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Flower Diversity and Floral Area on Four Mid-Hudson Valley Farms

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[**Please note**: This is a supplement to "The Unseen Farm: A Contribution to Mid-Hudson Valley Farmscape Ecology", which is preliminary summary of our 2017 fieldwork. As will be evident, this is not a draft journal publication. It does not include a review of relevant literature.]

METHODS

As part of FEP's multi-farm research into the relationships between on-farm insects, on-farm habitats and the habitat surrounding the farm, we documented the diversity and abundance of flowers at four farms and two spatial scales:

- around the insect traps placed in crops (mixed vegetables) and directly adjacent semi-wild habitats
- in all habitats within 125m from the center of the crop (mixed vegetables) field

We documented flower diversity and abundance at each farm three times during 2017, concurrent with the insect sampling.

The basic sampling unit was a circular plot of 3 feet radius (area of 28.26 ft^2 = 2.6 m^2).

Within this plot, we noted all plant species in flower and counted/estimated the number of flowers (or inflorescences) of each species. We used Aaron Iverson's unpublished spreadsheet of floral areas (somewhat modified by our own observations of flower sizes) to calculate floral area per species and total floral area within the plot.

Around the insect traps, we sampled 8 plots within a 6m radius of the trap, two in each cardinal direction at 3 and 10 steps distance.

In the habitats within a 125m radius from the center of the crop field, we sampled 10 (or multiples of 10, if the habitat patch was very large) plots along a linear transect with the plots +/- evenly spaced. We mapped the areas of each habitat within the 125m radius of the crop fields, and then calculated overall average floral area by weighing the average floral area in each habitat by the relative size of the habitat at each farm.

We calculated three measures of flower diversity: alpha diversity around the insect traps was calculated by averaging the number of flowering species in the eight sample plots; beta diversity around the insect traps was the cumulative number of flowering species in the eight sample plots; overall diversity of flowering plants around the crop fields was the total number of flowering species encountered in the sample plots inventoried within the 125m radius from the center of the crop fields.

In order to explore in more detail which plants provided the flowers at the different farms and in different seasons, we classified the flowering plants into four groups. We considered as "cultivated plants" all species grown in the crop fields (vegetables, culinary herbs, cut flowers, and insectary plants), as well as those species regularly seeded into pastures and/or hayfields (such as Alfalfa and clovers), even if these species were growing wild in the drive strips or around the field edges. We considered as "weeds" the annual species—native or not--that thrive almost exclusively in tilled soil (e.g., Galinsoga, Chickweed, Purslane). We defined as "Wildflowers" those perennial species that grow in natural areas, pastures and/or hayfields, and along field edges, without having been intentionally seeded or planted in recent years. These can be non-native (e.g., Dandelion, Common Bedstraw, Wild Carrot, Knapweed, or Multiflora Rose) or native (e.g., asters, goldenrods, dogwoods).

QUESTIONS and RESULTS

<u>Which flowers occurred in and around the vegetable fields of four farms and what do we know about their value for insects</u>? Before considering any habitat improvements, it is important to have a baseline of the *status quo*.

We documented 160 plant species in flower within 125m of the center of the crop field, 120 of which occurred within 6m of an insect trap. 68% of these flowering plants were growing wild (of these, 60% were native and 40% non-native), 19% were weeds (mostly non-native), and slightly less than 13% of the species were cultivated plants. The Appendix lists all these species and indicates their value for insects (based largely on incomplete and unpublished data from Xerces).

<u>Which flowers were the most abundant overall</u>?

Across all farms, the most abundant and widespread flowers were (their relative value for insects, according to unpublished information by the Xerces Society, is indicated by the number of stars): goldenrods***, Common Fleabane**, Galinsoga*, asters s.s. (*Symphyotrichum* spp.)***, White Clover***, Common Bedstraw, Wild Carrot***, and Red Clover***. In our 2017 insect data, bee abundance was positively correlated with floral area of Red Clover (right around the traps) and Common Fleabane (within 125m of the center of the crop field); wasp abundance was positively correlated with the floral area of asters s.l. (Asteraceae); while hoverfly abundance was positively correlated with the floral area of mustards (Brassicaceae).

<u>How similar were the most abundant flowers between farms and across the growing season</u>?

The most abundant flowers varied considerably among farms (Table 1). Not a single species was amongst the ten most abundant flowers within the 125m circle around the vegetable fields of *all four farms*. However, White Clover and Canada Goldenrod were amongst the most prolific bloomers on *three farms*, and Galinsoga, Red Clover, Wild Carrot, Annual Fleabane, and Wrinkle-leaved Goldenrod on *two farms*. A subset of these (Annual Fleabane, Galinsoga, White and Red Clover) were also amongst the most abundant flowers around the insect traps of all four farms and provided ample flowers throughout the growing season.

Table 1: The ten most abundant flower species within a 125m radius around the crop (vegetable) fields of four farms. The plants are listed in order of decreasing floral area across all seasons. Colors highlight those species which were amongst the 10 most prolific bloomers at more than one farm.

HR	Hub	HVF	IW
all seasons			
Galinsoga	**Red Clover**	**White Clover**	**Canada GR**
ornamental Amaranthus	Blackberry	**Galinsoga**	Awl Aster
Tomatoe	Crimson Clover	**Red Clover**	Willow-leaved Aster
White Clover	Chickweed	**Wild Carrot**	**Wild Carrot**
Sheperd's Purse fl/infl	Multiflora Rose	Gill-over-ground	**Wrinkle-leaved GR**
Sunflower	American Germander	**Wrinkle-leaved GR**	**Annual Fleabane**
Summer Squash	**White Clover**	Orange Jewelweed	Spotted Knapweed
Brassica cultivated	Plains Coreopsis	**Canada GR**	Birdsfoot Trefoil
Annual Fleabane	Lepidium virginicum	Arrow-leaved Tearthumb	Brn Knapweed
Canada GR	Dame's Rocket	Tomatillo	Calico Aster

<u>How abundant were flowers at the four farms and throughout the growing season</u>? In order to find possible correlations between flowers and insects, we need to describe the flower abundance (measured as floral area) at each farm during the time of insect sampling.

The total floral area within 125m of the crop (vegetable) fields varied considerably between farms and seasons (Fig. 1). At Hawthorne Valley Farm and Ironwood, floral area increased throughout the growing season, while floral area at the Farm Hub showed the inverse pattern, and floral area at Hearty Roots stayed relatively constant throughout the seasons.

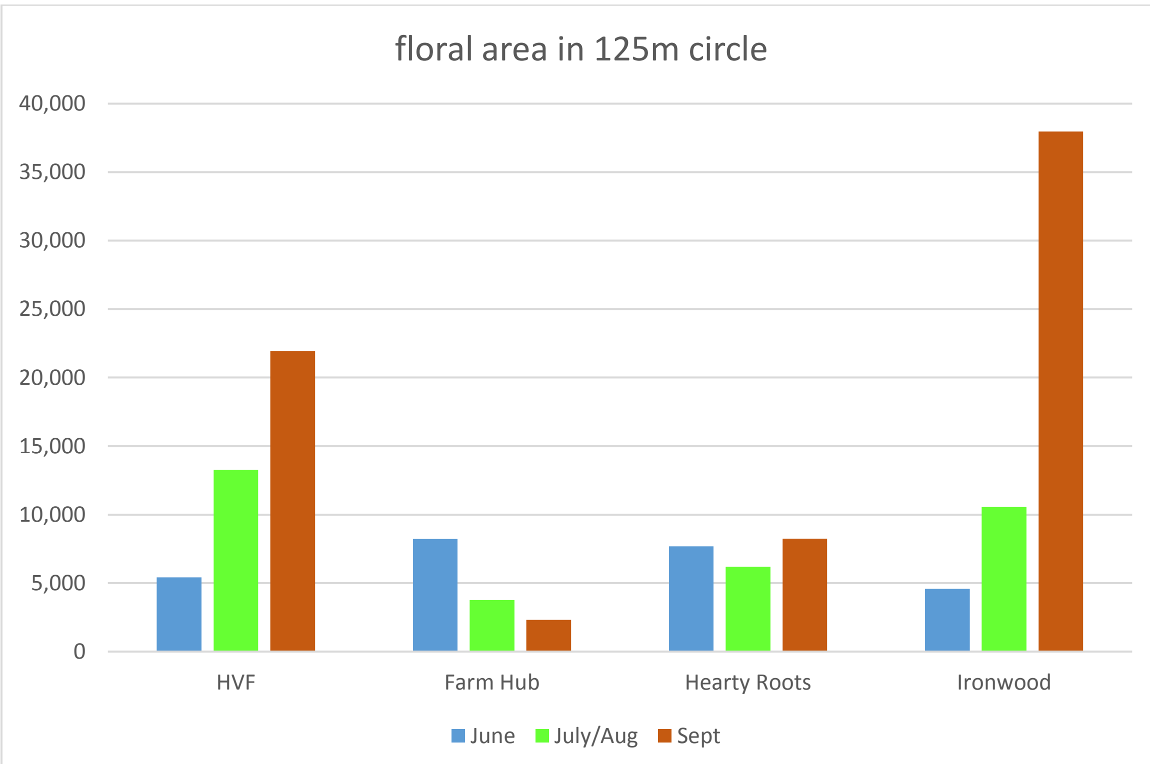

Figure 1: Total floral area within 125m from the crop (vegetable) fields at the four farms throughout the growing season. Values reflect the average total floral area (in mm^2) within the circular sampling plots of 3 feet radius, weighted by the relative area of each habitat within 125m of the vegetable fields.

The differences in habitat composition between the farms are illustrated in see Fig. 4 and the relative contribution of flower area by different habitats throughout the growing season is illustrated in Fig. 8 and discussed in the accompanying text.

<u>Which flowers were most important during each part of the growing season</u>? Again, before considering any habitat modifications, it is important to know the status quo.

Figure 2 details the groups of flowers (defined in the METHODS above) and their relative abundance at the four farms throughout the growing season.

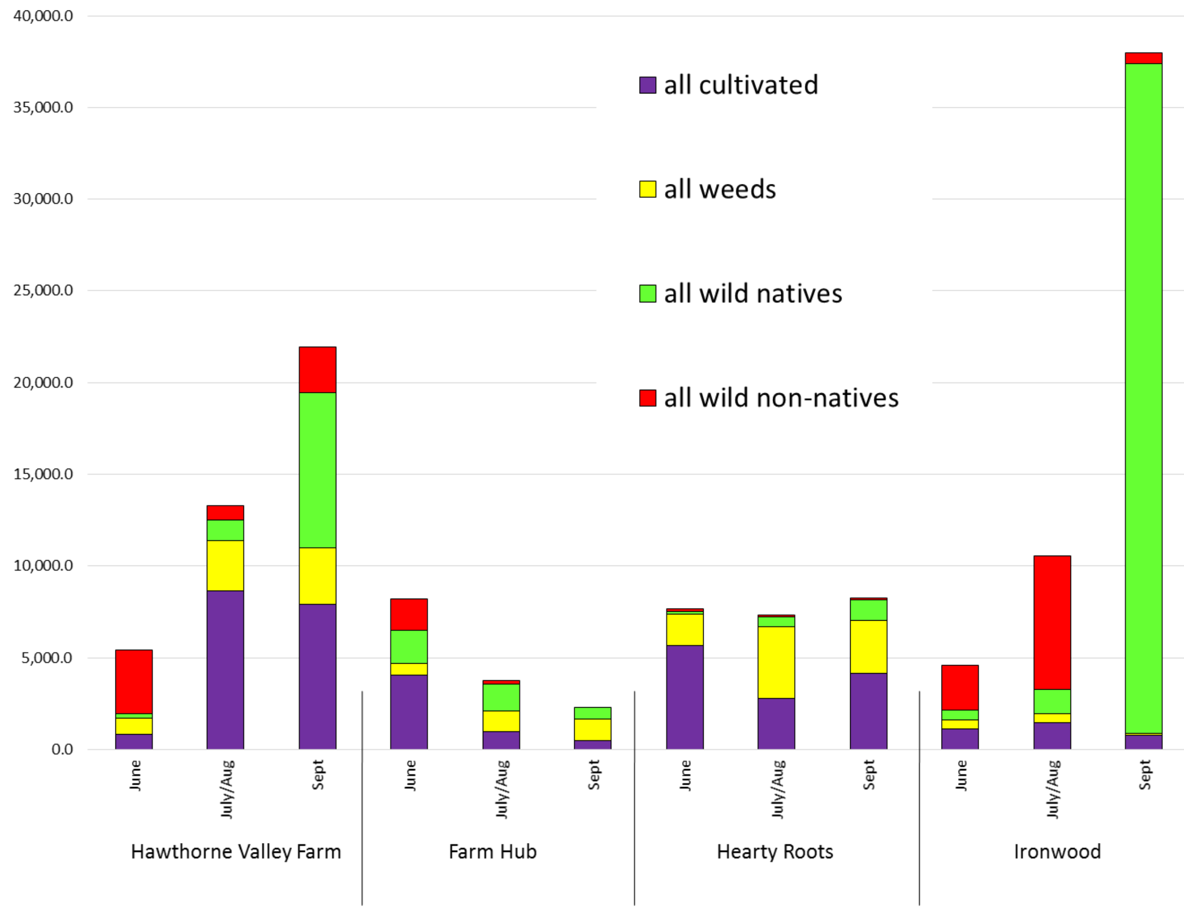

Figure 2: Total floral area by plant groups (defined in the METHODS) within 125m from the crop fields at the four farms throughout the season.

While cultivated plants provided at least half of the flowers at the Farm Hub (mostly Red Clover) and Hearty Roots (Tomatoes and White Clover) in June, they became relatively and absolutely less important later in the season, whereas cultivated plants (mostly White Clover) blossomed profusely in July/Aug. and September at Hawthorne Valley. Weeds (mostly Galinsoga) provided a considerable proportion of the flowers in July/Aug and September at Hearty Roots, and—to a lesser degree—at Hawthorne Valley. Non-native wild plants provided most of the flowers at Hawthorne Valley in June (e.g., Ground-ivy) and at Ironwood in June (Common Bedstraw, Ox-eye Daisy, Annual Fleabane) and July/August (Wild Carrot, Brown and Spotted Knapweed, Annual Fleabane), while native wild plants (asters s.s. and goldenrods) provided the bulk of flowers at Ironwood and, to a lesser degree, at Hawthorne Valley in September.

<u>Was there a difference in the overall flower diversity at the four farms throughout the growing season</u>? Because we didn't yet know if insect captures were more dependent on flower abundance or flower diversity, we documented both.

The overall flower diversity at the four farms throughout the growing season is shown in Fig. 3.

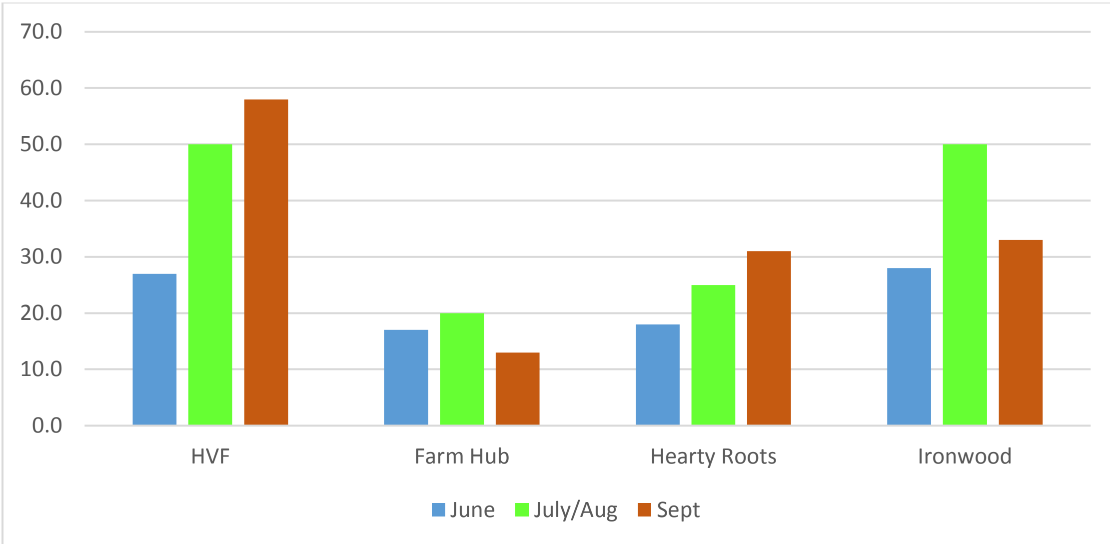

Figure 3: Overall flower diversity (number of all species in flower documented in the sample plots within 125m radius from the vegetable fields) at the four farms throughout the seasons.

While there was a tendency for the flower diversity to increase during the growing season, two of the farms actually had fewer species in flower in September than in mid-summer. There also seemed to be a marked difference in average flower diversity between the farms.

<u>Is flower diversity related to landscape diversity</u>?

Figure 4 shows the aerial views of the vegetable fields on the four farms studied. It also shows for each farm the habitat units within 125m radius of the center of the cropfield studied (note, at Hearty Roots, we delineated three circles of 125m radius).

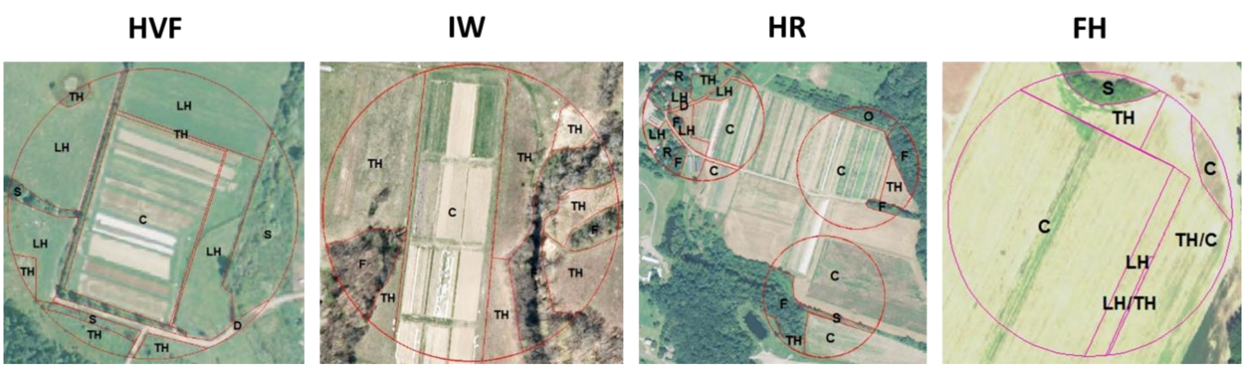

Figure 4: On-farm habitats within 125m radius of the crop fields at the four farms. The habitats were c=crop (vegetables); LH=low herbaceous; TH=tall herbaceous; S=shrub; F=forest; R=residential; D=developed (farm road & yard). Note that there was considerable variation within each of these categories. For example, low herbaceous habitat at Hawthorne Valley Farm was mostly pasture, at Hearty Roots it was closely mowed lawn, and at the Farm Hub a closely mowed headland. Tall herbaceous habitat at Hawthorne Valley Farm was a wet meadow dominated by Reed Canary Grass, at Ironwood it was represented by wet meadows of different vegetation composition as well as old fields of different successional stages, at the Farm Hub it was a Red Clover field.

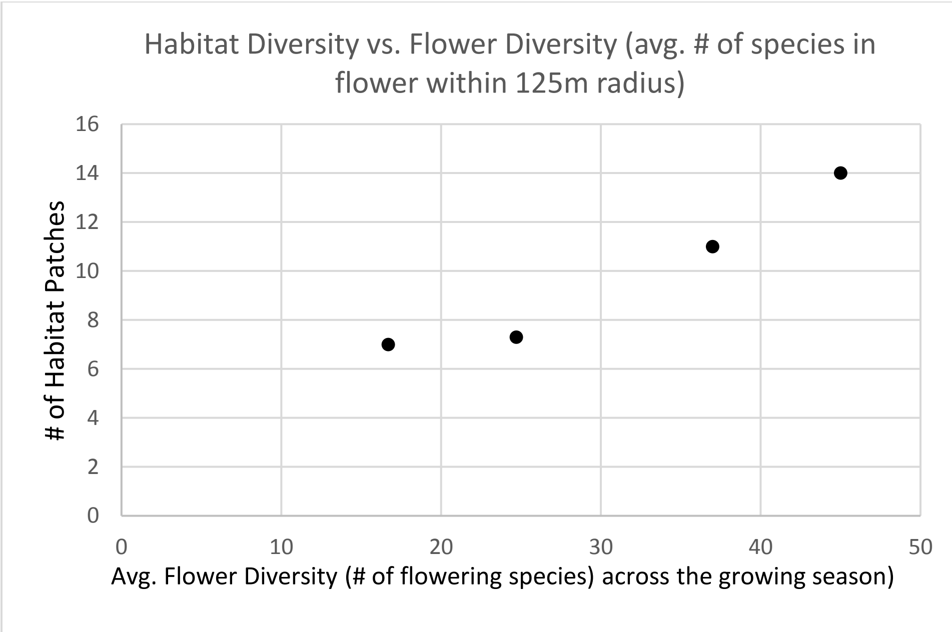

Figure 4a: Scattergram of habitat diversity vs. flower diversity within 125m circles at four farms.

A rough measure of landscape diversity (number of habitat patches within the 125m circle) was significantly positively correlated with average (across the growing season) flower diversity (Fig. 4a; R^2=0.94; p=0.031).

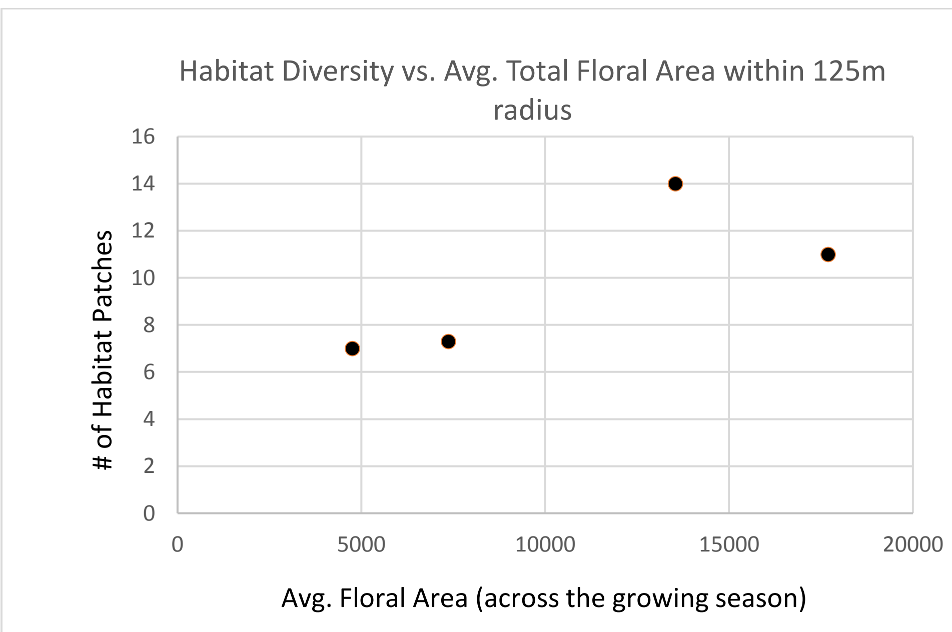

Figure 4b: Scattergram of habitat diversity vs. avg. total floral area within 125m circles at four farms

The correlation between landscape diversity and average floral area was also positive, but not as tight and not statistically significant (Fig. 4b; R^2=0.6; p=0.227). Given the fact that these correlations are based on only four data points, they should be taken as a preliminary result, but there clearly seems to be a tendency for a more diverse landscape to result in more diverse flower communities and, to a lesser degree, in higher floral area.

<u>Did flower diversity and abundance (floral area) differ between on-farm habitats</u>?

Figure 5 compares the average beta-diversity of flowering species (June-Sept.) in the four habitats where the insect traps were located at each farm.

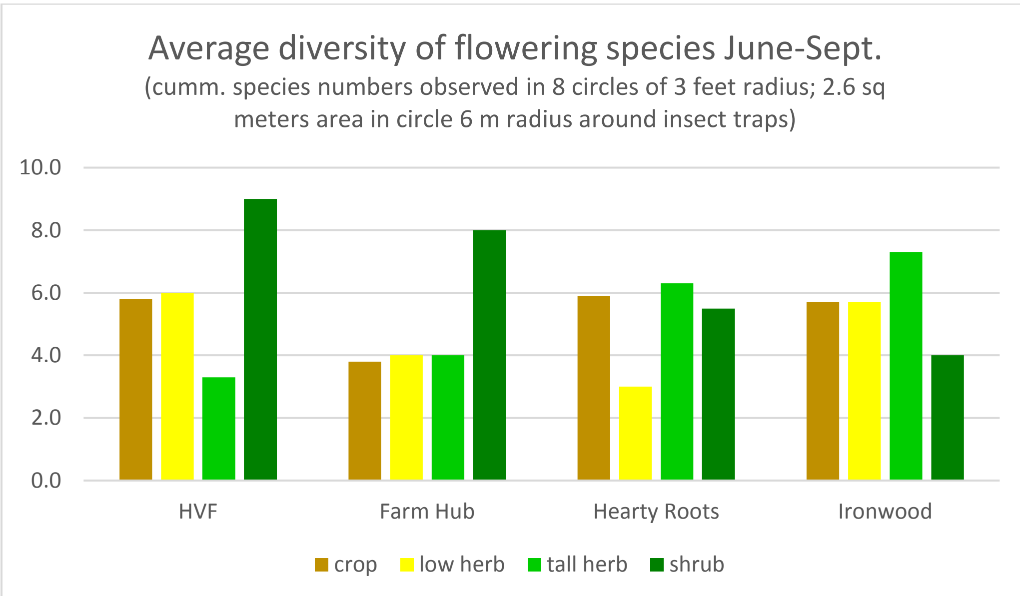

Figure 5: Comparison of the average beta-diversity (across growing season) of flowering species in four habitats at the four farms

While flower diversity might have been somewhat higher in shrubs and/or tall herbaceous vegetation, than in crops or low herbaceous vegetation, the differences were not striking. However, the flower abundance (floral area) was clearly higher in shrub and tall herbaceous vegetation (combined) than in crops and low herbaceous vegetation (combined) on three of the farms (Figure 6). HVF was the exception, because the tall herbaceous vegetation was a wet meadow dominated by Reed Canary Grass with very few flowers interspersed.

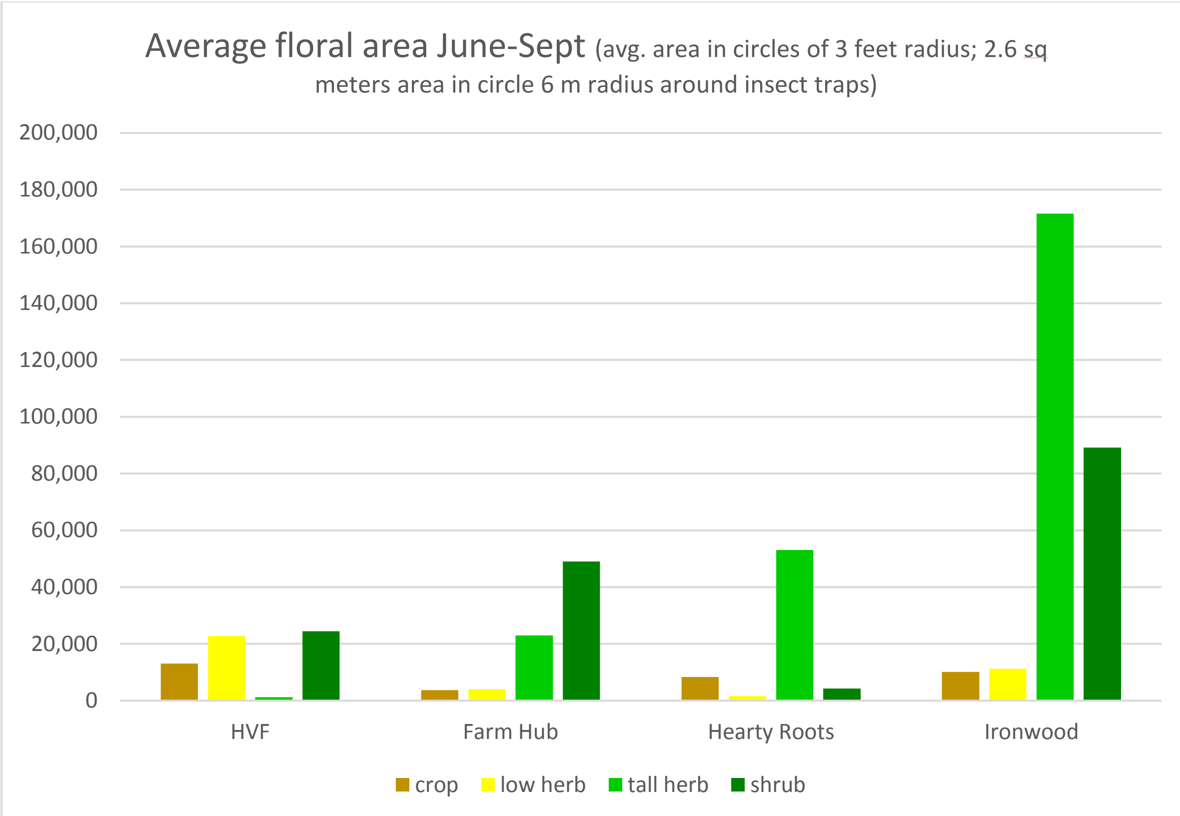

Figure 6: Comparison of the average floral area (across growing season) in four habitats at the four farms

What was the seasonal pattern of flower abundance (floral area) in the four habitats?

Figure 7 separates the seasonal patterns within the data shown in Figure 6 and indicates the species that make up the bulk of flowers at certain times in certain habitats. It becomes obvious how very variable the floral area is across farms and seasons, and how variable the plant communities that provide most of the flowers are.

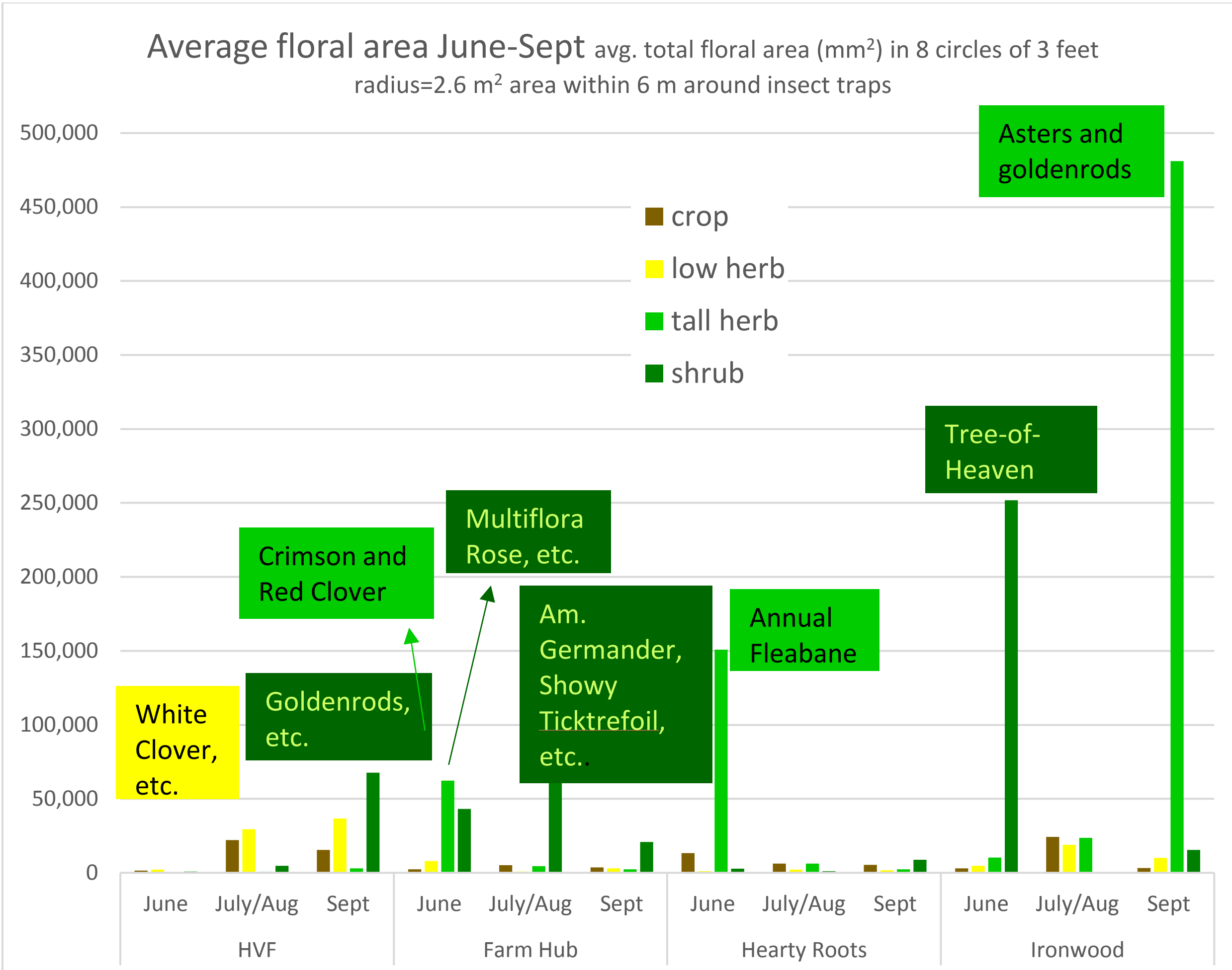

Figure 7: Comparison of the seasonal variation in floral area in four habitats at the four farms

<u>How did floral area change across the landscape at each farm during the growing season?</u>

Figure 8 shows the same aerial views of the four farms already presented in Fig. 4. Average floral area is color-coded with green colors indicating no (dark green) or few (light green to yellow) flowers, and increasing intensity of orange to red indicating more flowers. This illustrates the spatial and temporal dynamics of floral area within the farms. For example, all farms had only small areas of abundant flowers in June, but those areas were markedly different habitats (shrubby riparian corridor at Hawthorne Valley Farm, hedgerow and Red Clover fields at the Farm Hub, old fields at Ironwood, and the vegetable fields at Hearty Roots). In mid-summer, floral area was low across the habitats at Hearty Roots and Farm Hub (with the tiny exception of a hedgerow and adjacent Red Clover patch), while most of the old fields at Ironwood and both, the vegetable garden and the pastures at Hawthorne Valley Farm had a high floral area. In the fall, floral area increased again in the shrubby riparian corridor and remained high in the vegetable garden and most pastures at Hawthorne Valley Farm, increased on some of the old fields at Ironwood, but stayed low at the Farm Hub and Hearty Roots (with the exception of the cut flower beds).

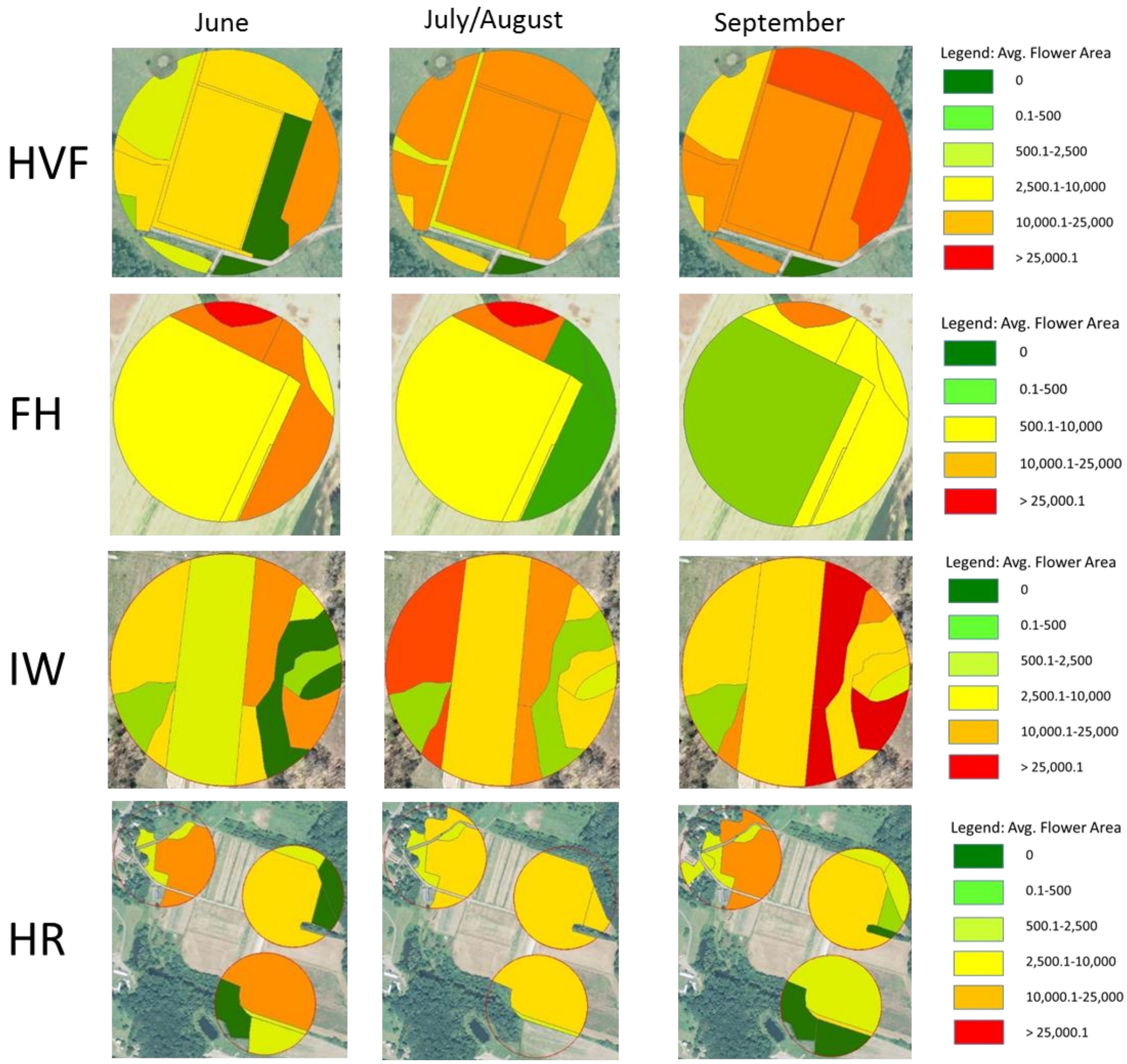

Figure 8: Seasonal changes in average floral area within on-farm habitats. Please see Fig. 4 for identification of the habitats.

<u>Finally, a methodology question: Was there a correlation between flower diversity and abundance (floral area)</u>? This is of interest in considering the most appropriate/efficient measure of flower availability for future studies; tallying flower diversity takes significantly less time than tallying floral area.

At first sight, overall flower diversity and floral area within the 125m circle don't seem to be significantly correlated (Fig. 9), with an R^2-value of 0.4825 (p=0.1122).

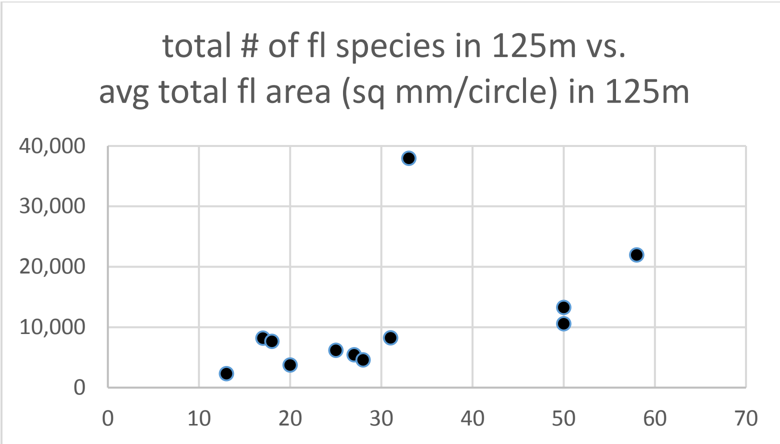

Figure 9: Scattergram of flower diversity (data depicted in Fig. 3) vs. floral area (data depicted in Fig. 1) within 125m radius of the crop fields at four farms in three seasons.

However, if the data point from Ironwood in September (when a few species of asters and goldenrods produced prolific flowers) is removed, the remaining data result in a strong positive correlation of flower diversity and floral area, with an R^2-value of 0.850 (p=0.0009).

There was absolutely no correlation of floral area and alpha diversity (average number of flowering species in eight sampling plots around each trap) or beta diversity (cumulative number of flowering species in the eight sampling plots) at the smaller scale around the insect traps (R^2-value=0.140; p=0.6636 for alpha diversity; R^2-value=0.193; p=0.5481 for beta diversity).

However, beta diversity (and--to a lesser degree--alpha diversity) at the trap level were somewhat positively correlated with the overall diversity of flowering plants within a radius of 125m from the crop fields (R^2-value=0.7673; p=0.0036 for beta diversity, Fig. 10; R^2-value=0.7342; p=0.0065 for alpha diversity).

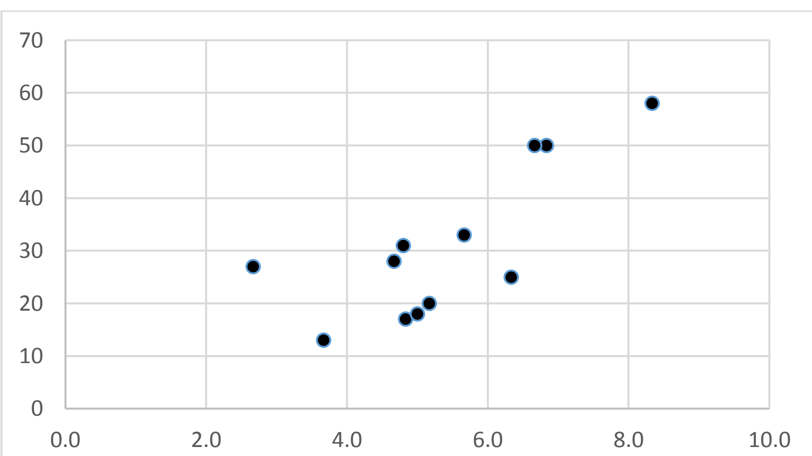

Figure 10: Beta diversity of flowering plants at the trap level vs. overall diversity of flowering plants within a 125m radius around the crop fields of four farms in three seasons.

While floral area at the trap level and within a 125m radius from the crop fields seemed somewhat positively correlated (R^2-value=0.7682; p=0.0035), once the outlying data point from Ironwood in September is removed there is no correlation whatsoever between the floral area at the trap level and that within a 125m radius (R^2-value=0.190; p=0.5799) (Fig. 11).

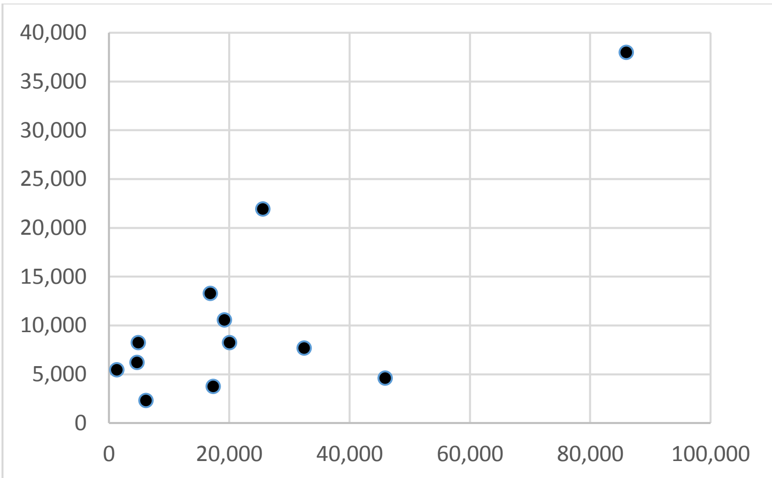

Figure 11: Floral area within 125m radius from the vegetable fields vs. floral area around the insect traps at four farms during three seasons.

While the different measures of flower diversity—both at the trap level, as well as within the larger radius of 125m--all correlated quite well with each other, the average floral area at different spatial scales varied considerably. Furthermore, the relationship between flower diversity and floral area at the same spatial scale seemed complex. Generally, a higher diversity of flowering species in the larger landscape was significantly positively correlated with a higher floral area; however, this correlation was weakened by the presence of dense patches of extremely prolific bloomers (such as goldenrods in late fall). In our 2017 insect samples, the abundance of several insect groups had a significant correlation with the floral area of certain plants. However, we did not find any significant correlations between insect abundance and flower diversity (we have not tested for correlations between insect *diversity* and plant diversity). Therefore, it seems prudent to continue to document not only the diversity, but also the abundance of flowers. To simplify the documentation of flower abundance in the long run, we are considering to rank the flower abundance in 4 or 5 classes, rather than attempting to count/estimate flower numbers in order to calculate floral area.

CONCLUSIONS

- Flower abundance (measured as floral area), diversity, and species composition varied considerably between the four farms, throughout the growing season, and between on-farm habitats.
- However, a handful of species, most markedly Red and White Clover, Galinsoga, Annual Fleabane, provided much floral area at all farms and throughout the growing season.

- The floral areas of Red Clover and Fleabane, asters s.l. (Asteraceae), and mustards s.l. (Brassicaceae) were positively correlated with the abundances of bees, wasps, and hoverflies, respectively, in our 2017 data (see accompanying insect report). However, neither total floral area (all species combined), nor flower diversity were good predictors of insect abundance. Future research will show to what degree these plant-beneficial correlations are valid at more farms and in different years.
- Shrubby areas and tall herbaceous vegetation generally provided more floral resources (higher floral area) than cropfields or low herbaceous vegetation.
- Landscape diversity correlated positively with flower diversity and, to a lesser degree, with flower abundance (floral area) in our, admittedly small, sample of four farms. This supports the idea that landscape diversity not only provides a variety of habitats for overwintering, breeding, and general shelter for beneficial insects (as noted in our insect report), but, by harboring a larger diversity of flowers, such diversity also has the potential to provide flower resources over a longer and more continuous period of time.
- Flower diversity and abundance were generally positively correlated within the farmscape (125m radius around the vegetable fields), with the exception of one farm where few profusely blooming fall wildflowers defied that pattern. We did not find a good correlation of flower diversity and total abundance at the local scale (around the insect traps), where often one or a few species provided many flowers. Nor was there a good correlation between the flower abundance at the local scale and in the larger farmscape.
- In future work, we will focus our efforts on documenting the flower diversity and abundance at the scale of the farmscape (not at the field or bed scale), and we will continue to asses floral area, because it proved to be a much better predictor of insect abundance in our 2017 data than flower diversity.
- The positive correlations of the abundance of some beneficial insect groups with the abundance of certain flowers encourages us to promote on-farm management that results in increased flower abundance, be it through less frequent mowing of field margins and semi-wild areas, or through planting of perennial wildflower areas or the integration of annual insectary strips/flowering cover crops within the crop rotation.
- Flower watches will help get a better handle on the relative importance of different flower species for different insect groups on farms.

ACKNOWLEDGEMENTS

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