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RESEARCH ARTICLE

Seed mix design and floral resources drive multitrophic interactions in prairie restoration

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Abstract

1. Ecological restoration often targets plant community recovery, but restoration success may depend on the recovery of a complex web of biotic interactions to maintain biodiversity and promote ecosystem services. Specifically, management that drives resource availability, such as seeding richness and provenance, may alter species interactions across multiple trophic levels. Using experimentally seeded prairies, we examine three key groups—plants, pollinators and goldenrod crab spiders (*Misumena vatia*, predators of pollinators)—to understand the effects of species richness and admixture seed sourcing of restoration seed mixtures on multitrophic interactions.
2. Working with prairie plants, we experimentally manipulated seed mix richness and the number of seed source regions (single-source region or admixture seed sourcing). In each experimental prairie, we surveyed floral abundance and richness, pollinator visitation and plant–*M. vatia* interactions.
3. A high richness seed mix increased floral abundance when seeds were sourced from a single geographic region, and floral abundance strongly increased pollinator visitation, *M. vatia* abundance and prey capture. Seeding richness and admixture seed sourcing of the seed mixture did not affect floral species richness, but floral species richness increased pollinator visitation.
4. Pollinators interacted with different floral communities across seeding treatments, indicating a shift in visited floral species with restoration practices.
5. *Synthesis and applications*. Long-term success in prairie restoration requires the restoration of plant–arthropod interactions. We provide evidence that seed mix richness and admixture seed sourcing affect arthropod floral associations, but effective restoration of plant–arthropod interactions should consider total floral

resource availability. Incorporating a food web perspective in restoration will strengthen approaches to whole ecosystem restoration.

KEYWORDS
biodiversity, crab spider, ecological restoration, flower resources, plant–pollinator network, seed sourcing, seed sowing, species interactions

1 | INTRODUCTION

Ecological restoration is key to recovering degraded ecosystems (Buisson et al., 2022). The goal of restoration is to promote biodiversity and ecosystem functioning, yet restoration strategies often only prioritize the restoration of a single taxon, typically plants (Brudvig, 2011). Prioritizing restoration of the plant community may lead to the recovery of higher trophic levels (Kaiser-Bunbury et al., 2017; Sexton & Emery, 2020), but success is highly variable (Brudvig et al., 2017; McAlpine et al., 2016). Moreover, species interactions in food webs, such as plant–arthropod interactions, though integral to maintaining plant diversity, are often not considered during restoration (Benvenuti, 2022; Cusser & Goodell, 2013).

Plant–pollinator interactions are critical for maintaining ecosystem functioning and the long-term success of restoration through pollination services (McAlpine et al., 2016; Noreika et al., 2019). Because plant–pollinator networks may be structured by floral resources, understanding how restoration strategies influence floral resources and the subsequent effect of floral resources on plant–pollinator interactions is required for predicting restoration outcomes for species interactions (de Souza et al., 2022). Floral abundance and diversity increase pollinator diversity and visitation rates (Bucharova et al., 2022; Stewart & Waitayachart, 2020). However, floral species differ in their attractiveness and resource quality for pollinators (Nichols et al., 2019), and restoration strategies that promote these floral resources may promote plant–pollinator interactions. For example, Wen et al. (2022) found that bees interacted with floral species included in the seed mix more frequently than other unsown species in restored prairies, yet unsown floral resources still increased the stability of the plant–bee network. Because plant–pollinator interactions have implications for pollination efficiency and success (Arceo-Gómez et al., 2020; Valido et al., 2019), network size and structure in restored areas may signal effective restoration of pollination services.

Although bottom-up effects of the plant community on plant–pollinator interactions are increasingly considered in restoration (Otto et al., 2017; Simanonok et al., 2022), top-down effects from interactions with higher trophic levels may also alter plant–pollinator interactions. Flower-dwelling crab spiders (Araneae: Thomisidae), which are sit-and-wait predators of insects, provide a strong example of this interaction (Benoit & Kalisz, 2020; Romero et al., 2011). Predation risk from flower crab spiders can cause changes in pollinator foraging behaviour, decreasing pollinator visitation rates and seed set on flowers hosting crab spiders (Antiqueira & Romero, 2016; Brechbühl et al., 2010). Although individual plant fitness may be reduced by crab spiders, crab spiders may still promote the pollination of a diversity of species by reducing pollinator foraging activity on only high reward or common flowers (Benvenuti, 2022; Heiling & Herberstein, 2004). Because of their close association with the floral community and role in trophic interactions, crab spiders have been suggested as indicators of prairie restoration success (Orlofske et al., 2010). Despite this, little research considers the role of crab spiders in restoration and the effect of floral resources on crab spider interactions (Benvenuti, 2022).

Seed-based restoration practices, such as seed mix diversity or seed source, are commonly used to promote plant diversity with the assumption that higher trophic level recovery will follow (McAlpine et al., 2016). Restoring with a higher richness seed mix can lead to an increase in plant species richness (Grman et al., 2013), particularly of target restoration species (Larson et al., 2011; Lepŝ et al., 2007). Current restoration practices also promote species establishment by using seeds sourced locally to the restoration site (McKay et al., 2005), as locally sourced plants may be better adapted to the local climate and environmental conditions (Bucharova et al., 2017; Raabová et al., 2011). However, seeds from geographically distant regions may be better adapted to future climate conditions (Breed et al., 2013; Prober et al., 2015). Including seeds sourced from both local and geographically distant regions in the seed mix ('admixture' seed sourcing) may promote plant establishment under both local and future climate conditions (Breed et al., 2013; but see Bucharova et al., 2019; Woolridge et al., 2023). Although high richness seed mixes and admixture seed sourcing have been used in restoration to increase plant diversity, it is unclear whether these practices increase the resources for floral-associated arthropods and interactions between species, as we investigate here.

We consider how restoration practices aimed towards promoting plant diversity affect floral resources, then evaluate the bottom-up effects of these floral resources on higher trophic level interactions. We worked in prairies that were experimentally restored to test the effects of seed mix diversity and admixture seed sourcing, asking: (1) How do seed mix richness and admixture seed sourcing affect floral abundance and richness? (2) How do floral resources affect the abundance of the goldenrod crab spider *Misumena vatia*, prey capture and plant–pollinator networks? (3) Are pollinators and *M. vatia* interacting with similar flower species across seed mix and seed source treatments? We expect floral resources to have a strong bottom-up control on pollinator and *M. vatia* interactions due to the close floral association of both arthropod groups.

2 | MATERIALS AND METHODS

2.1 | Site description

We conducted this study in 12 experimentally restored prairie sites at the W.K. Kellogg Biological Station in Michigan, United States (Figure S1) (Catano et al., 2021). These sites were restored in 2015 to test the ecological effects of seeding richness and admixture seed sourcing in a full-factorial design. To manipulate seed mix richness, half of each site was seeded with 12 plant species and the other half was seeded with the same 12 species and an additional 59 species (71 total species) (Table S1). To manipulate the number of seed source regions, six sites were sown with a mixture of seeds sourced from three geographic regions: local Midwest (sourced from northern Indiana, Michigan, eastern Illinois, northern Ohio, Ontario), non-local northern (sourced from Wisconsin, Minnesota, Iowa, western Illinois) and non-local southern (sourced from Missouri, Iowa) (Table S2). The other six sites were sown with seeds sourced from only one of the regions (two sites sown with seeds from each of the three regions). Seed mixes contained native C3 and C4 grasses, legumes and non-legume forbs, and both high and low richness half-sites were sown with equal total seeding densities (Catano et al., 2021). Prairies ranged from 0.2 to 3.0 ha and were restored from herbaceous old fields on former agricultural land. To restore the fields, a glyphosate herbicide was applied twice in summer 2015 to remove pre-existing vegetation. Fields were sowed with the seed mixes in November–December 2015 using a modified seed drill and were mowed in spring 2016 and 2017 to reduce competition from weedy plant species. Fieldwork was done with the approval of site managers and no permits or ethical approval was needed to sample.

2.2 | Surveys

Within the restored prairies, we surveyed floral resources, plant–pollinator interactions and plant–*M. vatia* interactions three times between 6 June and 15 August 2018. All surveys occurred along four 29 m × 2 m permanent transects in each site, with two transects placed in the low richness seed mix treatment and two transects placed in the high richness seed mix treatment (2 transects per treatment per site, 48 transects total). To measure the abundance of floral resources ('floral abundance') and the species richness of these resources ('floral species richness'), we counted all flowering individuals per species within each transect. For up to 10 randomly chosen individuals per species, we counted the number of open flowers per individual. We multiplied the average open flowers per individual by the number of individuals of that species to get an estimate of the number of open flowers per species, then summed the estimated number of open flowers of all species to estimate floral abundance for each transect. Sampling rounds and transects within a seed mix treatment were pooled to obtain one floral species richness or abundance measure per seed mix treatment per site. All flowers were identified to species or morphospecies (Table S3).

We surveyed pollinator visitation at each transect for two 10-min periods per sampling round, once in the morning (between 10:00 and 12:30) and once in the afternoon (between 13:00 and 16:30) (total sampling effort per transect over all survey rounds = 60 min). Stopwatches were used to keep time and were paused during pollinator collection and recording. Surveys were conducted on sunny days with low wind speeds and temperatures ranging from 18 to 36°C. Bees (Hymenoptera: Apoidea: Anthophila) and syrphid flies (Diptera: Syrphidae) actively visiting a flower were collected, except for *Bombus* spp. that were identified on the wing, and the associated flower species was recorded. We identified all collected insects to species or morphospecies using published keys and with the assistance of experts (Syrphidae: Shorter, 1966; Apoidea: Gibbs et al., 2017; LaBerge, 1967, 1969, 1971, 1973, 1986, 1989; Mitchell, 1960, 1962). We chose to narrow the network to only include bees and syrphid flies as these groups were frequent flower visitors in our surveys and tend to show more avoidance of crab spiders (Brechbühl et al., 2010; Marrero et al., 2013). All three sampling rounds at each transect were pooled to obtain one plant–pollinator network per transect.

Additionally, we measured plant–*M. vatia* interactions and *M. vatia* prey capture. Along each transect, we checked every open flower for adult *M. vatia*, collecting observed individuals and recording the floral association and the presence of a prey item in the spiders' chelicerae. We measured prey capture as a proportion of *M. vatia* observed with prey to the number of *M. vatia* individuals at that transect. *Misumena vatia* surveys occurred within a week prior to the plant–pollinator survey at each transect and all three sampling rounds were pooled to obtain a total abundance of *M. vatia* within each transect.

2.3 | Plant–pollinator network analysis

For each plant–pollinator network, we calculated the total number of plant–pollinator interactions and four indices of network structure and specialization: (1) weighted connectance, (2) nestedness, (3) H_2' and (4) niche overlap of pollinators. Weighted connectance is the proportion of realized links weighted by network size and is related to network stability to perturbations (Dormann et al., 2008, 2009). Nestedness was calculated with the NODF index (Nestedness metric based on Overlap and Decreasing Fill) and is a measure of the degree to which rare species interact with a subset of the species that generalists interact with, with more nested networks tending to be more robust to species losses (Almeida-Neto et al., 2008). To determine network specialization, we used H_2', which is the deviation of observed interactions from expected interactions of the entire network and ranges from 0 (high generalization) to 1 (high specialization) (Blüthgen et al., 2006). Finally, to measure niche overlap, as estimated by the extent to which pollinators in the network visit the same plant species, we used Horn's index, which is based on the dissimilarity in visited plant species among pollinators (Horn, 1966). All network indices were calculated using the bipartite package v. 2.18 (Dormann et al., 2009).

Because network indices can be influenced by network size, we standardized nestedness, H_2' and niche overlap against comparisons to null models (Dormann, 2011; Dormann et al., 2009). We used the *vaznull* null model because it randomizes the patterns of interactions while maintaining the connectance, number of species and total number of interactions of the original network in the null model, making it more relevant for ecological processes (Vázquez et al., 2007). For each network at a transect, we simulated 1000 null matrices using the *nullmodel* function. Next, we calculated a *z*-score for each network index as the difference between the observed value and the mean of the null matrices, divided by the standard deviation of the null matrices. The resulting *z*-scores were used as response variables in analyses. A *z*-score for weighted connectance could not be calculated because *vaznull* maintains the connectance of the original network in the null network.

2.4 | Statistical analysis

To test the effects of restoration treatments on floral resources and species interactions, we used generalized linear mixed-effect models. In all models, we used 'site' as a random intercept due to the split-plot design and to account for any unmeasured variation between restored prairies. First, we asked how seed mix richness and the number of seed source regions affect floral species richness and abundance. We included an interaction term between seed mix richness and seed source treatments to allow us to test if the effect of one restoration treatment changed with the other. We log-transformed floral abundance to meet the assumptions of a normal distribution, and we used a Poisson distribution to model floral species richness.

Next, we tested the effects of floral resources (abundance and richness) on species interactions. We fit a single mixed-effect model for each of the following responses: *M. vatia* abundance, *M. vatia* prey capture, number of plant–pollinator interactions, and plant–pollinator network metrics (weighted connectance, nestedness, H_2' and pollinator niche). We used a binomial distribution weighted by *M. vatia* abundance to fit prey capture models. We used a negative binomial distribution to model *M. vatia* abundance and number of plant–pollinator interactions and a Gaussian distribution to model network metrics.

Additionally, to visualize differences in floral interactions between arthropod groups (pollinators and *M. vatia*), we used non-metric multidimensional scaling (NMDS; vegan package v. 2.4-6, Oksanen et al., 2022). Each point in the plot represents the floral composition (flower species identity and relative abundance) that pollinators or *M. vatia* were observed to interact with at a transect during the plant–pollinator and plant–*M. vatia* interaction surveys (floral species × transect/arthropod group matrix). We calculated the Morisita–Horn dissimilarity index between arthropod interactions within transects and chose three dimensions for the final ordination (stress = 0.143) based on the visual inspection of a scree plot. We used permutational multivariate analysis of variance (PERMANOVA) to test if floral associations differed among arthropod groups, seed mix richness treatments and seed source treatments. We used the *pairwise.adonis* function from the pairwiseAdonis package v. 0.4.1 using the *horn* simulation method and Bonferroni *p*-value correction (Martinez, 2017).

All analyses were conducted in R v. 4.2.3 (R Core Team, 2023) and all figures were created with ggplot2 v. 3.4.2 and interactions v. 1.1.0 (Long, 2019; Wickham, 2016). We evaluated models for suitability with graphs of residuals and Q-Q plots using the DHARMa package v. 0.4.6 (Hartig, 2022). Continuous predictors were scaled and centred, and all predictors were checked for collinearity prior to being included in the model. We fit generalized linear models using the glmmTMB package v. 1.1.7 (Brooks et al., 2017) and tested for significance with type III sum of squares using the car package v. 3.1-2 (Fox & Weisberg, 2019).

3 | RESULTS

3.1 | Floral resources

Restoration treatments affected floral abundance, but not floral species richness (Figure 1a,b) (Table S5). Seed mix richness and the number of seed source regions interactively affected floral abundance ($\chi^2 = 7.62$, df = 1, $p = 0.006$) (Figure 1a). In sites with seeds sourced from three regions, floral abundance did not differ between seed mix richness treatments, whereas in sites with seeds sourced from a single region, floral abundance was 65.7% lower in sites with a low seed mix richness.

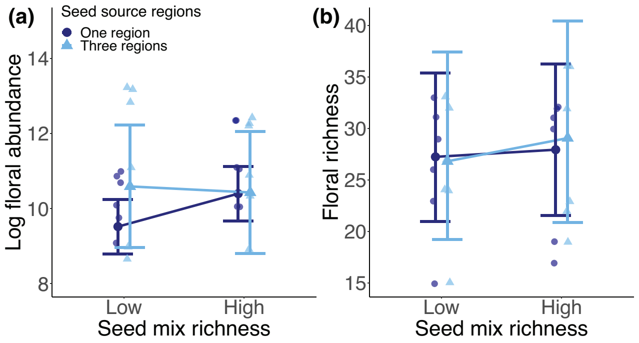

FIGURE 1 Effects of seed mix richness and the number of seed source regions on (a) floral abundance and (b) floral species richness. Six prairies were restored using seeds sourced from one geographic region and six were restored using seeds sourced from three geographic regions. Within each prairie, half-sites were sown with a low richness seed mix (12 species) and a high richness seed mix (71 species). Error bars represent 95% confidence intervals.

3.2 | Misumena vatia abundance and prey capture

We observed 620 *M. vatia* individuals across sites, 13% with prey. Higher floral abundances increased *M. vatia* abundance ($\chi^2=6.15$, df = 1, $p=0.013$) (Figure 2a), and at higher floral abundances, *M. vatia* were also more likely to be observed with prey ($\chi^2=7.69$, df = 1, $p=0.006$) (Figure 2b). Floral species richness had no effect on *M. vatia* abundance or prey capture (Table S6).

3.3 | Plant–pollinator network

Overall, we observed 2678 plant–pollinator interactions, consisting of 17 syrphid fly species and 73 bee species foraging on 48 flower species. We found higher floral abundance ($\chi^2=8.68$, df = 1, $p=0.003$) and richness ($\chi^2=4.18$, df = 1, $p=0.041$) increased the number of plant–pollinator interactions (Figure 2c,d). Higher floral species richness decreased network connectance by 14% ($\chi^2=11.4$, df = 1, $p=0.001$), but we found no other effect of floral resources or restoration treatment on other measures of network structure (Table S6).

3.4 | Pollinator and Misumena vatia floral associations

The first two axes of the NMDS ordination plot explained 79% of the variance in community structure, and all four axes of the NMDS explained 90% of the variance (Figure 3). Among arthropods groups, we found that pollinators and *M. vatia* interacted with different floral assemblages in high richness seed mix treatments (*F*-value = 5.53, $R^2=0.11$, $p=0.006$), but not low richness seed mix treatments (*F*-value = 2.75, $R^2=0.06$, $p=0.162$) (Figure 3a). Additionally, arthropod groups also interacted with different floral assemblages from each other in prairies sown with seeds sourced from one region (*F*-value = 4.22, $R^2=0.09$, $p=0.006$) and three regions (*F*-value = 4.22, $R^2=0.09$, $p=0.018$) (Figure 3b). Generally, *M. vatia* tended to be found on *Erigeron* spp., *Achillea millefolium* and *Lotus corniculatus*, while pollinator most frequently visited *Achillea millefolium*, *Echinacea purpurea* and *Centaurea maculosa*. Within an arthropod group, pollinators interacted with different floral assemblages between low and high richness seed mix treatments (*F*-value = 3.78, $R^2=0.08$, $p=0.036$), but *M. vatia* did not interact with significantly different floral assemblages between seed mix richness treatments (*F*-value = 2.15, $R^2=0.05$, $p=0.456$) (Figure 3a).

4 | DISCUSSION

Our results demonstrate that restoration practices aimed at restoring the plant community affect floral resource availability, and these floral resources structure higher trophic level interactions. We show that admixture seed sourcing and seed mix richness interactively affect floral abundance, and floral abundance promotes *M. vatia* abundance, prey capture and plant–pollinator interactions. Pollinators and *M. vatia* interacted with different floral assemblages, indicating the value of diverse floral resources for restoring multiple taxonomic groups. As a result, prioritizing restoration techniques that promote floral abundance and diversity may be integral for restoring higher trophic level interactions of taxa that rely on floral resources.

4.1 | Floral resources

We found that using seeds sourced from three regions increased floral abundance in prairies seeded with a low seed mix richness (Figure 1a). Because we measured cumulative floral abundance to understand the total availability of floral resources across the growing season, this increase in floral abundance may be due to phenology differences between the three regions that seeds were sourced from (local Midwest, non-local northern, non-local southern). In many plant species, seeds sourced from southern regions flower sooner

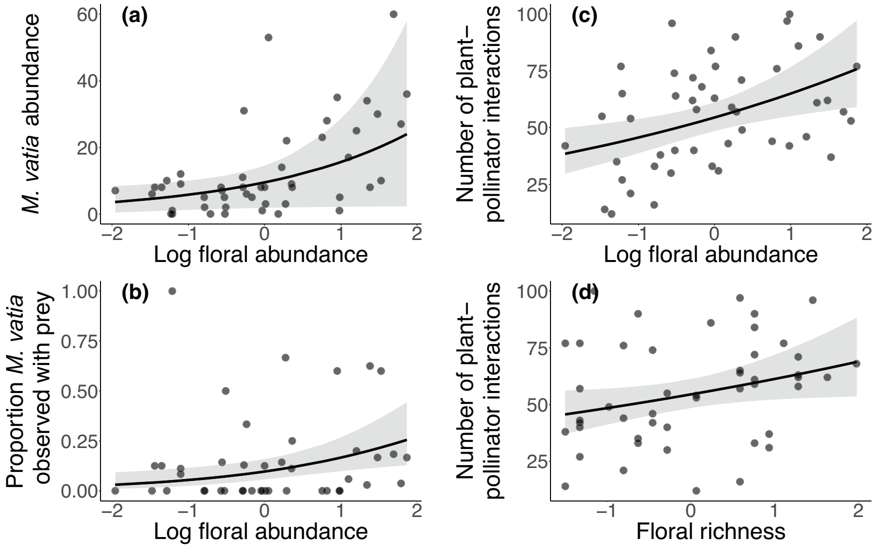

FIGURE 2 Higher floral abundance increased (a) *Misumena vatia* abundance; (b) the proportion of *Misumena vatia* observed with prey, weighted by total abundance; and (c) the number of plant–pollinator interactions. (d) Higher floral species richness increased the number of plant–pollinator interactions. Each point represents data from one transect. Line represents model predictions from generalized linear models and the shaded region represents 95% confidence intervals.

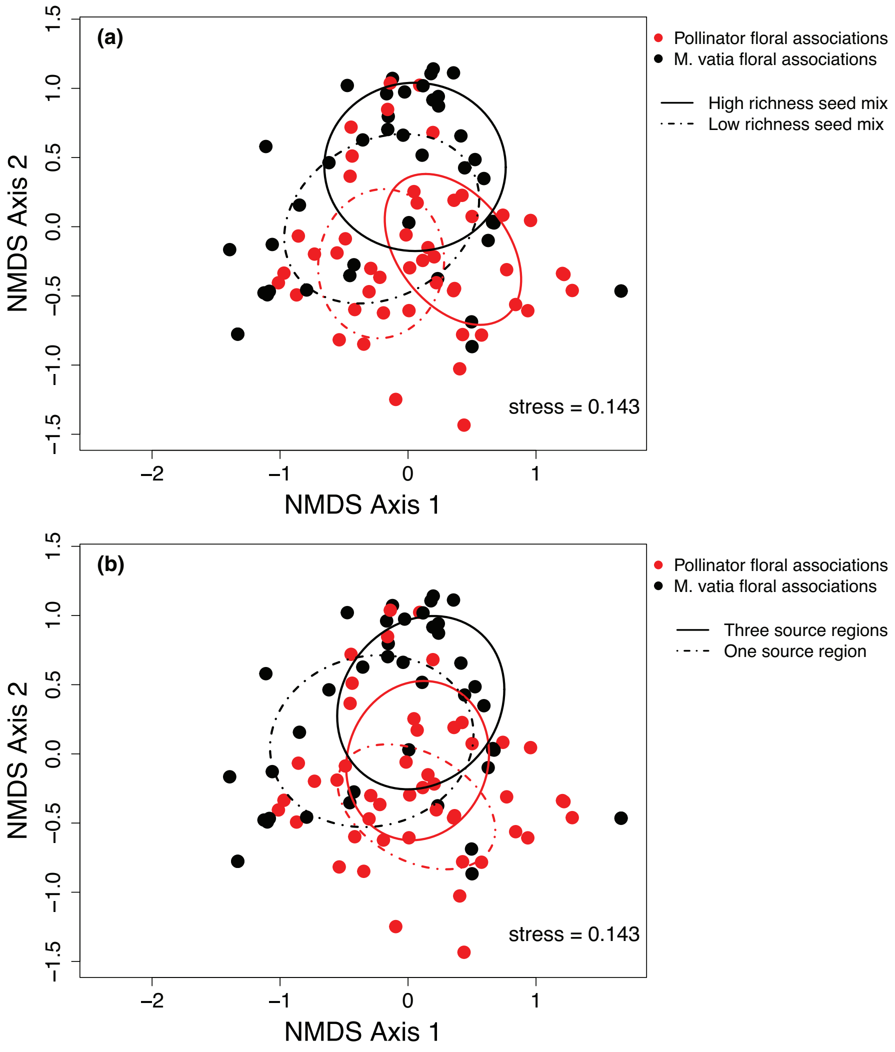

FIGURE 3 First two axes of the non-metric multidimensional scaling (NMDS) ordination of the floral assemblages associated with pollinators and *Misumena vatia* (Morisita–Horn dissimilarity). Points represent the floral assemblage at a transect that either pollinators or *Misumena vatia* individuals were observed to interact with; (a) ordination grouped by arthropod taxa and seed mix richness and (b) ordination grouped by arthropod taxa and number of seed source regions.

than those from higher latitudes (Bucharova et al., 2022; Woolridge et al., 2023). Using seeds from multiple regions may promote flowering across the entire season. However, sourcing seeds from multiple regions had little impact on floral abundance when paired with a high richness seed mix that contains plant species that differ in phenology (Figure 1a). Our results suggest that admixture seed sourcing may only increase floral resource abundance when the richness of the seed mix is low. Additionally, because unsown species accounted for a large proportion of the flowers in the prairies, these trends may also be driven by differences in competitive interactions between restoration treatments. A low seeding richness with phenologically different conspecifics due to admixture seed sourcing may result in reduced competition for resources such as light, nutrients or pollinator visitation. Unsown floral species may establish more easily with this reduced competition (Kaul & Wilsey, 2021; Larson et al., 2011), increasing the total floral abundance of the prairie.

Contrary to our expectations, we did not find a clear effect of seed mix richness or admixture seed sourcing on floral species richness. Previous research has found that seed mix richness increased plant diversity (Larson et al., 2011), but responses can be highly variable (Paraskevopoulos et al., 2022). Although many of the target species in the seed mixes established, we observed high numbers of unsown species in the prairies, and these may have swamped out differences in sown seed richness. Additionally, we surveyed floral species richness in the third year of prairie restoration, and we expect more species to establish with time (Grman et al., 2015).

4.2 | Species interactions

A high seed mix richness is commonly used to increase plant diversity (Barr et al., 2017; Larson et al., 2011), but less is known about how these practices translate to species interactions (Bucharova et al., 2022). Despite no apparent effect of seeding richness on floral species richness, we found that pollinators interacted with different floral communities between low and high richness seed mix treatments (Figure 3a). Although floral species richness may not differ between restoration practices, the community composition or relative abundances of flowers that are significant for pollinators may shift between treatments, contributing to a shift in pollinator floral associations (Figure S2). Additionally, *M. vatia* and pollinators interacted with different floral communities, indicating that arthropod taxa are using floral resources differently. Although these results do not directly indicate pollinator avoidance of *M. vatia*, they are consistent with previous research that found *M. vatia* tend to sit on a few dominant and high reward flower species (Benvenuti, 2022; Heiling & Herberstein, 2004), while pollinators tend to avoid flowers that *M. vatia* are present on (Antiqueira & Romero, 2016).

Our findings that floral abundance increased the number of *M. vatia* and plant–pollinator interactions complements previous research that has found that floral abundance is a strong determinant of plant–arthropod interactions in restoration (Benvenuti, 2022; de Souza et al., 2022; Kaiser-Bunbury et al., 2017). More plant–pollinator interactions may also have contributed to higher *M. vatia* abundances and prey capture in prairies with an increased floral abundance, providing more opportunities for prey capture. These resource–consumer–predator trophic interactions are integral to maintaining biodiversity (Benvenuti, 2022; Schmitz, 2003) and facilitating ecosystem services, such as pollination (Menz et al., 2011), promoting the long-term success of restoration. Our findings emphasize the dependency of *M. vatia* and pollinators on floral resources and the subsequent importance of considering resources in prairie restoration for species interactions.

Although floral species richness and abundance increased the number of plant–pollinator interactions, we found few effects of floral resources and restoration treatments on plant–pollinator network structure. Previous research has found that floral resources can impact plant–pollinator network structure (de Souza et al., 2022; Doublet et al., 2022); however, other factors in restoration, such as the surrounding landscape context, may also be significant in structuring pollinator response to restoration (Griffin et al., 2021). Additionally, network structure may vary with other floral measures, such as community composition (Kelly & Elle, 2020), which may not be captured in our measure of floral abundance and richness.

4.3 | Implications for restoration

We demonstrate that seed mix richness and admixture seed sourcing affect some components of floral resources and species interactions. Factors such as seed mix richness and the number of seed source regions may be important in structuring the composition of flower species that pollinators interact with, and future research should directly test the implications of this shift for ecosystem services, such as pollination. Approaching restoration to prioritize floral-associated arthropods could involve using seed mixes that are optimized to meet the needs of a diverse arthropod community, such as incorporating forbs that are high-quality resources for pollinators or are phenologically diverse (Havens & Vitt, 2016; Otto et al., 2017; Simanonok et al., 2022). Additionally, more work is needed to assess the role of non-seeded species in restoration, as arthropods interacted frequently with non-seeded species in our system. Assessing how plant-focused restoration affects resource availability for higher trophic level interactions will further our ability to predict restoration outcomes (Forup et al., 2008).

Importantly, both *M. vatia* and pollinator interactions were strongly increased by floral abundance. Passive plant-focused restoration strategies often prioritize promoting plant diversity to restore higher trophic levels (Catterall, 2018), but restoration of food web interactions may not necessarily follow. Our findings suggest that total resource availability should explicitly be considered for the restoration of plant–arthropod and arthropod–arthropod interactions. As a result, although most restoration work approaches restoration as a bottom-up process, incorporating a food web perspective that considers resource–consumer–predator dynamics will advance our understanding of restoration at the ecosystem level.

AUTHOR CONTRIBUTIONS

Lindsey R. Kemmerling, Sean R. Griffin and Nick M. Haddad conceived the ideas and designed methodology; Lindsey R. Kemmerling, Sean R. Griffin, Jessica Webb and Ally K. Brown collected the data; Katherine A. Hulting analysed the data and wrote the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

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CONFLICT OF INTEREST STATEMENT

No conflicts of interest.

DATA AVAILABILITY STATEMENT

Data available from the Dryad Digital Repository: https://doi.org/10.5061/dryad.zpc866tg0 (Hulting et al., 2024).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Figure S1: Map of the 12 restored prairies at Kellogg Biological Station in southwest Michigan.

Figure S2: First two axes of the nonmetric multidimensional scaling (NMDS) ordination of the floral assemblages in restored prairie sites (Morisita–Horn dissimilarity, three dimensions).

Table S1: Species compositions of seed mixes.

Table S2: Primary seed provenance origins of local Midwest, non-local Northern and non-local Southern seed source regions.

Table S3: Flower species observed in all sites including all treatments and transects.

Table S4: List of syrphid fly and bee species identified.

Table S5: Results of generalized linear mixed effect models testing the effects of restoration treatments on floral abundance and richness.

Table S6: Results of generalized linear mixed effect models testing the effects of floral abundance and richness on *Misumena vatia* and pollinator interactions.

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