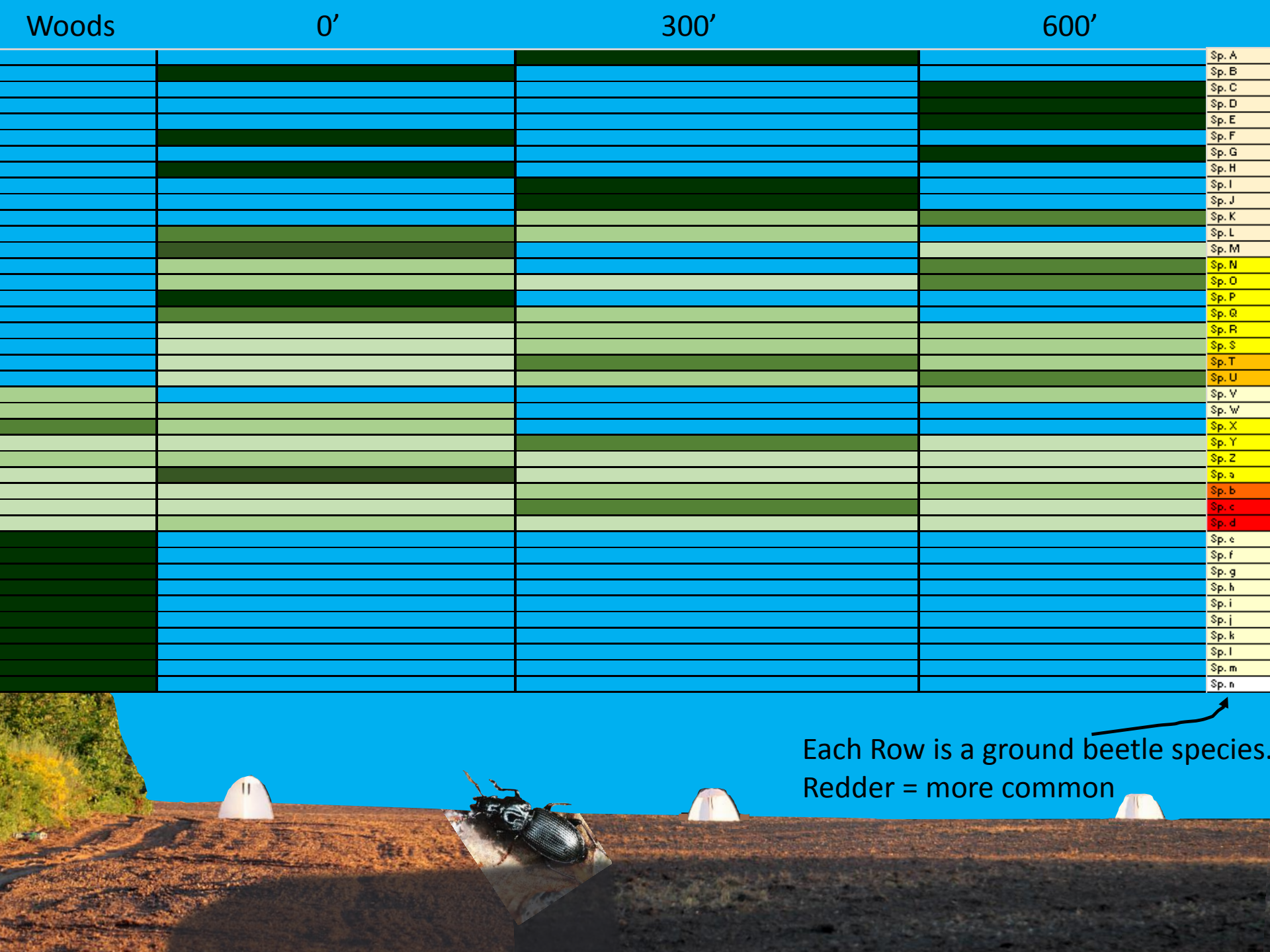
Woods 0’ 300’ 600’

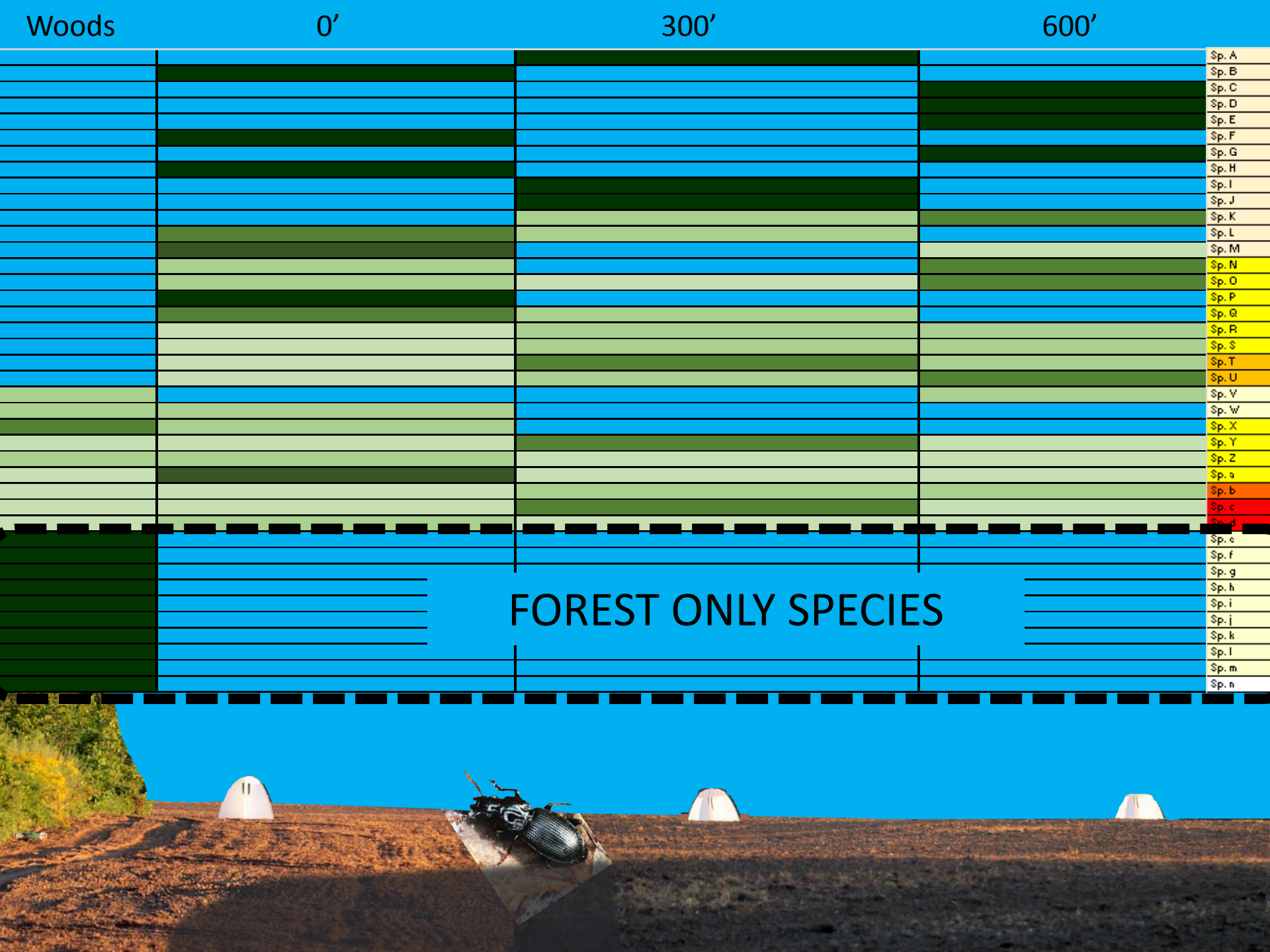
Here’s an example with one species, darker green = greater catch. This species was only found in fields.

Chlaenius aestivus

Woods 0’ 300’ 600’

Here’s an example with another species, this species was only found in forests.


Woods
0’
300’
600’
Sp. A
Sp. B
Sp. C
Sp. D
Sp. E
Sp. F
Sp. G
Sp. H
Sp. I
Sp. J
Sp. K
Sp. L
Sp. M
Sp. N
Sp. O
Sp. P
Sp. Q
Sp. R
Sp. S
Sp. T
Sp. U
Sp. V
Sp. W
Sp. X
Sp. Y
Sp. Z
Sp. a
Sp. b
Sp. c
Sp. d
Sp. e
Sp. f
Sp. g
Sp. h
Sp. i
Sp. j
Sp. k
Sp. l
Sp. m
Sp. n
Each Row is a ground beetle species.
Redder = more common


Woods
0’
300’
600’
Sp. A
Sp. B
Sp. C
Sp. D
Sp. E
Sp. F
Sp. G
Sp. H
Sp. I
Sp. J
Sp. K
Sp. L
Sp. M
Sp. N
Sp. O
Sp. P
Sp. Q
Sp. R
Sp. S
Sp. T
Sp. U
Sp. V
Sp. W
Sp. X
Sp. Y
Sp. Z
Sp. a
Sp. b
Sp. c
Sp. d
Sp. e
Sp. f
Sp. g
Sp. h
Sp. i
Sp. j
Sp. k
Sp. l
Sp. m
Sp. n
FOREST ONLY SPECIES


Woods
0’
300’
600’
Sp. B
Sp. C
Sp. D
Sp. E
Sp. F
Sp. G
Sp. H
Sp. I
Sp. J
Sp. K
Sp. L
Sp. M
Sp. N
Sp. O
Sp. P
Sp. Q
Sp. R
Sp. S
Sp. T
Sp. U
Sp. W
Sp. X
Sp. Y
Sp. Z
Sp. a
Sp. b
Sp. c
Sp. d
Sp. e
Sp. f
Sp. g
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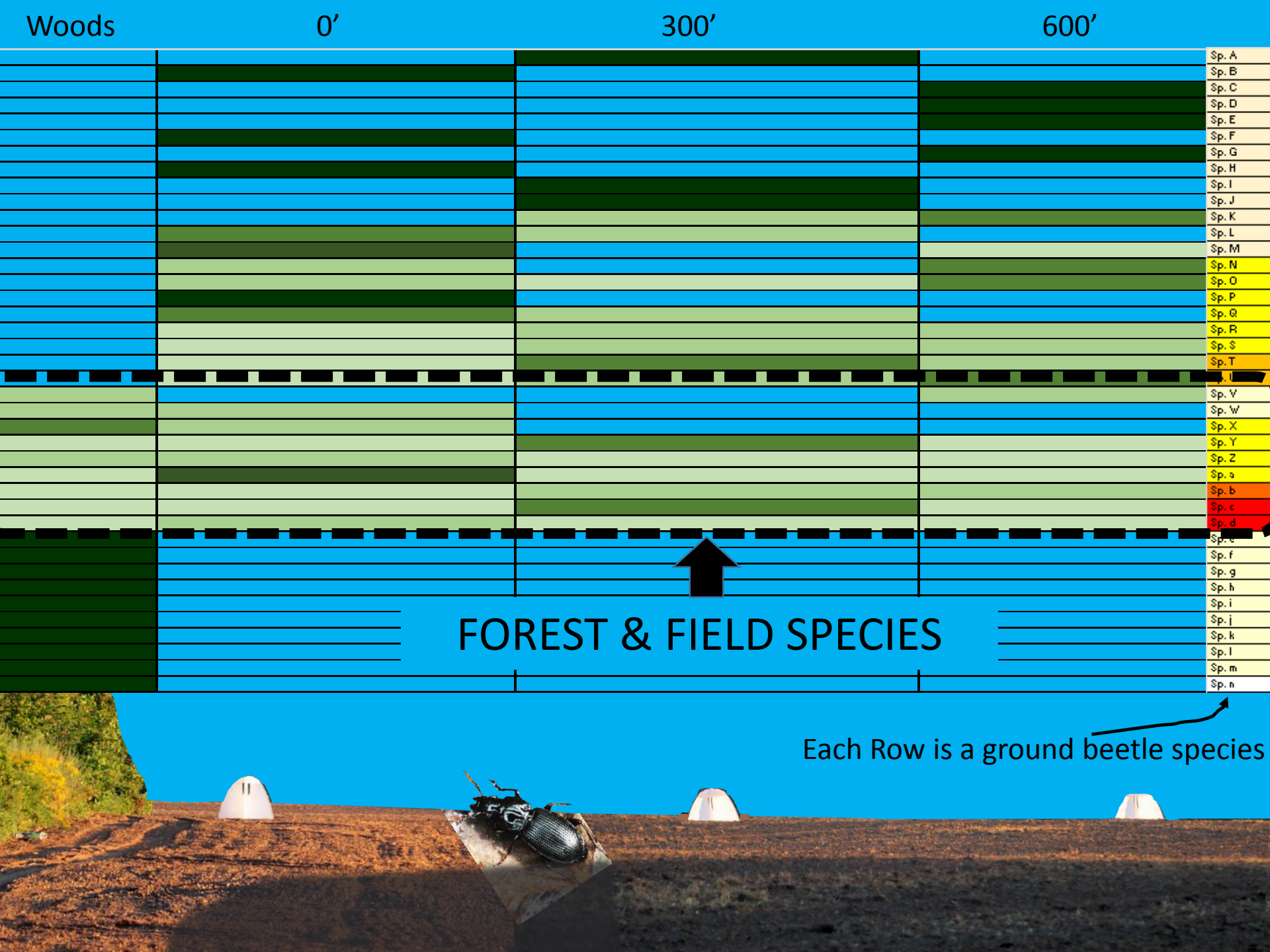
Sp. i
Sp. j
Sp. k
Sp. l
Sp. m
Sp. n
FIELD ONLY SPECIES
Each Row is a ground beetle species


Woods
0’
300’
600’
Sp. A
Sp. B
Sp. C
Sp. D
Sp. E
Sp. F
Sp. G
Sp. H
Sp. I
Sp. J
Sp. K
Sp. L
Sp. M
Sp. N
Sp. O
Sp. P
Sp. Q
Sp. R
Sp. S
Sp. T
Sp. V
Sp. W
Sp. X
Sp. Y
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Sp. a
Sp. b
Sp. c
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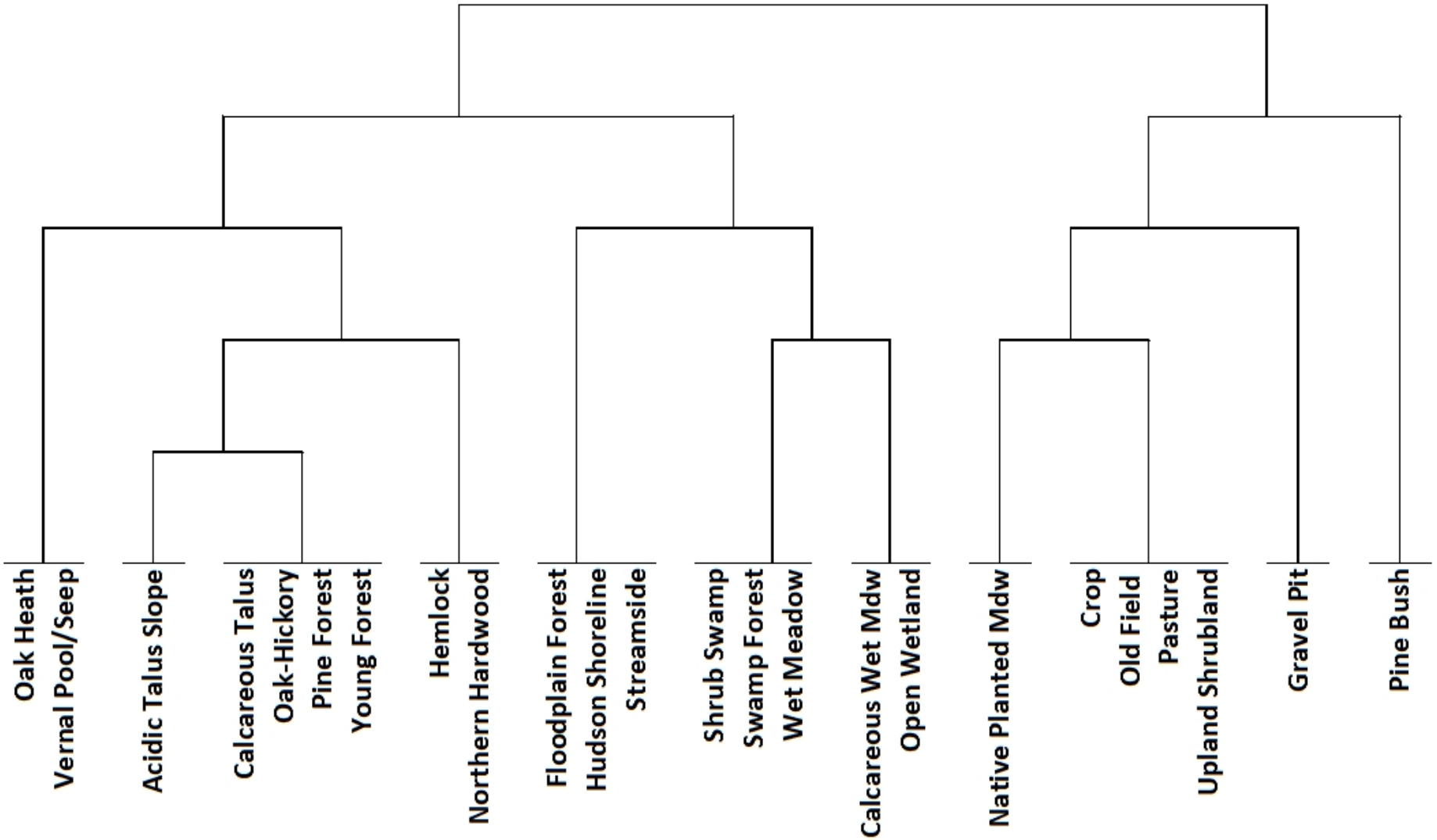
Sp. g
Sp. h
Sp. i
Sp. j
Sp. k
Sp. l
Sp. m
Sp. n
FOREST & FIELD SPECIES
Each Row is a ground beetle species

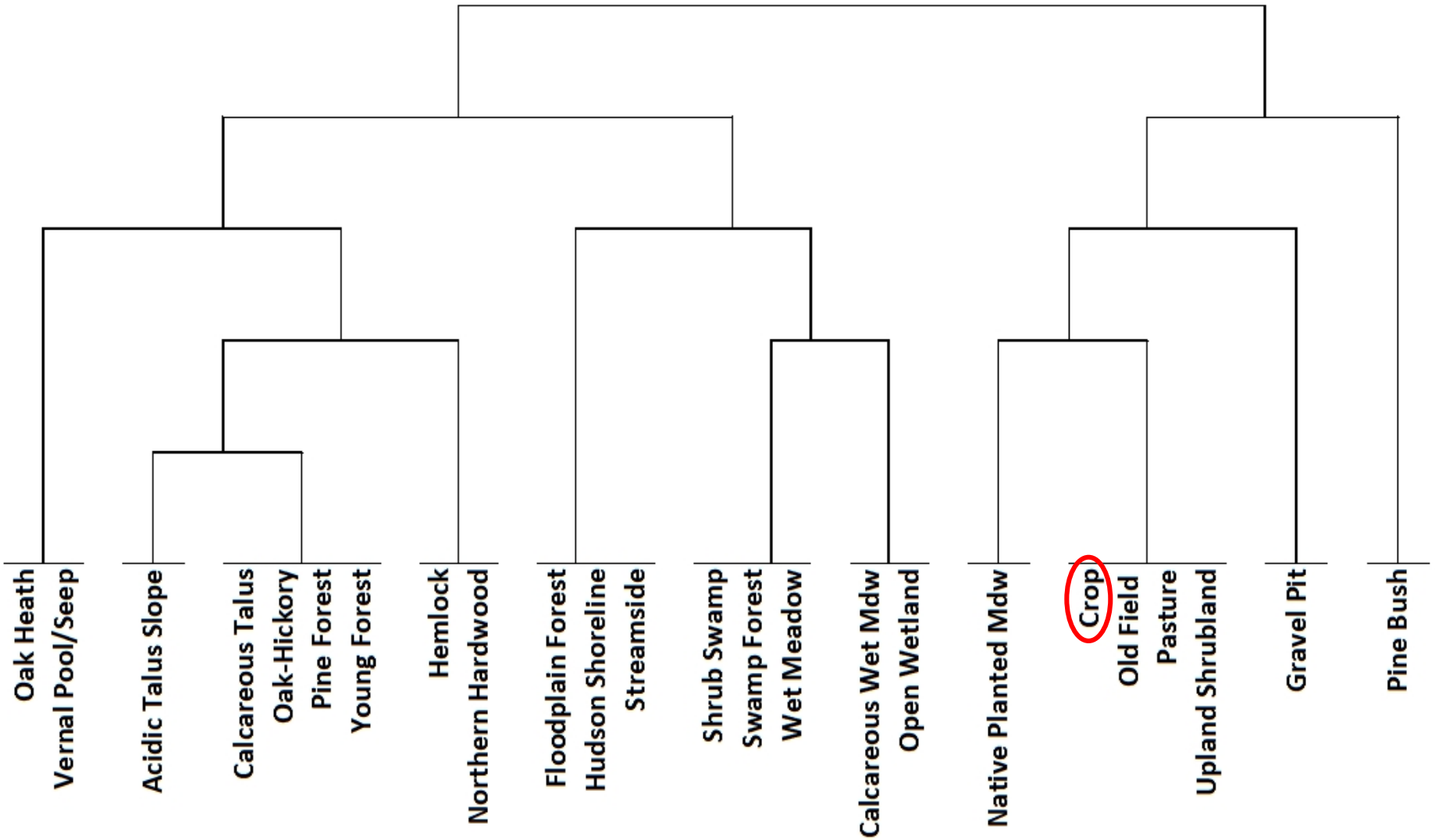

For ground beetles, ‘Forest & Field’ species are the group which has the most potential to be helped by woody habitat management. They are also some of the most common species.

2012-2014, *Columbia County Living Land Project*

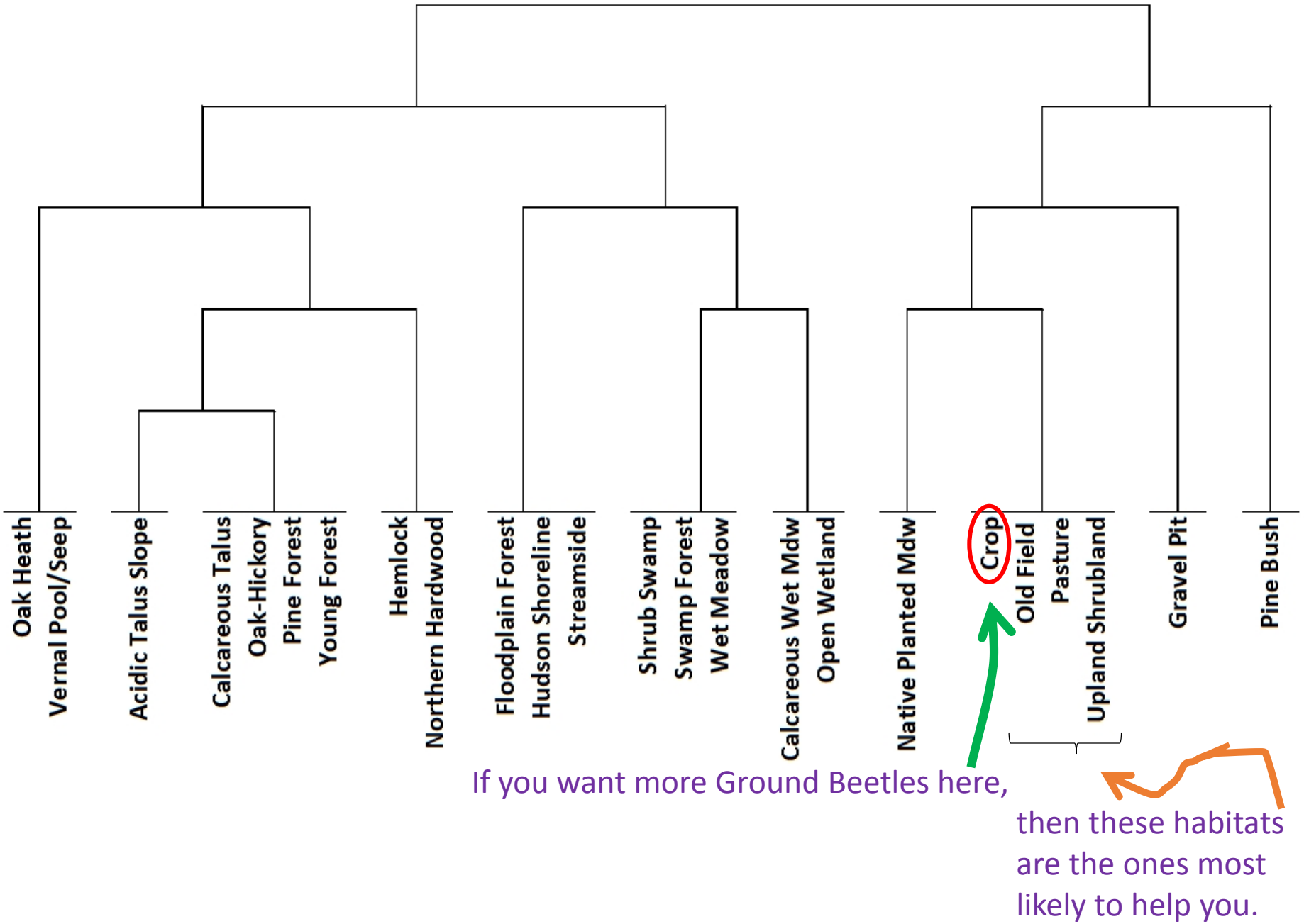


These are data from another project in which we compared ground beetle communities across habitats in Columbia County.

Columbia County Ground Beetle Communities



Columbia County Ground Beetle Communities


Oak Heath
Vernal Pool/Seep
Acidic Talus Slope
Calcareous Talus
Oak-Hickory
Pine Forest
Young Forest
Hemlock
Northern Hardwood
Floodplain Forest
Hudson Shoreline
Streamside
Shrub Swamp
Swamp Forest
Wet Meadow
Calcareous Wet Mdw
Open Wetland
Native Planted Mdw
Crop
Old Field
Pasture
Upland Shrubland
Gravel Pit
Pine Bush
If you want more Ground Beetles here,
then these habitats are the ones most likely to help you.

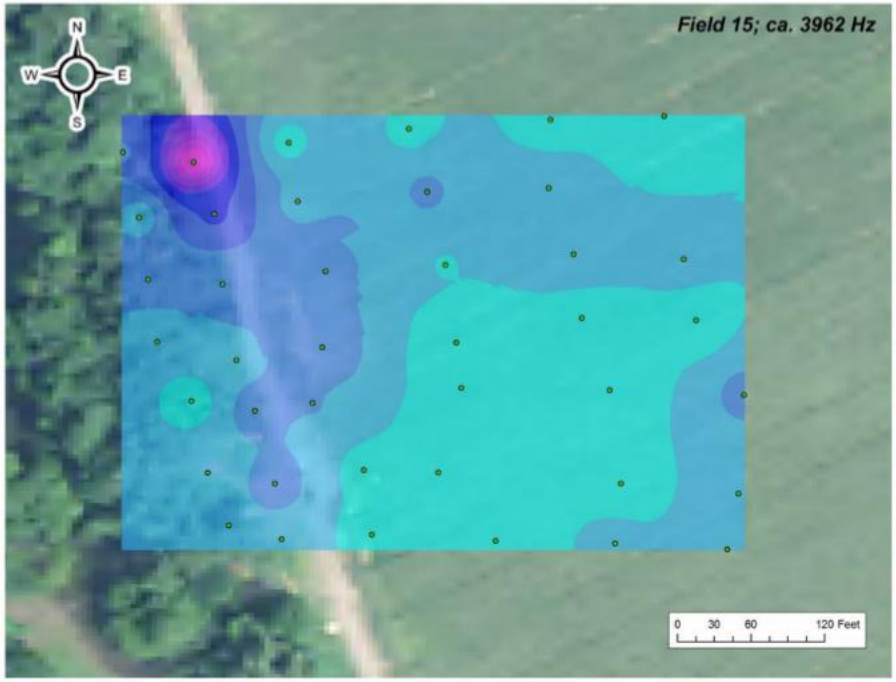
The same general idea holds for bees.

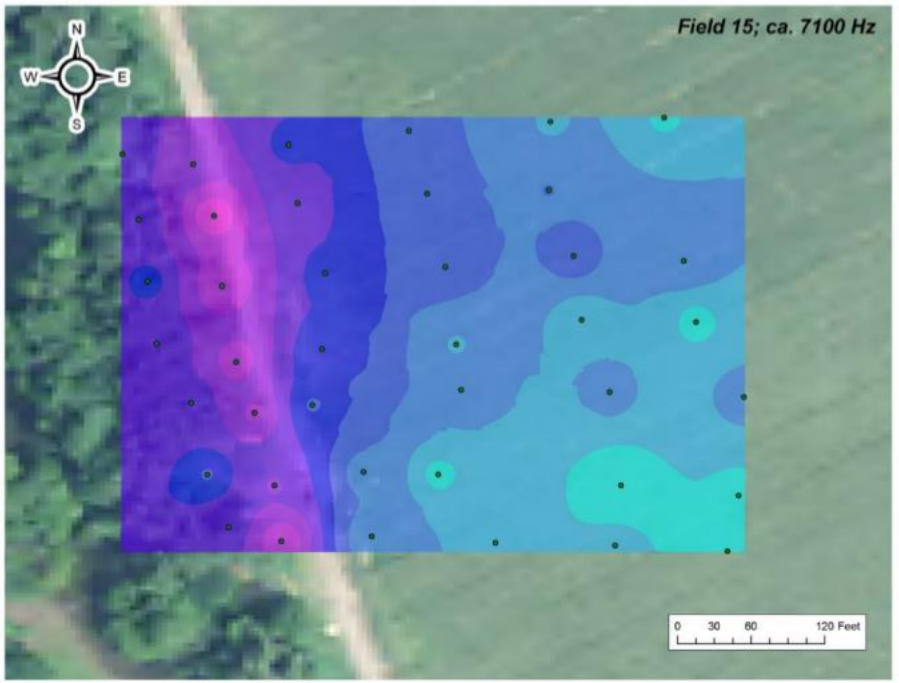
Of 29 Hub bee species:

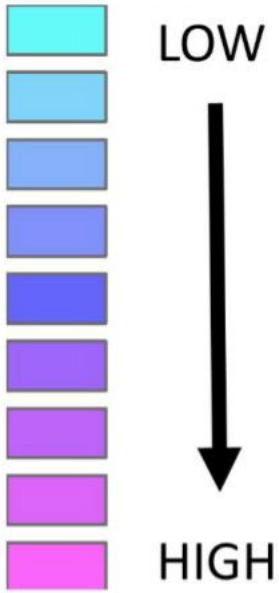
- 3 were only found in the woods
- 6 were found in field and woods
- 20 were only found in the field

Of 29 Hub bee species:

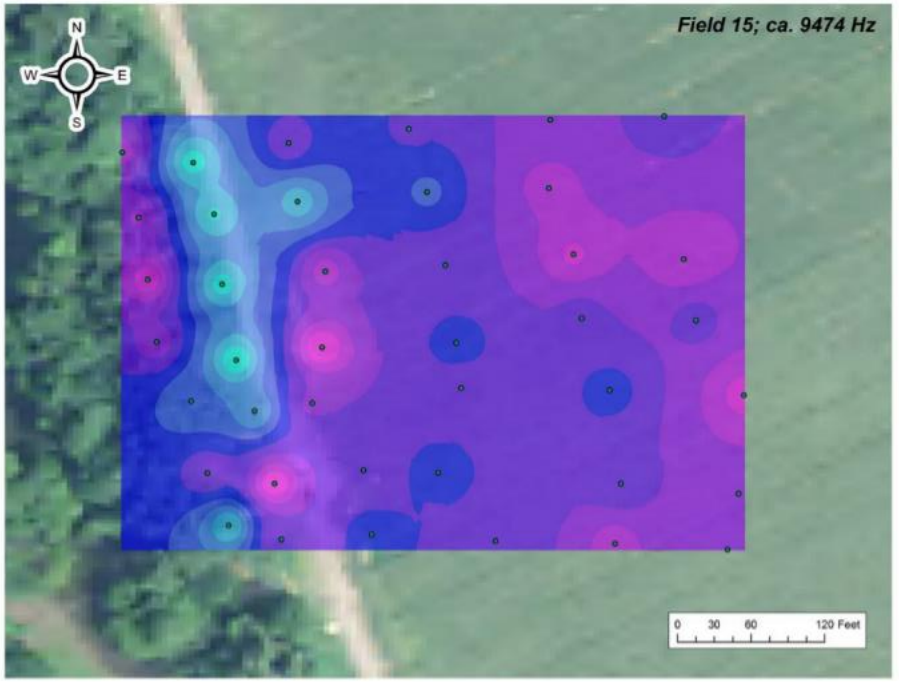
- 3 were only found in the woods (100% of these were pith-, stem- or wood-nesters)
- 6 were found in field and woods (only 17% of these were pith-, stem- or wood-nesters)
- 20 were only found in the field (only 15% of these were pith-, stem- or wood-nesters)







These are three different species of singing orthopterans whose distributions we mapped using sound recordings. Again, not surprisingly, species are picky in their habitat use.



A Caveat: How many new species do you see?

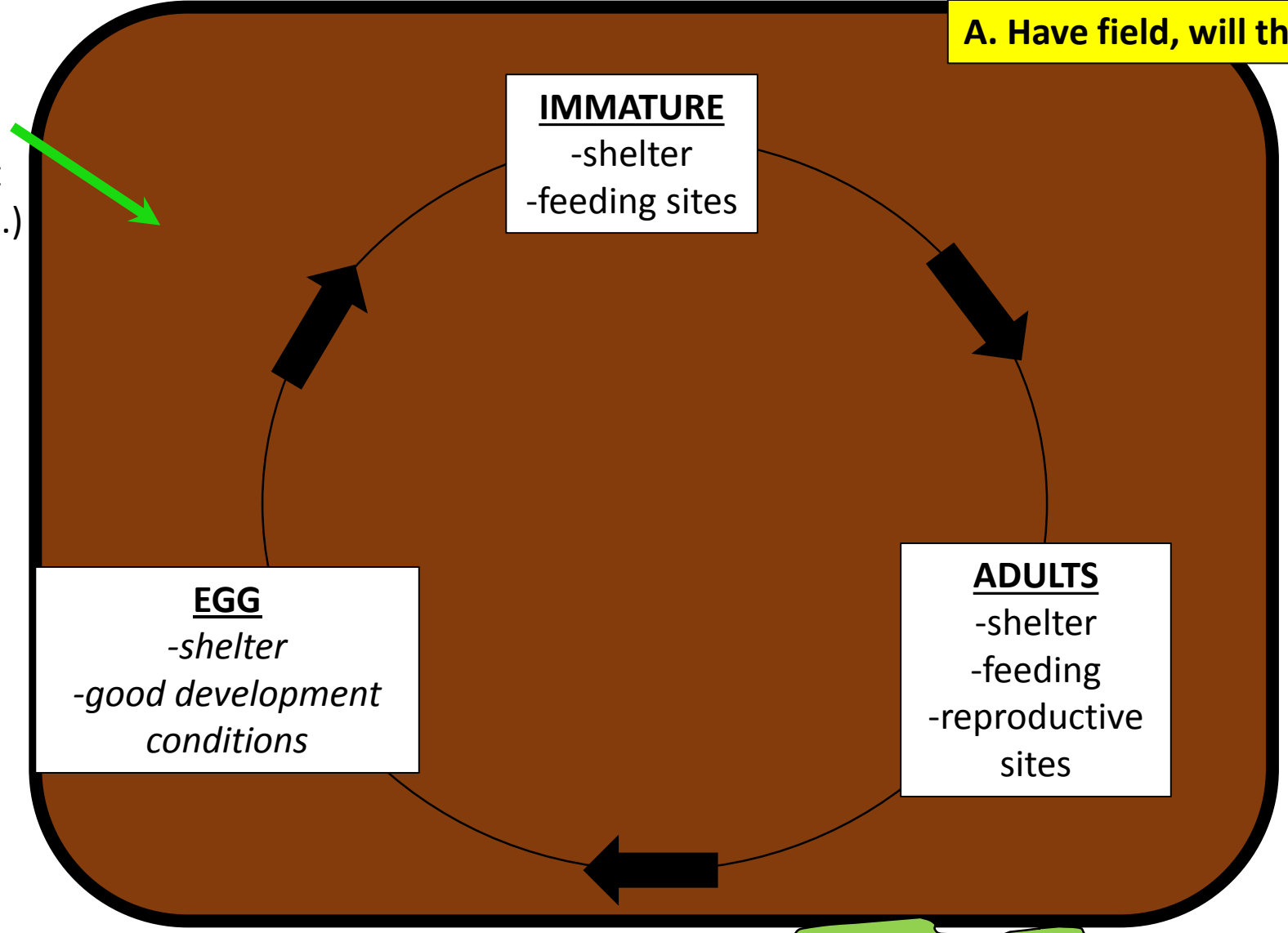
R.o.T. #2:

Within general groups of beneficials, different species have different habitat preferences, so species-specific data are important.


*To better understand habitat needs, how can we **categorize the relationships** between beneficials and non-crop habitat?*

A. Have field, will thrive.

(Brown glob is meant to represent farm field.)

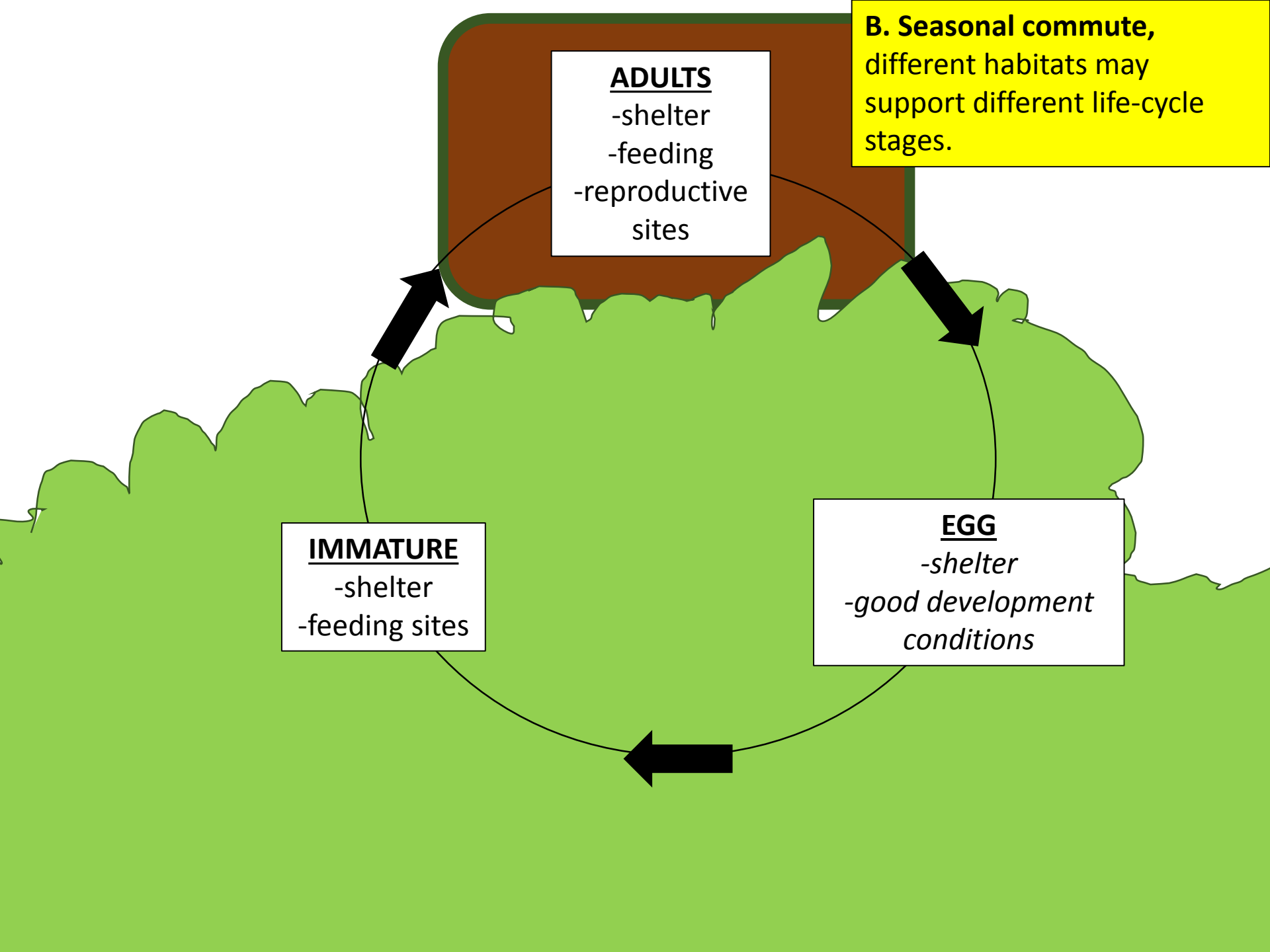


IMMATURE
-shelter
-feeding sites

ADULTS
-shelter
-feeding
-reproductive sites

EGG
-shelter
-good development conditions

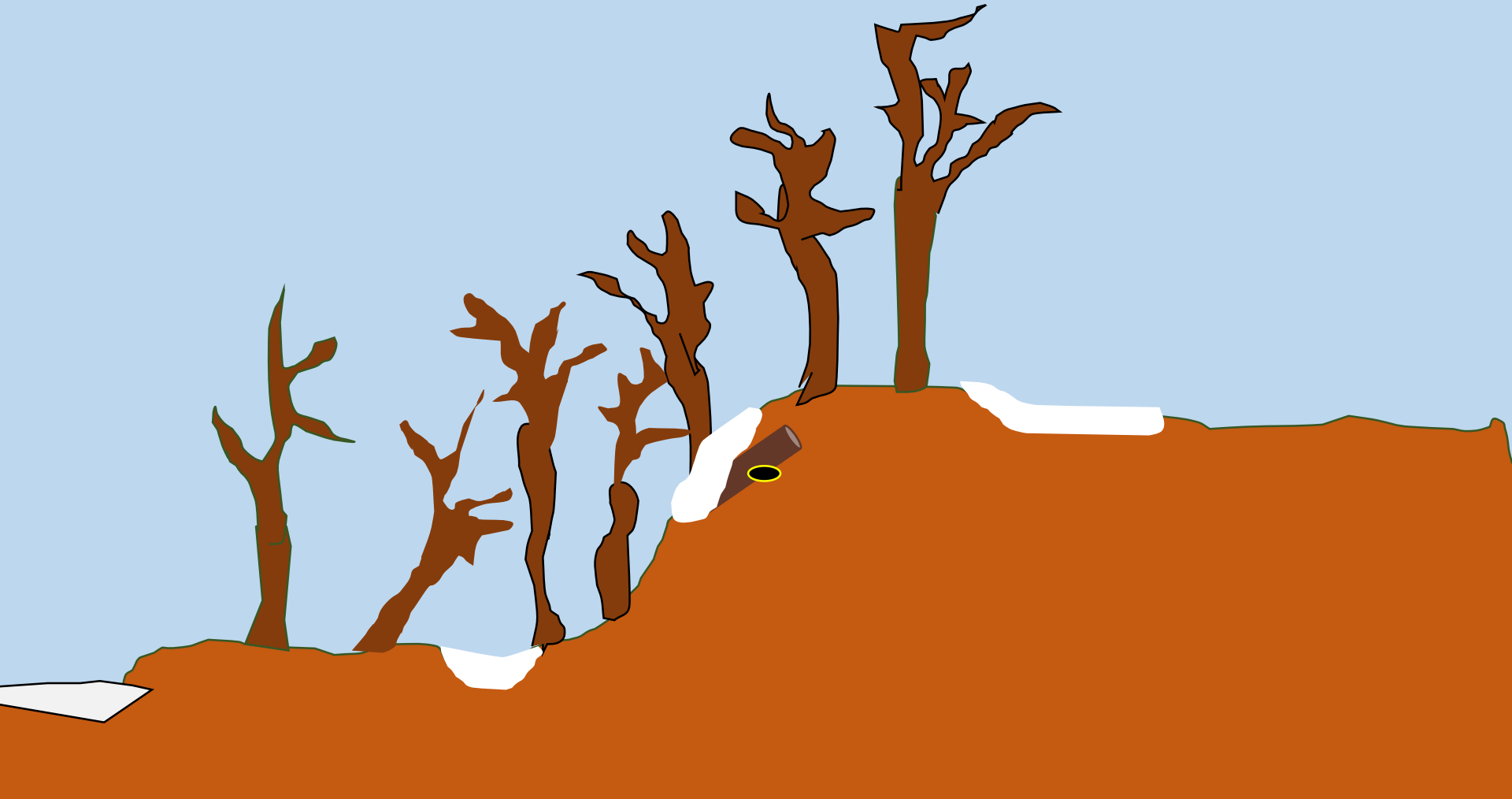
Astigmatid Mites (mostly decomposers, sometimes pests)

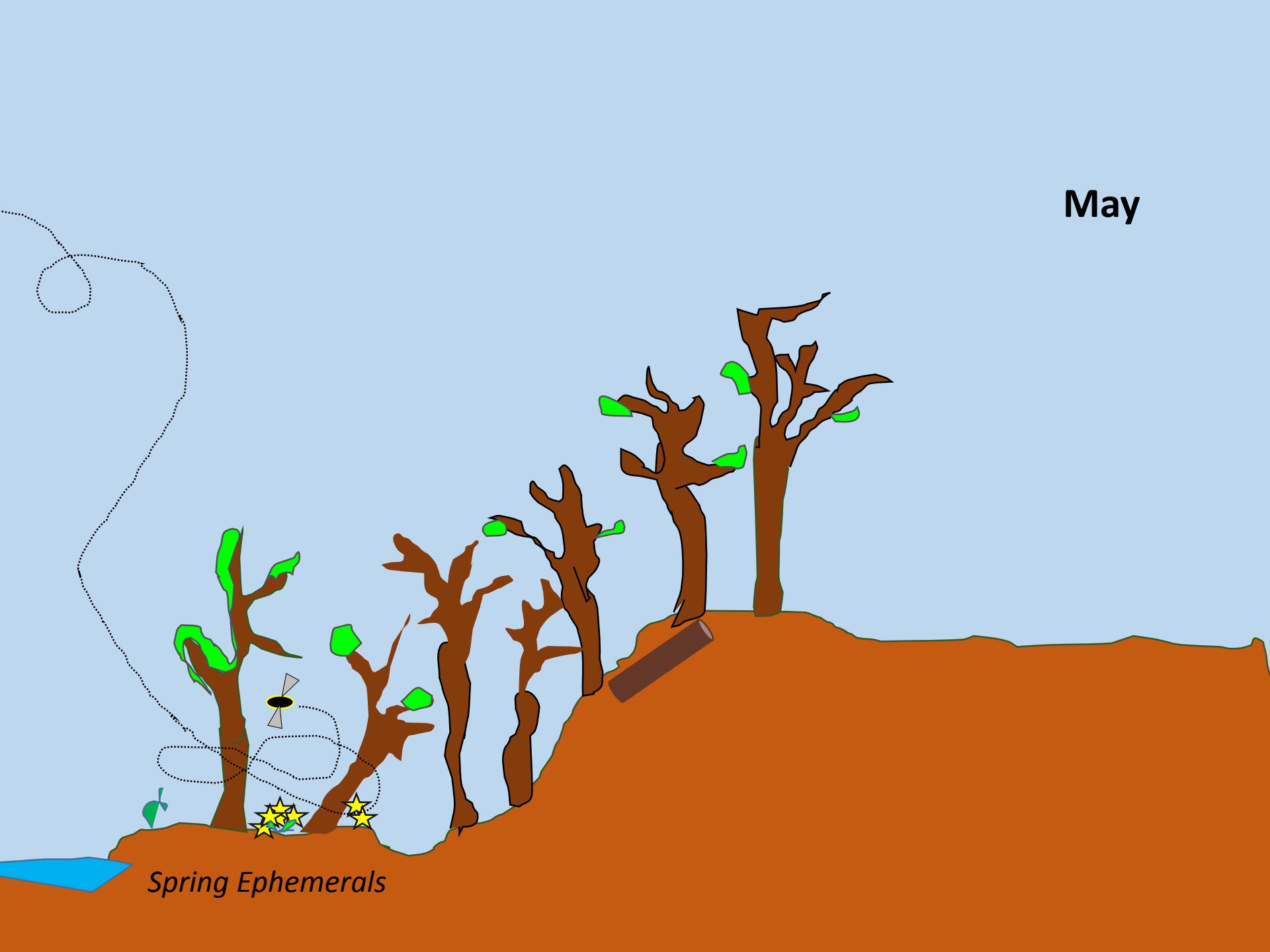

B. Seasonal commute, different habitats may support different life-cycle stages.
ADULTS
-shelter
-feeding
-reproductive sites
EGG
-shelter
-good development conditions
IMMATURE
-shelter
-feeding sites

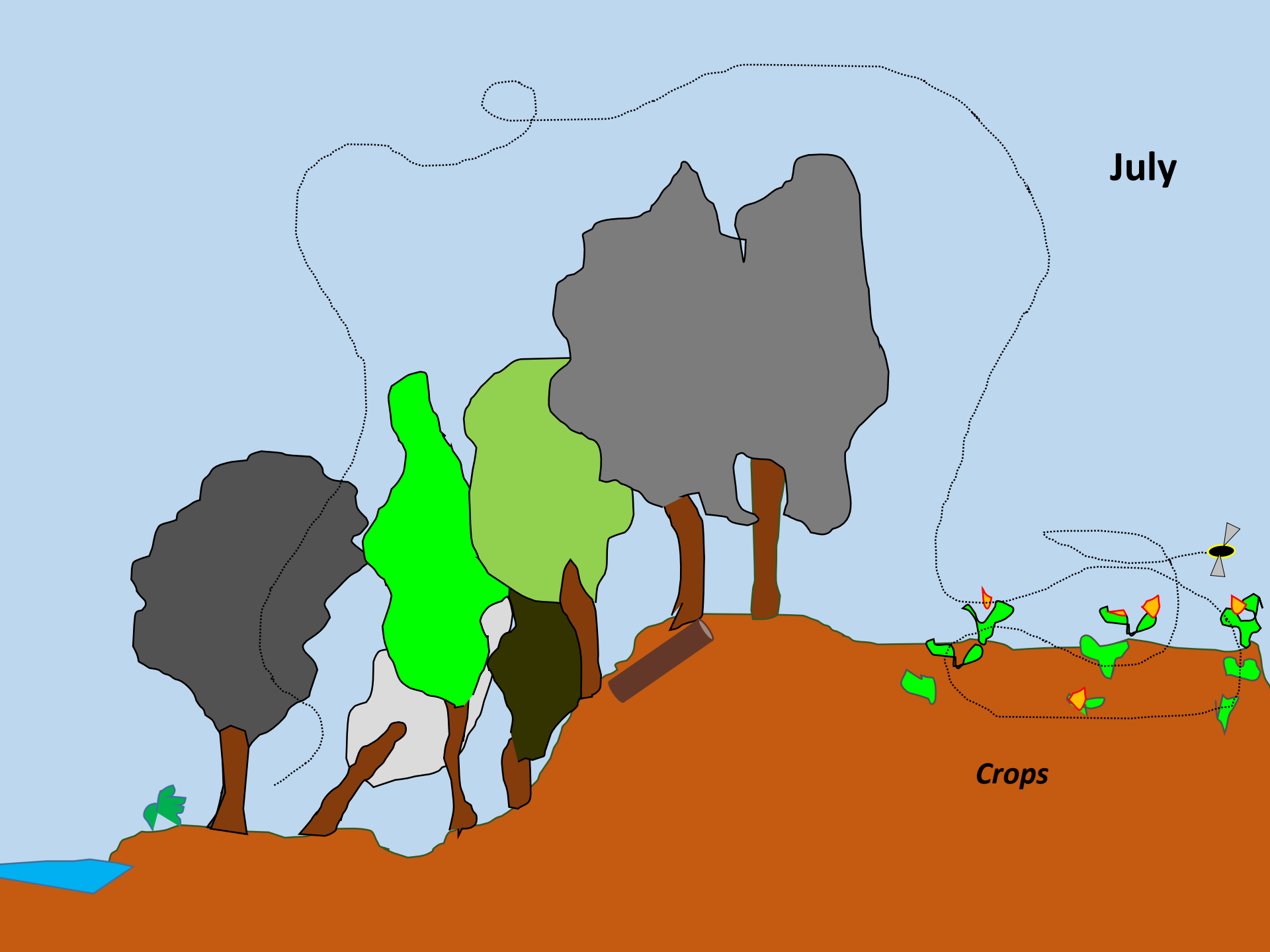
B. Life cycle occurs between farm field and adjacent lands.

A bee example….

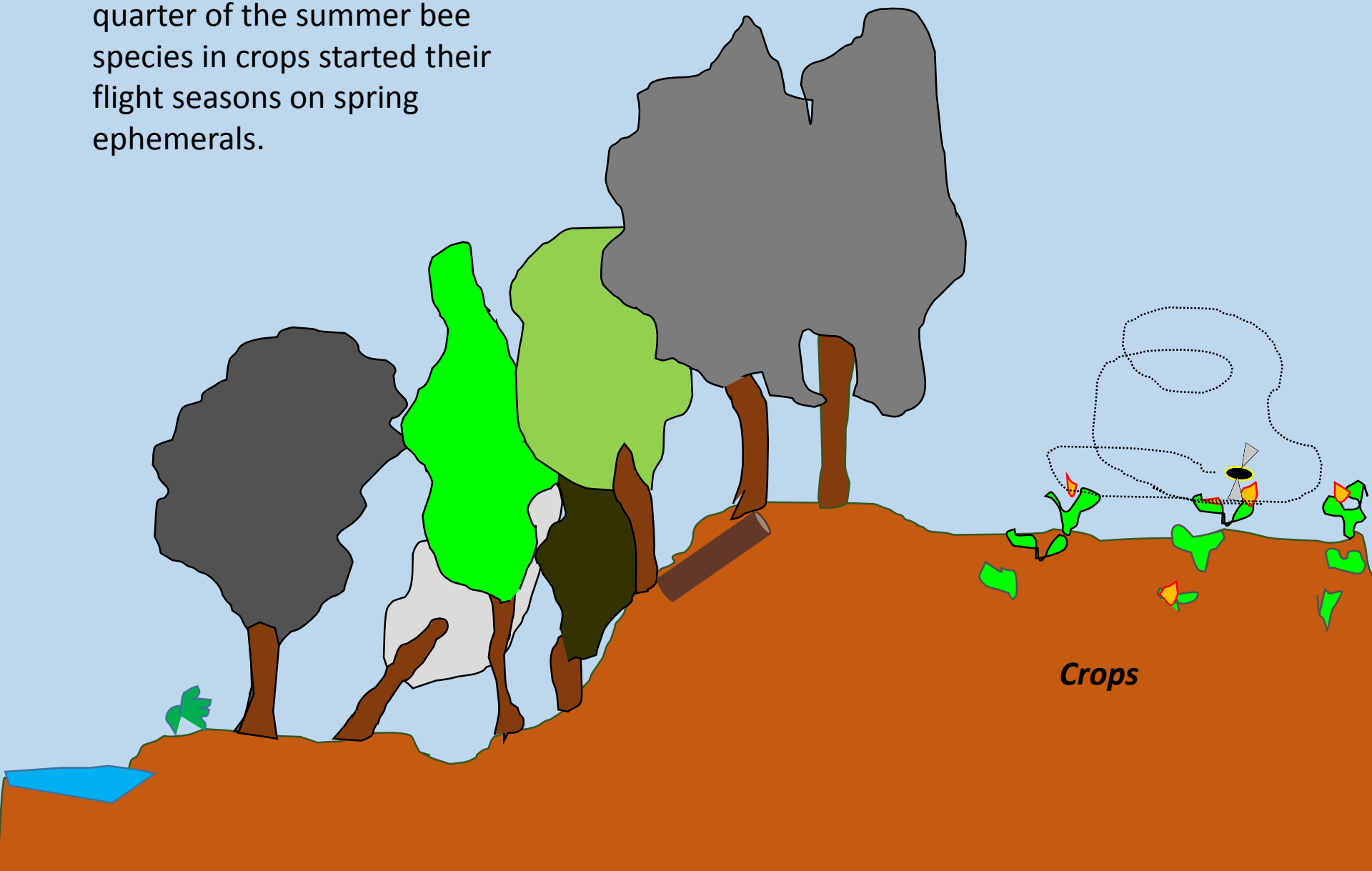
Winter

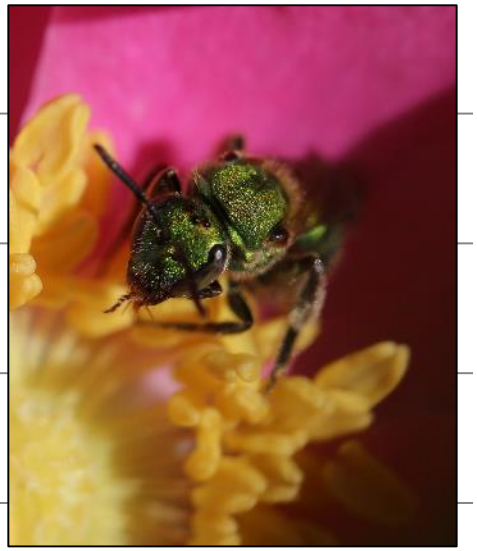



May
Spring Ephemerals


July
Crops

Based on our Columbia County work, at least one quarter of the summer bee species in crops started their flight seasons on spring ephemerals.





Number of Bee Species

70
60
50
40
30
20
10
0

Farm Only

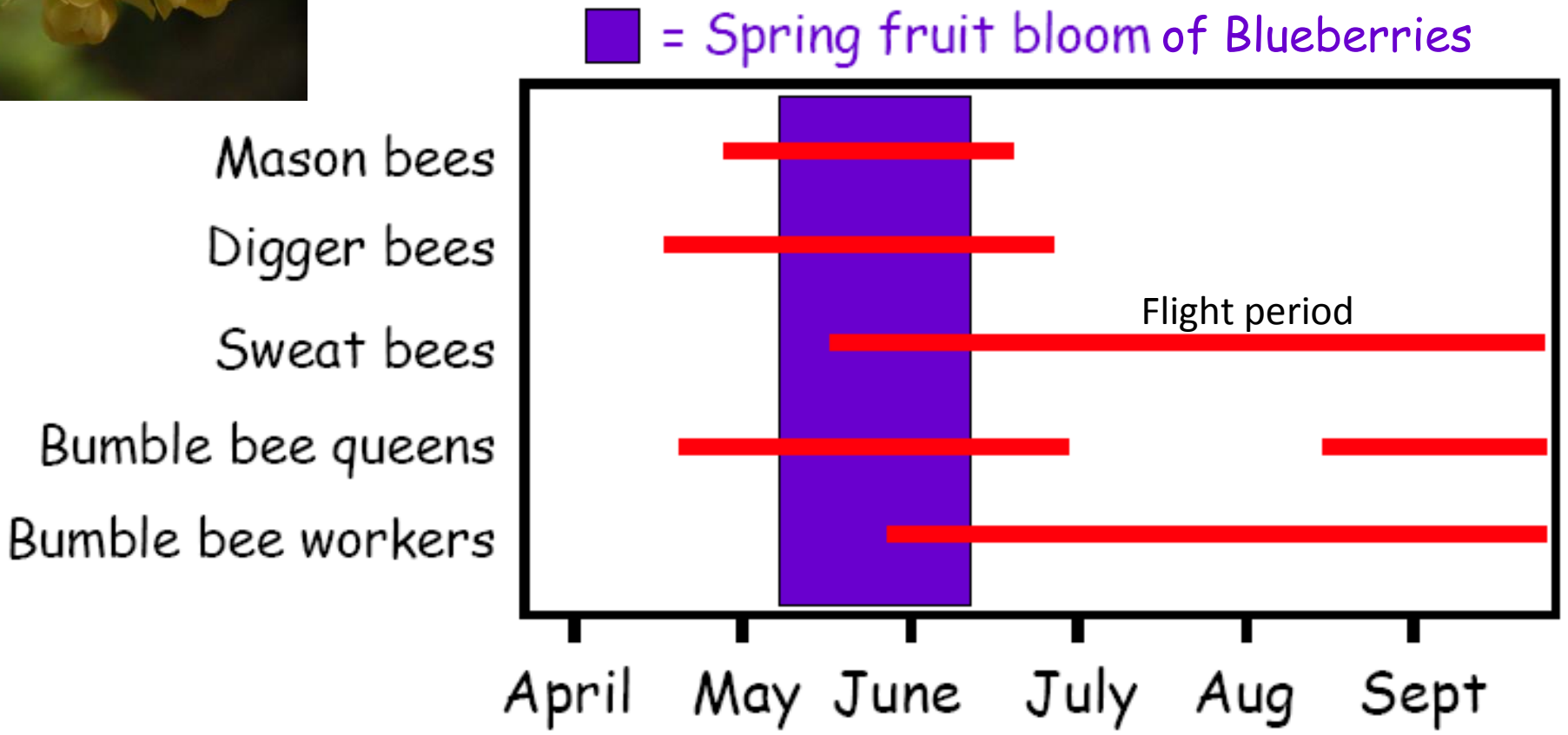
Farm and Floodplain

Floodplain Only

HABITAT

Bee work by student Martin Holdrege together with us.

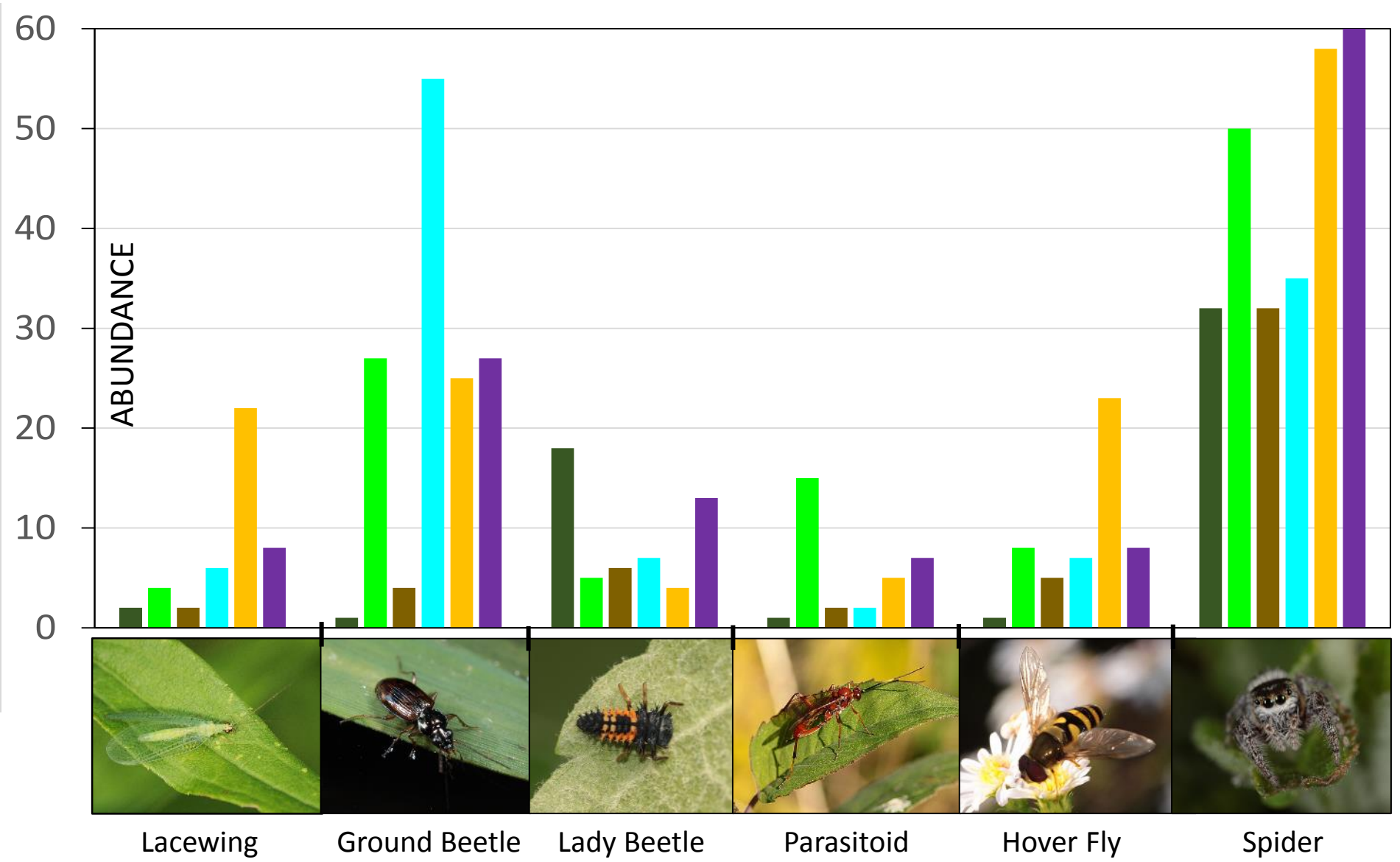
Work by others showing why considering full-season resources are important.



From: Rufus Isaacs, Michigan State University

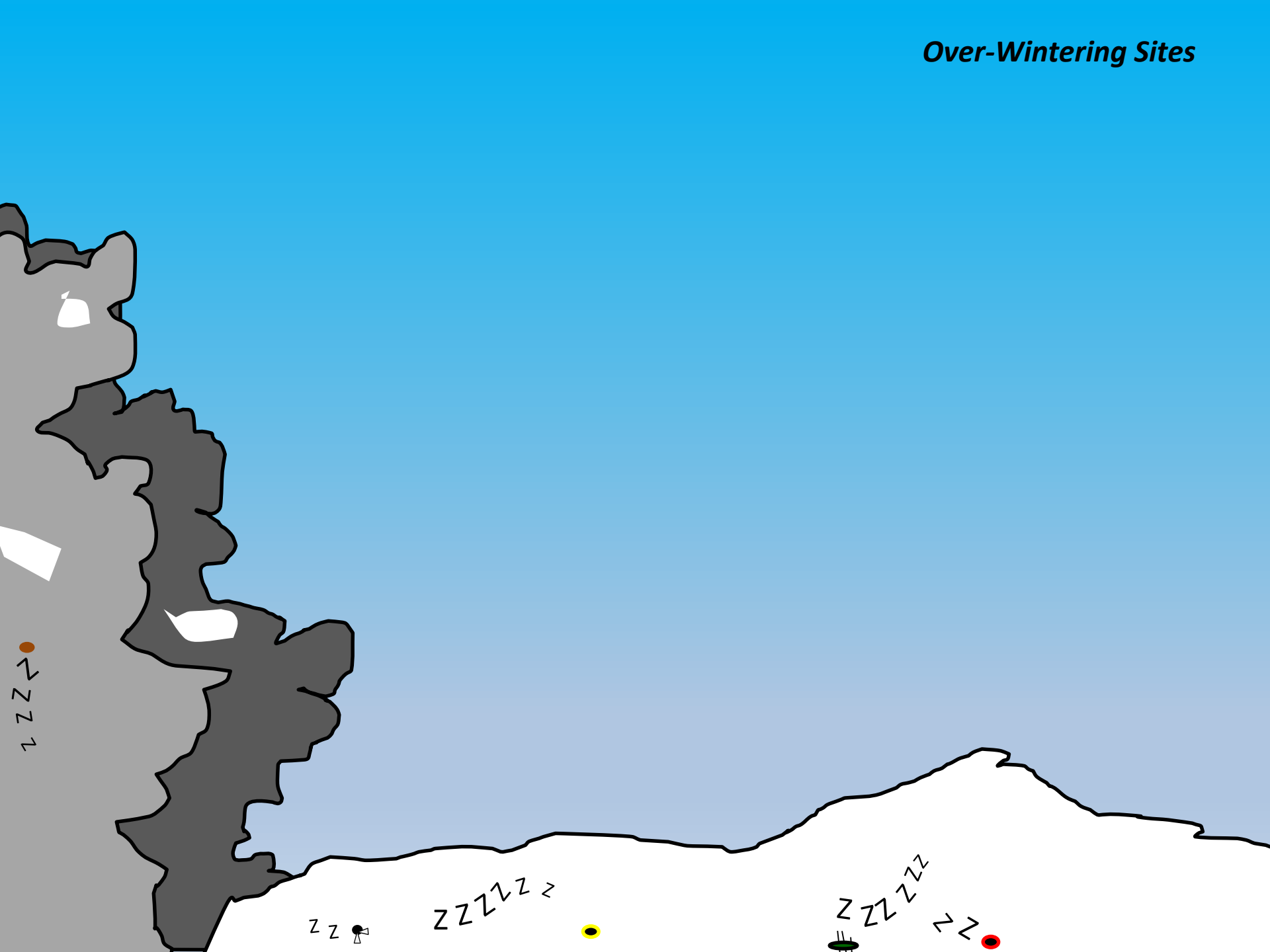
B. Another example of a seasonal commute.

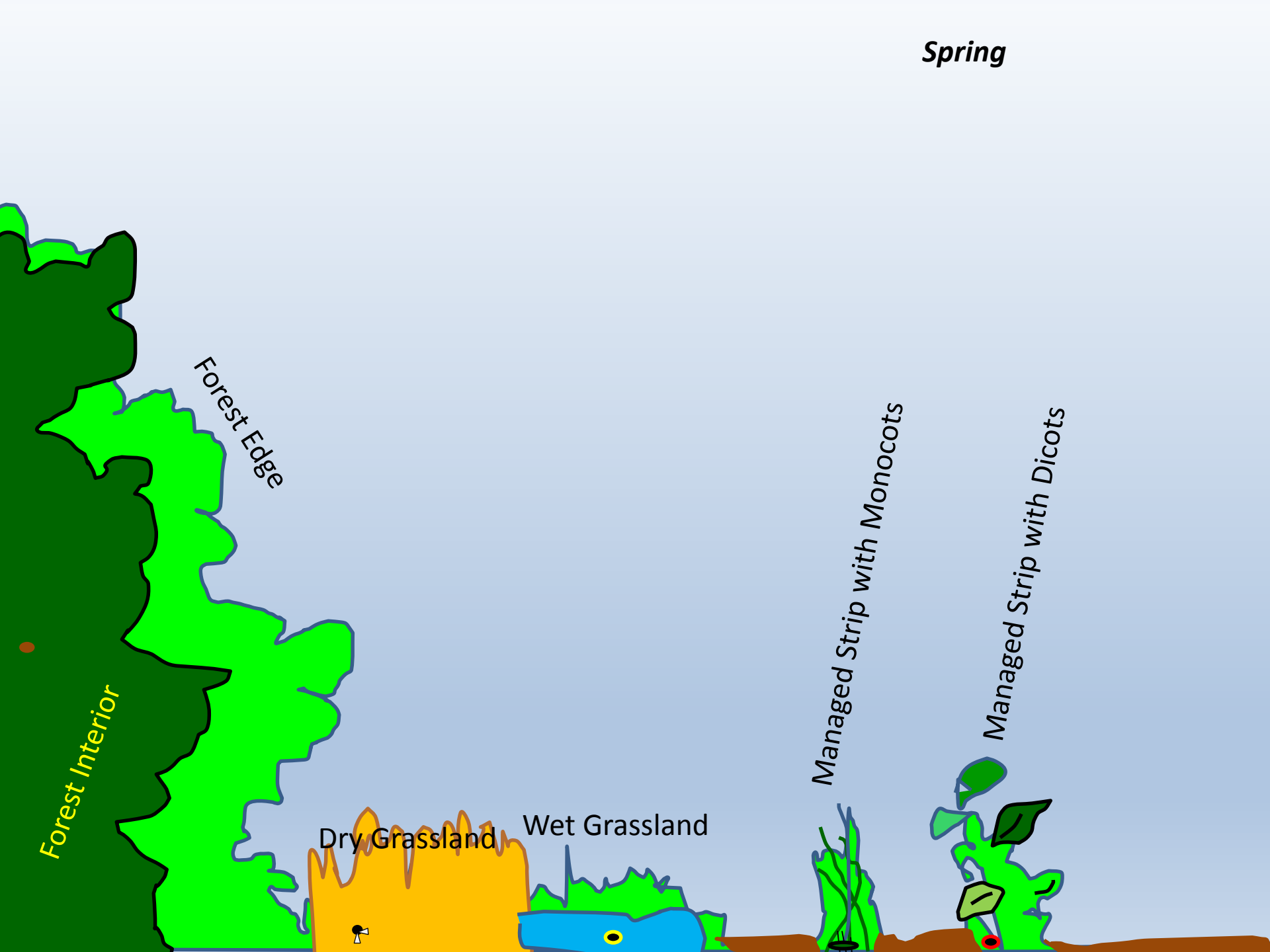
Other's work showing the Abundance of Insects Emerging in Spring from Different Habitats



Data from Sarthou et al. (2014) *Ag., Ecosys. & Envt.* 194: 17–28

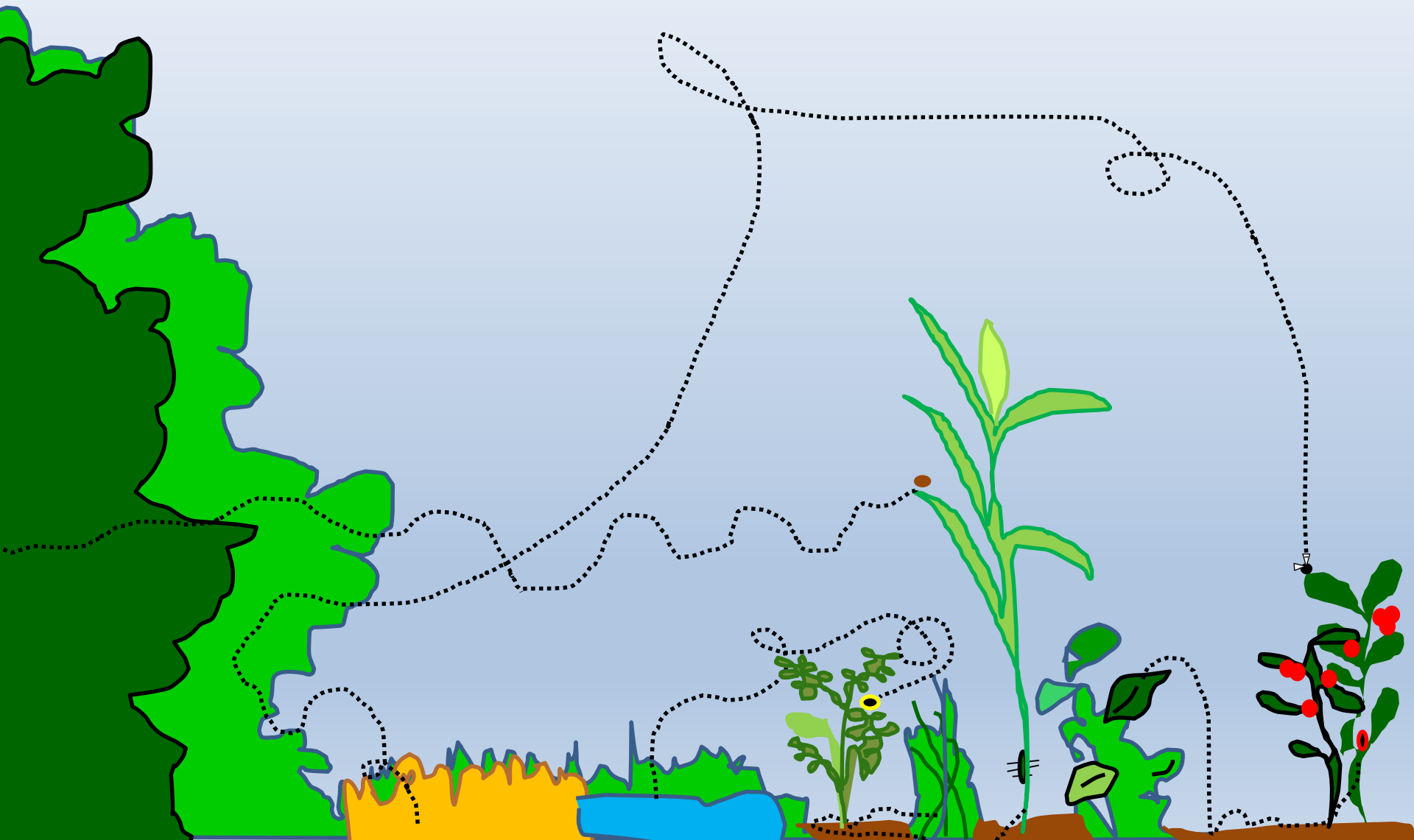
Over-Wintering Sites

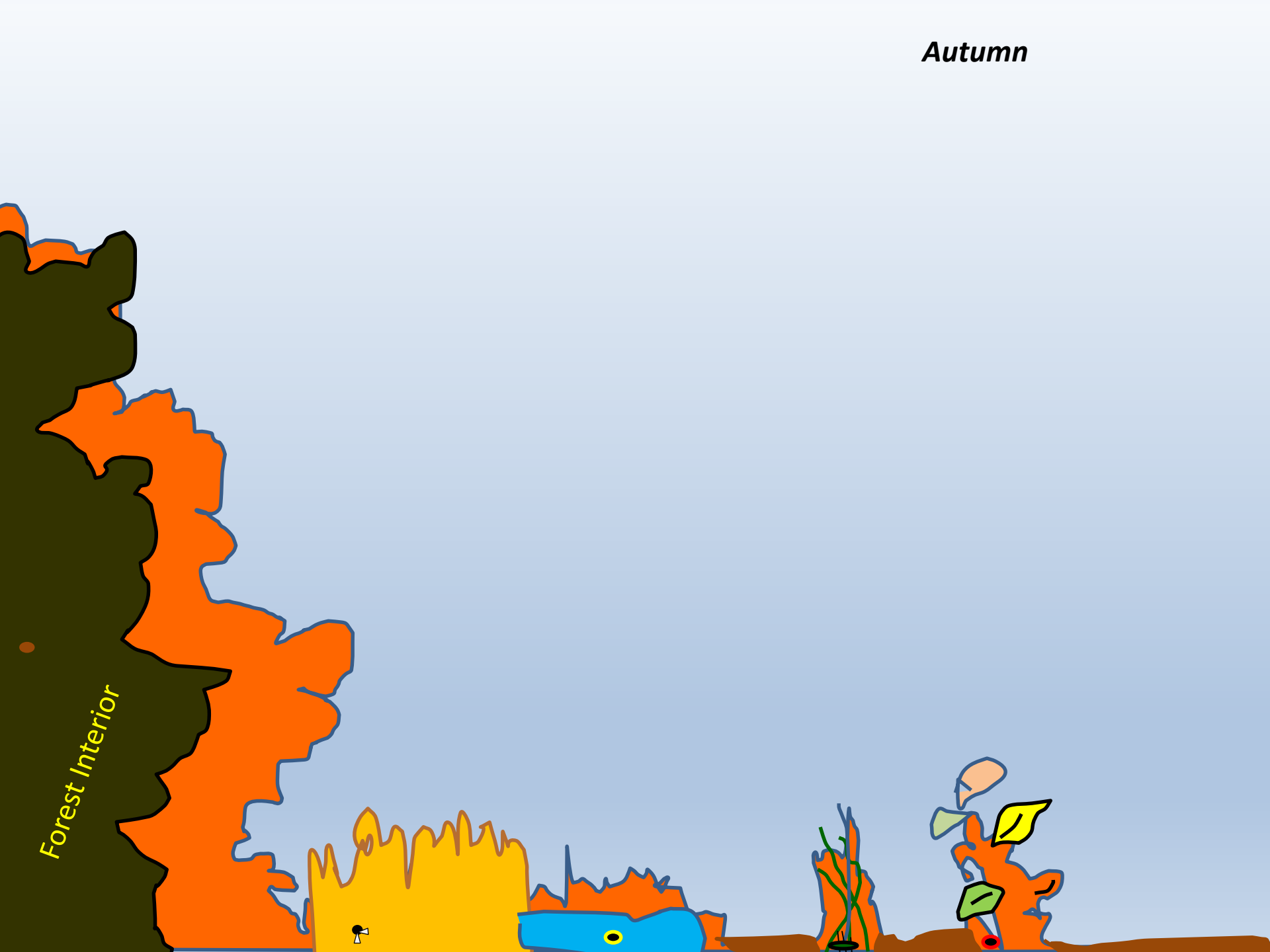



Spring
Forest Edge
Forest Interior
Dry Grassland
Wet Grassland
Managed Strip with Monocots
Managed Strip with Dicots


Late Spring

Summer

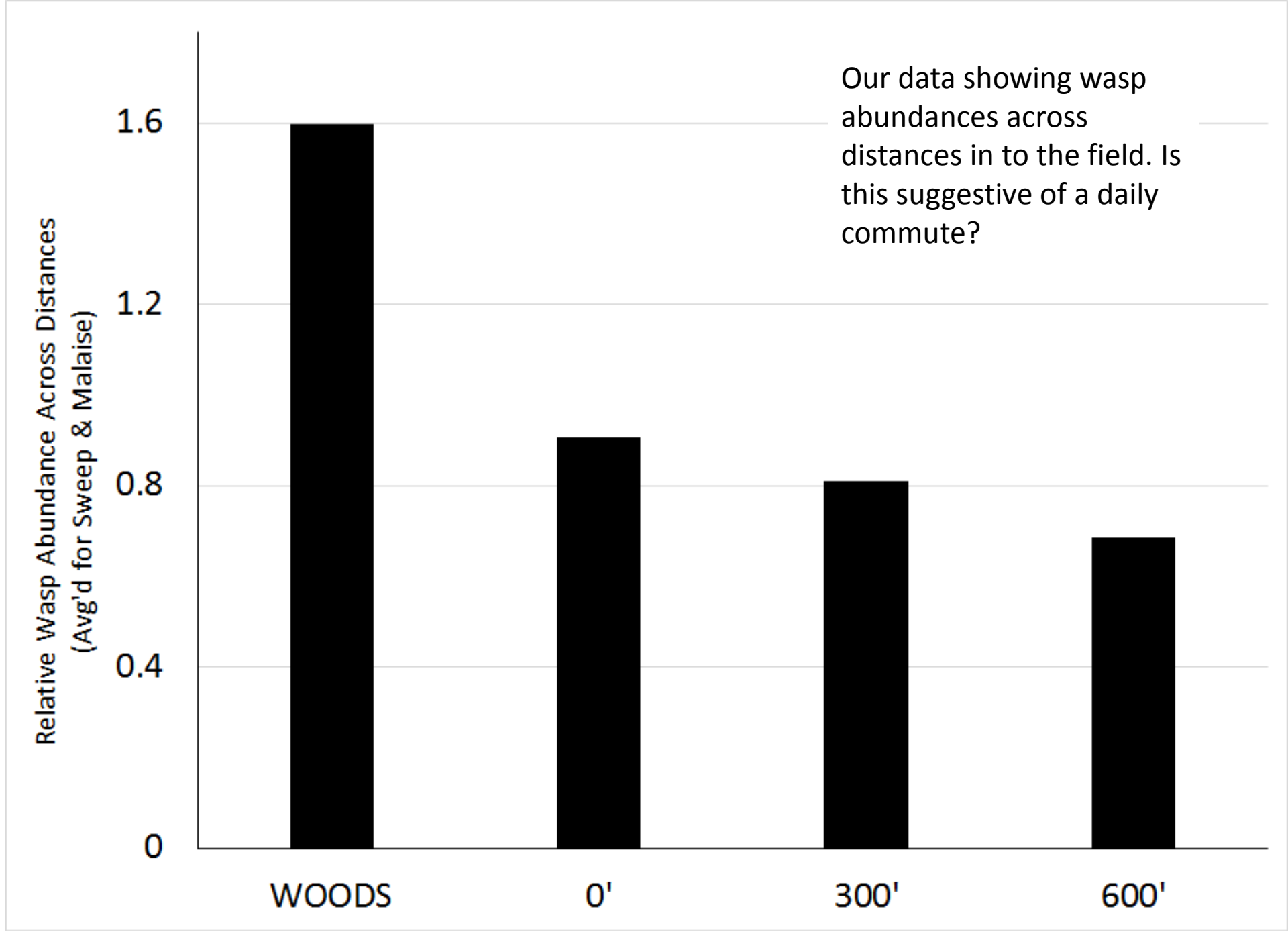



Autumn
Forest Interior

C. Daily Commute between farm field and adjacent lands.

C. Daily Commute between farm field and adjacent lands.

Nutmeg's Wildlife Photography

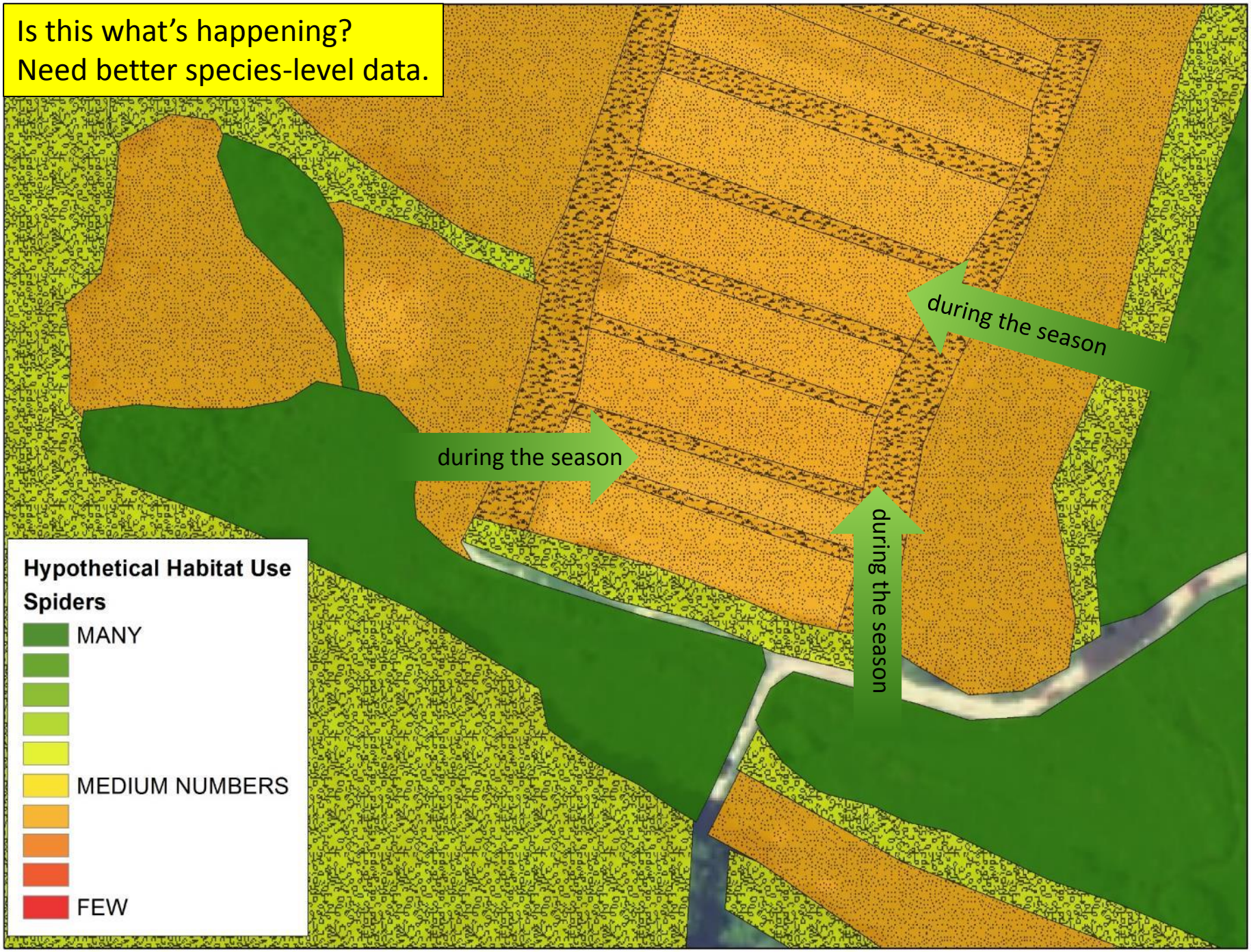

Our data showing wasp abundances across distances in to the field. Is this suggestive of a daily commute?
Relative Wasp Abundance Across Distances (Avg'd for Sweep & Malaise)
1.6
1.2
0.8
0.4
0
WOODS
0'
300'
600'

D. Wild area is source; cultivated area is sink.

Spiders kiting on “Gossamer” might be an example.

Photo from http://www.hirundomaine.org

Notice how, at least until late summer, drive strip and wilder areas had more spiders; and how until that time, crop edge also had more than crop center.


Is this what's happening?
Need better species-level data.
during the season
during the season
during the season
Hypothetical Habitat Use
Spiders
MANY
MEDIUM NUMBERS
FEW

R.o.T. #3:

Different beneficials may need wild habitat for different reasons; some may not need it at all.

These ecologies have management implications, the relevance of which will depend somewhat on the particular crop system.

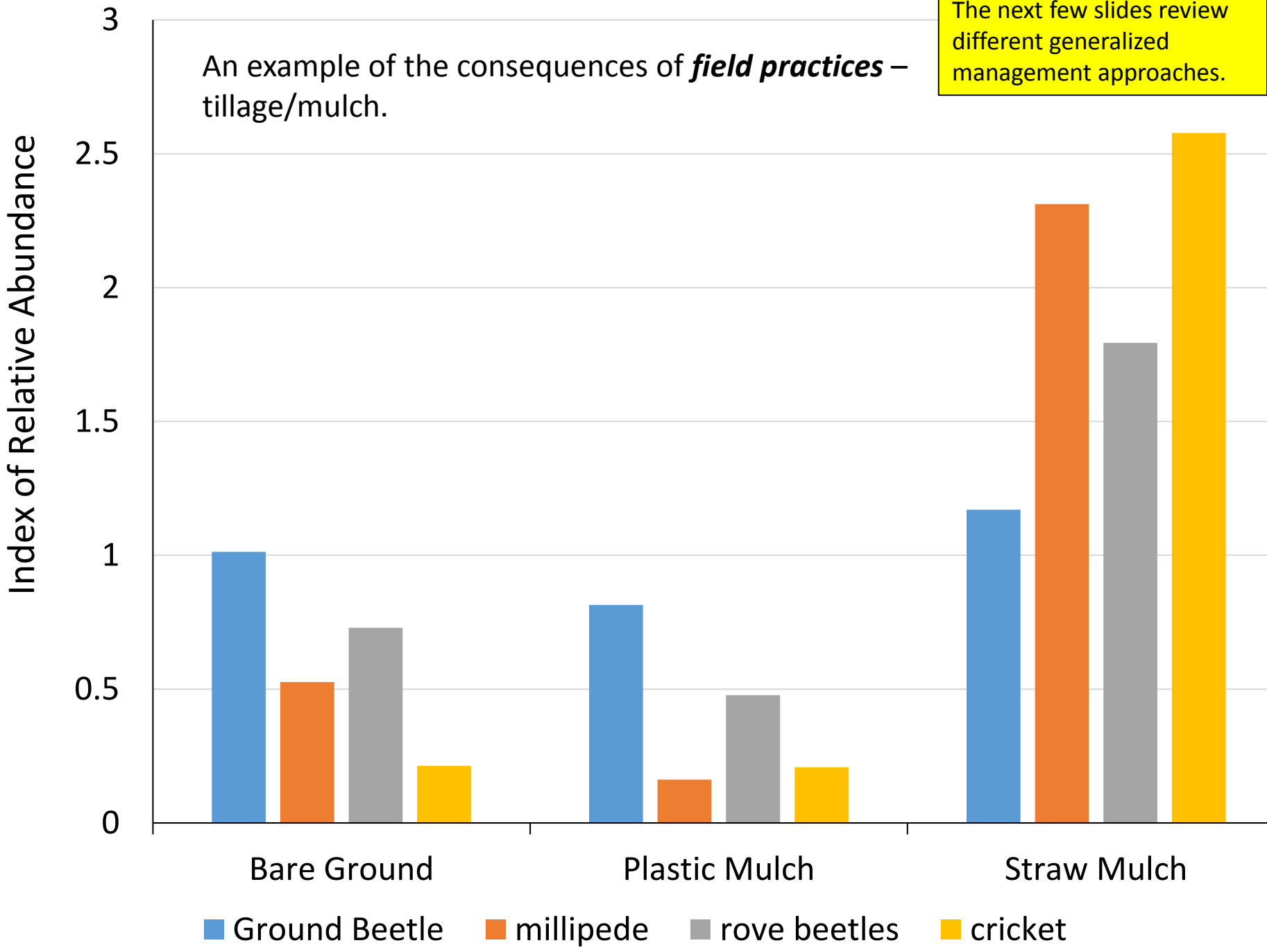
Type of Management for Beneficials

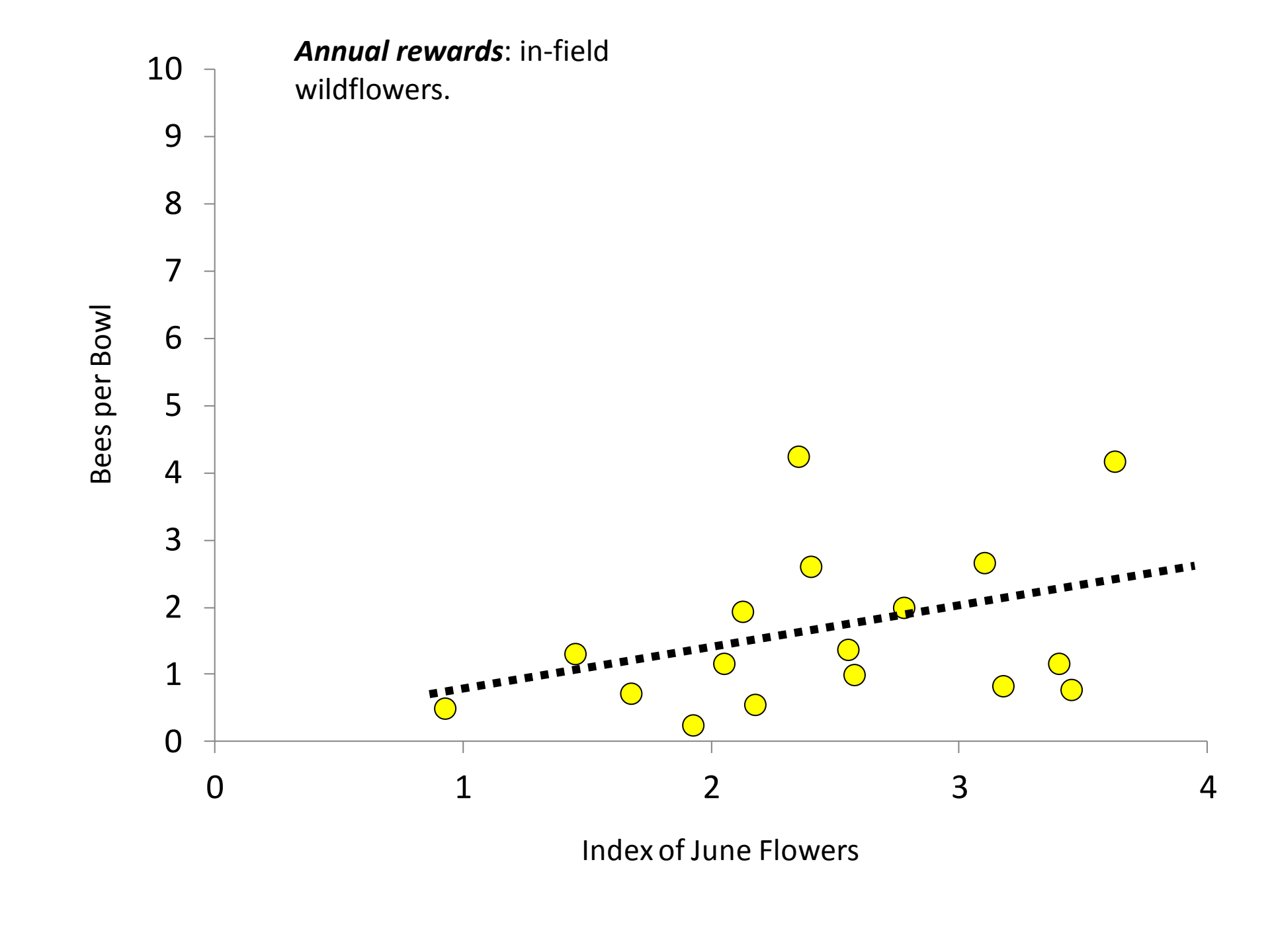
Ecological Category of Beneficial	Field Practices (Tillage, etc)	Annual Habitat Inserts (Wild Flower strips, etc)	Semi-permanent Habitat Inserts (Beetle banks, hedgerows, etc)	Landscape Diversification
Field Focussed	■			
Daily Commuter		■		
Seasonal Commuter		■	■	■
Source/Sink				■

(This is an over-generalization, but the point is to think about how the ecology of the beneficial and the type of management interact.)

The next few slides review different generalized management approaches.

An example of the consequences of ***field practices*** – tillage/mulch.




Annual rewards: in-field wildflowers.
Bees per Bowl
10
9
8
7
6
5
4
3
2
1
0
0
1
2
3
4
Index of June Flowers

Semi-permanent habitat is also important as this work by others shows.

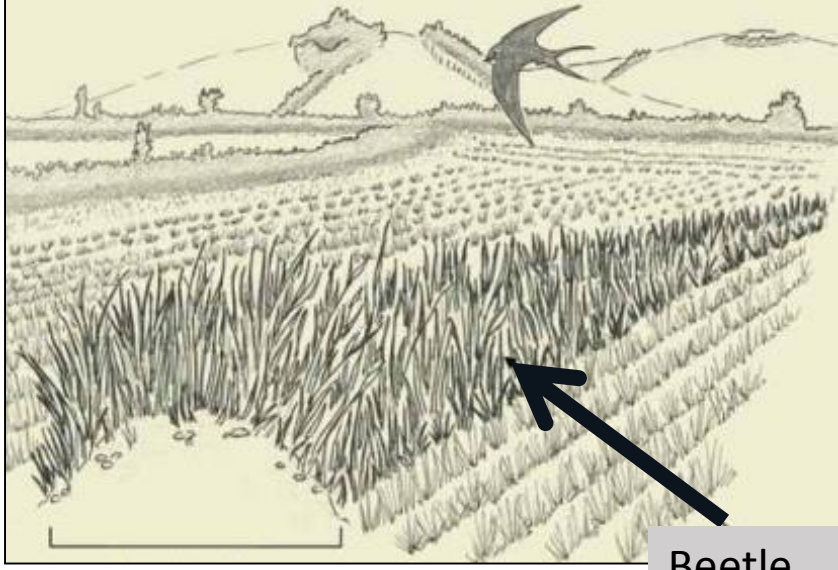
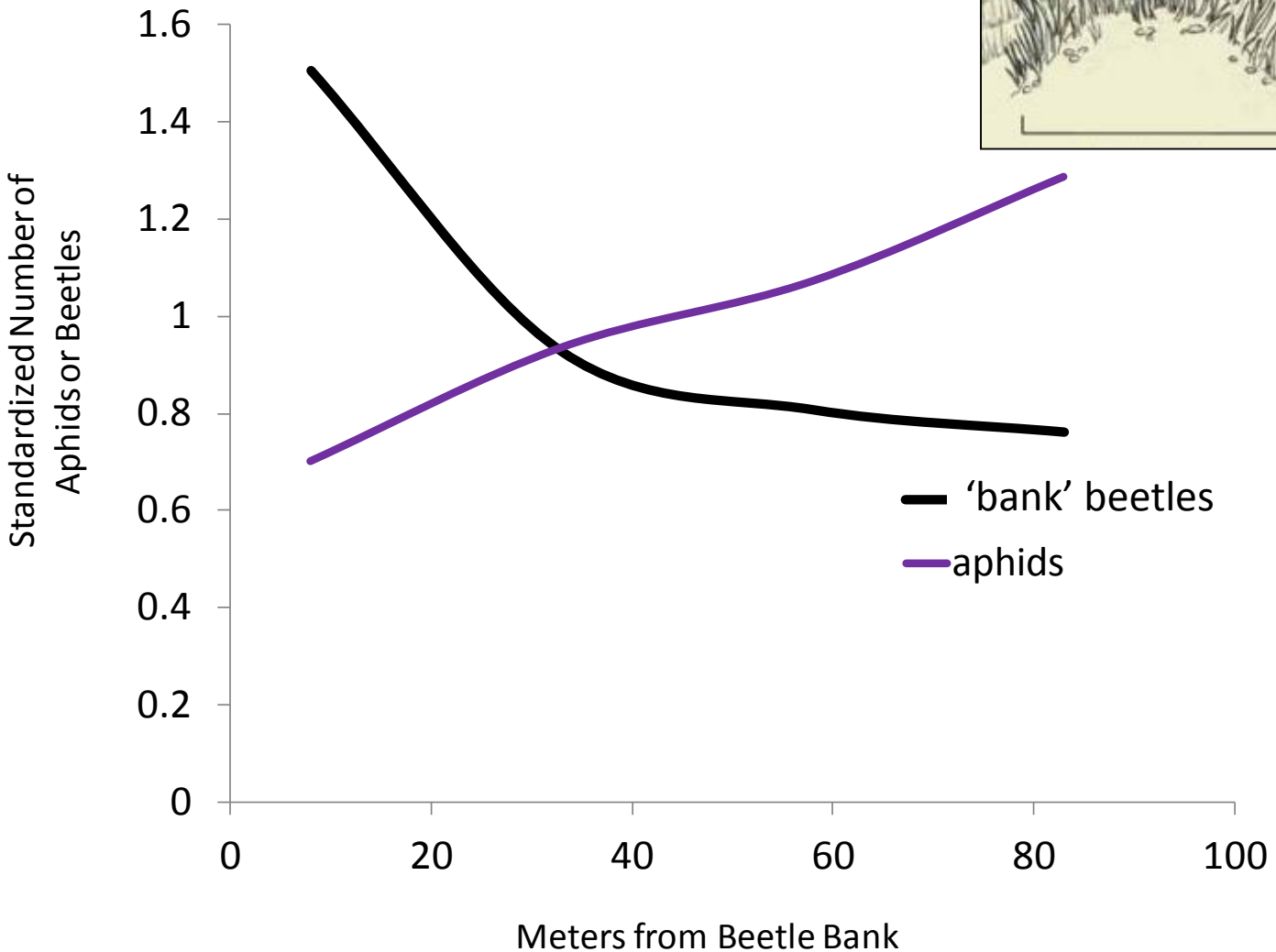
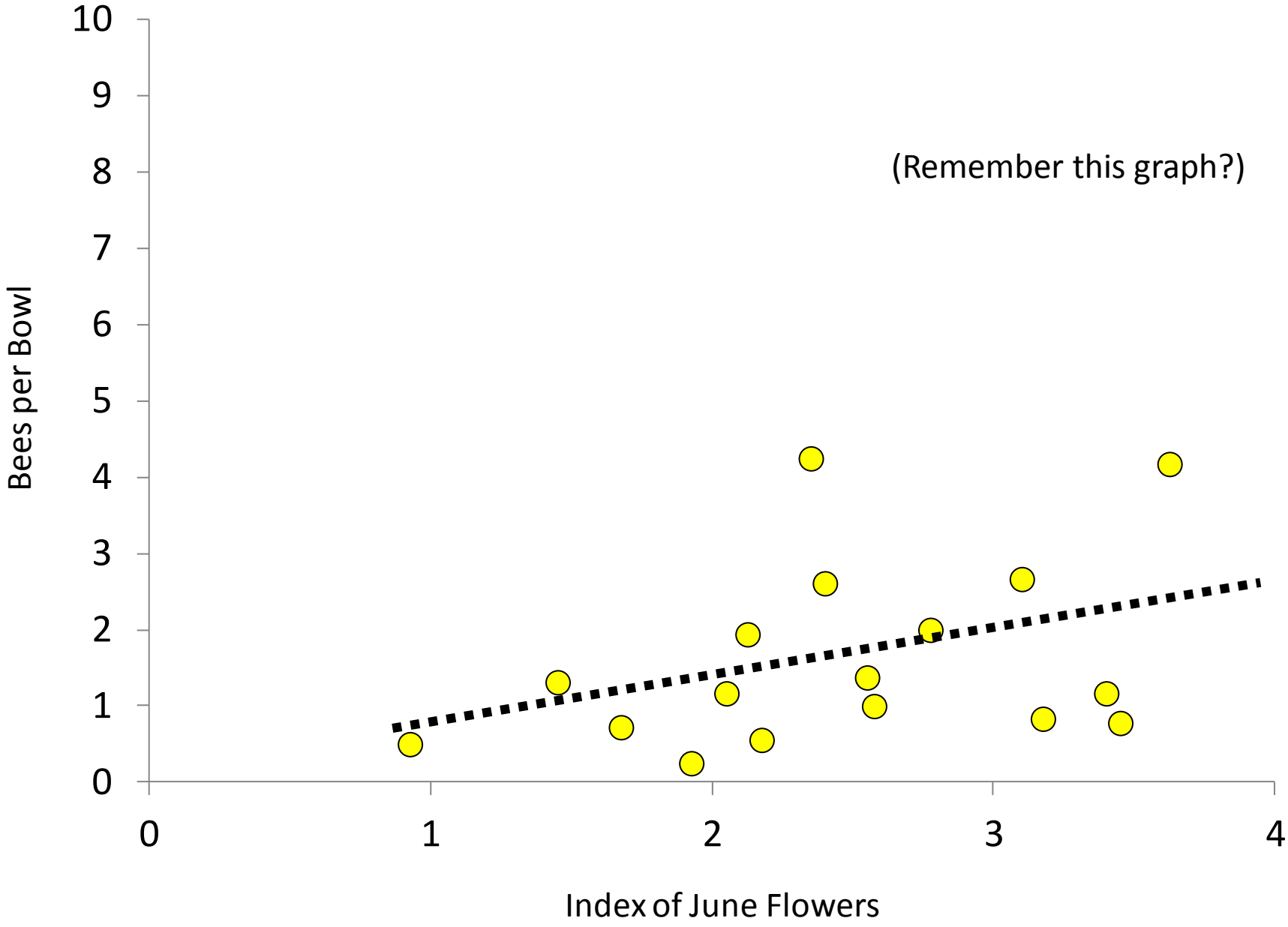
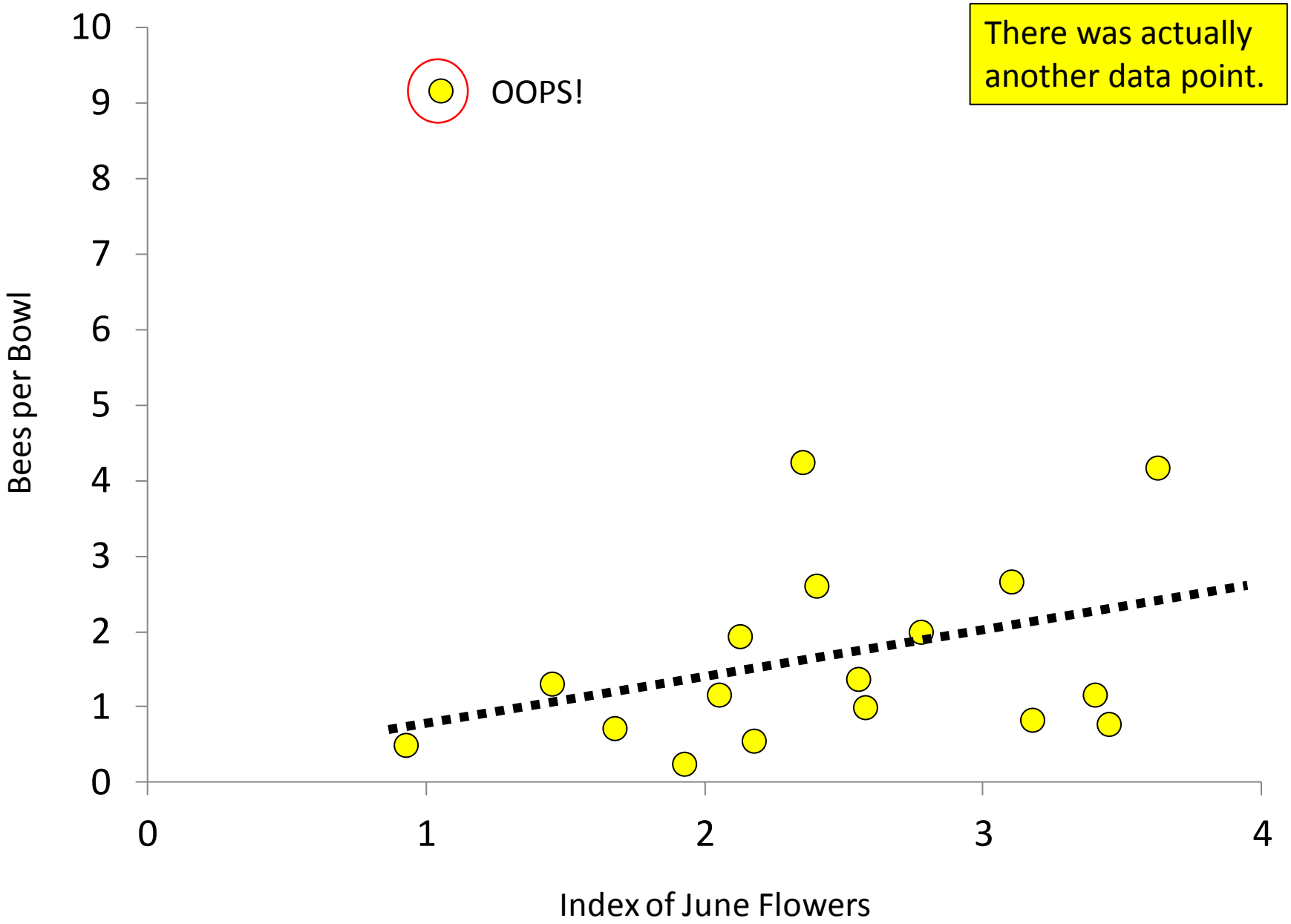


Image defra uk



Data from:
Collins, K.L., N.D. Boatman, A. Wilcox, J.M. Holland, and K. Chaney. 2002. The influence of beetle banks on aphid population predation in winter wheat. *Agriculture, Ecosystems and Environment* 93:337–350.


(Remember this graph?)
Bees per Bowl
Index of June Flowers
0
1
2
3
4
0
1
2
3
4
5
6
7
8
9
10


There was actually another data point.
OOPS!
Bees per Bowl
Index of June Flowers
0
1
2
3
4
5
6
7
8
9
10

Sandy Soil =
Easy Nesting

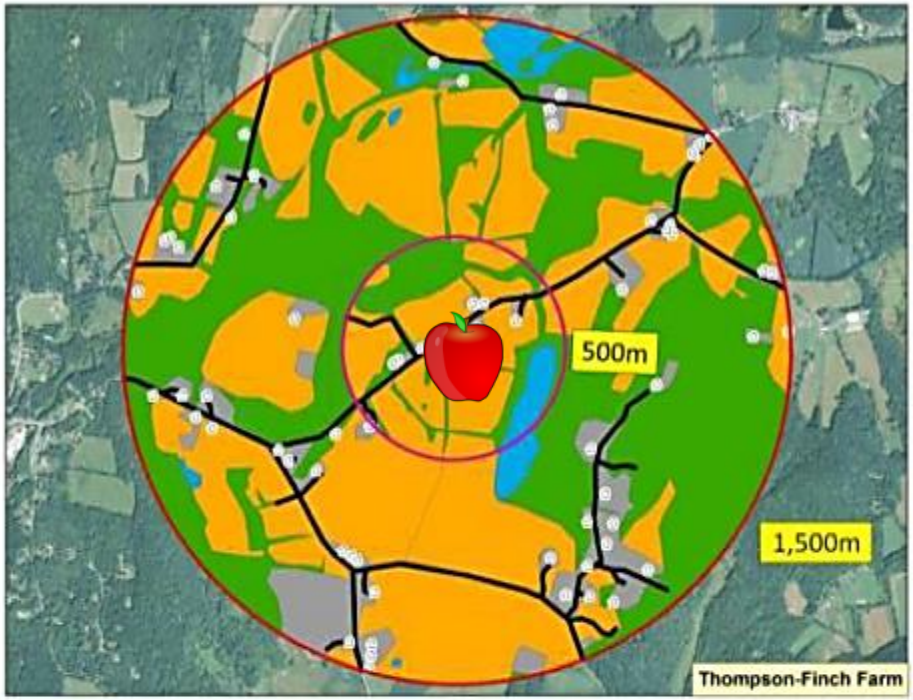
Bees per Bowl

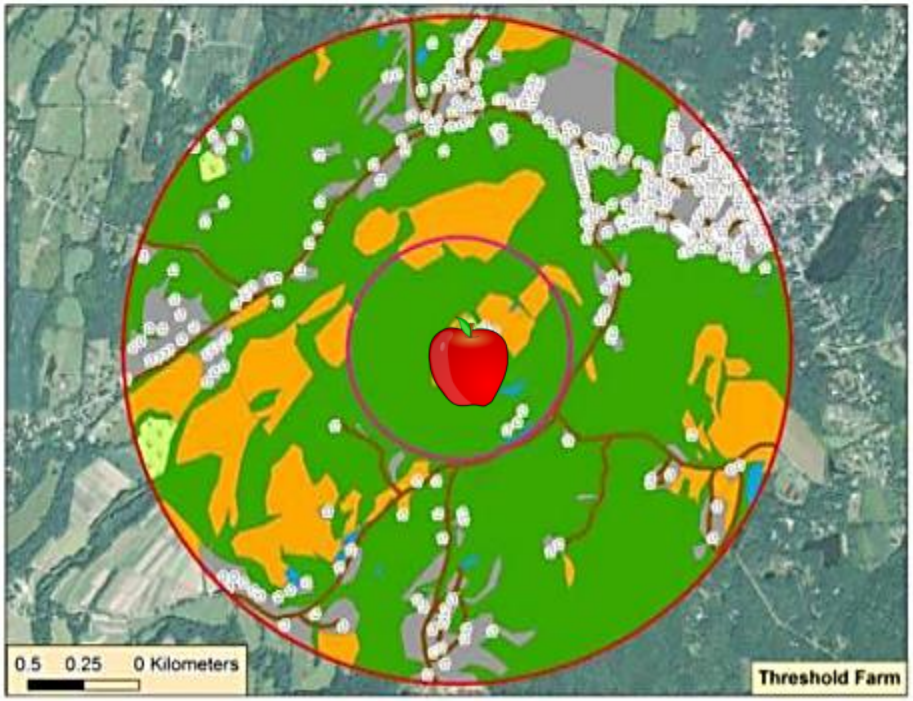
Index of June Flowers

0 1 2 3 4 5 6 7 8 9 10

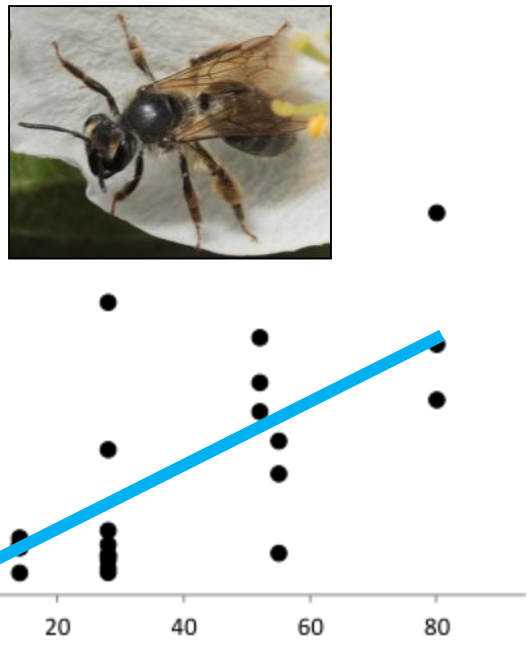
0 1 2 3 4

Photo by Rosi Rollings,
http://www.rosybee.com

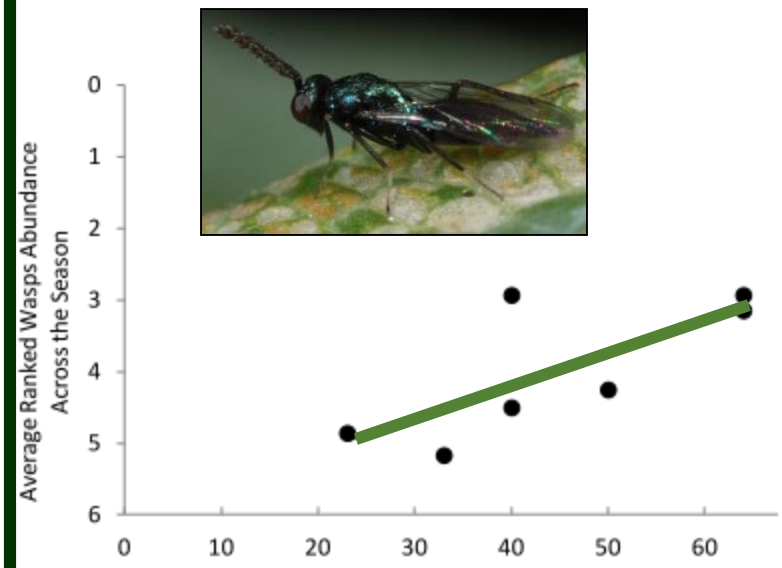




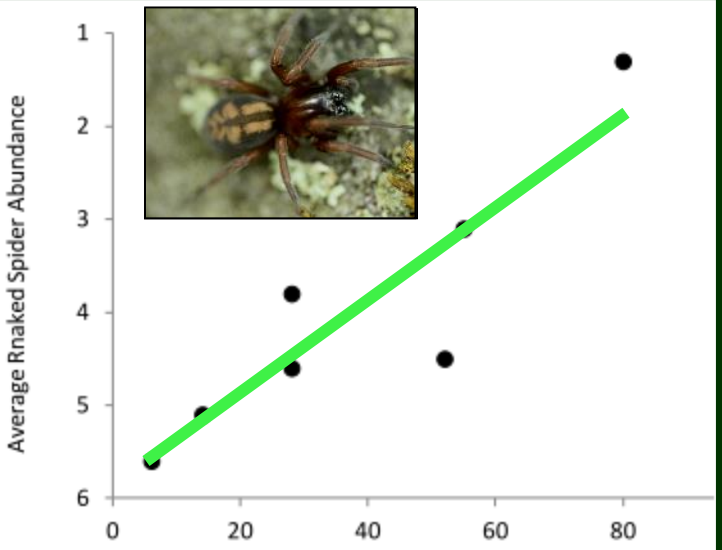
Finally, don't forget about **the greater landscape**, even if management at that scale depends upon societal change rather than on-farm practices. We compared orchard insects to landscape context during our orchard work.



% forest within 500m



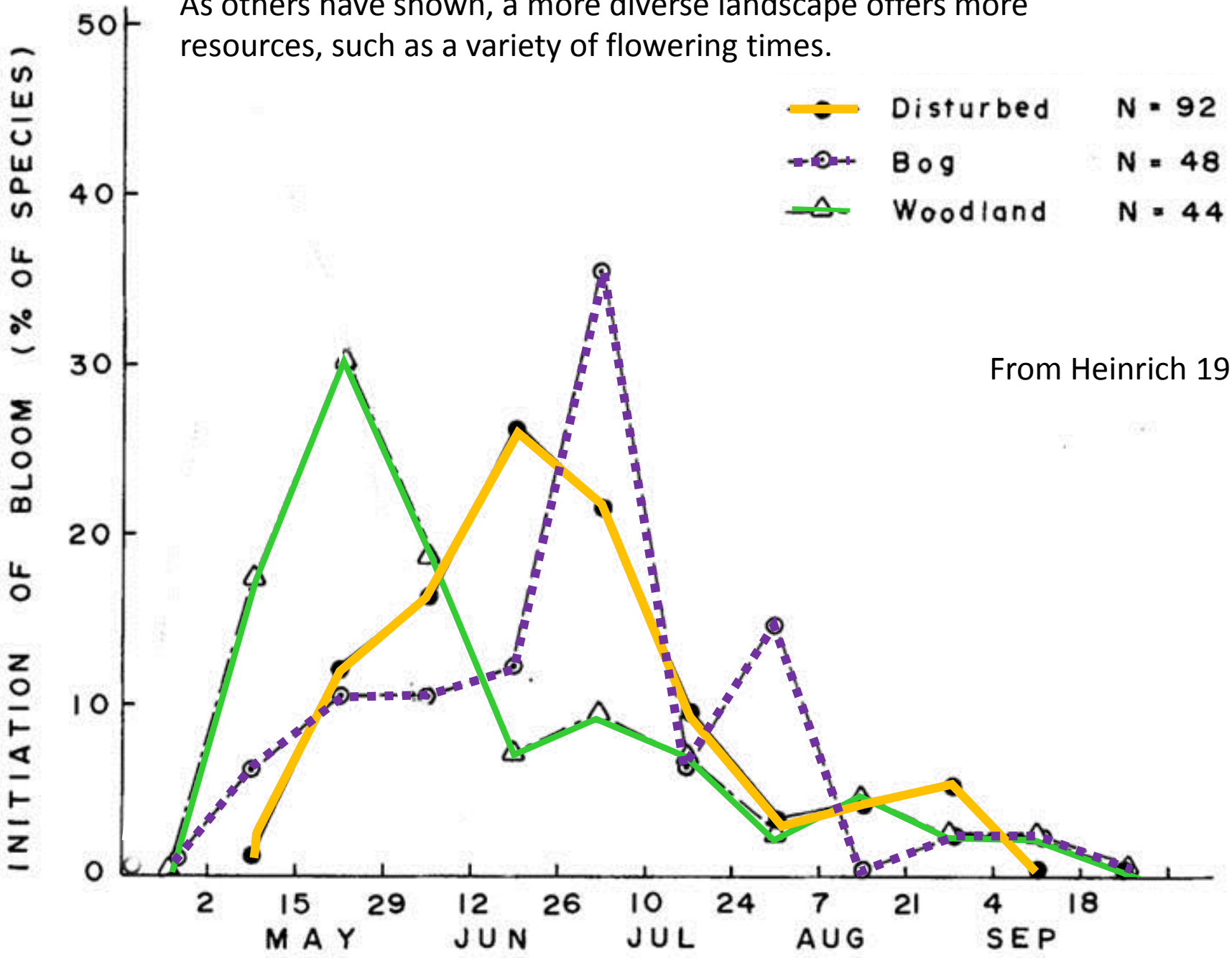
% forest within 1,500m



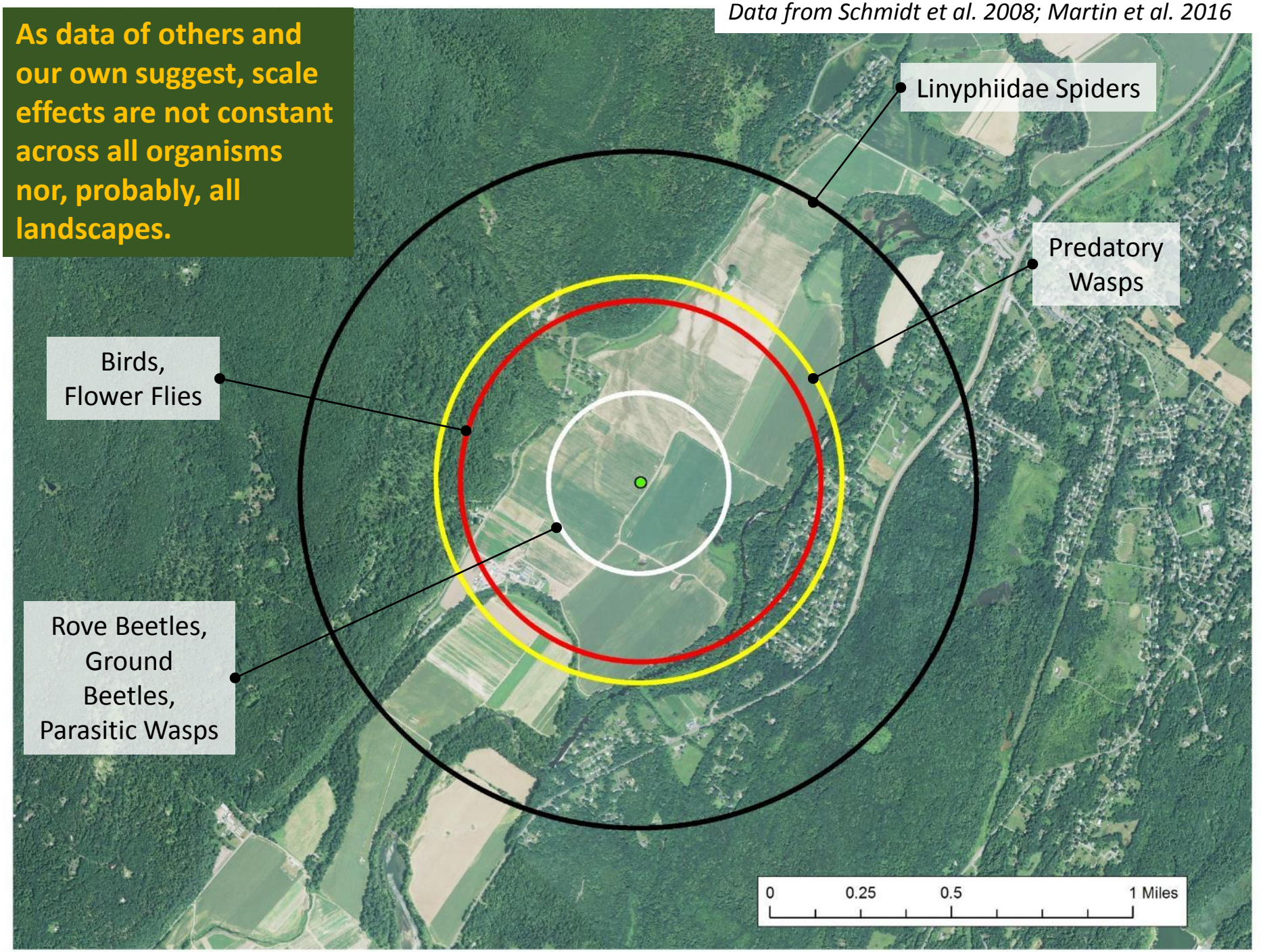
% forest within 500m

Landscape context seemed to affect beneficials in apple orchards.

As others have shown, a more diverse landscape offers more resources, such as a variety of flowering times.



From Heinrich 1976


As data of others and our own suggest, scale effects are not constant across all organisms nor, probably, all landscapes.
Data from Schmidt et al. 2008; Martin et al. 2016
Linyphiidae Spiders
Predatory Wasps
Birds, Flower Flies
Rove Beetles, Ground Beetles, Parasitic Wasps
0
0.25
0.5
1 Miles

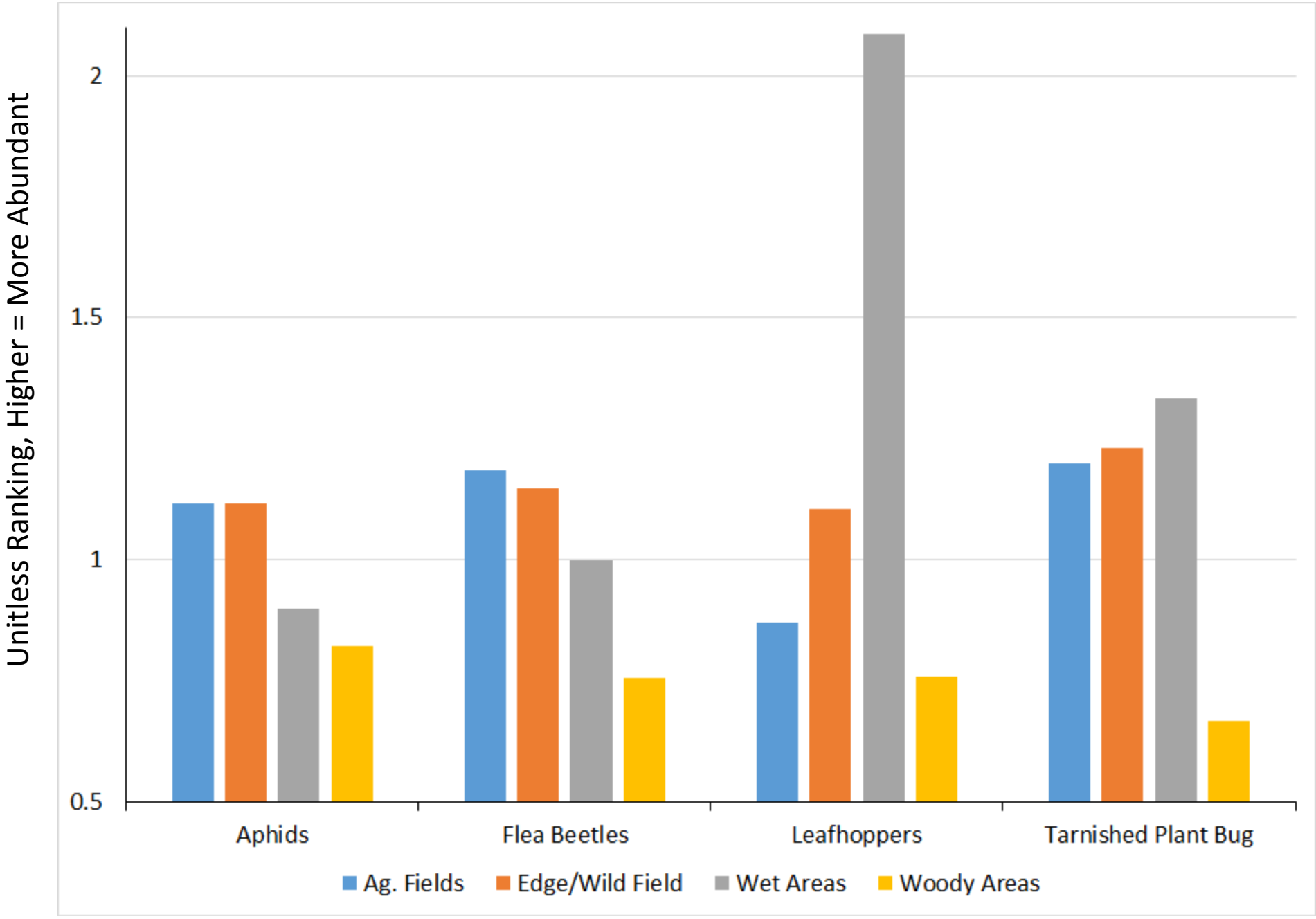
R.o.T. #4:

Those different beneficial ecologies translate into different approaches to their management.

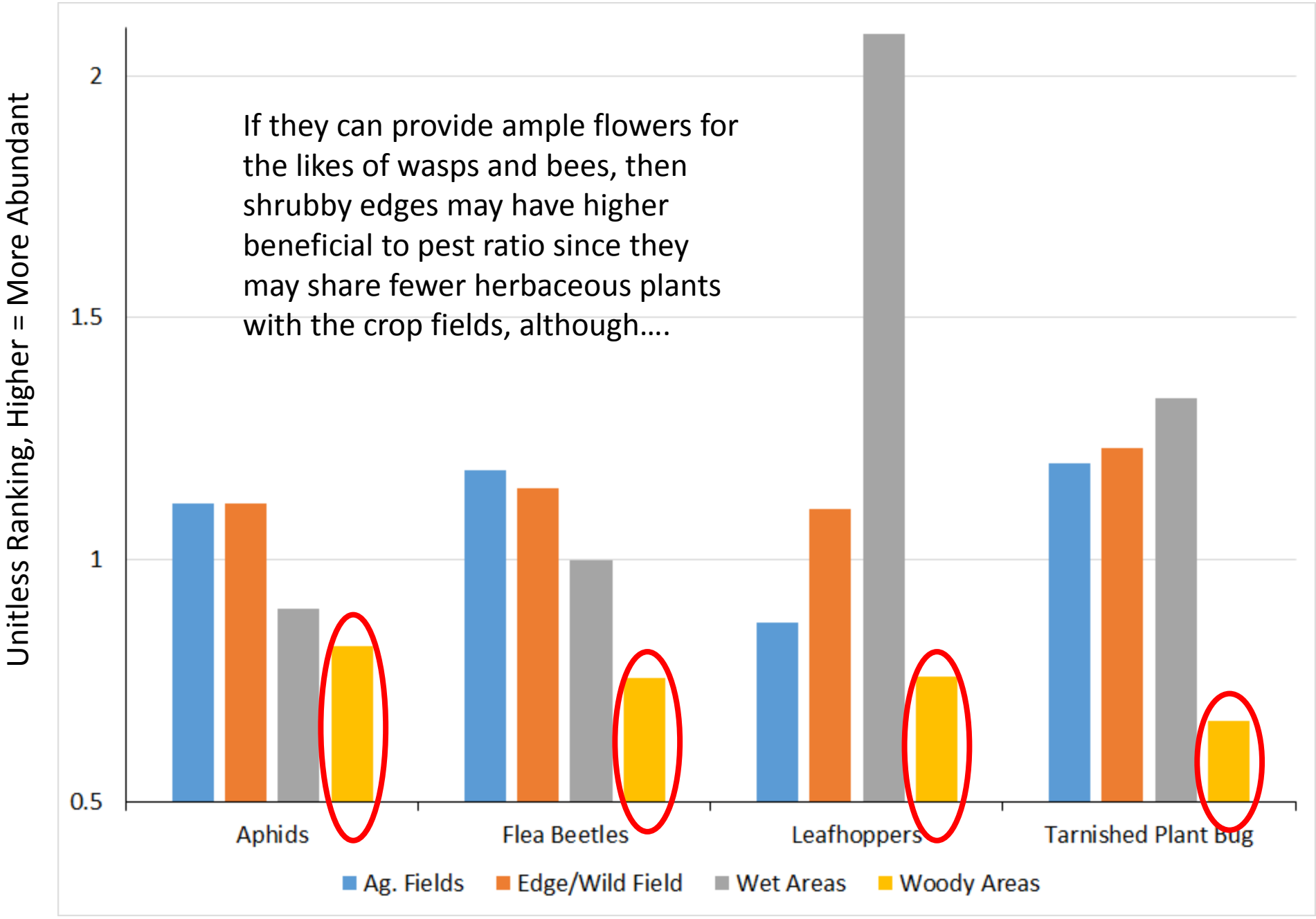
What about pests?

Aren’t they affected by these habitats too?

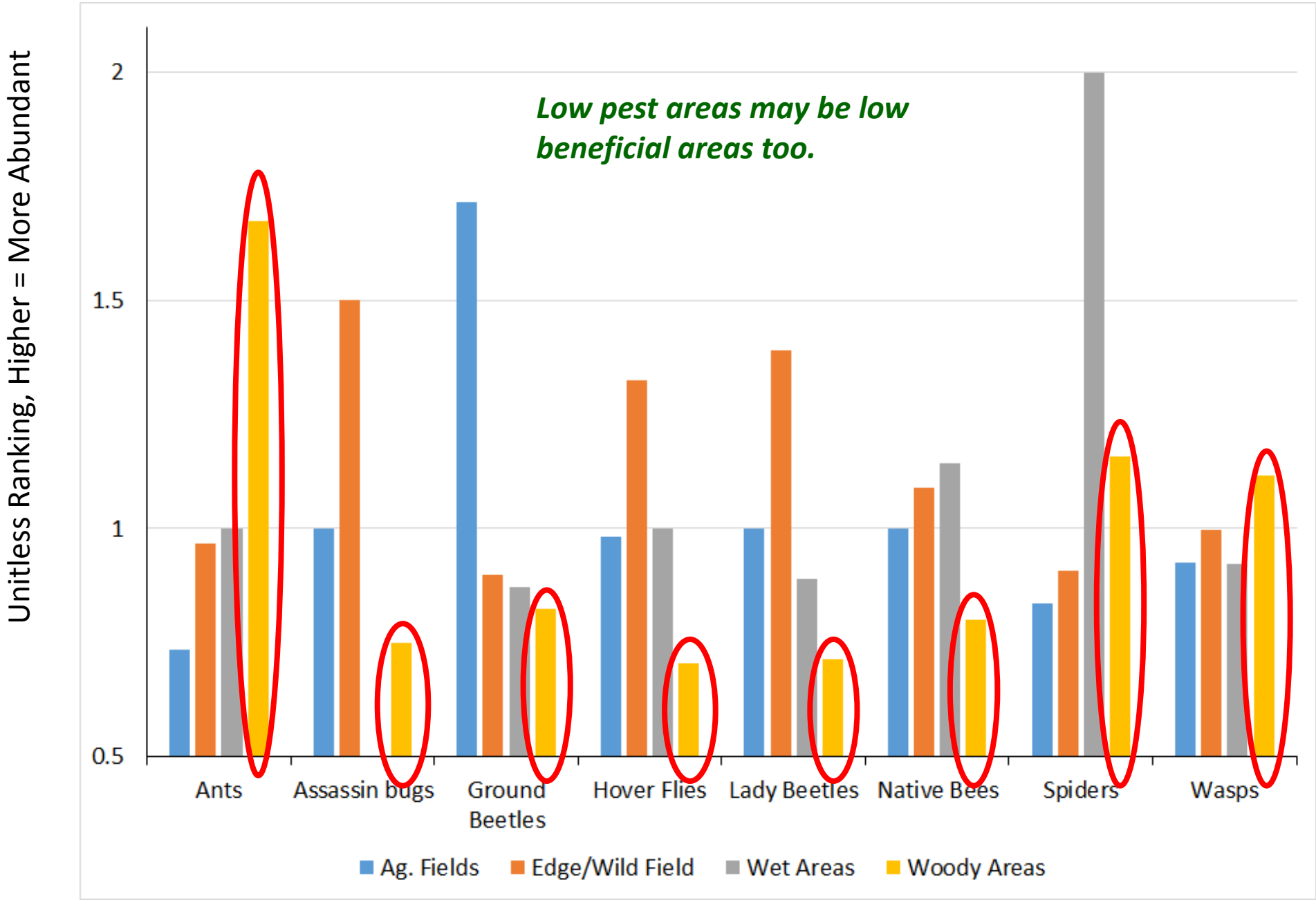
PESTS (5-8 data sets)



PESTS


Unitless Ranking, Higher = More Abundant
2
1.5
1
0.5
If they can provide ample flowers for the likes of wasps and bees, then shrubby edges may have higher beneficial to pest ratio since they may share fewer herbaceous plants with the crop fields, although….
Aphids
Flea Beetles
Leafhoppers
Tarnished Plant Bug
Ag. Fields
Edge/Wild Field
Wet Areas
Woody Areas

BENEFICIALS



But, as with beneficials, categories like “aphid” don’t necessarily tell you much. We need to be more rigorous in identifying the pests.

R.o.T. #5:

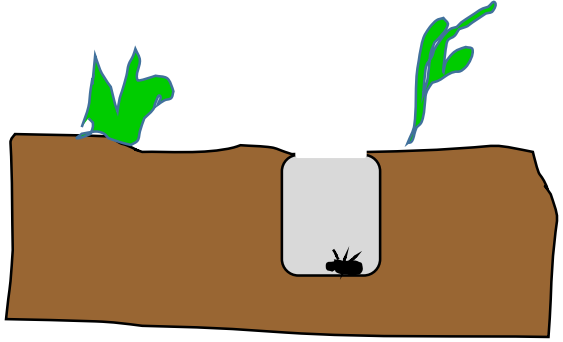
Don’t forget the pests
(if only you could)!

Why beneficial abundance does not necessarily equal beneficial contribution:

- Not all beneficials are equally easy to capture and ease of capture (& ID) is not directly proportional to benefits!
- Even if it were, the per-individual beneficial effect is not constant across species.
- “Beneficial effect” is very dependent on the crop and cultivations system.
- What really indicates an effective beneficial? A high number of beneficials in response to a high pest population, or a low but effective population that keeps pests in check and keeps both pests and beneficials from exploding?


Time-lapse camera data looking at who feeds on fall army worm and meal worm bait.
WINGSCAPES
1 MIN
PLOT -08
01 SEP 16
09:31 PM


Woods



= Ground Beetles

= Other Beetles

= Spiders

= Ants

= Crickets

= Slugs

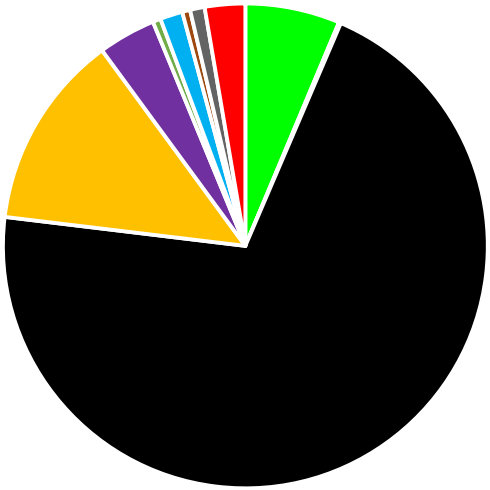
= Daddy Longlegs

= True Bugs

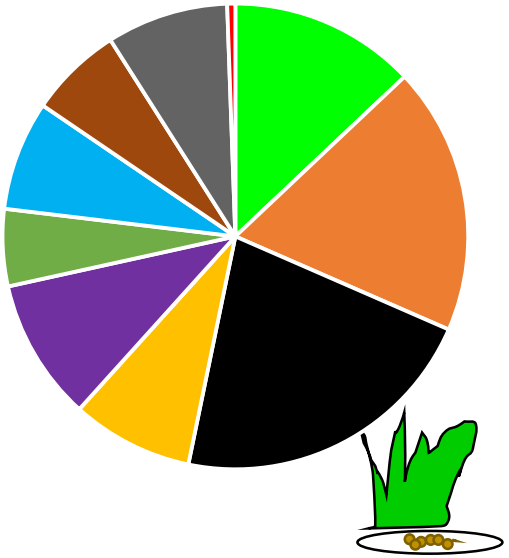
=Beetle Larvae

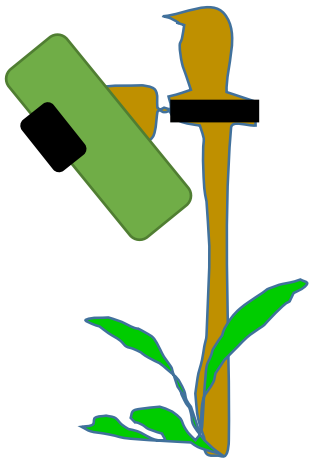
=Centipedes/ Millepedes

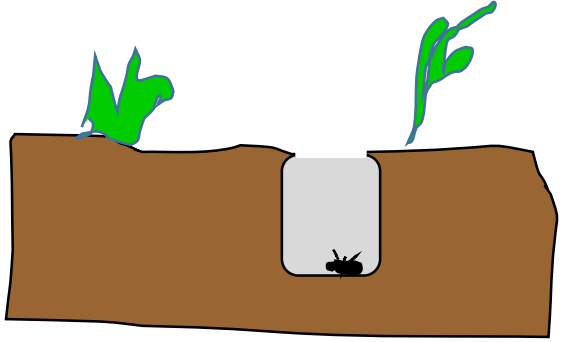
Pit Traps: Creatures Captured, 225 Trap Nights



Time-Lapse Cameras: Hours with at least One of Given Creature, 833 camera-hours







= Ground Beetles

= Other Beetles

= Spiders

= Ants

= Crickets

= Slugs

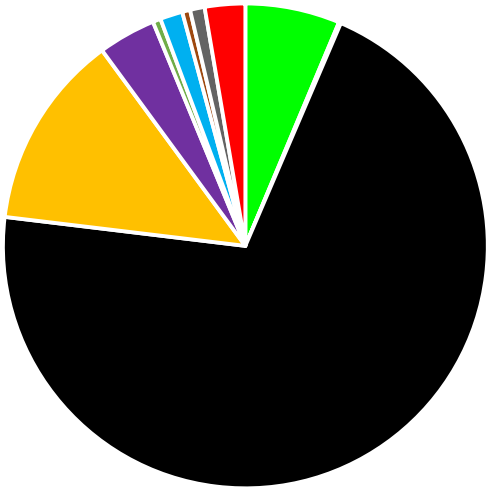
= Daddy Longlegs

= True Bugs

=Beetle Larvae

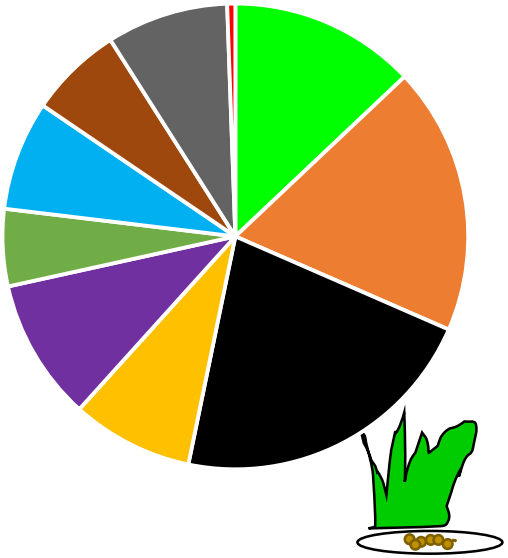
=Centipedes/ Millepedes

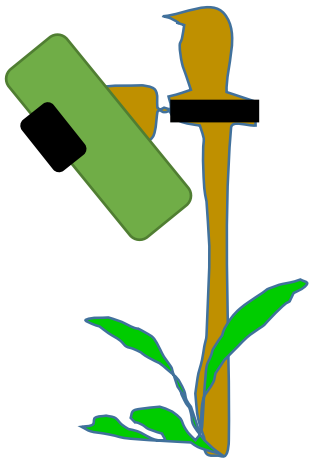
Pit Traps: Creatures Captured, 225 Trap Nights

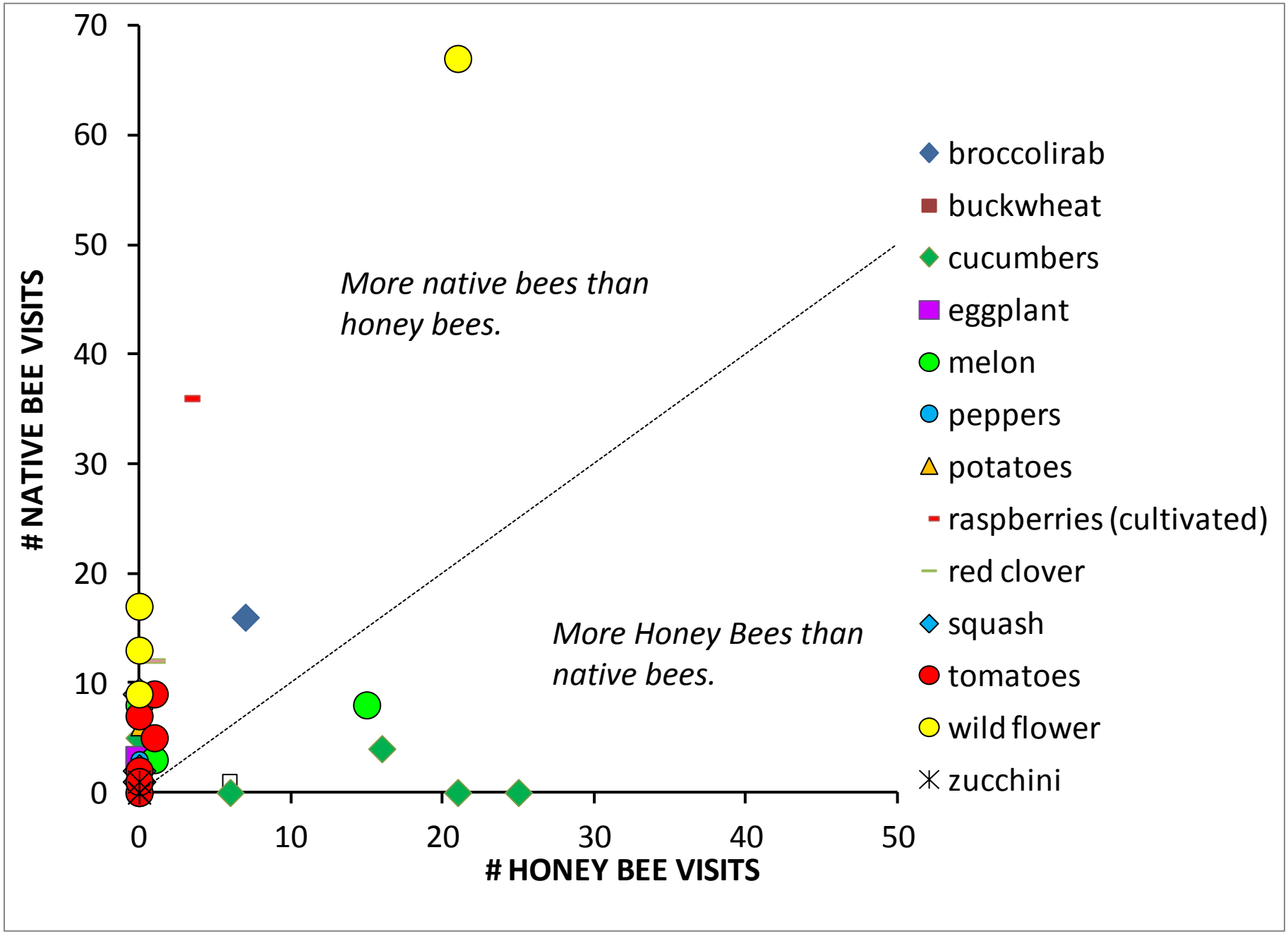


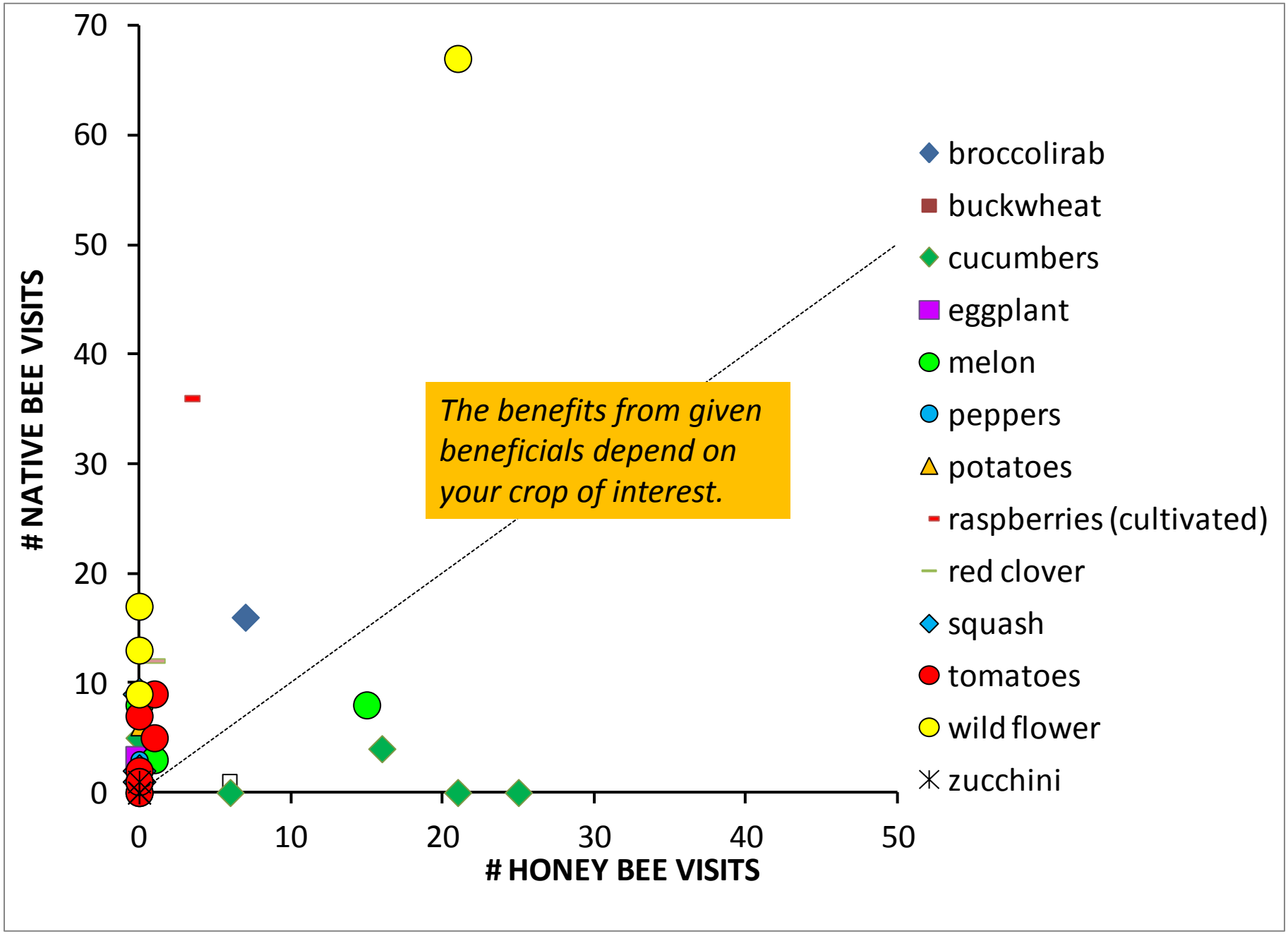
Services (as measured by egg/larvae consumption) is not proportional to abundance.

Time-Lapse Cameras: Hours with at least One of Given Creature, 833 camera-hours






70
60
50
40
30
20
10
0
NATIVE BEE VISITS
0
10
20
30
40
50
HONEY BEE VISITS
More native bees than honey bees.
More Honey Bees than native bees.
broccolirab
buckwheat
cucumbers
eggplant
melon
peppers
potatoes
raspberries (cultivated)
red clover
squash
tomatoes
wild flower
zucchini


70
60
50
40
30
20
10
0
NATIVE BEE VISITS
0
10
20
30
40
50
HONEY BEE VISITS
The benefits from given beneficials depend on your crop of interest.
broccolirab
buckwheat
cucumbers
eggplant
melon
peppers
potatoes
raspberries (cultivated)
red clover
squash
tomatoes
wild flower
zucchini

R.o.T. #6:

'Beneficiality' depends on more than abundance – it depends on the behavior of the beneficial and the benefit desired.

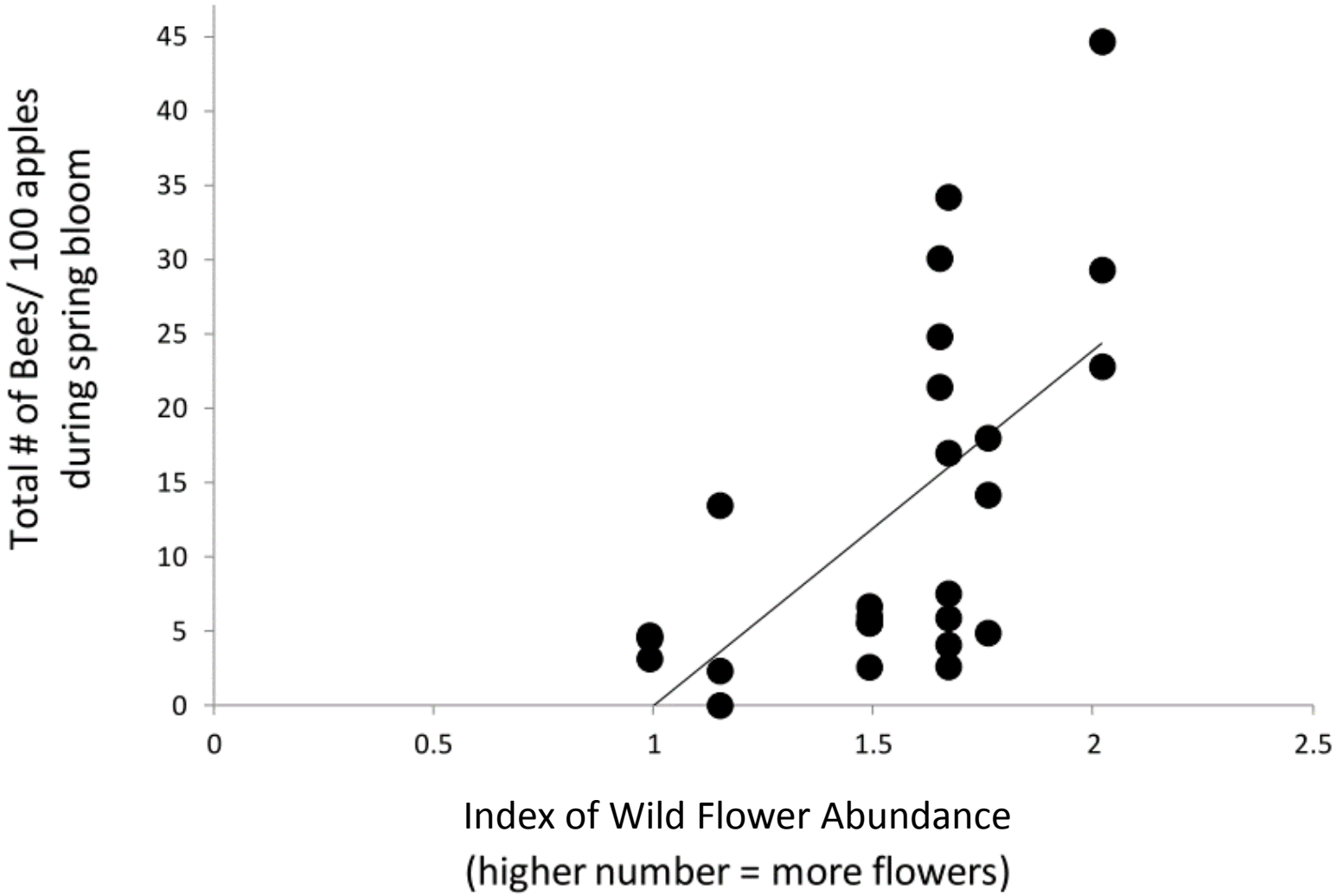
For the above two reasons (i.e., pests are also influenced by management and benefits depend on who & where) and because ‘the bottom line’ is an important criterion of success, if one wants to verify and share results, ***it is important to document that abundance is indeed related to ‘service’ and that the net benefits of a given habitat do improve the economics of crop production.***


That ain’t easy.

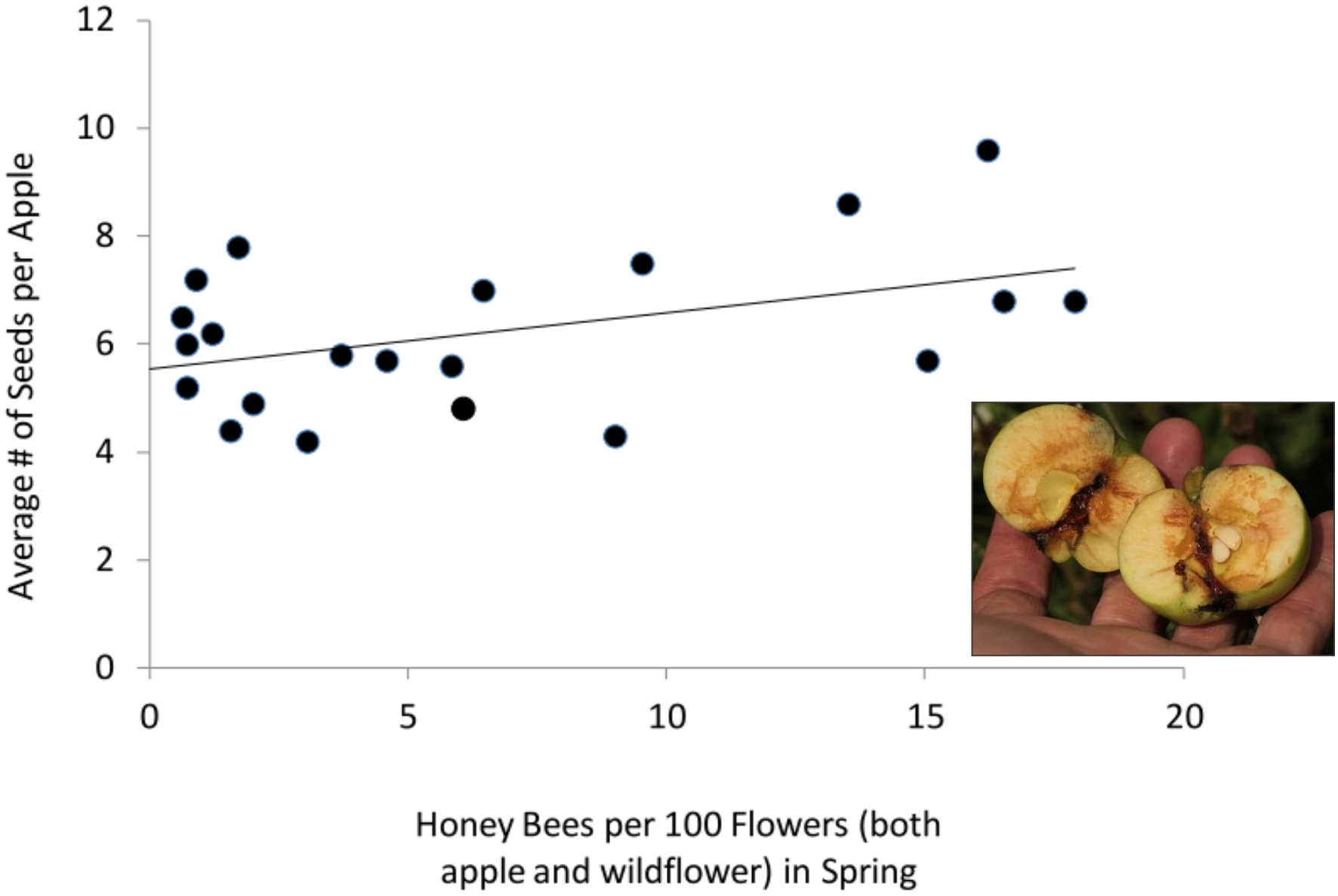
An Example

Photo by Kyle Bradford

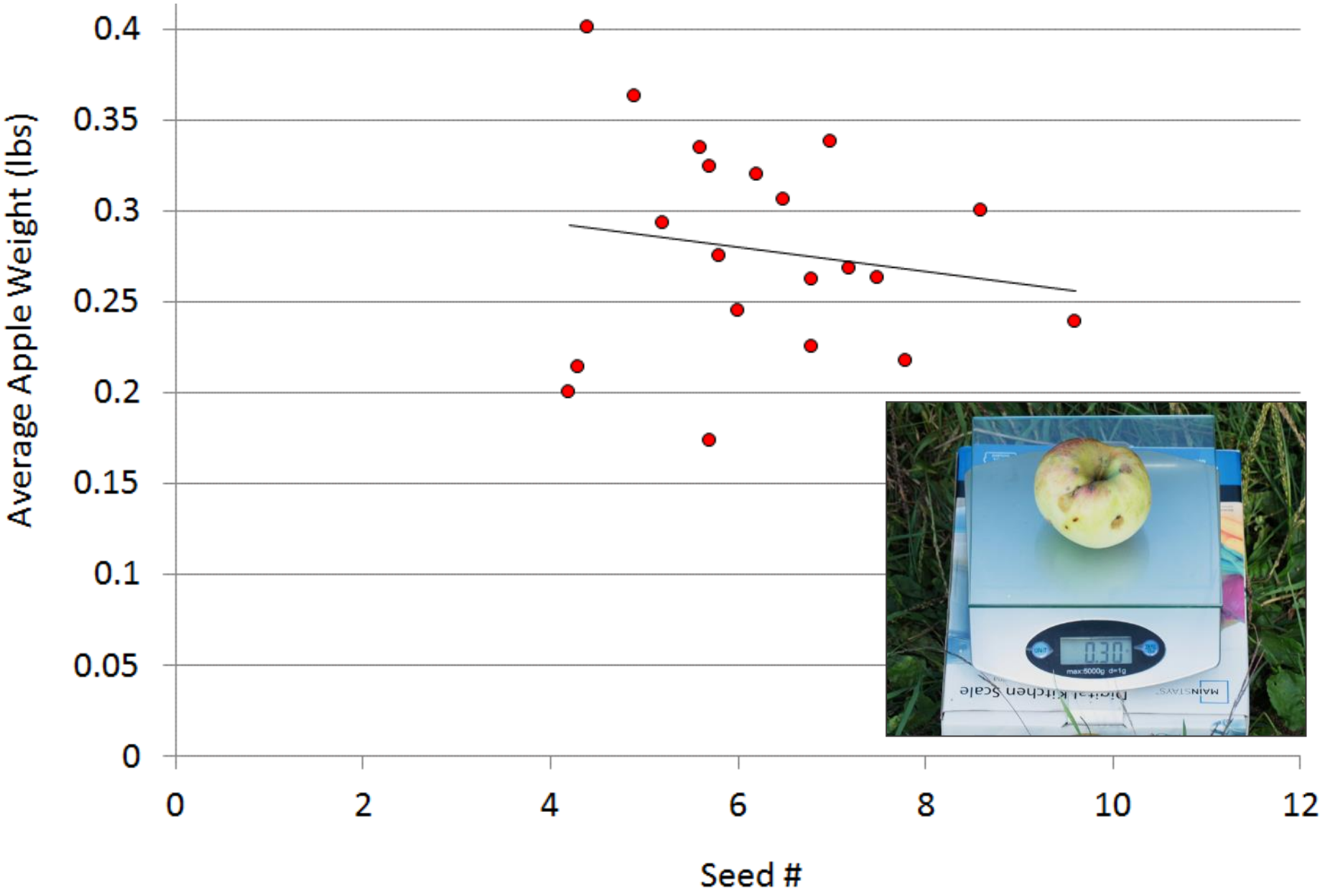
More wild flowers in the neighborhood = more bees on the apple blossoms.

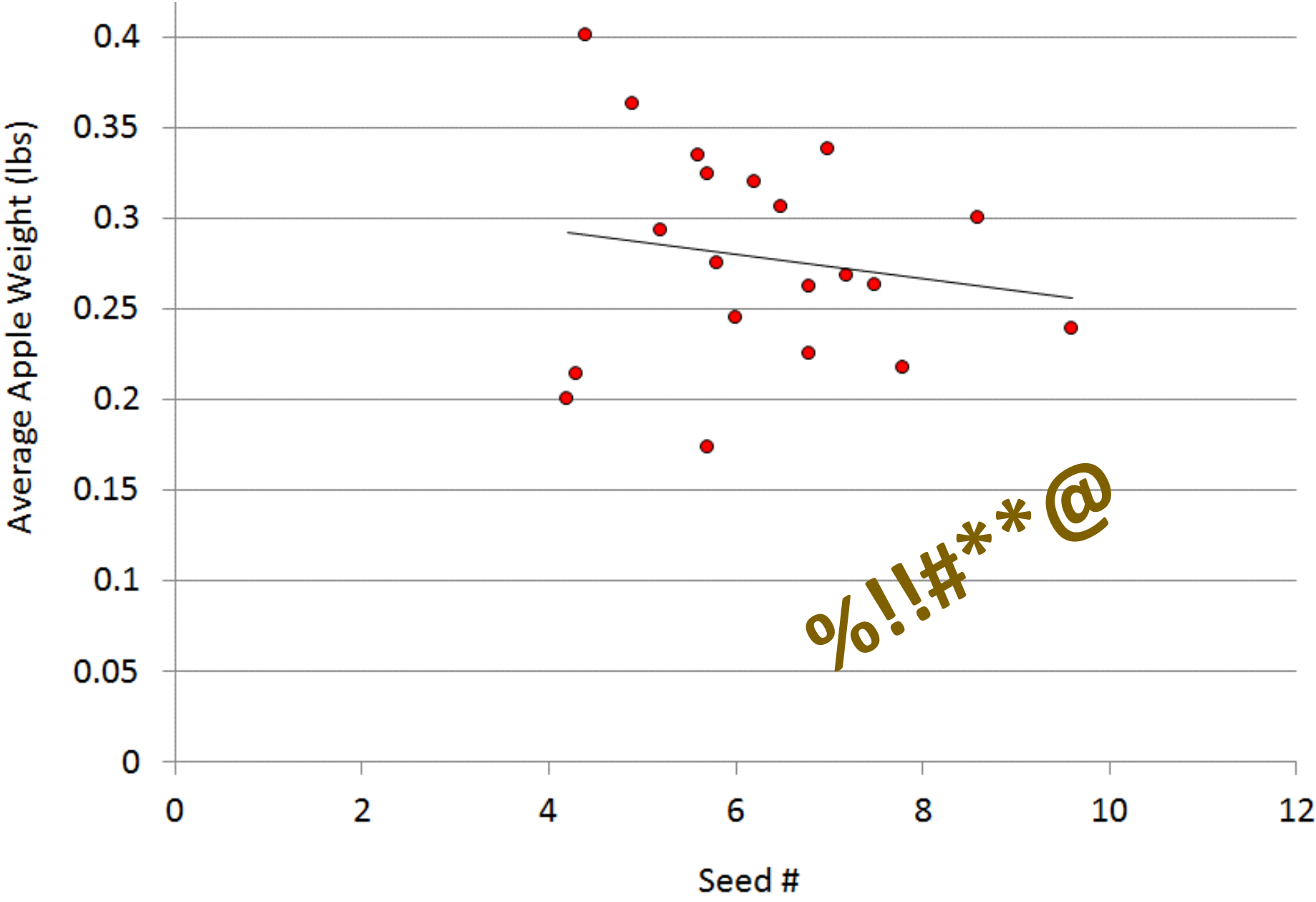


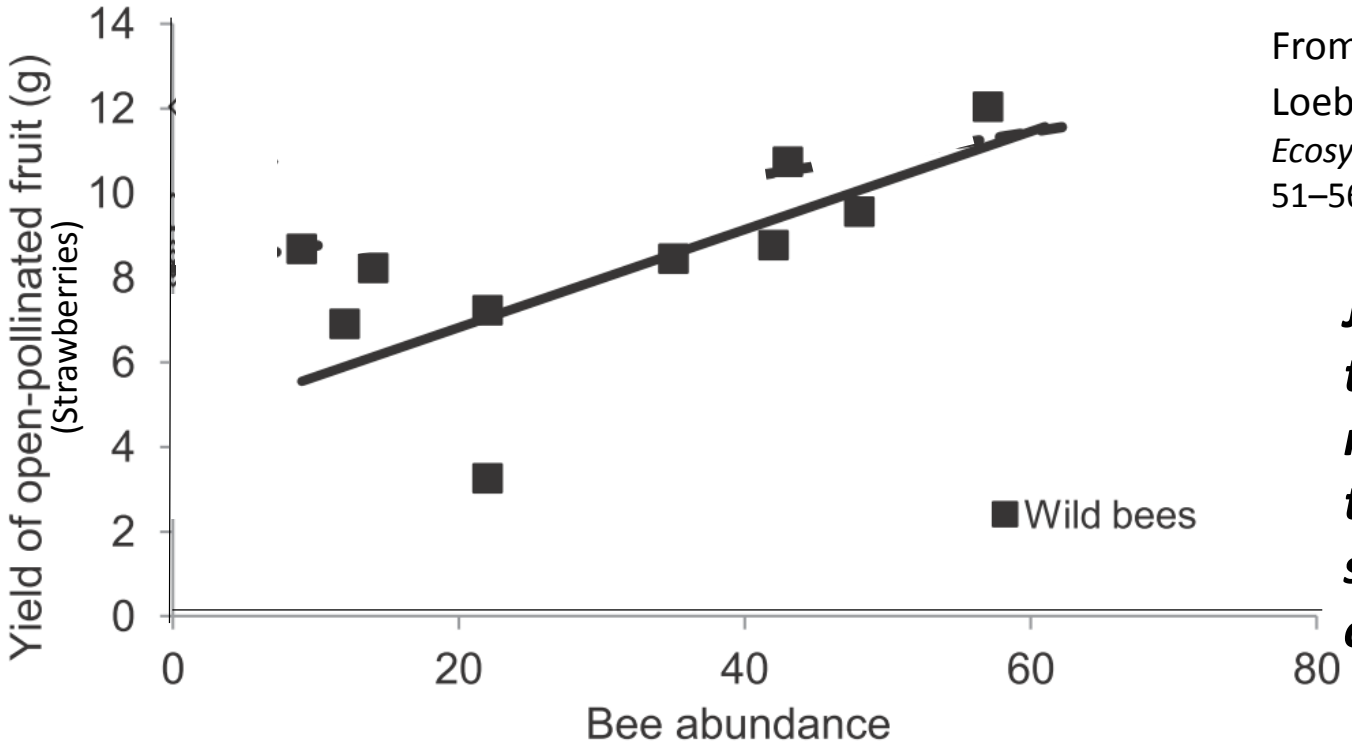
and more bees on flowers means more pollination (as measured by viable seeds/apple)…



But seed number was not related to apple weight!




Average Apple Weight (lbs)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
2
4
6
8
10
12
Seed #
%!!#**@



From Connelly, Poveda & Loeb. 2015. *Agriculture, Ecosystems and Environment* 211: 51–56

Just to show you that it can work – more native bees led to more fruit in this strawberry study by others.

R.o.T. #7:

Ultimately (ugh!), to assess beneficial habitat, we need to measure not just abundance of beneficials, but also their services and the net effects of the habitat.

Conclusions (the Rotters):

1. *Different types of habitat are important for different groups of beneficials.*

2. *Within general groups of beneficials, different species have different habitat preferences, so species-specific data are important.*

3. *Different beneficials may need wild habitat for different reasons; some may not need it at all.*

4. *Those different beneficial ecologies translate into different approaches for their management.*

5. *Don't forget the pests.*

6. *'Beneficiality' depends on more than abundance – it depends on the behavior of the beneficial and the benefit desired.*

7. *Ultimately, to assess beneficial habitat, we need to measure not just abundance of beneficials, but their services and the net effects of the habitat.*

General Long-term Approach:

1) Study the year-around habitat use of those beneficials & pests for which we can get species-level information. These data will be incomplete.

2) Devise and apply ways of measuring beneficial effects, first in terms of service, ultimately in terms of net effect of habitat on production.

3) Document the biodiversity benefits at the same time.

4) Use the habitat and services research together with suggestions of others to choose trial approaches.

5) Monitor those trials - do they work?

6) Based on all of the above, come up with and document management approaches that have demonstrable agronomic effect. After trialing them ‘at home’, trial with collaborators, share successes more widely.

Specific Plans for 2017