PROJECT DETAILS

- **Title**: Surveillance networks for beneficial insects: can natural habitats serve as insect reservoirs, and do they contribute to canola yield?
- **Funders:** Manitoba Canola Growers, SaskCanola and Albert Canola
- **Research program:** Canola Agronomic Research Program (CARP)
- **Principal investigator:** Paul Galpern
- **Collaborators/additional investigators:** Jessamyn Manson, Monica Kohler, Jess Vickruck
- **Year completed:** 2020

Final report

Development of a beneficial arthropods database
This project produced what is likely to be the most geographically-extensive database on the distribution and abundance of beneficial arthropods found in Canadian prairie croplands**.** This database is being further analyzed as part of the second phase of the Beneficial Insects Surveillance Network funded by the Canola Agronomic Research Program (CARP).

Key features of this database are summarized in Table 1. Figure 1 indicates the distribution of sampling. Figure 2 summarizes the abundance and the diversity of beneficial pollinators, including honey bees and wild bees. Figure 3 summarize the abundance of beneficial predators that may be natural enemies of crop pests. The database will be made available for download by canola growers when all network second phase analyses have been completed.

Find more information on this project and many other relevant canola studies on the **Canola Research Hub.**
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Table 1. Database summary. Arthropods sampled, curated and databased since 2016 where collection and/or taxonomic work was supported, in whole or in part, by Canola Agronomic Research Program funds. Sampling data is summarized by collection near fields (Margins), at multiple distances from pivot corners (Pivots) and at multiple distances from wetlands that were surrounded either by crop fields or grasslands. These data are provided, here, primarily as an indication of sampling, curation and taxonomic identification effort.

		Abundance by site type				*Species richness[1] by site type*				*Unique locations by site type*			
Order	**Family**	**Total**	**Margins**	**Pivots**	**Wetlands**	**Total**	**Margins**	**Pivots**	**Wetlands**	**Total**	**Margins**	**Pivots**	**Wetlands**
Spiders	Lycosidae	10841	8067	636	2138	28	27	18	20	113	86	10	17
	Thomisidae	501	352	49	100	14	13	7	6	91	67	9	15
Harvestmen	Phalangiidae	8909	2010	566	6333	1	1	1	1	57	36	8	13
Bees	Andrenidae	8105	4985	179	2941	48	39	15	26	258	200	10	48
	Apidae	101053	67140	7594	26319	116	102	37	70	317	246	10	61
	Colletidae	561	480	13	68	24	18	5	17	137	108	5	24
	Halictidae	22904	13518	1857	7529	90	77	30	55	316	245	10	61
	Megachilidae	4533	3234	567	732	97	83	22	61	303	234	10	59
Beetles	Carabidae	10657	2683	5152	2822	57	33	35	45	163	116	10	37
	Totals	157407	99786	11461	46160	418	360	135	256	317	246	10	61

[1]Rarer species of bees (fewer than 10 individuals) are typically identified to the genus or subgenus level and are counted here as morphospecies.

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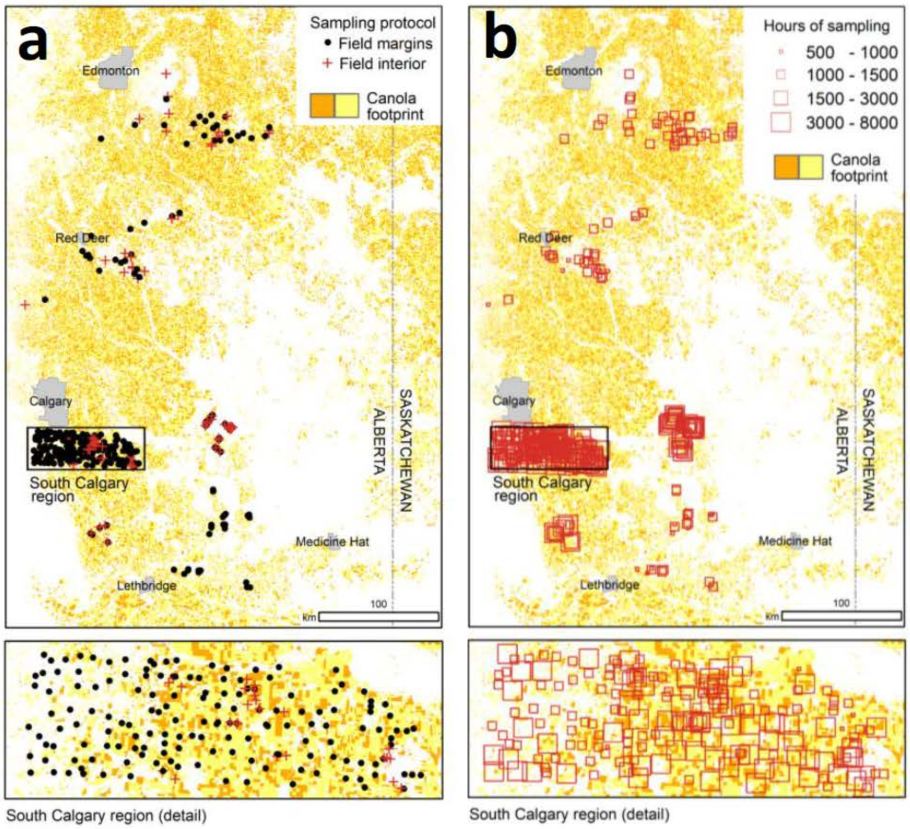
Figure 1. Sampling locations that represent the Beneficial Insect Surveillance Network. (a) Sampling occurred between 2016 and 2018 at 317 locations, with sites located at field margins or within the crop itself. (b) Passive trapping equipment was used, and resulted in 500 to 8000 trap-hours of sampling effort at any given site. Trapping occurred most often in a single year, but sometimes in two or three consecutive years.



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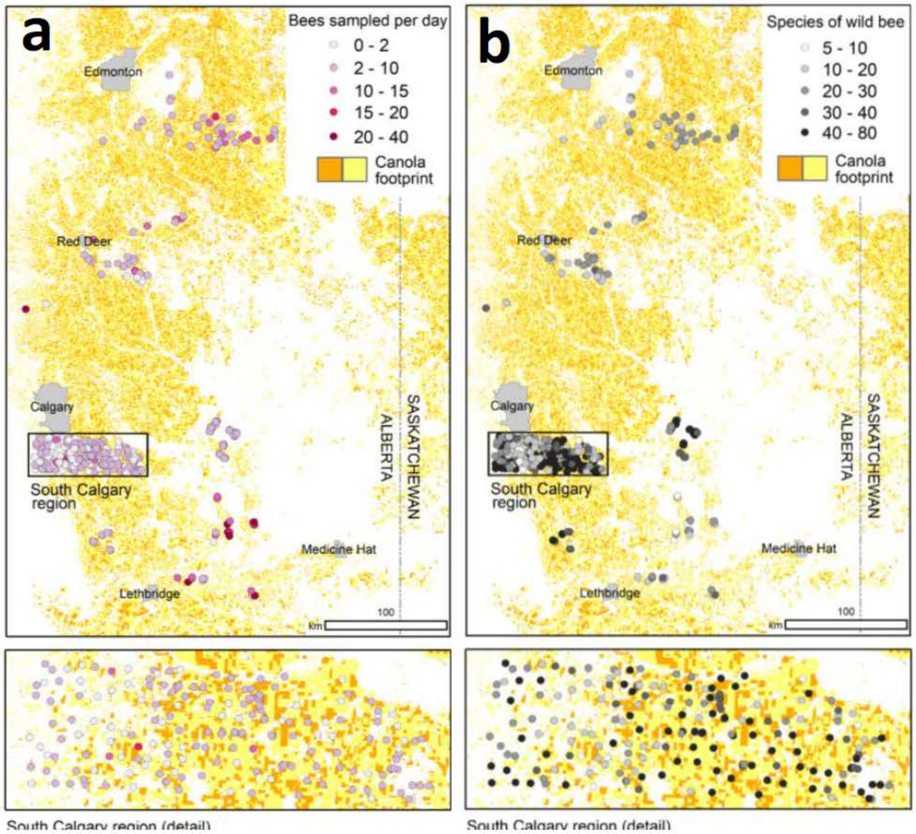

Figure 2. Beneficial pollinators sampled by the Beneficial Insects Surveillance Network, demonstrating wild bees are found in canola field interiors and margins and use this habitat for nesting and collecting pollen. (a) Pollinators, such as wild bees, were collected with varying abundance across all sites sampled. (b) Some sites recorded up to 80 different species of bee.

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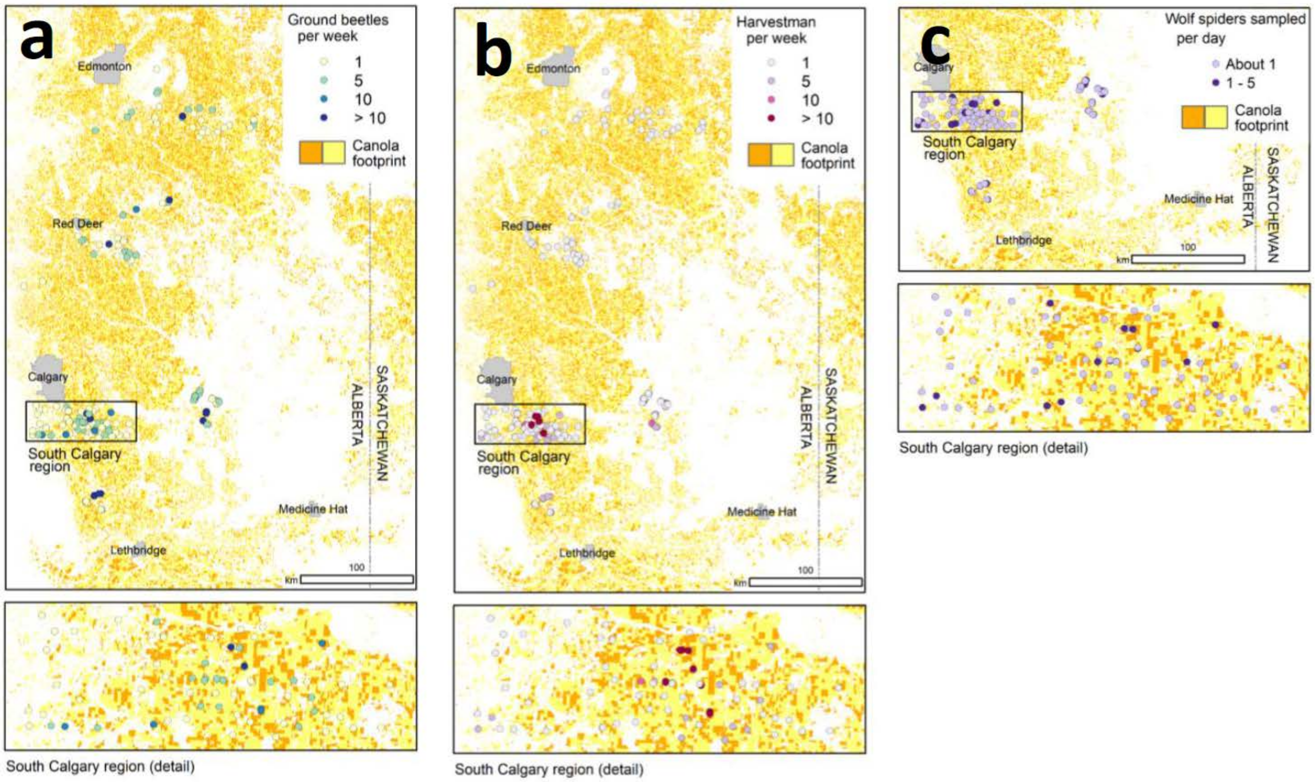
Figure 3. Natural enemies of crop pests sampled by the Beneficial Insects Surveillance Network, demonstrating (a) ground beetles, (b)harvestmen, and (c)and wolf spiders use field margins and field interior habitats where they are in a position to provide pest control services to canola crops.



Key findings

1. The network identified approximately 375 species of wild bees in or near Alberta canola fields. This is in addition to the managed honey bee, *Apis mellifera* and managed alfalfa leafcutter bee, *Megachile rotundata,* also recorded in canola fields. ▪ Many of these bee species were rare, and are unlikely to play any economically-important role in canola pollination. Fifteen species were found at 50% or more of the 313 sites sampled, suggesting that there are a core group of bee species that are widely-distributed and abundant and therefore should be considered the most probable visitors to canola flowers during bloom. The study did not examine flower visitation by these species, however.

2. The network identified at least 42 species of the most common spiders in or near Alberta canola fields. There were dozens of rarer species in canola fields that were not identified taxonomically. ▪ Two species of wolf spider were notably abundant and widely-distributed. *Pardosa distincta* was most common and found at 98%

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of the 125 sites sampled, while *Pardosa moesta* was second most common and found at 67% of sites.

3. The network identified at least 57 species of ground beetles (in the family Carabidae). There were a small number of rarer species in canola fields that were not identified taxonomically. ▪ The ground beetle *Pterostichus melanarius*, was the most abundant and universal in distribution. It was sampled both in field interiors and margins.

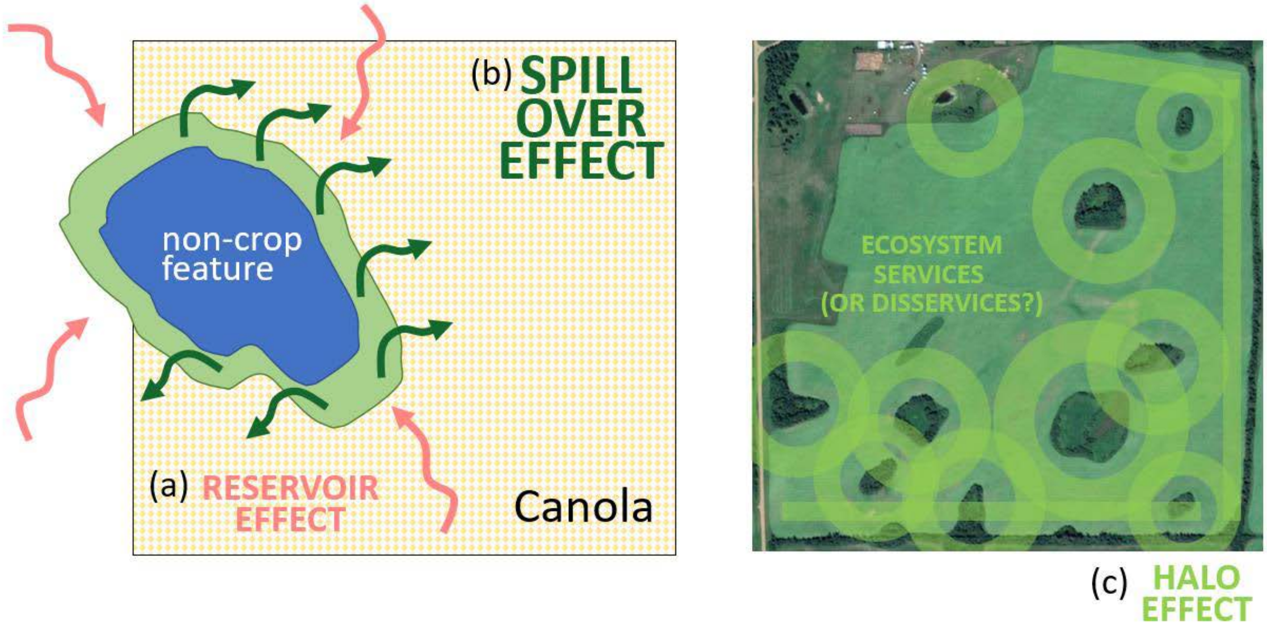

Figure 4. Three hypothesized effects that together would demonstrate a role for beneficial arthropods in supporting canola yields. Evidence for all three effects was recorded in the first phase of the network. (a) A reservoir effect (pink) implies that beneficial arthropods use non-crop features as habitat to support their life cycle, throughout the growing season or at specific times of the year. (b) A spill-over effect (dark green) implies that beneficial arthropods are more abundant within and near to a non-crop feature and that this abundance drops off with distance from the feature; this drop off implies that these features are also hotspots for these animals in the agricultural landscape. (c) A halo effect (light green) implies that any beneficial arthropods spilling over from a feature are providing ecosystem services (e.g. pollination or pest control) or ecosystem disservices (e.g., pests) to the crop, and this is revealed in a localized difference in crop yields. The “halo” of increased or decreased yield, however, may also be caused by non-living processes such as soil moisture or shading.

4. Non-crop areas within or near to fields are likely to serve as a source as well as a destination for beneficial arthropods at different times of the season (Robinson et al, submitted; see Section C). This date-dependent

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reservoir effect (Figure 4, a) was observed in multiple taxa. For example: ▪ The ground beetle *Pterostichus melanarius* appears to migrate to canola during the early summer (May-June), then migrates to nearby grasslands and wetlands around harvest time (late August)

▪ The wolf spider *Pardosa moesta* also moves to canola during the early summer, but migrates to nearby road margins and grasslands at the end of the growing season
▪ Several species of bumble bee (e.g., *Bombus ternarius*) tend to be found more often in uncultivated wetland margins later in the summer than in field margins, perhaps representing a shift in the availability of flowers.

5. Non-crop areas may often serve as hotspots for beneficial arthropods that spill over into canola fields, where they have the potential to provide services to canola growers such as pest control and pollination. This *spill-over* effect (Figure 4, b) into crop was tested specifically for wild bee species near wetlands in canola fields (Vickruck et al., 2019; see Section C). The trapping rate of wild bees was nearly twice as high at a wetland margin than it was at traps located at a distance of 75 m into the field from the wetland. ▪ This drop-off in trapping rate suggests that wetlands may be localized hotspots within a field, either because bees are attracted to flowers growing in uncultivated buffers near the wetland, or because bees nest there.
▪ A spillover effect implies that the chance of a pollinator visiting a canola plant increases when it is closer to a non-crop area like a wetland or a field margin. Our study did not directly measure pollinator visitation nor did we link this visitation directly to the productivity of a canola plant.

6. A correlational study of 60 million seeded acres of yield data in Alberta obtained from Agricultural Financial Services Corporation (AFSC) showed that counties in Alberta where fields tend to contain more non-crop areas also have slightly higher canola yields (Galpern et al, 2020; see Section C). This statistical effect was observed while controlling for climate and soil differences observed across the province, and correcting for annual trends in yields between 2012 and 2017. ▪ This should be considered preliminary and indirect evidence for a *halo effect* (Figure 4, c). The cause of this effect remains uncertain. Among the possible causes are: (i) pest control or pollination services provided beneficial arthropods that use non-crop features as reservoirs and spillover into fields, and (ii) soil moisture or shade that may vary in proximity to non-crop areas within fields.

▪ The size of the increase in yield observed was small. The observation of any increase at all, however, implies that negative effects of non-crop areas in fields on yield, such as reservoirs for pests or weeds, are not the dominant effect across Alberta's canola fields.

▪ A correlational study at this scale reveals very broad trends, and is a first step to accurately measuring the size and agronomic importance of a non-crop area effect on yield. More localized studies are needed to understand the specific effects of non-crop areas on yield in a particular grower's field, as these are likely to depend on many factors. The second phase of the network, funded by CARP, begins such a study.

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7. The *halo effect* was also tested experimentally in a study of five canola fields. In this experiment, cages were used to keep beneficial arthropods out, and the difference in canola plant productivity was measured inside and outside the exclosure at three distances from a wetland. ▪ This pilot study suggested that it was only at intermediate distances from a wetland (e.g., Figure 5; 75 m) that plants had heavier seeds outside the exclosures than inside.

▪ A hypothesized mechanism for this effect is that the spill over of bees near wetlands visiting canola flowers is increasing seed size, but an edge or soil moisture effect that reduces canola productivity is counteracting the positive effects of pollination at distances closer to the wetland. The absence of natural enemy species may also have played a role in the lower yields observed under the exclosure.

▪ The pilot study is being repeated over three years in an additional nine canola fields as part of the second phase of the network.

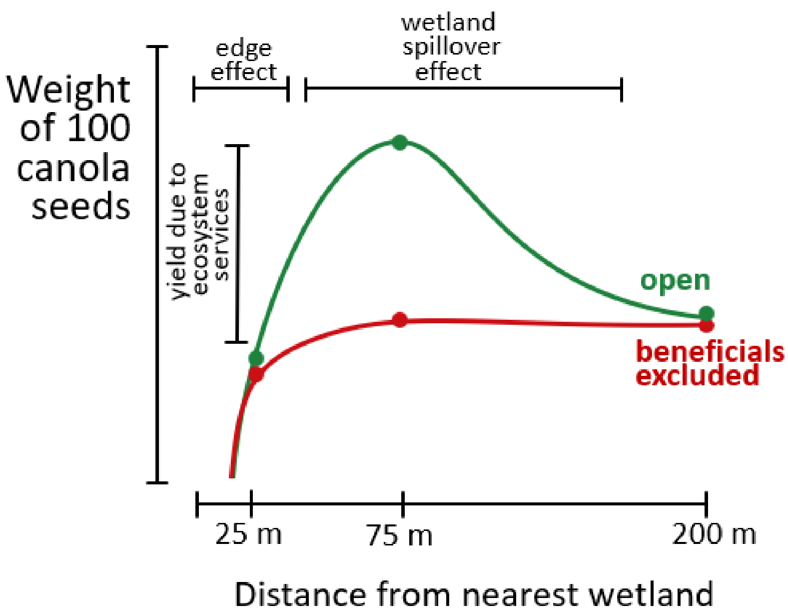

Figure 5. A stylized representation of the results from a pilot study of five fields, where pollinators and other beneficials were excluded using cages, and yield was compared inside (red) and outside (green) of the exclosure at three distances from a wetland. The small boost in yield observed in the pilot study at an intermediate distance (75 m) is being confirmed in the second phase of the network.

8. Different species of arthropod at our study sites have peaks in abundance at different times of the growing season. Growers are advised to think about pollination or pest control services in terms of a portfolio of

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different species providing services at different times of the growing season, rather than in terms of a single pollinator or natural enemy species that should be encouraged to visit the crop. For example:

▪ Maintaining non-crop areas that provide habitat for a diverse community of insects and spiders which together have peaks in abundance at different times of the season is likely to maximize the chance that at least one pollinator species is abundant when canola is in bloom, or a natural enemy species is available to respond to a pest outbreak.

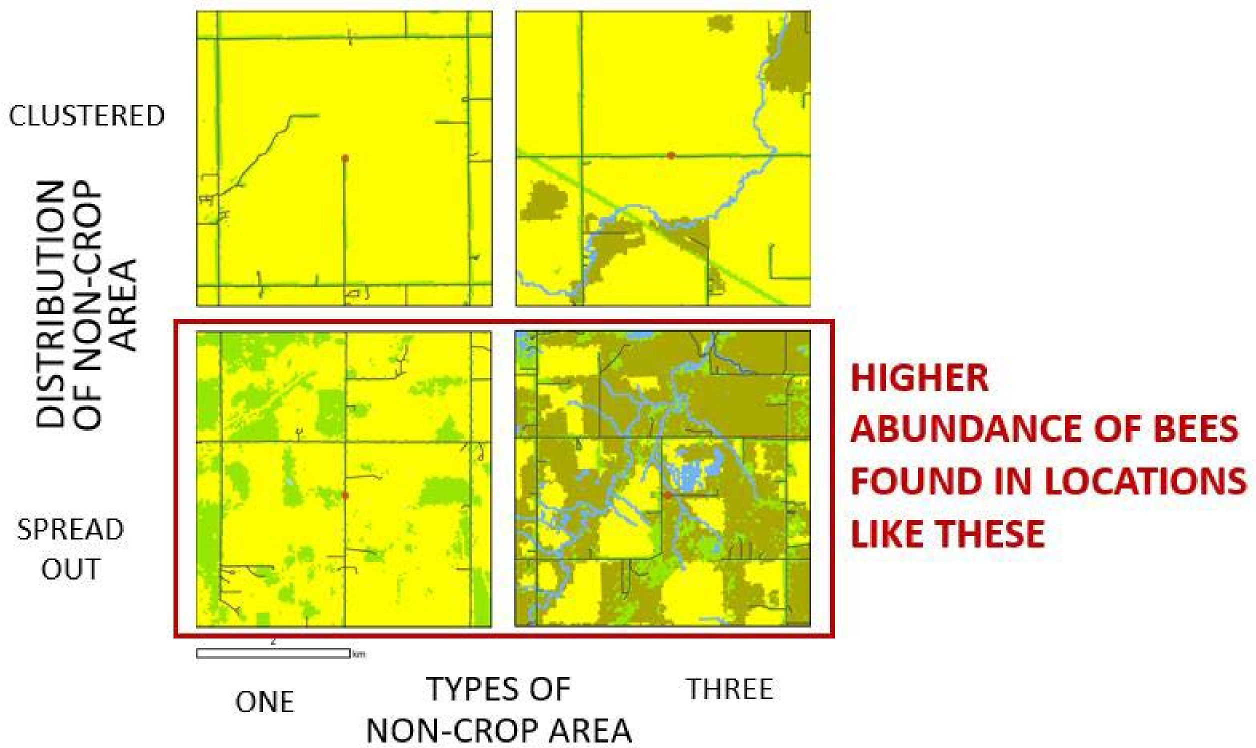

Figure 6. More complex landscapes, such as those in the lower two images, that have a spread-out distribution of non-crop area, are likely to host a higher abundance of bees. This effect may be due to landscape complementation, where different types of non-crop area complement one another by providing resources that together support the life cycle of the bee species studied. Yellow in these images are crop fields, while other colours indicate non-crop areas such as pasture, shrublands, wetlands, and intermittent stream courses. A manuscript detailing this work is in preparation.

9. Study locations that had smaller patches of non-crop area where these were distributed more evenly within and near fields had higher abundances of many bee species (Figure 6; Galpern et al., in preparation). ▪ This could be caused by an effect known as landscape complementation. It may be helping

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beneficial arthropod increase their population sizes, by allowing them to move between crop and non-crop areas to complete their life-cycles.

In other words, different types of non-crop features are complementary with one another and the crop itself, and when they are all available in close proximity, a higher population size is supported.

▪ Growers can take advantage of the landscape complementation effect by retaining many small non-crop areas within and near their fields. This effect is likely to be stronger rather than fewer larger areas that are not evenly distributed.

▪ Evidence suggests this effect exists for pollinator species. It may also exist for natural enemies such as spiders and beetles. Tests for these groups will be reported in the second phase of the network.

Related Publications

Pothole wetlands provide reservoir habitat for native bees in prairie croplands (*Biological Conservation*, 2019; v232, pp. 43-50)
Jess L. Vickruck, Lincoln R. Best, Michael P. Gavin, James H. Devries, Paul Galpern

Landscape complexity is associated with crop yields across a large temperate grassland region (*Agriculture, Ecosystems and Environment*, 2020; v290, 106724)
Paul Galpern, Jess Vickruck, James H. Devries, Michael P. Gavin

Non-crop sources of beneficial arthropods vary within-season across a prairie agroecosystem (Submitted for publication)
Samuel V. J. Robinson, Diane Edwards, Jess L. Vickruck, Lincoln R. Best, Paul Galpern

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