Flowers, Banks & Transects, Oh My!:

A Report on Above-ground Entomological Studies Conducted by the Hawthorne Valley Farmscape Ecology Program at the Hudson Valley Farm Hub.

Written by Conrad Vispo, relying on the crucial fieldwork and data gathering of Claudia Knab-Vispo, Kendrick Fowler, Kyle Bradford, Dylan Cipkowski and a string of volunteers and interns (my thanks to all of them!).

Introduction

This year's report sacrifices depth for breadth. It provides an updated overview of the three main above-ground entomology projects we have been conducting: the continued monitoring of the Native Meadow Trials, our on-going standardized transect work, and the first full year of monitoring of the Beetle Bank. The preparation of more detailed manuscripts is underway, and so this report provides just a brief summary of the main results.

Methods

Our methods are described in earlier reports and readers are referred to those documents for details (see https://hvfarmscape.org/agroecology for downloads).

Entomological Aspects of the Native Meadow Trials (NMTs)

As the botanical report details, the NMTs are not static entities. Instead, their floras are undergoing continuous change. Given the dearth of long-term data on native meadow seedings, this is interesting in and of itself. The obvious question (at least to us!) becomes, 'is that change also reflected in above-ground invertebrate communities?'. The answer appears to be "sometimes".

Since 2017: Native Meadow Trial; three 1.5 acre trial areas, each with .5 acres of seeded native wild flowers, of seeded native grasses and of fallow.

Map showing location of the Native Meadow Test Plots at the Hudson Valley Farm Hub, Hurley NY.

Fig. 1 repeats an image from Claudia's work and illustrates one of the botanical changes that is potentially important to the invertebrates – the change in flower abundance. As can be seen, flower abundance in the wild flower planting has declined steeply since the first few years after seeding. What has this meant for the insects?

Figures 2 and 3 illustrate the corresponding evolution of two of the taxa we have been studying, bees and hover flies. Malaise and sweep trapping results are presented separately because they may be sampling slightly different components of the fauna. Our earlier work (detailed in previous reports) had shown that bees and hover flies were significantly more common in wild flower seeded plots than in either of the controls or in the grass seeding. Presumably, this was because these creatures are flower visitors who were taking advantage of the abundance of floral resources in the wild flower treatment. Although Figs. 2 and 3 do not exactly duplicate each other, it seems apparent that, in keeping with the decline in floral resources, bee numbers have declined since earlier peaks. Malaise captures of hover flies show a similar pattern; sweep netting results for hover flies are less clear. Our preliminary data thus suggest that the temporal changes in the botanical community are being reflected in components of the invertebrate community.
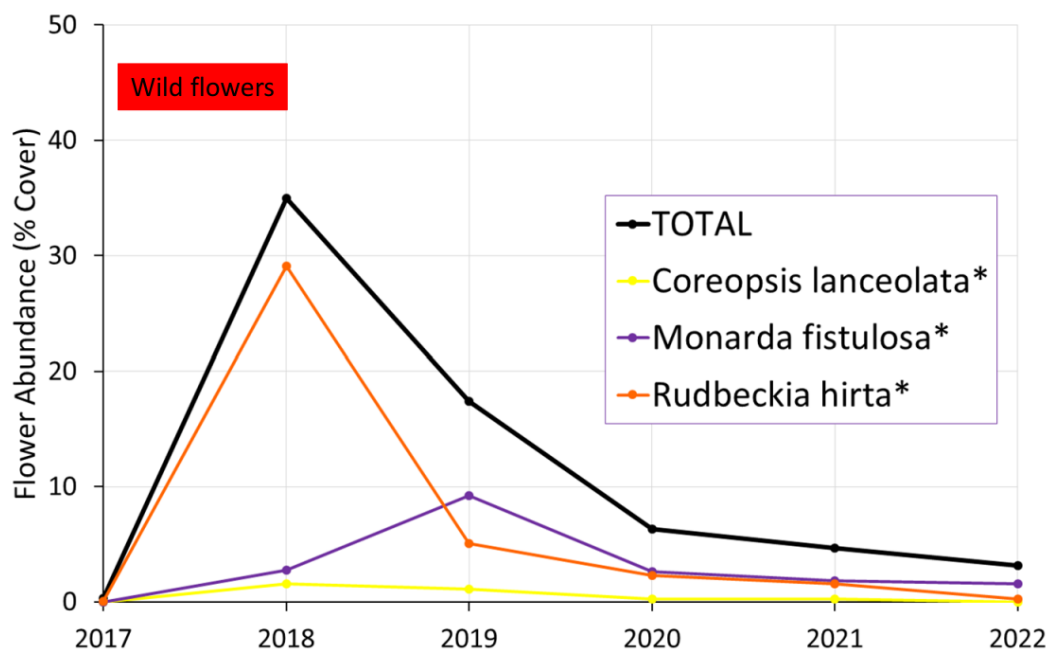

Figure 1. Flower abundance in the plots seeded with native wild flowers. For more details on these and other changes, see the botany report.
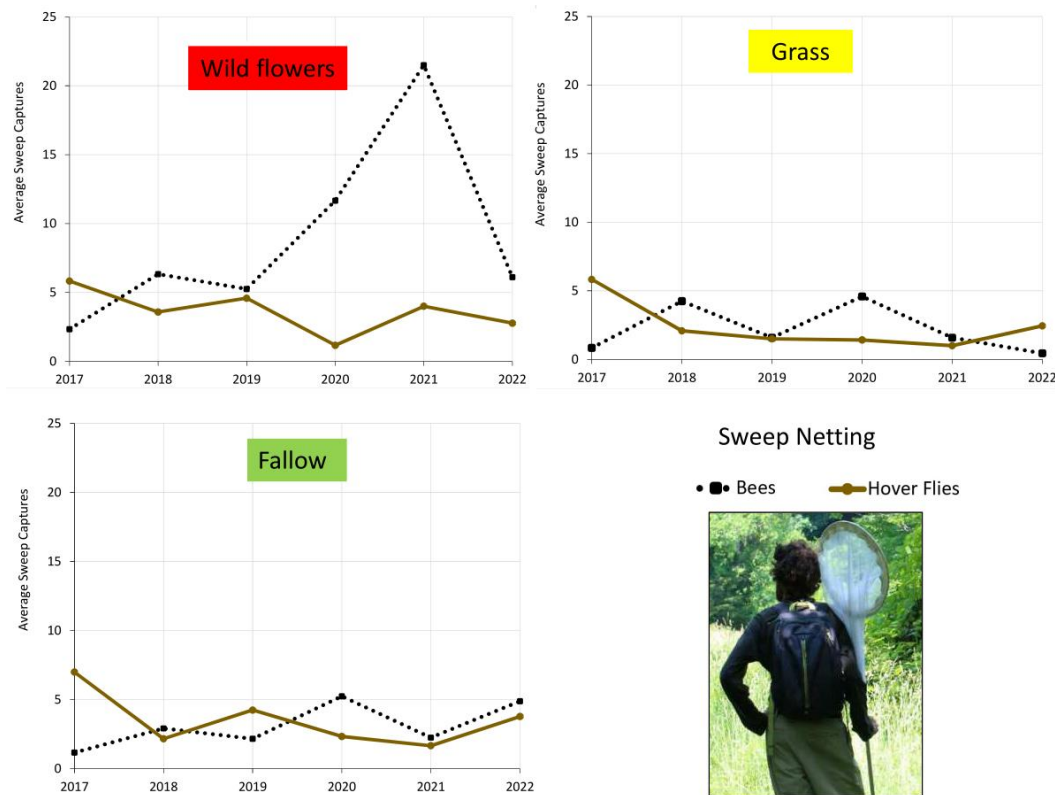
Figure 2. Sweep sample results for bees and hover flies across the three NMT treatments. Note the apparent recent decline of bees in the wild flower treatment.
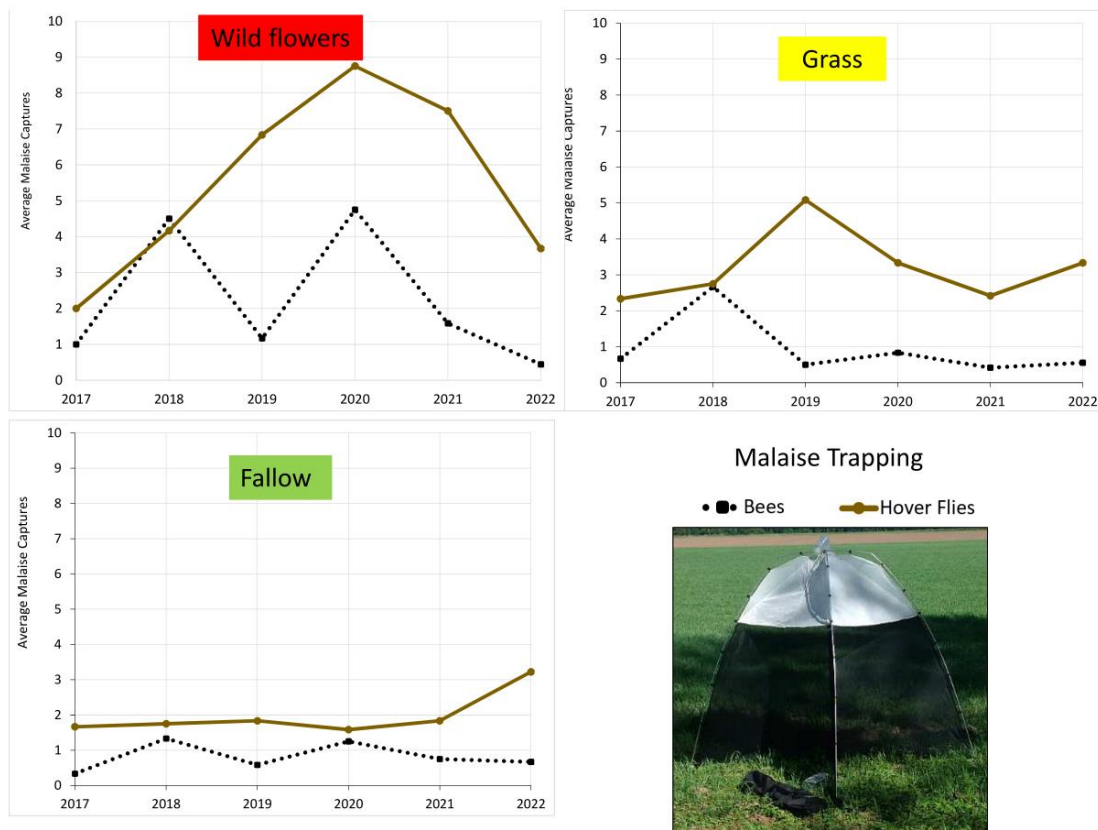

Figure 3.NMT Malaise trap results across the years. Note the recent declines in bee and hover fly numbers in the wild flower seeding.
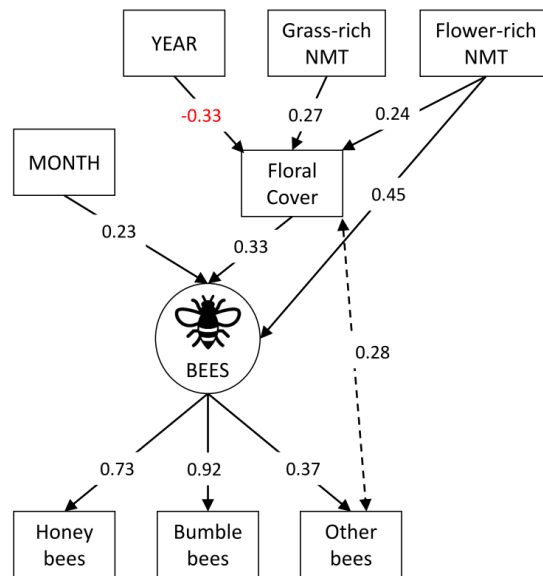
Figure 4. A diagram representing the results of a structural equation model. Red numbers indicate negative interactions and relative strength of the intercations is indicated by the number appearing along the arrows. This model suggests that, while floral cover is positively associated with bee abundance, other factors such as month and other aspects of treatment might also be relevant. Thanks to Megan Garfinkel for the diagram and modelling

Piecewise structural equation modelling (a statistical technique that identifies important in interactions within a system) was used to tease apart some details of this pattern. It (Fig. 4) suggested that bee numbers were affected not only by floral cover but also, independently by month and some additional, as-yet-unidentified aspect of treatment.

The patterns seen with bees and ground beetles were not repeated in all taxa. Our earlier work has shown relatively little treatment effect on the populations of ants and ground beetles. Indeed, similar patterns of ground beetle decline and ant increase have repeated themselves across our treatments (Fig. 5), suggesting that a factor other than treatment is driving these changes. It is likely that this general pattern is due to opposite reactions to the lack plowing/tillage that occurred after 2017. With their nest-based social system, ants seem to be less tolerant of regular plowing than are the field-adapted ground beetles. Whether the field ground beetles are actually disadvantaged by the lack of plowing *per se* or whether they are outcompeted by other, rising taxa is not completely clear. However, piecewise structural equation modeling (Fig. 6) suggested that, at least in so far as ants and ground beetles are considered, there is little direct interaction but rather that, as already suggested, the prime determinant of their evolving numbers is their inverse reactions to the lack of soil disturbance.
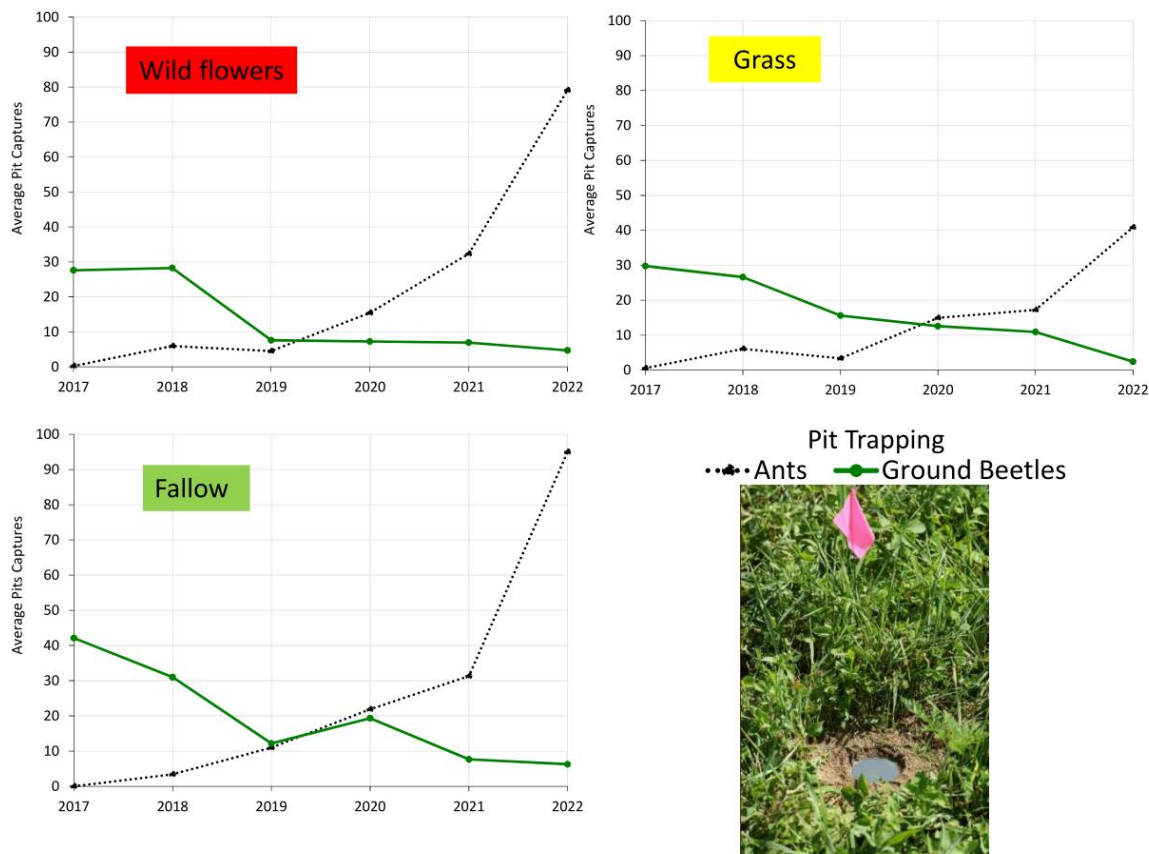
Figure 5. Changes in the pit trap catch of ants and ground beetles across years and among treatments. Note that ground beetles declined and ants increased in all three treatments.
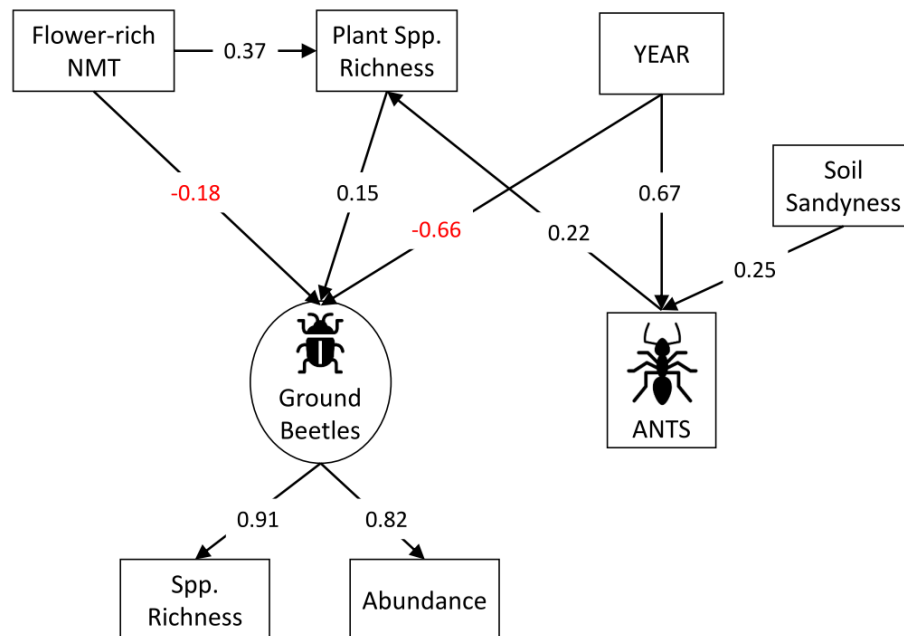

Figure 6. A diagram representing the results of piecewise structural equation modelling, conventions as in Fig. 4. The lack of a direct interaction term between ants and ground beetles suggests that these taxa are responding to a common external factor rather than strongly interacting with each other. Thanks to Megan Garfinkel for the diagram and modelling
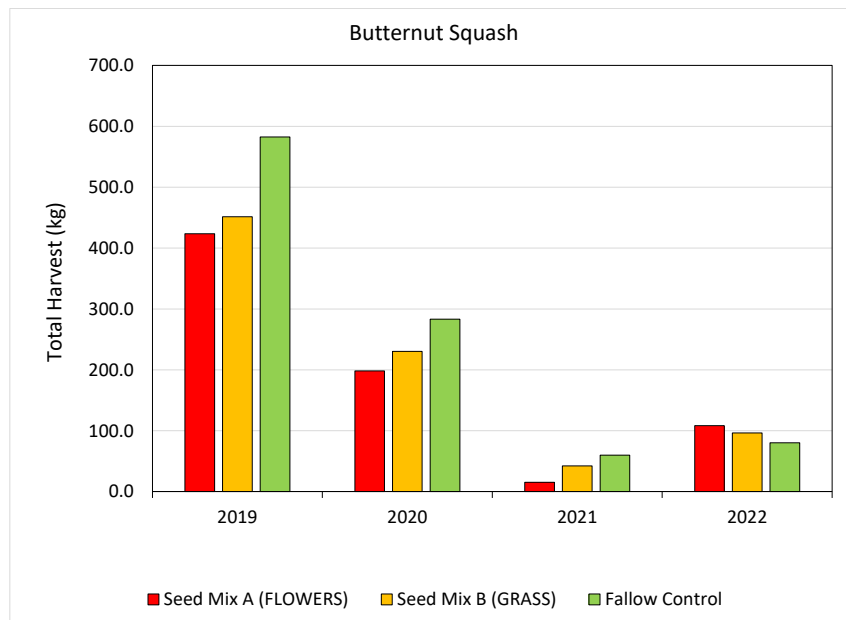
Figure 7. Total butternut squash harvest in veggie plots adjacent to the three NMT treatments indicated. 2022 results reversed the pattern of the first three years.

Grow Outs

We attempted to repeat our butternut squash and sweet corn grow outs this year. The sweet corn was too heavily damaged by deer and bear to permit the gathering of harvest data. Squash were harvested and showed higher production than last year (Fig. 7). For the first time in our four years of data collection, harvest by the Wild Flower treatment averaged higher than the harvest next to grass and fallow treatments. However, the variability of our results makes the drawing of any conclusions difficult.
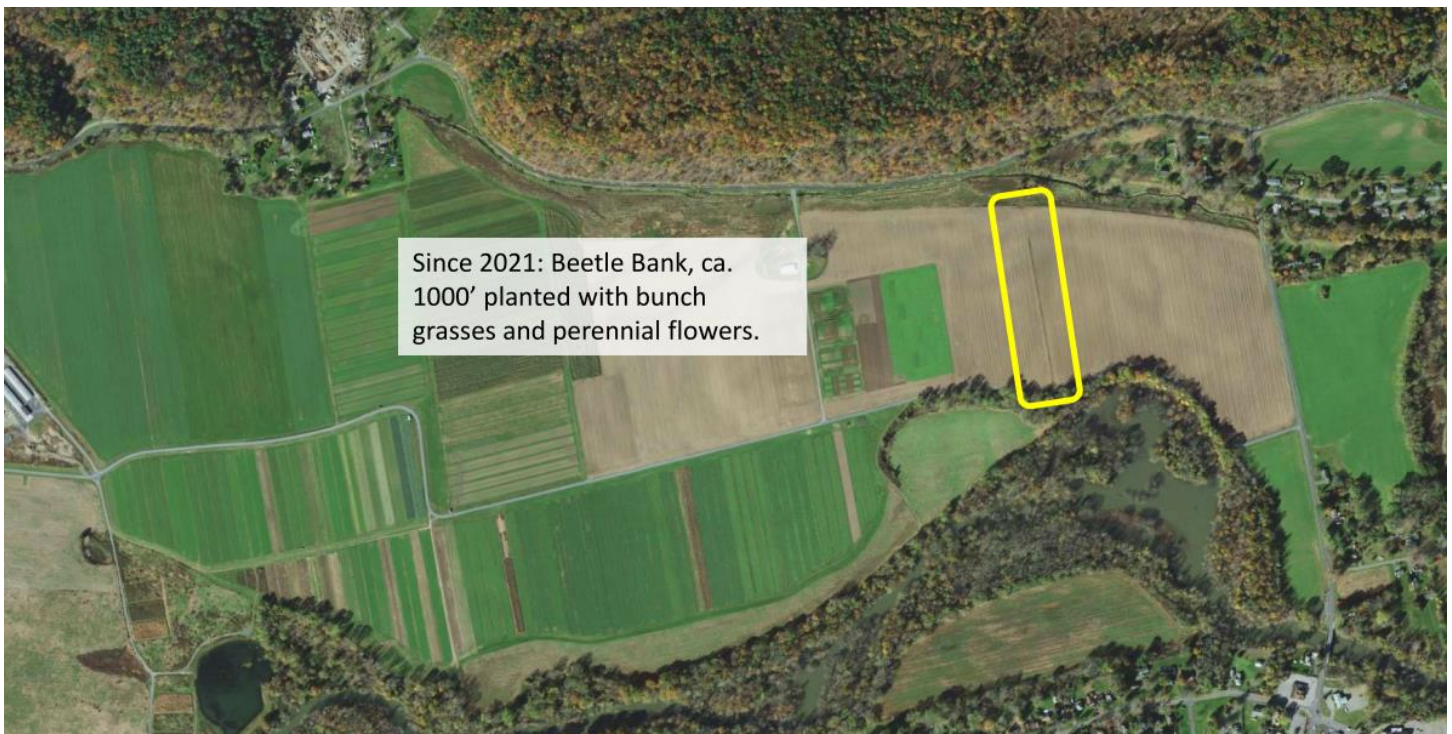
Map showing the location of the beetle bank at the Hudson Valley Farm Hub, Hurley, NY.

Beetle Bank.

The beetle bank was seeded in the Spring of 2021. During 2022, we sampled beetles along the bank and at various distances into the adjacent field using catch & release pit trapping.

To facilitate our description of occurrence patterns we identified two ground beetle communities – those primarily associated with plowed ground and those associated with the perennial vegetation of the beetle bank. From an applied perspective, we are most interested in the plowed ground beetles, because these are the species most likely to be influencing crop production.

The line graphs in Figs. 8 – 10 illustrate the season evolution of these two communities. The beetle bank ground beetle community showed very little penetration of the plowed ground. Meanwhile, the plowed ground beetles showed a shifting distribution, beginning with a bank-weighted June distribution and ending with a field-weighted September distribution. While it would be easy to assume that this shift reflected a demographic wave of a single species dispersing out from a refuge in the bank, the bar graphs suggest that, instead, this changing distribution pattern at the group level reflects changes in the species composition of the group. *Pterostichus melanarius*, a Spring breeder with a hint of bank affinity dominated early in the season, while *Harpalus rufipes*, a species that seems perfectly at home in plowed ground, dominated that September captures.

These preliminary data suggest if the bank is favoring ground beetles on the adjacent fields, then it is not by enhancing the abundance of all beetles at all times during the growing season, but rather by supporting one or a few particular species during the Spring. More study will be needed to understand whether this pattern repeats itself.

Standardised Transects

Annual Trends (or lack thereof). We have continued to monitor our three 600' transects, with their sampling points just inside the forest edge, on the edge of the field, and roughly 300' and 600' into the adjacent field. It has been three years since we last reviewed these data. These transects were established with two complimentary goals. First, they are simply meant as long-term monitoring sites – locations to help us detect broad changes in invertebrate populations. Secondly, they are designed to help us understand the role of adjacent wild semi-natural habitat (SNH) in influencing in-field invertebrate communities.

Our monitoring data from across the years (Figs. 11-13) are dominated by year-to-year variation, and there is little obvious evidence of trends. This is not surprising – invertebrate data is notoriously variable (Doug Landis has said that one can't expect to detect trends in invertebrate data without 20-30 years of data.) Furthermore, the farmland around our transects has, as is likely typical of many working organic vegetable farms, seen a diversity of uses over the years.
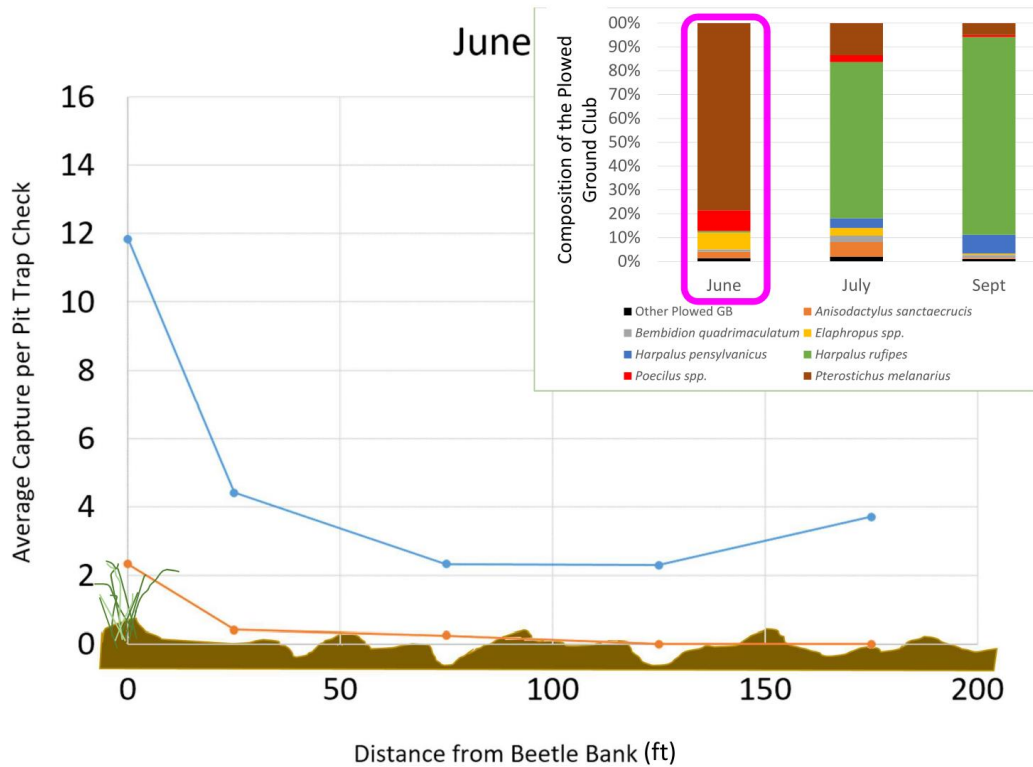
Figure 8. The June abundance of plowed-soil ground beetle species (blue line) and beetle bank-favoring species (orange line) as a function of distance from bank. The inserted bar graph shows species composition of the total captures by month. In June, ground highest on and near the beetle bank, and the community was numerically dominated the introduced P. melanarius.
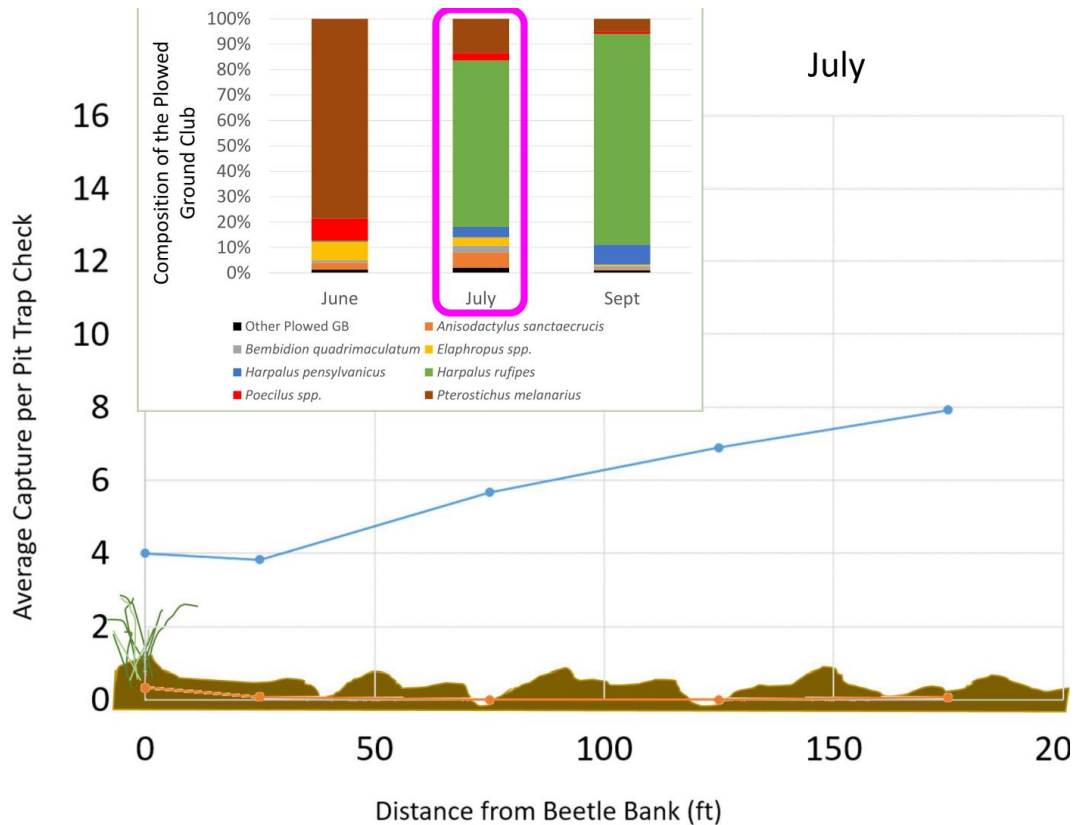

Figure 9. See figure 8 for conventions. In July, the abundance of beetle bank ground beetle species had faded, and the abundance of the plowed soil beetles, now dominated by the introduced H. rufipes*, had shifted away from the beetle bank.*
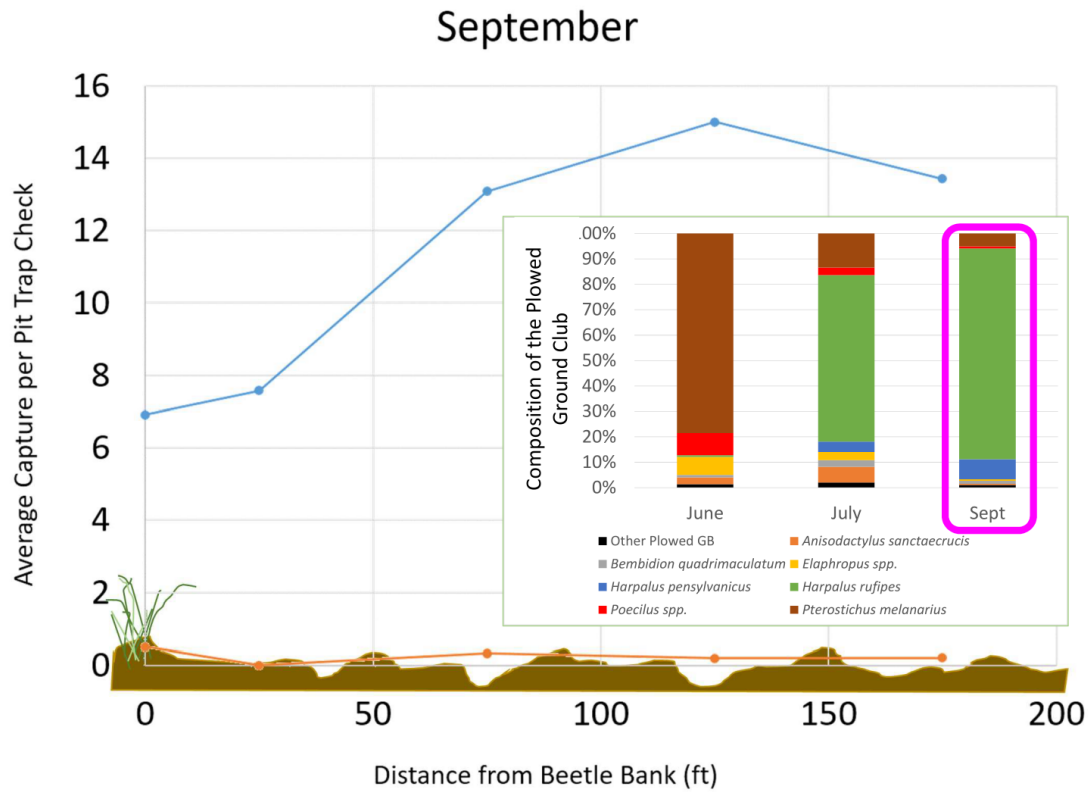
September

Figure 10. Refer to Fig. 8 for explanation. In September, beetle-bank ground beetles remained low, while the abundance of plowed-soil species, (dominated by H. rufipes*) built up deeper into the field.*
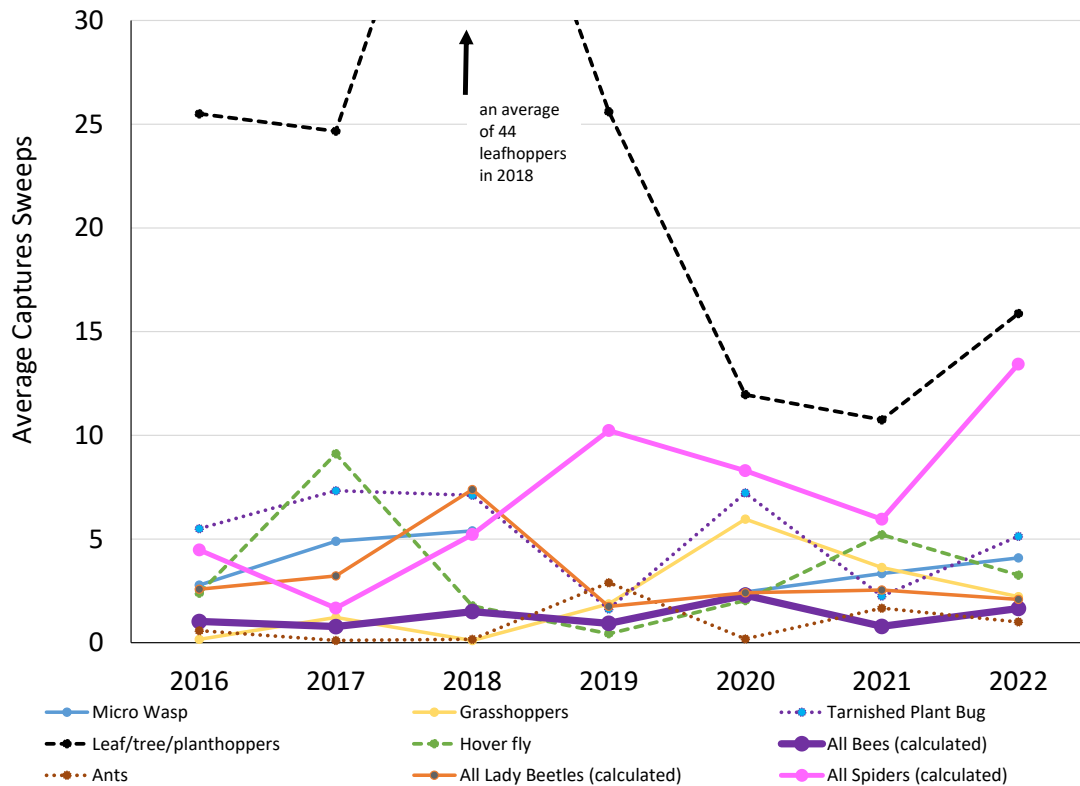

Figure 11. Average annual sweep net captures (June-Aug) of select taxa across all distances of our transect. While variation is apparent, distinct trends are not yet evident.
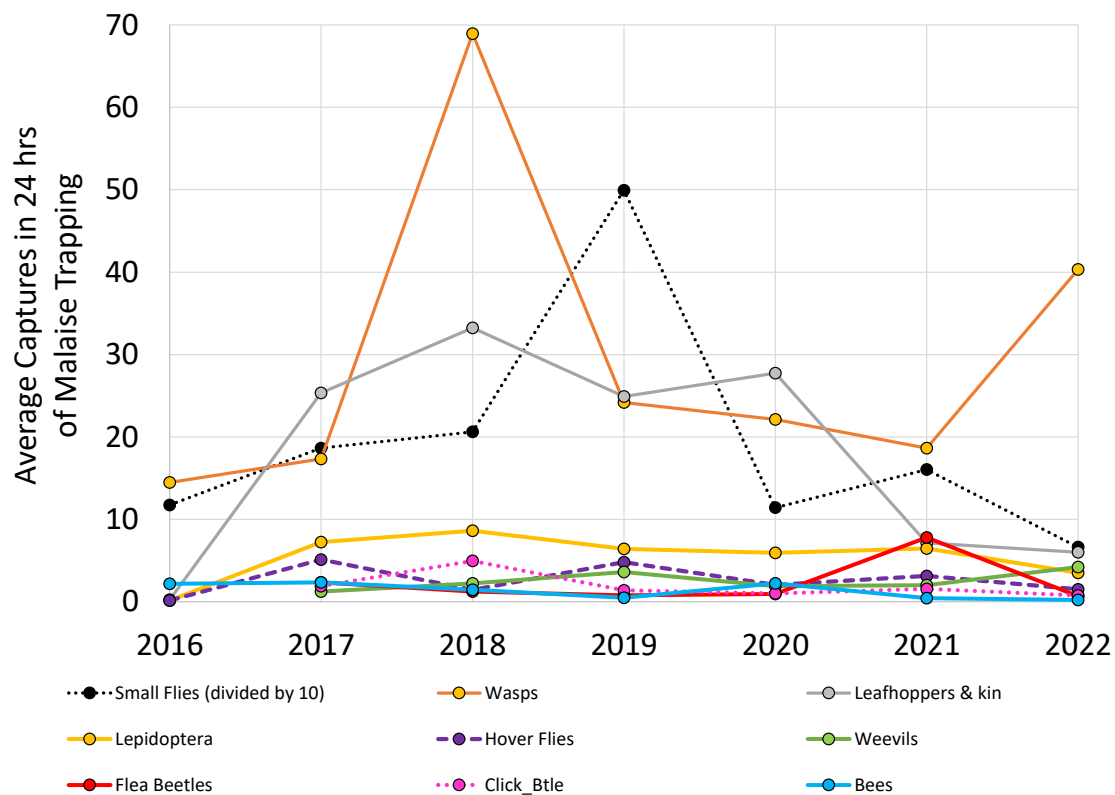
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Figure 12. Average annual malaise trap captures (June-Aug) of select taxa across all distances of our transect. While variation is evident, distinct trends are not yet apparent.
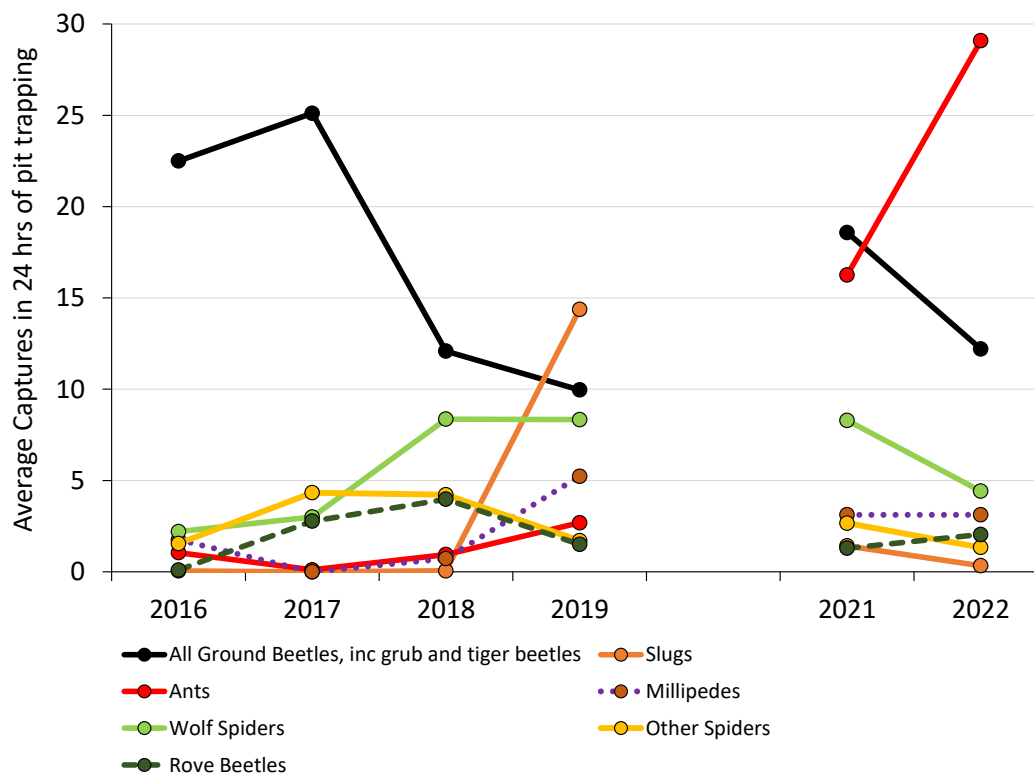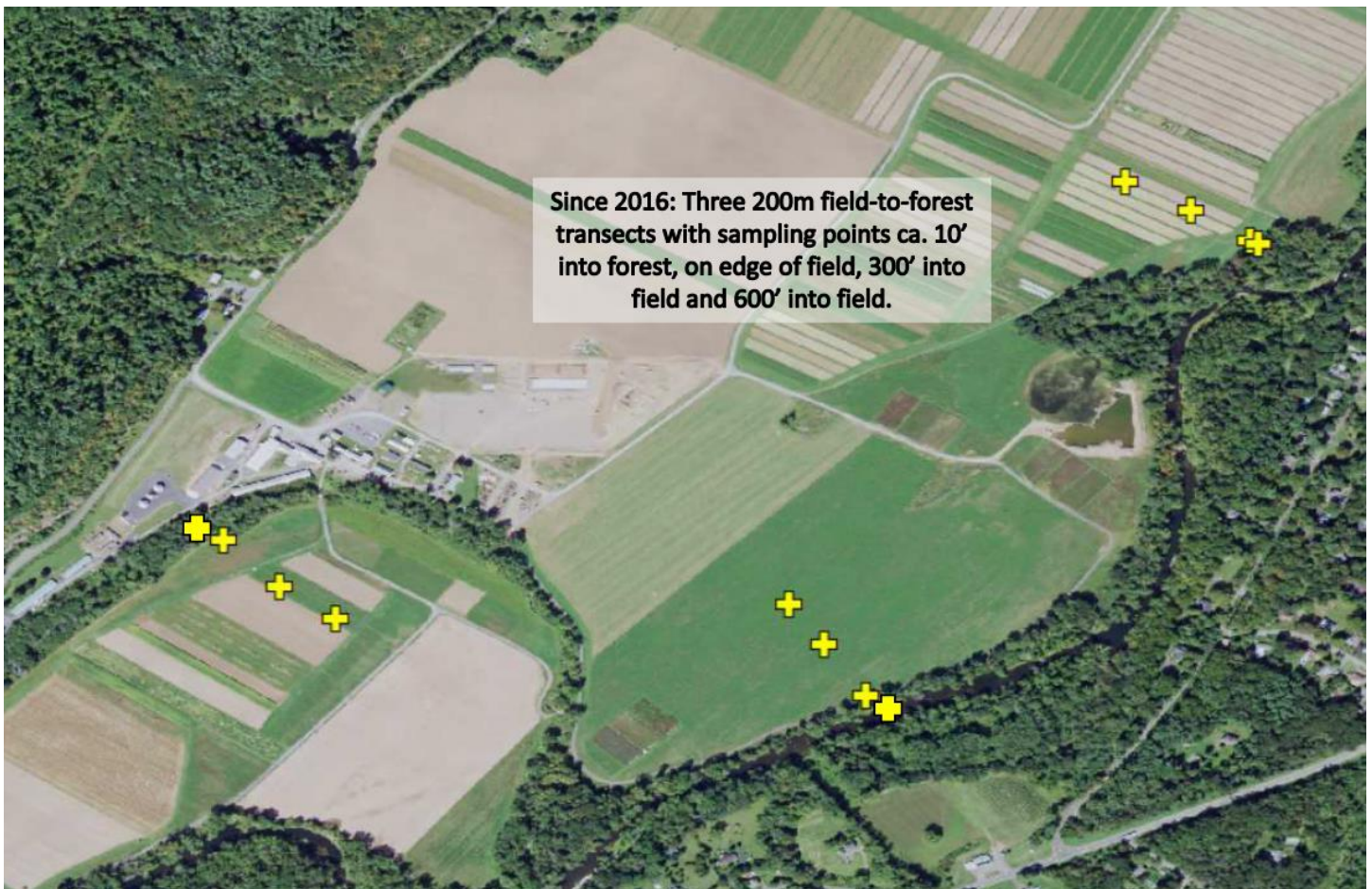

Figure 13. Average annual pit trap captures (June-Aug) of select taxa across all distances of our transect. No pit trapping was done along the transects in 2020. While variation is evident, distinct trends are generally not yet apparent. The possible increase in ants is likely due to the fact that at least one of our transects was taken out of tillage in 2017.

Map showing the location of the forest-to-field transects at the Hudson Valley Farm Hub. The uppermost transect replaced a more northerly transect (not shown) after the first year.

Edge Effects on Invertebrate Distributions. We can also look at our transect data to get insight into questions around the role of adjacent SNH habitat in affecting cropland ecology.

Our work and that of others has indicated the existence of such effects. Our own evidence comes from time lapse cameras we deployed along the transects in four years. These cameras were focused on bait cards holding freeze-killed Fall Army Worm eggs. The cameras recorded visitors to these cards (Fig. 14), and we tallied the disappearance of eggs from the cards (Fig. 15). Taken together, these data indicate that predation was highest near the field edge.

We can also use our data to explore the patterns of invertebrate occurrence across our transects (Figs. 16-19). Several taxa apparently favor the edge at least during certain times of year, although there is a diversity of patterns and the occurrence of some groups is highest near the field center. (Note that in these abundance diagrams, we do not include captures in the woods for our sweep and malaise data, because those techniques are so affected by forest structure that the magnitudes of those captures is probably not comparable to those of the field captures. Later, we do however consider the *proportional* taxonomic composition of captures at all four distances.)
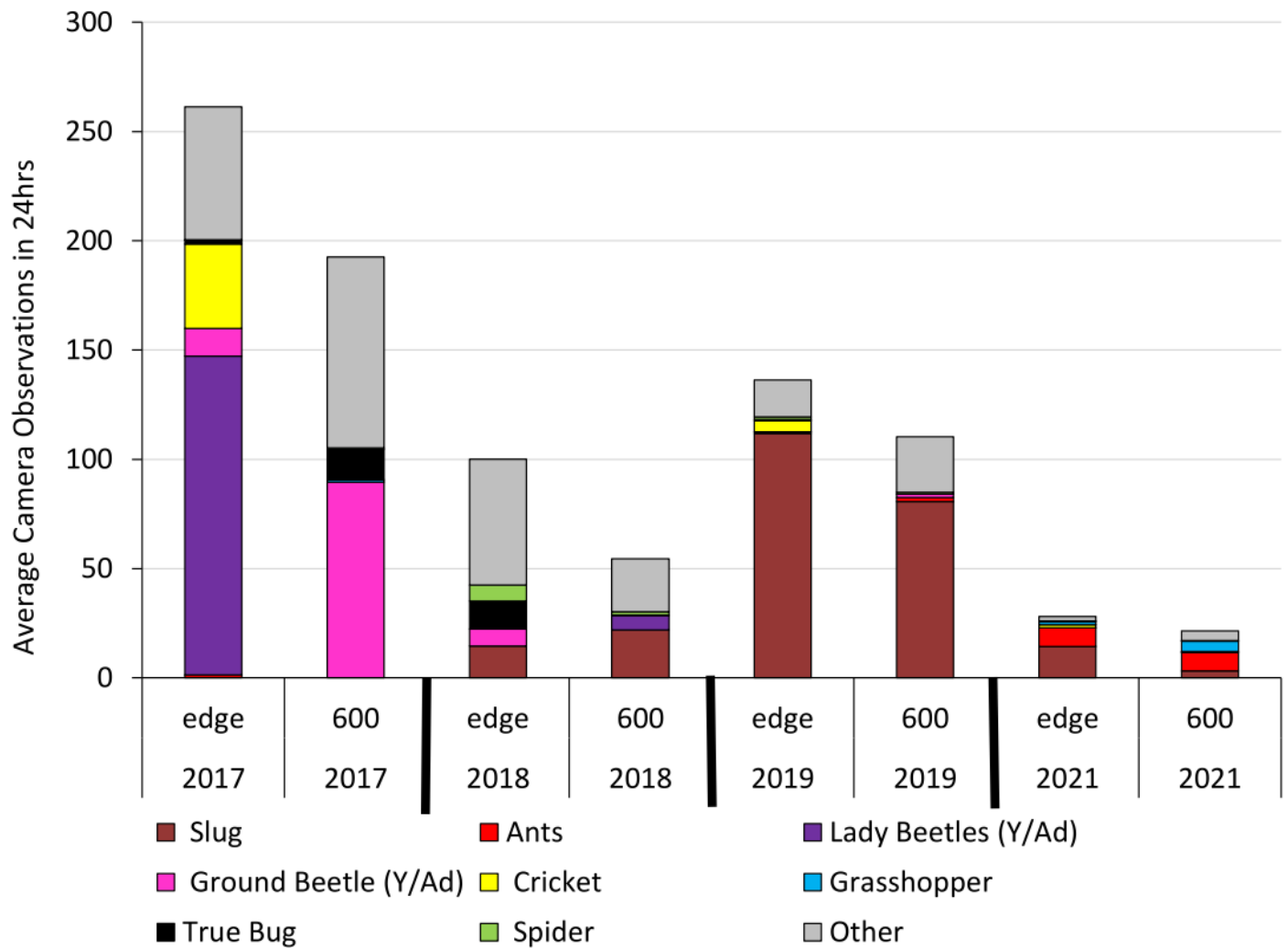
Figure 14. Visits to baits of Fall Army Worm eggs as tallied from 24-hour time lapse camera photos. Notice how, in all years, putative egg predation was higher at the edge than at 600' into the field and how the composition of visitors changed markedly over the years. No conclusions about inter-year variation in the absolute amount of predation should be drawn from this diagram due to slight inter-year variation in tallying techniques.
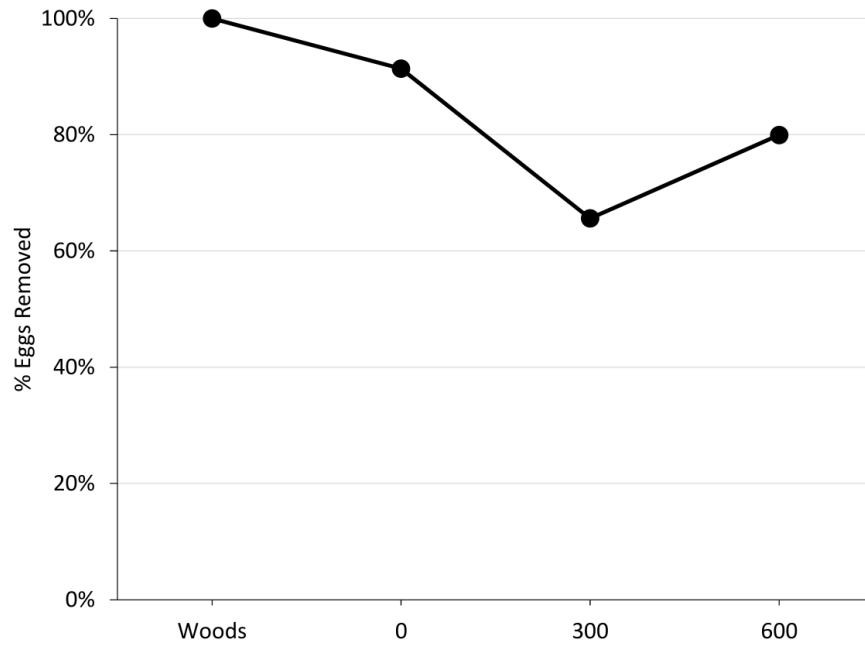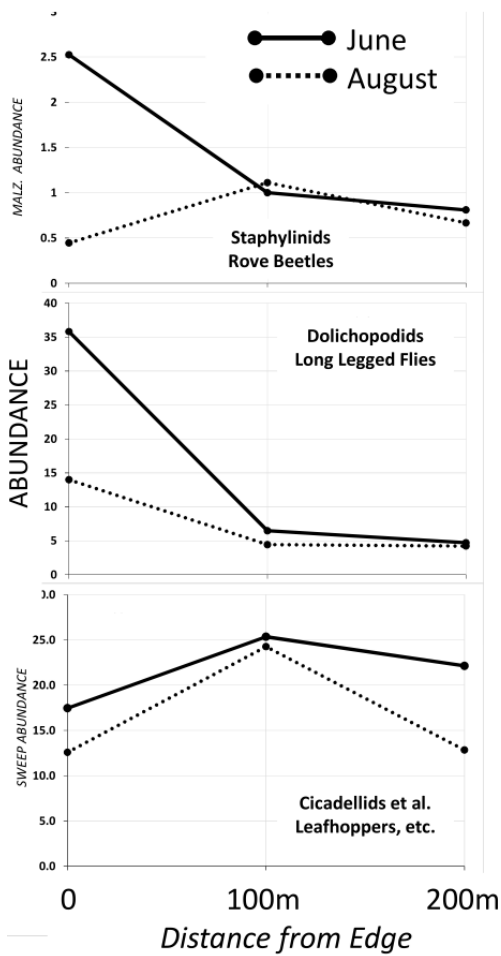
Figure 15. Fall Army Worm egg removal from the bait cards used in the camera observations. Note the apparent decline in agg removal farther into the field.

PATTERNS ON THE EDGE

A. Favor Edge Early But Not Late
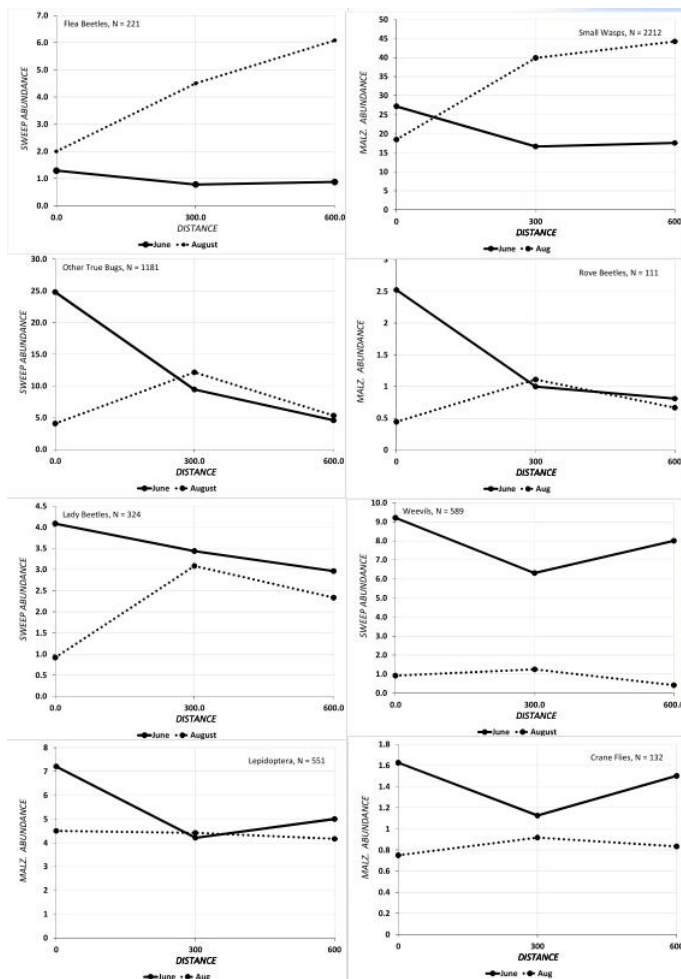*Early-season dispersal from edge followed by establishment?*

B. Favor Edge Early and Late
Continual dispersal from edge / high field center predation?

C. Never Favor Edge
Uniform distribution with edge predation?

Figure 16. A summary of the seasonal edge-to-center patterns evident in our data. At this point, we are just highlighting these as generalities, not proposing that they represent 'real' ecological groupings. The three slides that follow present those taxa falling into each group.
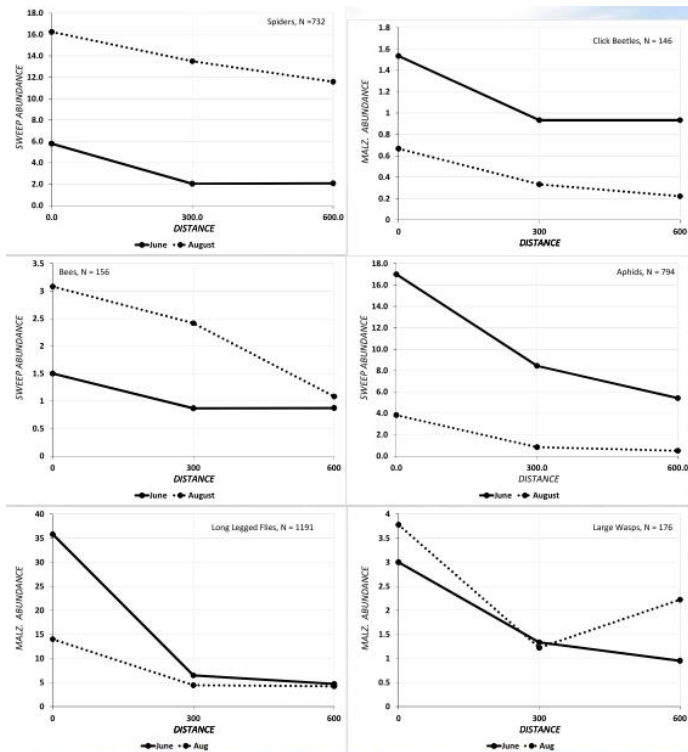
Figure 17. Creatures that seem to favor edge in June but not later in the year. The diagrams are for the sweep or malaise trapping (depending upon which technique caught the largest number of the given taxon); the do not include data on woodland captures because of difficulty of obtaining comparable captures in the forest. The yellow box lists those taxa that seem to reflect the given pattern.
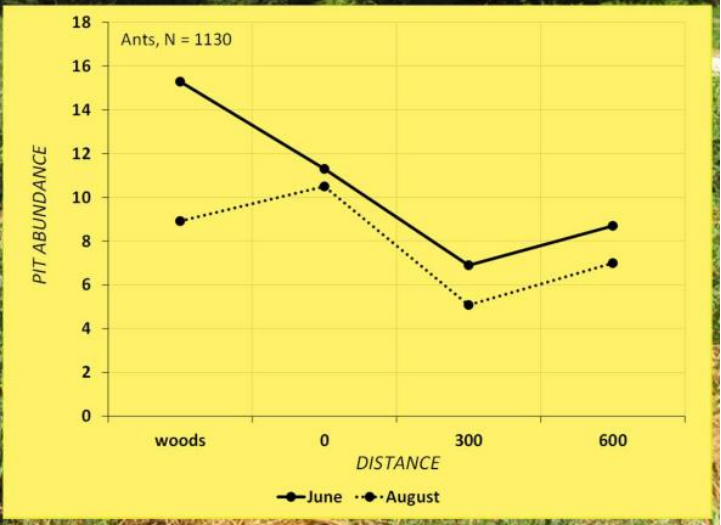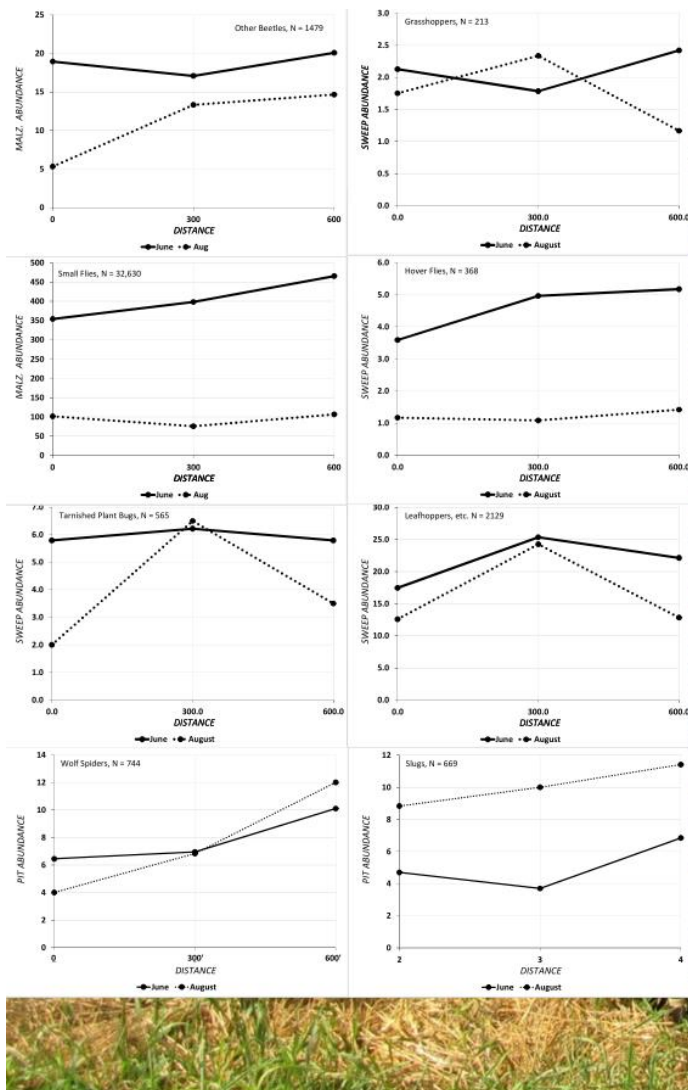
Figure 18. Creatures that seem to favor edge in June and also later in August. The diagrams are for the sweep or malaise trapping (depending upon which technique caught the largest number of the given taxon); the do not include data on woodland captures because of difficulty of obtaining comparable captures in the forest. The yellow box lists those taxa that seem to reflect the given pattern. The tan box shows the pattern for ants in pit traps; including woodland captures seemed more valid for this technique.
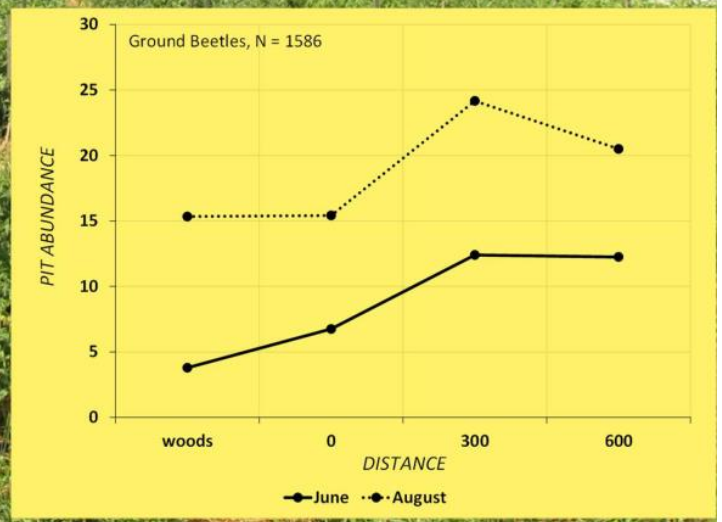
Figure 19. Creatures that seem to favor edge neither in June nor in August. The diagrams are for the sweep or malaise trapping (depending upon which technique caught the largest number of the given taxon); the do not include data on woodland captures because of difficulty of obtaining comparable captures in the forest. The yellow box lists those taxa that seem to reflect the given pattern. The tan box shows the pattern for ground beetles in pit traps; including woodland captures seemed more valid for this technique.

Figs. 20-23 present our deeper taxonomic information on ants, ground beetles and bees (wasp data should be forthcoming). While the specific patterns vary amongst the taxonomic groups, three general types of species can be recognized – those almost entirely confined to forests, those almost entirely confined to fields, and those regularly found in both field and forest. It is the presence of this last group which indicates the potential for biotic exchange. These are often, but not always, relatively common species. In some cases, such as the introduced ground beetle *Pterostichus melanarius*, the relative abundances between field and forest would suggest that the main direction of flow might be from field to forest, i.e., high in-field populations are seeping out into the adjacent forest. It is important to highlight the incompleteness of our data – as Kass Urban-Mead's bee work has shown and our ground beetle study also suggest, species sharing is likely to vary by season, and our summertime data summaries shown here may omit important information on overwintering sites and/or Spring and Autumn resource use.
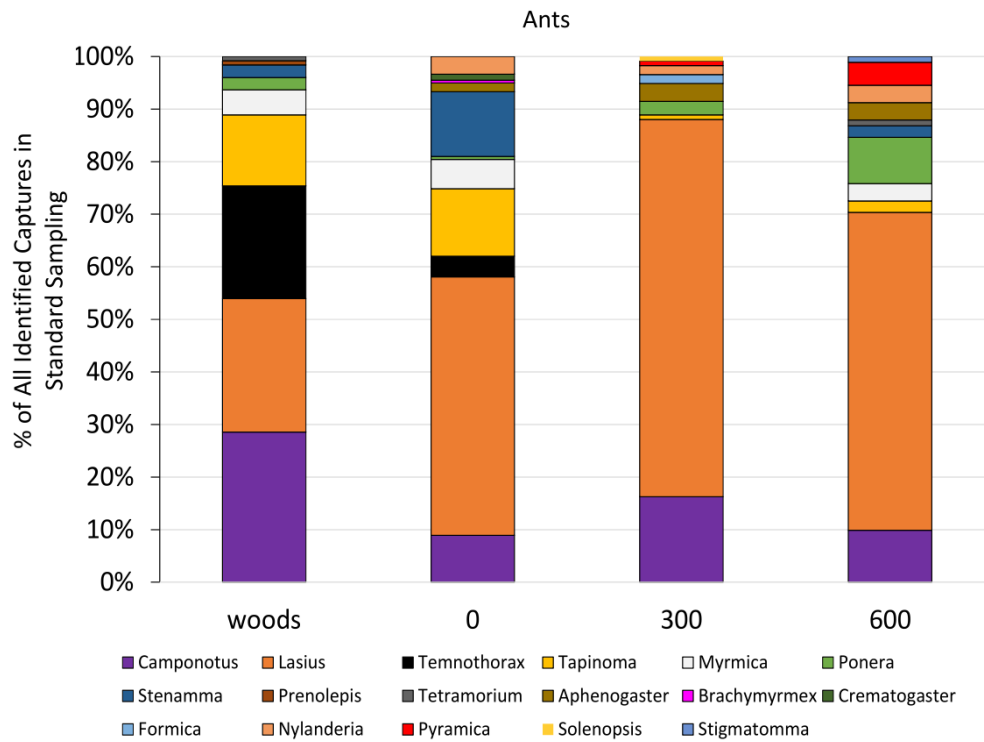
16

Figure 20.The proportional, genus-level composition of the ant community from forest to field. Notice how some genera, namely Tapinoma, Temnothorax *and* Camponotus, *seem to be most common in the woods, while* Lasius, Ponera*, and* Pyramica *seem to be primairly field genera, although there is subtantial occurrence of* Lasius *in the woods as well. Most of the field-captured* Camponotus *were dispersing breeders, not terrestrial workers.*
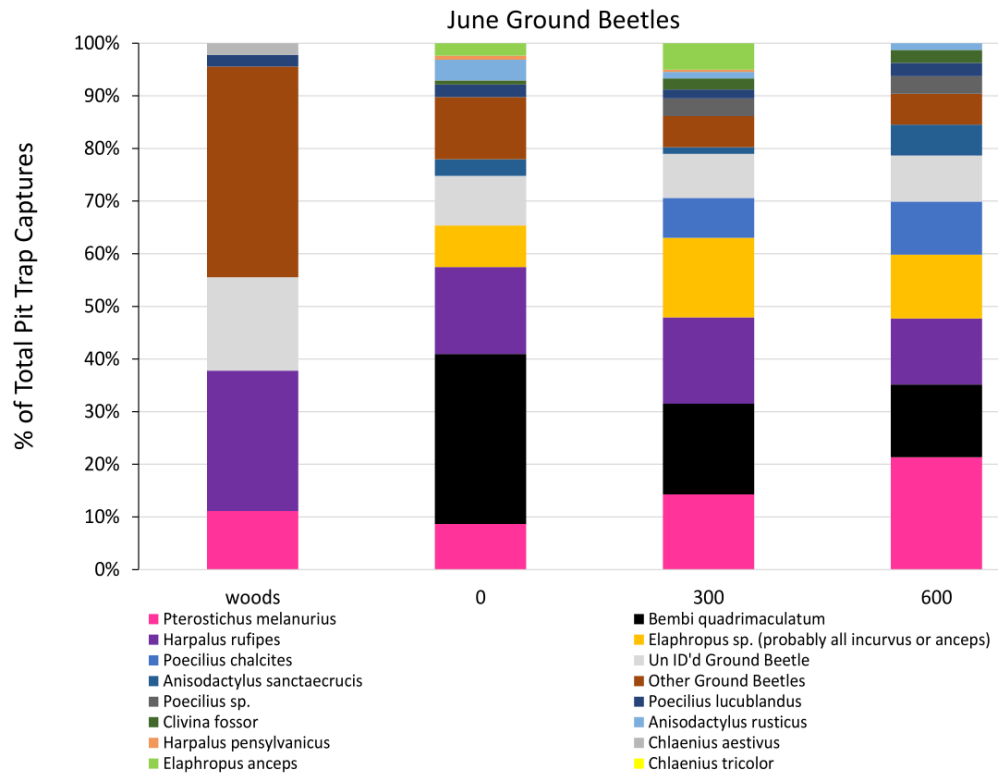

Figure 21. The proportional, species-level composition of the June ground beetle community from forest to field. The "other Ground Beetle" and the "unidentified Ground Beetle" categories, which are relatively common in the woods, primarily represent the occurrence of several rarer species. Notice how Bembidion quadrimaculatum *(known affectionately as Bembi quad) is almost entirely absent from the forest, while the introduced* Harpalus rufipes *and* Pterostichus melanarius *are common across all distances.*
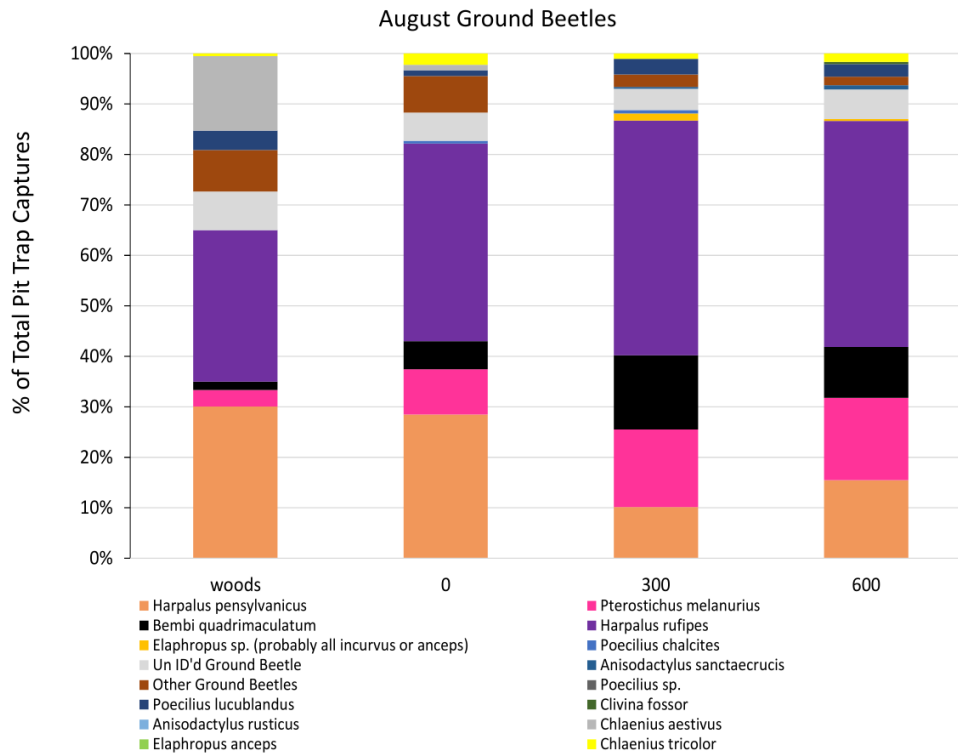
17

August Ground Beetles

Figure 22. The proportional, species-level composition of the August ground beetle community from forest to field. The native Harpalus pensylvanicus *is now relatively common across all four distances, and* Chlaenius aestivus *has become noticeably common in the woods. The introduced* Harpalus rufipes *and* Pterostichus melanarius *remain proportionately common across all distances.*
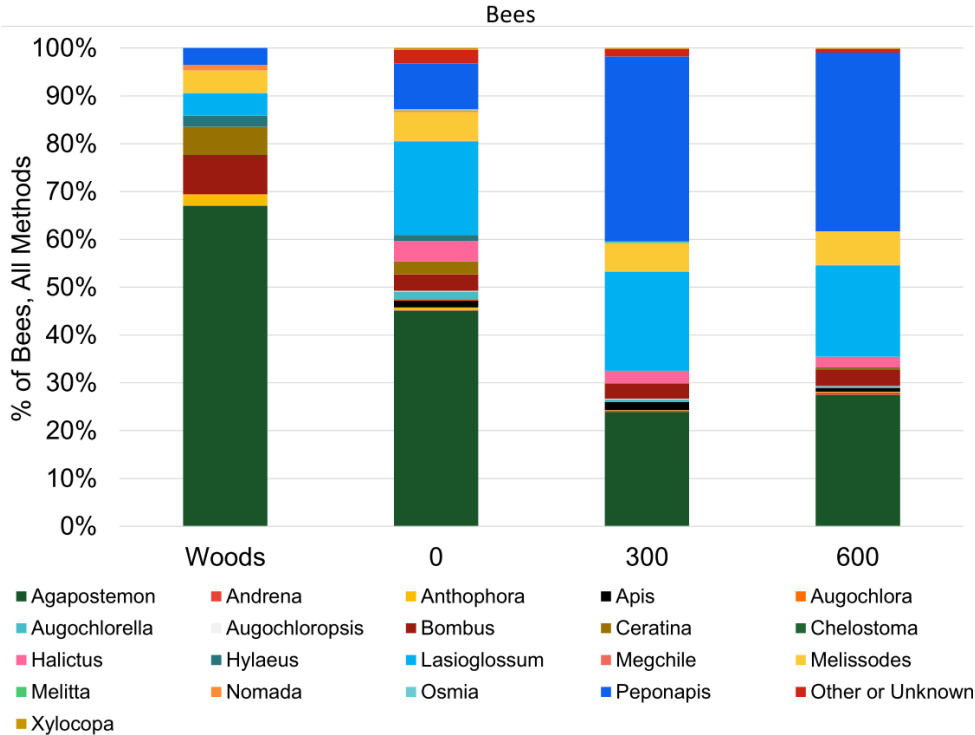

Bees

Figure 23. The proportional occurrence of bee genera across our transects in June- August captures. Agapostemon *is proportionally most common in the forest, but also relatively abundant across all distances.* Melissodes *is similarly common across the distances, while* Peponapis *and* Lasioglossum *are distinctly higher in relative abundance in the fields.*

Directional Movement at the Forest-Field Edge. In order to better understand actual movement patterns, we have been deploying a directional trap at the edge location of our transect sampling. This trap, while otherwise similar to the malaise traps used at the other distances, allows us to record the direction from which captured creatures enter the trap before dying in our samples. These data (Fig. 24) suggest that many taxa indeed do move out of the forest and into the adjacent field, although it will be important to study the taxonomic composition of these samples in more detail and consider what other behaviours might drive such captures. Unfortunately, sample sizes are relatively small. Intriguingly, based on our work elsewhere, we have seen these apparent flow patterns repeated, albeit at differing intensities, between a variety of SNHs and at least two crop habitats (veggies and orchard).
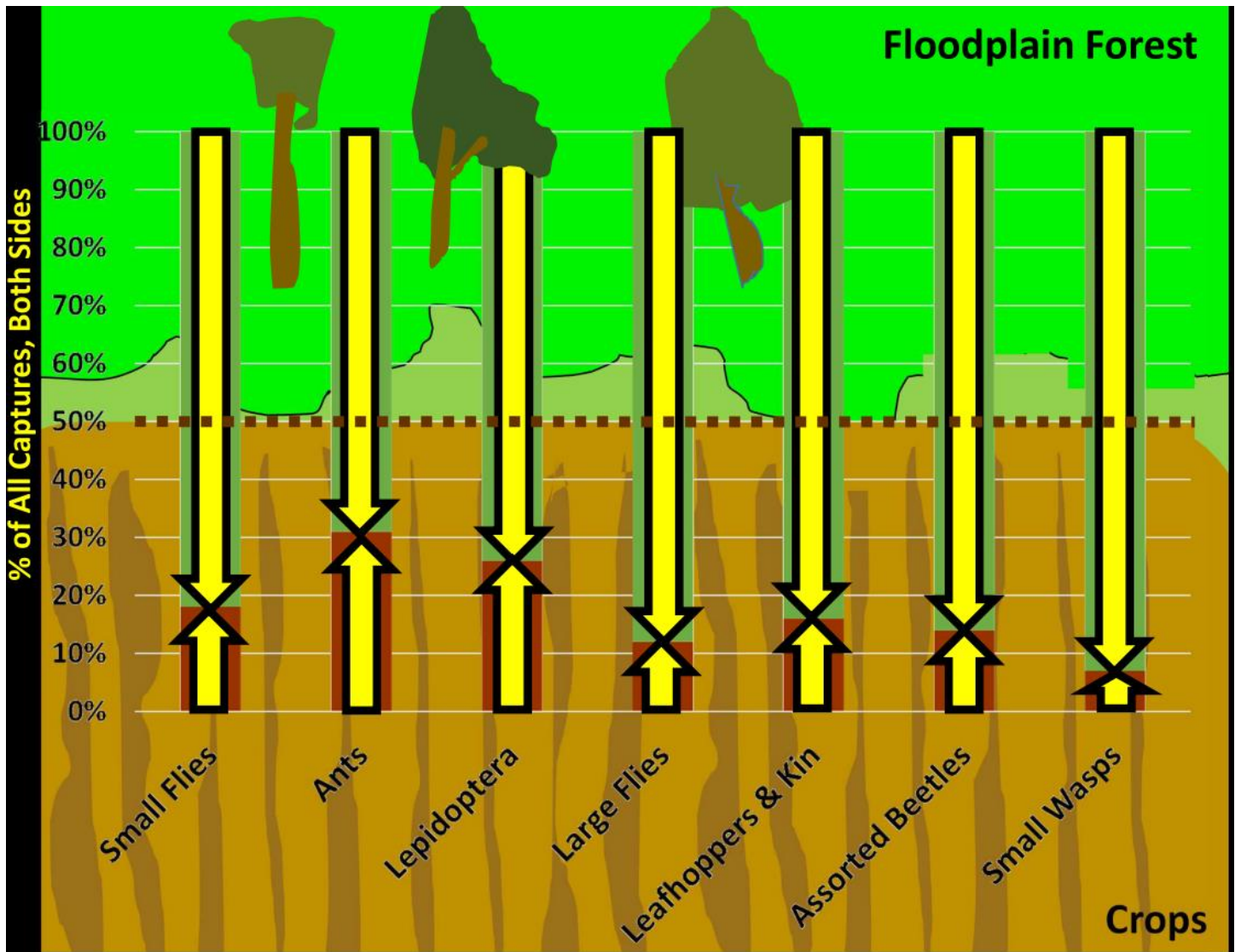

Figure 24. The balance of captures at the forest/field edge for June-August since 2019. The extent of the top arrow shows the percentage of captures recorded on the forest side of our trap relative to the total captures on both the forest and field side. The lower arrow is, of course, the corresponding percentage of field-side captures. Were captures equal, the arrows would meet on the 50% line. For all taxa, forest-side captures predominated.

So what? The transect data suggest at least two applied questions: 1) *Should farming be tailored to adjacent SNH (i.e., are some types of SNH more likely to support beneficial insects in particular crops)?* To some degree, such considerations are already recognized by organic orchardists – SNH with high densities of Red Cedar can augment the presence of apple-cedar rust in adjacent orchards and high forest abundances of other members of the Rosaceae (e.g., cherry, serviceberry) can heighten in-orchard Plum Curculio abundances. 2) *Can a better understanding of the ecologies of the relevant species allow us to facilitate the dispersal of desired beneficials into crops?*

19

We have relatively little data to address question one, however, we present Fig. 25 as an example of the type of data one might want. This shows the similarities among ground beetle communities in various regional habitats including veggie fields. Although ground beetles might be a poor taxon to choose because of the apparent existence of a healthy, relatively distinct plowed-soil ground beetle community (we chose them only because we had the data to create the similarity tree), the logic would be that SNH close to veggies in the community-similarity tree would be most apt to actually share species with cultivated land (in this case, old field, lawn or gravel pit!). Of course, we're not recommending that farmers surround their crops with lawn or gravel pits, but this is potentially a logic that could be applied to tailoring ag. systems and SNH for other taxa.
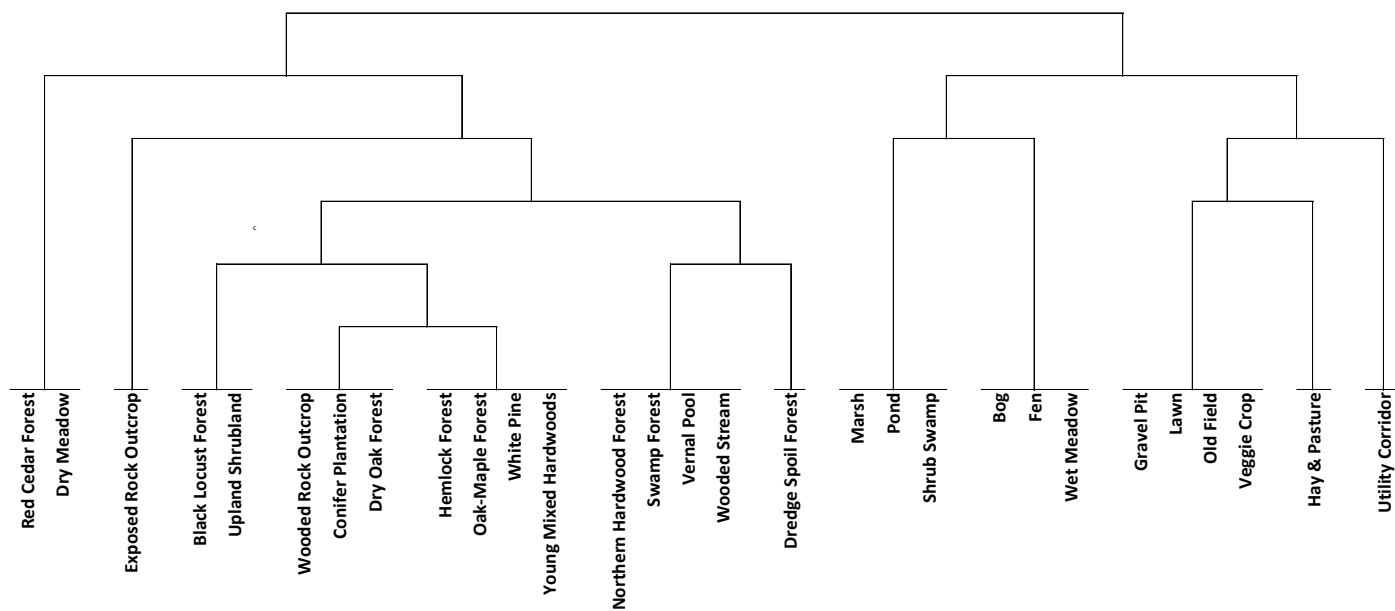

Figure 25. A TWINSPAN community similarity tree for regional ground beetles. Data are from county-wide surveys in Columbia County, NY. Note that the veggie crop ground beetle community (third from left) appears to be most similar to the communities found in gravel pits, lawns and old fields.

Functional traits. Finally, we can analyze functional traits in order to better understand the ecologies of the relevant taxa and start to get glimpses of techniques that might encourage biotic sharing. Figs. 26-29 summarize ant, ground beetle and bee communities in terms of select functional aspects. While some of these diagrams only offer academically interesting ecological insights (e.g., there appears to be a distinct ecological grouping of open-ground, wide-ranging ground beetles), other suggest potential manipulations that might be worth trying (e.g., providing in-field nesting boxes for cavity- nesting bees so as to potentially draw more forest dwellers into croplands).

What's missing?

Last year we collected fecal or regurgitate samples for the study of ground beetle, bird and bat (from another farm) diets. However, we have yet to receive the DNA analyses from any of these samples. Kendrick also gathered information on aphid parasitism, but those data are not summarized here. We are still digesting our analyses and trying to determine our future plans, so this report lacks any 'next steps'. We made no attempt to include a literature review in this report. Be thankful for the brevity but bemoan the lack of academic context.

Thanks to, aside from those listed on the first page, Megan Garfinkel for encouragement and brainstorming (not to mention pSEM models), and Anne Bloomfield, Teresa Dorado, Jeff Arnold and the Hub's field crew for crucial on-site assistance. Gratitude to the Hudson Valley Farm Hub and Hawthorne Valley for funding and institutional support.
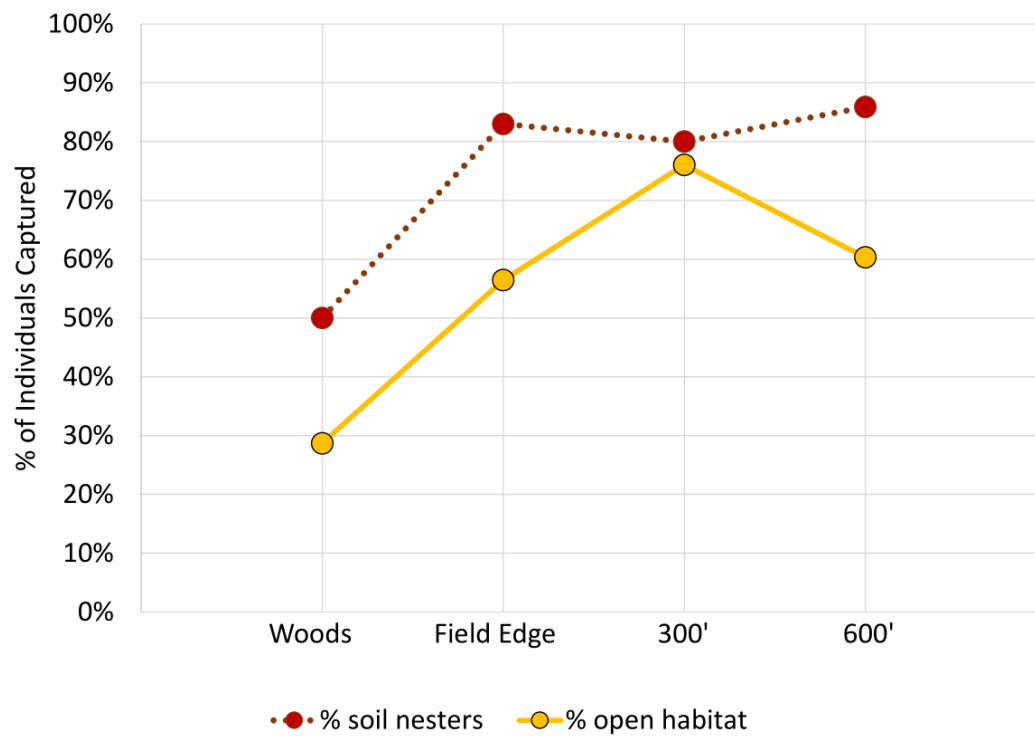
Figure 26. The composition of two ant functional traits across our transect. The field community of ants tended to be composed of more soil nesting and open-habitat favoring individuals than the forest community.
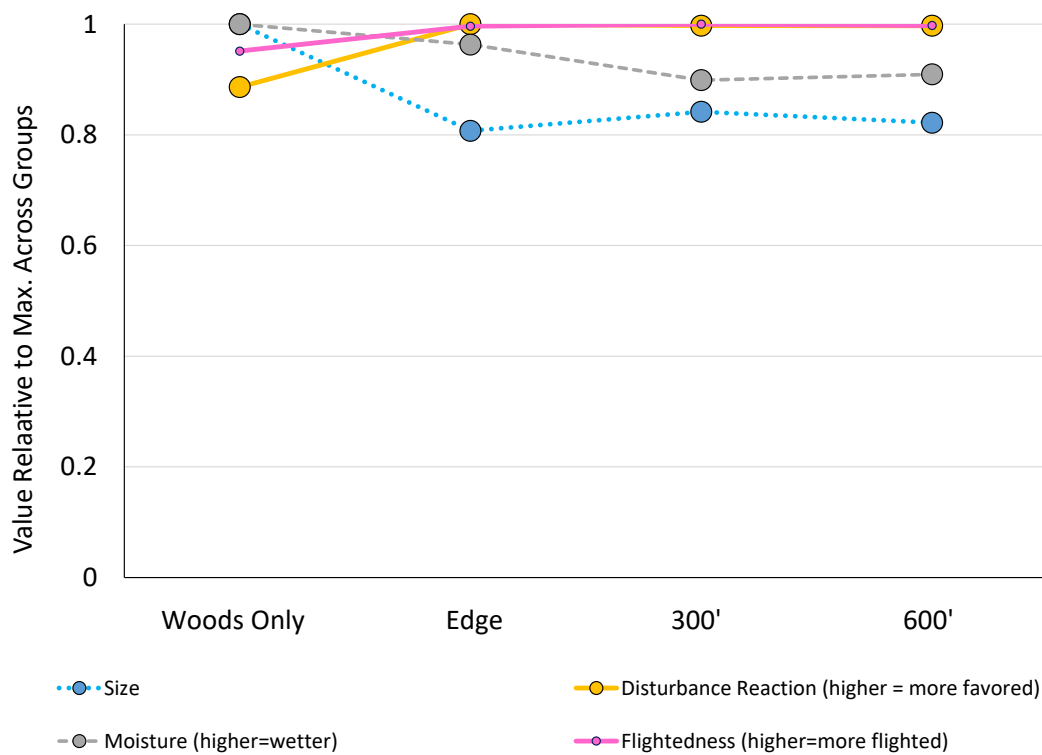

Figure 27. Similar to the above diagram for ants, this figure shows the distribution of four ground beetle functional traits across our transects. Variation does not seem marked.
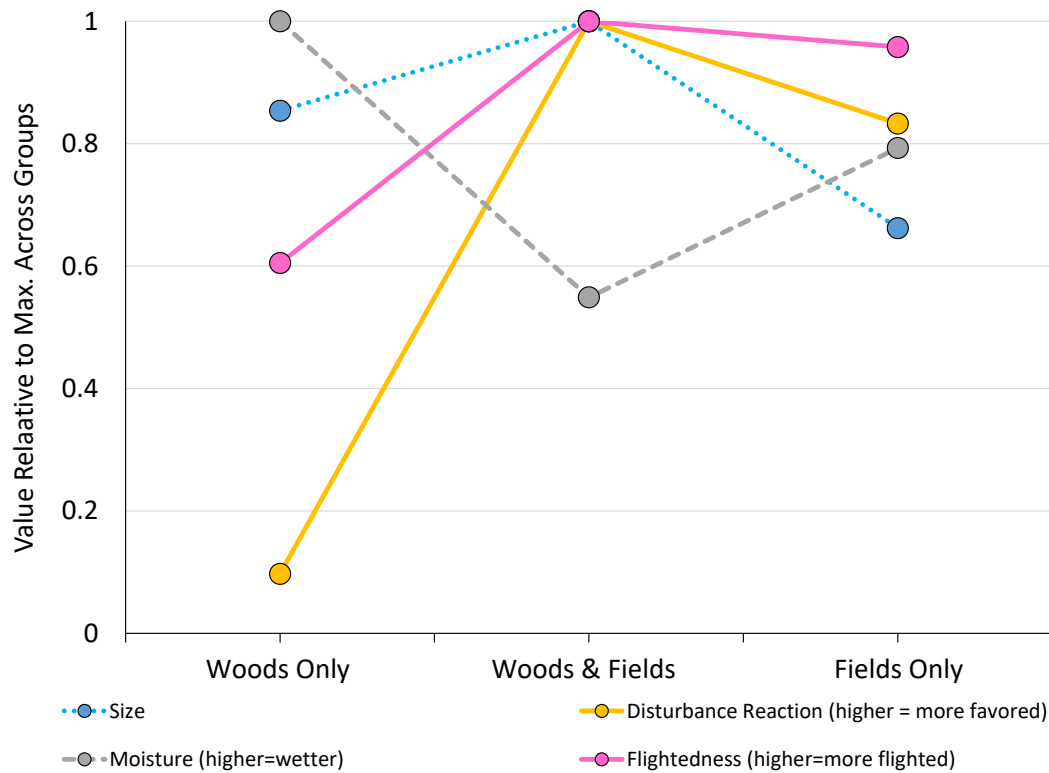
Figure 28. Much more variation is apparent if, instead of categorizing ground beetles by distance along the transect, we categorize them by the breadth of their distribution. Those species that were common at all distances tended to be larger, more favored by disturbance, and more likely to be able to fly than those species largely confined to either forest or field.
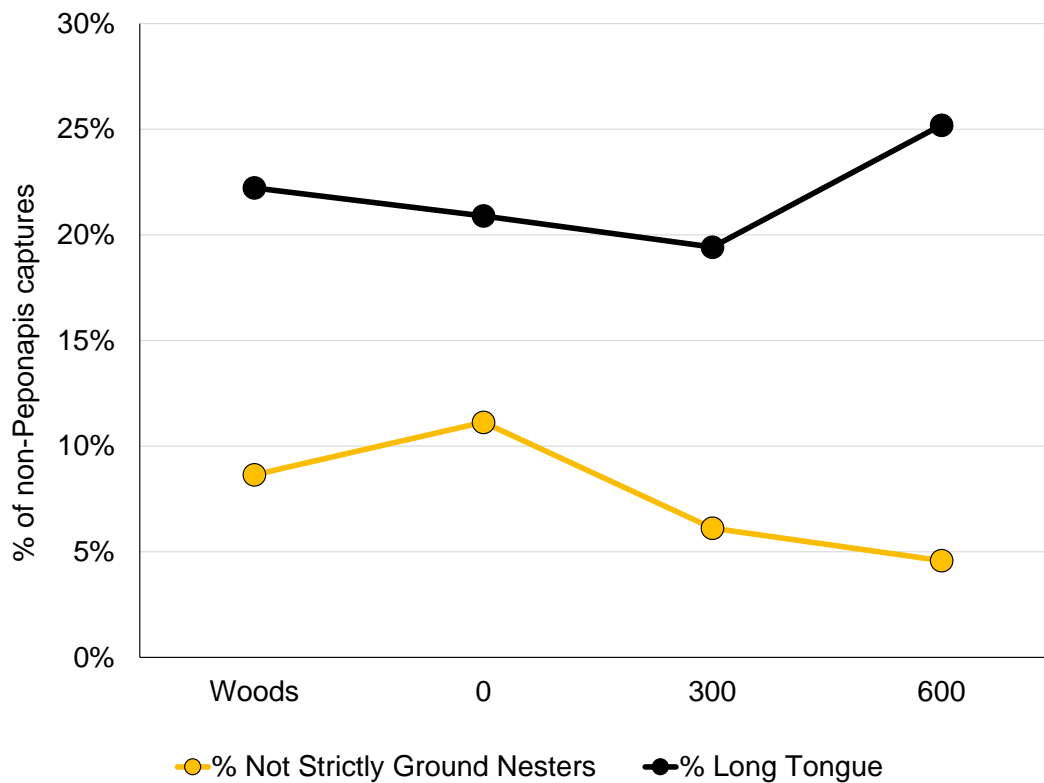

Figure 29. The functional traits of bees found at various distances along our transects. Note that ground nesting is slightly less common among forest and edge bees than among field bees. Might providing in-field hotels for cavity nesters draw such species further into crop fields?

22