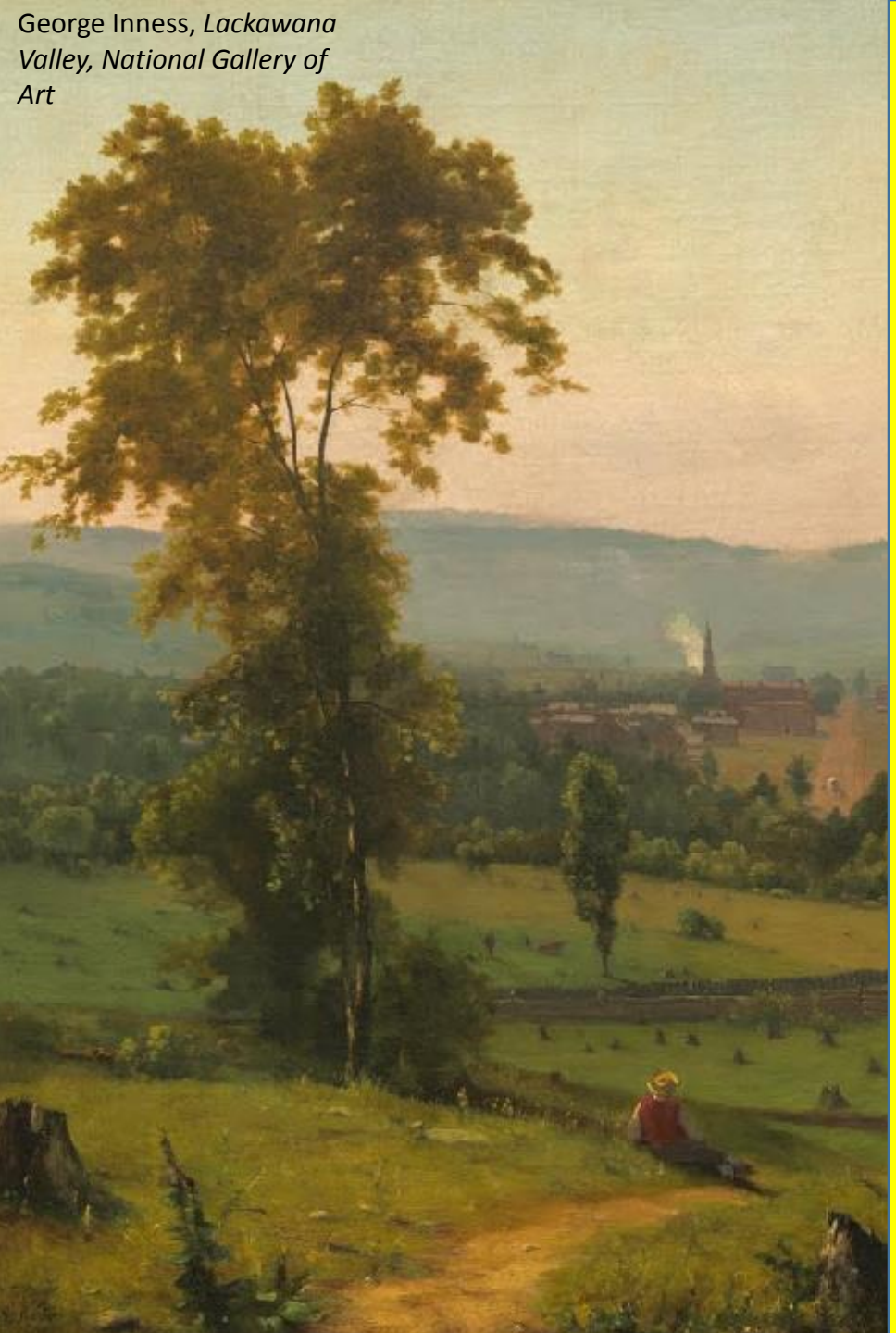
Some Insect Aspects of Habitat Farming.

Conrad Vispo.
Hawthorne Valley Farmscape Ecology Program

George Inness, *Lackawana Valley, National Gallery of Art*



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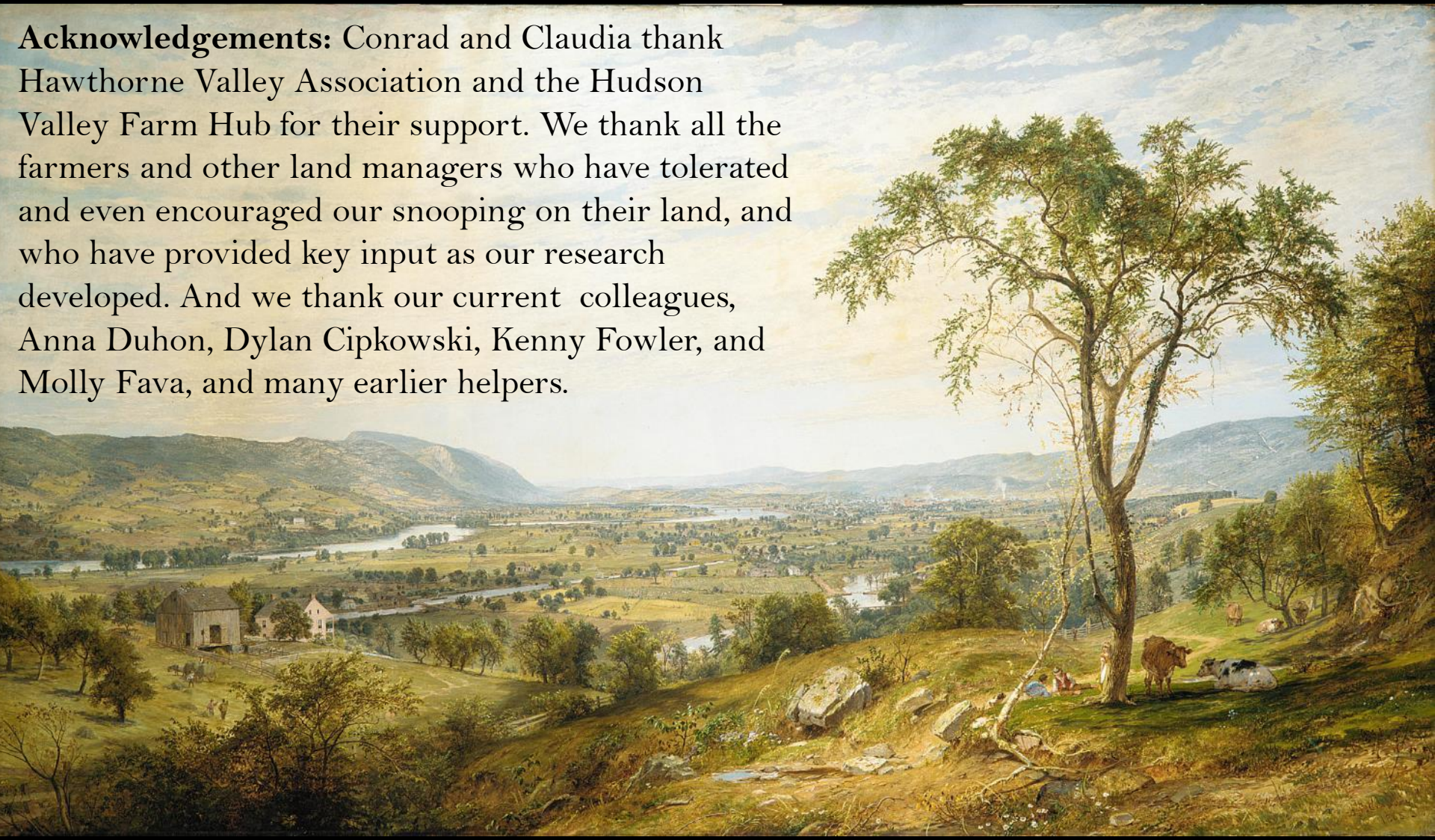
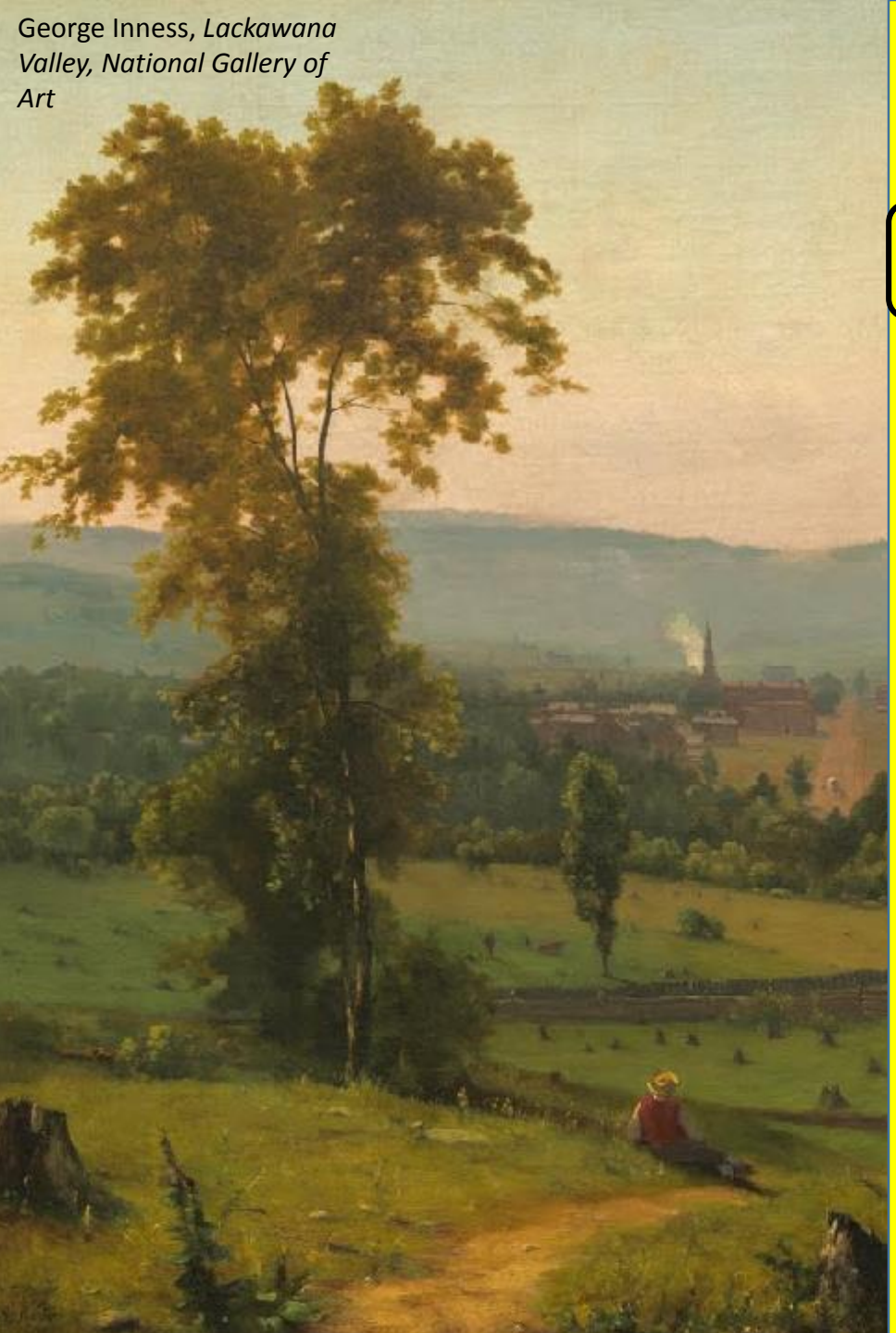
Acknowledgements: Conrad and Claudia thank Hawthorne Valley Association and the Hudson Valley Farm Hub for their support. We thank all the farmers and other land managers who have tolerated and even encouraged our snooping on their land, and who have provided key input as our research developed. And we thank our current colleagues, Anna Duhon, Dylan Cipkowski, Kenny Fowler, and Molly Fava, and many earlier helpers.



Jasper Francis Cropsey, 1865, *The Valley of Wyoming*, www.metmuseum.org



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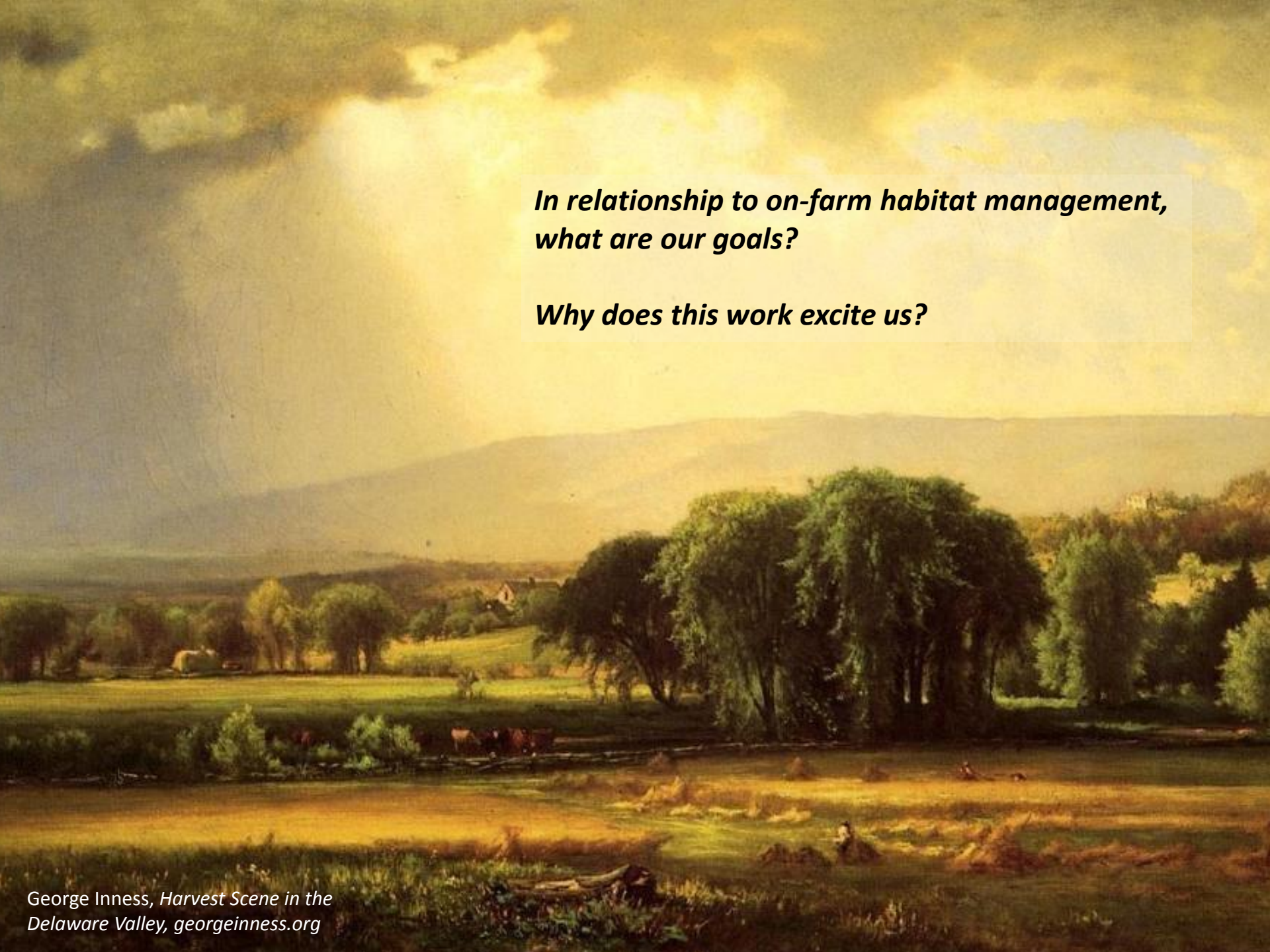
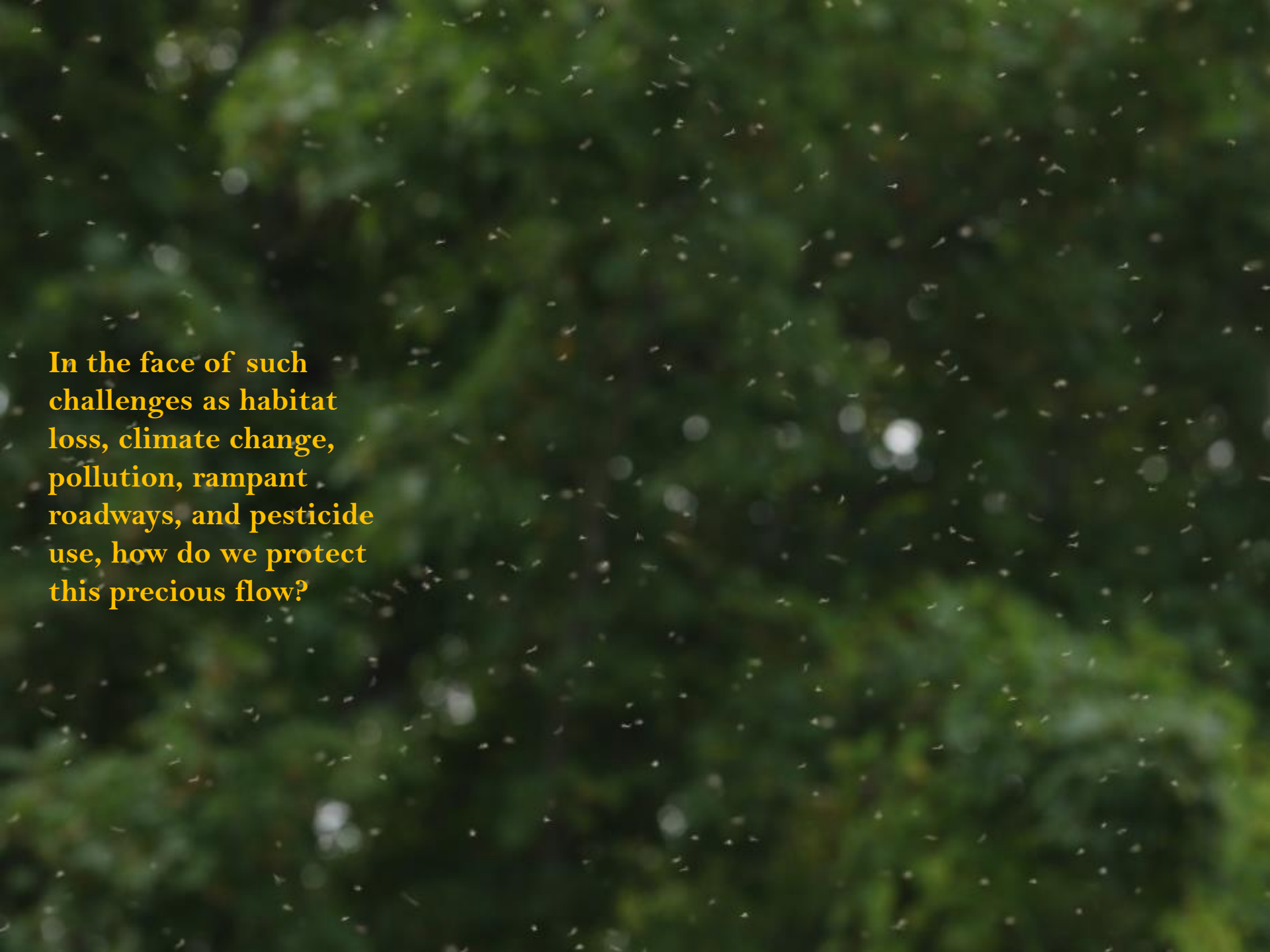


George Inness, *Harvest Scene in the Delaware Valley, georgeinness.org*

It excites me when I get little glimpses of the flow of life.


In the face of such challenges as habitat loss, climate change, pollution, rampant roadways, and pesticide use, how do we protect this precious flow?


How can we build synergies between nature conservation and human use?

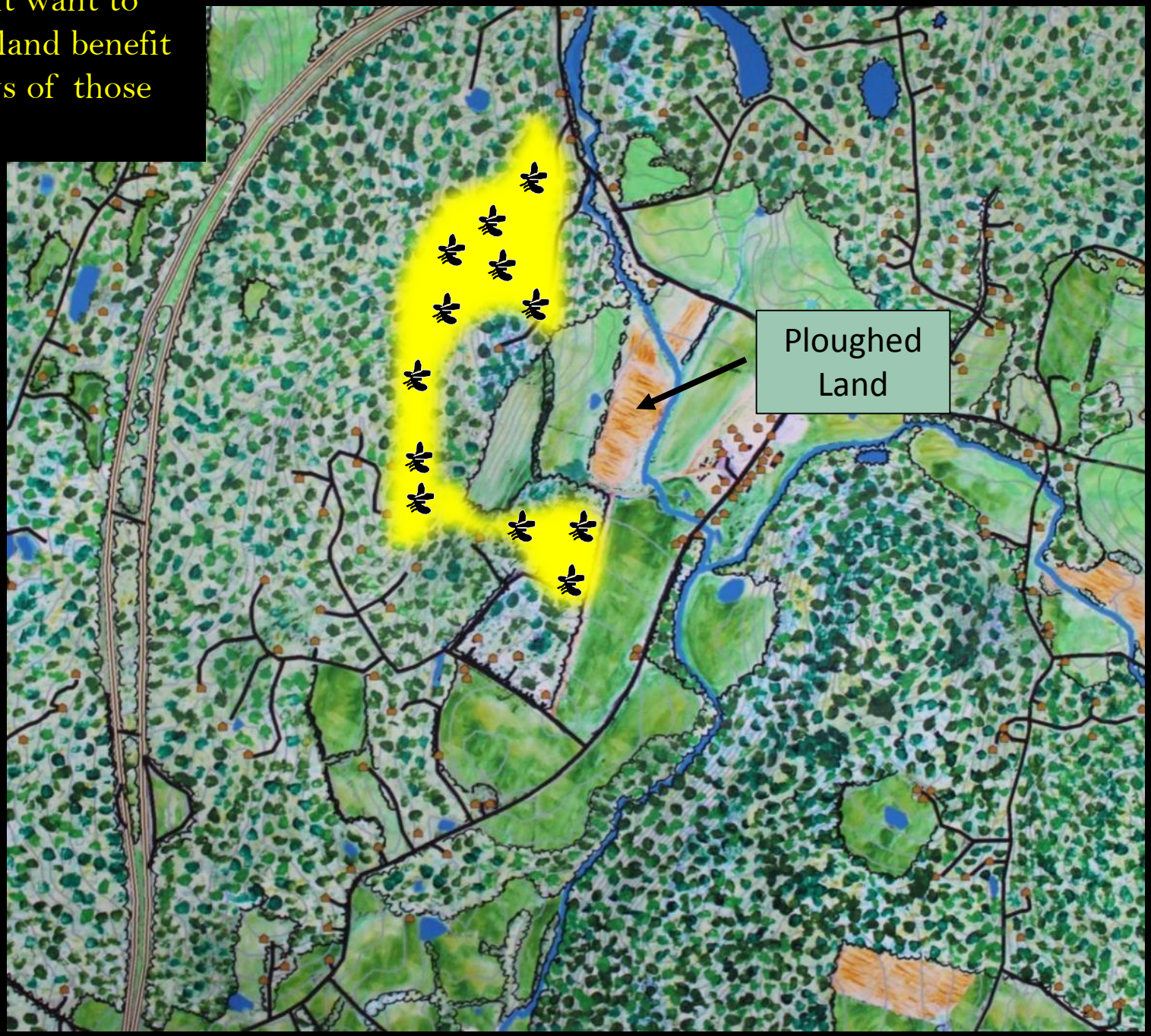
One can imagine flows, puddles, eddies of life on the landscape.

Those distributions vary across time for various reasons.

Perhaps your goal is to increase the populations of rare and/or beneficial insects.

By conserving/ improving habitats, one can help enhance local populations of such species.

You might want to help cropland benefit from flows of those creatures.



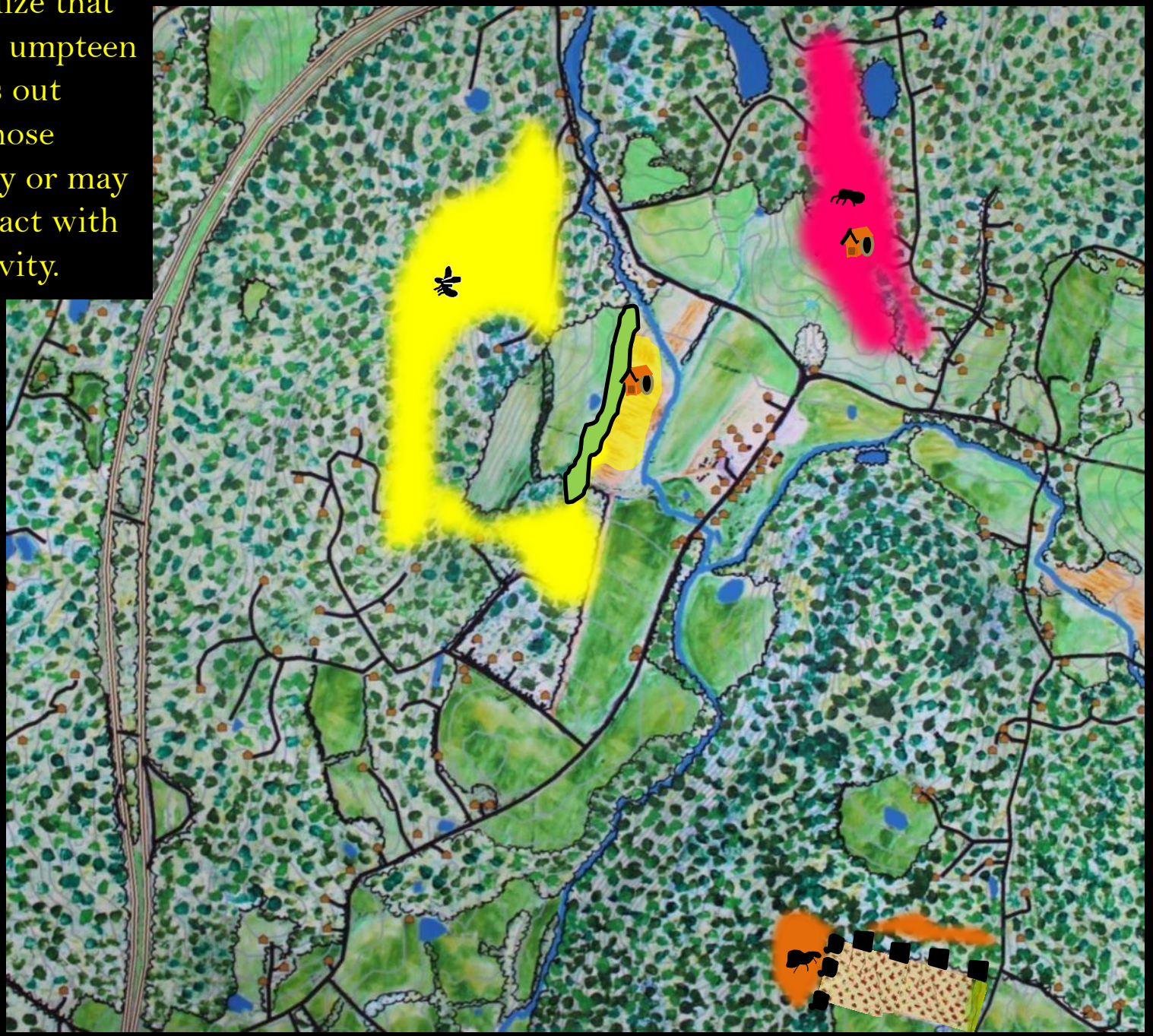
For example, you might need to create ‘habitat guideposts’ to draw insects out towards crop lands.

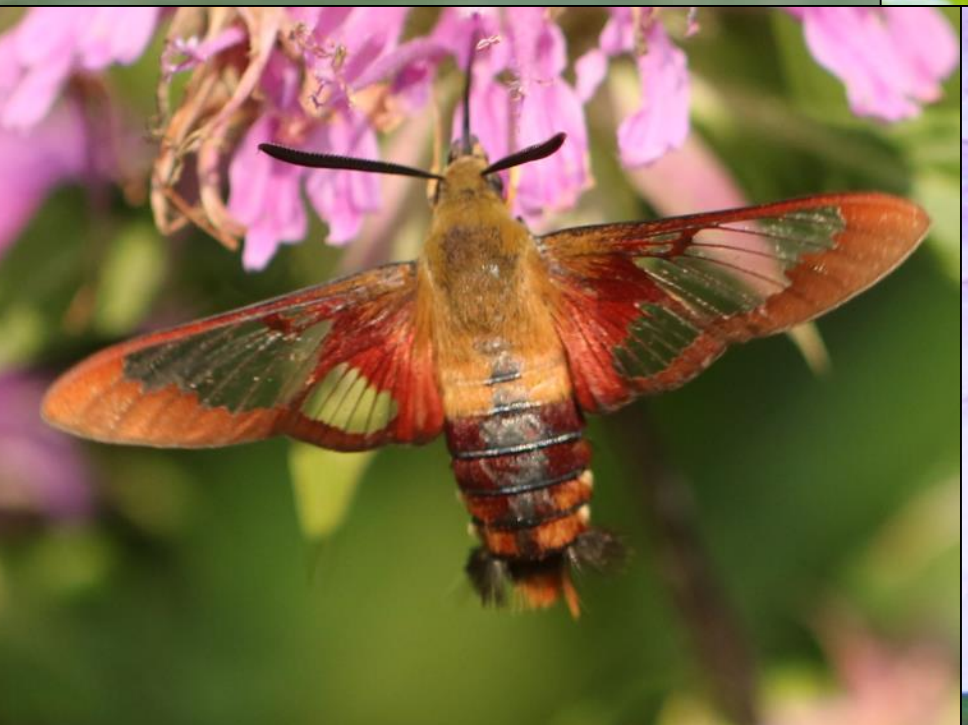
For example, you might need to create ‘habitat guideposts’ to draw insects out towards crop lands.

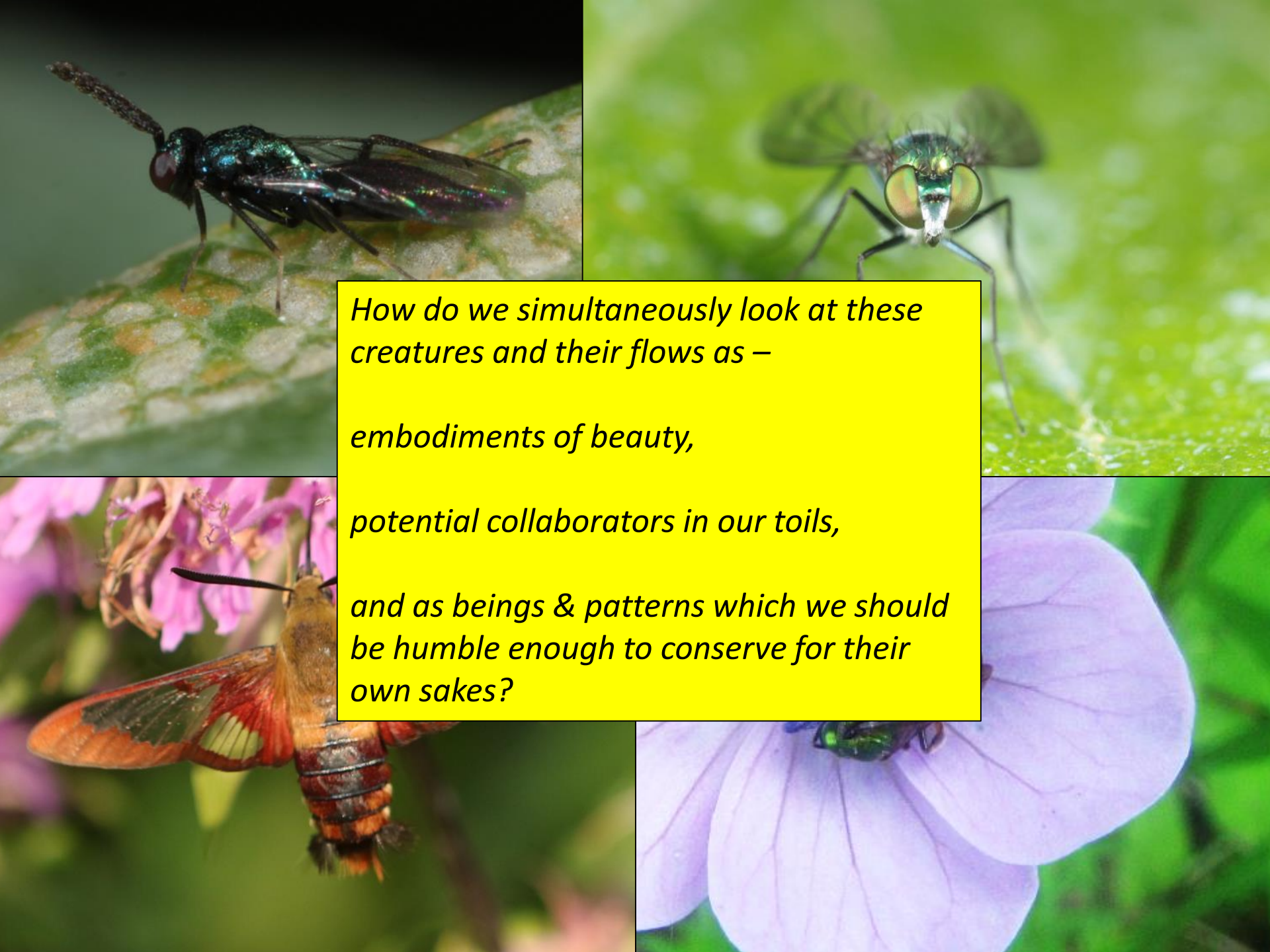
And create suitable crop conditions for taking advantage of these insects.

i.e., you want to install the 'mill'

Now realize that there are umpteen creatures out there, whose flows may or may not interact with your activity.







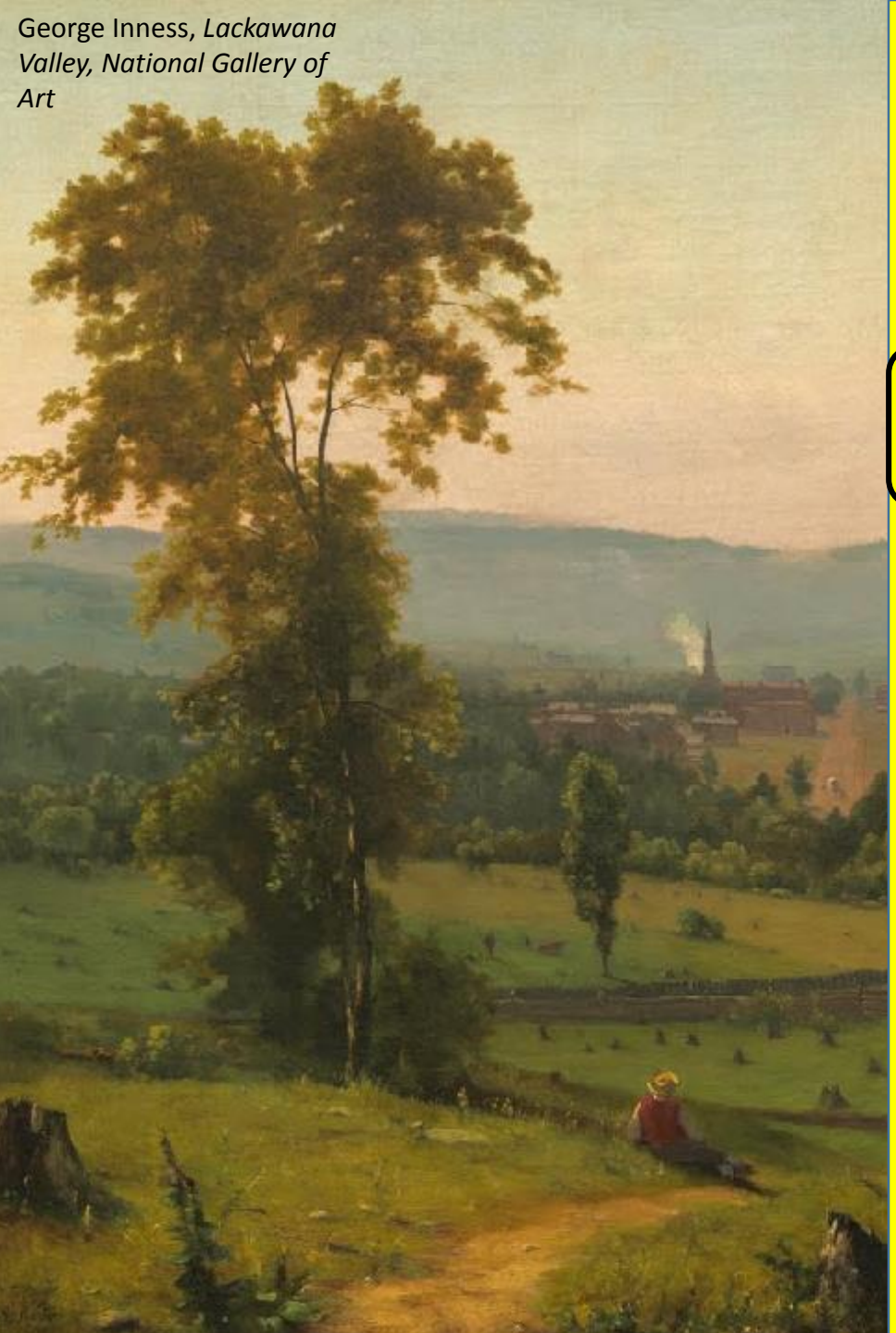
How do we simultaneously look at these creatures and their flows as –

embodiments of beauty,

potential collaborators in our toils,

and as beings & patterns which we should be humble enough to conserve for their own sakes?

William Boden. *Followers of the Plough*. (1919)



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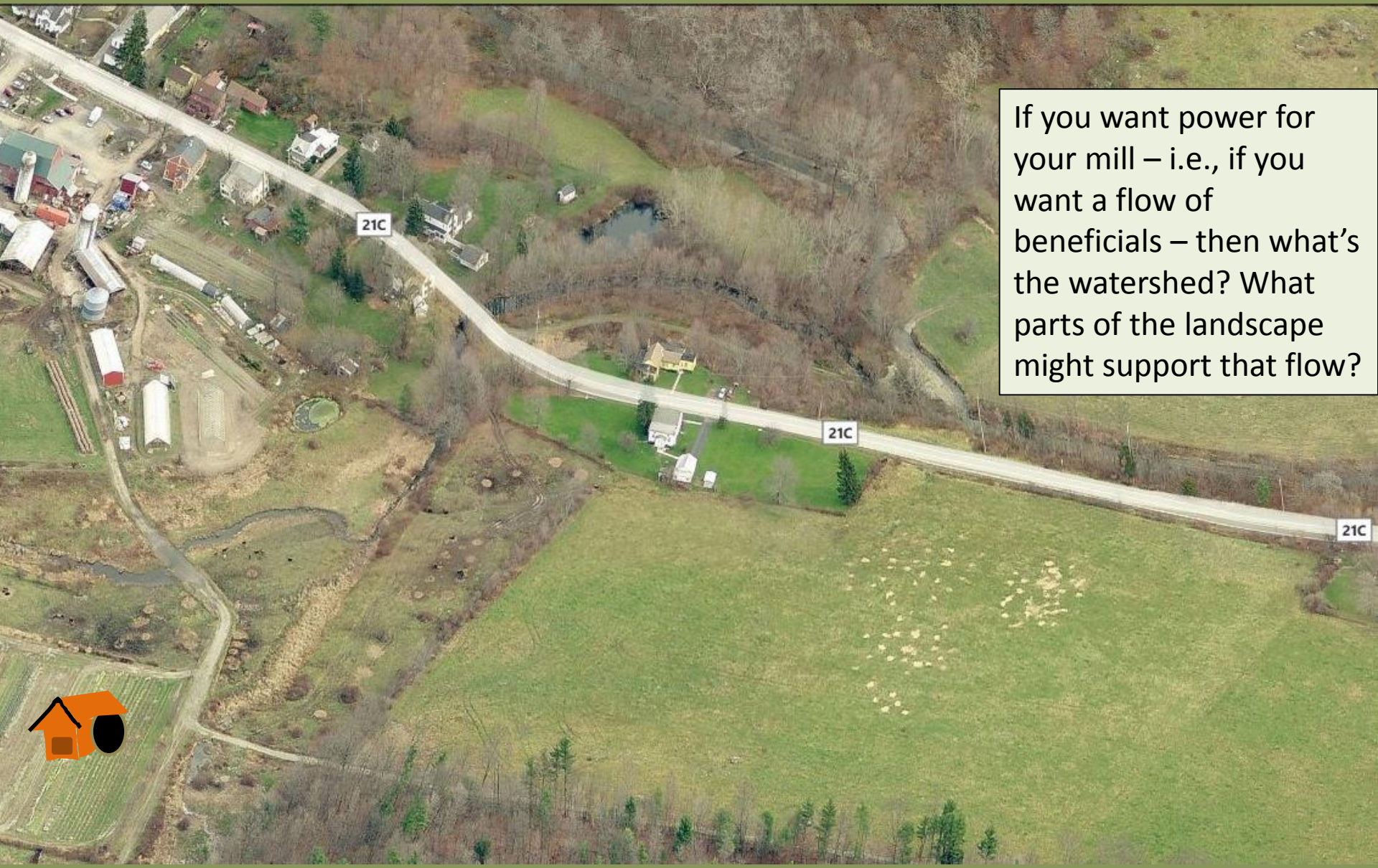
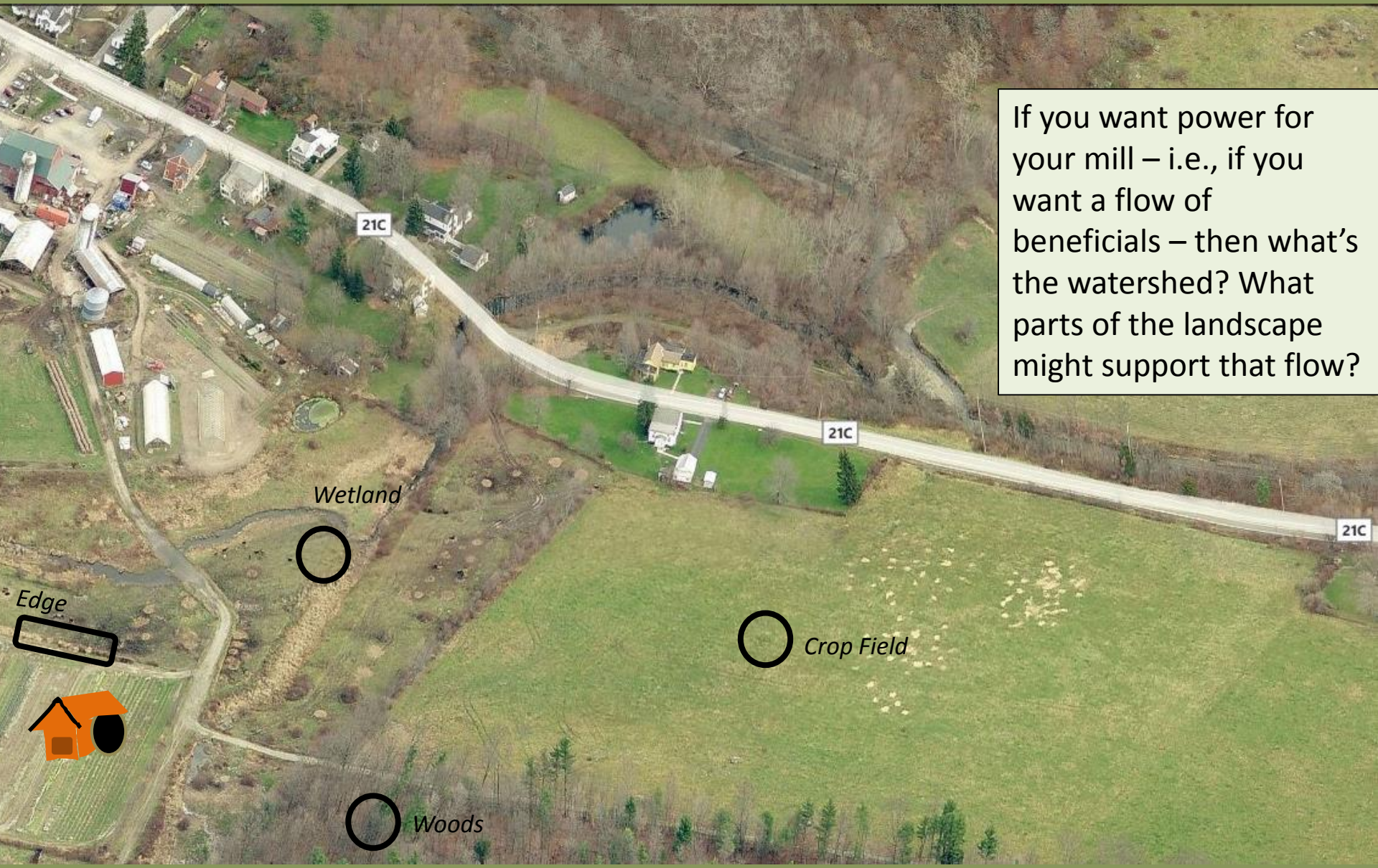
Broadly speaking, what are our tools both in terms of habitat creation/conservation and in terms of 'support structures', e.g. appropriate crops and cultivars, healthy soils, appropriate scale?

John Mortimer, *The Whole Art of Husbandry*, Dublin, 1721



If you want power for your mill – i.e., if you want a flow of beneficials – then what's the watershed? What parts of the landscape might support that flow?



If you want power for your mill – i.e., if you want a flow of beneficials – then what's the watershed? What parts of the landscape might support that flow?


Crop Field


Edge


Wetland


Woods


Crop Field
Ground Beetles
Hover Flies
Lady Beetles
Native Bees
Wasps
Spiders


Edge
Ground Beetles
Hover Flies
Lady Beetles
Native Bees
Wasps
Spiders


Wetland
Ground Beetles
Hover Flies
Lady Beetles
Native Bees
Wasps
Spiders


Woods
Ground Beetles
Hover Flies
Lady Beetles
Native Bees
Wasps
Spiders

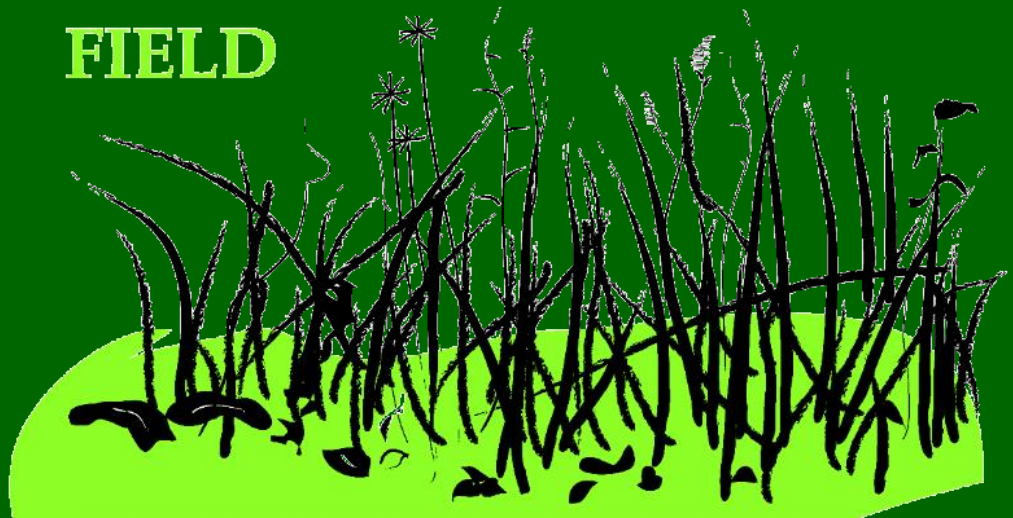
A diversity of beneficials may require a diversity of habitats in the 'watershed'.

Let's look at one group more closely:

Ground Beetles can be pest and weed-seed predators, they're also interesting ecologically.

There are distinct ground beetle communities associated with different habitats in the landscape, for example….

FIELD




Calleida punctata
Anisodactylus sanctaecrucis
Harpalus rubripes
Amara familiaris
Harpalus spadiceus
Colliuris pensylvanica
Anisodactylus rusticus
Stenolophus comma
Amphasia sericea
Harpalus pensylvanicus
Harpalus somnulentus
Harpalus erraticus


FOREST


Pterostichus rostratus
Sphaeroderus stenostomus
Calathus gregarius
Pterostichus stygicus
Amphasia interstitialis
Pterostichus tristis
Dicaelus politus
Pterostichus coracinus
Synuchus impunctatus
Trichotichnus autumnalis
Trichotichnus vulpeculus
Agonum retractum

A 'Family Tree' of Regional Ground Beetle Communities

Diagrams like this indicate which communities have the most similar sets of species.

A 'Family Tree' of Regional Ground Beetle Communities

For example, the Ground Beetles communities of Hemlock & Northern Hardwood Forests are very similar, whereas…

A 'Family Tree' of Regional 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

those of Hemlock Forests and Pastures are very different.

A 'Family Tree' of Regional Ground Beetle Communities

Oak Heath
Vernal Pool/Seep
Acidic Talus Slope
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Pine Forest
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Shrub Swamp
Swamp Forest
Wet Meadow
Calca eous Wet Mdw
pen Wetland
Native Pla ted Mdw
Crop
Old Field
Pasture
Upland Shrubland
Gravel Pit
Pine Bush

If you want more Ground Beetles here,

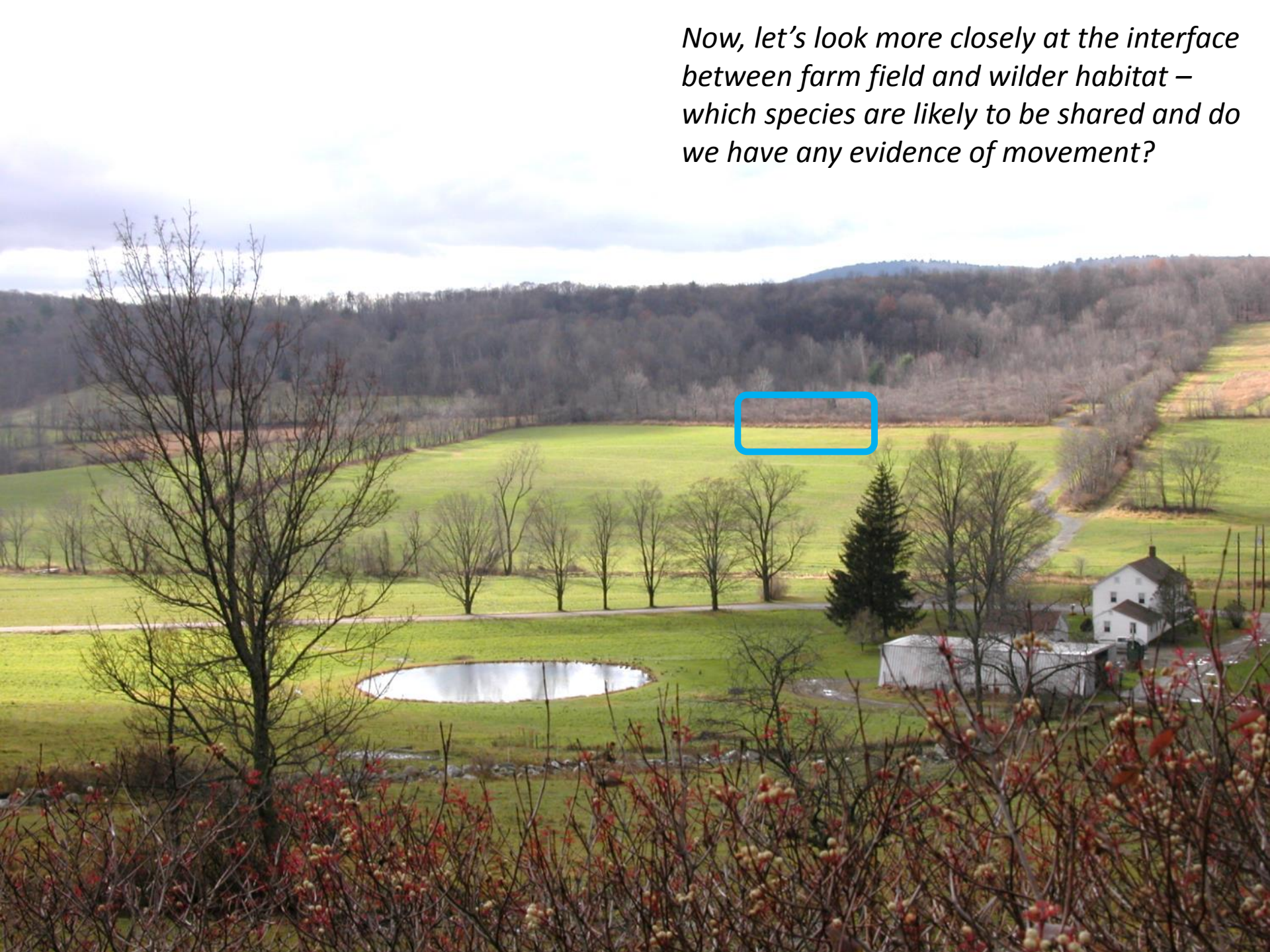
A 'Family Tree' of Regional Ground Beetle Communities

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

then these habitats are the ones most likely to help you.

Imagine those flows again – with work like this, we are better able to predict which habitats might do the most species sharing.

Now, let's look more closely at the interface between farm field and wilder habitat – which species are likely to be shared and do we have any evidence of movement?

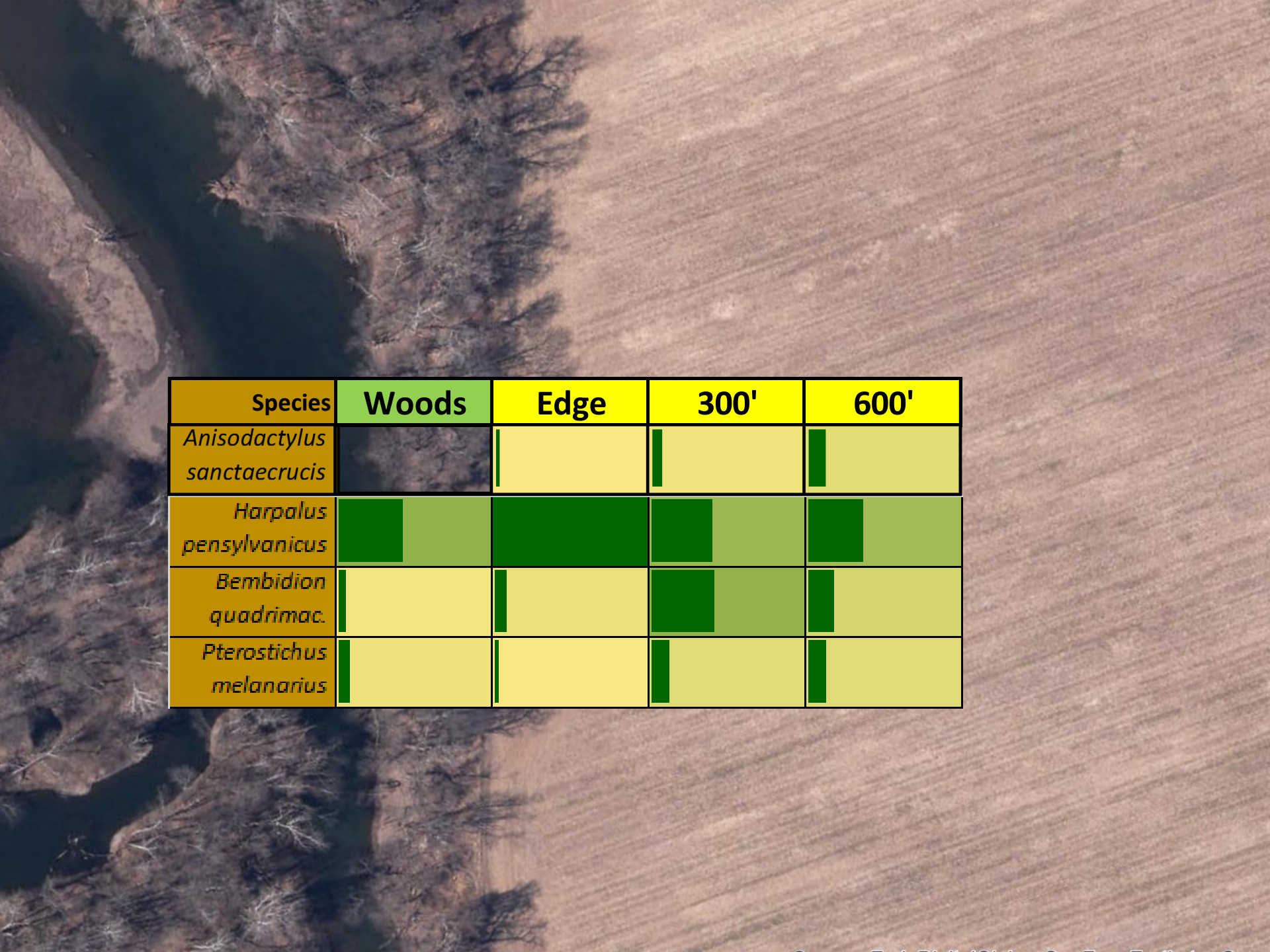


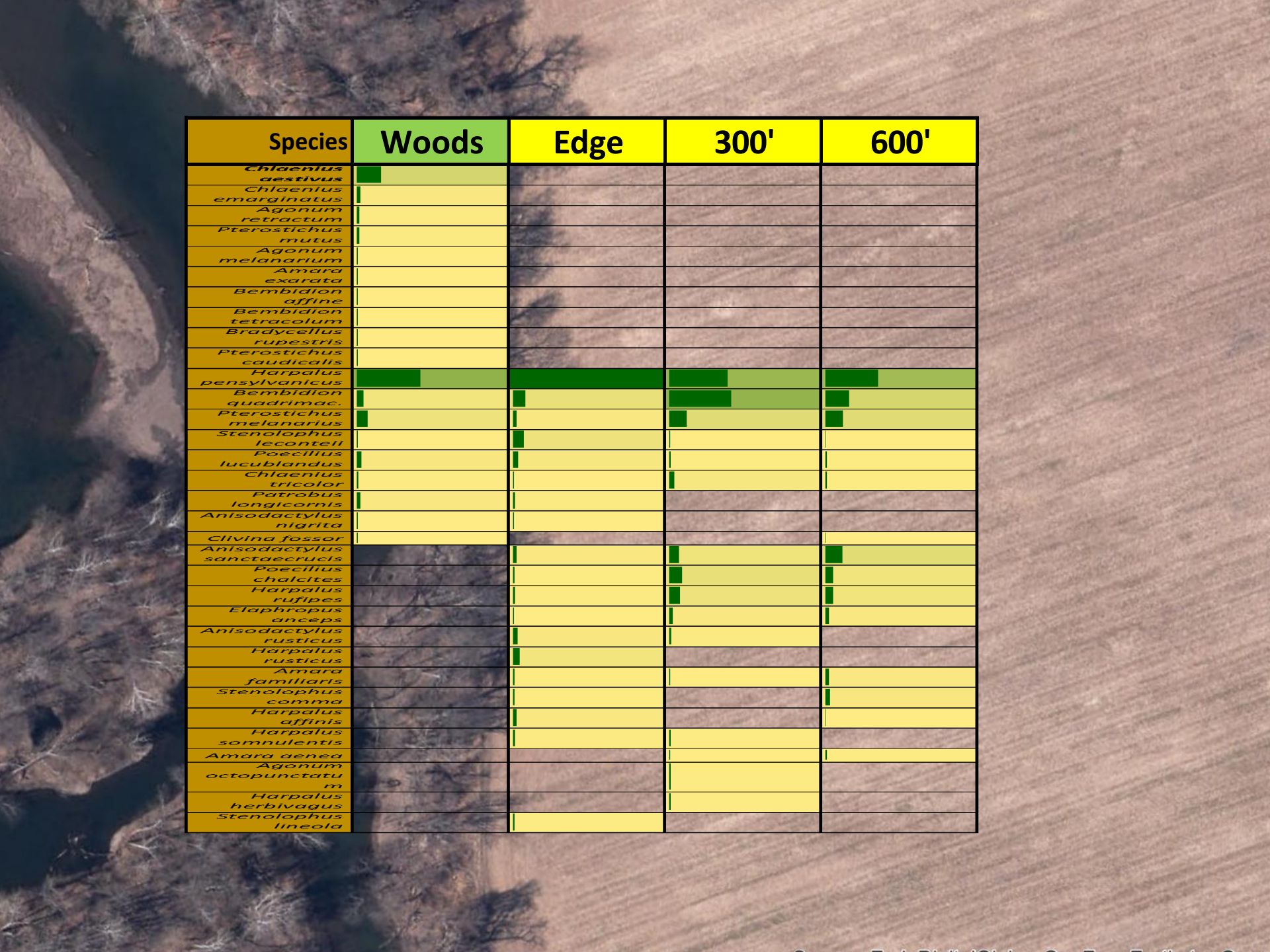

To what degree do the beneficials here,
overlap with the beneficials here?

Species	Woods	Edge	300'	600'
Chlaenius aestivus				

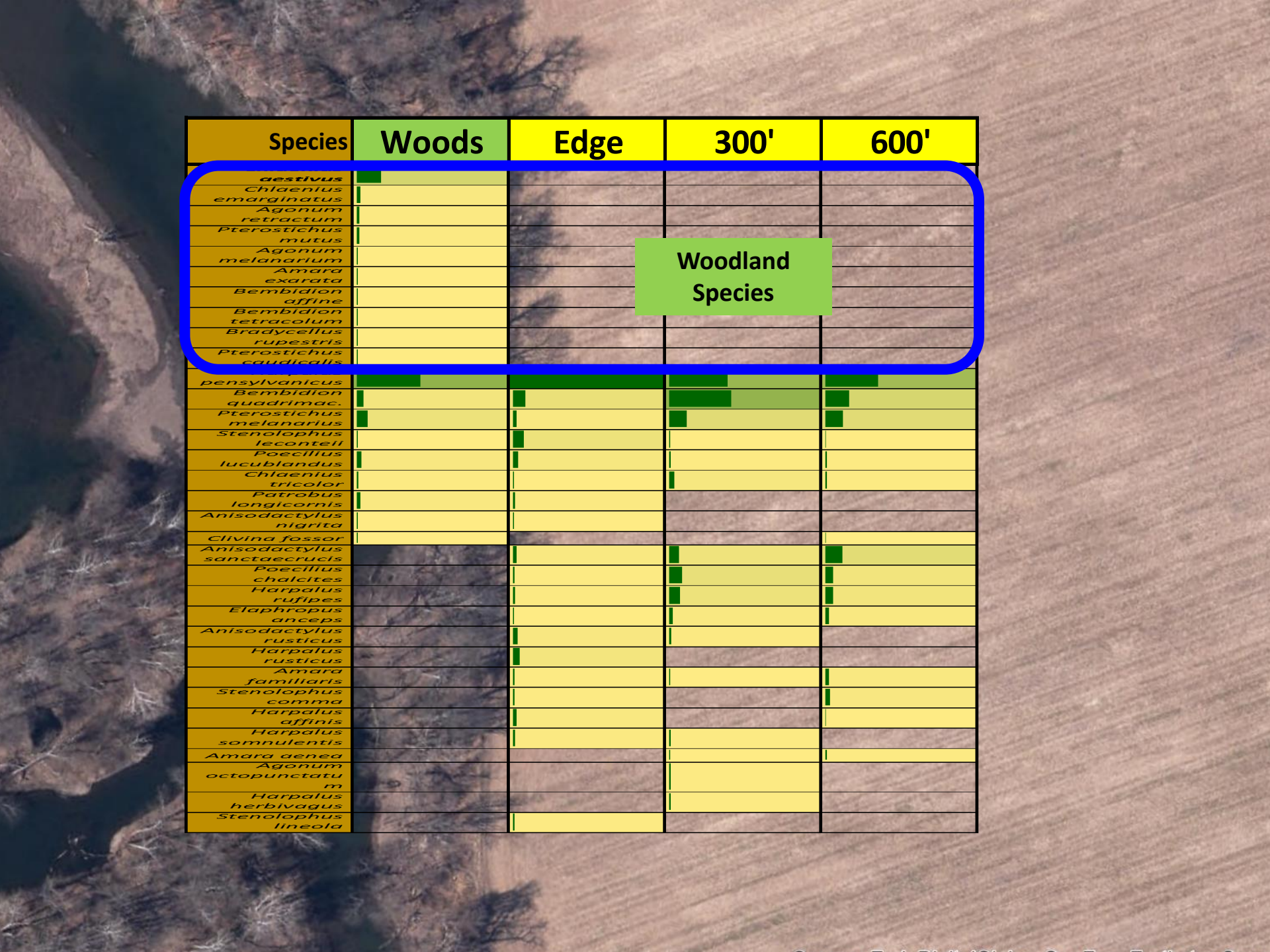
An example with ground beetle communities…

Species	Woods	Edge	300'	600'
Anisodactylus sanctaecrucis				


Species
Woods
Edge
300'
600'
Anisodactylus sanctaecrucis
Harpalus pensylvanicus
Bembidion quadrimac.
Pterostichus melanarius



Species	Woods	Edge	300'	600'
Chlaenius aestivus				
Chlaenius emarginatus				
Agonum retractum				
Pterostichus mutus				
Agonum melanarium				
Amara exarata				
Bembidion affine				
Bembidion tetracolum				
Bradycellus rupestris				
Pterostichus caudicalis				
Harpalus pensylvanicus				
Bembidion quadrimac.				
Pterostichus melanarius				
Stenolophus lecontei				
Poecilus lucublandus				
Chlaenius tricolor				
Patrobus longicornis				
Anisodactylus nigrita				
Clivina fossor				
Anisodactylus sanctaecrucis				
Poecilus chalcites				
Harpalus rufipes				
Elaphropus anceps				
Anisodactylus rusticus				
Harpalus rusticus				
Amara familiaris				
Stenolophus comma				
Harpalus affinis				
Harpalus somnulentis				
Amara aenea				
Agonum octopunctatum				
Harpalus herbivagus				
Stenolophus lineola				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300'
600'
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Agonum retractum
Pterostichus mutus
Agonum melanarium
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Bembidion tetracolum
Bradycellus rupestris
Pterostichus caudicalis
pensylvanicus
Bembidion quadrimac.
Pterostichus melanarius
Stenolophus lecontei
Poecilus lucublandus
Chlaenius tricolor
Patrobus longicornis
Anisodactylus nigrita
Clivina fossor
Anisodactylus sanctaecrucis
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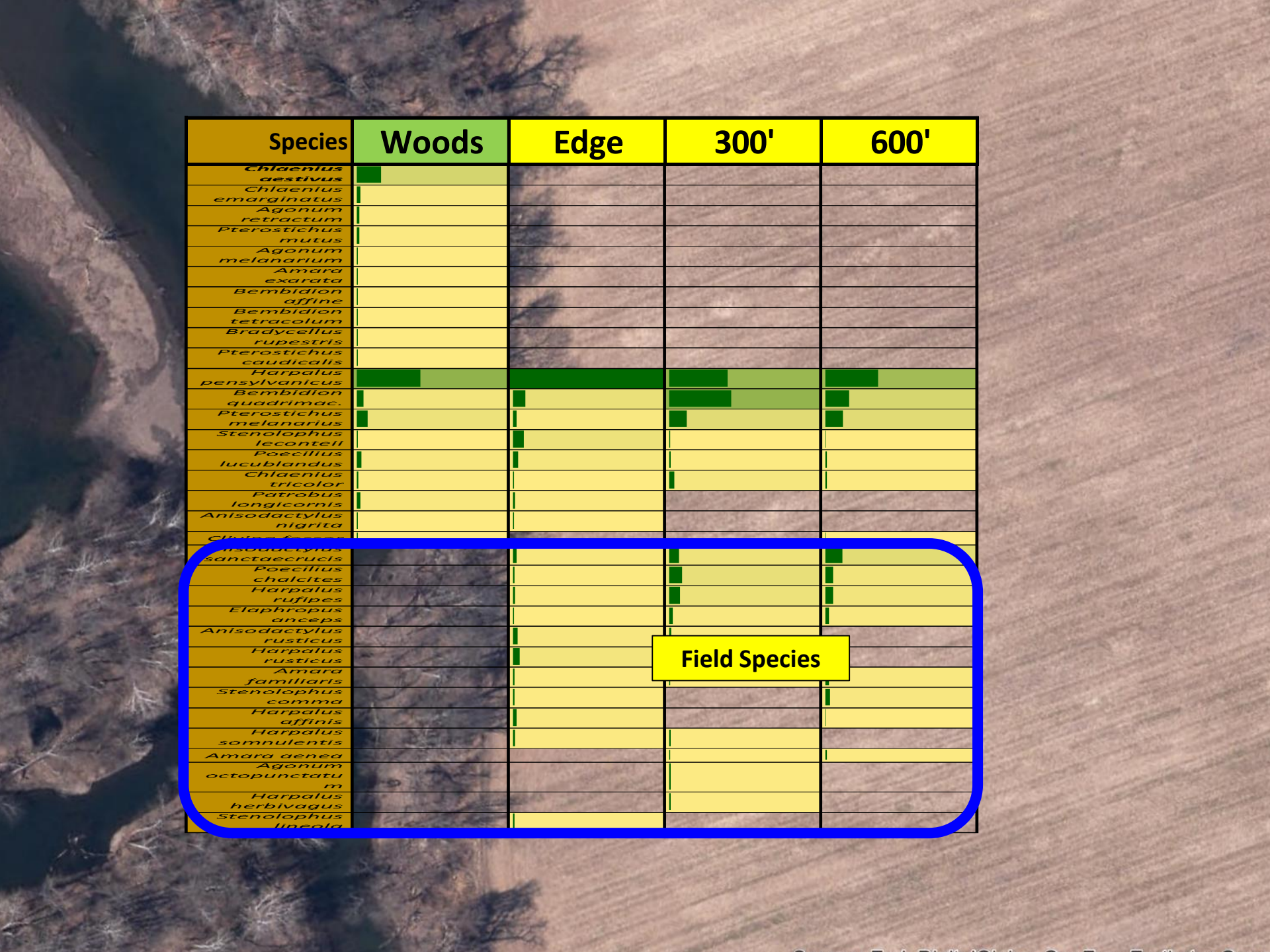
Stenolophus comma
Harpalus affinis
Harpalus somnulentis
Amara aenea
Agonum octopunctatum
Harpalus herbivagus
Stenolophus lineola
Woodland Species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Chlaenius tricolor
Patrobus longicornis
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Stenolophus comma
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Harpalus somnulentis
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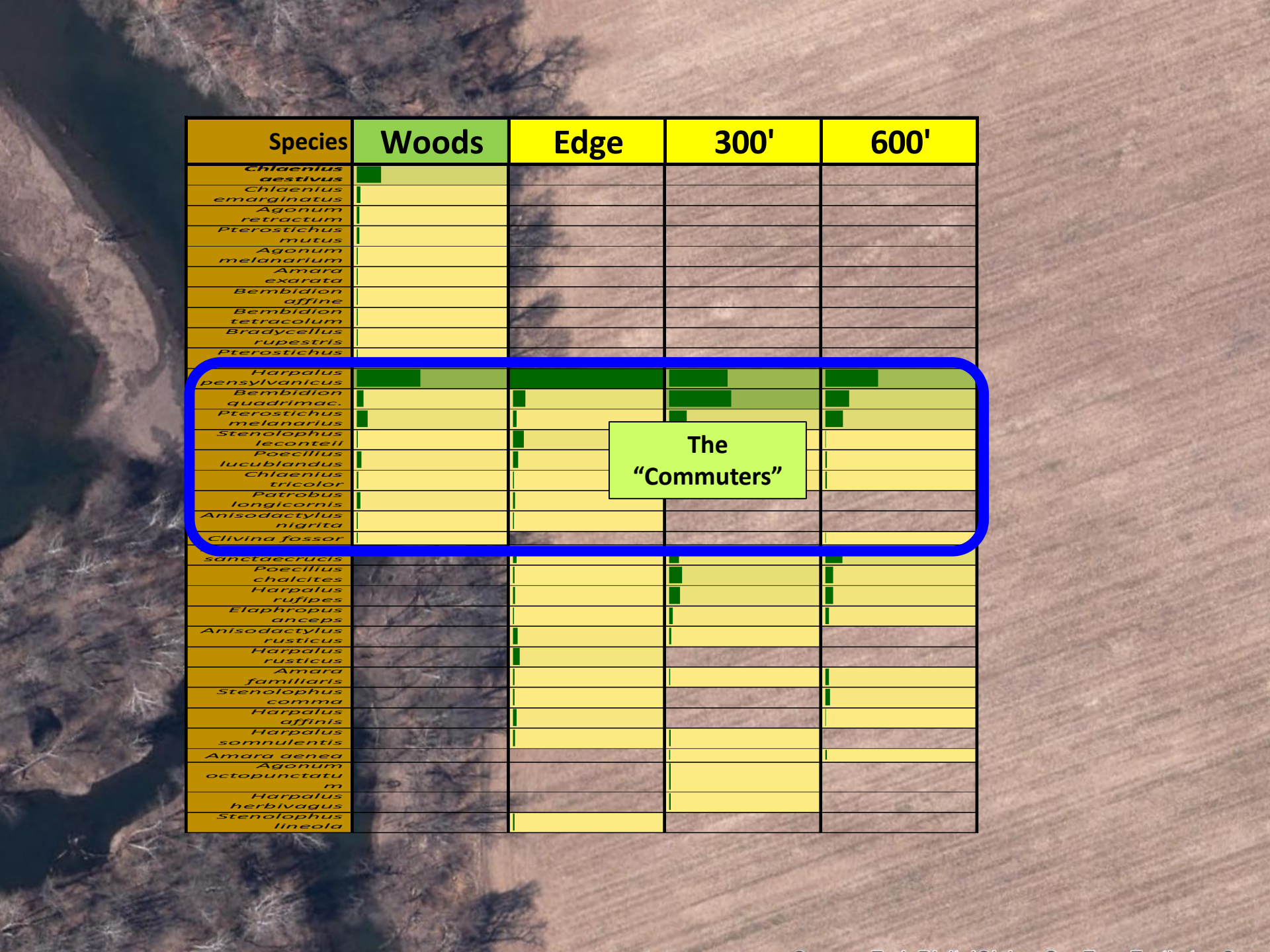
Harpalus herbivagus
Stenolophus lineola
Field Species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Stenolophus comma
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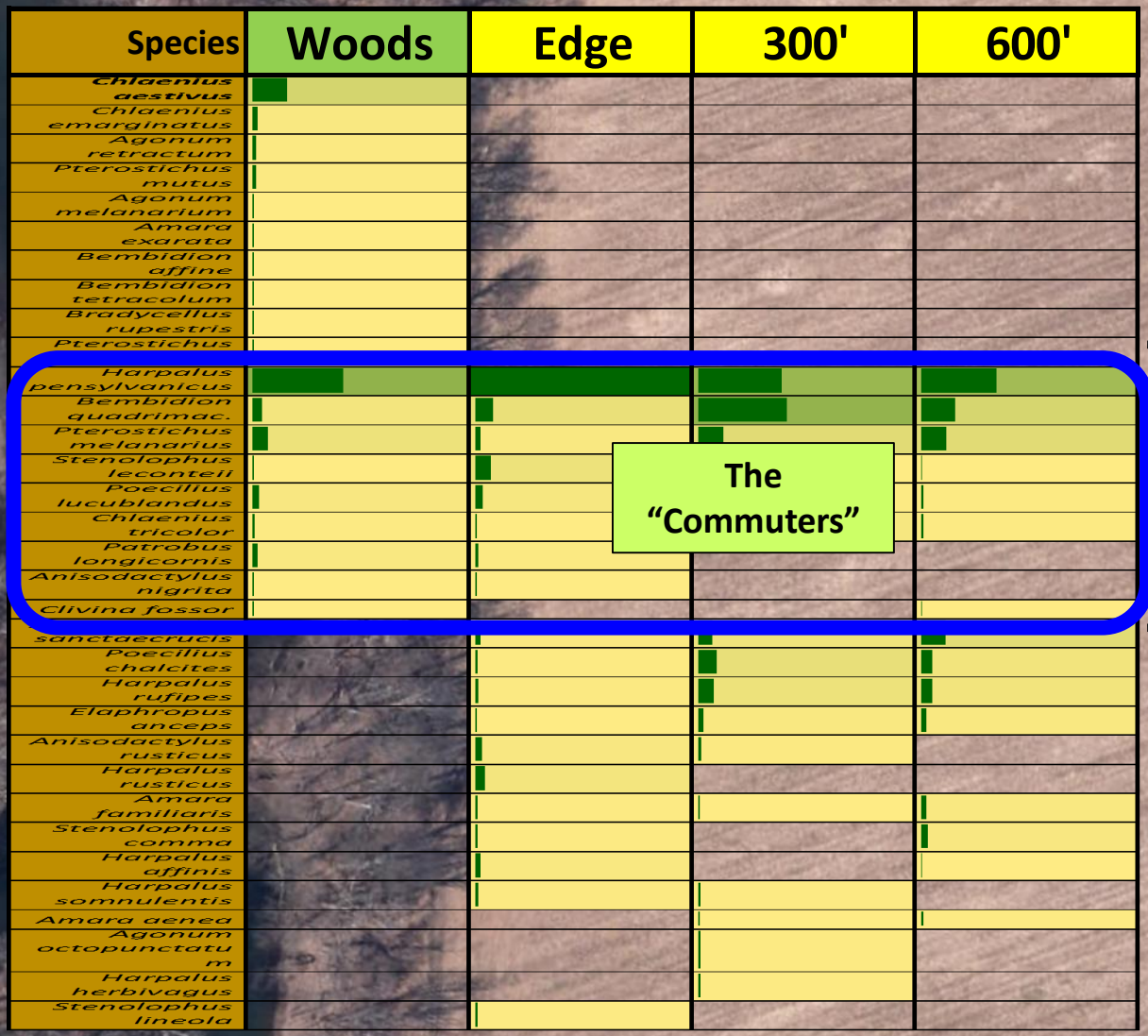
Harpalus somnulentis
Amara aenea
Agonum octopunctatu m
Harpalus herbivagus
Stenolophus lineola
The "Commuters"



These are probably the crop field species most likely to be affected by adjacent woodland habitat.

Species	Woods	Edge	300'	600'
Hylaeus modestus				
Ceratina calcarata				
Ceratina dupla				
Lasioglossum cressonii				
Lasioglossum imitatum				
Peponapis pruinosa				
Melissodes bimaculata				
Lasioglossum sp				
Lasioglossum pectorale				
Lasioglossum pilosum				
Melissodes trinodis				
Lasioglossum admirandum				
Agapostemon virescens				
Apis mellifera				
Melissodes agilis				
Bombus impatiens				
Bombus rufocinctus				
Xylocopa virginica				
Melissodes desponsa				

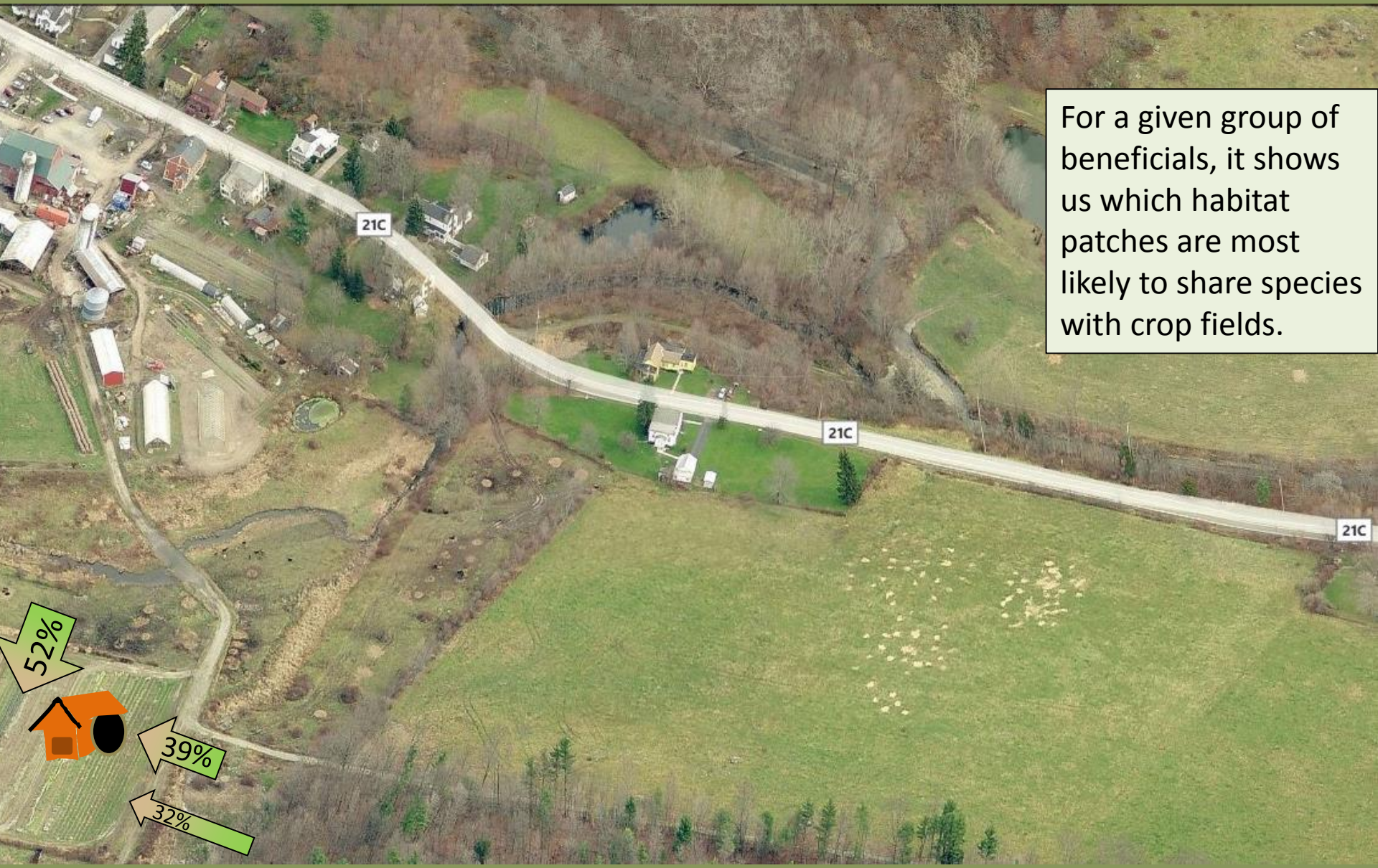
BEES

The "Commuters"

Another example – BEES!

The "Commuter" species associated with various non-crop habitats

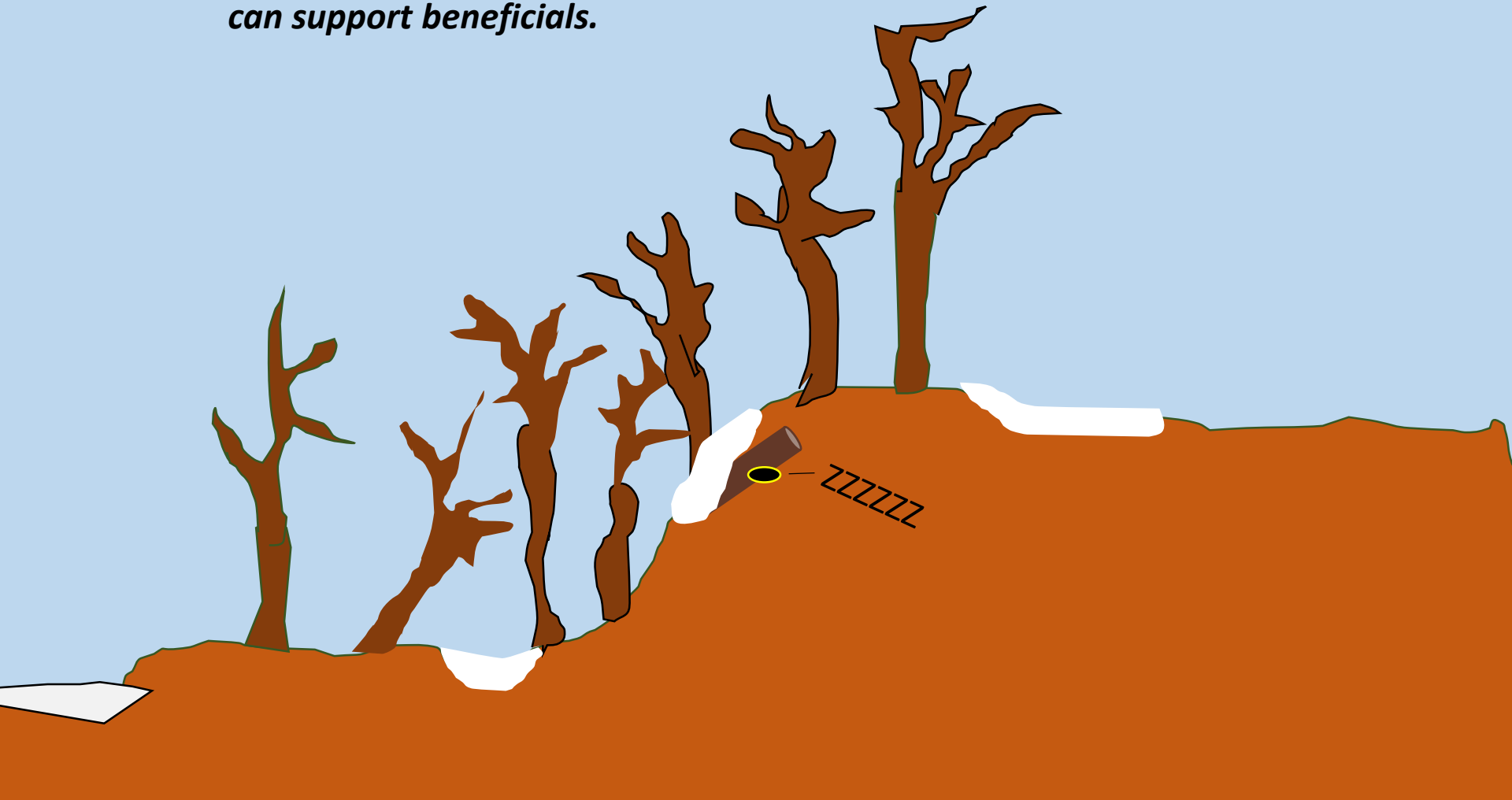
Information like this helps us map the potential ‘watershed’

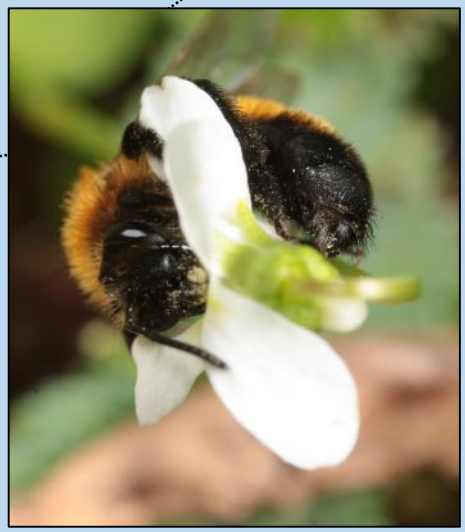


For a given group of beneficials, it shows us which habitat patches are most likely to share species with crop fields.

Winter

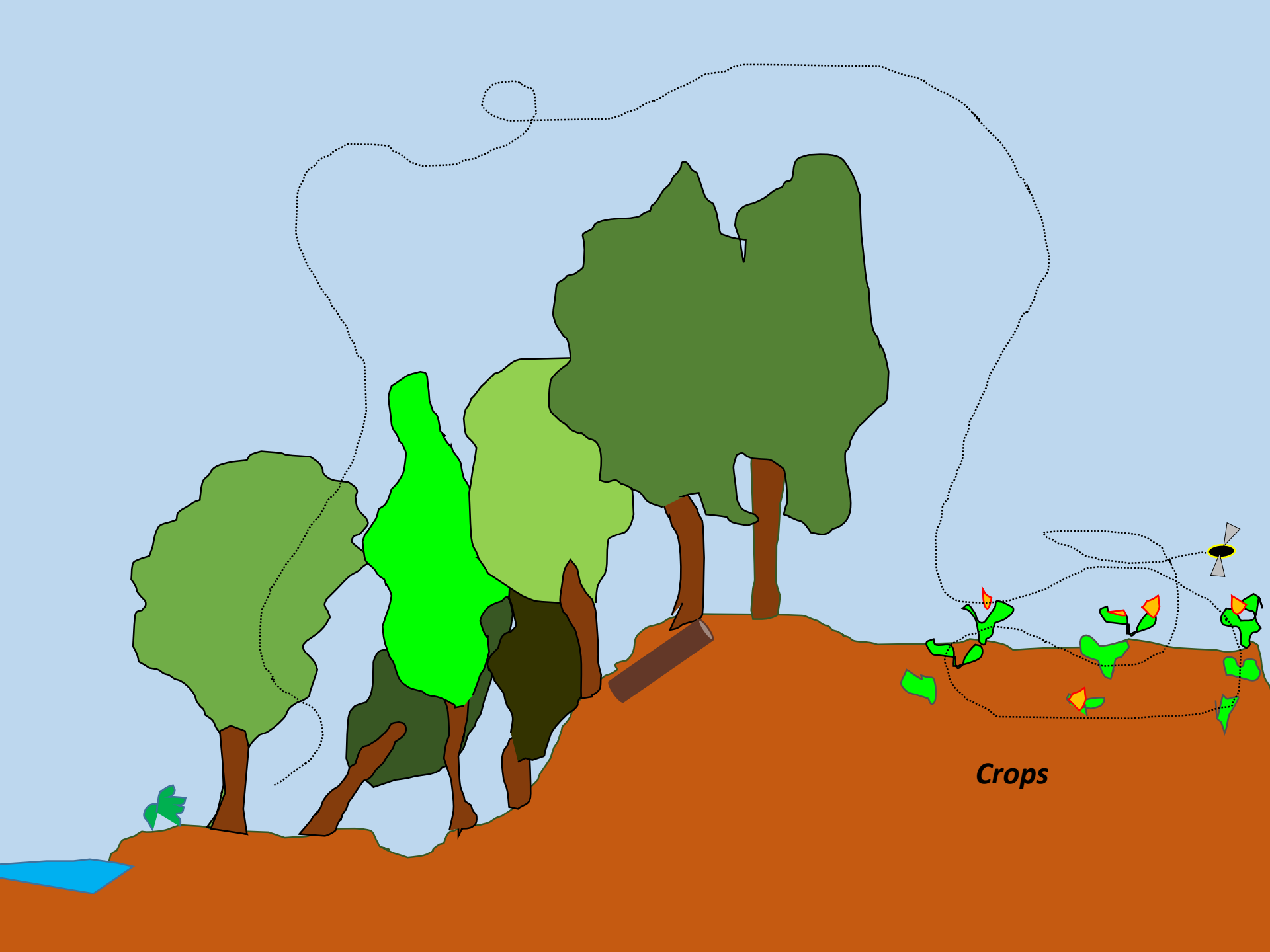
A specific example of how a diversity of on-farm habitats can support beneficials.





May

Spring Ephemerals in floodplain forest

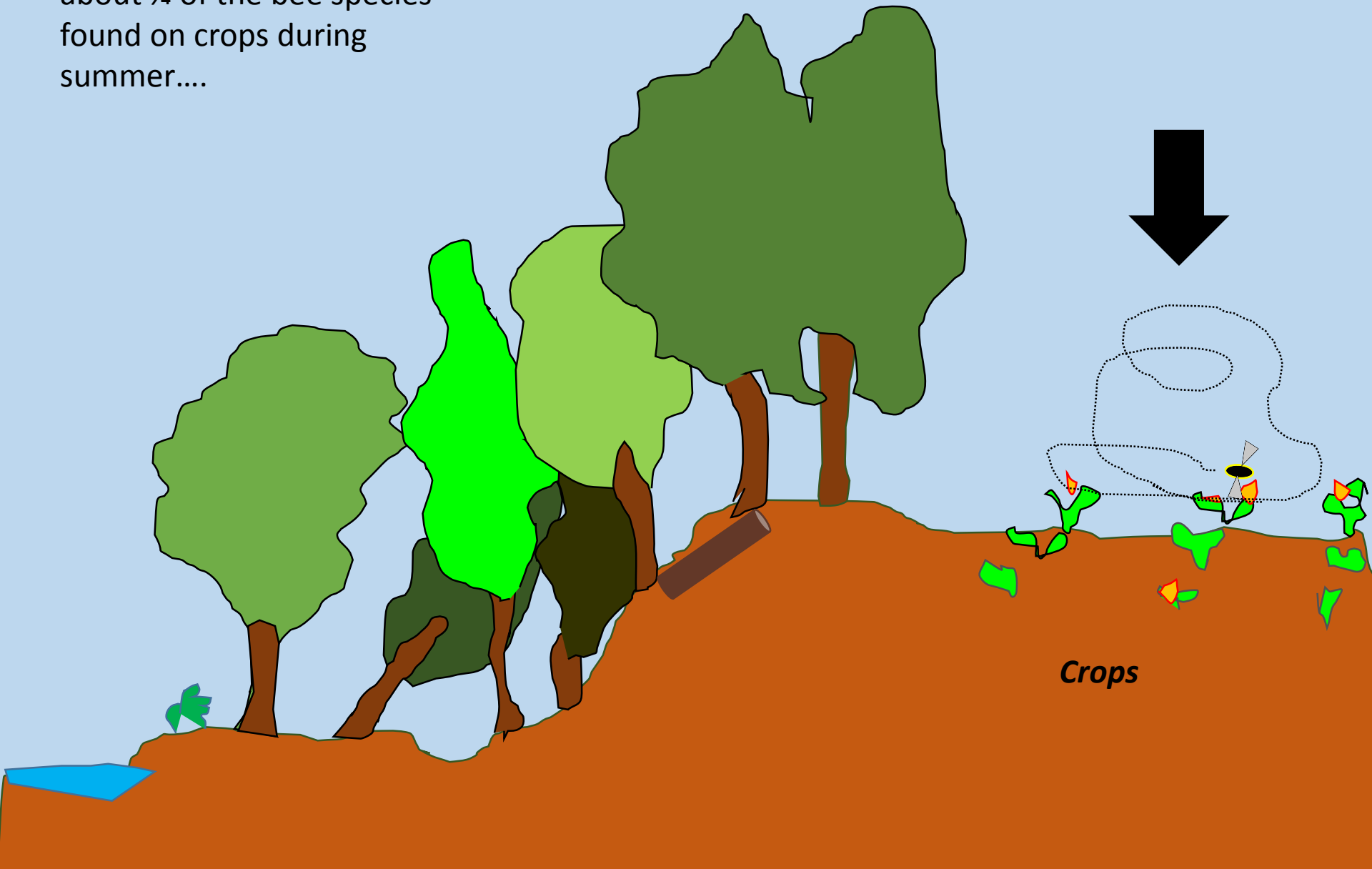

Crops

July

Crops

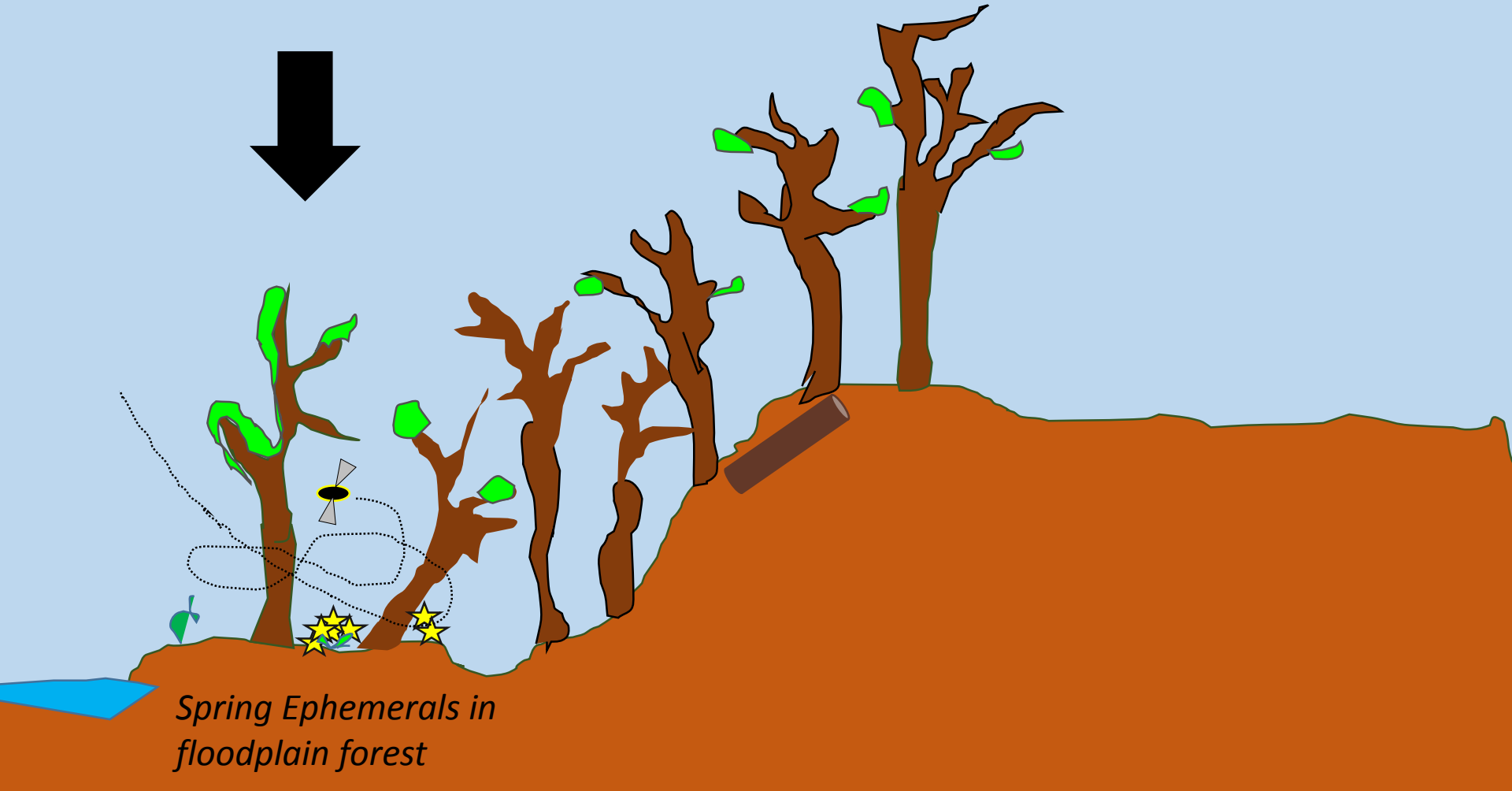
Based HVS student Martin Holdrege's senior project, about ¼ of the bee species found on crops during summer….

July



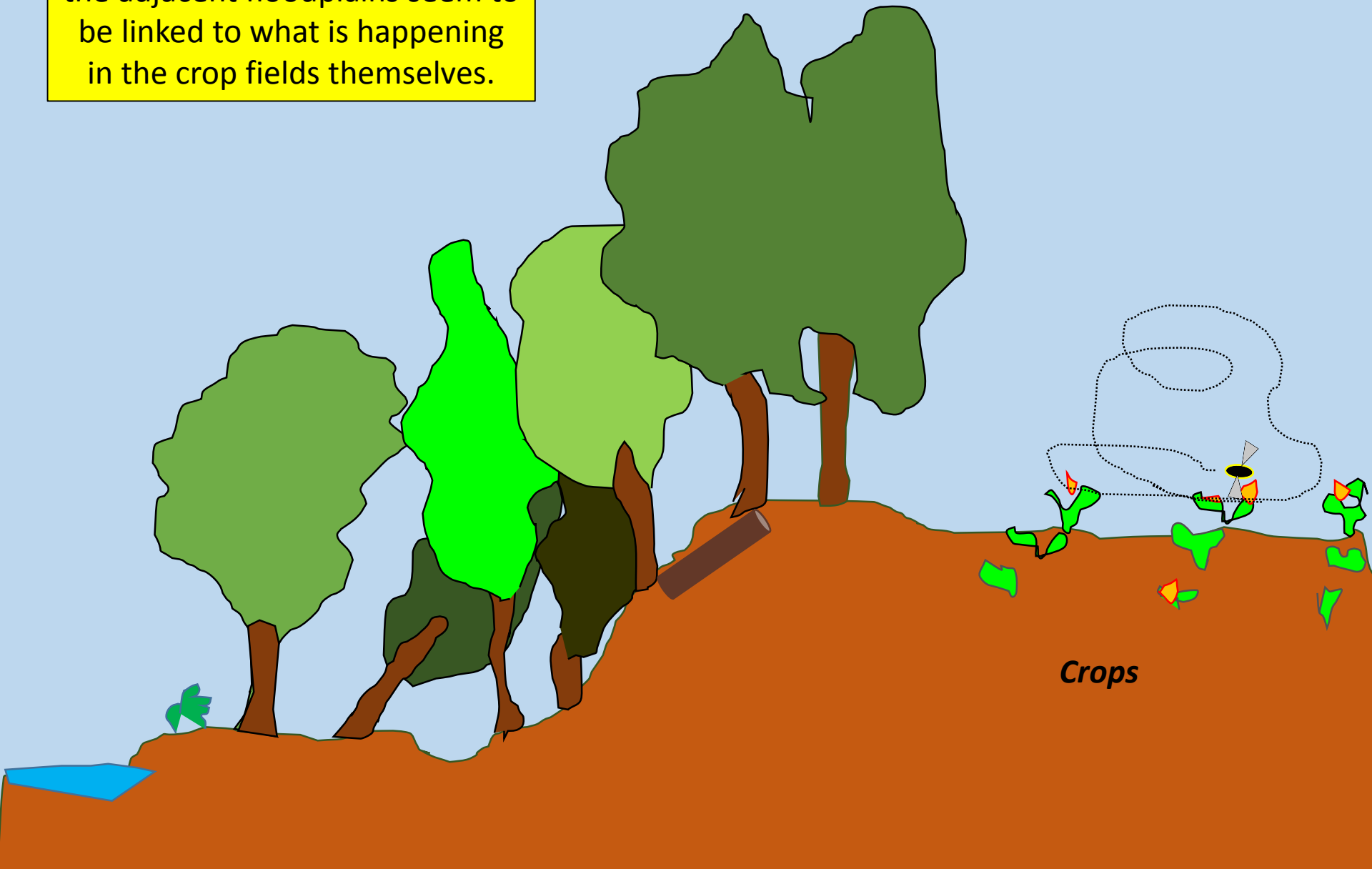
started the season on the wildflowers of adjacent floodplain forests.

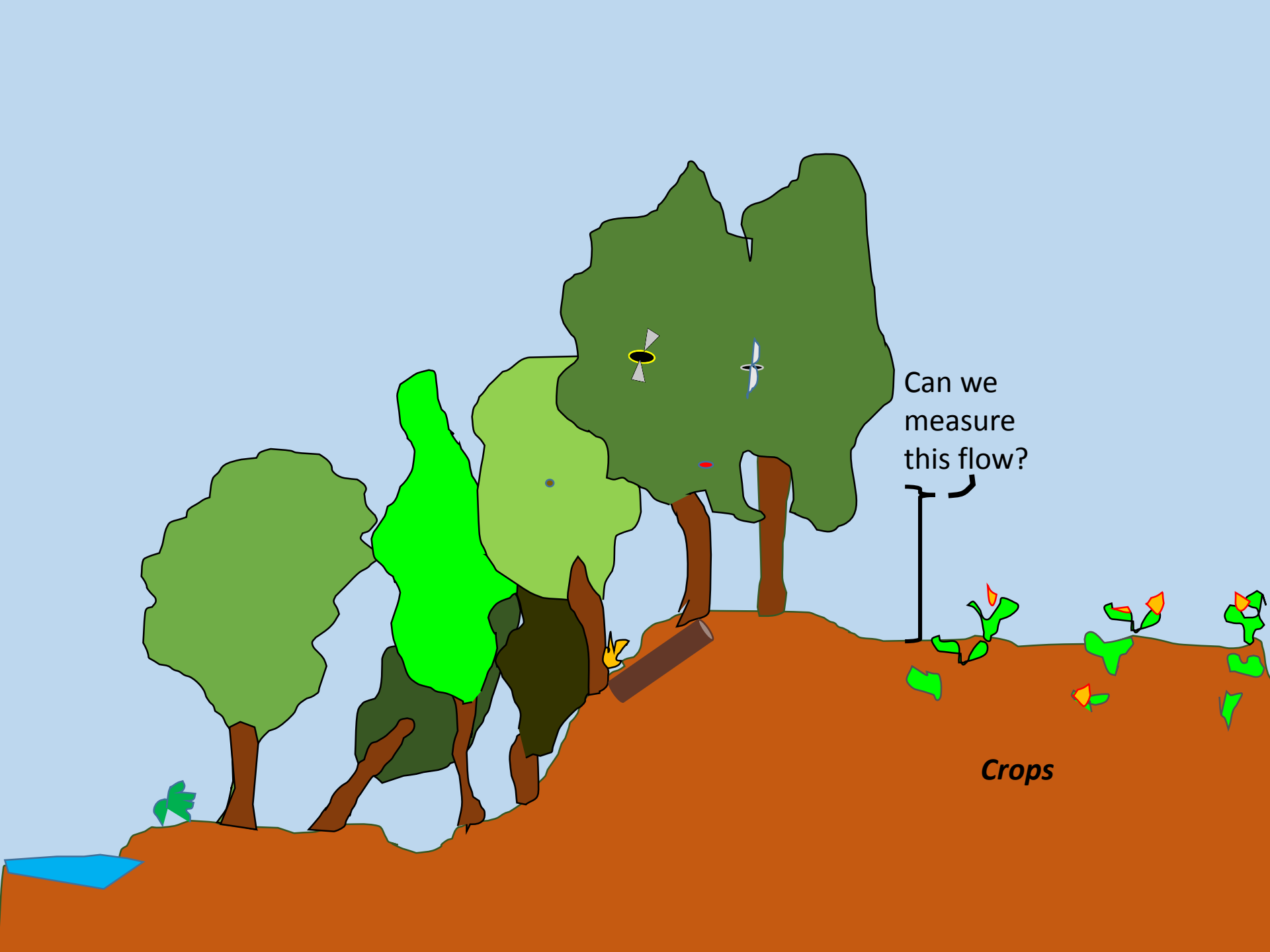
May



Spring Ephemerals in floodplain forest

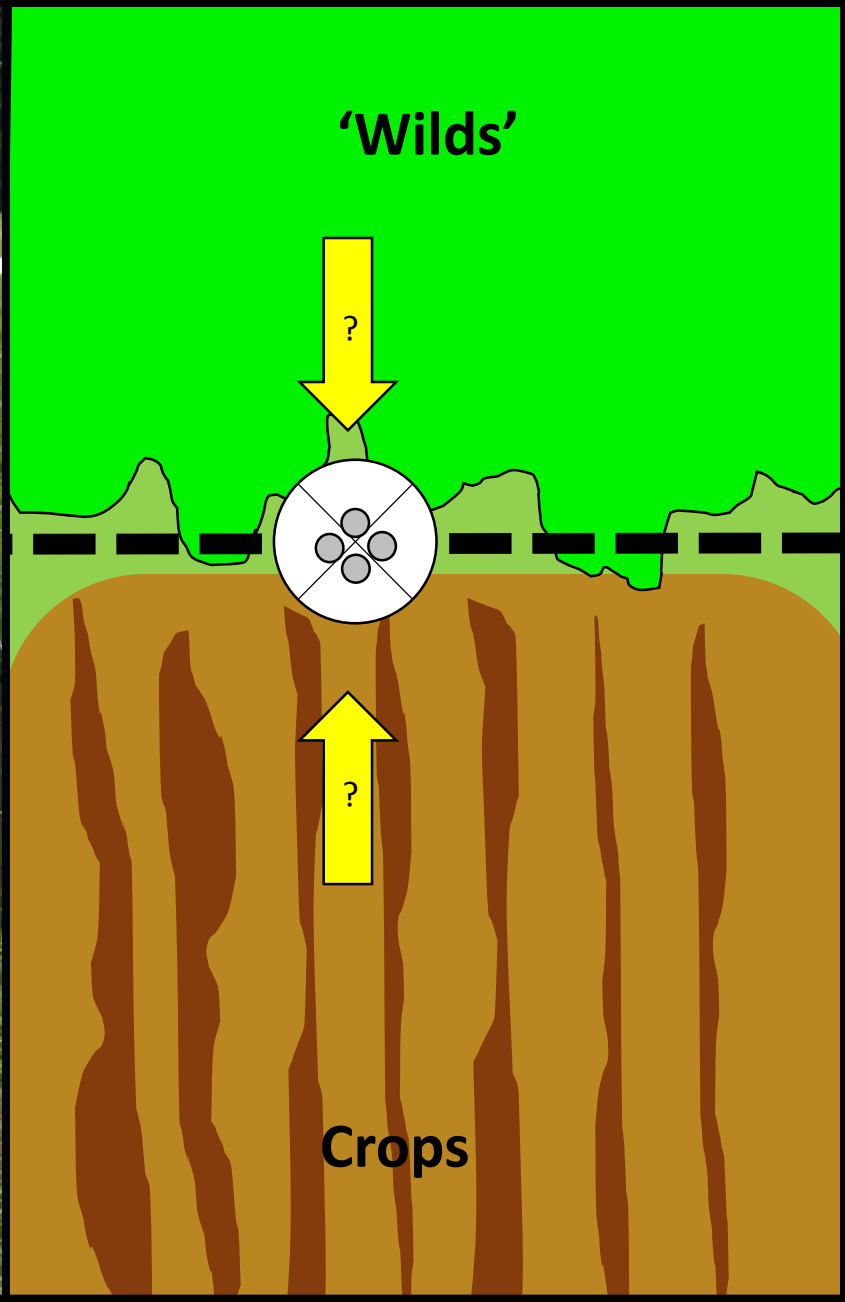
In other words, for bees at least, the adjacent floodplains seem to be linked to what is happening in the crop fields themselves.

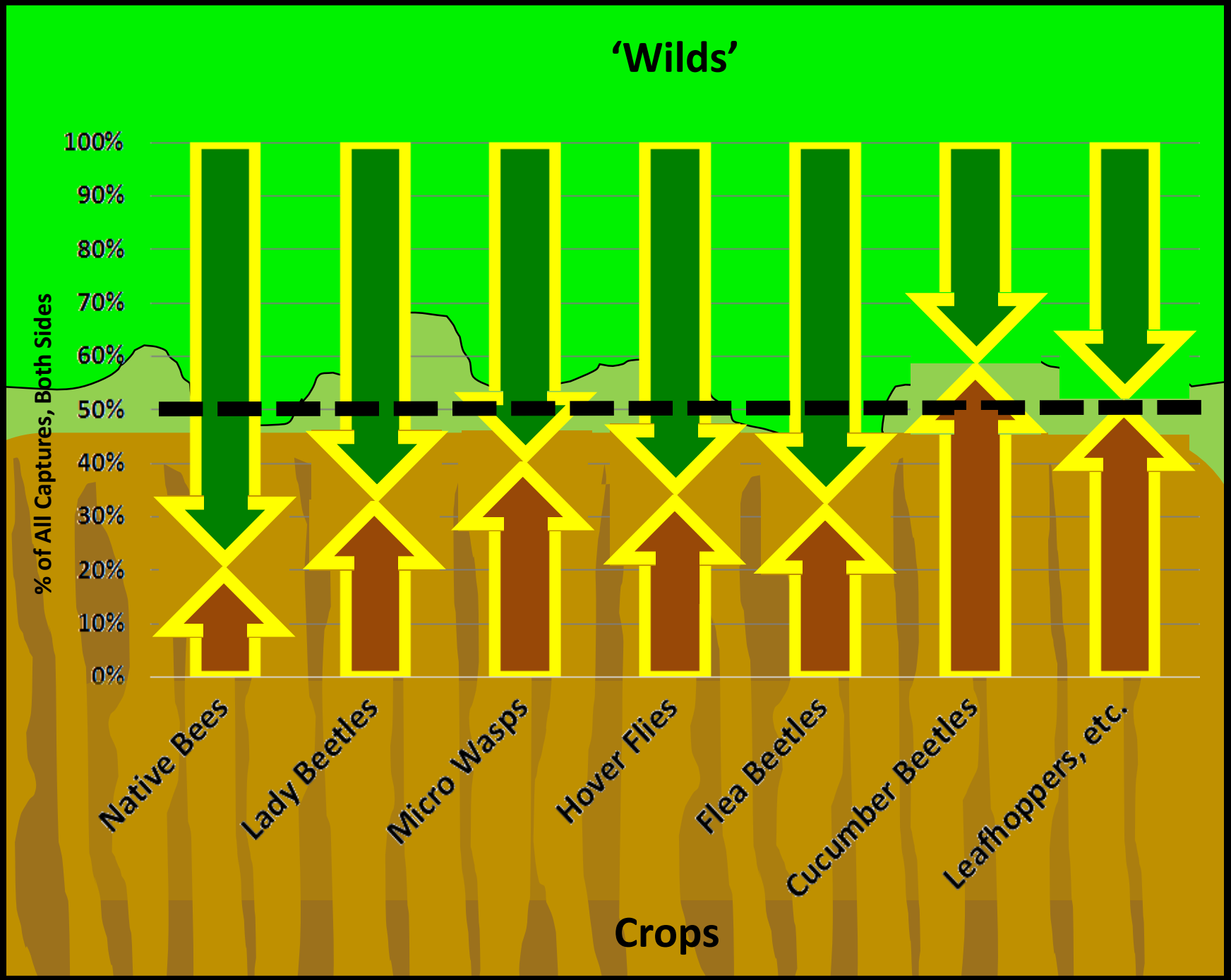


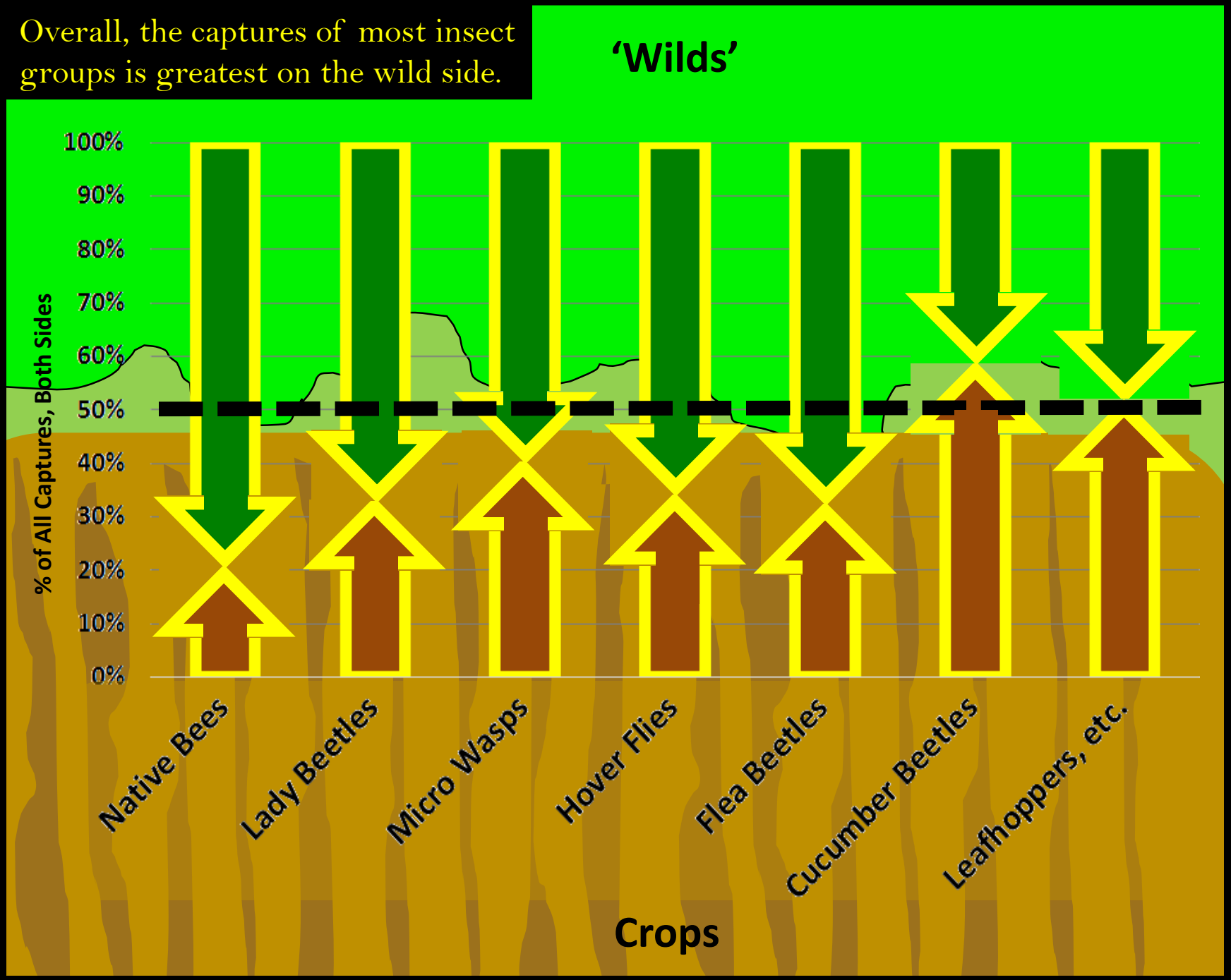

Can we measure this flow?
Crops

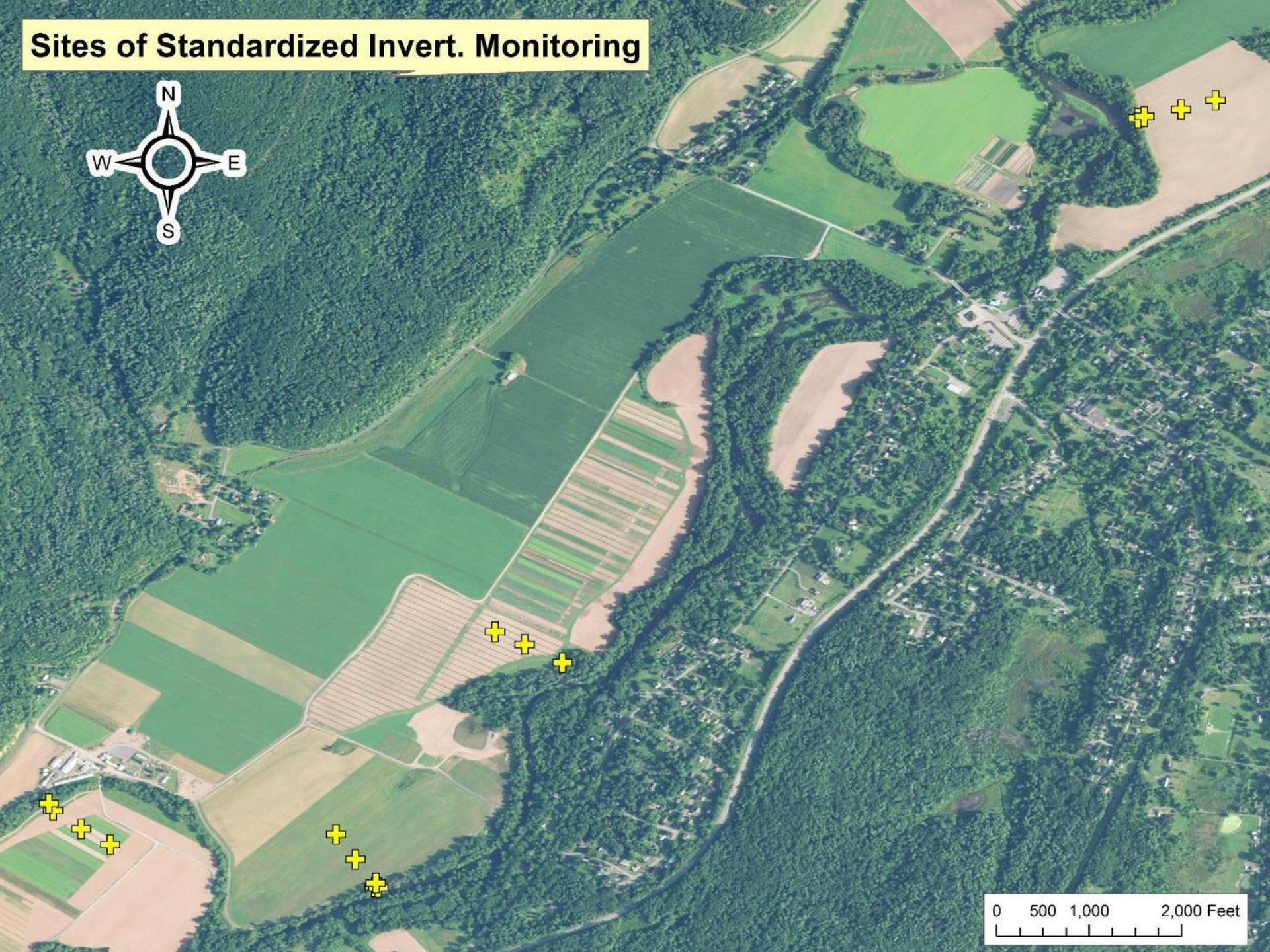

CROPS
“WILDS”


Directional, 4-headed Malaise Trap

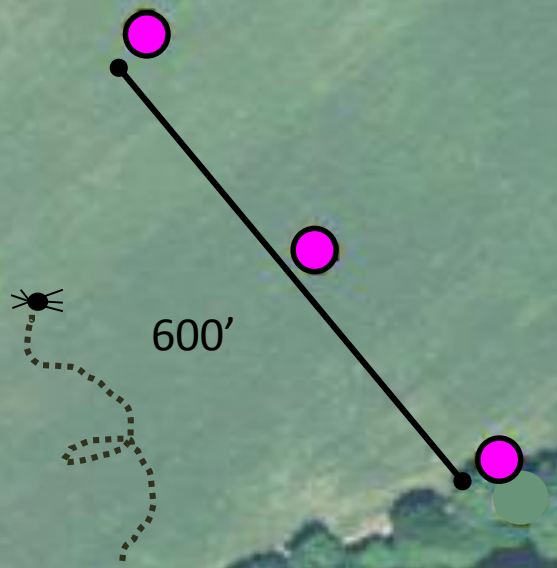

‘Wilds’
?
?
Crops


‘Wilds’
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% of All Captures, Both Sides
Native Bees
Lady Beetles
Micro Wasps
Hover Flies
Flea Beetles
Cucumber Beetles
Leafhoppers, etc.
Crops

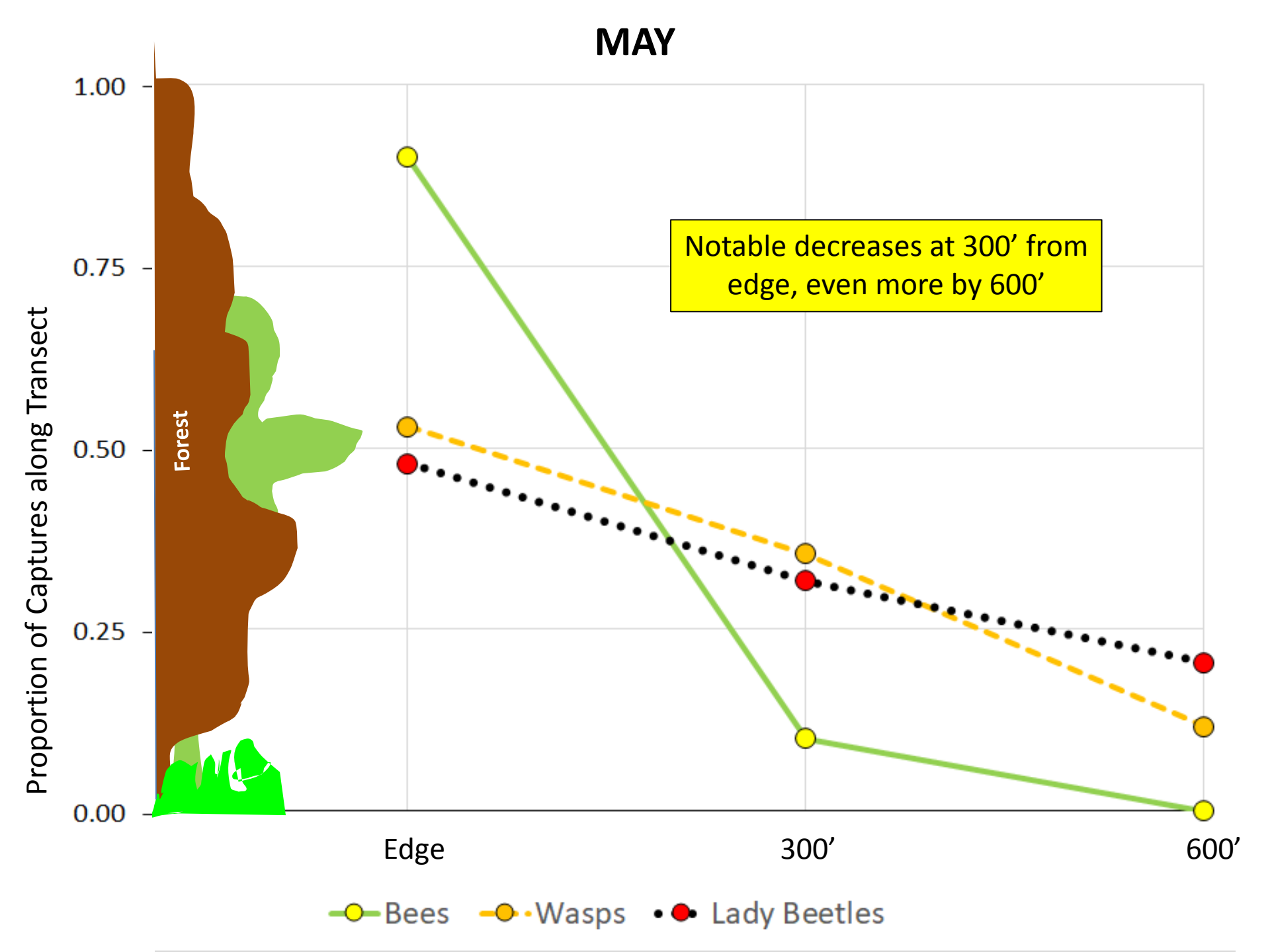

Overall, the captures of most insect groups is greatest on the wild side.
'Wilds'
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% of All Captures, Both Sides
Native Bees
Lady Beetles
Micro Wasps
Hover Flies
Flea Beetles
Cucumber Beetles
Leafhoppers, etc.
Crops

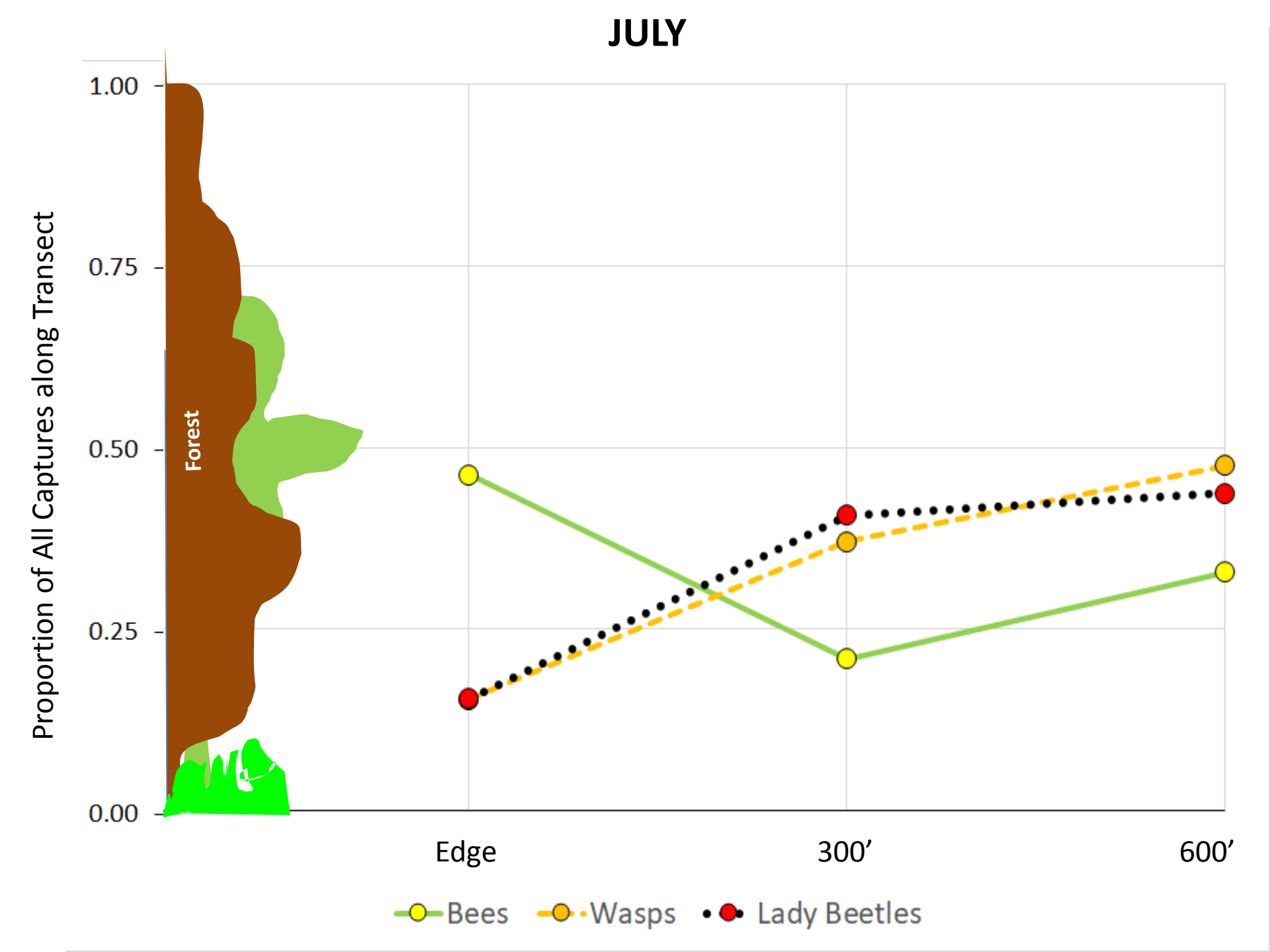

Sites of Standardized Invert. Monitoring
N
W
E
S
0 500 1,000 2,000 Feet

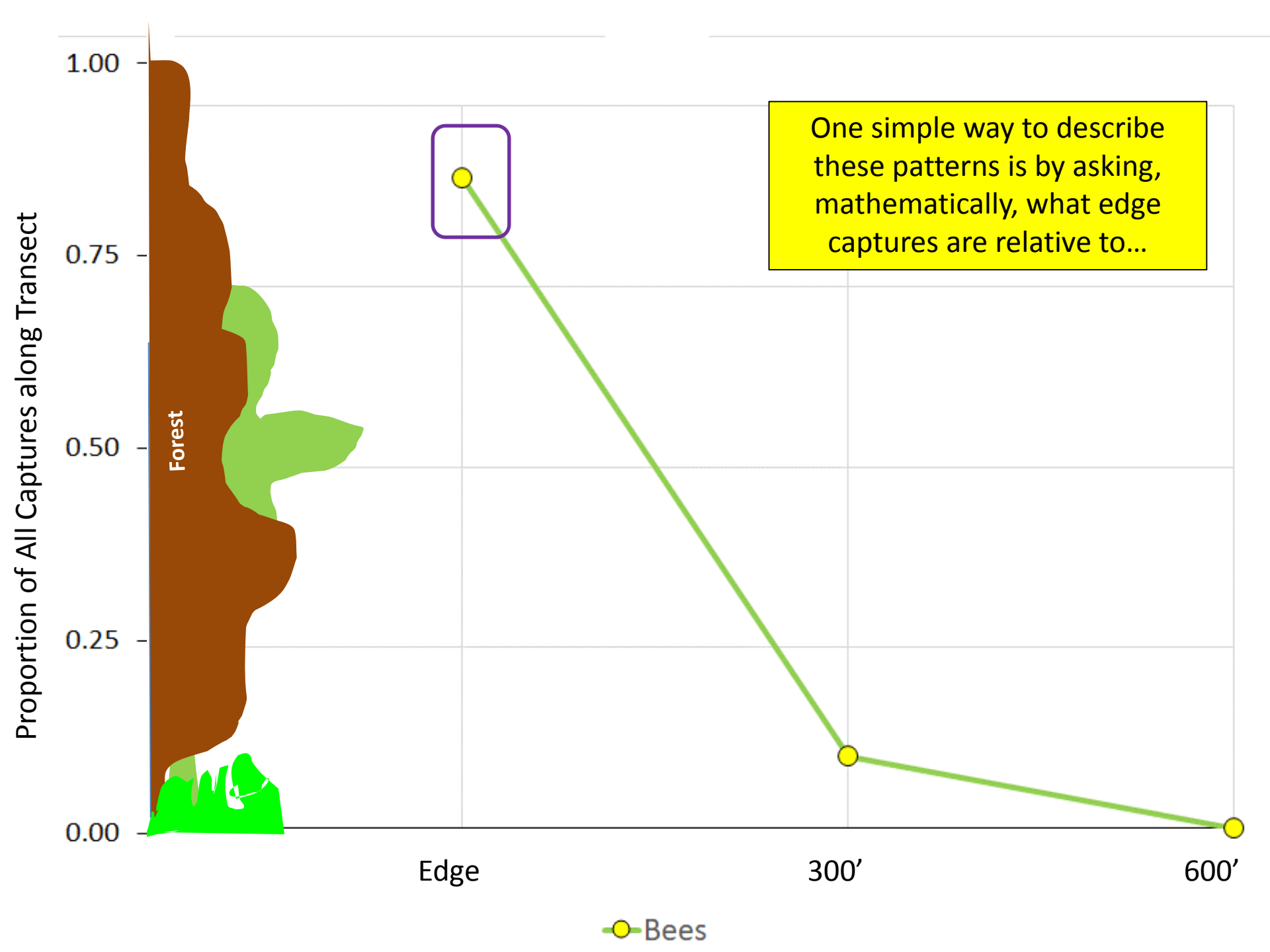
Do we have evidence that beneficials from non-crop habitats move into crops and, if so, how far?

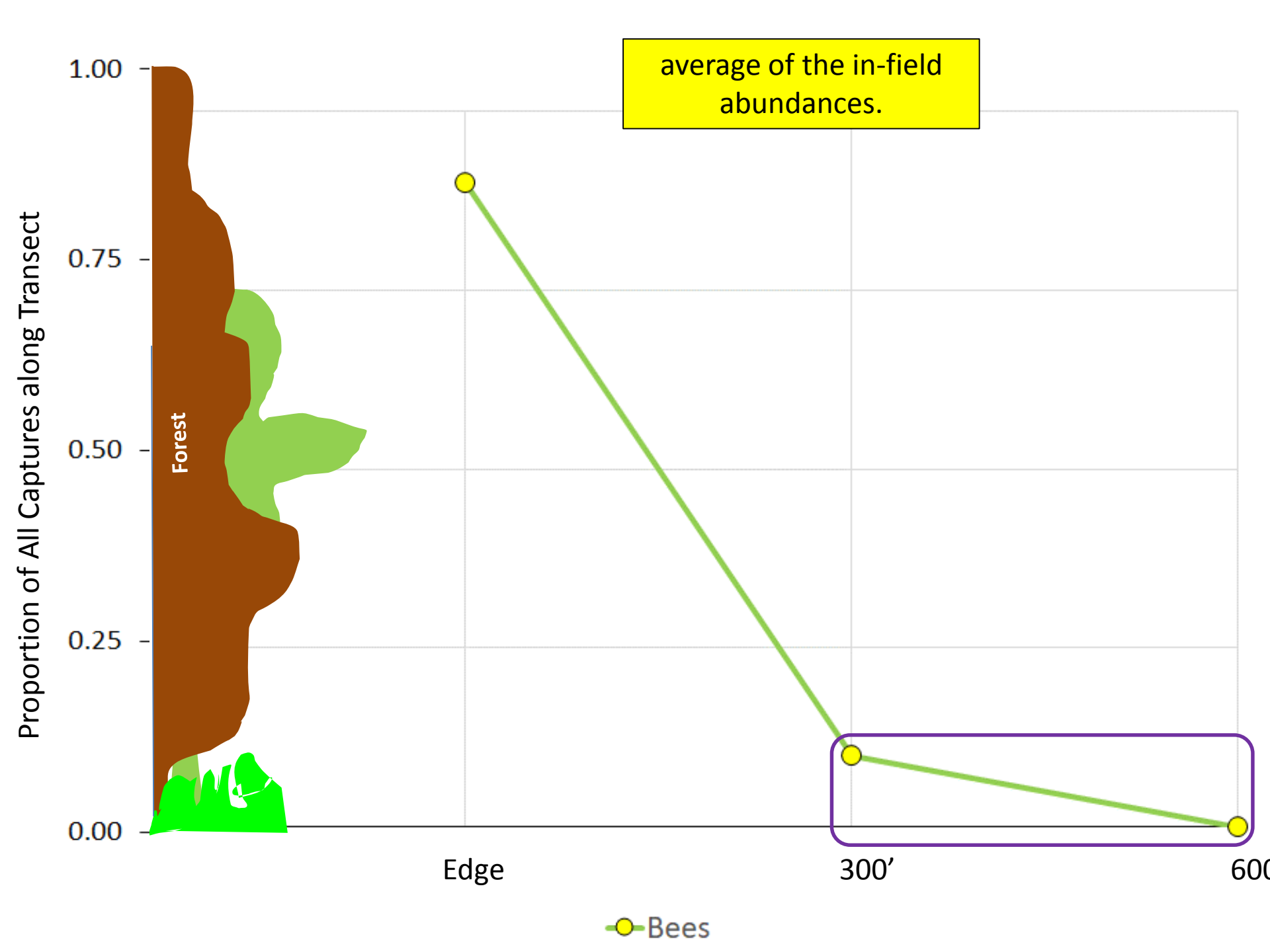


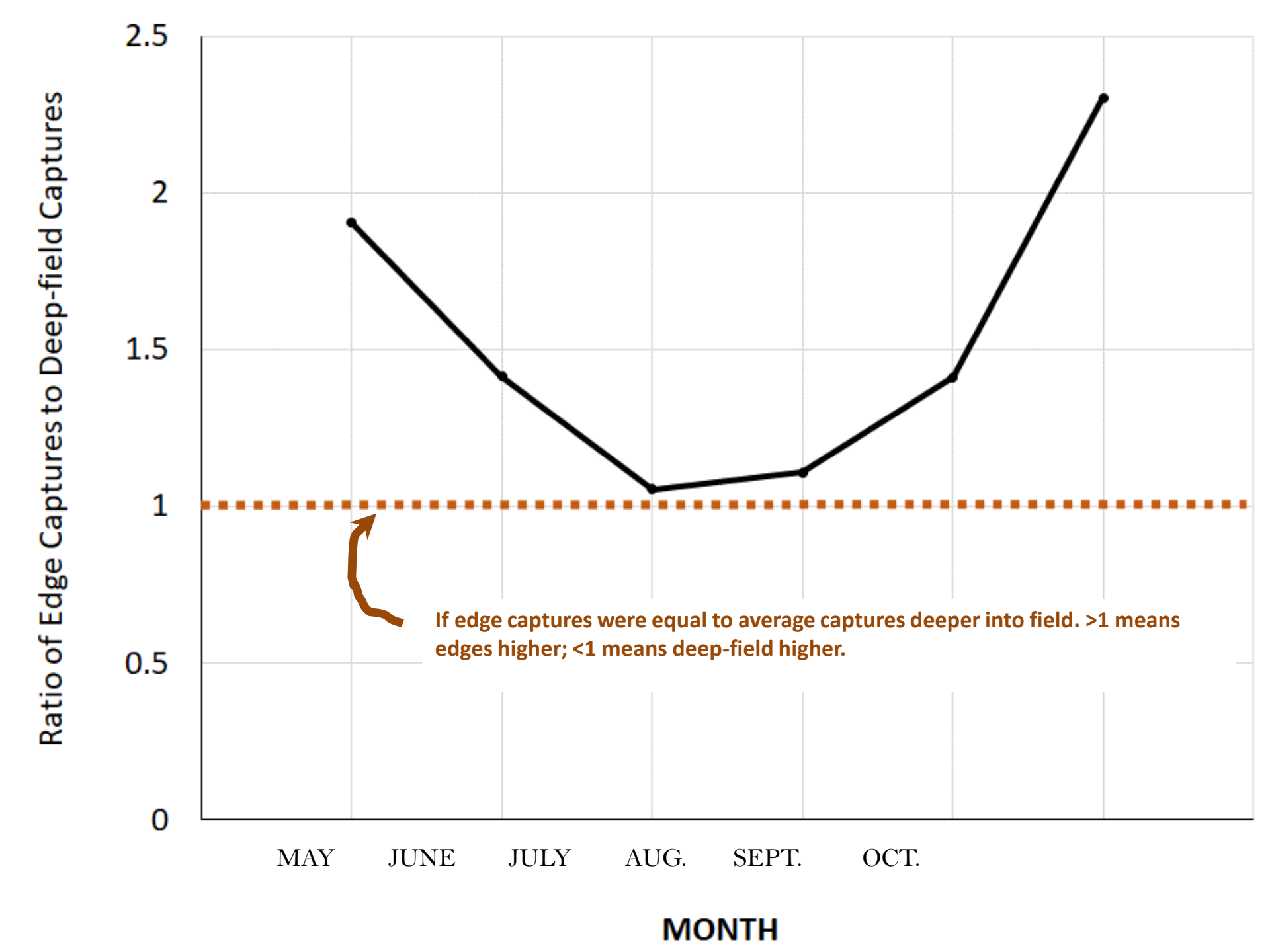

MAY
1.00
0.75
0.50
0.25
0.00
Proportion of Captures along Transect
Forest
Edge
300’
600’
Bees
Wasps
Lady Beetles

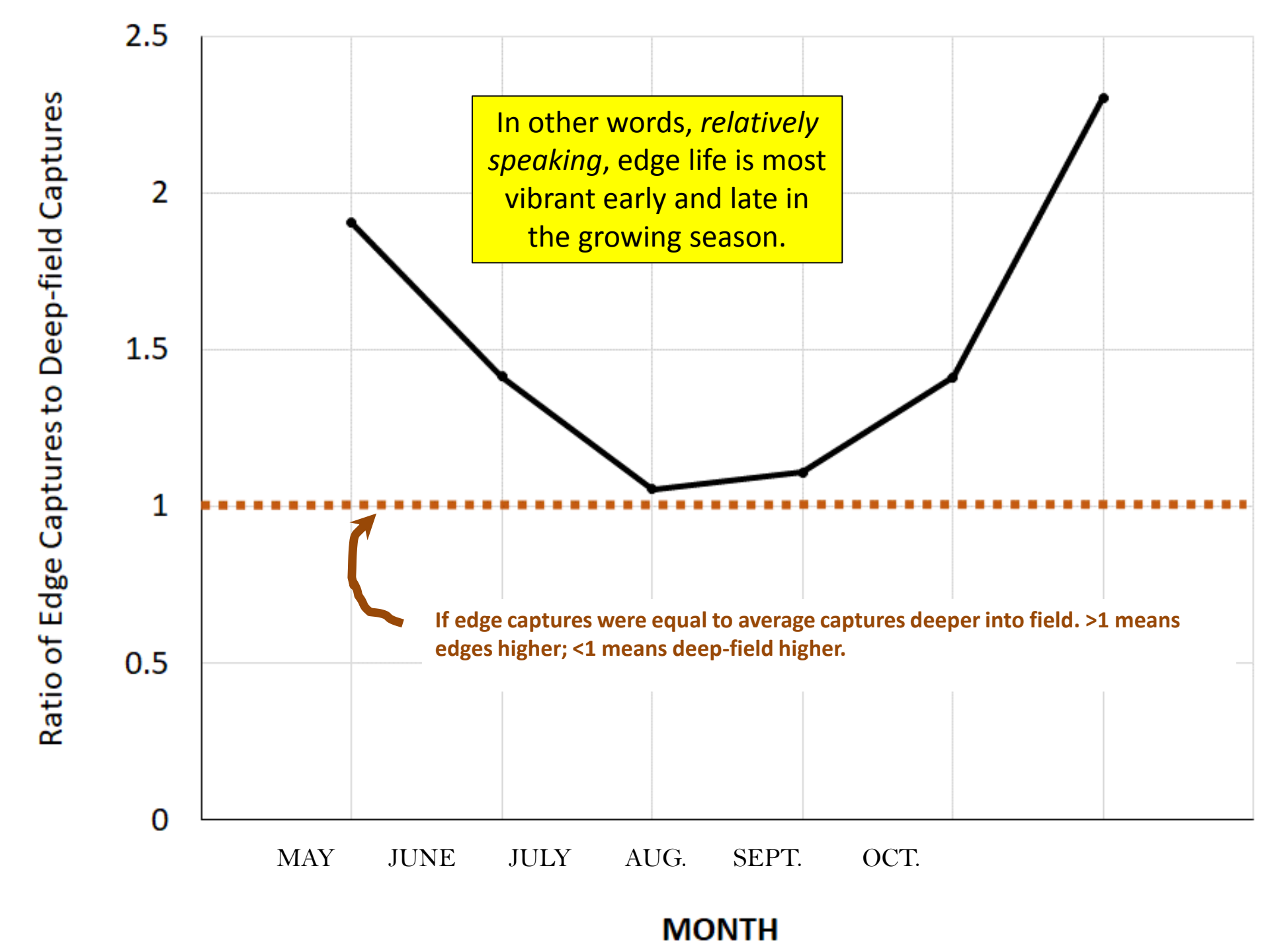

MAY
1.00
0.75
0.50
0.25
0.00
Proportion of Captures along Transect
Forest
Notable decreases at 300’ from edge, even more by 600’
Edge
300’
600’
Bees
Wasps
Lady Beetles

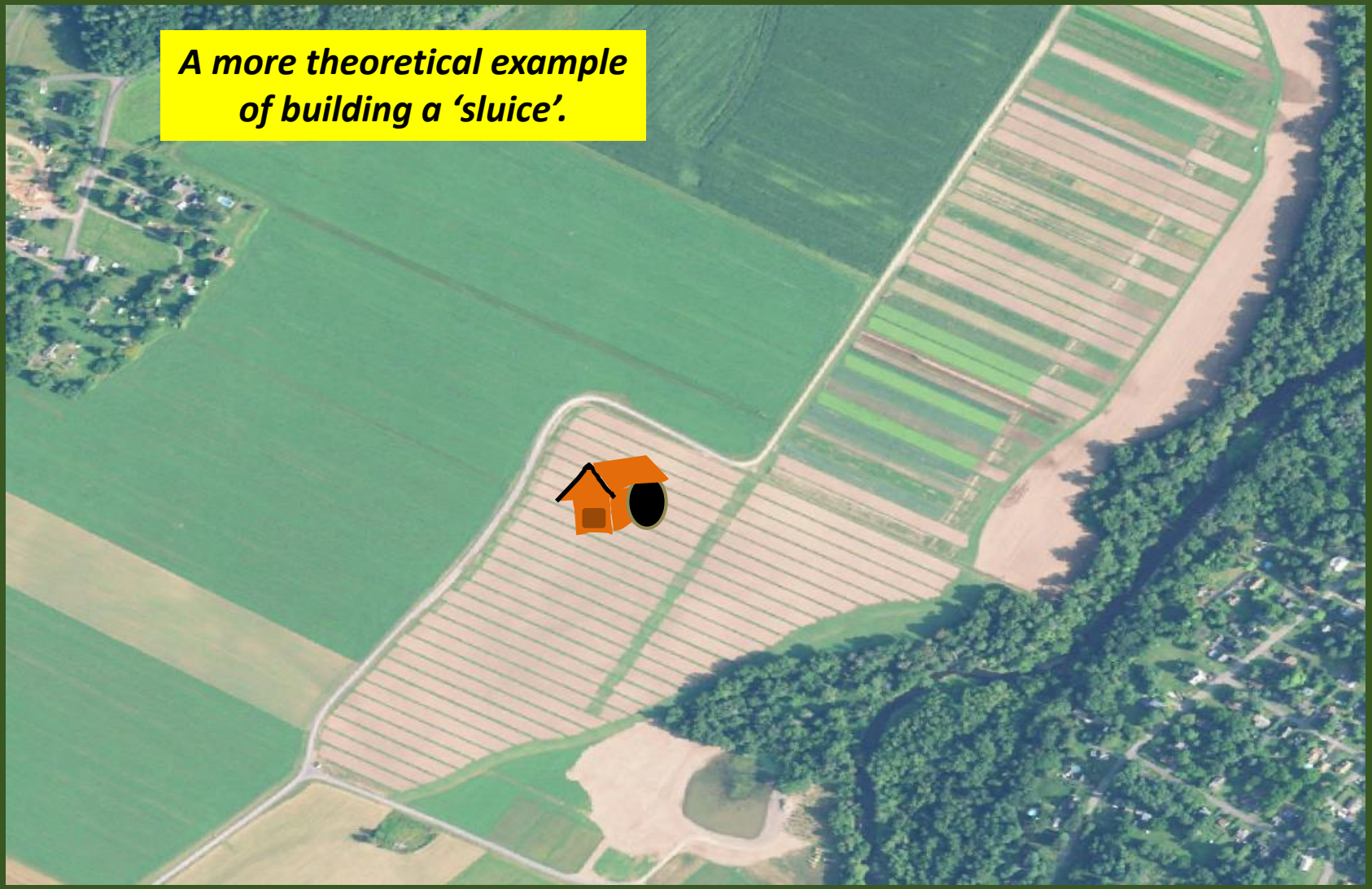

JULY
1.00
0.75
0.50
0.25
0.00
Proportion of All Captures along Transect
Forest
Edge
300’
600’
Bees
Wasps
Lady Beetles

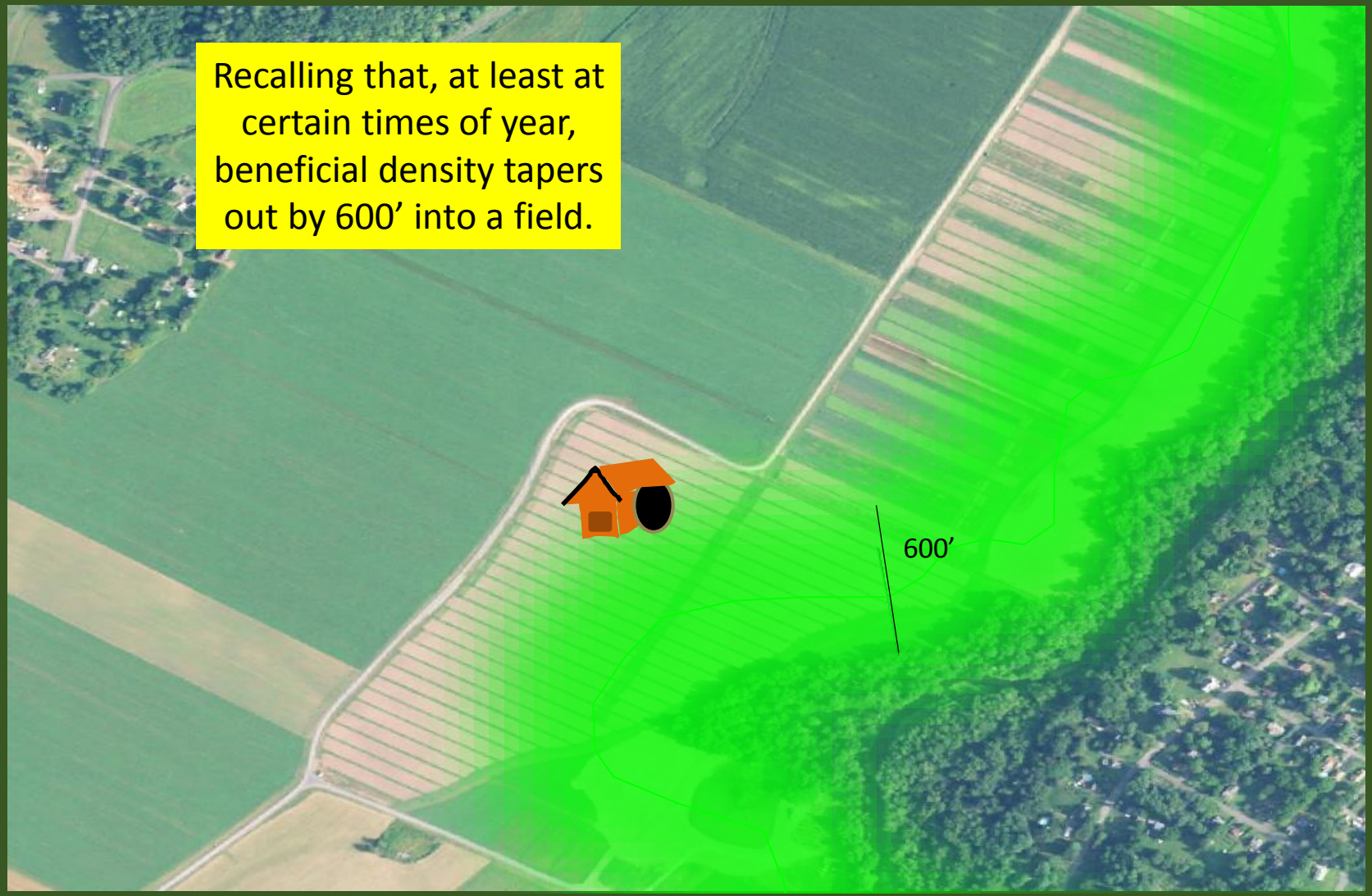

1.00
0.75
0.50
0.25
0.00
Proportion of All Captures along Transect
Forest
One simple way to describe these patterns is by asking, mathematically, what edge captures are relative to…
Edge
300’
600’
Bees

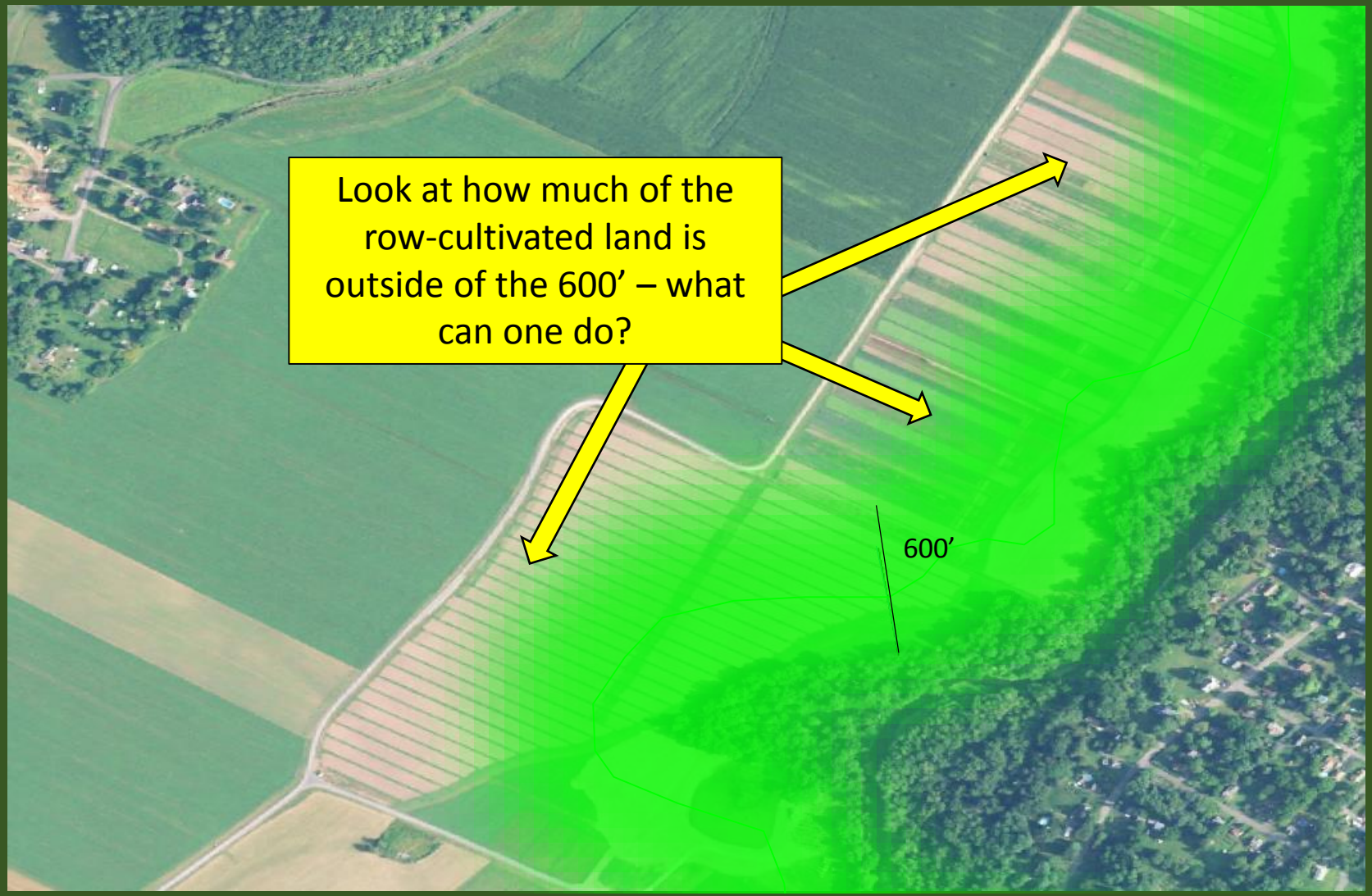

average of the in-field abundances.
1.00
0.75
0.50
0.25
0.00
Proportion of All Captures along Transect
Forest
Edge
300’
600
Bees


Ratio of Edge Captures to Deep-field Captures
2.5
2
1.5
1
0.5
0
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
MONTH
If edge captures were equal to average captures deeper into field. >1 means edges higher; <1 means deep-field higher.

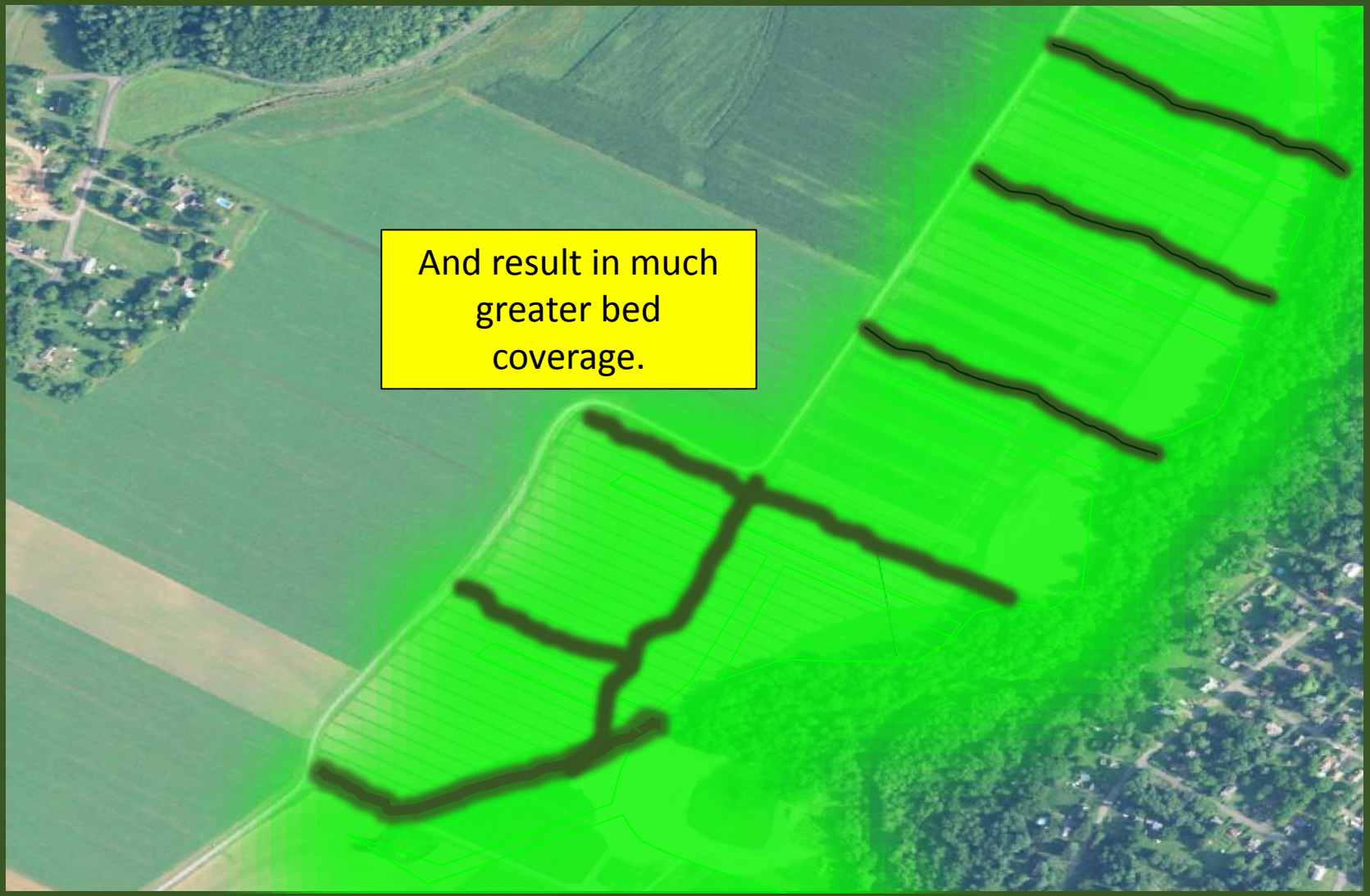

Ratio of Edge Captures to Deep-field Captures
2.5
2
1.5
1
0.5
0
In other words, *relatively speaking*, edge life is most vibrant early and late in the growing season.
If edge captures were equal to average captures deeper into field. >1 means edges higher; <1 means deep-field higher.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
MONTH

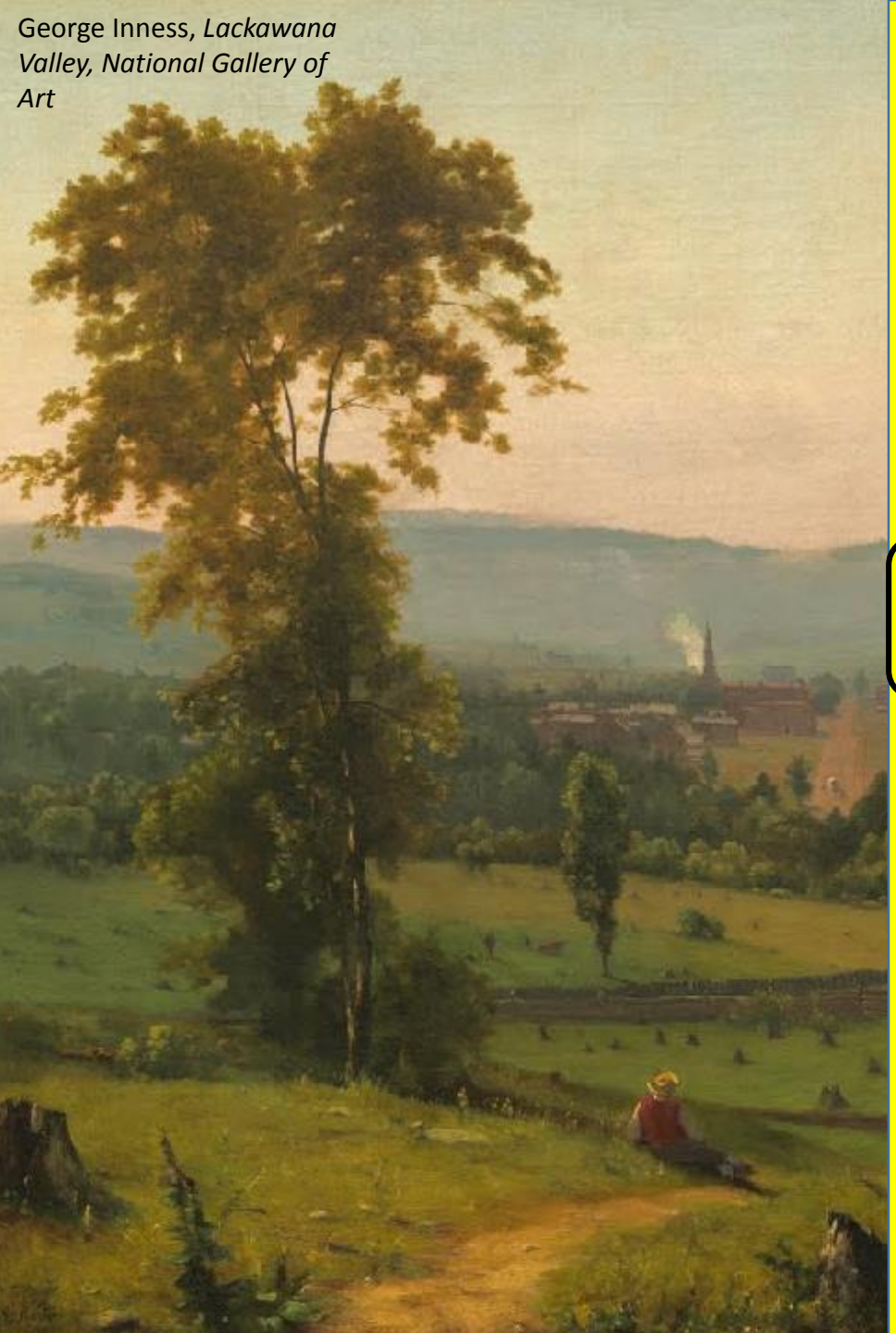

A more theoretical example
of building a ‘sluice’.


Recalling that, at least at certain times of year, beneficial density tapers out by 600’ into a field.
600’


Look at how much of the row-cultivated land is outside of the 600’ – what can one do?
600’


Installing hedgerows might improve ‘circulation’.


And result in much greater bed coverage.



George Inness, *Lackawana Valley, National Gallery of Art*

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In relationship to on-farm habitat management, what are our goals?

Broadly speaking, what are our tools both in terms of habitat creation/conservation and in terms of 'support structures'?

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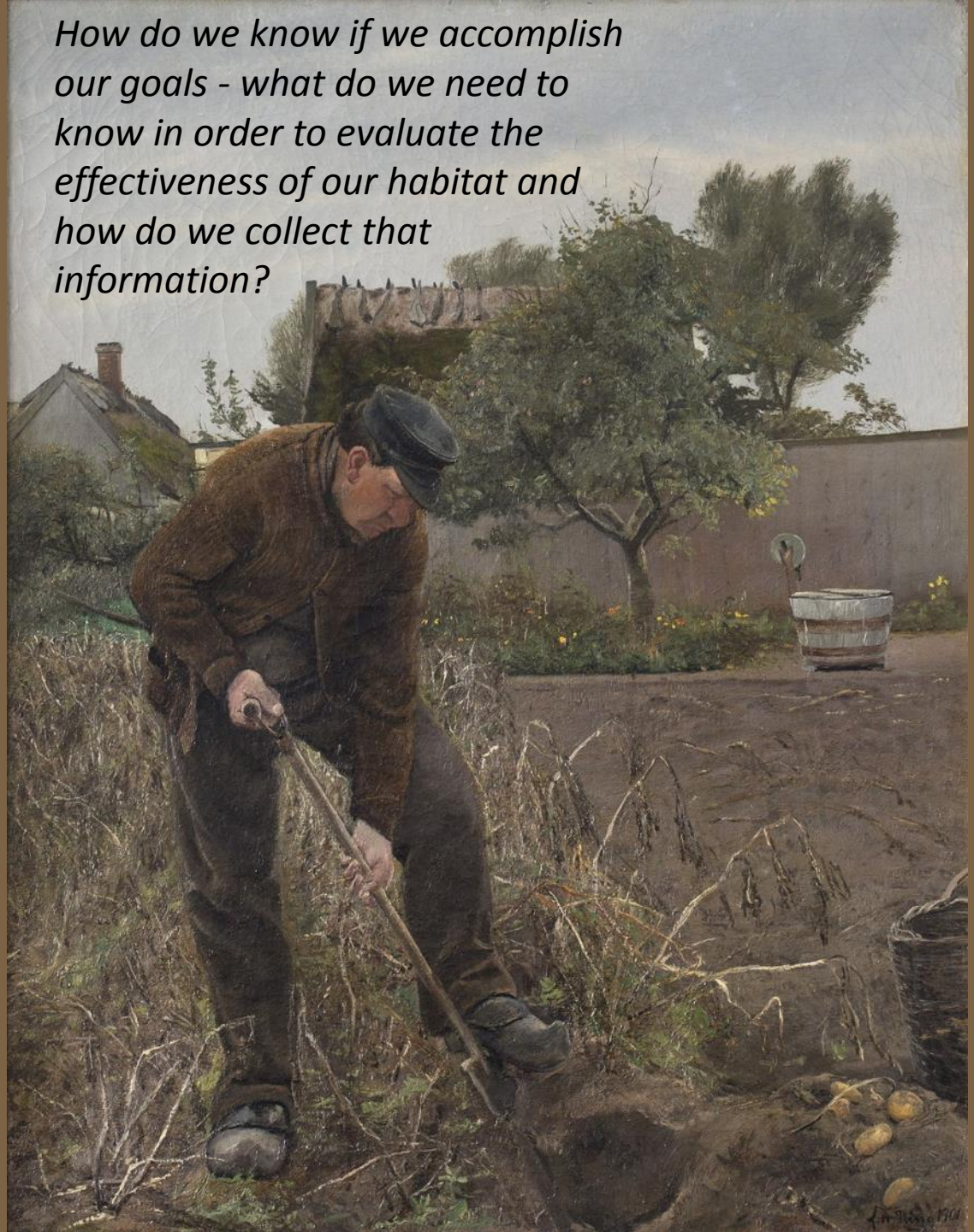
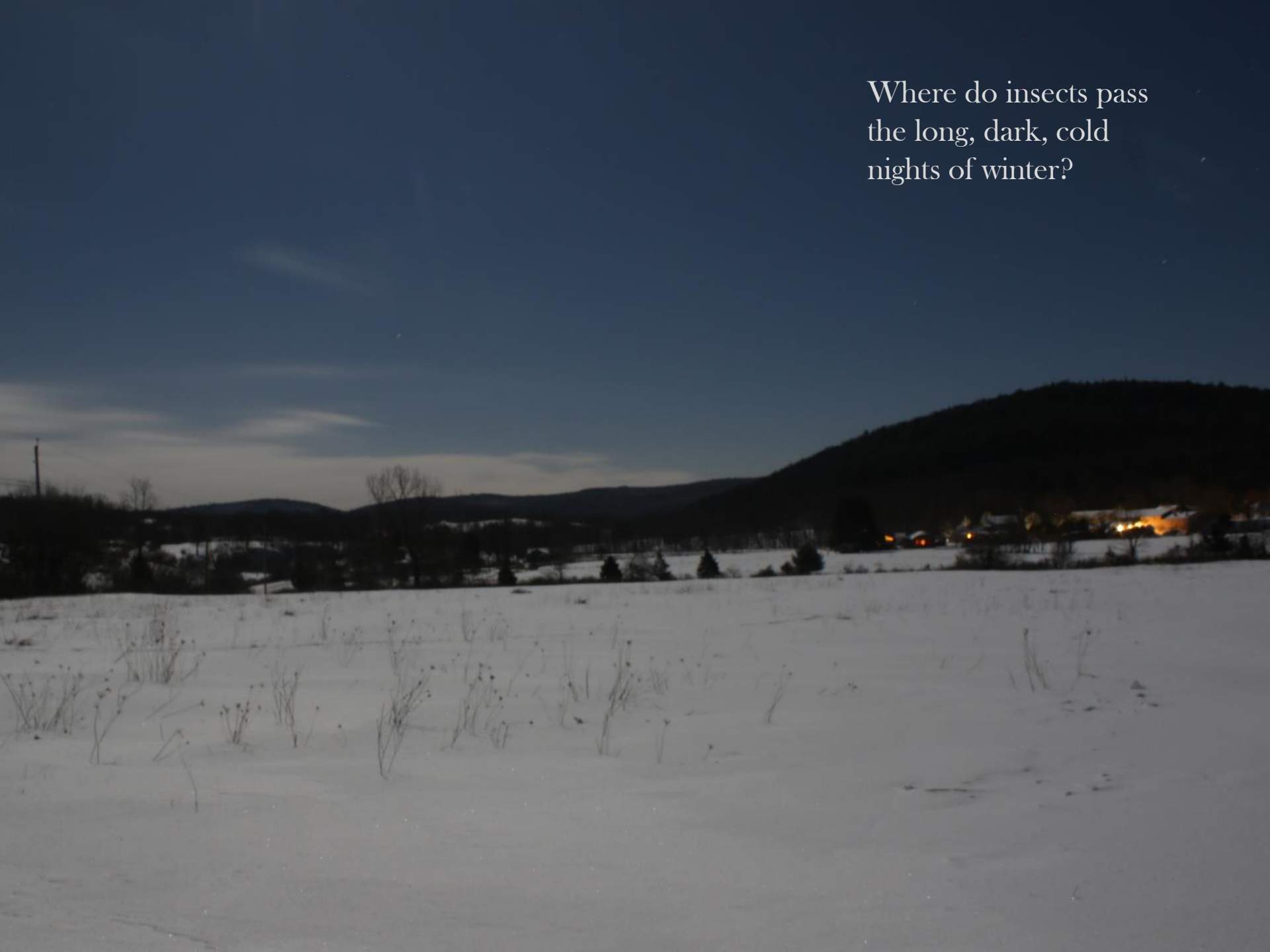
(Are the terms "pest" and "beneficial" stereotypes? How do perceptions of 'good' and 'bad' differ with farming system and what you measure?)



Laurits Andersen Ring, *A Man Digging Potatoes,* 1901


Where do insects pass
the long, dark, cold
nights of winter?


"Emergence" traps – catch insects as they come out of hibernation in the Spring.
Btle. Bank
Rocky Edge
Lawn
"Rough"

Ant
Caterpillar
Ground Beetle
Rove Beetle
Micro Wasp

Ground
Beetle
Rove Beetle
Bugs
Click Beetle
Micro Wasp
Leafhopper
Wolf Spider
Other Spiders
Flea Beetle
Caterpillar

Btle. Bank	Rocky Edge
Lawn	“Rough”

Flea Beetle
Ant
Other
Spiders
Click Beetle

Micro
Wasp
Wolf Spider

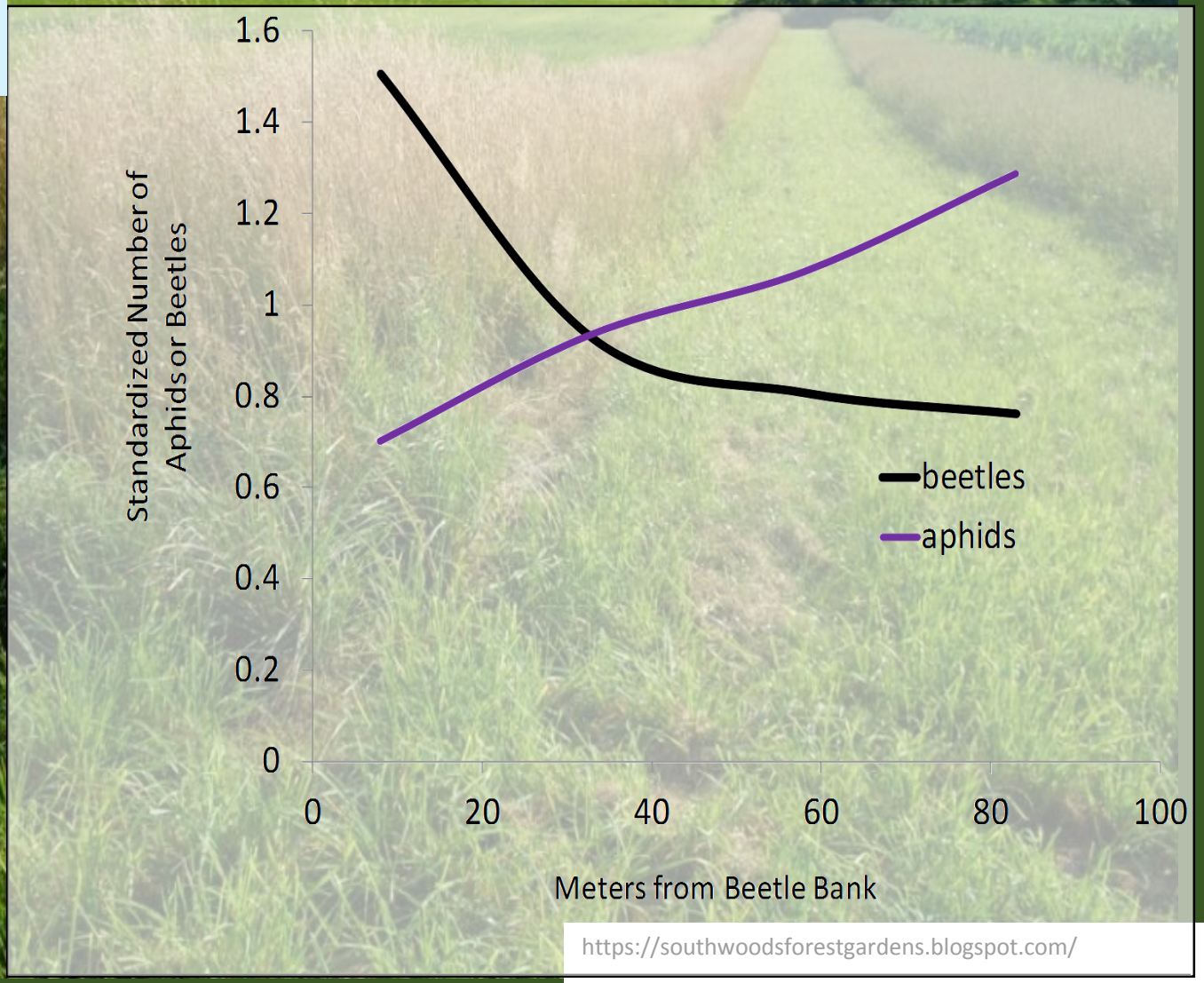
Data from:
Collins, K.L., N.D. Boatman, A. Wilcox, J.M. Holland, and K. Chaney. 2002. The influence of beetle banks on aphid population predation in winter wheat. *Agriculture, Ecosystems and Environment* 93:337–350.

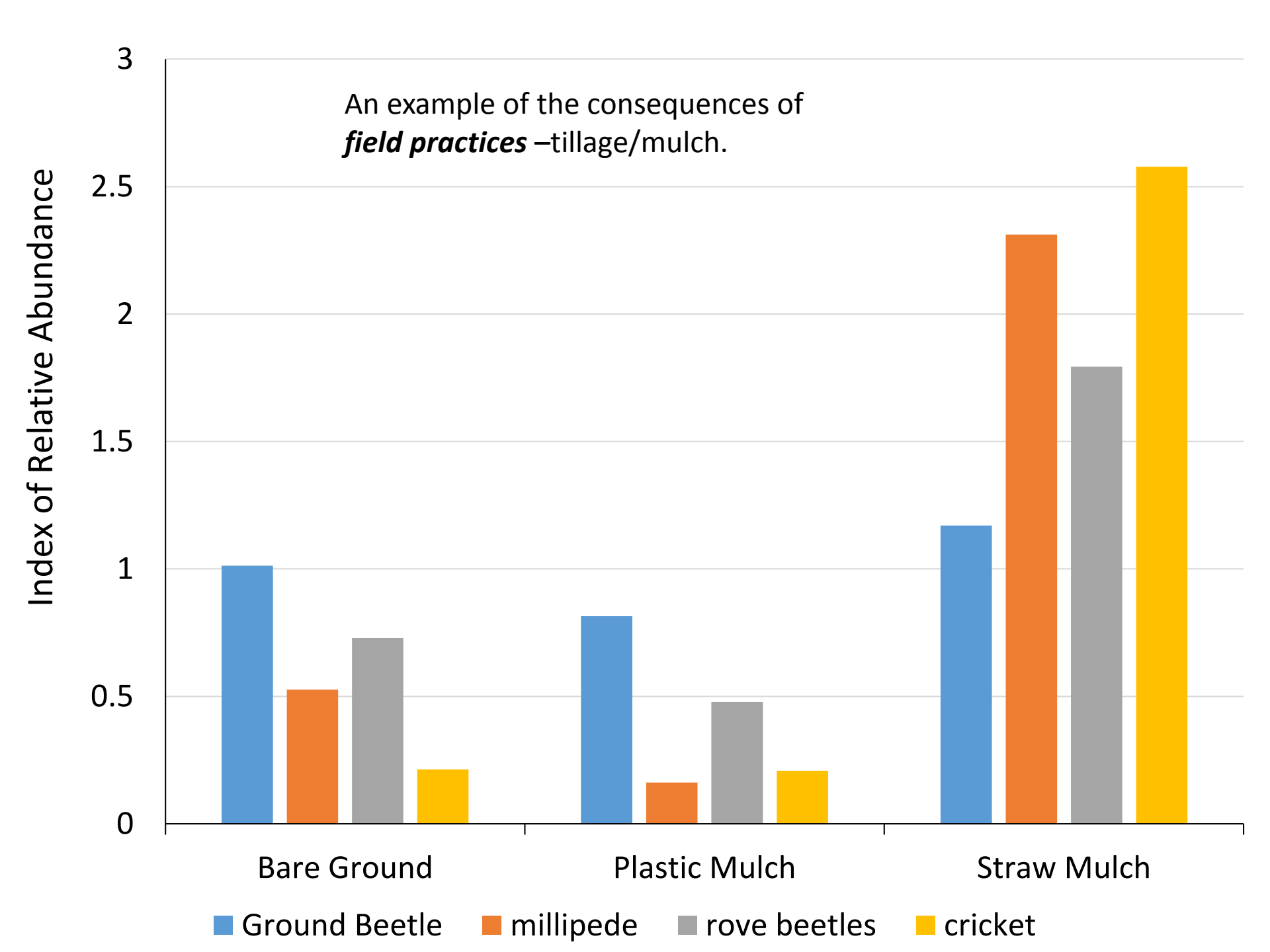
Beetle Banks as winter beetle refuges.

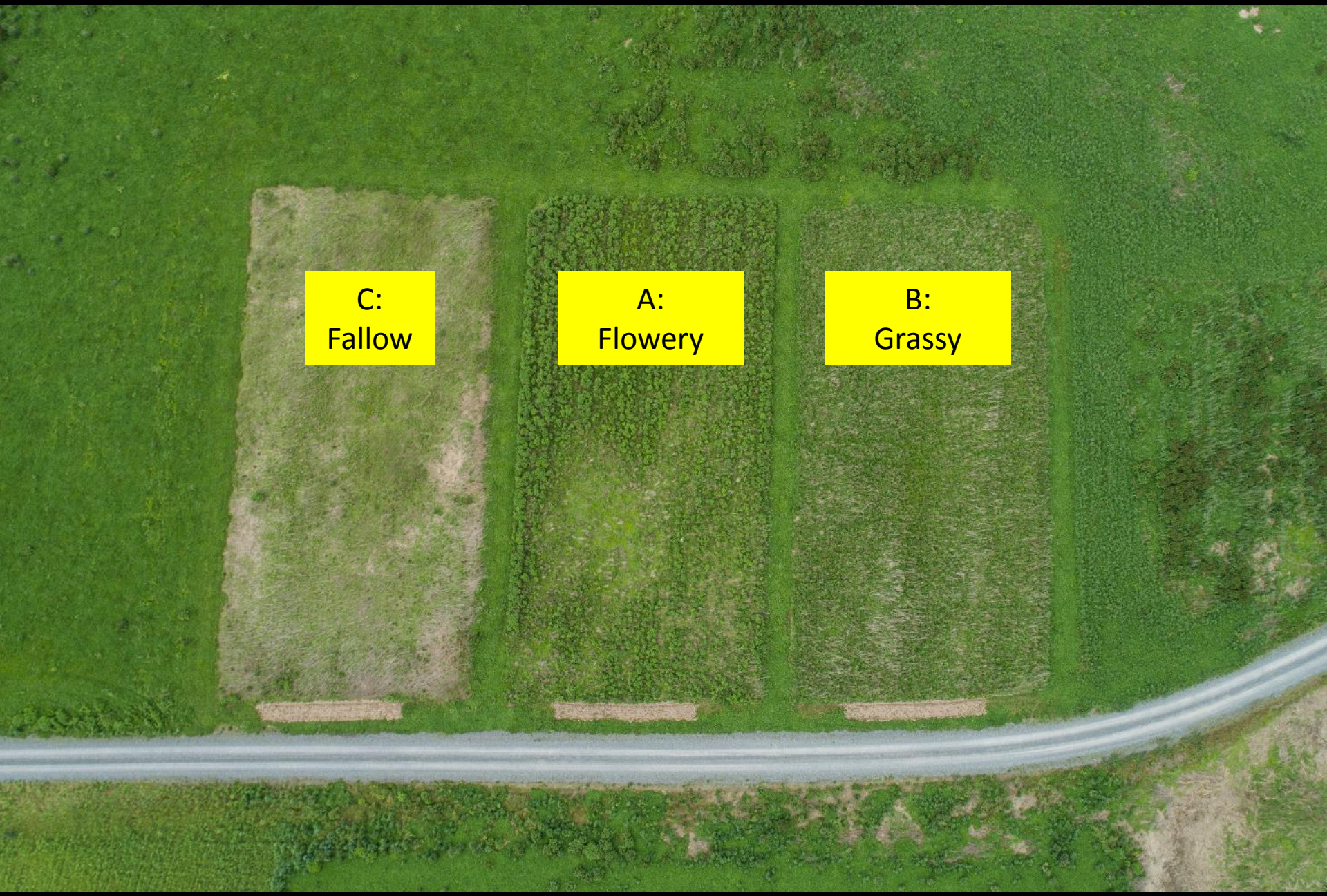
https://southwoodsforestgardens.blogspot.com/

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.

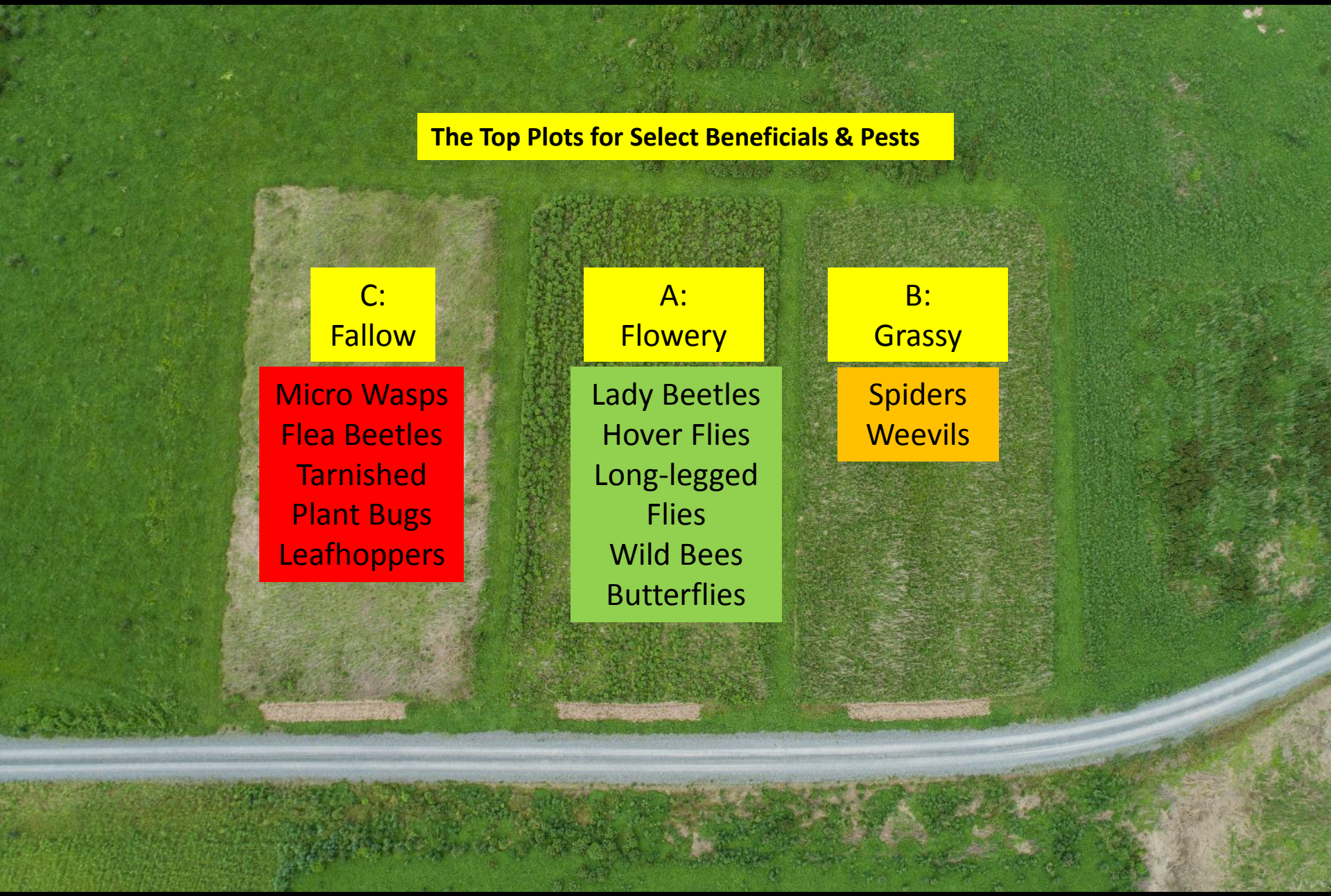
Beetle Banks as winter beetle refuges.




An example of the consequences of
field practices –tillage/mulch.
Index of Relative Abundance
3
2.5
2
1.5
1
0.5
0
Bare Ground
Plastic Mulch
Straw Mulch
Ground Beetle
millipede
rove beetles
cricket

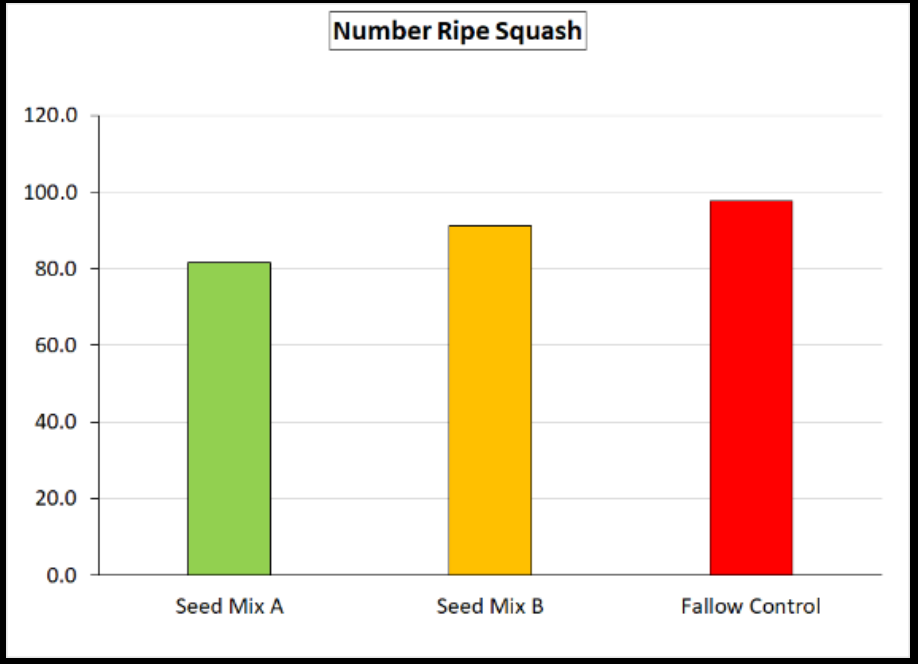

C:
Fallow
A:
Flowery
B:
Grassy

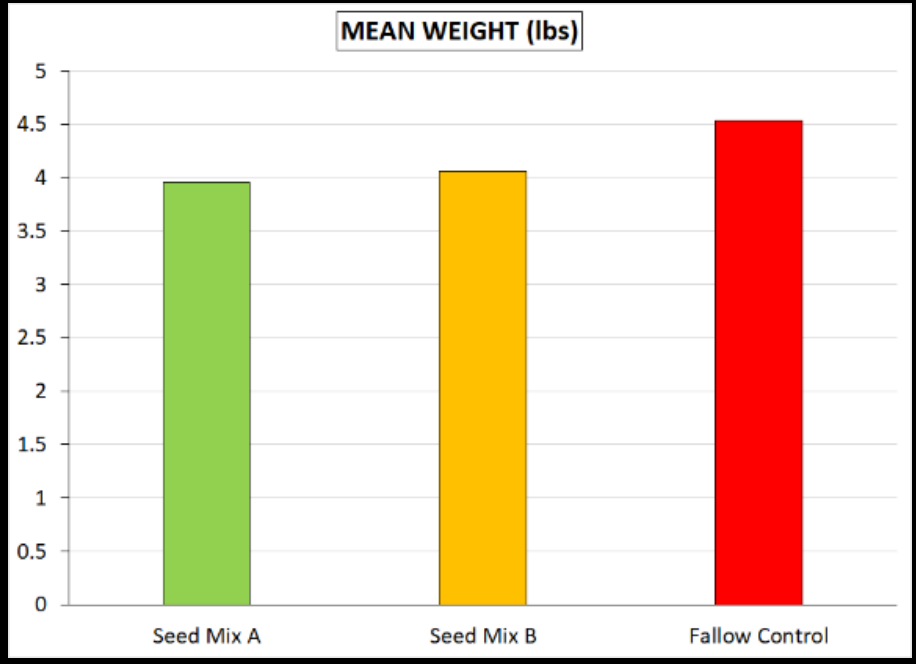
We try to use an array of techniques because no one technique is perfect, but if we're seeing consistent results across methods, then maybe, just maybe, we're seeing something 'real'.

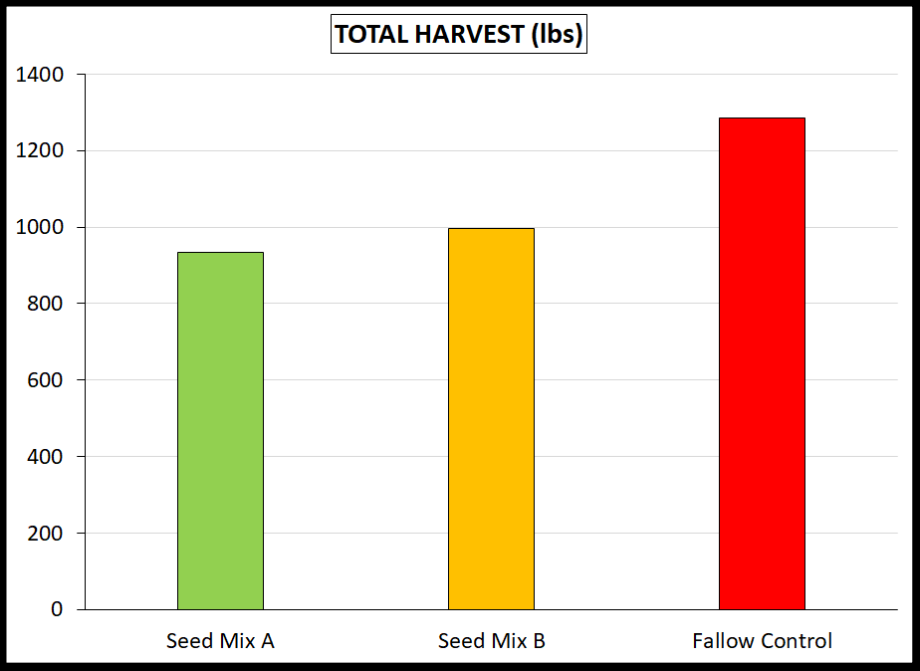

The Top Plots for Select Beneficials & Pests
C:
Fallow
Micro Wasps
Flea Beetles
Tarnished
Plant Bugs
Leafhoppers
A:
Flowery
Lady Beetles
Hover Flies
Long-legged
Flies
Wild Bees
Butterflies
B:
Grassy
Spiders
Weevils

Diversity
Number of Taxa
20
18
16
14
12
10
8
6
4
2
0
Butterflies
Bees
Wasps
A
B
Fallow Control


Squash & Broccoli Beds





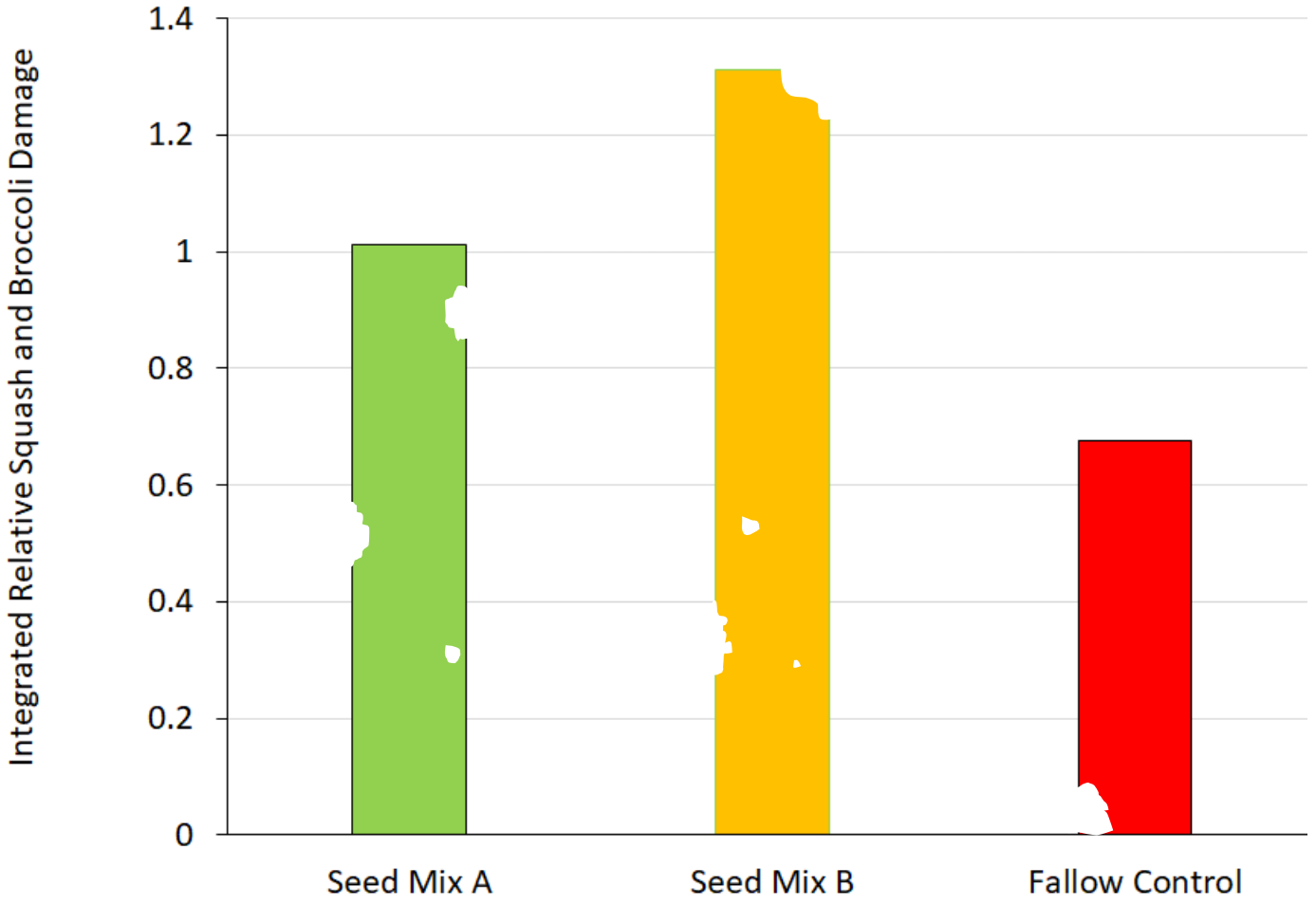


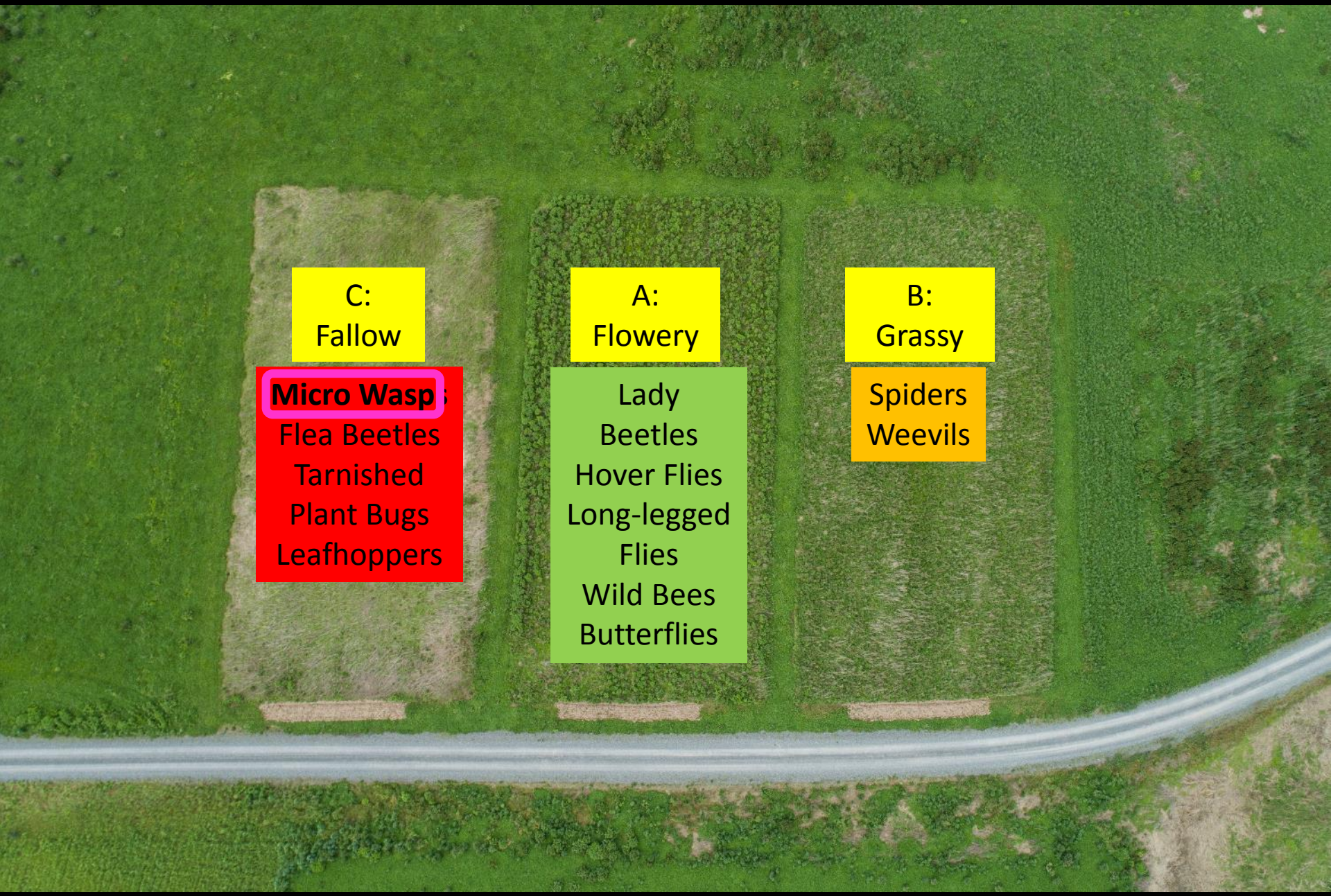
More and bigger squash,
resulting in greater total harvest
beside the Fallow Control.

Hold on, what?!

Why might squash grow best next to our fallow control plots?

Might pest damage be stunting growth in mixes A and B?




C:
Fallow
Micro Wasp
Flea Beetles
Tarnished
Plant Bugs
Leafhoppers
A:
Flowery
Lady
Beetles
Hover Flies
Long-legged
Flies
Wild Bees
Butterflies
B:
Grassy
Spiders
Weevils

Why wasps might be having an effect on pest damage.

Why might micro wasps favor → over?

12-June-2019



15-July-2019



14-Aug-2019



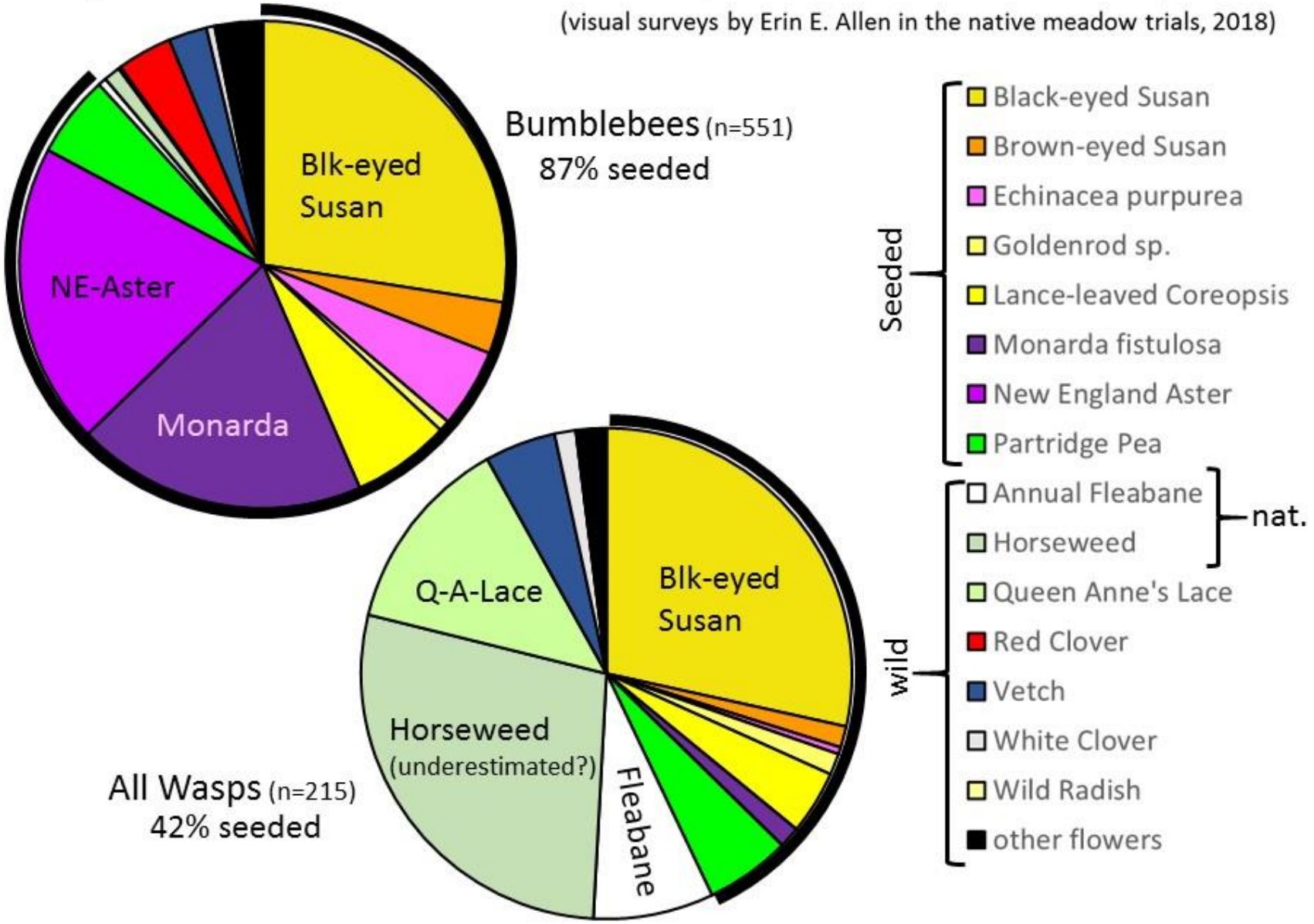
20-Sept-2019



NMT 1A NMT 1B NMT 1C

Comparison of Flower Use by Bumblebees and Wasps

(visual surveys by Erin E. Allen in the native meadow trials, 2018)



Beauty is in the eye of the beholder
and, to a small wasp, this -

may be more
appealing than….

Beauty is in the eye of the beholder
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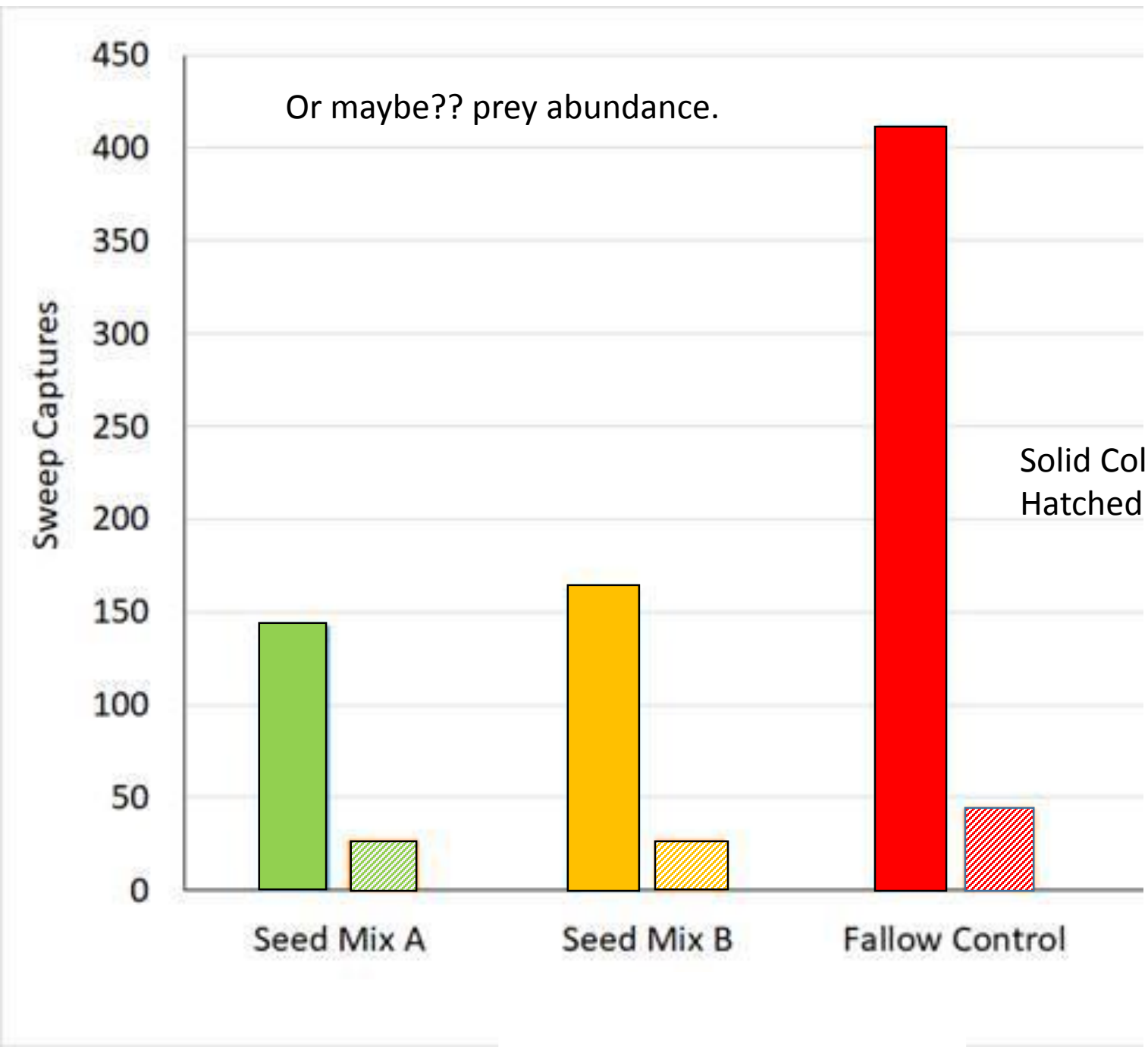
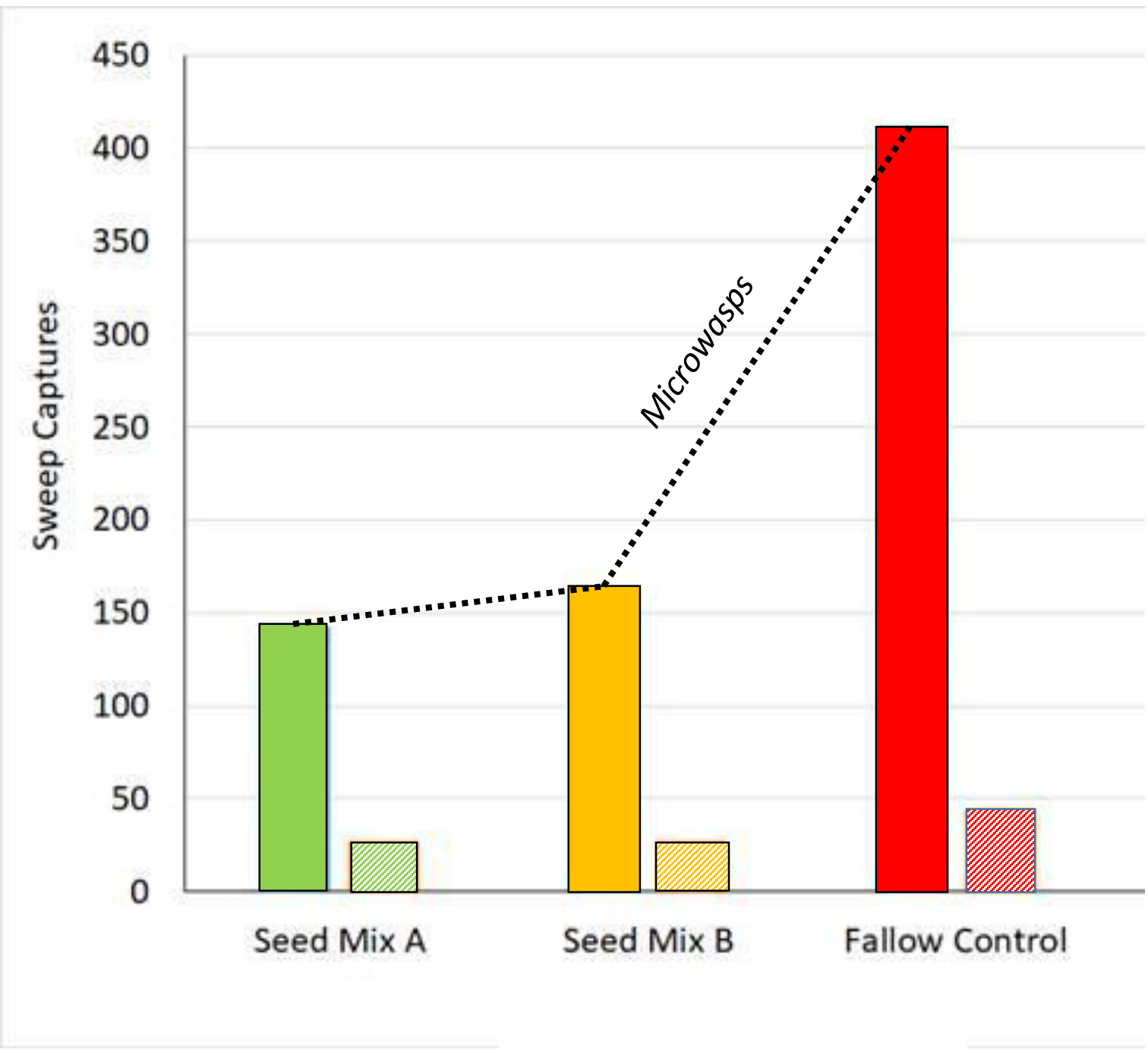
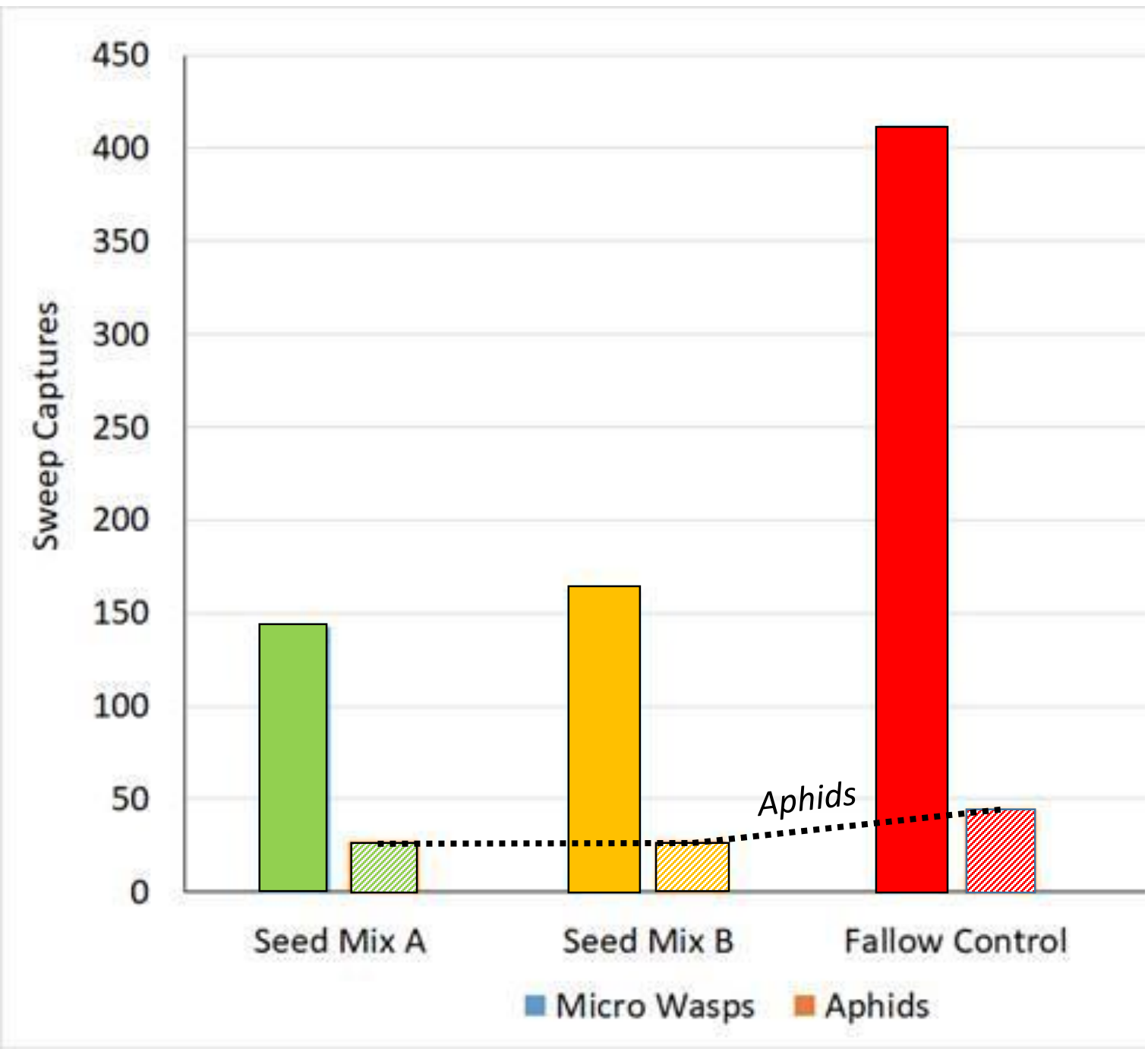
may be more appealing than this -

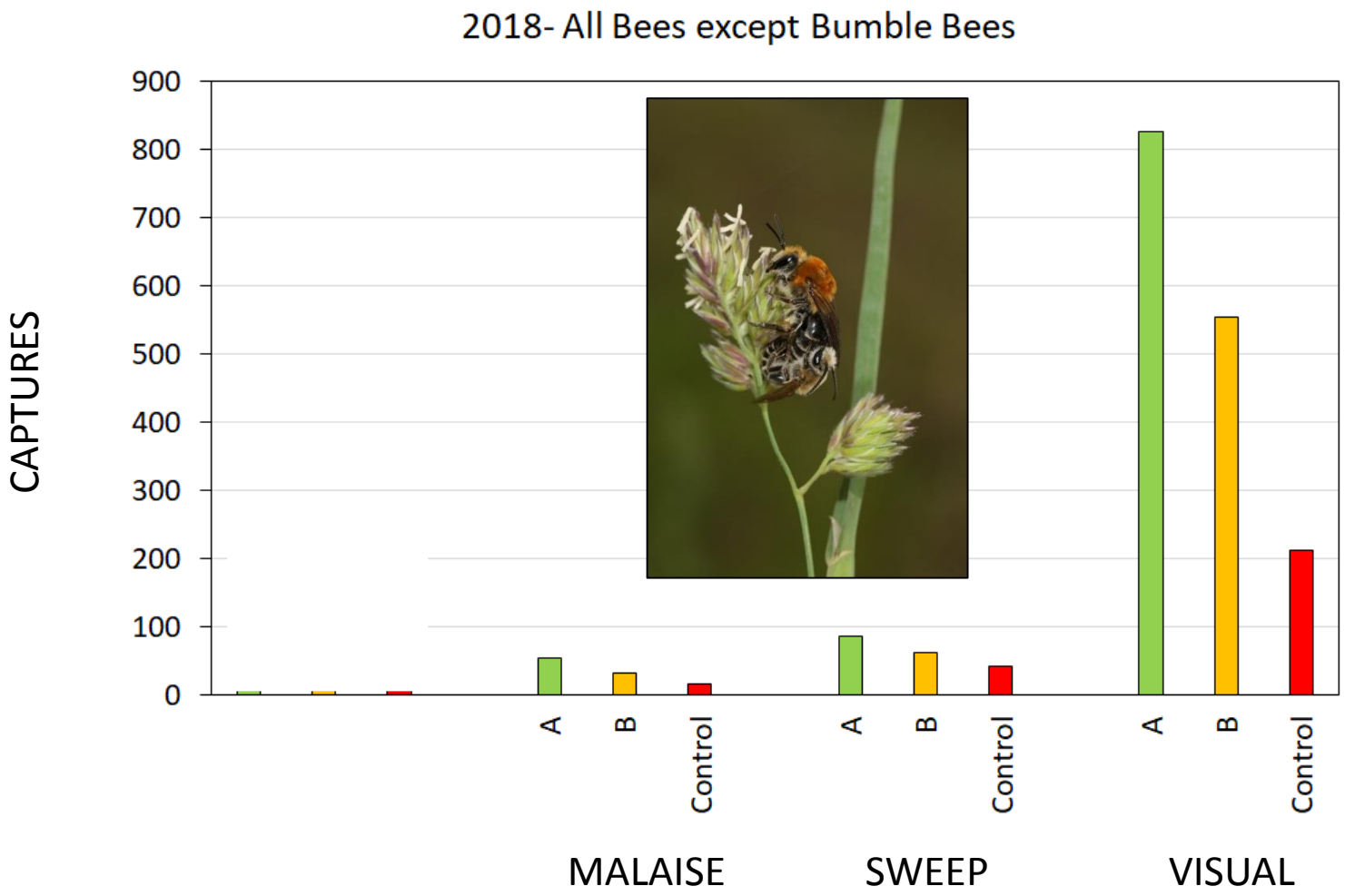

Or maybe?? prey abundance.
Sweep Captures
450
400
350
300
250
200
150
100
50
0
Seed Mix A
Seed Mix B
Fallow Control
Solid Colors = Microwasps
Hatched Colors = Aphids

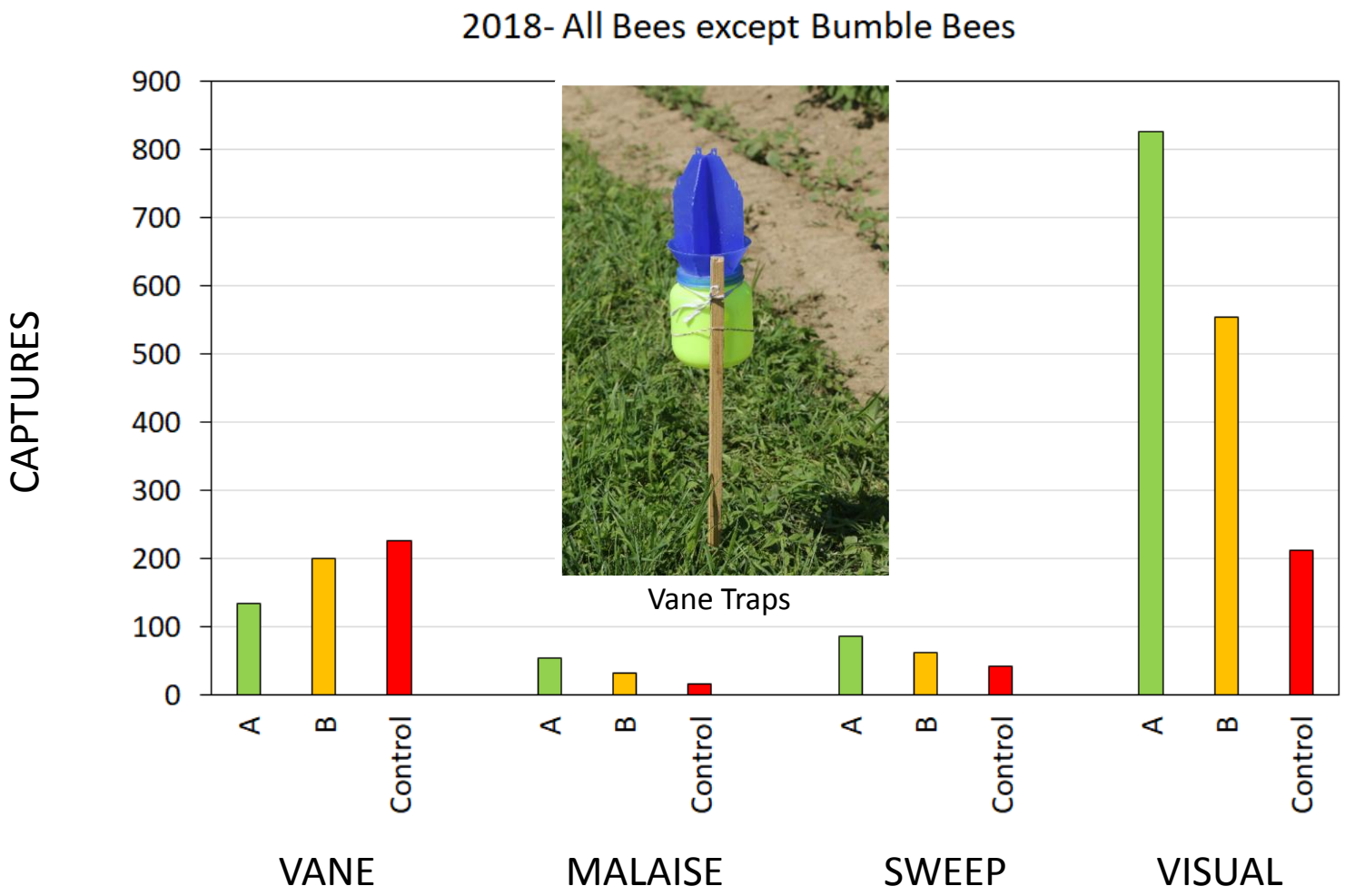

450
400
350
300
250
200
150
100
50
0
Sweep Captures
Microwasps
Seed Mix A
Seed Mix B
Fallow Control


450
400
350
300
250
200
150
100
50
0
Sweep Captures
Aphids
Seed Mix A
Seed Mix B
Fallow Control
Micro Wasps
Aphids

Are the weight differences due to pollination differences??


‘Fruit’ size in squash is often affected by pollination. (Yes, these are cucs, but the same is said to hold for Butternut Squash.)
https://vegetablegrowersnews.com/news/disorders-in-summer-squash-cucumbers-revisited/
G Johnson


2018- All Bees except Bumble Bees
CAPTURES
900
800
700
600
500
400
300
200
100
0
A
B
Control
A
B
Control
A
B
Control
MALAISE
SWEEP
VISUAL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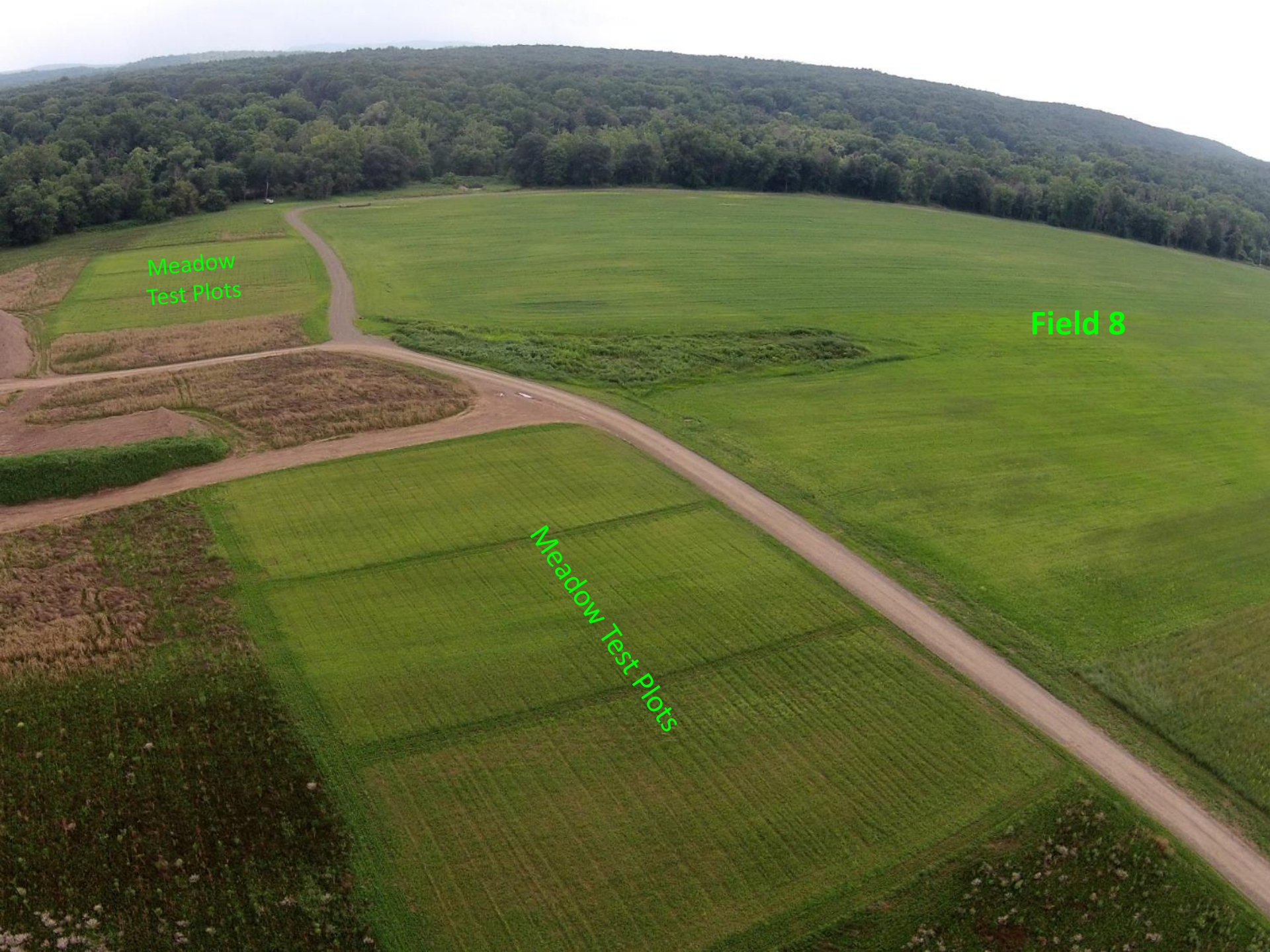
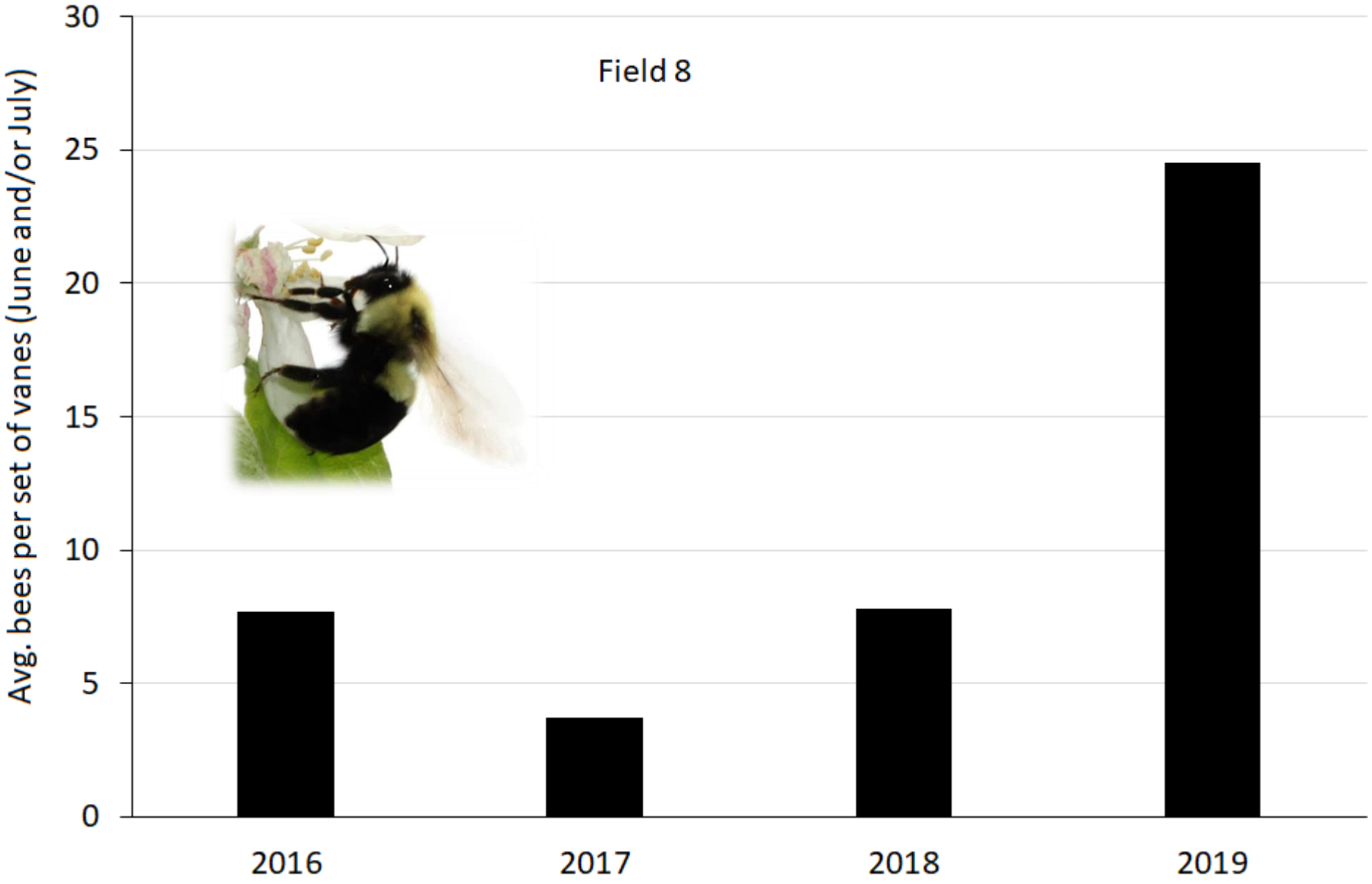
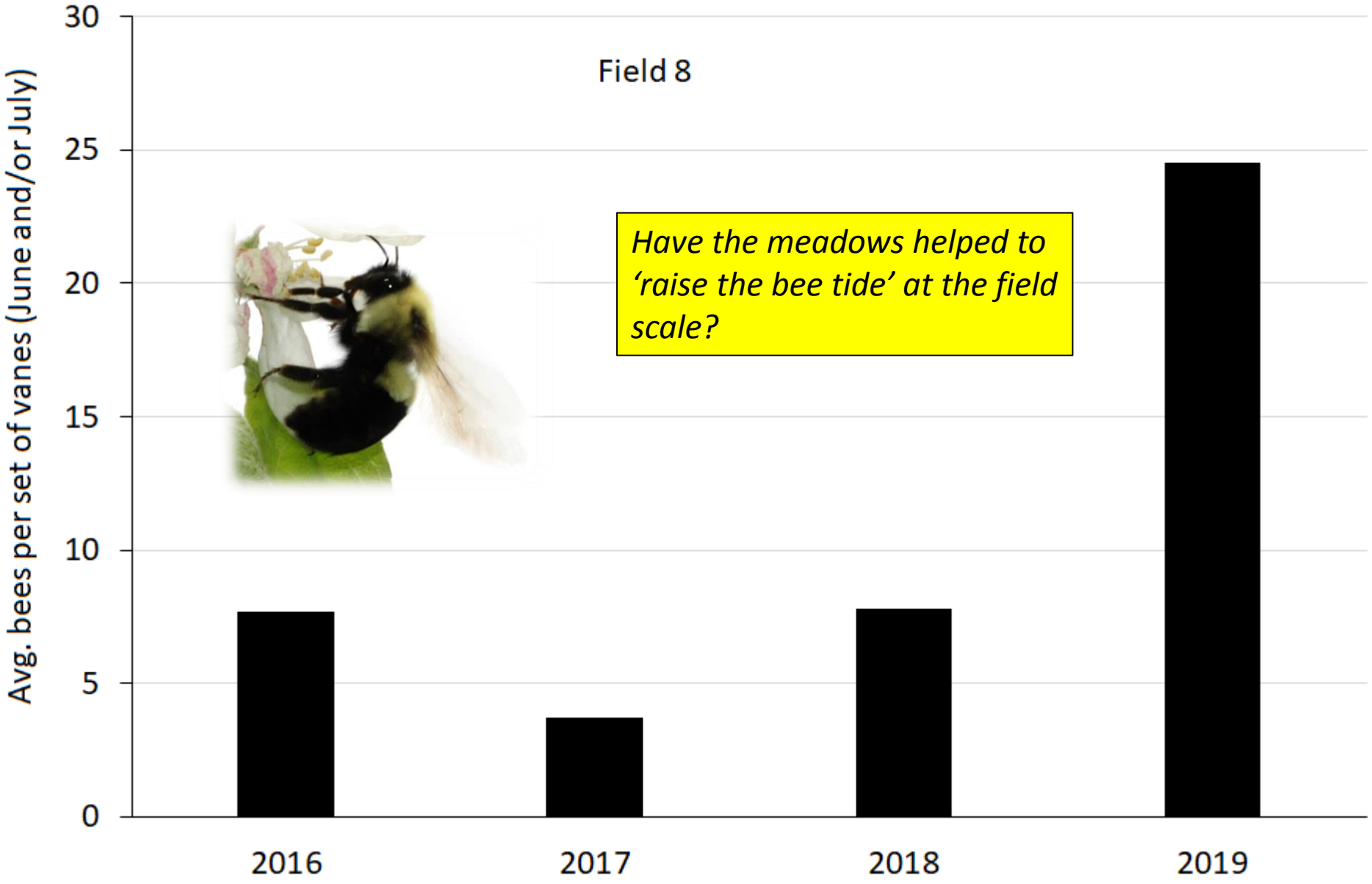
CAPTURES
900
800
700
600
500
400
300
200
100
0
A
B
Control
A
B
Control
A
B
Control
A
B
Control
VANE
MALAISE
SWEEP
VISUAL
Vane Traps

A Case of the Walmart Effect?


Meadow
Test Plots
Field 8
Meadow Test Plots

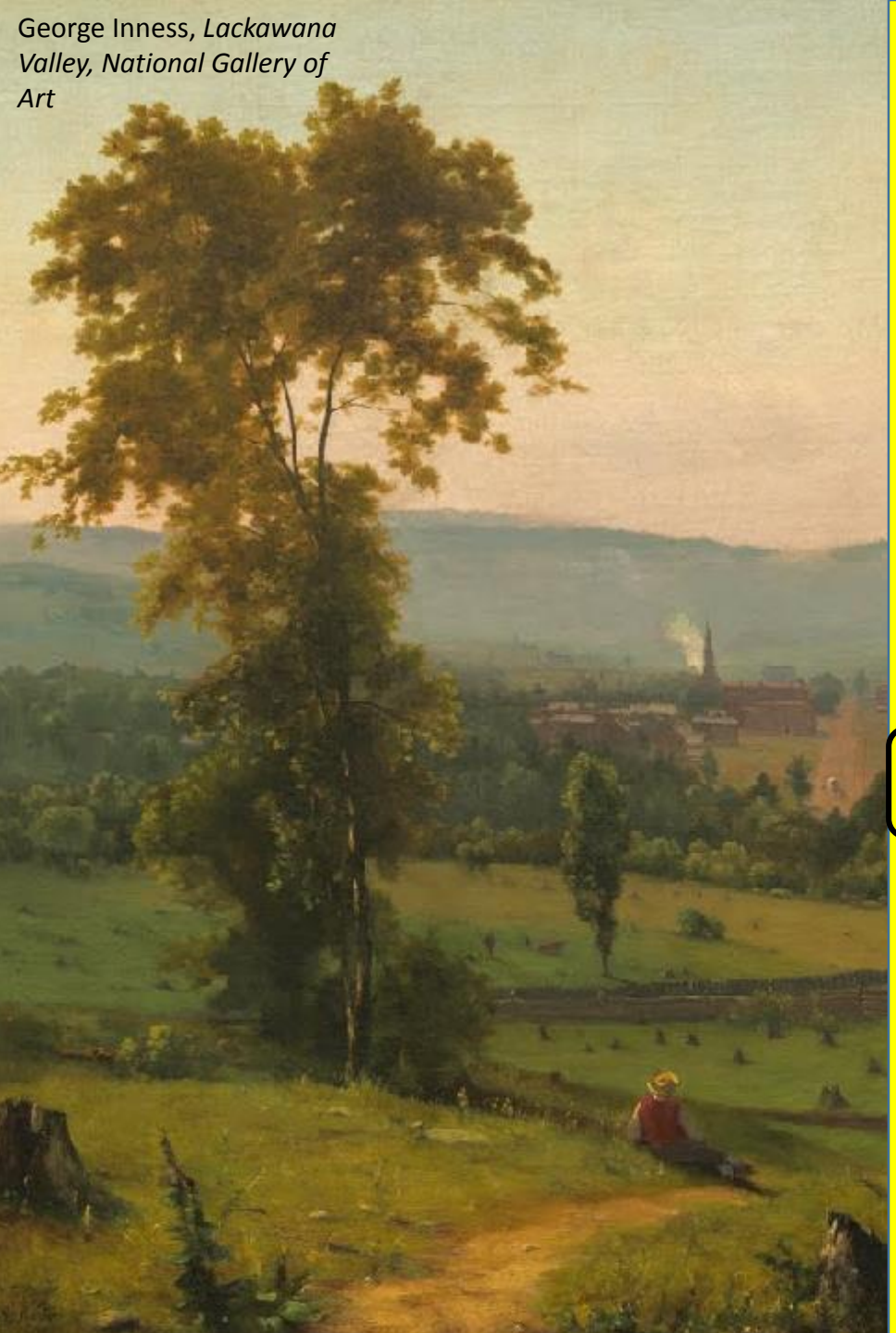

Field 8
Avg. bees per set of vanes (June and/or July)
30
25
20
15
10
5
0
2016
2017
2018
2019


Field 8
Avg. bees per set of vanes (June and/or July)
30
25
20
15
10
5
0
2016
2017
2018
2019
Have the meadows helped to 'raise the bee tide' at the field scale?

Future Work:

- *Repeat & diversify crops*
- *Study food webs in more detail (e.g., parasitoids and predators)*
- *Add more small flowers to seed mix and monitor results*
- *Establish and monitor beetle banks in large fields.*

George Inness, *Hackensack Meadows Sunset*



George Inness, *Lackawana Valley, National Gallery of Art*

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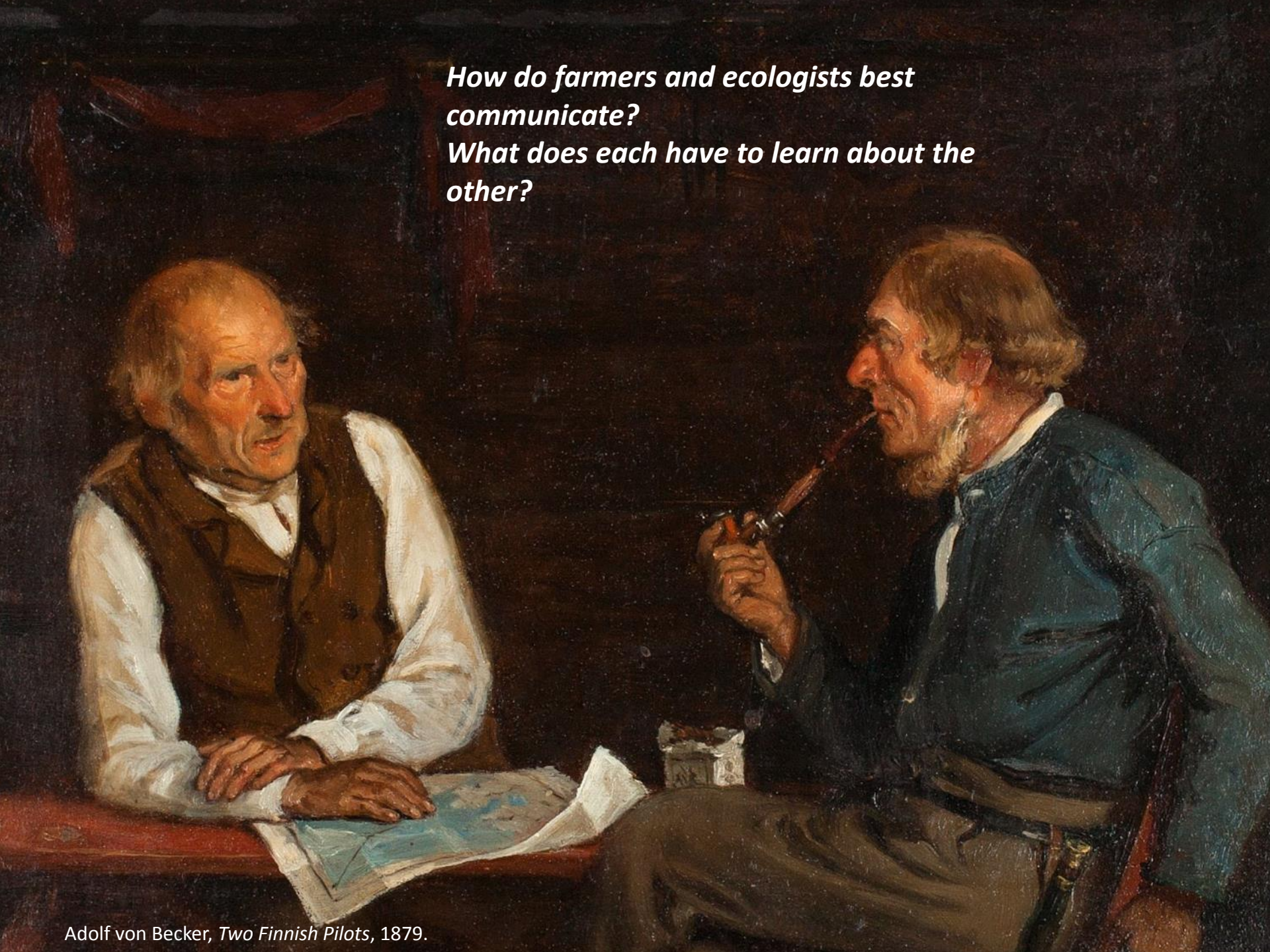
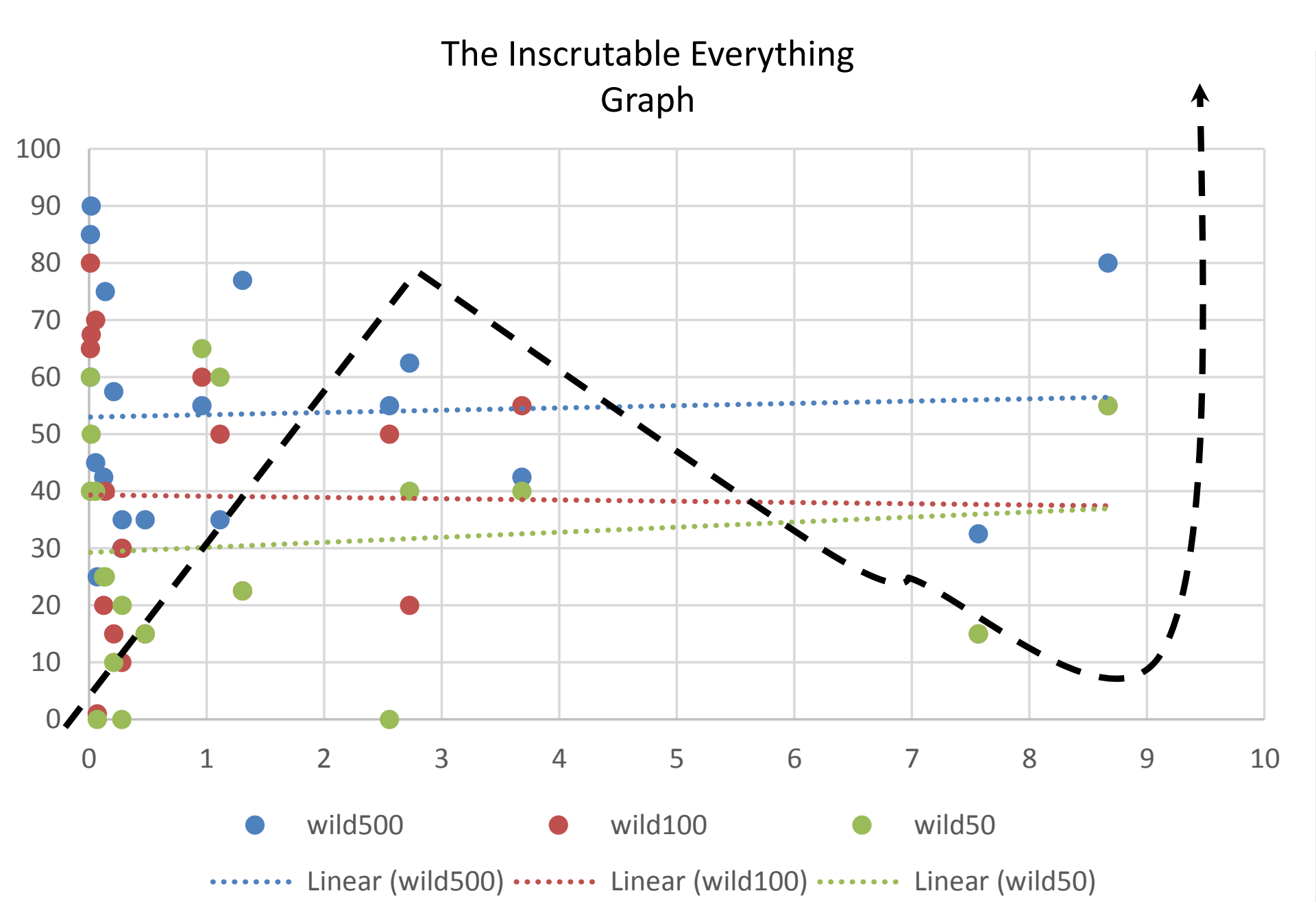
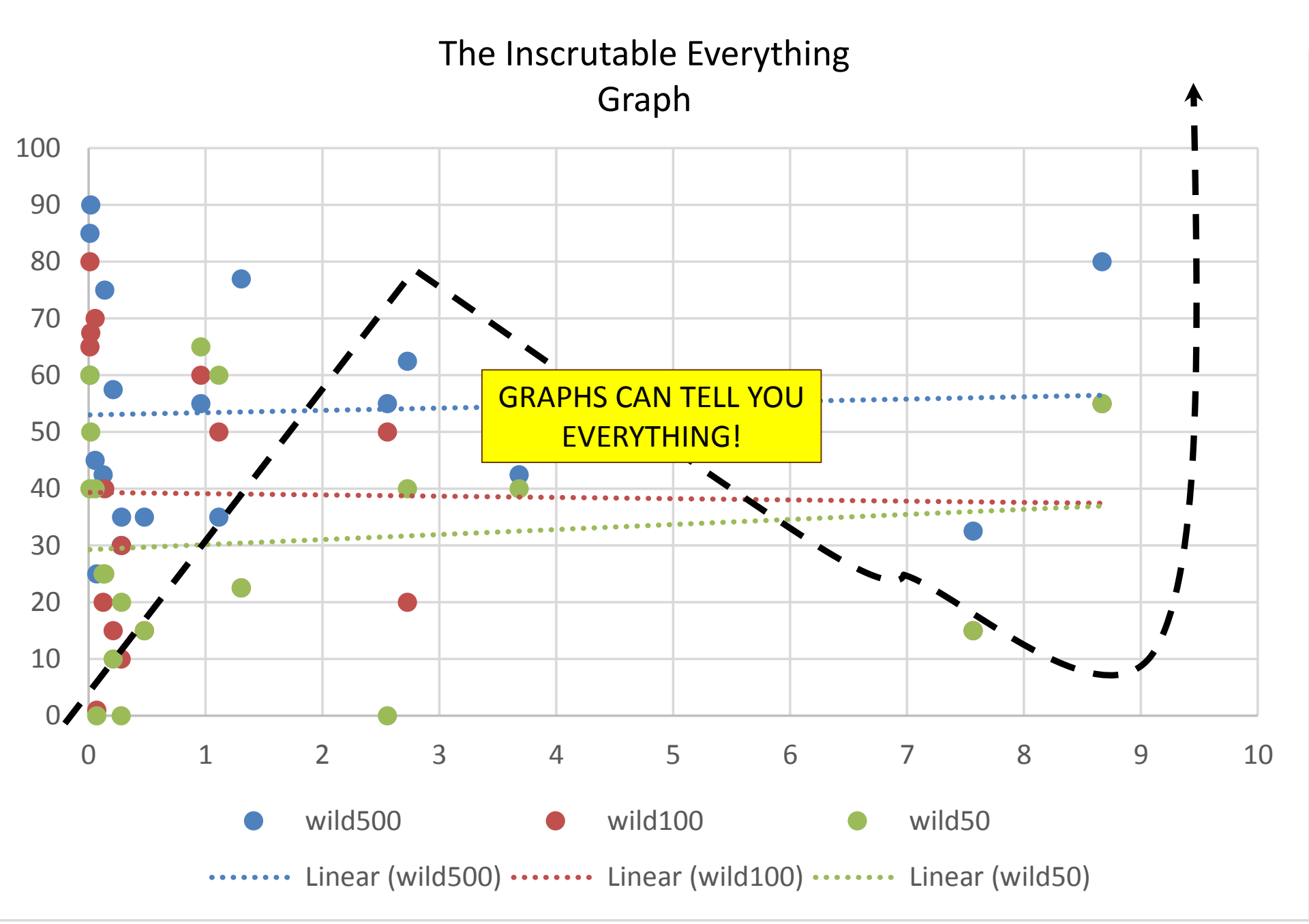


Adolf von Becker, *Two Finnish Pilots*, 1879.


The Inscrutable Everything
Graph
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
8
9
10
wild500
wild100
wild50
Linear (wild500)
Linear (wild100)
Linear (wild50)


The Inscrutable Everything Graph
GRAPHS CAN TELL YOU EVERYTHING!
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
8
9
10
wild500
wild100
wild50
Linear (wild500)
Linear (wild100)
Linear (wild50)

VANE

Row Labels	Average of All Bees	Average of All Wasps	Average of All True Bugs (except aphids)	Average of all microflies	Average of All Spiders	Average of All Macroflies	Average of All Beetles	Average of All Hoverfly	Average of All Lady Beetles	Average of micro wasp
0	8.3	4.9	7.1	16.6	0.7	1.2	78.8	0.8	0.5	1.8
300	13.5	2.3	19.8	20.8	1.3	2.0	132.5	0.8	0.5	1.6
600	15.8	3.2	16.3	24.1	0.9	2.2	134.2	0.9	0.4	2.8
woods	1.6	1.6	3.4	7.2	0.3	1.3	12.6	1.6	0.0	0.8
Grand Tota	10.9	3.2	12.8	18.6	0.9	1.7	100.5	0.9	0.4	**1.9**

Row Labels	Average of All Bees	Average of All Wasps	Average of All True Bugs (except aphids)	Average of all microflies	Average of All Spiders	Average of All Macroflies	Average of All Beetles	Average of All Hoverfly	Average of All Lady Beetles
2016	3.9	1.9	0.7	10.9	0.0	1.0	2.6	0.2	
2017	8.8	3.9	13.7	30.8	0.3	2.4	59.9	0.4	1.0
2018	8.0	5.0	8.1	23.6	2.7	2.4	77.3	1.3	0.3
2019	17.3	2.4	21.1	12.8	0.5	1.3	185.4	1.4	0.2
Grand Tota	10.9	3.2	12.8	18.6	0.9	1.7	100.5	0.9	0.4

MALAISE

Row Labels	Average of all microflies	Average of All bees	Average of other beetle	Average of Treehopper/leafhopper/spittlebug	Average of All Macroflies (except Hvrs)	Average of All Beetles	Average of All Hoverfly	Average of all spiders	Average of long-legged fly (Dolichopodidae)	Average of ant	Average of All True Bugs except aphids and leafhoppers	Average of All Wasps	Average of All Lady Beetles (all ages)	Average of micro wa
2016	234.2	1.8	19.2	15.0	52.4	23.8	3.0	1.2	19.5	1.4	6.9	21.9	27.0	22.5
300	305.7	0.8	19.9	17.1	59.0	20.8	2.1	2.0	5.5	0.4	2.6	25.9	29.5	31.9
600	363.5	1.0	24.3	18.1	48.2	23.3	2.5	2.0	4.2	0.5	2.9	31.0	32.1	37.9
woods	104.6	1.0	11.3	3.4	11.7	14.4	0.5	0.5	0.8	1.3	1.8	9.4	0.3	4.0
Grand Total	269.7	1.2	20.0	14.6	46.6	21.7	2.2	1.6	8.7	0.9	3.7	23.6	26.1	

Row Labels	Average of all microflies	Average of All bees	Average of other beetle	Average of Treehopper/leafhopper/spittlebug	Average of All Macroflies (except Hvrs)	Average of All Beetles	Average of All Hoverfly	Average of all spiders	Average of long-legged fly (Dolichopodidae)	Average of ant	Average of All True Bugs except aphids and leafhoppers	Average of All Wasps	Average of All Lady Beetles (all ages)
2016	110.1	1.8		0.2	30.3	12.4	0.1	0.8		0.4	2.8	12.5	
2017	100.6	1.4	18.8	12.9	15.8	25.6	2.4	1.0	3.3	1.4	2.2	15.4	38.5
2018	191.1	1.0	23.4	23.8	66.3	34.1	1.1	5.1	1.6	0.7	8.9	50.4	58.0
2019	568.5	0.5	18.7	24.9	69.0	27.0	4.8	0.7	15.8	1.2	2.6	24.2	1.1
Grand Total	269.7	1.2	20.0	14.6	46.6	21.7	2.2	1.6	8.7	0.9	3.7	23.6	26.1

SWEEP

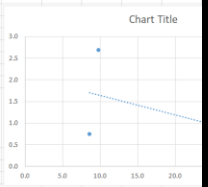
Row Labels	Average of All non-GB Beetles	Average of All Bugs (except aphids and Ifhprs)	Average of Weevils	Average of Leaf/tree/planthoppers	Average of Micro Fly	Average of All Bees	Average of Ants (keep specimen)	Average of All wasps	Average of All Lady Beetles	Average of All Hoverflies	Average of All Spiders
2016	12.7	44.1	0.2	27.5	27.9	1.3	0.0	2.8	3.4	2.9	2.0
2017	15.9	33.8	2.0	70.3	80.8	1.5	0.5	8.1	3.3	5.7	6.4
2018	25.4	120.3	7.2	43.9	44.7	1.5	0.2	6.4	7.4	1.8	5.2
2019	23.7	25.8	10.7	25.6	68.5	0.9	2.9	20.0	1.7	4.5	10.2
(blank)											
Grand Tota	20.0	46.9	6.2	36.3	56.8	1.2	1.4	11.7	3.3	3.9	6.8

Row Labels	Average of All non-GB Beetles	Average of All Bugs (except aphids and Ifhprs)	Average of Weevils	Average of Leaf/tree/planthoppers	Average of Micro Fly	Average of All Bees	Average of Ants (keep specimen)	Average of All wasps	Average of All Lady Beetles	Average of All Hoverflies	Average of All Spiders	Average of Micro Wasp
0	21.7	83.2	8.2	35.1	58.1	1.6	0.6	11.5	5.2	3.4	8.6	9.3
300	22.6	39.4	5.5	36.1	70.6	0.9	0.3	13.8	2.8	3.8	5.0	12.3
600	19.8	30.2	6.4	43.4	46.9	1.3	0.3	6.8	2.9	4.9	4.1	5.5
woods	9.0	13.4	1.9	20.6	42.3	0.7	9.3	20.0	0.6	2.3	14.1	16.8
(blank)												
Grand Tota	20.0	46.9	6.2	36.3	56.8	1.2	1.4	11.7	3.3	3.9	6.8	**9.9**

PITS

Row Labels	Average of All Ground Beetles	Average of Ants	Average of All Beetles (minus GBs)	Average of Slug	Average of All Spiders	Average of Harpalus rufipes	Average of Ground Beetle	Average of Wolf Spider
0	16.0	0.7	3.9	5.1	8.7	3.8	7.5	5.6
300	24.4	0.8	5.3	5.2	8.1	10.6	6.4	4.8
600	15.7	0.3	5.1	7.2	10.1	2.7	5.2	7.5
woods	13.0	6.4	3.3	1.9	1.9	4.4	7.4	0.4
(blank)								
Grand Tota	17.8	1.5	4.5	5.3	7.9	5.5	6.7	5.1

Row Labels	Average of All Ground Beetles	Average of Ants	Average of All Beetles (minus GBs)	Average of Slug	Average of All Spiders	Average of Harpalus rufipes	Average of Ground Beetle	Average of Wolf Spider
2016	29.0	1.3	2.0	0.1	5.3	11.3	17.6	3.1
2017	28.2	0.2	4.5	0.0	6.0	6.6	10.1	1.2
2018	8.6	0.7	8.5	0.4	9.1	2.4	0.3	5.9
2019	9.8	2.7	4.0	14.4	10.0	2.8	1.1	8.3
(blank)								
Grand Tota	17.8	1.5	4.5	5.3	7.9	5.5	6.7	5.1



VANE

Row Labels	Average of All Bees	Average of All Wasps	Average of All True Bugs (except aphids)	Average of all microflies	Average of All Spiders	Average of All Macroflies	Average of All Beetles	Average of All Hoverfly	Average of All Lady Beetles	Average of micro wasp
0	8.3	4.9	7.1	16.6	0.7	1.2	78.8	0.8	0.5	1.8
300	13.5	2.3	19.8	20.8	1.3	2.0	132.5	0.8	0.5	1.6
600	15.8	3.2	16.3	24.1	0.9	2.2	134.2	0.9	0.4	2.8
woods	1.6	1.6	3.4	7.2	0.3	1.3	12.6	1.6	0.0	0.8
Grand Total	10.9	3.2	12.8	18.6	0.9	1.7	100.5	0.9	0.4	**1.9**

Row Labels	Average of All Bees	Average of All Wasps	Average of All True Bugs (except aphids)	Average of all microflies	Average of All Spiders	Average of All Macroflies	Average of All Beetles	Average of All Hoverfly	Average of All Lady Beetles
2016	3.9	1.9	0.7	10.9	0.0	1.0	2.6	0.2	
2017	8.8	3.9	13.7	30.8	0.3	2.4	59.9	0.4	1.0
2018	8.0	5.0	8.1	23.6	2.7	2.4	77.3	1.3	0.3
2019	17.3	2.4	21.1	12.8	0.5	1.3	185.4	1.4	0.2
Grand Total	10.9	3.2	12.8	18.6	0.9	1.7	100.5	0.9	0.4

MALAISE

Row Labels	Average of all microflies	Average of All bees	Average of other beetle	Average of Treehopper/leafhopper/spittlebug	Average of All Macroflies (except Hvrs)	Average of All Beetles	Average of All Hoverfly	Average of all spiders	Average of long-legged fly (Dolichopodidae)	Average of ant	Average of All True Bugs except aphids and leafhoppers	Average of All Wasps	Average of All Lady Beetles (all ages)	Average of micro wa
2016	110.1	1.8	19.2	0.2	30.3	12.4	0.1	0.8	19.5	1.4	6.9	21.9	27.0	22.5
2017	100.6	1.4	18.8	12.9	15.8	25.6	2.4	1.0	3.3	1.4	2.2	15.4	38.5	
2018	191.1	1.0	23.4	23.8	66.3	34.1	1.1	5.1	1.6	0.7	8.9	50.4	58.0	
2019	568.5	0.5	18.7	24.9	69.0	27.0	4.8	0.7	15.8	1.2	2.6	24.2	1.1	
Grand Total	269.7	1.2	20.0	14.6	46.6	21.7	2.2	1.6	8.7	0.9	3.7	23.6	26.1	

Row Labels	Average of all microflies	Average of All bees	Average of other beetle	Average of Treehopper/leafhopper/spittlebug	Average of All Macroflies (except Hvrs)	Average of All Beetles	Average of All Hoverfly	Average of all spiders	Average of long-legged fly (Dolichopodidae)	Average of ant	Average of All True Bugs except aphids and leafhoppers	Average of All Wasps	Average of All Lady Beetles (all ages)
2016	110.1	1.8		0.2	30.3	12.4	0.1	0.8		0.4	2.8	12.5	
2017	100.6	1.4	18.8	12.9	15.8	25.6	2.4	1.0	3.3	1.4	2.2	15.4	38.5
2018	191.1	1.0	23.4	23.8	66.3	34.1	1.1	5.1	1.6	0.7	8.9	50.4	58.0
2019	568.5	0.5	18.7	24.9	69.0	27.0	4.8	0.7	15.8	1.2	2.6	24.2	1.1
Grand Total	269.7	1.2	20.0	14.6	46.6	21.7	2.2	1.6	8.7	0.9	3.7	23.6	26.1

SWEEP

Row Labels	Average of All non-GB Beetles	Average of All Bugs (except aphids and Ifhprs)	Average of Weevils	Average of Leaf/tree/planthoppers	Average of Micro Fly	Average of All Bees	Average of Ants (keep specimen)	Average of All wasps	Average of All Lady Beetles	Average of All Hoverflies	Average of All Spiders
2016	12.7	44.1	0.2	27.5	27.9	1.3	0.0	2.8	3.4	2.9	2.0
2017	15.9	33.8	2.0	70.3	80.8	1.5	0.5	8.1	3.3	5.7	6.4
2018	25.4	120.3	7.2	43.9	44.7	1.5	0.2	6.4	7.4	1.8	5.2
2019	23.7	25.8	10.7	25.6	68.5	0.9	2.9	20.0	1.7	4.5	10.2
(blank)											
Grand Total	20.0	46.9	6.2	36.3	56.8	1.2	1.4	11.7	3.3	3.9	6.8

Row Labels	Average of All non-GB Beetles	Average of All Bugs (except aphids and Ifhprs)	Average of Weevils	Average of Leaf/tree/planthoppers	Average of Micro Fly	Average of All Bees	Average of Ants (keep specimen)	Average of All wasps	Average of All Lady Beetles	Average of All Hoverflies	Average of All Spiders	Average of Micro Wasp
0	21.7	83.2	8.2	35.1	58.1	1.6	0.6	11.5	5.2	3.4	8.6	9.3
300	22.6	39.4	5.5	36.1	70.6	0.9	0.3	13.8	2.8	3.8	5.0	12.3
600	19.8	30.2	6.4	43.4	46.9	1.3	0.3	6.8	2.9	4.9	4.1	5.5
woods	9.0	13.4	1.9	20.6	42.3	0.7	9.3	20.0	0.6	2.3	14.1	16.8
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Grand Total	20.0	46.9	6.2	36.3	56.8	1.2	1.4	11.7	3.3	3.9	6.8	**9.9**

PITS

Row Labels	Average of All Ground Beetles	Average of Ants	Average of All Beetles (minus GBs)	Average of Slug	Average of All Spiders	Average of Harpalus rufipes	Average of Ground Beetle	Average of Wolf Spider
0	16.0	0.7	3.9	5.1	8.7	3.8	7.5	5.6
300	24.4	0.8	5.3	5.2	8.1	10.6	6.4	4.8
600	15.7	0.3	5.1	7.2	10.1	2.7	5.2	7.5
woods	13.0	6.4	3.3	1.9	1.9	4.4	7.4	0.4
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Grand Total	17.8	1.5	4.5	5.3	7.9	5.5	6.7	5.1

Row Labels	Average of All Ground Beetles	Average of Ants	Average of All Beetles (minus GBs)	Average of Slug	Average of All Spiders	Average of Harpalus rufipes	Average of Ground Beetle	Average of Wolf Spider
2016	29.0	1.3	2.0	0.1	5.3	11.3	17.6	3.1
2017	28.2	0.2	4.5	0.0	6.0	6.6	10.1	1.2
2018	8.6	0.7	8.5	0.4	9.1	2.4	0.3	5.9
2019	9.8	2.7	4.0	14.4	10.0	2.8	1.1	8.3
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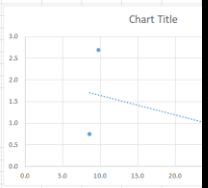
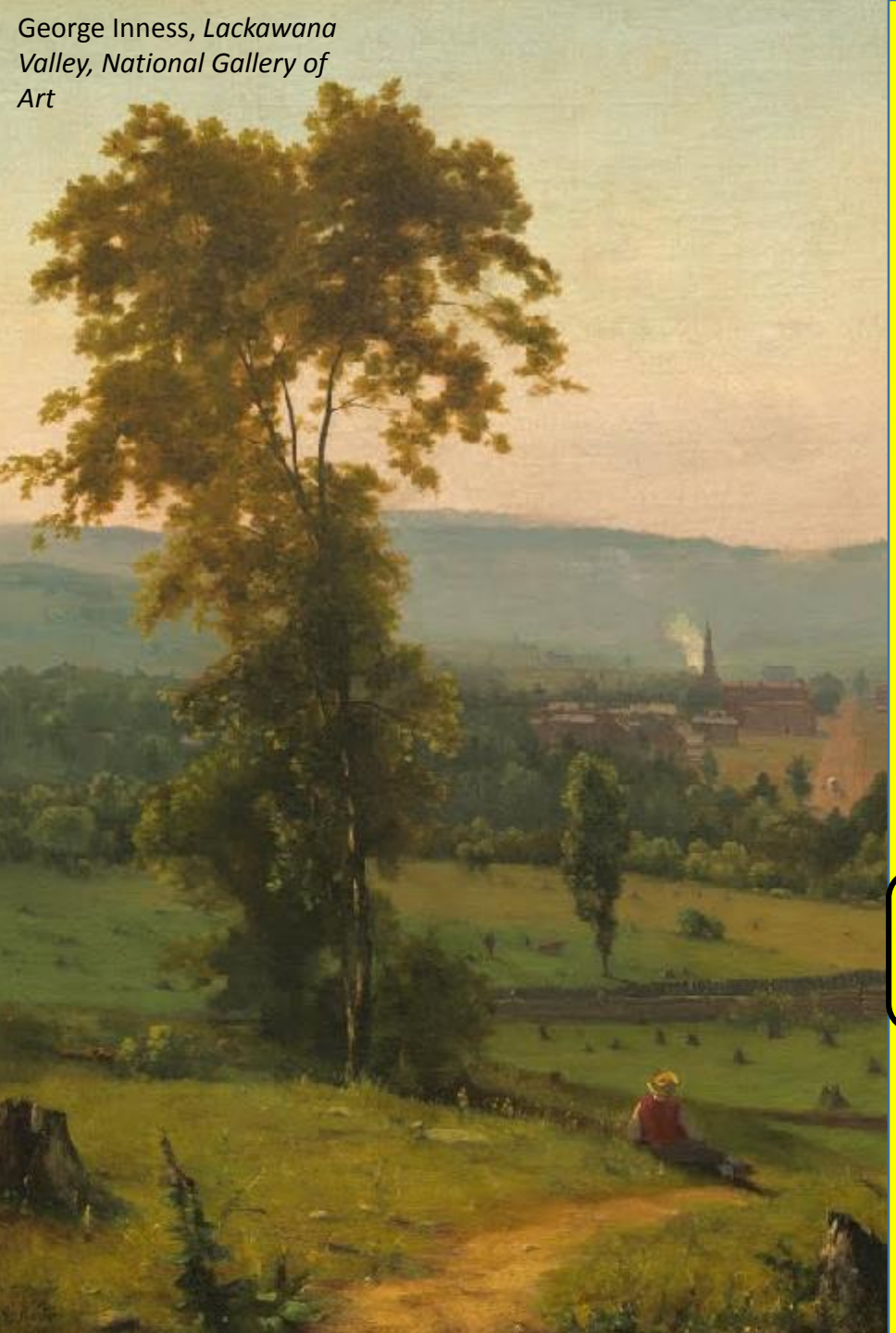
Grand Total	17.8	1.5	4.5	5.3	7.9	5.5	6.7	5.1



Tables can tell you a lot too, especially if the print is really small!



George Inness, *Lackawana Valley, National Gallery of Art*

This Talk in 5 ½ Questions.

In relationship to on-farm habitat management, what are our goals?

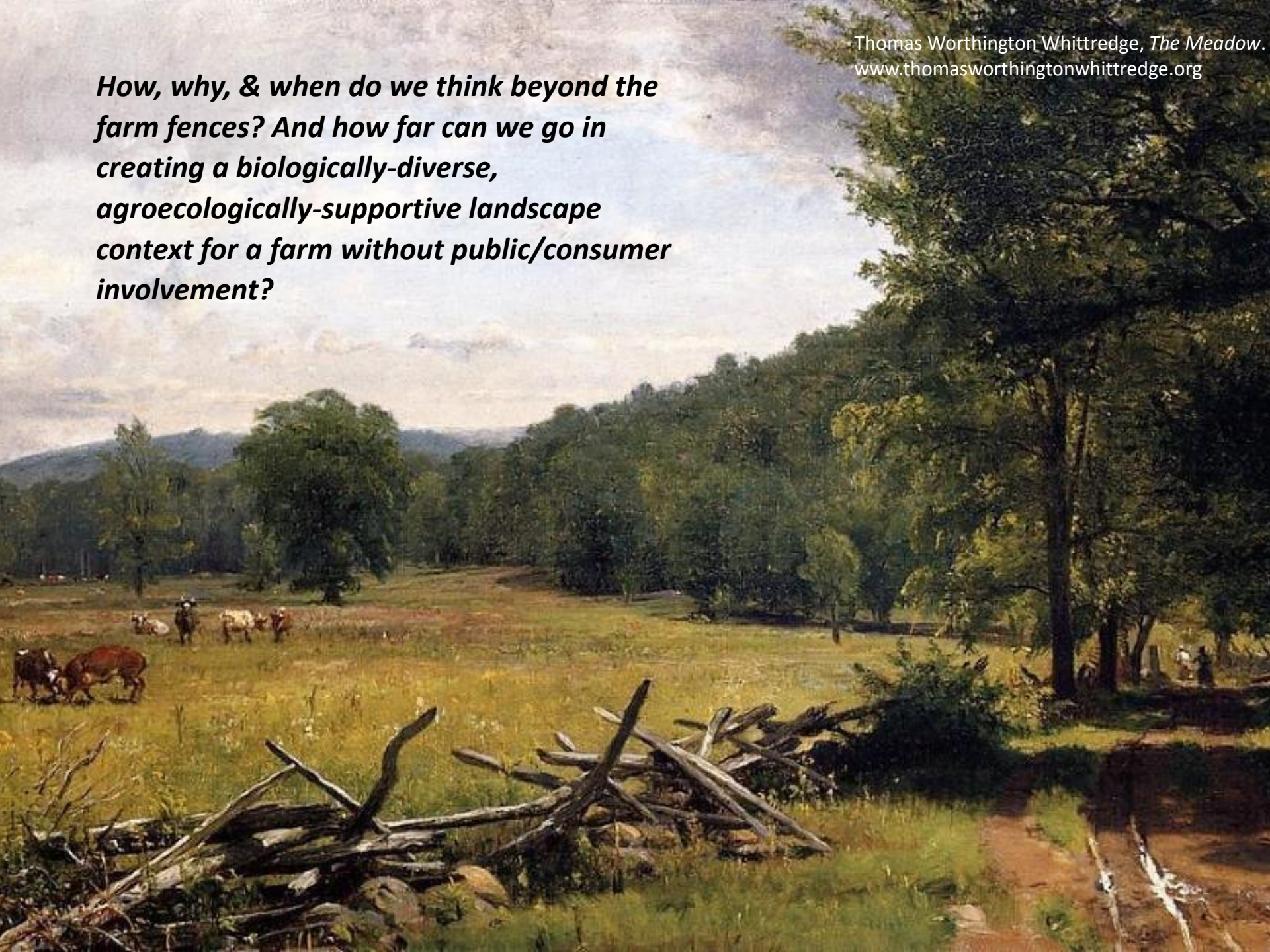
Broadly speaking, what are our tools both in terms of habitat creation/conservation and in terms of 'support structures'?

How do we know if we accomplish our goals - what do we need to know in order to evaluate the effectiveness of our habitat?

How do farmers and ecologists best communicate? What does each have to learn about the other?

How, why, & when should we think beyond the farm fences? What is the role for public/consumer involvement?

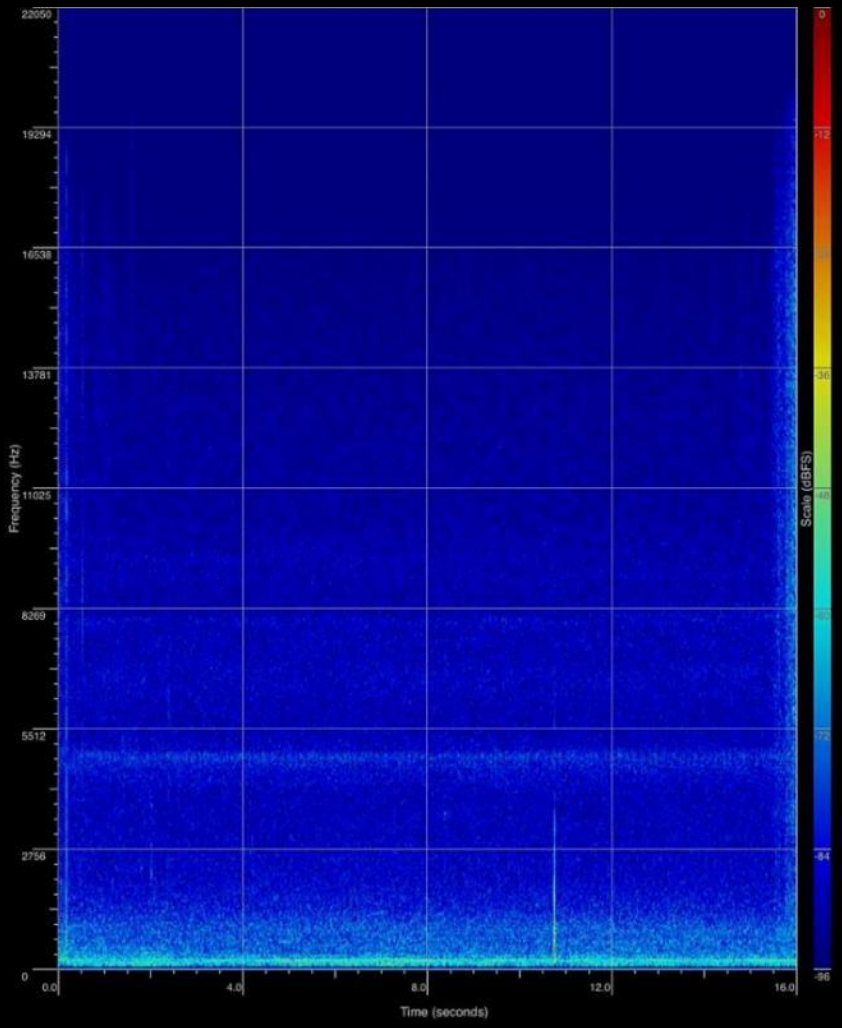
(Are the terms "pest" and "beneficial" stereotypes? How do perceptions of 'good' and 'bad' differ with farming system and what you measure?)



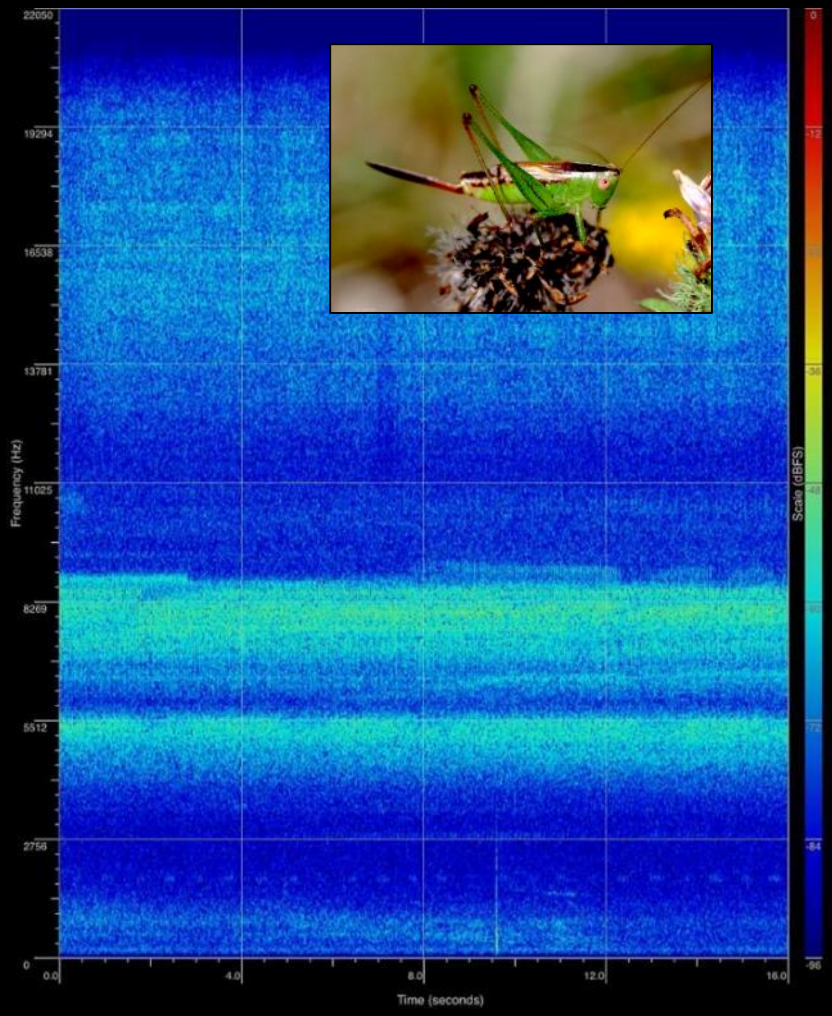
How, why, & when do we think beyond the farm fences? And how far can we go in creating a biologically-diverse, agroecologically-supportive landscape context for a farm without public/consumer involvement?

The results of biological control after millions of years of co-evolution… don't expect complete pest control to come naturally.

Achieving expectations will come, in part, through changing expectations.



Conventional Orchard

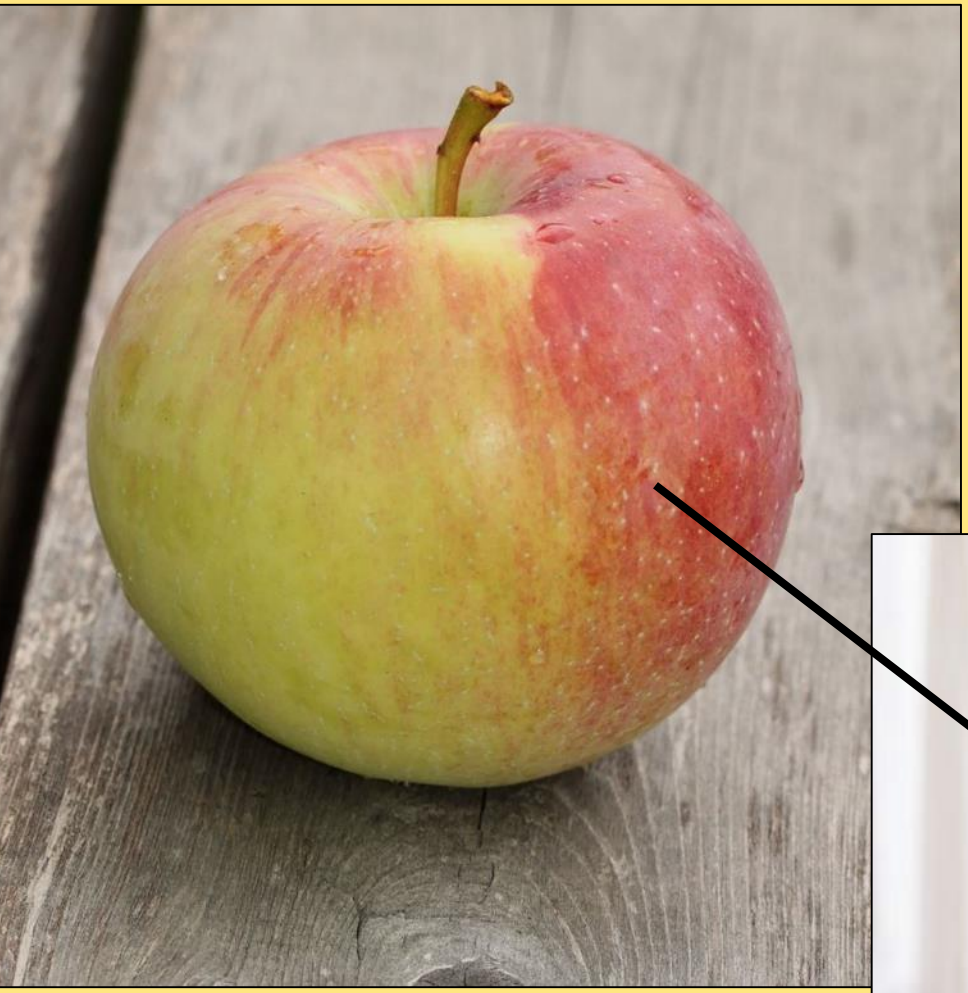


Organic Orchard

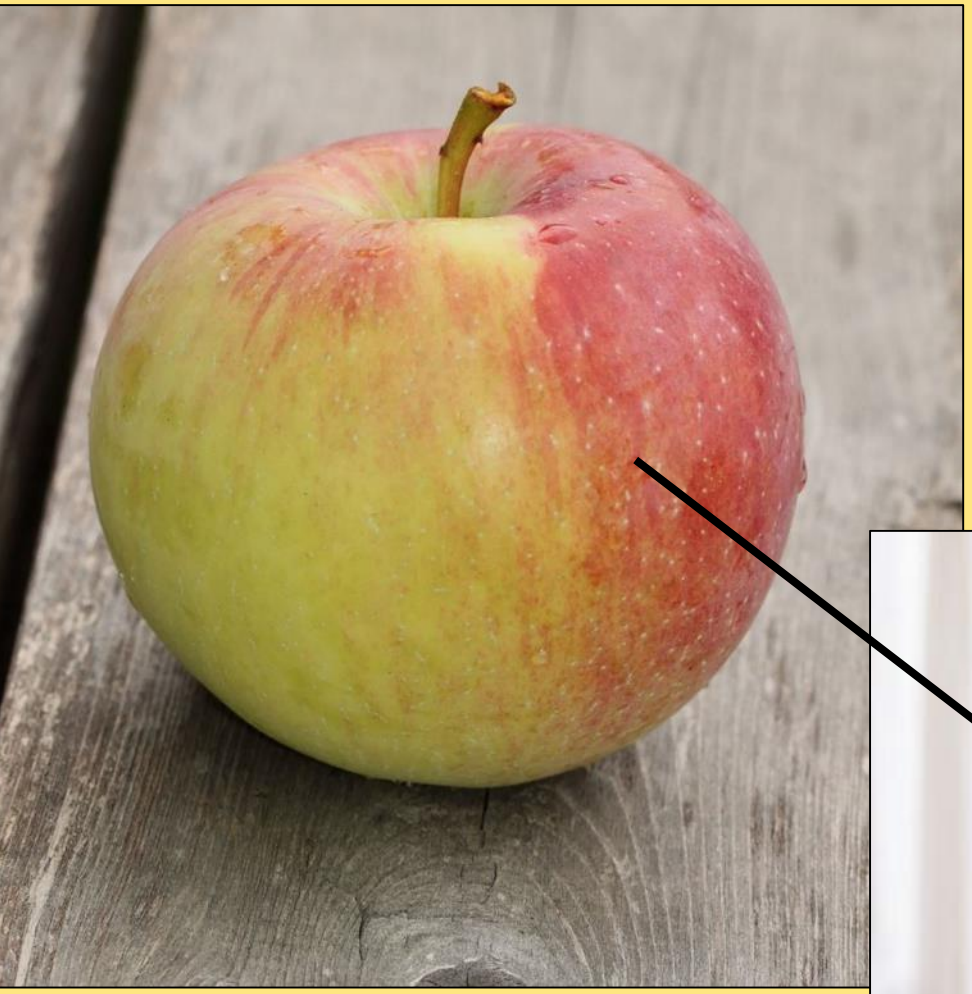
Conventional Orchard

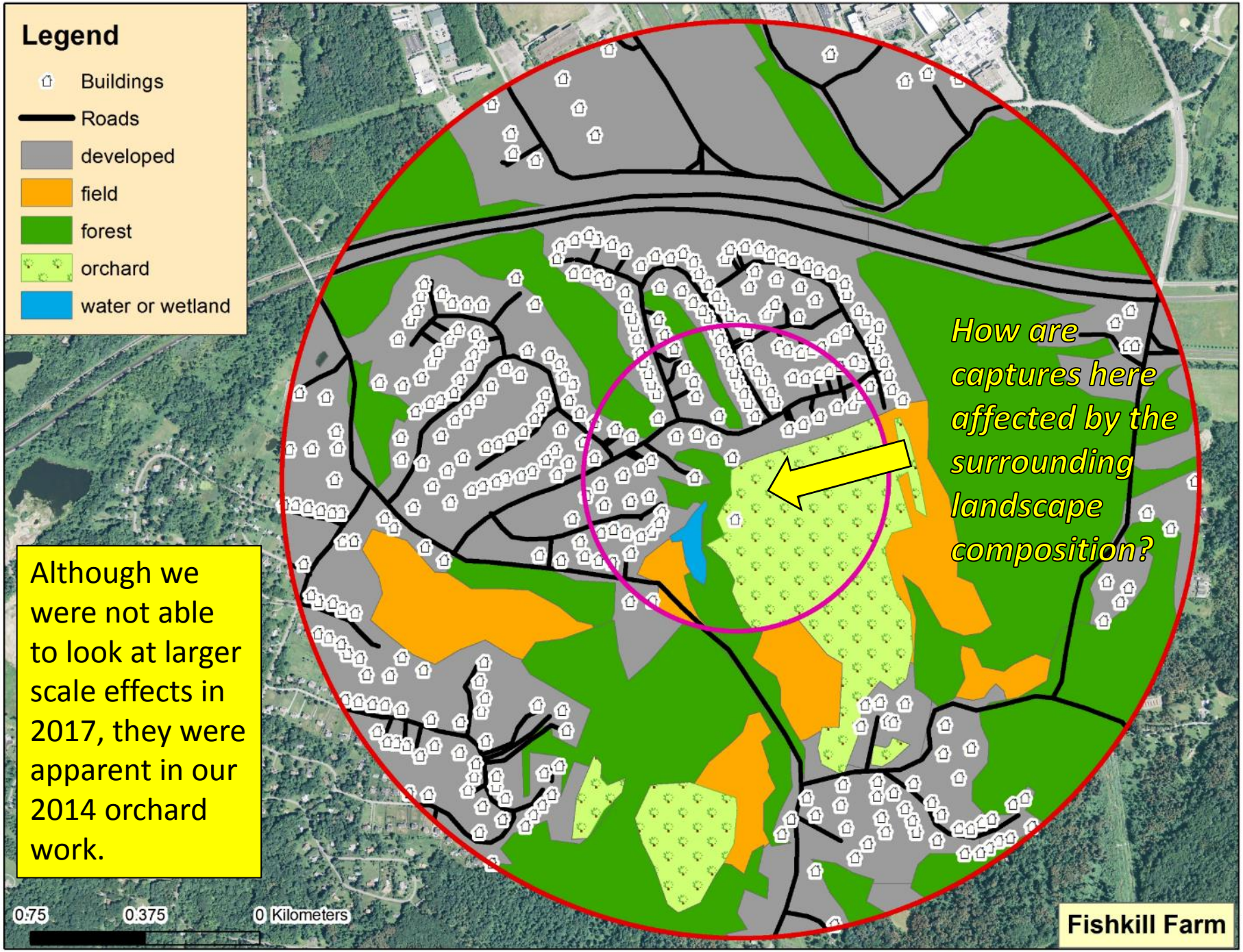
Organic Orchard

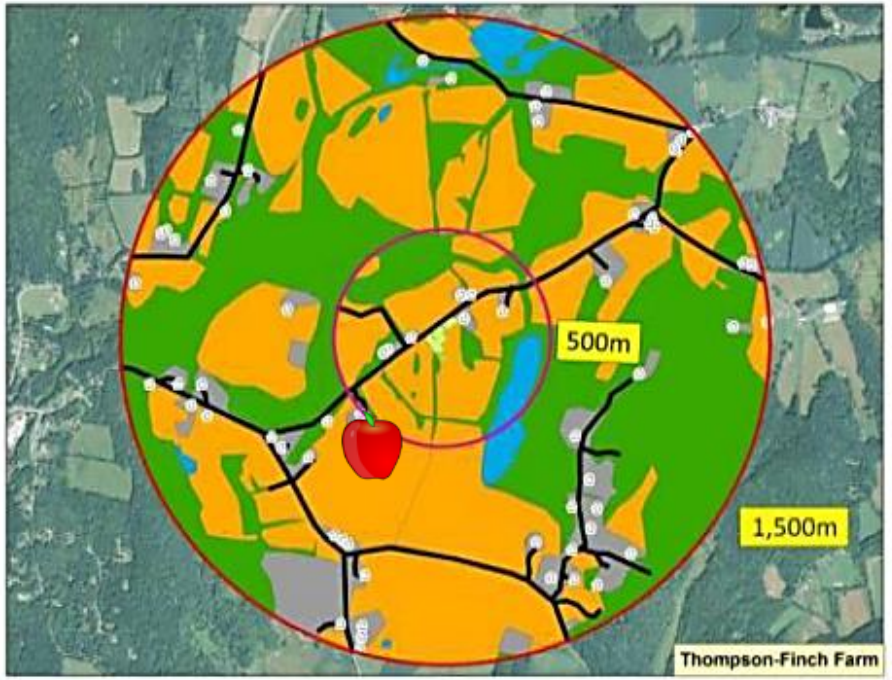
Apple “looks” vs. insect diversity

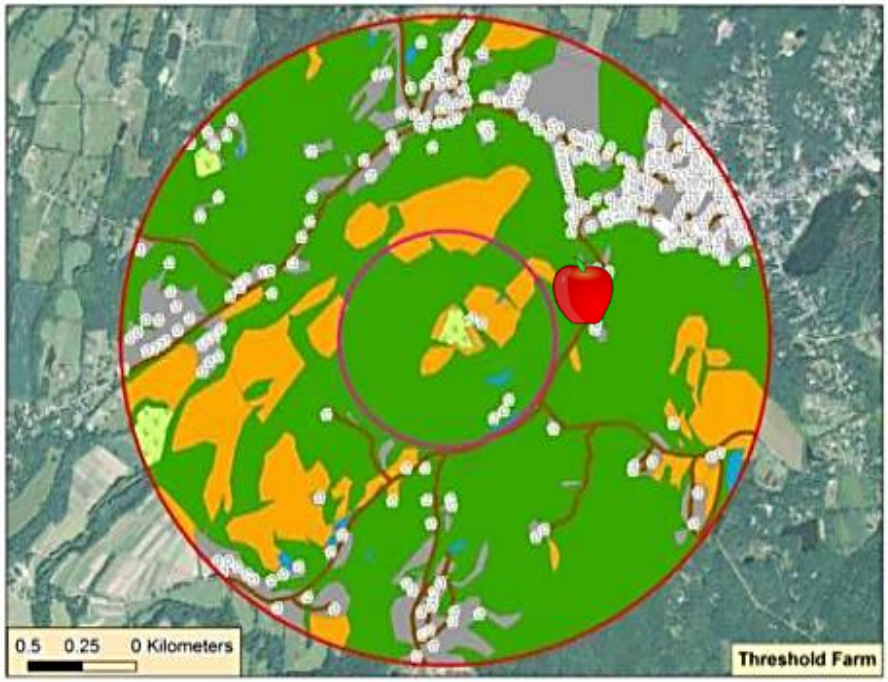


Apple “looks” vs. insect diversity




Legend
Buildings
Roads
developed
field
forest
orchard
water or wetland
How are captures here affected by the surrounding landscape composition?
Although we were not able to look at larger scale effects in 2017, they were apparent in our 2014 orchard work.
0.75
0.375
0 Kilometers
Fishkill Farm





How did the land use ***around*** an orchard affect the beneficials found ***in*** the orchard?

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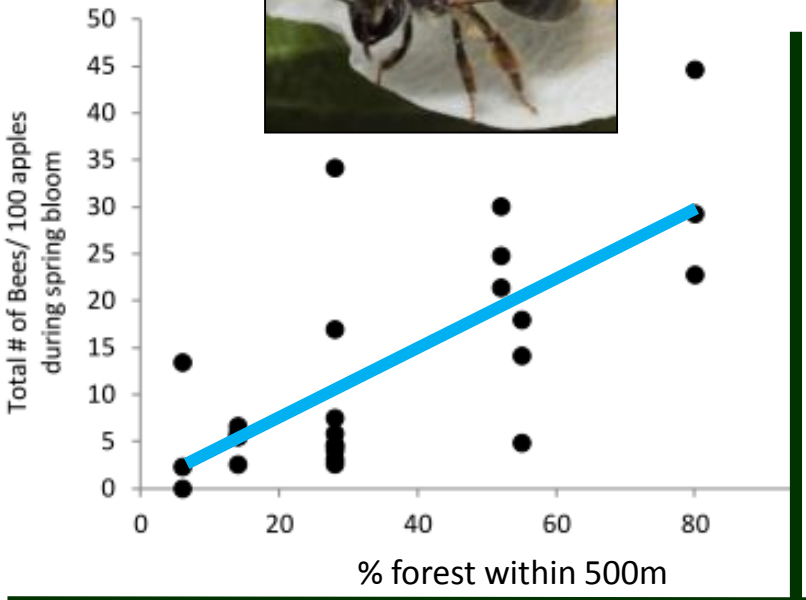

Total # of Bees/ 100 apples during spring bloom
0
5
10
15
20
25
30
35
40
45
50
0
20
40
60
80
% forest within 500m

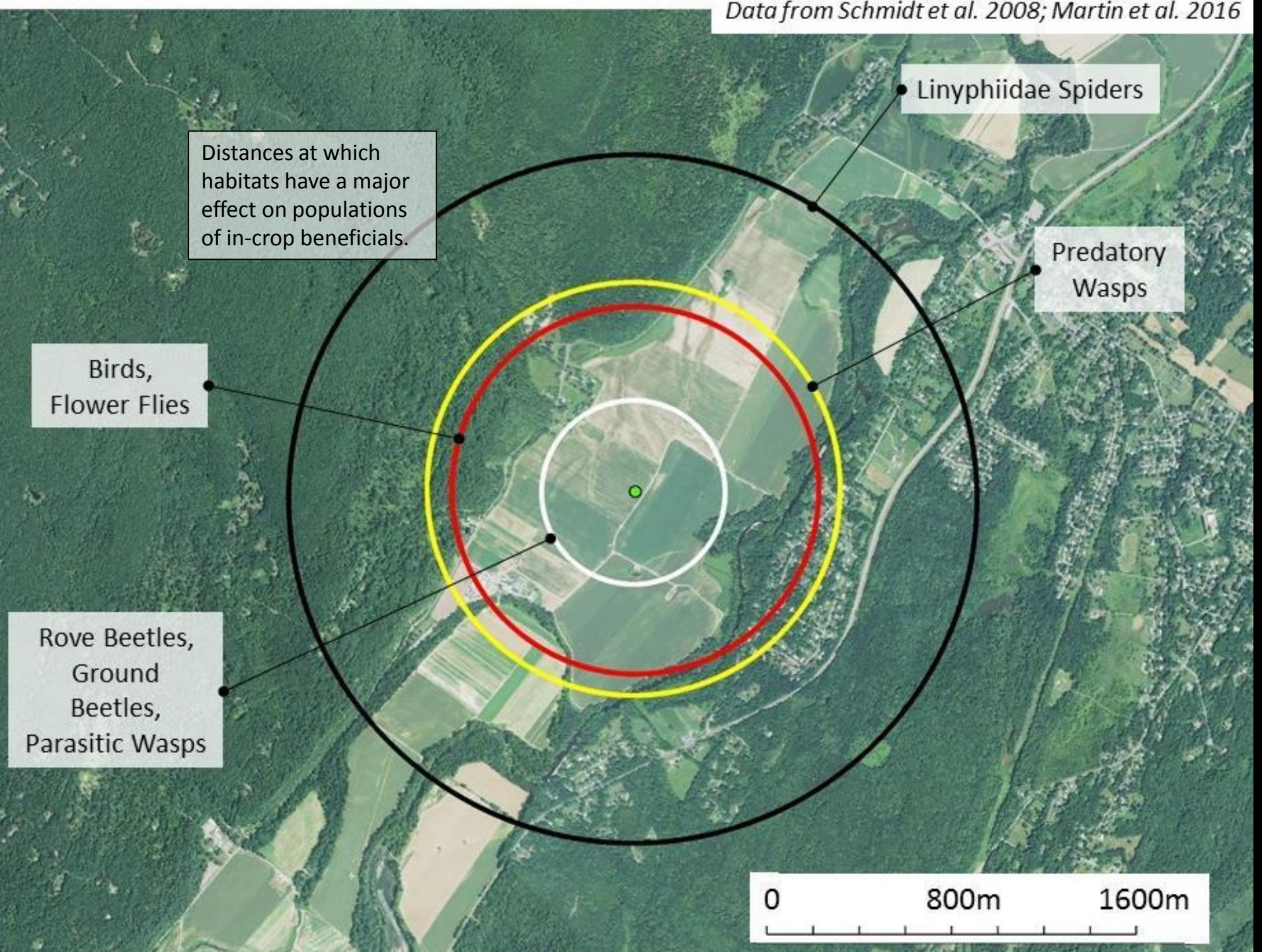
Average Ranked Wasps Abundance Across the Season
0
1
2
3
4
5
6
0
10
20
30
40
50
60
% forest within 1,500m

Average Rnaked Spider Abundance
1
2
3
4
5
6
0
20
40
60
80
% forest within 500m

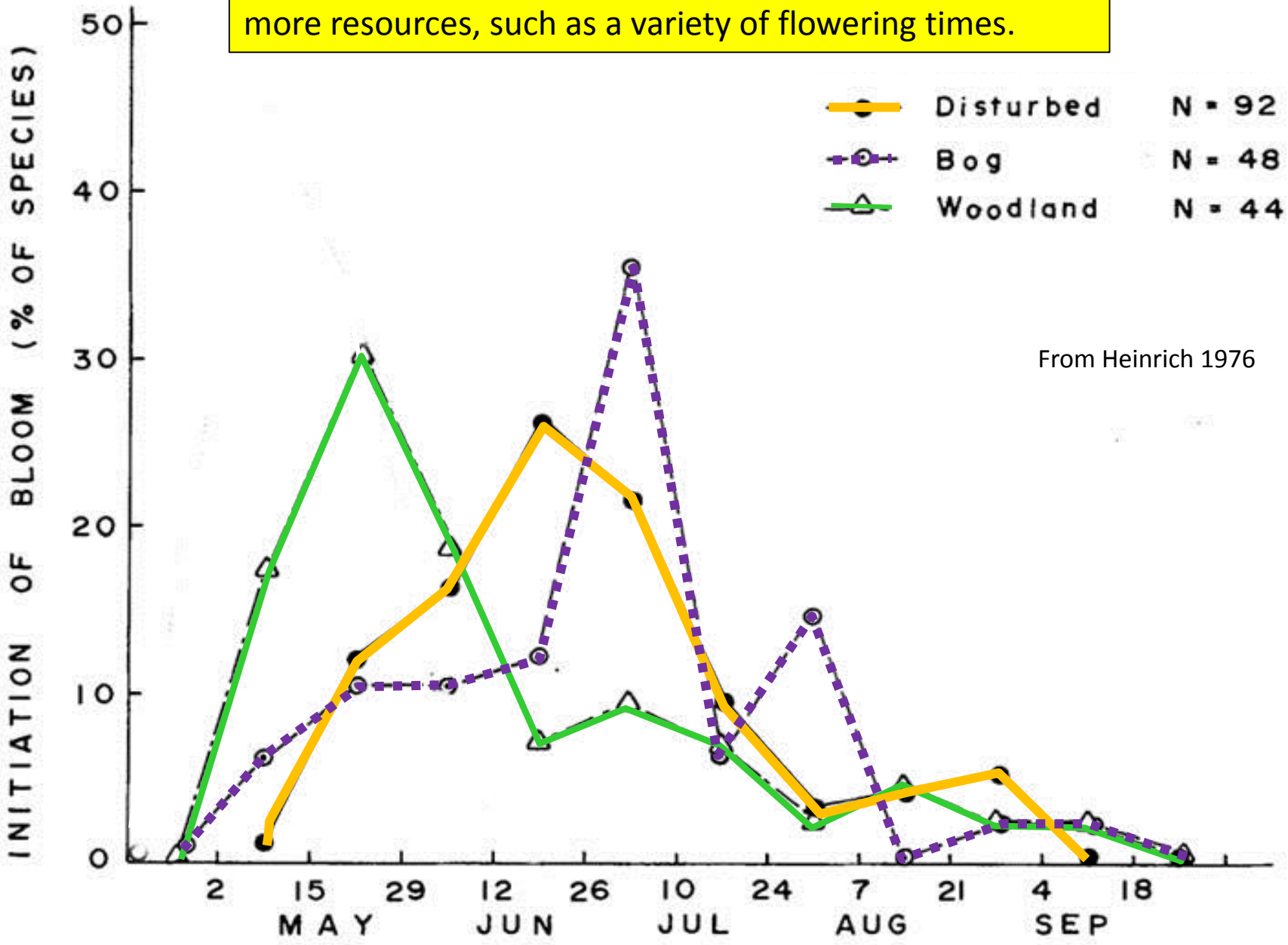
Average Ranked Butterfly Abundance Across the Season
1
2
3
4
5
6
7
0
10
20
30
40
kms of road within 1,500m

Correlations between in-orchard invertebrate abundances and surrounding land use characteristics.

		All Flies	Hover Flies	Native Bees	Wasps	Moths	Butterflies	Spiders
At 125m	Wildflower	POS		POS	POS			POS
At 500m	Roads			NEG				
	Buildings			NEG				
	Forest			POS				POS
	Orchard			NEG	NEG	NEG		NEG
	Field							
	Developed			NEG		NEG		
	Water	NEG						
At 1500m	Roads				NEG		NEG	
	Buildings						NEG	
	Forest	POS	POS		POS			
	Orchard			NEG	NEG	NEG		
	Field							
	Developed							
	Water	NEG						


Data from Schmidt et al. 2008; Martin et al. 2016
Linyphiidae Spiders
Distances at which habitats have a major effect on populations of in-crop beneficials.
Predatory Wasps
Birds, Flower Flies
Rove Beetles, Ground Beetles, Parasitic Wasps
0
800m
1600m

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



From Heinrich 1976


What is the socio-economic system within which these farms are operating?

A New England Food Vision

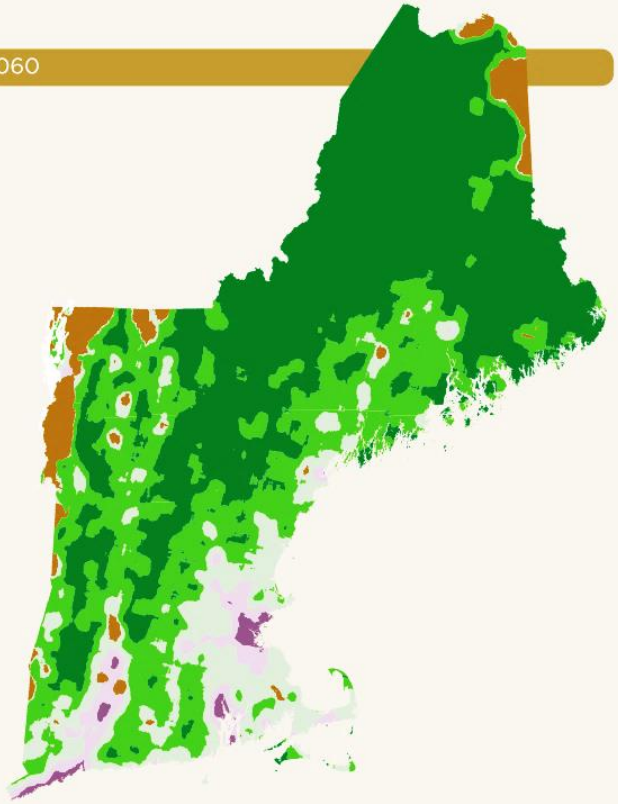
Healthy Food for All
Sustainable Farming and Fishing
Thriving Communities

Brian Donahue, Joanne Burke, Molly Anderson, Amanda Beal, Tom Kelly, Mark Lapping, Hannah Ramer, Russell Libby, Linda Berlin

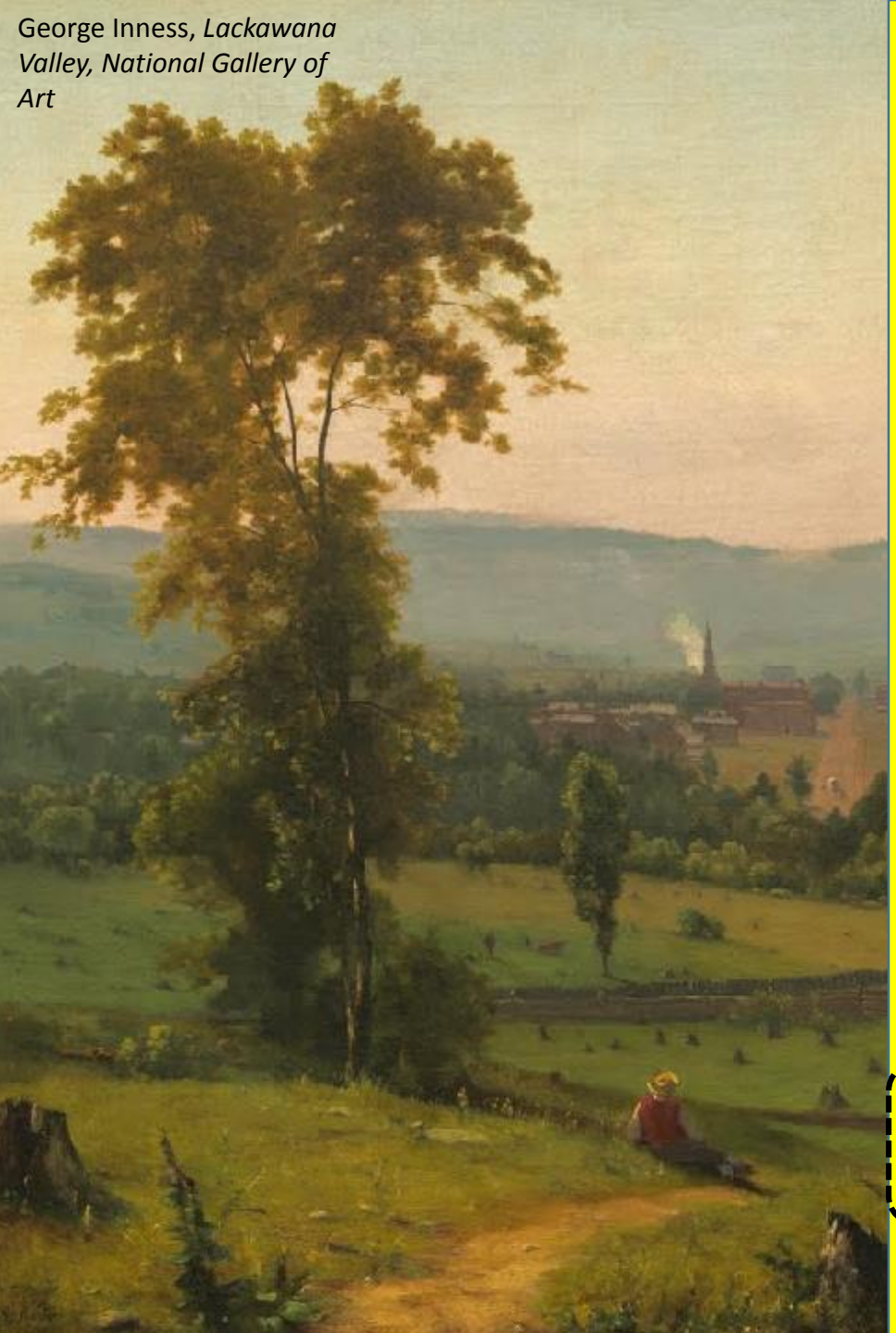
Fulfilling the vision of this map would mean a tripling of New England farmland.

Figure 7. New England Farmland 2060

Farmland, developed land, and forest are found in a range of mixtures across the landscape. The landscape types and percentages shown here are broad estimates, but taken together they reflect over 70% of the land in forest, some increase in "smart" development, and 6 million acres of farmland. Several hundred thousand acres of intensively cultivated land can be found in small pieces within cities and suburbs. In semirural areas there is room for more fruit and livestock production as well. The woods and pasture part of the landscape, along with places within the heavily forested area, provide scope for several million acres of dairy and beef production. Parts of New England that have remained devoted to agriculture, such as Aroostook County, the Champlain Valley, and the Connecticut Valley, become even more highly cultivated.



LANDSCAPE TYPE	ACRES FARMLAND	PERCENT FARMLAND	PERCENT DEVELOPED	PERCENT FOREST
Urban	20,000	5	85	10
Suburban	210,000	15	60	25
Semi-rural	1,300,000	25	25	50
Highly Cultivated	1,170,000	60	10	30
Woods & Pastures	2,120,000	17	8	75
Forest	1,240,000	6	4	90
TOTAL	**6,050,000**	**15**	**11**	**74**



George Inness, *Lackawana Valley, National Gallery of Art*

This Talk in 5 ½ Questions.

In relationship to on-farm habitat management, what are our goals?

Broadly speaking, what are our tools both in terms of habitat creation/conservation and in terms of 'support structures'?

How do we know if we accomplish our goals - what do we need to know in order to evaluate the effectiveness of our habitat?

How do farmers and ecologists best communicate? What does each have to learn about the other?

How, why, & when should we think beyond the farm fences? What is the role for public/consumer involvement?

(Are the terms "pest" and "beneficial" stereotypes? How do perceptions of 'good' and 'bad' differ with farming system and what you measure?)

Are the terms "pest" and "beneficial" stereotypes? How do perceptions of 'good' and 'bad' differ with farming system and what you measure?)

Jan van Kessel, *A Dragon-fly, Two Moths, a Spider and Some Beetles, With Wild Strawberries*.

Something to think about:
How do you get certified as a bona fide 'beneficial'?

NEW YORK STATE

David J. Swarts
Commissioner of Insects

Jumpin' Joe

ENHANCED

BENEFICIAL LICENSE

ID: 012 345 678 **CLASS D**

DOCUMENT
SAMPLE, LICENSE
2345 ANYPLACE AVE
ANYTOWN NY 12345

DOB: 06-09-85

SEX: **M** EYES: **BR** HT: **1cm**
E: NONE
R: NONE
ISSUED: **09-30-08** **EXPIRES: 10-01-16**

ORGAN DONOR

8AJ120T521

After two generations of conventional management which was advised by standard soil nutrient tests, this farm had excellent ***chemical*** scores on the Cornell soil health test.

chemical	Soil pH	**6.5**	**100**
chemical	Extractable Phosphorus	**11.0**	**100**
chemical	Extractable Potassium	**122.4**	**100**
chemical	Minor Elements Mg: 74.1 / Fe: 1.7 / Mn: 7.6 / Zn: 1.2		**100**

Measured Soil Textural Class: **sandy loam**

Sand: **66%** - Silt: **28%** - Clay: **5%**

Comprehensive Assessment of Soil Health

From the Cornell Soil Health Laboratory, Department of Soil and Crop Sciences, School of Integrative Plant Science, Cornell University, Ithaca, NY 14853. http://soilhealth.cals.cornell.edu

Group	Indicator	Value	Rating	Constraints
physical	Available Water Capacity	0.20	83	
physical	Surface Hardness	252	15	Rooting, Water Transmission
physical	Subsurface Hardness	495	3	Subsurface Pan/Deep Compaction, Deep Rooting, Water and Nutrient Access
physical	Aggregate Stability	4.3	6	Aeration, Infiltration, Root… Sealing, Erosion, Runoff
biological	Organic Matter	0.9	7	Nutrient and Energy Storag… C Sequestration, Water Re…
biological	ACE Soil Protein Index	2.9	10	Organic Matter Quality, Or… N Mineralization
biological	Root Pathogen Pressure	3.5	84	
biological	Soil Respiration	0.3	19	Soil Microbial Abundance and Activity
biological	Active Carbon	152	6	Energy Source for Soil Biota
chemical	Soil pH	6.5	100	
chemical	Extractable Phosphorus	11.0	100	
chemical	Extractable Potassium	122.4	100	
chemical	Minor Elements Mg: 74.1 / Fe: 1.7 / Mn: 7.6 / Zn: 1.2		100	

But you get what you test for – many of the remaining soil life and structure measurements were less positive.

Overall Quality Score: **49** / Medium

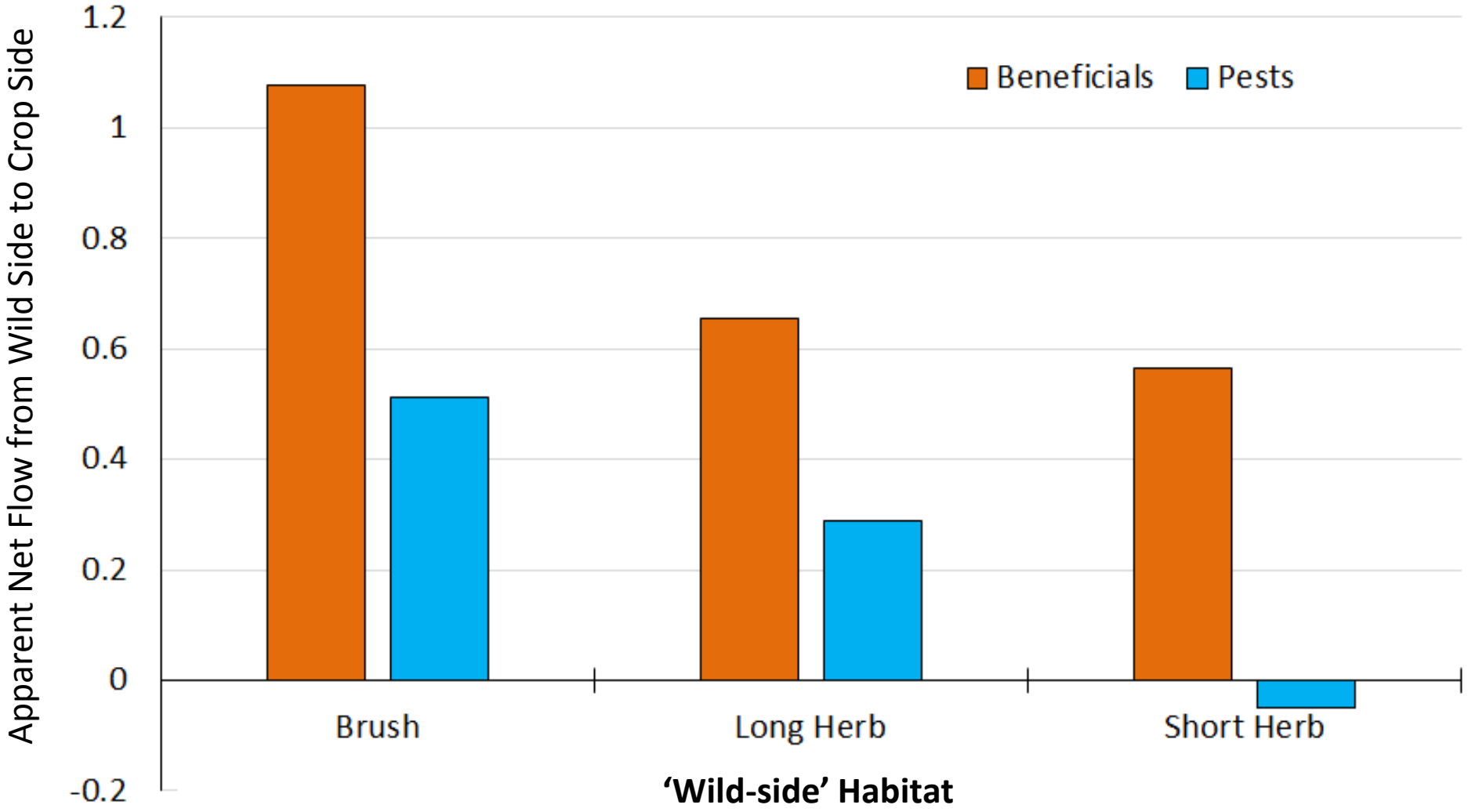
In conventional/IPM orchards, leaf damage was greatest at the edge; in organic orchards, leaf damage was highest farther in.

Dates: 29 May -16 June

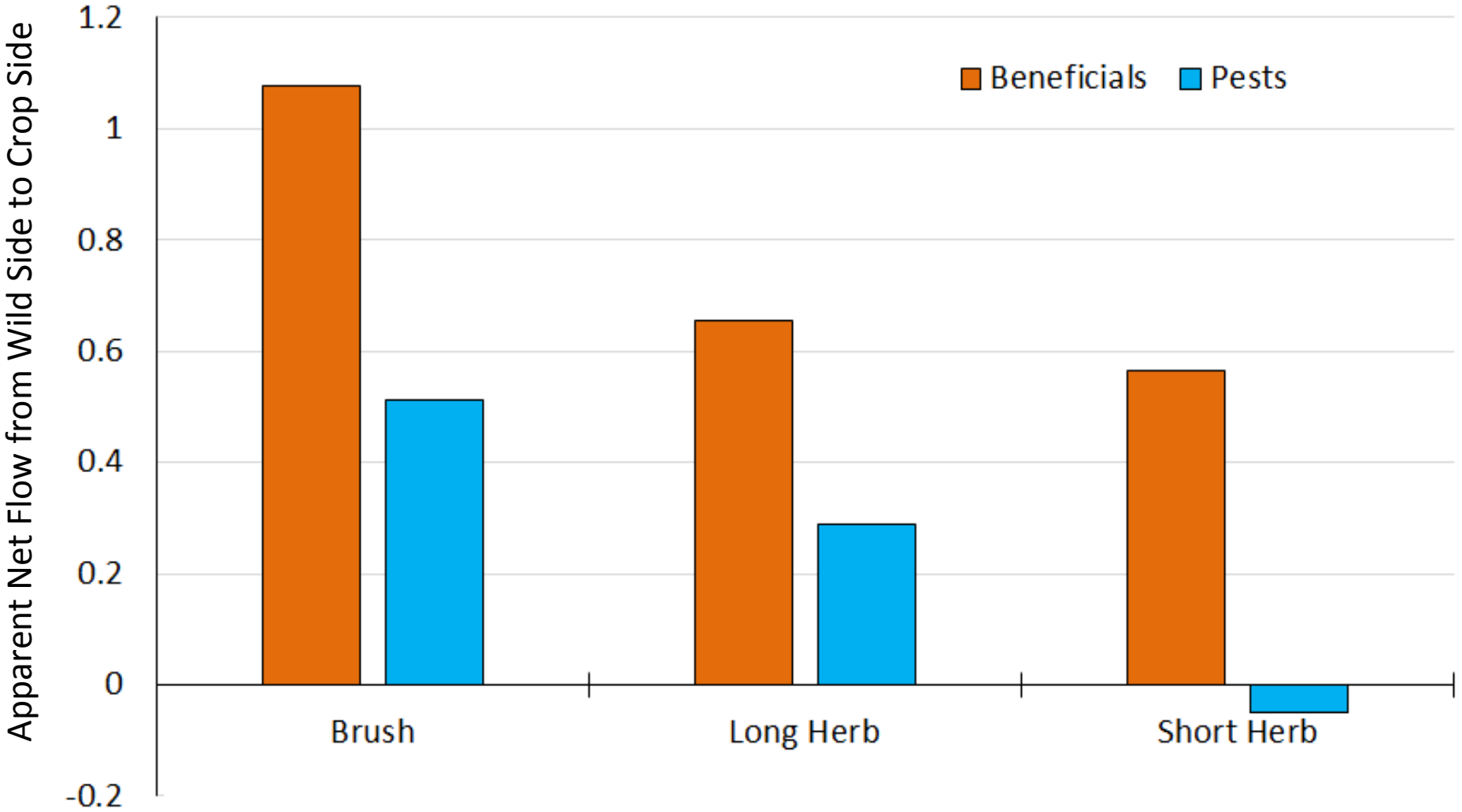
distance from edge tree	Conventional (1136 leaves, 181 aphids) =IPM			Organic (2747 leaves, 601 aphids)	
	% leaf area damaged	*aphids/100 leaves*		*% leaf area damaged*	*aphids/100 leaves*
0 ft	6.9%	28.7		7.8%	15.0
75 ft	2.5%	10.9		6.4%	17.5
150 ft	3.6%	4.9		8.0%	28.4


CROPS
“WILDS”

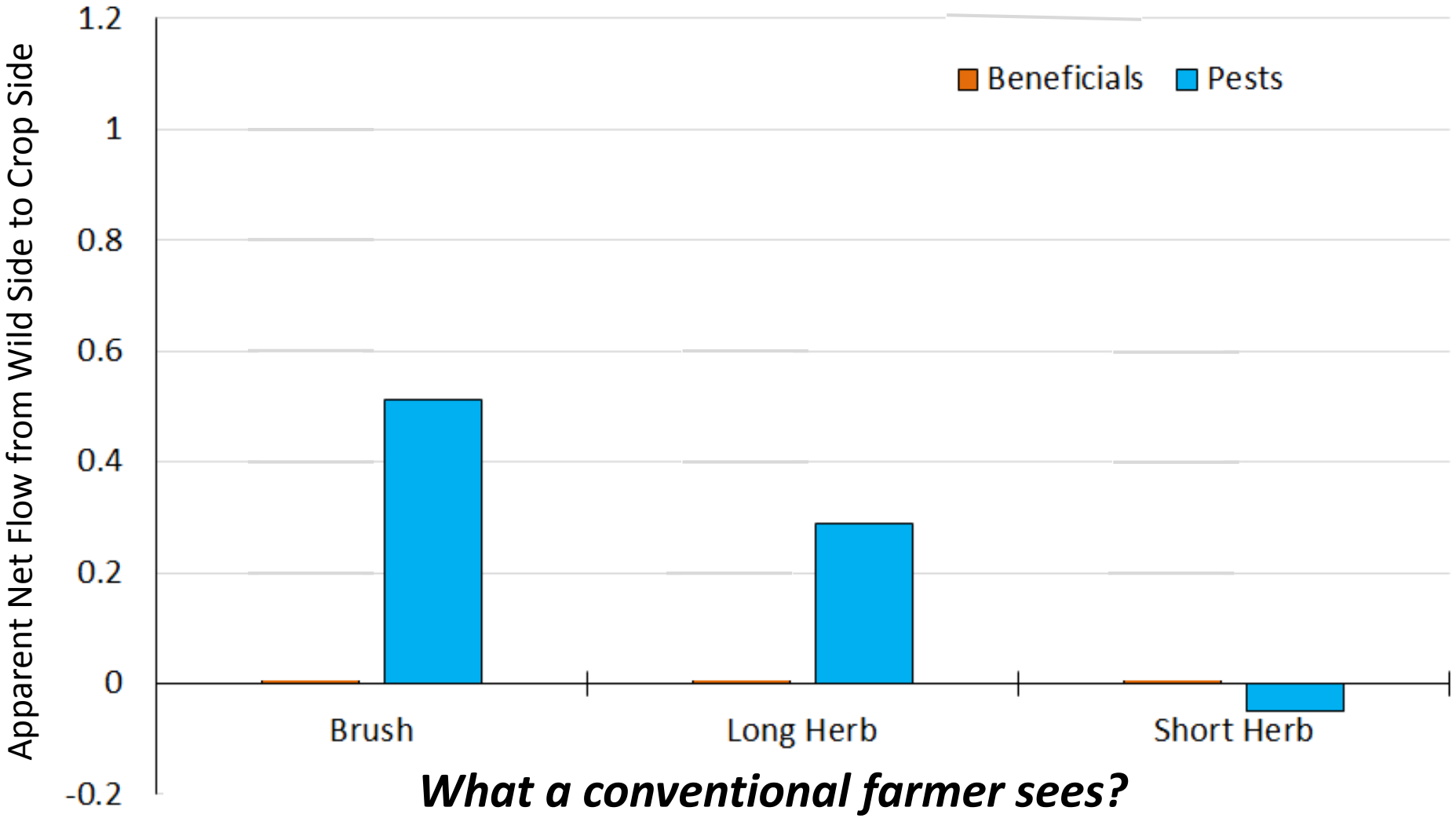
(The more positive the value, the more wild-side captures exceeded crop-side ones. ‘0’ means that wild-side captures = crop-side)



(The more positive the value, the more wild-side captures exceeded crop-side ones.)

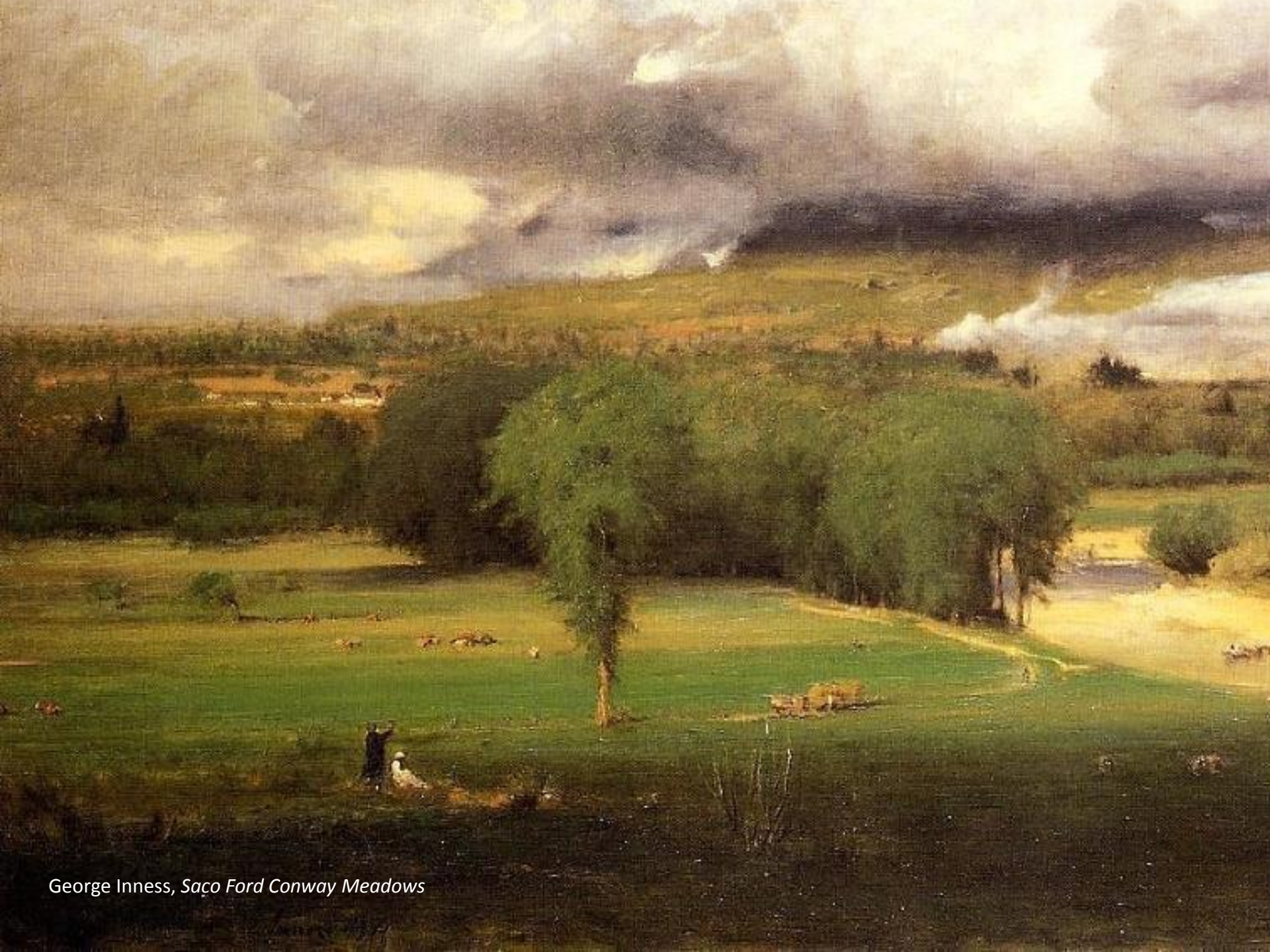


What an ecological farmer sees?



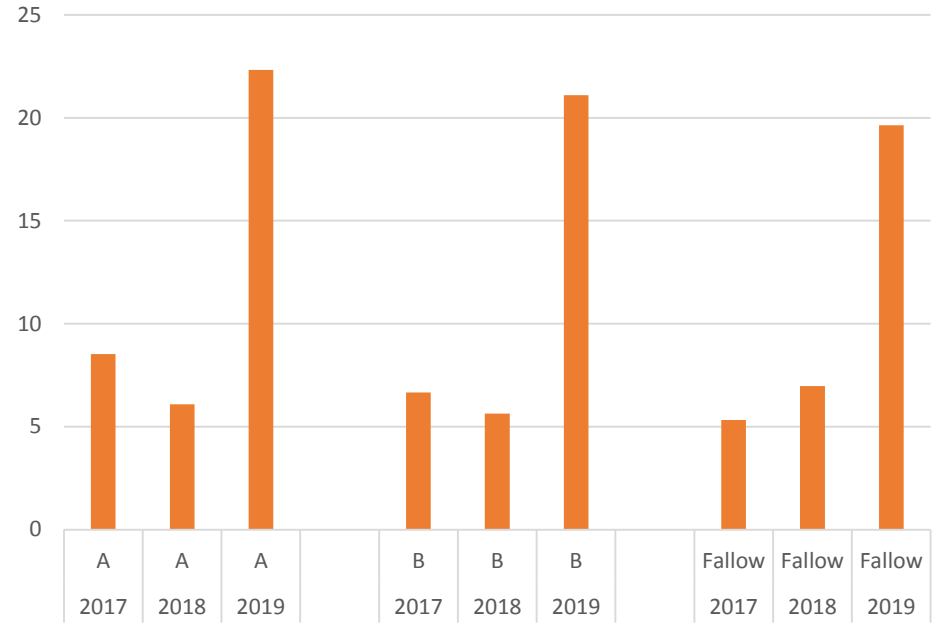
What a conventional farmer sees?

George Inness, *Winter Evening*

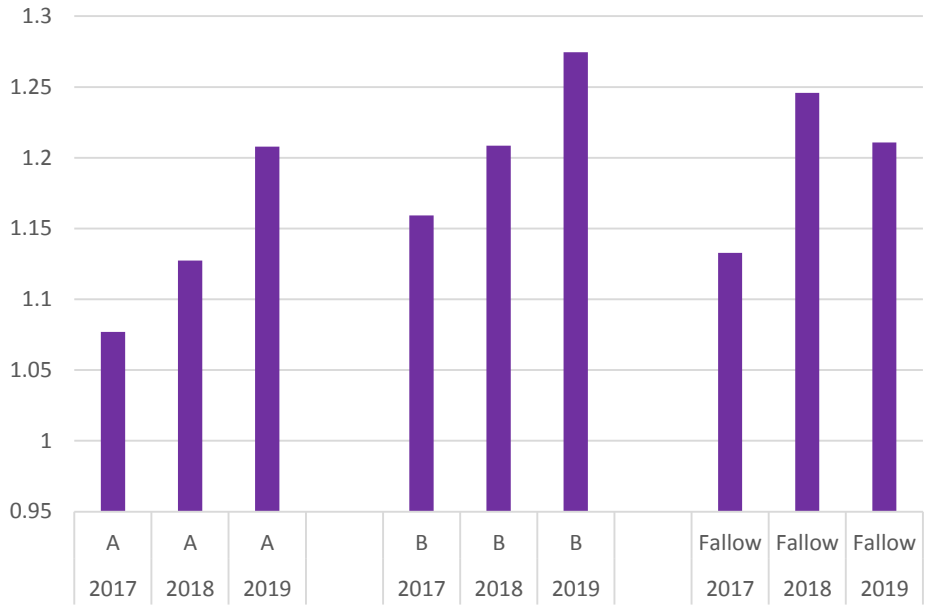


George Inness, *Saco Ford Conway Meadows*

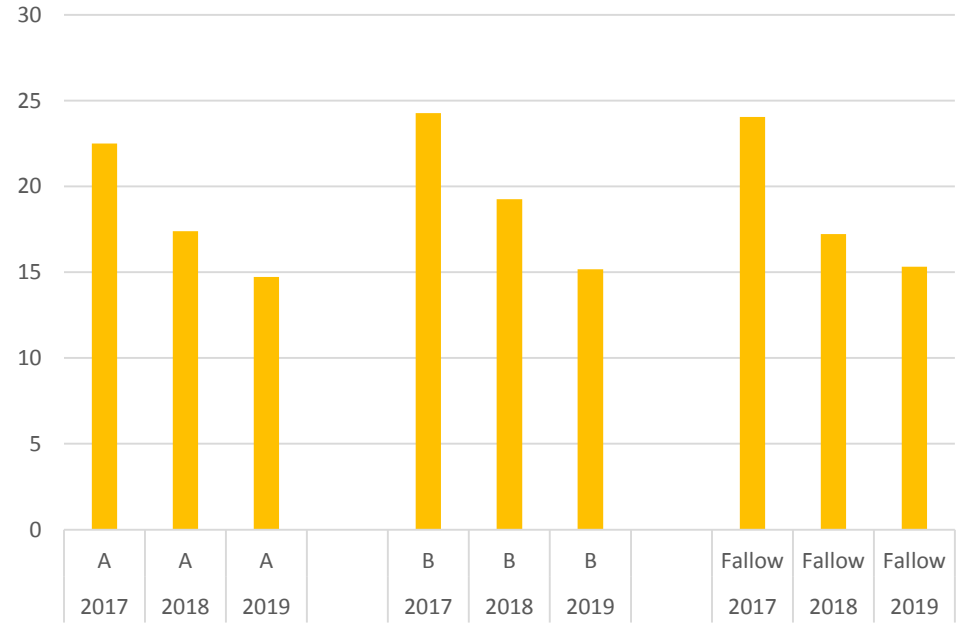
Aggregate Stability



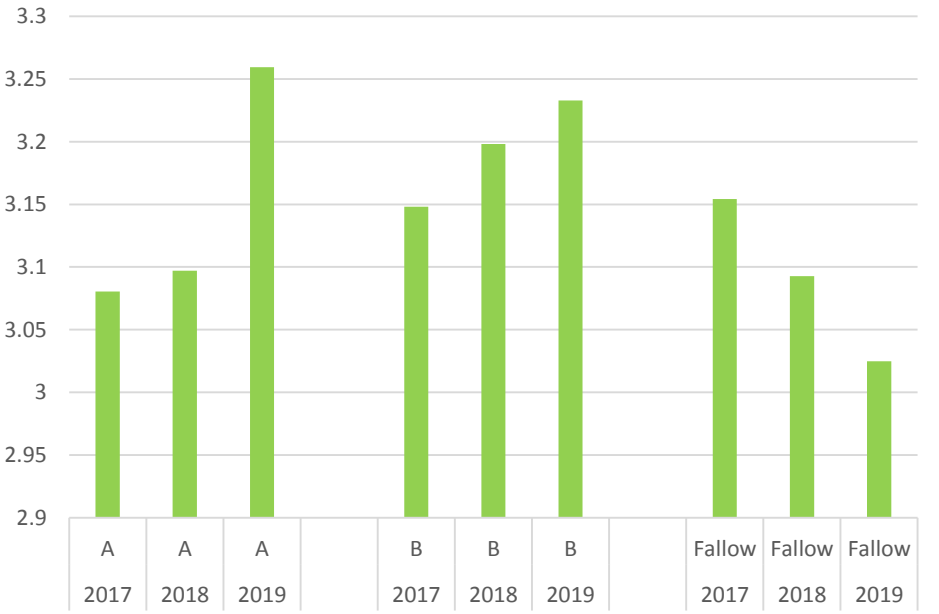
Organic Matter

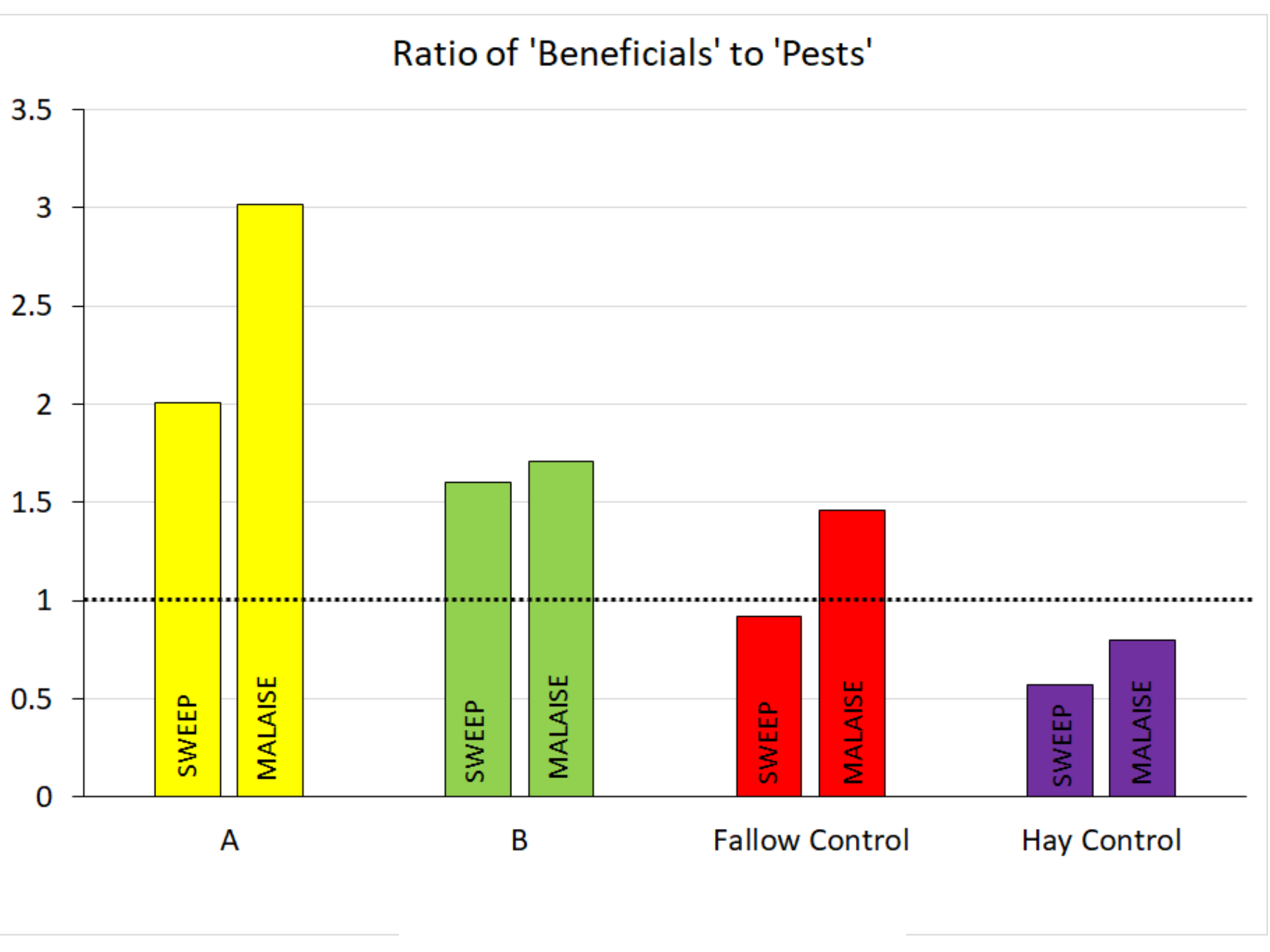


Phosphorus



Ace Soil Protein Index




Ratio of 'Beneficials' to 'Pests'
3.5
3
2.5
2
1.5
1
0.5
0
SWEEP
MALAISE
SWEEP
MALAISE
SWEEP
MALAISE
SWEEP
MALAISE
A
B
Fallow Control
Hay Control