Battle River Research Group

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OVER THE FENCELINE

Winter 2025

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Vision

Improving sustainability through innovation in agriculture

Mission

To perform high-quality producer-driven research & knowledge transfer for the advancement of all agriculture stakeholders

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PRESIDENT'S NOTE

Donald Kroetch

The Battle River Research Group (BRRG) continues its mission to promote sustainable agricultural practices, environmental stewardship, and scientific research in the Battle River region. Over the past year, BRRG made significant strides in ongoing projects, fostered collaborations with local and regional stakeholders, and contributed to initiatives focused on climate change adaptation, land health, and rural sustainability.

We are excited to welcome a new team member to BRRG! Ahsan Rajper will be joining us as BRRG's new manager. Ahsan transitions from his role as Research Coordinator at Suncrest College in Yorkton, Saskatchewan. He brings a wealth of expertise and will undoubtedly be a valuable addition to our team, joining Alex Olsen and Kabir Makan in driving BRRG's mission forward. The board is thrilled to begin 2025 with such a talented and dedicated team.

In 2024, BRRG continued its efforts to explore and implement sustainable farming practices. The team conducted several soil health and crop rotation studies aimed at improving land productivity while enhancing sustainability in agriculture.

Partnerships with local farmers were strengthened through workshops and field days, where researchers shared insights into the latest sustainable agriculture techniques and innovations. BRRG also partnered with local schools and educational organizations to engage youth and raise awareness about the importance of agriculture in our region.

The group hosted public workshops and seminars focusing on agricultural innovation, sustainable practices, and emerging technologies. These events, driven by the needs of our producers, helped to bridge the gap between research and practical application.

BRRG successfully secured new funding for research projects through grants from provincial agencies such as RDAR and Alberta Agriculture, federal programs, and private sector partnerships. These funds enabled the group to expand its research on topics critical to local producers.

Looking ahead, BRRG is committed to strengthening its partnerships with agricultural producers to increase the adoption of sustainable practices. Research will focus on pressing challenges such as water management and crop diversification to help farmers adapt to drought conditions. The organization will also place a strong emphasis on new technologies, including precision agriculture tools that provide real-time data to optimize resource use.

Additionally, BRRG plans to broaden its educational programs and workshops to reach a wider audience, fostering connections between rural and urban communities and enhancing awareness of agriculture's vital role.

For more information about BRRG's programs, services, and updates, follow us on social media:

- Facebook
- Twitter
- Instagram
- YouTube

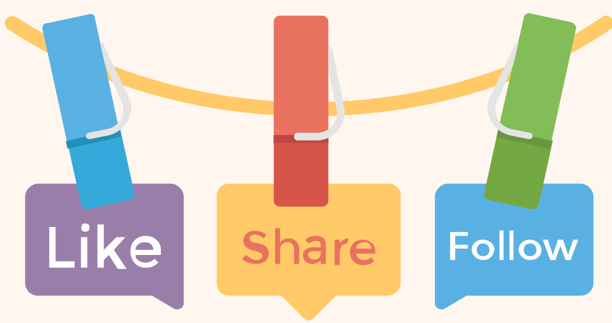
Thank you for your continued support as we work together to advance agriculture in the Battle River region.

Catch Up on Missed & Upcoming Webinars, Seminars

For those who missed any of these enriching events, Battle River Research Group offers the opportunity to catch up on their website here or our YouTube channel.

Stay connected with Battle River Research Group on Twitter: Battle River Research Group
@BRRG_Ag for updates and information about upcoming events.

With a year filled with growth, learning, and community spirit, Alberta's farming community is thriving, and the Battle River Research Group is at the forefront of this growth, continuously enriching the lives of farmers and promoting sustainable agriculture. Here's to a year of growth, learning, and continued success!



SCAN ME

MANAGER’S NOTE

Ahsan Rajper, PhD

I am very excited and privileged to join the Battle River Research Group (BRRG) as your new manager. This opportunity is an honor, and I am eager to contribute to the incredible work that BRRG has been doing as a producer-driven non-profit organization. BRRG’s dedication to supporting agricultural innovation and sustainability has had a remarkable impact across the counties of Beaver, Camrose, Flagstaff, Paintearth, and Stettler. The organization's focus on addressing the evolving challenges faced by producers in our region is truly inspiring, and I am thrilled to play a part in advancing this legacy.

As I step into this role, I am deeply committed to strengthening our applied research programs and aligning them with the needs of our producers. Applied research lies at the heart of BRRG’s mission, and we will continue to focus on practical solutions that deliver measurable benefits to our agricultural community. Among our top priorities will be projects aimed at enhancing soil health, improving crop productivity, and addressing the challenges posed by resource optimization, climate variability, and shifting market demands. By prioritizing these areas, we can help producers build resilient and sustainable farming systems that will thrive for generations to come.

Collaboration is an essential ingredient for success, and I am eager to engage with a diverse network of stakeholders, including producers, industry partners, academic institutions, and government agencies. By working together, we can ensure that our research projects are not only scientifically sound but also practical and relevant to the challenges and opportunities faced by our local agricultural community. I believe in the power of collective expertise and am committed to fostering strong partnerships that amplify our shared impact.

In addition to strengthening our research programs, I aim to enhance BRRG’s outreach and extension efforts. Sharing knowledge and innovation is critical to empowering producers to make informed decisions and adopt new practices with confidence. Through field days, workshops, and training sessions, we will strive to provide producers with the tools and insights they need to implement innovative and sustainable farming practices. Whether it’s through hands-on demonstrations, webinars, or one-on-one consultations, my goal is to ensure that the knowledge generated through our research reaches those who can benefit from it the most.

I am particularly excited to work alongside BRRG’s passionate and talented team. The dedication, creativity, and expertise of this team have been pivotal to BRRG’s success over the years, and I am confident that together we can drive meaningful change. I look forward to collaborating with each of you to achieve great success in our mission to promote sustainability and innovation in agriculture.

Thank you for welcoming me to the BRRG family. I am truly honored to be part of such an incredible organization and am excited about the opportunities that lie ahead. Together, we can continue to build a stronger, more sustainable future for agriculture in our region. I look forward to working with all of you to advance BRRG’s mission and make a lasting impact on our community.

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SCAN ME

ZOOM WEBINAR
PROFITABLE RANCHING

Ken Stewart

Ken Stewart, alongside his wife Jenny and their family, is a dedicated cattle rancher based in Northern Wyoming. With extensive experience managing both large commercial herds and innovative seed-stock operations, Ken focuses on improving the cattle industry through strategic genetics, science-based practices, and practical management. Passionate about ranching, he has developed expertise in optimizing breed composition, phenotype, and EPD profiles for sustainable, high-value production. The Stewarts raise Sim-Angus cattle and market their bulls through the Big Country Genetics Bull Sale while offering female groups privately. Living and working alongside their customers, they are committed to supporting success across the beef industry.

Topics Covered

Encompassing overall philosophy
Replacement Heifer/youngstock development
Grazing out in the winter
Proper low-cost cattle supplementation

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TREED FIELD BORDERS NET-EXPORT OVER 82,000 MORE HOVERFLIES PER KM EVERY WEEK INTO CANOLA CROPS THAN HERBACEOUS FIELD BORDERS, REGARDLESS OF MASS-FLOWERING CROP BLOOM

Rachel Pizante *, John H. Acorn , I. Pilar Jim´enez , Carol M. Frost
Department of Renewable Resources, University of Alberta, Edmonton, Alberta, Canada

ABSTRACT

Hoverflies (Diptera: Syrphidae) provide dual ecosystem services, as the adults act as pollinators and the larvae can be predators of crop pests. Because bloom time is limited in mass-flowering crops, resources within crops for hoverfly adults can also be limited and change temporally. Therefore, hoverflies need to move between crops and their borders. It may be that some field border vegetation types support the provision of hoverflies to crops better than other vegetation types. We sought to determine how field border type (herbaceous vs. treed), canola bloom, and border vegetation structure and composition (border width, canopy cover, grass height, grass cover, plant cover, flower availability, and density of trees, shrubs, snags, stumps, and downed woody debris) affect hoverfly movement into and out of crop fields from field borders. We placed bi-directional Malaise traps in herbaceous and treed field borders at 10 fields seeded with canola, and sampled continuously from May 17 to August 20, 2021 in central Alberta, Canada. We found that field border type affected hoverfly movement such that, across the whole summer, net-export of hoverflies into crops was over 33-times higher from treed field borders (an estimated 84,699 hoverflies per km per week) than from herbaceous field borders (an estimated 2515 hoverflies per km per week). We did not find any single component of the vegetation within treed field borders that explained the difference in movement. We found more hoverfly activity in herbaceous field borders than in treed field borders during and after canola bloom, but that overall activity was equal between field border types prior to canola bloom. Treed borders had greater Hill-Shannon and Hill-Simpson diversity and evenness than herbaceous borders. Throughout the growing season, the community became dominated by Toxomerus marginatus, which drove all temporal trends. We conclude that treed field borders act as net exporters of hoverflies to canola fields and are therefore important features for optimizing the magnitude of the ecosystem services provided by hoverflies in agricultural systems.

Introduction

Hoverflies (Diptera: Syrphidae) are a diverse family of flies that are understudied in agroecosystems given their potential utility to provide two ecosystem services to crops (Doyle et al., 2020; Dunn et al., 2020; Rader et al., 2020). Adult hoverflies visit flowers to access pollen and nectar, which are important resources for egg development and energy reserves respectively, and also to find mates and shelter (Rotheray and Gilbert, 2011). Because they visit flowers, hoverflies can pollinate, and have been shown to contribute substantially to yield in a variety of crops (Doyle et al., 2020; Jauker and Wolters, 2008; Rader et al., 2009). Furthermore, the larvae of some hoverflies, particularly those of the subfamily Syrphinae, are predators of crop pests such as aphids, thrips, and other small, soft-bodied arthropods (Rodríguez-Gasol et al., 2020). Individual larvae have been found to consume upwards of 2000 prey items during their larval stage (Fauteux et al., 2023). Life histories in this family are highly variable, but in our region (Northwestern North America) adult hoverflies typically begin activity in late March and early April when the snow begins to melt, and remain active until October (Skevington and Locke, 2019). Timing of the immature life stages in this region is less well known but is variable across species such that adults are emerging throughout the growing season (Rotheray and Gilbert, 2011; Skevington and Locke, 2019). As such, hoverflies are able to offer dual ecosystem services and efforts to augment their abundance in 2020; Pekas et al., 2020). Surrounding most crops in central Alberta, there exist non-cropped borders that separate the crop from other crops, roads, wetlands, and other landscape features.

These non-cropped field borders exhibit a variety of vegetated states such as herbaceous (dominated by grasses) or treed (dominated by trees and shrubs), and these different field border types house different ecological resources for beneficial insects (Aviron et al., 2023; Purvis et al., 2020). In agroecosystems that lack larger semi-natural areas, these borders provide crucial resources for beneficial insects that cannot be provided by the crops (Blaix and Moonen, 2023; Kells, Holland, and Goulson, 2001). The bolstering of resources provided by these areas can result in greater biodiversity (Martin et al., 2019) and even in increased crop yields (Galpern et al., 2020). Therefore, there are both conservation and economic incentives to not only retain these features on the landscape (Morandin and Winston, 2006), but also to ensure they function optimally for important groups such as hoverflies (Bartual et al., 2019; Dolezal et al., 2022; Ramsden et al., 2015). Hoverflies likely move between field borders and crops at differing rates in each direction, such that hoverflies should move more frequently to the area with more available resources (Incl ´an et al., 2016). Moreover, in order for hoverflies to be effective crop pollinators, they must be active within the crop during bloom, which, for species that are also active outside of the crop, would require moving from field borders into the crop, in a process called spillover (Blitzer et al., 2012; Rand et al., 2006; Zamorano et al., 2020). Given that hoverflies do not return to a nest or colony, the adults are free to move throughout the landscape to access resources (Jauker et al., 2009). Hoverfly movement is therefore likely driven by the availability of resources (Meyer et al., 2009), which will vary depending on the type of field border (Alignier et al., 2014; Burgio et al., 2015; Incl´an et al., 2016; Samaranayake and Costamagna, 2019), the species of hoverfly (Haenke et al., 2009; Miliˇci´c et al., 2021; Rader et al., 2020), and the time of year (Blitzer et al., 2012). Here, we are interested in the net export of hoverflies from field borders. That is, more hoverflies moving into the crop from the border than moving into the border from the crop would strongly suggest that the field border is acting as a source of hoverflies to the crops and is therefore valuable in maintaining the ecosystem services provided by hoverflies. Conversely, equal movement to and from field borders throughout the season would suggest that hoverflies do not experience field borders as different from crops, such that field borders might not play an important role in supporting hoverfly biodiversity or hoverfly- mediated ecosystem services in agricultural landscapes. Finally, there is a possibility for net import into the borders such that hoverflies move mostly from the crops into the borders, indicating that borders either draw hoverflies away from the crops or that they act as important sources of resources (Blitzer et al., 2012). Given the large increase and subsequent decrease in floral resources within crops during mass-flowering crop bloom, we would expect to see greater net export of hoverflies from borders during bloom than before or after (Haenke et al., 2014; Trillo et al., 2020) and greater net import when the crop is not in bloom (Blitzer et al., 2012). Dominant vegetation type plays a large role in determining the hoverfly community (Sommagio, 1999). Treed areas seem to support hoverflies best, at least in places where this has been studied. Ricarte et al. (2011)and Schirmel et al. (2017)found that hoverfly abundance and species richness was higher in treed or woody areas than in her baceous areas, while Burgio et al. (2015)found that hoverfly abundance was positively associated with woody vegetation, but species richness was positively associated with herbaceous vegetation. In addition, associations between hoverflies and vegetation have been found to change temporally. For example, Alignier et al., (2014)found that non-adult hoverfly abundance was positively associated with woody vegetation in the early spring, but positively associated with hedge and grassland vegetation in the late spring. Additionally, vegetation associations have also been found to change spatially such that habitat associations were found to be different among sites in Germany, Switzerland, and Italy (Pfister et al., 2017; Schirmel et al., 2017). Because designing vegetated areas for hoverflies may have the potential to substantially increase hoverfly abundance and species richness, the relationship between hoverflies and vegetation needs to be studied in each system and location where we want to optimize the ecosystem services provided by hoverflies. The variation of vegetation components within field borders of a given type may also affect the net export of hoverflies to the crop (Bartual et al., 2019; Meng et al., 2012). For example, in tropical southwest China, Meng et al. (2012)found that hoverfly species richness decreased with liana species richness, canopy cover, vegetation height, and successional stage, but found no relationship between hoverfly species richness and overall plant, grass, forb, shrub, and tree species richness or percent ground cover. Another study from temperate Europe found that specialist hoverfly species were affected by local habitat diversity, amount of and distance to woody and herbaceous landscape elements, crop rotation, and pesticide and

nitrogen application, whereas generalists were not (Schweiger et al., 2007). Furthermore, the large diversity of larval feeding habits (e.g., zoophagy, saprophagy, and phytophagy; Rotheray and Gilbert, 2011) and habitats (terrestrial and aquatic; Rotheray and Gilbert, 2011) add complexity and will no doubt affect how, and which, hoverflies use field borders (Incl´an et al., 2016; Mili ˇci´c et al., 2021; Rader et al., 2020; Ricarte et al., 2011). For example, non-predatory larvae that rely on decaying organic matter and vegetation as their food have been found to overwinter mostly in field borders where downed woody debris, leaf litter, and other plant matter are abundant, while the larvae of predatory species more often overwinter within the fields themselves (Raymond et al., 2014). Therefore, we expect that hoverfly diversity will change with vegetation composition such that more species will exist where there is a higher diversity of larval resources (Harwood et al., 1994; Speight, 2017). In our study region (the aspen parkland of central Alberta, Canada; Fig. 1), the major mass-flowering crop is canola, for which hoverflies have been found to be effective pollinators (Jauker and Wolters, 2008; Rader et al., 2009). We sought to quantify the net rate of hoverfly movement from treed vs. from herbaceous field borders into canola crops in order to estimate the relative amount of hoverfly-provided ecosystem services supplied by each field border type. Specifically, we asked three questions: (Q1; Fig. 2). How does hoverfly directional movement between field borders and canola crops vary with field border type (herbaceous or treed), canola bloom, and their interaction? (Q2; Fig. 2) How do species richness and diversity of the hoverflies active within field borders change with field border type and canola bloom? and (Q3; Fig. 2) Are there any components of the vegetation (canopy cover, grass height, grass cover, plant cover, flower availability, or density of trees, shrubs, snags, stumps, or downed woody debris) in treed field borders that can explain the magnitude of hoverfly net export into crops? For the third question, we focused only on treed borders because most of these vegetation components are not found in herba
ceous borders by definition.

Our first hypothesis (H1A; Fig. 2) was that there would be greater net export of hoverflies from treed field borders than from herbaceous field borders, given the importance of treed areas to hoverflies (Burgio et al., 2015; Ricarte et al., 2011; Schirmel et al., 2017). Our second hypothesis (H1B; Fig. 2) was that hoverfly movement direction would vary with field border type and canola bloom. That is, we would observe more hoverflies moving into the crop from the field borders regardless of type during canola bloom due to the increase in floral resources, but that herbaceous field borders would have more bi-directional movement, and lower net export overall, due to their structural similarity to a canola crop. Our third hypothesis (H2; Fig. 2) was that hoverfly diversity would be greater in treed field borders due to the greater amount and variety of larval habitat. Lastly, our fourth hypothesis (H3; Fig. 2) was that movement would vary within treed borders in relation to the different vegetation components available in each border.

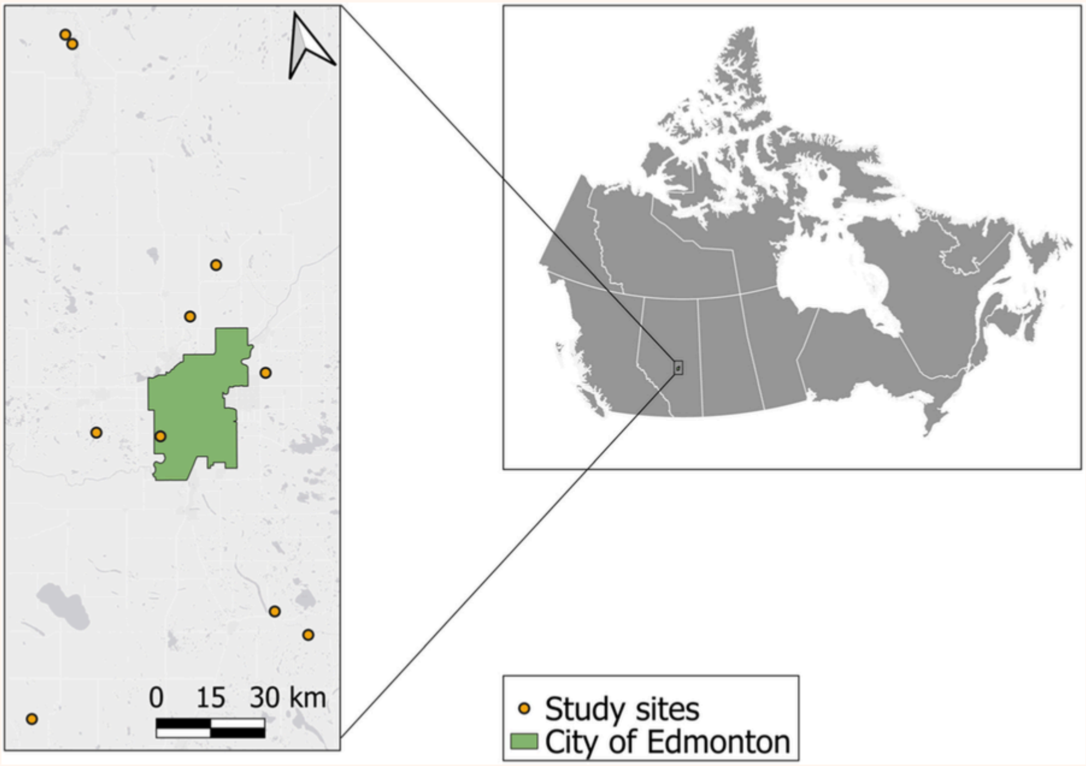

Fig. 1. Map of study sites with reference to Edmonton, Alberta, Canada. All sites were at least 2 km apart. Edmonton shapefile made available to the public by the City of Edmonton (2019). Canada shapefile made available to the public by the Government of Canada (2016). Basemap sources: Esri, DeLorme, HERE, MapmyIndia (ESRI, 2011). Map created in QGIS (QGIS Development Team, 2023).

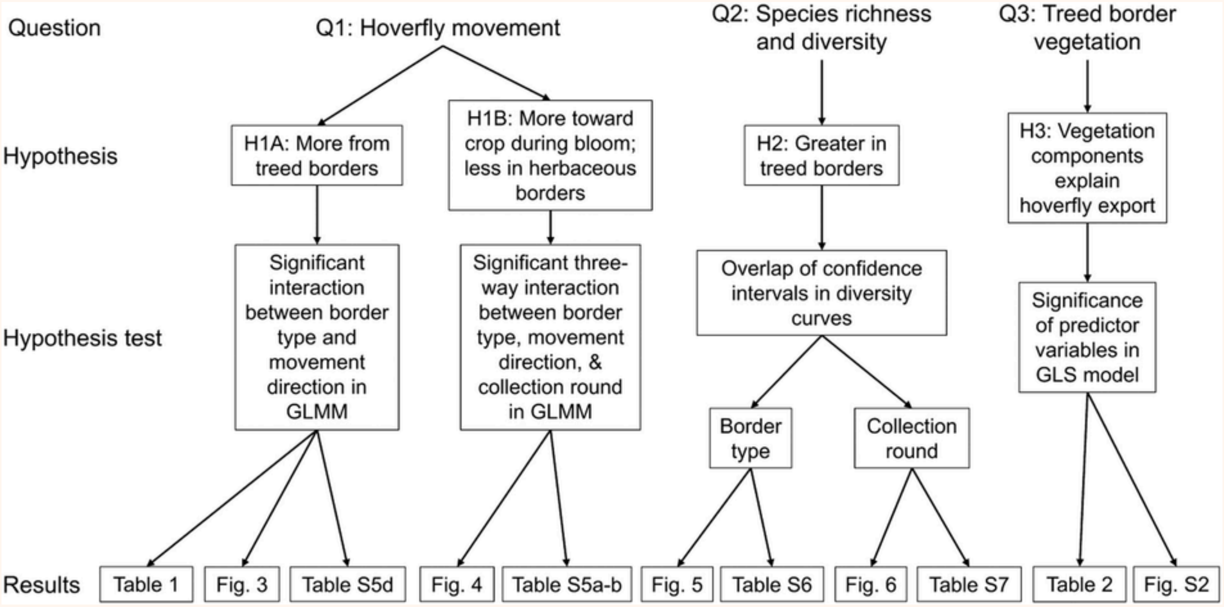

Fig. 2. Schematic that shows which results relate to which question, hypothesis, and hypothesis test.

Methods

2.1. Site description and selection

This study took place in the aspen parkland ecoregion in central Alberta, Canada. This ecoregion is a transition zone between the grasslands in the south of the province and the boreal forest in the north. In undeveloped areas it consists of mixed tree stands interspersed with grasslands. The mean summer temperature is c. 15 ◦ C, the mean winter temperature is c. −12.5 ◦ C, and the mean annual precipitation ranges from 400 to 500mm which mostly occurs from May to September (Nature Conservancy of Canada, 2019). Much of this ecoregion has been converted into agricultural land that is dominated by oilseed and grain farming (the most common crops being canola and spring wheat) and by beef farming and feedlots (Statistics Canada, 2021). In a typical year in this region, canola is seeded in May, blooms in July, and is harvested in September (Canola Council of Canada, 2023).

For this study, we selected ten fields seeded to canola within 100km of Edmonton, Alberta, Canada (Fig. 1). The fields were at least 2km apart. Each field had at least one field border consisting of trees (i.e., treed field border) and at least one field border lacking trees and large shrubs (i.e., herbaceous field border). Border widths varied from 5m to 130m. In our study, the trees in the treed field borders were mostly trembling aspen (Populus tremuloides) and balsam poplar (Populus balsamifera). The treed field borders also contained many shrub species including raspberry (Rubus idaeus), prickly rose (Rosa acicularis), and beaked hazelnut (Corylus cornuta) among others. The herbaceous borders consisted of grasses which were not identified further. Both field border types contained a variety of forbs.

2.2.Hoverfly collection

In both field border types at each field, we set up a Malaise trap (NHBS Black and White Malaise Trap) within 1m of, and with the openings running parallel to, the crop edge, for a total of twenty traps in the study. To measure hoverfly movement in each direction between the crop and the field border, the Malaise traps were modified to be bi- directional, such that there were two collection heads that separately collected the insects flying towards and away from the crop (Figure S1; after Macfadyen and Muller, 2013). We used 100% propylene glycol as a preservative in the trap heads. The traps were active from May 31 to August 20, 2021 and we collected the contents of the traps about every two weeks, for a total of six collection rounds (Table S1). Because we continuously operated the traps, the collection rounds overlapped among the traps, such that, for example, the beginning of collection round 2 overlapped with the end of collection round 1 and the end of collection round 2 overlapped with the beginning of collection round 3. Collection rounds 1 and 2 took place before canola bloom, collection rounds 3 and 5 took place during partial canola bloom (just before and just after bloom respectively), collection round 4 took place during full canola bloom, and collection round 6 took place after canola bloom but before harvest.

We brought the trap contents back to the lab, where hoverflies were sorted under dissecting microscopes. We then identified each specimen to species using the taxonomic resources listed in Table S2(especially Miranda et al., 2013; Skevington and Locke, 2019; Vockeroth, 1992). Exceptions to species-level identifications were the subfamily Pipizinae, which were identified to genus, but where each of four genera appeared to contain one morphospecies each (4 Heringia, 1 Neocnemodon, 2 Pipiza, and 4 Trichopsomyia specimens), and the genus Neoascia which were identified to subgenus (2 subgenera: 16 Neoascia (Neoasciella) and 2 Neoascia (Neoascia)) because we only had females which cannot be reliably identified to species via morphological characters (Skevington and Locke, 2019). Voucher specimens of all species identified have been deposited in the E. H. Strickland Entomological Museum, Edmonton, Canada (accession numbers 423863–423995; Table S3).

2.3.Vegetation survey

To investigate how the vegetation present in each field border was related to hoverfly abundance and movement, we performed a vegetation survey in every field border once during the summer. We measured 11 vegetation components: border width, canopy cover, grass height, grass cover, plant cover, average flower count, and density of trees, shrubs, snags (standing dead trees), stumps, and downed woody debris. In each field border, we randomly placed four 0.5 ×0.5m quadrats. Within each quadrat, we measured the height of the tallest blade of grass in the quadrat (pulled to a fully vertical position), percent grass cover within the quadrat, and percent plant cover (grass +other plants) within the quadrat. Both percent cover variables were measured by three dependent observers whose measurements were then averaged to count for the difficulty and subjectivity of visually estimating percent cover.

In the treed field borders, we also randomly placed one 30 ×2m transect, parallel to the field edge, and identified and counted all trees, shrubs, snags, stumps, and downed woody debris along the transect. Additionally, we also measured canopy cover at three points (0, 15, and 30m) along the transect using a spherical densiometer. We measured border width at the sites when possible, but some borders were either too wide or had obstacles such as barbed wire fences and so much understory growth that we could not measure the width at the site, and so we measured the width of the border on Google Earth (version 7.3.6.9345 (64-bit); imagery dated Aug 22 2015, Sept 9 2015, and Jul 6 2021).

We also conducted four flower surveys in every field border: twice before canola bloom, corresponding with collection rounds 1 and 2 respectively, once during canola bloom which corresponded with either collection round 3 or 4 depending on the site, and once after canola bloom which corresponded with either collection round 5 or 6 depending on the site. In each survey, we placed one 30 ×2m transect within the border, with placement along the field edge selected to maximize the number of flowers along the transect. Then, along the transect we identified and counted every flower or inflorescence depending on the flower species (e.g., we counted inflorescences for Trifolium species, but flowers for Brassica species).

2.4.Estimation of the number of hoverflies exported to crops by each field border type

To estimate the mean number of hoverflies moving to and from the crops every week for each field border type, of hoverflies collected per collection head by the number of trapping hours to get the rate of hoverfly movement (hoverflies/hour). Then, we averaged this rate of hoverfly movement for each field border type and movement direction and multiplied it by 168 (the number of hours in a week) to calculate the mean number of hoverflies collected per week moving in each direction at each field border type. Finally, we multiplied that number by 1000 (1000m per 1km) and divided it by the length of the Malaise trap (1.88m) to estimate the mean number of hoverflies moving in each direction in each field border type per km every week. The opening of the Malaise trap is 0.9m in height; therefore, this estimate is only for hoverflies flying below that height, which should constitute most hoverflies (Wratten et al., 2003), but is also certainly an underestimate. Given that our hypothesis was that treed field borders would supply more hoverflies to crops than herbaceous field borders, we then calculated the difference in net hoverfly export between field border types: [net hoverfly movement from treed borders to crops] minus [net hoverfly movement from herbaceous borders to crops].

2.5.Statistical analysis

2.5.1.Effect of field border type and canola bloom on movement direction

We conducted all analyses using R version 4.1.2 (R R Core Team, 2021). We used a generalized linear mixed effects model (GLMM) to determine how canola bloom and field border type affected hoverfly movement in and out of the crop using the package glmmTMB (Brooks et al., 2017). Our response variable was hoverfly abundance, and our fixed effect predictor variables were collection round, field border type, movement direction, all two-way interactions, and the three-way interaction between these predictor variables. Here, abundance is a measure of hoverfly activity and not true abundance, such that the Malaise traps only collect individuals that are flying about. We used a negative binomial distribution and included movement direction nested within field border type nested within field as random factors, and the number of trap hours as an offset term to account for the variation in number of hours that each trap was open in each collection round (Table S1). We checked assumptions of linearity, normality, homogeneity of variances, and overdispersion of the model residuals using the package DHARMa (Hartig, 2022) and found that all assumptions were met except for homogeneity of variances for the field border type predictor variable. To account for the violated assumption, we added a dispersion formula to the model for that predictor variable (Hartig, 2022). Because we were specifically interested in testing hypotheses about interactions, we began with a model selection approach in which we compared models containing nested subsets of our fixed effects using ANOVA (Crawley, 2007). We began with the full model, and first removed the three-way interaction. If that did not significantly improve the model, then we fit a model with all two-way interactions and removed each one in turn from the model containing the other two two-way interactions and tested its significance. Finally, we tested the removal of any main effects for which interactions were not retained. We followed up by checking AICc values for all models to ensure that the order of tests in the previous process had not biased our conclusions (Quinn and Keough, 2002). We ran posthoc Tukey's Honestly Significant Difference (HSD) tests from the package emmeans (Lenth, 2023) to determine significant differences in hoverfly abundance among collection rounds.

2.5.2.Effects of field border type and collection round on hoverfly diversity

To understand how field border type and collection round affected the diversity of hoverflies active within field borders (moving in both directions pooled), we used the iNEXT4steps function in the iNEXT.4-steps package (Chao et al., 2020). We used this function to generate plots and calculate empirical and asymptotic diversity profiles, sample completeness profiles, and evenness profiles for q =0, 1, 2 (i.e., species richness, and Hill numbers of Shannon and Simpson diversity respectively; Chao et al., 2020). The different orders of q weight relative abundances differently and thus describe different portions of the community (Chao et al., 2020; Chao et al., 2014). When q =0, the resulting diversity value is species richness and therefore represents all species. When q =1, more weight is given to more abundant species and the resulting diversity value (Hill-Shannon) represents "typical" species, such that rare species do not heavily influence the resulting value (Chao et al., 2014). Finally, when q =2, even more weight is given to abundant species and the resulting diversity value (Hill-Simpson), primarily represents dominant species. The empirical and asymptotic diversity files allow us to compare our observed (empirical) values of species richness, Hill-Shannon and Hill-Simpson diversity to estimated "true" values (asymptotic) that are calculated based on the numbers of singletons and doubletons collected and the expected species abundance distribution of the community (Chao and Jost, 2015). The sample completeness profiles allow us to estimate the proportion of the "true" total diversity our sampling detected, and are calculated by dividing the empirical diversity value by the asymptotic diversity value for each order of q (Chao et al., 2020). The evenness profiles are calculated by assessing the slope of the asymptotic profile such that if the community was completely even (all species were present in equal abundances), then the slope of the asymptotic profile would be 0 (estimates at all three orders of q would be the same) and evenness would be equal to one (Chao and Ricotta, 2019). In these analyses, significance is determined by non-overlapping 95% confidence intervals (Chao et al., 2020).

2.5.3.Vegetation analysis

Finally, to determine if vegetation characteristics in treed field borders could explain hoverfly net-export into crops, we ran a generalized least squares (GLS) model using the nlme package (Pinheiro et al., 2021) to allow use of alternate variance structures to aid model fit. We used net export (# of hoverflies moving towards the crop - # of hoverflies moving towards the border) as the response variable. From the full list of 11 vegetation components that we had measured, we excluded border width, canopy cover, percent grass cover, and percent vegetation cover as they were only weakly correlated with net hoverfly movement ($r < 0.1$; Figure S2). We then ran a model for every combination of additive effects of our remaining seven vegetation variables: grass height, average flower count (calculated from our four flower surveys at each border), and density of trees, shrubs, snags, stumps, and downed woody debris. Trap time was included as an offset term to control for uneven trapping effort. As this was an exploratory analysis, we used AICc to select the best model (Barto´n, 2023). We checked the model residuals for normality using a Shapiro-Wilk test and for linearity and homogeneity of variance by inspecting a plot of fitted values vs. residuals and found that both assumptions were met.

Results

We collected a total of 2175 hoverflies from 98 taxa, including 92 species, four morphospecies, and two subgenera, representing three subfamilies (Eristalinae, Pipizinae, and Syrphinae). The vast majority of individuals were syrphines (n =1989), which included the five most common species (in descending order): Toxomerus marginatus, Eupeodes americanus, Sphaerophoria philanthus, Platycheirus scambus, and Eupeodes volucris). As such, 90% of the hoverflies we collected have zoophagous larvae, 6.8% have saprophagous larvae, 1.3% have saproxylic larvae, 1.1% have phytophagous larvae, and 0.5% have parasitic larvae (i.e., Volucella species). We estimate that we collected 75% of the hoverfly species in the overall community and missed roughly 32 species (Table S4a). We collected nearly three times more females than males, a trend which held across collection rounds, border types, and movement directions (Figure S3).

3.1.Export of hoverflies by treed vs. herbaceous field borders

We estimate that over 1km of treed field border, a mean of 91,819 hoverflies per week moved into the crops (Table 1). In contrast, we es timate that over 1km, a mean of only 7120 hoverflies moved from the crops into the treed borders per week, meaning that hoverfly movement was almost 13 times greater moving into the crop from treed borders than moving into the treed borders from the crop (Table 1). There was an estimated net export of 84,699 hoverflies into canola crops per week per km of treed field border.

In herbaceous borders, there was also a net directional movement of hoverflies from borders into canola crops, but it was much smaller.

We estimate that a mean of 65,165 hoverflies per week per 1km moved into the crops from herbaceous borders and a mean of 62,650 hoverflies per week per 1 km moved into the herbaceous borders from the crops (Table 1). Thus, there was an estimated net export of 2515 hoverflies per week per km from herbaceous borders into canola crops.

Table 1
Estimated rates of hoverfly movement per week and over 1 km per week between field border types and movement directions. Rates have been rounded to the nearest whole number.

Field border type	Movement direction	Estimated rate of hoverfly movement (#/week)	Estimated rate of hoverfly movement over 1 km (#/week)
Herbaceous	Towards crop	123	65,165
	Towards border	118	62,650
	Net export from border to crop	5	2515
Treed	Towards crop	173	91,819
	Towards border	13	7120
	Net export from border to crop	160	84,699

Comparing the two field border types, treed borders had a net export of hoverflies that was over 33 times greater than that of herbaceous field borders (Table 1). That is, the net export of hoverflies from treed field borders per week per km was an estimated 82,184 hoverflies greater than the net export of hoverflies from herbaceous field borders into canola crops (Table 1).

Our statistical tests (GLMM results) suggested that our finding that there was a higher net export of hoverflies from treed field borders into crops compared to from herbaceous field borders into crops was significant (two-way interaction between border type and direction of movement: X2 = 14.102, p-value < 0.0001; Fig. 3; Table S5d).

Furthermore, this did not depend on canola bloom, such that higher net export of hoverflies from treed field borders than from herbaceous field borders was more or less constant throughout the growing season (nonsignificant three-way interaction between border type, movement direction,and collection round: X2 = 2.016, p-value = 0.8469; Table S5a). We found that there were proportionally more hoverflies with saprophagous larvae exported from treed borders than exported from or imported to herbaceous borders, while export of hoverflies with zoophagous larvae was somewhat similar between treed and herbaceous borders (Figure S4).

Canola bloom did not affect hoverfly movement in and out of crops such that predominant movement direction did not change with collection round (non-significant interaction between collection round and movement direction: X2 = 5.27, p-value = 0.3841; Table S5c).

However, the difference in mean hoverfly abundance between border types varied among collection rounds (significant interaction between field border type and collection round: X2 = 19.70, p-value = 0.0014;

Fig. 4; Table S5b). We did not find a significant difference in mean hoverfly abundance between field border types before canola bloomed in collection rounds 1 (estimate = 0.301, p-value = 0.4876), 2 (estimate = 0.149, p-value = 0.6685), and 3 (estimate = 0.481, p-value = 0.1235). However, we found that the mean abundance of hoverflies was higher in herbaceous borders than in treed borders during and after canola bloom in collection rounds 4 (estimate = 0.832, p-value = 0.0248), 5 (estimate = 1.097, p-value = 0.0059), and 6 (estimate = 1.929, p-value < 0.0001).

3.2. Hoverfly diversity among field border types and collection rounds

We found that there was significantly higher diversity of typical and dominant species in treed field borders than herbaceous field borders (significantly higher Hill-Shannon and Hill-Simpson diversity, q = 1 and q = 2; Fig. 5a; Table S6b).

We also found that there was higher evenness in treed field borders than in herbaceous field borders (Fig. 5b; Table S6c). However, there was no significant difference in species richness between the field border types (overlap of 95 % confidence intervals at q = 0 in Fig. 5a; Table S6b q = 0).

We found that highly abundant species became more dominant as the summer went on, such that evenness was highest in collection round 1 and lowest in collection round 6 for all three diversity measures tested (q = 0, 1, and 2 in Fig. 6b and Table S7c). The only exception to that pattern was an increase in evenness when canola was in full bloom during collection round 4, although this difference is not significant given the overlapping confidence intervals (Fig. 6b; Table S7b). Furthermore, collection round 6 had significantly lower diversity of typical and dominant species (Hill-Shannon and Hill-Simpson diversity) than all the other collection rounds and collection round 1 had significantly higher diversity of typical and dominant species than all collection rounds other than 4 (q = 1 and q = 2 in Fig. 6a; Table S7b). All other comparisons among collection rounds regarding typical species (Hill- Shannon diversity) were non-significant (Fig. 6a; Table S7c). We found no significant difference in species richness among collection rounds (q = 0 in Fig. 6a, Table S7b).

3.3. Effect of vegetation on hoverfly movement in treed field borders

We found that no vegetation variable within treed field borders significantly explained hoverfly net export into the crop. After model selection, the only vegetation variable left was stump density, and it did not have a significant relationship with net export of hoverflies (Table 2; Figure S5).

Discussion

We estimated that treed field borders net-exported nearly 85,000 hoverflies per km to canola crops every week on average (Table 1). In comparison, herbaceous field borders only net-exported 2515 hoverflies per km every week (Table 1), meaning that treed borders net-exported more than 33-times more hoverflies than herbaceous field borders. Additionally, we found that treed borders had higher Hill-Shannon and Hill-Simpson diversity and a higher evenness than herbaceous borders, meaning that treed borders support a greater diversity of hoverflies than herbaceous borders. Therefore, treed field borders are important components of agroecosystems for maximizing hoverfly-mediated ecosystem

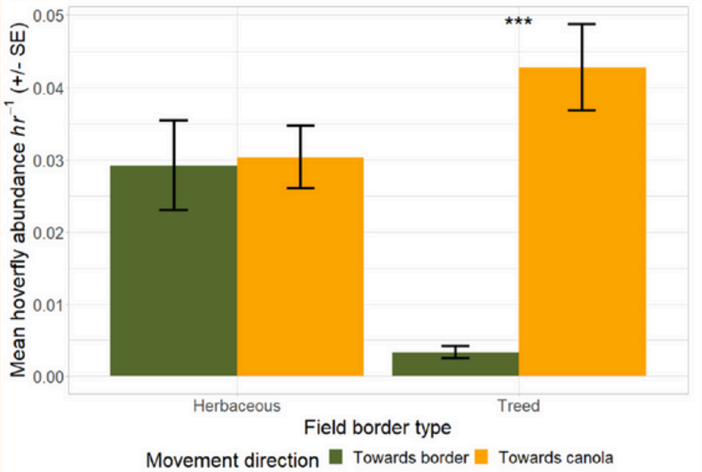

Fig. 3. Mean hoverfly abundance per trap hour by field border type and movement direction (pooled across collection rounds). Asterices denote significance between movement directions within that field border type at p-value < 0.0001.

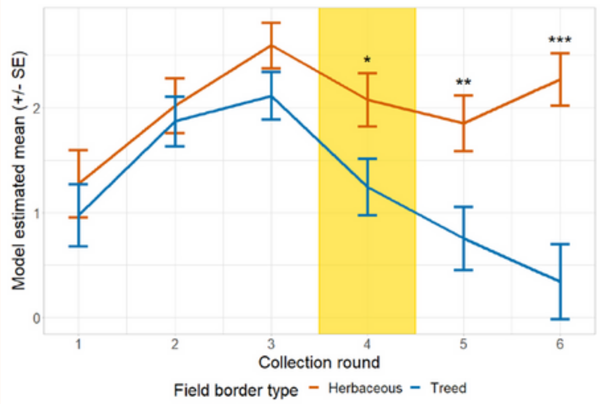

Fig. 4. Hoverfly abundance by collection round and field border type (pooled across movement directions), and controlling for trap effort. Model estimated means and standard errors generated using the package emmeans (Lenth, 2023) are presented. The approximate timing of canola bloom is shown by the yellow box. Asterices denote significant differences between field border types within a collection round (* = p-value < 0.05; ** = p-value < 0.01; *** = p-value < 0.0001).

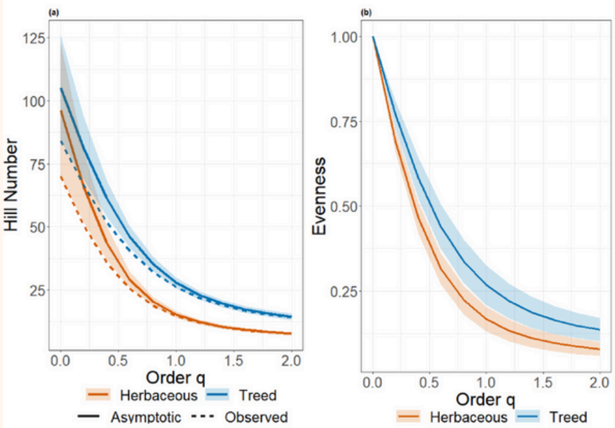

Fig. 5. Diversity and evenness profiles comparing field border types (herbaceous and treed). (a): Asymptotic and empirical diversity profile where q = 0 is species richness, q = 1 is Shannon's Hill number, and q = 2 is Simpson's Hill number. The dashed lines show the observed values while the solid lines show the estimated "true" values. (b): Evenness profile where q = 0 is Pielou J' while q = 1 and q = 2 are the same as the diversity profile. Because q can be a range of values, q can be plotted on a continuous x-axis. The border type with the higher solid line indicates that that border type had a greater Hill Number or evenness at that order of q than the other border type. Shaded areas are the 95 % confidence intervals, where overlap indicates a lack of statistical significance. More output from iNEXT4steps can be found in Table S6.

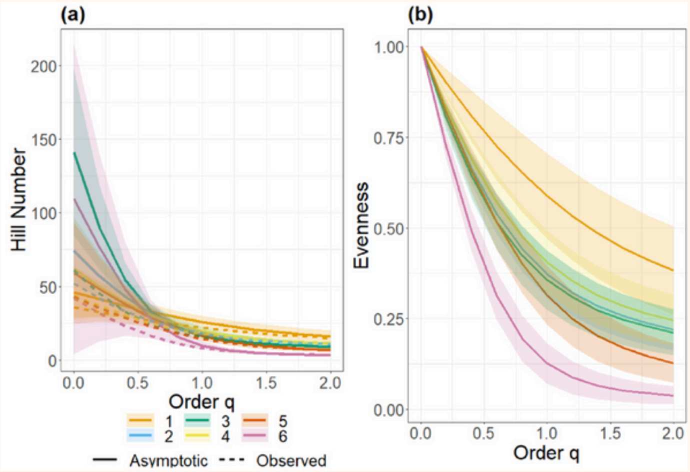

Fig. 6. Diversity and evenness profiles comparing collection rounds. (a): Asymptotic and empirical diversity profile where q = 0 is species richness, q = 1 is Shannon's Hill number, and q = 2 is Simpson's Hill number. The dashed lines show the observed values while the solid lines show the estimated "true" values. (b): Evenness profile where q = 0 is Pielou J' while q = 1 and q = 2 are the same as the diversity profile. Because q can be a range of values, q can be plotted on a continuous x-axis. A collection round with a higher solid line indicates that that collection round had a greater Hill Number or evenness at that order of q than the lower collection rounds. Shaded areas are the 95 % confidence intervals where overlap indicates a lack of statistical significance. More output from iNEXT4steps can be found in Table S7.

Table 2
Results of the best GLS model examining the relationship between our vegetation variables and net hoverfly export (# of hover flies moving toward the crop - # of hover flies moving away from the crop). Adj-R^2 = 0.21. "Value" gives the estimated intercept and slope, respectively.

Predictor variable	Value	Standard error	t-value	p-value
(Intercept)	58.27	25.52	2.28	0.0564
Number of stumps	17.11	12.42	1.38	0.2108

services. However, counterintuitively, mass-flowering crop bloom did not affect hoverfly movement, as the export of hoverflies into crops was more or less constant throughout the summer and did not increase with canola bloom (Table S5a).

While we observed many hoverflies exiting the treed field borders, we found very few hoverflies moving into them (Fig. 3). Therefore, treed field borders should be good for crop pollination because they seem to keep hoverflies in the crop, while herbaceous borders encourage movement out of the crop. Our result corroborates Samaranayake and Costamagna's (2019) finding that treed field borders exported aphidophagous hoverflies to soybean fields while herbaceous borders did not. We recommend that landowners retain and even plant treed borders along the edges of their fields to maximize hoverfly-mediated ecosystem services. Our finding that treed borders net export so many hoverflies to crops may be one of the mechanisms behind Galpern et al.'s (2020) finding that proximity to non-cropped areas increases crop yield in this ecoregion. However, we were not able to identify any vegetation component that could explain the variation in movement from treed field borders (Table 2). Thus, there seems to be something inherent to treed borders that most adult hoverflies either avoid or are uninterested in during foraging. Visually, it is likely that the large difference in vegetation structure between the crop and the treed border deters hoverflies from moving into the treed borders (Klaus et al., 2015; Wratten et al., 2003). Moreover, flowers may be easier to locate in a herbaceous border than among trees and shrubs in a treed border, which encourages hoverflies to move into herbaceous borders. Similarly to our study, Garratt et al. (2017) were also unable to associate hedgerow characteristics (species richness, "gappiness" of the hedgerow, and when the hedge had last been cut) with hoverfly abundance. Additionally, Wratten et al. (2003) also found that treed boundaries acted as barriers for hoverfly movement even when comparing "dense" tree boundaries to "gappy" boundaries, which corroborates our finding that variation in the vegetation in treed field borders does not influence hoverfly movement.

Based on the patterns we observed, it seems that treed field borders are likely only larval habitat and pupation sites for hoverflies and the export we observed was emerging adults. Meyer et al. (2009) found that within agricultural systems, hoverfly communities were strongly determined by resource quantity for both adults and larvae. It is unlikely that treed field borders are providing any sort of habitat for adult hoverflies given how few entered the treed field borders compared to how many entered and exited the herbaceous field borders (Fig. 3). In our study, treed field borders contained a wide range of microhabitats for hoverfly larvae such as decaying wood and swampy areas (Alignier et al., 2014; Rotheray and Gilbert, 2011). Indeed, we found a greater proportion of hoverflies with saprophagous larvae moving out of the treed borders than into or out of the herbaceous borders (Figure S4).

Therefore, it does appear that the increase in hoverflies with saprophagous larvae moving out of the treed borders accounts for the increase in total hoverfly export in treed borders compared to in herbaceous borders.

Although hoverflies with zoophagous larvae do not require the microhabitats exclusive to treed field borders, they also overwinter and move from treed field borders (Raymond et al., 2014; Samaranayake and Costamagna, 2019). Therefore, it could be that it is mostly gravid females that enter the treed borders to lay eggs. In some species, one female can lay upwards of 400 eggs (Rotheray and Gilbert, 2011), thereby demonstrating how so few hoverflies could enter the border yet so many exit. This does not mean that treed field borders are the only larval habitat for hoverflies in agricultural landscapes, but rather that treed borders act mainly as larval habitat and not as adult habitat. The crop and herbaceous field borders almost certainly also act as larval habitat for predaceous syrphine larvae, as found by Raymond et al. (2014). Furthermore, herbaceous borders contain late-season flowers and vegetation that provide oviposition sites for hoverflies after crop harvest (Salveter, 1998). In our region, crop harvest happens around the end of September, which coincides with the end of many hoverfly species' flight periods (Skevington and Locke, 2019). Thus, herbaceous field borders could be important overwintering sites for hoverflies in our region (Raymond et al., 2014).

Although herbaceous field borders did not net-export more hoverflies to canola crops than treed field borders, they did contain more adult hoverflies than treed borders, both during and after canola bloom (Fig. 4). Furthermore, we also found that herbaceous field borders had lower Hill-Shannon and Hill-Simpson diversity and evenness than treed field borders, which suggests that the observed greater abundance in herbaceous field borders was driven by a few species. Indeed, we found that Toxomerus marginatus, the most abundant species in our study, explained these trends almost perfectly. The species was found in high abundances in herbaceous borders compared to treed borders (368 individuals collected in herbaceous borders compared to 156 individuals collected in treed borders; Figure S6). Additionally, it was one of only two species whose abundance increased following canola bloom (Figure S7). Given that it is extremely abundant in North America and is highly successful in disturbed habitats such as agricultural landscapes (Samaranayake and Costamagna, 2019; Skevington and Locke, 2019), it is not surprising that T. marginatus had such a strong influence on our results. To our knowledge, T. marginatus is non-migratory (Menz et al., 2019). In a laboratory feeding trial, Eckberg et al. (2014)found that T. marginatus larvae were effective predators against soybean aphids.

While there is no research regarding T. marginatus' contribution to crop pollination, a similarly sized and abundant Palaearctic species, Episyrphus balteatus, has been found to be an effective pollinator of oilseed rape in Europe (Jauker and Wolters, 2008). Therefore, although its abundance increased markedly after canola bloom when it would no longer be able to pollinate the canola (Figure S7), T. marginatus may contribute substantially to crop yield in our system, especially in years where peak emergence matches better with canola bloom. Thus, T. marginatus is the best candidate out of all the species we observed to provide the sought-after dual ecosystem services provided by hoverflies in our region and further research should focus on this species (Dunn et al., 2020).

Interestingly, we found that mass-flowering crop bloom did not affect the export of hoverflies into canola crops (Table S5). Moreover, we found that hoverfly abundance actually decreased during full bloom, especially in treed field borders (Fig. 4). This is counterintuitive because the large increase in floral resources during the bloom of the mass-flowering crop should have increased the abundance of flower-visiting insects (Ebling et al., 2008; Meyer et al., 2009). However, Malaise traps capture activity rather than real abundance. Therefore, we suspect that we did not observe this increase because the hoverflies were less active in field borders during canola bloom, as they remained within the crop where floral resources were plentiful and were thus collected less by the Malaise traps. Additionally, because the structural composition of the vegetation is much more similar to the crop in herbaceous borders than in treed borders, the hoverflies were more likely to interpret the herbaceous borders as the same as the crop, which explains why the decrease was more pronounced in treed field borders.

There are a few limitations to our study. First, our estimates regarding the net export of hoverflies from both field border types are extrapolated from the catch of replicate malaise traps, and as such do contain some uncertainty. Our reported means assume that the rate of hoverfly movement remains constant, whereas it would certainly fluctuate. However, the mean export/import of hoverflies across the entire season is the best representation of the level of movement that is possible from our data, given that we found no significant effect of time on the pattern of direction of movement relative to border type. Furthermore, Malaise traps only capture activity below the height of the trap. Given that hoverflies are also active above that height, these estimates underestimate the number of hoverflies moving between the crop and the border. However, these estimates are still useful in describing the large effect size we observed in this study and demonstrating the enormity of how many hoverflies are moving between crops and their borders every week.

Another limitation is that we did not survey immature hoverflies, so we can only speculate that the treed field borders contain hoverfly larvae, and that is why we observed so many hoverflies moving out of the border but not into it. It could be that adult hoverflies moved into the treed borders from the other side of the border where we did not place a Malaise trap. However, this possibility is unlikely because four out of ten of our treed borders separated the focal crop (i.e., the side with the Malaise trap) from another crop. It is reasonable to assume that if hoverflies were entering treed borders from the non-crop side, then we should see very little activity in those dual crop borders.

However, we still observed considerable movement from those dual crop borders, therefore demonstrating that the adult hoverflies were likely originating within the borders themselves. Additionally, we did not sample within the crops so we do not know whether the export of hoverflies from the borders actually resulted in increased activity within the crop (Morandin and Kremen, 2013). Nonetheless, the small number of hoverflies moving towards the treed borders is strong evidence that treed borders deter hoverflies from leaving the crop, which means they are likely to visit crop flowers and contribute to crop pollination.

Furthermore, we only used one crop type in this study and additional studies on different crop types are therefore needed (e.g., Samaranayake and Costamagna, 2019). For example, we would expect that hoverfly movement in and out of wheat fields would show a different pattern given that wheat is not a mass-flowering crop and aphid predation changes depending on the percentage of different crops on the landscape (Samaranayake and Costamagna, 2018). Finally, we did not sample in a non-agricultural area, so we cannot say for certain whether the decrease in hoverfly activity we observed during and after canola bloom was due to canola bloom or if that is the natural phenology of hoverflies in our region. Either way, the potential real decrease in hoverfly abundance as evidenced by the decrease in activity during canola bloom is concerning given that more hoverflies during canola bloom is important for optimizing crop pollination and crop yield (Doyle et al., 2020).

Our results demonstrate that field border vegetation management can have a large effect on hoverfly abundance and diversity in agricultural fields (Samaranayake and Costamagna, 2018). Given this, further research regarding the aspects of hoverfly biology pertaining to their provision of ecosystem services, such as larval habitats and feeding and adult nectaring preferences, could fine-tune our ability to maximize their utility in agricultural systems (Dunn et al., 2020). Also, because the response of hoverfly communities to vegetation types has been found to vary by location (Pfister et al., 2017), this research needs to happen in a variety of systems, especially in regions where hoverflies have rarely been studied such as our own. Nevertheless, we found that treed field borders net-export nearly 85,000 hoverflies per km per week to canola crops, thereby demonstrating how important treed borders are to the provision of ecosystem services by hoverflies. We did not find that any vegetation component that we measured affected the export of hoverflies by treed borders, thus according to our study, any treed border should be capable of considerable hoverfly export with the potential to increase crop yields (Galpern et al., 2020). Furthermore, we found that this export did not vary with mass-flowering crop bloom as we expected. Overall, our results demonstrate the importance of these small, non-cropped areas for these economically important insects and stress the value of treed borders within agroecosystems.

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CrediT authorship contribution statement

Rachel Pizante: Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Conceptualization. John H. Acorn: Writing – review & editing, Supervision, Methodology Conceptualization. I. Pilar Jim´enez: Writing – review & editing, Methodology, Investigation, Conceptualization. Carol M. Frost: Writing – review & editing, Supervision, Methodology, Funding acquisition, Formal analysis, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

The data will be uploaded to Dryad after acceptance

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Appendix A.Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.agee.2024.109271.

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ENVIRONMENT FARM PLAN WORKSHOP

The Alberta Environmental Farm Plan covers an entire farm using a self-assessment tool to help producers identify their on-farm environmental risks. At the completion of the program, the farmer has an itemized list of adjustments that can be made in their operation. The EFP is a useful tool for analyzing a farming operation and guiding changes as time and resources allow. Having a completed EFP Certificate is a pre-requisite for many grants and funding available to producers.

Before attending the workshop, ensure the following:

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JANUARY 28 10 AM LUNCH PROVIDED

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BEEF PRODUCTION & MARKETING

Rod Wendorff
Windy Ridge Ultrasound Inc.

Brenna Grant
Canfax

Dr. Susan Markus
Lakeland College

Dr. Kelly Loree
Veterinarian

Rod Wendorff **and his wife, Sherri, reside on a small irrigated farm near Raymond, Alberta. In April 1994, Rod made his first of many trips to Kansas to meet with beef scientist John Brethour at Kansas State University. John, a pioneer in beef ultrasound, sparked Rod's interest in the field, and by late December 1994, Rod returned to Kansas to acquire the first commercially available ultrasound system developed by John and his partners. Initially, Rod focused primarily on ultrasound work in feedlots, but over the years, his work gradually shifted to seed stock and purebreds. His passion for ultrasound and teaching has taken him far beyond Alberta—he has traveled to Kazakhstan, Portugal, and across Canada, training others in cattle ultrasound and scanning techniques. Rod considers it the best job in the world, as it allows him to collaborate with exceptional people and work with cattle of every kind and color.**

Dr. Susan Markus has over 30 years of extensive experience in beef cattle production and sheep nutrition being currently involved in a large cow/calf, backgrounding and feedlot operation. Susan is also an adjunct professor at both the University of Alberta and Dalhousie University, and regularly mentors students in various class projects and research.
She holds a PhD in Animal Behaviour from the University of Alberta, a Masters in Ruminant Nutrition from the University of Manitoba and a BSc in Agriculture from the University of Saskatchewan. Susan worked for Alberta Agriculture for 25 years, initially as a beef and forage specialist in Coronation, AB, then at the Ag Info Center in Stettler, and since 2006, as a Livestock Research Scientist. Currently, since 2021, she is an RDAR Livestock Research Scientist, Technology & Innovation, with Lakeland College with a focus on production efficiencies and utilizing new technologies where feasible.

Brenna Grant is the Executive Director of Canfax, having been with the organization since 2007. Brenna grew up in SW Saskatchewan on a cow/calf, yearling grasser operation where her family still operates.

Dr. Kelly Loree graduated from the Western College of Veterinary Medicine in 1999. After four years in Sundre, as both a veterinarian and practice owner, he moved to Ponoka where he owned and operated Central Veterinary Clinic for the past 21 years. Kelly is a true mixed animal practitioner, but has had a special interest in both dairy and beef production medicine and theriogenology and has primarily worked in that area for the last ten years.

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Event	Date	Click On the Link to Register
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Beef Production & Marketing	31st January 10 AM MDT	https://us06web.zoom.us/webinar/register/WN_8oPFUTlDQ9mieEUJIWPRrg
Environment Farm Plan Workshop Daysland	12th February 10 AM MDT	https://us06web.zoom.us/webinar/register/WN_KDkZmNOWR9CFSj6dGQHDcg

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SCAN ME

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- **Kindly bring a laptop or tablet to facilitate working on the EFP.**

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